Data assimilation of radar reflectivity volumes in a LETKF scheme

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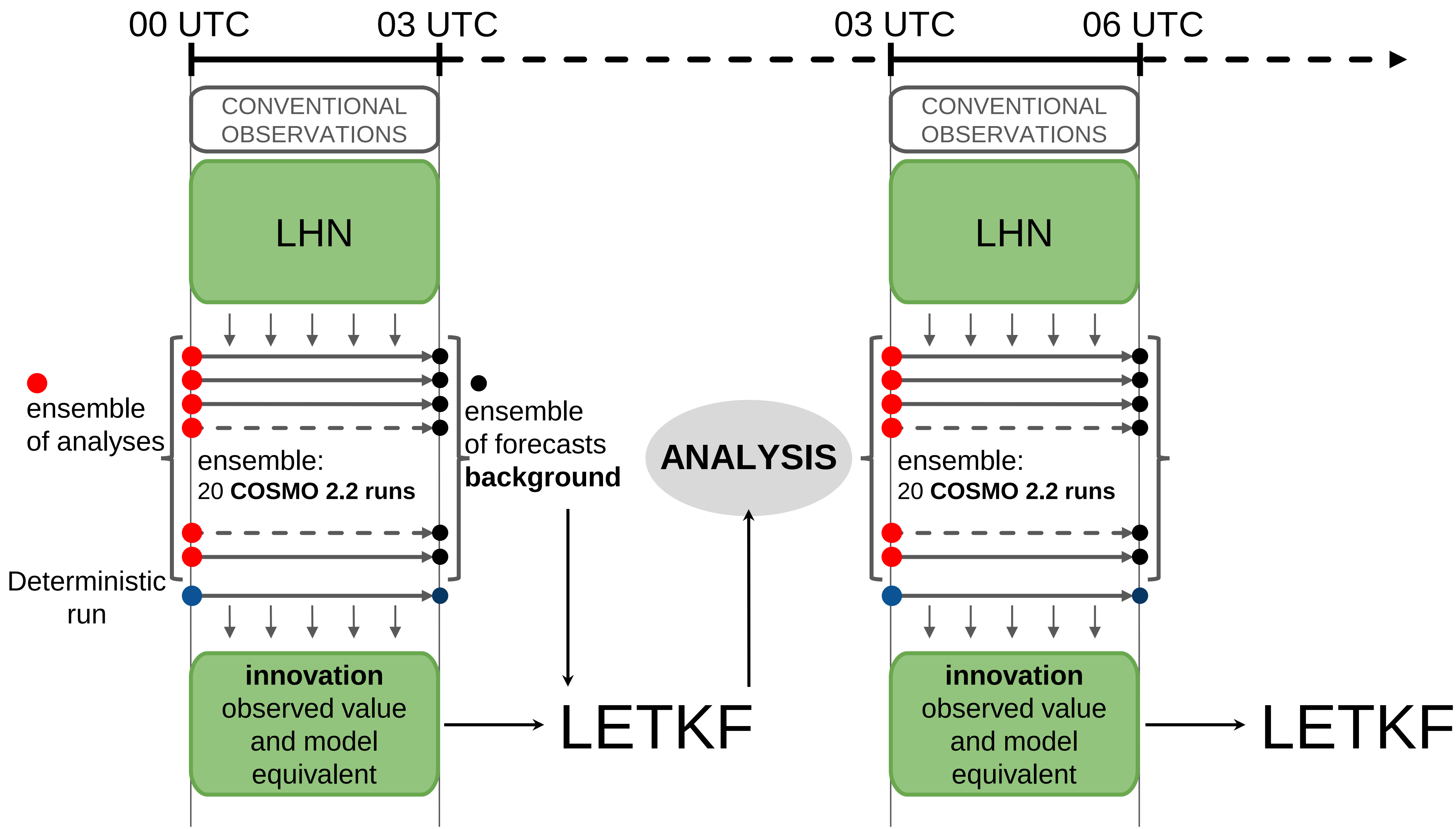
The KENDA system (operational set-up)



