Strategy for Hurricane Modeling in NEMS

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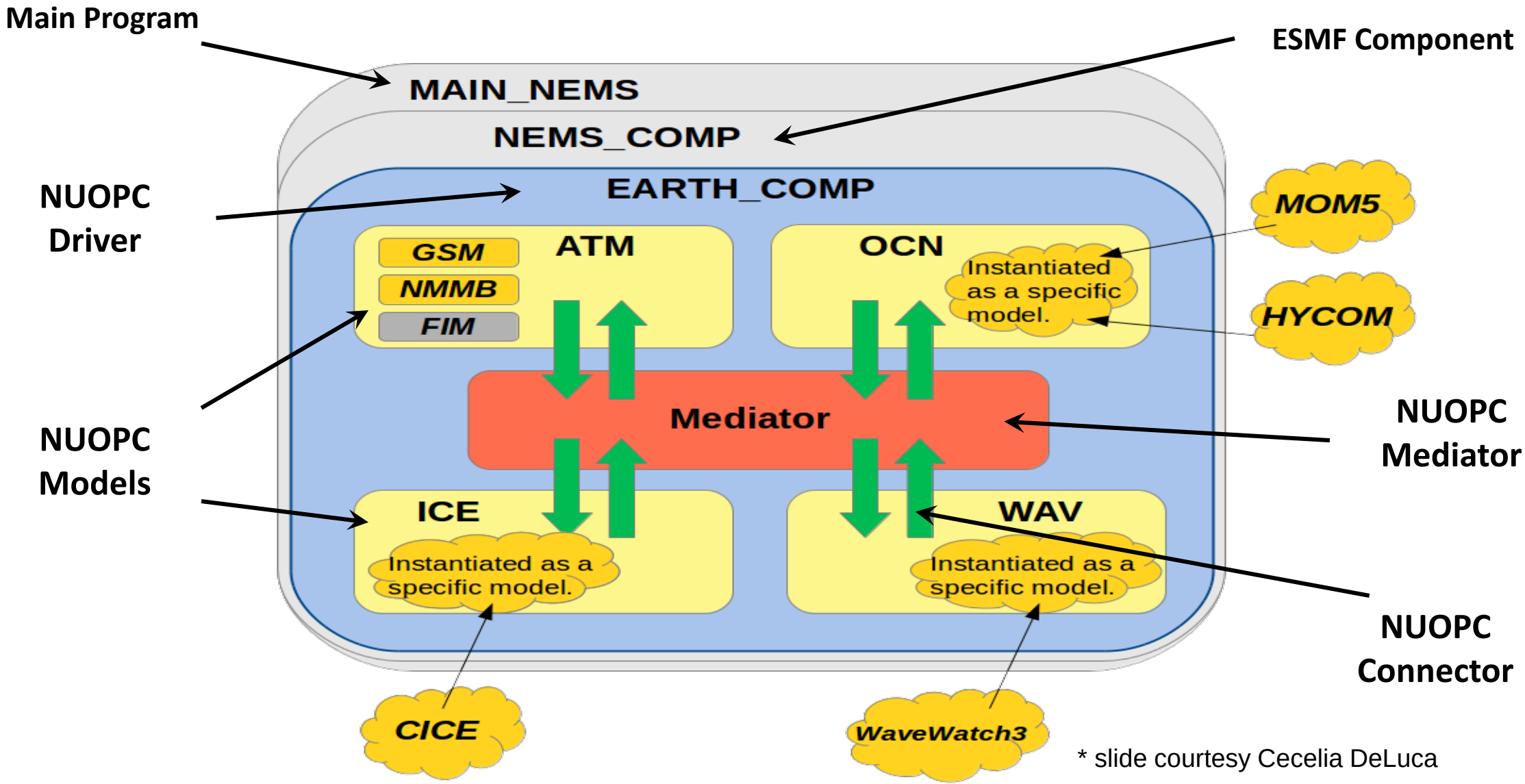
What is NEMS?

- NEMS stands for: **NOAA's Environmental Modeling System**
- A shared, portable, high performance software superstructure and infrastructure
- For use in operational prediction models at the National Centers for Environmental Prediction (NCEP)
- Leveraging NUOPC related community developments

