2017 Hurricane Model Implementations Briefing to NCEP Director:

Much improved operational forecast guidance for global tropical cyclones

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(on behalf of the EMC Hurricane Team)

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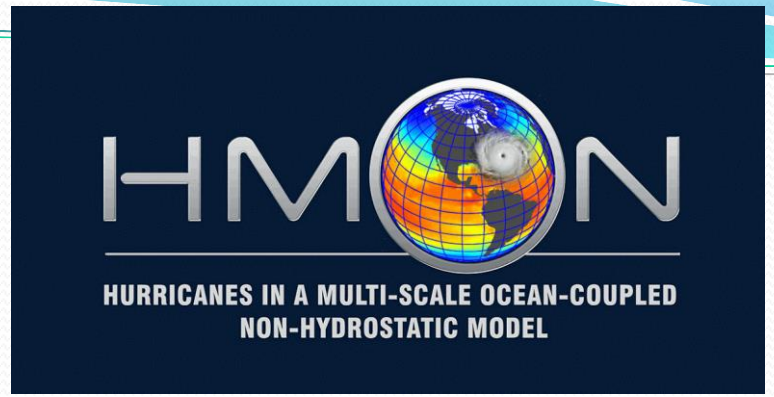
in collaboration with
NHC, DTC, JTWC, GFDL, ESRL, HRD and URI

Briefing to NCEP Director, April 28, 2017

FY17 NCEP Operational Hurricane Models (proposed)

2017 HMON V1.0.0

Briefing to NCEP Director, April 28, 2017



2017 HMON V1.0.0

(A new Operational Hurricane Model at NCEP)

HIWPP

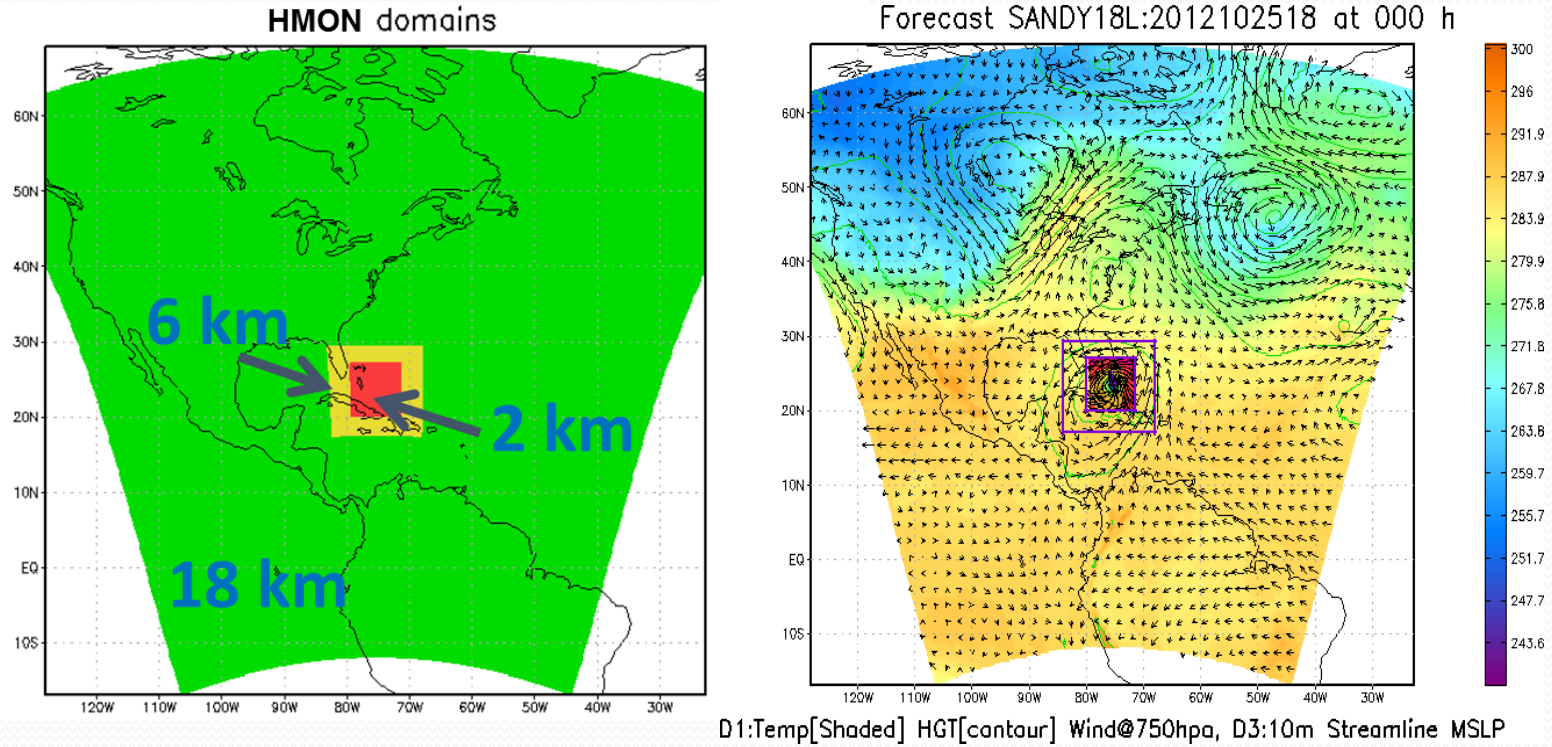
NOAA HURRICANE FORECAST IMPROVEMENT PROJECT

NGGPS

HMON: Hurricanes in a Multi-scale Ocean coupled Non-hydrostatic model

- **HMON:** Advanced Hurricane Model using NMMB (Non-hydrostatic Multi-scale Model on a B grid) dynamic core which is currently being used in NCEP's operational NAM and SREF systems.
- Shared infrastructure with unified model development in NEMS. A step closer towards NEMS/FV3 Unified Modeling System for hurricanes
- Much faster, scalable and uses CCPP style physics package
- Development supported by NGGPS, HFIP and HIWPP programs
- Provides high-resolution intensity forecast guidance to NHC along with HWRF (replacing the legacy GFDL hurricane model)

