Impact of Assimilating Environmental Satellite Observations on Tropical Storm Position and Intensity Analyses and Forecasts

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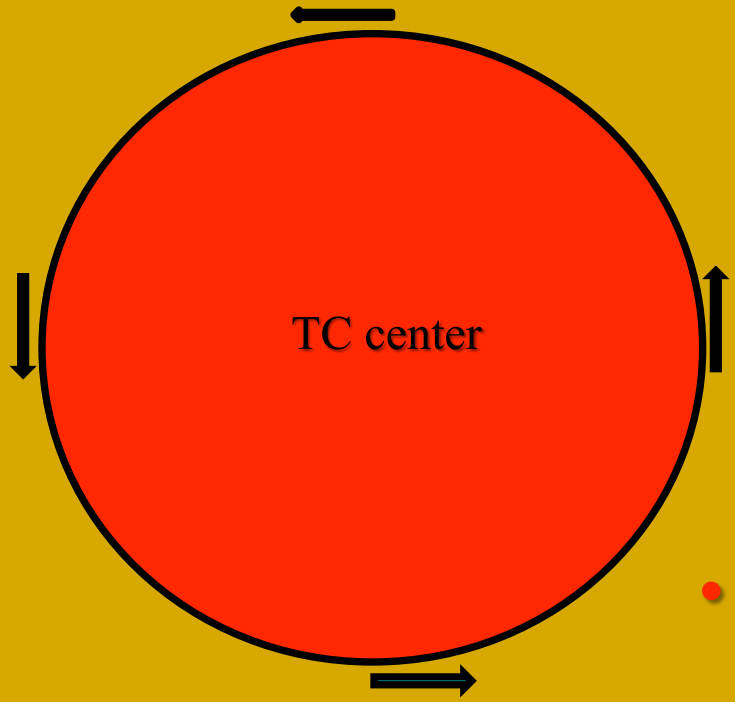
NCAR

Acknowledgements:

Jun Li, CIMSS

Satellite Data for TC Application

- It is a challenge to apply satellite Q/T data for TC application with traditional DA approaches
- Sat data irregular distributed and not representing the entire TC system and all variables



Can an OBS make consistent corrections to all variables with TC structure?

e.g., can a Q OBS correct wind?

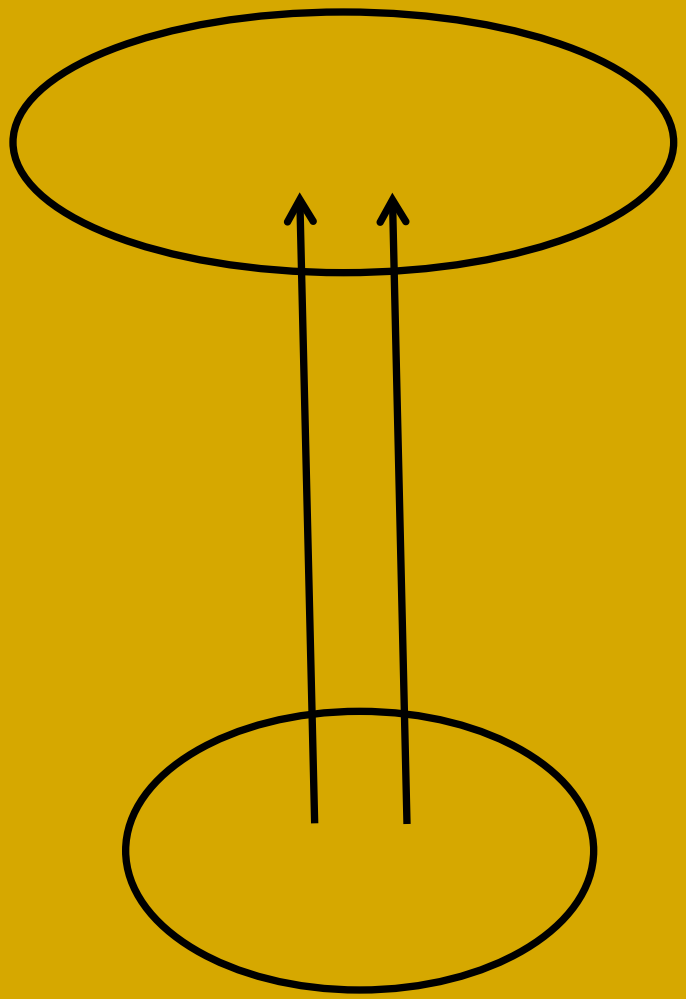
- OBS

Features of Ensemble DA for TC Analysis

- Ensemble forecasts provide multivariate forecast error covariance estimates with TC structure
- Can generate analysis corrections according to TC structure as well as multivariate corrections

  e.g., Water vapor impacts distant circulation

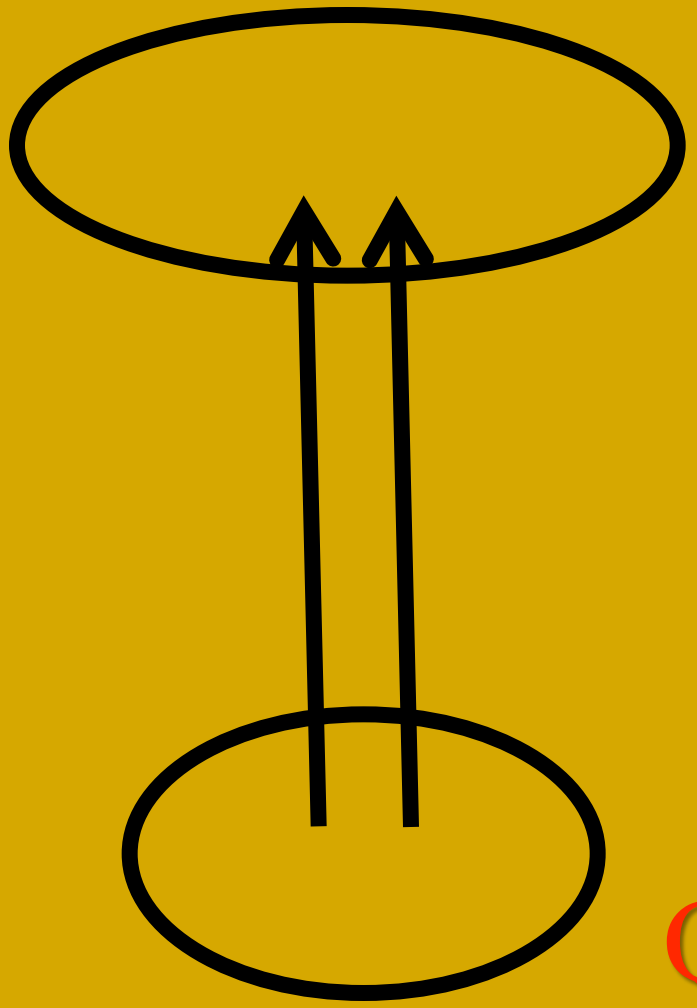
How EnKF makes winds adjustments by assimilating a Water Vapor OBS in a convective environment



Member 1

Q

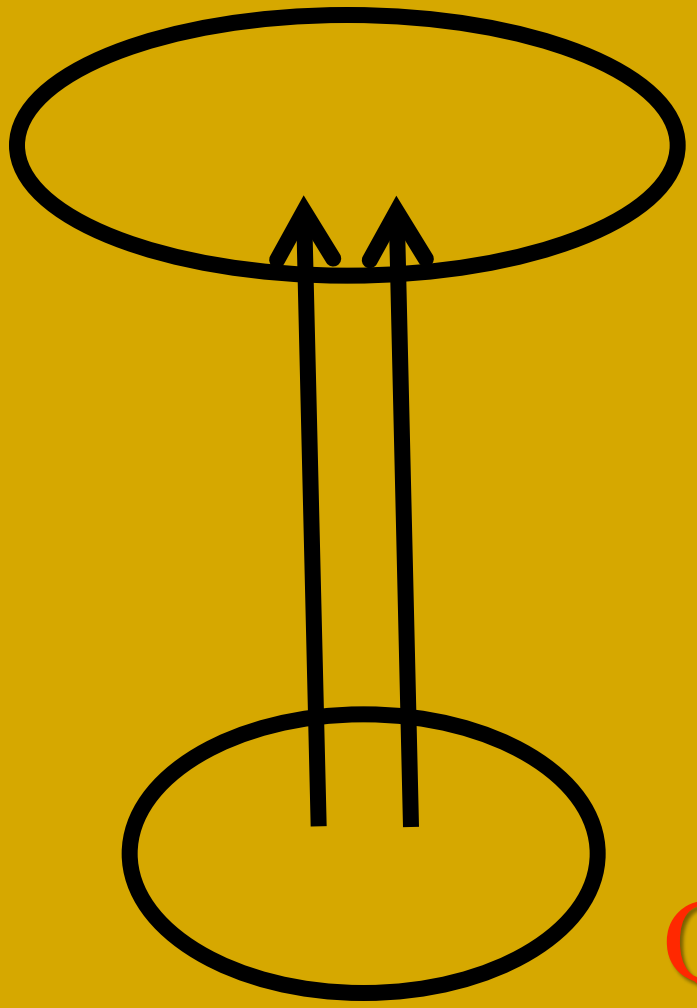
How EnKF make winds adjustments by assimilating a Water Vapor OBS in a convective environment



