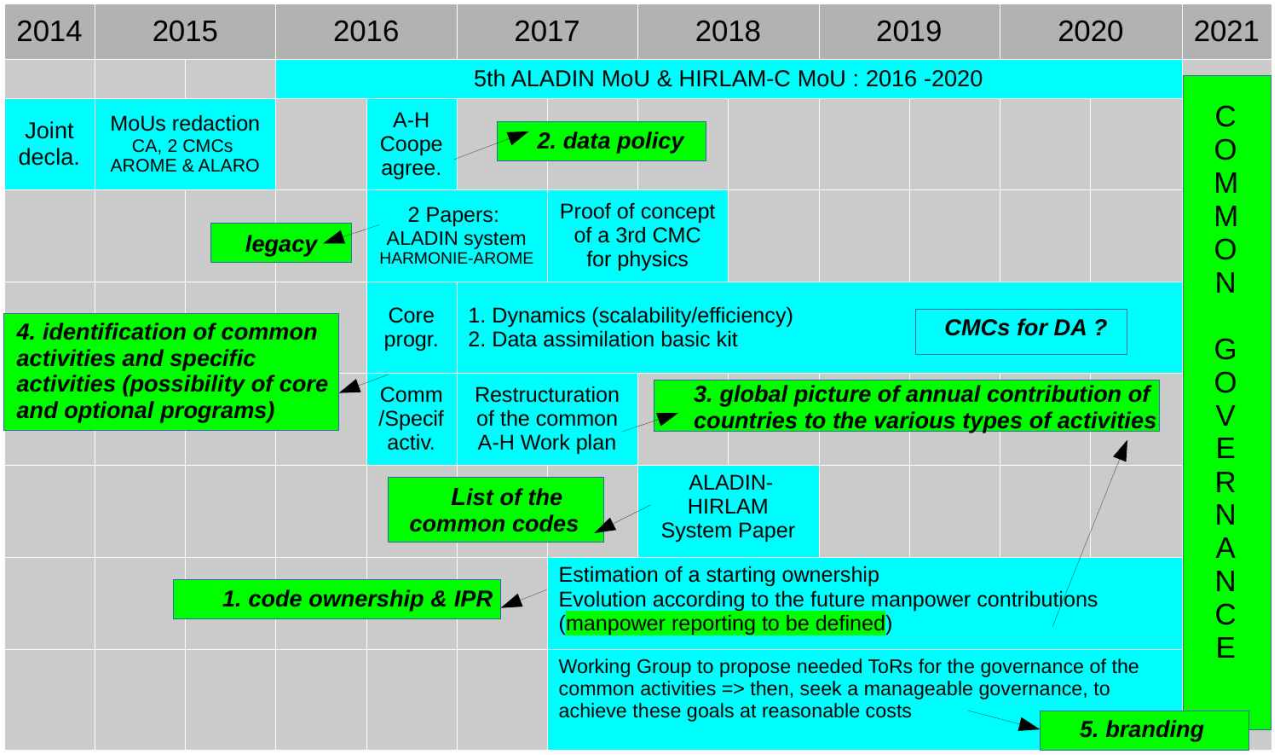
# ALADIN Report 2020

**Introduction**

The ALADIN consortium was created in 1990 and the scientific and technical program has been led by Jean-François Geleyn until 2010. The success of the ALADIN collaboration was the result of 20 years of Jean-François Geleyn's tireless dedication to the program, both by virtue of his exceptional intellect and his unique human dedication. This year we had the occasion to commemorate his legacy during his tribute meeting organized by Pascal Marquet and Patricia Pottier, in February this year.

By 2009, Jean-François realized that his retirement was approaching and he decided to pass the leadership of the consortium to the younger generation. Many people started to play an active role in the coordination of the consortium from 2010 onwards to continue his work. Some renewed efforts were made to coordinate the organizational and code engineering activities of the consortium, in particular the so-called phasings (i.e. the integration of the science into the computer codes), the coordination of the networking across the local ALADIN teams, aspects of the code design, the link with the code versioning at the ECMWF, the coordination of the data assimilation activities and the scientific administration. A few people merit special attention here: Claude Fischer, Patricia Pottier, Mária Derková, Daan Degrauwe, Maria Monteiro and Oldřich Španiel. Some of the management of the codes was formalized by the so-called ACNA activities with regular meetings and coordinated interactions of the Local-Team-Members (LTMs) of the participating ALADIN countries.




*Convergence road map after the 2014 Declaration*

After the 2014 meeting in ECMWF and the Declaration of the ALADIN General Assembly and the HIRLAM Council a road map was proposed to address the requested clarifications asked in the Declaration. In order to streamline the different approaches in the physics parameterization packages, the notion of Canonical Model Configurations (CMCs) was introduced. The position of the Code Architect was created, motivated by the need to monitor the defintion and the maintainance of the CMCs. This was implemented in the Fifth Memorandum of Understanding of the ALADIN consortium that was signed in 2016. After the 2016 strategy meeting, it became clear that the issue of the spectral nature of the ALADIN-NH dynamical core had to be addressed. Since this is intrinsically linked to code structure, the code architect spent a considerable effort analyzing this problem. The proposed approach became part of a strategic program with the ALADIN activities, leading to the development of Atlas and the development of a alternative gridpoint solver for the ALADIN-NH dynamics, as will be reported later in this document.

At the same time it was realized that some extra efforts were necessary to coordinate the data assimilation activities within the non-LACE, non-Météo France countries (the so-called flat rate countries) and the DAsKIT coordinator was appointed. The increased ativities allowed the

participating partners to configure data assimilation cycles in their Institutes.

Also in 2016, the collaboration agreement with HIRLAM was renewed. This formed the start of the convergence process with the aim to create a single consortium in 2021. In order to settle the legacy of both consortia a few papers were published (e.g. Termonia et al. 2018). A basic proof of concept was carried out to test the new HARMONIE-AROME CMC that HIRLAM created. In 2016 we organized a strategy meeting with HIRLAM. The catalogue of the activities presented during this meeting, formed the basis for a restructuring of the ALADIN-HIRLAM work plan. A common ALADIN-HIRLAM manpower registration tool was created based on the common work plan. At the same time new efforts were stimulated on dynamics and data assimilation (the so-called DasKIT program). From 2018, an ALADIN-LACE-HIRLAM convergence working group started to address the issue of the intellectual property rights (IPR). In 2019 a first draft of the MOU of the common consortium was created. In the beginning of 2020 a strategy meeting was organized, leading to a joint ALADIN-LACE-HIRLAM strategy. Based on the common work plan and the joint strategy the management structure of the new consortium was determined. At the time of writing, all Members of the ALADIN-LACE-HIRLAM community are ready to sign the MoU.

During the 2015-2020 period it was decided to take SURFEX as the surface scheme for all CMCs, including ALARO. Part of the needed analysis of the code structure and the code maintenance was carried out by the Code Architect. At the same time, quite some R&D was performed on the use of the simplified Extended Kalman Filter (SEKF), a step that would allow to increase the number assimilated data considerably in comparison to ones used by the current OI methods. These developments are not finalized yet. Within ALADIN a lot of development took place within the RC-LACE consortium to assimilation non-conventional data (radar, mode-S, GNSS, …) and this is beautiful example of how such a coordination can help (small) countries to set up state-of-the-art NWP cycles. Within ALADIN, it was decided to consider 4DenVar as the main strategic approach for flow dependent data assimilation. This year, as will be reported in this document, first convincing tests we presented by Météo France, which can be considered as an important milestone. Also the OOPS project has entered a mature stage, and it has been found that the OOPS features in the code were useful to implement the 4DEnVAR.

One of the remaining issues is the variety in physics paprameterization schemes. This issue has been addressed at various stages by the ALADIN CA in the past 5 years. However, one can conclude that a more appropriate management (inluding a mechanism for man power identification

and decision making) would be needed to make further progress on this. Such step is planned as part of the current ALADIN-LACE-HIRLAM strategy.

Piet Termonia

**2020 Report**

This remaining part of this report describes the activities of the ALADIN consortium in 2020 following the work plan as it can be found in http://www.umr-cnrm.fr/aladin/IMG/pdf/rwp2020-approved.pdf .

**MGMT1: Management**

All tasks have been executed as planned.