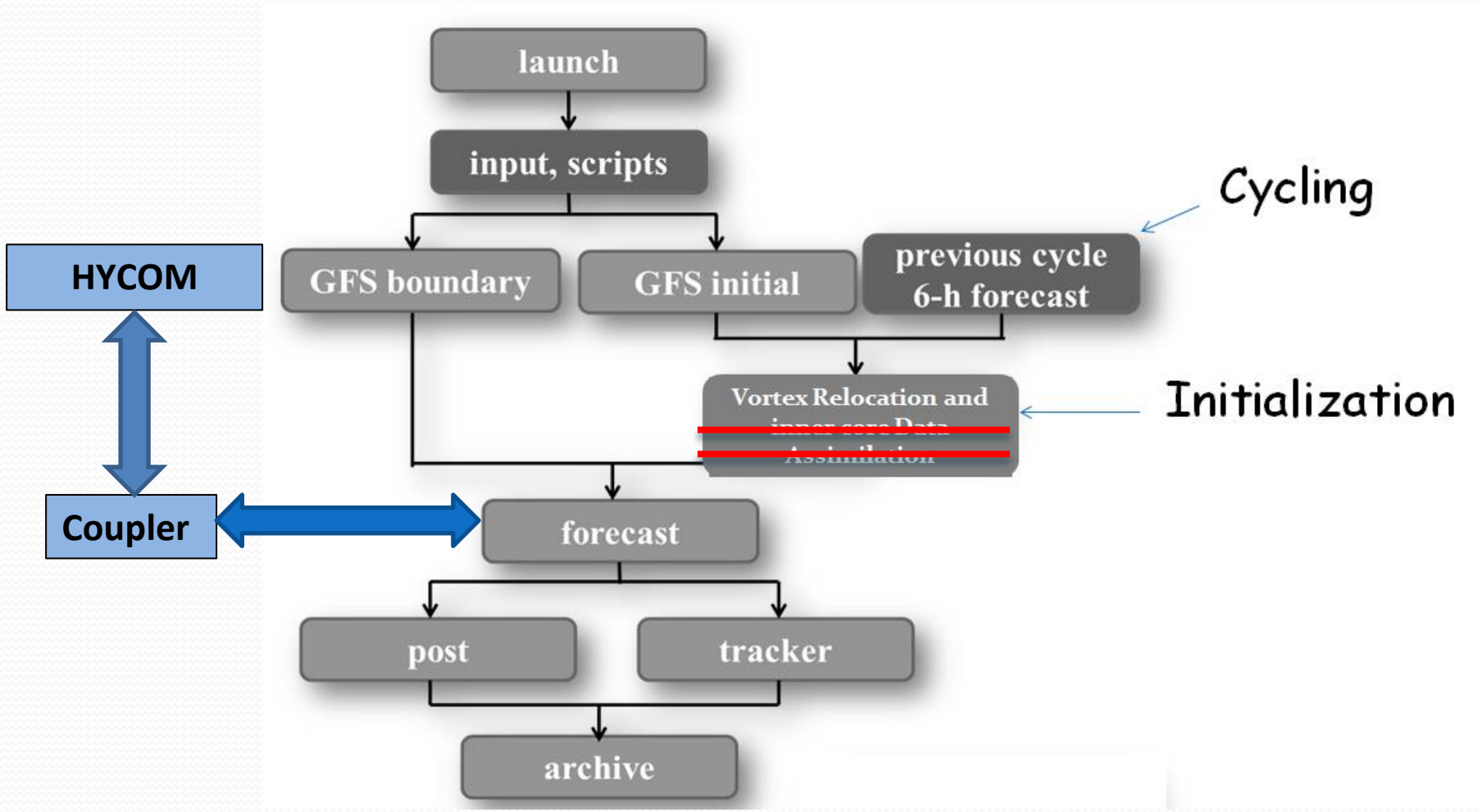
HMON: A New Operational Hurricane Model at NCEP



HMON: **H**urricanes in a **M**ulti-scale **O**cean coupled **N**on-hydrostatic model

HMON: Implements a long-term strategy at NCEP/EMC for multiple static and moving nests globally, with one- and two-way interaction and coupled to other (ocean, wave, land, surge, inundation, etc.) models using NEMS-NUOPC infrastructure.

Design of HMON Workflow



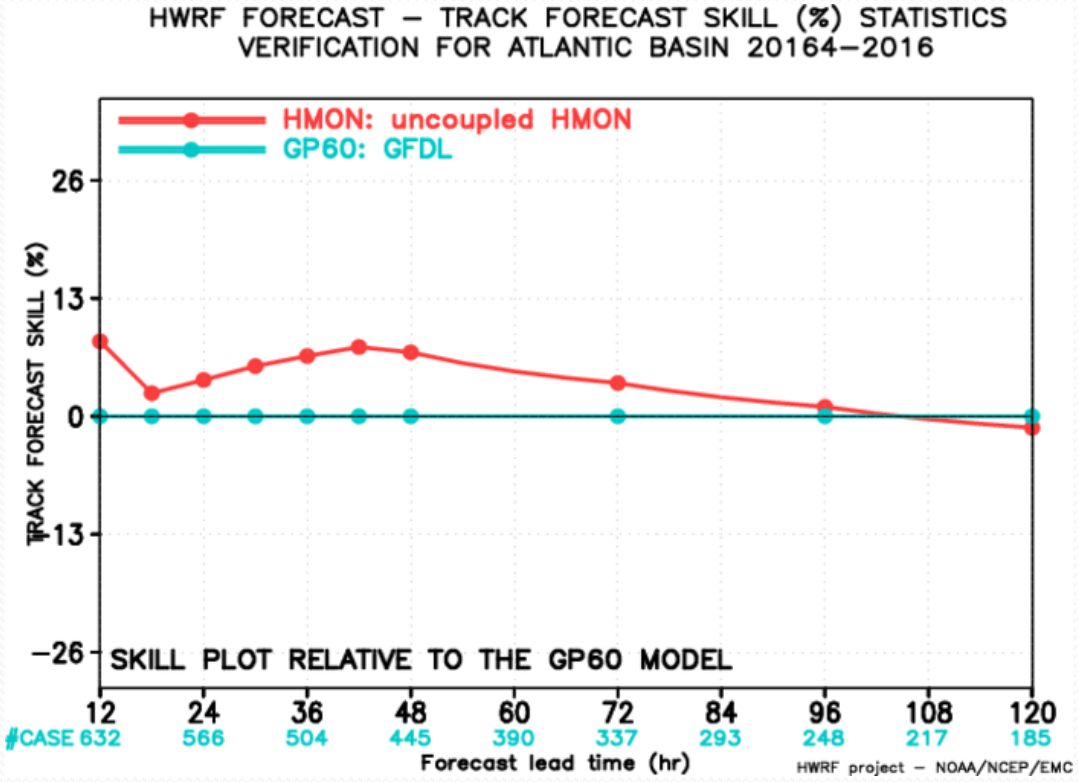
HWRF vs GFDL vs HMON
(Maintain Diversity of Hurricane Numerical Guidance)

