# NWP activities at ARSO (Slovenia)

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ARSO METEO
Slovenian Environment Agency

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## HPC system

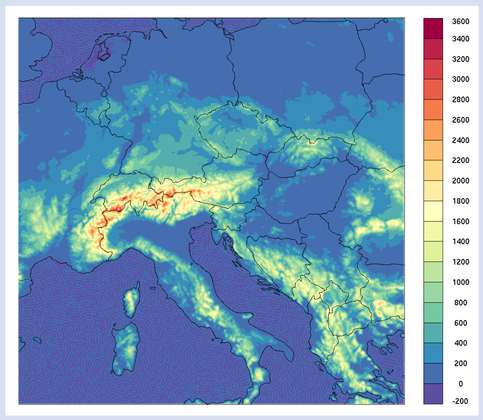
Technical characteristics (SGI ICE X):

- 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),
- new in 2020: 144 Intel Sandy Bridge compute nodes (2304 cores, E5-2670 @ 2.6 GHz) - each 64 GB of memory,
- two Infiniband FDR networks,
- 500 TB of disk space (HA NFS),
- 80 TB beegfs file system,
- robot tape libraries.

Software:

- OS: SGI ProPack on top of Suse Entreprise Server,
- Intel Fortran compiler v16, openMPI,
- Open PBS job queueing system,
- EcFlow suite management.

## Operational suite (ALADIN-SI)




*Model domain and orography of operational ALADIN-SI.*

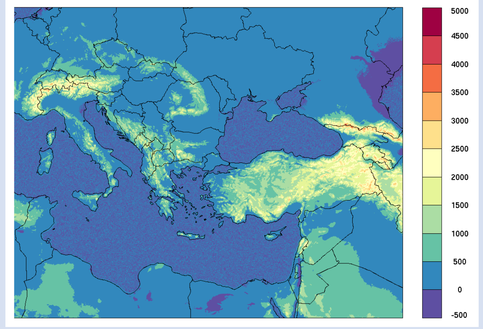
Model characteristics:

- code version cy43t2_bf10, ALARO-v1B physics,
- 4.4 km horizontal resolution, 87 vertical levels, 432 x 432 horizontal grid points,
- 180 s time step,
- coupling with ECMWF (6h lag), 1h (assim. cycle) / 3h (forecast),
- space-consistent LBC at initial time, no initialization,
- 4 production runs to 72 h (every 6 h), 4 runs to 36 h.

Data assimilation:

- 3h 3D-Var for atmosphere, OI for soil,
- static downscaled ensemble B-matrix,
- observations (mostly from the OPLACE system): SYNOP, AMV, HR-AMV, TEMP, AMSU&MHS, SEVIRI, IASI, ASCAT, OSCAT, Mode-S MRAR SI/CZ, MUAC EHS, ZTD (passive).

## ALADIN for SEE-MHEWS-A




*Model domain of ALADIN-SEE-MHEWS.*

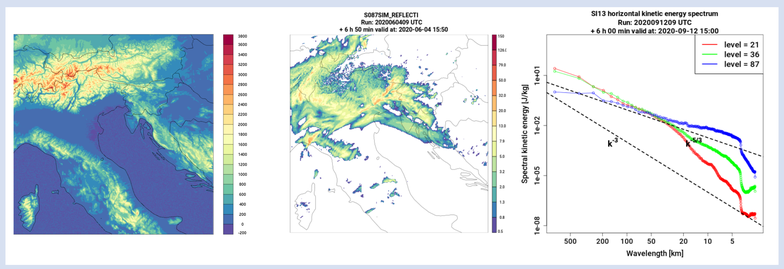
Within the South-East European Multi-Hazard Early Warning Advisory System (SEE-MHEWS-A) project, ARSO provides non-hydrostatic ALADIN results as one of NWP inputs:

- setup at ECMWF infrastructure (cca/ccb),
- same model version and assimilation setup as in operational ALADIN-SI,
- 2.5 km horizontal resolution, 87 vertical levels, 1429 x 1141 horizontal grid points,
- 90 s time step,
- coupling with ECMWF, 1h (assim. cycle) / 3h (forecast),
- observations from OPLACE preprocessing system.

