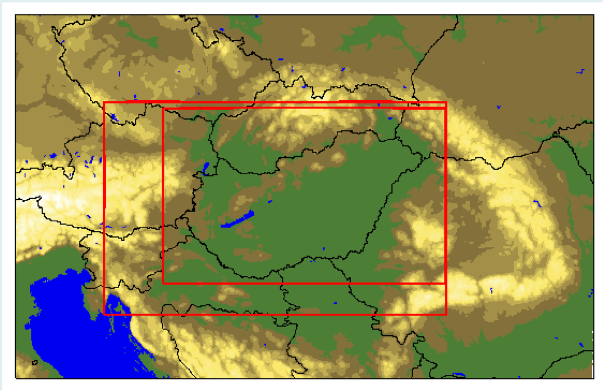
Experiments with AROME model at HMS

László Kullmann

AROME/HU model characteristics

- cycle: cy30t1, cy32t2
- domains
  - small : 250x160 horizontal points
  - medium : 300x192 horizontal points
  - (large : 500x320 horizontal points)
- vertical levels: 49
- coupling model: ALADIN/HU
- machine: SGI Altix 3700
- computational cost: 24h integration on 32 CPUS: **80 min** (on the small domain)



The different domains used at HMS for AROME model.

Initialization of hydrometeor variables

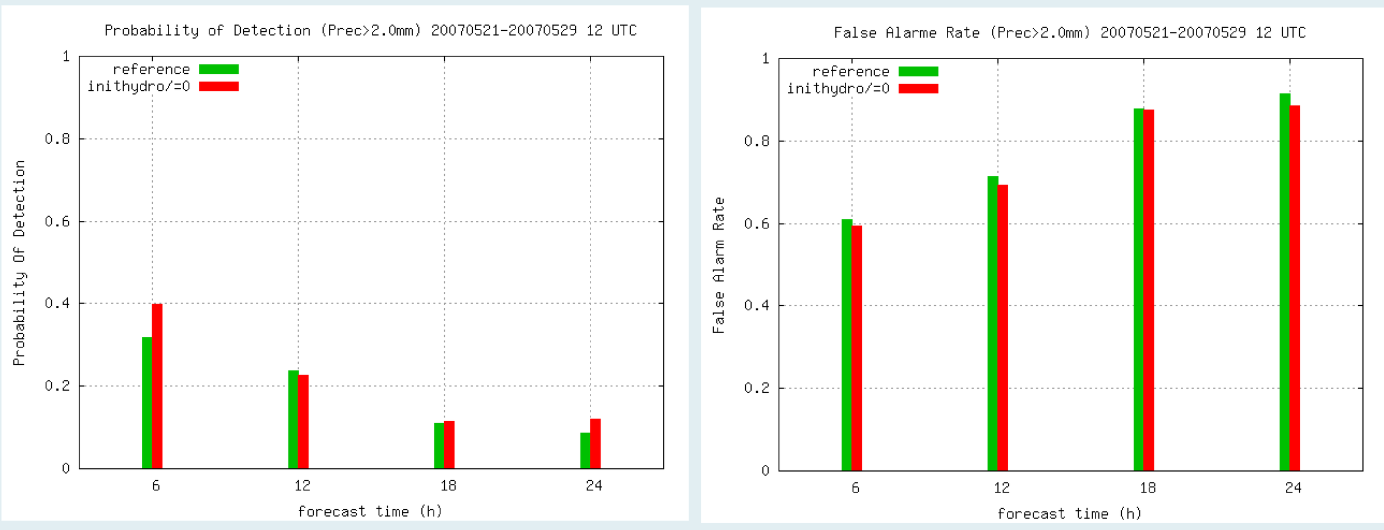
AROME microphysics uses 6 prognostic hydrometeors. Since the coupling model (ALADIN) does not contain "condensed" prognostic hydrometeors (only vapor) the initial values of these variables are taken zero for AROME. This results in a poor precipitation forecast in the first few hours. To improve the forecast we tried the following initialization methods:

a) All hydrometeors are taken from the initial condition of the coupling model, i.e. "condensed" hydrometeors (everything except vapor) are zero. (Original case.)

b) All hydrometeors (including specific humidity) are taken from the forecast of an earlier AROME run.

c) Specific humidity is taken from the initial condition of the coupling model, "condensed" hydrometeors from the forecast of an earlier AROME run.