* slide courtesy Cecelia DeLuca

NEMS Architecture

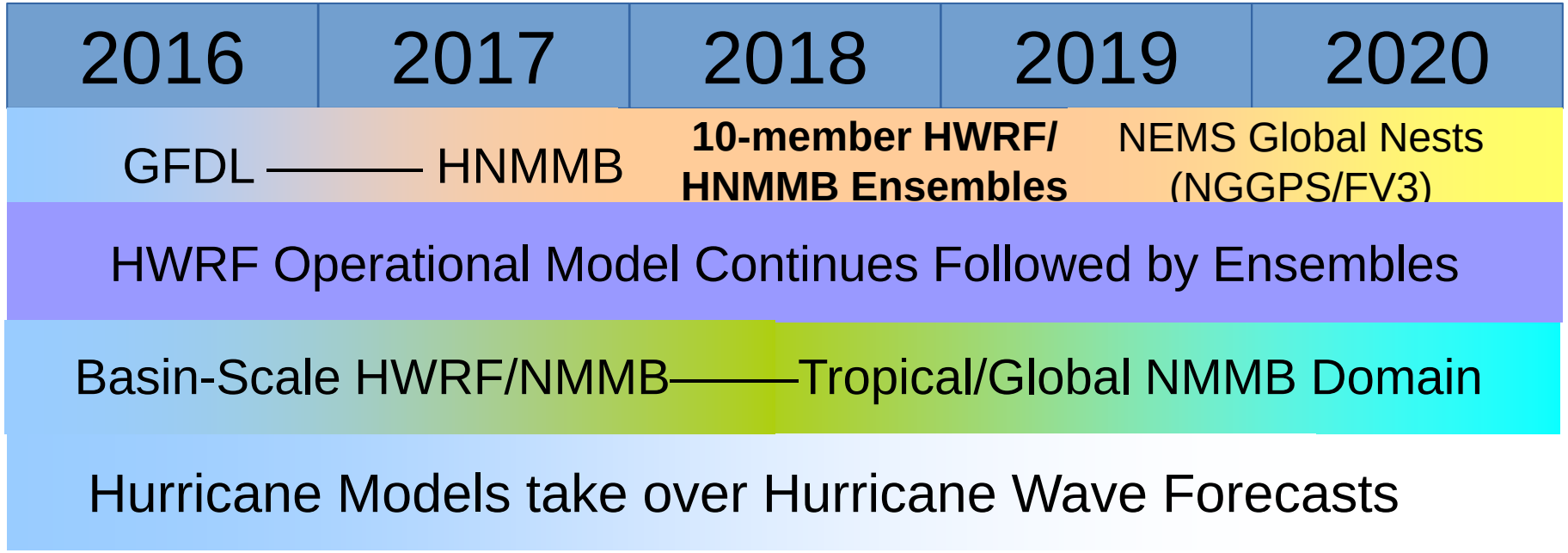


* slide courtesy Cecelia DeLuca

Unification of operational hurricane modeling in NEMS

1. **Strategies for unified regional (meso-scale) models in the NEMS framework**
   - Be able to meet the performance of current operational HWRF
   - Accommodate future development strategies including coupling to ocean, waves, land, surge and hydrology
   - Retain and expand community interactions fostered by HFIP
   - Flexible options for inner-core data assimilation
   - Enable future ensemble strategies and potential genesis and 7-day intensity forecasts
2. **Strategies for unified global model with multiple moveable nests**
   - Take advantage of NGGPS/FV3 supported development of non-hydrostatic global model in NEMS with high resolution nests for hurricanes
   - Leverage NMMB and GFS physics unification
   - Transition regional hurricane model components to global system for seamless prediction of hurricanes and severe weather
3. **Strategies for serving the next-generation needs of operational tropical cyclone forecasters**
   - Expand the products to include deterministic and probabilistic forecast guidance on genesis, rapid intensity changes, size, structure, storm-surge, rainfall, flooding and inundation and warn on forecasts

HNMMB Long-Term Plans



Development, T&E and Implementation Plans for HNMMB (supported by HFIP and NGGPS)

2016 June-Nov: uncoupled real-time demo
2016 Nov: single-storm, coupled, no-DA ready retrospectives
2016 Dec- 2017 Feb: HNMMB pre-implementation test
2017 March: HNMMB EMC CCB and code hand-off
2017 May: HNMMB replaces GFDL operationally

FY17 HNMMB Configuration

- Current status
- Domain
- Flowchart
- Physics options

Hurricane NMMB

- **NMMB:** **N**on-hydrostatic **M**ulti-scale **M**odel on the **B** grid. Being used in NCEP operational NAM and SREF.
- **HNMMB: Advanced Hurricane Model using NEMS framework**
  - Vortex initialization
  - Two-way interactive moving nests
  - Well-tuned hurricane Physics package
  - Designed to address NHC's operational needs
- Development supported by HFIP and HIWPP (with EMC/HRD collaboration)
- Provides high-resolution intensity forecast guidance to NHC along with HWRF (planned replacement for GFDL hurricane model)

Status of HNMMB at EMC (Jan. 17)

1. HWRF physics package and storm motion algorithm have been added to HNMMB.
2. HNMMB vortex initialization has been developed.
3. HNMMB restart capability has been implemented.

   (1) , (2), and (3) via active collaboration between EMC-HRD funded by HIWPP
4. Post and tracker scripts are working with NMMB.
5. Python workflow has been built.
6. **HNMMB ran in real-time on Theia for 2016 Hurricane season (using 1-5)**
7. **Retrospectives (2014-2016) completed using 2016 GFS.**
8. **Ocean Coupling is ready. Redo retrospectives using 2017 GFS.**

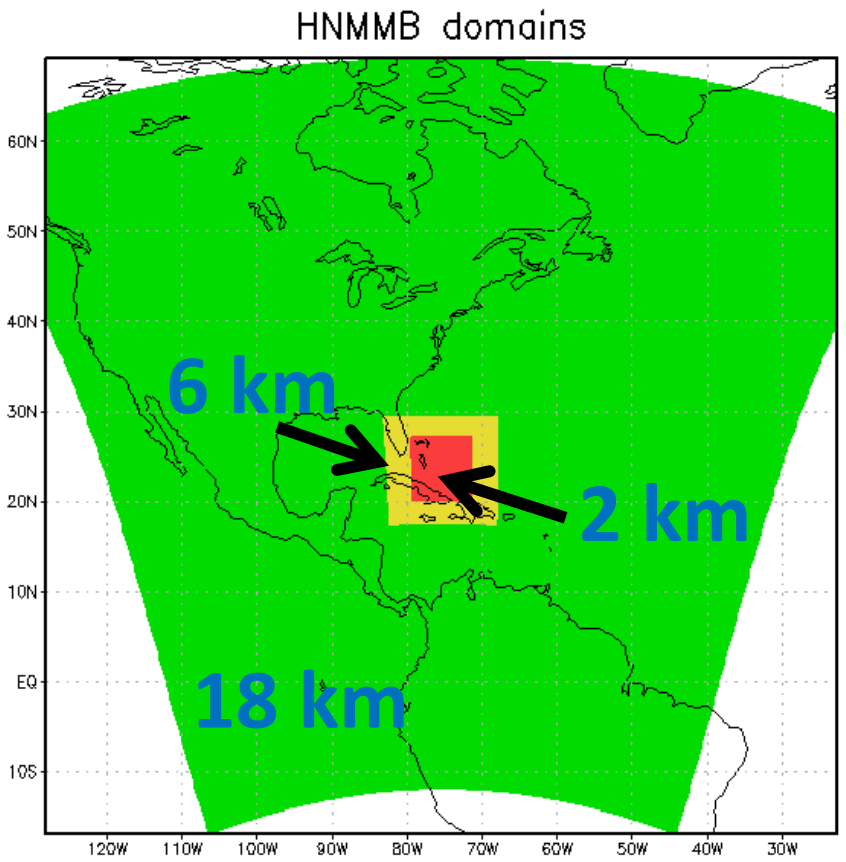
Status of HNMMB at EMC (Jan. 17)