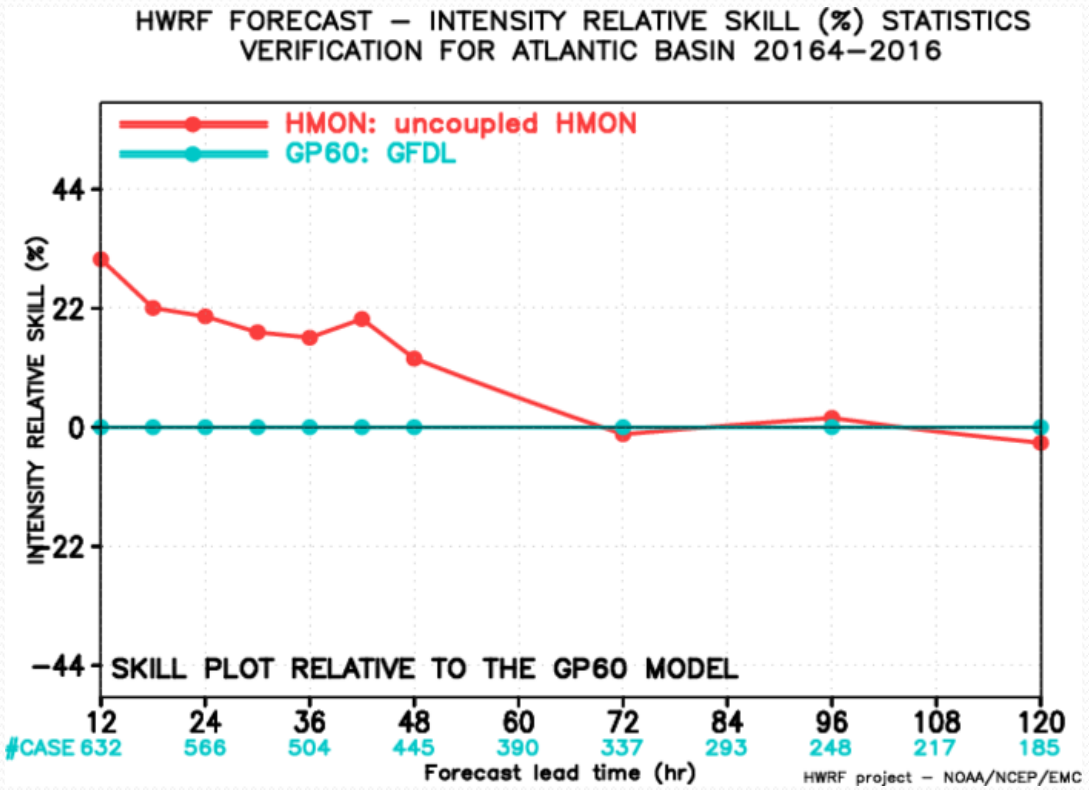
	2017 HWRF	2016 GFDL	2017 HMON
Dycore	Non-hydrostatic, NMM-E	Hydrostatic	Non-hydrostatic, NMM-B
Nesting	18/6/2 kms; 75°/25°/8.3°, Full two-way moving	½.°,1/6°,1/18°; 75°/11°/5°, Two-way moving with bc	18/6/2 kms; 75°/12°/8°, Full two-way moving
Data Assimilation and Initialization	Self-cycled two-way HWRF EnKF-GSI with inner core DA (TDR); Vortex relocation & adjustment	Spin-up using idealized axisymmetric vortex	Vortex relocation & adjustment
Physics	Updated surface (GFDL),GFS-EDMF PBL, Scale-aware SAS, NOAH LSM, RRTM, Ferrier	Surface (GFDL), GFS PBL(2014), SAS, GFDL LSM, RRTM, Ferrier	Surface (GFDL), GFS PBL (2015), SAS, NOAH LSM, RRTM, Ferrier
Coupling	MPIPOM/HYCOM, RTOFS/GDEM, Wavewatch-III	MPIPOM, RTOFS/GDEM, No waves	HYCOM, RTOFS/NCODA, No waves
Post-processing	NHC interpolation method, Updated GFDL tracker	NHC interpolation Method, In-line tracker	NHC interpolation method, GFDL tracker
NEMS/NUOPC	No	No	Yes with moving nests

HMON Verification for Atlantic Storms (2014-2016)

Configuration: HWRF physics + vortex initialization + no data assimilation + no ocean coupling

