High-resolution experiments with Aladin

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1 Introduction

Non-hydrostatic dynamics, SLHD (Semi-Lagrangian Horizontal Diffusion) and different time-stepping schemes (semi-implicit and predictor-corrector) have been tested on a case of severe bura. The domain and set-up are similar to the operational high-resolution dynamical adaptation one that is used for more sophisticated prediction of 10m wind in the Croatian Meteorological Service.

Since the physics package of Aladin is not yet adapted to the usage of NH dynamics, a case where moist processes are not very important has been chosen for the tests. It is also a very severe test case due to strong flow over steep orography and strong gradients in horizontal and vertical.

A case of severe bura on 14th November 2004 is shown. In the experiments nodel Aladin version AL28T3 that includes SLHD has been used. All runs were performed on Maslenica domain with 2 km resolution starting from the operational 8 km resolution 42 hour forecast (00UTC run of 13th November 2004) on the Croatian domain. The model was run for 30 minutes with 1 minute timestep using same file as the initial and boundary condition (so the fields on the boundaries do not change) as in the operational set-up for high-resolution dynamical adaptation for the forecast of 10m wind. Only turbulence scheme is used from physics. The truncation is quadratic.

The 9 experimets are:

1. The reference run is using hydrostatic dynamics, pure 4th order numerical diffusion, semi-implicit time-stepping and envelope orography. It is the most similar one to the currently used operational set-up. All other experiments were run using mean orography.

2. hydrostatic dynamics, numerical diffusion, semi-implicit time-stepping and mean orography. Orography representation is the only difference with respect to the reference.

3. non-hydrostatic dynamics, numerical diffusion, semi-implicit time-stepping and mean orography. Non-hydrostatism is the only difference with respect to the experiment number 2.

4. hydrostatic dynamics, SLHD, semi-implicit time-stepping and mean orography. Different horizontal diffusion is the only difference with respect to experiment number 2.

5. non-hydrostatic dynamics, SLHD, semi-implicit time-stepping and mean orography. Uses different horizontal diffusion scheme than experiment 3 and different (non-hydrostatic) dynamics than experiment 4.

6. hydrostatic dynamics, numerical diffusion, predictor-corrector and mean orography.

7. hydrostatic dynamics, SLHD, predictor-corrector timestepping and mean orography.

8. non-hydrostatic dynamics, numerical diffusion, predictor-corrector and mean orography.

9. non-hydrostatic dynamics, SLHD, predictor-corrector and mean orography.

2 Results

This part of the operational suite is used to provide a high-resolution forecast of the 10 m wind. It is most important in the severe windstorm events, this usually means bura.

Removal of envelope from orography resulted in stronger 10 m wind upstream from the obstacle. The other parts of the model have far less significant impact on the predicted wind speed. Introduction of nonhydrostatism had reduced wind speed on the steepest slopes. Introduction of SLHD in the nonhydrostatic run has reduced the windspeed on the part just in place where the hydraulic jump should take place. The vertical cross-sections of the horizontal wind and temperature show that SLHD reduces the speed of the downslope jet. It also reduces a feature in the temperature field just after the first obstacle about 1.5 km height.

The vertical cross-sections of vertical velocity (omega in Pa/s) also show the smoothing effect of SLHD, especially for the area between the two peaks that produce downslope windstorms.

The vertical cross-sections of potential temperature show modification in the shape and reduction in the wave amplitude above the mountain peak.

The vertical cross-section of potential vorticity shows a strange pattern in the reference run, especially above mountain peaks that is not realistic. There are areas with very high PV values that should not exist in the troposphere and very unstable areas with very low values of PV that might be unrealistic too. Its intensity above mountains is reduced when envelope is removed so the peaks become lower but increases downstream of the obstacle, above the lowlands and the sea. SLHD reduces the intensity further (maybe even too much in the downslope windstorm area, just above the slope). The nonhydrostatic run also reduces the high PV values in 1.5 km height above mountains. And when SLHD is acting in NH model, it does not reduce the downslope windstorm peak of PV just above the slope too much.

When the intensity of numerical diffusion is decreased, the runs with only numerical diffusion do not show almost any difference in the obtained fields, while the results with SLHD are different.

