NOAA HURRICANE FORECAST IMPROVEMENT PROJECT

Hurricane Forecast Improvement Project Overview:
2018 HFIP Annual Meeting

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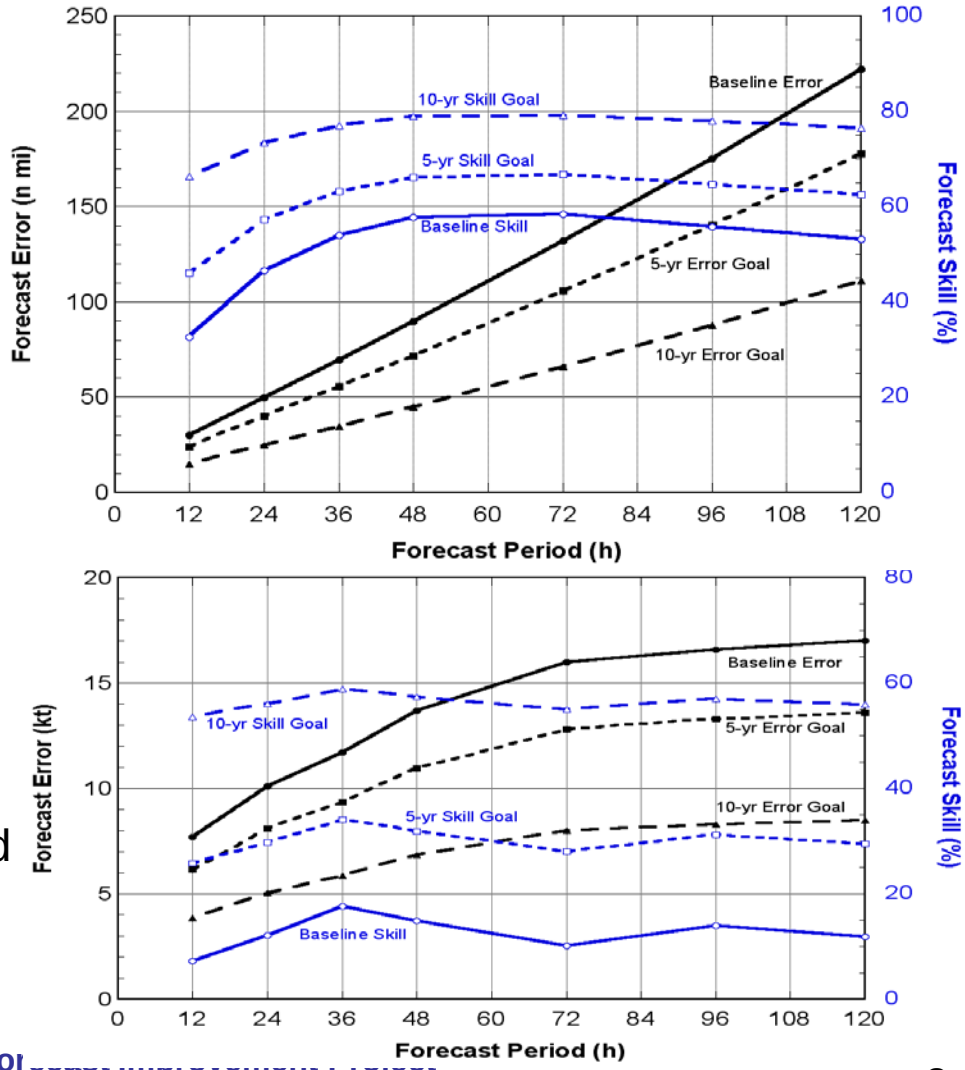
HFIP Vision/Goals (2009-2018)

- **Vision**
  - Organize the hurricane community to dramatically improve numerical forecast guidance to NHC in 5-10 years
- **Goals**
  - Reduce numerical forecast errors in track and intensity by 20% in 5 years, 50% in 10 years
  - Extend forecast guidance to 7 days with skill comparable to 5 days at project inception
  - Increase probability of predicting rapid intensification (RI) at day 1 to 90% and 60% at day 5
  - Improve storm surge prediction

