Impact of Assimilating AMSU-A Radiances on forecasts of 2008 Atlantic TCs Initialized with a limited-area EnKF

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Outline

- Introduction to NCAR WRF/DART system and Radiance DA in EnKF
- Results from 2008 Atlantic hurricane season
- Conclusions

Data Assimilation Research Testbed (DART)

- Ensemble Adjustment Kalman Filter (EAKF) algorithm, a two-step square-root filter
  - Ensemble update in observation space

$$\mathbf{y}_i^a = \mathbf{A}_y^{1/2}(\mathbf{HBH}^\mathrm{T})^{-1/2}\left(\mathbf{y}_i^b - \overline{\mathbf{y}^b}\right) + \overline{\mathbf{y}^a}, \quad i = 1, \ldots, N$$

  - Followed by ensemble update in model space through linear regression between observation-space increment and model-space increment

$$\mathbf{x}_i^a - \mathbf{x}_i^b = \mathbf{BH}^\mathrm{T}(\mathbf{HBH}^\mathrm{T})^{-1}\left(\mathbf{y}_i^a - \mathbf{y}_i^b\right)$$

Common practice of EnKF

- Use ensemble of model forecasts to compute prior sample covariances

$$\mathbf{BH}^T = \frac{1}{N-1}\sum_{i=1}^{N}\delta\mathbf{x}_i^b(\delta\mathbf{y}_i^b)^T$$

$$\mathbf{HBH}^T = \frac{1}{N-1}\sum_{i=1}^{N}\delta\mathbf{y}_i^b(\delta\mathbf{y}_i^b)^T$$

- Control sampling error
  - Variance inflation (adaptive approach in DART)
  - Covariance localization (adaptive approach in DART)

Radiance DA in WRF/DART

- Make use of observation operators built in the WRFDA-3DVAR.
  - Radiance obs prior is calculated from WRFDA-3DVAR using CRTM
- Peak level of weighting function used for vertical localization
- Make use of bias correction utility in WRFDA-3DVAR

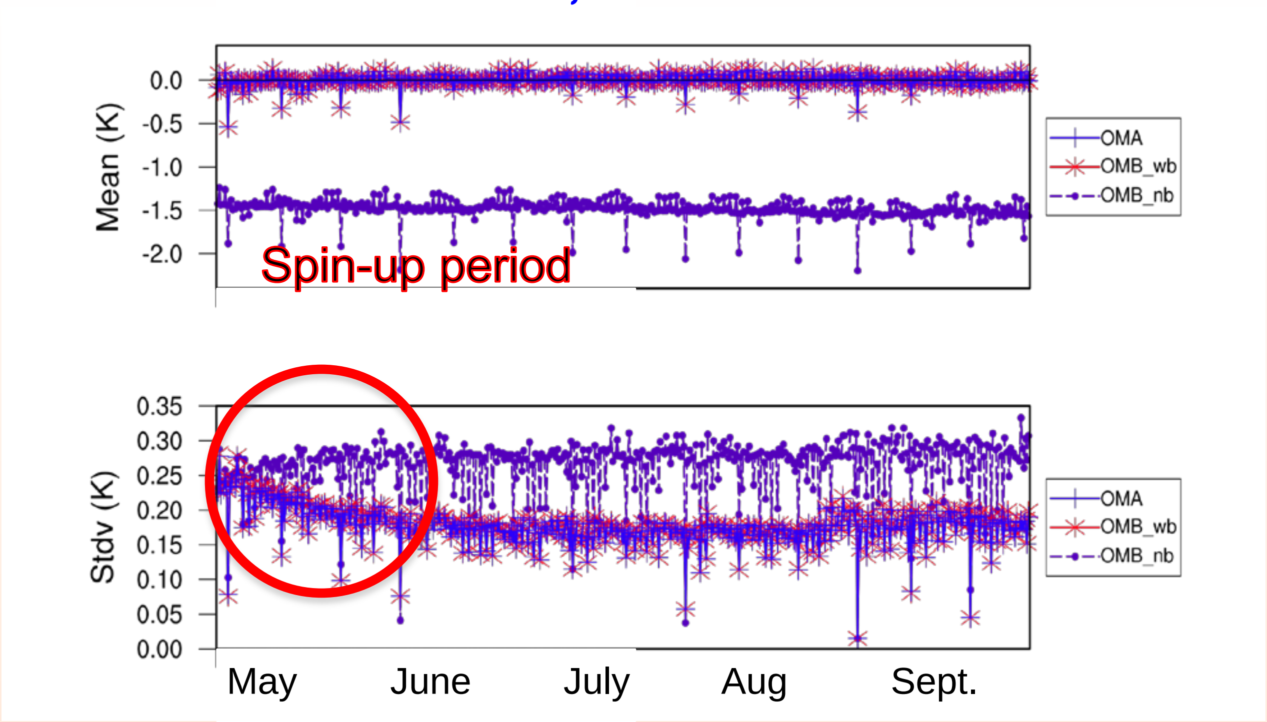
Radiance Bias correction coefficient spin-up

