Sea Level Stations in the Caribbean: Lessons from the 2017 Hurricane Season

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IOCARIBE
Atlantic 2017 Hurricane Season

• Harvey
• Irma
• Maria
• Nate
Hurricane Harvey
August 17 - 30, 2017

NOAA - Initial Wind Field and Watch/Warning
IOC of UNESCO - Sea Surface Level Monitoring
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Source: UN OCHA, September 2017
Irma

• August 30 – September 11, 2017
• Became category 5 hurricane in the Eastern Atlantic Ocean on Tuesday September 5, 2017.
• CARIBE EWS States with most significant impact: Antigua and Barbuda, Saint Barthelemy, Saint Martin, Sint Maarten, Guadeloupe, Dominica, St. Kitts and Nevis, Anguilla, Montserrat, British Virgin Islands, US Virgin Islands, Puerto Rico (Sep. 6), Dominican Republic, Turks and Caicos Islands, northern border of Haiti. Cuba, and southeastern Islands of the Bahamas (Sep. 7).
• Resulted in the loss of lives, significant damage to homes and critical infrastructure (including seismic and sea level stations and communications)

From CDEMA
Hurricane Irma
August 30- September 11 2017

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IRMA.mp4
Anguilla

Before

After
This combination of satellite images provided by DigitalGlobe shows Codrington in Antigua and Barbuda on April 24, 2014, and Friday, Sept. 8, 2017, after Hurricane Irma. Irma cut a path of devastation across the northern Caribbean, leaving thousands homeless after destroying buildings and uprooting trees. PHOTO: DIGITALGLOBE/ASSOCIATED PRESS
Location Selection Example: Barbuda

Through funding from the U.S. State Department, NOAA installed a multi-hazard Caribbean sea level station in 2011.

Selection of Barbuda was a three tiered decision:
1. Scientific Justification (including avoiding duplication of efforts)
2. Strong partnership
3. Accessibility/Infrastructure
Barbuda Example - Foundation

- Bedrock 14’ below the surface → pile foundation necessary (jetting)
- Concrete piles were selected due to durability in marine environments, high tensile strength (for handling and placement), and resistance to movement/bending
- Station needs to withstand hurricane winds, storm surge, waves, erosion, and scour
  - Storm surge saturates sandy soil, resulting in soil strength loss (vulnerable to settlement, lateral movement, uplift, etc)
  - Tall structures can overturn in high winds
- Foundation must connect the structure to the ground that supports it. It must be capable of transmitting all dead and live loads from the superstructure into the soil or rock.
  - Transmitting the foundation load to solid ground
  - Resisting vertical, lateral, and uplift loads.
Barbuda Example - Platform

• Design height based on SLOSH model output, confirmed with local knowledge
• Modular platform
  • Flat pieces for shipping
  • Lightweight, but strong (aluminum)
Barbuda – WL Measurement Challenges

- Depth of water
- Dock not strong enough to support anything but the sensors
- Distance between sensor and DCP pushes the limits of pressure sensor technology
Maria

• Became a category 5 hurricane near the Leeward Islands on Monday September 18th, 2017.
• Hurricane Maria impacted Dominica (Sep. 18), Antigua and Barbuda, Montserrat, St. Kitts and Nevis (Sep. 19) and Puerto Rico and the Virgin Islands (Sep 19 – 20), Dominican Republic (Sep. 20-21)
• Resulted in the loss of lives, severe damage and destruction to infrastructure in various islands, “catastrophic flooding” in several areas and loss of utility services and infrastructure (including seismic and sea level stations and comms).

From CDEMA and AccuWeather
Maria Wind Track

National Weather Service - National Hurricane Center
Tropical Storm and Hurricane Force Wind Swaths of Maria From Advisories 1 Through 59
Hurricane Maria
September 17 - 29, 2017

NOAA - Initial Wind Field and Watch/Warning
IOC of UNESCO - Sea Surface Level Monitoring
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MARIA.mp4
Mayaguez Station
France – Saint Martin

Deshaies Station - Guadeloupe
Some Sirens Survived, Others Did Not

Mayaguez

Isabela
Tropical Storm/Hurricane Nate

- October 4-11, 2017
- Affected the CARIBE EWS MS of Nicaragua, Costa Rica, Guatemala, Panama, Honduras, and El Salvador, Mexico (Yucatan Peninsula), Cayman Islands and Cuba
- Flooding
Lessons Learned

• Sea level gauges installed for tsunami were useful for storm surge observations
• Sea level stations are vulnerable to high category hurricanes
• Sea Level stations that resist Category 5 conditions are feasible, but expensive
Way Forward
Way Forward

• Stations requiring refurbishing/new installation – Dominica, Anguilla, BVI, USVI, PR, Turks and Caicos, Bahamas (?)
• NE Caribbean Data Gaps need to be filled: Cuba, Antigua, Bahamas
• Other Gaps: Central America (Nicaragua, Honduras, Guatemala)
• Training
  • Station operation/strengthening station installations
  • Sea level data analysis – Tidal Predictions, Hurricane Monitoring, scheduled for January 15-19, 2018 in Mexico City (UNAM)
• Funding: Monaco (Training), UK (Training, Possibility for Rebuilding Anguilla and TCI), PRSN (PR, BVI, DR stations, training)
Thank You

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