HWRF Simulation in the COASTAL Act

Zaizhong Ma[1,2], Avichal Mehra[2] and Vijay Tallapragada[2]

[1]I. M. Systems Group, Inc. (IMSG); [2]NOAA/NWS/NCEP/EMC

Acknowledgements: HWRF Project team at EMC and Coastal Act project team

Outline

- Brief of the COASTAL Act Program
  - Why do we need to revisit the retrospective storms?
- HWRF Simulation in the COASTAL Act
  - Land-falling storm selection
  - Challenges for data assimilation
  - Hurricane IKE (2008) simulation
- Technical issues remaining in HWRF
- Summary and Future plan

Coastal Act Program

COASTAL Act:

The Consumer Option for an Alternative System to Allocate Losses Act was signed into law on July 6, 2012.

Purpose:

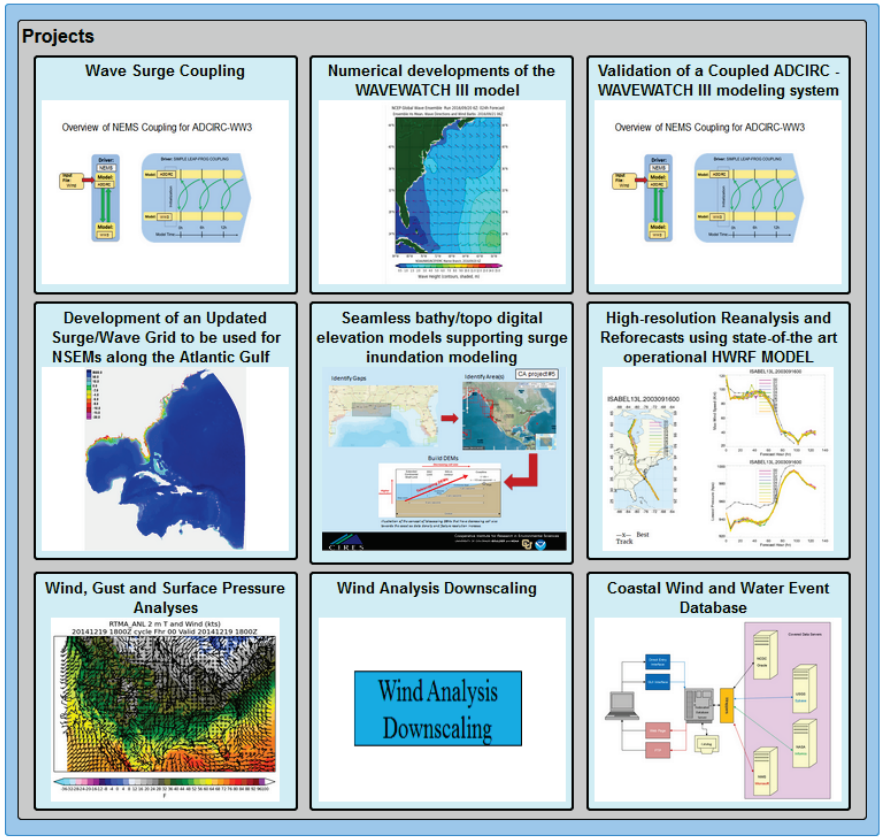
To lower costs to FEMA's National Flood Insurance Program (NFIP) by better discerning wind versus water damage in the case of "indeterminate losses."

(website: http://www.weather.gov/sti/coastalact)

Require:

- NOAA to produce detailed "post-storm assessments" in the aftermath of a damaging tropical cyclone that strikes the U.S. or its territories.
- Develop the Named Storm Event Modeling (NSEM) system

COASTAL Act Component Projects



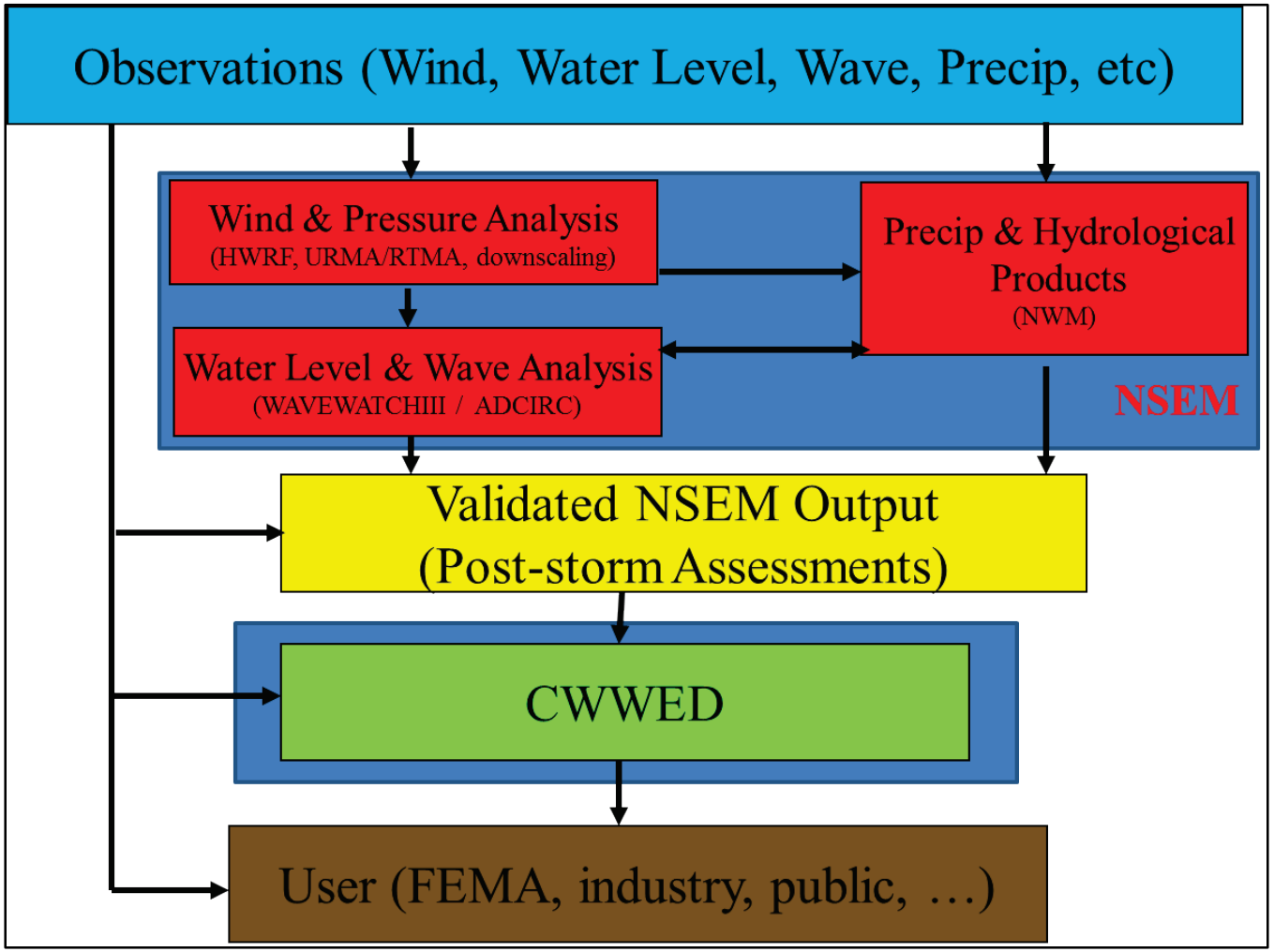
Coastal Wind and Water Event Database (CWWED)

