ALADIN-AUSTRIA : increasing the vertical resolution in ALADIN

Yong Wang, Alexander Kann, Thomas Haiden, Klaus Stadlbacher,
Harald Seidl and Franz Wimmer

(ZAMG, Vienna, Austria)

1. Summary

The growth in computing power has made it possible to use higher model resolution. Indeed, the example of Méso-NH has shown that very high horizontal resolution with better model physics can improve the quality of numerical weather prediction. However, one should question the adequacy of vertical resolution in the NWP models, and at ZAMG we have experienced with ALADIN-LACE and ALADIN-VIENNA that increasing the horizontal resolution alone cannot guarantee a better forecast.

Linzen and Fox-Rabinovitz (1989) derived a consistency criterion between horizontal resolution Δx and vertical resolution Δz, for example for quasi-geostrophic flows,

$$\Delta z = \frac{f}{N}\Delta x \qquad (1)$$

where f is the Coriolis parameter and N is the buoyancy frequency. It is apparent from Eq. (1) that vertical and horizontal resolution should be proportional to each other. Pecnick and Keyser (1989) studied the relationship between Δz and Δx for a frontal structure, Persson and Warner (1991) for the conditional symmetric instability associated with frontal systems; similar investigations have also conducted to examine the importance of model resolution consistency in heat transport (Weaver and Sarachik, 1990) and cloud and radiation parameterisations (Lane et al., 2000). All the mentioned studies suggested that one should not simply increase the horizontal resolution without considering appropriate vertical resolution. In addition, these studies indicated that a consistent model resolution would lead to more realistic simulations and eliminate some artificial features and noises, such as spurious gravity waves. Thus, to examine the impact of increasing the vertical resolution is the aim of our work. In the following, we will give a brief report of the impact studies performed with ALADIN-AUSTRIA, the new LAM system at ZAMG.

2. ALADIN-AUSTRIA

To use the computer power efficiently and to simplify the operational production procedure of ALADIN forecasts at ZAMG, we have changed the operational suite of ALADIN at ZAMG, from two Central European domains (LACE and VIENNA) to one domain (AUSTRIA). The main characteristics of ALADIN-AUSTRIA are as follows:

- The model domain is almost the same as LACE.
- The horizontal resolution is 9.6 km, similar to VIENNA.
- The vertical resolution is increased from 37 (for both LACE and VIENNA) to 45.

Figure 1. shows the LACE and AUSTRIA domains and the model topography with the horizontal resolutions 12.2 km and 9.6 km respectively. The vertical levels in ALADIN-LACE and ALADIN-AUSTRIA are shown in Fig. 2. Most additional levels are set in the lower atmosphere.

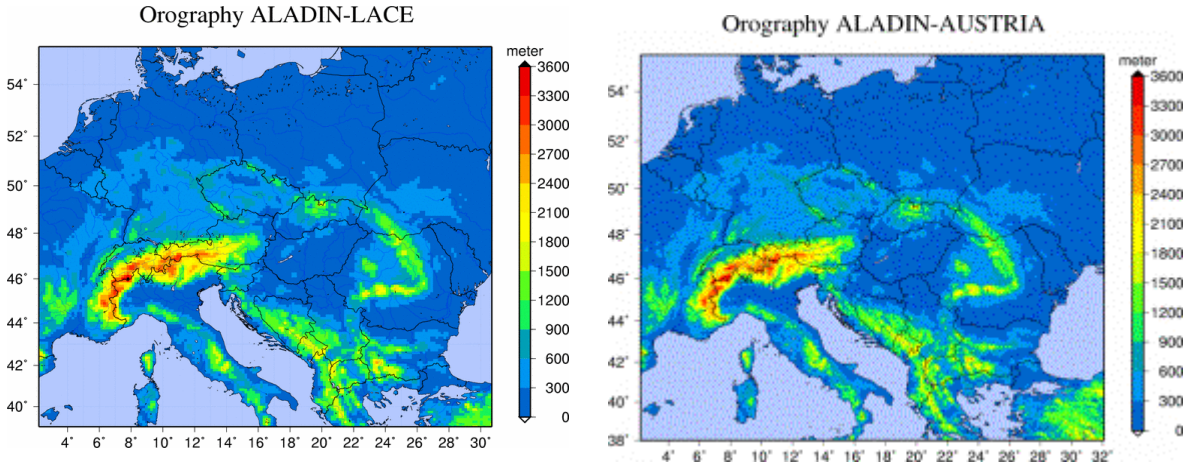

Figure 1 : Domain and model topography of ALADIN-LACE and ALADIN-AUSTRIA.

