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

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

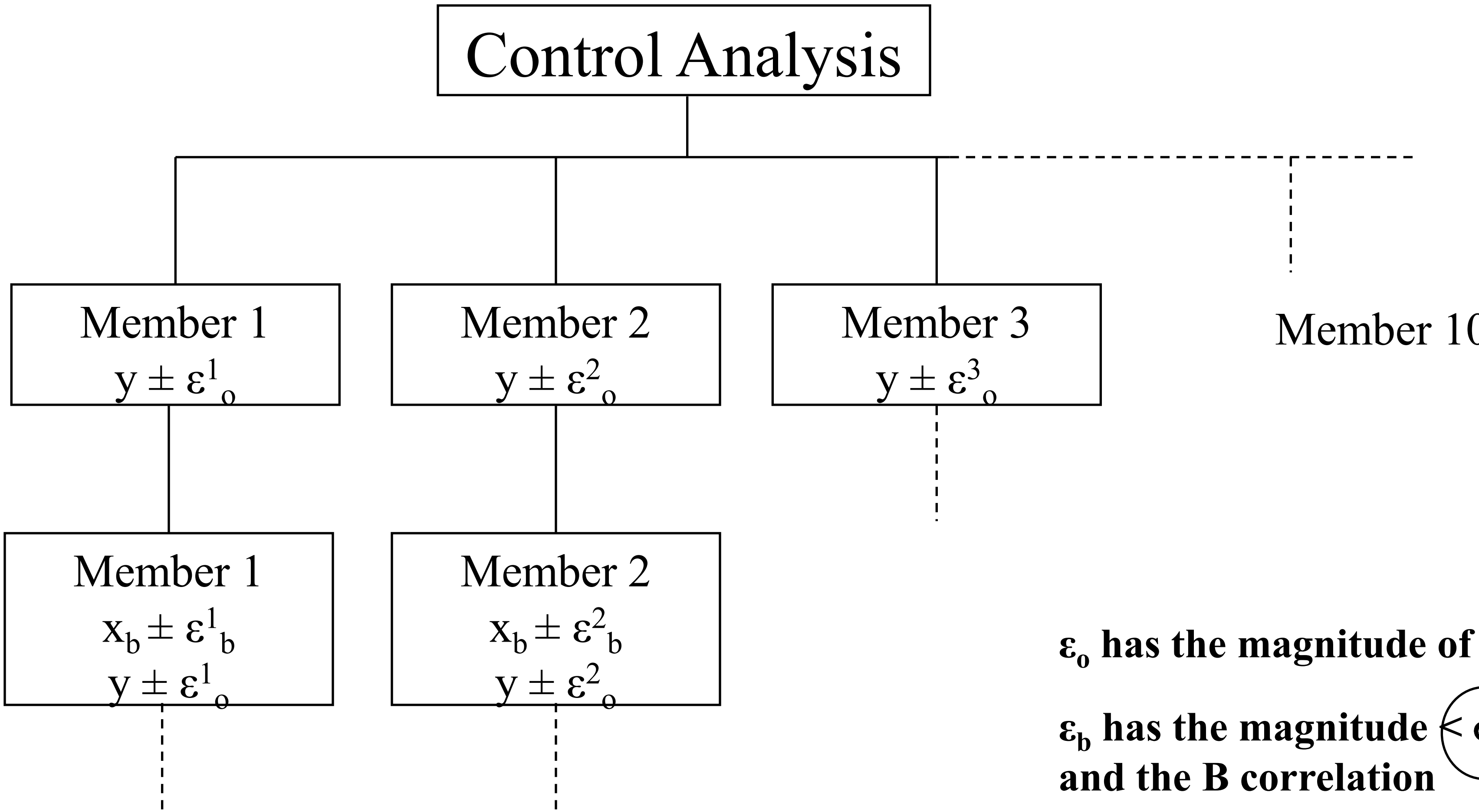
data uncertainties model uncertainties

outline

- EDA perturbing y and x_b
- 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



ε_o has the magnitude of σ_o

ε_b has the magnitude $< \sigma_b$ and the B correlation

ECMWF

Ensemble Data Assimilation
Experiment set-up

Systematic kinetic energy loss → numerical integrations and parametrization

Realization:10 member

Resolution: T399T159L91

Period: 20081005-20081115

Infl Model error representation:

-**BS** Spectral Stochastic Kinetic Energy Backscatter scheme (Berner et

Infl al. 2009)

-**ST** Stochastic representation of model error associated to parametrized physical processes tendencies (Buizza et al. 1999)

-$\mathbf{X_b}$ Perturbed background with gaussian random correlated perturbation $\boldsymbol{\varepsilon_b = 0.5\ \sigma_b}$

