SPOKE 03

Funded by the European Union NextGenerationEU | Ministero dell'Università e della Ricerca | Italiadomani PIANO NAZIONALE DI RIPRESA E RESILIENZA | RAISE

cima RESEARCH FOUNDATION

Quality Control and Observation Thinning for 2-metre Temperature Assimilation in an Operational Convective Nowcasting Framework

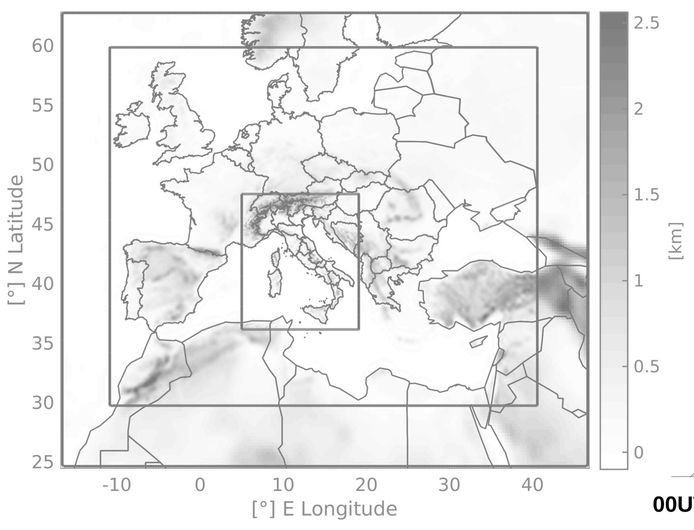
Francesco Uboldi, **Elena Oberto**, Massimo Milelli, Andrea Zonato, Martina Lagasio, and Antonio Parodi
CIMA Foundation, Meteorology and Climate, Savona, Italy (elena.oberto@cimafoundation.org)

Abstract

This study explores the effect of assimilating 2-metre temperature (T2M) observations into an operational convective-scale nowcasting system based on the 2.5 km WRF model. The system already integrates radar reflectivity (3DVAR) and lightning data (nudging) to provide high-frequency forecasts supporting real-time civil protection decisions. The analysis, focused on August 2024, employs T2M observations from the Italian Civil Protection Department and MeteoNetwork (MNW, https://www.meteonetwork.eu/it), which collects private amateur data. A unified automated quality control (QC) procedure includes metadata validation and quality checks on observed values, mainly based on the Spatial Consistency Test (SCT, Lussana *et al.*, 2010). The QC procedure is applied to T2M observations before assimilation. The standard WRFDA internal consistency test further removes observations diverging from the short-range forecast background. This research is conducted within the PNRR RAISE initiative - Spoke 3, which develops innovative technologies for environmental safeguard in water, air, and soil domains over the Ligurian region.

