# 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** 2010

**Project Title:** Flow dependent Error statistic for satellite data Assimilation in Regional model – FEAR

**Computer Project Account:** SPITFEAR

**Principal Investigator(s):** Chiara Marsigli
Francesca Di Giuseppe

**Affiliation:** ARPA-SIMC, Bologna, Italy

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

**Start date of the project:** 2009

**Expected end date:** 2011

**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) | | | 1000000 | 250000 |
| **Data storage capacity** | (Gbytes) | | | | |



This template is available at:
http://www.ecmwf.int/about/computer_access_registration/forms/

## Summary of project objectives

(10 lines max)

The aim of this project is to develop and improve a short range limited-area ensemble (COSMO-SREPS), here with the final aim to determine flow dependent model error statistics to be employed in the assimilation system of the high-resolution non-hydrostatic limited-area model COSMO. For this purpose, it is desirable that the ensemble spread in the first 12 hours is representative of the forecast uncertainty at the correct spatial and temporal scales. To meet this necessity, a set of perturbations of the COSMO model have been tested and implemented in the COSMO-SREPS system. The final aim of this task is to end up with a system where the ensemble spread is representative of the model error during the first 12 hours of model integration, especially in terms of T, Q and surface variables.

**For this purpose, the SPITFEAR BUs have been sued to run the CSPERT suite, the suite where the new COSMO model perturbations are implemented and tested, permitting to have a robust statistical assessment of the perturbation impact.**

## Summary of problems encountered (if any)

(20 lines max)

Despite some promising results in the methodology as a whole, it was recognised a general lack of spread in the COSMO-SREPS ensemble in terms of the variables of concern for the data assimilation. This has lead to the necessity of tackling more directly the issue of the ensemble perturbation strategy, before concentrating on the data assimilation itself. Hence, the investigation and the computing resources are mainly focussed to develop and test more adapt perturbations of the parameters included in the physics of the COSMO model, particularly in turbulence, soil scheme and microphysics. A strategy for the perturbation of the soil moisture field which serves as initial condition at the lower boundary of the model is also being developed to be tested in this system, thanks to the SPITFEAR BUs, but this task has been delayed of few months due to some problems encountered in the implementation of the methodology.

## 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

See the Annex.

## List of publications/reports from the project with complete references

- Di Giuseppe F., Paccagnella T. and Marsigli C., 2010. The relevance of background error covariance matrix localisation: an application to the variational retrieval of vertical profiles from SEVIRI observations. Quarterly Journal of the Roy. Met. Soc., under revision.
- Marsigli C., 2009. COSMO Priority Project "Short-Range Ensemble Prediction System (SREPS)": Final Report. Available on the COSMO web site at http://www.cosmo-model.org/content/model/documentation/techReports/docs/techReport13.pdf


## Summary of plans for the continuation of the project

(10 lines max)

In the last part of the project, the object of the investigation will be to test a new type of model perturbations. In particular, a strategy (taken after Sutton and Hamill, 2004) for the perturbation of the soil moisture field which serves as initial condition at the lower boundary of the model is being developed at HNMS for this purpose in the framework of the COSMO cooperation. During the second part of 2010 and during 2011 the impact of this new model perturbation needs to be assessed on a robust statistical manner. **The SPITFEAR BUs will then be used to run some COSMO-SREPS additional members where the perturbed soil moisture field will replace that used in the present configuration.** Several runs will be needed, since the methodology require some tuning, at this stage, and a proper assessment of the impact of the use of the perturbed field will require to run for at least a couple of seasons (1 wet and 1 dry).

## Status of the project.

The aim of this project is to develop and improve a short range limited-area ensemble to determine flow dependent model error statistics to be employed in the assimilation system of the high-resolution non-hydrostatic limited-area model COSMO.

The use of an ensemble system permits to provide an assessment of the model error which is dependent on the meteorological situation and on the model dynamics. During the first part of this project, the flow dependent model error statistics have been employed in the 1DVAR assimilation system of the COSMO model. A spatial localization of the error was performed, identifying regions of homogeneous 2-dimensional spread field. The system was then used to retrieve temperature and humidity profiles from MSG-SEVIRI data.

For this purpose, it is desirable that the ensemble spread in the first 12 hrs is representative of the forecast uncertainty at the correct spatial and temporal scales. Ensemble perturbations come both from the use of multi-model initial and boundary conditions and from stochastic model perturbation, being the first representative of large scale uncertainty and the latter describing sources of local-scale errors.

The results of this experiments were presented in the previous project reports and in a scientific paper currently in revision at the Quarterly Journal of the Royal Meteorological Society.

