High-resolution dynamical adaptation of the wind forecast using the non-hydrostatic version of the ALADIN model

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ABSTRACT

The high-resolution dynamical adaptation procedure of the wind field from the low-troposphere consists in the interpolation of the wind forecast of the ALADIN model to a higher resolution, taking into account the new description of the surface parameters (as a result of increasing the resolution). It is well known that the surface wind is highly influenced by the orography described into a NWP model. By increasing the resolution, the orography has been improved, and consequently the surface wind field is expected to be a better forecast. Two case studies have been investigated for some meteorological situations. The novelty of these experiments is that the non-hydrostatic version of the ALADIN model has been used. PHYSICAL PROCESSES

1. Introduction

The wind field from the planetary boundary layer is influenced by the orography described in the model. There are many situations when the surface wind is mis-forecasted, mainly in the mountainous regions or on the seaside, because the orography in the model is smoother than in reality. So it happens that some points over the mountains are at a lower altitude or, on the seaside, some grid-points, which are located on land, are considered as being on water.

The dynamical adaptation procedure of the surface wind at high resolution has been developed by ZAGAR and RAKOVEC (1999) and is performed in two steps. First the wind forecast of the ALADIN/Romania hydrostatic model at 10 km horizontal resolution is interpolated to a finer grid of about 2.5 km. As a result of increasing the resolution, the representation of the surface parameters (including the orography) has been improved (comparing with those of the coupling model). Thus the wind field is influenced by the new model orography. After the interpolation to the high resolution, the next step of the dynamical adaptation of the wind field to these new characteristics of the orography is the integration of the non-hydrostatic model, for a corresponding period of time (for 30 minutes with a time-step of 60 seconds). Because the time-scale for some physical processes is longer than the necessary time for the dynamic adjustment of the fields, parts of the physical parameterizations are further omitted. As mentioned by ZAGAR and RAKOVEC, if the coupling model fails to have a reasonable prediction in some special meteorological situations, the dynamical adaptation of the wind field at higher resolution cannot improve the forecast.

Because the wind forecast is mainly influenced by the orography, the number of vertical levels describing the higher troposphere and stratosphere has been reduced. Thus from the 41 levels in the operational version of the ALADIN/Romania model, only 26 levels have been kept. These are mainly located in the lower part of the troposphere (Figure 1).

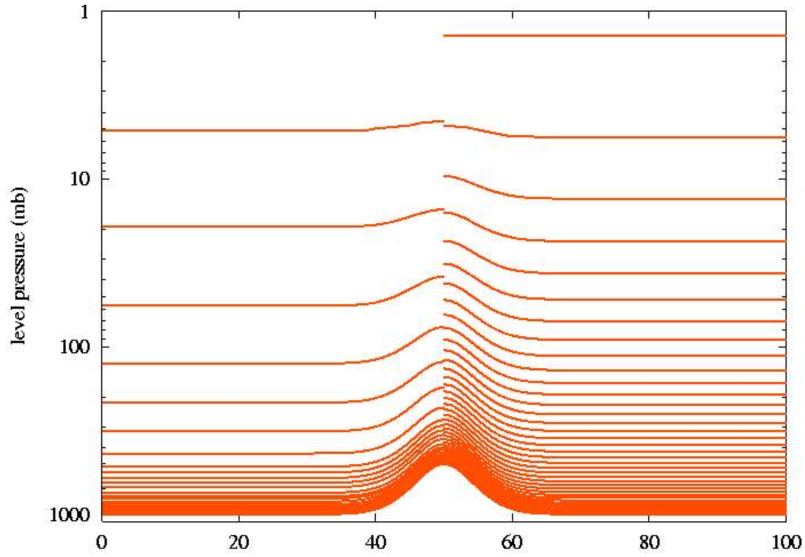

Figure 1: Distribution of the vertical levels for the ALADIN/Romania model in dynamical adaptation at high resolution (left side) and for the operational one (right side)

2. The experimental results

The experiments have been performed for two cases : for the 12th - 13th of October 2004 and for the 17th - 18th of October 2004. They were selected because the 10 m wind intensity reached values of about 25 m/s in the mountainous region. The hydrostatic model has been integrated at 10 km horizontal resolution, in order to have a reference for the experiments at high resolution. The dynamical adaptation of the surface wind was carried out on a domain covering Romania at 2.5 km resolution.

The results of the reference experiment can be seen in Figure 2, where the forecast of the surface wind field of ALADIN/Romania at 10 km resolution is represented for the case from the 17th of October 2004. In order to point out the region of interest, the pictures represent a zoom confined within 45°- 47.5°N in latitude and 23°- 27°E in longitude.

