Variable resolution version of the SL-AV global NWP model

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Russia is stretched along longitude, and most part of it is located north from the 50 degree latitude. As the meridians of the spherical coordinate converge towards the poles, the longitudinal resolution increases while approaching the pole. A model on the latitude-longitude grid with variable resolution in latitude can provide local increase of resolution in this area by a factor of 2.2 with respect to the constant resolution version without significant deformation of the horizontal grid. This increase can be achieved at virtually no cost.

The SL-AV is a global semi-Lagrangian NWP model [1]. This model uses the absolute vorticity as a prognostic variable and compact high-order finite differences on the unstaggered grid. A detailed description of the numerics for the 2D version of the model is given in [2]. The model includes the parameterization package of subgrid-scale processes from the French operational model ARPEGE/IFS [3].

The variable resolution in latitude is implemented by introduction of an auxiliary coordinate (pseudolatitude) with constant step. The partial derivative in latitude of some function can be written as

$$\frac{\partial f}{\partial \varphi} = \frac{\partial \varphi'}{\partial \varphi}\frac{\partial f}{\partial \varphi'},$$

where φ' is pseudolatitude, and $\frac{\partial f}{\partial \varphi'}$ is discretized as in the case of constant resolution. All derivatives in this expression are discretized with the fourth order accuracy.

This approach was tested with the set of twelve 5-day forecasts starting at 15th day of each month 1996, 0000 UTC. The initial data were uninitialized ECMWF analyses (truncated to T119 spectral resolution). Digital filter initialization was applied. The resolution was 1.40625 degrees in longitude, 28 irregularly spaced σ-levels and the time step was equal to 36 min. The resolution in latitude as a function of grid point number is depicted in Fig. 1. The high resolution ($\approx$ 75 km) zone is placed between 30 and 90 N. The ratio between the adjacent mesh intervals does not exceed 1.065.

On Fig. 2 we present averaged over 12 cases RMS errors for 500, 850 hPa heights and mean sea-level pressure (MSLP) for the 50N-90N band for constant resolution (1.125 degrees) and variable resolution versions of the model.

It is known that the variable grid strategy is limited to the relatively short-range forecasts, since for medium-range forecasts, the high resolution region will come under influence of weather systems that at initial time are far away, and hence are poorly resolved in the analysis. Indeed, one can see that the variable resolution version is more accurate than constant resolution one up to approximately 84 hours range. At the same time, the RMS errors for ranges up to 72 hours are better by 1-2 m. The improvement is more visible in skill score S1 (not shown).

The plans include the increase in horizontal resolution and also testing a configuration with rotated poles and variable resolution.

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References

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[3] J.-F. Geleyn, E. Bazile, P. Bougeault *et al*, Atmospheric parameterization schemes in Meteo-France's ARPEGE N.W.P. model. In *Parameterization of subgrid-scale physical processes*, ECMWF Seminar proceedings (1994), 385-402.

