Importance of Buoy Data in Tropical Cyclone and Marine Analysis & Forecasting

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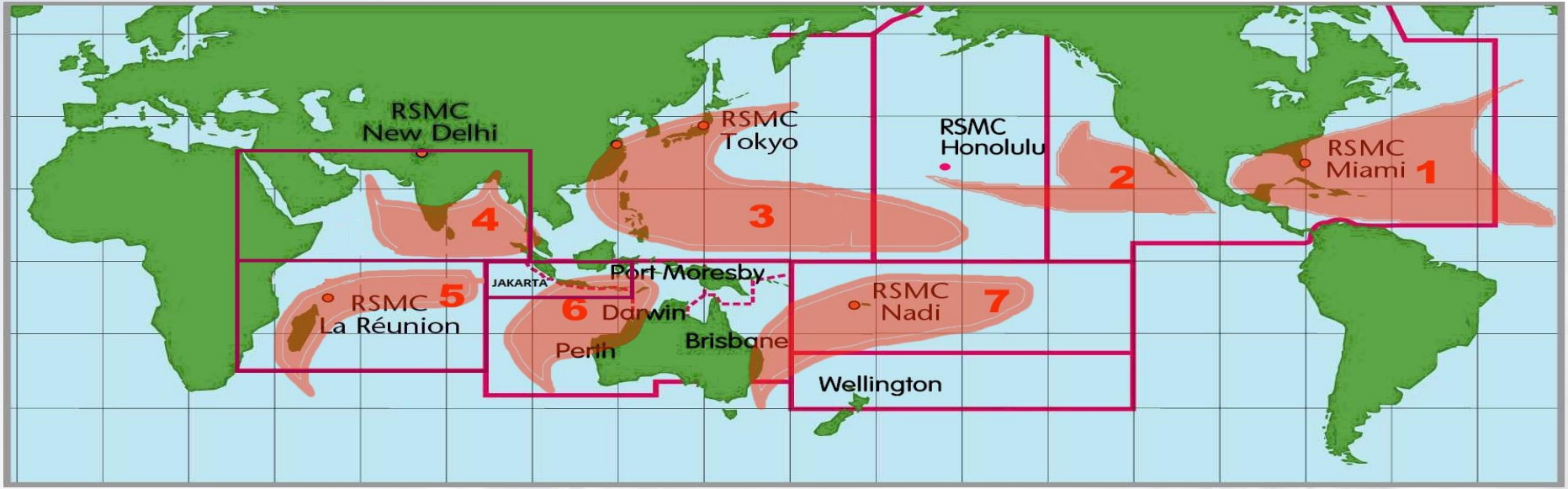
National Hurricane Center

PIRATA 24 / TAV Virtual Meeting
5/12/2021

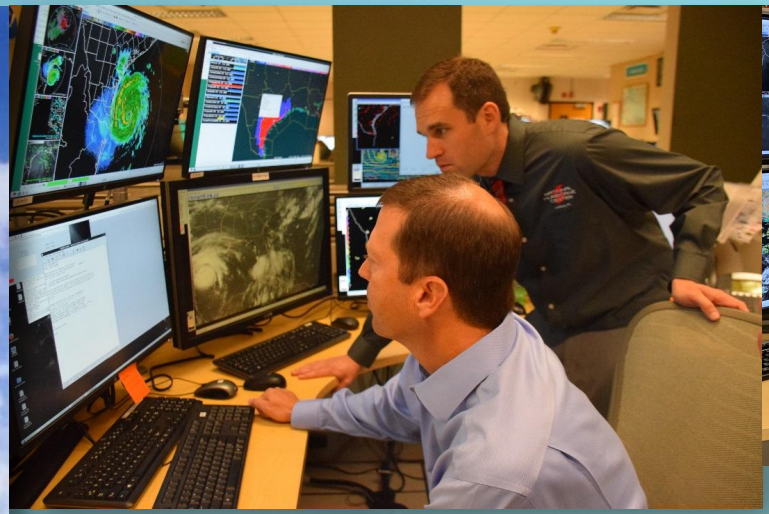
NHC International Collaboration

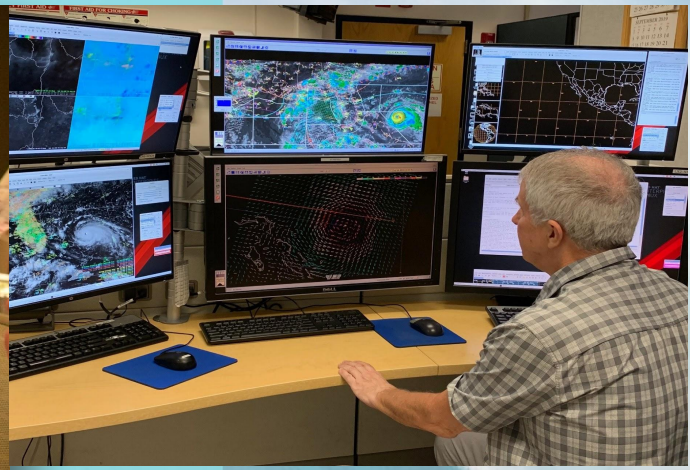
World Meteorological Organization



NHC is one of 7 Regional Specialized Meteorological Centers (RSMC) that produce and coordinate tropical cyclone forecasts for various ocean basins.

National Hurricane Center





Mission:

Save lives, mitigate property loss, and improve economic efficiency by issuing the best watches, warnings, and forecasts of hazardous tropical weather and by increasing understanding of these hazards

NHC forecasts Tropical Cyclones 4x per day

Hurricane specialist receives estimates of location and intensity via satellite imagery from 2 different agencies

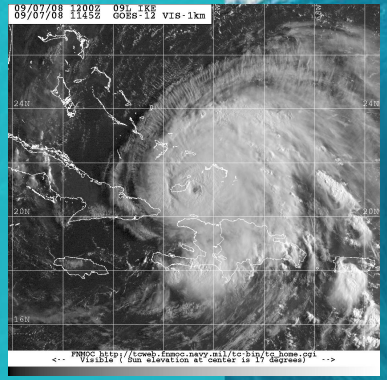
Determine the center location

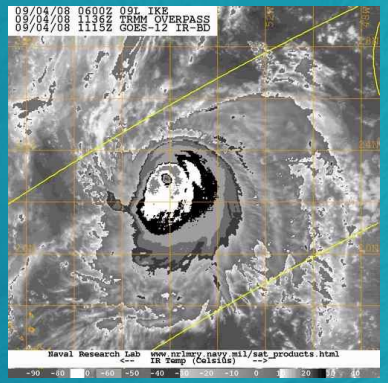
Determine past motion (6-12 h)

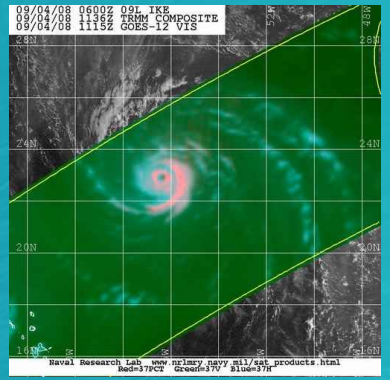
Determine the intensity/wind speed

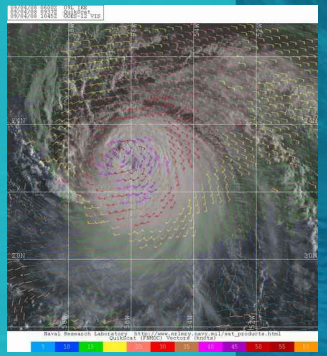
Determine various wind radii

34-, 50-, and 64-kt (when applicable)





