SPECIAL PROJECT FINAL REPORT

Project Title:	Initial and lateral boundary perturbations for Convective Permitting Ensemble Prediction Systems
Computer Project Account:	spnokolt
Start Year - End Year :	2016-01-01 – 2017-12-31
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Summary of project objectives

The aim of the project is to explore strategies for initial condition perturbations and lateral boundary conditions/perturbations for CPEPSs. The methods that will be tested are Scaled Lagged Average Forecasting (SLAF) and the use of perturbations based on IFS-ENS. A first goal is to establish the quality of the new HARMONIE version harmonie-40h1 with respect to the current operational one, harmonie-38h1.2.

Summary of problems encountered

One of the tasks for this year was to investigate the usage of hourly IFS ENS data with hourly resolution as initial and boundary data for HARMONIE. The retrieval of the 50 members from MARS in near real time turned out to be a non trivial task and required a major rewriting of the MARS request strategy in HARMONIE. It also triggered some concerned emails from the MARS user support about our aggressive usage of the MARS server. With support from ECMWF we managed to speed up and control the requests. The strategy is now part of the HARMONIE system developed and used by HIRLAM and running at ECMWF.

A second technical problem is the convention to encode SST data from IFS with valid data over land. As reported on the TAC subgroup meeting (Andrae 2018) this creates problems along the coasts. The problem will to a large extent be solved with the implementation of MIR, but properly defined SST data with missing value indicators over land points would be even better. In the experiments using IFS ENS data in this report SST from the HRES setup have been used.

Experience with the Special Project framework

No problems encountered.

Summary of results

In the last part of the project a 30 day summer period in 2017 has been investigated comparing boundary perturbations using the SLAF method (Andrae 2016) with HRES data, mbr 0-10 from IFS ENS and clustered IFS ENS bounaries. The a version of the clustering method by Molteni (2001) have been used and aims to maximize the spread using surface pressure, wind and temperature at 850/925hPa at +24h and +36h. Due to technical problems with the SST interpolation introducing near surface temperature biases along coastline SST in IFS ENS has been replaced by SST from HRES.

The experiments have been running with harmonEPS-40h1.1 using a 1+10 member ensemble. The control member has been running 3DVAR for the atmospheric part and optimum interpolation for the surface state and with a 3h cycling using conventional observations only. The perturbed members are running their own surface analysis with a 6h cycling. Apart from the initial and boundary perturbations coming from the methods investigated in this study the initial surface state is perturbed following Bouttier et. al. (2016). The domain of integration is the operational domain for MetCoOp covering Scandinavia.

The properties of the boundary perturbations are investigated by comparing surface pressure STDV and BIAS with respect to the control member at initial time for each member over the period. We note that the SLAF perturbations has the largest variability between the members. This is due to the ad hoc method used to tune the SLAF coefficients determining the size of the perturbations. We also see that the clustered IFS ENS boundaries has slightly larger perturbations which is natural given that the method should maximize the spread. For the BIAS we note that when using the IFS ENS we introduce a small positive pressure bias whereas the SLAF perturbations are, by construction, symmetric around zero. Leutbecher et. al. (2017) describes how perturbations in physics introduces biases in the IFS ensemble system and this is probably what we see in the diagnostics.

The basic properties of the ensemble can be examined by the spread/skill relation for mean sea level pressure (MSLP) shown in figure 2. We see that the initial spread is largest for the SLAF perturbations but at the same level after 9 hours and lowest at the end of the forecast range. The perturbations in SLAF are constructed to have a certain size initially whereas this may not be representative for the forecast differences at longer lead times hence giving a smaller spread. For the IFS ENS boundaries we see that the clustered version maintains the largest spread although it appears to be too high for parts of the forecast span. For other parameters like screen level temperature (T2M) and wind (U10M) we find that SLAF has the highest initial spread whereas the clustered IFS ENS boundaries maintains the spread best throughout the forecast. We find no significant differences for 12h precipitation (PE12).

The quality as measured by the continuous ranked probability score (CRPS) can be seen in figure 3. For T2M and U10M the largest differences can be seen during the first hours whereas for MSLP and PE12 we see that using SLAF gives the smallest CRPS values and the clustered IFS boundaries the largest values over the whole forecast range. The differences between SLAF and IFS ENS member 1-10 are in general small.

