# Numerical Weather Prediction at Czech Hydrometerological Institute

Joint 29th ALADIN workshop & HIRLAM All Staff Meeting, 1 - 5 April 2019, Madrid, Spain

## NWP system

**ALADIN/CHMI** couples non-hydrostatic (NH) dynamics and the set of ALARO-1vB physical parameterizations suited for modeling of atmospheric motions from planetary up to the meso-gamma scales:

- domain 1069x853 grid points, Δx~2.3km
- linear truncation E539x431
- 87 vertical levels, mean orography
- ICI scheme with 1 iteration, time step 90 s
- 3h coupling interval
- 00, 06, 12/18 UTC forecast to +72/54h
- hourly analysis system VarCan Pack
- **ALADIN cycle 43t2plus_op1 (ALARO-1vB)**

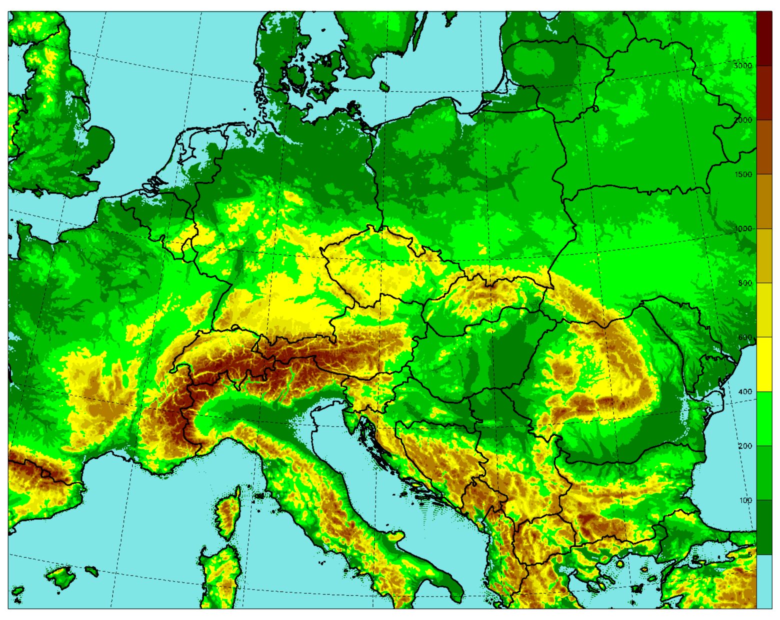
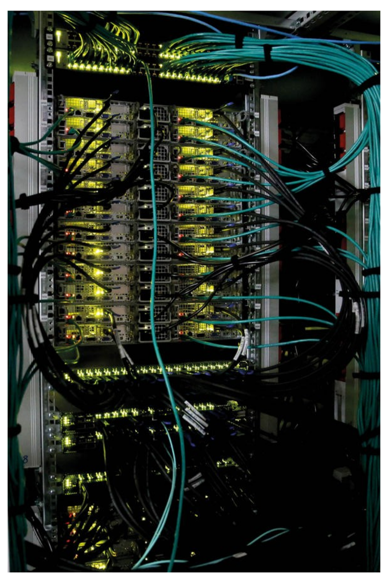


Figure 1: Orography of model domain

Data assimilation includes surface analysis based on an optimal interpolation (OI) and **BlendVar** analysis for upper air fields, which consists of the digital filter spectral blending (Brozkova et al., 2001) followed by 3DVAR analysis based on the incremental formulation originally introduced in the ARPEGE/IFS global assimilation (Courtier et al., 1994, doi: 10.1002/qj.49712051912).

