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

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(with help from Gil Compo, Xuguang Wang)

- How much impact is there?
- What might be limiting the impact?

Pros/Cons of Ensemble DA

+ **Flow-dependent background-errors**
+ **Automatic initialization of ensembles.**
+ **No adjoint needed, no need to specify B.**

- **Sampling error (cov localization).**
- **Must run ensemble.**
- **Interactive covariances - specification errors can feedback.**

Examples of Flow-Dependent Analysis Increments

Analysis Increments for 3 Different Surface Pressure Obs
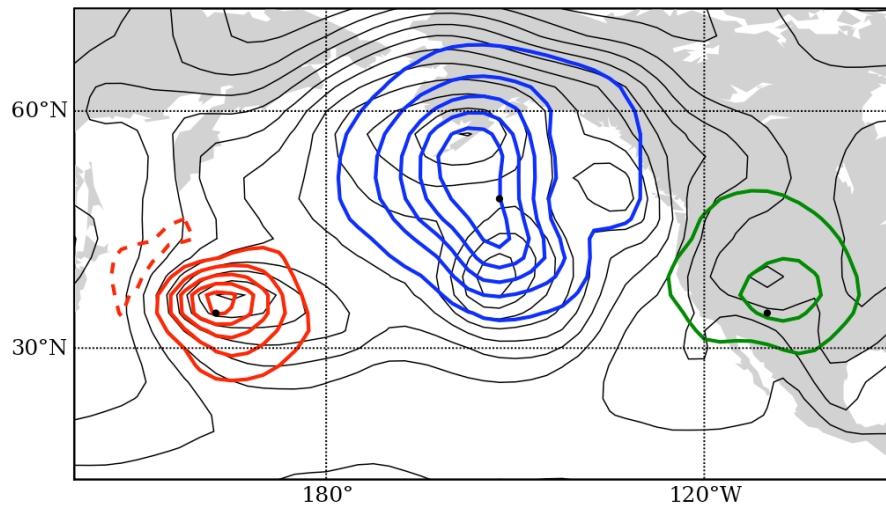
Precipitable Water Analysis Increment 2004013000
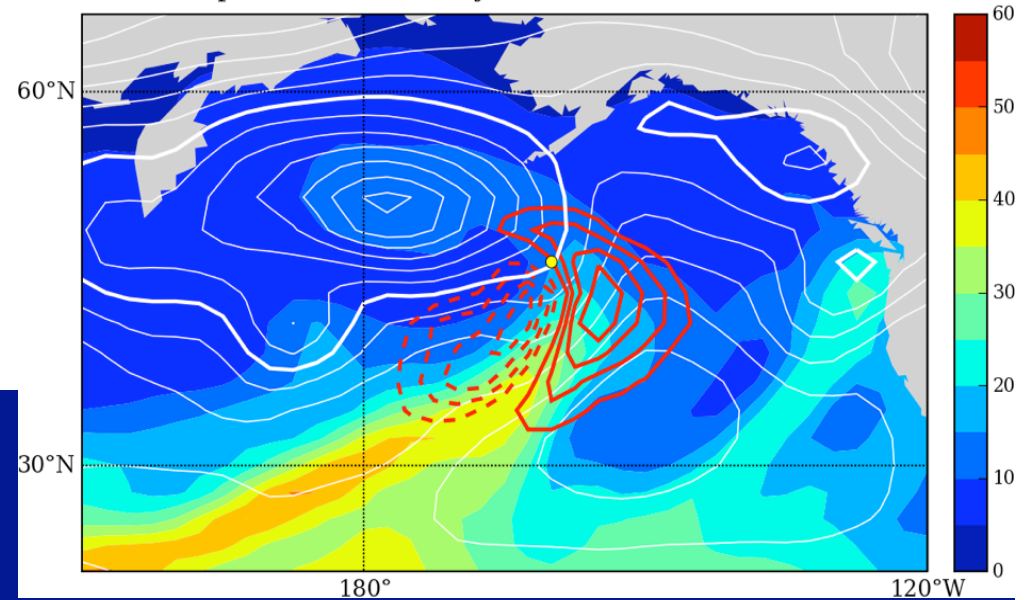
Ensemble DA with NCEP GFS

