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Limited area modelling activities at the Hungarian Meteorological Service (HMS)

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Operational configuration

The ALADIN/HU model domain and orography

Main features of the operational ALADIN/HU model

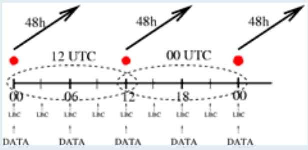
- Model version: AL28T3 (AL30T1 since 2nd of October, 2006)
- Initial conditions: 3D-VAR assimilation
- 48 hour production forecasts twice a day
  (four times a day since 2nd of October, 2006 on the Altix machine)
- Boundary conditions from the ARPEGE French global model

Model geometry

- 8 km horizontal resolution (349*309 points)
- 49 vertical model levels
- Linear spectral truncation
- Lambert projection

Assimilation settings

- 6 hour assimilation cycle
- Short cut-off analyses for the production runs
- NMC background error covariances
- Digital filter initialisation
- LBC coupling at every 3 hours



The schematic illustration of the data assimilation cycle

Observation usage

- SYNOP (surface pressure)
- TEMP (T, u, v, q)
- ATOVS/AMSU-A (radiances from NOAA 15 and 16) with 80 km thinning distance
- ATOVS/AMSU-B (radiances from NOAA 16 and 17) with 80 km thinning distance
- AMDAR (T, u, v) with 25 km thinning distance and 1 hour time-window, together with a special filter (that allows only one profile in one thinning-box)
- Web-based observation monitoring system (see below)

Different observations (SYNOP, TEMP, AMDAR, AMSU-A, AMSU-B) used in the operational data assimilation system

Forecast settings

- Digital filter initialisation
- 300 s time-step (two-time level SISL advection scheme)
- LBC coupling at every 3 hours
- Hourly post-processing in the first 36 hours and 3 hourly afterwards

Operational suite / technical aspects

- Transfer ARPEGE LBC files from Météo France (Toulouse) via Internet and ECMWF re-routing as backup
- Model integration on 24 processors (32 processors on Altix)
- 3D-VAR on 24 processors (32 processors on Altix)
- Post-processing
- Continuous monitoring supported by a web based system

The computer system

- IBM p690 server (regatta) + IBM (p655) cluster server + SGI Altix 3700
- CPU: 32 + 32 + 144 processors (1,3 Ghz + 1,7 Ghz + 1,5 Ghz)
- 64+ 128 + 288 Gbyte internal memory
- IBM TotalStorage 3584 Tape Library (capacity: ~ 30 Tbyte)
- Loadleveler job scheduler on IBM, PBSpro on Altix
- Totalview debugger (on Regatta)

The two IBM supercomputers (top): p690 (left) and p655 (right); the new SGI Altix 3700 supercomputer (bottom left) and the IBM TotalStorage 3584 Tape Library (bottom right)at HMS. The Altix machine is operationally used for the exploitation of the ALADIN model from 2nd of October, 2006.

Latest verification (objective and subjective) and post-processing results

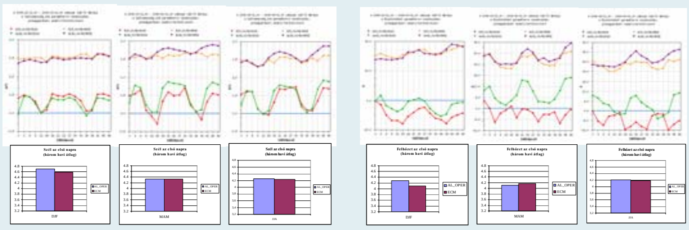
Objective verification

The interactive web-based verification system is in operational use. It provides the verification of NWP forecasts used at HMS against SYNOP observations, including: scatterplots, contingency tables, maps and temporal evolution diagrams (MAE, BIAS, RMSE), probability distributions and wind-direction pie charts. The system is going to be extended in the near future with the use of upper-air observations as well. There is also a version of the verification system, which visualises pre-defined products for the forecasters.

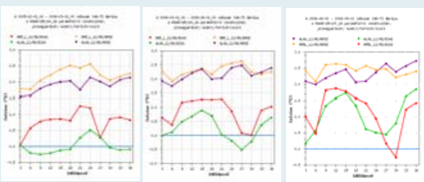
Subjective verification

The subjective verification is carried out in order to complement the objective verification scores, especially for variables that are hard to evaluate in an objective way (e.g. cloudiness, precipitation). The present system includes the comparison of the 0-48 h forecasts of 3 different ALADIN model versions (operational and test versions) and ECMWF. The 5-degree qualification indices together with some additional data (e.g. synoptic situation) are fed into a database that can be accessed through a web interface.

The verification of the most important NWP models used at the Hungarian Meteorological Service is carried out in a quarterly (seasonal) basis.



