HFIP Project Overview

for

NOAA/WSWC Seasonal Forecasting Workshop

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Project Overview

- Motivated Advocacy
- Tangible Societal Benefits
- Empowered Leadership
- Aggressive Goals
- Solid Technical Strategy
- Community Effort
- Critical Mass of Resources

Key Elements of HFIP Success

HFIP Motivation
Reduced Evacuation Costs

- **Executive Office of President, Statement of Administration Policy, Oct 5, 2008**:
  - "… the administration urges the Congress … to support accelerated improvement of hurricane track and intensity forecasts, which will help to prevent unnecessary and costly evacuations."
- **Improved forecasts**
  - Increased forecast accuracy at longer lead times, especially during periods of rapid intensity changes; raise confidence levels for all forecast periods
  - Reduced over-warning
- **More effective emergency management response**
  - Reduced Evacuations
  - Overall reduction in preventable economic losses
  - Hundreds of millions of dollars saved annually

HFIP Provides Tangible Economic Benefit

Forecasting Techniques

- Additional R&D in hurricane dynamics, physics, and environmental interaction
- Improved algorithm and forecasting techniques in hurricane track, intensity, and storm surge
- Accelerate R2O

Computing and Modeling

- Increased MET observations including dropsondes, UASs, aircraft
- Higher resolution models

Enhanced computation capacity

Track forecast improvement

- **Hurricane Charlie – 2004**
- **Hurricane Floyd – 1999**

Track forecast inaccuracy in each storm forced major evacuations of areas ultimately not affected by the storm → **Improved track forecasting could mitigate this!**

- Estimated evacuation cost avoidance: **$1000/person**

- Potential evacuation avoidance **CHARLIE: 380K people**

  Potential Savings: $380M
- Potential evacuation avoidance **LILI: 225K people**

  Potential Savings: $225M

Intensity forecast improvement

- **Wilma – 2005**
- **Lili – 2002**

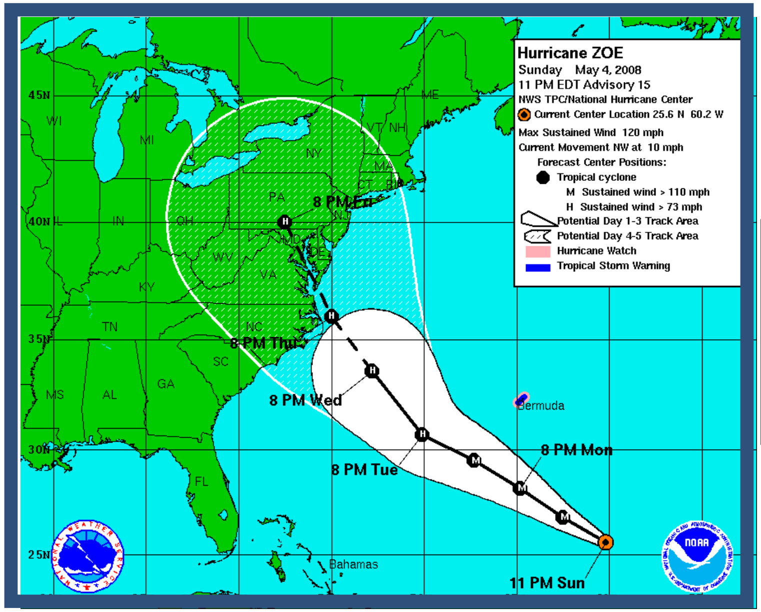
Neither Wilma's explosive intensification, nor Lili's rapid weakening just before landfall, was accurately forecast. Lack of forecast skill with rapid changes in hurricane can lead to improper warnings, with significant economic consequences → **Improved intensity forecasting could mitigate this!**

HFIP Charter and Leadership

- **HFIP Charter signed August 1, 2007**
- **Hurricane Executive Oversight Board**
  - Jointly chaired by AA for National Weather Services and AA for Oceanic and Atmospheric Research
  - Cross-NOAA Membership
- **HFIP Management**
  - Project Manager: Fred Toepfer, NWS/STI
  - Development Manager: Vijay Tallapragada, NCEP/EMC
  - Research Lead: Frank Marks, OAR/AOML/HRD
  - Operations Lead: Ed Rappaport, NCEP/NHC

