Future Plans for HWRF

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

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HWRF Tutorial, NCWCP, 23-25 January 2018

FY18 HWRF v12.0.0
Potential Upgrades

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)

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 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 d01, d02 and d03

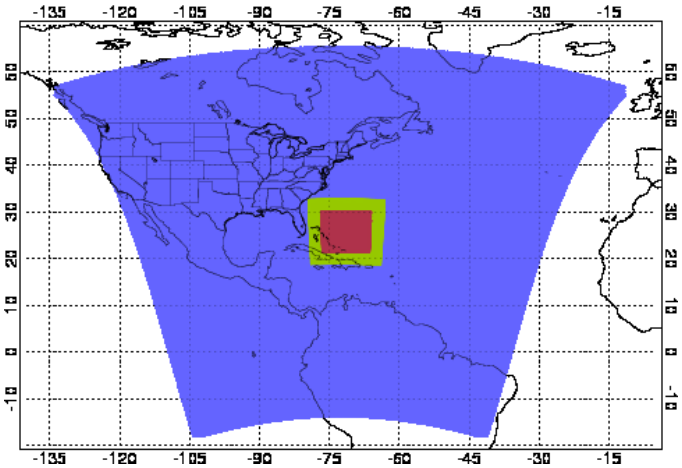
  or

- Increase domain size (d01, d02, d03) with 18/6/2 km configuration

-- Green: **Included in Baseline**
-- Blue: **Included in Baseline (if ready)**
-- Orange: **Tested separately as an option**

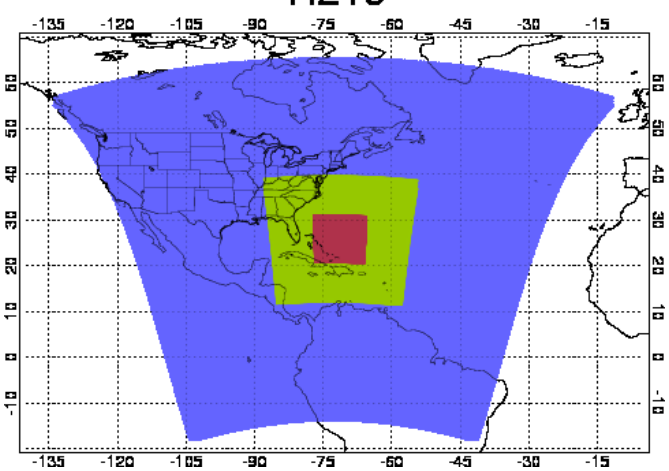
Adjusted Domain Sizes for H217 with higher vertical resolution

H215



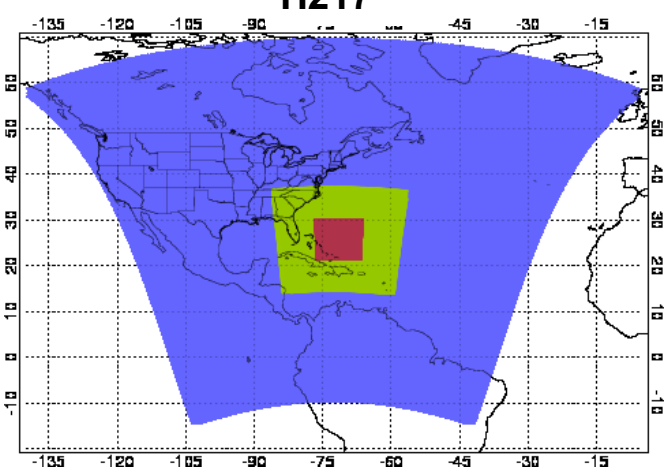
d02: 142 x 274
d03: 265 x 472
Levels: 61
Top: 2 mbar

