Hybrid ensemble-variational data assimilation for HWRF - ongoing efforts and plan

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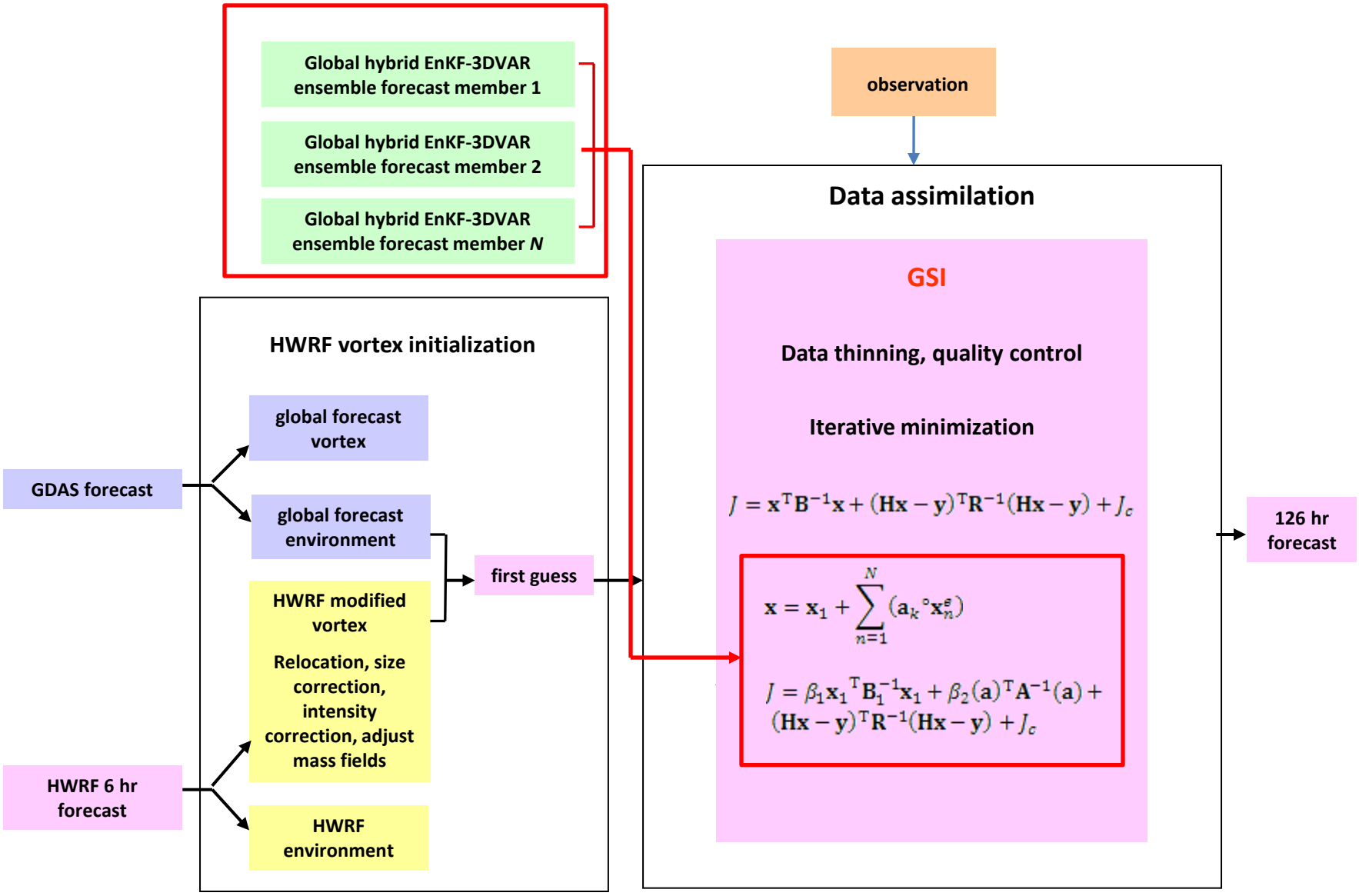
Hybrid Ensemble-3DVAR System for HWRF

- Current HWRF hybrid ensemble-3DVAR DA system is one way coupled system

- Ensemble perturbations can be either from global EnKF-3DVAR hybrid system ensemble forecasts or independent HWRF ensemble forecasts

- Ensemble perturbations in vortex area can come from a TC vortex library (Pseudo ensemble hybrid method, more later)

- Ensemble covariance is incorporated as part of the background error covariance though extended control variable method (Lorenc 2003; Buehner 2005; Wang et al. 2007)



HWRF Initialization

Ongoing efforts

- Testing and tuning the one way coupled hybrid system using global hybrid ensemble

