



Plans for Operational Hurricane Modeling in FY18

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(with ongoing collaborations from AOML, DTC, NHC, GFDL, ESRL, CCU, OU and others)

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HFIP Annual Review Meeting, November 8, 2017





Outline



- Resources
- Potential 2018 HWRF upgrades
- Potential 2018 HMON upgrades
- Current and near-term future plans
- Long term plans for HWRF & HMON



Operational Resources for Hurricane Modeling (maximum per storm forecast)



Operational System	2016 (nodes)	2017 (nodes)	Max Storms	Comments
HWRF (plus WW3)	63	63	8	Max # of storms increased by 1
WW3-multi2	7	0	0	WW3 subsumed in HWRF
GFDL	5	0	0	Discontinued
HMON	0	26*	5	Uses much less resources than HWRF
TOTAL	75	89	--	18.7% resource increase

Target Increase in FY18 Resources: 20% (max)



FY18 HWRF v12.0.0 Potential Upgrades



Scope of FY18 HWRF Upgrades



➤ System & Resolution Enhancements

- Framework upgrade to HWRFV3.9.1 with bug fixes
- T&E with 2017 GFS IC/BC, increase BC frequency to 3 hrs
- Increase vertical resolution for non-NHC basins to 75 levels

- I/O optimization (IBM analyst)
- Increase horizontal resolution to 1.5/4.5/13.5 km, with adjusted domain sizes for do1, do2 and do3
or
- Increase domain size (do1, do2, do3) with 18/6/2 km configuration

-- Green:

Included in Baseline

-- Blue:

Included in Baseline (if ready)

-- Orange:

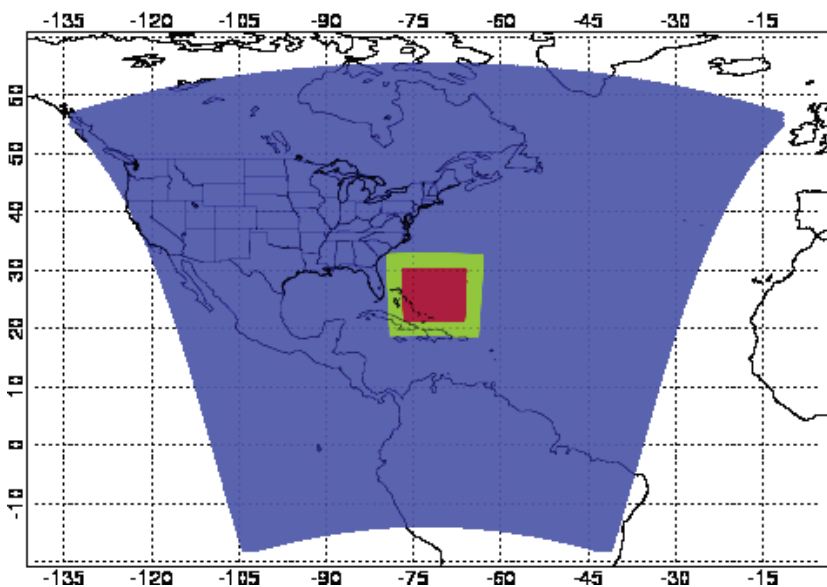
Tested separately as an option



Adjusted Domain Sizes for H217 with higher vertical resolution

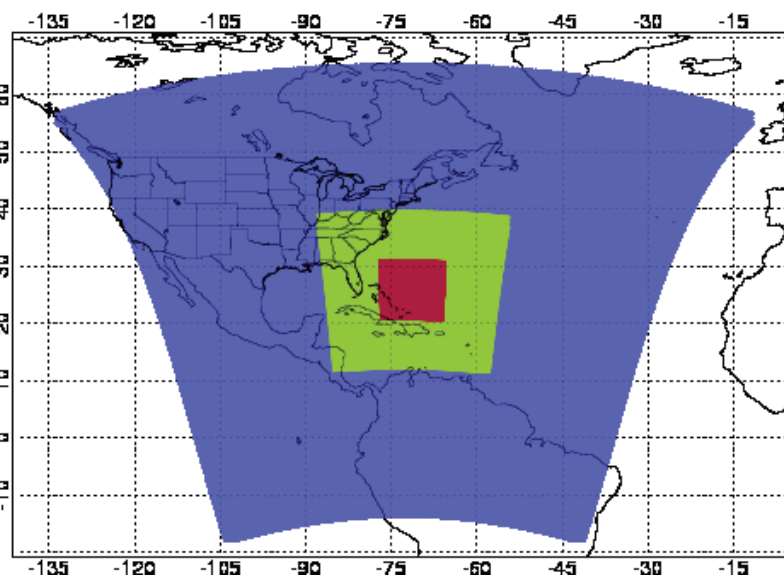


H215



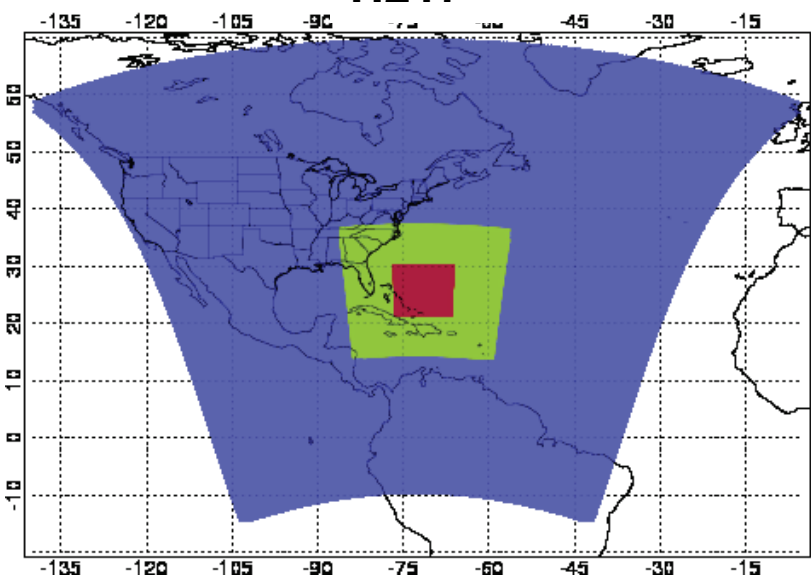
d02: 142 x 274
d03: 265 x 472
Levels: 61
Top: 2 mbar

H216



d02: 288 x 576
d03: 288 x 576
Levels: 61
Top: 2 mbar

H217



d02: 265 x 532
d03: 235 x 472
Levels: 75
Top: 10 mbar



Scope of FY18 HWRF Upgrades



➤ Physics Advancements (Lin's talk)

- Updates/options for PBL schemes (GFSEDMF changes; in-cloud mixing; YSU)
- Update/tune scale-aware SAS scheme or adopt G-F cumulus scheme (DTC)
- Consider YSU surface layer scheme (with YSU PBL)
- Radiation, RRTMG- cloud overlap (DTC)
- Consider microphysics scheme upgrades (advected F-A or Thompson)
- Adjust surface flux exchange coefficients

-- Green:

Included in Baseline

-- Blue:

Included in Baseline (if ready)

-- Orange:

Tested separately as an option



Scope of FY17 HWRF Upgrades



➤ Initialization/Data Assimilation Improvements (Jason's talk)

- Improve vortex initialization (new composite storm vortex)
 - GSI code upgrades; add new data sets (example: GOES-16 AMV's)
 - Unflag u/v data from dropsondes
 - Use full ensemble covariances
-
- Increase number of GSI outer loops
 - Consider other new datasets: SFMR, CYGNSS
 - Extend fully Cycled EnKF two-way hybrid DA to 2 storms
 - Stochastic physics for DA ensembles
 - Changes in blending thresholds, VM (when TDR data is available)
 - Extend DA to WPAC

-- Green:

Included in Baseline

-- Blue:

Included in Baseline (if ready)

-- Orange:

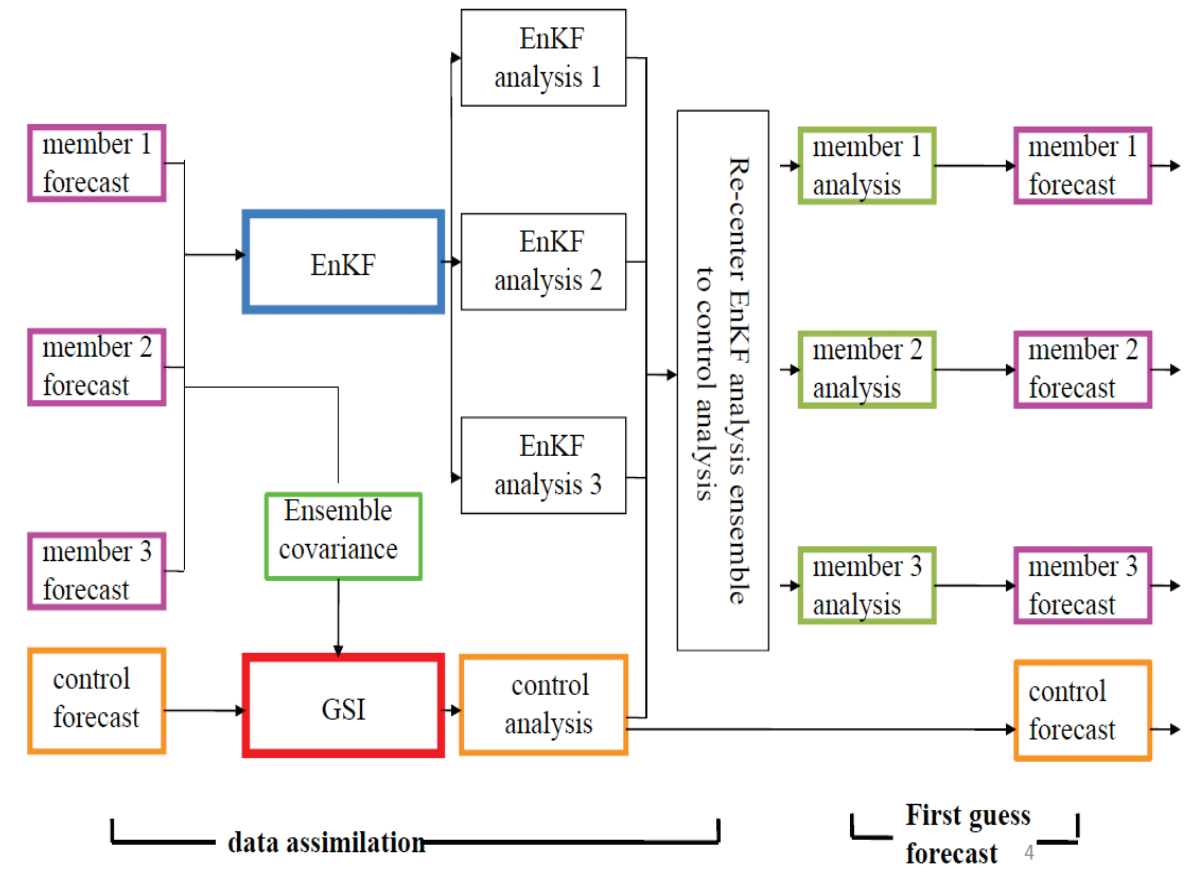
Tested separately as an option



2018 Data Assimilation Upgrades (NATL and EPAC)

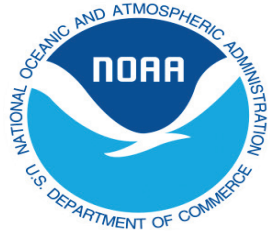


Hybrid EnKF-GSI DA system: 2 way coupling



Advanced self-cycled HWRF EnKF-GSI Hybrid Data Assimilation System (HDAS)

Extend it to two priority storms for 2018



Scope of FY18 HWRF Upgrades



➤ Other upgrades in 2018....

