Numerical Weather Prediction at IMGW-PIB

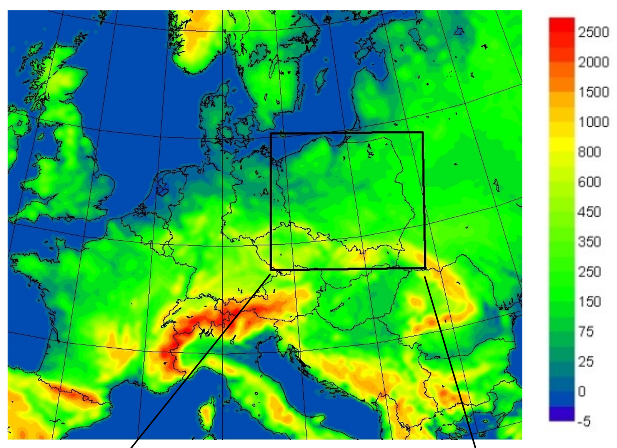
Joanna Linkowska[1], Marcin Kurowski[2], Andrzej Mazur[1], Bogdan Rosa[2], Damian Wójcik[2], Michał Ziemiański[2]

[1] IMGW-PIB Center of Numerical Weather Forecasts, [2] IMGW-PIB, Numerical Methods Development Group, Warsaw, Poland

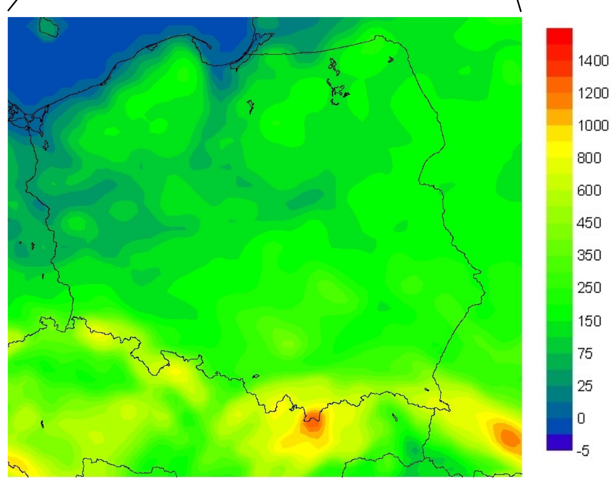
Status of operational suite & Computing system

Horizontal Grid Spacing [km]	7	2.8
Domain Size [grid points]	385 x 321	285 x 255
Time Step [sec]	40	20
Forecast Range [h]	78	36
Initial Time of Model Runs [UTC]	00, 12	00 12
Model Version Run	4.0	4.0
Lateral Boundary Conditions	Interpolated from GME at 3h intervals	Interpolated from COSMO-PL 7
Initial State	Interpolated from GME	Interpolated from COSMO-PL 7
Prognostic Variables	U, V, W, T, P, P_S, Q_V, Q_C, Q_I, Q_{VS}, TKE	

