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 2016-2017

Project Title: Testing perturbation of surface/soil conditions and of PBL for the prediction of thunderstorms and fog in the framework of the SRNWP-EPS Phase II Project.

Computer Project Account: spitsrep

Principal Investigator(s): Chiara Marsigli

Affiliation: Arpae SIMC

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

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Start date of the project: November 2016

Expected end date: December 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)	9 M	5 M	9 M	9 M
Data storage capacity	(Gbytes)	500	500	500	500

Summary of project objectives

(10 lines max)

The aim of this Project is to study the sensitivity of convection-permitting ensemble prediction systems to soil conditions and PBL modeling in the prediction of selected phenomena (fog and thunderstorms), in the framework of the SRNWP-EPS II Project.
Each participant to the Research Task of the project tests the impact of their own perturbation method(s) on their own ensemble system and on their own domain. The common focus on the selected weather phenomena (mainly thunderstorms and fog) provides the common basis of this work, allowing a meaningful exchange of the results obtained.
This is achieved through a test of the perturbations on two periods long enough to permit some statistical evaluation and including events relative to the selected weather phenomena.
This Special Project is aimed at executing the ensemble runs which are needed for the tests by a group of Participants: Italy, Norway, Spain and Sweden.

Summary of problems encountered (if any)

(20 lines max)

The SBU asked for the year 2016 have been not used entirely due to the time needed to perform the runs of the experiments.

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

During the first year of the project (2016, November and December) experiments have been run on the ECMWF supercomputer, thanks to the SBUs provided by the present Special Project, by two groups: MetCoOp and Italy. In the first half of 2017, instead, experiments have been run by AEMET (Spain).

MetCoOp (which is the cooperation between Norway, Sweden, and now also Finland) are testing different configurations of the convection-permitting 10+1 member ensemble HarmonEPS at 2.5 km horizontal resolution. This project is to get better predictions of fog and thunderstorms, and in MetCoOp we are trying to create perturbations that will lead to better prediction of especially these variables.
Extensive experiments with surface perturbations have been carried out, but that is not reported here as that has used SBUs from national resources.
MetCoOp's fraction of the SBUs for this project has been used for running one experiment where a parameter that represents the transport term of TKE, influencing the top entrainment and with it the clouds, in the turbulence scheme (HARATU) is perturbed. In this first experiment the parameter is randomly perturbed for each member and each cycle, but kept constant in time and space. In later experimentations we have included one more parameter and also a spatio-temporal correlation pattern for the perturbations.
This used resources from another special project (spnogep) and is therefore reported for that project.
The period chosen was 30 May - 15 June 2016, and the area was the MetCoOp domain, see figure below.