Recent work indicates spinning up coeffs for O(months) is beneficial

$$J(\beta) = \frac{1}{2}(\beta - \beta_b)^{\mathrm{T}} \mathbf{B}_{\beta}^{-1}(\beta - \beta_b) + \frac{1}{2}[\mathbf{y} - \tilde{H}(\mathbf{x}_r, \beta)]^{\mathrm{T}} \mathbf{R}^{-1}[\mathbf{y} - \tilde{H}(\mathbf{x}_r, \beta)]$$

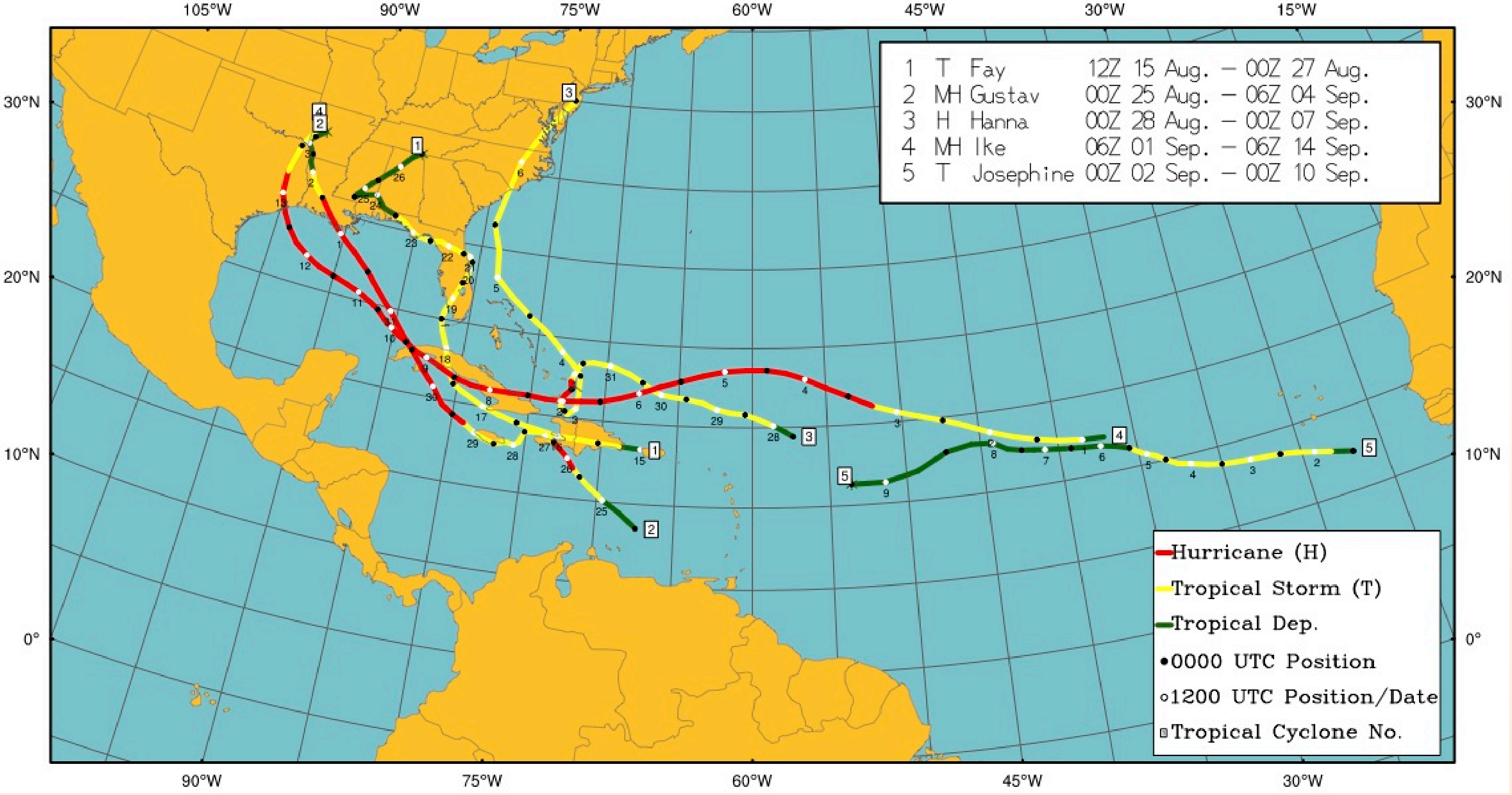
Reference field for coeffs training can be: from global analysis (**NCEP GFS used in this study**), or EnKF analysis, or other regional analysis

