Report on stay at ZAMG

03/11 – 28/11/2014, Vienna, Austria

Non Cycling Surface Breeding versus the ensemble of surface Data Assimilations by CANARI in ALADIN-LAEF system (preparation of the publication)

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::Acknowledgement

Many thanks to my austrian colleagues for always friendly atmosphere and their valuable cooperation. I am especially grateful to the co-authors of proposed paper Dr. Yong Wang and Florian Meier.

::Foreword

A new method for perturbing the initial surface and soil variables in ALADIN-LAEF system was implemented during my RC LACE stay at ZAMG two years ago (Dec/2012). It uses the ensemble of surface Data Assimilations processed by CANARI configuration of model ALADIN. The uncertainty of initial conditions is entering the assimilation procedure through the randomly perturbed screen level measurements (Temperature and Relative Humidity). This new approach replaced the older but original method called NCSB (Non Cycling Surface Breeding). Since the last year, said ensemble of surface Data Assimilations by CANARI is successfully used in the operational version of ALADIN-LAEF system to generate the initial perturbation of the surface and soil variables. However, a clean comparison of the two listed methods has not been published yet. Hence, this 4-weeks stay was fully dedicated to the preparation of such publication in the cooperation with Dr. Yong Wang and Florian Meier.

::I. Non Cycling Surface Breeding technique

Non Cycling Surface Breeding technique was the very first method implemented in ALADIN-LAEF system to generate the initial perturbation of surface and soil variables. In principle this approach was introduced for the two reasons: a) to simulate the uncertainty of the surface initial conditions and b) to start the integration from the soil and surface fields which are compatible with the ALADIN-LAEF system. Since the ALADIN-LAEF ensemble system is originally coupled with the European Centre for Medium-Range Weather Forecast global Ensemble Prediction System (ECMWF EPS), the later reasoning was especially important, because the ARPEGE/ALADIN soil/surface treatment is not completely compatible with the IFS one. Such discrepancy was (among the other things) producing unwanted cold bias for the Temperature at 2m.

In this experiment, the initial soil perturbations were generated by NCSB technique for the 16 ALADIN-LAEF ensemble members. Firstly, the surface fields in each downscaled member of ECMWF global EPS were replaced by the surface taken from the unperturbed ARPEGE analysis. Thus, 16 different initial conditions with perturbed atmospheric fields and one uniform set of the surface fields have been created. They are used to initialize 12h integration coupled with the perturbed lateral boundary conditions provided by ECMWF global EPS. At the end of this short integration the 16 sets of perturbed surface fields are produced due to the atmospheric and orographic forcing. Moreover, the perturbations are naturally applied on ALADIN-LAEF compatible surface and are well balanced with the high resolution topography. Afterwards, the main ALADIN-LAEF ensemble integration takes place using these perturbed surface/soil fields as the Initial Conditions. The advantage of such approach is, that there is no need for an own observation assimilation system. On the other hand it strongly depends on the quality of the downscaled soil analysis of model ARPEGE. Therefore, a comparison with a direct assimilation of screen level observations in the high resolution ALADIN-LAEF ensemble system has been conducted.

