

Application of Chapeau/Aladin in operational classroom

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1. Introduction

The Department of Physics at the Faculty of Mathematics and Physics at the University of Ljubljana is carrying out the only undergraduate and graduate program in meteorology in Slovenia. A major fourth-year course is “Weather analysis and forecasting” which presently runs throughout the year including four hours of the classroom lessons, one hour of seminar and two hours of exercise per week. A special attention in the lessons has been given to the description of the Aladin model and the operational model products available via the Environmental Agency of Slovenia (ARSO) have been used in the teaching process.

In the spring term of the academic year 2009/2010 we implemented the Chapeau/Aladin model and prepared initial and lateral boundary conditions for selected weather cases for students to run the model, to analyze results and to prepare written reports. The goal of the Chapeau/Aladin lab was to learn technical aspects of NWP model implementation, to learn about post-processing of model results and to apply theoretical lessons in real case studies. Selected cases were characterized by extreme weather which allowed easier diagnosis and discussion of dominant circulation patterns and application of theoretical and conceptual models in real cases.

Below we summarize technical details of the minimal computing system used for the model implementation, organisation of the student lab and provide excerpts from their reports.

2. Technical characteristics

The Chapeau/Aladin package comes with the user guide written by Daan Degrauwe. We used the version dated February 4, 2010 and it worked well. The model was installed on Intel x64 platform with Linux OS – Debian Lenny distribution.

Post-processing and visualization of the model results were performed by the open source software R. Its use with Chapeau/Aladin requires the Rfa package prepared and made available by Alex Deckmyn. We followed the installation procedure described in the document "Rfa and geogrid: R packages for analysis of ALADIN files" by Alex Deckmyn, dated 23 December, 2008. Based on difficulties experienced with the installation of the Rfa package we suggest to add to the instruction file a brief description and installation instructions for the mapNew package (additional map database) which is required by the Rfa package. Due to conversions of data structures to big endian inside the Fortran code, that is a part of Rfa, we needed to compile the Rfa/R package with the Intel compiler using the instruction `ARCH=LX_ifort R CMD INSTALL Rfa_3.0.6.tar.gz`. When the GNU compiler was used as `ARCH=LX_gfortran R CMD INSTALL Rfa_3.0.6.tar.gz` the Rfa package was not working correctly even when R was run with the environment variable `export GFORTRAN_CONVERT_UNIT='big_endian:10'`.

The applied sequence of installations steps which in our case provided optimal installation and correctly working software can be provided upon request.

3. Organisation of the Chapeau/Aladin lab

The first time Chapeau/Aladin lab involved nine students and it lasted little over a month with a few extra weeks allowed for the report submission. Students otherwise had a permanent access to the computer classroom and could spend any time there or work remotely.

A common class account was created under which the model was installed and all scripts stored. Each student had an own directory to copy necessary scripts to run the model and to process the outputs. A short instruction manual was prepared which described the sequence of steps needed to run the model, to run the R and to make the basic manipulation of the prognostic fields and their visualization. During this lab most of students for the first time used the Linux system, the R package and scripts. Therefore the teacher's presence and support is crucial. (The fact that some students keep playing games even while the teacher is talking is a topic for another kind of paper.)

In advance we prepared a model domain to be used by all students which approximately equals the operational Aladin-SI domain. Initial and boundary conditions were prepared from the Arpege like in the case of the operational model. Default simulations thus reproduced the operational ARSO results. Three selected weather cases included extreme bora wind and precipitation in March 2010, extreme precipitation around Christmas 2009 and convective storms in August 2009. Three groups, each involving three students, were formed to work together on a common case. Each group member had to submit own report up to 10 pages long including answers to three questions. The first question for each group was the same: to describe dominant atmospheric process in selected case and to choose, study and discuss the most relevant variables and levels. Other two questions were case dependent. For example, for the August storms we requested students to quantify how the model predicted convection and to check differences between the forecast of different lengths. In selected grid points they needed to extract profiles of model prognostic variables (pseudo-temps) and to estimate theoretically defined vertical velocity from their own calculation of the convective available potential energy. The estimates of w had to be compared with vertical velocities diagnosed directly in the model by Full-Pos and available in the post-processed pressure-level files. The importance here was on discussing the differences.

Such comparison is presented in Fig. 1 as performed by Matic Šavli.

