

Improving forecasts of tropical cyclone intensity and track using AIRS water vapor observations with an ensemble data assimilation system

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Satellite Water Vapor Data Assimilation Challenges for TC Forecasts

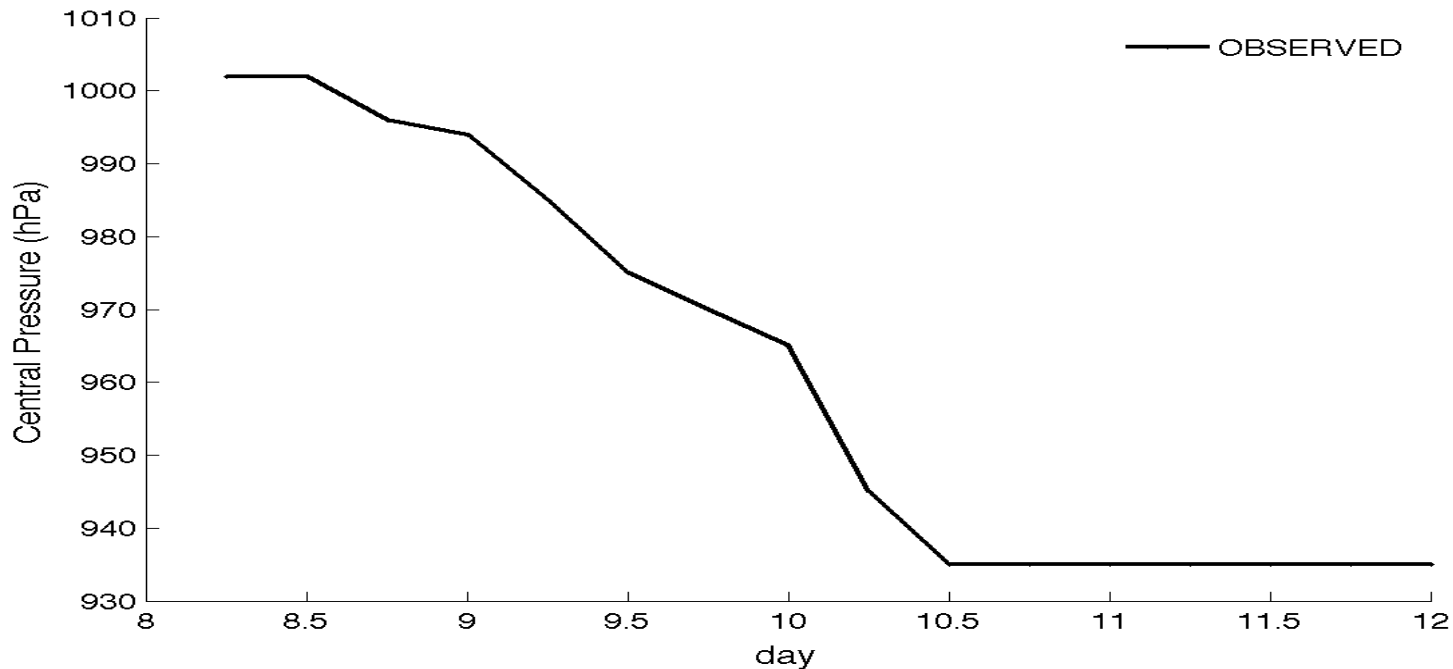
- Satellite Q data is a major resource of observations available around TC
- It has been hard for use of Q data to improve TC forecast
- Highly complicated flow dependent Q forecast error variances and multivariate correlations with T and winds, which are not well understand
- It is hard to describe the complicated covariance in one static covariance as with traditional data assimilation techniques
- In NWP centers, large errors are applied for Q data (including rawinsondes)

Ensemble Data Assimilation for TC Forecast

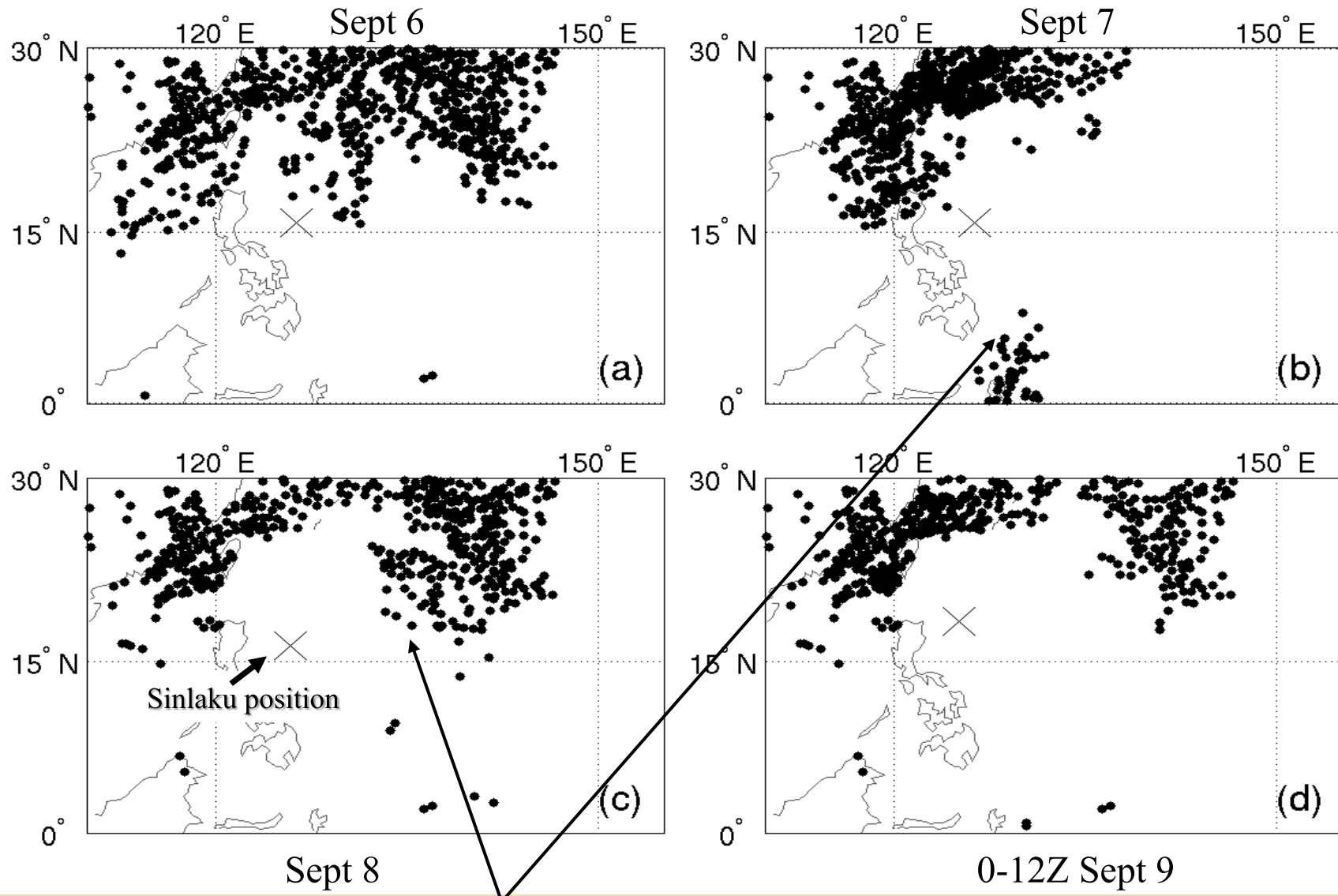
- Use of short range ensemble forecasts to estimate flow-dependent forecast error Q variance and multivariate covariance
- Q observations can correct ALL analysis variables consistent with the forecasts, which is vital for making balanced analyses and good forecasts
 - e.g., Water vapor observations impact wind analysis
- Applied AIRS Q data for hurricane Ike (2008), Ernesto(2006), and Sinlaku (2008)

Super Typhoon Sinlaku (September 8-21, 2008)

