Assimilation of Airborne Doppler Radar Observations Using the Unified GSI-based Hybrid Ensemble-Variational Data Assimilation System for HWRF

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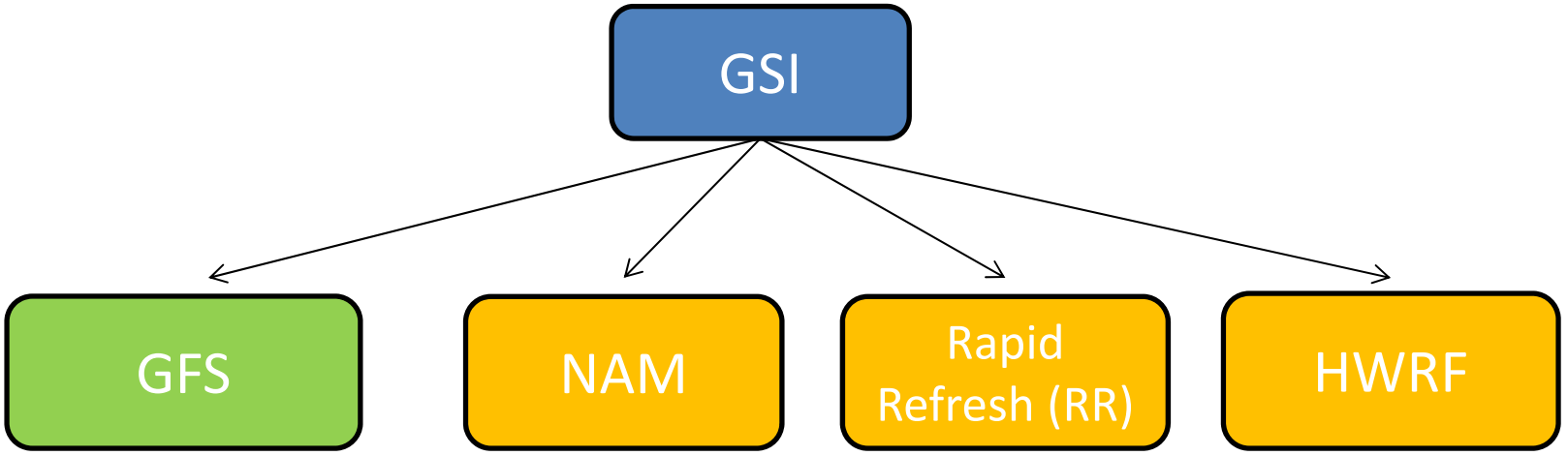
Background

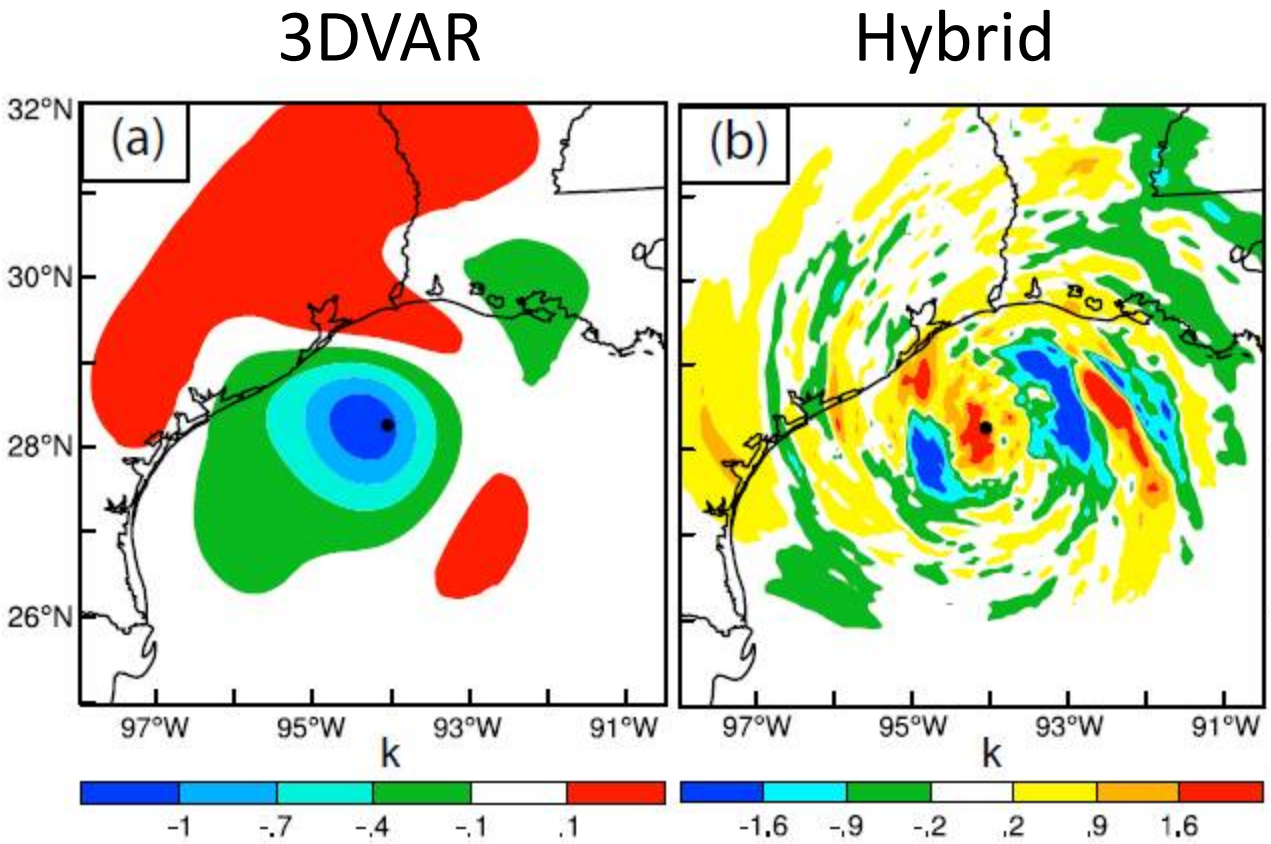
- The GSI-based hybrid DA system showed significant improvement for global forecast compared to GSI (3DVAR) and became operational on May 22, 2012 for the Global Forecast System (GFS).
- GSI is a unified system which provides data assimilation for all operational global and regional forecast system.



Background

- Efforts are being conducted to integrate the same GSI-based hybrid DA system with operational regional forecast systems.
- Unifying GSI-based hybrid DA system with operational regional systems facilitates faster transition to operations.
- The focus of the project is the extension, application, extensive testing and research of the GSI-based hybrid data assimilation for the HWRF modeling system at high resolutions.
- Also motivated by encouraging results of ensemble based data assimilation for tropical cyclones.

Background

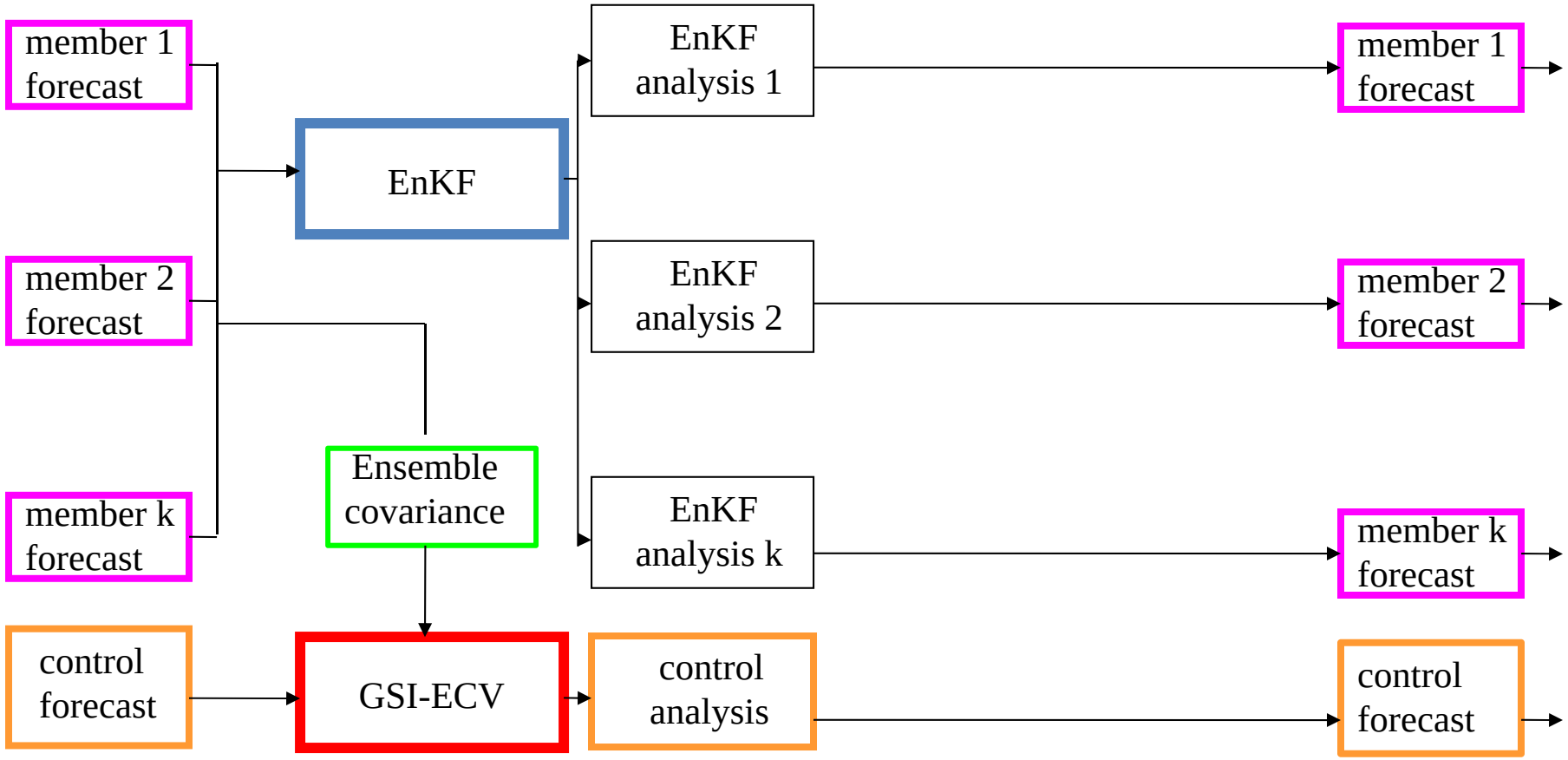


Li, Wang, Xue 2012

850 mb temperature increment after assimilating ground based radar radial velocity using WRF 3DVAR (a) and WRFVAR hybrid (b, Wang et al. 2008)

