

13th WRF Users' Workshop, June 25-28, 2012, Boulder, CO

DTC Data Assimilation System Community Support and Tests: Variational, Ensemble and Hybrid

Hui Shao

Collaborators:

Ming Hu², Kathryn Newman¹, Chunhua Zhou¹, Don Stark¹, and X.Y. Huang¹, Developmental Testbed Center (DTC), ¹NCAR, ²NOAA/ESRL

John Derber and Michael Lueken, NCEP/EMC

Zhiquan Liu and Craig Schwartz, NCAR/MMM

Sponsors: AFWA, NOAA, COSMIC and NCAR. NCAR is sponsored by NSF.



Developmental Testbed Center

Outline

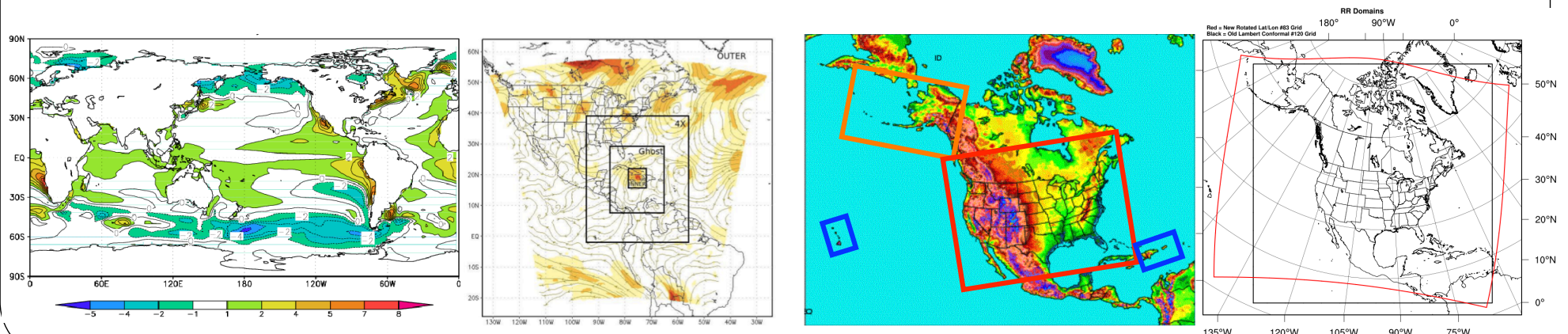
- GSI code update
- Testing and evaluation:
 - Variational:
 - GSI
 - WRFDA
 - Hybrid: GSI-based hybrid
 - Ensemble:
 - NCAR/DART Ensemble Smoother... system
 - NOAA/PSD ENKF system
- Summary and outlook



Community Gridpoint Statistical Interpolation (GSI) Data Assimilation System

- Operational at NOAA since 2006, replacing SSI
- Being used by NOAA/ESRL, NCEP, NASA/GMAO, NESDIS, and the research community
- Current works for following systems
 - NCEP GFS
 - GMAO global
 - WRF-NMM
 - WRF-ARW
 - HWRF
 - HARW
- Supported by DTC since 2009
 - User friendly (tested on multiple-platforms) with interfaces to multiple applications
 - Annual code release with documentation
 - Users helpdesk (gsi_help@ucar.edu)
 - Annual Tutorial (since 2010)
 - Workshop (1st in 2011, next planned for 2013)

<http://www.dtcenter.org/com-GSI/users/index.php>



Observations Types:

- Radiosondes
- Pibal winds
- Synthetic tropical cyclone winds
- Wind profilers
- Conventional aircraft reports
- ASDAR aircraft reports
- MDCARS aircraft reports
- Dropsondes
- MODIS IR and water vapor winds
- GMS, JMA, METEOSAT and GOES cloud drift IR and visible winds
- GOES water vapor cloud top winds
- Surface land observations
- Surface ship and buoy observation
- SSM/I wind speeds
- QuikScat and ASCAT wind speed and direction
- SSM/I and TRMM TMI precipitation estimates
- Doppler radial velocities
- VAD (NEXRAD) winds
- GPS precipitable water estimates
- GPS Radio occultation refractivity and bending angle profiles
- SBUV ozone profiles and OMI total ozone
- SST
- SBUV: n17,n18,n19
- HIRS: metop-a, metop-b,n17,n19
- GOES_IMG: g11,g12
- AIRS:aqua
- AMSU-A: metop-a, metop-b, n15,n18,n19
- AMSU-B: metop-b,n17
- MHS: metop-a, metop-b,n18, n19
- SSMI: f14, f15
- SSMIS: f16
- AMSRE: aqua
- SNDR: g12
- IASI: metop-a, metop-b
- GOME: metop-a, metop-b,
- OMI:aura
- SEVIR: m08, m09, m10
- ATMS: NPP
- CRIS: NPP
- Tropical storm VITAL

GSI V3.1 Beta (just released June 8, 2012)

- Updated GSI-hybrid capability. Add dual resolution capability for regional hybrid application
- Added 4d capability for ensembles to allow several flavors of 4dvar using ensembles
- Added features for cloudy radiance assimilation
- RAP enhancement on cloud analysis and surface analysis
- Added NPP radiance data assimilation
- Added DWL data assimilation
- Added SEVIRI data assimilate
- Added MLS ozone bufr data assimilation
- Added MODIS AOD assimilation with input from WRF-CHEM GOCART
- Bug fixes to the CMAQ PM2.5 analysis
- Added bi-CG minimization option
- Added guess bundle
- Added the capability to use significant levels of radiosonde data
- Added climatological monthly zonal mean CO2
- Updated the RTMA capability (GSI-2dvar)
- Updated QC for radiance data and satellite winds
- Added radiance bias correction spin-up capability of new instrument
- Updated radial wind data data assimilation
- Updated GPS RO assimilation-bending angle DA

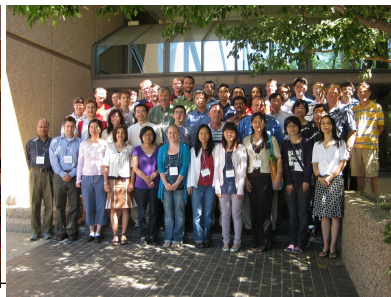
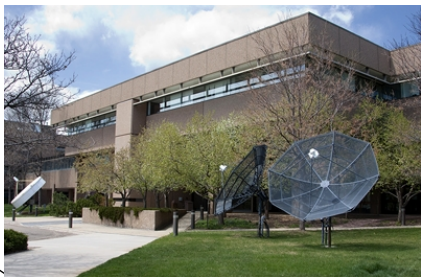
GSI V3.1 official version will be available in **July!**