- Formed at 06Z 8 Sept. over W. Pacific; became Super typhoon-4 at 18Z 10 Sept.
- Interested in if AIRS Q data can improve analyses and forecasts of the initial intensification during 9-11 Sept.
- AIRS Q Data 2 days before the TC genesis



Daily AIRS Q Data Coverage (Clear sky, September 6-9, 2008)



Good error variance and covariance are needed to spread Q observation information

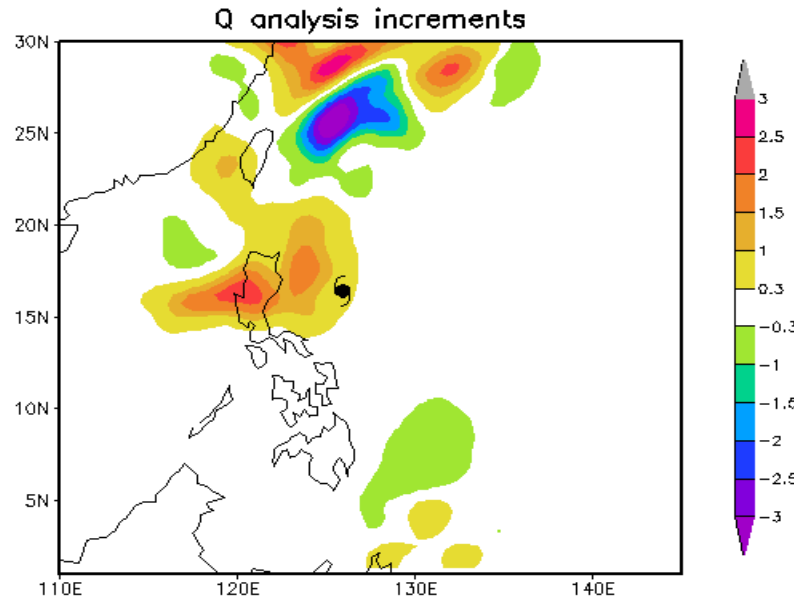
Assimilation experiments for Sinlaku

- Use NCAR's WRF/DART research ensemble data assimilation system
- Cycling analysis every 2-hours from 00Z 6 to 12Z 9 September
- Initial ensemble mean conditions from NCEP 1 degree global analysis; initial ensemble generated with 3DVar perturbations
- *Only-Q run*: Assimilation of only CIMSS Q soundings
- *FCST run*: Ensemble forecasts from the initial conditions; assimilation of no observations

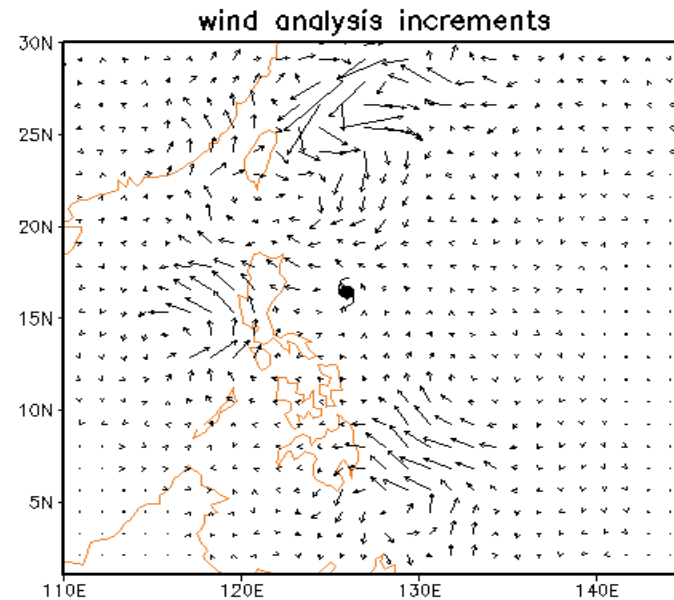
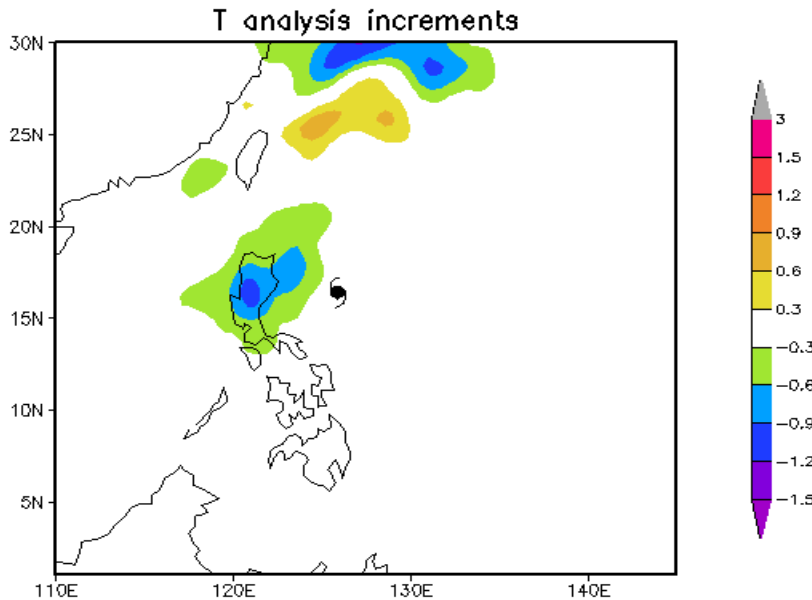
- Analyses increments of ONLY_Q run demonstrate CLEARLY where Q soundings can provide information of Q, T, and winds.

Daily Analysis Increments (7 Sept. 2008)

Q Observations impact Q, T and wind analyses.

