Data assimilation activities at ItaliaMeteo-Arpae

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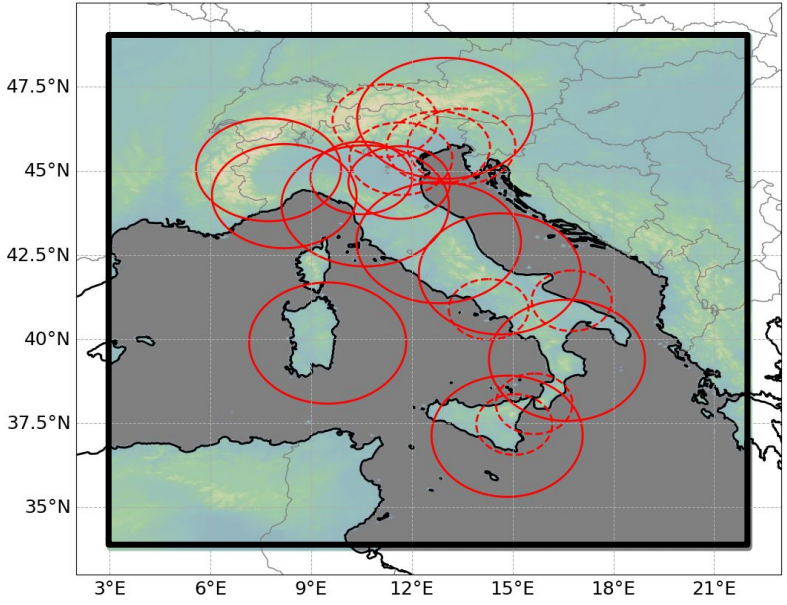
Outline

- Assimilation at 1 km resolution (*Virginia Poli, Thomas Gastaldo*)
- Assimilation of MHS data (*Marcello Grenzi*)
- Other activities on satellite data (*Francesca Vittorioso*)
- Assimilation of T2M and RH2M (*Thomas Gastaldo, Valerio Capecchi*)
- Reanalysis (*Antonio Giordani*)
- Implementation of soil moisture nudging (*Davide Cesari*)
- LHN impact (*Virginia Poli*)

Current status

Model setup: 2.2 km resolution, 65 levels; only shallow convection parametrization (no grayzone tuning)

ICON-2I domain



KENDA implementation:

- 40 members + deterministic run
- 1h assimilation cycles, employing IAU
- RTPS
- Control vector: pf, t, q, u, v, qcl, qci, qr, qs, qg

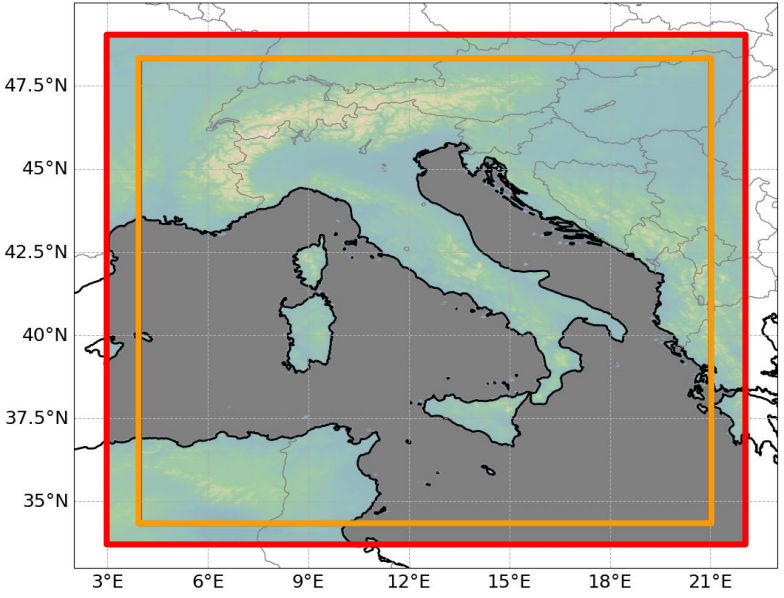
Assimilated observations:

- AIREP, TEMP, SYNOP (wind and surface pressure) and radar volumes (solid lines) of reflectivity and radial wind through KENDA
- radar estimated precipitation via LHN using the composite of all radars (solid+dashed lines)

Towards 1 km resolution: 2-way nesting

Model setup: **2.2 km** and **1.1 km** resolution; same namelist employed operationally except for topographic smoothing on the 1.1 km domain.

ICON-2I-NEST domain



Evaluation over a 5-days period (16-20 Oct. 2024).

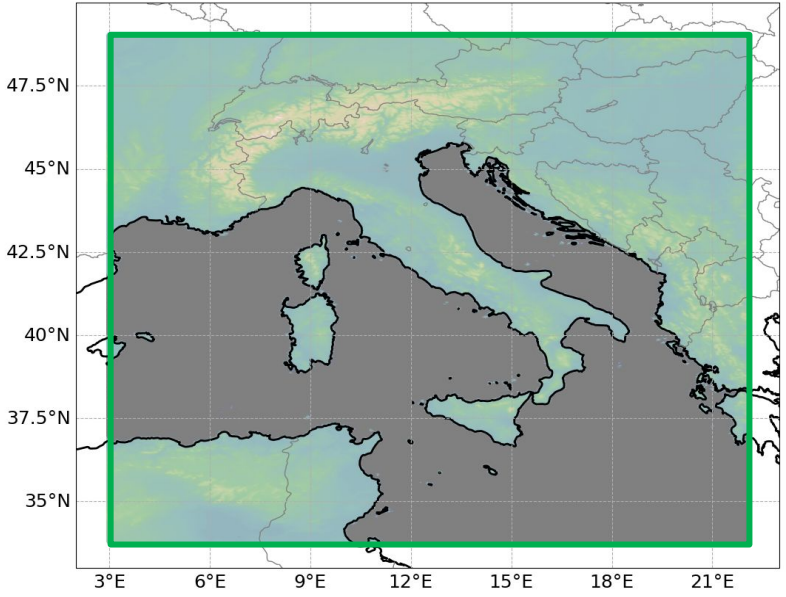
Results (shown at ICCARUS):

