NOAA HURRICANE FORECAST IMPROVEMENT PROJECT

HFIP
After 10 Years…. What's Next?

HFIP Annual Meeting

November 9, 2017

Continued Need for Improvements

- Need to reduce loss of life
  - Population continues to increase – 50% of US population now live within 50 miles of coast.
- Risk to life and property continues to escalate in coastal regions
  - Value of coastal infrastructure and economic activity continues to rise – estimated at over **$3 Trillion**
- More accurate hurricane forecasts and warnings can reduce response and recovery costs
  - More accurate forecast ➔ fewer false alarms, reduced warning footprint


Galveston, TX after Ike 2008


Bolivar Peninsula, TX after Ike 2008

NOAA Response Establishment of HFIP

NOAA established the Hurricane Forecast Improvement Project in May 2007.

Considers key recommendations from:

- Hurricane Intensity Research Working Group (NOAA Science Advisory Board)
- National Science Foundation/National Science Board (NSB)
- Office of the Federal Coordinator for Meteorology (OFCM)

Considered the direction of Congressional language introduced to establish the *National Hurricane Research Initiative*

- S.931 (Sen. Martínez)
- HR.2407 (Rep. Hastings)

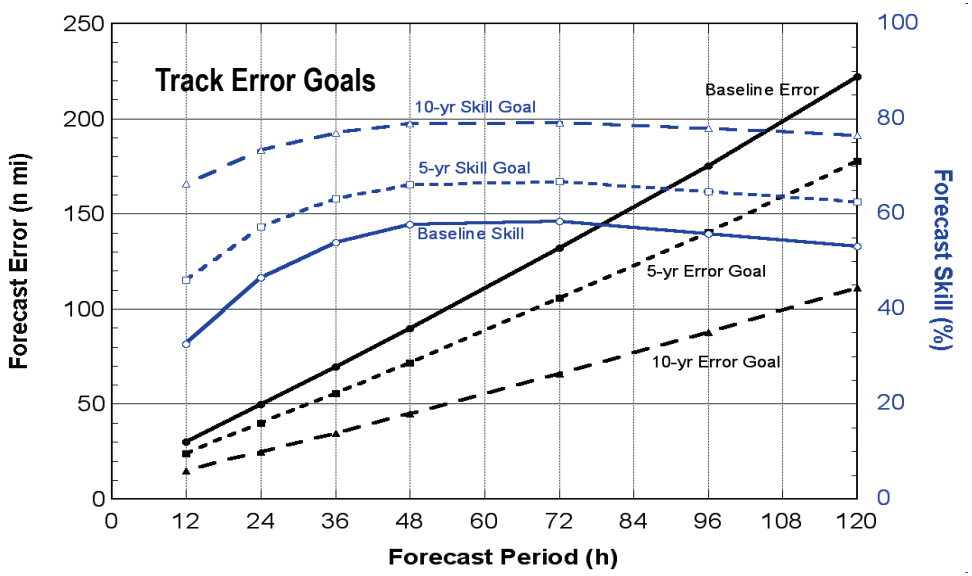
Overarching HFIP Goal

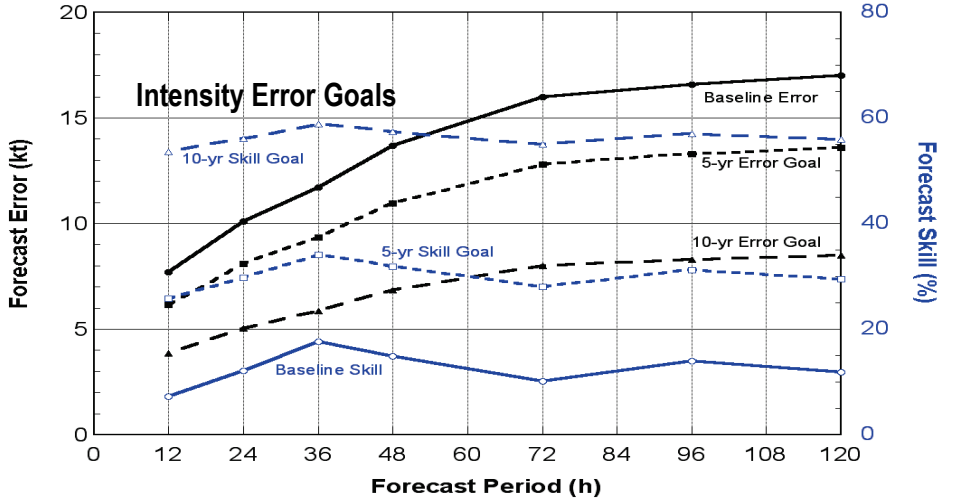
- Improve forecasts and warnings of tropical cyclones
- Increase confidence in those forecasts to enhance mitigation and preparedness decisions
- “Reduce unnecessary evacuations”*

* George W. Bush, in letter to Congress amending 2009 President’s Budget to include funding for HFIP

The HFIP Project Vision/Goals

- **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 at day 1 to 90% and 60% at day 5
  - Improve storm surge prediction



