Initialization of the Environment of Tropical Cyclogenesis by Assimilating RO Data using an Ensemble Filter

Hui Liu

IMAGE/COSMIC/NCAR

Acknowledgements:

J. Anderson, B. Kuo, C. Snyder, and Y. Chen

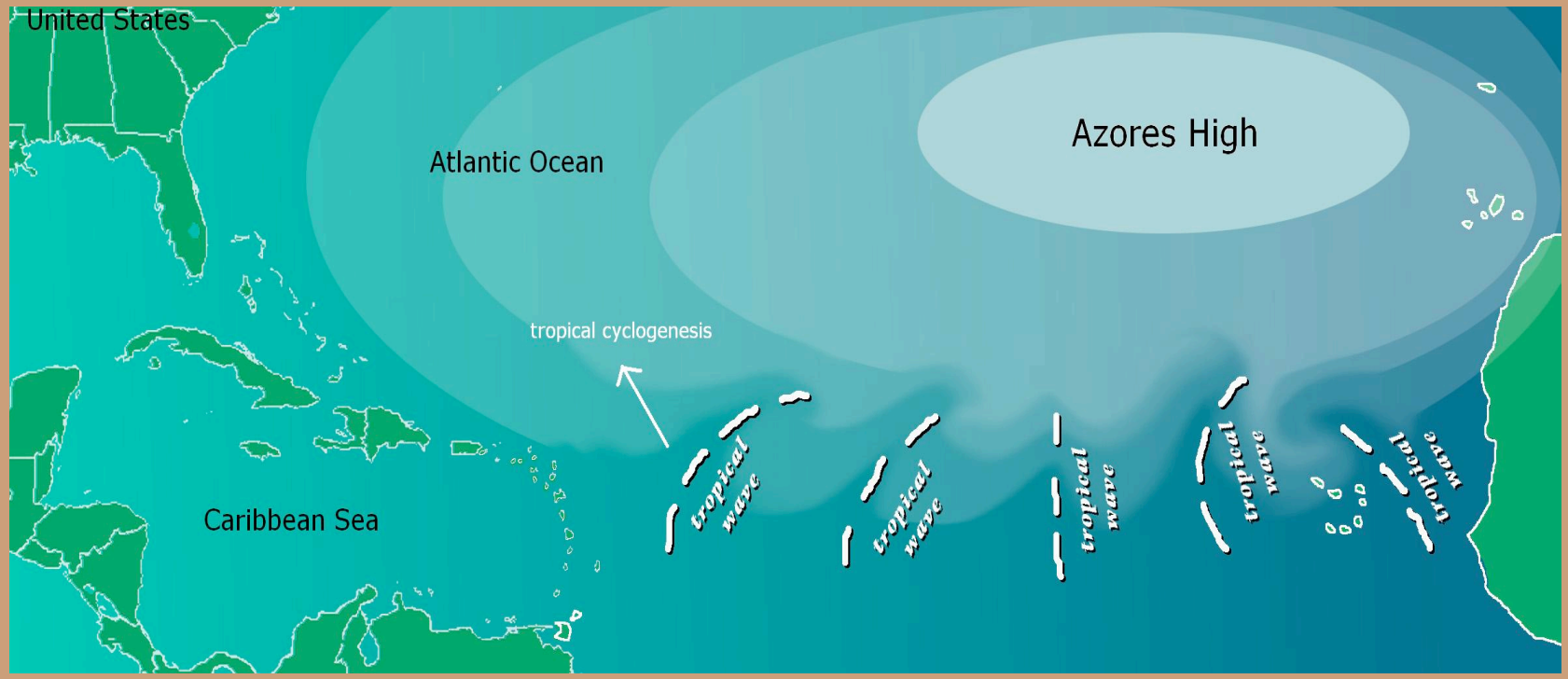
Motivation

- 3-D water vapor, temperature, and wind of the environment are crucial for tropical cyclogenesis.
- Wind information is mainly obtained by tracking cloud and water vapor; not available under all weather conditions.
- Can wind information be obtained through data assimilation of RO refractivity?
- In tropics, circulation of convective systems is driven by latent heat and related to water vapor.
- Ensemble data assimilation offers an ability to explore this.

Features of Ensemble Filtering

- Use online ensemble forecasts to estimate full forecast error covariance including the correlation of water with winds.
- Covariance is weather system dependent.
- Wind can be updated through the error covariance by assimilation of RO observations.

Application of RO data in Initialization of Tropical Cyclogenesis



• Can RO refractivity profiles provide 3-D water vapor, temperature, and wind information in the easterly wave area?

• Can assimilating an RO profile have significant impact on the initialization of easterly waves and how?

RO-only assimilation experiments for Hurricane Ernesto (2006)

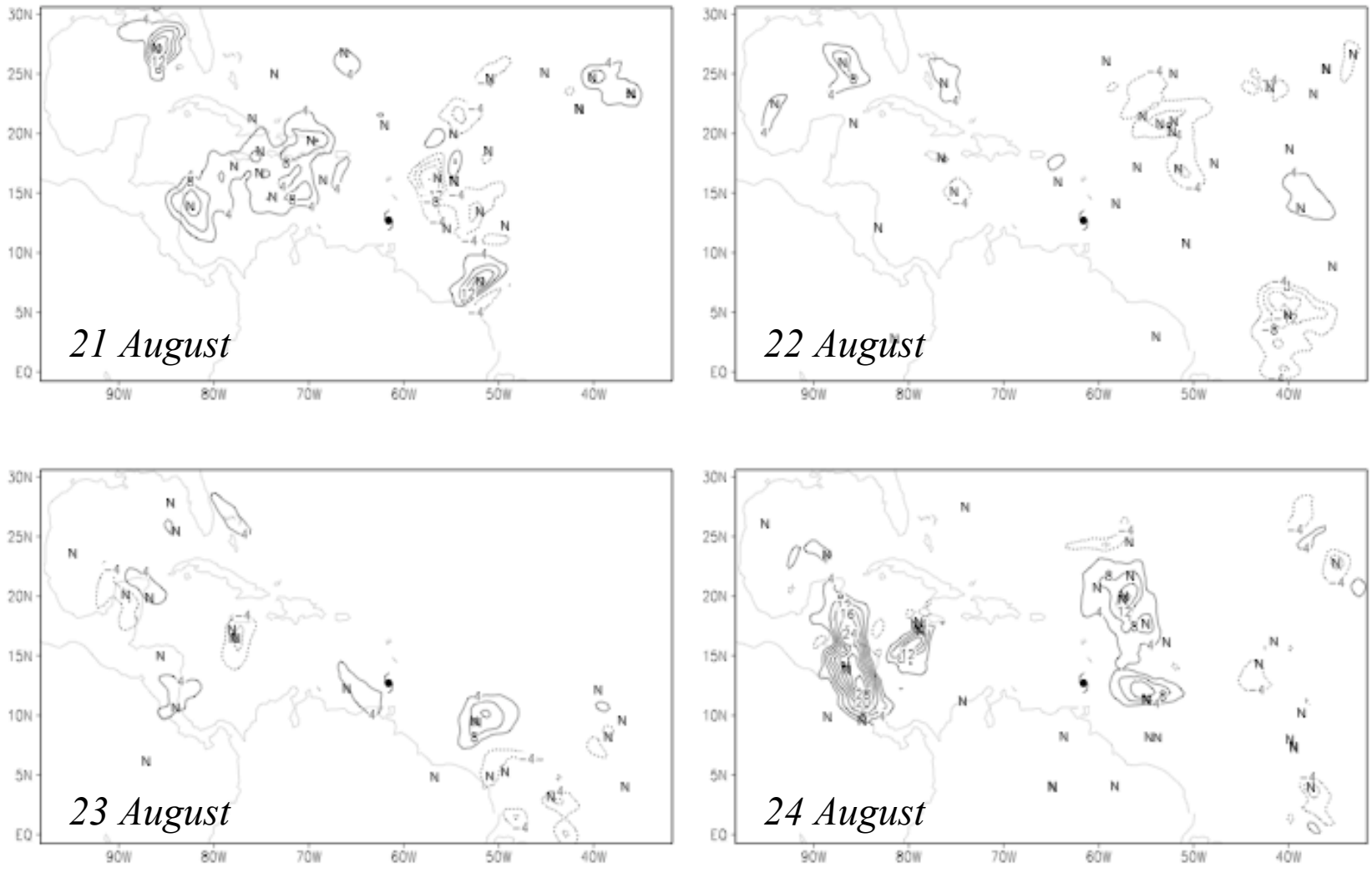
- Hurricane Ernesto originated from an easterly wave and formed as a depression on 18Z August 24, 2006 over Atlantic.
- Assimilation experiments using WRF/DART ensemble assimilation system for 21-25 August 2006:

  36 ensemble members, 36km resolution;

  Continuously 2-hourly cycling.
- *NODA run*: No data assimilation.
- *RO-only run*: Assimilate only RO refractivity profiles.