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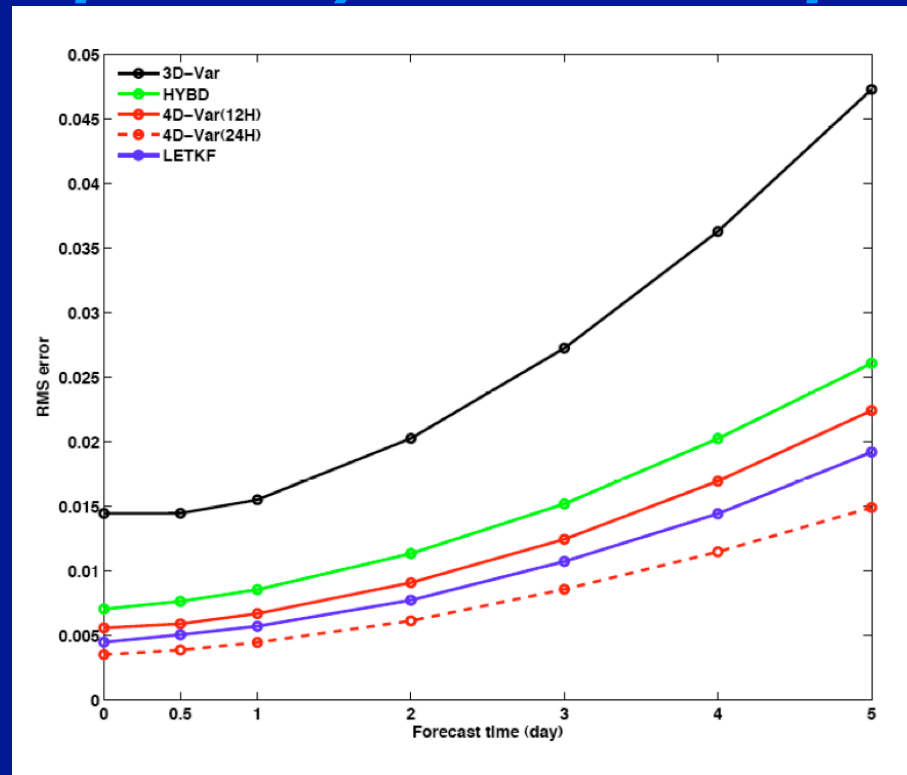
	3D-Var	HYBD	4D-Var		LETKF			
			12hr	24 hr	I=3	I=5	I=7	I=9
RMS error	1.44	0.70	0.56	0.35	0.67	0.48	0.44	0.44

EnsDA/3D-Var comparisons - real obs

modern network (without radiances)

p_s only (1915)

Z500

EnSRF RMS Err (Mean 37.59)
EnSRF Spread (Mean 38.47)
CDAS-SFC RMS Err (Mean 63.52)