Member 2

Q more moist

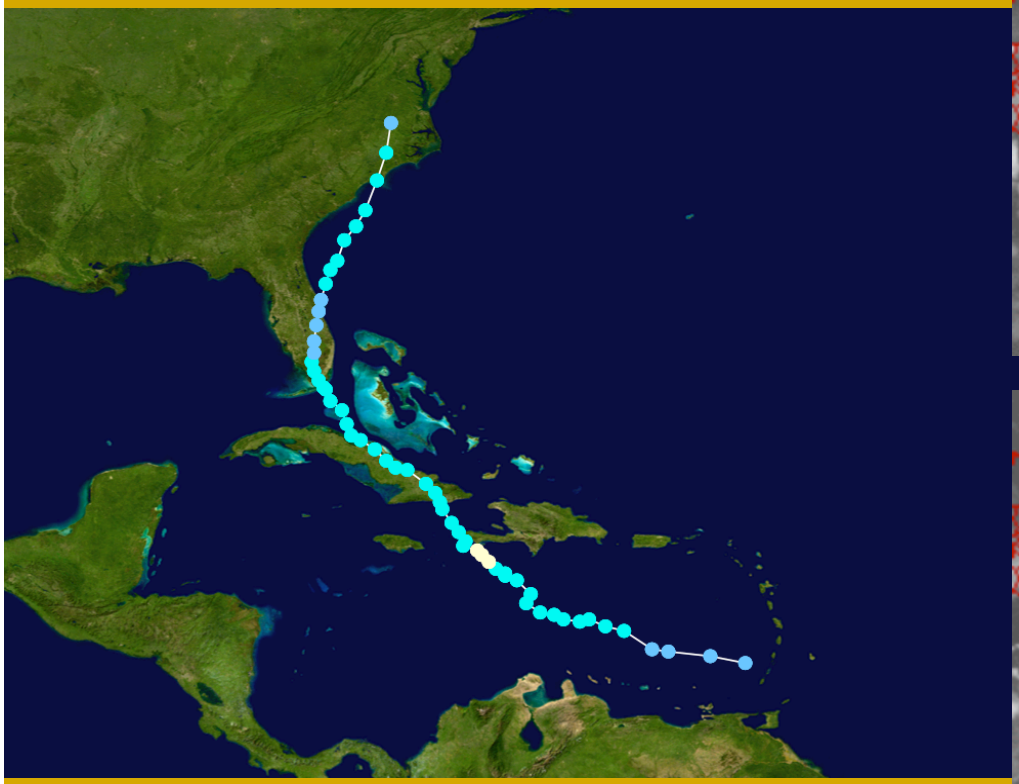
How EnKF make winds adjustments by assimilating a Water Vapor OBS in a convective environment

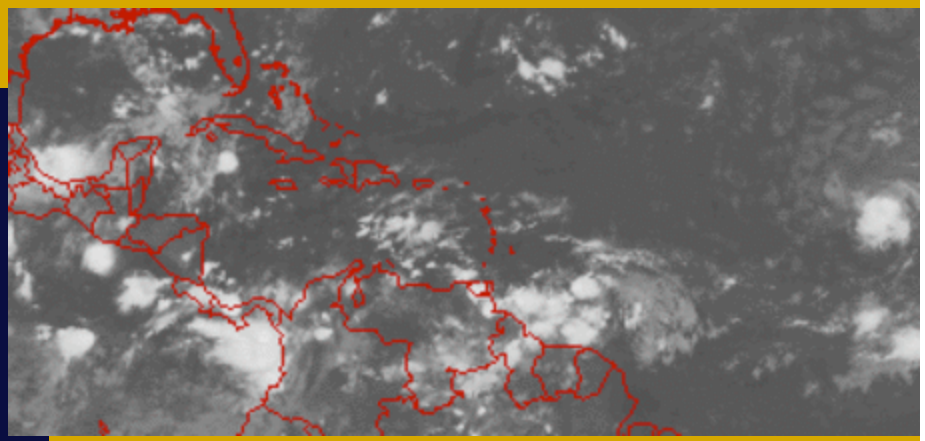


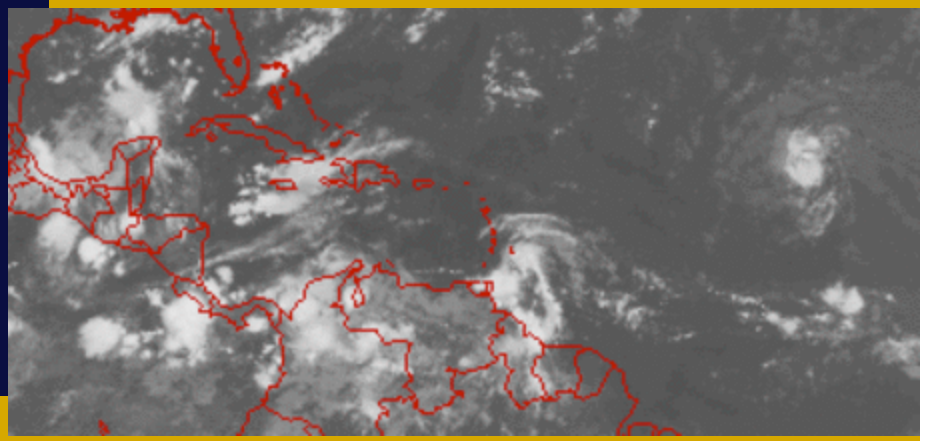
Q OBS

Q more moist

Hurricane Ernesto case (2006)







Hurricane Ernesto (2006):

Formed as DS: 18Z 24 August

Reached Hurricane strength: 27 August

Dissipated: 1 September

12 UTC 23 and 24 August 2006

SAT IR image

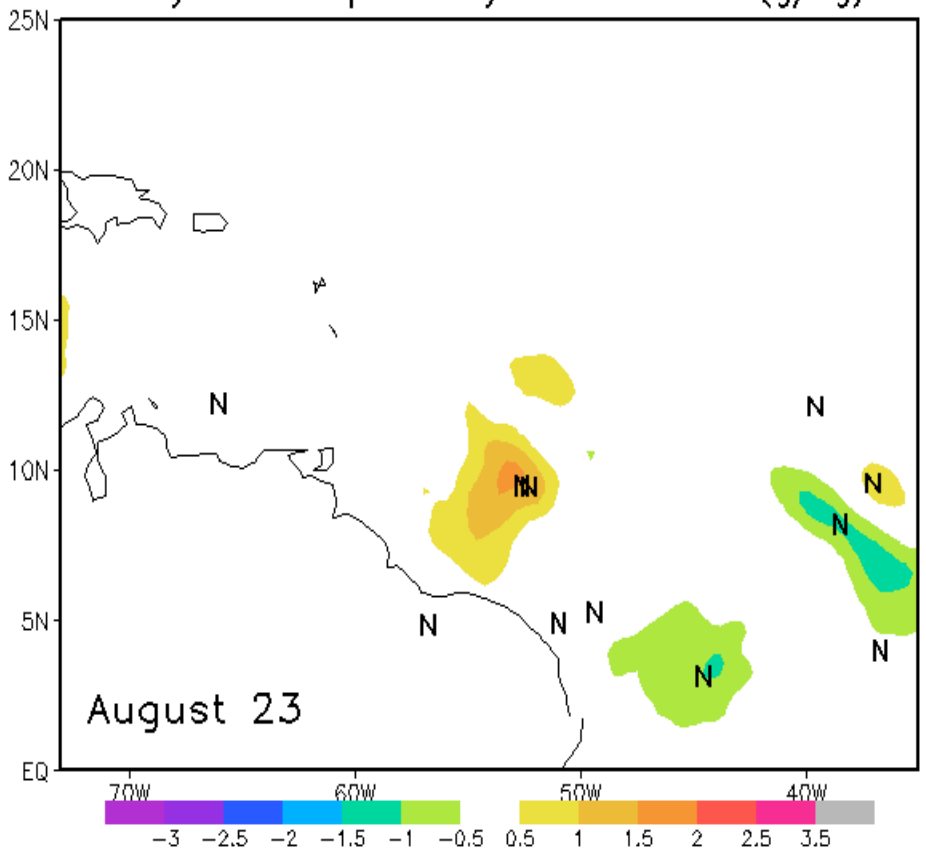
GPS Data Assimilation Experiments (1)

