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ALADIN Newsletter 23

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July - December 2002

http://www.cnrm.meteo.fr/aladin/ & http://www.cnrm.meteo.fr/alatnet/

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These joined Newsletters present you the principal work around ALADIN or ALATNET during the second half of 2002. The news about work or events are related with informations that you sent.

An electronic ALADIN Newsletter 23 is available on the ALADIN web site and an electronic ALATNET Newsletter 6 can be consulted on the ALATNET web site.

Please do bring to our notice anything that you would like to be mentioned in the next Newsletters (ALADIN 24 & ALATNET 7) before mid-July 2003.

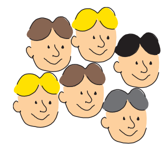
Any contribution concerning announcements, scientific progress, publications, news from the ALADIN versions on workstations or on big computers, verifications results, ... will be welcome.

ALADIN and ALATNET News

1. A rainy summer

Weather was not very nice last summer, especially over Central and Eastern Europe which had to face very severe floods. ALADIN forecasts proved quite good in these circumstances. More details can be found in the dedicated paper from the Austrian team and in the LACE report.

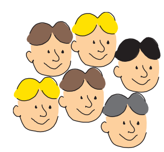
A dedicated SRNWP workshop was organized in De Bilt (Nl) on October 10th, after the annual joint EWGLAM/SRNWP meeting. Presentations and reports should be available soon on the SRNWP web site : *http://srnwp.cscs.ch/*.



2. LACE training course "on physics"

A training course on physical parameterisations was organized in Prague, from the 16th of September to the 4th of October. This was a pure LACE action, aiming at training a team likely to start research in physics within the new LACE structure. Students were few : Alexander Kann, Harald Seidl (Au), Martina Tudor (Cr), Martin Janousek, Richard Mladek, Petra Smolikova, Alena Trojakova, Filip Vana (Cz), Laszlo Kullmann (Hu), Martin Bellus (Sk), Kay Suselj (Si) (and not all expected to focus on physics afterwards, as one may guess).

The program was quite ambitious and training very intensive : general lessons about the NWP physics and special ones about the parameterisations used in ARPEGE/ALADIN, comparison between code and documentation, study and report on papers, work in small groups. For more details, contact *Filip.Vana@chmi.cz* or the teacher : *Jean-Francois.Geleyn@meteo.fr* .



3. "ALADIN maintenance and phasing training" workshop

Compared to the previous one, this training course was short, only one week (25-29 November) long, and more widely open (5 non-LACE students among 18). Considering the a-priori daunting topics concerned and the standing difficulty to find volunteers for phasing, it was a success : only 10 students were expected at first. The program was quite dense, with lectures, exercises and discussions. Details on the organization and presentations may be found on the dedicated web site :

http://omsz.met.hu/english/popsc/wshops/aladin_ws/prog.html (with a link from the ALADIN site)

This workshop also gave an opportunity to renew or write documentation on ALADIN. The final discussions are summarized hereafter, thanks to András Horányi.

Round table discussion
(ALADIN Maintenance Workshop, 2002 Budapest)

Source code management (validation)

- Use of *cc_depend*, *gmkpack*

Code has more and more dependencies. Use of sophisticated compilation and building tools is recommended. Possibilities:
- *gmkpack*'s (Météo-France) advantage is, that there is support for *ODB* as well.
- *cc_depend* (CHMI) is the other option, but it is currently does not handle *ODB*.

- *cc_depend* could be perhaps built in *gmkpack*.

⇒ Recommendation :

Developers outside Toulouse are encouraged to use *gmkpack*. The possibility to merge *cc_depend* and *gmkpack* should be explored.

- Source code management:

There will be more and more need to have local source code management due to local development and local operational applications.

⇒ Recommendation :

The usage of *CVS*. Export version of *CVSTUC* (a set of scripts making *CVS* more user friendly for ALADIN) will be created. For the package contact Martin Janousek.

Xrd problems

- *xrd* should be cleaned (useless routines to be removed etc.).
- duplication of *.c* and *.F* routines.
- All project (except *xrd*) can be compiled without explicit promotion of real and integer values.
- Problem of explicit declaration of arrays (memory consumption)

⇒ Conclusions :

Olda, Gabor, Martin, Stjep and Jure write a list of existing problems in *xrd* with a proposal of solutions. Olda starts the action. Jean-Daniel Gril will be the Météo-France contact person. It should be decided inside the above nominated group how to sort out problems and in which format to enter the modifications, after a possible (mandatory) check with ECMWF.

Documentation

- Users manual for configuration 001 would be very useful. There are some parts partially covered (i.e. non-hydrostatic) from scientific and architecture point of view.
- Technical/scientific documentation (with the structure similar to Alain Joly's paper) has to be written.

⇒ Conclusion :

Météo-France will invite a volunteer to Toulouse to set up the skeleton of documentation. Afterwards, the documentation will be completed and maintained with the help of experts for specific parts.

- Other proposal is improve self-documentation in the code (modules): short explanation of the module + description of module variables (easier to follow changes)
- Exercise for phasing: enhance explanations in modules

⇒ Conclusion :

Prototype namelists of all working configurations have to be added to export versions of new cycles with explanations in separate file or in the namelist itself.

Coding rules

- A great part of the work has been done with Ryad's documentation.
- Automatic checker for the code is needed.

⇒ Conclusions :

> Read and comment the coding rules and send the comments.
> Météo-France will discuss the usage of coding rules with ECMWF.
> Coding rules are obligatory while working on the ALADIN code.
> Coding rules are recommended while working on external tools related to ALADIN.
> Concerning the automatic checker, it could be the supplementary part of new *fortran2html* parser.

Future code evolution

- Further externalization, modularization (as TFL/TAL)

goal :	step by step towards more rationalized and modular code.
proposals :	biperiodization, coupling?, FullPos...
question :	how to handle the interfaces to modular part?

- Parallel I/O: follow the evolvement of implementation of MPI-2, but no concrete actions for the time being.
- Revision of data flow (not decided yet who and how it is going to do the job)
- Reformulation of physics/dynamics interface

Phasing (validation) strategy

- Number of phasers is limited, on the other hand the number of configurations has increased and they have to be phased rather sequentially than in parallel

⇒ The spirit of phasing has slightly changed :

> rather continuous than a "one go" procedure
> the job has been split to direct code phasing followed by the phasing of data assimilation parts (a core-group works on the basic configurations and the rest is phased afterwards)

⇒ Further proposals :

> Some parts of the phasing could be exported.
> Training of newcomer phasers (this workshop was a proper introduction).

Export version

- Some additional information to be attached to export versions:

> prototype namelists
> specific document about validated configurations

- Incremental strategy for export versions was proposed which means:

> a basic export version (at least 927, 001, Full-Pos)
> bugfixes for other working configurations (bugfixes with respect to the basic version)

- LACE ASC (Olda) will be responsible to report the platform-specific modifications of the code with respect to the reference version in Météo-France and other local specific issues.

ODB

- Generic problem is the lack of documentation:

- installation guide would be very useful
- validation guide/doc.   - " -

Both have to evolve with modifications cycle by cycle...

- It was decided that the LACE Data Manager (Stjep) will take over the coordination of the *ODB* related work, to start with the writing of an installation guide.
- It is planned that possibly Sandor + Stjep will work together on next cycle's installation in Budapest.

<u>Web server</u>

- Recommendation: Visit to Météo-France has to be organized to maintain the web server.
- Mirroring between intranet and internet part of ALADIN web server.

<u>AOB</u>

- Next workshop about maintenance in 2004, decision at the next ALADIN Assembly of Partners
- Format has to change perhaps to the lectures in the morning and exercises in the afternoon.
- Undiscussed topics : Optimization, E923

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4. EWGLAM and SRNWP events

<u>a. Annual 2002 EWGLAM and SRNWP meetings + SRNWP workshop on floods</u>

De Bilt (Nl), 7-10 October 2002
The corresponding LAM Newsletter and some pictures are already available at : *http://www.knmi.nl/hirlam/EWGLAM2002/* , thanks to the efficiency of Gerard Cats.

<u>b. HIRLAM workshop on Mesoscale Modelling</u>

Dublin (Ir), 14-16 October 2002
Dijana Klaric was the ALADIN representative at this workshop. For more details, contact her or have a look at the HIRLAM web site. The proceedings are also available in Toulouse.

<u>c. SRNWP workshop on Numerical Technics</u>

Toulouse (Fr), 12-13 December 2002

The corresponding report should be available soon on the SRNWP web site (updated recently) : *http://srnwp.cscs.ch/*

d. SRNWP workshop on Statistical and Dynamical Adaptation

Vienna (Au), 5-7 May **2003**
"The scope of these meetings has been enlarged : not only the statistical adaptation will be the topic of the meeting, but also the dynamical adaptation. This includes presentations on, as examples : 1d models, road condition models, trajectories, orographic precipitation models, down-scaling methods, etc ... " (extracted from the official announcement). More details on the dedicated site :
http://www.zamg.ac.at/swsa2003/

e. Annual 2003 EWGLAM and SRNWP meetings

Lisbon (Pt), 6-9 October **2003**
The scientific topic will be : Use of new data for short-range NWP.

f. SRNWP workshop on High Resolution Modelling

Bad Orb (De), 27-29 October **2003**
with special emphasis on physical parameterizations.

g. SRNWP workshop on Verification Methods

De Bilt (NL), autumn **2003** ?
focussing on precipitations.

h. A new SRNWP Lead Centre

HMS, as a member of the ALADIN group, volunteered to be the new Lead Centre for LAM EPS, but there are 3 candidacies ...

i. SRNWP report for 2002

The annual SRNWP report, written by Jean Quiby, may be found hereafter. It should be available soon on the SRNWP web site.

EUMETNET
C-SRNWP Programme

Annual Report 2002

Workshops

The workshop activity has followed the rule that each Lead Centre has to organise a workshop every two years. With one exception, all the workshops of the even years have take place, the exception being the UKMO which, because of the move of its headquarters from Bracknell to Exeter, has postponed its 2002 workshop on Variational Methods.

Workshop on LAM-EPS
At the initiative of the INM (Spain) and in cooperation with it, the first workshop in Europe on EPS (Ensemble Prediction Systems) for LAM (Limited Area Models) has been organised in Madrid the 3-4 October. The motivation was the following: the EPS technique is successful for the medium-range and there is no scientific reasons hindering the use of this technique for the short-range. That the technique will be more delicate to apply at short range due to a smaller spread between the members is to be expected.

Workshop on Numerical Techniques

Following the decision taken at the SRNWP Annual Meeting 2001, the Numerical Technique Workshop moved from the odd to the even years and took place at Meteo-France Headquarters the 12-13 December. This workshop was again very interesting and experiences amplification: numerical problems more specific to the climate GCM were also discussed, as the conservation of mass in the lagrangian advection. This problem is not of primary importance for the short-range, but is a preoccupation for the climate simulations. Concerning our high resolution LAM's, a problem is emerging that will become very important with the steadily increase of the horizontal resolution: to have numeric schemes that can cope with very steep slopes.

Workshop on the August floods in Central Europe
With the full support of KNMI, the Coordinator organized a one day workshop (10 October) on the August floods that caused large-scale damages in Austria, in the Czech Republic and in Germany. That workshop took place immediately after the SRNWP Annual Meeting. The purpose of this workshop was to see how our models have coped with the huge amount of precipitations measured on the 12th and 13th of August. The workshop has been very successful in the sense that not only the affected countries or their neighbours presented their precipitation forecasts, but also more distant countries like UKMO, Spain or Ireland. The presentations were followed by a general discussion where the impression given by the presentations has been confirmed: it was only for 24h in advance that our LAM's gave the right amount of precipitations at the right place. It is not known why most models put the precipitations systematically too far to the East. Many participants shared the opinion that the source of this inaccuracy must lie in the boundary conditions yielded by the global models. It has also been said that the usefulness of the ECMWF EPS has been very limited.

EU projects

The Coordinator has been deeply involved in two projects:

ALATNET
The Coordinator has been asked by the Commission to act as expert advisor for the mid-term review of the ALATNET Project (22-23 April, Brussels). This Project which permits to 12 young scientists to be trained as PhD candidates or as Post-Doc's in numerical and dynamical meteorology using the structure and the support of the ALADIN/LACE Consortia is a very good promotion for the NWP science in Europe. The Coordinator has been impressed by the large scientific scope covered in this project and by the quality of the works presented.

Framework Programme 6
In May, the Coordinator has proposed to the SRNWP Members to submit an EoI (Expression of Interest). The answer has been very positive. With the help of colleagues of 4 NWS, he has drawn up and submitted a proposal for a "Network of Excellence", this network being the NWS of our 5 Consortia. The title of the proposal was: "Improvement of Weather Forecasting and Risk Assessment in Europe by Very High Resolution Simulations, Ensemble Forecasting and Modelling System Developments".

Annual Meeting

It took place in the Headquarters of the Dutch NWS in De Bilt (9-10 October). 23 European NWS were represented (which is remarkable) plus the ECMWF. The main points of discussion have been:

EUMETSAT ATOVS Retransmission Service
Several NWS have been pleased to hear that with the new station Athens the South and South-East of Europe will also be covered by this Retransmission Service. The Coordinator has expressed to the EUMETNET Deputy Director his thanks for the fulfilment of his request (cf. Annual Report 2001).
Hourly SYNOP's

With the continuous data assimilation schemes (as 4D-Var or nudging) and for the validation of the model diurnal cycle, it becomes each year more important to have SYNOP's on an hourly basis. The Coordinator showed, as example, the SYNOP chart of the 25 Jan. 2002 at 11h00 UTC. The discrepancy is maximum : either is a country covered with SYNOP (as for example Portugal, France, Ireland, United Kingdom, Germany, Belgium, The Netherlands, Austria) or the country is void of any observation (as, for example, Switzerland, Italy, Spain, Denmark, Sweden, Norway, Finland, Island, Greece). The Coordinator will try in 2003 to find out the reason of this dichotomy.

LC for LAM-EPS

After the success of the Madrid Workshop (see above under Workshops), the Assembly has decided to create a new Lead Centre for LAM-EPS. SRNWP Members have had the possibility to apply till the end of the year to become this new Lead Centre. Four NWS have applied.

Hourly frames from ECMWF

Switzerland reiterated his wish to receive from ECMWF the frames for each forecast hour (+00, +01, +02, etc) instead of the 3-hourly frames (+00, +03, +06, etc) as today. But no other country supported this requirement.

SRNWP Multi-Model Ensemble

All the EPS works done today in Europe and presented in Madrid last October are single-model EPS. DWD volunteered to assess the feasibility of the multi-model LAM-EPS. We have in Europe four models : HIRLAM, ALADIN, Local Model and UKMO UM. These models will form the basis of the multimodel short-range EPS. This work will be established in 2003. In order to avoid administrative difficulties, these multi-model ensemble forecasts will be computed in a first step in delayed mode, i.e. with a delay of one or two days. Surface pressure, wind at 10m and precipitations at +48 will be produced one a day.

FP6

At the time of the Annual Meeting, the situation was not very clear what FP6 would be. Nevertheless it was thought that SRNWP should follow its intention expressed in its EoI: to propose a Network of Excellence and not an Integrated Project.

EUMETSAT SAF's

Some of the developments made in the Satellite Application Facilities (SAF) centres are of great importance for the NWP. It was always accepted - as far as NWP is concerned - that the benefit of these developments goes mainly to the global models. It must today be realised that the benefits could be of the same importance for the high-resolution LAM's that it is for the global models.

SAF on Land Surface Analysis: 8-10 July 2002. Lisbon

As the soil processes are of the utmost importance as forcing for the boundary layer and more generally for the hydrological cycle (cloudiness included), it has been judged important to attend this workshop also because the LAM community was weakly represented next to the ECMWF.

The coordinator has brought successfully three amendments to the final recommendations which should be positive for the short-range NWP community:

- Snow cover: to concentrate to the simple method (the so-called spectral one) in order to have products as soon as possible and to have the more complicated method (the directional one) as a second step.
- Resolution of the albedo maps: as albedo is a function of vegetation, same high resolution for the vegetation as for albedo (and not a coarser one as envisaged).
- In the priority list: to give to the snow cover a higher priority than to the land surface temperature.

For the report:

J. Quiby
C-SRNWP Programme Manager

5. ALADIN cooperation

a. 7th Assembly of Partners

The 7th assembly of ALADIN partners was held in Bucharest, Romania, on the 28th of October, 2002. It welcomed participants from 14 ALADIN countries and an ECMWF observer.

The minutes should be soon available, but some points may already be mentioned :

- agreement concerning the use of the ALADIN model in climate mode for scientific purposes (climate simulations), by the International Arctic Research Center (IARC) of the University of Alaska in Fairbanks, Alaska (USA);
- agreement on the cooperation with African countries, with Morocco as main intermediate (see hereafter);
- problems with ODB (lack of documentation and support) underlined once more;
- idem for the subcritical size of some ALADIN teams, the need for more publications and documentation, etc;
- presentation by Jure Jerman of the "Prototype for common objective verification at synoptic scales". No agreement was found on the problems of financial and technical support to the Slovenian team, so it was suggested to continue the prototype development and present both the results and a detailed documentation including the foreseen economical efforts next time;
- presentation of some opportunities within the 6th Framework Program of the European Union;
- creation of a "rotating foreign bureau" hosted by the last organizer of the Assembly of Partners, starting with Romania. This committee will monitor the MoU modifications required by the cooperation of the ALADIN Consortium with ACMAD (see hereafter);
- no volunteer to host the next ALADIN workshop.

Next meetings : Cracow, end of October 2003; Croatia in 2004.

b. Cooperation with African countries

Following the conclusions of the working group’s meeting in Ston-Dubrovnik (Croatia - 04.2002) and of the WMO meeting in Pretoria (RSA - 10.2002), and within the cooperation between ACMAD and Météo-France on one hand and between ACMAD and DMN Morocco on the second hand, to develop NWP in Africa, a new configuration of ALADIN, called ALADIN-NORAF, is running operationally in Casablanca since the 24th of February. The NWP products issued from this new model should be sent to the covered NMSs via RETIM 2000 or Internet. The final agreement is for the following list of African countries : Algeria, Benin, Burkina-Faso, Chad, Egypt, Eritrea, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Liberia, Libya, Mali, Mauritania, Niger, Nigeria, Senegal, Sierra-Leone, Sudan, Togo (Morocco and Tunisia being full ALADIN members).

The ALADIN-NORAF domain covers nearly all the African countries to the north of the equator (from 43.86°N to 0.70°S and from 36.20°W to 56.48°E). This model is run twice a day, at 00 and 12 h UTC, with respectively 72h and 60h forecasts. Data assimilation is realized every 6 hours, using optimal interpolation in a first step. By the end of this year Morocco plans to use raw radiances from TOVS AMSU-A with a 3d-var implementation. The coupling files are provided by Météo-France from the ARPEGE stretched global model. In parallel a local model ALADIN-ALBACHIR, covering Morocco, is run without data assimilation and coupled with the regional model ALADIN-NORAF.

A new users’ group, the Committee of Users of the Model ALADIN-NORAF (CUMAN), has been created by ACMAD to define the best products which should be produced and distributed to the NMSs, and to discuss on the different topics linked to the exploitation of this new model. The first meeting of the CUMAN will be held in Casablanca by the end of April.

For more details contact Radi Ajjaji in Casablanca or Philippe Caille in Toulouse.

c. Scientific reports

Thanks to the thematic coordinators, a detailed scientific report covering the first 10 months of 2002 (prepared for the Assembly of Partners) is available on the ALADIN web site :

http://www.cnrm.meteo.fr/aladin/scientific/2002/rapport_long_2002.html

Many other documents are now available on these pages. A scientific plan for ALADIN in 2003 has not been prepared yet, because of the uncertainties resulting from the problematic relationships between ALADIN and AROME (see below).

d. New LACE organization

The organization of the LACE group (including Austria, Czech Republic, Croatia, Hungary, Slovakia and Slovenia) has been modified. From the beginning of 2003, the common operational LACE suite stops. Each partner is responsible for its own operational applications, only the coupling files computed from ARPEGE are the same for all domains. Hence several teams were very busy with the design of new operational domains along the last months. Cooperation remains in research (3 working groups), training (next topic : ODB) and maintenance actions.

The new team of coordinators is the following :

- project leader : Dijana Klaric
- dynamics and coupling : Petra Smolikova
- data assimilation : Gergö Bölöni

- physics : Thomas Haiden
- maintenance : Oldrich Spaniel
- data management : Stjepan Ivatek-Sahdan

e. Next ALADIN workshop ?

Though the problem was raised again and again, no partner volunteered to organize the 2003 ALADIN workshop till the end of February ! Since the Newsletter is late (as often), we are glad to announce that the Czech team offers to welcome the next workshop in Prague, during the last week of November. More details soon.

Austria candidated for 2004.

f. ALADIN and AROME ☺ ? ☹ ?

AROME is a Météo-France project aiming to design a NWP LAM of very high resolution (2-3 km) within 2010, "as far as possible in cooperation with ALADIN partners".

However, though the ALADIN non-hydrostatic dynamics (and the ALADIN source code) was chosen as the starting point for AROME, a future cooperation may really be questioned. The following report, issued from CSSI discussions, was sent to Directors and a dedicated scientific+political workshop will be organized in Prague (11-12 April), just before the next WMO session.

Report from the CIPN (Comité Informel sur la Prévision Numérique) ad-hoc working group meeting

Météo-France, 5 February 2003

by Radmila Brozkova and Luc Gerard, members of the Group of Coordinators for Scientific and Strategic Issues (CSSI) established by the ALADIN Assembly of Partners

In short:

In the context of the introduction of the new AROME project, a new willingness to merge gradually and as far as possible the different modelling projects (ARPEGE-CLIMAT, ARPEGE-ALADIN and Meso-NH), has arisen at Météo-France.

The idea is to maintain only two branches, namely the global applications and the very high resolution applications (note that the present ALADIN model sits midway between these two branches).

This translates in the following actions:

1) The ARPEGE model remains with its 1D physics the basic global model, providing lateral boundary conditions to the Limited Area Models.

2) Convergence must be searched between ARPEGE-CLIMAT and ARPEGE-NWP (ALADIN) Physics; a new physics-dynamics interface will be realized in concertation with the ECMWF.

3) The AROME model (intended for meshes below 3 km) will use the non hydrostatic ARPEGE-ALADIN dynamics and possibly its data assimilation (this shall be further discussed), together with the Meso-NH (3D) high resolution physics.

A simpler version of the AROME physics will be developed for meshes around 10 km, but remaining still computationally significantly more expensive than the recent ARPEGE-ALADIN physics.

4) Since AROME could be for a long time out of computer capacity for many ALADIN countries but also for specific applications, the interest of the ALADIN physics at high resolution remains, and particularly the developments intended to mesh sizes between 7 and 3 km. These resolutions require specific refinements in the physics, particularly for the convective processes whose scales are partly resolved by the model grid.

Météo-France prefers to focus on AROME-3km and *it is a challenge for the ALADIN community to carry out research and its applications (in a continued ARPEGE-type phasing context) for these intermediate resolutions.*

A sensibilisation and discussion workshop is planned on 11 and 12 April 2003 in Prague.

1) Introduction

Following the decisions made by CIPN in December 2002, a meeting of the so-called ad-hoc enlarged working group of CIPN was scheduled for the end of January 2003. The main goal of this meeting was to review the work accomplished by the CNRM teams to respond to the strategy decided last December and to discuss with Météo-France Directors an analysis of the ALADIN and AROME convergence and a proposal on how to proceed. The agenda contained still some smaller items, like information on the recent parallel suite results, information and demands from forecasters etc., as well as a technical part on the interfacing of the mesoscale physics. The meeting was attended by the Director for Strategical Issues (over phone from Paris), head of CNRM, head of the NWP unit (GMAP), head of the climate unit (GMGEC), head of the mesoscale modelling unit (GMME), chief of AROME, key experts from the above mentioned units, representatives of the forecasting division and two members of CSSI invited from outside. There were two major items concerning ALADIN in the agenda, both linked to the model physics, which are reported here below.

2) Perspective of the convergence of ARPEGE-NWP and ARPEGE-CLIMAT physics

The physics of ARPEGE-CLIMAT has gradually drifted away from the operational ARPEGE physics, corresponding to new specific needs for the climate. This resulted in various switches deciding to call different parameterizations following the kind of run being performed.

To limit double work or perpetual overhead and delays in cycling, but also in regard to the limited impact of "screwdriver tunings" in the NWP model, it was decided that a convergence of both models should be searched in a reasonable time.

The advantage of the convergence of the two models would be first a neater code, easier to understand and to handle. The operational constraints of NWP can be quite different from those of Climate runs, but it will now translate mainly in differences in use, which should all be clearly justified, while the code should satisfy the two uses without acrobatics.

We could summarize the differences as next:

- The use of the Fouquart-Morcrette radiation scheme in CLIMAT, which is an accurate scheme called every 3 hours, opposed to the simplified radiation scheme of `ACRANEB`, much quicker to compute and called every time step.
- For the climate model, additional parameterisations of ozone, different kinds of aerosols give an important input to the radiation scheme, while they have no impact in NWP.
- The surface and vegetation scheme ISBA from CLIMAT has successfully been applied in the NWP applications, where it uses only one layer below the surface instead of three.
- ARPEGE-CLIMAT has used a diagnostic Turbulent Kinetic Energy scheme (TKE, Mellor and Yamada) for several years, and now a prognostic TKE scheme has been developed. The goal was to get a better representation of the diurnal cycle in the model. The TKE field is not

advected and doing it would not be easy since the variable was coded on the half levels of the model. The NWP model still uses a classical Monin Obukhov approach, while only preliminary work has been achieved for a TKE scheme at full levels.

- Stratiform cloudiness and precipitation are handled differently in the two models, the present diagnostic scheme of the NWP is very crude. This is in close relation to the developments in microphysics (next point).
- Work has been performed in both teams about the representation of cloud water.
  a) In ARPEGE-CLIMAT, the scheme developed by Ph. Lopez has been successfully tested.
  b) Parallelly in the frame of ALADIN some tests have been performed on a slightly modified adapted version of Lopez's scheme (keeping a separation of ice and liquid phases)
- New CAPE and mass flux-based shallow convection parameterisations have been tested in ARPEGE-CLIMAT
- The diagnostic convection scheme is still common to both models, but for the NWP, important developments have been started on a prognostic convection scheme, addressing cloud water and that should also solve the conflicts between subgrid and resolved precipitation at high resolutions.
- ARPEGE-CLIMAT also uses a scheme for the convective drag, which is represented the same way as the orographic gravity wave drag.

On many topics, the convergence between the two models seems feasible in reasonable time, with still some unavoidable specificities for the different operational constraints.

The following actions are proposed:

- For the radiation, the Fouquart-Morcrette has been tested in NWP, tests of a call at each time step is also planned. But this stays too heavy for NWP, so the possibility of an intermediate complexity scheme is still investigated.
- For the surface scheme, the convergence is practically realized. Some enhancements have been achieved in the NWP context, as the introduction of surface ice.
- A prognostic TKE scheme with continuity at the surface and large scale advection (requiring that TKE be defined at full levels) is the best choice.
- The cloud water scheme from Lopez seems a good choice, as its adaptation with a separate advection of ice and liquid has succeeded, and current developments around deep convection for NWP are compatible with this scheme. (The NWP should probably be able not to call the prognostic option for the precipitation itself.)
- The precipitating convection parameterisation is presently under important developments. It will benefit of the work performed in both contexts, and going to a more prognostic closure condition, associated to the moist TKE scheme, could help to solve together the shallow and deep convection.
- For the mountain drag, the NWP will suppress the use of the envelope orography, and one will assess the behaviour of the convective drag in the same frame (the code is identical). Common work will search the better equilibrium between gravity wave drag, form drag, lift and convective drag.

3) Problem of the AROME vs ALADIN physics

Chief of the AROME project prepared an analysis of the problem on the AROME/ALADIN convergence together with proposals on possible solutions, as he was charged by CIPN. This document is of a restricted distribution and it was submitted to the Météo-France Directors and summed-up at the meeting. The general problematics of the AROME and ALADIN convergence was discussed shortly, and it appeared that the Director was satisfied with the analysis. Then CSSI members were invited to express the needs of ALADIN Partners and their point of view. They stated that the reactions on the ALADIN side to the CIPN decision are very few for the time being and the main reason is probably a lack of proper information in order to get the right picture of the practical aspects of the policy decided by CIPN. The Director then concluded that a workshop ought to be organised with the ALADIN scientists and ALADIN Partners representatives. The head of GMAP was put in charge of the organisation of this workshop.

Then, within a short discussion it was re-confirmed that the most difficult item of the AROME and ALADIN convergence is the model physics. While for the dynamics and data assimilation it can be considered that these are de-facto joint and that the research and development work in these domains made in ALADIN shall contribute directly to AROME and vice versa, the best solution on the strategy for the development of an ALADIN-type physics is difficult to be found.

To sum up, the problem for a follow-on of the present ALADIN strategy lies in the requirements below:

- The need for a parametrization of convection suited for the 7-3 km scales, which is a tough challenge;
- The need for parameterization schemes which should by their philosophy and quality approach those of AROME but be closer to ARPEGE for their cost. This seems to be an issue difficult to solve but a crucial one for ALADIN Partners;
- It was proposed to start by testing the Meso-NH parameterizations in the ARPEGE/ALADIN 1D model first and when successful to proceed to 3D model (and to add the 3D turbulence only later) while keeping the 1D-type interface in AROME compatible with the present interfacing practice of ALADIN. This action responds to a need of AROME but also to most of the interface question for ALADIN 7-3 km semi-cheap physics;
- However the existence of this semi-cheap physics will have to be ensured by developers from the ALADIN Partners of Météo-France. It should be well understood that the 1D lower resolution AROME physics is meant for about 10 km scales, that it will be about twice more expensive than our current ARPEGE-like 10 km physics and that it still does not solve the moist convection problem of 7-3 km scales;
- The need for the maintenance of the physics specific to ALADIN (see above) and, in very specific cases, of its interface;
- The need for an anyhow increased maintenance effort when both ALADIN and AROME physics will coexists in some code.

At the same time there are already first steps made to cope with the requirements of the AROME's physics interface, like how to solve the organisation of the time-step, how to introduce new necessary variables, how to access 1D versions of the schemes.

The first outline of the time-step with 3D AROME physics may be described as follows:

a) inverse spectral transforms;
b) adaptation step of the physics;
c) evolution step of the physics depending on the previous adaptation;
d) preparation of the dynamical source terms;
e) addition of the tendencies of the steps b) and c) to the prognostic variables in the semi-Lagrangian interpolation buffers (to obtain these quantities at the origin point of the trajectory by sometimes monotonous- interpolations);
f) 3D minus 1D computations needing local information, processed within the semi-Lagrangian halo at the same part of the code when the interpolations are made;
g) semi-Lagrangian advection;
h) second adaptation step of the physics;

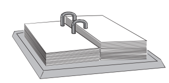
i) rest of the dynamical computations and direct spectral transforms;
j) spectral semi-implicit solver and possibly other spectral computations.

Compared to the current organisation of the model time-step a reader can easily imagine what would mean the interfacing of the AROME 2.5 km physics. One part of these computations will be iterated in the predictor-corrector schemes (from the step d) to the step j)).

For the introduction of new variables needed for the AROME physics, an analysis was already made together with ECMWF and there will be new data flow structure, treating via F90 descriptors the various attributes of model variables (spectral or gridpoint, needing derivatives or not, being advected or not, being coupled or not and so on) in a single framework (except for the big six variables part of the semi-implicit scheme for which the current structure will remain unchanged). After handling the attributes at the level of the setup, the data flow will become transparent to the user and the addition of a new variable will become far more easier. In a first step this will apply only to upperair variables of KLEV vertical extension. As a first consequence, model will have to use as a spectral variable the quantity RT instead of T (a first challenge for the ARPEGE/ALADIN community). The major rewriting of the code will take place in late spring early summer and new library is hoped to be available in late summer (preliminary component of cycle 27).

4) Conclusions

The important point of the meeting was the decision to organise an ALADIN-AROME workshop in order to explain well the new practical and political issues of the convergence of the two models. At the same time it remains clear that this convergence will bring important benefits to both sides but also has some potential drawbacks for small or medium computing resources, if some appropriate reorganization of efforts are not taken-on in parallel by the ALADIN Partners of Météo-France.



6. ALATNET events

<u>a. Timetable of stays</u>

The ALATNET stays of Christopher Smith in Prague, Ilian Gospodinov in Bruxelles, Cornel Soci and Gianpaolo Balsamo in Toulouse are now finished. Cornel and Gianpaolo should defend their PhD thesis before the end of Spring 2003.

<u>b. Workshop on coupling</u>

A one-week (17-21 February 2003) workshop on coupling issues has been organized by the Slovenian team in Ljubljana. The program is available at the following address :

http://www.rzs-hm.si/alatnetseminar/mcw.html

<u>c. Reports</u>

The next annual report must be sent before the end of April. A meeting of the steering committee is scheduled on the 24th of March in Ljubljana.

More informations are now available on the personal web pages of the ALATNET students.

<u>d. Last workshop</u>

A workshop gathering ALATNET students, their mentors and an additional member of each ALATNET team will be organized by the Hungarian team from the 15th to the 17th of October 2003. The SRNWP coordinators and representatives of the other consortia are also invited.

This meeting was scheduled after a demand from the EU representative, Mrs Jane Shield, at the mid-term review. Its aim is to allow students to present their results and discuss together once again. Part of the workshop will also be devoted to the preparation of the final review.

e. And afterwards ?

A proposal for a new RTN in the framework of the 6th FP of the EU (second call, November 2003) is to be considered. When compared to ALATNET, the network should focus more on training and involve more European countries. Along informal discussions during the EWGLAM meeting, COSMO expressed some interest in a joint venture.

7. Some practical informations

a. About 2003 stays

In Toulouse :

Many visitors are expected in Toulouse in 2003 !

Embassy fundings for Central and Eastern Europe asked for 2002 are now available, while in the meantime maintenance fundings slightly increased and the department of international affairs of Météo-France (D2I/INT) obtained extra fundings for ALADIN (both as a counterpart to the disappearance of Embassy fundings). Embassy fundings for Morocco and Tunisia will be negotiated soon, and are likely to keep the same level as last year, at least. And ALATNET stays are to be added.

However the situation is quite messy. The management of fundings depends on their origin, let us recall the rules :

Type of fundings	MF- maintenance	Embassy "CEE"	Embassy "Mo-Tu"	MF - D2I/INT
Responsibility	GMAP	D2I/INT+partner	D2I/INT+partner	D2I/INT
Contact points : organization official papers practical details	 Dominique Giard Jean Maziejewski Jean Maziejewski	 Dominique Giard Sylvie Rivals Jean Maziejewski	 Dominique Giard Sylvie Rivals Jean Maziejewski	 Dominique Giard Sylvie Rivals Jean Maziejewski
Travel paid by	Météo-France	partner	partner	partner
Per-diem paid by	EGIDE/Toulouse	EGIDE/Paris	SMF	SMF
Number and length of stays	≤ 25 ≤ 40 months	8 13 months	9 ? 16 months ?	≤ 4 ~ 6 months

All stays should start before the end of 2003, but EGIDE/Paris is not yet ready, and there are now few offices available at GMAP for visitors. If we don’t obtain some more (the demand is already a few years old) we won’t be able to welcome everyone. Small (very small) indices that discussions might start soon appeared along the last weeks.

The timetables are available on the ALADIN web site.

In Budapest :

A grant for a stay in Budapest is offered by HMS, as in 2002. Here is the official proposal :

The Hungarian Meteorological Service offers on its own expenses a 2-4 month research stay in Budapest for 2003 : we would provide 1400 euros as monthly allowance and possibility for a cheap accommodation at the guest room of our Service (the travel costs and the social insurance is on the responsibility of the candidate). Working conditions : PC or X-terminal accessing our IBM Regatta server, last ALADIN code version, *totalview* debugger available.

The proposed topics are as follows:

Further optimisation (parallelisation) of the ALADIN code : Work had been already started on the B-level parallelisation of the ALADIN code together with the implementation of the LSPLIT option. The enhancement of these features together with the tests using *OpenMp* parallelisation are the main objectives of this work.

First experiments on LAM EPS : At the beginning of the year some plans were formalised in order to start the LAM EPS (limited area ensemble) experiments for the ALADIN model. The first investigations will concentrate on the application of ARPEGE EPS information as initial and lateral boundary conditions for the limited area run. It is expected that first LAM EPS runs are going to be performed and evaluated.

Data assimilation : The ALADIN 3d-var data assimilation scheme is quasi-operationally running at the Hungarian Meteorological Service. The proposed work would concentrate on the extension of the 3d-var scheme towards four-dimension with the implementation of the 3d-fgat procedure, which allows the consideration of the observations at the exact observed time together with the first guess information at the appropriate time.

For the interested candidates, experience in running ALADIN and sufficient scientific background are desirable. In case of interest potential candidates should contact András Horányi (*horanyi.a@met.hu*) for further details.

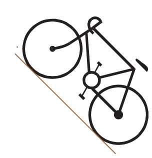
Deadline for applications is 31st of March, 2003, the candidates will be informed about the decision until mid-April.

LACE actions :

Fundings are available within LACE for research stays : 8 months (4 for dynamics, 3 for data assimilation, 1 for physics), in Budapest (1), Prague (6) and Vienna (1).

b. Documentation and publications

A significant effort was dedicated to documentation along the last months, thanks to the workshop on maintenance. The corresponding information is available on the (internal) GMAP web site and on the ALADIN pages, referring to the HMS web ones. This will be pursued along 2003, with some reports already scheduled : general ALADIN documentation (update by Jan Masek), 923, DFI,... PhDs and publications will also be considered (and in practice are restarting). Several maintenance stays in Toulouse have been scheduled for such a work. The next step should be an update of the ALADIN and ALATNET web sites, to take this into account. Any volunteer ?



c. New cycles and export versions

• ***Export version for cycle 25T1*** *(AL25T1_export_01)*

A new export version, based on cycle 25T1, has been prepared recently. Apart from the reference version, whose main advances have been described by Claude Fischer in the previous Newsletter, it includes further debugging, especially in data assimilation configurations, and the latest changes for operations in Toulouse (in 2002). A short description of changes and the source code of convertors (for geometry and namelists) are available in the export package.

This cycle has been implemented operationally in Toulouse (17 December), and the change of geometry within coupling files was quite smooth. It has also been installed in Slovakia, for research on NH dynamics mainly, and in Morocco, for operations.

Let us briefly recall the contents of this version :
- a lot of pruning (removing unused options etc), cleaning, debugging (as usual), and more safety locks, especially in physics;
- new ALADIN geometry (and induced changes);
- implementation of a "unified" predictor-corrector time-stepping scheme;
- introduction of the source code for blending;
- update of data assimilation configurations, new management of satellite data, small changes in ODB (but with no ascending compatibility), improved use of land-sea mask in some "surface" observation operators;
- use of local climatological ozone profiles in radiation (on demand), changes in the anti-fibrillation scheme;
- update of options `LVERCOR` (relaxation of thin layer hypothesis) and `LVERTFE` (finite elements for vertical discretisation) in dynamics;
- refinements for the vertical-plane model, with still some problems;
- and pure ARPEGE modifications.

• *Cycle 25T2*

A new cycle was created last autumn, including:
- new developments in NH dynamics : new prognostic variable *d4*, predictor-corrector scheme, new sponge, advection of vertical velocity, corrections in the vertical-plane model ... (this was the main purpose of this intermediate cycle);
- tendency-coupling for surface pressure (only for 2TL schemes and standard DFI);
- 4d-screening in ALADIN;
- introduction of an "obs pre-processing" for ALADIN : geographical selection of observations, in C+I zone;
- improved handling of "mean wind" in variational applications;
- use of raw radiances in ALADIN;
- improvements in the selection of surface observations (case of isles and lakes, use of SYNOPs with missing height information);
- merge of the new snow scheme (described in the previous Newsletter), safer handling of liquid water and ice in physics;
- optimizations, cleaning, and pure ARPEGE modifications.

There is no corresponding export version.

• *And*

Modifications for configuration *923*, based on the export versions *AL12_export_04* and *AL15_export_03*, are available. They allow, first to run *e923* on AL15, second to solve some standing problems and use new developments. A documentation has been sent to the e-mail list *aladin@meteo.fr*.

A new export version for AL15 should be prepared soon, including the bugfix for *923* and new developments in physics, at least.

A new export version for AL25T1 will also be prepared, for changes in physics.

For more details, contact Claude Fischer : *claude.fischer@meteo.fr*, or the GCO team (with a newcomer !) : *gco@meteo.fr* .

d. ODB

Complains about ODB (lack of support and documentation, very quick evolution,...) were many and strong along the last "official" meetings. We got an answer from ECMWF : they listen but cannot provide a documentation before Spring 2003. In practice the most recent news are : (***i***) ECMWF asked for the documentation written by Dominique Puech (GMAP), to translate it; (***ii***) Databases must be rebuilt at each new cycle.

e. New e-mail addresses in Romania

The new ones read : *forename.name@meteo.inmh.ro* (e.g. *doina.banciu@meteo.inmh.ro*).

And, thanks to Mateja Irsic, informations on ALADIN teams are now up-to-date on the ALADIN web site.

The operational ALADIN models

1. Changes in the operational version of ARPEGE along the second half of 2002

(more details samuel.westrelin@meteo.fr)

22 October 2002 : "New observations"

From the 22th of October at 06 UTC run, the raw radiances AMSU-A are assimilated in the 4d-var suite, instead of processed radiances HIRS and AMSU-A. The geopotential from radiosondes is not assimilated any more, but temperature at standard levels is now (in addition to that at characteristic levels). Wind data from European and American profilers are now assimilated. Concerning the physics, a few minor bug corrections have been introduced.

The coverage of polar zones with radiances is far better now. Evaluation statistics are good from low levels to the stratosphere. The relative humidity in the tropics is deteriorated due to the loss of HIRS channels.

17 December 2002 : "New cycle"

Starting from the 17th of December at 06 UTC run, the following modifications have been carried out :

- implementation of the new cycle, 25T1 ;
- assimilation of NOAA17 AMSU-A radiances ;

These changes did not bring a significant impact on scores.

Latest parallel suite : "DICORA" *(DIffusion COnvection RAdiation)*

Successfully tested from the 18th of December 2002 till the 10th of February 2003, it included the "first package" of changes in physics described in the dedicated paper by Jean-François Geleyn, and a few technical changes or bug corrections (ODB, Full-Pos, ISP, ...)

Next parallel suite : "COCONUT", "second package" of changes in physical parameterisations.

CAUTION

These changes will significantly enhance the discrepancy between the physics of the coupling and the coupled models, for those applications till on old versions, with a possible negative impact on forecasts. Back-phasing of the modifications in physics may be performed for those not yet on cycle 25T1, but not further than AL15.

2. Operational versions in Austria

(more details thomas.haiden@zamg.ac.at)

At the end of September 2002 the operational suite was switched from AL12 to AL15_Cycora-ter, with bug corrections in *accoefk* and *aplpar*. Roughly at the same time, daily pre-operational integrations of the LACE domain were started. Since 1 January 2003, both the ALADIN-LACE domain and the ALADIN-VIENNA domain are integrated operationally. ARPEGE coupling files (3-hourly) are downloaded via Internet.

3. Operational version in Belgium

(more details olivier.latinne@oma.be)

The installation of AL15/CY24T1 on SGI implied a long debugging task, because of some portability problems and some weaknesses of the compilers. Some shifts in the concepts of the output file contents required adapting our local post-processing tools and operational chain. At the same time, we decided to review the contents of the archives to limit the occupied volume and give a quicker access (avoiding additional post-processing) to the most often needed products. A parallel suite was launched in March, and later adapted in June following the discover of some bugs at Météo-France. However, the comparisons of some precipitation events showed a severe degradation compared to AL12; this was traced to be linked to the return to `GCOMOD`=1, which seemed to be inappropriate at high resolution.

4. Operational version in Bulgaria

(more details andrey.bogatchev@meteo.bg)

Nothing new along the last months.

5. Operational versions in Croatia

(more details ivateks@cirus.dhz.hr, tudor@cirus.dhz.hr)

Main features of the ALADIN-CROATIA operational suite in the Croatian Meteorological service:

SGI 3400, 16 processors, Irix 6.5

A) ALADIN-LACE: 12.176 km mesh size, 229x205 (240x216) gridpoints, SW corner (34.00, 2.18), NE corner (56.96, 55.07), on 37 vertical levels, coupled to ARPEGE with 3 hour interval, 48h forecasts using AL12T1 cycle.
   1) LBCs retrieved from *sirius* servers in Météo-France using CARNet (Croatian Academic and Research Network) Internet connection.
   2) e927 starts as soon as the LBC file is downloaded, e001 starts after e927 is finished for the second file.
   3) When all LBCs are available on time, the 48h forecast integration, with 14 DFI steps, takes 65 minutes using 11 processors.

B) ALADIN-CROATIA: 8 km mesh size, 127x109 (144x120) gridpoints, SW corner (41.79, 8.93), NE corner (49.53, 21.98), on 37 vertical levels, coupled to ALADIN-LACE with 3 hour interval, 48h forecasts using AL12T1 cycle.
   1) The suite starts after the ALADIN-LACE 48h integration is finished.
   2) 48 h forecast takes 30 minutes on 14 processors.
   3) Both parts were used in a test suite since 1st November and became operational on 20th December 2002.

C) Dynamical adaptation (DADA) - wind field is adapted to higher resolution climatological surface data using the dynamical adaptation method on 4 domains along the Adriatic coast and 1 inland. It starts after the ALADIN-CROATIA 48 h integration is finished. Only surface wind field is used for operational purposes

D) Output fields are visualised using GrADS visualisation package.

E) PSEUDOTEMPs are produced from both 48h forecasts and HRID meteograms are visualised.

F) Visualisation of ALADIN-LACE, ALADIN-CROATIA, dynamical adaptation forecast data and data measured at SYNOP stations in Croatia (example on Figure 3).

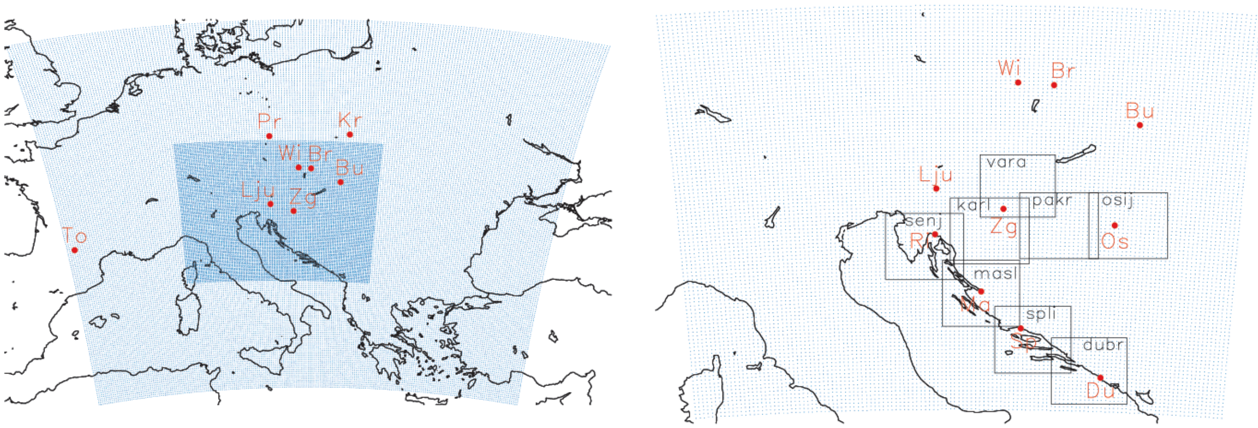


Figure 1: ALADIN/LACE (12 km resolution) and ALADIN/HR (8 km resolution) domains (left). ALADIN/HR (8 km resolution) and Dynamical adaptation (2 km resolution) domains for the surface wind fields (right), domains *senj*, *masl*, *spli*, *dubr* and *karl* are used operationally.

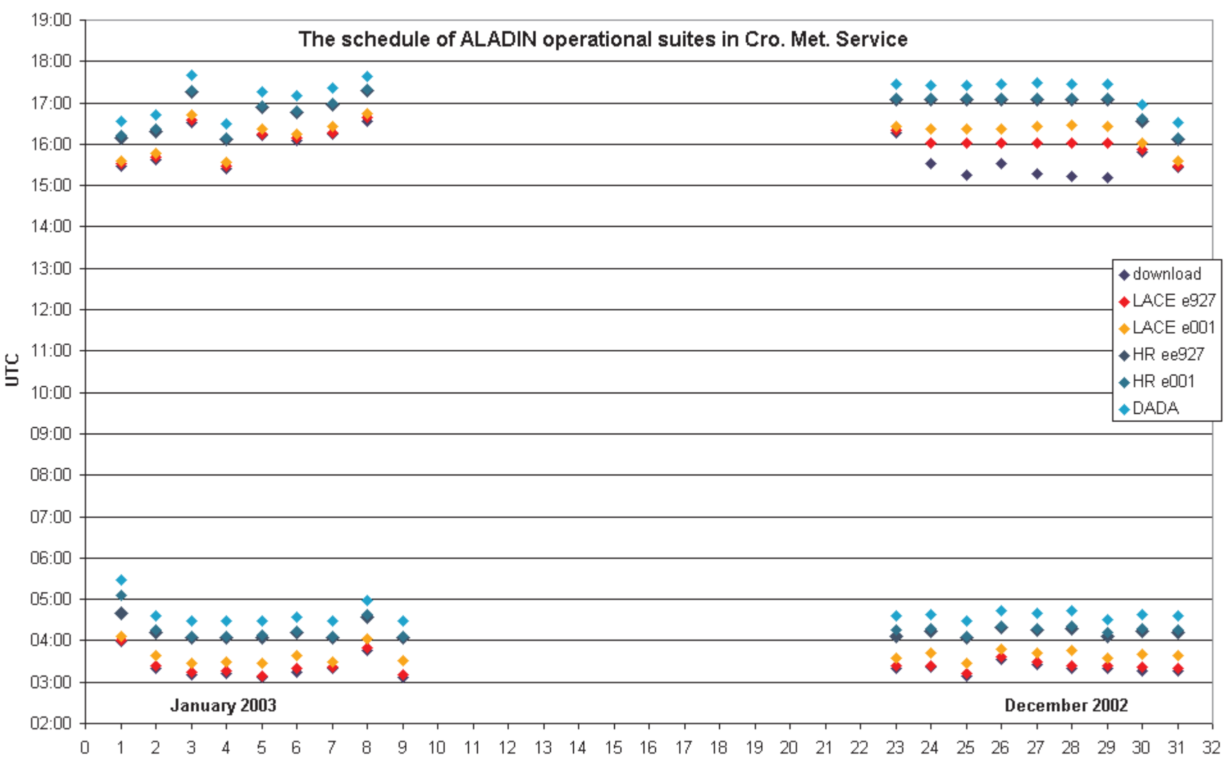


Figure 2: The dates when parts of the ALADIN operational suite in the Cro. Met. Service finished, for end of December 2002 and beginning of January 2003

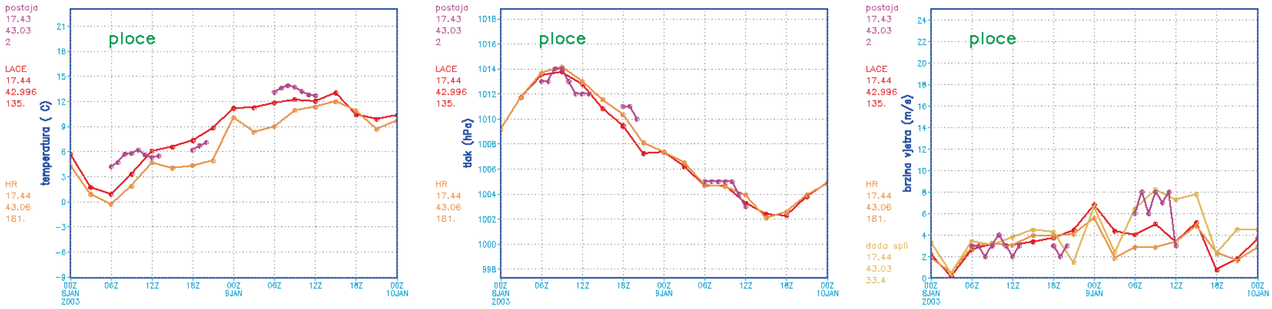


Figure 3: Visualisation of ALADIN-LACE, ALADIN-CROATIA, dynamical adaptation forecast data and data measured at SYNOP stations in Croatia for temperature (left), mean sea level pressure (centre) and wind speed (right).

6. Operational versions in France

(more details samuel.westrelin@meteo.fr)

Similar changes in ALADIN-France as in ARPEGE along these months :

"New cycle"

Together with the implementation of AL25T1, some changes were brought to post-processing : adding new dynamical fields (iso-PV fields, isobar PV), filtering derived fields (vertical velocity, dynamical fields)

"DICORA"

The benefits on temperature, from ground to the top of the mixed layer, are noticeable (see Figures 1 and 2), and the same holds for 2 meters humidity (Figure 3).

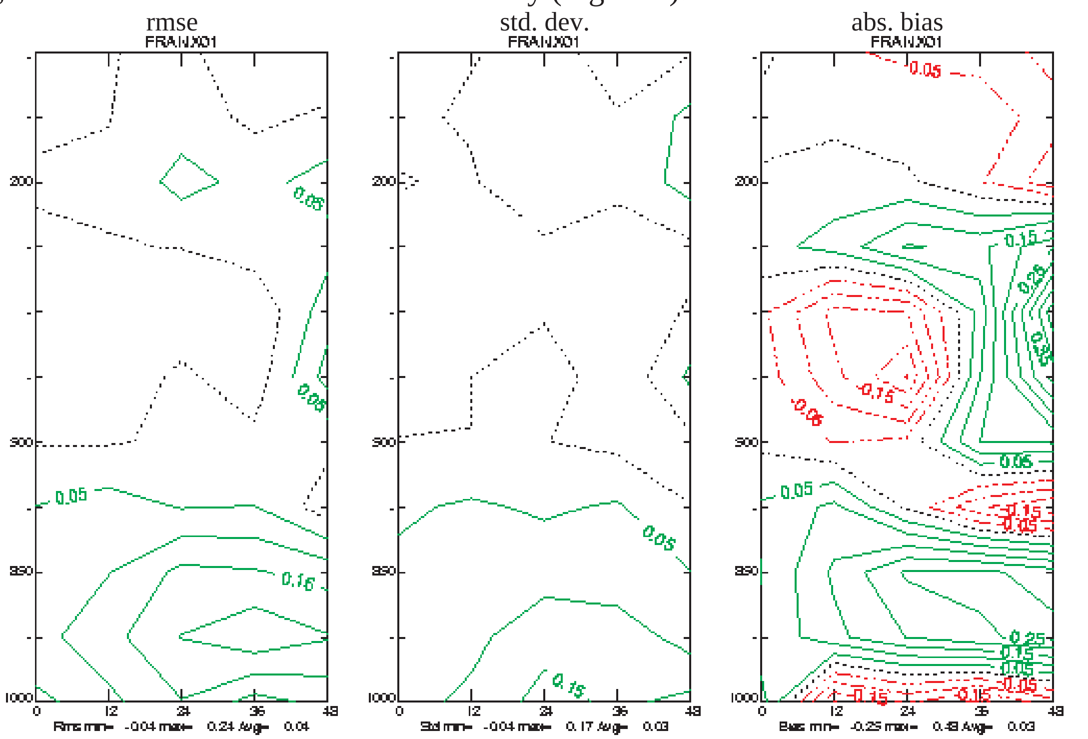


Figure 1. Scores against TEMP observations for ALADIN-France: oper/radiosonde - test/radiosonde.
(isolines every 0.05 K; 43 cases, from 21/12/2002 00 UTC to 05/02/2003 00 UTC)
(green : improvement, red : deterioration)

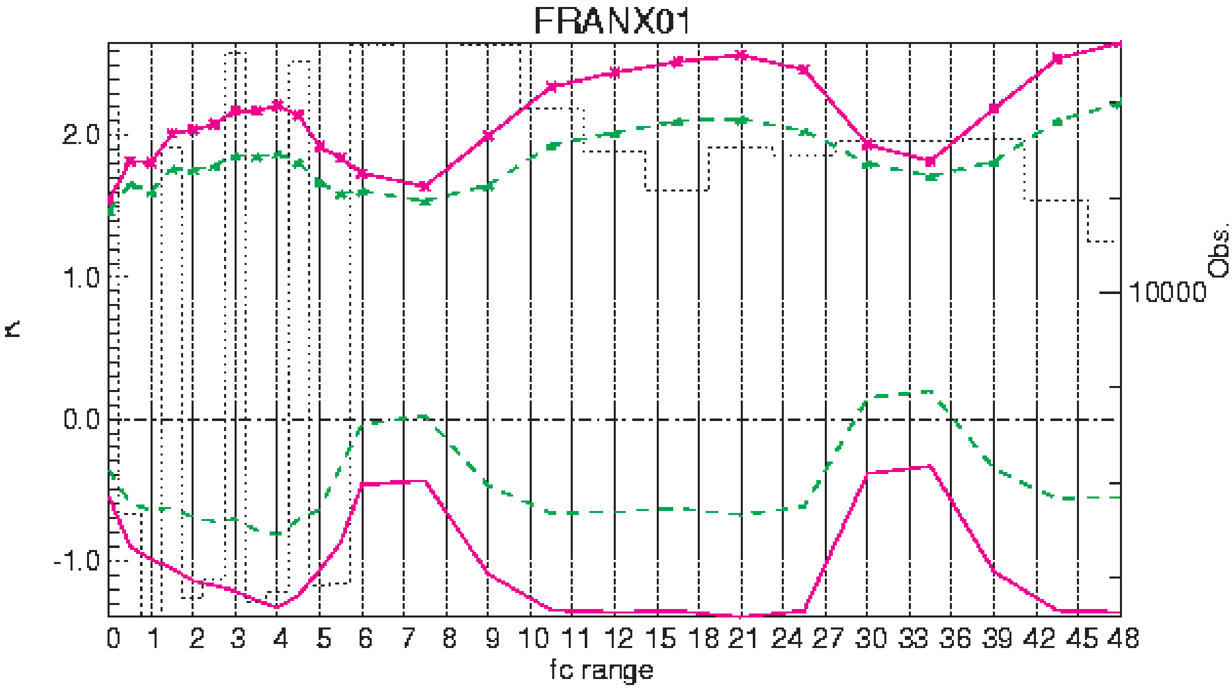


Figure 2. Scores against SYNOP observations of 2m temperature for ALADIN-France (43 cases, from 21/12/2002 00 UTC to 05/02/2003 00 UTC; with height correction)

—— bias oper/SYNOP ×—× rms oper/SYNOP
—— bias test/SYNOP ×—× rms test/SYNOP

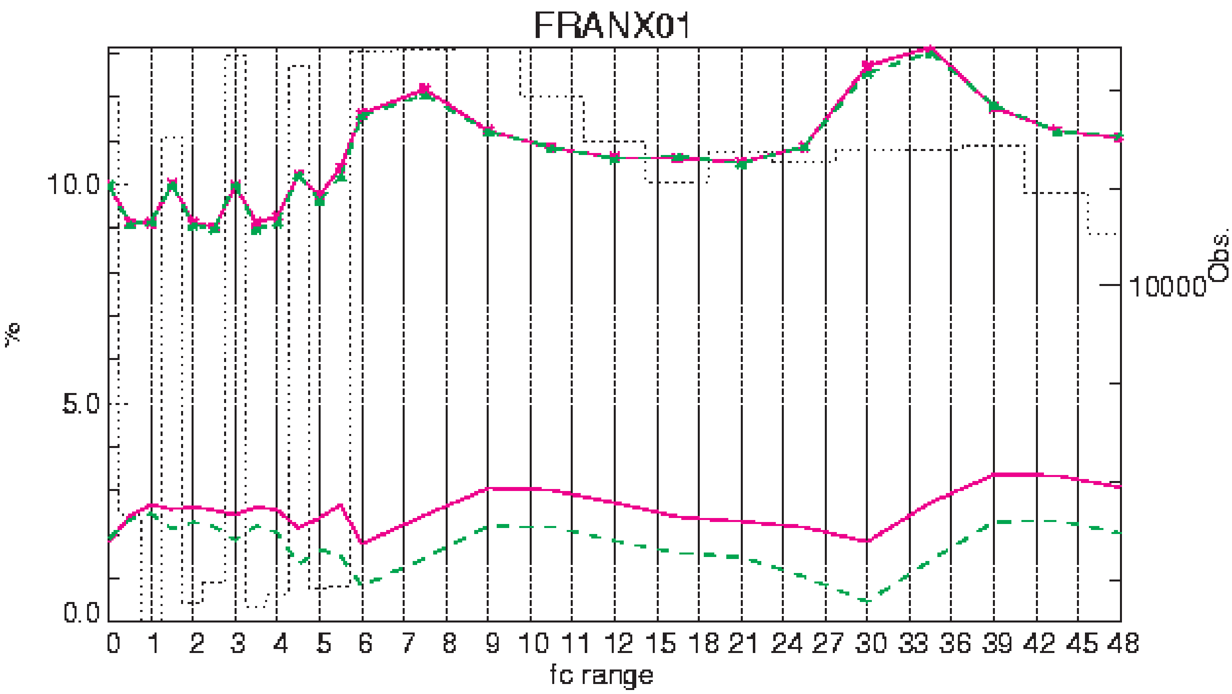


Figure 3. Scores against SYNOP observations of 2m relative humidity for ALADIN-France (43 cases, from 21/12/2002 00 UTC to 05/02/2003 00 UTC)

—— bias oper/SYNOP ×—× rms oper/SYNOP
—— bias test/SYNOP ×—× rms test/SYNOP

ALADIN-Réunion stopped on the 26th of November 2002, after an increase of horizontal resolution in its former coupling model, ARPEGE-Tropiques (from T_L299 to T_L359).

7. Operational version in Hungary

(more details horanyi@met.hu)

During the first half of 2002 the main migration from the SGI Origin 2000 platform to the IBM Regatta (p690) platform was successfully completed. The main achievements during the second part of 2002 were concentrating around the definition of new model domain and resolution together with the preparations needed for the foreseen changes in the operational part of the RC-LACE project. Beside that the major scripts were developed for the exploitation of the ALADIN 3d-var assimilation scheme in Budapest.

The most important activities around the local version of the ALADIN model in Budapest are detailed hereafter:

-- Installation of the loadleveler job scheduling system on the IBM machine. The loadleveler ensures that the operational applications get the full priority during their execution, while the research jobs are pre-empted during this time window. Different job classes were created for jobs with different memory and CPU consumption (*oper*, *mono*, *small*, *medium*, *big* and *inter_class*). The operational scripts were modified accordingly having a header needed for the loadleveler.

-- Definition of new model domain and creation of new climate files needed for the operational application (it is noted here that the 923 procedure was still executed on the old SGI machine due to the fact that in the newer model versions that configuration is not working). The new sets of climate files are : input climate files of ARPEGE resolution (Lambert projection), ALADIN/HU domain climate files (Lambert projection), post-processing climate files (lat × lon), dynamical adaptation climate files (Lambert projection).

-- Access was asked and obtained to the BDPE database of Météo-France for the operational access of LACE lateral boundary data available in Toulouse. Fail-safe scripts were written for accessing the LBC data (in 3 hours temporal frequency) from Toulouse through internet. The internet transfer rates were continuously monitored and evaluated since the operational application of the transfer (from mid-July). The reliability of the internet transfer was found to be satisfactory for a possible operational application, however it is emphasized that for the longer range a more reliable solution should be thought (this solution will be probably the RETIM 2000 satellite dissemination system, which is supposed to be operational at the first part of 2003).

-- Parallel suite was established for the new model domain, resolution, LBC frequency and systematic basic statistical comparison was carried out for comparing the operational and test model versions. The parallel suite was running from mid-July until the beginning of November. The results of the comparison showed an overall neutral impact, therefore the operational introduction of the new model version was scheduled for the beginning of November.

-- Accumulation of forecast information was ensured during the parallel suite phase (from mid-July until the beginning of November) and background error statistics were computed over the new ALADIN/HU domain.

-- New scripts were written for the exploitation of the 3d-var application. The 3d-var model version was put into parallel suite during the second part of December (see some more details in the ALATNET Newsletter in the same volume).

-- Special post-processing (Full-Pos) scripts were written and tested for converting the new domain's result into the nowcasting domain for the application of the Diagpack scheme (the domain for the CANARI optimal interpolation scheme has been kept unchanged). It is also noted here that instead of the previously used on-line Full-Pos post-processing an off-line solution was adopted (due to the not reliable functioning of the on-line version of Full-Pos package)

-- Some auxiliary softwares (pseudo-TEMP creation, VERAL verification package, etc.) were adapted and introduced before the end of the year in order to ensure smooth transition for the operational changes coming from the disappearance of central LACE operational exploitation in Prague.

-- After the careful evaluation described above (for a period of about 3 months) on the 5th of November, new model version was introduced operationally (see details of the operational version below).

The main characteristics of the new ALADIN/HU application are as follows:

-- The horizontal domain covers practically the same area as the former LACE domain (see the enclosed figure for the domain and its orography).

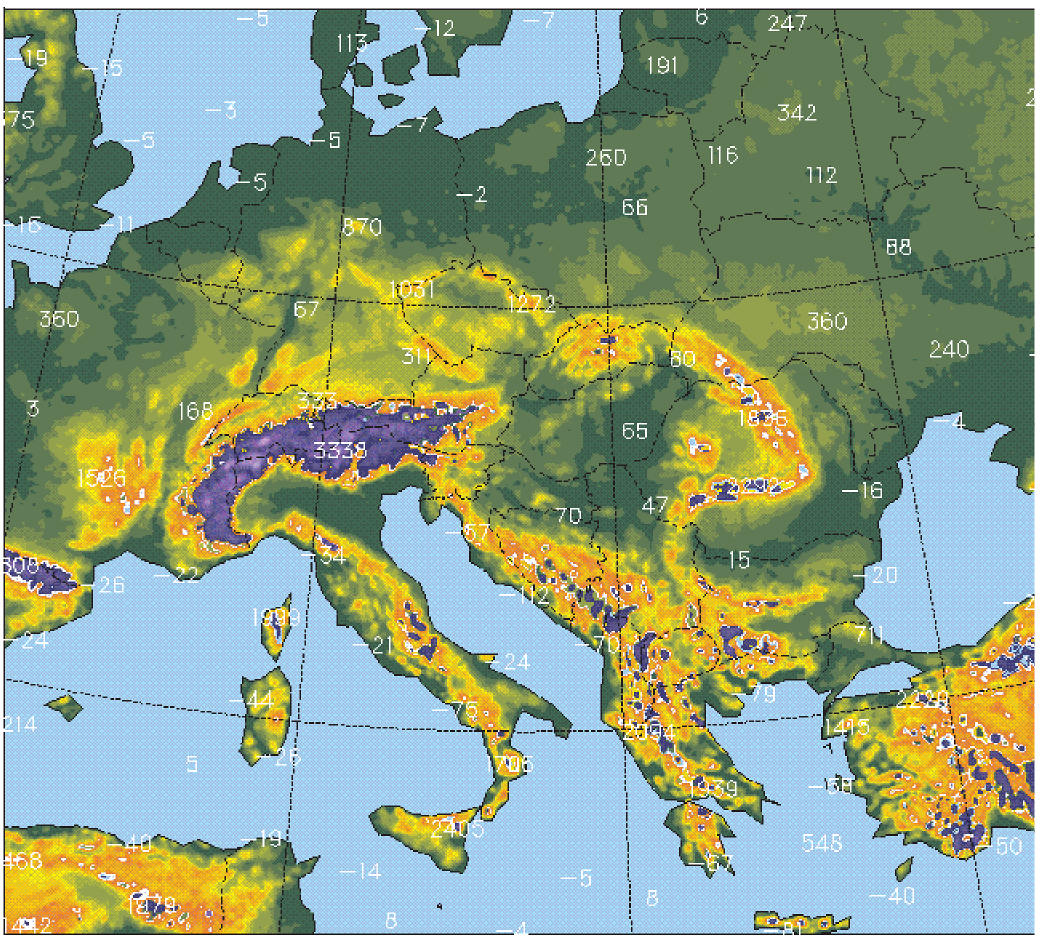
-- The horizontal resolution is 6.5 km and the vertical one is 37 model levels.

-- The number of gridpoints including the extension zone is 432×384.

-- The time-step used is 270 s.

-- The coupling frequency is 3 hours and the coupling information is coming directly from the ARPEGE global model (so the double-nested strategy was replaced by a single nesting solution).

-- The integration time of the model is around 1 hour using 24 processors of the IBM machine.



Since the introduction of the new model version it is running with high reliability. For the near future the following plans are considered:

-- Development of a graphical diagnostic tool for the monitoring of the operational suite by the operators.

-- Revision of the old and development of new operational scripts. The new script system is supposed to be more modular and systematically logical and will be prepared by a professional software company).

-- 24 hours monitoring of the operational suite with the possible intervention of the scientists in case of necessity (mobile phone and laptop for remote login possibility).

-- In the first half of 2003 (after completing the previously mentioned tasks) the operational application of the 3d-var scheme is planned.

8. Operational LACE application

(more details vana@chmi.cz)

1. Evolution of the ALADIN/LACE application.

The ALADIN/LACE suite switched to CYCORA-ter +++ :

26/11/2002 at 12 UTC network time for the production run and at 06 UTC network time for the assimilation cycle: CYCORA TER +++

This physics package known under the name of CYCORA-Ter became operational in ARPEGE already in November 2001. ALADIN-LACE did not follow the change due to a negative impact on the screen level temperature scores in the "continental winter" type of weather. Many tests were made to understand the cause; finally the retuning of mixing length profiles provided more satisfactory results. Besisde, in spring 2002 there were a few cases of too intense rain produced by the stratiform precipitation scheme. As a cure, shear-linked convection scheme was introduced and tested. The results were mostly improving the precipitation patterns. Finally, a time-smoothing of the shallow-convection scheme was introduced. All these changes were tested together in a parallel suite run, for winter and summer periods (parallel suites ABU and ABW described below). For both periods the score response was satisfactory.

Impact on the forecast : slight improvements in the scores and a significant improvement of the temperature forecast

Technical impact : none.

2. Parallel Suites & Code Maintenance

The Prague Team launched the following parallel tests to assess the impact of different modifications :

- *Suites ABR, ABS and ABT:* All these suites refer to the ABR suite (reported in the previous Newsletter), where we have tested the latest version of CYCORA-ter with (ABR) or without (ABS) activating the recently developed shear-linked convection scheme (in the previous Newsletter this development was denoted as slantwise convection but later it was renamed in order to fit better the nature of the scheme). In ABT suite we used another tuning of the `USURID` and `USURIDE` parameters. Among these three tests the ABR suite was giving the best results, however we noticed that the computations were not giving stable results pending which version of cross-compiler was used. This behaviour was analysed more in depth and it was obvious that the recently used compiler release contained a bug. The problem was addressed to NEC and with the help of an analyst it was possible to verify that a higher release of the compiler was stable and thus this newest version was installed both on the NEC computer as well as on the other servers with a cross-compiler licence. To be sure about the results, the suites denoted as ABU, ABV and ABW were recomputed using the stable compiler release and their performance is described below.

- *Suite ABU:* It is the ABR suite launched for the winter period. There is a slight improvement of geopotential, temperature and moisture scores near the surface.

- *Suite ABV:* It is like the ABR suite but with retuned `USURID` and `USURIDE` parameters (in fact it is the ABT setting). This suite was also launched for the winter period. It did not give as good results as the suite ABU.

- *Suite ABW:* This suite has the ABU settings and it is run for summer period. Like in winter, the scores are slightly better. The best result is reached for temperature score. This suite was further tested on the disastrous Central-European floods. Even here the precipitation pattern looked even more realistic than the already excellent precipitation forecast provided by the operational configuration.

The results of parallel tests may be consulted on *www.chmi.cz/meteo/ov/lace/aladin_lace/partests*/ pages.

9. Operational versions in Morocco

(more details radi.ajjaji@cnrm.meteo.fr)

In addition to the operational ALADIN-Morocco suite, Casablanca is running, since the 18th of February, a second ALADIN version on the large North Africa area: ALADIN-North Africa (NORAF) is now a reality. Here is all the technical details of the new and the old applications.

The operational ALADIN-Morocco (ALBACHIR) is running until 60 hours twice a day at a new resolution of 9 km and without data assimilation. The associated grid is (360x320x41), the time step is 469.566 s . This new configuration for ALADIN-Morocco is very similar to that of ALADIN-France in terms of resolution, post-processed fields, frequency of coupling (3 hours) and code level (25T1 at the time of writing). But this configuration is now coupled with ALADIN-NORAF whose the characteristics are as follows:

Time step :	900 s
Horizontal resolution :	31 km
Number of vertical levels :	41
Number of gridpoints on the horizontal :	180x300
North-East corner, latitude :	43.°
North-East corner, longitude :	56.°
South-West corner, latitude :	0.°
South-West corner, longitude :	-36.°

This model is coupled asynchronously with ARPEGE with a coupling frequency of 6 hours. It runs twice a day for a 72 hours range. ALADIN-NORAF is performing its own assimilation using the Optimum Interpolation code CANARI under ODB (which is running correctly on IBM since the migration to 25T1), for 4 networks (r00, r06, r12 and r18). All the observations are collected through the SMT channel and organized in a local "BDM" which is now well interfaced with ODB (thanks to the *Batodb* package given by Dominique Puech).

The wall-clock time taken by the several components of this new system (on IBM SP) are :

<u>concerning ALADIN-NORAF</u> :

Assimilation:	5 minutes per network	(10 processors in MPI mode)

Coupling:	30 seconds per ee927 transformation	(4 processors in MPI mode)
72 hours forecast:	25 minutes	(16 processors in MPI mode)
Full-Pos:	20 seconds per output range	(4 processors in MPI mode)
Graphics & GRIB:	30 seconds by output range.	

<u>concerning ALADIN-Morocco :</u>

Coupling:	50 seconds by ee927 transformation	(4 processors in MPI mode)
60 hours forecast:	40 minutes	(32 processors in MPI mode)
Full-Pos :	40 seconds by output range	(4 processors in MPI mode)
Graphics & GRIB:	30 seconds by output range.	

We are now working on preparing our operational suite to a new configuration performing assimilation with the 3d-var technique (Blendvar mode). It seems that it is not obvious, taking into account the complexity of observation handling with ODB (Batodb, Lamflag, Shuffle, Screening, Minimization, etc). We hope that when 3d-var will become ready for operations, all these different components will be more flexible and less complex!

We are working especially on the observation part : we intend to prepare our own radiance observations using a local HRPT station and we hope to be helped by our colleagues in Lannion (France).

With the migration to cycle 25T1, the model timing performances were very bad : calculations corresponding to a diabatic time-step were very expensive compared to the old operational model with AL13 : more than 30 % of extra-cost. This encouraged us to investigate on the use of OpenMP into the source code.

To turn on OpenMP in the model on an IBM SP machine equipped by XLF Fortran compiler, you need just to compile using ‘‘–qsmp=omp’’ option. The ARPEGE branch is safe in terms of OpenMP syntax; it is not the case for some ALADIN routines (*espc.F90*, *eslextpol.F90*, *eslextpol1.F90*, etc). But the correction of these compilation bugs is not difficult.

During executable static linking, you need to specify also ‘‘-qsmp=omp’’ option in order to take into account OpenMP libraries.

This table shows the results found in several mixed mode (MPI+OpenMP) configurations for a small ALADIN-Morocco version (180x180x41 points):

MPI tasks (`NPROC`)	OpenMP threads (`OMP_NUM_THREADS`)	Wall clock time for one diabatic time step
16	1	4.6 s
8	4	3.4 s
16	2	2.9 s
4	8	4.0 s
2	16	6.0 s

To optimize performance on ‘‘mixed-mode’’ hardware like the IBM SP :

- MPI is used for ‘‘inter-node’’ communication, and threads (OpenMP / Pthreads) are used for ‘‘intra-node’’ communication.
- Threads have lower latency and, as it is clear on the table, can speed up a code when MPI becomes latency bound.
- Threads can alleviate network contention of a pure MPI implementation.
- Runtime checking of overhead must be controlled by runtime environment variables.

But OpenMP performances are good if the size of the piece of work is large (as it is the case of ARPEGE/ALADIN). Theses performances are degraded by other processes on the computation node; it is important, thus, to be dedicated on an SMP node.

We suggest for all the ALADIN community to make efforts on OpenMP. One method to detect where we must include OpenMP directives, is to remember where the CRAY multi-tasking was (especially for Full-Pos and CANARI, which are not treated by the ECMWF specialists). For the time being, all the model part is OK! (at least regarding the few experiments done here at Casablanca), the examinations of norms into e001 listings relatively to one same run for the different cases expressed in the above table showed no differences ! This is perhaps wrong, but we suggest more investigations on different platforms.

10. Operational version in Poland

(more details zijerczy@cyf-kr.pl)

In the second half of year 2002 main efforts focused on three aims. The first one was the preparation of a new ALADIN suite based on AL15 and enhanced capabilities of operational software environment for the model. The second aim was the preparation of a dynamical adaptation application for the territory of Southern Poland. Two configurations with respectively 4.0 km and 2.6 km resolution are ready to use. The third target was building preliminary versions of two user interfaces for nowcasting of deep convection, fog and visibility. The interfaces are being built in *www* technology and give opportunity of simultaneous presentation NWP fields along with Meteosat images. All three tasks are to be continued in 2003.