COSMO-PL 7



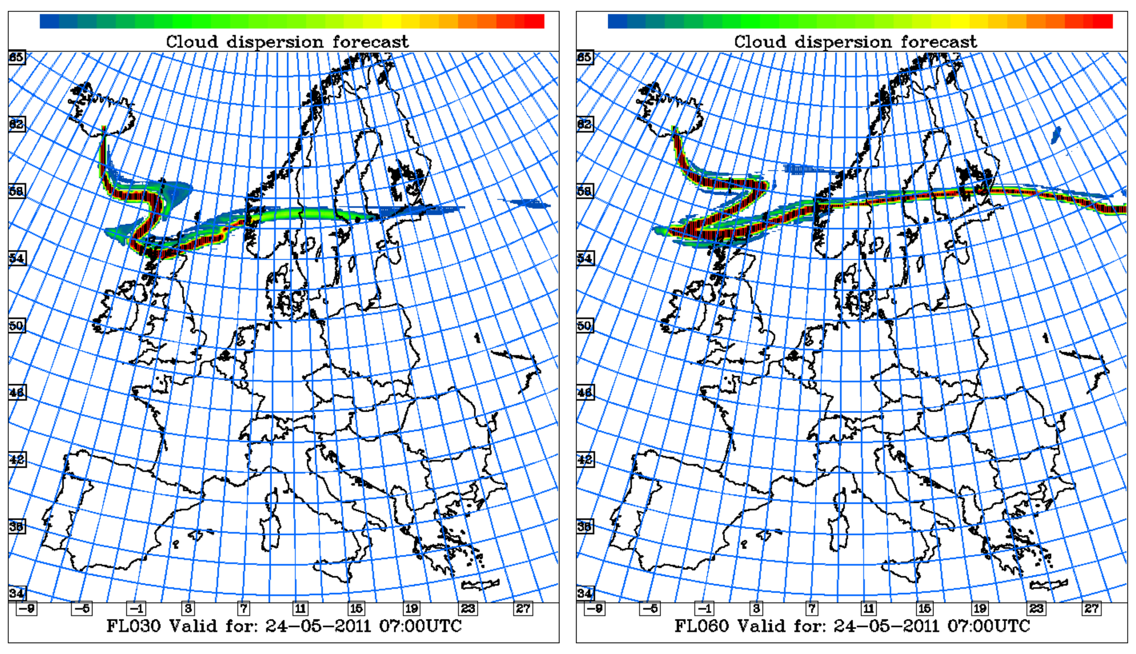
COSMO-PL 2.8 quasi-operational



- HP Bl460c - 32 blades in 2 racks c7000 - LINUX CLUSTER controlled by 2 managing servers.
- Every blade contains 2 4-core 16 GB processors Intel Xeon X5570.
- Blades interconnected with InfiniBand 4xQDR.
- Computing power above 2,5 T FLOPS.
- Cluster with 2TB storing volume connected with NetApp disks via the Fibre Channel protocol.

Post-Processing - examples

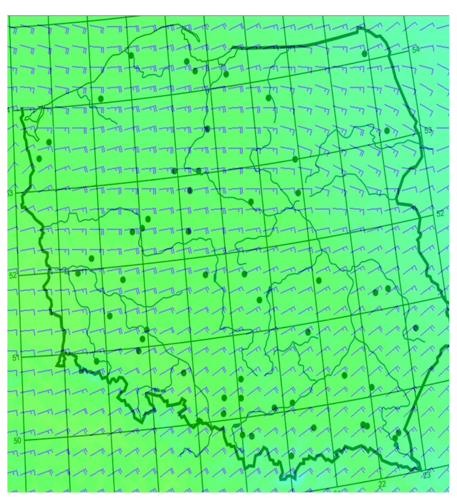
Forecast of volcanic ash dispersion, Grímsvötn volcano eruption, Iceland, 24 May 2011, 07 UTC



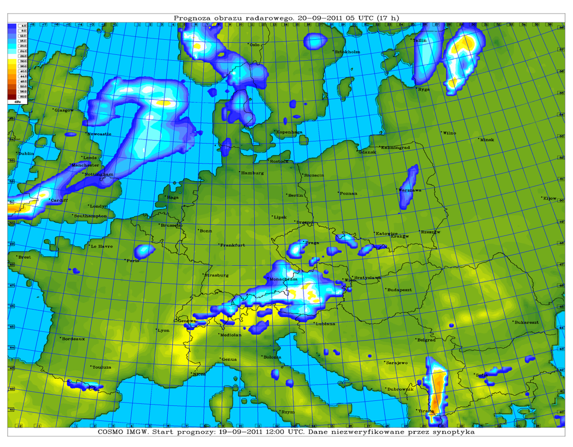
Operational simulation of emission accidents (e.g. volcano eruption, Nuclear Power plant accidents etc.). The examples show the forecast of air dispersion at Flight Level 3000 feet (FL30) and 6000 feet (FL60) of volcanic ashes due to Grímsvötn volcano eruption on Iceland, 24 May 2011. Ashes concentration in relative units (0-100% of maximum). The application has been set up to be used by Polish Air Navigation Services Agency.

