Establishing and Maintaining a Regional Ocean Wave Observing System

Miguel Canals & the CariCOOS Team
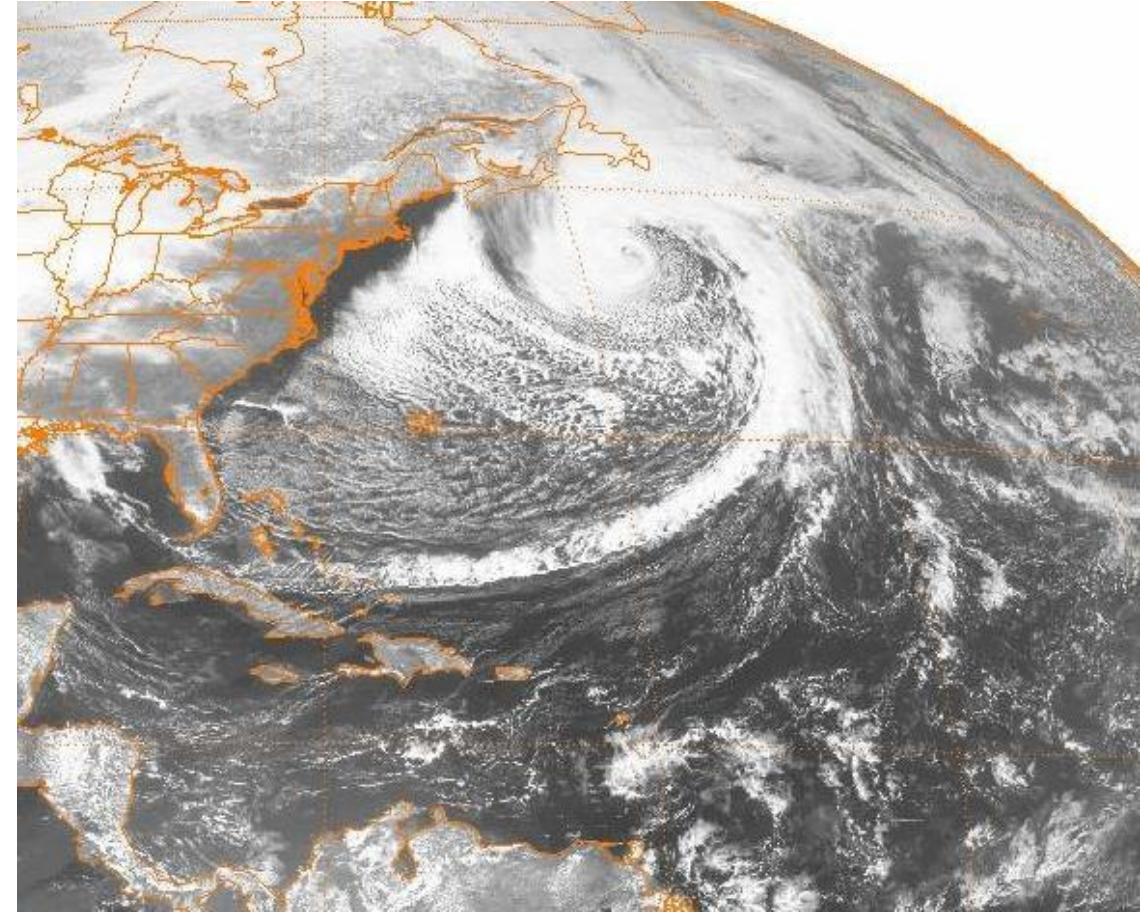
Feb 29 – March 2 2016
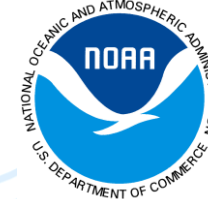
Overview

- Region overview, wave climate & challenges

- CariCOOS wave observing assets & modeling

- Examples of applications of wave observations and modeling
  - Beach safety
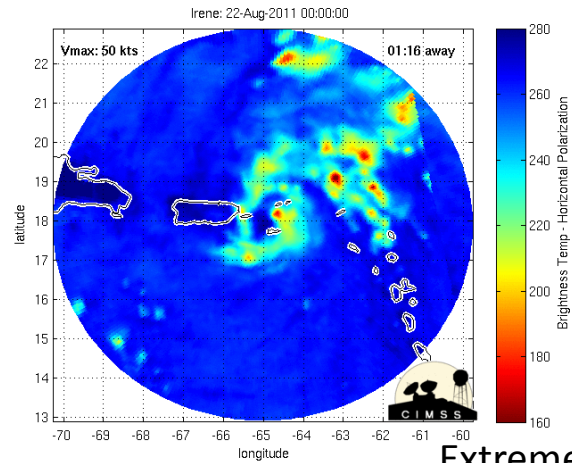 - UKC & Coastal Intelligence for Safe Navigation

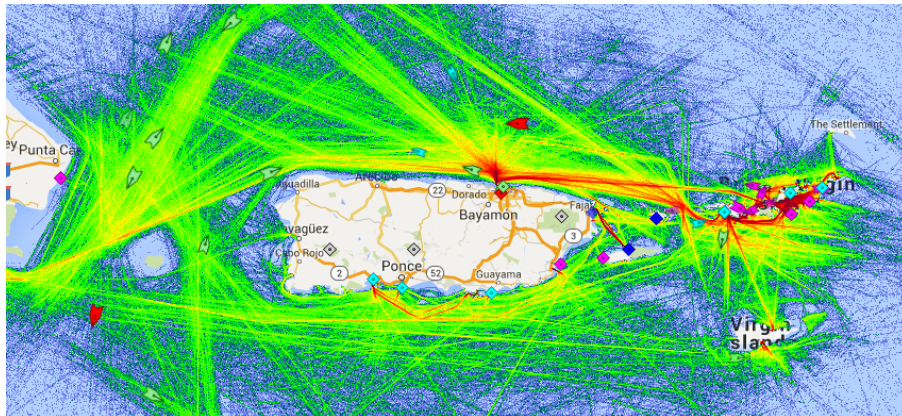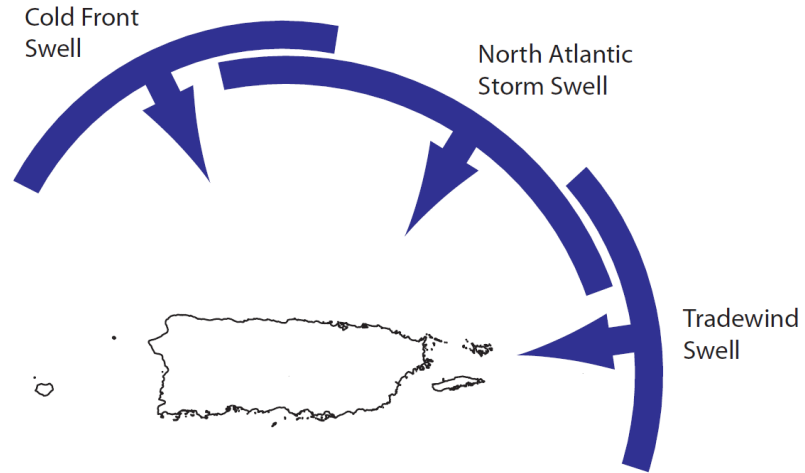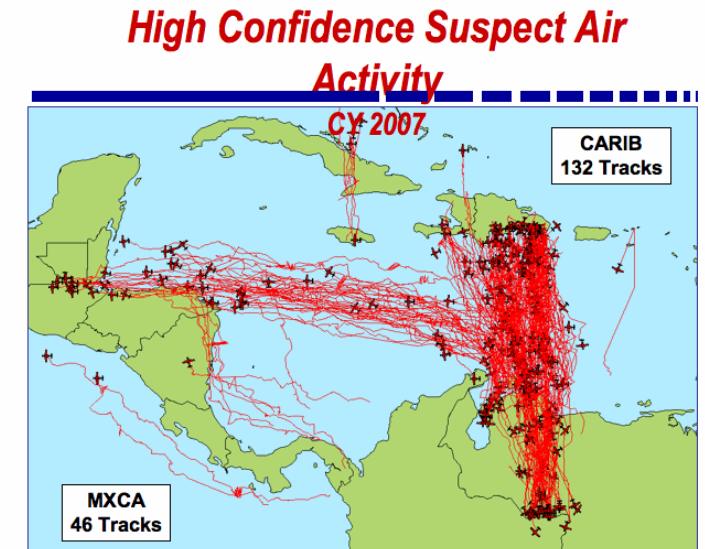- Concluding remarks

Region overview

Regional challenges

Cold Front Swell

North Atlantic Storm Swell

Tradewind Swell

Extreme events

Navigation safety, UKC & currents in ports

High Confidence Suspect Air Activity
CY 2007

CARIB 132 Tracks

MXCA 46 Tracks

Maritime security, illegal immigration & trade, very high USCG & CP activity

CARICOOS

CAOSE

Ocean observing in the Caribbean – then & now

BEFORE 2008:

- No ocean data buoys

- No real-time wave or current data

- Very limited coastal weather stations

- Some numerical models but with inadequate resolution to accurately predict waves and currents for the region

- This presented a problem not only for everyday ocean users but also for researchers & engineers