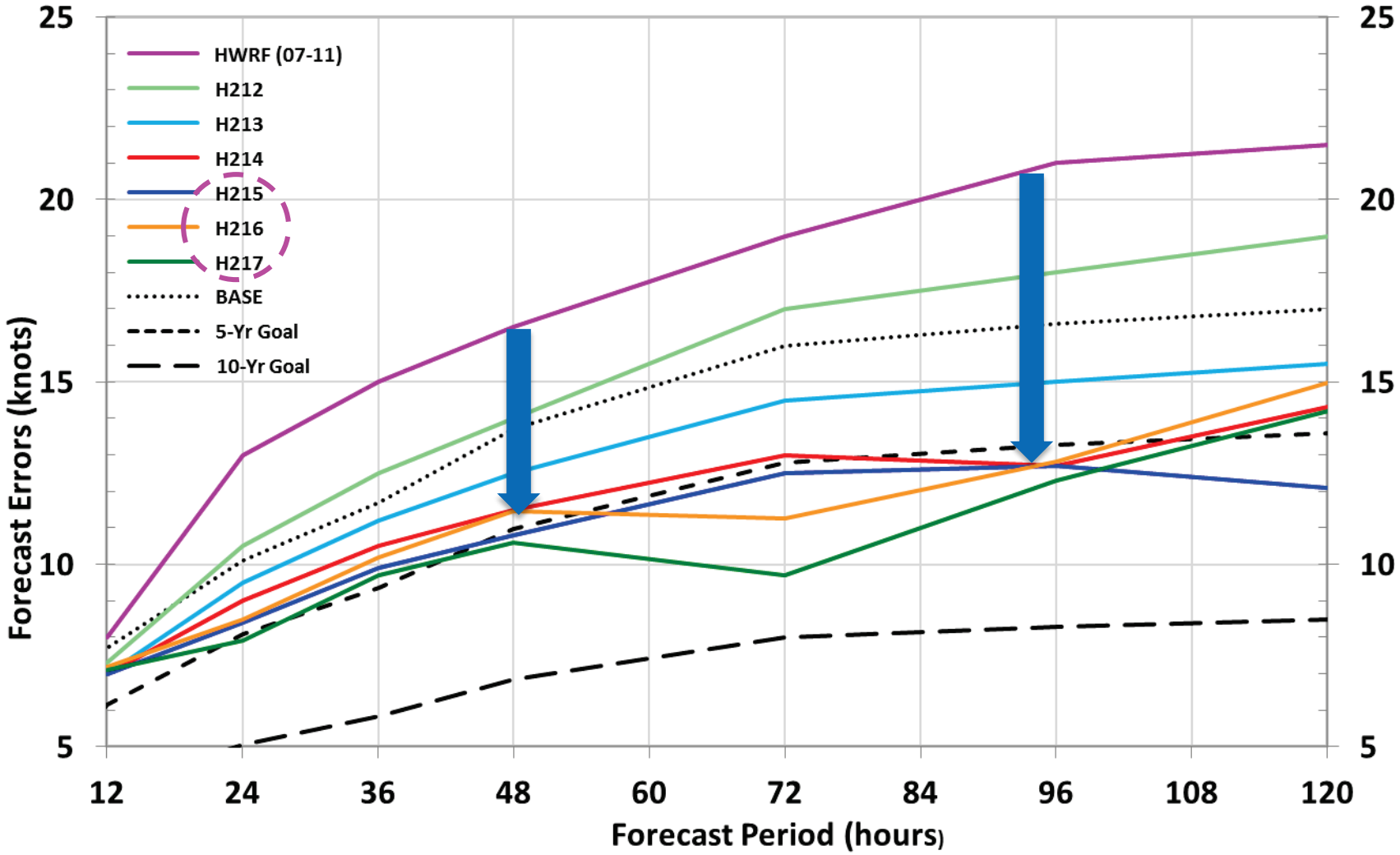


Keys to Success

- Built Partnerships: NOAA Research working closely with NCEP, and Federal & Academic Partners (NASA, NSF, ONR, NRL, NCAR)
- Diversity: Manpower to evaluate model performance with hurricane data sets
- Outreach and Community Participation
  - Developed and facilitated next generation of TC researchers for NOAA
- HFIP R&D computing has been critical
- More integrated use & support of Testbeds (JHT, DTC, JCSDA)

Achieved an approximate 20% decrease in average hurricane track and intensity forecast errors – reached our 5 yr goals.

HWRF Intensity Error Improvements Atlantic Basin (incl 2017 upgrade)



Outreach and Community Participation - Significant

- Supported HWRF, GFS, and GSI to community through DTC
  - DTC conducted HWRF training sessions twice a year from 2010-2015, two of which were international
- Conducted 10 Community Workshops on topics ranging from physics, observations, ensemble product development, satellite DA, to social science
- Supported Science Review Committee with 6 members from outside research community
