# Impact of the observational error in the assimilation of radar reflectivity volumes

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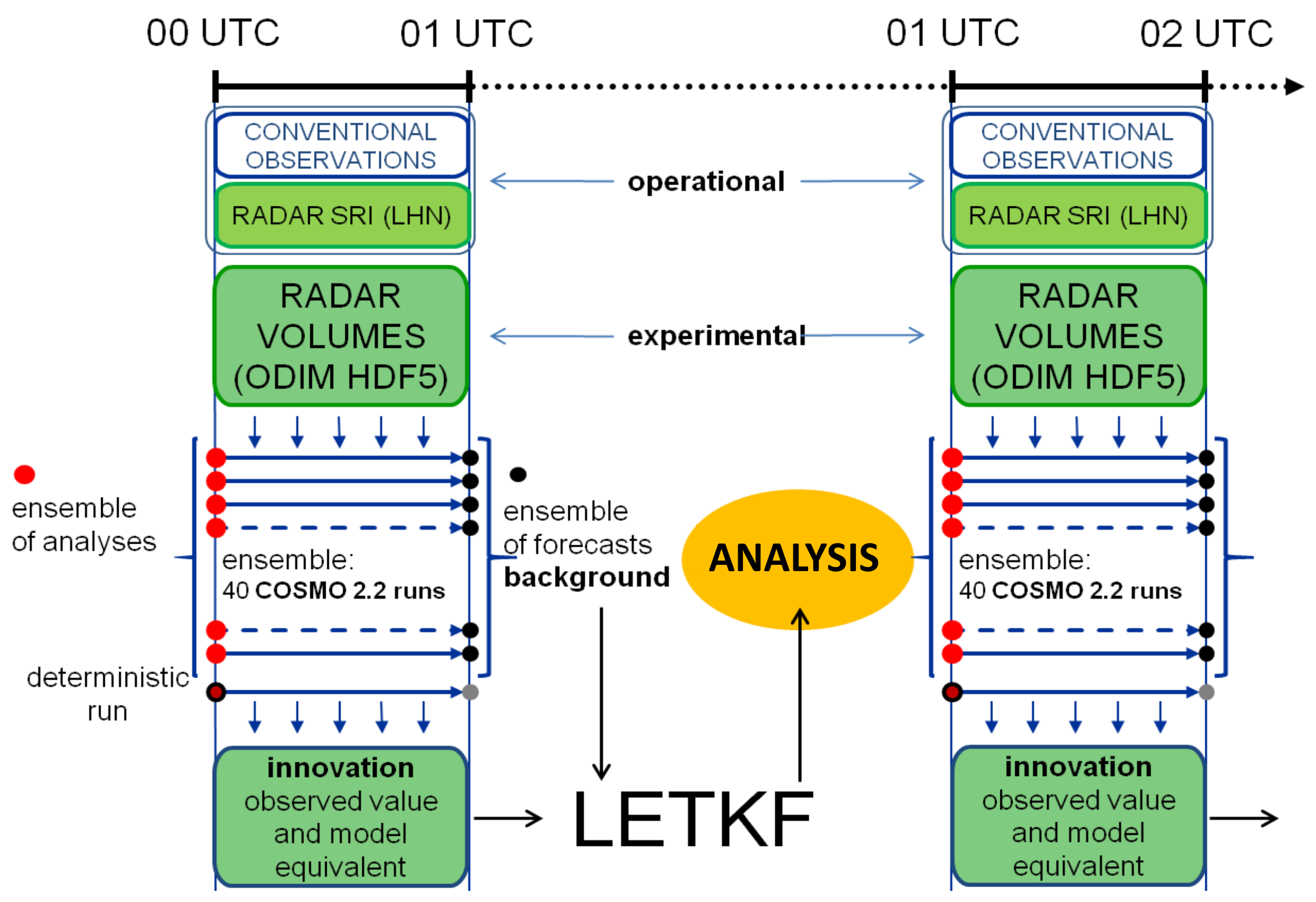
## INTRODUCTION

An ensemble data assimilation system at the convection permitting scale (KENDA)[1], based on the LETKF scheme[2], has been developed for the non hydrostatic numerical weather prediction model of the Consortium for Small-scale Modeling (COSMO)[3]. This system is operational at Arpae (Hydro-Meteo-Climate Service, Bologna, Italy) since May 2017. Currently, only conventional observations are assimilated and a latent heat nudging (LHN) based on the precipitation estimated from the Italian radar network is performed on each member of the ensemble.