GSI-based Hybrid ensemble-VAR DA system

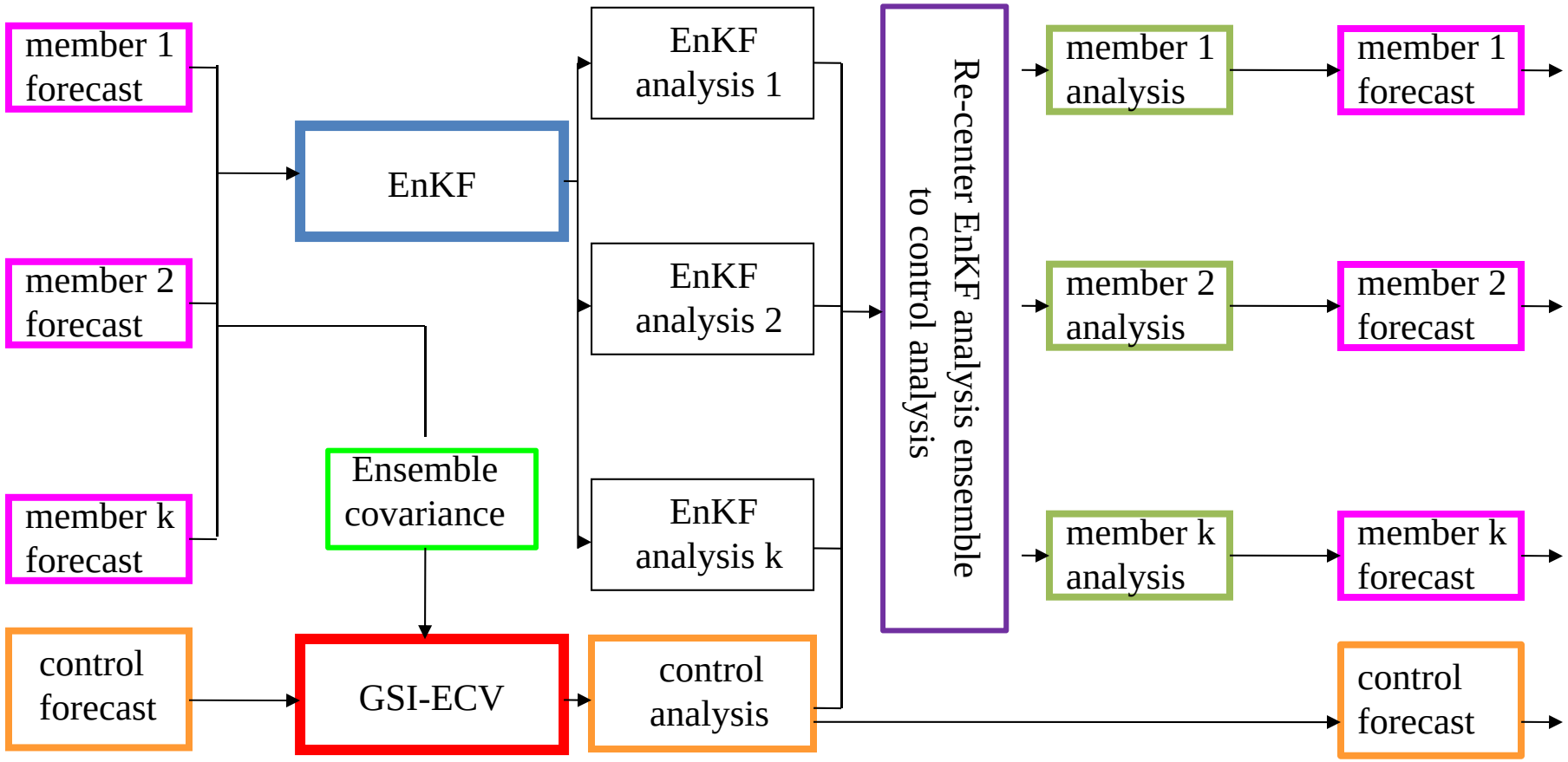
1-way coupling



Wang et al. 2012

GSI-based Hybrid ensemble-VAR DA system

2-way coupling



Wang et al. 2012

Code changes related to Airborne radar data so far

EnKF

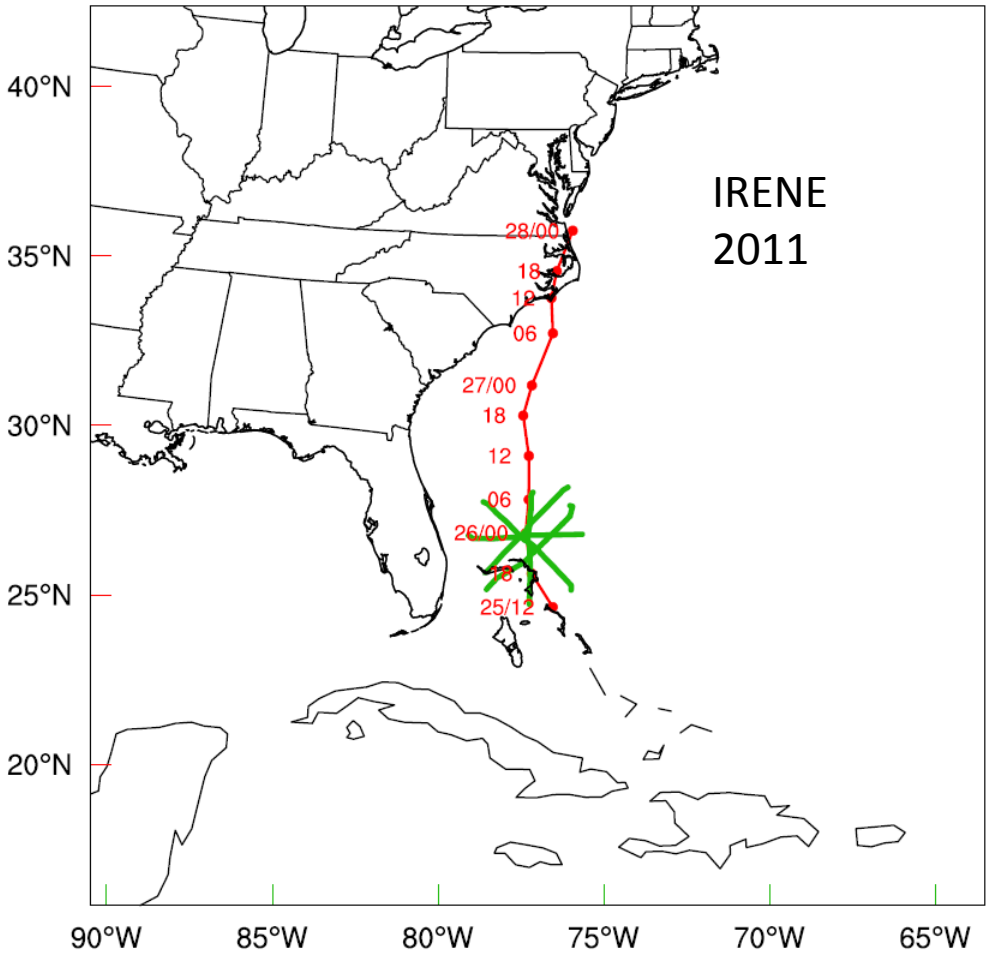
-- Add airborne radar wind observation assimilation capability

GSI

-- Separate the Fore and Aft scans during data thinning in GSI
(TDR data transferred remain the same, changes made inside GSI code)

-- option to assimilate TDR data based on leg

Experiment Setup



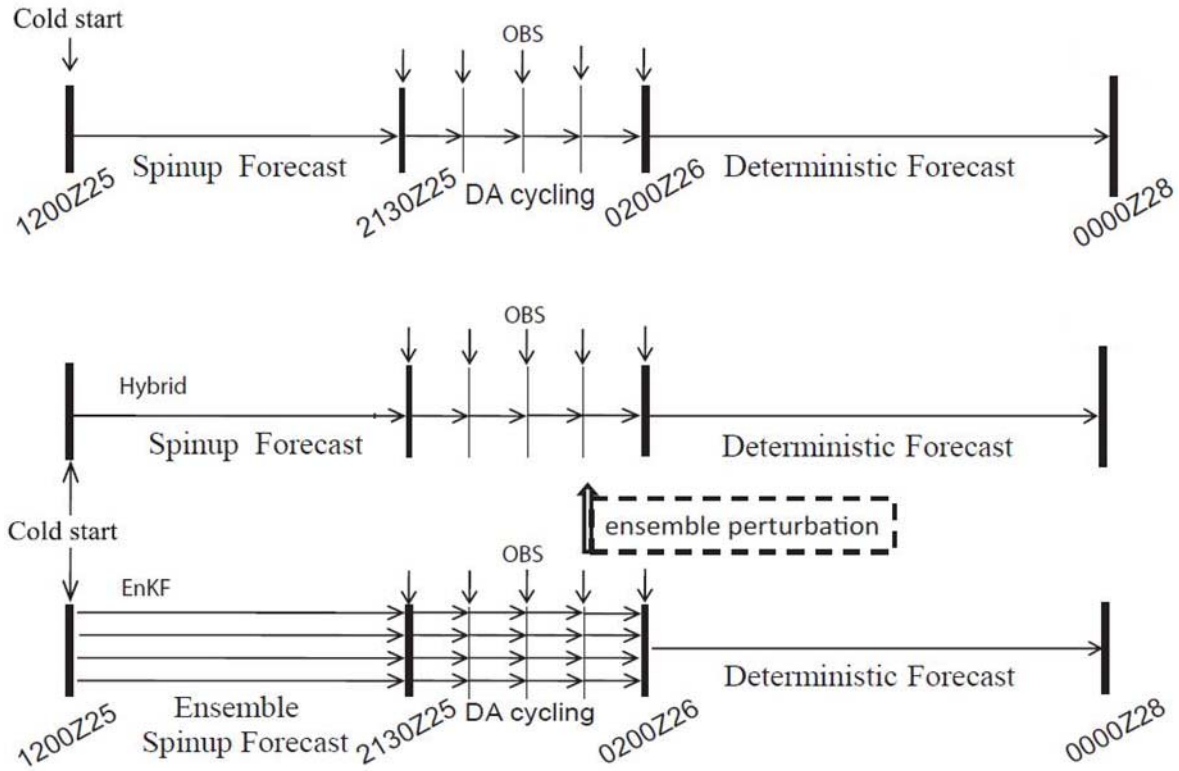
- Model: HWRF Δx=9km
- Observations: radial velocity from Tail Doppler Radar (TDR)
- Case: IRENE 2011
- Initial and LBC ensemble: GFS global hybrid DA system
- Ensemble size: 40