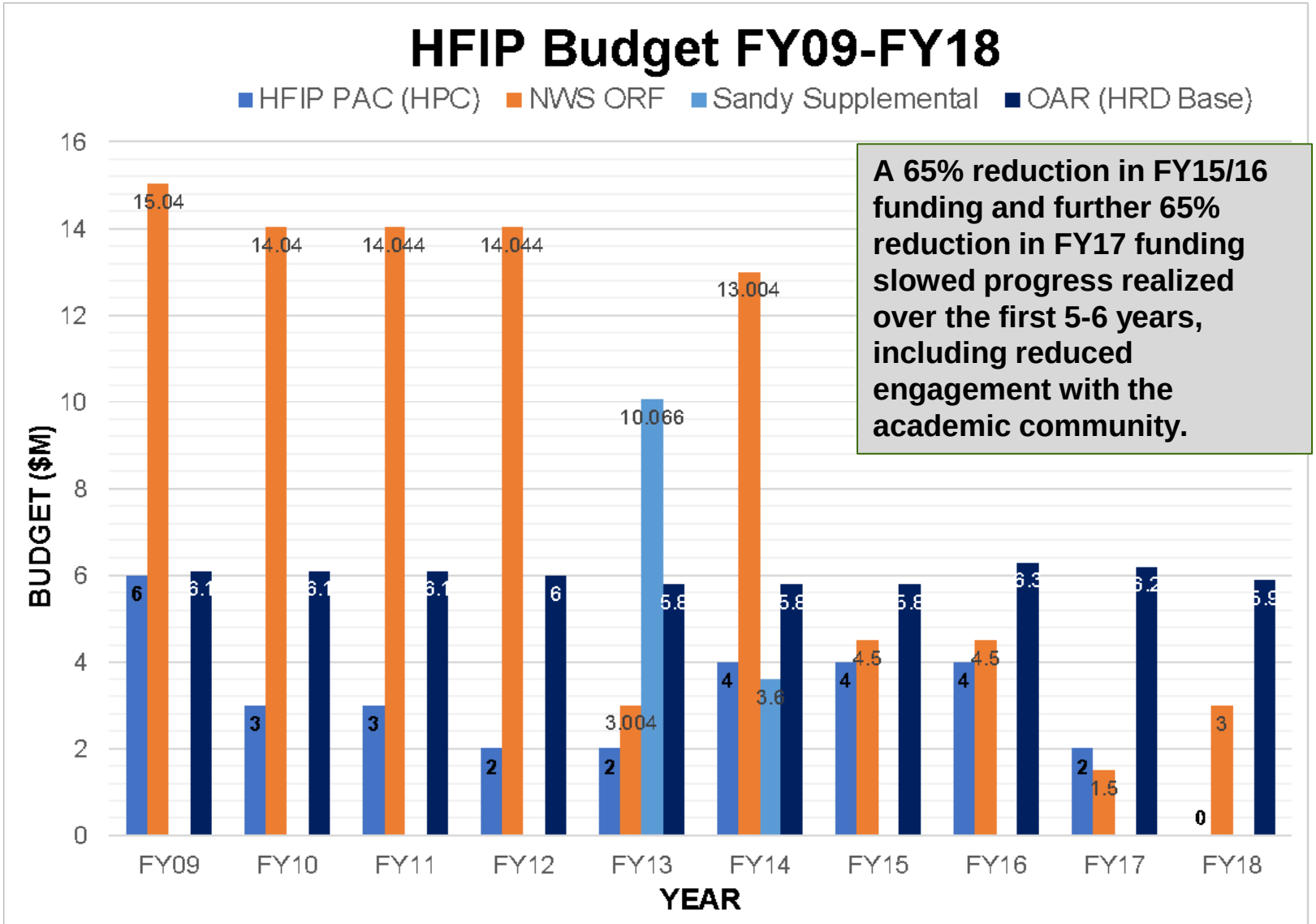


Keys to Success

HFIP achieved ~20% decrease in average hurricane track and intensity forecast errors, reaching the 5-yr goals, and for track very close to the 10-yr goal.