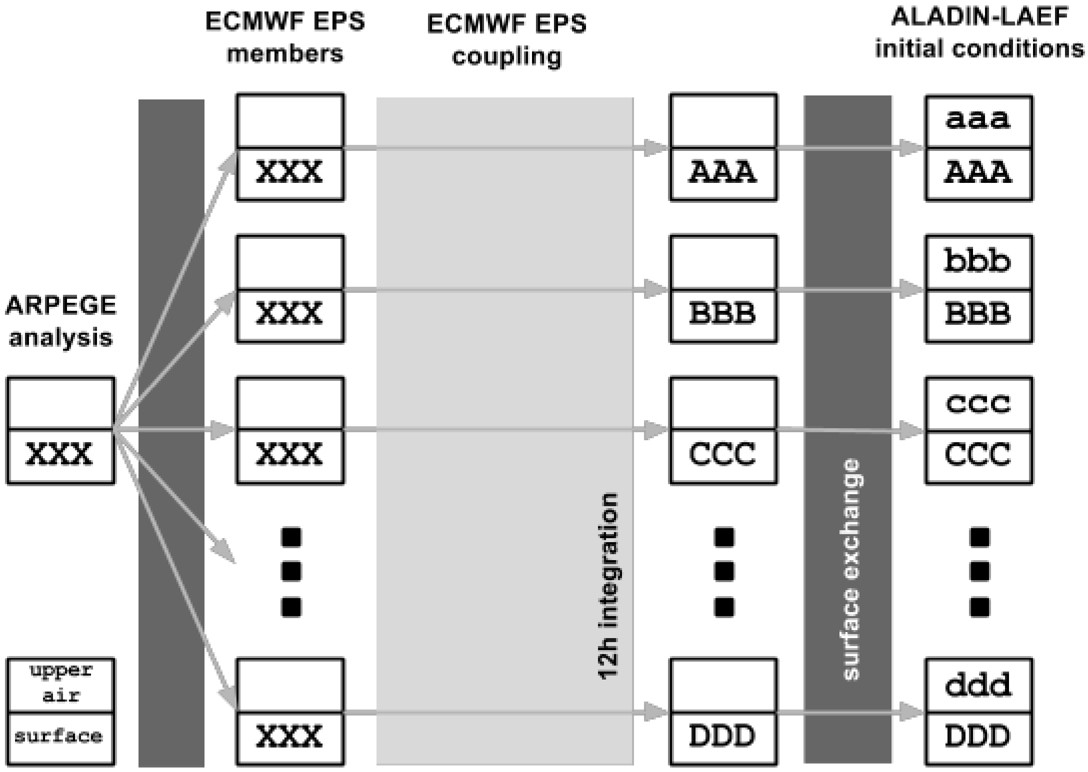

Fig.1: NCSB scheme

A scheme presenting the data flow of the NCSB experiment and describing its perturbation method is shown on the Fig.1. The inputs are downscaled ECMWF global EPS members and ARPEGE analysis. Surface fields are perturbed by means of the perturbed atmospheric forcing, which acts during a short 12h model integration. The different labels in the picture mean different perturbations, while the unmarked file parts for the upper air fields are downscaled from ECMWF global EPS. But these are not used later anyway, since at the end of the procedure only the perturbed surface and soil prognostic variables are copied into the final Initial Conditions, while the atmospheric fields are taken from the current downscaled ECMWF global EPS members.

::II. Ensemble of surface Data Assimilations

CANARI (Code d'Analyse Nécessaire à ARPEGE pour ses Rejets et son Initialisation) is standard ARPEGE/ALADIN assimilation tool based on the Optimal Interpolation (OI) method. It was implemented into the ALADIN-LAEF ensemble system in order to perform the surface assimilation along with the surface perturbation. For this purpose, the observations are perturbed randomly using a Gaussian distribution function with zero mean and standard deviation equal to the observation errors. It is important to make the obligatory quality control check just before the OBS perturbation and not after. Otherwise the desired effect could be lost due to the automatic rejection of such perturbed values. Subsequently, for each of the 16 ALADIN-LAEF members its own OI analysis of soil moisture, soil ice and temperature is processed, using also a set of perturbed first guess files from the previous assimilation cycle. As a result from this procedure, 16 different

Initial Conditions for ALADIN-LAEF ensemble integration are created, containing more realistic uncertainty of the soil/surface variables.

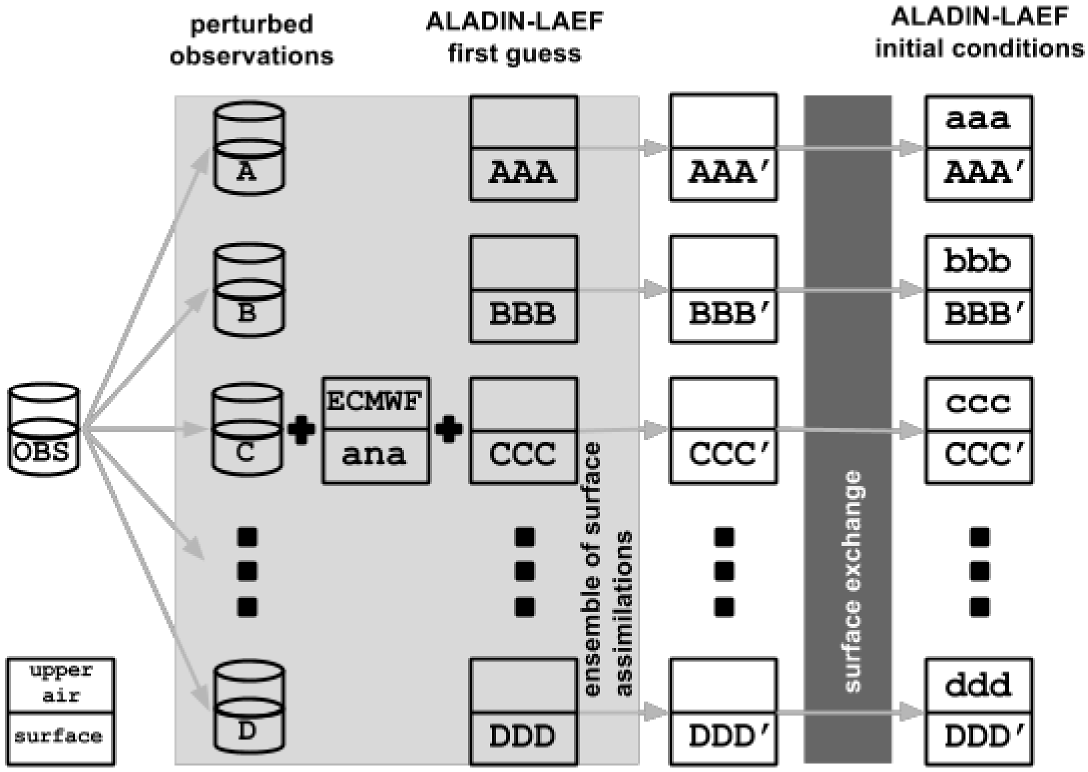

Fig.2: CANA scheme

Infographic on Fig.2 has to present the data flow of CANA experiment and its perturbation method. The inputs are randomly perturbed screen level measurements of 2m Temperature and Relative Humidity, a set of ALADIN-LAEF first guess files from the previous assimilation cycle and the actual analysis of ECMWF EPS control run. Surface fields are perturbed by the ensemble of surface Data Assimilations (with the exception of Sea Surface Temperature, which is simply reused from the control analysis of ECMWF). The different labels in the picture mean different perturbations, while the unmarked file parts for the upper air fields are not necessarily without the perturbation. But these are not used later anyway, since at the end of the procedure only the perturbed surface and soil parameters are copied into the final Initial Conditions, while the atmospheric fields are taken from the current downscaled ECMWF global EPS members (exactly in the same way as for the NCSB experiment).

