Improvements to WRF/DART Ensemble Assimilation System for RO Data Assimilation

Hui Liu, Jeff Anderson, Bill Kuo

Acknowledgement: Judith Berner, and Chris Snyder

Outline

- Advantages of EnKF for RO data assimilation
- WRF/DART system
- Test of stochastic physics in WRF/DART:

  2-week period of June 2011,

  Track and intensity forecast of three major typhoons of 2008
- Summary

Advantages of EnKF for RO Assimilation in the moist lower troposphere

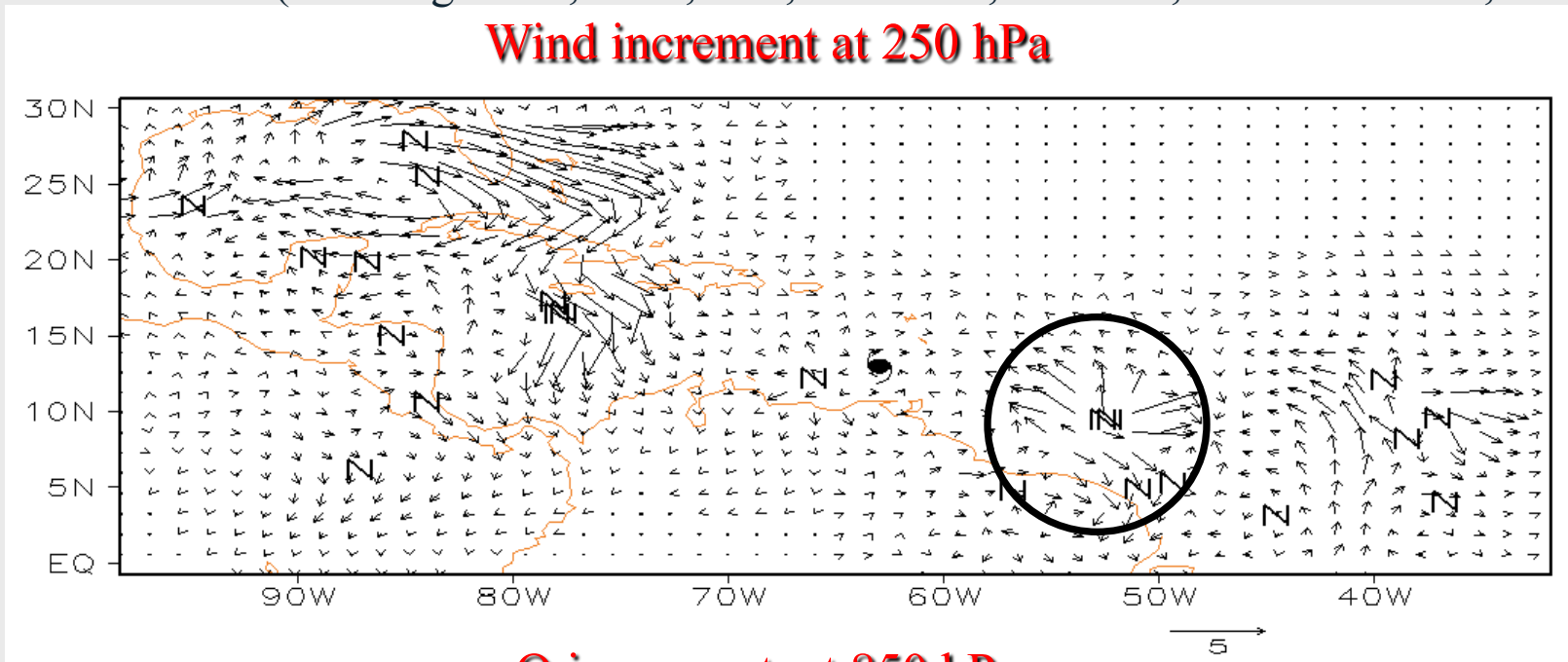
- GPS RO data is sensitive to both water vapor and temperature,
- Forecast errors are flow dependent and multivariate,
- Ensemble forecasts can provide flow dependent forecast error and full multivariate covariance estimate,
- Through EnKF, assimilation of RO refractivity/bending angle can have consistent updates to T, Q, and wind analyses, particularly in convective environment.