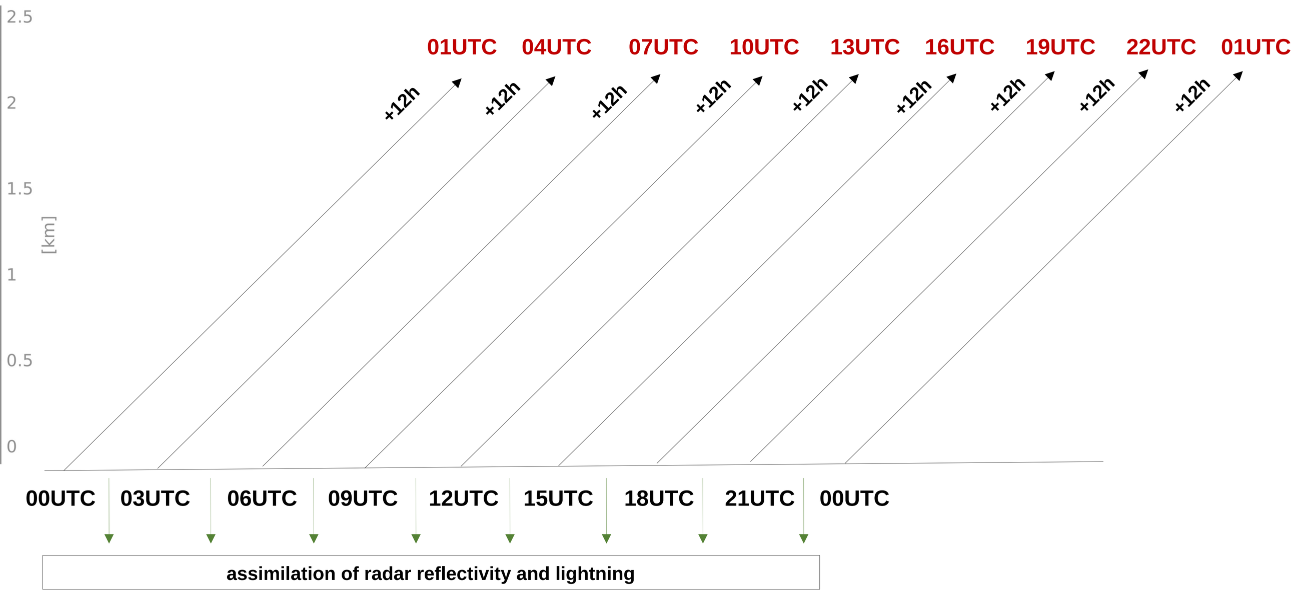
WRF-DA-ITA 2.5 KM: run DA - 00 and 12UTC (@CIMA)

3 nested domains: 22.5, 7.5, and 2.5 km. 50 vertical levels. Initialized with GFS data.