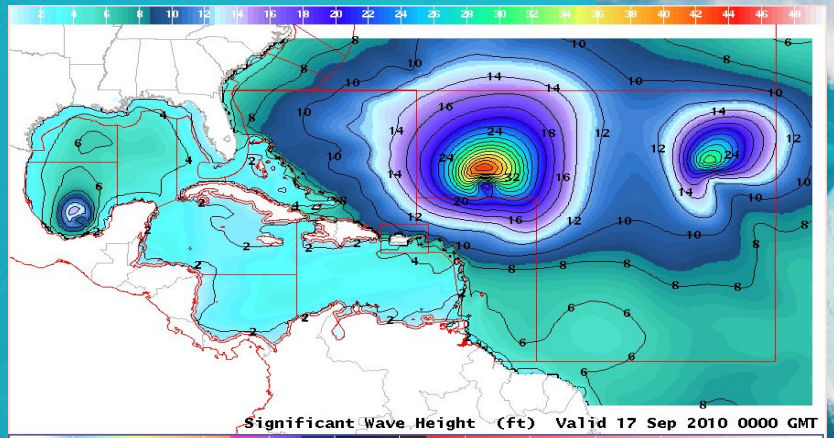


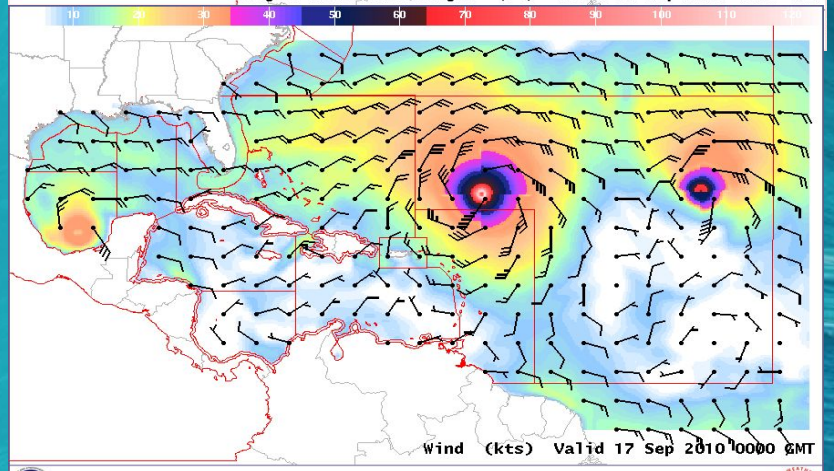


TAFB National Digital Forecast Database Gridded Marine Forecasts

- Spatial/Temporal resolution
  - 10 KM
  - 6 Hourly out to 144 hr (3 Hourly to 72 hr)
- Parameters
  - 10-M Wind/Gusts
  - Significant Wave Height
  - Hazards

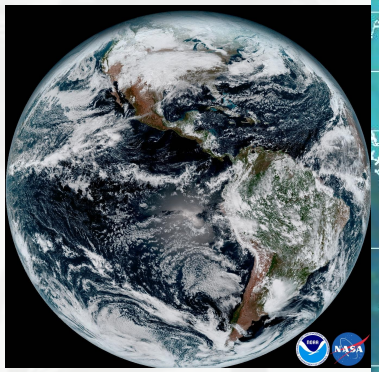
https://digital.weather.gov/

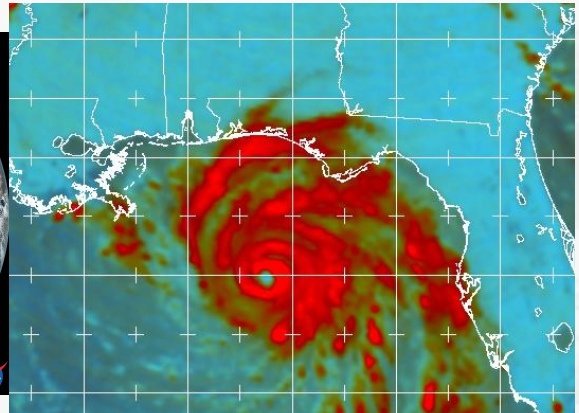




Key Meteorological Parameters Needed for TC Analysis and Marine Forecasting

- Wind speed – intensity, size of wind field, gale/storm warnings
- Wind direction – center location, closed circulation
- Wind gust – intensity
- Atmospheric pressure – intensity, modeling
- Temperature (surface and subsurface)
- Ocean heat content - intensity
- Wave height (period and direction)



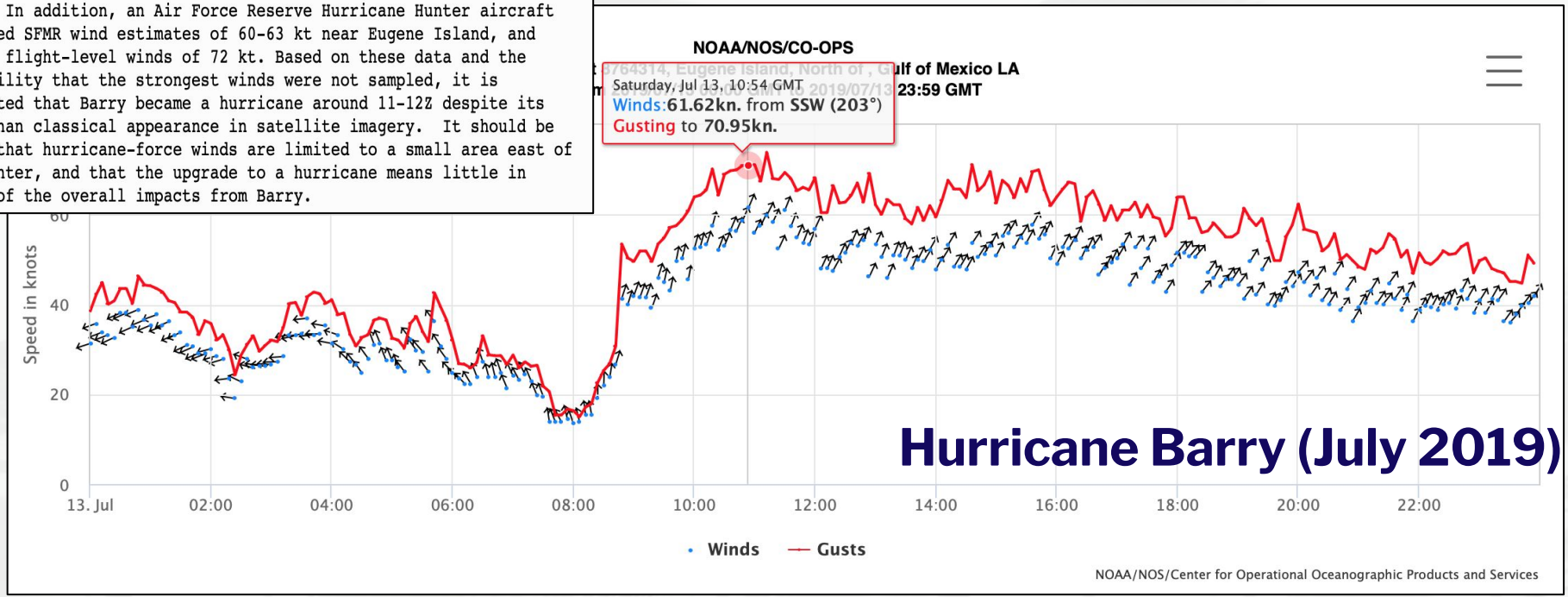


Recent Examples of Valuable Observations

Unusual case of a marine observation supporting the estimated peak intensity

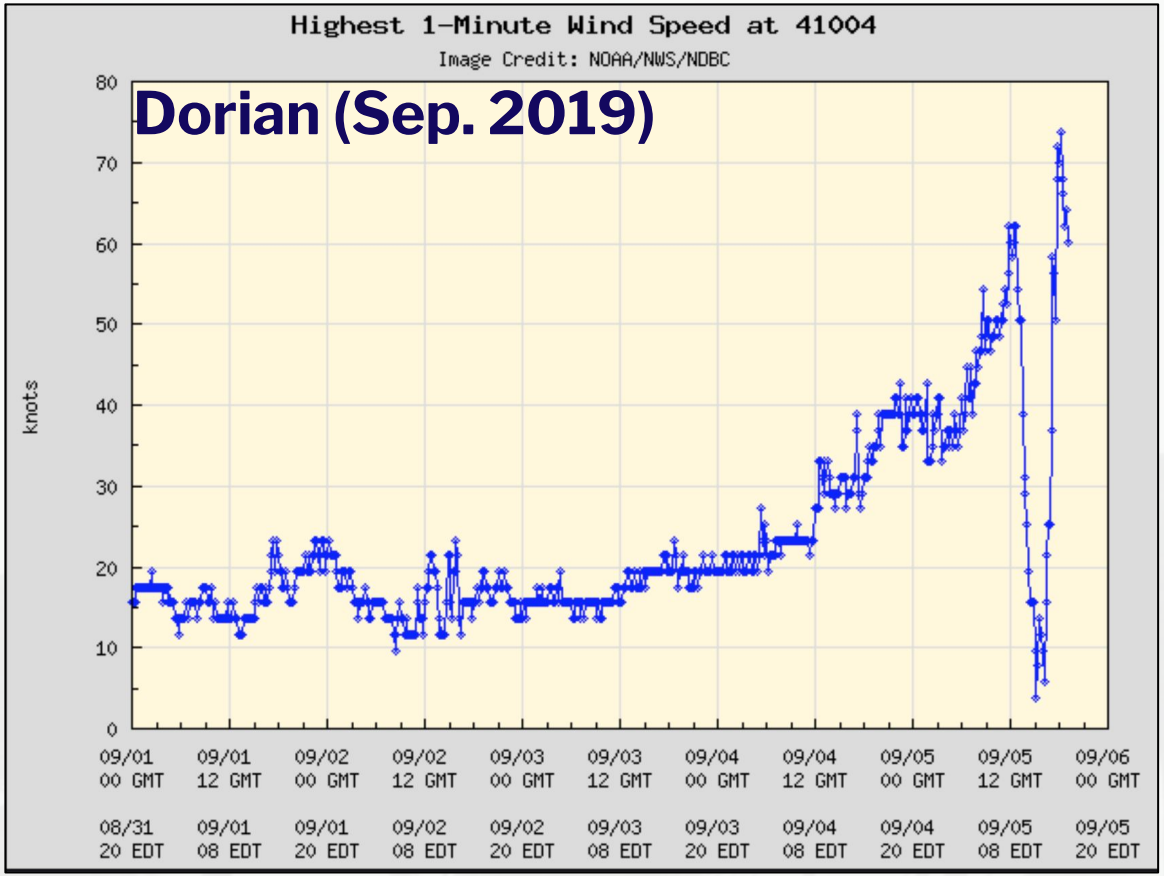
Hurricane Barry Discussion Number 13
NWS National Hurricane Center Miami FL AL022019
1000 AM CDT Sat Jul 13 2019