- **Partnerships**: NOAA research working closely with operations (NWS/NCEP, DOD/JTWC), Federal & academic partners (NASA, NSF, ONR, NRL, NCAR), & international collaborations
- **Outreach and community participation**
  - Developed and facilitated next generation of TC researchers for NOAA
- **HFIP R&D computing**
- **Integrated use & support of testbeds** (DTC & JCSDA)

Appropriation History
(2009-2018)

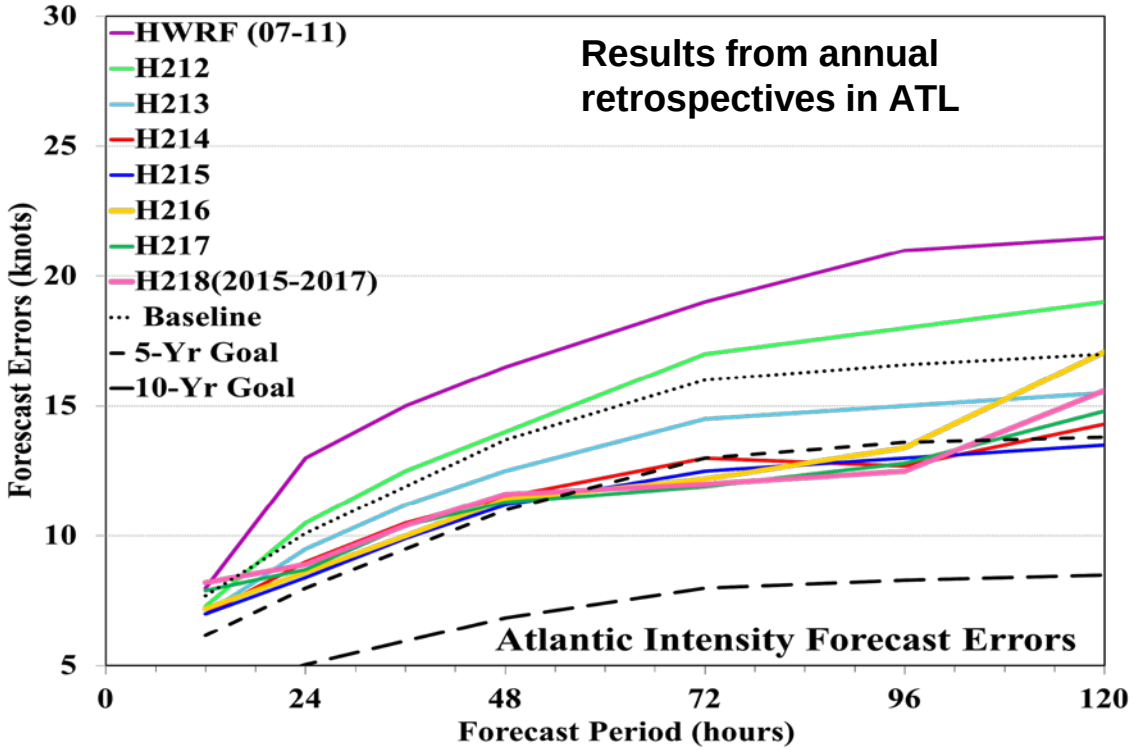


Highlights for 2018

- Operational HWRF was best individual intensity forecast in the ATL
  - HWRF was best individual model for RI cases
  - Storm size errors and bias were reduced for both basins
- Improved Data Assimilation system in HWRF
  - Admit new data sets (GOES-16 AMV's, NOAA-20, SFMR, Dropsonde drifts, TDR from G-IV)
- Improvements in numerical guidance continuing to appear in NHC official forecast
- Initial results of HWRF model driven by new FV3GFS data run during the realtime season
  - Oper HWRF outperforms FV3-HWRF with continued development is ongoing to address the degradations
- HWRF v4.0 public release includes the capability to test HWRF using FV3GFS BC/ICs

HWRF: Hurricane Weather Research and Forecast System

- HWRF continuously improved in the past seven years through support from HFIP
- Successful community modeling approach for accelerated transition of research to operations
- New in 2018 for operational HWRF:
  - Increase horizontal resolution to 13.5/4.5/1.5 kms
  - Updates to RRTMG radiation scheme
  - Unified HWRF/HMON coupler