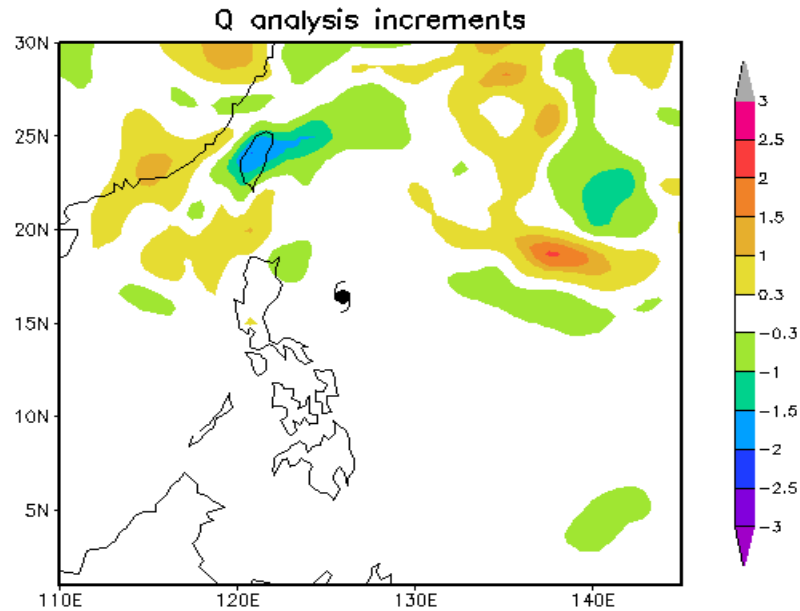


Isolated wind analyses increments are induced

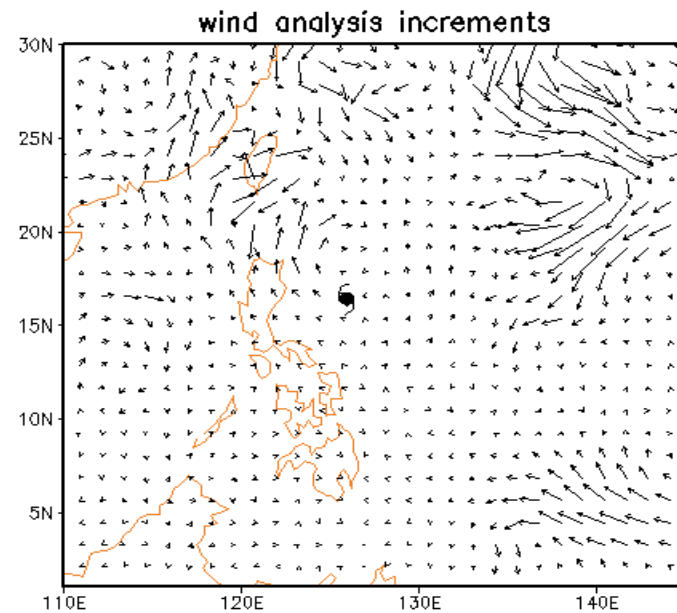
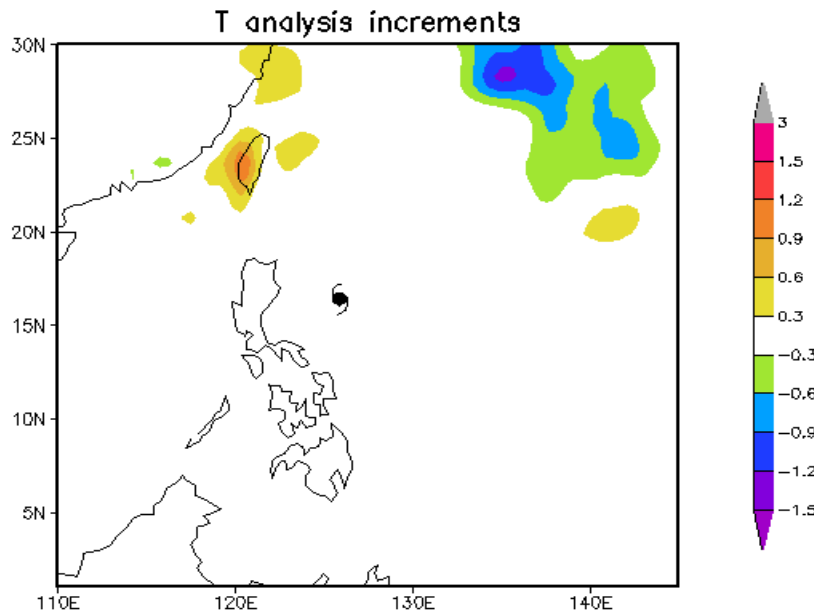


Daily Analysis Increments (8 Sept. 2008)

Clear sky soundings
are not available
close to the TC.

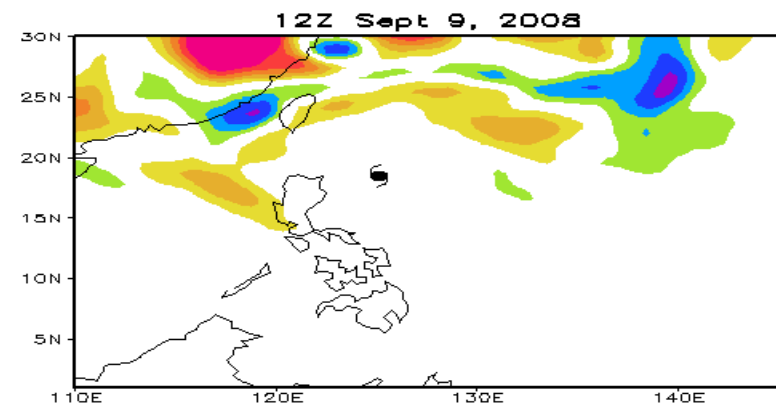
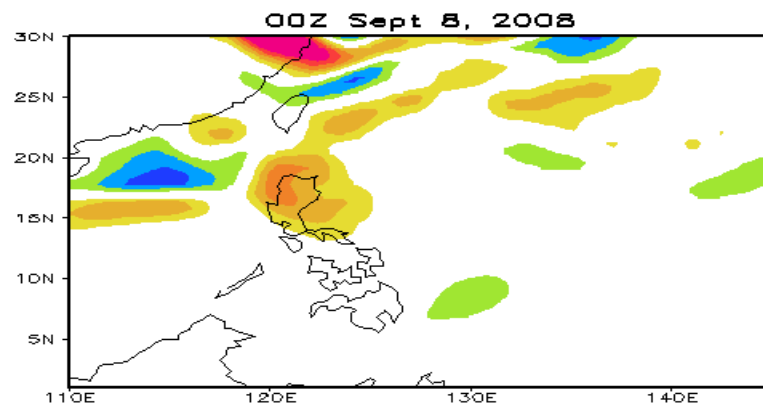
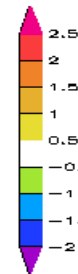
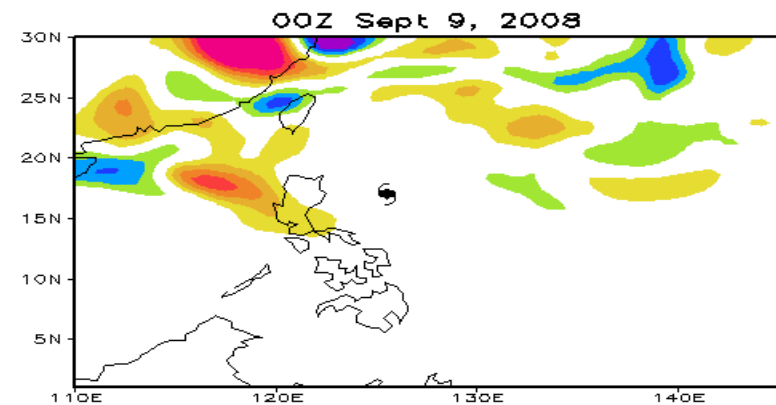
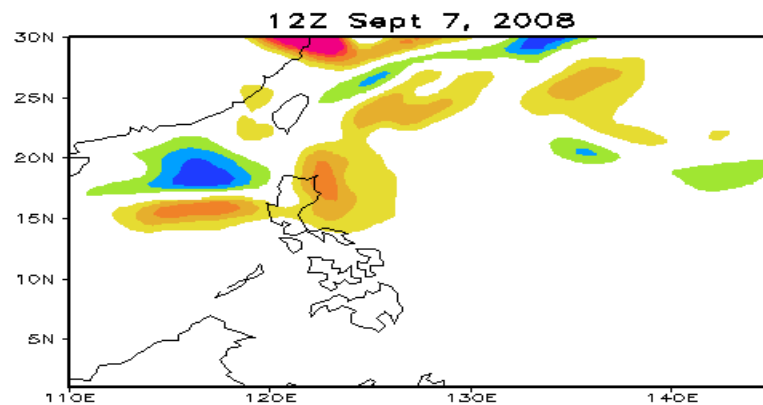
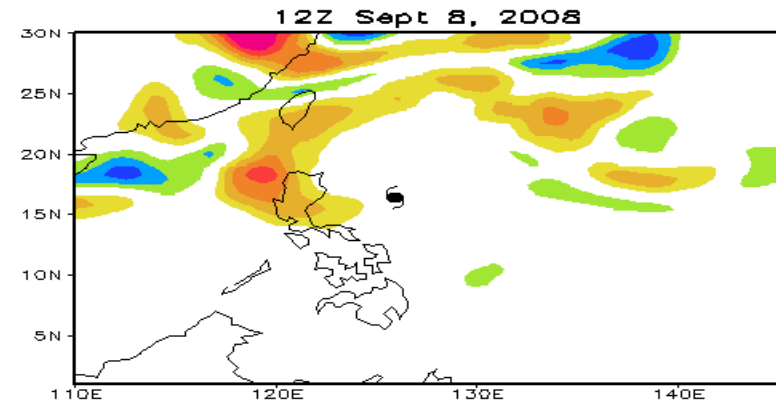
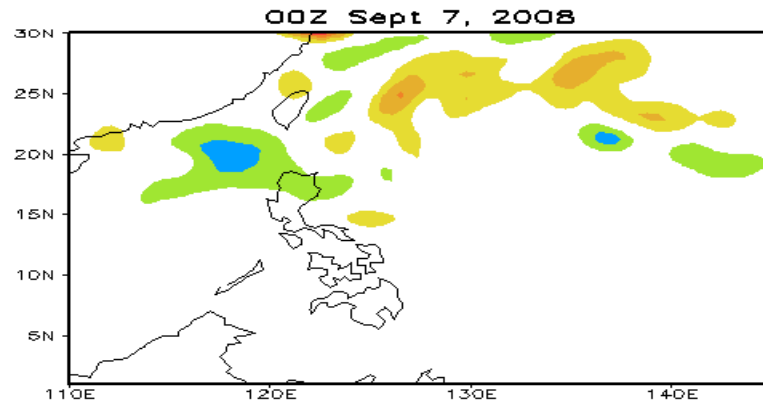