Between 11-12Z, the National Ocean Service station at Eugene Island, Louisiana, reported sustained winds of 62 kt and a peak gust of 74 kt at an elevation of about 10 m. Doppler radar winds from the Slidell WSR-88D suggested surface winds of 60-65 kt as well. In addition, an Air Force Reserve Hurricane Hunter aircraft reported SFMR wind estimates of 60-63 kt near Eugene Island, and 850-mb flight-level winds of 72 kt. Based on these data and the possibility that the strongest winds were not sampled, it is estimated that Barry became a hurricane around 11-12Z despite its less than classical appearance in satellite imagery. It should be noted that hurricane-force winds are limited to a small area east of the center, and that the upgrade to a hurricane means little in terms of the overall impacts from Barry.



Hurricane Barry (July 2019)

Recent Examples of Helpful Observations



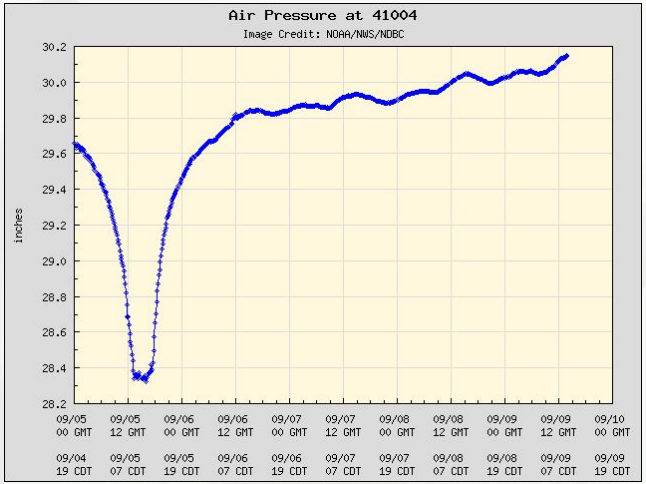
Peak Wind Speeds

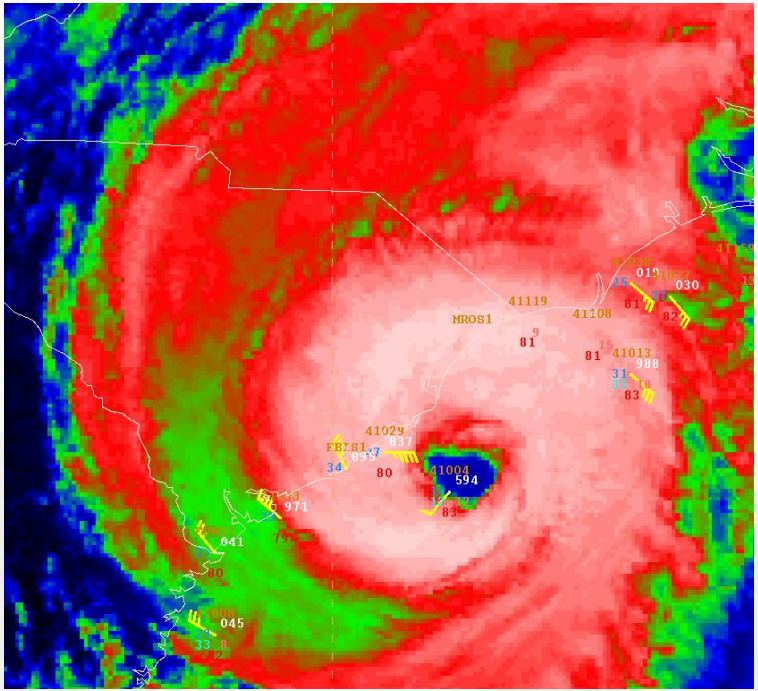
Very useful data, but rare that peak winds in a tropical cyclone are observed by a buoy!

Recent Examples of Valuable Observations

Observing Minimum Sea Level Pressure

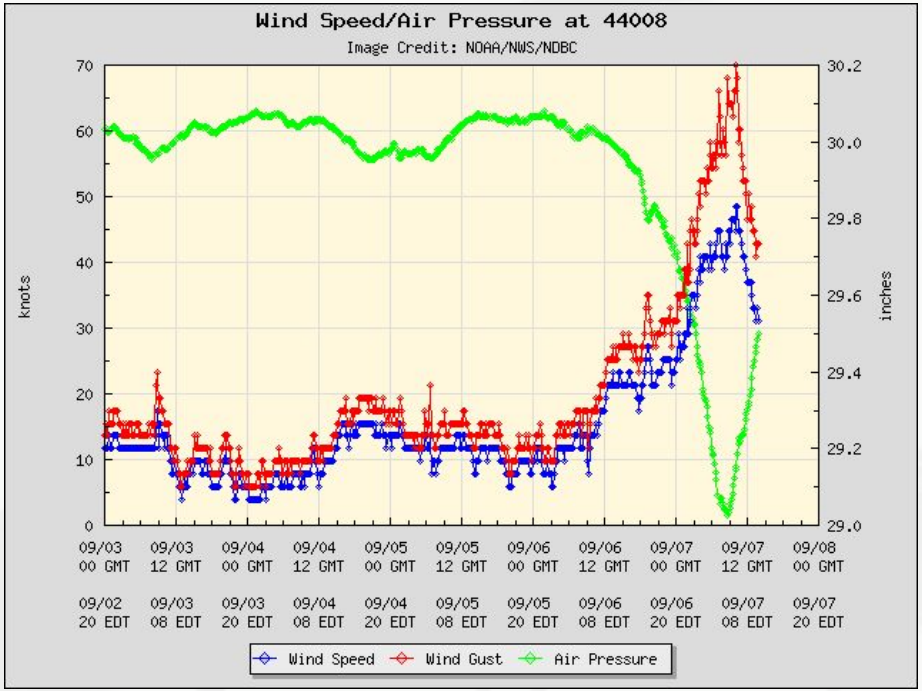
Buoys occasionally provide minimum sea level pressure data. Even if the storm's center does not pass directly over the buoy, minimum pressure can be estimated by pressure and wind data.