::III. Verification results

The two above experiments were run to study the different approaches for perturbing the surface and soil variables in the ALADIN-LAEF ensemble system. Only the initial surface and soil conditions were modified in otherwise just dynamically adapted global EPS using ALADIN-LAEF model and its domain (no other LAEF enhancements were applied like upper-air spectral blending or multi-physics). Both experiments (NCSB and CANA) consisting of 16 ensemble members each were run for the verification period from 15th of May till 15th of July 2011. The systems were integrated up to 54h once per day, for 12 UTC network time. However, to keep the 12h update cycle for the soil initialisation in the assimilation experiment CANA, there was an additional short 12h integration starting at 00 UTC executed as well.

The maps showing the distance between the two neighbour members (abs[mb01 - mb02]) can give some measure about the surface perturbations generated by these two methods. Of course, the impact is more obvious for the surface Temperature (Fig.3) and surface Moisture (Fig.4), because these prognostic fields are directly perturbed. For the diagnostic fields like 2m Temperature the differences are much less pronounced even though still visible (not shown). Generally speaking, more structured perturbations are created by CANA method and over the areas with dense observation network.

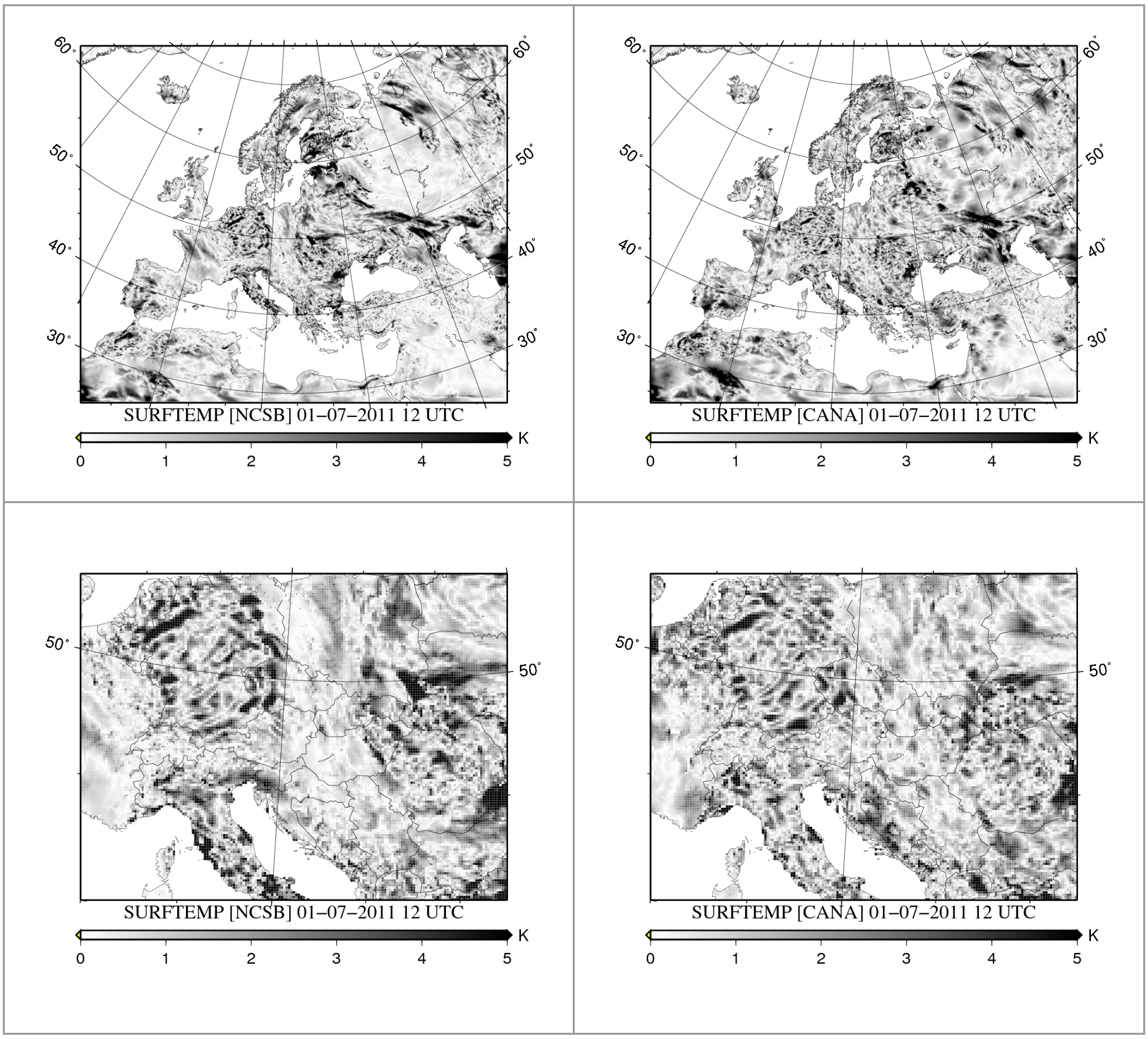

Fig.3: Surface Temperature “perturbation” for experiments NCSB (left) and CANA (right), with zoom over the central Europe at the bottom.