The work of the convergence working group (CWG) continued during 2020. This group consists of the three PMs (ALADIN, LACE, HIRLAM), the chairs of the PAC and HAC, the CSSI chair and a representation of the Météo France (Philippe Bougeault) and the ALADIN Scientific Secretary (Patricia Pottier). The main event that took place was the organization of the A-L-H Strategy Meeting in Toulouse, 3-4 February 2020: http://www.umr-cnrm.fr/aladin/spip.php?article353. This led to the ALH strategy document. During joint ALADIN General Assembly/HIRLAM Council organized in Istanbul in 2019 a number of open issues in the proposed ALH MoU were still identified. It was then decided to create a High-Level group of four Members of the ALADIN General Assembly/HIRLAM Council to clarify them. The main issues to be addressed were IPR (transfer of national IPR to the consortium) and the voting mechanism including (subjects to vote about and voting systems). The CWG also prepared a list of the legacy codes owned by the ALADIN and the HIRLAM consortium respectively. A proposal was made for the management structure of the new consortium. During the extraordinary 25th ALADIN General Assembly and 6th joint ALADIN GA and HIRLAM Council, 25-26 June 2020, most of the proposed changes to the MoU were accepted. The CWG was tasked to address a few remaining ones (filling of Annex III, a few details about the format and some clarification about the code convergence). The participants of that meeting expressed their willingness to sign the updated version of the MoU, albeit after the requested minor modifications will have been implemented. The procedure for the appointment of the program manager was accepted.

Regarding physical meetings, due to the COVID-19 travel restrictions, none took place since March. The annual Joint 30th ALADIN Workshop and HIRLAM ASM 2020, 30/03-02/04/2020 was organized by web conferencing. While we had no experience beforehand to organize such a workshop virtually, it took more or less place in a normal way. It has however been remarked that such a format does not favor good discussions. During the CSSI/HMG meeting that took place on

2 and 3 April the 2021 rolling work plan was adapted according to the outcomes of the ALH Strategy meeting.

Two Newsletters were published (MGMT1.6); the 14th edition Newsletter of the HIRLAM and ALADIN consortia. This first 2020 edition is a big Tour d'ALADIN & HIRLAM, and, there was second one: Newsletter 15, published on 23 June 2020. A tribute meeting to honour Jean-François Geleyn, the former PM of the ALADIN consortium, was organized after the strategy meeting: http://www.umr-cnrm.fr/aladin/spip.php?article349.

**COM1.1** ALADIN Code architect coordination activities

COM1.1.1 Development of LAM features in the Atlas library (see also SPDY5)

The Atlas library is a software library being developed at ECMWF, to prepare for massive parallelism and heterogeneous hardware platforms. Given the close relation between ECMWF's IFS model and the ALADIN-HIRLAM models, it is necessary that the Atlas library also supports limited area configurations. In 2020, two aspects were worked on. First, LAM versions of so-called NWP dwarfs (small stand-alone programs that test a key feature of a NWP model) were developed, and fixes to Atlas were implemented where necessary. This was done for the GCR(k) elliptic solver dwarf and for the semi-Lagrangian advection dwarf. Second, as it is the plan to implement an iterative multigrid-preconditioned Krylov solver for the Helmholtz problem in the dynamical core of the ALADIN-LACE-HIRLAM model (see SPDY2), some features were introduced in Atlas that are necessary for this development. Concretely, Atlas was extended with stencil operations on a regular grid, partial halo exchange functionality, and multigrid operators like refining and coarsening.

COM1.1.2 Evolution of canonical model configurations

The future evolution of the three canonical model configurations (CMC's) was discussed during the 2020 ALADIN-LACE-HIRLAM strategy meeting. To streamline these discussions, an input paper on physics parameterizations was prepared, including the organization of the CMC's. Following these

strategy meeting discussions, the topic of convergence between the CMC's resurfaced. A document on this issue is currently in preparation.

COM1.1.4 Attend technical meetings between ECMWF, MeteoFrance, Hirlam and Aladin.

- 21 January: IFS/ARPEGE technical meeting
- 23 March: IFS/ARPEGE coordination meeting
- 15 June: Upcoming novelties on IFS programming (DSL, ATLAS, SCA etc.) and exchange of experience about porting to GPU
- 18 June: Working practices for the IFS/Arpege code evolution

**COM2** Code generation and maintenance

**Cycles, code releases:**

**CY47T1**: this is the major scientific interim cycle of the shared NWP codes, built in Météo-France this year. It does contain a number of scientific contributions from the ALADIN partners (updates to ALARO-1, new diagnostic model output fields in Full-POS), from the GMAP team and specific items agreed upon with the Météo-France climate group. Another essential target of CY47T1 was to complete the official updating of the operational code versions from Météo-France (which are based on a CY43T2 code version, CY43T2_op3). This goal has been achieved. Declaration of CY47T1 eventually occurred on 30 January 2020. A technical update of that cycle was planned (mostly for continuation of DAVAI results). The construction of CY48 took place in 2020 with ECMWF, with special attention for synchronizing OOPS/IFS-ARPEGE codes. CY48T1 is planned for October-December 2020.

To anticipate the implementation of the outcomes of the Strategy Meeting some efforts were made to use DAVAI and mitraillette, and build the CY48T1 in a more continuous integration process (rather than a few big merge steps). In order to progress towards a more flexible and visible code management process a task force was created lead by A. Mary to make proposals for a shared and accessible environment, documentation and ticketing tool. Partly motivated by the COVID-19 sistuation, a first trial was made in 2020 to organize a remote phasing.

**COM3.1** Maintenance and Partners' implementations of ALADIN system

This report summarizes ACNA (Aladin Coordinator for Networking Aspects) activities in 2020, executed by Maria Derkova, Slovak Hydrometeorological Institute (maria.derkova@shmu.sk).

The tasks of ACNA include:

1. Preparation and chairmanship of the LTM video meetings
2. Participation in the preparation and validation of CY43t2_bf11 export version
3. Other networking aspect within the ALADIN consortium

1) Preparation and chairmanship of the LTM video meetings

ACNA has (co-)prepared and chaired two LTMs video meetings: LTM28 on 31/March 2020 along the ALADIN/HIRLAM video conference; and LTM29 on 05/Oct 2020, just after the EWGLAM/SRNWP video conferences. Agendas and minutes are available on the ALADIN web page http://www.umr-cnrm.fr/aladin/spip.php?article108&lang=en .

2) Participation in the preparation and validation of CY43t2_bf11 export version

ACNA has assisted the LACE ASC and MF team in the preparation of the incremental bugfix _bf11 of the CY43T2 code version, that was released on June 25, 2020. ACNA has participated in collecting the bugfixes and their documentation from ALADIN and HIRLAM Partners, and in local validation of the source codes and executables at SHMU.

3) Other networking aspect within the ALADIN consortium

Apart from the participation at the video conferences with PM, TTS, CA, DA coordinator (held when necessary) ACNA networking activities comprise:

a) *Participation at the CSSI/HMG meeting, evaluation of RWP2020 fulfillment, redaction of RWP2021*

ACNA participated at the HMG/CSSI video meeting on April 03, 2020. ACNA was involved in the RWP2020 status evaluation and RWP2021 preparation (COM3.1, PH5).

*b) Supervision of the CY43t2 code version installation at the Partners' NMS*

ACNA follows the installation of the CY43t2bf[10|11]_export versions at the Partners' NMS, collects the reported problems and their fixes once available. ACNA reports on the progress of the installation if relevant (GA, LTM meetings).

No major problem with porting of CY43t2bf[10|11]_export was noted. For particular progress reports check the links:

April 2020:
https://docs.google.com/spreadsheets/d/1_lQMFDaRRDNEng21asHKQ42Hx_-llOnRG3EX3BtfzVo/edit#gid=1916423903

Sept 2020:
https://docs.google.com/spreadsheets/d/1_lQMFDaRRDNEng21asHKQ42Hx_-llOnRG3EX3BtfzVo/edit#gid=1647033479

For the overall status as of September 2020 see the attached table.

*c) Participation at the Strategy meeting*

ACNA participated at the ALADIN-HIRLAM Strategy meeting held in Toulouse, February 3-4, 2020, aiming to define the strategic objectives of future ALH Consortium for 2021-2025, and to identify the activities and resources needed to achieve them. Later on ACNA commented on the CEpQA note (the code engineering, phasing and quality assurance).