- If you wanted to undertake an ocean engineering project, there were **no boundary conditions, no initial conditions, no background characterization of ocean sites…**
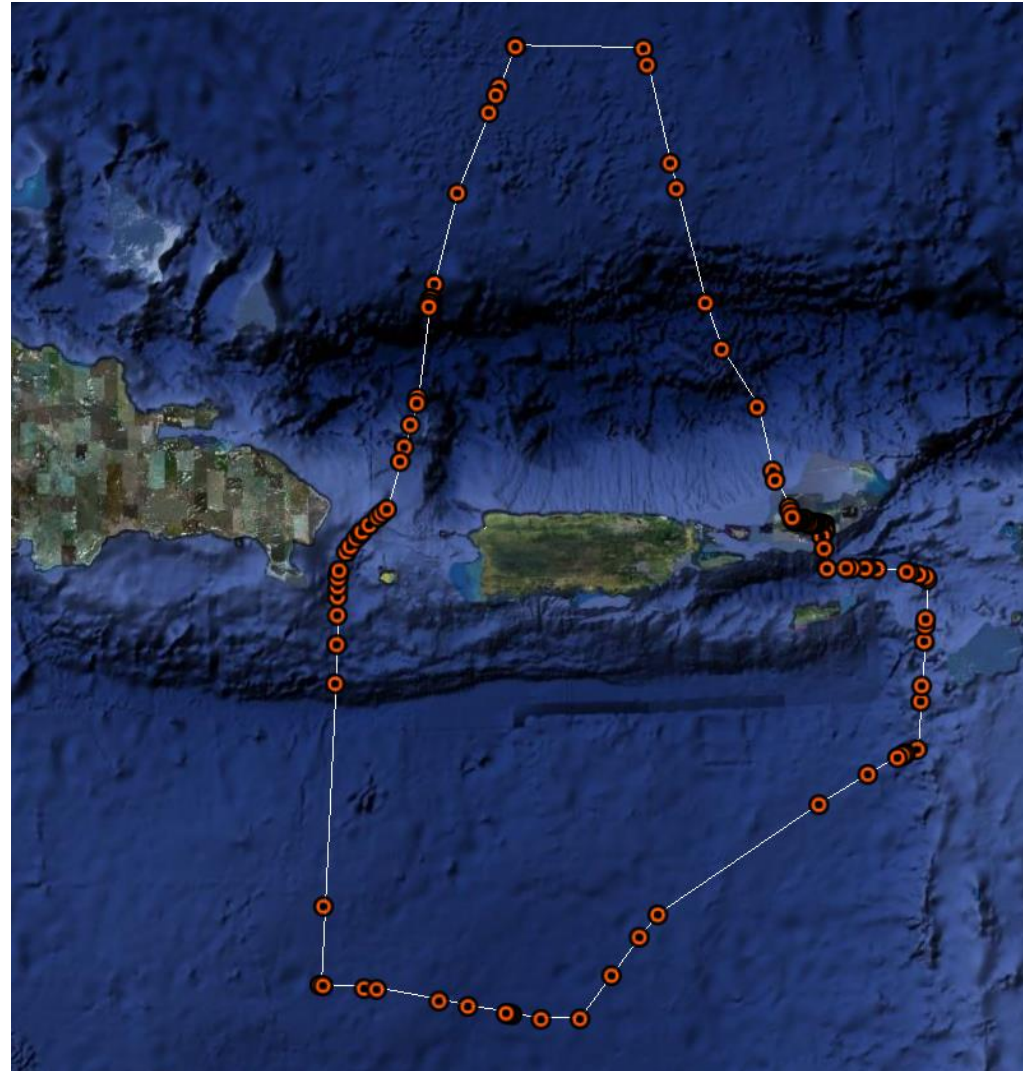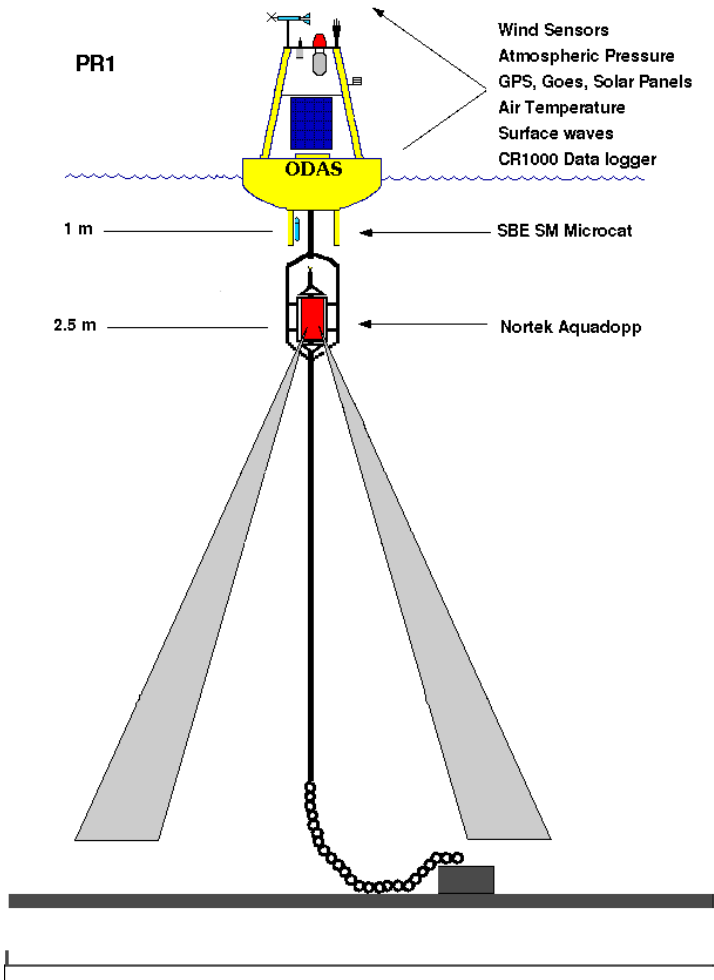
Current assets

- Efficient design minimizing observing assets that meet stakeholder needs for coastal information

- Strategic buoy placement to capture dominant wave directions

CariCOOS ODAS Buoys

PR1

Wind Sensors
Atmospheric Pressure
GPS, Goes, Solar Panels
Air Temperature
Surface waves
CR1000 Data logger

ODAS

1 m — SBE SM Microcat

2.5 m — Nortek Aquadopp

AXYS TECHNOLOGIES INC.

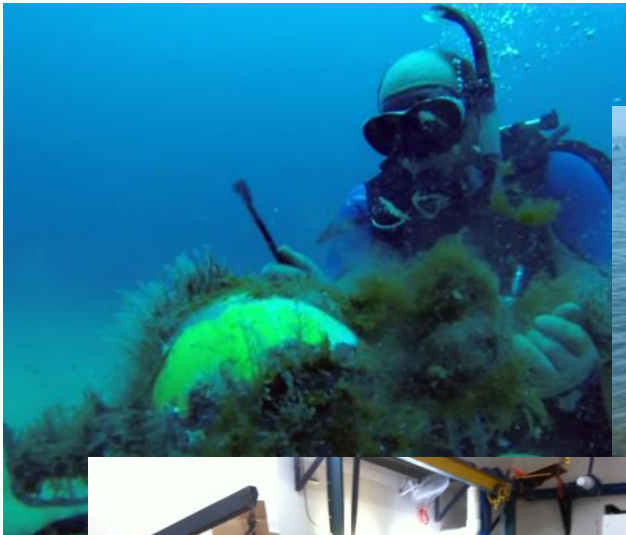### TRIAXYS™ *Next Wave* Sensor

FEATURES & BENEFITS

- Designed for low power applications
- No moving parts
- Continuous wave sampling
- Supports any telemetry
- Supports other sensor inputs
- >5 years data storage capacity

» TRIAXYS™ Directional Wave Sensor
» TRIAXYS™ Non-Directional Wave Sensor
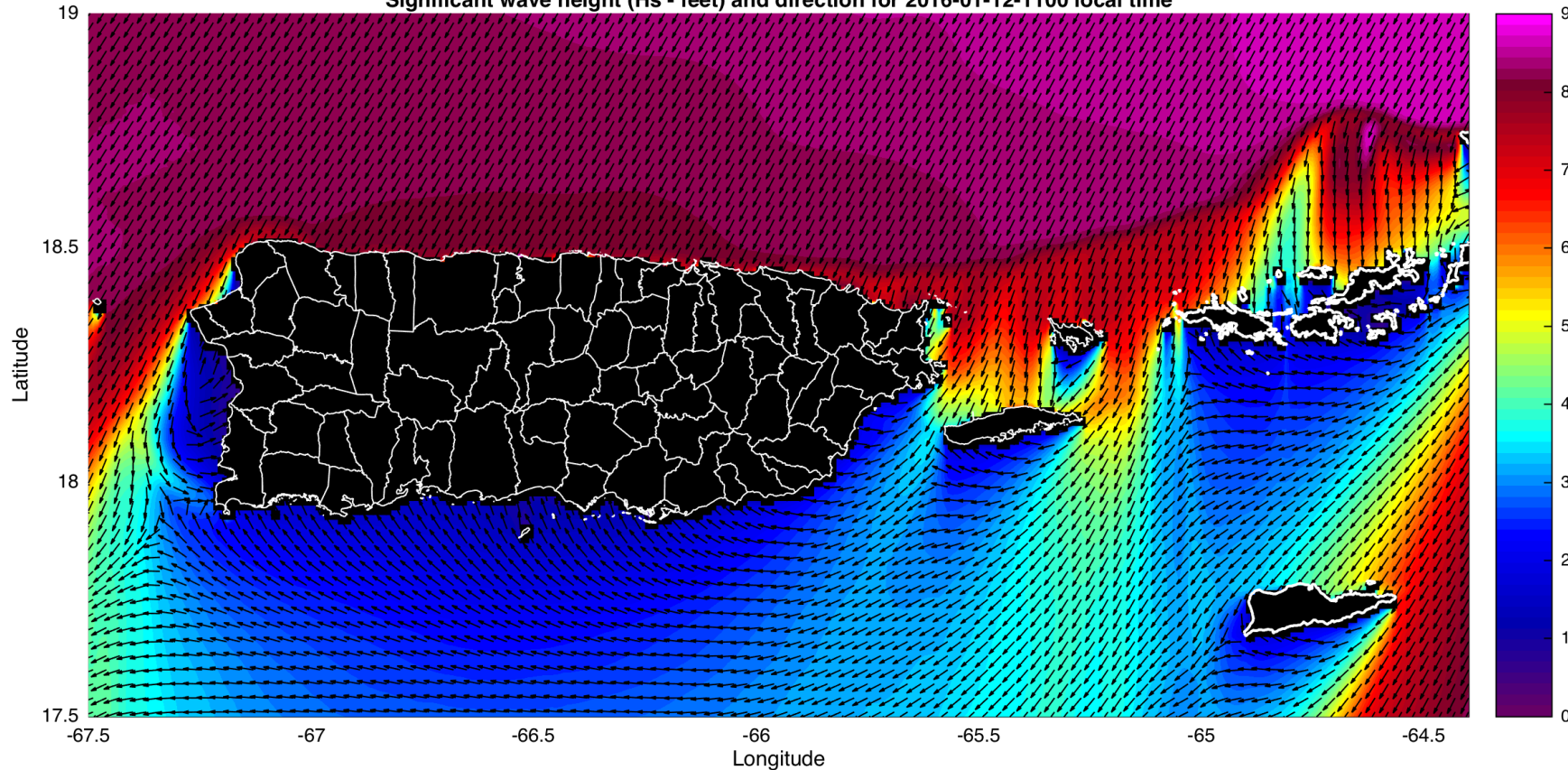» TRIAXYS™ Motion Sensor