- Held 4 open competitions to research community

	Award total	Number of Projects
2009	$1.00M	4
2011	$2.46M	12
2013	$3.78M	12
2016	$1.52M	5

2016 Awarded Mission-Oriented Research Grants ($1.518M – 2yrs)

Project Title	Principle Investigator	PI Affiliation	Start date	End date	Total budget (Yr 1 &2)
Evaluating Methods of Parameterizing Model Error in the HWRF Ensemble Prediction System	Ryan Torn	SUNY Albany	9/1/16	8/31/18	$328,574
Characteristics of Hurricane Intensity Error Growth and Predictability Limit in the HWRF Model	Chanh Kieu	Indiana Univ	9/1/16	8/31/18	$205,843
Probabilistic Prediction of Tropical Cyclone Track, Intensity, and Structure with an Analog Ensemble	Christopher Rozoff	Univ of Wisc	9/1/16	8/31/18	$352,627
Further Advancement of HWRF Self-consistent Ensemble-variational Hybrid Data Assimilation System to Improve High Resolution Hurricane Vortex Initialization	Xuguang Wang	Univ of Oklahoma	9/1/16	8/31/18	$292,285
Improving HWRF's Ability to Predict Rapid Change in Tropical Cyclone Intensity Governed by Internal Physical Processes	Ping Zhu	Florida Int'l Univ	9/1/16	8/31/18	$339,161