## ALADIN for nowcasting

A NWP-based hourly nowcasting system (NWCRUC) centered over North Adriatic:

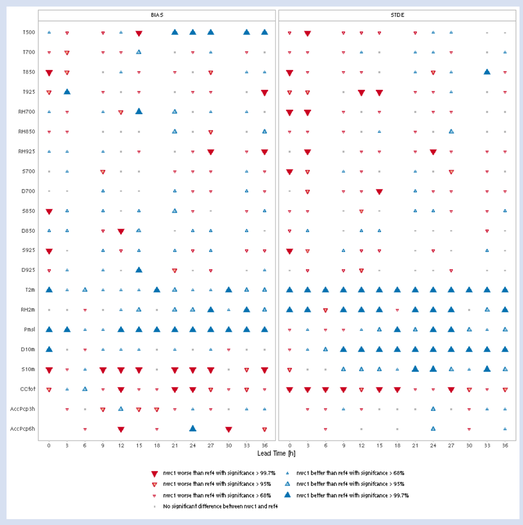
- same model version as operational ALADIN-SI,
- 1.3 km horizontal resolution, 87 vertical levels, 589 x 589 horizontal grid points,
- 60 s time step,
- hourly assimilation cycle with 3D-VAR + OI,
- all observations + radar.




*ALADIN-NWCRUC model domain (left), simulated radar reflectivity field (middle) and kinetic energy spectra at several levels (right).*

NWCRUC validated over winter and summer periods:

- clear improvements for most surface fields,
- mostly neutral impact on upper air fields (verification wrt. radiosondes),
- improvement of hourly precipitation demonstrated by categorical verification,
- cloudiness forecast degraded which needs further investigation.




*Comparison of scores for NWCRUC ("nwc1") and reference ALADIN 4.4 km ("ref4"), for main surface and upper-air variables. Score card obtained from HARP.*

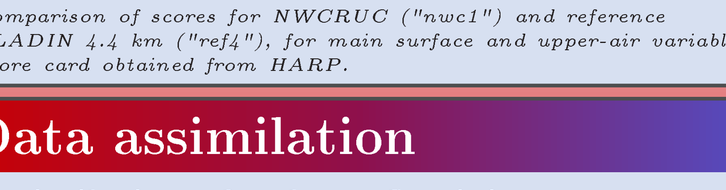
## Data assimilation

**Assimilation of radar reflectivity:**
Radar reflectivity DA (OPERA dataset) was tested in two configurations:

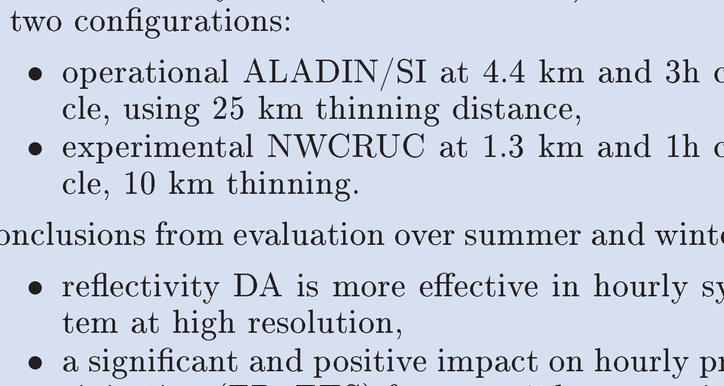
- operational ALADIN/SI at 4.4 km and 3h cycle, using 25 km thinning distance,
- experimental NWCRUC at 1.3 km and 1h cycle, 10 km thinning.

Conclusions from evaluation over summer and winter:

- reflectivity DA is more effective in hourly system at high resolution,
- a significant and positive impact on hourly precipitation (FB, ETS) for up to 7 hours, mainly for low intensities,
- reflectivity DA removes spurious precipitation from first guess and correctly adds moisture into larger precipitation systems,
- struggles with isolated convection as dry pixels are typically selected and assimilated so the existing convection dries out.



*Precipitation sums in the 1h first guess for NWCRUC without (left) and with radar reflectivity assimilation (middle) and reference hourly INCA analysis (right).*




*Frequency bias (left) and equitable threat score (right) for hourly precipitation and different intensity classes. Experiments are NWCRUC without (nwc1) and with radar DA (nwr1) and reference ALADIN 4.4 km without (ref4) and with radar DA (rad4).*