11. Operational version in Portugal

(more details maria.monteiro@meteo.pt)

During the last half of 2002 no changes have taken place on the Portuguese operational suite (AL12_bf_CYCORA_bis). The dissemination of ALADIN/Portugal surface parameters fields is now used to feed an operational scheme of sea conditions forecasts running under the Portuguese Navy supervision.

The package CANARI/DIAGPACK is still a target for validation/verification purposes. On the other side, the identification of extreme precipitation events in order to test and validate the diagnostic tools with the ALADIN/Portugal fields is taking place.

12. Operational version in Romania

(more details banciu@meteo.inmh.ro)

Implementation of a new operational suite with shared tasks between SUN E4500 and ALPHA DEC platforms (detailed in the report on "ALADIN developments")

13. Operational version in Slovakia

(more details Olda.Spaniel@mail.shmu.sk)

There was nothing new in operations for ALADIN-SLOVAKIA. The workstation DEC Alpha Xp1000 was upgraded by 1GB of memory and AL25 version was implemented (at least DIGITAL Fortran F90 version V5.2 must be available for that ALADIN version).

Automatic text forecast from ALADIN for selected towns was updated (now full English version is available).

The new meteorological workstation ''Visual Weather'' was implemented in forecasters department for visualisation and data processing on NWP data. More information you can find on the site *http://www.meteoam.it/egows/*

The main effort during this period was concentrated on provision of ALADIN/LACE products for the beginning of 2003 year. The SHMI will cooperate with ZAMG Vienna on this field for the next period.

14. Operational version in Slovenia

(more details neva.pristov@rzs-hm.si)

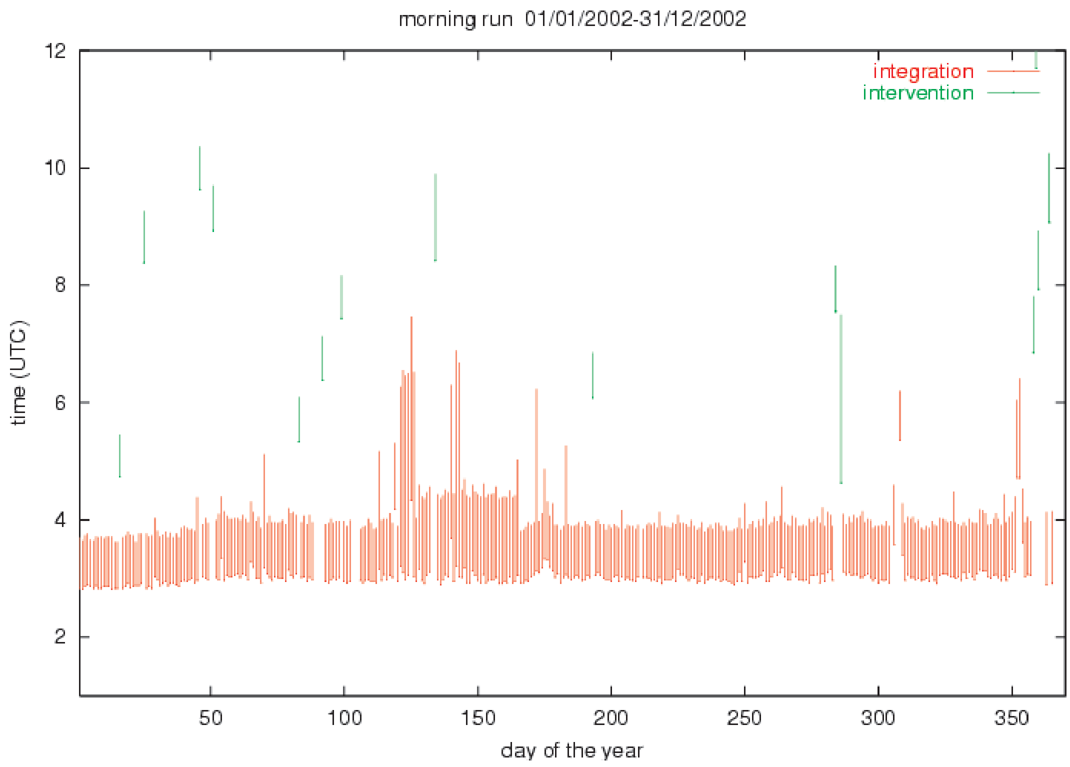
Operational suite was still running on our old cluster of workstations during the second half of year 2002. Characteristics of operational model configuration can be found in ALADIN Newsletter 21. Two changes were implemented recently:

- switch to 37 vertical levels in the model

- replacement of coupling files prepared from ALADIN/LACE in Prague with coupling files prepared from ARPEGE in Toulouse at the end of the year. Coupling time-frequency changed from 6 hours to 3 hours.

Operational performance of the ALADIN/SI model was checked for year 2002. We can notice that the number of unsuccessfully finished model integrations increased compared to the previous year.

	2000		2001		2002	
	00 run	12 run	00 run	12 run	00 run	12 run
operational not finished	27 (7.4%)	25 (6.8%)	14 (3.8%)	13 (3.6%)	28 (7.7%)	19 (5.2%)
hardware problems	19	15	4	3	26	19
missing LBC	7	6	6	4	1	0



Anyway products were available in reasonable time in 14 cases when model was rerun manually. The main reason for missing runs were hardware problems. It happened that the integration stopped few times because of floating point exception error, which did not always reappear when the model was rerun. Files with lateral boundary conditions from Prague and also from Toulouse during second half of December were transferred very regularly.

15. Operational version for Tunisia

(more details nmiri@meteo.nat.tn)

The arrival of a dedicated computer was unluckily delayed to 2003. See the ALADIN report.

ALADIN developments during the second half of 2002

1. In Austria

A lot of work was devoted to the design of the new operational suite. See the report on operations and the two joint papers (plus one from the Vienna University).

2. In Belgium

Most efforts focused on ALATNET related research, and consequently are described in the ALATNET Newsletter.

Olivier Latinne finalized the study of the assimilation by optimal interpolation, using CANARI. The major conclusions of this are that the obtained surface analysed states are closer to the observations than those resulting from the interpolation of the global analysis, with an effect being felt on the ALADIN forecasts scores, up to 9 or 12 hours.

Then the migration on SGI started, as well as the operational implementation of the corresponding suite. This one will allow us, amongst other things, to supervise the correct operations of the Belgian automatic network stations. Still for the operational, we don’t have yet carried out the transition towards AL15, since, along many comparisons of situations of strong precipitations, for August and September 2002, with the current operational version AL12, it appeared as very bad. Indeed the structure and the timing of the precipitations zones are changing in a direction which moves away from the observed reality. However when we change namelist setting to `GCOMOD=0`, which correspond to the switch of the double dependency of parameterisation of the precipitation on resolution, the degradation is quite less.

The work of Piet Termonia, on predicting peaks of air pollution by means of the ALADIN model, ended. A paper has been written and will be submitted for publication. During 2002, this method became operational to send warnings to the ministry of the environment of the Brussels Region.

As ALADIN coordinator (CSSI member), Luc Gerard prepared the annual report about the current status of the research in physics.

3. In Bulgaria

Research work was performed along stays in Bruxelles (Ilian Gospodinov), Prague (Lora Gaytandjieva) and Toulouse (Maria Rousseva) : see the corresponding reports.

4. In Croatia

Most of the work was devoted to the design of the new operational suite. See the report on operations and the joint paper.

5. In Czech Republic (RC-LACE report)

<u>A. Central European Flood event</u>

In August 2002 we witnessed a major flood in Central Europe, affecting namely Austria, Czech Republic and Germany. There were two periods of heavy rain, the first came on 6-7 August and the second on 11-13 August. In Czech Republic, the first heavy rain event caused floods on some rivers in the South of the country, but the dammages were still limited. The true catastrophe was caused by the second precipitation event, when the soil was already saturated from previous rain. Most of the precipitation fell in the catchement of the Vltava river, as it can be seen on Figure 1. Waters of the Vltava registered the historical flood in Prague (Figure 5). The Vltava flood wave then reached the Labe river (Elbe in German) and together with the contribution of other small rivers coming from the Krusne hory (Erzgebirge Mountains) it provoked a disaster in Germany, namely in Dresden.

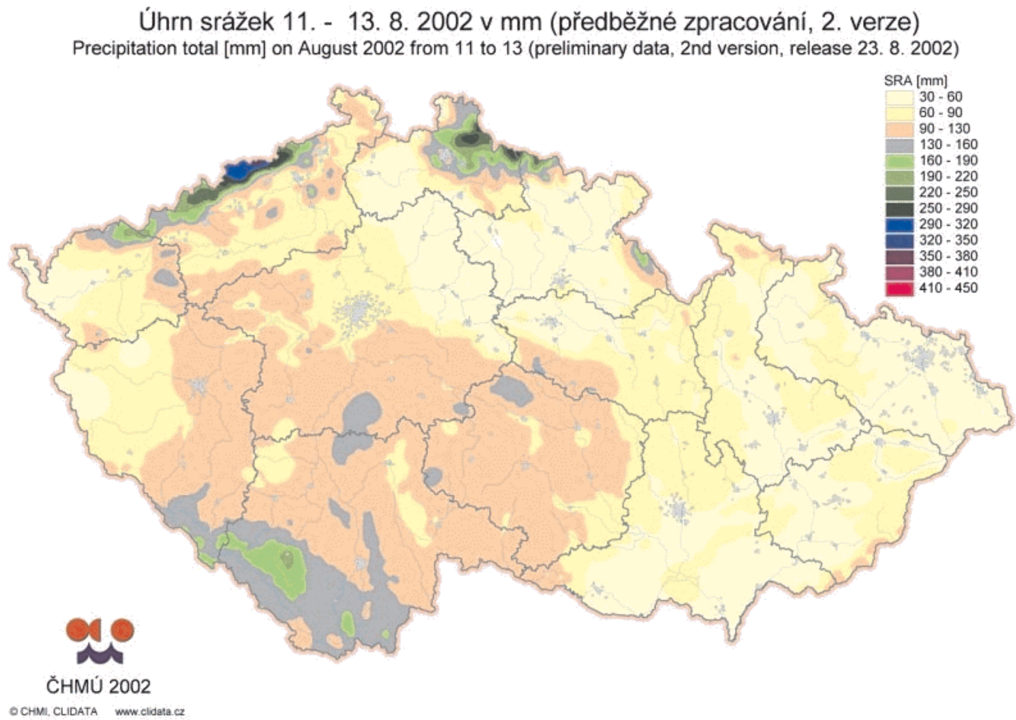


Figure 1: Map of the observed precipitations from 11 to 13 August 2002. It includes also the detailed observations from the climatological network.

From what was said above, it is clear that a good forecast of the second rain period (11-13 August) was crucial. Unfortunatly the medium range forecast, which would have been quite valuable, was missed by global models, including ECMWF. A small indication of the well known Genova bay cyclone scenario was present in the global model forecast of DWD from 8 August 0 UTC but this signal was lost in the following forecasts. More correct picture of the precipitation event models provided with a lead time of 48 hours. Here ARPEGE and ALADIN provided an excellent forecast. In Czech Republic the performance of ALADIN Quantitative Precipitation Forecast (QPF) allowed to CHMI to provide timely warnings to the Central Crisis Management body and also locally to the Fire&Rescue Service operating centers at the regional level. Although the total dammages in Czech Republic are very high (more than 2 mld of Euros), the amount of lost lifes is remarkably low, certainly in comparison with the similar event in 1997.

The quality of the ALADIN QPF forecast may be illustrated by the comparison with respect to the professional synoptic stations (Figure 2). For the whole period of 11-13 August we have also cummulated the 12 hour precipitation amounts for the consecutive ALADIN forecasts in order to get a pattern comparable with the map of observed preciptation (Figure 3). This event became of course our reference case and we have tested on it the recent version of CYCORA TER +++ (now operational). The results may be seen on Figure 4: by a simple pattern comparison we may see that there are not significant differences, a bit better distribution of rain can be seen in Moravia. Finally, the ALADIN/LACE operational results were presented at the special SRNWP workshop on the Central European Flood Event associated to the EWGLAM meeting in De Bilt, Netherlands, October 2002. We may say that compared to the results obtained by other European NWP models for the forecast ranges up to 48 hours, ARPEGE/ALADIN system was the best both in amplitude and localisation of precipitations.

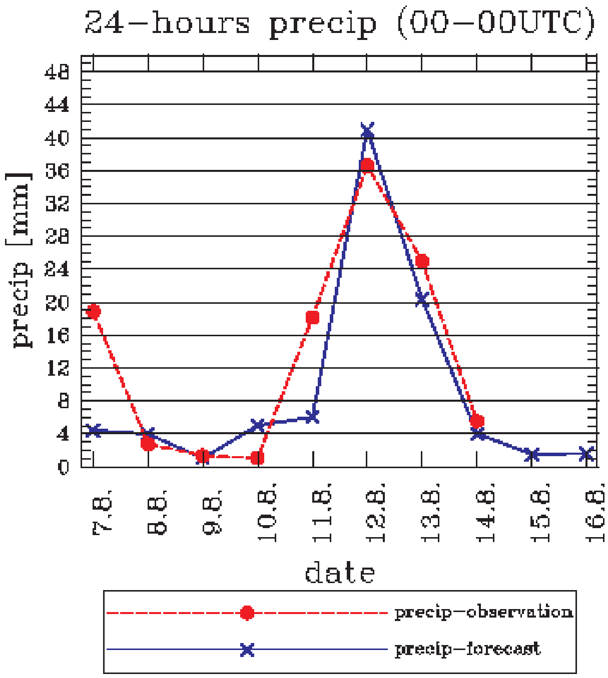


Figure 2: Verification of the ALADIN/LACE operational QPF 24 hours amounts. It is an average picture of comparison to all the professional synoptic stations in Czech Republic.

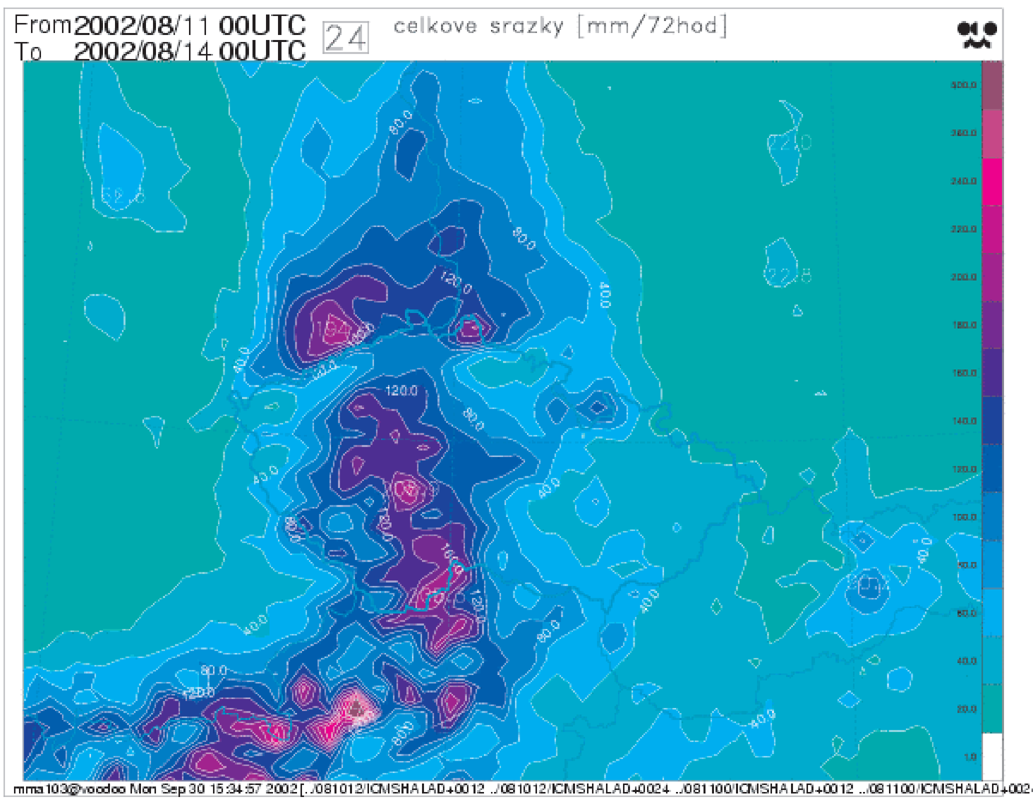


Figure 3: The cumulated ALADIN/LACE operational QPF for 3 days (11, 12 and 13 August 2002). The sum is constructed from the 12 hours QPF amounts from the consecutive forecasts: it starts with the forecast based on 10 August 12 UTC and the amount is taken in the interval P12 – P24, the following forecast is the one based on 11 August 00 UTC taking again P12 – P24 interval and so on. The resulting map may be compared to the observations on Figure 1, although the colour scale intervals are not the same.

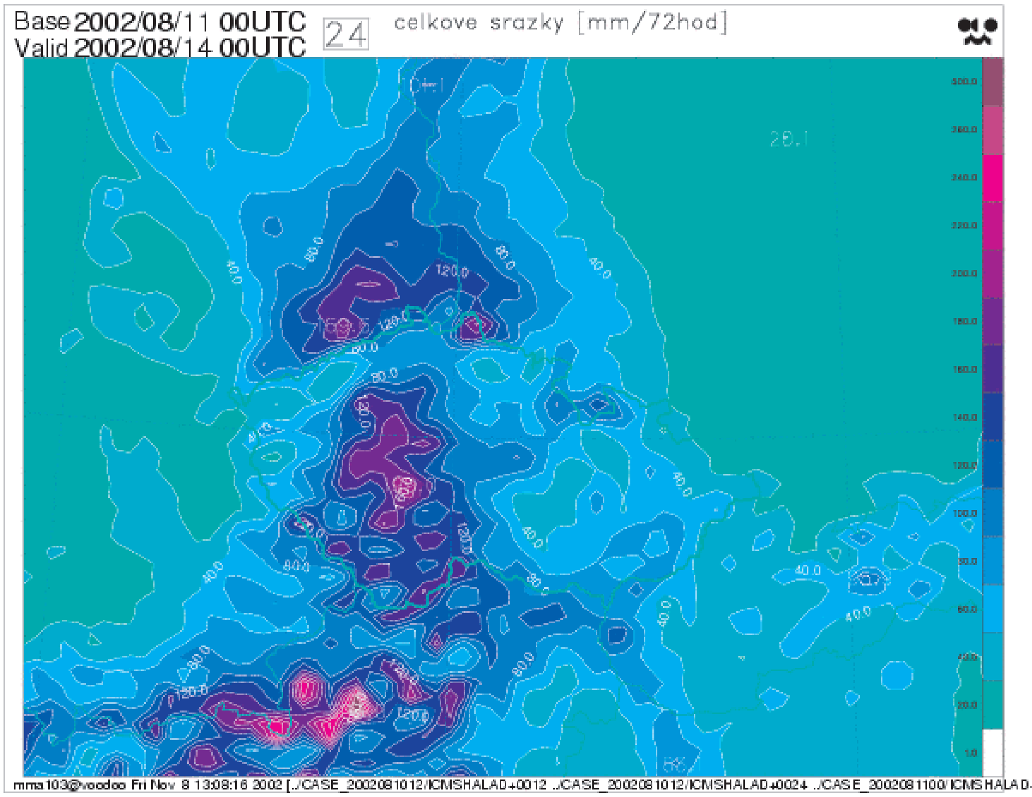


Figure 4: The same QPF map like on Figure 3, but obtained with the test of CYCORA-ter+++ settings.

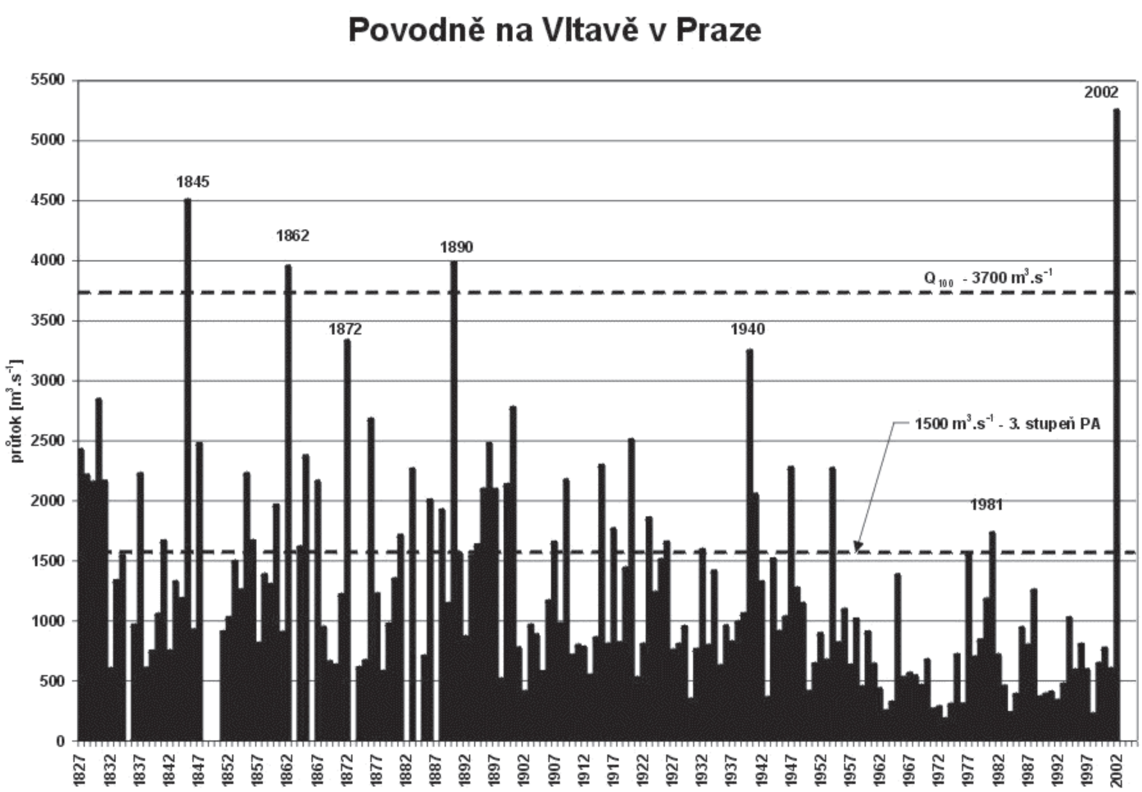


Figure 5: History of floods on the Vltava river in Prague. The water flux in cubic meters per second is drawn on the y-axis. There are denoted two limits by a dashed line: the first one is the flux of 1500 m^3/s corresponding to the third level of flood warning: danger; the second one is the flux of 3700 m3/s corresponding to the so-called 100 years waters (it occurs statistically once per 100 years). We can see that the last "100 years flood" was in Prague in 1890. The normal water flux of the Vltava is 150 m^3/s in Prague. The flood in 2002 was historical.

B. Research and developments

Note**:** all ALATNET related R & D, representing the majority of the effort, is reported in ALATNET Newsletter. Here we sum-up topics which are not referred as ALATNET ones for Prague centre.

Tuning of the background error variances for surface analysis *(S. Ivatek - Sahdan)*

The model errors were analysed for the ALADIN/LACE model in comparison with SYNOP measurements. The errors were computed as differences between ALADIN/LACE guess entering the blending procedure and the screen level observations. Then the statistics were computed in gridpoint space using 28 classes dependent on the distance between gridpoints and on the variances. It was also checked whether to use Gaussian or exponential correlation function: like in ARPEGE, the exponential function seems better. The statistics was computed on results for four network times (00, 06, 12 and 18 UTC), for a period from November 2001 to October 2002. New radius and ratios of σ_b to σ_o were obtained to be used in surface CANARI analysis.

6. In France

Note : Only non-ALATNET work is reported here. And part of the effort of the Toulouse team was dedicated to purely ARPEGE (4d-var) problems (stretching and incrementality, new management of observations) during the present period.

Embassy fundings for Central and Eastern Europe (for 2001 and 2002) were not yet available, but many stays were organized during the last 4 months of 2002 (on "maintenance" fundings or bilateral support for Morocco and Tunisia), and the few left offices were full.

A large part of the work aimed at the creation and validation of a new library, cycle 25T2, with the help of Jan Masek, Chantal Moussy, Zahra Sahlaoui, Christopher Smith, Petra Smolikova and distant support from Jozef Vivoda. Its contents are described in the present Newsletter, in section 7 of the "ALADIN and ALATNET News" part. Besides Stjepan Ivatek-Sahdan introduced in the CANARI code the spatial smoothing of soil moisture (more precisely of the soil wetness index), which was performed externally in the previous tests. There are still some problems with ALADIN (when more than 1 processor is used).

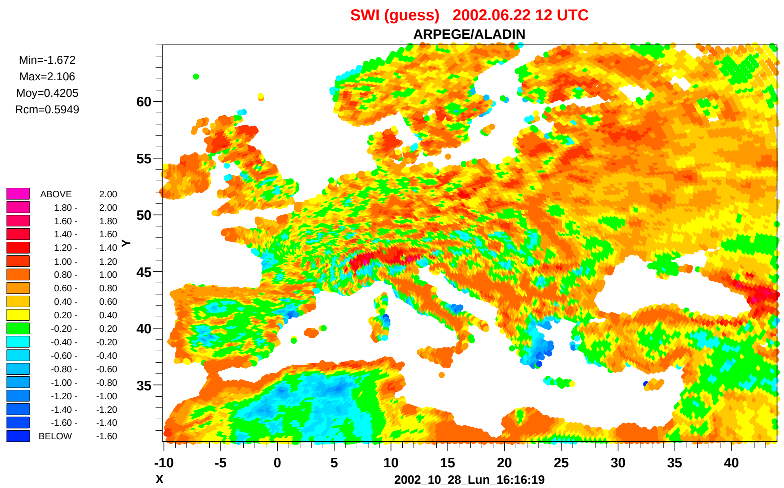
Jean-Daniel Gril updated several ALADIN tools (*PALADIN*, *CHAGAL*, *EGGX*, ...) and started with new ones : *DOMOLALO* to design an ALADIN domain from lat×lon coordinates, and *CONEO* for conversions between the old and new versions of *EGGX* (not yet ready).

Another important part of maintenance, documentation, was also addressed, fostered by the workshop on maintenance in Budapest. Up-to-date documentations on the "direct-code" architecture, Full-Pos, 3d-var (and other variational configurations), CANARI, PALADIN, are now available thanks to Ryad El Khatib, Claude Fischer, Françoise Taillefer and Jean-Daniel Gril. See the first part of the Newsletter.

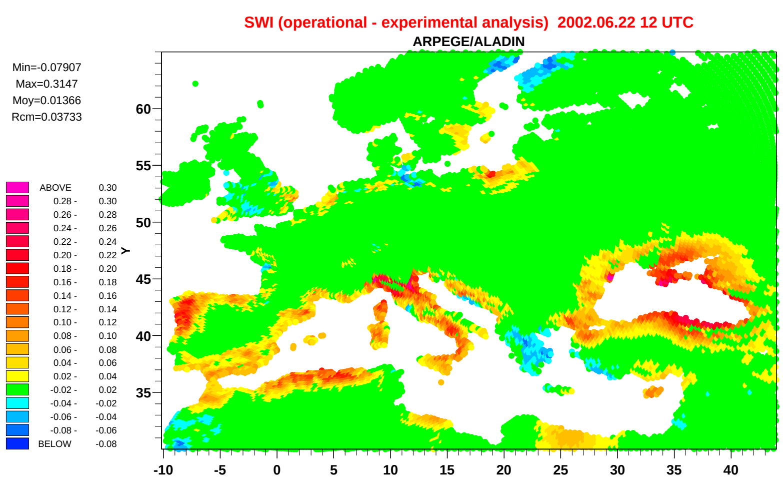
Work on configuration 923 restarted. Jadwiga Woyciechowska started to gather available papers and study the code, in order to write a detailed documentation. Khoudhir Tounsi focused on the input physiographic databases, making some more documentation available on the archive, testing and documenting associated tools. He also tried to introduce a local smoothing in the procedure previously designed by Neva Pristov and Mehdi Elabed to merge low- and high-resolution informations on orography. Outside the area of dense information, the resulting fields were "step-like", which is likely to provide unrealistic derived fields and even make the model blow up at very high resolution (below 3 km, i.e. when reaching that of global databases). To end with, Dominique Giard updated the code to make it work with cycles AL12 (shared- and distributed-memory versions) and AL15, with the same output. However, spectral orography was shown to be sensitive to compilation options, through the minimization process. The problem of ALADIN domains with hardly any water (or similarly land) points was solved. Work will go on in 2003 (further phasing, introduction of new developments, documentation).

Françoise Taillefer addressed the improvement of sea-ice description within SST analysis. First, albedo and emissivity over sea are now updated at each analysis step, considering the "effective" sea-ice limit (according to surface temperature). Second, the sea-ice limit will be improved using SSM/I observations. The underlying code modifications are ready.

Agnesz Mika investigated two problems in the assimilation of soil and surface fields, on simple analysis experiments (to start). First she analysed the impact of coastal observations. These may lead to a local spurious moistening of soil for the corresponding observed 2m fields are not representative of the neighbouring land points. Simply excluding such observations is likely to improve the situation, as shown by comparisons performed on a summer and a winter cases. The impact is stronger in summer, when conditions for soil moisture correction are more often met. Figures 1-4 illustrate how spurious changes may be avoided.



(a)



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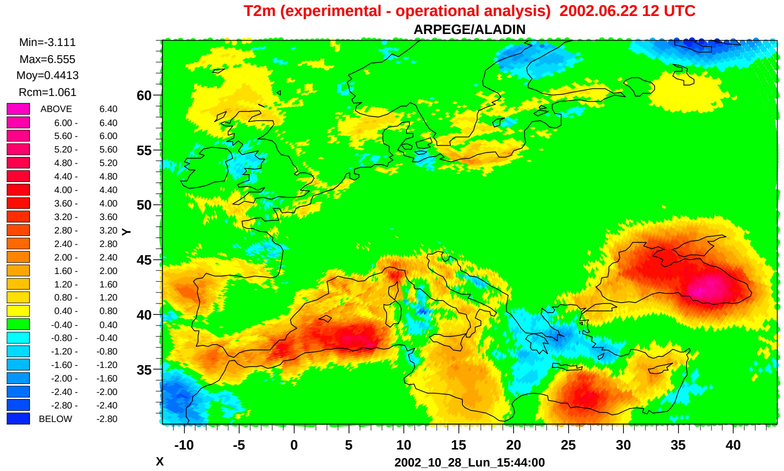

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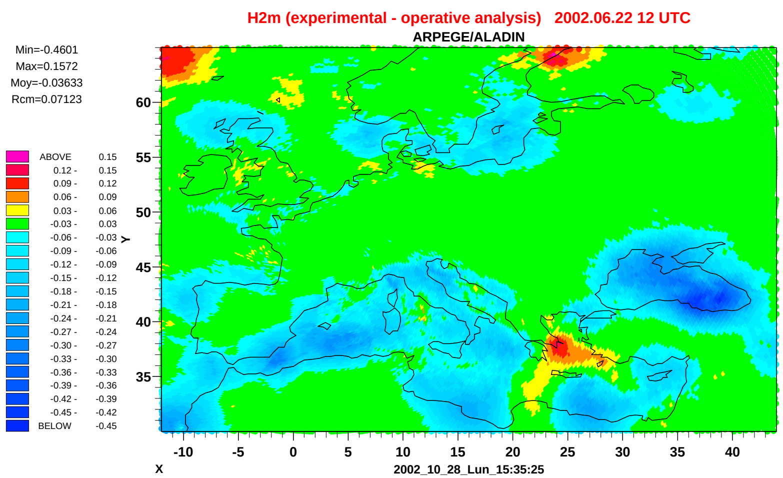

(d)

Figures 1

(a) Soil wetness index (SWI) for the first guess : one may notice very wet or dry zones along the coasts
(b) Difference in corrections for the soil wetness index : excluding coastal observations (experimental analysis) induces changes in the right direction, consistently with the changes in analyzed 2m fields (see below).
(c) Difference in the corresponding analysis increments for 2m temperature
(d) Difference in the corresponding analysis increments for 2m relative humidity

Second she tried to estimate the impact of performing surface and upperair analyses simultaneously in ARPEGE. Operationally surface analysis and hence soil moisture/temperature assimilation use as input analysed upperair fields. Historically this aimed at preventing soil moisture corrections from forecast failures intrinsic to upperair fields, based on some experimented problems. However this was not quite satisfactory, especially since the implementation of 4d-var, for the balance between the surface and the lowest model levels is lost, 2m observations cannot be used in upperair assimilation, and it induces some delay in operations. The potential combinations may be illustrated by the tables hereafter. The question is valid for ALADIN too. The impact of such a modification on analysed 2m fields (temperature and relative humidity) was computed and compared to the corresponding operational analysis increments on 8 situations covering the full annual cycle.

Relative changes are generally very small : less than 6 % (12 % in summer) for about half of the land points, and significant (of the same order of magnitude than analysis increments) for less than 0.36 % of land points (0.77 % in summer).

Table 1 : Combinations with 3d-var upperair analysis (or O.I. or blending)

assimilation step / time		-6h	0h	+6h
initial 6h forecast		$X_0(-6)$ / $S_0(-6)$	$X_0(0)$ / $S_0(0)$	
oper	input to 3d-var		$X_0(0)$ / $S_0(0)$	
	output of 3d-var		$X_1(0)$ / $S_0(0)$	
	input of surface analysis		$X_1(0)$ / $S_0(0)$	
	output of surface analysis		$X_1(0)$ / $S_2(0)$	
test	input to 3d-var		$X_0(0)$ / $S_0(0)$	
	output of 3d-var		$X_1(0)$ / $S_0(0)$	
	input of surface analysis		$\mathbf{X_0}(0)$ / $S_0(0)$	
	output of surface analysis		$X_0(0)$ / $S_2(0)$	
or ?	input of surface analysis		$\mathbf{X_0}(0)$ / $S_0(0)$	
	output of surface analysis		$X_0(0)$ / $S_2(0)$	
	input to 3d-var		$X_0(0)$ / $\mathbf{S_2}(0)$	
	output of 3d-var		$X_1(0)$ / $S_2(0)$	
subsequent 6h forecast			$X_1(0)$ / $S_2(0)$	$X_3(0)$ / $S_3(0)$

Indices 1 and 2 for upperair and surface analyses changes respectively. The basic differences with the (old) operational version are in bold characters.

Table 2 : Combinations with 4d-var upperair analysis

assimilation step / time	-6h	-3h	0h	+3h
initial 6h forecast and	$X_0(-6)$ / $S_0(-6)$	$X_0(-3)$ / $S_0(-3)$	$X_0(0)$ / $S_0(0)$	
first outer loop of 4d-var		$X_0(-3)$ / $S_0(-3)$	$X_0(0)$ / $S_0(0)$	$X_0(+3)$ / $S_0(+3)$
final outer loop of 4d-var		$X_1(-3)$ / $S_0(-3)$	$X_1(0)$ / $S_1(0)$	$X_1(+3)$ / $S_1(+3)$
input of surface analysis (oper)			$\mathbf{X_1}(0)$ / $S_0(0)$	
input of surface analysis (test)			$\mathbf{X_0}(0)$ / $S_0(0)$	
subsequent 6h forecast			$X_1(0)$ / $S_2(0)$	$X_3(+3)$ / $S_3(+3)$

Indices 1 and 2 for upperair and surface analyses changes respectively. One important impact of the move to 4d-var is that the analysed upperair fields are balanced with gridpoint fields modified by the internal forecasts, which may differ from the initial 6h first guess.

*Table 3 : Ratio of the difference between the 2 experiments to the operational analysis increment, for 2m temperature and 2 situations : a)*10/02/2002, *b)* 05/08/2002 *(histogram for land points, over the whole globe, i.e. 59015 points)*

limits	0.	1/32	1/16	1/8	0.25	0.50	0.75	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	>
a	24078	10344	8757	5688	2795	764	316	183	59	26	17	8	0	0	1	0	1	0	0	0	0
b	17072	10094	10296	7548	3884	938	405	279	57	28	13	4	2	2	3	0	0	0	0	1	0

7. In Hungary

Most of the activities performed in Budapest around the ALADIN model are either directly related to the operational model version (see our report at that section) or related to the ALATNET project (see ALATNET part of the Newsletter), hereafter those activities are listed briefly which are not falling into these above mentioned categories.

Very important event of the second half of 2002 was the organisation of the ALADIN maintenance and phasing training workshop held in Budapest at the last week of November (the summary of the final discussions of the workshop can be found elsewhere in this Newsletter). All the information together with the powerpoint presentations and postscript documents are available on the homepage of our Service (please consult the following internet address :
http://omsz.met.hu/ismeretterjesztes/rendezvenyek/aladin_ws/prog.html)

Other important initiative was the preparations for building a team and necessary infrastructure for efficient participation on the LAM-EPS (Limited Area Models Ensemble Prediction System) project of the SRNWP network. A working plan was written and accepted (which is under discussion with the Météo-France LAM EPS experts) and it was ensured that from the summer 2003 two students just finishing the university will join the team in order to be active in this important field of interest. After consultation with Météo-France we have contacted the SRNWP coordinator (Jean Quiby) and we have expressed our wish and intention to be the lead centre of this SRNWP project (unfortunately despite of several e-mails we didn't get any answer until the deadline of this Newsletter).

A new homepage of the Department of Research and Development was created, where the activities of the NWP group is detailed (please visit *http://omsz.met.hu/english/kfo/neo_en.html*).

8. In Moldova

Nothing new.

9. In Morocco

Most of the work was devoted to the implementation of the new operational suites, and the investigation of various problems (with observation management, use of OpenMP, etc ...). See the report on operations.

10. In Poland

See the report on "Operations".

11. In Portugal

See the report on "Operations".

12. In Romania

Implementation of a new operational suite with shared tasks between SUN E4500 and ALPHA DEC platforms (Cornel Soci)

The main idea of the new NWP operational suite was to share tasks between two workstations. While the ALADIN model integration is carried out on a SUN E4500 platform, as soon as a historical file becomes available, it is transfered on a DEC 500 workstation where all the post processing tasks, such as creating grib files, pseudo satellite images, meteograms etc. are performed. The results of the new and old operational suites have been compared for two weeks.

Verification of the ALADIN results including statistical adaptation (Otilia Diaconu)

(A very interesting presentation about tools and needs was also prepared for the Assembly of Partners.)

Preparation of the CANARI presentation for the phasing and maintenance training workshop held in Budapest, 2002, 25-29 November. (Cornel Soci)

The power point form of the presentation can be found at : *http://omsz.met.hu/omsz.html*

Organization and participation to the 7th Assembly of the Aladin Partners (Bucharest, 28th of October, 2002)

13. In Slovakia

See the report on operations.

14. In Slovenia

Verification

The main activity in Slovenia was the development of the prototype ALADIN verification project. More information about the concept of the project is available at :

http://www.cnrm.meteo.fr/aladin/concept/verification/verif.html

The working prototype has been developed and presented at 7th Assembly of ALADIN partners in Bucharest. The application consists of : a data extraction part from the model outputs (the so-called filter), a database for the storage of extracted model data and observations and a web application for on-line retrieval of results. The prototype is quasi-operational in Slovenia since August 2002. However, quite significant work has to be invested before operational use also in other ALADIN centres will be possible.

Croatia contributed to this project, with the working visit of Lovro Kalin to Ljubljana (1 week stay). It is planned to continue this collaboration.

Developments for operational activities

The main working subject in November and December was the installation of the new computer, the porting of ALADIN cycles 12, 15 and 25T1 to the new machine and the preparation of a redesigned operational suite.

Contributions to the Budapest training course on maintenance

Jure Jerman and Neva Pristov prepared lectures about OpenMP, debugging, optimization, E923, ...

15. In Tunisia

Computing system for ALADIN : the best news.

Getting the best news they have never got since they integrated the ALADIN consortium, the ALADIN/Tunisie team had spent a happy new year 2003 when learning finally the agreement between INM and the IBM company to purchase the required computer.

The expected machine is an IBM pSeries 690 (8 processors POWER4, 35 GFlops, 16 GB RAM, 280 GB HD). The installation of that machine locally will start during the week of March 17th,

2003. The implementation of the whole ALADIN/Tunisie suite should be starting by the last week of April 2003.

Verification

Some tests have been made in order to downscale some extracted ALADIN/Tunisie outputs. Even if these tests are not yet achieved, the first results seem to be similar to those obtained using the classical multi-linear downscaling. We decided therefore to maintain for a while the downscaling of ARPEGE temperature field.

Miscellaneous items

- The set up of a new local web site for ALADIN which contains mainly:
  - The most extracted fields from ALADIN/Tunisie outputs, under a convivial interface easily consultable for the benefit of the forecasters. That interface will replace the postscript *gmeta* file produced by CHAGAL .
  - The results of the daily objective control of ALADIN/Tunisie outputs.
  - The ALADIN/Tunisie news, the reports and bibliography of the ALADIN team.

- Optimization of the script which repatriate the post-processed ALADIN/Tunisie outputs from the *delage* machine in Toulouse.

Since the installation of the new procedure we have regularly got the ALADIN/Tunisie files correctly.

ALATNET developments during the second half of 2002 in ALATNET centres

1. In Toulouse

The work of the five ALATNET PhD students in Toulouse, Gianpaolo Balsamo, Margarida Belo Pereira, André Simon, Cornel Soci and Malgorzata Szczech, is described in separate reports, as well as other PhD reports. The summary hereafter corresponds to the joint efforts of the other visitors and the permanent staff.

1. <u>Theoretical aspects of non-hydrostatism (NH)</u> *(many persons !)*

A large part of the work in this domain is extensively described through 3 articles in this Newsletter (2 by Pierre Bénard, 1 by François et al.), completed by the papers written by Petra Smolikova and Jozef Vivoda.

As a summary, the latest developments performed by the Prague and Toulouse teams were merged within a new reference library, allowing to combine the use of the new NH prognostic variables or the alternative handling of vertical velocity with the predictor/corrector scheme. The newest version of the ALADIN NH dynamics was intensively tested and successfully compared to that of some other limited-area models.

The 2d vertical-plane tests (with respect to a standard oscillating trapped lee-wave situation) which are described in Bouttier et al. were extended to the 3d (still semi academic) case by Jean-François Geleyn. The mountain is therefore not any more a transversal "wall" but gets an elliptical shape in the middle of the domain. The rest of the setup is the same. Thanks to this new geometry one gets the combination of two phenomena : the trapped lee-wave (that attenuates quicker than in the 2d case) and a V-form wake (see Fig1 hereafter). The welcome smaller attenuation rate of the wave in ALADIN-NH than in Meso-NH appears like it was already the case in the vertical plane experiments but there is an even more interesting feature. There exists with ALADIN-NH a wavy pattern in both branches of the wake, absent from the Meso-NH simulation. While there is this time no exact knowledge of the true solution, similarity with cloud structures in the lee of isolated islands seem to indicate that this is another "plus" for ALADIN-NH in this very demanding test (made here at 2 km resolution for 6 h with an Eulerian scheme on both sides).

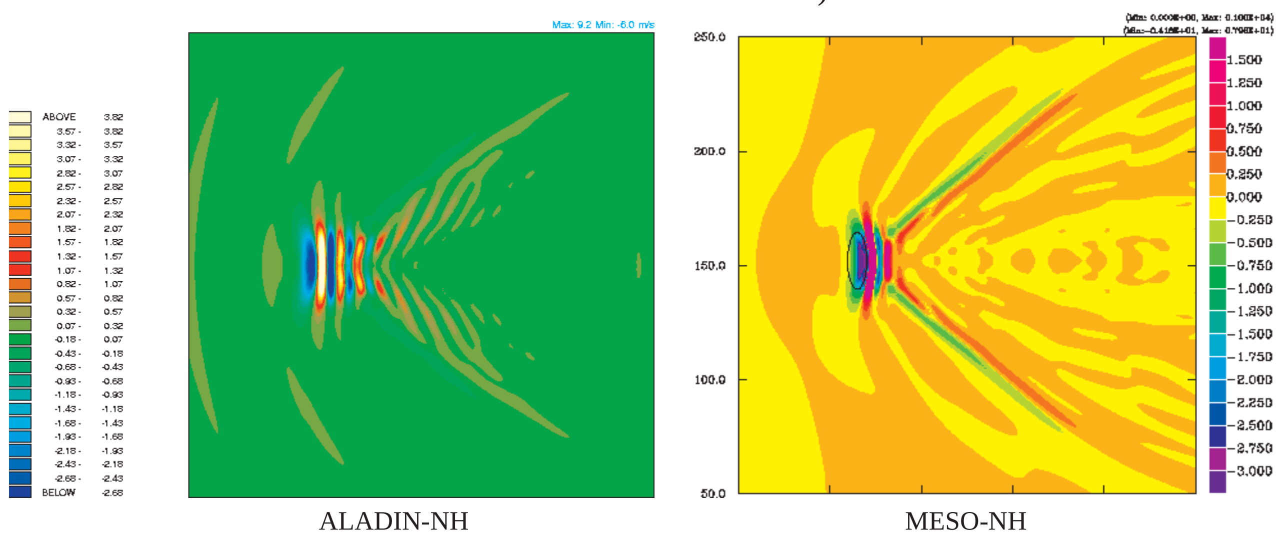

Figure 1 : Horizontal cross-sections of the vertical-velocity field at 2000m after a 6h forecast.

As a conclusion, we may say that the robustness, accuracy and efficiency of the ALADIN non-hydrostatic dynamics were demonstrated and it proved at least as good as the most advanced schemes.

2. Case studies aspects of NH *(K. Yessad)*

The stability of NH dynamics was tested on a past situation (14 July 1999, 00 h UTC) with ALADIN-France, along a 48-h adiabatic forecast. Neither the situation nor the resolution, around 10 km, were critical, allowing a simple comparison with the efficiency of hydrostatic (H) dynamics.

Several combinations of the two possible prognostic NH variables ($\mathcal{P}$ for pressure departure and d for vertical divergence), with and without a predictor/corrector approach, were evaluated for both two-time-level (2TL) and three-time-level (3TL) schemes, looking for the maximum allowed time-step each time. The results obtained in simpler experimental frameworks were confirmed :

- d_1, d_2, d_3, d_4 lead to more stable runs than d_0 ,
- $\mathcal{P}_1$, $\mathcal{P}_2$ lead to more stable runs than $\mathcal{P}_0$,
- for the pair ($\mathcal{P}_2$, d_3) :
    - 3TL : NH is less stable than H but the time-step is still acceptable,
    - 2TL : the maximum time-step for NH is far lower than the H one,
- for the pair ($\mathcal{P}_2$, d_4), similar time-steps as for H can be used, both in 3TL and 2TL.

This last proposal was again proved to be the best combination.

3. Noise control in high-resolution dynamics

This topic was addressed only in the framework of non-hydrostatism (topics 1 and 2).

4. Removal of the thin layer hypothesis *(A. Nmiri, K. Yessad)*

This issue has now come to an end, temporarily. The required code modifications, following the proposal of White and Bromley (1995), were coded and validated both in ARPEGE and ALADIN. Sensitivity studies with ARPEGE, i.e. at the global scale and with a rather low resolution, showed hardly any impact of the change on global budgets.

Experiments based on the ALADIN-Réunion model, covering part of the Indian Ocean, were launched recently. A more noticeable impact was expected in tropical regions and at higher resolutions. Forecasts with and without relaxation of the thin layer hypothesis were launched, for a 48 h range, with the operational resolution of the model (33 km), both coupled to the same global forecasts each time. Six cyclonic situations were chosen along the first semester of 2002, two of them (Guillaume and Dina) being described in a paper by Eiselt and Lasserre-Bigorry in this Newsletter. Results were again quite deceiving, even when going to a still higher resolution (7 km).

The trajectory and depth of tropical cyclones seem to be presently governed essentially by problems in physics and data assimilation. The impact of such a small refinement in dynamics will have to be evaluated later, once the forecast skill significantly improved.

In the meantime, a new approach was proposed by Wood and Staniforth (2003), fully consistent with the ALADIN NH dynamics, and more easy to implement (see the "check-up" report by Pierre Bénard). The work is likely to restart from the very beginning, but only once all present developments in NH dynamics achieved.

References :

White, A., and R. Bromley, 1995 : Dynamical consistent, quasi-hydrostatic equations for global models with a complete representation of the Coriolis force, *Q. J. R. Meteor. Soc.*, **121**, 399-418.

Wood, N., and A. Staniforth, 2003 : The deep-atmosphere Euler equations with a mass-based vertical coordinate, *Q. J. R. Meteor. Soc.* **129**, 1289-1300.

6. Specific coupling problems

a) Blending (P. Riber)

Tests have started with ALADIN-France in a quasi-operational framework. Two long (15 days) summer and winter periods were covered, as well as some situations such as rising of local wind gusts (Autan). The sensitivity to an extra digital filter initialization (with variants) was also investigated : no, standard with a rather strong filter (stop-band edge period 3h), incremental or standard with a light filter (stop-band edge period 1h½). Final results show a small positive impact, as happened for the LACE model. However this was not considered worth introducing such deep changes in the operational suite.

b) Tendency coupling for surface pressure (J.M. Audoin, C. Moussy)

Porting and debugging tasks, once again as the reference source code was updated, followed by more sensitivity studies. No positive impact was noticed up to now.

7. Reformulation of the physics-dynamics interface

a) Sensitivity of physics to time-stepping (M. Jerczynski)

An analysis of the stability of physics and its relationship with the advection scheme started, focusing on the gravity wave drag parameterisation first. Several configurations were tested, with the physics reduced to this sole scheme : two-time-level and three-time-level semi-Lagrangian advection, computation of physical tendencies at various points of the trajectory (departure, final, "average"). The impact of the internal safety locks against linear and nonlinear instabilities were checked, as well as that of the specific tuning parameter of the parameterisation `(GWDSE)`.

It appears necessary to keep the safety lock against nonlinear instability, while the location of physical computations within the time-step is not important in this case.

b) Solving some unstability problems in the physics (D. Banciu, J.F. Geleyn)

The parameterisation of shallow convection was initially designed for a low-resolution model, and only conditionally stable due to a mixed explicit-implicit formulation. Indeed problems appeared as the vertical resolution increased and the time-step decreased. This was solved through an implicit formulation of the contribution of shallow convection to the vertical exchange coefficients, the "classical" part keeping unchanged (still computed explicitly). This has a drastic positive impact, described in the joint paper on recent changes in ARPEGE physics.

8. Adaptation of physics to higher resolution

a) Resolution and the description of subgrid-scale convective precipitations
(S. Sbii, E. Bazile, F. Bouyssel, J.F. Geleyn)

A test-bed was designed to evaluate the impact of horizontal resolution and time-step on the behaviour of physical parameterisations. It includes 4 identical ALADIN domains, covering France, at increasing resolutions, i.e. with mesh-sizes of 20 km, 15 km, 10 km and 5 km respectively. Initial and boundary conditions are the same. The impact of the horizontal resolution and of the time-step (usually decreasing with the mesh-size) may be uncoupled performing experiments with the minimum time-step (that corresponding to 5 km).

The first investigations concerned the partition between large-scale and subgrid scale precipitations, focusing on a well-documented situation with floods in Southern France (8th of September, 2002). A former change, moving from an explicit modulation with resolution of the moisture convergence used as input to the deep-convection scheme to a mixed implicit-explicit one (with a preliminary elimination of the large-scale precipitation contribution), was proved to be reconsidered.

Experiments clearly confirmed the problem : with the operational formulation, as the mesh-size or the time-step increase, resolved precipitations increased significantly, while unresolved ones did not decrease in similar proportions, slightly increasing. This led to an overall very large increase in the total precipitations, indicating an excessive dependency of rainfalls on horizontal resolution. The behaviour of various contributions was analysed. For instance, a positive impact of the stabilization of the shallow-convection scheme (see 7b) was exhibited, with smoother (and more sensible) variations on the vertical.

Research around this problem led to go back to the initial explicit formulation, with a strong retuning however, while improving the internal consistency of the deep-convection scheme : full balance between convective and turbulent fluxes, additional safety constraints.

b) Improved representation of the boundary layer (many persons !)

Important progress was achieved in two directions : the stability of the involved parameterisations was improved; the previous refinements and tunings (concerning mainly stable cases) were deeply reconsidered. Changes are described in the paper on recent changes in physics and in the PhD report of André Simon.

c) Improved representation of orographic effects

(M. Rousseva, Y. Wang, E. Bazile, B. Catry, J.F. Geleyn)

The formulation of the thermal roughness length was revised. Up to now, it is fixed to one tenth of that for momentum, according to a former study. However not only the impact of vegetation and urbanisation is taken into account, but also that of mountains. This is quite convenient for momentum, but not for the formulation of heat and water fluxes near the surface. The impact of a simple modification, i.e. not considering the orographic contribution in the computation of the thermal roughness length, was evaluated. Two sets of 10 96-h forecasts, on a summer and a winter cases, were performed. As expected, latent and sensible heat fluxes are modified, as well as the diurnal cycle of surface temperature (higher maxima), especially over desert or mountainous areas. However, the overall impact, on scores against observations or on global budgets, is very small.

The impact on precipitations (too much upslope) of the "envelope" orography was investigated in ALADIN-Vienna, after that of some other parameterisations. A strong retuning started, going to the so-called "semi-envelope" to keep part of the blocking effect without increasing height so much. This experiment underlined how much such refinements depend on the model (extension, resolution, location).

See also the ALATNET report for Bruxelles.

9. Design of new physical parameterisations

a) Implementation of a new parameterisation of turbulence (J.M. Piriou, P. Marquet)

A prognostic "Turbulent Kinetic Energy" (TKE) scheme has been implemented in the vertical 1d version of ARPEGE/ALADIN, and interfaced with EUROCS datasets, for a preliminary evaluation before more in-depth adaptations for use in the 3d model. The first simulations, on a dry desert case, provided encouraging results.

b) Refinements in the parameterisations of radiation and cloudiness

(H. Toth, Y. Bouteloup, J.F. Geleyn, J.M. Piriou, F. Bouyssel)

Work on radiation started on two directions along the last 6 months. First the previous (6 years old) developments aiming at an exact computation of radiative exchanges with the surface (EWS) were tested once again, for longer forecast ranges and in data assimilation mode, and proved to bring significant improvements. Second a longer-term study started, aiming at first identifying the most critical / detrimental assumptions in the present scheme, then going to a more sophisticated but still cheap parameterisation. A paper dedicated to the developments in this domain along the last year is published in the present Newsletter.

The main drawbacks of the former operational physics : not enough low-level clouds at mid-latitudes and high-level ones in the Tropics, were solved by the combination of two changes :

- an improved consistency between cloudiness and condensed water, using diagnostic liquid water and ice as input to the Xu-Randall scheme (which previously proved quite efficient in the prediction of marine stratocumulus),
- an improved consistency between cloudiness and precipitations, through a modified description of the involved large-scale processes.

Careful retunings ensured that the cyclogenetic activity of the model (whose stability is strongly influence by low-level cloudiness) keeps close to that of the atmosphere. Changes are drastic, as described in the joint paper on physics.

c) Test of new parameterisations (Y. Bouteloup, P. Marquet)

The physics of the climate version of the ARPEGE model was tested in NWP mode, in the global model only. The main differences lie in the more sophisticated description of radiation, the use of a TKE scheme, a "statistical" description of cloudiness, another parameterisation of precipitations. This package does not lead to better results (scores, global budgets, ...) than the physics tested at the beginning of 2003, but the comparison fostered many improvements in the ARPEGE/ALADIN parameterisations set.

10. <u>Use of new observations</u>

a) Quality control and selection of observations for a mesoscale LAM

First the ALADIN specific features for the selection of observations are now available in an official library, as well as the adaptations required to use raw radiances (mainly including surface temperature in the 3d-var control variable for ALADIN). Second Z. Sahlaoui, R. Randriamampianina and E. Gérard designed a tool to eliminate the bias of raw ATOVS data for a limited-area model (LAM), using statistics of the distance between model and observations. The whole pre-processing suite for observations in ALADIN is described in the joint paper by R. Randriamampianina.

b) More extensive and accurate use of conventional observations (P. Moll)

Feasibility analyses, developments and impact studies (in the global model) were performed for the following innovations :

- improved use of radiosonde data (considering temperature rather than geopotential observations),
- use of wind-profilers data.

These studies should be completed by experiments in ALADIN, delayed until a version of 3d-var is operational.

c) Use of satellite data

The major step forward was performed by enabling the use of raw radiances. See also the paper by T. Montmerle.

11. <u>3D-Var analysis and variational applications</u>

a) Description of background error statistics (F. Hdidou, C. Fischer, V. Guidard, L. Berre)

The standard and lagged background error statistics have been computed for the ALADIN/NORAF domain. A set of 95 days of 36 minus 12 hour forecasts (the latter using the same boundary conditions as the 36 hour integrations) was used to sample the error statistics based on the NMC method. The structure functions show very similar structures when compared with ALADIN/FRANCE or ALADIN/LACE. The most significant difference is for the T/Divu and q/Divu couplings, where the error variance is dominated by the large scales in the NORAF domain, while this signal usually is stronger at small scales. We propose that this particular result is linked to the Hadley cell circulation, which is rather well inserted in the NORAF domain.

A specific work was done in order to allow for some "gridpoint flavour" inside the Jb structure functions. An in-depth investigation of the gridpoint correlation functions derived from the ALADIN/FRANCE spectral Jb suggested that the use of compactly supported correlation functions could force more local analysis increments, and benefit more from the mesoscale nature of the lagged Jb. The implementation of compact supports was worked out by systematic bi-Fourier transforms forth and back, and application of a mask. The alternative approach, by 1d Bessel transforms, is not tractable since it requires to store both 1st and 2nd order Bessel functions, and a precise number of periods of zeros of the Bessel basis along the gridpoint axis.

b) Investigation of the problems related to biperiodicity (C. Fischer, L. Berre, V. Guidard)

Recent results have stressed that the biperiodic formulation of the variational analysis increments still causes some undesired, if not unrealistic, features in 3d-var :

- analysis of biased satellite data strips causes a spurious increment over the full domain (as noticed by Roger Randriamampianina),
- analysis of bands of observations also causes unrealistic large-scale increments, and increments that wrap around the extension zone,
- there is around 5 to 10 % of energy in a single-observation increment which spreads throughout the full domain.

Several solutions have been proposed so far, some being investigated and others not so far (but perhaps needed in the last extreme) :

+ compact support for correlation structures : The code is ready, but the compact support cannot force a full analysis increment to be compact on the ALADIN torus. The use of this method probably must be coupled with some other ingredient.

+ modification of the spectral shape of the power spectra : An ad-hoc modification does not make sense. Moreover, compact support already performs a modification of the power spectra, in a way which is consistent with a spectral convolution.

+ force background error variances to be almost zero in a rim zone around the extension zone : This technique has some impact, but it is limited at least by the very short width of the usual ALADIN extension (E) zones (roughly 10 times the mesh-size).

+ an indirect benefit from the off-diagonal B-matrix terms, as proposed by Simona Stefanescu and Loïk Berre, could also help to distinguish the E-zone in the structure functions.

+ larger E-zones (with a longer physical lengths) : although the increase of the E-zone requires some careful technical overview, it is not impossible that some of the possible solutions listed above only really work when the E-zone is more significantly increased, with respect to the typical length-scales of the correlations

c) Intensive scientific validation (V. Guidard, C. Fischer)

Further work on the MAP IOP14 situation was achieved. See the "ALADIN PhD studies" part.

d) Cycling strategy (F. Hdidou, C. Fischer)

The definition of an assimilation suite for the ALADIN-NORAF model started, based on Blendvar (a combination of spectral DFI-blending and 3d-var analysis). Beside the computation and evaluation of background error statistics, the resolution of the intermediate grid (for the filtering of the large-scale analysis increments provided by the coupling model, ARPEGE) was defined. An "assimilation" suite based on blending only, was launched over the whole month of November 2001, and compared both to ARPEGE and the present assimilation suite for ALADIN-Morocco.

e) A-posteriori evaluation of assimilation schemes using variational tools (W. Sadiki, C. Fischer)

See the "ALADIN PhD studies" part.

12. 4d-var assimilation *(C. Fischer, V. Guidard)*

The implementation of 3d-FGAT (First Guess at Appropriate Time) in ALADIN started. 4d-screening, where the distance between the forecast and the observations is computed at the observation time, no longer assuming that all observations are valid at the middle of the assimilation window, is ready. But the corresponding changes in the minimization process were not addressed, since it appeared necessary to focus first on the shape of analysis increments and the problems related to biperiodicity.

2. In Bruxelles

1. Coupling problems (topics 5 & 6)

a) Time-interpolation of coupling data (Piet Termonia)

The work on the "quality control" of coupling frequency was pursued. A paper presenting all the ideas around the "acceleration term", entitled "Monitoring and Improving the Temporal Interpolation of Lateral-Boundary Coupling Data for Limited-Area Models", was accepted to *Monthly Weather Review.*

During a 2-months stay in Budapest, last summer, a method was developed, to quantify the corruption of the spectrum due to the temporal interpolation of coupling data. A paper on this topic should be ready soon.

b) Well-posed lateral boundary conditions (Chantal Moussy, Piet Termonia)

The idea is to resume the work of Aidan Mc Donald, who is studying the problem of "transparent" boundary conditions and searching for an alternative to the Davies' relaxation scheme for some years in the (gridpoint) HIRLAM model.

To start with, the results of Mc Donald (2002) will be tested in a simple 2d (barotropic) version of ALADIN. The last months were therefore devoted to bibliography and the setup of the experimental framework, which is now ready. A program was built from some ALADIN elements, allowing to choose the LAM domain, change the geometry, define "normal modes" (an option not present in the model), so as to enable a prescription of lateral boundary conditions.

Reference :

Mc Donald, A., 2002 : A Step Toward Transparent Boundary Conditions for Meteorological Models, *Mon. Wea. Rev.*, **130**, 140-151

2. Reformulation of the physics-dynamics interface (topic 7, Ilian Gospodinov)

The dedicated Post-Doc stay is now finished, and a description of the corresponding results is expected for the next Newsletter.

3. Refinements in physical parameterisations (topics 8 & 9)

a) Introduction of prognostic cloud water in a refined convection scheme (Luc Gerard)

Developments aimed at a more coherent treatment of cloud water and convection at high resolution. The work included bibliographies and testing several possible hypotheses and paths for parameterisation.

The following steps were achieved in 2002:

➤ Adaptation of the cloud-water scheme developed by Philippe Lopez to the ALADIN context, with personal contributions in separating 2 prognostic cloud-phases and changing the precipitation content from a prognostic to a pseudo-historic variable. It required also restructuring the interface routine to the physics (*aplpar*). The code, based on cycle AL15, and documentation were made available to ALADIN partners.

➤ Porting the previously developed prognostic convection scheme (Gerard, 2001) to cycle AL15. This brought particular difficulties : the introduction of new prognostic variables implies wide adaptations, and the lack of documentation and of "debugging-friendliness" of some codings makes the things worse. These could only be solved with the arrival of a more powerful PC in August 2002.

➤ Raw combination of the prognostic convection and the prognostic cloud-water schemes (without adaptation of some contradictory hypotheses)

➤ Development of a new treatment of convection, compatible with the presence of cloud water, and implying the separation of updraught and downdraught calculations, with the microphysics computations in-between. Many different ideas were developed and tested, and the first viable solutions emerged in early 2003.

b) Improved representation of boundary layer, based on a parameterization of Turbulent Kinetic energy (Martin Gera)

The work is described in the ALATNET reports from Young Researchers.

c) Improved representation of orographic effects (Bart Catry)

The following text covers the work performed both in Belgium and during the stay in Toulouse.

Our main problem for the subgrid scale orographic forcing at high resolution and in the lower part of the atmosphere is currently the following : not only is such a forcing highly nonlinear and multiform (roughness effect on PBL, form-drag, lift, blocking effect of barriers), in the model as in nature, but it also does not scale correctly when the horizontal resolution is modified. Said differently, between runs at different resolutions what changes in the parameterized forcing is not the mirror image of what is taken over by the resolved dynamics that "sees" further details of the orography. This result, unknown at larger scales from the little results we have there, is confirmed by a wealth of tests. Bart Catry is trying to find the reasons of this odd behaviour of ALADIN in a novel way : using the ALPIA semi-academic environment he wants to reproduce the problem in a model without baroclinic forcing and encompassing only dynamics, turbulence and drag, on a variety of mesh-sizes and for a domain encompassing the strongest slopes of the Alpine region at the 10 km scale.

<u>4. 3D-Var analysis and variational applications</u> (topic 11) : Wavelet representation of background error covariances (Alex Deckmyn)

First of all, the Meyer wavelet transform, which in general is only valid when the number of gridpoints in each direction is a power of 2, was generalized to (any) non-dyadic configuration, which allows us to define the wavelet transform on any ALADIN domain. A paper entitled "On orthogonal Wavelet transforms with variable dilation factor" was submitted to *Applied and Computational Harmonic Analysis*.

Another problem was that the variance was too much concentrated around a few points of the large-scale grid. This was partially solved by keeping the variance in gridpoint space and (effectively) working with a wavelet representation of correlations instead of covariances. This improves the representation a lot, but the shape of structure functions is still slightly skewed towards points of the large-scale grid.

Further studies addressed the local (horizontal) correlation length at different levels. A diagonal-B matrix in wavelet space is able to represent the local variations in correlation length quite well although there is an underestimation in absolute values.

3. In Prague

1 Theoretical aspects of non-hydrostatism

1a) Top and bottom boundary conditions *(C. Smith)*

In the second half of 2002 the so-called *w* scheme was phased into the main trunk of the ALADIN library. This *w* scheme means that vertical wind *w* (*dz/dt*) is advected in case of the semi-Lagrangian scheme and not the vertical divergence type of variables (derived $\partial w/\partial\eta$ quantities). As it was mentioned in the previous newsletter, this scheme solves the problem of spurious standing wave above the mountains when the semi-Lagrangian scheme is used. This wave is well noticeable both in the 2d (mountain wave) and 3d (SCANIA/ALPIA type) academic experiments. However, the *w* scheme is technically difficult to maintain due to the advection of half-level quantity *w*. Even worse drawback is the problem how to restitute tendencies for the vertical divergence variables (except the one where $\partial w/\partial\eta$ is simply scaled by quantities constant in time) from the *w* tendencies.

Since the research stay of C. Smith has finished and since this topic is very important in the research plan, the following of this work is mainly taken by P. Smolikova and R. Brozkova.

Further research will go along two main lines: **i)** investigation of the true diagnostic formulation of the cinematic bottom boundary condition as reporting from the w scheme to the pseudo-vertical divergence scheme; **ii)** investigation of possible source term problem in case of the pseudo-vertical divergence scheme.

1b) Predictor-Corrector scheme *(J. Vivoda)*

The Predictor-Corrector (PC) scheme for two-time-level semi-Lagrangian non-hydrostatic ALADIN is phased and working for almost all options in the library cycle CY25T2. It is not yet fully harmonised with the ECMWF PC hydrostatic scheme.

In order to increase the stability of the scheme, an investigation was made for a non-isothermal reference profile. The results are mitigated: while one could intuitively expect a better stability thanks to the diminished amplitude of the linear residuals, there is not much gain observed in the experiments. Another subject was to look also to the problem of the computation of pseudo-divergence tendencies (see a contribution in this Newsletter).

1c) Test of new prognostic variables *(J. Masek)*

This work was mainly done in the first half of 2002 and was reported in the previous Newsletter. Recently, however, a bug was found in the coding of sponge which was used for these academic experiments on mountain waves. Some tests were rerun with a correct sponge code. The bug improved results for the variables *d4* and *d5* which were those affected by the error. Now then seems that *d4* variable is a best candidate to be retained as a basic option.

1d) Clean introduction of the prognostic variable d4 *(P. Smolikova)*

A clean introduction of the *d4* variable was technically quite difficult task due to the necessary introduction of a pseudo prognostic spectral variable needed for the computation of horizontal derivatives. This additional variable is simply diagnosed within the gridpoint computations and needs to be biperiodicised before getting transformed to the spectral space. Due to the fact that the externalisation of the biperiodicising operator has not yet been done, one part of it was dropped when used here in order to avoid additional transpositions of data on the processors. The extension in the x-direction is made still in the gridpoint space while the one in y-direction is applied on

Fourier coefficients (before the y-direction transform). The transversal smoothing is the skipped part.

The code of *d4* was first validated for 2d vertical plane model and also for 3d model. It is phased with the PC scheme in a working branch of CY25T2 and this branch will be introduced in CY26. The tests were made for the PYREX case and compared to the results obtained with the *d3* variable. It was shown that the *d4* variable provides better stability. More details can be seen in a contribution on this topic.

(Note: trapped lee wave experiments in 2d (Bouttier) and in 3d (Geleyn, Brozkova) should be reported by Toulouse)

2. Data assimilation related issues

2.a) Comparison of data assimilation, blending and Blendvar *(G. Boloni, R. Brozkova)*

This work was a continuation of the 3d-var cycling experiments including the Digital Filter (DF) blending. An experiment was set up in order to assess the relative performance of each ingredient of the system, starting by the dynamical adaptation, then adding the DF-blending and then 3d-var analysis (in Blendvar configuration). The dynamical adaptation technique did not use any observations, while for the next step of the DF-blending a surface OI analysis was performed (configuration DF-blending and surface CANARI, known as Blendcan) and in the next step the DF-blending was topped by the 3d-var analysis using the lagged background error statistics (configuration Blendvar). The observations used inside the analysis were the conventional observations used already by ARPEGE. This time there was not a special case study but a short like parallel suite was run and the classical scores were looked at. We can say that the scores of all the three experiments were not significantly different from each other and that the signal they contained was rather week. When making the relative comparison, we can say that each step brought some improvement. First, when looking to the dynamical adaptation and Blendcan, then we could notice an improvement in some scores up to 24h forecast range in case of Blendcan. Then, when adding the 3d-var step, there was another little improvement, certainly at the initial time when the fit to observations is ensured by the analysis. For the following ranges there was a relatively weaker improvement compared to the pair of the dynamical adaptation versus Blendcan noticeable only up to 12h range. We may conclude that this experiment gave expected results and also that the weak signal in the scores shows once more that we get only little information out of them on the behaviour of the schemes. The scores serve us as an indicator, but their should not be used blindly.

2.b) Test of the variance coefficient in nested 3d-var *(G. Boloni)*

When the lagged statistics are computed for a nested and quite small domain (of about 1200km large), the resulting background error variance is quite small, even in comparison to the one computed for the larger domain by the same method. The LACE domain and the Hungarian domain (nested in and coupled with ALADIN/LACE) were used for this computation. The goal of a little study was to examine how the potential increase of this variance by the multiplication coefficient (usually taken as 0.9 but here bigger than 1.0) influences the analysis results. Three small suites were cycled, the first one with the coefficient equal to 1.0, the second one with the increased coefficients of 2.6 and the third one was using the standard background errors matrix with a default coefficient. No suite was using blending (any kind), since this technique was not developed for the nested domain. The result was a bit surprising, since there was only a little sensitivity to the tested options. First, the vertical velocities at the initial time were examined at the level of 500 hPa. When using the lagged statistics, they were weaker than in the standard case, due to the absence of blending. But they were not much different, even in the amplitudes, when using the value of 1.0 or 2.6 to multiply the variances. The vertical velocities in the standard experiment were stronger and having a bit different structure. It should be noted that also the scores were looked at again, and that there was almost no difference for the three suites after the range of 12 hours. This experiment simply shows that the strategy to be chosen for an analysis at quite small domains is not obvious, since the role of the lateral boundary conditions is here even more important.

2.c) 3d-var analysis of screen-level humidity *(L. Gaytandjieva, M. Jurasek, R. Brozkova)*

In spring 2002 the operational application of ALADIN/LACE was switched to the 37 vertical levels. Consequently, the background error statistics for 37 levels were computed. They were computed both by the standard method (to be able to make comparisons) and also by the lagged method. Then the experiments were made to assimilate screen level humidity. As a first exercise, a single observation experiment was made, where the increments were looked at for humidity and temperature (the humidity is coupled to the other variables in the Jb term). The single observation experiments were using a negative increment in relative humidity of 41%, the observation was put nearby a middle of the domain. The resulting increments in relative humidity and temperature for both the standard and lagged statistics are shown on Figure 1.

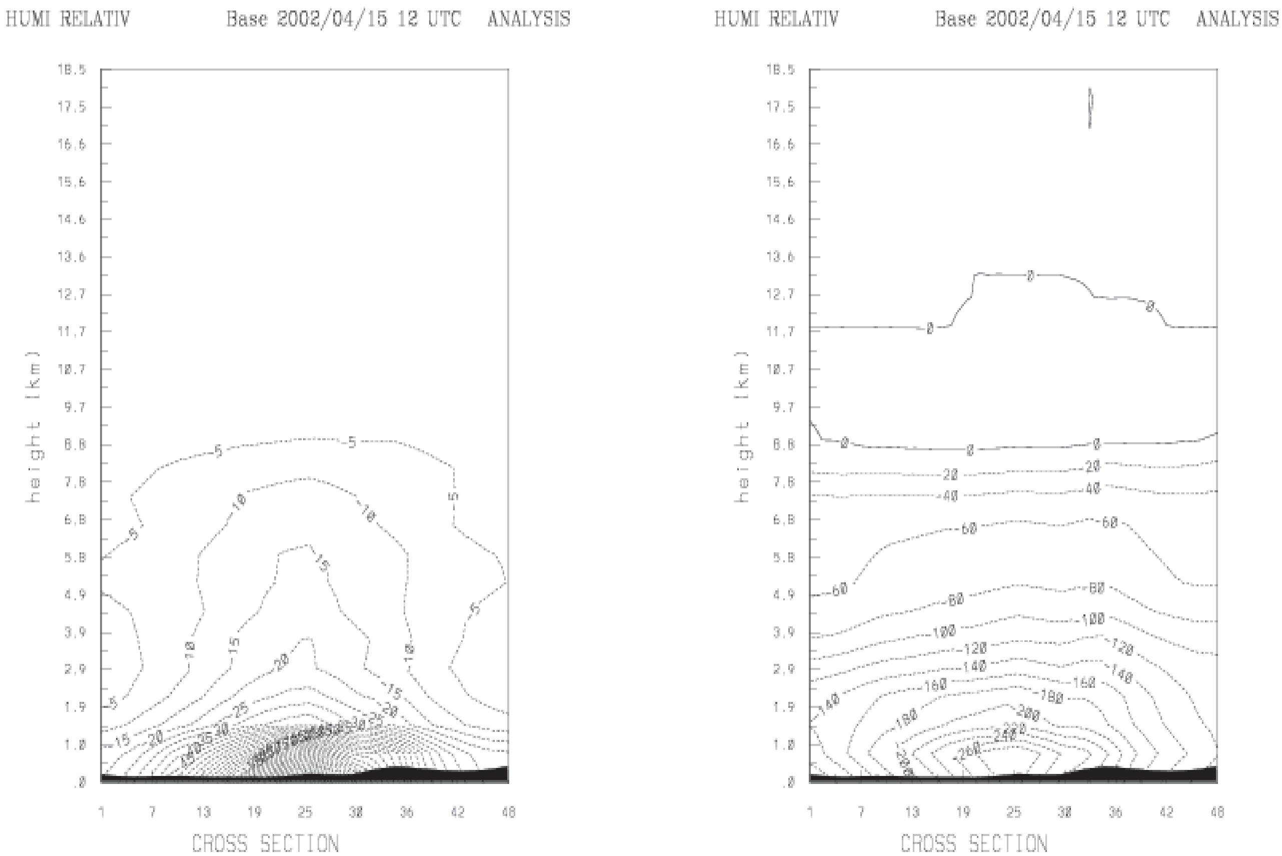

Figure 1: *Vertical cross-sections of the relative humidity increments. The values are in % multiplied by the scaling factor of 10. The case of the standard statistics is shown on the left (contour interval 20), the case of the lagged statistics is shown on the right (contour interval 5).*

The shape and amplitude of increments show that in case of the lagged statistics the impact of the observation is more local, both in vertical and horizontal directions. This is a desirable feature, since the screen level observations should not influence higher model levels too much, and also they should not have too wide horizontal impact. In vertical, a reasonable demand is that the increments become negligible at about 3km height. At this height the increments are around 14% in case of the standard statistics, which is certainly too much, while it is about 2% in case of the lagged statistics. At the height of 1,5 km (top of PBL), the increments are about 24% in the standard case while only 3,5 % in the lagged case. We may than hope that in case of the lagged Jb the increments will remain meteorologically reasonable.

Then some full observation experiments were performed, when assimilating either the humidity observations only, or assimilating also the other usually assimilated observations (from the conventional TEMP and SYNOP types). Again, both standard and lagged statistics were used, but this time the lagged Jb was used together with the digital filter blending, since these were real case studies. The results were similar to those obtained with a single observations, but the increments are a bit stronger. In the standard case the temperature increments are non negligible in the whole depth of the atmosphere (with the amplitude of 0.6K at the model level number 10). Their biperiodic feature can be easily checked. The standard Jb in its current formulation is unusable. The lagged Jb case is less catastrophic: the biperiodicity of increments is still visible, since it is an intrinsic feature of the current spectral Jb, but the amplitudes are much smaller (for temperature about 0.05 K at the model level number 10). However, according to the shape of the temperature-humidity cross-covariances, we can see in both cases maybe not very physical change of sign of the increments in the vertical. It is then questionable, whether it would be safer to decouple the temperature and humidity in the Jb term. Finally, a short assimilation cycle was run when assimilating only the relative humidity screen data. The results were not yet evaluated.