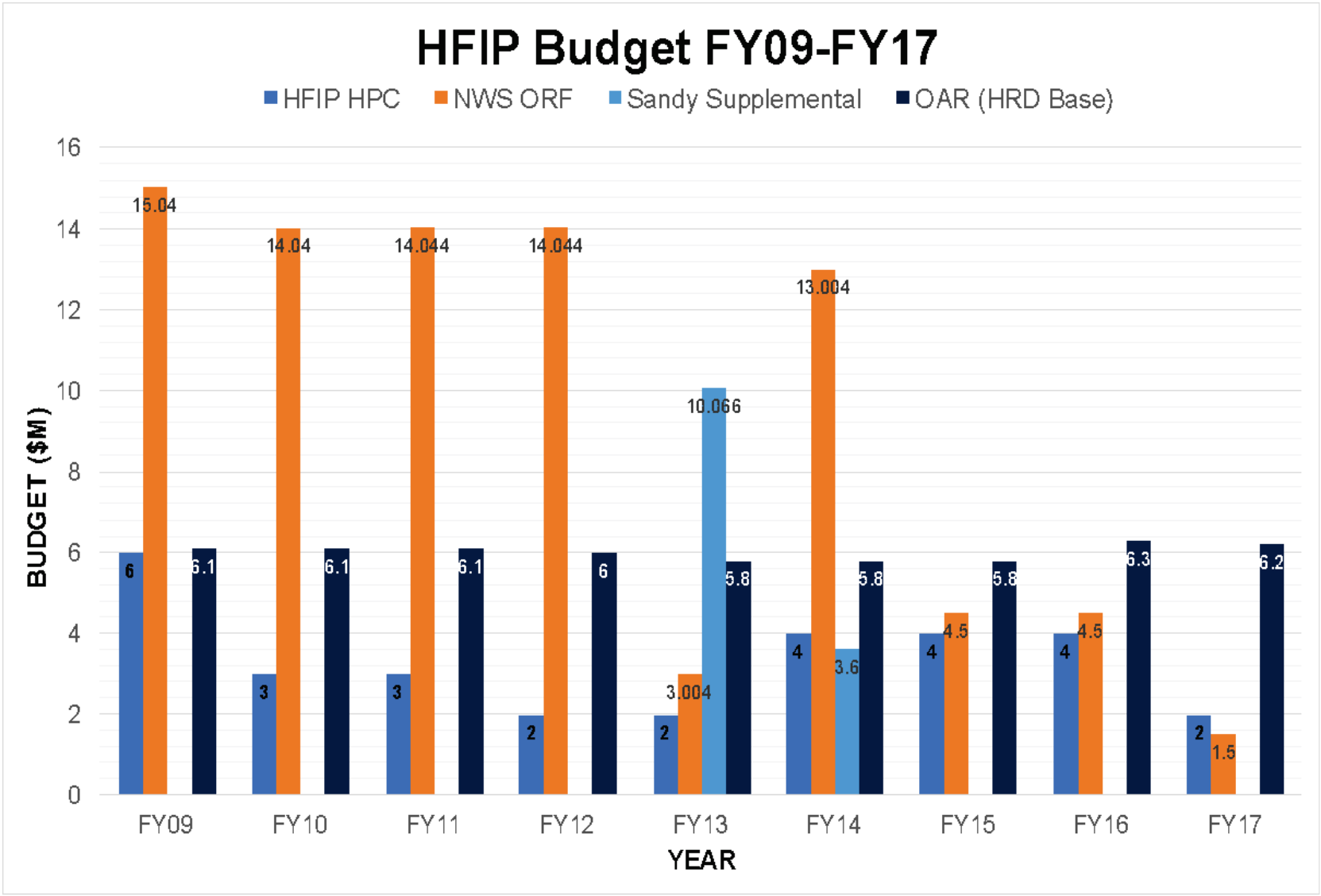
Upcoming Federal Funding Opportunities

- Upcoming: **2 companion Federal Funding Opportunities (FFO)**
- First FFO is two separate competitions: **HFIP** and NGGPS
  - HFIP: Collaborative projects with EMC or NHC researchers
  - NGGPS: Collaborative projects with EMC or CPC researchers, including S2S projects
- Open only to non-federal applications in the academic community (no funding for feds or contractors)
- Estimated funds available: **$1M for HFIP**, $2.5M for NGGPS
- 2-year projects, maximum funding $200K/year
- LOIs are strongly recommended and due December 1, 2017
- Full applications due: ~February 7, 2018
- Expected project start date: September 1, 2018

