Progress in Ensemble Data Assimilation at ECMWF

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ECMWF

Progress in Ensemble DA at ECMWF

- Recent and forthcoming operational upgrades
- Development plans

Recent upgrades

- Horizontal Resolution Upgrade (IFS Cycle 41R2, 8 March 2016)

  1. High Resolution assimilation cycle outer loop TL1279 -> TCo1279, inner loops (TL255/255/255) -> (TL255/319/399)

     Keep spectral truncation fixed, but increase the grid point sampling.
     Linear grid: the smallest wavelength is sampled on the grid by 2 points
     Cubic octahedral grid: the smallest wavelength is sampled on the grid by 4 points

Recent upgrades

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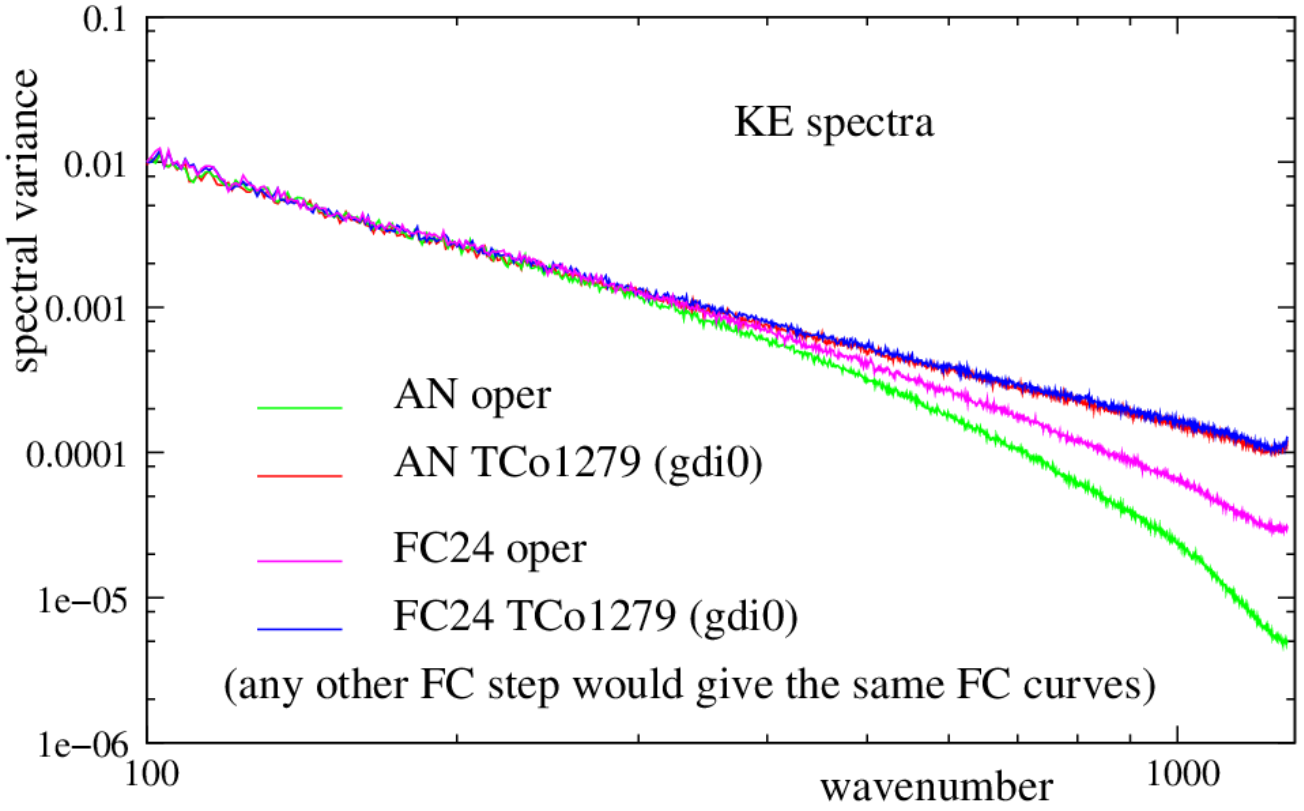
  1. High Resolution assimilation cycle outer loop TL1279 -> TCo1279, inner loops (TL255/255/255) -> (TL255/319/399)

     Higher grid point sampling results in no aliasing (up to cubic terms), less need for horizontal diffusion, more accurate surface fields -> higher effective resolution



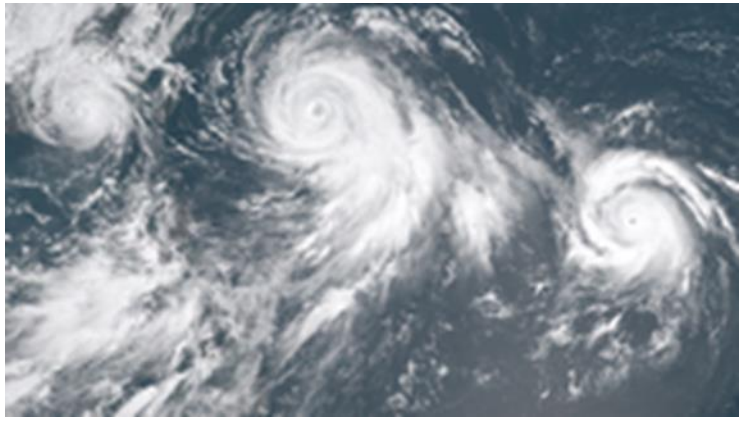
Recent upgrades

- Horizontal Resolution Upgrade (IFS Cycle 41R2, 8 March 2016)

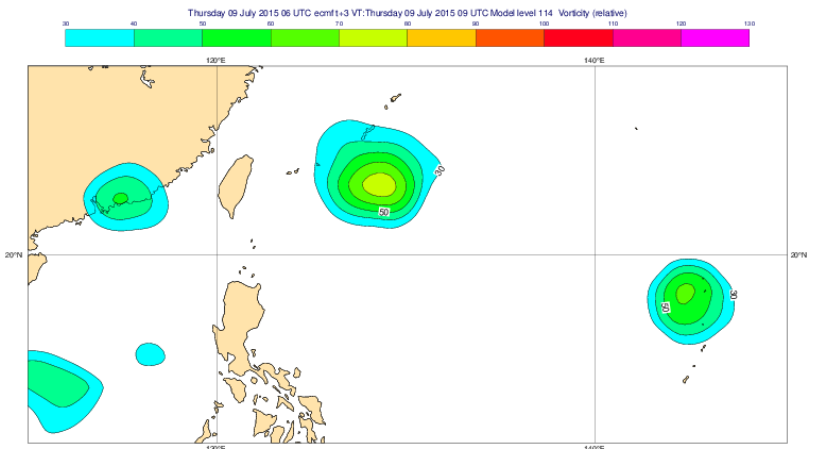
  2. Ensemble Data Assimilation forecast and outer loop TL399 -> TCo639, inner loops (TL159/159) -> (TL191/191)

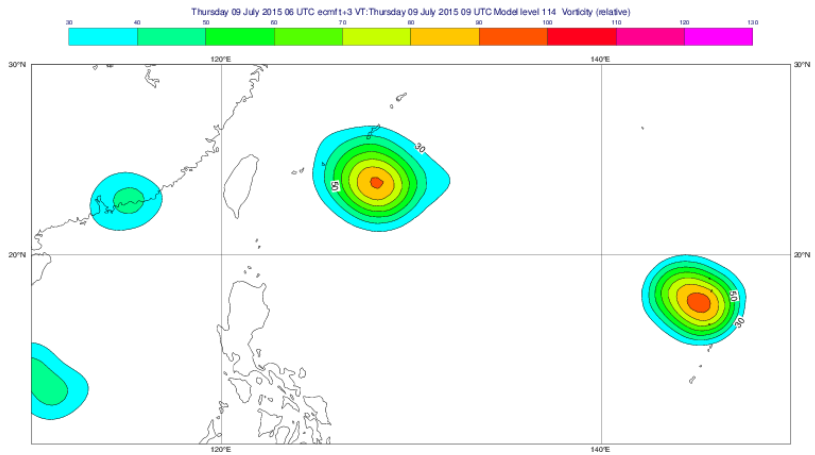
     Increased realism of represented error features