- NOAA established Version 0.1 of the CWWED in July 2013, per the Act's requirements. It will be repository for the storm observations ("covered data") used in the NSEM.
- CWWED will transition from prototype to experimental status upon the completion of the NSEM.
- CWWED will also be the platform for retrieving post-storm assessment results (produced by the NSEM) for a given location in the area covered by the NSEM.
- Quality Control will be critical, given the application of data for legal purposes. Therefore, CWWED will be a "federated database" in which data may or may not reside at the same physical location as the database core server (i.e. in most instances the database will operate by pointing to data in other databases).
- Will require data sharing and dissemination agreements with external partners in some cases.

Named Storm Event Model (NSEM)

- NSEM will be collection of separate, but interdependent, model products that provide time-dependent analyses of specific meteorological and hydrologic factors that contribute to indeterminate losses.
- The three main model product areas will be:
  - Storm Surge / Waves
  - Wind and Surface Pressure Analyses
  - Precipitation and Hydrologic Development

COASTAL Act Process



Technical and Observation Challenges

- **Technical**
  - Implementing 90% accuracy
  - End-to-end system; timeframe
  - Storm selection/prioritization
  - Data availability/accuracy

- **Observation Challeges**
  - Surface observation density not high enough to support wind analyses at high accuracy
  - Water level observation network also insufficiently dense
  - Mobile sensor network may not be sufficient
  - Durability of sensors in the most destructive hurricanes uncertain

Nicole P. Kurkowski (NWS)

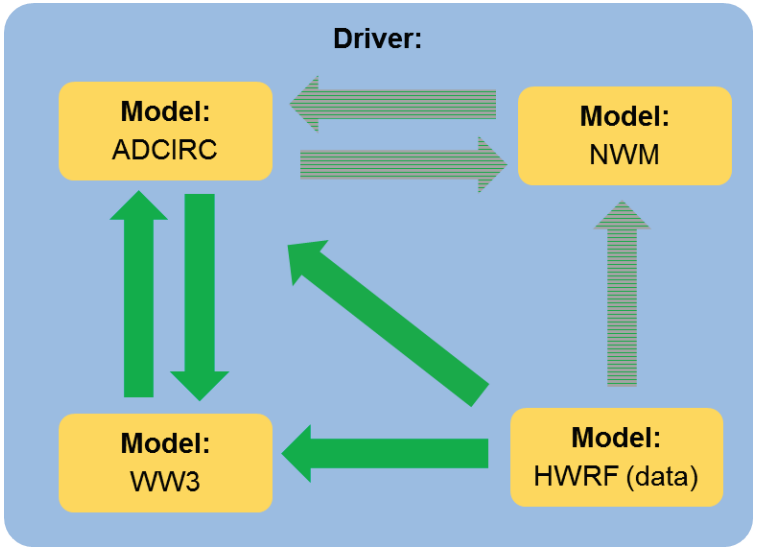
NOAA Technical Lead for COASTAL Act Implementation

HWRF in the COASTAL ACT

– High-resolution Hurricane Reanalysis and Reforecasts using state-of-art operational HWRF model

