The HWRF Basin-Scale Data Assimilation and Ensemble Forecasting Project

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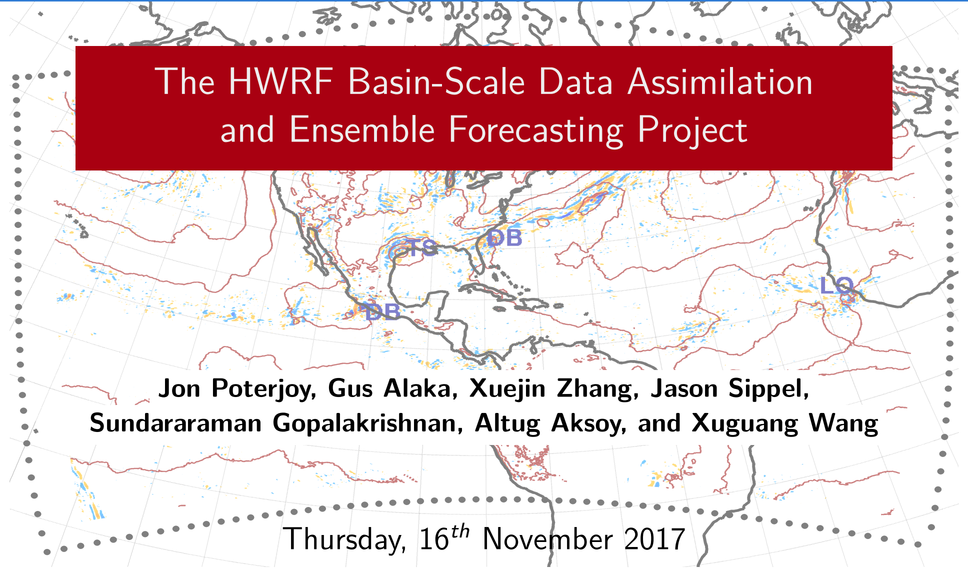


Introduction

Basin-scale HWRF DA and forecasting system:

- Pure ensemble-based analysis and prediction system for HWRF using DTC EnKF
- Built into HWRF rocoto framework—takes advantage of same community DA software as operational model
- No vortex relocation
- No dependence on GFS for initial conditions and satellite biases (after initial spin-up period)

Motivation for HWRF regional-scale DA

1. Tie together model and DA development at AOML/HRD
   - Perform vigorous evaluation of HWRF model through continuos cycling of model states over fixed domain
   - Explore regional biases using observation-space diagnostics
2. Turn basin-scale HWRF into a regional ensemble forecasting platform
   - Basin-scale HWRF ensemble has higher resolution than GFS ensemble
   - Adopting own DA system allows control over how ensemble is created and calibrated

Motivation for HWRF regional-scale DA

3. Establish a framework for satellite DA research
   - Initial tests examine impact of online bias correction for clear-sky radiance
   - Future research will focus on all-sky radiance DA

4. Build a testbed for developing new DA strategies with community software
   - Localized particle filter (Poterjoy 2016) will be tested using pre-existing DA software from DTC
   - All developments are directly applicable to operation models (GFS, FV3, etc.)

HFIP Real-Time Demo Project

Perform continuos 3-month ensemble analysis of August, September, and October, following spin-up from July.

Establish a benchmark for future DA and ensemble forecasting research and model development.

Configuration:

- 60-member 6-h cycling DA for reduced basin-scale parent domain (18-km grid spacing).
- Lateral and surface boundaries provided from GFS ensemble.
- All available conventional and clear-air satellite measurements assimilated (no TC vitals).

HFIP Real-Time Demo Project

Perform continuos 3-month ensemble analysis of August, September, and October, following spin-up from July.

Establish a benchmark for future DA and ensemble forecasting research and model development.

Configuration:

- Conventional obs thinned to model grid spacing.
- Satellite obs thinned using default HWRF options.
- Between 1.5M – 2.8M observations assimilated every 6 h.
- Radiance biases estimated online through continuos cycling.

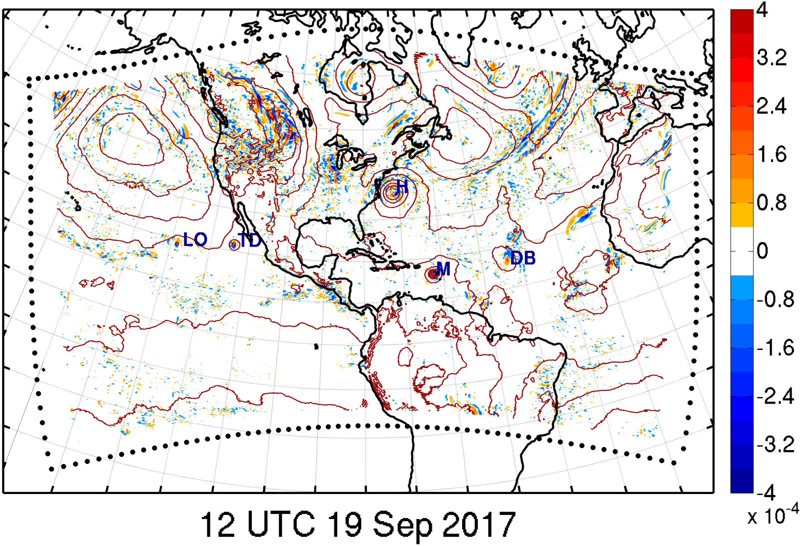
HFIP Real-Time Demo Project

System tuned based on July testing:

- 1200 KM localization ROI in NH and SH
- 1000 KM localization ROI in tropics
- 1 scale height vertical localization ROI for conventional observations
- 2 scale height vertical localization ROI for radiance
- 95% relaxation to prior spread (posterior variance inflation)
- Typical EnKF update takes between 30 – 45 min on 123 nodes of Jet.