3. Horizontal diffusion related issues

Tuning of the Semi Lagrangian Horizontal Diffusion (SLHD) scheme (R. Glavac-Sah, F. Vana)

In the first part of study the scale and time-step dependence of the SLHD scheme has been tested. The four different domains covering the geographic area of the ALADIN/LACE domain were defined with resolutions of around 17, 15, 12 and 9 km. As a first step the mesh dependence of the current spectral HD scheme was investigated in order to re-validate the commonly used convention and to have an estimation of acceptance for the scale dependency of a horizontal diffusion scheme.

Then the SLHD scheme was tested with intention to define the two scale dependent tuning parameters (P1 and P2). It was found that the scale dependency of the scheme really exists but is of very low magnitude. When just P1 was adjusted (the finer refinement P2 is not really needed), the SLHD scheme became completely scale independent, i.e. far better than the spectral HD.

Next step will just to verify the expected independent performance of the SLHD with respect to the chosen time-step. Then the scheme will be tested on very high resolution simulation (2.5 km of horizontal mesh) where the nonlinearity of it becomes to play an important role.

4. Interface physics-dynamics related issues

4.a) Linear and nonlinear instability tests for physics package (M. Tudor)

The stability or ‘stiffness’ tests were made for various parameterizations, using ARPEGE global model. Each tested scheme used a halved length of the usual time-step and then the time-oscillations were examined between the reference and the test solutions. It was shown that the parameterization of the large scale rain (*acpluie*) suffers from the fibrillations (par example around the Bering Strait and also in the Baltics for the chosen date).

Another test was made to check for a nonlinear instability, when the pressure thickness of model layers was increased or decreased by about 10% in the tested schemes. While decreasing the pressure thickness did not show any significant change, the convection routines (*accvimp* and *accvimpd*) make the model blow depending on the degree of increasing the pressure thickness of layers.

4.b) Changes in the subgrid-scale orographic gravity wave drag representation (D. Drvar)

The aim of this study was to try to replace the effect of the envelope orography by a better and more accurate parameterisations of the effect of mountain drag. Altogether, four changes are needed: to release the use of envelope orography, to activate the orographic lift, to decrease the low level drag and to increase the aspect ratio coefficient at the surface. Case study tests were made first, for which the cases were carefully chosen with a strong large scale flow in the Alpine area. In comparison to the reference the tested solutions were looking a bit more realistic and closer to the observations (at least for rain and surface winds). Although it would be a bit dangerous to conclude on these few cases, the proposed changes seem quite promising: the obtained results encourage further testing, maybe in a parallel suite.

4.c) Tests of the δm term in the mass conservation control *(A. Trojakova, P. Smolikova)*

Since a long time there is a sleeping option in the ARPEGE/ALADIN code, with a working notation δm term. This term enables to take into account the mass of water taken out of the atmosphere by the precipitation flux, compensated by the evaporation flux in the budget. In the past some tests were performed but without any real conclusion (there was hardly any sensitivity to this term) for NWP model (the climate version is using δm) Recently, tests were made in ALADIN using two cases of tropical cyclones in Indian Ocean. This extreme phenomenon was chosen on purpose: if the term has some effects, then it has to show here, otherwise it can be considered as negligible for NWP forecasts. The performed experiments has shown some differences in the forecasts; the activation of this δm term lead in general to a bit deeper cyclone and more precipitation. On the other hand it cannot be said that these results are better and more validation effort is needed. The work on this topic was initiated by the training course on ARPEGE/ALADIN physics (Prague, 16/09-04/10/2002) and shared with the department on tropical cyclones research in the Réunion island.

5. Physics related issues

5.a) Radiation scheme tuning *(H. Toth)*

This work is in fact a continuity of the experiments made already last year. The long-wave radiation fluxes computed by the operational radiation scheme were compared to results of a comprehensive but quite expensive scheme (this time a scheme developed at DWD was used for the expensive reference). A trial was made to change the absorption interval and/or optical depth of three gases (water vapour, carbon dioxide and ozone) in order to fit better the reference flux profiles. The comparison was evaluated for something like 400 profiles, representing patterns from around the Earth, but the statistics did not show any significant improvement. When looking to the vertical shape of the profiles, it turned out that for some tunings we may obtain a nice fit to the reference in the lower atmosphere while a divergence occurs nearby the tropopause, for example. This explains that no real improvement was seen in the whole statistics. It shows also that a simple tuning cannot improve the deficiencies observed in the currently used scheme. See also the paper on radiation.

5.b) Tests of the prognostic convection scheme *(S. Greilberger, T. Haiden)*

Some case studies were conducted using the prognostic convection scheme, developed by Luc Gerard. This study was a continuation of the previous effort. Here some more convective cases were added and the prognostic convection scheme was tested as well for the flood period in Central Europe. The results of precipitation forecasts were compared to the operational version (CYCORA BIS). The conclusion is that the prognostic convection scheme provides in general more realistic results and this was true for all six convective cases which were studied. In general, the amount of precipitation is decreased in case of the prognostic convection scheme and often these forecasts are closer to observations. On the other hand it does not help for some cases of unrealistic early morning convection. For the flood cases we may say that the prognostic convection scheme provides the same quality as the operational scheme and that there is no significant difference.

4. In Budapest

The most important ALADIN-related activities at the Hungarian Meteorological Service are concentrating on the scientific topics defined in the ALATNET research plan. Our Service is active in the following ALATNET sub-topics (in parenthesis the topic number refers to the ALATNET research plan) : coupling and high resolution modes (topic 5), specific coupling problems (topic 6), design of new physical parameterisations (topic 9), use of new observations (topic 10), 3d-var analysis and variational applications (topic 11).

Hereafter the main activities in these subtopics will be briefly described.

5. Coupling and high resolution modes

Piet Termonia from the Belgian Meteorological Institute was invited for a two-months stay in Budapest to work together with Gabor Radnoti on the coupling problem of the ALADIN model with special emphasis on such meteorological situations, where the evolving meteorological objects are passing very fast through the boundary relaxation zone making extremely difficult their consideration through the lateral boundaries of the limited area models. Piet Termonia was trying to find an alternative description of the fast propagating waves taking into account the lessons learned from the 1999 Xmas storms. The cornerstone of his idea is the decomposition of the model state variables into moving and growing parts. After this decomposition a spectral transformation is performed, and a functional is derived and minimised in order to ensure the best fit to the real data. The basic conclusion of his work that it is very difficult to find a new formulation for the temporal interpolation needed for the consideration of LBC information at every time-step, however a diagnostic tool can be developed, which provides the necessary lateral boundary frequency to be used in the given situation (it means a dynamic approach, where according to the meteorological situation always the sufficient boundary conditions are used for the limited area model). See more details about the work of Piet elsewhere in this Newsletter.

The development of the spectral coupling scheme had been continued in Ljubljana and close information exchange was ensured between the two centres regarding the latest progresses in this field.

6. Specific coupling problems

The investigations of the coupling problems in relation with the three-dimensional variational data assimilation (3d-var) scheme had been continued. Different schemes were tried and tested: space consistency (where the initial information is in agreement with the first boundary information, therefore the LBC information is consistent in space), time consistency (where the initial information and the first boundary information is different and the lateral boundary information are coming from the same model run, therefore the boundary information is consistent in time), Moroccan solution (where the first two boundary files for the cycling are analysis fields, therefore always the most exact possible boundary information is imposed). The investigations confirmed that in spite of the small differences between the performance of the three schemes the best strategy is probably the solution proposed in Morocco, where the boundary condition files are always coming from analyses fields.

The blending assimilation cycle was systematically compared with the "Blendvar" solution (see more details at topic 11).

9. Design of new physical parameterisations

The involvement of the Hungarian Meteorological Service in the field of physical parameterisations is increased in 2002 with the employment of a new physicists in the NWP team. The first activities of this new colleague was concerning the training on the physical parameterisation packages of the ALADIN model. Then a 3 weeks training course (organised in Prague) further supplemented his knowledge on the problems related to parameterisations. During and after this training action a small exercise was studied: the parameterisation of roughness length ratio. The problem is related to the fact that the ratio of the momentum and heat roughness length depends on the friction velocity and this dependency is not taken into account in the model (especially areas over land and sea ice are considered).

Some further activities were performed around the radiation scheme of the ALADIN model. The main weaknesses of the recent radiation scheme was identified and a strategy was adopted to test their improvements. For studying the tuning possibilities of the ALADIN radiation scheme (where single spectral interval is used for the mean characterisation of the absorption properties) a new scheme (GRAALS a German radiation scheme) was implemented for the Single Column Model version of the ALADIN model. This scheme was considered as a reference one for the comparison. The ALADIN radiation scheme is tried to be tuned in such a way, where the results of the scheme (radiative flux-divergence profiles) are approaching to the solution of the GRAALS scheme. Unfortunately this exercise didn’t bring sufficiently satisfactory results showing that the tuning of the ALADIN radiation scheme is not a trivial task in case of the usage of single spectral interval for absorption properties.

In the future it is planned to extend our activities for the problem of dynamic-physics interface (topic 7) and to the study of the prognostic cloud scheme (liquid water and ice as prognostic variable) beside some further work on the radiation scheme of the model.

10. Use of new observations

It is of great importance to use new observations into the 3d-var data assimilation scheme and it is especially true for the scheme applied at the Hungarian Meteorological Service, where only SYNOP (surface) and TEMP (upperair) measurements are used. Due to the limited spatial resolution of the radiosonde network the enhancement of the upperair description of the atmosphere is highly desirable for the further improvements of the performance of the scheme. The applicability of two new information sources is investigated: locally received ATOVS data and AMDAR aircraft data. Regarding ATOVS data there is significant progress achieved (see the detailed report of Roger Randriamampianina in this Newsletter) and the scheme is ready for impact studies. Regarding measurements from the taking off and landing aircrafts (AMDAR data) until now only technical achievements were performed, therefore new results are to be expected during 2003. More distinct plan is the work on radar data, this activity is planned to be started during 2003.

11. 3d-var analysis and variational applications

This topic is the most important one for the Hungarian Meteorological Service in the framework of the ALATNET project.

Our ALATNET fellow Steluta Alexandru continued her work with her second 7 month stay in Budapest working on the "Scientific strategy for the implementation of a 3d-var data assimilation scheme for a double nested limited area model". The more detailed report of Steluta can be also found in this Newsletter.

A systematic comparison study was performed in order to study the general performance of the blending suite with respect to dynamical adaptation, Blendvar and Varblend experiments. The main emphasis was put on studying whether the 3d-var scheme executing after the blending procedure brings additional benefits or not. According to the results an additional improvement on the top of blending is noticeable until the first 12 hours of the integration, however in the longer ranges this gain is lost, which means that there is a mesoscale signal present in the available observations, however their effect can be maintained only until maximum 12 hours. Probably the impacts of lateral boundary conditions are overwhelming the solution afterwards, therefore there is a need of improvements of the applied tools in order to preserve the improvements all along the short range integration.

The work started on the background error statistics had been continued with a further study of the double nested aspects of the background error covariance matrices. It was found that for the

ALADIN/HU double-nested model due to the small resolution ratio between the coupled and coupling models the lateral boundaries are dominating on the forecasts, i.e. the lagged method cannot be efficiently used in such case (the decrease in variance is too high resulting too small increments in the analyses). An alternative solution was tried when the lagged background error statistics were tuned in order to compensate the variance reduction with a multiplication factor (REDNMC).

Important developments were concentrating on the application of the best possible strategy for the ALADIN/HU (in its new model domain) 3d-var data assimilation scheme. Also based on the experiments of Steluta Alexandru the final settings of the scheme had the following main characteristics:

-- First guess: the 6h forecast of the ALADIN/HU model (it is the classical and most straightforward choice).

-- Initialisation: digital filter initialisation in cycling and production.

-- Background error statistics: standard NMC method with 36h - 12h forecast differences.

-- Coupling strategy: the "Moroccan" solution is adopted, where the 6h boundary information is also an analyses (it is noted that for the cycling boundary update frequency is 6h, while in production it is 3h).

After the technical realisation of the options mentioned above a throughout study had been started in order to evaluate the performance of the scheme with respect to the dynamical adaptation (longer periods for general performance and some case studies for extreme behaviour are going to be studied). In the near future the emphasis will be put in the further development and tuning of the 3d-var scheme with special emphasis on new data sources as satellite and aircraft data.

A work had been initiated during the second part of 2002 in order to continue the work on sensitivity studies using the adjoint of the ALADIN model (this work is to be carried out by a university student and can be considered as the continuation of the work of Cornel Soci in the same field). Until now the basic tangent linear and adjoint tests were performed and the sensitivity configuration (with and without simplified physical parameterisations) are started to be tested. In the future sensitivity studies will be conducted in such meteorological situations, where the ALADIN model provided very poor forecasts and the causes of the poor forecasts are planned to be investigated with the adjoint tool.

5. In Ljubljana

The preparation activities for the ALATNET workshop on coupling started in December. A report from the workshop will be available in the next Newsletter.

Other ALATNET activities are covered in detail in the reports from Raluca Radu and Klaus Stadlbacher.

ALADIN PhD studies

1. Radi AJJAJI : "Incrementality deficiency in ARPEGE 4d-var assimilation system"

In order to be able to work at home on 4d-var problems (those linked with incrementality aspects), I tried to adapt the configurations involved into 4d-var on IBM at Casablanca. As we could run 3d-var before, the work was not very hard. The huge problem that I encountered was the large memory required by 4d-var for minimisation at truncation T95 (incorporating simplified physics). This is due to the activation of physics especially radiation (the coefficients are stored in memory). As I was running just on one node (9 GB memory and 16 processors with a blocking factor `NPROMA` of 31), it was impossible to achieve T95 minimisation. The solution that allowed me to solve this problem was to distribute work on two nodes by specifying 8 processors on each node.

Now, it is possible to run the old 4d-var with 3 outer loops (T42, T63 and T95) on IBM for a reasonable cost (90 minutes execution on 16 processors with CY22T2). I succeeded in reproducing the wrong increments due "eventually" to the high incrementality in ARPEGE 4d-var.

I performed some experiments on internal DFI into 4d-var in order to catch the impact of strong or weak constraint on the increments. But no major sensitivity to notice.

As many changes have been introduced on 4d-var since CY22T2, I am working on adapting CY25T1 to be able to run 4d-var in a newer context. ODB and all the applications related to it (Batodb, Shuffle, screening, minimisation) are already adapted.

2. Karim BERGAOUI : "Investigation of the potential of a convection scheme using prognostic mass fluxes for NWP in the African-Mediterranean domain"

Nothing new (operational tasks in Tunis).

3. Vincent GUIDARD : "Evaluation of assimilation cycles in a mesoscale limited area model"

1. Additional results on MAP IOP 14

(completion of the study described in the ALATNET Newsletter 5, "Combined use of 3d-var and DFI-blending on MAP IOP 14")

Some scores against observations were computed over precipitation forecasts. The forecasts were performed with constant coupling from several initial states valid at 12 UTC, 02 November 1999 :

- OPER : dynamical adaptation of ARPEGE analysis, digital filter initialization (DFI);
- DFI-blending : 24-hour DFI-blending assimilation, DFI;
- 3D-VAR : 24-hour 3d-var assimilation, incremental DFI;
- BLENDVAR : 24-hour Blendvar assimilation, incremental DFI;
- BLENDVAR+pseudo-prof. : 24-hour Blendvar assimilation, including pseudo-profiles of humidity in the last 3d-var analysis, incremental DFI.

Figure 1 shows the results for short-range forecasts, which reinforce the previous results : DFI-blending assimilation improves precipitation forecasts. The introduction of humidity pseudo-profiles implies some interesting modifications.

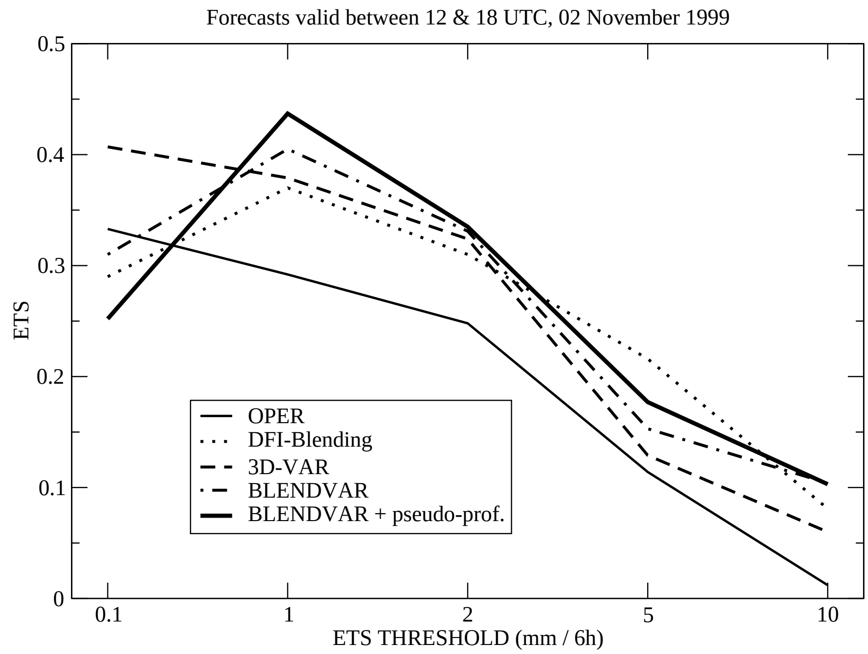

Figure 1 : Equitable Threat Score for short-range forecasts (ETS, the closer to 1. the better).

2. Biperiodisation & background error statistics : Impact on 3d-var analysis increments

‘‘Single observation’’ experiments

Some experiments using only one observation have highlighted a drawback of biperiodisation : if the observation is too close to the C+I border, one part of the analysis increment (roughly 10 % of the whole increment) goes through the extension zone and appears on the opposite side of the domain (Figure 2).

Two solutions were considered :

- enhancing the width of the extension zone, but this implies a recomputation of some statistics and an increase of the computational cost (therefore not tested) ;

- rejecting all observations closer than 200 km to the C+I border, but a little part of the increment still goes through the extension zone and too many observations would be rejected.

Similar experiments (not shown) were undertaken with a "band" of (real) observations instead of one (simulated) observation. The analysis increment generated by a 1000 km-wide band of observations in the southern part of the C+I domain is similar to a "single obs." increment. Neither rejecting the observations which are too close to the border, nor zeroing the σ_b in a rim zone around the domain, solve the problem. The analysis is still worse than the first-guess (in comparison with the observations) in that part of the domain where there is no observation (i.e., in this case, in the northern part of the C+I zone).

The next trial will consist of using the B-matrix auto-correlation functions as gridpoint filters (see below).

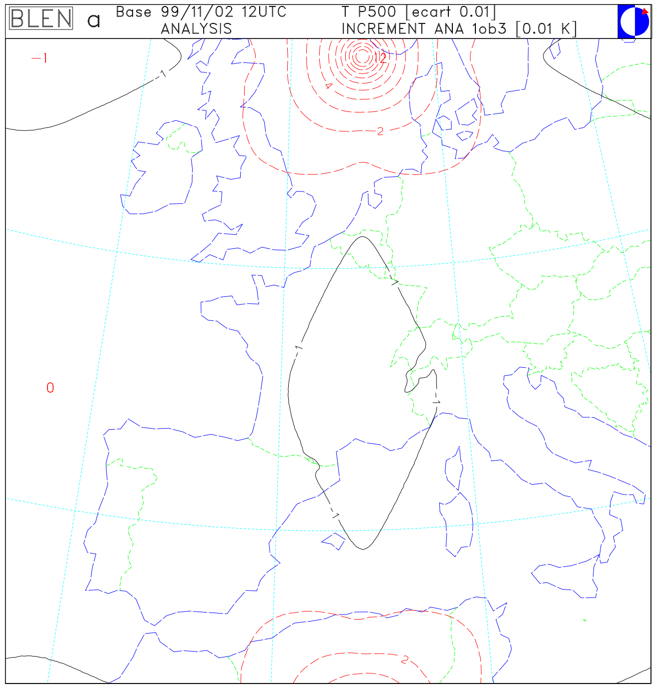

Figure 2 : Analysis increment for temperature at 500 hPa. The observation is a simulated TEMP observation of temperature at 500 hPa, verifying : observation - first-guess = 1 K. Units : 0.01 K.

Academic 1d model

An academic 1d assimilation model, with 300 gridpoints and no dynamics, is used to study in a simple way the gridpoint behaviour of the background error covariance spectrum and the impact of its modification. In order to damp the impact of an observation at long distance, a compact support has been implemented. It mimics ARPEGE ‘‘SUJBCOSU’’ routine, using a cosine-shape way to zero the gridpoint function. The first results are quite encouraging : the "undesirable" analysis increments are significantly reduced. This study has to go further : choice of the distance and the length of zeroing for various variables and vertical levels.

The next steps are expected to be :

- adapting ARPEGE ‘‘SUJBCOSU’’ to an ALADIN ‘‘SUEJBCOSU’’ and assessing the impact of compactly supported correlations in the ALADIN 3d-var analysis ;

- introducing dynamics into an academic model and studying the growth of forecast errors in a LAM and its coupling model (using a 1d shallow-water model, for instance).

4. Jean-Marcel PIRIOU : "Correction of compensating errors in physical packages; validation with special emphasis on cloudiness representation"

EUROCS project :

The wet prognostic TKE (Turbulent Kinetic Energy) scheme developed by Pascal Marquet has been introduced in the ARPEGE/ALADIN SCM. Some tests with this prognostic TKE were performed on the diurnal cycle of the PBL over desert areas. A case of diurnal cycle of deep convection over land was studied within the ARM /GCSS /EUROCS framework. Hovmöller diagrams of the diurnal cycle of ARPEGE precipitations in the Tropics were compared to the results from Yang and Slingo (*MWR* 2001). This was presented at the EUROCS workshop in Madrid, in December.

CLOUDNET project :

Write-up with Damian Wilson (Met-Office) of a paper "user requirement document" to explain to the observational community the expectations of the modelling community in this project. Modifications of some DDH codes to fit the requirements of the CLOUDNET model database.
Presentation in the CLOUDNET workshop in Utrecht: "How to improve a cloud model's physics from in-situ data like radar and lidars ?"

5. Wafaa SADIKI : "A posteriori verification of analysis and assimilation algorithms and study of the statistical properties of the adjoint solutions"

Wafaa Sadiki spent 3 months in Toulouse last summer, working intensively on her PhD topic with Claude Fischer. She has now left the NWP team and works in Rabat while writing her PhD manuscript, for a scheduled PhD defence in early summer 2003. Here is the summary written by Claude for the 2002 scientific report :

<<• A-posteriori validation tools and tuning of Jb / Jo :

This work has been re-started this summer in Toulouse, keeping a quite simple formulation of the a-posteriori functions. For a reminder, the main diagnostics are : the ratio Jmin/P, the estimated global background error variance rescaling "Sb" (=Jbmin/Tr(KH)) and the estimated global observation error variance rescaling "So" (=Jomin/Tr(Ip-HK)).

The main results so far:

- There is a clear need to compare the a-posteriori results with independent diagnostics (such as explicit statistics on the innovation vector), in order to have a more in-depth understanding of the possible misfits between modelled and real error statistics. Indeed, it appears that too many ingredients (possible misfits) enter these diagnostics so that extra knowledge is needed for the understanding. For example, Wafaa is now comparing her results with the output of a Lönnberg-Hollingsworth method for auto-covariances, for comparison of both variances and correlation length-scales.

- There remains a fundamental difficulty in assessing the amount of scale-selective error variances, since the innovation vector which is involved in the a-posteriori validation contains all the scales. A scale-selective approach could be a possible future direction of research, for a potential candidate.

- The diagnostics exhibit clearly case-dependent behaviours, which indicates that the error statistics in the LAM are sensitive to weather systems (e.g. synoptic storm inside the ALADIN domain, anticyclonic state, ...)

- A posteriori validation apparently can be used for retuning of statistical parameters, although the work with real data obliges one to depart from the strict theoretical framework and imagine tractable, pragmatical applications. For example, the perturbation method to compute the "Trace" operators demands to aggregate daily datasets together, and to verify afterwards that the (neglected) time-correlations do not spoil the results too much. Also, one needs to assess the stationnarity of the diagnostics over the period of aggregation, which in practice means that the diagnostics are more like monthly climatology. >>

6. Filip VANA : "The dynamical and physical control of kinetic energy spectra in a NWP spectral semi-Lagrangian model"

The work on "semi-Lagrangian horizontal diffusion" (SLHD) restarted, in collaboration with Rok Glavac-Sah (see also the Prague ALATNET report).

Basically from the user's point of view the scheme is ready to be used for current resolutions. The acceptable degree of quasi-independence of SLHD to time-step and horizontal resolution has been confirmed. Thus there are no obstacles to use the scheme within the range of 8-30 km of horizontal mesh-size. On the other side, there are not too many benefits from this scheme on such scales. This can be revisited for mountain regions where it performs better, or once some pure gridpoint prognostic variable will be introduced in the model.

The intention is now to go a bit further, i.e. to test with horizontal mesh-sizes of 2.5 km. Thus the scheme has been implemented as well for NH dynamics and the next step now is to repeat the ALPIA tests with it.

The scheme is not yet available in any ALADIN library, for dynamics is evolving quite rapidly (predictor-corrector approach, new NH variables, etc). Hence phasing will be performed only after the final evaluation of the scheme.

A paper has just been submitted to *Ocean-Atmosphere* : "Semi-Lagrangian advection scheme with controlled damping - An alternative way to nonlinear horizontal diffusion in a semi-Lagrangian numerical weather prediction model" (by Filip Vana, Pierre Bénard and Jean-François Geleyn), with the following abstract :

<< A nonlinear horizontal diffusion scheme using damping abilities of the semi-Lagrangian advection scheme interpolators is proposed. The behaviour of the scheme is tested in the framework of idealised 3d experiment by a statistical model. Then the scheme is introduced to the spectral LAM model and adapted for the real atmosphere with a typical resolution for current operational regional models. Finally the performance of the proposed scheme is examined by parallel test and for case studies compared with the spectral linear diffusion. >>

ALATNET PhD and Post-Doc studies

1. Steluta ALEXANDRU : "Scientific strategy for the implementation of a 3D-VAR data assimilation scheme for a double nested limited area model"

Further experiments with 3D-VAR scheme for the ALADIN/Hungary model

Introduction

In the previous ALATNET Newsletter the results of the first experiments with 3D-VAR data assimilation scheme for the double-nested limited area model ALADIN/Hungary were described. These experiments were performed only for one week (25.02.2002 - 02.03.2002), and their aim was to get a general idea about the best strategy for the application of the 3D-VAR scheme, trying to choose the best options among the several possible solutions as: first-guess, lateral boundary conditions, initialization methods to be applied in cycling and production, coupling techniques, etc. The main conclusions of these experiments were that as coupling technique, time-consistency seems to be a good choice, in cycling and in production we have to apply digital filter initialization, and it is better to use the files from the global model as lateral boundary conditions. Another conclusion was that it is better to use in cycling the analysis as the second lateral boundary conditions file. (Alexandru [2], 2002).

For these new experiments using 3D-VAR data assimilation scheme, the period was extended to one month, considering that the results will emphasize better the features of the variational assimilation, than those for one week only.

3D-VAR experiments

3D-VAR data assimilation scheme consists of the minimization of a cost function in order to get the best fit to all the available information sources. At the moment for ALADIN model, this cost function is a sum of two terms, the background term and the observation term. The ALADIN/Hungary model is using for the background term, the background error statistics computed by NMC method (Parrish and Derber, 1992), and for the observation term, only SYNOP and TEMP observations are considered.

We decided to perform experiments for one month's period (25.02.2002 - 25.03.2002). Both in cycling and in production, we have chosen to use as lateral boundary conditions (LBC), the ALADIN/LACE and ARPEGE files (from the assimilation cycle) and as coupling method the "Moroccan" solution. This latter means that in cycling, the initial and the first LBC files are the 3D-VAR analysis, and the second LBC file is the ALADIN/LACE, respectively ARPEGE analysis. In production, the initial and the first LBC files are the 3D-VAR analysis, and the second LBC file is the 6h forecast of the ALADIN/LACE, respectively ARPEGE models. It can be seen that using the "Moroccan" solution, the first two LBC files, both in cycling and in production are not coming from the same integration of the model. The first LBC file is identical with the initial file. Thus the information is consistent in space. So, as coupling technique, we used the space-consistency.

Digital filter initialization (DFI) was applied at the beginning of the integration, in cycling and in production. The integration in production was carried out only for 6h, because we had only two LBC files.

For simplicity, the notation of the experiments was chosen "*LACE*", when ALADIN/LACE LBC files were used and "*ARPEGE*" with the ARPEGE files.

Results

We have to mention first about the number of observations used in the assimilation process. In Figure 1, the typical geographical distribution of the observations is represented (the black circles show the location of SYNOP stations, and blue rhombuses are representing the TEMP stations). As we can see the number of TEMP observations at 06 UTC (around 5 stations) is much smaller, than at 00 UTC (around 20), which means that also the statistical scores do not have the same precision, as those for 00 UTC. The number of TEMP observations decreases for 12 UTC (with respect to 00 UTC), and for 18 UTC (with respect to 06 UTC). But even in this situation the scores give us a general idea about how the forecast using 3D-VAR data assimilation scheme is behaving compared to the operational one's (in dynamical adaptation).

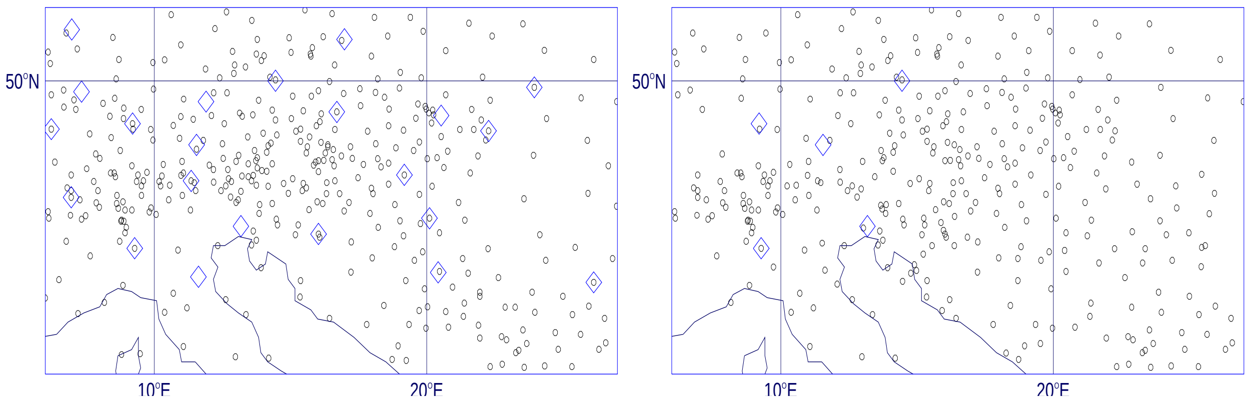

Figure 1 : Typical distribution of observations at 00 UTC (left) and at 06 UTC (right)
(black circles - SYNOP, blue rhombuses - TEMP)

The verification scores of the forecast of the model (from production) against observations (as vertical profiles, from the surface till 400 hPa) are presented in Figures 2-3. The scores of the operational forecast ("*oper*"), are plotted as reference for the 3D-VAR experiments.

- At the time 00h, the analyses for relative humidity and wind, using 3D-VAR scheme are better represented than the operational analysis, for all levels. The temperature has also better scores using 3D-VAR scheme, but the difference is not significant as for the previous fields. The geopotential analysis was improved with data assimilation, especially above 700 hPa. But this improvement shows only that the analysis is closer to the observations, which is expected.
- After 6h integration, the scores for temperature are almost neutral, with small variations near the surface. The forecast of geopotential, with data assimilation, was improved especially for some upper levels. The forecast of relative humidity, shows an improvement using the 3D-VAR scheme near the surface, but for the upper levels, the operational forecast is slightly better. The scores of the zonal wind forecast, with data assimilation, looks slightly better than in dynamical adaptation, but not for all levels. The meridional wind is better represented by the operational model (not shown).
- These last experiments emphasize that the choice of ALADIN/LACE or ARPEGE files as lateral boundary conditions is not so important. For analysis, the differences are very small, and for 6h forecast, the shapes are only slightly different, especially for wind. (Alexandru [1], 2002).

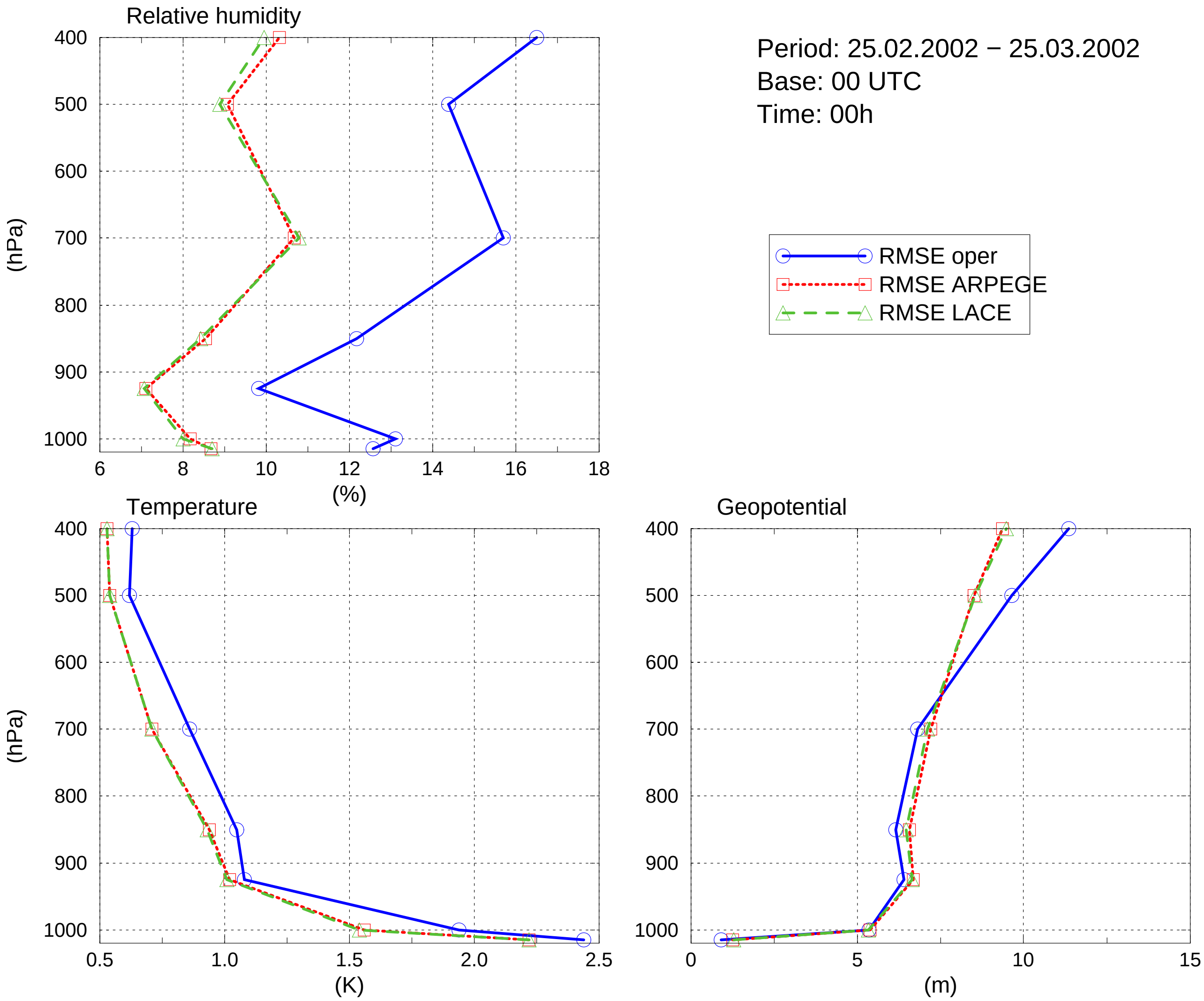

Figure 2 : The vertical profile of RMSE for the operational analysis (*oper*), and using 3D-VAR scheme with ALADIN/LACE (*LACE*) and ARPEGE LBC files (*ARPEGE*) for relative humidity, temperature, geopotential for the period 25.02.2002 - 25.03.2002, base 00 UTC

As another evaluation tools, the *"echkevo"* scores and the mean sea level pressure increments were plotted. Comparing the *"echkevo"* scores of the operational forecast (with digital filter initialization) to those using data assimilation, it was concluded that the fields are in balance. The maps with the mean sea level pressure increments did not show big differences between the 3D-VAR experiments with ALADIN/LACE and ARPEGE LBC files.

Conclusions

The results of the experiments using 3D-VAR data assimilation scheme for the ALADIN/Hungary model are described. The period of the experiments was extended to one month.

The 3D-VAR analysis fits closer to observations, as we expected. But after 6h integration, the forecast is losing from the initial improvement. The meridional wind is the only field that is better predicted in dynamical adaptation at all levels. The relative humidity and zonal wind have better scores using 3D-VAR scheme, but not for all levels. The forecasts of temperature and wind direction are very close to the operational one. For geopotential, the scores show a slight improvement after 6h integration, when 3D-VAR scheme was used.

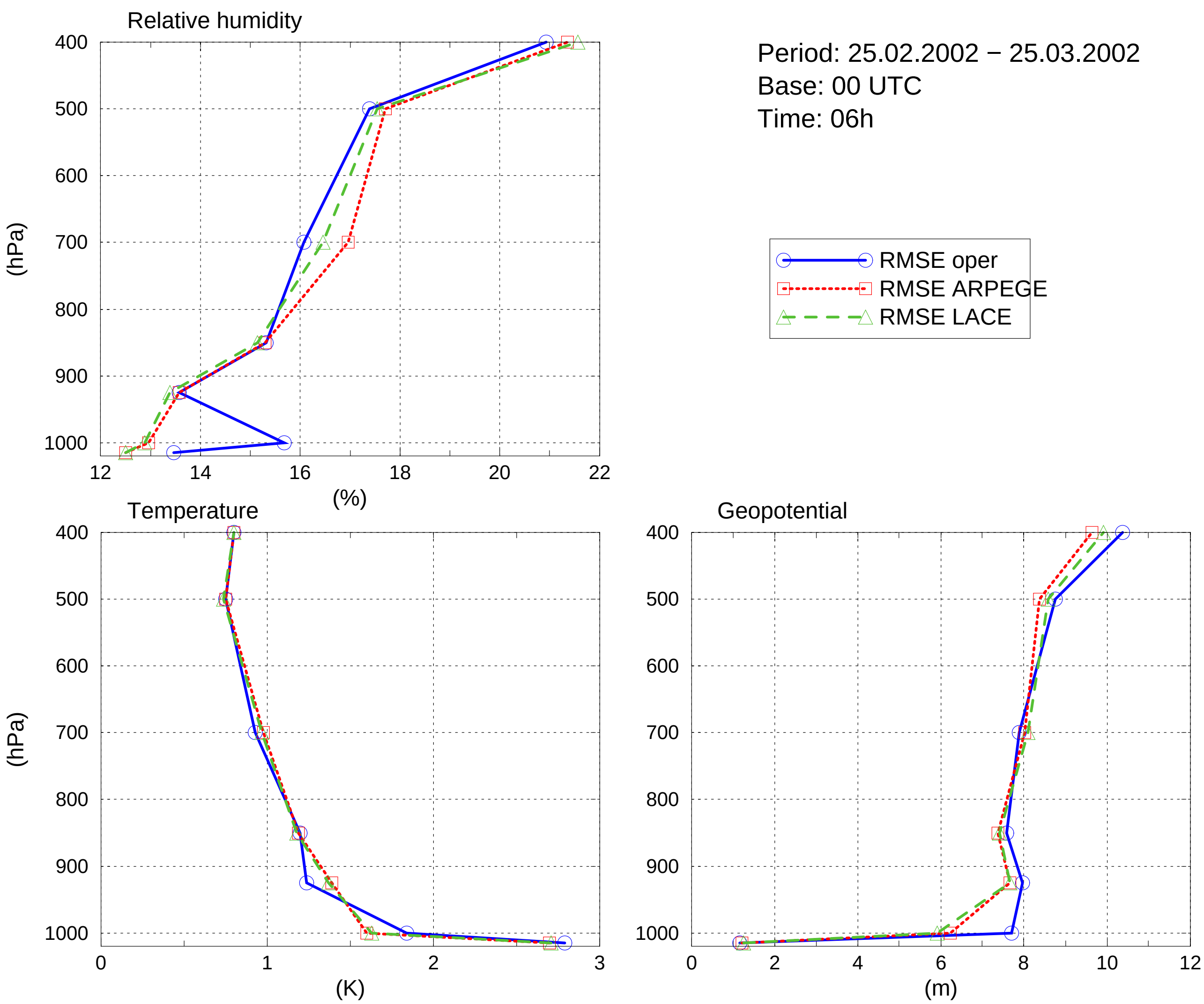

Figure 3 : The same as Figure 2, but after 6h integration

The fields are in balance, confirmed by the *"echkevo"* scores, and the maps with the mean sea level pressure increments did not show big differences between the two sets of the 3D-VAR experiments (with ALADIN/LACE and ARPEGE LBC files). This is in agreement with the verification scores, which were almost the same when different LBC files were used.

These experiments with 3D-VAR scheme for ALADIN/Hungary model were performed to select from many options that we have (different first-guess, lateral boundary conditions, initialization methods, coupling techniques, etc.), the best ones, to be able to study 3D-VAR scheme more in detail, for some interesting meteorological situations.

References

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3D-VAR experiments for the ALADIN/Hungary model :
a case study (the 17-18th of July 2002)

Introduction

After the best possible strategy for the 3D-VAR scheme for the ALADIN/Hungary model was established, the next step was to select some interesting meteorological situations, when on the one hand, the operational model (in dynamical adaptation) failed to provide a good prediction and on the other hand, when the operational forecast was reasonably good. In the first case the improvements were checked, and in the latter one, whether the 3D-VAR scheme is able to keep the good performance of the reference model. Therefore we started with a case when the operational forecast failed.

A short description of the synoptic situation of this case is presented below. On 13.07, a cold trough spread over Western Europe on 500 hPa. From this, a cold drop isolated on 14.07, moved to East, whirled over Northern Italy on 16.07, at noon, and filled slightly in between. From noon of 17.07, it got a cold supply on the backside, which made the cyclone to strengthen again and to move to East from 18.07. Between the 18-20th of July the cyclone remained over the Carpathian Basin. On 18.07, large quantity of precipitation (40-70 mm) was measured over the central part of Hungary, along the Danube river (Fig 1). (HMS, 2002).

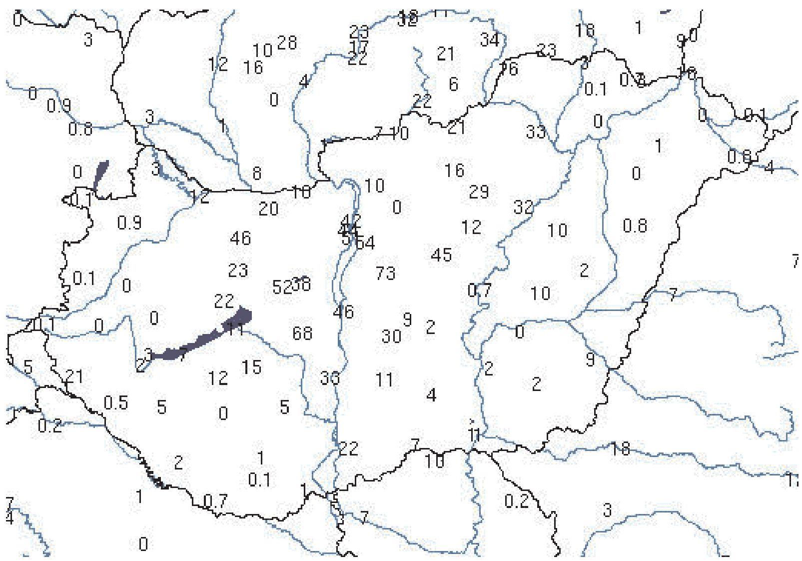

Figure 1: The quantity of precipitation measured over Hungary between 18.07 06 UTC-19.07 06 UTC

3D-VAR experiments

For this case study, three sets of experiments with 3D-VAR data assimilation scheme were chosen to be performed using different lateral boundary condition (LBC) files (from ALADIN/LACE and ARPEGE models), and different data for the observation term (SYNOP and TEMP data available at the Hungarian Meteorological Service, and data from Météo-France, zoomed over the ALADIN/Hungary domain). For the background term, standard NMC statistics were used (Parrish and Derber, 1992).

As coupling strategy, time-consistency was chosen both in cycling and in production. Time-consistency means that the lateral boundary data are coming from the same integration of the coupling model, thus the information is consistent in time. The initial file is the 3D-VAR analysis, and the first two LBC files are coming from the coupling model (Siroká, 2001). Digital filter initialization (DFI) was applied in cycling and in production.

The assimilation cycle was started from 15.07.2002 06 UTC, i.e. three days before the event. The pictures with different forecasts (Figs 3-4) have a zoom over the integration domain.

The first set of experiments was carried out using SYNOP and TEMP data available at the Hungarian Meteorological Service (HMS) and the operational LBC files for ALADIN/Hungary (from ALADIN/LACE model) in cycling and in production. The notation for these experiments is *"3dvar"*.

The second set of experiments was performed with data from HMS, and as LBC files, the ARPEGE files, interpolated over the ALADIN/Hungary domain. For these experiments, the notation is *"3dvar ARP"*.

For the third set, data from Météo-France (which include SYNOP, AIREP, SATOB, TEMP, PILOT observations) were used for the observation term, and the operational LBC files (from ALADIN/LACE model) in cycling and in production. It was called *"3dvar TLS"*.

In Figure 2 the typical geographical distribution of the data available is plotted for 18.07 2002 00 UTC. Number **1** represents the location of SYNOP observations, **2** for AIREP, **3** for SATOB, **5** for TEMP, and **6** for PILOT data. As we can see, almost the same TEMP observations can be found in the two data sets. Data from HMS have more SYNOP observations over the central part of the domain. For data from Météo-France (MF) one can see numerous AIREP and SYNOP observations, especially in the western part of the domain.

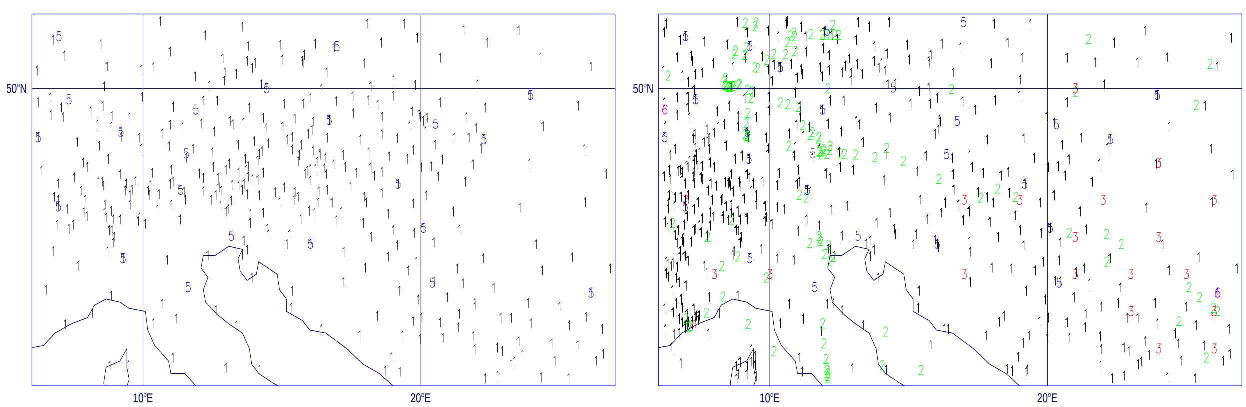

Figure 2: The typical geographical distribution of the data from HMS (left) and from MF (right) from 18.07 00 UTC

Results

The results of the 3D-VAR experiments are compared to the operational forecast of the ALADIN/Hungary model (*"oper"*). Mainly the forecasts of different fields from 17.07. 00 UTC, 12 UTC and 18.07 00 UTC runs, valid at 18.07 12 UTC are described.

17.07 00 UTC run

The operational forecast from 17.07 00 UTC run shows that the cold air is streaming from North-West, bringing cooler air in the western part of Hungary. The amount of precipitation cumulated in 24h is not bigger than 6 mm. All three sets of experiments with 3D-VAR scheme did not show a different forecast than the model in dynamical adaptation. The precipitation forecast is around 10 mm in 24h, but on a larger area than the operational model predicted (not shown). So, the models did not predict the event with more than 24h before. The 3D-Var scheme did not provide any additional information for this run.

17.07 12 UTC run

According to the 17.07 12 UTC run, the direction of the cold air remain northwesterly. The operational model forecasted an important quantity of precipitation (around 101 mm in 24h) (Fig 3). Unfortunately, the amount and also the location of the precipitation were not well predicted, being too far from the place of the event.

The amount of precipitation over the Danubian basin using 3D-VAR scheme is much higher than in the operational model. The *3d-var* experiments gave more than 10 mm in 24h, over a large area, and near the Danube are about 30 mm. There are also three small areas with higher precipitation (more than 50 mm), but farther than the real place of the rainfall. For the *3dvar ARP* set, the area with 10-30 mm precipitation, is more limited, but the location and the maximum value are closer to reality. In *3dvar TLS* experiments the area of big rainfall is well predicted, but the maximum is located too much to east. (Fig 3).

The main difference between the two models (in dynamical adaptation and with data assimilation) appears starting with this run. It was the first signal for the further event. Comparing the experiments with 3D-VAR data assimilation scheme, we can say that the closest forecast to reality was the one using ARPEGE files as lateral boundary conditions, and data from the Hungarian Meteorological Service.

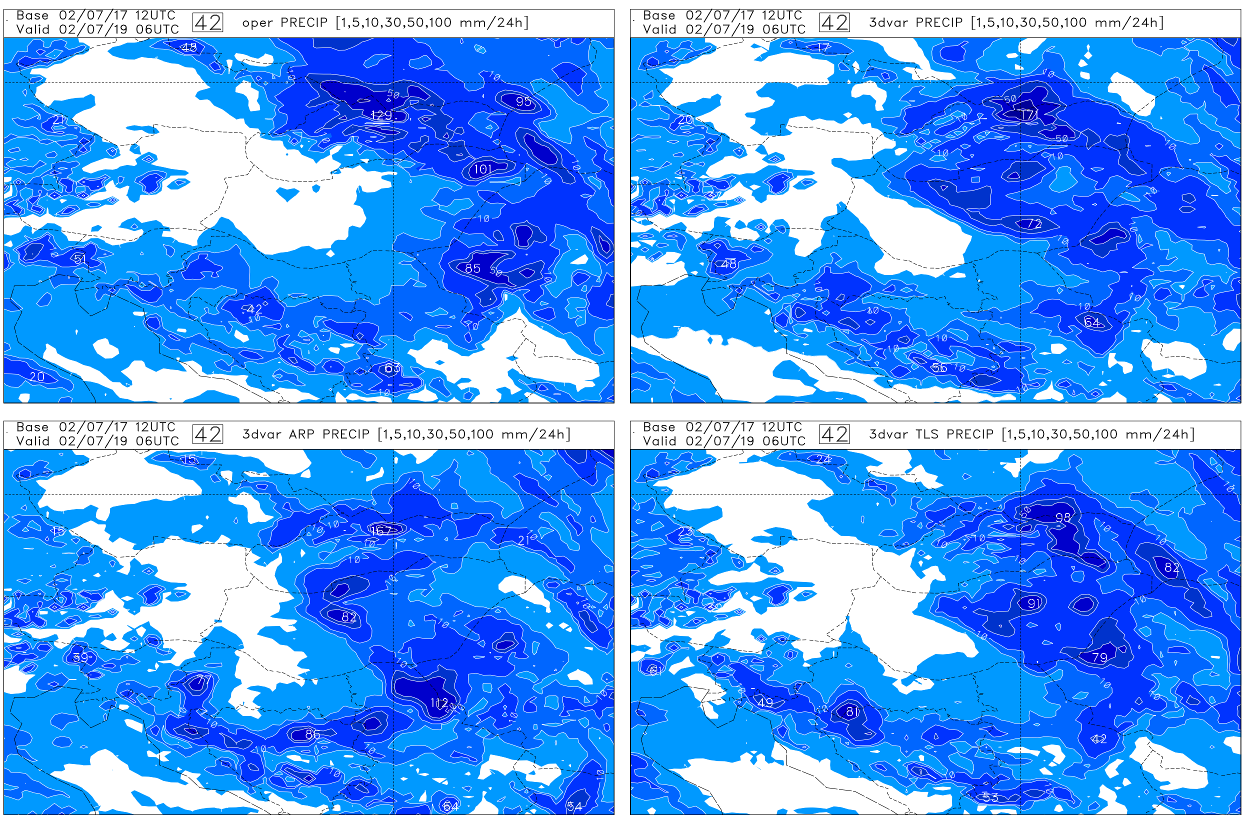

Figure 3 : The 24h precipitation forecasts of the model in dynamical adaptation (*oper*) and using 3D-VAR scheme with different data and LBC files (*3dvar*, *3dvar ARP*, *3dvar TLS*) between 18.07 06 UTC - 19.07 06 UTC, from 17.07 12 UTC run"

18.07 00 UTC run

This last run is the nearest one to the moment of the real event. The operational model still did not give any sign about the future event. One can see that the amount of predicted precipitation by the operational model is still too small (less than 10 mm in 24h), over almost the entire country (Fig 4).

The precipitation forecast of *3dvar* experiments have a good location generally, but too much extended in the south (area with more than 50 mm in 24h). The quantity of rainfall (almost 170 mm) is twice bigger than in reality. Compared to the real measurements, the forecast of *3dvar TLS* set shows the area of heavy rain, in the northern part of Hungary (so it is too high), and an overestimation of the quantity of precipitation (a maximum around 133 mm in 24h). The model with 3D-VAR scheme and ARPEGE files as LBC (*3dvar ARP*), have two small areas with more than 100 mm, and the place of large precipitation is well predicted. Indeed the maximum value of measured rainfall was about 73 mm in 24h, but we can consider that the predicted amount is acceptable in reasonable limits (Fig 4).

As a conclusion from this run, we can say that the operational model, even with 6 hours before the event was not able to predict any features of the phenomenon. All the experiments with data assimilation forecasted large quantity of precipitation. Among these the *3dvar ARP* set was the closest one to reality. (Alexandru [1], 2003).

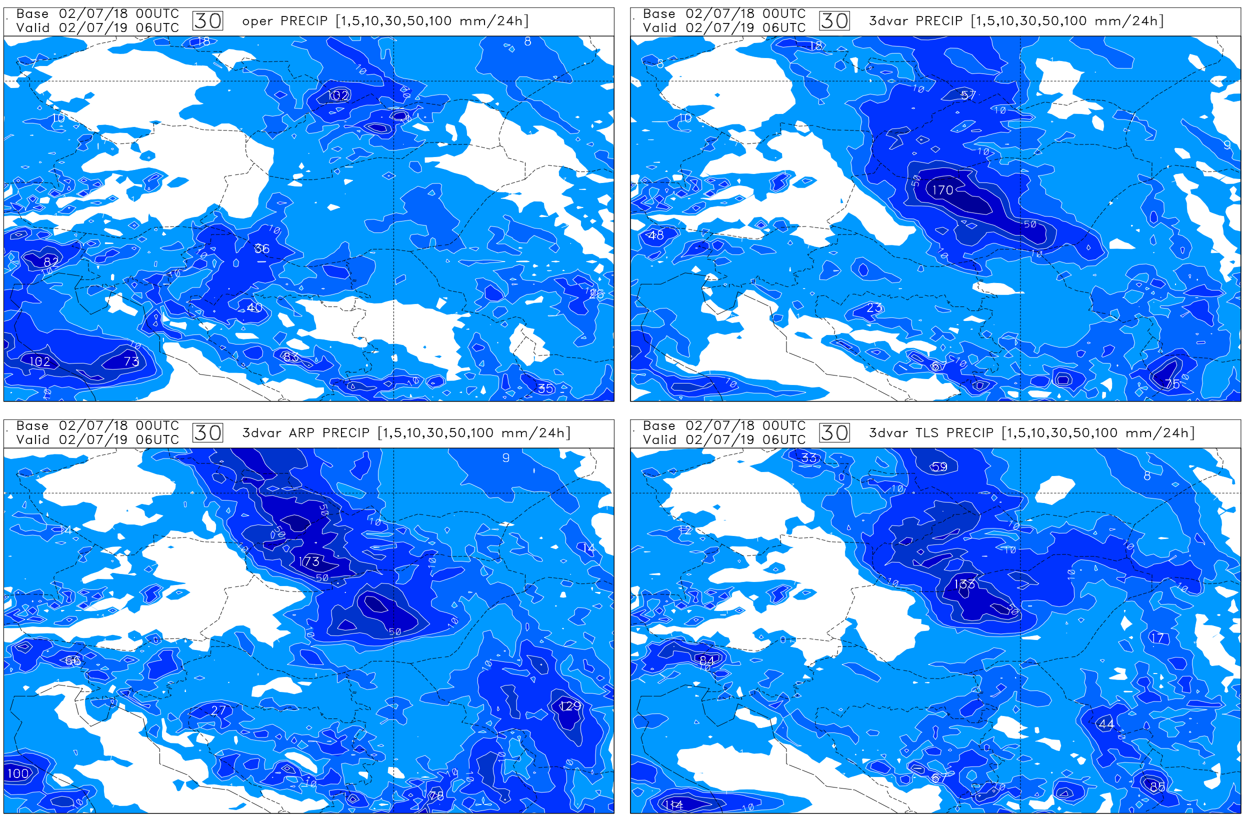

Figure 4 : The 24h precipitation forecasts of the model in dynamical adaptation ("oper") and using 3D-VAR scheme with different data and LBC files ("3dvar", "3dvar ARP", "3dvar TLS") between 18.07 06 UTC - 19.07 06 UTC, from 18.07 00 UTC run"

For all 3D-VAR experiments we plotted also maps with the temperature increments (3dvar analysis - first guess), for two levels: 15 (around 500 hPa) and 24 (around 750 hPa). Figure 5 shows only the increments for *3dvar* experiments, for the entire domain of ALADIN/Hungary model, including also the extension zone. The most worrying feature of the increments is the way that they are looking near the boundaries of the domain. It appears that they are bi-periodic. For the future, we have to find out a solution for this problem, because some spurious features could appear near to the lateral boundaries.

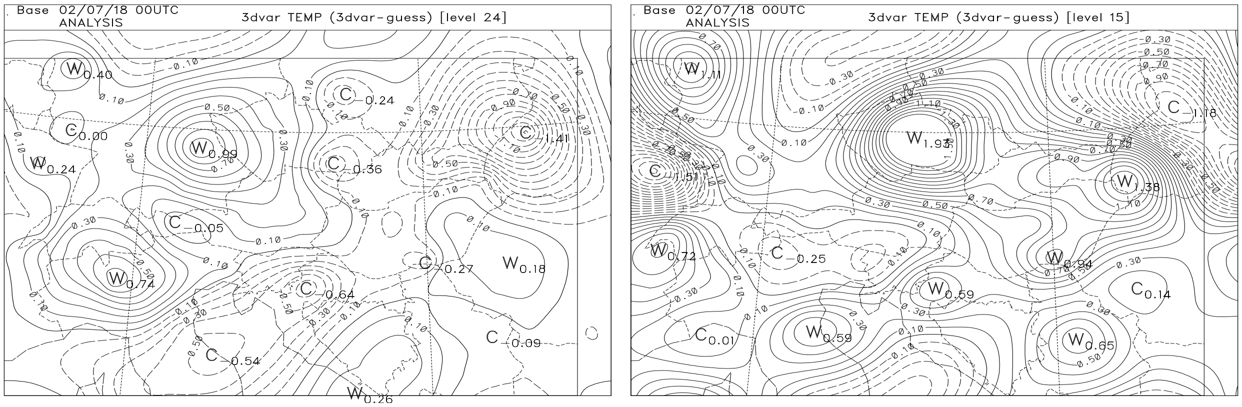

Figure 5 : The temperature increments at levels 15 and 24 for the *3dvar* experiments from 18.07 00 UTC run

The impact of observations over forecast

Working at this case study, we tried to understand how the observations influence the amount and location of precipitation, and especially which one. So we run some experiments which are similar with *3dvar* set, except that we used only SYNOP or TEMP observations available at HMS. Afterwards we removed gradually the closest TEMP stations to Hungary, then the observations between 10-26 degree longitude (remaining around 5-6 stations in the western part of the domain), and finally, the last experiments were performed using only one station in the assimilation cycle.

These experiments showed that using only SYNOP data, the precipitation forecast is overestimated and the location is not well predicted. Compared to *3dvar* results, the experiments when we assimilated TEMP observations gave a better location of precipitation and with reasonable quantities over the Danubian Basin. But also, some maximums appear in the south-eastern part of Hungary, with very big values. As we used less and less data near to Hungary the maximum of precipitation is decreasing gradually and it is moving to east.

These experiments performed only with SYNOP or TEMP data showed for this case that it is important to use observations from surface and upperair, and also the location of the data to be as close as possible to the area of interest.

Conclusions

The results of the ALADIN/Hungary model, using data assimilation for a case from the 17-18th of July 2002 were described in this report. The operational model (in dynamical adaptation) did not forecast the heavy rainfall which happened in the Danubian Basin. We tried to see how the assimilation of observations can change the actual forecast. For these experiments we used two different sets of data (from Hungarian Meteorological Service and Météo-France), and different lateral boundary conditions files (from ARPEGE and ALADIN/LACE models).

The 17.07 00 UTC run did not show any indication about the large quantity of precipitation to be occurred. All the experiments gave around 10 mm in 24h, which is a strong underestimation, compared to real values as 51 mm, or 42 mm.

The operational forecast from 17.07 12 UTC run did not predict any precipitation in the Danubian Basin. All three sets of experiments with 3D-VAR data assimilation scheme forecasted heavy rainfall in the central part of Hungary. The best location and quantity were given by the *3dvar ARP* set, with ARPEGE files as lateral boundary conditions, and data from Hungarian Meteorological Service. This run indicated the first signal about the future occurrence.

The experiments with 3D-VAR scheme from 18.07 00 UTC run gave a good forecast of the event, compared to the operational model. When ALADIN/LACE files were used as lateral boundary conditions (*3dvar* and *3dvar TLS*), the amount of precipitation seems to be overestimated (with maximum values as 170 mm and 133 mm, in 24h). The location of rainfall is better estimated, when the ARPEGE LBC files were used (*3dvar ARP*). The quantity (around 100 mm in 24h) is bigger than the real measurements, but it is acceptable. From the point of view of the forecasters, this run would not help them in elaborating a new forecast, because the time when the new information became available, was too late.

The experiments performed only with SYNOP or TEMP data showed that we cannot identify a set of observations, which are uniquely responsible for the improved prediction of the rainfall event. The most important features for the forecast are coming from the upperair observations. For this case, it is better to use observations from surface and upperair. As we removed more and more data near to Hungary, the results became more unrealistic. So also the location of the data has to be as close as possible to the area of interest, for this case.

As we could see the 3D-VAR data assimilation scheme helped to improve the forecast of the model. The amount of precipitation was significant, compared to what the operational model predicted. The next step will be to study a case when the model in dynamical adaptation had a good forecast, to be sure that the 3D-VAR scheme does not deteriorate the good features.

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2. Gianpaolo BALSAMO : "Mesoscale variational assimilation for land surface variables"

The PhD manuscript is now ready and the thesis has to be defended in April, 2003, in Genoa, Italy. Here is the synthesis of the overall work.

The analysis of soil moisture in the ALADIN mesoscale numerical weather prediction (NWP) model is considered. A linearised variational technique for the analysis of total soil water content via the assimilation of screen-level observations has been implemented and evaluated in the ALADIN NWP model. The soil moisture over land is a key component of the surface water and energy budgets. The soil water content regulates the partition of latent and sensible heat fluxes at the surface affecting a large number of boundary-layer and low-troposphere processes. An accurate estimate of this quantity over extensive areas might provide opportunities for many applications and for this reason agricultural, hydrological, meteorological and climatological studies have considered it for quite some time. No extensive observation exists because of the difficulty and the expense associated with measuring soil moisture on a routine basis. For this reason, the assimilation of indirect observations from ground-based (raingauges, radars, screen-level) and satellite instruments (infrared and microwave radiometers), has been studied for the analysis of soil moisture. In particular, the assimilation of 2m temperature and relative humidity observations with the optimum interpolation (OI) technique (Mahfouf 1991, Bouttier et al. 1993 a,b) has proven to be reliable in obtaining the soil water content under specific meteorological conditions, and is currently used in operations in different NWP centres (Giard and Bazile 2000, Douville et al. 2000). In recent years, several studies have shown the reliability of the variational technique for the analysis of soil moisture via the assimilation of screen-level observations, by Callies et al. (1998), Rhodin et al. (1999), Bouyssel et al. (2000), Hess (2001).

The present work focuses on the analysis of the total soil water content in ISBA, a two-layer force-restore land surface scheme (Noilhan and Planton, 1989), via a bi-dimensional (z and t) variational approach (2d-var). The analysis is performed on each grid point separately. As given by the variational analysis theory, the optimal weighting of the observation and the background components is achieved by the minimisation of a cost function J, which is of the form

$$J(\mathbf{x}) = ½\,(\mathbf{x} - \mathbf{x}^b)^T\,\mathbf{B}^{-1}\,(\mathbf{x} - \mathbf{x}^b) + ½\,(\mathbf{y} - H(\mathbf{x}))^T\,\mathbf{R}^{-1}\,(\mathbf{y} - H(\mathbf{x}))$$

where $\mathbf{x}$ is the vector containing the variables to analyse, $\mathbf{x}^b$ the background state (a short range weather forecast) and $\mathbf{y}$ the observations vector. $\mathbf{B}$ and $\mathbf{R}$ are, respectively, the background and the observation error covariance matrices, and H is the observation operator, that transports the model state vector $\mathbf{x}$ into the observation space, including the interpolation in space and integration in time. Under the Tangent Linear (TL) hypothesis, the H operator can be expressed by its first order Taylor expansion

$$H(\mathbf{x}+\delta\mathbf{x}) = H(\mathbf{x}) + \mathbf{H}\delta\mathbf{x}$$

where $\mathbf{H}$ is the TL observation operator matrix; the cost function is then quadratic. The $\mathbf{H}$ matrix is evaluated using a finite difference approach. The minimization of $J(\mathbf{x})$ is often an iterative process that uses the tangent linear and adjoint models to evaluate the cost function and its gradient but, for low dimension problems, the minimum of the cost function, imposed by $\nabla J(\mathbf{x}) = 0$, can be directly obtained. The estimate of the observation operator is obtained from extra integrations of the numerical model from perturbed initial states, and allows a direct computation of the analysis increments given the small dimension involved. The analysis increment for the total soil moisture W_p is given by multiplying the gain matrix $\mathbf{K}$ (defined as $\mathbf{K} = \mathbf{BH}^T\,(\mathbf{HBH}^T + \mathbf{R}^{-1})$, and the innovation vector ($\mathbf{y} - H(\mathbf{x}^b)$), in this case containing the observation departure of 2m temperature and relative humidity. The final expression for the analysis is given by :

$$W_p^{\,a} = W_p^{\,b} + \begin{pmatrix} k_1 & k_2 \end{pmatrix} \cdot \begin{pmatrix} \Delta T_{2m}^{(1)} \\ \Delta RH_{2m}^{(1)} \end{pmatrix}$$

In a first phase of the work, a better understanding of the relationship between soil and near-surface variables is pursued by the study of the linearised observation operator and the gain matrix obtained on selected real situations using soil moisture perturbations on initial conditions.

The estimate of the observation operator is studied in detail to optimize its evaluation, and to verify two fundamental assumptions of the method: linearity between the analysed and the assimilated variables and horizontal decoupling between grid points, that allow the 2d formalism. The validation of the method is shown with simulated observation experiments, that confirm the generally good approximation of both the linear and the horizontal decoupling hypotheses. The influence of model resolution as well as the sensitivity of the model parameterizations to perturbation of the control variable are highlighted as important factors to consider for the optimization. The gain matrix presents several features that show the capability of 2d-var to take into account the synoptic situation and the soil state. The comparison with the OI coefficients (figure 1) shows a clearer relationship with the radiative forcing together with the physiographic characteristics. Limits in linearity appear locally in perturbed meteorological conditions due to the higher variability of model screen-level response. Two solutions for the problem have been proposed: the use of a masking technique (as implemented in the OI) and an ensemble approach for the linear estimate of the observation operator.

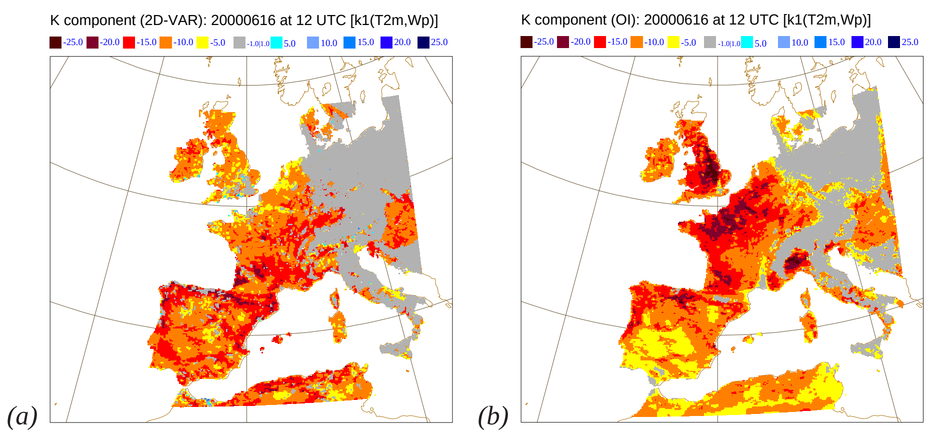

Figure 1 : The **K** matrix *(a)* compared with the optimum interpolation coefficient *(b)* for (T_{2m} , W_p).

The mask of non-sensitive zones is realized in the 2d-var via a simple set of thresholds that remove cyclonic and frontal areas. The comparison of 2d-var with OI shows the similarities of the two techniques and the potential improvements brought by the variational approach. This test also permits the evaluation of the magnitude of total soil moisture analysis increments applied by the OI sequential assimilation. The 6h analysis increments amount to about 15 % of the soil wetness index (SWI) active range, resulting in a relative low information content ascribed to the model background. This aspect is of contribution to a too high spatial and temporal variability of soil moisture (figure 3). The capability of the 2d-var analysis to correct a prescribed soil moisture error is tested, with special regard to the horizontal decoupling hypothesis, on a 6h assimilation test with simulated observations (figure 2).

The second part of the work has been devoted to the optimization of the method. A careful choice of the perturbation added to the control variable is able to improve the accuracy of the linear estimation of the observation operator. The use of multiple perturbations avoids the masking of non-sensitive zones (implicitly taken into account) extending the analysis to the whole domain. The 2d-var technique takes into account the full physics of the model, so that the corrections applied to the control variable are implicitly adapted to the current meteorological conditions and the grid point characteristics (texture and vegetation), as well as to the previous soil state without empirical adjustments.

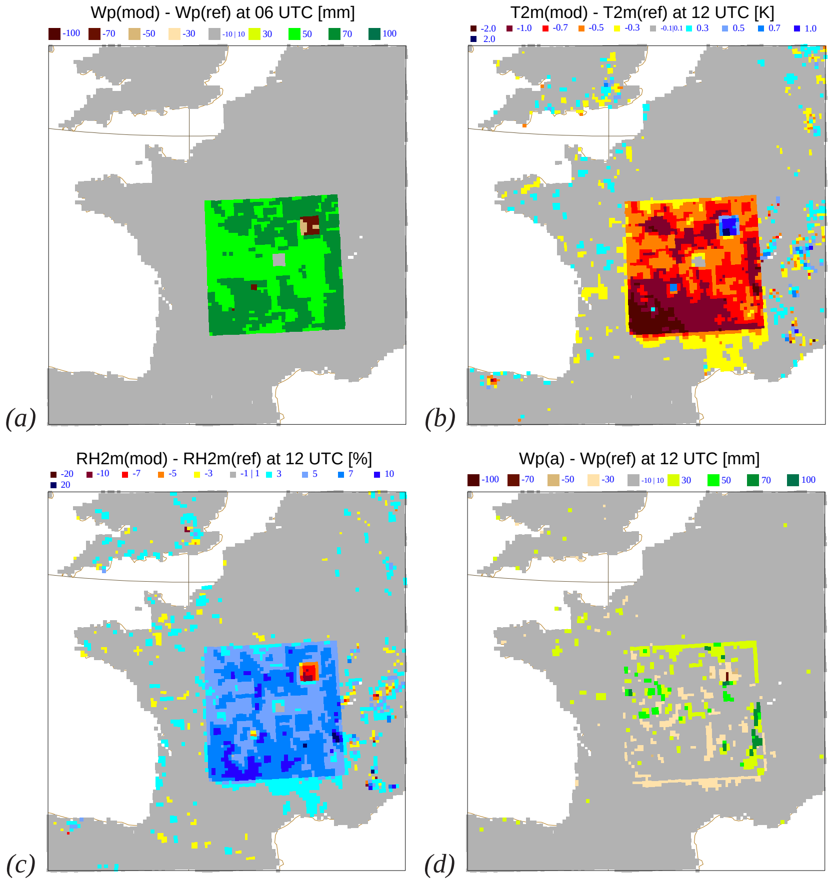

Figure 2 : Test on the 2d-var analysis convergence and the validity of the horizontal decoupling hypothesis. A perturbation of W_p is set on the 20000616 at 06 UTC *(a)*. The plots *(b)* and *(c)* report the perturbation obtained after 6h integration on 2m temperature and relative humidity (innovation vector for the soil moisture analysis). The analysis of W_p at 12 UTC is given in the plot *(d)*.

The validation tests done with real observation experiments show encouraging results for the mesoscale NWP analysis of land surface soil moisture: a net improvement of the 72h forecast score at 2m is accompanied by a more realistic field of the total soil moisture when comparing it with an off-line hydrological output produced by the SAFRAN-ISBA-MODCOU (SIM) system (figure 3), Habets et al. 1999 a,b. A sequential assimilation cycle with a 6-hour time-window allows the comparison with the optimum interpolation technique, while a 24-hour window is considered to extend the temporal consistency of the assimilated observations in the analysis.

Some limits of the method in presence of a systematic model bias have been shown in a coastal moistening during sea-breeze regime periods. This problem, detected in the preliminary tests, has been partially overcome by accurately tuning the background error statistics, but a real solution for persistent model errors should consider a bias filter technique or a relaxation towards an off-line soil moisture field (a variational approach is proposed) to avoid undesired drifts of the analysis.

The prospective of applying this method in the frame of the European Land Data Assimilation System (ELDAS) project (van den Hurk, 2002), will consider the use of satellite derived heating rates (from Meteosat and MSG when available) to extend the observation coverage, and the inclusion of analysed precipitation and solar radiation forcings in order to reduce the main sources of uncertainties in the modelling of soil moisture evolution.

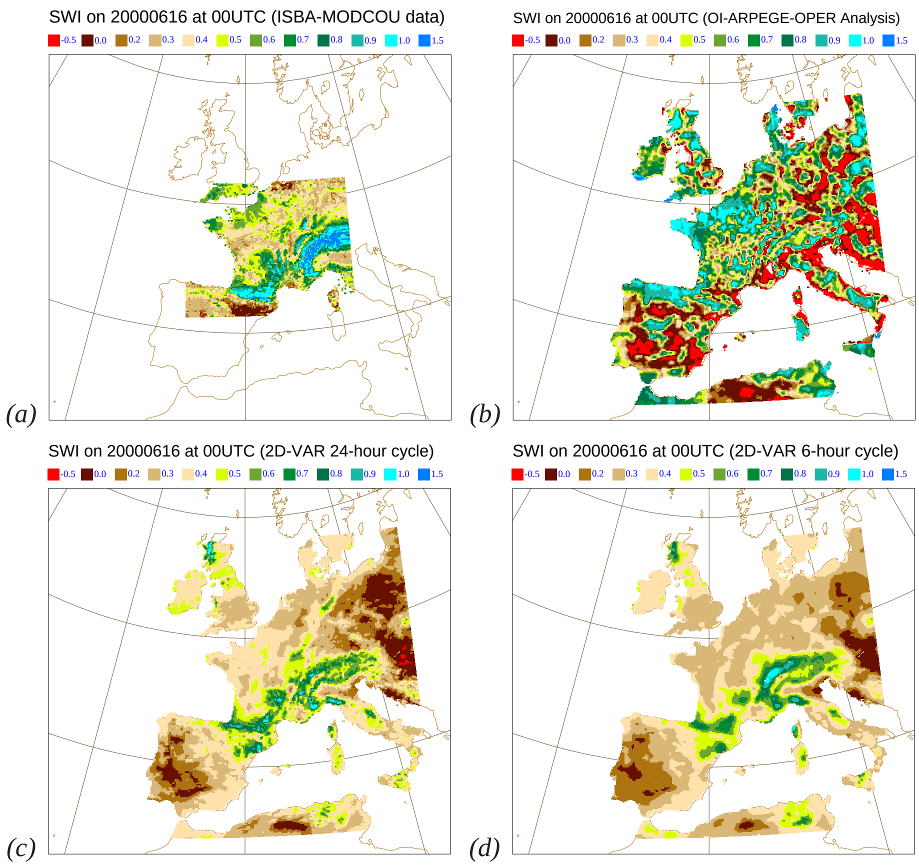

Figure 3 : Initial Soil Wetness Index (SWI) : First row, SAFRAN-ISBA-MODCOU *(a)* and ARPEGE analysis *(b)*. Second row, assimilation tests using 2d-var analysis with a 24h *(c)* and a 6h *(d)* assimilation time-window, after 12 days of assimilation.