"Linfa, Chan-hom, and Nangka in the West Pacific - Jul 9 2015 0230z"
SSEC/CIMSS, University of Wisconsin–Madison



Vorticity Errors
~ 850hPa
EDA TL399





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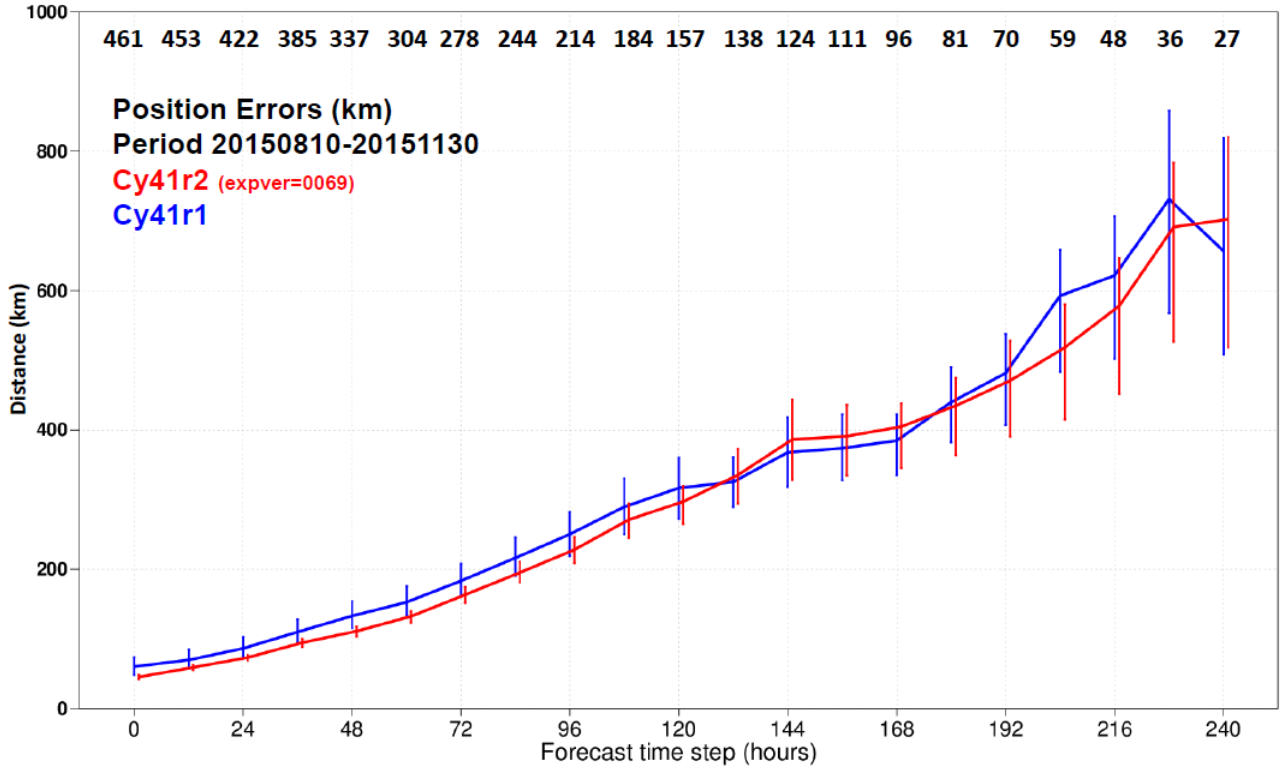
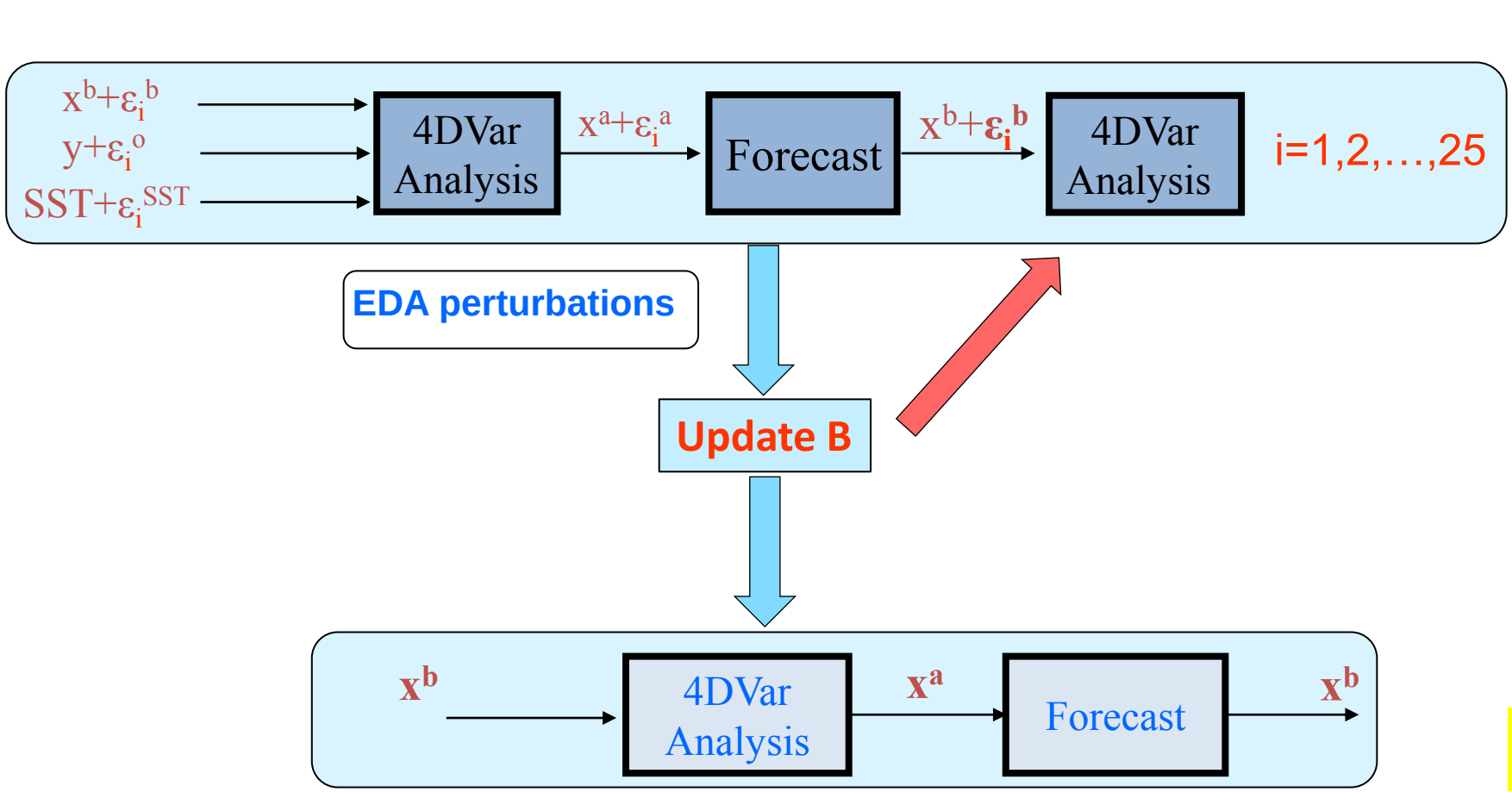


Recent upgrades

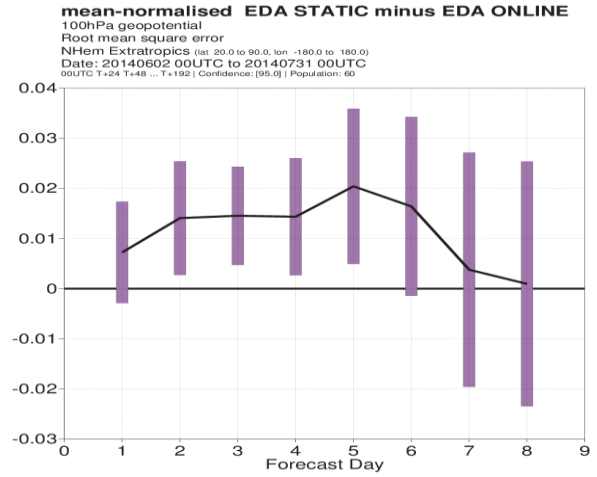
- Error cycling EDA (IFS Cycle 41R2, 8 March 2016)