- Overall, very small positive impact compared to operational configuration.
- Using ICON-2I-NEST for analysis and forecast has a very limited effect on QPF accuracy compared to using it for forecast only.
- Precipitation structures on the 1.1 km nest appear broader than at 2.2 km, with lower maxima.

Towards 1 km resolution: 1.1 km tests

Model setup: 1.1 km resolution, 65 levels; same namelist employed operationally except for frcsmot: **0.2** → **0.0** (vertical smoothing of TKE; 0: no smoothing) and dt_gwd: **360** → **120**.

ICON-1I domain



Evaluation over a 5-days period (16-20 Oct. 2024).

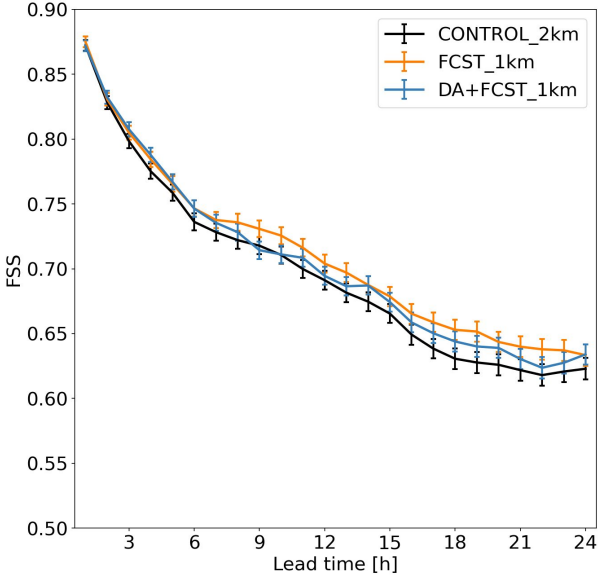
Three experiments compared:

- **CONTROL_2km**: data assimilation and forecast using ICON-2I operational setup.
- **FCST_1km**: forecast with ICON-1I initialized from CONTROL_2km analyses
- **DA+FCST_1km**: data assimilation and forecast with ICON-1I; KENDA uses the same namelist as CONTROL_2km

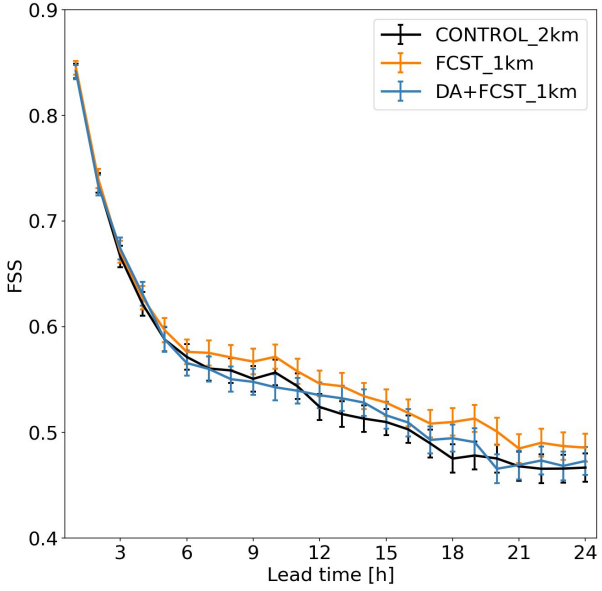
Towards 1 km resolution: QPF verification (FSS)

Verification of 24-h deterministic forecast initialized every 3h (33 forecasts per configuration)

