Ensemble Data Assimilation: Perturbing the background state to represent model uncertainties

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Ensemble Data Assimilation:

Perturbing the background state to represent model uncertainties

$$\mathbf{x}_a = \mathbf{K}\mathbf{y} + (\mathbf{I}_q - \mathbf{K}\mathbf{H})\mathbf{x}_b$$

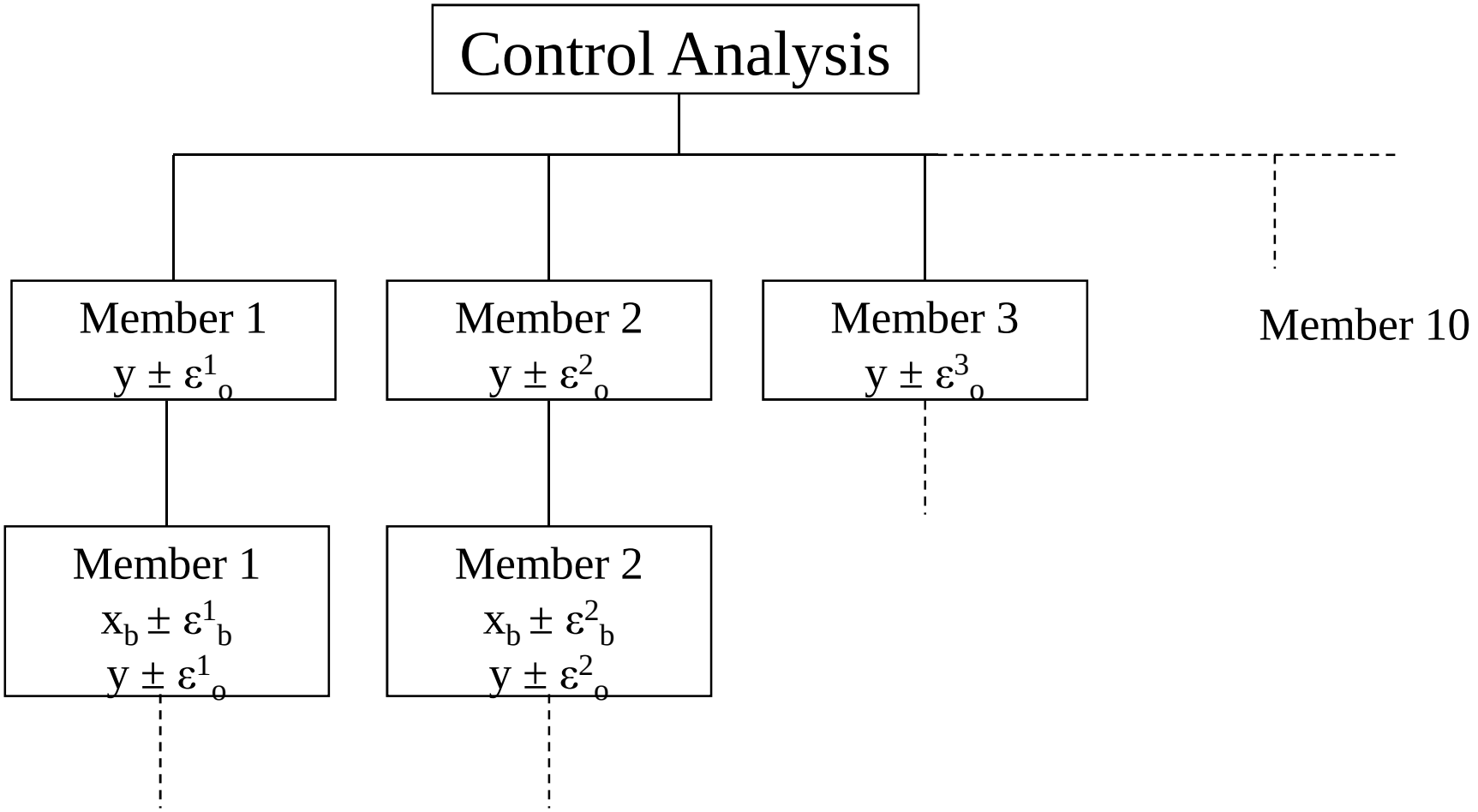
data uncertainties — model uncertainties

outline

- EDA perturbing y and x_b
- Spread comparisons with EDA with different model error representation and EDA where only data error is represented
- Diagnostics on the B derived from all different EDA
- EDAs performance in the EPS
- Conclusion