- Documentation
- Helpdesk support (gsi_help@ucar.edu)
- Updated online information

3rd GSI Annual Tutorial (GSI v3.1) on Aug 21-23, 2012

<http://www.dtcenter.org/com-GSI/users/tutorials/2012.php>

- Lectures
 - Fundamentals of DA
 - Overview of GSI
 - Setup and compilation
 - Run and namelist
 - Diagnostics and applications
 - PreBUFR/BUFR tools
 - Background error generation
 - Radiance data assimilation
 - GPS RO data assimilation
 - Hybrid GSI-EnKF
 - Cloudy radiance data assimilation
 - ...
- Hands-on sessions
 - Feel free to try your own cases
- Invited speakers:
 - EMC:
 - John Derber
 - Andrew Collard
 - NOAA/ESRL:
 - Jeff Whitaker
 - UCAR/NCAR:
 - Lidia Cucurull
 - Tom Auligne
 - Rizvi Syed
 - Ruifang Liu
- Registration:
 - Lecture & hands-on
 - Lecture only
 - Webcast option *New!*



DA Test and Evaluation

- Examine data ingestion
- Test and revisit operational configurations
- Enhance and test developmental capabilities
- Test and evaluate alternative DA techniques

Data Feed

The global PrepBUFR file (public accessed data for GSI))

- has much more sounding data at 00/12 (*cut-off time*)
- misses SSMI/airep/geoamv data
- assigns large QC flag value to METAR data (specific to global applications)

The AFWA-WRFDA data file:

- misses pibal/sat winds/gpsrf*

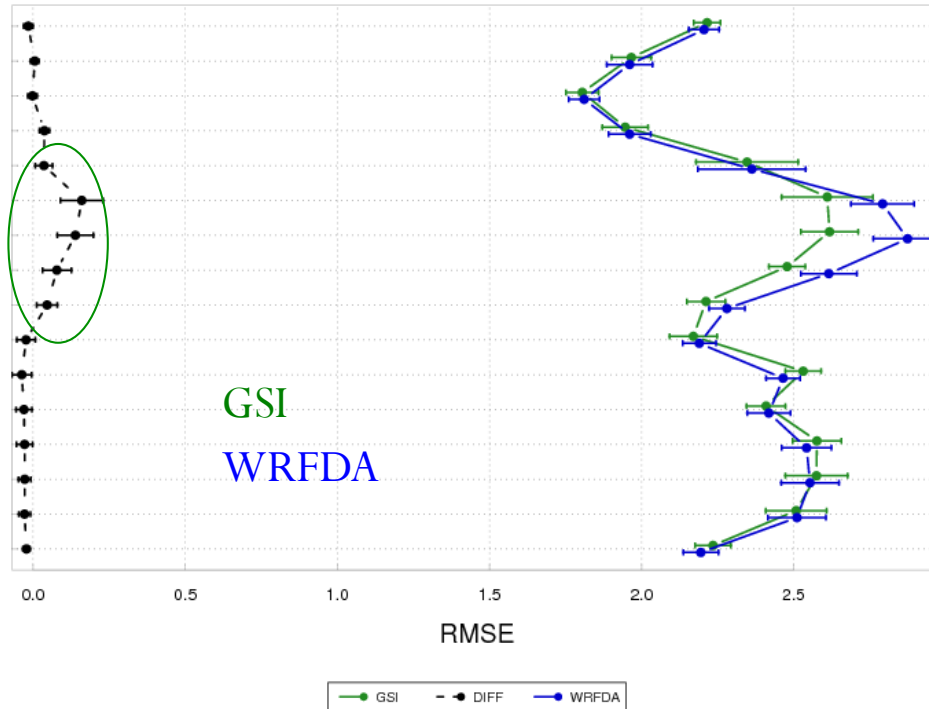
Observation type and variable		2010090918		2010091000	
		WRFDA	GSI	WRFDA	GSI
sounding	U	162	83	459	3068
	V	158		459	
	T	54	58	319	1870
	Q	42	29	301	910
metar	U	468		402	
	V	463		401	
	T	561		549	
	Q	270		281	
	P	364	641	365	635
geoamv	U	1833		1464	
	V	1833		1464	
airep	U	307		450	
	V	306		450	
	T	303		450	
ships	U	15	15	8	12
	V	14		10	
	T	16	16	11	13
	Q	0	15	0	13
	P	16	19	11	16
Ssmi retrieval	TPW			1353	
	Wind speed			1353	
pibal	U		40		21
	V				
Sat wind	U		155		116
	V				
gpsrf			565		640



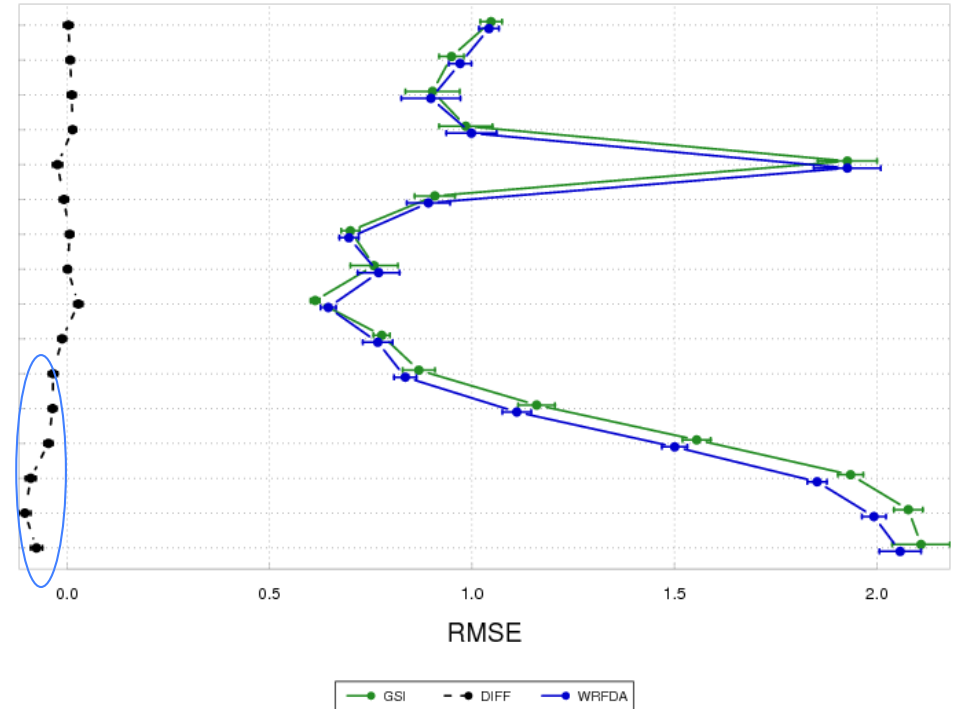
(Kathryn Newman)