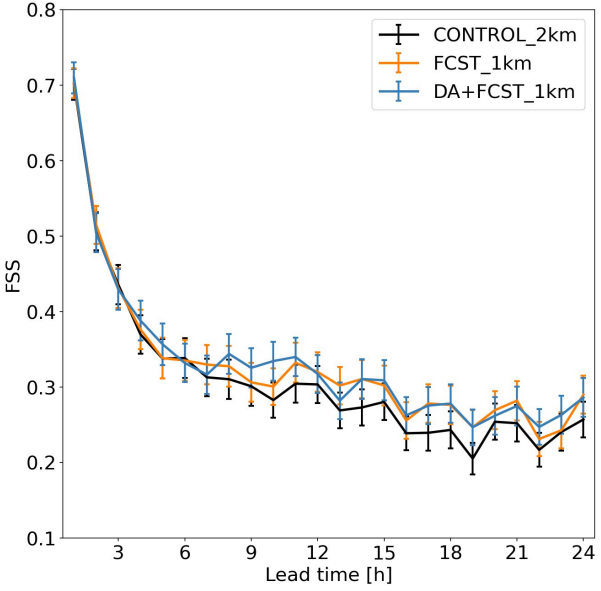
thr = 0.1 mm



thr = 1.0 mm

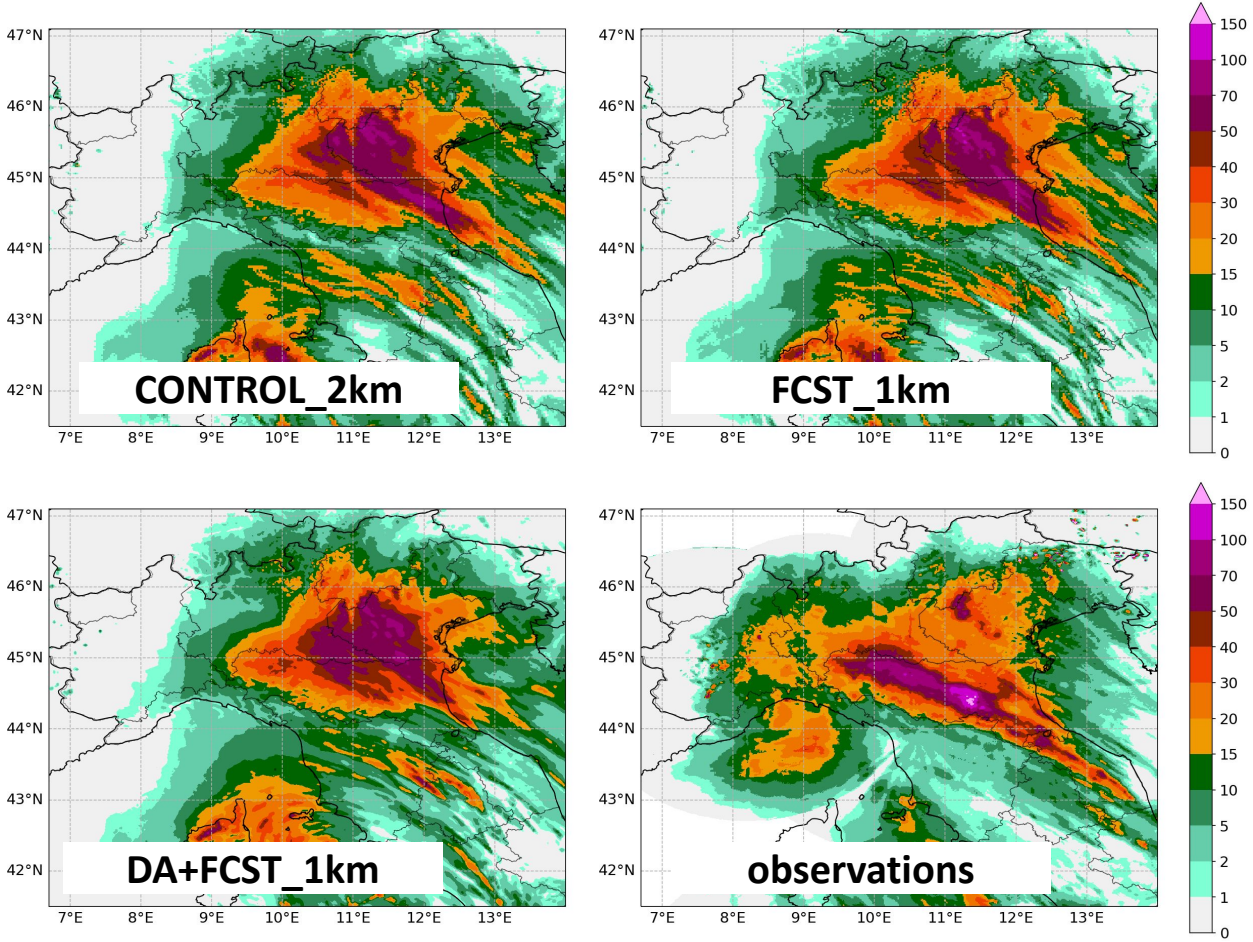


thr = 5.0 mm



Observations: hourly radar-estimated precipitation over Italy corrected with rain-gauges. Boxes: 0.2° x 0.2°

Towards 1 km resolution: Bologna flood

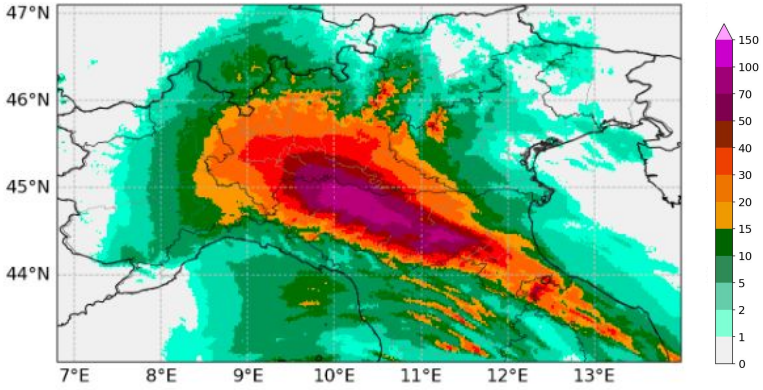


12h accumulated precipitation from 19/10 at 12 UTC to 20/10 at 00 UTC.