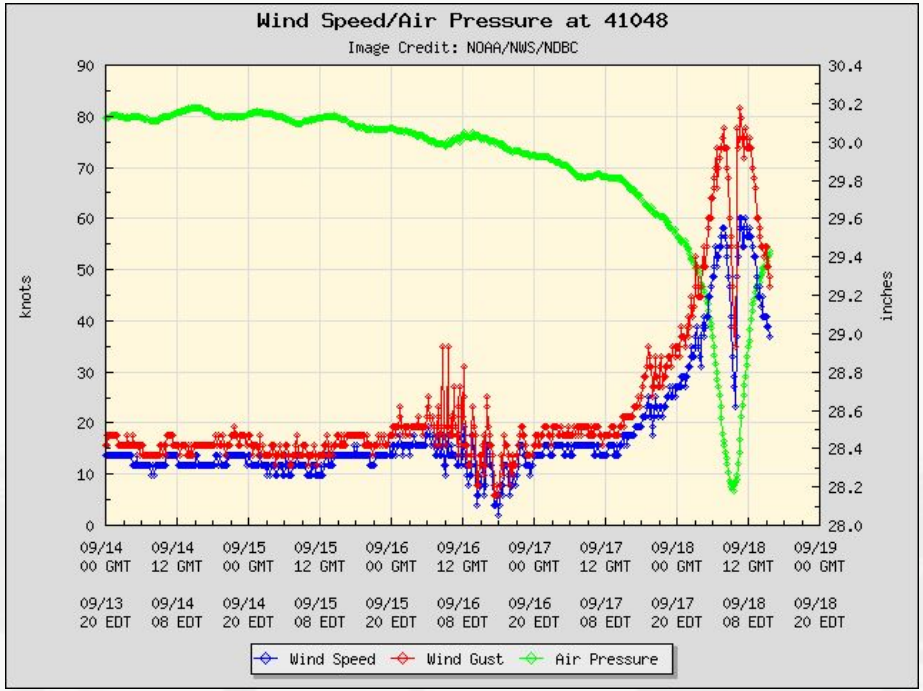




Dorian Passes Over NOAA Buoy 41004

Data Summaries Can Be Very Insightful



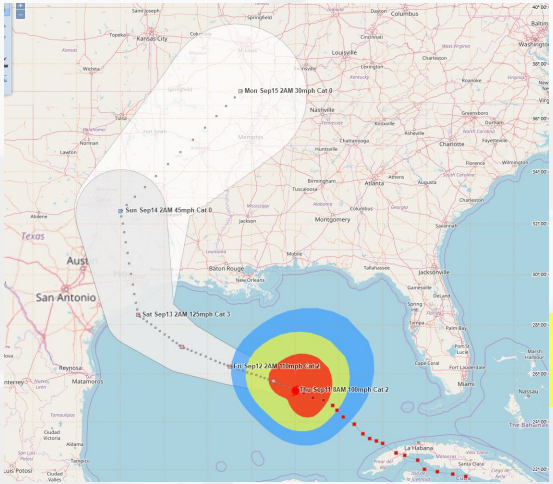


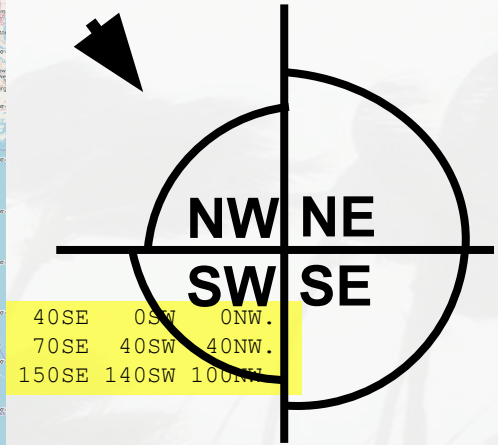
Analyzing Size of a Tropical Cyclone's Wind Field

WIND RADII

- NHC analyzes and forecasts the wind radii in four quadrants

Radii are the largest distance from the center in a quadrant



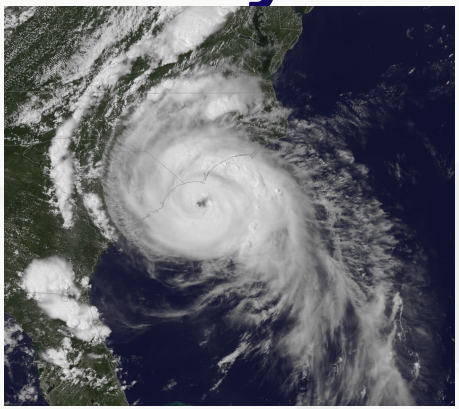


Leads to an inherent over-estimate of radii, especially near land

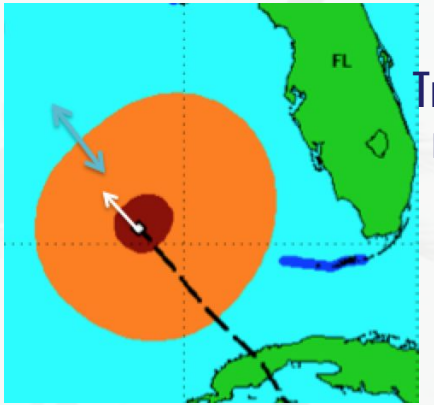
Typical Tropical Cyclone Analysis Uncertainty

Since there are insufficient observations of surface wind in tropical cyclones:

- Intensity estimates are believed to be good to within 10%
- Tropical storm wind radii (size estimate) are believed to be good to within 25% and hurricane wind radii to within 40%
- **Buoy data helps lower these uncertainties**



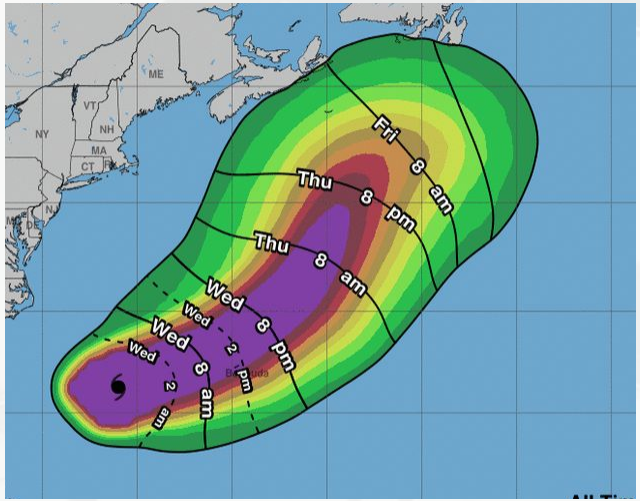
A 100 mph hurricane could have maximum winds of 90 mph o 110 mph



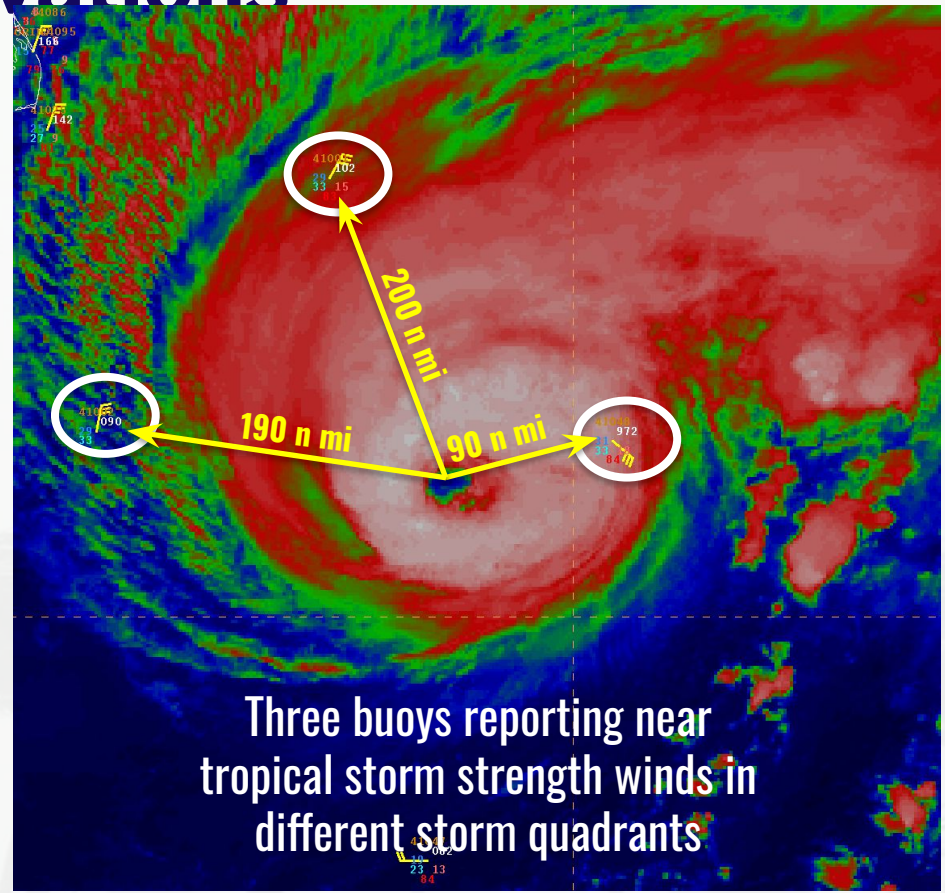
Tropical-storm-force wind radii of 100 n mi could mean a size of 75 n mi or 125 n mi