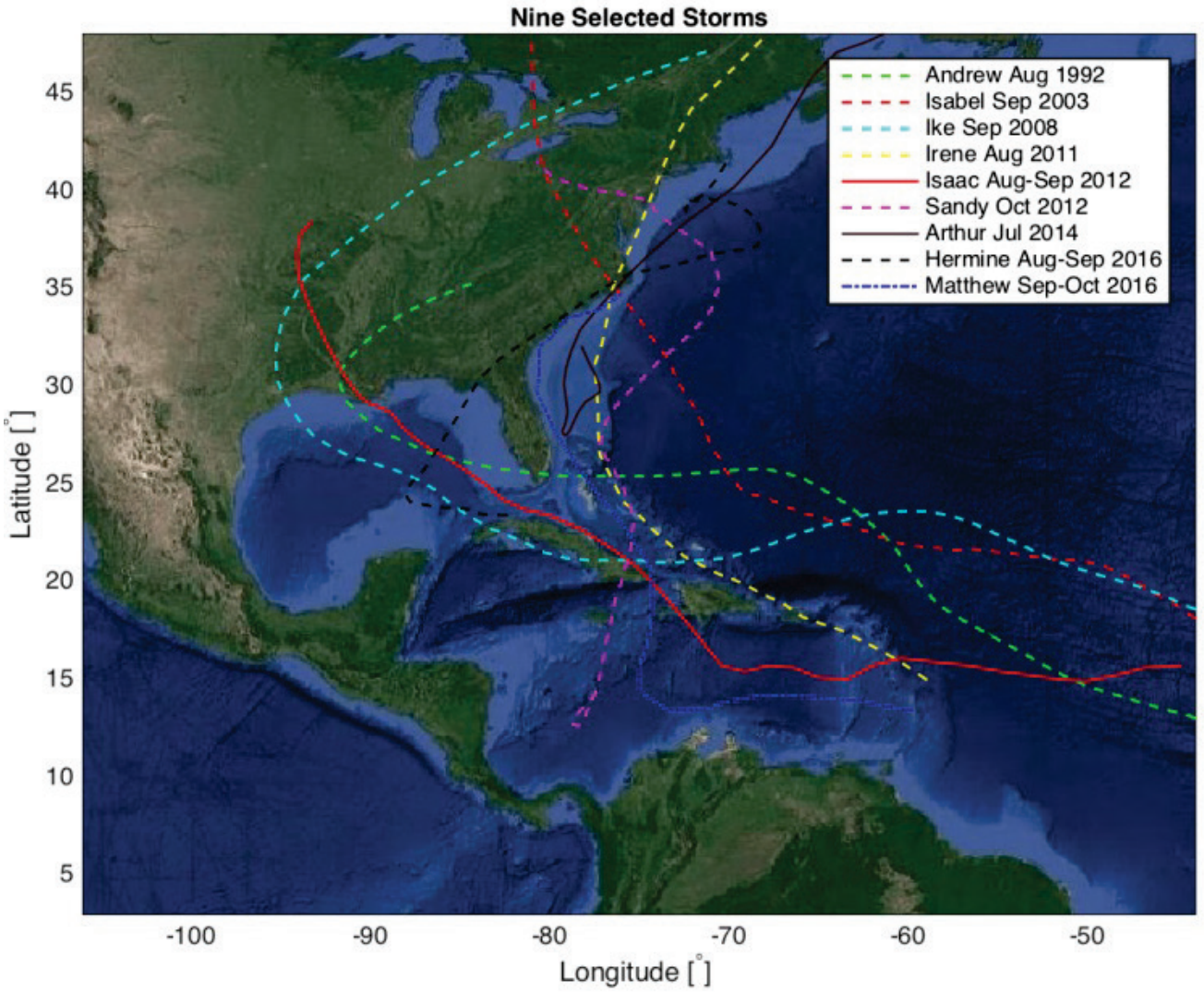
Role of HWRF in the COASTAL Act

- **HWRF System:**
  - Nested domain (18/6/2 km), 75 vertical levels with model top at 10hPa
  - ICs/BCs: with 4D-Hybrid GDAS/GFS
  - Ocean coupling with MPIPOM
  - Hybrid EnKF-3DVAR DA: hybrid 40-member HWRF-based high resolution ensembles and GSI system
  - Forecast outputs: including processed GRIB1 and GRIB2 files (projected to lat-lon grids), track files, rainfall swath data, and wind products containing information about the tropical cyclone.



- **For COASTAL Act:**
  - **Generate** wind and surface pressure analysis from HWRF retrospectives for the selected ***land falling tropical cyclones***.
  - **Provide** background fields for Un-Restricted Mesoscale Analysis (URMA) which will perform mean wind, gust, pressure and air-sea temperature difference (atmospheric stability, AS) surface analysis over the area impacted by a land falling tropical cyclone.

Land-falling storms selection

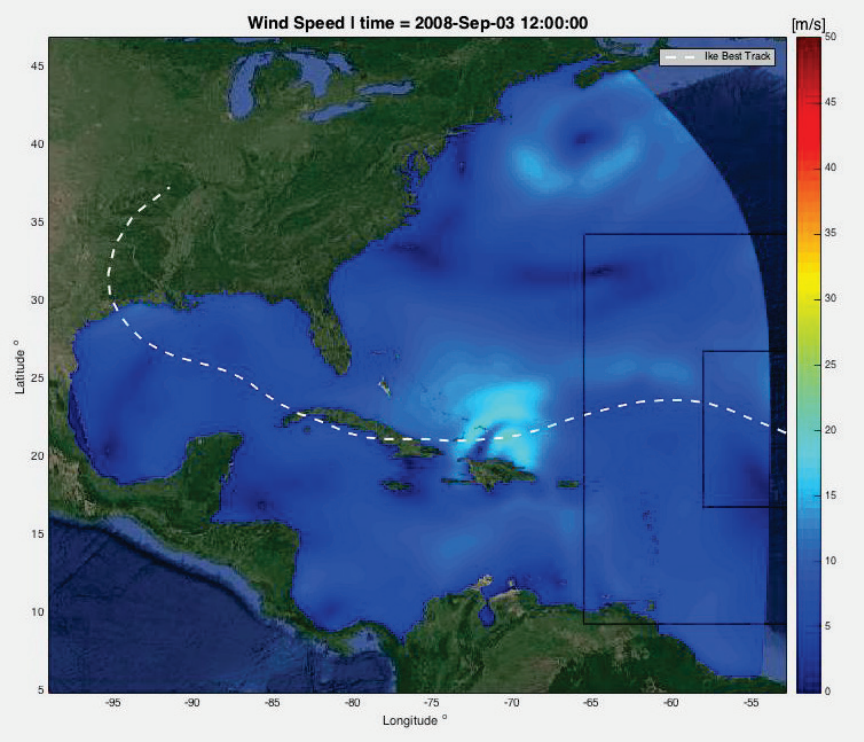


Milestones and Issues

- **Milestones:**
  - Three of nine selected retrospective storms simulations have been completed with HWRF system
  - Data collection
    - ICs/BCs: GFS Forecasts 2.5deg Reanalysis & 1.0deg GEFS
    - Observations: conventional, satellites, optional for TDR and High Density Observation data
  - HWRF configurations (ocean coupling, data assimilation)
- **Main Issues:**
  - Input Data for HWRF
  - Specify setup for each storms, especially about DA setup
  - No ensemble inputs for GSI hybrid ensemble-variational DA before 2012

Experimental Design for IKE Simulation

- **Time Period**: 1-14, September 2008
- **Experiments**:
  - **GR05**: IKE simulation with 0.5 degree GFS (No DA, No Ocean)
  - **OC05**: IKE simulation with 0.5 degree GFS (No DA, with Ocean)
  - **DA05**: IKE simulation with 0.5 degree GFS (With 3D-Var, with Ocean)
  - **BC05:** IKE simulation with 0.5 degree GFS (With 3D-Var, Ocean and adjusted satellite bias corrections)
- **Preliminary Results** focus on track and intensity forecasts