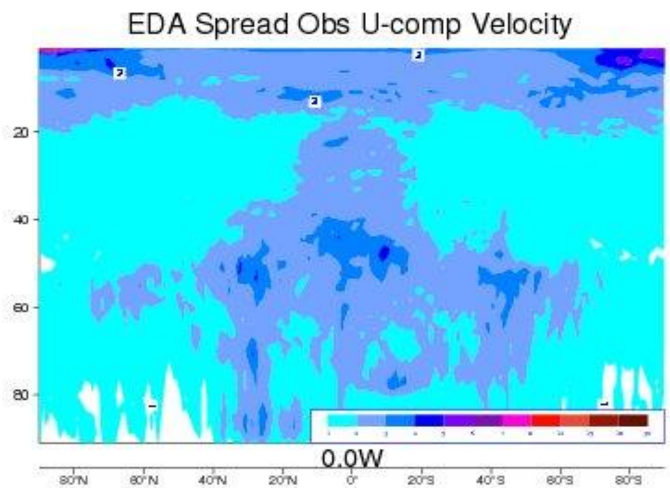
-**OBS (**Infl) Perturbed observation with gaussian random perturbation and inflated background error variances

Ensemble Data Assimilation

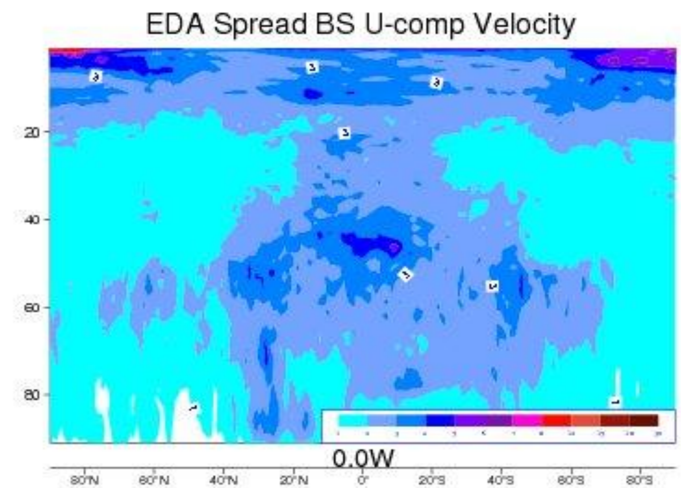
Zonal averaged cross section u-comp ensemble spread