Wind speed and direction, 500 m a.g.l. 20.09.2011, 06 UTC

Forecast for gliders - wind (speed, direction) on the background of temperature at 500 m a.g.l. High resolution forecast (2.8 km) with time horizon of 36 hours. The forecast includes also cloud base, top and type, height of a "zero degree", mixing level height, updraft and other elements needed by gliders.



Simulation of composite radar picture 20.09.2011, 05 UTC

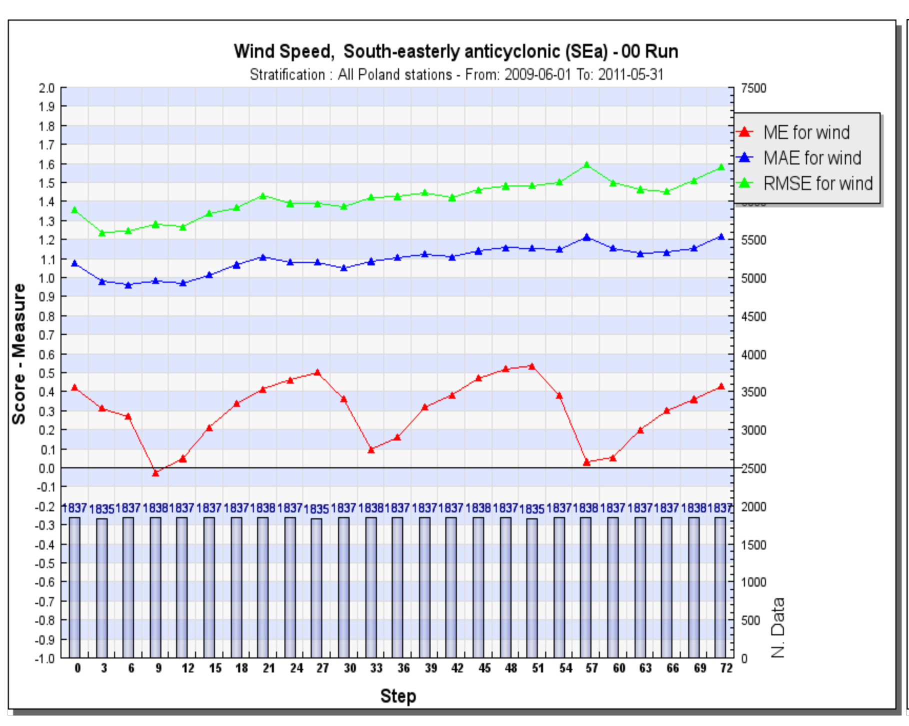


The simulation (model forecast) of a composite radar picture for model domain shows reflectivity in dBZ. dBz is calculated (in general) from the water and ice amount in air parcels "as it would be seen by radar".