Conclusions

Although the SLAF method performs well and is easy to use and implement operationally it has a clear limitation in the number of members that can be constructed. Without exploring new ways to construct perturbations MetCoOp is limited to 10 members with the current forecast length of 54h if we would like to maintain hourly boundaries. Given the small differences in performance found in this study using IFS ENS boundaries will open up for the possibility to extend the ensemble both in size and forecast range. The larger spread at longer forecast lengths seen in MSLP when using IFS ENS compared to SLAF is also a strong argument for using IFS ENS. Further, using IFS ENS boundaries allows us to benefit from future development at ECMWF. The choice of members is of course a bit arbitrary and further studies of clustering methods or similar are required to find the optimum choice. The initial spread is found to be larger when using SLAF as compared to IFS ENS. Within HIRLAM, but outside of this special project, EDA is examined as a perturbation method to increase the ensemble spread at initial time. The need to inflate the initial perturbations may also change as the IFS ENS setup evolves and may need further tuning in the future.

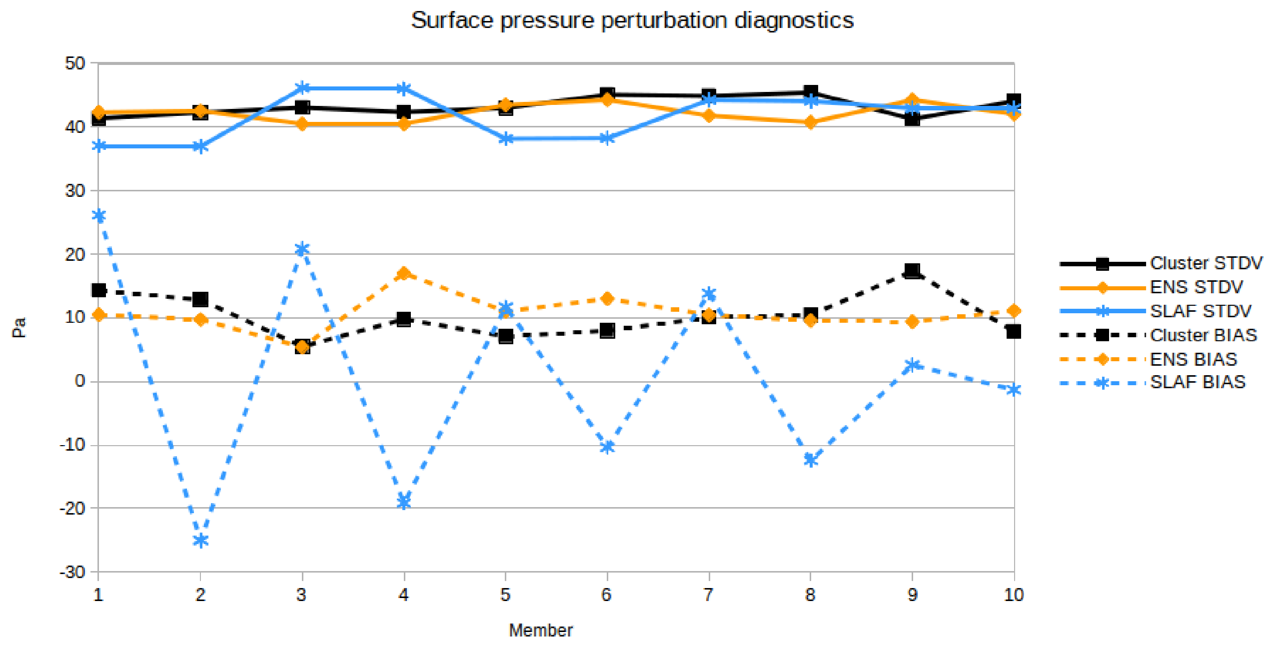

Figure 1: Surface pressure diagnostics. Standard deviation (solid) and bias (dashed). Boundaries perturbed with SLAF in blue, IFS ENS member 1-10 in orange and clustered IFS ENS boundaries in black.

