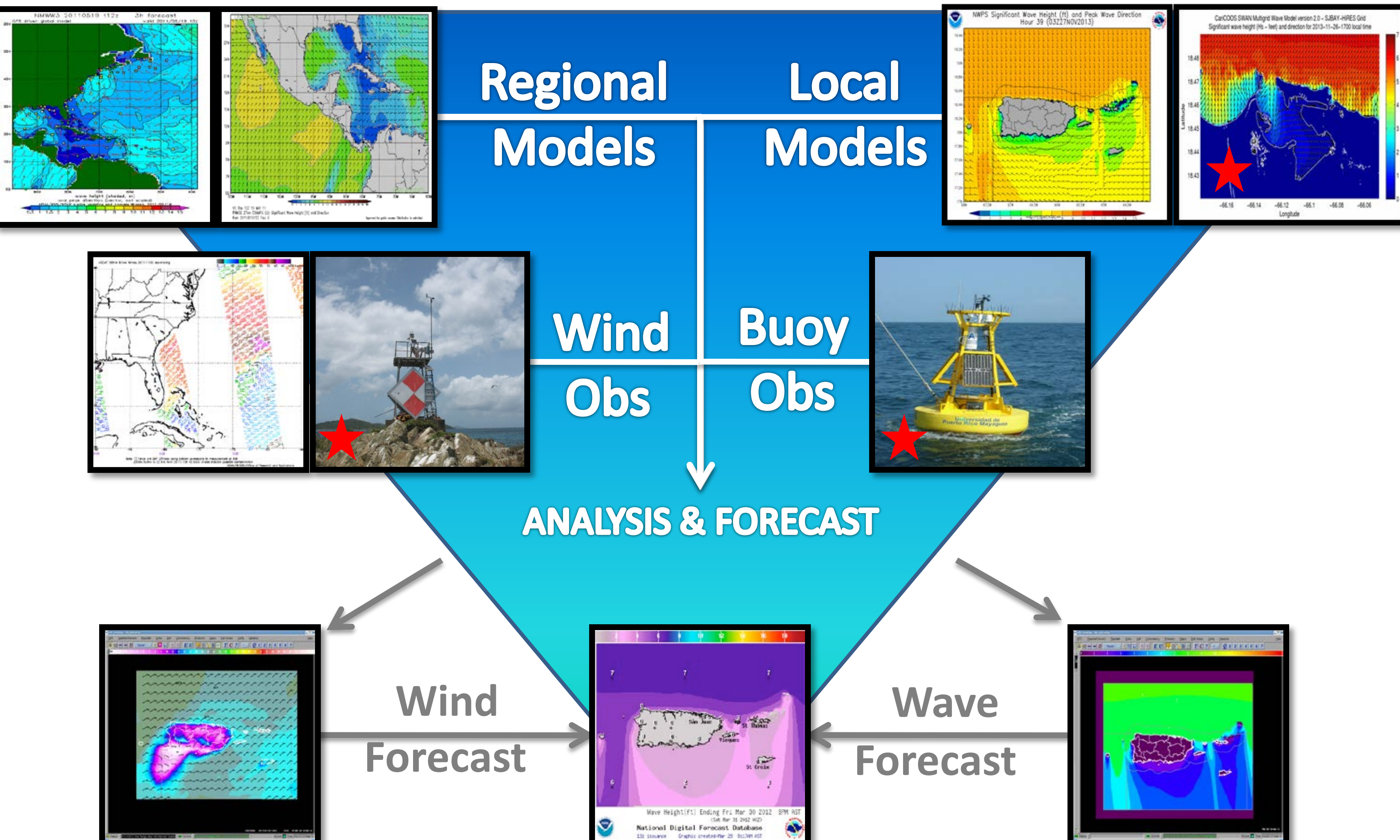
Collaboration efforts between CarICOOS and NWS-San Juan