H216



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

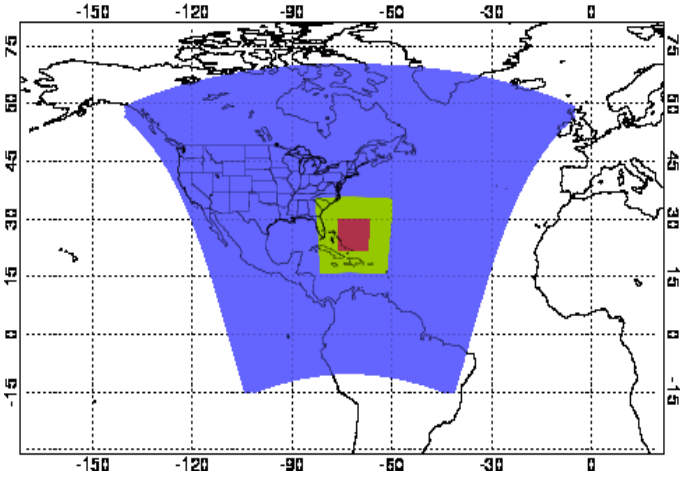
H217



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

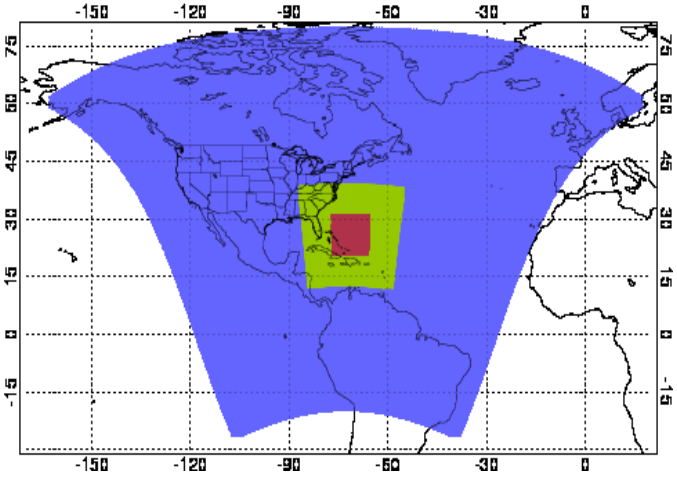
Adjusted Domain Sizes for H218 (some examples)

H218SET1



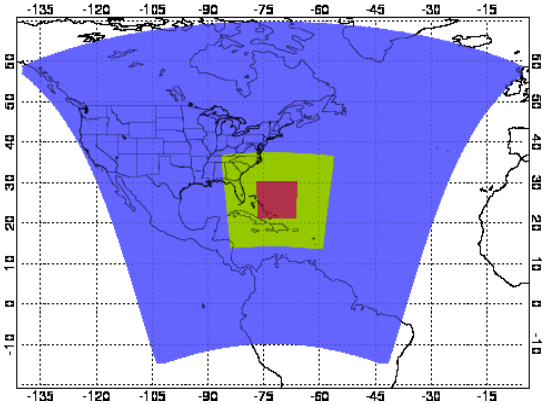
Res:	1.5/4.5/13.5
d01:	393 x 786
d02:	256 x 508
d03:	256 x 508

H218SET2



Res:	2/6/18
d01:	360 x 720
d02:	256 x 508
d03:	235 x 472

H217



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

Scope of FY18 HWRF Upgrades

Physics Advancements

- Radiation, RRTMG- cloud overlap (DTC)
- 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)
- Adjust surface flux exchange coefficients

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Scope of FY17 HWRF Upgrades

Initialization/Data Assimilation Improvements

- Improve vortex initialization (new composite storm vortex)
- Stochastic physics for DA ensembles
- **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
- Changes in blending thresholds, VM (when TDR data is available)
- Extend DA to WPAC