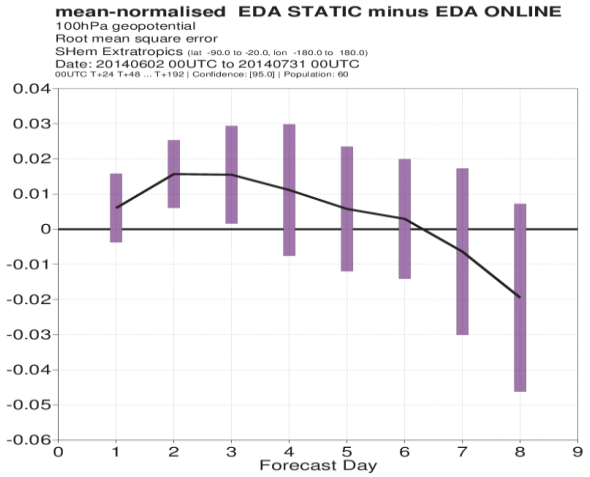


Recent upgrades

- Fully cycling EDA (IFS Cycle 41R2, 8 March 2016)

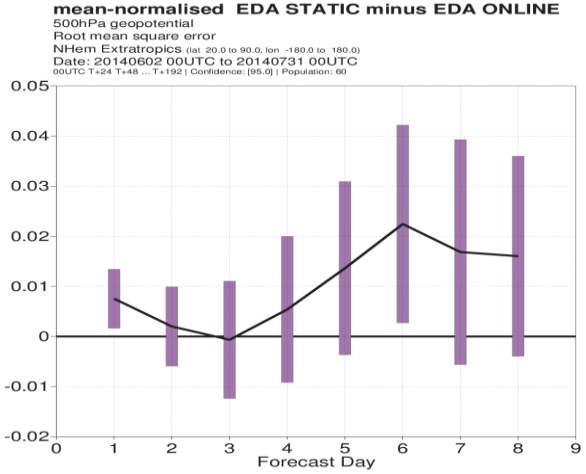
Z100 NHem

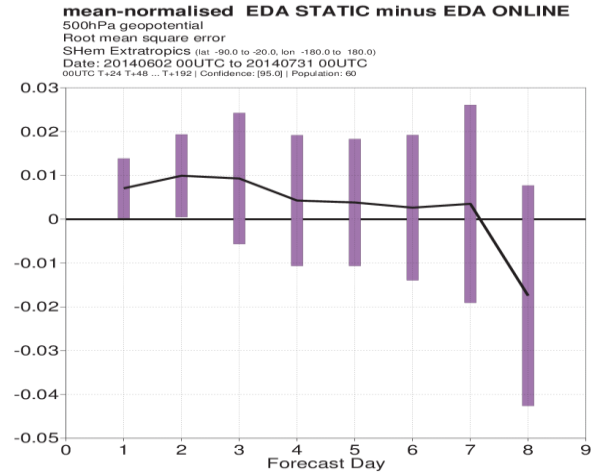




Z100 SHem

Z500 NHem





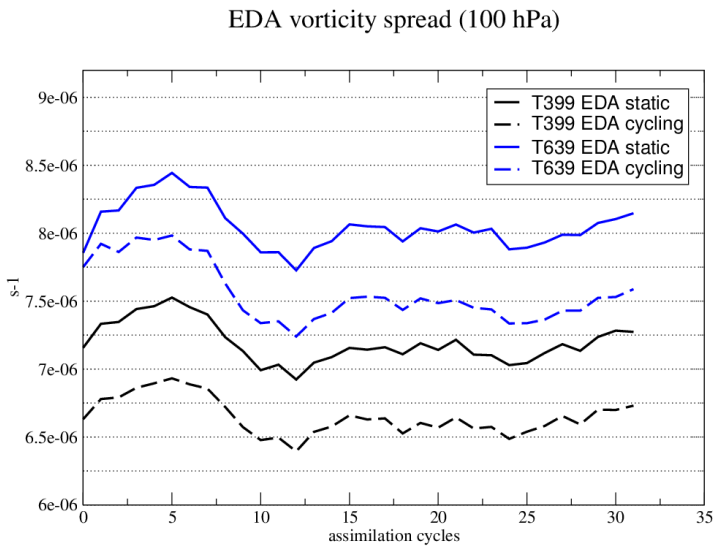
Z500 SHem

Recent upgrades

- Fully cycling EDA (IFS Cycle 41R2, 8 March 2016)

  With full error cycling in the EDA we have a system that closely resembles a Stochastic EnKF

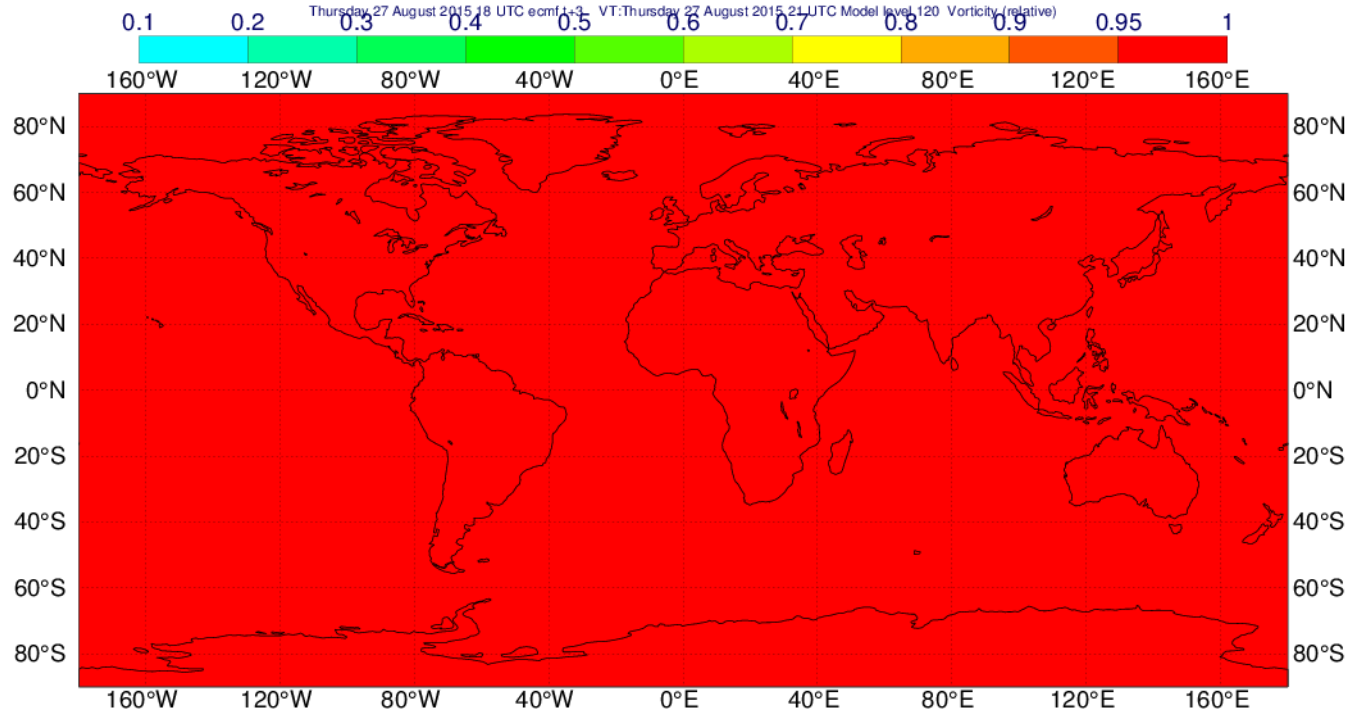
  As the same evolved B is used in the analysis update of all EDA members, inbreeding effects tend to reduce the diagnosed error variances



Future upgrades

- Wavelet-based noise filtering of EDA error estimates

  Introduce space variability in the noise filter (spectral filter is homogeneous) but keeps some spectral resolution