CONSORTIUM FOR SMALL SCALE MODELING COSMO

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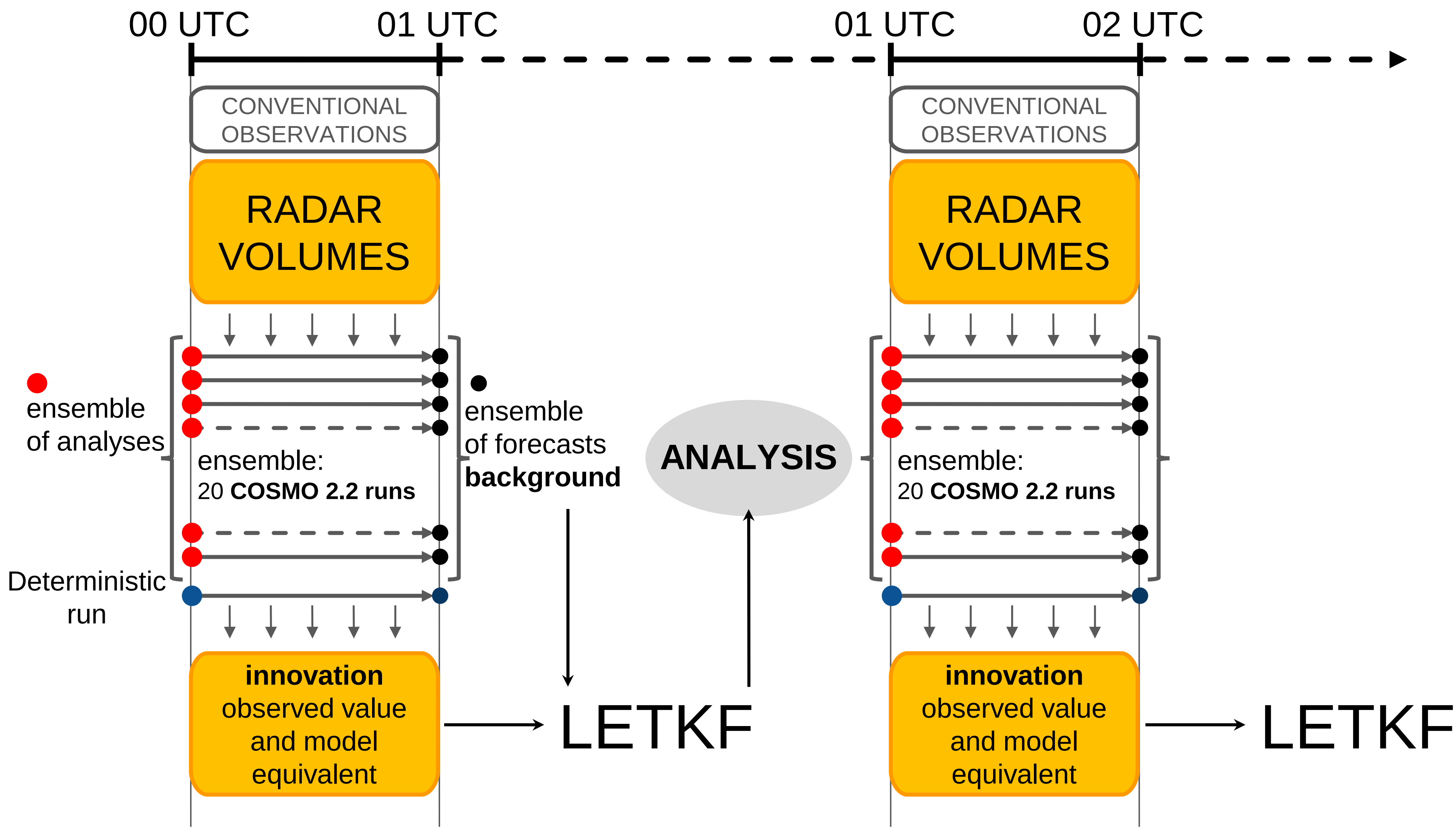
The KENDA system (experimental set-up)

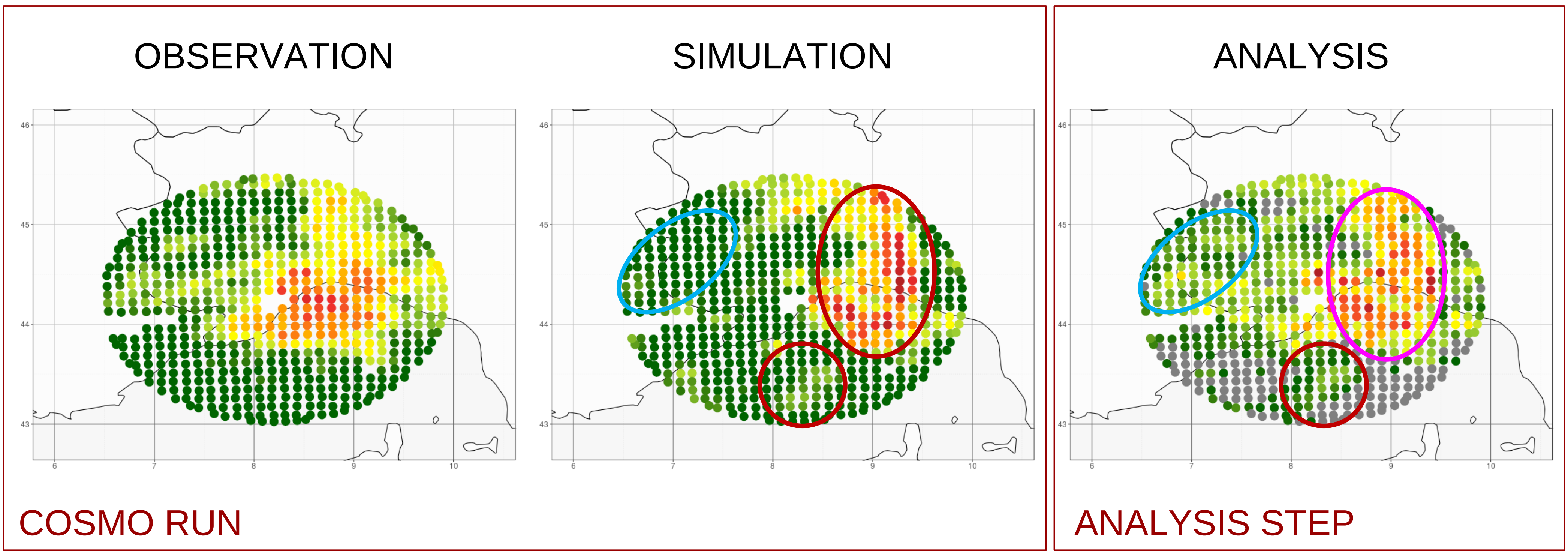


Not all data can be assimilated:

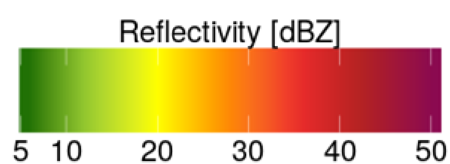
- observations denser than model resolution can deteriorate analysis
- too expensive computational cost

Radar operator:

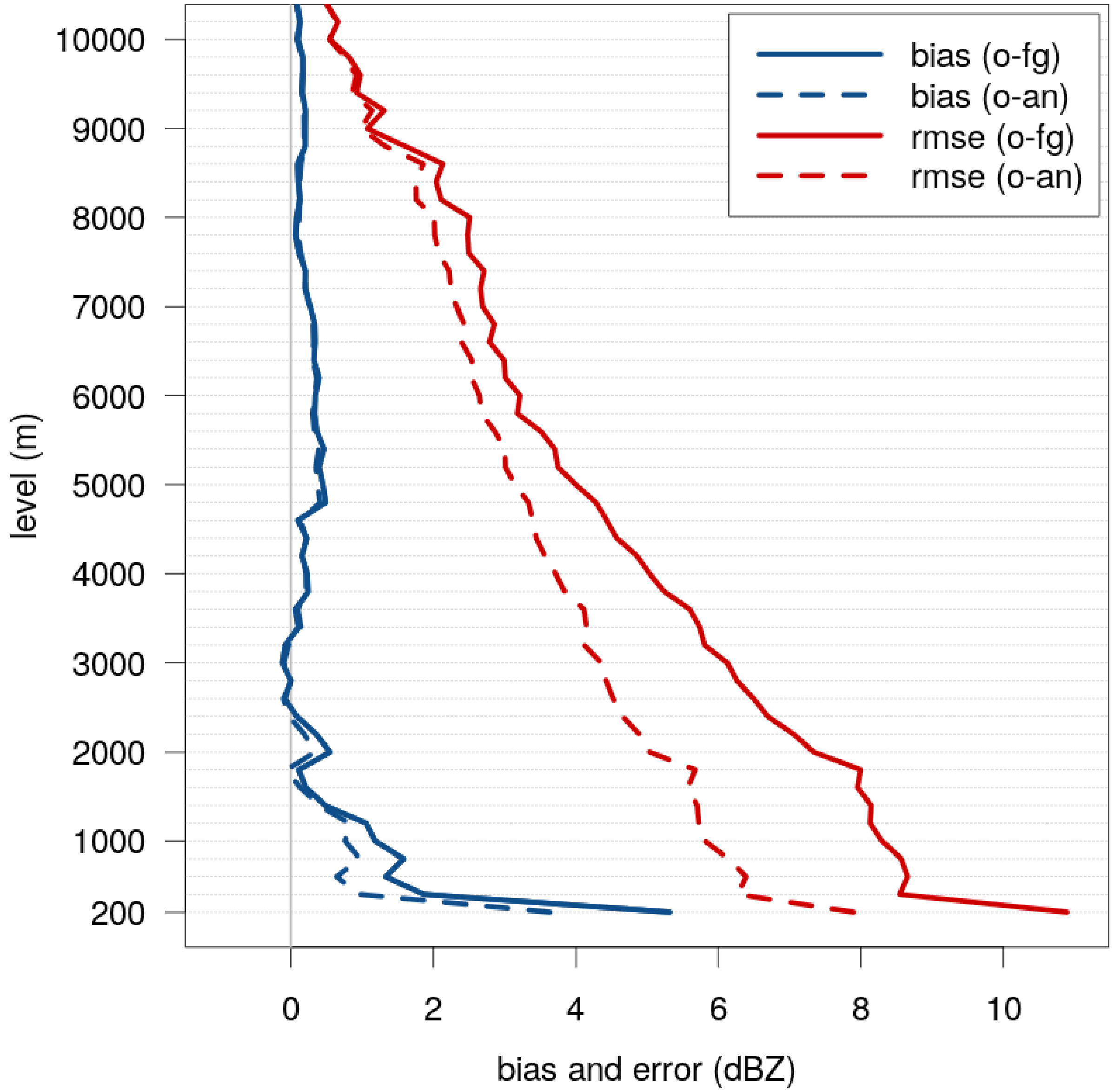
- Data should have a good quality (non meteorological signals should be removed)
- Superobbing = 10 km
- Reflectivities below 5 dBZ set to 5 dBZ



Radar: Settepani
Elevation: 0.7°
05/02/2017 10:00 UTC



Output statistics



Definition of the observational error

10 dBZ is used for all observed values, as default

$$\varepsilon_o = \varepsilon_M + \varepsilon_R + \varepsilon_H$$

ε_M = instrumental error

ε_R = representativity error

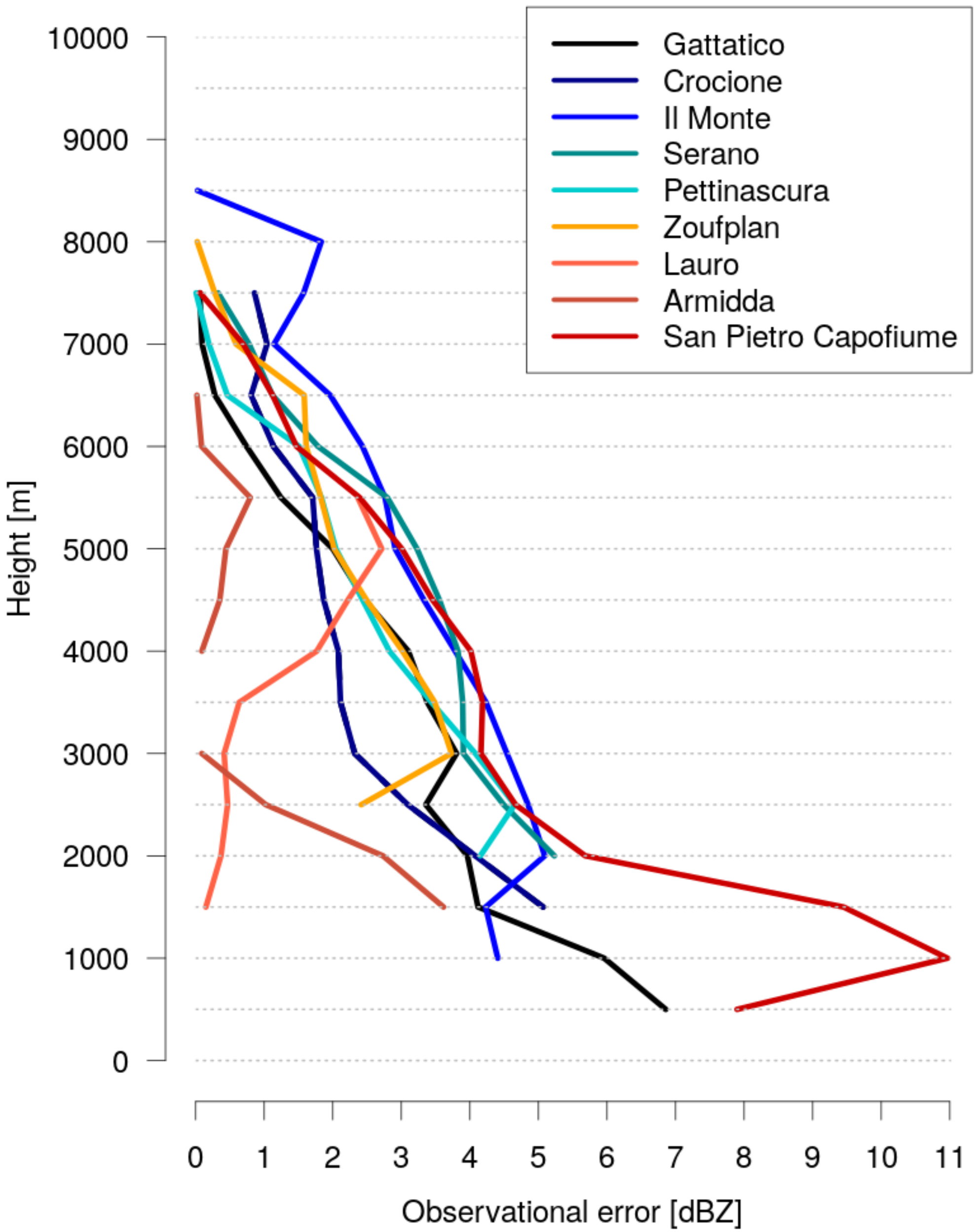
ε_H = error introduced by the operator *H*