GSI vs WRFDA verified against ECMWF (Conventional Data only)

24 h V-Wind RMSE Against ECMWF Analysis

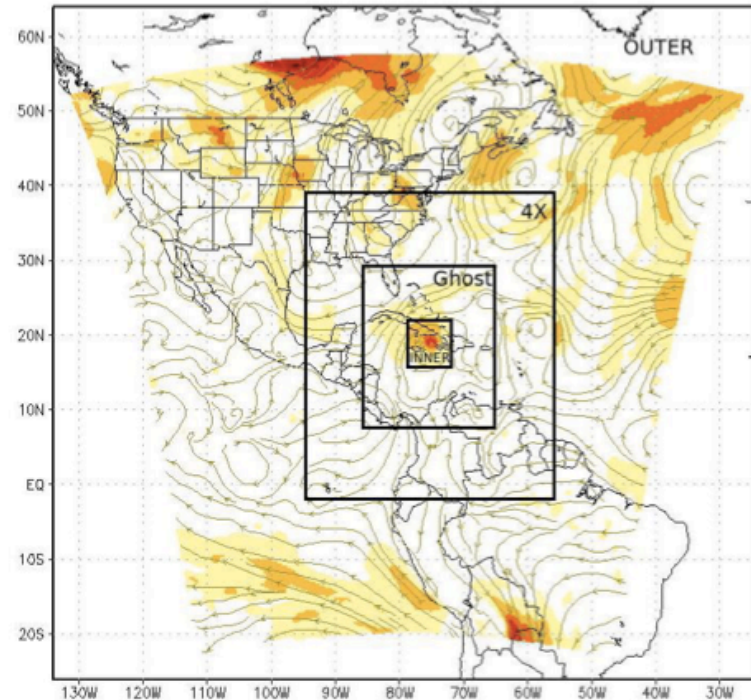
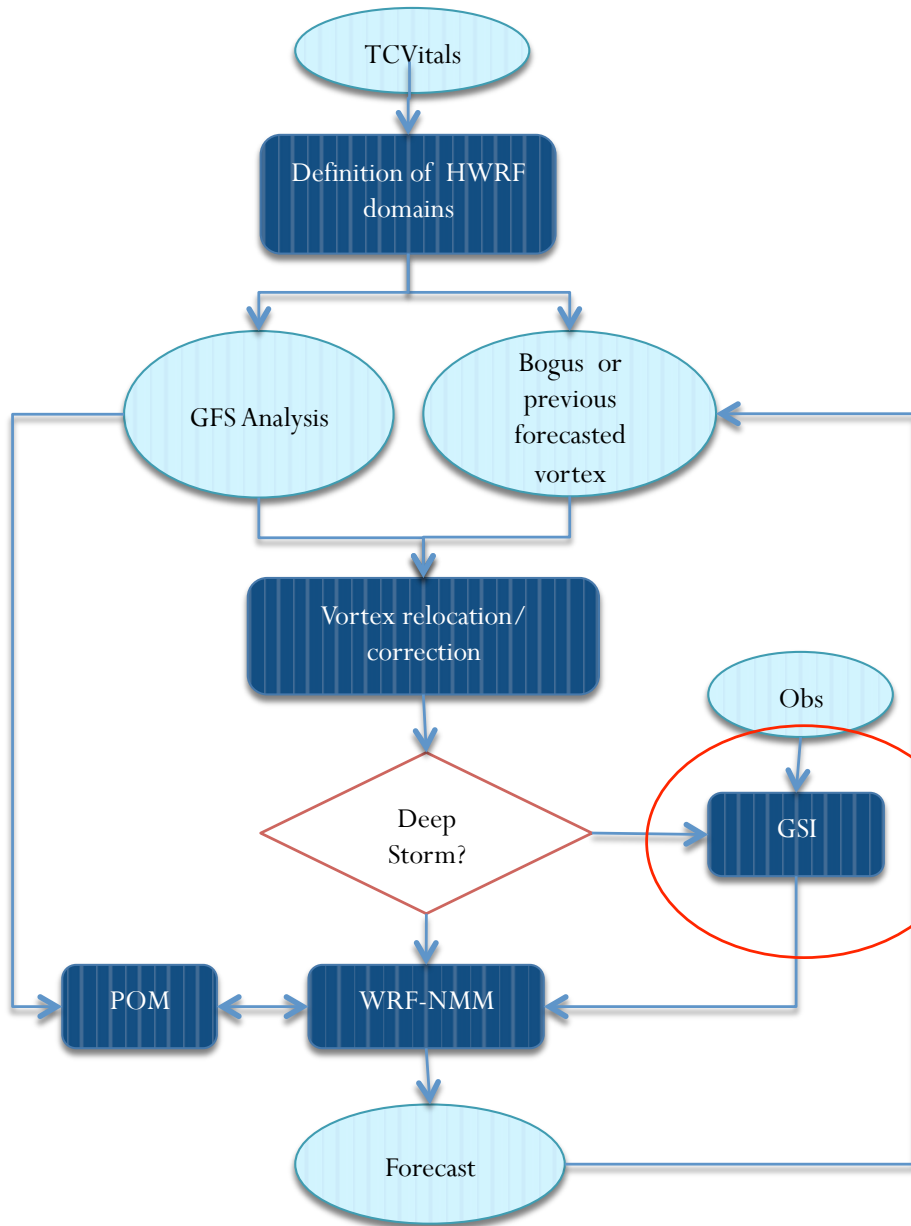


24 h Temperature RMSE Against ECMWF Analysis



- Global PrepBUFR data (e.g, surface data) QC flags should be appropriately set up for regional applications using GSI.
- Usage of regional background errors improves regional DA performance (separate study in 2010).