Daily Analysis Increments of RO refractivity

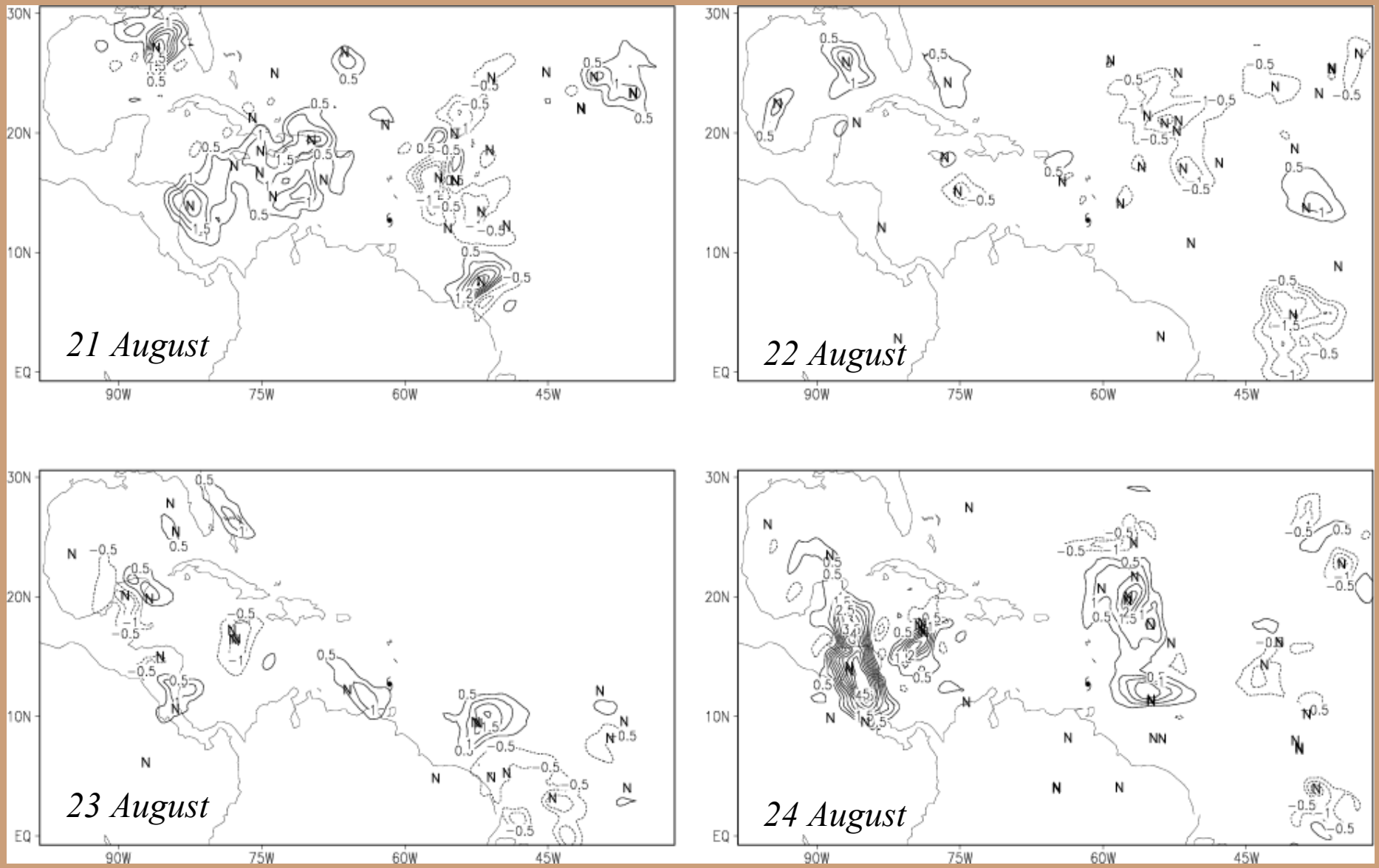
(700mb, 21-24 August)



"N" shows the locations of RO profiles.

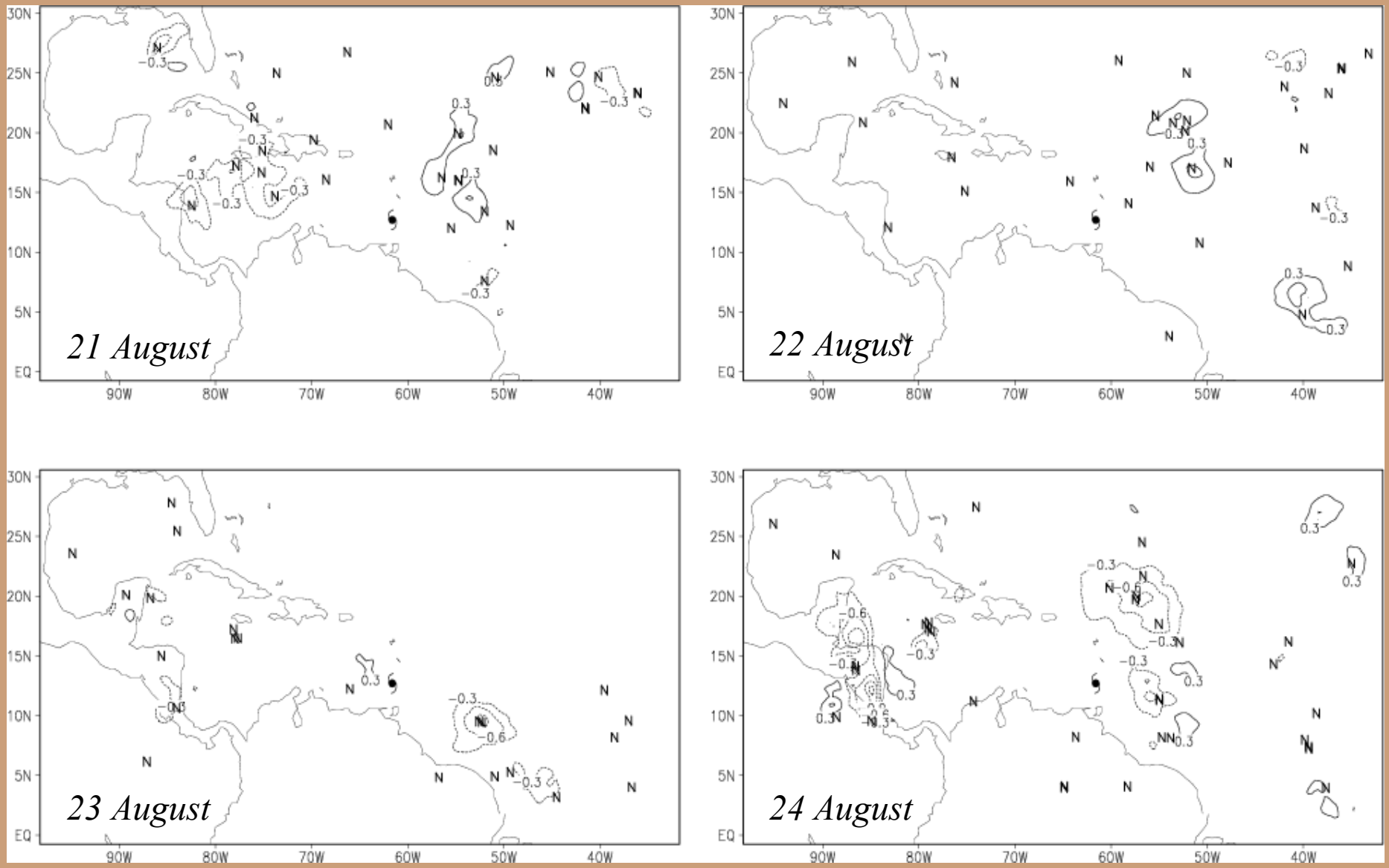
Daily Analysis Increments of Water Vapor

(700mb, 21-24 August)