NOAA-18 AMSU-A, ch 6 20080501--20080915



Experimental period

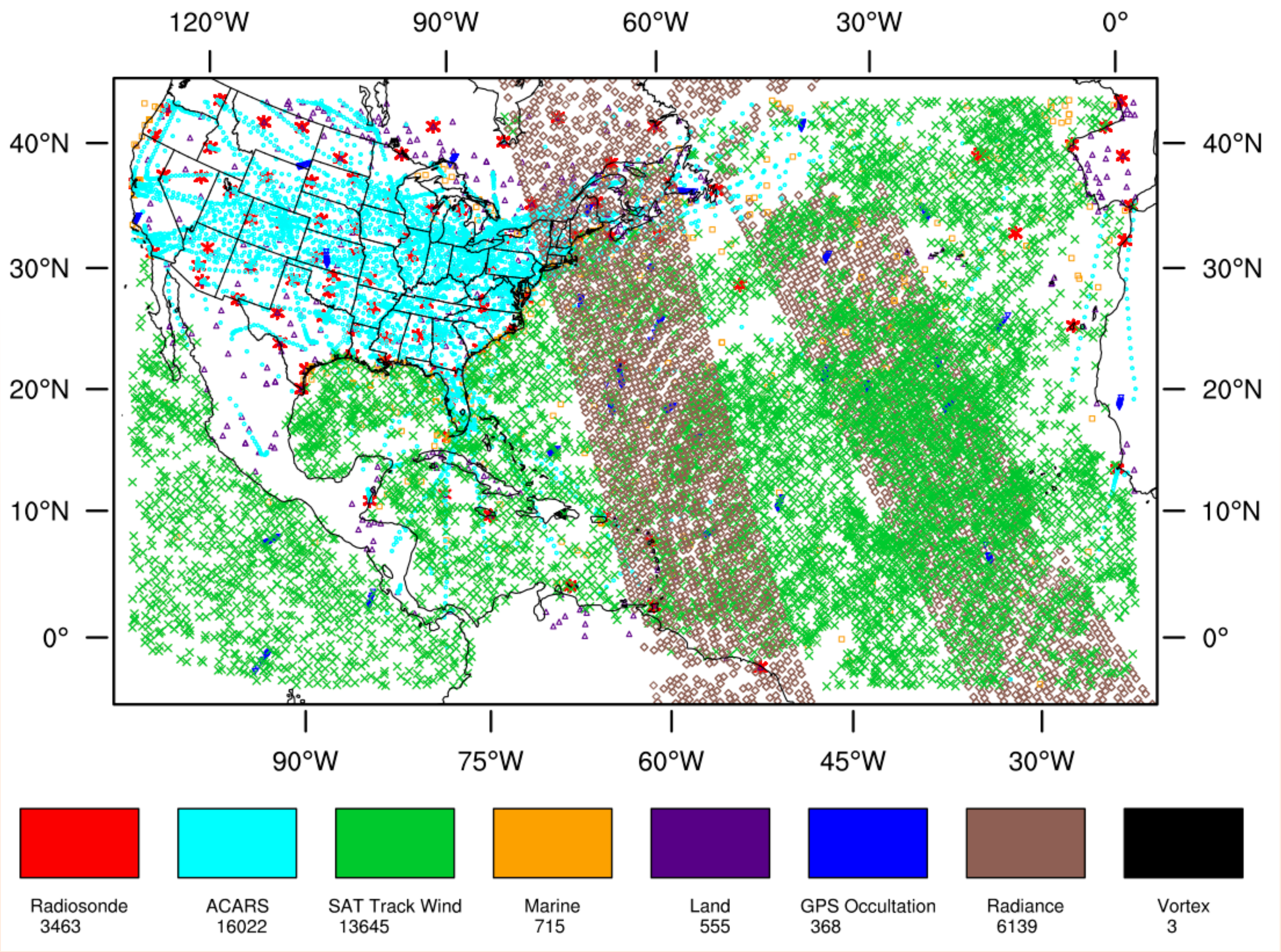
- 11 Aug-15 Sep 2008
  - 5 storms: Fay, Gustav, Hannah, Ike, Josephine



