SPECIAL PROJECT PROGRESS REPORT

Progress Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year 2016

Project Title: Development of a perturbation strategy for convection-permitting ensemble forecasting over Italy

Computer Project Account: spitconv

Principal Investigator(s): Chiara Marsigli

Affiliation: Arpae SIMC, Bologna, Italy

Name of ECMWF scientist(s) collaborating to the project (if applicable) …………………………………………………………….……

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Start date of the project: 01/01/2016

Expected end date: 31/12/2018

Computer resources allocated/used for the current year and the previous one
(if applicable)
Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	-	-	3,000,000	1,200,000
Data storage capacity	(Gbytes)	-	-	200	100

Summary of project objectives

(10 lines max)

The aim of this project is to develop a complete perturbation strategy for the convention-permitting ensemble over Italy based on the COSMO model (COSMO-IT-EPS). This project represents the third step of a work which has been performed thanks to previous the SPITCONV Special Project (2010-2012 and 2013-2015).

The third phase (2016-2018, this SP) is aimed at:

1) further developing the use of the LETKF scheme for providing perturbed Initial Conditions to the ensemble

2) testing the combination of the different perturbations which are being developed in COSMO (physics and soil). In particular, SPPT scheme will be tested in combination with Perturbed Parameters and with perturbation of soil moisture.

The tests for the system further developments and upgrades will be carried out on ECMWF resources, thanks to this SP and to Italian resources.

Summary of problems encountered (if any)

(20 lines max)

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Summary of results of the current year (from July of previous year to June of current year)

This section should comprise 1 to 8 pages and can be replaced by a short summary plus an existing scientific report on the project

Summary.

During this reporting period (second half of 2015 of the previous SPITCONV project and first half of 2016, new and current SP) the work has focused on the LETKF scheme developed for ensemble data assimilation in the COSMO Consortium.

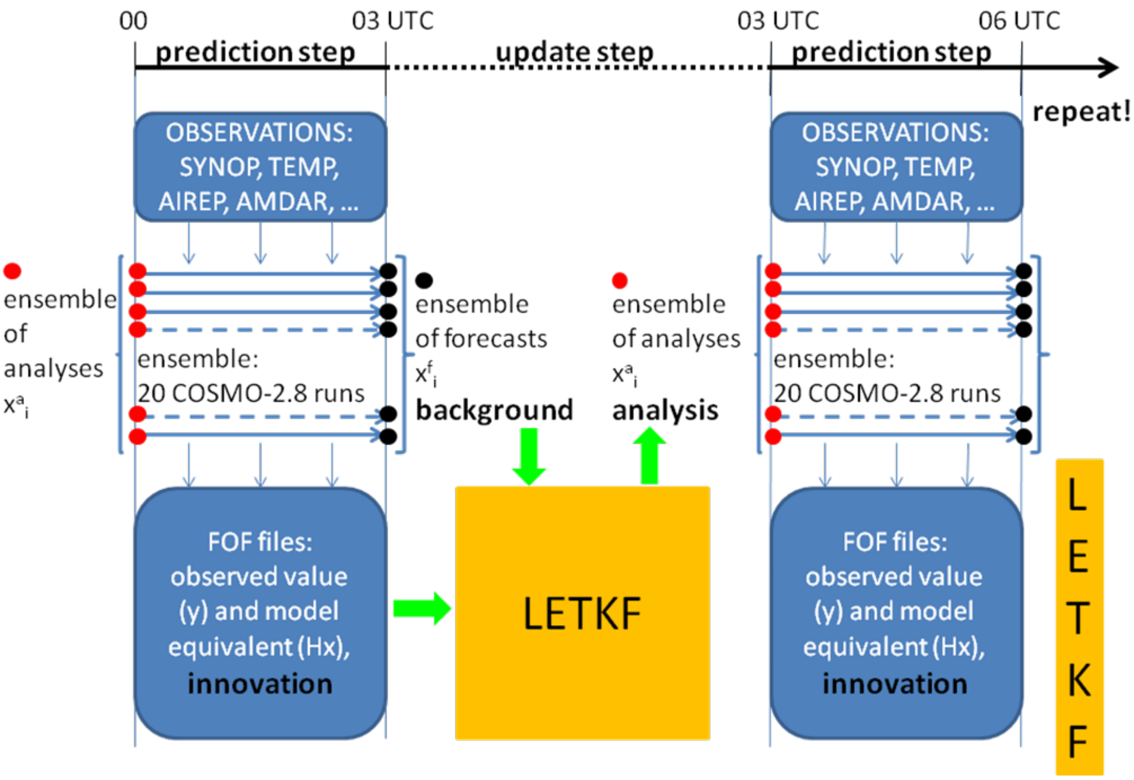
In particular the work included:

- implement and investigate the impact of the representation of the model error in the KENDA cycle by adding perturbations to the COSMO runs (SPPT)
- the impact of doubling the ensemble size from 20 to 40 members,
- a two-step assimilation of conventional and non-conventional observations (not on spitconv SBU).