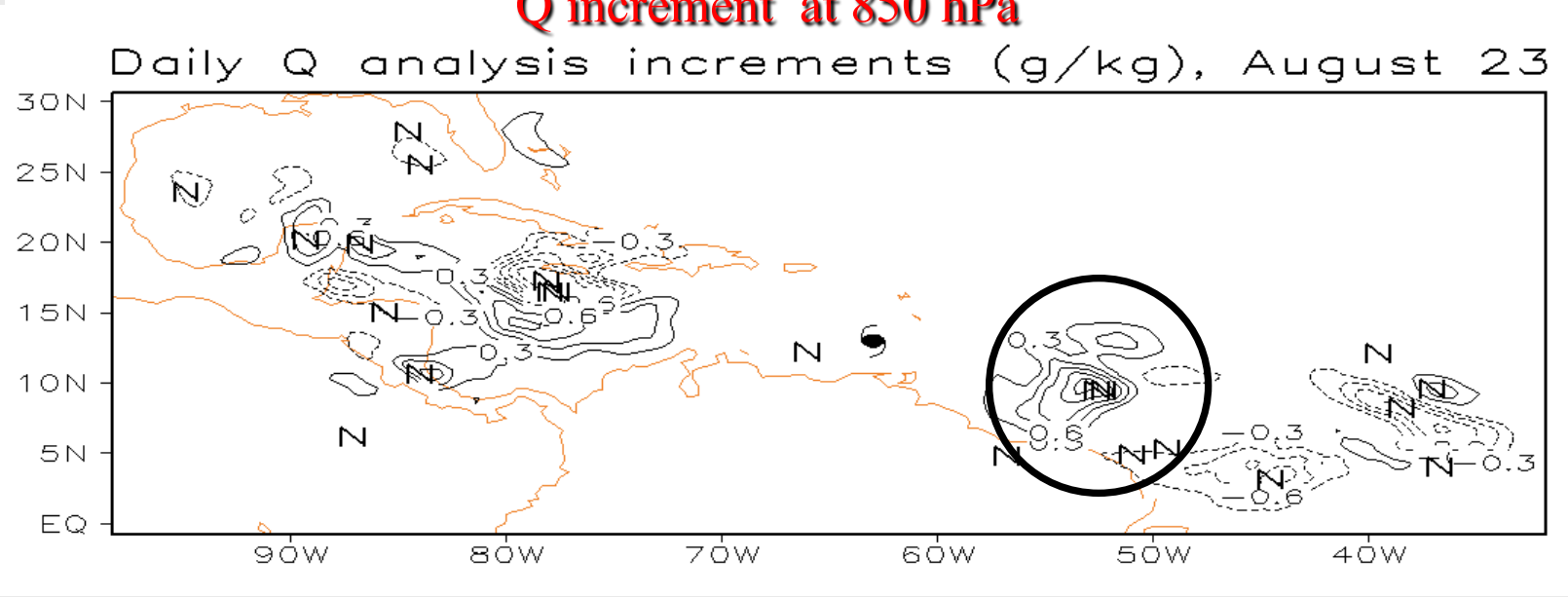
WRF/DART ensemble system

- Ensemble Adjustment Kalman Filter (Anderson and Collins, 2003, 2007),
- Spatial and temporal adaptive ensemble inflation,
- 32 - 96 ensemble members,
- WRF/ARW core, All prognostic variables can be updated by any observations in a dynamically consistently way,
- Conventional observations, Radar data, plus RO refractivity, Typhoon bogus winds, Typhoon positions
- RO refractivity local and non-local operators available (Liu et al., 2007, 2012).

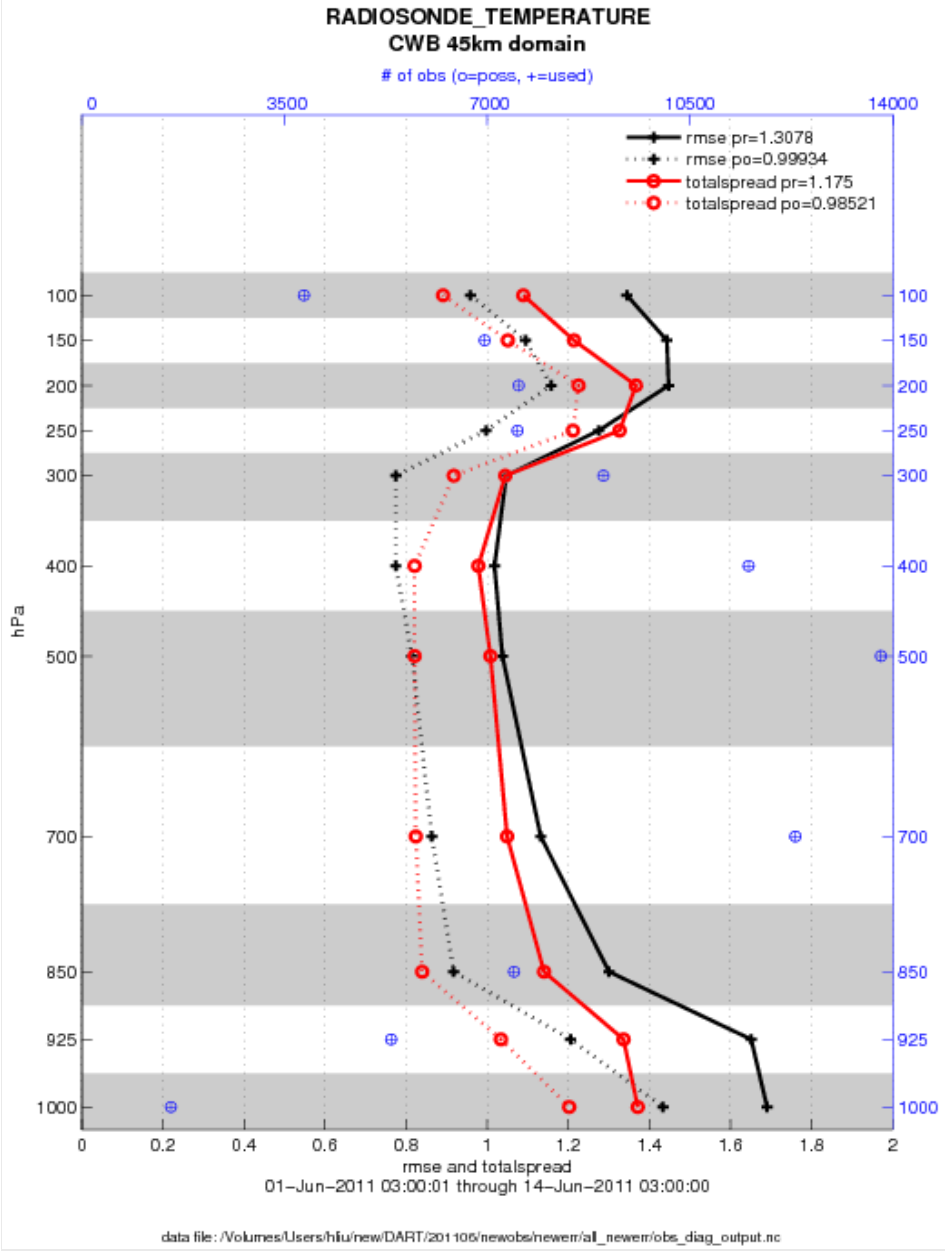
Wind and Q analysis Increments from assimilation of RO data only

