Assimilation of radar derived surface rain rate: a new framework for 1D-Var + nudging tecnique

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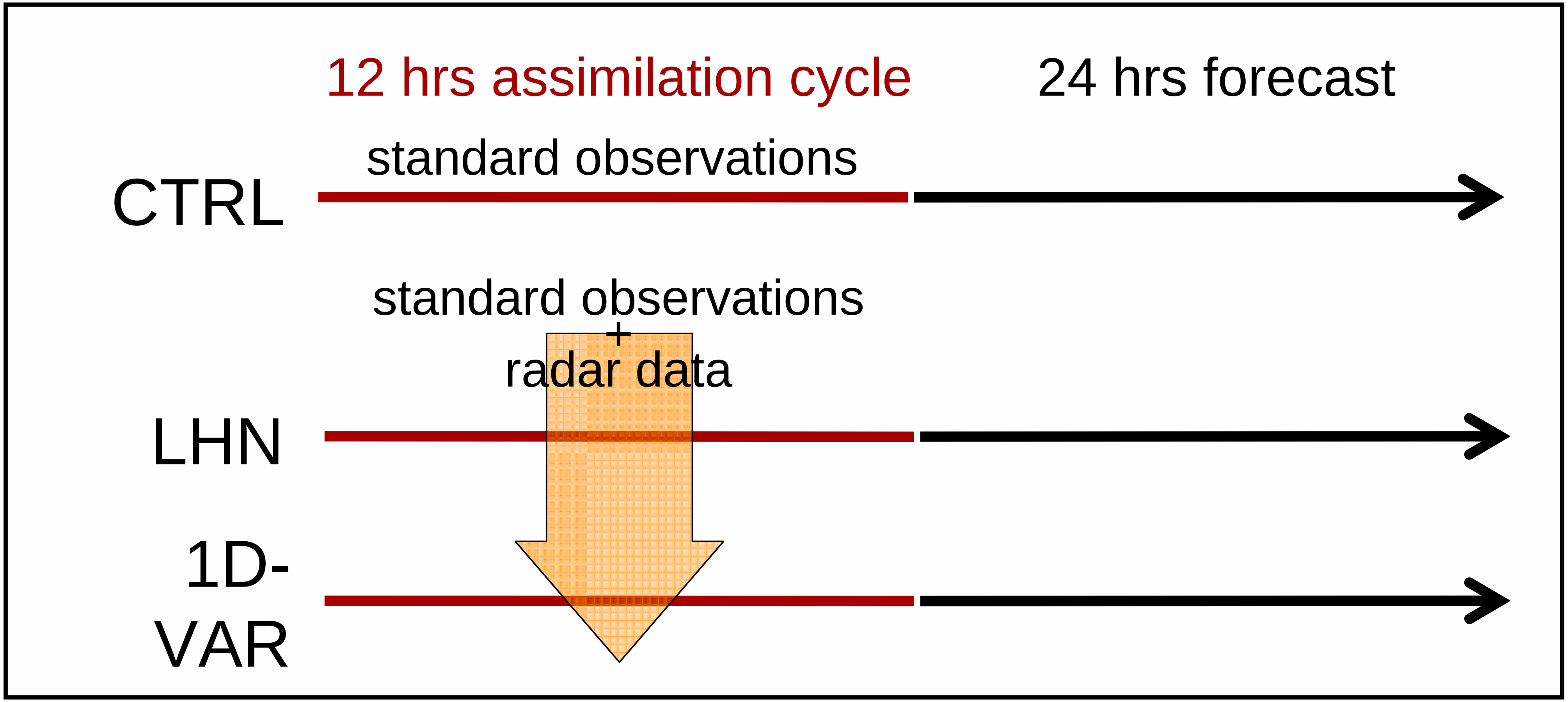
STATE OF THE ART

We tried to assess the supposed benefits of high resolution observations (radar derived precipitation) comparing 1D-Var+nudging and LHN approaches.



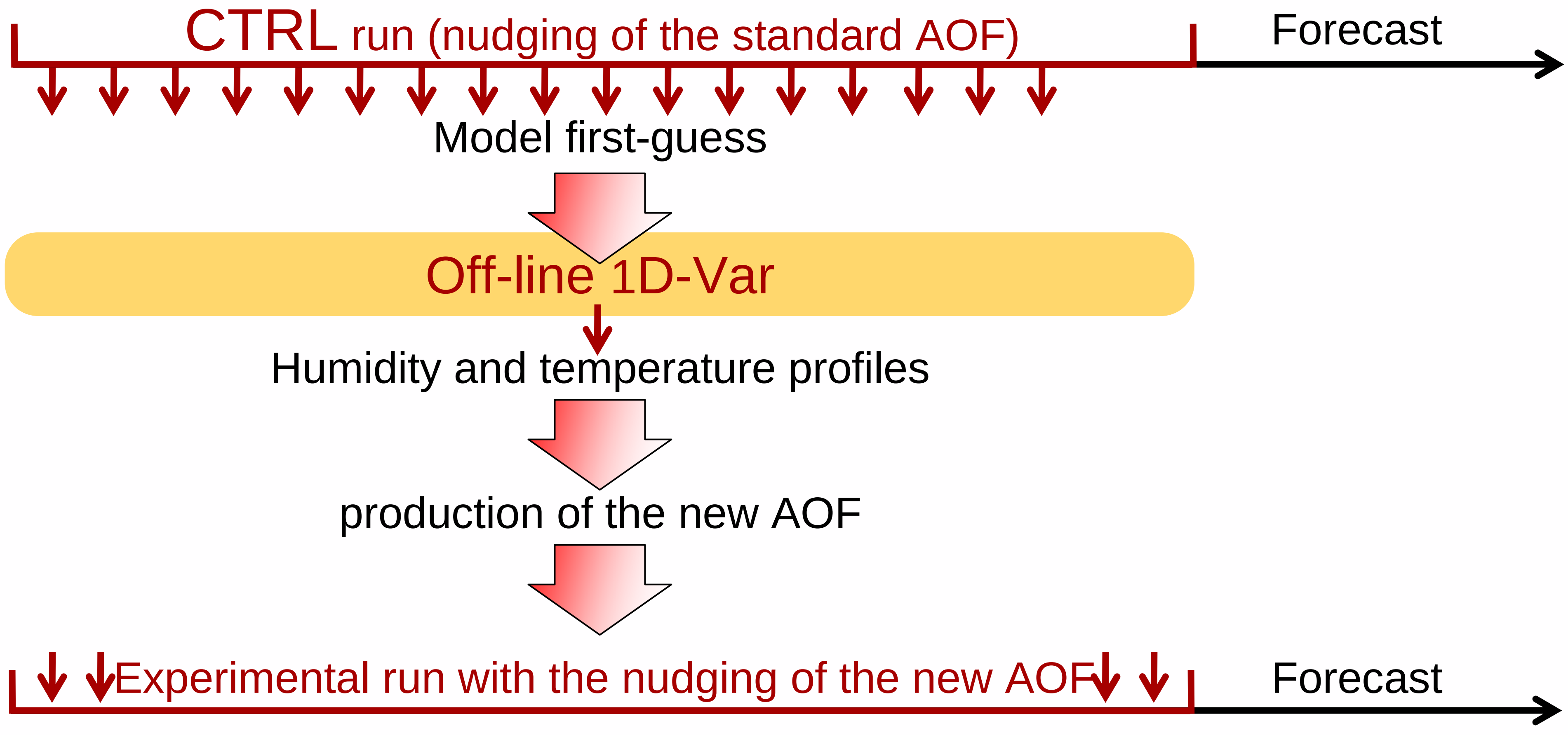
TESTS RESULTS

The proposed methodology did not give the expected results (no significant improvements in verfication scores)