The impact of the above mentioned tests has been evaluated by assessing the quality of the resulting analyses. This has been assessed both by evaluating the quality of the analyses themselves and by objectively evaluating the performances of the forecasts initialized with these analyses. In order to perform the latter evaluation, deterministic runs with the COSMO model in forecast mode have been performed, with the KENDA analysis as initial conditions. These runs have also been made on SBU of the Special Project.

Set-up of the experiments.

Three experimental data assimilation suites have been run, each consisting of one week of continuous data assimilation, following the scheme described here below.



In the first experiment a so called "control run" of the data assimilation cycle has been used: this is a run in which only conventional data (AIREP, TEMP and SYNOP data) have been assimilated into the model. The inflation is provided by multiplicative covariance inflation and RTPP (Relaxation to Prior Perturbations). The localization radius is fixed to 80 km. This run is referred to as control analysis.

In the second experiment the SPPT scheme is activated into the COSMO model. The other settings are as in the control run. This run is referred to as SPPT analysis.

In the third experiment, also non-conventional data are assimilated, namely 3d volume of radar reflectivity. This run is referred to as radar analysis and it has not been run on the SBU of the Special Project.

The experiments are run from 00 UTC on the 7th to the 00 UTC of the 15th of October 2014. The control run has been run also with 40 members instead of 20 in order to assess the impact of doubling ensemble size.

In order to evaluate the quality of the KENDA analyses in providing initial conditions for COSMO-I2, deterministic forecasts have also been run for each of the three experiments.

The 00 UTC analyses (8 analyses) have been used as initial conditions of 8 runs of the COSMO model at 2.8 km of resolution, with a 24 h forecast range.

Sanity check

As a sanity check, the statistics of the analysis increments in observation space has been computed, over the Italian domain, between 6° E and 19° E of longitude and 36° N and 48° N of latitude, from 00 UTC of 7th to 00 UTC of 15th of October 2014, using control run of COSMO model with 20 members. The statistics is computed for each observation type separately, comparing the model equivalent with observations which are assimilated, at observation location. The purpose is to check that the scheme is able to ingest the observations.

As an example, here are shown the statistics relative to the radiosondes in terms of temperature (figures 1) and wind (figures 2).

In the left panels the errors are for the model states before the assimilation step (first guess), while in right panels they are after the assimilation step (analysis).

The observational error (black line) is prescribed, therefore it does not vary. The spread of the first guess is also plotted as a red line.

Errors are displayed as a function of the altitude (pressure). Because radiosonde observations have large biases in the upper troposphere, they are currently used only below 300 hPa.

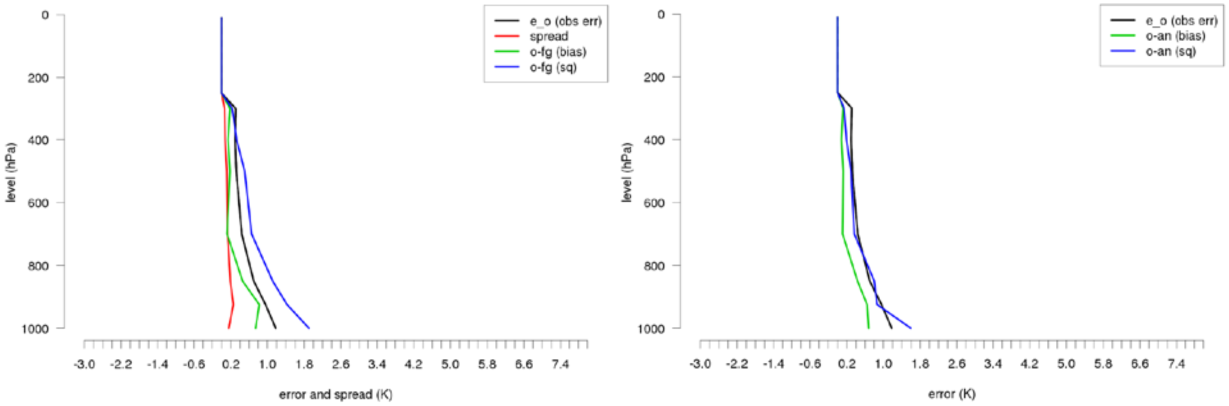


Figure 1. Statistics relative to the radiosondes in terms of temperature.