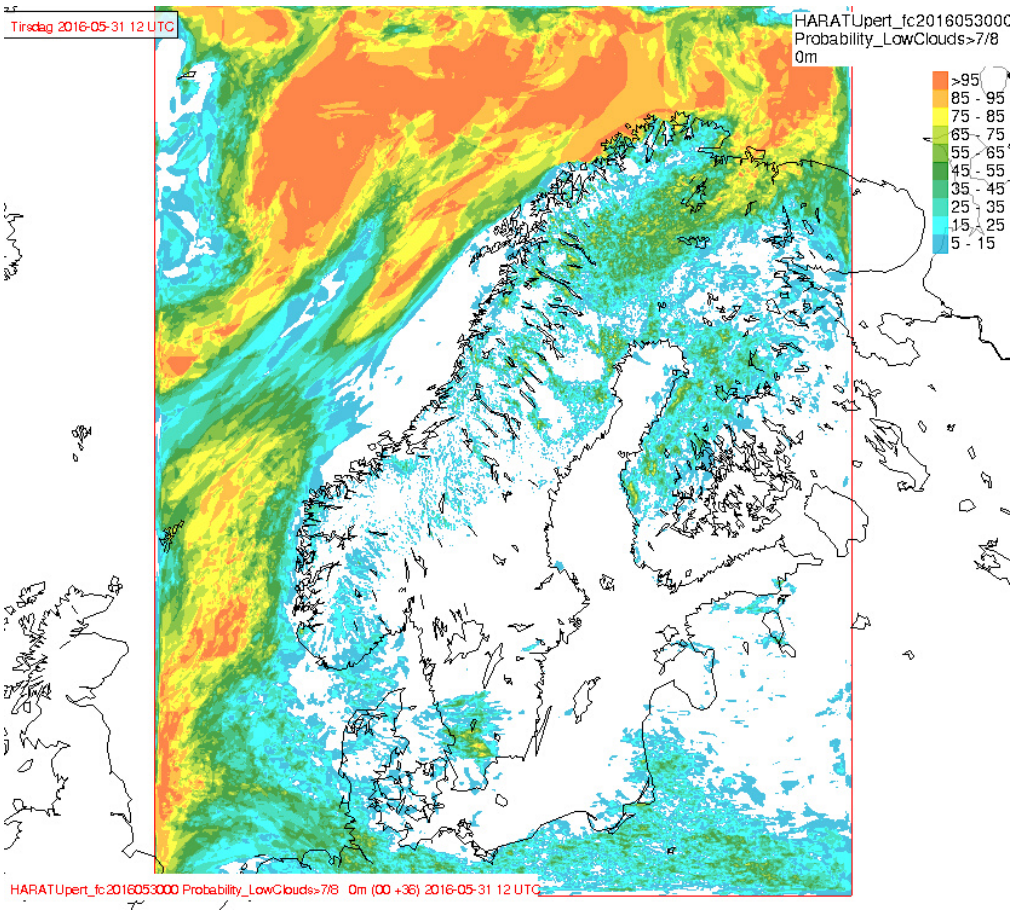

Figure: MetCoOp area used in the experiment. Show is the probability of low clouds from the perturbed experiment for 30 May 2016.

All members have three hourly cycling, but only 00 run was run until +36 h. This period was chosen because it included many cases of thunderstorms in Sweden and Norway, and also interesting cases of fog. The parameter perturbed in the experiment described here is expected to have most influence on fog and low clouds.
A reference run without perturbing this parameter was run on a different account.
In the figure below the Continuous Rank Probability Score (CRPS) for low clouds is shown for the perturbed (blue) and unperturbed (black) runs with HarmonEPS. Note that the score is negatively oriented. The difference is small, but there is a tendency that the perturbed run scores better for night-time, and worse for day-time for day 2.

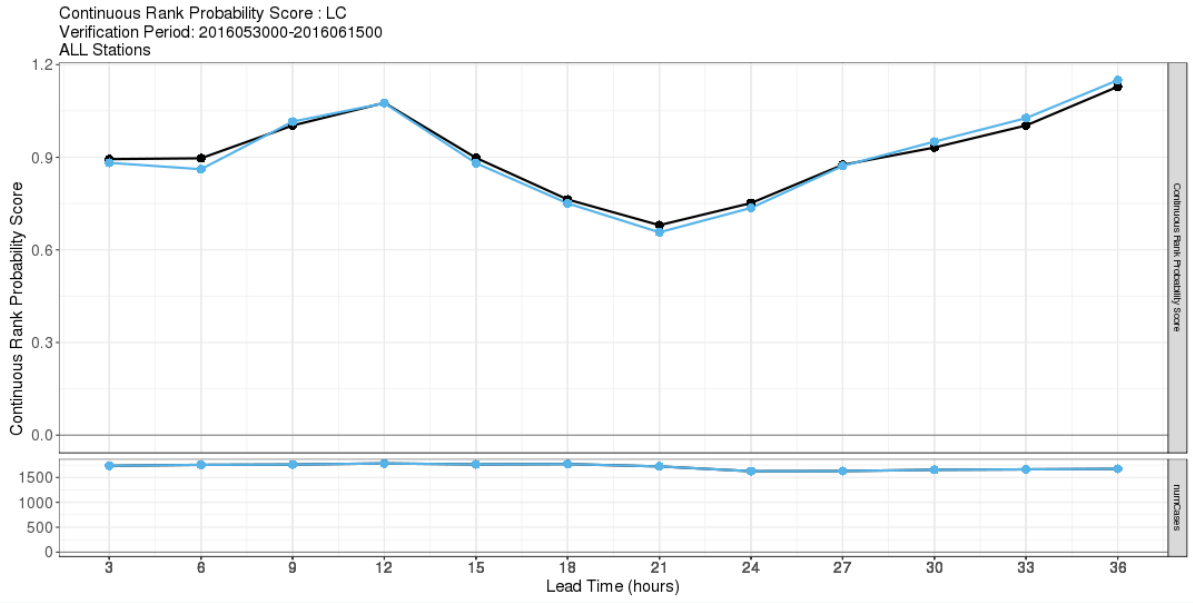

Figure: CRPS for low clouds. Perturbed run (blue), reference run (black).