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

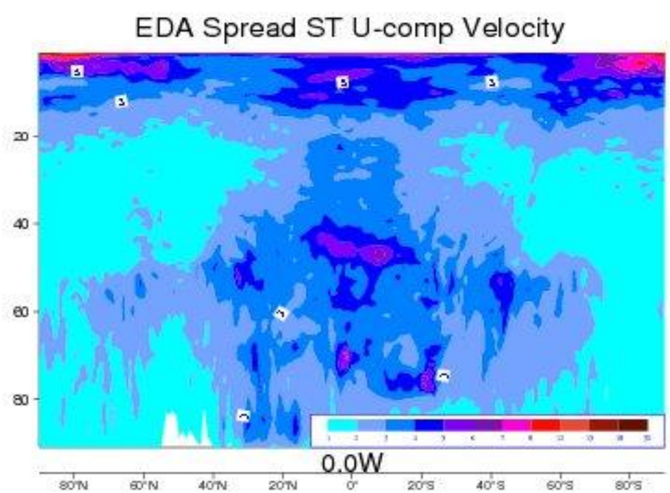
OBS



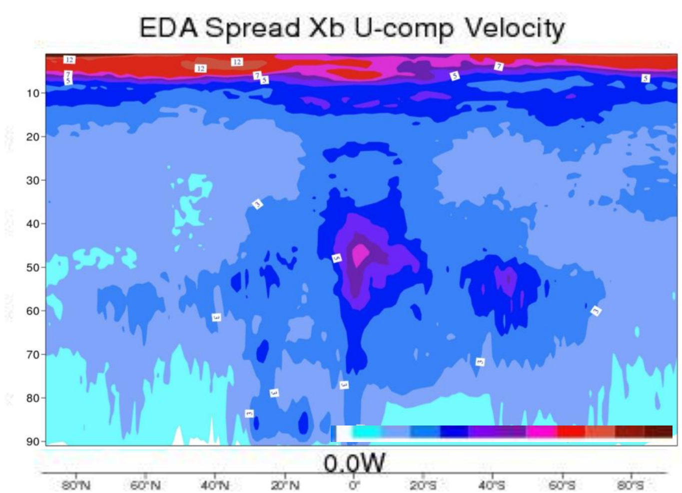
BS



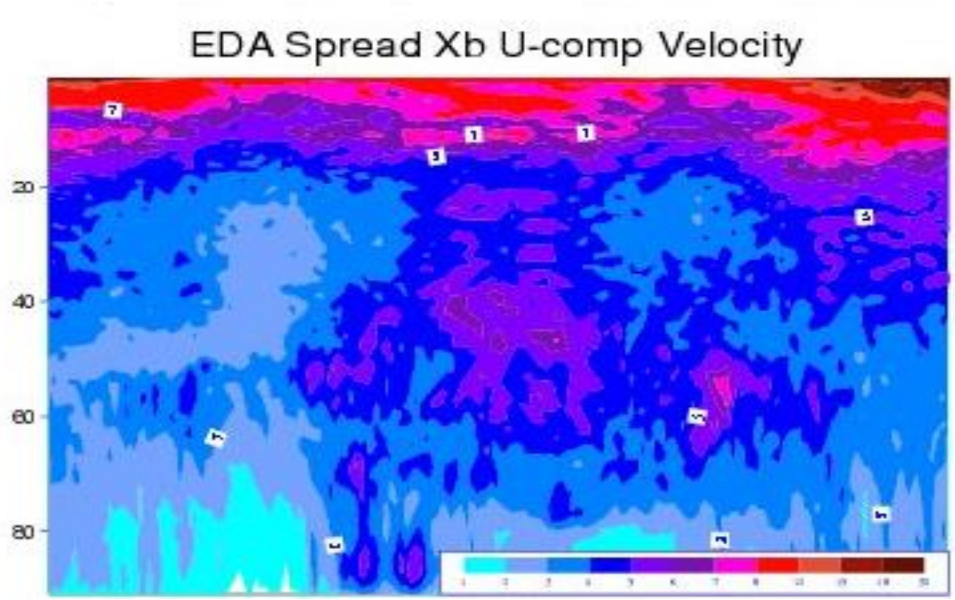
ST



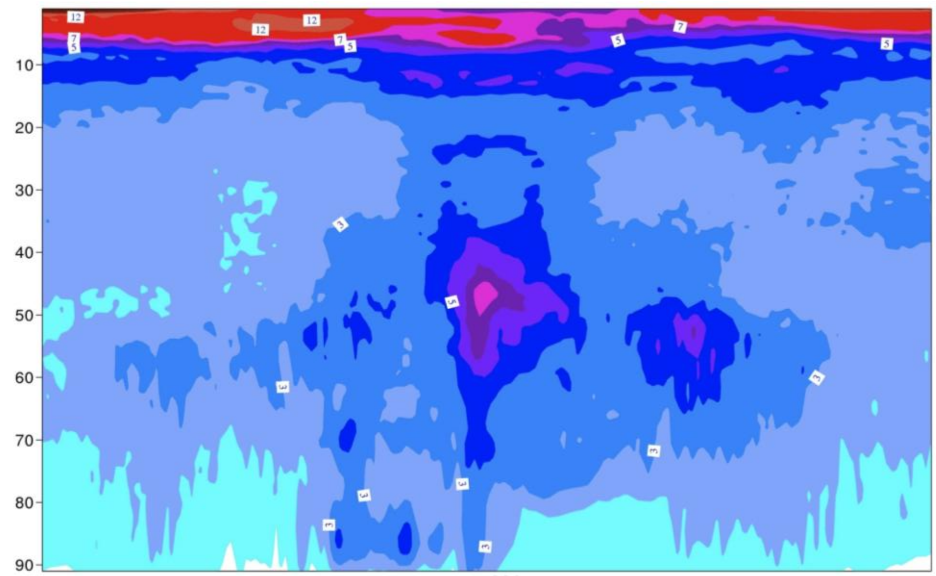