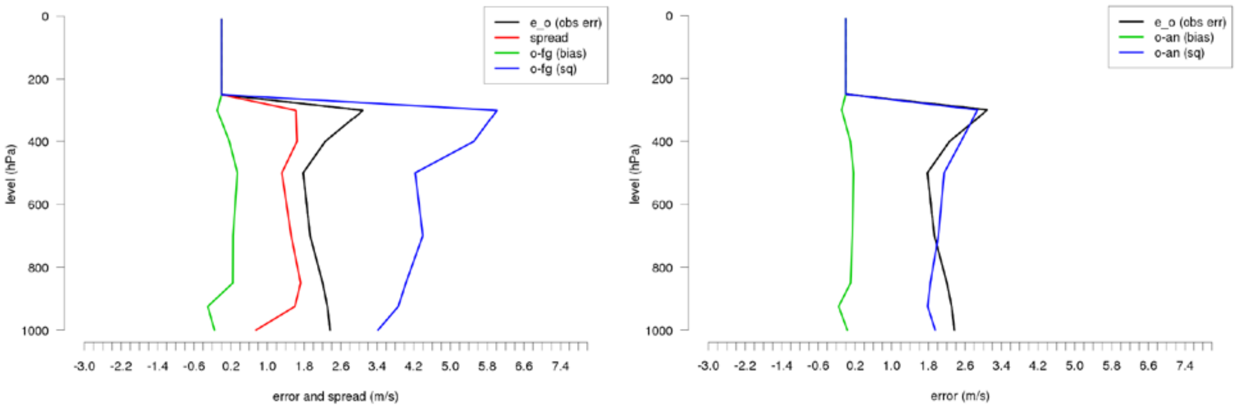


Figure 2. Statistics relative to the radiosondes in terms of wind.

Comparing the panels of figure 1 it is possible to note that the errors, expressed as differences between observed value and modeled one (green for the mean error and blue for the mean squared error) are reduced after the update step. Between 500 hPa and 900 hPa of altitude mean squared error of observation - first guess is reduced by about 0.5 K, while at the lowest level by about 0.3 K. The maximum value of the mean squared error before analysis is 2 K.

Comparing the panels of figure 2 the errors are largely reduced after the update step: the squared error is reduced by about 2-3 m/s, in particular at 300 hPa the squared error is reduced even from 6.2 m/s (maximum value) to 2.8 m/s

Evaluation of the analyses.

A comparison between predicted temperatures before (first guess) and after (analysis) the update step with observed temperature at the screen level has been made from 00 UTC of 7th to 00 UTC of 15th of October 2014 for a few location. Here the results over a location in Switzerland is shown (figure 3).