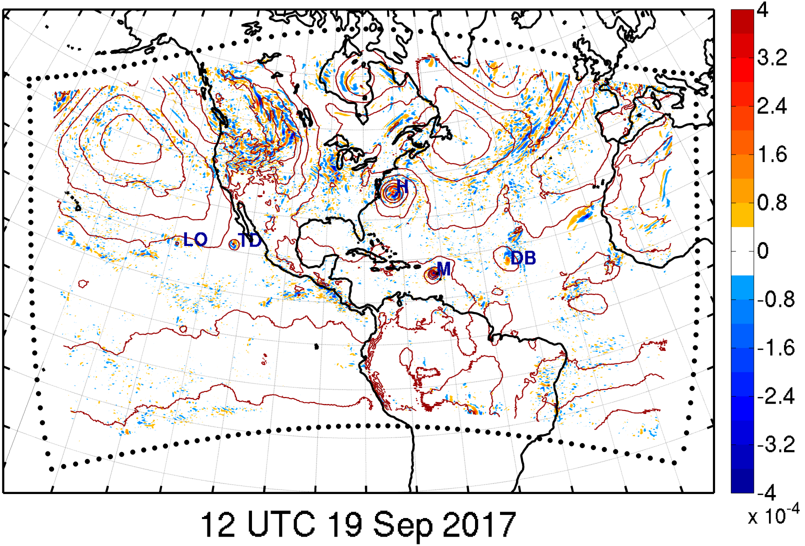
Posterior member 1

MSLP and vorticity increments at level 20 (~875 mb)



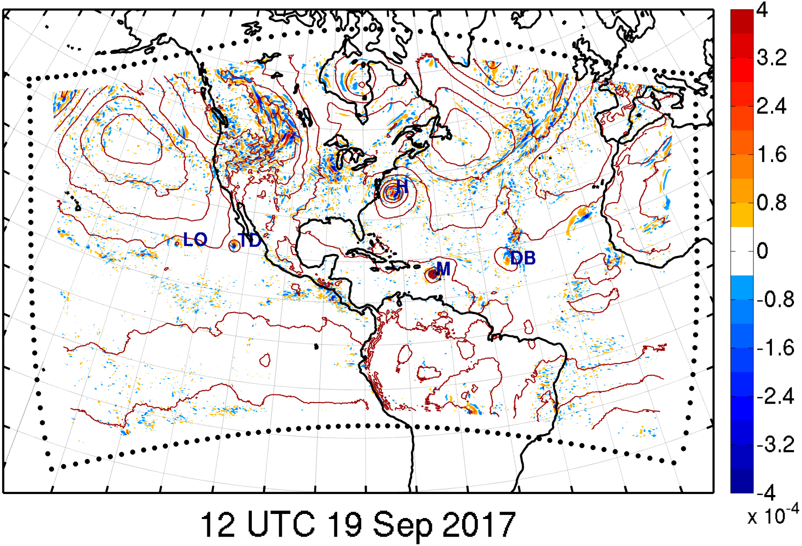
Posterior member 2

MSLP and vorticity increments at level 20 (∼875 mb)



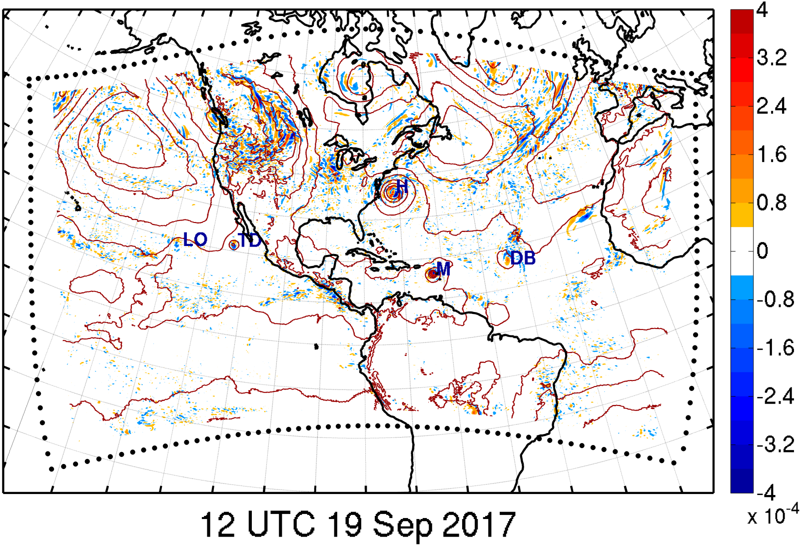
Posterior member 3

MSLP and vorticity increments at level 20 (∼875 mb)



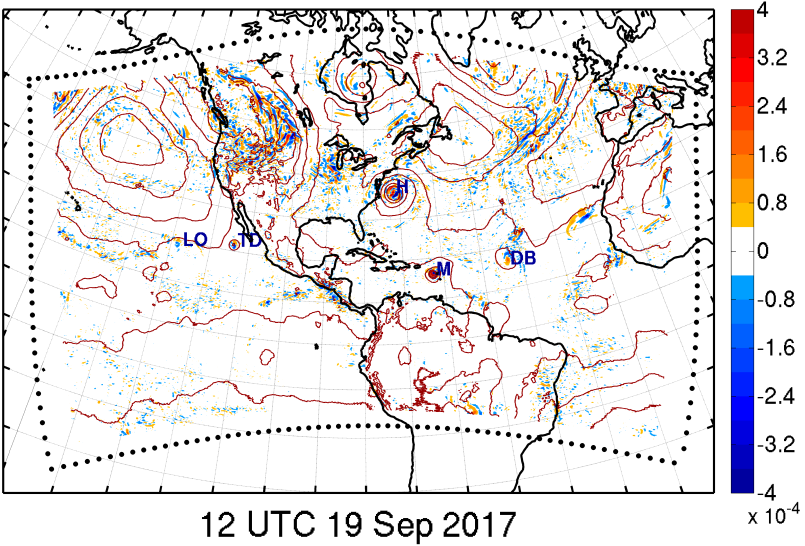
Posterior member 4

MSLP and vorticity increments at level 20 (∼875 mb)