  - New datasets for assimilation in the hurricane inner core and environment
    - SFMR, dropsonde drifts
    - G-IV TDR
    - GOES-16 AMV's and NOAA-20 data sets

Real-time Reservation Projects run during the 2018 Season

Real-time Reservation Project	User Name	Organization
HWRF driven by FV3GFS Parallel Experiment	Avichal Mehra (base project PI), Biju-Thomas (RT PI), Bin Liu (Tech.Lead)	EMC
HWRF Ensemble: rthwrf-EPS	Avichal Mehra (Base PI), Zhan Zhang (RT PI), Weiguo Wang (Tech.Lead)	EMC
3-km nested hfvGFS (Atlantic)	Shian-Jiann Lin (Base PI), Andrew Hazelton (RT PI), Matt Morin (Tech.Lead)	GFDL
Real-time Basin-Scale HWRF (w/ cycled data assimilation)	Ghassan Alaka, Jr. (Base and RT PI) Jonathan Poterjoy, Xuejin Zhang, and Gopalakrishnan Sundararaman	AOML/HRD
HMON Ensemble real-time experiment: hwrfv3	Avichal Mehra (Base-PI) , Weiguo Wang (RT-PI), Lin Zhu (Tech. Lead)	EMC
FV3GFS, C768 with data assimilation (DA) cycle	Georg Grell (Base and RT PI), Judy Henderson (Tech.Lead)	ESRL, GSD
Real-Time Analog Ensemble: hwrf-anen	William E. Lewis (Base and RT PI), Chris Rozoff (New role or Tech.Lead)	UWI.edu

2018 HFIP FFO University Awarded Grants

Project Title (Linked)	Submitting Organization	Principal Investigator	Priority Area(s) - see below	Total $
Advanced DA Techniques for Satellite-Derived Atmos. Motion Vectors from GOES 16/17 in the HWRF	WI-CIMMS	**Lim, Agnes**	a	$221,400
Using Dynamically-Based Probabilistic Forecast Systems to Improve the NHC Wind Speed Speed Products	CSU-CIRA	**Schumacher, Andrea**	d,c	$200,004
RI changes: improving sub-grid scale model parameterization and microphysical-dynamical interaction	FIU	**Zhu, Ping**	b	$296,701
New Frameworks for Predicting Extreme Rapid Intensification	MIT	**Emanuel**	b	$339,571
Enabling Cloud Condensate Cyling for All-Sky Radiance Assimilation in HWRF	CSU-CIRA	**Wu, Ting-Chi**	a,b	$238,017
Evaluating initial condition perturbation methods in the HWRF ensemble prediction system	SUNY Albany	**Torn, Ryan**	c,d	$292,483

a: Data Assimilation

b: Prediction: Intensity/Track

c: Ensemble Development

d: Post-Processing

Priorities for the Next Phase of HFIP

- Evolution of HAFS - FV3 based hurricane application
- Reduce largest track and intensity errors
  - Target RI cases; improve initialization & physics impacting rapid intensity change
- Focus on improvements of model physics (scale aware)
- Continued focus on high-resolution ensembles and data assimilation (satellite data)
- Improve ensemble prediction & products
- Extend/improve guidance out to 7 days
- Provide improved products and tools to the forecasters

Revised HFIP Goals aligned with the Weather Act

1. Reduce forecast guidance errors, including during RI, by 50% from 2017
2. Produce 7-day forecast guidance as good as the 2017 5-day forecast guidance
3. Improve guidance on pre-formation disturbances, including genesis timing, and track and intensity forecasts, by 20% from 2017
4. Improve hazard guidance and risk communication, based on social and behavioral science, to modernize the TC product suite (products, information, and services) for actionable lead-times for storm surge and all other threats