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

NH Extratropics

SH Extratropics

RMS Error in meters

forecast hour

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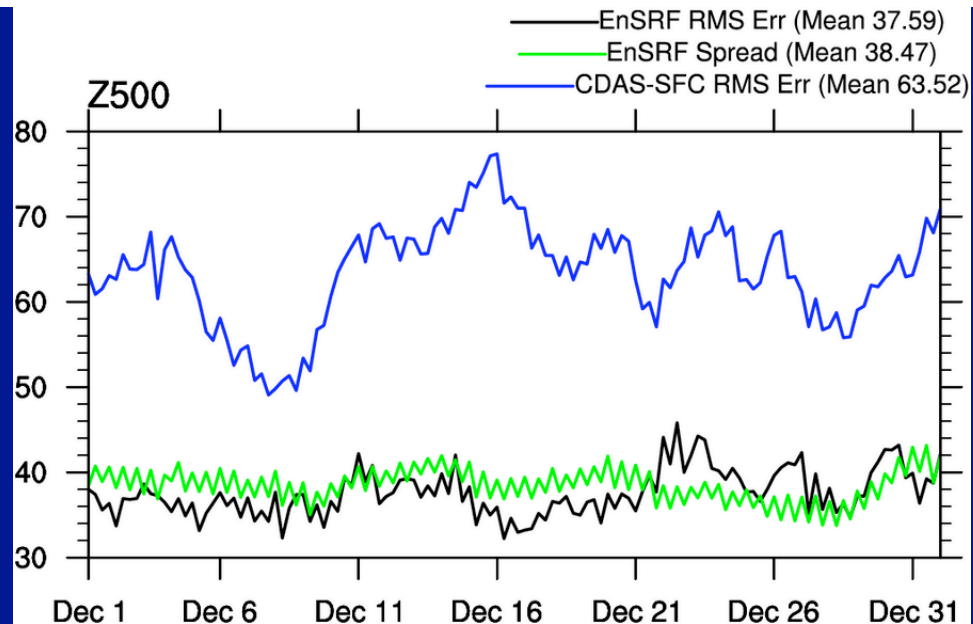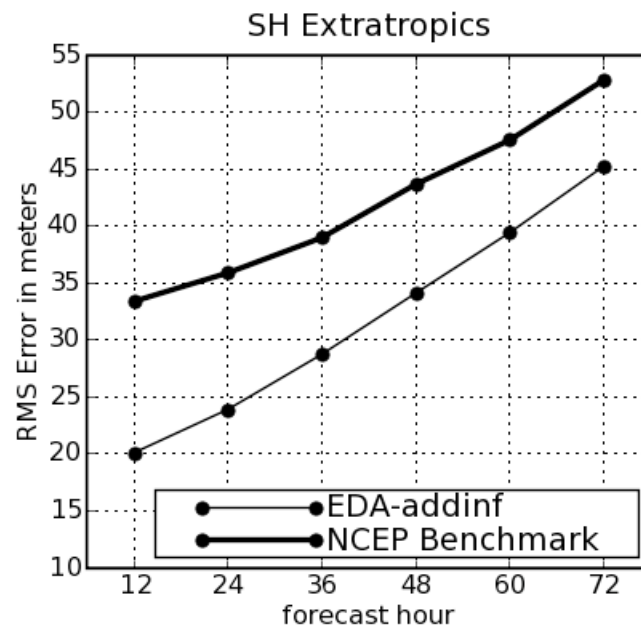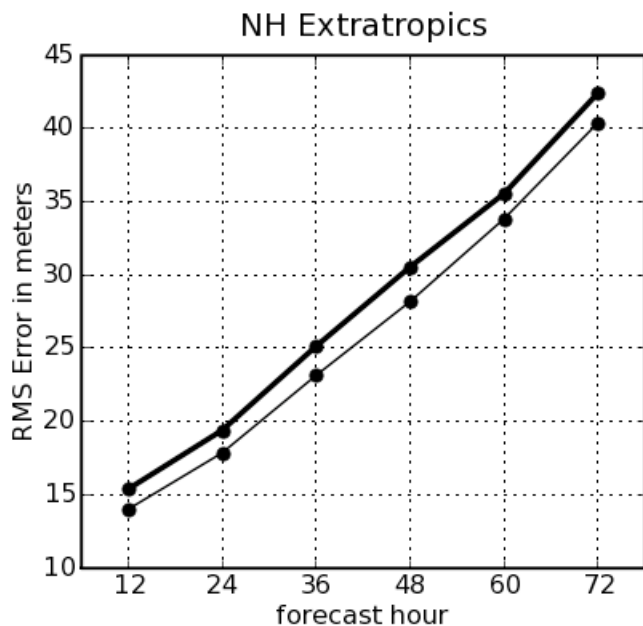
From *Whitaker et al, 2007 (accepted)* - **http://tinyurl.com/293vnu**