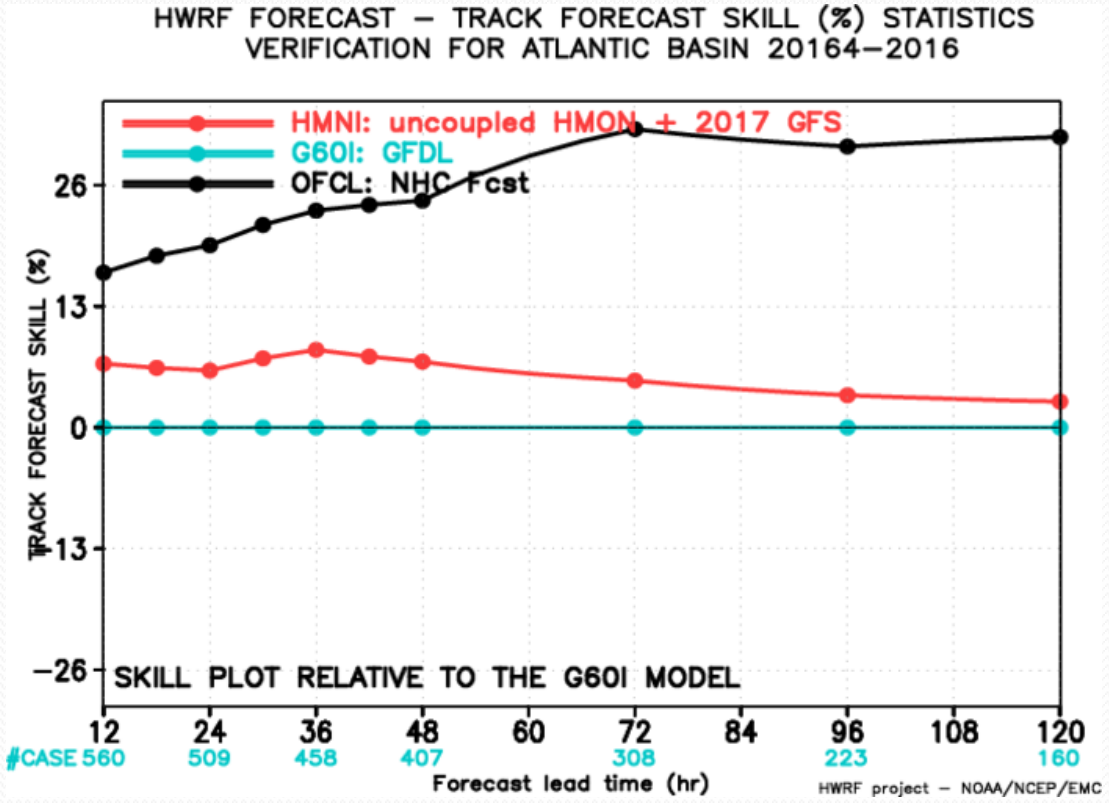
2014-16 Atlantic Basin: Relative to GFDL (Late model)

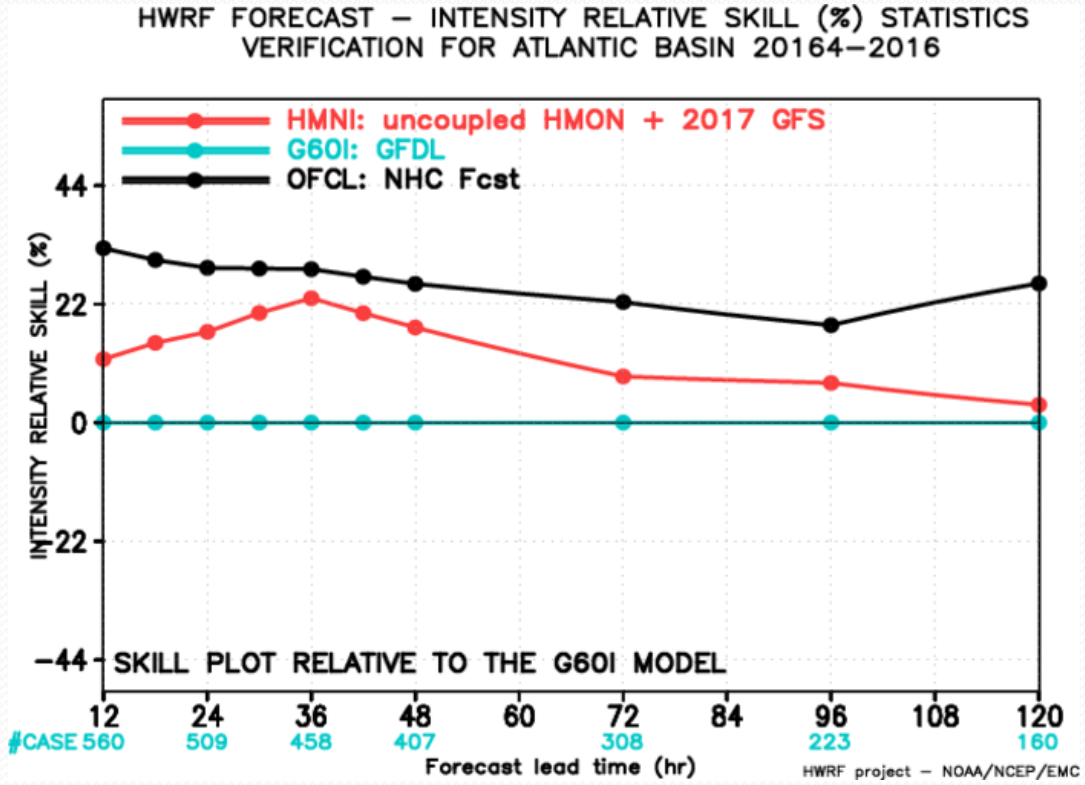




HMON has improved track skills as compared to GFDL at all lead times except for Day 5. The positive skill goes down by Day 4 for tracks and Day 3 for Intensity.

2014-16 Atlantic Basin: Relative to GFDL (Interpolated)