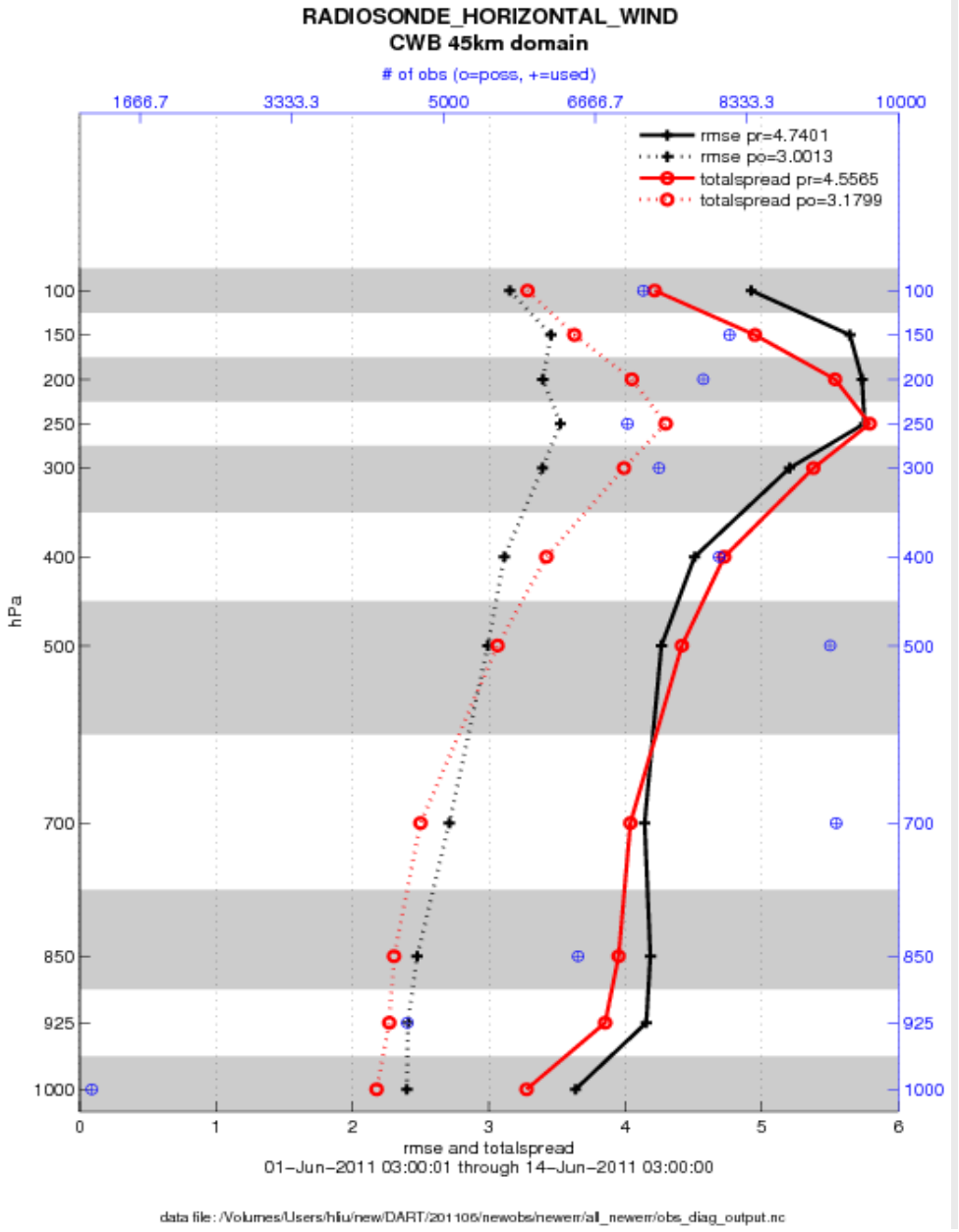
(06Z August 23, 2006, Liu, Anderson, and Kuo, *Mon. Wea. Rev.*, 2012)