- Testing and improving the pseudo-ensemble hybrid data assimilation

Hybrid data assimilation experiments using global hybrid ensemble

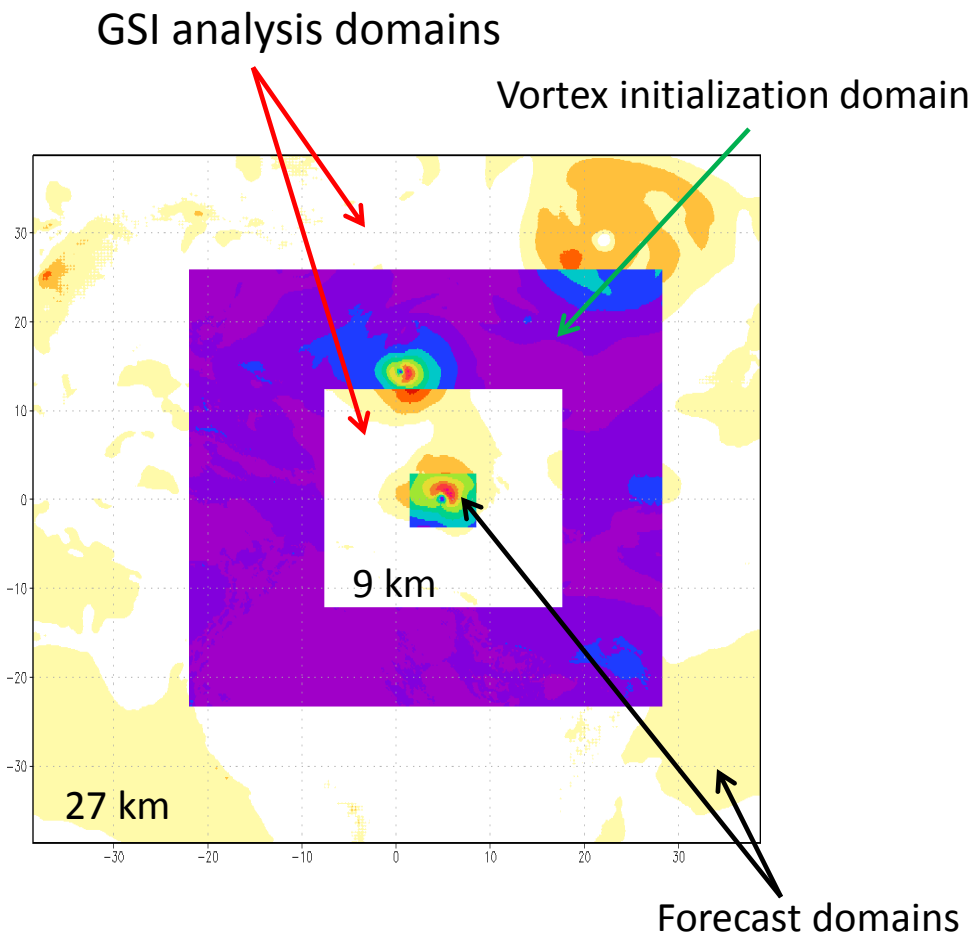
- 80 global ensemble members at T254L64 resolution (spectral data)
- β_1^{-1} = 0.2 (static background error covariance)
- horizontal localization