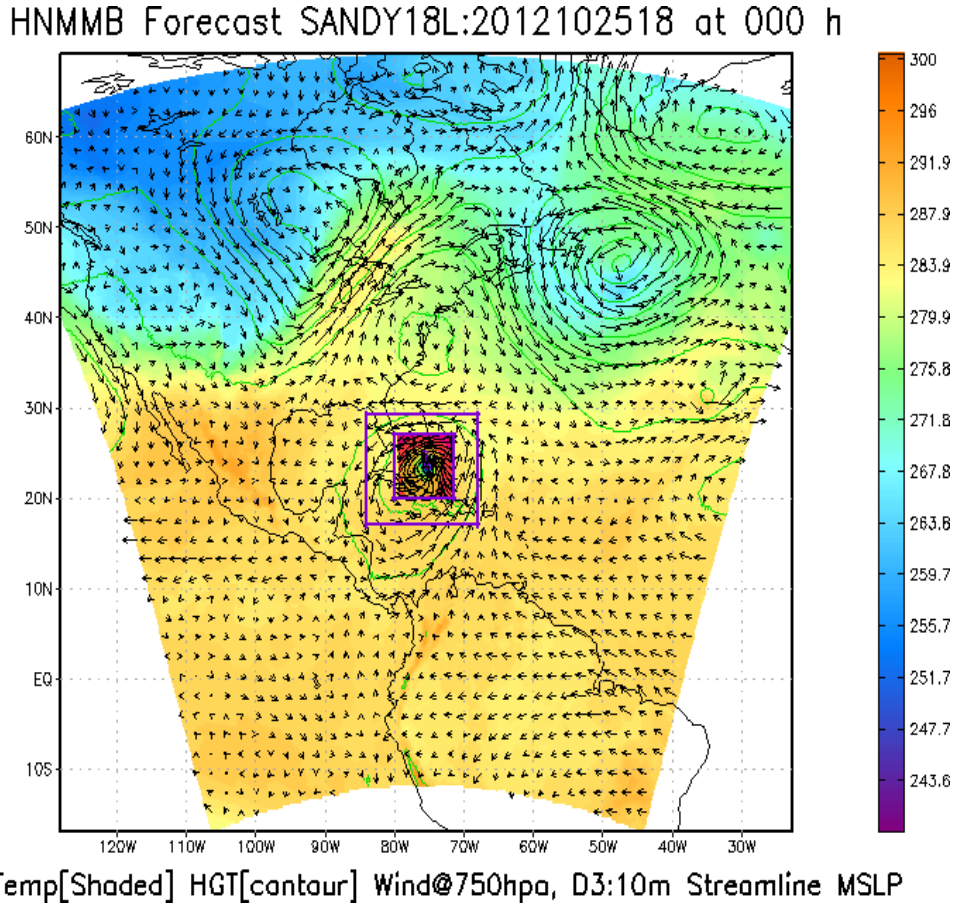
Two options for earth-system component coupling:

1. EMC legacy coupler (leverage HWRF developments)
   -- operationally ready
   -- extensively tested, robust
   -- configured for 3-way interactions (air-ocean-wave)

2. NEMS-NUOPC coupler
   -- unified modeling (Future)
   -- based on ESMF regridding/functionality/portability
   -- extensible to multiple-storm/component configurations
   -- extensible to FV3/NEMS based configurations
   -- leverage other coupled systems (NWS, NRL, NASA)