- Unified HMON/HWRF coupler
- WW₃ initial conditions from global wave model (multi_1)

- POM SST initialization from RTOFS in NATL (similar to EPAC)
- Full three-way coupling (Atmosphere-Ocean-Waves) for NHC domains
- Add ocean coupling (HYCOM) for Southern Hemisphere storms
- Graphics included in workflow

-- Green:

Included in Baseline

-- Blue:

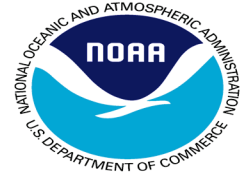
Included in Baseline (if ready)

-- Orange:

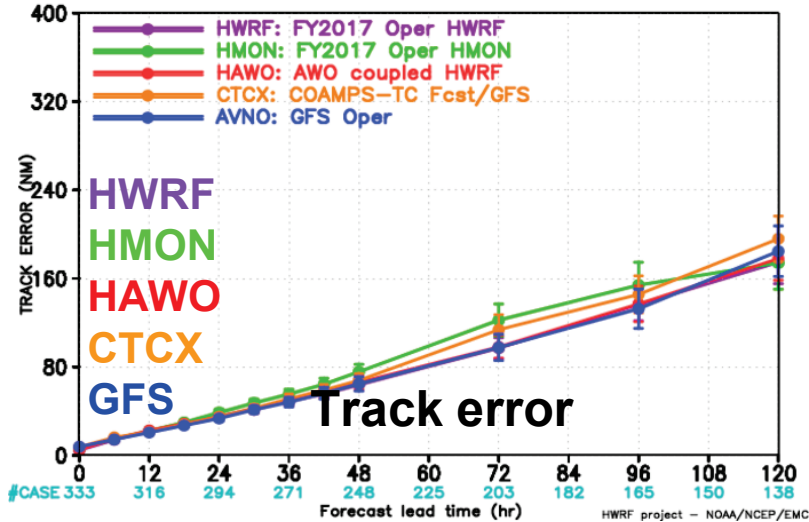
Tested separately as an option



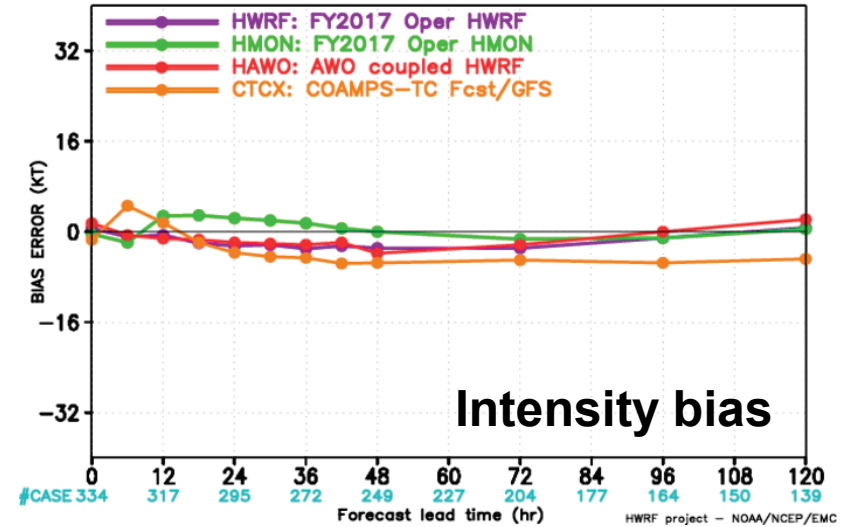
Stream 2.0: 3-way coupled HWRF (HAWO) Real-Time Performance for 2017 NATL Storms