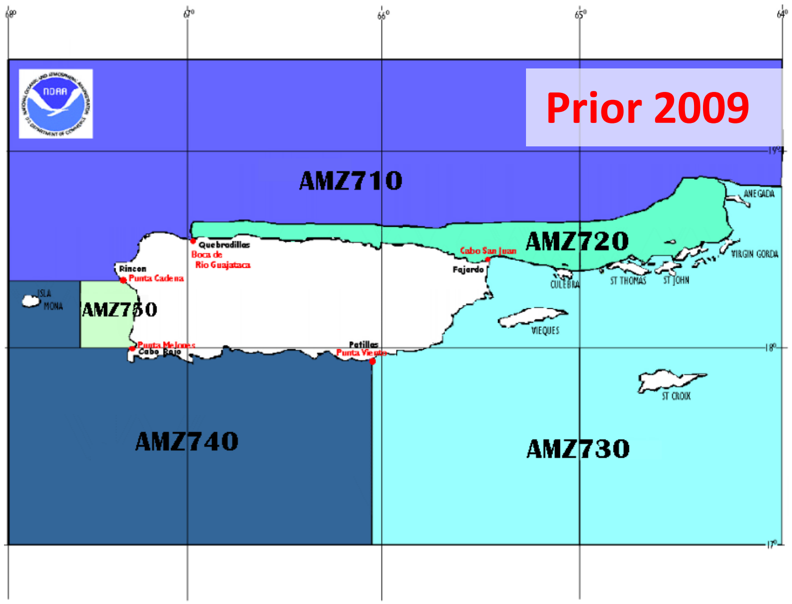
Roberto Garcia

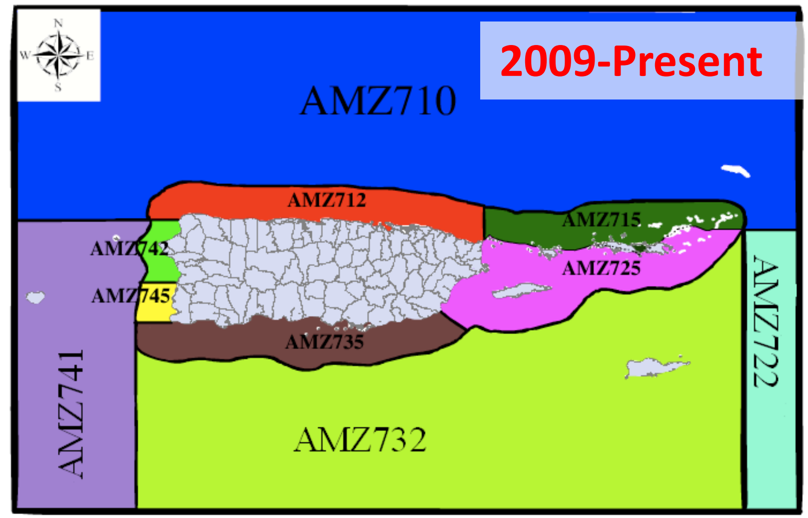
Meteorologist In-charge

Marine Forecast Process



Marine Zones

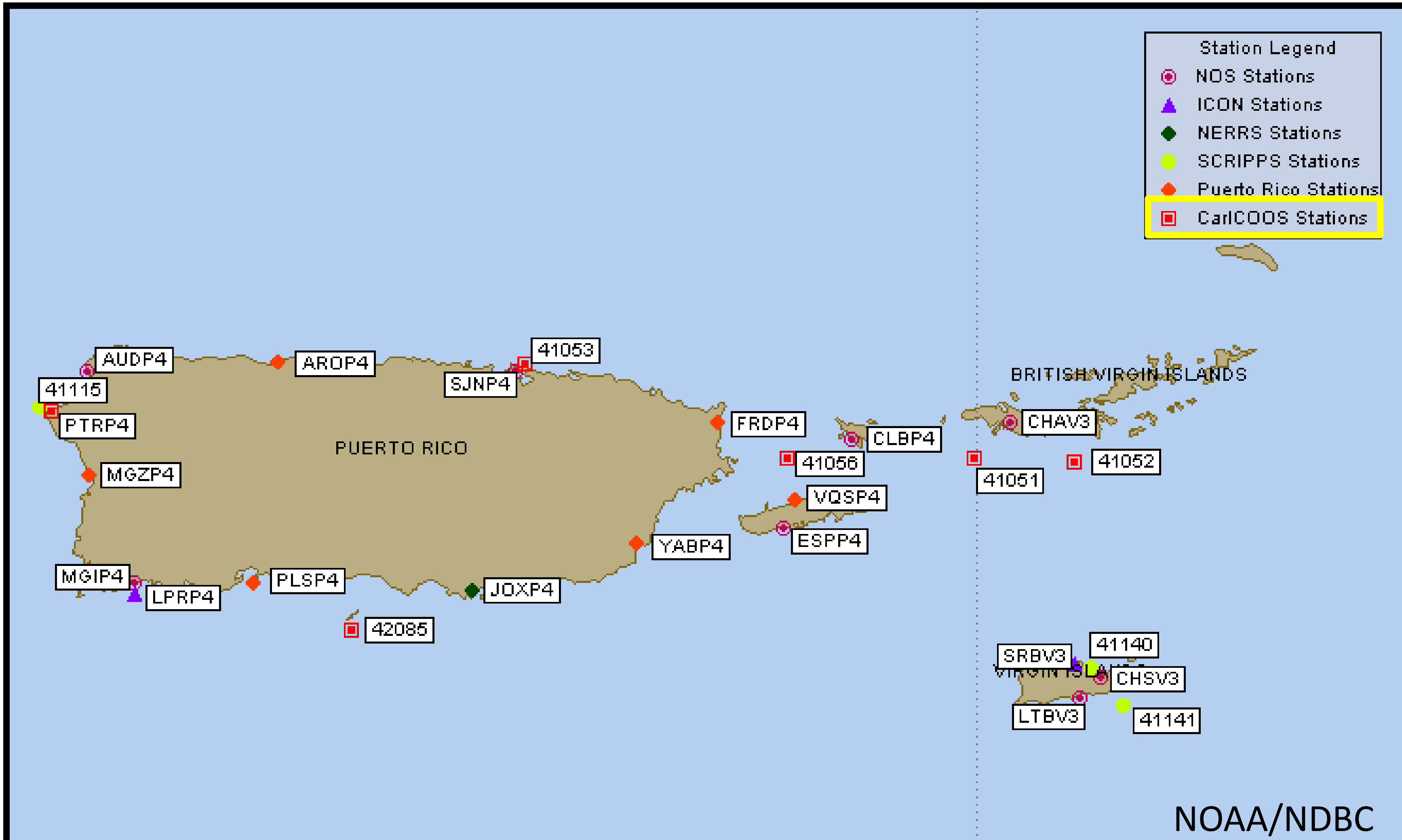




- CariCOOS' efforts for expanding the buoy network and the implementation of a high resolution wave model (SWAN) at WFO San Juan allow us to increase from 5 to 10 marine zones to provide detail information of sea state in the surrounding waters of Puerto Rico and the U.S. Virgin Islands.