6h-fcst T & wind RMSE and total spread (2011.06)





Test of a Stochastic Physics in WRF/DART

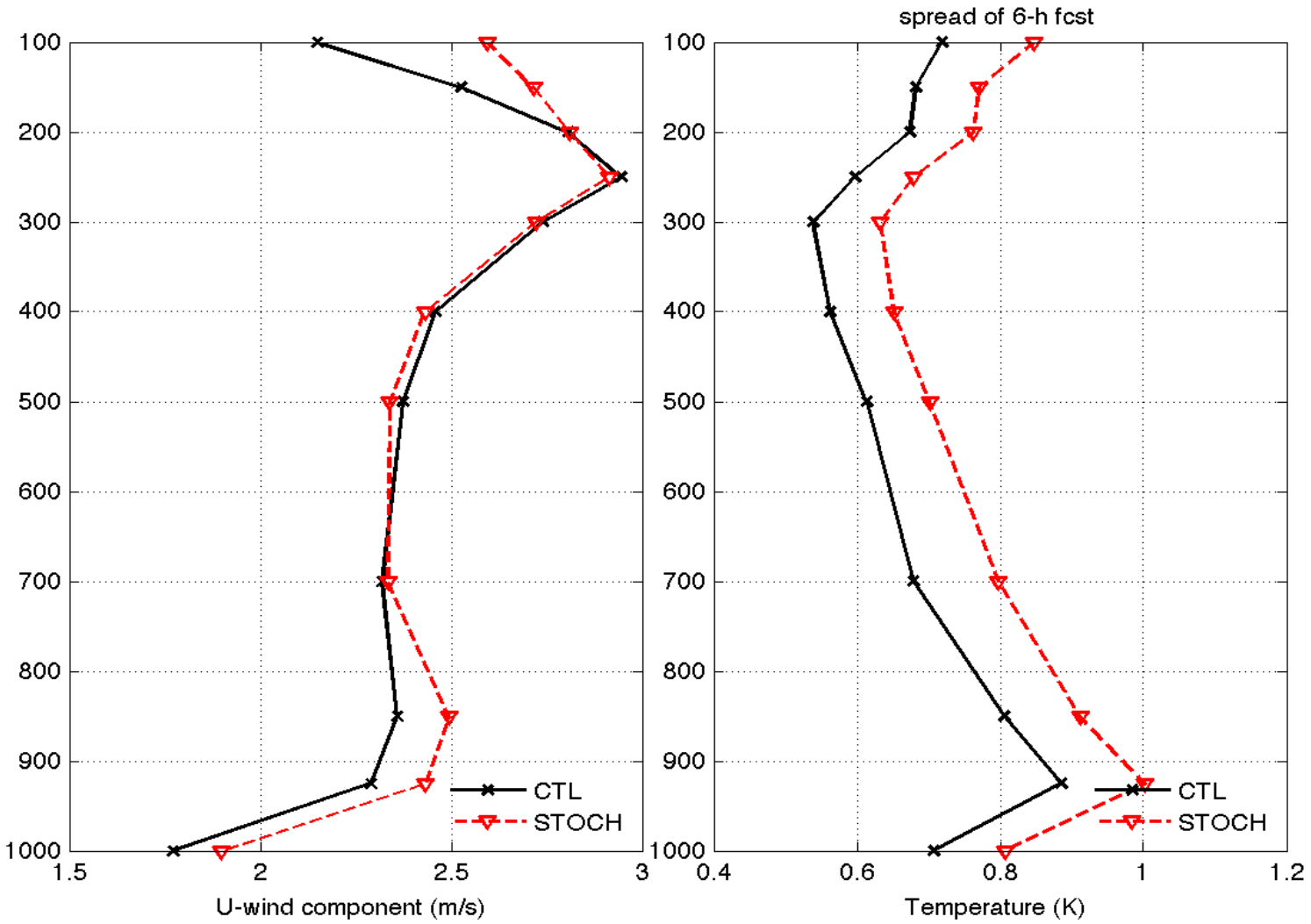
- Stochastic Kinetic Energy Backscatter Scheme (SKEBS, Berner, et.al, 2011)
- Feedback from unresolved smaller scales,
- Spatial and temporal correlated perturbations
- Forcing parameters tuned for the 45km Taiwan CWB domain:

- tot_backscat_psi = 0.5e-5 m^2/s^3,
- tot_backscat_t = 0.5e-6 m^2/s^3,

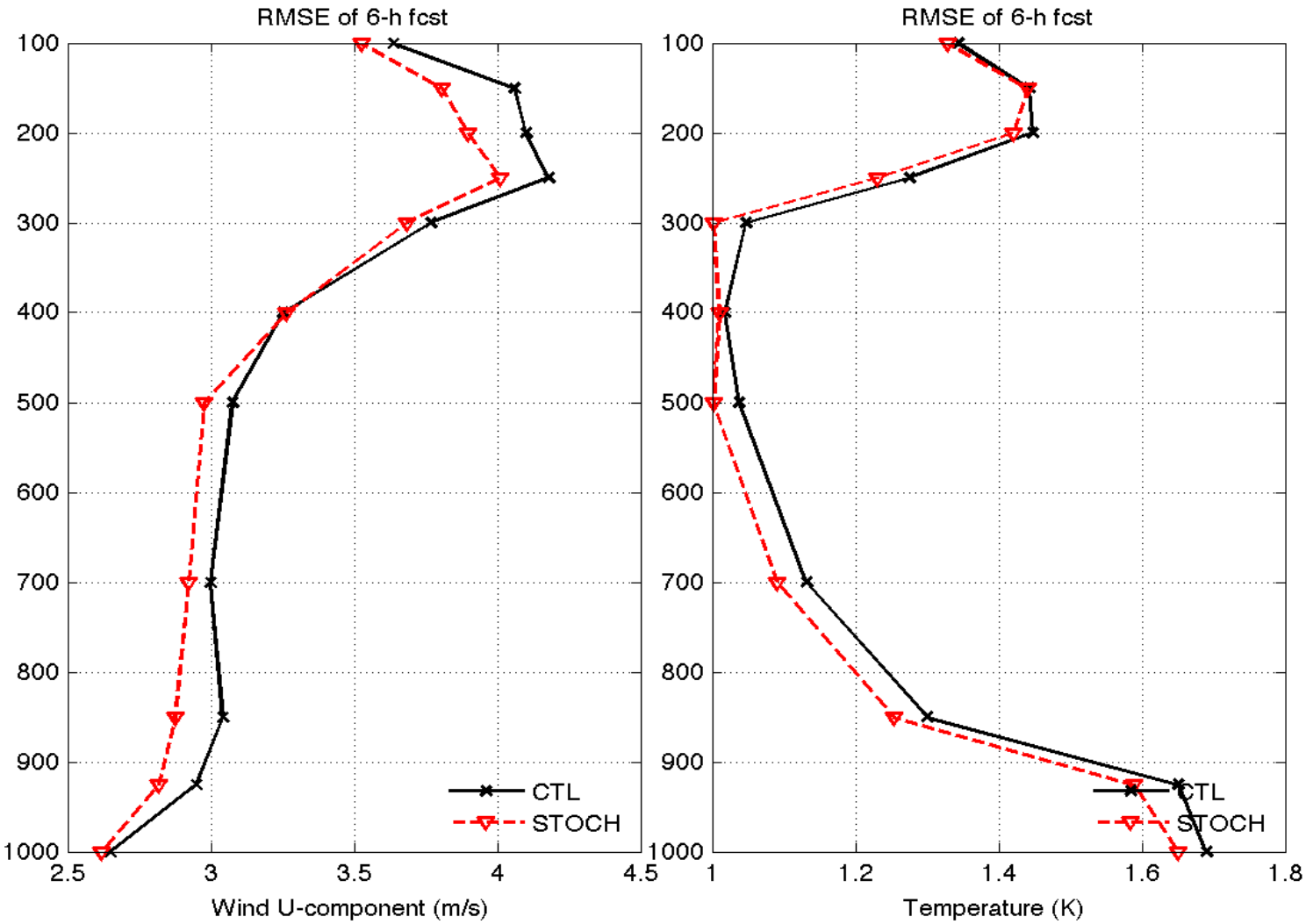
Assimilation Experiments with SKEBS

- CTL run: Taiwan CWB operational configuration with all operational observation types,
- STOCH run: Add the SKEBS in the WRF 6h forecasts,
- Full cycling assimilation with WRF/DART for June 1-14, 2011.