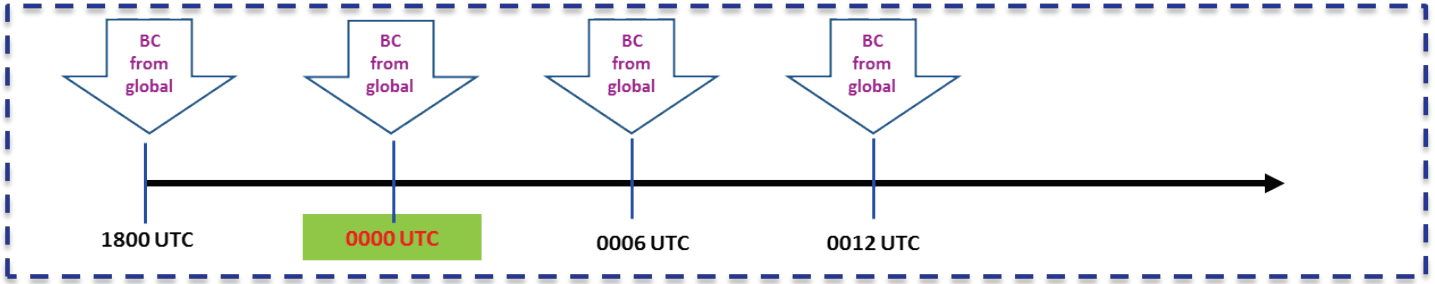


Special DA Adjustment for IKE

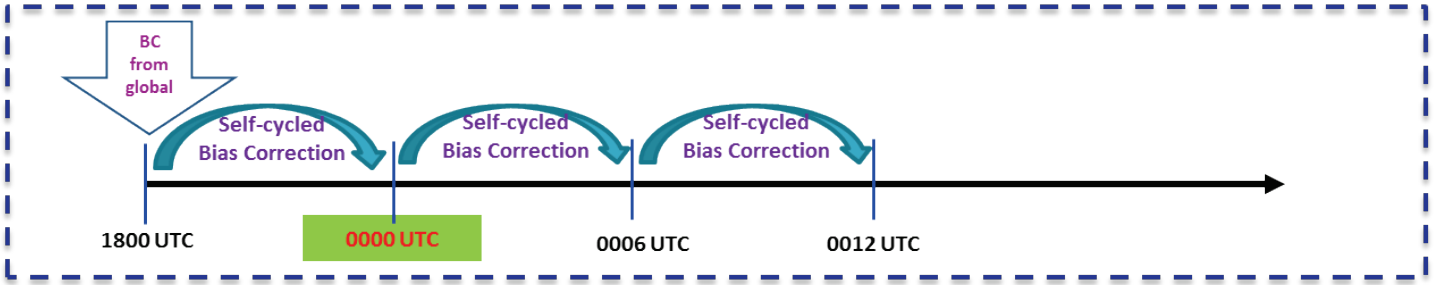
Issues:

- Satellite bias corrections available for the year 2008 can not use in current version of the GSI system.

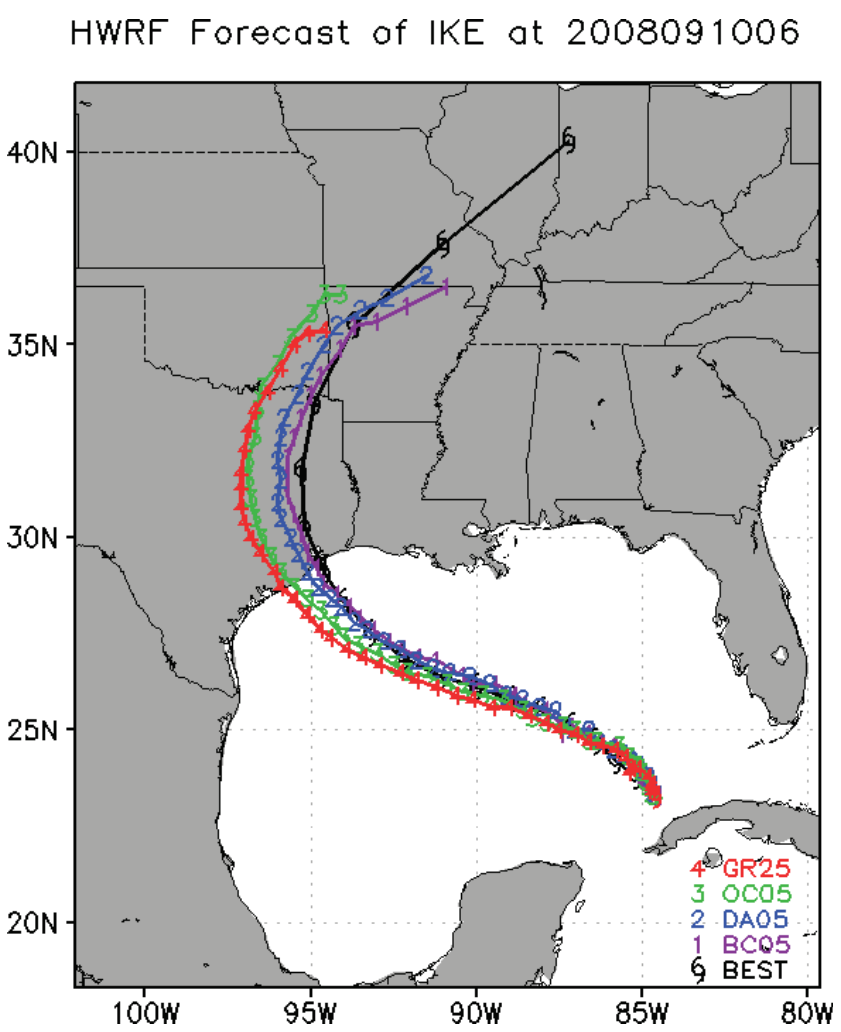
Default in HWRF:

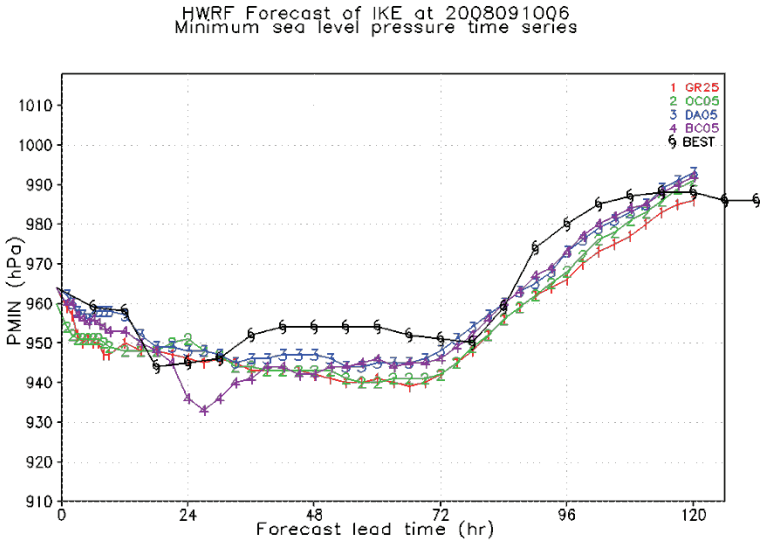


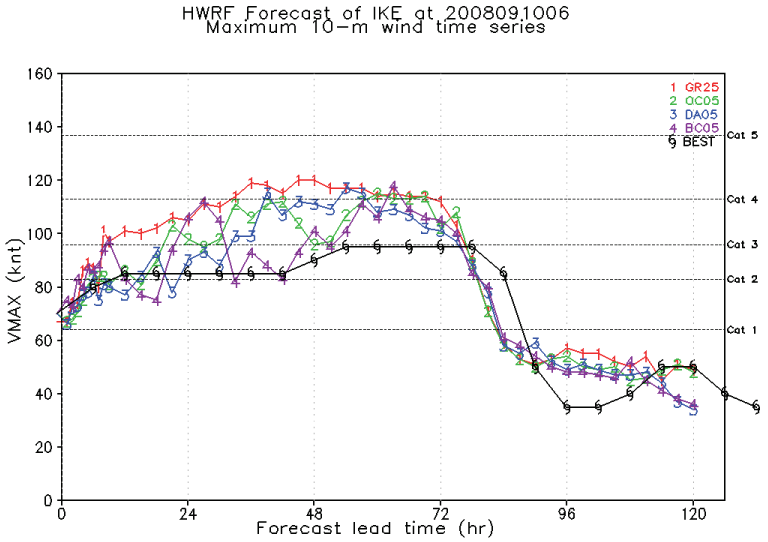
With Adjustment:



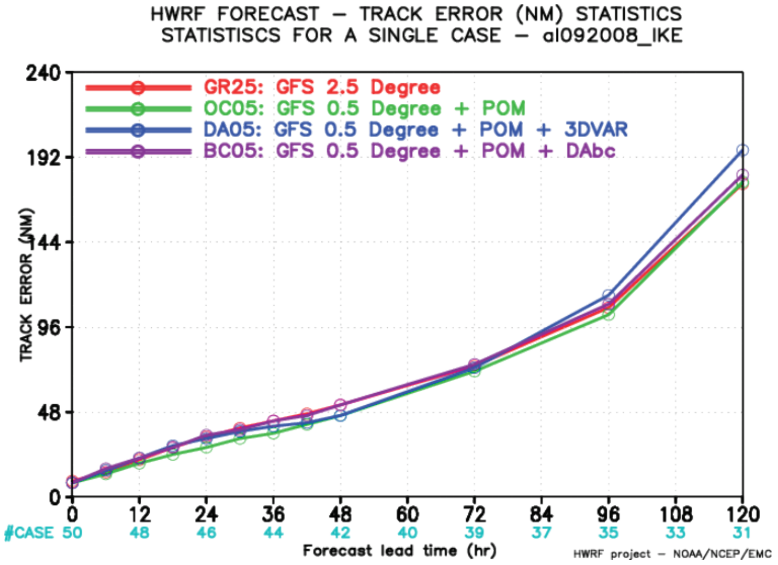
Single Cycle Comparison

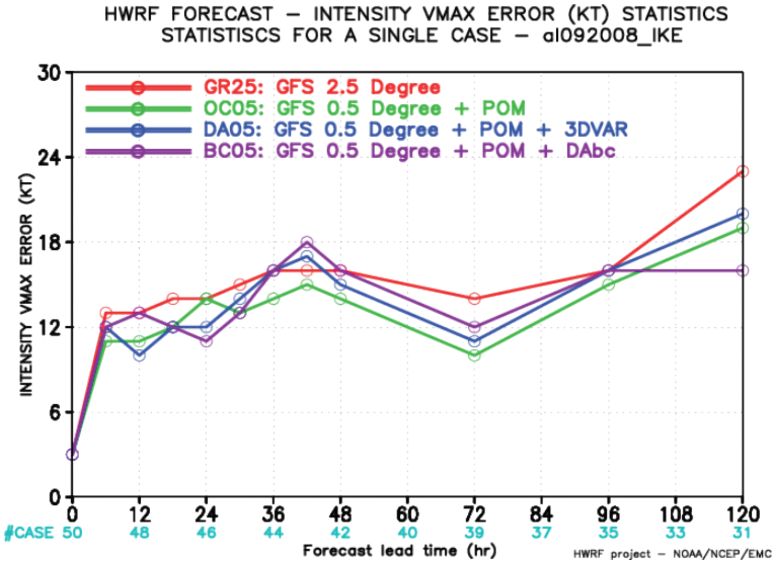


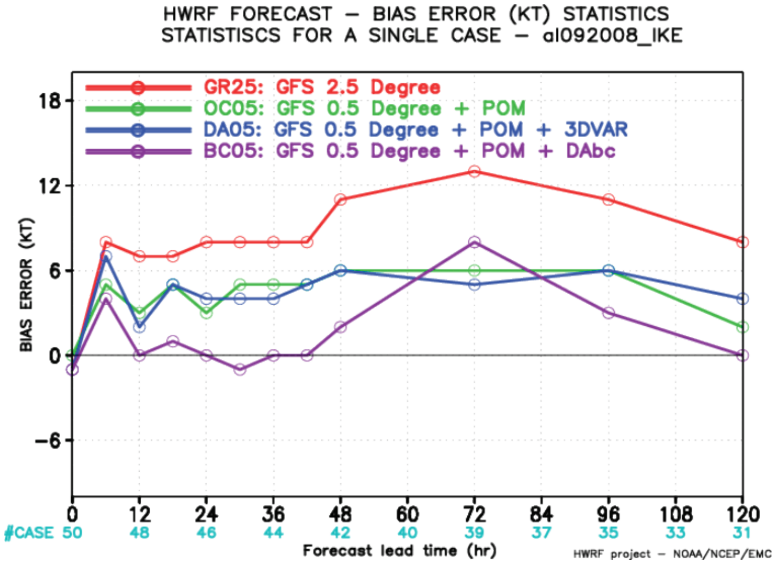




Preliminary Statistics Results for IKE

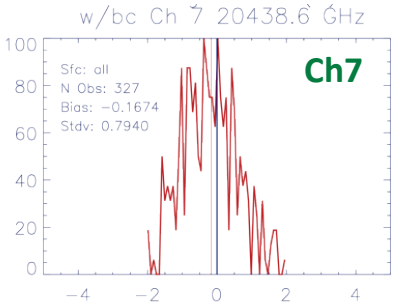


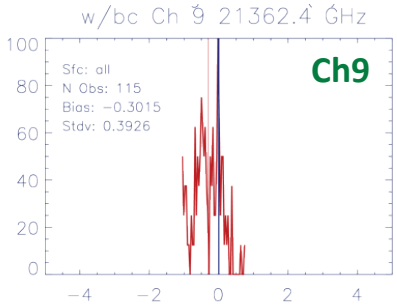


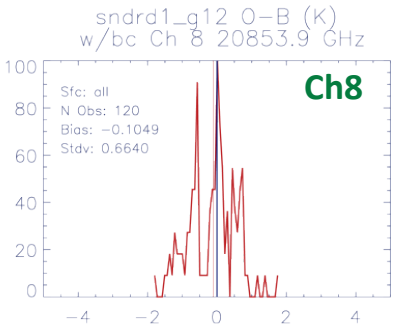


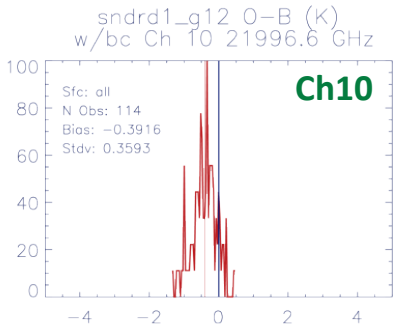
Technical Issue: Minor impacts from DA?

O-B

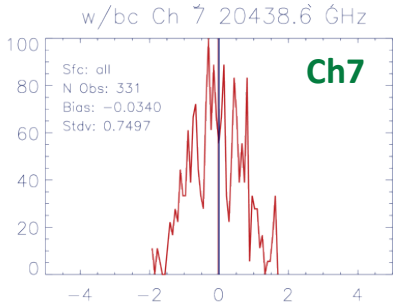


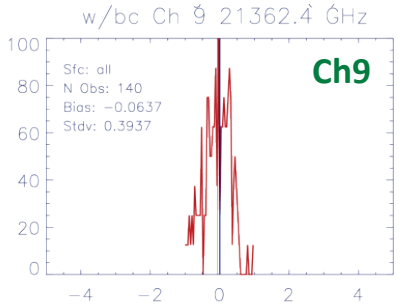


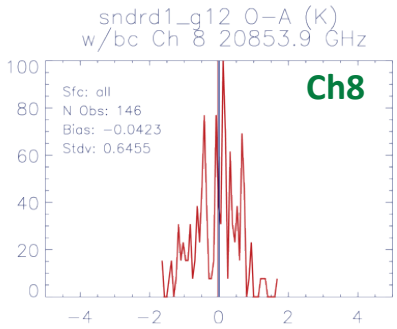


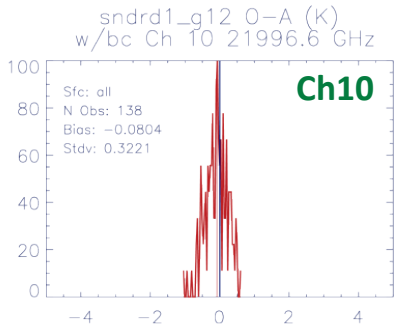


O-A



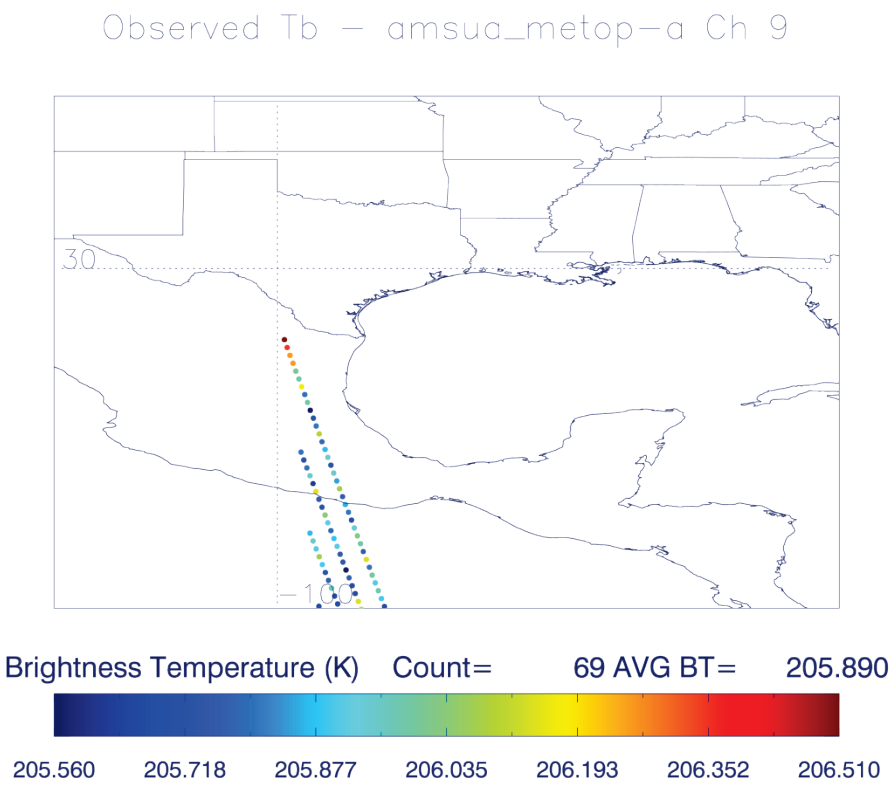




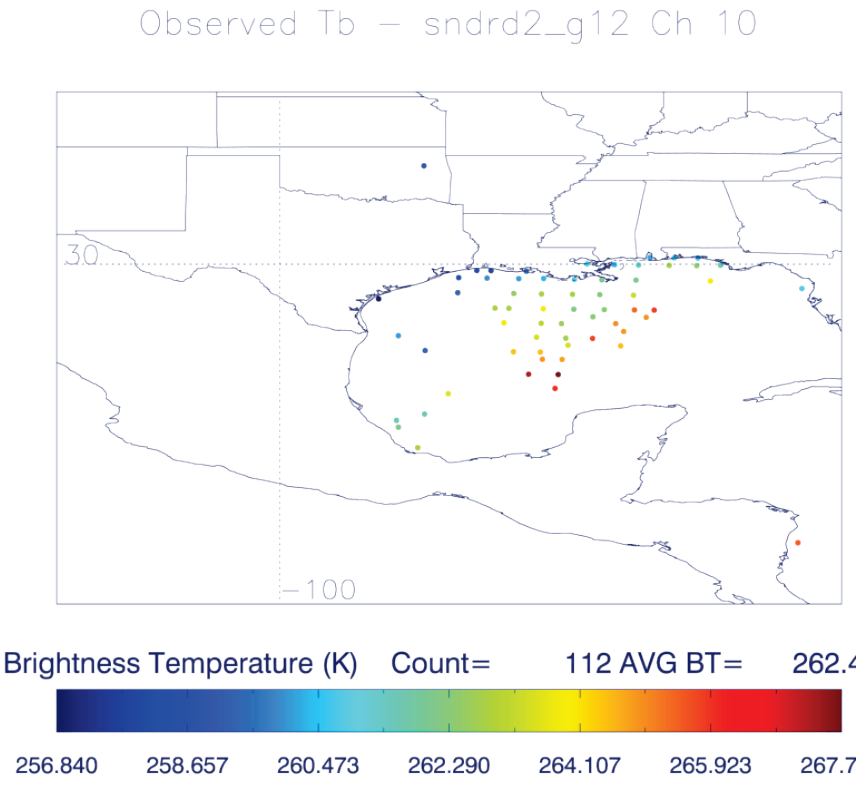


GOES-12 comparison before/after assimilation

Technical Issue: Minor impacts from DA?