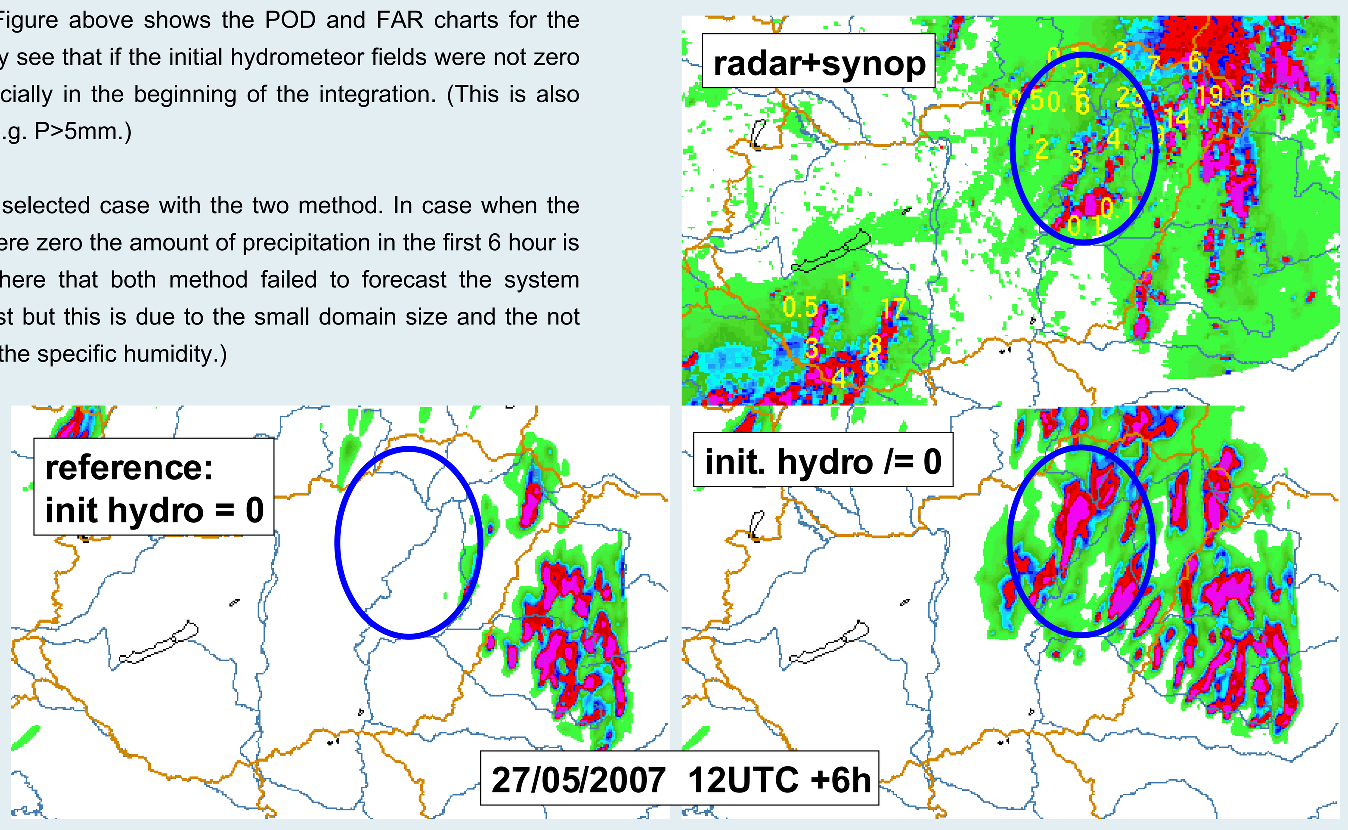
In case of method c) the initial values of condensed phase hydrometeors are inconsistent with the initial value of specific humidity. In case of method b) there will be inconsistency between initial and lateral boundary value of specific humidity and what is more important the initial value of specific humidity field is coming from a forecast and not from an analysis. Experiments showed that case c) gives better result than case b).



