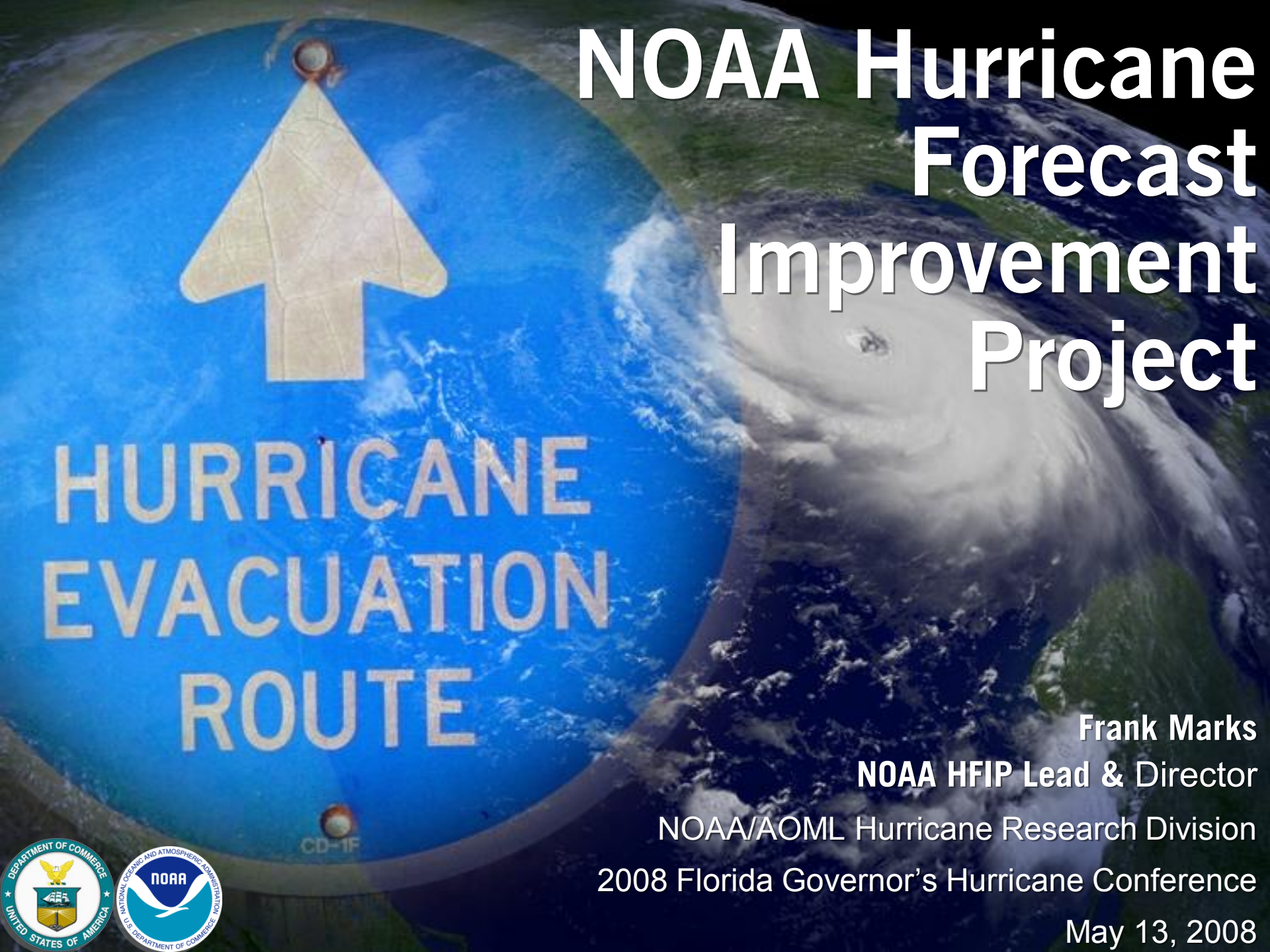


NOAA Hurricane Forecast Improvement Project

Frank Marks
NOAA HFIP Lead & Director
NOAA/AOML Hurricane Research Division

2008 Florida Governor's Hurricane Conference

May 13, 2008

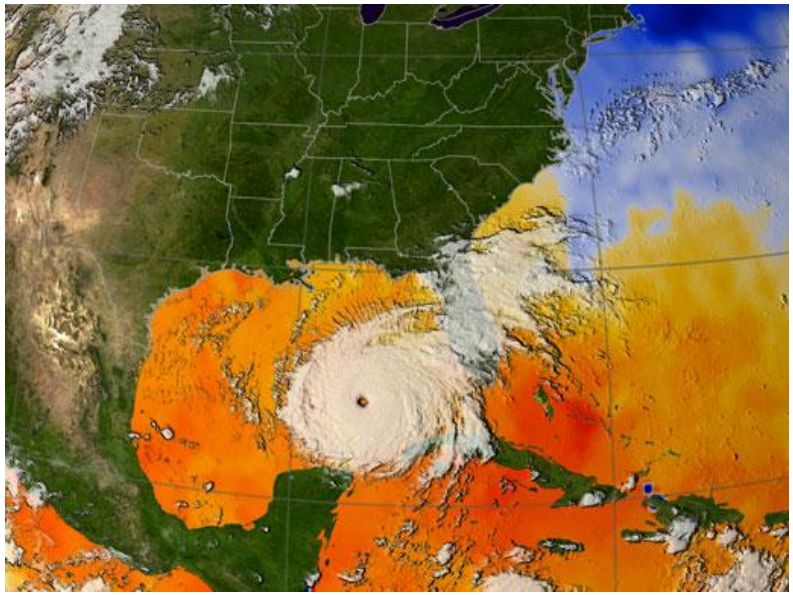
Outline

Where are we now with hurricane forecasting?

NOAA Hurricane Forecast Improvement Project (HFIP)

Preliminary Metrics of HFIP

What is important to you?



Current Capabilities

Track: NOAA reduced track error by about 50% since 1990 (current error is ~100 nm at 48 hr)

Intensity: Little progress has been made to reduce the intensity forecast error (current error is ~14 kt at 48 hr)

Storm Size: Progress is difficult to measure due to inadequate observations

Storm Surge: Accurate to within ±20% when track, intensity, and size are known

Lead Time: Lead time was extended from 3 to 5 days in 2001

Precipitation Forecasts: Modest annual improvements; forecast patterns match observations when track error is low

New/Improved Products: Refined calculation of cone graphic, wind speed probabilities, graphical tropical weather outlook, and probabilistic storm surge

Social/Behavioral Science: In its infancy

Improvements are still needed!

Given recent events,

- Katrina and Wilma causing catastrophic damage in 2005
- Back-to-back Category 5 storms in the Caribbean Sea - Dean and Felix in 2007
- Rapid intensifiers just prior to landfall – Charley (2004) and Humberto (2007)
- National reports calling for major investments in hurricane research

The time is now for NOAA to lead an aggressive effort with commensurate investments to improve its hurricane forecasting capability.

NOAA HURRICANE FORECAST IMPROVEMENT PROJECT

NOAA established the 10-year Hurricane Forecast Improvement Project in May 2007 and a project plan is under development

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)

NOAA HURRICANE FORECAST IMPROVEMENT PROJECT

- **Unified NOAA approach** to **guide and accelerate improvements in forecasts**, with **emphasis on rapid intensity change**, and **reduction in uncertainty**.
- Improve forecasts and increase confidence to **enhance mitigation and preparedness decisions**.
- Responds to input from stakeholders, **NSB**, **OFCM**, and **HIRWG** reports.
- Embraces **strong collaboration** with non-NOAA partners with objective to **transition research into operations**.

Overarching HFIP Goal

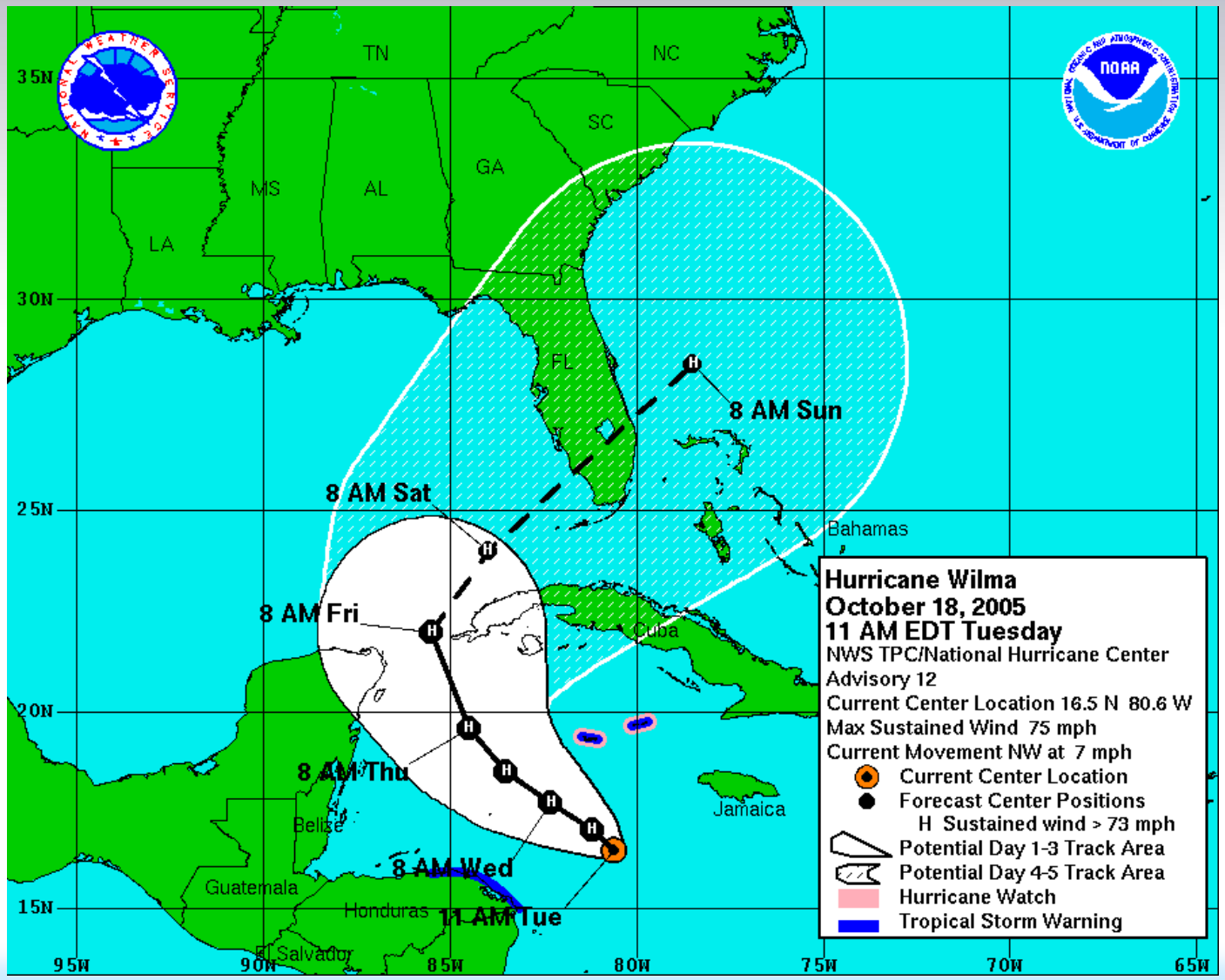
The goal of HFIP is to improve forecasts and warnings of tropical cyclones and increase the confidence in those forecasts in order to enhance mitigation and preparedness decisions by emergency management officials at all levels of government and by individuals