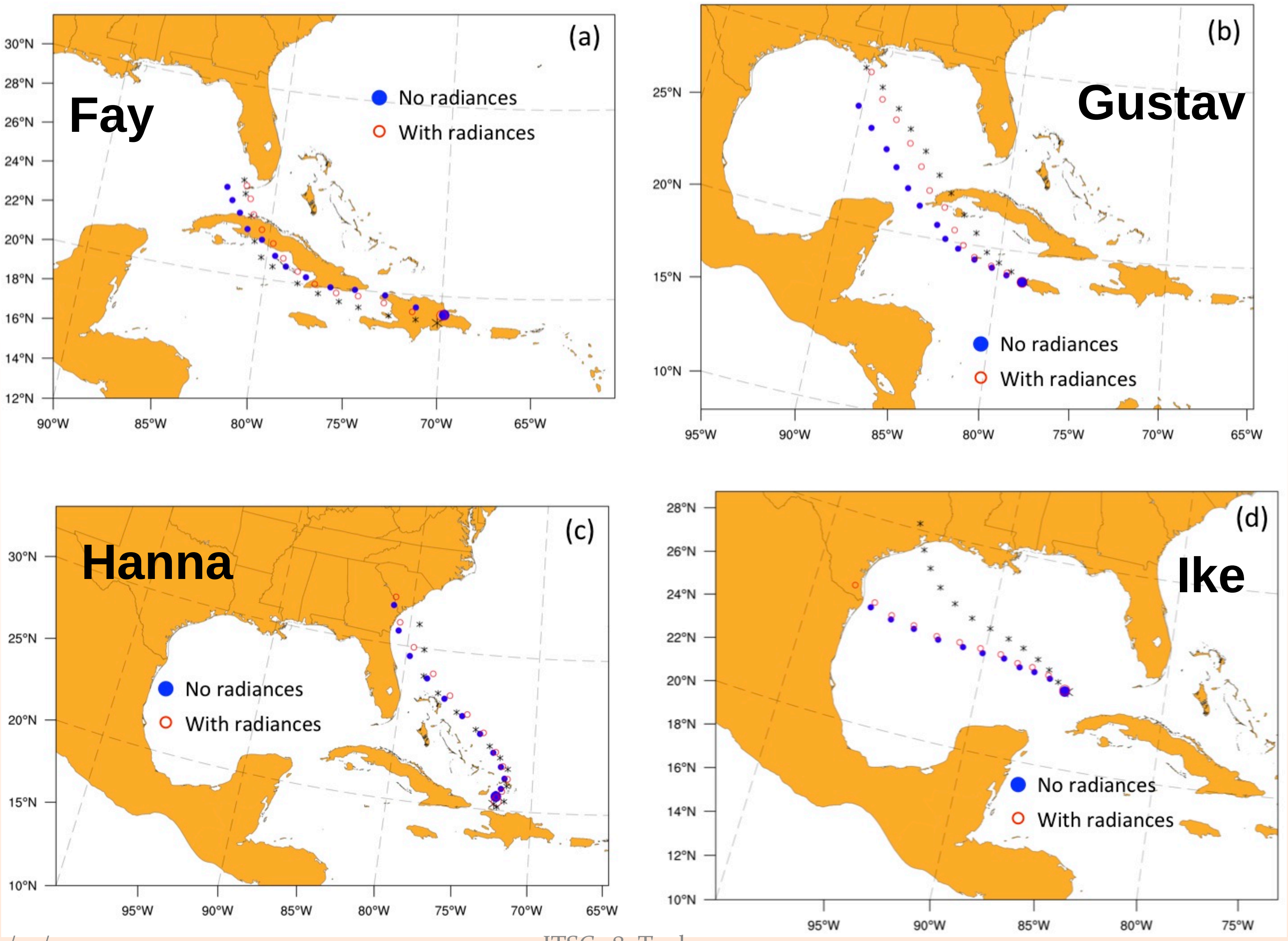
Experimental Design

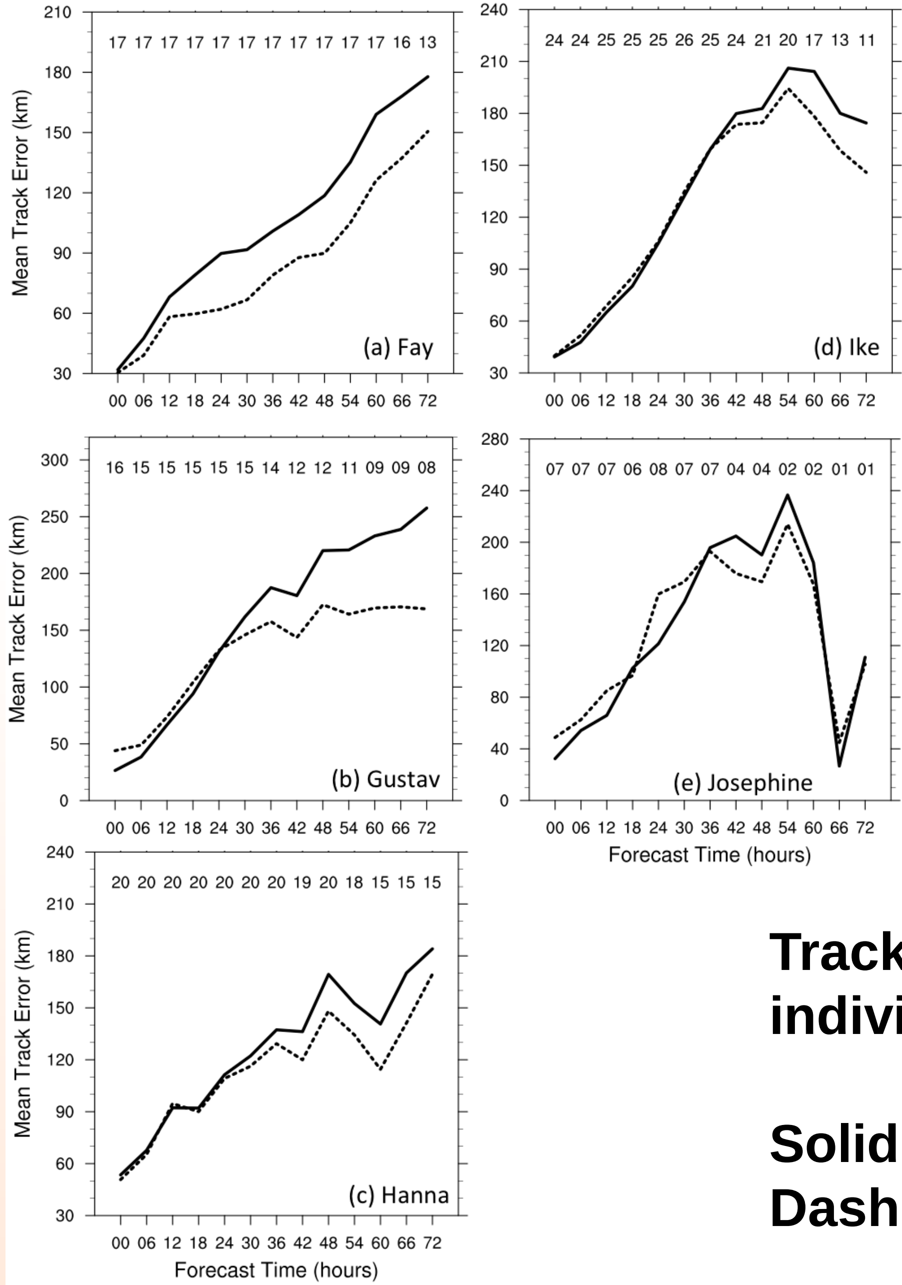
- Two principal WRF/DART 6-hourly cycling experiments
  - (1) Assimilate solely "conventional" (i.e., non-radiance) observations
  - (2) Assimilate conventional observations and AMSU-A channels 5~7 radiances from NOAA-18 and METOP-2.
- WRF V3.2.1: 36km, 36 levels to 20hPa.
  - Deterministic 72-h forecasts from ensemble mean analyses at 00Z, 12Z
- DART:
  - 96 members, ±1.5 h time-window, LBCs from GFS
  - Adaptive inflation and localization, No surface obs except altimeter
- Radiances:
  - Thinned to 72 km, CRTM via WRFDA
  - Vertical location assigned based on peak of Jacobian for each ob
  - Static bias correction coefficients from offline monitoring spun-up for 3 months prior to experiment using GFS as the reference field