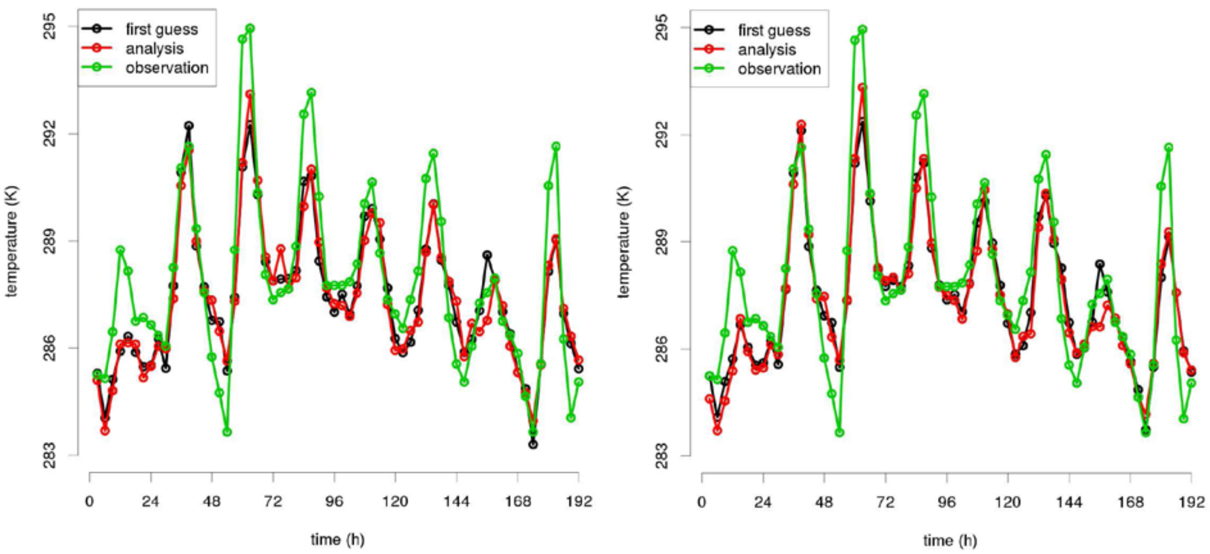


Figure 3. 2m temperatures of the first guess (black), of the analysis (red) and observed (green) over a point in Switzerland relative to the control experiment (left) and with the 40-member experiment (right).

The x-axis of the figures represents the time, in hours, since the beginning of the analysis cycle, starting from 00 UTC of the 7th of October 2014.

Considering the experiment of the control run, with both 20 (figure 3 left) and 40 members (figure 3 right), the update step on the 7th of October (time between 0 and 24 h) is not high performing in fact temperatures before the update step are closer to the observation than the temperatures after the

step. Moreover in that day predicted temperatures are between 1 K and 3 K lower than the observed temperature. The following day predicted temperatures, both before and analysis are close to the observed temperature, with a maximum difference on the order of 1 K.
Regarding figure 4 left panel, until the 18 UTC (at 42 h) of the 8th of October the graphics are quite similar, while between 21 UTC (at 45 h) on the 8th and 6 UTC (at 54 h) on the 9th of October, the SPPT analysis showed some problems in the forecast both before and after the update step: predicted temperature before the step was 2-3 K higher than the observation, while predicted temperature after the update step was even 3-4 K higher than the observed temperature, therefore the update step brought the temperature 1 K further from the observation.

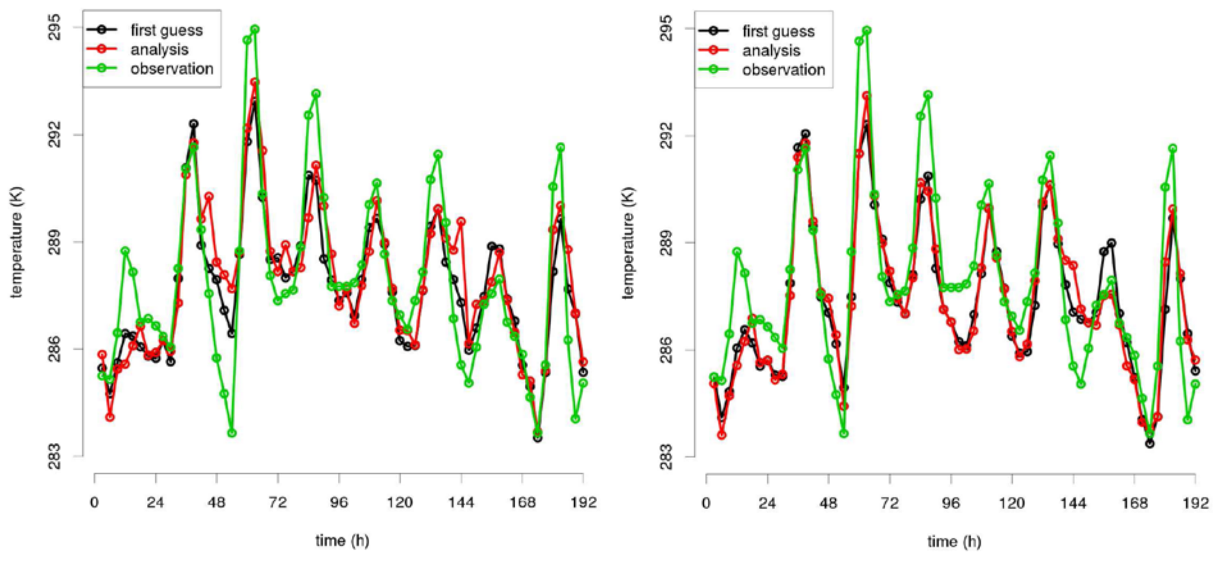


Figure 4. 2m temperatures of the first guess (black), of the analysis (red) and observed (green) over a point in Switzerland relative to the SPPT experiment (left) and with the radar experiment (right).