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.**
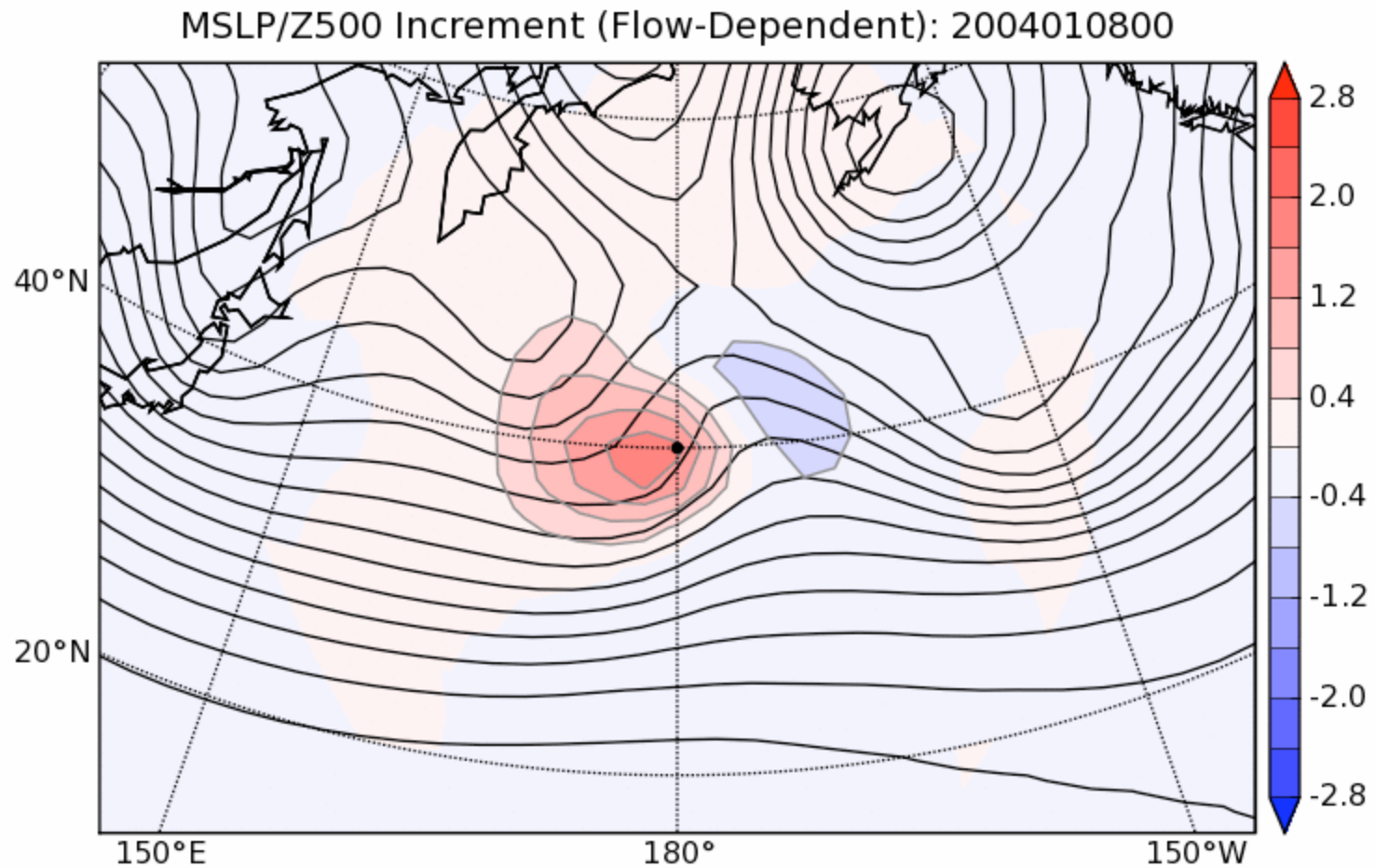
Experiments (more details)