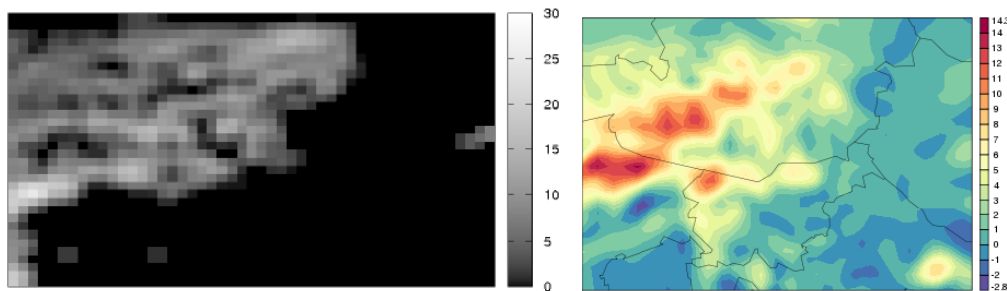


Figure 1. Left: Vertical velocity (in m/s) estimated as $\sqrt{2*CAPE}$ from own computation of CAPE from 1-hr forecast started on 22 August, 12 UTC. Right: vertical velocity obtained from the model post-processed (Full-Pos) ω field and transformed to w using the relationship $\omega = -qg w$. The area shown in two panels is the same. From the report by Matic Šavli.

In Fig. 2. we present a figure from a report by Blaž Šter who studied the severe bora case and compared forecasts of different length in the Vipava valley where the damage caused by storm winds was large. He wrote the following discussion of Fig. 2: “We notice right away that maximal forecasted wind speeds during early hours of forecasts are much smaller than forecasted by earlier runs. It takes about 2-3 hrs for the forecast to “catch up” with earlier simulations. We concluded that the cause of this behaviour is in the assimilation. Each time we started a new experiment we used new initial conditions which were computed by another

model which has a lower horizontal resolution and consequently more poor representation of orography. The orography is the key for the bora. Due to poorer orography, the model which produced initial conditions did not “see” the bora. When these boraless fields were applied in Aladin, it did not “see” enough strong bora during the first few hours. In addition, no wind observation from the studied bora region was used in the assimilation so that the bora influence could not come directly into initial conditions.”

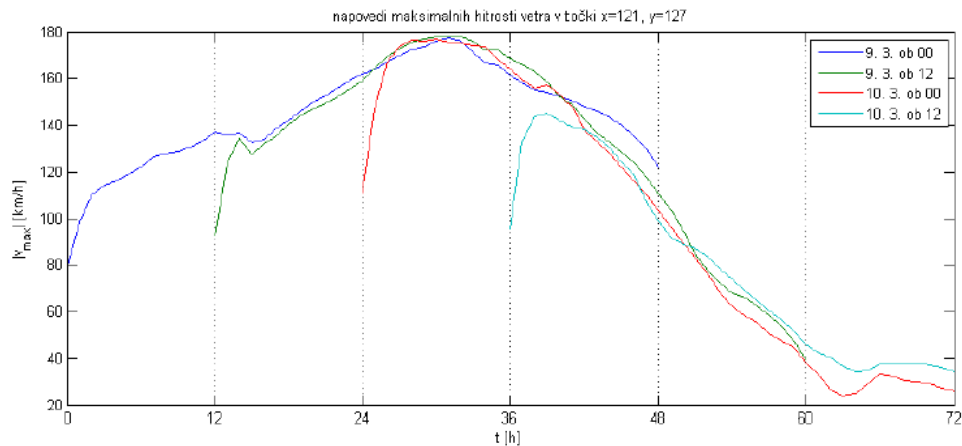


Figure 2. Maximal wind velocity of the bora wind at a grid point in the Vipava valley (southern Slovenia). Four different curves correspond to four forecasts starting on 9 March, 00 UTC (blue), 9 March, 12 UTC (green), 10 March, 00 UTC (red) and 10 March, 12 UTC (turquoise). From the report by Blaž Šter.

4. Concluding remarks

Fifteen years after the first author successfully run Chagal to visualize first “own” Aladin run on the Cray computer of Meteo-France in Toulouse the development of computers and modelling allows to run Aladin on a laptop by an average undergraduate student. Global developments in NWP has made it possible for anyone knowing basic computing to download and to run mesoscale models in real time, for example using the WRF model and in real-time available initial and lateral boundary conditions from the global NCEP model. Most scripts most of time work well and beginner modellers spend most of time on producing nice plots. However, it has always been the case that a difficult part is not to get a model running but to understand it and to advance its products and use in operations.

At the undergraduate level we aim to teach students basics of the practical work carried out by modellers at NMSs who provide pleasant to eye and friendly to use plots to forecasters. Numerical lab involving operational model also makes students aware of broadness of work in NWP. Getting own hands on model outputs is a best way to refresh and memorize theoretical aspect of the model formulation and to learn practical aspects of handling the model outputs in the operational environment. Such a lab inevitably must presume students use the model as a black box. Shortage of time and numerous technical details which need to be learnt make anything else impossible. Just handling the scripts and visualizing outputs require practically a permanent teacher’s help. Discussion of the model results and application of lessons heard in the classroom is strongly dependent on the supervision. It is unrealistic to expect that significant feedback useful for the model development feeds back from the University to NMSs. Such feedback is however fully possible within more advanced labs, for example carefully prepared and supervised master-level projects between the NMSs and Universities which last for a couple of months and involve more independent work