High resolution modelling of atmospheric flow over southern Poland

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<u>*Summary.*</u> A nonhydrostatic model of atmospheric flows EULAG is set up over southern Poland on grid with 1km horizontal resolution. The goal is to test a short-term numerical weather prediction over complicated topography with explicit treatment convective processes. Boundary and initial conditions are interpolated from routine mesoscale hydrostatic UMPL model running at 17km resolution.

OVERVIEW

One of the limitations of contemporary mesoscale numerical weather predition (NWP), resulting from the coarse grid resolution is necessity to parameterize convective processes. Convection is responsible for intense mesoscale phenomena, like thunderstorms, flash-floods, mesoscale convective complexes, gust fronts e.t.c.. Other mesoscale phenomena: valley circulations, gravity waves, forced convection result from interaction of the flow with topography, which at a coarse resolution differs significantly from the reality. This means, that many important intense phenomena, important from the point of weather forecasting are not directly solved by a routine NWP model. In the following we describe an attepmt to overcome these limitations by running a limited area mesoscale model at a high resolution mesh on which many convection/small scale phenomena can be resolved directly.

The high-resolution model was set up over southern Poland covering a square of 200x200x19km with switchable 1km/2km/4km horizontal grid with up to 60 unequally spaced levels in vertical. The area covered by symulations covers three different regions: a hilly terrain 200-450m a.s.l in the northern and middle part of the domain Wisła river valley, with flat bottom 190-250m a.s.l. and front ranges of Carpathian mountains peaking 1300m a.s.l. In the south. The computational area is embedded inside the mesh an operational hydrostatic UMPL NWP model [1], covering central Europe with 17km horizontal resolution.

The analytic equations of motion (in anelastic approximation), thermodynamic energy equation, water substance conservation equation and equations for the cloud water, rain water and ice parameterizations (bulk or detailed) are solved by means of finite-difference approximations using the semi-Lagrangian/Eulerian nonhydrostatic anelastic model EULAG. Sevaral parameterizations of subgrid scale turbulent kinetic energy, cloud and rain microphysics and other meteorological processes (e.g. Heat and humidity flux at the bottom) are available. More information on equations and numerical solutions can be find in [2,3,4,5].

In order to feed high -resolution EULAG with the low resolution UMPL data following operations were made:
1) conversion of UMPL's sigma-p to EULAG's sigma-z vertical coordinate;
2) interpolation of initial and boundary fields from UMPL's 17 km grid to EULAG's 1 km grid;
3) in a border of EULAG domain an interpolated topography with smooth transition from 17km resolution to 1km resolution was introduced;
4) since upper boundary of EULAG mesh is below the upper boundary of UMPL grid, the upper boundary condition has also been interpolated.
In practice initial/lateral data were interpolated horizontally, using linear or spline interpolation in each level separately, later the data were interpolated vertically in columns to obtain requested number of levels .Vertical interpolation was done together with sigma-p – sigma -z transition.

NUMERICAL SIMULATIONS

The case study presented below is based on meteorological situation from August 26, 2001. NNW inflow of a relatively dry air at the peripheral part of the high pressure system formed good conditions to observe convective clouds forced by topography. Calculations with EULAG began at 8 am, boundary conditions were taken from UMPL's output, heating of the surface by solar radiation was accounted for. Horizontal resolution of the mesh of the presented run was 2 km, the calculations were performed with 60 levels in vertical.

In the course of calculations development of convective clouds forced by NW flow was observed. One band of convective clouds began to form at 10:40 over Jura Krakowsko-Częstochowska. At the same time the second band of Cumulus clouds appeared over the front ranges of Carpathians. Within next three hours the first band grown up and drifted southwards over the Wisła river valley, while the second band was stationary, with some clouds dissipating and new appearing in the same area. A snapshot of this situation at 01:40 local time is presented in the figure on the next page.

At this time comparison of the model output to the satellite image collected at 01:46 by the polar orbiting Sea-Star was made. In the satellite image also two bands of clouds separated with a band of clear air over Wisła valley were visible. More detailed, quantitative comparisons were not possible due to a poor resolution of the available satellite image.

