The First Steps Towards The Realization Of Energy From Oceanic Waves In Jamaica

THE UNIVERSITY OF THE WEST INDIES MONA CAMPUS

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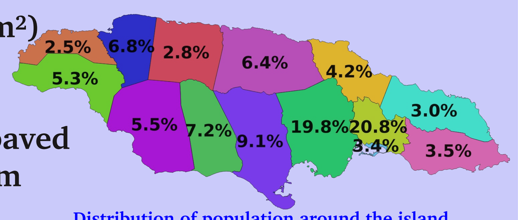
Jamaica : Typical Developing Tropical Island

- 2.89 M inhabitant but not well distributed on the territory
- Kingston the historical agglomeration (> 800K inhab)
- GDP of 9,200USD (USA 59,531USD & UK 39,720USD)
- Large Energy needs in Kingston vicinity due to industrialisation and A/C (Average Tmax > 33.6±0.5°C)
- Area of 2,890,299 km² (266 inhab/km²)

48% of the population are younger than 24 yo and 8% older than 65 yo

- 21,000 km of road with 15,000 km paved
- Railways up to 2013 less than 218 km



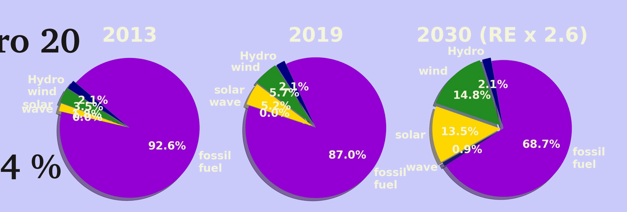
Distribution of population around the island

50% of Renewable Energy in Grid for 2030

Power Installed >1.1 GW

2019 : Solar Farm 57 MW...Wind 62.7 MW...Hydro 20 MW

Electricity consumption : commercial & industrial 64 % (large 19 - small 45)..residential 33 %..public service 3%



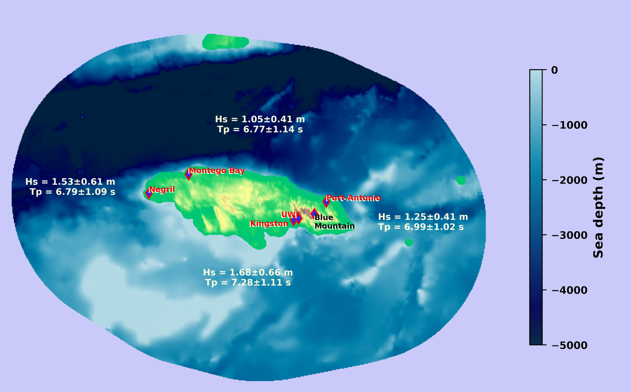
Must multiply by 2.6 the percentage of Solar and Wind Energy

Wave Energy a Good Solution

Vertical and horizontal wave motion can be converted to electrical or pneumatic energy