Ensemble Data Assimilation

perturbing the background state to represent model uncertainties

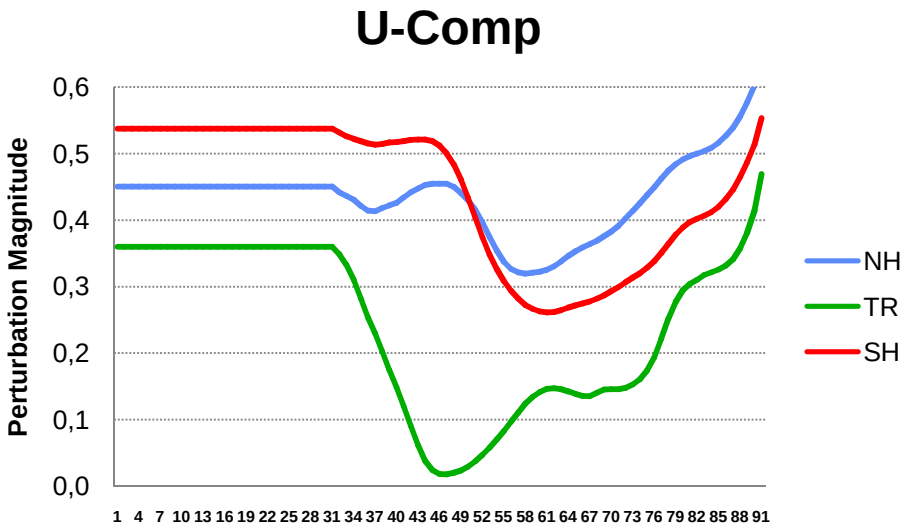


ECMWF

Ensemble Data Assimilation
Experiment set-up

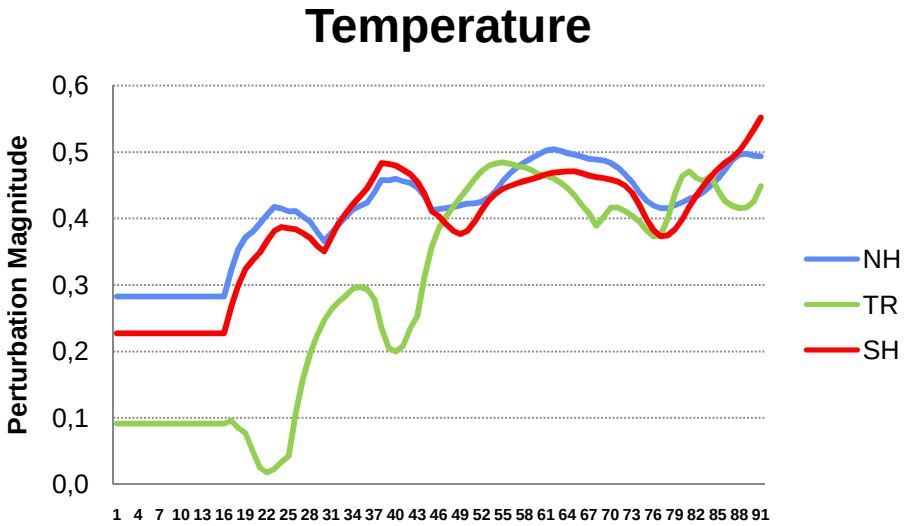
Realization:10 member
Resolution: T399T159L91
Period: 20081005-20081115
Model error representation:
-**ST** Stochastic representation of model error associated to parameterized physical processes tendencies (Buizza et al. 1999)
-$\mathbf{X_b}$ Perturbed background with Gaussian random correlated perturbation. Magnitude of the perturbation estimated from spread comparison between EDA-OBS and observation departure from the control analysis
-**OBS** Perturbed observation with Gaussian random perturbation
-**OBSobs** like **OBS** but NO Cycling

