Daily runs with ALADIN and AROME at SMHI

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1 Introduction

As a part of the development of a mesoscale model and the transition from HIRLAM to the ARPEGE/IFS system we believe that running continuous experiments is a good way to gain experience. Since 2005 we have performed experimental daily runs with first ALADIN, and later on also AROME, at SMHI. During the summer of 2006 cycle 31t0 of ARPEGE/IFS was introduced at SMHI as a basis for these experiments. The results have been useful not only for evaluation and developement, but also to raise the consciousness of the possibilities and the problems with forecasting at the kilometre scale. Results from AROME have also been used for other projects such as education and forcing of dispersion models. In this note, the setup of the experiments is described. The general performance of the system is discussed as well as some special cases and problems. Since most of the interest is on the mesoscale the emphasis is on the performance of AROME.

2 Technical setup

The system is setup to run on the SMHI research linux cluster Dunder. The size and the location of the domains are shown in Figure 1 and Table 1. Both model realisations are still pure dynamical adaptation. No surface or upper air analysis is done and the surface fields are reinitialised at every cycle. Experimentation with the ALADIN 3DVAR system has started recently at SMHI and the experiments with the ALADIN domain will be switched to a full assimilation cycle when 3DVAR is working on our system. With the lack of a good surface analysis the coupling between the different models has to be done with great care. Due to an earlier error in the soil freezing in HIRLAM the soil ice was set to zero when forcing with HIRLAM data. Two scatterplots for 2 metre temperature, Figure 5, shows that AROME has problems producing the very low temperatures. It has been shown by Sami Niemela that including the soil ice again partly resolves this problem.
A forecast with AROME takes a substantial amount of time see, Table 1. The model has not yet been fully optimized on our system. We may e.g. note that the initial time step takes a very long time due to a not fully parallelised initialization of the SURFEX part. This is something that has to be looked in to.

3 General performance

After some initial problems with the different files created by AROME a surface and upper air parameters have been verified on a monthly basis and presented at https://hirlam.org/portal/smhi/WebgraF/. Radiosonde verification shows that the high resolution model conserves the information from the host model (figure not shown). Since the model domains are relatively small (~600 km) we should not expect any large differences on the large scale flow. As expected it is also difficult with standard statistic measures to show any clear improvement or difference near the surface that is connected to the higher resolution. Scatterplots for screen level temperature and wind are shown in Figure 5. It's clear from these figures that it is very difficult to claim any significant difference between the two model/resolutions.

A more subjective case based assessment shows in general more realistic simulations of small scale features. A summer case from 23rd of June 2006 is shown in Figure 2. The satellite picture over southern Sweden shows a sea breeze front on the east coast of Sweden with locally deeper convective clouds that are advected out over the Baltic Sea. The 2.5km forecast resembles a similar picture, although with the clouds in slightly different positions. The 11km does not at all capture the front cloud structure on the east coast.

A correct surface energy balance is important for near surface variables as well as triggering of convection. A first comparison with surface fluxes from Sodankylä shows a nice correspondence between the daily cycle of the sensible heat flux from AROME and the measured one. Aladin has a totally different partition between the sensible and latent heat flux and heavily underestimates the sensible heat flux. The most important difference between ALADIN and AROME in this case is probably that AROME uses SURFEX. The evaluation will continue with a more thorough study of the different components of the surface budget.

Wind determined by the local topography has a good response to an increase in horizontal resolution. We should therefore expect an improvement especially for the valley winds. Figure 6 shows the wind speed at two mountainous stations in northern part of Sweden for a few days in April 2007. The stations represent the high plateau winds with a height of about 1000 m.a.s.l. As can be seen from the Figure 6 AROME heavily underestimates the wind speed at these sites. It is first around model level 55, about 300 meters above ground, that the model wind speed is comparable to the observed one. Although this is just one example from a short period of time, the pattern is very persistent. This is something that needs to be understood by looking at e.g. the local roughness and compare with other models such as HIRLAM and UM.

Most models have problems to capture the daily cycle of the 10 meter wind speed. In Figure 4 we see that none of the models HIRLAM, AROME or the Unified model are capable of reproducing a correct daily cycle. In similar cases ALADIN actually has a tendency to have a correct nocturnal wind but underestimate midday winds, in opposite to the other models. This is something that also has to be looked in to.