To fully exploit the potential of KENDA, non conventional data have to be employed. In particular, at Arpae are ongoing tests to evaluate the impact of the assimilation of reflectivity volumes from the Italian radar network. At present, very few studies have been carried out to investigate the impact of the reflectivity observational error (*roe*), despite its relevance. Three main sources of error contribute to determine its value: instrumental error, representativity error and error introduced by the observation operator. Due to the complexity of evaluating each of these components, the estimation of the appropriate value of *roe* is not straightforward and it seems reasonable that it may depend on the radar characteristics, on the height and range of the observation and on the particular synoptic condition. For this reason the first estimation is performed separately for each radar since the Italian radar network is inhomogeneous both in the acquisition strategy and from an instrumental point of view.



*References:*

*[1] Schraff et al., 2016, Kilometre-scale ensemble data assimilation for the COSMO model (KENDA). Q.J.R. Meteorol. Soc. 142, 1453-1472.*

*[2] Hunt et al., 2007, Efficient data assimilation for spatiotemporal chaos: a local ensemble transform Kalman filter, Physica D: Nonlinear Phenomena, 230, 1-2, 112-126, Elsevier.*

*[3] www.cosmo-model.org*

## ESTIMATION OF THE OBSERVATIONAL ERROR

The method employed to estimate the observational error is based on the expected value of the product between background and analysis innovations[4]:

$$E[\boldsymbol{d}_a^o(\boldsymbol{d}_b^o)^{\mathrm{T}}] \cong \mathbf{R}$$

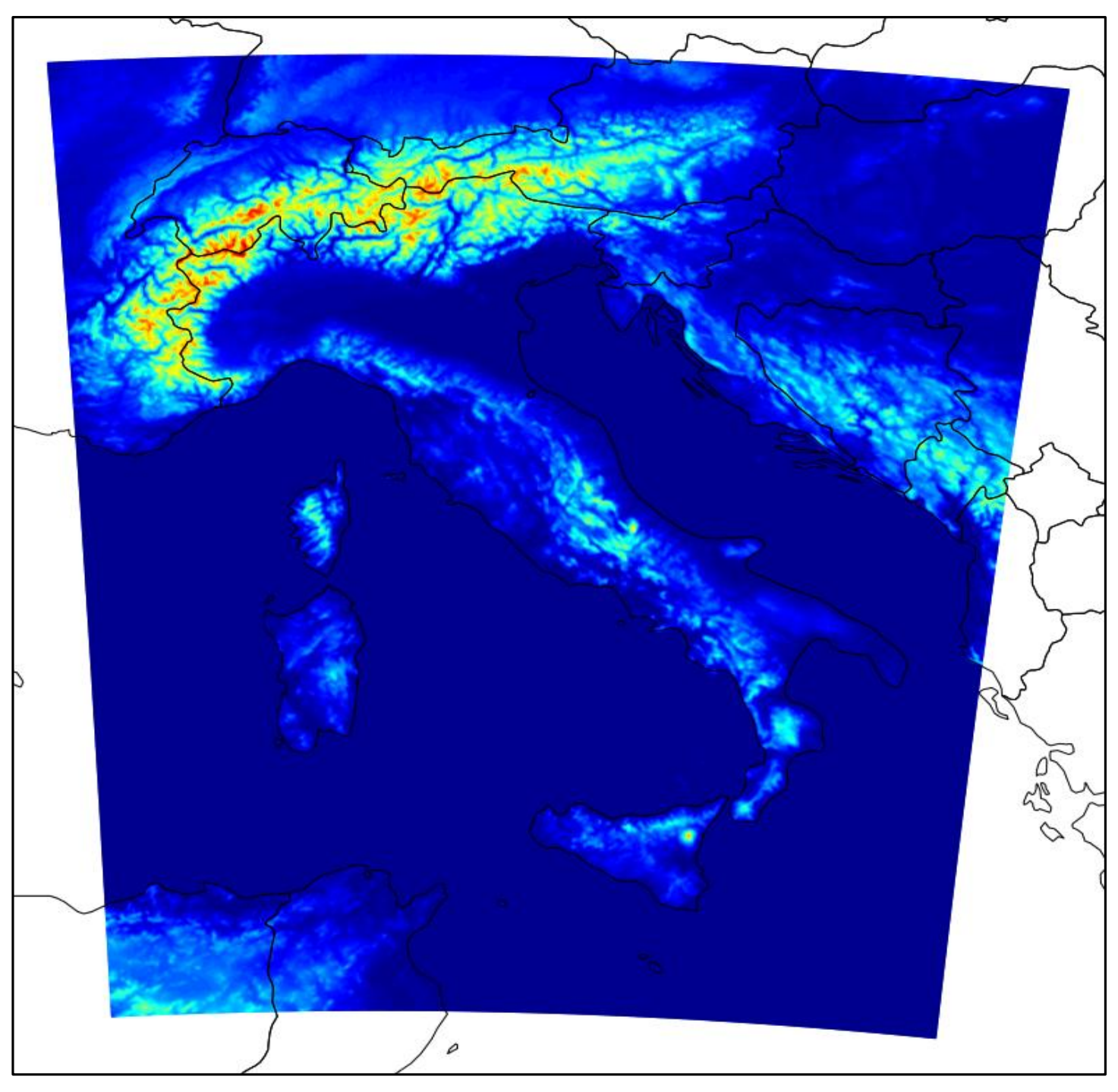
where

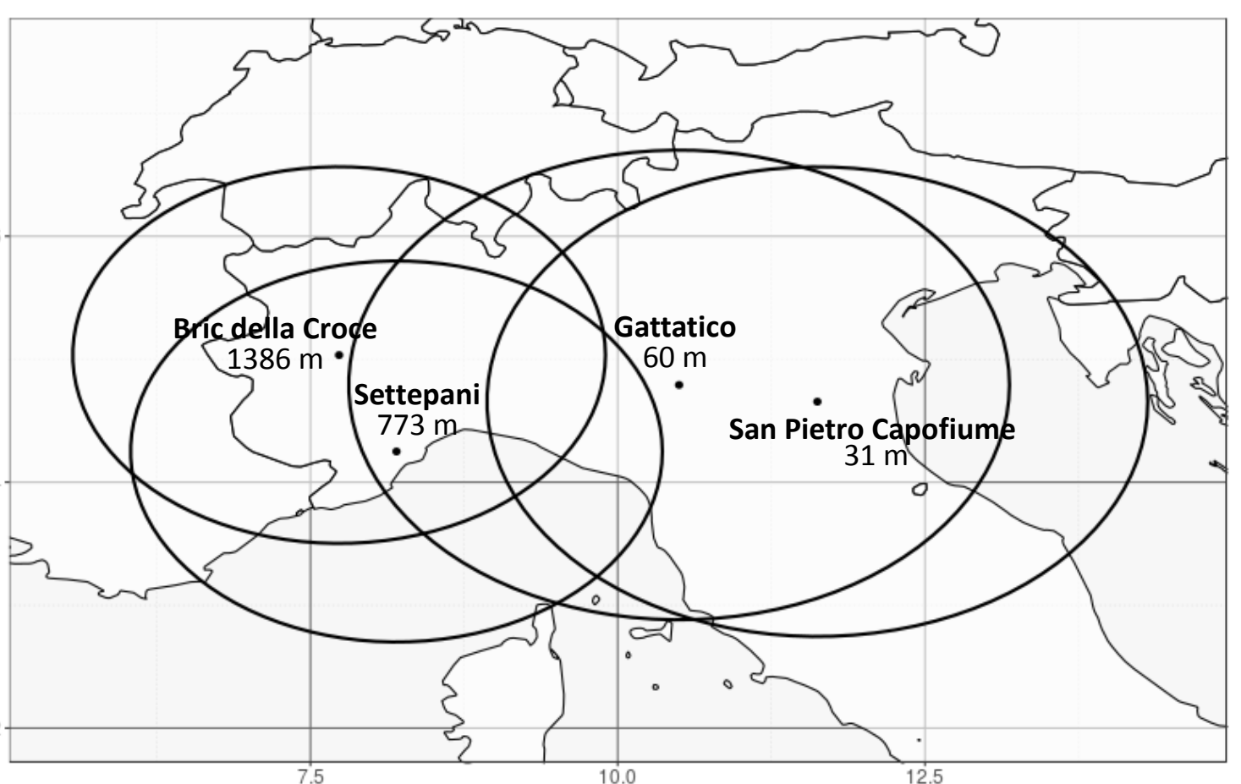
$$\boldsymbol{d}_a^o = \boldsymbol{y} - H(\boldsymbol{x_a}) \quad \text{and} \quad \boldsymbol{d}_b^o = \boldsymbol{y} - H(\boldsymbol{x_b})$$