Daily Analysis Increments of Temperature

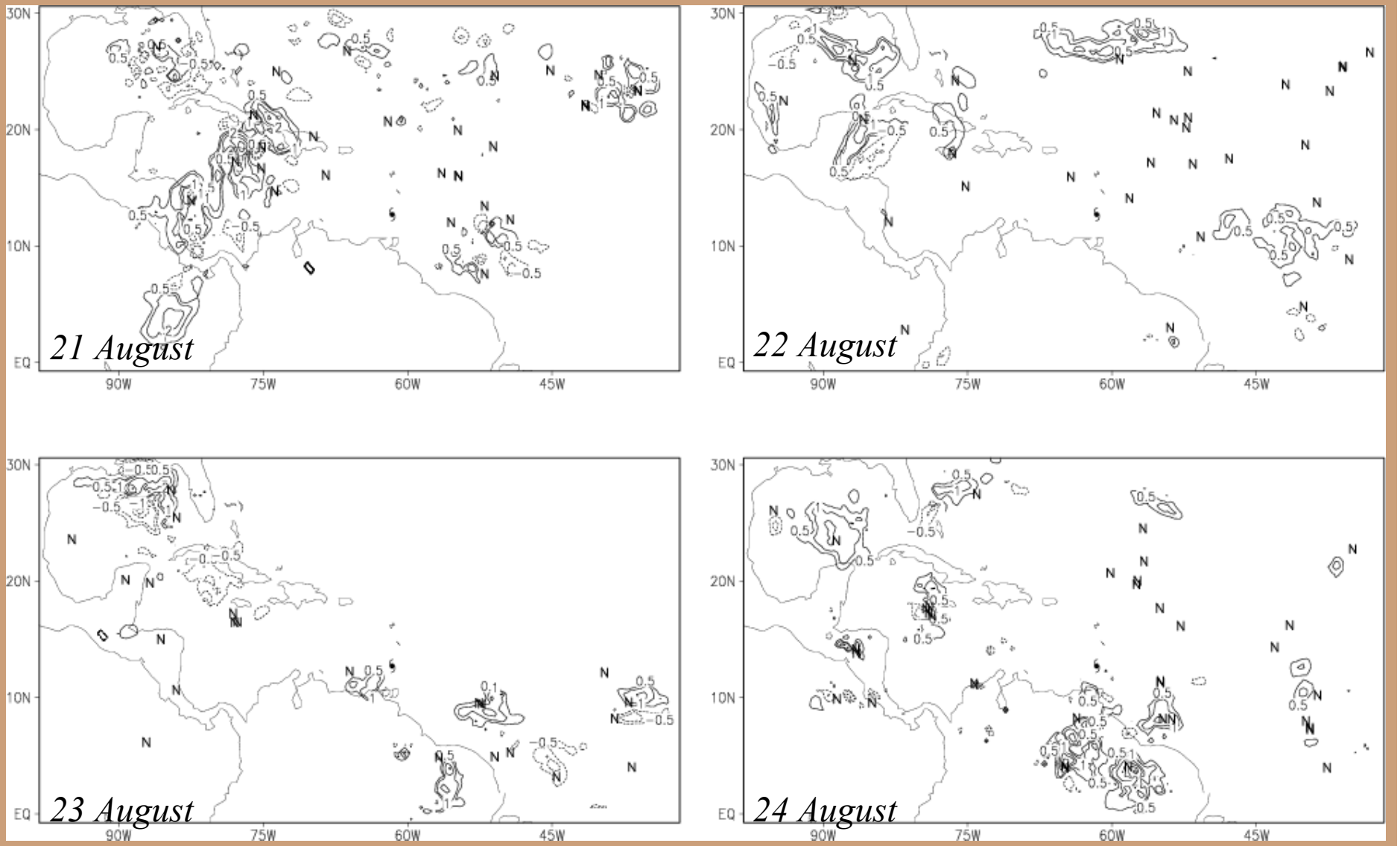
(700mb, 21-24 August)



T increments are small.

Daily Analysis Increments of Integrated Cloud Water

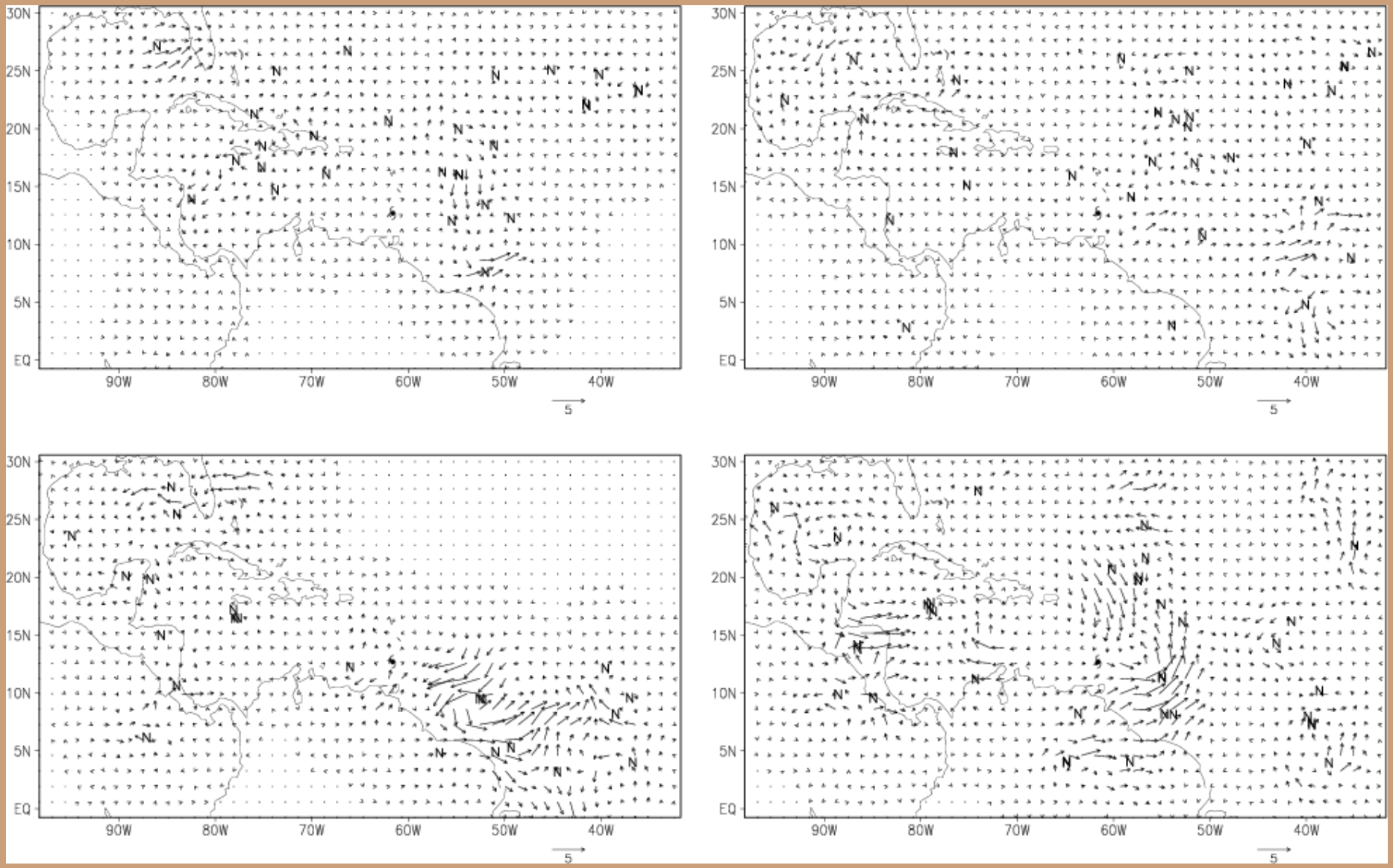
(21-24 August)



Cloud water is also modified/corrected by RO data.

Daily Analysis Increments of Low-Level Wind

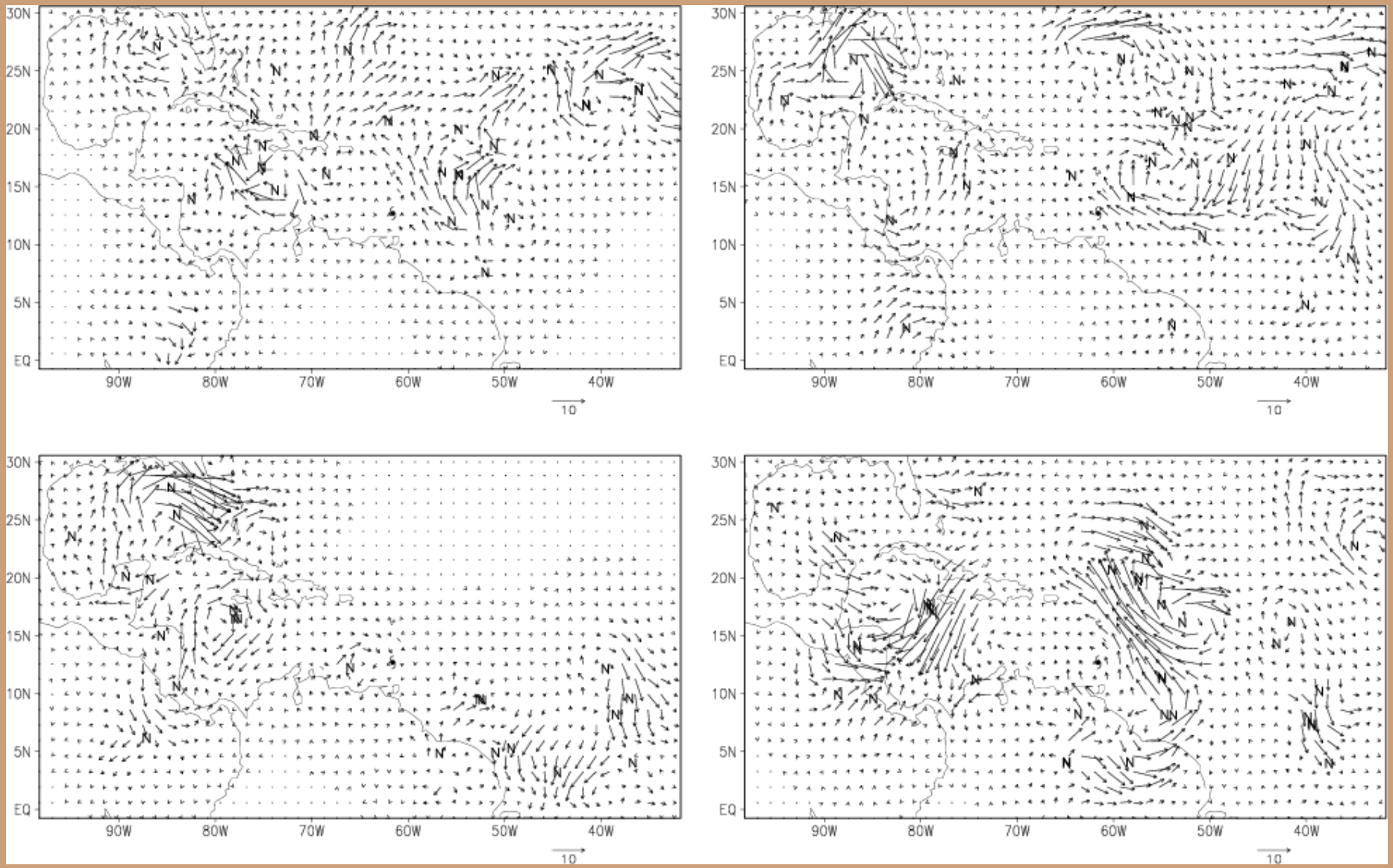
(700mb, 21-24 August)



Cyclonic circulation at low-levels is induced by RO data.