4 Future work

We are currently updating the system with cy32t2. Since standard verification methods do not give the full picture we have to create other tools for assessment of the model quality. At the moment we are working on preparing comparisons with satellite images and precipitation estimated from the radar network. There is a strong interest to be able to run AROME directly from HIRLAM, which is not possible, in a clean way, at the moment. An possibility to initialize SURFEX from HIRLAM is something that has to be developed in the near future.

Table 1 Description of the different models experiments and resolutions described in the text

	Domain	Forcing	Timstep	Forcast cycle and length	Wallclock time for a 24h forecast on 32 nodes
ALADIN al00_31t0	11km 245x277x60	22km HIRLAM@3h	300s	00/12+48h	~20 min
AROME ar026_31t0 ar025_31t0	2.5km 277x259x60 259x277x60	11km ALADIN@1h	60s	00+30h	~5h

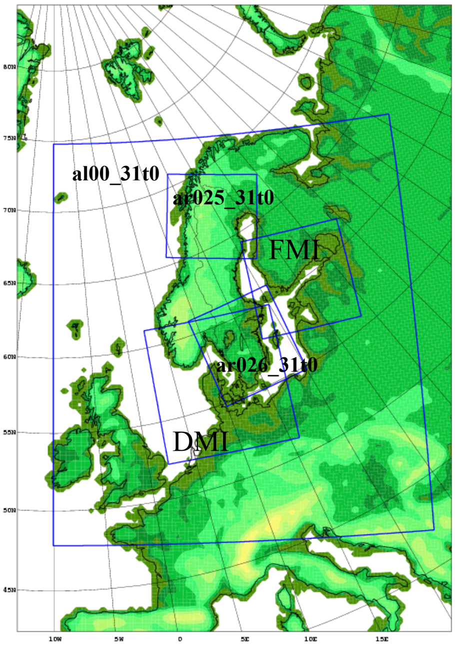


Figure 1 *Model domains used at SMHI. The DMI and FMI AROME domains are included as a reference.*