- digital filtering at truncation E102x81; space consistent coupling
- no DFI in long cut-off 6h cycle; incremental DFI in short cut-off production analysis



### HPC system

- **NEC LX series** HPC cluster
- 320 computing nodes connected through high-speed Mellanox EDR InfiniBand
- each node has two **Intel Broadwell** CPU (12 cores, 64GB RAM)
- **7680 computational cores** in total
- operating system is CentosOS 7.2 Linux OS
- more than 1 Petabyte of storage capacity
- SLURM scheduler
- Intel Parallel Studio XE Cluster Edition

## Major operational changes

**10 Jun 2018 - extended data assimilation of high-resolution aircraft observations by Mode-S EHS & modified computation of the shallow convection** (see description below)

**21 Aug 2018 - implementation of the new model release - cy43t2**

**4 Sep 2018 - new EPSgrams product (see description below)**

**5 Mar 2019 - high-resolution ALARO-NH at 2.3km (see description in the right panel)**

**Data assimilation** of aircraft observations (AMDAR and local Mode-S MRAR from the Czech Republic) was extended by high resolution aircraft **Mode-S EHS** observations from KNMI covering airspace of Germany, Belgium and the Netherlands.

- observations obtained from air traffic surveillance systems (Mode-S radars) (de Haan, 2011, doi:10.1029/2010JD015264)
- quality assessment w.r.t NWP showed Mode-S EHS data to be comparable with AMDAR observations:
  - good BIAS and STD for wind
  - good BIAS, but higher STD for temperature

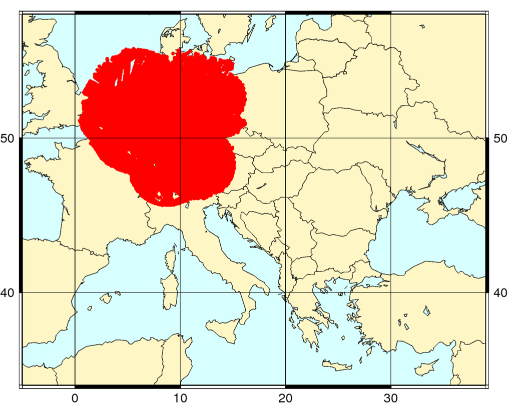
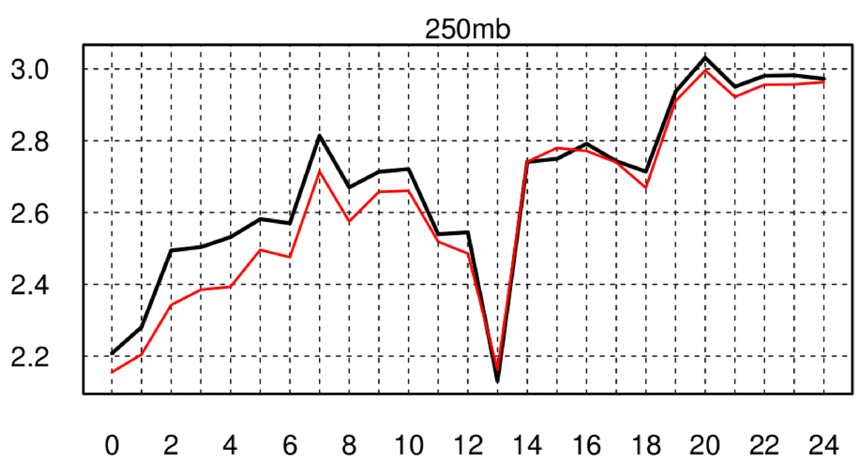


Figure 1: Geographical coverage of Mode-S EHS from KNMI.




Positive impact was found up to the first (<10h) hours of forecast (reduction of RMSE and BIAS of upper level wind and temperature).

Figure 2: Time evolution of **RMSE for wind speed at 250hPa** verified against aircraft observations for period of 11 Jan – 9 Feb 2017 12UTC. **Reference** and Mode-S EHS experiment.

New **EPSgrams product** - point based meteograms from a convection-permitting "lagged" ensemble of operational deterministic ALARO runs. The EPSgrams are based on the last 5 subsequent forecasts and provide an alternative estimate of forecast uncertainty.

The EPSgrams contain hourly evolution of the model simulation over last 2 days, together with corresponding observations when available, and forecasts for next 2 days.