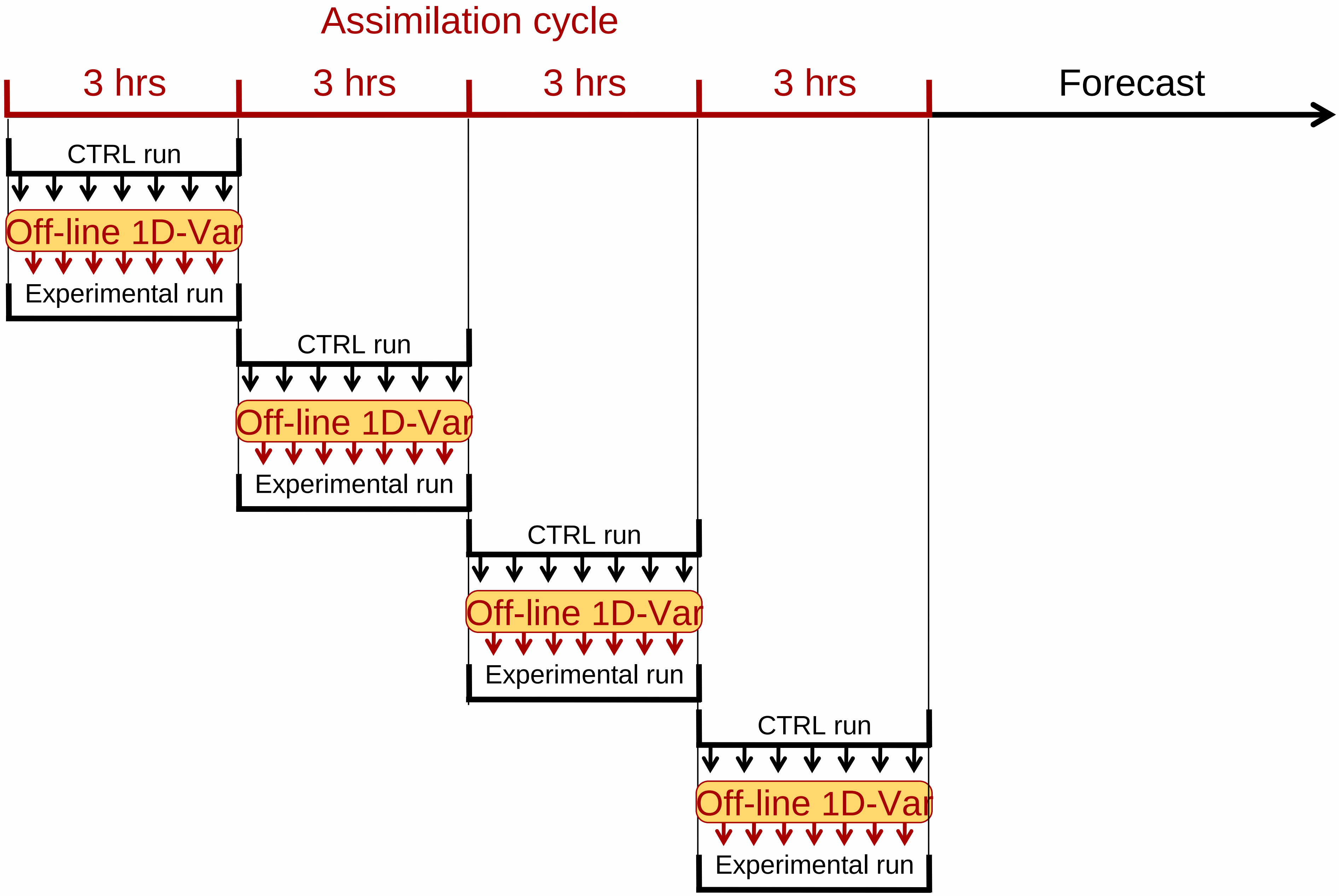
Critical points (I): use of 1D-Var off-line

COSMO fields used as 1D-Var input are not taken out run-time. This implies:

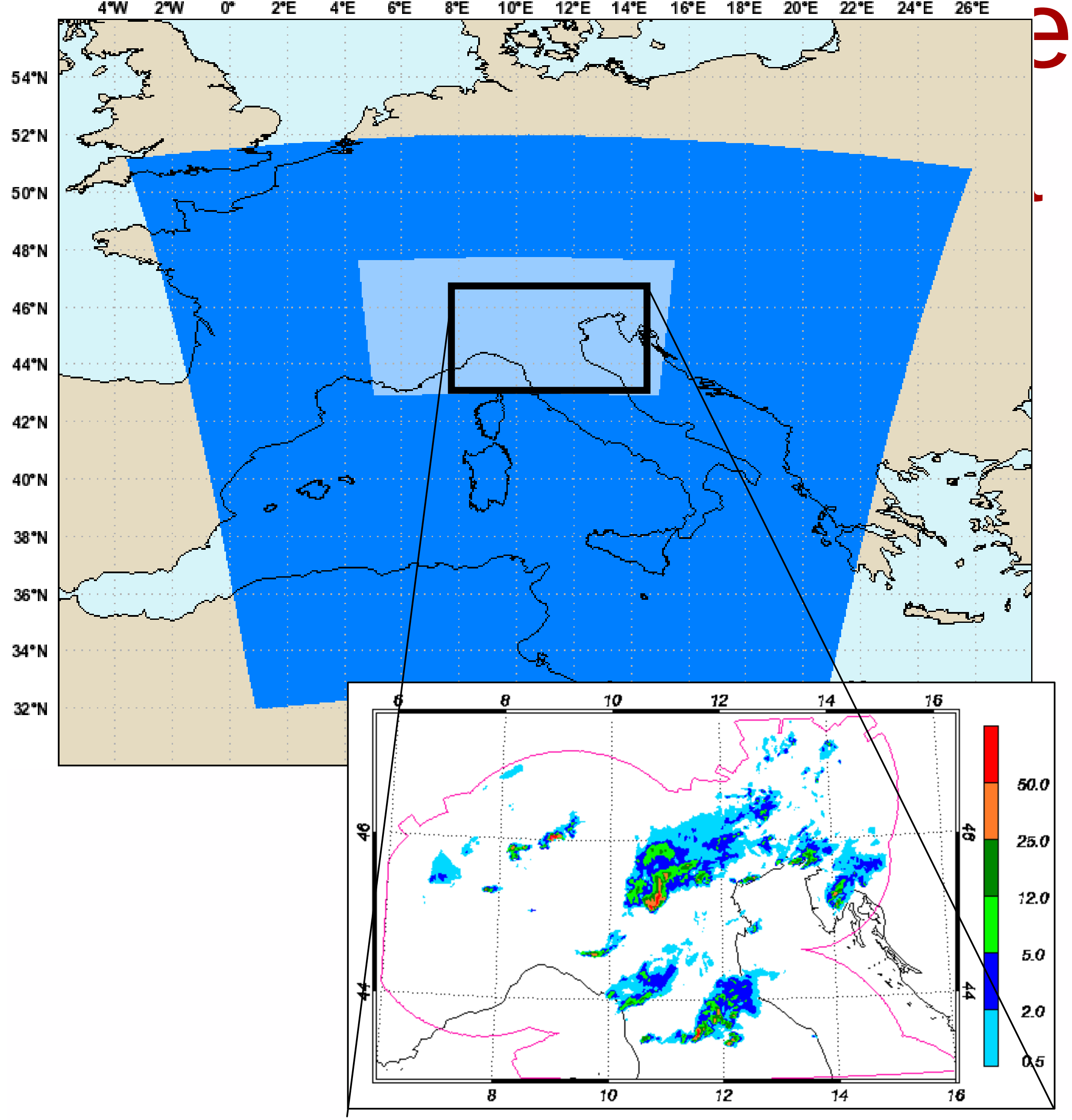
- a double assimilation cycle (a first COSMO run is made in order to get, every 15 minutes, the parameters needed by 1D-VAR)
- <u>the use of non-updated profiles</u>



1 1D-Var + nudging: the new framework



el and radar



- •COSMO I2, version 4.21
- •horizontal resolution=2.8 km
- •45 vertical levels

- •Nested in COSMO I7
- •horizontal resolution=7 km
- •40 vertical levels

- •Radar data from the radar network of italian Department of National Civil Protection
- •Horizontal resolution: 1 km
- •Temporal resolution: 15 min
- •Selected domain: Northern Italy
- •Data are interpolated on COSMO I2 grid before their assimilation

Critical points (II): data thinning

Radar data: amount of data very large (57491 profiles every 15 minutes)

A reduction of the number of data is needed. WHY?