**Porting of CY43t2bf[10|11]_export version in the ALADIN NMS.**

No major problem with porting of CY43t2bf[10|11]_export was reported. Progress in time is evident the table becomes more blue from right to left. Status as on 06/10/2020:

- 8 Partners are running this cycle operationally (at least for part of their applications)
- 2 Partners are running the e-suite
- 5 Partners do have this code version ported with ongoing validation
- 1 Partner did not succeed yet

.

| Partners | September2020 | September2019 | March2019 | September2018 |
|---|---|---|---|---|
| Algeria | operational | operational | operational | ported |
| Austria | e-suite | compiled | compiled | not yet |
| Belgium | operational | operational | ? | compiled |
| Bulgaria | operational | ported | ? | not yet |
| Croatia | ported | ported | ported | not yet |
| Czech R. | operational | operational | operational | operational |
| France | operational | operational | e-suite | exported |
| Hungary | ported | not yet | ? | not yet |
| Morocco | ported | ? | compiled | compiled |
| Poland | operational | operational (ALARO) | ported | ported |
| Portugal | ported (ECMWF) | not yet | not yet | started |
| Romania | ? | not yet | not yet | not yet |
| Slovakia | e-suite | ported | ported | ported |
| Slovenia | operational | operational | e-suite | ported |
| Tunisia | ported | ported | ongoing | not yet |
| Turkey | operational (AROME) | operational (AROME) | ported | not yet |

**SPDY** Strategic Program on Dynamics

In 2020 the R&D focused on SPDY1, SPDY2 and SPDY5. It was confirmed during the Strategy Meeting to discontinue the activities on HEVI methods (SPDY3). Regarding SPDY4 (the physics dynamics interface) it was decided to plan a specific action on this during the next MoU phase as one of the main strategic objectives for physics under the leadership of the future Area Leader for Physics.

**SPDY1 More stable formulations of the dynamical core**

Current CC-ICI scheme of the ALADIN-NH dynamica core has proven its robustness to deal with kilometric scales and moderate slope of orography. However, there is evidence that it may suffer from some drawbacks when hectometric scales and steep orography are considered. Currently attempts are made to derive a more robust CC-ICI scheme for the mass-based EE system that allow high-resolutions and attractive time-steps for NWP. This is done in a twofold way: (i) consider a new vertical momentum prognostic variable less sensitive to the destabilising effect of steep orography slopes and (ii) design of a bespoke linear ICI operator that somehow contains a key information about orography slope. This is done by the new variables (W, d5) proposed by Fabrice Voitus. Recent tests carried out by F. Voitus, K. Yessad, J. Vivoda and P. Smolíková have demonstrated and increased stability for the same accuracy, see Fig. 1. This work is invaluable for the strategic objective to move to the hectometric scales.

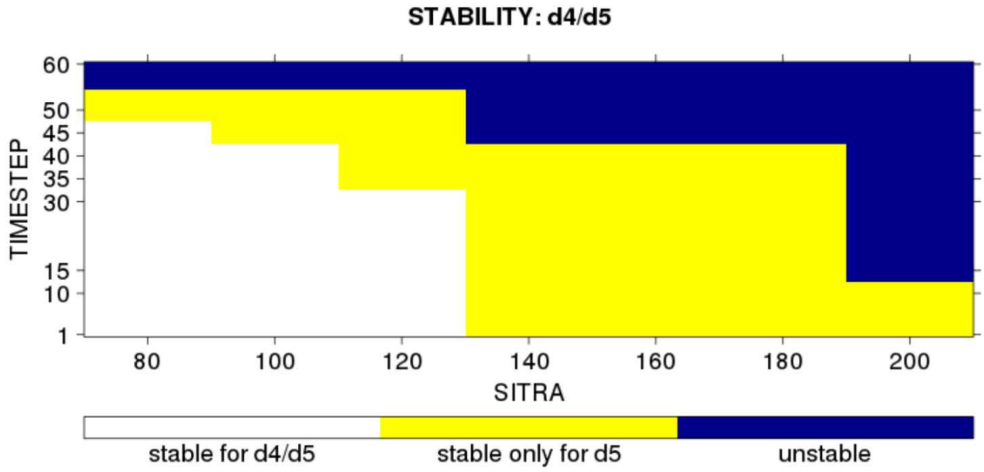



*Figure 1: Increased stability of the new W/d5 variable.*

**SPDY2 Development of methods for solving the implicit equation in gridpoint space.**

Relying on the work executed under COM1.1.1. the developments of the gridpoint solver within the dyamical core continued. Relying on the features of Atlas, the idea is to develop an option within the existing code to solver the Helmholtz equation in gridpoint space instead of spectral space. The main developments during 2020 were the implementation of T. Burgot to implement such a solver within the code of the ALADIN System under MPI in the cycle 46t1, allowing to run experiments on the entire domain (and no longer on only a quarter of the operational domain as previously). This work is still under development and some calculations remain made in the spectral space, such as numerical diffusion, the shift from the divergence of the wind to the zonal and meridional wind components and some derivative calculations in the RHS of the Helmholtz equation. In order to reduce the inconsistency between the derivatives computed in grid point space and these computed in spectral space, we currently use a finite-difference operators of 10-th order. Lower orders can probably be considered when all derivatives will be calculated in the grid point space. Tests in the full model have been executed showing the cumulated precipitation during the heavy precipitation event from 22/10/2019 00:00 to 23/10/2019 00:00 in the south of France, for the spectral and grid point versions, see Fig. 2. The differences are very small and are close to the Antilope reference. Several scores are calculated and seem to show no significant difference between these both versions providing confidence for this method.

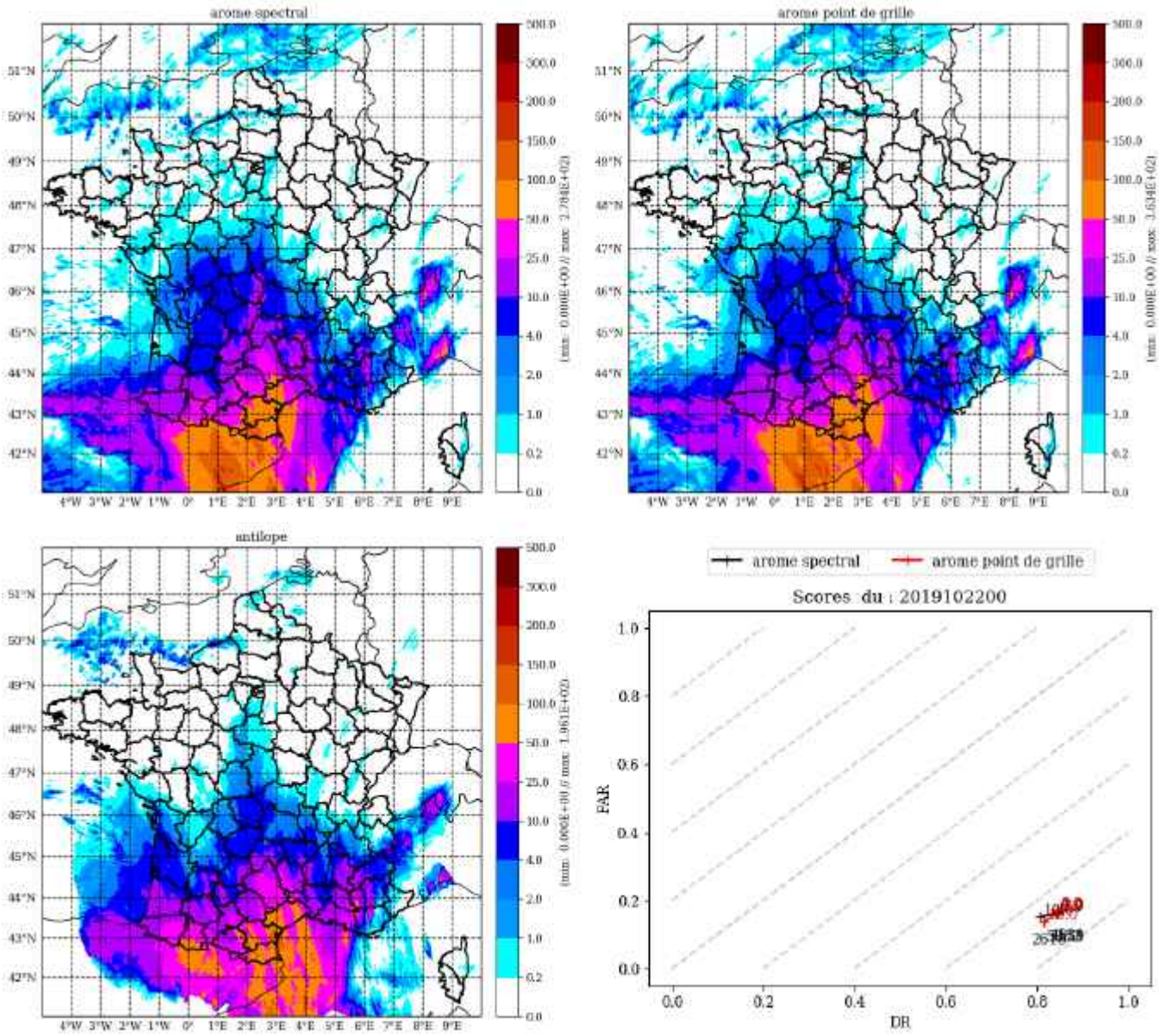



*Figure 2: Comparison of a run of AROME with spectral solver (upper left panel) to the one with the gridpoint solver (upper right panel), compared to the French Antilope observations (bottom left). Scores comparing model to radio soundings are presented (bottom right).*

**SPDY5 Development of LAM components in Atlas**

See report on COM1.1.1.