Obs coverage @ 00Z 17 Aug. 2008



Single 3-d forecast before landfall

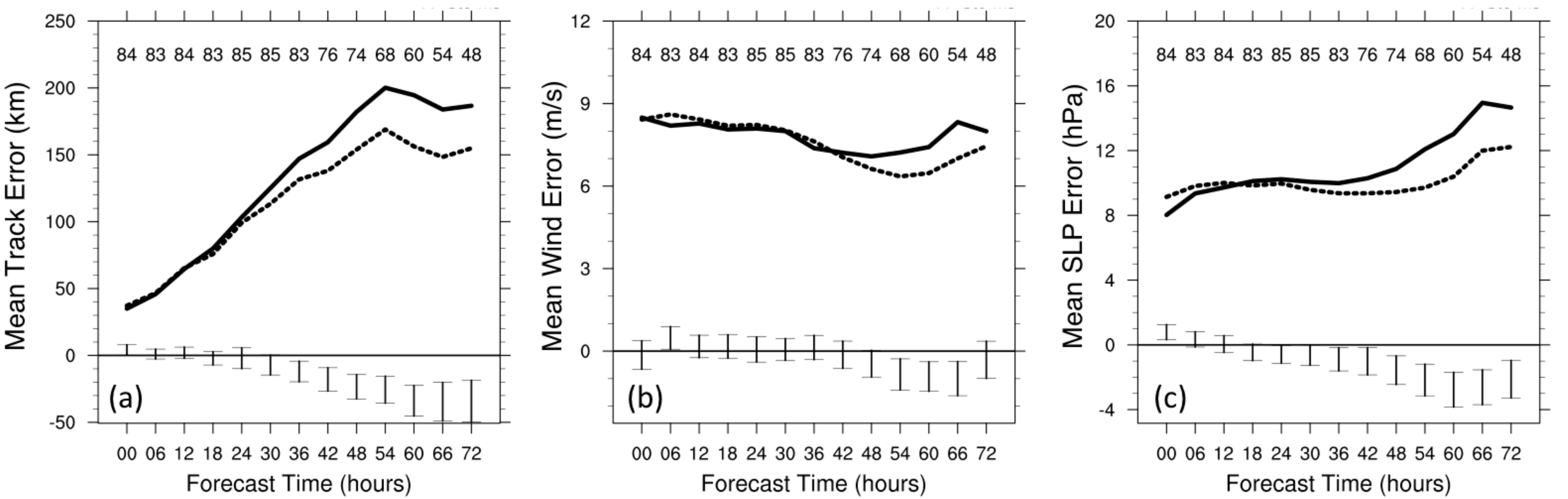




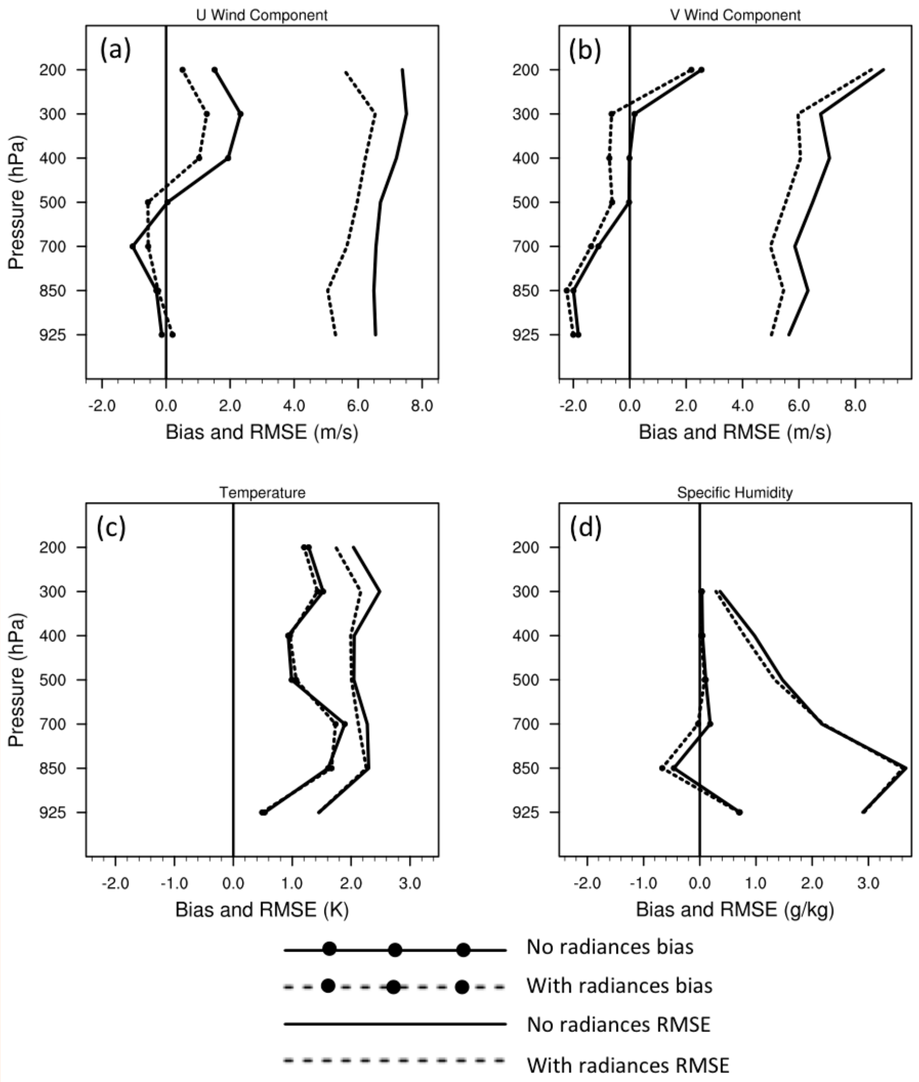
Track Error for individual storm

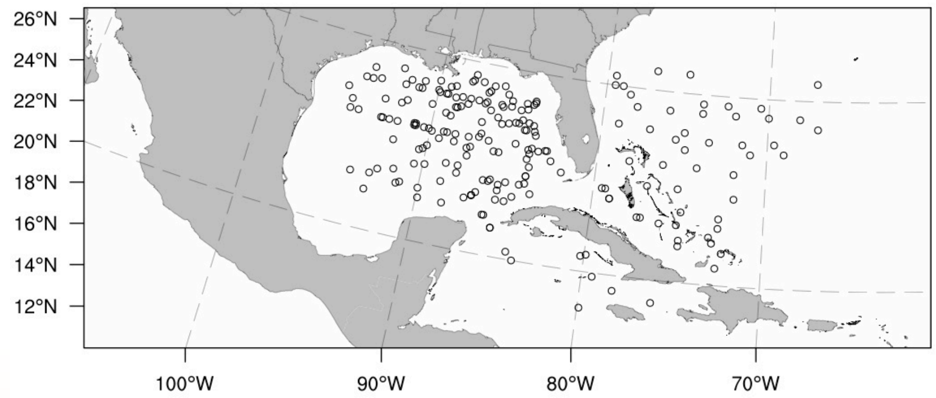
Solid: no-radiance
Dashed: radiance

Track/intensity errors for all storms



48-h forecasts vs. dropwindsondes obs

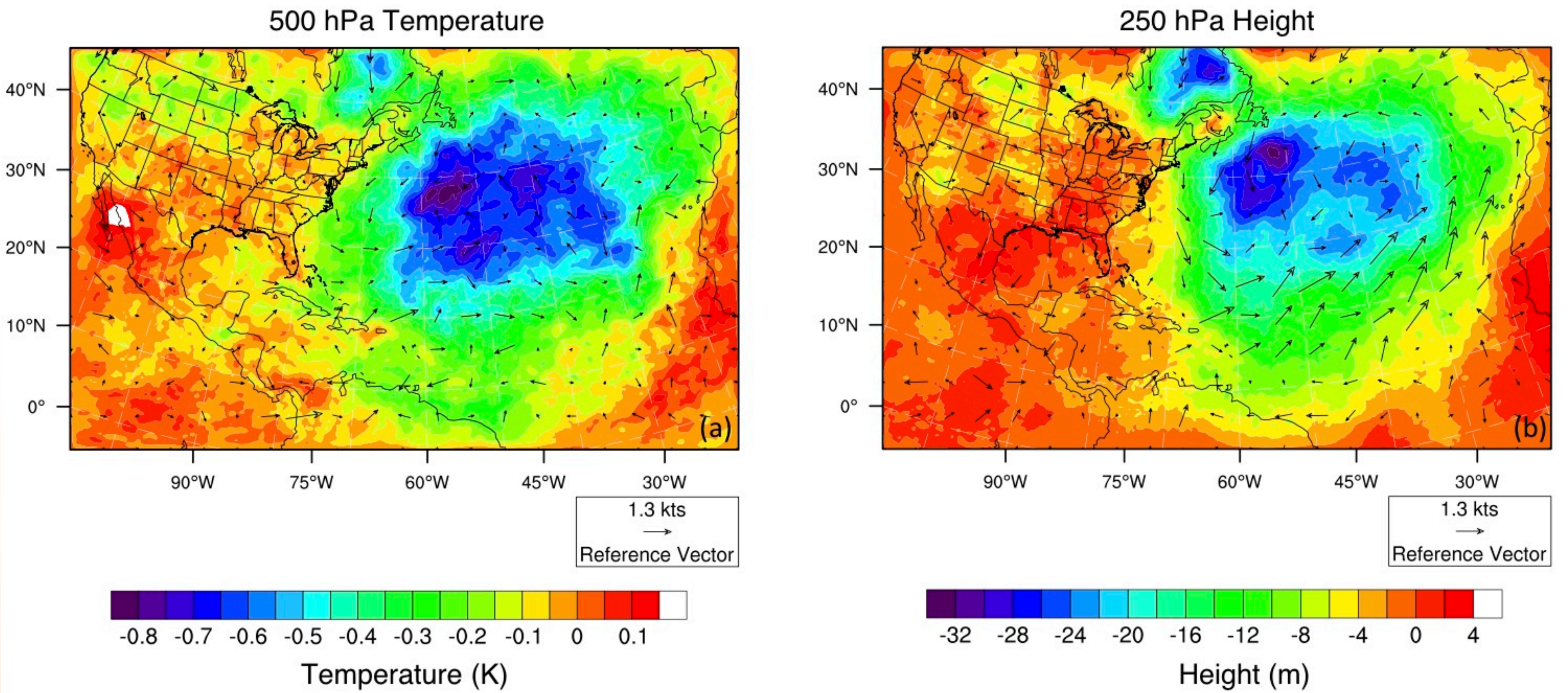