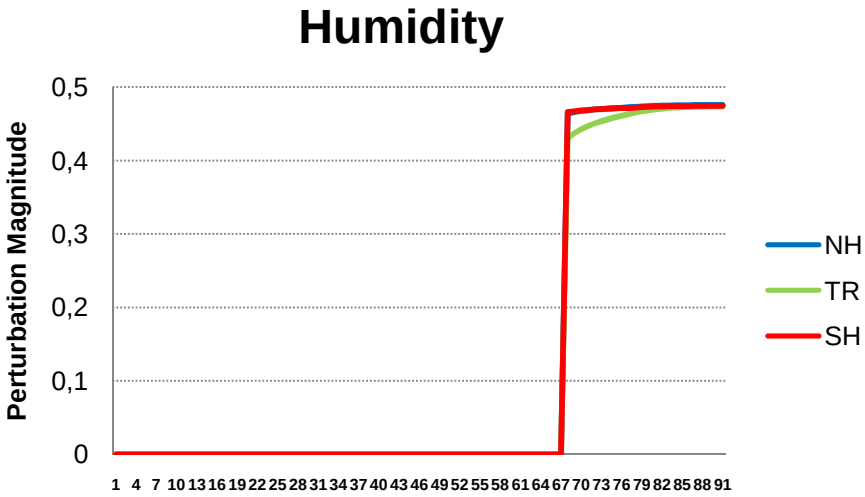
Perturbation Magnitude: ε_o computation



$$\frac{STD(\mathbf{d}) - STD(\mathbf{EDA})}{STD(\mathbf{d})}$$

$$\mathbf{d} = \mathbf{y} - H(\mathbf{x}_b)$$



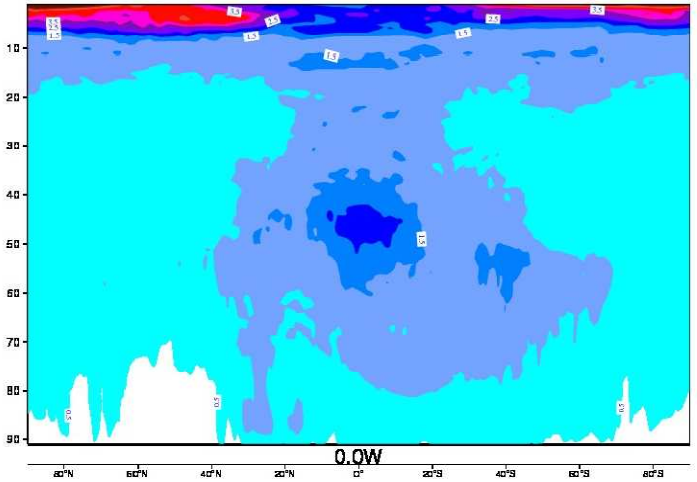


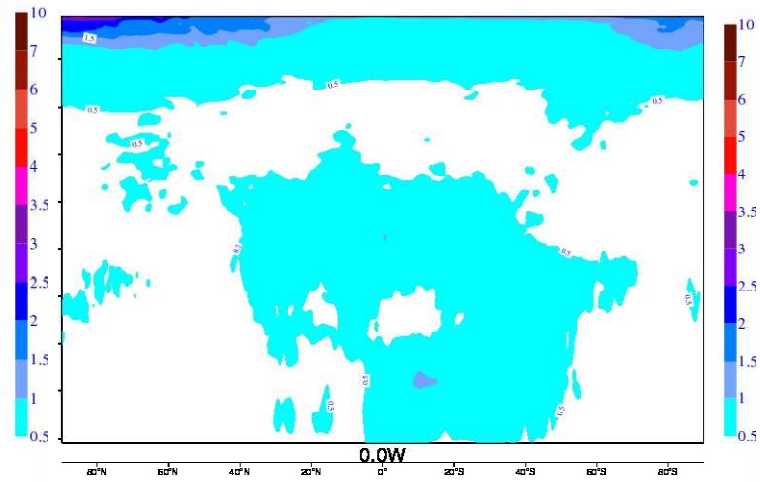
Ensemble Data Assimilation

Zonal averaged cross section u-comp ensemble spread

$$Spread(EDA) = E\left(\sqrt{\frac{\sum_{i=1}^{N}(m_i - \bar{m})^2}{N-1}}\right)$$