Daily Analysis Increments of Upper-Level Wind

(300mb, 21-24 August)

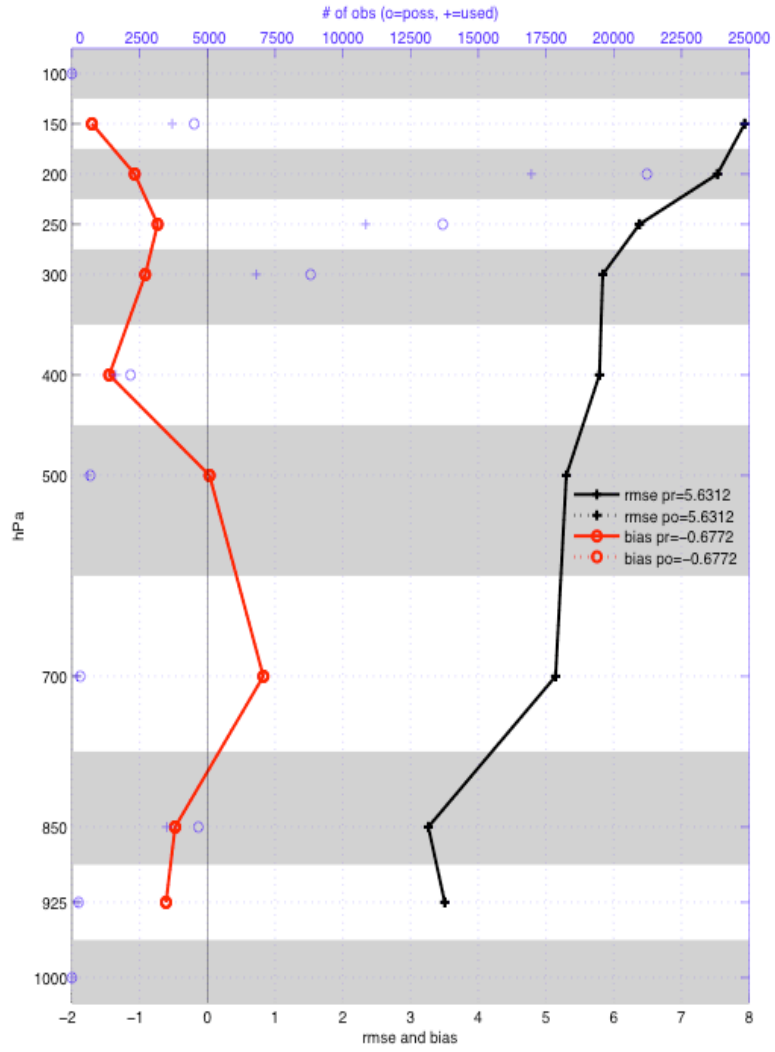


Anti-cyclonic circulation at upper-levels is induced by RO data.

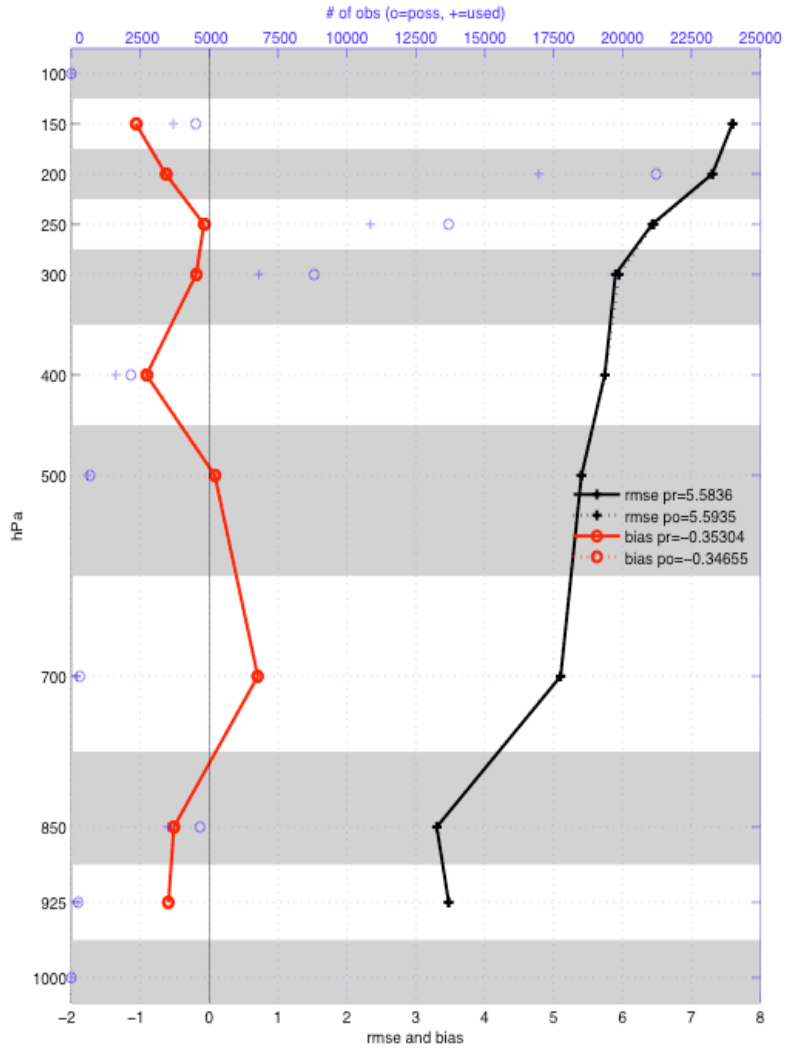
Verification to Independent Satellite Wind Observations

(August 21-24)

NODA run



RO-only run

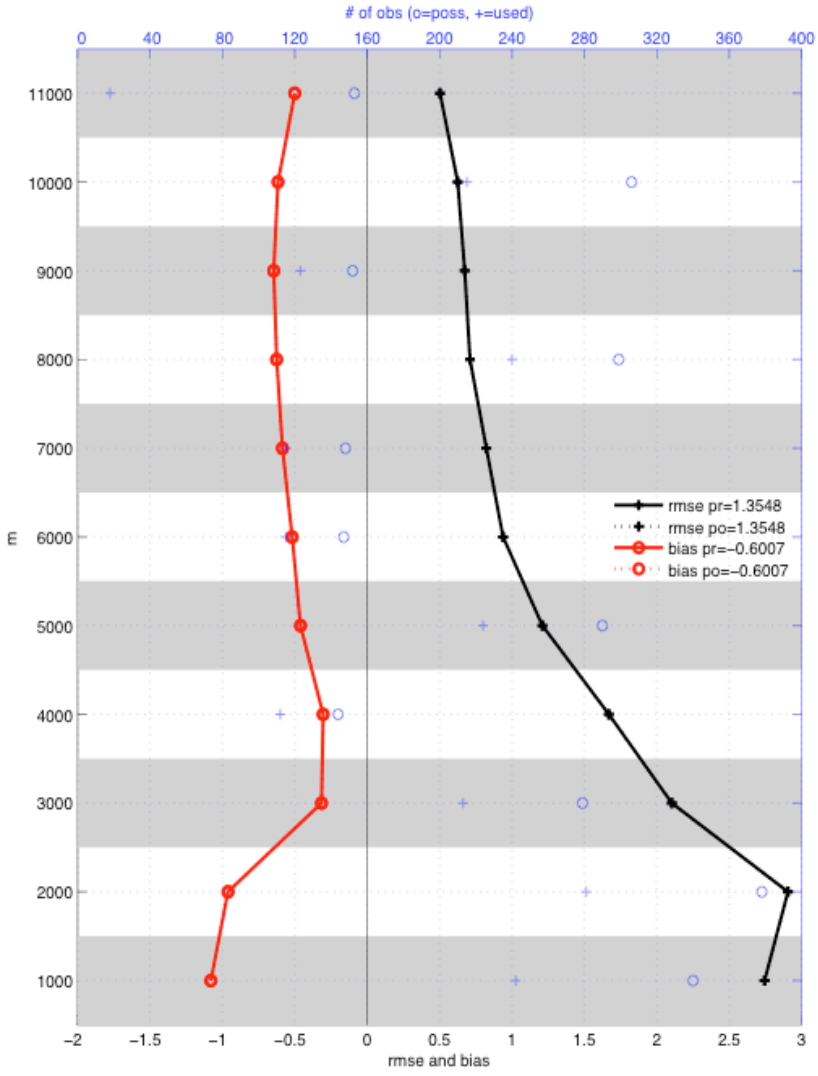


Bias of the analysis with RO data is reduced in the middle and upper levels.

