Limited Area Modelling in Slovenia - 2017

Neva Pristov, Jure Cedilnik, Benedikt Strajnar, Jure Jerman, Peter Smerkol, Anja Fettich, Matjaž Ličar - Slovenian Environment Agency

Matjaž Ličar - Marine Biology Station, National Institute of Biology, Slovenia

Nedjeljka Žagar, Matic Šavli - Faculty for Mathematics and Physics, University of Ljubljana, Slovenia

HPC system

Technical characteristics (SGI ICE X):

- 61 Intel Sandy Bridge compute nodes (976 cores, E5-2670 @ 2.6 GHz) - each with **64 GB** of memory,
- **11 Intel Broadwell compute nodes (308 cores)**,
- two Infiniband FDR networks,
- **500 TB of disk space (HA NFS)**,
- **Robot tape libraries.**

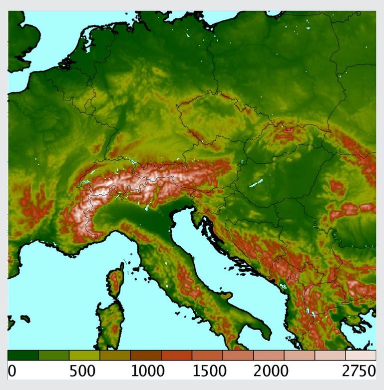
Software:

- OS: SGI ProPack on top of Suse Entreprise Server,
- Intel Fortran compiler, SGI mpt,
- Altair PBS job queueing system.

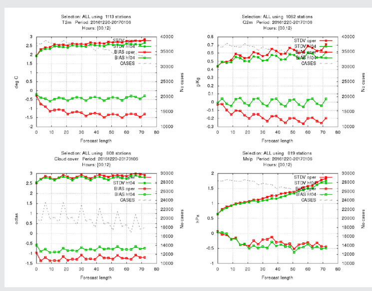
Operational suite

Model characteristics:

- CY40T2_bf7, ALARO-V1b,
- 4.4 km horizontal grid spacing, 87 model levels,
- linear spectral elliptic truncation,
- Lambert projection,
- 421x421 points, (with extension zone 432x432), E215x215,
- 180 s time-step,
- four production runs per day: 00, 06, 12, 18, forecast up to 72 hours, additionally four runs 03, 09, 15, 21 up to 36 hours,
- coupling at every 3 hours, LBC from ECMWF Boundary Conditions Optional project (time lagged coupling).
- a separate production run with ARPÈGE Boundary Conditions



ALADIN-Slovenia model domain.



Improvements of surface scores for cy40 (green) compared to previous operational cy38 (red).

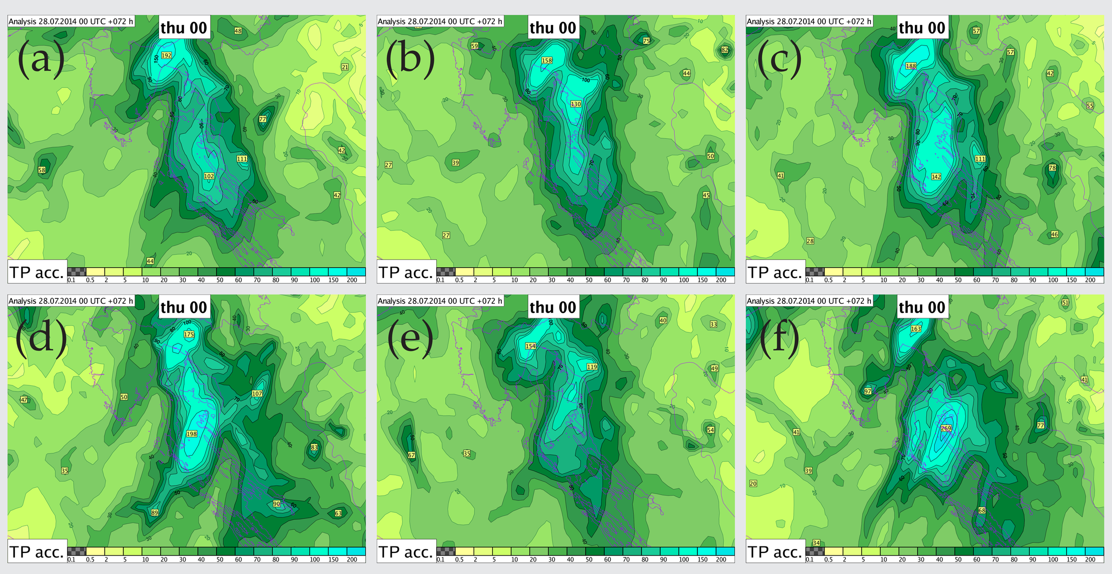
Assimilation cycle:

- 3-hourly 3D-Var assimilation cycle (RUC),
- B-matrix sampled from downscaled ECMWF ensemble members,
- CANARI surface analysis using surface observations (T and RH at 2 m),
- coupling frequency 1 hour,
- space consistent coupling, no digital filter initialization,
- observations: OPLACE data (SYNOP, AMDAR, AMV, TEMP, AMSU, MHS, SEVIRI) and local observations (SYNOP, Mode-S MRAR).

Two-way atmosphere-ocean coupling

Research on the importance of SST information and two-way coupling (with ocean model POM) over the Adratic Sea brings us to the following conclusions:

- the highest impact of two-way coupling can be expected for smaller synoptic systems (e.g., cut-off lows, fronts),
- both two-way coupling in the assimilation cycle and in subsequent forecast contribute to improved precipitation fields in such situations.

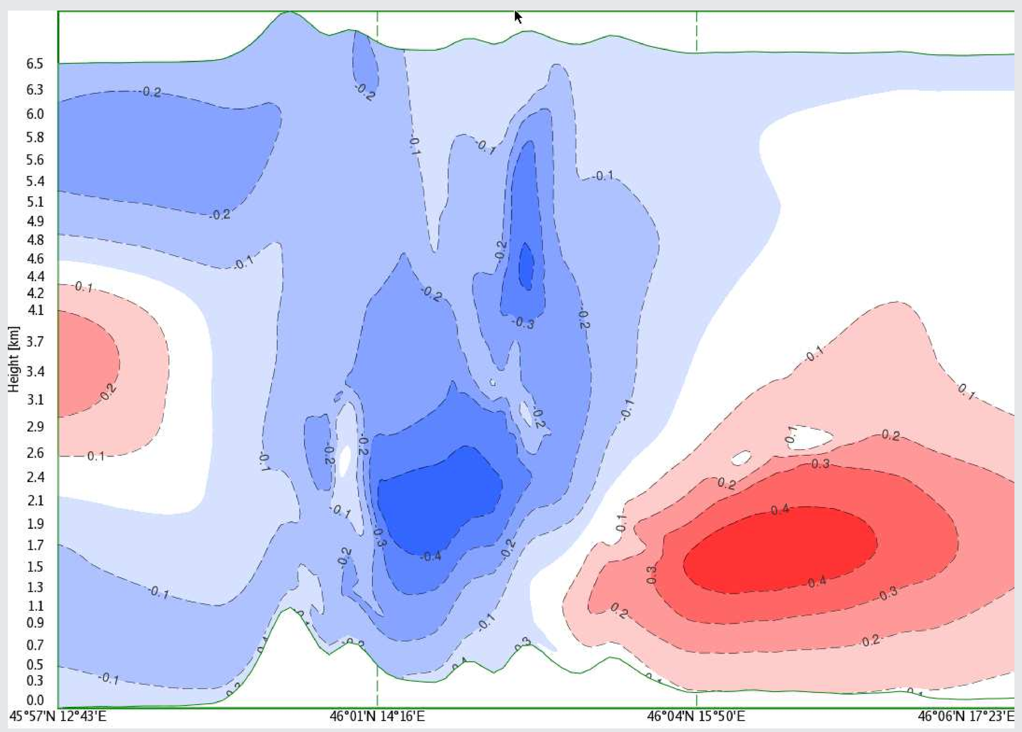


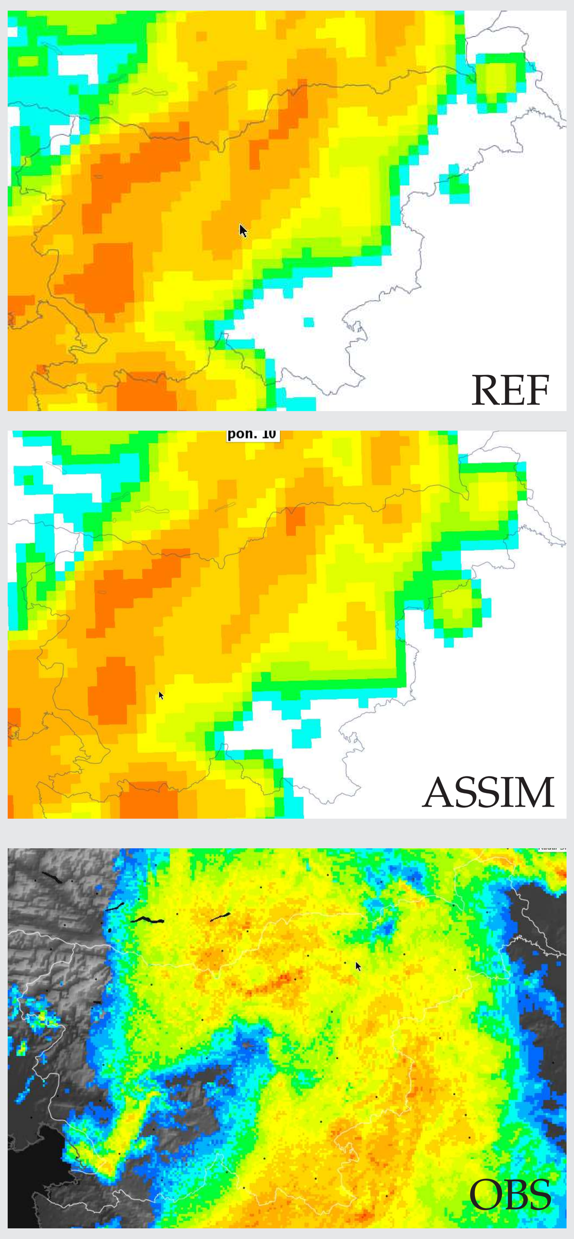
The 72 h precipitation accumulation using various SST implementations: (a) ECMWF/OSTIA, (b) MFS, (c) MFS + Adriatic POM, (d) MFS + Adriatic POM + two-way coupled forecast, (e) two-way coupled warm-up + uncoupled forecast, (f) two-way coupled warm-up and forecast. Performance of coupling is evaluated on severe flash flood case near Zadar, Croatia, on 30 July 2014.

First steps towards radar DA