Isolated wind
analyses increments
are induced



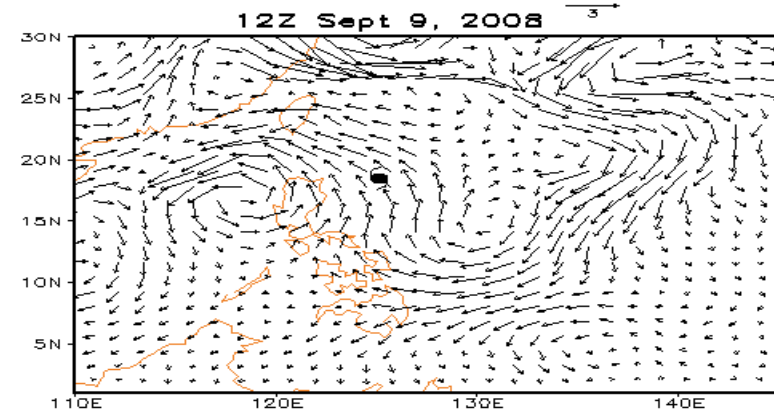
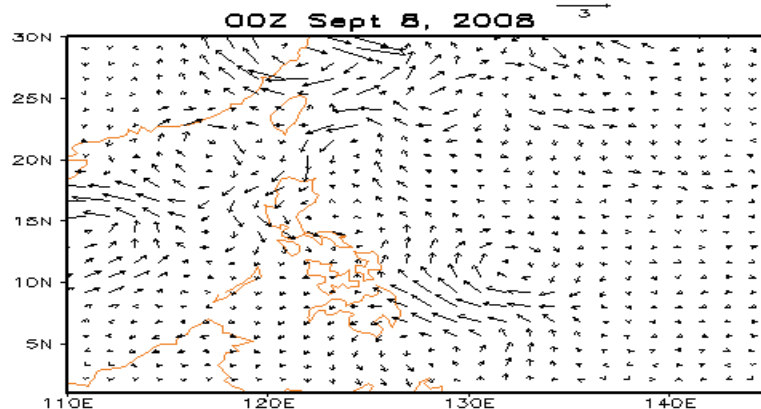
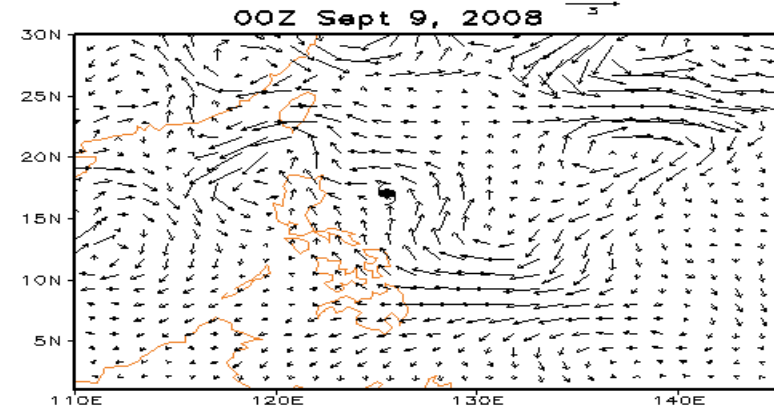
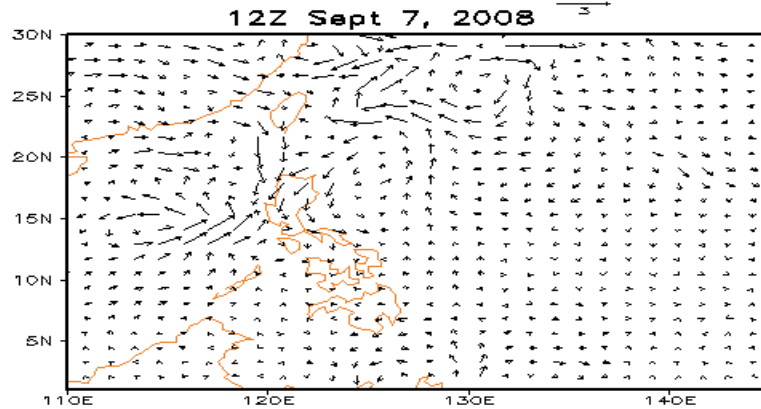
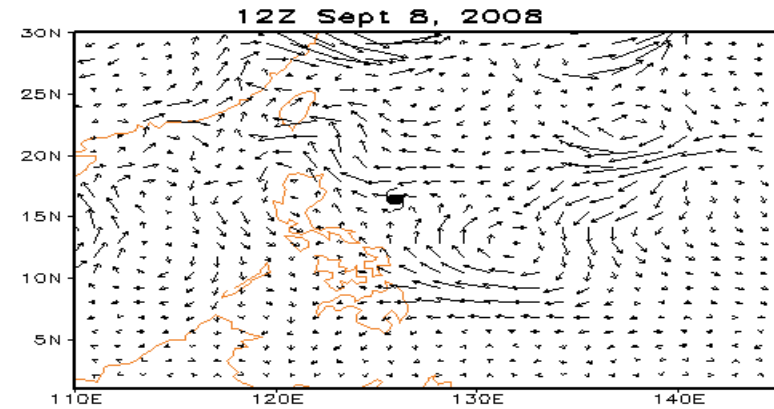
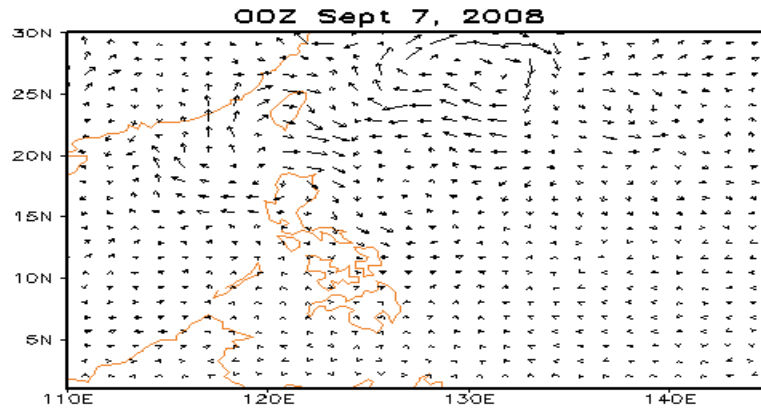
Q Analysis Differences (ONLY_Q – FCST, 700 hPa)