amsua_metop-a



G12

Technical Issue: Minor impacts from DA?

Issues:

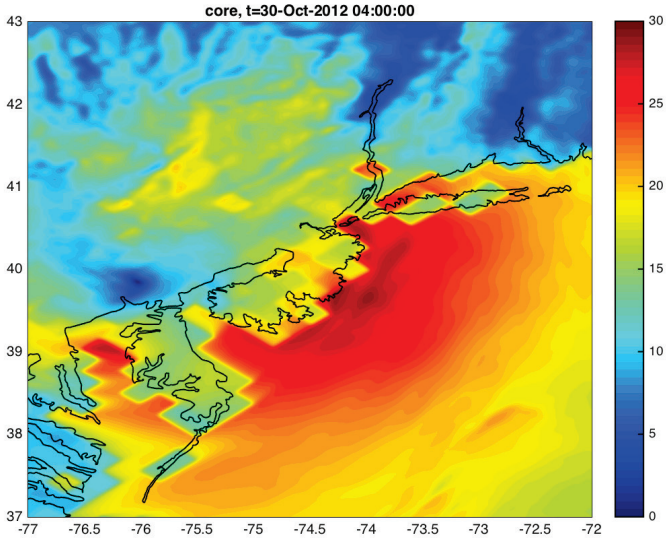
- Still have some satellite data no assimilated in GSI, i.e., n17.
- Work on satellite QC to assimilate more data, i.e., g12.
- Double check missing data for the reason of HWRF system update.

Data Check from one cycle: IKE (2008)

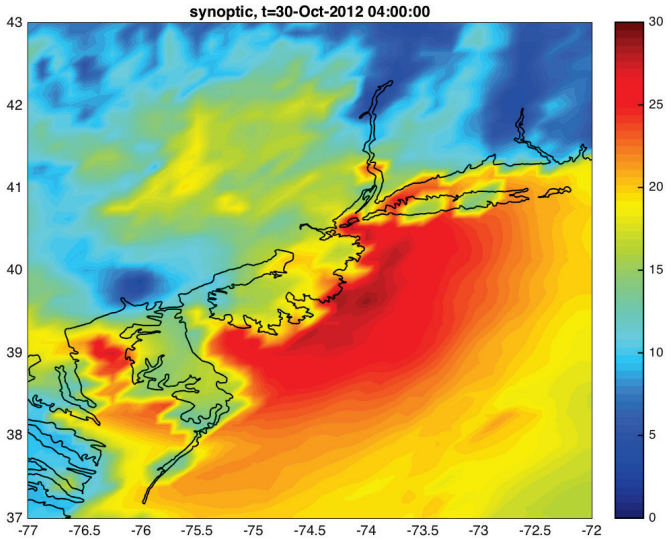
Zaizhong.Ma@tfe04:datagap

	it	satellite	instrument	# read	# keep	# assim	penalty
o-g	01 rad	n17	hirs3	59223	10773	0	0.0000
o-g	01 rad	metop-a	hirs4	2679	871	116	58.577
o-g	01 rad	g11	goes_img	0	0	0	0.0000
o-g	01 rad	g12	goes_img	0	0	0	0.0000
o-g	01 rad	aqua	airs	0	0	0	0.0000
o-g	01 rad	n15	amsua	0	0	0	0.0000
o-g	01 rad	n18	amsua	0	0	0	0.0000
o-g	01 rad	metop-a	amsua	1035	1035	455	277.35
o-g	01 rad	aqua	amsua	0	0	0	0.0000
o-g	01 rad	n17	amsub	64080	11465	0	0.0000
o-g	01 rad	n18	mhs	0	0	0	0.0000
o-g	01 rad	metop-a	mhs	2850	875	160	59.678
o-g	01 rad	f14	ssmi	0	0	0	0.0000
o-g	01 rad	f15	ssmi	0	0	0	0.0000
o-g	01 rad	aqua	amsre_low	0	0	0	0.0000
o-g	01 rad	aqua	amsre_mid	0	0	0	0.0000
o-g	01 rad	aqua	amsre_hig	0	0	0	0.0000
o-g	01 rad	f16	ssmis	0	0	0	0.0000
o-g	01 rad	f17	ssmis	0	0	0	0.0000
o-g	01 rad	f18	ssmis	0	0	0	0.0000
o-g	01 rad	f19	ssmis	0	0	0	0.0000
o-g	01 rad	g12	sndrd1	223560	8298	645	695.59
o-g	01 rad	g12	sndrd2	232974	8226	1381	1605.4
o-g	01 rad	g12	sndrd3	225918	8244	320	231.86
o-g	01 rad	g12	sndrd4	228114	8226	1145	1276.7
o-g	01 rad	g11	sndrd1	0	0	0	0.0000
o-g	01 rad	g11	sndrd2	0	0	0	0.0000
o-g	01 rad	g11	sndrd3	0	0	0	0.0000
o-g	01 rad	g11	sndrd4	0	0	0	0.0000
o-g	01 rad	g13	sndrd1	0	0	0	0.0000
o-g	01 rad	g13	sndrd2	0	0	0	0.0000
o-g	01 rad	g13	sndrd3	0	0	0	0.0000
o-g	01 rad	g13	sndrd4	0	0	0	0.0000
o-g	01 rad	metop-a	iasi	0	0	0	0.0000
o-g	01 rad	n19	hirs4	0	0	0	0.0000
o-g	01 rad	n19	amsua	0	0	0	0.0000
o-g	01 rad	n19	mhs	0	0	0	0.0000
o-g	01 rad	m08	seviri	0	0	0	0.0000
o-g	01 rad	m09	seviri	0	0	0	0.0000
o-g	01 rad	m10	seviri	0	0	0	0.0000
o-g	01 rad	metop-b	hirs4	0	0	0	0.0000
o-g	01 rad	metop-b	amsua	0	0	0	0.0000