- GPS refractivity has mainly WV info in lower troposphere
- GPS-only run: GPS refractivity only
- NODA run: assimilation of no data
- WRF/ARW v3.1; DART ensemble assimilation system
- 32 ensembles, 36km resolution
- Analysis 2-hourly, cycling 21-28 00UTC, August 2006

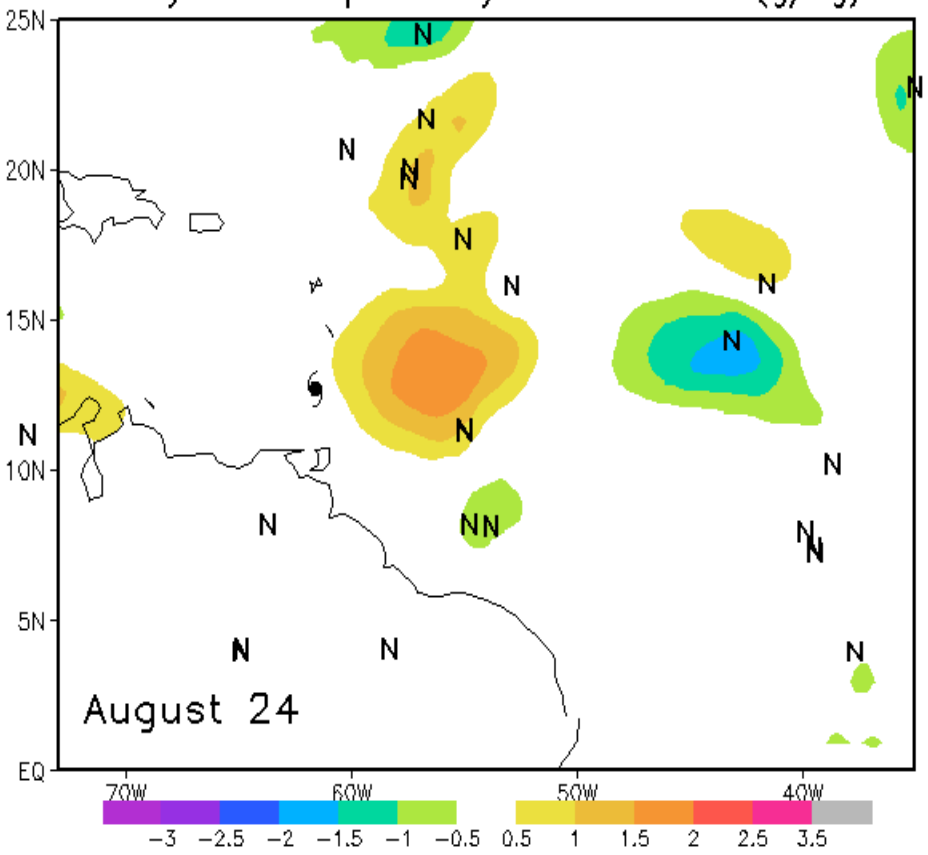
Daily Analysis Increments of water vapor (GPS-only run)

(700 hPa, 23-24, August 2006, g/kg)

Aug 23 (1.5-day before genesis)



Aug 24 (genesis day)

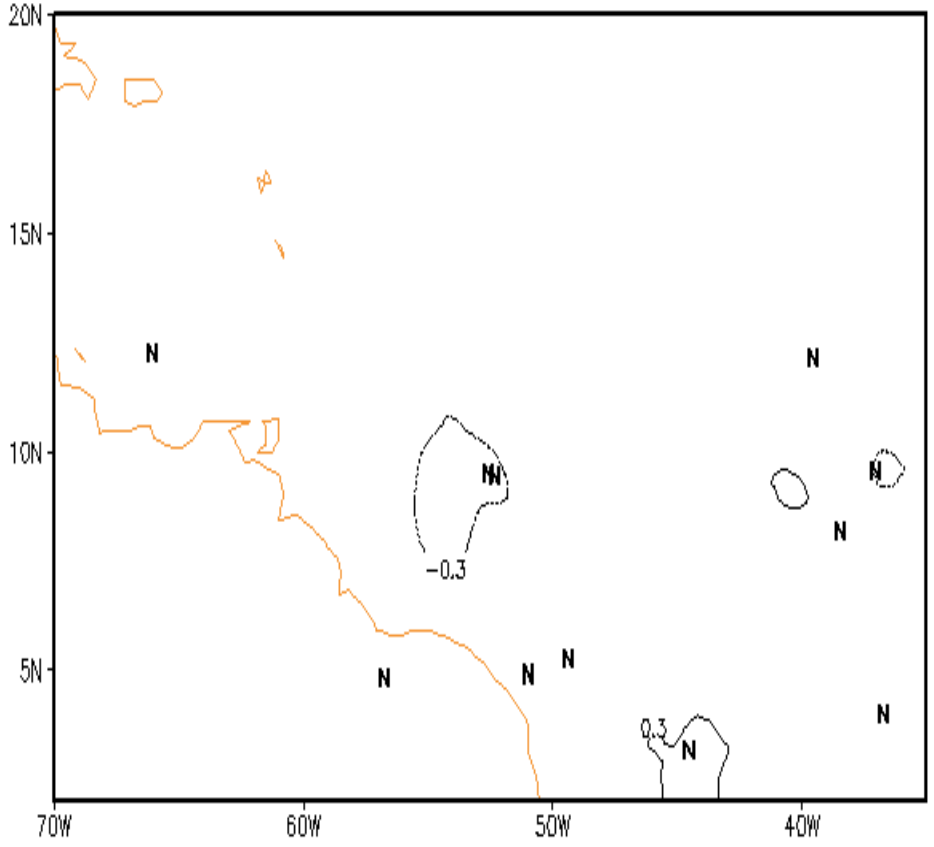


GPS data increases water vapor in the genesis area

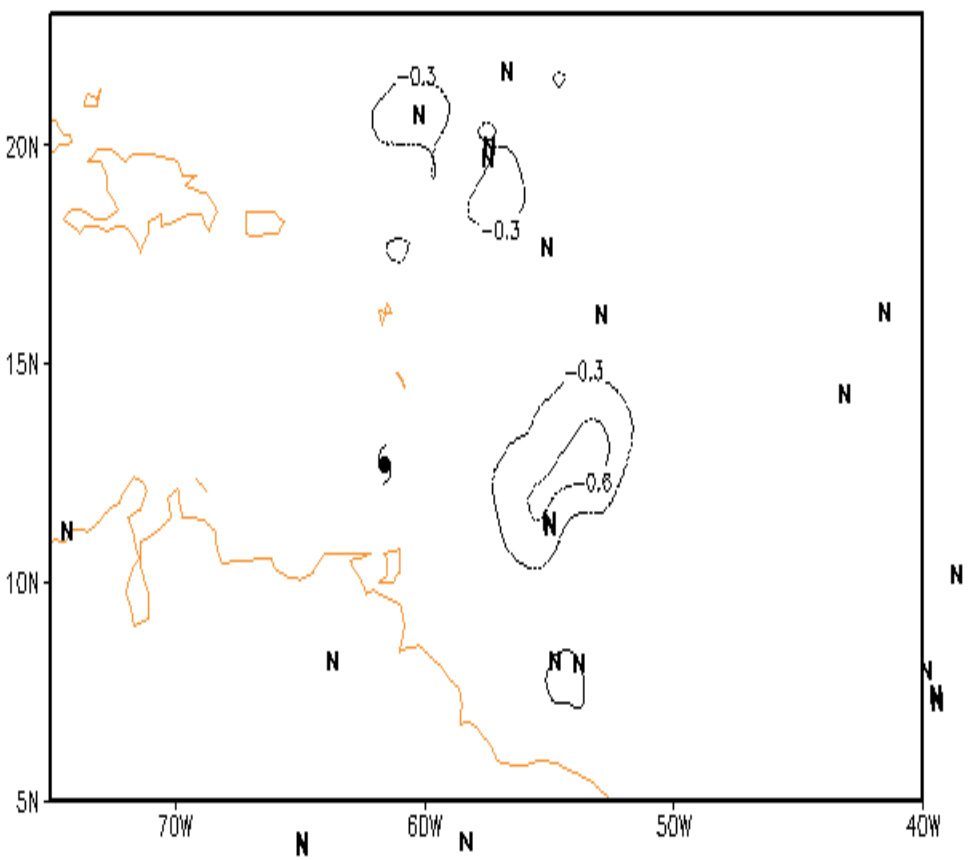
Daily Analysis Increments of Temperature (K), GPS-only run

(700 hPa, 23, 24, August 2006)