Radar data assimilation development at ARSO has been started by regular downloading of Opera ODIM hdf5 data since summer 2017. The reflectivity observations were successfully implemented as input to 3D-Var data assimilation in the ALADIN. First tests using numerous European radars provide reasonable humidity and temperature analysis increments.

Special attention was devoted to quality information added by Opera and their preprocessing steps. These were compared to local radar QC procedures withing rapid analysis and nowcasting system INCA. A general increase of the incoming raw reflectivity at Opera was detected, occasionally resulting in very high (saturated) echos. The attenuation, RLAN detection and ground clutter identification procedures are comparable to the local ones, while the more aggresive beam blockage correction algorithm at Opera presumably results in the above mentioned difference in the corrected reflectivity.





Above: A west to east vertical cross section of specific humidity increment over Slovenia due to assimilated radar reflectivities on 10 August 2017 0 UTC. Moistening (red) and drying (blue) correspond to areas with cooling and warming, respectively (not plotted).

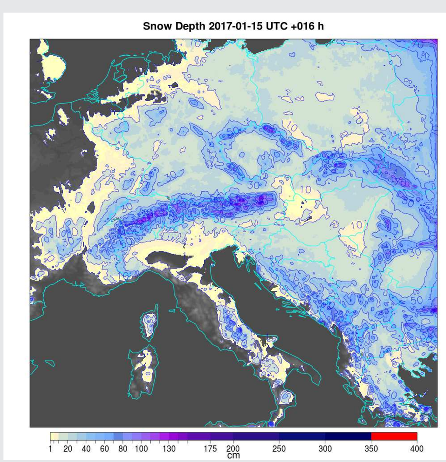
Left: Model simulated reflectivity in 1 h forecast starting from operational analysis (REF), analysis using radar data (ASSIM) and a reference radar observation (OBS) at 10 August 2017 10 UTC. Radar assimilation slightly shifts precipitating area towards east (in direction towards observation) in ASSIM.