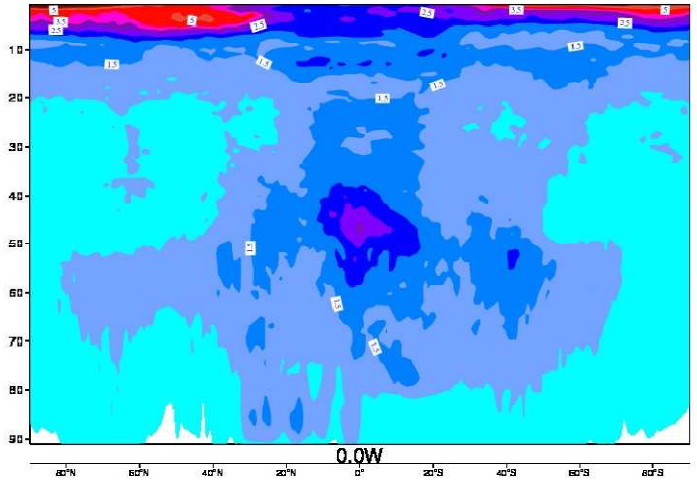
OBS

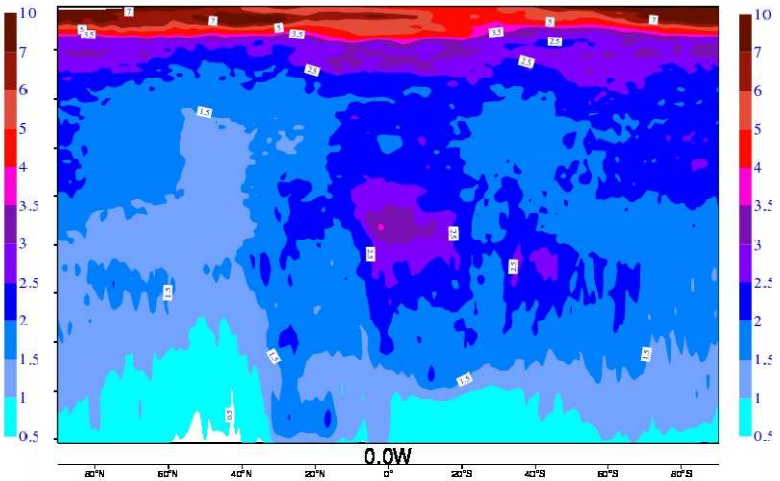




OBSobs

ST

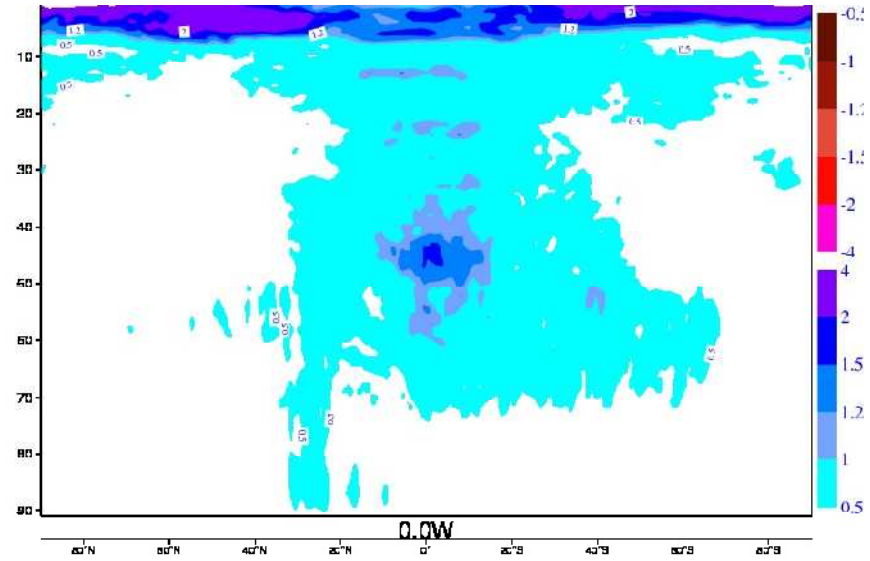




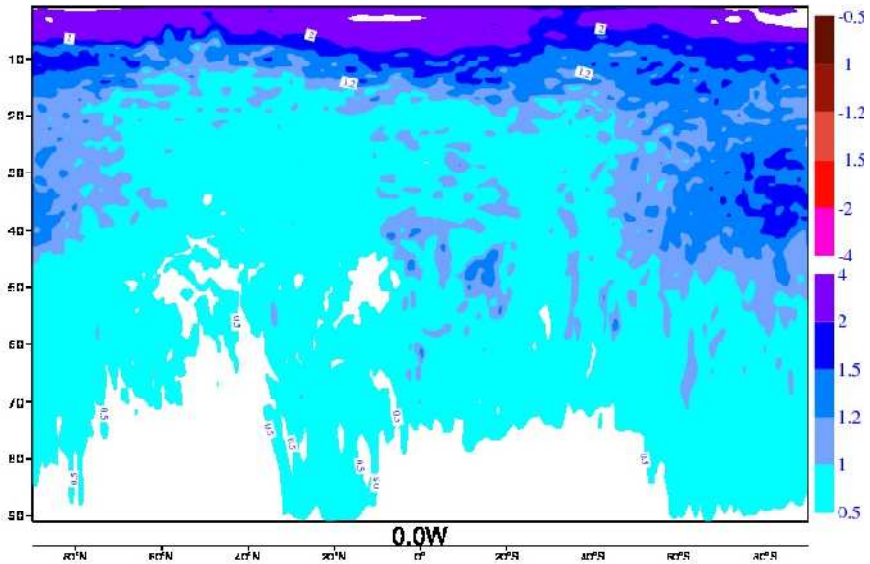
X_b

Ensemble Data Assimilation: X_b

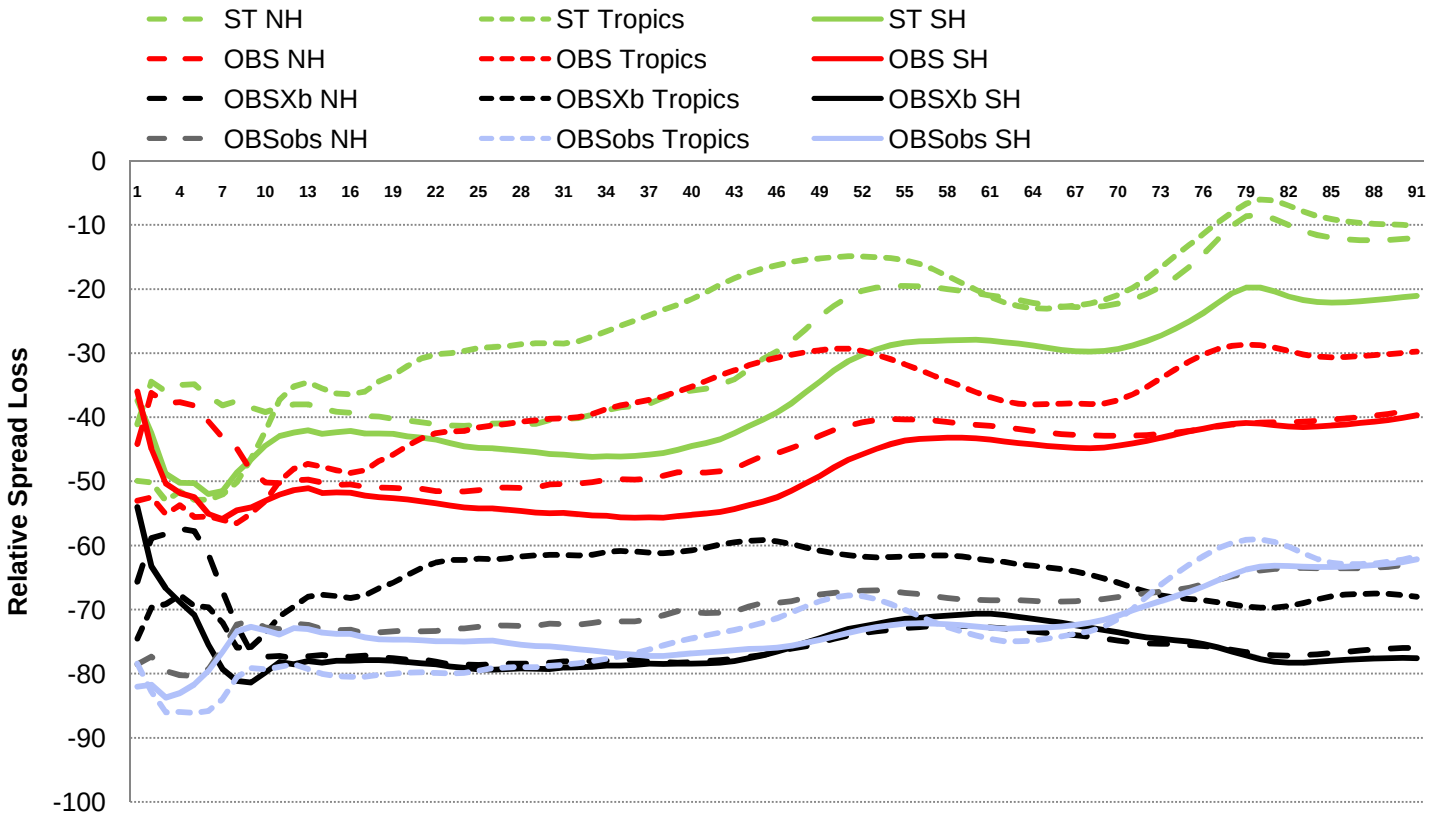
OBS-OBSobs



Xb-OBS



Ensemble Data Assimilation: u-spread level&area