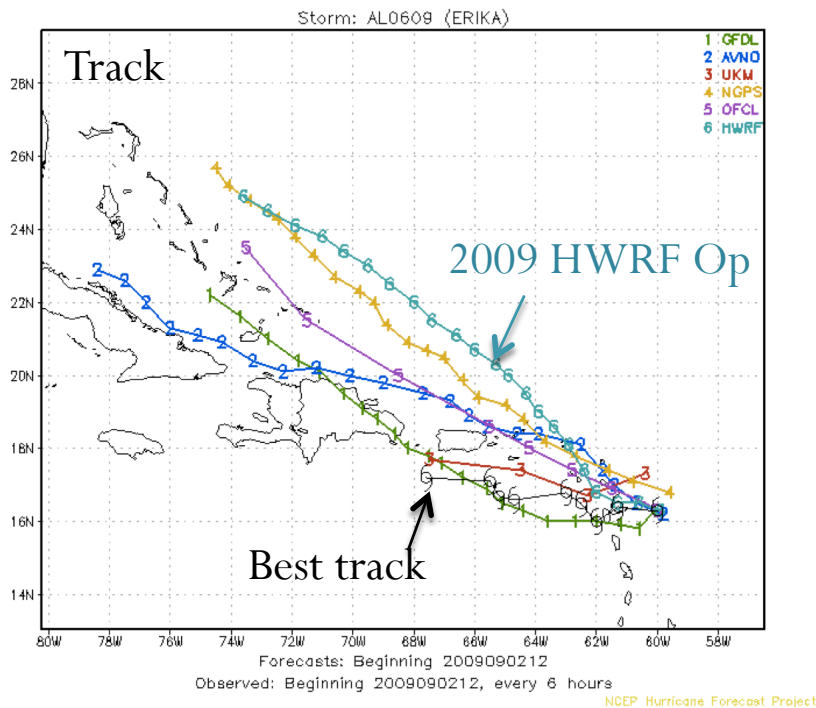
“Default” Configuration Test & Evaluation



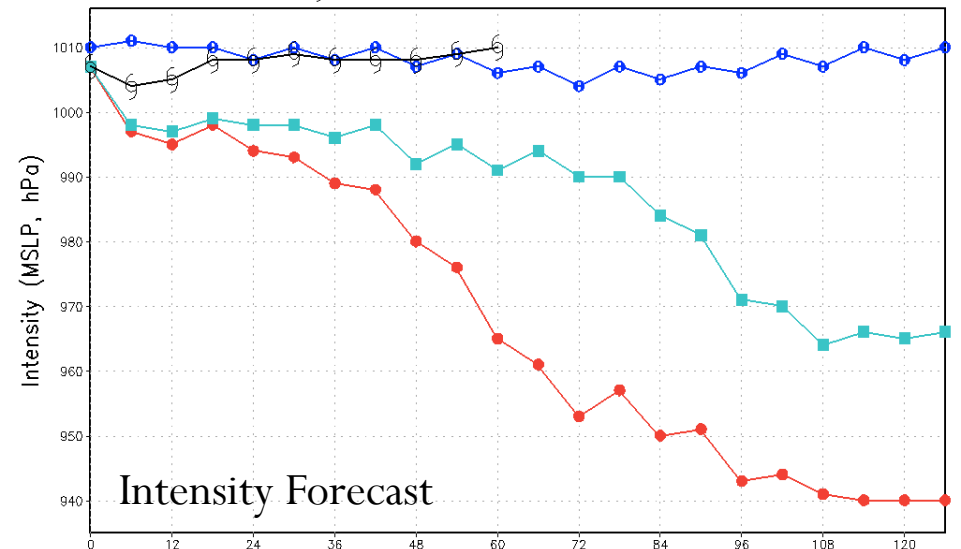
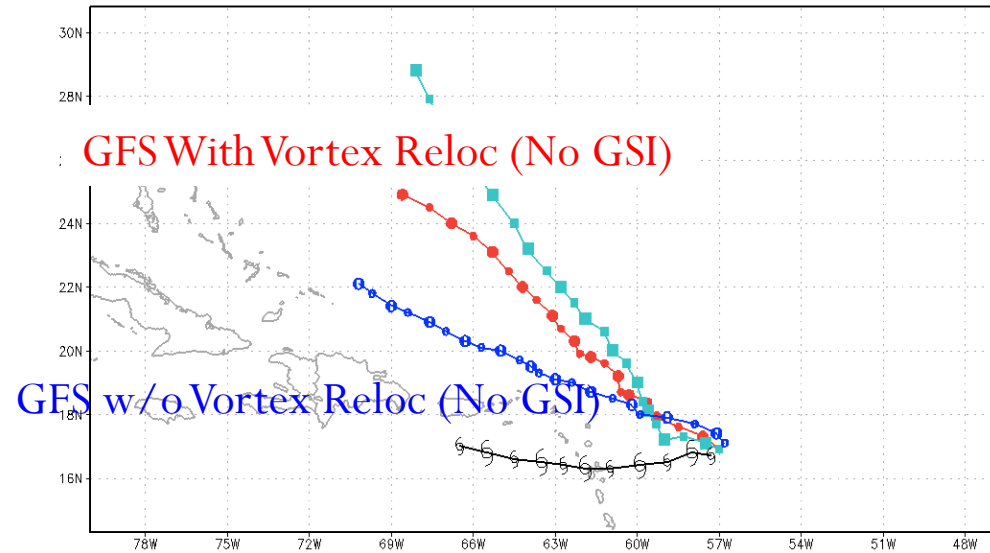
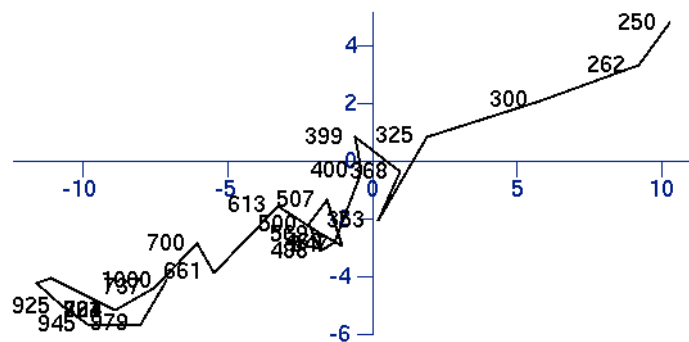
- Model forecast domains: outer and inner
- HWRP vortex initialization domain: 4x
- GSI analysis domain: outer (0.18deg) and ghost (0.06deg)