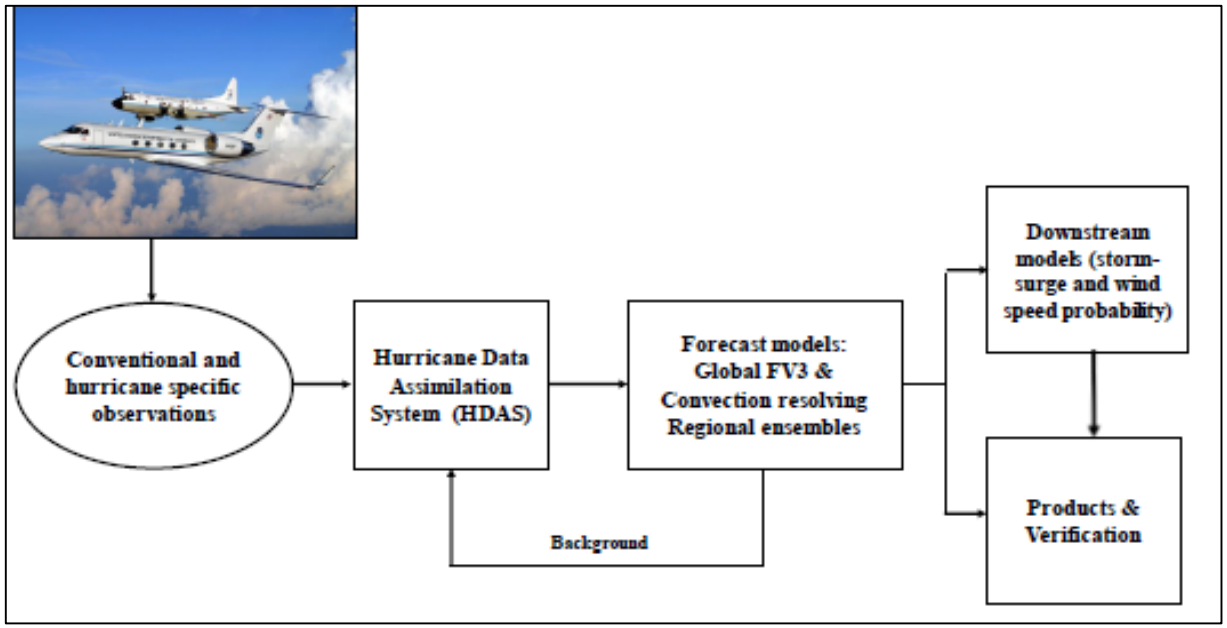
Key Strategies:

1. Advance an operational Hurricane Analysis and Forecast System (HAFS)
2. Improve probabilistic guidance
3. Enhance communication of risk and uncertainty
4. Support dedicated high performance computing allocation
5. R2O Enhancement
6. Broaden expertise and expand interaction with external community

Key Strategies: HAFS

1. Advance operational hurricane analysis and forecast system (HAFS)

- R&D for HAFS to advance deterministic and ensemble prediction capabilities
- R&D for fusion of modeling, data assimilation and observations to produce an analysis of record
- R&D for ensemble post-processing to extract guidance and uncertainty information



HAFS Yearly Milestones

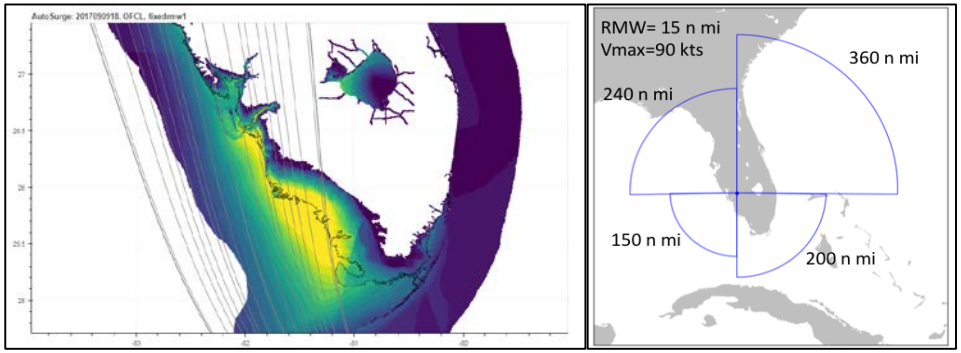
- HAFS v0.0 is HWRF
- Prototype HAFS v0.A: 3km single domain FV3 (3km) centered over the NATL basin -- Year 1
- Prototype HAFS v0.B: Global FV3 (13 km) with a static nest (3 Km) centered over the NATL basin -- Year 1
- HAFS v0.1: Single storm configuration over the NATL basin with HWRF physics, VI, DA and coupling to ocean -- Year 2
- HAFS v0.2: Fully coupled configurati*on with inner-core DA and multiple moving nests -- Year 3*