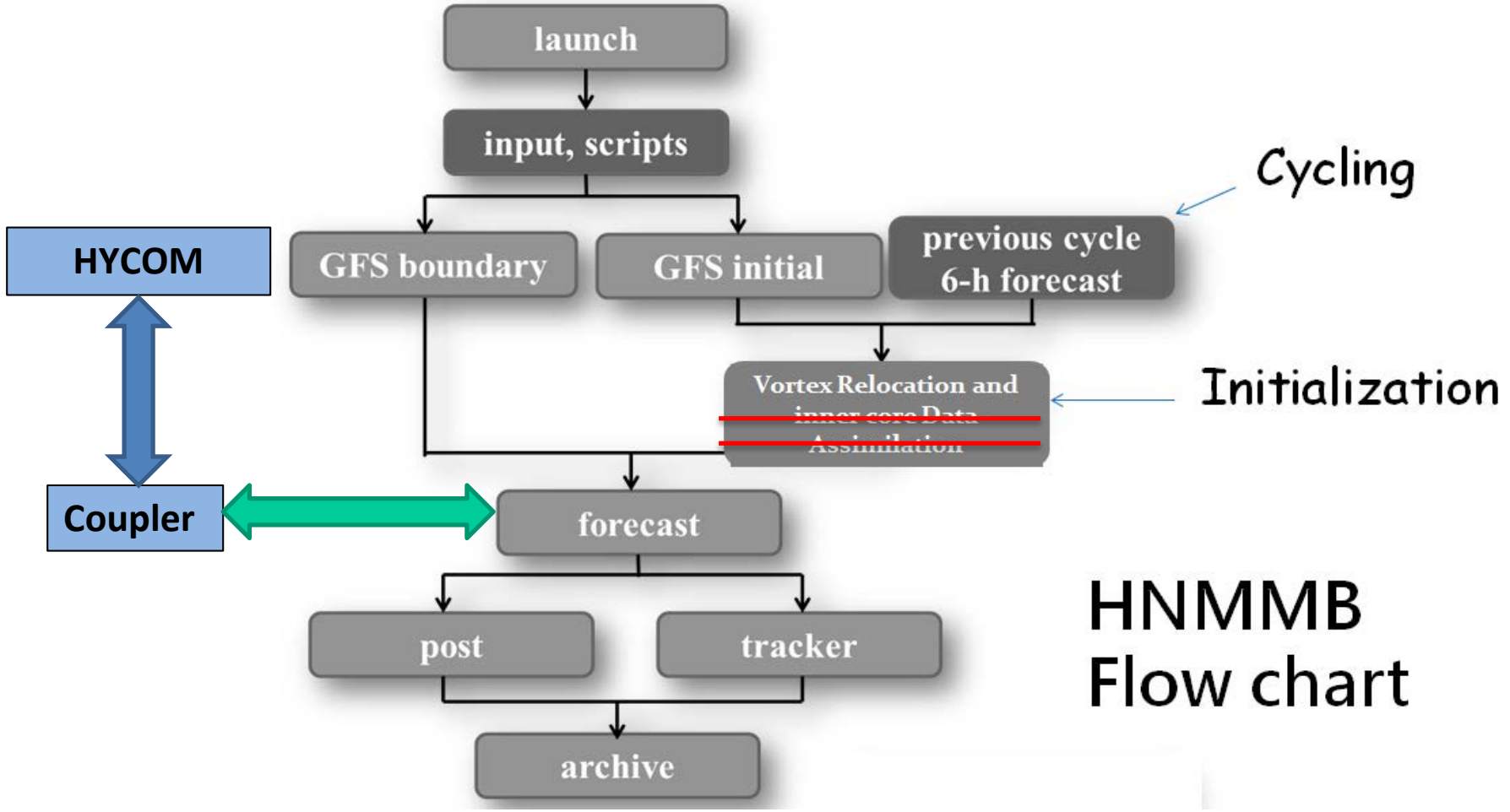
Regional HNMMB Domains





Long-Term Strategy: Implement multiple static and moving nests globally, with one- and two-way interaction and coupled to other (ocean, wave, sea ice, surge, inundation, etc.) models using NEMS-NUOPC infrastructure.