FFO Priority Areas

- Data assimilation
  - Advances in techniques using in-situ data to better depict 3-D circulation in TCs for improved initialization procedures
- Advances in the prediction sub-system
  - Hi-res model physics, BL processes, air-sea-wave-aerosols interactions
  - Hi-res vortex initialization
  - Downstream applications for landfalling storms for improved surge & inundation fcst, rainfall, size & structure
- Ensemble development
  - demonstrate the value of high resolution single model or multi-model ensemble approaches
- Post-processing techniques
  - genesis, track, intensity, surface wind structure and estimating forecast uncertainty

Appropriation History
(2009-2017)



Proposed FY18 PB funding levels

- HPC PAC funds decrease from $2M to $0
  - RDHPC Jet system will be shut off
- NWS ORF decrease $1.5M from FY16 Continuing Resolution level to $3.0M
- OAR ORF funds decreased slightly to $5.9M

Impacts:

- Significantly slowed progress since 2014
- Significantly reduced external participation
- Time to achieve 50% goal (original 10 yr goal) extended by several decades

Weather Research and Forecasting Innovation Act of 2017

Establishes the continuation of HFIP in Law

SEC. 104. HURRICANE FORECAST IMPROVEMENT PROGRAM

(a) IN GENERAL.—The Under Secretary, in collaboration with the United States weather industry and such academic entities as the Administrator considers appropriate, **shall maintain a project to improve hurricane forecasting**.

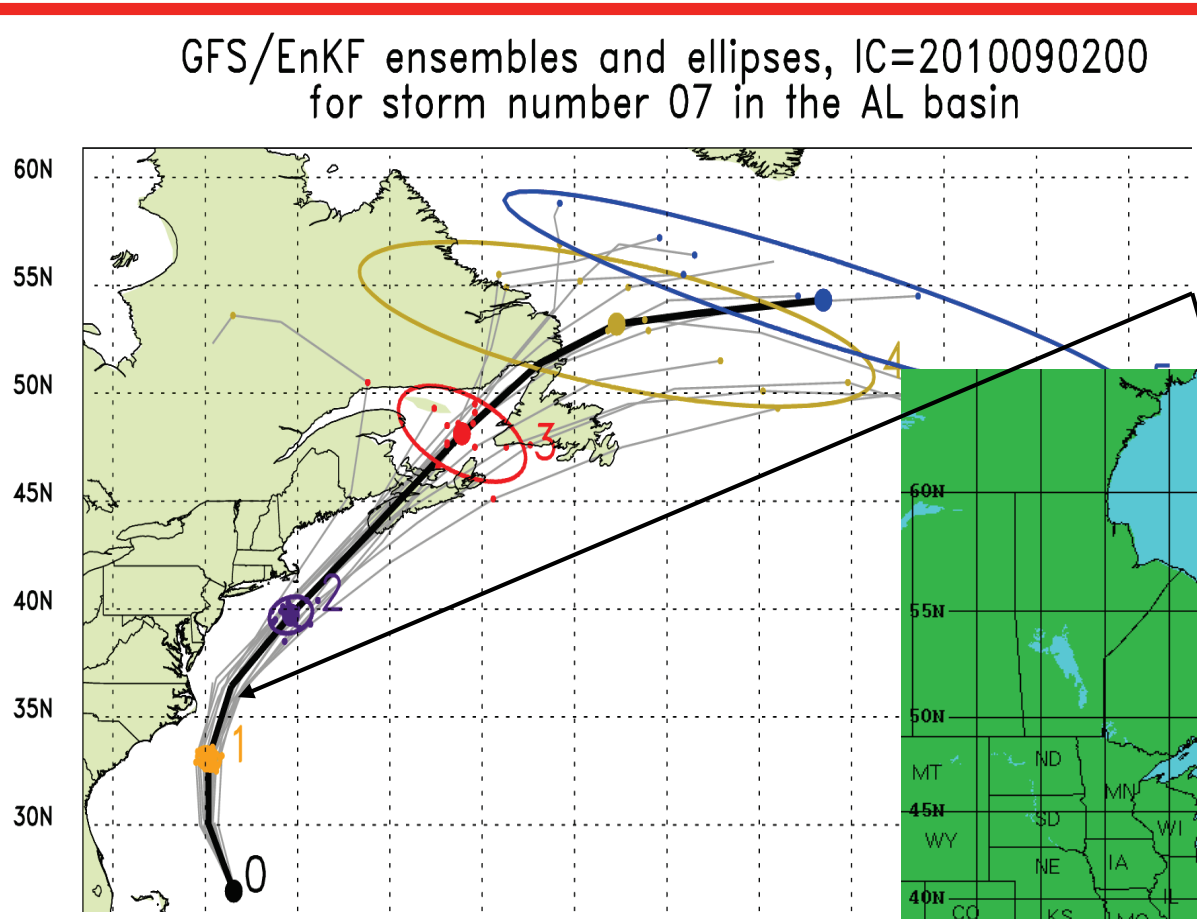
(b) GOAL.—The goal of the project maintained under subsection (a) shall be to **develop and extend accurate hurricane forecasts and warnings** in order to reduce loss of life, injury, and damage to the economy, **with a focus on**—