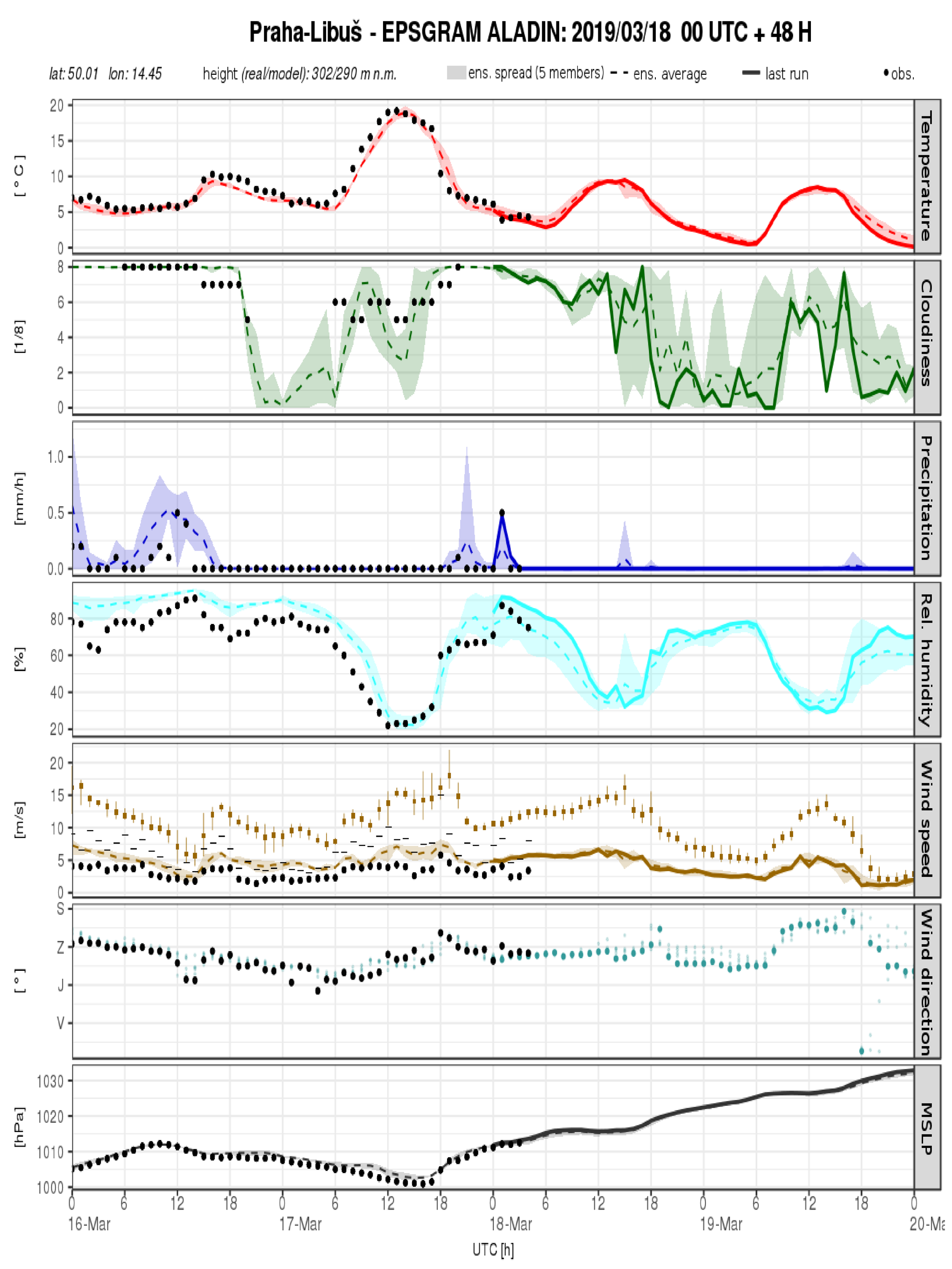



Figure 3: EPSgram for Prague from 18 March 2019 00UTC. The ensemble mean (dashed line), ensemble spread (shaded area), observations (dotted), last deterministic run (bold line) for 2m temperature, cloudiness, precipitation, 2m relative humidity, 10m wind speed & direction and mean sea level pressure.