Preliminary Metric #1

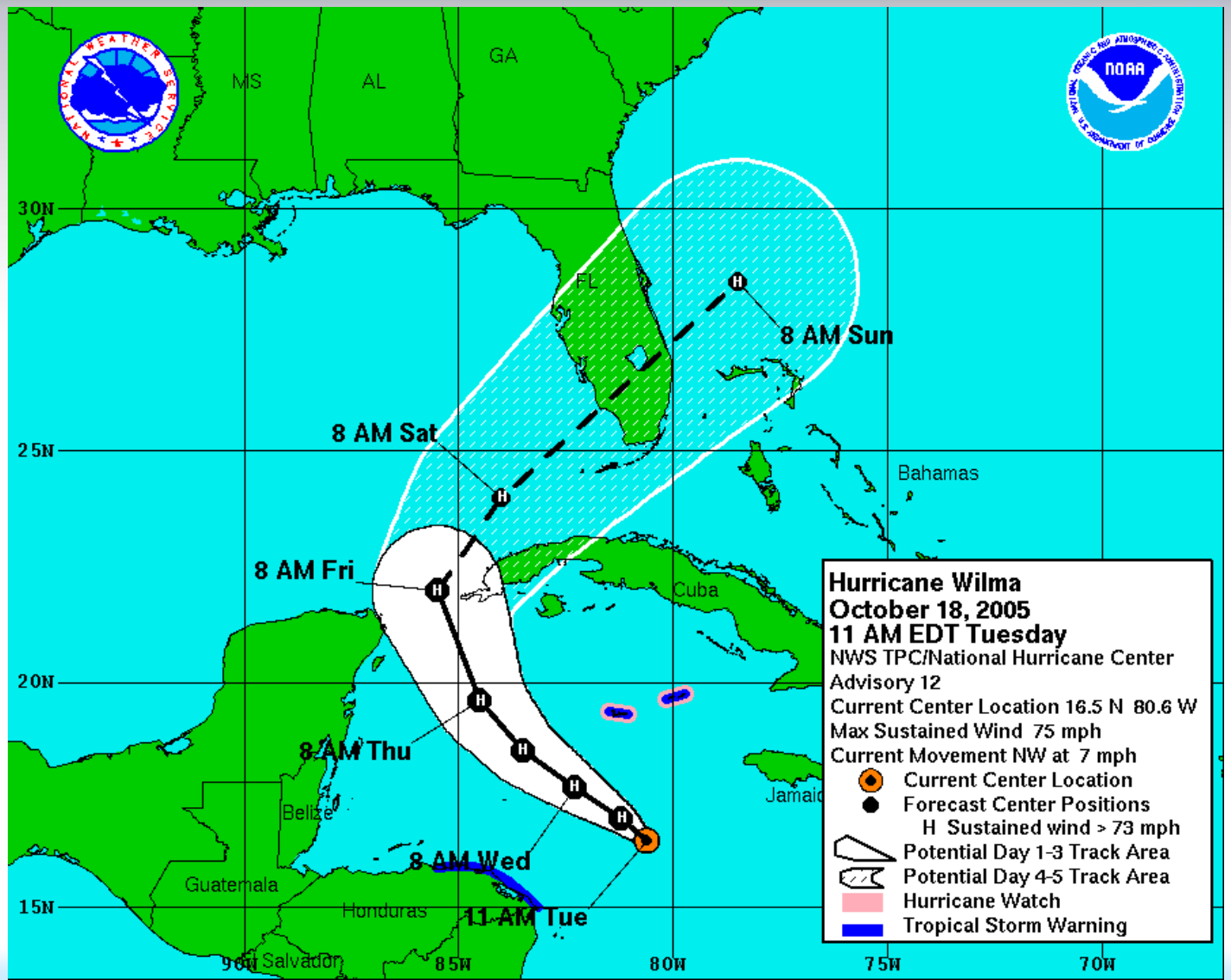
Reduce track error by 50% at all lead times

EXAMPLE: The 2007 average model error at 48 hours is ~100 nm – our goal would then be ~50 nm at 48 hours

Hurricane Wilma (today's track error)



Hurricane Wilma (HFIP goal)