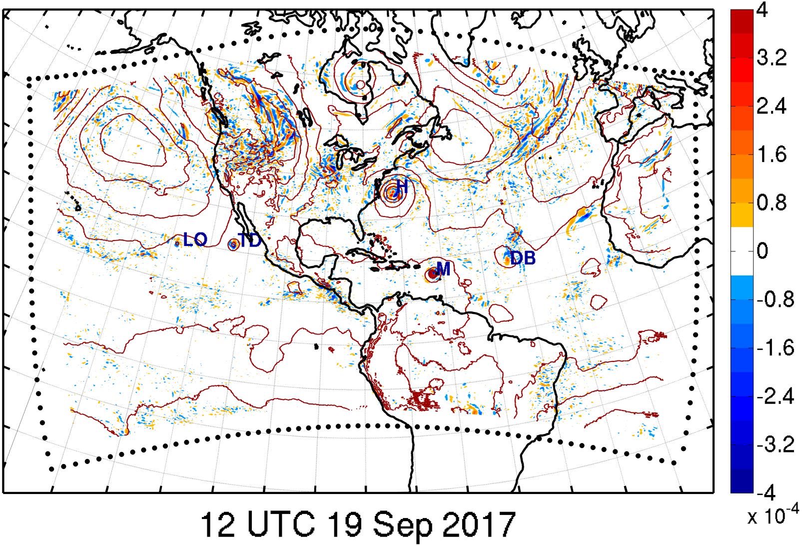
Posterior member 5

MSLP and vorticity increments at level 20 (∼875 mb)



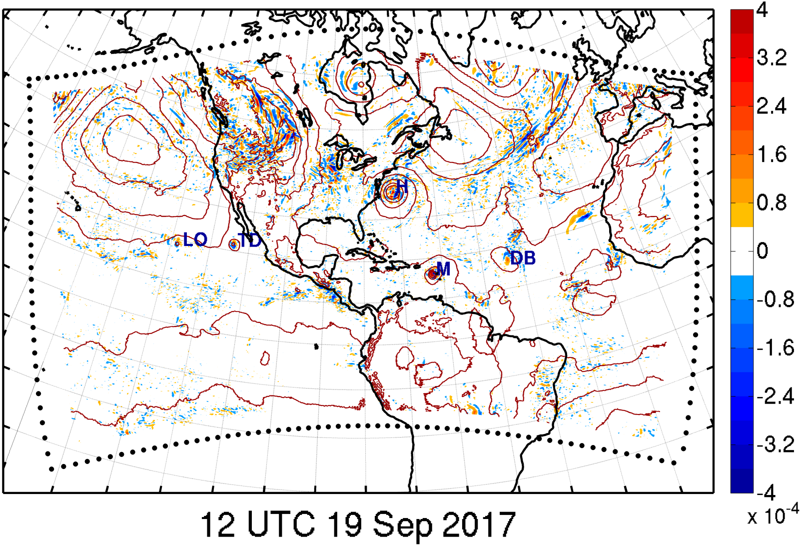
Posterior member 6

MSLP and vorticity increments at level 20 (~875 mb)



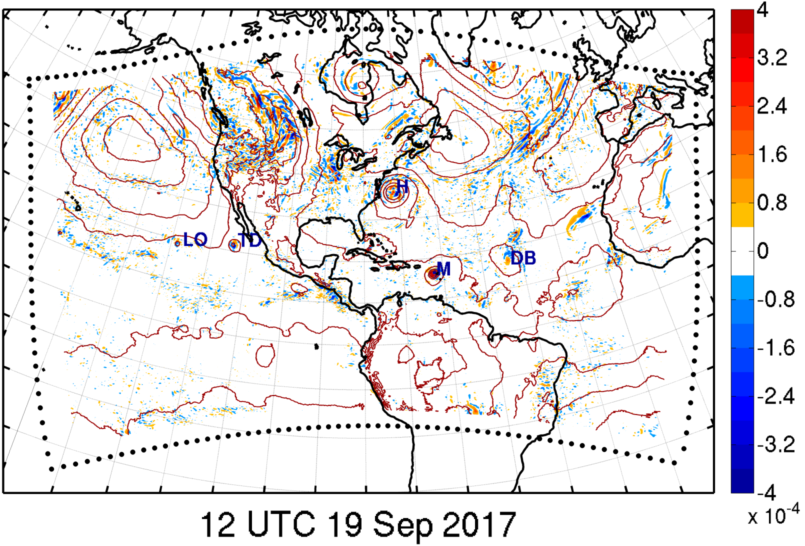
Posterior member 7

MSLP and vorticity increments at level 20 (∼875 mb)