Applying this statistics to all the reflectivity observations assimilated in the case study described here, we found an estimated value of roe equal to 5 dBZ.

*[4] Desroziers et al., 2005: Diagnosis of observation, background and analysis-error statistics in observation space, Quarterly Journal of the Royal Meteorological Society, 131, 3385-3396.*

## EXPERIMENTAL SET-UP





A 4 days period from 3 to 7 February 2017 is considered. The value of *roe* = 5 dBZ (same value for all observations) is used to test the assimilation of reflectivity volumes from 4 radars on Northern Italy (bottom left figure), employing an assimilation window of 60 minutes (*rad60_roe5*) and 15 minutes (*rad15_roe5*). Results are compared to those obtained employing *roe* = 10 dBZ (*rad60_roe10* and *rad15_roe10*), which is the value adopted in a previous study[5] to assimilate volumes from the German radar network using KENDA, and to those obtained assimilating only conventional observations (*conv60* and *conv15*).

The common set-up for all the experiments is the following:

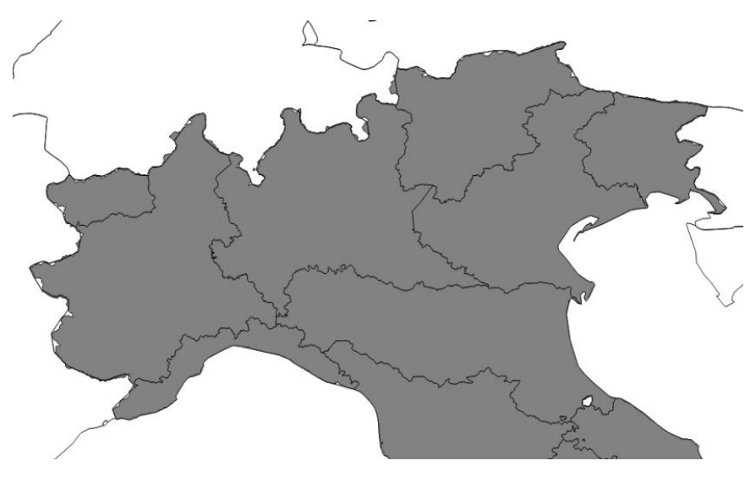
- **Model:** COSMO al 2.2 km horizontal resolution over the Italian domain (top left figure)
- **Ensemble:** 20 members with boundary conditions from LETKF ensemble of COMET (10 km horizontal resolution)
- **Deterministic run:** boundary conditions from COSMO-5M (5 km horizontal resolution)
- **Assimilation:**
  - LHN based on rain rates derived from the Italian radar network
  - conventional data (SYNOP, TEMP, AIREP)
- **Perturbations:** soil moisture and SST.

