How to Optimally Treat Large Scale Information in Limited Area Ensemble-Based Data Assimilation ?

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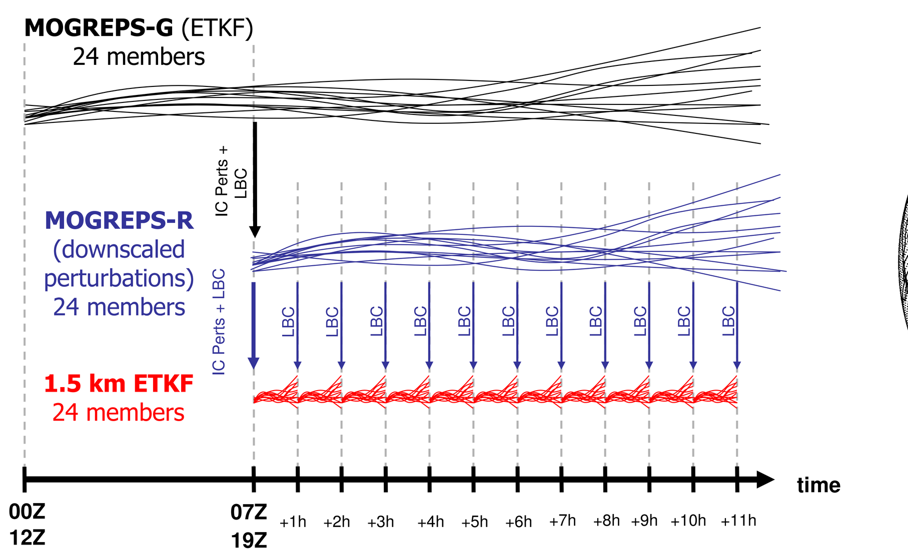
The Met Office has developed an experimental convective scale version of the Met Office ensemble prediction system, MOGREPS, where the analysis perturbations are produced using an Ensemble Transform Kalman Filter (ETKF). The primary goals of this work were 1) to conduct examinations of 1-hour forecast error covariances for the benefit of a NWP-based nowcasting system currently under development at the Met Office and 2) to perform predictability studies of localized weather at very short time scale.

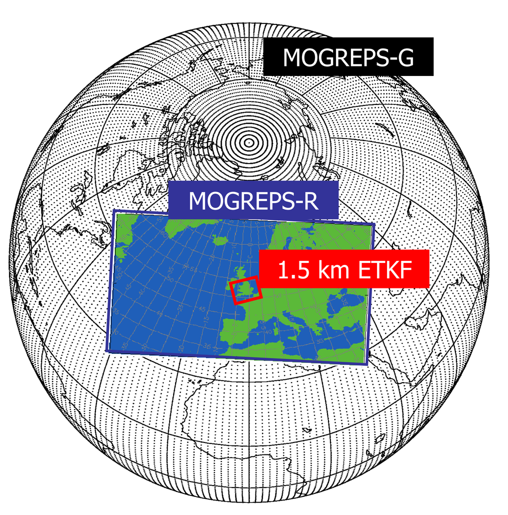
In this poster we present the issues we faced due to the discontinuities between the limited area initial condition (IC) perturbations and the parent EPS introduced by the ETKF method. A new method to alleviate these discontinuities is presented.

Note that all the results presented here come from a single case study only.

The Southern UK 1.5 km ETKF-based EPS

This convective scale ETKF system uses a model with a grid resolution of 1.5 km covering southern United Kingdom and has an hourly cycle. The lateral boundaries are provided by the 24 km (now 18 km) and 12-hourly cycling regional component of MOGREPS which cover the North Atlantic and Europe.