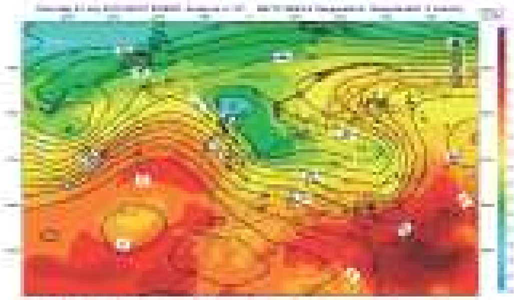
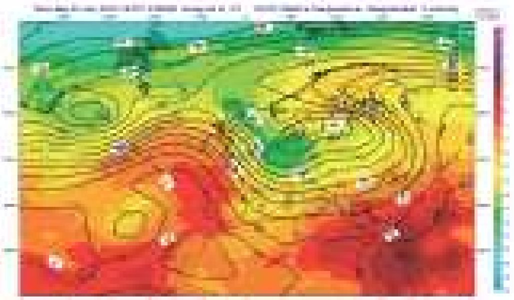
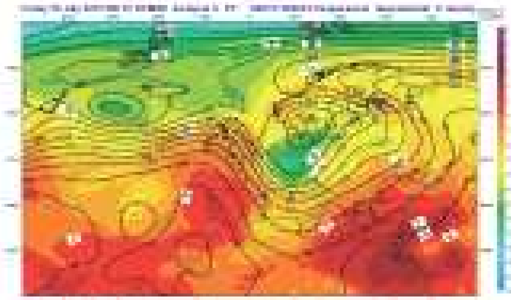
1)a spatial and/or temporal high density violates the assumption made in the most of operative models and experimental schemes in which observational errors are independent: we need to extract essential content of information preserving or even improving the quality of the analysis;

2)it is necessary to speed up the 1D-Var algorithm (minimization process is time consuming);

3)the use of all of the observations generates AOFs too big which cause the killing of the run by the system because of memory problems.

Thinning criterion			
regular thinning	choice of one observation every 5 gridpoints in both directions		
“rainy” thinning	application of 1D-Var algorithm to those points for which RR_{fg} >0 and RR_{obs} > 0 as suggested by Tech. Memo 627 (Lopez, 2010)	+	time-thinning (if AOF is too big)

Case study

29/07/2010 00:00	29/07/2010 12:00	30/07/2010 00:00
		

Assimilation — Forecast

RESULTS VERIFICATION

- only subjective verification against raingauges
- comparison of 12 hrs accumulated precipitation in the assimilation cycle
- comparison of 0-12 hrs accumulated precipitation in the forecast cycle

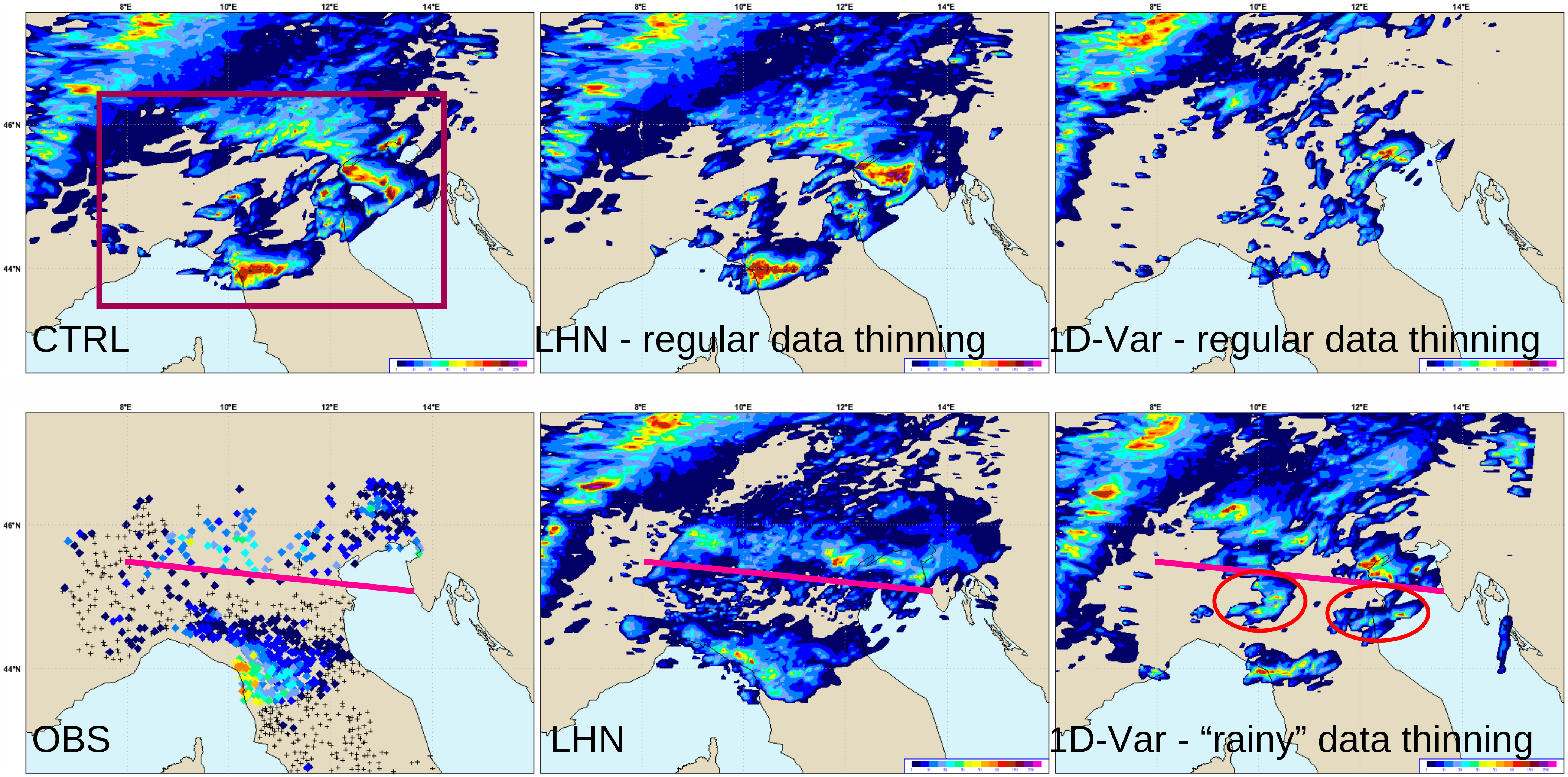
DIFFERENT RUNS USED IN THE COMPARISON

- CTRL
- LHN
- LHN with the same regular thinning of 1D-Var profiles (1 data every 5x5 gridpoints)
- 1D-Var with regular thinning + nudging
- 1D-Var with “rainy” thinning + nudging