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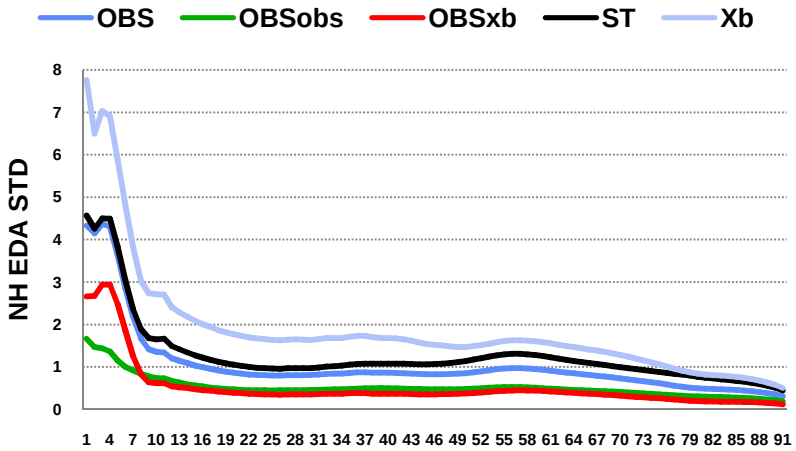
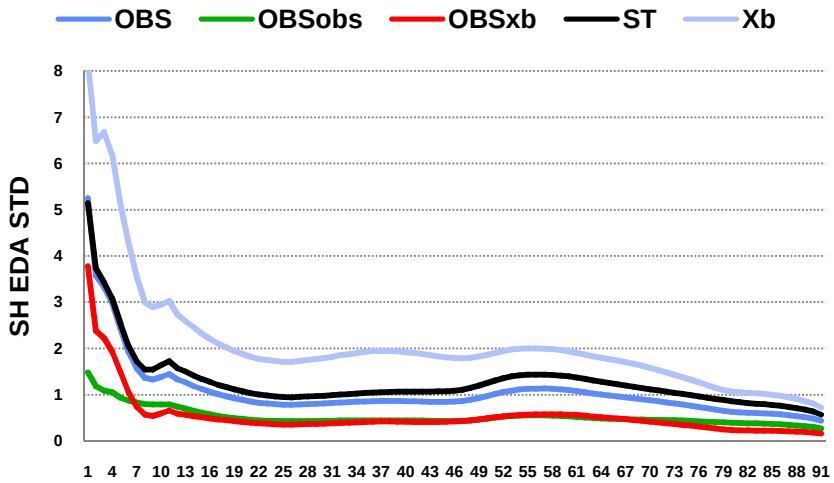
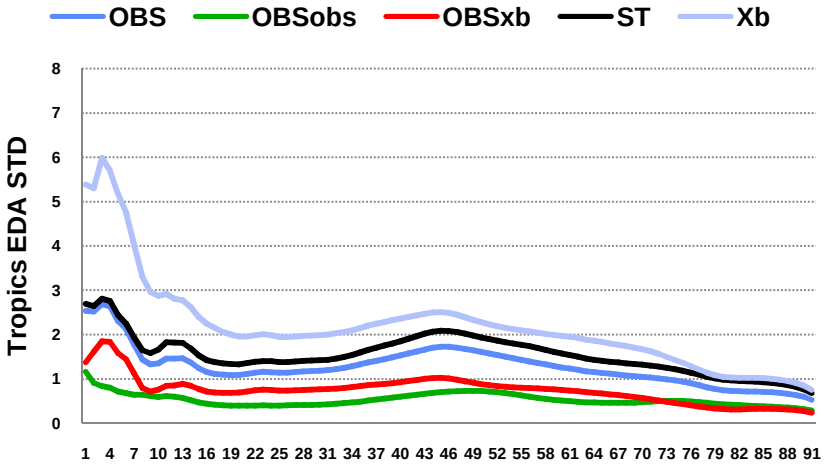
Ensemble Data Assimilation: u-spread level&area







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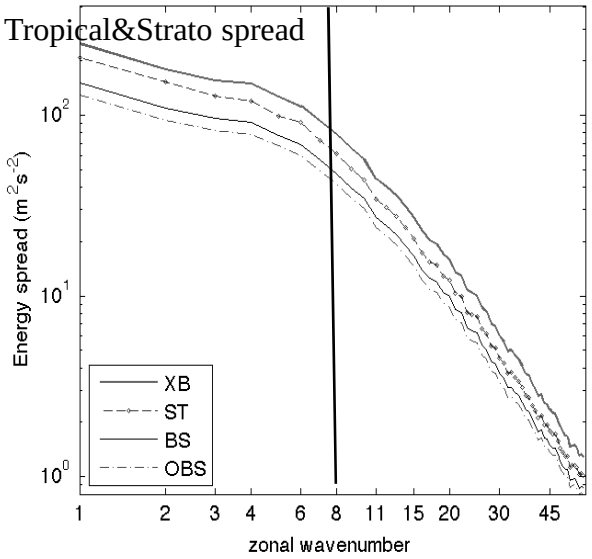
EDA: *Energetic diagnosis of the ensemble spread*