1.5 km ETKF setup

- Control analysis from a hourly cycling 1.5km 3DVAR with cloud and latent heat nudging and UK 4km LBC
- IC perturbations* are produced by the ETKF using +1h forecast perturbations.
- All the observations assimilated in 3DVAR are taken into account in the transform (Surface, Aircrafts, Radio-sondes, GPS and Radiances)
- No localizations
- Variable inflation factor derived from surface obs (u, v, T) and aircraft data (u ,v, T)
- No representation of model errors in the forecasting step

* The IC perturbations for the first cycle are taken from MOGREPS-G as in MOGREPS-R

Discontinuities between the IC perturbations and the Parent EPS

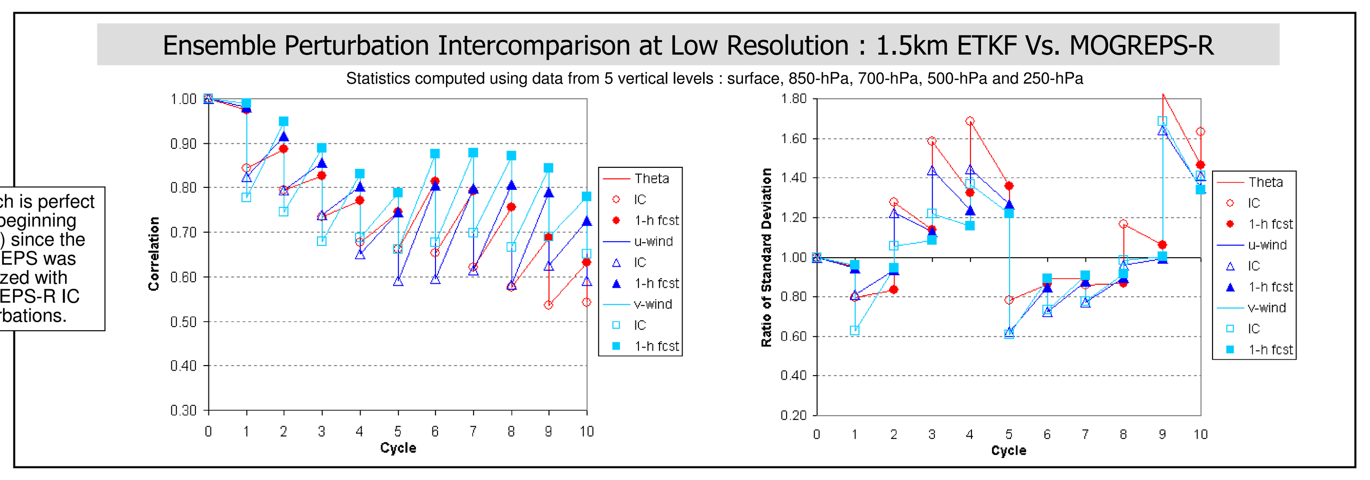
To what extent are the IC perturbations obtained with the 1.5km ETKF coherent with the parent EPS (here MOGREPS-R) ? To shed light on this we compared the perturbations from both ensembles using a low pass filter*.

* We applied the same low-pass filter (see L_96-192 in top right Fig.) to the perturbations from each ensemble member.

Ensemble Perturbation Intercomparison at Low Resolution : 1.5km ETKF Vs. MOGREPS-R

Statistics computed using data from 5 vertical levels : surface, 850-hPa, 700-hPa, 500-hPa and 250-hPa