**SPDA the DAsKIT project**

The main goal of the ALADIN strategic core program on Data Assimilation (here named as DAsKIT) is to develop a cross-consortia coordination to set up a basic 3D-Var Data Assimilation (DA) cycle with a limited set of observations suitable for operational implementation. The countries more directly involved in DAsKIT are: Algeria, Belgium, Bulgaria, Morocco, Poland, Portugal, Tunisia and Turkey.

The DAsKIT program working packages (WP), which simultaneously reflect the local steps to implement DA capacities, encompass: data acquisition; data pre-processing; BATOR pre-processing; observations monitoring and setting up a combined surface+upper-air (3D-Var) DA.

This progress report provides the status of the program after the recent 2020 Joint RC LACE DAWD & DAsKIT DA WD, held as a visio-meeting during 14-16 September. The visio-meeting was technically organized by ZAMG.

1. Data Acquisition

   The object of this WP is the local acquisition of WMO BUFR SYNOP, TEMP and (E-)AMDAR data. Since last year, a few modifications have taken part on this topic: all countries, except Poland which receive pre-processed observations from OPLACE – the RC LACE common initiative on pre-processing, have local access to WMO BUFR SYNOP and TEMP observations. Tunisia, which still receives data from OPLACE, started to receive local SYNOP. In same cases, local procedures allow the conversion from different data formats to WMO BUFR standards. Regarding (E-)AMDAR data, the conclusion is similar: all countries have access to this type of data, except Bulgaria which expects to finish the procedures to the acquisition of this type of data in the short-term.,. In the meantime, it was possible to see also that countries keep long-term plans to access other data types, like: local GNSS, OIFS radar, MODE-S, ATOVS and ASCAT.

2. Data pre-processing

This WP aims at the pre-processing of WMO BUFR SYNOP, TEMP and (E-)AMDAR data. For SYNOP and TEMP in particular, duplications between GTS original messages and 'retards' have to be removed; for (E-)AMDAR, no duplications are found but the filtering of different BUFR templates to assure its adequate ingestion by DA systems has to be done (in particular when dealing with the Bristish Airlines AMDAR data with the BUFR template 311001, not yet handled by BATOR at version 40T1). ***As a summary, it is possible to state all countries are able to pre-process WMO BUFR SYNOP (except Poland which receives SYNOP data from OPLACE);*** the pre-processing of TEMP and AMDAR was briefly discussed during this year, not presenting an extra difficulty to the procedures already done with SYNOP. Tunisia (which is not a member or co-operating state at ECMWF) started to relay on RMI (Belgium) pre-processing tool - the PoP-RMI tool, to pre-process local WMO BUFR SYNOP. In the meantime, half of the DAsKIT countries, which keep some relation with ECMWF, are implementing the ECMWF Scalable Acquisition and Pre-Processing tool (SAPP): Belgium, Bulgaria, Portugal and Turkey. However, there is still an issue which has to be clarify,, related to the participation conditions on the SAPP Optional Project for ECMWF non-cooperating or non-member states (as is the case of some DAsKIT countries: Algeria, Poland, Tunisia).BATOR pre-processing

BATOR is the interface of observations information to ALADIN-HIRLAM DA systems and the goal of this WP is to assure that local implementation of BATOR is able to ingest WMO BUFR SYNOP, TEMP and (E-)AMDAR. Along the DAsKIT program, ***all the countries got capacities to handle their conventional data through BATOR, even if different code cycles are in use in accordance with the on-going country plans.*** In particular, countries did a sucessfully joint porting of local BATOR procedures to CY43T2 during 2020 (except Morocco which got a new HPC platform and kept the bechmark cycle, CY41T1 as short-term priority). Furthermore, a demonstration exercise was prepared by Y. Celiz, from TSMS, in collaboration with HIRLAM experts, on how to make local DA implementations (BATOR) compatible with SAPP BUFR SYNOP templates provided. Plans include the handling of new observation types, like OIFS HDF5 radar data, GNSS ZTD and MODE-S.

4. Setup of observation monitoring

An observation monitoring system is an essential part of any data assimilation system. The main objective is to provide an informative selection of monitored parameters (statistics of availability and quality control (QC) status, time evolution of satellite biases, etc.). During 2018 DAsKIT DA WD, a standalone version of the OBSMON tool was provided by HIRLAM and installed locally by the countries with demo data. However ,during 2019 the tool was not yet in use by the teams. One of the reasons was because the tool was not compatible with the observations data bases which are automatically created by the DA T-code versions (BATOR). In this way, during 2020 an exercise was prepared by I. Dehmous (RMI, Belgium) which establishes the bridge between the locally produced ODB and the OBSMON facilities. This exercises was also supported by HIRLAM experts. As future plans, the methodologies on how to regularly use this tool should be commonly discussed and locally implemented.

5. Definition of the basic data asimilation configuration

The main goal of this WP is to set up a local cycling on a combined surface DA + upper-air DA for AROME. This WP corresponds to the main goal of the DAsKIT program. A common achievement is that all the countries are now locally progressing onto CY43T2. As a first step, all the countries (except Poland which is running ALARO) cycled a surface DA system over the geographic domain of interest by the so-called OI_MAIN method (Giard and Bazile, 2000), after the exercise done during the 2018 Joint RC LACE DAWD & DAsKIT DA WD in Romania. At this moment, RMI (Belgium) already implemented it in operational mode. Joint comparison of the first validation results have shown: i) surface DA has an impact over 2-metre temperature (T2M) and 2-metre relative humidity (H2M) forecasts (and 10-metre wind, depending on the model lowest level); moreover, ii) for the same season, impact results seem to be consistent for Belgium and Portugal, even with different resolutions (CY40T1 for Portugal). However, this was not yet the case for all the countries, which means some tuning studies should take place in the short-term. At the same time, some countries have developing efforts to port their single 3D-Var DA systems (Algeria, Morocco and Tunisia); while others are directly implementing or porting their combined OI_MAIN+ 3D-Var DA solution (Belgium, Portugal, Turkey). Details are available from the ALADIN newsletter, at http://www.umr-cnrm.fr/aladin/IMG/pdf/nl15.pdf. As short-term plans,

countries expect to finish the porting of the surface DA solution to CY43T2, to tune and validate it. Besides, those which do not have it yet, expect to compute a first B-matrix (needed for 3D-Var implementation) for the geographical domain of interest and to start working on the combined DA solution. As a sequence from the establishment of a local DA cycling, regular DA monitoring procedures should be started in order to adequately tune the usage of observations (see previous WP). An important milestone to these countries progress is the creation of a common DA workflow platform, therefore a set of scripts will be maintained and tested on MF computing platforms (and/or at ECMWF), taking into account the expertise of RC LACE and Belgium in order. Finally, efforts will also be made to adopt a common verification tool.