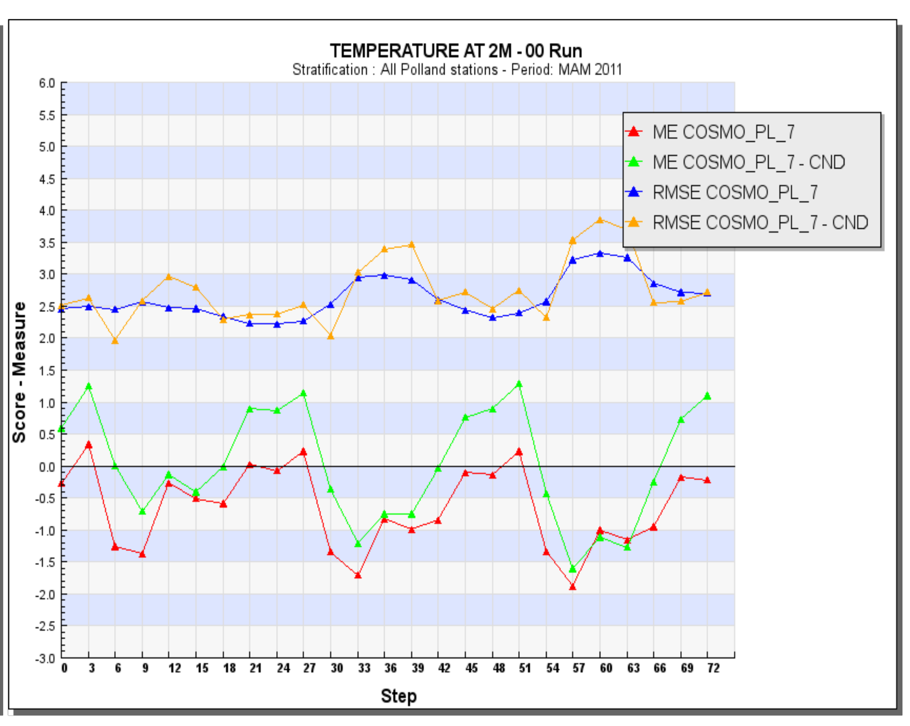
Verification - examples

The standard, conditional, weather dependent methods are used to verify continuous and dichotomous parameters. The examples of conditional and regime-dependent verification are shown bellow. The weather and circulation type classification is based on three indices, calculated from gridded MSLP (mean sea level pressure) data, for estimating the advection of air masses as well as a cyclonic characteristic. With the classification 27 different circulation patterns are obtained (e.g. South-easterly anticyclonic, Easterly cyclonic, Neutral anticyclonic, Southerly neutral).

Wind speed at 10 m, ME, MEA, RMSE
South-easterly anticyclonic
00 UTC, All Poland stations, 2009-06-01-2011-05-31



Temperature at 2 m, ME, RMSE
00 UTC, All Poland stations, 2011-03-01 – 2011-05-31
Conditions: TCC >= 75 % overcast, Wind Speed <= 2.5 m/s



Research & Development

Conservative Dynamical Core (CDC) - COSMO Priority Project

The anelastic branch of the CDC project is aimed at an application of the EULAG dynamical core as a prospective dynamical core of the COSMO model. EULAG is a computational research model for multi-scale flows. It is based on nonhydrostatic anelastic flow equations and employs the finite-volume nonoscillatory positive definite transport algorithm MPDATA.

According to the CDC project plan, the initial phase of the project, involving tests for idealized and semi-idealised flows, was successfully accomplished. Currently, the work is focused on limited experiments involving semi-realistic flows over the Alps with simplified representation of boundary layer processes and microphysics (1), and on merging of the EULAG dynamical core with COSMO (2).

