Impacts of flow-dependent background-error covariances in the NCEP Global Forecast System

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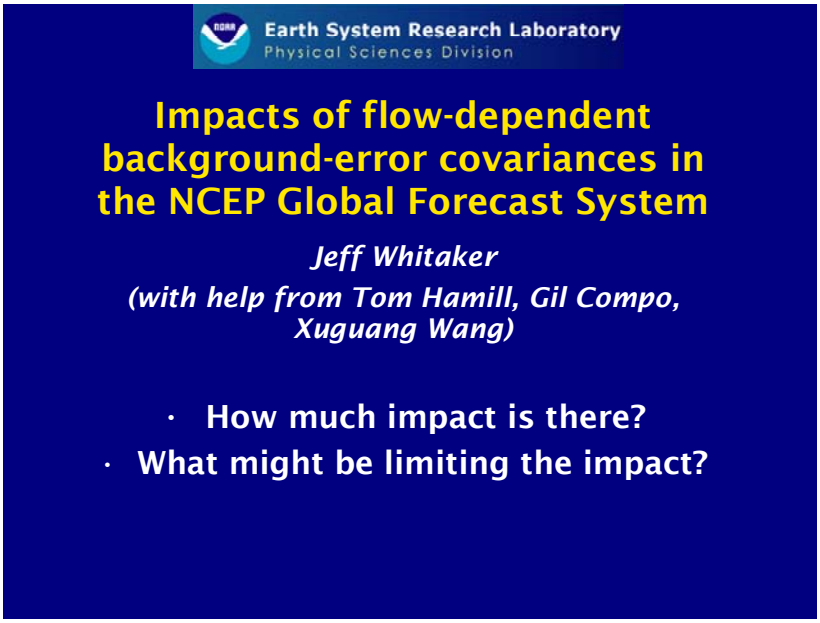
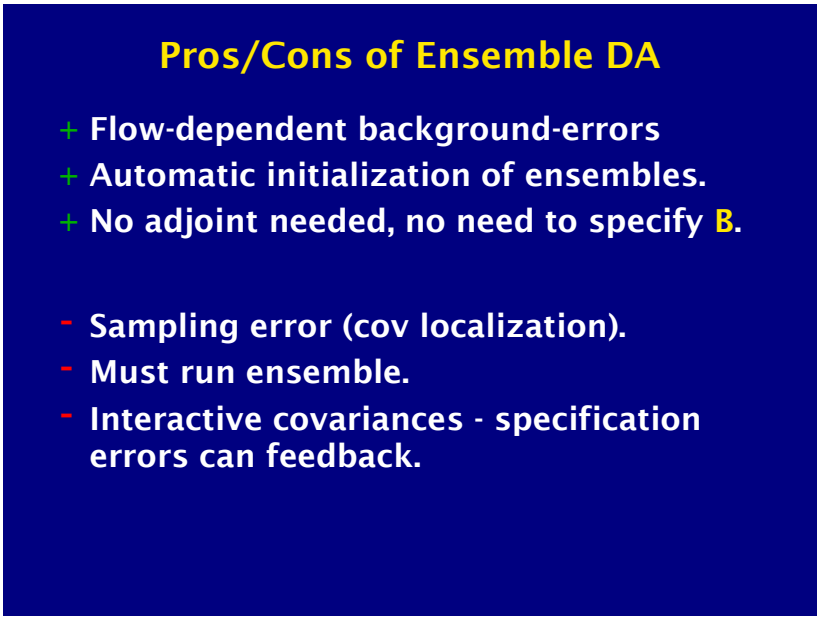
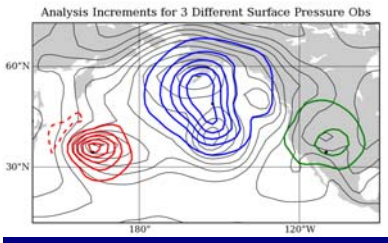
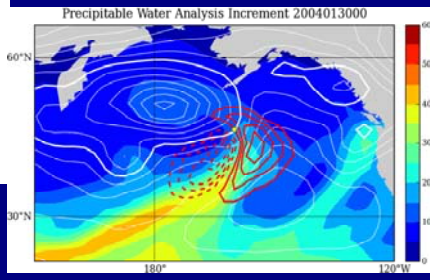




Examples of Flow-Dependent Analysis Increments





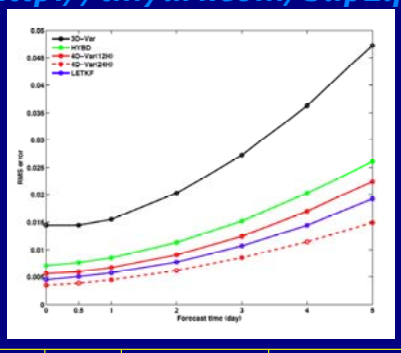
Ensemble DA with NCEP GFS

- Developed via collaborative THORPEX project.
- Uses existing 3D-Var for forward operator, LETKF (Hunt et al, Physica D, June 2007, 112-126) to compute increment.
- Outperforms existing 3D-Var when only p_s observations assimilated (Whitaker et al, MWR, 2004, p. 1190) and when all non-radiance obs assimilated (Whitaker et al, 2007, MWR, accepted, *http://tinyurl.com/293vnu*).