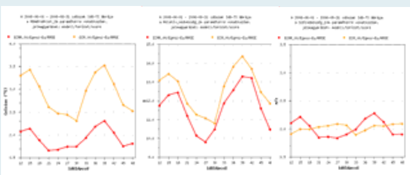
Objective (RMSE and bias; top) and subjective (bottom) verification of ALADIN and ECMWF forecasts for 10m wind speed (left three panels) and cloudiness (right three panels) for the winter, spring and summer periods respectively. It can be seen that the performance of the ALADIN model was degraded with respect to ECMWF during the spring and summer periods.



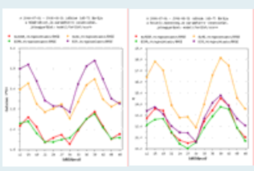
Objective verification (RMSE and bias) of ALADIN and MM5 (the MM5 model is operationally used for nowcasting purposes at the Hungarian Meteorological Service) forecasts for 2m temperature for the winter, spring and summer periods respectively.

Post-processing

The first results of a Model Output Statistics (MOS) based post-processing system are delivered. MOS is applied to ALADIN and ECMWF near surface temperature, humidity and wind forecasts. The MOS coefficients were computed via multiple linear regression for each variable, time-step, location and month.



Model Output Statistics for the ECMWF model for 2m temperature, 2m relative humidity and 10m wind speed respectively (RMSE, European domain).



Model Output Statistics for the ALADIN and ECMWF forecasts for the 2m temperature and 2m relative humidity (RMSE, the entire ALADIN domain). It can be seen that after post-processing the two model has very similar RMSE.

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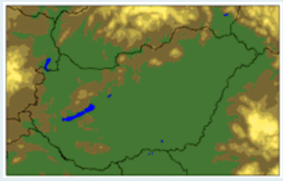
First investigations with the prototype of the AROME non-hydrostatic model

AROME model and its installation in Budapest

The AROME model is a non-hydrostatic model, which is built from the data assimilation (3d-var) system and non-hydrostatic kernel of the ALADIN model and the physical parametrisation package of the meso-NH French research model. The prototype version of the model was installed (see more details about technical aspects at http://www.cnrm.meteo.fr/aladin/newsletters/news29/PLANEWS.html) in Budapest. The first, preliminary tests of the model were aimed for demonstrating the capabilities of the AROME model in extreme meteorological situations with respect to the operationally used ALADIN model version. For that end, first, a new AROME domain was created taking into account the (heavy) computer resources needed for the model integration (24h integration takes around 4,5 hours on the 16 processors of the IBM p655 cluster server). Note that at that stage all the experiments were performed without data assimilation!



*The domain and orography of the AROME model over Hungary (2,5 km horizontal and 49 levels vertical resolution, 250*160 points)*

Preliminary conclusions of the case studies

The selected cases were heavy precipitation events, where the sensitivity of the model was examined with respect to the coupling model, coupling frequency and domain size.

- Sensitivity to the coupling model

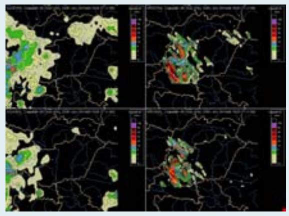
ALADIN model versions were used for initial and lateral boundary conditions for the AROME model: ALADIN with and without 3d-var data assimilation. The event investigated was a heavy precipitation case over the Western part of Hungary. The ALADIN forecasts were although giving precipitation, but its amount was strongly underestimated (the dynamical adaptation version was the slightly better one). The AROME forecasts could equally improve the precipitation forecasts independently from the differences in the lateral boundary conditions.

- Sensitivity to the coupling frequency

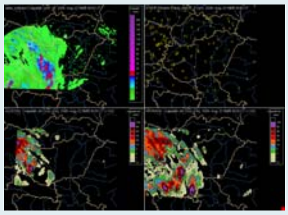
Different coupling frequencies were tried: 6h, 3h and 1h respectively. On the investigated cases no direct relation was found between the coupling frequency and the quality of the forecasts.

- Sensitivity to domain size

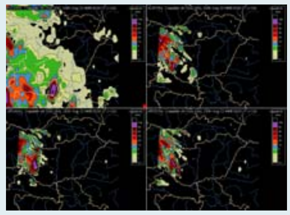
Based on the results on the coupling frequency it was decided to extend the originally defined domain slightly to the West and South. There is a clear improvement in terms of precipitation with the bigger domain.



18h precipitation forecasts of different ALADIN and AROME model versions: ALADIN is on the left and AROME is on the right; dynamical adaptation on the top and 3d-var on the bottom. The ALADIN model largely underestimates the precipitation at the Western part of Hungary, while the AROME forecasts provide meaningful improvements.



Precipitation measurements and 6h forecasts by the AROME model: radar image (upper left), rain gauges (upper right), AROME precipitation forecasts for the original domain (lower left) and for the extended domain (lower right). The application of the bigger integration domain significantly improves the precipitation forecast.



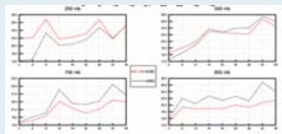
12h precipitation forecasts of ALADIN and different AROME model versions: ALADIN is on the upper left panel, AROME with 1h (upper, right), 3h (lower left) and 6h (lower right) coupling frequency respectively. The best forecast is provided by the AROME model with 6h coupling frequency.