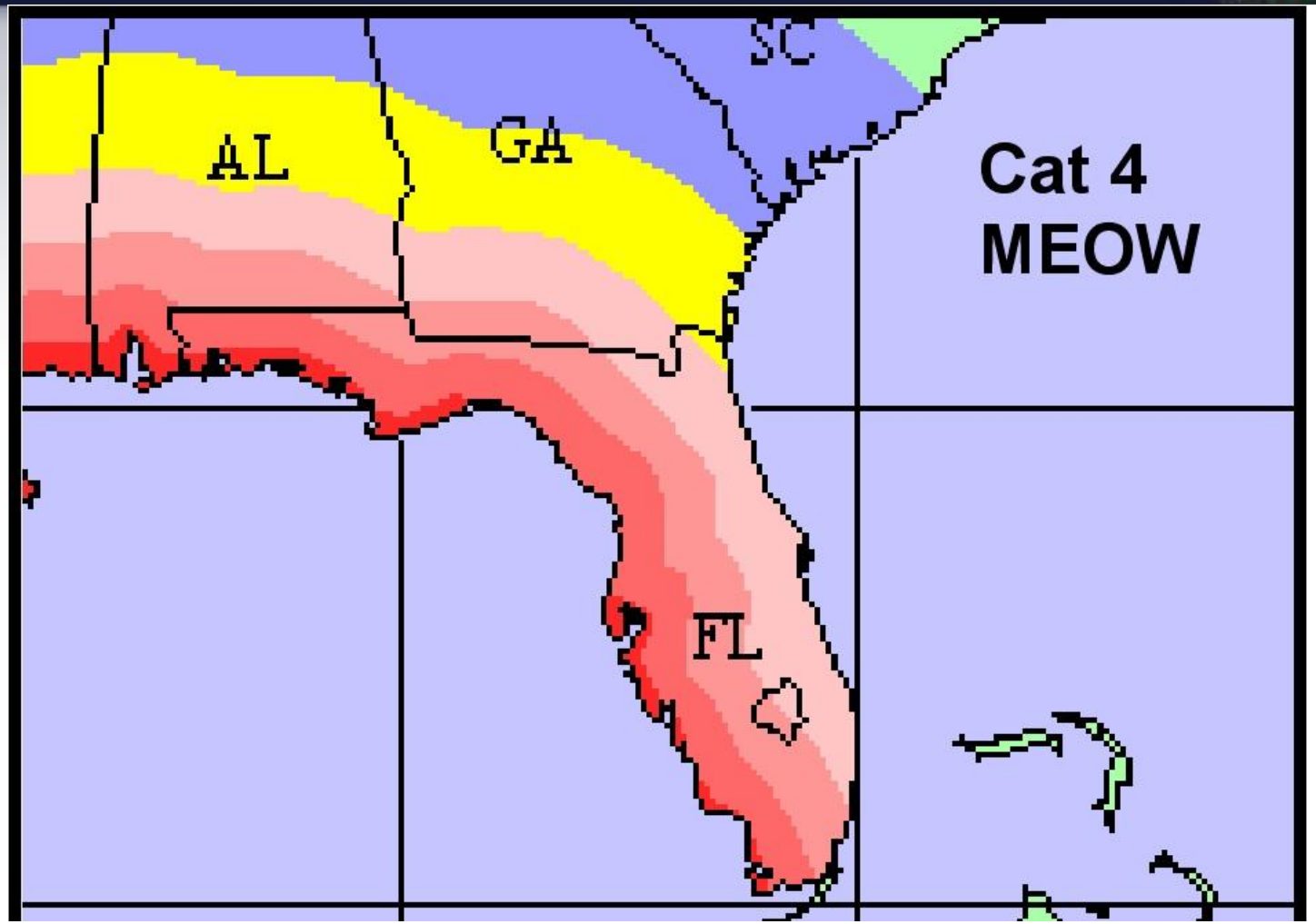


Preliminary Metric #2

Reduce intensity error by 50% at all lead times

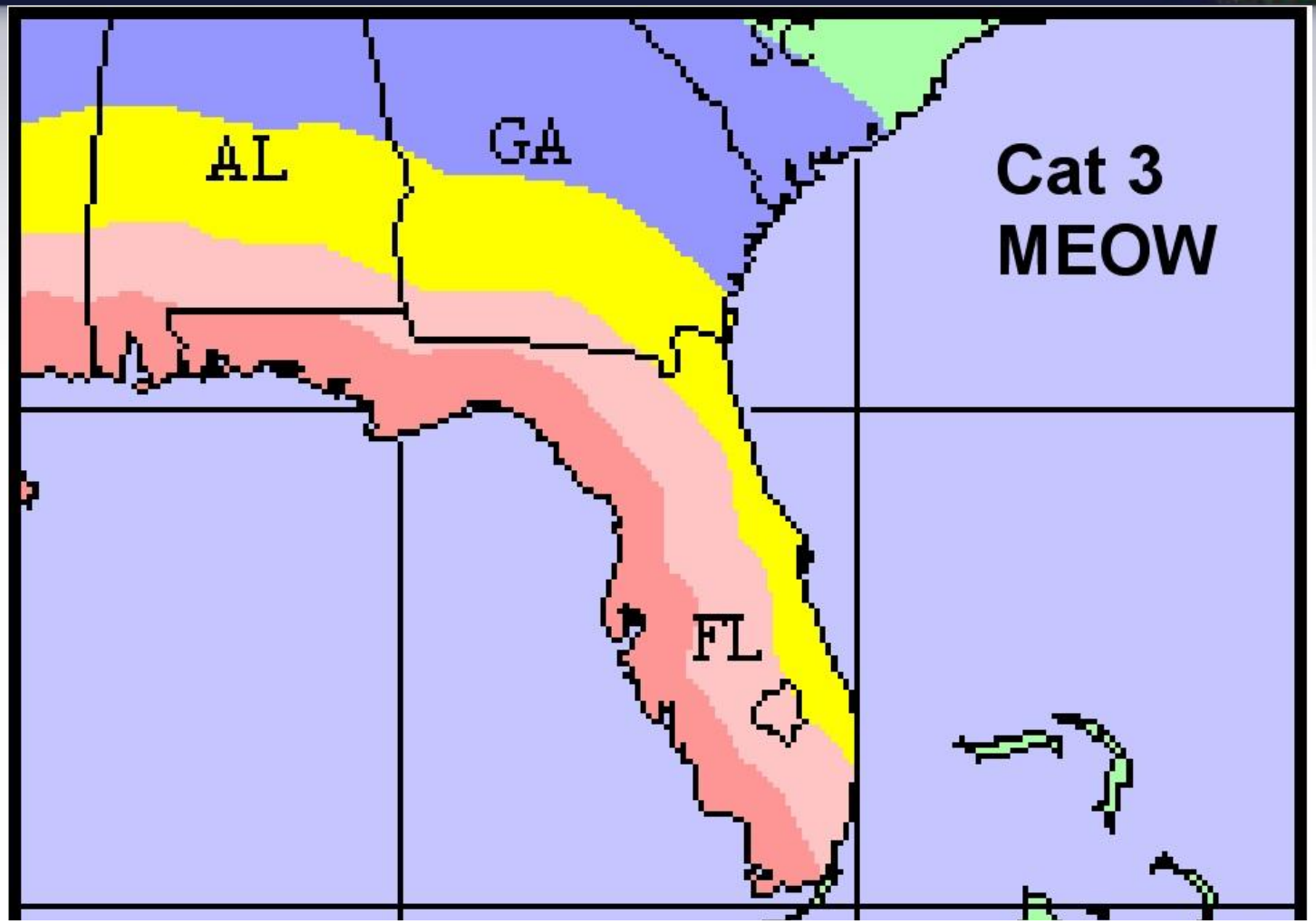
EXAMPLE: The 2007 average model error at 48 hours is ~14 kt or nearly the wind speed range of 1 Category – our goal would be ~7 kt at 48 hours

Typical Cat-4 MEOW



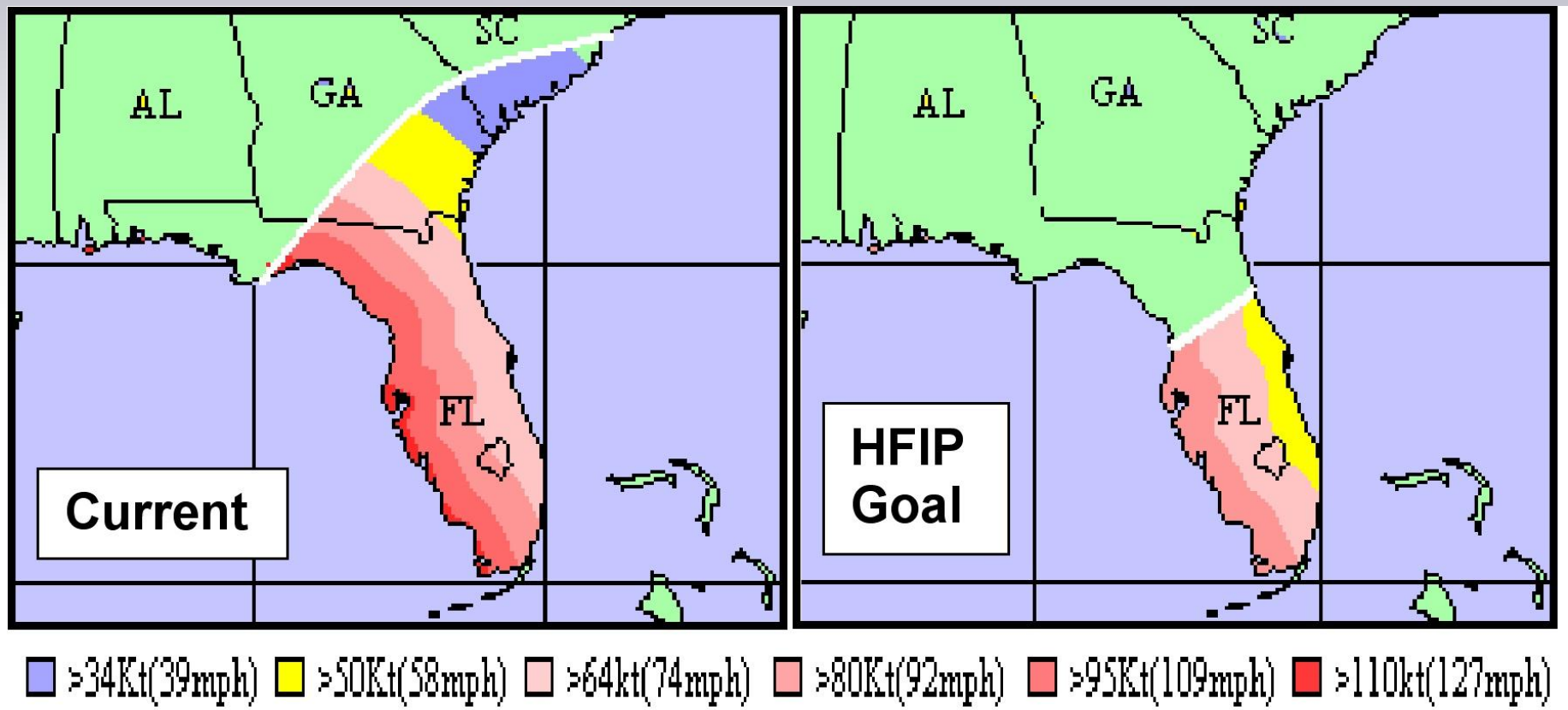
>34Kt(39mph) >50Kt(58mph) >64kt(74mph) >80Kt(92mph) >95Kt(109mph) >110kt(127mph)

Typical Cat-3 MEOW



>34Kt(39mph) >50Kt(58mph) >64kt(74mph) >80Kt(92mph) >95Kt(109mph) >110kt(127mph)

HFIP versus current



50% improvement in intensity and track for the Gulf Coast cases

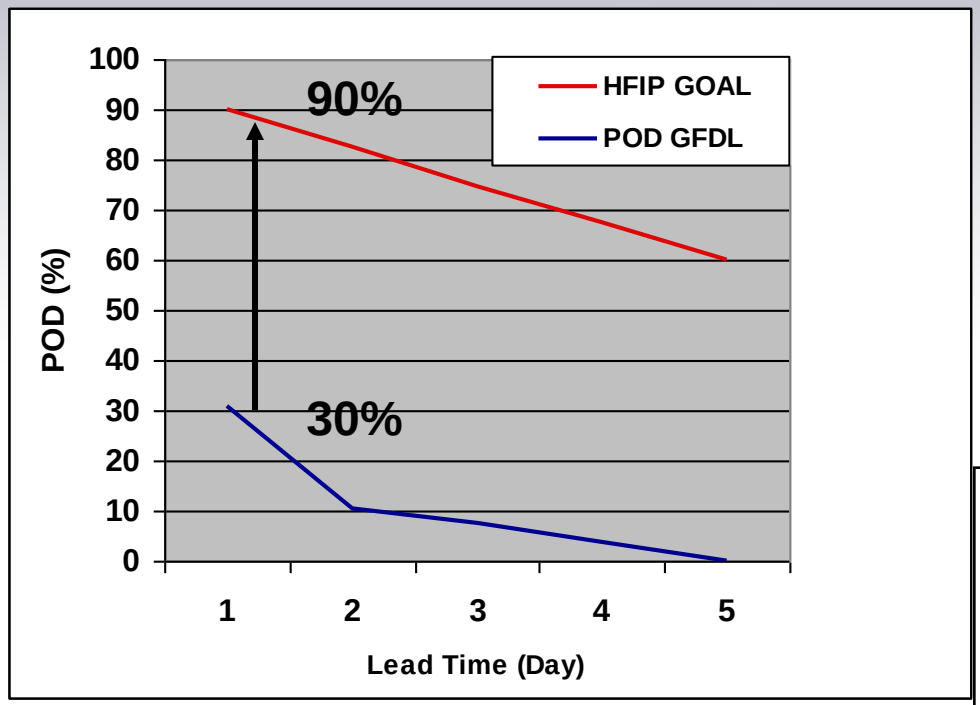
Preliminary Metric #3

Increase the Probability of Detection and reduce the False Alarm Ratio of rapid intensification events