(1) improving **the prediction of rapid intensification and track** of hurricanes;

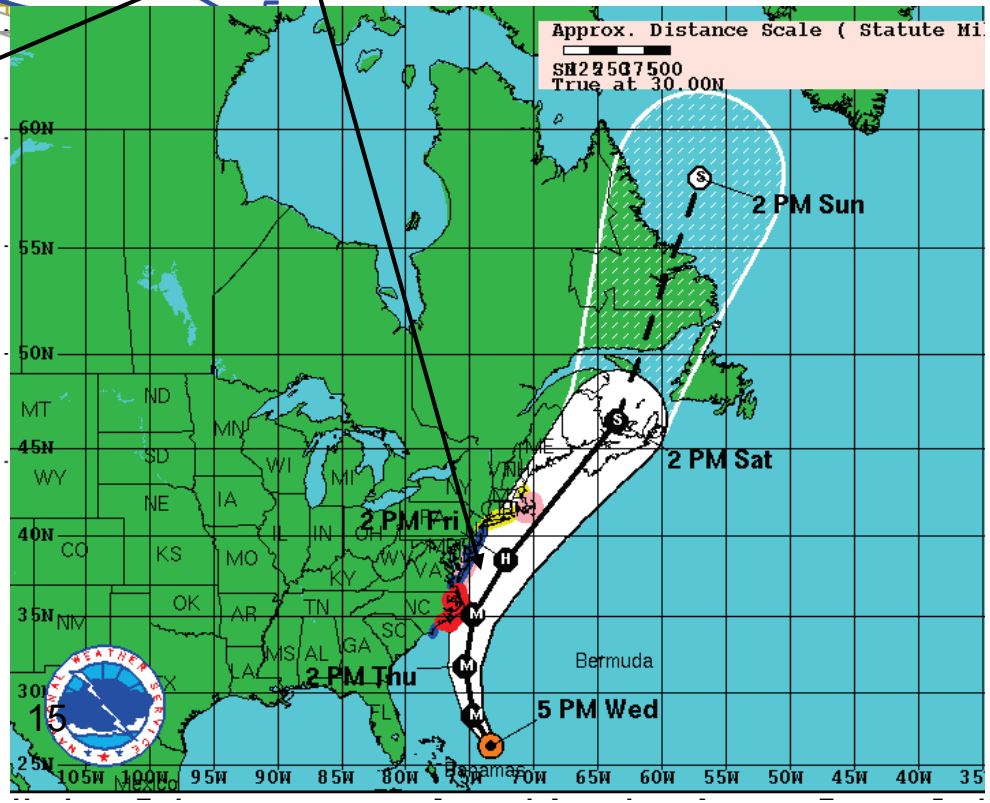
(2) improving the **forecast and communication of storm surges** from hurricanes; and

(3) incorporating **risk communication research** to create more effective watch and warning products.