The economic value is in the figure below for 6h lead time and for the threshold of 0 oktas (no low clouds), and here there is a small improvement of the perturbed experiment. However, the difference between the perturbed and unperturbed runs is in general small.

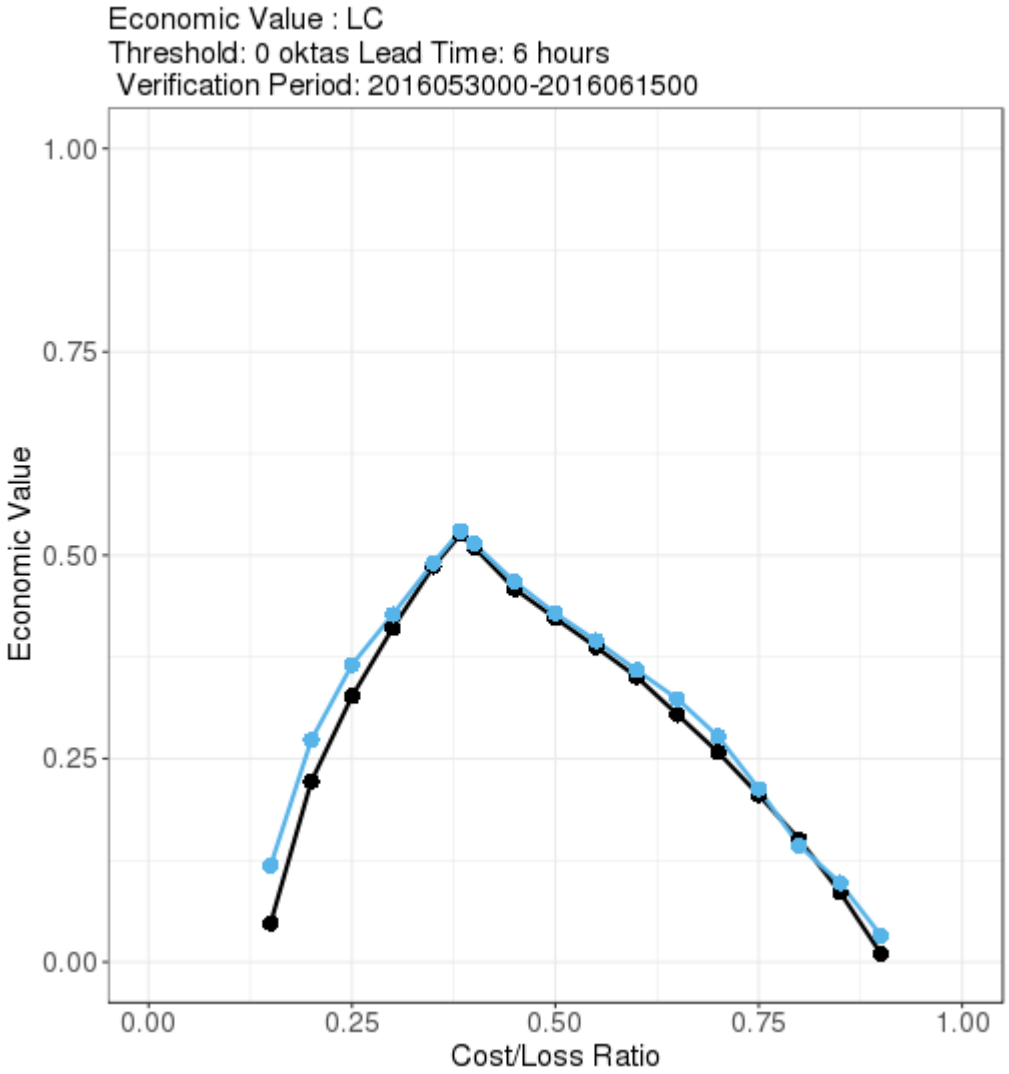

Figure: Economic value as a function of cost-loss ratio. Perturbed run (blue), reference run (black).