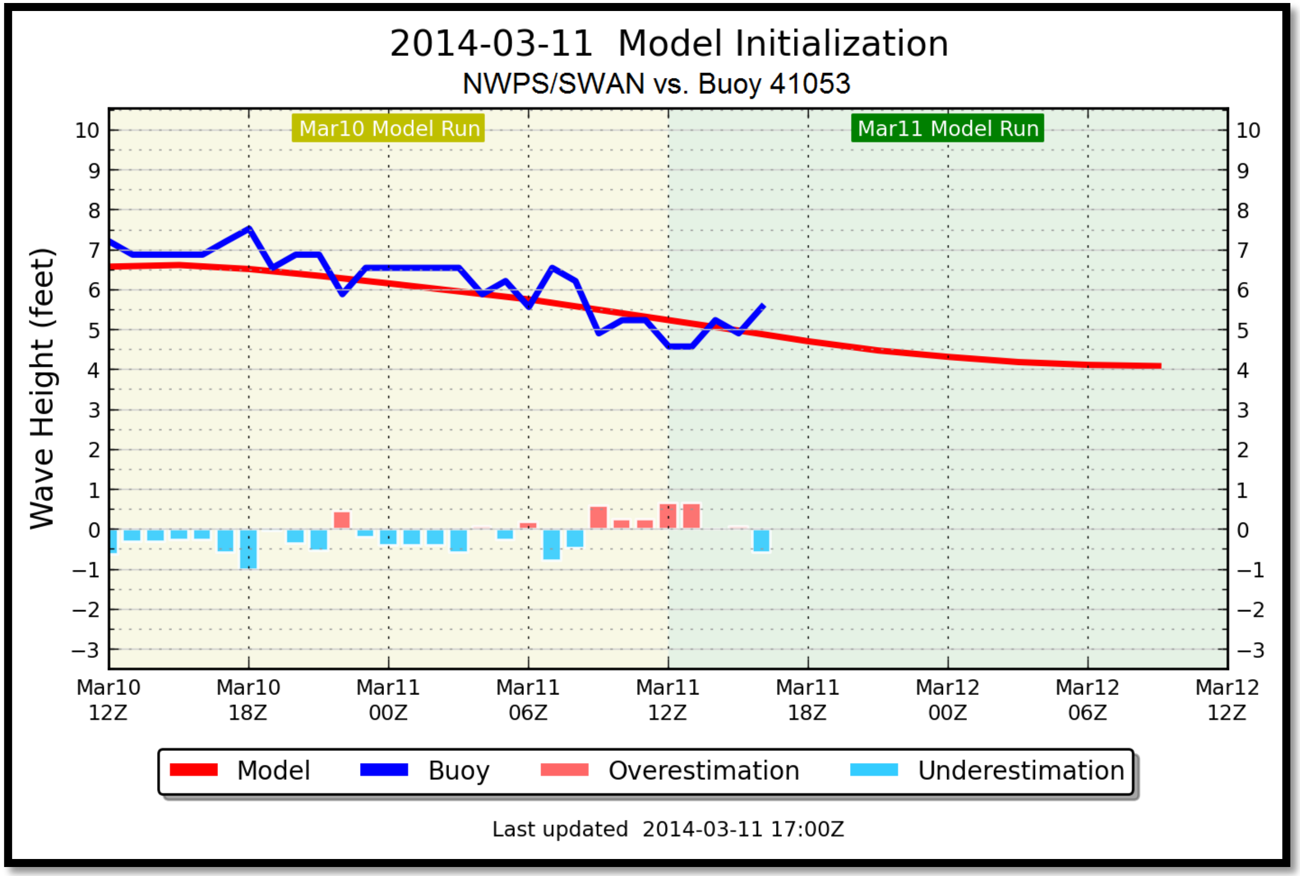
Observation Network

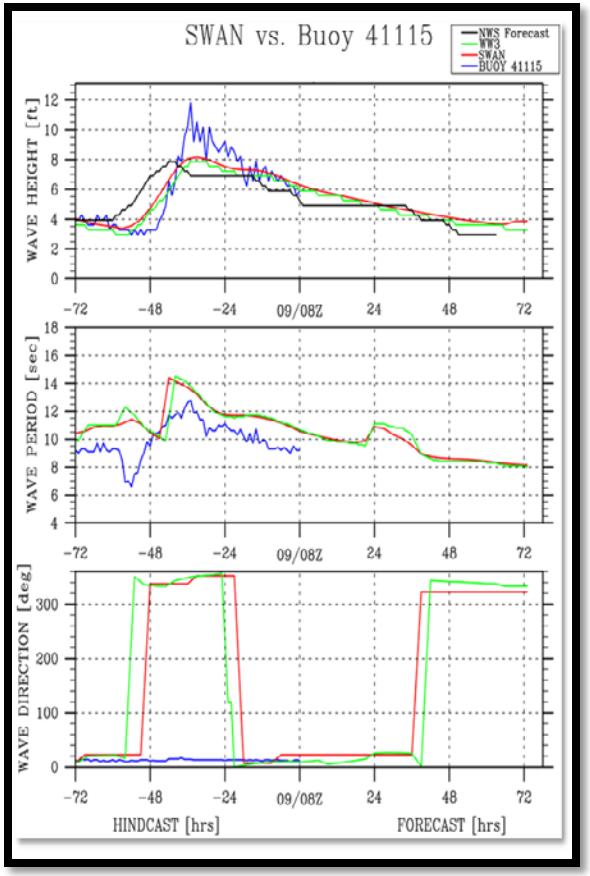
NOAA/CariCOOS



Forecast Verification

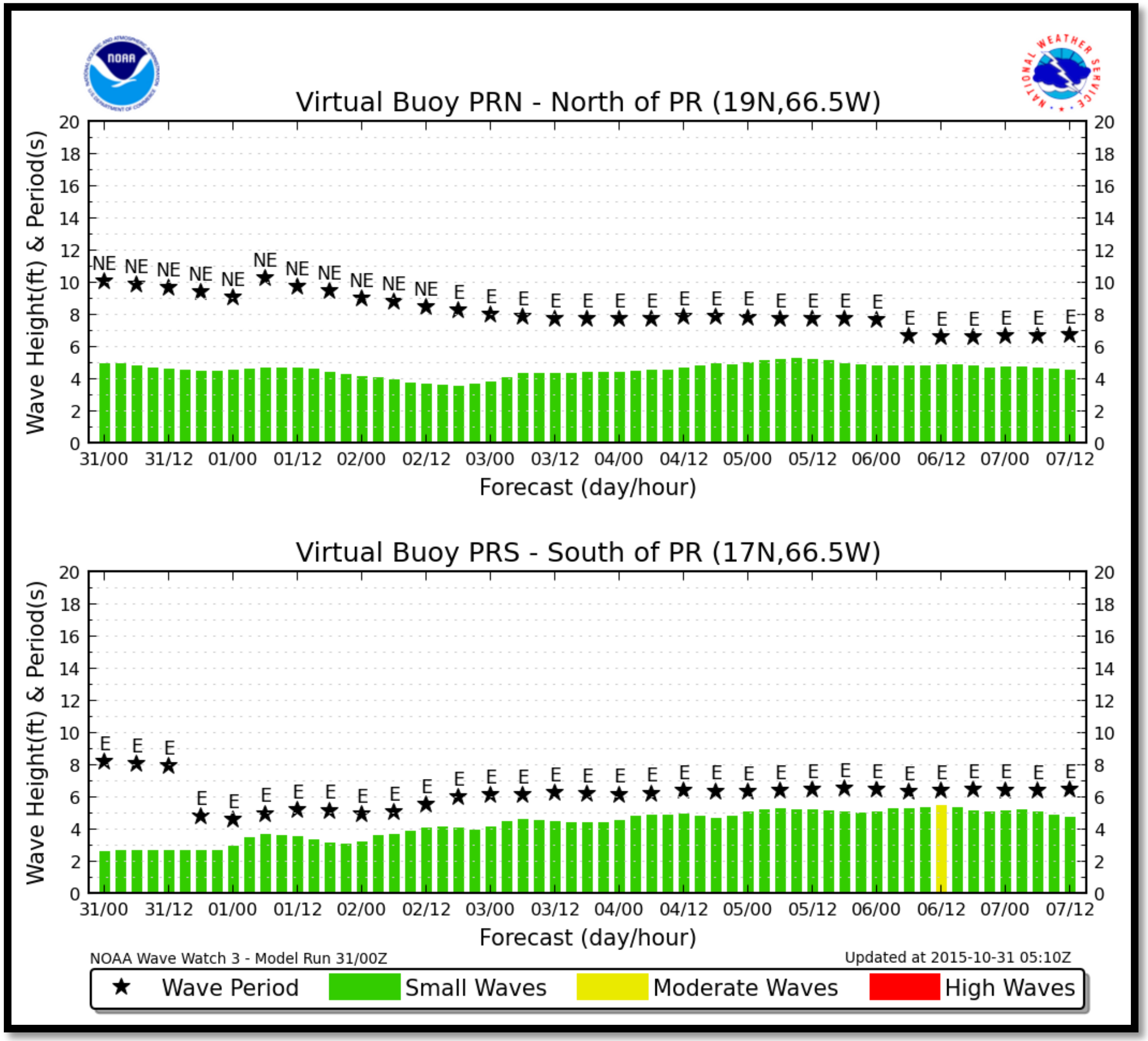
Internal Products