An estimation of ε_o can be derived using the statistics of Desroziers *et al., 2005*

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

$$\boldsymbol{d}_a^o = \boldsymbol{y} - H(\boldsymbol{x}_{\boldsymbol{a}}) \qquad \boldsymbol{d}_b^o = \boldsymbol{y} - H(\boldsymbol{x}_{\boldsymbol{b}})$$

Radar error



Due to:

- complex orography
- inhomogeneity in acquisition strategy
- inhomogeneity from instrumental point of view

Desroziers statistics applied separately for each radar

mean values for each radar range from 3.0 to 7.7 dBZ

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Experimental set-up

Analyses are obtained running KENDA with three different configurations:

1. assimilation of conventional observations + LHN of estimated surface rainfall rate

2-dimensional estimated rainfall field

1. assimilation of reflectivity volumes with an observational error of 10 dBZ for all the observations

1. assimilation of reflectivity volumes with an observational error different for each radar

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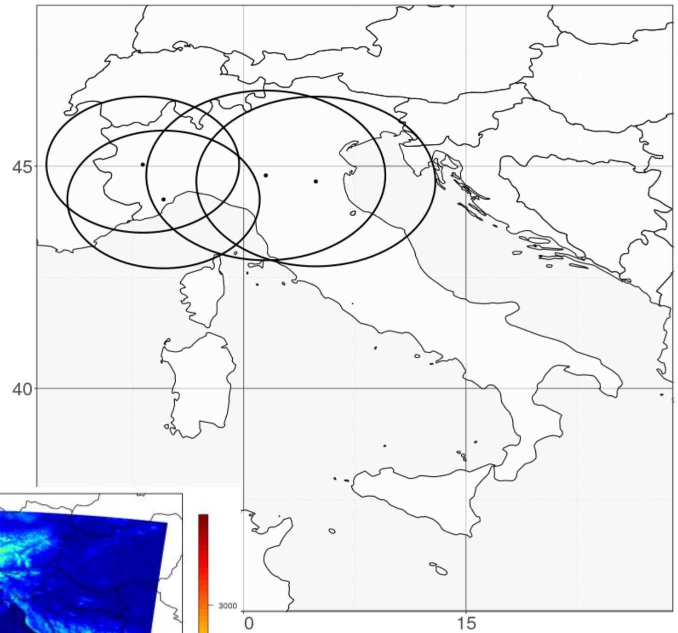
3-dimensional reflectivity volumes

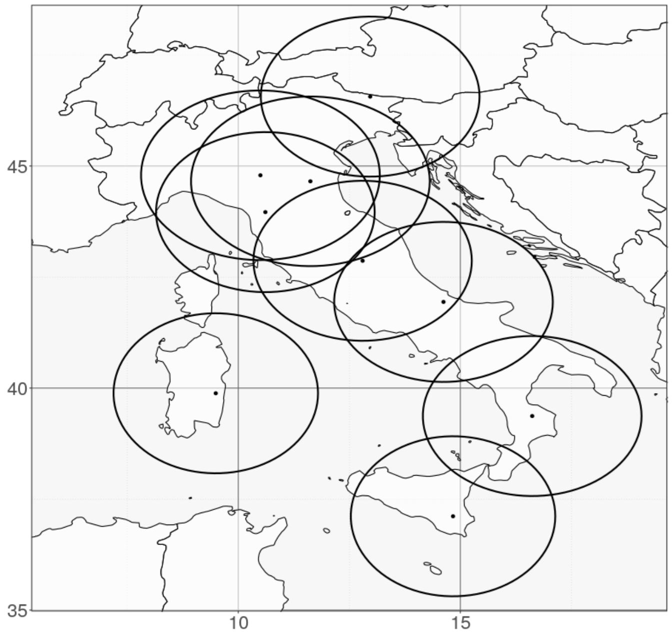
Case studies

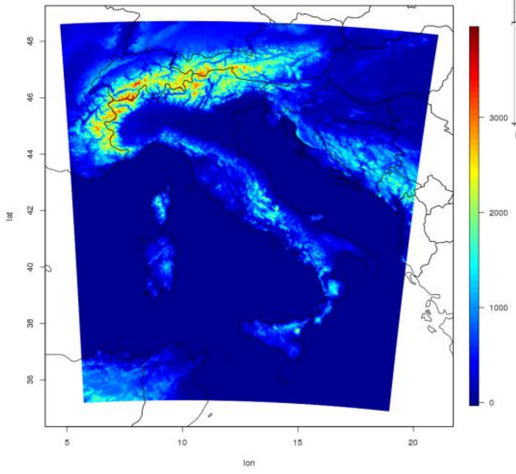
To evaluate the impact of the assimilation of reflectivity volumes and the quality of the obtained analyses, forecasts starting from KENDA deterministics analyses are performed