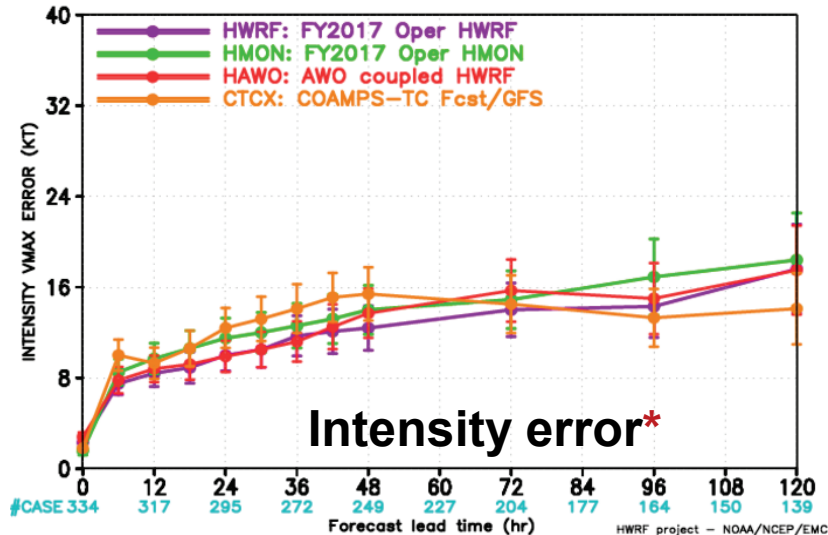
HWRf FORECAST – TRACK ERROR (NM) STATISTICS
VERIFICATION FOR NATL BASIN



HWRf FORECAST – BIAS ERROR (KT) STATISTICS
VERIFICATION FOR NATL BASIN



HWRf FORECAST – INTENSITY VMAX ERROR (KT) STATISTICS
VERIFICATION FOR NATL BASIN

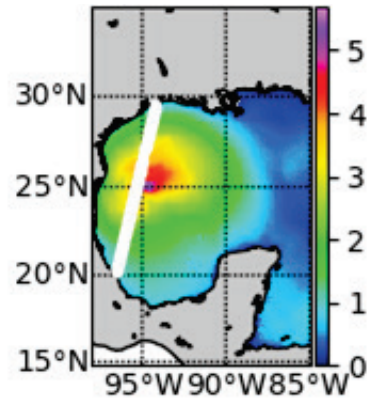
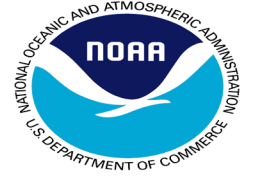


Track errors are almost identical to operational HWRf and GFS. Intensity errors are larger for HAWO for Days 2 and 3, similar otherwise. Intensity bias shows no marked difference.

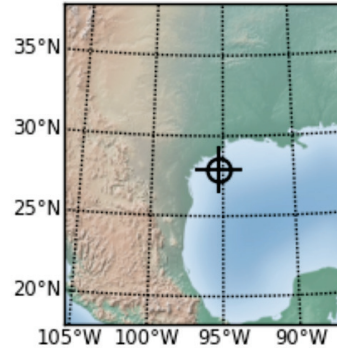
* HAWO has no self-cycled data assimilation



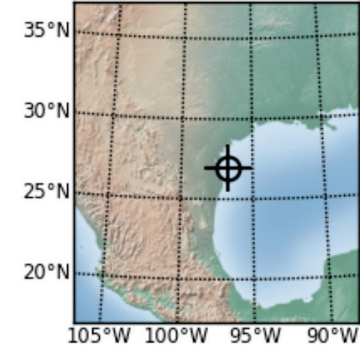
3-way Coupled HWRF (HAWO) Wave Forecast for Hurricane Harvey (09L) Comparisons with altimeter and buoy observations