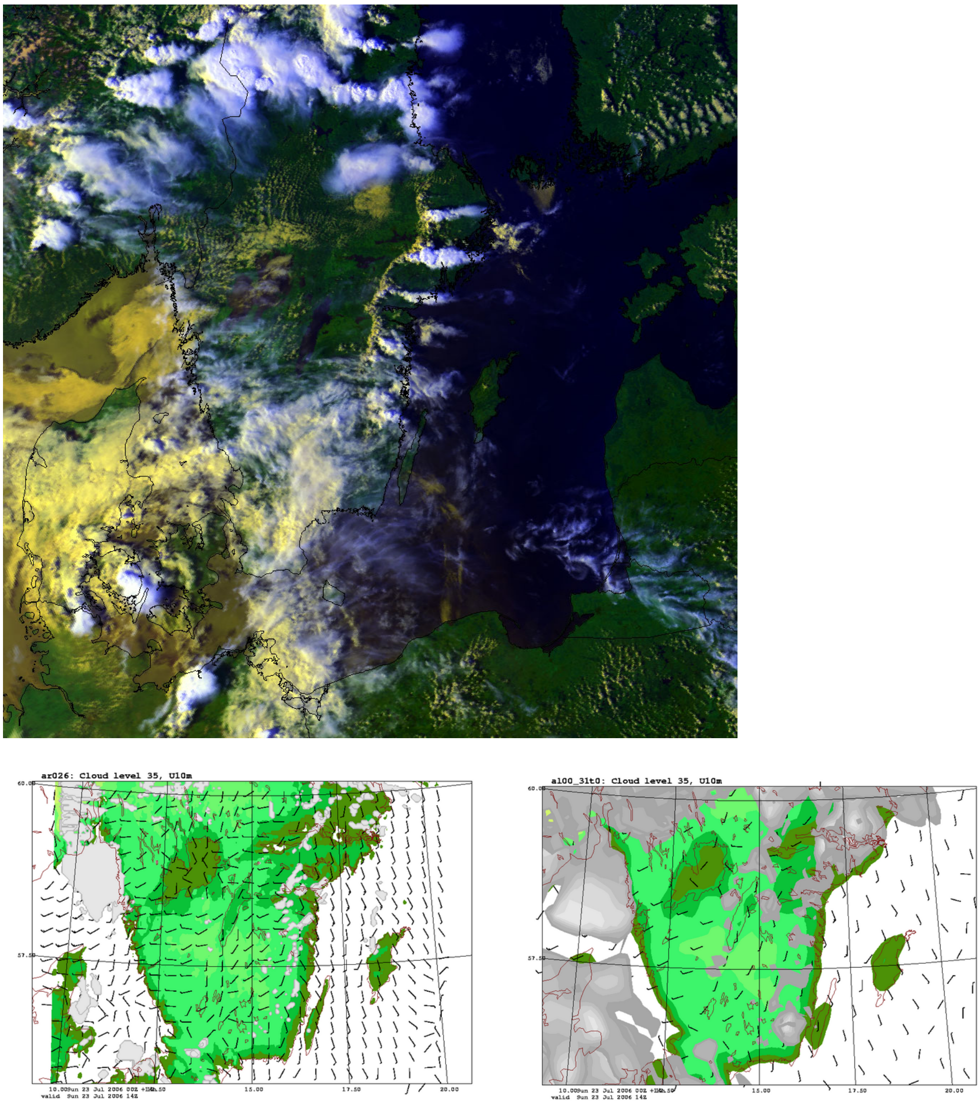
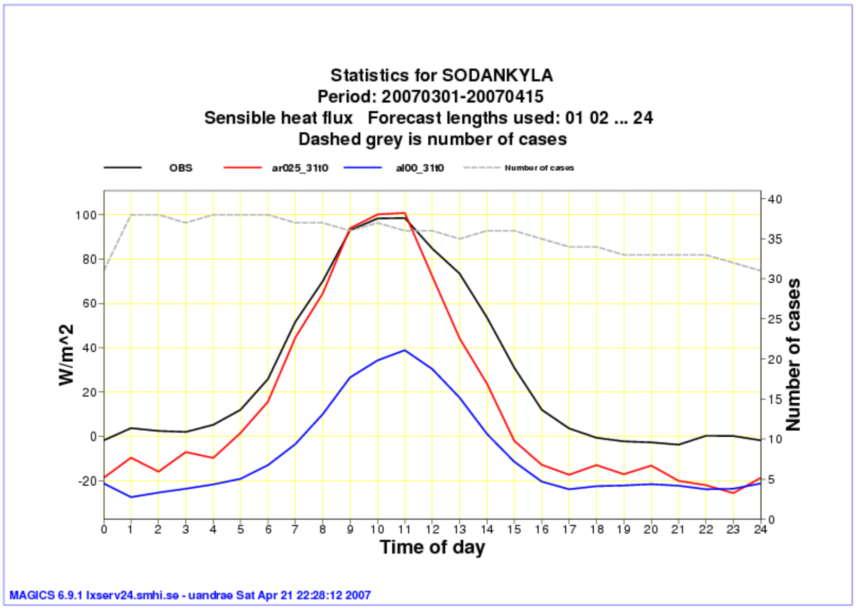


Figure 2 *Satellite picture and corresponding model simulations for the 23rd of June 2006. Left is AROME 2.5km and right is ALADIN 11 km.*