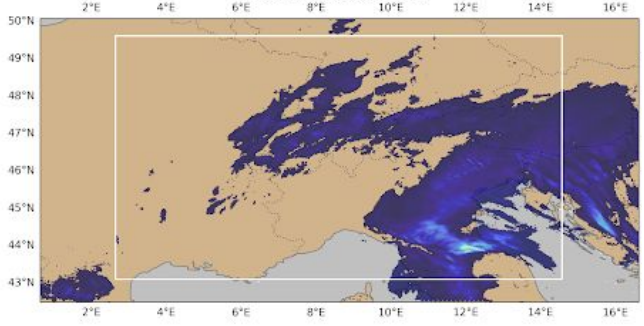
Run initialized at 12 UTC on 19/10

Towards 1 km resolution: Bologna flood in GLORI4DE

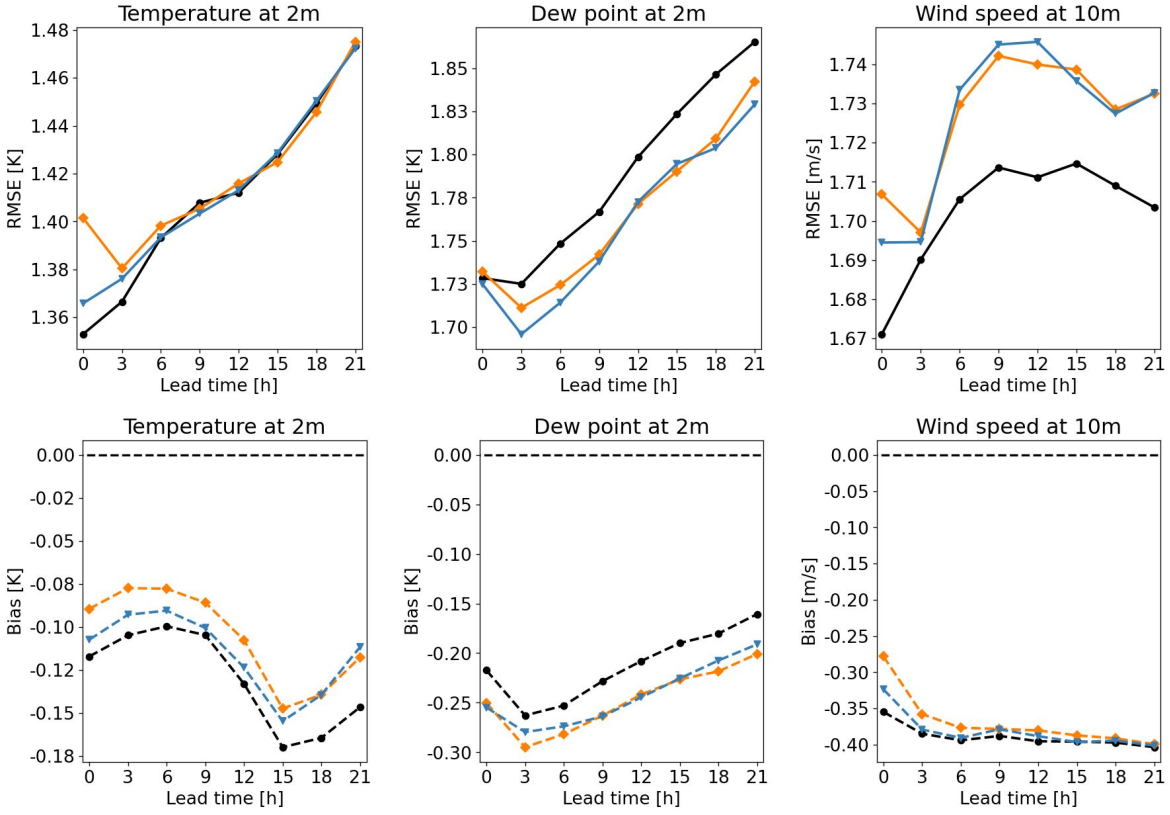
Simulations performed for the GLORI4DE project captured much better the event



- Same boundary conditions from IFS
- Different domain (with 2-way nesting)
- Different DA: only 20 members and only conventional observations assimilated



Towards 1 km resolution: near-surface variables



Satellite DA: MHS

Testing the assimilation of **humidity-sensitive microwave channels** from the Microwave Humidity Sounder (**MHS**)