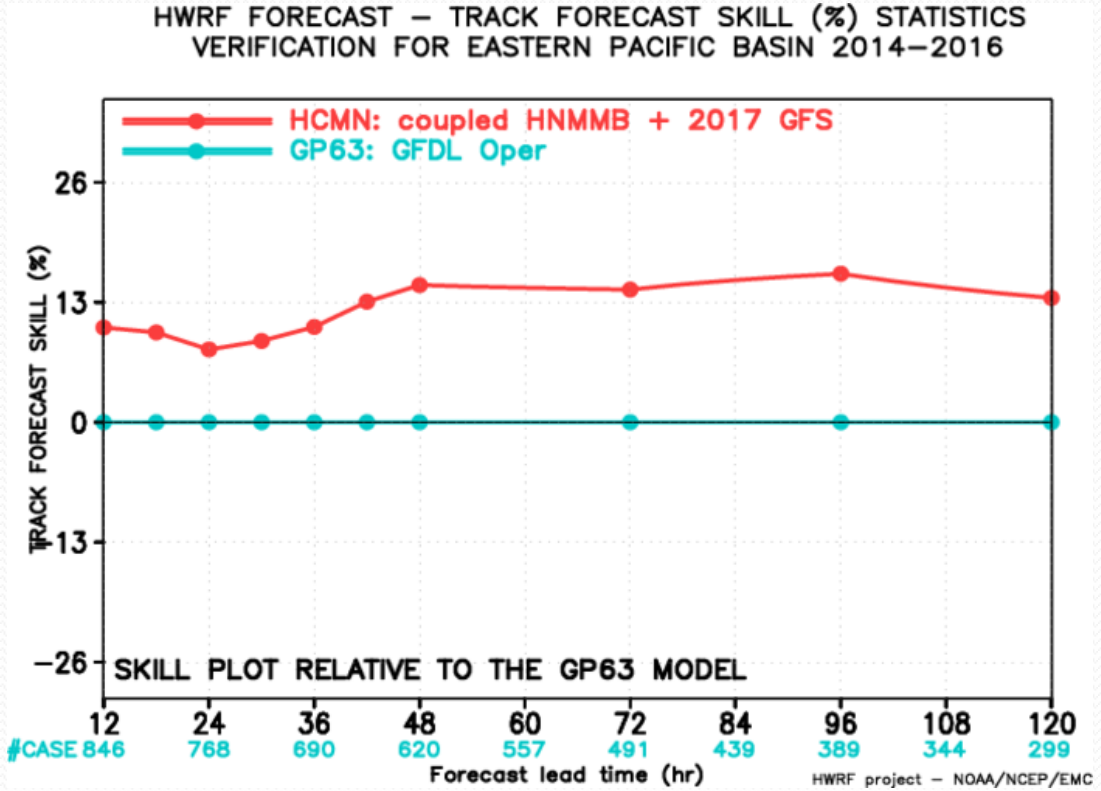


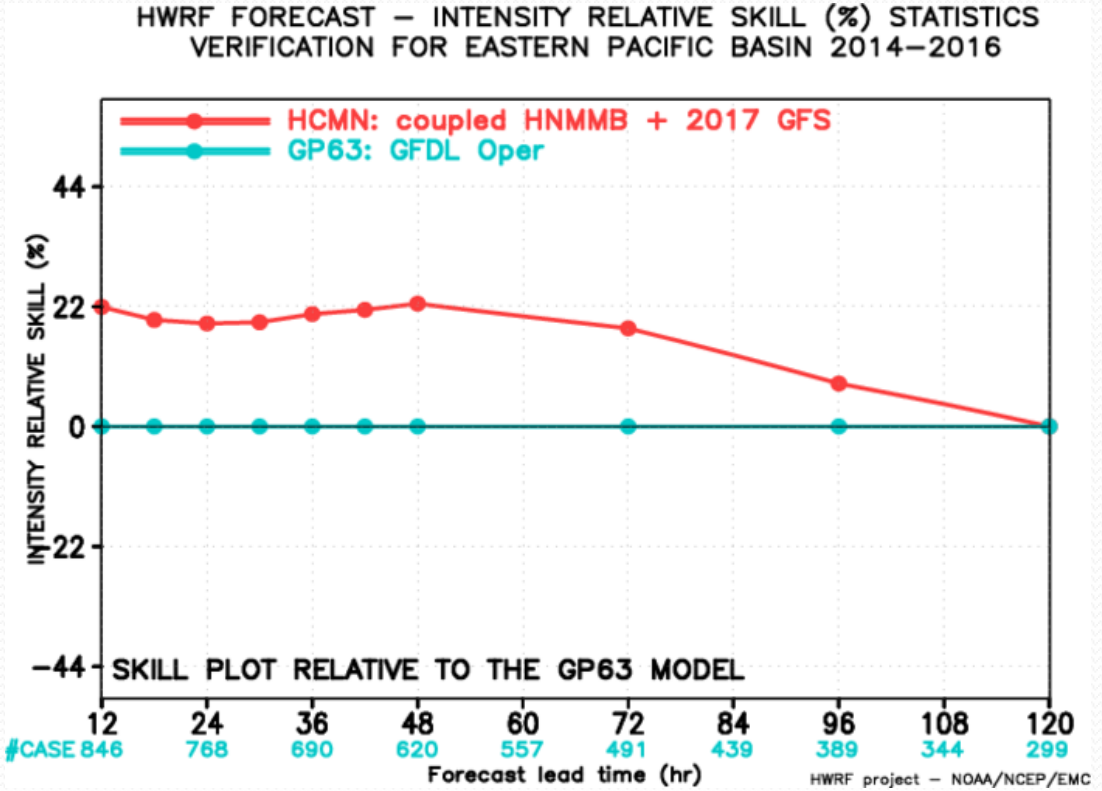
HMON has improved track skills as compared to GFDL at all lead times with an average improvement of more than 5%. It also has improved intensity skills with a mean improvement of >10%. Both tracks and intensity need to close gap with the official skill.

HMON Verification for East Pacific Storms (2014-2016)

Configuration: HWRF physics + vortex initialization + no data assimilation + ocean coupling with HYCOM

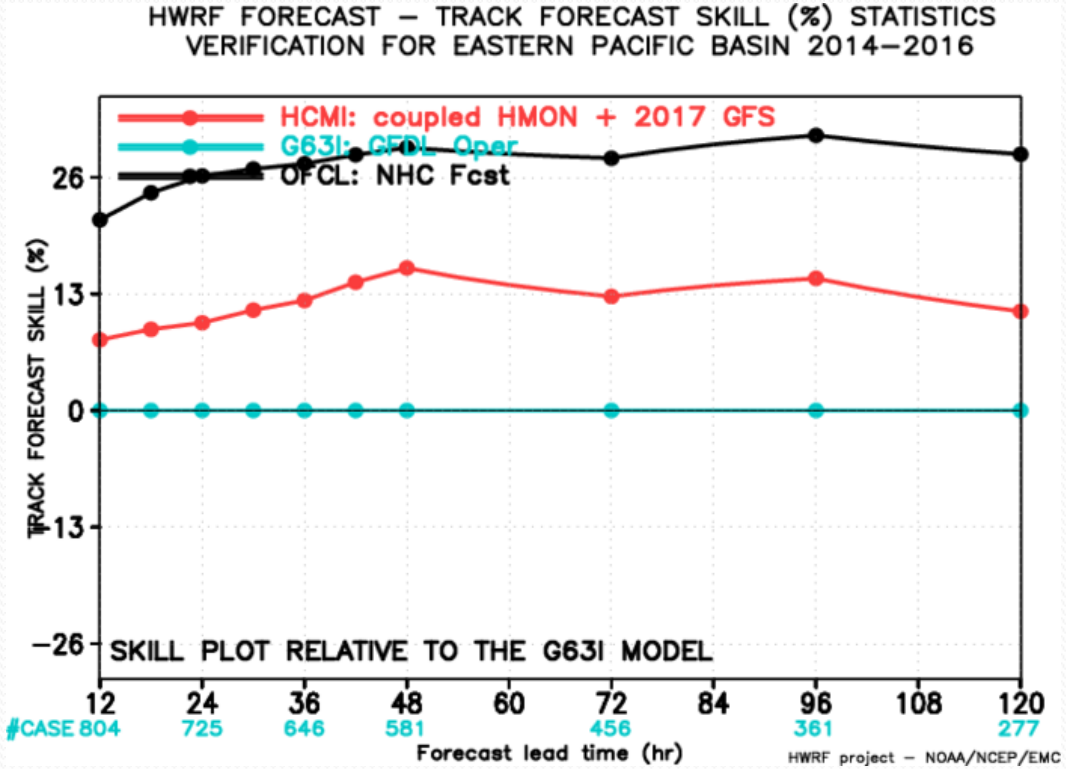
2014-16 East Pacific Basin: Relative to GFDL (Late model)