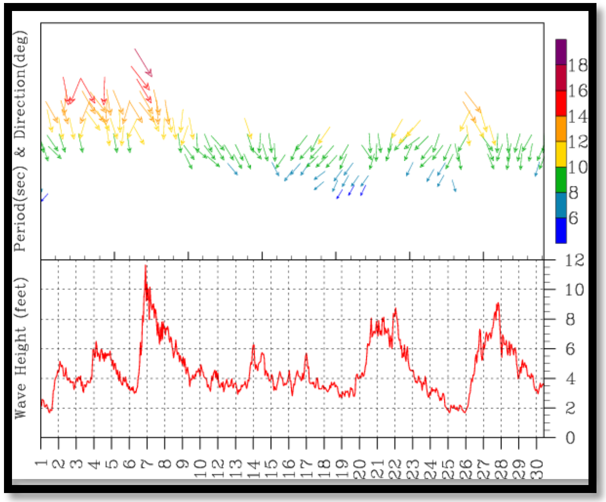


Internal Products

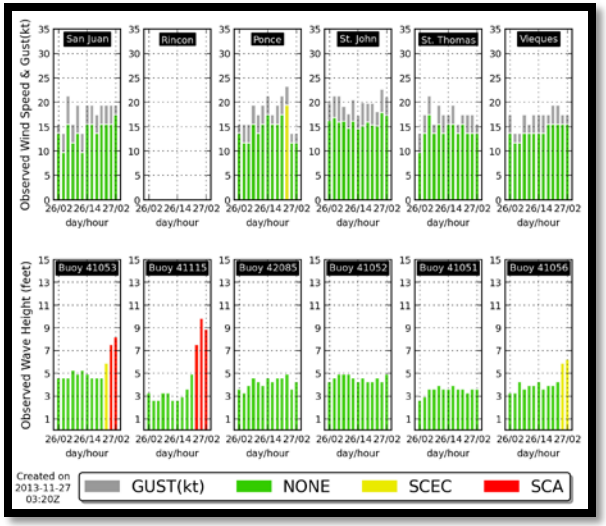
Using CariCOOS Data (buoys and weather stations)



Virtual Buoy Forecast



Monthly Summary



Observations (last 24 hrs)