Despite some promising results in the methodology as a whole, it was recognised a general lack of spread in the COSMO-SREPS ensemble in terms of the variables of concern for the data assimilation. This has lead to the necessity of tackling more directly the issue of the ensemble perturbation strategy, before concentrating on the data assimilation itself. Up to now, the investigation was carried out mainly on the perturbations of the parameters included in the physics of the COSMO model, particularly in turbulence and soil schemes.

**During the last year, more and more diverse parameters were perturbed, in particular parameters included in the microphysics scheme, and also some parameter combinations.**

**For this purpose, the SPITFEAR BUs have been sued to run the CSPERT suite, the suite where the new model perturbations are tested.** The COSMO model is run 16 times with the same domain, resolution, model version used in the COSMO-SREPS ensemble, but the initial and boundary conditions are provided by the deterministic IFS run. In this suite, hence, only the model perturbations are studied, each run having a slightly different configuration of the model physics.

**The suite has been run for one entire year, from Spring 2009 to Spring 2010.** The aim was to include different weather conditions and different seasons, in order to be able to evaluate the impact of the use of the new perturbations in different conditions (dry season, wet season, large-scale rainfall, convection). Two spring seasons have been included since the focus is mainly on microphysics perturbations.

## Results.

In the CSPERT suite, the COSMO model is run in the same configuration implemented in the COSMO-SREPS ensemble system. The integration domain covers the European area as shown in fig. 1 (blue area), the horizontal resolution is 10 km with 40 vertical levels.

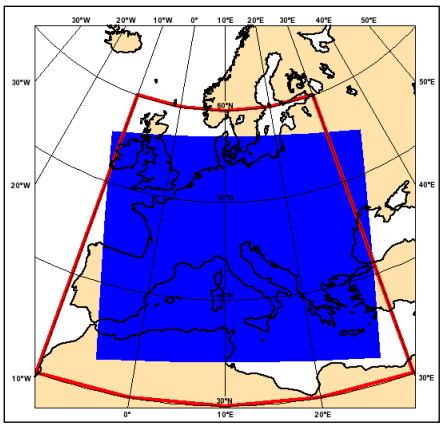

**Fig 1**. Integration domain for the COSMO model in the ensemble COSMO-SREPS configuration (blue area)

The system set-up for the year 2009/2010 is described in Table 1.

| member | conv | pat_len | rlam_heat | rat_sea | crsmin | cloud | mu_rain | gscp |
|---|---|---|---|---|---|---|---|---|
| 1 | T | 500 | 0.1 | 20 | 200 | 5.00e+08 | 0.5 | 4 |
| 2 | KF | 500 | 0.1 | 20 | 200 | 5.00e+08 | 0.5 | 4 |
| 3 | T | 500 | 1 | 1 | 200 | 5.00e+08 | 0.5 | 4 |
| 4 | KF | 500 | 1 | 1 | 200 | 5.00e+08 | 0.5 | 4 |
| 5 | T | 500 | 1 | 20 | 150 | 5.00e+07 | 0.5 | 4 |
| 6 | KF | 500 | 1 | 20 | 150 | 5.00e+07 | 0.5 | 4 |
| 7 | T | 500 | 1 | 20 | 150 | 5.00e+08 | 0 | 4 |
| 8 | KF | 500 | 1 | 20 | 150 | 5.00e+08 | 0 | 4 |
| 9 | T | 500 | 1 | 20 | 150 | 5.00e+08 | 0.5 | 3 (no gra) |
| 10 | KF | 500 | 1 | 20 | 150 | 5.00e+08 | 0.5 | 3 (no gra) |
| 11 | T | 10000 | 1 | 20 | 150 | 5.00e+07 | 0.5 | 4 |
| 12 | KF | 10000 | 1 | 20 | 150 | 5.00e+07 | 0.5 | 4 |
| 13 | T | 500 | 1 | 20 | 150 | 5.00e+07 | 0 | 4 |
| 14 | KF | 500 | 1 | 20 | 150 | 5.00e+07 | 0 | 4 |
| 15 | T | 500 | 1 | 20 | 150 | 5.00e+08 | 0.5 | 4 |
| 16 | KF | 500 | 1 | 20 | 150 | 5.00e+08 | 0.5 | 4 |

**Tab 1.** Set-up of the CSPERT suite for the new parameter perturbation testing.

Initial and boundary conditions for the 16 runs were provided by the same run: the operational deterministic integration of ECMWF. The runs were starting daily at 00 UTC and the forecast range was 24 hours only, not 72 as in the COSMO-SREPS suite. This was done to save computer time, restricting the analysis to the shorter forecast range, where a good representation of the "error of the day" was needed also for data assimilation purposes.