At the same hours, radar analysis worked much better, in fact the difference between the predicted and the observed temperature was smaller than 2 K, both before and after the update step. At 00 UTC (at 144 h) on the 13th of October a problem occurred both using SPPT and radar analyses: using SPPT analysis, the temperature after update step was about 4 K higher than the observation, while before the step was about 2 K higher than the observed temperature. A similar problem, though of smaller entity, was observed also in radar analysis.

Evaluation of the forecasts.

The forecasts issued by the COSMO model with the KENDA analysis as initial conditions have also been evaluated. The forecasted hourly precipitation, averaged over an area located between Liguria, Tuscany and Emilia-Romagna (44-45◦ N and 8.5-9.5◦ E), is shown (figure 5) for two 24h periods during which intense rain was recorded in the region (10th of October in the left panel and 13th of October in the right panel). Observed precipitation is also shown.

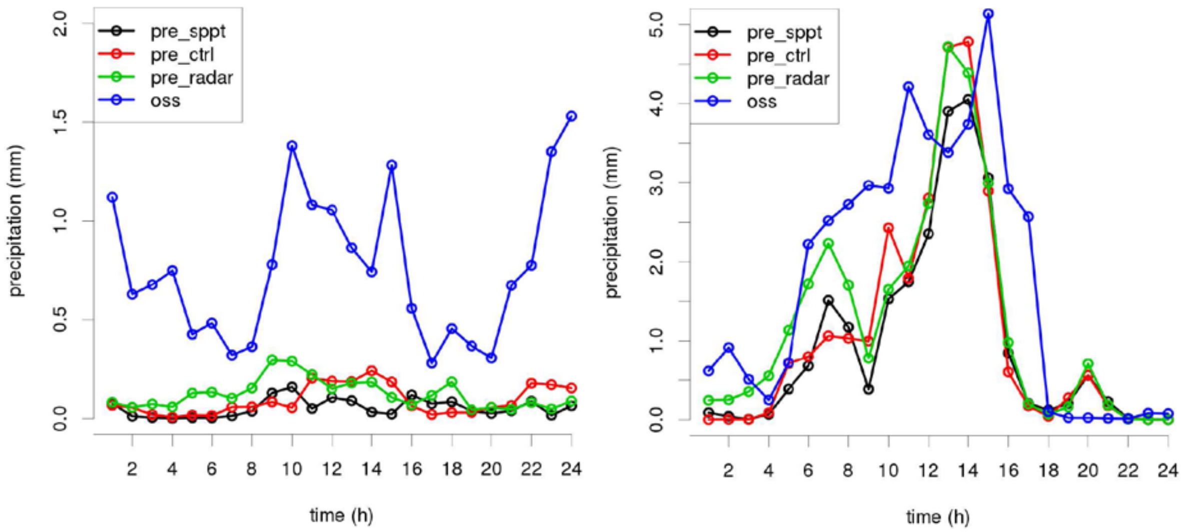


Figure 5. Hourly precipitation, averaged over an area (44-45◦ N and 8.5-9.5◦ E) for two 24h periods (10th of October in the left panel and 13th of October in the right panel). Observed precipitation is plotted in blue, while forecasted precipitation is plotted in red (control), black (SPPT) and green (radar).

In the Genova event (left panel) the blue line representing the observed precipitations is higher the other three lines representing the predicted precipitations, indicating that the average precipitation over the Genova area is underestimated by all experiments.