Design of HNMMB Workflow

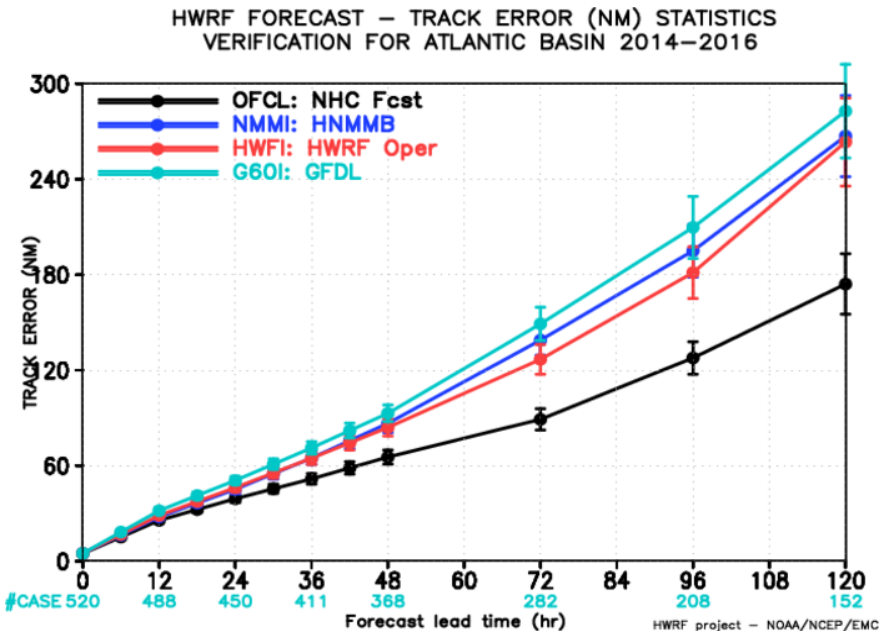


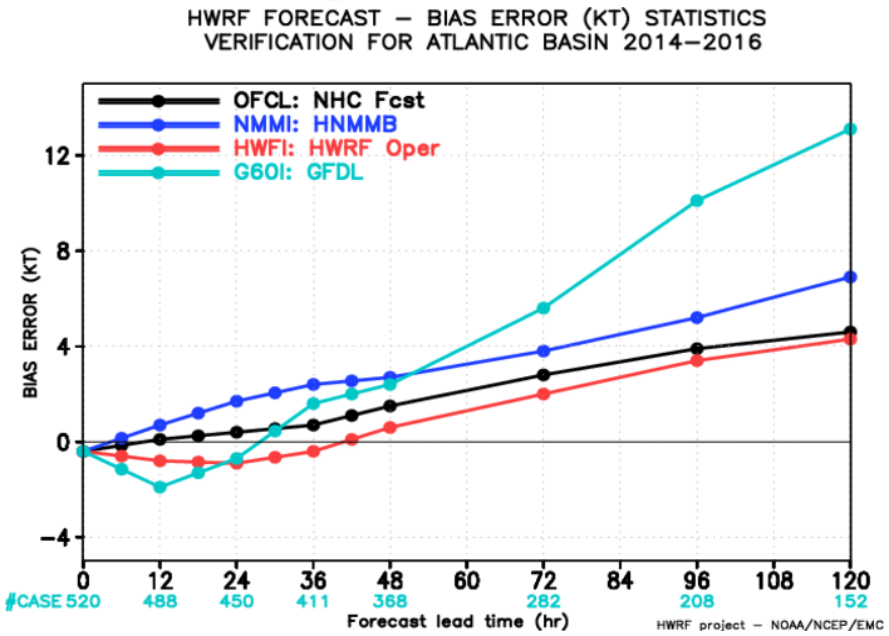
Physics options in HNMMB

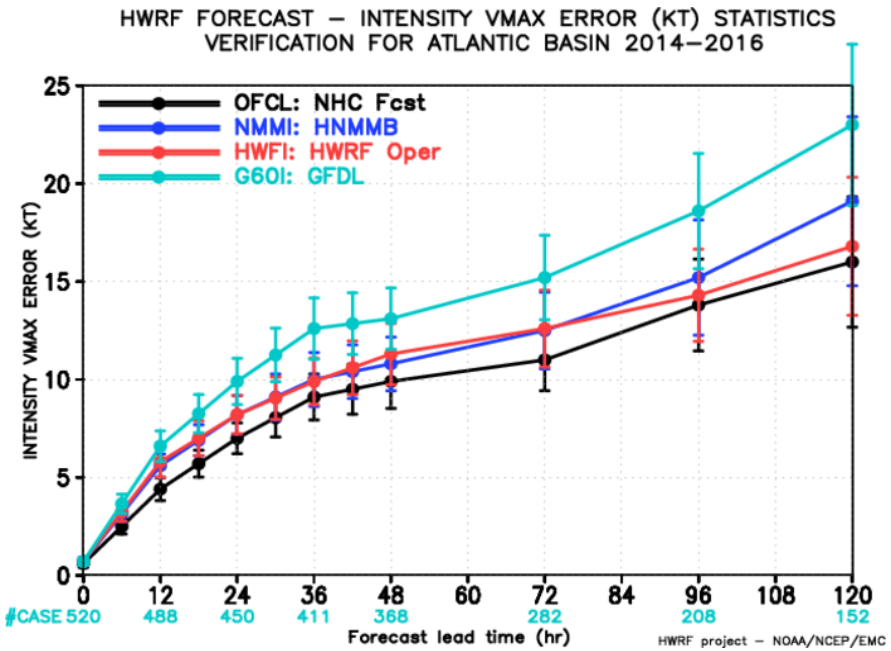
Physics Package	Option
microphysics	Fer_hires
shortwave	RRTM
longwave	RRTM
turbulence	GFSHUR
convection	SASHUR
sfc_layer	GFDL
land_surface	noah