## High-resolution ALARO-NH at 2.3km

The horizontal resolution was increased from 4.7km to 2.3km, preserving 87 vertical levels and size of the domain.

Key aspects:

- **non-hydrostatic (NH) dynamics** activated
  - Iterative Centered Implicit (ICI) scheme with 1 iteration
  - time step 90s
- **retuned horizontal diffusion** (HD)
  - both semi-Lagrangian (SLHD) & spectral HD (Figure 1)
- high resolution orography from **GMTED2010 database**
- **gravity wave drag parameterization still active**
  - form drag reduced & mountain lift coefficient reduced
- moist deep convection **3MT scheme still used**
  - It's activity is reduced on higher resolution as shown on the lowered sub-grid (convective) condensation rate w.r.t. the 4.7km case (Figure 2)
- **retuned cloudiness** to reduce its bias (Figure 3)
- **lowered vegetation thermal inertia** to increase the diurnal cycle amplitude of screen level temperature (Figure 4)
- **new treatment of thermal roughness**
- **unified computation of sub-grid snow fraction** for albedo and roughness length.

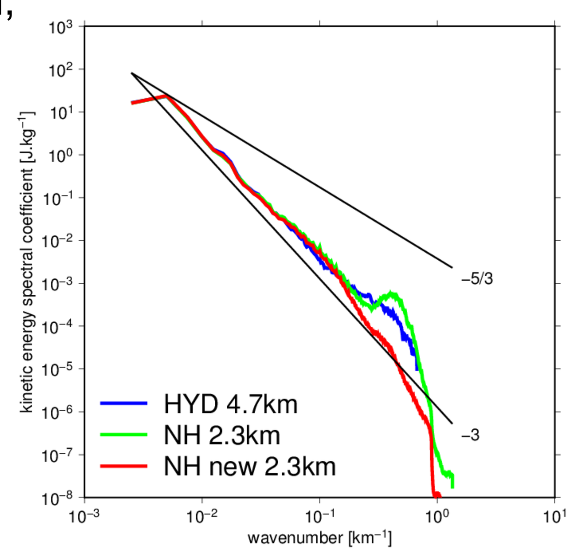



Figure 1: Kinetic energy spectra at 20th model level. (~ 220hPa). The **reference** hydrostatic experiment at 4.7km (blue), the NH experiment at 2.3km with a basic setting (green) and the NH experiment at 2.3km with retuned horizontal diffusion (red).

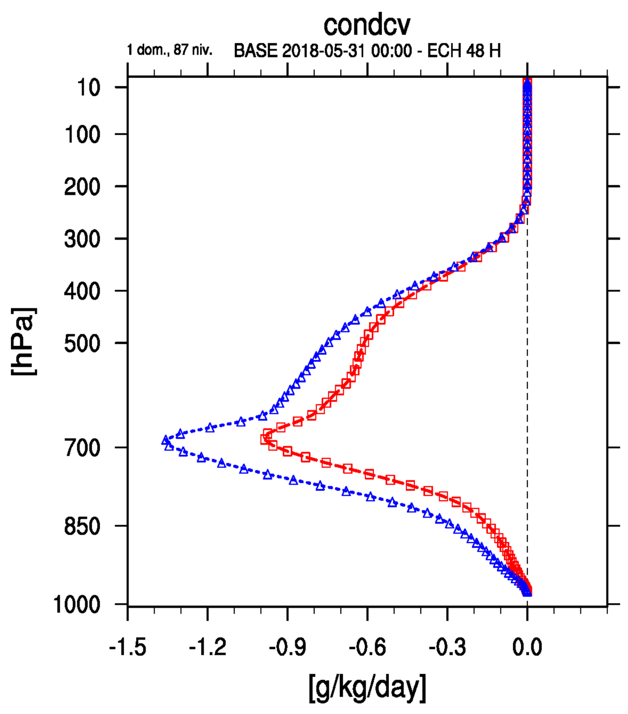



Figure 2: Sub-grid (convective) condensation rate. The **reference** experiment at 4.7km and the high-resolution experiment at 2.3km .