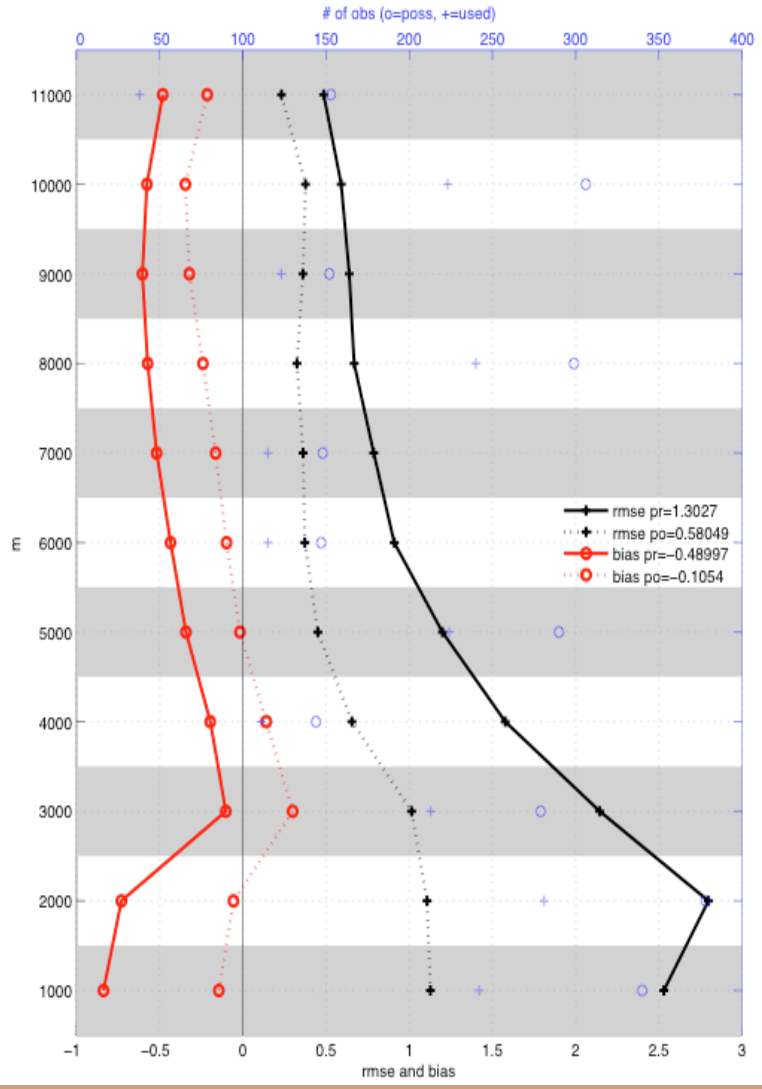
Verification of forecasts to RO Refractivity Observations

(August 21-24)

NODA run



ROonly run



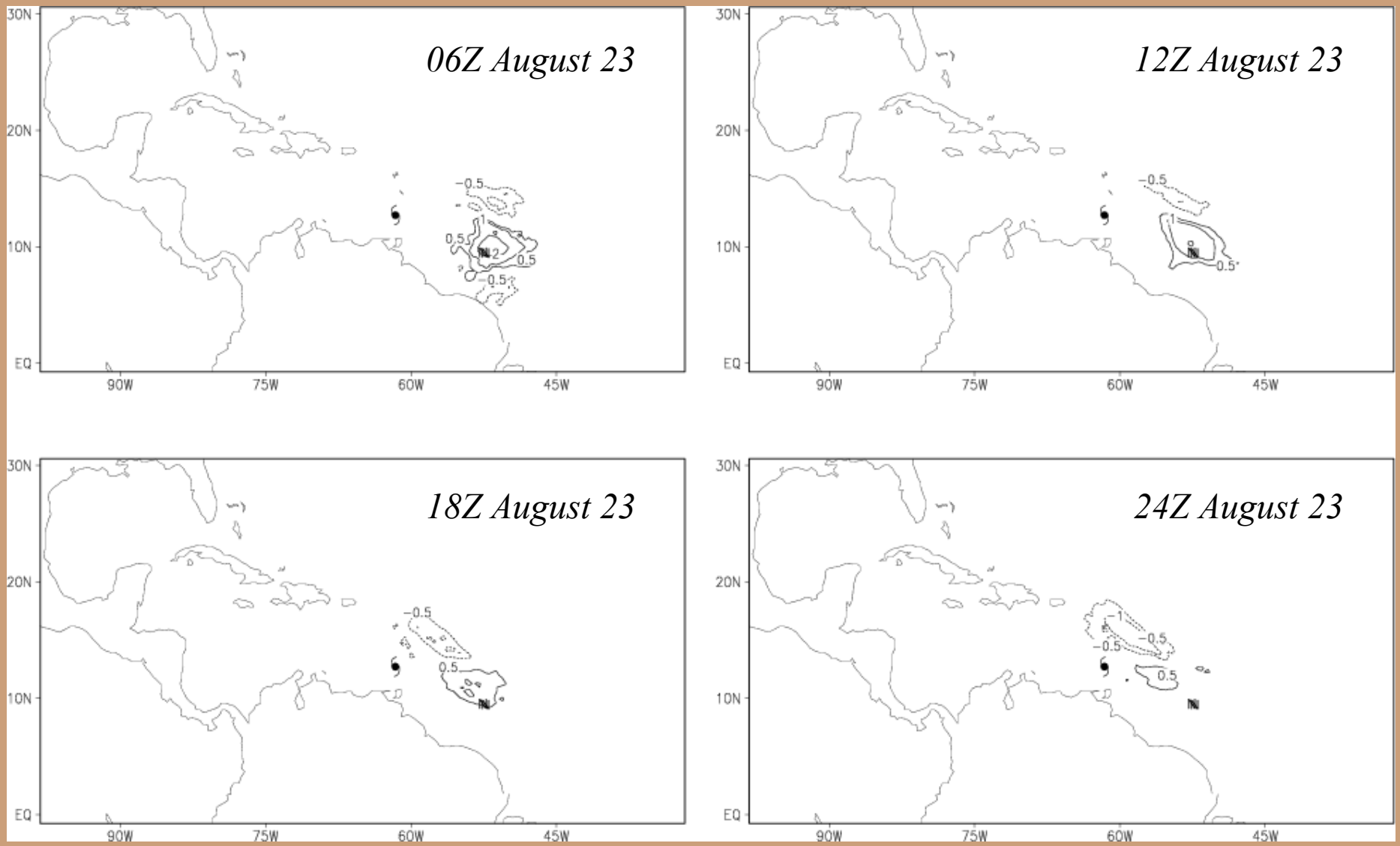
Bias and RMS error of the forecast with RO data is reduced at lower levels.

Selected RO Profiles Assimilation Experiments

- *S1 run*: assimilate ONLY two co-located RO refractivity profiles on 0510UTC and 0636UTC, August 23 (~52.3W, 9.5N).
- *S2 run*: assimilate ONLY two co-located RO refractivity profiles on 0508UTC, August 24 (~56W, 11.4N).
- Examine time evolution of resulting differences in water vapor and winds.

Evolution of Analysis Increment of Water vapor (S1)

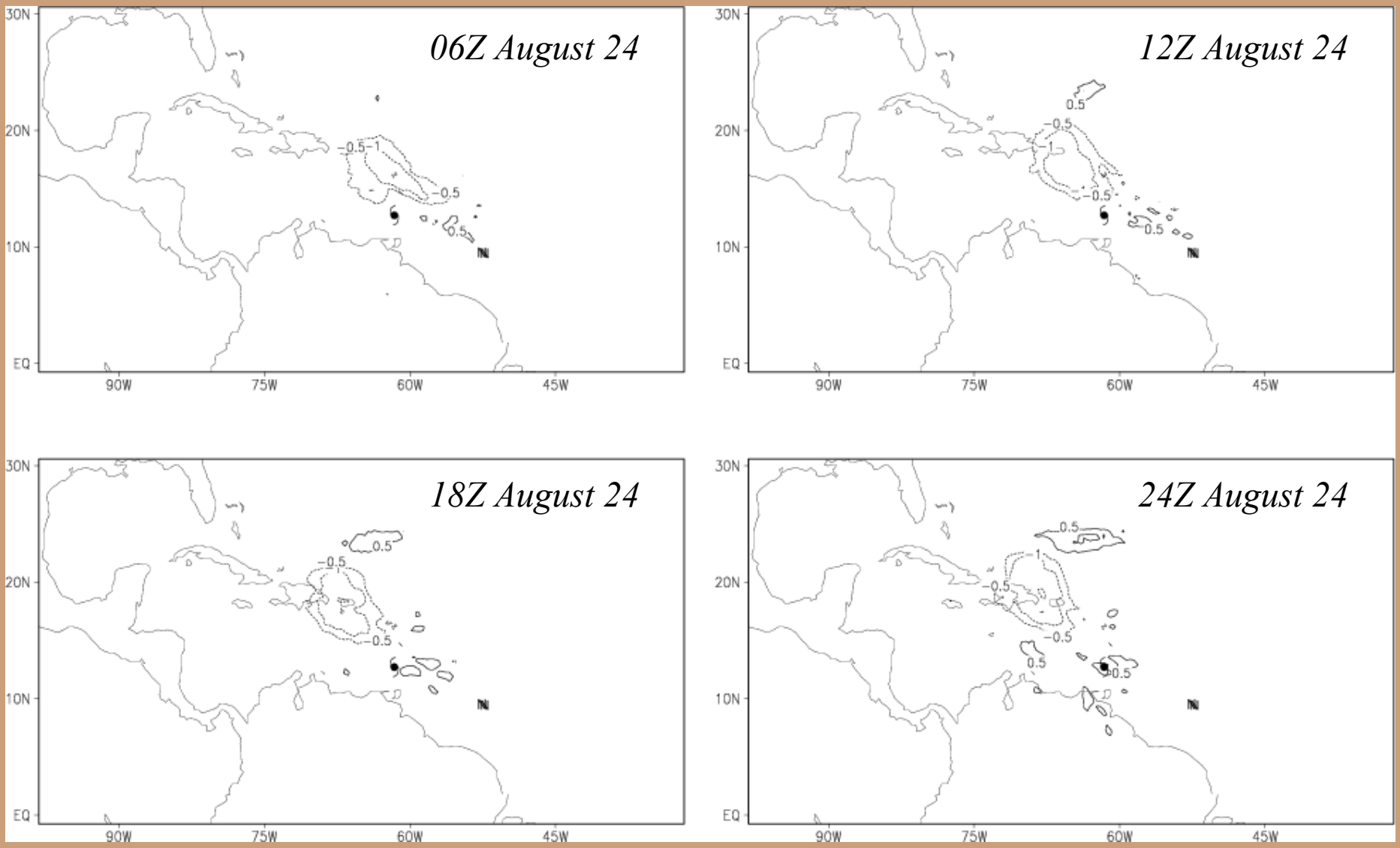
(850mb, 06Z August 23-24Z August 23, start 42-hours before TC genesis)