2014-2016 Retrospective Statistics for HNMMB

2014-16 Atlantic Basin: Early Model

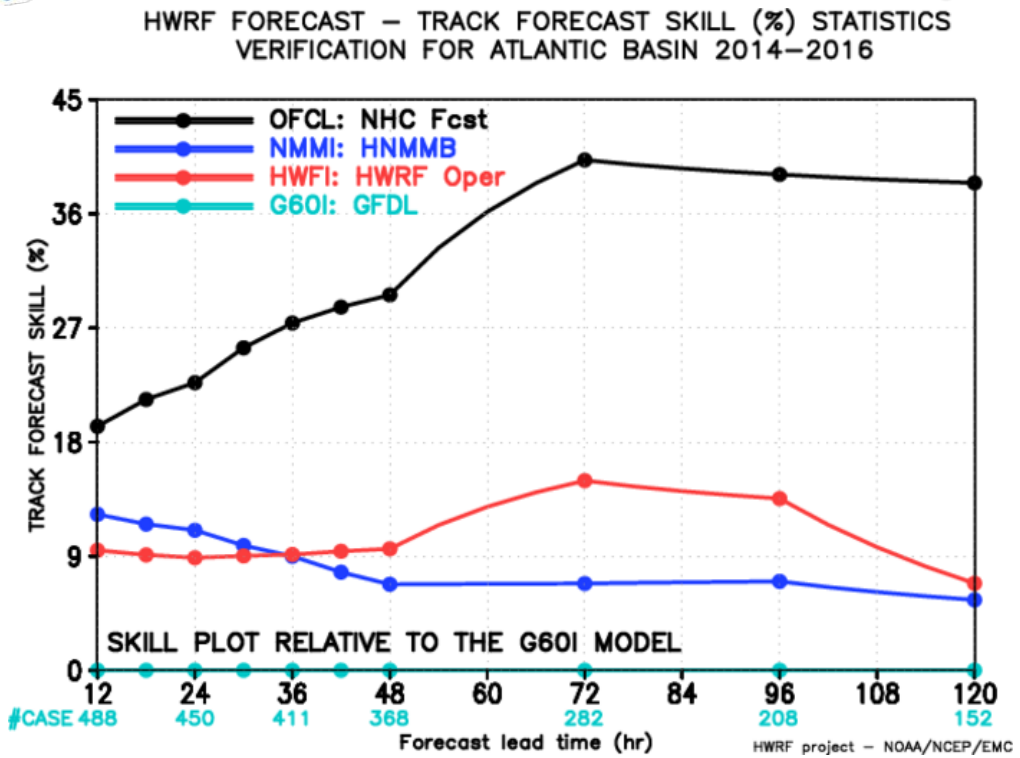


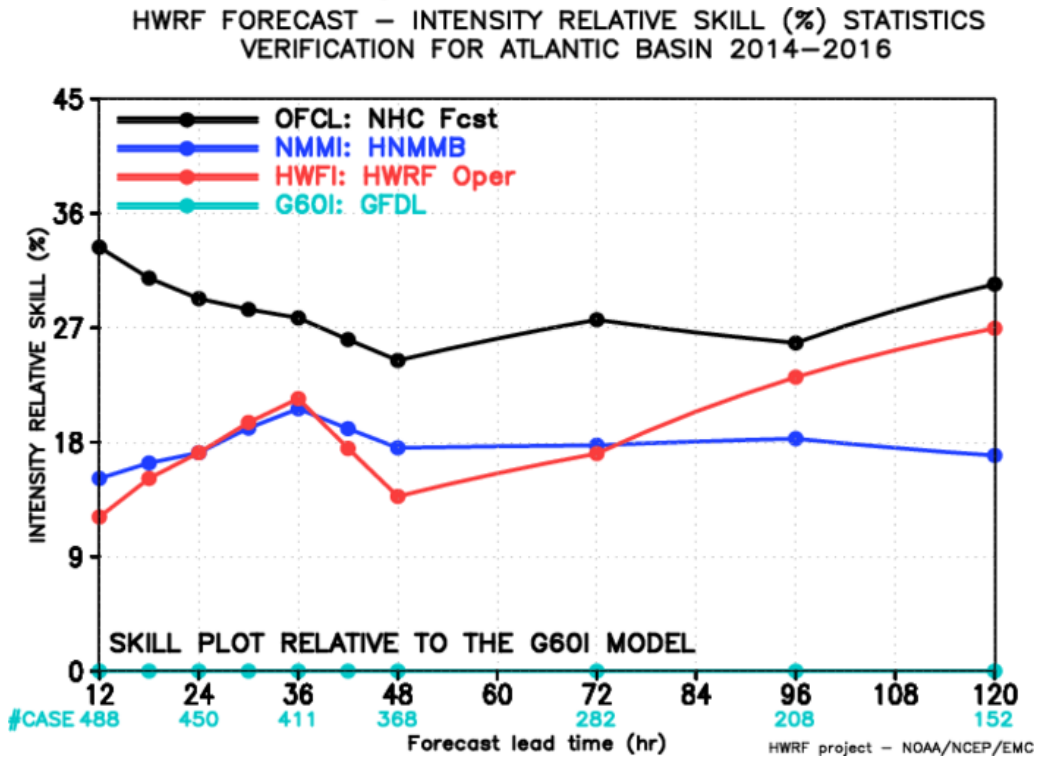




- HNMMB has **lower track errors than GFDL** at all lead times.
- Intensity errors are **significantly lower than GFDL** and comparable to HWRF but both errors and bias are larger than HWRF at longer lead-times but still **lower than GFDL.**

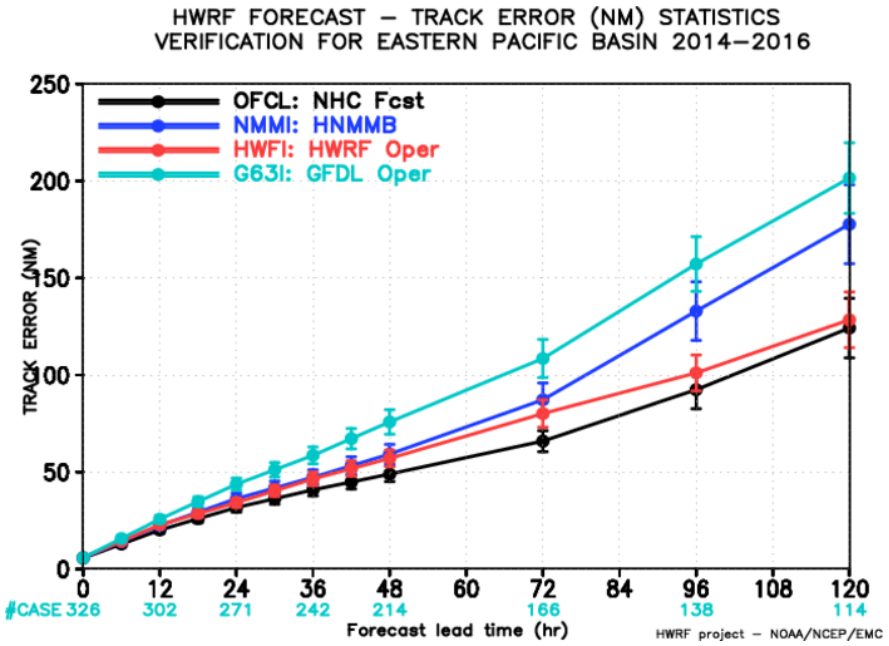
2014-16 Atlantic Basin: Relative to GFDL (interpolated)