Filter waveband 1-21
Vorticity ~900hPa

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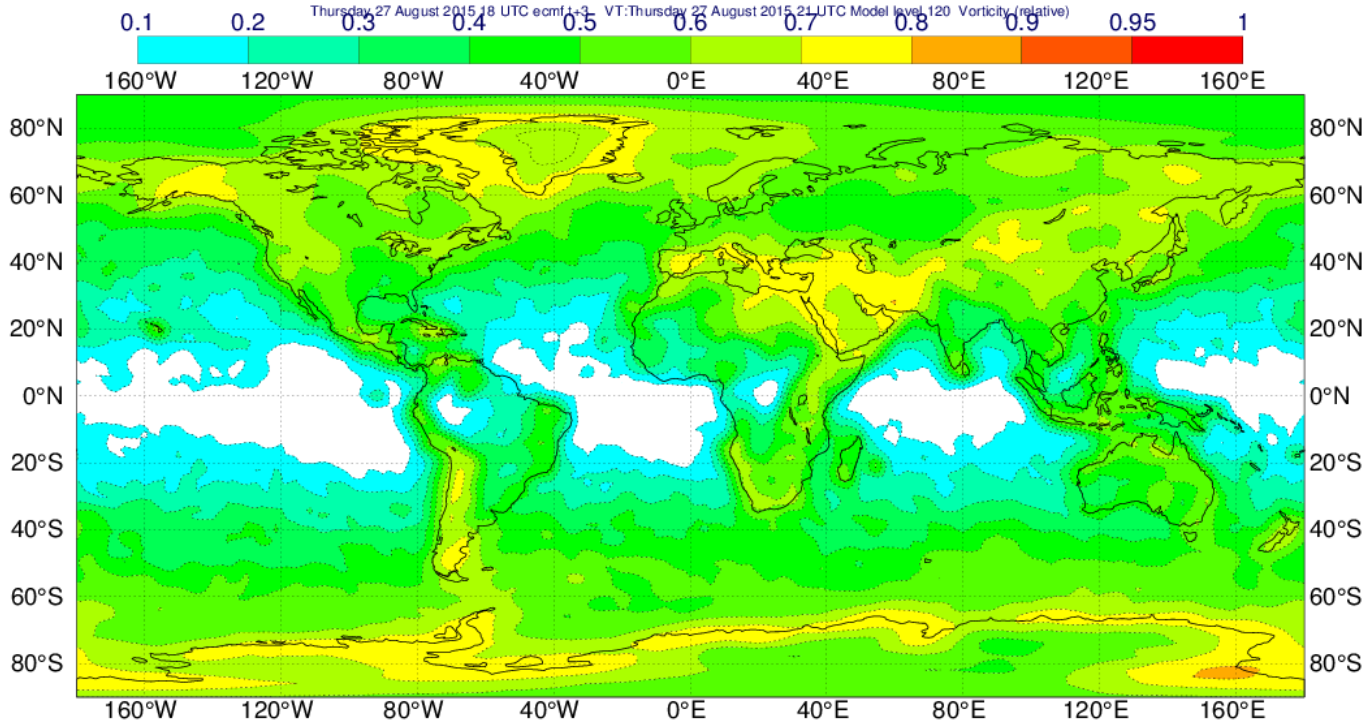
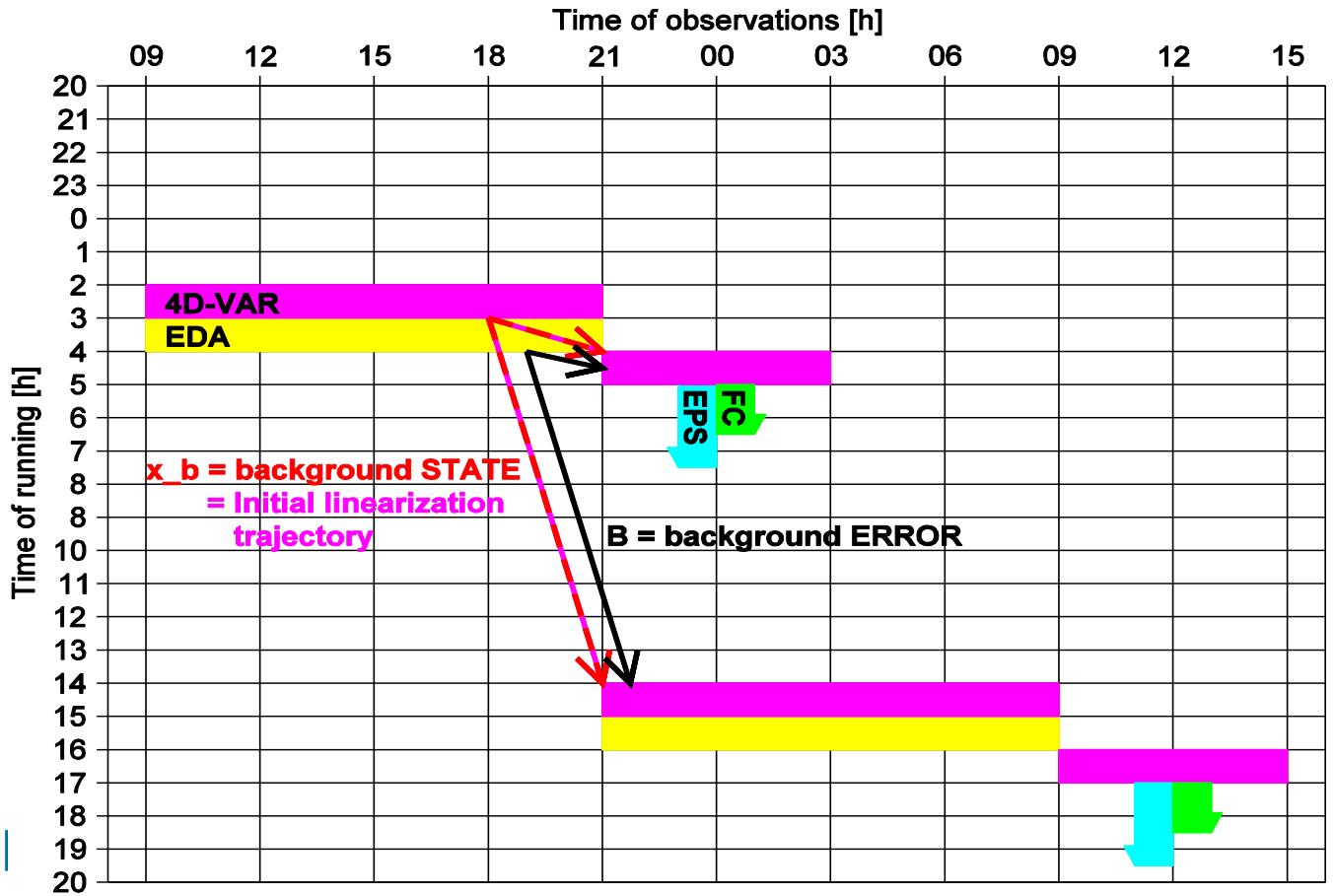