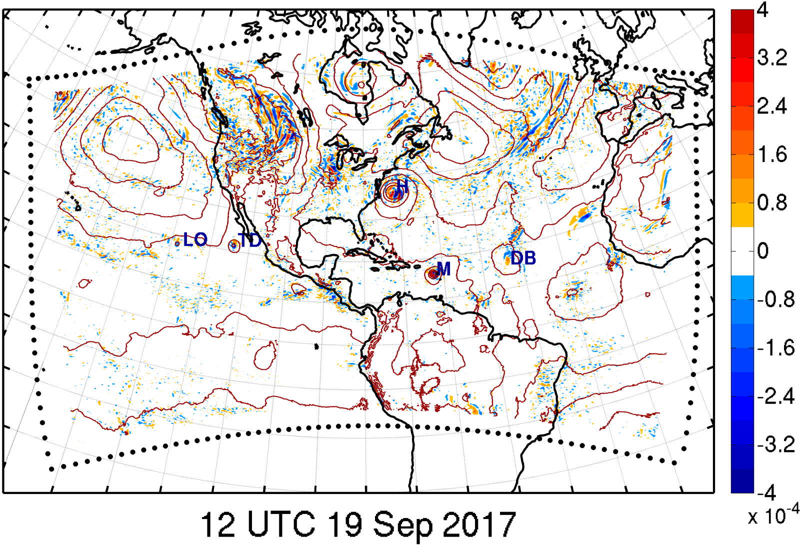
Posterior member 8

MSLP and vorticity increments at level 20 (∼875 mb)



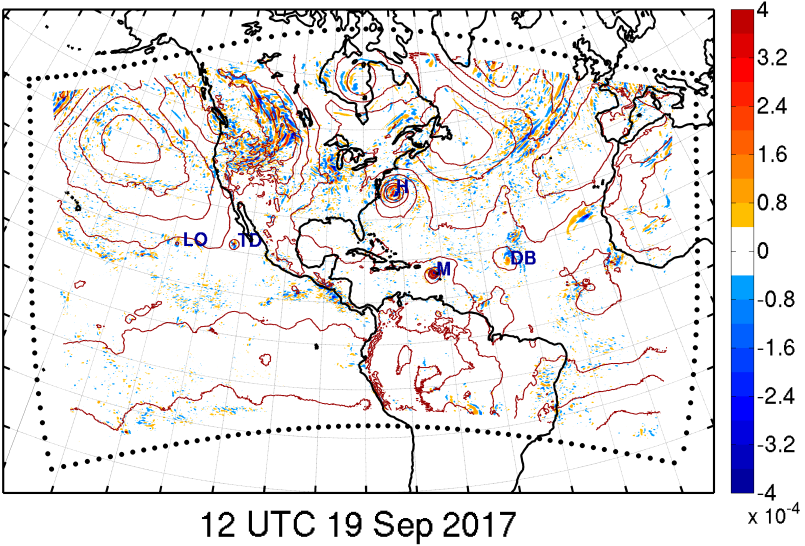
Posterior member 9

MSLP and vorticity increments at level 20 (∼875 mb)

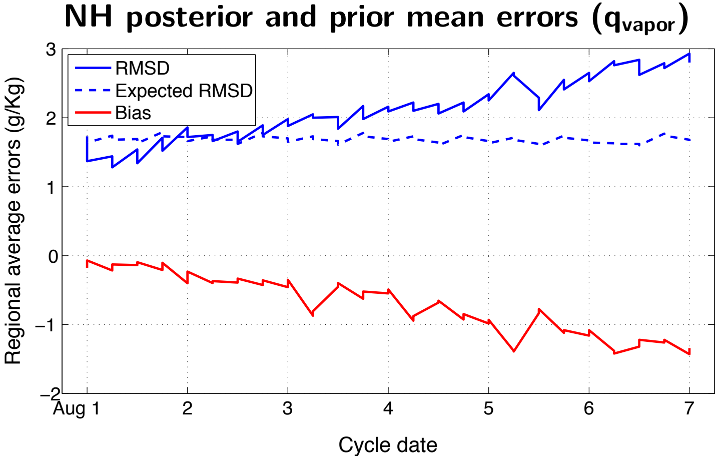


Posterior member 10

MSLP and vorticity increments at level 20 (∼875 mb)

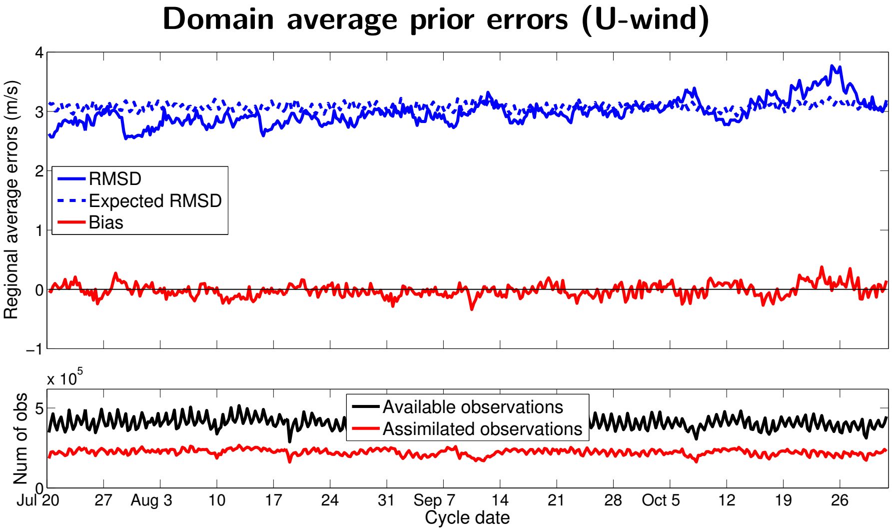


Identifying model and DA problems



Obs-space verification uncovered error caused by incorrect specification of lat/lon in single-domain HWRF configuration.