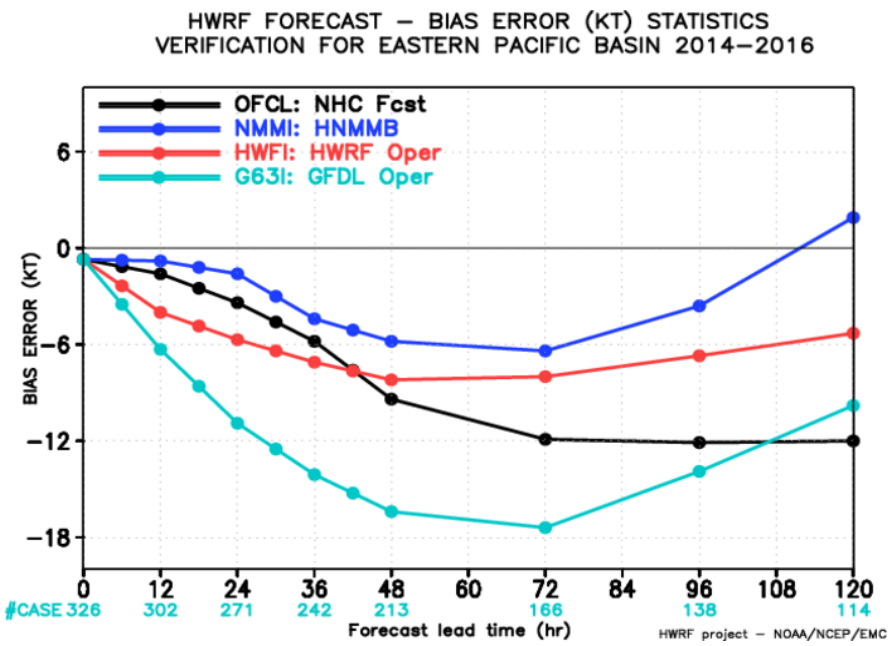


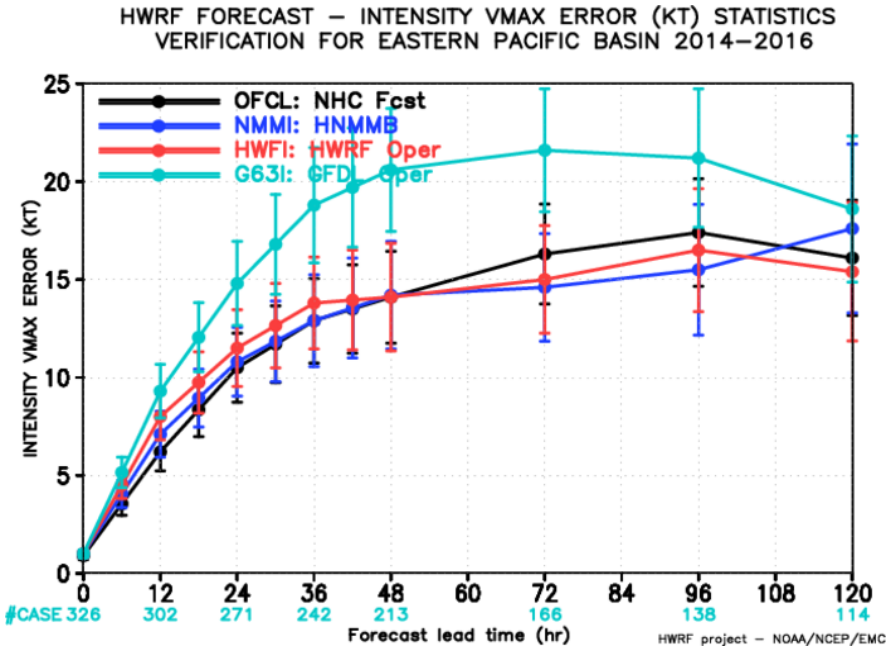


HNMMB has improved track skills as compared to GFDL with an average improvement of more than 8%. It also has improved intensity skills with a mean improvement of >15%.