Assimilation cycle

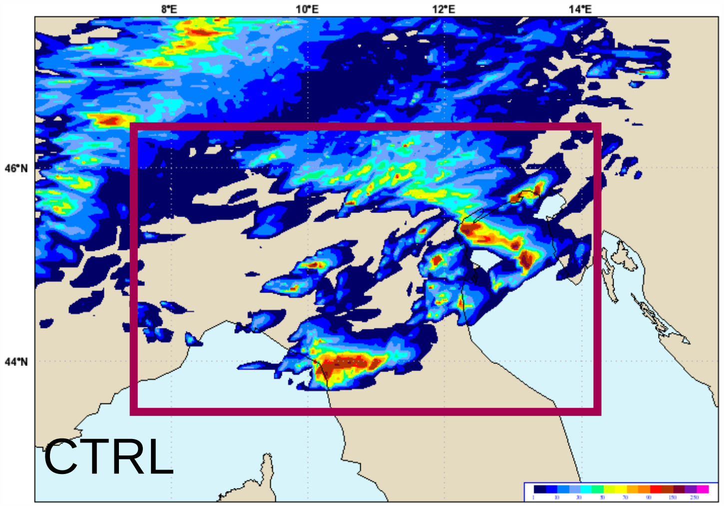
12 hrs accumulated precipitation

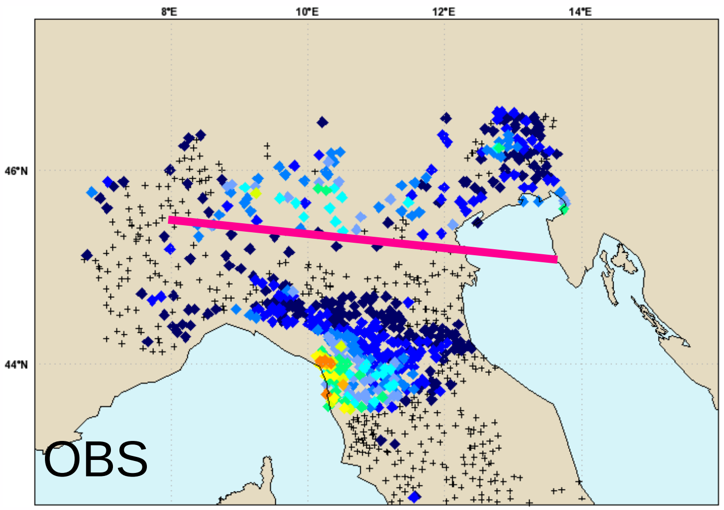
29 July 2010 - 00-12 UTC



Assimilation cycle

12 hrs accumulated precipitation

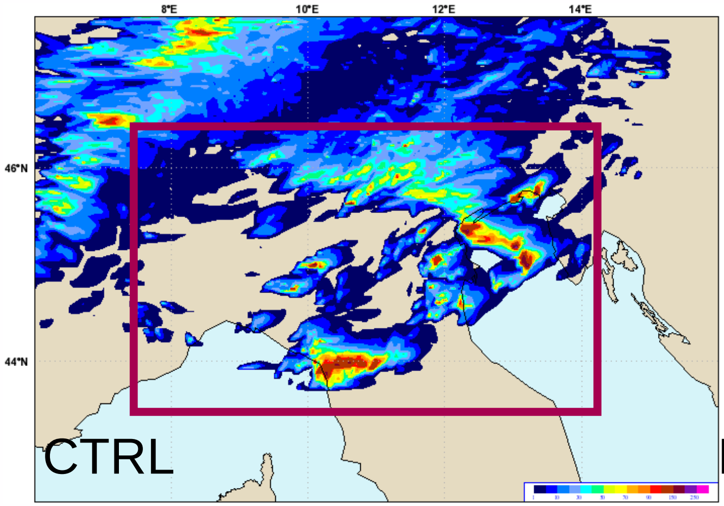


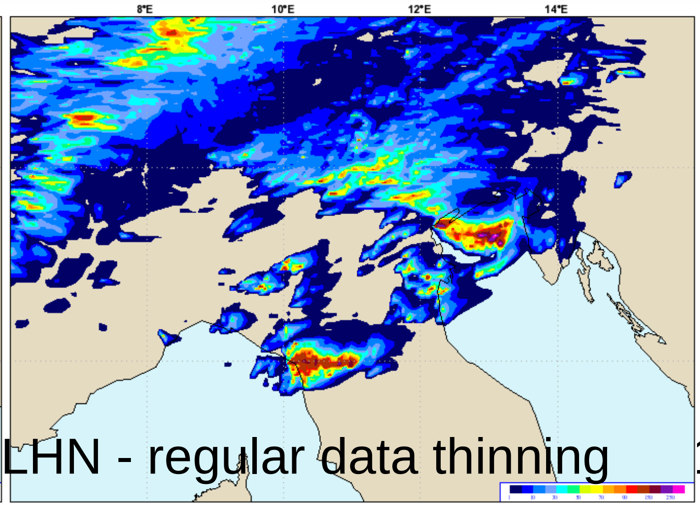


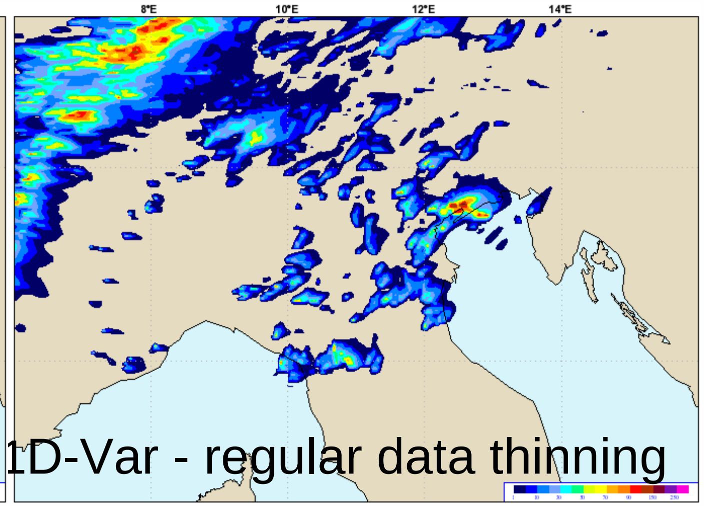
Assimilation cycle