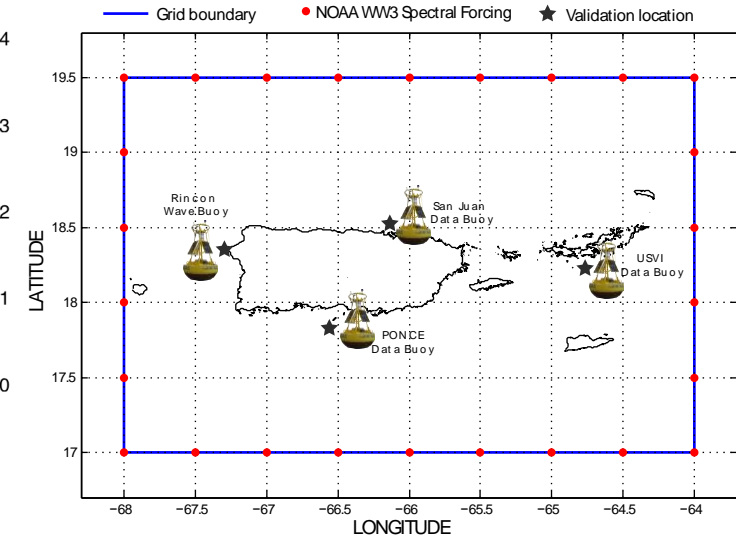# CariCOOS Waverider Buoys

Cost-effective buoy deployment

MODELING: The CariCOOS Nearshore Wave Model

CariCOOS Nearshore Wave Model v7.0 (run: 20160112.1200 machine:swanwrf)
Significant wave height (Hs - feet) and direction for 2016-01-12-1100 local time
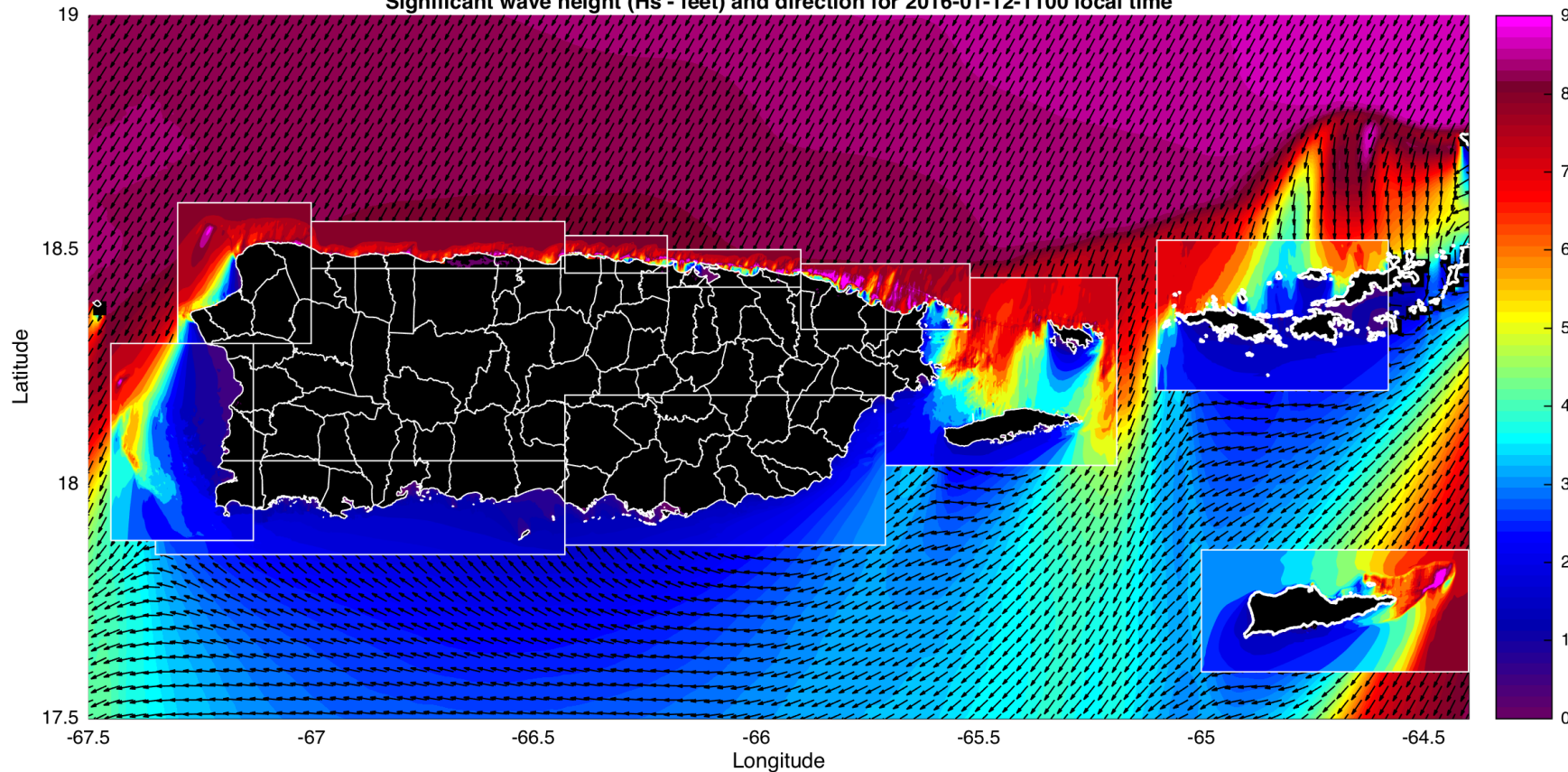
BOUNDARY CONDITIONS:

- Full 2D spectra from NECP WW3

- Surface wind forcing from CariCOOS WRF

- Frequency-direction space discretization: 36 x 36 bins

- 120 hour forecasts

MODELING: The CariCOOS Nearshore Wave Model

CariCOOS Nearshore Wave Model v7.0 (run: 20160112.1200 machine:swanwrf)
Significant wave height (Hs - feet) and direction for 2016-01-12-1100 local time

HIGHLIGHTS

- 12 nearshore grids at resolution from 240 meters to 10 meters

- Every single meter of inhabited coastline in US Caribbean covered by very high-resolution SWAN grid
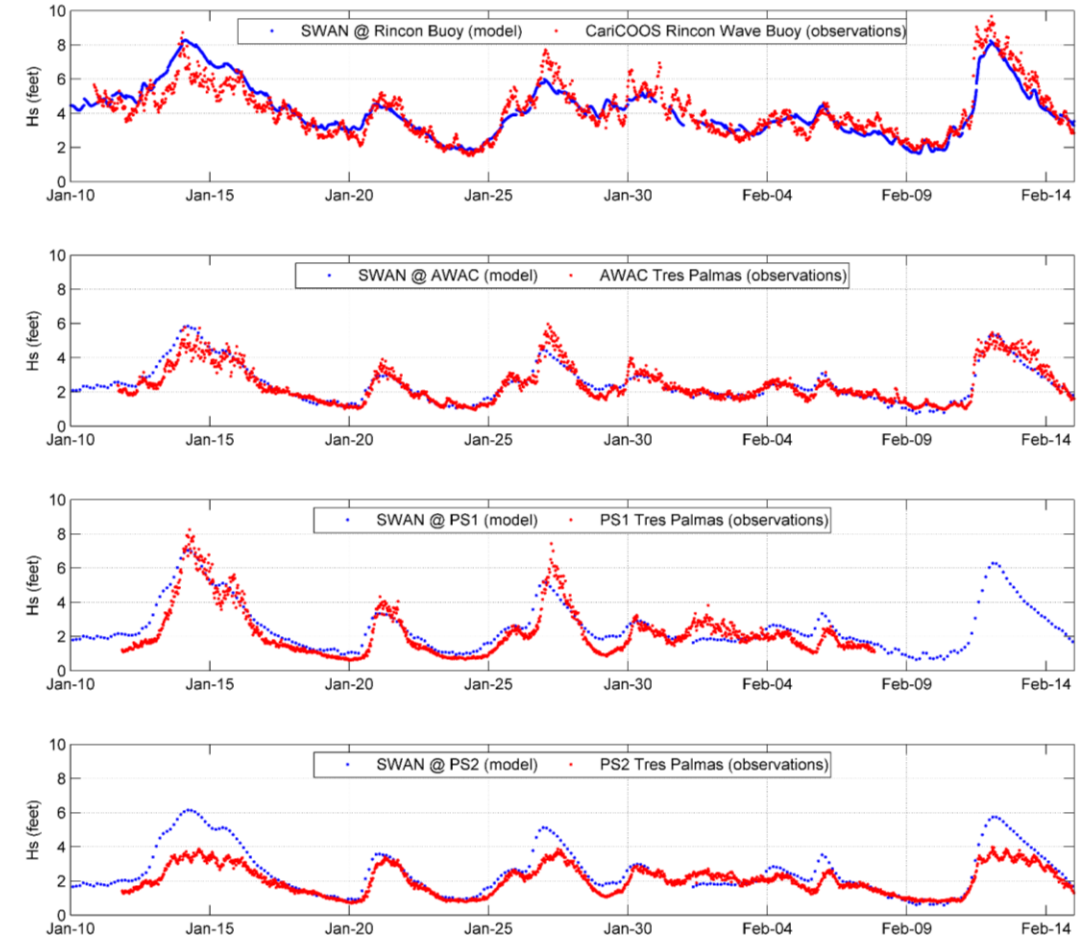
- Moving to unstructured SWAN in FY16