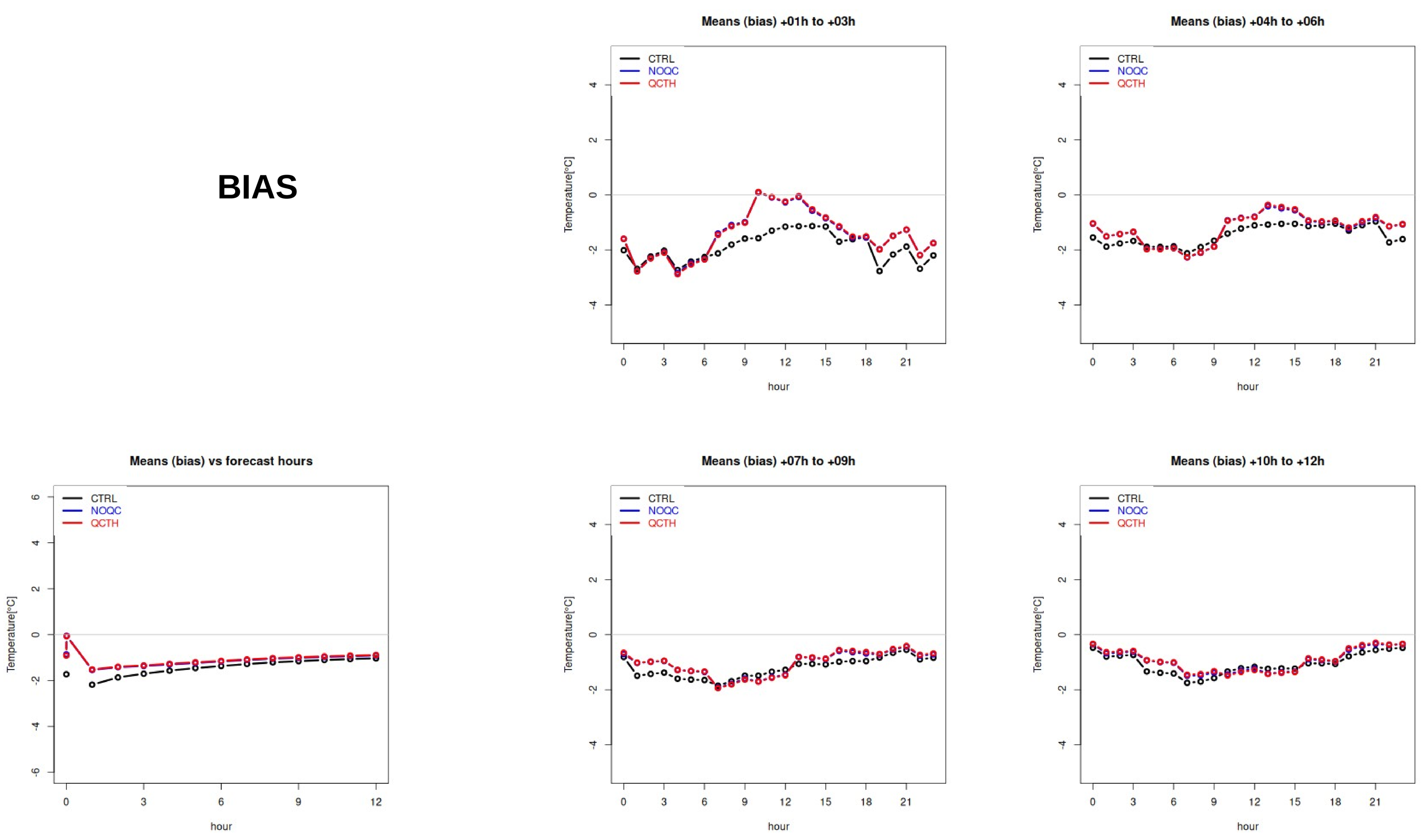


RUC (Rapid Update Cycle) WRF nowcasting

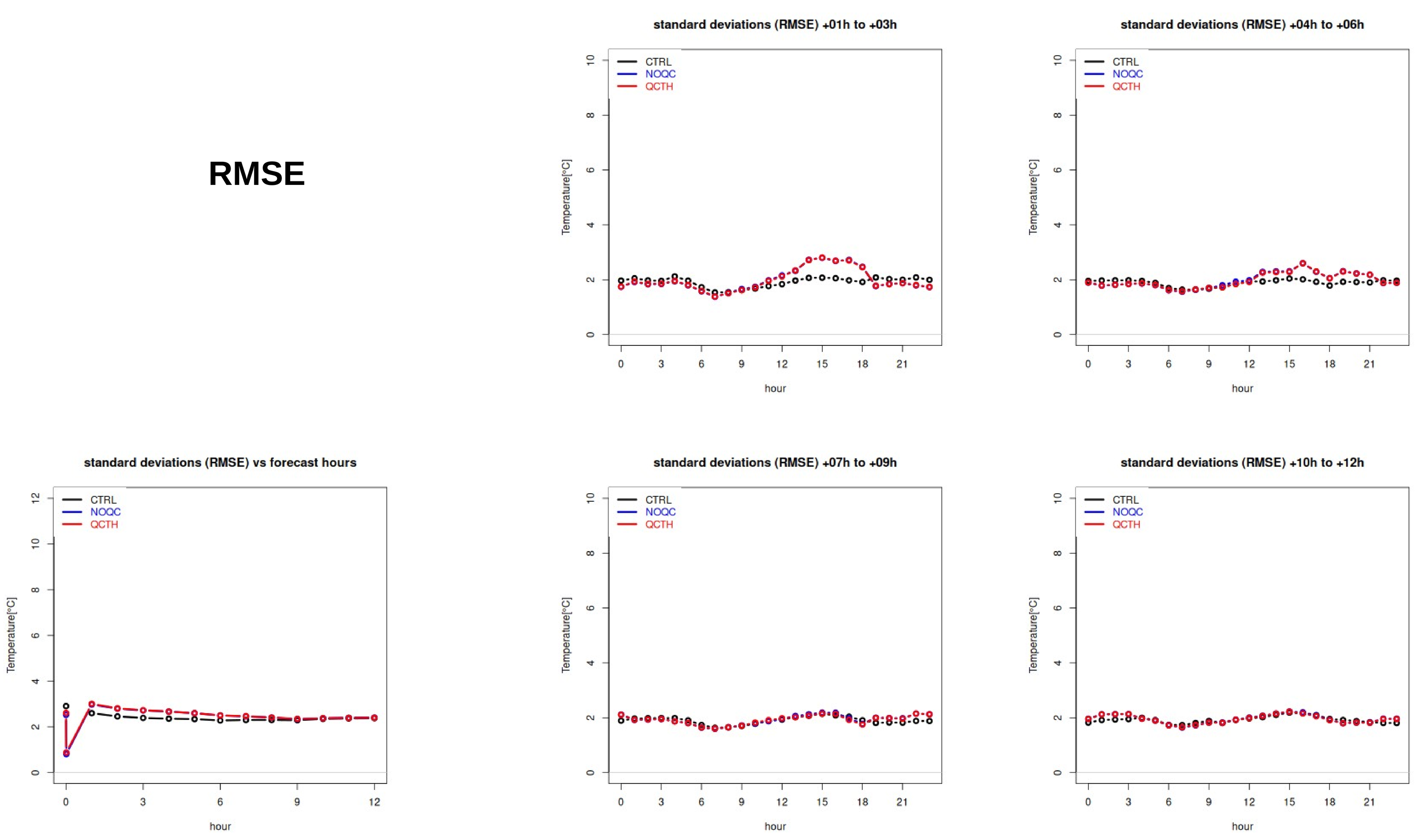
Rapid Update Cycle (RUC) scheme with 8 runs per day up to +12h: assimilation of radar data (reflectivity) and lightning from the LAMPINET network