Filter waveband 191-255
Vorticity ~900hPa

Plans

- 6-hourly analysis update with overlapping assimilation windows

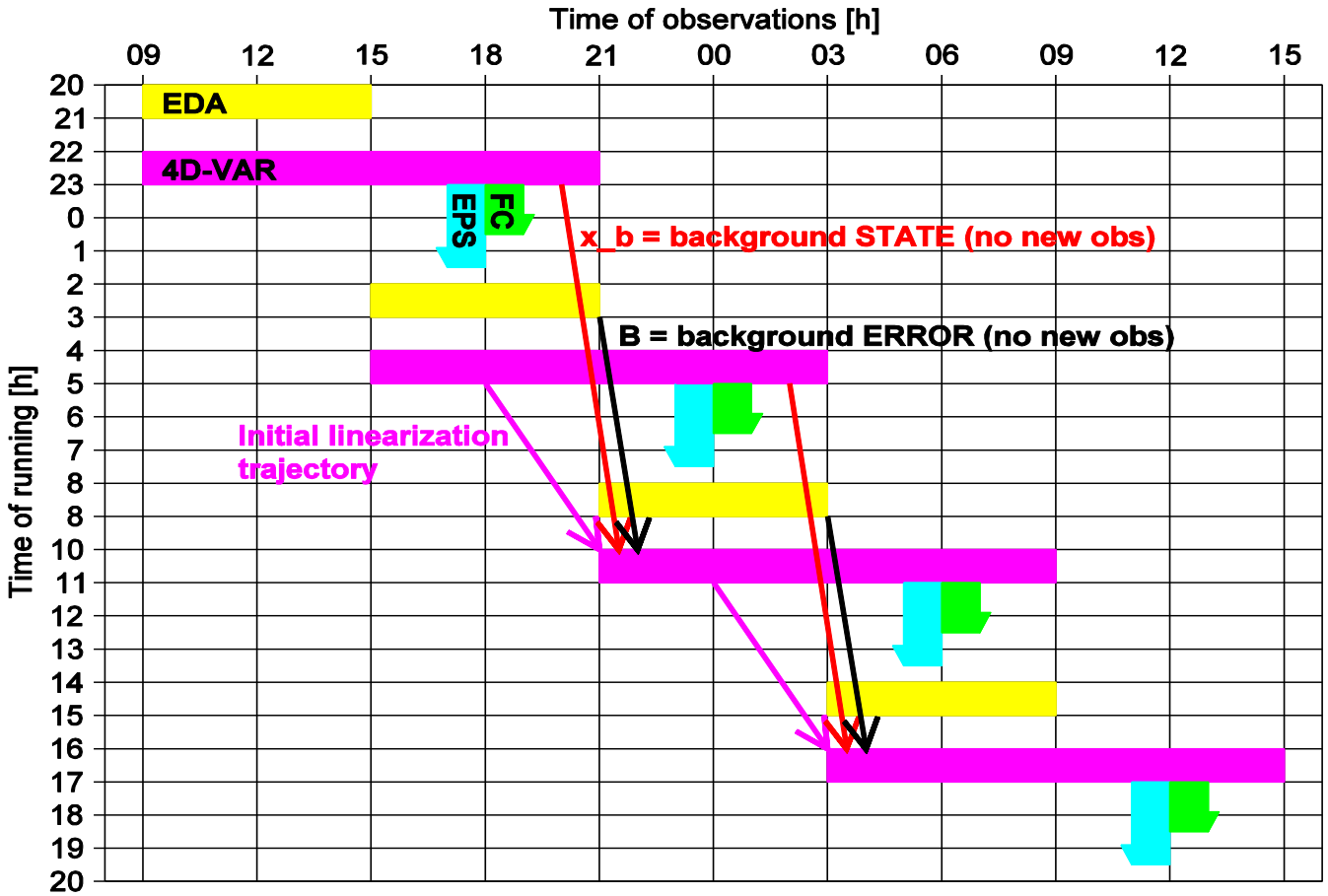
  Current operational setup:



Plans

- 6-hourly analysis update with overlapping assimilation windows

  Overlapping analysis window allows to pick up “late” observations

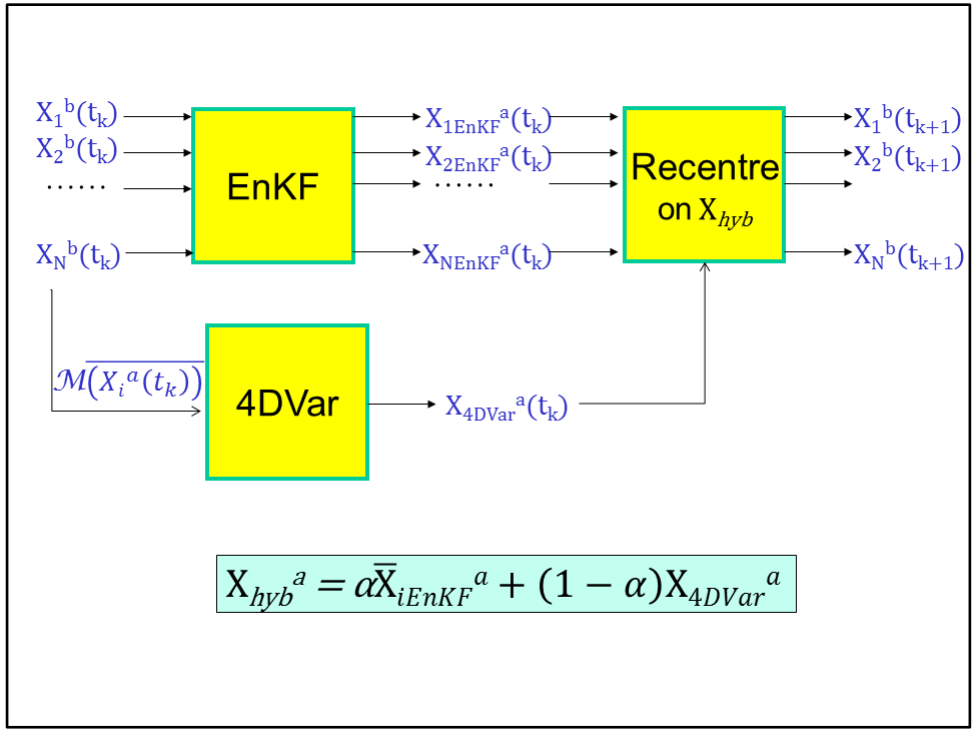


Plans

- Error cycling
  - The Ensemble of Data Assimilations (EDA) tries to model the errors of the high resolution analysis by running a set of simplified, lower resolution, perturbed 4DVars
  - This is theoretically sound (as much as the Kalman gain of the simplified 4DVars is a good approximation of that of the HRES 4DVar)
  - But it is very expensive and scales poorly with ensemble size as separate analyses are required for each member
  - This also applies to ensembles of 4D-Ens-Var

Plans

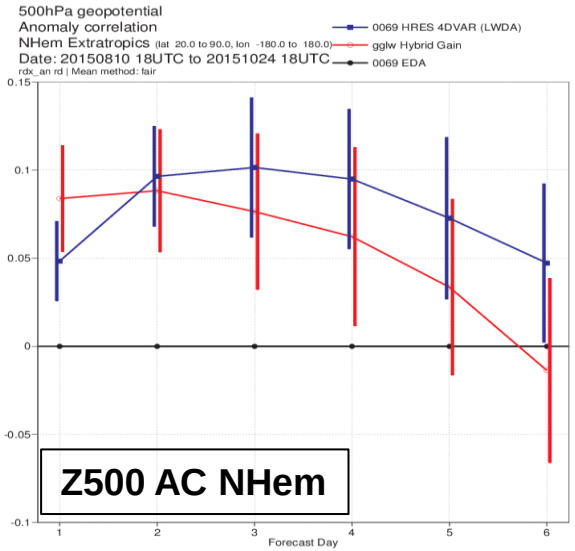
- Error cycling
  - Hybrid Gain EnDA (Penny, 2014; Hamrud et al., 2015) is a way to address the computational issues of the EDA
  - 100 member Hybrid Gain EnDA has similar computational cost as current operational 25 member EDA