Yabucoa Port Operational Wave Model (run: 20160130.0000 machine:swanwrf)
Significant wave height (Hs – feet) and direction for 2016-01-31-1700 local time
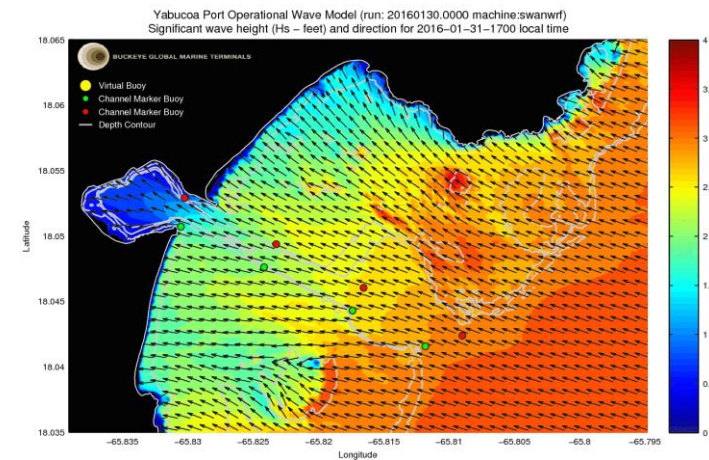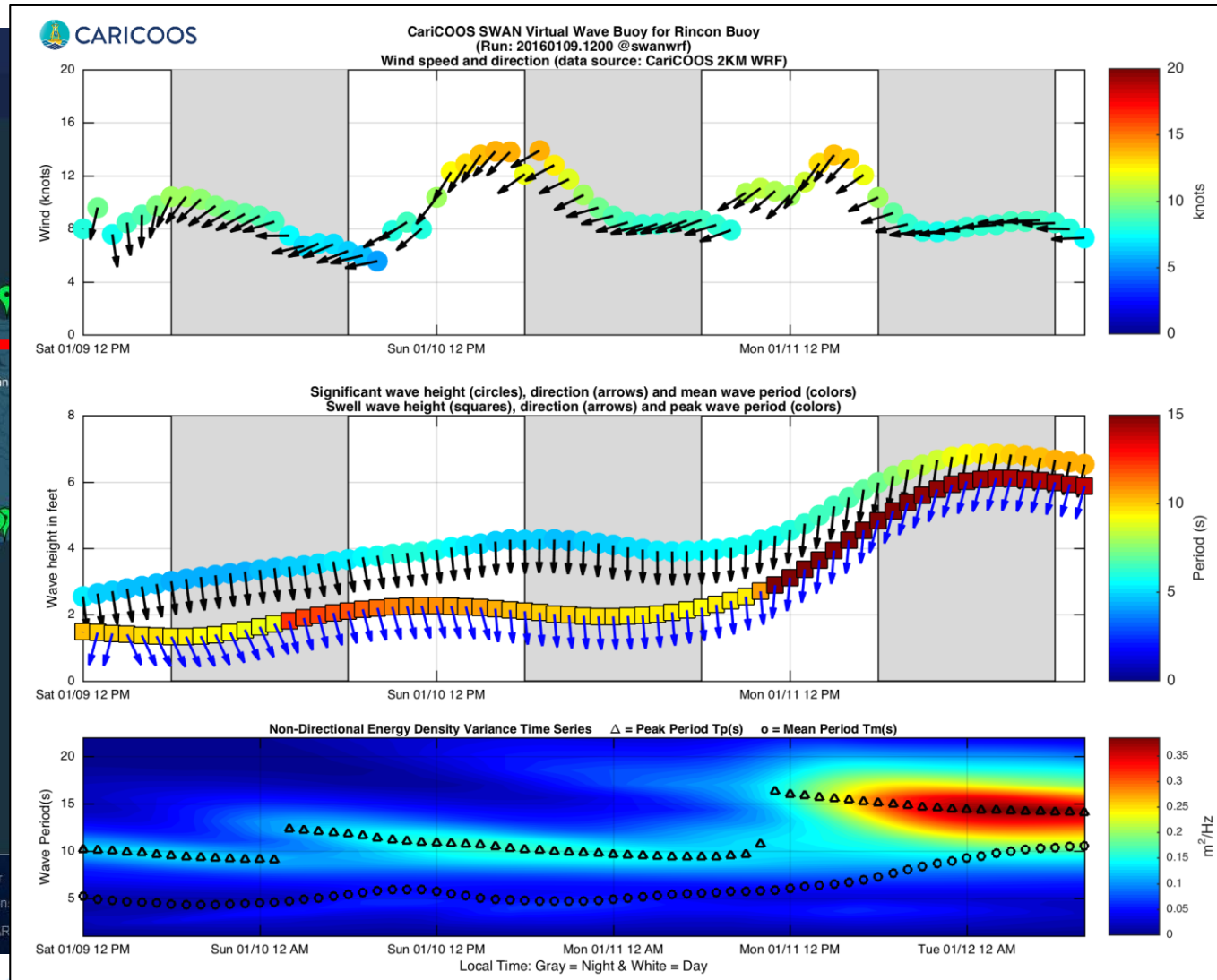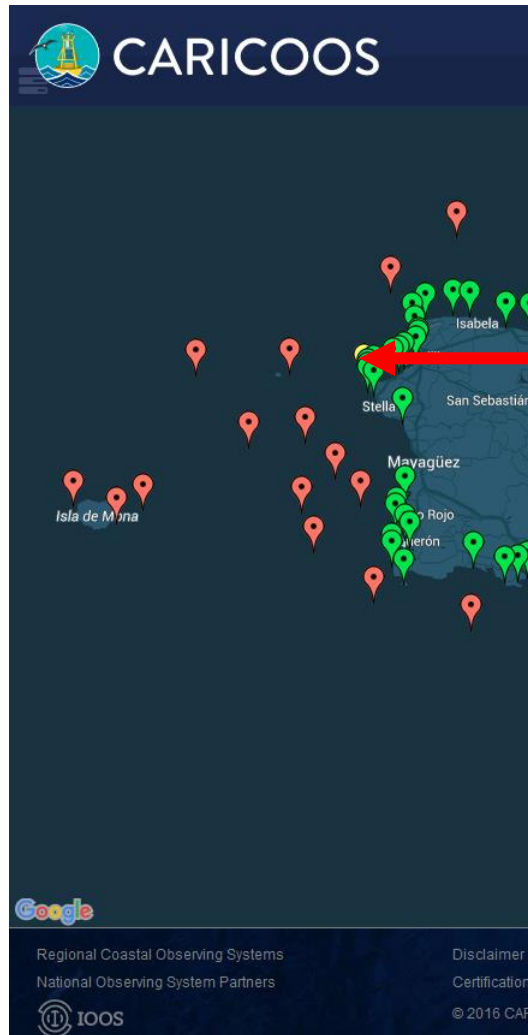
Model validation
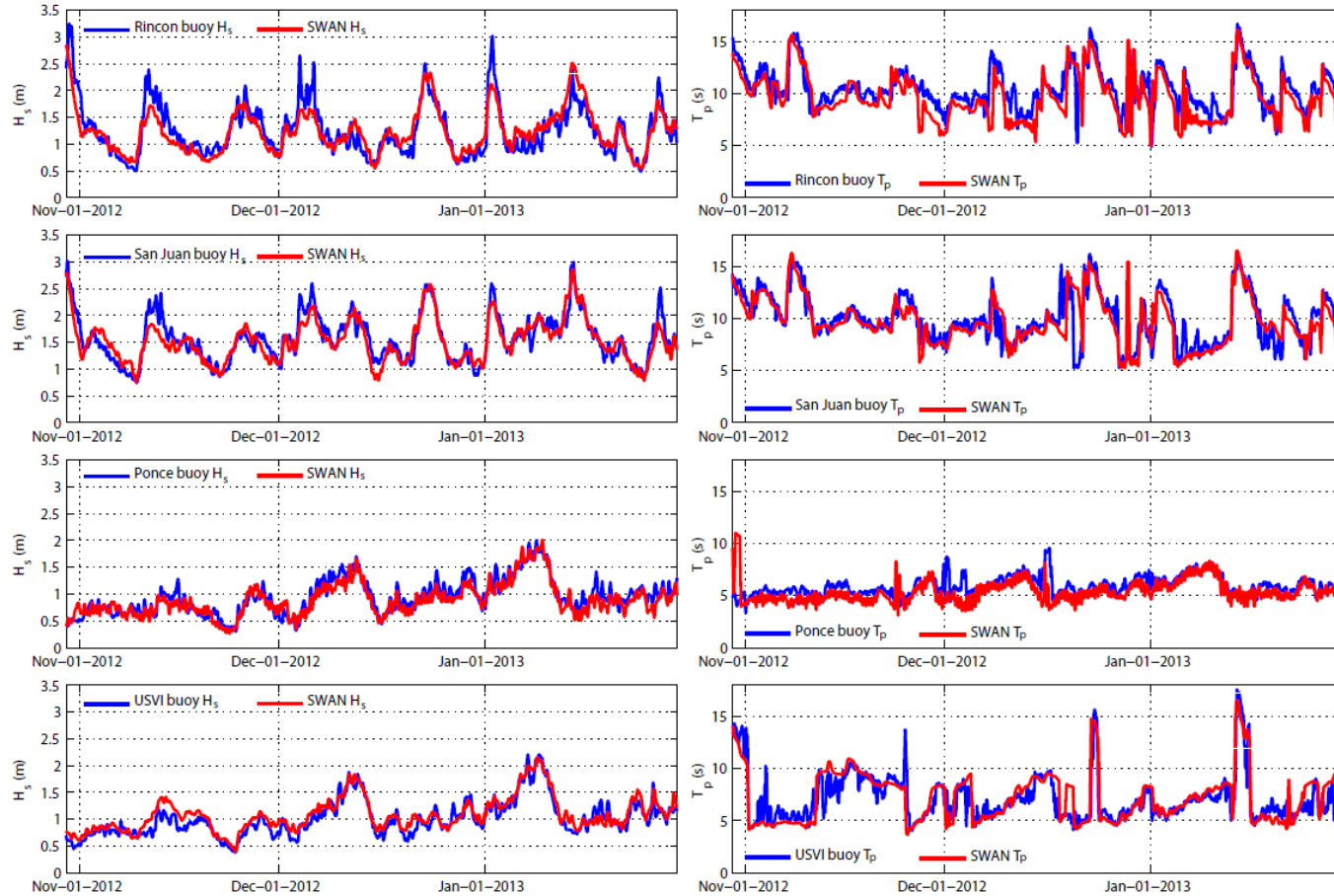
VALIDATION AT OFFSHORE BUOYS