3-6 February 2017



16-17 January 2018





COSMO integration domain

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Verification with FSS

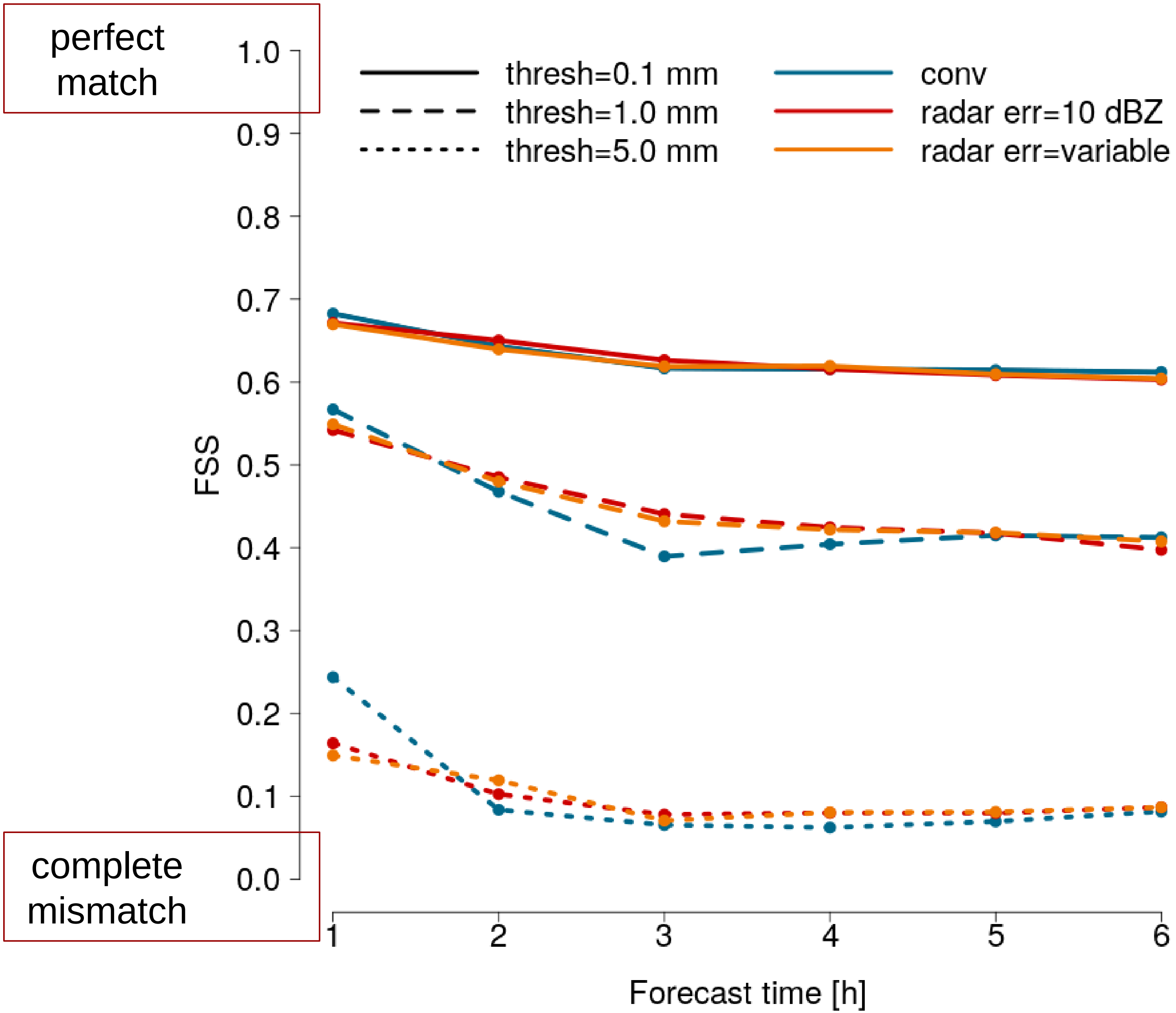
The Fractions Skill Score is a spatial verification measure which compares the forecast and observed fractional coverage of grid-box events in spatial windows of increasing size.

$$FSS = 1 - \frac{\frac{1}{N}\sum_N (P_f - P_o)^2}{\frac{1}{N}(\sum_N P_f^2 + \sum_N P_o^2)}$$