With model's evolution

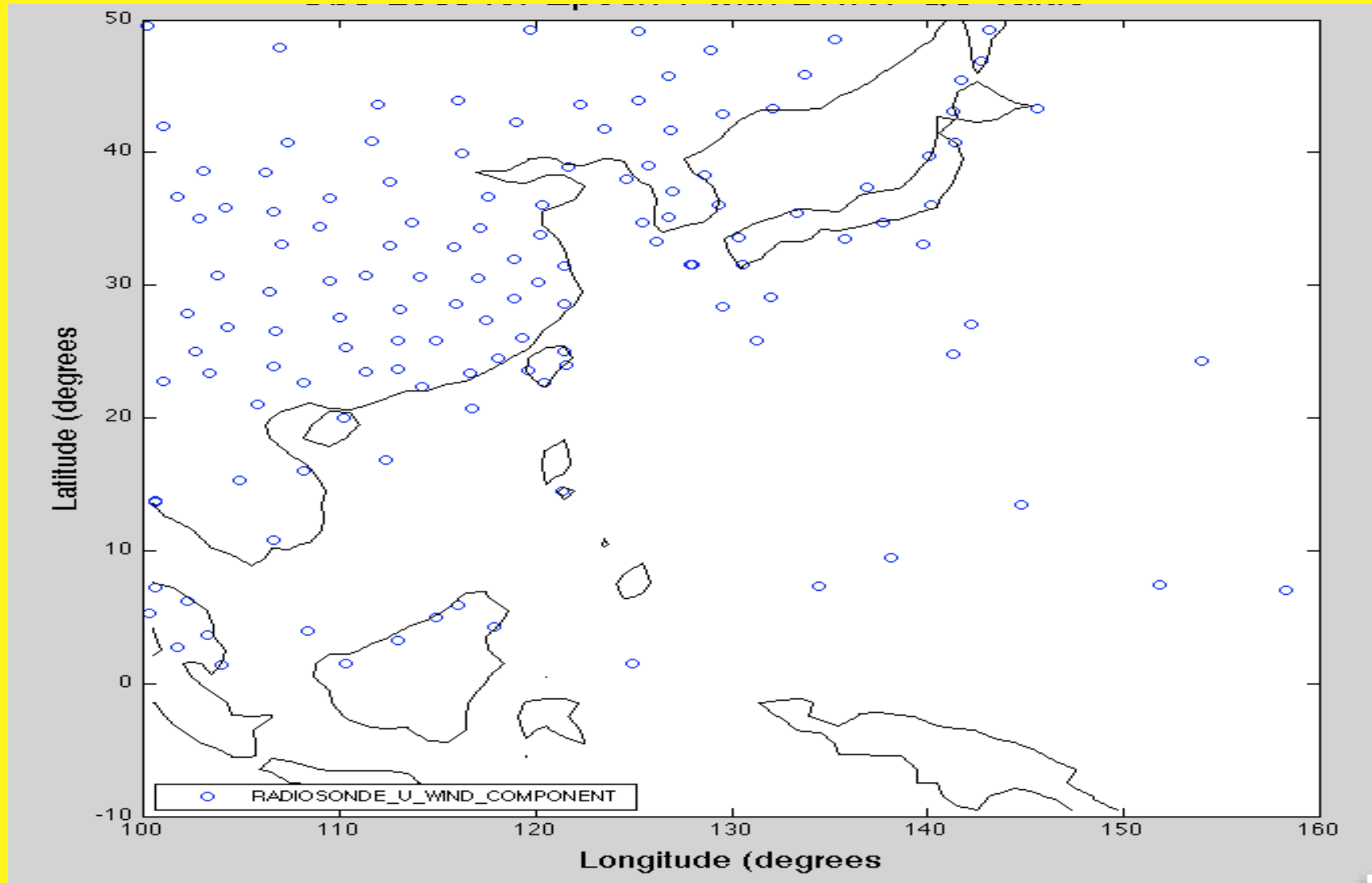


Wind Analysis Differences (ONLY_Q – FCST, 700 hPa)

With model's evolution

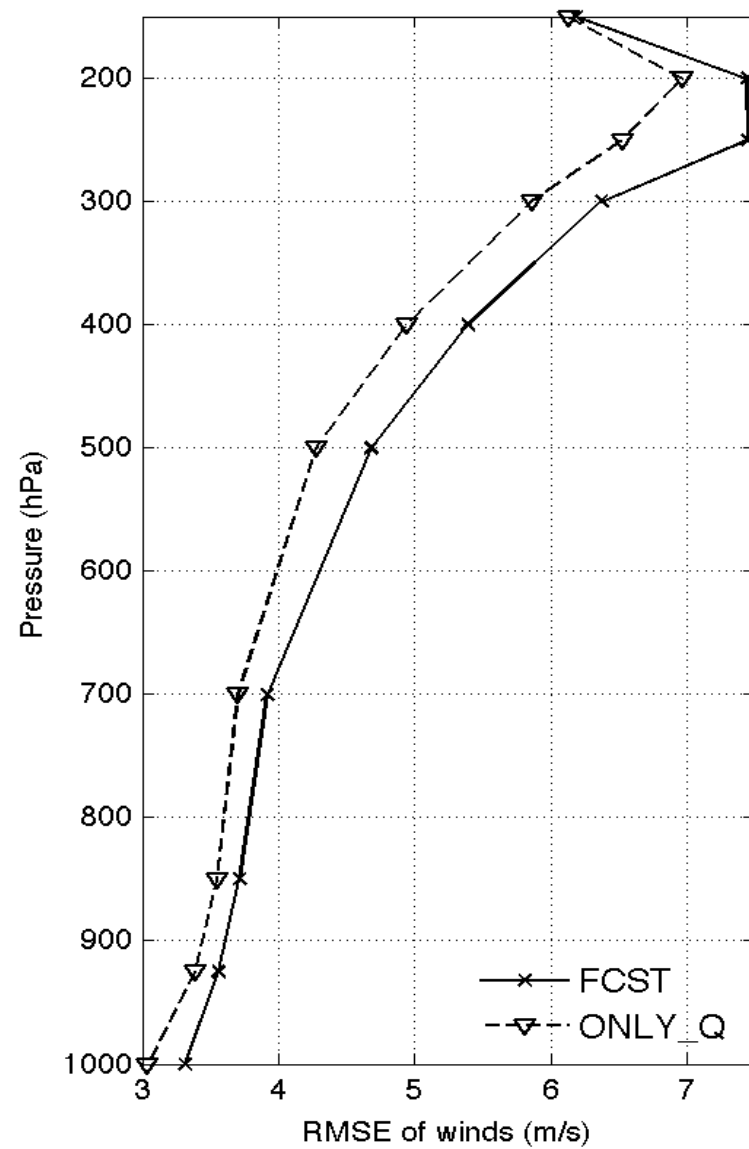
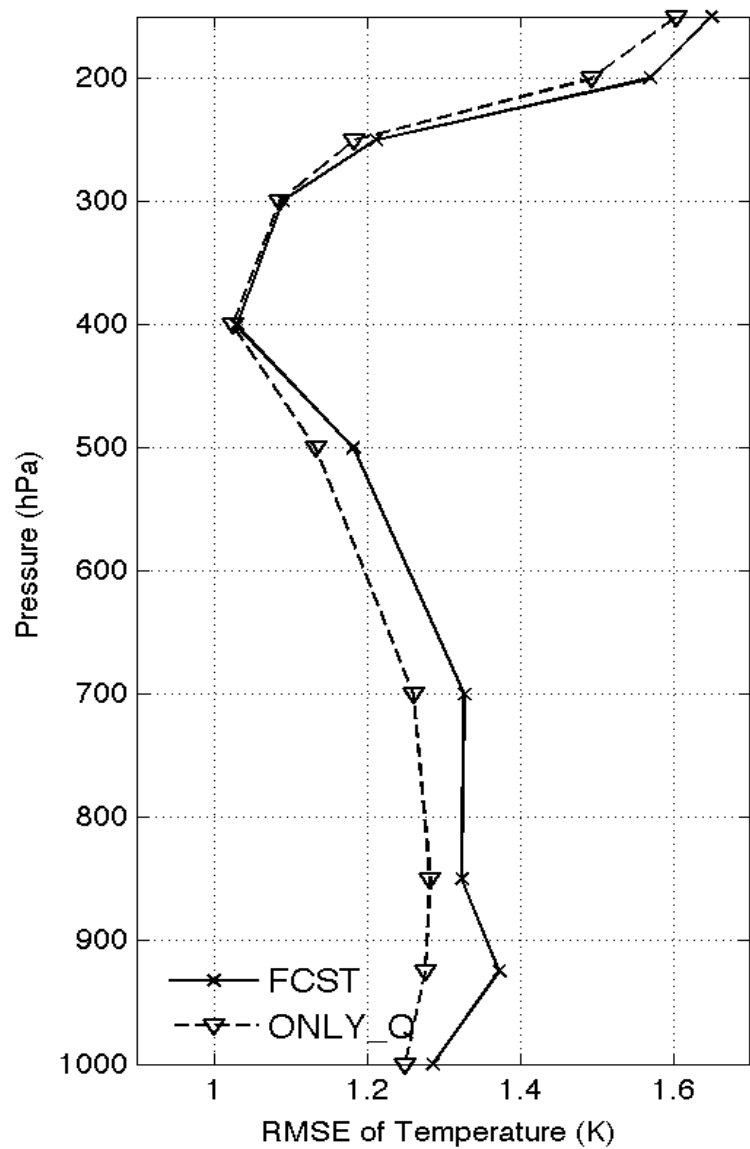