  Inner domain: 300 km

  Outer domain: 600 km, 900 km, and 1200 km.
- Vertical localization

  Inner domain: 10, 20 and 40 grid units

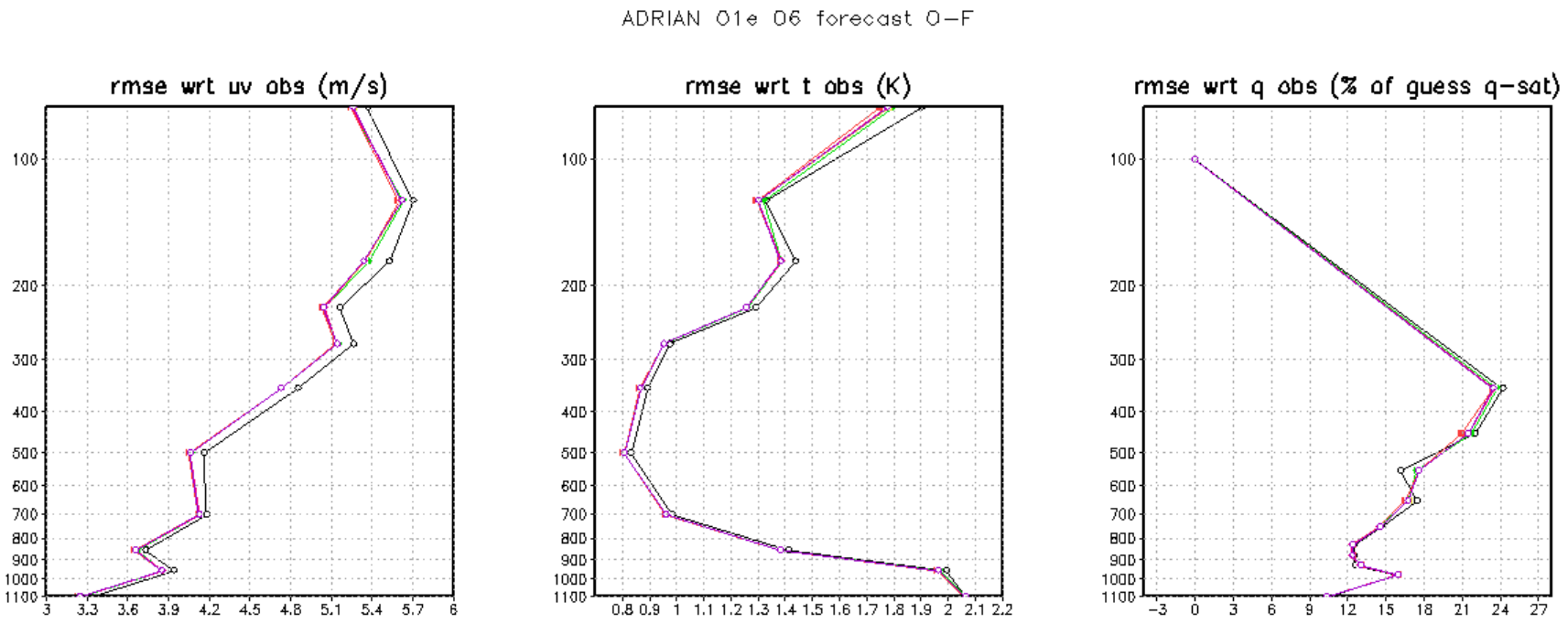
  Outer domain: 10 grid units



HWRF domains on rotated grid

Hybrid data assimilation experiments
Using global hybrid ensemble

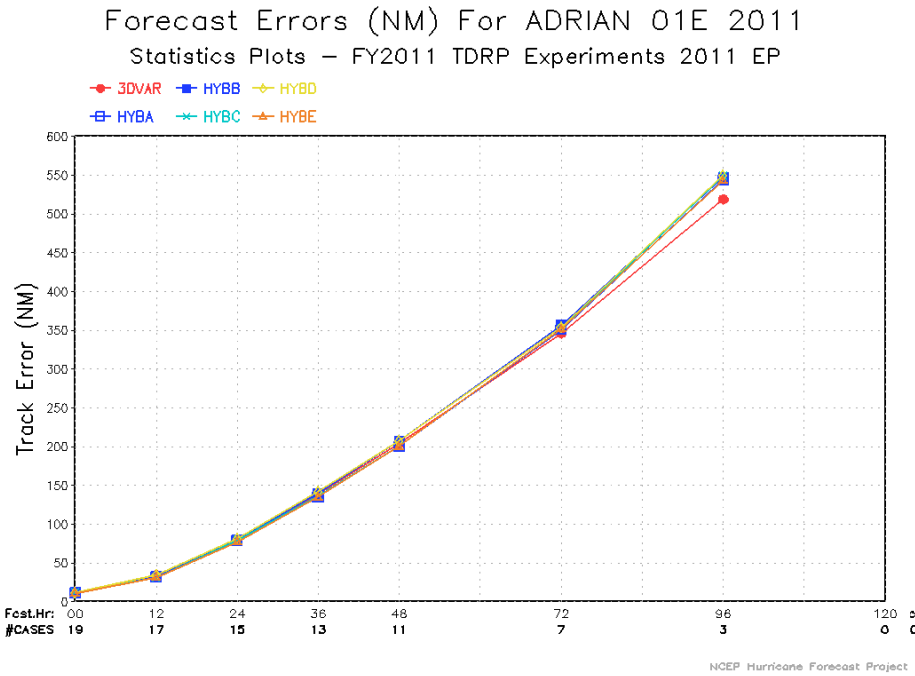
averaged 6 hour forecast rmse with respect to conventional observation

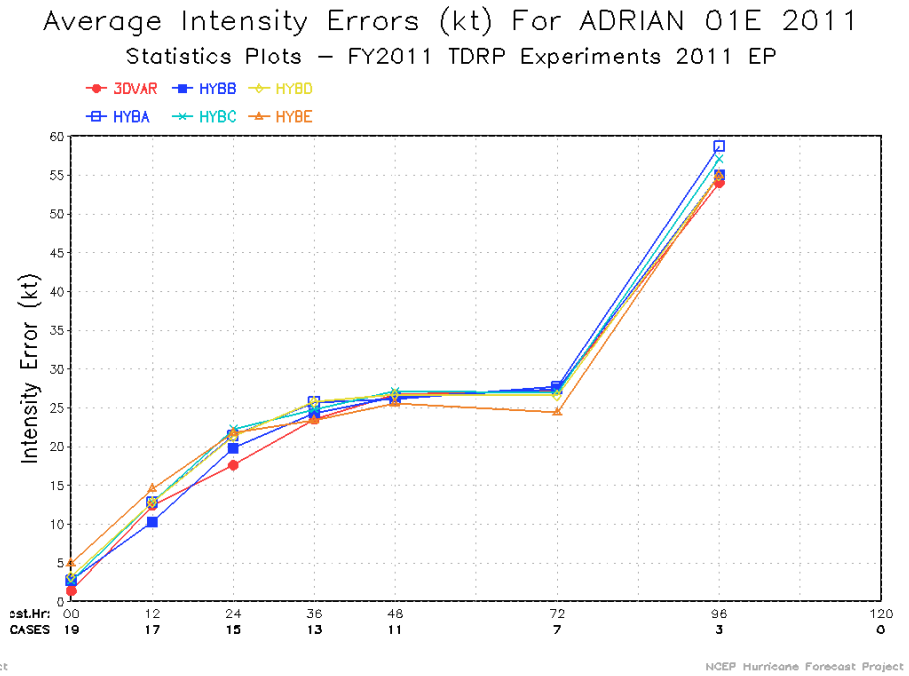


3DVAR – black, hybrid with different localization – colors

Rmse with respect to surface pressure obs (hPa)					
3DVAR	HYBA	HYBB	HYBC	HYBD	HYBE
1.0961	1.0355	1.0368	1.0320	1.0404	1.0400

Hybrid data assimilation experiments
Using global hybrid ensemble





Pseudo-Ensemble hybrid Data Assimilation
(Fuqing Zhang's idea)

- *Poterjoy and Zhang (2011)*: Wavenumber 0 storm structures have the largest influence on forecast uncertainty for TCs with category 1 or higher intensity.

- Back ground error covariance is dominated by wavenumber 0 component.

- Flow-dependent forecast covariance can be approximated from a sample of near-axisymmetric TC vortices

Pseudo-ensemble hybrid for HWRF

• TC vortices are created by running idealized 3 km resolution HWRF simulations and grouped by intensity

12.5<Vmax ≤17.5m/s	**17.5<Vmax ≤22.5m/s**	**22.5<Vmax ≤27.5m/s**	**27.5<Vmax ≤32.5m/s**	**32.5<Vmax ≤37.5m/s**	**……**

• TC library vortices are mapped to the background vortex region (300 km from background TC center) in inner analysis domain and perturbations are calculated

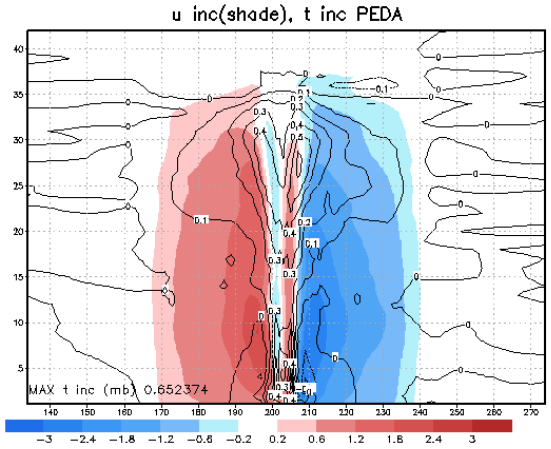
• Replace global ensemble perturbations with TC vortex library perturbations within 150 km from background TC center