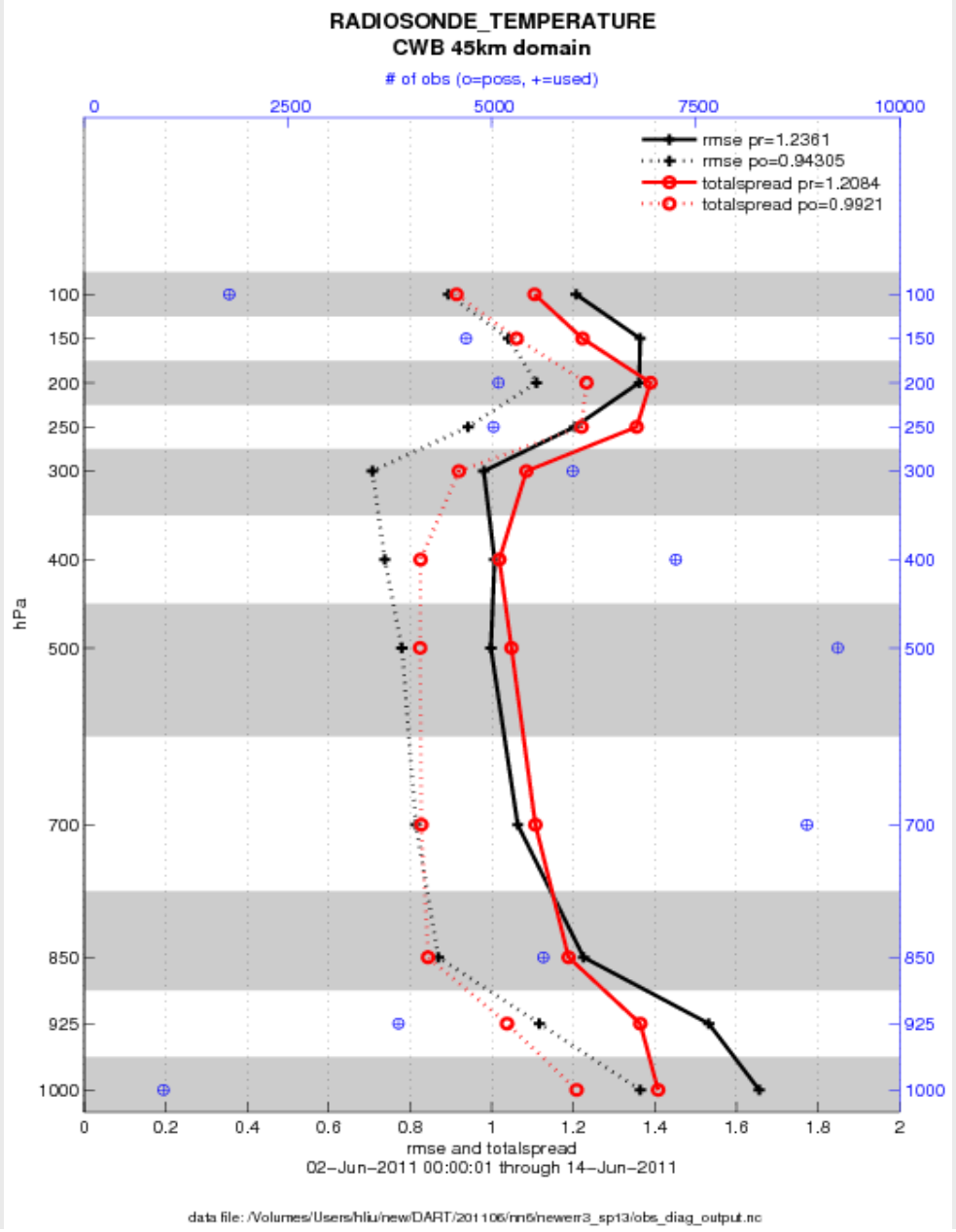
Ensemble spreads of 6h forecasts (2011.06 case)