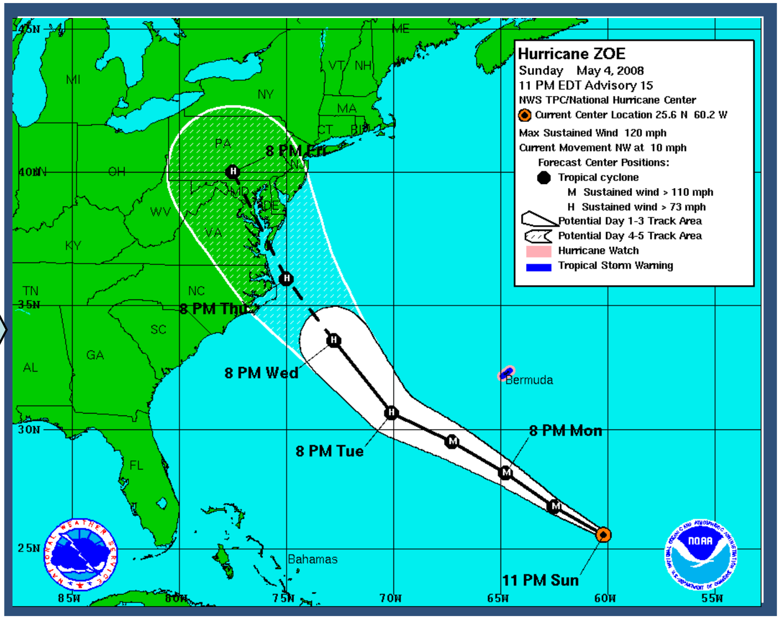
Goal of Track Forecast Improvement

Track forecasts at the start of HFIP



50% reduced forecast errors

10-yr Goal of Track Forecasts



- **50% improvements to hurricane track and intensity forecasts out to 7 days**
- **Reduce cone of uncertainty**