Probability of Detection and False Alarm Rate for precipitation bigger than 2 mm in 6 hour. The green bars denote the forecast where the initial hydrometeors were zero, red bars denote the forecast where the initial value of the hydrometeors (except vapor) were taken from 6h earlier forecast.

We have run the AROME model for 9 days (21-29 May 2007) with the above mentioned two methods (method a) and c)) and compared the verification of 6h accumulate precipitation. Figure above shows the POD and FAR charts for the two method. We can clearly see that if the initial hydrometeor fields were not zero the forecast is better especially in the beginning of the integration. (This is also valid for other categories, e.g. P>5mm.)

The figure below shows a selected case with the two method. In case when the initial hydrometeor fields were zero the amount of precipitation in the first 6 hour is much less. (We mention here that both method failed to forecast the system coming from the south west but this is due to the small domain size and the not appropriate initialization of the specific humidity.)



Case study with different hydrometeor initialization for the day 15th of May 2007, 12 UTC. Top left: 6h accumulated total precipitation from the reference run with zero initial condensed hydrometeors field. Top right: the initial hydrometeors were taken from 6h earlier AROME run. Bottom: 6h accumulated radar and synop precipitation observation.

Comparison of different soil schemes in SURFEX

In SURFEX over nature tile there are two methods to calculate the time evolution of soil water content and temperature.

Force-Restore scheme (Noilhan and Planton, 1989). The vertical diffusion of water and heat between the soil layers are parametrized by a force-restore method. The scheme contains 3 soil layers: surface layer, root layer and deep soil layer.

Diffusion scheme (Boone et. al. 2000). The diffusion processes are calculated explicitly. The number of layer is not restricted.

In order to be able to run the Diffusion scheme in AROME we had to modify the code since the initialization of the soil water and ice content was not consistent with the calculation of the melting/freezing processes in the Diffusion scheme. The initialized ice content was too high resulting in big temperature decrease (up to –60 Celsius!) in the beginning of integration.

We recalculated the water and ice content from the total water content in the following way.

$$w_{tot} = w_{l,ini} + w_{i,ini}$$

$$\psi_{max} = \frac{L_f(T - T_f)}{gT}, \quad and \quad \psi_{max} < \psi_{sat}$$

$$w_{l,max} = w_{sat}\left(\frac{\psi_{max}}{\psi_{sat}}\right)^{-1/b}$$

$$w_l = \max(w_{l,max}, w_{l,ini}), \quad and \quad w_l \le w_{tot}$$

$$w_i = w_{tot} - w_l$$

The following notations were used:

w_{ini}: initial water (liquid and frozen) content

T_f: triple point temperature

L_f: latent heat of freezing/melting

ψ: soil water potential

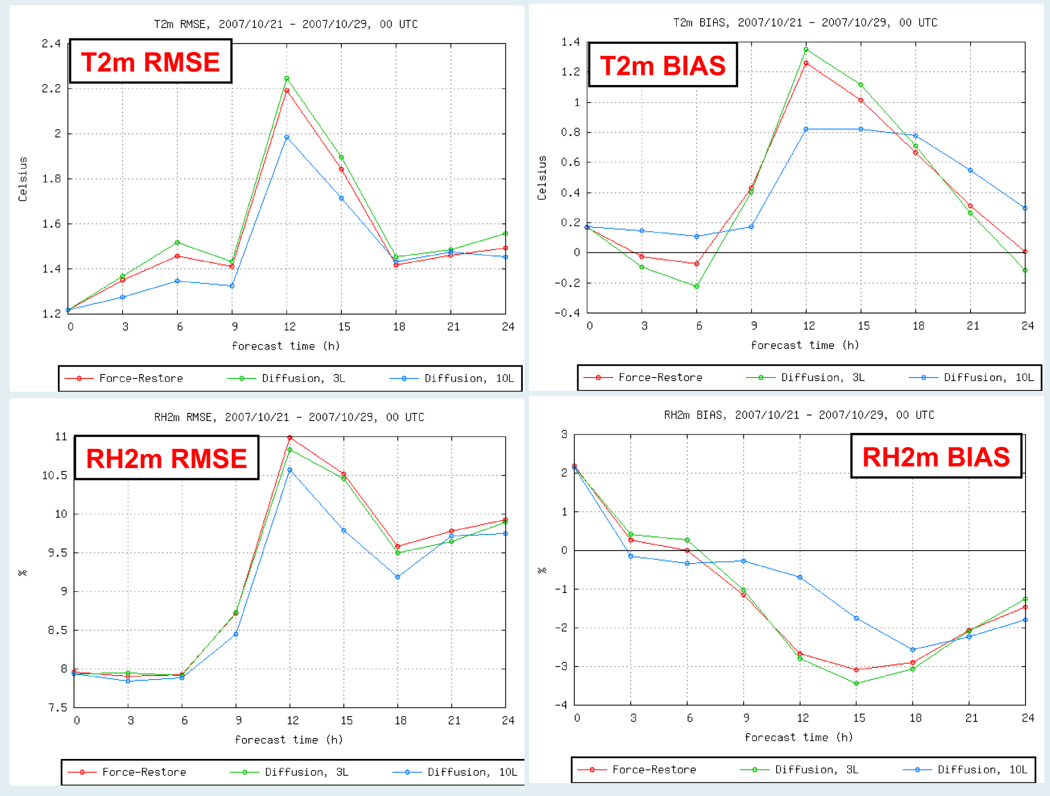
$w_{l,max}$: maximum unfrozen liquid water content at temperature T

We have made experiments to compare the two different schemes. Three different model configurations were taken into account:

- **FR3L**: Force-Restore method with 3 layers
- **DIF3**: Diffusion method with 3 layers
- **DF10**: Diffusion method with 10 layers

The 3 experiments were run for two distinct time period:

- 21-29 October, 2007
- 01-14 December, 2007



Verification of T2m and RH2m fields for the 3 different model configurations (FR3L, DIF3, DF10) Time period: 21-29 October, 2007

For the first time period the verification of T2m and RH2m show that the Diffusion scheme with 10 layer is better than Force-Restore. (Unfortunately surface observations were not available for this time period.) It is interesting that there is such a big difference in the 2m scores between the 3 and 10 layer version of Diffusion scheme.

(We should mention here that the layer depth are not the same for the 3 layer Force-Restore and the 3 layer Diffusion scheme.)