Water vapor differences decrease with time, small after ~18 hours.

Evolution of Analysis Increment of Water vapor (S1)

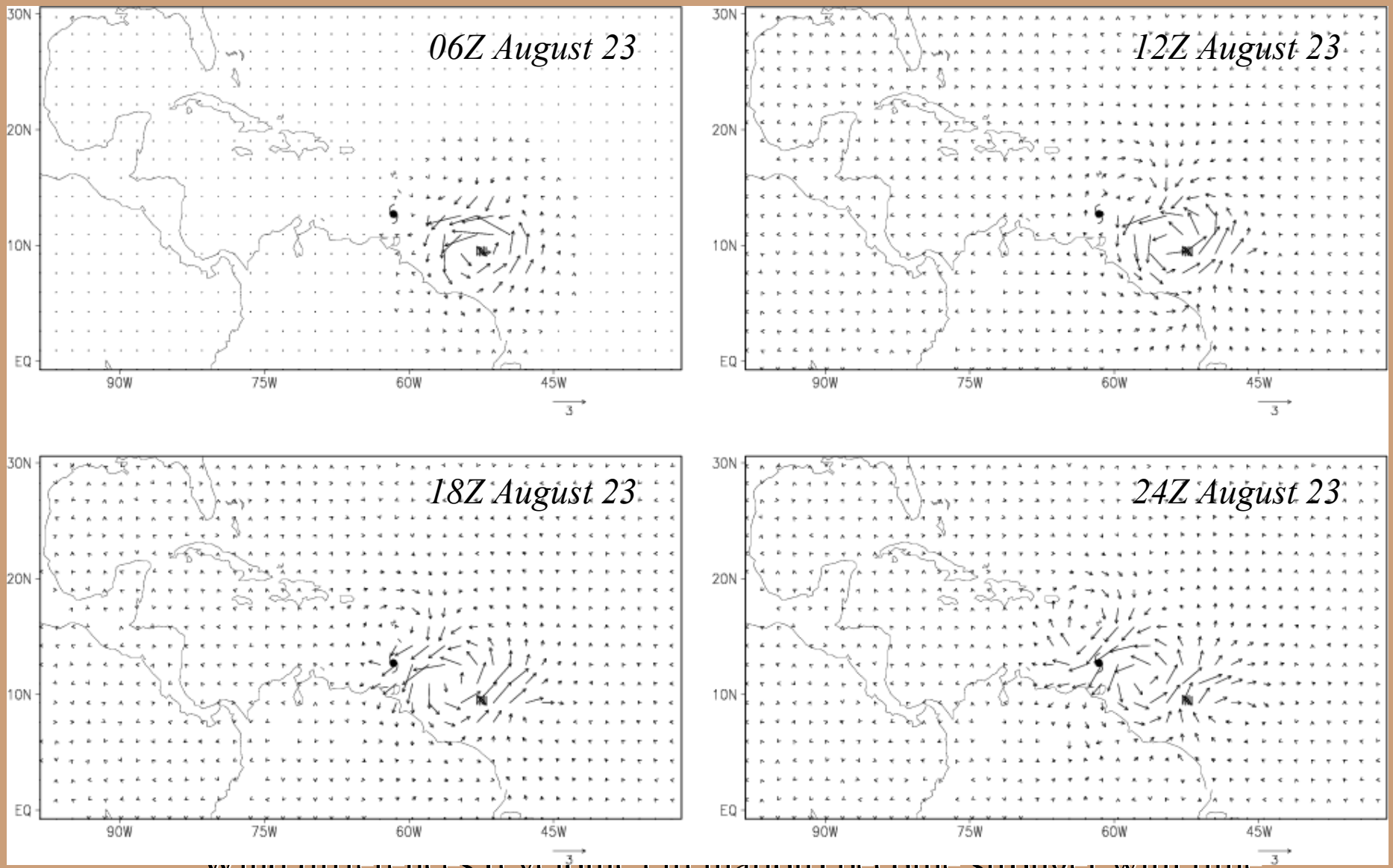
(850mb, 06Z August 24 - 24Z August 24)



Water vapor differences small after first day.

Evolution of Analysis Increment of Wind (S1)

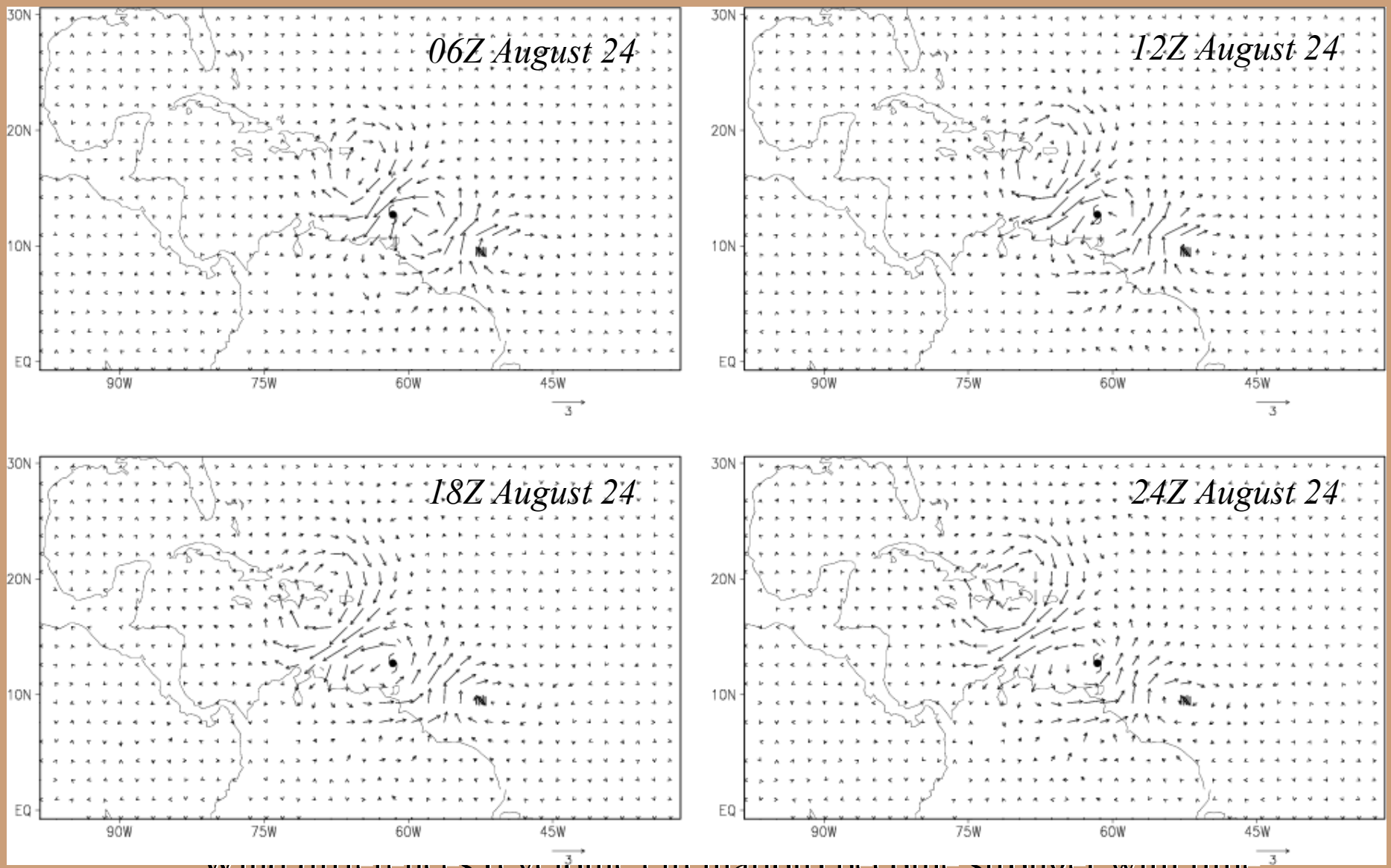
(850mb, 06Z August 23 - 24Z August 23)



Wind differences (cyclone circulation) become stronger with time.