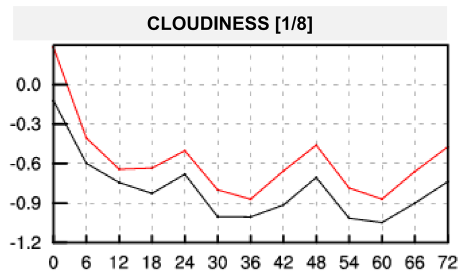



Figure 3: **BIAS of cloudiness** for period of 8 Feb – 3 Mar 2019 The **reference** at 4.7km and high-resolution experiment at 2.3km.

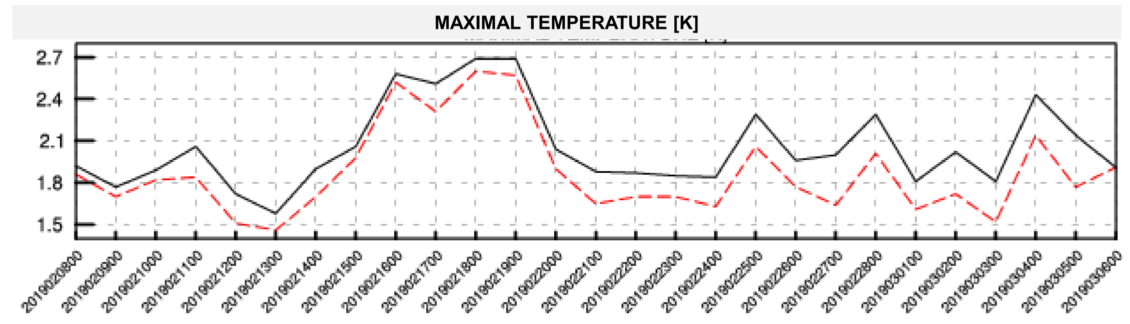