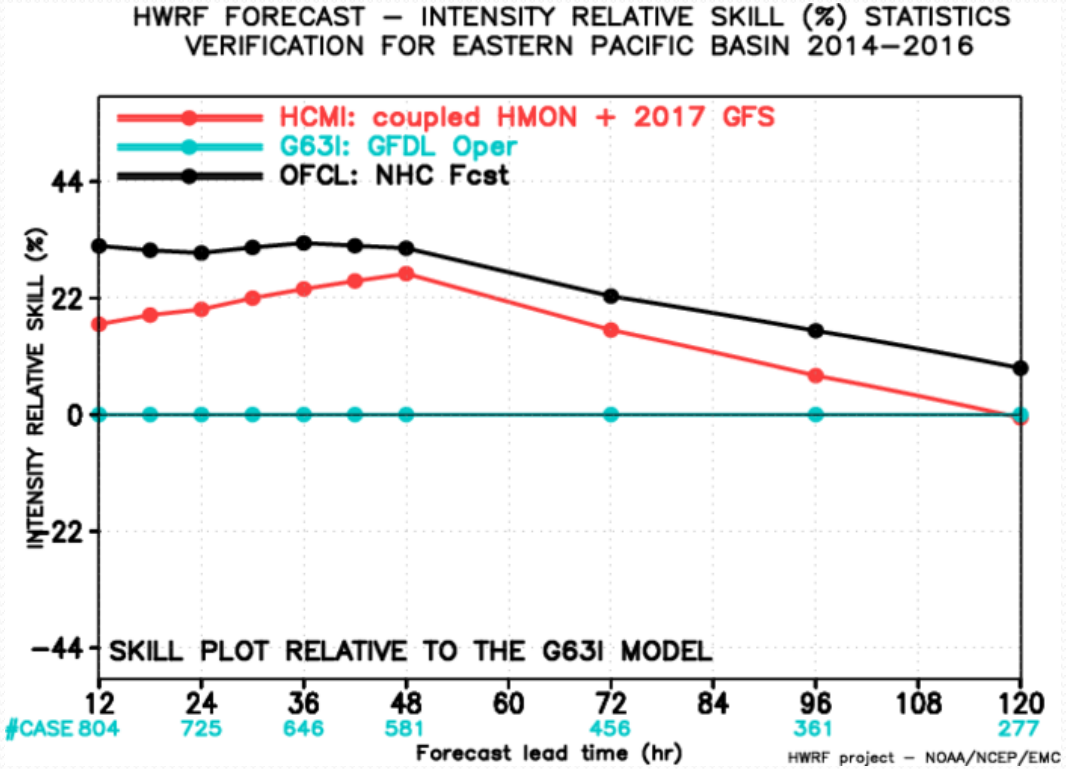




HMON has improved track skills as compared to GFDL with an average improvement of more than 12%. It also has significantly improved intensity skills with a mean improvement of > 10%.

2014-16 East Pacific Basin: Relative to GFDL (Interpolated)