Obs space verification



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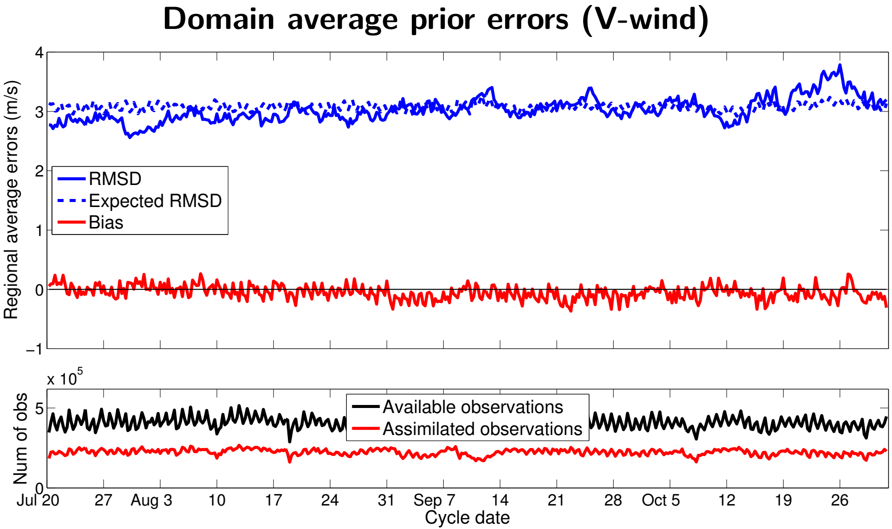

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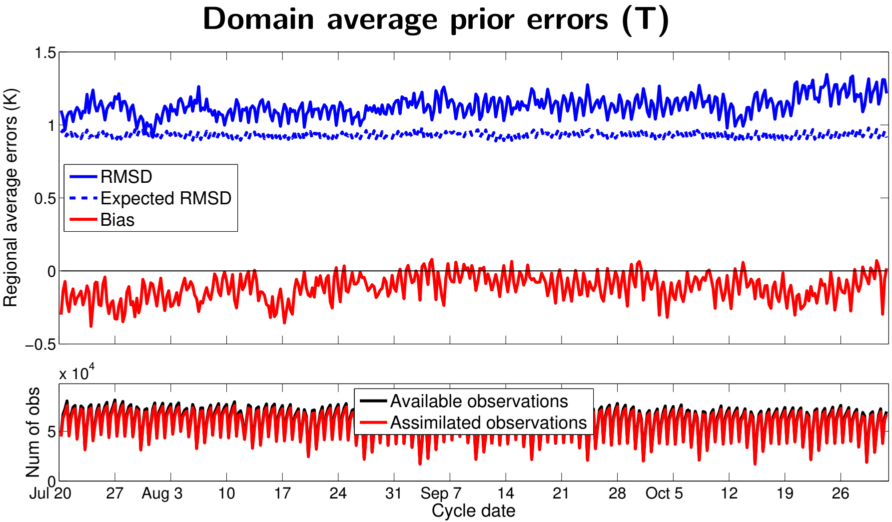

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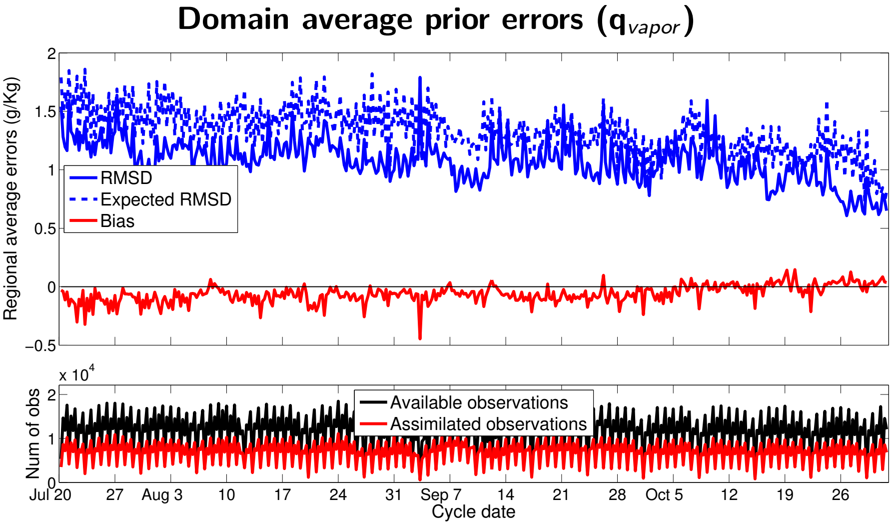

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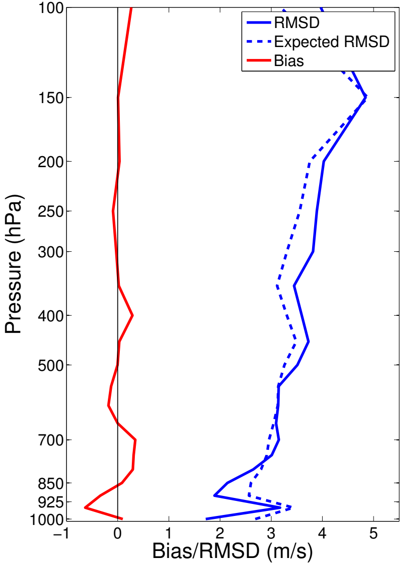
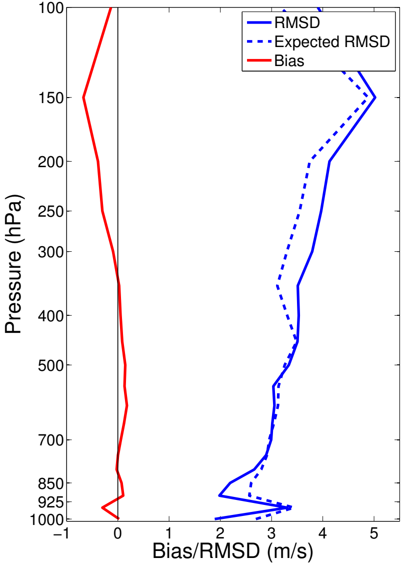


U-wind

- **Vertical profiles of time-space averaged prior errors.**
- **Mean RMSD (solid blue), mean "expected RMSD" (dashed blue), and mean bias (red)**.