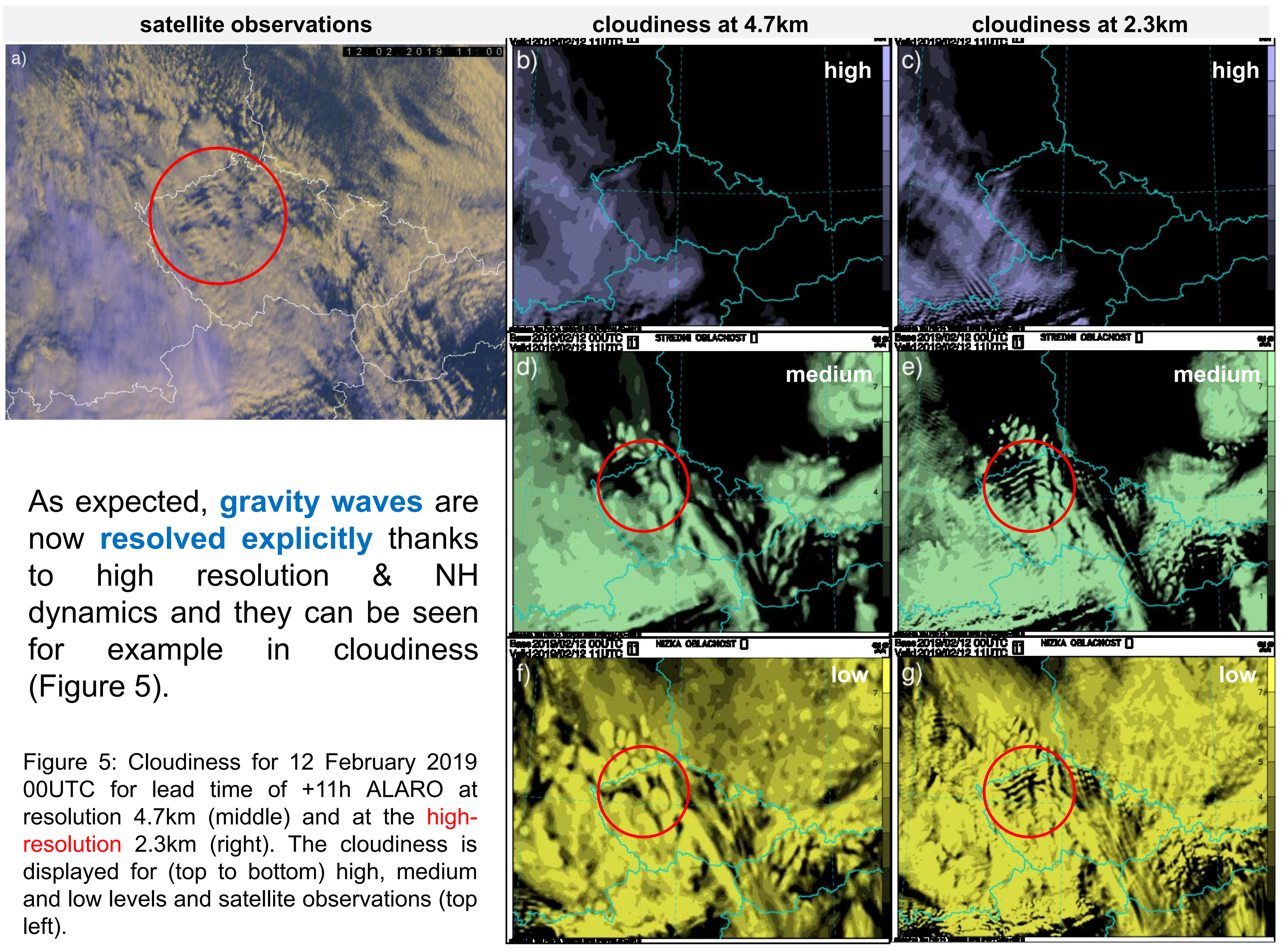
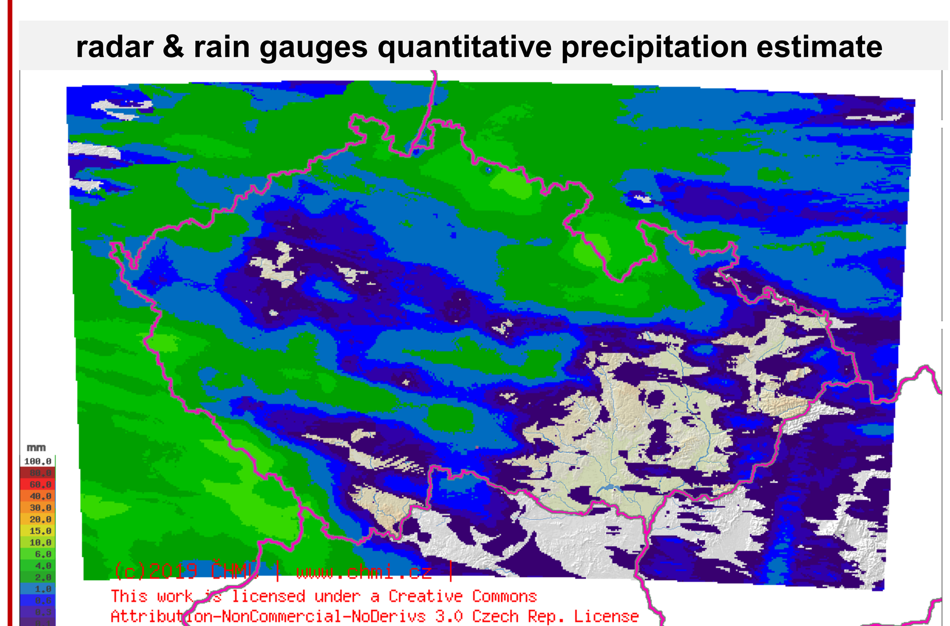



Figure 4: Time evolution of **RMSE for Tmax** for period of 8 Feb – 3 Mar 2019 the **reference** at 4.7km and high-resolution experiment at 2.3km.