The perturbed parameters belong to different schemes. Their meaning is here listed:

- **pat_len:** length scale of thermal surface patterns
- **rlam_heat:** scaling factor of the laminar layer depth
- **rat_sea:** ratio of laminar scaling factors for heat over sea
- **crsmin:** minimal stomata resistance
- **cloud:** cloud droplet number concentration
- **mu_rain:** Exponent of the raindrop size distribution
- **gscp:** switch on/off of the graupel scheme

The perturbations of the 3 new parameters of the microphysics are hence tested in runs 5-6 (cloud), 7-8 (mu_rain), 9-10 (gscp), each in combination with the use of either the Tiedtke or Kain-Fritsch convection schemes. Then, several combinations of parameters have been tested: rlam_heat + crsmin (runs 1-2), rat_sea + crsmin (runs 3-4), pat_len + cloud (runs 11-12) and cloud + mu_rain (13-14). The last two runs (15-16) provide the reference run for either the Tiedtke (15) and Kain-Fritsch (16) branches.

As an example, results for spring (MAM) 2009 are shown in Figures 2-4, for 6h precipitation forecasts over Norther Italy. The scores are computed comparing the mean values of both forecasts and observations over boxes of 0.5 x 0.5 degrees which cover Northern Italy, where precipitation observations are made available by some Italian Regions in the framework of the COSMO cooperation.

As for the "cloud" perturbations, results for MAM 09 indicate that:

- the runs where the two perturbations cloud=5e+07 and pat_len=10000 are combined generally tend to be more rainy
- the use of the cloud=5e+07 perturbation alone has a small impact. If combined with the T convection scheme the rainfall increases, leading to an improvement for high thresholds but with more false alarms; in combination with the KF convection scheme a little worsening is observed
- the runs where cloud=5e+07 and mu_rain=0 are combined are more skilful for higher thresholds

Results relative to autumn (SON) 2009 are shown in Figures 5-7. Results for the "cloud" perturbations are similar to those for the spring season.