DA cycling configuration

GSI (3DVar)

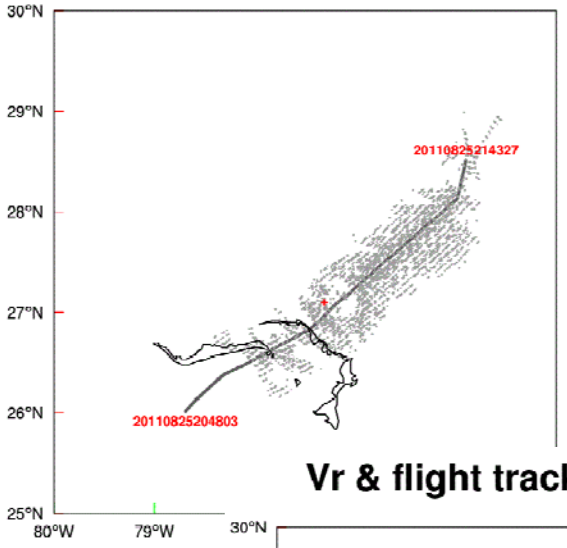
Hybrid (1 way coupling)

EnKF

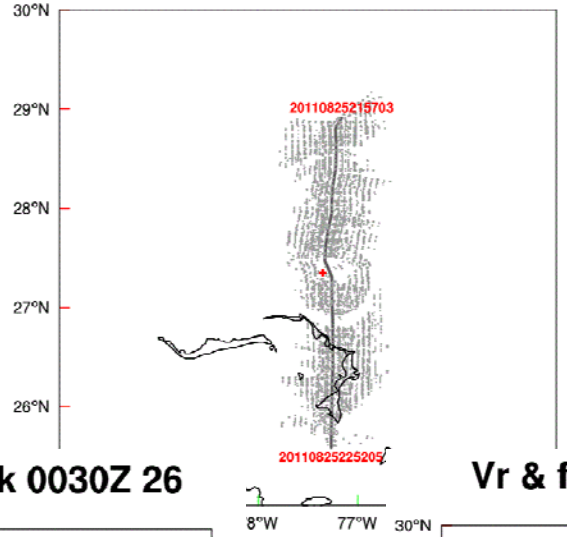


TDR data distribution

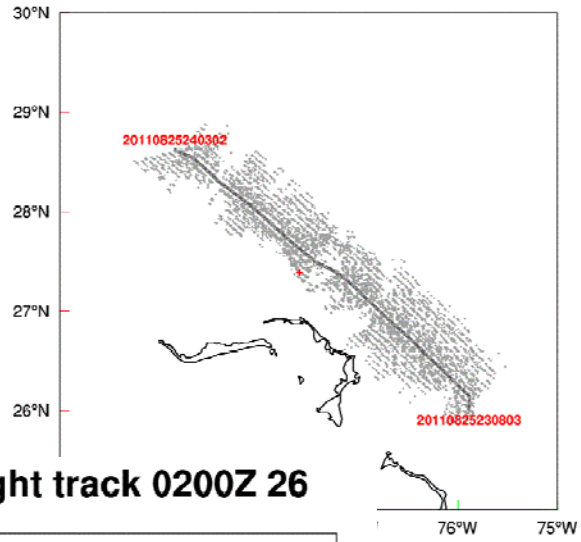
Vr & flight track 2130Z25



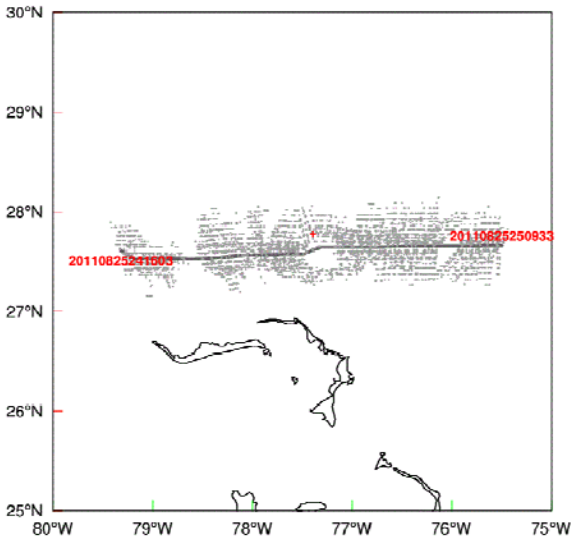
Vr & flight track 2230Z 25



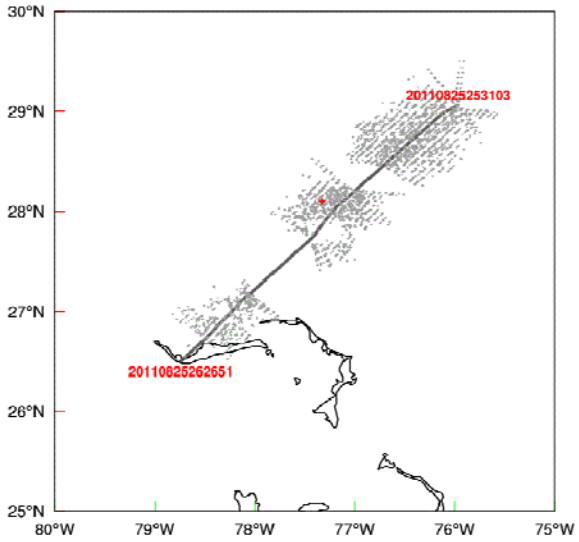
Vr & flight track 2330 UTC 25



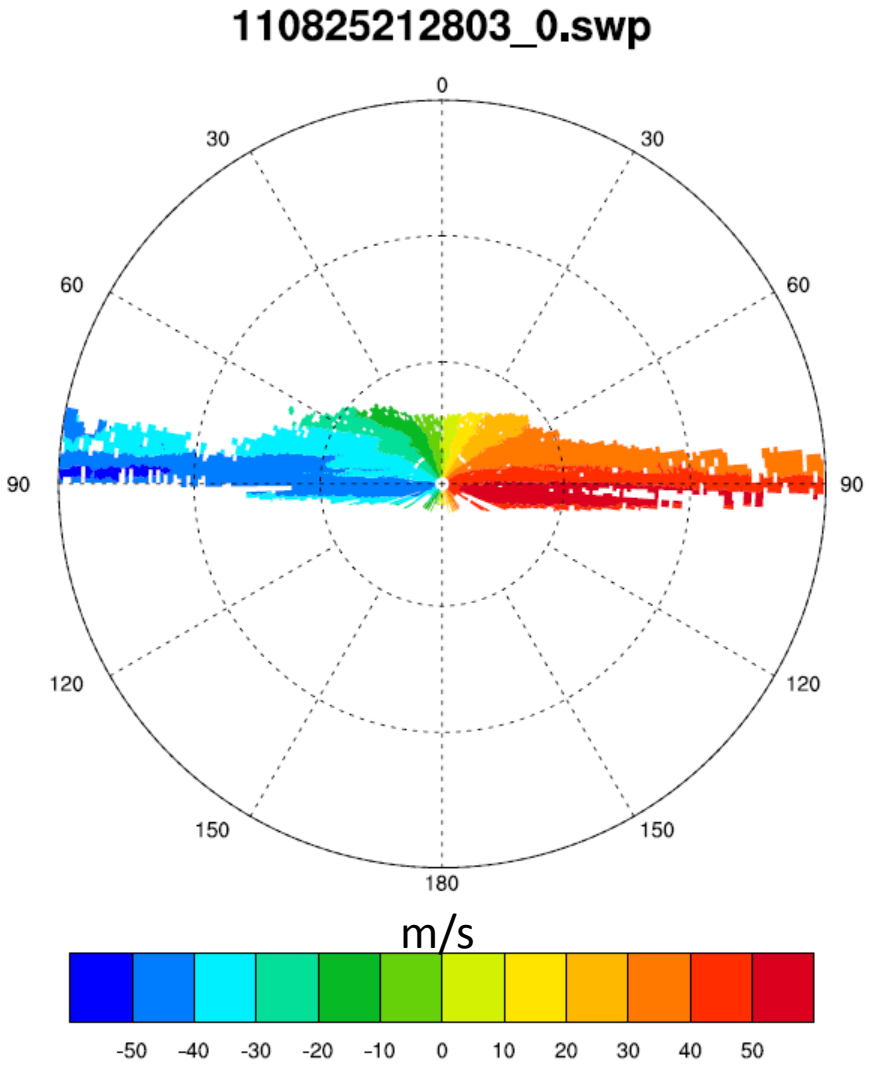
Vr & flight track 0030Z 26