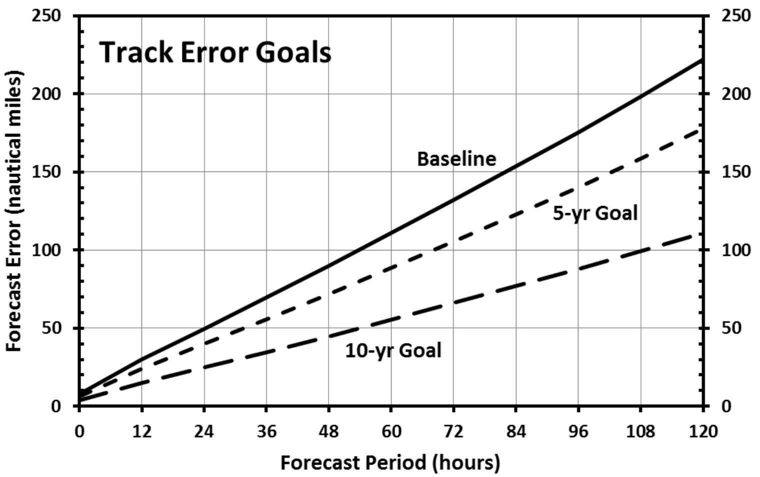
Aggressive Goals
HFIP Performance Goals

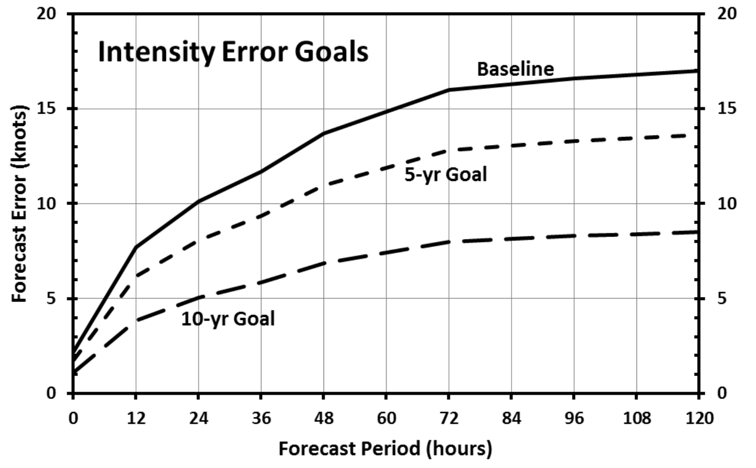
Vision

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 day 1 to day 5
  - 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 detection (POD) for rapid intensity change to 90% at day 1 decreasing linearly to 60% at day 5
- Decrease the false alarm ratio (FAR) for rapid intensity change to 10% for Day 1 increasing linearly to 30% at Day 5
- Improve storm surge prediction





Key to Success: Community Engagement with Accelerated Research to Operations

Overall Technical Strategy

- Use global models at as high a resolution as possible to forecast track out to 7 days
- Use regional models at 1-3 km resolution to predict inner core structure to meet intensity goals out to 5 days including rapid intensification
- Hybrid DA for both regional and global using as much satellite and aircraft data as possible
- Both regional and global models run as an ensemble
- Statistical post processing of model output to further increase forecast skill

Accelerating Transition of Research to Operations

Key Steps Implemented to Include Broader Community and Accelerate Research to Operations:

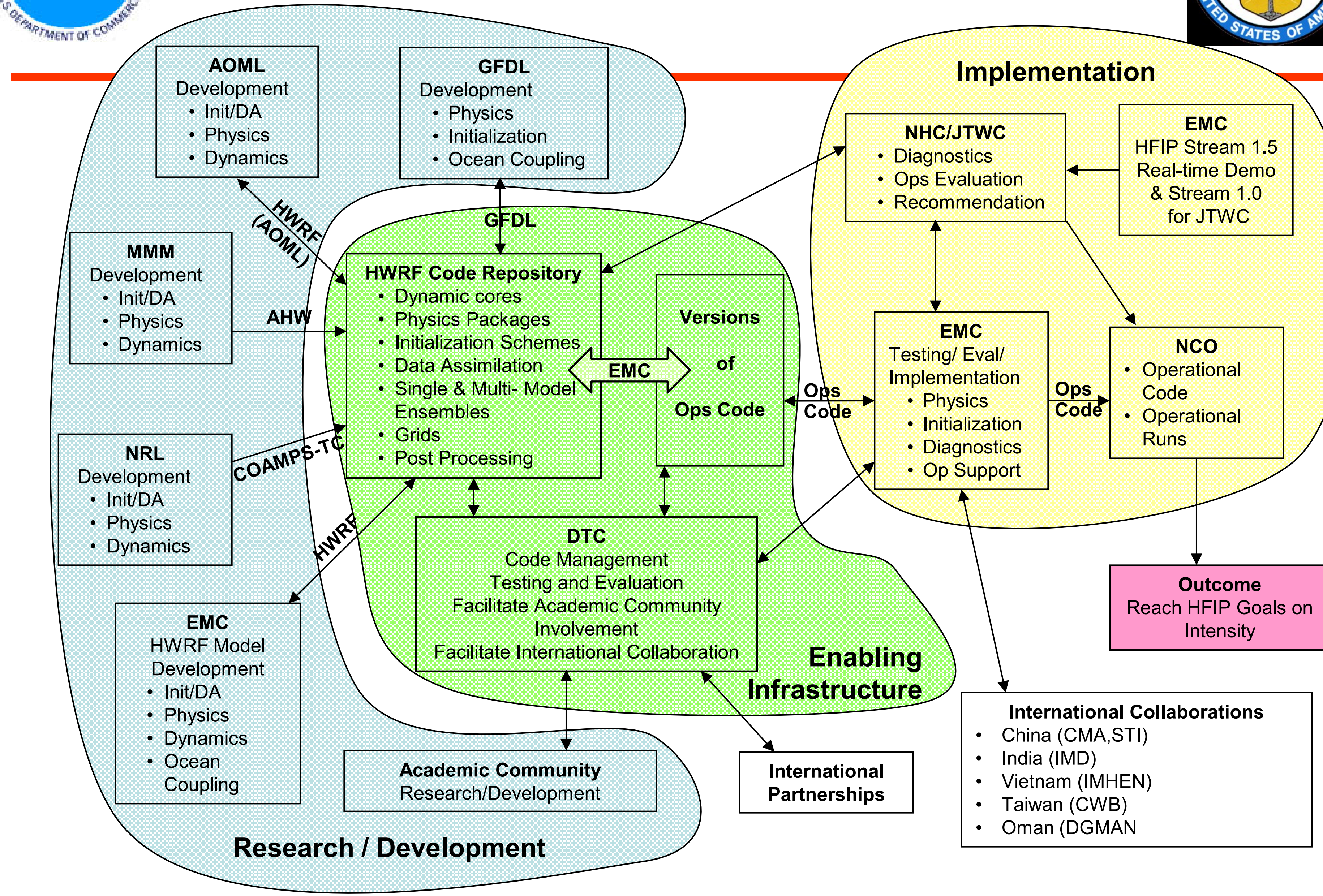
- Aligned research efforts within NOAA and with interagency and academic partners by establishing focused cross-collaborative development teams of subject matter experts from the research and operations communities