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3. Margarida BELO PEREIRA : "Improving the assimilation of water in a NWP model"

1. Introduction

The basic equation for analysis is :

$$x^a = x^b + K(y - Hx^b), \qquad K = BH^{\mathrm{T}}(HBH^{\mathrm{T}} + R)^{-1}$$

where x^b is the background field, x^a is the analysis field, y is the observation vector, H is the forward interpolation operator, R is the observation error covariance matrix and B is the background error matrix.

The role of B matrix is to spread the observation departures both in vertical and horizontal. Therefore, the accuracy of the B matrix is very important for the analysis quality.

In the present work, the B matrix is determined using the Analysis Ensemble Method (Belo Pereira, 2002).

2. Estimation of the length scale of auto-covariance

Using the Helmholtz's theorem, we obtain the rotational part of the meridional wind, $v^{\Psi}=\partial\Psi/\partial x$. So, the covariance of v^{Ψ} between two points is given by

$$\langle v_1^{\Psi}\ v_2^{\Psi}\rangle = \langle \frac{\partial\Psi_1}{\partial x_1}\frac{\partial\Psi_2}{\partial x_2}\rangle = \frac{\partial^2\langle\Psi_1\ \Psi_2\rangle}{\partial x_1\,\partial x_2}$$

and covariance of the streamfunction (Ψ) can be expressed as function of its auto-correlation function ρ and of its variances $\sigma(\Psi_1)$ and $\sigma(\Psi_2)$ respectively at points 1 and 2 :

$$\langle\Psi_1\ \Psi_2\rangle = \sigma(\Psi_1)\ \sigma(\Psi_2)\ \rho$$

deriving this expression,

$$\frac{\partial^2\langle\Psi_1\Psi_2\rangle}{\partial x_1\,\partial x_2} = \frac{d\sigma(\Psi_1)}{dx_1}\frac{d\sigma(\Psi_2)}{dx_2}\rho + \sigma(\Psi_1)\ \sigma(\Psi_2)\ \frac{\partial^2\rho}{\partial x_1\partial x_2} + \sigma(\Psi_1)\ \frac{d\sigma(\Psi_2)}{dx_2}\frac{\partial\rho}{\partial x_1} + \frac{d\sigma(\Psi_1)}{dx_1}\ \sigma(\Psi_2)\ \frac{\partial\rho}{\partial x_2}$$

Defining $x'=x_1-x_2$, we can assume that the first derivative of ρ vanishes at $x'=0$ (this assumption is reasonable since ρ is maximum at $x'=0$ and decreases as the distance from the origin increases).

And using the definition of length scale (Daley, 1991) for the one-dimensional case

$$\left(L_x^{\Psi}\right)^2 = -\left(\rho\Big/\frac{d^2\rho}{dx'^2}\right)_{x'=0}$$

we obtain the length scale for the streamfunction auto-covariance:

$$\left(L_x^{\Psi}\right)^2 = \sigma^2(\Psi)\Bigg/\left[\sigma^2\left(\frac{\partial\Psi}{\partial x}\right) - \left(\frac{\partial\sigma(\Psi)}{\partial x}\right)^2\right]$$

The length scale defined according to Daley (1991) gives an idea about how the auto-correlation function decays with distance from its initial value.

3. Experiments description

The background error statistics were estimated for three datasets of differences between 6 h forecasts. In the first set (called *metropole*) the background errors come from the differences between two 4d-var cycles of ARPEGE with spectral truncation T298 and stretching factor (c) equal to 3.5. The second set (denominated *tropic*) uses two 4d-var cycles of ARPEGE with truncation T299 and constant resolution (c=1). The observations used for this set include pseudo-observations of tropical cyclones ("bogus" observations). In both *metropole* and *tropic* sets, the uncertainties are caused only by the perturbations in the observations (see Belo Pereira, 2002). So it is assumed that the model is perfect and the background errors are only due to the propagation of observations uncertainties. The third set (called *arpf_arpt*) uses one experiment with constant resolution and another one with c=3.5 . So in the last set the model is not considered as perfect any more and it is considered that the background error is also related with the horizontal resolution.

The background differences come from 6 h forecasts valid at 18 h UTC, during the period between 4th of February and 14th of March, 2002.

4.1 Results: Statistics in spectral space

On average, the largest vorticity background errors are found in the high troposphere, for wavenumbers between 30 and 70, for all experiments, but the error magnitude is significantly larger for the *arpf_arpt* set (figures 1 and 2). On the other hand, the smallest errors occur for the *metropole* set, with a maximum is shifted towards larger scales relatively to the *tropic* set.

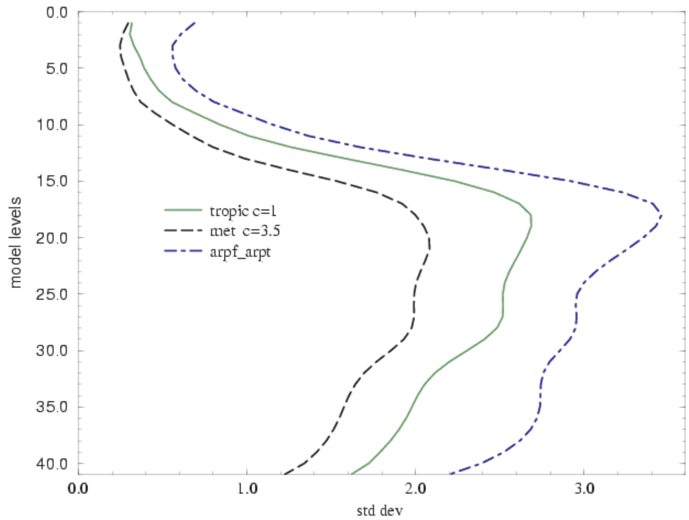


Figure 1 - Vertical profile of standard deviation ($10^{-5}s^{-1}$) for vorticity background error.

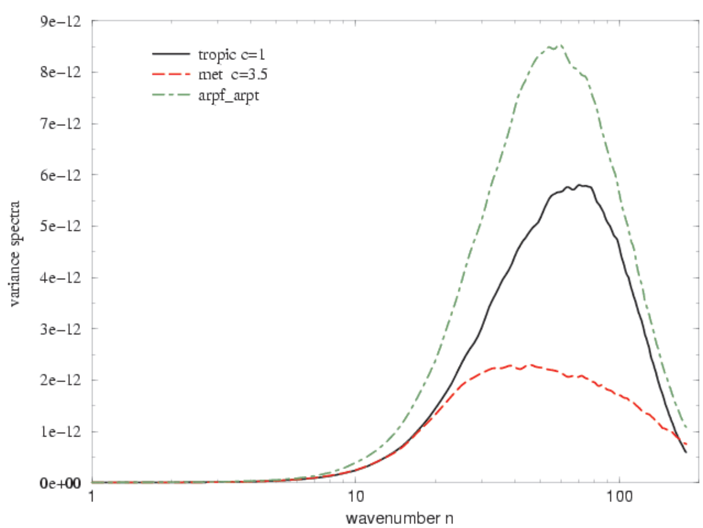


Figure 2 - Variance spectrum for vorticity for model level 21 (near 500 hPa).

The surface-pressure background errors are significantly larger when computed using the *arpf_arpt* set than with other sets. The largest differences occur for synoptic scales, for wavenumbers between 5 and 20 (figure 3). The same result is found for temperature and specific humidity errors.

The variance spectrum of streamfunction background error is very similar for both *tropic* and *metropole* datasets. This result can be explained by the fact that the largest contributions for the streamfunction background errors come from the planetary scales (figure not shown). The results show also that with the *arpf_arpt* set the error variance is larger than with the other datasets.

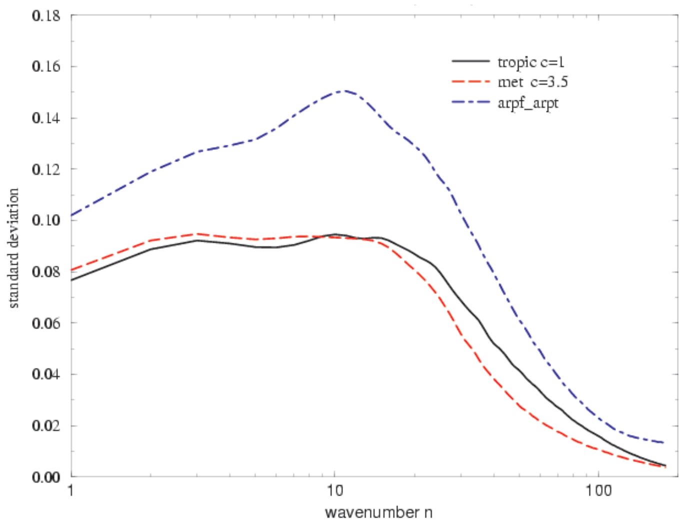
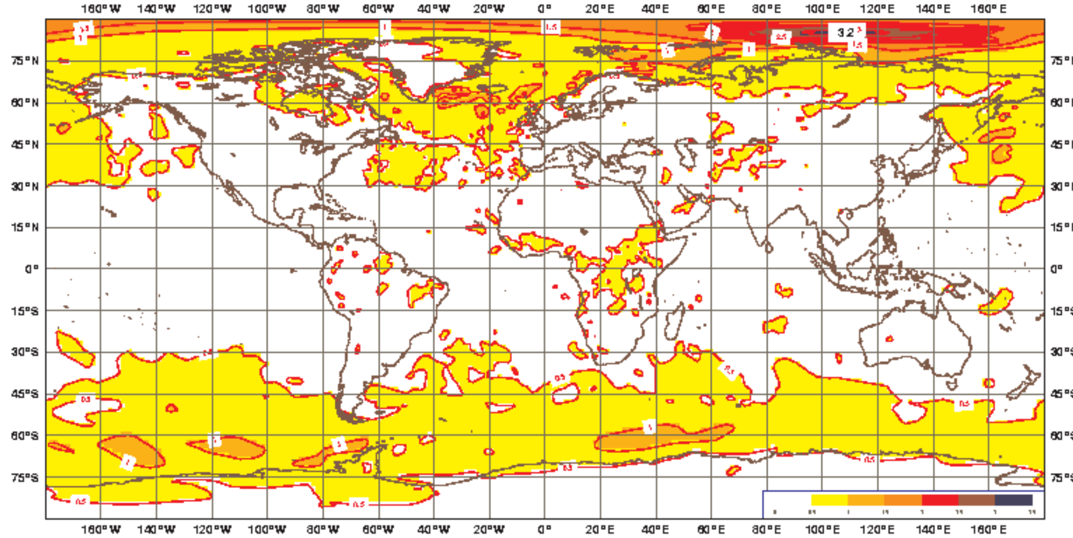


Figure 3 - Standard deviation (hPa) spectrum of surface pressure background error.

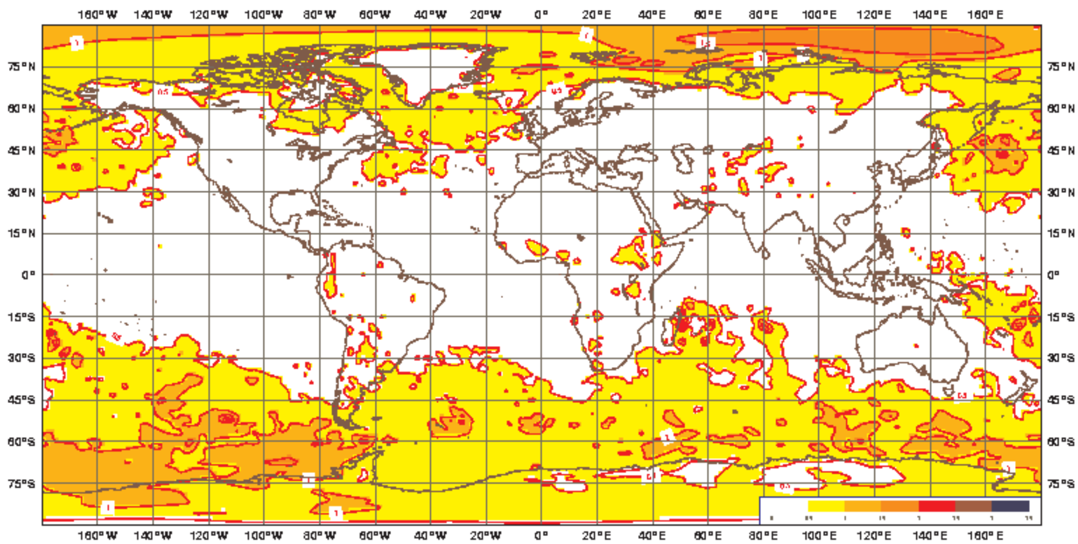
4.2 Results: Statistics in gridpoint space

For the *metropole* set, the largest surface-pressure background errors are found near the North Pole, to the North of Russia. Moreover large errors occur in the extra-tropics on oceans (fig. 4a). So the larger errors occur in the areas of larger surface-pressure variability and in data void areas, which seems reasonable. For the *tropic* set, the errors around the North Pole are reduced, comparing to the *metropole* set. On the other hand, the magnitude of the background errors in the extra-tropical Pacific ocean is increased here. It is also worthwhile to notice that the largest errors for the *tropic* set are found in the tropical Indian ocean, due to the use of "bogus" observations (fig. 4b). This shows the sensitivity of the Ensemble Method to the observations used during the assimilation cycle. For the *arpf_arpt* (figure not shown), the spatial distribution of the errors is very similar to the one obtained with the *tropic* set. However, in this case local maxima are found in Andes, Himalayas regions and near the North Pole to the North of Russia. Moreover, for the *arpf_arpt*, the magnitude of background errors is also significantly increased over the southern extra-tropical Pacific ocean, tropical Indian ocean and over the North Atlantic ocean, comparatively to the other two datasets.

For the *metropole* set, the vorticity background errors are concentrated in the high resolution areas, having very small values in the regions where the equivalent truncation is larger than 500. This result can be explained by the fact that the largest contributions for such errors come from the small scales (see fig. 2). On the other hand, for the *tropic* set, the largest errors are located in extra-tropical regions over the oceans, over Himalaya and over the North Pole. For the *arpf_arpt* set, the error magnitude is increased everywhere (when comparing with the *tropic* set), but this increase is stronger over North Atlantic and Europe. This result is due to the fact that the difference in resolution between the two runs used in this dataset is larger in these regions.



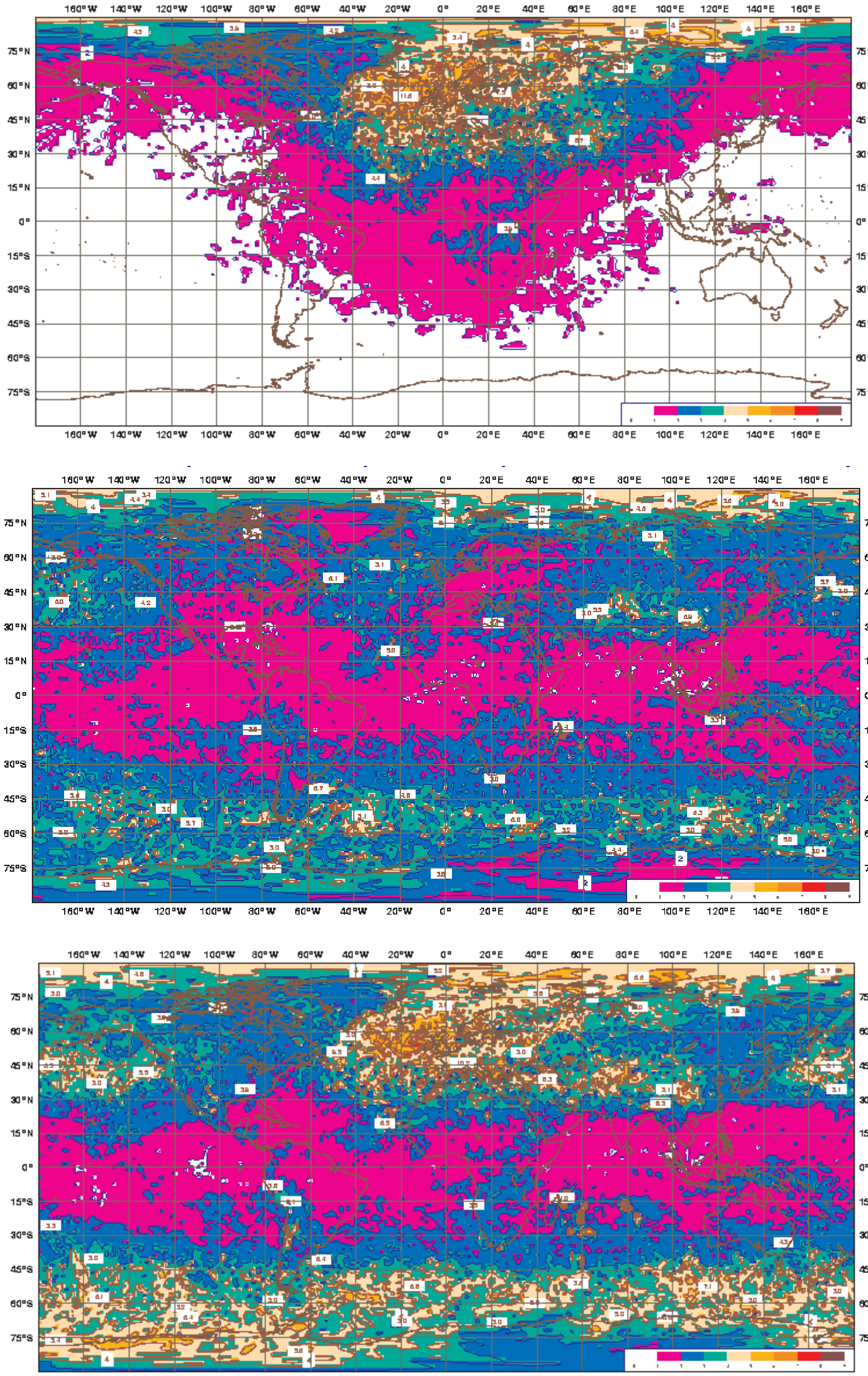
(a)



(b)

Figure 4 - Standard deviation (hPa) of surface-pressure background error :
(a) *metropole* set and (b) *tropic* set.

Applying the method described in section 2 to calculate the length scale of auto-correlations, we verified that for the *metropole* set the length scale tends to increase towards the coarser resolution areas (figures not shown), while for the *tropic* data set, the auto-correlation functions tend to be broader in the tropics (larger length-scales) than in middle and high latitudes (see fig. 6 for zonal wind near 500 hPa). Moreover, the results show that the meridional length-scale is more homogenous (less dependent on the geographical localization) than the zonal length-scale.

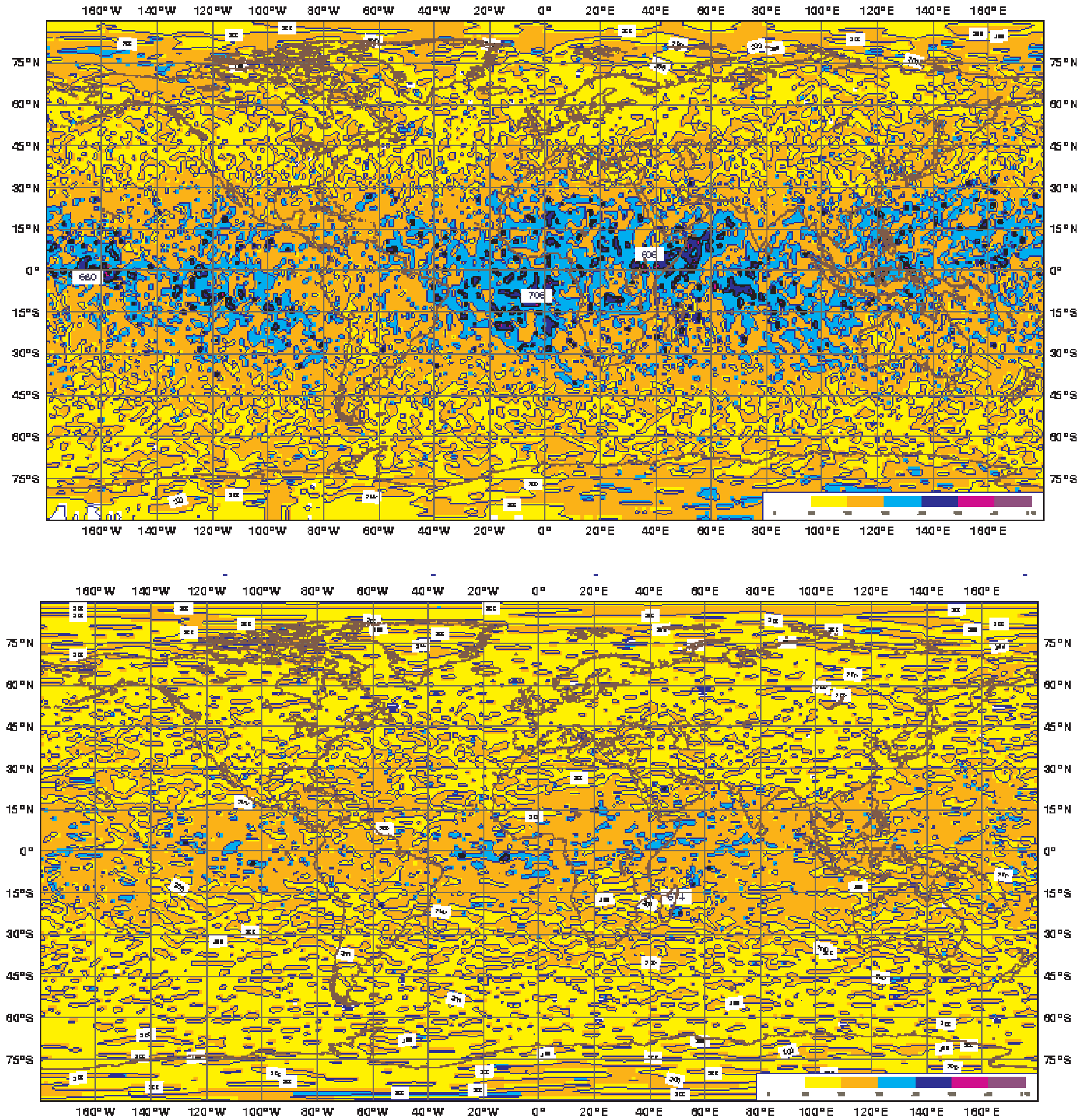


(a)

(b)

(c)

Figure 5 - Standard deviation ($10^{-5}s^{-1}$) of vorticity background error :
(a) *metropole* set, (b) *tropic* set and (c) *arpf_arpt* set.



(a)

(b)

Figure 7 - Length scale (km) of wind : (a) zonal and (b) meridional.

5. Conclusions

From the described experiments, one of the main results is the fact that the application of Ensemble Analysis Method to estimate the *B* matrix using only the perturbation of observations can lead to the underestimation of the standard deviation of the background errors.

6. References

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4. Martin GERA : "Improved representation of boundary layer"

To solve the Turbulent Kinetic Energy (TKE) equation one needs to know expressions for momentum, heat, turbulent kinetic energy fluxes, diffusion, dissipation of TKE and pressure correlation terms. Fluxes dependence of momentum and buoyancy terms (exchange coefficients) are expressed as functions of TKE :

$$K_x = cL_k E^{1/2}$$

where K_x is the exchange coefficient, c a parameterized constant, L_k the corresponding mixing length and E the TKE.
Shear-production, buoyant and dissipation terms are sources of this energy. Vertical diffusion (*Di*) is parameterized using the "eddy diffusivity" assumption, one can write the expression :

$$D_i \sim -c_d K_u \left(\frac{dE}{dz}\right)$$

where c_d is a parameterized constant, K_u the exchange coefficient for momentum and the last term is a vertical derivation of TKE.

To begin, we focus our attention on the pressure-correlation terms. The pressure-correlation terms include a transport term and an energy-redistribution term. This last one is important for the smoothness of energy fields. This means, that this term returns anisotropy of turbulence to the isotropic state. For finding an optimal parameterization of this term we need to know an estimation of magnitude and physical interactions for this covariance. The expression of pressure covariance has significant influence on the properties of parameterized equations. It is important to find a proper parameterization for this term.

The oldest methods of parameterization make this term proportional to the anisotropy component of momentum covariance. The newest approach, in addition tries to include the interaction between the velocity fluctuations and mean strain field. The way to find estimation is to subtract the isotropic components from the TKE equation. The anisotropy part contains a term which produces the TKE and also terms which work against the turbulence (pressure covariance, dissipation, ...). From measurements it seems that the three normal stress tensor components are comparable when mean stability in the Planetary Boundary Layer (PBL) decreases (Manton, 1979). We say that isotropy of velocity fluctuations can be assumed in this situation. Our next assumption is that the buoyant term does not contribute significantly to the anisotropy of the turbulence. We hope that this knowledge is sufficient to estimate the pressure return to the isotropy term. We did a comparison of these parameterization methods.

Nowadays, in limited-area models (LAMs), the subgrid effects are important. In models with high resolution the subgrid effects are less important. For example, for estimation of the turbulent fluxes it is sufficient assume that the mixing length equals the grid mesh. For LAMs one must find an expression for the mixing length. In addition, as the observations confirm, we must recognize the mixing and dissipative lengths (L_k and L_e respectively).
The comparison of the parameterization methods of the pressure-correlation term was done by evaluating the formulation of the ratio between mixing and dissipative lengths. This ratio has a close connection to the ratio of vertical perturbation velocity variance and TKE. We analysed properties of this ratio with dependence on the Richardson number (*Ri*). This evaluation was done with the aim of stationary approach in prognostic equations for heat and momentum fluxes and using parameterized formulas for fluxes. Stationary, here, means that shear, buoyant and dissipation terms are balanced in TKE equation. We started by analysing this ratio, because it contains no dependence to the dimensionless wind shear function. We suppose that L_k and L_e have same dependence to the dimensionless wind-shear function. This is an advantage of this approach.

The oldest scheme has had smaller values for stables and unstable case. The newest scheme, which is preferable in current numerical models, defines that ratio as a function of stationary TKE (E) :

$$\frac{L_k}{L_e} \sim f(Ri)$$

$$E \sim L_k L_e E^{\#} f(Ri)$$

where $E^{\#}$ is a neutral TKE.

The variations of this ratio are similar in both schemes :

- unstable case : $Ri < 0$, $L_k > L_e$
- neutral case : $Ri = 0$, $L_k = L_e$
- stable case : $Ri > 0$ $L_k < L_e$

After manipulation with parameterized equations one can refine formulas for this ratio. We can find not only dependence on the air stratification but also introduce dependence on the divergence and vertical shear of horizontal wind ($\vec{V}$) :

$$\frac{L_k}{L_e} \sim f(Ri)\left(\frac{\nabla.\vec{V}}{\left|\frac{\partial \vec{V}}{\partial z}\right|}\right)^2$$

This result is keeping the consistency for definition of momentum fluxes. We may not forget, that all results follow chosen parameterization. Phenomena are described with limits of application of our assumption.

There is close relation between TKE (E) and friction velocity (u^*). In simplest case, when homogeneous turbulence and neutral air stratification are assumed, we can write that E is proportional to the square of friction velocity , $E \sim$ a u^{*2}.

Generally, dependence is more complicated especially in unstable case. TKE is represented with diagonal part of Reynolds stress-tensor (isotropic part) and anisotropy of turbulence is usually more significant in vertical direction. Cascading of eddies to the viscous dissipation is different in horizontal and vertical directions. One can write

$$E \sim \alpha S(Ri) u^{*2} \left(\frac{L_e}{L_k} f(Ri)\right)^{1/2}$$

where $S(Ri)$ is a stability function.

Analysing the ratio of mixing to dissipative lengths shows that this parameterization presents the simplest relation which is close to the homogeneous and the neutral air stratify turbulence. For neutral and stable case expression ($E \sim a\ u^{*2}$) gives a good approximation of the relationship between energy and surface velocity. It is no surprise when we remember the manner of derivation of the covariances. From this it seems that stable situations are described more correctly than unstable cases with the present parameterization. For unstable cases is necessary to introduce some stability function $S(Ri)$ to have a correct result or introduce this contribution to the ratio (L_k / L_e).

One possible way is to estimate dissipation of the energy *(DE)* in the same manner as TKE. We obtain similar results as for TKE, but with different coefficients (we start from stationary equilibrium for the dissipation term).

$$DE = DE^{\#} g(Ri)$$

For this approach one has:

$$S(Ri) \sim \left(\frac{f(Ri)}{g(Ri)}\right)^{3/2}.$$

Other possibility to attenuate this disadvantage is to import features for the mixing and dissipative lengths from observations. However measurements have limitation too. Problems are to determine the mixing length during convective situations with weak vertical gradient ... On the next, the results show weak dependence of presented scheme to the convective situation. On the other hand, there is no reason to describe convective processes in turbulent scheme. This assertion supports, for example, Redelsperger (2001) results.

Before solving the prognostic TKE we did a deep analysis of the proposed parameterization. Again we use the support of stationary theory. This approach allows us to estimate the magnitude of fluxes and the suitability of coefficients settings. We find formulas for surface velocity, scaled potential temperature, eventually expression for vertical heat-flux. From these expressions we can get an estimation of system properties. It allow us to obtain a critical Richardson flux number (Ri_{fc}.), defined as:

$$Ri_{fc} = Ri\left(\frac{K_h}{K_m}\right)$$

where K_h and K_m are the exchange coefficients for heat and momentum respectively.

From analysing the series properties for $Ri \rightarrow \infty$ one gets

$$Ri_{fc} = c_2 Ri\varphi(Ri) = 1\text{-}f(Ri) = \left(\frac{c_2}{c_2 + c_3}\right)$$

where c_2 , c_3 are parameterized constants and $\varphi(Ri)$ is a stationary approximation of stability function from heat flux. Important is to say that this stability function has a little bit different expression when we compare results with other articles. Our results is the same as in Sommeria (1976), but differ by factor 2 in denominator with Cuxart (2000) and others.

This has an influence on the setting of parameterized coefficients. Coefficients setting can be done with help of measurements of fluxes. Concerning the setting of $R=K_m/K_h$, R=0.74, (0.95) in neutral stratification of air, keeping similarity with Monin-Obukhov theory, one obtains a condition for parameterized coefficients c_m, c from $1/c^2=R$, because $c^2=5c_m/(2c)$. Analogically, we can set a condition for c_0 and c_{ep} . We try to estimate this value from formula for Ri_{fc}. From measurement we expected, that the critical Richardson flux number Ri_{fc}. should be about 0.14. On the next, relation between TKE and momentum flux in neutral conditions is prescribed from measurements. It tell us that E/u^{*2} ranges from 3.75 to 5.47. These coefficient relations are coming from the choice of flux parameterizations. From these conditions we have still one parameter free. We set parameter c_m to c_m=3.115, (4.13). Constants c, c_m come from the pressure-correlation term, c=5.768, (7.648). Constants c_{ep}, c_0 come from dissipation parameterization, c_{ep}=0.831, (1.101) and c_0=0.271, (0.359). The setting of coefficients is very important for system "behaviour". The estimated values of constant correspond to the observations. In this way we adjust the shape of stratify functions $f(Ri)$ and $\varphi(Ri)$.

New formulation of fluxes (dependence to TKE) in different atmospheric stability conditions yields the following exchange-coefficient property for big Ri.

$$K_m \sim L_k{}^2\left(\frac{L_e}{L_k}\right)^{1/2} f^{1/2}(Ri) \sim L_k{}^2\left(\frac{L_e}{L_k}\right)^{1/2}\left(\text{constant} + Ri^{-1/2}\right)$$

$$K_h \sim L_k{}^2\left(\frac{L_e}{L_k}\right)^{1/2} c_2 f^{1/2}(Ri)\varphi(Ri) \sim K_m \frac{c_2}{(c_3 + c_2)Ri} \sim L_k{}^2\left(\frac{L_e}{L_k}\right)^{1/2} Ri^{-3/2}$$

These features allow us to express an estimation of the time-scale of eddies overturning

$$\tau = \frac{E}{DE} = S(Ri)\alpha\left(\frac{L_e}{L_k f(Ri)}\right)^{1/2}\left|\frac{\partial \vec{V}}{\partial z}\right|^{-1}.$$

We know that for closing the non-stationary system of parameterized equations we need to set a dependence of mixing and dissipative lengths on the air stratification. For computation of fluxes it

is necessary to add two parameters from outside in our case. With help of stationary equilibrium we eliminate this task to set only one parameter, for example mixing length from measurement. During the parameterized system analysis we eliminate this one unknown by analysing the ratio L_k / L_e.
We need to underline that this stationary simplification is interested for estimation of magnitude of parameterized terms and not for integration, because increment TKE in stationary case is zero.
In first step to do integration of TKE for simplicity we take the expression for L_k from the current ALADIN model and we apply ratio result $L_k=L_e.f(Ri)$. On the next we will improve ratio result by function $S(Ri)$ or we will take Redelsperger results (Redelsperger, 2001) for L_k and L_e, where blocked energy nearest the surface will be considered.

To describe the" history" of turbulence it is necessary to solve prognostic TKE equation. We had the idea to benefit knowledge from stationary balance for finding a more stable scheme for integration of TKE equation. The subtracting balanced energy from unbalanced system from equation terms trigger new difficulties. TKE as nonlinear equation contains new interaction terms with unbalanced and balanced energy, what in final point of view complicated solution.
For this reason we decided to solve TKE equation directly for full energy without subtraction (exactly say for square root of TKE). During the solution we can now get a better estimated range of processes for the knowledge acquired from stationary balance. In TKE equation Redelsperger term (*RE*) in stability function $\varphi(RE)$ is simplified by using result from stationary approach, Redelsperger term is substituted with Richardson number in this case one has function $\varphi(Ri)$. Integration of nonlinear TKE (second order differential equation in space) is done by the Powell hybrid method (compute the QR factorization of the Jacobian). Initial vector of solution has been set by balanced TKE. Boundary values of TKE on the ground and at the top are set to the zero.

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AOB : Workshop on boundary-layer clouds and consultation about progress on ALATNET project "Improved representation of boundary layer of model ALADIN".

The meeting was considered as productive. The most important problems of the current TKE were discussed. The main discussed topics wer e:

- current situation in models ALADIN, ARPEGE, ARPEGE-Climate and their 1D versions with TKE and implementation
- verification of current scheme and new scheme with TKE, at beginning with 1D ALADIN model on sensitive chosen situations, for stable, unstable profiles, for clouds developing in PBL and

the situations with wind shears; comparison of results on domains with cyclogenesis and inverse - stratified layer, concentration on antifibrillation scheme behaviour, (for example, test on EUROS frames data - shallow convection)

- advantages and disadvantages of TKE computation in half and full model levels
- surface or boundary value problem, anisotropy of turbulence
- integration of TKE equation, implicit or semi implicit scheme..., consistency, TKE as a new variable with other parts of model (dynamics, physics).

In addition I attended the Workshop on boundary-layer clouds, which was accessible at that time.

5. Ilian GOSPODINOV : "Reformulation of the physics-dynamics interface"

No news (in very long holidays...)

6. Raluca RADU : "Extensive study of the coupling problem for a high resolution limited area model"

Introduction

The hypothesis behind different treatments of the lateral boundary conditions could be as following: supplying large-scale flow information (at low resolution from a global model) to a limited-area model (LAM) as initial and lateral boundary conditions will allow the LAM to develop meaningful fine-scale structures (high-resolution information) inside its domain. The research topic of the project was to investigate the deficiencies of the present coupling method, the Davies' relaxation scheme (boundary relaxation of the flow towards the large scale solution in a transition zone, Davies 1983), and to introduce a new one based on the spectral representation of the fields (see previous ALATNET reports).

In our trial to find the best way how to tune the spectral coefficients of the spectral coupling method it looks reasonable to perform experiments with the 1D model and apply the conclusions to the 3D limited area model afterwards.

1D Shallow-Water tests :

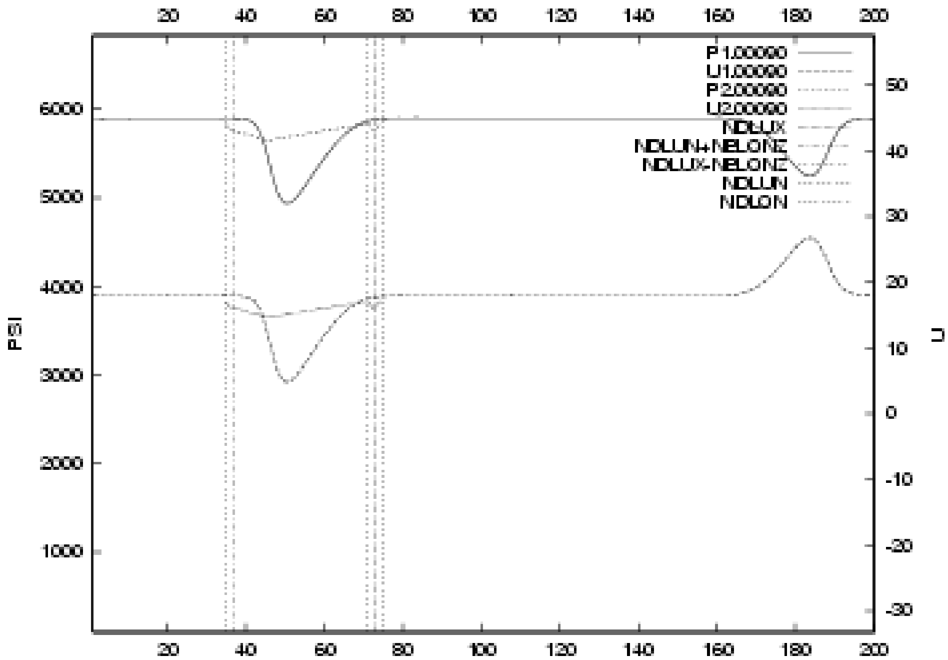
The sensitivity of the new method is studied using the 1D spectral shallow-water model developed by I. Gospodinov and P. Termonia, similar to the 3D model but simplified. The model fields are shallow-water velocity and shallow-water height, and it is running on two types of domains, a global and a limited-area ones. It is integrated with a two-time-level semi-implicit semi-Lagrangian scheme and a trajectory scheme proposed by I. Gospodinov with a second-order-accurate treatment of the nonlinear residual.

The calculation of the large-scale fields is generally done by using linear or quadratic gridpoint interpolations, but many tests were done before in order to find the optimum interpolation method. The relaxation takes place at the end of the gridpoint calculations, as in ALADIN. The first step concerning 1D tests was the introduction of the spectral coupling method in the shallow-water code, at the end of the routine which performs the calculation at the end of the time-step, where the fields are already stabilized. I tried the linear interpolation in time between the spectral coefficients of the large-scale fields. The spectral coupling is designed so that, for large scales, only long waves from ARPEGE are taken into account and, for small scales, short waves from ALADIN are considered with a smooth linear transition in between. The 1D shallow-water tests, coupling the global model with the LAM using the same initial conditions, consist in a depression of Gaussian shape which propagates from west to east with constant speed through the whole domain. This can be considered as the 1D version of the Christmas storm , December 1999, even if the propagation speed in the 1D model is higher.

Several experiments were performed, with the following setup :

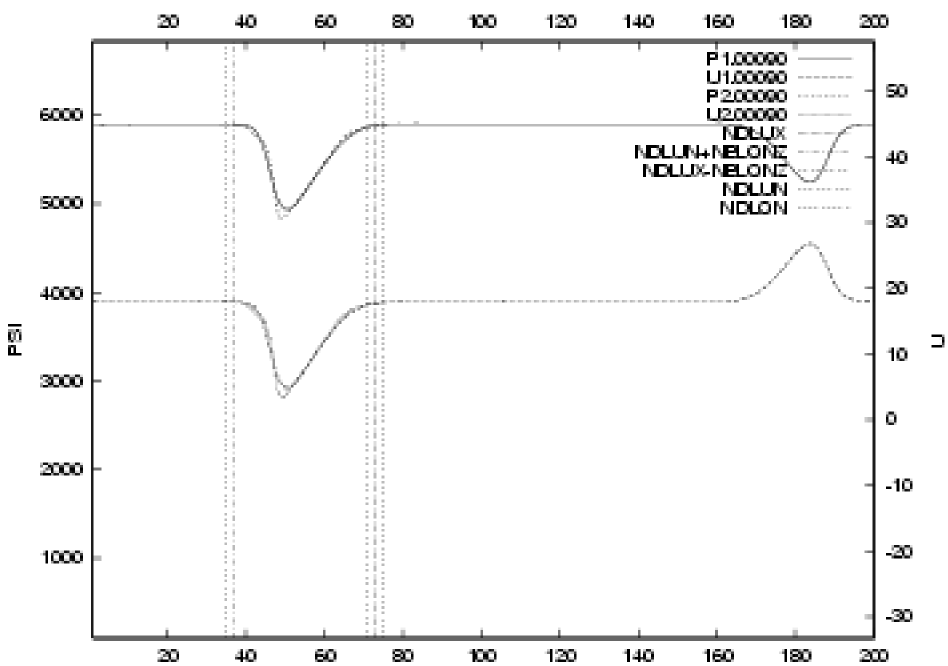
Global model : 200 gridpoints, Δx=50km, Δt=300s (length of the time step)
LAM : 200 gridpoints, 8 points E-zone, Δx=10km, Δt=300s
Time integration up to 36 h.

In Figures 1 to 6 the x-axis indicates the grid of the global model (200 points). The LAM is nested inside and the vertical lines represent the borders of the LAM's different zones (e.g. the extension zone is between the last two vertical lines). At the chosen forecast range, the depression should be completely inside the LAM domain. The upper curves show the geopotential, with the corresponding scale on the left y-axis, while the lower ones show the horizontal wind, with scaling on the right y-axis. The curves strictly inside the LAM borders represent the LAM forecast, while the other ones show that of the global model, which serves as a reference.



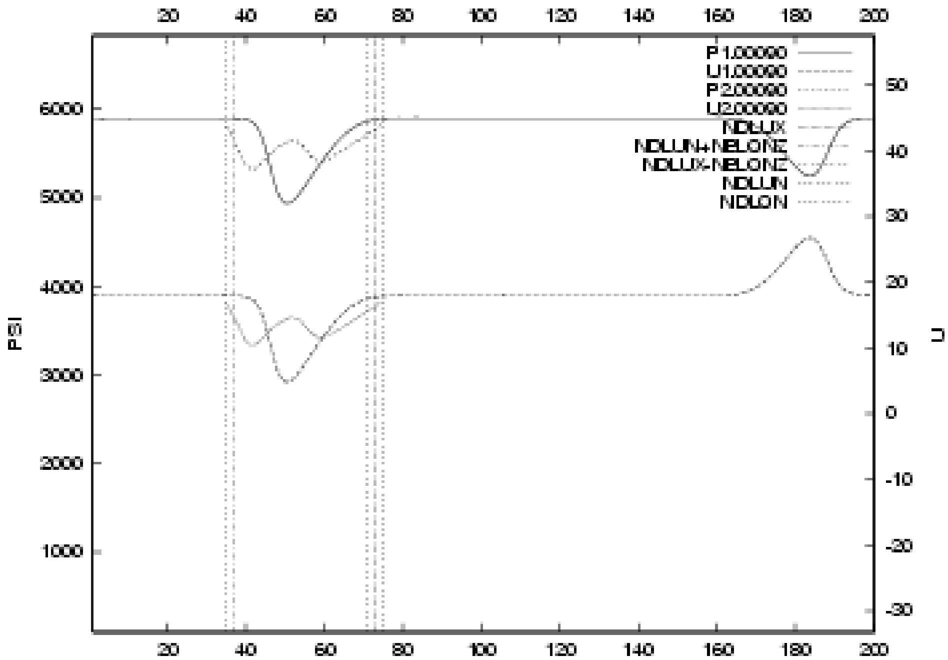
(A) <u>LAM forecast failure case</u> (Figure 1) - 3 h Davies relaxation

The cyclone is missing in the forecast.



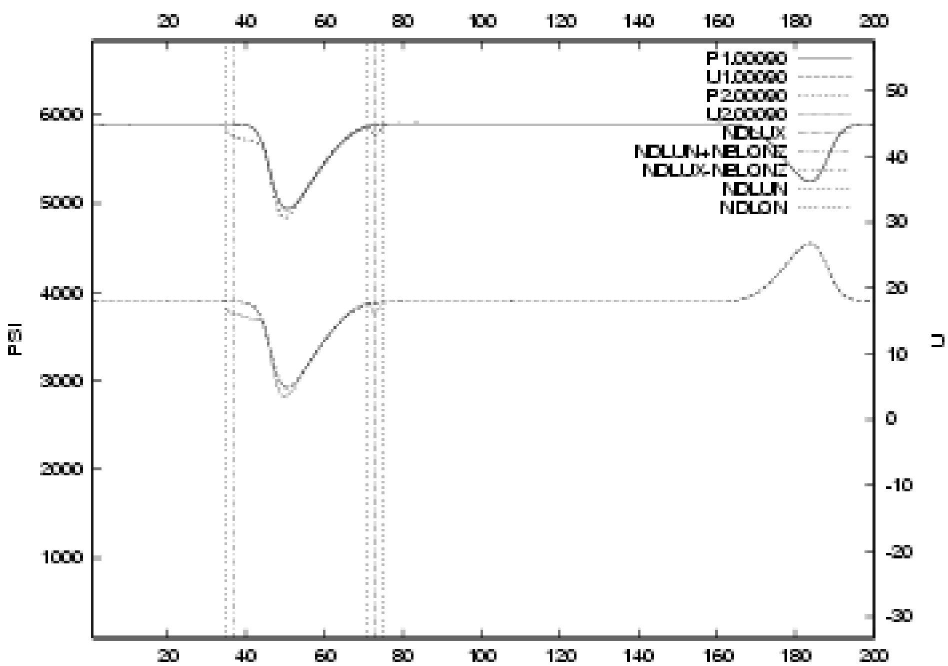
(B) <u>Reference case</u> (Figure 2) - 1 h Davies relaxation

By increasing the coupling frequency , the LAM is able to receive and keep the information from the large-scale model. The given LAM forecast is considered as the ideal one, but it is too expensive for operational use.



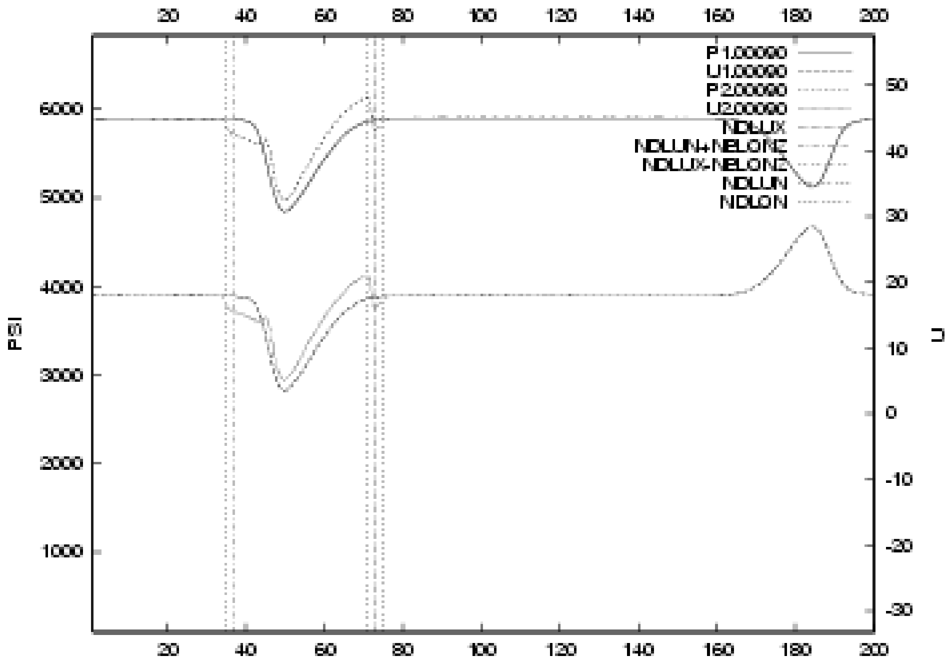
(C) <u>Forcing, jumps, dipole case</u> (Figure 3) -
3 h Davies relaxation combined with spectral coupling every time step

It gives too strong large-scale forcing. The cyclone oscillates inside the LAM domain, due to the external large-scale forcing. The LAM develops a dipole structure.



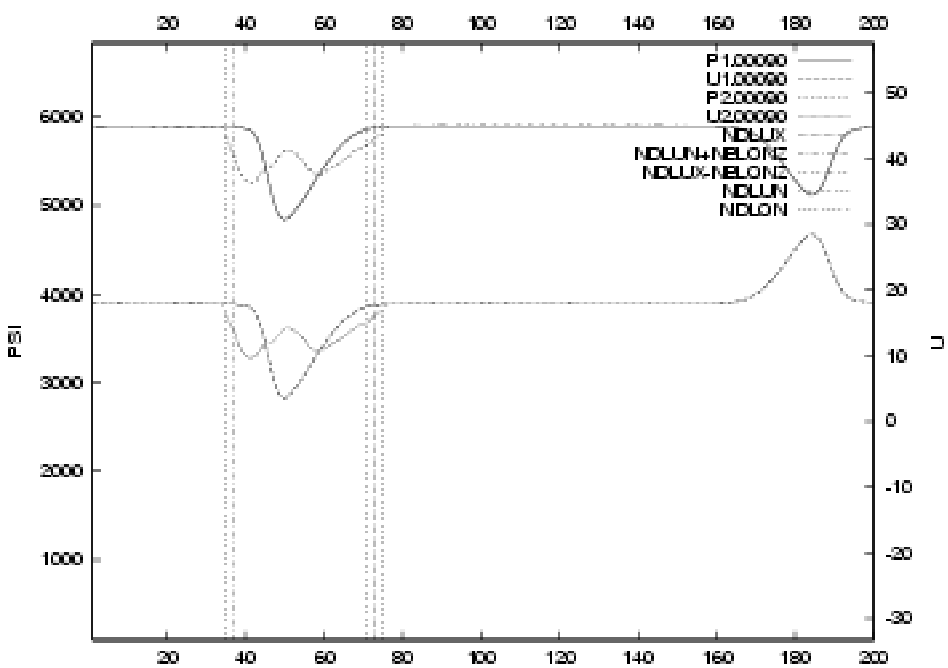
(D) <u>Small jumps case</u> (Figure 4) - 3 h Davies relaxation with 3 h spectral coupling

By decreasing the spectral frequency of coupling, the dipole structure is not present any more because of less forcing from large scales, which is a good sign. Still questionable is that the cyclone is not captured at the first spectral coupling time, but just at the second one when it suddenly appears inside the LAM domain.



(E) <u>One time spectral coupling case</u> (Figure 5) -
3 h Davies relaxation with spectral coupling at one time-step after 6 h

No dipole in the LAM solution, but the cyclone appears later because of the chosen spectral coupling time, and its lifetime is uncertain inside the LAM. We cannot be sure that the LAM keeps and resolves the problem correctly. If the spectral coupling is applied only once, the time has to be close to the real entering of the cyclone into the LAM domain.



(F) <u>Time relaxation case</u> (Figure 6) -
3 h Davies relaxation, spectral coupling every time-step with time relaxation

We observe the dipole structure again, and a strange evolution of the LAM solution as well. Introduction of the wavenumbers time-dependence proves that the idea to get large-scale information varying in time during the integration is far to be considered as a positive result.

Discussions

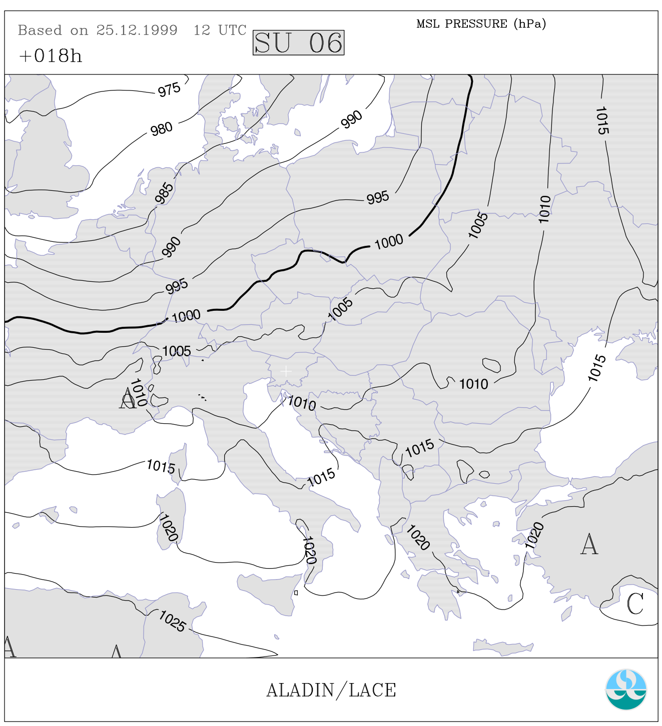
When introducing spectral coupling at every time-step, we are confronted to a dipole structure. The explanation can be found in the fact that, at the first coupling step, the LAM gets information from the linearly interpolated spectral coefficients between the two coupling files. This disturbs the dynamical evolution of the large-scale information inside the LAM during the integration time.

The forcing-dipole case raises the idea to introduce a spectral-coupling frequency, providing spectral features from large scales not at every time-step, but at a lower frequency . It can be tested together with the retuning of the relaxation coefficients of the Davies' method.

The 1D tests prove that the spectral coupling method succeeds to provide possibly missing large-scale spectral information, like it would be needed in the Christmas storm case, but the way to realize this should be tested further, in order to find a suitable way to keep and solve the information. We got the idea to provide the spectral information smoother into the LAM domain by tuning of the spectral α function shape and of the spectral parameters for relaxation.

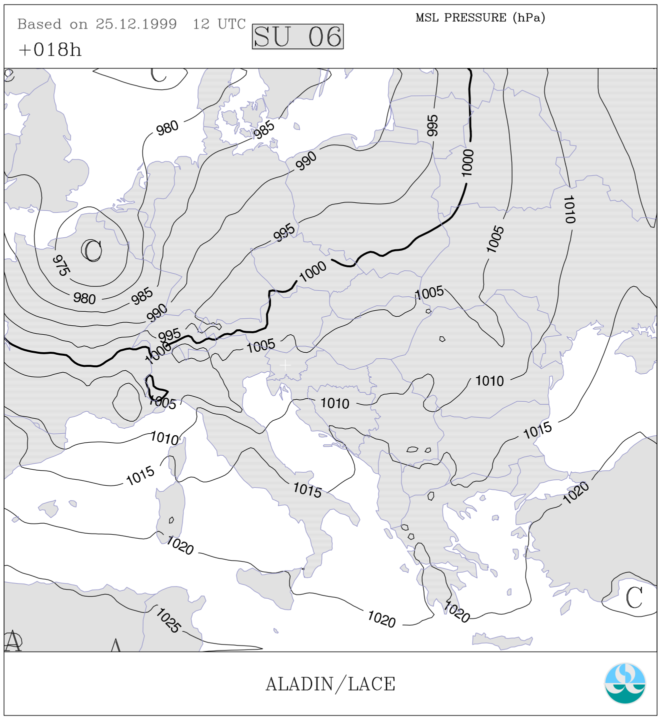
3D tests with ALADIN

Several tests with the ALADIN model were performed, with similar conditions as in the 1D shallow-water model. The results were very close to those of the 1D tests. As initial conditions we use the Christmas' storm case of 1999.



(G) Figure 7- <u>Davies relaxation failure case</u>- 6 h Davies relaxation coupling

The cyclone is missing



(H) Figure 8 - Spectral coupling -
6 h Davies relaxation coupling, spectral coupling every 3 time-steps

The cyclone is inside the domain.

Spectra of the vorticity were computed for elliptical wavenumbers (Figures 9 to 11), in order to identify the wavenumbers from the large-scale which represent the missing cyclone in the LAM :

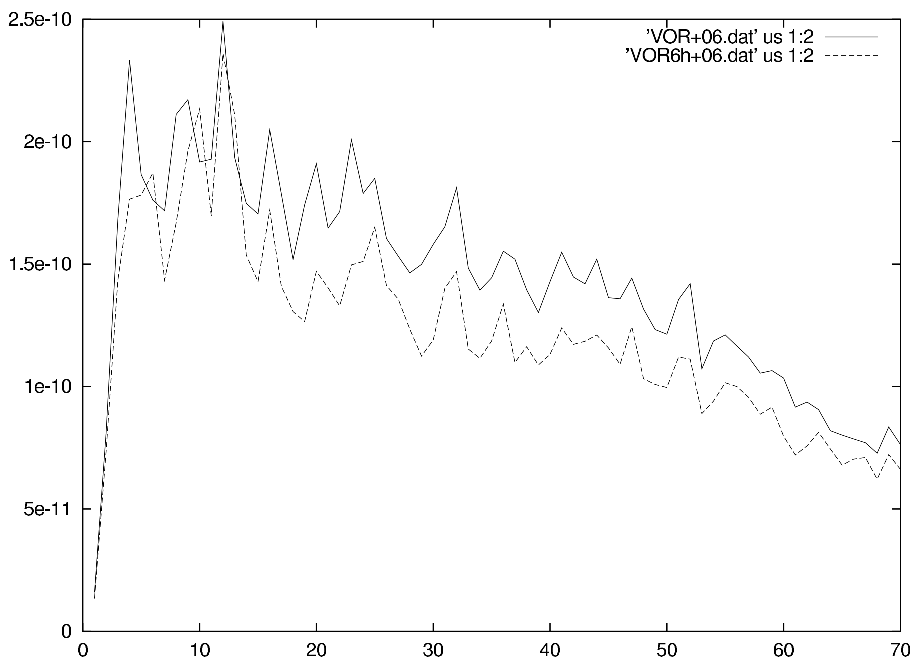


Figure 9 : comparison of the vorticity spectra of 1 h gridpoint coupling frequency, ideal case with cyclone inside (full line) with 6 h gridpoint coupling frequency, missing cyclone (dashed line) .

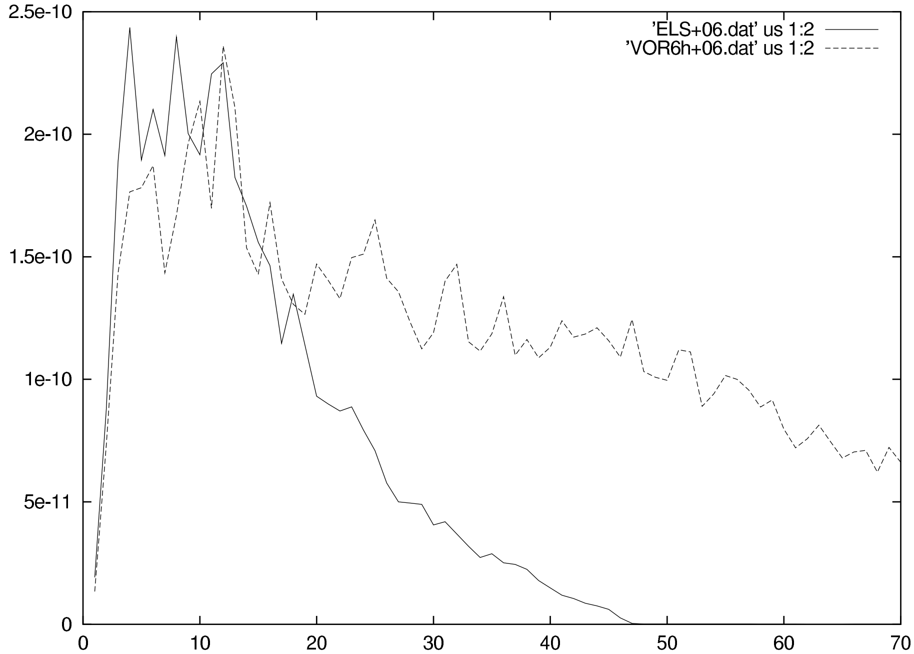


Figure 10 : comparison of the vorticity spectra from the coupling file at +6 h (full line) and 6 h gridpoint coupling frequency, missing cyclone (dashed line)

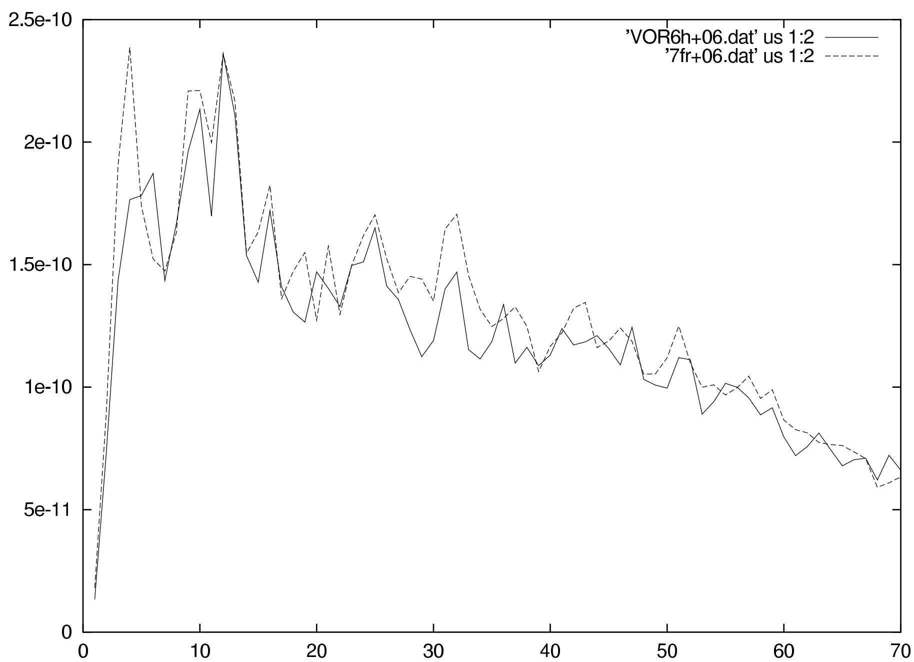


Figure 11 : comparison of the vorticity spectra with spectral coupling at 1 h frequency, cyclone is inside (dashed line) and 6 h gridpoint coupling frequency, missing cyclone (full line).

From these three figures it can easily be seen that the energy of the cyclone is carried only by the lowest wavenumbers . Future work :

- retuning of α function of gridpoint coupling together with tuning for spectral coupling
- tests with the 3D model for time relaxation
- tuning of spectral parameters for relaxation
- examination, with the 1D model, whether the large-scale information from spectral coupling might affect already present small-scale features inside the LAM domain.

7. Andre Simon : "Study of the relationship between turbulent fluxes in deeply stable PBL situations and cyclogenetic activity"

New investigations in the study of rapid cyclogenesis in Northern Atlantic

The physics-dynamics interaction in the simulation of the 20 December 1998 storm was explained in [2] using various diagnostic fields and the knowledge about general principles of cyclogenesis (e.g. based on the q.g. equation of vertical motions or surface pressure tendency equation). According to the fact that the turbulent exchange of heat can modify the vertical motions through static stability, we used it as main diagnostic parameter. After increase of the turbulent heat exchange in the PBL, considerable deviations in the field of mean static stability between 700 and 925 hPa were detected in the region eastward from Newfoundland. This area was then supposed to be crucial for the later development of the storm.

This approach had two principle drawbacks:

A) The above mentioned area was probably not the only one important for the deepening of the storm (by other words, the forecast of the cyclone depends not only on the magnitude of the changes done by model physics but on their position as well).

B) The former diagnostic studies didn't explain why we were not able to have realistic simulation of the cyclone without considerable decrease of static stability in the stable stratified PBL. Moreover, this impact helped to forecast the cyclone only in the 84 and 96 hour runs and the resulting changes in static stability were not positive, when compared to the model analysis.

To get a more objective solution in part A it was decided to provide adjoint sensitivity tests with respect to the development of the cyclone between 17.12.1998 12 UTC and 19.12.1998 06 UTC. The idea of these tests was to use forecasts from different runs instead of analysis. Hence we didn't study the sensitivity on initial conditions but the sensitivity created by the impact of different model physics at the beginning of the selected period.

It has to be noted, that at that time the sensitivity on the turbulent exchange of heat was supposed to be only in the first 24 (36) hours of model computation, valid to 17.12.1998 12 UTC (see also [1] and [2]).

On the other hand, it was shown that the rapid development of the storm depends directly on its stage 42 hours later (19.12. at 06 UTC). This knowledge helped us to decrease the computational requirements and to specify the target period of sensitivity tests.

Thus the observed run (used for building the trajectory) was the one with decreased heat exchange, that didn't forecast the storm. For the reference at the beginning of the adjoint run (19.12.1998 at 06 UTC) we used the successful forecast of the storm using the operational values of vertical diffusion.

The tests were done on model ALADIN with 33 km resolution, using the simple physical parameterisation of Buizza and the so-called dry total energy as the cost function. For more details about sensitivity studies using the adjoint of the ALADIN model one can read articles [3] and [4].

At the end of the adjoint model computation period (17.12.1998 12 UTC), the gradients of the 42 hour forecast error should mark the areas, that caused the wrong forecast of the cyclone (Fig.1). The gradient fields differ remarkably from the areas obtained by simple difference of the two forecasts of static stability valid to the same date (compare with the results published in [2], page 85).

This experience confirms our assumptions, explained in the point A. However, the results of the adjoint model could be influenced by the use of simple physical parameterisation over a relatively long period and by the small extent of the target area.

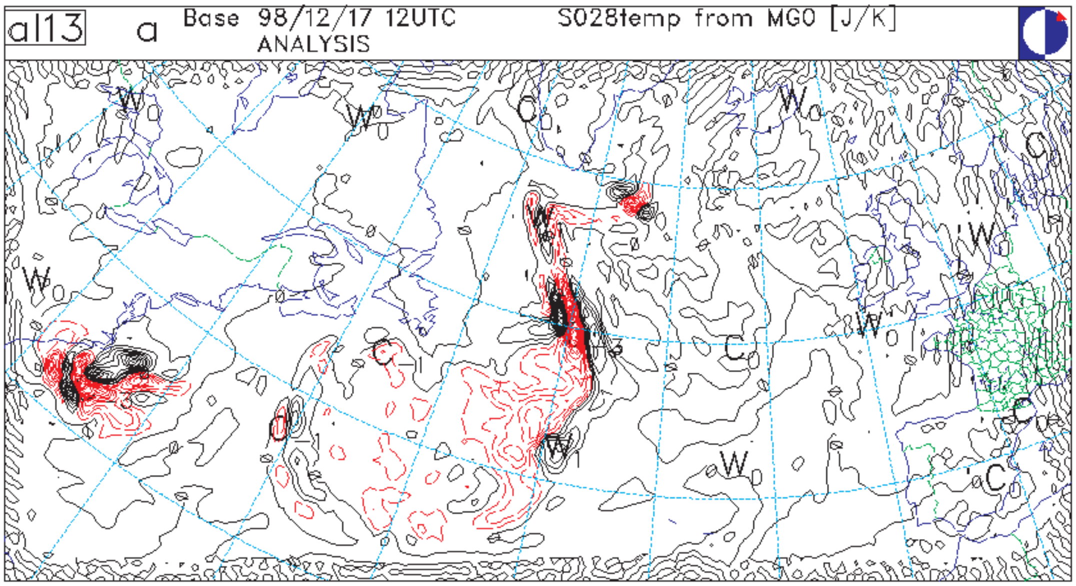


Figure 1 : Gradients of the 42 hour forecast error with respect to the temperature and with the dry total energy as the cost function at model level 28. The results show the sensitivity to errors of forecast with decreased turbulent flux of heat in the PBL valid to 17 December 1998 12 UTC (experiment with USURID=0.14).

These results were used to select a domain for the computation of temperature, water vapour and energy budgets, provided by the DDH tool. The selected domain, called ADJO, covers the areas with estimated highest sensitivity obtained from the adjoint model computations (Fig 2a).

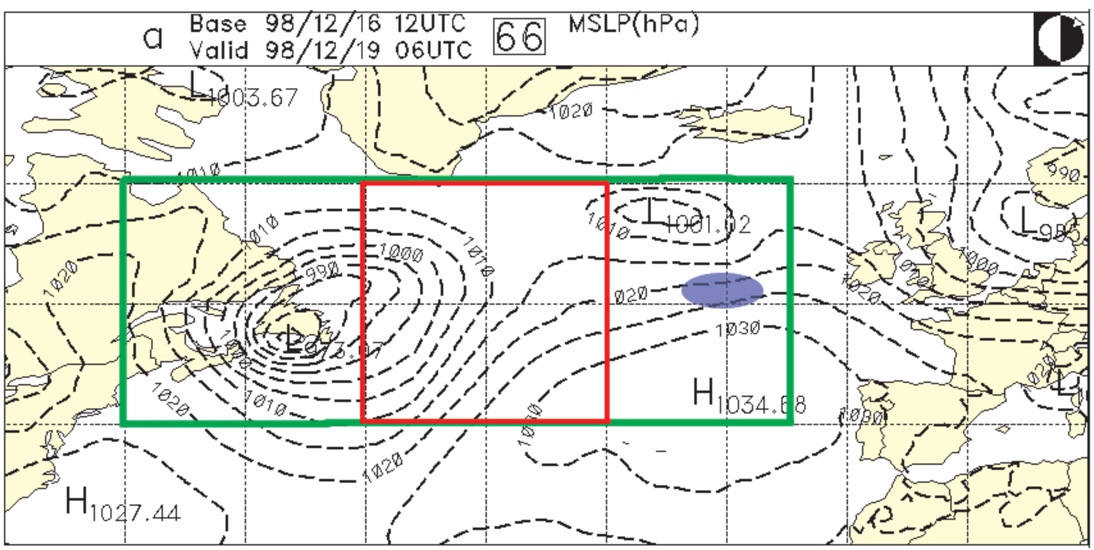


Figure 2a : 66 hour forecast of mean sea level pressure based on 16.12.1998 12 UTC using the modifications of ARPEGE/CLIMAT (experiment *ph1a*).
The area in blue marks the position of the cyclone valid at the same date and it is obtained from the ECMWF analysis and from the operational run (experiment *ric2*). The cyclone forecasted in the experimental run is, compared to the reference analysis and forecasts, shifted towards northwest and it is about 10 hPa deeper. The red rectangle represents the domain ADJO selected for the budget calculations according to the results of the adjoint sensitivity tests. The green rectangle represents the domain LABR used for the budget calculations and tests of the ARPEGE/CLIMAT modifications.

Outputs for the first 24 hours of integration from the 16 December 12 UTC (Fig. 3) show the differences between the reference forecast of the operational model (*ric2*) and the forecast with decreased vertical diffusion of heat (*ric7*), that would not predict the storm.

The horizontal mean of the temperature tendency (grey line) for the domain ADJO shows warming until approximately 850 hPa and cooling above this level, when going to the reference (setting the parameter USURID=0.042 instead USURID=0.14). This means a drop of static stability at the top of the PBL, as it was explained in [2] using simple diagnostic parameters. In addition, we can observe that the warming and cooling of the PBL in the domain is also due to the so-called dynamical terms included in the budget equation of enthalpy (e.g. by divergence of horizontal and vertical fluxes and conversion from potential to internal energy). These terms are related also to the advection of the temperature.

Both the turbulence and the large-scale precipitation terms show oscillations in the lower PBL. The contribution of the turbulence to the overall tendency is dominating around 750 hPa and higher.

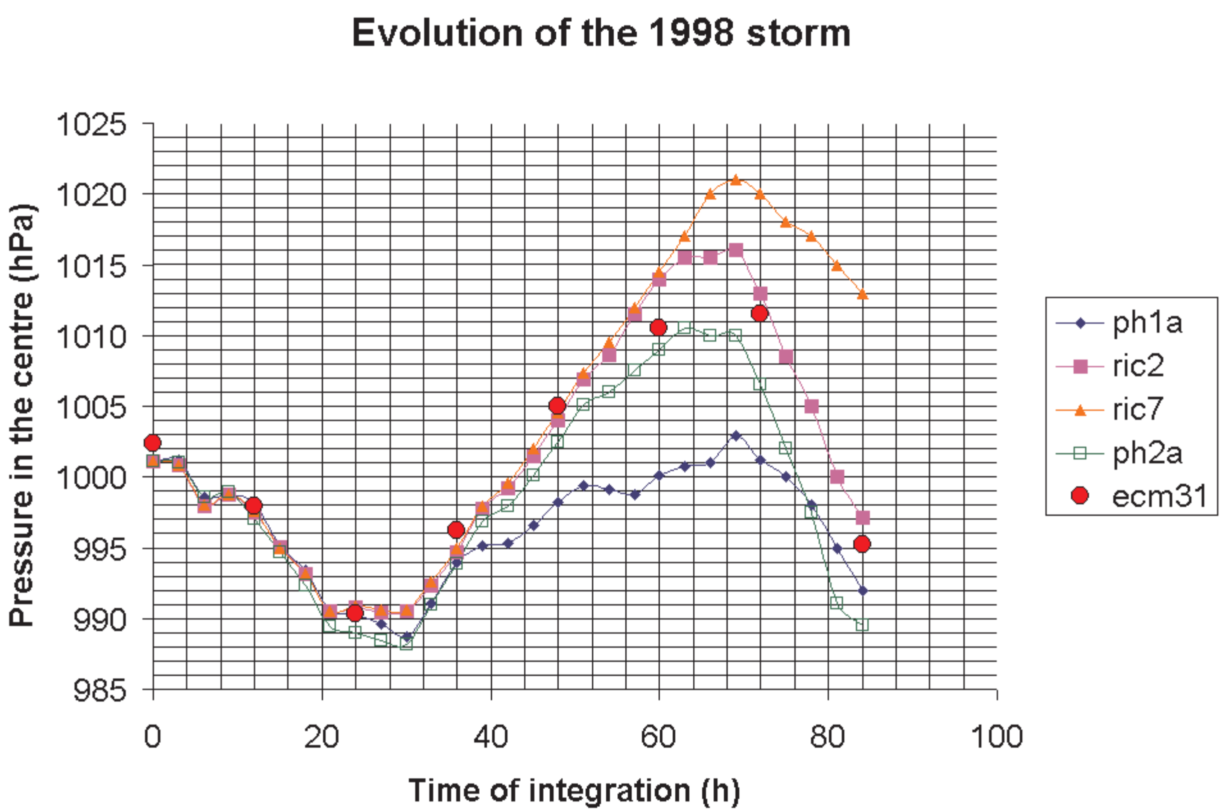


Figure 2b : Time-evolution of mean sea level pressure in the centre of the "20.12.1998 storm". All the 84 hour forecasts of the ARPEGE model were based on 16.12.1998 12 UTC. The meaning of the experiments is as follows :
ric2 - run of operational ARPEGE CY24T1 with USURID=0.042
ric7 - same as *ric2* but with USURID=0.14 (decreased transport of heat in the PBL)
ph1a - run using the modifications of ARPEGE/CLIMAT
ph2a - same as *ph1a* but with the stratiform precipitation scheme of the operational model
ecm31 - objective analysis based on the ECMWF model data

The problem explained in B was reopened after several experiments done in GMAP with the physics of the model ARPEGE/CLIMAT on situations with rapid cyclogenesis (as the winter storms 1998/1999) or false cyclogenesis of mesoscale dimensions (the so-called Arpegeades). This physical parameterisation package includes the Mellor-Yamada second-order closure scheme for turbulent fluxes, different parameterisations of cloudiness and large-scale precipitation fluxes (e.g. taking into account the condensation in the case of non-precipitating clouds and allowing over-saturation). The parameterisation is described in details in the part of ARPEGE/CLIMAT documentation revised by P. Marquet in November 2002 [5].

The application of the above-mentioned modifications in physical parameterisation changed our look at the problem of forecasting the 20 December 1998 storm.

The position and the depth of the cyclone is well forecasted not only in the 84 and 96 hour runs but partially also in the shorter range forecasts valid at 20.12.1998 00 UTC. The main benefit of the modified parameterisation is that it keeps higher static stability in the stable stratified PBL than the operational CY24T1 and CY25T1 versions of ARPEGE (this is going to be improved according to the recent modification of vertical diffusion tested in parallel suite from the middle of December 2002). Moreover, the physics of ARPEGE/CLIMAT solves also some of the problems with "Arpegeades".