**2020 DAsKIT summary conclusions**

During 2020, progress on DA activities in all countries was visible and is on-going. As planned, countries are now working at CY43T2. A noticeable achievement of the DAsKIT program was the operationalisation of the surface DA scheme at RMI (Belgium). As a proof of concept, the pre-processing tool PoP-RMI, created at RMI, was successfully tested in Tunisia (country not directly connected to ECMWF) and know-how also exists to locally ingest SAPP BUFR SYNOP (for the countries related to ECMWF). Besides, local know-how also exists to ingest (BATOR) locally available GTS/WMO BUFR, SYNOP, TEMP and AMDAR; and, after solving some issues, the monitoring tool OBSMON, can now be used regularly with locally produced observations data bases (T-codes). Finally, it should be mentioned this year's program activities have been registered at the ALADIN newsletter NL15; and, all the produced documentation was kept up to date in the usual program communications platforms: ALADIN web page, RC-LACE forum, dedicated google sheets and beaufix platform. Moreover, two (progress status) video-meetings and the annual Joint RC-LACE DAWD & DAsKIT working days have been organized. Future plans include: establishment of a common setup of a combined surface + upper-air DA solution, that should be tested and validated locally, step-by-step, with focus on B-matrix computation; the mitigation of the actual lack of now-how on verification procedures. Besides, some attention will be payed to sharing know-how on new program data types, as radar, GNSS and MODE-S. Joint working days should keep its format and progess status reporting on regular video-meetings should still occur. However, practical sessions or seminars on dedicated topics should now also be initiated (the first one will be organized by RMI, on HARP verification tool). Generally speaking the program has been considered as supportive of local DA activities by involved countries.

**PROSPECTIVE R&D WORK PACKAGES**

## DA Data Assimilation

The main progress to report in 2020 are developments of the 4DEnvVar method by Météo-France. First tests were carried out this year

A lot of efforts are spent on the handling of the data streams of the observations. Within ALADIN, RC LACE is well organized and managed to have all of their members running data assimilation cycles, as can be seen from table DA(a), that was taken from the RC LACE report written by B. Strajnar. The status in the flat-rate countries is presented in the SPDA work package. For a specific status of the DasKIT countries see report in SPDA above.

| DA | AUSTRIA AROME | AUSTRIA C-LAEF | CROATIA AL-ARO | CZECH REP. ALARO | HUNGARY ALARO | HUNGARY AROME | SLOVAKIA AL-ARO | SLOVENIA AL-ARO |
|---|---|---|---|---|---|---|---|---|
| Resol | 2.5L90, 600 x 432 | 2.5L90, 600 x 432 | 4.0L73 480 x 432 | 2.3L87-NH 1069 x 853 | 8L49 | 2.5L60 | 4.5L63 | 4.4L87 432 x 432 |
| Cycle | 40t1 | 40t1 | 38t1_bf8 | 43t2pt_op1 | 40t1 | 40t1 | 40t1 | 43t2_bf10 |
| LBC | IFS 1h (lagged) | IFS-EPS | IFS 3h (lagged) | ARP 3h | IFS 3h (lagged) | IFS 1h (lagged) | ARP 3h | IFS 1h/3h (lagged) |
| Method | OI_main MES-CAN + 3d-Var | OI_main MES-CAN + 3d-Var, pert. obs. + Jk | OI + 3D-Var | OI + BlendVar | OI + 3D-Var | OI_main + 3D-Var | OI + DF Blend-ing | OI + 3D-Var |
| Cycling | 3h | 6h | 3h | 6h | 6h | 3h | 6h | 3h |
| B matrix | Downscaled LAEF 11 km | static C-LAEF EDA | NMC method | EDA | EDA | EDA | - | Downscaled ECMWF ENS |
| Initiali-zation | No (SCC) | No (SCC) | No (SCC) | IDFI in pro-duction, SCC | DFI | No | No | No (SCC) |
| Obs. | Synop Amdar Geowind Temp Seviri AMSUA/MHS /HIRS ASCAT, Snow-grid/MODIS snow-mask.,Mode-S EHS EMADDC | Synop + AS Amdar Geowind Temp, ASCAT, Snow-grid/MODIS | Synop Amdar/MRAR Geowind Temp Seviri | Synop + AS (soil) Amdar/MRAR /EHS Ge-owind/HRWI ND,Profiler, ASCAT, Temp Seviri, | Synop + AS Amdar Geowind Temp Seviri AMSUA/MHS ASCAT | Synop + AS GNSS ZTD Amdar/MRAR Temp, Mode-S MRAR (SI) | Synop + AS Amdar/MRAR /EHS Geowind Temp Seviri AMSUA/MHS /IASI ASCAT | Synop + AS Amdar/MRAR / EHS Geowind Temp Seviri AMSUA/MHS /IASI ASCAT/OSCAT |

*Table DA(a): Operational status of data assimilation within the LACE countries.Courtesy B. Strajnar.*

Two RC-LACE countries have an operational RUC running, see table DA(.b)

| DA | AUSTRIA AROME-RUC | CZECH REP. VarCanPack |
|---|---|---|
| Resol | 1.2 L90 900 x 576 | 2.3L87-NH 1069 x 853 |
| Cycle | 40t1 | 43t2pt_op1 |
| LBC | AROME 1h | - |
| Method | OI_main MESCAN + 3d-Var + LHN + FDDA | 3DVAR + OI |
| Cycling | 1h | - |
| B matrix | Static EDA + differences of the day | EDA |
| Initialization | IAU | - |
| Obs. | Synop + AS, Amdar/MRAR/EHS national, EHS EMADDC, Geowind, Temp, Seviri, AMSUA/MHS/HIRS/ATMS/IASI (+ Metop-C), ASCAT, GNSS ZTD (Austria), GPSRO (ROMSAF), Radar RH/Dow, INCA + AS at hig.freq., MODIS snowmask | Synop + AS, Amdar/MRAR/EHS, Geowind/HRWIND,Profiler, ASCAT, Seviri |

*Table DA(b): Operational DA for NWP-based systems nowcasting systems at hourly scale run by RC LACE countries. Courtesy B. Strajnar.*

**DA1** Further development of 3D-Var

**DA1.2** *Background error statistics: Evaluate the impact of different formulations of the background error statistics (e.g. downscaled, EDA, Brand, large scale mixing or not) on the balance between control variables and on spinup.*

In Slovenia, an experimental EDA system with 20 ensemble members was developed at a current horizontal resolution of 4.4 km in 2019. The ensemble is used to compute background error covariances on a daily basis. Analysis of daily covariances shows that in all cases the variances were higher and more centered towards small scales in the EDA experiment, compared to operational downscaled (spin-up) B-matrix. Sensitivity experiment was carried out over 1- month period, where the results indicated slightly detrimental impact of the EDA B-matrices on most of parameters except short-range precipitation. This work continues.

In Hungary, efforts to recalculate B-matrix continued by running a full EDA experiment based on the previously calculated B-matrix (from the downscaled EDA) and computing a new B-matrix for a 90 level model setup. The impact on the forecast over longer period was not too promising, currently the tuning of background and observation error standard deviation is ongoing.

**DA2** Development of flow dependent algorithms

**DA2.3** *EnVar in OOPS*

The 4DEnVar method has been implemented on the AROME version as it is in Météo-France with a resolution of 1,3 km and 90 levels. The perturbations for the B matrix are taken from the AROME-Fr EDA computed with a 3D-var with 50 members at 3.2 km and a 3h DA cycle. The 4DEnVar is running with a 1h data assimilation cycle. Single observation experiments were performed. A first case study was performed validated with respect to the French radar network. 4DEnvVar showed a substantial increase of realism and performance compared to 3DEnVar.

The development of moving towards Envar (3D and 4D ) scheme benefited of the OOPS framework in various ways. Numerous ingredients already available and validated in the OOPS framework, B or B1/2 pre-conditioning, control variable extending (hydrometeors, non-hydrostatic variables,…), spectral/spatial localisation, localisation length-scale depending on the variable, height, scale, advection of the localisation (4D), resolution changes and variational bias correction.

The tests of 3DEnVar showed encouraging results using a low resolution configuration. These still have to be confirmed with the full system at 1,3 km over a long period. The 4DEnVar showed encouraging results on convective case studies but tests over a long period are still needed. They will begin soon, on the new Météo-France HPC.

**DA2.4** *EDA: AEARP and AEARO: scientific improvements in both EDA systems, increase of horizontal resolutions in AEARP, AEARO oper at MF.*

ARPEGE runs operationally with an incremental 4D-Var assimilation (6-h window and 30 min time-slots) with 2 loops of minimization: $T_L$224c1L105 (40 iterations) and $T_L$499c1L105 (40 iterations).