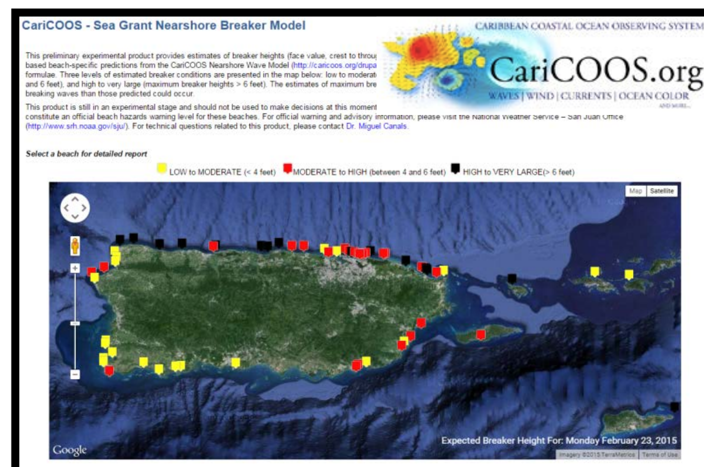
NOAA Collaboration

NOAA Sea Grant (Puerto Rico)

- Project for Aquatic Safety in Puerto Rico.
  - The research was used to pick the most dangerous beaches in Puerto Rico for the Surf Zone Forecast (SRF).

NOAA IOOS (CariCOOS)

- Sea Grant funded CariCOOS to develop a Nearshore Breaking Wave Model
  - The breaking wave height equation is currently used to calculate the surf height inside of the SRF.



Surf Zone Forecast

Product Components

Beaches

- Selected using the Sea Grant Project for Aquatic Safety in PR

Breaking Wave Height

- Use the equation from the CariCOOS-Sea Grant Breaker Model

Rip Current Risk

- The rip current risk is calculated using the wind speed, wind direction, wave height and wave period from our local NWPS/SWAN model at 500 meters.

Weather Forecast

- Use the official weather forecast prepare by WFO San Juan

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FZCA52 TJSJ 301941
SRFSJU

SURF ZONE FORECAST FOR PUERTO RICO
NATIONAL WEATHER SERVICE SAN JUAN PR
341 PM AST THU OCT 30 2014

PRZ001-311945-
SAN JUAN AND VICINITY-
INCLUDING THE BEACHES OF...LOIZA AND SAN JUAN
341 PM AST THU OCT 30 2014

BEACH                   PINONES         OCEAN PARK

BREAKING WAVE HEIGHT    2-4 FEET        3-5 FEET

RIP CURRENT RISK        LOW             MODERATE

DURING TIMES OF MODERATE RIP CURRENT RISK, PERSONS SHOULD ENTER THE
WATER ONLY IF THEY ARE EXPERIENCED WITH SWIMMING IN THE SURF. IF CAUGHT
IN A RIP CURRENT, DON'T TRY TO FIGHT ITS SEAWARD PULL. MOVE ACROSS THE
CURRENT IN A DIRECTION FOLLOWING THE SHORELINE.

.TODAY...PARTLY CLOUDY. SCATTERED SHOWERS. ISOLATED THUNDERSTORMS.
LOWS IN THE LOWER 70S. HIGHS IN THE UPPER 80S. SOUTH WINDS AROUND
5 MPH.

$$
PRZ002-311945-
NORTHEAST-
INCLUDING THE BEACHES OF...LUQUILLO...FAJARDO AND HUMACAO
341 PM AST THU OCT 30 2014

BEACH                   LA PARED        PLAYA ESCONDIDA  PALMAS DEL MAR

BREAKING WAVE HEIGHT    2-4 FEET        3-5 FEET         2-4 FEET

RIP CURRENT RISK        LOW             MODERATE         LOW

DURING TIMES OF MODERATE RIP CURRENT RISK, PERSONS SHOULD ENTER THE
WATER ONLY IF THEY ARE EXPERIENCED WITH SWIMMING IN THE SURF. IF CAUGHT
IN A RIP CURRENT, DON'T TRY TO FIGHT ITS SEAWARD PULL. MOVE ACROSS THE
CURRENT IN A DIRECTION FOLLOWING THE SHORELINE.

.TODAY...PARTLY CLOUDY. SCATTERED SHOWERS. ISOLATED THUNDERSTORMS.
LOWS AROUND 70. HIGHS IN THE UPPER 80S. SOUTH WINDS 5 TO 10 MPH.

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PRZ005-311945-
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Collaborative Research

CariCOOS: Real-time data validation of high-resolution wind forecast

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Abstract*— CariCOOS has implemented a mirror run of the operational numerical weather prediction model employed by the National Weather Service Weather Forecast Office San Juan (NWS WFO SJU), which is based on the WRF NMM model. The model configuration consists of a one-way nesting of two domains with a horizontal resolution of 6-km and 2-km, respectively. CariCOOS developed a single domain configuration of the WRF NMM model having a finer horizontal spatial resolution of 1-km. These models, in general, are discrete approximations in space and time of a continuous geophysical medium being simulated. The solutions to these models are not an exact representation of reality. The goal is to keep track of the relative ability of a model to make accurate predictions. A real-time validation MATLAB® script, for numerical weather prediction (NWP), was developed to assist CariCOOS end-users in comparing the forecasts to actual data. The validation of these models was conducted by comparing in-situ wind observations (O_i), of CariCOOS observing network, with model forecast (M_i). Time histories plots of in-situ and modeled wind speed and direction are compared in real time; while also solving statistical algorithms with various validation parameters as outputs. The statistical parameters included in the real-time validation tool are: (i) the Pearson's moment correlation coefficient (*r*), (ii) mean bias (*MB*), (iii) mean absolute gross error (*MAGE*), (iv) root mean square error (*RMSE*), (v) Willmott index of agreement (*IOA*) and (vi) hit rate (*HR*). This useful real-time validation tool allows NWS WFO SJU forecasters and CariCOOS researchers to measure the skill of the model and quantify the error to determine future needs for modeling enhancements. The real-time validation framework developed facilitates CariCOOS researchers to set any validation date range, which can vary from days to months. The validation skill appraisal revealed noticeable improvement in the forecasting for both wind speed and direction by the WRF-1KM when compared to the WRF-2KM and the NWS National Digital Forecast Database (NDFD) operational product. Typically the most improved locations are noticed for weather stations in regions surrounded by complex topographic features,, particularly the lee side of islands. These findings suggest that the 1-km model resolves better the local orographic forcing generated by the fine-scale topography, typical of the coastal meteorology of Caribbean islands. The improvement in forecasting 10-m winds is due to a better depiction of the 1-km resolution model of complex terrain. These findings may lead to better understanding of local convection process, which dominates the diurnal and nocturnal wind cycles of sea and land breeze, respectively.