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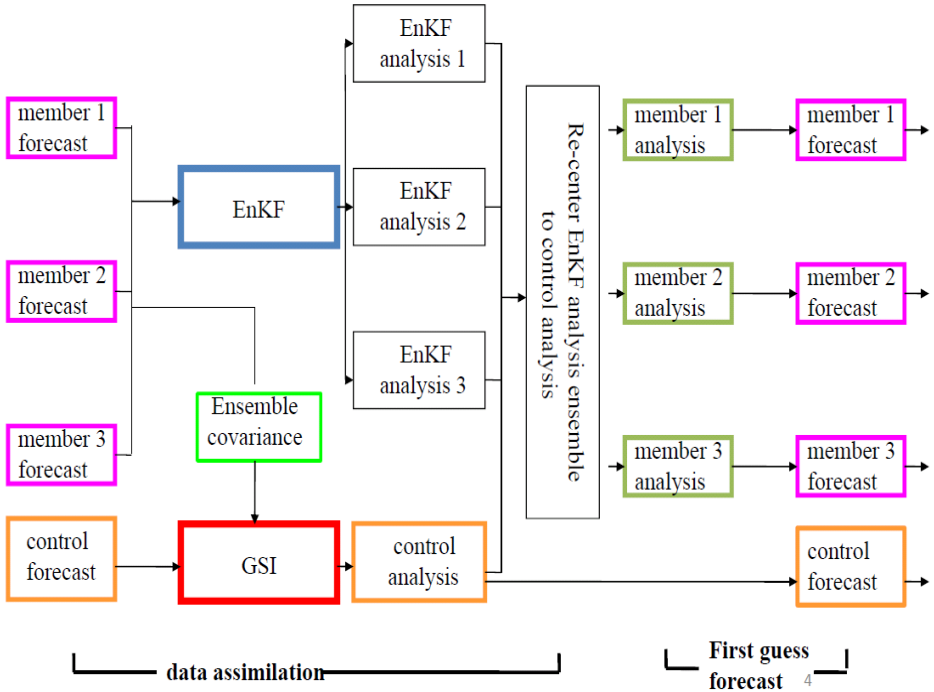
-- Orange: **Tested separately as an option**

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
- Extend fully Cycled EnKF two-way hybrid DA to 2 storms
- WW3 initial conditions from global wave model (multi_1)

- POM SST initialization from RTOFS in NATL (similar to EPAC)
- Add ocean coupling (HYCOM) for Southern Hemisphere storms
- Graphics included in workflow

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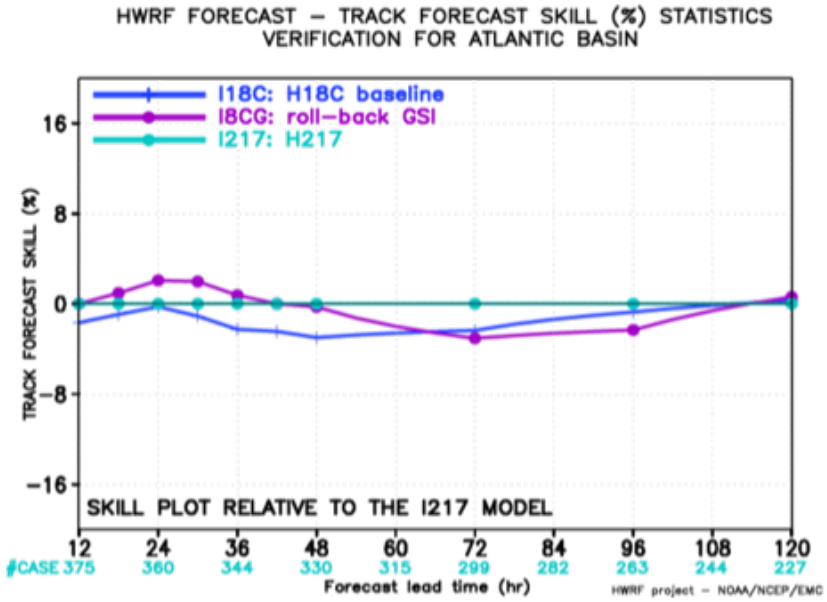
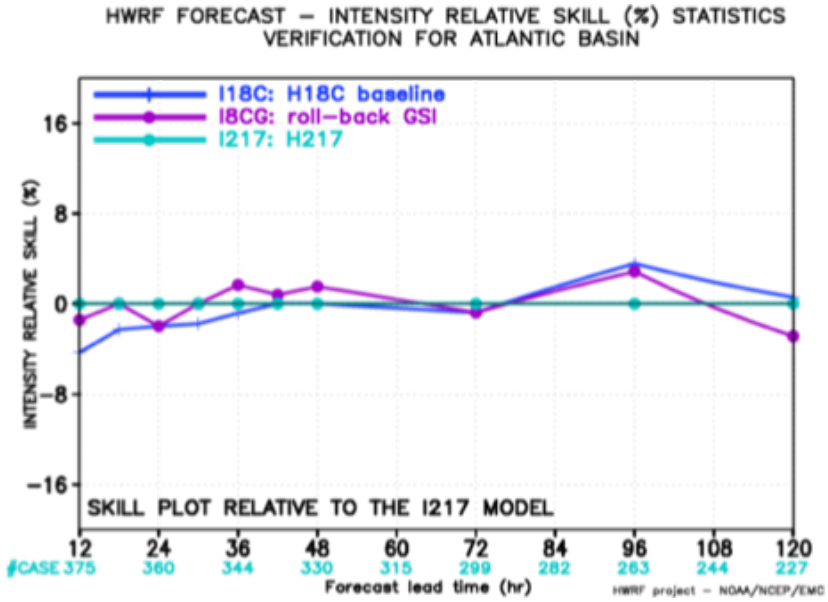
Preliminary H218 Baseline results (Interpolated)



