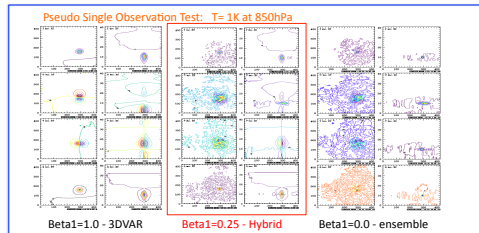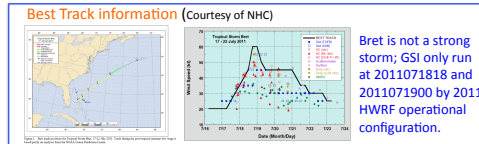# Testing and Evaluation of the GSI-Hybrid Data Assimilation for Hurricane Forecasts – A Case Study

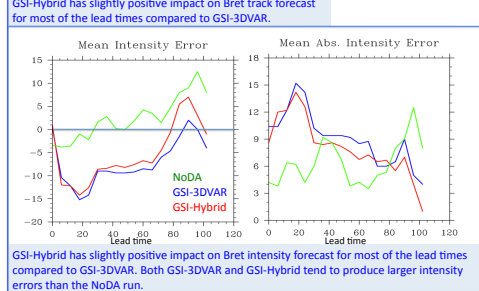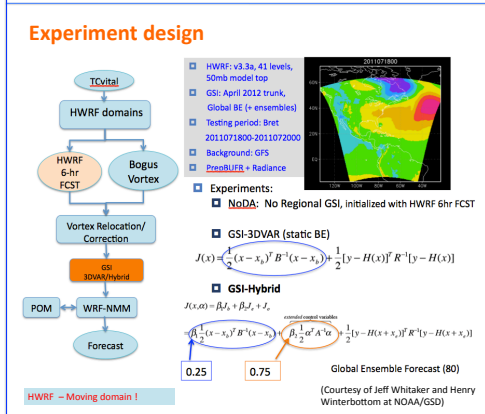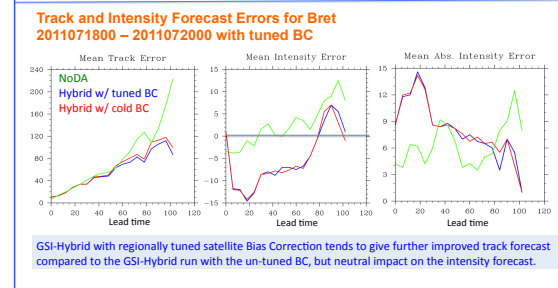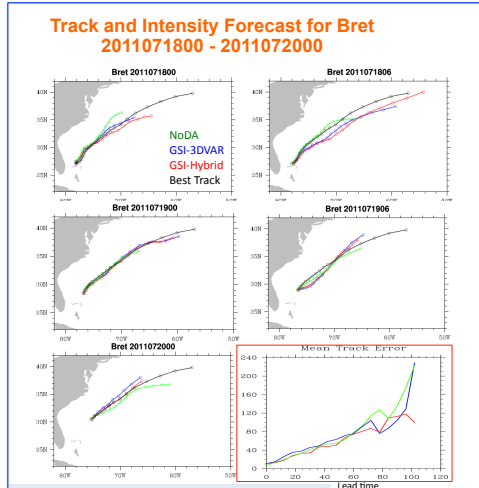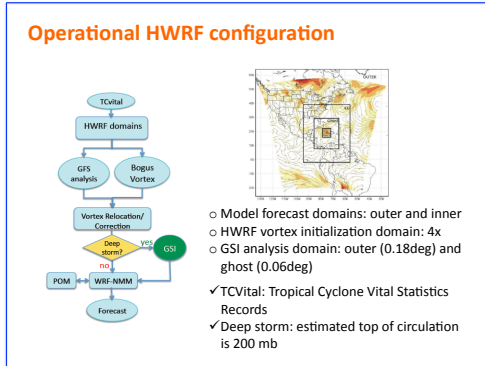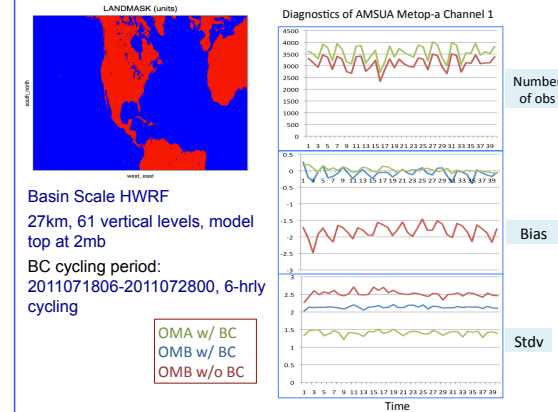Chunhua Zhou[1], Hui Shao[1], Ming Hu[2], Ligia Bernardet[2], Xiang-Yu Huang[1] and Brian Etherton[2]
[1]National Center for Atmospheric Science (NCAR), [2]NOAA/Global Systems Division