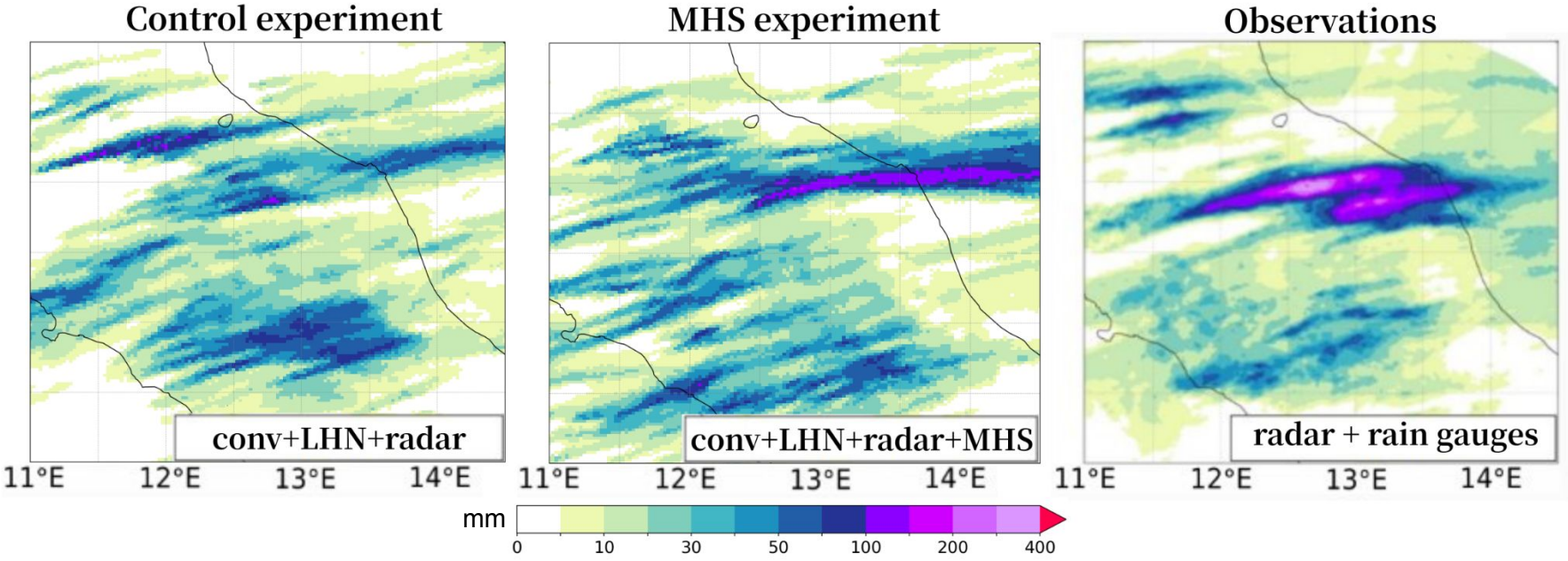
- Three channels peaking at different levels (lowest channel only over sea - experiments ongoing over land too)
- **Clear-sky** only (cloud detection - *Buehler et al. 2007*)
- No interchannel correlations and no bias correction applied
- Model & KENDA setup same as the operational system

Two 5-days experiments in September 2022 (severe convection event), presented at ICCARUS:

- **Control** (operationally assimilated obs.)
- **MHS** (operational obs. + MHS)

Currently experiments with the addition of **SEVIRI all-sky** data are also running: evaluate the benefit of combining infrared and microwave radiances.

MHS assimilation: daily accumulated rainfall

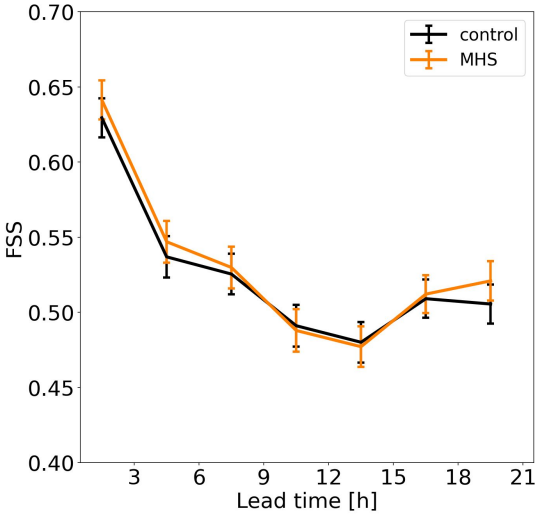


24h rainfall of 15 Sept. 2022 (forecast initialized at 00UTC), zoom over the area affected by the flood. MHS assimilation improves the forecast.

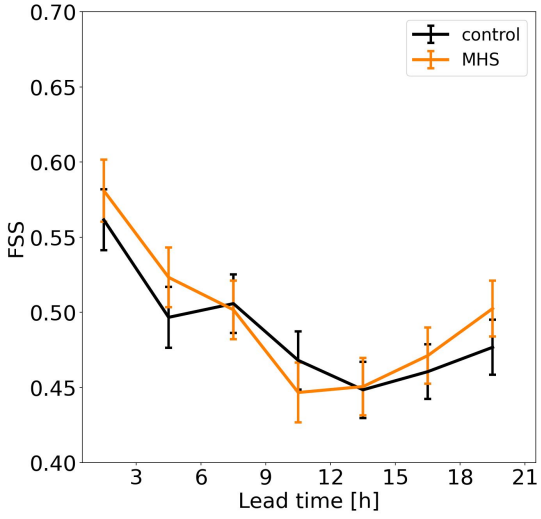
MHS assimilation: verification (FSS)

Verification of 21-h deterministic forecast initialized every 3h (40 forecasts per configuration)