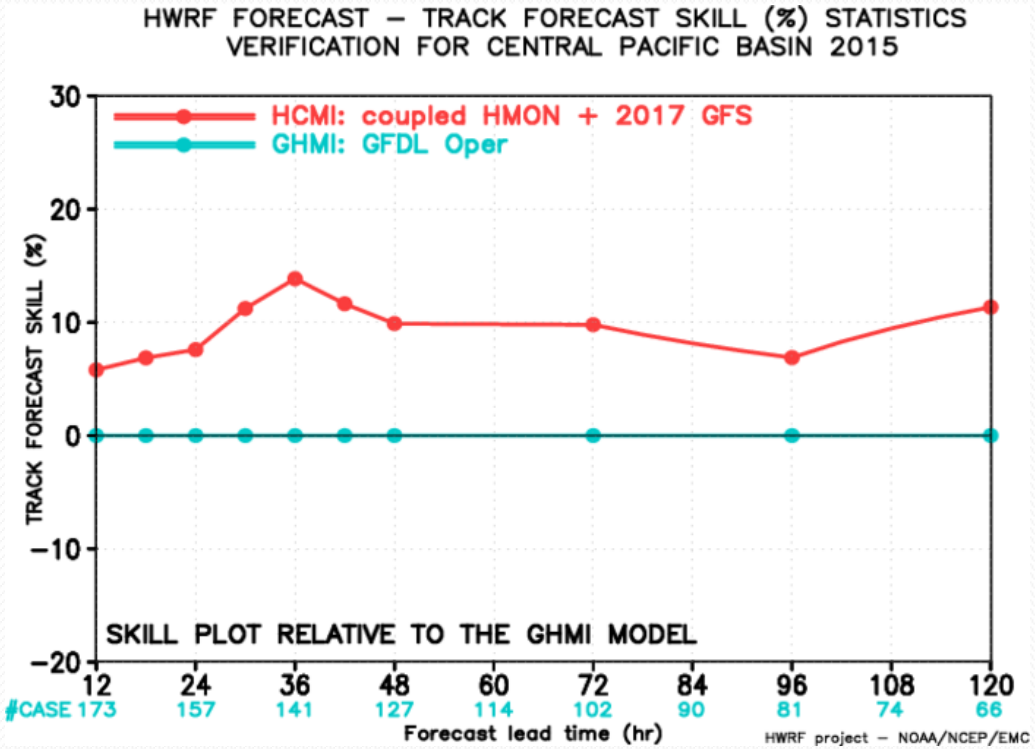


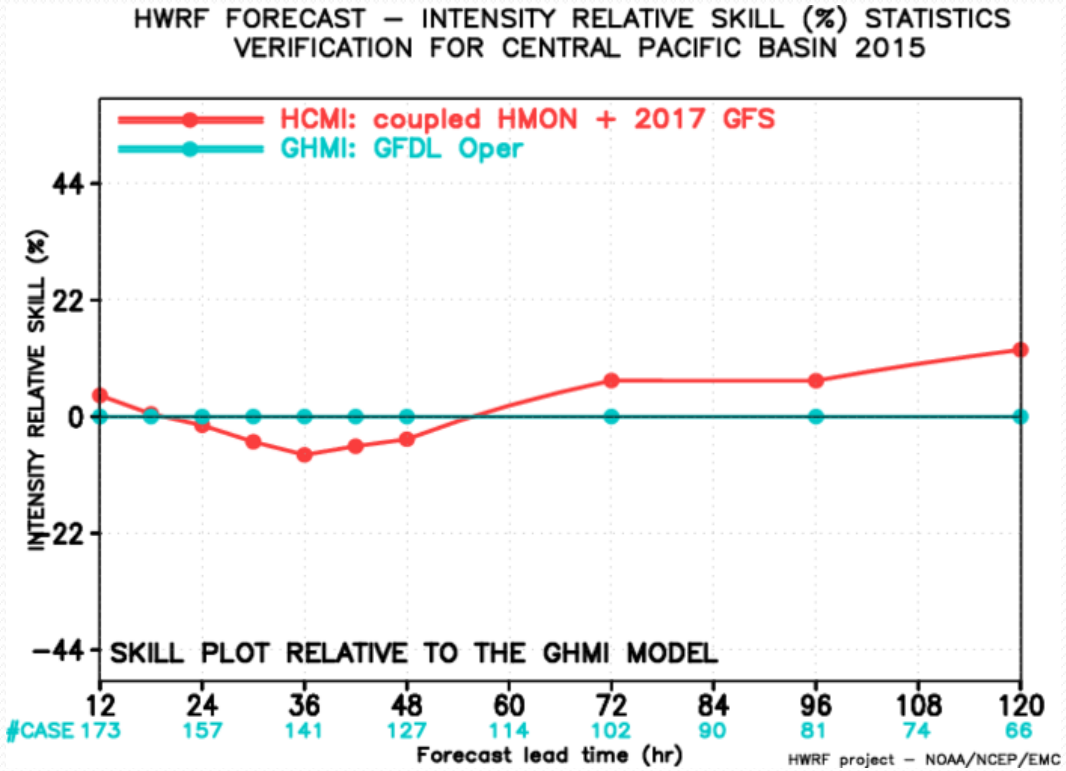
HMON has improved track and intensity skills as compared to GFDL but still needs to close gap with official skill especially for longer lead times for intensity.

HMON Verification for Central Pacific Storms (2014-2016)

Configuration: HWRF physics + vortex initialization + no data assimilation + ocean coupling with HYCOM

2014-16 Central Pacific Basin: Relative to GFDL (Interpolated)





HMON has improved track skills as compared to GFDL of more than 10% while intensity skills are neutral to positive for longer lead times.

HMON verification Statistics: Summary

- Compared with GFDL, HMON consistently shows **improved performance** for track and intensity skill for the North Atlantic basin (based on 2014-16 seasons)
- Compared with GFDL, it also consistently shows **improved performance** for track and intensity skill for the North East Pacific basin (based on 2014-16 seasons)
- Compared with GFDL, track skills are much **improved** while intensity skill are **neutral** for the Central Pacific basin (based on 2014-16 seasons)
- Results are different from HWRF and usually exhibit large errors in comparison especially at longer lead-times where improvement is needed.

Targeted 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*

* Initial implementation is targeted for only 5 storms serving NHC areas of responsibility (NATL, EPAC & CPAC)

NHC Recommendation

Based on the mostly improved TC track and intensity predictions for a large 3-year sample of cases for the Atlantic and eastern North Pacific basins, the National Hurricane Center endorses the operational implementation of the 2017 HWRF, and accepts the introduction of HMON into operations.

Dr. Richard J. Pasch
Senior Hurricane Specialist
National Hurricane Center

JTWC Recommendation

The improvements in the forecast guidance provided by HWRF in the western North Pacific, arguably one of the most difficult basins to forecast, especially the 20+ percent improvement in intensity skill at days 4 and 5, is truly impressive and we look forward to the implementation.

Robert J. Falvey
Director, Joint Typhoon Warning Center

Next Steps for Fy17 HWRF v11.0.0

1. Retrospective T&E at EMC: **April 10, 2017 --- Completed**
2. Briefing to NHC: **April 13, 2017 ----- Completed**
3. NHC Evaluation and Recommendations: **April 24, 2017 -- Completed**
4. Briefing to EMC Director and CCB: **April 25, 2017 --- Completed**
5. Briefing to NCEP Director's Office**: April 28, 2017 --- Now Completed**
6. Submission of Codes to NCO: ***April 28, 2017 --- Code hand-off, submission of RFC forms, release notes and flow diagram***
7. TIN for 2017 HWRF : ***May 3, 2017***
8. NCO IT Testing : ***????***
9. Briefing to NCEP Director's Office: ***????***
10. Implementation by NCO: **

** ***Recommend H217 be implemented after 2017 GFS***

Next Steps for FY17 HMON v1.0.0

1. Retrospective T&E at EMC: **April 07, 2017 --- Completed**
2. Briefing to NHC: **April 07, 2017 ----- Completed**
3. NHC Evaluation and Recommendations: **April 24, 2017 -- Completed**
4. Briefing to EMC Director and CCB: **April 25, 2017 --- Now Completed**
5. Briefing to NCEP Director's Office: **April 28, 2017 (scheduled)**
6. Submission of Codes to NCO: ***April 28, 2017 --- Code hand-off, submission of RFC forms, release notes and flow diagram***
7. TIN for 2017 HMON : ***May 3, 2017***
8. NCO IT Testing : ***????***
9. Briefing to NCEP Director's Office: ***????***
10. Implementation by NCO: **