Locations of the radiosondes used as validation (6-9, Sept. 2008)



The radiosondes provide large scale verification of the analyses by AIRS_Q

2-hour Forecast Fits to Radiosonde (6-9, Sept. 2008)

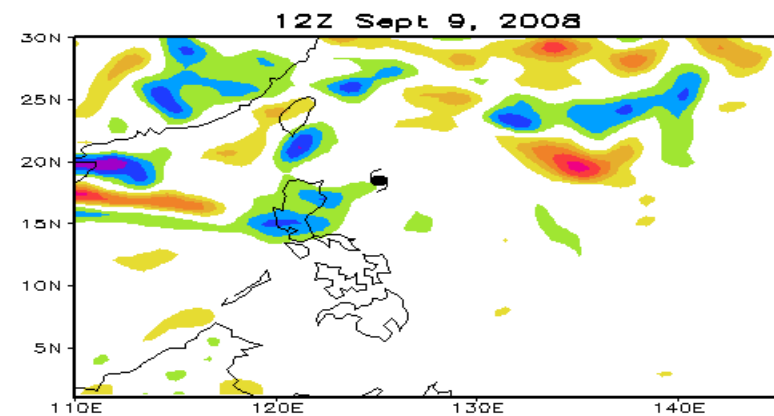
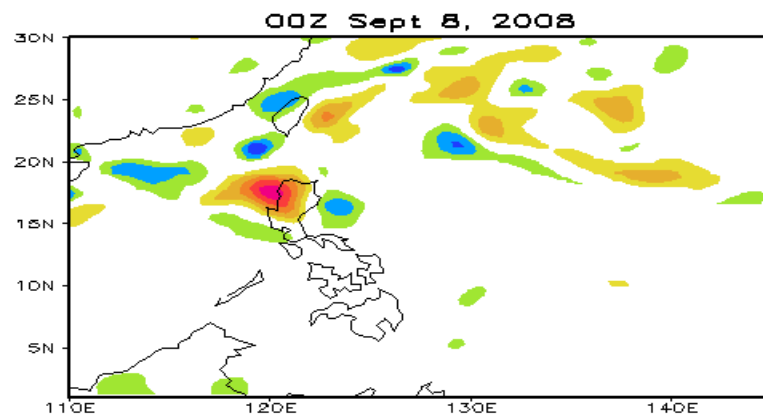
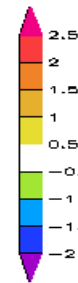
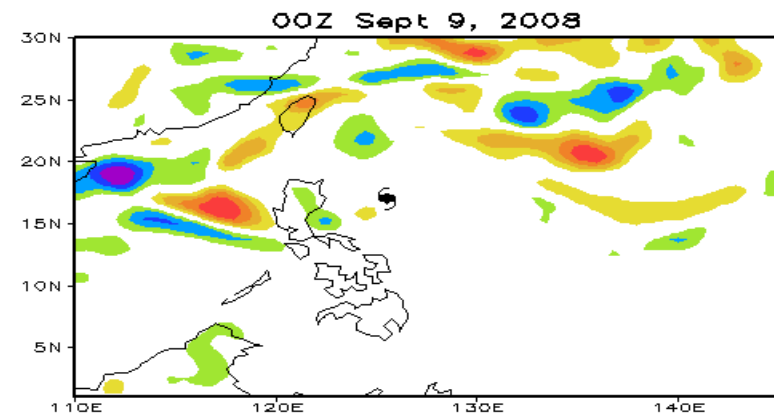
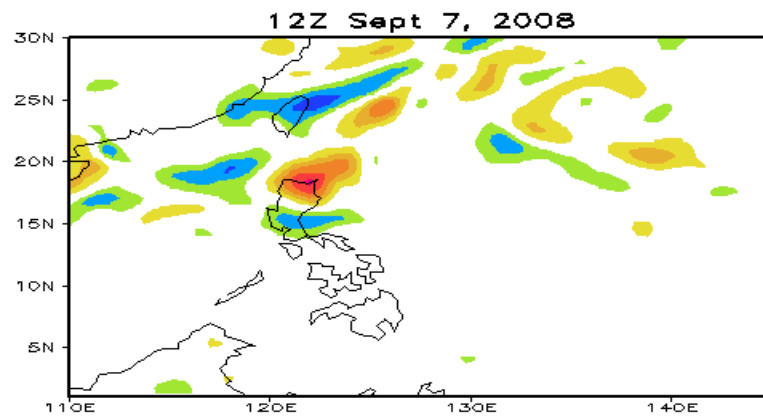
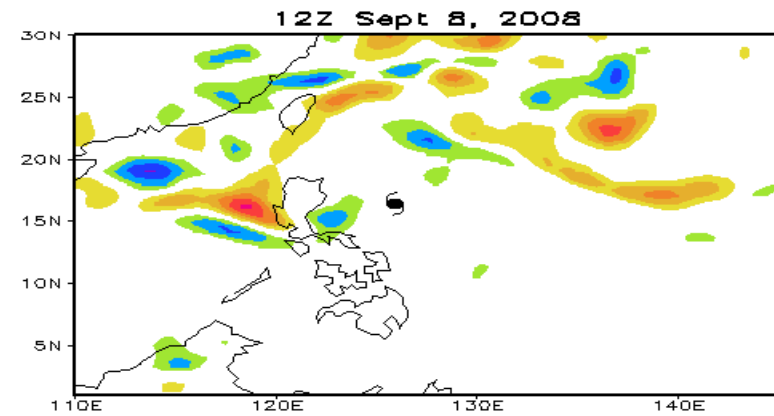
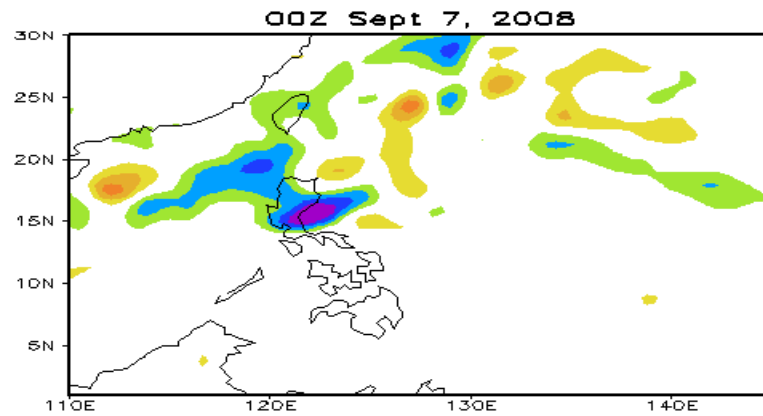


Assimilation experiments for Sinlaku(2)