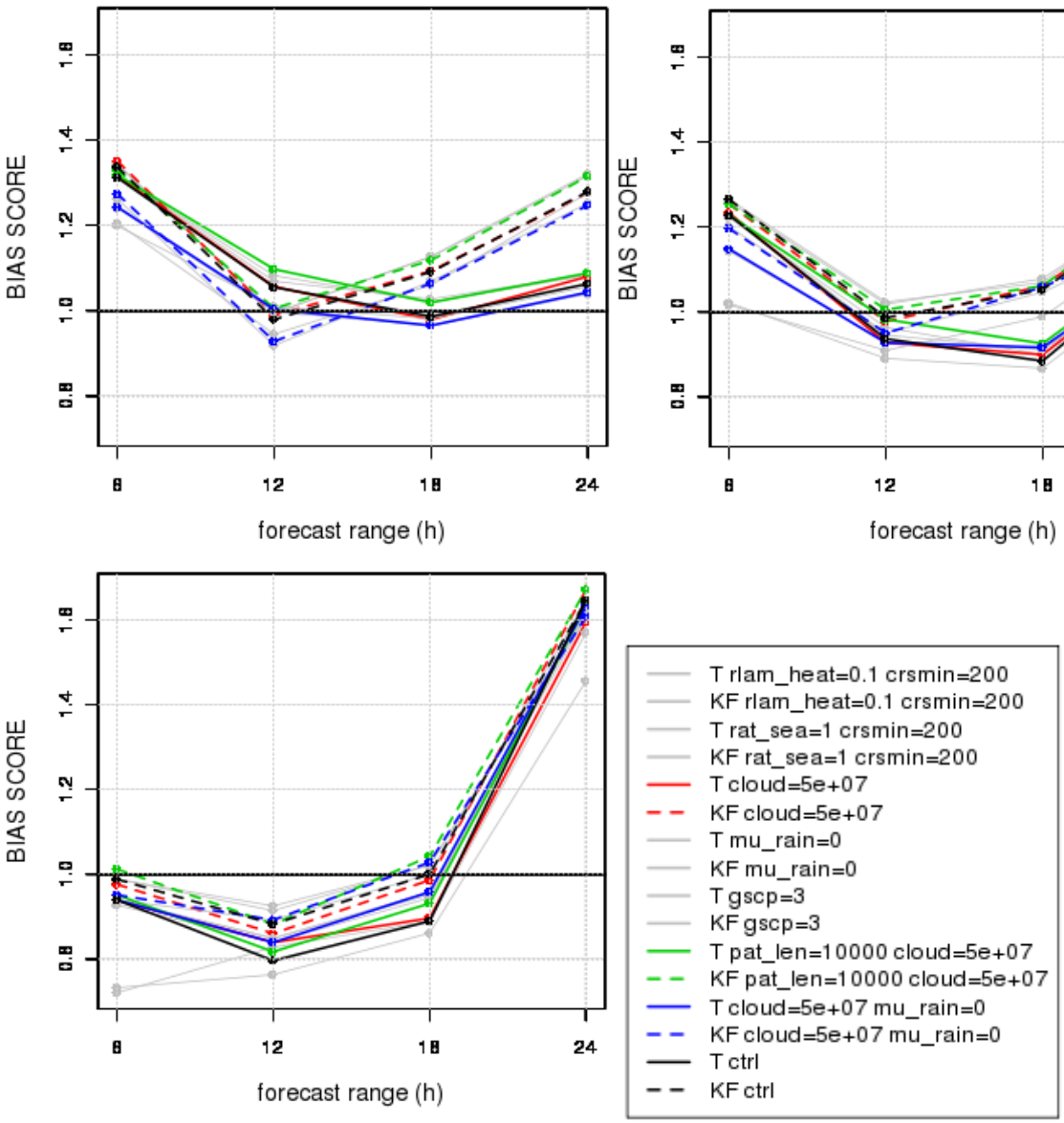


**Fig 2**. Bias Score of the 16 CSPERT members in terms of total precipitation accumulated over 6h, for the 1mm (top left), 5mm (top right) and 10mm (bottom left) thresholds. Score is computed over Northern Italy for Spring 2009. Only lines relative to members with the "cloud" perturbation are highlighted.