X_b



Ensemble Data Assimilation: X_b

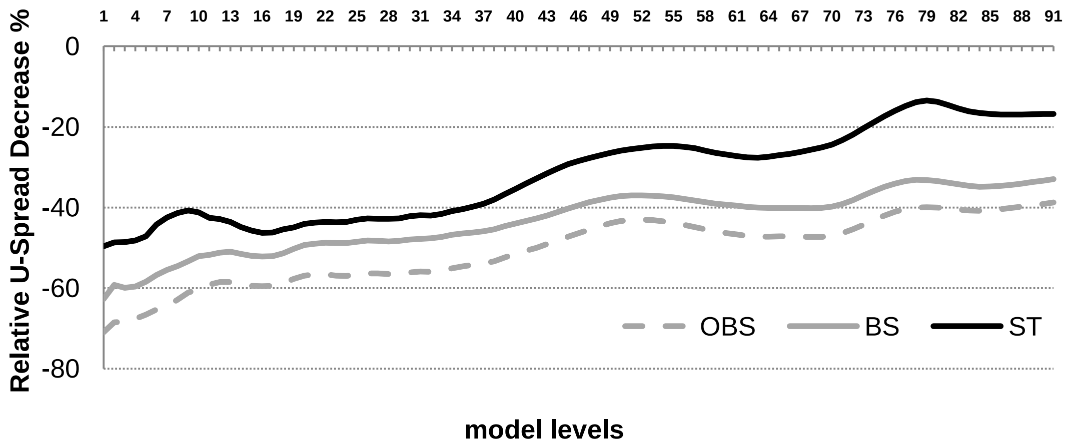


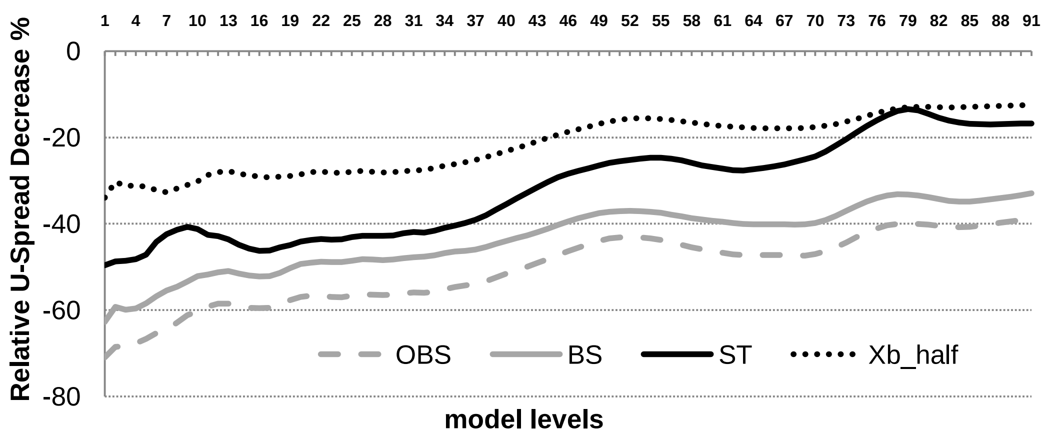
$\varepsilon_b = \sigma_b$



$\varepsilon_b = 0.5\ \sigma_b$