Predictor-corrector timestepping has very little effect on the predicted fields, only the PV field is smoother with the predictor-corrector than with the semi-implicit time-stepping.

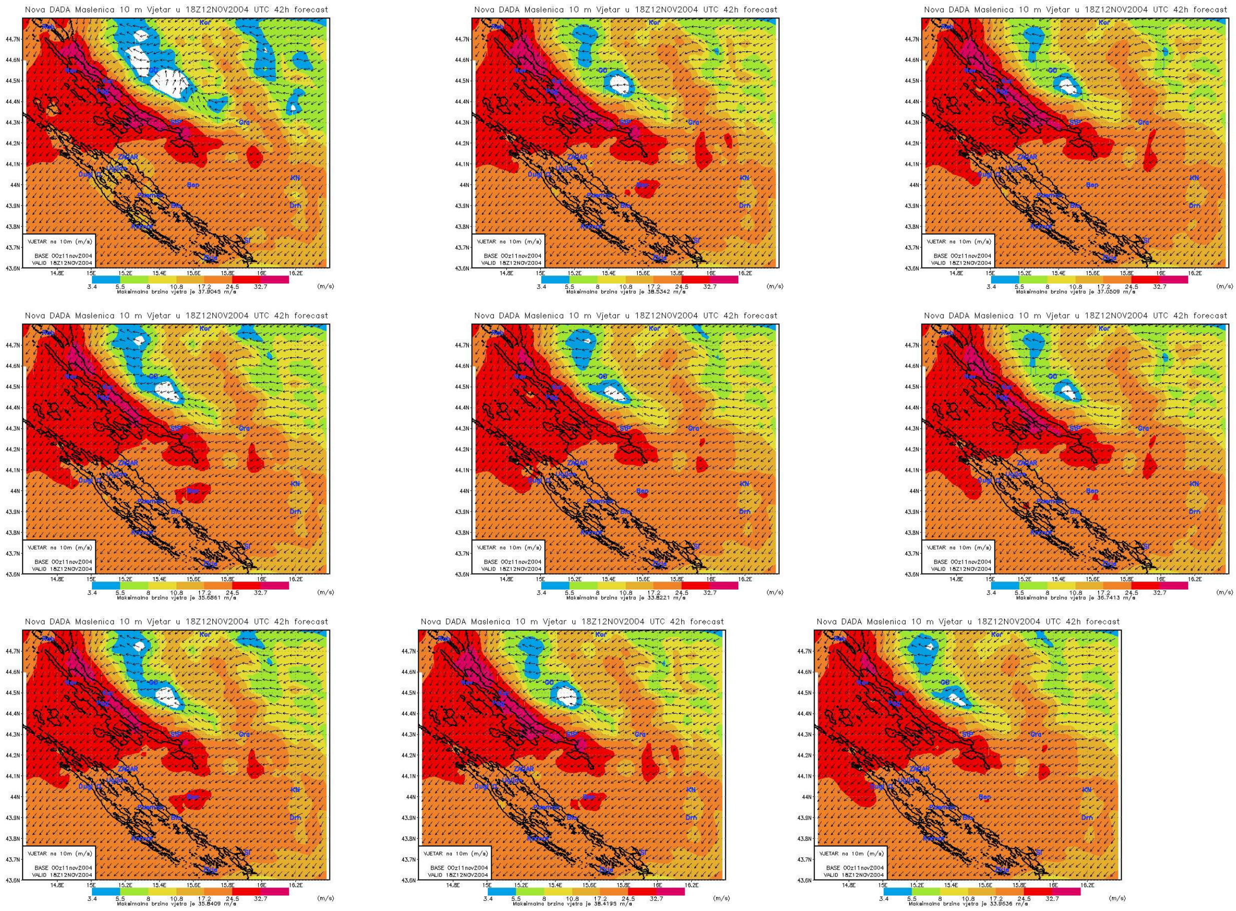

Figure 1: 10m wind, experiments 1 (top, left), 2 (top, center), 3 (top, right), 4 (middle, left), 5 (middle, center), 6 (middle, right), 7 (bottom, left), 8 (bottom, center) and 9 (bottom, right).