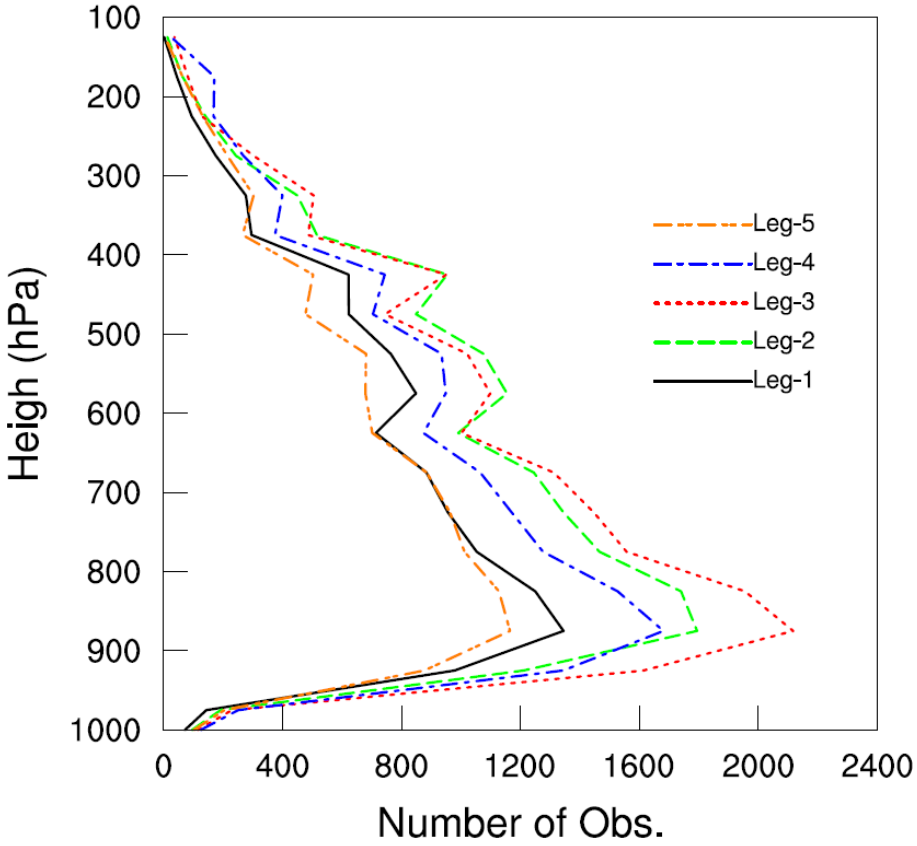


Vr & flight track 0200Z 26



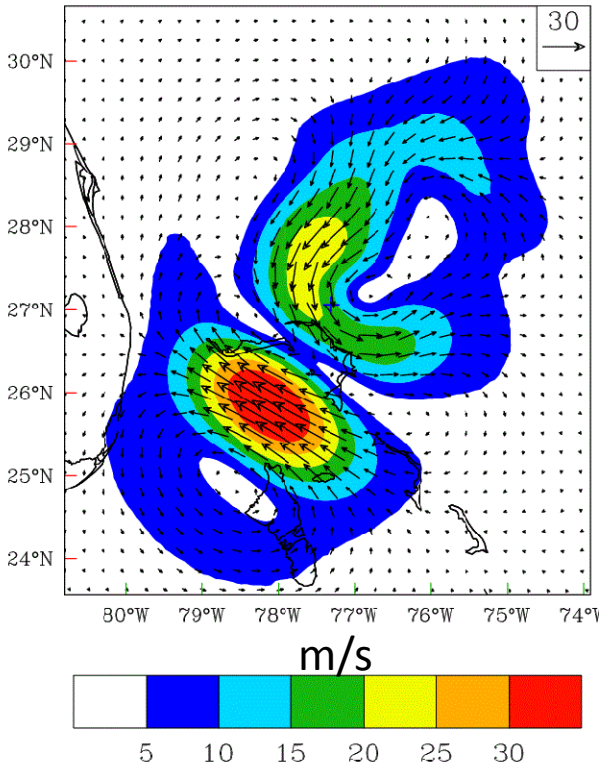
TDR data distribution



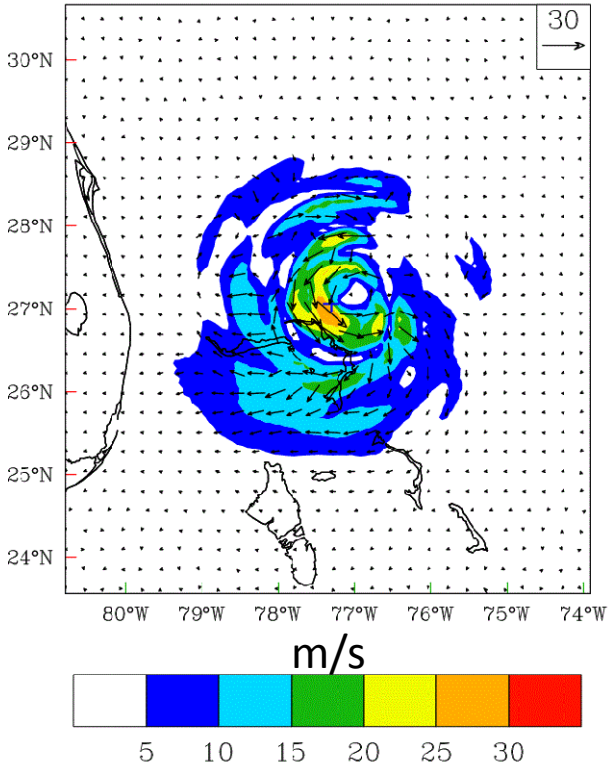


700 mb wind increment

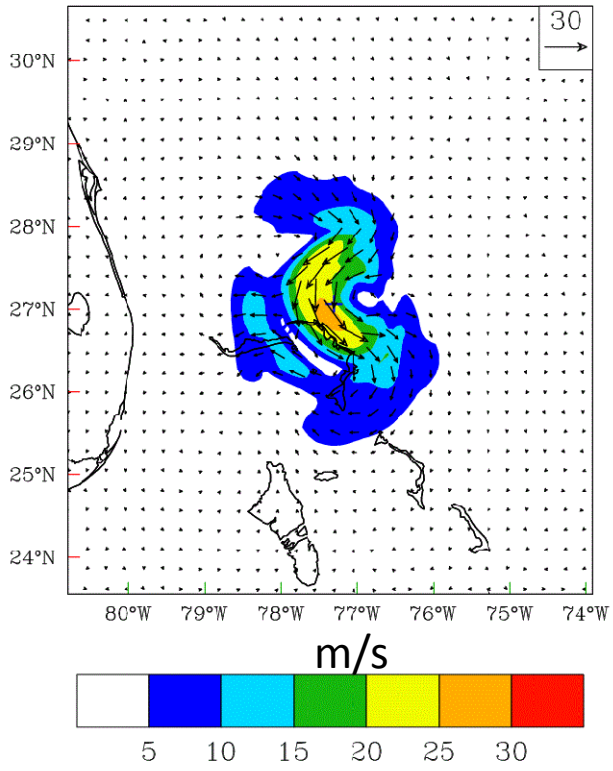
GSI



EnKF



hybrid

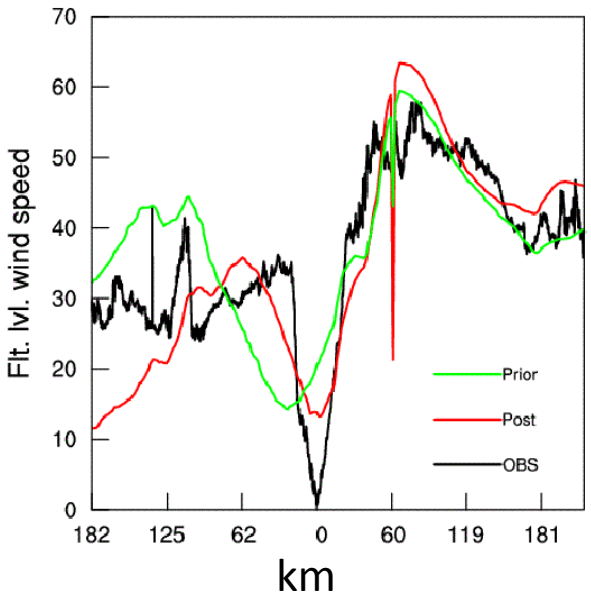


Verification against independent flight level wind speed

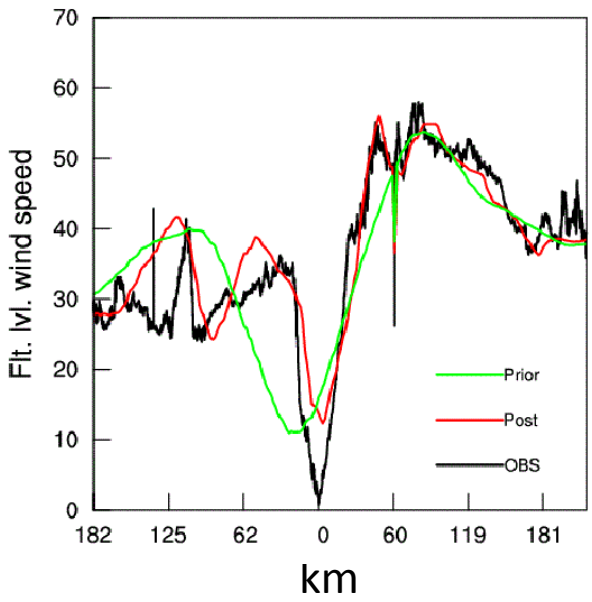
http://www.aoml.noaa.gov/hrd/HRD-P3_fl.html