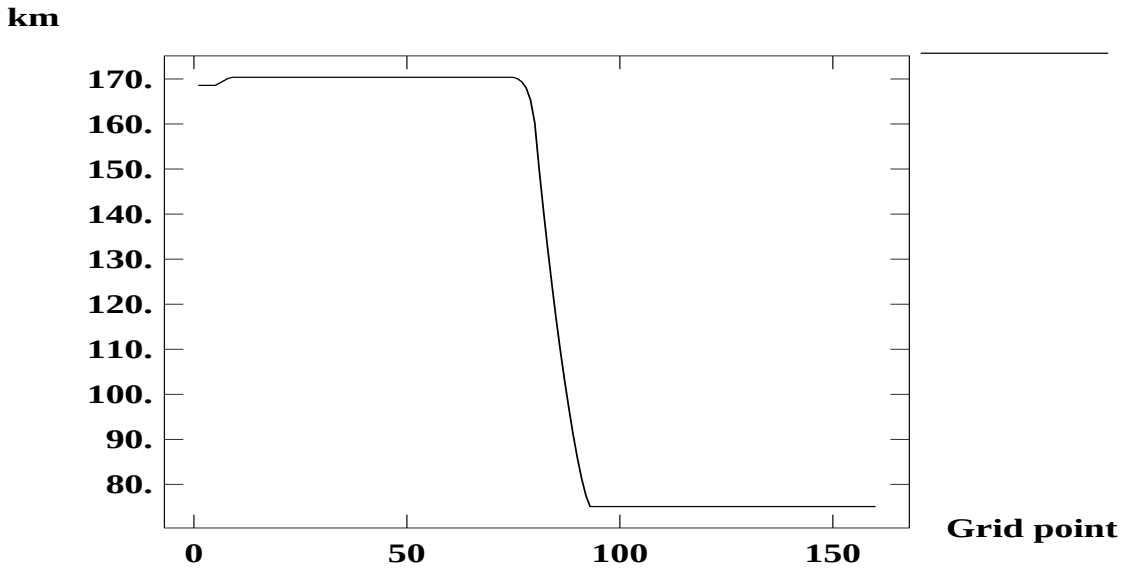

Figure 1: The latitudinal resolution as a function of gridpoint number. (from Southern pole to Northern pole)

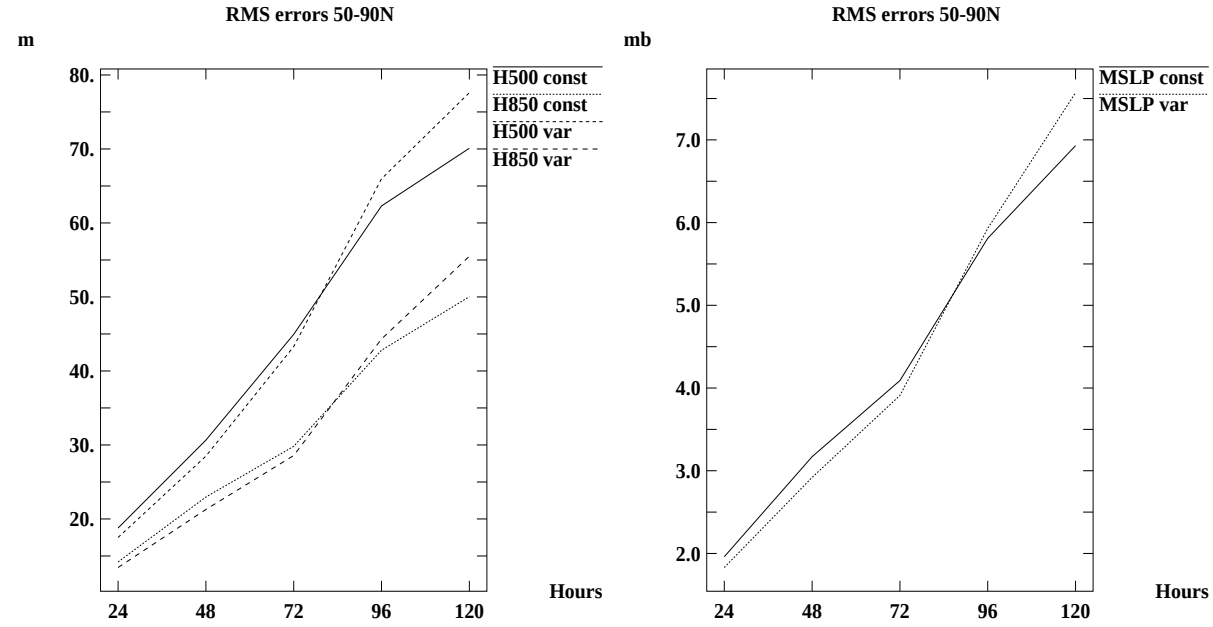

Figure 2: The averaged RMS errors of 500 and 850 hPa heights (left) and mean sea-level pressure (right) as functions of the forecast time.