- ✓ TCVital: Tropical Cyclone Vital Statistics Records
- ✓ Deep storm: estimated top of circulation is 200 mb

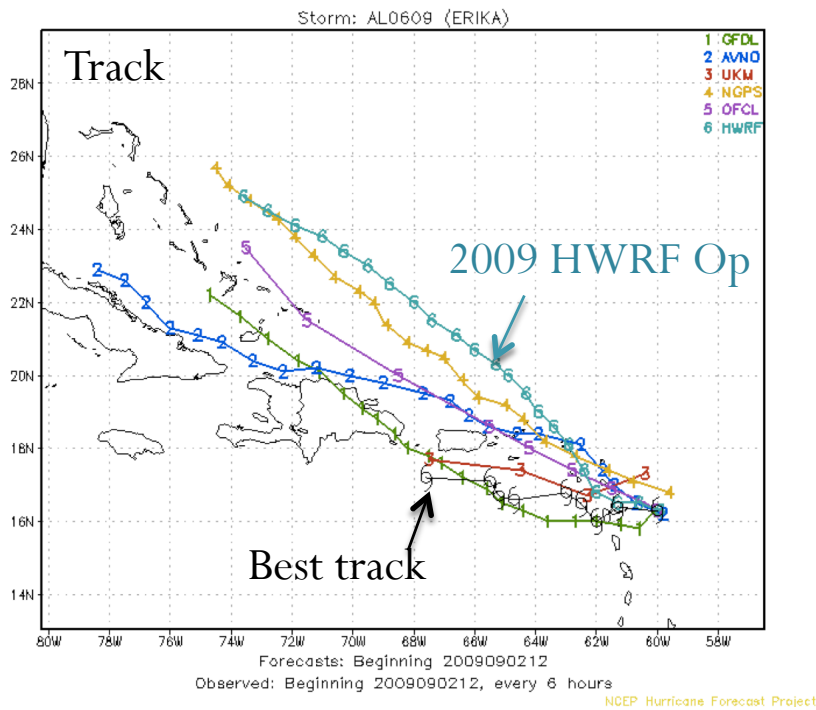
Vortex Initialization? Cycling of GSI?



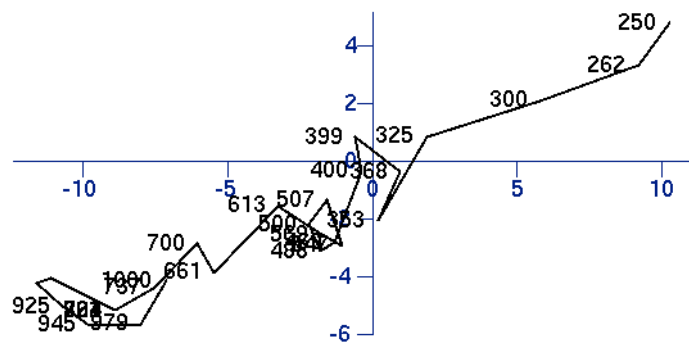
Hodograph at 2009090212 near Erika



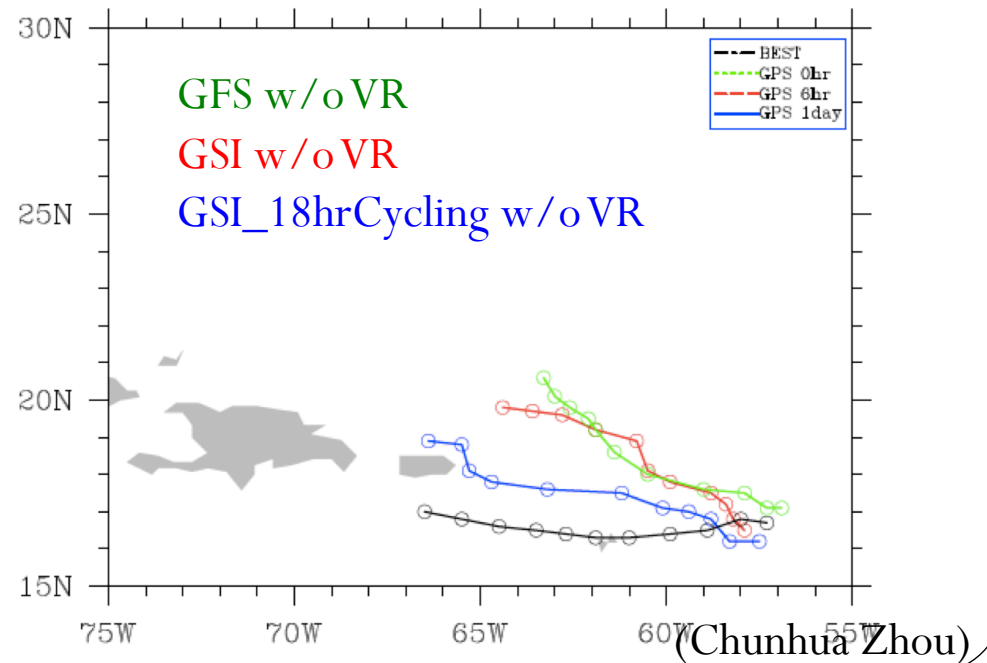
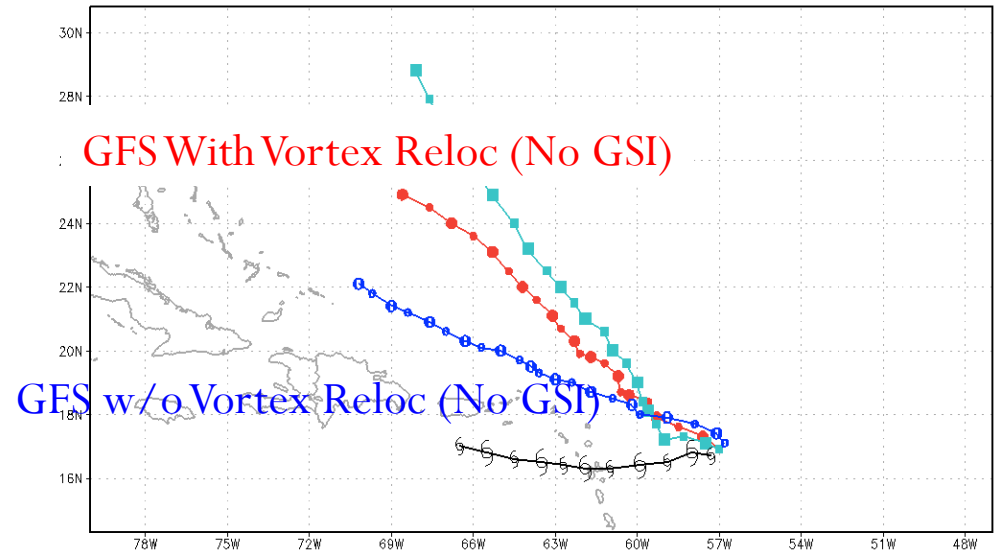
Vortex Initialization? Cycling of GSI?