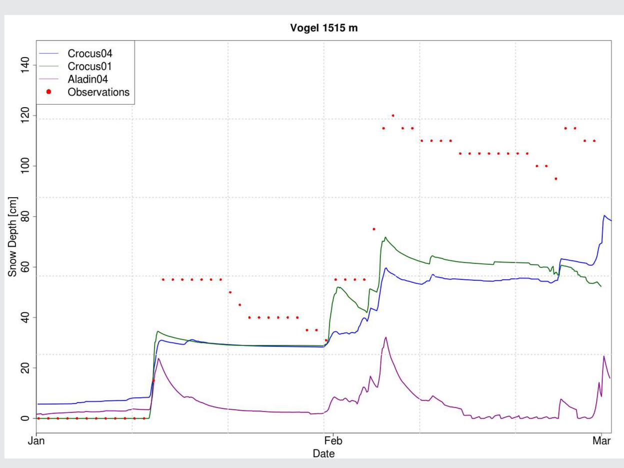
CROCUS snow model

Performance of snow model Crocus (offline SURFEX) was evaluated over the winter 2017:

- the model is either coupled to INCA analysis or ALADIN forecast,
- snow analysis and forecast is produced for each grid point of the model,
- results are generally encouraging.

The model will be used primarily as a snow product for hydrology and as a tool in snow avalanche risk diagnosis and forecasting, but could later also be used as snow analysis for ALADIN.



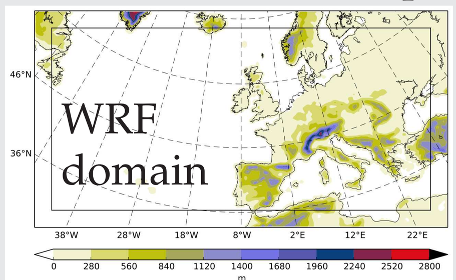


An example of snow depth forecast on ALADIN domain on 2017-01-15 (left) and performance of Crocus analysis for January-February 2017 on Slovenian mountain station Vogel. Crocus is coupled with ALADIN (Crocus04) or INCA analysis (Crocus01). Estimated snow depth from ALADIN is also shown (Aladin04). Points are snow depth observations.

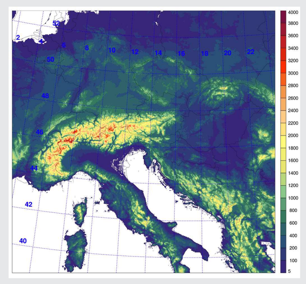
Growth of Uncertainties in LAMs

Forecast error growth in LAM domains consists of the growth from uncertainties in initial conditions (ICs) and lateral boundaries (LBs) in addition to the internal and model error growth.

Errors grow from the start of the forecast in all scales and there is both upscale and downscale cascade of the initial-state error. Errors from LBs are specially important in ensemble Kalman filter (EnKF) data assimilation which applies inflation methods. Similarly, practical limit of useful LAM ensemble forecasts depends on the domain size and the growth of uncertainties in LBs. An extensive set of experiments is performed to quantify the growth of uncertainties in two LAMs over Europe due to uncertainties in ICs and LBs.



AROME domain



Models:

- AROME model, 648x648 points, L87, 2.5km horizontal resolution
- WRF model, 241x127 points, L31, 30km horizontal resolution

Experiment setup: 50-member ensemble nested in the ECMWF operational ensemble prediction system (EPS). Three sets of experiments address the growth od LAM errors due to:

- uncertainties in initial conditions: each ensemble member has the same LBs ("IC" exp)
- uncertainties in lateral boundaries: each ensemble member has the same ICs ("LBC" exp)
- uncertainties in initial conditions and lateral boundaries: each ensemble member has its own ICs and LBCs ("IC/LBC" exp)

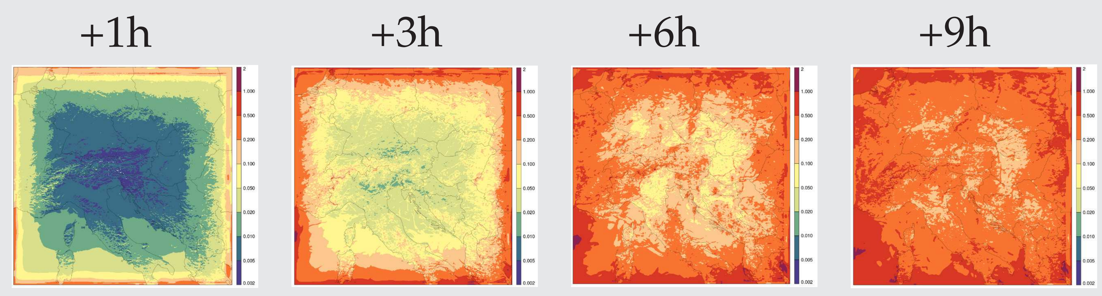


Figure 1: Dynamics of the lateral boundary "tsunami" in meridional wind in AROME at +1hr, +3hr, +6hr and +9hr forecast in the "LBC" experiment. Forecast initialization on 25 Jun 2016 at 12 UTC, shown is level 64 (roughly 850 hPa).