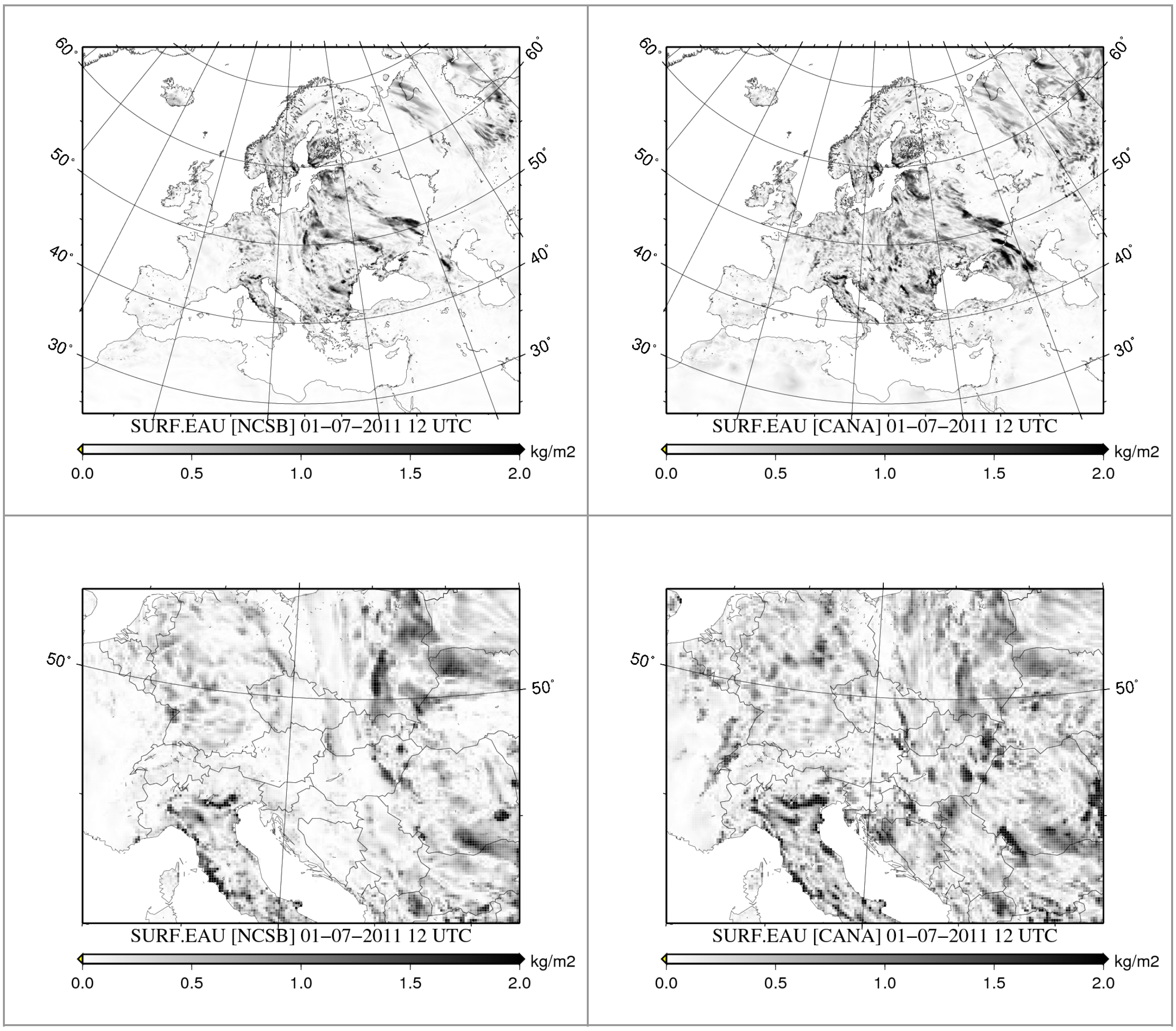

Fig.4: Surface Moisture “perturbation” for experiments NCSB (left) and CANA (right), with zoom over the central Europe at the bottom.

Selected statistical scores from the verification are shown below. In general, they clearly confirm the benefits of CANA method used for perturbing the surface/soil variables over the NCSB one, reducing the RMSE (Fig.5 and Fig.7) and CRPS (Fig.6 and Fig.8) of the system (most significantly for Temperature at 2m - logically) while enlarging the ensemble spread (not shown) and decreasing the percentage of outliers (Fig.9). One can clearly see also some less enhanced scores by CANA method at noon (since we integrate the model at 12 UTC it covers the forecast ranges +24 and +48). This is known and already reported as a CANARI “summer problem”, affecting all CANARI applications.