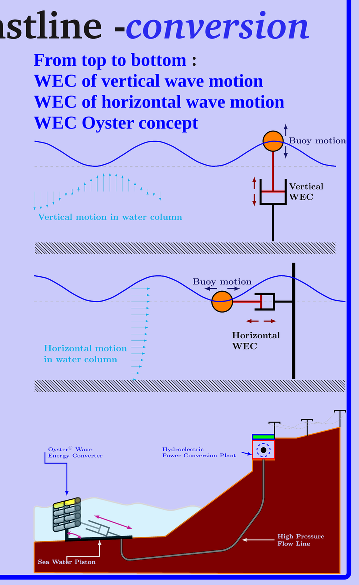
Wave available all around the island

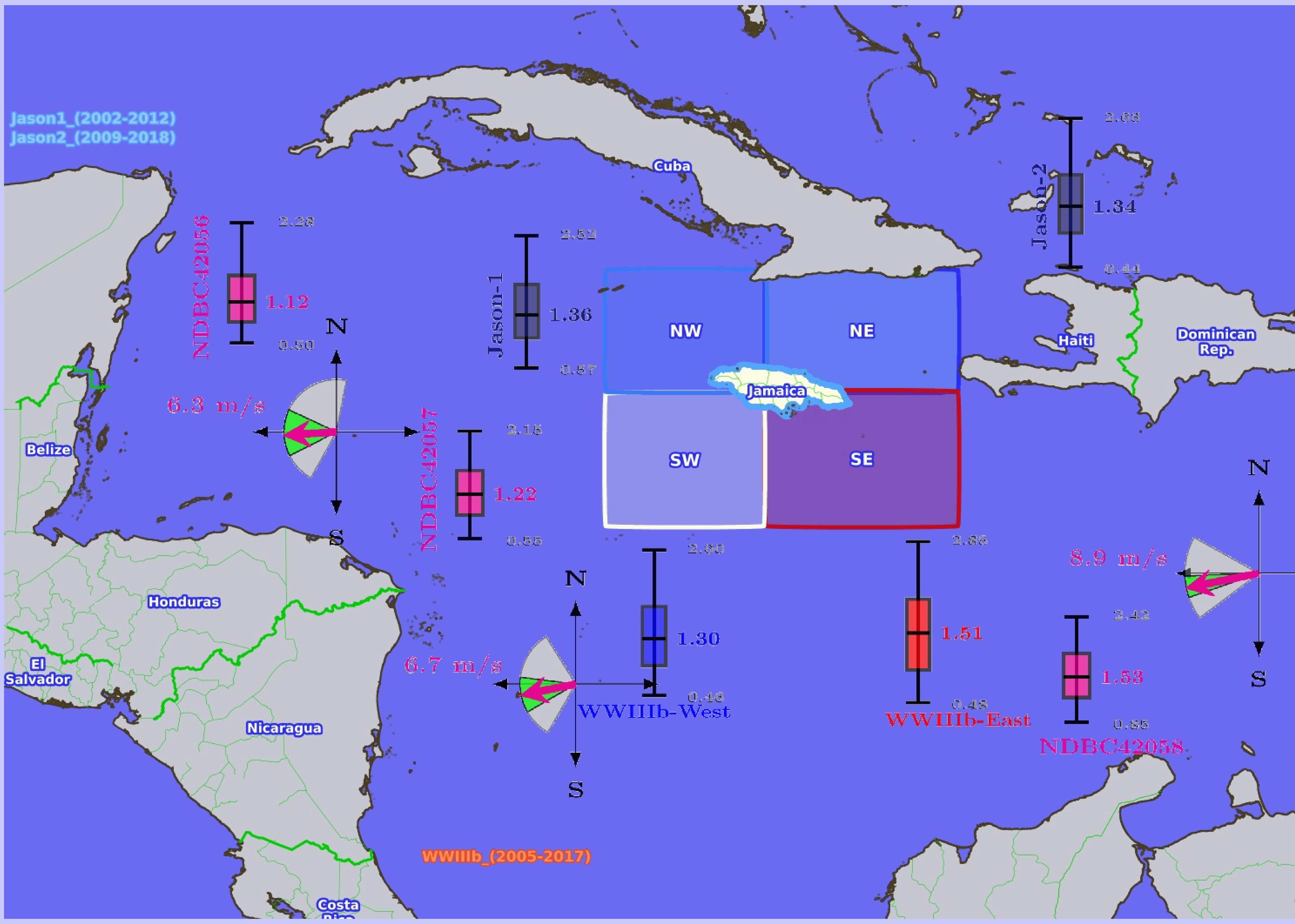
Wave can have negative effect on the coastline -*conversion of energy can protect these areas*- -*dynamic mitigation of coastal erosion*-



Map of oceanic conditions around Jamaica

From top to bottom :
WEC of vertical wave motion
WEC of horizontal wave motion
WEC Oyster concept