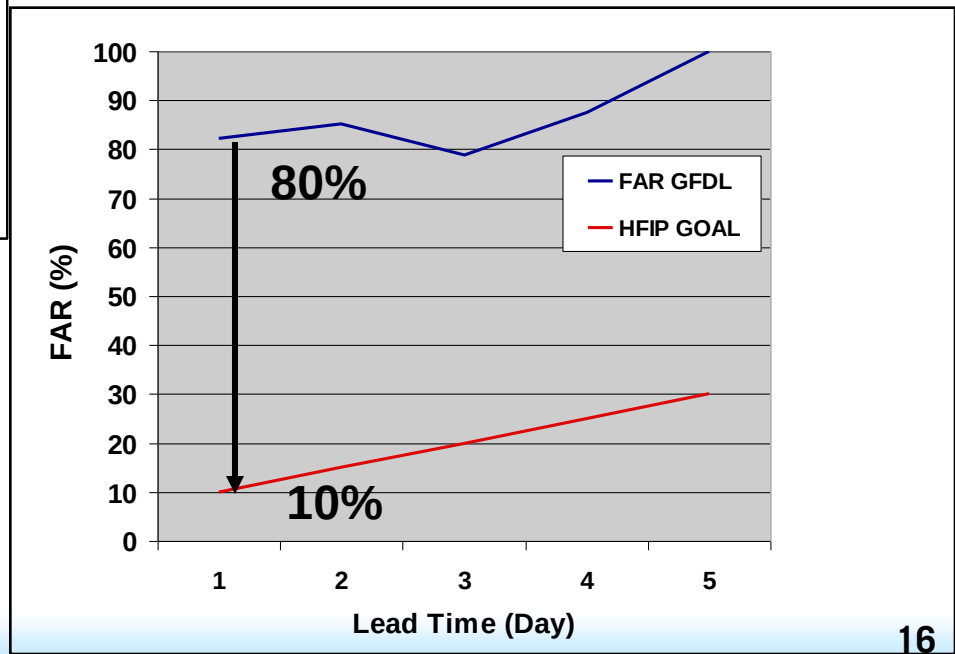
Rapid intensity (RI) change (≥30 kt in 24 hours or ~2 Categories on the Saffir-Simpson Hurricane Scale) has a significant impact on preparedness and evacuation actions for emergency managers

- Greatest forecast challenge for hurricane forecasters
- Not handled well by current operational models
- 83% of major hurricanes have at least 1 RI event
- Major hurricanes are responsible for 80% of all hurricane damage

Rapid Intensification Metric



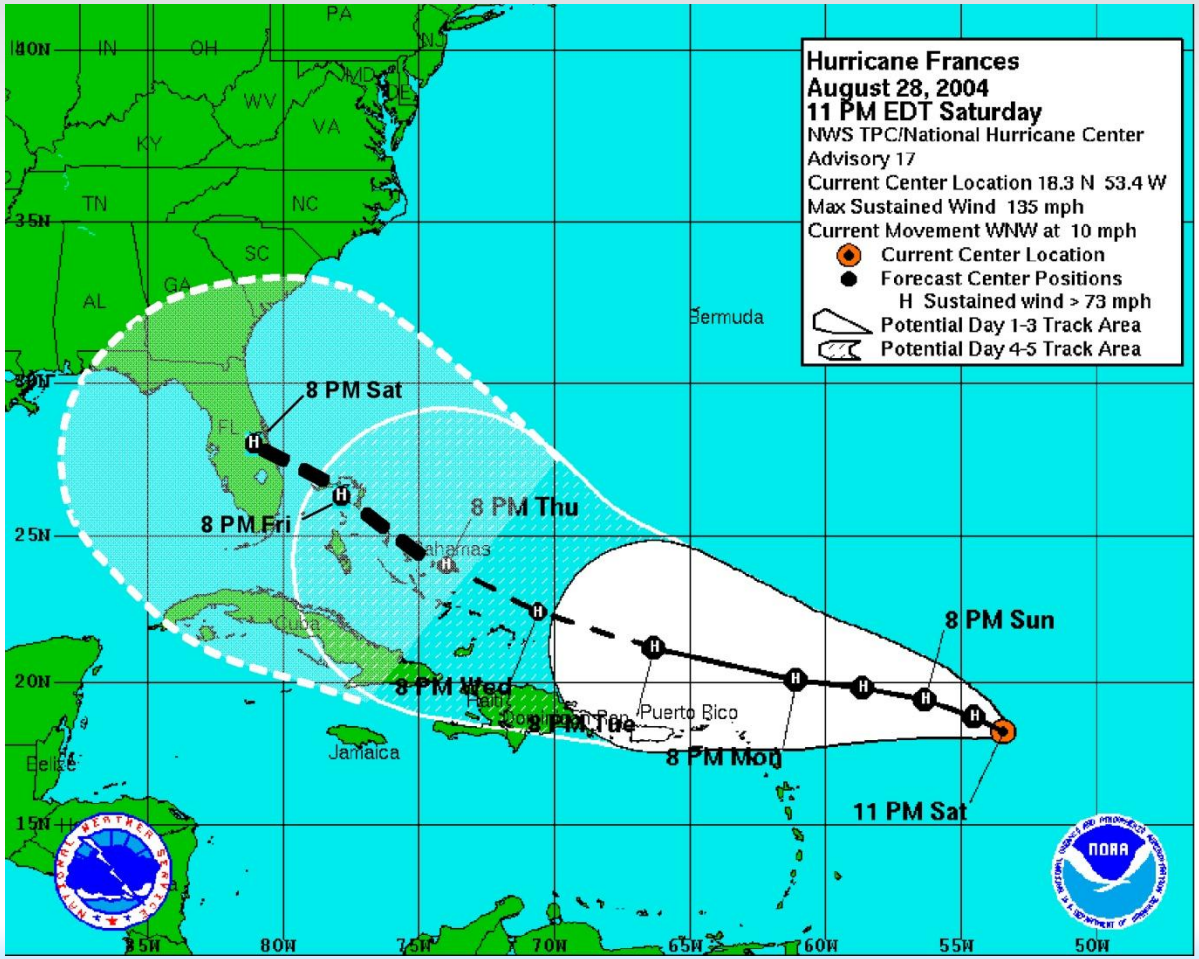
HFIP "stretch" goals for model guidance *for rapid intensification*



NOAA Geophysical Fluid Dynamics Laboratory (GFDL)

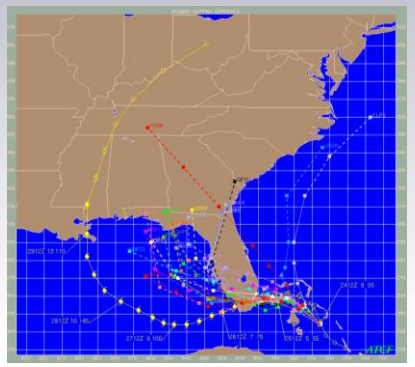
Preliminary Metric #4

Extend the lead time to 7 days



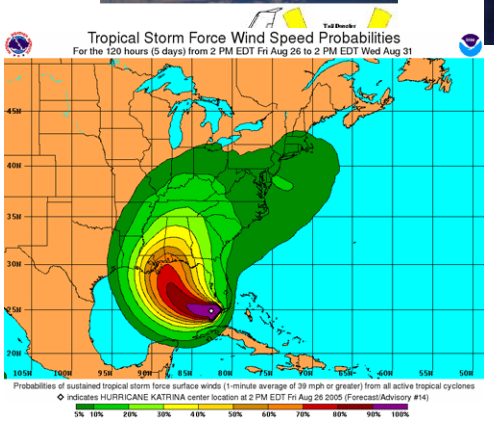
How to get there…

Improve numerical model guidance



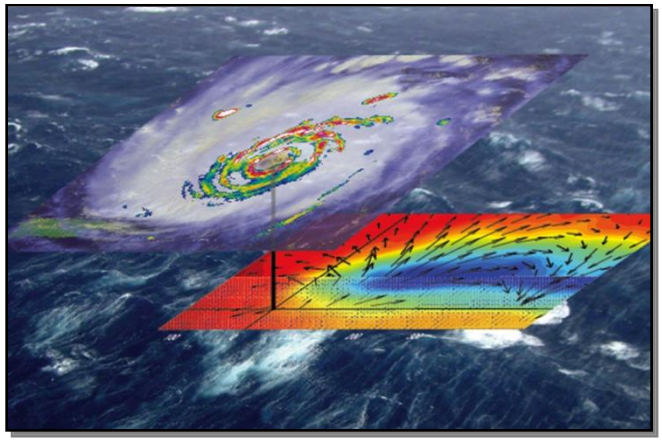
Optimize use of new and existing observing systems

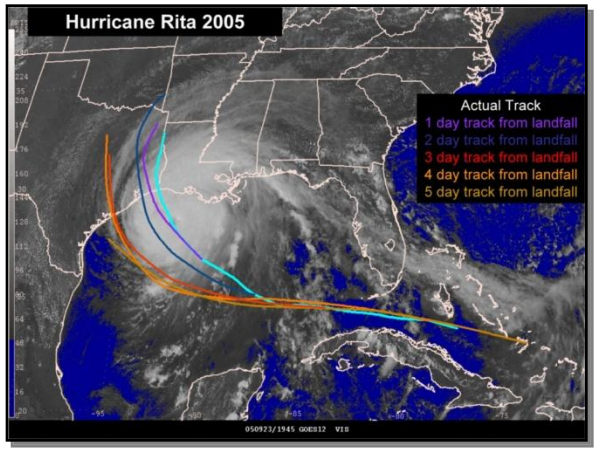
Expand and improve forecaster tools and applications

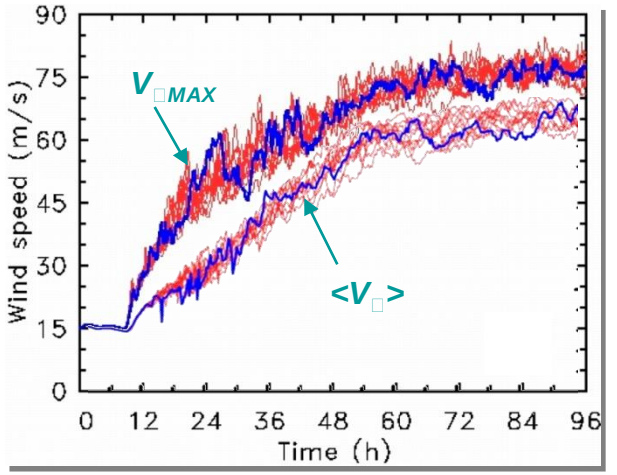


HFIP Research Thrusts

- **Intensity and structure change, with emphasis on RI:** processes that modulate internal storm dynamics and storm interactions with atmosphere and ocean;
- **Track:** interactions between tropical cyclone and its environment through optimal use of observations;
- **Forecast Uncertainty**: global and regional model ensembles to bound uncertainty and test predictability