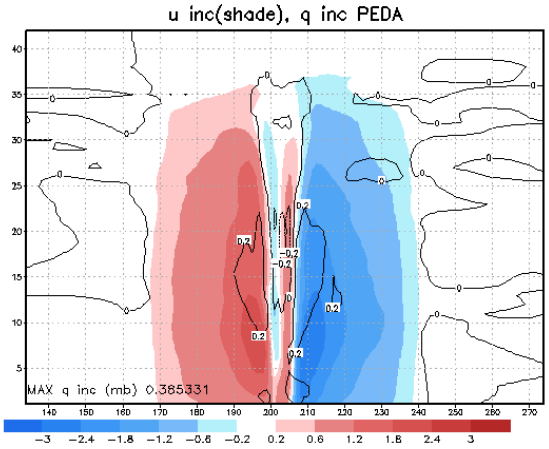
• TC library perturbations are gradually blended with global ensemble perturbations from 150 km to 300 km from background TC center

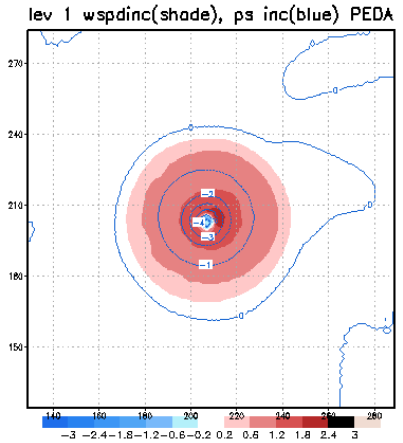
Analysis increment from single obs test

u obs at 0.5 degree north of storm center at 850 hPa level
3 m/s O-F, obs error 1 m/s