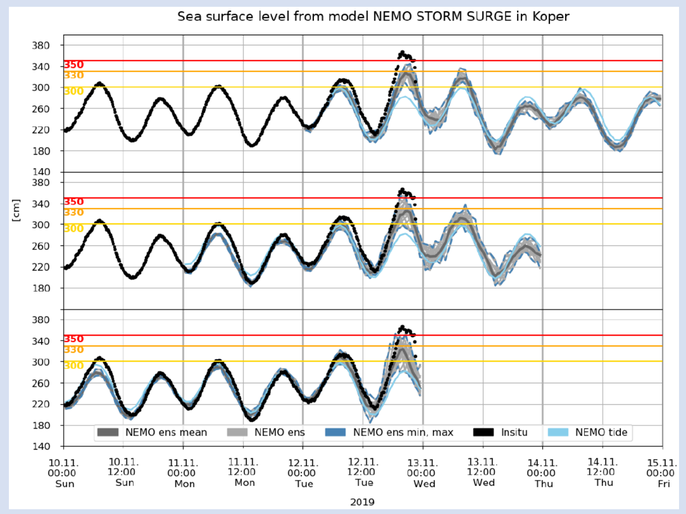
## Ocean modeling

The operational ocean system includes the following components:

- NEMO ocean circulation model,
- WAM wave model,
- ensemble of NEMO used for storm surge,
- Shyfem ensemble used for storm surge,
- ocean particle tracking (OpenDrift).

NEMO STORM SURGE is an operational ensemble version of the NEMO ocean model, adapted to predict storm surges in the Gulf of Trieste:

- model domain is the Adriatic Sea,
- lateral boundary conditions from CMEMS MFS,
- surface conditions are obtained from ECMWF ensemble forecast,
- forecast is performed for 17 subseted members of the ECMWF ensembles,
- two runs per day, 72 h forecast.




*Sea surface level as predicted by NEMO STORM SURGE.*

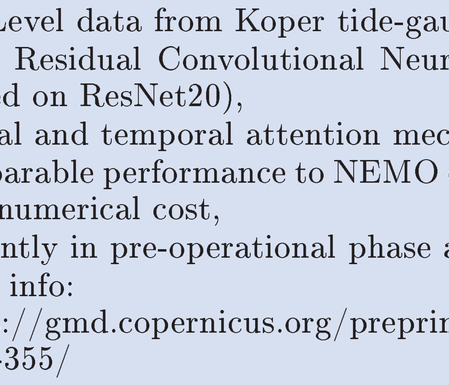
HIDRA Deep Learning Ensemble (collaboration with Lojze Žust and Matej Kristan from FRI UL):

- trained on 2006-2016 ECMWF ensembles and Sea Level data from Koper tide-gauge,
- Deep Residual Convolutional Neural Network (based on ResNet20),
- spatial and temporal attention mechanisms,
- comparable performance to NEMO ensemble at 1e-6 numerical cost,
- currently in pre-operational phase at ARSO,
- more info: https://gmd.copernicus.org/preprints/gmd-2020-355/

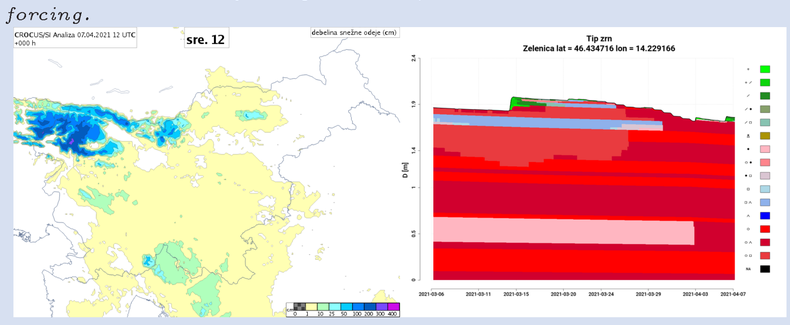
## Crocus - snow model

Crocus (SURFEX) is a detailed 1D physical model of the snowpack:

- to obtain daily information about snowpack conditions on a regional level,
- hourly analysis and forecast cycle once per day,
- 3 domains, different sources of meteorological forcing data,
- daily visualizations available at www.crossrisk.eu,
- can aid forecasters in avalanche risk assessment,
- test configuration to obtain snowmelt for hydrological modeling purposes.




*Domain extents for the 3 domains used operationally at ARSO. Green: 1km domain based on INCA-SI forcing. Red: 1km domain based on INCA-AT forcing. Blue: 4km domain based on ECMWF forcing.*




*Snowdepth analysis on INCA-SI domain (left) and analysis of grain type evolution for mountain station Zelenica (right).*