Ensemble Data Assimilation: u-spread





Xb_half

$\varepsilon_b = 0.5\ \sigma_b$

Ensemble Data Assimilation: Baroclinic development

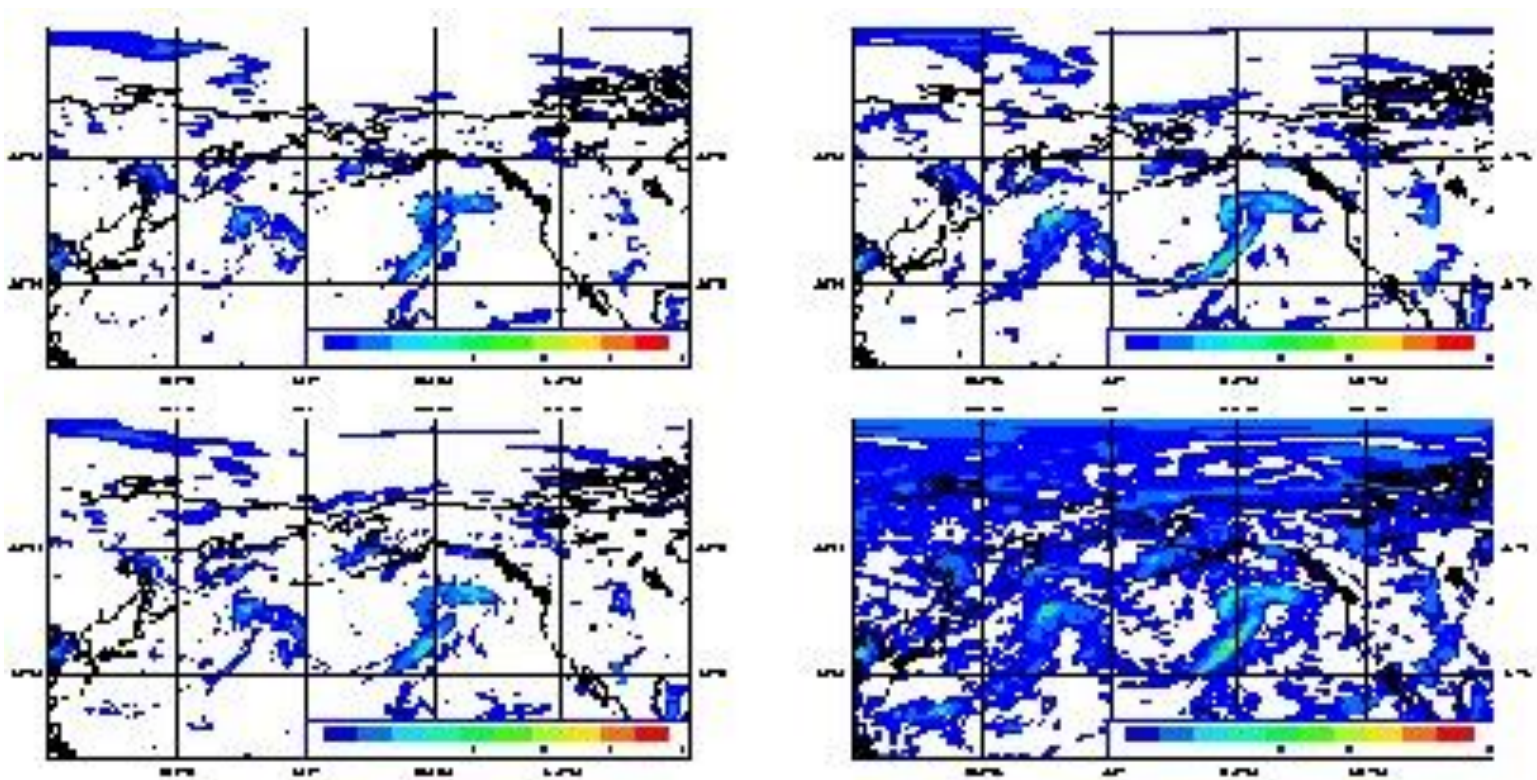
6-h fc valid on 21 October 12 UTC
850 hPa vorticity spread