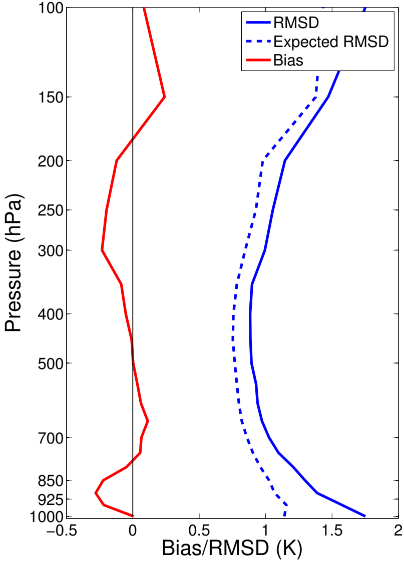
Obs space verification



V-wind

- **Vertical profiles of time-space averaged prior errors.**
- **Mean RMSD (solid blue), mean "expected RMSD" (dashed blue), and mean bias (red)**.

Obs space verification



T

- **Vertical profiles of time-space averaged prior errors.**
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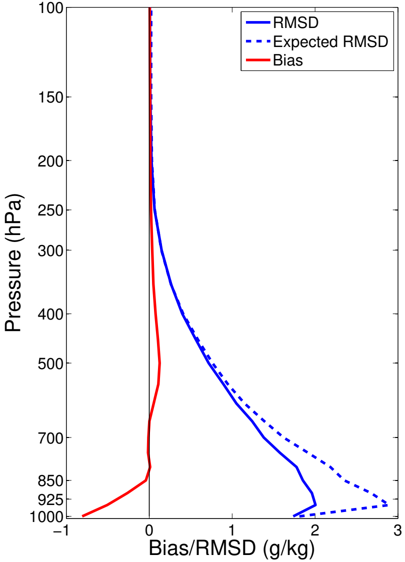
Obs space verification



q_{vapor}

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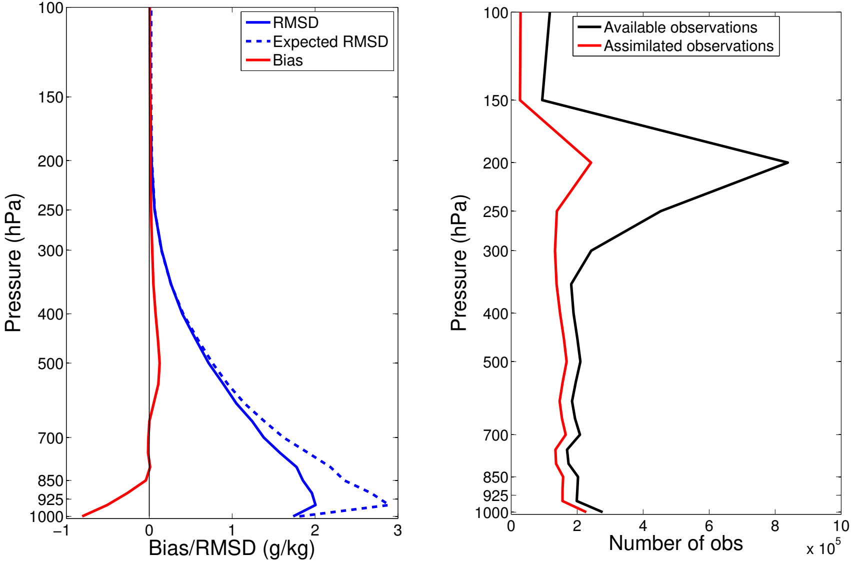
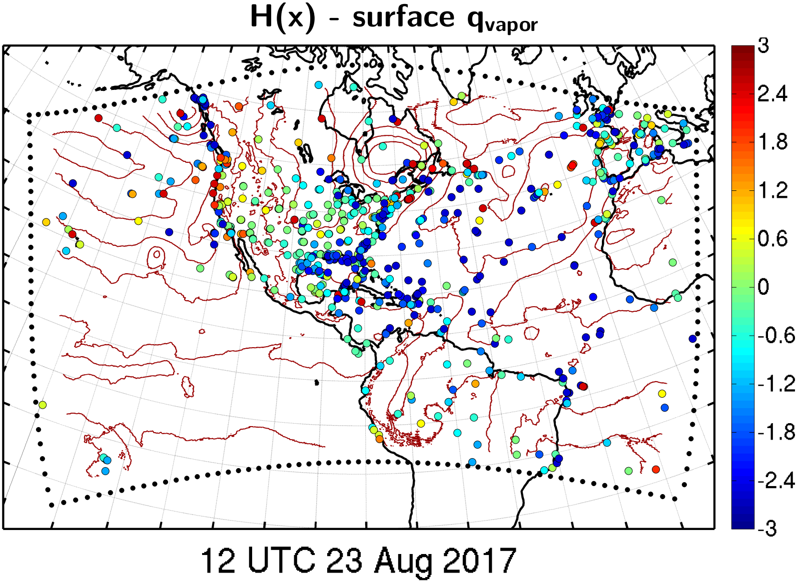
Obs space verification