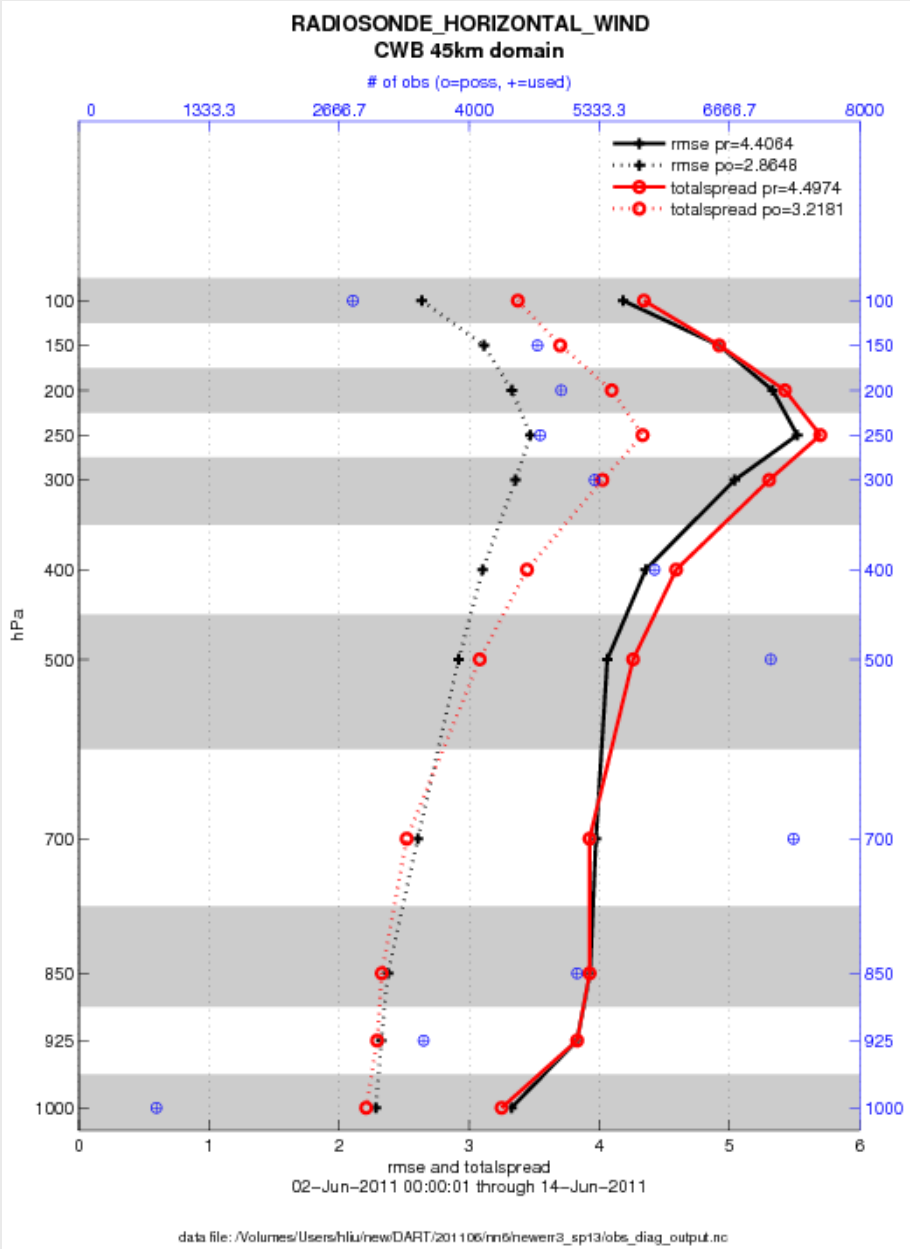


6h FCST ensemble mean RMS error (2011.06 case)



6h-fcst T & wind RMSE and total spread (with SKEBS 2011.06)





Assimilation experiments with SKEBS for 3 Typhoons of 2008

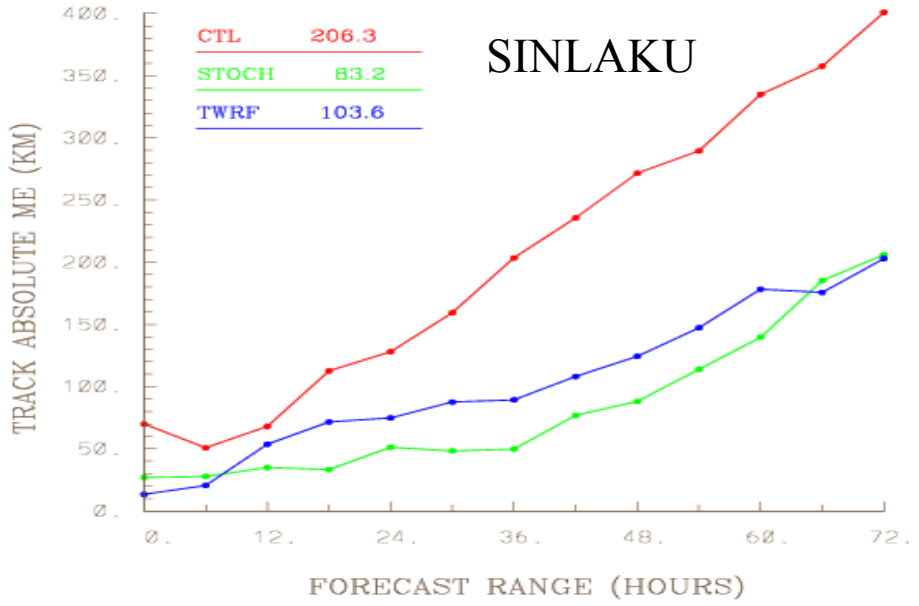
- Cycling assimilation for the period of 00Z Sept. 4 – 00Z Sept. 28, 2008 over the 45km CWB domain and operational observations.
- 72h forecasts are initialized every 12 hours from the ensemble mean analyses starting from the genesis of the tropical storms until their 1st landing.

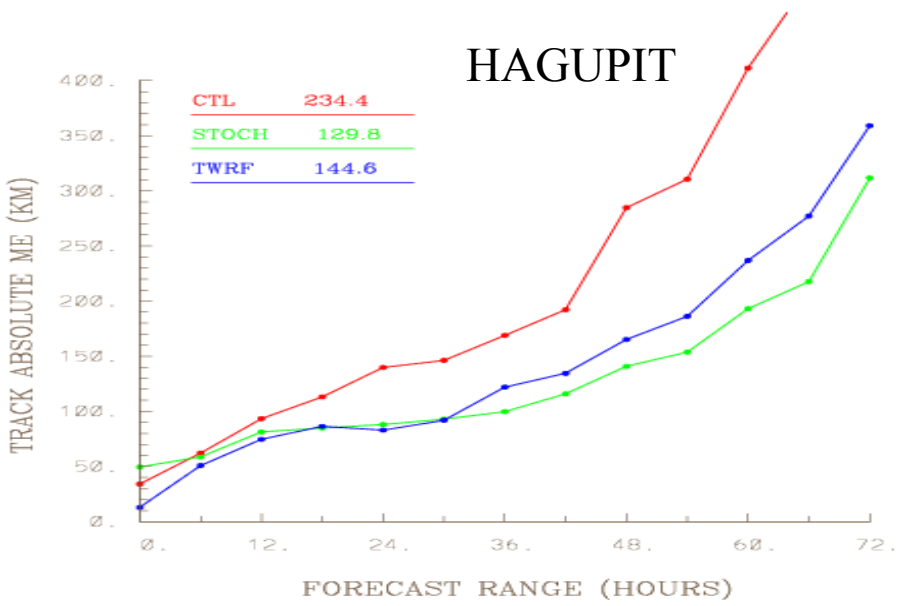
  Sinlaku: 2008.09.09.00Z – 13.00Z (9 forecasts)