Aug 23



Aug 24



T increments are small

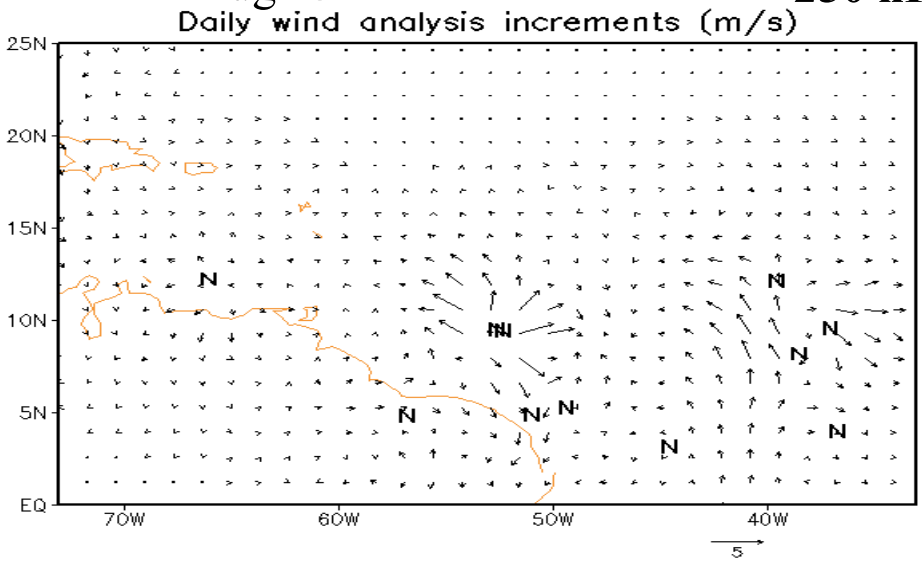
Daily Analysis Increments of Wind (m/s, GPS-only run)

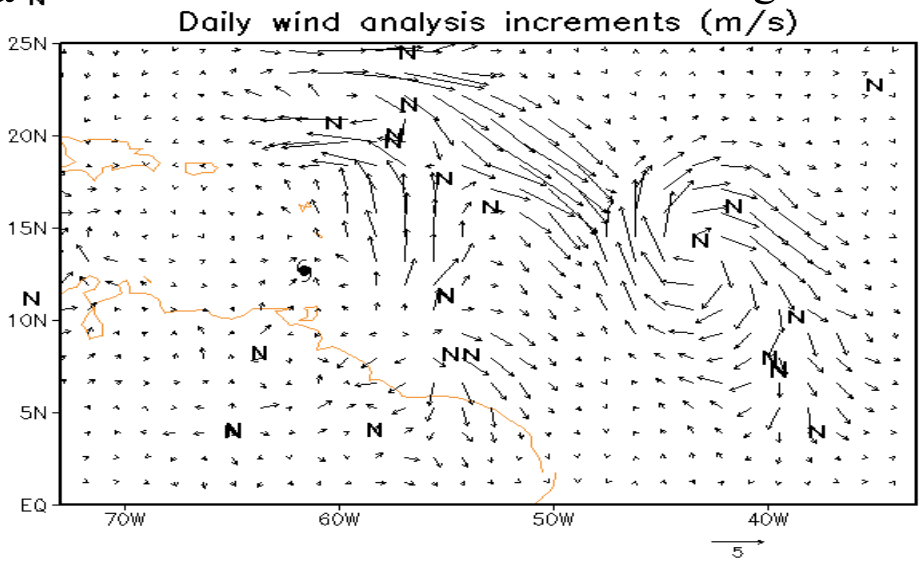
(23-24, August 2006)