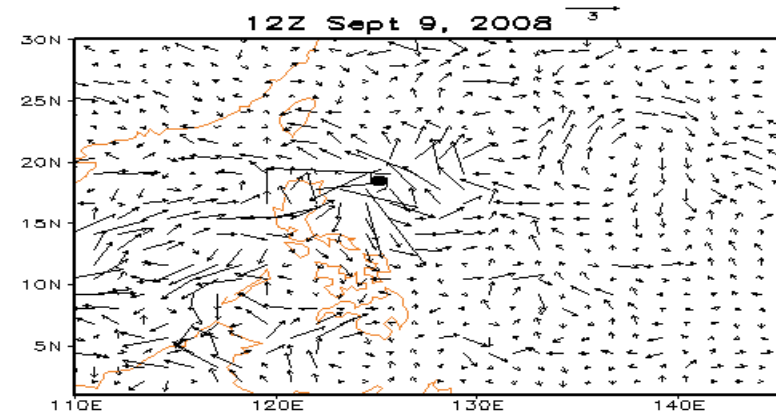
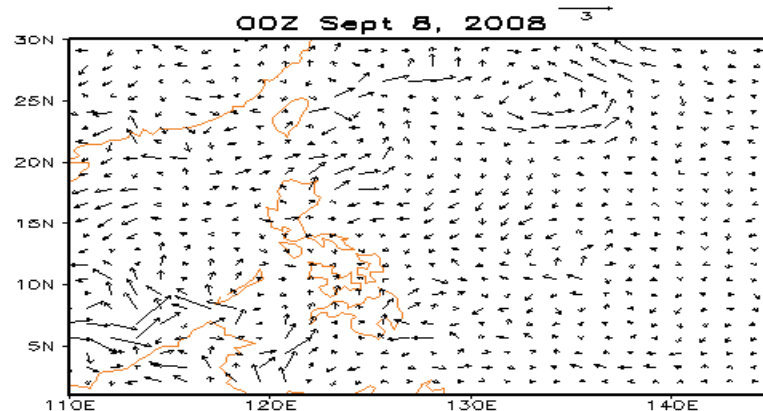
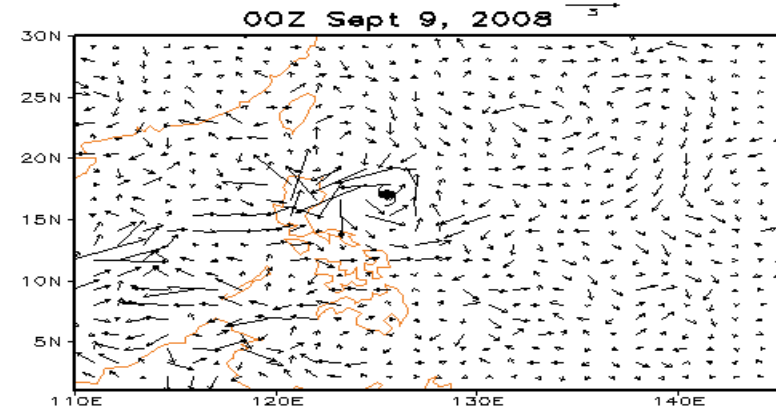
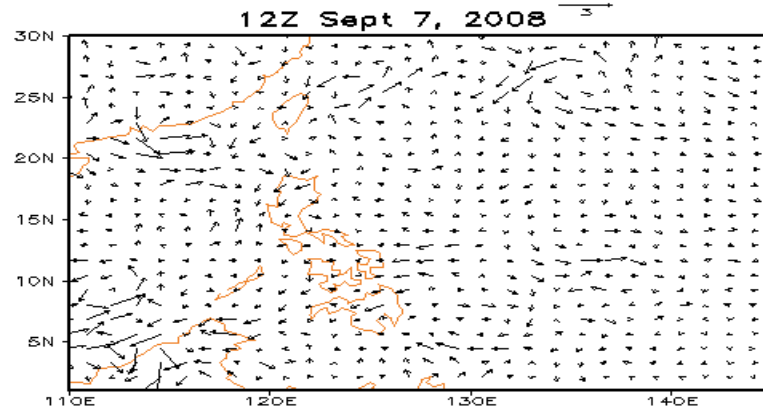
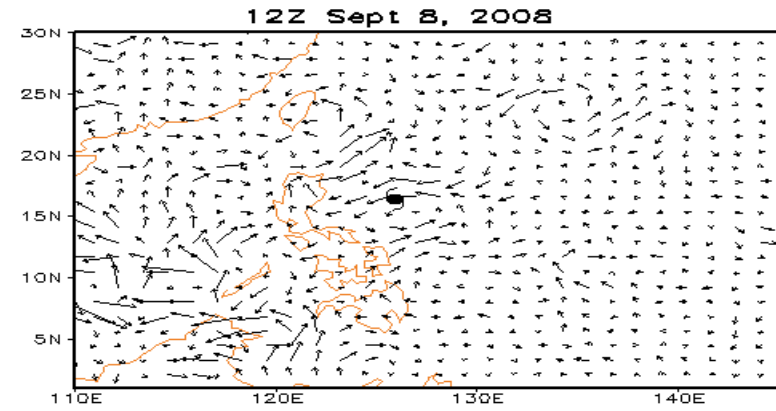
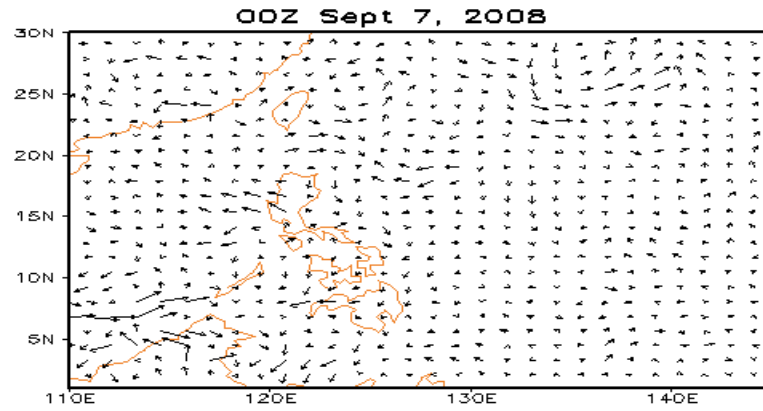
- *CTL run*: Assimilate radiosonde, cloud winds, aircraft data, surface pressure data
- *AIRS-Q run*: Same as CTL run plus AIRS Q soundings
- NO artificial TC vortex bogus data is used, which may contaminate impact of real satellite observations

- The impact of AIRS_Q may be mixed with the impacts from other observation types and less clear
- Can the addition of AIRS Q observations improve analyses and forecasts?

Q Analysis Differences (AIRS_Q – CTL, 700 hPa)