BIAS



RMSE



QC data and the experiment

Automatic Quality Control (QC) Procedure applied to both DPC and MNW datasets to build a nationwide, high-resolution network of 2-m temperature (T2M) observations, to ensure data consistency, reliability, and spatial consistency.

1. Metadata Validation checks station coordinates to detect duplicates (of coordinates and of data series). It verifies station elevation against high-resolution digital elevation models (DEM).

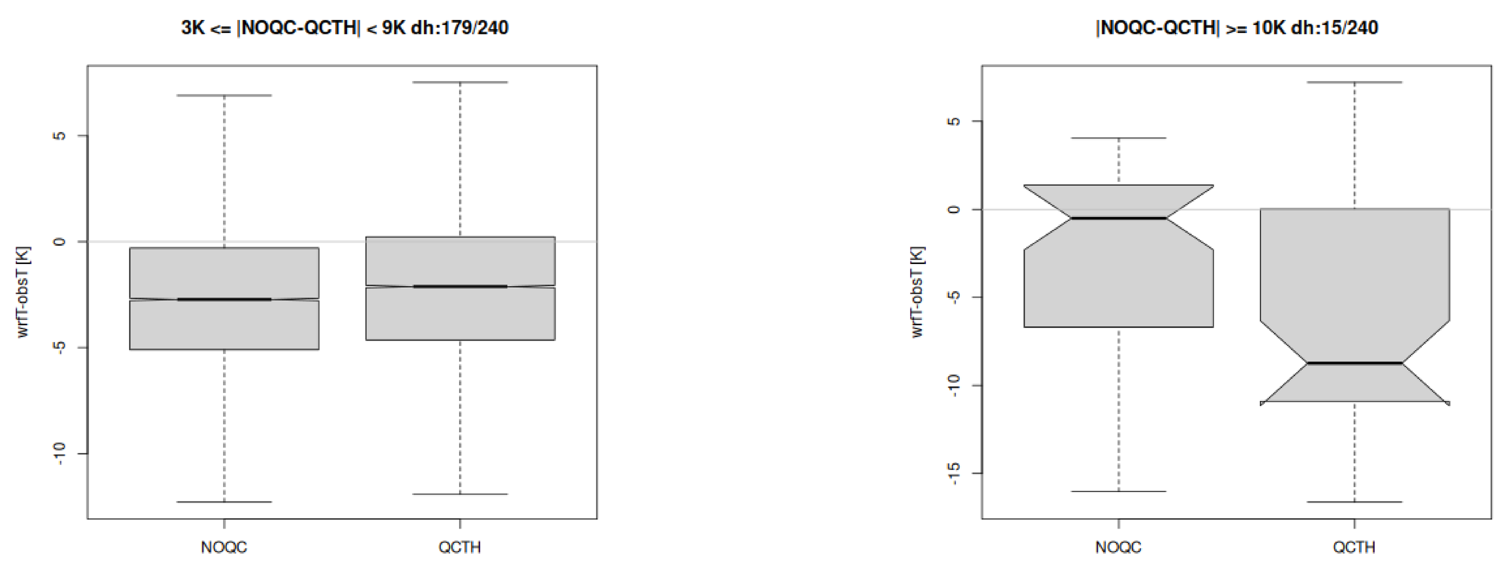
2. QC checks on Observed Values are formulated in an Optimal Interpolation context and include a preliminary "Background Field" (BF) check and the finer Spatial Consistency Test (SCT, Lussana et al., 2010), based on the availability of the leave-one-out Cross-Validation (CV) analysis. QC checks are routinely performed on temperature and relative humidity observations. Temperature observations only are assimilated in this study.