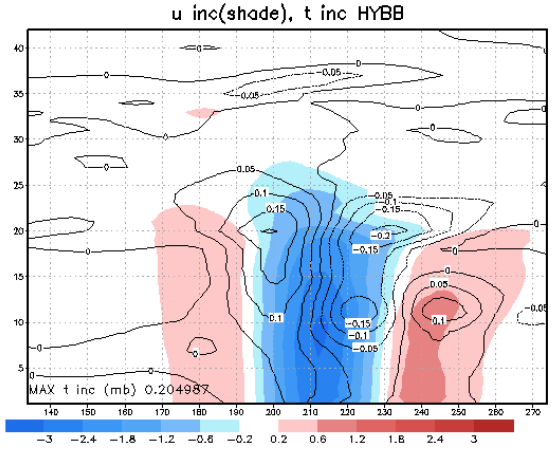
PEDA

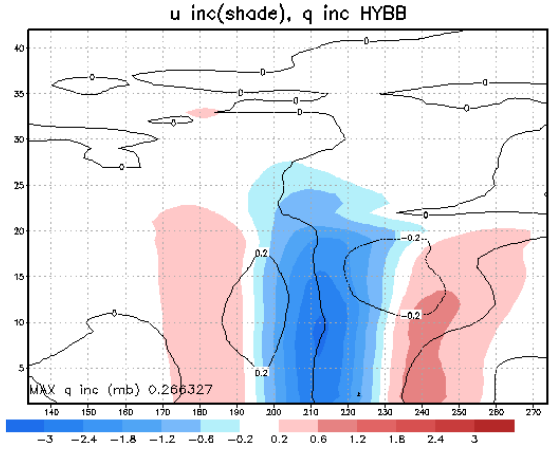


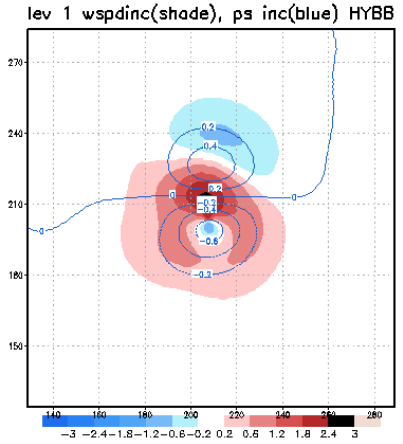




HYBB

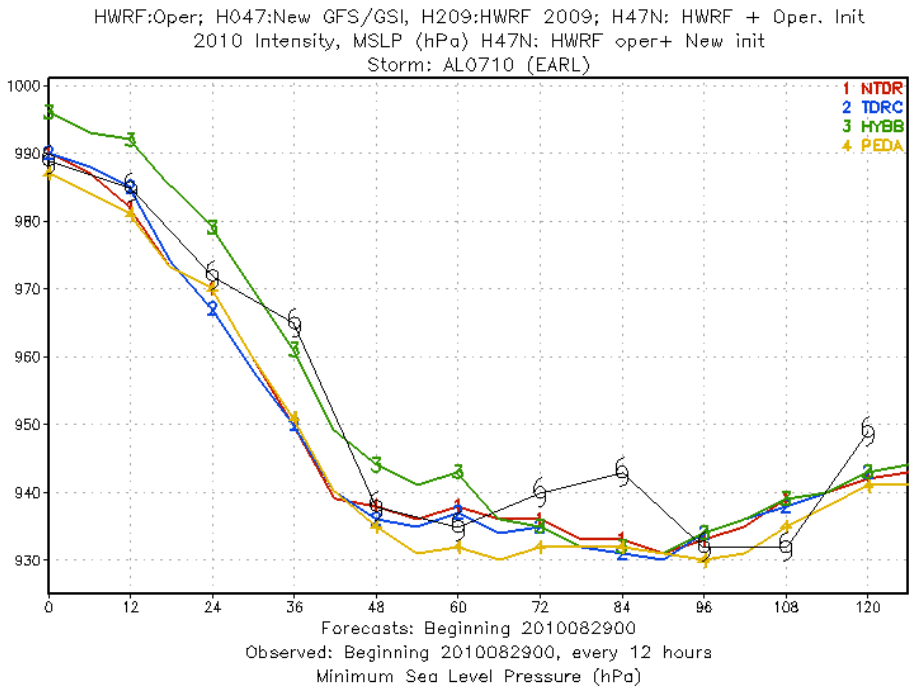


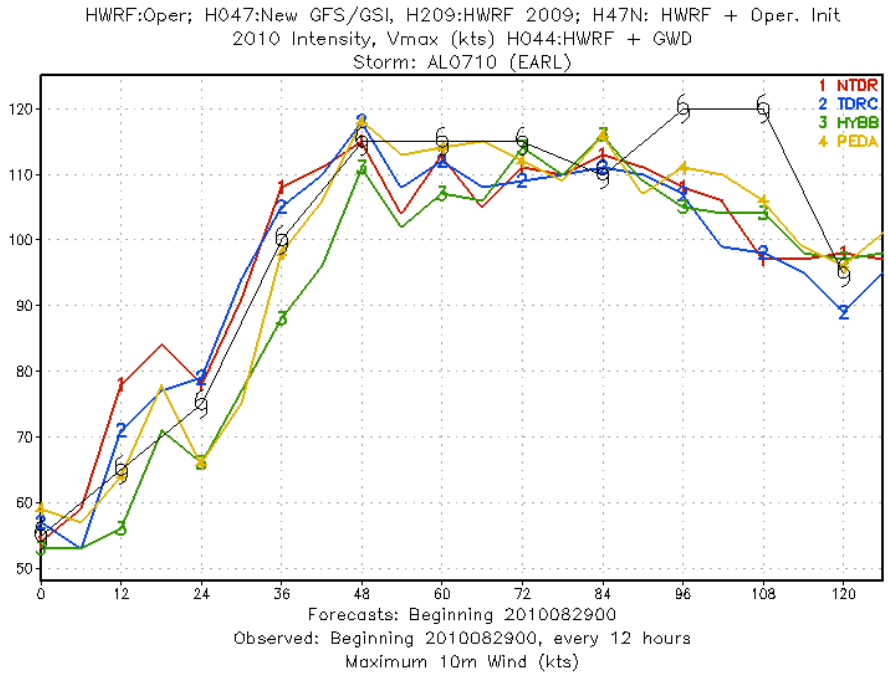




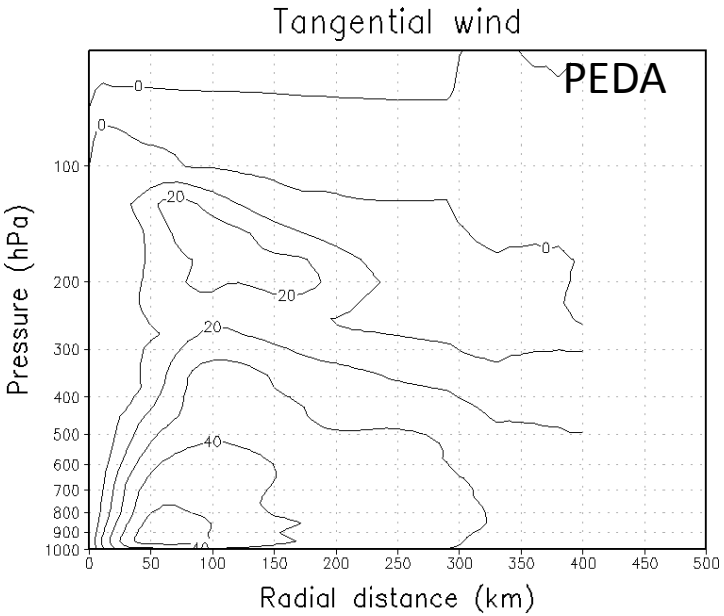
PEDA – hybrid DA with pseudo-ensemble HYBB – hybrid DA with global hybrid ensemble