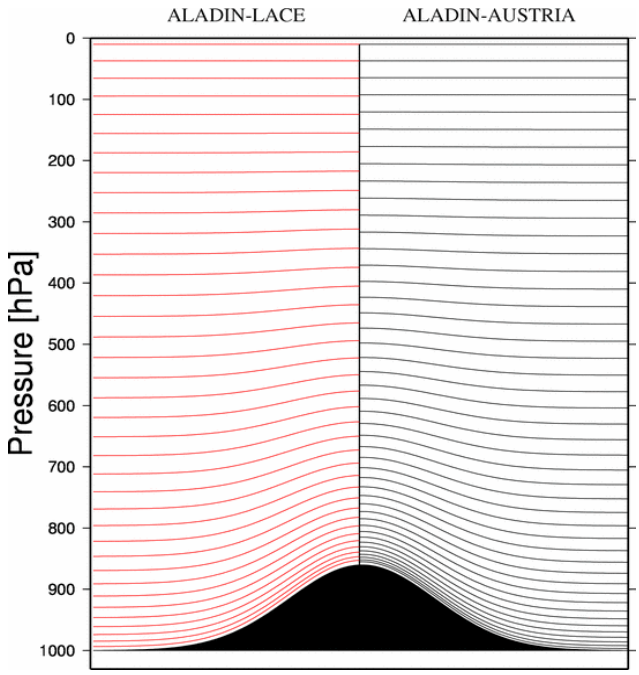

Figure 2 : Comparison of the vertical levels in ALADIN-LACE and ALADIN-AUSTRIA.

3. Results

For the present study, we carried on a two-months parallel suite of ALADIN-AUSTRIA from 20 Feb. 2004 to 20 Apr. 2004. To verify the results of ALADIN-AUSTRIA the model analysis (12 h interval), for the upperair parameters, and the observations, for the near-surface parameters, have been used. The forecasts of LACE, AUSTRIA and VIENNA have been compared against each other for investigating the impact of the model resolution.

3.1 Verification of upper air fields

In Figs. 3 and 4, we compare time series of the mean (BIAS) and root-mean-square (RMSE) errors (averaged over the whole domain) of ALADIN-LACE and ALADIN-AUSTRIA 24 h and 48 h forecasts for the 500 hPa geopotential. Both ALADIN configurations (AUSTRIA & LACE) behave similarly, but a slight improvement with ALADIN-AUSTRIA has been observed for longer forecast ranges (48h), at least regarding the BIAS (not shown).

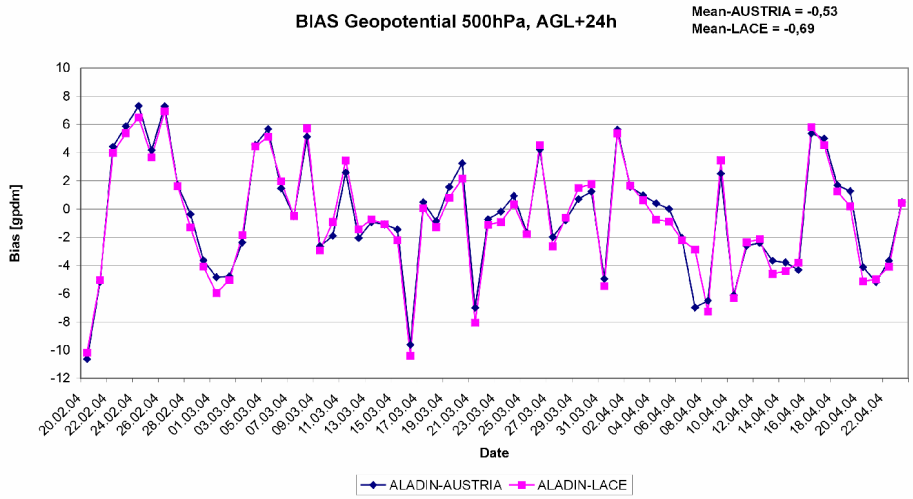

Figure 3 : BIAS for 500 hPa geopotential, 24 h forecast, the value indicates the model means.
Blue line : ALADIN-AUSTRIA, red line : ALADIN-LACE.