208 dropsondes used in verification

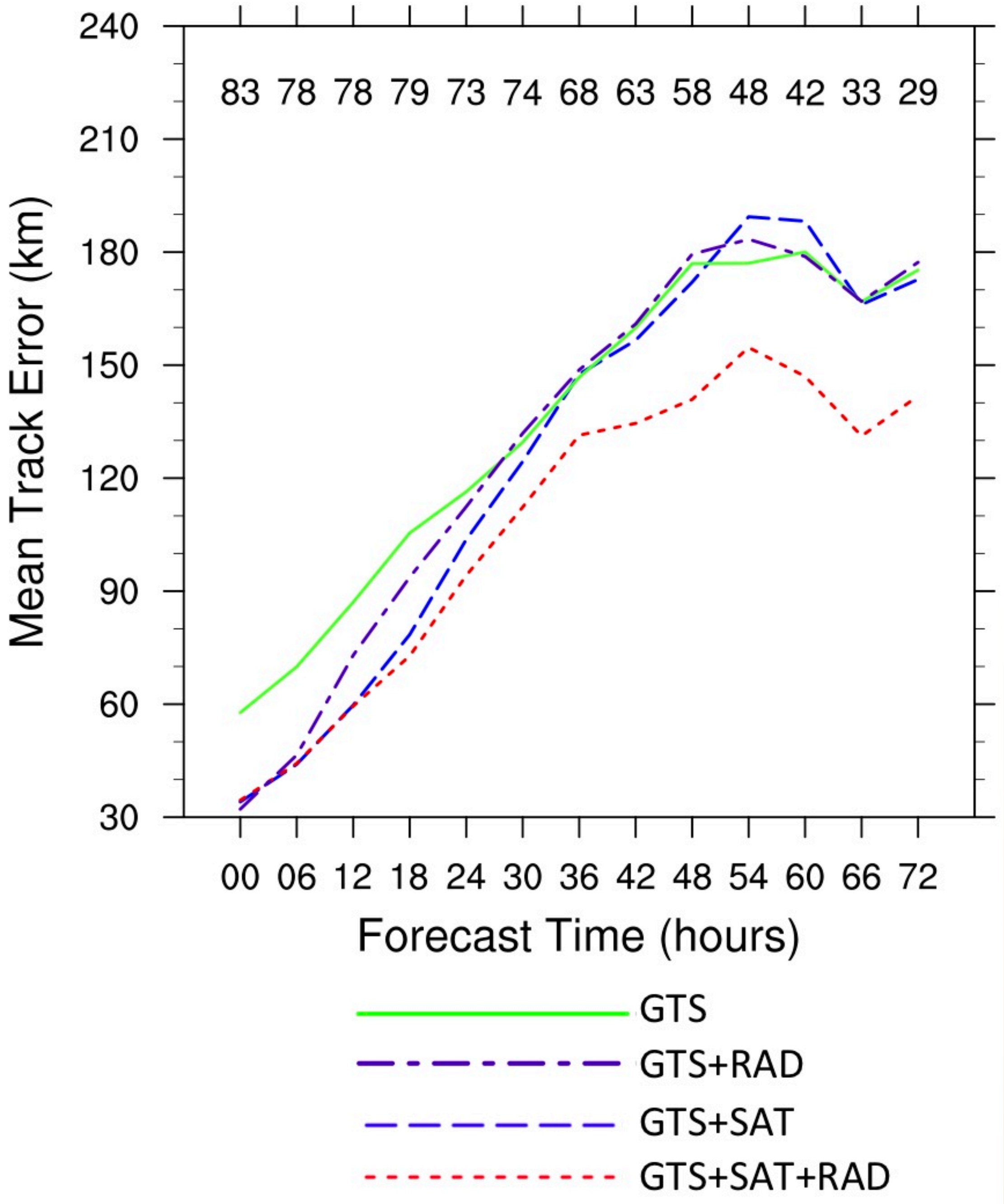
NOAA G-IV dropwindsondes sampled TC environment, not TC core.

Mean difference of Radiance minus non-radiance analyses



Radiances made the analyses colder over Atlantic, therefore reduced the warm bias (when compared to ERA-Interim re-analyses) and weakened steering flow.

Importance of simultaneously assimilating radiances and satellite winds



Conclusions

- Assimilating AMSU-A radiance improved TC track and intensity forecasts, particularly for forecast range beyond 36-h.
- Track improvement likely caused by improved environmental analysis.
- Simultaneous assimilation of radiances and satellite winds is important to maximize the benefit from both data sources.

More details can be found in the manuscript:
Liu et al., 2012, submitted to MWR.