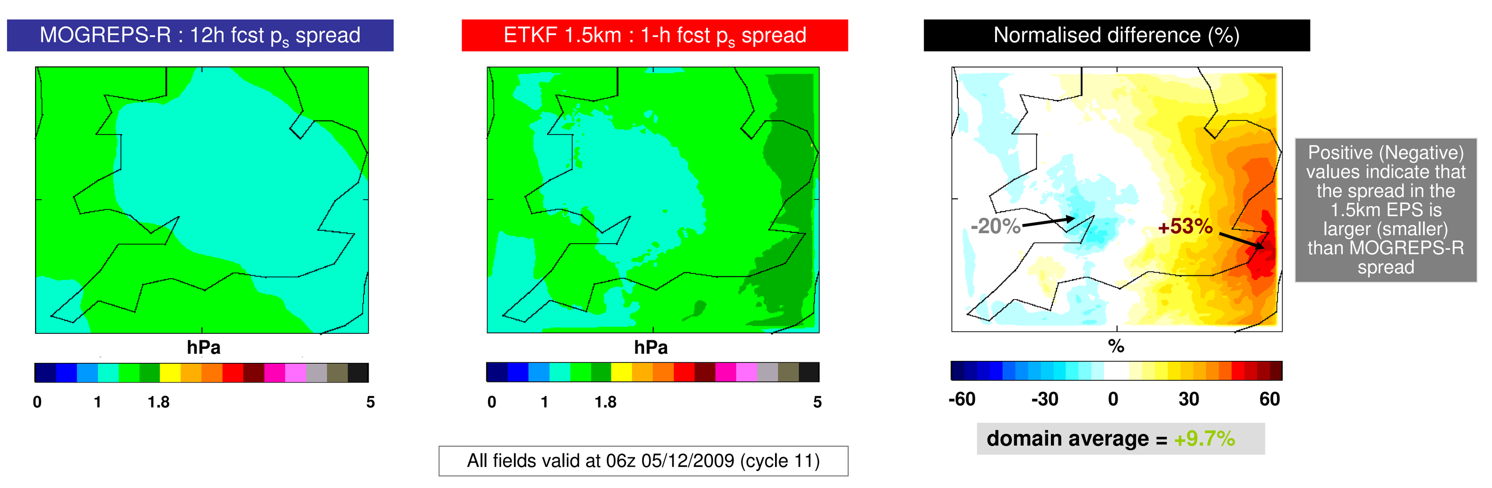
The match is perfect at the beginning (cycle 0) since the 1.5km EPS was initialized with MOGREPS-R IC perturbations.



- The correlation between the two EPSs decreases with time (due to the ETKF transform and the rapid update cycling).
- The amplitudes can differ significantly (due to the inflation factor and the time-varying number of observations)

The impact of the discontinuities on the surface pressure spread

The growing differences between the 1.5 km IC perturbations and the parent EPS introduce discontinuities at the lateral boundaries. This triggers spurious gravity wave activity and alters significantly the surface pressure spread in the 1.5 km EPS.