** ***Recommend HMON be implemented with 2017 GFS***

Request approval from NCEP OD for operational implementation of the following Hurricane model configurations:

II. 2017 HMON V1.0.0

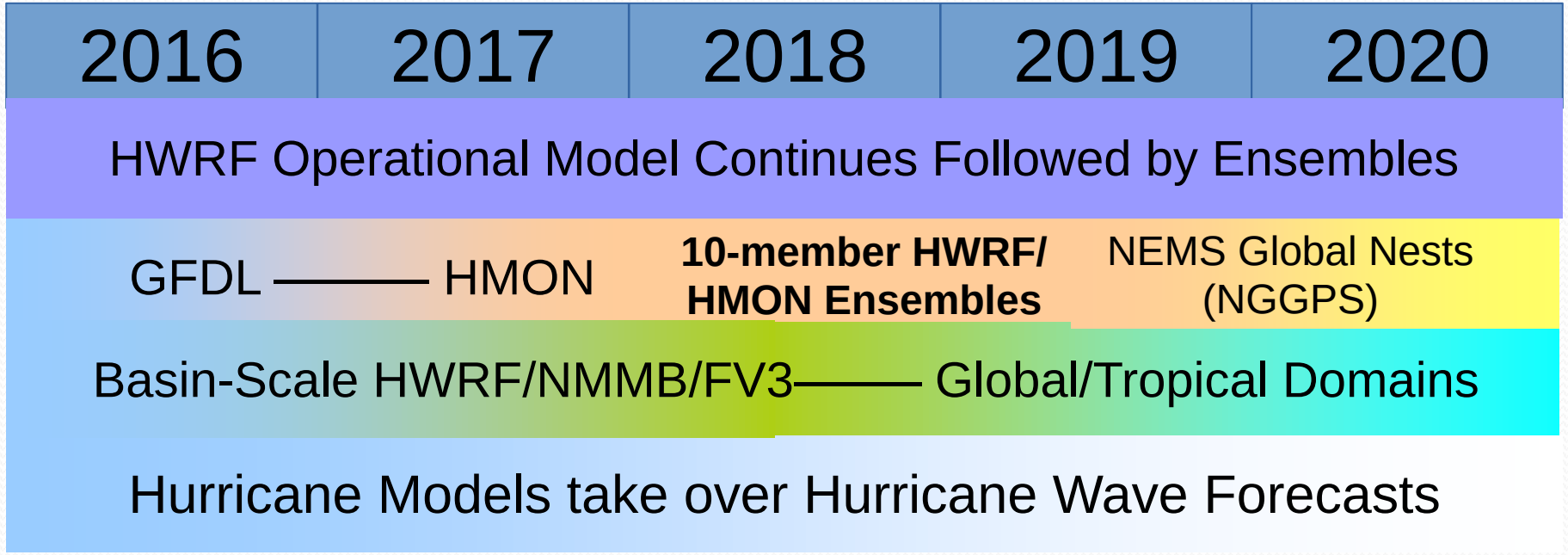
Supplementary Slides

Successful R2O in FY17 HWRF Upgrades

- **This upgrade is a result of multi-agency R2O efforts supported by HFIP/NGGPS**

  - **EMC**: Key model physics upgrades, increase in vertical levels, data assimilation upgrades, and pre-implementation T&E;
  - **DTC/NCAR:** code management and repository, physics upgrades;
  - **NHC/CPHC/JTWC**: Diagnostics and evaluation of the HWRF pre-implementation tests and real-time guidance
  - **HRD/AOML:** Data Assimilation and Physics upgrades;
  - **GFDL**: New Tracker;
  - **ESRL:** Physics upgrades;
  - **URI**: Ocean coupling

HWRF/HMON Long-Term Plans



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

2016 Nov: Configuration ready
2016 Dec- 2017 March: Pre-implementation retrospective testing
2017 April: EMC CCB and code hand-off
2017 June: Operational Implementation

HMON Version 1.0
Status as of 04/25/17

G

G Project Information & Highlights

Leads: Avichal Mehra & Tom Black, EMC and Steven Earle, NCO

Scope: Replace GFDL hurricane model with Hurricane NMMB (H-NMMB). Initial operating capability for NHC basins (ATL, EPAC and CPAC) with maximum 5 storms per cycle.Transition and tune HWRF physics, initialization, and ocean coupling for H-NMMB

Expected benefits: Improved track & intensity forecast skill compared to GFDL. Improved forecast guidance to NHC to fulfill their mission. Explore high-resolution hurricane ensemble products

Dependencies: N/A.

G Schedule

Milestones & Deliverables	Date	Status
Freeze system code; deliver to NCO if applicable	1/10/17	N/A
Complete full retrospective/real time runs and evaluation	4/07/17	In progress
Deliver final system code to NCO and conduct CCB	4/2517	On track
Issue Technical Information Notice	5/03/17	On track
Complete 30-day evaluation and IT testing	6/12/17	On track
Operational Implementation	6/27/17	On track

EMC | NCO | Red text indicates change from previous quarter

G Issues/Risks

Issue: Complex T&E due to dependency on NEMS/GSM and RTOFS upstream requirements**; Resolution:** Use 2016 versions.

Risk: Implementation dates are dependent on completion of T&E; Ongoing disruptive Cray upgrades and maintenance

Mitigation: Conduct T&E as soon as retrospective data are available. Use white space on production machine.

G Resources

Staff: 0.75 Fed FTEs + 4 contractor FTEs; including Dev (Vortex Initialization, Coupler and Physics)

Funding Source: STI

Compute: parallels: 150 nodes for 3 months (devmax/devonprod);; **EMC Dev**: 100 nodes for 3 months (devhigh); **Ops**: Delta = 26 nodes per storm

Archive: 0.3 PB (Delta = 0.3 PB)

R Management Attention Required	Y Potential Management Attention Needed	G On Target