Keywords—WRF model; high-resolution; ioos; caricoos

I. Introduction

Validation of a numerical model is an important aspect of the implementation process and operational phase. Model skill performance can be measured as how well the model results compare with reliable in-situ observations or predicted events. The Caribbean Coastal Ocean Observing System (CariCOOS) has implemented a mirror run of the operational numerical weather prediction (NWP) model employed by the National Weather Service Weather Forecast Office San Juan (NWS WFO SJU), which is based on the Weather Research and Forecast (WRF) model. The WRF model system contains two dynamical cores, referred to as the ARW (Advanced Research WRF) [1] and the NMM (Non-hydrostatic Mesoscale Model) [2]; the first developed at the National Center for Atmospheric Research (NCAR), and the second at the National Centers for Environmental Prediction (NCEP). The NWS WFO SJU currently employs WRF NMM model since it provides faster simulations run when compared to WRF ARW core, making it appropriate for operational forecasting. Also, both WRF core models are fit for use in a broad range of applications across scales ranging from meters to thousands of kilometers. The model configuration implemented by the NWS WFO SJU consists of a one-way nesting of two domains with a horizontal resolution of 6-km and 2-km, respectively, for the parent and child domains. Employing similar model setup, CariCOOS implemented a single domain WRF model configuration with a horizontal spatial resolution of 1 km. Both model configurations are implemented with 45 vertical levels. Boundary and initial conditions are driven by the Global Forecast System (GFS) and high-resolution sea surface temperature (SST) from NASA Short-term Prediction Research and Transition Center (SPoRT). These models, in general, are discrete approximations in space and time of a continuous geophysical medium being simulated. The solutions to these models are not an exact representation of reality. The fundamental problem lies in the numerical approximation to solve the complex Navier-Stokes equations used to simulate atmospheric flows. Our goal is to keep track of the discrepancy level in order to improve future model skill performance. The real-time validation results presented in this paper focus on current operational products by CariCOOS and NWS WFO SJU. These models are referenced as WRF_NMM_2KM, WRF_NMM_1KM and NWS NDFD operational product [3].

II. Methodology

The validation of modeled forecast (M_i) from the WRF model configuration and NWS NDFD are validated using in-situ wind observations (O_i) from CariCOOS Observing Network, shown in Figure 1. CariCOOS observing network consist of 5 buoys equipped with meteorological instrumentation [4] and fifteen land-based meteorological stations. The land base mesonet stations were deployed by Weather Flow Inc. (13 sites) and CariCOOS (2 sites). Additional details of CariCOOS assests are presented in [5].

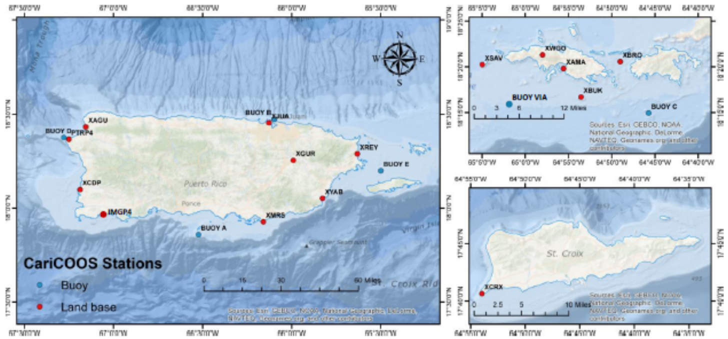


Figure 1. CariCOOS Observing Network of 5 meteorological buoys and 15 land-based weather stations.

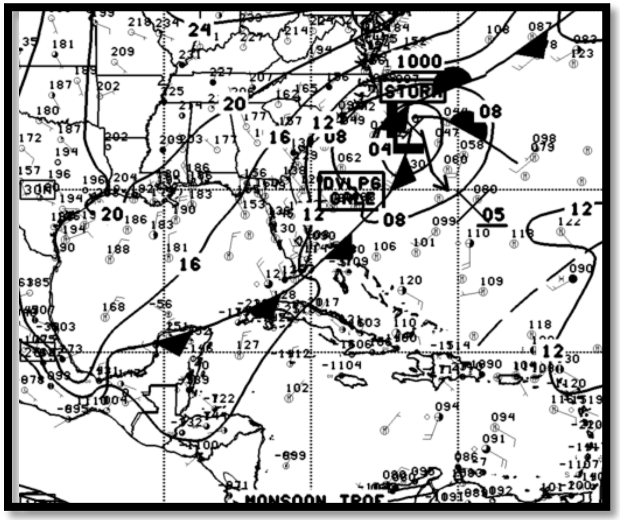
The validation methodology employed consisted in comparing in-situ observations to 10-m wind model simulation, for this task it is necessary to adjust the observation to a 10-m elevation following the logarithmic law, where U_{10} is the adjusted wind speed, U_z is the in-situ observation at elevation z (in m/s) from ground level or mean-sea-level at buoys, and z_0 is the terrain roughness (in m). Terrain roughness values were assigned to each site following recommended published values [6]. After all in-situ observations are adjusted by elevation, an hourly mean average is computed and compared to model outputs interpolated to each site's GPS coordinate.