The scores for upper air (850 hPa and 500 hPa) are neutral or little bit better for CANA experiment (not shown). The only drawback, if it can be called like that, is rather neutral or slightly negative impact on the precipitation scores (Fig.10 and Fig.11). But this is at least questionable, because used point-vs-point verification method for the ensemble system is indeed not very suitable for a spatially inhomogeneous fields like precipitation.

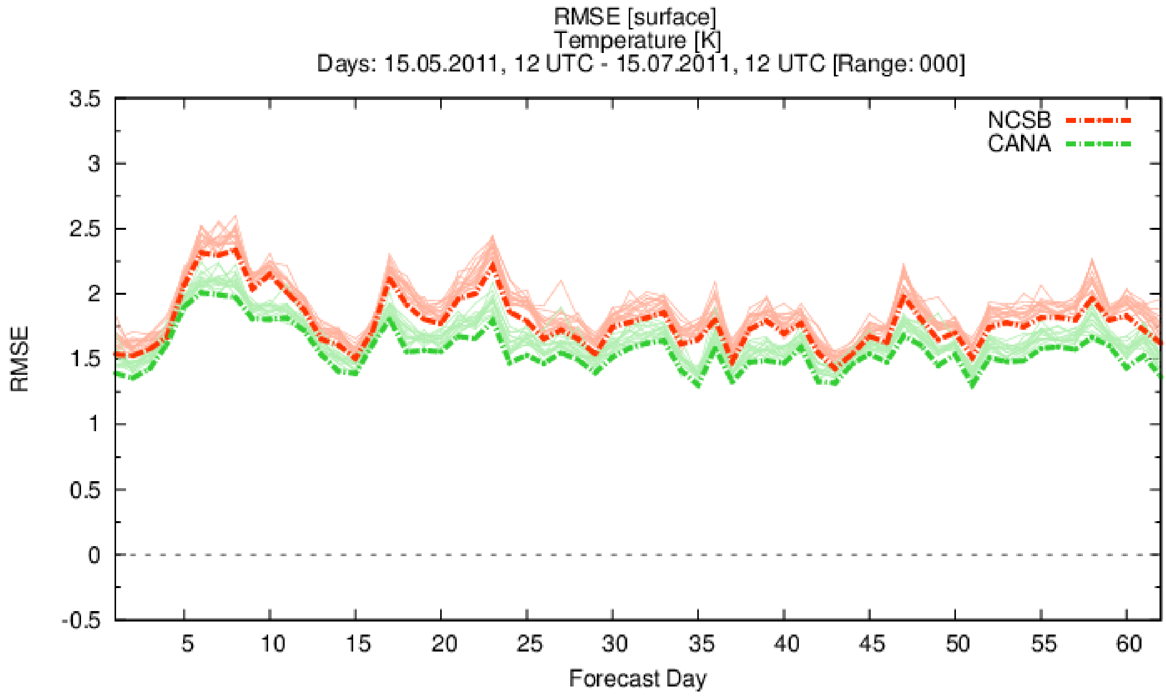

Fig.5: RMSE of ensemble mean and individual members for 2m Temperature at initial time by the experiment days.

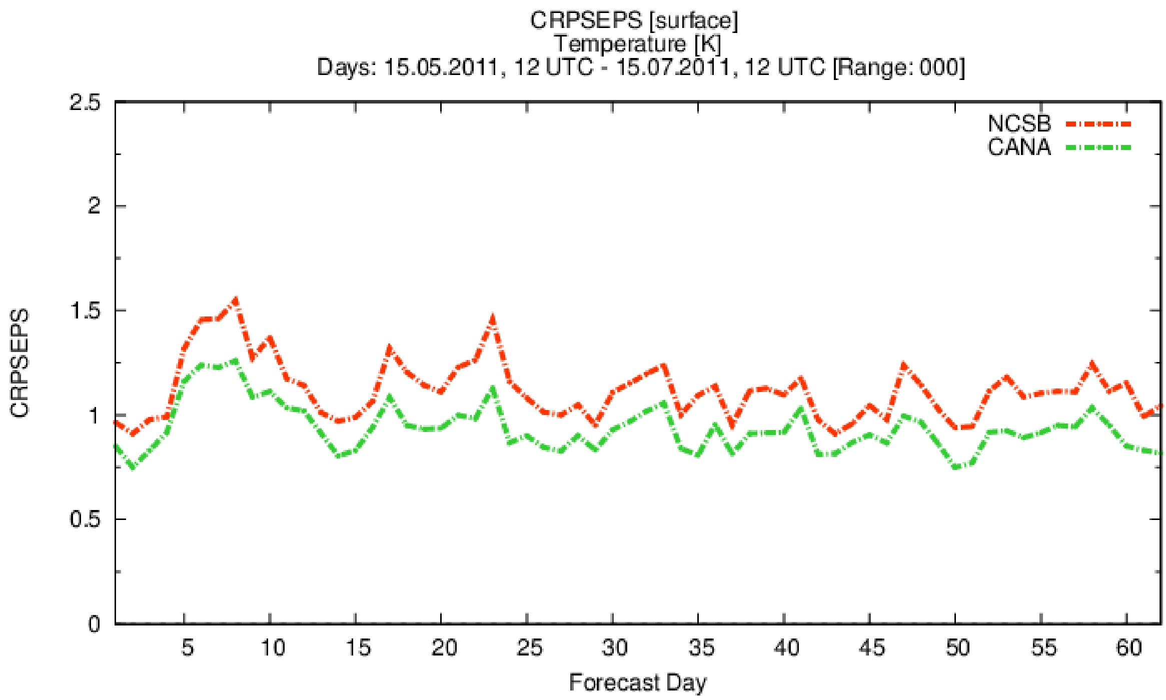

Fig.6: CRPS of ensemble mean for 2m Temperature at initial time by the experiment days.