Key Strategies: Guidance & Products

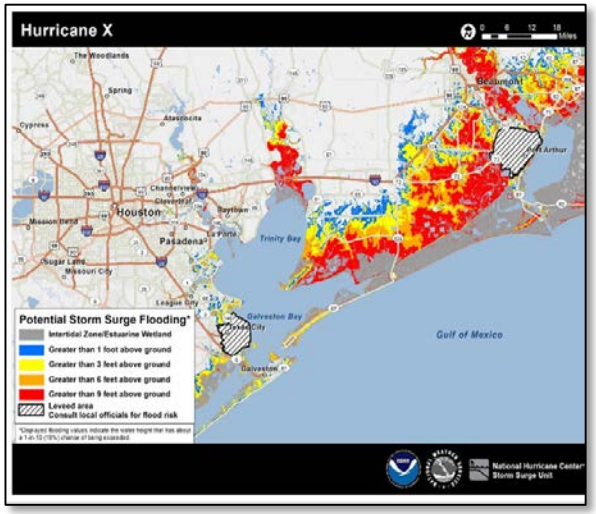
2. Improve probabilistic guidance

- Calibrate guidance with HAFS
- Incorporate dynamically-based uncertainty into hazard models and products
- R&D for hazard-specific products from TCAFS

Planned improvements to P-Surge to Improve the Potential Storm Surge Flooding Map



Potential Storm Surge Flooding Map



3. Enhance communication of risk and uncertainty

- Evaluate TC products for the effective communication of risk
- Modernize TC products as informed by social and behavioral science

Key Strategies: HPC

4. Increase HPC Capacity

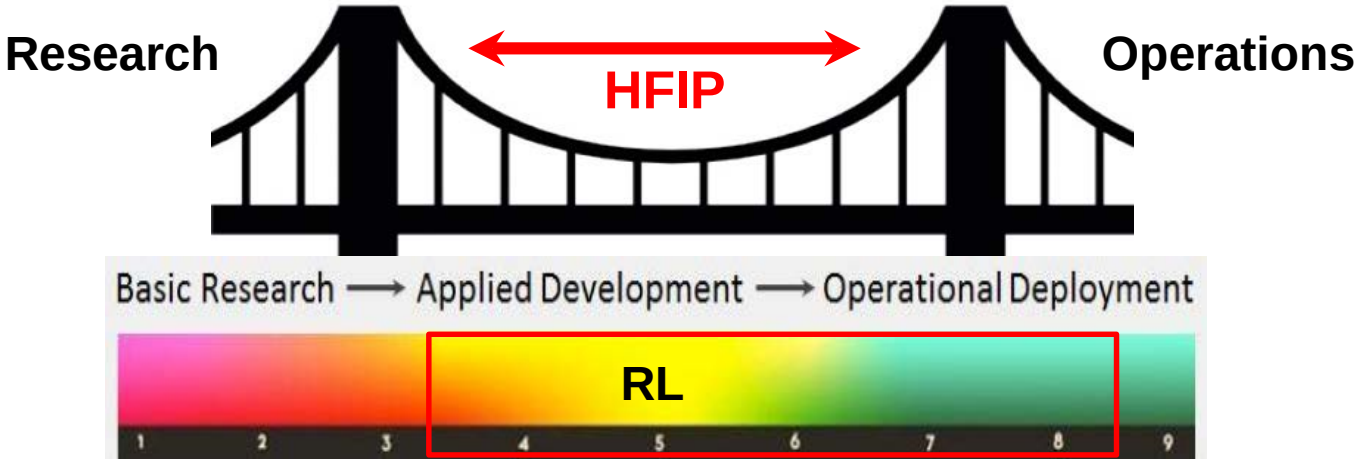
- NOAA R&D and operational computing to support HAFS development
- Sustain modeling and software engineering expertise
- Match with technological innovations