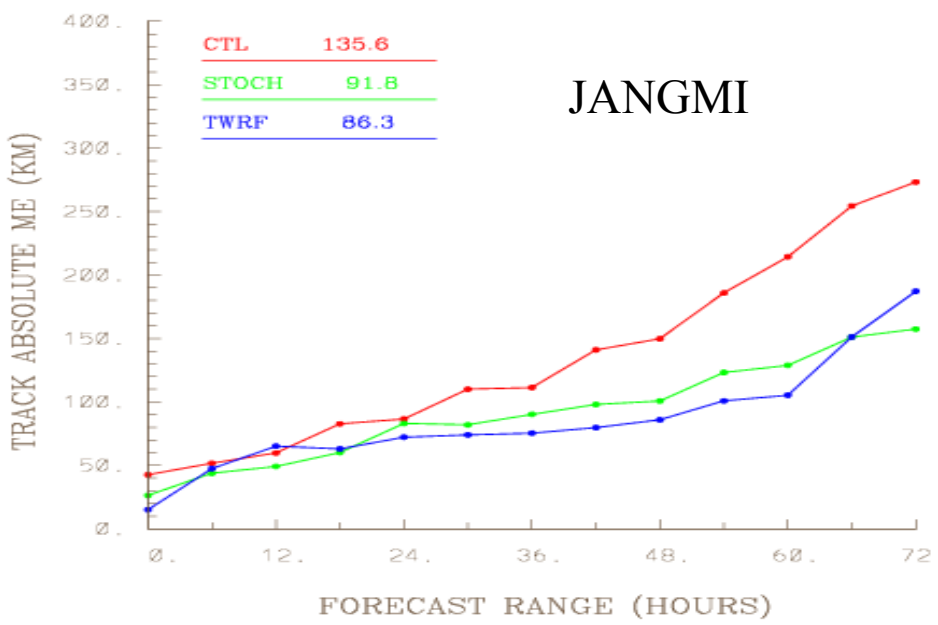
  Hagupit: 2008.09.19.12Z – 24.00Z (10 forecasts)

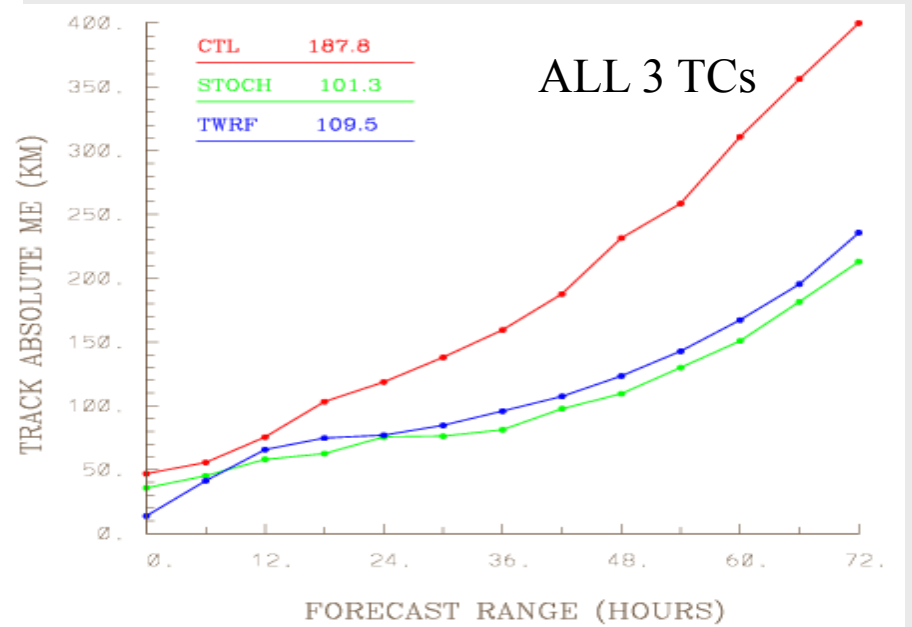
  Jangmi: 2008.09.24.12Z – 28.00Z (8 forecasts)
- TWRF: CWB operational typhoon forecasts are used for comparison.

Averaged forecast track errors









Summary

- Use of stochastic physics in WRF/DART significantly reduces the ensemble spread deficiency,
- Forecast errors, particularly typhoon track, are evidently improved and competitive with the operational 3D-Var,
- The WRF/DART system provides a good tool to study impact of RO data, especially in the lower troposphere.