Hodograph at 2009090212 near Erika



Courtesy of NHC, university Wyoming, Surgi and HWRF team

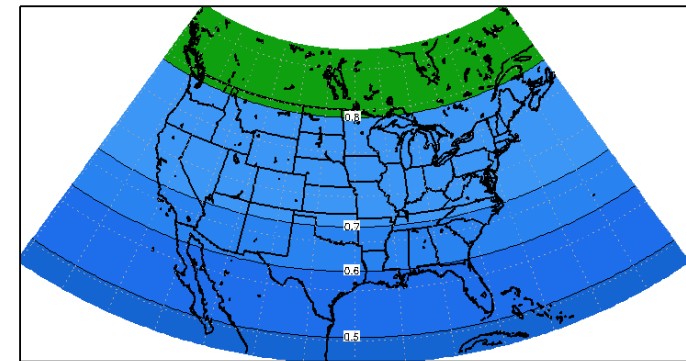


Background Errors (B) in GSI

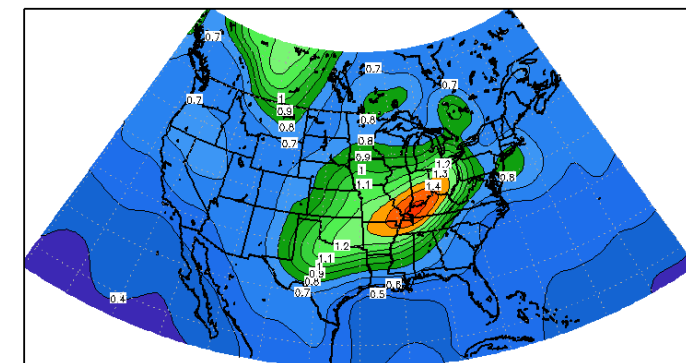
$$J(x) = \frac{1}{2}(x - x_b)^T B^{-1}(x - x_b) + \frac{1}{2}[y - H(x)]^T R^{-1}[y - H(x)]$$

- Three paths
 - Isotropic/homogeneous
 - Function of latitude/height
 - Vertical and horizontal scales separable
 - Variances can be location dependent
 - Anisotropic/inhomogeneous
 - Function of location / state
 - Background error variances modified based on 9 and 3 hour forecast differences
 - Ensemble BE

Sfc Pressure Default StDev aaave=0.671536



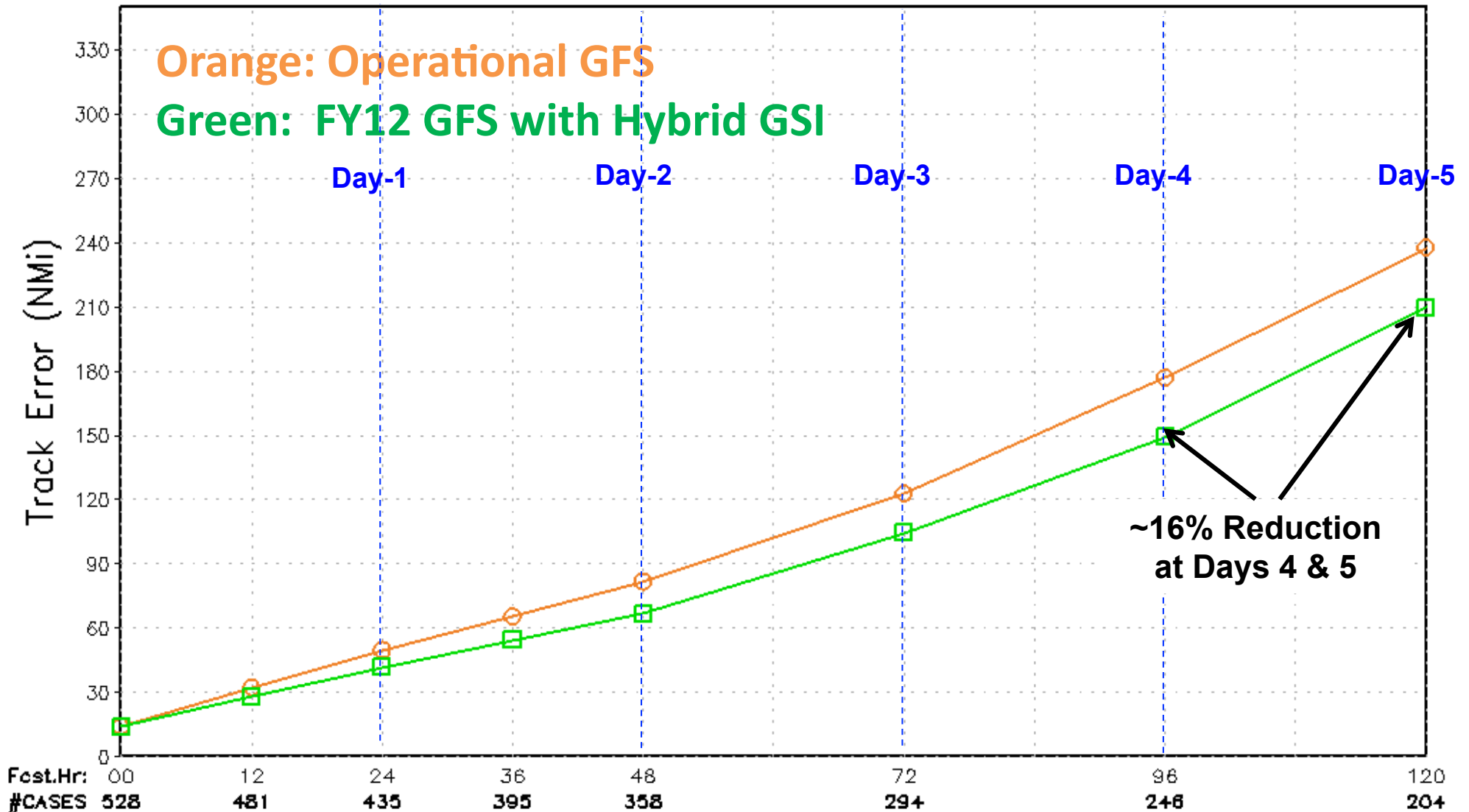
Sfc Pressure Rescaled StDev aaave=0.663781