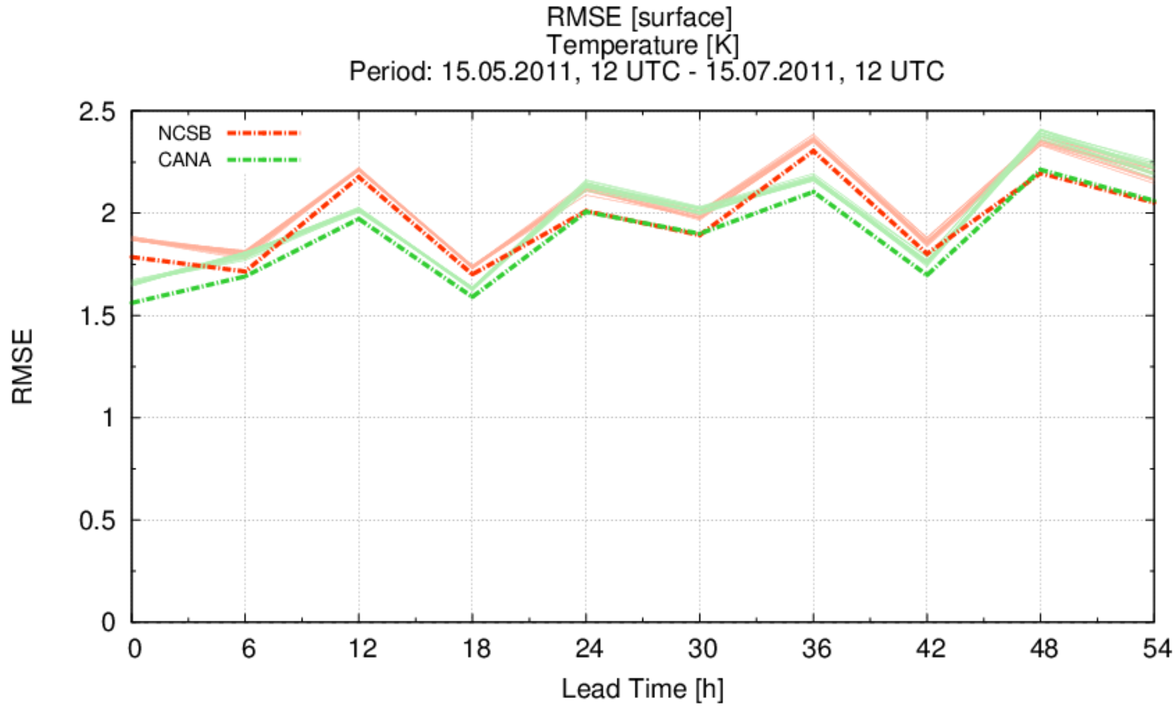

Fig.7: RMSE of ensemble mean and individual members for 2m Temperature by the forecast ranges.