Recent Examples of Valuable Observations

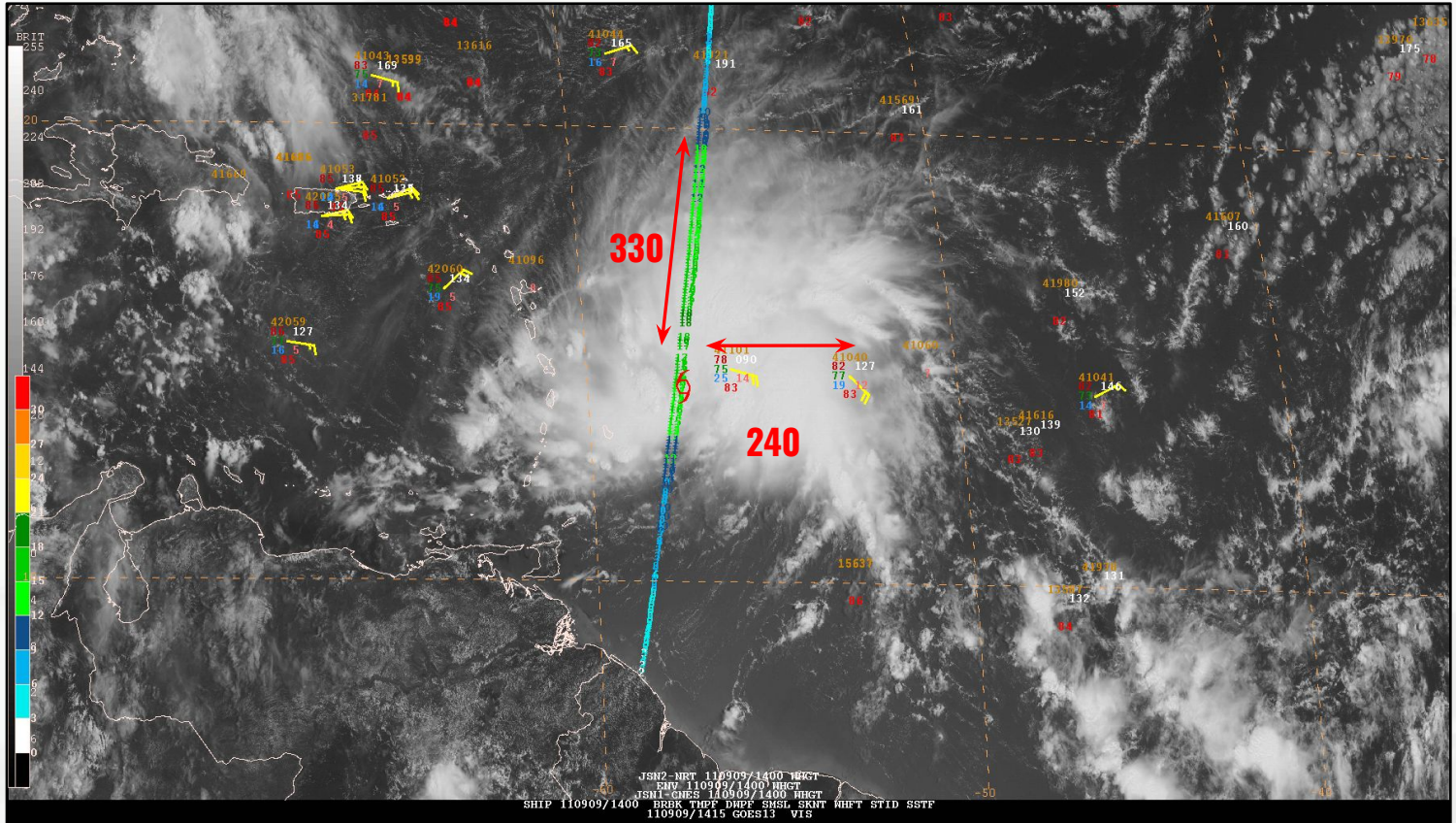
Buoy observations help analyze the tropical-storm-force wind radii during Hurricane Humberto (Sep. 2019)



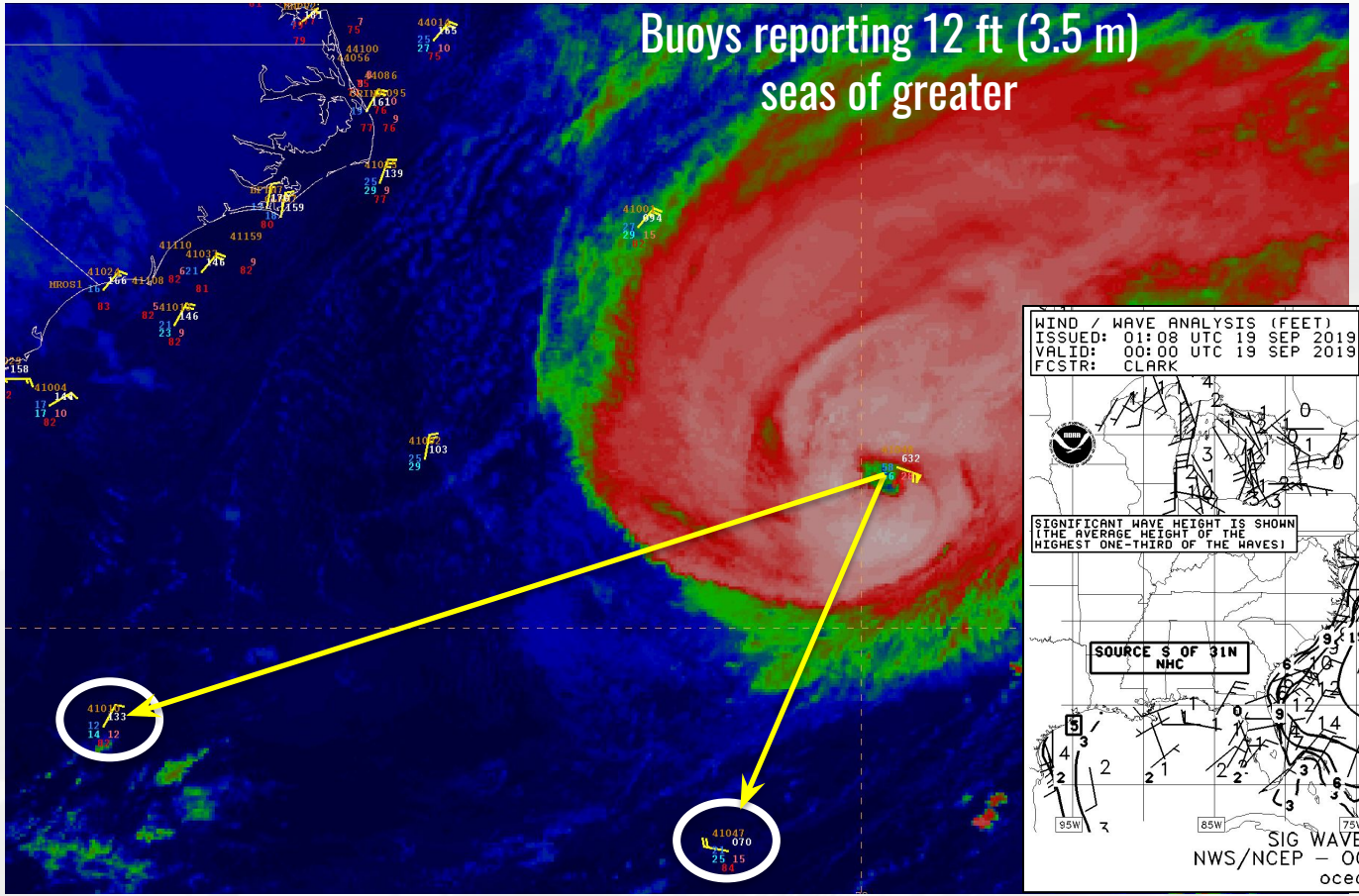
Wind radii drive timing information and NHC's probabilistic guidance



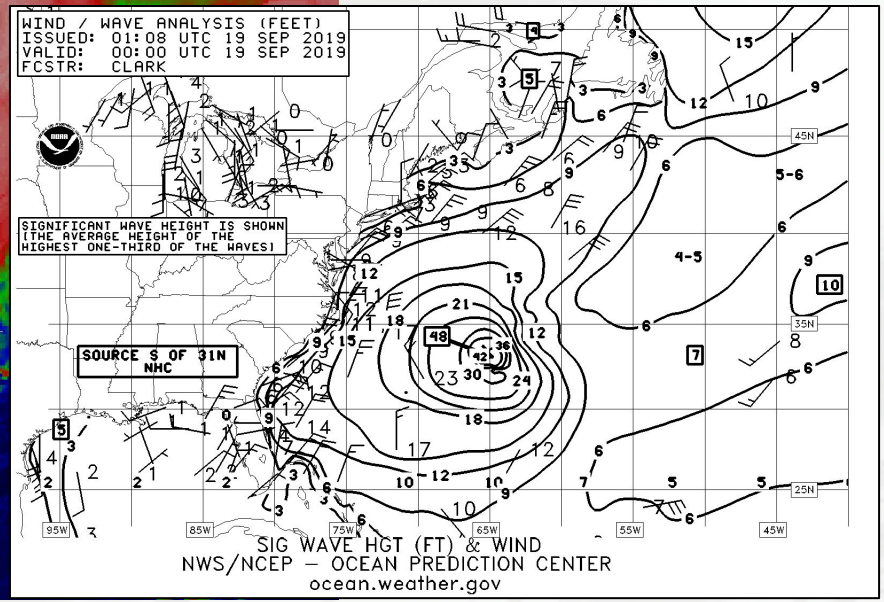
Maria (2011) as a Tropical Disturbance Produces a Huge Wave Field



Recent Examples of Valuable Observations



Observations help analyze the 12 ft (3.5 m) seas during Hurricane Humberto (Sep. 2019)