VALIDATION IN NEARSHORE / SURFZONE

MARITIME SAFETY: Safe navigation - improved sea-state forecasts

ver 150 CariCOOS rtual buoys

Major users:
ecreational boaters,
ommercial fishing,
w enforcement,
urfers & beachgoers
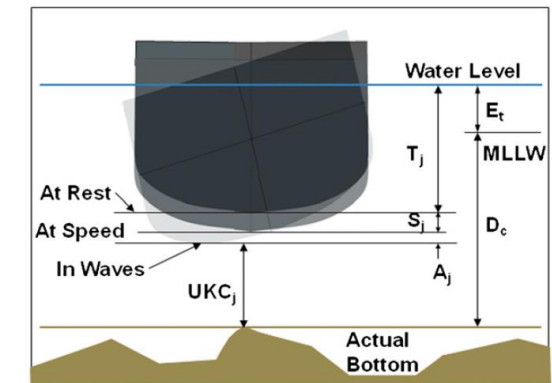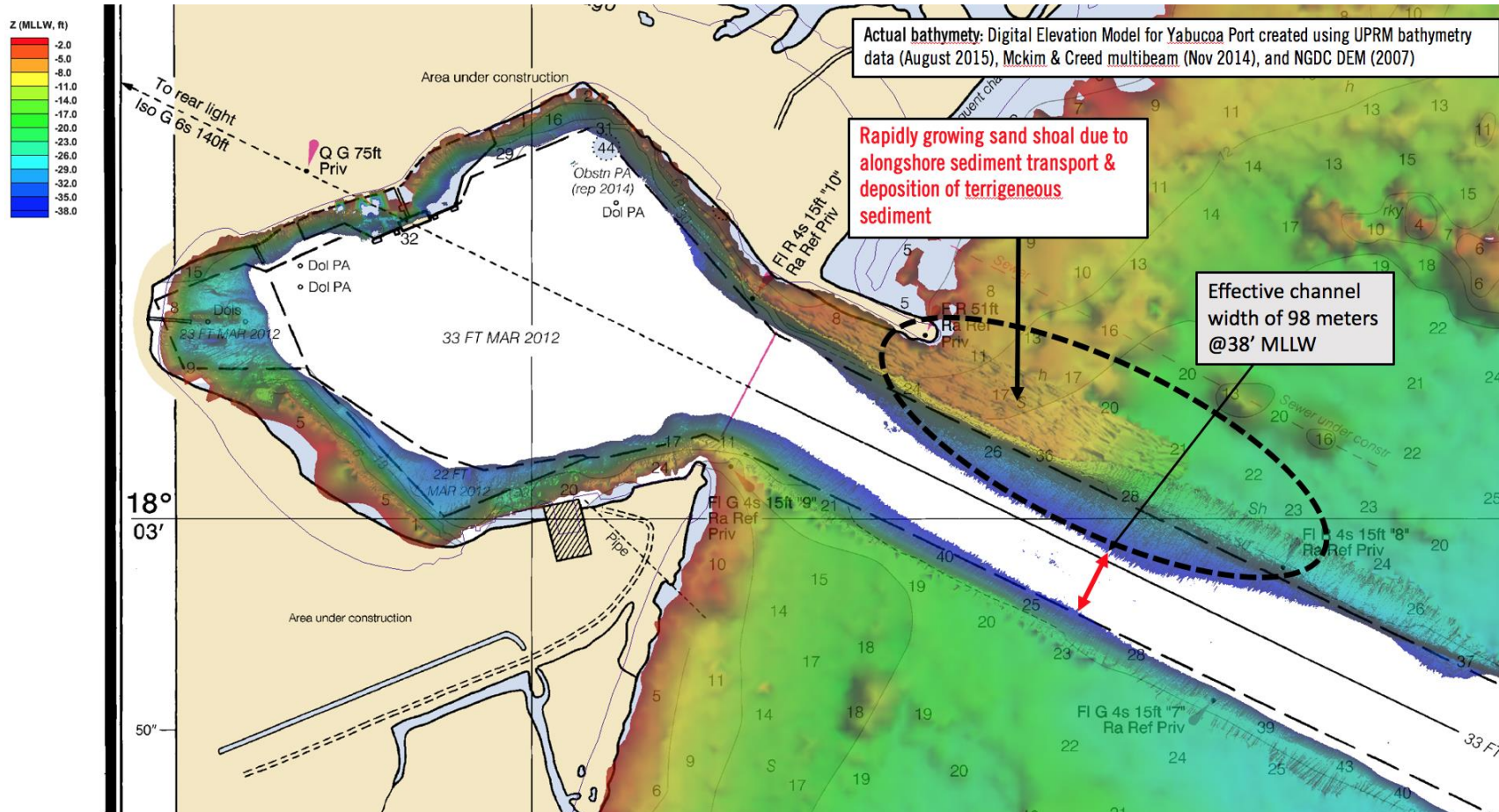
Case study: Port of Yabucoa (work funded by Buckeye Global LLC)

http://yabucoa.caricoos.org/us
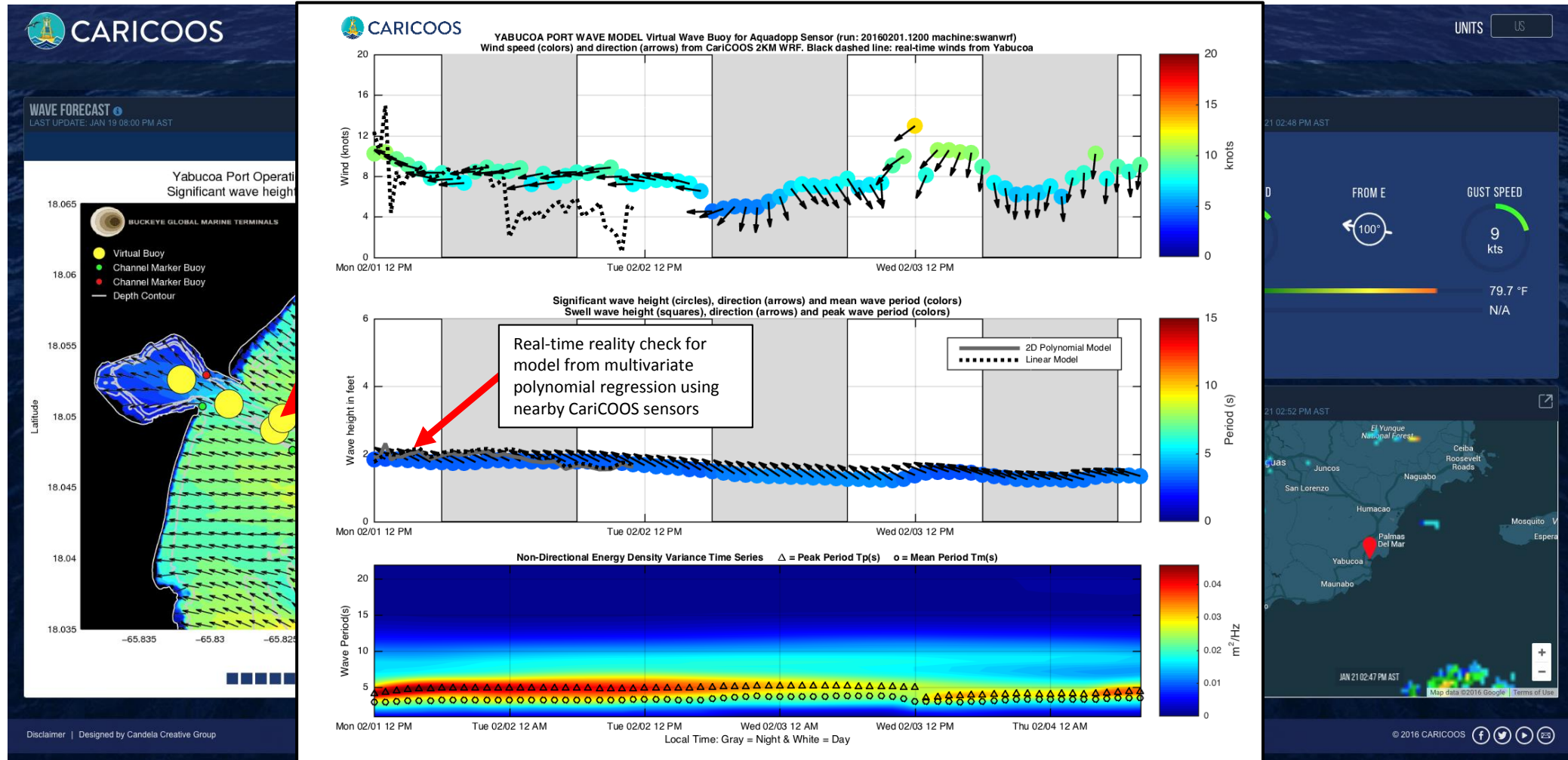
COASTAL HAZARDS: Beach safety & wave-induced drownings

- PR's 15 most dangerous beaches are wave-dominated beaches (Sea Grant UPRM data):

Source: Primera Hora /Sea Grant UPR

Goals & Overview

- Develop an operational high-resolution wave model capable of accurately predicting the nearshore wave climate

- Using the wave model output, develop a nearshore breaker prediction system, with the following design criteria:
  - Be able to predict the expected range of breaking heights across the PR/USVI archipelago
  - Be modular, with additional beaches added on-the-fly (over 100 beaches)
  - Be a user-friendly tool to increase coastal intelligence in the region
  - Target users: beachgoers, lifeguards, beach safety focus – *need to err on safe side, but not overly conservative*