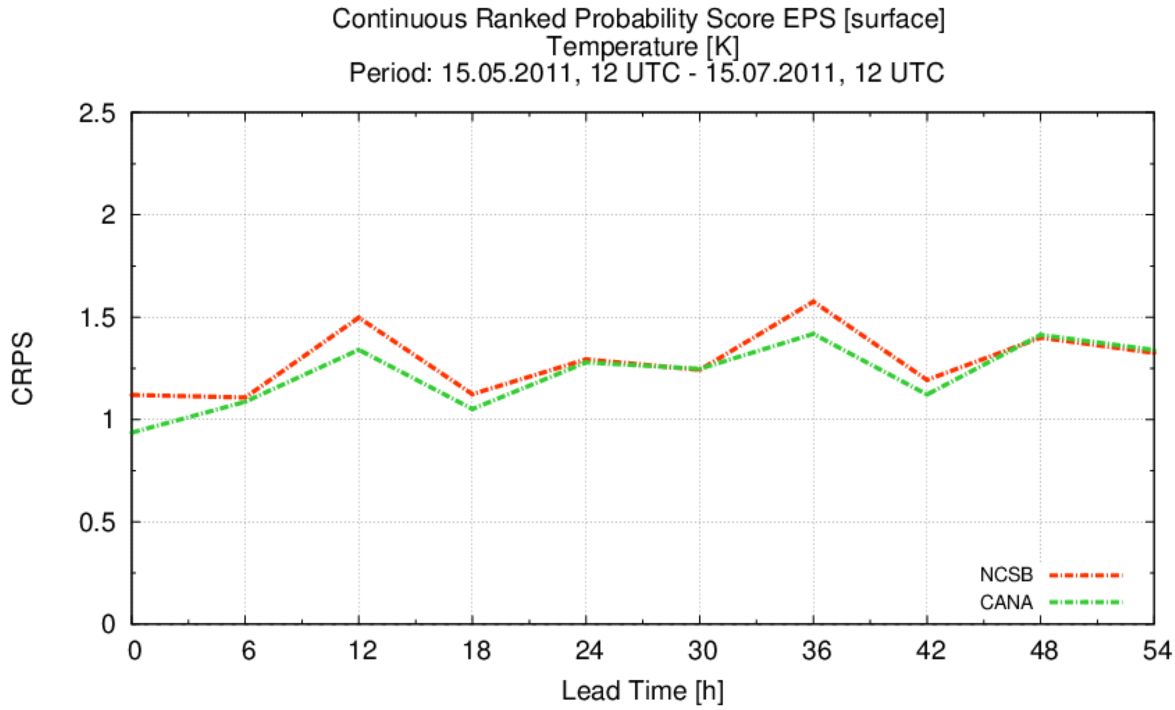

Fig.8: CRPS of ensemble mean for 2m Temperature by the forecast ranges.

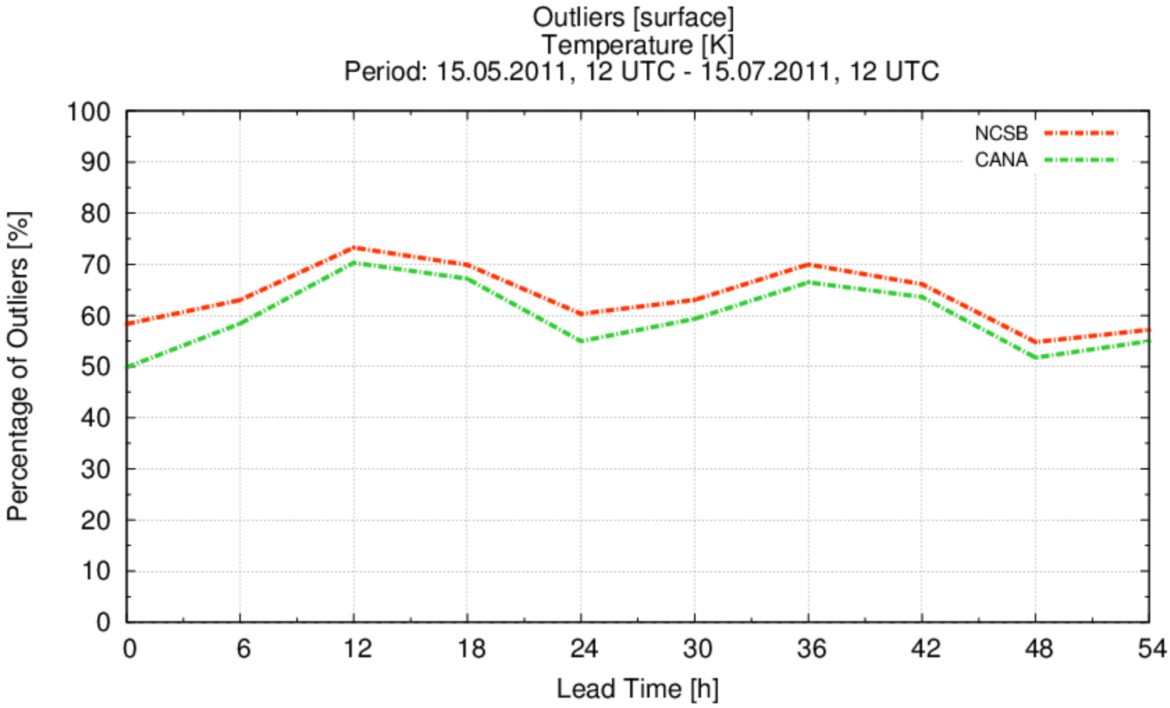

Fig.9: Percentage of ensemble outliers for 2m Temperature by the forecast ranges.