Aug 23

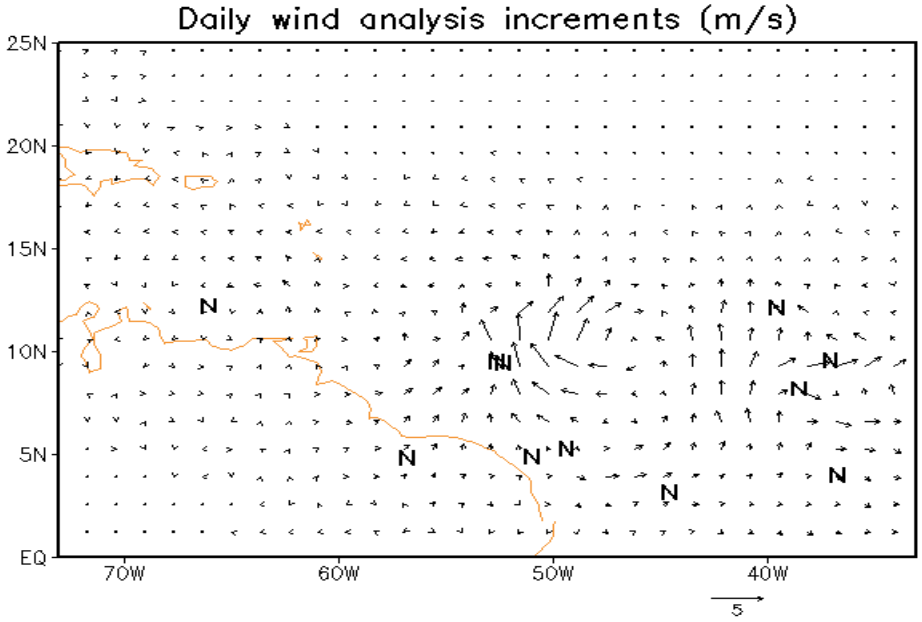
250 hPa

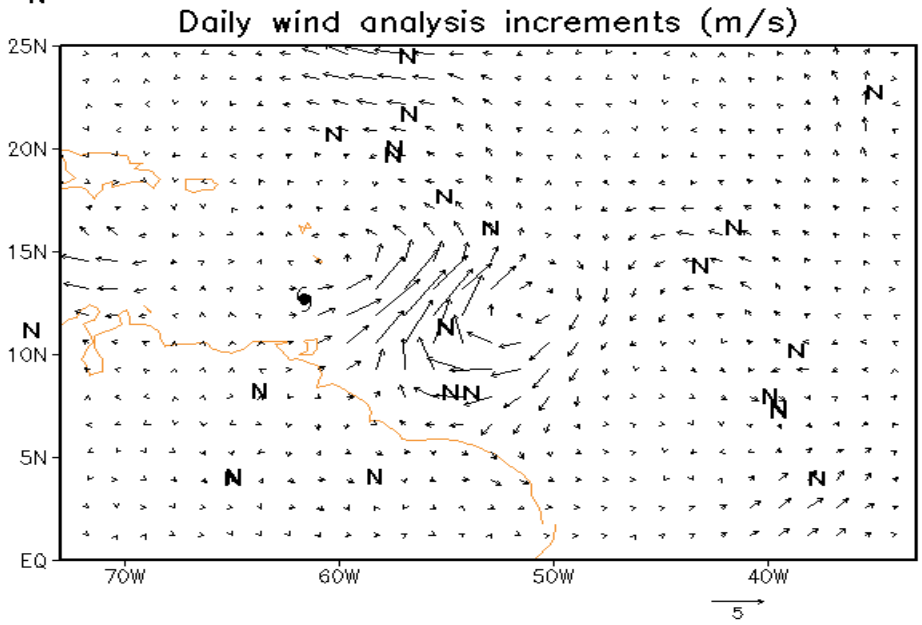
Aug 24





700 hPa

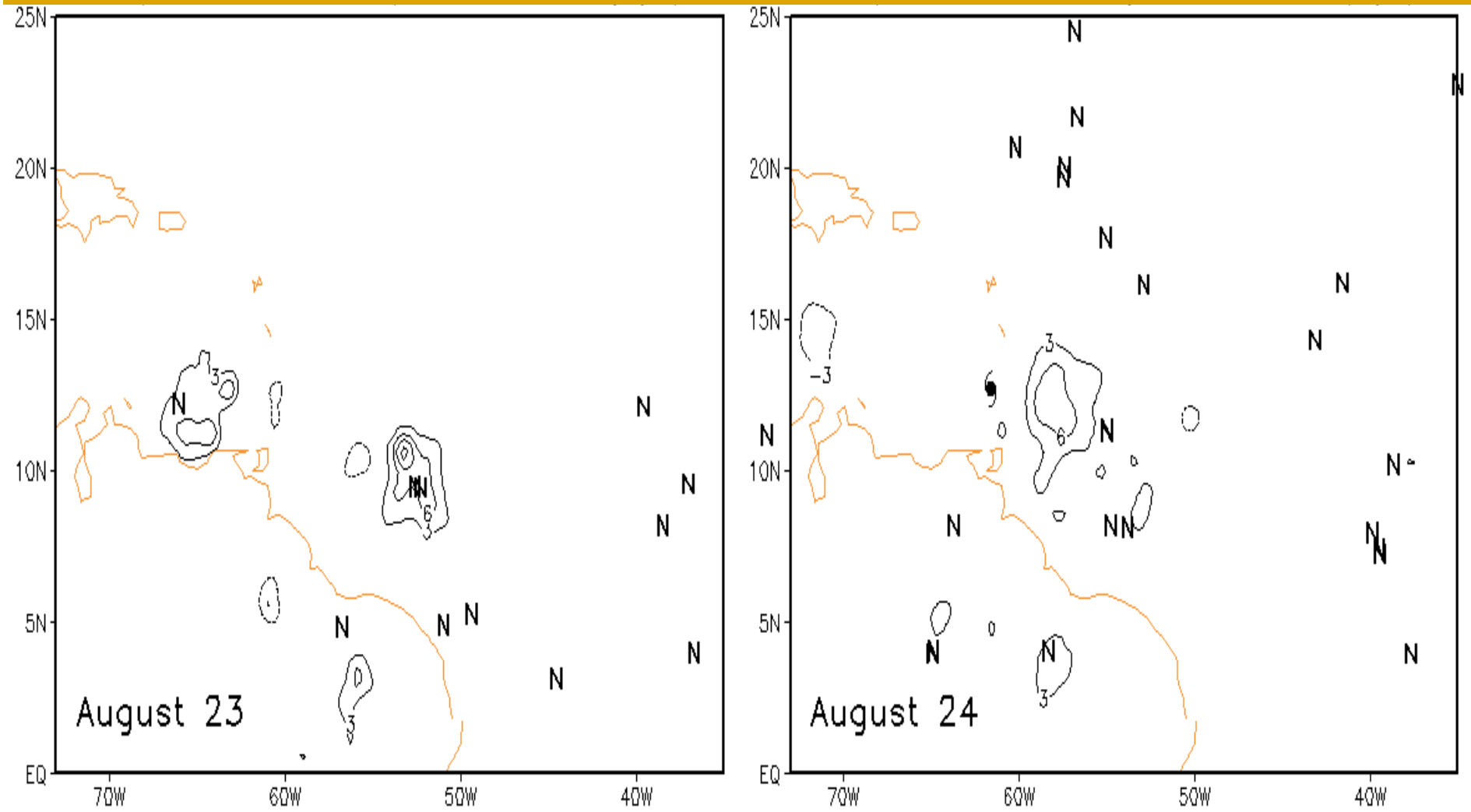




Daily Analysis Increments of Vertical Wind (cm/s, GPS-only run)

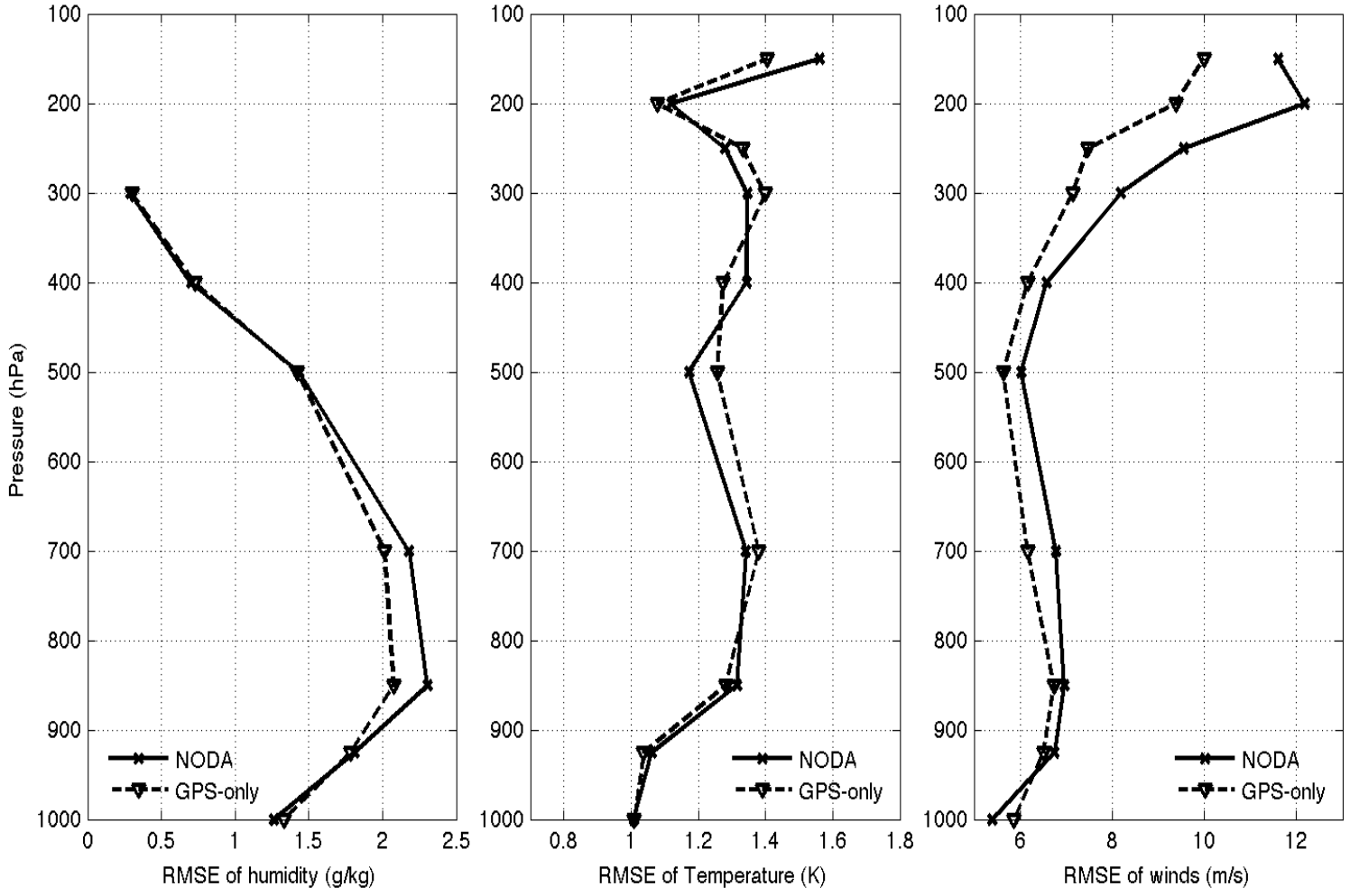
(23-24, August 2006)

Aug 23 **500 hPa** Aug 24



GPS data induces upward motions

Fits of 2-hour Forecasts to Radiosondes (GPS_only, 21-28 00Z, August 2006)



Water vapor and wind RMS errors are reduced

RO Data Assimilation Experiments (2)

- CTL run: Radiosondes (UV,T,Q), cloud winds, aircraft data (UV,T), Ps
- GPS run: same as CTL run + GPS refractivity
- Examine analyses of TC tracks with and without GPS data

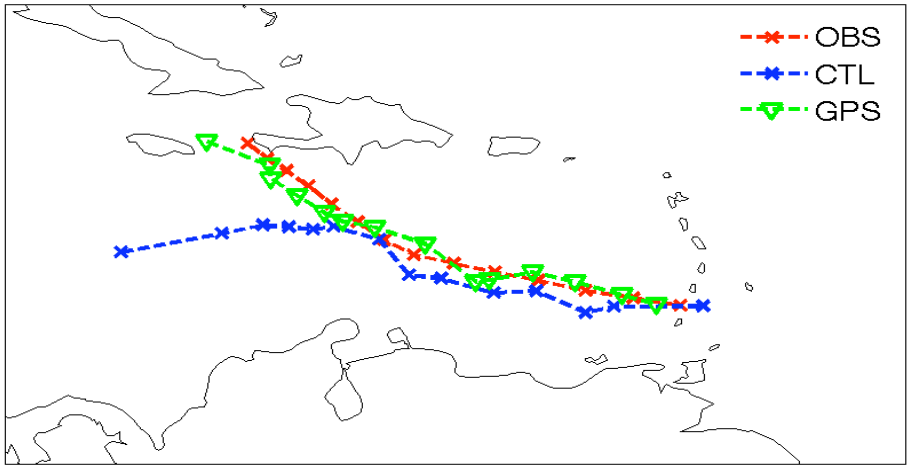
Analyses of 500 hPa height and SLP, UV

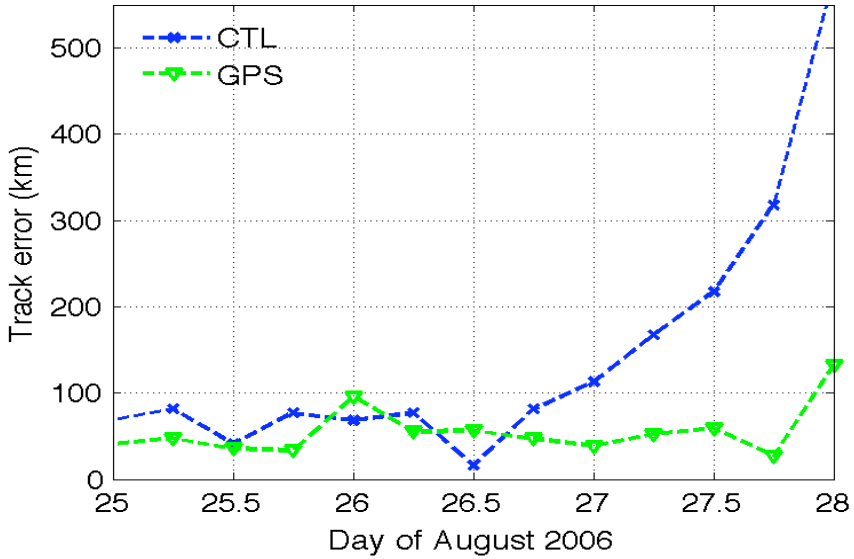
(initialized 00UTC 25, August 2006)