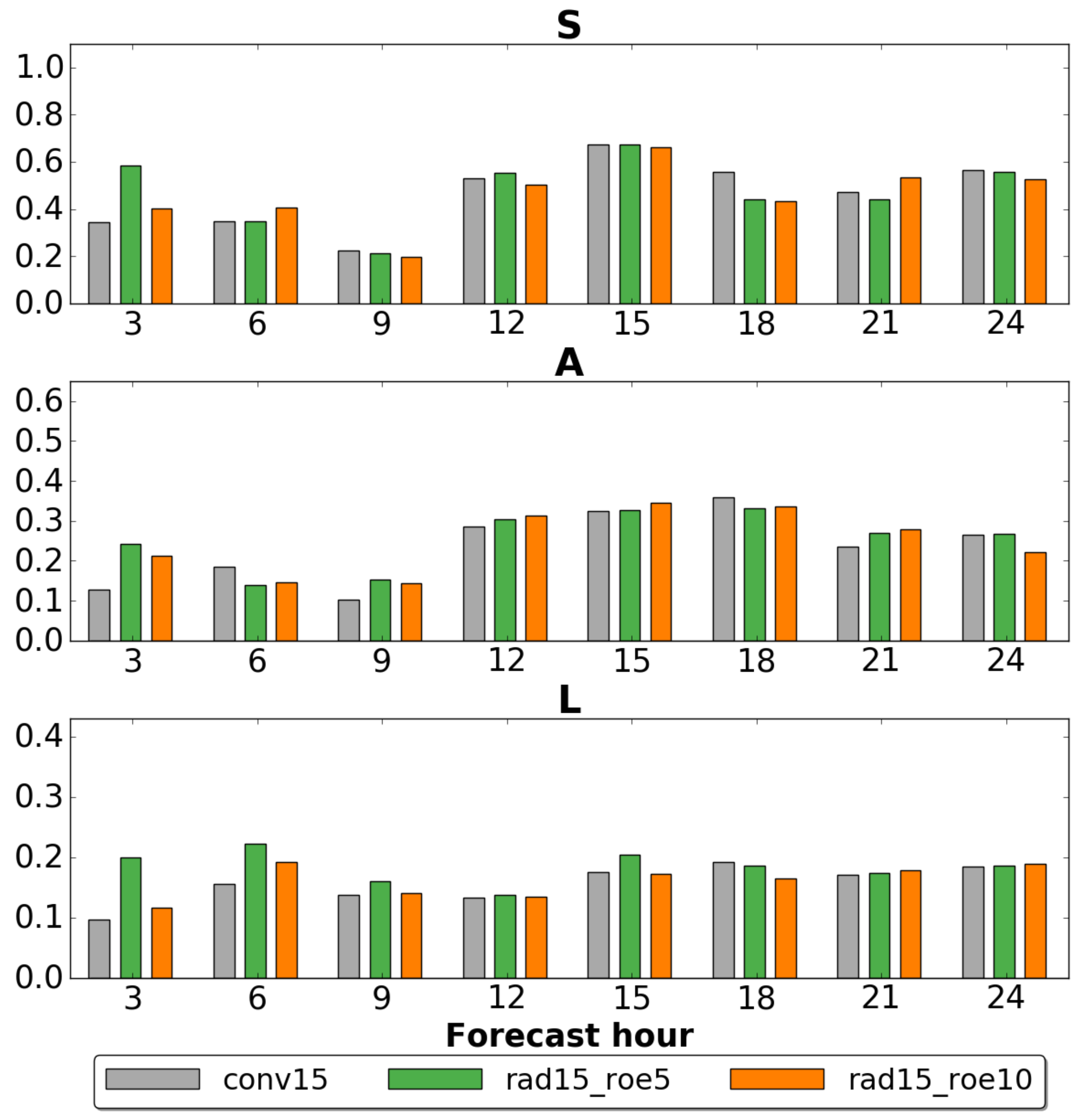
*[5] Bick et al., 2016: Assimilation of 3D radar reflectivities with an ensemble Kalman filter on the convective scale, Quarterly Journal of the Royal Meteorological Society, 142, 1490–1504.*

## RESULTS

To evaluate the quality of analyses produced with the configurations described in the "Experimental set-up" block, for each experiments 5 forecasts are initialized at different analysis time (4 February at 00 UTC and 12UTC, 5 February at 00 UTC and 12UTC and 6 February at 00 UTC).