As expected, **gravity waves** are now **resolved explicitly** thanks to high resolution & NH dynamics and they can be seen for example in cloudiness (Figure 5).

Figure 5: Cloudiness for 12 February 2019 00UTC for lead time of +11h ALARO at resolution 4.7km (middle) and at the high-resolution 2.3km (right). The cloudiness is displayed for (top to bottom) high, medium and low levels and satellite observations (top left).




Higher resolution also helps to get more detailed precipitation forecast, as shown on the case from 5 March 2019 computed over the Czech Republic.

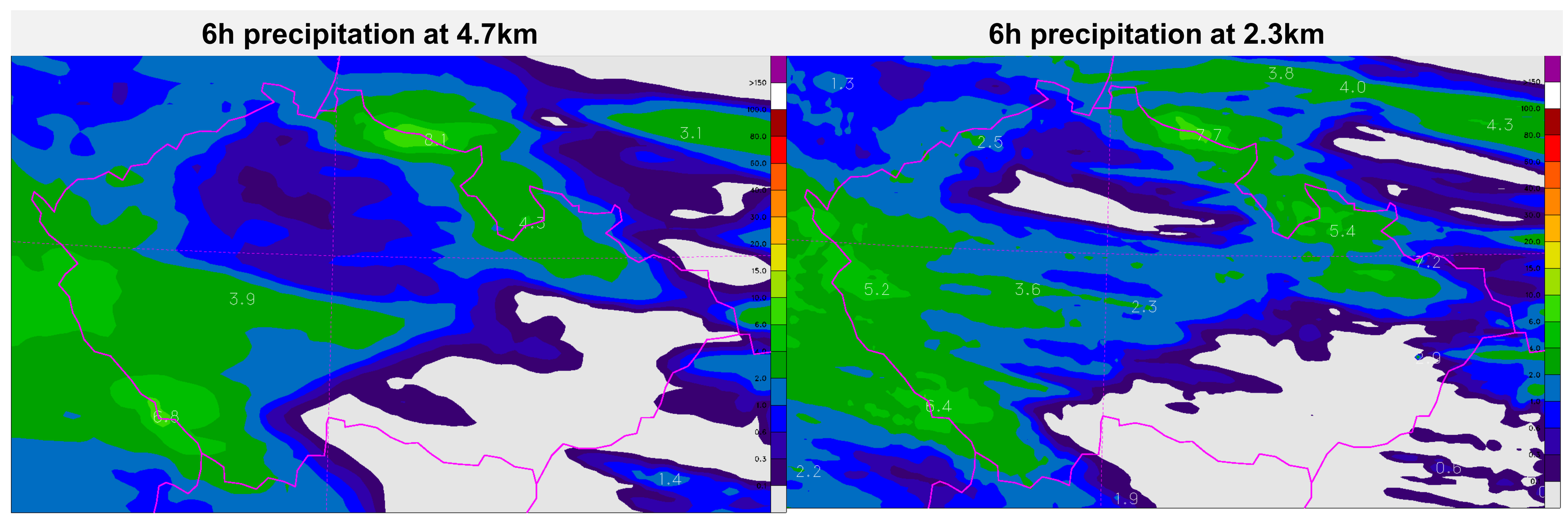



Figure 6: The 6h precipitation forecast for 5 March 2019 00UTC for lead time of +18h ALARO on resolution 4.7km (left), the new resolution 2.3km (right) and observations – radar and rain gauges based quantitative precipitation estimate (top).