$$J(x, \alpha) = \beta_1 J_b + \beta_2 J_e + J_o$$

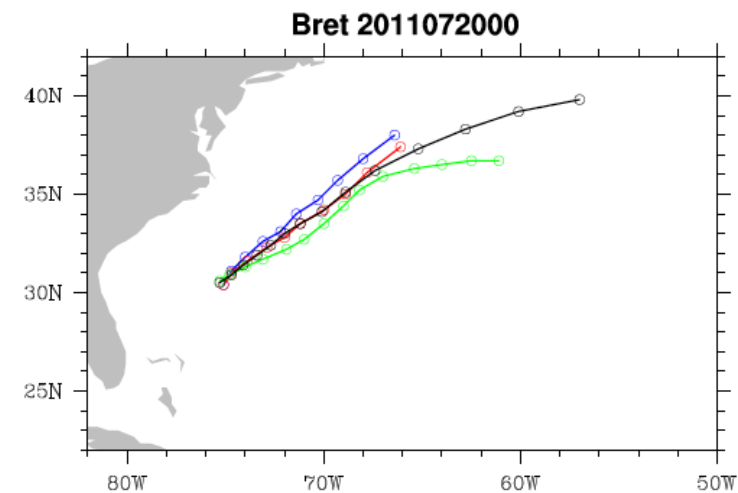
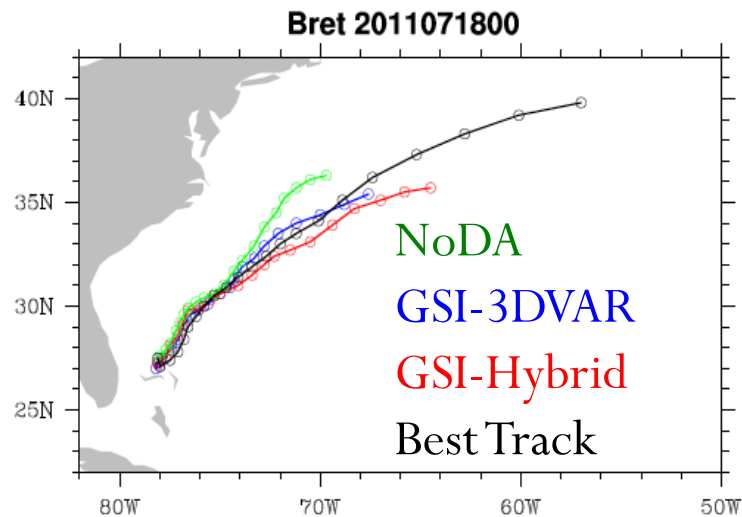
$$= \beta_1 \frac{1}{2}(x - x_b)^T B^{-1}(x - x_b) + \underbrace{\beta_2 \frac{1}{2} \alpha^T A^{-1} \alpha}_{\text{extended control variables}} + \frac{1}{2}[y - H(x + x_e)]^T R^{-1}[y - H(x + x_e)]$$

2010-2011 Atlantic TC Track Errors For Hybrid GDAS Parallel

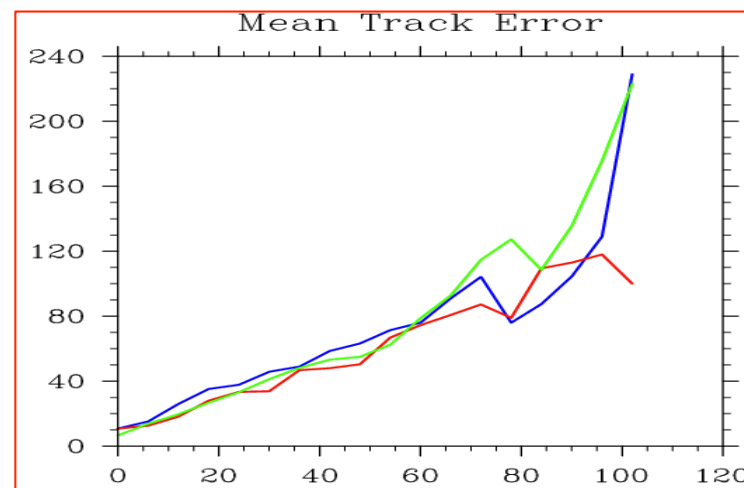


Courtesy of Bill Lapenta, 2012

Test of GSI-hybrid Capability in Regional Applications



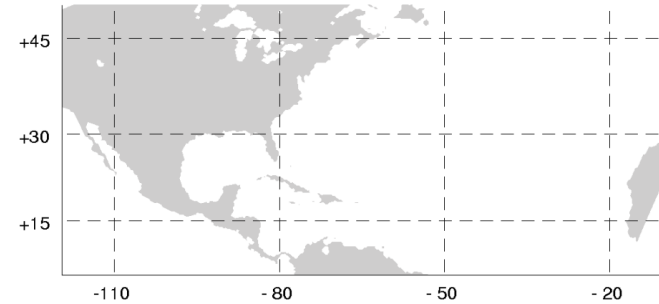
- Global ensembles were used here to calculate ensemble B contributions
- Regional ensembles specific to the forecast model and the application domain will be used and tested once the regional EnKF-GSI hybrid capability is ready (ongoing HFIP development at NOAA/PSD and NCEP/EMC...)