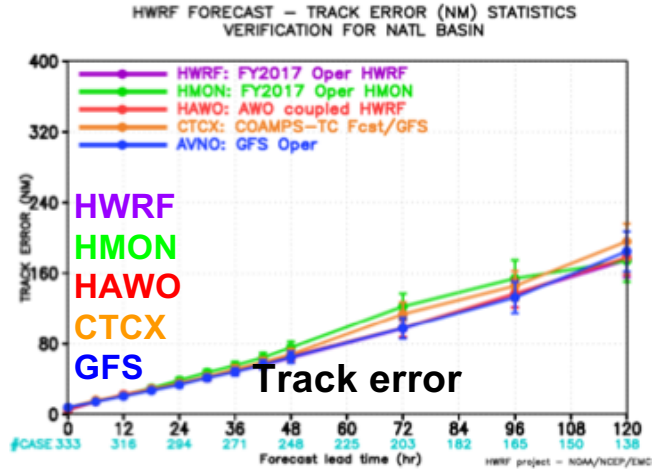


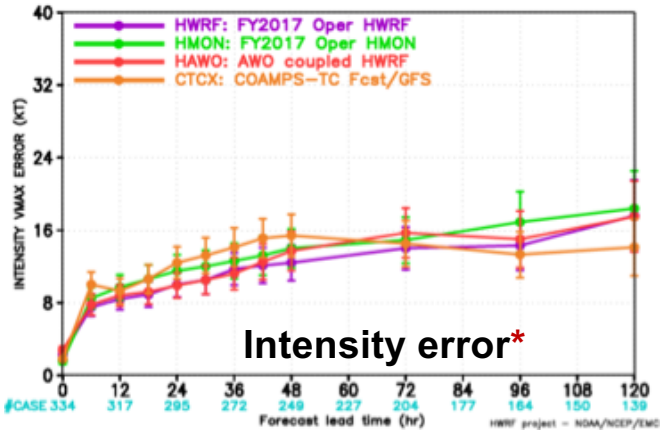
I8CG exhibits better track and intensity forecast skill at early lead times while I18C is better at longer lead times for intensity skill. Both experiments are neutral with respect to I217 (operational 2017 HWRF).