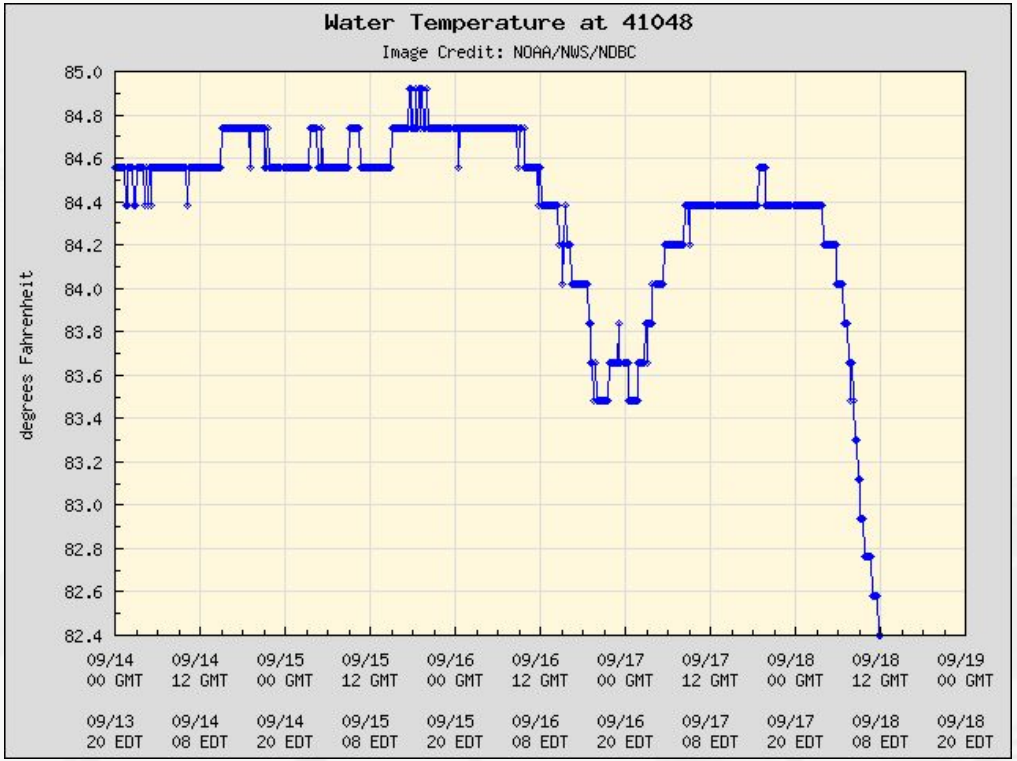


Recent Examples of Valuable Observations

Observing Sea Surface Temperature Changes

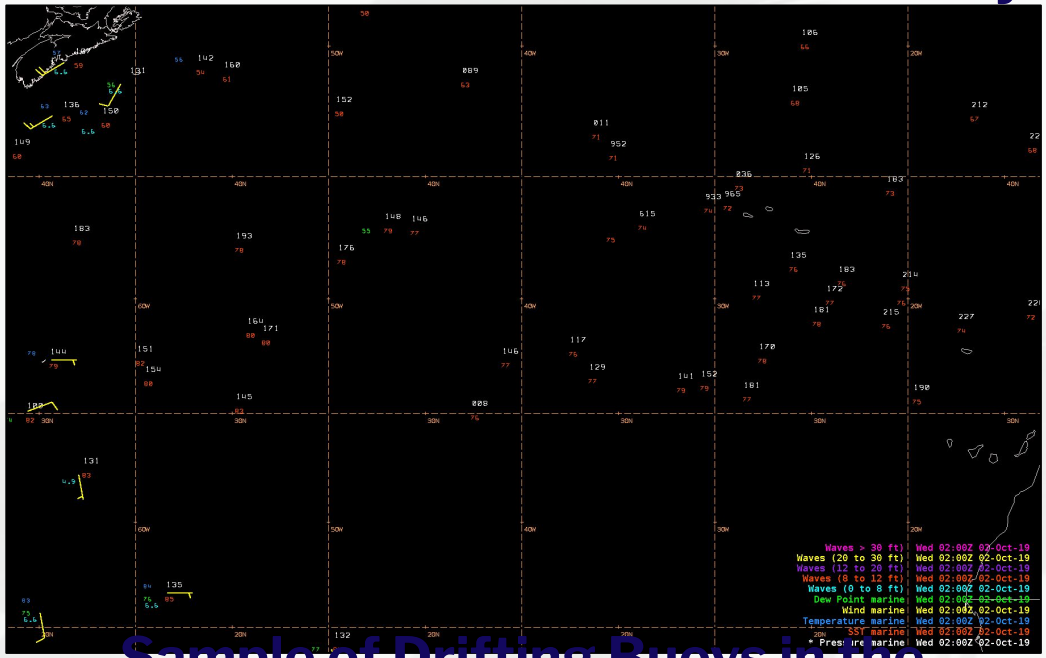
Can be useful to determine amount of upwelling that has occurred along the path of a tropical cyclone.

Would be useful to have SST depth information for modeling.

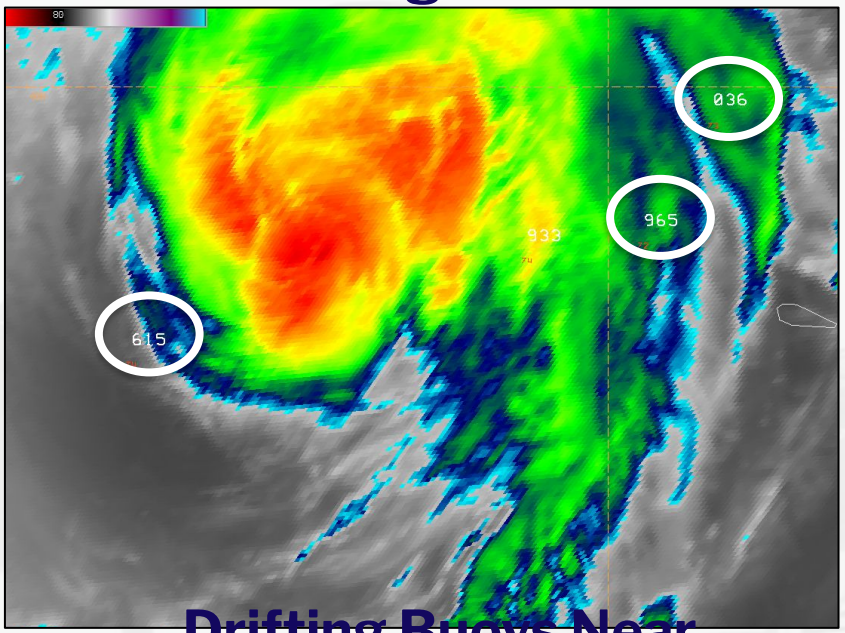


Recent Examples of Valuable Observations

Drifting Buoys with that Report Sea Level Pressure Only are Also Useful for Analysis and Modeling



Sample of Drifting Buoys in the Atlantic



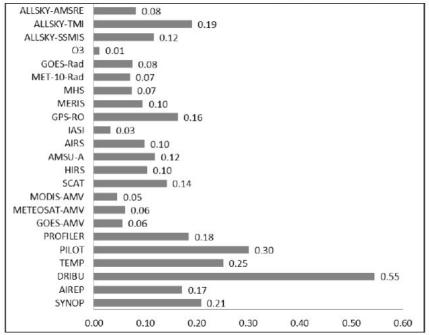
Drifting Buoys Near Lorenzo

Buoy Observations Have Significant Contributions in Numerical Modeling*

Observation Influence results in 2 global systems

ECMWF (IFS)

Nov-Dec 2010

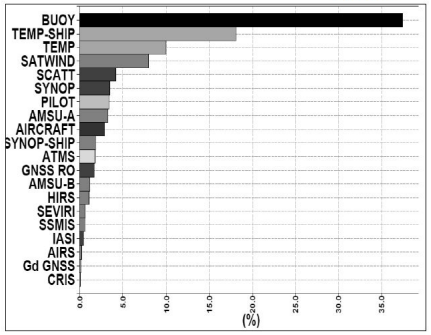


Horányi, A. , C. Cardinali, and L. Centurioni, 2017: The global numerical weather prediction impact of mean-sea-level pressure observations from drifting buoys. *Q.J.R. Meteorol. Soc.*, DOI:10.1002/qj.2981.

Météo-France

Météo-France (Arpège)

Sep 2013



Doerenbecher, A., J.-F. Mahfouf, N. Boullot, 2014: E-SURFMAR impact study, presented to EUMETNET Observation Programme Scientific Expert Team.