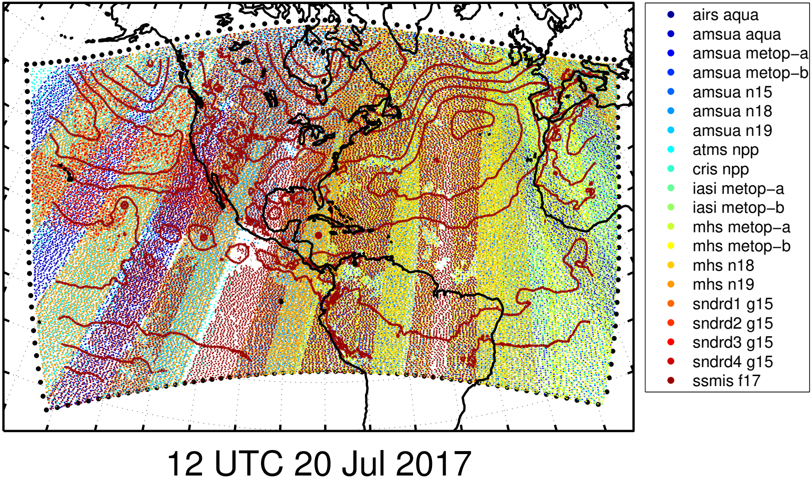


Regional water vapor errors

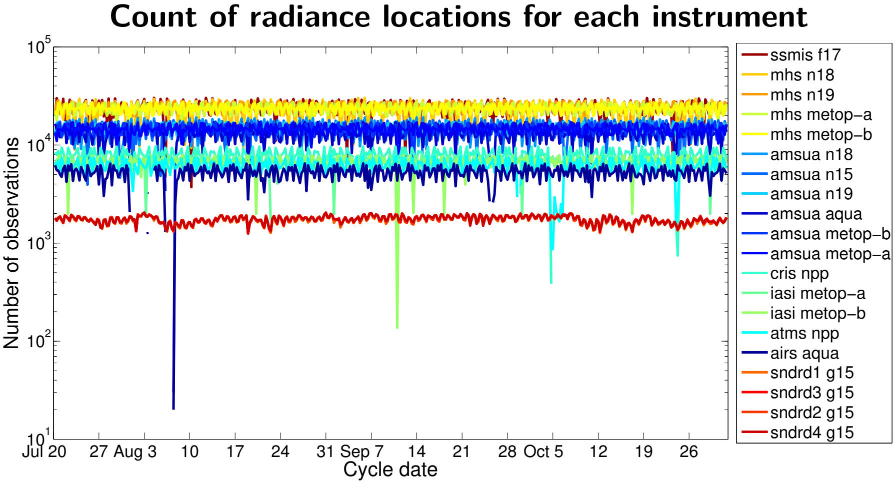


Satellite observation coverage

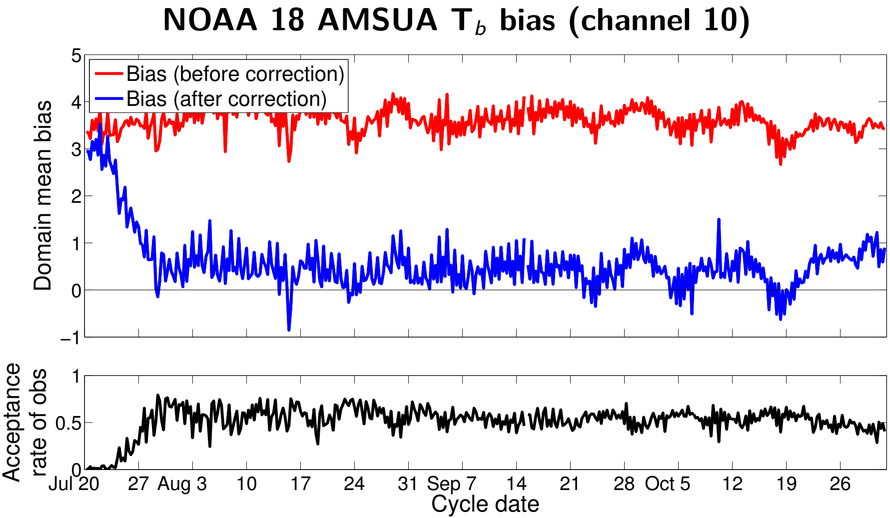
12 UTC radiance observation locations



Satellite observation coverage



Radiance bias estimation



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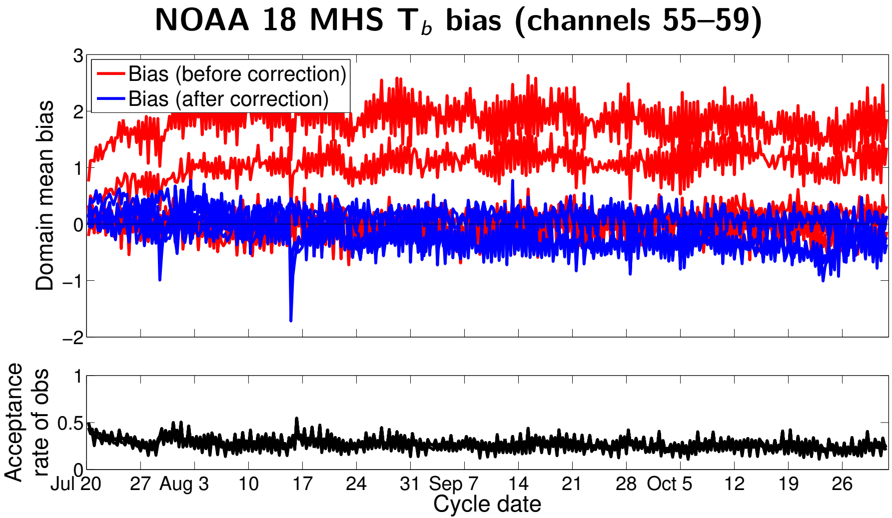