Nevertheless, problems occurred while examining the results of the new scheme with respect to more "details". One can see for instance the time-evolution diagram of the forecasted pressure in the centre of the December 1998 storm (Fig. 2b). While using the physics of ARPEGE/CLIMAT, we obtain a very good forecast of the pressure in the centre of the storm at the end of the 84 hour run. But this is compensated by the fact, that during the 36-84 hour period the forecasted storm is unrealistically deep and it’s position is artificially shifted towards northwest (see for instance Fig. 2a).

Paradoxically, we can get the "correction" of the forecast by replacing the stratiform precipitation scheme used by ARPEGE/CLIMAT with the scheme of the operational ARPEGE version, that is generally considered to be less exact (e.g. it doesn’t allow over-saturation).

To understand how the parameterisation scheme of ARPEGE/CLIMAT influenced the trajectory and the depth of the forecasted cyclone, budget calculations were done, using the domains already created for the vertical diffusion tests (remember Fig. 2a).

We compared the run with the ARPEGE/CLIMAT physics (experiment *ph1a*) with the run of the operational ARPEGE version of the cycle CY24T1 (experiment *ric2*).

From several experiments came out, that the influence of the ARPEGE/CLIMAT physics is distributed more proportionally during the 84 hour run, but the main changes should be observed during the 24 - 48 hour forecasting period. Figure 4 shows the differences in the mean temperature budget for the domain LABR for the above mentioned period.

The static stability has been increased in the domain for the experiment with the ARPEGE/CLIMAT in the upper part of the PBL. On the other hand, there is a drop of stability in the very low levels, below 900 hPa. The change in the contribution of turbulent fluxes is remarkable, mainly in the levels below 800 hPa. But one should note, that these tendencies are compensated from a big part by the precipitation fluxes. Thus the differences in the temperature tendency are caused by several changes of physical parameterisation and one could not determine the dominating one.

While comparing the energy budget of the two experiments, it is possible to see the increase of kinetic energy in the entire troposphere for the run using ARPEGE/CLIMAT version (Fig. 5). Apart from the fluxes related to the model physics, there are very large contributions of the so-called baroclinic term (containing the conversion of potential and internal energy to kinetic energy) and of the advection term hidden in the residual. The difference in the turbulent transport of momentum has a strong contribution in the PBL and, except in the lowest layers, it acts to increase the overall budget of the kinetic energy, compared to the operational ARPEGE scheme.

Last, but not least, we compared the temperature and energy budgets after change of the precipitation scheme for the operational one, while keeping other modifications of the

ARPEGE/CLIMAT (experiment *ph2a*). On both figures (Fig. 6 and Fig. 7) we can see that the replacement of the scheme pushed the results a bit back towards the operational ARPEGE scheme.

Remarkable is the drop of the temperature in the mid-troposphere and the oscillations of the turbulent and the precipitation fluxes in the PBL. The kinetic energy was decreased almost in the entire profile, with maximal rate of change in the upper troposphere. However, the link between the modification of the precipitation fluxes and the decrease of the kinetic energy of the flow is not obvious from the diagnostics.

We can guess, that bigger release of latent heat coming from the precipitation supports the warm advection (or suppress the cold advection) and this should imply a weaker cyclogenesis and probably also the change of the trajectory of the cyclone in the modified environment.

Because of large contribution of the terms not directly related to local physical fluxes, we can expect significant influence of changes outside of the selected domain. Thus the sensitivity tests, similar to the ones explained above, could help to specify the dimensions and the position of the required domain with more precision.

Conclusion:

The case study of the 20 December 1998 storm confirms, that a big number of tests is needed to understand the impact of physical parameterisations on the simulation of large-scale atmospheric motions. The adjoint of the ARPEGE or ALADIN model and diagnostic methods such as budget calculations seem to be powerful tools, that provide more objective informations about the processes related to the cyclogenesis and its prediction. However, it is still insufficient to recognize the reason of the forecast errors comparing to real atmospheric processes. As it comes from the experiments with the physics of ARPEGE/CLIMAT, there are different ways to obtain a successful forecast of an extreme event. Unfortunately, probably by every experiment mentioned in this article, the success of the storm forecast was balanced by some not realistic features due to physical parameterisations. Thus the introduction of more sophisticated schemes may not improve the forecasts of the polar cyclones in general. The operational implementation of different vertical diffusion or stratiform precipitation schemes will require in the future retuning of several parts of the physical parameterisation setup and additional experiments done on case studies.

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[5] Documentation ARPEGE/CLIMAT (cycle 24T1), 2002, Météo-France

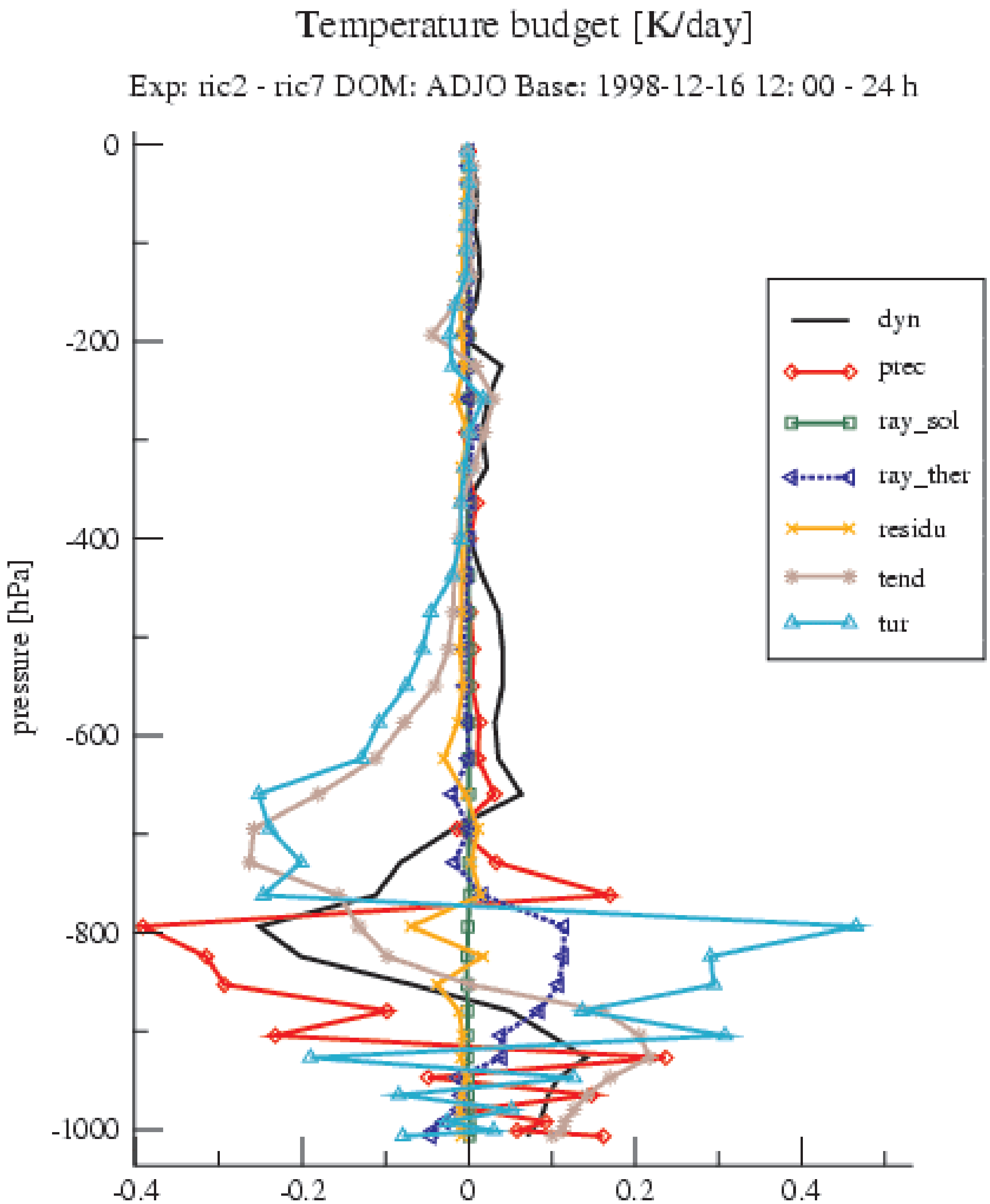


Figure 3 : Comparison of the temperature budgets between the operational CY24T1 run (USURID=0.042) and the run with decreased transport of heat in the PBL (USURID=0.14). Note the contribution of the terms not including physical fluxes (black line), the contribution of the turbulent fluxes (light blue line) and the overall tendency (tend).

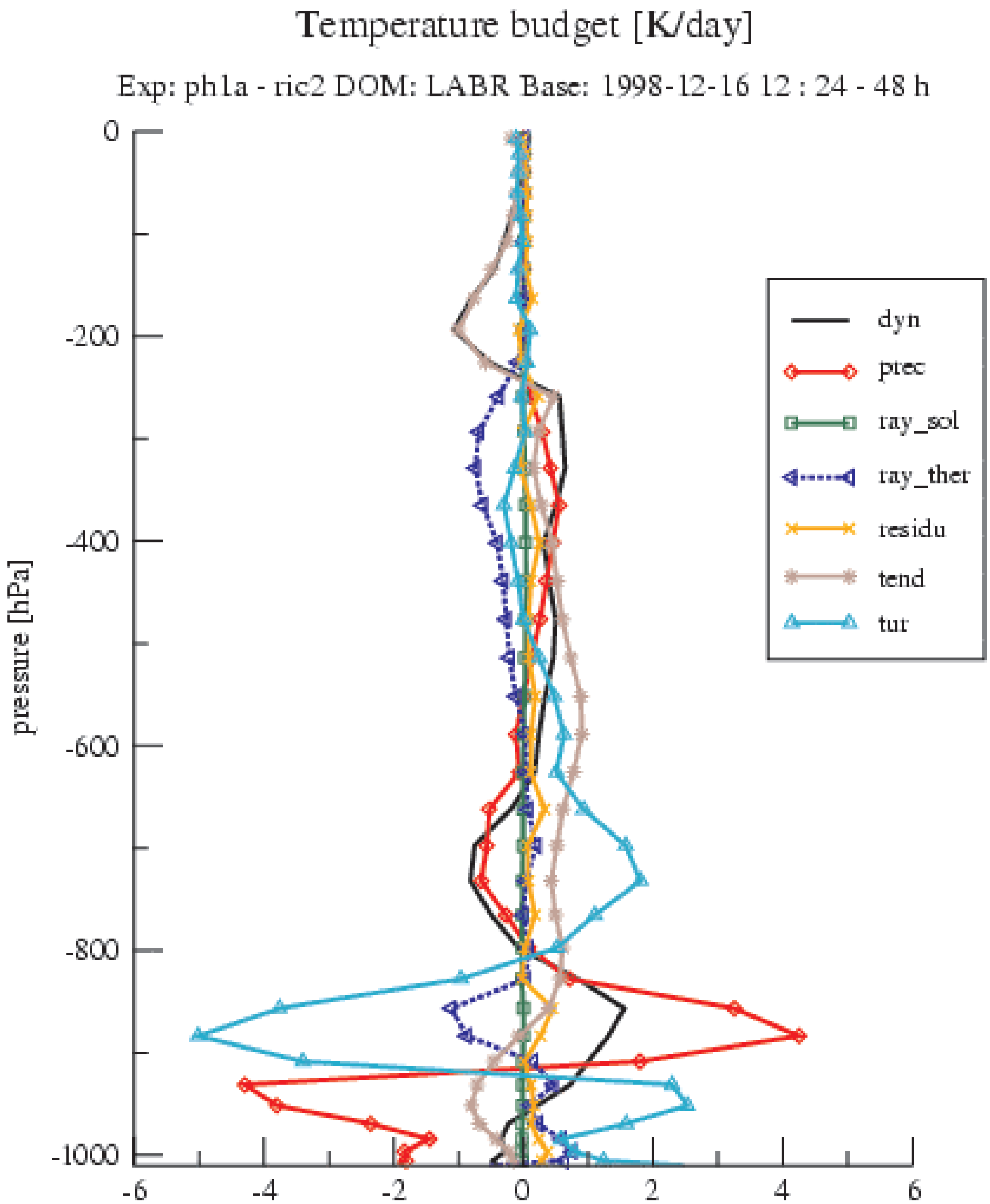


Figure 4 : Difference of the temperature budgets between the experimental run with physical parameterisation of ARPEGE/CLIMAT and the operational CY24T1 run.

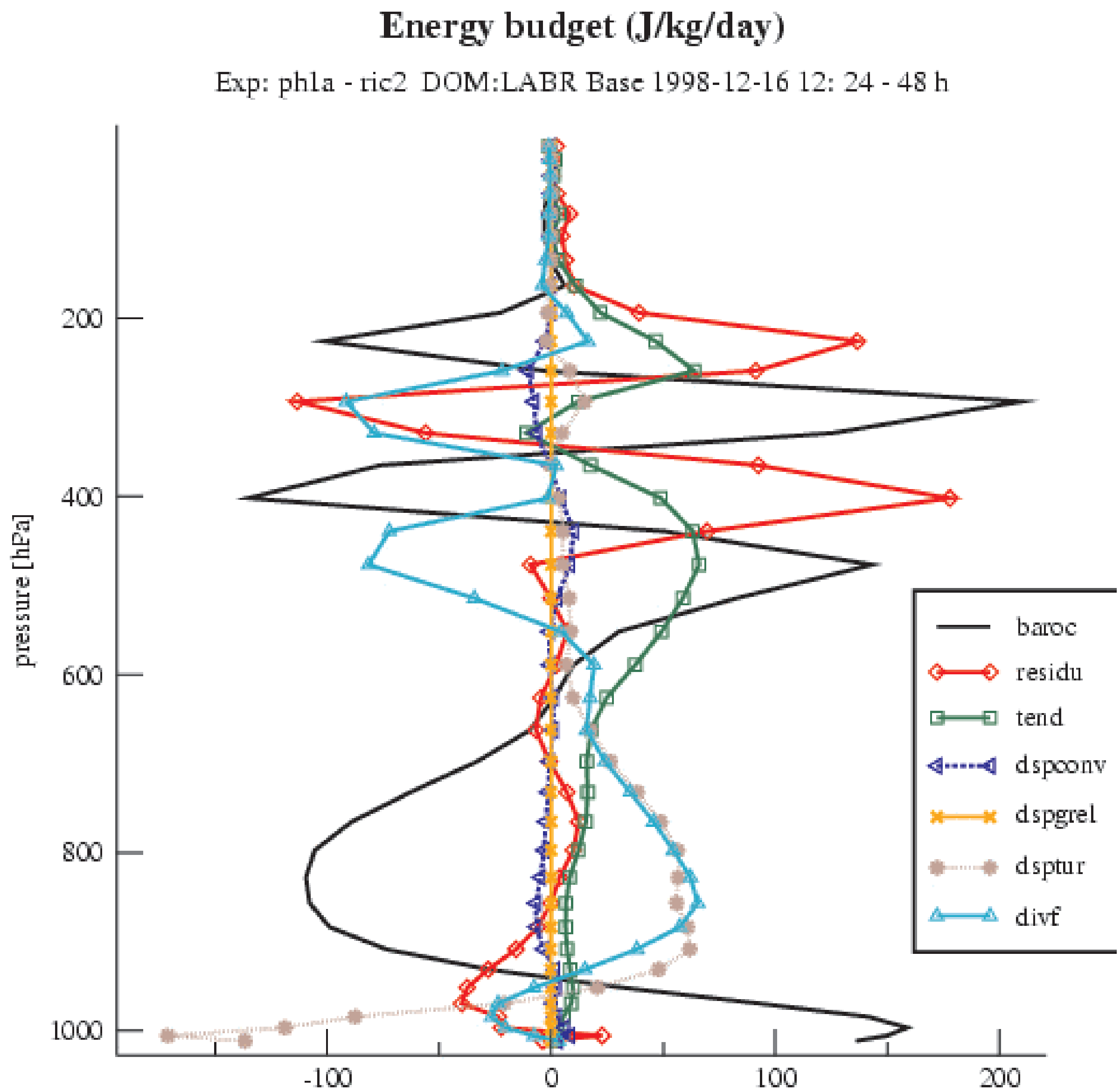


Fig. 5 : Difference of the kinetic energy budgets between the experimental run with physical parameterisation of ARPEGE/CLIMAT and the operational CY24T1 run. Note the contribution of the so-called baroclinic term (black line), the turbulent dissipation term (dsptur) and the overall tendency (green line). The residual term (red line) can contain, beside others, the contribution of the horizontal diffusion or the advection of the kinetic energy.

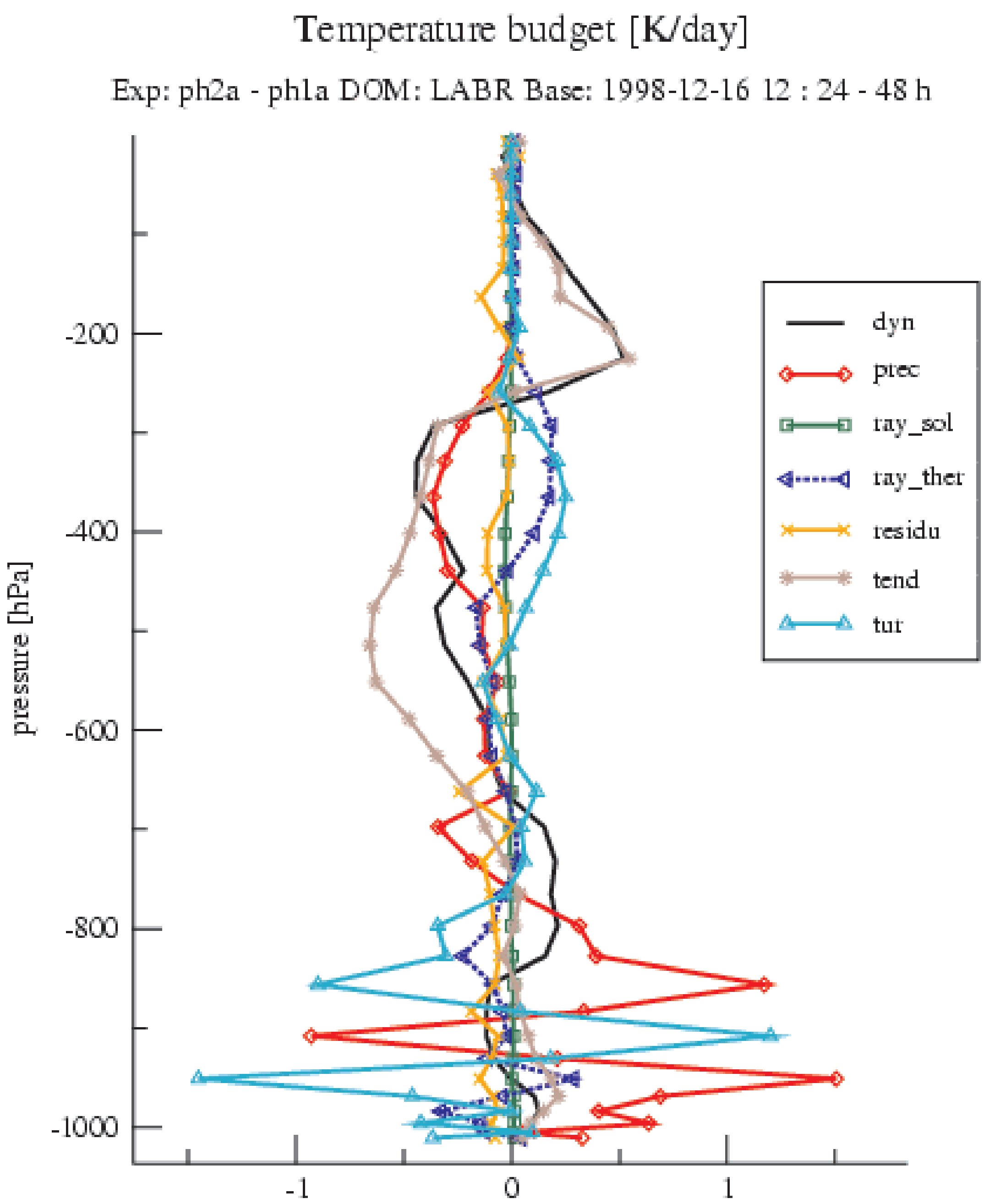


Figure 6 : Difference of the temperature budgets between the experimental runs using physical parameterisation of ARPEGE/CLIMAT but different large scale precipitation schemes.

Experiment *ph2a* - operational Kessler's type of precipitation scheme

Experiment *ph1a* - Smith's type of scheme for precipitation fluxes (ARPEGE/CLIMAT)

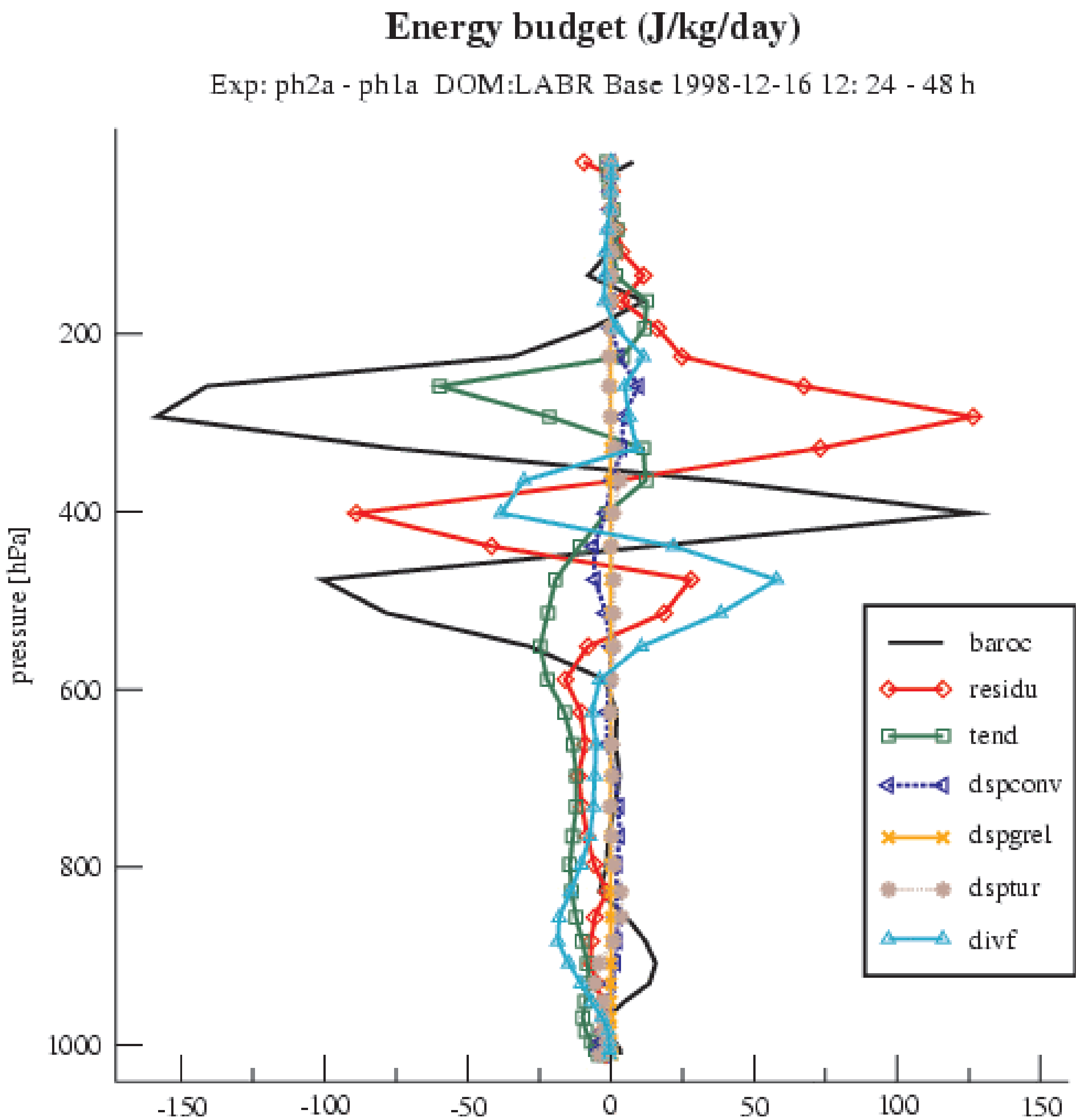


Figure 7 : The same as in Fig. 6 but for the differences of the budgets of the kinetic energy

8. Chistopher SMITH :"Stability analysis and precision aspects of the boundary condition formulation in the non-hydrostatic dynamics and exploration of the alternatives for discrete formulation of the vertical acceleration equation both in Eulerian and semi-Lagrangian time marching schemes"

The Post-Doc stay ended last summer. Christopher Smith is now working again at UKMO. The Czech, Slovak and French teams will complete his work.

9. Cornel SOCI : "Sensitivity study at high resolution using a limited-area model and its adjoint for the mesoscale range"

The paper submitted to *Idöjaras* and entitled "Preliminary results of high resolution sensitivity studies using the adjoint of the ALADIN mesoscale numerical weather prediction model" (by Cornel Soci, Andras Horanyi and Claude Fischer) has been accepted. Writing of the PhD manuscript has now started, and the defence should take place in Spring 2003. More details in the next Newsletter.

10. Klaus STADLBACHER : "Systematic qualitative evaluation of high-resolution non-hydrostatic model"

Generalities :

The last months of the ALATNET stay in Ljubljana were mainly dedicated to two different topics. On one hand it was tried to find a more optimal description of the orography at very high resolution, to obtain more realistic precipitation fields in mountainous areas. As basis served an additional spectral cost function, which has been developed in Toulouse (and evaluated first on ALADIN-France) and has been tested for its usefulness for smaller domains here. On the other hand the evaluation of the non-hydrostatic dynamics at very high resolution continued, and therefore the switch to cycle 25T1 of ALADIN had first priority.

The Orography :

The fact that precipitation fields in mountainous areas have a strong tendency of becoming stranger and stranger with increased resolution led to the idea to find a more proper description of the orography, which was mainly meant to be the main cause for the "chaotic" structure of the fields.

Based on the new spectral cost function developed in Toulouse for the optimization of orography, it was tried to test the usefulness for small domains and the impact on the forecasted fields. Different weights are put to different wavenumbers to damp out the smallest wavenumbers, hence smoother orography is obtained.

The tests were done on small domains in the Alps with 2.5 km resolution on MAP-cases. The sizes of the domains did not exceed 100x100 points.

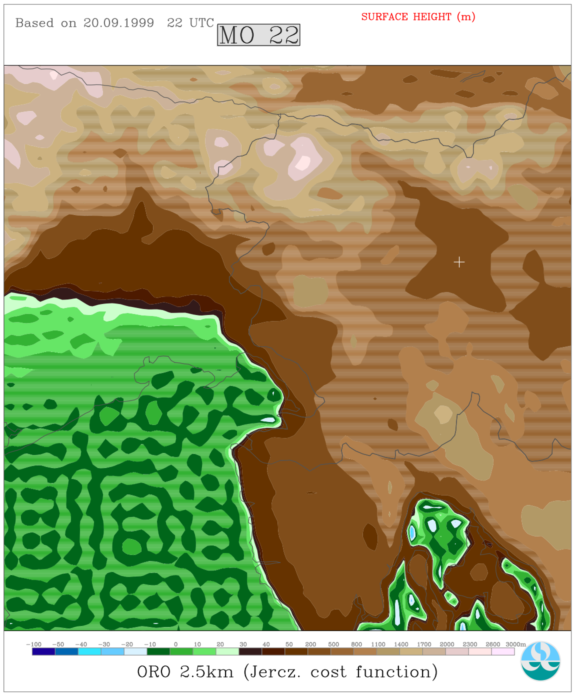
Figure 1 shows an example of the orography that was obtained by using the often used "Jerczinsky" cost function, while in Figure 2 spectral smoothing was applied additionally. The spectral cost function has two independent tuning parameters, which means that the shown orography is just one possibility how the orography could be modified. In this case the differences to the original orography are rather big, to enable a clear illustration of the impact in this example.

The corresponding precipitation forecasts can be seen in Figures 3 and 4. It is not hard to recognize the dramatic impact of the "new" orography on the resulting precipitation field. The loss of "accurate" information about the orography has the expected positive influence on the precipitation field (smoother field and reduced peak amounts). On the other hand one has to expect that other fields (like horizontal wind) become less accurate. The real loss on other meteorological information has to be checked in detail, but as a preliminary result it can be stated that the gain for precipitation might compensate the rather small losses for the other surface fields. This is valid, if a rather balanced way of applying the spectral cost function is done in order not to destroy relevant and realistic meteorological information.

The trial of using a spectral smoothing can be seen as a prolongation of the tests performed with keeping a "quadratic" spectral truncation for the orography, while calculating the other fields with a "linear" spectral resolution, which more or less follows the same idea. The spectral smoothing provides one more degree of freedom and allows some finer tuning, while in the former approach the truncation of the wavenumber for orography was restricted to a single value.

The tests were performed with cycle 12, but spectral smoothing will also be included in the more recent cycles. (see the mail from Dominique Giard)

<u>Caution</u>: The spectral cost function is very sensitive to the domain characteristics (mainly the shape and height of the mountains inside it) and the coefficients have to be tuned individually and carefully, because if this is not done it is even possible to get some undesirable effects.



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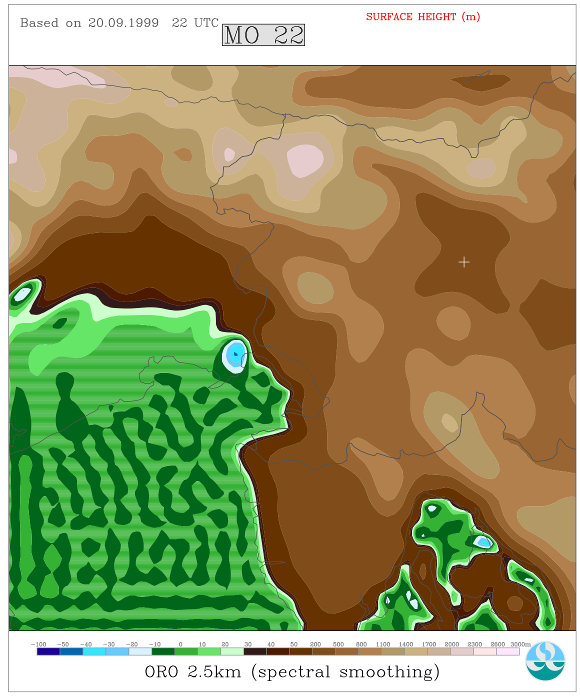

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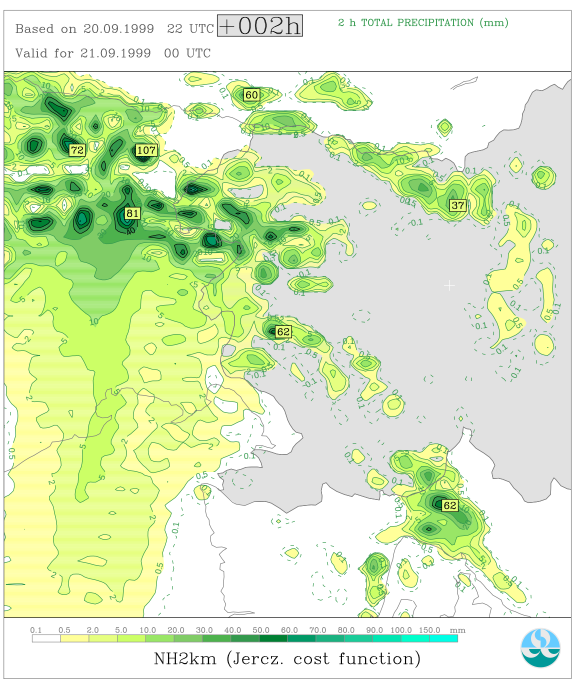
Figure 1 : Orography on 2.5 km resolution - applying the Jerczinsky cost function

Figure 2 : Orography on 2.5 km resolution - additional introduction of a spectral cost function



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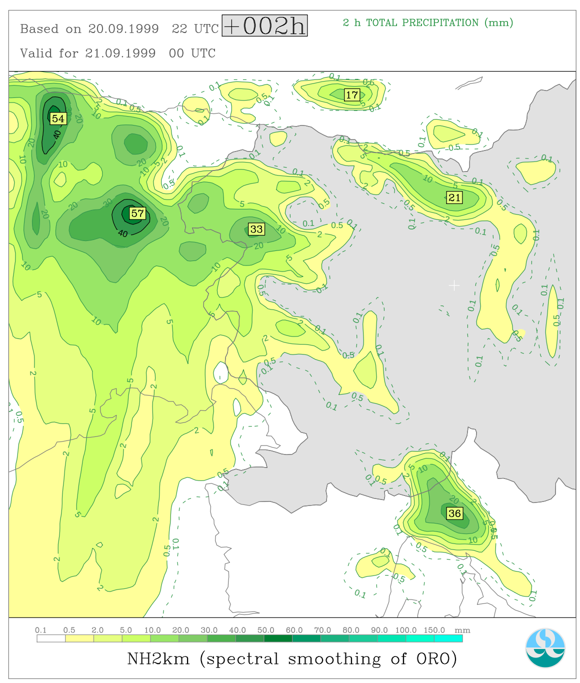

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Figure 3: 2.5 km resolution; NH-dynamics (3TL-SL) ; 30 s time-step; cycle AL12; 2 hours precipitation forecast using the orography shown in Figure 1

Figure 4: 2.5 km resolution; NH-dynamics (3TL-SL) ; 30 s time-step; cycle AL12; 2 hours precipitation forecast using the orography shown in Figure 2

Running NH with AL25 :

Due to the progress in NH developments, that entered cycle 25T1, the decision was made to switch as soon as possible to this Cycle in Ljubljana. Thanks to Jure Jerman this was possible within a very short time and some experiments have been performed already. Please notice that the orography used in these experiments is the "standard" one, hence the fields itself aren't looking too nice, but the focus here is put on the differences concerning the various options for dynamics.

Figures 5 and 6 show 8h-10h precipitation forecasts on a domain with 5 km resolution (the pictures are a zoom of the whole domain to make them comparable with the following ones at a resolution of 2.5 km). Figure 5 is the hydrostatic run while Figure 6 shows the NH counterpart. The forecasted fields are very similar and introducing non-hydrostatism doesn't have a big influence on the forecasted precipitation field in this case .

In figures 7 and 8 the same forecasts at 2.5 km resolution can be seen. It is obvious that there is a remarkable difference if compared to the former figures. The non-hydrostatic dynamics leads to an extended precipitation field and additionally increases the peak values.

Figures 9 and 10 show differences in the forecast of the 850 hPa temperature field. In figure 9 the 2.5 km NH-model was run from different coupling files: first directly from the ALADIN-LACE forecast and second from the 5 km hydrostatic run, while in figure 10 the shown differences are purely due to the dynamics (the coupling is done from the 5 km hydrostatic run for both the hydrostatic and the non-hydrostatic 2.5 km runs).

It is noticeable that the difference in resolution of the coupling files causes bigger differences in the forecasted fields. It should be mentioned that the differences for the different dynamics became bigger compared to cycle 12. It follows that the recent developments in NH dynamics that entered cycle 25T1 have a significant impact on the forecasted fields. Unfortunately the influence of the resolution of the coupling files still dominates. Therefore the problem of a straightforward comparison of NH and H dynamics and of identifying advantages and disadvantages still remains.

Further it should be mentioned that the use of 5 km resolution NH coupling files for the 2.5 km NH run additionally leads to differences in the forecasts, although the magnitude is small compared to the previously depicted ones.

Up to now the results for finding the optimal nesting chain indicate that down to ~ 5 km the non-hydrostatism doesn't seem to play that important role compared to higher resolutions, though other cases with different meteorological situations will be examined to generalise this result.

At higher resolution NH seems to become much more different from the hydrostatic model. This would mean that just the best choice of the resolution of the coupling files remains an open question.

The work in the near future will be dedicated to try to find conclusive results concerning the prove of the theoretical confirmed necessity of NH for practical forecasts and the corresponding resolution, where NH should be introduced. The other topic is the trial to somehow quantify the impact of the resolution of the coupling files in order to find the optimal nesting strategy.

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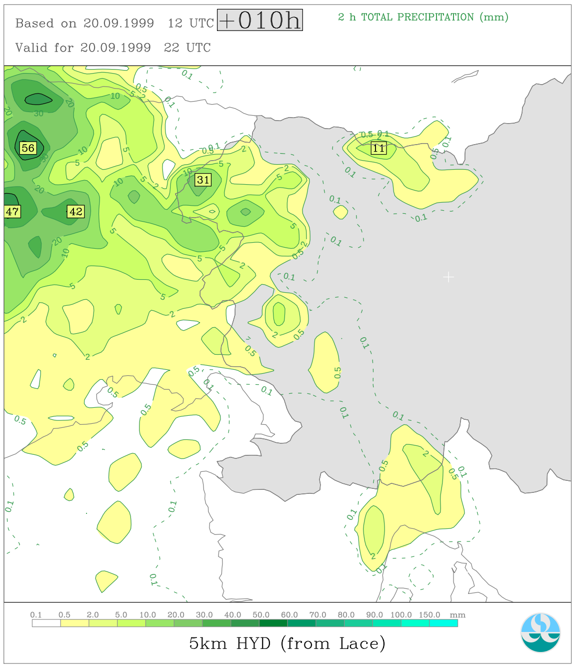

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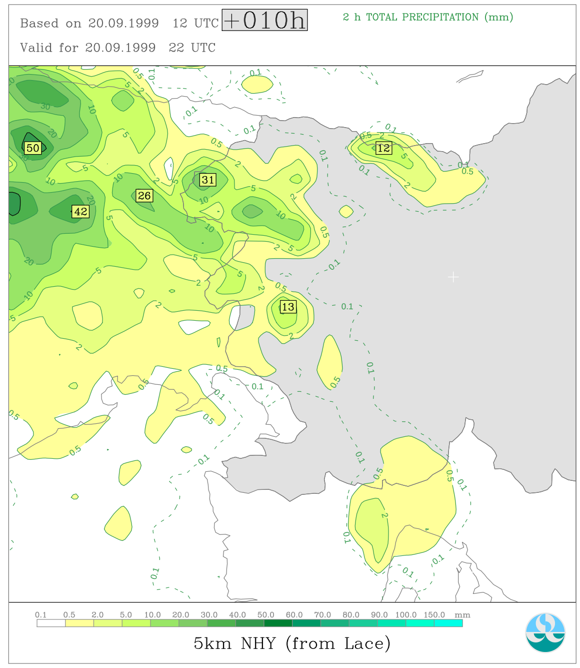

Figure 5 : 5 km resolution; H-dynamics (2TL-SL) ; 60 s time-step; cycle AL25T1; 2 hours precipitation forecast, from +8 h to +10 h - coupled from LACE

Figure 6 : 5 km resolution; NH-dynamics (3TL-SL) ; 60 s time-step; cycle AL25T1; 2 hours precipitation forecast, from +8 h to +10 h - coupled from LACE

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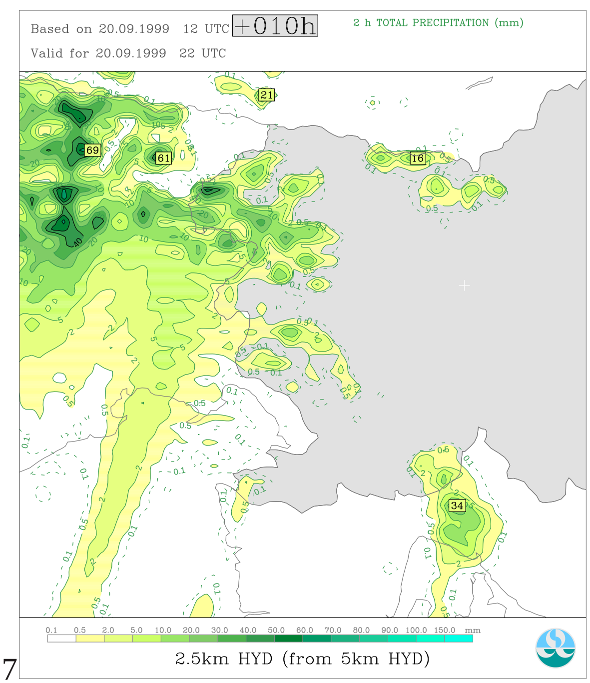

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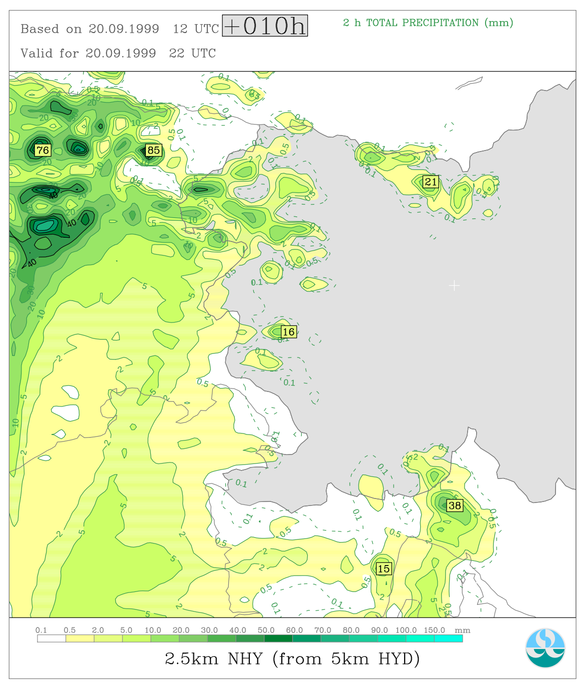

Figure 7: 2.5 km resolution; H-dynamics (3TL-SL); 30 s time-step; cycle AL25T1; 2 hours precipitation forecast, from +8 h to +10 h - coupled from 5 km hydrostatic run

Figure 8: 2.5 km resolution; NH-dynamics (3TL-SL); 30 s time-step; cycle AL25T1; 2 hours precipitation forecast, from +8 h to +10 h - coupled from 5 km hydrostatic run

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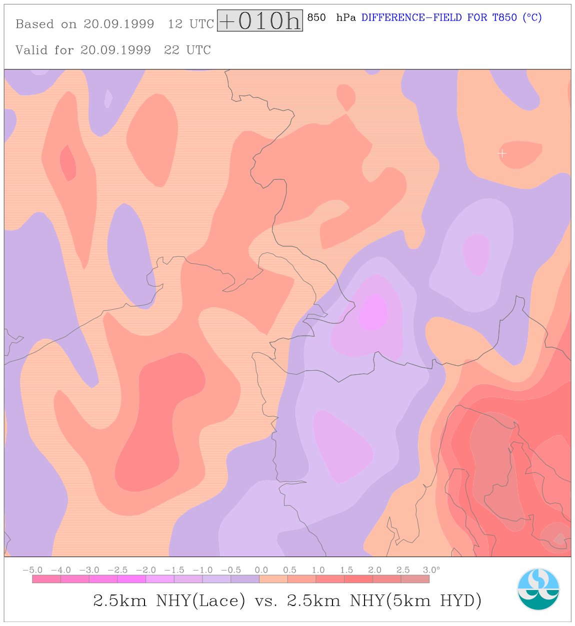

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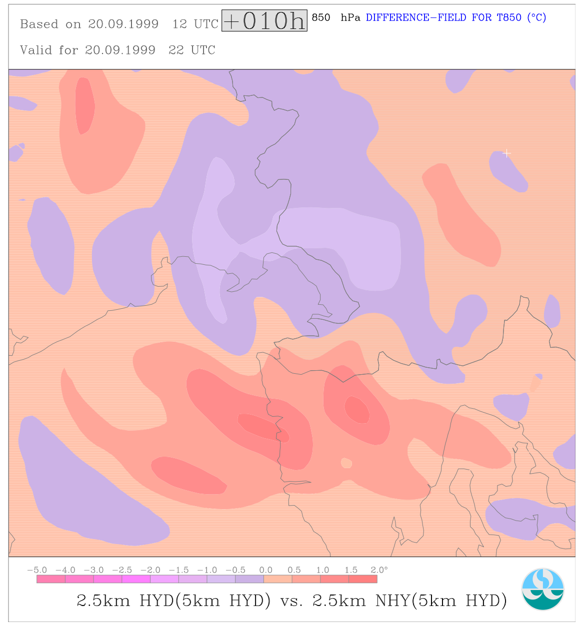

Figure 9 : 2.5 km resolution; NH-dynamics (3TL-SL) ; 30 s time-step; cycle AL25T1; difference in the 10h forecasts of the 850 hPa temperature field between different resolutions of the coupling files (LACE versus 5 km, H)

Figure10: 2.5 km resolution; coupled from 5 km H run ; 30 s time-step; cycle AL25T1; difference in the 10h forecasts of the 850 hPa temperature field between different dynamics (NH and H-dynamics respectively, 3TL-SL)

11. Malgorzata SZCZECH-GAJEWSKA : "Use of IASI / AIRS observations over land"

Nothing new (operational tasks in Cracow).

12. Jozef VIVODA: "Application of the predictor-corrector method to non-hydrostatic dynamics"

Semi-implicit scheme with non-isothermal reference temperature

1. Introduction

There are three main sources of instability in the non-hydrostatic ALADIN model.

- pressure instability

  This is a weak instability due to fact that the model surface pressure differs from the reference surface pressure. The instability can be fully eliminated using correct prognostic variables ($ln(\pi_s)$ and one of $ln(p/\pi)$ or $(p-\pi)/\pi$) and σ vertical coordinate.

- thermal instability

  This instability is caused by the fact that the actual temperature varies from the reference isothermal temperature. It is apparent that full elimination for real atmospheric states is impossible because atmosphere is not isothermal. To pacify this instability in non-hydrostatic model, iterative temporal schemes have been implemented (predictor-corrector schemes).

- instability due to orography

  In spectral models, it is impossible to include orography into the reference state, because the Helmholtz solver has to be linear with constant coefficients. Orography is therefore not represented in the semi-implicit calculations. The signals from the orographic forcing are treated explicitly, if classical semi-implicit approach is used. This is not sufficient for high resolution NH models like ALADIN. Implicit treatment of the signals has to be assured by iterative temporal schemes (predictor-corrector schemes).

In real cases over areas with complex orography both critical instabilities are present, the thermal instability and the orographic one. It is not possible to separate them and to determine which kind of instability is more relevant for a given situation.

We found that the two-time-level predictor-corrector scheme is sufficient and it pacifies both kind of instabilities, with three iterations at least to achieve sufficient robustness, though we expected that one iteration would be sufficient. We could not claim which kind of instability is responsible for such behaviour.

This contribution deals with the elimination of thermal instability. A non-isothermal reference temperature is considered and consequently a new linear model is derived, for the purpose of semi-implicit calculations. According to linear analyses of stability the introduction of a non-isothermal reference temperature is sufficient to pacify the thermal instability. Structure equation is derived to determine constraints for linear vertical operators analogous to those defined in Bubnova et al., 1995.

2. Linear continuous system with non-isothermal reference temperature

An isothermal reference temperature T^* is implemented in the ALADIN model. To pacify thermal instability we assume a non-isothermal reference temperature $T^*(\eta)$. All other reference quantities remain unchanged. The reference state is considered to be at rest ($D^*= 0$, $w^* = 0$), hydrostatically balanced ($\pi^* = p^*$), with no orography ($\phi_s^* = const$) and horizontally constant ($\nabla X^* = 0$).

We apply a linearization procedure, assuming small departures from reference state. In the following, the departures are substituted by full prognostic quantities. This can be done due to the precisely chosen reference state.

For the purpose of better understanding we generalize vertical operators defined in Bubnova et al., 1995. Operators are applied on prognostic variables (X) :

$$\begin{aligned}
\mathbf{G}^* X &= \int_{\eta}^{1} \frac{m^*}{\pi^*} X\, d\eta \\
\mathbf{N}^* X &= \frac{1}{\pi_s^*} \int_{0}^{1} m^* X\, d\eta \\
\mathbf{S}^* X &= \frac{1}{\pi^*} \int_{0}^{\eta} m^* X\, d\eta \\
\mathbf{L}^* X &= \partial^* (\partial^* + 1) X
\end{aligned} \tag{1}$$

with $\partial^* X = (\pi^*/m^*)\, \partial X/\partial\eta$. We define two new operators $\mathbf{A}^*$ and Ψ^* as :

$$\begin{aligned}
\psi^* X &= \mathbf{G}^* T^* X = \int_{\eta}^{1} \frac{m^* T^*}{\pi^*} X\, d\eta \\
\mathbf{A}^* X &= \mathbf{G}^* \frac{\partial T^*}{\partial \pi^*} X = \int_{\eta}^{1} \frac{m^*}{\pi^*} \cdot \frac{\partial T^*}{\partial \pi^*} X\, d\eta
\end{aligned} \tag{2}$$

We start from the system formulated with temperature (T), horizontal divergence (D), hydrostatic surface pressure (π_s), rescaled pressure departure ($\mathcal{P}_0 = (p-\pi)/\pi^*$) and pseudo vertical divergence ($d_0 = -g\, \pi^*/(m^* R T^*)\, \partial w/\partial\eta$) as prognostic variables. If we use instead of d_0 and $\mathcal{P}_0$ other "non-hydrostatic" prognostic variables based on the pressure departure ($p-\pi$) and the vertical divergence ($\partial w/\partial\eta$), then the set of linearized equations would not change and the presented results would be the same.

Applying the linearization procedure, we get linearized model equations :

$$\begin{aligned}
\frac{\partial D}{\partial t} &= -R\mathbf{G}^* \Delta T + R\psi^* \Delta\mathcal{P}_0 - RT^* \Delta\mathcal{P}_0 - R\frac{RT_s^*}{\pi_s^*}\Delta\pi_s + R\mathbf{A}^* \Delta\pi - \Delta\phi \\
\frac{\partial T}{\partial t} &= -\frac{RT^*}{C_v}(D + d_0) - \left(m^* \frac{d\eta}{dt}\right)\frac{\partial T^*}{\partial \pi^*} \\
\frac{\partial \pi_s}{\partial t} &= -\pi_s^* \mathbf{N}^* D \\
\frac{\partial \mathcal{P}_0}{\partial t} &= \mathbf{S}^* D - \frac{C_p}{C_v}(D + d_0) \\
\frac{\partial d_0}{\partial t} &= -\frac{g^2}{RT^*}\mathbf{L}^* \mathcal{P}_0
\end{aligned} \tag{3}$$

The term : $(m^* d\eta/dt)\, \partial T^*/\partial\pi^*$ represents the vertical advection of reference temperature (T^*). It can be expressed in terms of prognostic variables as :

$$\left(m^* \frac{d\eta}{dt}\right)\frac{\partial T^*}{\partial \pi^*} = -\frac{\partial T^*}{\partial \pi^*}(B\pi_s^* \mathbf{N}^* D - \pi^* \mathbf{S}^* D) \tag{4}$$

We want to eliminate from our linearized system of equations to get a structure equation. We apply operator $\partial/\partial t$ on prognostic equations for D and d_0, and then we eliminate variables T, π_s and $\mathcal{P}_0$ from our system. We get after some manipulations :

$$\frac{\partial^2 D}{\partial t^2} = -R\mathbf{G}^* \cdot \Delta\left[-\frac{RT^*}{C_v}(D+d_0) - \frac{\partial T^*}{\partial \pi^*}(B\pi_s^* \mathbf{N}^* D - \pi^* \mathbf{S}^* D)\right]$$

$$+R\psi^* \cdot \Delta\left[\mathbf{S}^* D - \frac{C_p}{C_v}(D+d_0)\right] - RT^* \cdot \Delta\left[\mathbf{S}^* D - \frac{C_p}{C_v}(D+d_0)\right]$$

$$-\frac{RT_s^*}{\pi_s^*} \cdot \Delta\left[-\pi_s^* \mathbf{N}^* D\right] + RA^* B \cdot \Delta\left[-\pi_s^* \mathbf{N}^* D\right] \tag{5}$$

$$\frac{\partial^2 d_0}{\partial t^2} = -\frac{g^2}{RT^*} \cdot \mathbf{L}^* \left[\mathbf{S}^* D - \frac{C_p}{C_v}(D+d_0)\right]$$

The equations can be further simplified using relationships between vertical operators :

$$\mathbf{S}^* \psi^* X = \psi^* X + \mathbf{S}^* T^* X$$
$$\mathbf{G}^* T^* X = \psi^* X \tag{6}$$
$$\mathbf{G}^* \frac{\partial T^*}{\partial \pi^*} X = \mathbf{A}^* X$$

and the generalized constraint (called C1 in Bubnova et al., 1995)

$$\text{C1:} \qquad -\mathbf{A}^* \pi^* \mathbf{S}^* X + T_s^* \mathbf{N}^* X - T^* \mathbf{S}^* X + \psi^* \mathbf{S}^* X = 0 \tag{7}$$

After simplification we get the set of equations :

$$\left(\frac{\partial^2}{\partial t^2} - \frac{C_p}{C_v} RT^* \Delta\right) D = \left(-R\psi^* \Delta + \frac{C_p}{C_v} RT^* \Delta\right) d_0$$

$$\left(\frac{\partial^2}{\partial t^2} - \frac{g^2}{RT^*} \cdot \frac{C_p}{C_v} \mathbf{L}^*\right) d_0 = +\frac{g^2}{RT^*} \cdot \mathbf{L}^* \left(-\mathbf{S}^* + \frac{C_p}{C_v}\right) D \tag{8}$$

We could further define vertically dependent Laplacian speed of sound $c^2(\eta) = C_p/C_v \cdot RT^*$ and vertically dependent scale height $H(\eta) = RT^*/g$ and rewrite equations to get a more known form :

$$\left(\frac{\partial^2}{\partial t^2} - c^2 \Delta\right) D = \left(-R\psi^* + c^2\right) \Delta d_0$$

$$\left(\frac{\partial^2}{\partial t^2} - \frac{c^2}{H^2} \mathbf{L}^*\right) d_0 = +\frac{g}{H} \cdot \mathbf{L}^* \left(-\mathbf{S}^* + \frac{c^2}{gH}\right) D \tag{9}$$

No further elimination of variables is possible if c and H are vertically dependent. To get a structure equation average values of c and H are usually considered (Miller, 1987). This has no meaning for our purpose since it would lead to the same solution as with an isothermal reference state (the non-isothermal temperature profile would be replaced by an isothermal average temperature).

To get the solution we have to solve simultaneously the two equations (9).

We did not find an equivalent of the constraint C2 from Bubnova et al., 1995, due to fact that further elimination was not possible. One constraint C1 has been found only.

The linear Helmholtz equation for semi-implicit adjustment cannot be eliminated to one variable in the continuous context as well.

3. Linear discrete system with non-isothermal reference temperature

Our continuous domain is divided into L discrete vertical layers. Full levels are defined inside the layers (denoted as *l*, *l = 1, 2, 3,..., L*) and half levels are boundaries between layers (denoted as *l'*, *l'= 0, 1, 2, 3,..., L*).

When going from the vertically continuous to the vertically discrete case we go through the following steps (Bubnova et al., 1995) :

1. definition of discrete analogous of vertical operators with unknown vertically dependent variables
   - layer pressure thickness, $\delta\pi^*$
   - layer log-pressure thickness, δ^*
   - shift from top half-level of layer to its full level, β^*
   - shift from bottom half-level of layer to its full level, α^*

   All variables are full-level quantities. The main problem of vertical discretisation is to determine the above-mentioned unknown thicknesses and shifts.

   New problem is whether $T^*(\eta)$ shall be a full-level or half-level quantity, because T^* and its vertical derivative shall be both full-level quantities due to the new operators $\mathbf{A}^*$ and Ψ^* :

$$(\psi^* X)_l = [\sum_{k=l+1}^{L} \delta_k^* T_k^* X_k + \alpha_l^* T_l^* X_l \;]$$

$$(\mathbf{A}^* X)_l = [\sum_{k=l+1}^{L} \delta_k^* (\frac{\partial T^*}{\partial \pi_s})_k X_k + \alpha_l^* (\frac{\partial T^*}{\partial \pi_s})_l X_l \;] \tag{10}$$

   We decided to put T^* on half levels. The vertical derivative of T^* is then naturally a full-level quantity. Full-level T_l^* is then interpolated from half levels using the relationship :

$$T_l^* = (1 - \frac{\alpha_l^*}{\delta_l^*}) T_{l'}^* + \frac{\alpha_l^*}{\delta_l^*} T_{l'-1}^* \tag{11}$$

2. discretization of the linear continuous system using discrete vertical operators
3. elimination to get a discrete analogous of (9).

   This is possible only if the discrete operators satisfy the discrete equivalent of constraint C1. But there are more unknowns than degrees of freedom in problem C1. Therefore we are not able to determine analytically all the unknown variables. This is not valid for the isothermal problem where also constraint C2 has to be fulfilled and the problem is over-determined.

   We looked for a solution using the software package *Mathematica*. We did not find any reasonable analytical solution to the full problem defined by constraint C1, even with 5 layers, which is the minimum number of layers to describe the full problem. Therefore we had to further linearize constraint C1 around average reference temperature. For this simplified C1, we've got solution of thicknesses and shifts exactly the same as for isothermal case. Therefore we decided to adopt the complete solution of unknown variables from Bubnova, 1995. The adopted thicknesses and shifts are first-order approximations of the analytical solution to the full non-isothermal constraint C1 (7).

As we already mentioned, full elimination of variables is not possible if a non-isothermal reference temperature is assumed. This becomes valid for discrete systems as well. The linear semi-implicit solver with minimum dimension 2L has to be solved in spectral space for each wavenumber (in isothermal case it is a linear problem with dimension L). So, semi-implicit scheme with non-isothermal reference state is less effective than existing scheme with isothermal reference state.

4. Practical implementation and idealized experiments with 2d plane version of NH ALADIN

Our main aim was to assess the importance of thermal instability for non-isothermal flows over orography. Implementing a non-isothermal reference state we could pacify thermal instability and study orographic instability that is the only one remaining.

We implemented semi-implicit scheme in such a way that we solve in spectral space the full linear system (3), with dimension 4L+1 for each wavenumber.

We have run the set of idealized experiments with the 2d plane NH version of ALADIN. We studied the importance of the thermal instability for idealized flows with various degrees of nonlinearity.

We simulated idealized flows over an Agnesi-shape obstacle defined by its height H_a and half-length L_a. The flow is vertically constant with wind speed V and the temperature profile is determined by temperature T_s and constant Brunt-Vaisala frequency N. The character of the flow depends on its :

1. linearity

   It is measured by non-dimensional number $C_L = N\, H_a\, /\, V$. Flow is linear if $C_L << 1$. The flows with $C_L \approx 1$ are very nonlinear. Linearity can be controlled by obstacle height.

2. hydrostaticity

   The measure of hydrostatism of the flow is dimensionless number $C_H = V\, /\, N\, L_a$. Only flows with $C_H << 1$ are considered to be hydrostatic. Hydrostatism can be controlled by the half-width of the obstacle.

The integration has been performed for various CFL ($CFL = k_{max} V \cdot \Delta t$) criteria. All the tests were run with isothermal and then with non-isothermal reference state.

All the following results are for non-hydrostatic flow regime with $C_H = 1$ ($V = 10\ ms^{-1}$, $N = 0.01\ s^{-1}$ and $L_a = 1000\ m$). Horizontal mesh size was $dx = 200\ m$, number of vertical levels : 120, with a sponge applied on the 60 top levels.

Each experiment runs for n time-steps of length Δt. The length of integration was measured by dimensionless length of integration $t = V \cdot \Delta t \cdot n / L_a$, which represents length of average particle trajectory rescaled by horizontal half-width of Agnesi obstacle. Each experiment has been considered to be stable of integration finished at $t = 50$. This approach allows us to compare correctly integrations with various CFL. $t < 50$ means that the integration was unstable and it stopped earlier with an error.

4.1 Experiments with 2TL SL SI scheme with isothermal and non-isothermal reference state

The results in the tables hereafter were obtained using two-time-level semi-Lagrangian semi-implicit scheme. t is shown in the tables as a function of linearity of flow and used CFL.

From the table on the left we see that it is impossible to integrate stably non-isothermal idealized test with 2TL SL isothermal SI scheme ($T^* = 220\ K$). Already very linear flow regimes with small CFL are very unstable.

The table on the right shows that with 2TL SL non-isothermal SI scheme we can run stably linear cases (with maximum $C_L \approx 0.2$). We impose the reference temperature profile to be exactly the same as the actual temperature profile ($T_s^* = 293\ K$ with $N = 0.01\ s^{-1}$). There was no thermal instability in experiments. The orographic instability is therefore the primary reason for model instability.

2TL SL Isothermal SI scheme						
	Linearity					
CFL	1	0.8	0.6	0.4	0.2	0.1
3	2	2	2	2	2	2
2	2	2	2	2	2	2
1.5	2	2	2	2	2	2
1	2	2	2	2	2	2
0.75	2	2	2	2	2	2
0.25	1	1	1	1	1	1

2TL SL Non-isothermal SI scheme						
	Linearity					
CFL	1	0.8	0.6	0.4	0.2	0.1
3	2	2	2	2	8	10
2	2	2	2	2	**50**	**50**
1.5	2	2	2	4	**50**	**50**
1	2	2	2	4	**50**	**50**
0.75	2	2	2	4	**50**	**50**
0.25	1	1	1	**50**	**50**	**50**

4.2 Experiments with 2TL SL PC scheme with isothermal and non-isothermal reference state

We further study stability properties of 2TL SL predictor-corrector scheme with isothermal and non-isothermal reference state. In the following tables the dimensionless integration length is presented for scheme with one corrector.

2TL SL Isothermal PC scheme						
	Linearity					
CFL	1	0.8	0.6	0.4	0.2	0.1
3	5	6	8	9	12	14
2	5	6	8	28	34	35
1.5	5	6	8	**50**	**50**	**50**
1	5	6	8	**50**	**50**	**50**
0.75	5	6	**50**	**50**	**50**	**50**
0.25	**50**	**50**	**50**	**50**	**50**	**50**

2TL SL Non-isothermal PC scheme						
	Linearity					
CFL	1	0.8	0.6	0.4	0.2	0.1
3	x	x	x	x	x	x
2	x	x	x	28	34	35
1.5	x	x	x	**50**	**50**	**50**
1	x	x	8	**50**	**50**	**50**
0.75	4	6	**50**	**50**	**50**	**50**
0.25	**50**	**50**	**50**	**50**	**50**	**50**

The table on the left shows results for PC scheme based on isothermal reference state. Scheme with one corrector is sufficiently robust for tests with very small *CFL* ($CFL \leq 0.25$). Linear flows are stabilized for $CFL \leq 1.5$.

The table on the right is for PC scheme with non-isothermal reference state. "x" means that experiment has not been performed, since we expected the same results as for isothermal PC scheme. We see that the "island" of stability is the same as for isothermal PC scheme. Taking into account the fact that the thermal instability has not been present in experiments, we showed that orographic instability is the main source of model instability and the assumption of reference state non-isothermality doesn't improve the speed of PC scheme convergence.

5. Summary

In the present article we dealt with the introduction of a non-isothermal reference state into the semi-implicit part of the NH ALADIN model.

We found that it is analytically impossible to eliminate structure equation for single variable. Instead, the vertical modes have to be analysed by simultaneous solution of two linear differential equations.

We adopt the same discretisation methodology as in Bubnova et al., 1995. We found that discrete integral constraint C1 has no analytical solution for unknown layers thicknesses and shifts. Therefore we expand C1 around average temperature of non-isothermal profile. We get the same solution for unknowns as in Bubnova, 1995.

We found that there is no analogical constraint to C2, present in isothermal case (Bubnova, 1995). Therefore the problem in non-isothermal case is under-determined. To avoid this we fully adopt the solution from Bubnova, 1995.

Experimentally we found that the thermal instability plays minor role in unstable behaviour of 2TL schemes for NH ALADIN model. The orographic instability prevails for flows with $C_L \geq 0.4$. In operational model we could expect $C_L \approx 1$ (we consider atmospheric stability $N = 0.02\ s^{-1}$, wind speed $V = 20\ ms^{-1}$ and average height of obstacles $H_a = 1000\ m$). Therefore the 2TL non-iterative schemes based on a non-isothermal semi-implicit reference state cannot be exploited operationally in NH ALADIN model.

The thermal instability is important only for linear flows.

The speed of convergence of 2TL SL PC scheme is still a crucial issue to make it competitive with 3TL SL scheme. We found that introducing a non-isothermal reference state doesn't influence the speed of convergence.

We found out that the question of isothermality or non-isothermality of the reference flow is not important since it influences the thermal instability only. The best solution would be introduction of orography into the semi-implicit reference state $\phi_s{}^* = \phi_s$, but this is unfortunately impossible in a spectral model.

To solve orographic instability in 2TL schemes, we have two different approaches:

1. to move semi-implicit calculations from spectral space into gridpoint space and to include orography into the reference state. This would lead to a very complex semi-implicit problem that would have to be solved iteratively. Due to spectral calculations of horizontal derivatives, this approach would be very expensive. Such a solution is adopted for example in new UK Met' Office model.
2. to adopt an iterative scheme with existing isothermal semi-implicit solver as a kernel. This solution is currently implemented in ALADIN NH.

Analysis and ALADIN prediction of a heavy precipitation event on the Eastern side of the Alps during MAP IOP 5

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During the Mesoscale Alpine Program - Intensive Observing Period 5 (MAP IOP 5) heavy precipitation occurred in the early morning of 4 October 1999 along the border between Slovenia and western Croatia. Orographic influence on convectively unstable air advected by the warm and humid current from the Mediterranean caused a large amount of rain. The existing frontal zone was modified by the convergence between the southerly winds associated with the Alpine lee cyclogenesis, and the northerly flow around the eastern flank of the Alps after a splitting process in the north Alpine orographic blocking.

For special MAP IOP5 soundings, observations were made at 3- or 6-hourly time intervals, while prognostic TEMPs on the direct ALADIN/LACE mesoscale model output at every 3 hour were taken for Ljubljana, Udine and Zagreb. These datasets were used as the input data for objectively derived vertical/time cross-sections indicating both the observed and predicted atmospheric structure and its temporal changes at considered localities (Figs. 1 and 2). The diagnostic procedure was based on the HRID model (High Resolution Isentropic Diagnosis).

The analysis of the low tropospheric structure offers an explanation of this extraordinary case with a rapid frontal and orographic development. The basic features are:

1. the strong vertical wind shear and pronounced convective instability ahead of the front;
2. the very high humidity concentration inside the frontal zone;
3. a typical bora layer covered by temperature inversion after the frontal passage, and
4. a layer characterized by a weakening wind system above the temperature inversion

The latest process inhibits the vertical growth of convective clouds. Consequently, the observations of hourly precipitation amount in Zagreb and its surroundings show gradual decrease and, finally, cessation of rainfall.

It is shown that the ALADIN/LACE model and its application by HRID were able to predict the essential features of these phenomena with high reliability as well as their usefulness and applicability in making local forecasts and nowcasting.

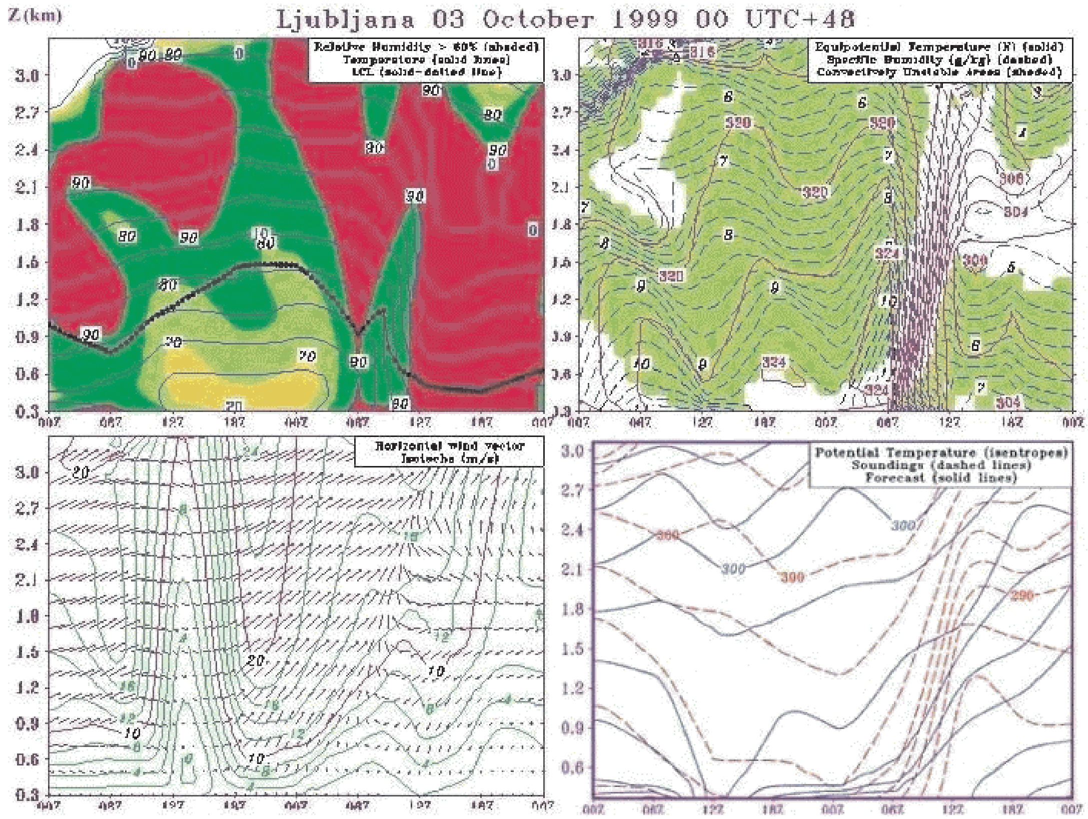

Figure 1: HRID composite vertical/time cross-sections for Ljubljana

3 October 1999, 00 UTC - 5 October 1999, 00 UTC based on 6-hourly soundings observations.

a) relative humidity > 60 % (shaded), temperature (°C, solid lines) and lifting condensation level (LCL line, dotted);

b) equipotential temperature (K, solid lines), specific humidity (g/kg, dashed lines), convective unstable areas (shaded);

c) ALADIN/LACE forecast of horizontal wind vector and isotachs (m/s);

d) potential temperature (isentropes): soundings (dashed lines) versus ALADIN forecast (solid lines).

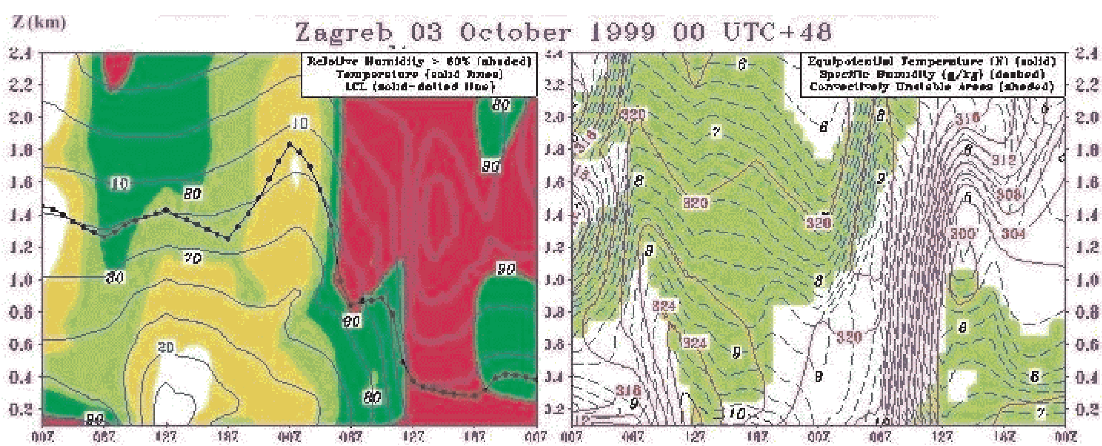

Figure 2: HRID composite vertical/time cross-sections for Zagreb

3 October 1999, 00 UTC - 5 October 1999, 00 UTC based on 3-hourly soundings observations.

a) relative humidity >60% (shaded), temperature (°C, solid lines) and LCL line (dotted);

b) equipotential temperature (K, solid lines), specific humidity (g/kg, dashed lines), convectively unstable area (shaded).

Impact of the assimilation of MSG/SEVIRI geostationary radiances in a mesoscale NWP model : preliminary 1d-var studies

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Météo-France/CNRM/GMAP

1. Introduction

In the context of high-resolution weather forecasting, the high horizontal and temporal resolutions of measurements performed by geostationary satellites are an asset compared to polar satellites, despite their weaker spectral and vertical resolutions. At the beginning of summer 2003, the SEVIRI radiometer onboard MSG (Meteosat Second Generation) will provide a complete set of radiance observations in the visible and infrared spectrum every 15 mn with an approximate spatial resolution of 3 km over Europe. Those measurements therefore seem to be particularly well adapted for weather prediction at convective scales, since they allow continuous access to information about the variation rates of temperature and humidity fields in space and time.

In order to quantify the impact of the assimilation of SEVIRI radiances in the analysis of the vertical distribution of those meteorological quantities, a 1d-var method has been adapted from Rabier et al. (2001) and applied on two different datasets. The first one is made of radiances which have been simulated using the radiative transfer model RTTOV-7 (Saunders et al., 1999) from an ALADIN analysis, and the second one is composed of real radiances observed by the 5 channels of the MODIS radiometer whose spectral responses are comparable to SEVIRI ones. After a presentation of the experimental framework in section 2, the results of these two different studies are exposed respectively in sections 3 and 4.

2. Experimental framework

The analysis $\mathbf{x^a}$ represents the atmospheric state which is the best fit between the background $\mathbf{x^b}$ and the available observed radiances stored in the $\mathbf{y}$ vector. In this nonlinear 1d-var method, $\mathbf{x^a}$ and $\mathbf{x^b}$ are made of vertical profiles of temperature, specific humidity and ozone. $\mathbf{x^a}$ minimizes the following cost-function :

$$J(\mathrm{x}) = (\mathbf{x} - \mathbf{x^b})^{\mathrm{T}}\, \mathbf{B}^{-1}\, (\mathbf{x} - \mathbf{x^b}) + (\mathbf{y} - H(\mathbf{x}))^{\mathrm{T}}\, \mathbf{R}^{-1}\, (\mathbf{y} - H(\mathbf{x}))$$

where $\mathbf{B}$ is the background covariance error matrix used by the ECMWF global model, $\mathbf{R}$ the observation covariance error matrix and H the observation operator which makes the link between the model and observation spaces. In this study, H is composed of the radiative transfer model RTTOV-7 and of a vertical interpolation operator allowing to interpolate fields from the model to RTTOV-7 vertical levels.

$\mathbf{x^a}$ is the optimal unbiased estimate of the true state $\mathbf{x^t}$: $\mathbf{x^t}$: $\mathbf{x^a} = \mathbf{x^t} + \alpha$, where α denotes the analysis error that follows a probability distribution with a covariance matrix $\mathbf{A}$ given by :

$$\mathbf{A}^{-1} = \mathbf{B}^{-1} + \mathbf{H}^{\mathrm{T}}\, \mathbf{R}^{-1}\, \mathbf{H}$$

where $\mathbf{H}$ is the matrix associated with the tangent linear of the observation operator H.

3. Simulated SEVIRI radiances

This 1d-var analysis has been used to infer the information content of simulated infrared radiances coming from 8 SEVIRI channels. These 8 channels cover the 3.9 - 13.4 μm spectrum and include two channels in the water vapour absorption spectrum that allow to sense a broad layer in the middle troposphere (Fig. 1). Since real SEVIRI observations are not yet available, the radiances stored in $\mathbf{y}$ have been simulated from a vertical profile located in a cloud-free area of an ALADIN analysis, which represents the true state $\mathbf{x^t}$, and a Gaussian centred random noise ε : $\mathbf{y} = H(\mathbf{x^t}) + \varepsilon$. The background $\mathbf{x^b}$ is the sum of the true state $\mathbf{x^t}$ and a centred random noise β with $\mathbf{B}$ covariance : $\mathbf{x^b}=\mathbf{x^t}+\beta$

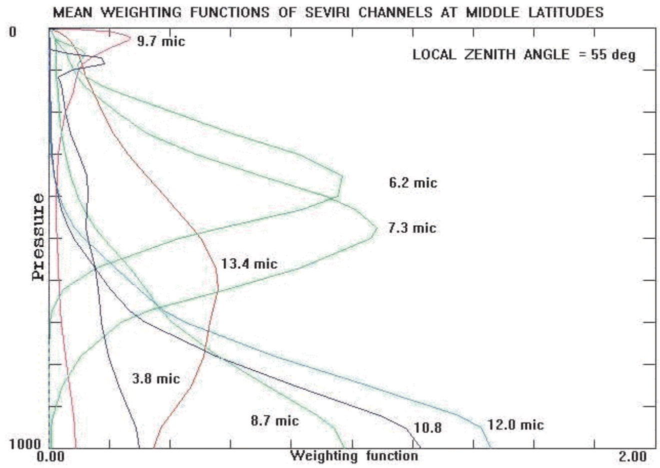

Figure 1: *SEVIRI normalized weighting functions*

The mean results of the nonlinear 1d-var analysis applied on 895 vertical profiles extracted from the ALADIN analysis of the 13th of May 2002 at 12 h UTC are presented in Fig. 2. This figure shows a positive impact on specific humidity above 800 hPa, characterized by a notable reduction (up to 50 %) of the error between analysis and background. However, the poor vertical resolution of SEVIRI for the channels that are sensible to temperature variations implies a very weak improvement of the analysed temperature compared to the background one. This improvement is only noticeable in the boundary layer. These results are more pronounced for the theoretical variances, which are the diagonal terms of **A** and **B** matrices (Fig. 3).