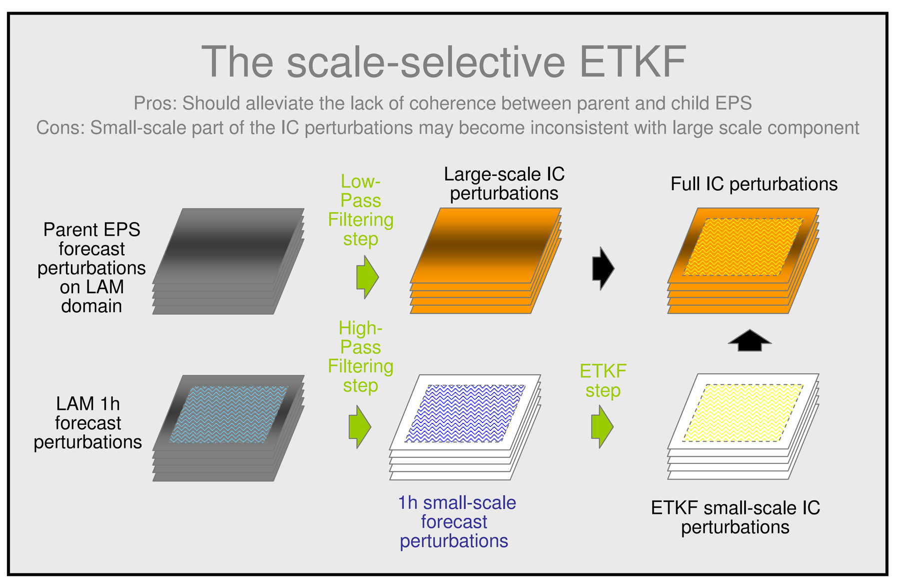


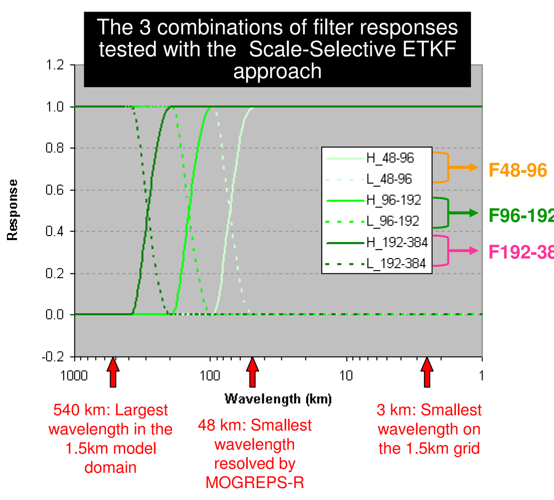
Positive (Negative) values indicate that the spread in the 1.5km EPS is larger (smaller) than MOGREPS-R spread

All fields valid at 06z 05/12/2009 (cycle 11)

How to build IC perturbations coherent with the parent EPS ?

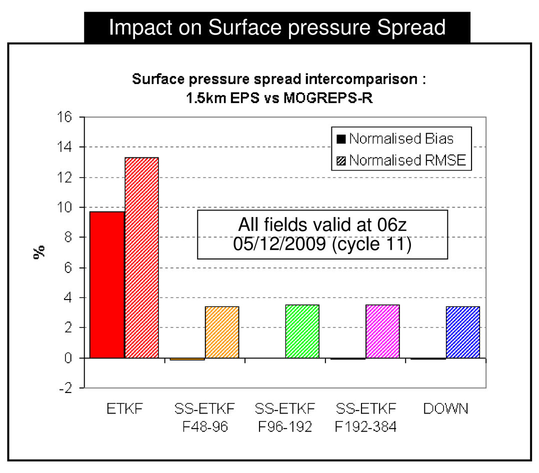
Discontinuities arise because the limited-area ETKF (like other limited-area ensemble methods) does not explicitly take into account the large scale perturbations from the parent EPS when computing the IC perturbations. We tried to correct this by implementing a blending technique where the large scale part of the IC perturbations is taken from the parent EPS while the small scale part is obtained by applying the ETKF transform only to the small-scale part of the forecast perturbations. We called this approach the **scale-selective ETKF**.





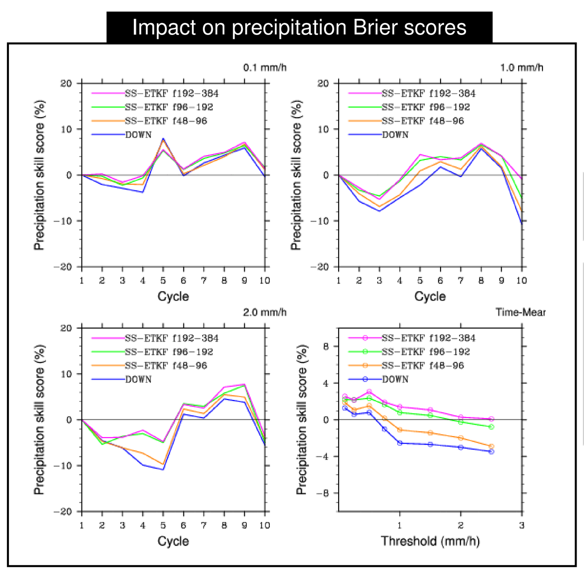
The impact of the scale-selective ETKF approach

a) On 1-h ensemble forecasts



DOWN experiment

1.5 km EPS IC perturbations taken from MOGREPS-R forecasts in all cycle (i.e. perturbation downscaling)



Reference line (y=0) = ETKF

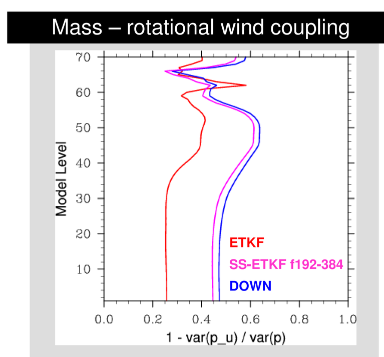
Positive (Negative) values indicate a better (worst) Brier score than the ETKF

- All three scale-selective configurations removed the bias in the surface pressure spread w.rt. MOGREPS-R and mitigated the r.m.s. of the differences.
- The scale-selective configuration using the filter response F192-384 gave the best results. However there is only a small benefit on average with respect to the ETKF.