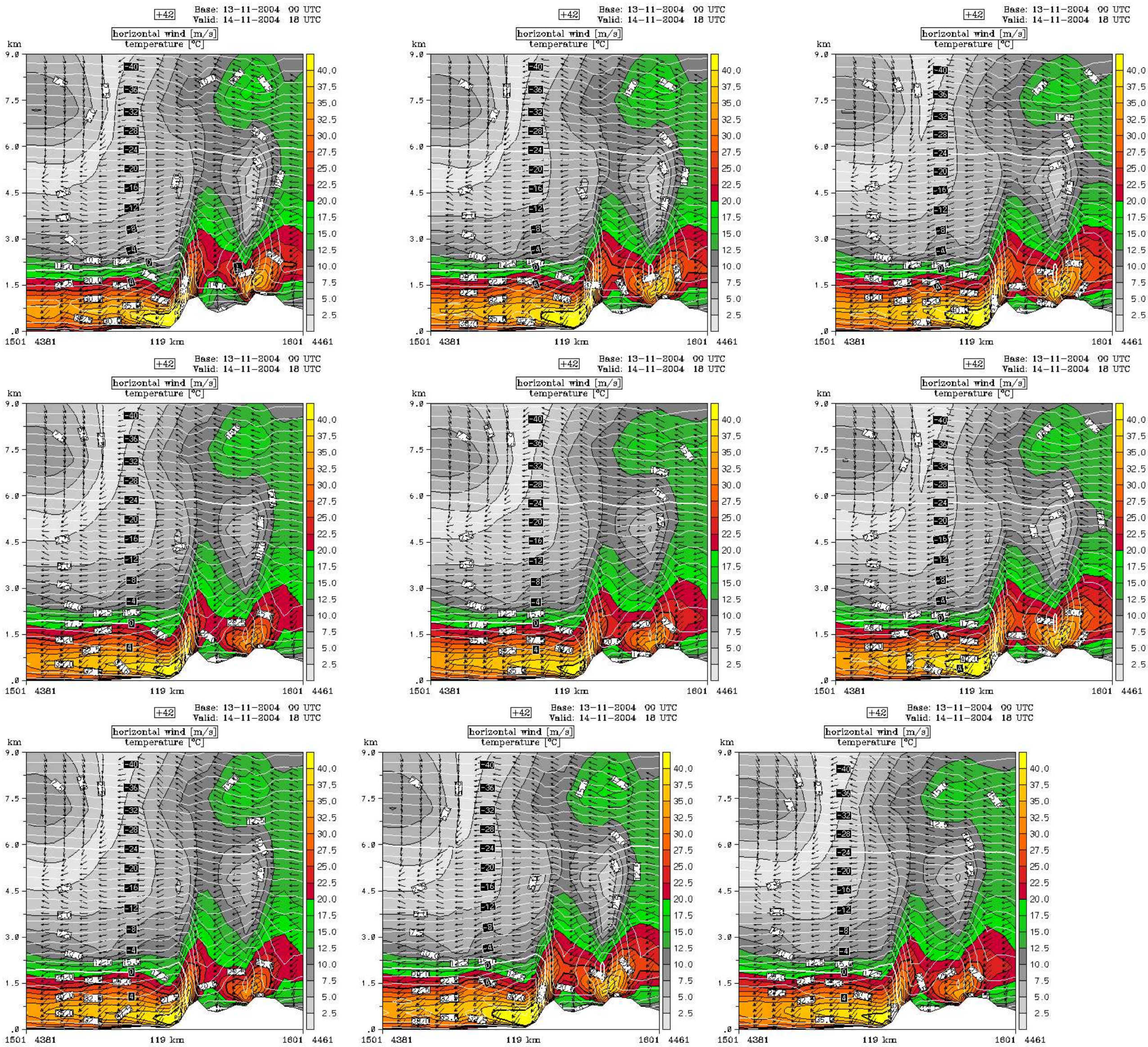

Figure 2: Vertical cross-sections of temperature and horizontal wind experiments 1 (top, left), 2 (top, center), 3 (top, right), 4 (middle, left), 5 (middle, center), 6 (middle, right), 7 (bottom, left), 8 (bottom, center) and 9 (bottom, right).