$$U_{10} = U_z \frac{\ln\left(\frac{10}{z_0}\right)}{\ln\left(\frac{z}{z_0}\right)} \qquad (1)$$

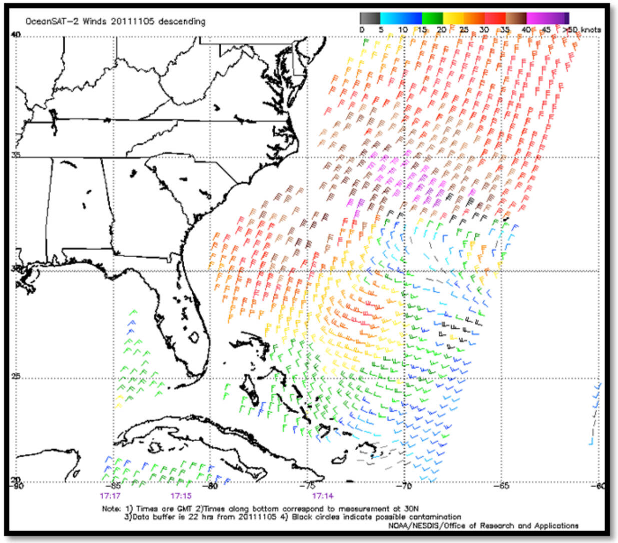
A MATLAB® script was developed as a toolbox to enable real-time validation of NWP models. The main tasks performed were: (i) gathering of all model data, (ii) gathering of all in-situ observations and compute statistical parameters, and (iii) disseminate graphical result thru CariCOOS web portal. The first task involves accessing model data from CariCOOS DMAC Catalogue THREDDS Data Server (TDS) [7] and interpolating it to each in-situ GPS