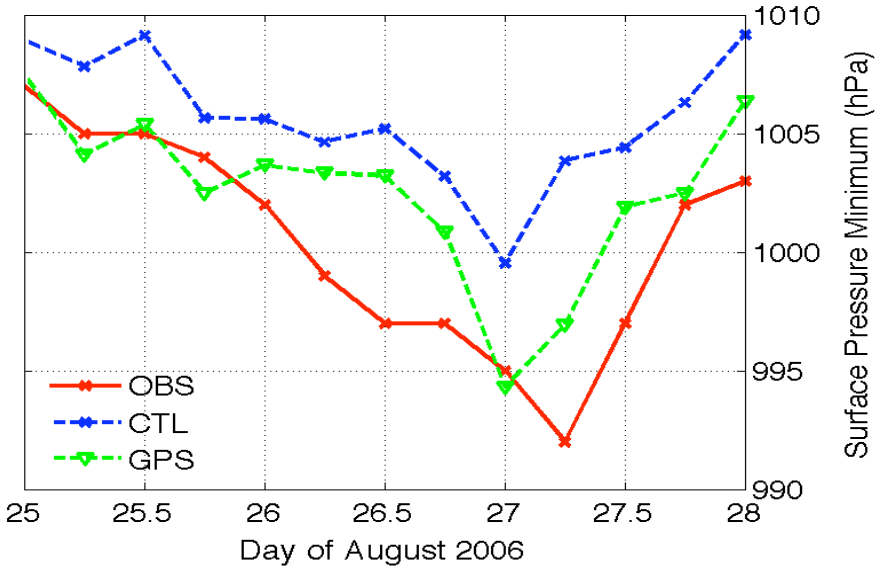
Track and MSLP errors are reduced

Analyses of Track and MSLP

(initialized 00UTC 25, August 2006)



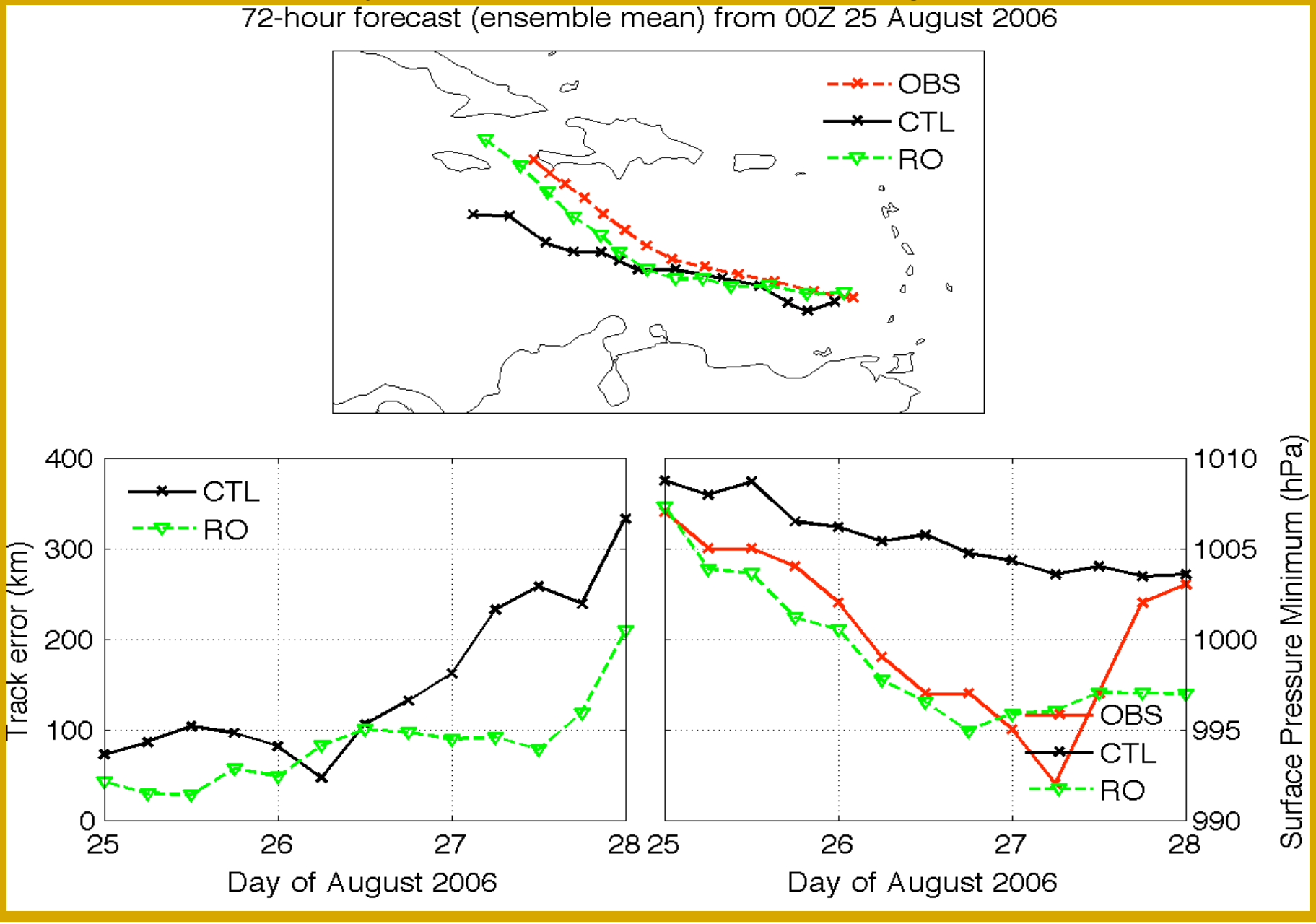




Track and MSLP errors are reduced

Track and MSLP 3-day Forecast

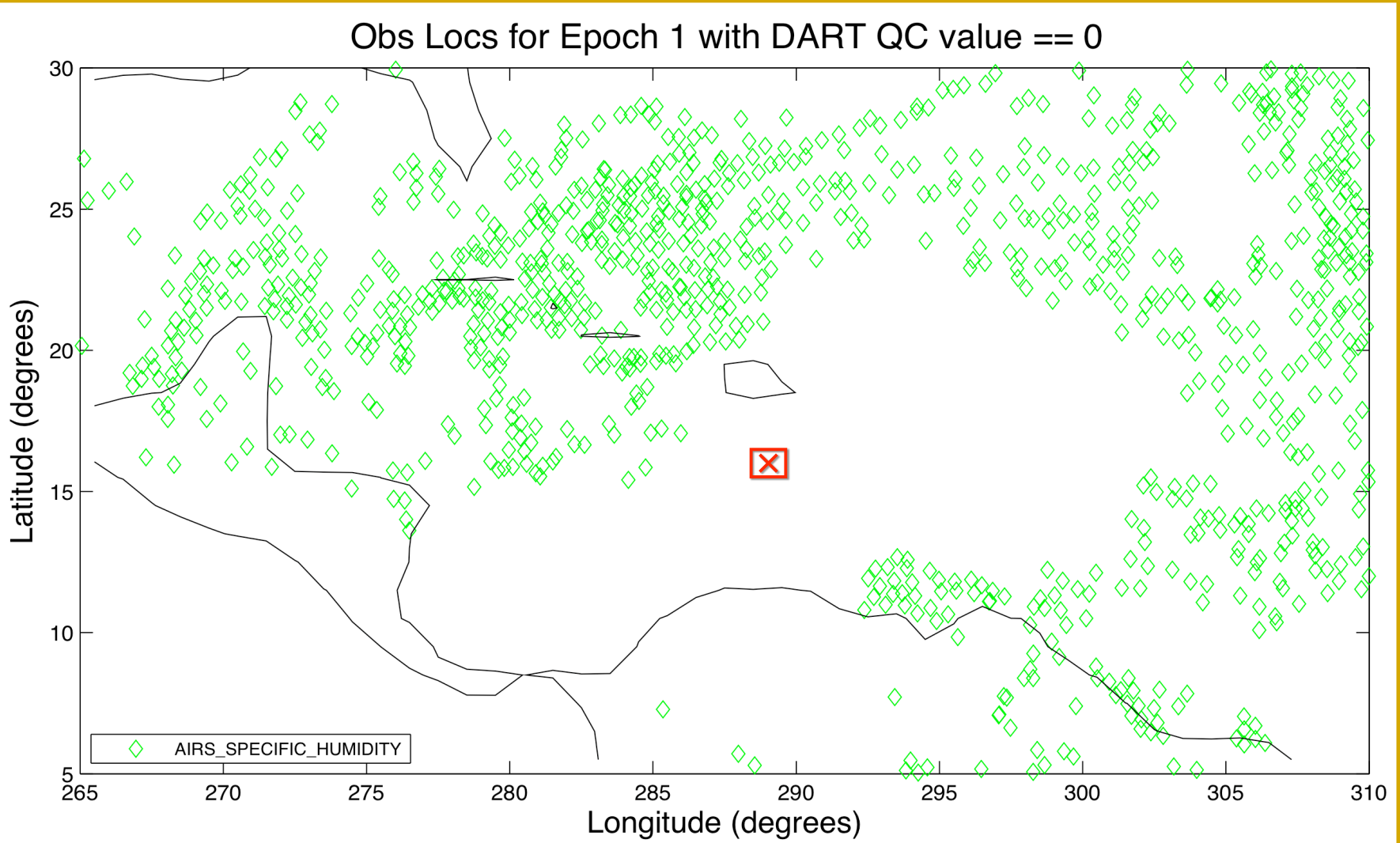
(after 4-days assimilation, from 00UTC 25, August 2006)