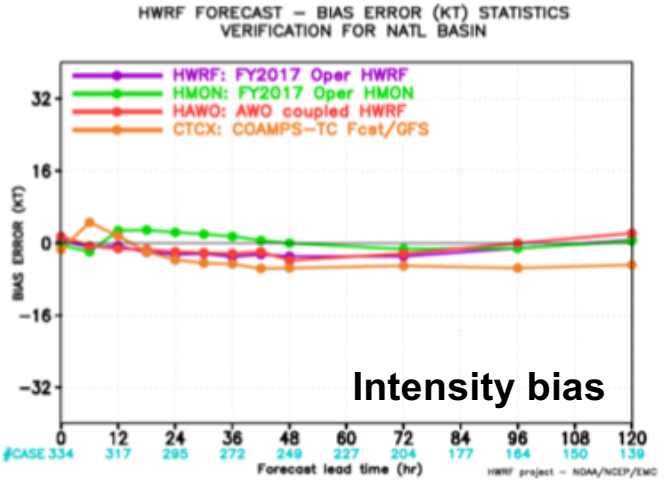
Ongoing and Future Tasks

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

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





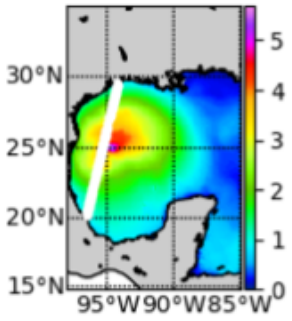


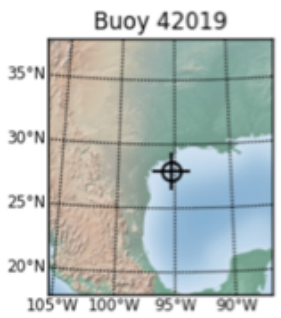
Track errors are almost identical to operational HWRF and GFS. Intensity errors are larger for HAWO for Days 2 and 3, similar otherwise. Intensity bias shows no marked difference.

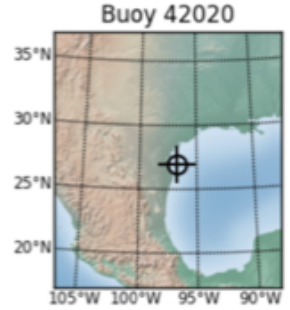
* HAWO has no self-cycled data assimilation

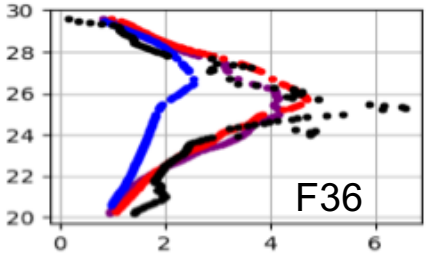
3-way Coupled HWRF (HAWO)
Wave Forecast for Hurricane Harvey (09L)
Comparisons with altimeter and buoy observations