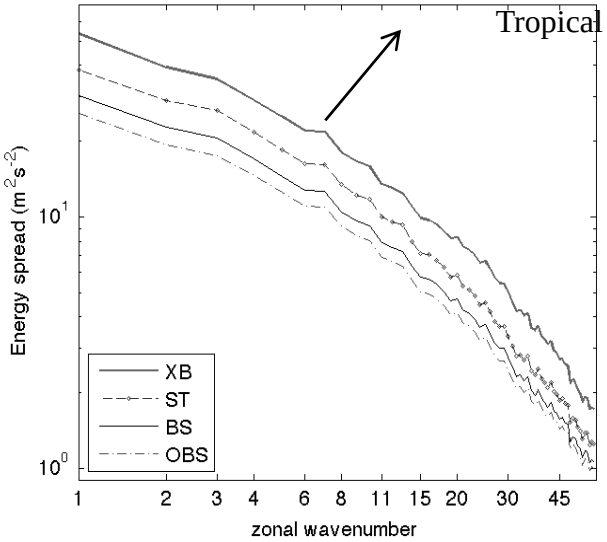
Balanced flow

Tropical&Strato spread

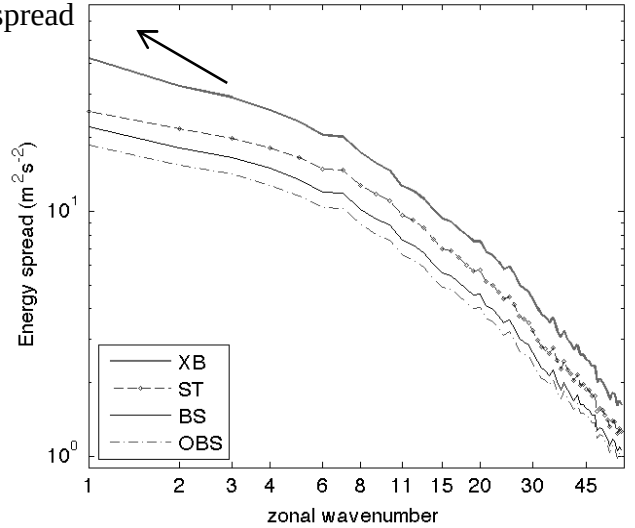


EIG

Tropical spread



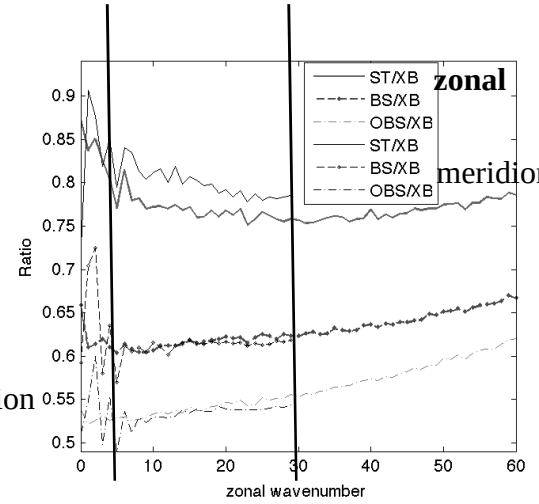
WIG



$$S_v = \left[\frac{1}{N-1} \sum_{i=1}^{N} (E_{v,i} - \bar{E}_v)^2 \right]^{1/2}$$

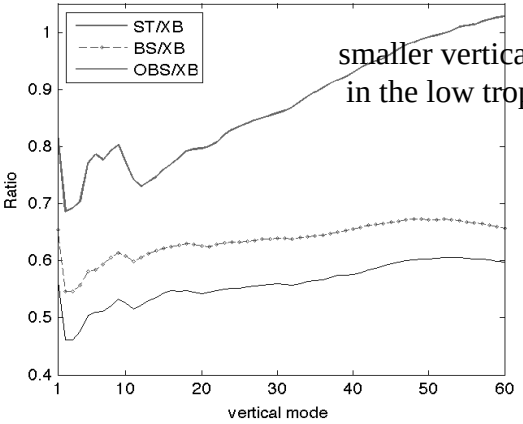
$$E_v = gH_v \chi_v \chi_v^*$$

X_v non-dim complex proj. coef.
v=v(k,n,vert.mode,wave type)
H equivalent depth coupling hor+vert motion



zonal

meridional



smaller vertical scale
in the low troposphere

5

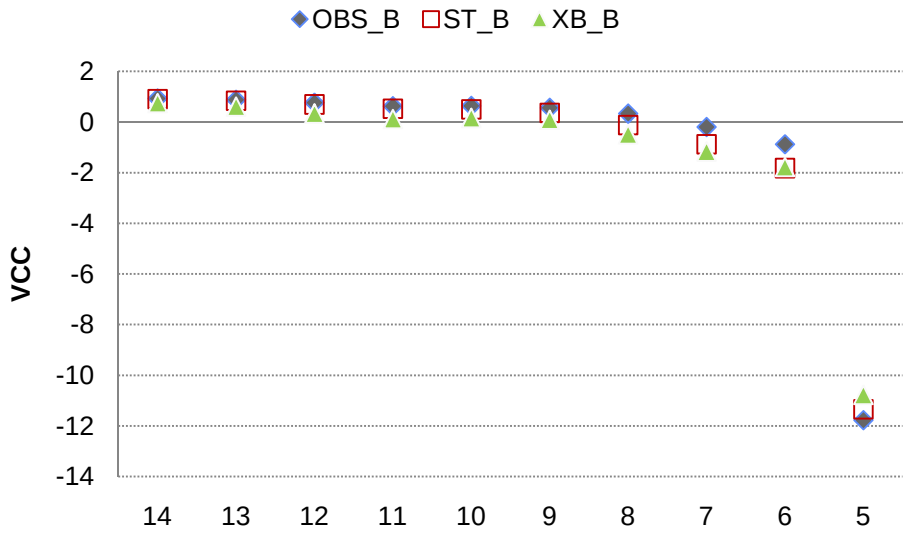
Observation Space Diagnostic

B computed from EDAs Desroziers et al. 2005

$$\mathbf{HBH^T = E(d_b^a (d_b^o)^T)} \qquad \mathbf{d_b^a = Hx_a - Hx_b} \quad \mathbf{d_b^o = y - Hx_b}$$

$$\text{Variance Consistency Check} = \frac{\mathbf{HBH}^T{}_E - \mathbf{HBH}^T{}_A}{\mathbf{HBH}^T{}_E}$$