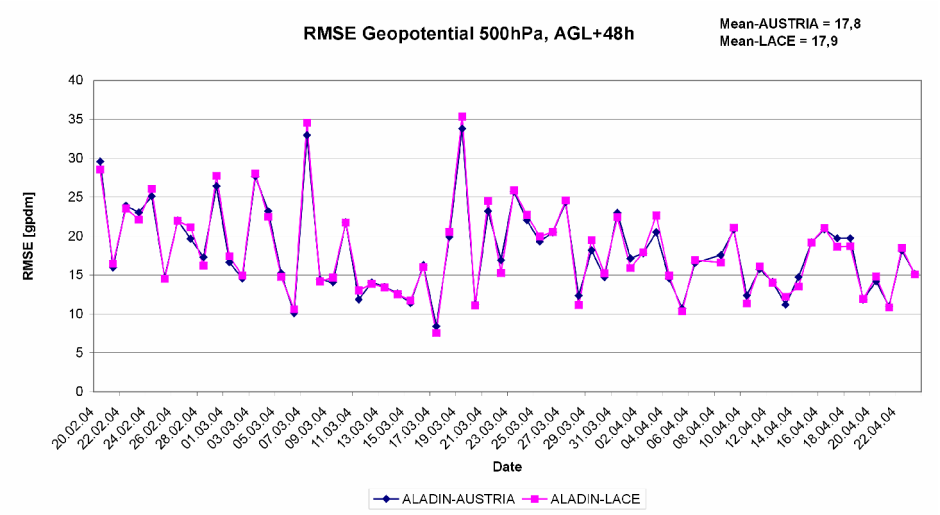

Figure 4 : Same as Fig. 3, but for RMSE and 48 h forecast.

3.2 Verification of surface fields

The verification of the surface fields is done for 2m temperature, mean-sea-level (MSL) pressure and 10m wind speed for the 9 major Austrian cities. Figure 5 is the comparison between ALADIN-AUSTRIA and ALADIN-VIENNA for the averaged BIAS over the 9 cities. For 2m temperature, BIAS and RMSE are reduced by up to 10% by ALADIN-AUSTRIA, errors of wind speed do not differ much between ALADIN-AUSTRIA and ALADIN-LACE. Focusing the verification on station Vienna, as shown in Figs. 6 and 7, the slight improvement of the 2m temperature and MSL pressure forecasts is confirmed, whereas the quality of the wind speed forecast remains rather unchanged.

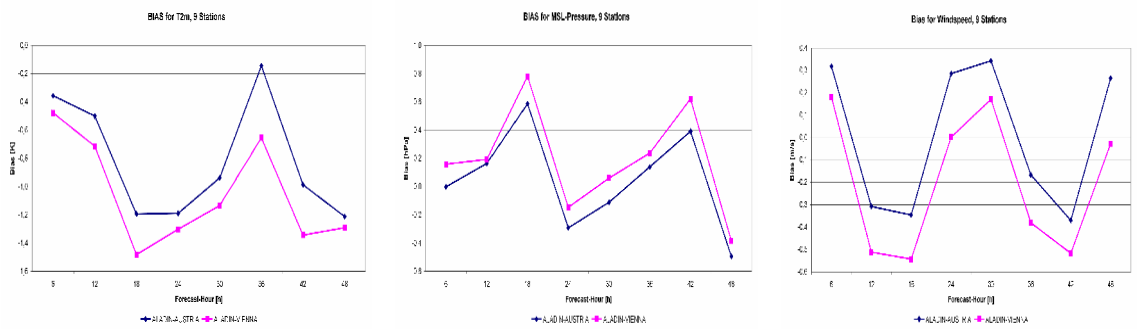

Figure 5 : BIAS for T2m, MSL pressure, 10m wind speed (averaged over 9 major Austrian cities). Line in blue : ALADIN-AUSTRIA; in red : ALADIN-VIENNA.