Evolution of Analysis Increment of Wind (S1)

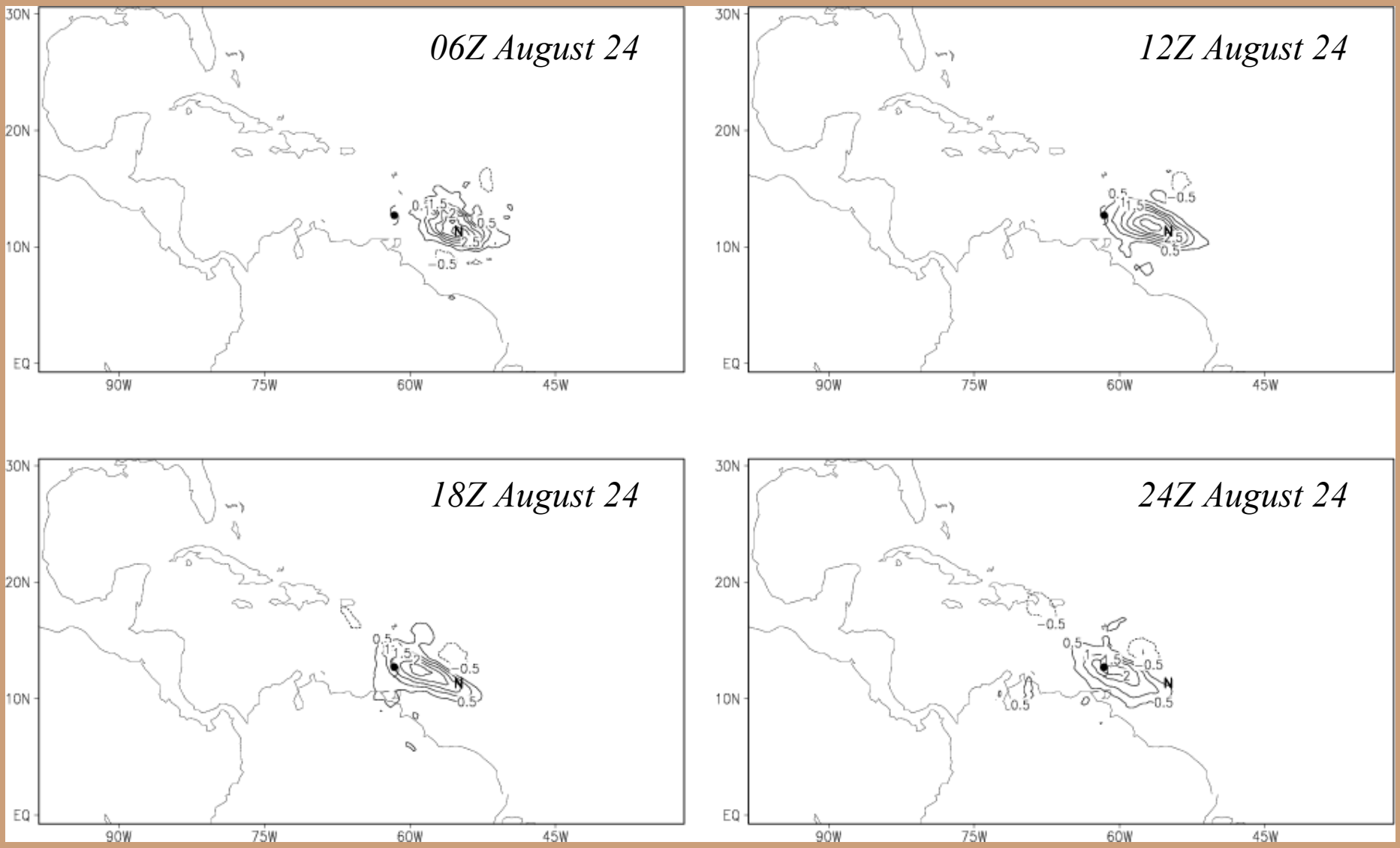
(850mb, 06Z August 24 - 24Z August 24)



Wind differences (cyclone circulation) become stronger with time.

Evolution of Analysis Increment of Water vapor (S2)

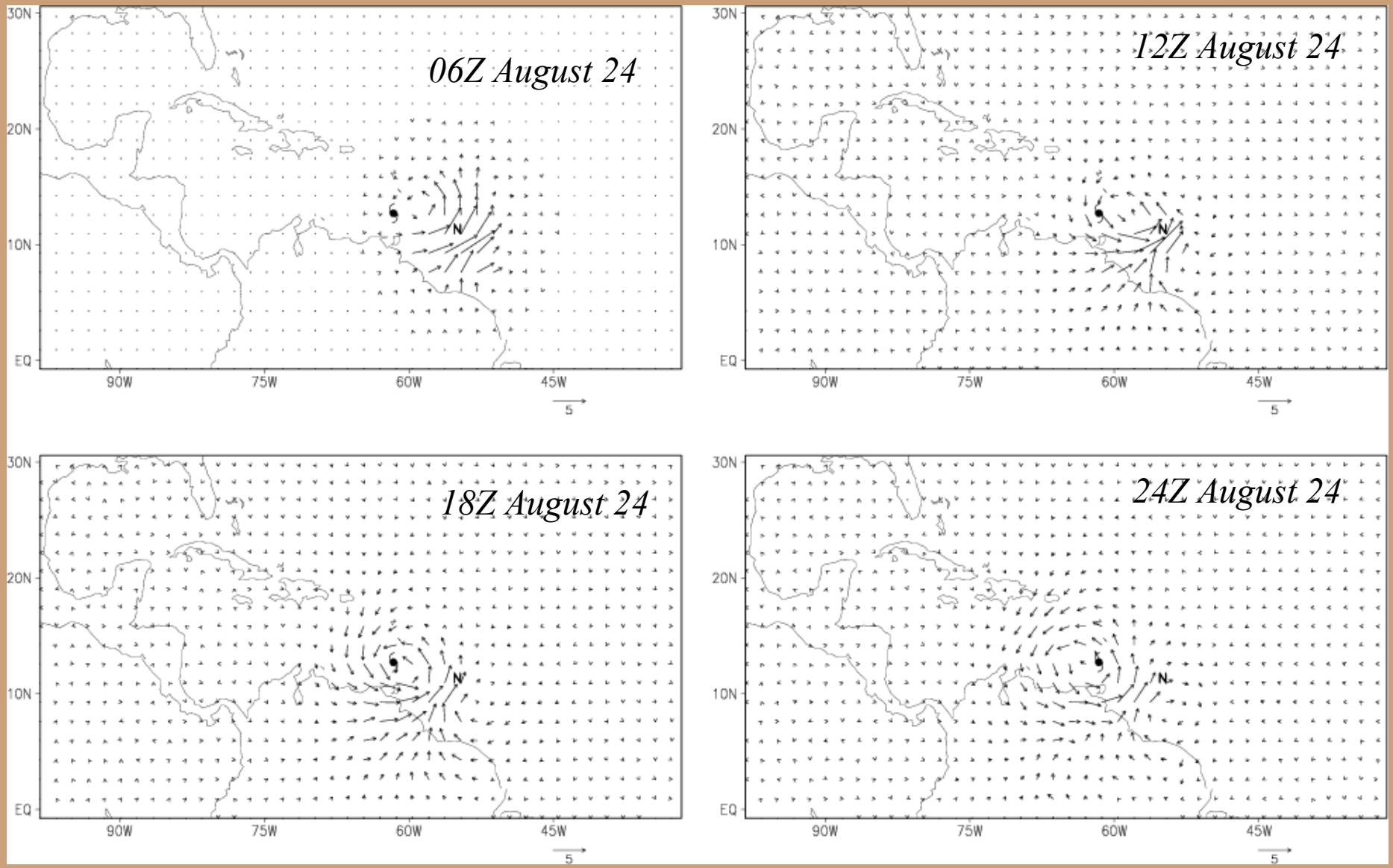
(700mb, 06Z - 24Z, August 24, start 18 hours before TC genesis)



Water vapor differences decrease with time.