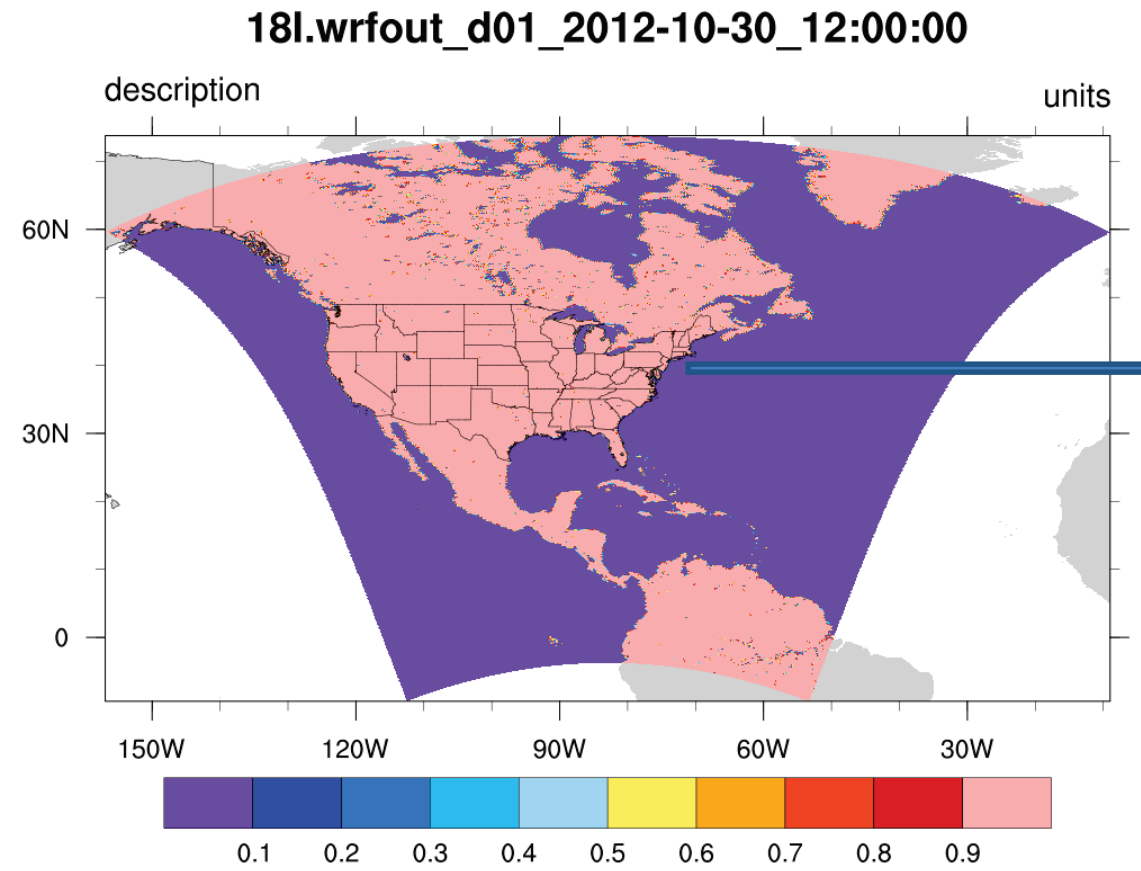
Technical Issue: Land-Sea mask in HWRF

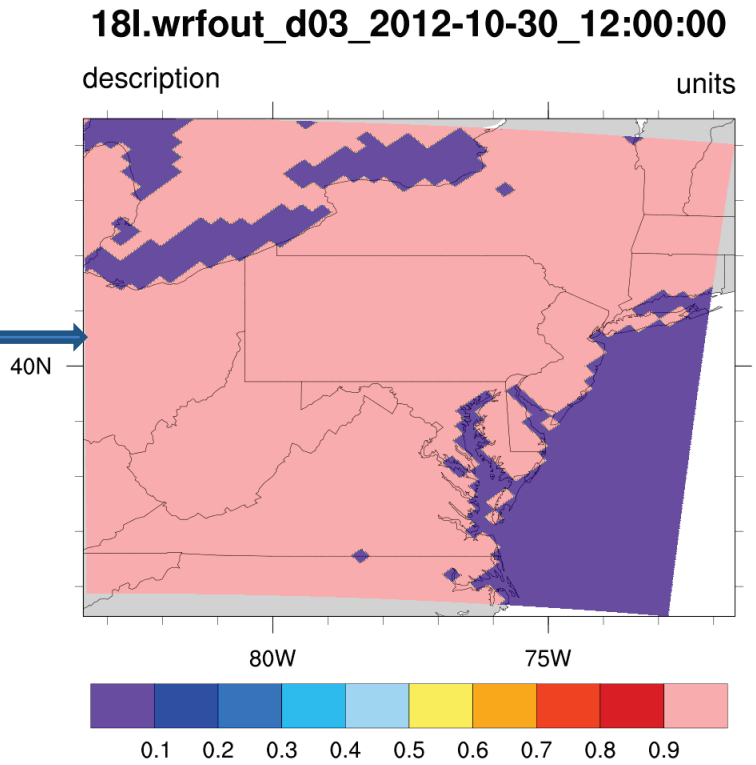


10m Wind from each domain in HWRF system



Technical Issue: Land-Sea mask in HWRF





Full D1 (18km)

D3 (2km)

Other Technical Issues …

Issues:

- Reduce HWRF forecast from 120 hours to 12 hours;
- Reperform retrospective landfalling storms with higher resolutions;
- Assimilate more observations with “new data set” which is generated after storms occur.

Summary and Future Plan

Summary:

- Completed HWRF simulations for three selected land-falling storms;
- Applied satellite self-cycle bias corrections in HWRF for IKE (2008);
- Working on multiple experiments for Hurricane Sandy (2012) simulations.

Future Plans:

- Test satellite self-cycle bias corrections in HWRF for more recent storms, such as Sandy (2012) etc.;
- Simulate Recent retrospective storm with hybrid ensemble-variational DA;
- Fix the technical issues remaining, i.e., satellite data assimilation, land-sea mask and etc.
- Consider the possibility of assimilating satellite data with advanced satellite bias corrections in the parent domain D1.
- Continue work on HWRF simulations for the rest of nine selected storms.