AROME France runs at a Horizontal resolution of 1.3 km with 90 vertical levels (from 5 m up to 10 hPa). It uses a 3D-Var assimilation (1-h window) with an IAU, with forecast range from 7 to 48 hours (8 times a day). AROME-Fr assimilates the following observations:

- Radar DOW + Z (RH)
- Surface (SYNOP + RADOME)

- Radiosoundings (BUFR HR)
- Aircrafts
- GEO radiances (METEOSAT)
- LEO satellites (IASI, AMSU, AMVs, SCAT)
- Ground based GNSS (ZTD)

Since January 2020, the radar network use in AROME-Fr has been extended with 62 additional European radars from the EUMENTET OPERA network with positive impact on specific (extreme) cases.

AROME-FR also has a nowcasting version (operational since 04/2016) with forecasts up to 6 h issued every hour (assimilation not cycled) and an assimilation window of [-10 min, + 10 min].

The B matrix of both ARPEGE and AROME is computed by the global and LAM EDAs: AEARP and AEARO respectively. The current scheme is summarized in Fig. DA(c).

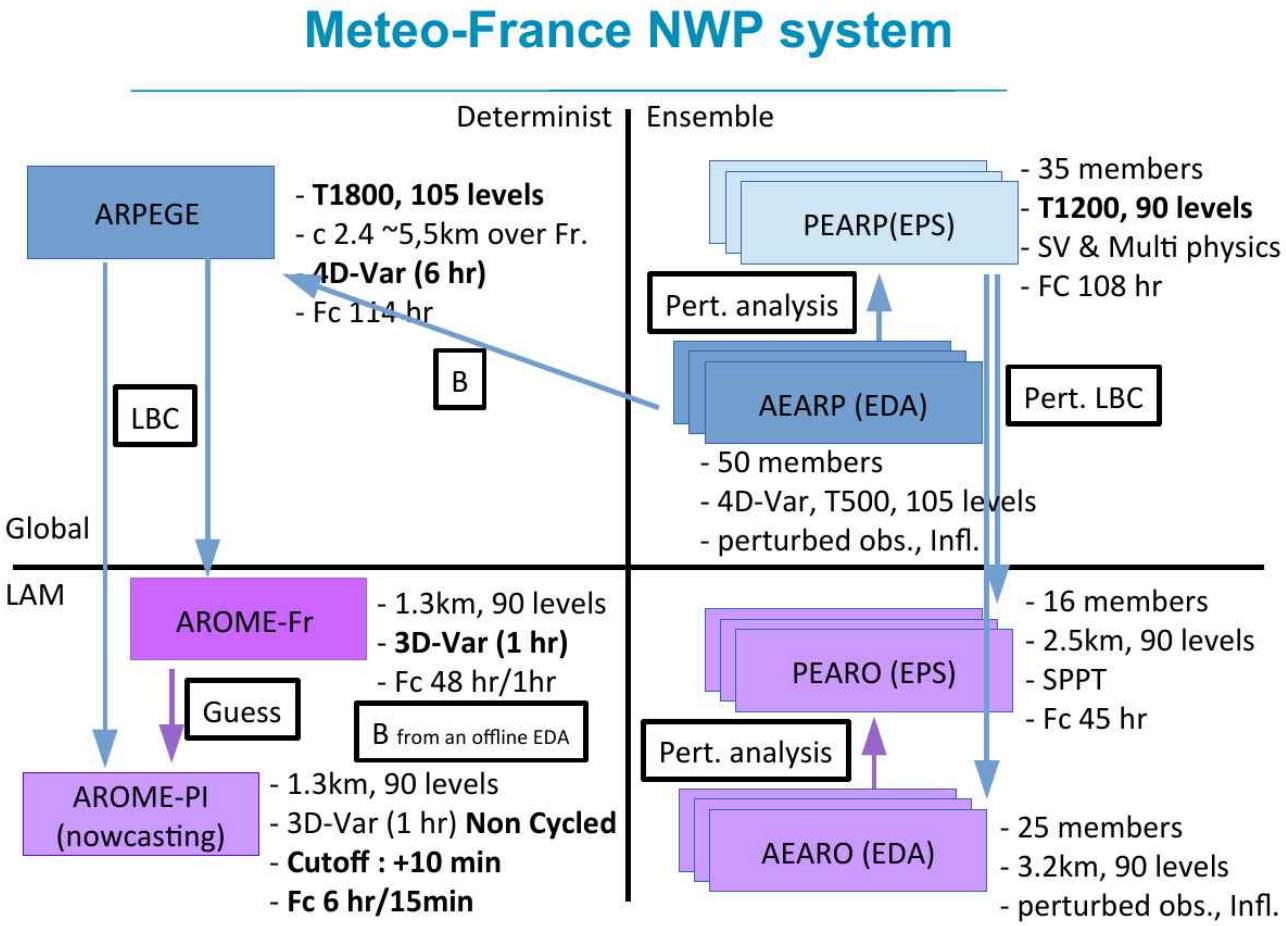



*Figure DA(c): The current operational setup of Météo-France: deterministic global model (ARPEGE) and LAM AROME-Fr. The B matrix comes from an EDA from the EPS systems PEARP and PEARO.*

**DA3** Use of existing observations

**DA3.1** *Assist local implementation of radar data assimilation*

The use of radar reflectivity observations within ALARO was tested to study the effect of graupel on the radar reflectivity. Some tests have been performed. The preliminary results, based on a single case study, show that the ALARO version with prognostic graupel provides very similar precipitation structures with slightly smaller intensities compared to the version without prognostic graupel. In these tests the graupel initialization was put to zero is necessary to avoid extremely high simulated reflectivity in radar assimilation. The initialization of graupel in both cases should be better understood and eventually fixed. It was found that prognostic graupel in ALARO microphysics has positive effect on simulated reflectivity, namely by a small reduction of random error (STD) of reflectivity innovations. A comparison of ALARO and AROME-FR showed that both setups provide qualitatively similar statistics which give us more confidence for further testing of radar reflectivity data assimilation within ALARO configuration.

In Slovenia, three methods (the method used in Austria, CINDA method, torus mapping) for wind dealiasing were implemented and tested on a set of precipitation cases over two years, via check versus other observations (little overlapping observations) and more successfully ALADIN/SI first guess. The methods were shown to give comparable results, the torus method being slightly better than others.

In Morocco the work on 1Dvar + 3Dvar assimilation of radar precipitation in AROME Framework continues. The sensitivity of 1D-Var inversion of radar precipitation to bias correction and observation error is being studied.

**DA3.2** *Aircraft-derived data (ADD): assist implement Mode-S (EHS and MRAR) pre-processing*

During the Covid-19 outbreak in 2020, the EMADDC service of KNMI started to provide new Mode-S data sets, containing EHS data from MUAC and Denmark, and later also Austria and Romania. In OPLACE, two data streams are now available. In all Austrian AROME suites, the Mode-S EHS from MUAC and Denmark are assimilated from May 2020 on top of national EHS observations. In

AROME-RUC, the EMADDC data are also used operationally. The impact was not evaluated so far, but the number of observations in AROME-Aut with new data is higher than before COVID AMDAR only data.

In Hungary, an experiment the impact of Czech Mode-S MRAR data on the quality of the forecast was investigated for a winter period (December 2019) and was based on the operational AROME/HU. The verification results show little improvement for the winter period: scores are usually very close to the operational ones, although a slight improvement can be detected in most cases. A remarkable, albeit small positive impact can be seen regarding precipitation, although it has to be noted that there were only a few days with considerable amount of precipitation in this specific period. This work continues. Also a first test with 4 weeks of Hungarian data, provided by Hungarian ATC (HungaroControl) were conducted. The first verification results show that the accuracy of the AROME/HU forecasts were not affected remarkable by the raw MRAR dataset.

In Slovakia, a comparison of Mode-S EHS and Mode-S MRAR data originating from the same aircrafts was performed. The dataset was retrieved from Buchtuv kopec (Czech Republic) where both data types were available over the period of Jan-Feb 2018. S

**DA3.3** *Ground-based GNSS ZTD*

In Belgium, the data assimilation team started to deal with the ground GNSS data. Samples of near-realtime ZTD (Zenith Total Delay) measurements encoded in COST 716 format was provided by colleagues from Royal Observatory of Belgium (ROB). The data are updated hourly or every 15 minutes, which is suitable to use them for Rapid Update Cycling assimilation system. A quality check of the GPS ZTD data as performed. This first study allowed us to have a fairly good idea of the quality of the data provided by the ROB center. In addition, it allowed to estimate the static bias for each of the stations that could be assimilated later in the AROME 3Dvar with static bias correction. The data assimilation of GNSS entered in a preoperational mode of AROME-Be running at 1.3 km.