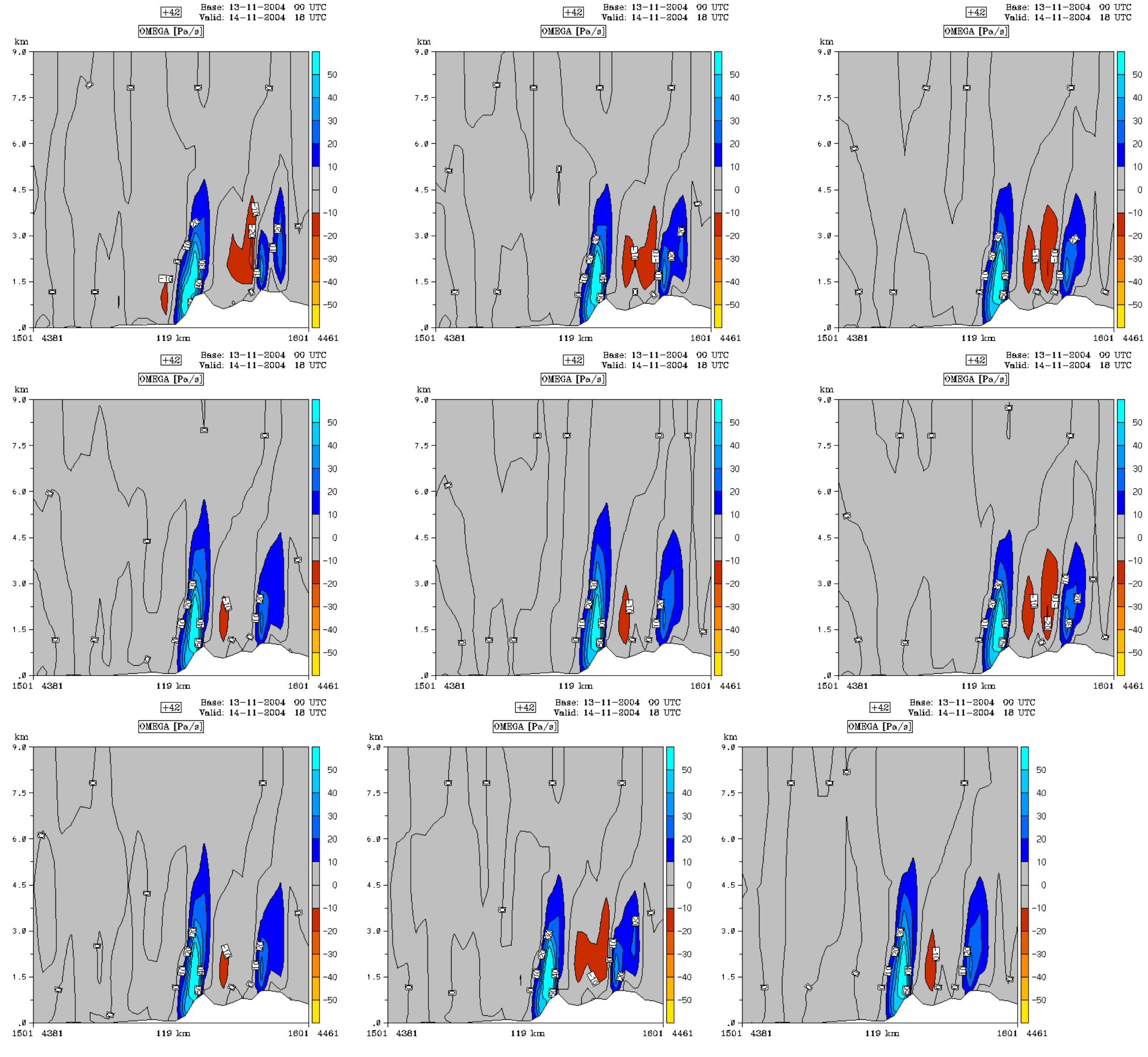

Figure 3: Vertical cross-sections of vertical velocity experiments 1 (top, left), 2 (top, center), 3 (top, right), 4 (middle, left), 5 (middle, center), 6 (middle, right), 7 (bottom, left), 8 (bottom, center) and 9 (bottom, right).