Tropical Atlantic Buoys in the Global Observing System

Conclusions

Data buoys in the Tropical Atlantic

- Only a small part of the global observing system (in numbers)
- Yet significant impact on reduction of total 24-h forecast errors

*Credit Paul Poli, E-SURFMAR Programme Manager

Buoy Reports Can Help Forecasters Provide Accurate Spot Forecasts in Support of U.S. Coast Guard Operations

Supporting Life-Saving Operations

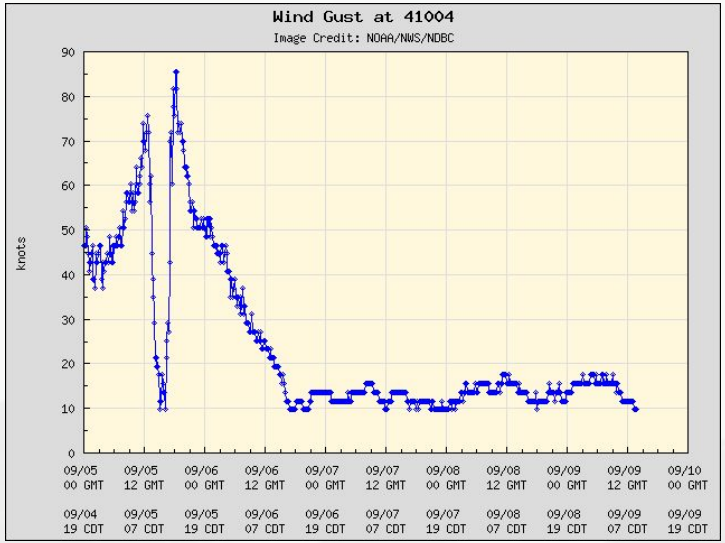
Most Useful Data Buoy Parameters and Frequency for TC Analysis and Marine Forecasting

- Not just top of the hour data!
- Peak 1-minute wind data during the hour, 10-min frequency is ideal (NDBC continuous wind standard), air temp and dewpoint too
- Peak 3-sec wind gust during the hour
- Minimum surface pressure during the hour
- Hourly reported peak seas (sig wave height)
- Ocean temperature & salinity at depth (~100m) for numerical modeling

Supplemental Data from NOAA Buoys in Areas Typically Affected by Tropical Cyclones

Several NOAA Buoys across the Atlantic, Caribbean, and Gulf of Mexico report the following data each hour:

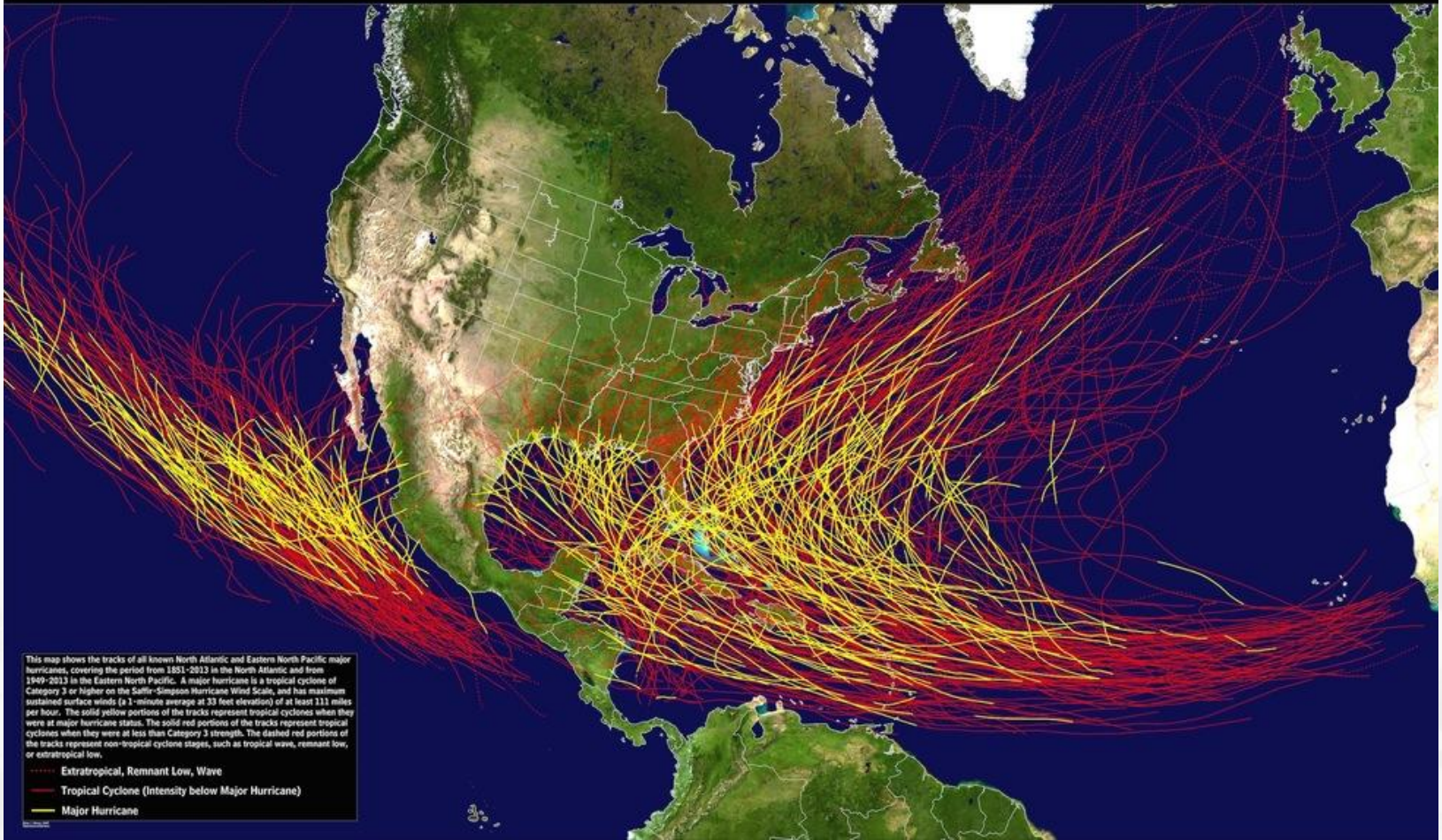
- Minimum pressure data
- Peak 1-minute wind observations
- Peak wind gusts
- 10-min observations



Many buoys that are climatologically in the path of hurricanes or intense low pressure systems have the capability of measuring supplemental one-minute average pressure data. These data are recorded after the hourly pressure data fall below a predetermined threshold (e.g. 1008 hPa in the tropics.) IDs associated with supplemental pressure data are as follows.

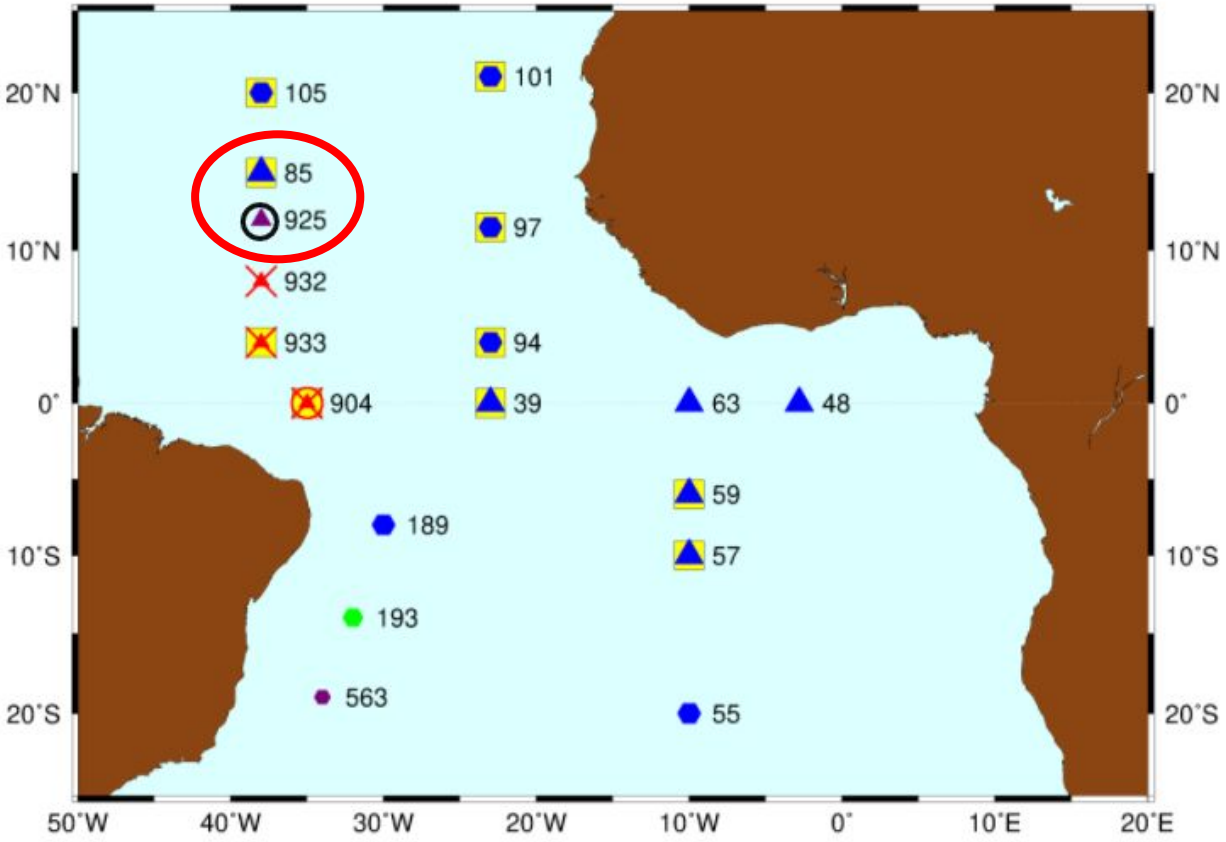
Major Hurricane History

Data from 1949 in the Pacific, from 1851 in the Atlantic



Status of Presently Deployed PIRATA Moorings

Updated May 11, 2021



(Click Mooring Symbol for Summary)