ECMWF/IFS model as initial and boundary conditions for the ALADIN model

There is a technical possibility in ALADIN to use ECMWF/IFS data for initial and lateral boundary conditions for the ALADIN model integration. From 2006 onwards there is a Special Project at ECMWF, which (beside others) plans to investigate the possibility of using IFS as driving model for ALADIN. The study detailed below was performed in the framework of this Special Project at the Hungarian Meteorological Service.

Methodology: technicalities

The ALADIN model cannot use the frames provided by the optional BC project of ECMWF, therefore the IFS GRIB information stored in the MARS database can be applied for research puroses. The GRIB files are converted to ARPEGE/ALADIN FA file format with the help of special ARPEGE/ALADIN model configurations. The difficulty of the exercise is coming from the fact that the surface parameterisation in the IFS system is different than that of the ALADIN one, i.e. additional surface variables should be initialised for the ALADIN model. This problem can be circumvented with the help of ARPEGE surface characteristics and some climatic information. Nevertheless this treatment might be some source of possible problems in the model integration (see later).



The impact of ECMWF initial and boundary conditions for the ALADIN relative humidity forecasts on different isobaric levels (RMSE with respect to TEMP observations)

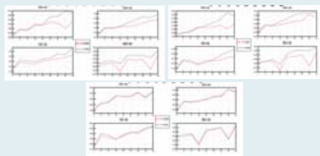
Experiments

The inter-comparison experiments were carried out for the period of 10 days (1-10 January, 2005). No data assimilation was involved, therefore always dynamical adaptation integrations were performed with different (ARPEGE and IFS) initial and lateral boundary conditions. The following experiments were realised:

- the "traditional" setting: ARPEGE initial and lateral boundary conditions (ARBC)
- application of IFS lateral boundary conditions, but keeping ARPEGE initial conditions (ECB1)
- both initial and lateral boundary conditions from the IFS model (ECBC)

/IFS initial and ARPGE lateral boundary conditions were not tried/

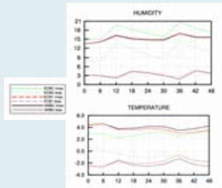
These experiments could give a hint about the relative importance and impact of initial and lateral boundary conditions in the course of ALADIN integrations.



The impact of ECMWF initial and lateral boundary conditions for the ALADIN wind forecasts (RMSE with respect to TEMP observations)) on different isobaric levels: impact of initial and boundary conditions (upper left); impact of lateral boundary conditions (upper right); impact of initial conditions (bottom)

Results

It can be clearly seen that significant improvements can be identified with the use of ECMWF/IFS lateral boundary conditions in during the ALADIN model integration. At the same time the IFS initial conditions also provide important improvements. However there are also some problems (weaknesses) mostly coming from the surface treatment, more particularly in the 2m relative humidity fields (when the IFS model is used for initial conditions). Therefore future attention should be paid to the careful investigation of the surface initialisation of the ALADIN model. It is also noted that the reason for the erroneous behaviour of the relative humidity at 250 hPa is not yet known for the time being.



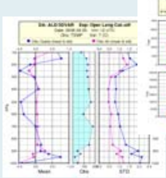
The impact of ECMWF initial and boundary conditions for the ALADIN surface humidity and temperature (bias and RMSE with respect to SYNOP observations).

Observation monitoring system

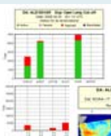
A prototype of an observation monitoring system has been developed to support the maintenance and evaluation of the ALADIN 3D-VAR data assimilation systems, concerning both the operational suites and the experimental runs. The work has been carried out within the RC-LACE Data Manager activity.The system is dealing with all kinds of observations that are available in the recent 3D-VAR system in Budapest. It can handle analysis dates and periods of analyses, as well. The system can monitor the number and status flag of observations and compute statistics for the the observation and background, and the observation and analysis departures. Advanced visualization on maps, vertical profiles, time-series and time-height diagrams is provided. The system can be used both in batch mode and interactive mode, the latter is based on a web interface with on-the fly graphics generation.

The interactive web interface of the observation monitoring system with the visualization of the spatial distribution of the status of AIREP reports

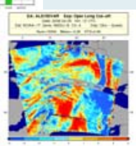
Time-series of the status of AIREP temperature observations for a one-month period



Vertical profile of departure statistics for TEMP temperature observations. The figure in the middle shows the number of active observations



Sum of observation status flags per observation types



Spatial distribution of obs-guess departures for a selected NOAA-17 AMSU-A channel

Technical background

The recent version of the system is using an ASCII dump of the ODB observational database. The system was written in C++ and the graphics is based on the GMT package.

Recent developments

The ongoing work is the modification of the system to use ODB directly. It will make possible the advanced usage of the wide range of information stored in ODB. New statistics (Jo-table, residuals), graphical types (histograms, time distribution graphs) and automatic report generation is also under development. The new system will be capable of performing local blacklisting of SYNOP and TEMP observations.