Success of Earl: Reduced Evacuation Costs



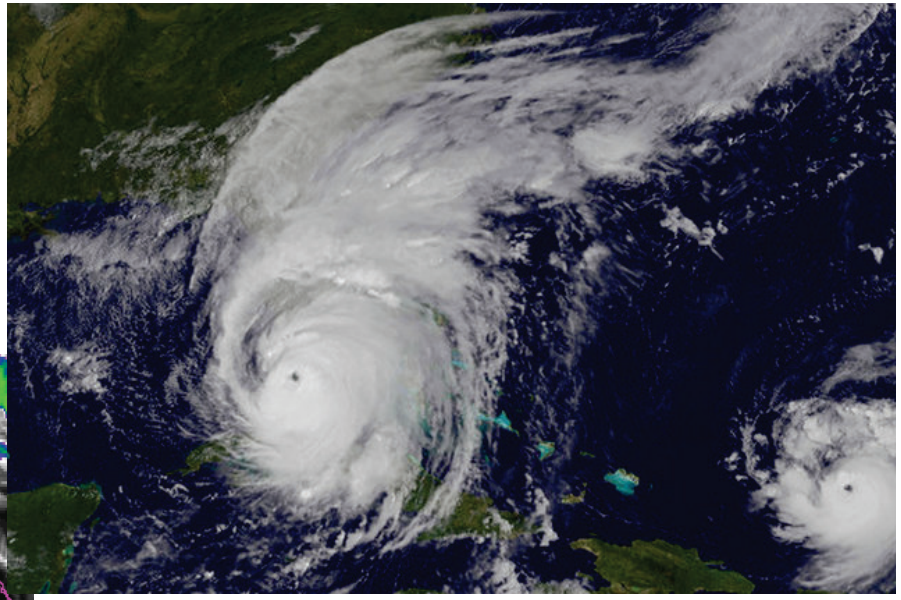
Hurricane Earl 2010 threatened to sideswipe much of the East Coast – **the entire Navy fleet at Norfolk was *not* evacuated due to the narrow cone of uncertainty** from the ensemble ellipses.