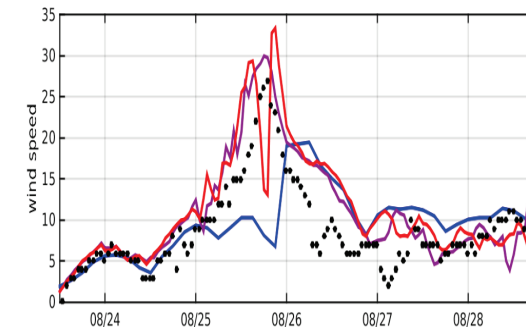
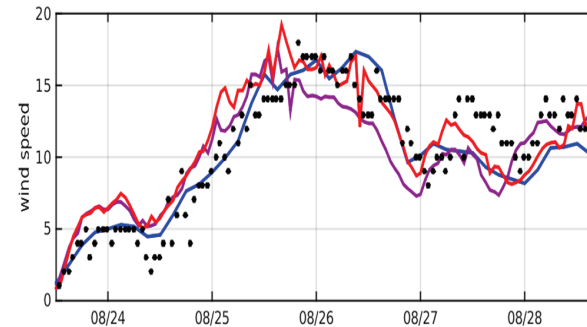
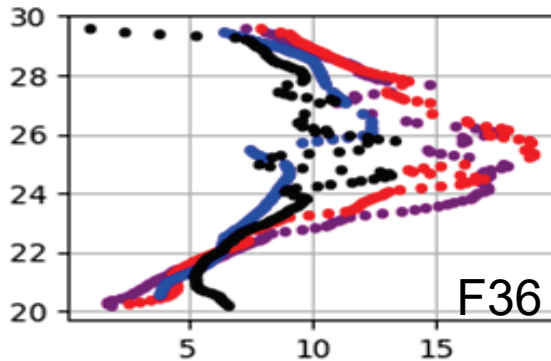
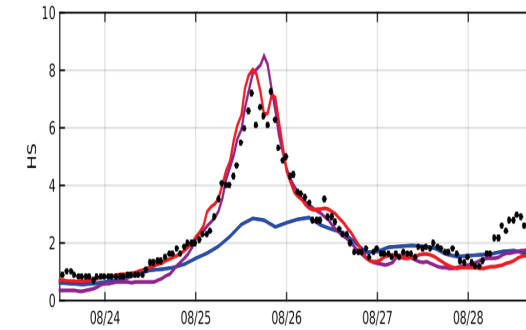
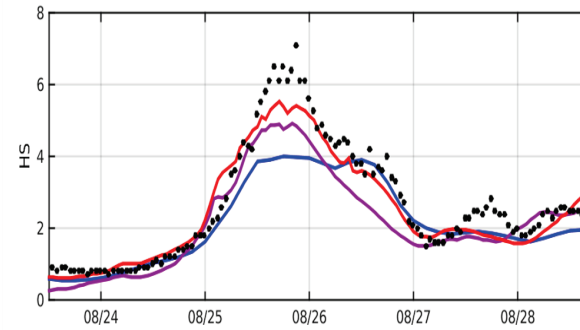
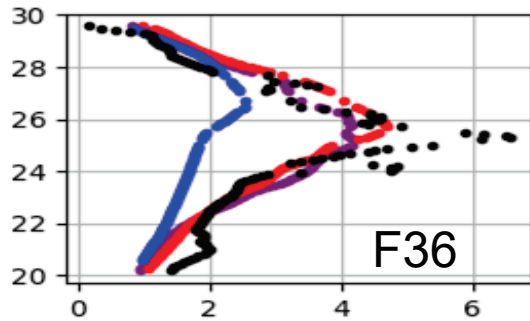
Buoy 42019



Buoy 42020



- HWRF
- HAWO
- Multi_1
- SARAL/ATK





Scope of FY18 HMON Upgrades



➤ System & Resolution Enhancements

- Upgrade to the latest NMMB dynamic core
- Add Vertical levels, revise nest domain sizes
- NMMB dycore optimization (IBM analyst)

➤ Initialization/Data Assimilation Improvements

- Updated composite vortex
- Change co-ordinates for VI
- Use HWRF initialization