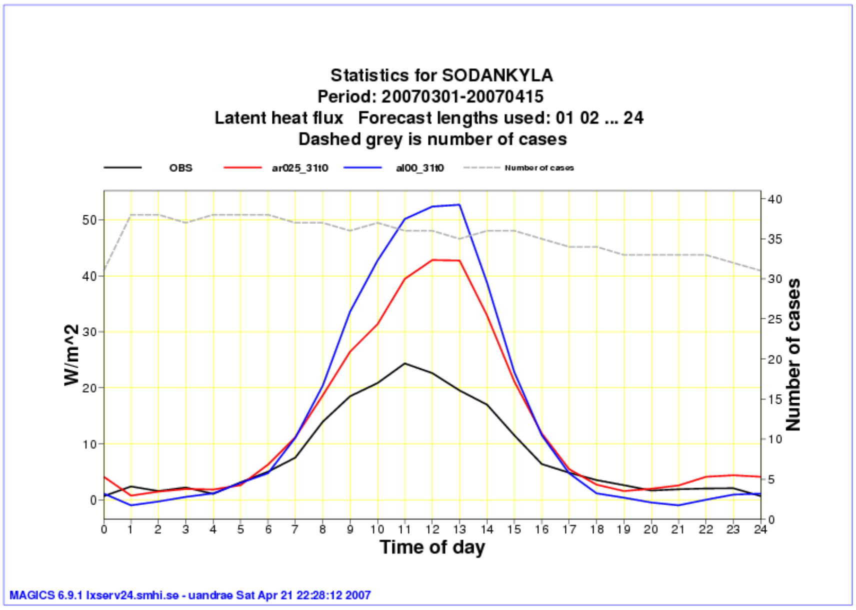


Figure 3 Surface fluxes from Sodankylä. Top : Sensible heat flux. Bottom: Latent heat flux. Black line is observations, red is AROME and blue is ALADIN.

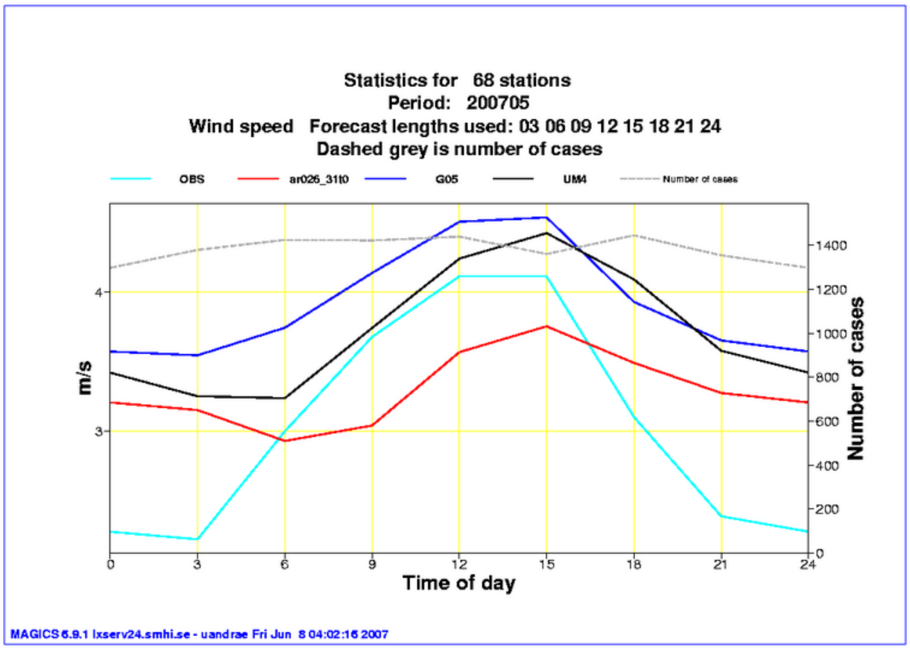


Figure 4 *Daily variation of 10 metre wind speed for May 2005. ar026_31t0 is 2.5km AROME, G05 is 5km HIRLAM and UM4 is 4km Unified model.*