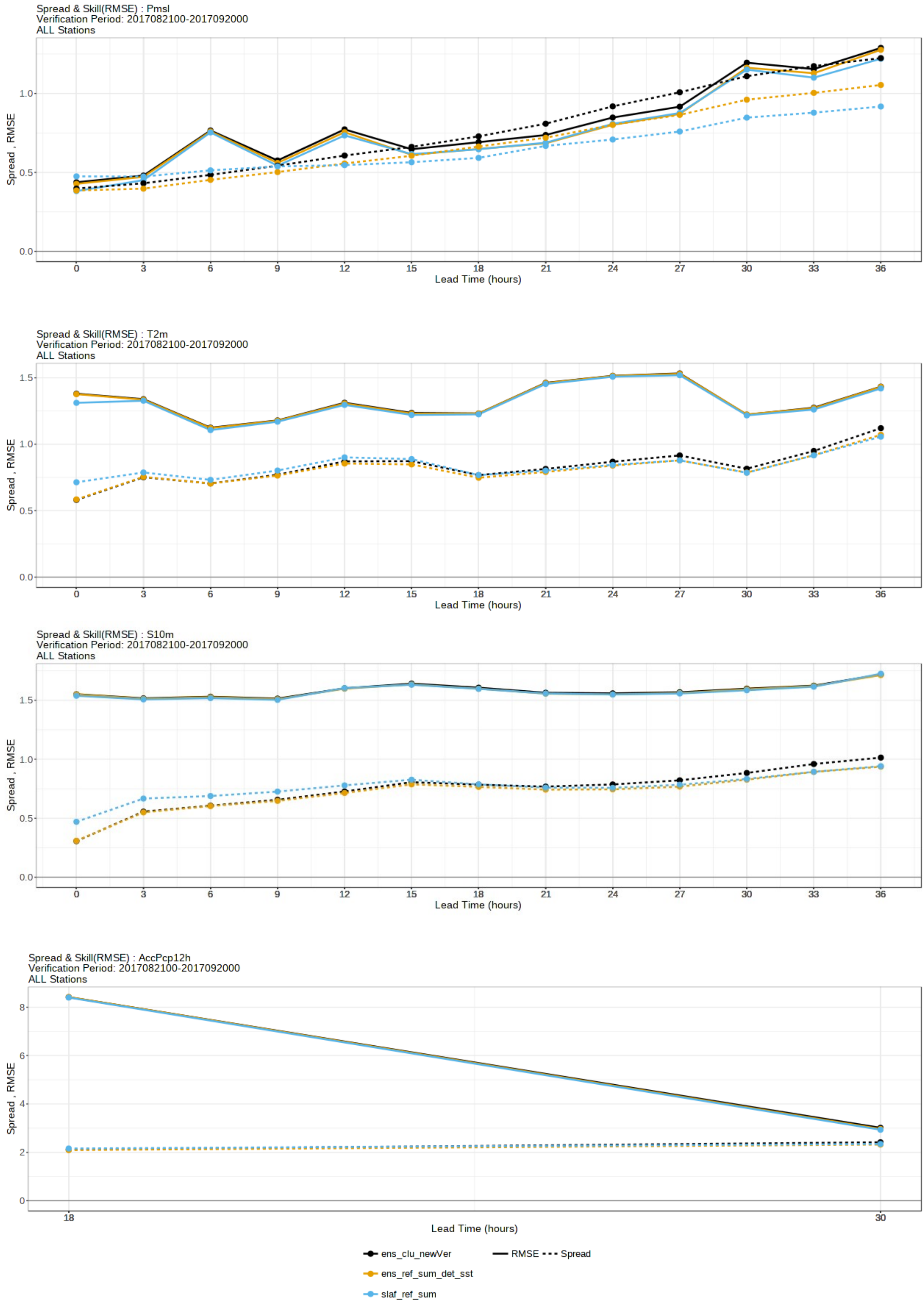

Figure 2: Skill(solid) and spread(dashed) for (from top to bottom) Mean sea level pressure, 2m temperature, 10m wind speed and 12 h accumulated precipitation. Boundaries perturbed with SLAF in blue, IFS ENS member 1-10 in orange and clustered IFS ENS boundaries in black.