- '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).
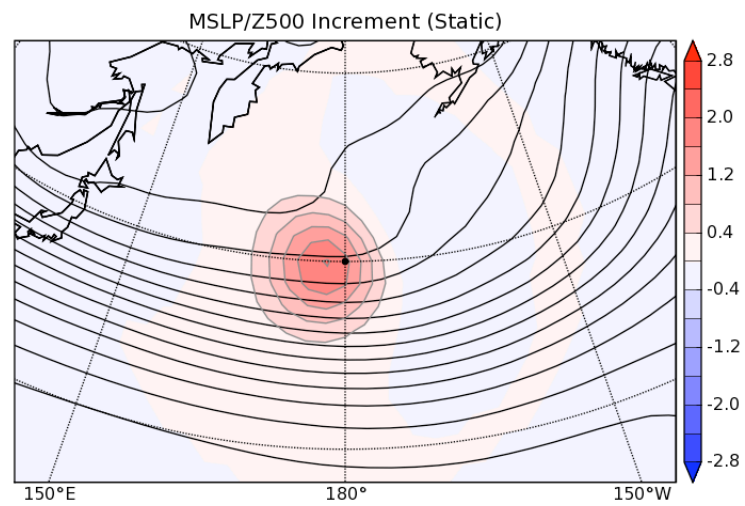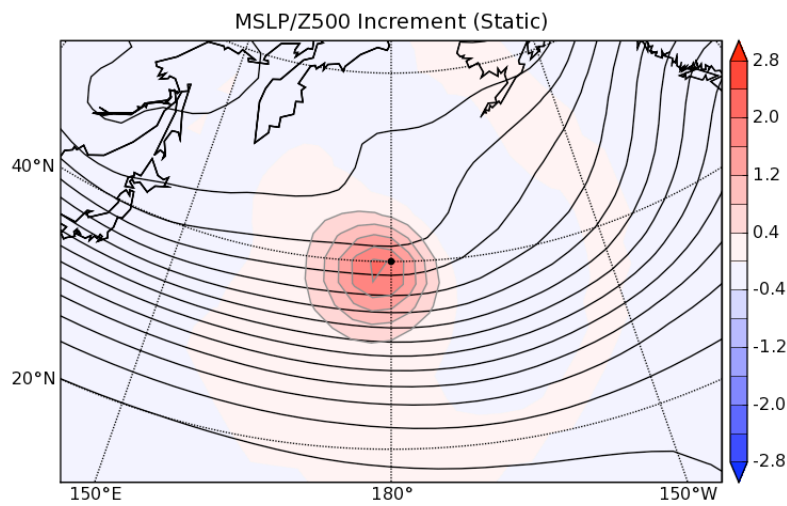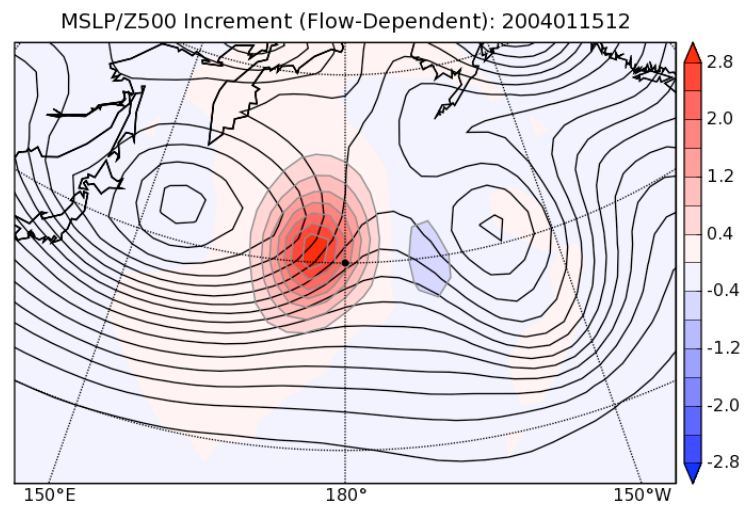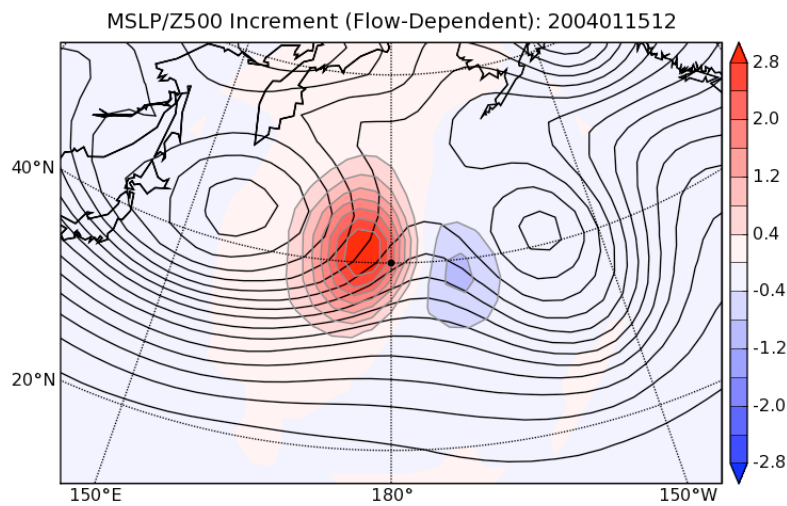
Experiments (yet more details)