Compute	(core hr/month)	FY2018	FY2019	FY2020	FY2021	FY2022	FY2023
Hurricane	Prediction (R&D)	41.6M	57.2M	72.8M	88.4M	104.0M	119.6M
Hurricane	Operations (NCEP)	1.54M	1.85M	2.21M	2.66M	3.20M	3.84M
Storm surge	NHC/SLOSH/ SWAN	4.8M	6.6M	8.4M	10.2M	12.0M	13.8M
	MDL	0.36M	1.58M	2.02M	3.32M	6.85M	7.09M
	NOS		0.45M	0.45M	0.55M	0.55M	0.71M
Disk	**(TB)**						
Hurricane	Prediction	6,040	8,280	10,520	12,760	15,000	17,500
Hurricane	Operations (NCEP)	800	960	1152	1383	1660	1990
Storm surge	NHC/SLOSH/ SWAN	80	110	140	170	200	230
	MDL	32	44	56	68	80	92
	NOS	6	88	91	101	104	140

Key Strategies: R2O

5. Research to Operations (R20) Enhancements

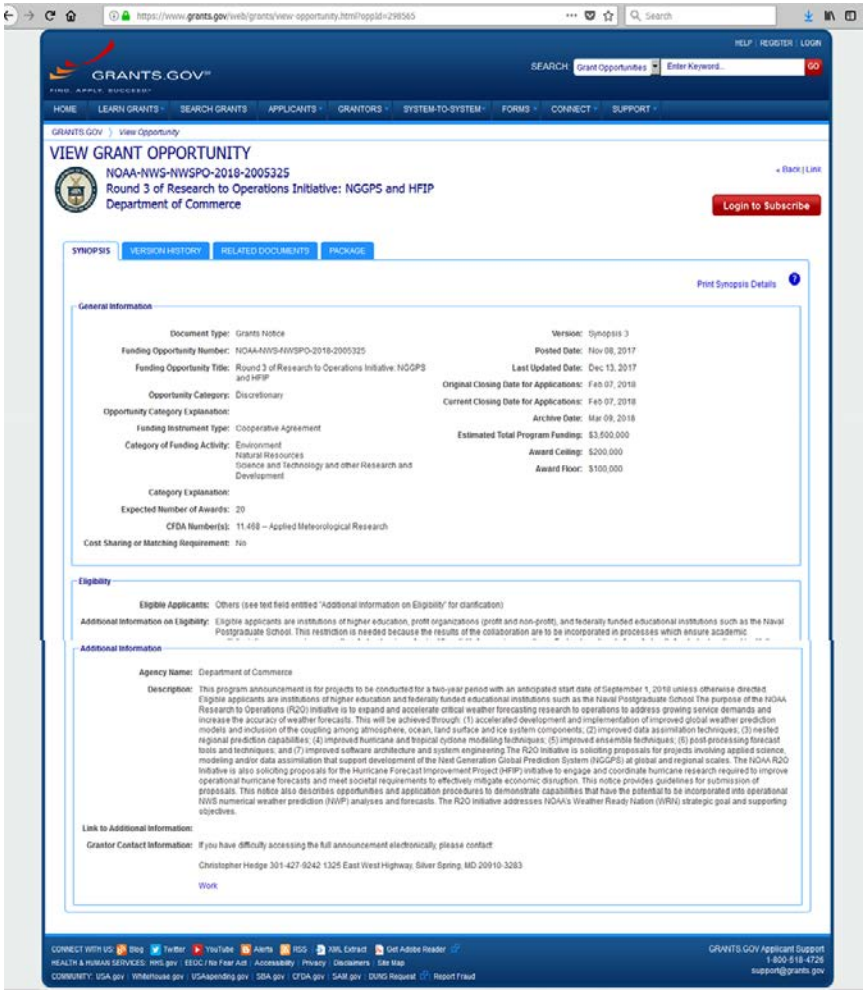
- Accelerate transition to operations by following NOAA's best practices for promoting readiness levels (RLs)
- Develop a process to prioritize research targeted for operational improvements
- More integrated use & support of Testbeds (JHT, HWT, HMT, DTC, JCSDA)