Hybrid Tail Doppler Radar DA test with Hurricane EARL

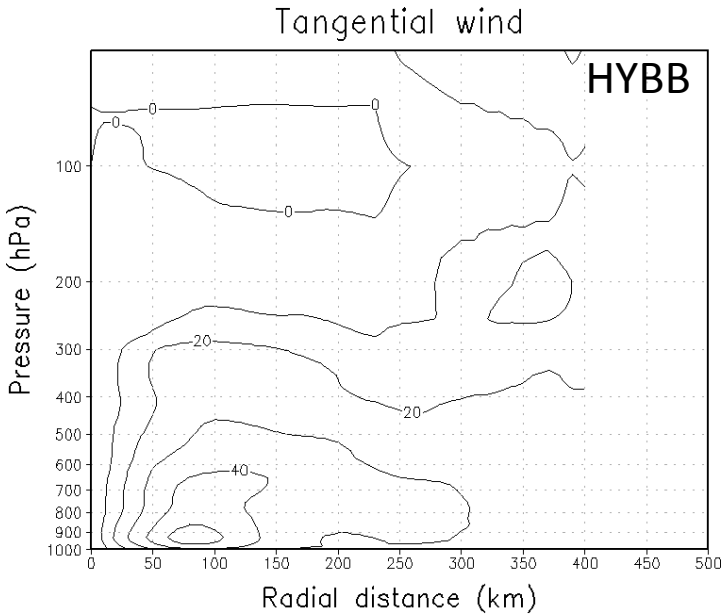




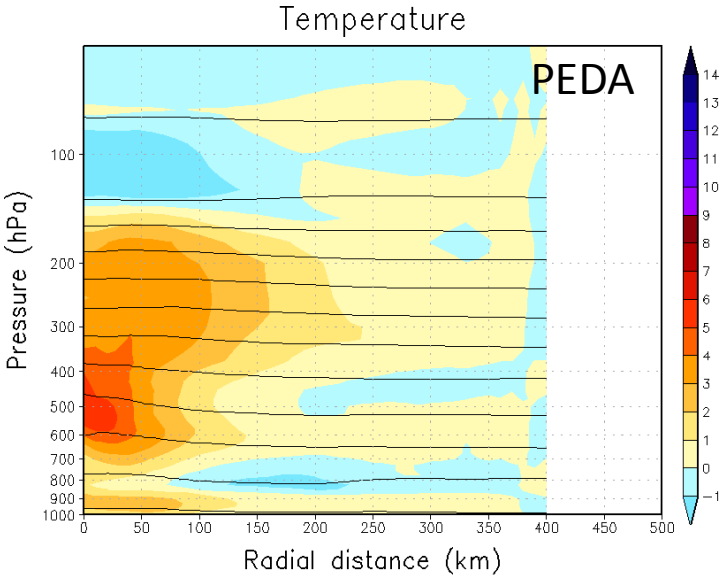
analysis



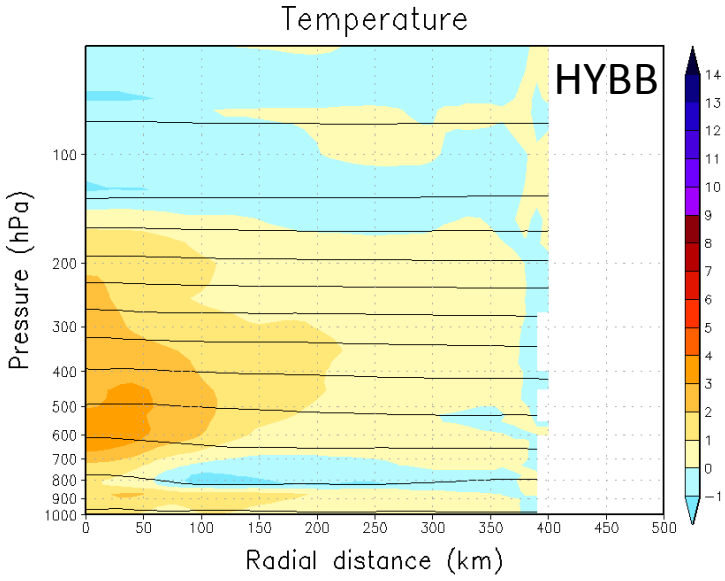
PEDA, EARL 07l, d02, Azimuthally averaged, Init. date: 2010082900, 00 h FCST
Tangential wind (contour), Min=−9.86736 kts, Max=56.9508 kts



HYBB, EARL 07l, d02, Azimuthally averaged, Init. date: 2010082900, 00 h FCST
Tangential wind (contour), Min=−4.43061 kts, Max=55.437 kts

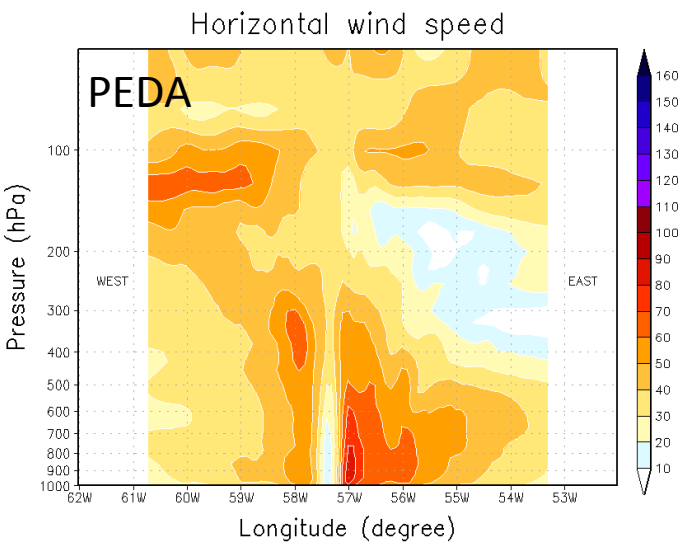


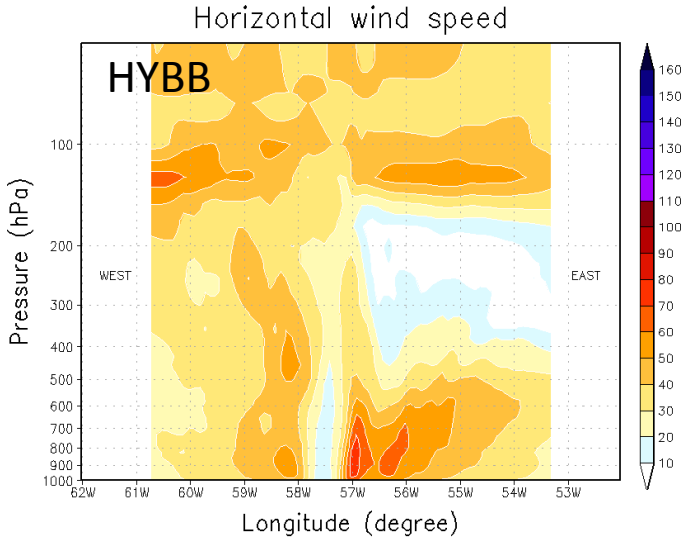
PEDA, EARL 07l, d02, Azimuthally averaged, Init. date: 2010082900, 00 h FCST
Temperature deviation (shaded), Min=−2.98245 K, Max=5.73224 K
Temperature (contour), Min=192.454 K, Max=302.881 K