Average speed of lateral boundary tsunami in AROME

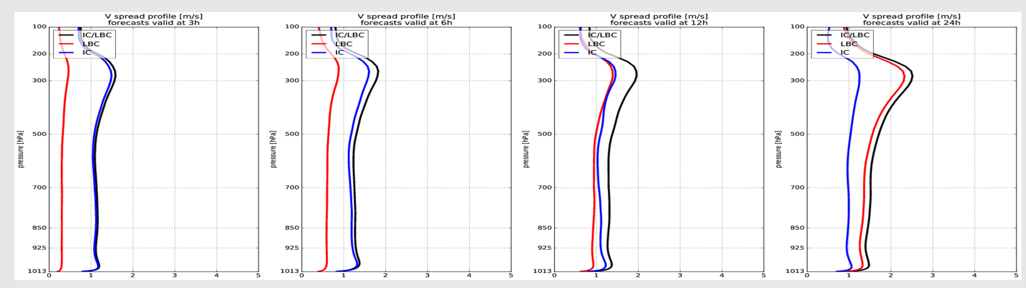


Figure 2: Comparison of the growth of forecast errors in meridional wind in 3 experiments after 3-hour, 6-hour, 12-hour and 24-hour forecasts. Averaging is done over the AROME domain in Fig. 1.

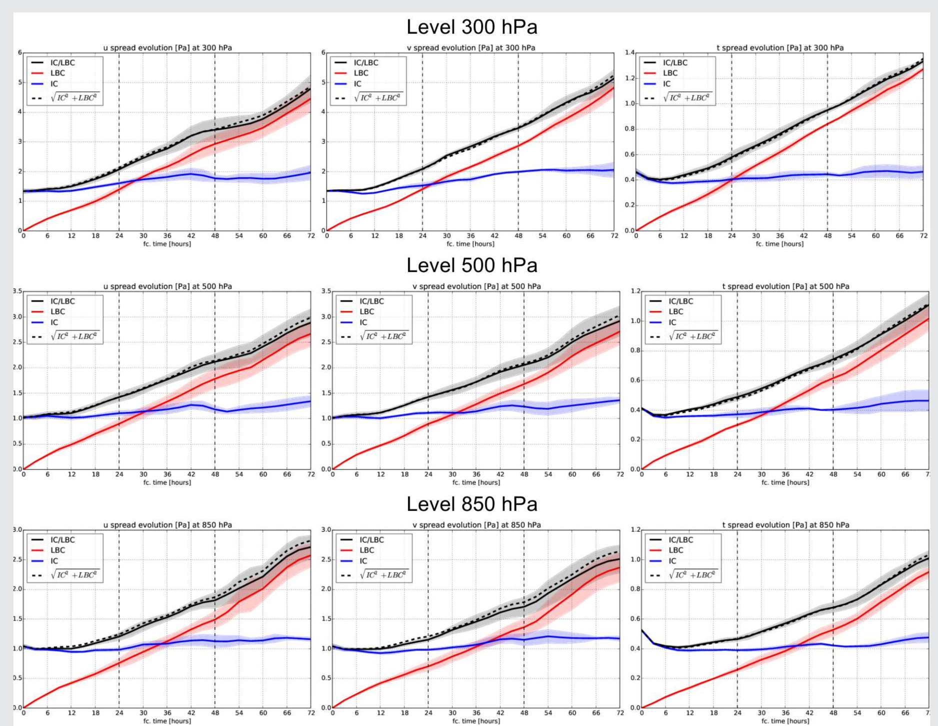


Figure 3: Average growth of forecast uncertainties in the three sets of experiments in the WRF domain. Results are averaged for all forecasts initialized at 12 UTC. The shaded area corresponds to one standard deviation of the statistics.

The impact of the LBs is seen much stronger in the results of AROME than WRF due to its smaller domain size. Figure 1 illustrates how the "tsunami" of uncertainties emanating from the LBs quickly spreads over the model domain. In the lower troposphere, it takes up to 18 hours for the LB impact in the AROME model to cover the entire domain (Fig. 2). Quantification of the role of LB uncertainties is especially important for the tuning of the covariance inflation in the EnKF data assimilation in the WRF model at the University of Ljubljana. Figure 3 shows that the growth forecast uncertainties due to LBs is nearly linear and much faster than the growth associated with ICs which is due to a lack of growth in small scales.