AIRS WV Assimilation Experiments (1)

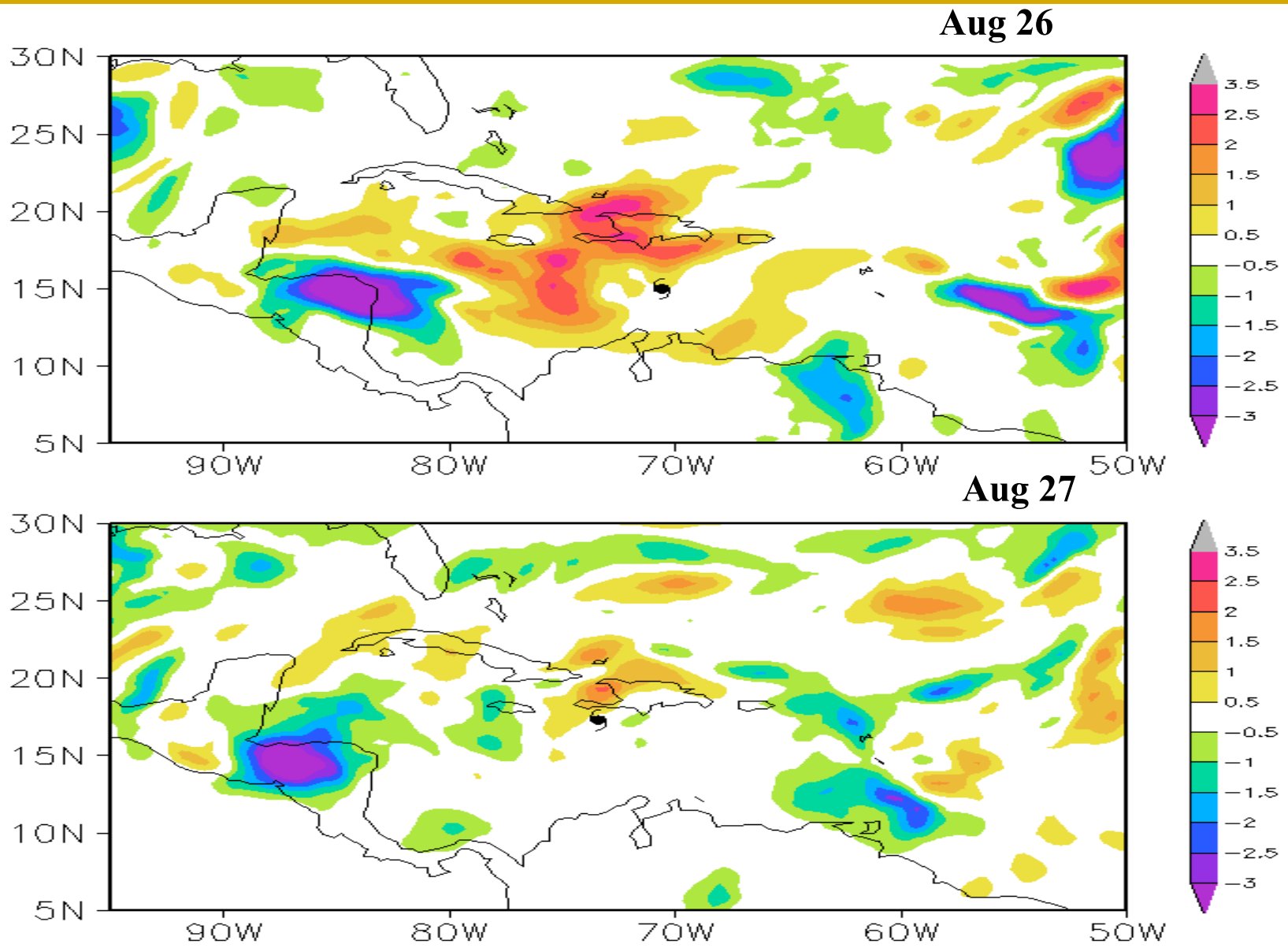
- Single field-of-view water vapor soundings (13.5 km at nadir) derived using CIMSS physical retrieval algorithm (Li et al. 2000)
- Clear sky only soundings are provided
- *AIRS-Q-only run*: Assimilation of only CIMSS Q soundings
- *NODA run*: Assimilation of no observations

AIRS WV data Coverage (August 26, 2006)