H_b
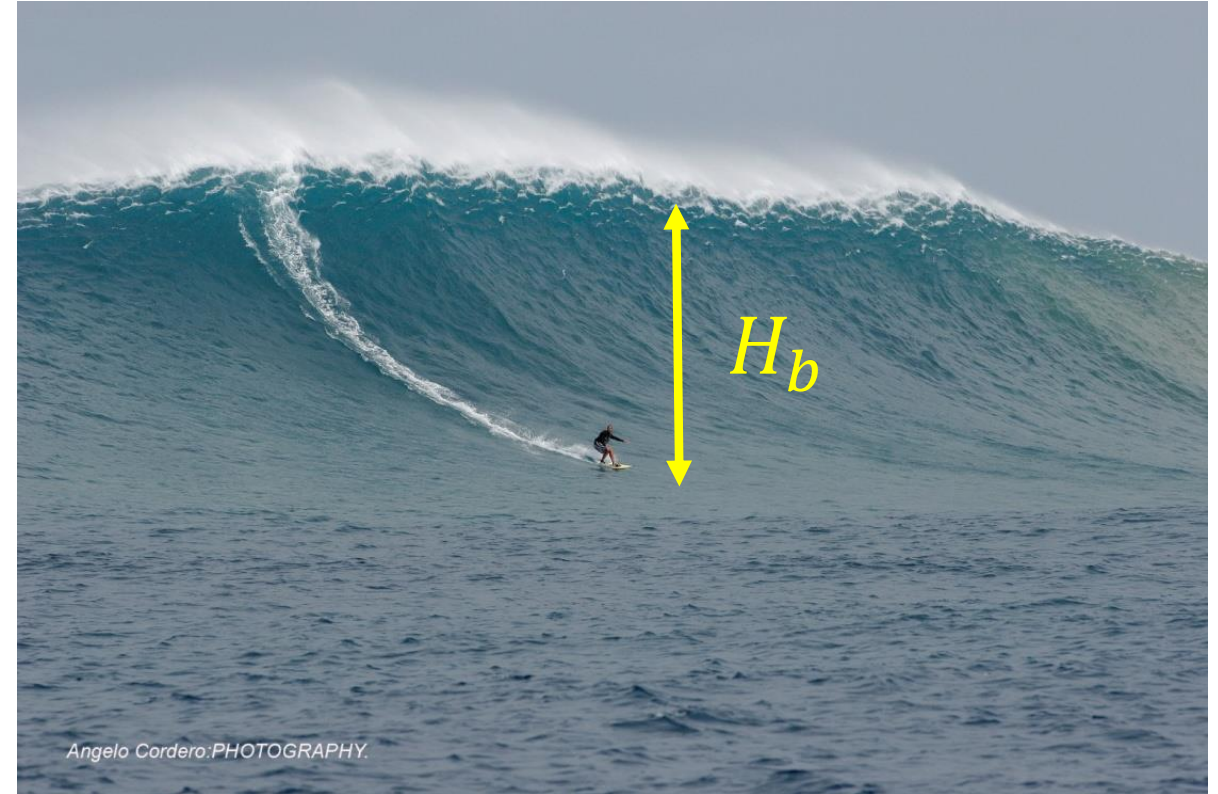
$$H_{b_{min}} < H_b < H_{b_{max}}$$

CariCOOS Nearshore Wave Model v7.0 (run: 20160112.1200 machine:swanwrf)
Significant wave height (Hs - feet) and direction for 2016-01-12-1100 local time
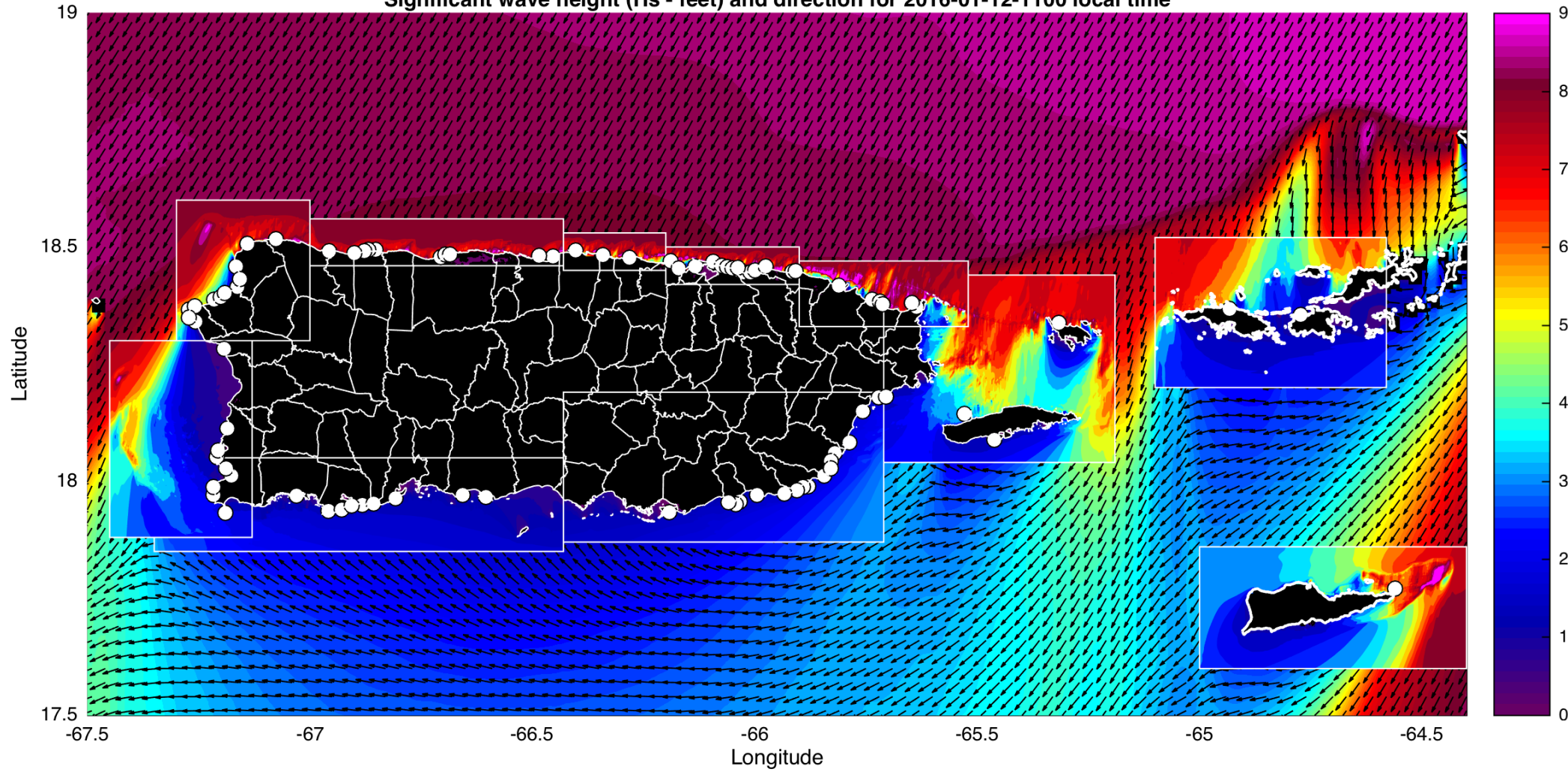
Virtual buoy design

- Design criteria for virtual buoys (VB)
  - Located just seaward of surfzone expected during storm
  - Each VB was manually located taking into account local knowledge and predominant wave climate
  - VB location being optimized frequently based on stakeholder feedback

COASTAL HAZARDS: Beach safety & wave-induced drownings

CARICOOS / SEA GRANT NEARSHORE BREAKER MODEL
Breaker height (crest to trough) estimates for Domes Beach ; Virtual buoy depth = –23 feet

$Hb_{1/100}$

Hs

H_b

TMD tide prediction (ft – MSL) for Domes Beach

Wind speed (knots) and direction (data source: NWS SJU NDFD)

Local Time (Puerto Rico, GMT–4): Gray = Nighttime & White = Daytime
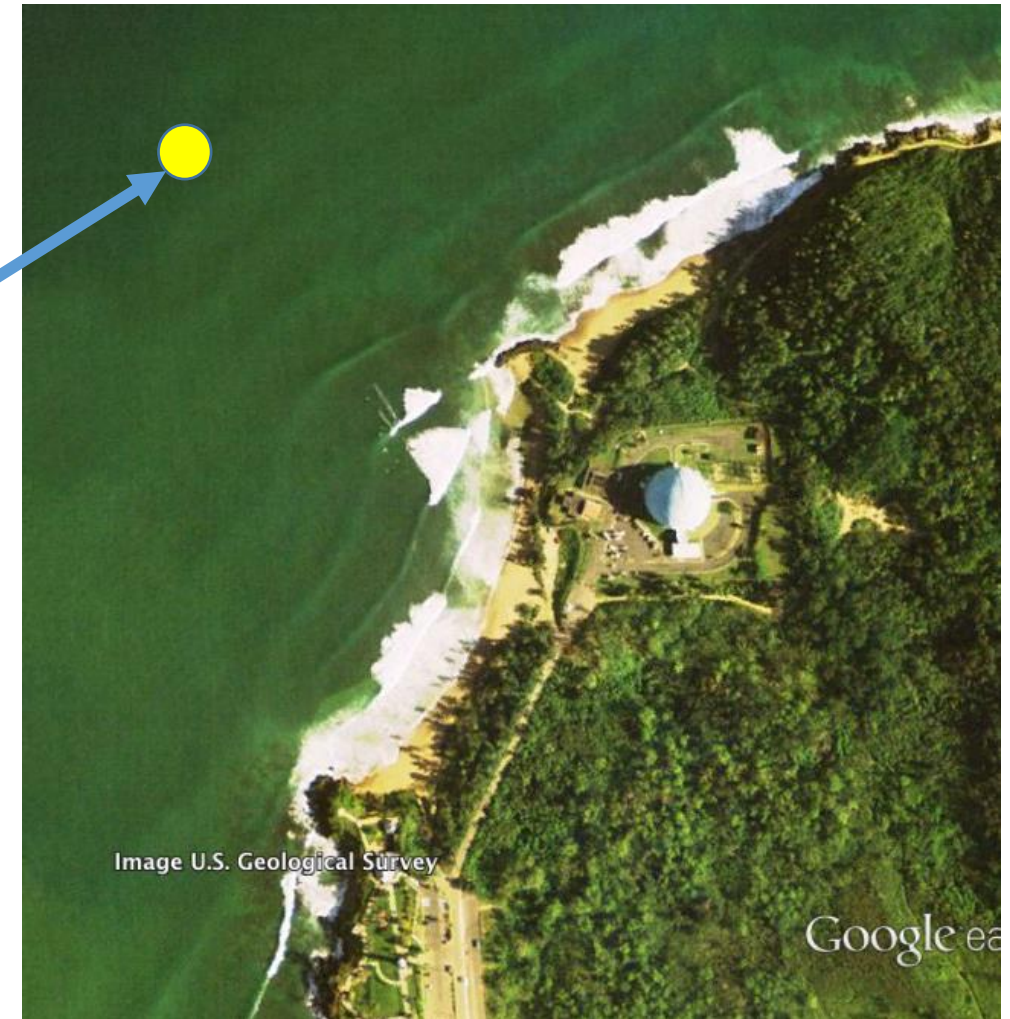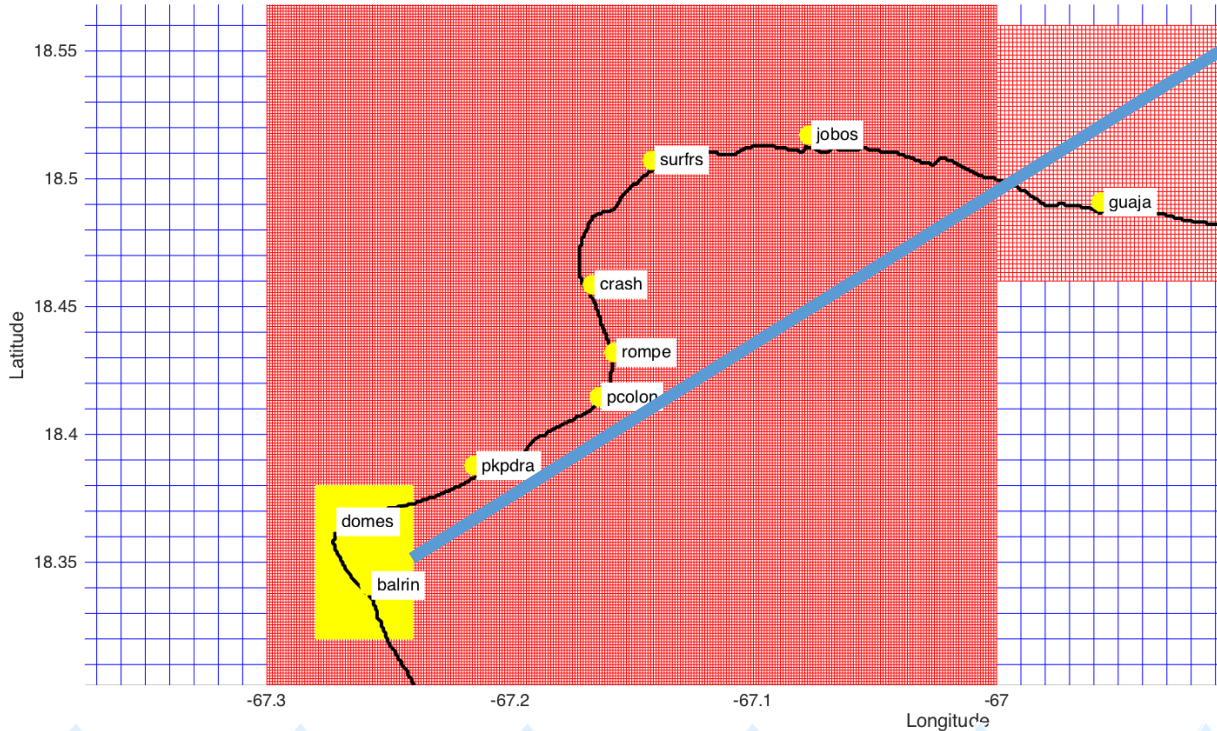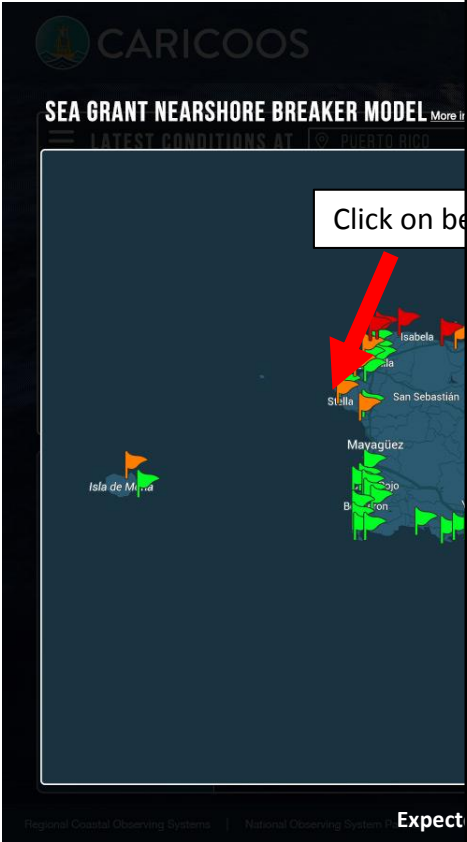
$< H_{b_{max}}$