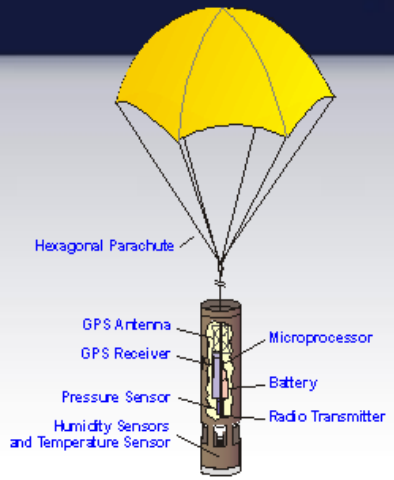


HFIP Research Thrusts

- Predictability/Uncertainty: Ensembles
- Model representing key processes
  - Large-scale wind and moisture structure
  - Convection in vorticity-rich environment
  - Air-sea interface
  - Vortex dynamics
  - Atmospheric boundary layer
  - Upper ocean structure
  - Microphysics/aerosols
- Optimal use of inner core observations

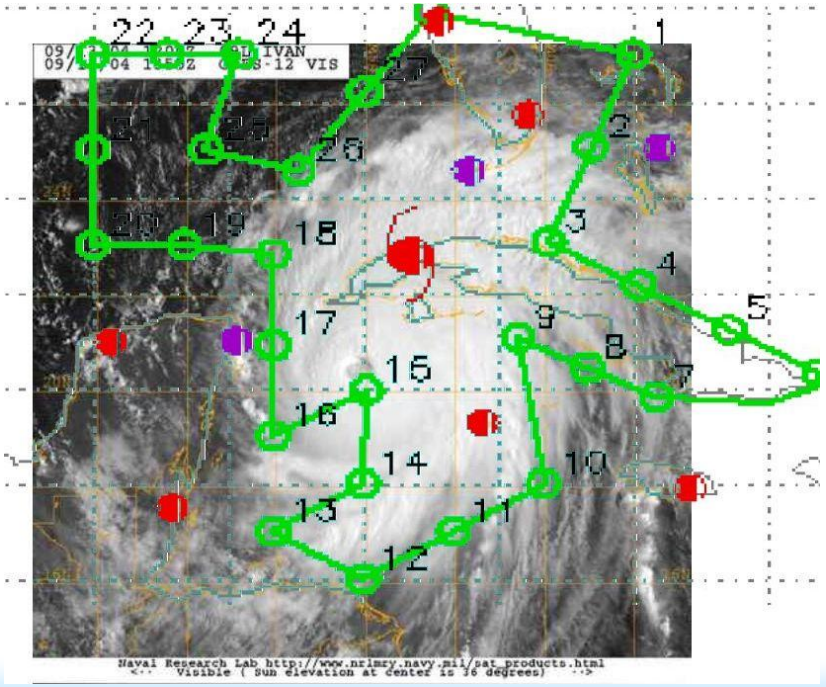
Large-scale Structure

Synoptic-surveillance using dropsondes.

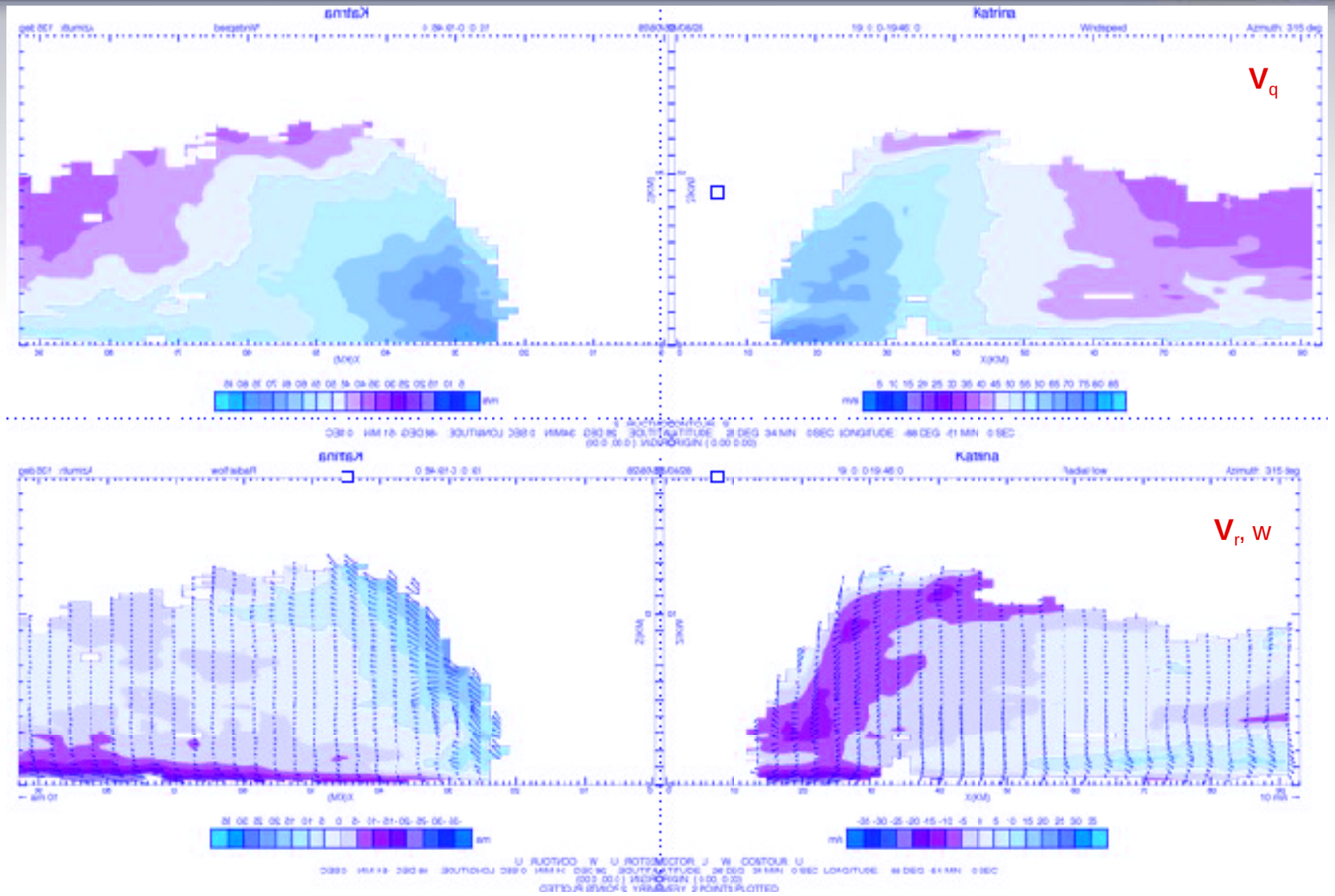


Analytical & numerical studies.

Ensemble track forecasting & targeted observations.



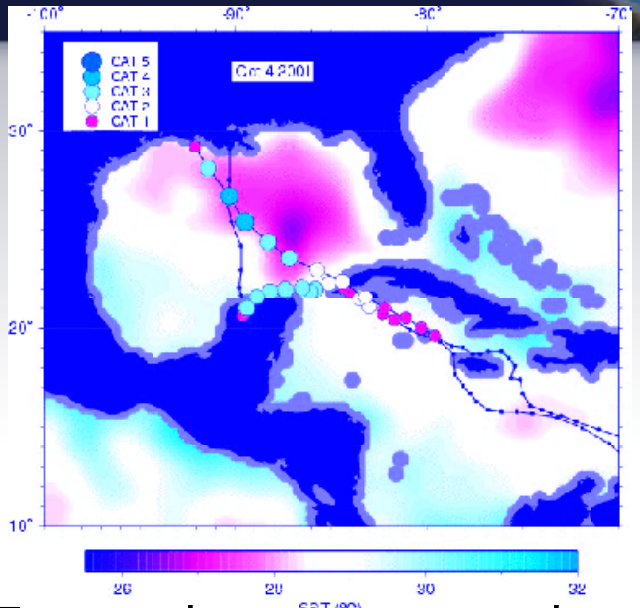
Convection /Vorticity



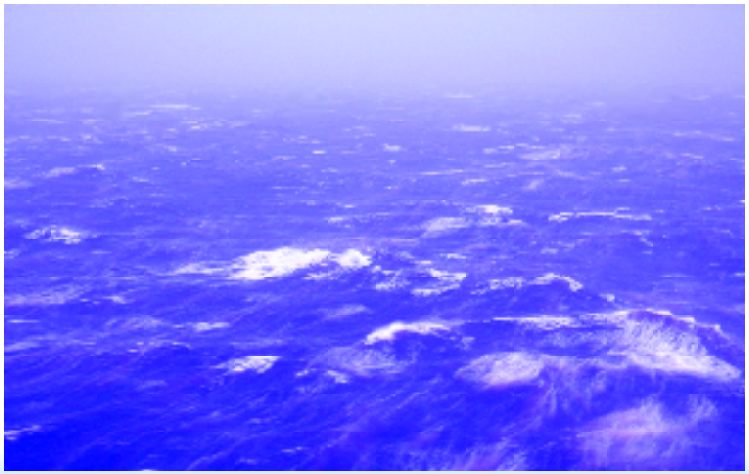
Airborne Doppler-analyzed wind field Hurricane Katrina, 28 September 2005

Air-sea interaction

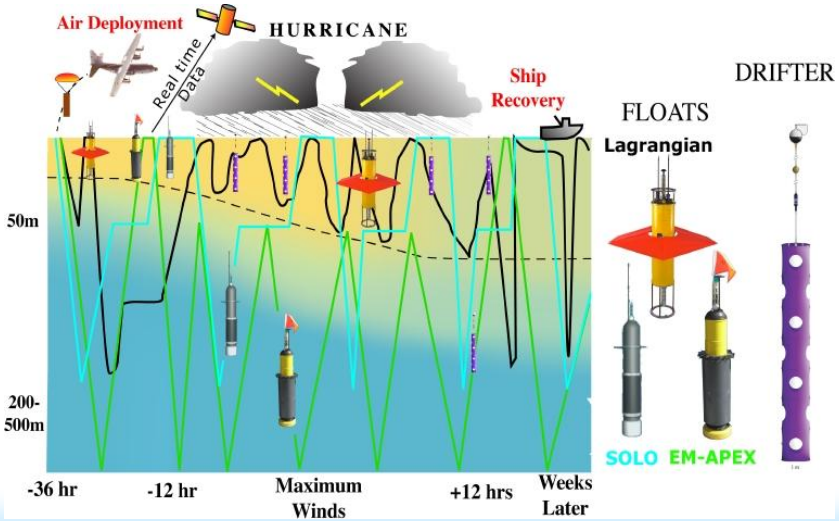
TC impact on upper ocean
effect of Hurricanes Isidore and Lili (2002)