4. Real MODIS radiances

The impact of real data was studied using measurements coming from 5 channels of the MODIS radiometer (onboard the TERRA polar satellite), the spectral responses of which are comparable with SEVIRI ones. The band-width of the selected channels are stored in Table 1.

MSG/SEVIRI		TERRA/MODIS	
IR.1 :	3.5- 4.4	IR.23 :	4.02- 4.08
WV.3 :	6.8- 7.8	WV.28 :	7.17- 7.50
IR.4 :	8.3- 9.1	IR.29 :	8.4 - 8.7
IR.6 :	9.8-11.8	IR.31 :	10.8 -11.3
IR.7 :	11.0-13.0	IR.32 :	11.8 -12.8

Table 1 : *Band width (in m) of the different channels that are comparable between MODIS and SEVIRI.*

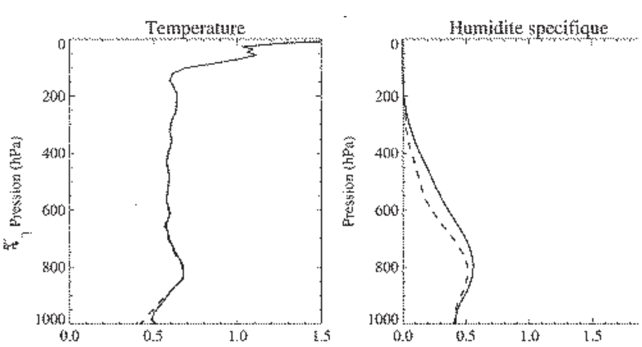

Figure 2: *Mean background (solid line) and analysis (dashed) errors standard deviations for 895 clear air profiles after the assimilation of simulated SEVIRI radiances.*

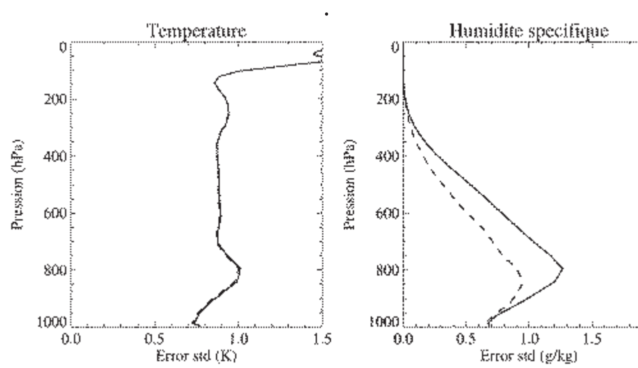

Figure 3: *Mean theoretical background (solid line) and analysis (dashed) errors standard deviations for 895 clear air profiles after the assimilation of simulated SEVIRI radiances*

In the present case, the profiles $\mathbf{x^t}$ that represent the true state are composed of 8 different soundings performed over western Europe at 12 h UTC on the 13th of May 2002 in clear air conditions (cf. their localization in Fig. 4). The $\mathbf{y}$ vectors contain the pixel values of the 5 selected MODIS channels at 11h35 UTC that are collocated with the soundings. Finally, the background vector $\mathbf{x^b}$ is composed of profiles coming from the ALADIN analysis at 12 h UTC.

Fig. 4 shows good agreement between MODIS data from channels 28 and 31 and the simulated data obtained by applying RTTOV-7 on the ALADIN analysis (it has to be noted that a systematic bias has been subtracted for each MODIS channels following the examination of the innovation term $(\mathbf{y} - H(\mathbf{x^b}))$). However, ALADIN totally miss the undulation at the rear the frontal rain band over the bay of Biscay.

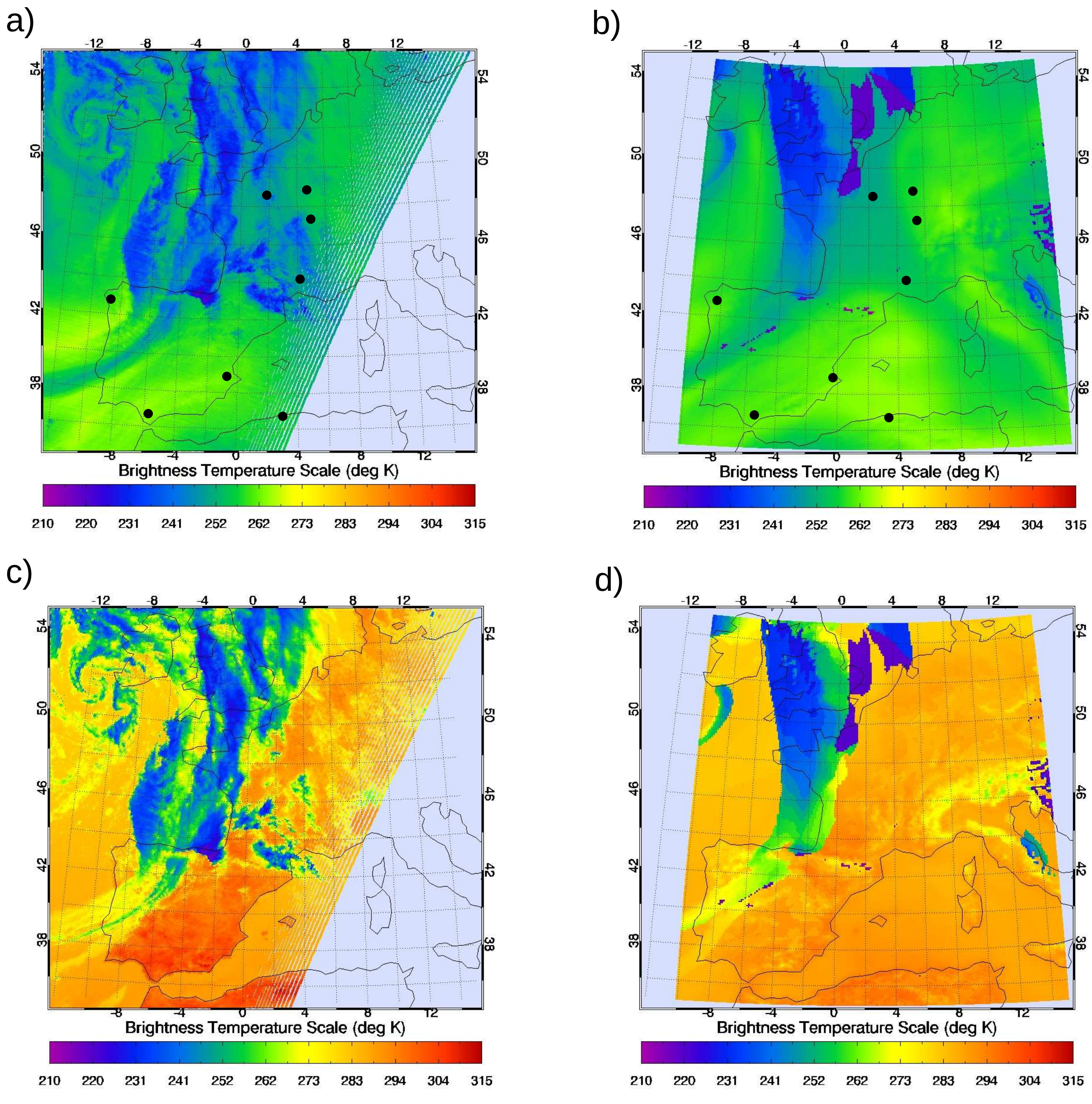

Figure 4: *.Brightness temperatures (a,c) observed respectively by MODIS in channels #28 and #31 the 13th of may 2002 at 11h35 UTC (b,d) simulated by RTTOV-7 applied on profiles coming from the ALADIN analysis at 12h UTC (the spots indicate the locations where the soundings used in the analysis have been launched).*

The mean results of the 1d-var analysis for the 8 cases show a good agreement with the previous results, obtained with simulated data. As a matter of fact, Fig. 5 displays also an error reduction between the analysis and the background for the vertical structure of the humidity field in the middle troposphere. Furthermore, the assimilation of MODIS radiances has a quasi-null impact on the temperature analysis except in the boundary layer.

5. **Conclusions**

The impact of the assimilation of SEVIRI geostationary infrared radiances has been studied using a nonlinear 1d-var analysis applied on simulated and real data coming from the 5 MODIS channels that have spectral resolutions comparable with SEVIRI ones. In both cases, a notable positive impact has been observed in the analysis of the vertical structure of specific humidity in the middle troposphere. The poor vertical resolution of the channels that are sensible to temperature variations implies a very weak reduction of the error in the analysis of this quantity, this reduction being visible only in the boundary layer.

Work is currently under progress to assimilate simulated SEVIRI radiances with ALADIN 3d-var in order to infer the usefulness of that kind of data in a high resolution weather forecast context. To maximize their potential effect during the assimilation step, a new formulation of the B matrix for the humidity has been proposed (Montmerle and Bouttier, 2002) and has to be evaluated in a 3d-var framework. This adaptive formulation is obtained using a multiple linear regression function of the relative humidity of the previous forecast and of the norm of its gradient.

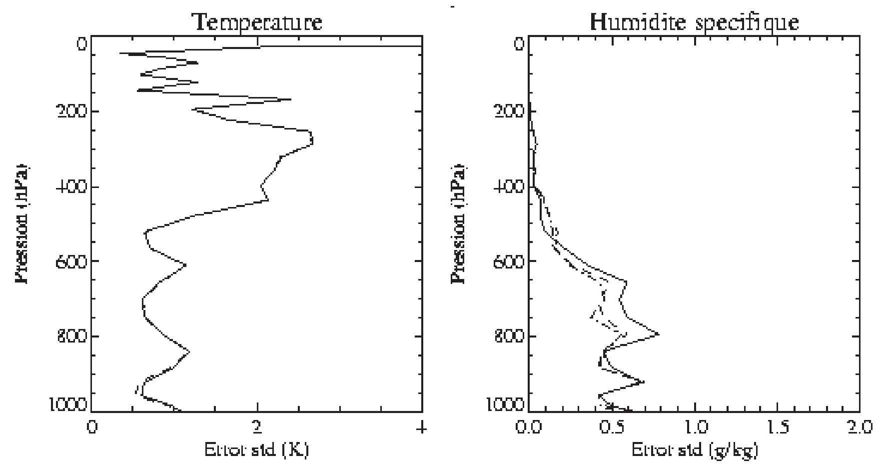

Figure 5: *. Mean background (solid line) and analysis (dashed) errors standard deviations for 8 clear air profiles after the assimilation of real MODIS radiances using ECMWF **B** matrix (the dot-dashed line represents the mean analysis error standard deviation while using the **B** sub-matrix for the humidity as explained in Montmerle and Bouttier (2002)).*

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Investigation of the application of local ATOVS data in Budapest

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INTRODUCTION

In 2001 a complex study was performed to compare the quality of locally pre-processed ATOVS radiances from CMS (Centre de Météorologie Spatiale, Météo-France) in Lannion with those from NOAA/NESDIS[1] (Randriamampianina and Rabier, 2001). According to the results of this study, the quality of the locally pre-processed ATOVS data is better than the quality of NESDIS data. Moreover, the positive impact of the locally pre-processed ATOVS data on the forecast of the ARPEGE model over Europe (Lannion reception area) was more significant than that of NESDIS.

These encouraging results were one of the reasons to choose the ATOVS data as potential observations to complete the observation database at the Hungarian Meteorological Service (HMS). In 2002 the implementation of the locally pre-processed ATOVS data was performed. Hence, a new concept of data pre-processing was worked out, followed by the implementation of a bias correction program to estimate the systematic error of the local ATOVS data. Furthermore, the debugging and implementation of ATOVS radiances into the AL15 library was performed.

This paper gives an overview of how the above-mentioned tasks were solved to ensure the use of ATOVS data in the ALADIN three-dimensional variational analysis (3D-Var). I also use this opportunity to share my experience on first implementation of satellite data into a limited area model.

DATA PRE-PROCESSING

The earlier version of data processing - prior to the satellite data implementation - consisted of pre-processing of TEMP and SYNOP data in two steps : the initial observation files (in NetCDF format) were converted into ASCII format at first, then the MANDALAY program was applied to create CMA files. CMA files used to be the input files of the ALADIN model up to AL13. The MANDALAY program is rather complicated to use with the 1C ATOVS (more explanation later) radiances, so we adapted the pre-processing scheme from Toulouse consisting of programs OULAN and BATOR.

The implementation of the ATOVS radiances was performed into the AL15 model that requires ODB files as input instead of CMA file. We have created ODB as follows :

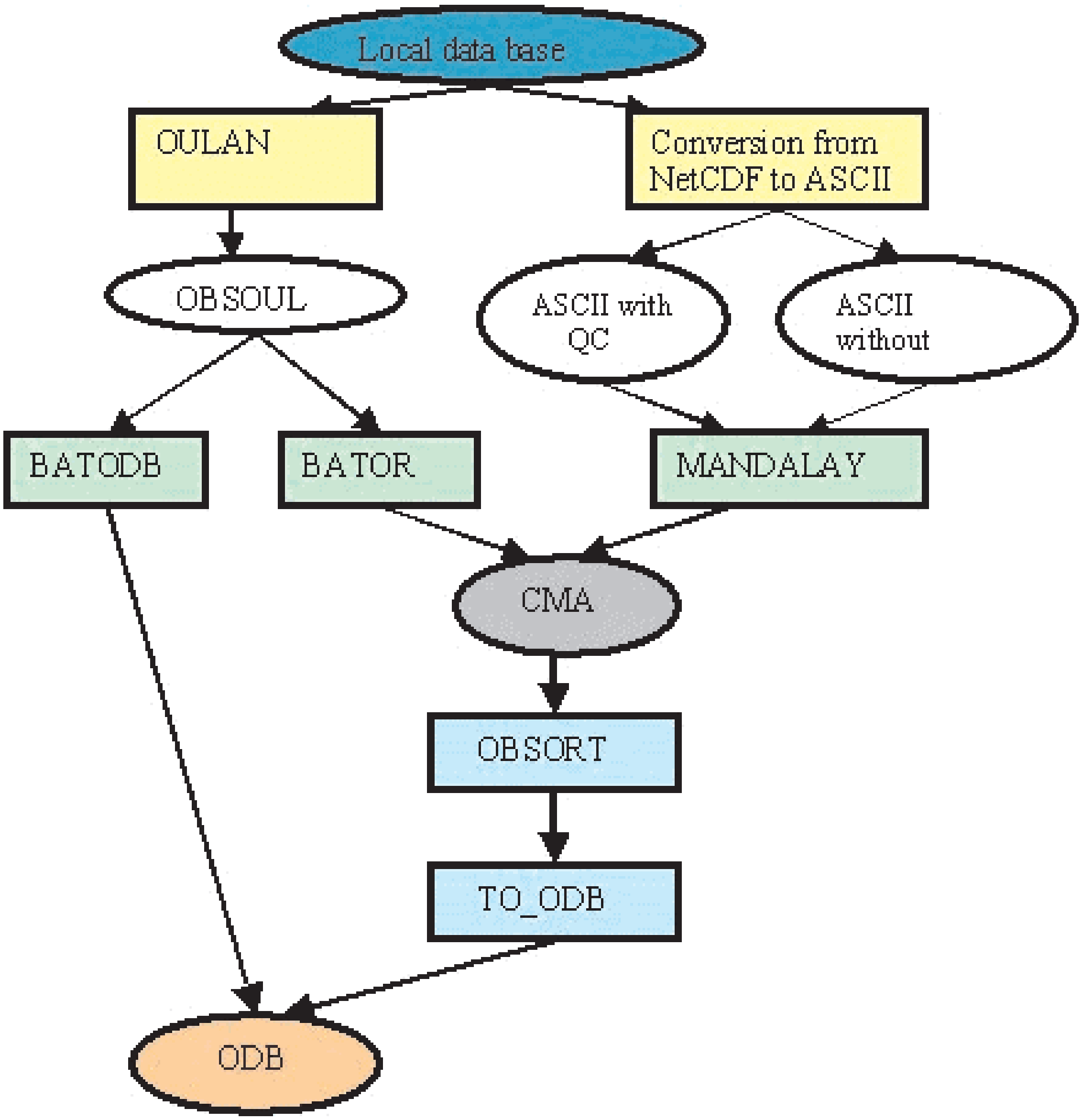
At the HMS we receive HRPT (High Resolution Picture Transmission) files from the NOAA satellites (NOAA-15 and NOAA-16). These files are pre-processed by the AAPP[2] package until the level 1C. The AAPP package has 4 pre-processing levels, namely 1A (instrument count), 1B (instrument count, navigation and calibration information appended), 1C (instrument reflectance factors or brightness temperatures, navigation and calibration information appended) and 1D (instrument reflectance factors or brightness temperatures, mapped on one common instrument grid, navigation, calibration and contamination information appended). As the level 1C radiances do not contain information about the contamination (e.g. cloudiness), the use of infrared radiances became problematic. Hence data from the microwave sensor AMSU-A are investigated at the moment. We use direct read-out of the AAPP output. The OULAN program converts the TEMP and SYNOP data, extracted from the local database as well as the ATOVS data into a well-organized file in

[1] NOAA/NESDIS- National Oceanic and Atmospheric Administration/National Environmental Satellite Data and Information Service

[2] AAPP - ATOVS (Advanced TIROS Operational Vertical Sounder) and AVHRR (Advanced Very High Resolution Radiometer) Processing Package

ASCII format (OBSOUL). From this stage there are three possible approaches : we could use the BATOR program in case we would need CMA files. We receive ODB files from the ASCII format either by applying directly BATODB or using BATOR, OBSORT and TO_ODB in the given order (see Figure 1). Due to some technical requirements the latter scheme was chosen.

Figure 1. Different ways to create ODB at HMS

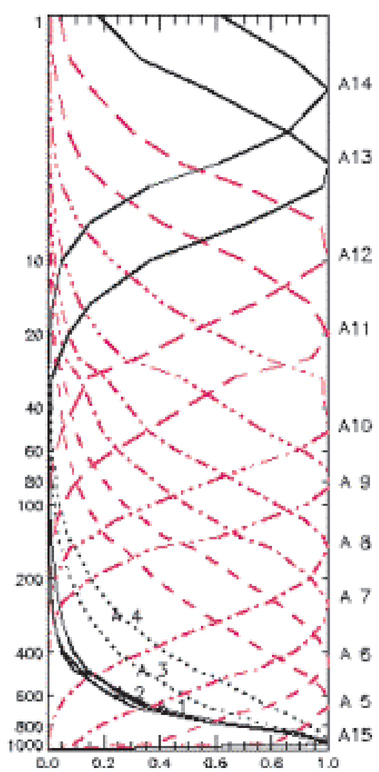


BIAS CORRECTION

Well known that satellite data contain systematic errors. As it was reported by Harris and Kelly (2001), the bias of data measured by the NOAA satellites varies along the scan angles (from the nadir) and depends on air-mass. The first conclusion means, that the bias varies along the different latitude bands. Since the "observation minus first-guess" information is used to evaluate the bias, the "air-mass bias" is model dependent. Thus, the bias correction coefficients have to be calculated for our latitude band (domain) as well as for our model (ALADIN/HU). The bias correction procedure (script and programs) used in Toulouse computes biases for the globe. The particularity of our case is that we compute bias for a relatively small domain, 90 percent of which is over land. According to this, we have to solve the following problems :

- We do the computation of biases at each assimilation time. In case the satellite path does not "hit" the C+I zone, a division by zero appears. To avoid this problem some modifications were done.
- The land/sea proportion or the distribution of territories with different altitudes in the domain is important to compute biases for channels used over sea only or for those used over land with some restrictions on altitude, respectively. These channels are sensitive to lower atmospheric layers (see Figure 2). Increasing the size of the domain we increase the amount of data available. Thus, the probability of getting "representative" statistics for a certain channel increases. As an example, in case of old domain (Figure 3) the bias at scanning angles 1, 5 and 6 for channels 3-6 equals zero (see Figure 5). So, at these conditions there is no data available. This is not the case for the new domain (Figure 4) that includes bigger territory and more pixels over sea. The bias at scanning angles 1, 5 and 6 for channels 3-6 is not equal to zero (Figure 6), so more data can be used for statistical calculations. In our case a 3-week period was not enough to compute "representative" statistics for the mentioned channels neither for the old, nor for the new domain. Note that channels 3 and 4 are not used in ARPEGE, so we are not going to use them as well. We are to compute statistics for channels 5, 6 and 7 for a longer period. In case we do not get "representative" statistics, we will not use these channels in the 3D-Var ALADIN.
- Other important thing is that the bias computation procedure uses a routine (the one that computes eigenvalue and eigenvector) from the NAG package. Since we do not have the NAG software, we had to perform this computation with other routines.

Figure 2. Example of weighting function for the AMSU-A channels



The left-hand side vertical scale refers to the height in hPa. The channel numbers are given on the right hand side.

Source:
http://www.meteorologie.eu.org/ici

Figure 3. Satellite observations inside of the old domain of the ALADIN/HU (C+I zone)

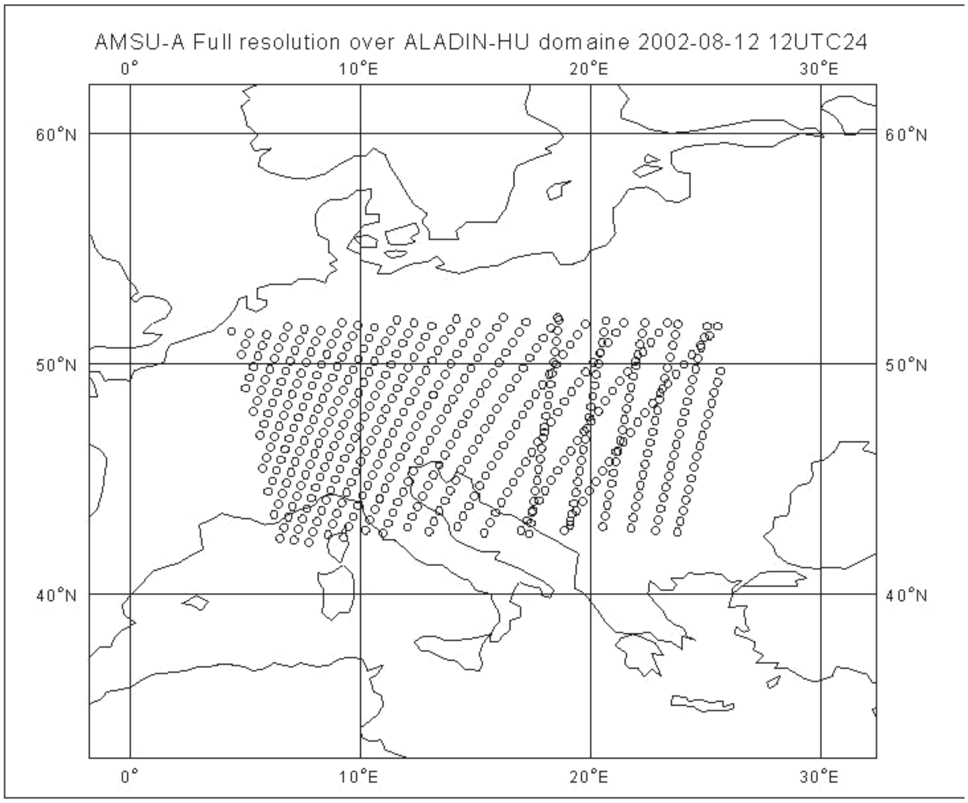
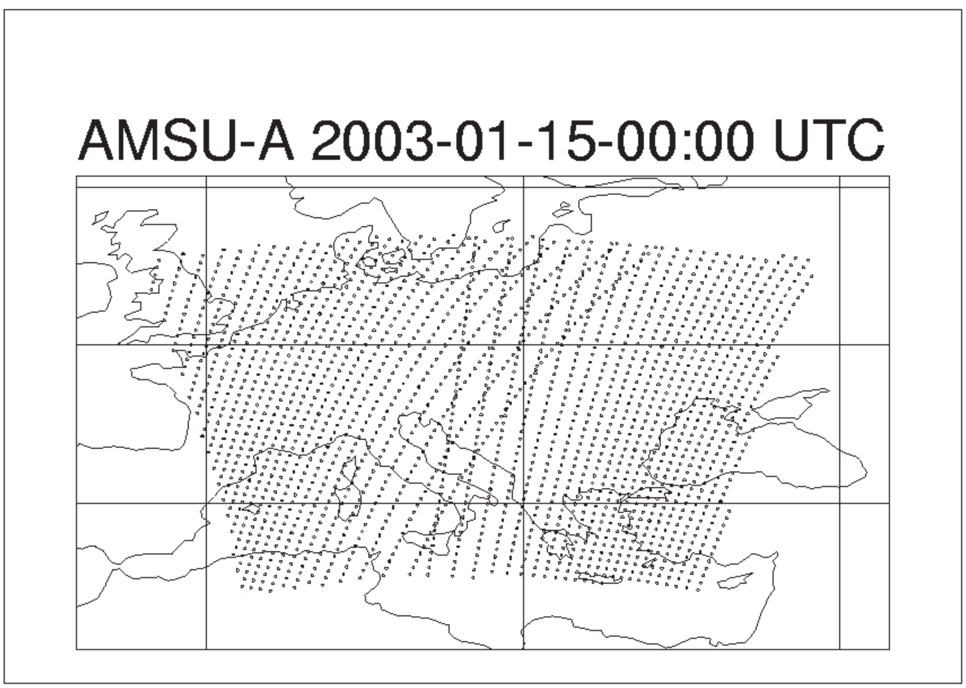


Figure 4. Satellite observations inside of the new domain of the ALADIN/HU (C+I zone)



DEBUGGING AND IMPLEMENTATION

The results of screening with AL15 are presented in Figures 7a-b. One of the modifications in the model consisted in the insertion of TOVS/ATOVS data as a control variable when performing the minimization of the cost function. This modification was done in the *yemecain.F90* routine plus all modifications from Elisabeth Gérard. The TOVS variable was put after the one-dimensional mean wind.

Routine *fgchk.F90* was modified as well - we fill up the first-guess error array (`ZFGERR`) for ATOVS data only in case we have ATOVS data in the ODB. Otherwise the model blows up when there is not ATOVS data in the ODB, that may happen in our case. The problem is that this local array is defined with `NMXTCH` (total number of TOVS/ATOVS channels), which is initialized only in case of presence of satellite data (`MNSERIES` not equal to zero) in the ODB (see *surad.F90* and *rtsetup.F90*). If we do not have ATOVS data in ODB, `NMXTCH` is not defined, thus, in *fgchk.F90* we fill up an array with an undefined number of elements.

Some practical advises for the first implementation of TOVS/ATOVS data

- Note, that constant files (*bcor_noaa.dat*, *rt_coef_ieee.dat*, *bcor_noaa.dat*, *chanspec_noaa.dat*, *rmtberr_noaa.dat* and *cstlim_noaa.dat*) are needed for the processing of TOVS/ATOVS data. These files are very important. They have to be updated according to the version of the RTTOV used as well as to the level of the TOVS/ATOVS radiances (eg. 1C or 1D) and to the series of the satellite we are using. We have to take care about these conditions when copying these files from another centre. A rather confusing problem appeared in my case. The model did not stop but gave wrong results and very short comments just because one of the above-mentioned files was not updated.
- Note, that the switch `LTOVSCV` should be set to `TRUE` for both screening and minimization.

CONCLUSIONS AND PERSPECTIVES

The implementation of the locally pre-processed ATOVS radiances into the 3D-Var assimilation scheme was successful. Figure 8 illustrates the difference between the analysis with ATOVS and analysis without ATOVS data (using TEMP and SYNOP only).

We are about to start the impact study. Different thinning strategies are to be investigated.

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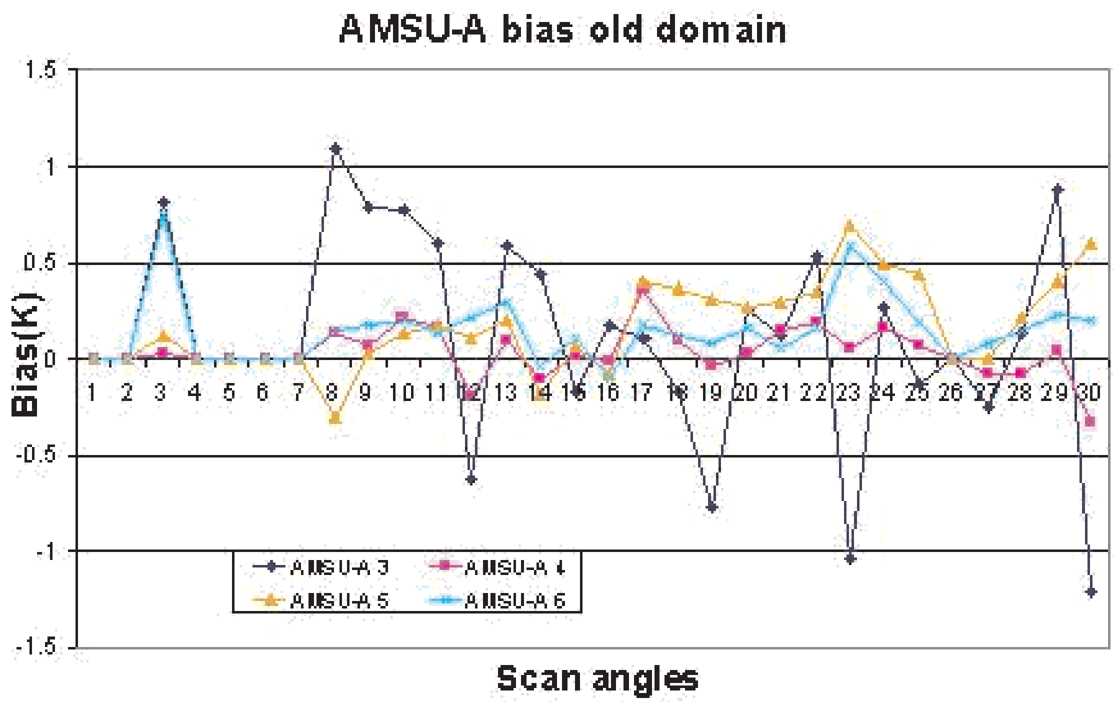
Figure 5. Scan angles bias calculated over the old domain of the ALADIN/HU (NOAA-16). Note, that AMSU-A channels 3 and 4 are used over sea, while channels 5 and 6 are used over sea and over land with restriction on altitude. Channels 7-14 can be used anywhere.



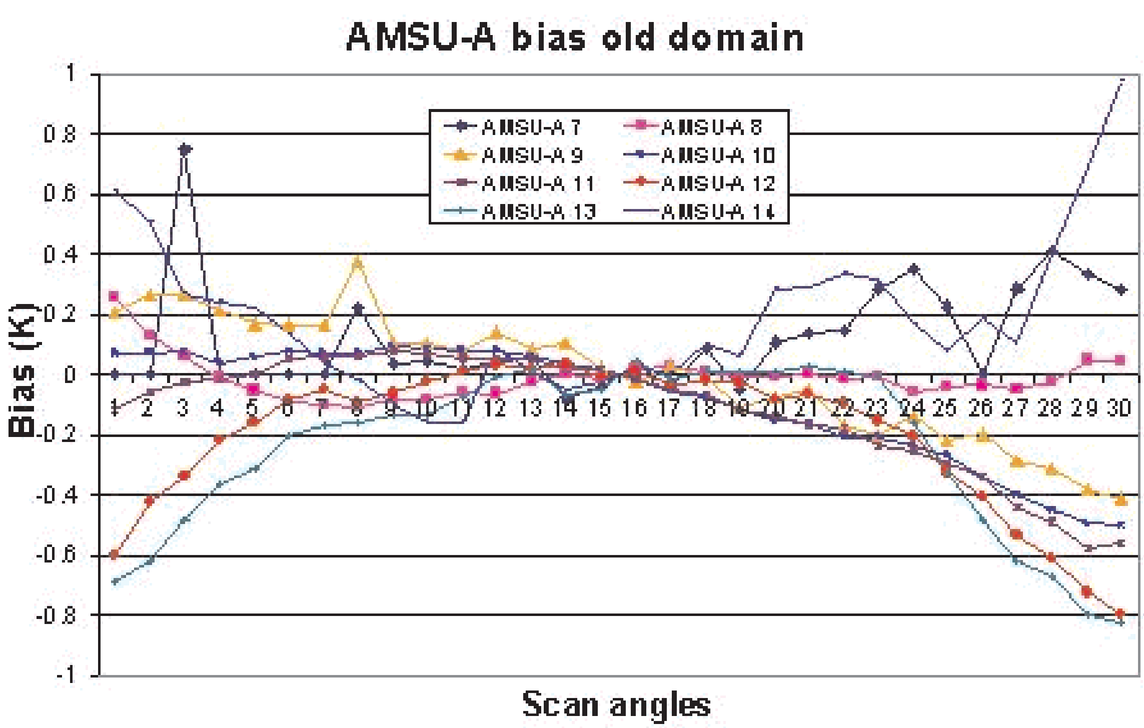
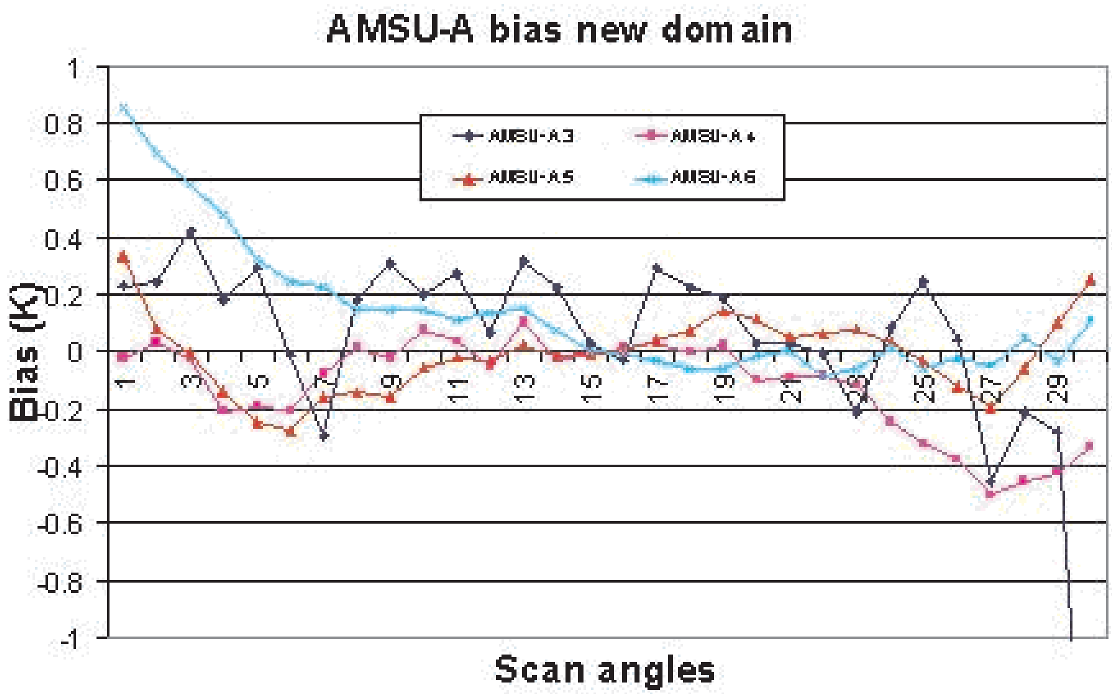


Figure 6. Scan angles bias calculated over the new domain of ALADIN/HU (NOAA-16). Note, that AMSU-A channels 3 and 4 are used over sea, while channels 5 and 6 are used over sea and over land with restriction on altitude. Channels 7-14 can be used anywhere.



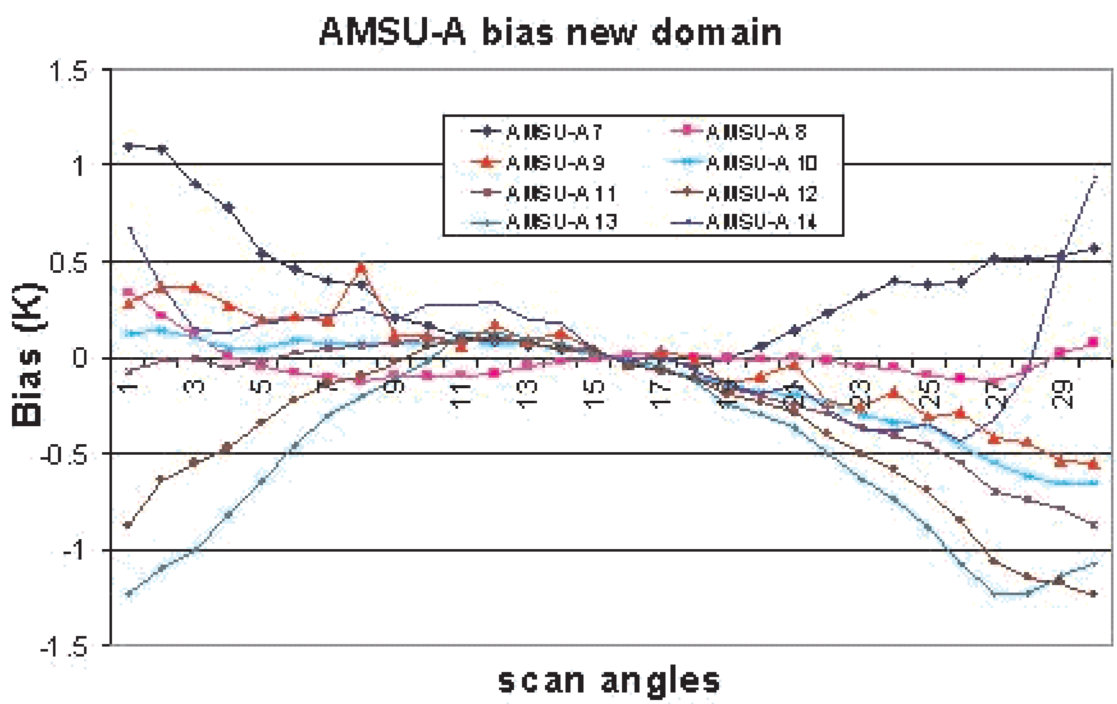
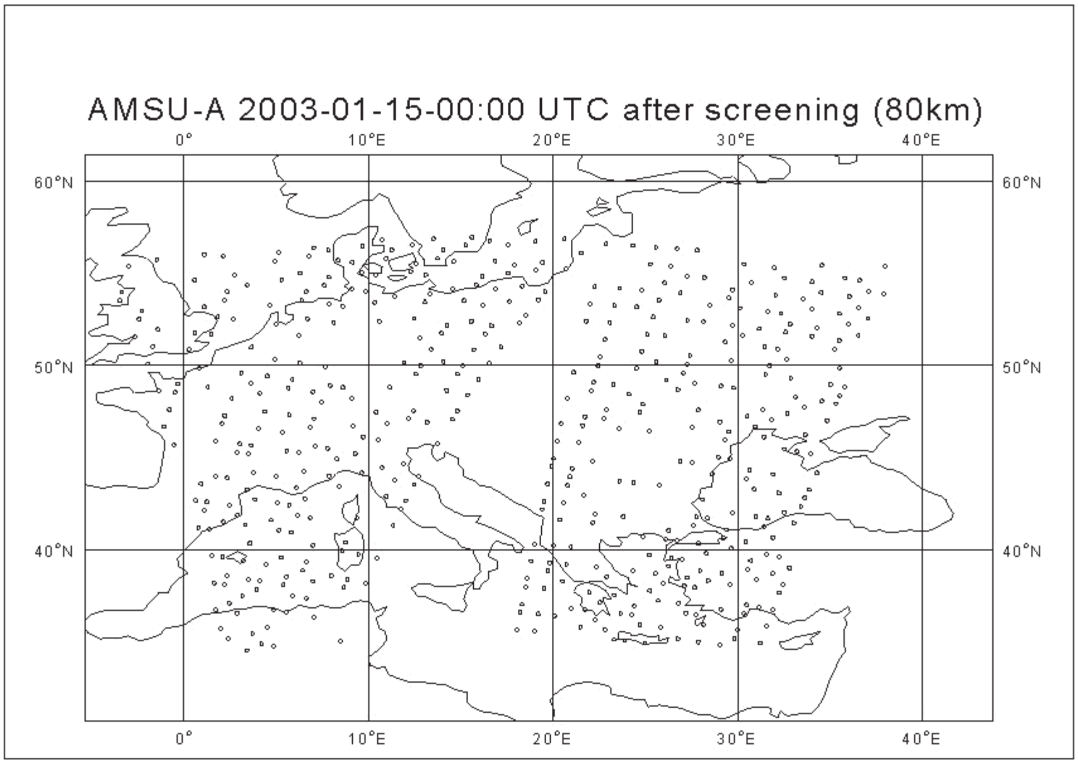


Figure 7. Result of the screening with thinning at 80km (a) and 120km (b)

a)



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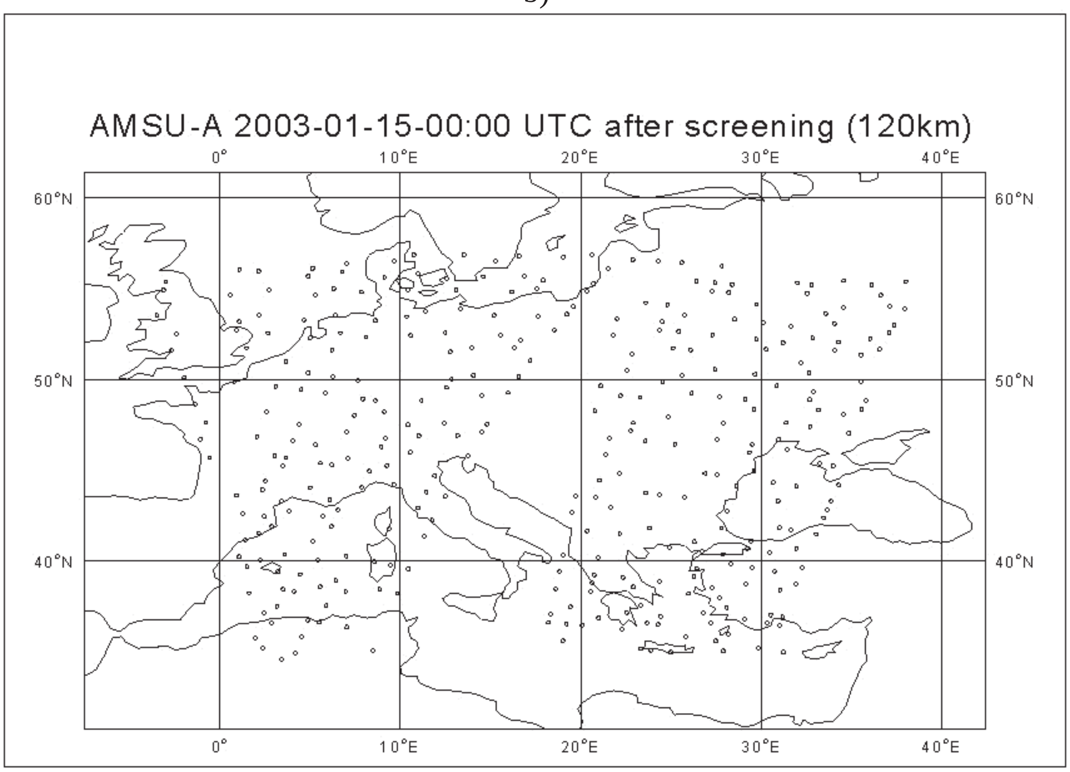
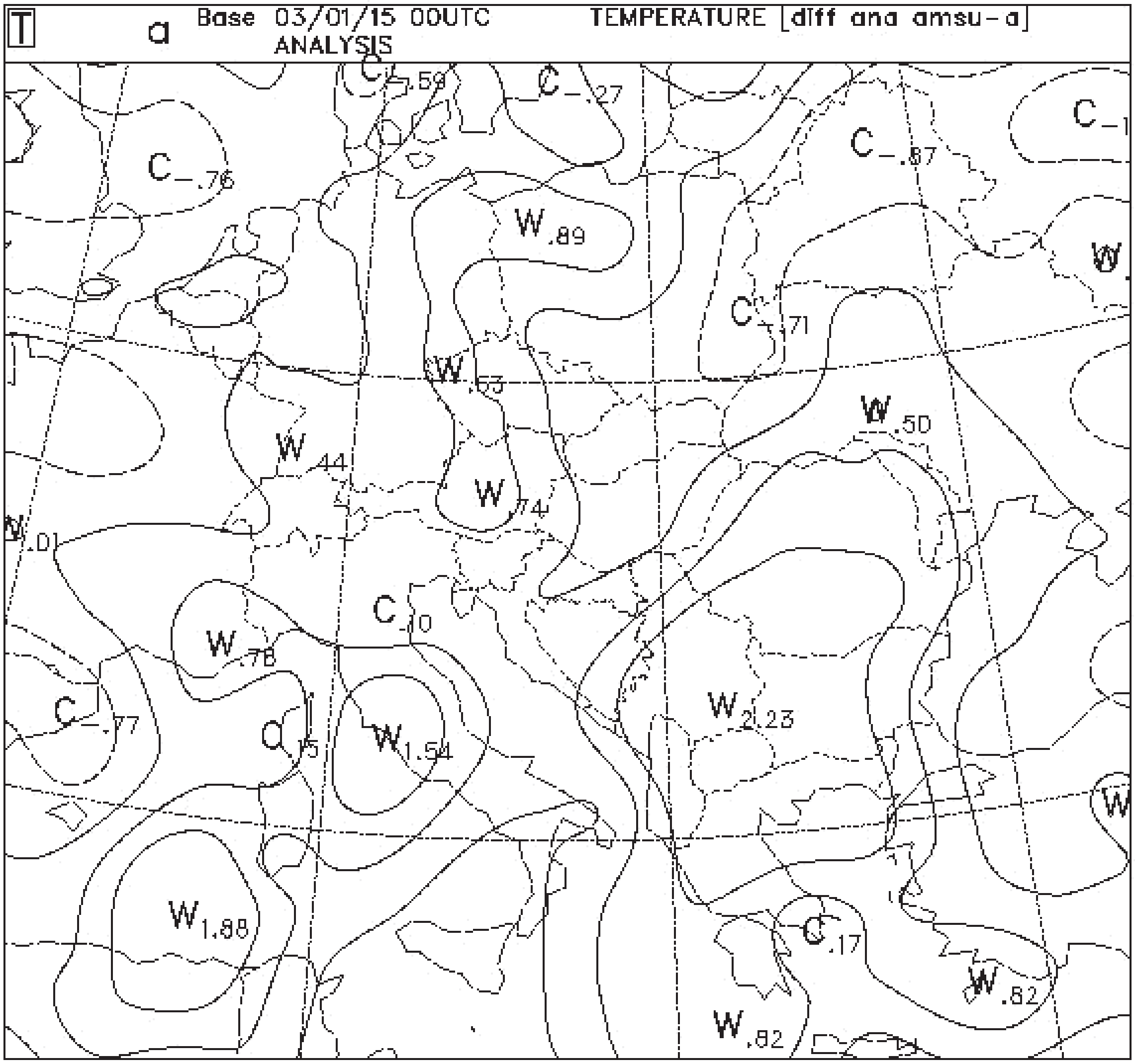


Figure 8. Difference between the analyses performed with ATOVS and without ATOVS (TEMP and SYNOP only) data over the ALADIN/HU domain (thinning distance 80km, level 16)



T2m Nowcasting

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Problem

There is a growing demand for very accurate forecasts of 2m temperature for the next couple of hours, in particular during the winter season. Nowadays, a typical value of mean absolute error for height-corrected point forecasts of T2m in the short range is about 1.5 K. Classical MOS techniques allow to reduce this error by a few tenths of a degree. Since T2m is not assimilated, the nowcasting range (say, up to +03 hours) is usually not significantly better predicted than the whole first 12 hours of a forecast. Thus, any method which takes into account the current observed value can greatly improve the skill of the point forecast in the first few hours. Kalman filtering has often been used in this context (e.g. Izsak, 2002).

A problem with Kalman filtering methods is that changes in the type (and reason) of model errors caused by changes in the weather situation are not handled well. By design the system needs some time to adapt to a new error structure. At ZAMG a project has been started, to develop a combined physical/statistical correction system that produces short-term T2m forecasts for the station Vienna Hohe Warte with highest possible accuracy.

As part of this project, the mean absolute error (MAE) of ALADIN forecasts (corrected for true station height) was compared with persistence and adapted climatology forecasts. "Adapted" means that the forecast is shifted to match the observed temperature at the current hour. Thus an adapted climatology forecast simply puts the mean diurnal cycle during that time of the year on top of the observed current temperature. Interestingly, this method which does not involve any NWP gives rather good results in terms of MAE (Figure 1) and is therefore a good benchmark for measuring the skill of NWP forecasts.

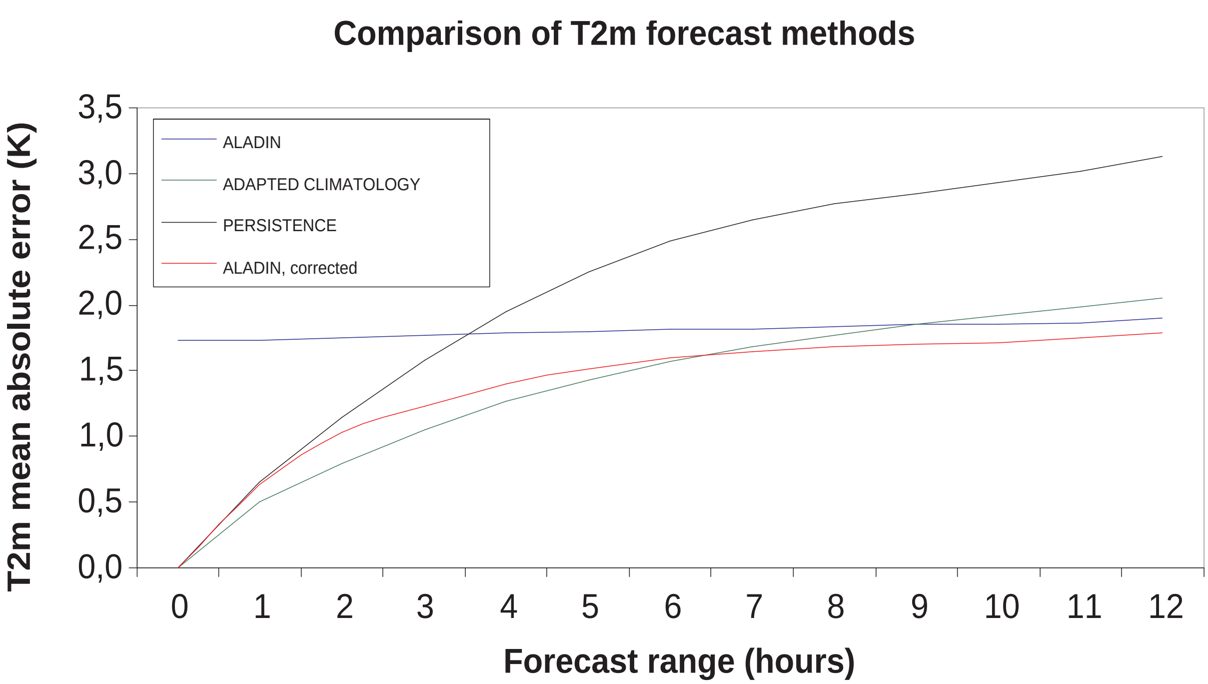

Figure 1: Mean absolute error (K) of different T2m forecast methods as a function of forecast range. The verification period is 1 Nov. 2000 - 30 Nov. 2002 (without summer months June-Sept.).

Other interesting details are that ALADIN becomes better than persistence at about +3.5 h, and better than adapted climatology around +9 h. Also shown is a linear combination of persistence and ALADIN, with statistically determined optimal weights for each forecast range. It can be seen that this method beats the adapted climatology in the +7 to +12 h range, but not in the first 6 h.

Process-specific approach

In order to obtain forecast improvements beyond those provided by purely statistical methods, one needs to identify the primary processes causing errors. A large part of wintertime T2m errors in ALADIN is caused by underestimations of low cloudiness. Frequently, the modelled diurnal amplitude of T2m is significantly larger than observed. To account for this specific source of error, a simple correction based on the ratio between predicted and observed low cloudiness has been developed and is being tested. Results will be published in the next Newsletter.

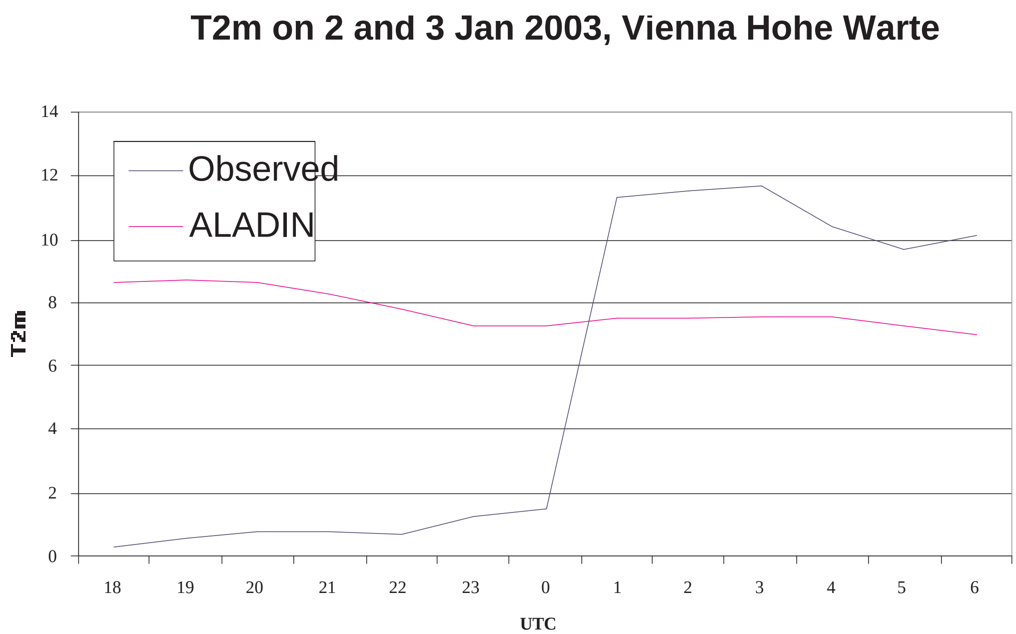

Figure 2: A shallow (100-200 m) cold PBL in the Vienna area is replaced by a well-mixed one. T2m rises by 10 K within 1 hour. The largest T2m forecast errors occur during shallow cold air episodes.

Another problematic situation arises when cold air pools are eroded or advectively removed. In such cases the temperature error can become very large, due to difficulties in modelling shallow (100-200 m deep) cold air pools and their removal. A recent, quite extreme case is shown in Figure 2. For this type of process we plan to use ALADIN model trajectories to advect a corrected temperature field based on the ALADIN forecast and the most recent observations. In order to handle the process of warming by vertical mixing, a high-resolution 1d model with prognostic TKE will be used. Our goal is to push the error of the forecast significantly below the adapted climatology values shown in Figure 1.

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The alternative variable d_4 for vertical divergence in ALADIN-NH model

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1. Introduction

Motivation

It was shown that the choice of prognostic variables has an important impact on the stability and accuracy of the model. In addition to the standard prognostic variables, temperature T, horizontal divergence D and logarithm of surface pressure $\ln \pi_s$, two additional non-hydrostatic (NH) variables may be chosen in several different ways. There are three choices available in the current ALADIN-NH code for the variable representing pressure departure, $(p-\pi)/\pi^*$, $(p-\pi)/\pi$ and $q=\ln(p/\pi)$, with different effect on the stability of integration.

The last NH prognostic variable is based on vertical divergence. There were already six different variants (denoted d_0, d_1,... d_5) of this variable implemented and tested in ALADIN-NH. We mention only some of them. The remaining variants are somehow on the "half-way" between them. In 2001, the vertical divergence itself

$$d_3 = -g \cdot \frac{p}{mRT} \cdot \frac{\partial w}{\partial \eta} = \frac{\partial w}{\partial z} \tag{1}$$

has been implemented in the ALADIN-NH model and has been proven to ensure better stability properties than the previously used pseudo-vertical divergence

$$d_0 = -g \cdot \frac{\pi^*}{m^* R T^*} \cdot \frac{\partial w}{\partial \eta} \tag{2}$$

with * denoting values of the semi-implicit (SI) reference state (see [4]). Let us consider the atmosphere as dry. We know that in the presence of steep orography, the stability is strongly affected by the so-called X-term, the nonlinear part of the 3-dimensional divergence D_3, i.e.

$$X = \frac{p}{mRT} \cdot \nabla \Phi \cdot \frac{\partial \mathbf{V}}{\partial \eta} \tag{3}$$

$$D_3 = D + d_3 + X$$

This term was treated in an iterative process which results in a temporal average applied not only to the linear part of D_3, but to the whole D_3; see [2].

An idea has emerged (P. Bénard according to MC2 model) that X could be included into the variable used for vertical divergence representation. Then D_3 will be purely linear, and the corresponding instability could be cured in 3-time-level (3TL) scheme without a need for expensive iterations, while in 2-time-level (2TL) we cannot get rid of the iterative process and need to cure the instability by the so-called predictor/corrector scheme anyway; see [6]. Experiments in the 2d NH version of ALADIN were made which showed that the choice of

$$d_4 = d_3 + X \tag{4}$$

instead of d_3 may prevent the model from blowing up if no iterative procedure is used in 3TL scheme; see [3]. Hence the decision was made to implement d_4 into the (3d) code as a prognostic variable. It revealed that for the implementation of d_4, an auxiliary prognostic variable is needed. The reason for this is the following :

For the computation of the right hand side of the prognostic equation (6) for the variable d_4, the term ∇w is needed. To compute this term from (9) we need indispensably ∇d_3. And to compute ∇d_3 from the prognostic variables we have to calculate ∇X. But ∇X cannot be obtained in gridpoint space diagnostically from the other variables, since it needs second derivatives $\nabla^2 T$, $\nabla^2 p$, ... (through $\nabla^2\Phi$) and it would be too expensive. On the other hand, ∇X cannot be calculated in spectral space from the other variables, since (3) is nonlinear.

Thus the necessity of the introduction of an additional spectral variable is justified. We decided to define the auxiliary spectral variable as the previous d_3. Then ∇d_3 is obtained easily in spectral space. The auxiliary spectral field is biperiodicized in both horizontal directions by cubic splines (in x direction in gridpoint space before direct transformations when we have access to the whole row for a given latitude, and in y direction in Fourier space after transposition when we have access to all latitudes for a given zonal wavenumber).

In this short description of d_4 implementation, we first mention how the moisture is included, which prognostic equations are used and how they are time discretised. Then we present some results obtained in the 2d vertical-plane version of ALADIN and in 3 dimensions on PYREX case. We make some conclusions.

Inclusion of moisture

All "*d*"-variables are defined as "dry", while moisture is included in the term X through the gas constant R, i.e. the following formulas are used

$$d_3 = -g\cdot\frac{p}{mR_dT}\cdot\frac{\partial w}{\partial\eta} = \frac{\partial w}{\partial z}$$

$$X = \frac{p}{mRT}\cdot\nabla\Phi\cdot\frac{\partial \mathbf{V}}{\partial\eta}$$

$$d_4 = d_3 + X$$

Since the true 3d-divergence is defined as

$$D_3 = D + X - g\cdot\frac{p}{mRT}\cdot\frac{\partial w}{\partial\eta}$$

we get the following relationship

$$D_3 = D + \frac{R_d}{R}\cdot d_4 + \left(1 - \frac{R_d}{R}\right)\cdot X \tag{5}$$

Thus if moisture is included there is still a small nonlinear part of D_3, equal to $(R_d/R - 1)\,d_3$. We expect that this small part may not cause any instability.

Prognostic equations

There are several possible algorithmic approaches to the problem; see document [1] of Pierre Bénard for details. The analysis shows that some of them could result in a more stable solution than the others. Here only the variant denoted as "variant 2" is described for 3TL Eulerian scheme; see [5] for the specificity of other variants and temporal schemes. We restrict ourselves to purely adiabatic case. We start from the time-continuous system of prognostic equations derived in terms of d_4 and $q = \ln(p/\pi)$:

$$\frac{d(d_4)}{dt} = -g^2 \cdot \frac{p}{mRT} \cdot \frac{\partial}{\partial\eta}\left(\frac{1}{m} \cdot \frac{\partial p}{\partial\eta}\right) + g \cdot \frac{p}{mRT} \cdot \frac{\partial \mathbf{V}}{\partial\eta} \cdot \nabla w$$

$$-d_4 D_3 + d_4 D + X D_3 - X D + \frac{dX}{dt} \tag{6}$$

$$\frac{dq}{dt} = -\frac{C_p}{C_v} \cdot D_3 - \frac{1}{\pi} \frac{d\pi}{dt} \tag{7}$$

$$\frac{dT}{dt} = -\frac{RT}{C_v} \cdot D_3 \tag{8}$$

where $g\nabla w$ is given by

$$g\nabla w = g\nabla w_s + \int_\eta^1 \nabla\left(\frac{mRT}{p} \cdot d_3\right) d\eta \tag{9}$$

The remaining equations (for D and $\ln \pi_S$) are not touched by our considerations.

Time discretisation

Let $\mathcal{M}$ denote the matrix form of the r.h.s. of the fully compressible Euler equation system, and $\mathcal{L}^*$ its linearization around a dry, resting, horizontally homogenous isothermal reference stay ψ^* in hydrostatic equilibrium that is fully defined by the values of reference temperature T^* and reference surface pressure π_S^*. The linear model $\mathcal{L}^*$ may be written in the following form

$$\frac{\partial d_4}{\partial t} = -\frac{g^2}{R_d T^*} \cdot \mathbf{L}^* q$$

$$\frac{\partial q}{\partial t} = -\frac{C_{pd}}{C_{vd}} \cdot (D + d_4)$$

$$\frac{\partial T}{\partial t} = -\frac{R_d T^*}{C_{vd}} \cdot (D + d_4)$$

plus two equations (for D and $\ln \pi_S$) not touched by our problem; see [2] for the definition of the vertical operator $\mathbf{L}^*$. Let ψ^-, ψ^0, ψ^+ denote the state vector at time t-Δt, t and t+Δt. If the 3TL SI time scheme is employed, we have

$$\frac{\psi^+ - \psi^-}{2\Delta t} = \mathcal{L}^* \left(\frac{\psi^+ + \psi^-}{2}\right) + (\mathcal{M} - \mathcal{L}^*)(\psi^0)$$

We use a first order approximation to dX/dt and get the following discretised prognostic equation for d_4

$$\frac{d_4^+ - d_4^-}{2\Delta t} = -\frac{g^2}{R_d T^*} \cdot \mathbf{L}^* \left(\frac{q^+ + q^-}{2} - q^0 \right) - g^2 \left(\frac{p}{mRT} \right)^0 \frac{\partial}{\partial \eta} \left(\frac{1}{m^0} \cdot \frac{\partial p^0}{\partial \eta} \right)$$

$$+ \left(\frac{p}{mRT} \right)^0 \left(\frac{\partial \mathbf{V}}{\partial \eta} \right)^0 \cdot g \nabla w^0 - d_4^0 D_3^0 + d_4^0 D^0 + X^0 D_3^0 - X^0 D^0 + \frac{X^0 - X^-}{\Delta t}$$

The term X is calculated by (3) and D_3 by (5), both from prognostic variables at corresponding time level. Moreover, $g\nabla w^0$ is calculated as

$$g\nabla w^0 = g\nabla w_s^0 + \int_\eta^1 \left(\frac{mRT}{p} \right)^0 \cdot \nabla d_3^0 \cdot d\eta - \int_\eta^1 d_4^0 \cdot \nabla \left(\frac{\partial \phi}{\partial \eta} \right)^0 \cdot d\eta + \int_\eta^1 X^0 \cdot \nabla \left(\frac{\partial \phi}{\partial \eta} \right)^0 \cdot d\eta$$

Hence, d_3 appears only in derivatives ∇d_3^0 in prognostic equation for vertical divergence (d_4) and nowhere else.

We derive a "pseudo-prognostic" equation for d_3 from

$$\frac{d_3^+ + d_3^-}{2} = \frac{d_4^+ + d_4^-}{2} - X^0$$

as

$$d_3^+ = d_4^+ + [d_4^- - d_3^- - 2\, X^0]$$

The part in brackets is calculated in gridpoint space and then the final addition is made in spectral space after d_4^+ is obtained.

Variable d_4 has been introduced in cycle 25T2, and it will be enabled to use it with 3TL predictor-corrector (PC) scheme in the next cycle (26).

2. 2d vertical plane experiments

Experiments settings

We are using the experimental setting that was prepared and used by Jan Masek for the evaluation of the newly proposed NH prognostic variables d_4 and d_5 ("easy" implementation in 2d vertical plane version of the cycle CY24T1/AL15). It will enable us to compare our results with previously obtained ones. Let us briefly summarize, see report [3] for details.

- initial state : temperature profile with Brunt-Väisälä frequency $N = 0.01\ s^{-1}$ up to tropopause (sea level temperature 293 K), isothermal above (133 K); constant wind profile $V = 10\ m.s^{-1}$; sea level pressure 1013.25 hPa
- orography : bell-shaped mountain with height h and half-width a depending on the regime
- geometry : 128 horizontal points (114 in C, 14 in I, 0 in E zone), quadratic grid (NSMAX=42), 100 regular z-levels, 30 or 60 levels above tropopause (depending on the regime), total vertical extent ≈30 km
- integration settings : T^*=220 K, π_s^*=900 hPa, no decentering, no horizontal diffusion, semi-Lagrangian (SL) advection treatment

■ regime dependent settings :

regime	Δx [m]	a [km]	h [m]	hill [gp]	C_{LH}	`REPONBT` [m]	`REPONTP` [m]	`REPONTAU` [s]	timestep [s] 3TL	2TL
LH	2000	10	100	64	0.1	21 000	29 500	2 000	50.	100.
QLQH	1000	5	200	64	0.2	21 000	29 500	1 000	25.	50.
NLNH 1	400	2	500	32	0.5	12 000	29 500	400	10.	20.
NLNH 2	200	1	1000	32	1.0	12 000	29 500	200	5.	10.

LH : linear hydrostatic, QLQH : quasi-linear quasi-hydrostatic, NLNH : nonlinear non-hydrostatic

Table 1 : 2d experiments setting

We evaluate the dimensionless flow dependent parameter C_{LH} which measures the linearity and hydrostatism at the same time, $C_{LH} = N\,h/V = V\,/\,(N\,a)$. The growth of this parameter from 0 to 1 represents the move from a linear hydrostatic regime to a nonlinear non-hydrostatic one.

We consider an experiment as stable if 1000 timesteps are completed without respect to the length of timesteps. We adopt the convention that the numbers of completed timesteps of experiments with acceptable results are written in tables with bold fonts.

For 2TL scheme, we used PC scheme with one iteration (`LPC_FULL=TRUE`, `NSITER=1`), either extrapolating (`LPC_NESC=FALSE`), or not (`LPC_NESC=TRUE`). Without any iteration, the model is unstable even in LH regime independently from the choice of prognostic variable for vertical divergence (with our settings, only 10-13 completed timesteps).

Results

number of completed timesteps										
		3TL , SI		2TL , PC		2TL , PC , NE				
								+`XIDT`=0.1		
"d" var.	C_{LH}}	σ	η	σ	η	σ	η	σ	η
d_3	0.1 (LH)	**1000***	**1000***	**1000**	**1000**	**1000**	**1000**	—	—
	0.2 (QLQH)	**1000***	**1000***	**1000**	**1000**	**1000**	**1000**	—	—
	0.5 (NLNH1)	**1000***	**1000***	81	108	**1000**	**1000**	—	—
	1.0 (NLNH2)	44*	55*	14	14	20	21	53	72
d_4	0.1 (LH)	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	—	—
	0.2 (QLQH)	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	—	—
	0.5 (NLNH1)	**1000**	**1000**	**1000**	**1000**	**1000**	**1000**	—	—
	1.0 (NLNH2)	43	1000	104	109	1000	1000	1000	1000

* experiments done by Jan Masek, see [3]

Table 2 : 2d experiments

There is a clear indication of enhanced stability of 2TL PC scheme with d_4 in comparison to d_3 in NLNH regimes. In the most severe regime (NLNH2), for any chosen type of 2TL PC scheme and for 3TL SI scheme the d_4 implementation is more stable than d_3. Neither non-extrapolating 2TL PC scheme (previously in NLNH1 more stable than the full PC), nor 2TL PC with pseudo second-order decentering (ξ = 0.1) is able to stabilize the integration with d_3. For d_4 we got a stable integration with 2TL PC NE and 2TL PC NE with decentering (ξ = 0.1), but the accuracy of obtained solutions is touched.

3. 3d experiments - PYREX case

Experiments settings

For 3d experiments, we have chosen the real case named PYREX from 16.4.2002, 12 UTC, with domain placed over Pyrénées mountains and the following settings :

- geometry : 277×181 horizontal points (269×173 in C, 8 in each direction in I, 0 in E zone), quadratic grid (`NMSMAX`=92, `NSMAX`=60), Δx =2635 *m*, 41 vertical levels with hybrid η-coordinate
- integration settings : T^*=350 *K* for 3TL and T^*=300 *K* for 2TL schemes, π_s^*= 1013.25 *hPa*, horizontal diffusion applied, SL advection
- timestep : Δt =15 *s* for 3TL scheme, Δt =30 *s* for 2TL scheme;

  we have integrated for 2 hours, i.e. 480 timesteps for 3TL and 240 timesteps for 2TL schemes.

We use as a reference experiment the run with d_3 and 3TL SI scheme in the same setting as for the other experiments, but with a 3-times shorter timestep (Δt = 5 *s*).

We adopt the following criterion for stability: we consider an experiment as a stable one if the forecast for 2 hours is performed. This criterion is a compromise between an ideal stability criterion (the forecast may be run forever) and the time requirement for experiments we are able to accept.

We can see on the example of experiment with 3TL SI scheme and d_4 variable that this criterion may not give evidence of stability: this experiment may be considered as perfectly stable after 1 hour of forecast and it crashes shortly after (at 1:17:30).

Results

number of completed timesteps					
"*d*"-variable	3TL SI		2TL PC	2TL PC NE	
	—	`VESL`=0.1	—	—	`XIDT`=0.1
d_3	83	480	13	19	240
d_4	281	310	240	240	240

Table 3 : 3d experiments - PYREX

For all used time schemes the choice of d_4 gives more stable integration than the choice of d_3. For 3TL SI scheme with first order decentering, one can see on the fields plotted after 1 hour of integration (Fig. 1) that with d_3 there is a noise spread over a large mountainous area, while with d_4 there is almost no noise except for one small spot. This spot makes the model blow up after another 70 timesteps, while with d_3 the whole 480 timesteps are completed, but the resulting fields are extremely noisy (we conclude also here that the system with d_4 is more stable than with d_3).

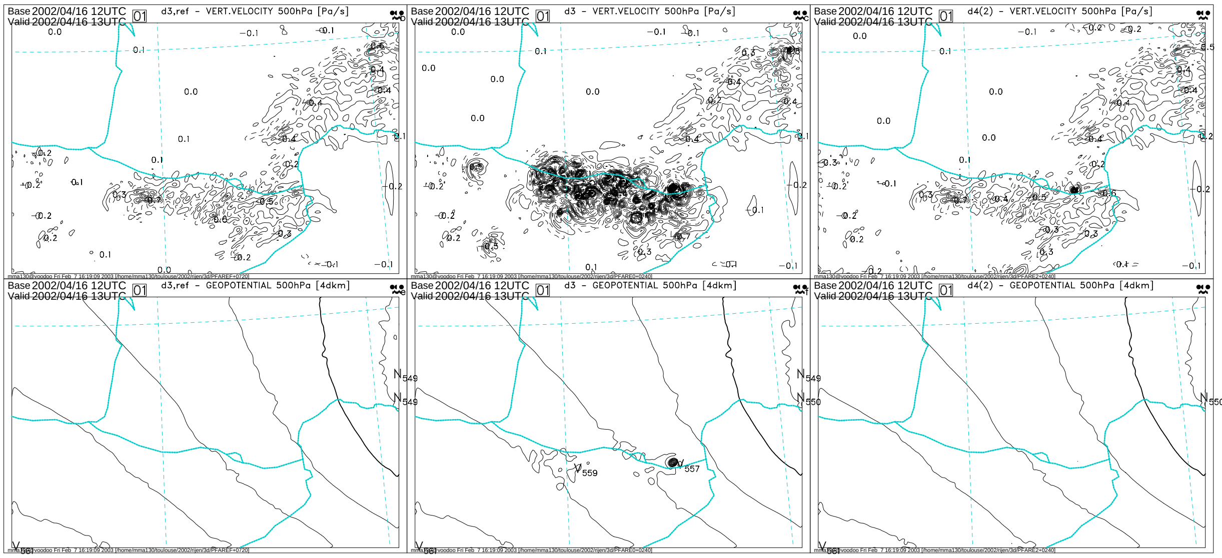

Figure 1 : Vertical velocity (up) and geopotential (down) at 500 *hPa*, using 3TL SI time scheme with decentering (ε = 0.1), forecast for 1 hour. From left to right: reference experiment with d_3, experiment with d_3 and experiment with d_4.

For 2TL PC scheme, the integration with d_3 becomes stable only after the introduction of a strong pseudo second-order decentering (ξ = 0.1). In the field of vertical velocity, we can see bigger noise on the top of the domain (50 *hPa*) in the case of extrapolating PC scheme in comparison to NE PC. This noise is removed completely by decentering. In other features, the fields are very similar for both variables; see fig. 2.

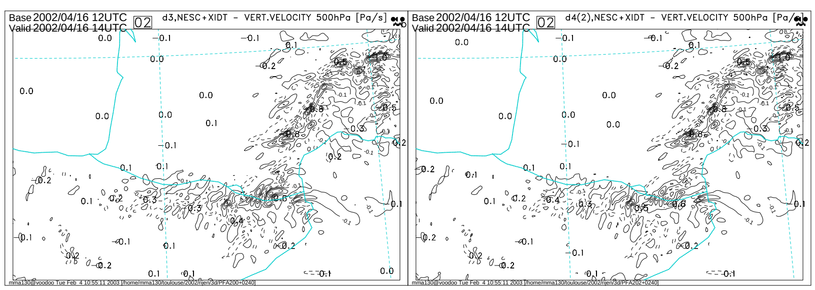

Figure 2 : Vertical velocity at 500 *hPa*, with 2TL PC NE and XIDT=0.1.
Left : experiment with d_3. Right : experiment with d_4.

4. CPU time & memory aspects

For all tested integration schemes, the usage of d_4 requires about 5 % extra memory and about 5 % extra CPU-time in comparison to the same integration run with d_3. A remarkable retardation appears at the level of setup. This retardation is caused by the conversion procedure from the initial historical file (where $g\,\partial w/\partial\eta$ is saved) to the model variable. The reason for this is that for d_4 in contrast to the other possible "*d*-variables", spectral transforms are needed for the computation of the term X that are very time-demanding. An optimization of the code for better vectorization capacity could improve the integration time & memory statistics.

5. Conclusions

From the set of carried out experiments we can conclude that the system with d_4 used as variable for vertical divergence shows enhanced stability in comparison with the system using d_3. The stabilizing effect is more pronounced in experiments with steeper orography. Better stability properties of d_4 have to be judged against more complicated model code and CPU time & memory requirements of the d_4 implementation.

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On ALADIN Precipitation Forecasts over the European Alps

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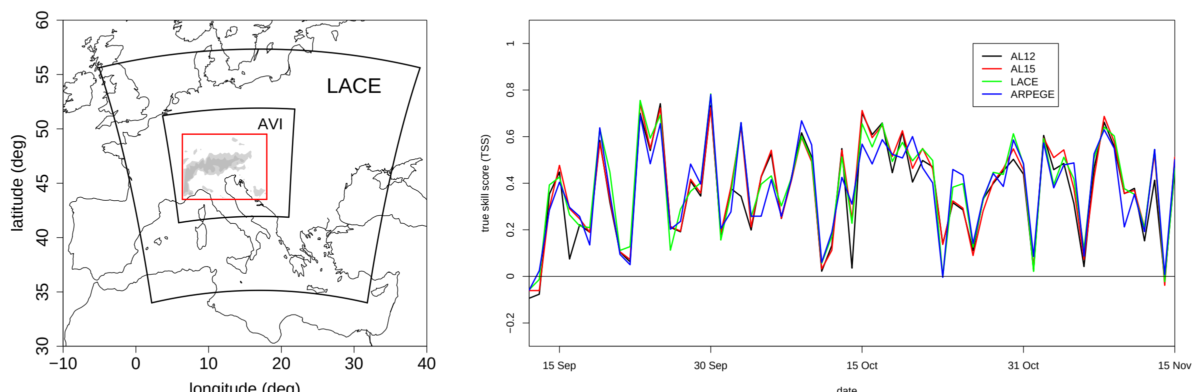
1 Introduction

Forecasting precipitation over complex terrain is a challenging task, in particular, for high-resolution limited-area models. In this report we compare ALADIN precipitation forecasts (9.6 km gridspacing) from different model versions to the high-resolution rain-gauge analysis (Frei and Haeller, 2001) available for the Mesoscale Alpine Programme Special Observation Period (MAP SOP, Sept. 7 to Nov. 15, 1999). This precipitation analysis has a time resolution of 24 h and a spatial resolution of 25 km, thus the forecasted precipitation fields are aggregated to 25 km. To assess the impact of the validation grid, additional comparisons have been carried out for gridspacings of 50 and 100 km, respectively.