OBS

ST

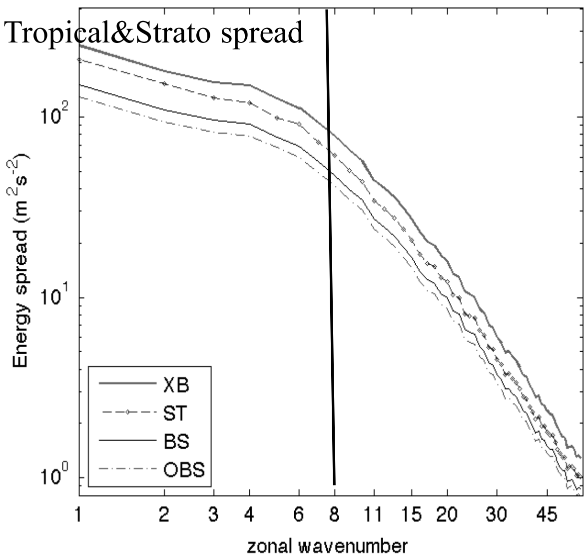
BS

X_b

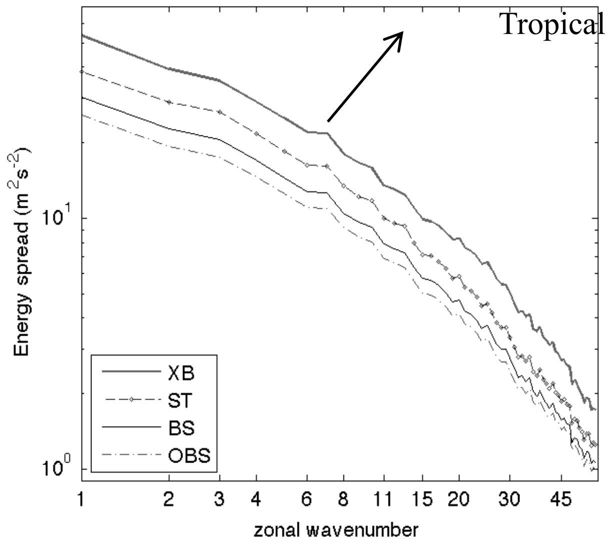


EDA: *Energetic diagnosis of the ensemble spread*

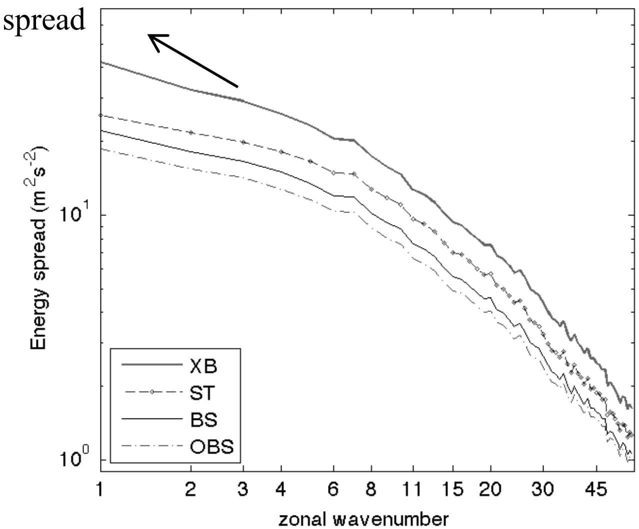
Balanced flow



EIG



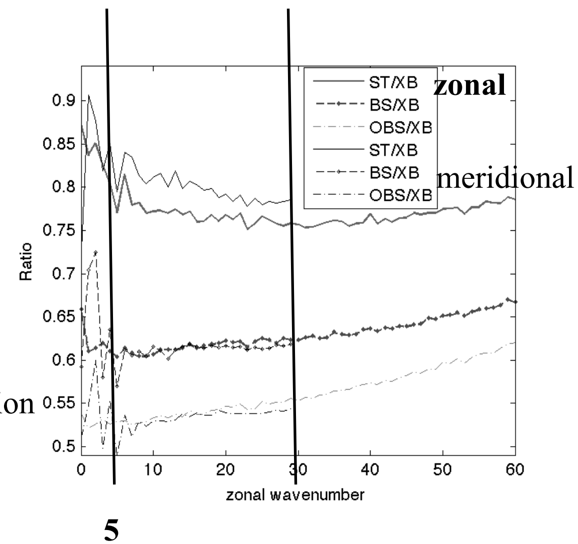
WIG

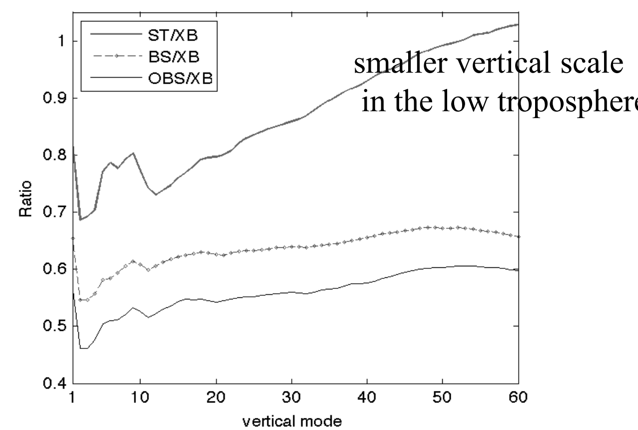


$$S_n = \left[\frac{1}{N-1}\sum_{i=1}^{N}(E_{v,i} - \bar{E}_v)^2\right]^{1/2}$$

$$E_n = gH_n c_n c_n^*$$

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





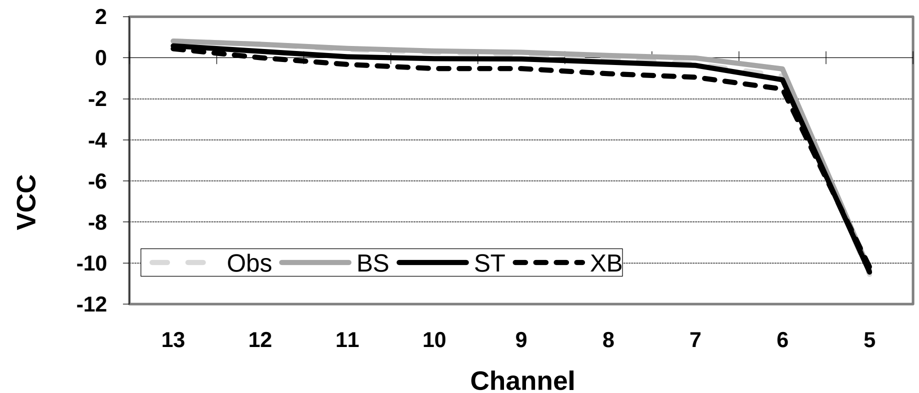
Observation Space Diagnostic

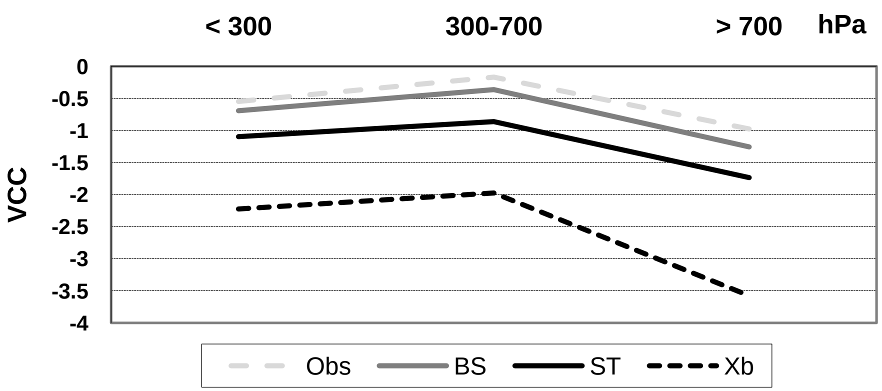
B computed from EDAs   Desroziers et al. 2005

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

$$\text{VarianceConsinstencyCheck} = \mathbf{HB\,H^T}_{\text{estimated}} - \mathbf{HBH^T}_{\text{assigned}}$$