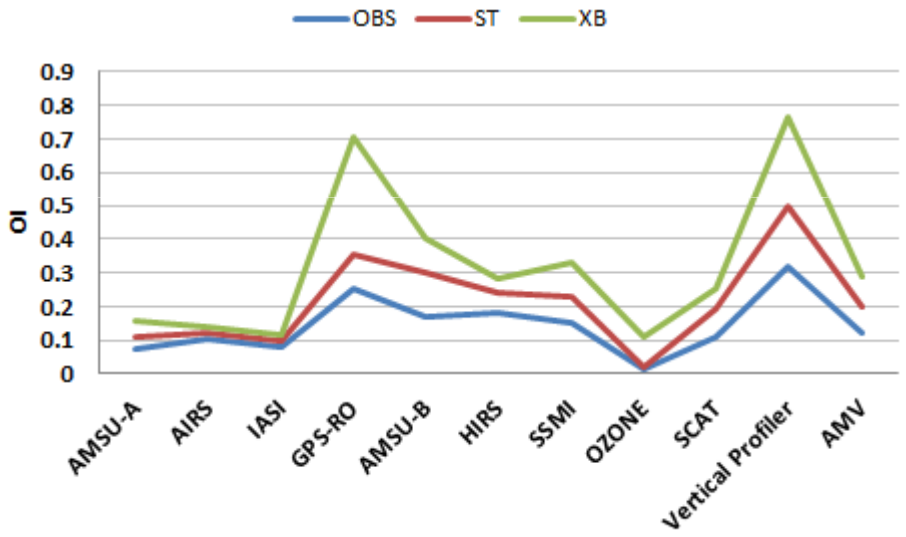
AMSU-A



Observation Space Diagnostic

Observation Influence Cardinali et al. 2004

$$\frac{\partial \mathbf{H}\mathbf{x}_a}{\partial \mathbf{y}} = \mathbf{K}^T \mathbf{H}^T \qquad \mathbf{K} = (\mathbf{B}^{-1} + \mathbf{H}^T \mathbf{R}^{-1} \mathbf{H})^{-1} \mathbf{H}^T \mathbf{R}^{-1}$$



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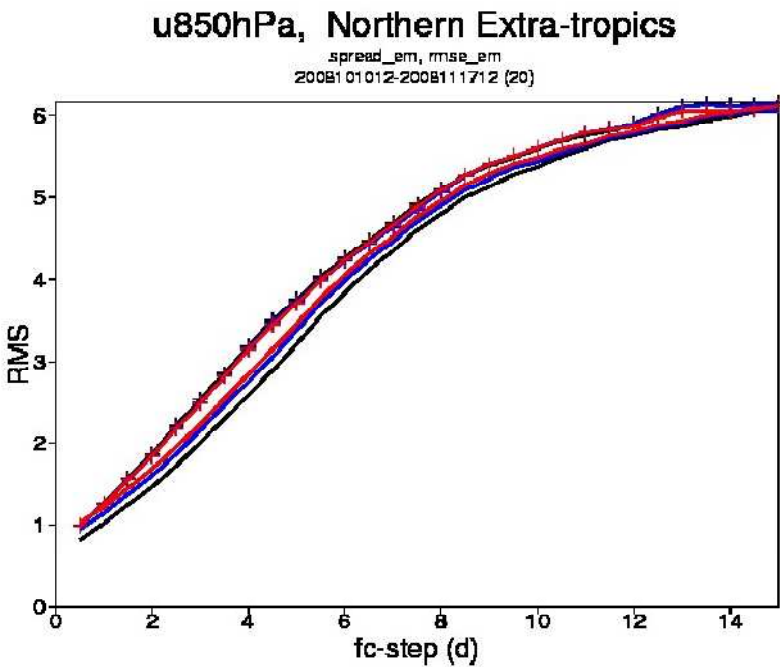
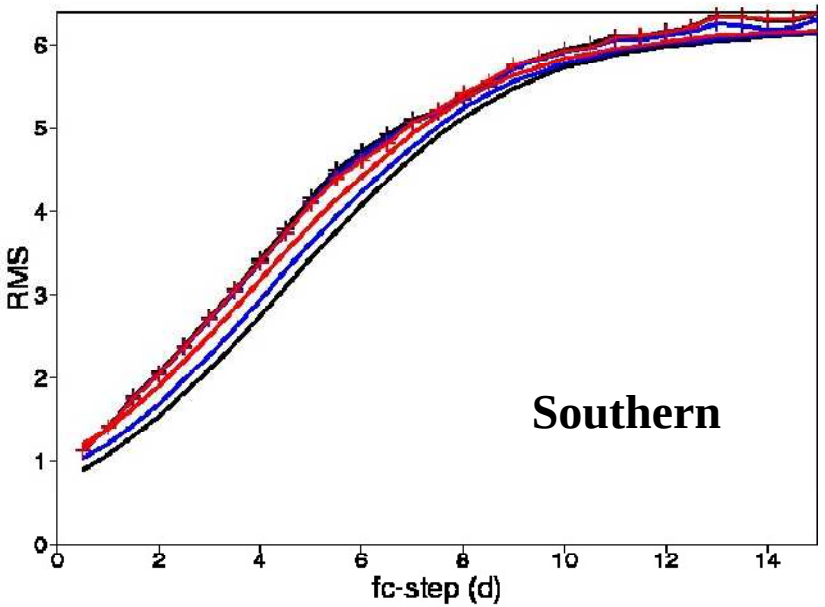
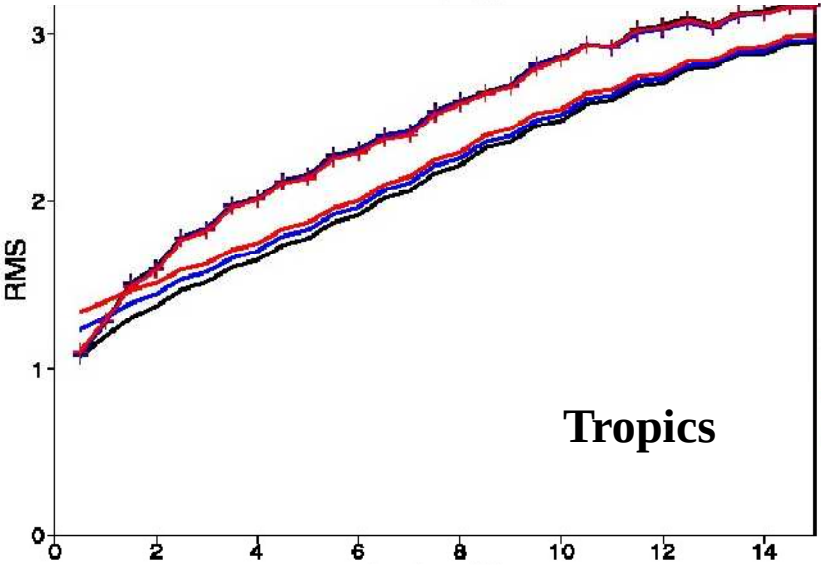
EDAs used to generate initial perturbations for the EPS