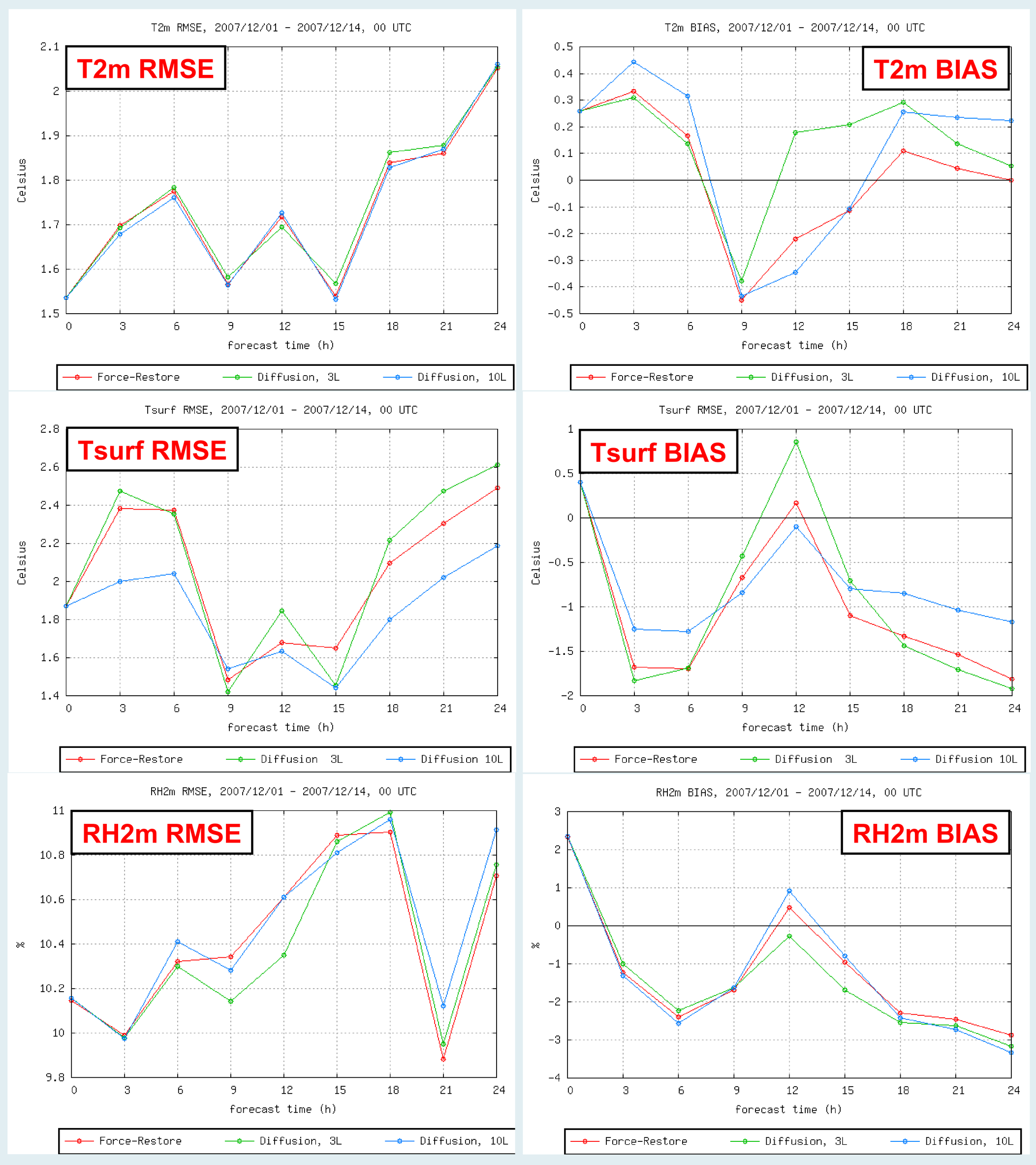
The second time period was colder, the amount of frozen soil water content was bigger.

In this case the the difference in the 2m scores are less and it is not obvious which of them is the best. However the surface temperature scores show that the 10 layer Diffusion scheme is still the best except during the daytime.

Future plans:

The above experiments were done with 3D AROME forecast. We plan to redo the experiments with offline SURFEX in order to be able to force the surface processes with more accurate atmospheric values (e.g. observations).

We plan to study what is the main reason for the quite large difference between the results of the 3 and 10 layer Diffusion scheme.