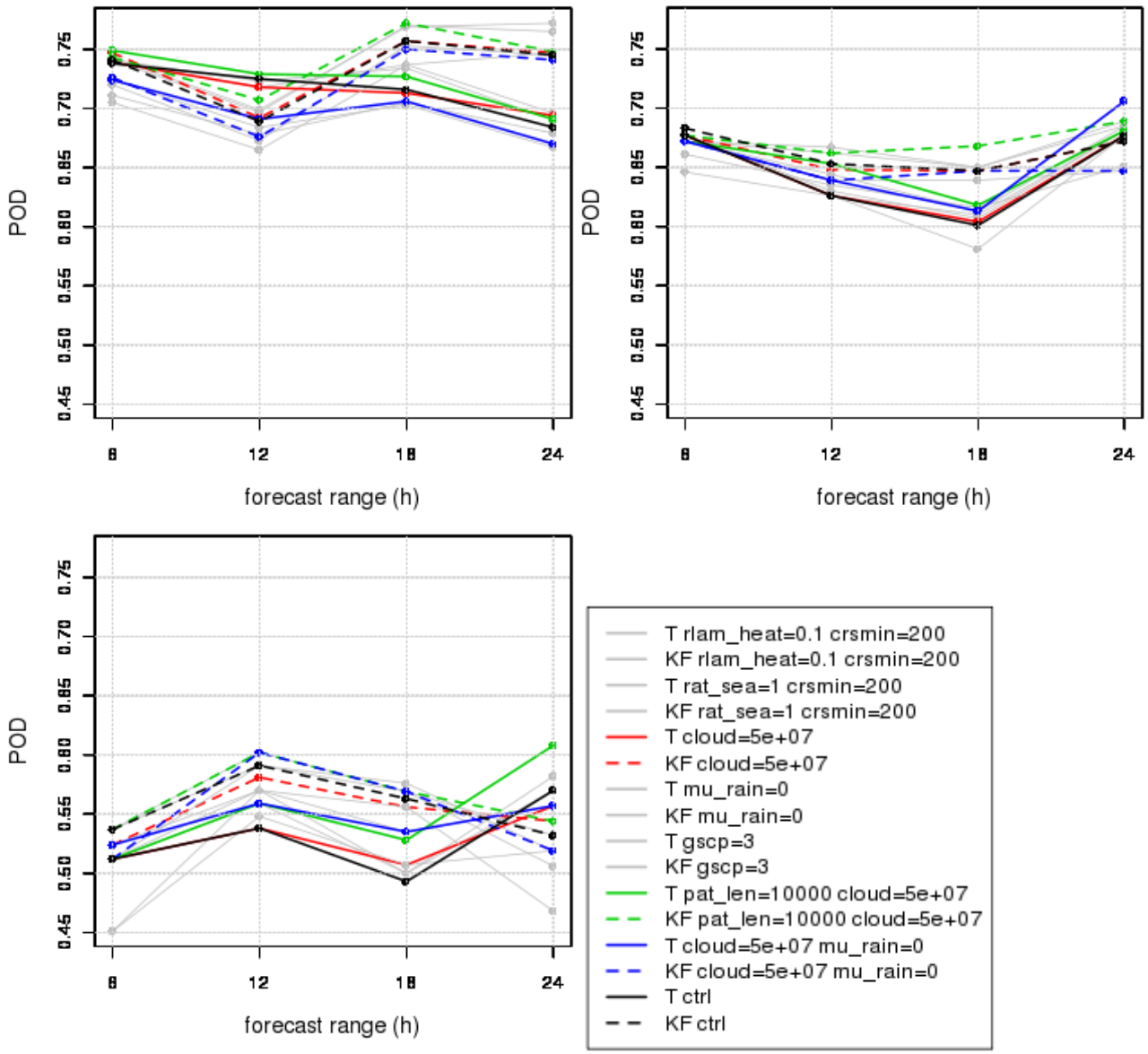


**Fig 3**. The same as Figure 2 but in terms of Probability of Detection.

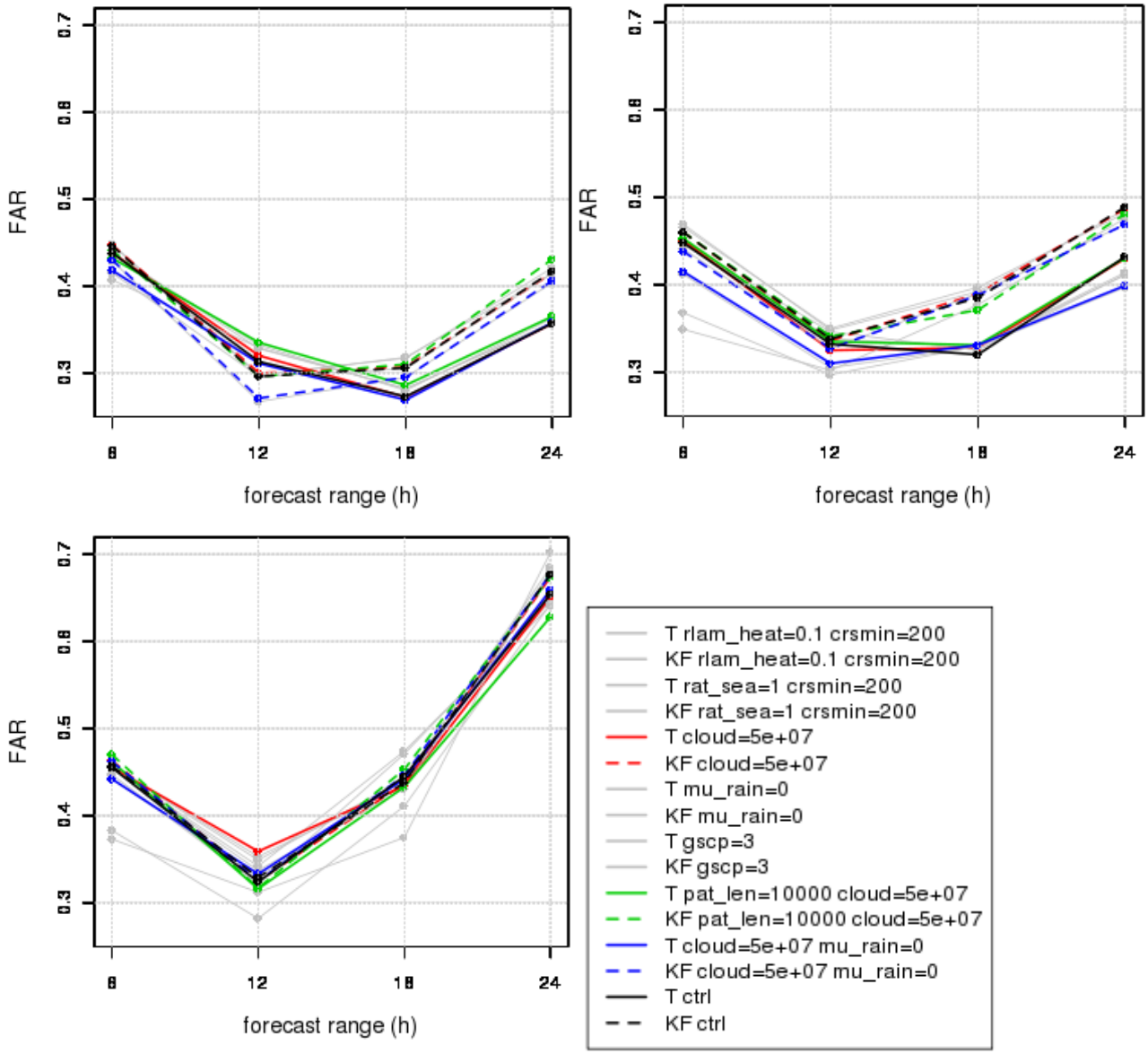


**Fig 4**. The same as Figure 2 but in terms of False Alarm Rate.

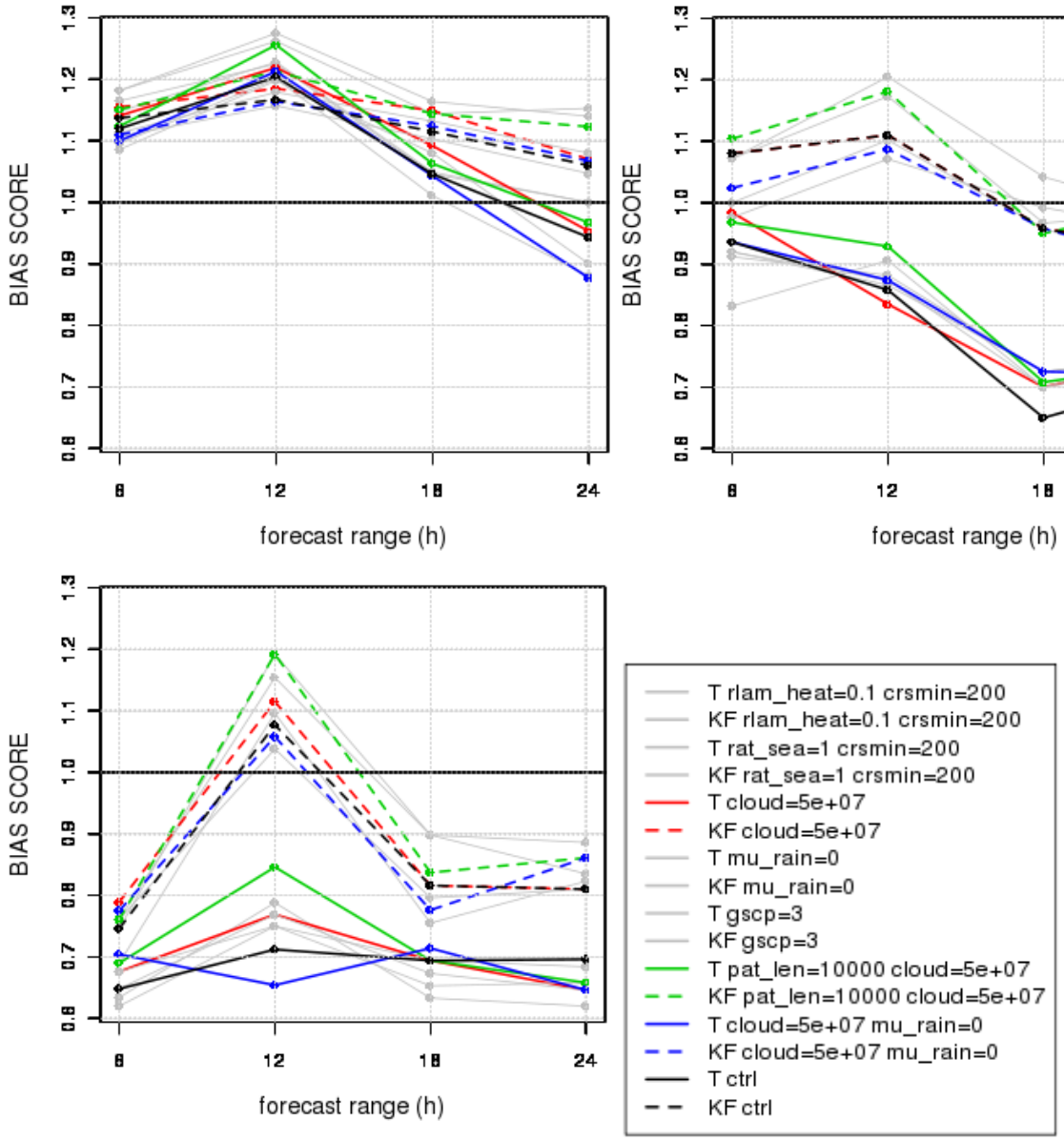


**Fig 5**. The same as Figure 2 but for the autumn season.

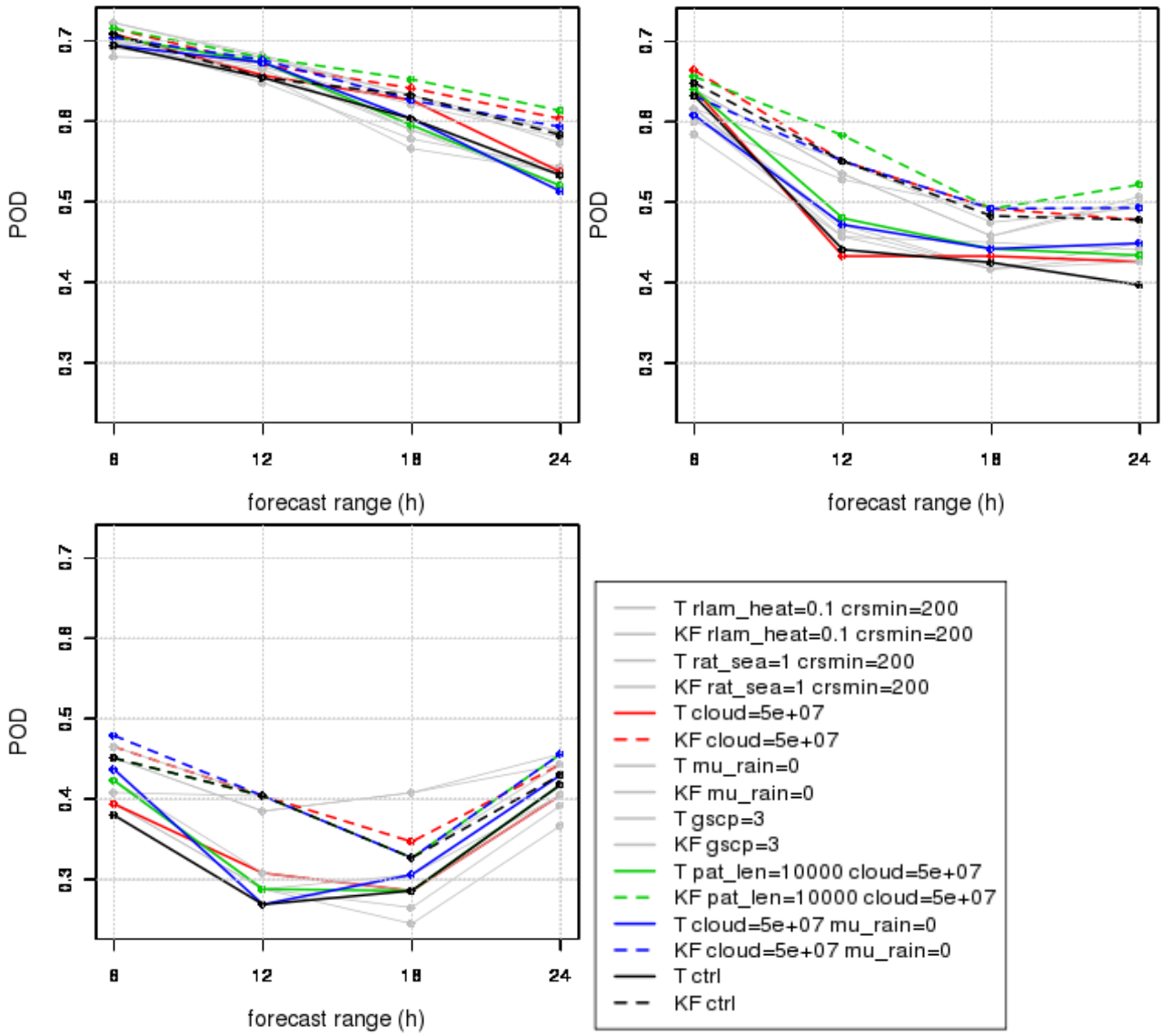


**Fig 6**. The same as Figure 5 but in terms of POD.

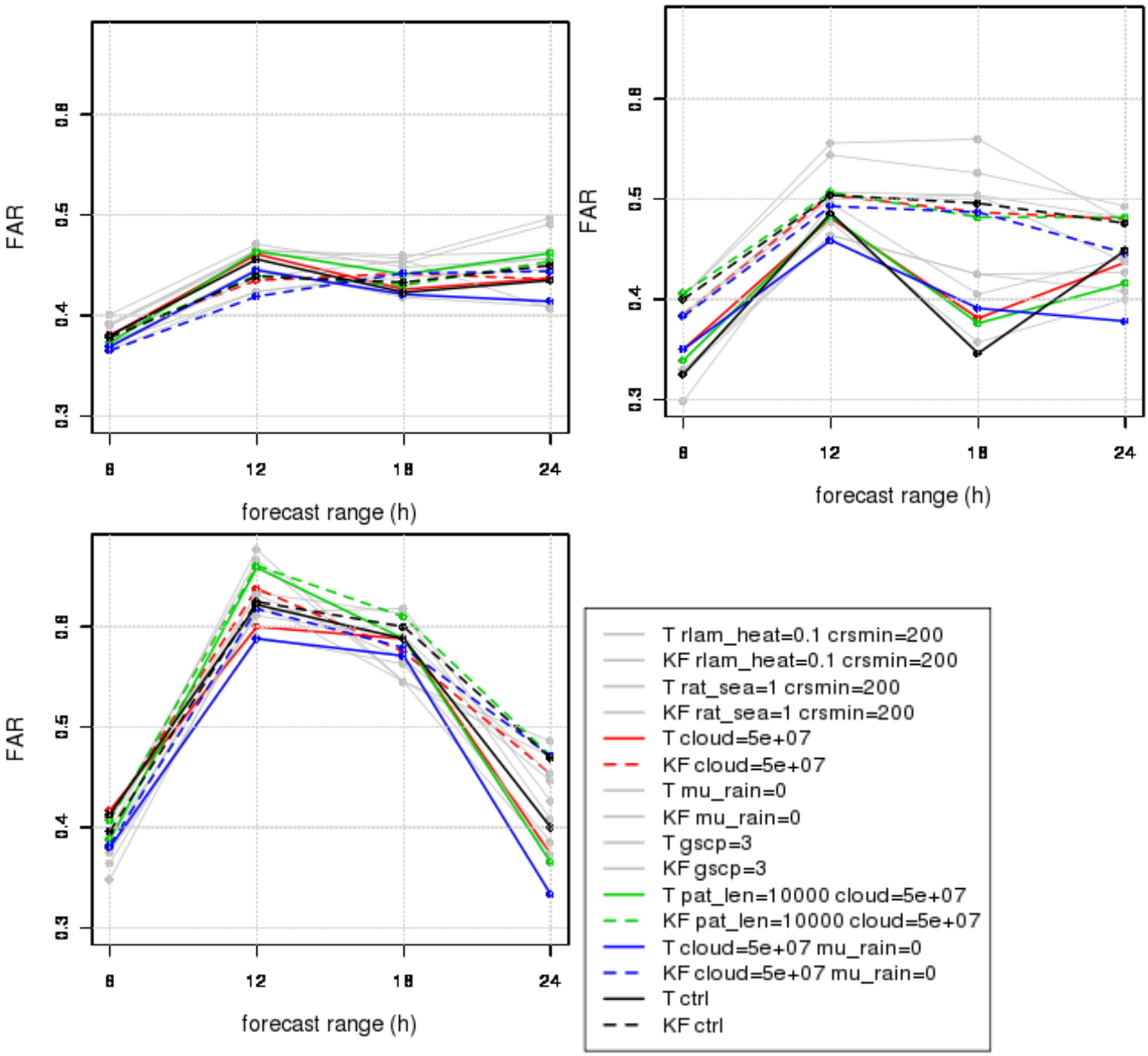