The target area covers most of the European Alps and substantial part of the domain of ALADIN/VIENNA, the operational configuration at the Austrian weather service (ZAMG). Investigations have been performed for the period Sept. 12 to Nov. 15, 1999. Within this period several events of heavy precipitation have been observed with 24 h accumulated rainfall of more than 100 mm in particular regions.

2 ALADIN simulations



(a) (b)

Figure 1: (a) Domain bounds for model configurations and (b) time-series of true-skill-score (TSS) for different configurations.

We have performed simulations with the hydrostatic ALADIN/VIENNA (AVI) system for model cycles 12 and 15. With both model configurations sequences of 65 forecasts (Sept. 12 to Nov. 15, 1999) have been carried out, each over 30 hours discarding the leading 6 hours of the forecast to avoid a possible spin-up within the model. The forecasts are nested (6 hour coupling) into ALADIN/LACE data for 1999. From these forecasts daily precipitation amounts are obtained, as the difference between forecasts valid at t+30 and t+6, respectively. In addition, precipitation forecasts from ALADIN/LACE as well as from ARPEGE are used for comparison. For every configuration the precipitation fields are interpolated onto the validation grid using an inverse-distance-weighting method on the basis of the 16 nearest gridpoints. Assuming that the effective resolution is $4\Delta x$ and above (see e.g. Grasso, 2000) this choice seems reasonable. The agreement between the forecasted precipitation fields and the rain gauge analysis is investigated through bias and RMS fields as well as quantitatively in terms of skill scores. Fig. 1a illustrates the model configuration domains (i.e., LACE and AVI) as well as the validation region shown as red box. In the following, results are presented for the comparison of predicted precipitation rates derived from the model forecasts with the MAP SOP rain-gauge analysis. The statistics are computed on the basis of the 65 consecutive days from Sept. 12 to Nov. 15, 1999.

Table 1 summarizes the performance for the four model configurations in terms of bias, root-mean-square error (rms) and skill scores for gridspacings of 25, 50, and 100 km, respectively. The bias is computed as analysed precipitation minus model prediction. The individual entries in Table 1 are bias [mm/day], rms [mm/day], rank-correlation (cor), variance ratio (r.var, computed as ratio model/analysis), hit rate (HR), probability of detection (POD), and true-skill-score (TSS). For the definition of accuracy and skill scores, refer to Wilks (1995). Focusing on the comparison between model versions 12 and 15 (i.e. the first two rows in Table 1) reveals that there is a clear difference between the two model versions in terms of predicted rainfall. The TSS as well as the rank-order correlation suggest that AL15 produces slightly more accurate precipitation fields. The most significant differences between the two configurations are observed for the model bias and the variance ratio. Comparing the statistics of the different ALADIN configurations to ARPEGE reveals that the performance of ARPEGE is similar or even slightly better in terms of skill-scores, although the model bias is larger. Increasing the gridspacing of the underlying validation grid results in smaller rms differences as well as higher correlations as expected due to the inherent smoothing of the fields.

25km	bias [mm/day]	rms [mm/day]	cor [1]	r.var [1]	HR [1]	POD [1]	TSS [1]
AL12	0.21	7.07	0.44	1.40	0.75	0.66	0.36
AL15	-0.41	6.99	0.49	1.72	0.78	0.71	0.39
LACE	-0.53	7.00	0.49	1.91	0.78	0.73	0.40
ARPEGE	-0.50	6.88	0.49	1.98	0.78	0.74	0.39

50km	bias [mm/day]	rms [mm/day]	cor [1]	r.var [1]	HR [1]	POD [1]	TSS [1]
AL12	0.26	6.32	0.48	1.40	0.77	0.71	0.40
AL15	-0.38	6.18	0.52	1.69	0.80	0.75	0.42
LACE	-0.51	6.18	0.53	1.83	0.80	0.78	0.43
ARPEGE	-0.52	6.20	0.53	1.94	0.79	0.77	0.42

100km	bias [mm/day]	rms [mm/day]	cor [1]	r.var [1]	HR [1]	POD [1]	TSS [1]
AL12	0.30	5.59	0.55	0.76	0.79	0.76	0.40
AL15	-0.43	5.32	0.58	1.19	0.81	0.80	0.39
LACE	-0.53	5.30	0.59	1.28	0.81	0.82	0.39
ARPEGE	-0.57	5.45	0.59	1.27	0.81	0.82	0.41

Table 1: Statistics of precipitation fields for different model configurations computed with respect to MAP SOP rain gauge analysis for gridspacing of 25, 50, and 100 km

Fig. 1b shows TSS for the 65 individual dates computed for a gridspacing of 25 km. It is clear that even for the large validation domain considered here more than 10 dates are associated with very poor forecasts. The best skill-scores within this period are close to 0.8 for all configurations. The mean values of the individual curves can be seen from the last column in Table 1 (25 km).

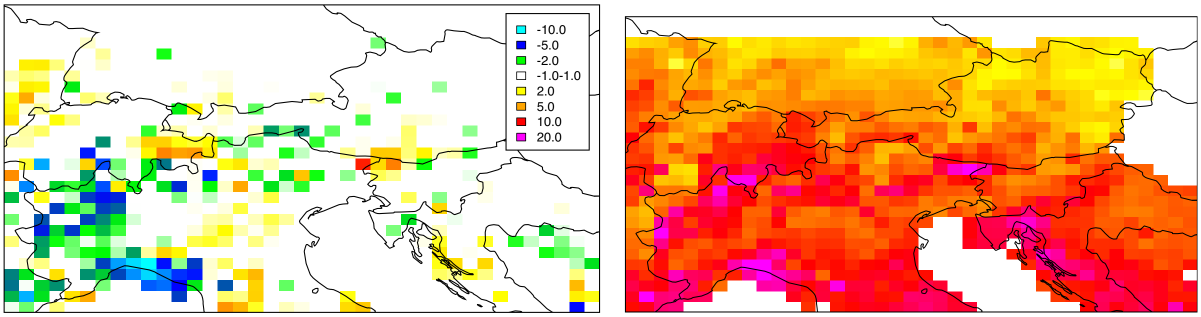


Figure 2: Bias (left) and rms (right) [mm/day] for AL12 computed from the 65 consecutive dates and gridspacing of 25km. Bias is computed as rain-gauge analysis minus model forecast.

Let us now look at the difference between model versions 12 and 15 in terms of spatial fields. Figs. 2 and 3 show bias (a) and rms (b) fields for 25 km gridspacing. Not surprisingly, the strongest bias is found on the windward side of the Alps with extrema of -10 mm/day. The differences between Figs. 2 and 3 are small though the statistics (see Table 1) suggest that version 15 produces more accurate precipitation forecasts with respect to the rain-gauge analysis considered here.

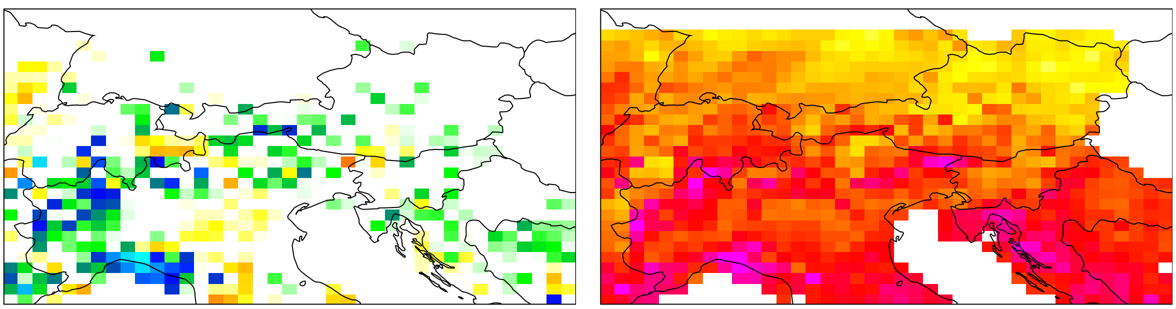


Figure 3: as Fig. 2, but for model version 15 (AL15).

3 Conclusions

Precipitation forecasts over the Alps have been compared to the MAP SOP rain-gauge analysis for different validation grids. The smallest gridspacing considered for the validation grid is 25 km. The results suggest that there is an improvement in terms of predicted rainfall between ALADIN versions 12 and 15 even on the (fairly) large scales considered within this study. The average TSS is between 0.4 and 0.5 depending on the validation grid considered. The comparison of the ALADIN configurations to ARPEGE suggests that on scales of 25 km or above, as considered here, there is hardly any improvement in terms of precipitation forecasts. We stress that the results presented here are by no means complete and are presumably dependent on the reference analysis as well as the validation method chosen. Nevertheless, we think that the MAP SOP and the approaches considered here might serve as a basis for future evaluations of the performance of ALADIN not only with respect to precipitation but also for other variables.

Consequently, the next step is to investigate approaches for validation on scales of 10 km suitable for ALADIN precipitation forecasts. These approaches include the use of precipitation fields derived from radar data as well as the indirect validation of precipitation against observed runoff measurements (Ahrens et al., 2003).

Acknowledgements

We are grateful to Jure Jerman and others for there help and advice in setting up ALADIN at IMG Vienna and salute the outstanding work of the ARPEGE/IFS/ALADIN community. Technical support from ZAMG is acknowledged. The authors are supported by the Austrian Academy of Sciences, Project Hö 22.

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ALADIN behaviour in two cases of tropical cyclones in South-West Indian Ocean (GUILLAUME for genesis and DINA in a mature phase)

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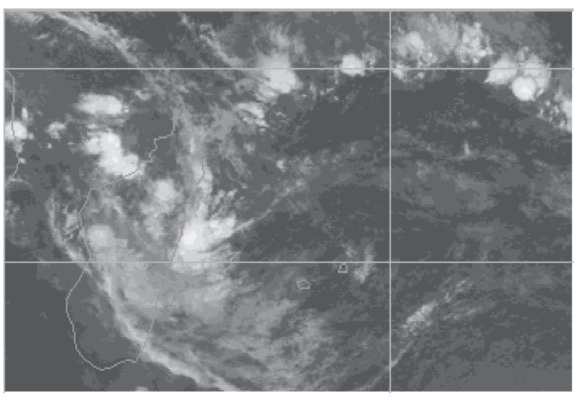
Météo-France - DIRRE/CRC

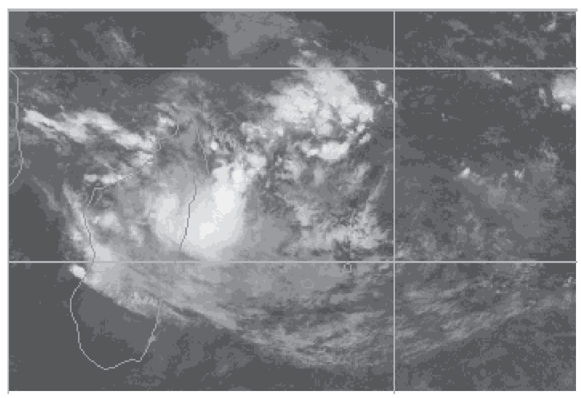
I. Introduction

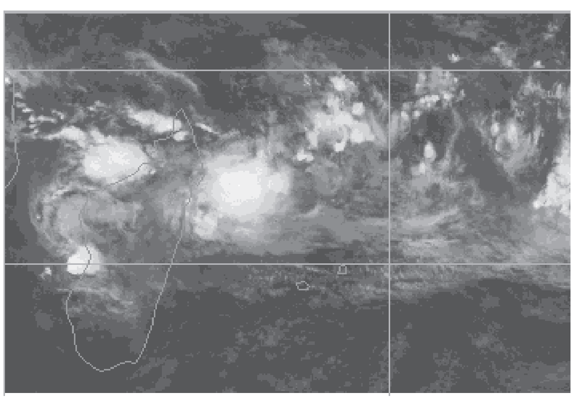
During all tropical cyclone season in South-West Indian Ocean, we have checked the quality of the tropical chain (ARPEGE-Tropiques and ALADIN), and have found that the ALADIN model with only a 33 km mesh has not improved the forecasts made by the ARPEGE-Tropiques model. In order to better test ALADIN we decided to have a close look on the impact of the mesh-size on the ability to simulate a tropical cyclone. We have then tested two cases. The first one is Guillaume in the cyclogenesis phase and the second one concern Dina in a mature case. In tropical cyclone Guillaume, with a 15 km mesh model, we have also tested the impact of the "shear-linked convection" parameterisation in addition to the CYCORA-ter operational physical package.

II. First case: GUILLAUME

II.1 General description


13/02/2002 at 00 UTC


14/02/2002 at 00 UTC


15/02/2002 at 00 UTC

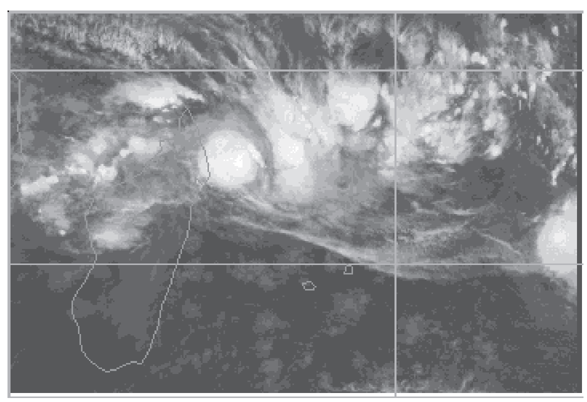

16/02/2002 at 00 UTC

Figure 1 : Infrared images from Météosat 5

Near the East cost of Madagascar on the 13th February 2002, we notice the development of a mesoscale convective system. The intensification of the convection is noticeable during the two next days, and on 15th at 06 UTC, the tropical depression n°10 is there. It will become the tropical cyclone Guillaume. Figure 1 shows the evolution of the convection during these four days from 13th to 16th February at 00 UTC.

We have performed a 72 hours forecast from the 13th February at 00 UTC to 16th February at 00 UTC. The analysis and the boundaries conditions came from the ARPEGE-Tropiques operational analysis and forecast at the same date. No bogus was introduced in his simulation as it was only available after 15th February at 06 UTC.
In order to have a better fit to fine mesh, ALADIN with 15 km mesh is coupled with the 33 km ALADIN operational forecast that has very few differences with the ARPEGE-Tropiques one. The two experiments are called respectively Al-15 and Al-33.

2. Mesh-size impact

A/ Trajectory and intensity of the system.

On Figure 2 we show four trajectories. One is from subjective analysis from forecaster with the Dvorak method. Another one is from an objective analysis with the ICI 200 hPa temperature retrieval model. The two others are from ALADIN simulations at 15 km and 33 km.
With 33 km mesh ALADIN gives a tropical depression going very quickly to the North-West. Even if the localisation is not at the right place, with 15 km mesh the depression has a displacement that is in accordance with the ICI analysis. On satellite images the localizing the centre of the depression is very difficult with a weak system. But at the end of the forecast the trajectory given by ALADIN 15 km is not too far from the ICI objective analysis.

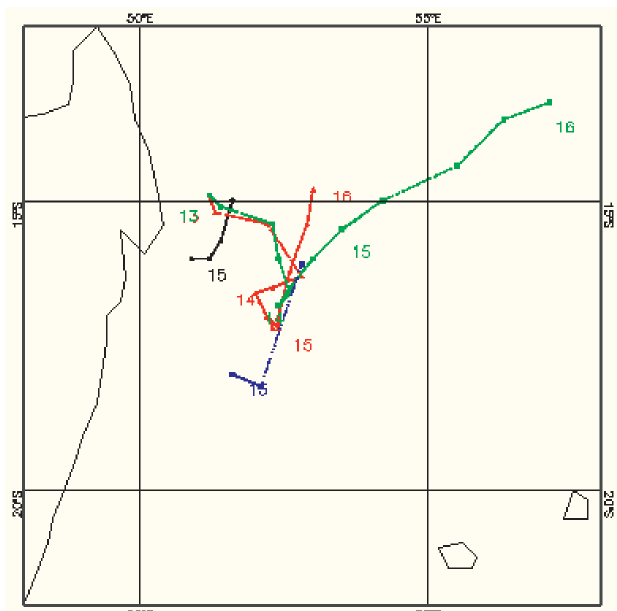


Figure 2 : Tropical depression Guillaume trajectory (red: Al-15; green: Al-33; blue: ICI objective analysis; black: forecaster subjective estimation - best track)

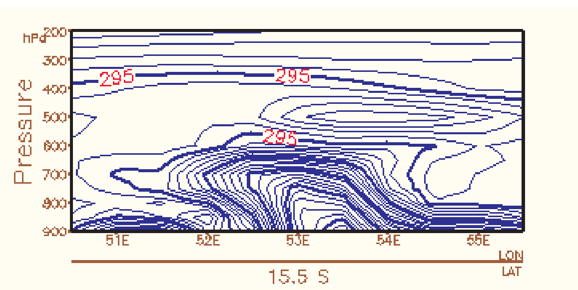
Table 1 shows the mean-sea-level pressure (mslp) at the centre of the tropical depression at all forecast ranges for both simulations (15 km and 33 km). We can compare these results with best track estimation from forecasters after 15th February at 06 UTC, as they can see a tropical disturbance in Dvorak analysis. For the 36 first hours the models do not differ that much, but after 14th at 18 UTC Al-15 begins to deepen a tropical depression with a 991 hPa low at 72 hours range, as Al-33 stays above 1000 hPa. The Dvorak mslp is 5 or 6 hPa above the Al-15 one but the tendency from 15th at 06 UTC to 16th 00 UTC is almost the same (-6 hPa for Dvorak, -7 hPa for Al-15).

Dates	Time (UTC)	Al-33 mslp (hPa)	Al-15 mslp (hPa)	Best track mslp (hPa)
2002 02 13	00:00	1007.2	1007.2	
2002 02 13	06:00	1008.3	1008.0	
2002 02 13	12:00	1006.8	1006.5	
2002 02 13	18:00	1007.5	1007.3	
2002 02 14	00:00	1007.4	1005.9	
2002 02 14	06:00	1006.5	1007.6	
2002 02 14	12:00	1004.6	1004.5	
2002 02 14	18:00	1005.6	1002.6	
2002 02 15	00:00	1004.0	999.2	
2002 02 15	06:00	1004.1	998.2	1003.0
2002 02 15	12:00	1001.6	995.1	1000.0
2002 02 15	18:00	1003.2	994.5	1000.0
2002 02 16	00:00	1001.5	991.3	997.0

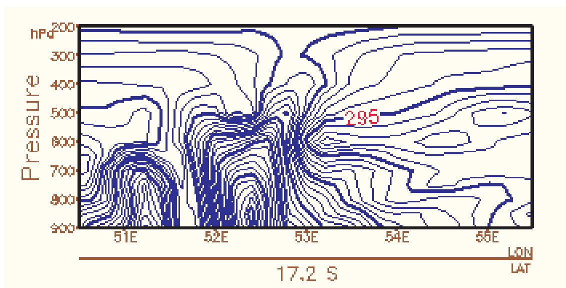
Tableau 1 : Mean sea level pressure at the centre of the tropical depression

B/ θ'*w* vertical structure of Guillaume

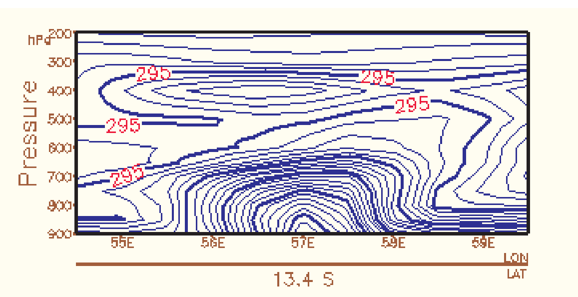
Figure 3 shows the vertical structure of the tropical depression in the 48 h- and 72 h-range forecasts for θ'*w* parameter, for both models Al-15 and Al-33. As the deepening of the system is observed after the 48 h-range forecast, it is interesting to compare the vertical structure of both models. For Al-33 the influence of the convection is localised in the low levels of the atmosphere (under 600 hPa), but with the Al-15 simulation we get a vertical structure that looks like a tropical cyclone with a vertical extension through the whole troposphere.



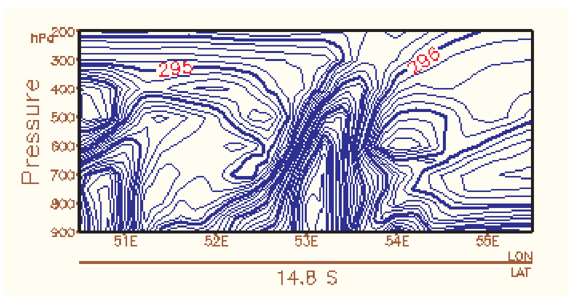
Al-33 ; 48 h forecast



Al-15 ; 48 h forecast



Al-33 ; 72 h forecast



Al-15 ; 72 h forecast

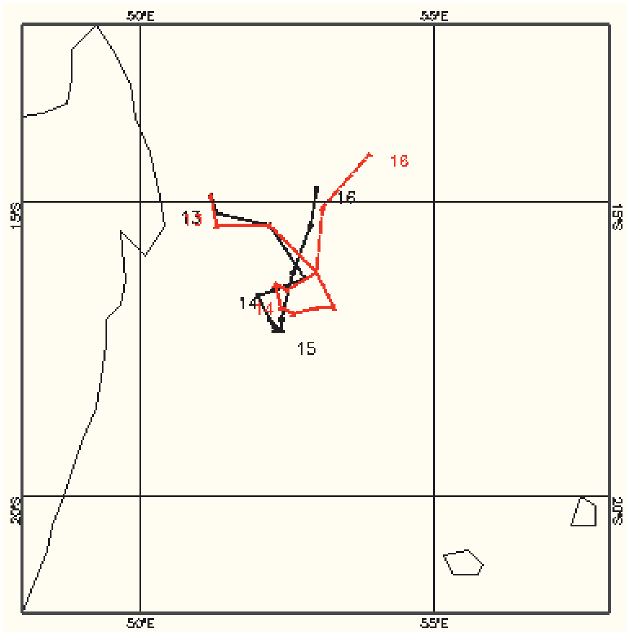
Figure 3 : Meridian vertical profiles of θ'w at the centre of the depression, for 33 km and 15 km mesh models at 48 and 72 hours forecast.

3. Impact of the "shear-linked convection" scheme

We have conducted an experiment similar to Al-15 with the recent "shear-linked convection" parameterisation (F. Bouyssel et J.F. Geleyn, Newsletter 22). This experiment is called Al-15slc.

<u>A/ Trajectory and intensity of the system.</u>

In figure 4 we can see that the trajectories show no big differences. The difference is always less than 100 km. One can notice that the displacement speed of the tropical storm for the Al-15slc simulation is slightly higher than with the other simulation (Al-15).



<u>Figure 4</u> : Guillaume trajectories (Black : Al-15; Red : Al-15slc)

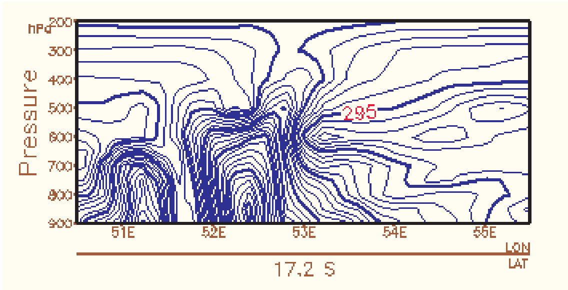
For mslp at the centre of the tropical depression, the Al-15slc values are closer to the forecaster ones than for Al-15. Table 2 shows that at 06 UTC the 15th the difference is only 2 hPa, and 1 hPa 18 hours later.

Dates	Hours (UTC)	Al-15 mslp (hPa)	Al-15slc mslp (hPa)	Best track mslp (hPa)
2002 02 13	00:00	1007.2	1007.2	
2002 02 13	06:00	1008.0	1008.0	
2002 02 13	12:00	1006.5	1006.6	
2002 02 13	18:00	1007.3	1007.7	
2002 02 14	00:00	1005.9	1008.1	
2002 02 14	06:00	1007.6	1007.1	
2002 02 14	12:00	1004.5	1003.4	
2002 02 14	18:00	1002.6	1001.1	
2002 02 15	00:00	999.2	1000.8	
2002 02 15	06:00	998.2	1001.2	1003
2002 02 15	12:00	995.1	1000.0	1000
2002 02 15	18:00	994.5	1000.0	1000
2002 02 16	00:00	991.3	996.0	997

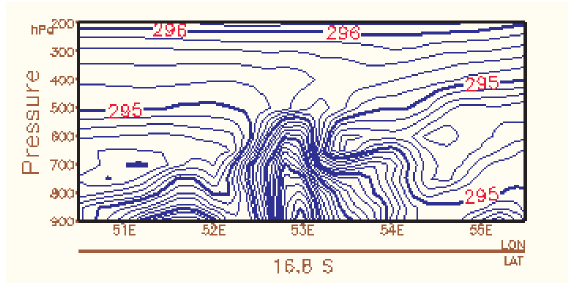
<u>Tableau 2 :</u> Mslp at the centre of the tropical depression

B/ θ’*w* vertical structure of Guillaume

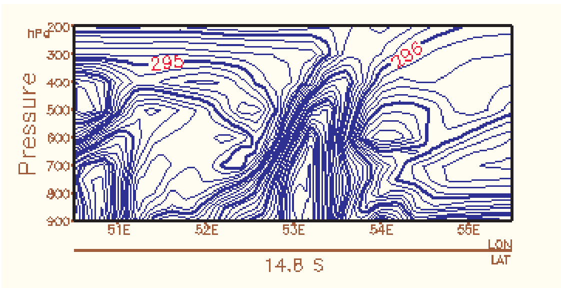
There are no big differences between the two simulations. The only one come from Al-15 that gives a centre for the tropical cyclone a bit warmer (1 or 2 K) than Al-15slc. This remark is in agreement with the less deep depression in Al-15slc than in Al-15



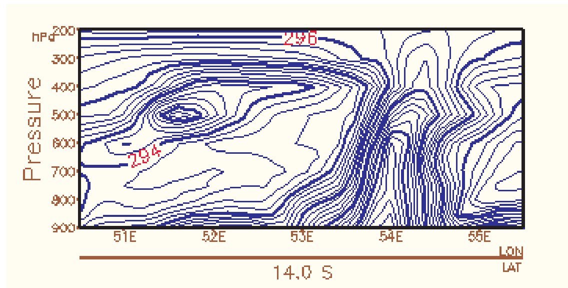
Al-15 ; 48 h forecast



Al-15slc ; 48 h forecast



Al-15 ; 72 h forecast

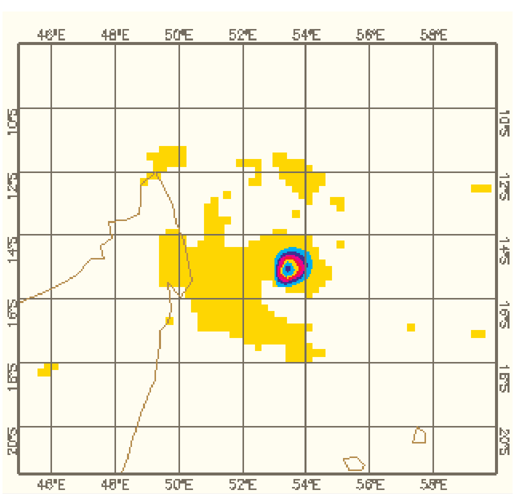


Al-15slc ; 72 h forecast

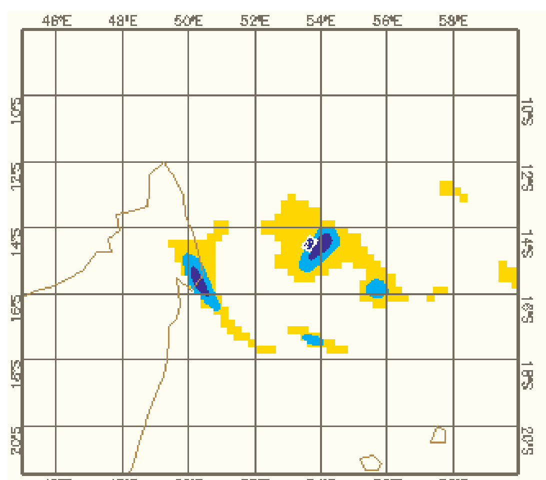
Figure 5 : Meridian vertical profiles of θ’w at the centre of the depression for 15 km mesh models with (right column) and without (left column) shear-linked convection parameterisation at 48 and 72 hours forecast

C/ Rain band structures

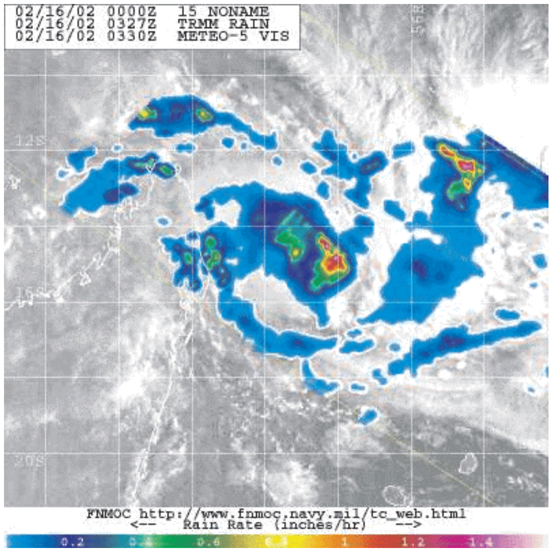
We have compared the structure of the precipitation forecasts by both models with the reality, as seen through TRMM satellite. In order to compare these two kinds of data we had to focus our study on 72 h-range forecasts with a 6 h cumulative rain quantity.



a)



b)



c)

Figure 6 :a) Total rain in 6 hours for Al-15 72 hours forecast ; b) Total rain in 6 hours for Al-15slc 72 hours forecast c) TRMM rain from microwaves 16/02/2002 at 03:27UTC

The results are very different. With Al-15 (figure 6a), one can notice a circular pattern for the intense precipitation zone. This area is surrounded by a large flat one, with small rain (< 15 mm in 6 hours). With the shear-linked convection parameterisation (figure 6b), one can notice many rain cores, but with a smaller intensity. The Al-15slc simulation has a similar shape as that shown by satellite data (figure 6c).

III. Second case: DINA

To achieve the study on the impact of mesh-size, we decided to conduct another study but with a mature tropical cyclone. Dina at 00 UTC the 22nd January 2002 was a good case. As it has been done for Guillaume we have studied the impact of a smaller mesh (15 km against 33 km) on Dina's trajectory and deepening. As we had also data from TRMM, we have decided to study the structure of rain bands.

1. General description

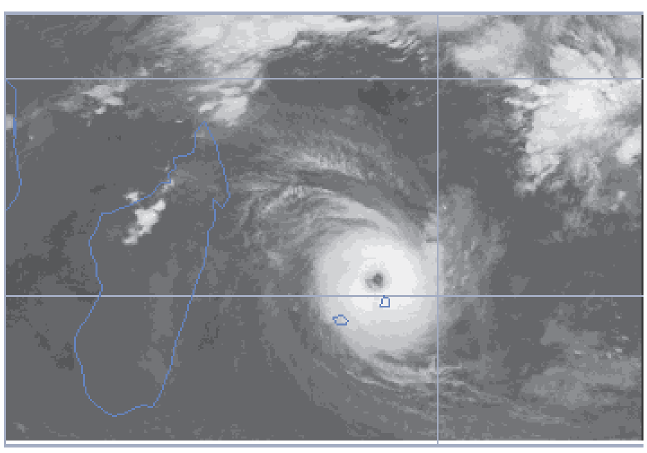


Figure 7 : Infrared Météosat 5 Image; DINA 22/01/2002 at 00 UTC

On 16th January 2002 Dina appears in the middle of the Indian Ocean. After an explosive genesis Dina is a tropical cyclone only 48 hours later. Its maximum intensity (915 hPa) is reached on 20th January 2002. Two days later it is at the north of Mauritius island, and goes straight to Reunion island. We have decided to conduct the 72 hours forecast experiments at this date of intense activity of the tropical cyclone Dina, as shown on figure 7.

2. Trajectory and intensity of the system

As for Guillaume the two experiments are named Al-33 and Al-15. On figure 8 one can notice that the two experiments are not so different. The trajectories are exactly the same till the 48 hours forecasts and the gap between them is less than 100 km at 72 h range. The 24 hours delay of the Al-33 simulation is still here in the Al-15 one. It is due to the westward trajectory during the first day of simulation, and a too slow meridional speed of the simulated tropical cyclone.

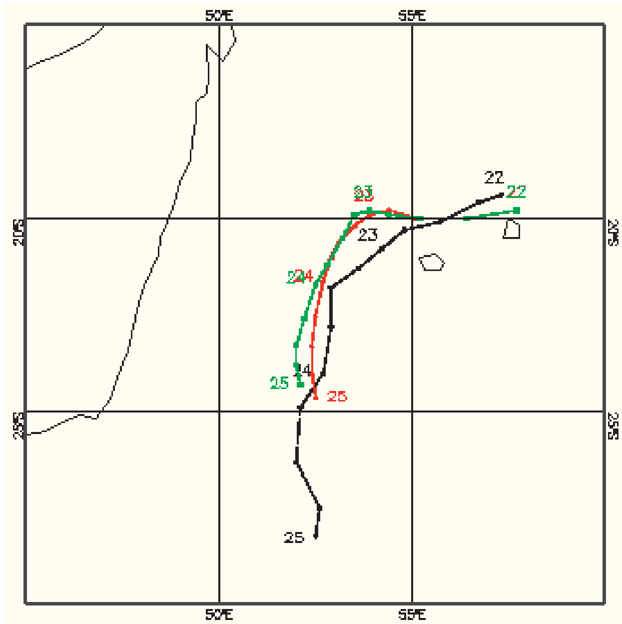


Figure 8 : Dina Trajectory (green: Al-15; red : Al-33; black : best-track from forecaster

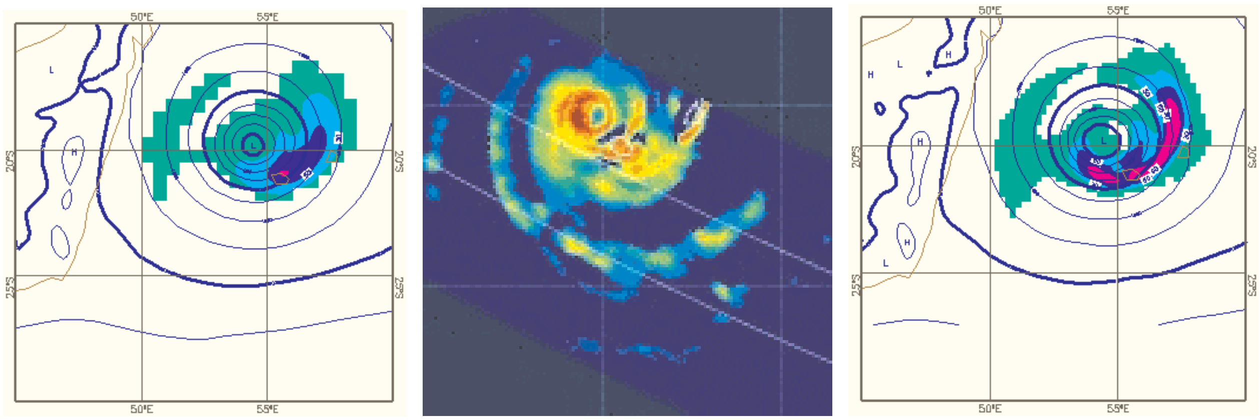
For the pressure field structure the 15 km simulation gives a bigger horizontal gradient than the 33 km one.
Table 3 shows the evolution of the mean sea level pressure at the centre of the tropical cyclone. The minimum of pressure is reached in Al-33 after 36 h forecast, but only after 72 h forecast in Al-15. Both simulations are not very realistic, as the observed minimum is at the beginning of the period.

Dates	Hours (UTC)	Al-33 mslp (hPa)	Al-15 mslp (hPa)	Best track mslp (hPa)
2002 01 22	00:00	979.3	979.3	935
2002 01 22	06:00	980.4	980.2	930
2002 01 22	12:00	976.9	976.5	930
2002 01 22	18:00	974.4	973.2	930
2002 01 23	00:00	969.4	970.2	930
2002 01 23	06:00	966.7	969.7	940
2002 01 23	12:00	964.5	967.0	950
2002 01 23	18:00	965.6	965.9	955
2002 01 24	00:00	966.7	964.1	960
2002 01 24	06:00	967.1	963.7	966
2002 01 24	12:00	967.3	958.4	972
2002 01 24	18:00	967.9	955.8	975
2002 01 25	00:00	967.3	953.7	985

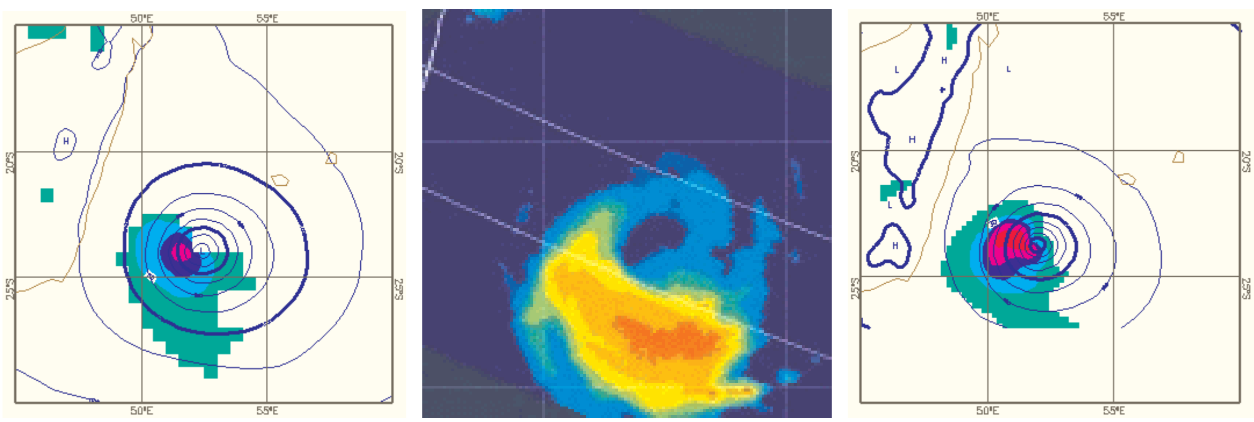
Tableau 3 : MSLP at the centre of the tropical depression

3. Rain band structures

In this part we want to have an objective estimation of rain band structures with two swaths of TRMM over Dina.
The TRMM data are available on 22/01/2002 at 00:21 UTC and 24/01/2002 at 16:38 UTC. We can notice on figure 9 that both numerical simulations with ALADIN succeed in reproducing rain band structures around Dina's centre. The localisation of high intense precipitation is in good agreement with TRMM observations.



Al-33 ; cumulative rain 12-18 h   TRMM 22/01/2002 at 16:52 UTC   Al-15 ; cumulative rain 12-18 h



Al-33 ; cumulative rain 60-66 h   TRMM 24/01/2002 at 16:38 UTC   Al-15 ; cumulative rain 60-66 h

<u>Figure 9</u> : cumulative rain on 6 hours as seen by ALADIN and by microwaves imager from TRMM.

IV. Conclusions

By these studies on two different cases we have shown that mesh size is very sensitive for tropical cyclone simulations, especially for cyclogenesis. With a 33 km mesh, ALADIN is not able to create the tropical depression Guillaume, as it is possible with a 15 km mesh model. But for a mature tropical cyclone as Dina, a finer mesh is not very useful, for the track forecast, and even worth for intensity forecast.
The impact of shear-linked convection parameterisation scheme on GUILLAUME cyclogenesis gives very encouraging results. This scheme tends to reduce rain and give a less deep depression than in the simulation without it. The rain bands are also more realistic in comparison with real data.

Some more simulations are now under test, as we have a 20 km mesh model ALADIN with shear-linked convection parameterisation operating daily over western south Indian Ocean.

Current Status and Plans on ALADIN-NH Version

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(Météo-France)

I) INTRODUCTION

Similarly to previous years, a considerable activity has taken place in the domain of the NH version of ALADIN. There are basically two reasons for this : the horizontal resolutions used in operations in our countries for LAM applications are now approaching the limit for which the hydrostatic hypothesis is no longer valid; and more specifically for Météo-France, the AROME project needs in 2003 a reasonable basis of evaluation for choosing between two dynamical cores to be considered for the future mesoscale NH operational application planned in 2008 (Meso-NH or ALADIN-NH).

The activity has been mainly devoted to demonstrating the possibility of a NH version robust enough to allow a significant benefit from using semi-Lagrangian (SL) schemes and their long time-steps. We can say that this goal has been reached, and that we have now a good hope that future mesoscale applications of ALADIN-NH will be at the cutting edge in terms of robustness and cost-effectiveness compared to other more advanced applications in the world.

Some other activities have taken place and will be reported as well here.

Concerning the cooperation and human point of view, the work of the small "ALADIN NH community" have been very enjoyable and fruitful. It is worth noting that the capabilities of the CHMI-SHMU group (J. Vivoda, J. Masek, P. Smolikova) in the area are rapidly reaching a top level, and there is no doubt that this small (promising) Eastern nucleus will overrun its French (declining ?) counterpart (P. Bénard, J.F. Geleyn) in future years.

II) WORK DONE FOR STABILIZING THE ALADIN-NH VERSION

1) Implementation of ICI scheme

The program initiated few years ago for implementing an Iterative Centred-Implicit (ICI) scheme, and performed in the framework of the PhD work of J.Vivoda, has received a considerable progress. This scheme, which is more robust and sophisticated than the old Semi-Implicit (SI) scheme, has been widely validated and implemented in the official code library of ALADIN since CY25T1. Although in this first implementation the totality of the desirable options are not coded (e.g. only 2TL versions are coded, not Leap-Frog ones), this allows a wide community to use and test this new scheme extensively.

It is to be noted that the implementation of the ICI scheme has been accompanied by a deep rationalization of the gridpoint part of the adiabatic computations, which makes the new code more readable than the old one in spite of its more sophisticated character.

In parallel, an action for harmonizing the ALADIN and IFS codes of ICI schemes has been initiated in order not to result in a too much complicated code. However, ECMWF decided recently to abandon their version of the ICI scheme, hence this action becomes obsolete and will be re-oriented simply in the cleaning of this option from the ARPEGE/IFS code.

2) Implementation of new prognostic variable (*d4*)

After the demonstration of a benefit in terms of robustness when using the prognostic variable "*d3*", another step was done by introducing a new prognostic variable "*d4*" (see P. Smolikova's paper in the same volume for details). The code for this new variable has also been introduced in the official code library of ALADIN from CY25T2 in order to allow extensive testing.

It is to be noted that the code for this new variable is a little bit more complicated and heavy than for older prognostic variables up to *d3*. As a consequence, a significant benefit will be required for this variable to be kept in the code. This question is the one to be answered to after more testing.

3) Implementation of a *w* prognostic variable

In order to try to remove a distortion of the response of ALADIN-NH in SL mode, compared to the correct Eulerian response, a prognostic *w* variable has been introduced in ALADIN during the visit of Christopher Smith. This code has also been implemented in the official ALADIN library from CY25T2. However, there are currently two flaws with this code : first it has a lack of scientific justification, and second it is not fully debugged and does not work properly. The status of this piece of code needs to be discussed and examined scientifically more in detail, since it will not be kept in the code if the SL distortion response can be removed in a more simple way.

III) WORK DONE FOR TESTING THE ALADIN-NH VERSION

Implementation of the two previous key ingredients (ICI and *d4*) in the official ALADIN code library has led to a wide spontaneous stream of testing in all directions. This is a good point since the corresponding changes are quite deep and must be extensively tested before acceptance by the community. For the use of ICI scheme, it can be observed that there is an emerging consensus in a significant part of the fine-scale NH modelling community in the world to say that the SI scheme may not be sufficient to insure an acceptable robustness (as was claimed by Tanguay et al., *MWR* 1990), and that more sophisticated schemes such as ICI schemes are required. The position of ALADIN on time-schemes is thus not a position of "isolationism".

Testing has been done in the following adiabatic frameworks :

- Classical academic set of 2D bed-tests of the NH group (flows over orography)
- Specific severe 2D tests for the AROME project
- Quasi-academic 3D tests for the AROME project
- 3D PYREX case
- 3D ALADIN-France (summer) case

A general conclusion is that for ICI schemes, a single iteration (on top of the normal SI-like iteration) should normally be enough for insuring the desired robustness. In this case, the scheme is sometimes called "Predictor/Corrector" or "PC" scheme, since the first SI-like iteration is a predictor iteration, and the additional one is a corrector iteration. Contrary to the UKMO approach, both predictor and additional iterations are based on the solution of an implicit equation : this is thought from our side to result in a better robustness.

A significant increase of robustness has generally been observed in the tests performed so far compared to older existing versions of ALADIN-NH, and even we have been able to give some "scoops" (e.g. first successful nonlinear NH integrations with 2-TL schemes, due to the use of the ICI scheme). However, the choice of the optimal combination of all the new functionalities is not easy because it seems to depend on the practical configuration examined. In case of difficulty in this area, the criterion would of course be the optimization of the robustness in the projected operational-like context.

However, after this phase of "enthusiastic testing", a phase of synthesis will be necessary to localize the areas of weakness, and to conclude more firmly, in order to possibly remove useless options.

IV) SHORT-TERM PLANS

1) Accuracy problems in SL

Since we are now almost convinced that a satisfactory final choice of the time-scheme and prognostic variable is available in the ALADIN code (hence potentially solving the robustness problems), the next priority is to study the problem of accuracy : in effect, as said above, a distortion of the response of ALADIN-NH appears when a SL scheme is used, compared to the correct Eulerian response. There is indication that this problem may be correlated to the discretisation of some nonlinear terms or to the formulation of the Bottom Boundary Condition (BBC). A significant part of the working force (including the possible help of some newcomers) will be progressively oriented towards this topics from the beginning of this year, since this appears to actually be the next burning subject.

2) Choosing and pruning obsolete options

After more extensive testing will have been performed, a necessary step will be to remove the less interesting options of the ICI and *d0-d4* code. These provisional options had been coded originally because there was no obvious way to decide what were the best scientific choices, and practical testing often allowed to answer these questions. One of the most important pieces of code concerned here is the "LPC_NOTR" option of the ICI scheme, in which the trajectories are not iterated. This allows to gain a small amount of computation at the possible expend of a potentially slight and acceptable decrease in quality. This option could have been interesting for operational use, but it appears that the potential benefit is small compared to the disadvantage of a very heavy and inelegant code. Various sub-options of the *d4* variable will have to be removed as well. Removal of *d0-d2* and $\mathcal{P}1$ prognostic variables will also have to be considered.

3) New Linear operator

There is an indication that a slight change in the linear operator could contribute to a further increase of robustness especially for the 2TL schemes (see P. Bénard’s paper in the same volume). This small topic will be explored in more details in Toulouse.

V) LONGER TERM PLANS

1) Inclusion of the physics

So far, few attention has been paid to the robustness of ALADIN-NH when the physical package is turned on. For instance, some 3D experiments exhibit strange behaviours when the physical package is abruptly turned on. There is hence a potential danger of bad surprises in this domain although the possible associated problems should not become insurmountable hopefully. Anyway, this problem will be partly tackled by the AROME team, and the initial work in this area should be done in Toulouse.

2) Deep atmosphere for NH

Recent examination of the extension of Euler Equations to the Deep Atmosphere (i.e. removing the Shallow Atmosphere approximation) shows that this can be done very naturally if the hydrostatic pressure-based coordinate is generalized to a mass-based coordinate (see forthcoming paper by Wood and Staniforth, *QJRMS* 2003, WS03 hereafter). The amount of changes in the model should be much less than the one needed for implementing the older White and Broomley (1995, WB95 hereafter) approach. The advantage of this new WS03 approach is hence twofold : the extension is absolutely exact (the WB95 approach contained an ad-hoc approximation), and it is much simpler. The generalization of the coordinate from an hydrostatic pressure to a mass coordinate is purely conceptual and has very few code consequences in itself (similarly to the extension from pressure to hydrostatic pressure when going from hydrostatic to NH equations).

This work has of course a lower priority, but could be initiated in future years, once "immediate pressure" for other topics will decrease. It is to be noted that the extension to the deep atmosphere (altogether with the release of some similar approximations) is sometimes claimed to become important for the small-scale modelling with typically 2 km horizontal mesh.

VI) COMMUNICATION

The ALADIN-NH community has worked so hard these two past years that the aspects of communication have been somehow pushed into the background. In 2002, one oral communication has been performed:

"Alternative time-discretizations for mesoscale applications: some results". P. Bénard, J. Vivoda, P. Smolikova, J. Masek. SRNWP-NT mini-workshop, Toulouse, 12-13 December 2002.

Additionally, one publication has been submitted:

"Stability of Semi-Implicit and Iterative Centred-Implicit Time Discretisations for Various Equations Systemes Used in NWP", P. Bénard, Submitted to *Monthly Weather Review*.

It should be noted that this latter paper sets the theoretical and methodological framework for a series of planned subsequent papers on connected aspects, to be written during next months. A significant effort will also be devoted in next months to the rewriting of the ALADIN-NH documentation.

Proposal of a modified linear operator for Aladin NH model

Pierre Bénard

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1 Introduction

In a recent submitted paper (Bénard, 2003, submitted to MWR) analysing the stability of the EE system in the space-continuous time-discretised context, it appears clearly that the 2-TL EE system with the classical SI time-discretisation is thermally SHB-unstable whatever is the choice of T^*, which was not the case for the HPE system in the same context.

Further examination shows that this dramatic destabilization originates from the fact that the sign of the thermal "non-linear" residuals corresponding to the terms responsible for gravity and acoustic waves systematically have opposite signs. As a consequence, if T^* is chosen so as to stabilize gravity waves, acoustic waves will be unstable, and *vice versa*.

To illustrate this explanation we can examine the couple of following excerpts of the complete linearized EE system :

$$\frac{\partial D}{\partial t} = -R\mathcal{G}\nabla^2 T \tag{1}$$

$$\frac{\partial T}{\partial t} = -\frac{R\overline{T}}{C_v}D \tag{2}$$

$$\frac{\partial \mathsf{d}}{\partial t} = -\frac{g^2}{R\overline{T}}\mathcal{L}\mathcal{P} \tag{3}$$

$$\frac{\partial \mathcal{P}}{\partial t} = -\frac{C_p}{C_v}\mathsf{d} \tag{4}$$

where d is "d_3", $\mathcal{P}$ is "P_2", and other notations are standard to Aladin model.

The first sub-system describes the horizontal propagation of external gravity waves, while the second describes the vertical propagation of acoustic waves. It is clear that these two systems are formally identical the only noticeable difference being the place of the $\overline{T}$ factors (at numerator vs. denominator). For a given set of actual and reference states ($\overline{T}$, T^*) the non-linear residual always have an opposite sign in the two systems. Let us define a non-linearity parameter by $\alpha = (\overline{T} - T^*)/T^*$. The stability properties of the first system for α are thus the same as those of the second system for $-\alpha/(1+\alpha)$. Since the stability of the first system (in 2-TL SI) implies $\alpha < 0$, the stability of the second system implies $\alpha > 0$, and the stability domain of the complete system vanishes.

Several solution could be found to avoid this problem:

- Abuptly remove the SHB problem by using a reference state identical to the current state. However, this requires a complete revisitation of the dynamical core of the model, which is out of the scope of this note. Moreover, this rises many theoretical problems which are not trivially solved.
- Change the set of prognostic variables: the nature of residual terms is highly dependent on the choice of the set of prognostic variables, hence we could expect that a "clever" set removes the corresponding non-linear terms, or at least make them the same sign (maybe for instance the use of θ as a prognostic variable would be a solution). However, such a "clever" set has not been found or examined so far.

Moreover, this would presumably require a big amount of change in the model formulation, namely because the SI scheme would need to be deeply changed.

- Finally, a slight modification of the reference linear operator itself can avoid the problem, by changing the nature of the non-linear residuals. It is this approach which is examined in this note.

2 Background for the SI operator modification

The SI time-discretisation writes symbolically:

$$\frac{\partial X}{\partial t} = \mathcal{M}.X + \mathcal{L}^* \left(\overline{X}^t - X \right) \tag{5}$$

The tradition in NWP is to choose $\mathcal{L}^*$ as the tangent-linear operator of $\mathcal{M}$ around a stationnary reference-state $\mathcal{X}^*$. However, this choice is not strictly a constraint, and any linear operator could be chosen (with the risk that a too "exotic" linear operator will not have stabilizing properties).

For instance, if $\mathcal{L}^*$ is replaced by $(1+\kappa)\mathcal{L}^*$ where κ is a small positive number, we obtain a linear operator which is *not* the TL of $\mathcal{M}$ around any existing state $\mathcal{X}^*$, and yet we obtain a "decentred SI " scheme which is generally more stable than the normal one.

Here, we explore the impact of choosing a warm reference temperature T^* in the terms responsible for gravity waves, while a cold reference temperature T_a^* is chosen for the terms responsible for acoustic waves. In addition, we note $r = T_a^*/T^*$.

The adiabatic linearized system writes:

$$\begin{aligned}
\frac{\partial D}{\partial t} &= -R\mathcal{G}\nabla^2 T + R\overline{T}(\mathcal{G}-\mathcal{I})\nabla^2\mathcal{P} - R\overline{T}\nabla^2 q && (6)\\
\frac{\partial \mathsf{d}}{\partial t} &= -\frac{g^2}{R\overline{T}}\left(1+\sigma\frac{\partial}{\partial\sigma}\right)\left(\sigma\frac{\partial}{\partial\sigma}\right)\mathcal{P} && (7)\\
\frac{\partial T}{\partial t} &= -\frac{R\overline{T}}{C_v}(D+\mathsf{d}) && (8)\\
\frac{\partial \mathcal{P}}{\partial t} &= \mathcal{S}D - \frac{C_p}{C_v}(D+\mathsf{d}) && (9)\\
\frac{\partial q}{\partial t} &= -\mathcal{N}D, && (10)
\end{aligned}$$

and the reference system writes:

$$\begin{aligned}
\frac{\partial D}{\partial t} &= -R\mathcal{G}\nabla^2 T + RT^*(\mathcal{G}-\mathcal{I})\nabla^2\mathcal{P} - RT^*\nabla^2 q && (11)\\
\frac{\partial \mathsf{d}}{\partial t} &= -\frac{g^2}{RT_a^*}\left(1+\sigma\frac{\partial}{\partial\sigma}\right)\left(\sigma\frac{\partial}{\partial\sigma}\right)\mathcal{P} && (12)\\
\frac{\partial T}{\partial t} &= -\frac{RT^*}{C_v}(D+\mathsf{d}) && (13)\\
\frac{\partial \mathcal{P}}{\partial t} &= \mathcal{S}D - \frac{C_p}{C_v}(D+\mathsf{d}) && (14)\\
\frac{\partial q}{\partial t} &= -\mathcal{N}D, && (15)
\end{aligned}$$

3 Derivation of the Structure Equation

The derivation of the structure equation is important since its allows to demonstrate the feasability of the elimination in the model SI scheme.

The evolution equations for perturbation in the linear system writes:

$$
\begin{aligned}
\frac{\partial D}{\partial t} &= -R\mathcal{G}^*\Delta T' + gH\mathcal{G}^*\Delta\mathcal{P} - RT^*\Delta\mathcal{P} - RT^*\Delta q && (16)\\
\frac{\partial T'}{\partial t} &= -\frac{RT^*}{C_v}(D+\mathsf{d}) && (17)\\
\frac{\partial q}{\partial t} &= -\mathcal{N}^* D && (18)\\
\frac{\partial \mathcal{P}}{\partial t} &= \mathcal{S}^* D - \frac{C_p}{C_v}(D+\mathsf{d}) && (19)\\
\frac{\partial \mathsf{d}}{\partial t} &= -\frac{g}{rH}\mathcal{L}^*\mathcal{P} && (20)
\end{aligned}
$$

The d equation gives:

$$\left(\frac{\partial^2}{\partial t^2} - c^2\frac{\mathcal{L}^*}{rH^2}\right)\mathsf{d} = \frac{\mathcal{L}^*}{rH^2}\left(-gH\mathcal{S}^* + c^2\right)D \tag{21}$$

The time derivative of the divergence equation gives:

$$\left(\frac{\partial^2}{\partial t^2} - c^2\Delta\right)D = \left(-gH\mathcal{G}^* + c^2\right)\Delta\mathsf{d} \tag{22}$$

The elimination can be carried out by multiplying (21) by the left hand side term operator of (22):

$$
\begin{aligned}
\left(\frac{\partial^2}{\partial t^2} - c^2\Delta\right)\left(\frac{\partial^2}{\partial t^2} - c^2\frac{\mathcal{L}^*}{rH^2}\right)\hat{d} &= \left(\frac{\partial^2}{\partial t^2} - c^2\Delta\right)\frac{\mathcal{L}^*}{rH^2}\left(-gH\mathcal{S}^* + c^2\right)D\\
&= \frac{\mathcal{L}^*}{rH^2}\left(-gH\mathcal{S}^* + c^2\right)\left(\frac{\partial^2}{\partial t^2} - c^2\Delta\right)D\\
&= \frac{\mathcal{L}^*}{rH^2}\left(-gH\mathcal{S}^* + c^2\right)\left(-gH\mathcal{G}^* + c^2\right)\Delta\hat{d}
\end{aligned}
$$

The latter equation develops in:

$$\frac{\partial^4}{\partial t^4} - c^2\frac{\partial^2}{\partial t^2}\left(\frac{\mathcal{L}^*}{rH^2} + \Delta\right)\hat{d} - \frac{g^2}{r}\mathcal{L}^*\left(\mathcal{S}^*\mathcal{G}^* - \frac{C_p}{C_v}\mathcal{S}^* - \frac{C_p}{C_v}\mathcal{S}^*\right)\Delta\hat{d} = 0$$

An operator $g^2\mathcal{L}^*.\mathcal{A}_2^*$ applying to $\Delta\hat{d}$ appears. This operator simplifies by virtue of the above mentionned properties of the continuous operators (see NH documentation):

$$g^2\mathcal{L}^*.\mathcal{A}_2^*.\Delta\hat{d} = g^2\mathcal{L}^*\left(\mathcal{S}^*\mathcal{G}^* - \frac{C_p}{C_v}\mathcal{S}^* - \frac{C_p}{C_v}\mathcal{G}^*\right)\Delta\hat{d} = N^2c^2\Delta\hat{d}$$

Finally:

$$\left[-\frac{1}{c^2}\frac{\partial^4}{\partial t^4} + \frac{\partial^2}{\partial t^2}\left(\Delta + \frac{\mathcal{L}^*}{rH^2}\right) + \frac{N^2}{r}\Delta\right]\hat{d} = 0 \tag{23}$$

The derivation is thus formally identical to the normal derivation, simply replacing everywhere $(\mathcal{L}^*/H)$ by $(\mathcal{L}^*/rH)$. Hence we see that the derivation of the structure equation is very similar than for the classical SI formulation. Consequently, the normal modes of the reference system are the same as for the normal SI system (the effect is the same as slightly changing N and H) in (23).

4 Time-Discretisation

The time-discretization is not dramatically changed by this modification, because it relies on the same algebraic manipulations as for the above continuous structure equation. The detail of the time-discretised elimination is not detailed here, but it closely follows the one in the NH documentation.

$$\begin{aligned}
\underline{D'}^{+} - \beta\Delta t\ \Delta' \left[RT^{*}\left(\mathbf{G}^{*}-1\right)\underline{\mathcal{P}}^{+} - R\mathbf{G}^{*}\underline{T}^{+} - RT^{*}\underline{q}^{+}\right] &= \underline{\widetilde{D'^{+}}} \\
\underline{\mathsf{d}}^{+} - \beta\Delta t\ \left(-\frac{g}{rH}\mathbf{L}^{*}\underline{\mathcal{P}}^{+}\right) &= \underline{\widetilde{\mathsf{d}^{+}}} \\
\underline{\mathcal{P}}^{+} - \beta\Delta t\ \left[\left(\mathbf{S}^{*}-\frac{C_p}{C_v}\right)\overline{\mathbf{m}}^{2}\underline{D'}^{+} - \frac{C_p}{C_v}\underline{\mathsf{d}}^{+}\right] &= \underline{\widetilde{\mathcal{P}^{+}}} \\
\underline{T}^{+} - \beta\Delta t\ \left(-\frac{RT^{*}}{C_v}\overline{\mathbf{m}}^{2}\underline{D'}^{+} - \frac{RT^{*}}{C_v}\underline{\mathsf{d}}^{+}\right) &= \underline{\widetilde{T^{+}}} \\
\underline{q}^{+} - \beta\Delta t\ \left(-\mathbf{N}^{*}\overline{\mathbf{m}}^{2}\underline{D'}^{+}\right) &= \underline{\widetilde{q^{+}}}
\end{aligned}$$

with:

$$\begin{aligned}
\underline{\widetilde{D'^{+}}} &= \frac{1}{\mathbf{m}^{2}}\underline{D_{E}^{+}} + \frac{1}{\mathbf{m}^{2}}\underline{\delta D_{ESI}^{+}} \\
\underline{\widetilde{\mathsf{d}^{+}}} &= \underline{\mathsf{d}_{E}^{+}} + \underline{\delta\mathsf{d}_{ESI}^{+}} \\
\underline{\widetilde{\mathcal{P}^{+}}} &= \underline{\mathcal{P}_{E}^{+}} + \underline{\delta\mathcal{P}_{ESI}^{+}} \\
\underline{\widetilde{T^{+}}} &= \underline{T_{E}^{+}} + \underline{\delta T_{ESI}^{+}} \\
\underline{\widetilde{q^{+}}} &= \underline{q_{E}^{+}} + \underline{\delta q\ ESI^{+}}
\end{aligned}$$

and:

$$\underline{\delta\mathsf{d}_{ESI}^{+}} = \beta\Delta t\ \left(-\frac{g}{rH}\mathbf{L}^{*}\right)\left(\underline{\mathcal{P}}^{-} - 2\underline{\mathcal{P}}^{0}\right) \tag{24}$$

The only differences with the normal SI set is that a r appears in the LHS of the d equation, and the same r appears in the linear part of the RHS of the d equation, $\underline{\delta\mathsf{d}_{ESI}^{+}}$. The explicit part of equations is of course not touched.

The elimination proceeds as for the normal SI except that the $\mathbf{L}^{*}$ operator is replaced by $(1/r)\mathbf{L}^{*}$. Since the $\mathbf{T}^{*}$ operator is in fact $\mathbf{T}^{*} = \mathbf{L}^{*}.\mathbf{A_2}^{*}$, it also has to be replaced by $(1/r)\mathbf{T}^{*}$.

The final equation to be solve is thus:

$$\underline{\mathsf{d}}^{+} = \mathbf{B}^{-1}.\underline{\mathsf{d}}^{**} \tag{25}$$

with:

$$\mathbf{B} = \left[1 - \beta^{2}\Delta t^{2}c^{2}\overline{\mathbf{m}}^{2}\Delta'\right] - \left[\beta^{2}\Delta t^{2}c^{2}\frac{\mathbf{L}^{*}}{rH^{2}} + \beta^{4}\Delta t^{4}N^{2}c^{2}\overline{\mathbf{m}}^{2}\Delta'\frac{1}{r}\mathbf{T}^{*}\right] \tag{26}$$

and:

$$\underline{\mathsf{d}}^{**} = \left(1 - \beta^{2}\Delta t^{2}c^{2}\overline{\mathbf{m}}^{2}\Delta'\right)\underline{\mathsf{d}}^{*} + \beta^{2}\Delta t^{2}\frac{\mathbf{L}^{*}}{rH^{2}}\left(-RT^{*}\mathbf{S}^{*} + c^{2}\right)\overline{\mathbf{m}}^{2}\underline{D'}^{*} \tag{27}$$

where:

$$\underline{\mathsf{d}}^{*} = \underline{\widetilde{\mathsf{d}+}} + \beta \Delta t \left[\left(-\frac{g}{rH} \mathbf{L}^{*} \right) \underline{\widetilde{\mathcal{P}+}} \right] \quad (28)$$

$$\underline{D'}^{*} = \underline{\widetilde{D'+}} + \beta \Delta t \Delta' \left[RT^{*} \left(\mathbf{G}^{*} - 1 \right) \underline{\widetilde{\mathcal{P}+}} + \left(-R\mathbf{G}^{*} \right) \underline{\widetilde{T+}} + \left(-RT^{*} \right) \underline{\widetilde{q+}} \right] \quad (29)$$

We see that ihe modification consists in changing the second RHS term of $\underline{\mathsf{d}}^{*}$ in (28), then the second RHS term of $\underline{\mathsf{d}}^{**}$ in (27), then finally, the two terms in the second RHS bracket of $\mathbf{B}$ in (26). In addition, the RHS of (24) has to be modified.

- Modif in (24): `SUBROUTINE GNHDYN` and `LANHSI`: These routine compute the explicit part of the linear computations. Note that in `LANHSI`, two occurences are found, in case of 3-TL or/and 2-TL.
- Modif in (28) : `SUBROUTINE SIDD`: This modifies all computations of $(-g^2/RT)\mathbf{L}^*$ by this subroutine, but this subroutine is used with non void $\mathcal{P}$ argument only in the computation of the RHS of (24). Some other used of `SIDD` are made in the code, but always with $\mathcal{P} = 0$. It would be more transparent to devote `SIDD` only to the computation of the linear RHS or D, and to replace the d part of `SIDD` by a simple call to `SEVE` with scaling $(-g^2/RT)$.
- Modif in (27) : `SUBROUTINE ESPC`
- Modif in (26) : `SUBROUTINE SUEHEL`

5 Stability analyses

5.1 isothermal framework

In 2-TL SI we saw above that the external gravity waves are stable when $\overline{T} < T^*$ (i.e. $\alpha < 0$). The 1D vertical acoustic waves are now stable when $T_a^* < \overline{T}$ (i.e. $r - 1 < \alpha$). As a consequnce, the complete 2-TL SI system can be expected to be stable for $r - 1 < \alpha < 0$, a domain which is not vanishingly small if $r < 1$. In the following we chose $r = 0.5$ and we examine the stability of various schemes with the classical SHB method for the complete 3D EE system.

The domains for unconditional stability are summarized in the following table:

	Normal (r=1)	modified (r=0.5)
3TL SI	$-0.5 < \alpha < 1$	$-0.75 < \alpha < 1$
2TL SI	$\alpha = 0$	$-0.5 < \alpha < 0$
2TL PC	$-0.5 < \alpha < 1$	$-0.75 < \alpha < 1$

We see that applying the modified linear operator always contributes to stabilize the time-discretization. For 2-TL SI scheme, the modified linear operator allows a non-vanishing stability domain for the complete 3D system, which is a new feature, never encountered with the classical linear operator.

5.2 non-isothermal framework

The non-isothermal case can be examined in the vertically discretised framework, using the Aladin-NH discretisation. A realistic profile is chosen for $\overline{T}$: surface temperature 285 K, constant lapse-rate in the tropopause, and isothermal stratosphere at 220 K.

In this analysis, T_a^* =210K is chosen (colder than $\overline{T}$ at any level), and T^* is varied from 220 K to 320 K, and the growth rate is examined for Dt=200s and k=0.0005. The growth rates are depicted on the figure for the normal 2-TL SI scheme with $r = 0$ and for the modified SI scheme with T_a^* =210 K.

We see that for any T^*, the 2-TL SI scheme is unstable, while for warm T^*, the modified 2-TL SI becomes stable.

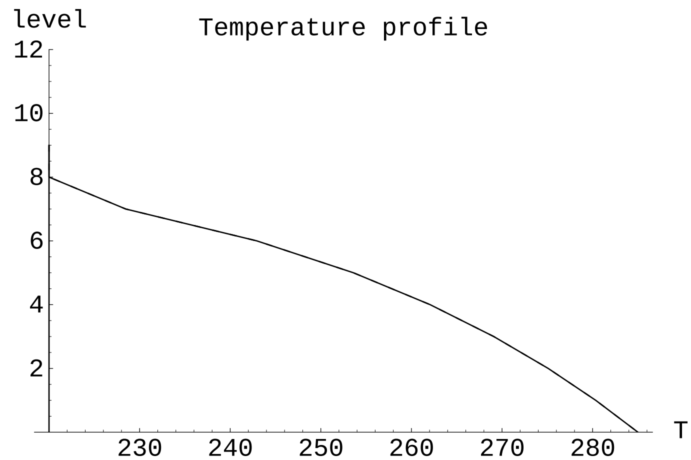

FIG. 1: Thermal profile $\overline{T}$ of the actual atmosphere.

6 Coding aspects

- Introduction of a new SITRA NAMELIST parameter
- Corresponding set-up
- Modification of the matrix $\mathbf{B}$
- Modification of RHS d**

7 Perspectives

It would be nice to discuss a little bit between our small Aladin-NH group to decide if there is something silly in this very preliminary proposal. Any comment or question is welcome of course. Anyway, the coding seems so easy that maybe the best way is to try to code it and think after...
Jean-Francois asks about the loss of accuracy implied by this modification. My first opinion would be : "if r is not chosen too small, the accuracy should be the same as for r=1". In other words, the modification only changes the magnitude of the acoustic non-linear residuals (and inverts their sign). If $r \to 0$ the acoustic residual become unbounded (but with stable sign), and the scheme is not accurate, however if r is chosen such as to invert the sign without generating large magnitude for the non-linear acoustic residual, the level of accuracy should remain basically unchanged. Contrary to decentering, stabilisation would *not* in this case be obtained at the direct expense of the accuracy.

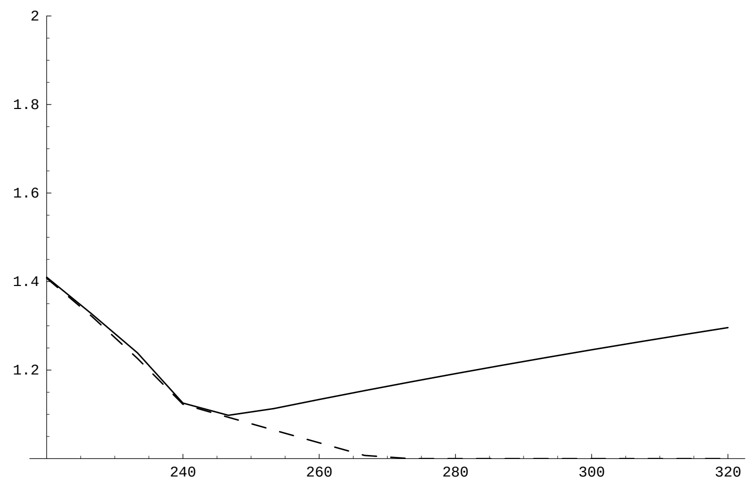

FIG. 2: Asymptotic growth-rates for 1D vertical system as a function of T^*. solid line: original 2-TL SI scheme; dashed line: modified 2-TL SI scheme.

Kilometric-scale non-hydrostatic dynamical core studies for the AROME project

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Abstract

The development of an operational NWP facility starts with the choice of a dynamical core, which has to be non-hydrostatic if one aims at horizontal scales of the order of one kilometre. To that end, a well-documented case of intense lee-waves has been simulated using vertical-plane versions of three models: ALADIN-NH, Méso-NH and HIRLAM-NH, using horizontal resolutions of 500 m and 2 km. The models have been assessed in terms of their qualitative and quantitative realism : as well as numerical stability, behaviour with long timesteps and sensitivity to details of the experimental setup.

It turns out that Méso-NH and ALADIN-NH have comparable degrees of realism when short timesteps are used. The semi-implicit semi-Lagrangian scheme of ALADIN-NH allows fourfold longer timesteps with no noticeable impact on the simulation quality.

1. Introduction: the AROME project

AROME (Applications of Research to Operations at MesoscalE) is a CNRM initiative to provide Météo-France with a data assimilation and numerical prediction facility around 2008, that resolves convective systems over mainland France. This requires the development of a state-of-the-art non-hydrostatic model at 2 to 3 km resolution. The model shall include detailed parameterisations of continental surfaces (through interfacing with an external soil and hydrology model around the ISBA scheme), of cloud microphysics and subgrid turbulence. Data assimilation will rely on a 3d variational algorithm that handles geostationary radiances, radar reflectivities, and conventional mesoscale networks.

Such a system is going to be numerically expensive. Degrading its resolution is not an option, as it would impede the description of convective cells. The first implementation of the model will be on a small domain for short-range prediction of locally-forced phenomena such as deep convection (squalls, intense precipitation, thunderstorms) and local low-level features (actual weather and fog). The numerical cost will be driven by the model timestep, which may be constrained by the dynamical core's stability and accuracy. The choice of a dynamical core has consequences on the whole forecasting system software, in particular on technical maintenance and physics/dynamics coupling. AROME will require a dynamical core that supports long timesteps for NWP applications. In addition, AROME must be suited for more fundamental research activities where physical accuracy is more important than numerical efficiency, usually for runs at very high resolution on tiny domains.

Several non-hydrostatic dynamical cores can be considered, among which Méso-NH, the anelastic research model used at CNRM and Toulouse University (Lafore et al. 1998), and ALADIN-NH, a compressible prototype version of ALADIN /ARPEGE /IFS (Bubnová et al. 1995) which is still being improved. It is instructive to compare oneself with other models such as HIRLAM-NH, an anelastic prototype suggested as a replacement for the operational HIRLAM community model (Rõõm 2001, Rõõm and Männik 2001, Männik and Rõõm 2002). A comparison with the Unified Model of the British Met'Office is under way (documentation available from Nigel Wood, *nigel.wood@metoffice.com*).

Dynamical core intercomparison requires the examination of relevant test cases, for which the correct result is known. Ideally one would like a deep convection case for AROME, unfortunately the appropriate physical parameterisations are not available in a consistent form in all models. An orographic lee-waves case has been chosen instead. It features intense waves with non-hydrostatic effects and strong vertical velocities that are akin to convective circulations.

2. The trapped lee-waves test case

This is a low-level trapped lee-waves case which has been observed in nature (Shutts and Broad 1993) and studied by Nance and Durran (1998) who explained the underlying mechanisms and published an idealised simulation which we will use as a reference. Shortly put, a strong enough (about 40 m/s) high-level jet will interact with a small analytical mountain (600 m high) under well-chosen stability conditions (4 layers of uniform Brunt-Vaisala frequencies) to produce two wave-trains. One propagates upwards, the other one remains trapped in lower layers with an horizontal wavelength around 8 km and vertical velocities up to 8 m/s at 3000 m height. This behaviour is confirmed by mathematical analysis. The wave-trains interact nonlinearly to create quasi-periodic phase oscillations downstream. This case seems to contain the main dynamical aspects needed for explicit convective cell simulation. It is sensitive to resonance and propagation properties of gravity waves over long distances, which makes it a stringent test.

The case can be simulated by a model with a vertical 2d-plane geometry, no humidity, and no physical parameterisations. However, enough resolution (500 m) is needed to correctly describe the waves. Thus, one needs to distinguish the purposes of 500 m experiments, for which the correct solution is known, from 2 km experiments (AROME's target resolution) which will be sensitive to the discretisation properties of each model.

All experiments have in common the initial state, which is hydrostatic and horizontally homogeneous, extrapolated upwards where needed, since the models have different tops. Orography is specified by a formula of the form $y=1/(1+x^2)$. Vertical resolution is about 200 m throughout the troposphere. The spectral ALADIN-NH resolution is identical to the gridpoint space resolution using a linear grid with no extension zone. The wind blows from left to right on the plots. Lateral boundary conditions are stationary. Downward wave reflection from the model top is prevented using an ad-hoc absorbing layer. A weak horizontal and vertical diffusion is used in most cases. Simulations are run for 6 hours : after a spin-up phase for a few minutes, wave-trains develop and propagate mainly downstream until they reach the model outflow boundary.

All plots use the same contouring (1 m/s for vertical velocity) and the same geography, the abscissa ranging from 20 km upstream of the mountain top to 1000 km downstream, the vertical coordinates is height, from zero to 10 km. Hovmöller diagrams (figs. 2 and 6) use model output every 15 mn.

3. Results at resolution 500 m

ALADIN-NH produces a wave-train (fig. 1) and a time evolution (fig. 2) consistent with Nance et Durran (1998) and with Méso-NH (fig. 3) and HIRLAM-NH (fig. 4). The main inconsistency is in HIRLAM-NH, in the downstream damping of the waves (on the right of the plot) and in the lack of phase oscillation. This may be due to the system of equations used (the Lamb wave is filtered out of HIRLAM-NH) or to excessive wave-damping in the stratosphere.

The timestep is limited to 4 s in Méso-NH and 7 s in HIRLAM-NH, by the stability of the explicit integration scheme. The ALADIN-NH timestep is 10 s. The vertical velocity maxima are somewhat dissymmetric in ALADIN-NH because the model is resolving part of the low-level boundary layer turbulence in the most dynamically unstable areas. The Méso-NH run is affected on the right by some wave-interaction with the boundary of the simulation domain.