➤ Physics Advancements

- Use scale-aware SAS scheme
- Update momentum and enthalpy exchange coefficients(Cd/Ch)
- Use EDMF PBL scheme
- Explore use of MYJ surface layer + MYJ PBL

➤ Coupling Upgrades

- Add HYCOM coupling in NATL basin

-- Green:

-- Blue:

-- Orange:

Included in Baseline

Included in Baseline (if ready)

Tested separately as an option

FY2017 HWRF/HMON Configuration (maintain diversity for FY18)

	HWRF	HMON
Dynamic core	Non-hydrostatic, NMM-E	Non-hydrostatic, NMM-B
Nesting	18/6/2 km; 75°/25°/8.3°; 75 vertical levels Full two-way moving	18/6/2 km; 75°/12°/8°; 43 vertical levels Full two-way moving
Data Assimilation and Initialization	Vortex relocation & adjustment Self-cycled hybrid EnKF-GSI with inner core DA (TDR)	Vortex relocation & adjustment
Physics	Updated surface (GFDL), GFS-EDMF PBL, Scale-aware SAS, NOAH LSM, RRTM, Ferrier	Surface (GFDL), GFS PBL (2015), SAS, NOAH LSM, RRTM, Ferrier
Coupling	MPIPOM/HYCOM, RTOFS/GDEM, WaveWatch-III	HYCOM, RTOFS/NCODA, No waves
Post-processing	NHC interpolation method Updated GFDL tracker	NHC interpolation method GFDL tracker
NEMS/NUOPC	No	Yes with moving nests
Computation cost for forecast job	63 nodes in 95 mins	26 nodes in 95 mins



Ongoing and **Future** Tasks

- Further improvements to hurricane physics
- Further improvements to vortex initialization and data assimilation
- Increase/change horizontal resolution, domain sizes
- Three-way Atmosphere-Ocean-Wave coupling (HWRF)
- **5-10 Member Ensembles**
- **Fully cycled DA for parent domains (HWRF)**



HWRF/HMON Long-Term Plans

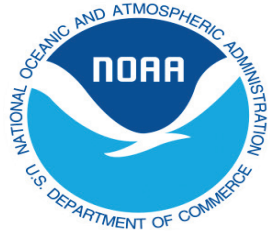
2016	2017	2018	2019	2020
HWRF Operational Model Continues Followed by Ensembles				
GFDL ——— HMON		10-member HWRF/ HMON Ensembles		NEMS Global Nests (NGGPS)
Basin-Scale HWRF/HMON/FV3 ——— Global/Tropical Domains				
Hurricane Models take over Hurricane Wave Forecasts				

Development, T&E and Implementation Plans for 2018 HWRF & HMON

- 2017 Nov: Baseline configuration ready
- 2017 Dec- 2018 March: Pre-implementation retrospective testing
- 2018 April: EMC CCB and code hand-off
- 2018 June: Operational Implementation



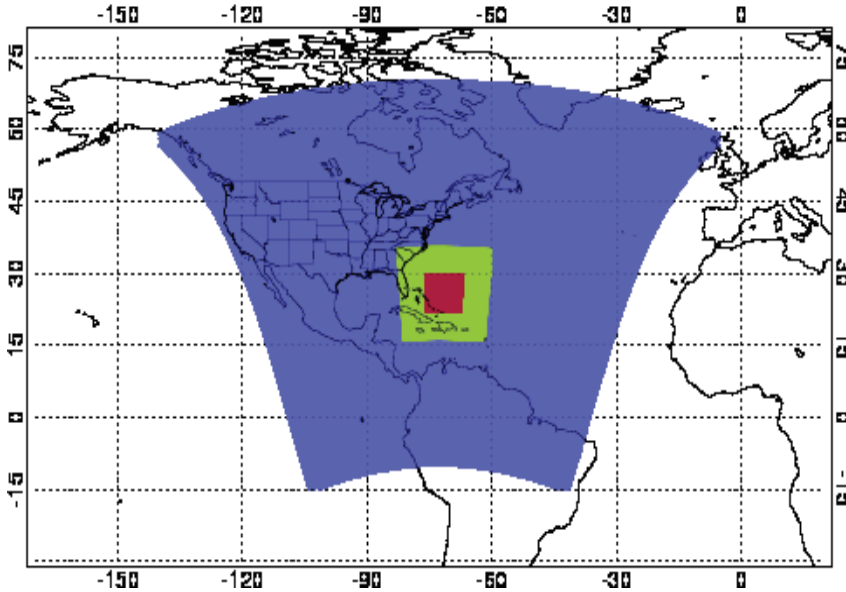
Thank You!