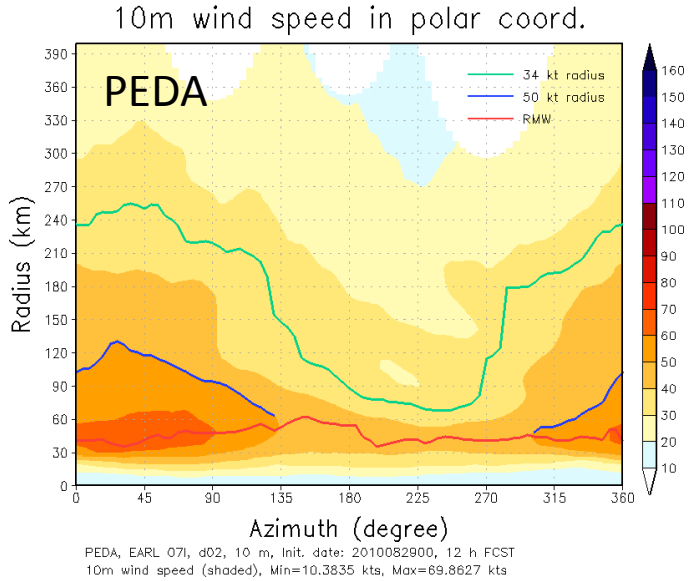


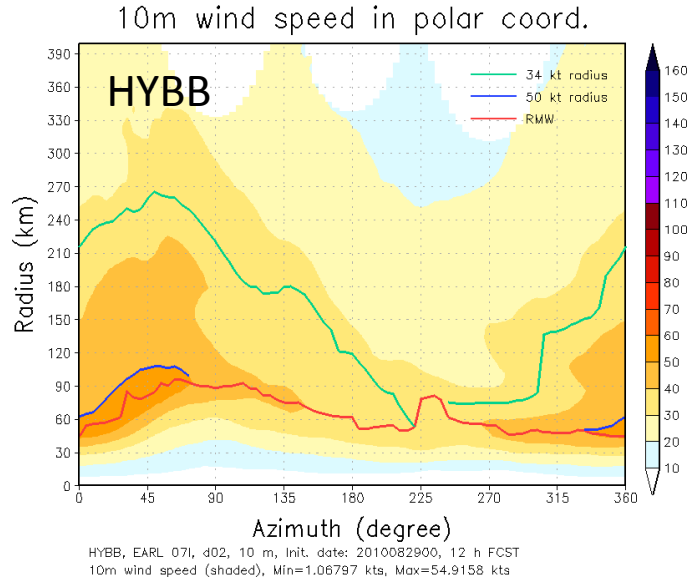
HYBB, EARL 07l, d02, Azimuthally averaged, Init. date: 2010082900, 06 h FCST
Temperature deviation (shaded), Min=−1.42023 K, Max=3.7081 K
Temperature (contour), Min=192.701 K, Max=302.688 K