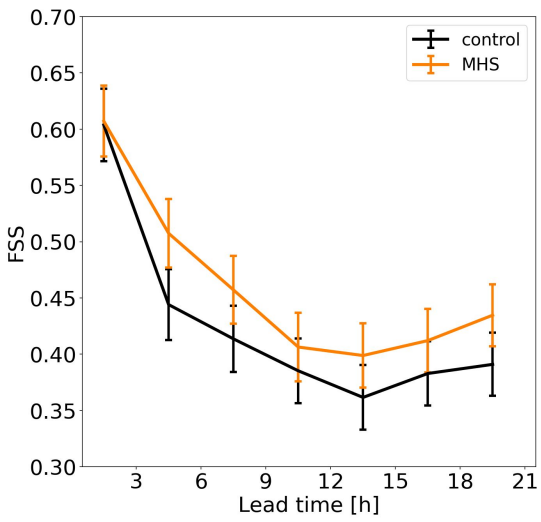
thr = 0.1 mm



thr = 1.0 mm

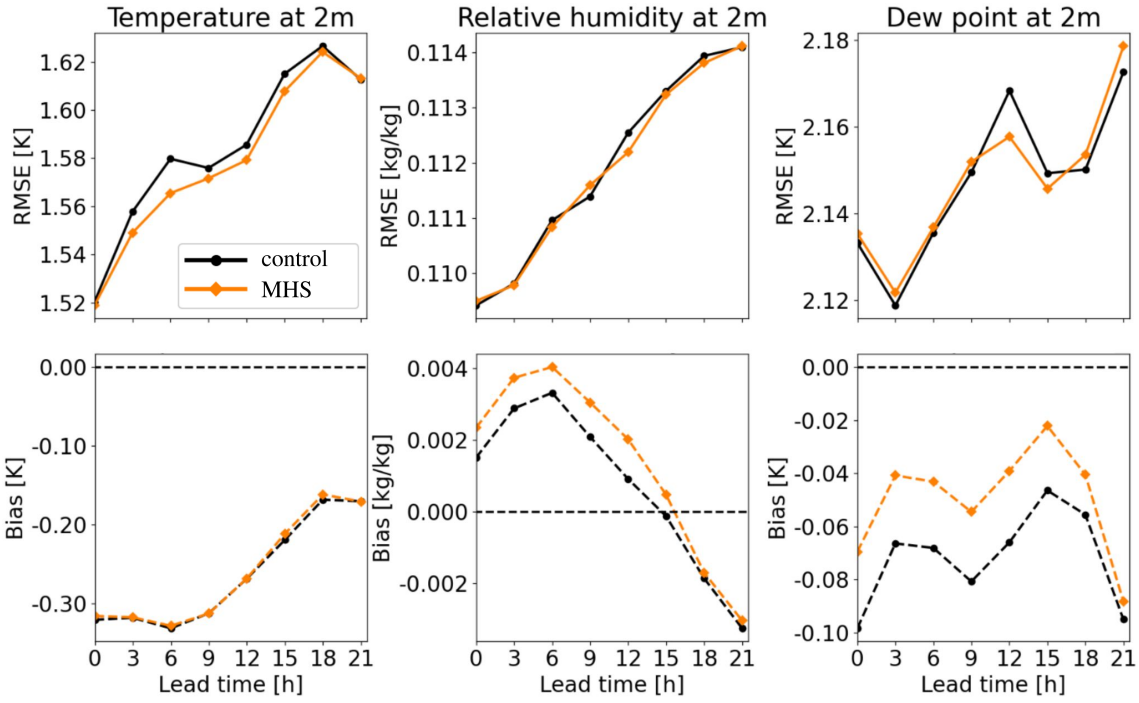


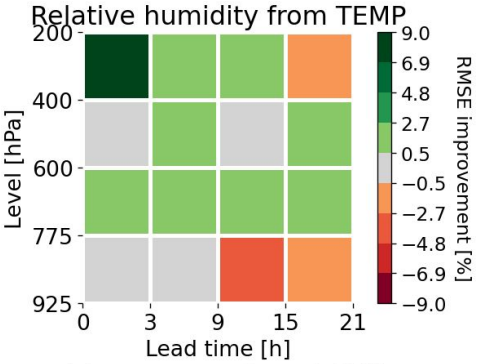
thr = 5.0 mm

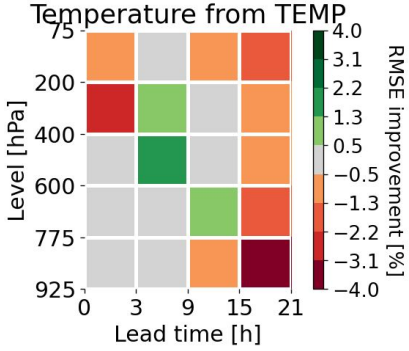


Observations: hourly radar-estimated precipitation over Italy corrected with rain-gauges. Boxes: 0.2° x 0.2°

MHS assimilation: surface and upper levels variables







Overall positive impact on surface variables and upper levels humidity. Neutral on wind and pressure (not shown).

Positive values (green): MHS experiment better

Satellite DA: ongoing activities

- **Pre-processing strategy under development**
  - Satellite data now received (since August) from EUMETSAT via the Terrestrial network
  - As no satellite data assimilation is yet performed at ItaliaMeteo, the focus is on setting up a robust **pre-processing chain**
  - Goal: ensure standardized, quality-controlled input data ready for future assimilation