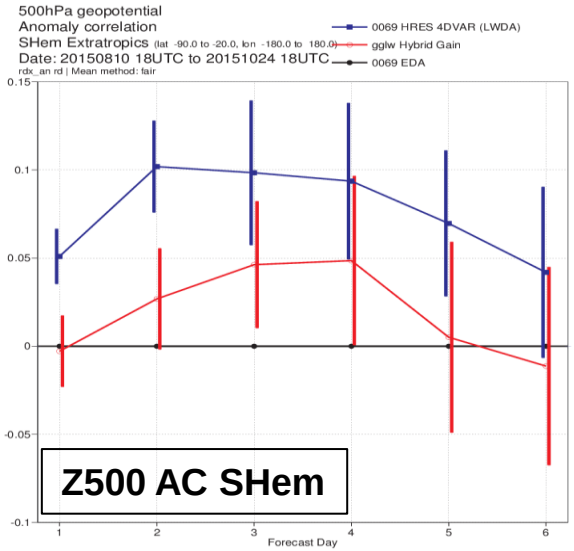


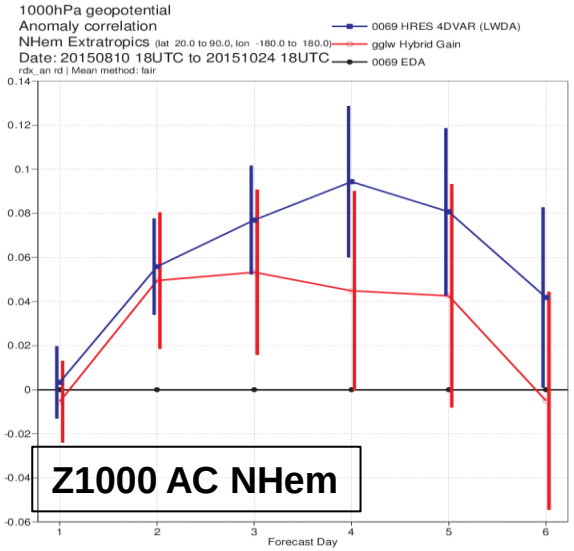
Plans

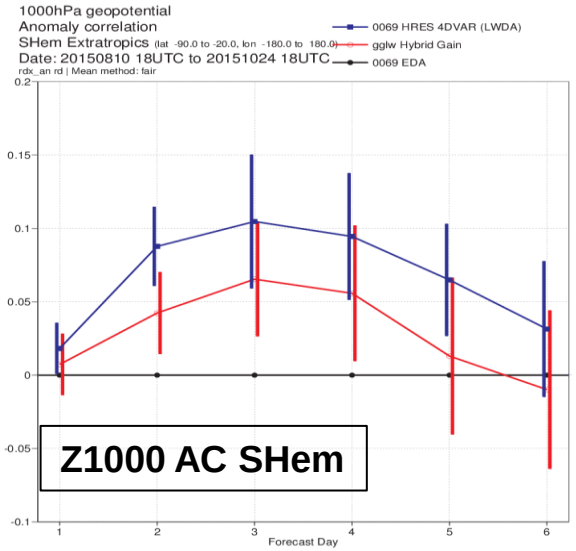
--- EDA ctrl (Tco639)
--- HG ctrl (TCo639)
--- HRES (TCo1279)

HG experiment not using ALL-SKY obs.







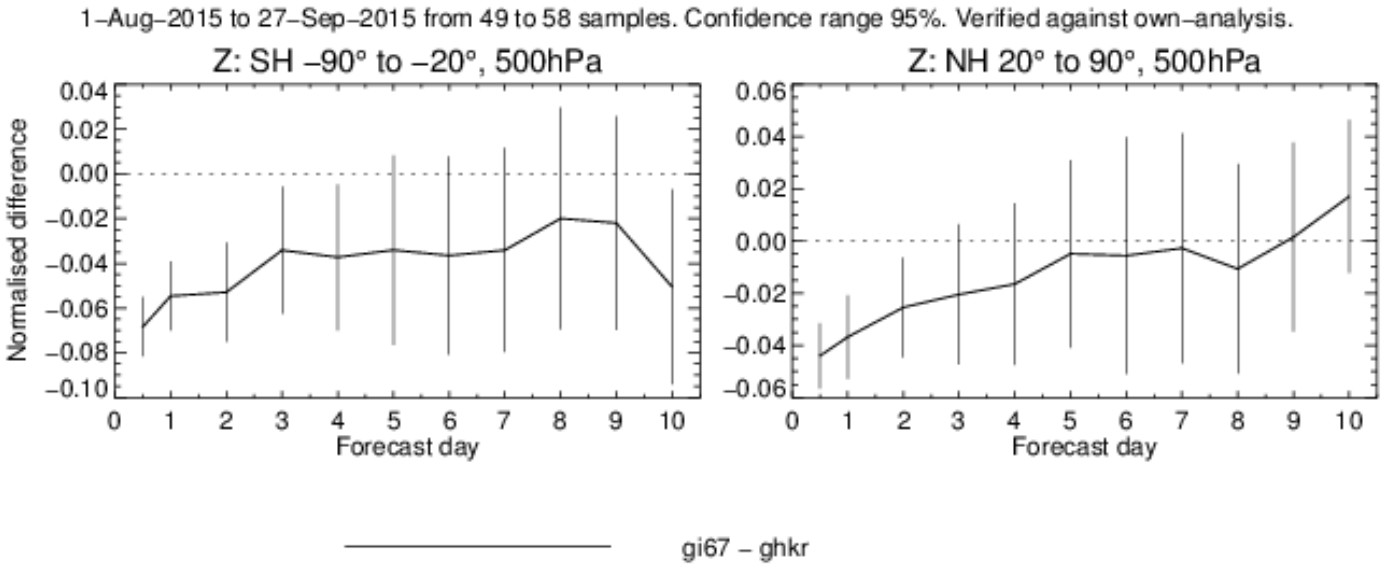


Use of All-Sky Radiances in the EnKF

Z500 RMSE REDUCTION

S.Hem. **N.Hem.**

ALLSKY Positive



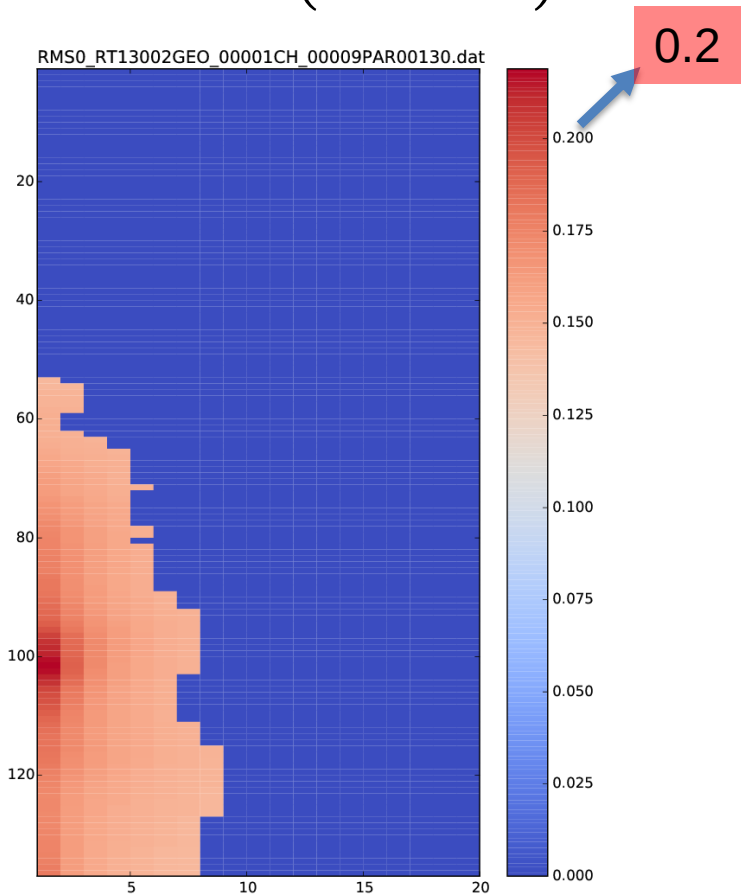
Plans

- Error cycling
  - Hybrid Gain EnDA is an effective and efficient error cycling system
  - When we use error covariances from an HG-EnDA to feed a HRES hybrid 4DVar we get very similar results as when we use an EDA to do the same job
  - These results (and other evidence) suggest:
    1. Error statistics produced by the EDA and HG-EnDA are very similar;
    2. There is clear scope of further enhancing the use of the flow-dependent B component in our hybrid 4DVar, either by modelling refinements and/or direct use of ensemble perturbations

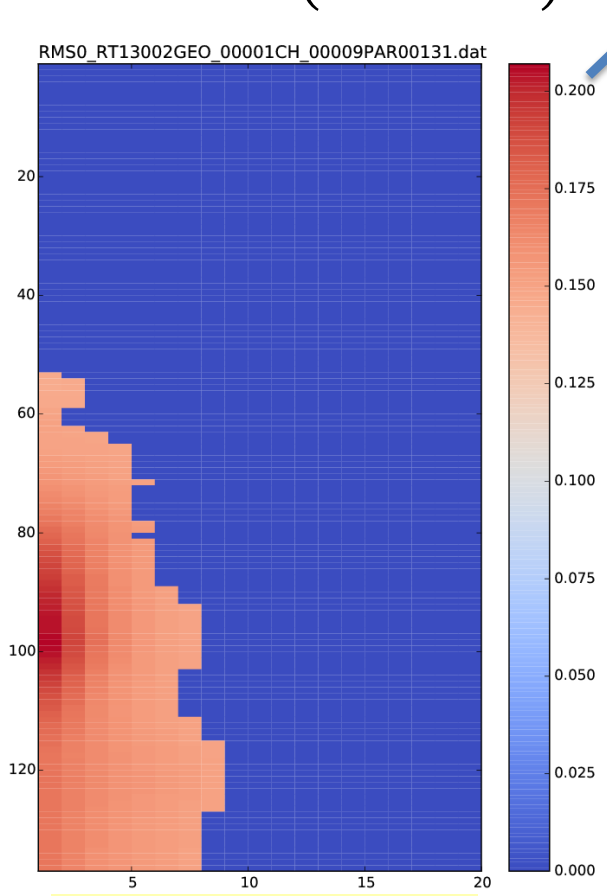
Thank you!