EnKF/Var comparisons in a perfect (QG) model

Shu-Chih Yang et al., submitted to MWR

http://tinyurl.com/3dpzqd

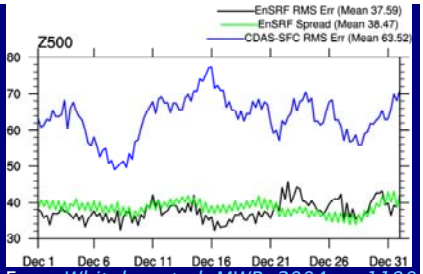


	3D-Var	HYBD	4D-Var		LETKF			
			12hr	24 hr	l=3	l=5	l=7	l=9
RMS error	1.44	0.70	0.56	0.35	0.67	0.48	0.44	0.44

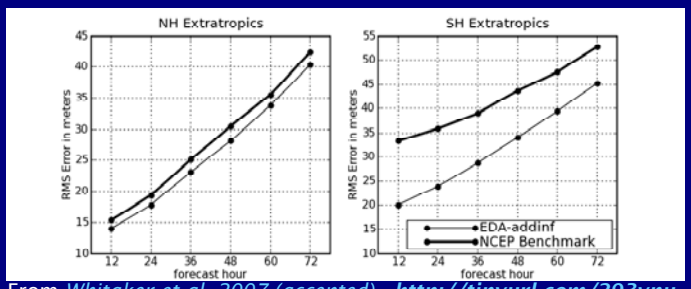
EnsDA/3D-Var comparisons - real obs

modern network (without radiances)

p_s only (1915)



From *Whitaker et al, MWR, 2004, p. 1190*



From *Whitaker et al, 2007 (accepted)* - ***http://tinyurl.com/293vnu***

Questions

- *What is limiting impact of flow-dependent covariances?*
  - *Observational density? Model error?*

Experiments

- **T62L28, 54-member LETKF with NCEP GFS.**
- **Vary observing network (everything, or only surface pressure).**
- **Limit impact of model error by using "perfect" model (ensemble mean first guess from all-obs assimilation == 'truth').**
- **Static vs. flow-dependent ensemble.**

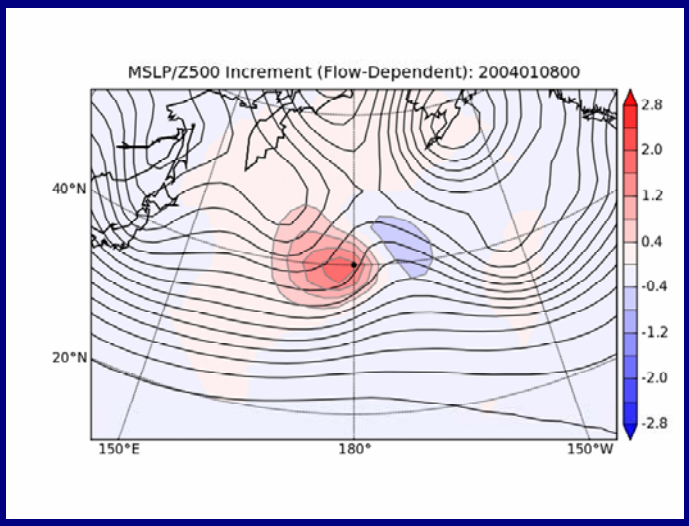
Experiments (more details)

- **'ob-error localization' - limits impact of obs. with distance from state variable.**
- **Obs for Jan and Feb 2004 (full set, and surface-pressure only subset).**
- **Vertical level of radiance == maximum of weighting function.**
- **Model error parameterized with additive inflation (random samples from NCEP/NCAR reanalysis tendencies).**