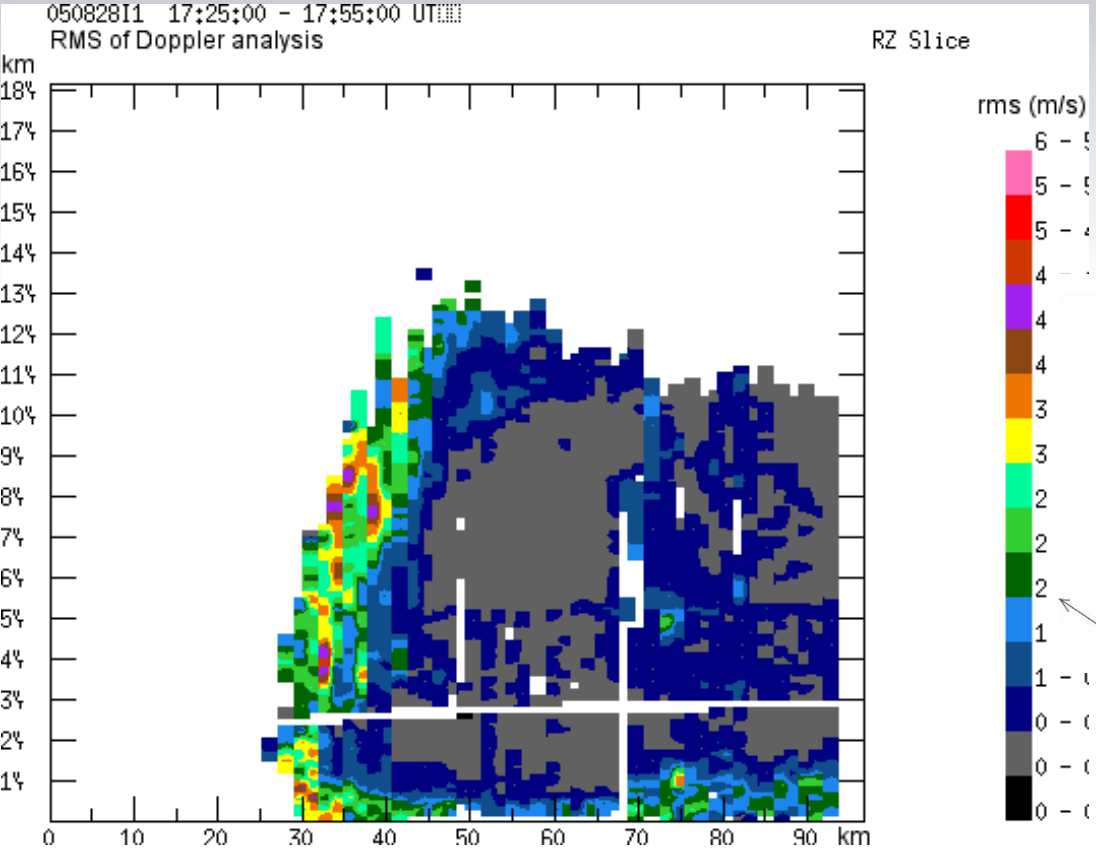
CBLAST
Waves from 200' in Isabel

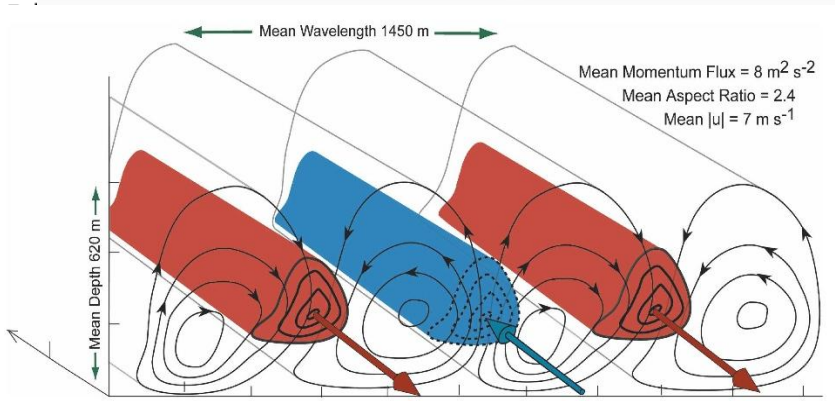


Targeted upper ocean observations



Boundary Layer

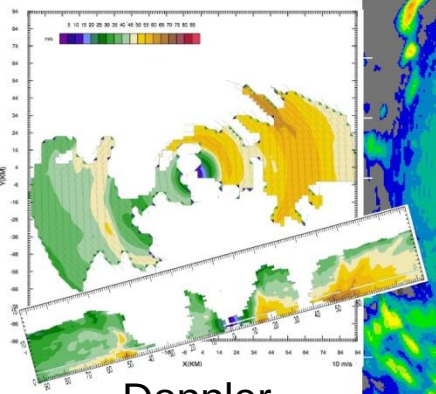




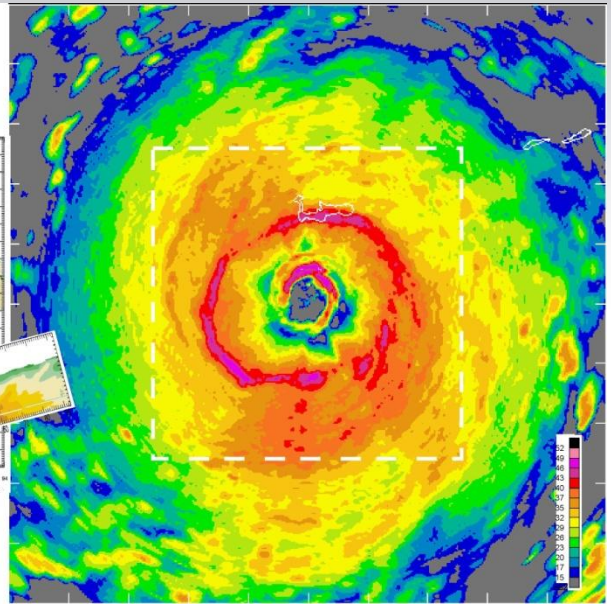
Turbulent structure / Rolls

Vortex Dynamics

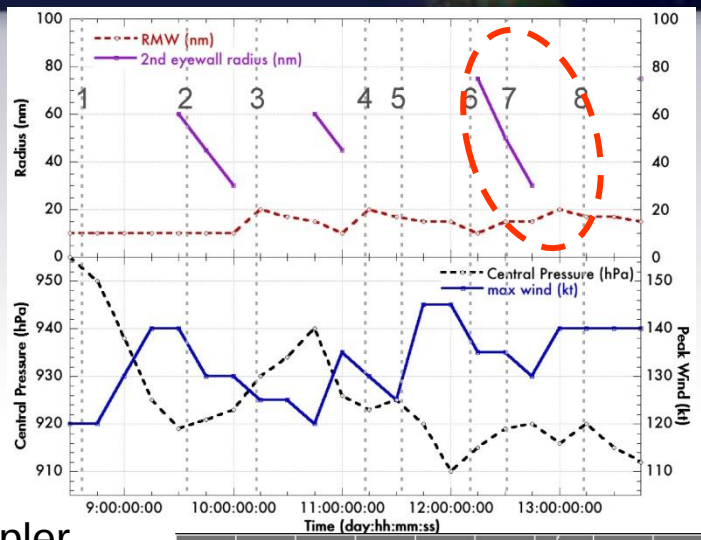
Eyewall Replacement: Hurricane Ivan



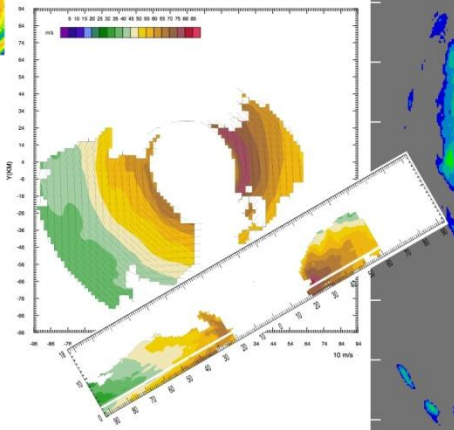
Doppler analysis



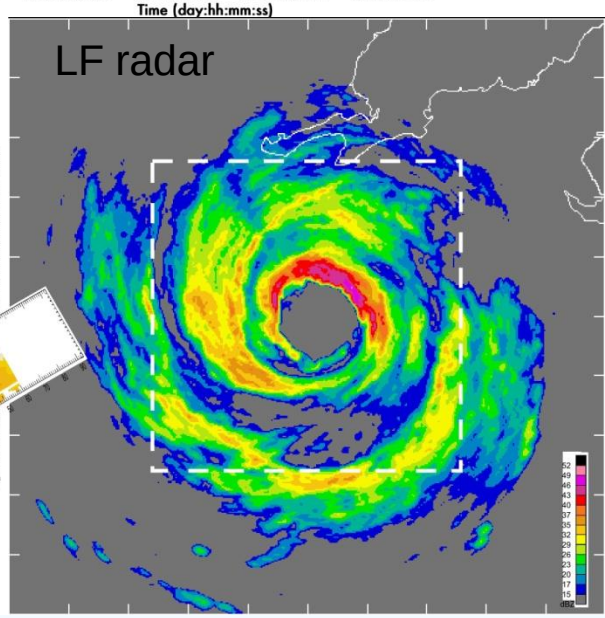
LF radar



Doppler analysis

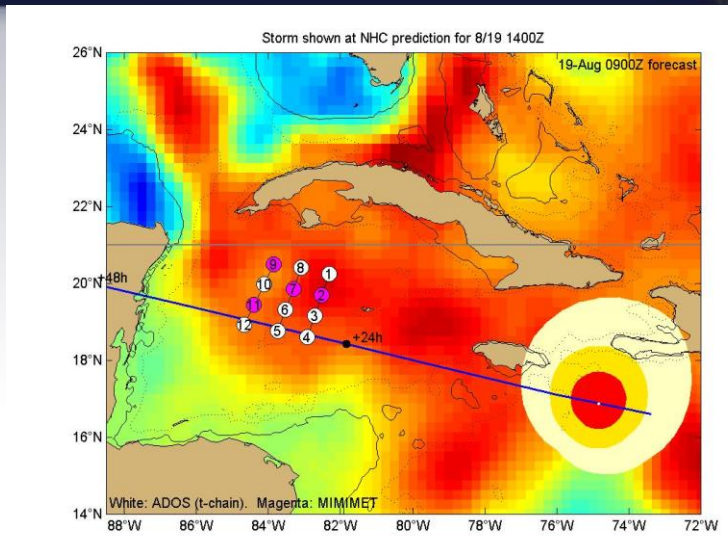


LF radar

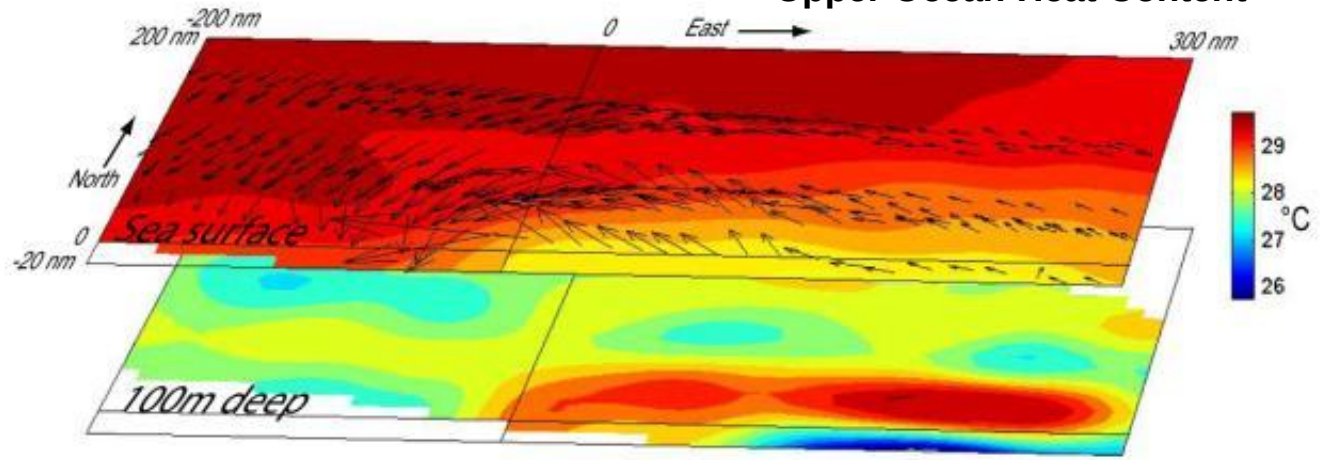


Horizontal radar reflectivity (dBZ), horizontal and vertical cross-sections of wind speed (m s^{-1}) for 12 (top, **7**) and 13 (right, **8**) September showing transition from double eyewall to larger single eyewall over 18 h period