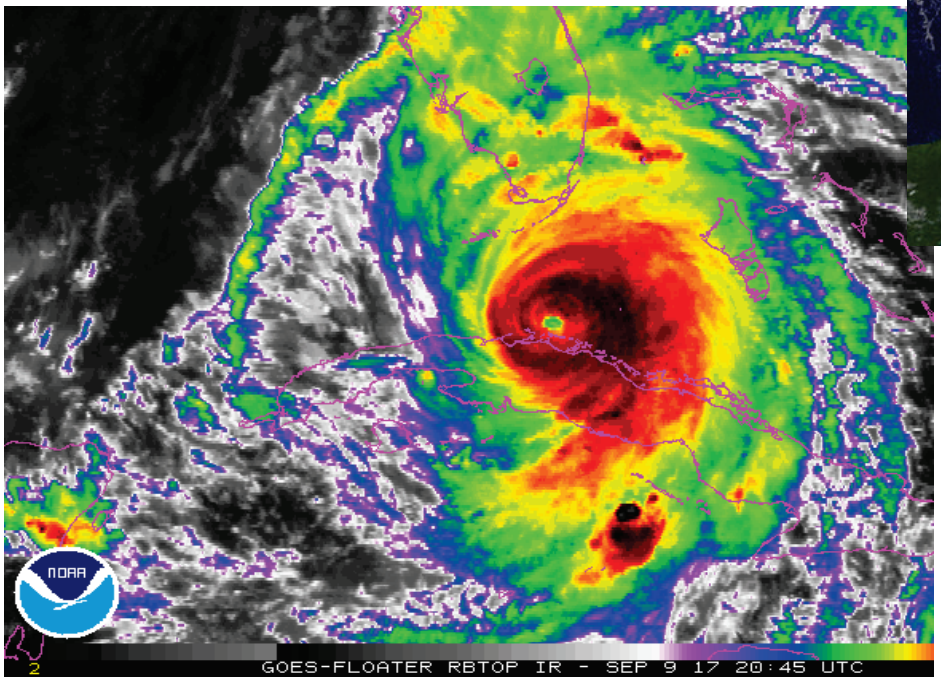


Work Still to Be Done:
Storm Size and Track Uncertainty

- Storm size of Irma stretched across 400mi; nearly 7 million residents ordered to evacuate

- HFIP 5-yr track error goal at 72hrs is 100nm while the state of Florida is 90mi in diameter





Work Still to Be Done

- Reestablish dedicated HFIP computing; refresh aging cores
- Improve size, track and intensity skill at longer range - accelerate development of HWRF based systems within FV3
- Improve guidance on genesis, and extend the forecast skill from 5 to 7 days
- Improve total water predictions due to landfalling storms
- Accelerate development to increase resolution to fully-resolve convection in the eye-wall
- Improve satellite data assimilation
- Improve NHC products
- Develop techniques and products addressing probabilistic hurricane genesis, track uncertainty at longer lead-times

Back Up

Appropriation History
(2009-2017)

	FY09	FY10	FY11	FY12	FY13	FY14	FY15	FY16	FY17
WCOSS PAC (HFIP	6.000M	3.000M	3.000M	2.000M	2.000M	4.000M	4.000M	4.000M	2.000M
NWS ORF	*15.040M	*14.040M	*14.044M	*14.044M 8.540M Due to NWS reprogram	**13.004M 1.999M Due to NWS reprogram	13.004M 3.2M due to reprogram of Sandy	4.500M	4.500M	1.500M (PB) Under 6mo CR
Hurr Sandy Suppl					10.066M	3.600M Use for FY14 R2O Enhancement			
OAR ORF	6.100M	6.100M	6.100M	6.000M	5.800M	5.800M	5.800M	5.800M	5.800M
TOTAL	*$27.140M	*$23.140M	*$23.144M	*$18.540M	*$22.737M	*$22.804M	$14.300M	$14.300M	$9.300M

*Includes $1,040K in NCEP Base allocation for HWRF and SLOSH O&M
** OMB Restored NOAA and DOC proposed reductions

Near-Term Priorities under 2017 Budget Reduction

- Leverage NGGPS resources to maintain cross-NOAA and external community involvement
- Operational Partnership for Multi-Model Ensembles in all Basins
- Focus on improvements of model physics (scale aware), vortex initialization and data assimilation
- Evolution of Hurricane Forecast System includes:
  - global-to-local scale predictions with emphasis on multi-scale interactions
  - Improved forecasts for land falling storms and downstream applications
  - Precipitation after land fall
  - Development of Nesting Technology
- Continued focus on high-resolution ensembles, advanced air-sea-wave-land-hydrology coupled systems
- Improved products to the forecasters

We Will Achieve Long Term Goals – just will take little longer!

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R&D HPC
Configuration of Jet System

	Install Date	Total Cores	Performance (Tflops)	Storage (TB)
Phase 1 (Njet)	Aug 2009	3184	35.6	350
Phase 2 (Tjet)	Aug 2010	10600	113.0	416
Phase 3 (Ujet)	Oct 2011	16648	182.0	1166
Phase 4 (Sjet)	Aug 2012	22088	272.0	1613
Phase 5 (Vjet)	Aug 2014	24456	340.26	3261
Phase 6 (Xjet)	Oct 2015	32520	576	3773
Phase 7 (Xjet+) expansion	Aug 2016	45388	820	4400