- Established a process to leverage outside research capabilities in support of project objectives (Federally funded grantees working within a community code repository);

- Defined and implemented a solution (the seasonal, real-time experimental forecast system) to accelerate research into operational products; and

- Established a high performance computing infrastructure and attendant protocols to support research-to-operations activities.

Operational Hurricane Modeling System Development



HFIP Strategic Teams

HFIP Teams	Contributions for Research Transitioned to Operations
Model and Physics Strategy Team	Strategic design of annual upgrade implementation plans Establish infrastructure and support for community model development Engage research community in advancing research and development for hurricane modeling techniques and physics
Data Assimilation / Ensemble Strategy Team	Develop advanced vortex scale data assimilation techniques: Ensemble based hybrid EnKF-3DVAR DA, self-cycled high-resolution EnKF based ensembles for DA, cloudy radiance assimilation using innovative microphysics independent techniques Impact assessment of aircraft data, GOES AMVs, microwave derived temperature anomalies and other cloud impacted satellite radiance data
Post-Processing and Verification	Advanced synthetic satellite imagery; high-frequency model output for track, intensity and structure; hurricane related tornado genesis products, ensemble based probabilistic products for genesis, wind and precipitation; statistical predictors for intensity using consensus of global and regional models (SPICE); advanced model diagnostics tools and verification techniques
Socio-economic Team	Determine best ways to convey tropical cyclone risk and uncertainty and present NHC products, information and services

HFIP Tiger Teams

HFIP Tiger Teams	Contributions for Research Transitioned to Operations
HiRes Physics *(components in bold transitioned to ops)*	Test most promising alternate physics packages ((2011-2012-2013) ***NOAH LSM, RRTMG Radiation; Observations based GFS PBL and GFDL Surface Physics; GFS Shallow Convection;*** MYJ PBL; Thompson MP, Meso-SAS convection etc.
Radar Data Impact	Test and evaluate impact of Aircraft Reconnaissance Data assimilation. (2012-2013-2014): ***One-way hybrid DA for TDR and dropsonde data outside the inner core; 40-member warm start HWRF ensemble based DA with all inner core data including GH/UAV sondes.***
Satellite Data Impact	Regional hybrid system for testing and assessing the impacts of satellite data assimilated in hurricane models (2013-2014-2015): AMSU temperature anomalies, high-res GOES AMVs, ***clear-sky radiance***
Ocean Model Impact	Document the importance of ocean model impacts on hurricane intensity prediction: (2014-2015): Design and develop new and ***improved ocean initialization techniques*** and physics at air-sea interactions using observations
HFIP Website	Test and evaluate most promising techniques evaluated by NHC and products displayed on HFIP website