2014-16 East Pacific Basin: Early Model

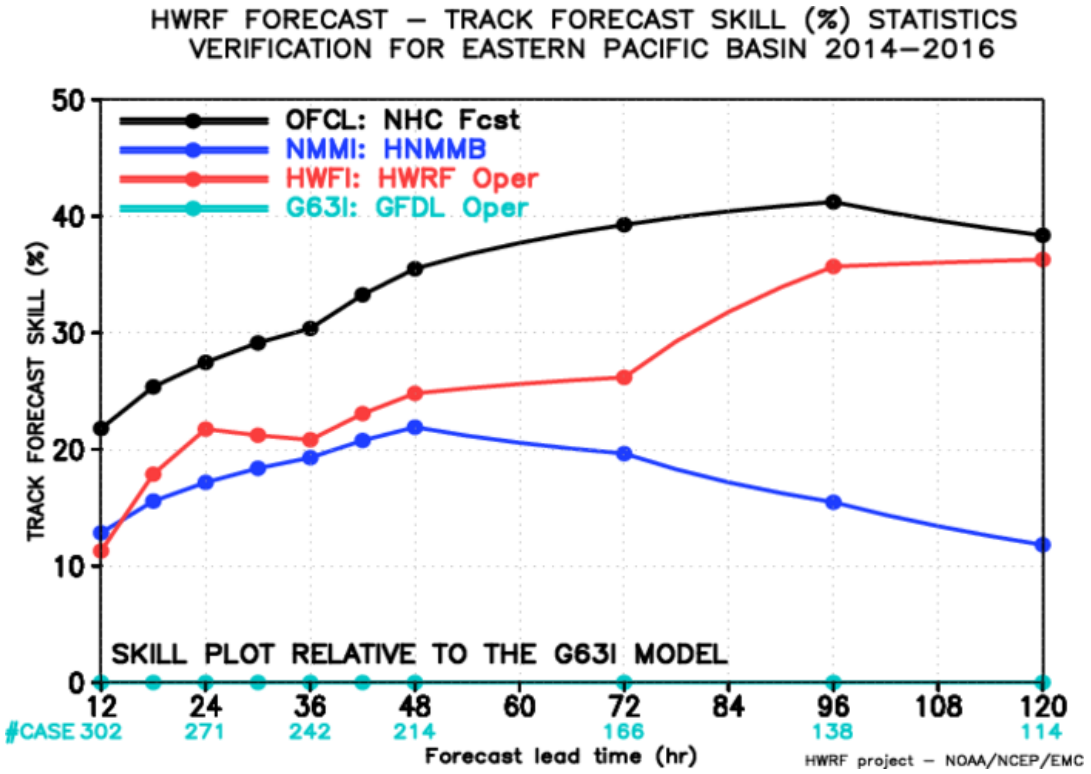


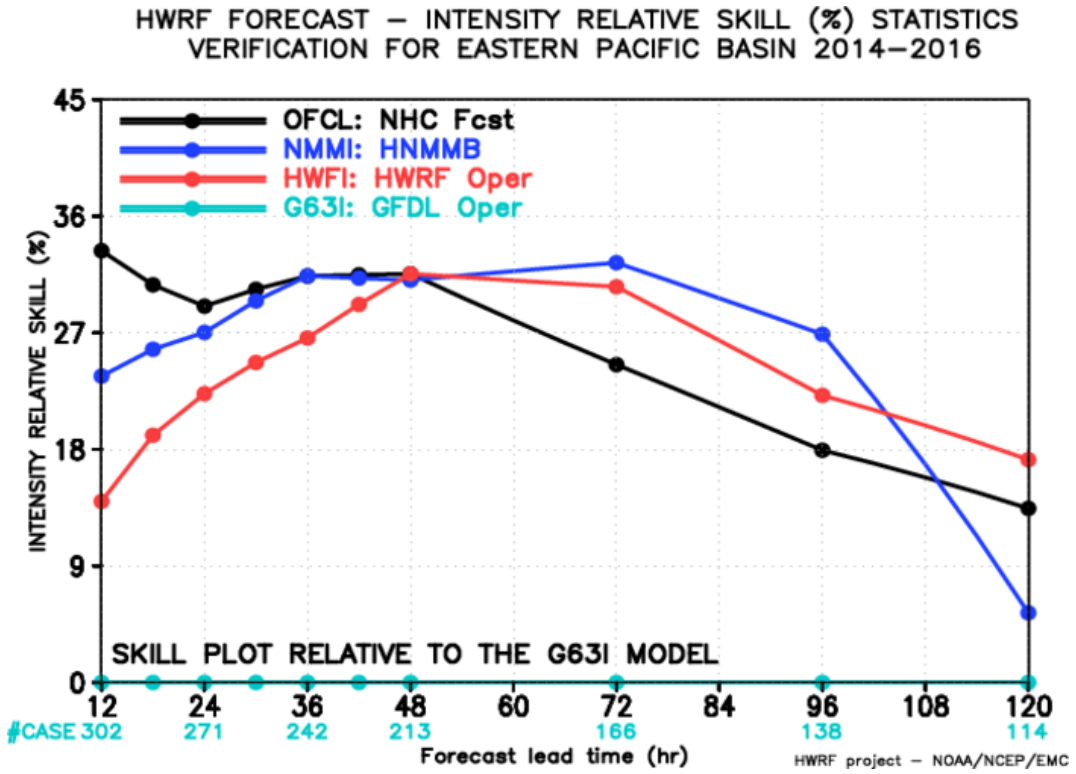




- For East Pacific also, HNMMB has **lower track errors than GFDL** at all lead times but larger than HWRF.
- Intensity errors are again **significantly lower than GFDL** and comparable to Official and HWRF.
- Bias errors are negative but much lower than both Official and HWRF.

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





HNMMB has improved track skills as compared to GFDL with an average improvement of more than 15%. It also has significantly improved intensity skills with a mean improvement of >25%.

HNMMB verification Statistics: Conclusions

- Compared with GFDL, HNMMB 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)
- Results are different from HWRF and usually exhibit larger track errors in comparison especially at longer lead-times
- **Redo retrospectives with 2017 GFS data (plus ocean coupling plus other upgrades) to assess these improvements for final stats before operational implementation (EMC)**
- **Check impact on NHC consensus model tracks and intensity forecasts before operational implementation (NHC)**

HNMMB: Current and Future Tasks

- Redo retrospectives with 2017 GFS data plus ocean coupling plus other upgrades
- Data Assimilation developments (sync with HWRF)
- Nesting under active development with NESII/ESRL using NEMS/NUOPC
- Basin-scale with multi-nest configuration in NEMS (includes genesis capability)
- Potential migration from NMMB to FV3-based NGGPS dycore under NEMS

HWRF vs GFDL vs HNMMB

	HWRF	GFDL	HNMMB
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	NDAS, NLDAS with partial cycling; 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, RTOFS/GDEM Wavewatch-III	MPIPOM, RTOFS/GDEM, No waves	HYCOM, RTOFS/NCODA, No waves
Post-processing	NHC interpolation method, GFDL tracker	NHC interpolation Method, In-line tracker	NHC interpolation method, GFDL tracker
NEMS/NUOPC	No	No	Yes with moving nests

Q3FY17 Hurricane NMMB V1.0.0

Project Status as of 10/19/16

Project Information and Highlights

Lead: Avichal Mehra, EMC and Steven Earle, NCO

Scope:

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

Expected Benefits:

1. Improved track & intensity forecast skill compared to GFDL and/or operational HWRF
2. Improved forecast guidance to NHC to fulfill their mission
3.Explore high-resolution hurricane ensemble products for intensity and structure

Issues/Risks

Issues: Complex T&E due to dependency on NEMS/GSM and RTOFS upstream requirements

Risks: Implementation dates are dependent on completion of T&E

Mitigation: Conduct T&E as soon as (or along with) NEMS/GSM and RTOFS retrospective data are available.

Scheduling

Milestone (NCEP)	Date	Status
Identify preliminary System Configuration	11/01/2016	
Start preliminary evaluation	11/01/2016	
Finalize System configuration	01/10/2017	
Initial coordination with SPA team	01/10/2017	
Freeze codes for real-time and retrospective runs	01/10/2017	
Pre-CCB Briefing to EMC management	02/15/2017	
Completion of full retrospective runs and external evaluation	02/15/2017	
EMC CCB/NCEP OD approval	02/28/2017	
Deliver final code to NCO (including downstream codes)	02/28/2017	
Technical Information Notice Issued	03/07/2017	
Special event if applicable		
Complete 30-day evaluation and IT testing	05/15/2017	
Final Management Briefing	05/22/2017	
Operational Implementation	05/31/2017	

Resources

Human Resources: 3 FTE full time for 6 months.

Funding Sources: STI

Compute:

Archive:

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

HNMMB Home Page

www.emc.ncep.noaa.gov/gc_wmb/vxt/HNMMB/