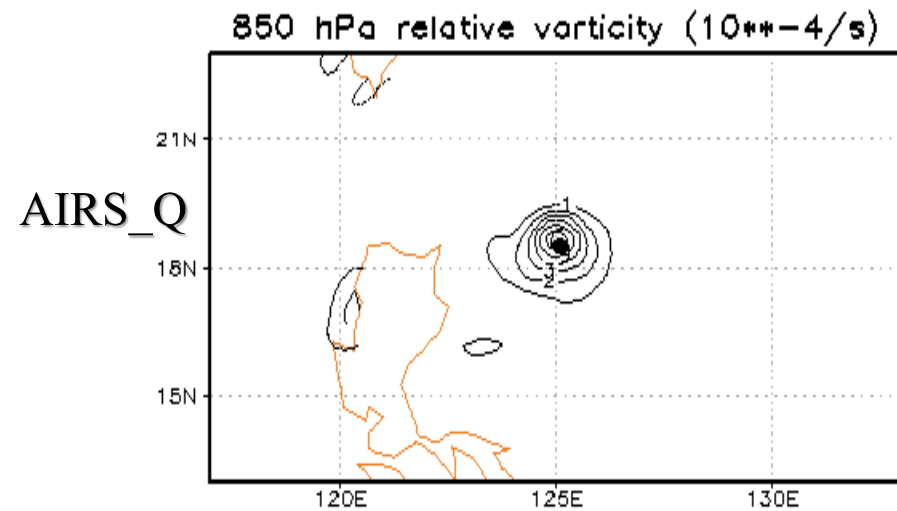
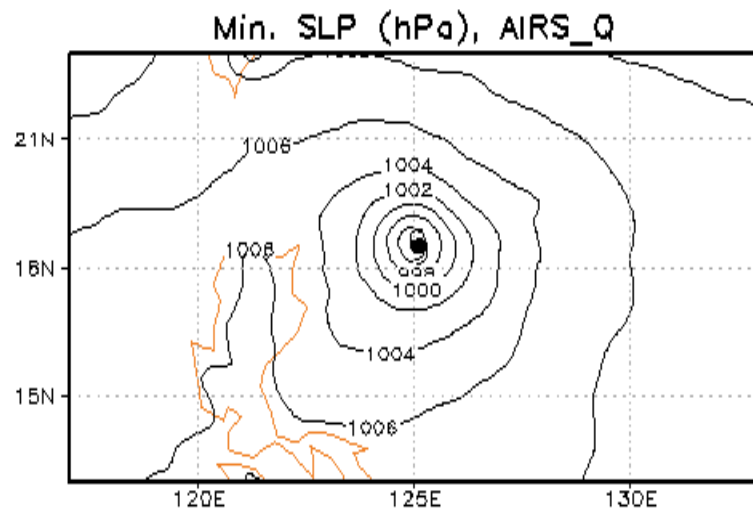
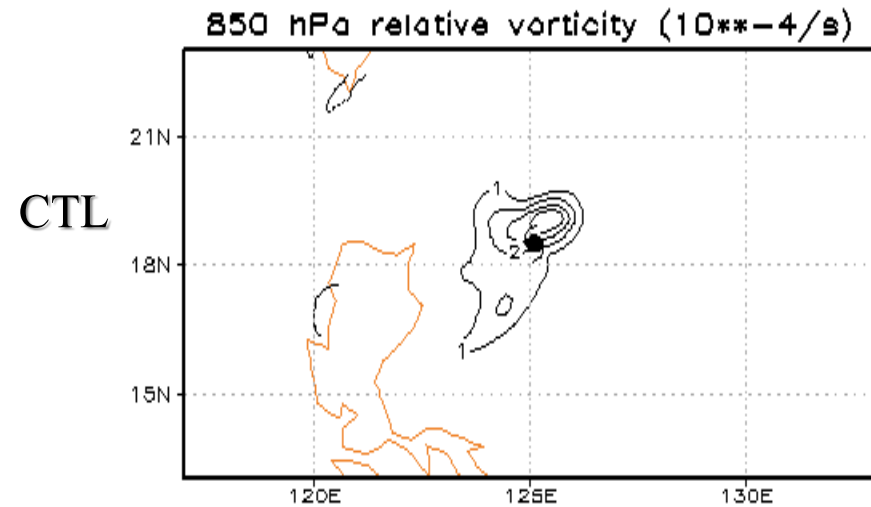
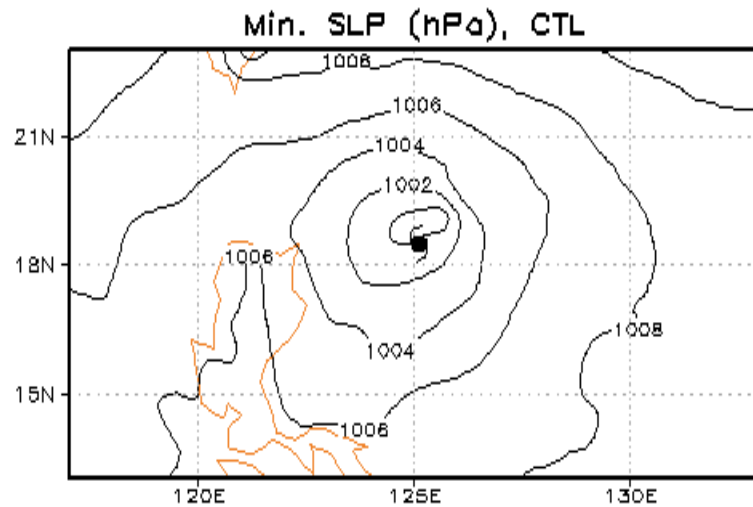


Wind Analysis Differences (AIRS_Q - CTL, 700 hPa)

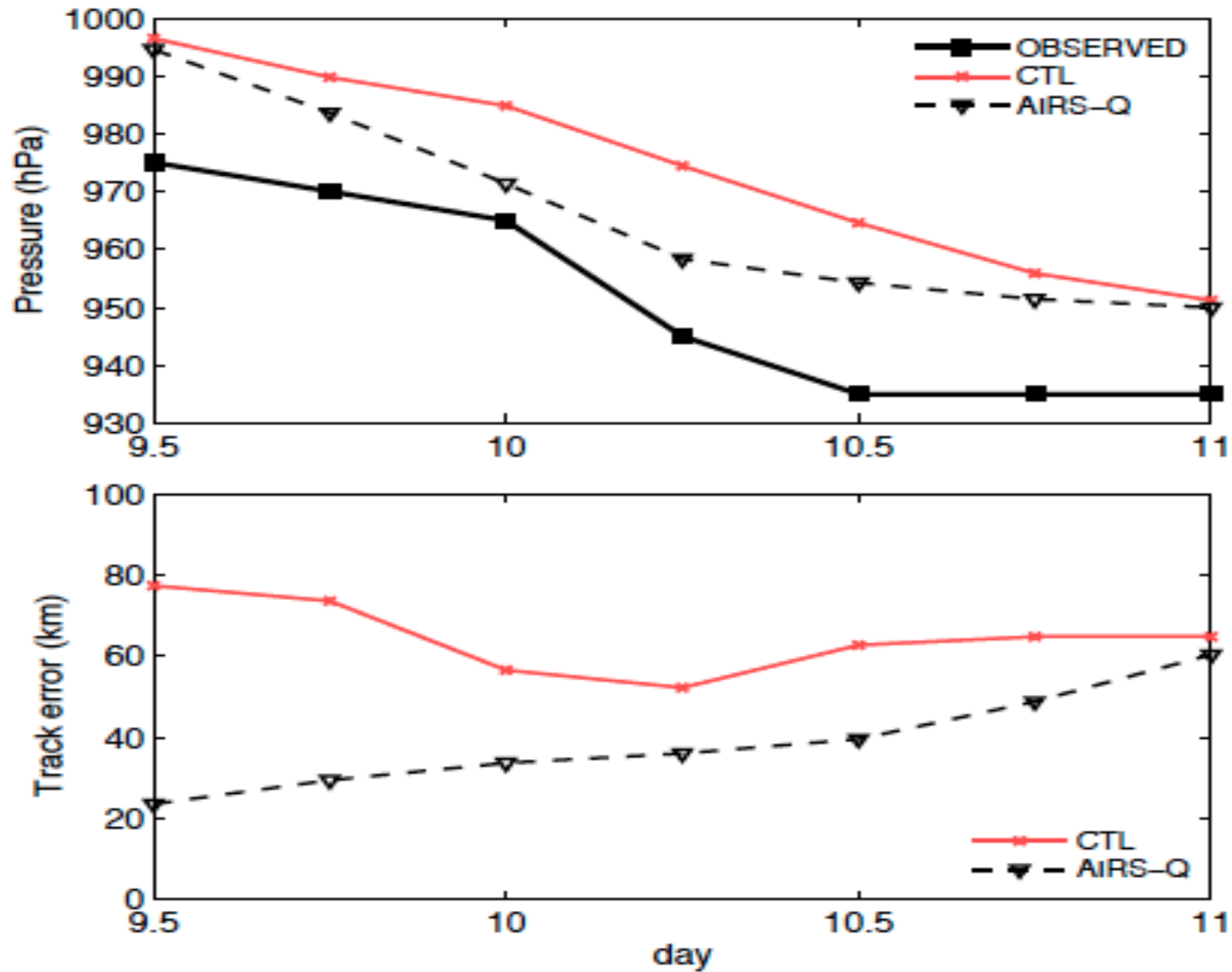


Central SLP and Relative Vorticity Analyses

(12Z Sept. 2008, after 3.5 days assimilation)



Mean of 36-hour Ensemble Forecast from 12Z 9 Sept.



Concluding remarks

- Through the advanced ensemble DA technique, AIRS Q data improve water vapor, temperature, and wind analyses in TC environment;
- The analysis of TC vortex structure and subsequent forecasts of TC track and intensity are also improved
- Similar results are obtained for AIRS T profiles

- Plan to test other water vapor products from AIRS and IASI