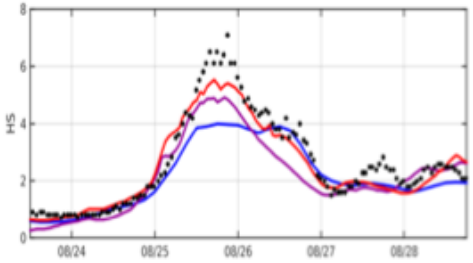
- HWRF
- HAWO
- Multi_1
- SARAL/ATK

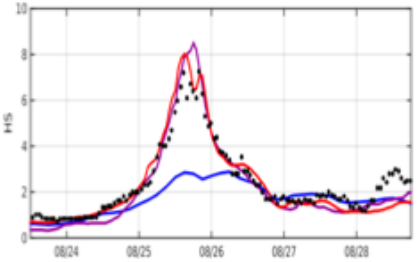


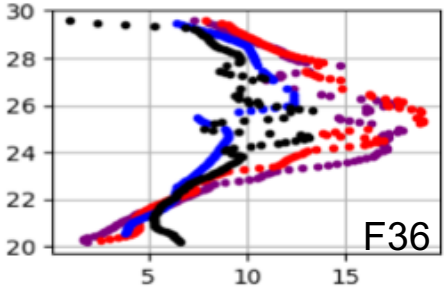


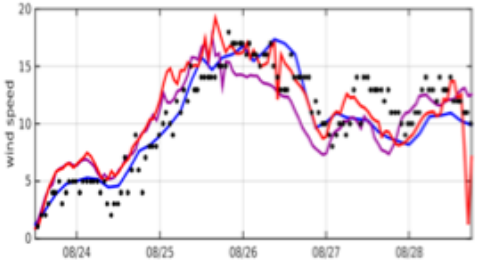


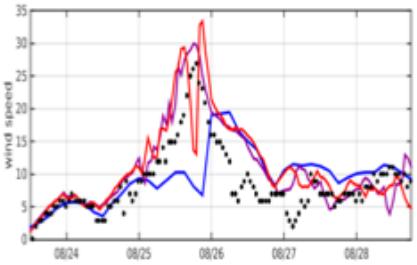












Near-term plans at NCEP/EMC*

- 2018-: Annual upgrade of HWRF; possible larger parent and nested domains, finer horizontal resolution, improved DA, improved physics and initialization, coupling improvements.

- 2019-: Annual upgrade of HWRF; potential fully cycled DA for HWRF; three-way coupling; improved DA and physics; explore higher resolution or larger domains, possible HWRF operational ensembles.

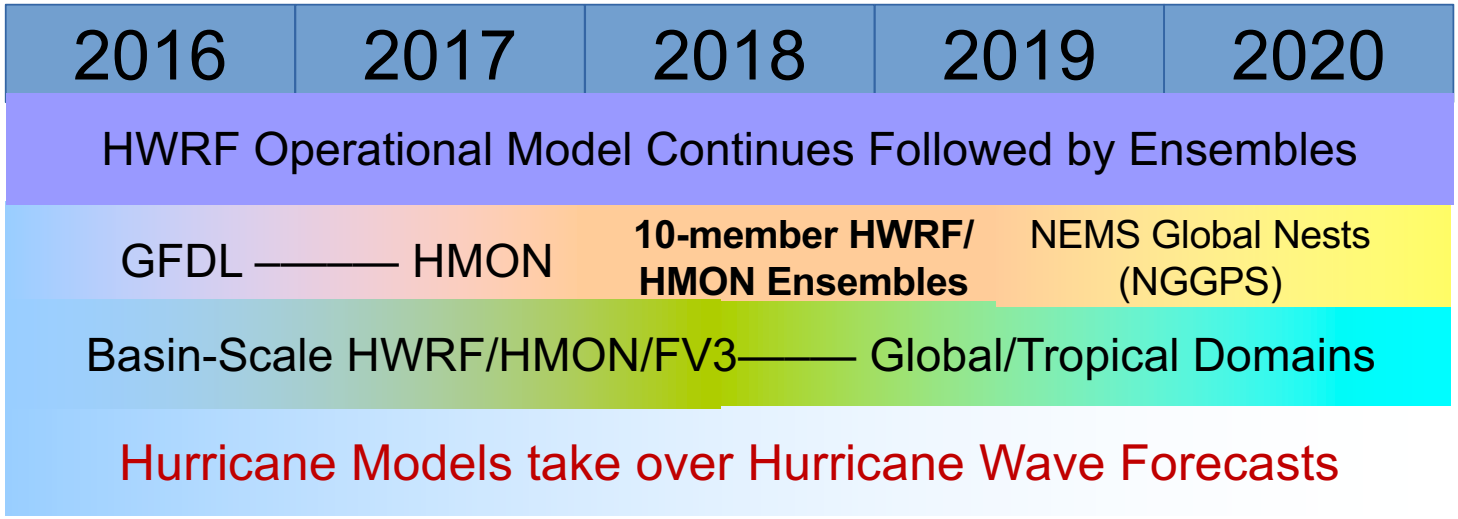
* All upgrades depend upon availability of computing resources at NCEP.

Near-term plans at NCEP/EMC*

2020- beyond: Integrating HWRF & HMON into FV3, explore multi-storm capability, high resolution nests into global system with moving nests strategy. Advanced unified physics and data assimilation with developments of UFS (Vijay's talk).

* All upgrades depend upon availability of computing resources at NCEP.

HWRF/HMON Long-Term Plans



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

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

Thank You!