Use of All-Sky Radiances in the EnKF

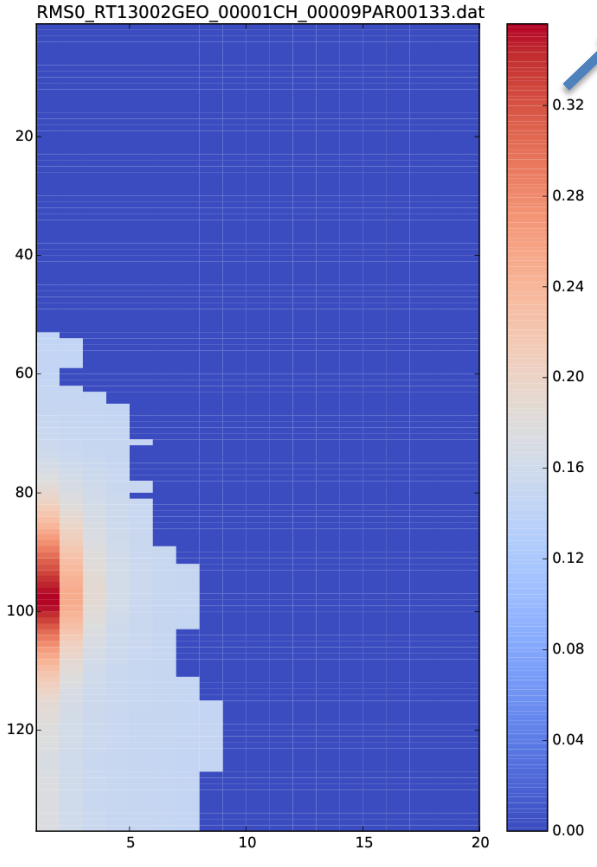
RMS of $corr\left(T_b^i, H(x_b^i)\right)$



RMS of $corr\left(u_b^i, H(x_b^i)\right)$

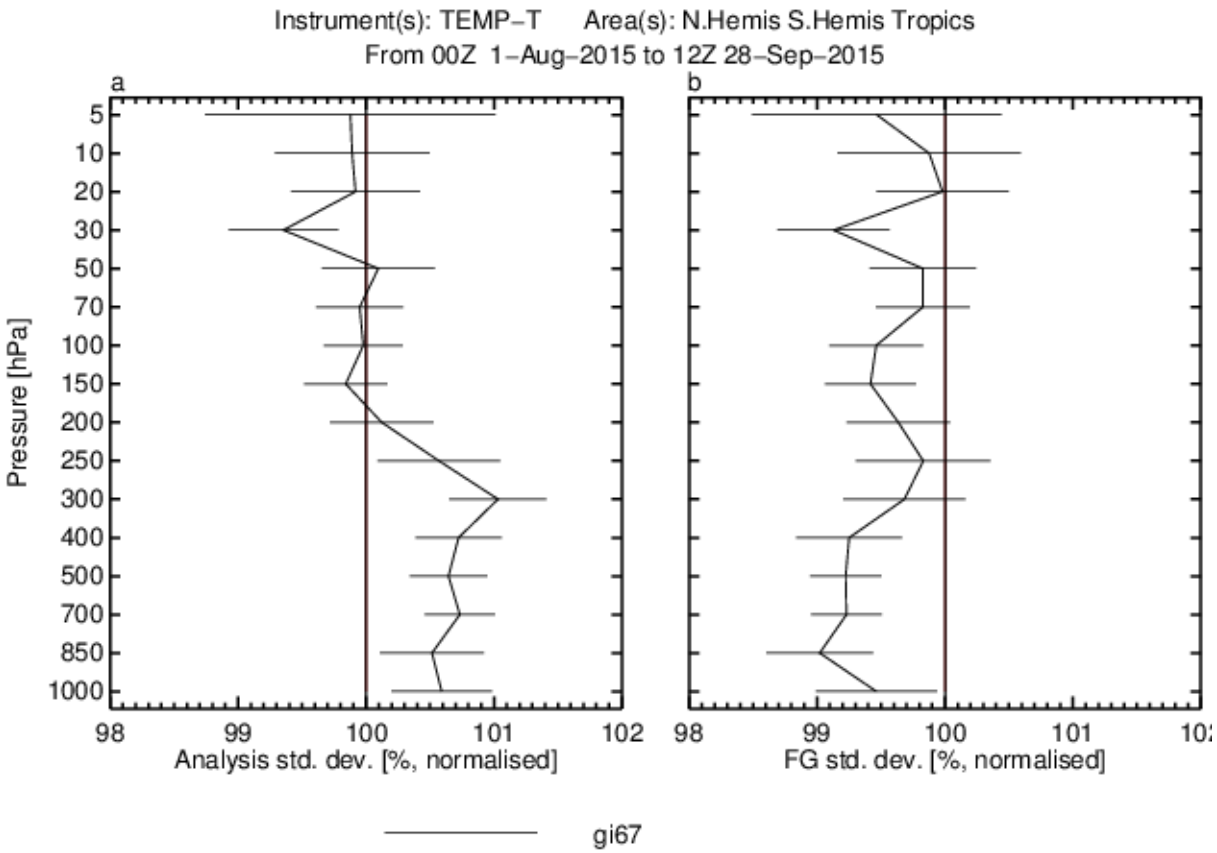


RMS of $corr\left(q_b^i, H(x_b^i)\right)$

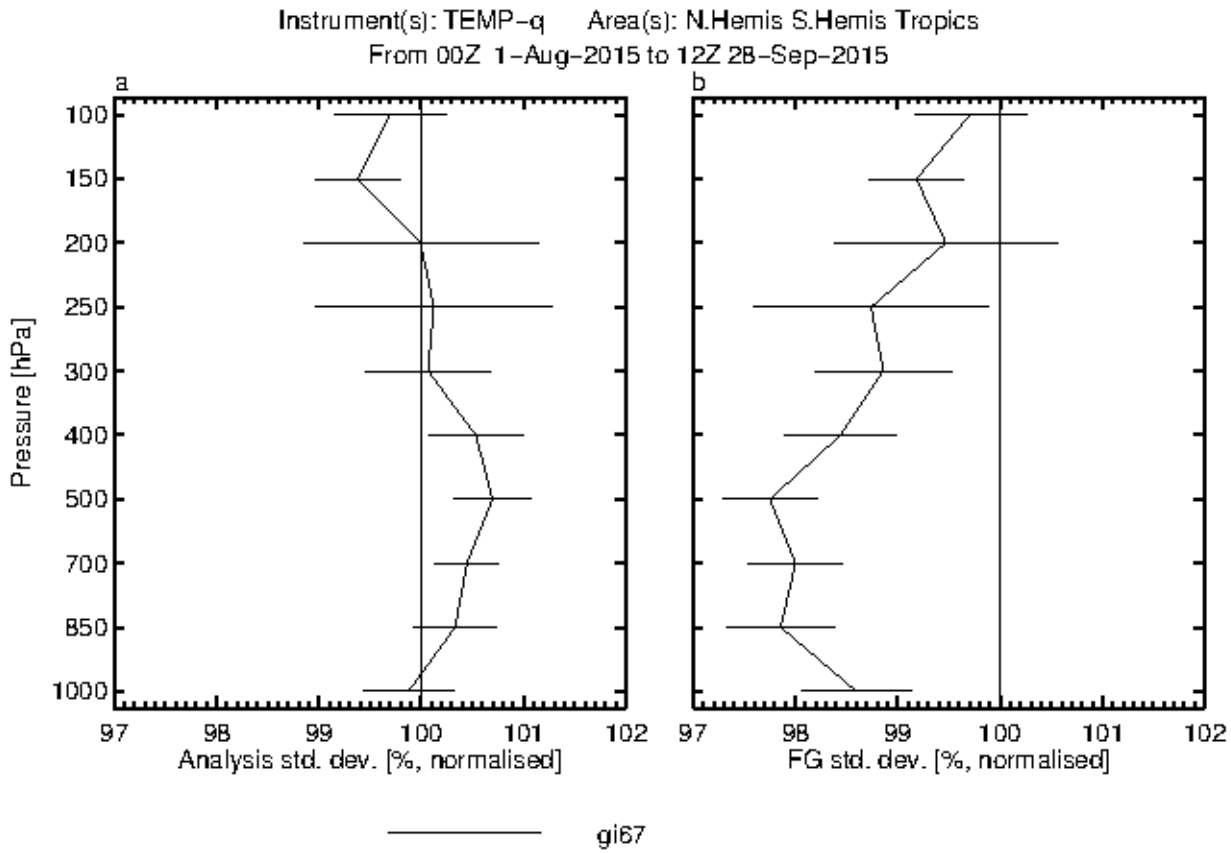


Distance (100Km)