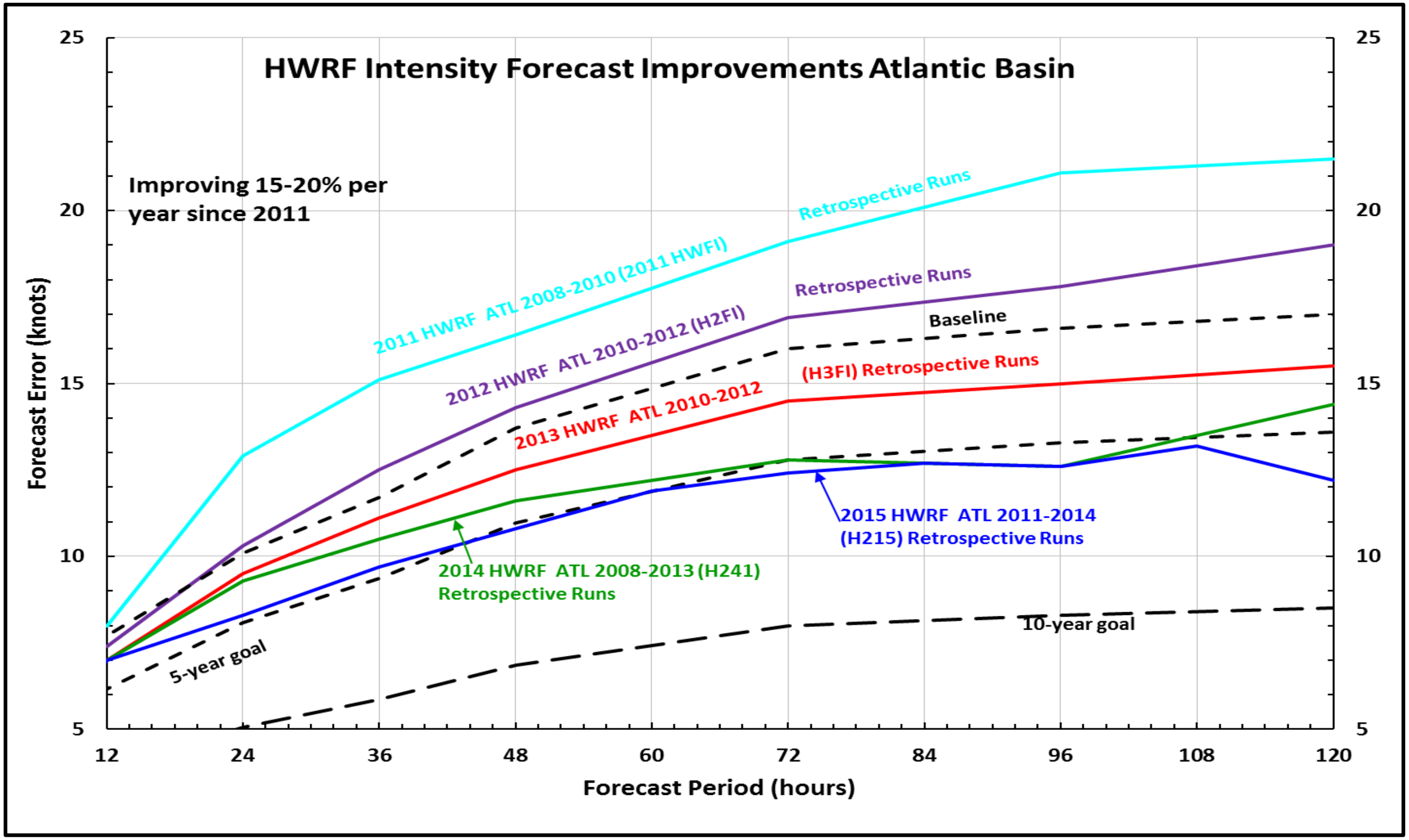
R&D HPC Configuration of Jet System

	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)	Sep 2015	32250	576	3773

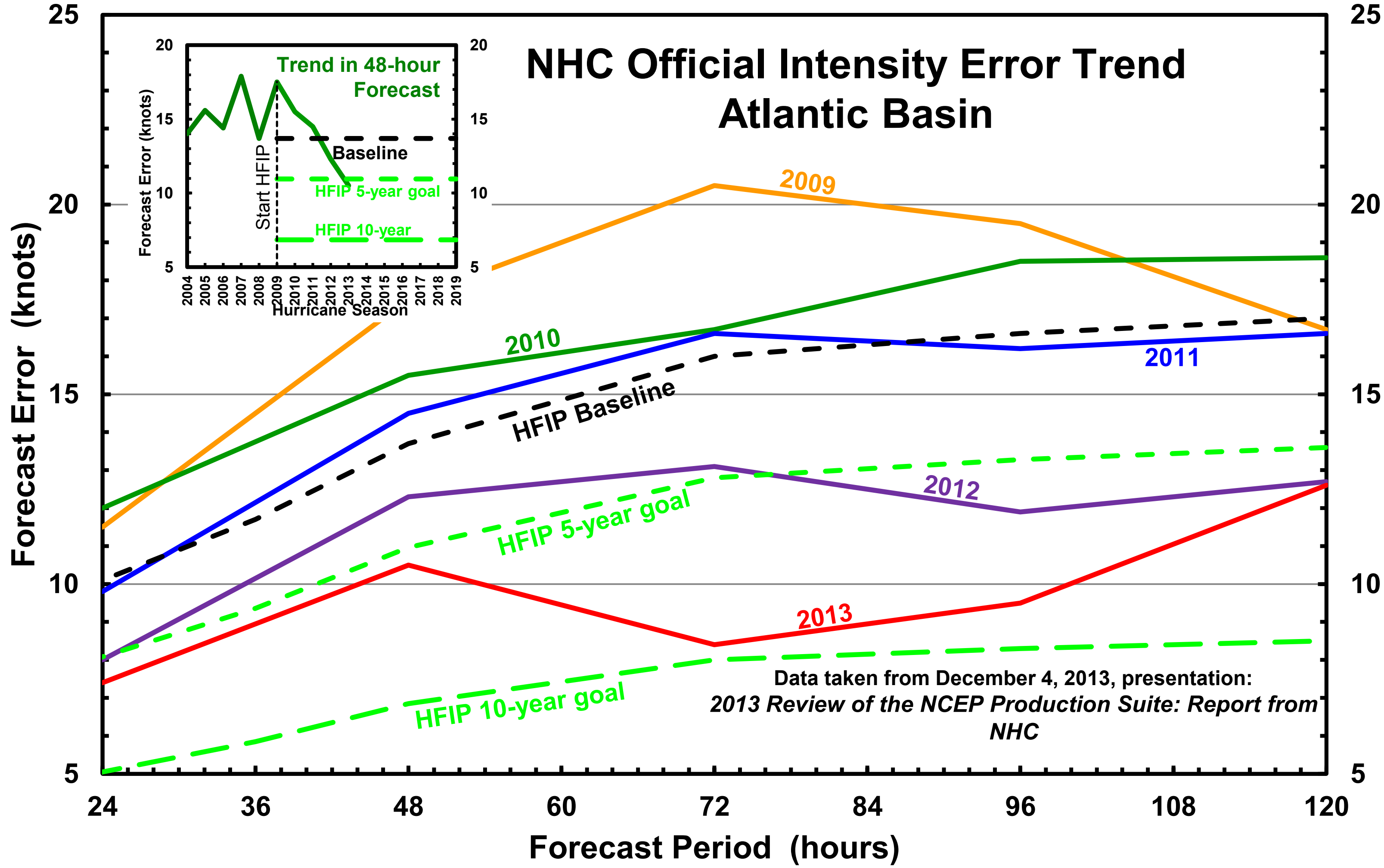
Success!
5 – Year Goals Met in 5 Years

4 years of continuous improvements in intensity forecasts

HWRF Intensity Error Improvements
Atlantic Basin (2011-2015)



Hurricane Forecast Improvement Project
NHC Intensity Error Trend



In Closing!

- Useful Seasonal Precipitation Forecasts are a Societal Imperative
- Solid Plan is Critical
- Opportunity will come with Plan

Thank You

Questions?