Adjusted Domain Sizes for H218 (some examples)

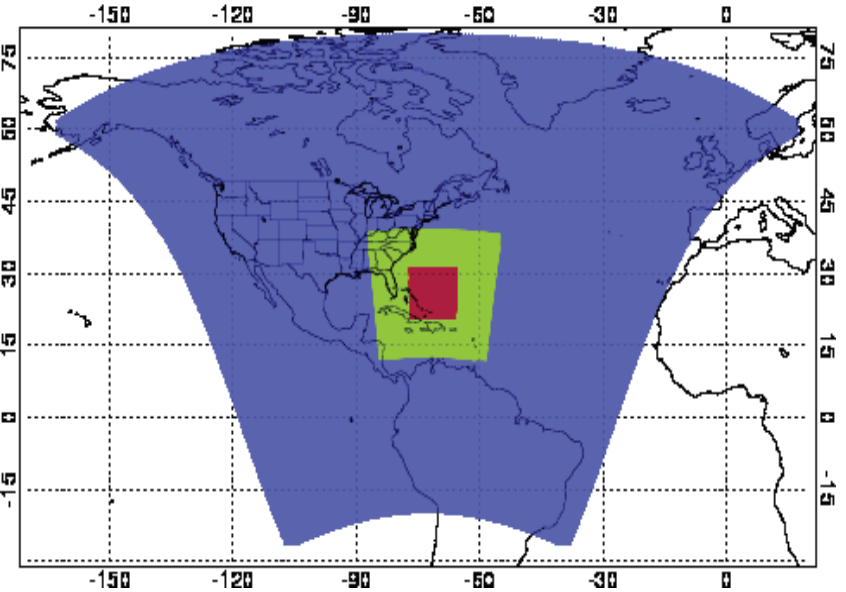


H218SET1



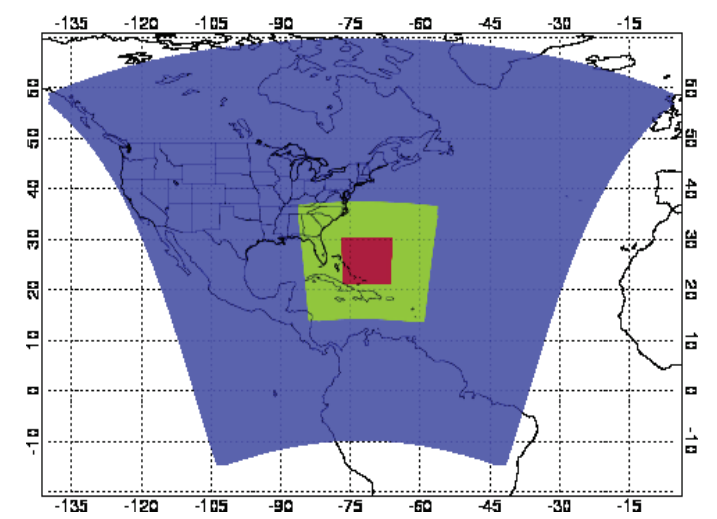
Res: 1.5/4.5/13.5
d01: 393 x 786
d02: 256 x 508
d03: 256 x 508

H218SET2



Res: 2/6/18
d01: 360 x 720
d02: 265 x 532
d03: 265 x 532

H217



Res: 2/6/18
d01: 288 x 576
d02: 265 x 532
d03: 235 x 472