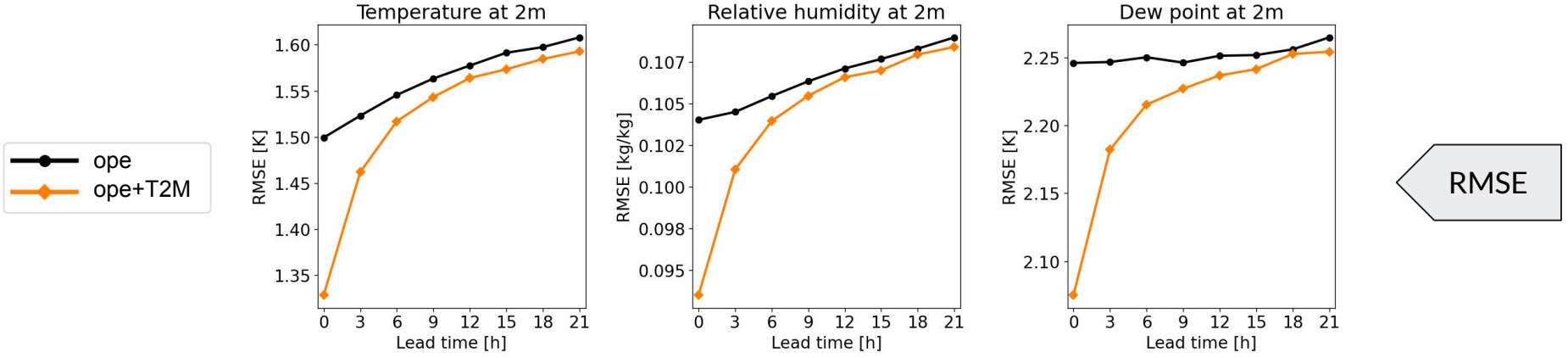
- **Discussion with DWD on common approach**
  - Exploring the possibility of adopting or adapting the DWD pre-processor (sat_pp)
  - Potential for joint documentation and knowledge transfer
  - Opportunity to **harmonize practices within the COSMO community**, reducing duplication and facilitating interoperability

Satellite DA: upcoming activities

- **Assimilation of infrared atmospheric sounder data**
  - Kick-off of activities aimed at studying the impact of assimilating IASI and IASI-NG observations
  - These first experiments will prepare the ground for future work with IRS
  - Longer-term goal: establish operational assimilation of hyperspectral IR sounder data

Assimilation of T2M and RH2M

Tests conducted on two periods of 3 weeks period in summer and spring showed a strong improvement in T2M and RH2M forecasts, slight improvement on QPF and an overall neutral impact on other variables (shown at ICCARUS)

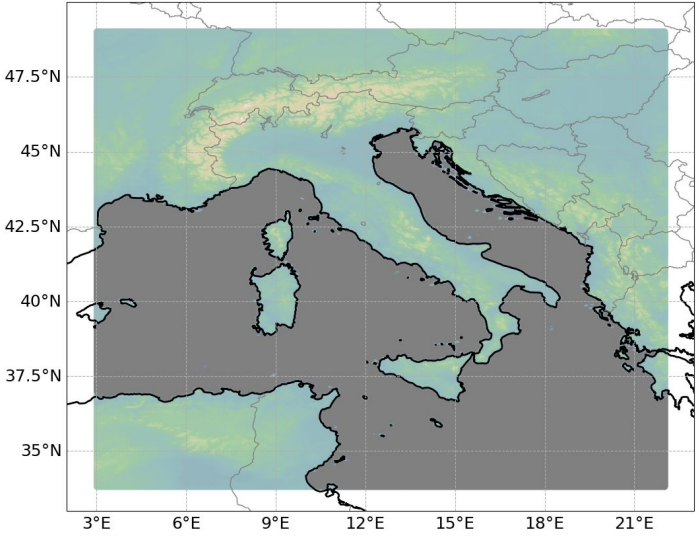


Work is ongoing to evaluate the impact on a winter case with strong inversions and to perform an in-depth analyses at single stations.

Reanalysis

Planned the development of **I-DREAM-IT** (**I**con-**DREAM** over **IT**aly)**:**

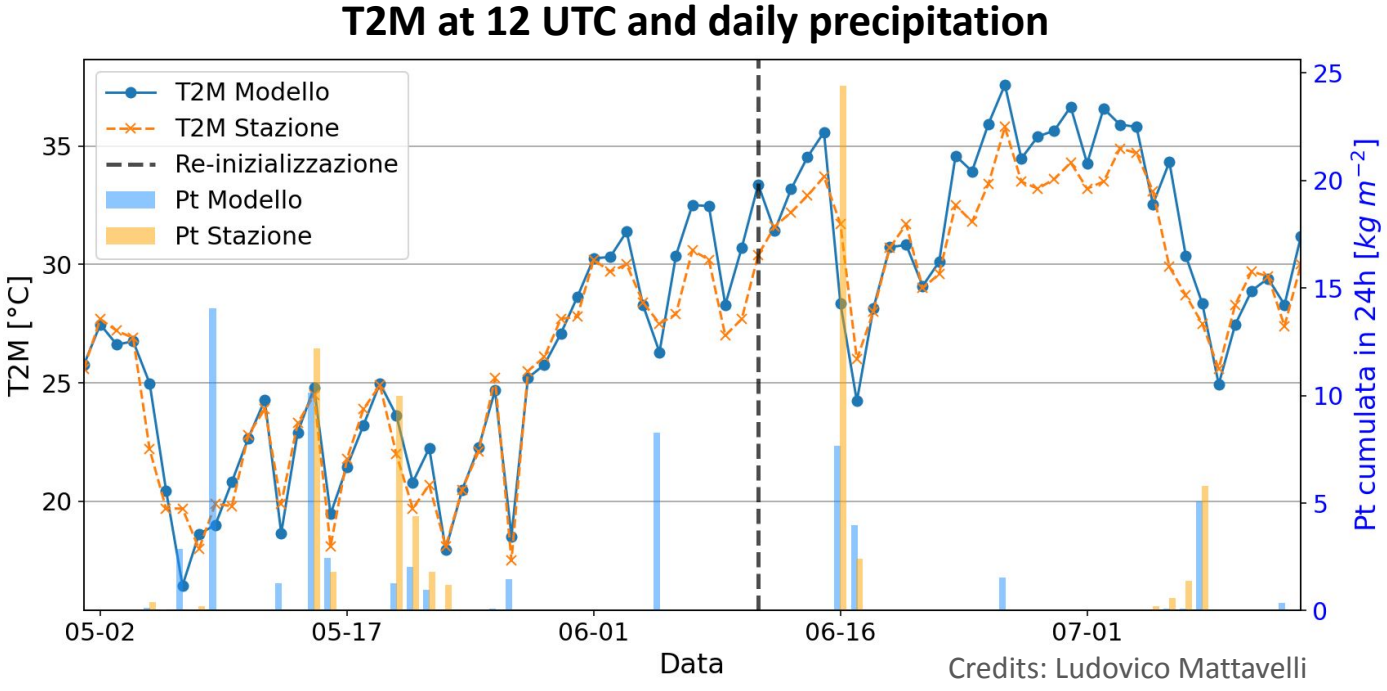
- A new limited-area regional reanalysis dataset at convection-permitting resolution over Italy
- ICON-2I (2.2 km) resembling operational + BC from EU nest of ICON-DREAM reanalysis (DWD)