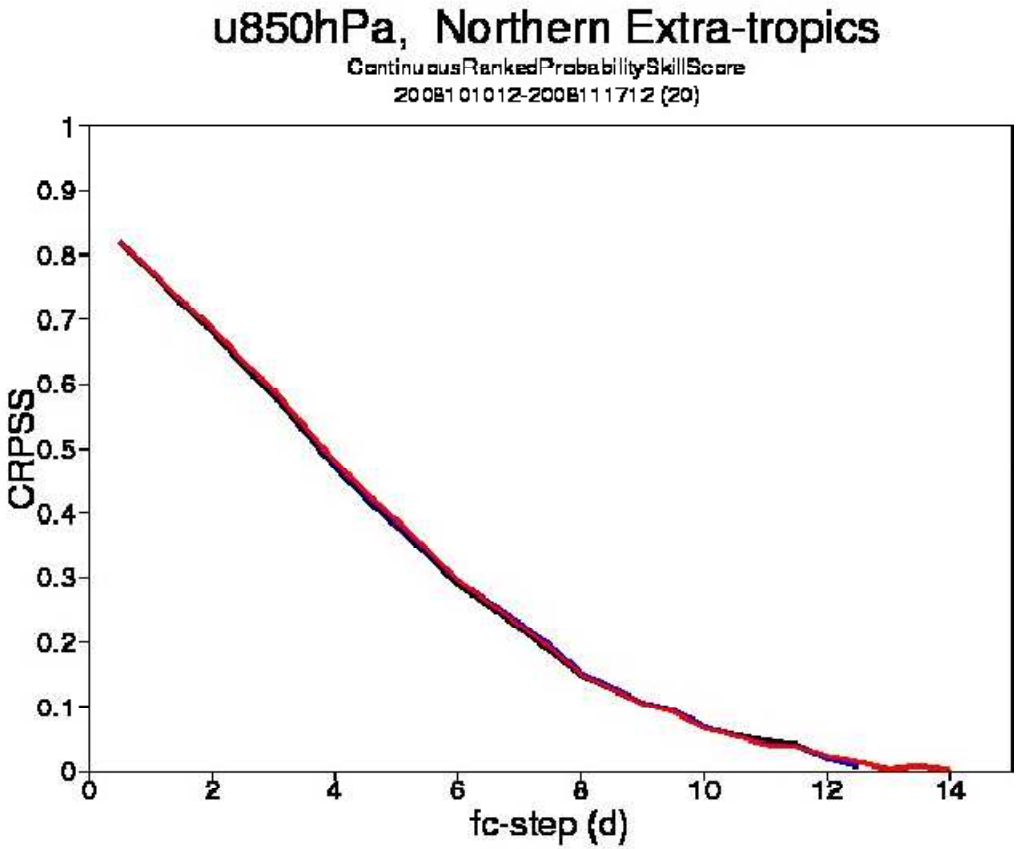


OBS
ST
Xb

EPS 51 members ST+BS perturbations
T399L62 0-10 day
T255L62 11-15 day

EDAs used to generate initial perturbations for the EPS

OBS
ST
Xb



ECMWF

Perturbing the background state versus Others

- Perturbing the background state add more spread in the tropics and extra-tropics
- Increase of spread in the stratosphere
- Increase of spread in less observed areas and dynamically active areas
- When the B is computed from the EDAs largest OI is achieved
- Results from EPS show better spread-skill relationship with slightly better skill scores
- Very easy to maintain does not require tuning from one model-cycle to an other