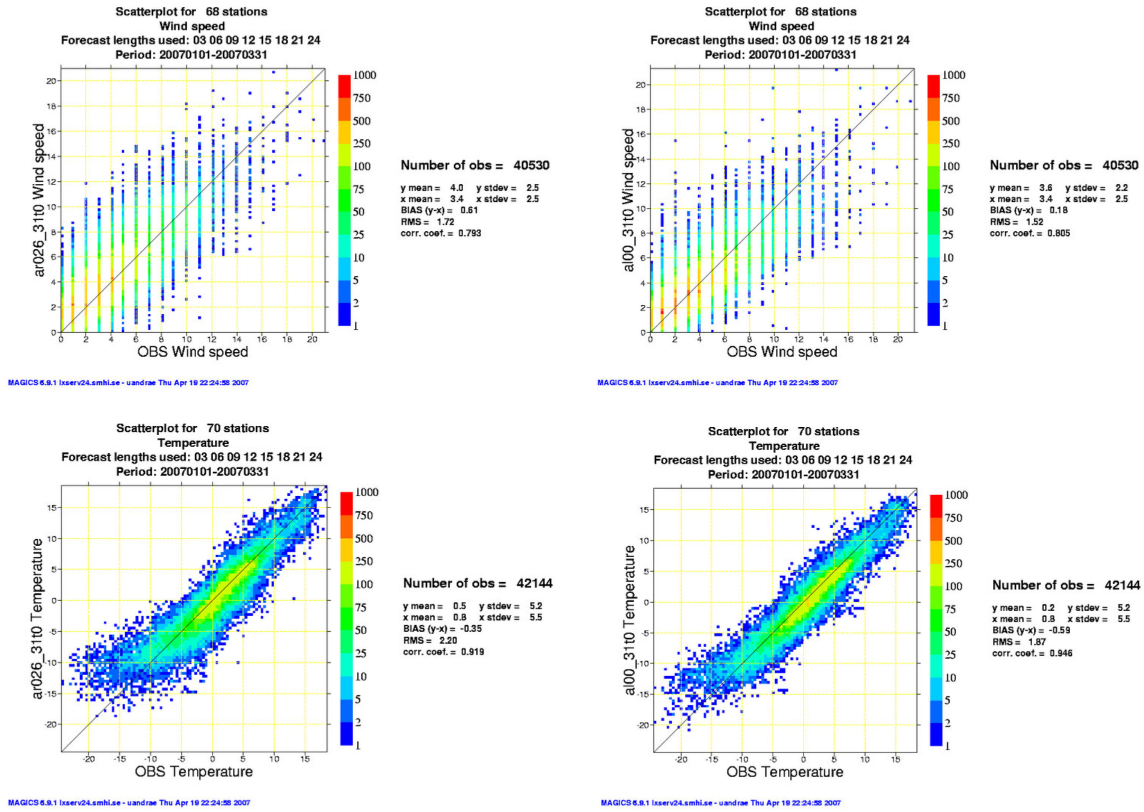


Figure 5 *Verification against synop stations for the southern part of Sweden. Top: Scatterplot for 10 metre wind speed (top) and 2metre temperature (bottom). Left is AROME and right is ALADIN.*

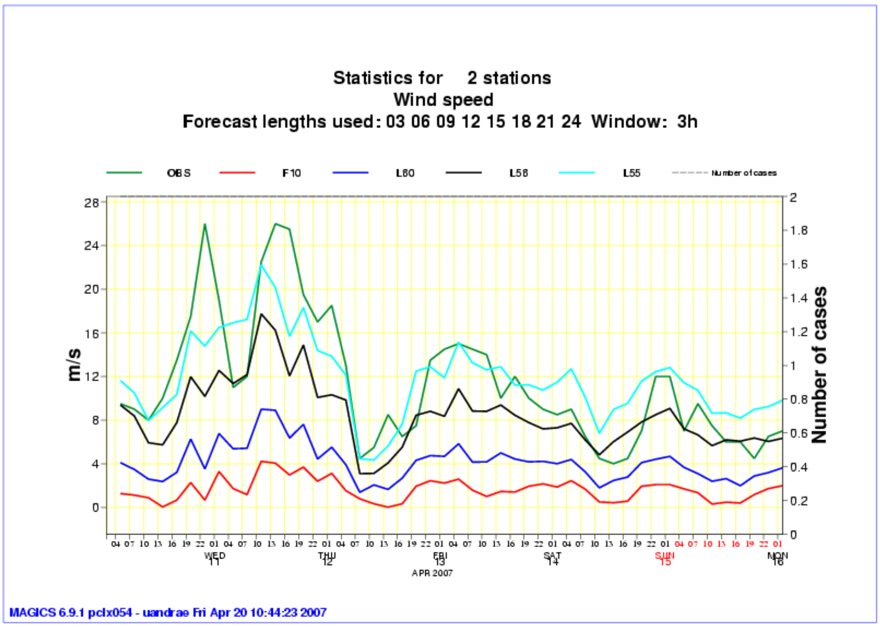


Figure 6 *10 metre windspeed at two Swedish mountain stations during April 2007. Green line is observation, red is 10 meter. Blue, black and cyan means model levels 60, 56 and 55 respectively.*