12 hour forecast



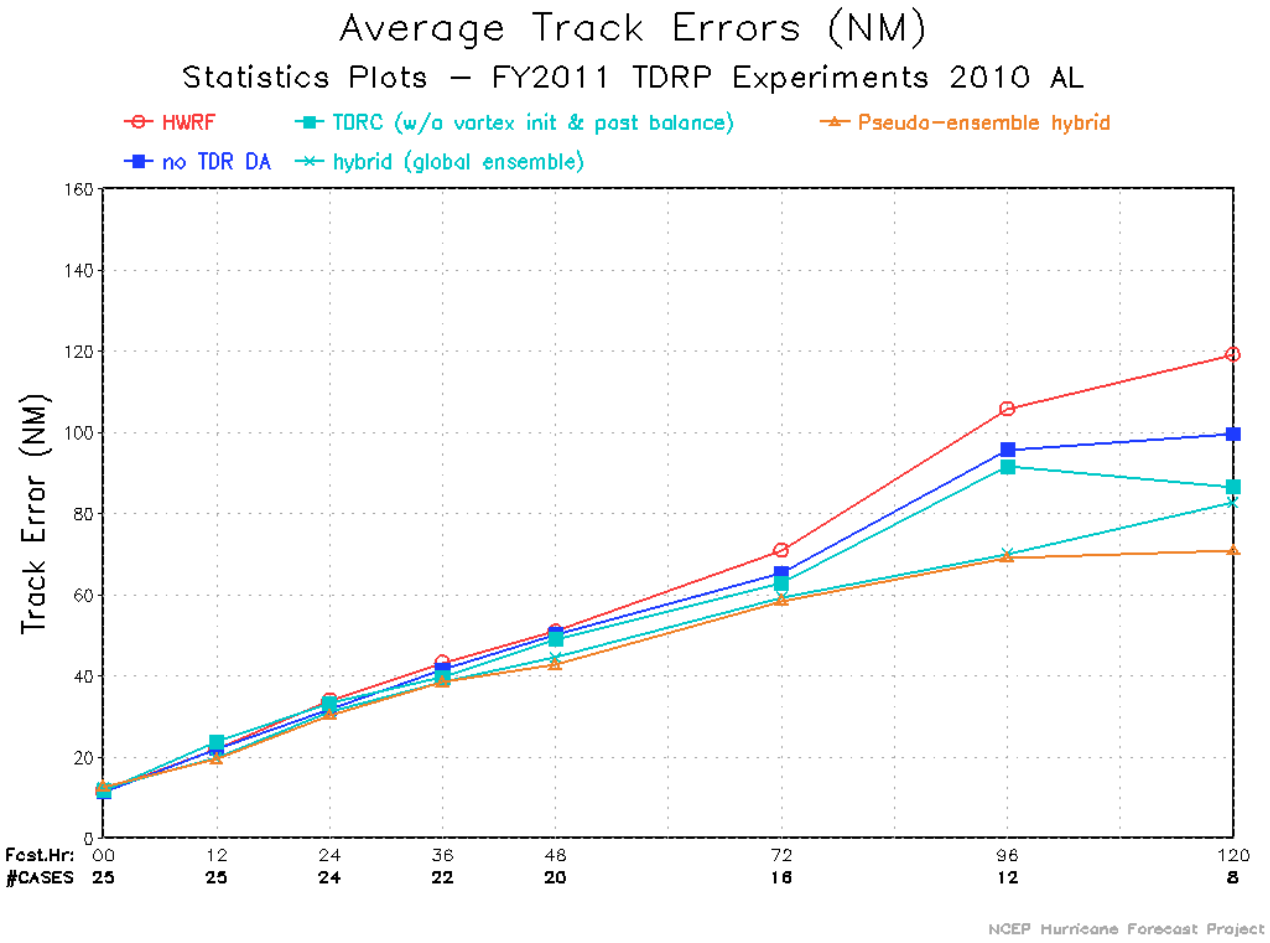




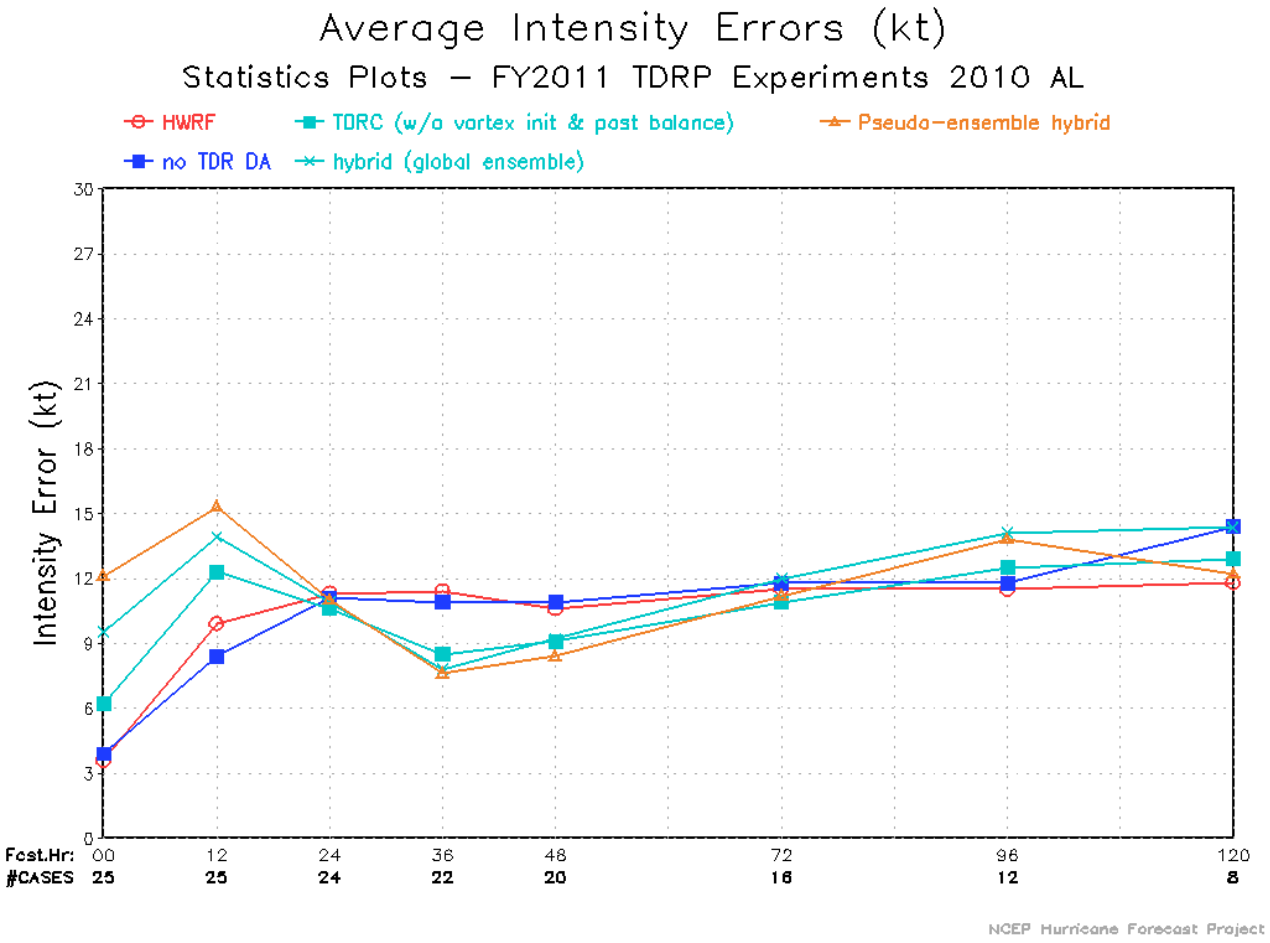


RMW: 28 km

Hybrid TDR DA test with Hurricane EARL



Hybrid TDR DA test with Hurricane EARL



Plans

• The one way coupled hybrid system has the potential to be implemented within the current operational environment.

• No much more computational cost is added by using PEDA. No need to worry about moving nests.

• More hybrid test and comparison will be done for interested storms.

• Will test new options in GSI hybrid code, e.g. using vertical integrated ensemble control variable α for Ps, spatially varying weighting parameter β_1^{-1}.

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Plans

- Improve the TC library for PEDA, e.g. introduce size variability in the TC library.

- Will soon move on to higher resolution HWRF (27-9-3 km). Future PEDA test will be mostly done on higher resolution HWRF.

- Plan to run real-time one way coupled hybrid parallel next hurricane season

- Will start to build the two way coupled hybrid system for HWRF

Two way coupled HWRF hybrid system