First Leg

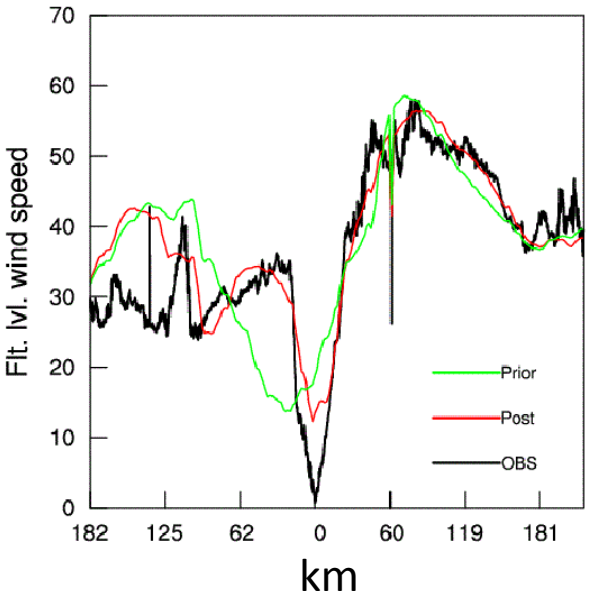
GSI



EnKF



Hybrid

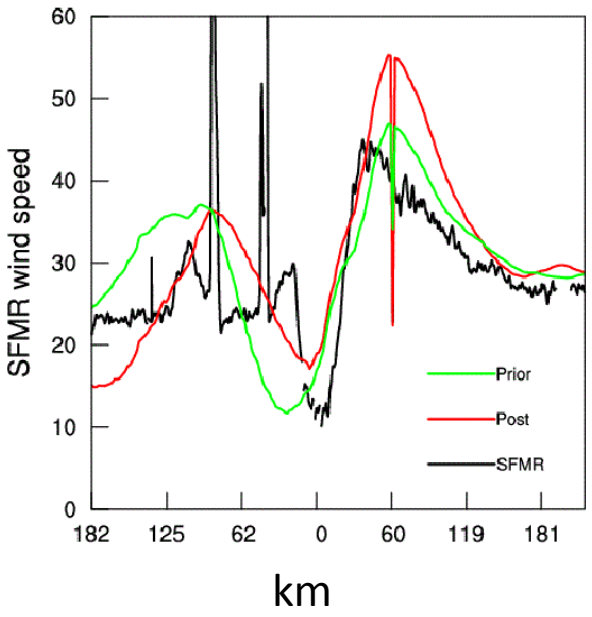


Verification against SFMR wind speed

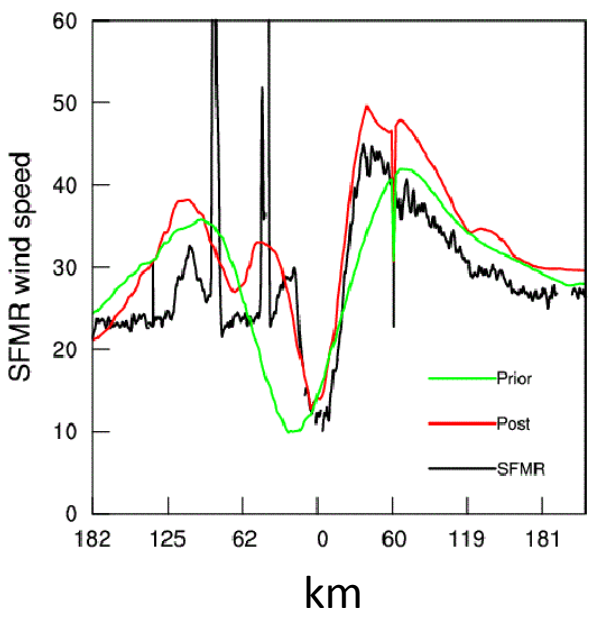
http://www.aoml.noaa.gov/hrd/format/sfmr.html

First Leg

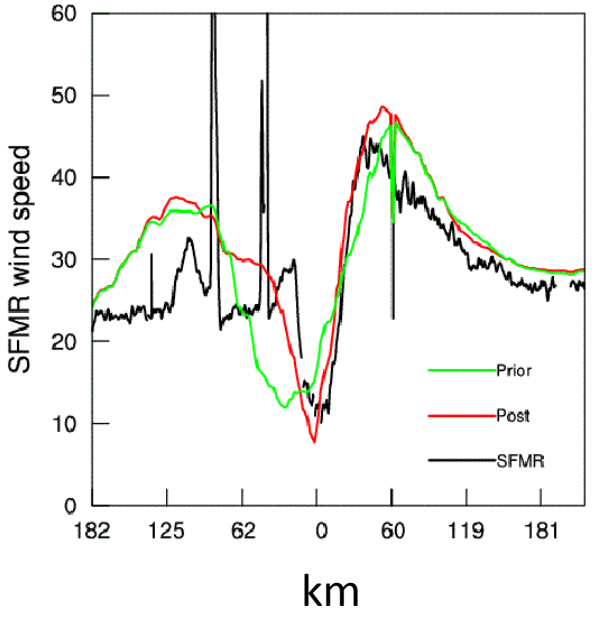
GSI



EnKF



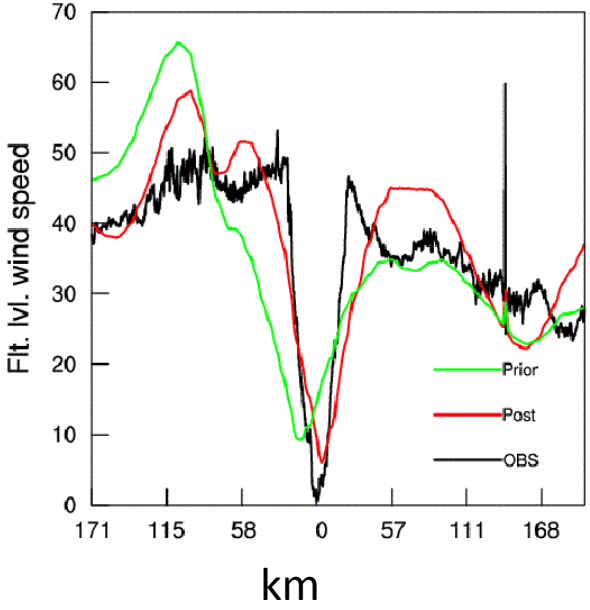
Hybrid



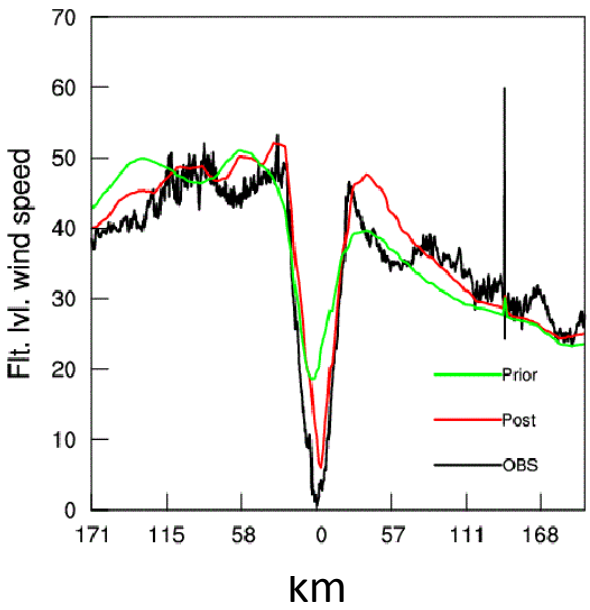
Verification against independent flight level wind speed