Key Strategies: Outreach to Community

6. Broaden expertise and expand interaction with external community

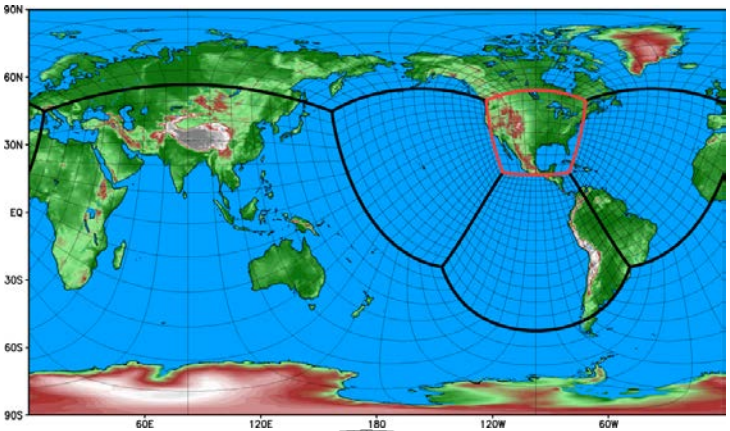
- Re-invigorate the grants program
- Maintain a visiting scientist program at research and operational centers
- Advisory committees, community workshops
- Collaborate/coordinate with social and behavioral sciences
- Outreach to America's Weather Industry (AWI)

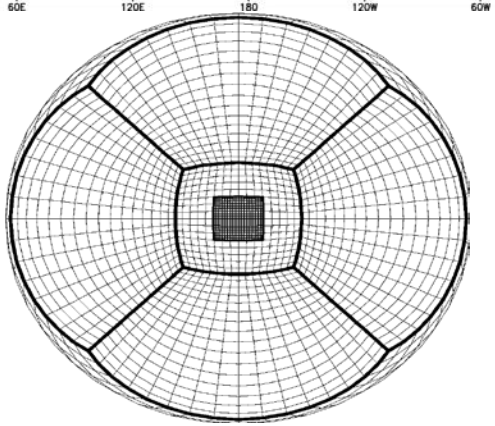


Questions and Discussion

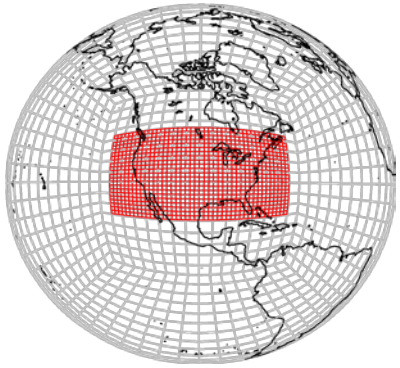
Global-to-Regional Modeling

Grid Stretching

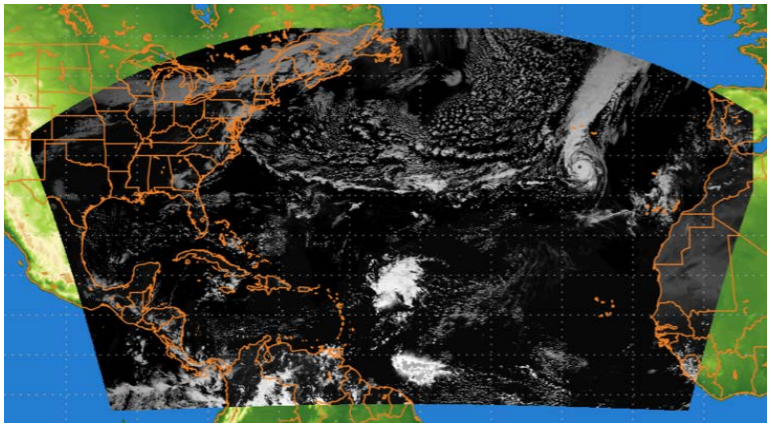




Grid Nesting



CONUS Nest



Hurricane Nested Domain

Nested 3-km FvGFS for Hurricane Harvey

Model configuration of nested 3-km FvGFS

- FV3 dynamical core with GFS physics (fvGFS)
- 13-km global, 3-km nest (2-way interaction) covering the entire Atlantic
- GFDL 6-class microphysics
- Scale-aware SAS convective scheme
- 63 vertical levels

Nested fvGFS captured the double max structure with the core near Corpus Christi and the band training into Houston

OBSERVED 72h PRECIPITATION TOTALS