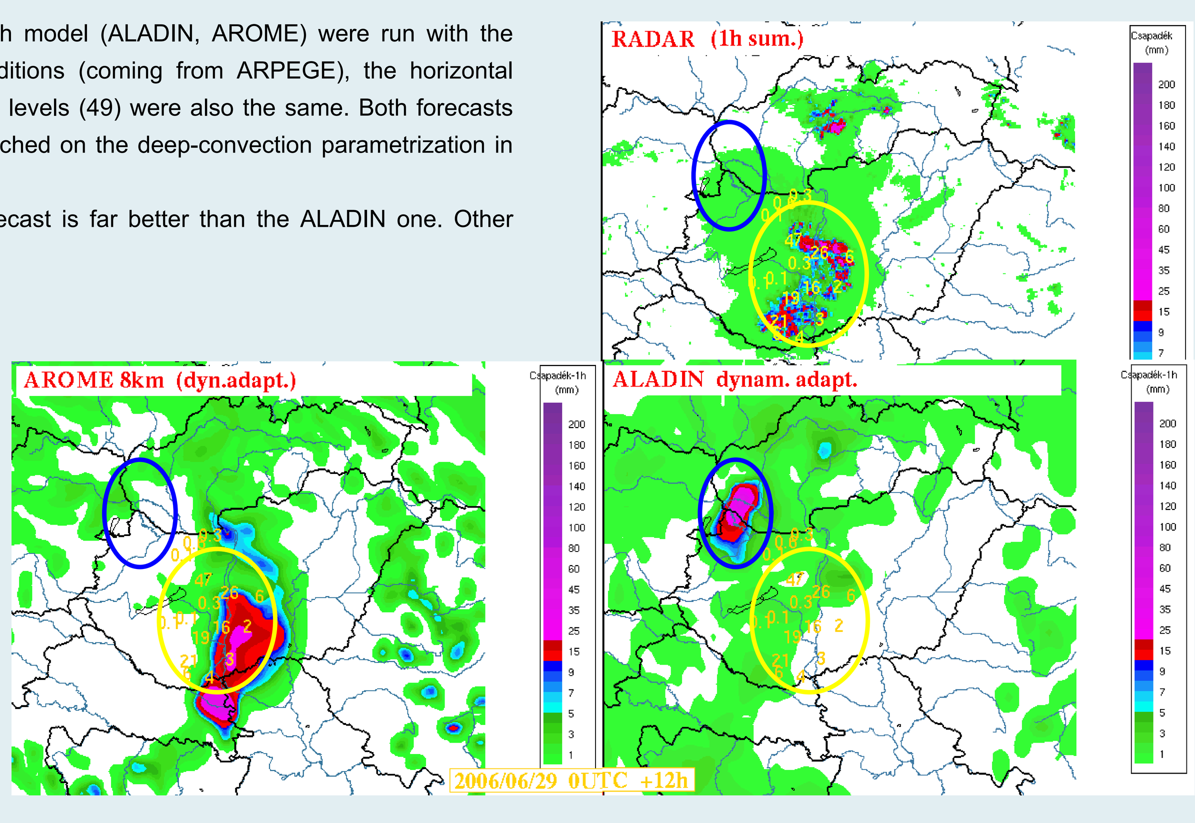
Verification of T2m, Tsurf and RH2m fields for the 3 different model configurations (FR3L, DIF3, DF10) Time period: 1-14 December, 2007

Experiments with lower resolution AROME

The precipitation forecast of AROME model is usually better than the forecast of ALADIN. The question arises what is the main reason for the better forecast. Is it due to the higher horizontal resolution (possibility to resolve convection) or due to the non-hydrostatic dynamics or due to the more sophisticated physics. To analyze the problem we have run case studies with AROME model with lower horizontal resolution and with hydrostatic dynamics and compared the result with ALADIN forecast.

One example can be seen below. Both model (ALADIN, AROME) were run with the same initial and lateral boundary conditions (coming from ARPEGE), the horizontal resolution (8km) and number of vertical levels (49) were also the same. Both forecasts used hydrostatic dynamics and we switched on the deep-convection parametrization in AROME.