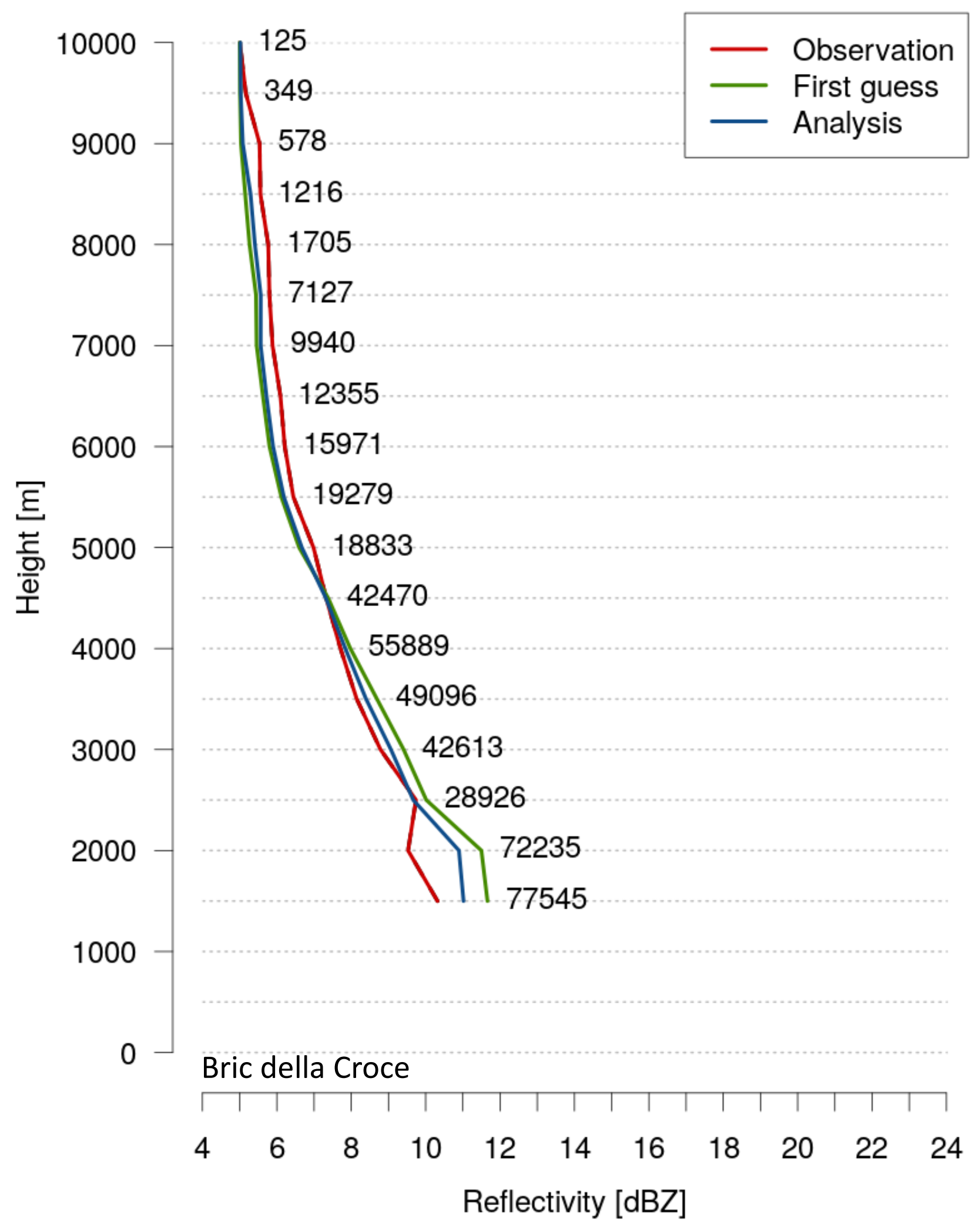
The SAL technique[6] is applied for the verification of 3-hourly accumulated precipitation over the domain on the right, using as reference the precipitation estimated from radars and corrected by rain-gauges. The average over the 5 forecasts of the absolute value of each component of SAL is plotted as a function of forecast hour.