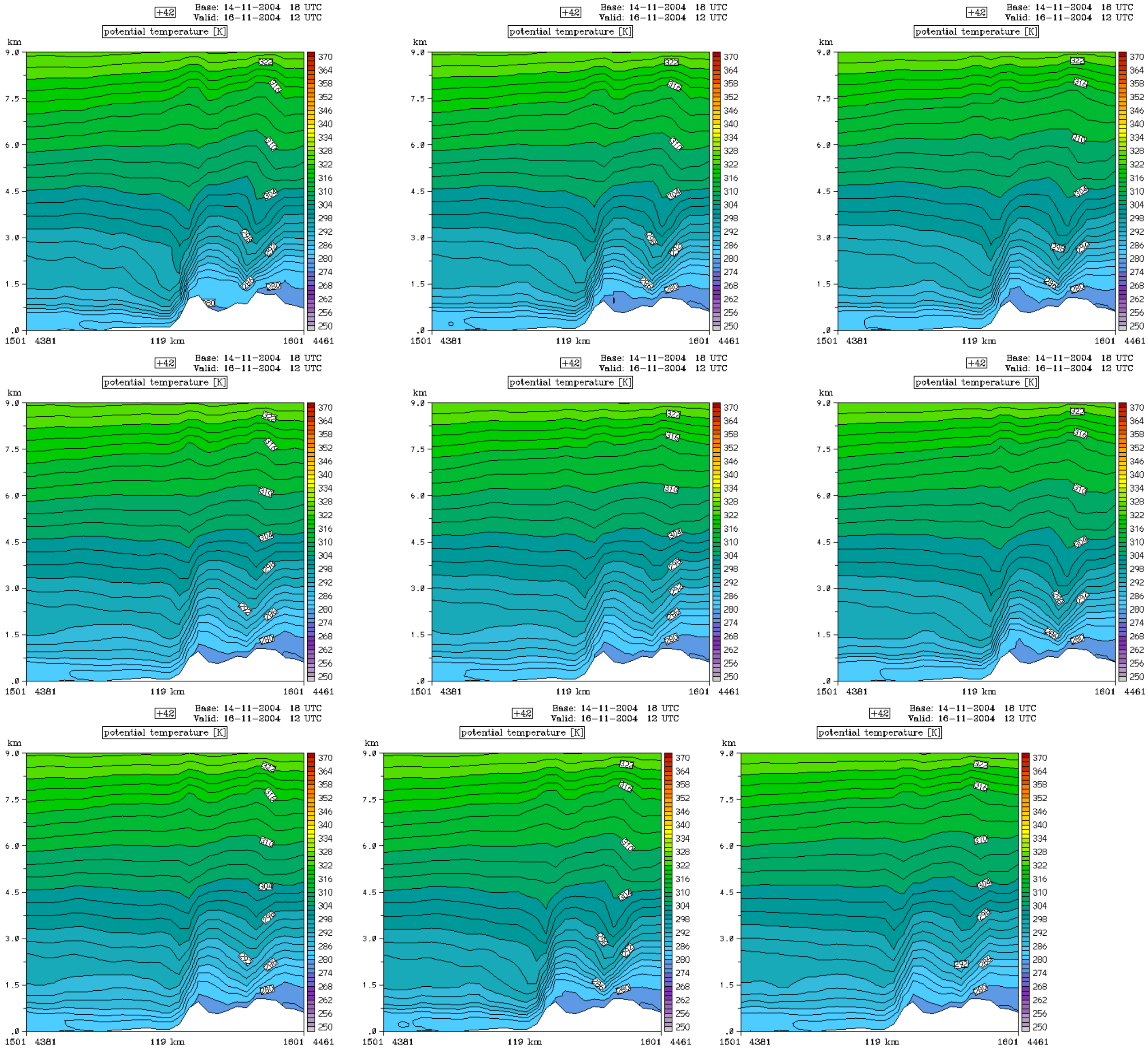

Figure 4: Vertical cross-sections of potential temperature experiments 1 (top, left), 2 (top, center), 3 (top, right), 4 (middle, left), 5 (middle, center), 6 (middle, right), 7 (bottom, left), 8 (bottom, center) and 9 (bottom, right).