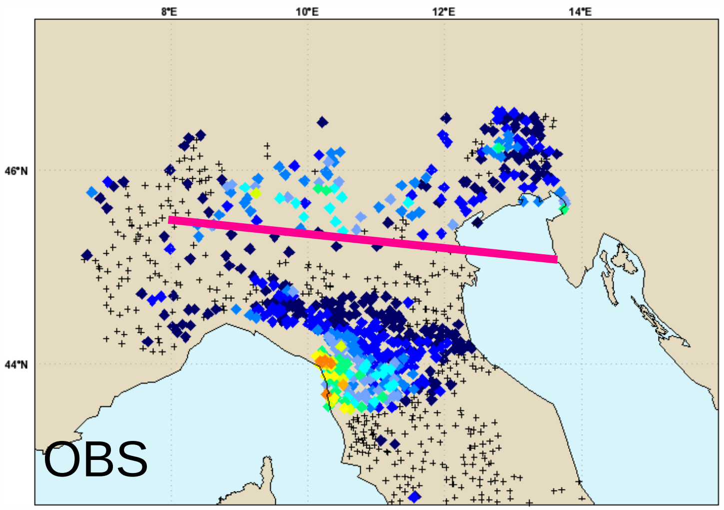
12 hrs accumulated precipitation

29 July 2010 - 00-12 UTC





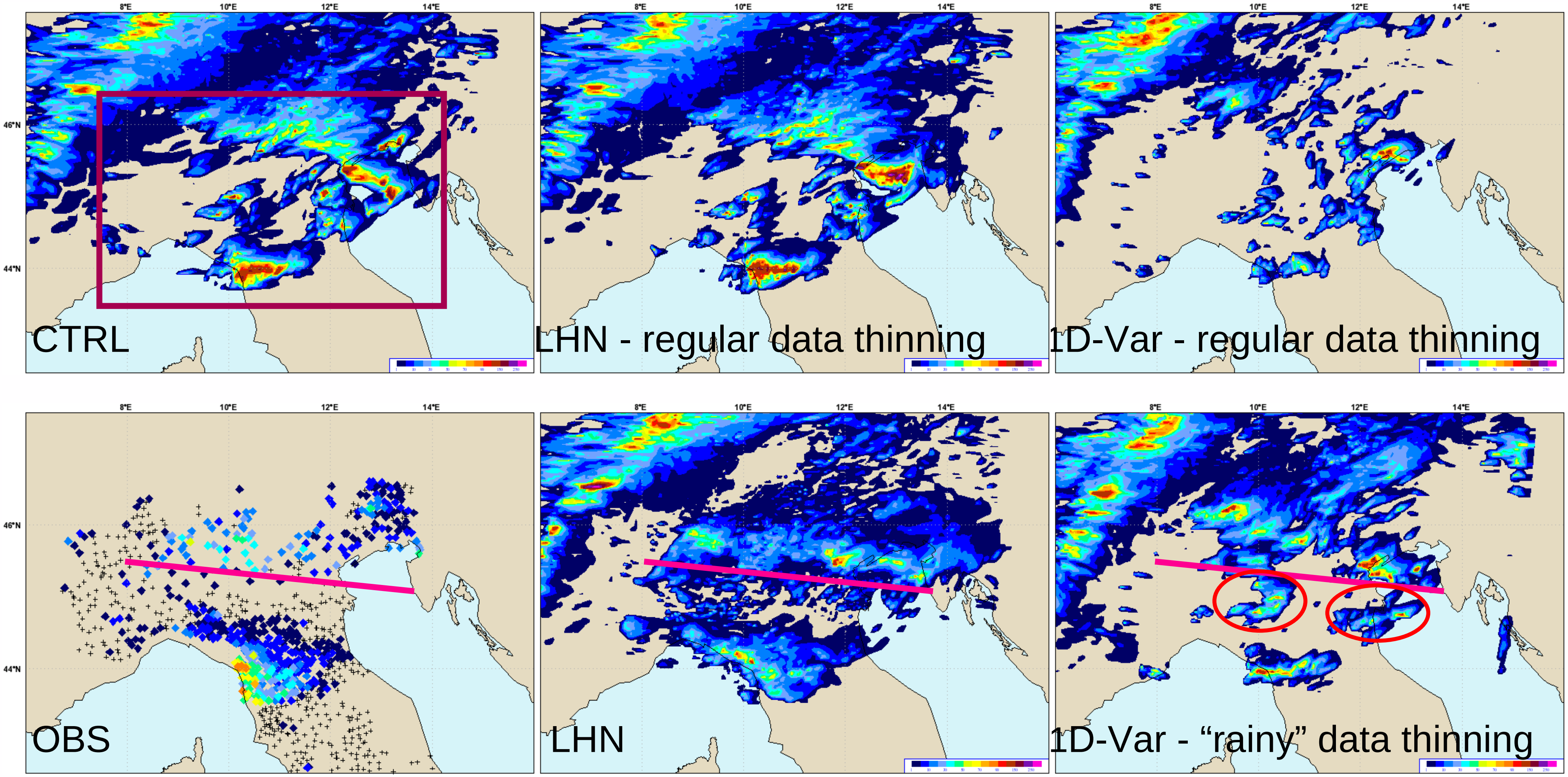




Assimilation cycle

12 hrs accumulated precipitation

29 July 2010 - 00-12 UTC



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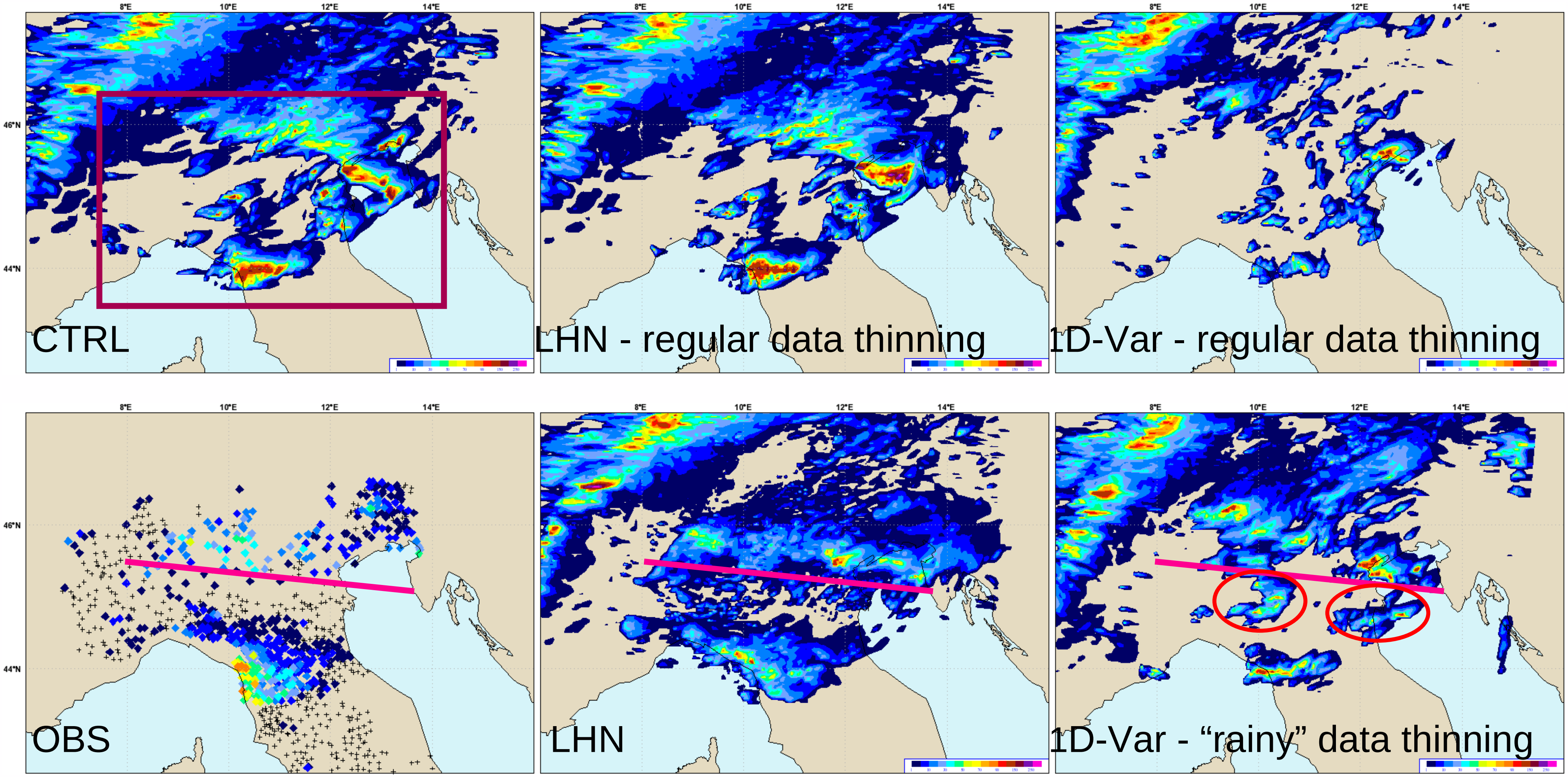
Assimilation cycle