- Breaker height predicti
- **CariCOOS breaker heig
  their rip current warni**
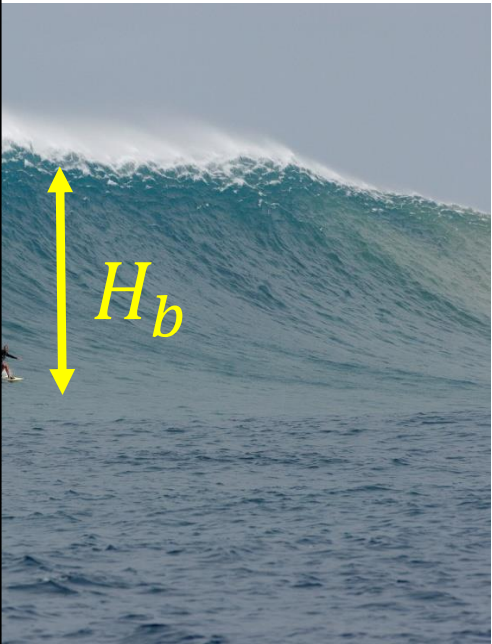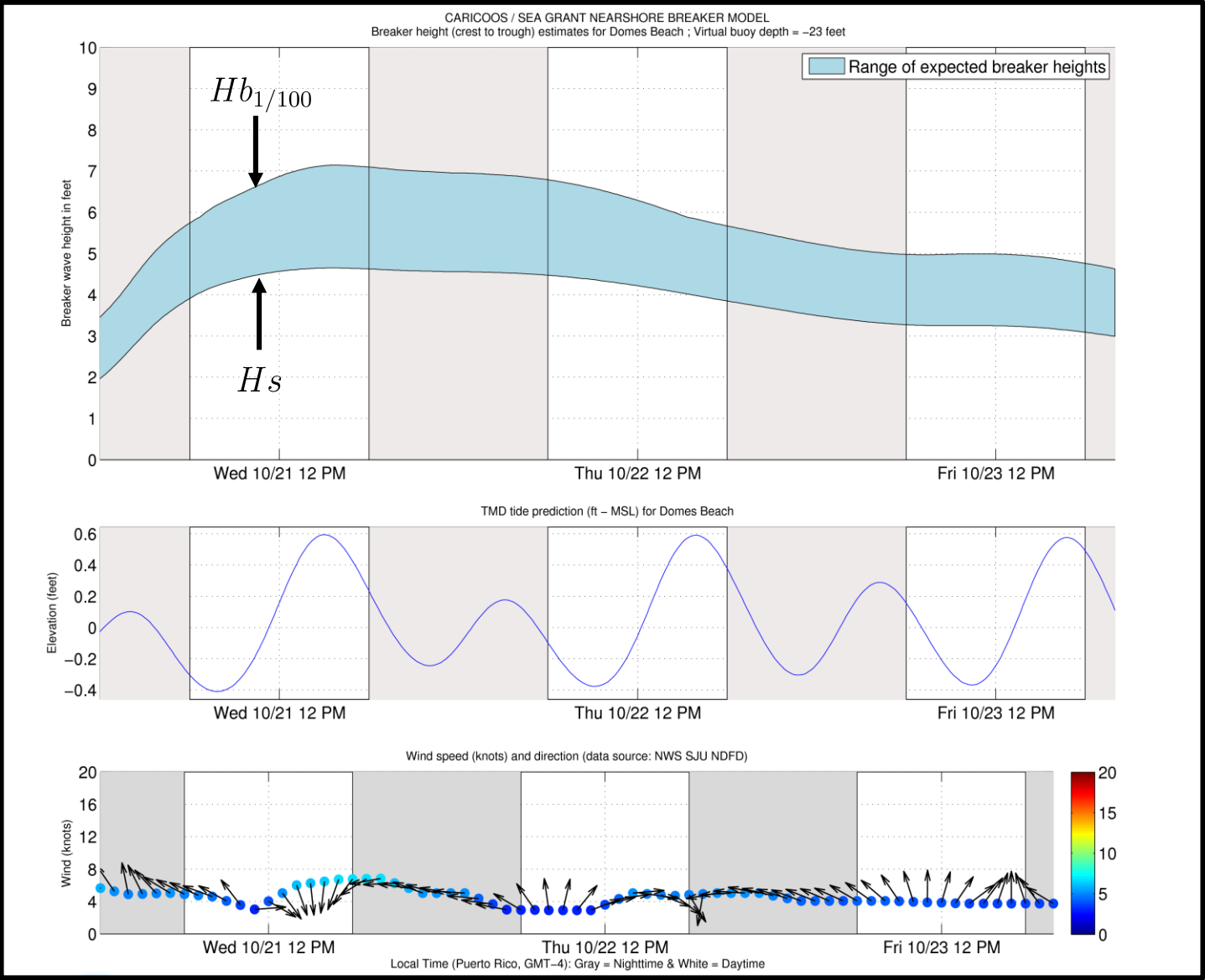
Model "validation" at Domes beach

Comparison of breaker height estimates

Assuming Rayleigh distribution:

$$Hb_{1/10} = 1.27 Hb_{1/3}$$

$$Hb_{1/100} = 1.67 Hb_{1/3}$$

Legend (left plot):
- Model estimated Hb 1/10
- Model estimated Hb 1/100
- Rincon Surf Report