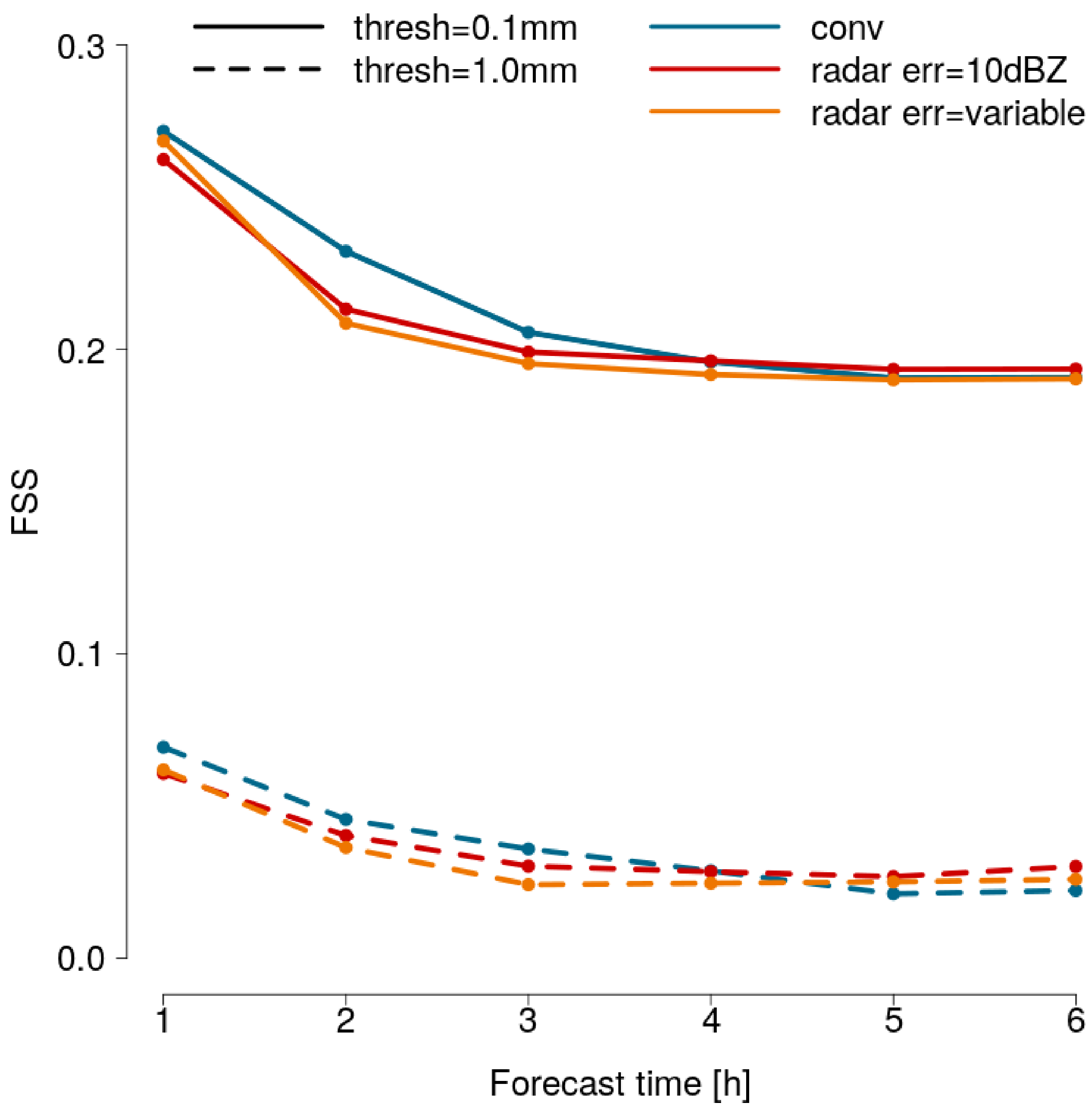
P_f = forecast fraction
P_o = observed fraction
N = number of spatial windows in the domain

- Domain covered with boxes: 0.2 X 0.2 degrees
- Verification of hourly precipitations
- Verification of all the forecasts at the same forecast time
- Observations are hourly rainfall fields from the Italian radar composite adjusted by rain-gauges
- Events were defined by different precipitation thresholds

