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

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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

**Wind increment at 250 hPa**

**Q increment at 850 hPa**

*Daily Q analysis increments (g/kg), August 23*
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)
- **TWRF**: CWB operational typhoon forecasts are used for comparison.
Averaged forecast track errors

SINLAKU

HAGUPIT

JANGMI

ALL 3 TCs
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.