The work on parameter perturbations in HarmonEPS will continue with more parameters, and also utilizing a spatio-temporal correlation pattern.

In Italy, Arpae SIMC is now putting in operations the COSMO-IT-EPS ensemble. The ensemble is based on the COSMO model, run at 2.2 km (explicit convection), with 65 vertical levels, over Italy. The ensemble has 10 members, which receive Boundary Conditions from COSMO-ME-EPS, the 10-km ensemble over the Mediterranean area run by COMET.
In the first implementation, COSMO-IT-EPS receives also ICs from the parent ensemble but soon it will get ICs from an ensemble data assimilation, using the LETKF scheme developed in the COSMO Consortium (KENDA). The KENDA system has been implemented at ECMWF for testing thanks to the SPITCONV SP (still on-going), where most of the experimentation takes place.
COSMO-IT-EPS benefits also of model perturbations. Thanks to the same SPITCONV SP, different configurations of the model perturbations have been tested, on the basis of which it has been decided to use in the ensemble a combination of SPPT and physics parameter perturbation.
In its experimental phase, different parent ensemble for providing BCs have also been tested, in particular the ENS of ECMWF.

At the end of 2016, the SBU provided by the present SP SPITSREP have been used to run the COSMO-IT-EPS ensemble on one of the two test period chosen by Italy in the framework of the PBL and soil perturbation testing of the SRNWP-EPS II Project of EUMETNET.
The two periods are respectively characterised by the two types of phenomena object to study in the project: thunderstorms and fog. The thunderstorm period has been defined from 18 June 2016 to 8 July 2016. The fog period is a collection of sub-periods, including several fog episodes (December 2016, February 2017, March 2017).
The experiment carried out at the end of 2016 (which has used 2 M SBUs) has been focussed on the thunderstorm period. The COSMO-IT-EPS ensemble has been run for the entire period (20160618-20160708), with ICs and BCs from ECMWF ENS, in order to test the model perturbations which have been selected for influencing the prediction of the thunderstorms.
In particular, SPPT has been combined with perturbation of parameters, as described above. The selected parameters belong to different physics schemes and are shown in the table below.

member	tur_len	rlam_heat	cloud_num	entr_sc	pat_len	crsmin	thhmin
1	150	1	5.00e+08	0.0003	500	150	0.4
2	150	1	5.00e+07	0.0003	500	150	0.4
3	150	1	5.00e+08	0.0003	500	200	0.4
4	150	1	5.00e+08	0.002	500	150	0.4
5	500	1	5.00e+08	0.0003	500	150	0.4
6	150	0.1	5.00e+08	0.0003	500	150	0.4
7	150	1	5.00e+08	0.0003	1000	150	0.4
8	150	1	5.00e+08	0.0003	500	500	0.2
9	150	1	5.00e+08	0.0003	500	150	0.7
10	150	1	5.00e+07	0.002	500	150	0.4

The parameters are:

- tur_len: maximal turbulent length scale (m)
- rlam_heat: scaling factor for the thickness of the laminar boundary layer for heat
- cloud_num: cloud droplet number concentration
- entr_sc: mean entrainment rate for shallow convection
- pat_len: length scale (m) of sub-scale surface patterns over land
- crsmin: minimum value of stomatal resistance
- tkhmin and tkmmin: minimal diffusion coefficients for heat (h) and momentum (m)

As for IC and BCs, this experiment will be compared with the experiment currently on-going, where the COSMO-IT-EPS ensemble receives the BCs from COSMO-ME-EPS. This is a 40 members ensemble, based on the COSMO model run at 10 km, with BCs from ECMWF ENS and ICs from a LETKF developed by COMET.
The results will be shown in the next report, where these experiments will be analysed aiming at understanding the role of the different parameter perturbations in influencing the thunderstorm prediction.