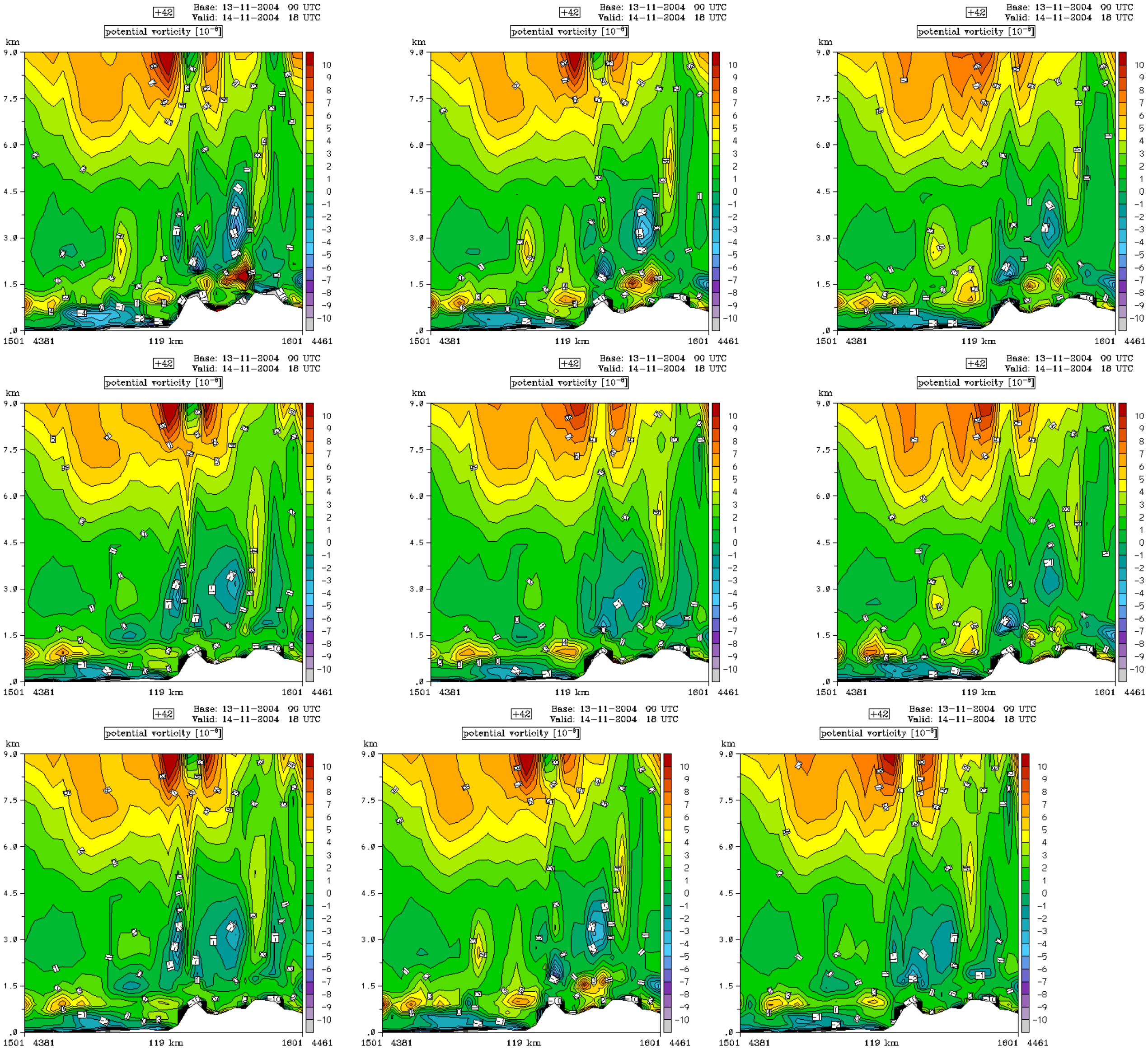

Figure 5: Vertical cross-sections of potential vorticity experiments 1 (top, left), 2 (top, center), 3 (top, right), 4 (middle, left), 5 (middle, center), 6 (middle, right), 7 (bottom, left), 8 (bottom, center) and 9 (bottom, right).