Last Leg

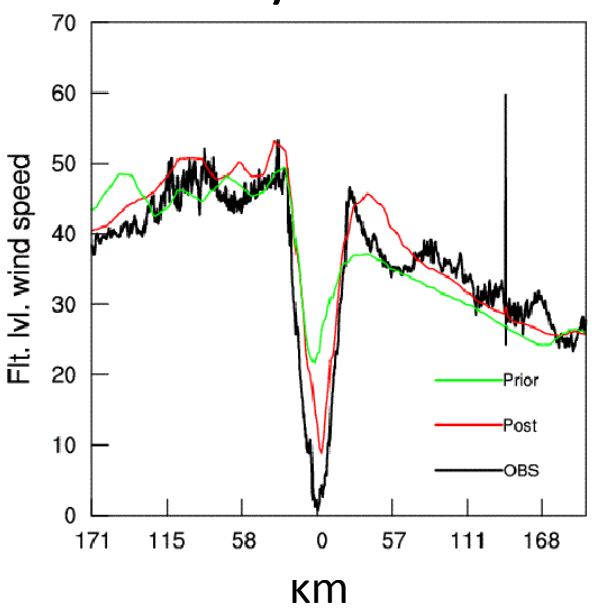
GSI



EnKF



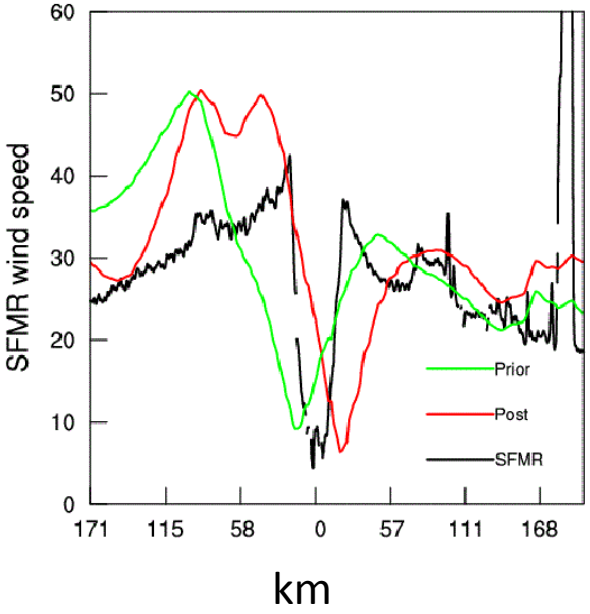
Hybrid



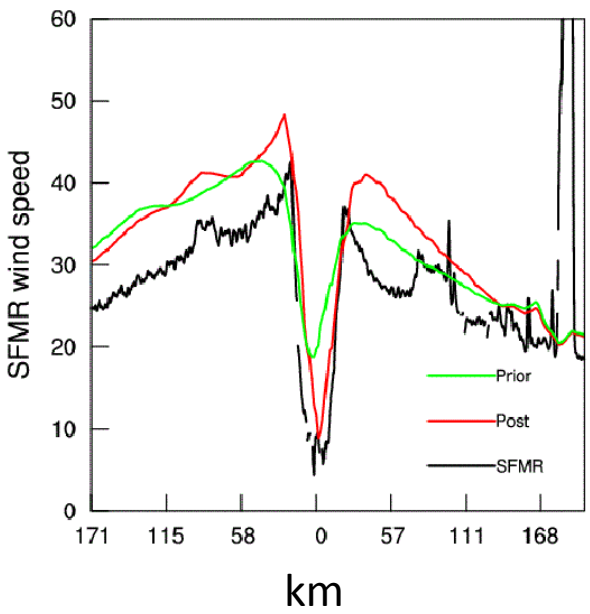
Verification against SFMR wind speed

Last Leg

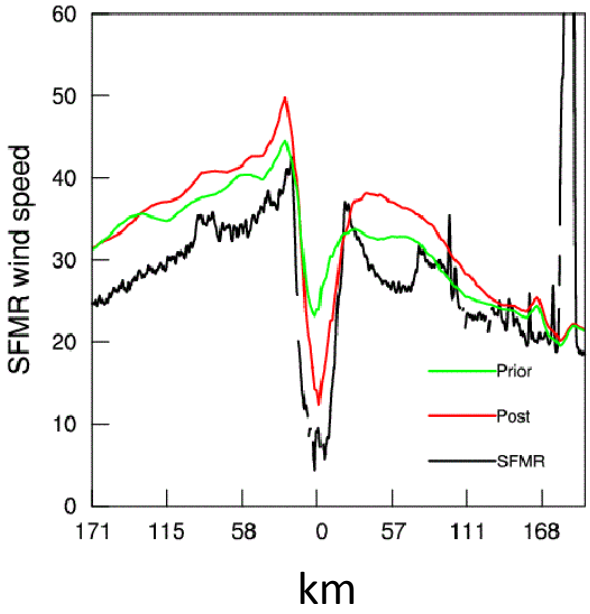
GSI



EnKF

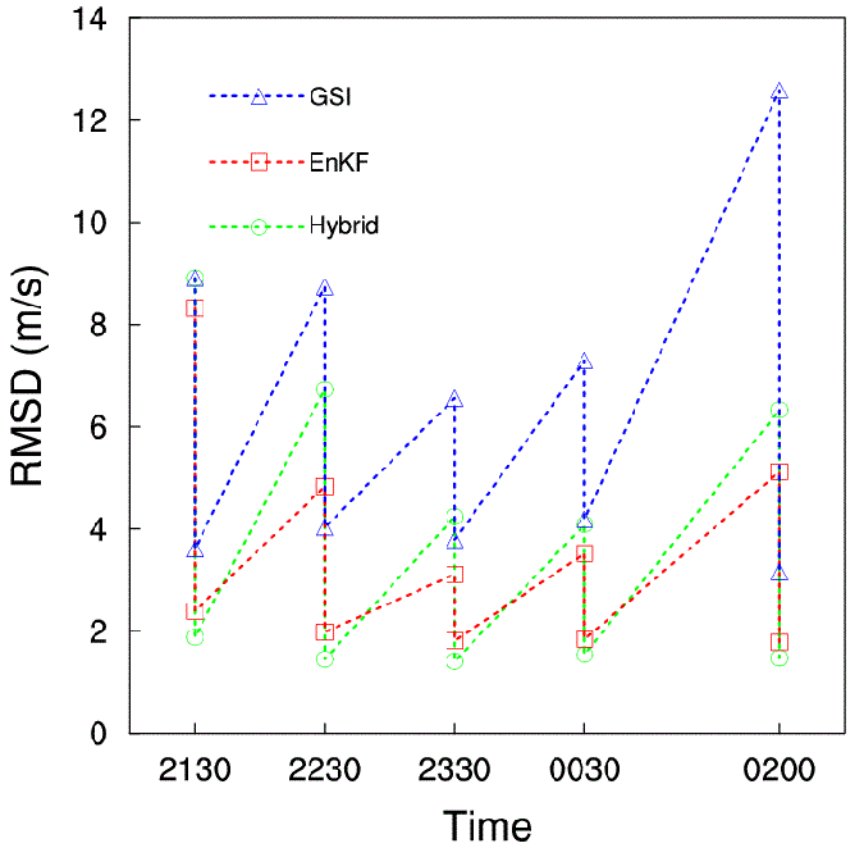


Hybrid

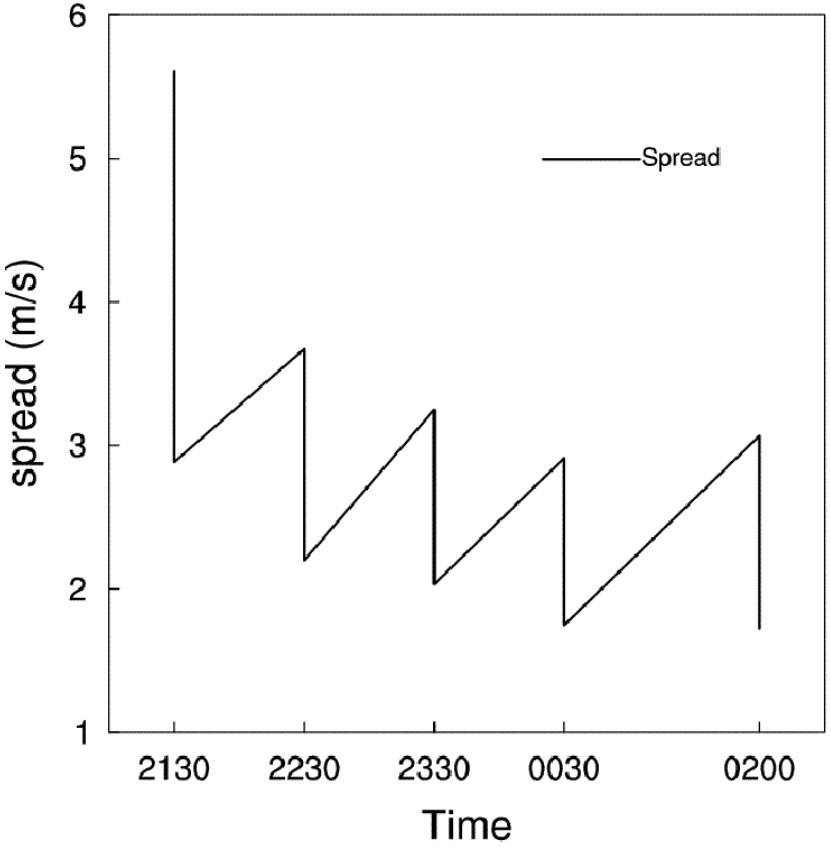


Vr RMSE vs. Spread during DA

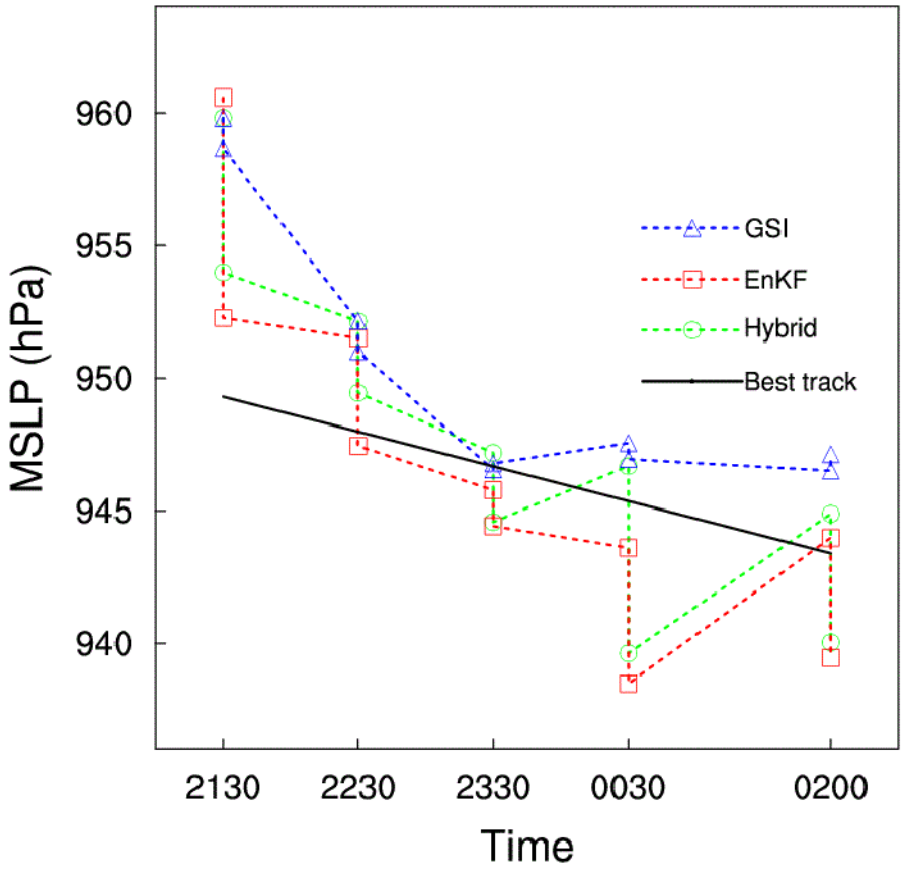
RMS fit to Vr



Vr ensemble spread



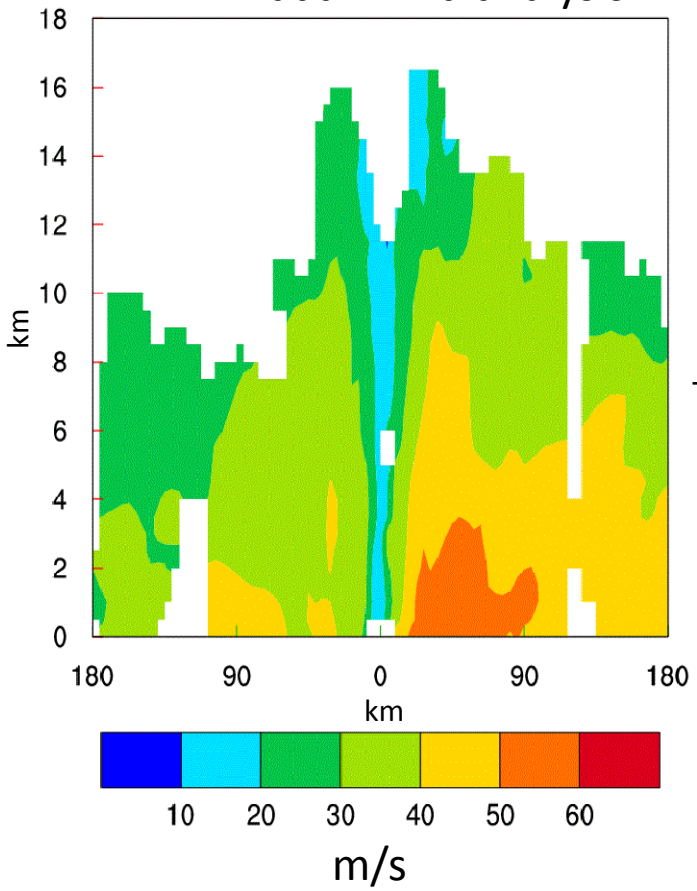
MSLP during DA



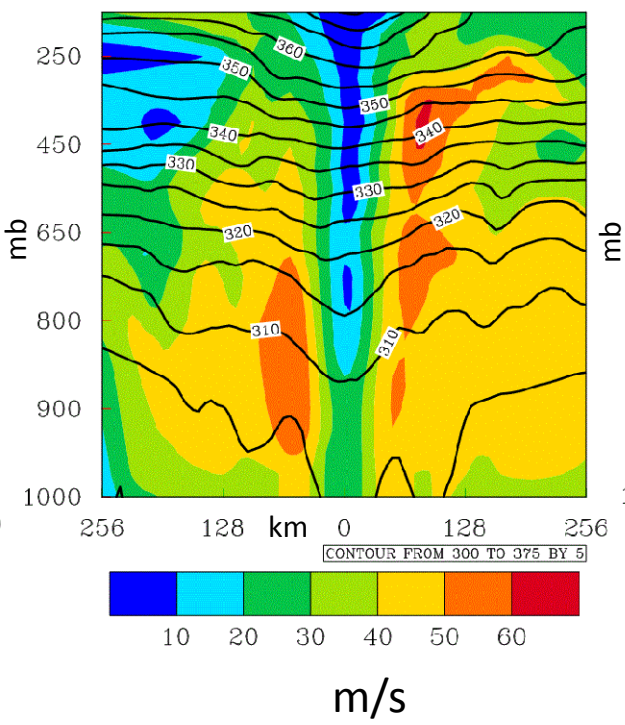
Comparison with radar wind analysis

http://www.aoml.noaa.gov/hrd/Storm_pages/irene2011/radar.html

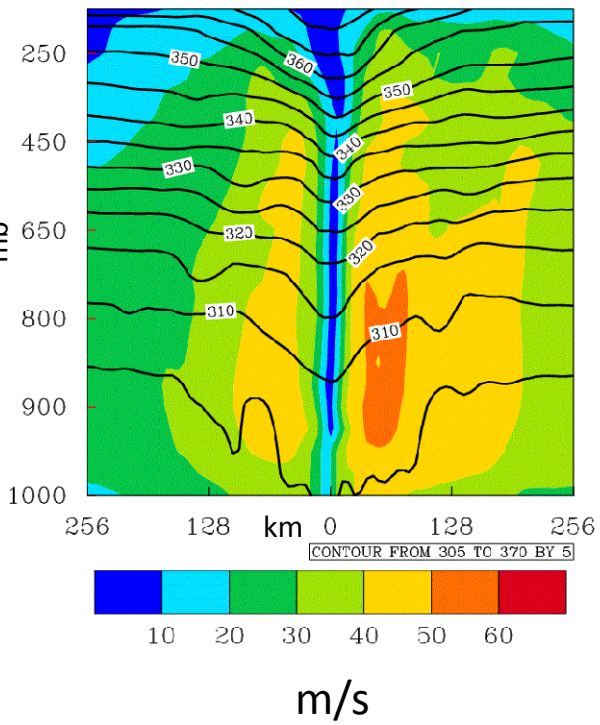
HRD radar wind analysis



GSI

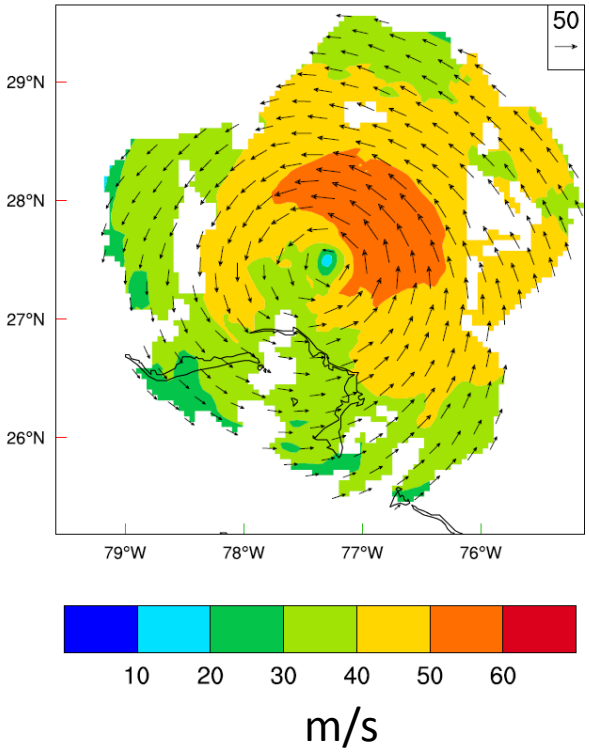