In Spain, AEMET, as a member of the HIRLAM Consortium, runs the convection-permitting high-resolution non-hydrostatic Harmonie-AROME model on a daily basis in their high-performance computing facilities sited in Madrid (Spain).
Experiments on surface perturbations are carried out with the Ensemble Prediction System based on the Harmonie-AROME model: harmonEPS.
Detailed information about the Harmonie-AROME model can be found in the publication: “The HARMONIE-AROME model configuration in the ALADIN-HIRLAM NWP system”, which describes the forecast model configuration used in the Reference System (Cy40h1) configuration and it can be accessed at:

http://journals.ametsoc.org/doi/abs/10.1175/MWR-D-16-0417.1 .

The model setup and other options for the configuration of the harmonEPS are listed in Table:

Model setup	Model version: **harmonie-40h1.1** Resolution: **2.5 km** grid spacing, **65 vertical levels** Domain: **Iberian Peninsula** (same domain for all members) Physics: **Harmonie-AROME physics**
Assimilation	3h **3DVAR** for the control member 3h **surface assimilation** for the control member (**CANARI Optimal Interpolation**) 6h surface assimilation for all members (**CANARI Optimal Interpolation**)
Forecast Lengths	36h at 00, 06, 12, and 18 UTC for the control member 3h at 03, 09, 15 and 21 UTC for the control member 36h at 00, 06, 12 and 18 UTC for all members
Perturbations	Inital and boundary perturbations from ECMWF forecasts (**SLAF**) every 06 h
Members	**1 control + 10 members**

In the framework of the SRNWP-EPS Project, AEMET decided to run a battery of selected case studies on severe weather that took place over the Iberian Peninsula during the winter season of 2016/2017, the spring season of 2017 and those weather situations that may occur during the summer season of 2017 that we think may be of interest to the SRNWP-EPS II Project.

Experiments on the perturbation of surface fields have been carried out. The perturbation pattern generation is based on the paper of Bouttier et al (2016): Sensitivity of the AROME ensemble to initial and surface perturbation during HyMeX (Quarterly Journal of the Royal Meteorological Society,Volume 142, Issue Supplement S1).

A brief description of the procedure is:

- The model grid is filled with white noise (uniformly disturbed random number between 0 and 1).
- Spatially smoothed by repeated application of a recursive low-pass filter in both grid directions until a pre-defined correlation length scale is achieved (default ~300 km, 10 iterations).
- After smoothing, the pattern is clipped to have max/min value of ± specified value.
- Perturbation fields are rescaled and clipped with spatially constant values that are tuned for each parameter: the perturbation standard deviations are roughly consistent with the precision at which the surface parameters are known and perturbed values are clipped to constrain them to realistic values.
- The perturbation field is applied either additively or multiplicatively depending on the parameter.

AEMET decided to perturb the Sea Surface Temperature in such a way:

Perturbation	Parameter	Output to SURFEX	Std. dev. (+/-)	Clip Min.	Clip Max.
SST	SST	SST	1.5+	272 K	350 K

Every case study is formed by a reference run and a set of perturbed sea surface temperature experiments of an ensemble prediction system composed by 10 ensemble members plus a control member, so it needs high quantity of CPU resources and it takes long time to run it.

For this reason, case studies have been at the High Performance Computing Facilities (HPCF) of the ECMWF on the account of the spitsrep Project and results will be present at the Conference within the framework of the SRNWP-EPS II Project that will be held in Madrid next Autumn. Results will be included in the next report of the Special Project.

List of publications/reports from the project with complete references

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Summary of plans for the continuation of the project

(10 lines max)

The results of the experiments run thank to the SBU of the SP will be elaborated and analysed in the second part of the 2017, hence included in the next report.

The SRNWP-EPS II project has been extended by EUMETNET to the entire year 2018. Therefore, a continuation of the research activity included in the Project is foreseen. This implies that more experiments will be carried out, on the basis of the results of the experiments carried out in the first period. In October 2017 a Project Workshop will take place in Madrid, where the results of the experiments conducted until then will be presented and discussed. On the basis of these, new experiments will be decided and scheduled. Therefore, we would like to extend also the duration of the present SP to the year 2018, presumably asking for a similar allocation of SBU.