Upper Ocean



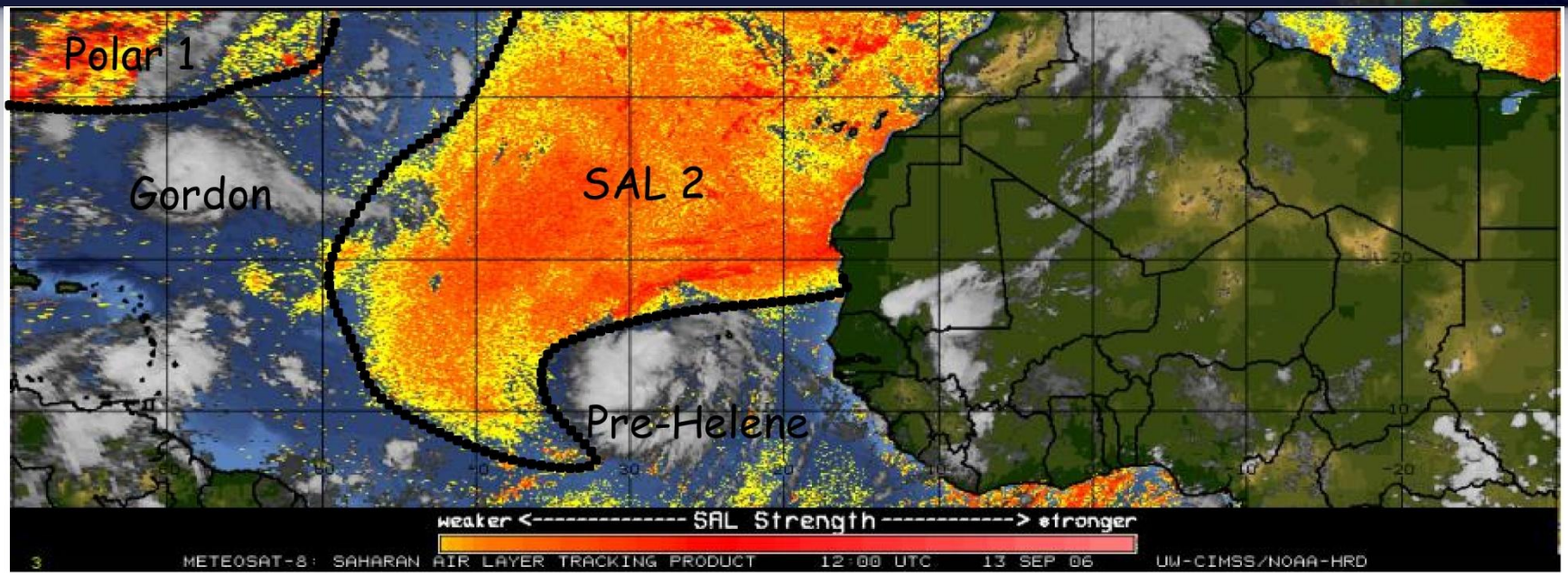
Upper Ocean Heat Content



Top: Sea surface temperature (shading, ºC) and winds (arrows) measured by the hurricane drifter array at top. Bottom: subsurface temperatures at a depth of 100m.

Array of 12 Minimet and ADOS (thermistor chain) drifters deployed in front of major hurricane "Dean", August 2007.

Aerosol/Microphysics

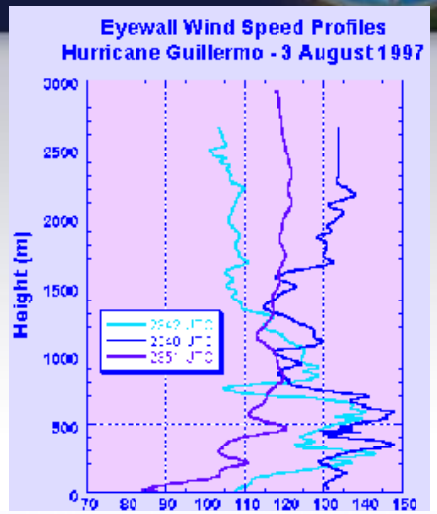


Saharan Air Layer (SAL)
Impact on intensity and rain

Inner Core Data

In-situ

- Wind, press., temp.



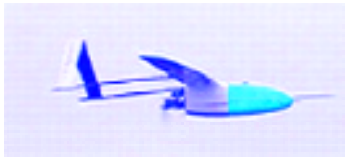
Expendables

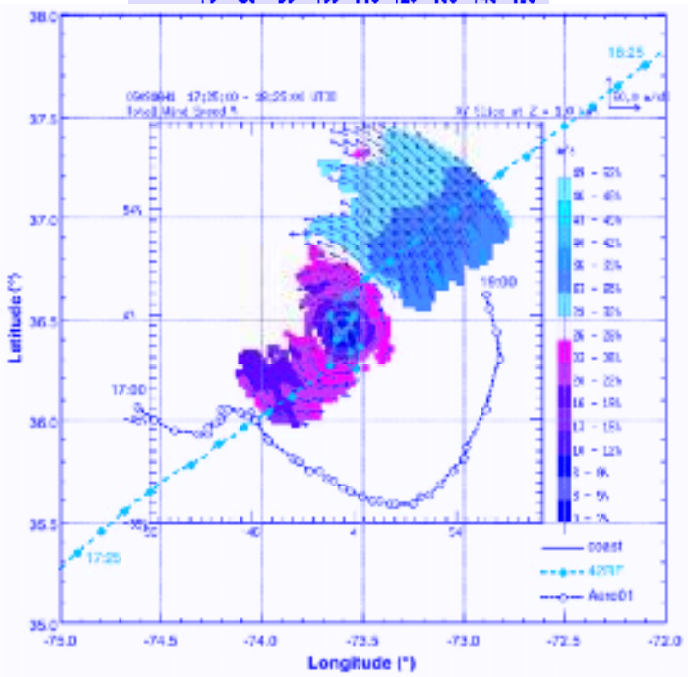
- Dropsondes
- AXBT, AXCP, buoy

Remote Sensors

- Doppler Radar
- SFMR
- Scatterometer/ profiler
- UAS

Doppler radar analysis overlaid by Aerosonde and coincident WP-3D track in TS Ophelia 16 Sept 2005