The Moroccan team is validating GPS data. In this stage, this work is aimed to make an inter-comparison between the integrated water vapor resulting from the Model AROME (IWV-AROME) by the integrated water vapor (IWV-GPS) deduced from the 9 permanent GPS stations. This inter-comparison was made through a statistical study between 3 hours forecasts of IWV that is

calculated from the AROME model and the IWV from GPS. The integrated water vapor from zenith tropospheric delay (ZTD) which is provided from GPS observations by BERNESE processing software (Hdidou FZ et al, 2018)(IWV-GPS) has already been validated by integrated water vapor from radiosonde with correlation and (Root Mean Square Error) RMSE respectively 0.98 and 2.51 mm. The model data used for this inter comparison are the data from the AROME-Morocco model. The comparison is made in Root Mean Square Error (RMSE), bias and correlation for all stations in the Moroccan GPS meteorology network.

Subsequently, for the first time, the assimilation of the Moroccan GNSS network on the high-resolution convection-resolved AROME-Morocco (2.5km). An impact study undertaken and is expected to provide a new assessment of the impact of GNSS ZTD data over the North African region, which has a different climate and has received until now little attention in the literature. The results of the Moroccan developments are published a paper in Tellus: *Impact of the variational assimilation of ground-based GNSS zenith total delay into AROME-Morocco model.*

The usage of GNSS-derived observations is planned in most of the RC LACE member countries and is currently operational in Hungary and Austria (in AROME-RUC).

In Slovakia, a comparison between TPW (total precipitable water) from NWC SAF and PWV (precipitable water vapour) from GNSS was performed. The PWV were computed from ZTD estimated at near real time and atmospheric parameters from operational configuration ALADIN/SK. Positive correlations were noticed between TPW and PWV at multiple GNSS stations. The assimilation tests of available STDs from GNSS station BASV were performed, the positive increments (more specific humidity in analysis) are located mainly eastwards of the station. Actually, some negative increments were noticed west of the station. Asymmetrical increments at GNSS station are an expected feature of assimilation of all available slant total delays at GNSS station. The STD code was compiled into cy46t1 on beaufix (MF). The aim is to implement all the developments first to this release and later to cy48.

In Slovenia, it was agreed with a data provider (GIS institute) to verify their observations by comparison to other E-GVAP data, so it adapted the local solution, called SIGNAL. Initial updated datasets were provided by the end of 2019 and now much more correspond to other E-GVAP solution, compared on common reference GNSS sites. An evaluation of those observations were

performed in ALADIN, suing 3 VarBC predictors. In the first place, comparison of observation and the model reveals systematic biases between SIGNAL2 and ALADIN. These can originate both from the model deficiencies or observations, and a common source of such bias is a mismatch between station height and the model terrain height. The experiment was also recycled for another month using the VarBC parameters from previous run. The verification suggests rather high impact of ZTD but increase of bias for 2 m temperature and humidity (reduced in the experiment with longer warm-up period) while the cloudiness as well as some layers in the free atmosphere are improved. Even though the results with ZTD assimilation are not yet satisfactory, the new SIGNAL dataset performed clearly better than the previously used dataset.

**DA3.4** *Scatterometer winds*

In Austria, experiments to investigate the impact of a local observation error for SCATSAR-SWI on the forecast of screen level parameters have been finalized. While the assimilation algorithm is working properly, the improvement on the forecast quality compared to the global observation error is small and not significantly positive.

The approach to assimilate LST data with SEKF in AROME is working, but the impact is rather small and not continuously positive. As the surface temperature is a rapidly changing parameter both in space and time due to the missing storing capacity of the surface, it is difficult to achieve long-lasting changes in the model soil due to the assimilation.

Based on the combined MSG-Sentinel3-LST data set that has been developed at ZAMG, measurements are available with a spatial spacing of 1 km and a temporal spacing of 15 minutes (in case of cloud free conditions). Comparing different settings lead to the conclusion that a short OFFLINE perturbation window (1 hour) and a rapid update (hourly LST assimilation) leads to the best results. AROME forecasts have been computed once per day for up to +24 hours. Furthermore it is beneficial to use the soil temperature of the uppermost six layers (0 to 60 cm) as control variables in the SEKF (given short memory of near surface fields). The forecast performance currently limits operational implementation.

In Slovenia, the impact of OSCAT wind observations (onboard Indian Scat) in ALADIN/SI NWP model was investigated over a period of one month. OSCAT is a scatterometer instrument on board ScatSat-1 satellite and provides near surface wind vector observations over ocean. OSCAT data represent a complementary dataset to the more widely used ASCAT data. As both cover data sparse regions over the seas and oceans they represent a valuable source of information for NWP. The data are available over ocean surfaces with the horizontal resolution of approx. 25 km. OMG/OMA investigation showed an impact of OSCAT data on the analysis, however, the impact on the forecast at some distance from the observations was largely neutral. When both are assimilated OSCAT reduces the impact of ASCAT data and causes the problem of redundancy. Still, this does not cause any negative impact on the forecast.

**DA3.5** *AMV*

An impact study was carried out in Hungary in order to evaluate AMV (GEOWIND and HRWIND) in AROME/HU over two periods with frequent weather fronts and convection. The AMVs were generated form IR, VIS and WV channels. In both periods, only a small fraction of the data was active in the assimilation, with lots of blacklisted data (above QI 85%). According to this, most of the active wind vectors were located between 300 and 250 hPa and a few measurements were used between 1000 and 850 hPa. The experiments showed very small, mostly neutral impact of the AMV data in both periods for the surface parameters (temperature, humidity, wind, pressure). In the convective period a small, rather positive effect was found for the surface wind gusts. In the precipitation larger differences could be observed between the experiment results obtained with and without AMVs. For days with very small and large precipitation amount a positive impact can be seen while for moderate precipitation amount the reference model run performed better.

In the Czech republic, HRWIND data were investigated in an impact study (together with wind profiler and scatterometer data) in order to extend the use of existing observations in the operational version of ALADIN/CHMI. The comparison with respect to the NWP model was used to assess the quality of the additional observations. Sensitivity studies were performed to evaluate impact on forecast. Statistical analysis of observation-minus-background (OMG) showed a larger number and a better quality of HR-AMV compared to standard AMV. Therefore AMV data were replaced by HR-AMV. The impact study showed neutral forecast scores.

**DA7** Observation pre-processing and diagnostic tools

The HOOF tool for homogenization of OPERA/OIFS radar measurements was improved with a number of small corrections based on user feedback (discovered especially during radar stays). Further work is needed for data splitting, which is not satisfactory for the radar sites with irregular/random scanning order.

Turkey is testing SAPP (Scalable Acquisition and Pre-processing System). Synop, temp, airep, amdar, ship obs available at GTS and also data from automatic stations located in TURKEY are collected by SAPP servers and then converted to BUFR format. Since August 2020, synop observations processed by SAPP have been using by AROME-Turkey surface assimilation system.

## PH Physics

### PH1 Developments of AROME (and ARPEGE) physics

Research on AROME physics in 2020 mostly focused on: improvements of mass conservation, improving the surface fluxes with the ECUME scheme, lightning diagnostics, improving the fog forecasts, improvement of the ice/mixed clouds. Important steps were made towards 3D turbulence. Progress was made on the soil diffusion scheme and radiation.

Improved conservatism of the semi-Lagrangian advection was obtained by switching to linear interpolators of the semi-Lagrangian scheme. This was demonstrated by semi-academic tests and tested in a quasi operational setting for an extreme convective precipitation case (25 July 2018), where the linear interpolators gave more realistic and more extreme precipitation as compared to the radar.

Different configurations were tested for their potential to improve fog forecasts:

- the operational AROME at 1.3 km resolution with 90 levels,
- an AROME with resolution of 500 m with 156 levels with a low level at 1 meter height (using ICE3),
- an AROME with resolution of 500 m with 156 levels with a low level at 1 meter height and with the LIMA scheme.

This led to mixed results: the increase of resolution led to more fog but also more false alerts, some model delay and too long fog events. LIMA then gave more short events than ICE3. Finally, LIMA improved the timing but not the depth of the fog event.

Thanks to technical work on the model data flow three-dimensional horizontal gradients can now be computed, opening the way for 3D turbulence. Work is planned to increase the mixing in deep convective clouds by adding turbulence terms. A shear production term has been added for TKE over orography.

Furthermore, tests have been performed with ISBA-Diff and a mulitlayer snow scheme with promising results and SRTM radiation scheme has been tested leading to neutral scores. The aim is to go to the EcRAD scheme of the ECMWF.