February 2017

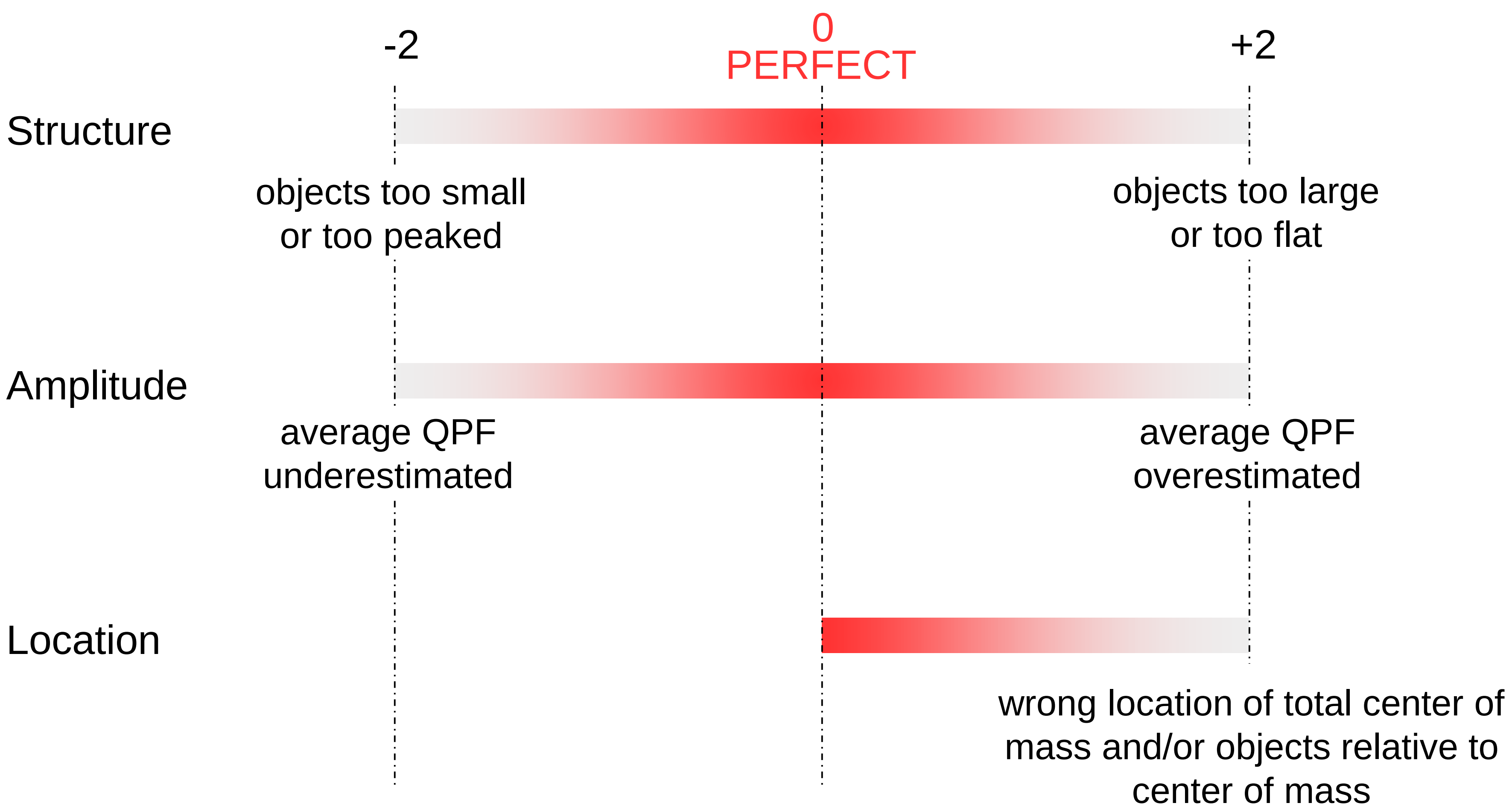


January 2018



Verification with SAL

The SAL metrics is an object based verification score. It detects individual objects in the accumulated precipitation fields by considering continuous areas of grid points exceeding a selected threshold.

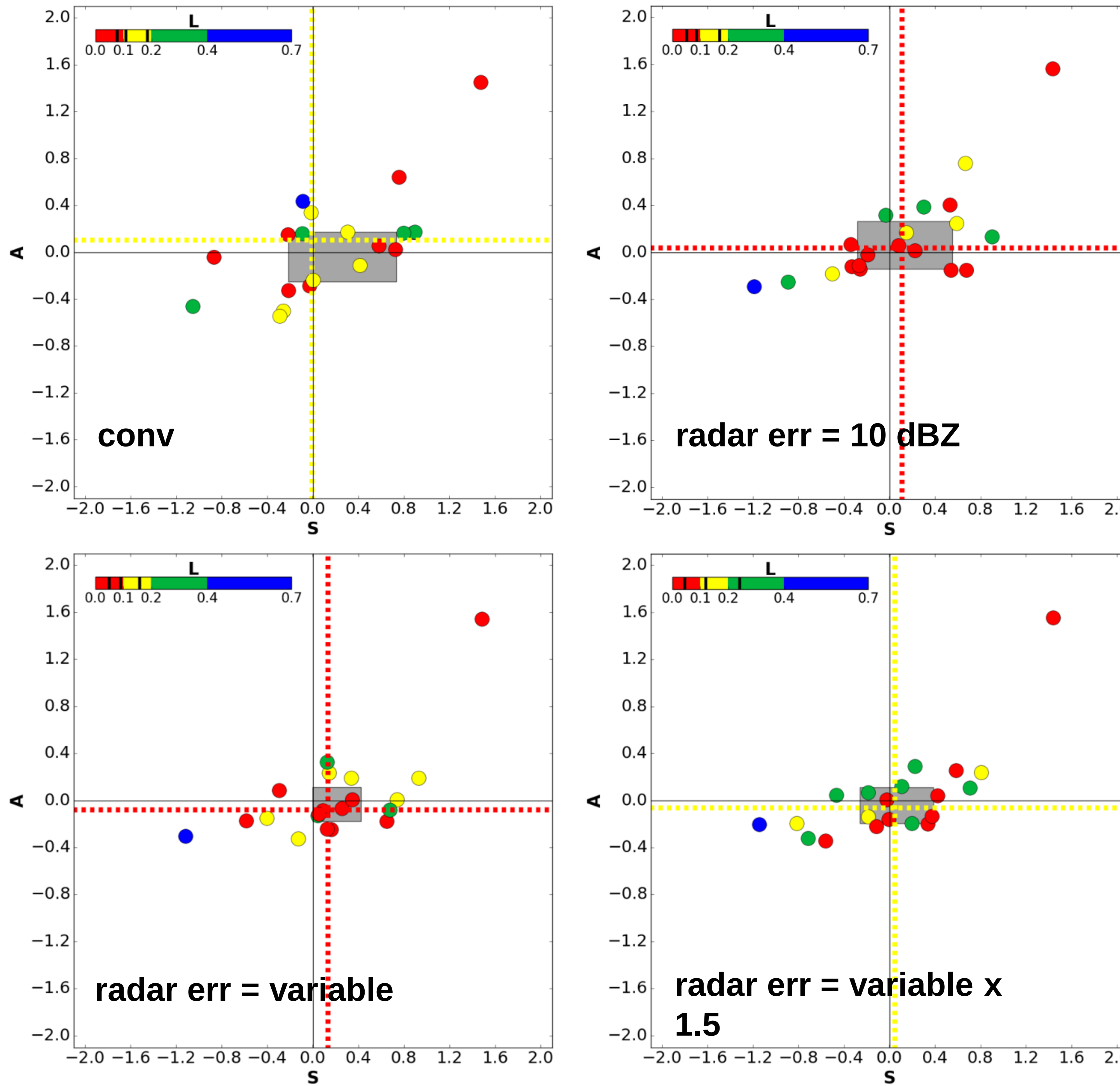


February 2017

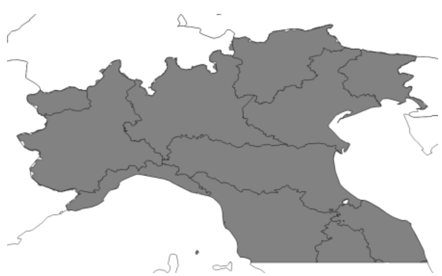
3h acc. precipitation

Forecasts time = **+3h**

Threshold = 1 mm



Verification domain:



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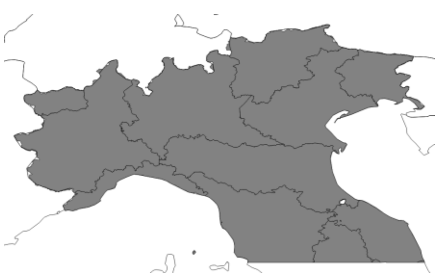
February 2017

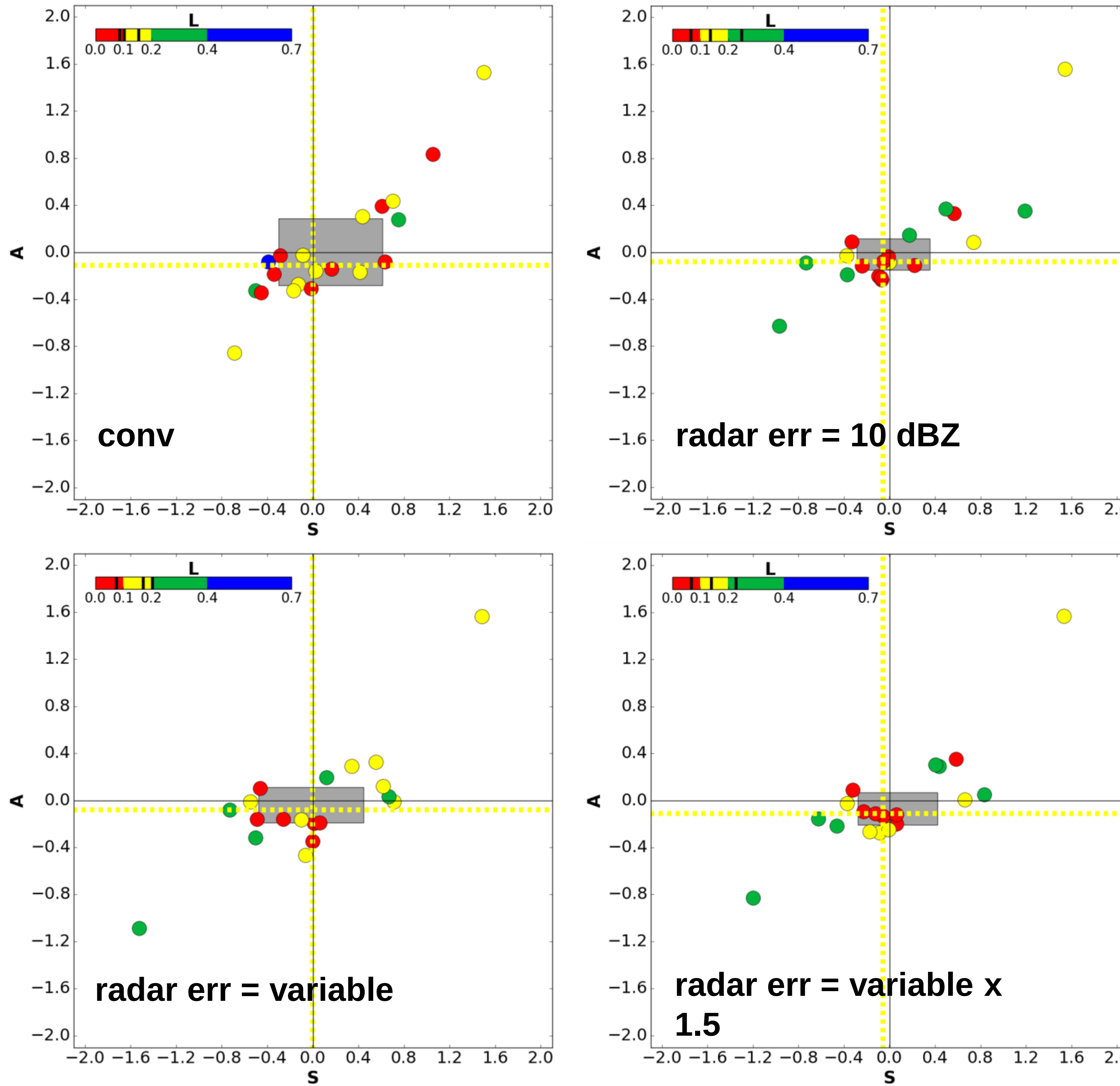
3h acc. precipitation

Forecasts time = **+6h**

Threshold = 1 mm

Verification domain:





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Other activities

- Between March and July, Thomas, our PhD student, has done an internship at Environment Canada, supervised by Peter Houtekamer. During this internship, he studied the problem of imbalances in the analyses generated by the EnKF system of the Canadian global model. His activity was mainly focused on characterizing and evaluate the amount of imbalances, especially considering kinetic energy spectra decomposed in their divergent and rotational part.
  In the future, this diagnostic may be applied to the analyses generated by KENDA, as well as the implementation of some correcting methods which seem to be promising (like the "divergent adjustment" employed at ECMWF).
- Some of the results presented here together with other obtained in the last year have been used to write a paper (*Data assimilation of radar reflectivity volumes in a LETKF scheme*) which is now under revision.

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Conclusions

Assimilation of reflectivity volumes has a great potential due to the high spatial and temporal density of this type of observations.

The KENDA system has been implemented and run at Arpae with the aim of improving forecasts assimilating radar volumes instead of assimilating conventional observations and surface radar rainfall, thereby taking advantage of the three dimensional structure of radar data.

First results are promising, showing some positive impact on forecast precipitation up to 6 hours. Despite this, results strongly depend on the synoptic conditions.

Future work

- The verification will be carried out over longer periods of time, including different types of events; furthermore, the verification will be extended to other variables.
- Different tunings of model must be tested to understand if assimilation of reflectivity volumes can have a more positive impact
- Ensemble size should be increased both by using more members and different inflation techniques.
- It will be tested the use of a reflectivity observation error dependent, for each volume, on the distance from the radar station, on the height and on the weather regime.
- More in-depth diagnostic on the imbalances of the analyses.
- First tests on the assimilation of radial winds.

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