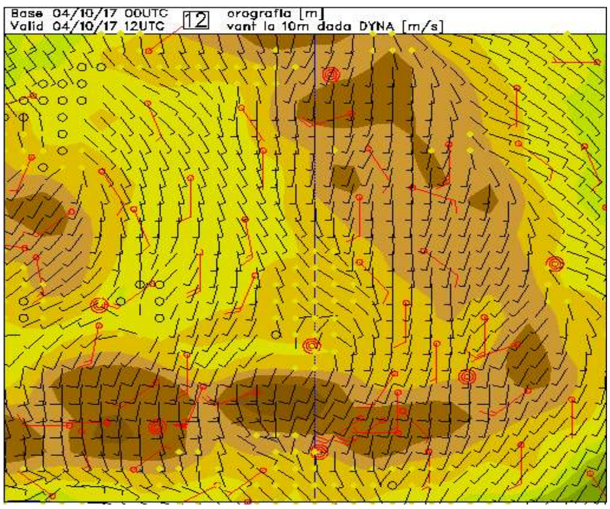

Figure 2 : The 12 h forecast of 10 m wind field, performed by the ALADIN/Romania hydrostatic model at 10 km, from 17.10.2004 00 UTC run, together with the real measurements of the wind (represented by red barbs)

In Figure 3 the forecasts of the wind field from the low troposphere with the ALADIN/Romania model in its non-hydrostatic (left side) and hydrostatic (right side) versions at 2.5 km horizontal resolution are compared. As one can see the differences between the results of the model appeared mainly in the regions of high orography. Having a better representation of the orography, new valleys and higher peaks appeared. These new features influence mainly the wind direction. Regarding the forecast of the wind intensity, both versions of the model at 2.5 km resolution succeeded to give a rather good prediction, although the biggest values of the 10 m wind, as measured in the Meridional Carpathian Mountains (in the southern part of Figure 3), were not forecasted.

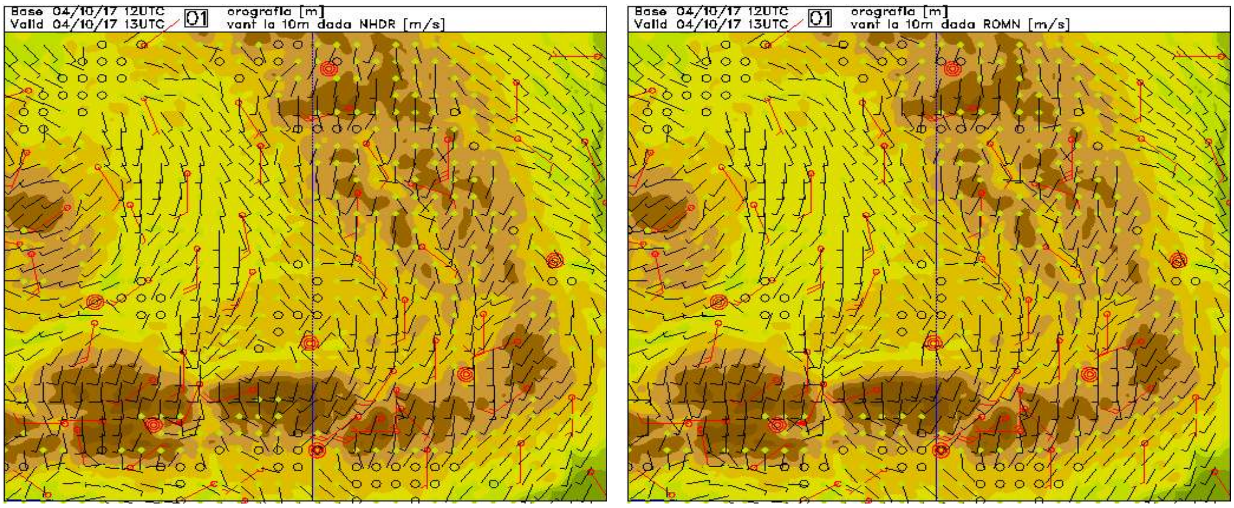

Figure 3 : The 10 m wind forecast in dynamic adaptation at 2.5 km resolution, performed by the non-hydrostatic (left side), and the hydrostatic (right side) ALADIN/Romania model from 17.10.2004 00 UTC run, valid at 13 UTC, together with the real measurements of the wind (represented by red barbs)

Another method to evaluate the results of the dynamical adaptation procedure of surface wind at high resolution consists in computing some statistical measures (such as standard deviation or mean absolute error). Figure 4 presents the standard deviation scores of all three experiments. One can see that the differences between the model results at 2.5 km resolution are quite small. As one might expect, the operational model (i.e. at 10 km resolution) gives bad scores for the surface wind intensity.