AMSU-A



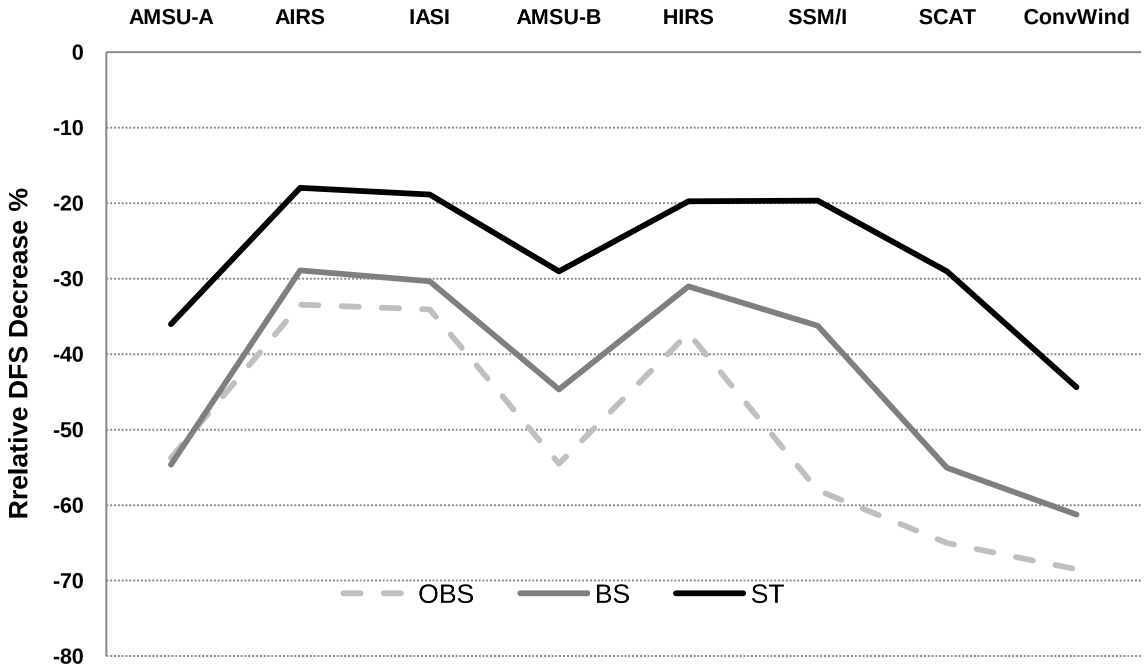


Wind Observations

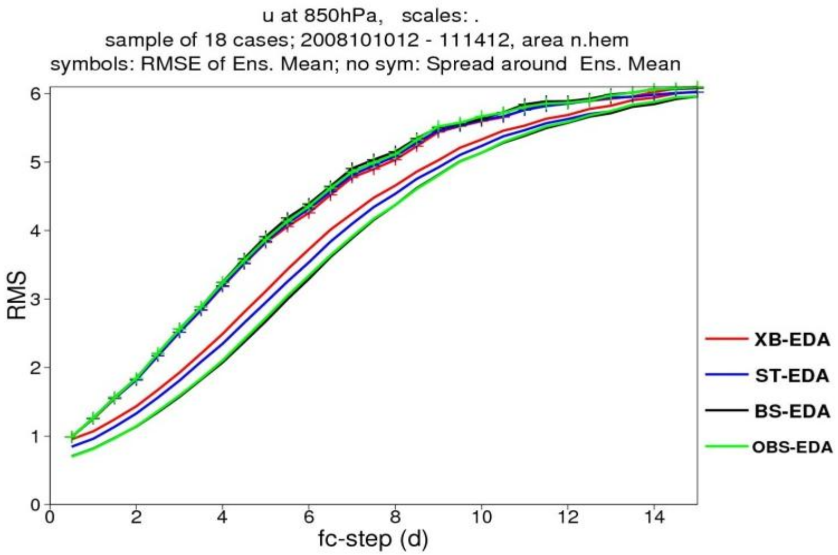
Observation Space Diagnostic

Observation Influence   Cardinali et al. 2004

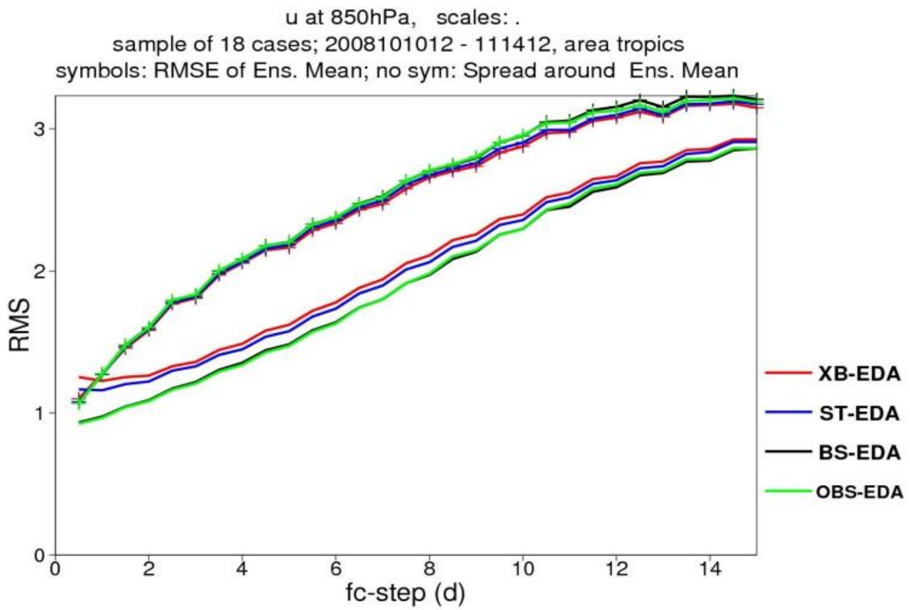
$$\frac{\partial \mathbf{H}\mathbf{x}_a}{\partial \mathbf{y}} = \mathbf{K}^T \mathbf{H}^T \qquad \mathbf{K} = (\mathbf{B}^{-1} + \mathbf{H}^T \mathbf{R}^{-1} \mathbf{H})^{-1} \mathbf{H}^T \mathbf{R}^{-1}$$