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.

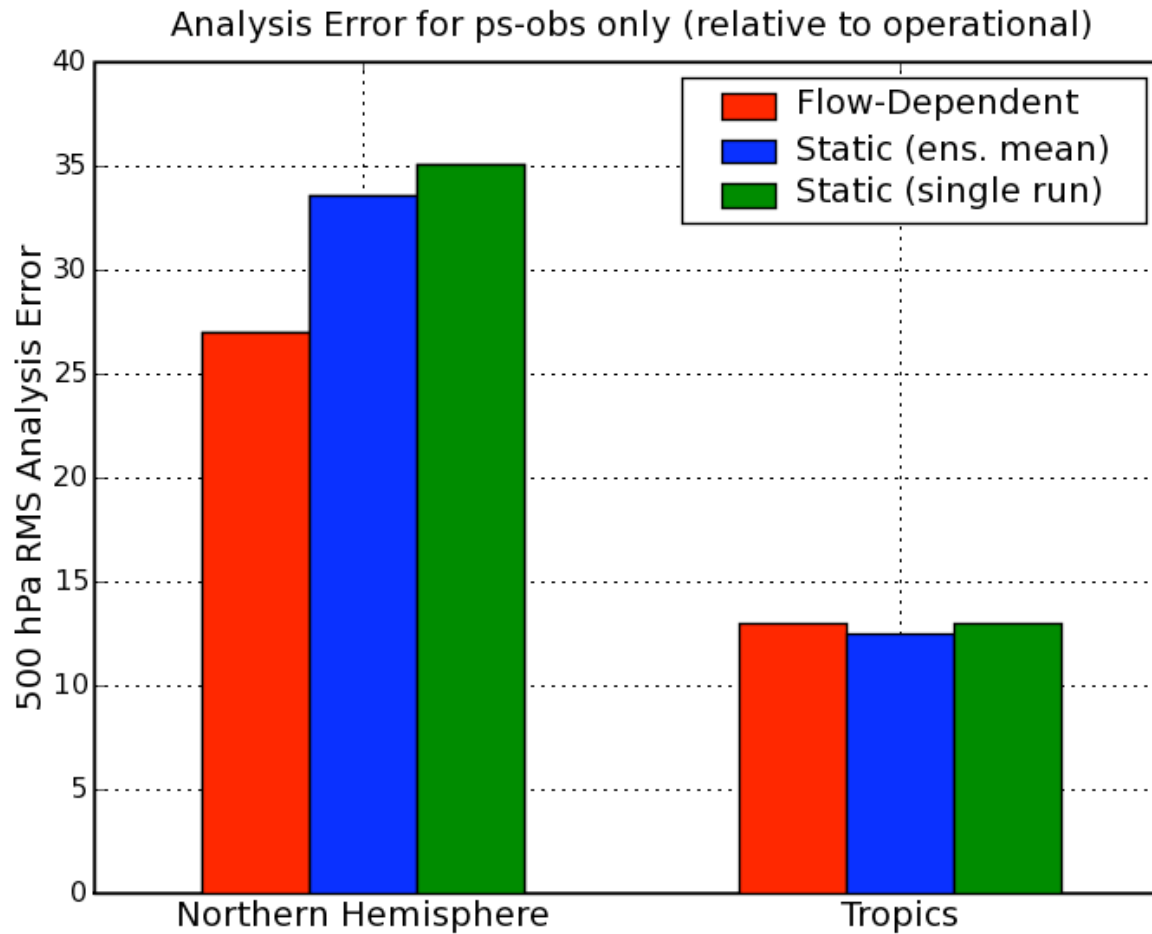# Flow-Dependence of Analysis Increments - p_s obs only