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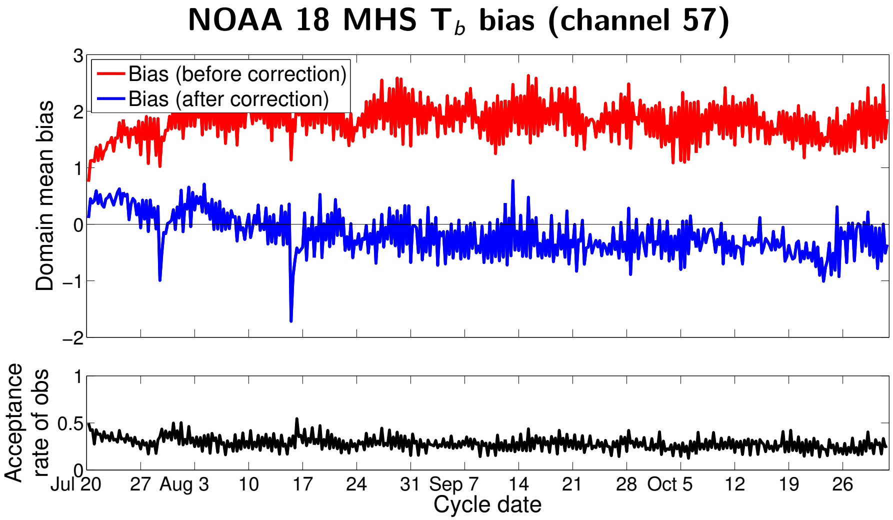

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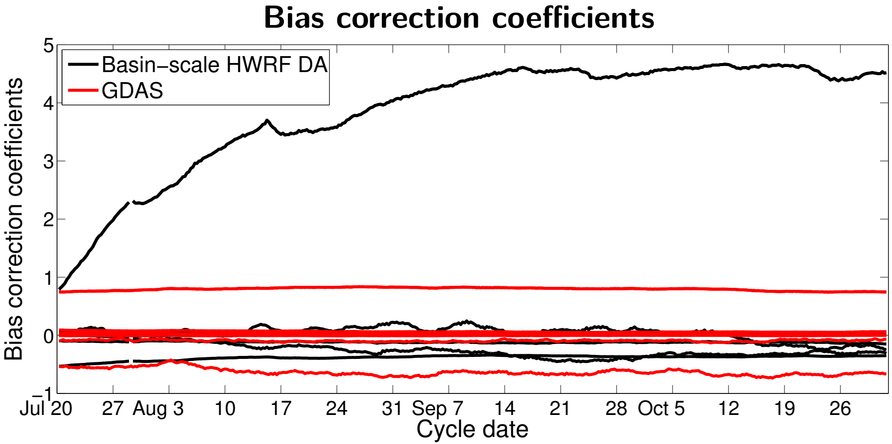
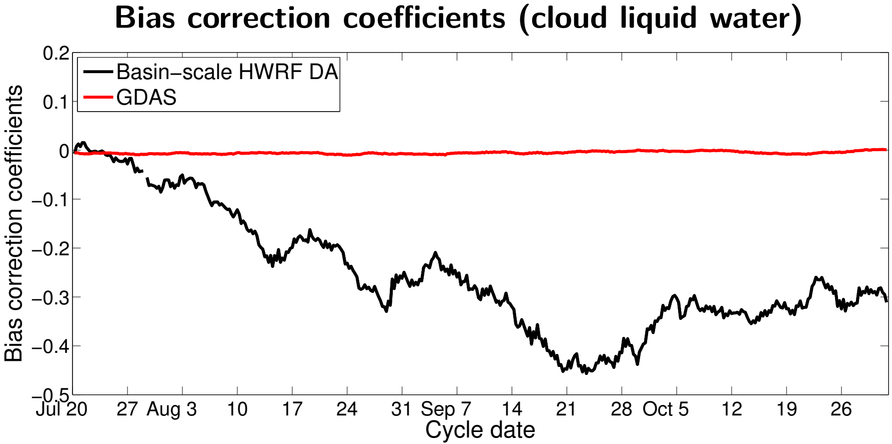


$$\tilde{h}(\mathbf{x}, \beta) = h(\mathbf{x}) + \sum_{i=1}^{K} \beta_i p_i(\mathbf{x})$$

Radiance bias estimation



$$\tilde{h}(\mathbf{x}, \beta) = h(\mathbf{x}) + \sum_{i=1}^{K} \beta_i p_i(\mathbf{x})$$

Ongoing and future work

Perform a more thorough analysis of observation-space errors.

- Apply regional and temporal stratification of prior errors to examine sources of bias.

Explore online bias correction in more detail and provide additional comparisons with GFS values.

- Use predictor weights to explore sources of error in the model or DA methodology.
- Currently performing additional data assimilation experiments using GFS bias correction values (no online estimate).

Ongoing and future work

Generate ensemble forecasts from EnKF analyses (10 – 20 members subsampled).

- Examine benefits and deficiencies in probabilistic skill over global models.
- Identify areas where improvement is needed.

Run localized particle filter for basin-scale HWRF

- Code efficiency still needs improving.
- Initial experiments will target select periods from 3-month seasonal analysis.