Axes: Breaking wave height (ft) vs. Local time

Legend (right plot):
- Visually estimated Hb vs. simulated Hb 1/10
- Visually estimated Hb vs. simulated Hb 1/100
- LS Fit of Visually estimated Hb vs. simulated Hb 1/10
- LS Fit of Visually estimated Hb vs. simulated Hb 1/100
- Perfect fit
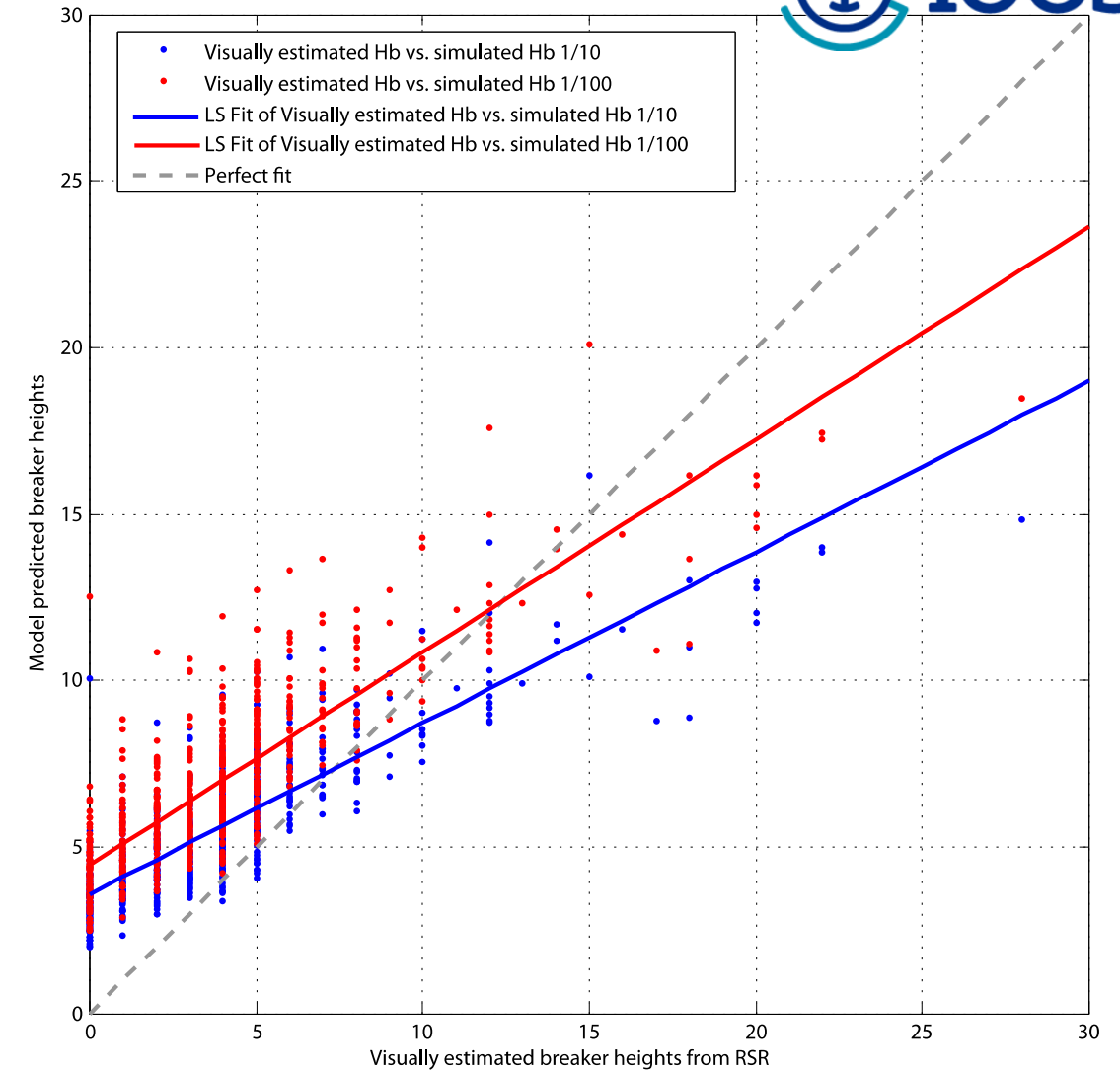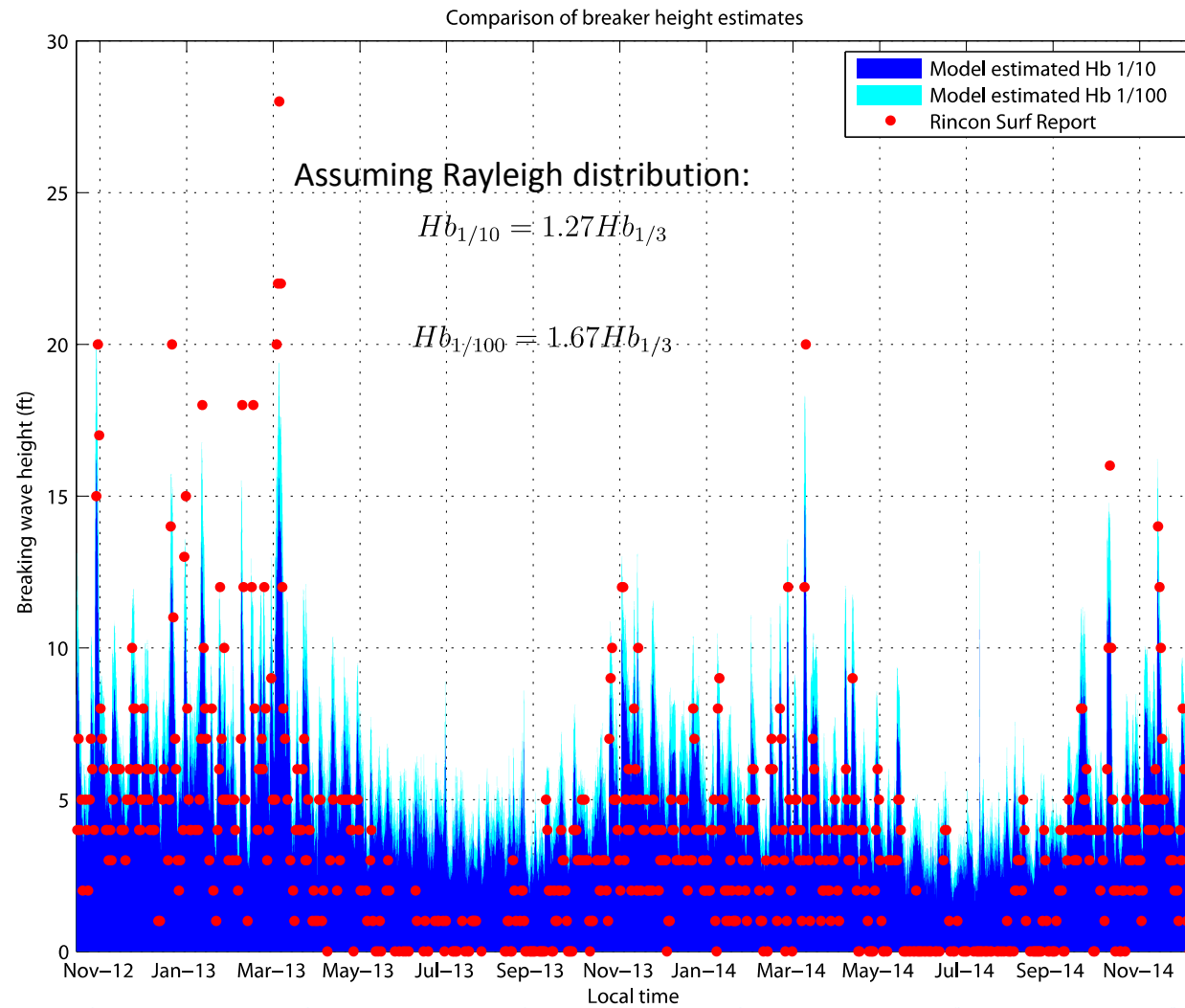
Axes: Model predicted breaker heights vs. Visually estimated breaker heights from RSR
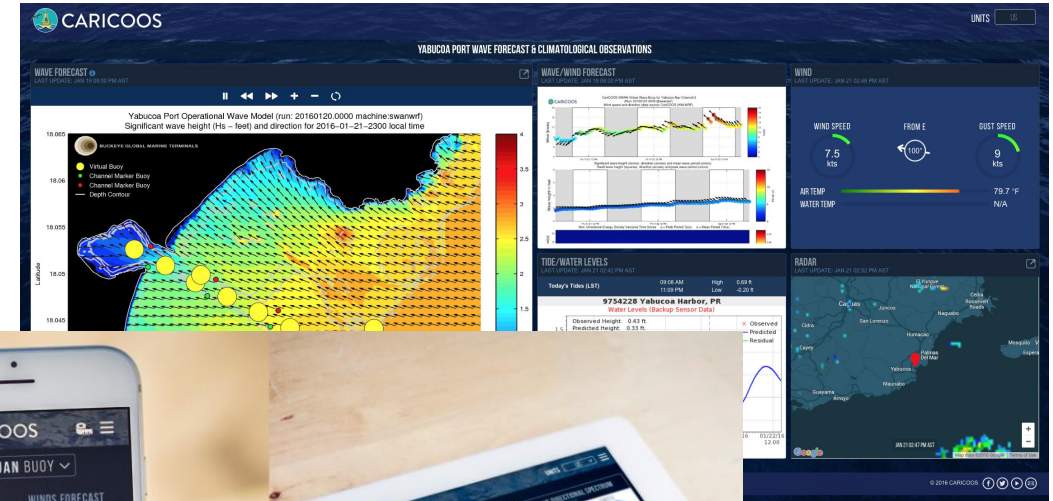
# Better data accessibility - new CariCOOS website

- Delivering coastal intelligence requires user-friendly web interfaces

- New CariCOOS website designed in close collaboration with stakeholders

- Full website expected by late March 2016 – it's been a long process, but getting there

FULL RESPONSIVE DESIGN
SAN JUAN BUOY

EASY & FAST NAVIGATION
RINCÓN BUOY

The future: International collaboration

- Several ongoing CariCOOS led initiatives to collaborate with neighboring island nations on ocean observing
  - Dominican Republic
  - Saba & Netherland Antilles
  - BVI

- Collaborations to take place within the context of IOCARIBE & GOOOS

- You are all invited to the 2016 CariCOOS General Assembly in April 27-28 2016 in San Juan, PR

Speeds for drifter trackers 3 to 18
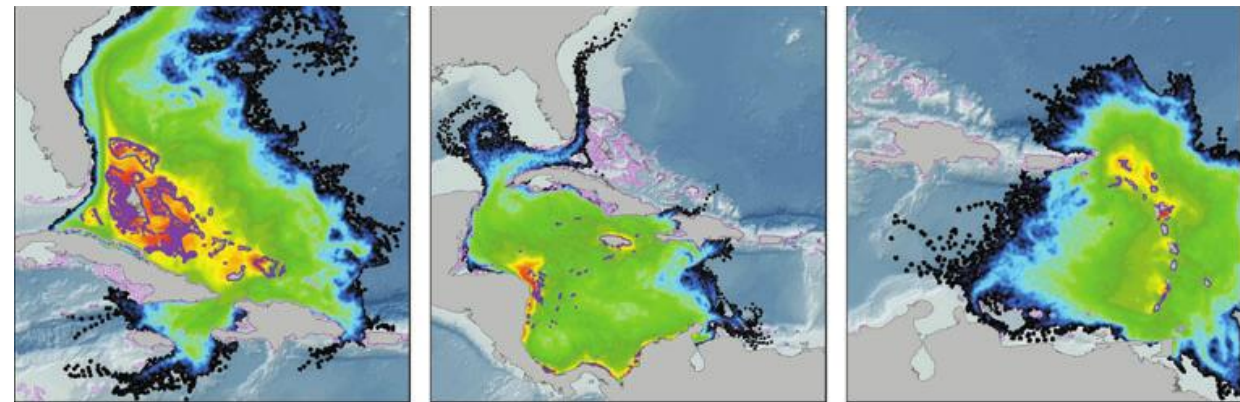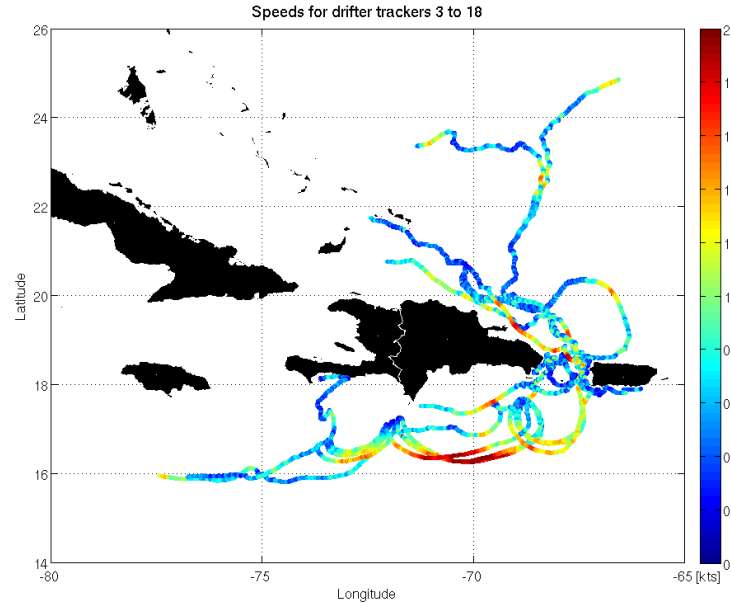
Cowen & Sponaugle, 2009

Questions?