Hybrid/EnKF

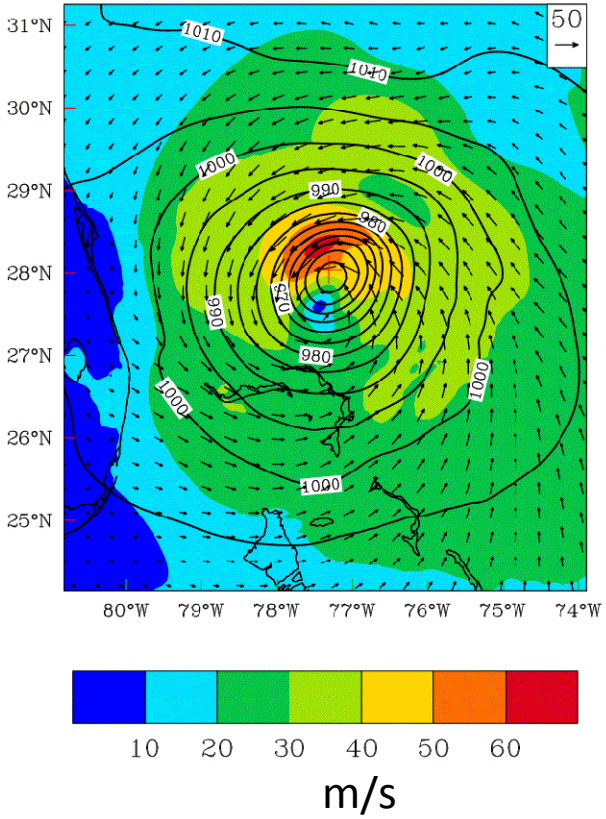


Comparison with radar wind analysis

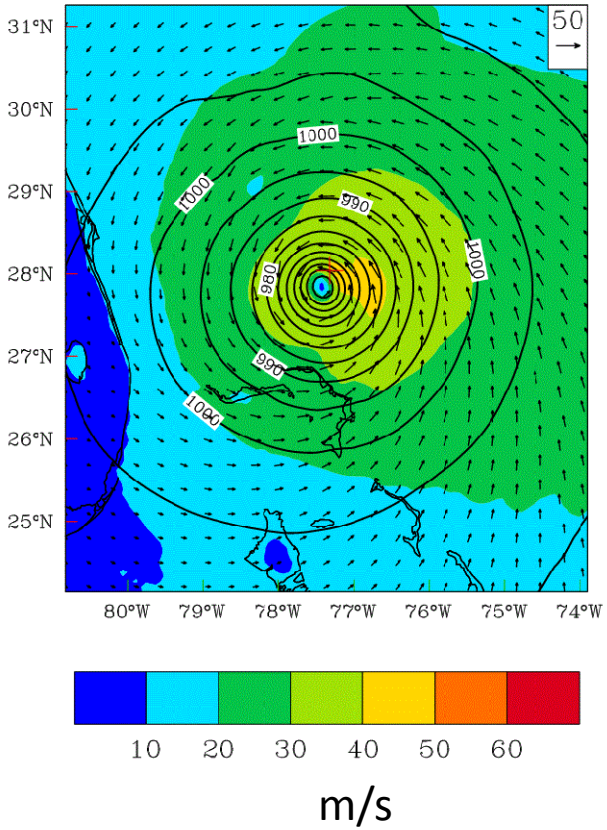
HRD radar wind analysis @ 1km



GSI @ 1000mb

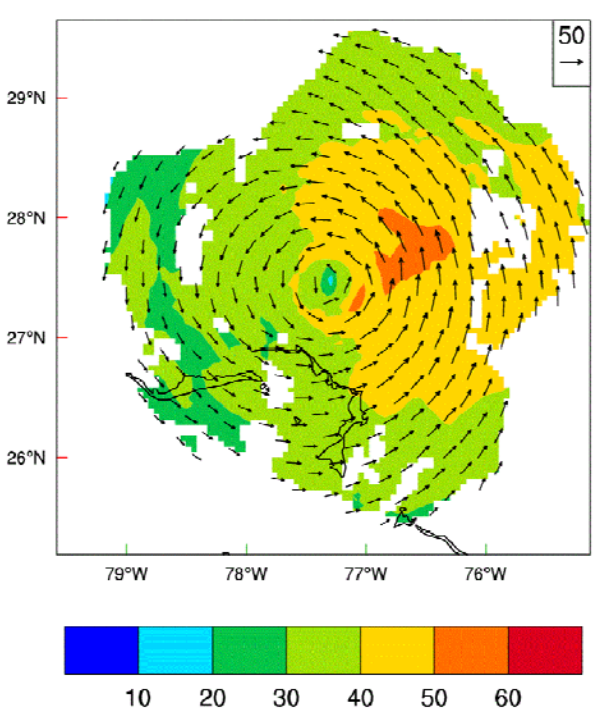


Hybrid/EnKF @ 1000mb

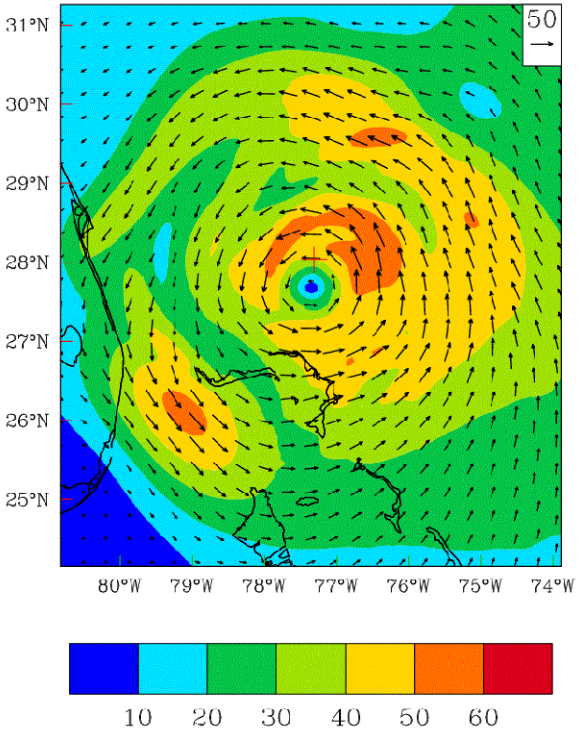


Comparison with radar wind analysis

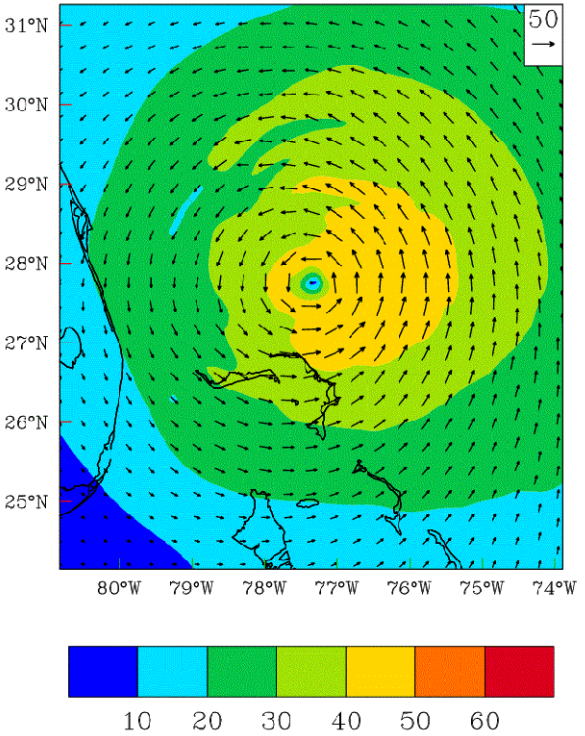
HRD radar wind analysis @ 3km



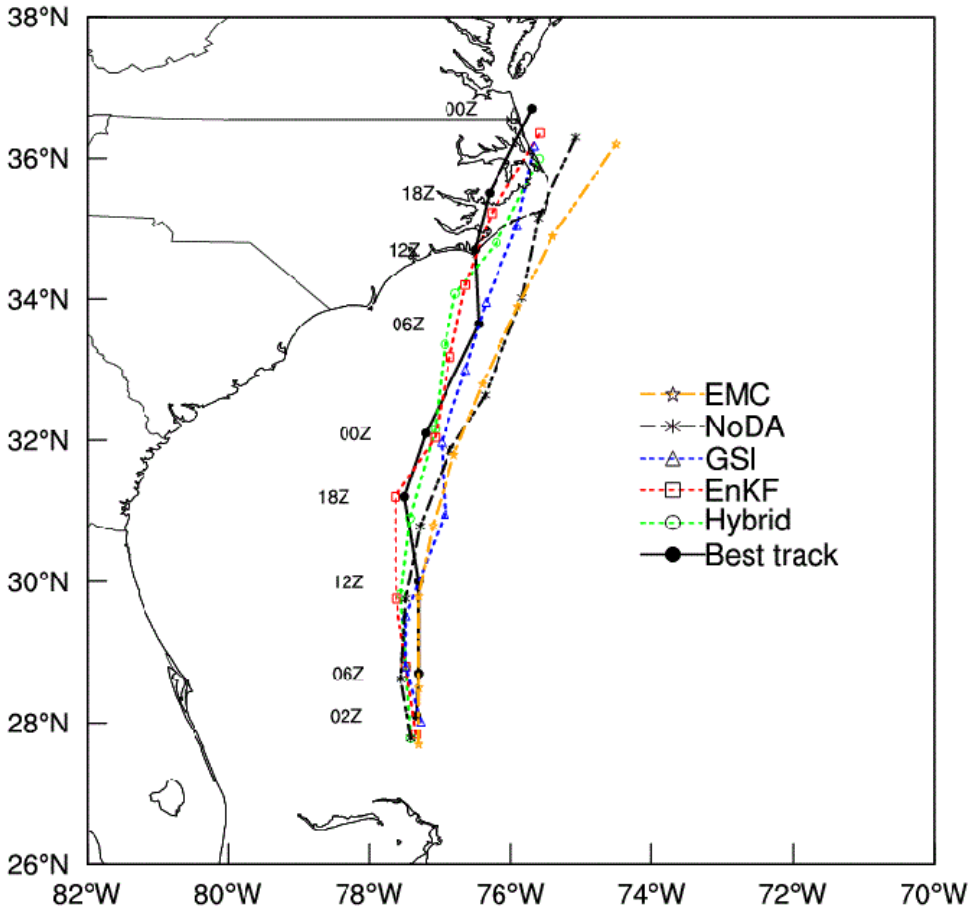
GSI @ 700mb



Hybrid/EnKF @ 700mb

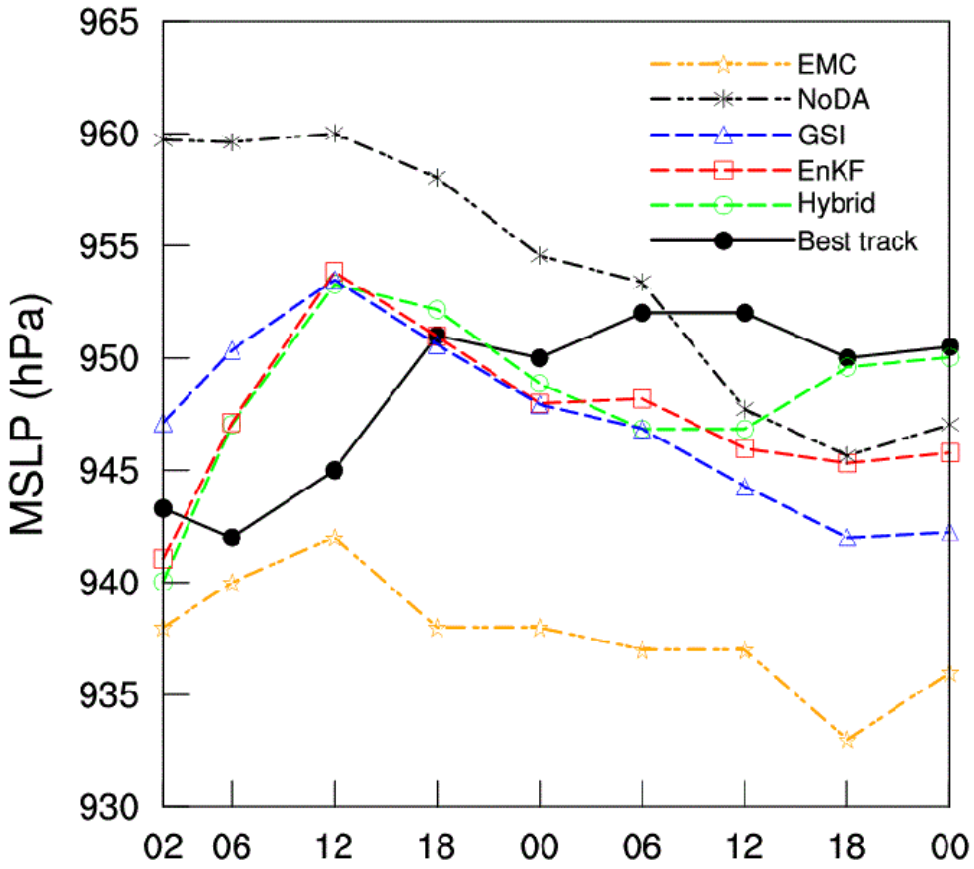


Track forecast



EMC: HWRF official forecast
NoDA: no TDR assimilation
GSI: assimilating TDR using GSI
EnKF: assimilating TDR using EnKF
Hybrid: assimilating TDR using hybrid

Intensity forecast



EMC: HWRF official forecast
NoDA: no TDR assimilation
GSI: assimilating TDR using GSI
EnKF: assimilating TDR using EnKF
Hybrid: assimilating TDR using hybrid

Summary and ongoing work

a. The GSI-based hybrid EnKF-Var data assimilation system was expanded to assimilate TDR data for HWRF.
b. TDR data showed positive impact on TC track and intensity forecasts and verification against independent observations.
c. Various diagnostics and verifications suggested ensemble-based data assimilation (hybrid, EnKF) provided more skillful TC analysis and forecasts than the GSI.
d. Testing more missions/cases.
e. Testing dual resolution 3km/9km hybrid; 3km's own hybrid.
f. Developing and testing GSI/EnKF hybrid with moving nests.
g. Add and test more observations.
h. Develop and research on various new capabilities for hybrid.