Case Studies

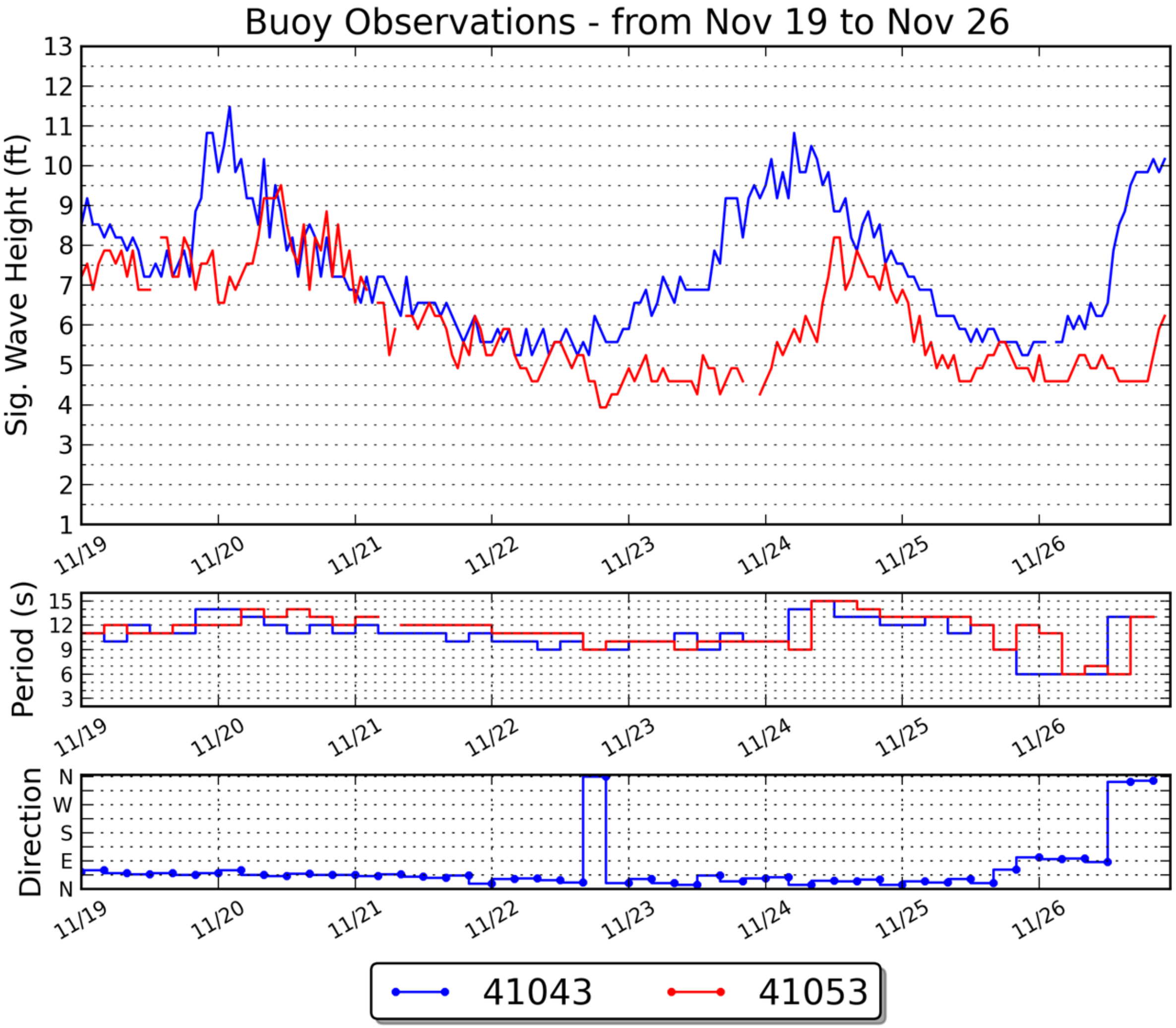
Winter Swell Events



WPC/OPC Surface Analysis

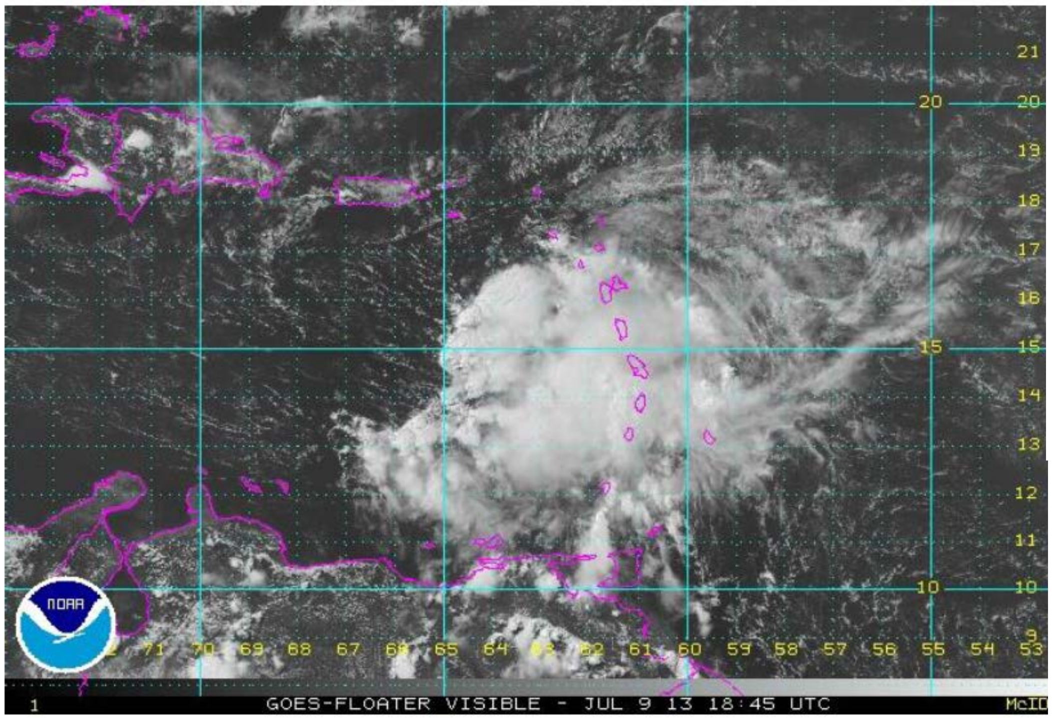


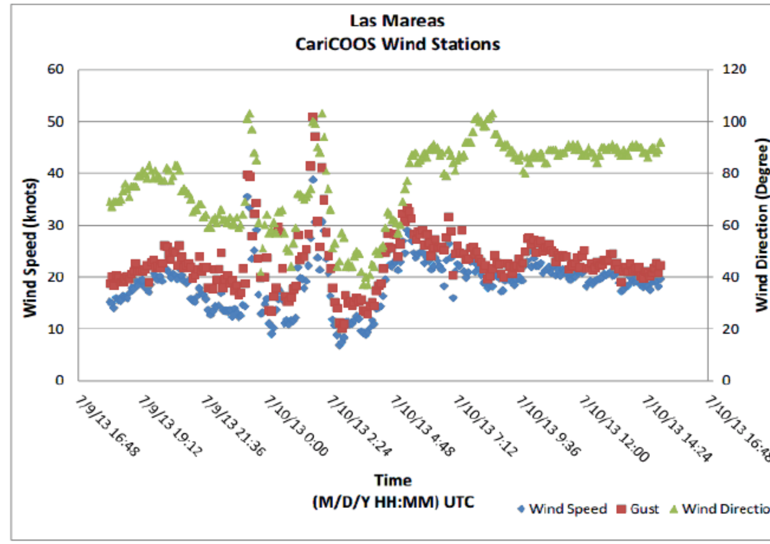
Observations (last 24 hrs)

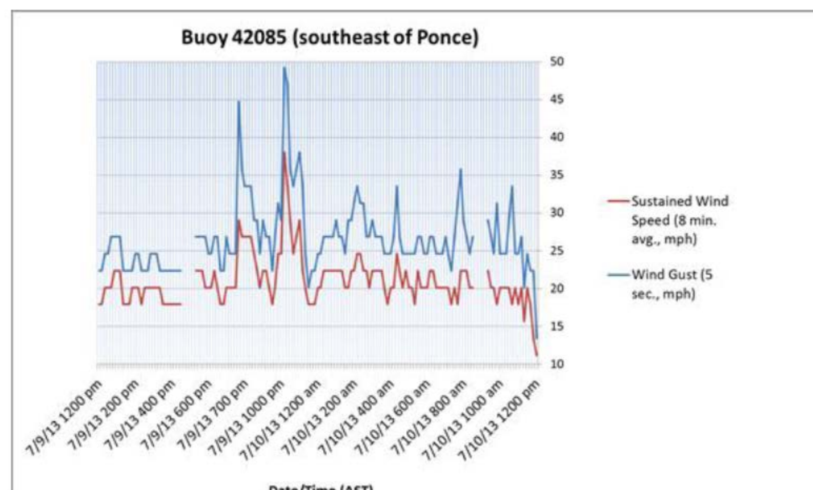


NDBC/CarICOOS Buoy Data

Post-Storm Reports







CariCOOS/WeatherFlow stations are used in Post-Storm Reports

Interagency Collaboration

- **CariCOOS** and **NWS San Juan** have worked together on several projects since 2009.
- A key goal of this collaboration is to improve forecasts of meteorological and oceanographic phenomena by speeding up the transfer of new technology and research ideas into forecast operations. This is accomplished by combining the skills and mutual research interests of scientists and forecasters.