Testing and Evaluation of the GSI-Hybrid Data Assimilation at DTC and its Applications for Hurricane Forecasts

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Abstract

In collaboration with various research and operational centers, the Developmental Testbed Center (DTC) conducts testing and evaluation of the GSI (Gridpoint Statistical Interpolation) based hybrid variational-ensemble Data Assimilation (DA) system for hurricane forecast applications. Multiple cases of tropical storms are run to investigate the various aspects of the GSI-Hybrid DA system, including the cross covariance feature, cycling scheme, background error tuning and data impact, in the framework of the NCEP/EMC (Environmental Modeling Center) GSI-Hybrid DA system for basin scale HWRF (Hurricane Weather Research and Forecast) model. Diagnostics are performed to study the configurations of this developing system and its impact on hurricane forecasts, as part of the effort of operational implementation of the GSI-Hybrid DA system in HWRF.

What is GSI-Hybrid 3DVAR?

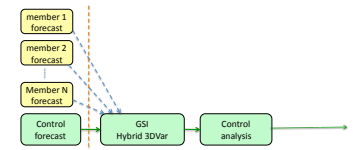
- GSI-3DVAR (static BE)

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

- GSI-Hybrid 3DVAR

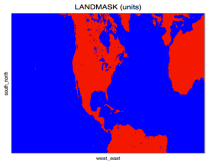
$$J(x,\alpha)=\beta_1 J_1+\beta_2 J_2+J_c$$

$$\beta_1\frac{1}{2}(x-x_b)^T B^{-1}(x-x_b)+\beta_2\frac{1}{2}\alpha^T A^{-1}\alpha+\frac{1}{2}[y-H(x+x_e)]^T R^{-1}[y-H(x+x_e)]$$



Model Configuration

- HWRF: basin scale branch from EMC, 61 vertical levels, model top at 2mb, horizontal grid spacing=27km
- GSI: basin scale branch from EMC
- Background: GFS

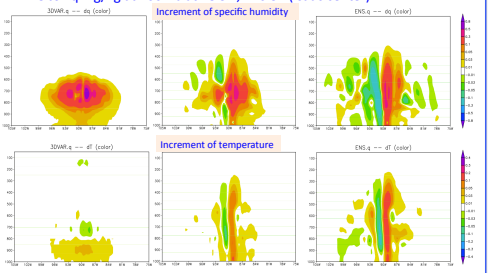


Cross-covariance investigation

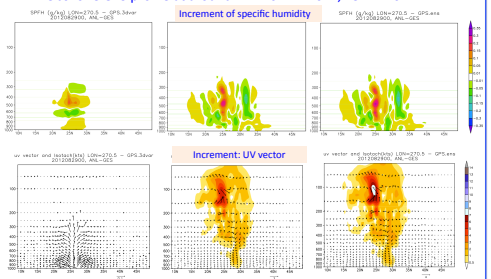
- 3DVAR: β_1=1.0, β_2=0.0
- HYB: β_1=0.25, β_2=0.75
- ENS: β_1=0.0, β_2=1.0

- 80 global ensembles
- Horizontal localization scale 600km
- Vertical localization scale -0.5 (lnP)
- Single observation is at or around storm center of Isaac (28.9N, 270.5E)
- Background: 2012082900

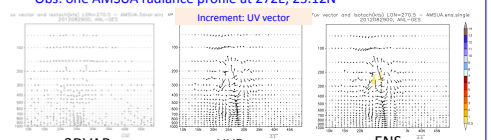
- Obs: q=1g/kg at 700mb at 28.9N, 270.5E (Isaac center)



- Obs: one GPS profile at around 271.46E-272.64E, 25.2N-26.4N



- Obs: one AMSUA radiance profile at 272E, 25.12N



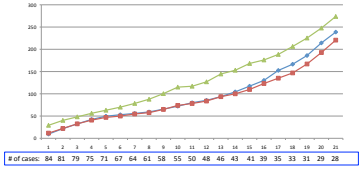
Configuration Test

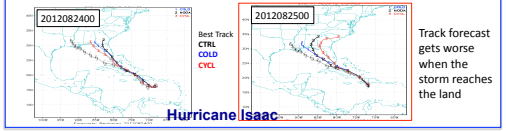
- "Minimal" GSI-hybrid Versus GFS

CTRL: GFS analysis as background
COLD: cold-start with GFS 6hr forecast
CYCL: 1-day cycling prior to analysis time

Conventional data only!

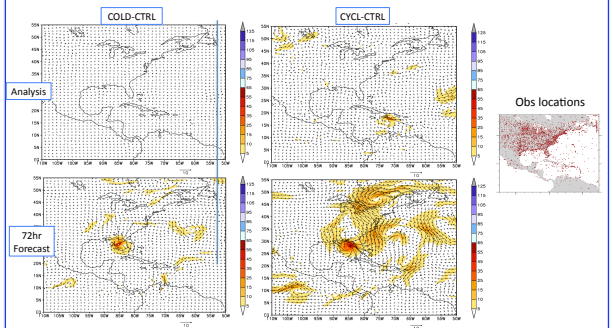
Aggregated track errors
(5 Storms in August 2012)





Track forecast gets worse when the storm reaches the land

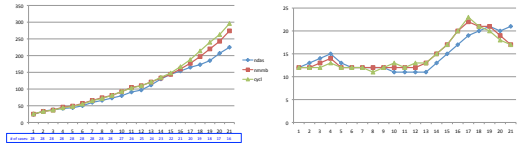
Isaac (2012082500): Tropospheric Deep-layer Mean (DLM) Wind Vector



- Background error tuning

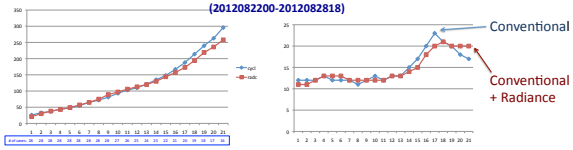
anavinfo file	Normalized scale factor for Background Error				
	sf	vp	ps	t	q
hwrf_basinscale (cycl)	0.2	0.2	0.3	0.7	0.2
ndas_netcdf (ndas)	1.0	1.0	0.5	0.7	0.7
nems_nmmb (nmmb)	0.28	0.28	0.3	0.7	0.1

Aggregated track and intensity errors for Isaac
(2012082200-2012082818)



- Radiance data impact

Aggregated track and intensity errors for Isaac
(2012082200-2012082818)



Discussion

- Single observation tests show reasonable cross covariances from ensembles;
- Data assimilation (GSI-Hybrid) with only conventional data in Basin scale HWRF doesn't seem to add value to the model performance in TC forecasts;
- Tuning background error and adding radiance data help improve the track and intensity forecasts;
- Future work: Better error representation; Radiance DA (new bias correction scheme, cloudy radiance); vortex scale DA.

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