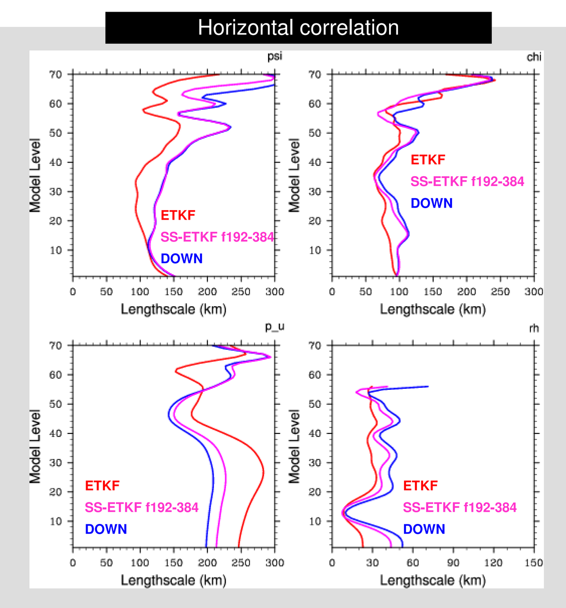
b) On 1-h ensemble forecast perturbation covariances

We computed the forecast perturbation covariances using all ensemble forecasts from the last 7 cycles to estimate the potential impact of these forecast error estimates on e.g. a hybrid DA system.

The covariances were computed in terms of the Met Office's climatological covariance model with control variables : streamfunction (psi), velocity potential (chi), unbalance pressure (p_u) and relative humidity (rh).

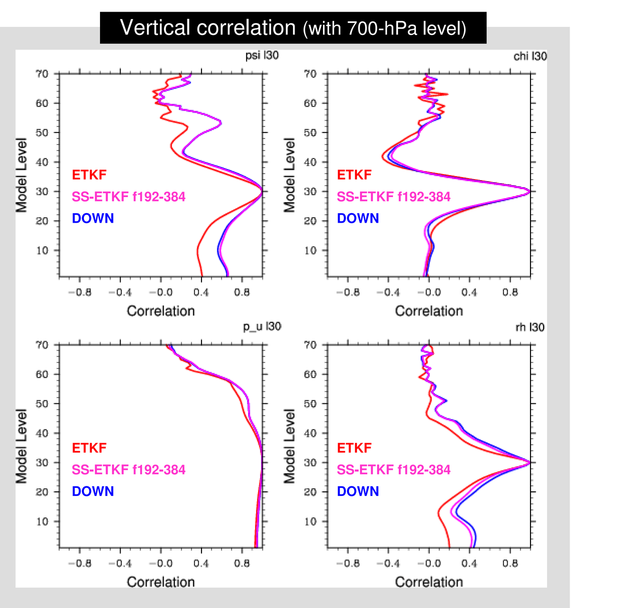


The (linear) coupling is much stronger with the Scale-Selective approach.



Except for the unbalanced pressure, correlations are generally broader both horizontally and vertically with the scale-selective approach compared to the ETKF.

The results from the scale-selective ETKF training data are closer to the results from perturbation downscaling.



Conclusions and Discussion

- Not taking explicitly into account the parent EPS perturbations in the generation of limited-area IC perturbations can introduce significant discontinuities at the lateral boundaries in the child EPS and trigger spurious gravity wave activity. These issues are not only relevant for EPS but for EnDA also.
- All approaches to generate limited-area IC perturbations/increments currently used (apart from downscaling and except perhaps breeding) should face this problem to some extent.
- The scale-selective approach tested here in a ETKF context provided generally good results but this approach introduces an arbitrary criteria (the filter response) in the method. Moreover, the small-scale component of the IC perturbations may become inconsistent with the large-scale component.
- What is the best way to take into account large scale information from parent EPS/EnDA and produce small-scale IC perturbations/increments coherent with the large-scale component ?

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