Algeria and Tunesia are testing the LIMA scheme over their domains. The work of the Algerian colleagues on dust aerosols in the AROME configuration continued. In 2020 the sensitivity of precipitation with respect to these aerosols was demonstrated. This configuration is now used to contribute to the SDS-WAS WMO project (https://sds-was.aemet.es/forecast-products/dust-forecasts/forecast-comparison). The real-time operational ALADIN forecasts are now available for Northern part of Africa on the project website.

**PH3** Development of ALARO Physics

The main development related to ALARO physics focused on:

- further continued development of TOUCANS to implement a TKE-based mixing length;
- further tuning to realize the coupling with SURFEX
- the use of new topography and roughness length.

For the coupling to SURFEX a fix was introduced for the computation of the snow albedo leading to better results. Some parameters of the roughness length (vegetation and surface) have been retuned for different physiographic databases: GMTED2010, GTOPO30, ECOCLIMAPI and ECOCLIMAPII.

In Belgium the developments of stochastic perturbations continued. In this method the model errors originating from switching off the deep convection scheme were quantified. The proposed method is based on a sampling technique that samples model errors from a database and randomly uses them to perturb the physics each time step in an EPS setup. In 2020, the link between the model error and the underlying profiles was trained using with a neural network. This neural network was then used to perturb the physics. It has been demonstrated that this can lead to similar results as the sampling method.

In Bulgaria the work on the development of thunderstorm indices continues. In 2020 this work was published (*Senova, B., Bogatchev, A, 2020, On the use of atmospheric instability indices based on NWP model production for thunderstorm forecast, BJMH, Accepted for Publication*).

**PH5 Model Output Postprocessing Parameters**

Poland started to carry out experiments with machine learning for model postprocessing. In the experiment forecasted 2m temperatures from three operational models (ALARO 4km, AROME 2km and COSMO 7km) were compared with observed 2m temperature synop values. A machine learning algorithm *Random Forest Approach* was applied to improve forecasts. This led to a significant reduction of RMSE for all stations, for the first half year of 2020, especially in mountainous regions.

Slovakia investigated the possibility to use A-LEAF for Local quality control (QC). They found that a physically consistent spread of the meteorological fields provided by the A-LAEF ensemble can be used in an automatic QC procedure of the AWS measurements to identify suspicious values that are out of the A-LAEF spread.

## SU Algorithms of surface data assimilation

The validation of EKF has (re)started in Hungary by validation over the Hungarian domain with AROME cy40t1 and SURFEX 7.3. Two (summer and winter) cases very studied in detail by conducting impact studies with respect to AROME/HU OI-MAIN operational model. 3-hourly data assimilation cycle was started two weeks before the events. Forcing required to offline SURFEX run were coming from AROME inline forecasts at 9 m (radiation, precipitation, wind, humidity, pressure). In the winter case, too much low clouds and corresponding under- forecast of daytime surface temperature were observed. For this case, the analysis of 2 m temperature and low-level cloudiness using SEKF did not really differ from the result of the operational run: similarly false low-level cloud and overestimated temperature analysis were obtained. The analysis increments and Jacobians of the observation operator were investigated.

In Austria, SEKF experiment at ZAMG have been a combination of AROME CY40T1 with code extensions of HIRLAM to activate the ISBA diffusion scheme for forecasts and a standalone version of SURFEX 8.1 for the soil assimilation. This solution is facing the problem that the input/output files of SURFEX7.3 (in AROME) and 8.1 are not compatible. Thus it is planned to update AROME to CY43T2 and switch from the ISBA force-restore (3-L) to the ISBA diffusion (DIF) soil scheme. As a first step in this direction, a comparison of the two soil schemes is taking place. For this purpose, AROME was computed from 07/2018 to 06/2020 with ISBA 3-L and D95 snow scheme on the one hand and ISBA DIF and 3-L snow scheme on the other hand. Both runs are computed once per day at 00UTC with +24 hours forecast range. This setting makes it possible to cycle the soil fields. The goal of this experiment is to find out if the more sophisticated ISBA DIF scheme leads to – at least – equal results as the ISBA force-restore scheme.

## EPS

While the main activities on EPS are done within the RC-LACE consortium, it is a pleasure to note that, in 2020, Morocco started the development of an EPS system, based on AROME-MAROC. The Moroccan colleagues have started to investigate the perturbation techniques of the IFS.

After 2019 became a milestone for turning the convection permitting C-LEAF system operational, in 2020 many efforts were spent on its further refinement and the validation of the various LAEF systems.

In the first half of 2020 a lot of work was done on A-LAEF suite in order to achieve the status of time critical application (see more details in S2). Since May 12 the full 3-day forecasts from A-LAEF suite were disseminated to the two RC LACE members (Slovakia and Slovenia) via operational ECPDS streams. This was indeed very good occasion to look at the forecasts very closely. The performance of A-LAEF has been documented and studied for several extreme weather cases. Several products (maps) have been developed.

The experiences gained through INCA nowcasting and high resolution ALARO-1 reanalyses on 1-2 km grids lead to a necessity of automatic quality control (QC). Without a proper QC, the automatic weather station (AWS) measurements often brought a spurious signal into the analysis.

At OMSZ, a non-hydrostatic convection-permitting system AROME-EPS is being developed and operationally used, running on their new HPC. New system runs once per day coupled to 18 UTC run of ECMWF ENS. In the lagged mode the forecast from 00 UTC is produced for the next +48h. The ensemble comprises 10 members + 1 control forecast, and covers a Carpathian Basin domain with the horizontal grid spacing of 2.5 km (see figure 18). For the time being there is no assimilation cycle involved and the initialization uses first guess (hydrometeors) and surface analysis of deterministic AROME, which runs with 3-hourly assimilation cycle. The upper-air fields are downscaled from the boundary conditions. AROME-EPS runs operationally at OMSZ since February 4, 2020. To see the strengths and weaknesses as well as the seasonal variation of AROME-EPS quality, a comparison of ALARO-EPS (ALEPS) and AROME-EPS (AREPS) have been made for a longer period (from June 2019 till January 2020), covering three seasons of parallel run. For the main surface parameters, the following conclusions can be drawn:

● Wind gust is getting better for the ensemble mean of the convection-permitting EPS in all seasons.
● For 2-meter temperature, relative humidity, total cloudiness, and in the convective season, also mean sea level pressure (MSLP) have a lower RMSE of EPS mean for AROME-EPS in the daytime hours, but get worse during the night. Except convective months, AROME-EPS has a better quality in these parameters, than ALARO-EPS.
● For precipitation, one can see lower RMSE values in winter and autumn, and higher values in summer for the AROME-EPS forecast, especially in the afternoon hours, when thunderstorm activity and heavy precipitation events occur most frequently.

C-LAEF now runs operationally at ECMWF HPCF with 4 runs per day (00, 06, 12 and 18 UTC). The lead times vary between +60h (00 UTC), +48h (12 UTC) and +6h (06 and 18 UTC).
In the first half of 2020, the following activities were realized:
● Implementation of new cy43t2 including reporting of bugfixes
● Set-up of a complete C-LAEF e-suite with cy43t2 including adaption of script system
● New observations (GNSS, Mode-S, ...) were tested in C-LAEF EDA; several short e-suites with different sets of new observations were prepared and verified
● C-LAEF SPP scheme was extended by the additional perturbation in microphysics for 2 processes connected to sublimation of snow/graupel
● Different orographies (GMTED, GTOPO, filtered vs. non-filtered) were tested and their impact on temperature in Alpine valleys / mountain tops was checked

Time lagged EPS out of AROME-RUC was created using neighborhood methods. Furthermore, the AROME-RUC-PEPS system was technically implemented for the precipitation. It runs regularly for selected INIT times of the AROME-RUC, generating a lagged ensemble with 5 members (lag=0h, -1h, ..., -4h), with forecast range up to +8h and output frequency of 15 minutes. AROME-RUC-PEPS visualization was implemented in Visual Weather (see figures 25 to 27). Post-processing of precipitation probabilities within AROME-RUC-PEPS;
● The calculation of upscaled probability fields was implemented
● Outputs being in grib (version 1) files that contain the calculated probability fields
● Probabilities for different thresholds and upscaled probabilities can be calculated for different search radius using different methods (maximum probability, mean probability, and further methods are subject of current work)

- The visualization of probability grib files has some technical issues in Visual Weather software