Evolution of Analysis Increment of Wind (S2)

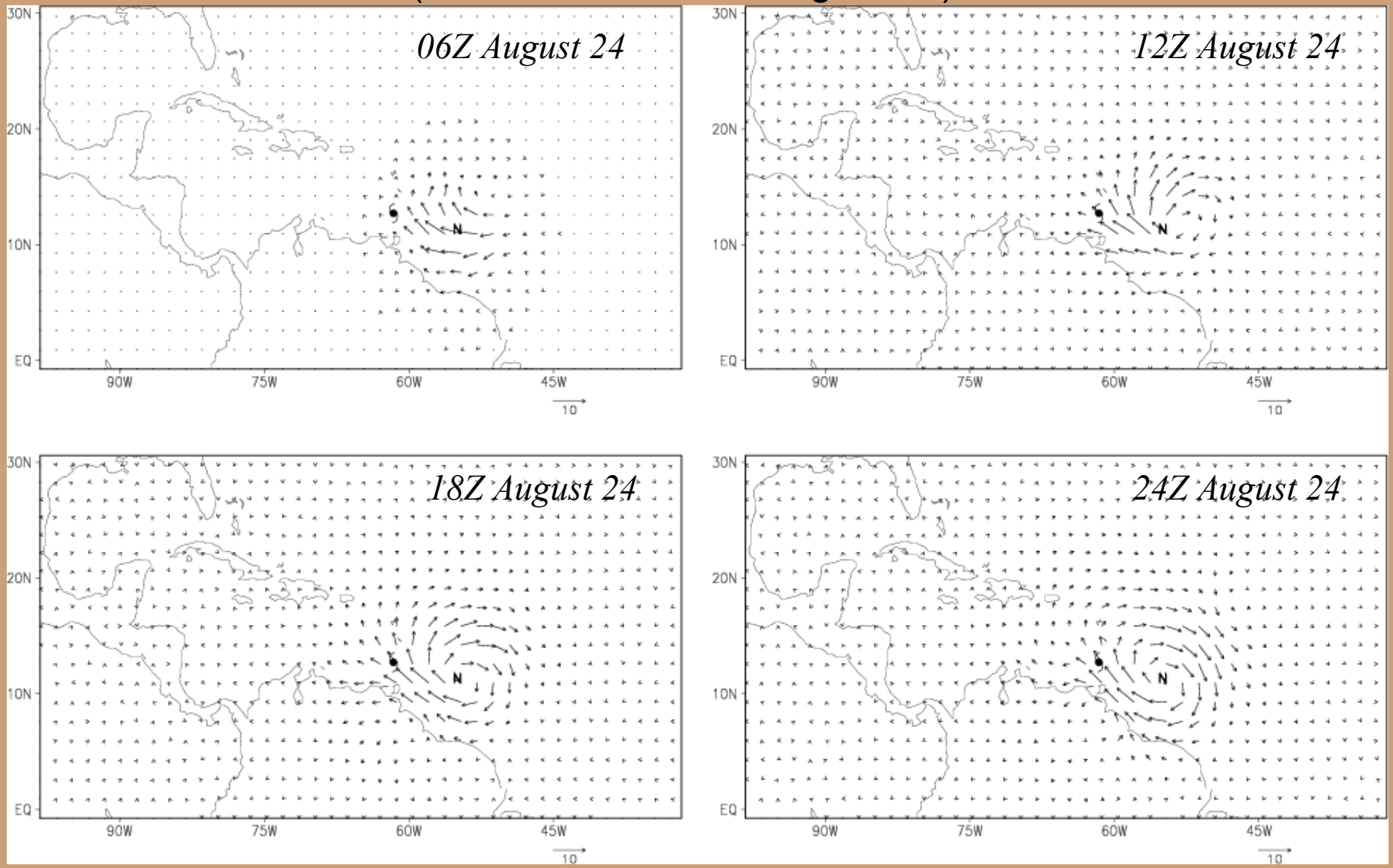
(700mb, 06Z - 24Z, August 24)



Wind differences get stronger and more organized with time.

Evolution of Analysis Increment of Wind (S2)

(300mb, 06Z - 24Z, August 24)



Upper level anti-cyclonic circulation develops with time due to RO obs.

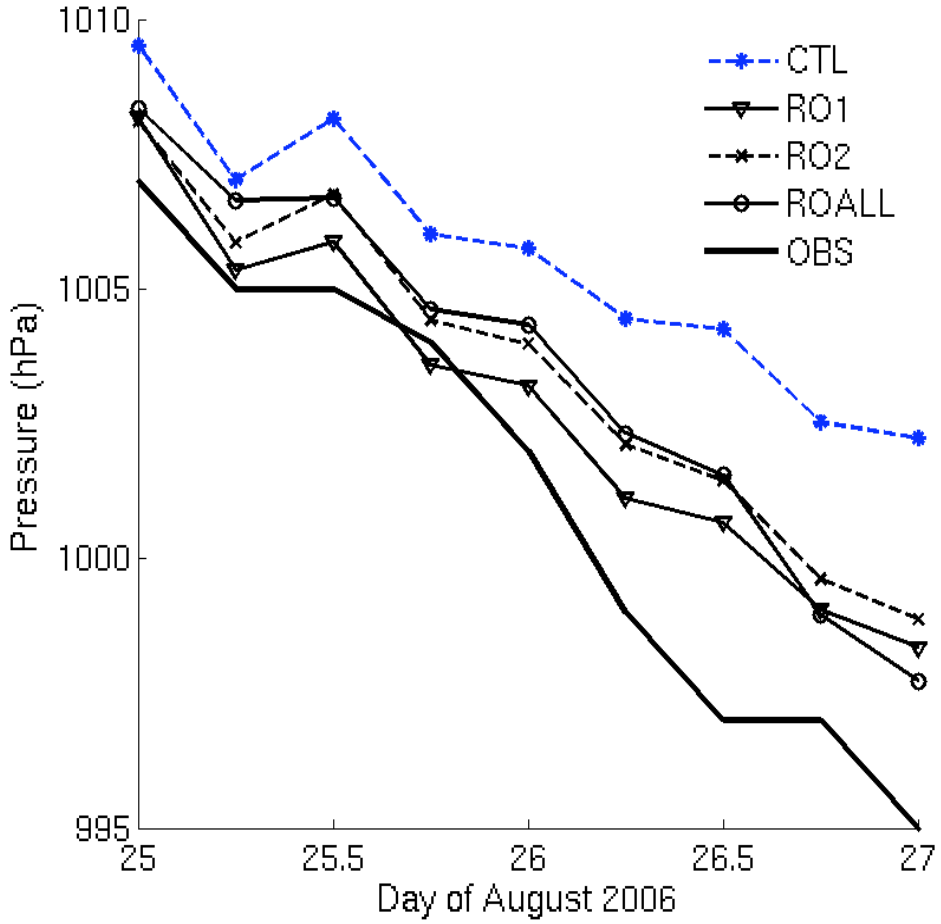
Additional Assimilation and Forecast Experiments

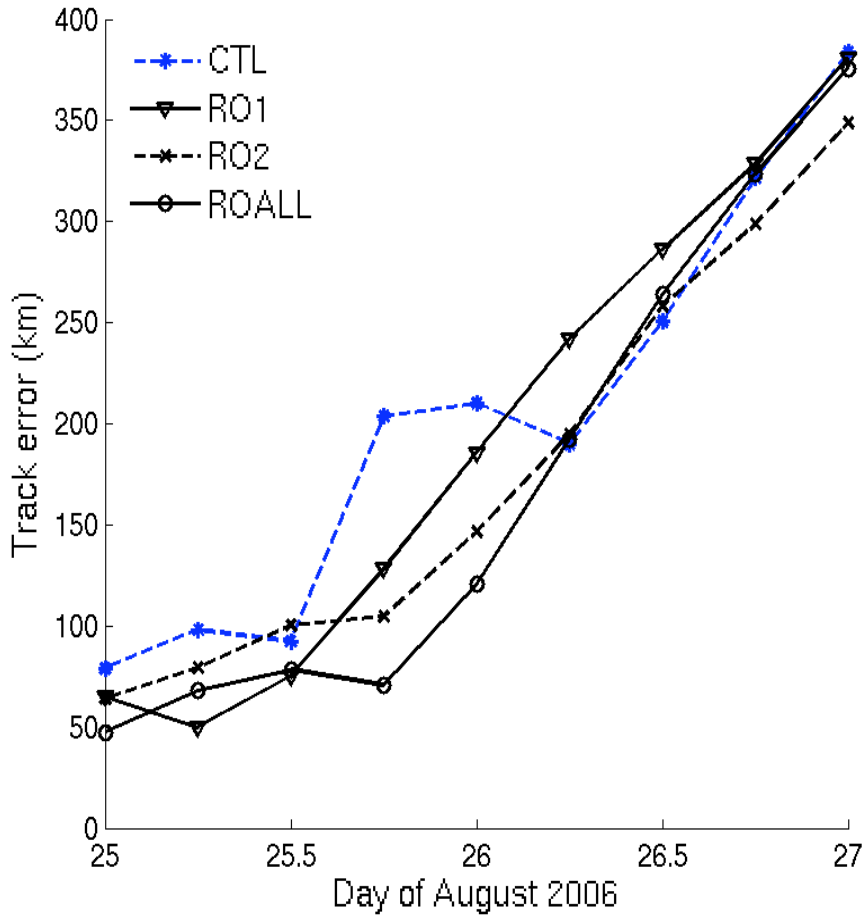
- *CTRL run*: Assimilate radiosondes, aircraft data, satellite cloud drift winds, and surface pressure observations.
- *RO1 run*: Same as CTRL run + the two RO profiles on 23 August.
- *RO2 run*: Same as CTRL run + the two RO profiles on 24 August.
- *ROall run*: Same as CTRL run + all RO profiles.

- Continuous cycling for 21-25 00Z August, 2006.
- Two-day forecast starts from the end of the assimilation.

SLP Central Pressure and Track Errors of 48-hour Forecast

(start from August 25 00Z)





Summary of Findings

- RO refractivity data can generate useful 3-D wind information in convective active areas with ensemble data assimilation.
- Wind differences can develop with time, lasts at least 2 days.
- Water vapor differences decrease with time, gone after 1 day.
- To improve initialization of the wind environment of tropical cyclogenesis by RO data, it is better to do continuous cycling assimilation (for several days).