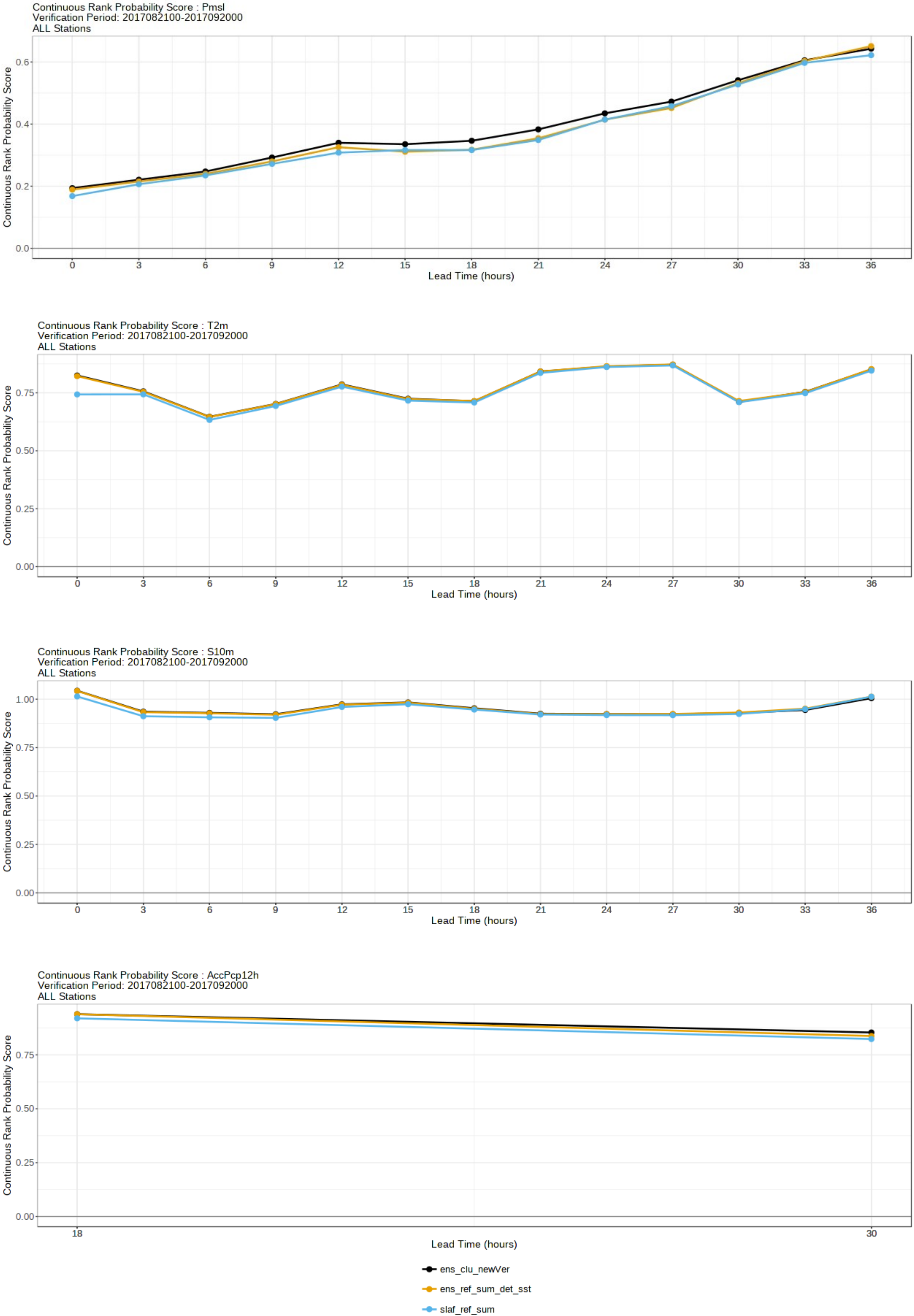

Figure 3: CRPS for (from top to bottom) Mean sea level pressure, 2m temperature, 10m wind speed and 12 h accumulated precipitation. Boundaries perturbed with SLAF in blue, IFS ENS member 1-10 in orange and clustered IFS ENS boundaries in black.

References

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Future plans

MetCoOp will implement the use of non-clustered IFS ENS boundaries in the operational runs during the last quarter of 2018. Research around clustering will continue.