- DA of conventional (+ possibly satellites) through LETKF + radar data via LHN.
- Up to now recent Italian products based on downscaling of ERA5 or including nudging of conventional data only
- Spanning 2010-2025 (ICON-DREAM availability), back and forth extensions envisaged
- Archiving of sfc, upper air variables and vertical integrals
- Will be available to train data-driven models
- Know-how sharing within COSMO consortium

Implementation of soil moisture nudging

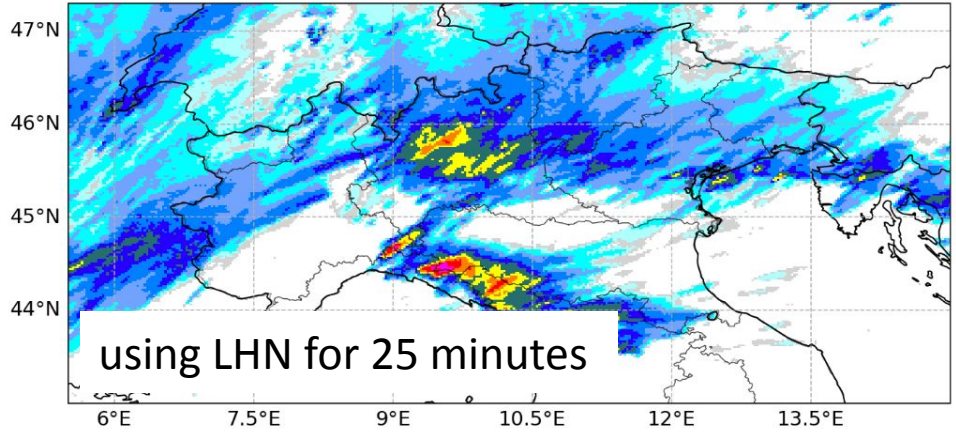
The implementation of the nudging of soil moisture towards ICON-EU is ongoing. It will be tested on different periods

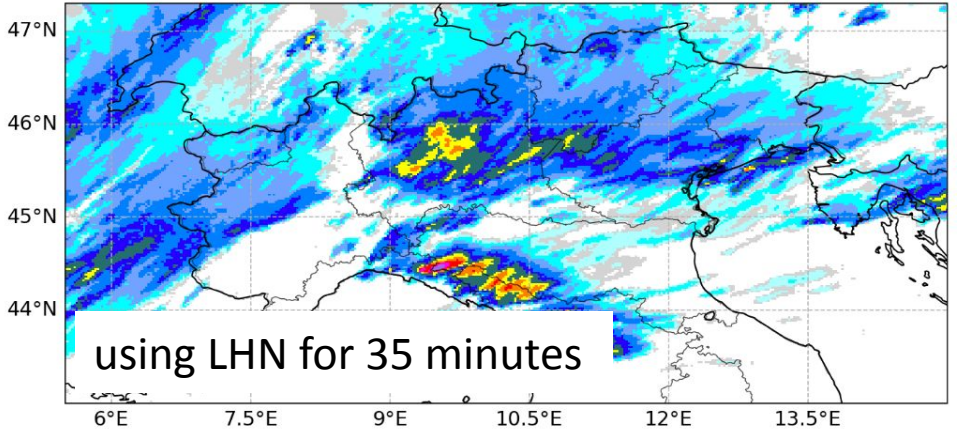


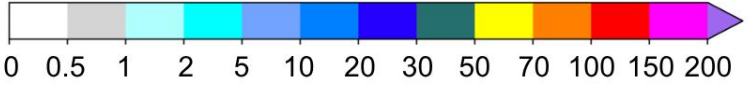
LHN impact

In our forecast (both ICON-2I and ICON-2I RUC) we apply LHN in the few minutes after the analysis.
The different duration of the lhn, even if only 10 minutes, changes the forecasted accumulated precipitation.

Run: 19/08/2025 - 12 UTC
Accumulated precipitation between +12 and +24







Thank you for your attention!