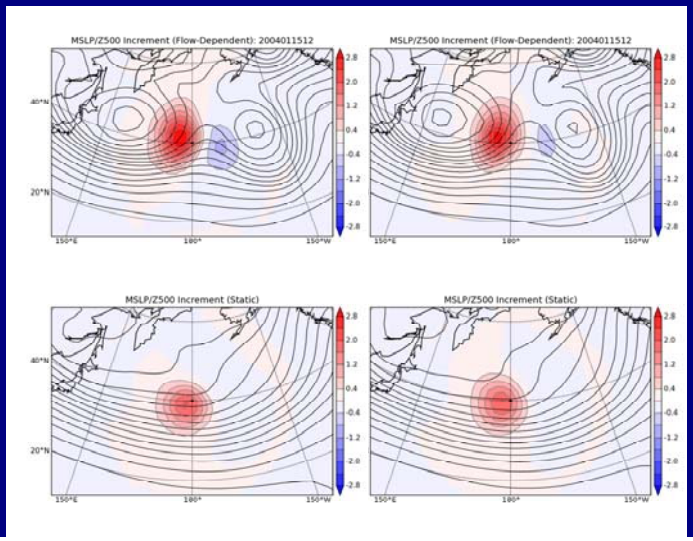
Experiments (yet more details)

1. **'Flow-dependent' B** - full LETKF as described.
2. **'Flow-independent' B** - ensemble perturbations constructed from a random sample from one month run of (1). Prior from full ensemble mean, or single run from ensemble mean analysis.
3. **'Perfect model' B** - substitute $N(Hx^b,R)$ from (1) for real observations.

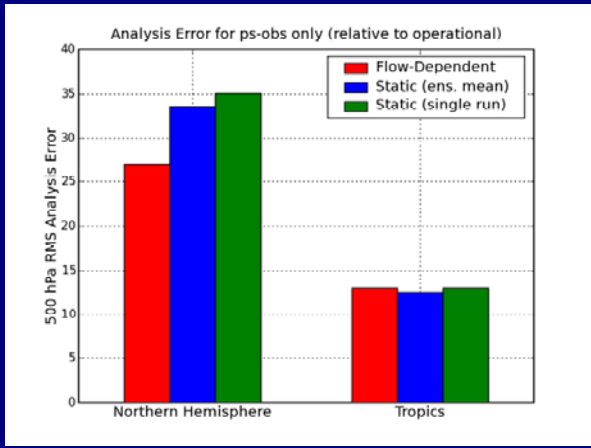
Flow-Dependence of Analysis Increments - p_s obs only



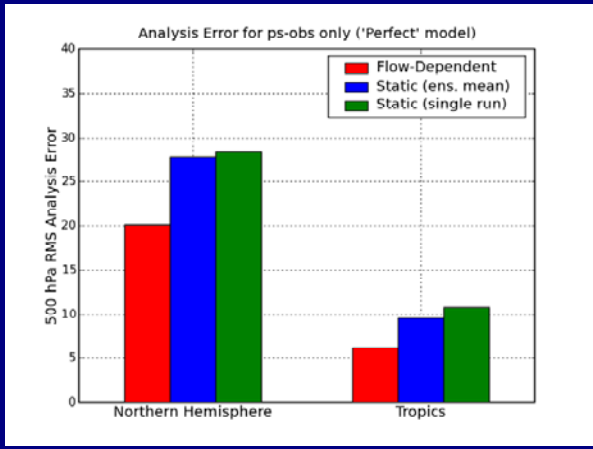
Only p_s obs | All obs



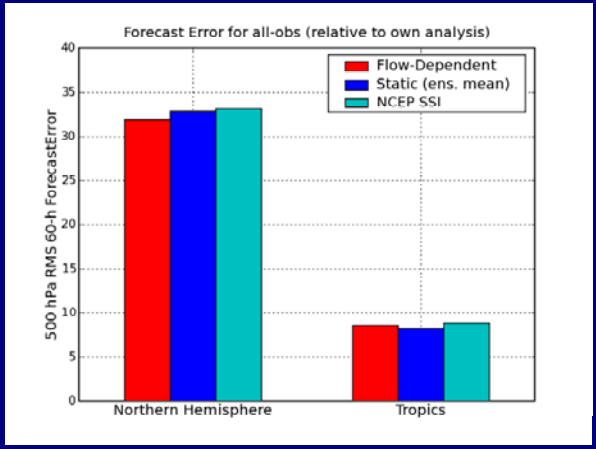
Effect of Flow-Dependent Covariances (p_s-only)



Effect of Flow-Dependent Covariances (p_s-only - "Perfect" model)



Effect of Flow-Dependent Covariances (all obs)



Conclusions

- In EDA systems, impact of flow-dependent **B** depends on how well observed the phenomena of interest is.
- Impact is limited by model error (especially in tropics). Situation should improve as models are improved and/or better representations of model error are developed.