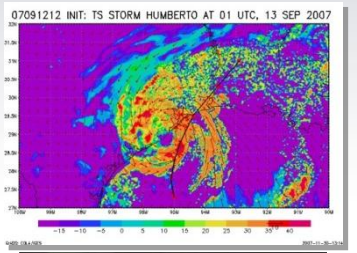


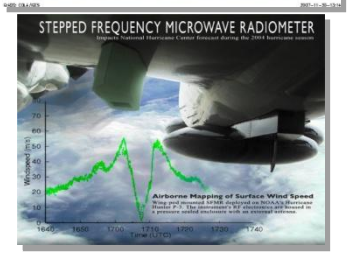


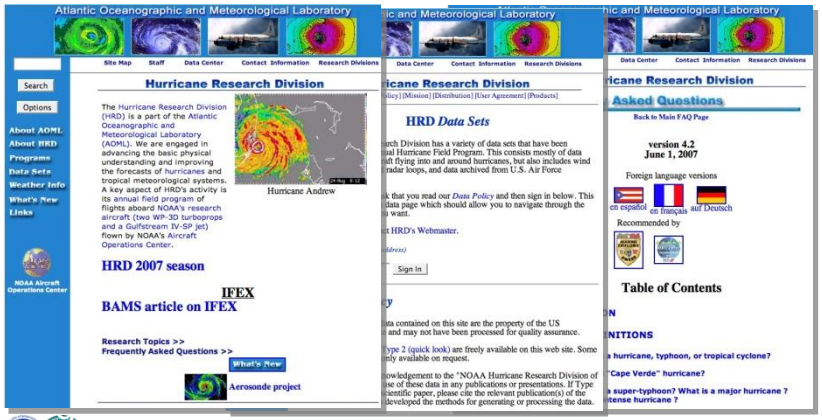
HFIP Research Thrusts

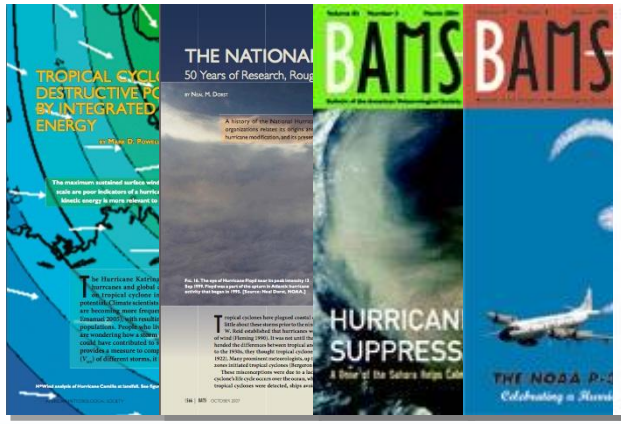
Accomplished through:

- Research experiments in hurricane
- Improving hurricane observing
- Developing & evaluating numerical models
- New technology and applications
- Outreach to the public.









Given where we are today…

Do you support these metrics?

Is anything missing?

Where should NOAA make its investments for improvements?

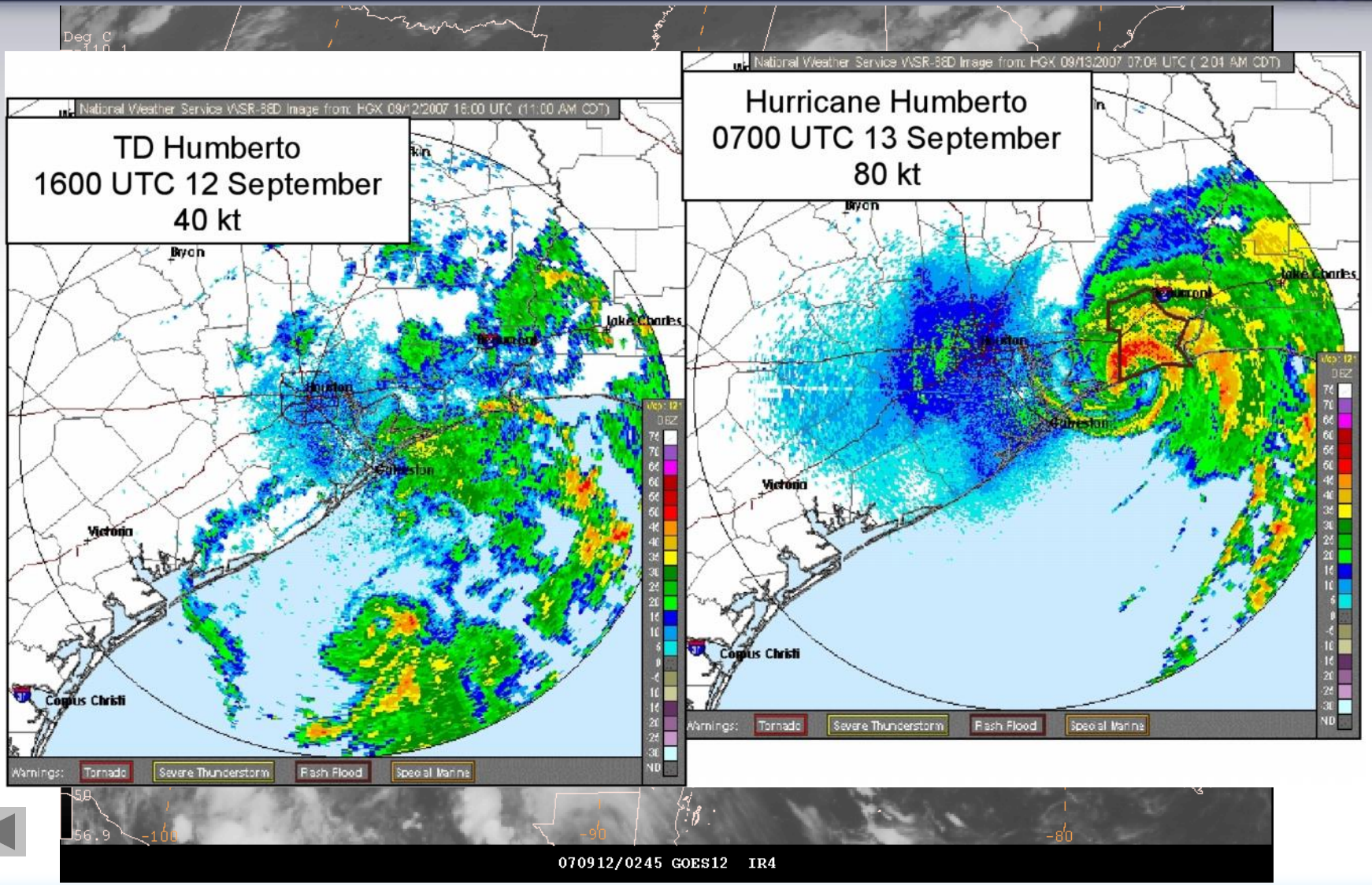
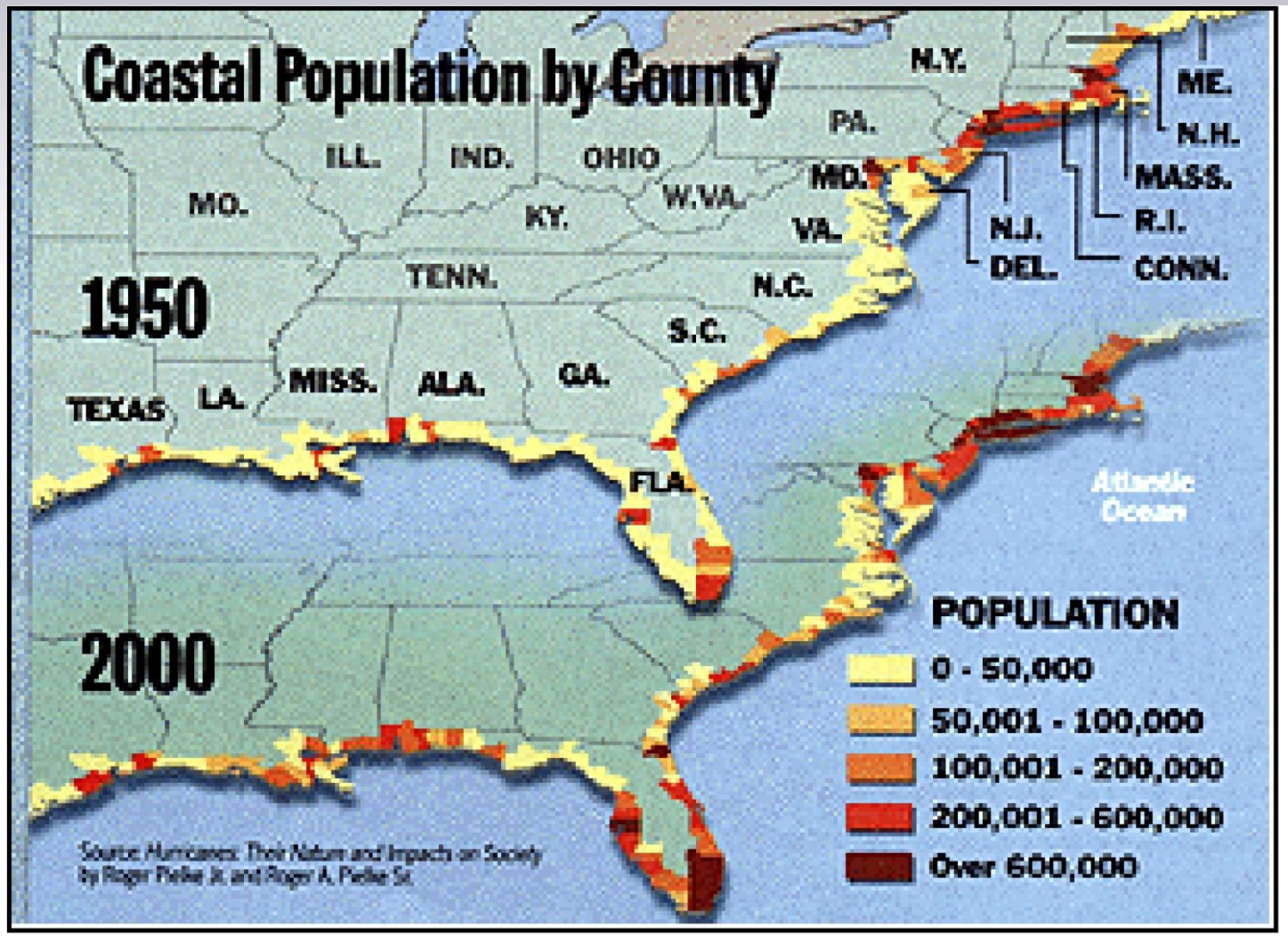
Frank.Marks@noaa.gov

SUBJECT: HFIP Comments

HFIP Plan is now open for public comment at:
http://www.oar.noaa.gov/constituents/

Questions?

Preliminary Metric #3



Improvements are still needed!