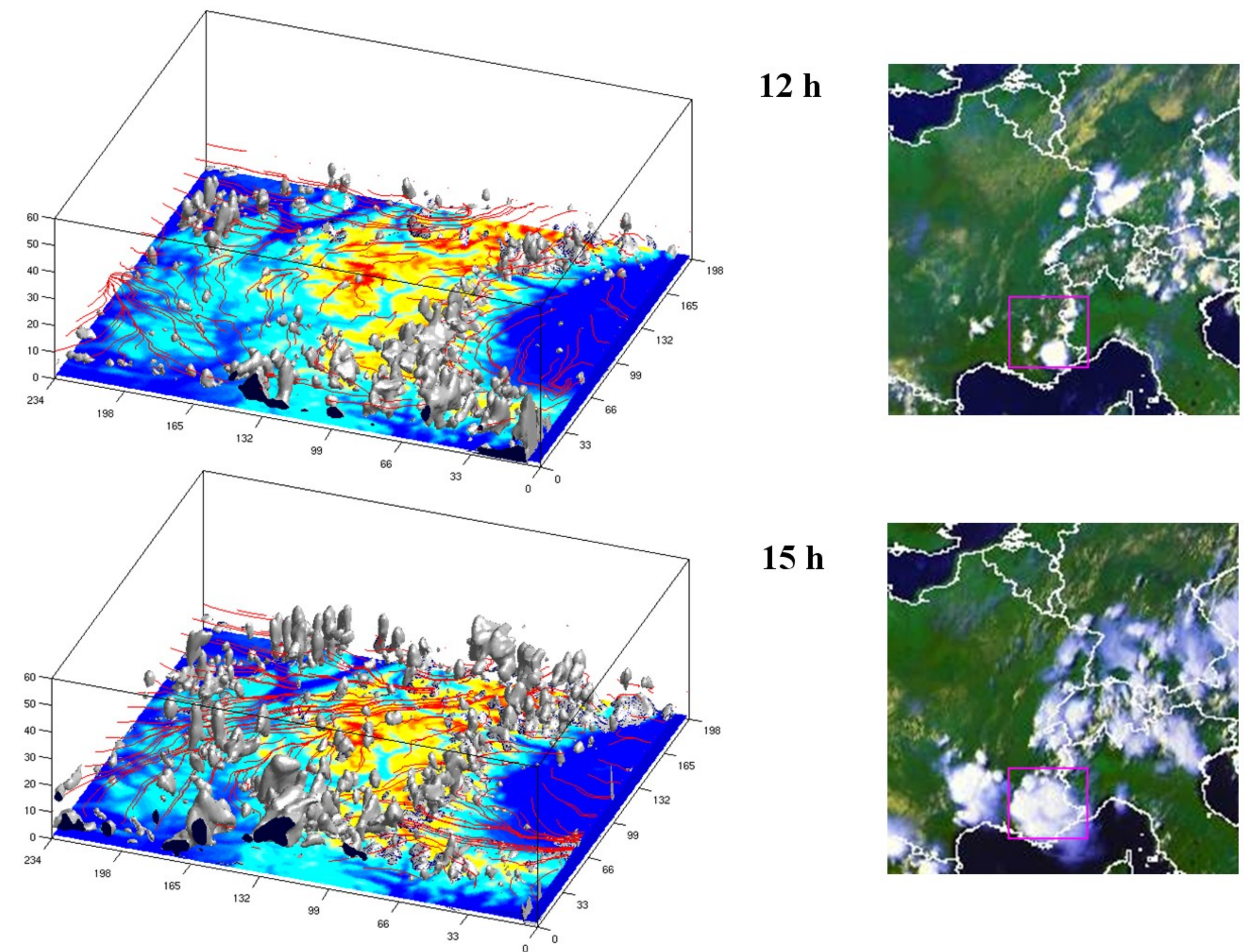
1. Semi-realistic flows over the Alps - summer convection on 12 July 2006

Simplified parameterizations:
Boundary layer processes are represented by TKE (turbulent kinetic energy) model.
Surface fluxes and drag taken from the operation run of COSMO2 model for Switzerland.
Simple representation of moist processes (warm rain Kessler-scheme).

Experiment setup:
Horizontal resolution 1.1 km, vertical resolution.
The computational domain is restricted to 234 x198 km and covers the Southern Alps.
Initial, boundary conditions from COSMO2 operational run.

Comparison of the EULAG simulation with satellite images

EULAG simulation of the Alpine summer convection on 12th July 2006 (left) is compared with METEOSAT data (right). The domain is restricted to 234x198 km and covers the Southern Alps. The model employs simplified TKE parameterization of PBL and bulk microphysics (no ice processes). Streamlines (red) and cloud water (isosurface of 0.05 g/kg) are shown. Surface color represents orography structure. Temporal and spatial structure of simulated convection closely resembles the actual development (convection on the eastern slopes followed by vigorous development south of the Maritime Alps).



2. Coupling of the EULAG dynamical core with COSMO

- **Migration of F77 EULAG code into F90**

Dynamic memory allocation, no COMMON blocks, modularization (data and source code separation, specialized modules), Fortran 90 language syntax, etc.

- **Plugging the new dynamical core in**

The dynamical core is temporarily plugged instead of default Runge-Kutta dynamical core in the COSMO code. The EULAG core is fed with COSMO forcings at each time step.

- **Testing COSMO&EULAG hybrid model**

The first set of tests includes inertia-gravity wave (Skamarock and Klemp, 1994) and cold density current (Straka, 1993) experiments.

Potential temperature after 15 min for Straka (1993) experiment