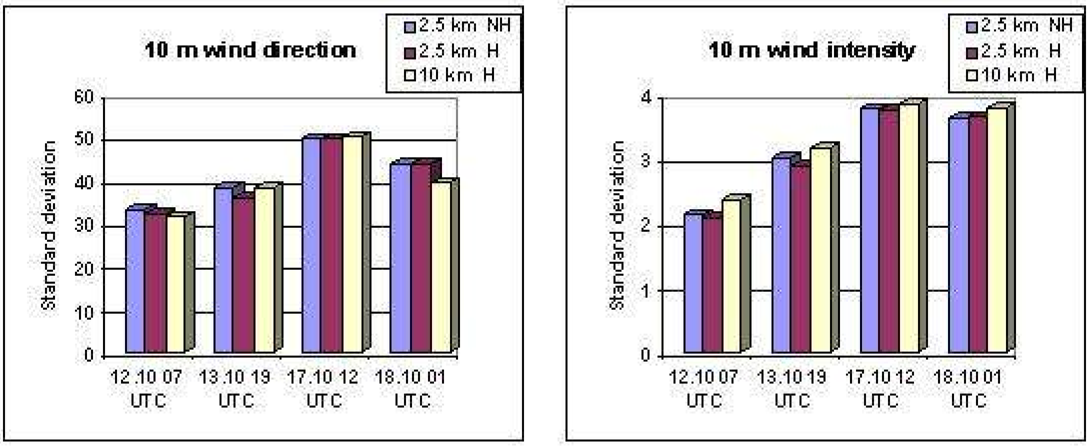

Figure 4 : The verification scores (standard deviation) of the 10 m wind forecasts performed by both non-hydrostatic (NH) and hydrostatic (H) ALADIN models, in dynamical adaptation mode at 2.5 km (blue/red colors) and at 10 km (hydrostatic version, yellow color) for four different forecast ranges

From the operational point of view, it was important to assess the time needed to run the dynamical adaptation procedure on SUN E4500 workstation, which is the platform for the operational suite at NMA (National Meteorological Administration) (Figure 5). For the first step, i.e. the interpolation of the forecasts of the coupling model from 10 km to 2.5 km resolution (EE927), around 1.7 minutes is necessary (for each forecast range) for the non-hydrostatic (NH) version, compared with 1.23 minutes for the hydrostatic (H) model. During the integration of the NH model in dynamical adaptation (C001), new computations are performed, although some physical parameterizations are not used. The integration time is very long (almost 22 minutes) for only one forecast range. At the post-processing step, there is no difference between the NH and H versions at high resolution.

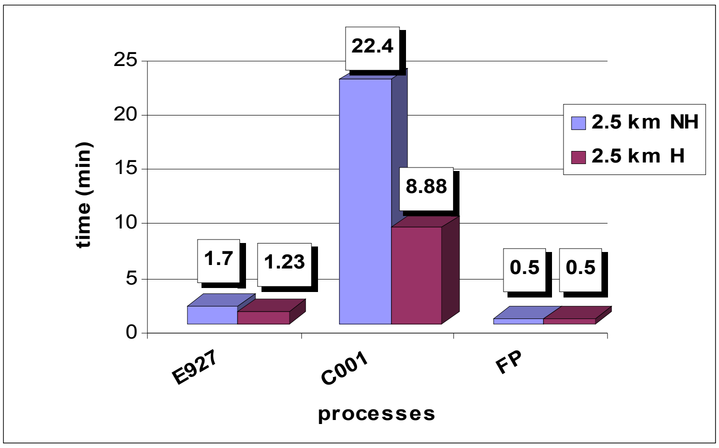

Figure 5 : The processing time (expressed in minutes) necessary for only one forecast range performed by the ALADIN/Romania model in the non-hydrostatic (NH) and hydrostatic (H) versions, in dynamic adaptation at 2.5 km (blue/red colors)

3. Conclusions

In this paper, the preliminary results of the procedure for the dynamical adaptation of the surface wind forecast of the ALADIN/Romania using the non-hydrostatic version are presented briefly. For the two selected cases, the results of the NH and H models are relatively similar. In addition, taking into account the processing time (almost three times longer for the ALADIN/NH than for the ALADIN/H model), we consider that the experiments performed were not convincing enough to state the necessity of using the non-hydrostatic model for the dynamical adaptation procedure of the wind field. In this respect more investigations are needed.

4. References

Zagar, M., and Rakovec, J., 1999 : Small-scale surface wind prediction using dynamic adaptation. *Tellus*, **51**, 489 – 504.

CONTENTS