Abstract

Hybrid 3DVAR incorporates flow-dependent information from the ensemble perturbations into the static background error covariances used in 3DVAR, and has been shown to have positive impact on global forecasts and some regional applications. In this study, GSI (Grid-point Statistical Interpolation)-Hybrid is being tested for the HWRF (WRF for Hurricanes) system. A case study is performed for Bret 2011 and slightly positive impact from the GSI-Hybrid data assimilation is shown for the hurricane forecast, in comparison to pure GSI 3DVAR applied for HWRF. Further studies are being conducted to assess the impact of satellite radiance data in the framework of GSI-Hybrid and preliminary results show that regionally tuned BC contributes to further improvements.

Operational HWRF configuration

o Model forecast domains: outer and inner
o HWRF vortex initialization domain: 4x
o 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

Experiment design

□ HWRF: v3.3a, 41 levels, 50mb model top
□ GSI: April 2012 trunk, Global BE (+ ensembles)
□ Testing period: Bret 2011071800-2011072000
□ Background: GFS
□ PrepBUFR + Radiance

■ Experiments:
  □ NoDA: No Regional GSI, initialized with HWRF 6hr FCST
  □ 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

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

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

0.25   0.75   Global Ensemble Forecast (80)

(Courtesy of Jeff Whitaker and Henry Winterbottom at NOAA/GSD)

HWRF ~ Moving domain !

Best Track information (Courtesy of NHC)

Bret is not a strong storm; GSI only run at 2011071818 and 2011071900 by 2011 HWRF operational configuration.

Pseudo Single Observation Test: T= 1K at 850hPa

Beta1=1.0 - 3DVAR   Beta1=0.25 - Hybrid   Beta1=0.0 - ensemble

Track and Intensity Forecast for Bret 2011071800 - 2011072000

Bret 2011071800   Bret 2011071806
Bret 2011071900   Bret 2011071906
Bret 2011072000   Mean Track Error

NoDA
GSI-3DVAR
GSI-Hybrid
Best Track

GSI-Hybrid has slightly positive impact on Bret track forecast for most of the lead times compared to GSI-3DVAR.

Mean Intensity Error   Mean Abs. Intensity Error

NoDA
GSI-3DVAR
GSI-Hybrid

GSI-Hybrid has slightly positive impact on Bret intensity forecast for most of the lead times compared to GSI-3DVAR. Both GSI-3DVAR and GSI-Hybrid tend to produce larger intensity errors than the NoDA run.

GSI-Hybrid with tuned satellite Bias Correction

LANDMASK (units)

Diagnostics of AMSUA Metop-a Channel 1

Number of obs
Bias
Stdv

Basin Scale HWRF
27km, 61 vertical levels, model top at 2mb
BC cycling period: 2011071806-2011072800, 6-hrly cycling

OMA w/ BC
OMB w/ BC
OMB w/o BC

Time

Track and Intensity Forecast Errors for Bret 2011071800 – 2011072000 with tuned BC

Mean Track Error   Mean Intensity Error   Mean Abs. Intensity Error

NoDA
Hybrid w/ tuned BC
Hybrid w/ cold BC

Lead time

GSI-Hybrid with regionally tuned satellite Bias Correction tends to give further improved track forecast compared to the GSI-Hybrid run with the un-tuned BC, but neutral impact on the intensity forecast.

Discussions

• GSI-Hybrid
  slightly improves the track forecast for Bret 2011;
  slightly positive impact on the intensity forecast over GSI-3DVAR;

• GSI-Hybrid with tuned BC
  further improves the track forecast;
  neutral impact on the intensity forecast.

• Proposed work to tune BC and further improve the hurricane forecast:
  . Satellite Platform/Channel selection
  . Diurnal variation in BC