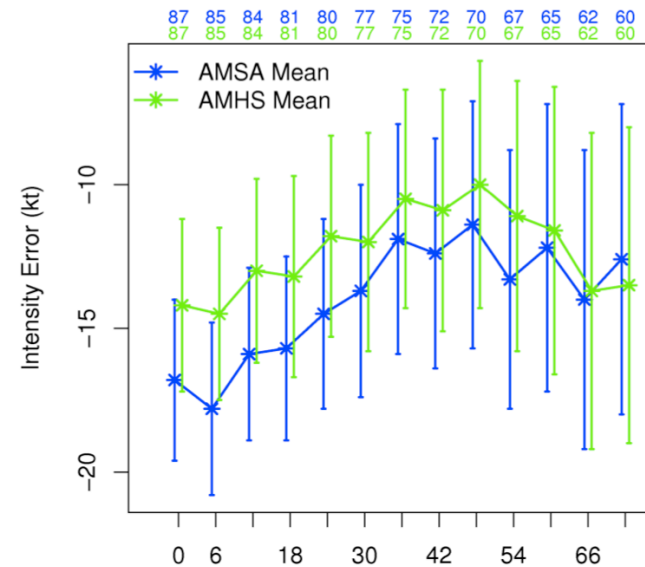
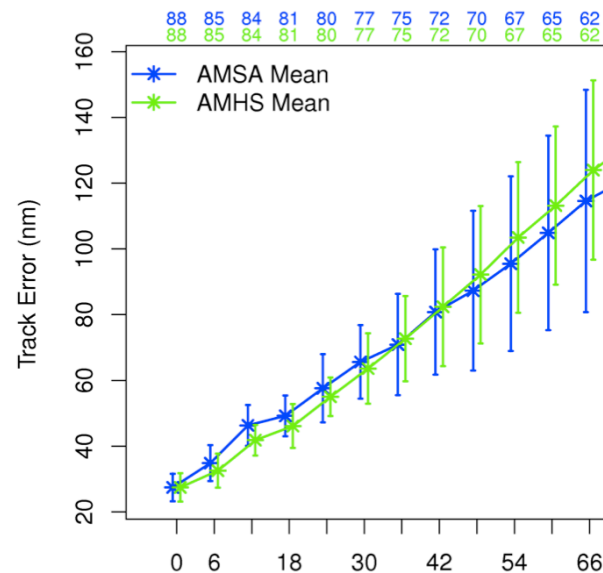
(Chunhua Zhou)

NCAR DART Ensemble DA System

- AMSU-B/MHS radiance data assimilated added by DTC.
- Assimilated observations for experiments:
 - AMSU-A radiance (**AMSA**): conventional obs from radiosondes, aircraft, sat-derived winds, land/ocean sfc stations, GPS dropsondes (NOAA G-IV aircraft), COSMIC GPSRO, AMSU-A radiances from NOAA-18/METOP-2
 - AMSU-A + MHS radiance (**AMHS**): same as AMSA + MHS radiances from NOAA-18/METOP-2
- Radiance data were thinned on a 72-km grid
- +/- 1.5 hr observation assimilation window
- Bias Correction Coefficients from 3-mo offline statistics (spun-up)
- AMSU-A channels 5-7 and MHS channels 3-4 NOAA-18/ METOP-2 assimilated



Averaged over runs for 5 TCs: Fay, Gustav, Hanna, Ike, Josephine



(Kathryn Newman)

Summary

The ongoing efforts of the DTC DA team are to

- Start to examine the data pre-processing process
- Test and revisit default configurations
- Enhance and test developmental capabilities
- Test and evaluate alternative DA techniques

The DTC seeks input from the community:

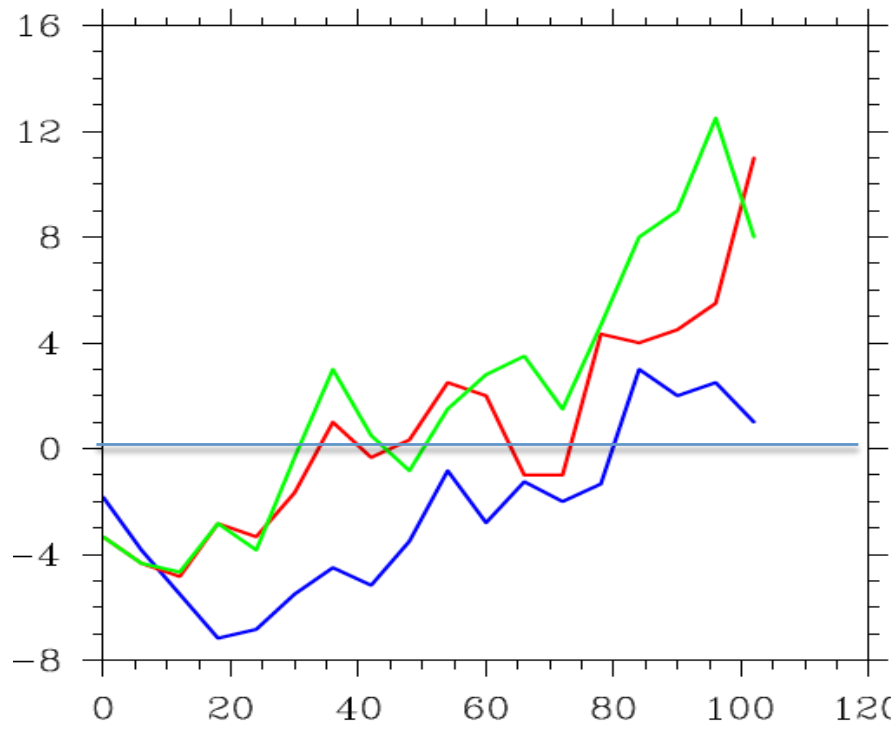
- New DA development (help bring it to the operational applications)
- Suggestions for new T&E activities
- Defining future direction

DTC GSI Resource

- Community GSI User's website:
 - <http://www.dtcenter.org/com-GSI/users/>
- Community GSI Helpdesk:
 - gsi_help@ucar.edu
- Community GSI release:
 - V3.1:
 - beta version, June 8, 2012;
 - Official version scheduled for July, 2012
- Upcoming events:
 - The 3rd Community GSI tutorial: August 21-23, 2012, Boulder, CO (Register now!)



Mean Intensity Error



Mean Intensity Error