Use of All-Sky Radiances in the EnKF



RAOB-T

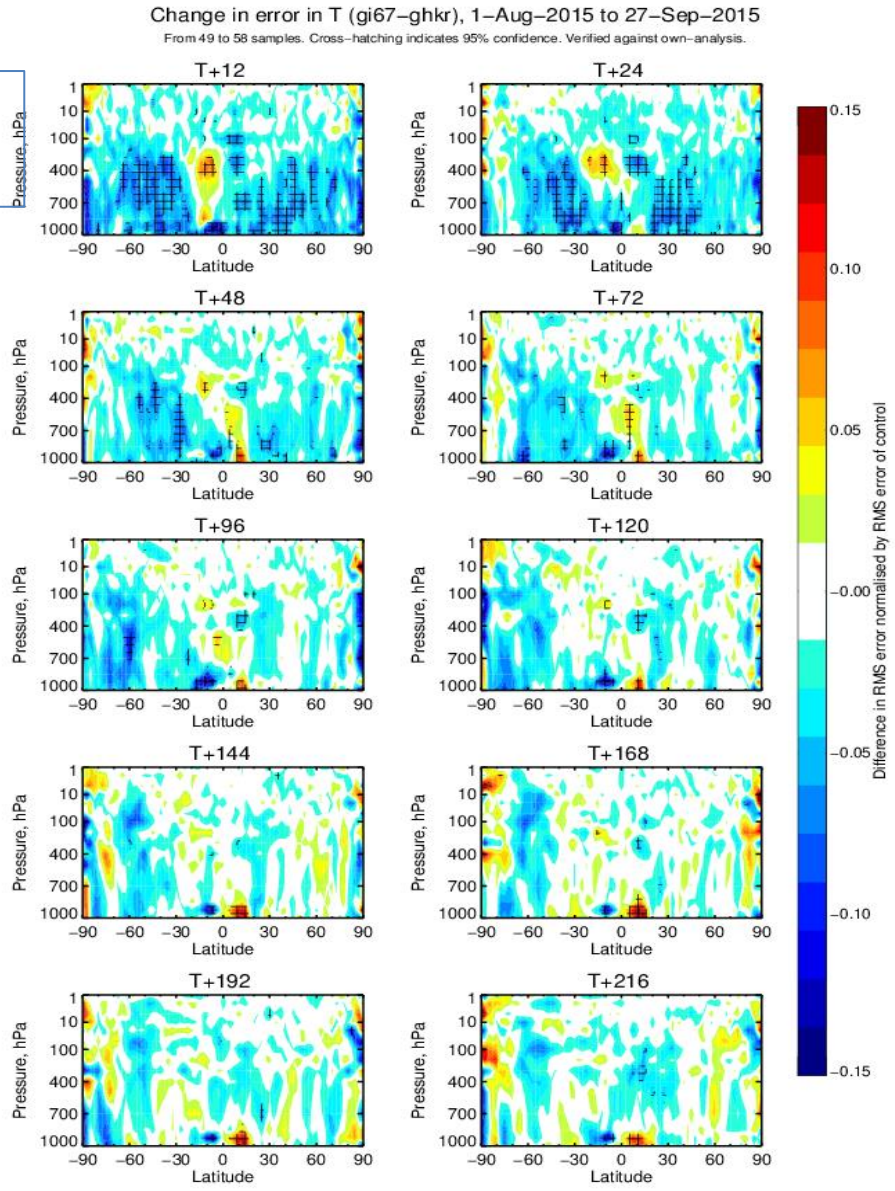


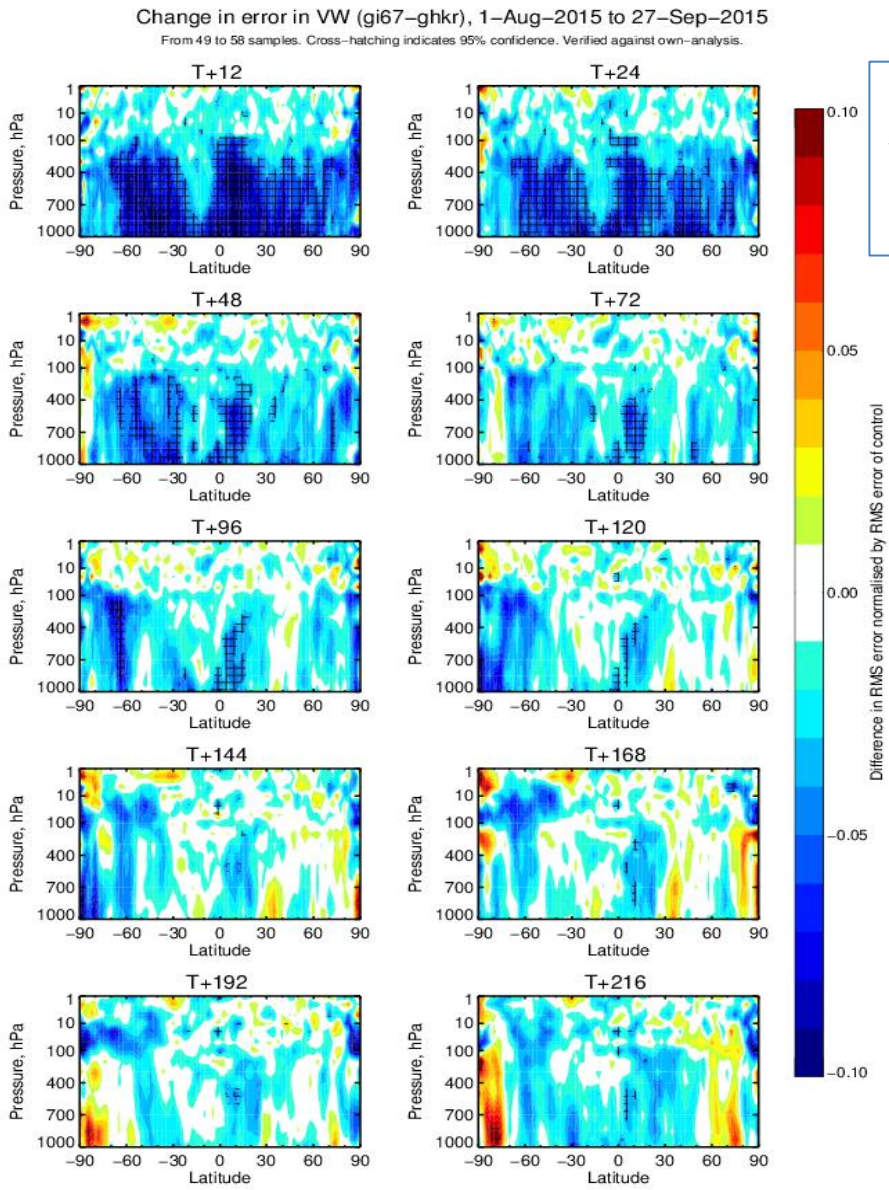
RAOB-Q

Use of All-Sky Radiances in the EnKF

Reduction in Temp. RMSE

The bluer the better!





Reduction in Wind vector RMSE