EDAs used to generate initial perturbations for the EPS

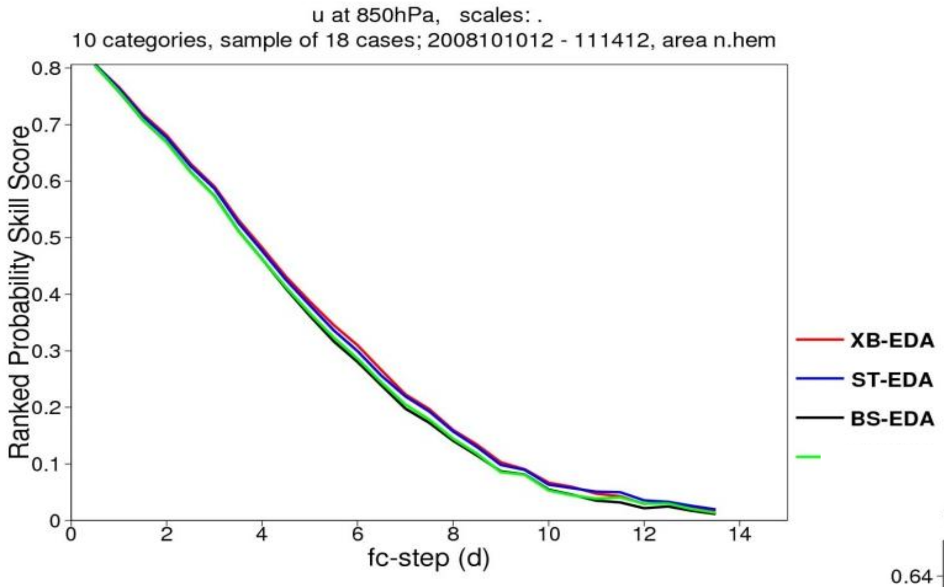


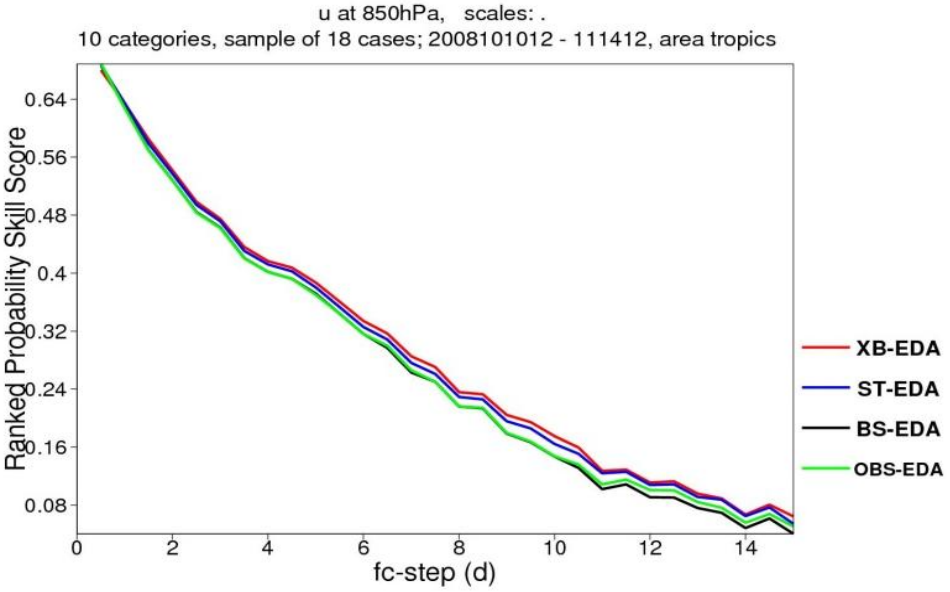
EPS 51 members ST perturbations
T399L62 0-10 day
T255L62 11-15 day



ECMWF

EDAs used to generate initial perturbations for the EPS





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 larger spread in the Tropics and in the Extra-Tropics
- Very easy to maintain does not require tuning from one model-cycle to an other
- **To determine the correct perturbation amplitude the following comparisons are planned:**
  - OBS ensemble spread versus innovation vector spread of the Control analysis