MSLP/Z500 Increment (Flow-Dependent): 2004010800

Only p$_s$ obs

All obs

MSLP/Z500 Increment (Flow-Dependent): 2004011512

MSLP/Z500 Increment (Flow-Dependent): 2004011512
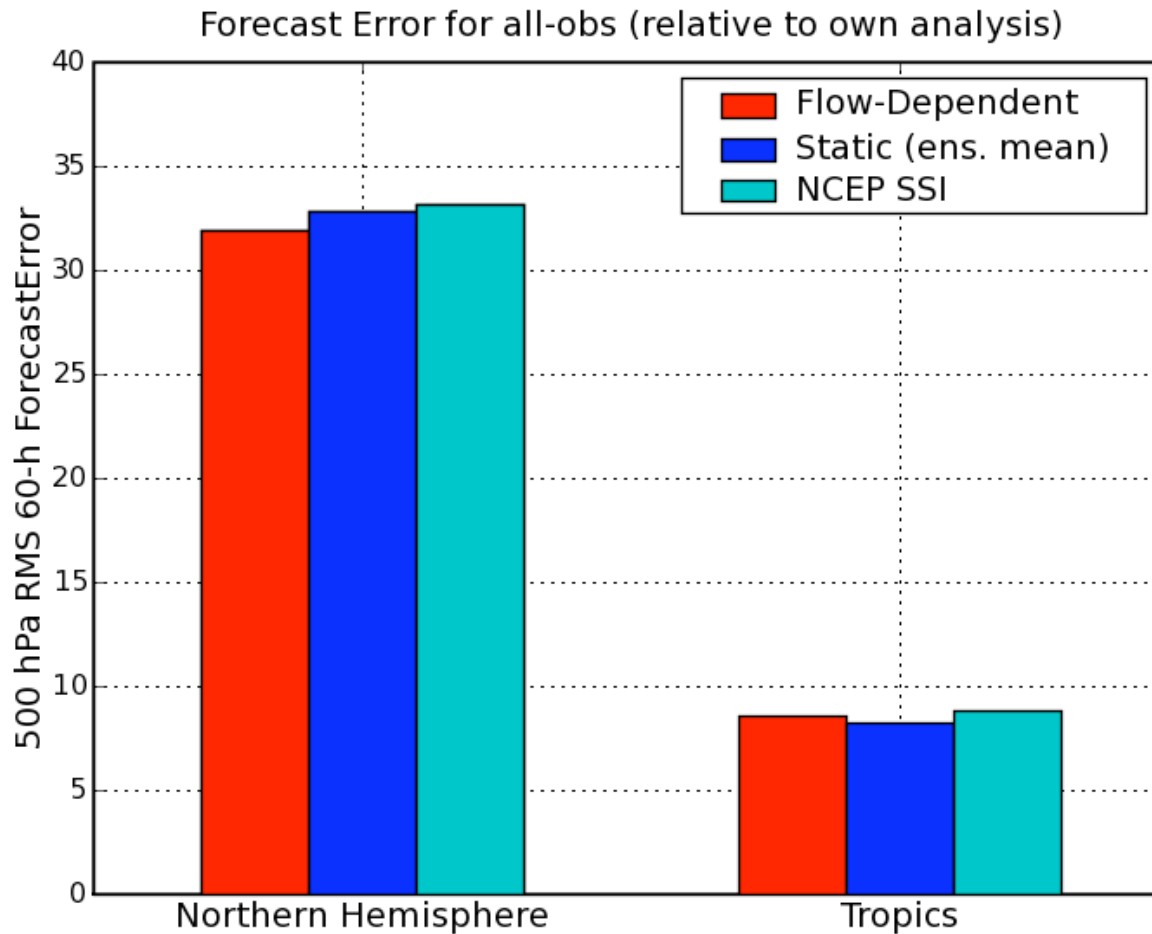
MSLP/Z500 Increment (Static)

MSLP/Z500 Increment (Static)