Later during the day both bands of clouds merged over Carpathians, producing small amount of precipitation, which evaporated before reaching the ground level. The calculations were stopped at 16:00 in the afternoon.
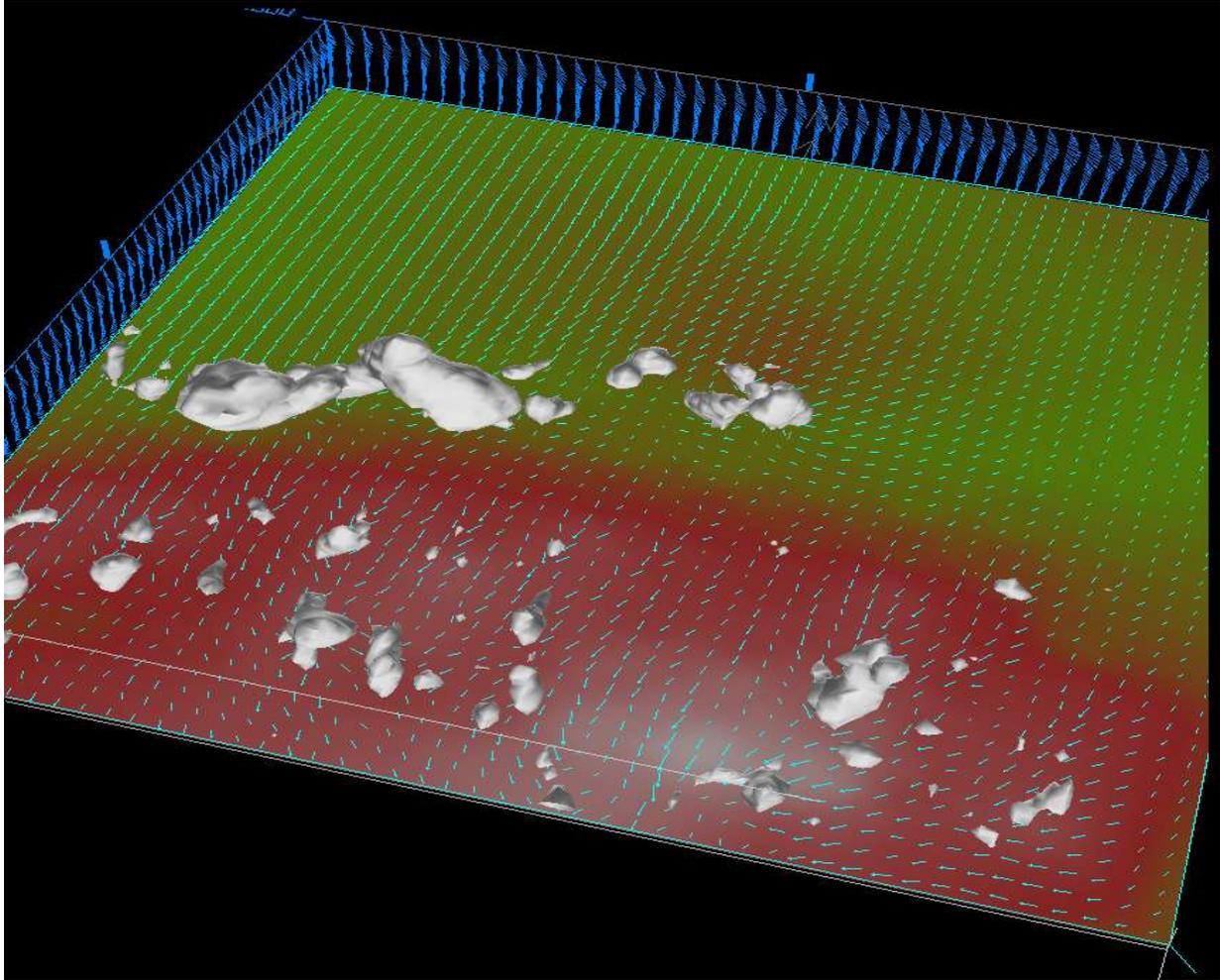

Fig.1. A snapshot of the simulated situation at 13:40 local time. Topography is represented by colour scale with green lowlands in the north and pink highlands in the south of the domain. Airflow at 1500m level is visualized with light blue arrows. Darker arrows at the domain edge show the inflow through the lateral boundary. Clouds are visualized with the isocontour (0.1g/kg) of condensed water.

CONCLUSIONS

The presented case study indicates, that simulations of convective atmospheric processes driven by a local orography at a small (of order kilometer) scale are possible. Even in a case of very complicated topography, careful inretpolation of initial and boundary data and existence of smooth transition region between high-resolution and low-resolution topography makes such a simulations possible.

References.

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