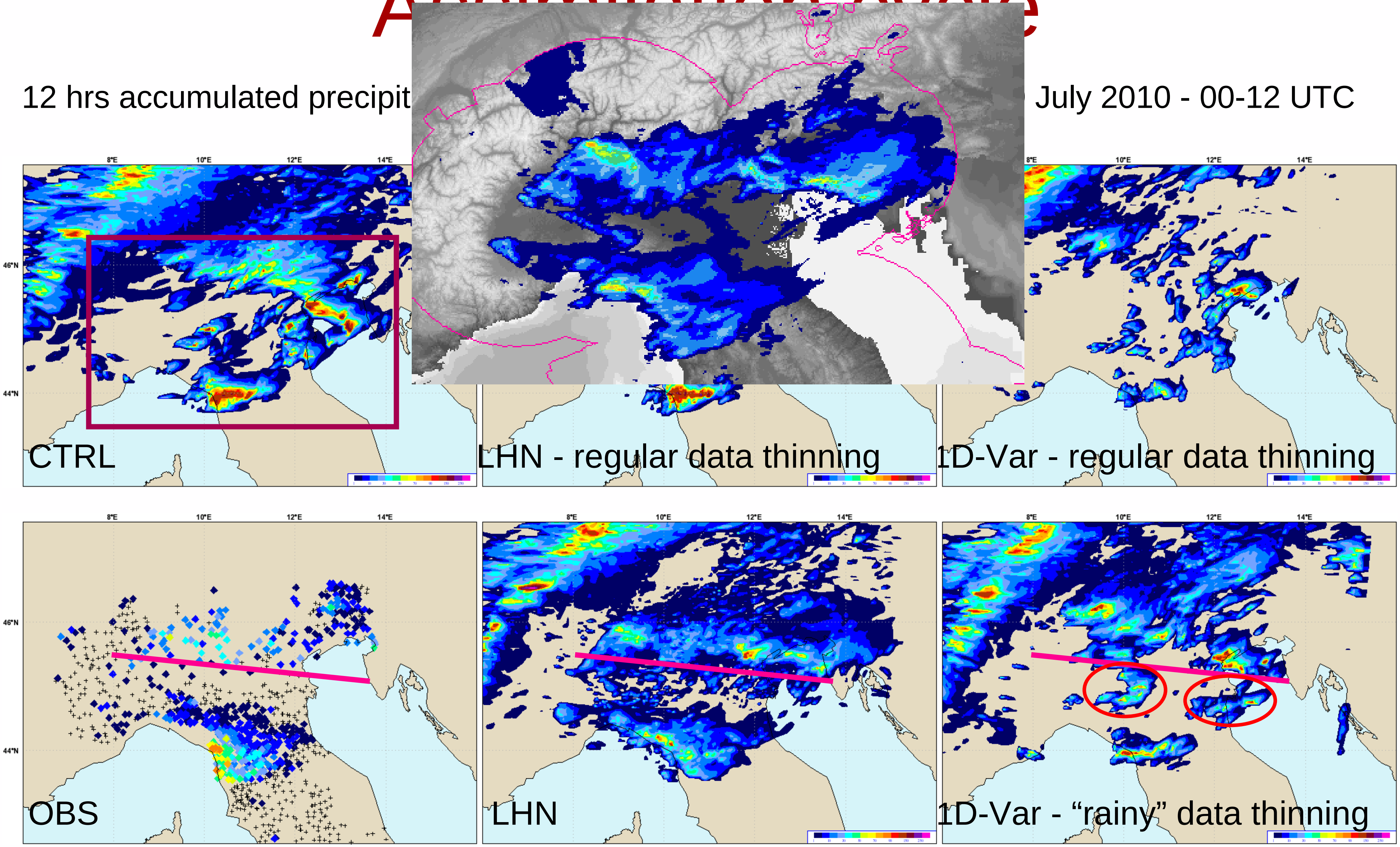
12 hrs accumulated precipitation

29 July 2010 - 00-12 UTC



Assimilation cycle

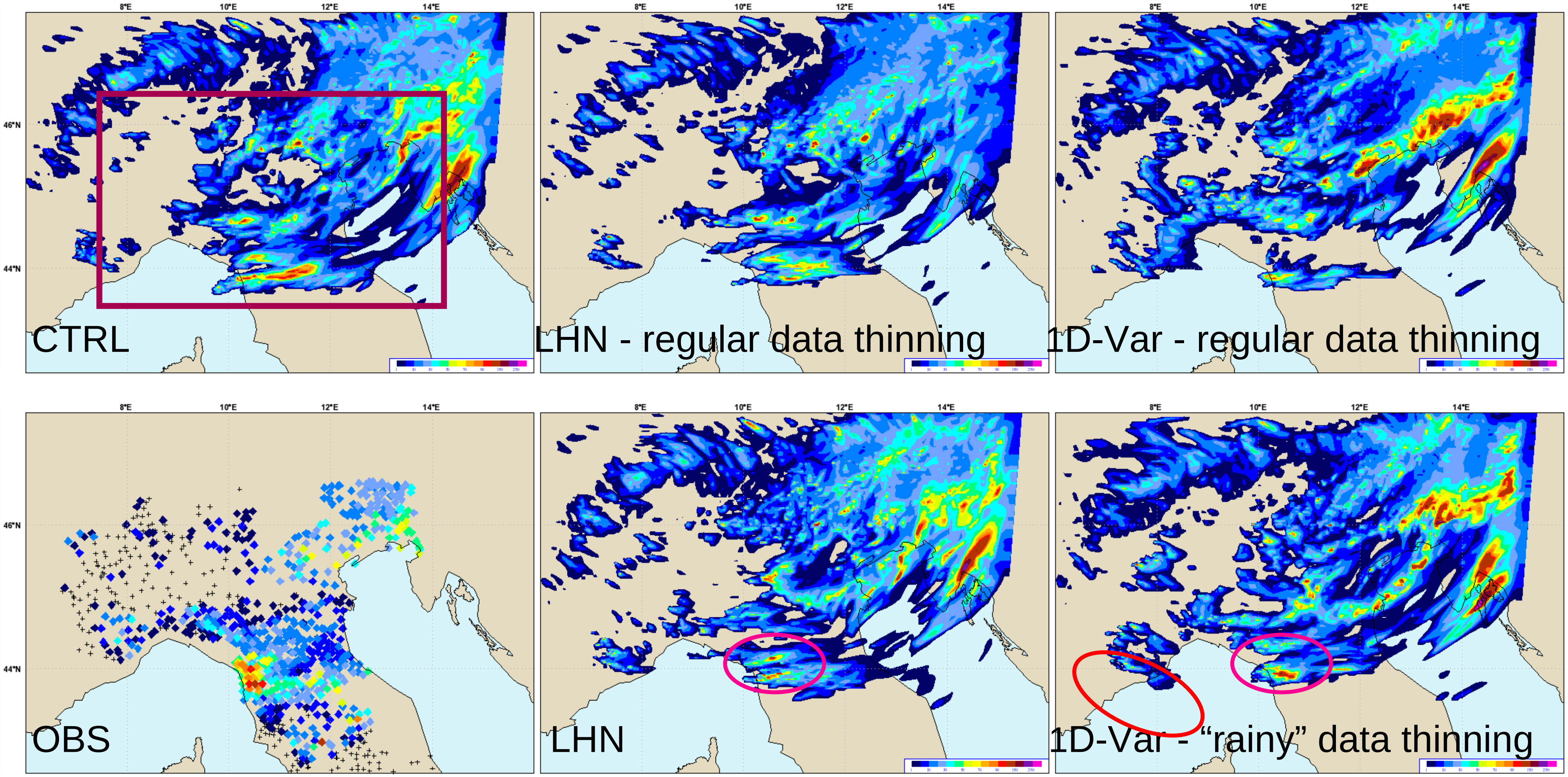
12 hrs accumulated precipit … July 2010 - 00-12 UTC