4. Results at resolution 2 km

At this resolution it would not make sense to use the same mountain as Nance and Durran (1998) because it would be too narrow (6 km width) to be properly resolved. A wider mountain (12 km) is used here, which is going to alter the phase of the waves, but hardly their wavelength or amplitude.

ALADIN-NH exhibits a damped wave-train (fig. 5) with little phase oscillation (fig. 6), although the simulation remains qualitatively correct with still intense vertical velocities. The downstream damping is due to the lack of horizontal resolution. The Méso-NH (fig. 7) and HIRLAM-NH (fig. 8) behaviour is similar with some alteration. Méso-NH has the strongest vertical velocities with grid-scale ("2Δx") features that do not exist at 500 m resolution. HIRLAM-NH has the weakest waves with a strong damping, whereas ALADIN-NH has the most realistic wave-train far downstream of the mountain.

The timesteps are 16 s for Méso-NH, 20 s for HIRLAM-NH, 30 s for ALADIN-NH.

A rigorous assessment of the 2 km resolution runs raises the question of the reference, since the orography is not the same as the one in section 3. Tracking down resolution problems requires reference runs at 500 m resolution with the 12 km mountain. These runs are not available for HIRLAM-NH. The 500 m Méso-NH and ALADIN-NH runs are (as in section 3) in nearly perfect agreement with the same vertical velocities within 5 %. The exception is the first updraught which is 12 % stronger in Méso-NH. When moving to 2 km resolution, Méso-NH strongly reduces the vertical velocities except in the first updraught, and shifts the wave-train phase upstream by almost π. ALADIN-NH reduces its velocities by a similar amount but shifts the wave-train phase downstream by $\pi/2$ or so. This explains the strong phase-inconsistency between the two models at 2 km resolution.

5. Additional tests

The sensitivity to the timestep and time-stepping scheme was investigated in ALADIN-NH. The simulations are unchanged when using a shorter timestep, or an explicit Eulerian scheme, or an older ("*d3*") version of the semi-implicit scheme. In this paper the most recent two-time-level semi-implicit semi-Lagrangian scheme was used ("SISL2TL *d4*"). This version allows timesteps up to 15 s and 60 s for the 500 m and 2 km runs, respectively, with no visible degradation of the fields. Timesteps of 20 s and 90 s, respectively, produce qualitatively satisfactory runs with some deformations (phase shifting and sparse occurrences of numerical noise). In summary one concludes that the ALADIN-NH dynamics allows four times longer timesteps than the explicit Eulerian limit values that apply to Méso-NH.

The stratospheric part of the simulations is sensitive to vertical resolution, to the upward extrapolation of the Nance and Durran (1998) profiles, to the functional form and strength of the top absorbent. Precise tuning is required to suppress downward wave-reflection, although it does not affect the waves at low levels.

A fraction of the waves propagates upstream. Downstream, waves start interacting with the model boundaries near the end of the runs. Sensitivity studies to the horizontal domain size and to the position of the mountain indicate that lateral boundary conditions do not affect the trapped lee-waves that appear on the plots.

Tests at 1 km and 1.5 km resolution show that the impact of degrading the horizontal resolution is progressive.

The application of horizontal numerical diffusion is necessary to prevent numerical noise at the scales of the model grid, in explicit runs as well as ALADIN-NH SISL2TL runs with very long timesteps. The trapped lee-waves are not sensitive to the strength of this diffusion.

Vertical diffusion has an impact near the surface under the crests of the trapped lee-waves. It represents the mixing effect of unresolved turbulence. It affects the wave-phase in runs with the wide (12 km) mountain. Since vertical diffusion schemes are very different between ALADIN-NH and Méso-NH, one cannot tell whether this would be enough to explain their phase inconsistencies.

The phase inconsistencies at 2 km resolution are sensitive to other details of the experimental framework e.g. the mountain height or the definition of the vertical profile of the large-scale atmosphere : changes of the order of precision of meteorological observations are enough to compensate for the phase differences. This high sensitivity seems to be linked to a mechanism of hydraulic jump formation (rotor), as depicted by Doyle and Durran (2002) who find a similar sensitivity of orographic waves to surface friction of mountain height. Hence the mechanism for the 2 km phase inconsistencies seems to be the interaction between a physical bifurcation and minor discretisation differences between Méso-NH and ALADIN-NH.

6. Conclusions

The intercomparison of ALADIN-NH and Méso-NH dynamical parts was carried out in a dry, non-hydrostatic test case with little sensitivity to physics, which requires a 500 m horizontal resolution to be accurately resolved. The conclusion is that both models produce realistic simulations when similar timesteps are used. With a 2 km resolution, which is on the border of resolving the considered phenomenon, results are degraded in a similar fashion in both models, with some differences in details that do not place any model clearly above the other. HIRLAM-NH produces heavily damped features which lack the unstationary component of the reference simulation. One notes that ALADIN-NH allows a fourfold increase in timestep size over Méso-NH, with no visible degradation in physical accuracy.

The results are liable to revision in the future, as the three models are still evolving. They shall be extended to three-dimensional runs. They are not necessarily representative of the quality of the full models, with physical parameterisations, physics-dynamics coupling, and unstationary lateral boundary conditions. It is possible that the maximum admissible timesteps will be limited by the physics, such as the cloud microphysics.

At this stage one can only conclude that the ALADIN-NH dynamics offer the best prospects for operational use in the AROME project thanks to its good behaviour with long timesteps, which should make the AROME model as economical as possible.

7. Acknowledgements

Philippe Bougeault masterminded this study. Large parts of the ALADIN-NH code were developed by Radmila Brozková, Jean-François Geleyn and Gwenaëlle Hello among others, and more recently, Jan Masek, Petra Smoliková and Jozef Vivoda. Thanks to Isabelle Mallet for their work on Méso-NH and to Aarne Männik (Tartu University, Estonia) for running the HIRLAM-NH tests.

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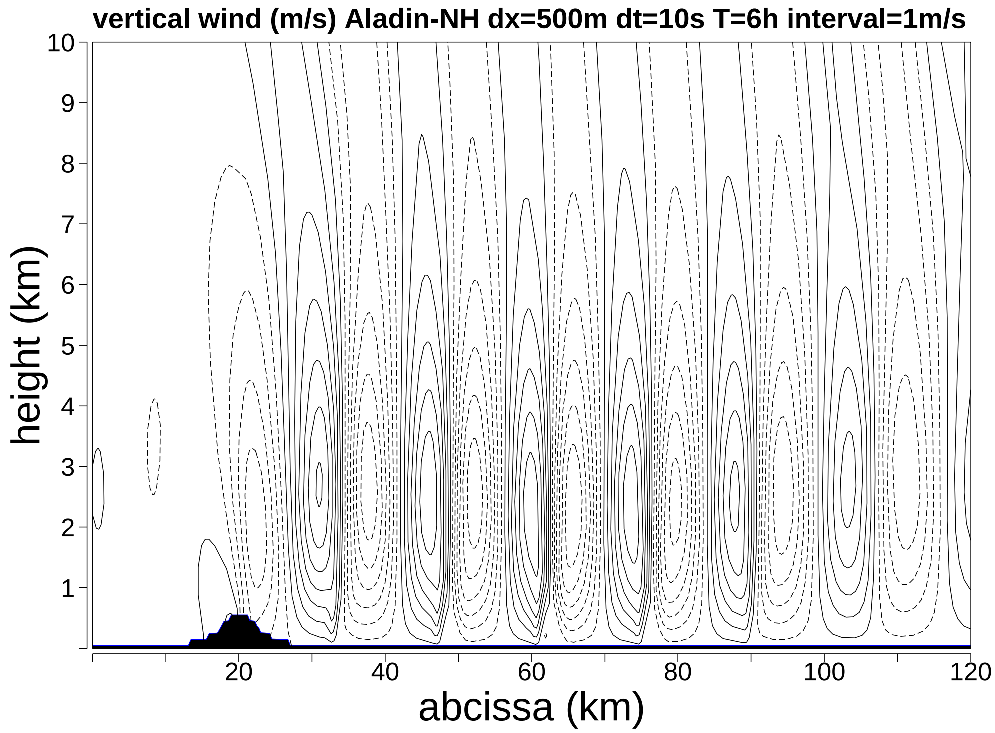

Figure 1 : ALADIN-NH vertical velocities at 500 m horizontal resolution. Contour spacing is every 1 m/s with a contour at 0.5 m/s. Downward velocities are dashed. The orography is in black at the bottom of the plot.

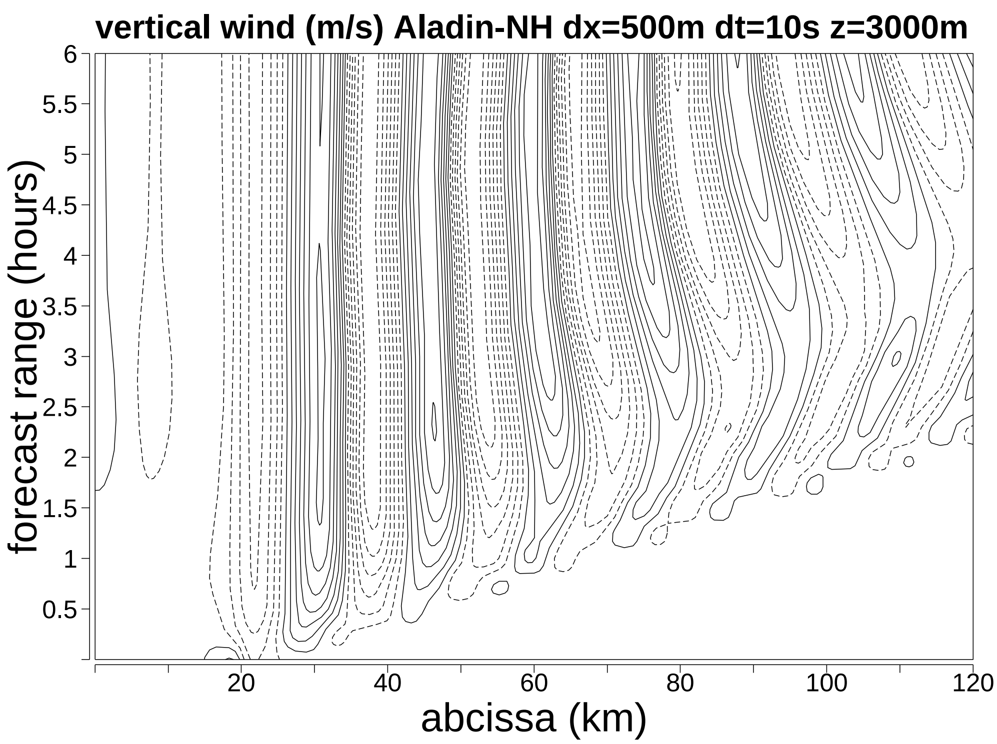

Figure 2 : Time evolution of 500 m resolution ALADIN-NH vertical velocities, at height 3000 m.

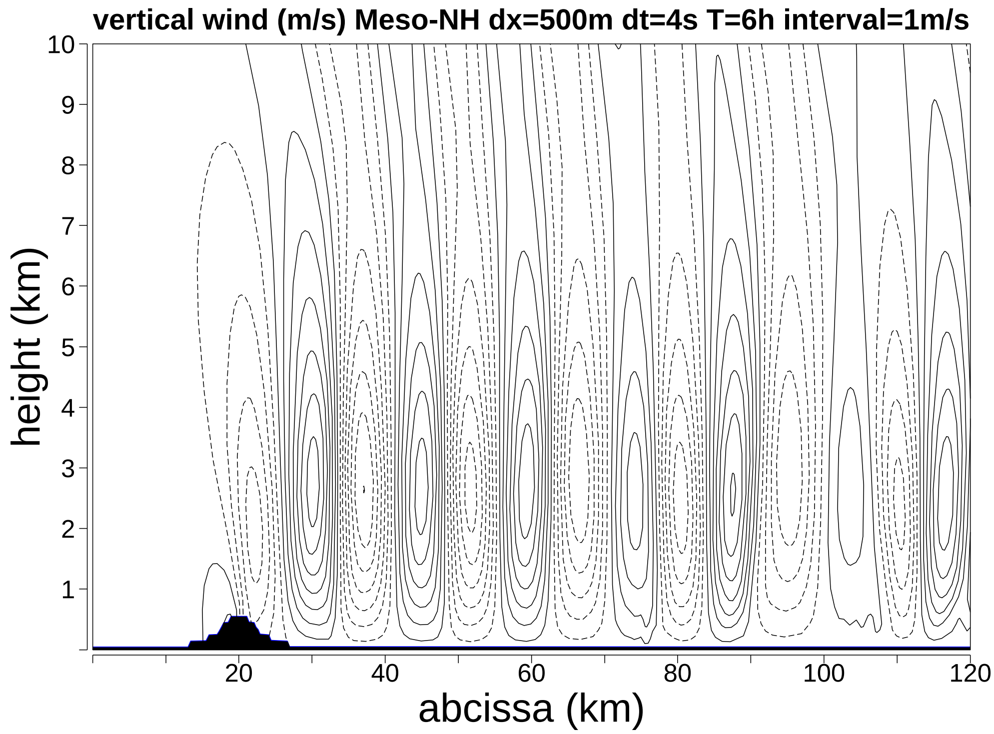

Figure 3 : As in fig. 1, using Méso-NH at 500 m resolution.

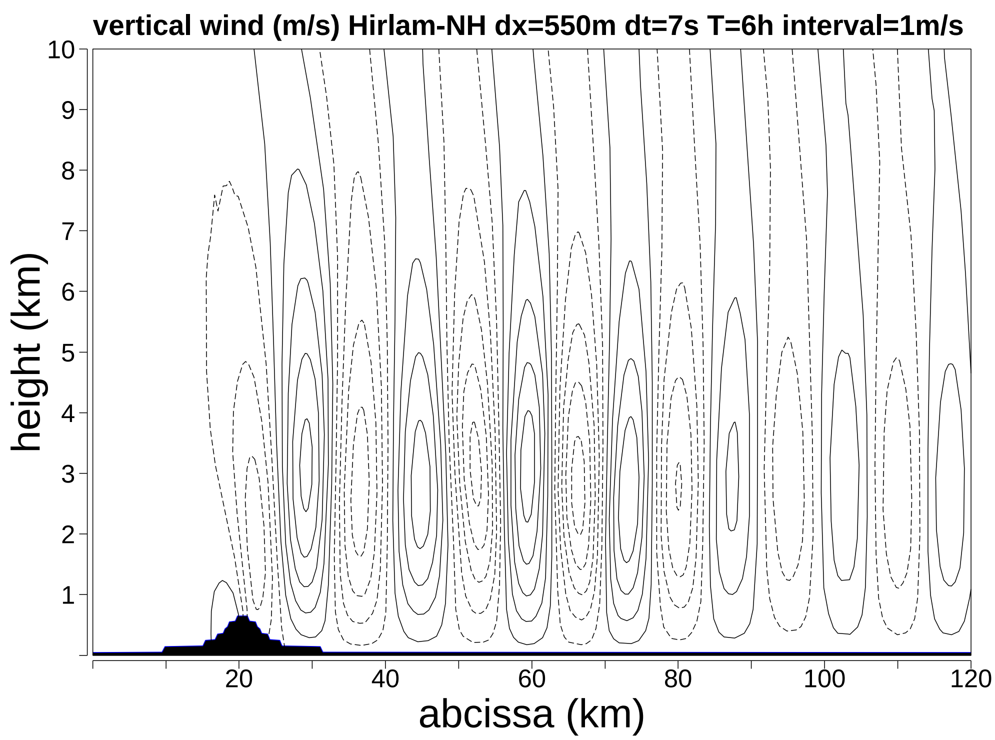

Figure 4 : As in fig. 1, using HIRLAM-NH at 550 m resolution.

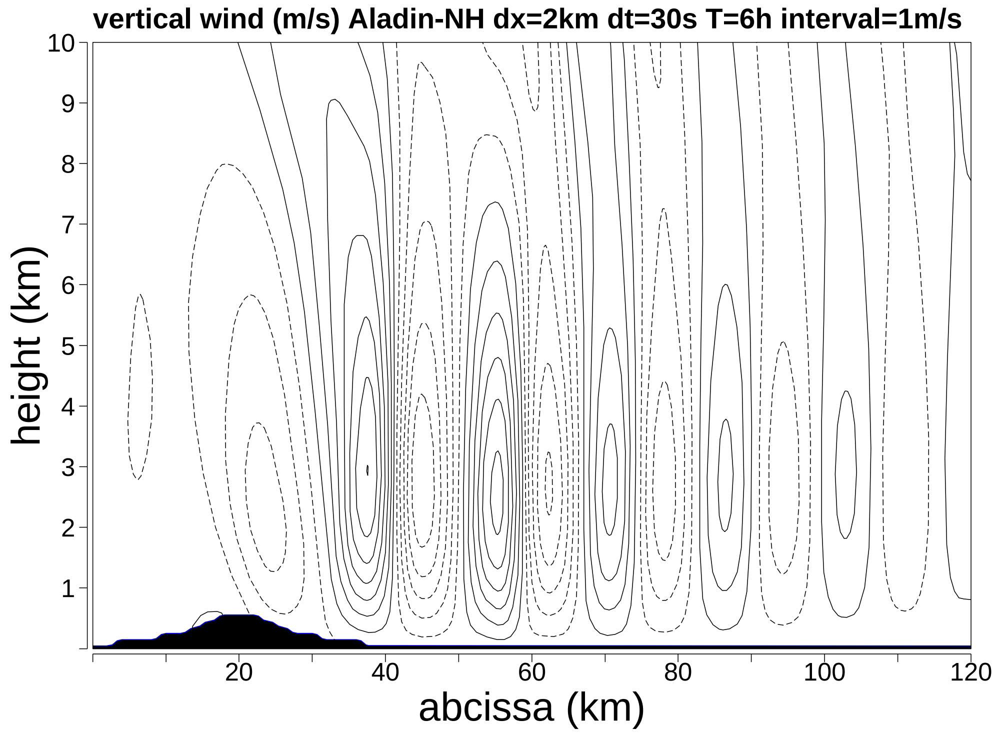

Figure 5 : As in fig. 1, using ALADIN-NH at 2 km horizontal resolution.

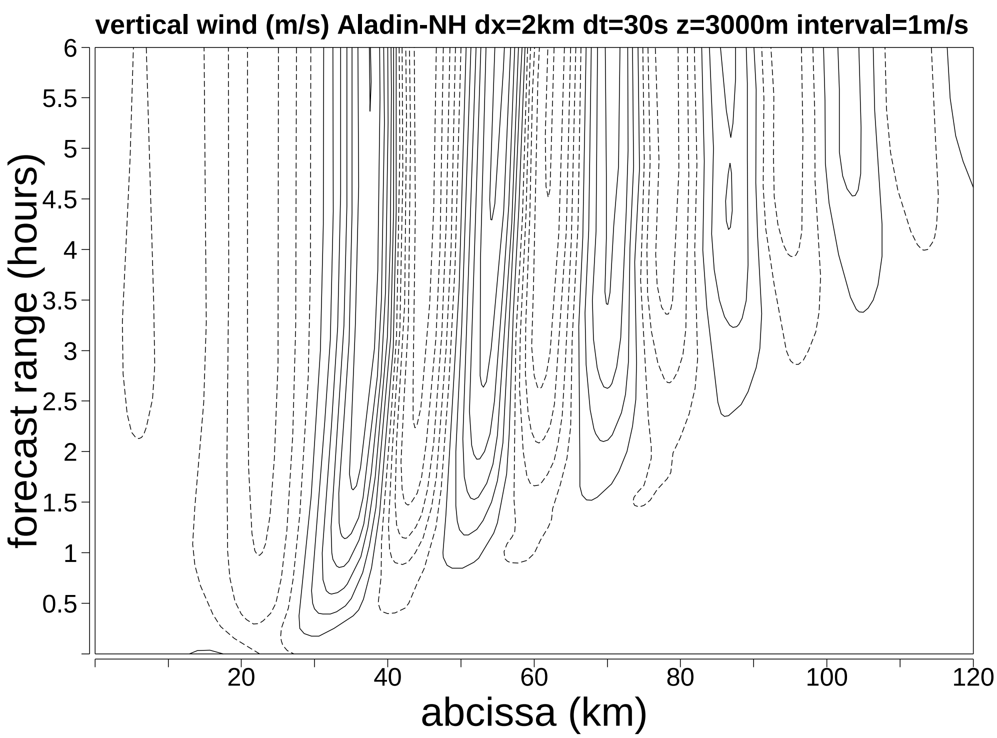

Figure 6 : As in fig. 2, at 2 km horizontal resolution.

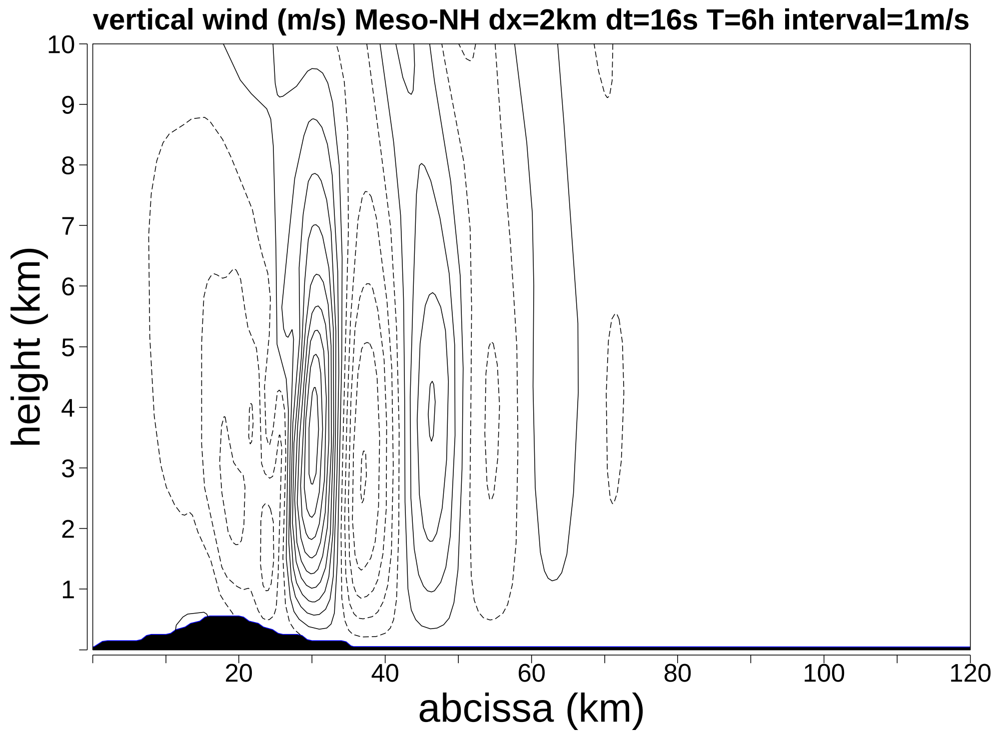

Figure 7 : As in fig. 1, using 2 km Méso-NH.

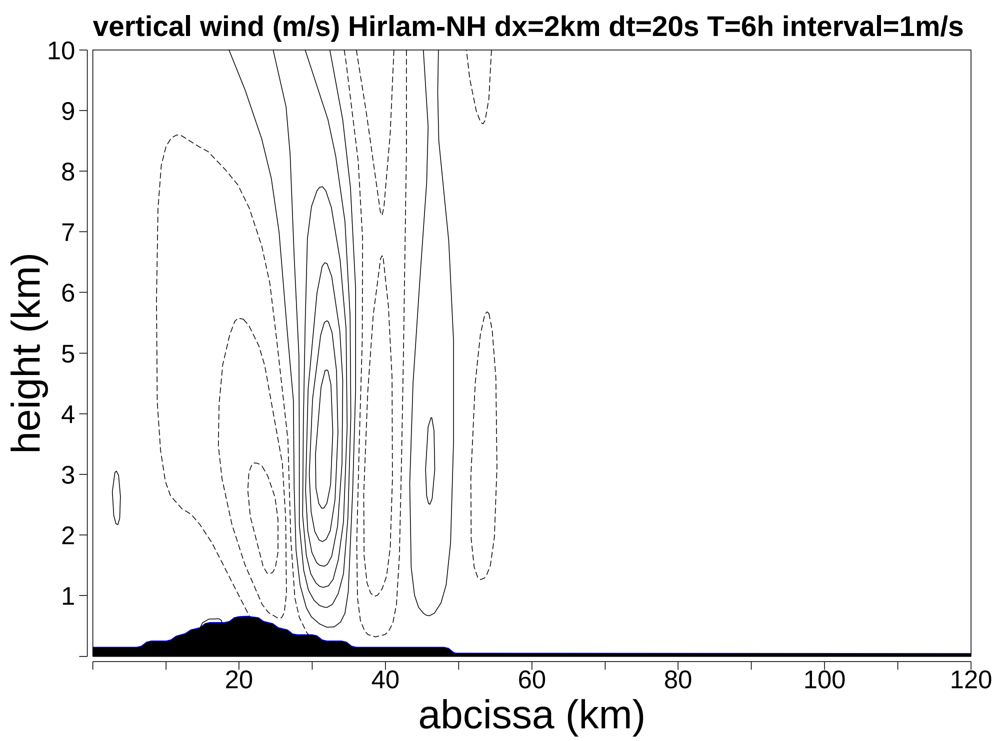

Figure 8 : As in fig. 1, using 2 km HIRLAM-NH.

Refinements in the parameterisation of radiative exchanges

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INTRODUCTION

This year developments started around the parameterisation of radiative exchanges in ARPEGE/ ALADIN. First the radiation scheme was modified in order to take into account the "Exchange With Surface" (EWS) term in the long-wave domain. The second issue was a modification of the ozone profile used by the model, introducing a geographical and temporal dependence. Third an important work was undertaken in Toulouse an Prague by Helga Toth, aiming at a more general improvement of the radiation scheme.

NEW TEST OF THE EWS PARAMETERISATION

The radiation scheme used in ARPEGE/ALADIN (subroutine `ACRANEB`) is far from expensive but on the other hand it relies on many approximations. This weak cost, compared with other schemes like *GRAALS*, used at DWD, or *FMR*, used in the Météo-France ARPEGE-climate model, makes it possible to call the radiation scheme at every time-step. This is very important in a fine-mesh model for well evaluating the interactions with clouds.

The parameterisation of the long-wave flux is based on the radiative transfer method. That consist of four main integrations : angular, vertical, spectral and optical. The optical integration is performed using the emissivity method. In this framework, the equation of radiative flux divergence can be formalised into three major terms. The first one is the cooling to space term (CTS), which is the part of the emission from a given layer transmitted directly to the space. The second term is the mutual exchanges between layers (EBL). The third term accounts for the exchanges between the layers and the surface (EWS). An exact solution requires the computation of $n(n+1)/2$ integrals (where n is the number of vertical levels). This is made in Roger Randriamampianina's "reference code", but this is very expensive. The particularity of the operational version of the long-wave radiation scheme in ARPEGE/ALADIN is that the two last terms are computed (and approximated) together.

For each layer two optical depths are computed, the first one is the optical depth between the layer and the space (δ_{CTS}), the second is the optical depth between the surface and the layer (δ_{EWS}). The minimum of these two optical depths is also computed (δ_{EXC}). Then, three terms are calculated :

- Fa : Exact calculation of cooling to space using δ_{CTS}
- Fb : Approximation of all the exchanges between layers (including CTS and EWS) using δ_{EXC}
- Fc : Approximation of the CTS term, using δ_{EXC}

The radiative flux is then computed in the following way : F = Fa + Fb - Fc

A new suite moved to operations on 11/02/03, including a new radiation scheme based on a exact calculation of the EWS term.

It is easy to see that the exact computation of the EWS term is possible using the δ_{EWS} optical depth. Two new terms are now computed.

- Fd : Exact computation of EWS term using δ_{EWS}
- Fe : Approximation of the EWS term using δ_{EXC}

The radiative flux includes two additional terms : F = Fa + Fb - Fc + Fd - Fe

A version of ACRANEB performing such a computation had been already prepared in 1996 by Neva Pristov (Pristov 1996), but unfortunately deemed as too expensive for its assumed "low impact". This version will be called *EWS* hereafter.

Within the framework of a more general test of the ARPEGE-climate physics (including the sophisticated *FMR* radiation scheme) in NWP conditions, it seemed interesting to test also the EWS version of ACRANEB. As expected, the impact is very important close to the surface. Figure 1 shows the evolution of an average of surface temperature over a Siberian area along a 96 h forecast in January 2002. Operational and *EWS* forecasts are presented, together with the corresponding operational analysis and first guess. The analysis is colder than the first guess, indicating that the model tends to introduce a hot bias. This is confirmed by the strong tendency of the operational forecast. Being colder, the *EWS* forecast seems to be better. Figure 2 presents the same diagnostics over a Saharan area. The tendencies are opposite and, this time, *EWS* code corrects completely the forecast error.

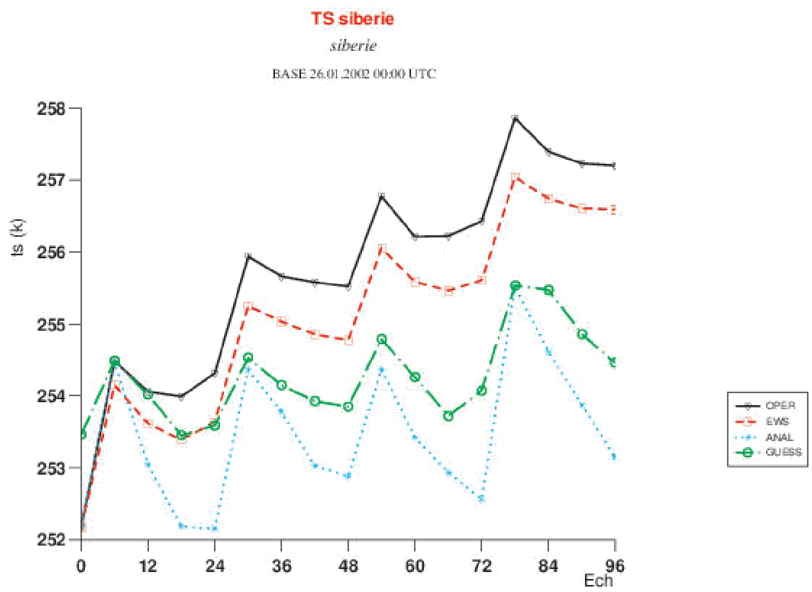

Figure 1 : Evolution along a 96 h forecast of an average of the surface temperature over a Siberian area during January 2002

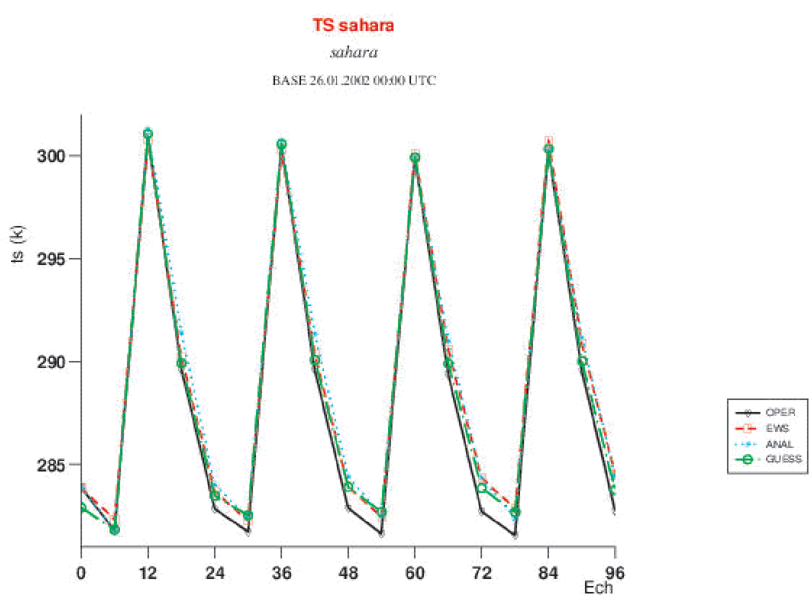

Figure 2 : Same as fig. 1, but for a Saharan area

The reason why the modification of the radiation scheme does not completely correct the problem over the Siberian area is linked to a too strong vertical turbulent transport in stable conditions. The new result of these experiments is that the modification of the radiation scheme has an impact not only close to the ground, but quickly (within 4d-var assimilation or during a medium-range forecast) on large-scale dynamics. Figures 3 to 5 show the corresponding modification of the Hadley circulation. Figure 3 presents the average over 14 days of the Hadley circulation in the analyses. On fig. 4 the average of the difference between the analyses and the operational 72 hours forecasts (valid at the same date) is plotted. Figure 5 is the equivalent of fig. 4 for the *EWS* forecast. One can see on fig. 4 a large difference between analysis and forecast at 300 hPa, close to 5 °N. This shows that the Hadley circulation is too weak. On fig. 5 the difference is smaller, consequently the Hadley circulation is better simulated in the EWS forecast.

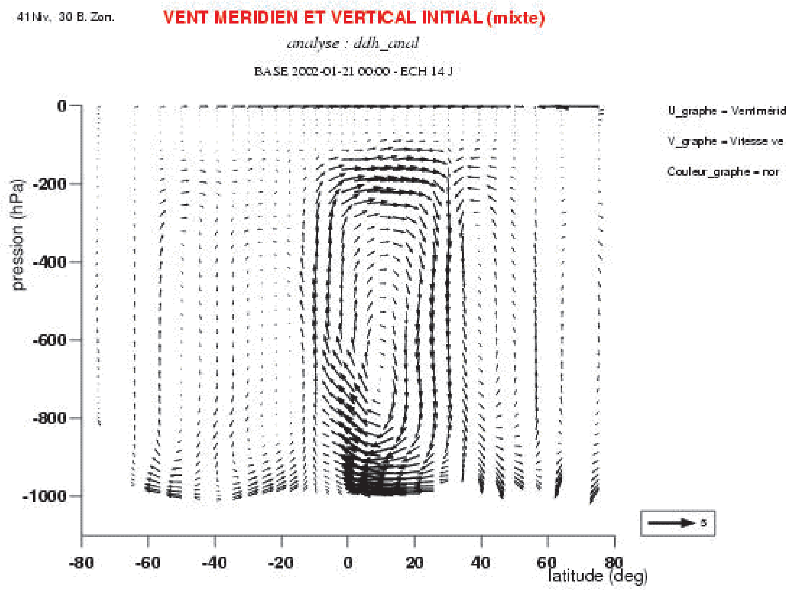

Figure 3 : Average over 14 days of the Hadley circulation, based on analyses

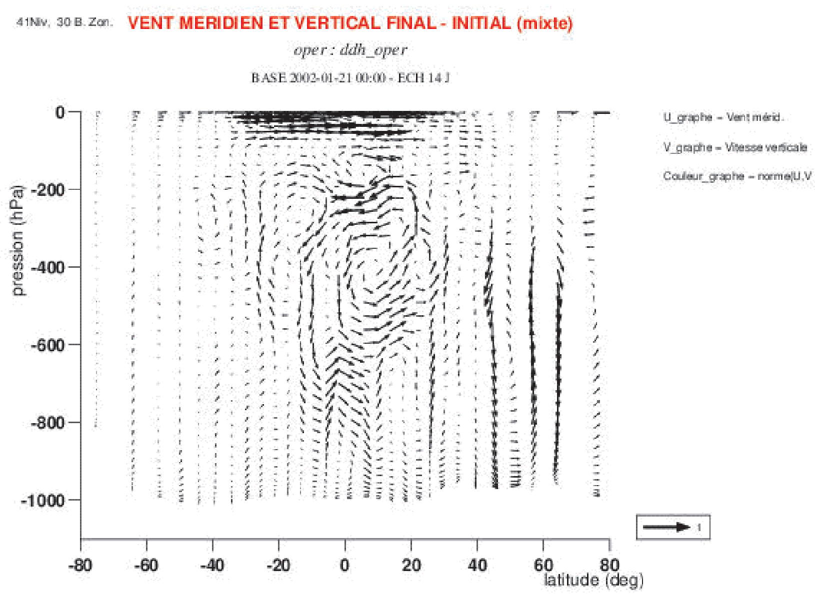

Figure 4 : Average of the difference between the analysis and the operational forecast

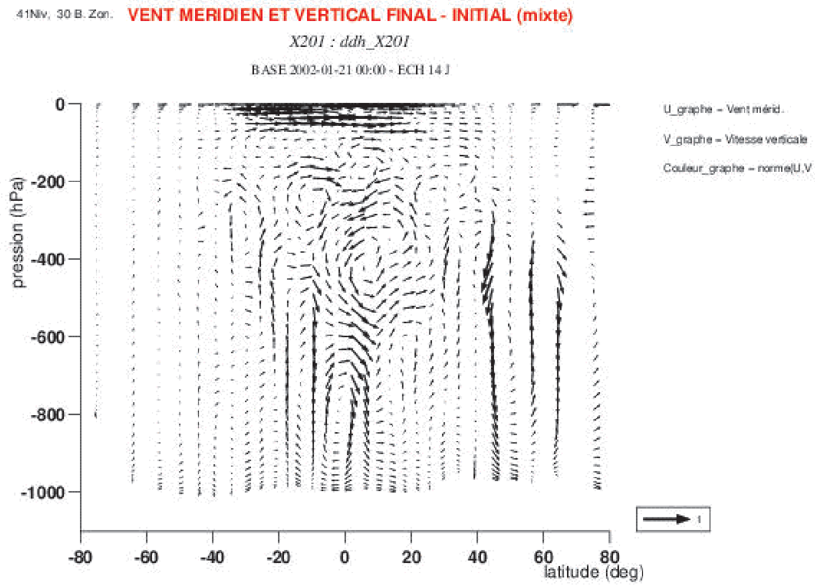

Figure 5 : Same as fig. 4 but for the EWS forecast.

Because of the improvement in the steady-state structure of the PBL brought by the changes in radiation code, it becomes possible to relax some of the modifications in the parameterisation of vertical turbulent transport in stable conditions, done for CYCORA (-bis, -ter) packages in order to have a good capacity of simulation for the storms of December 1998 and 1999. The new tuning, while keeping untouched this "storm" quality, involves a strong reduction of the overall friction in stable cases. This change leads to a far better thermal structure of the PBL in case of low-level inversions and to even less large-scale geopotential biases than with the sole EWS improvement.

All these differences have positive impacts on the large scale scores, as shown on fig. 6. This is the difference between the standard deviations of geopotential for the old, operational, suite and the new one. The reference is the ECMWF analysis.

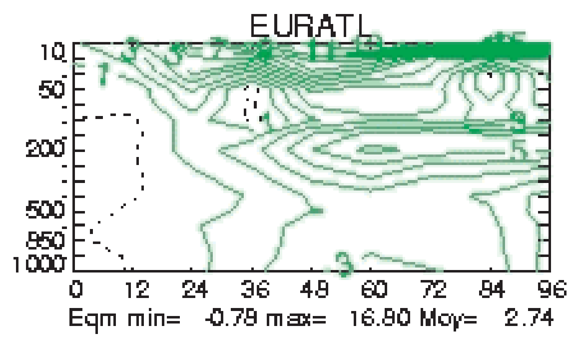

Figure 6 : Difference between the standard deviations of the geopotential of the old operational suite and the new one. The score is computed over an European area, the reference is the ECMWF analysis. Green corresponds to an improvement.

MODIFICATION OF THE OZONE PROFILES

Ozone profiles, in the operational ARPEGE-ALADIN physics are adjusted by an analytical function of three parameters. This profiles are currently the same at any point and any season. It was decided to improve this representation by preserving this function while making the parameters dependent on place and time. A similar experiment was performed by C. Rada, A. Sima and M. Caian (Rada et al. 2000). They used ozone profiles fitted to Bucharest measured data in the ALADIN model, integrated over the Romanian domain.

The UGAMP 3D ozone climatology was chosen as reference here. The UGAMP climatology was built up by Dingmin Li and Keith P. Shine, at the Department of Meteorology of the University of Reading. It is a 4-dimensional distribution of atmospheric ozone resulting from the combination of several observational data sets. For more details, see Li et al. (1995) or :

http://badc.nerc.ac.uk/data/ugamp-o3-climatology/ .

A specific program was written to adjust the parameters of the function to a given profile. It was observed that 3 parameters are not enough to take into account the variability of the profiles. As there are 3 degrees of freedom, 3 constraints to be respected (quantities to be preserved) were chosen. The first one is the ozone content integrated on the vertical, the second one the height of the maximum and the third one the value of this maximum. The ozone profile in the upper atmosphere are then not perfectly restituted.

A profile of ozone at the point (0 °E, 20 °N) in July is shown on fig. 7. The thin dashed line is the operational ozone profile, the thick dashed line the UGAMP profile and the red line the fitted profile. Another example is given on fig. 8 for the point (175 °E, 67.5 °S) in August. In this case one can see that the profile in the upper atmosphere is not good.

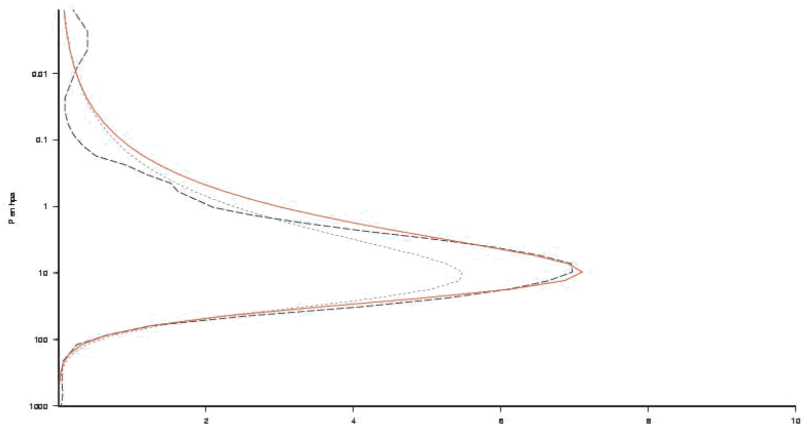

Figure 7 : Ozone profile in July at (0 °E, 20 °N), in Dobson Unit per hPa.
thin dashed line: operational profile, thick dashed line: UGAMP profile, red line: fitted profile

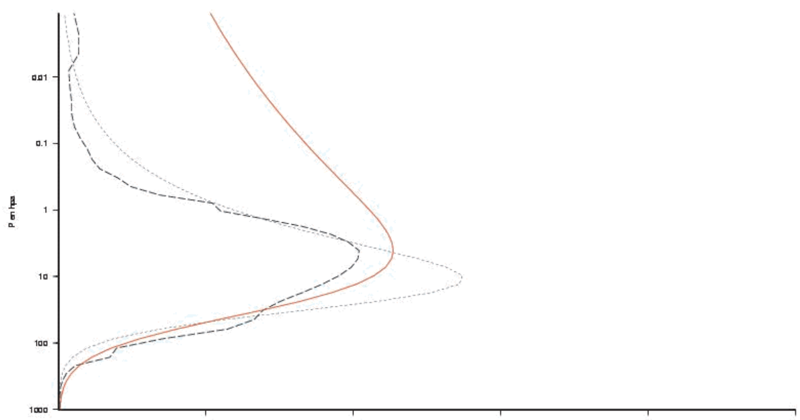

Figure 8 : Same as fig. 7 but for August at the point (175 °E, 67.5,°S).

A very important work was necessary to include the corresponding new fields in the data flow of the ARPEGE 4d-var, and also to automatically update them at the beginning of each month. A 4d-var experimental suite is presently running to evaluate the impact of this modification.

WORKS ON AN "INTERMEDIATE" RADIATION SCHEME

As said previously, the present radiation scheme contains a lot of approximations :

- The EBL term is approximated.
- There is no dependence on the type of cloudiness in the computation.
- There is only one spectral interval in the long-wave domain, with averaging of the absorption properties for each band using a Malkmus model and an integration over the interval using a Padé formula.

More complete schemes exist but their cost does not make it possible to call them at each time-step. It would be interesting to preserve this possibility and conceive a scheme of "intermediate" complexity. To advance in this way, exploration studies are necessary, to determine from which approximation the largest part of the error comes.

In this framework it seemed interesting to test if the deficiencies of the radiation code come from the single spectral interval or from other approximations. To do that a tuning of the coefficient of the Malkmus model was done by Helga Toth (2002). The problem is the choice of a reference. It is necessary to have a complete radiation code. *GRAALS* was chosen. To isolate the spectral integration approximation, it would have been necessary to use the "reference" code developed by Roger Randriamampianina in 2000. Unfortunately this code seems to have some problems in the 1D model. So the EWS code was used and it is not obvious that the approximation of the EBL term is negligible. As a preliminary conclusion this experiment shows that "a simple tuning cannot improve the deficiencies observed in the currently used scheme".

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Information about the ARPEGE physics and its relevance for ALADIN

J.-F. Geleyn and F. Bouyssel, for the enlarged Toulouse physics team
CNRM/GMAP . 21/02/03

We are now at the junction between two ARPEGE parallel suites dedicated to physics changes. The first one was made operational on 11/02/03, following big improvements in objective scores, mainly but not only in terms of biases. The second one, starting 20/02/03, should also bring an improvement in objective scores, but its main target is to diminish the frequency and intensity of spurious small-scale cyclogeneses without destroying the model's capacity to simulate big storms like the ones of Christmas 98 and 99. Part of these changes were fostered by the comparison between the "NWP" and "climate" physical packages in ARPEGE, performed by Yves Bouteloup with the help of Pascal Marquet. We shall now see the content of the two packages, one by one.

FIRST PACKAGE

First ingredient: New option for the radiative computations

Following his comparison work with expensive radiation computations (done together with Helga Toth on FMR-15, GRAALS and Roger Randriamampianina's "reference code"), Yves Bouteloup decided to retest the option of adding a more sophisticated treatment of the "exchange with surface" (EWS) term of the thermal radiation overall budget. This development had been prepared back in 1996 by Neva Pristov but unfortunately deemed as too expensive for its "low impact". The problem is that the impact is indeed low in stand-alone three days forecasts but that its cumulative character starts to tell beyond five days and dramatically changes not only the PBL thermal structure but also, indirectly, the whole of the model's upperair circulation. And this change is for the best, whatever parameter one looks at, as showed by the multiple tests performed by Eric Bazile and Jean-Marcel Piriou. Once a few days of data assimilation have benefited from the activation of the EWS more exact computation, any compatible ARPEGE or ALADIN forecast is likely to be further improved by this new feature.

Second ingredient: Stabilization (yet again) of the deep convection computations

Jean-François Guérémy discovered a small bug in the partition of convective tendencies between diffusive transport (that was wrongly also treating the detrained condensates) and precipitations. This was corrected.

Martina Tudor and Jean-François Geleyn discovered another bug with only small consequences in *ACCVIMP* (respectively *ACCVIMPD*) : the securities against nonlinear instability of the pseudo-advection by compensating subsidence (respectively ascendance) were written in the wrong direction with respect to the mass flux (downstream instead of upstream). This was corrected. The combination of these two changes does not improve any of the forecast fields but it leads to slightly smoother vertical profiles of all prognostic variables.

Third ingredient: Reduction and reorganisation of the vertical turbulent transport in stable conditions

Thanks to the improvements in the steady state structure of the PBL brought in by the change of the radiation code, it became possible to relax some of the changes done in CYCORA, CYCORA-bis and CYCORA-ter in order to have a good capacity of simulation for the storms of December 98 and 99. The new tuning, while keeping untouched this "storm" quality, involves a strong reduction of the overall friction in stable cases (`USURIC:` 1.→ 0.25) and also a retuning of the ratio between the coefficients for heat and momentum (`USURIDE:` 1.→ 0.25 & `USURID:` 0.042 → 0.1). The mixing-length structure of CYCORA-ter is kept untouched in this tuning mainly made by François Bouyssel and Jean-François Geleyn. This change leads to a far better thermal structure of the PBL in case of low-level inversions and to even less large-scale geopotential biases than with the sole EWS improvement. See Figs 1 and 2a-b hereafter.

Fourth ingredient: New formulation and tuning of the horizontal diffusion

Following the work of Pierre Bénard to reproduce the behaviour of the Fourier space horizontal diffusion within the current framework of the "unified diffusion" (specific to stretched ARPEGE), François Bouyssel did some retuning of the absolute amount of diffusion (which was found to be about six times higher in ARPEGE than in ALADIN once the two could be compared owing to the new possibility). A multiplication by two of the current ALADIN level (i.e. a reduction by ~3 in ARPEGE together with a better latitudinal dependency) was found to be the best new tuning. This corresponds, for vorticity and temperature, to something closer to what other models (IFS, Meso-NH) have. Filip Vana did a parallel test in ALADIN-LACE that showed neutrality of dividing the coefficients `HDIR*` by 2. Hence the idea is to harmonise things around this new compromise for ARPEGE and also for ALADIN, setting in this case : `HDIRDIV=EDEL*`/123. for a "linear" grid, `HDIRDIV=EDEL*`/44.635 for a "quadratic" grid, and `HDIRVOR=HDIRT=HDIRQ`=5.×`HDIRDIV`). It would probably be good if all ALADIN partners would follow the same trend.

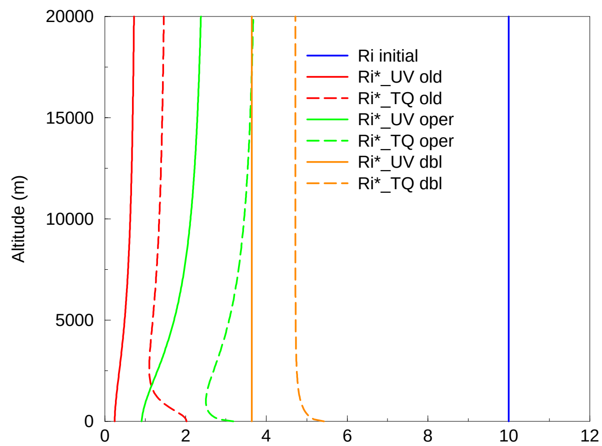
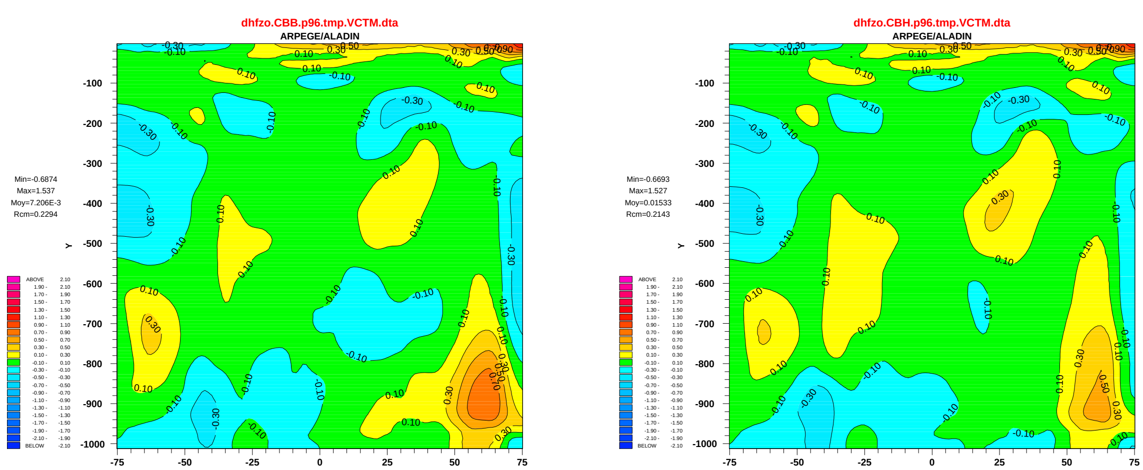


Figure 1 : Impact of the successive sets of modifications (1:3, 2:4) on the vertical profile of the modified Richardson number (Ri*), for the computation of turbulent momentum (UV) and heat (TQ) fluxes. First package : from "old" to "oper". Second package : from "oper" to "dbl"



a b

Figure 2 : Impact of changes in vertical diffusion (1:3, 2:4) on the mean zonal tendency of temperature for a set of 8 96-h forecasts (in January 2002) : a) old, b) modified runs. The systematic warm trend in the lowest layers for the Winter hemisphere is less now.

SECOND PACKAGE

First ingredient: Rewriting of the diagnostic cloudiness scheme (for radiation computations)

This work follows the one done on an in-depth rewriting of the diagnostic cloudiness scheme (especially for missing low-level cloudiness) by Jean-Marcel Piriou with the help of several ALADIN colleagues. François Bouyssel finally found a better tuning for a selective cyclogenetic activity, mainly inspired by the comparison with the «statistical cloud scheme» of ARPEGE-Climat. One keeps the spirit of the current operational scheme (diagnostic of the condensate amount first, taking empirically into account three types of clouds - stratiform, cumuliform, below inversion - and cloudiness computation afterwards according mainly to the first result) but (i) one now combines the various water contents before a single diagnostic of cloudiness and (ii) the used formula is more realistic (following the work of Xu and Randall on observed cases). The obtained cloudiness is more realistic in its main features (especially more low-level clouds and better latitudinal contrasts, see Figs 3a-c), even if sometimes much more «0/1» locally. These features help maintaining a very reasonable capacity to simulate the intense storms of Christmas 98 and 99, and this even when the other ingredients (see below) lead to a strong reduction of fictitious small-scale cyclogenetic developments. Diagnosed cloud structures for various applications should be significantly modified (probably more than the radiative forcing itself) and everyone intending to use this new tuning ought to pay attention to these downstream aspects.

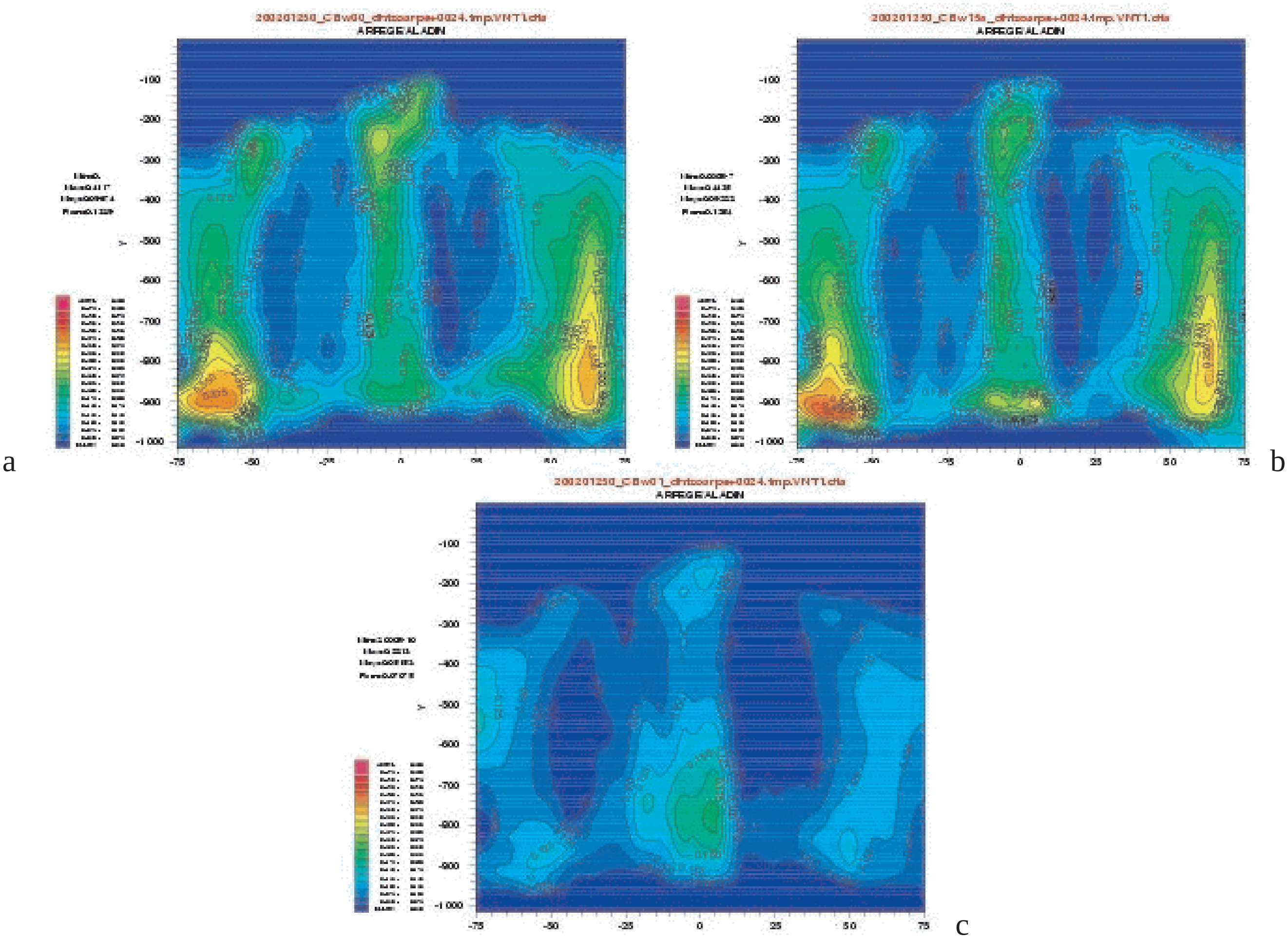


Figure 3 : Zonal mean cloudiness, as resulting from a 24-h ARPEGE forecast with : a) the operational physics (including the first package of modifications); b) the operational physics and the modified cloudiness scheme; c) the "climate" physics

Second ingredient: Modification of the closure conditions for deep convection

One comes back, for the humidity convergence's calculation, to the situation before October 99: only the dynamical and turbulent parts are taken into account and the former is modulated according to the mesh-size, but about 3 times less than previously, in order not to diverge exceedingly from the current operational tuning. In short (and for experts) : "`LSRCON=LSRCONT`=.F. ; `GCOMOD`=1. ; `REFLKUO`=5000."

In a similar line of thoughts, one chooses a completely local compensation (and not any more a partially "smoothed" one) of turbulent fluxes by convective fluxes. In short : "`GCVPSI`=1." plus an additional security in order to inhibit moist convection in case of absolute dry instability. All these modifications, following scores of experiments performed by François Bouyssel, Eric Bazile, Siham Sbii and Jean-François Geleyn, are the essential damping ones for the reduction of cyclogenetic tendencies (frequency and intensity) at various scales.

Third ingredient: Less "noisy" numerical schemes

Making it proportional, at unchanged total amount, to the quantity of sustended condensate, and not any more to the vertical divergence of the convective precipitation flux, modifies the vertical profile of the convective contribution to the diagnostic cloudiness. There is no significant impact on the forecasts of this change, developed by Eric Bazile, but the vertical cloud-cover profiles are more realistic and one gets a smoother radiative forcing.

A far more stable numerical algorithm is now implemented (for an unchanged analytical formulation) in the shallow-convection parameterisation. Resulting from various remarks, it was developed, tested and optimized by Doina Banciu. The impact is quite important: disappearance of spurious oscillations of shallow convection (of course) but also of deep convection (i.e. elimination of the scintillation syndrome on pseudo-satellite animations); markedly less noisy vertical profiles of temperature and humidity in the planetary boundary layer; reduction of the moist bias in the free atmosphere and of the dry bias underneath; contribution to the reduction of cyclogenetic tendencies. This ingredient makes completely unnecessary the time-smoothing option of the shallow-convection intensity developed earlier by Martin Bellus and used in at least one of the operational ALADIN applications.

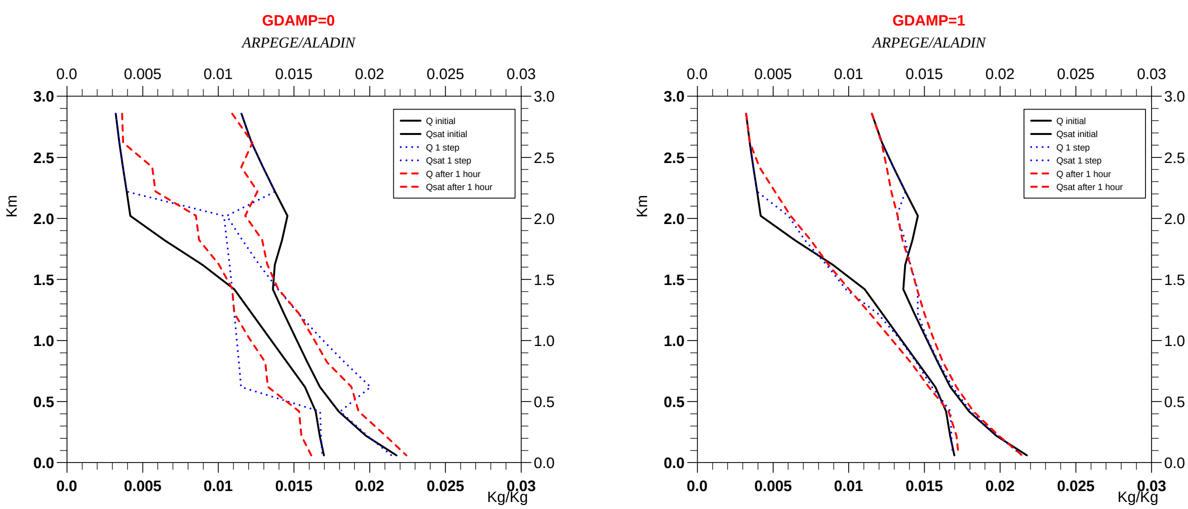


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Figure 4 : Vertical profiles of q and qsat , on a BOMEX case, at initial time (full lines), after 1 time-step (dotted lines) and after 1 hour, i.e. ~ 4 time-steps (dashed lines).
a) Operational shallow-convection scheme : the model tends to quickly and strongly modify the initial profile
b) Modified shallow-convection scheme : changes are far less, and the low levels keep close to saturation

Fourth ingredient: Further reduction of the vertical turbulent transport in stable conditions

Following the improvement diagnosed within the parallel suite for the first package, concerning the reduction of friction in stable condition (in terms of less geopotential biases and of strength of low level inversions), the work was pursued in the same direction by François Bouyssel. This time only the overall effect is reduced without any further change in the ratio of the momentum and heat parts (`USURIC:` 0.25 → 0.175 & `USURICL:` 4. → 1.). There is also a small consequence in terms of reduced cyclogenetic tendencies, which makes the "cloud" ingredient even more paramount in this package.

Fifth ingredient: Addition of a prognostic albedo for snow

Following the work of Eric Bazile with several Bulgarian and Moroccan colleagues, one adds (in full ascending compatibility for those not yet able to use this refinement) to the operational algorithm an "historical" treatment of the snow albedo with a "fresh" value of 0.85 and a diminishing trend with age until 0.65. Furthermore, in order to obtain the total albedo, one introduces a specific computation in order to better take into account the vegetation's albedo (to consider snow-free canopy). All this leads to a reduction of cold and warm biases for surface and lower boundary-layer in snow-covered areas. Diagnostic variables for snow density and "historical" (i.e. modified according to snow and sea-ice covers) albedo were also introduced. See the previous Newsletters for more details.

ADDITIONAL INFORMATION

The so-called "shear-wind linked convection" parameterisation is still under investigation. However, (i) its previously advocated version was partly bugged and (ii) results concerning the capacity to forecast big storms are still disappointing, even with all the above-mentioned progress behind us.

The bug, found by André Simon, is linked to what happens when one goes towards the equator (a classical «0/0» situation). The initial idea was to eliminate the Coriolis parameter f from both upper and lower case of the equations. But a simple geometrical analysis shows that there is no tilting any more of the slanted ascent in such a case (the upper case f takes priority) and that the correct behaviour should come from a multiplication by the ratio of the Coriolis parameter to the absolute vorticity. For mid-latitude applications the problem is probably minor, but a bug is a bug in any case. The "official" code should soon be corrected but a "patch" is already available.

It remains to be seen if all the ingredients of the two new packages can give back the advantages that the shear-linked convection brought in some specific circumstances (Adriatic or Balearic spurious cyclogeneses, some grid-point-storm-type situations, ...).

CONCLUDING REMARKS

Even if the second package has still to be carefully evaluated in ARPEGE and ALADIN-France, its already known benefits are likely to lead to an operational implementation somewhere in March this year. At that stage there should be a huge contradiction between differing physics at the edge of ALADIN applications that would not follow a parallel evolution (it is already "half the case" since 11/02 and some of you may have already noticed it, but the second set of changes ought to be of even bigger impact). The ALADIN performances per-se should also be dramatically improved for everyone adopting the above-described set of changes. All this calls for a rapid re-harmonisation of our parameterisation environment. Tunings (mixing lengths, shear-linked convection, amount of every type of cloud, level of friction, closure for convection, ...) might of course differ from place to place, but we believe that the advances in radiation, shallow convection and cloudiness diagnostic as well as all the bug fixes ought to be taken into account everywhere.

Since this double package is built on top of the serial of corrections that were necessary in order to cope with the "black spell" of late 2001 and early 2002, it seems difficult to itemise the upgrades and it would be preferable if everyone interested would undertake an overall back-phasing of the final outcome (~13 routines). Like previously advocated, this is only possible if you are already at the AL12 level (in other words, let us say that we are convinced that the present target is as good a basis as CYCORA-bis used to be). Toulouse people are ready to help you in such an exercise but it will surely not be a completely transparent one on your side. If you do not feel in a hurry despite all the advocated advantages of moving, there should be (in the spring) an export package on cycle 25T1 containing all the above-mentioned, but its implementation will involve a lot of other aspects than physics, especially for those partners late in terms of general phasing level.

In any case, an harmonisation of horizontal diffusion settings is easy and likely to help us continuing to speak a common language when it comes to the signal/noise ratio in our applications.

On the performance of ALADIN during the August 2002 floods

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Introduction

The August 2002 flooding events have caused widespread damage in Central Europe, in particular in parts of the Czech Republic, Germany, and Austria. This short report summarizes the performance of ALADIN (LACE and VIENNA) precipitation forecasts in the worst hit areas in Austria. To put the forecast skill in proper context, comparisons with ECMWF forecasts are shown.

Areal precipitation forecasts

Operationally, ZAMG produces areal precipitation forecasts for the catchment-type regions shown in Figure 1. The models used are ECMWF, ALADIN-LACE (denoted by ALA00 and ALA12), ALADIN-VIENNA (denoted by AVI00 and AVI12), and a linear statistical combination of ECMWF and ALADIN-VIENNA (COM). Raingauge observations from ZAMG's network of semi-automatic stations (TAWES) are used for verification. All precipitation values are interpolated to the same grid and averaged over the respective areas. Verification results are shown for area 9, which experienced unprecedented amounts of rainfall in the event.

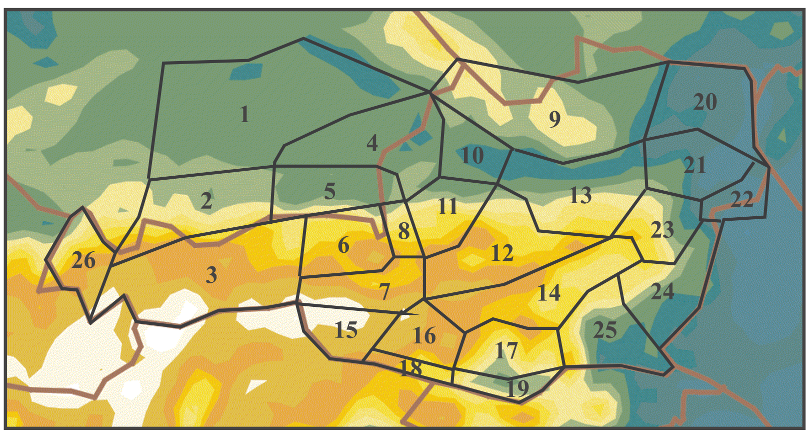

Figure 1: Catchment-type regions for which areal precipitation forecasts are issued operationally. The colour field shows the ALADIN-VIENNA model topography.

Verification results

For the first event (6-8 August 2002) the 12 UTC run of ALADIN-VIENNA correctly predicted the 6-hourly peak precipitation rate 36 hours ahead (Figure 2). No strong signal was present in the corresponding ALADIN-LACE and ECMWF forecasts. The large difference between the two ALADIN models is unusual, and would be worth further investigation. On 6 August ECMWF still gives a rather weak signal, whereas both ALADIN models now indicate a more significant event. Note that none of the models predicted the second observed peak. This unanticipated peak posed a severe problem and contributed to the unprecedented amount of flooding in the area.

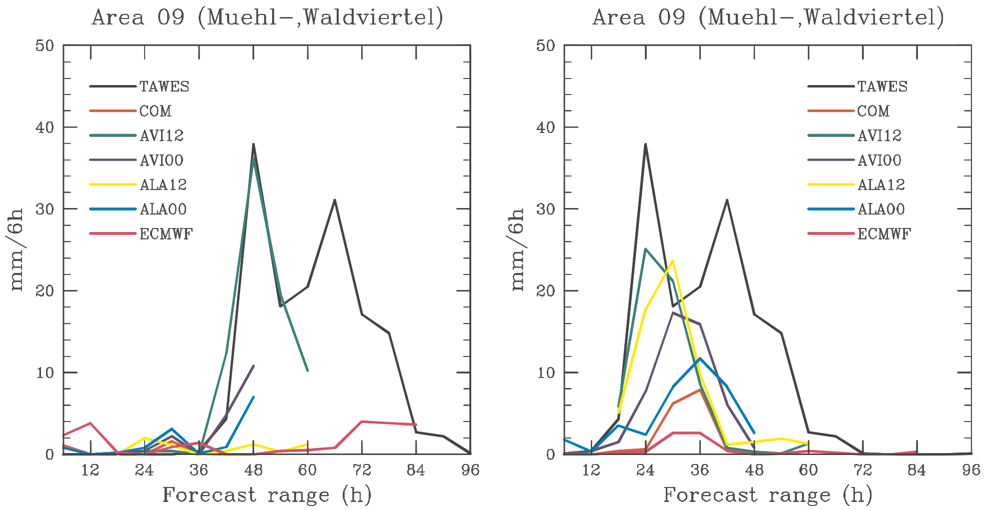

Figure 2: Areal precipitation forecasts compared with observations (black) for area 9 during the first August 2002 event. Analysis time is 5 August (left) and 6 August (right).

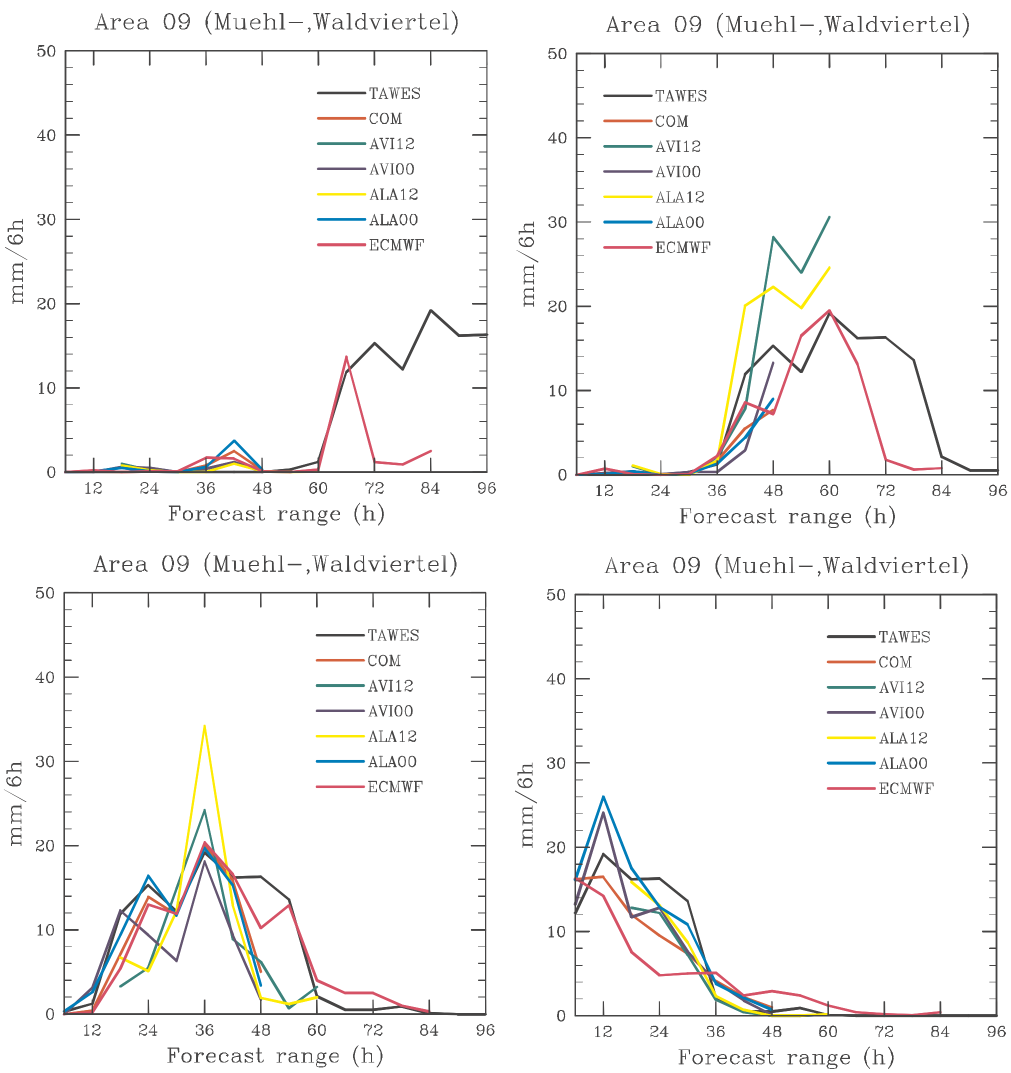

Figure 3: Areal precipitation forecasts compared with observations (black) for area 9 during the second August 2002 event. Analysis time is 9 August (upper left), 10 August (upper right), 11 August (lower left), and 12 August (lower right).

The onset and intensity of the second event was forecasted well by all models 36 hours ahead. At the time of the beginning of the event, its duration was also predicted correctly. Verification results for other areas are similar. In the northern alpine upslope precipitation areas the forecasts are even somewhat better than in the area shown here.

Short-term precipitation fluctuations

The above diagrams show a verification of 6-hourly precipitation amounts. From the hydrological modelling community, however, one gets requests for forecasts of hourly precipitation rates. Figure 4 (and many other cases that have been studied) show that we cannot yet claim much skill on the time-scale of 1 hour, even in cases where the corresponding 6-hour totals are predicted well and deep convection does not play a significant role. The model recognizes to some extent the observed peaks, but there is no robust correlation. Due to partial compensation of errors on time-scales larger than 1 hour, the comparison of cumulative precipitation looks rather good, with the model underestimating the total rainfall by only about 20%.

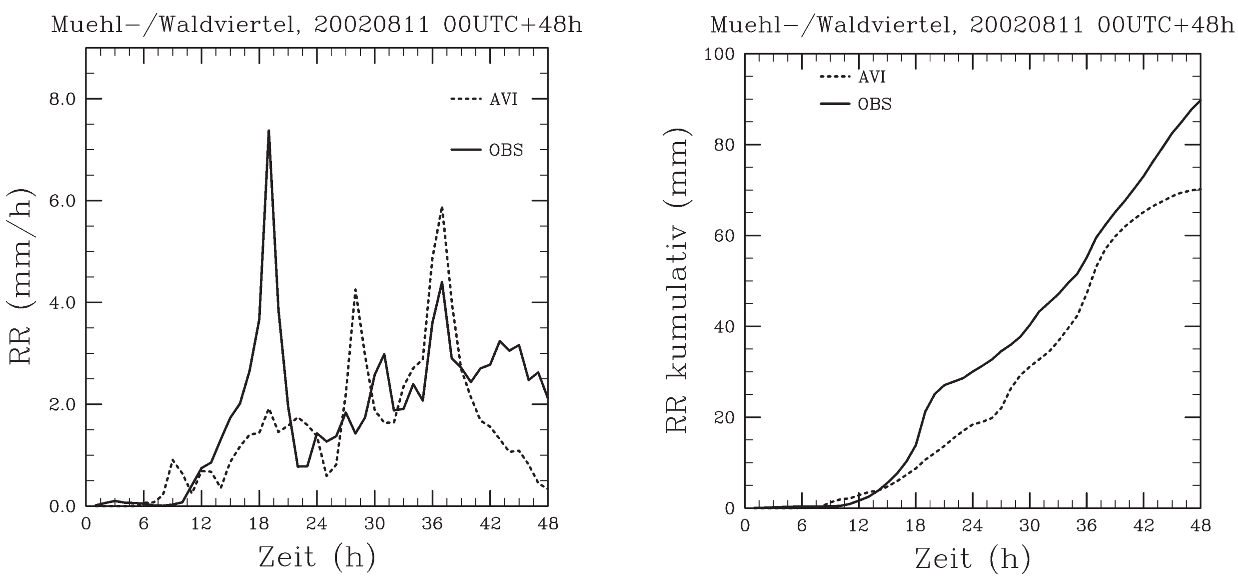

Figure 4: Comparison of modelled and observed 1-hourly precipitation rate (left) and cumulative amounts (right) for the second August 2002 event.

In summary it can be said that ALADIN handled the August 2002 flooding cases well. This was also found for areas in the Czech Republic, according to the analysis given by R. Brozkova at the Flood Workshop in October 2002 in De Bilt. It remains to be investigated why the global models predicted these events rather poorly, including the EPS of the ECMWF.

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