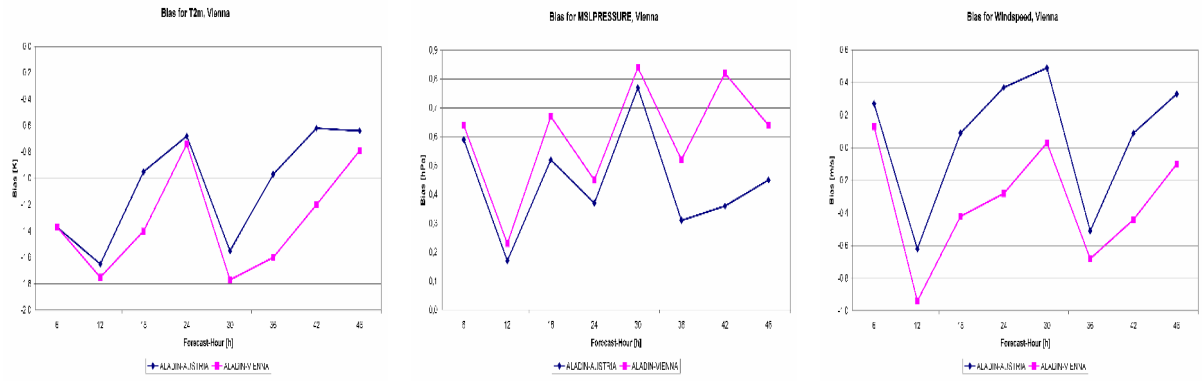

Figure 6 : Same as Fig. 5, but for station Vienna.

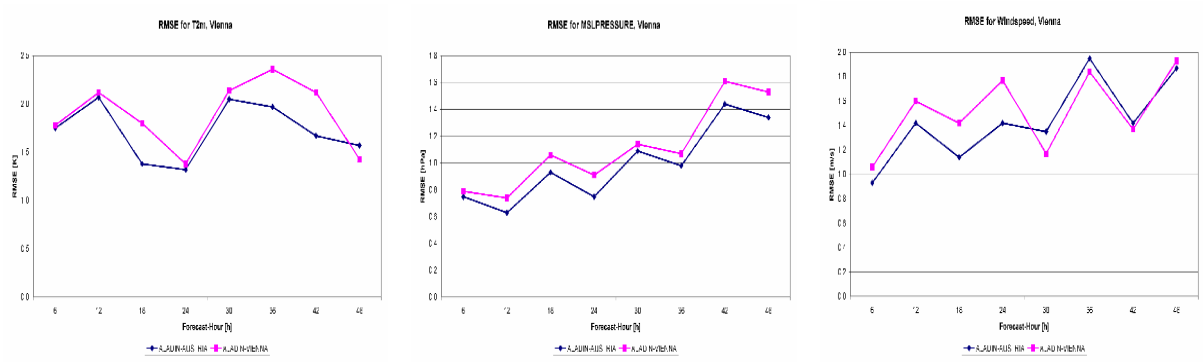

Figure 7 : Same as Fig. 6, but for RMSE.

4. Conclusion

In this work we investigated the performance of ALADIN-AUSTRIA, in which we have not only increased the horizontal model resolution but also the vertical one, from 37 to 45 levels. The results of a 2-months parallel run of ALADIN-AUSTRIA have been compared with ALADIN-LACE and ALADIN-VIENNA. Observations and model analysis have been used for the verification. The verification statistics show a slight improvement, especially for surface parameters, like 2m temperature, and at longer range forecasts. The quality of the wind speed forecast remains rather the same as in ALADIN-VIENNA.

5. Acknowledgement

We gratefully acknowledge Karim Yessad of Météo-France, for providing the program for computing the vertical coordinate.

6. References

Lane, D.E., R.C.J. Somerville, and S.F. Iacobellis, 2000 : Sensitivity of cloud and radiation parameterisations to changes in vertical resolution. *J. Climate*, **13**, 915-922.

Lindzen, R.S., and M.S. Fox-Rabinovitz, 1989 : Consistent vertical and horizontal resolution. *Mon. Wea. Rev.*, **117**, 2575-2583.

Pecnick, M.J., and D. Keyser, 1989 : The effect of spatial resolution on the simulation of upper-tropospheric frontogenesis using a sigma-coordinate primitive equation model. *Meteor. Atmos. Phys.*, **40**, 137-149.

Persson, P.O.G., and T.T. Warner, 1991 : Model generation of spurious gravity waves due to inconsistency of the vertical and horizontal resolution. *Mon. Wea. Rev.*, **119**, 917-935.

Weaver, A.J., and E.S. Sarachik, 1990 : On the importance of vertical resolution in certain ocean general circulation models. *J. Phys. Oceanogr.*, **20**, 600-609.

CONTENTS