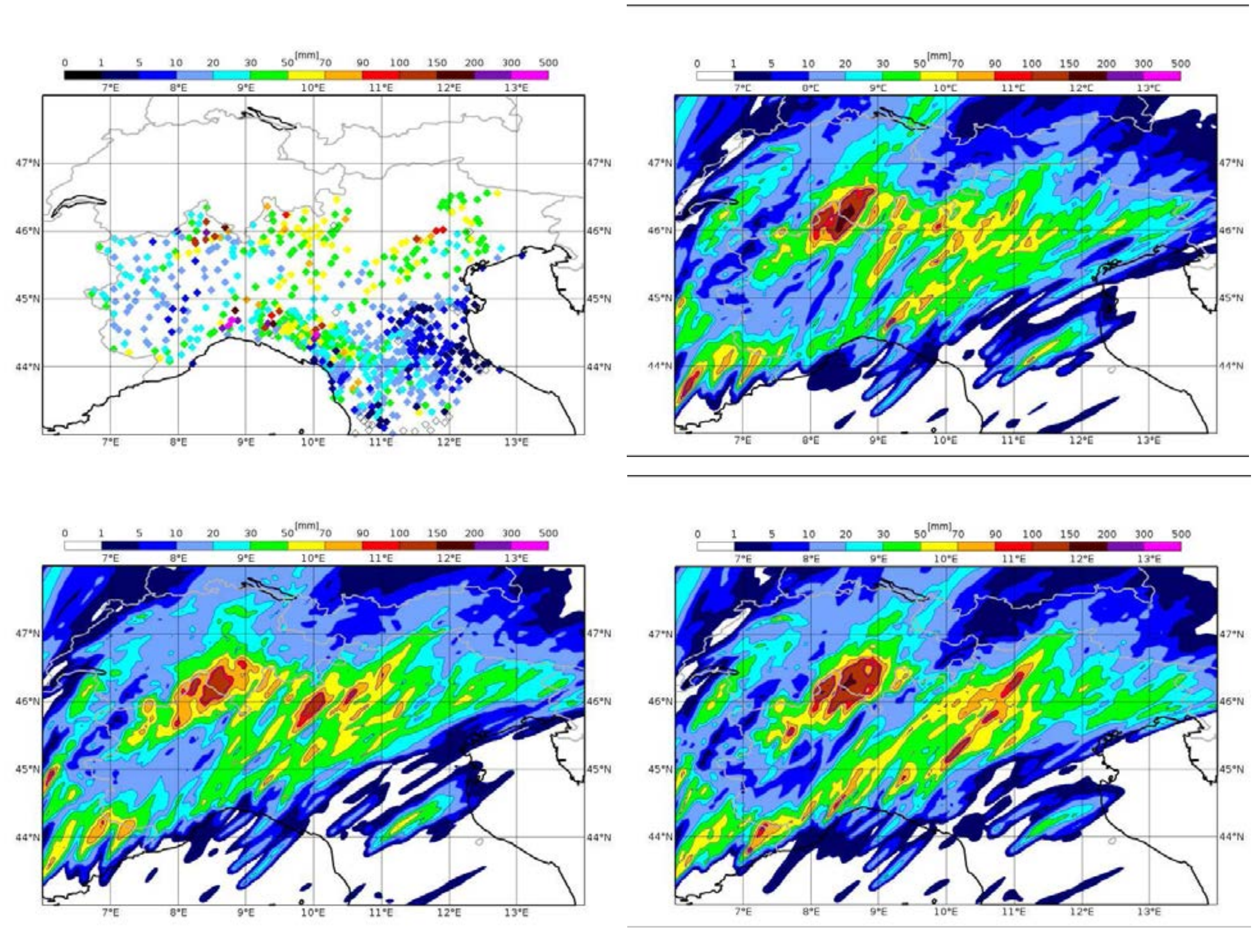
The radar experiment determines a small positive impact to the hourly precipitations for the first 10 hours of the 10th of October run. The use of the SPPT during the analysis cycle does not produce a good result in terms of this evaluation of the forecast.

In the Parma event (right panel) the three forecasts are quite consistent with the observed precipitations, with a better performance of the radar run in the first 8 hours.

In order to shown better the extent of the differences between the forecasts, the predicted and observed rainfall is also shown for the Parma event.

In figure 6 it is shown the observed precipitations on the 13th of October 2014 (top left), when an extended and locally severe perturbation affected Northern Italy causing a flood in Parma (44.8◦ N and 10.3◦ E). In particular there are three "lines" of severe precipitations: one on the border between Piedmont and Liguria, another on the border between Liguria and Emilia-Romagna, and the last on the border between Emilia-Romagna and Tuscany.

The forecasts are shown in the other panels: control (top right), SPPT (bottom left) and radar (bottom right).



The forecasts are generally of good quality, but in particular the deterministic run of COSMO initialized with radar analysis managed to identify three lines of precipitation between Liguria, Emilia-Romagna and Tuscany. However, the localization is not exactly corresponding to the observations, in particular the line of precipitation on the border between Emilia-Romagna and Tuscany is north-shifted.

List of publications/reports from the project with complete references

M. Corbani, 2016, Assimilation of data from conventional and non conventional networks through a LETKF scheme in the COSMO model, Master Thesis, University of Bologna, 86 pp.

Summary of plans for the continuation of the project

(10 lines max)

The next period will be devoted to further studies of the quality of the KENDA analyses. In particular, they will be used as initial conditions to the run of the ensemble system COSMO-IT-EPS, for the period of 8 days here studied.

Then, the work on model perturbation will also continue, by considering the perturbation of more parameters of the physical schemes and the combination with perturbations of the soil moisture.