Assimilation experiments

Two assimilation experiments are performed and compared with the operational run of August 2024, labelled **CTRL**, which does not make use of T2M *in situ* observations:

NOQC: T2M observations are assimilated without automatic QC checks. Only QC included in WRFDA 3D-Var is applied;

QCTH: T2M dataset undergoes automatic QC and THinning before assimilation. The **IDI** (Integral Data Influence) and **CV-IDI** (leave-one-out Cross Validation IDI) values are combined to assess observational redundancy, supporting data thinning for assimilation.



QCTH improves in 179 / 240 moderate error cases (times) QCTH worsens in 15 / 240 large error cases (times)

- Both NOQC and QCTH, by assimilating T2M, reduce bias with respect to CTRL, not only in the first forecast hours, but more pronounced during the first hours of the forecast in the central part of the day.
- Both NOQC and QCTH, compared to CTRL, worsen forecast RMSE in the afternoon hours.
- No significant differences emerge between NOQC and QCTH in the monthly statistics because their differences are localized in space and time, being due to different data rejections.
- QCTH reduces bias compared to NOQC when considering maximum differences between 3–4 K and 7–8 K.
- QCTH worsens bias compared to NOQC for larger differences (above 7 K, especially above 8 K): possibly due to harmful interaction with the assimilation of reflectivity and lightning and vertical propagation of surface inconsistencies by vertical correlations → further investigation needed

Results show an important impact of the assimilation of T2M *in situ* observations, lasting several hours into forecast time. A general bias reduction is obtained, although, for both NOQC and QCTH, the root-mean-square error on T2M appears increased with respect to CTRL for forecast from +1 hour to +3 hours in the afternoon of this summer convective case. Differences between NOQC and QCTH do not significantly appear in monthly statistics: differences between NOQC and QCTH are localized in space and time. QCTH performs better when errors are moderate but can worsen forecasts in cases of very large errors due to vertical propagation of surface inconsistencies by vertical correlations. Further investigation is needed to optimize T2M assimilation.

Acknowledgements: We are grateful to **MeteoNetwork Association** for data availability

References

F. Uboldi, C. Lussana and M. Salvati, 2008. Three-dimensional spatial interpolation of surface meteorological observations from high-resolution local networks. *Meteorological Applications*, **15**, 331-345, doi: 10.1002/met.76 and erratum, doi: 10.1002/met.108

C. Lussana, F. Uboldi and M. R. Salvati, 2010. A spatial consistency test for surface observations from mesoscale meteorological networks. *Quarterly Journal of the Royal Meteorological Society*, **136**, 1075-1088, doi: 10.1002/qj.622