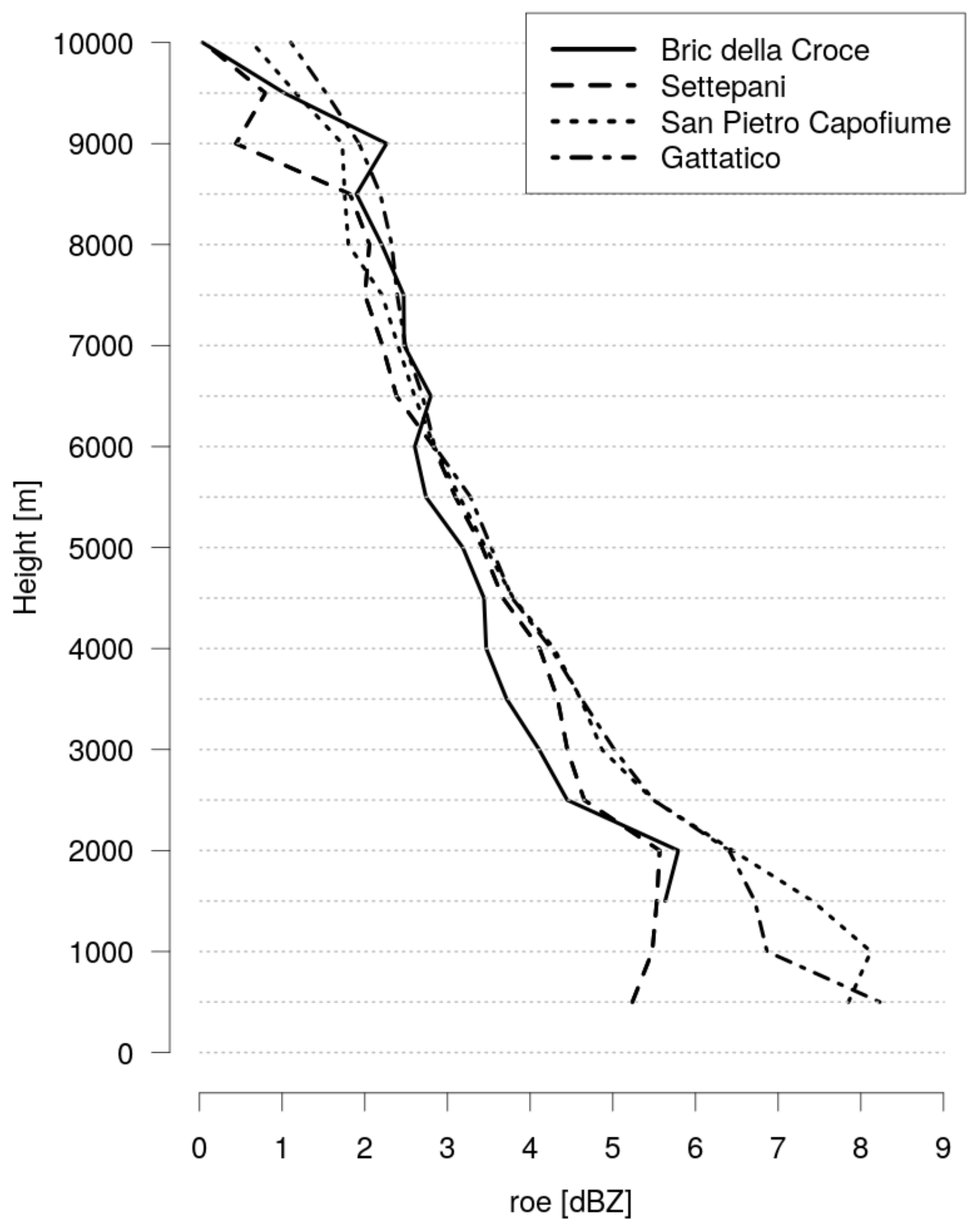




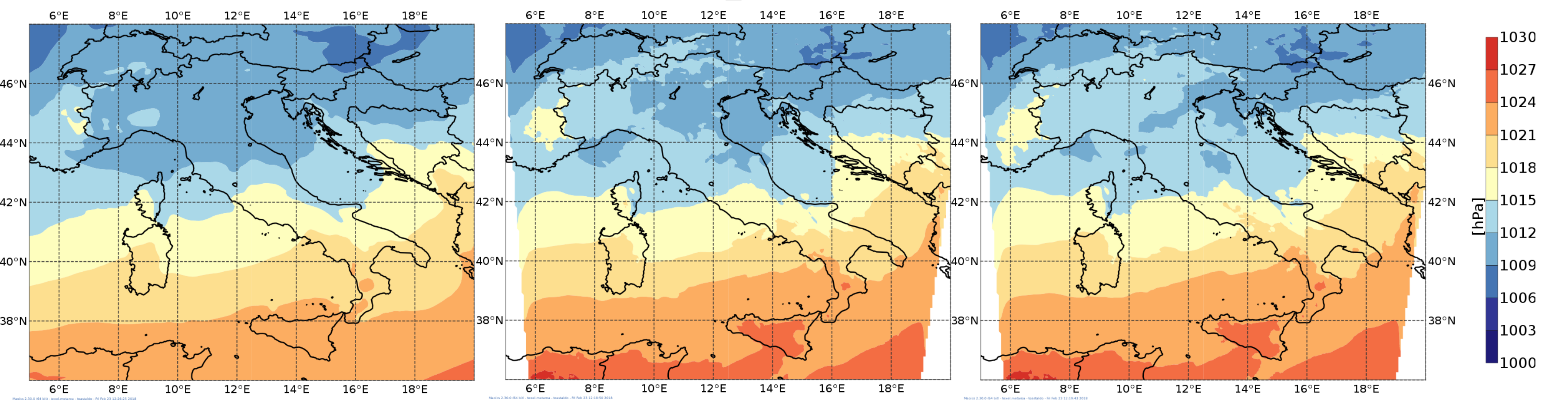
*[6] Wernli et al., 2008,. SAL: A Novel Quality Measure for the Verification of Quantitative Precipitation Forecasts. Monthly Weather Review, 136(11), 4470-4487.*

## ESTIMATION OF THE OBSERVATIONAL ERROR: individual radar stations

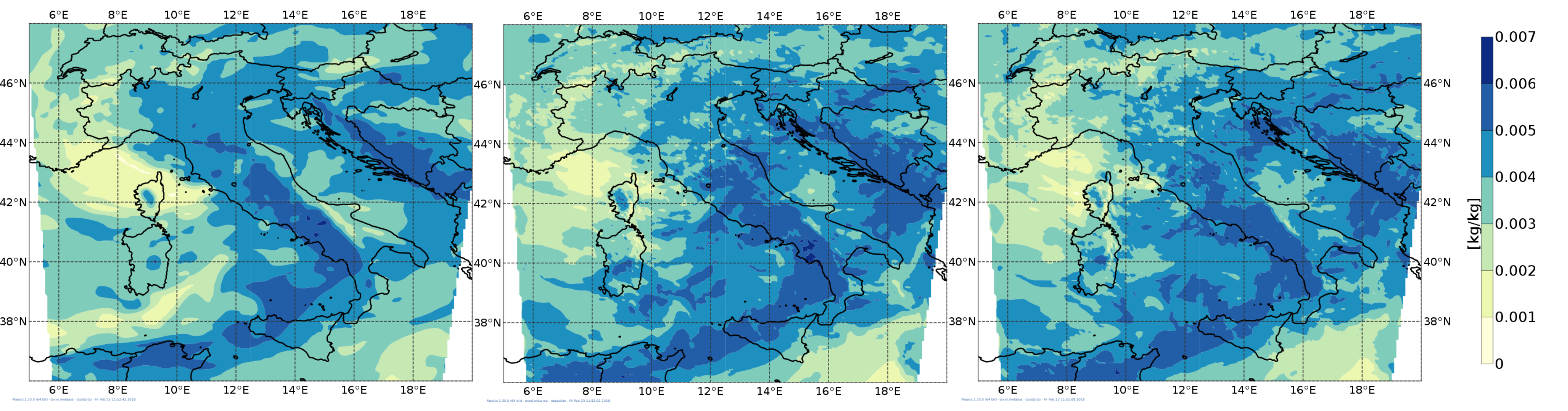




**Mean sea level pressure – 04 February 00 UTC**



**Specific humidity at 850hPa – 04 February 00 UTC**



## FUTURE PLANS

Performed tests to evaluate the impact of the reflectivity observational error have provided variable results. Therefore, further trials are necessary to better understand the role of this parameter and to improve the assimilation of reflectivity volumes. In particular, it seems reasonable to introduce an error which depends not only on the radar station but also on the height, range and value of the observation. Furthermore, information about correlations between neighbouring observations need to be exploited. Finally, these experiments should be performed over other periods of the year to investigate the sensitivity to different synoptic conditions.