Mooring Type

- PIRATA Core
- PIRATA Extensions
- TFLEX System

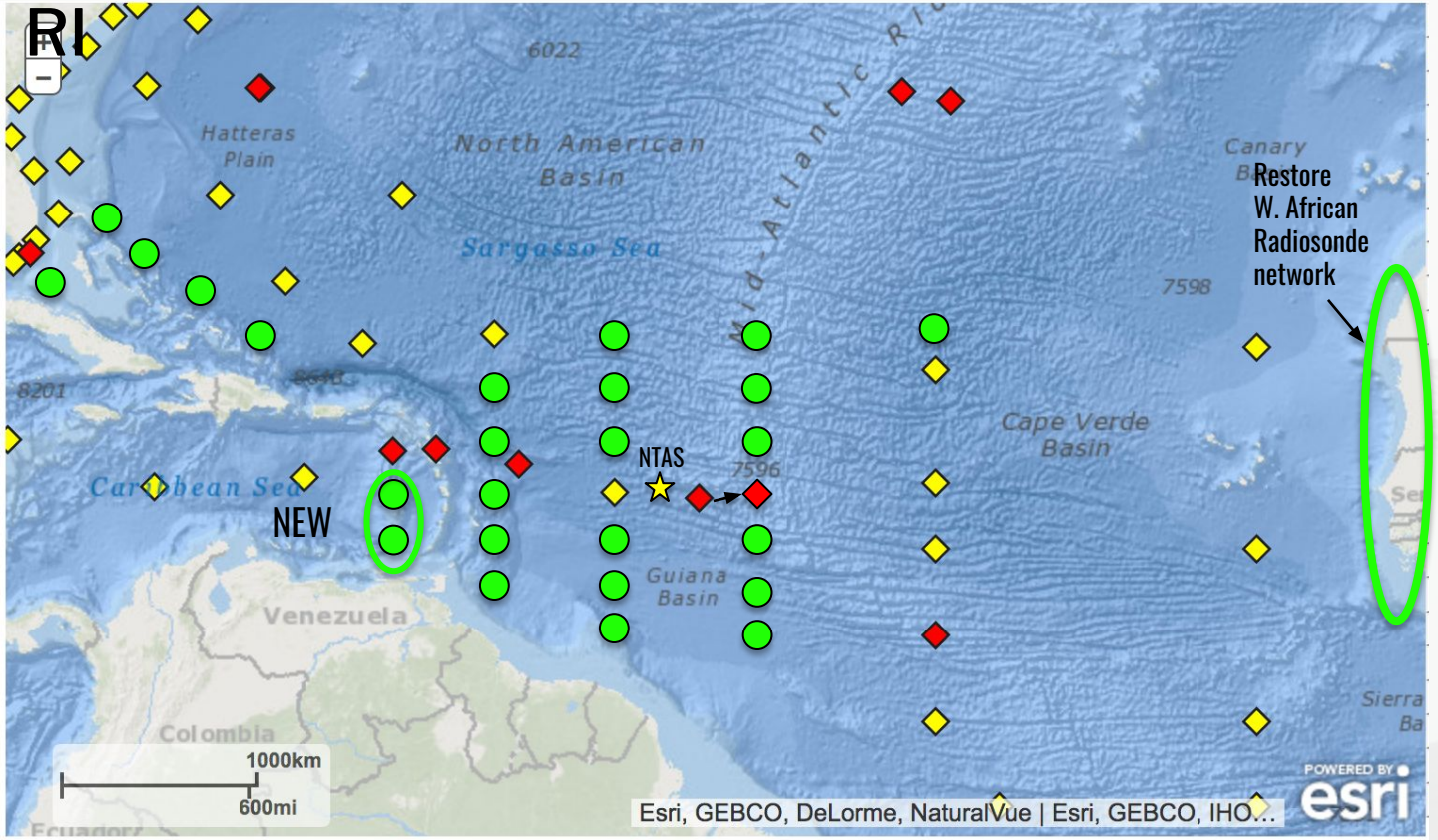
Mooring Status

- ### Days Deployed
- Moved or Adrift
- Out of Position
- Not Transmitting

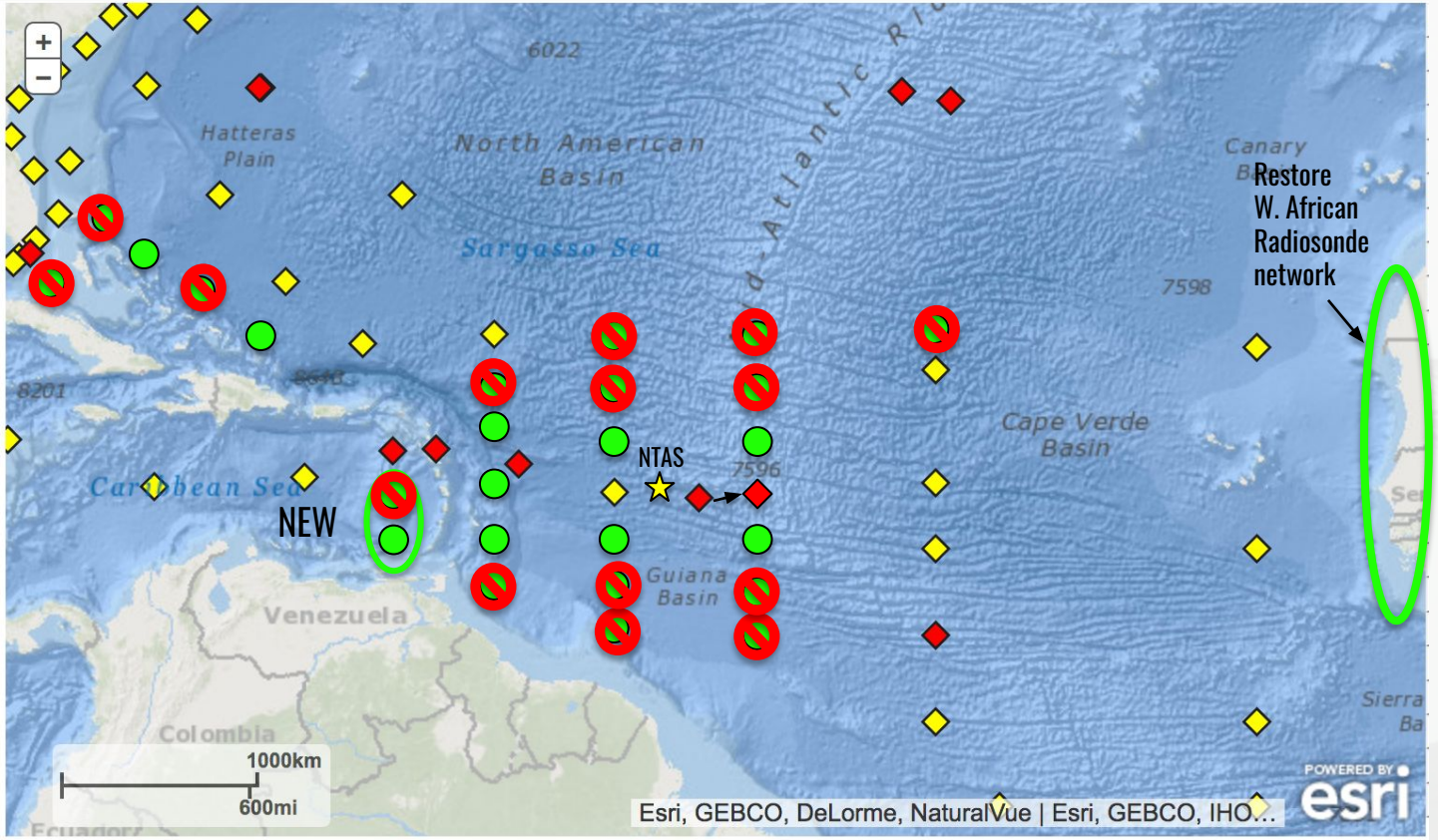
Data Return

- 0% - 50%
- 50% - 75%
- 75% - 90%
- 90% - 100%

Full NHC Recommended enhancements for RI



Bare minimum (10) NHC Recommended enhancements for RI



Bare minimum (10) NHC Recommended enhancements (wide grid)