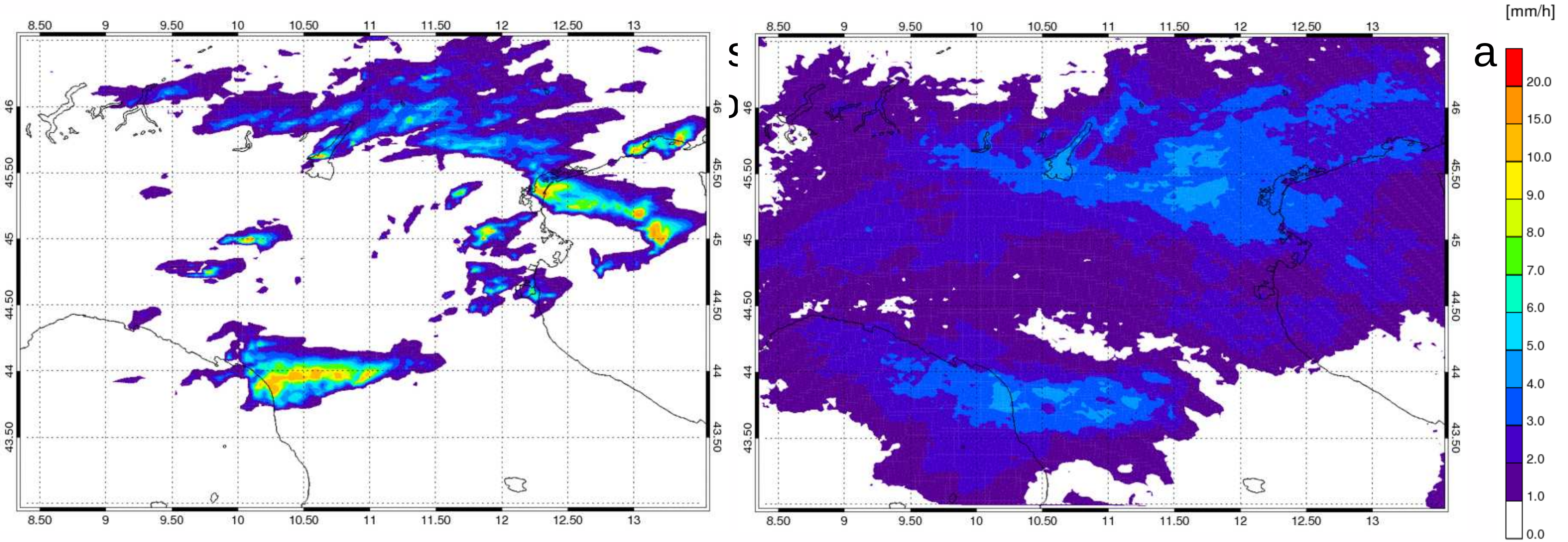
Forecast cycle

12 hrs accumulated precipitation

from 29 July 2010 - 12 UTC to 30 July 2010 - 00 UTC



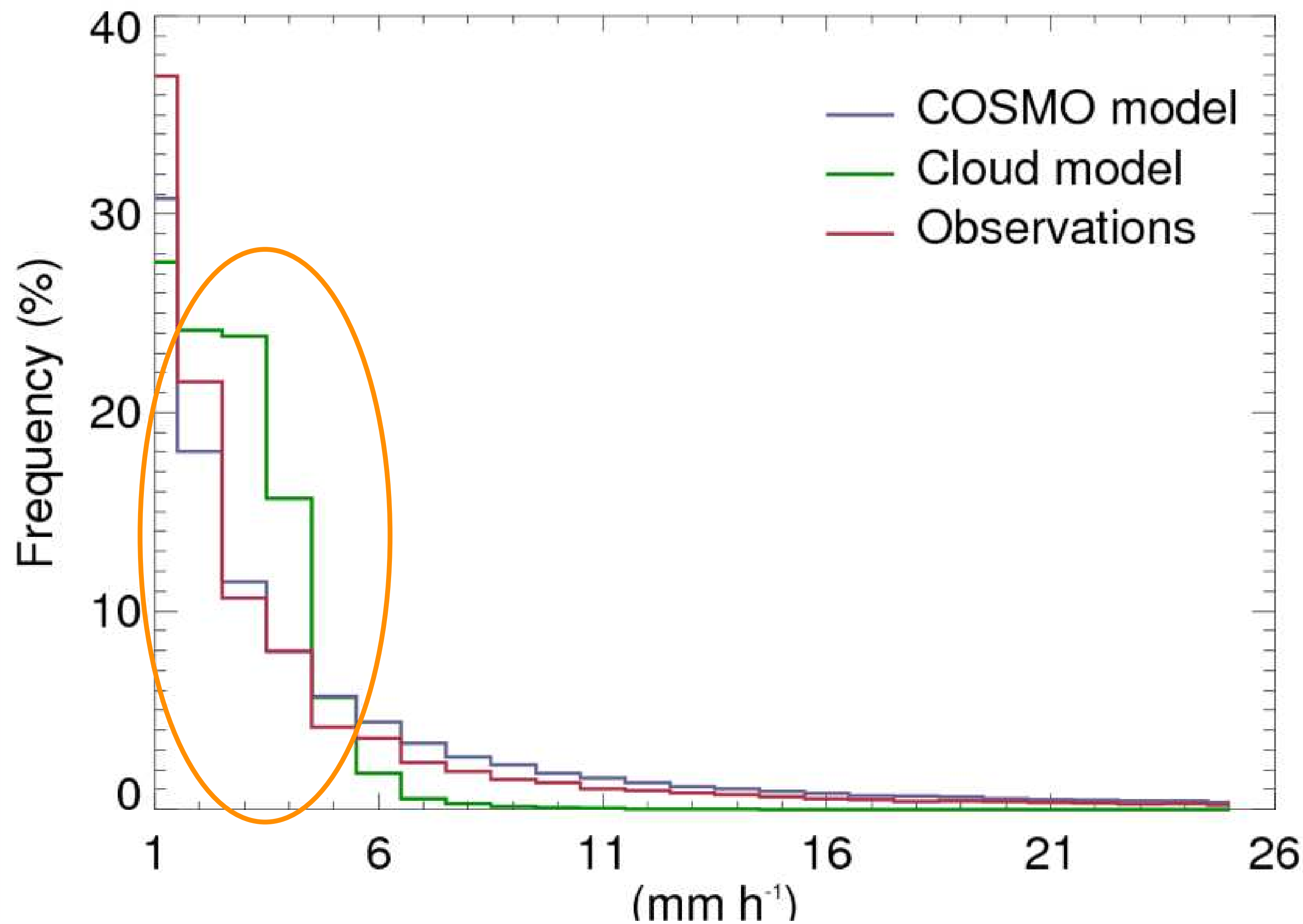
Critical points (III): bias removal



In our system, the forward operator H, which is a simplified version of the cloud scheme implemented in the ECMWF forecast model, has a different physics with respect to the actual one implemented into the COSMO model.

Given a set of temperature and humidity profiles the mean properties of the cloud model generated precipitation field diverges from the ones which would be produced by the COSMO model. Precipitation is not only determined by the "physical" balance of the total water contained in a 1D column but it also depends on dynamical driven processes. The simplified cloud model cannot take these effects into account.

To quantify the difference between the two models the instantaneous surface rain rate has been analyzed.

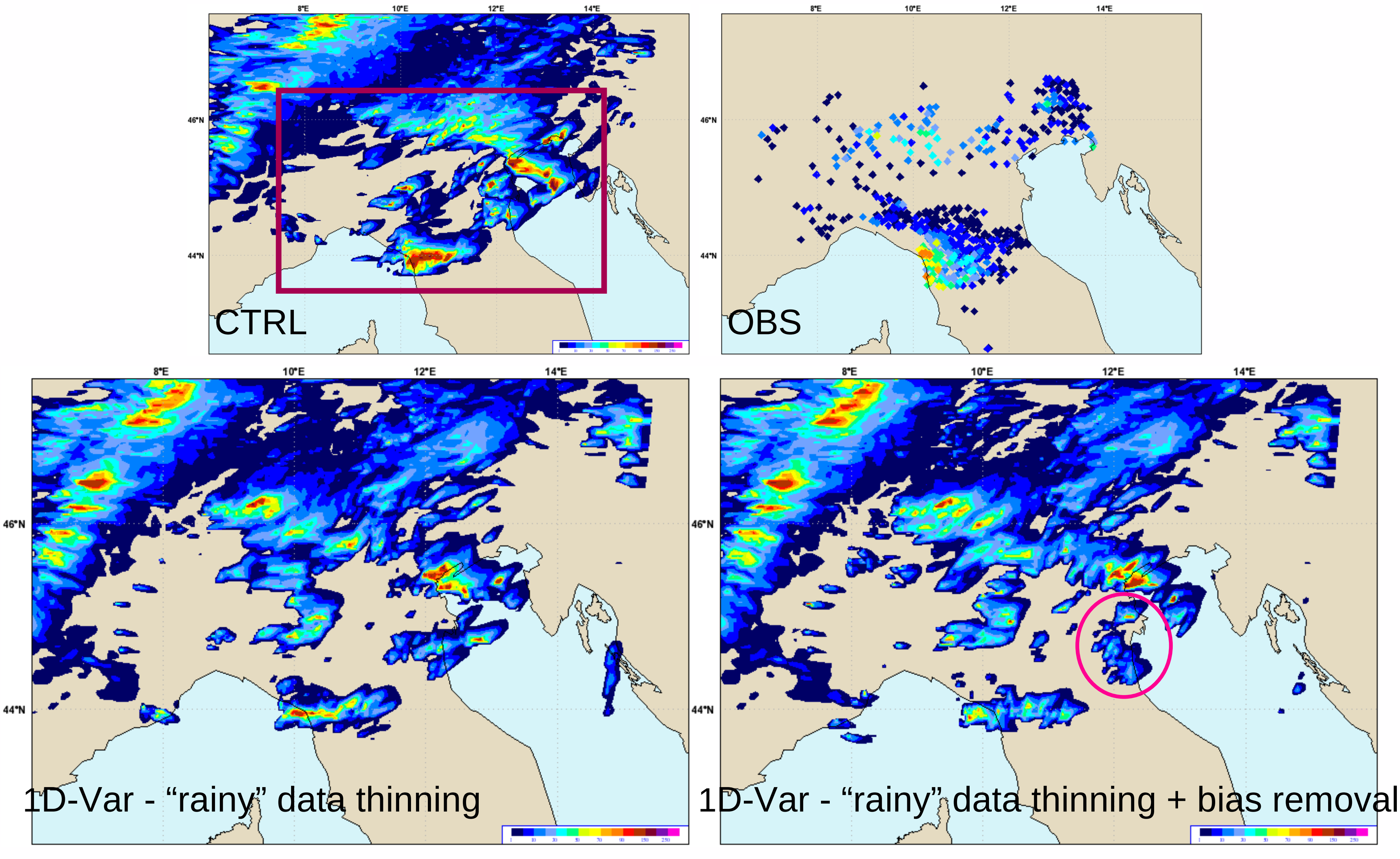


A bias correction is applied only to those precipitation rates for which cloud model overestimates observations.