Effect of Flow-Dependent Covariances (p$_s$-only)

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

Analysis Error for ps-obs only ('Perfect' model)
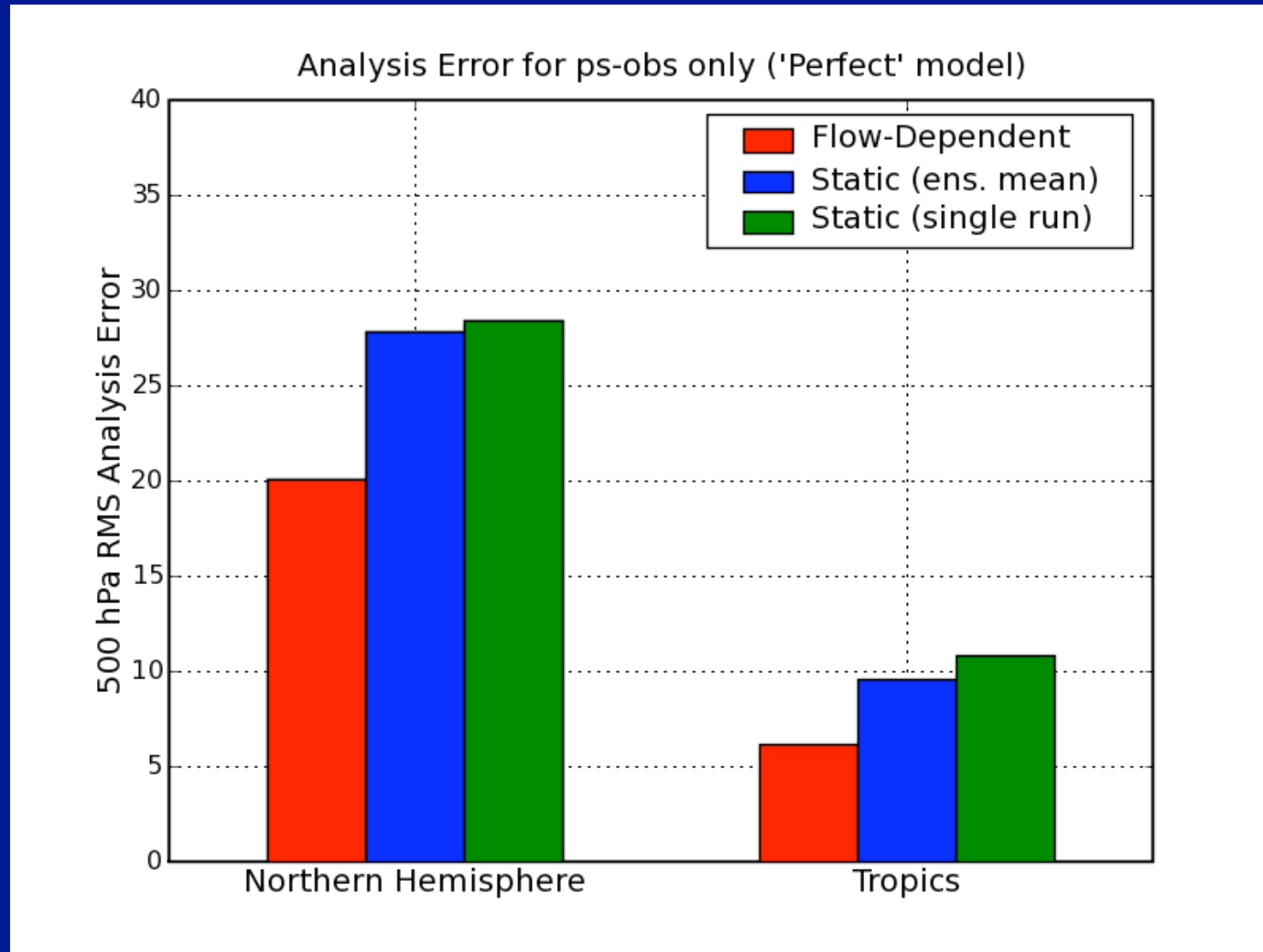
Effect of Flow-Dependent Covariances (all obs)

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.**