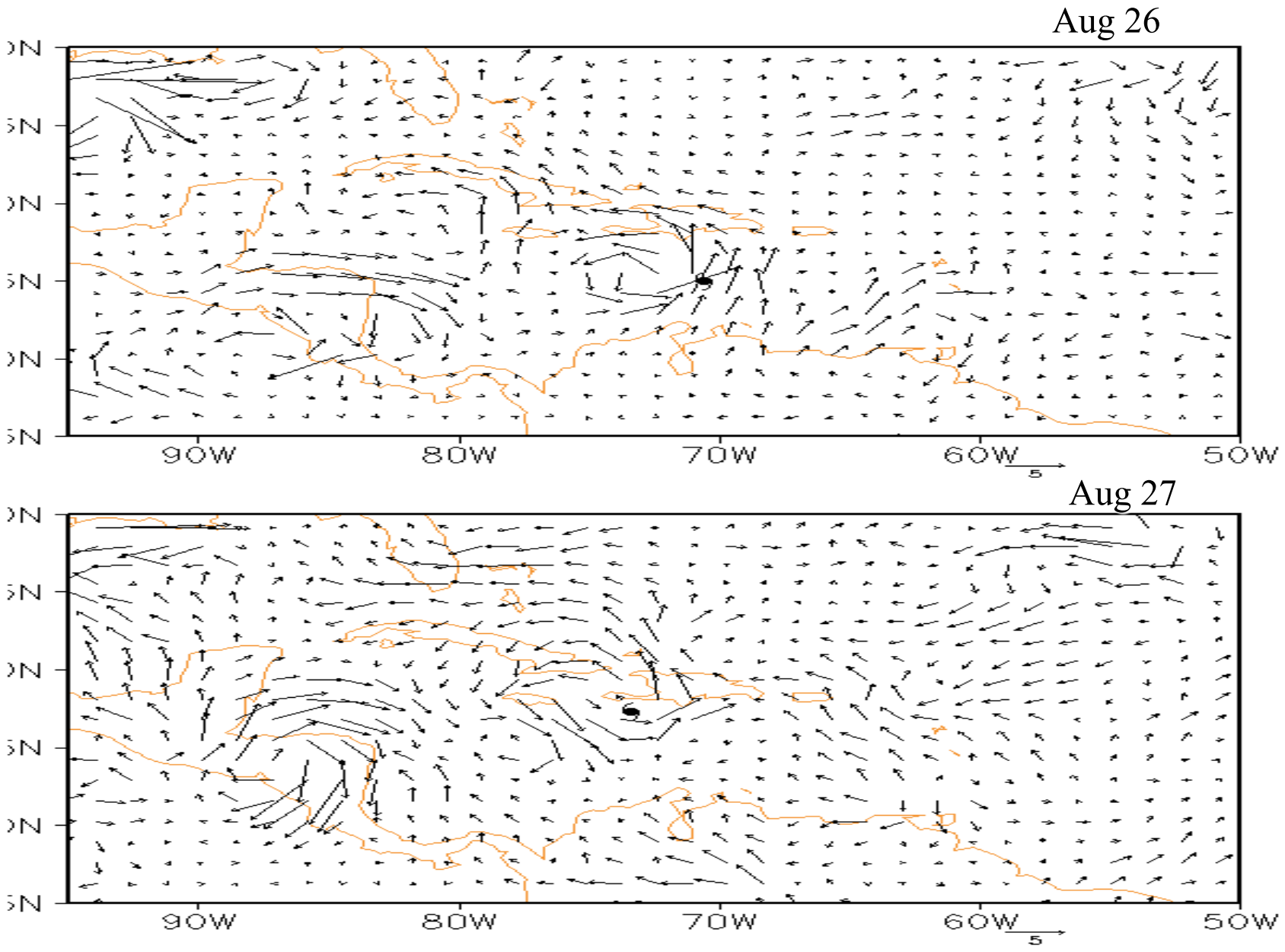


AIRS WV data coverage is much denser than GPS RO data in 2006

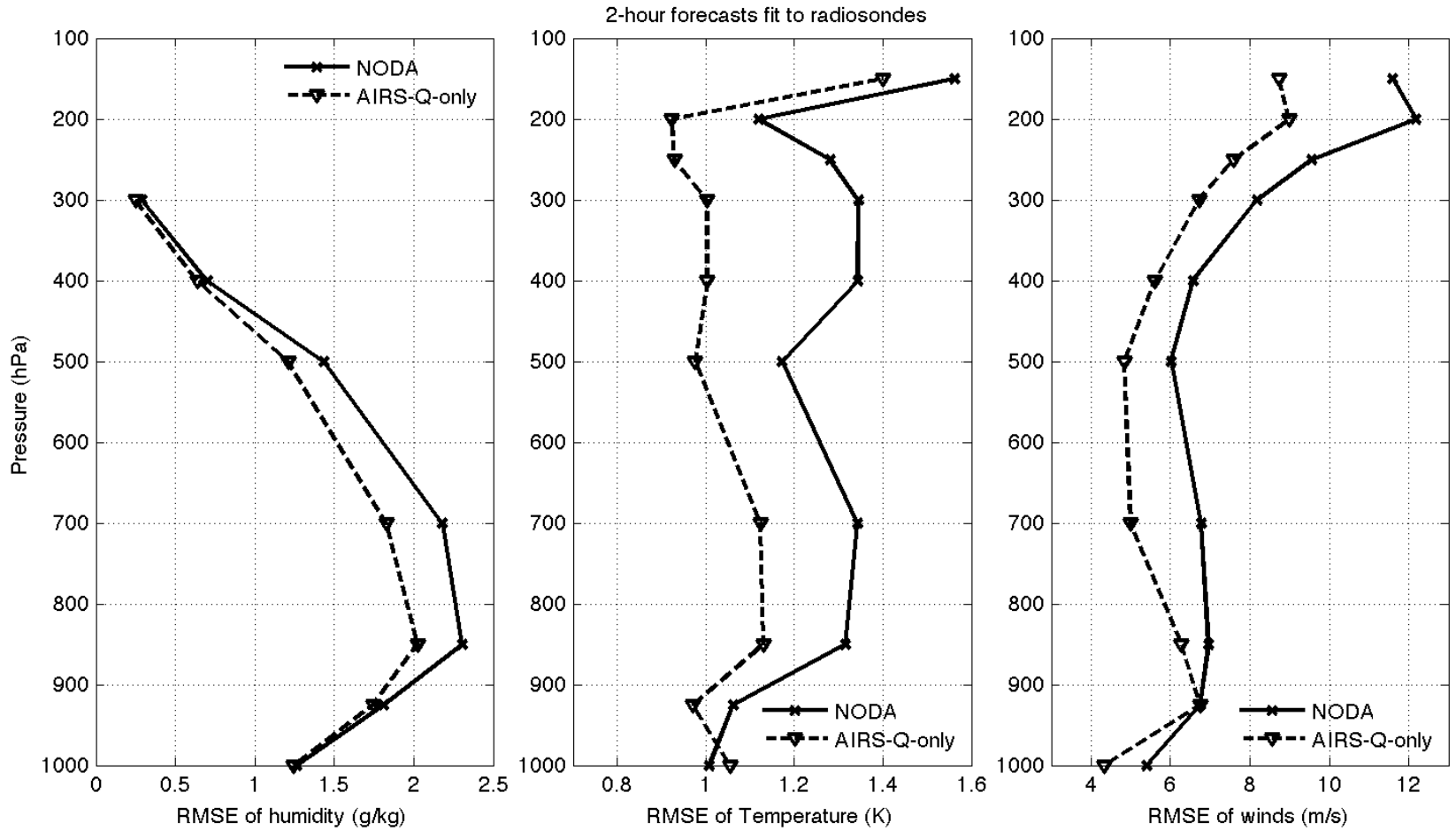
Daily water vapor increments (700mb, AIRS-Q-only run)



Daily wind analysis increments (700mb, AIRS-Q-only run)



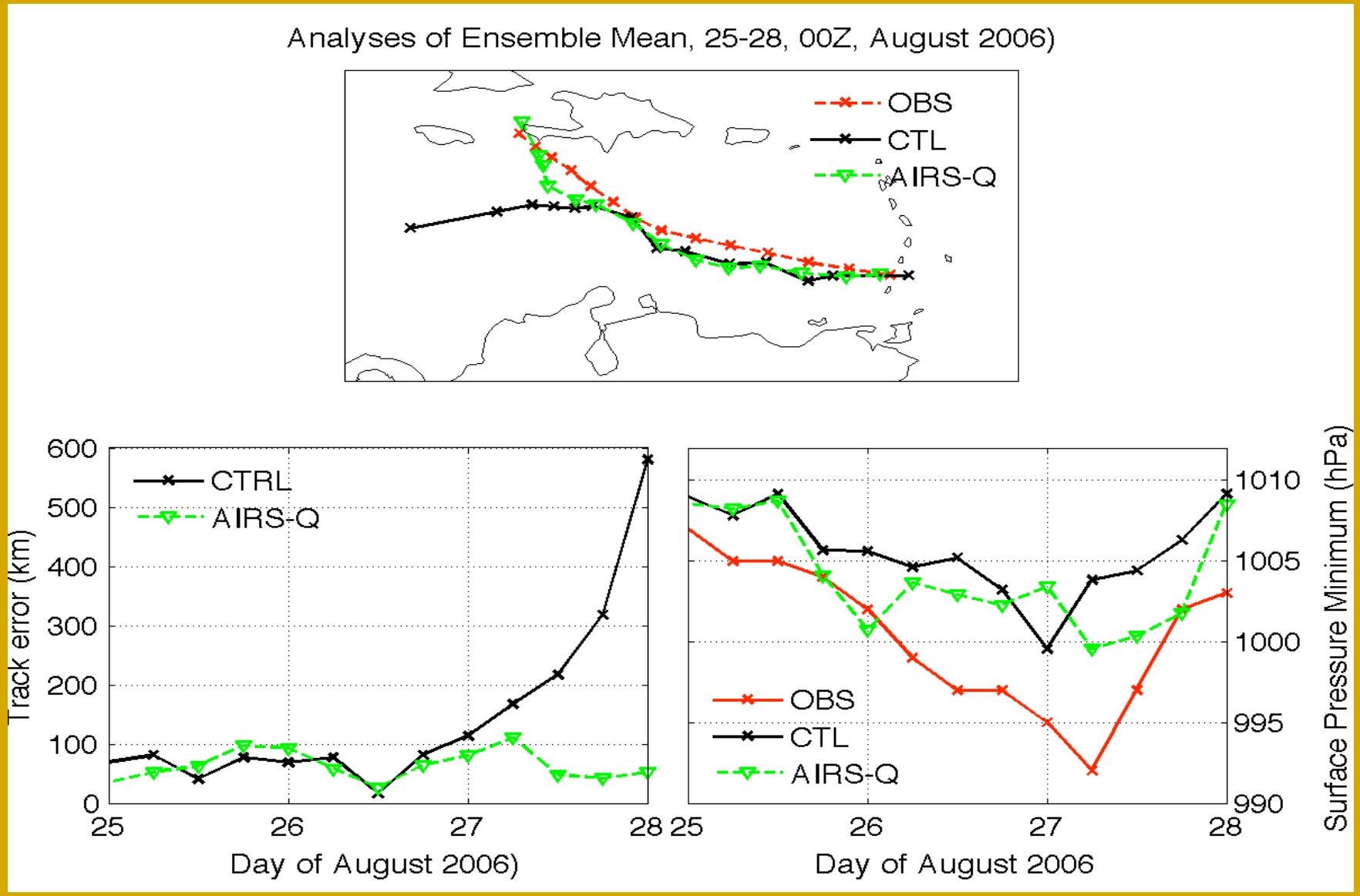
2-hour Forecasts Fits to Radiosonde (22-28, August 2006)



AIRS Assimilation Experiments (2)

- *CTL run*: Assimilate radiosonde, cloud winds, aircraft data, surface pressure data.
- *AIRS-Q run*: Same as CTL run plus CIMSS Q soundings.

Ensemble mean analyses on Hurricane Ernesto



Conclusion

- Satellite Q/T data in the environment of the TC can generate reasonable water vapor, temperature, and wind analysis corrections in TC environment and center through ensemble DA
- These data shows benefits in improving analyses of the hurricane track and intensity