**Fig 7**. The same as Figure 5 but in terms of FAR.

Here only a preliminary analysis of the scores in terms of 6h precipitation has been shown, for both the spring and autumn 2009 seasons. A more detailed analysis, showing the impacts in other seasons and for other variables, will be presented in the next report.

## Next developments.

In the last part of the project, the object of the investigation will be to test a new type of model perturbations. In particular, a strategy (taken after Sutton and Hamill, 2004) for the perturbation of the soil moisture field which serves as initial condition at the lower boundary of the model is being developed at HNMS (National Meteorological Service of Greece), in the framework of the COSMO cooperation (CONSENS PP). During the second part of 2010 and during 2011 the impact of this new model perturbation needs to be assessed on a robust statistical manner. **The SPITFEAR BUs will then be used to run some COSMO-SREPS additional members where the perturbed soil moisture field will replace that used in the present configuration.** Several runs will be needed,

since the methodology require some tuning, at this stage, and a proper assessment of the impact of the use of the perturbed field will require to run for at least a couple of seasons (1 wet and 1 dry).
This testing of the soil moisture perturbations was scheduled for the second quartile of 2010, but it has been delayed of few months due to some problems encountered in the implementation of the methodology. Due to this delay, less BUs than envisaged has been used at to now, but a more intense use of them is envisaged for the last part of 2010, when the experimentation will actually take place.