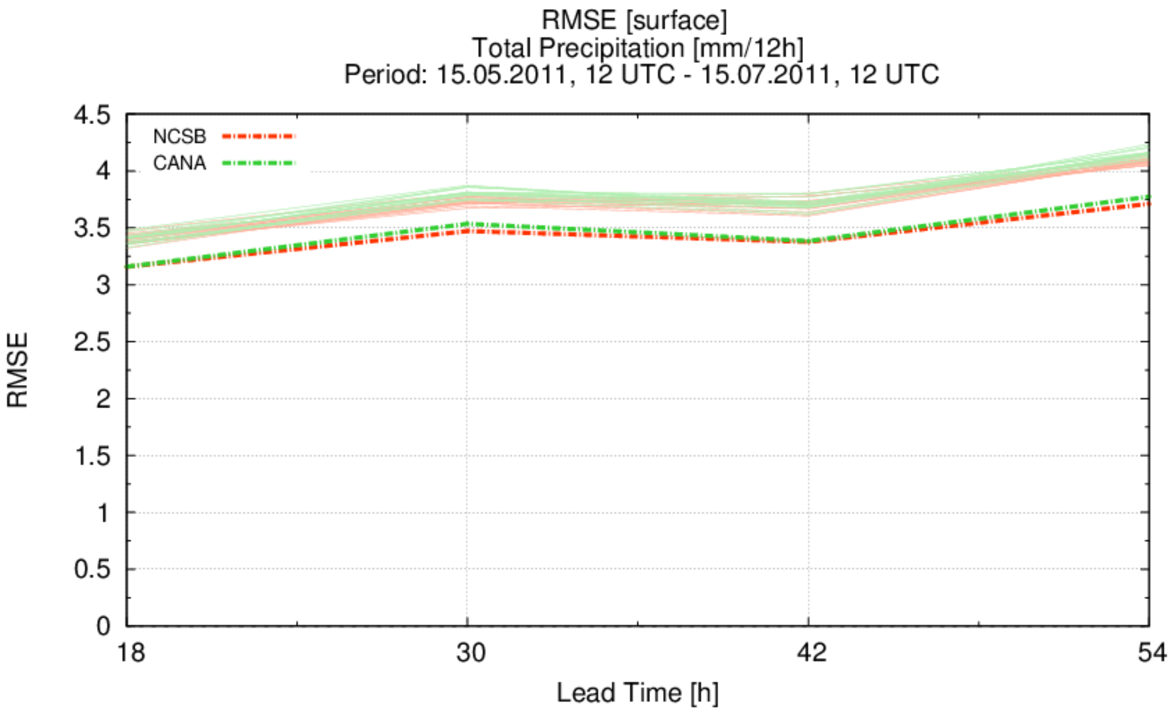

Fig.10: RMSE of ensemble mean and individual members for Total Precipitation by the forecast ranges.

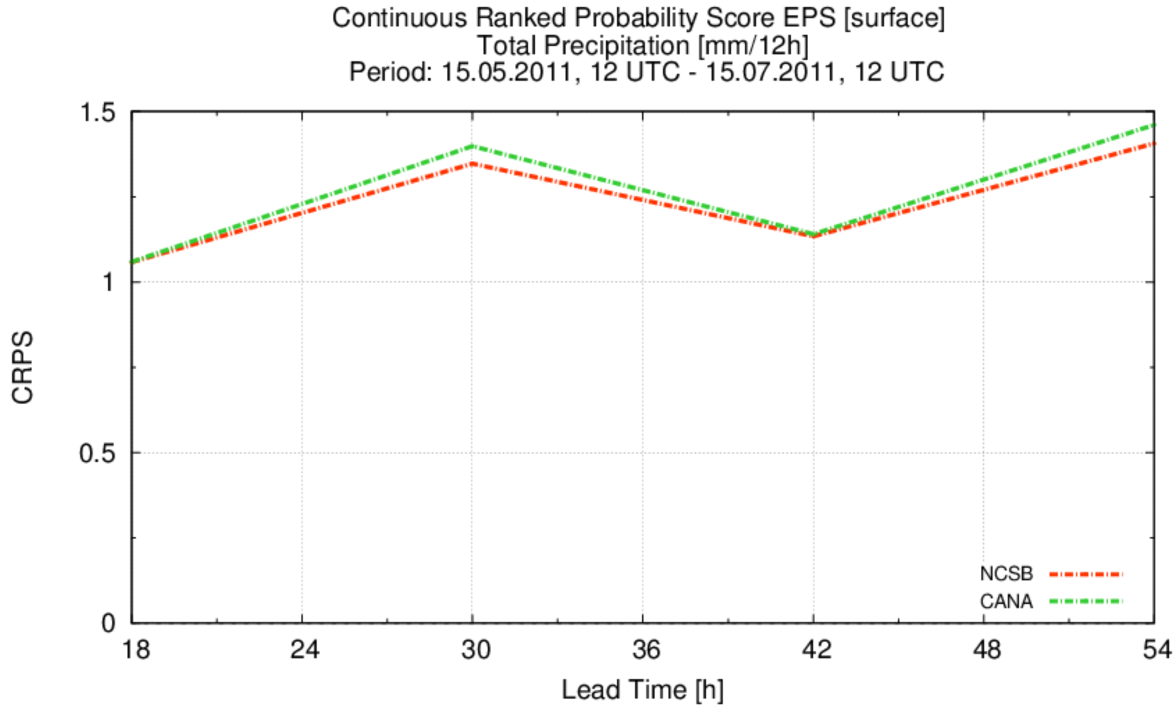

Fig.11: CRPS of ensemble mean for Total Precipitation by the forecast ranges.

::Conclusions

The outputs from described NCSB and CANA experiments, which were performed during the previous stay at ZAMG, were used to run 2-months statistical verification using new LAEF verification package. The obtained results have shown clear benefit of the surface perturbation technique by the ensemble of surface Data Assimilations over the former Non Cycling Surface Breeding method. In the fruitful cooperation with Florian and Yong, also the general structure of the proposed paper was determined and first draft of the paper was written. Obviously, the work will continue in order to improve and finish the manuscript. We believe, that its submission in Quarterly Journal of the Royal Meteorological Society will be feasible.

/\/\bell, 12/2014