Assimilation cycle

12 hrs accumulated precipitation

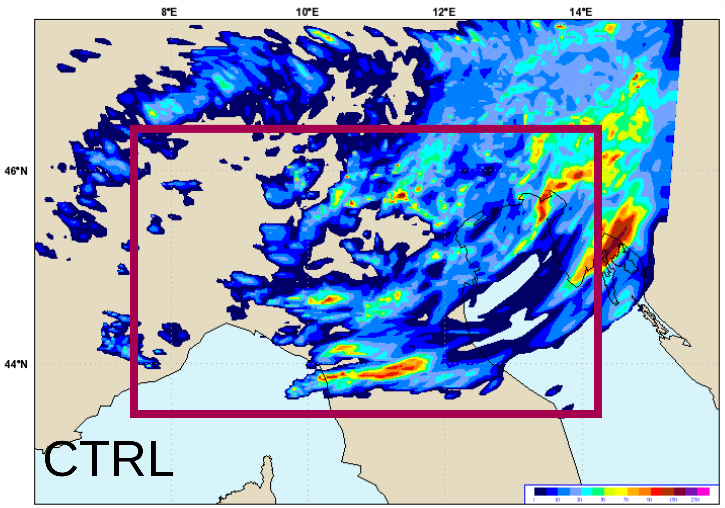
from 29 July 2010 - 12 UTC to 30 July 2010 - 00 UTC

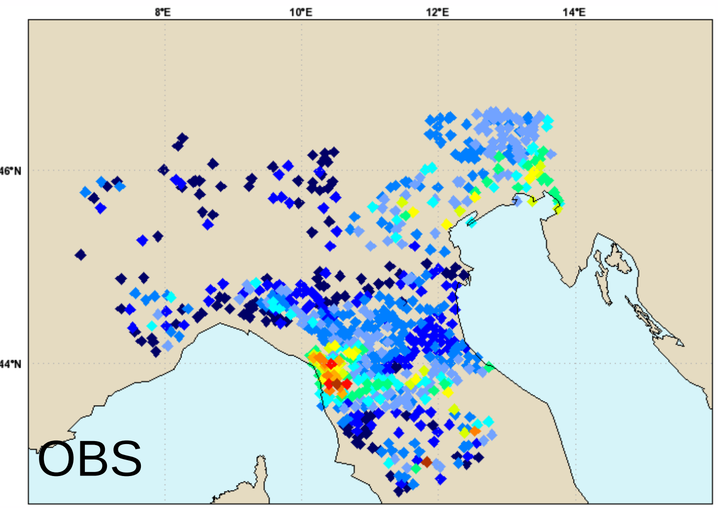


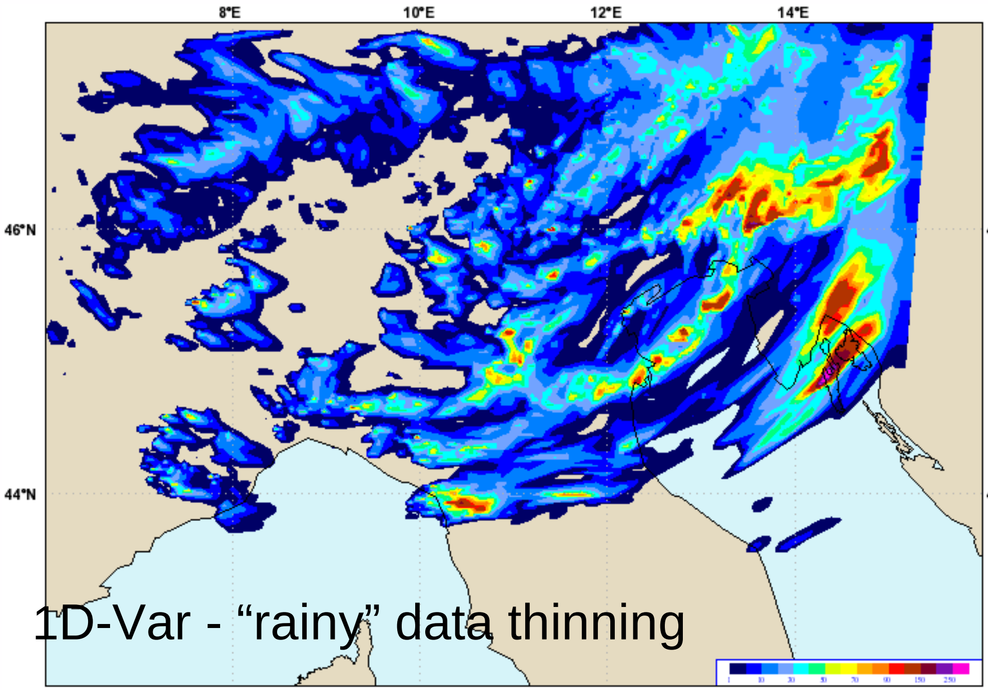
Forecast cycle

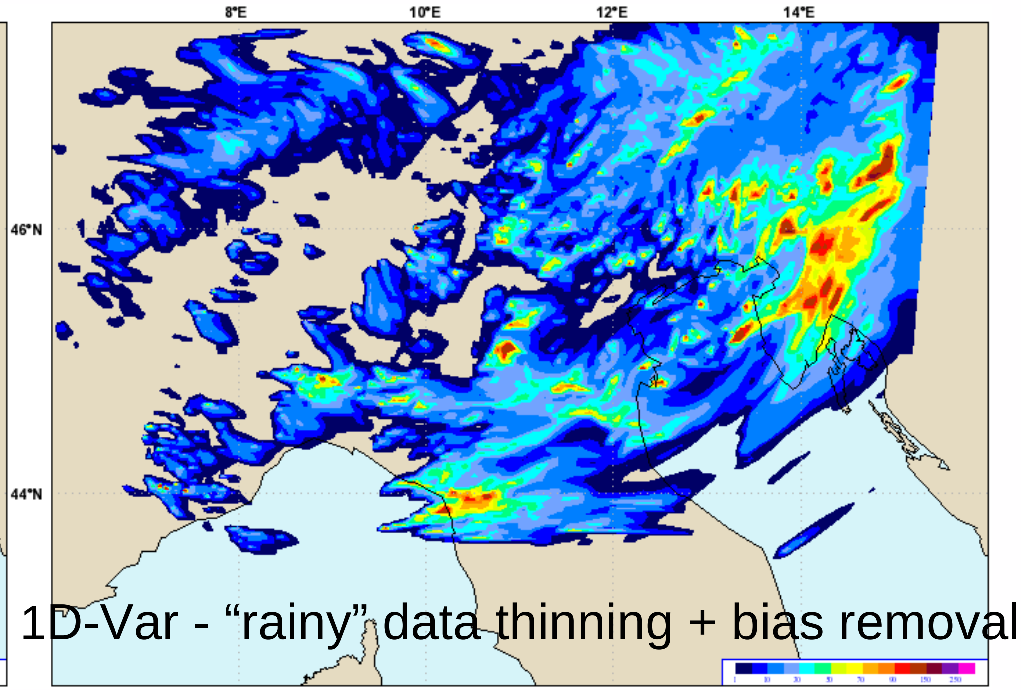
12 hrs accumulated precipitation

29 July 2010 - 00-12 UTC









Conclusions

LIMITATIONS	SOLUTIONS
Off-line application of 1D-Var algorithm	Creation of a new framework: instead of a 12 hours assimilation window, radar data are ingested in short (3 hours) and frequent assimilation cycles
Regular data thinning: choice of one observation every 5 gridpoints in both directions	Application of 1D-Var algorithm to those points for which $RR_{fg} > 0$ and $RR_{obs} > 0$ (Lopez 2010, Tech. Memo 627)

From the subjective analysis of the selected case study these two modifications to the proposed methodology have a good impact on forecasted precipitation fields making results comparable to LHN ones.

Comparing mean precipitation fields of COSMO model and cloud model, a limitation of the cloud model by itself is shown in case of strong precipitation. In this case the application of a bias correction seems to have a good impact on results, in particular in the forecast cycle.

The impact of these changes to the methodology will be tested and verified in a new case study in which the control run misses precipitation.