The result shows that the AROME forecast is far better than the ALADIN one. Other experiments gave similar results.



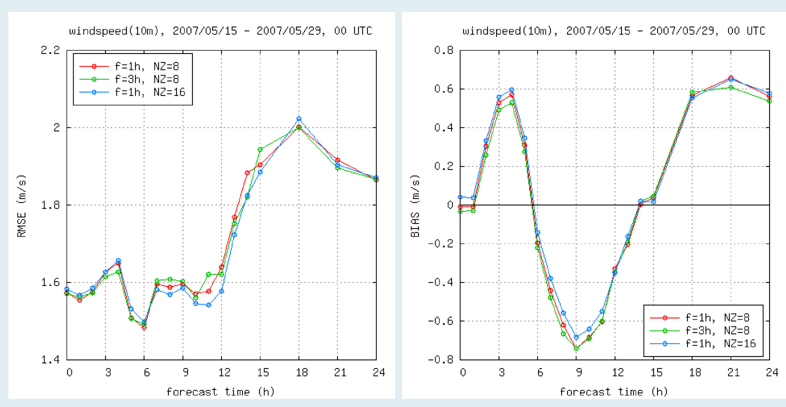
One hour precipitation forecast for 29/06/2006 0 UTC +12h. Top: radar observation (1h accumulated precipitation); left: AROME model with 8km horizontal resolution; right: ALADIN model.

Sensitivity on coupling frequency and coupling zone size

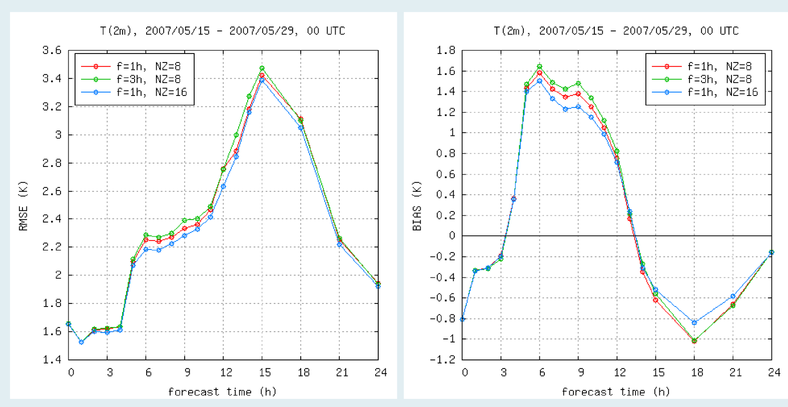
The experiments showed that due to the small domain size of AROME the coupling model has too large influence on the forecast especially near the border of domain. The other problem is that the coupling zone size is set fixed to 8 grid points in ALADIN/AROME. This value was determined for ALADIN with a typical 10km horizontal resolution. The AROME model however has a higher horizontal resolution (2.5km) which means that the relaxation domain is small. This can lead to big gradients in the coupled fields.

We have run case studies and also forecasts for longer time periods with different coupling zone size (NBZON) values. The results (see below) showed that it has a small but not significant positive impact if we enlarge the NBZON value from 8 to 16 grid points.

We have studied the sensitivity on the coupling frequency as well. We have found cases when 1h coupling frequency produced slightly better forecast but on the average the impact is not significant. Running AROME with different coupling frequencies for longer time period (15-29 May 2007) also showed that although there is a slight improvement in T2m scores the difference is not significant. Verification of upper air fields however showed the opposite behaviour, i.e. coupling with 3h frequency gave small but not significant improvement.



10m wind speed scores (left: RMSE, right BIAS) in case of different coupling frequency and coupling zone size



2m temperature scores (left: RMSE, right BIAS) in case of different coupling frequency and coupling zone size

Acknowledgement: This poster presents results of research program supported by Hungarian National Office for Research and Technology (NKFP 2/007/2005, Jedlik Ányos project).