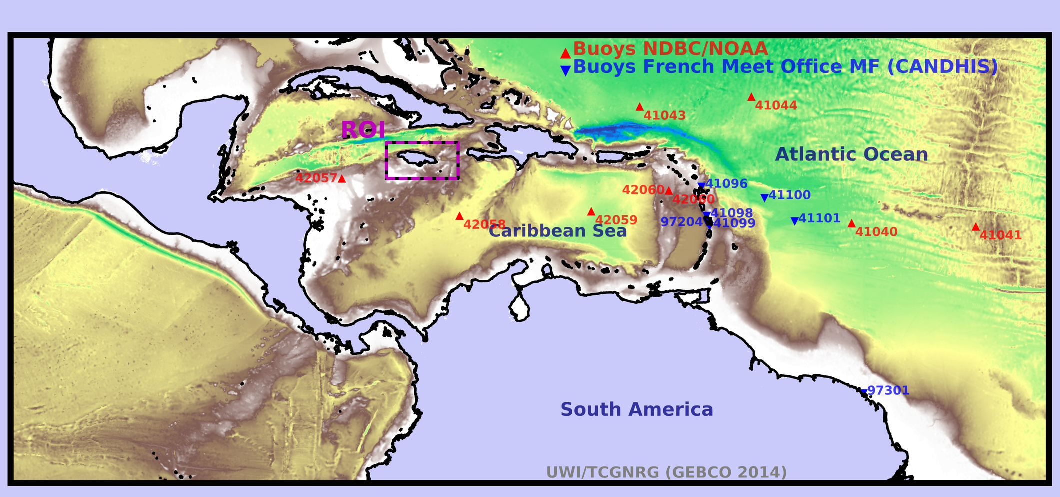




Lack of Local Measurement

Compared to other areas the number of insitu measures around Jamaica vicinity is low:

Caribbean Area	4.10^{-5} buoys/km²	Requires other source of data
Puerto-Rico	3.10^{-2} buoys/km²	
Jamaica	8.10^{-7} buoys/km²	



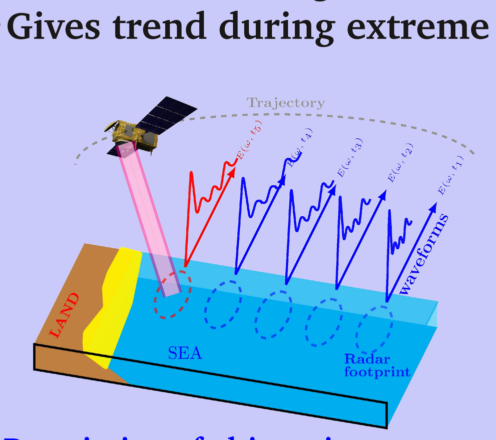
Need for Remote Sensor

Altimetric data available from Jason 1 (2001) & jason 2 (2008) satellite

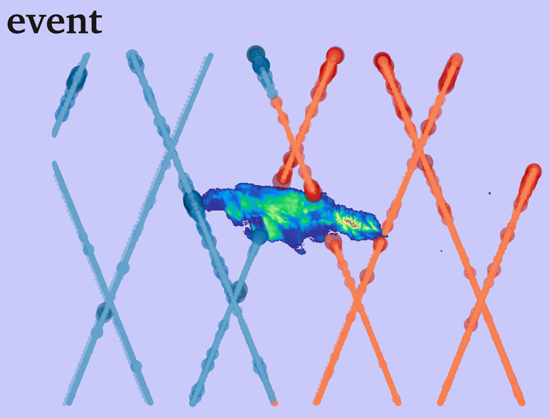
Mesure of elevation of the sea surface at frequency around 1 or 20 Hz using reflectance of electromagnetique signal at the sea surface from 1300 km

Low density of point (*75 points per day - one every 11 min*)

- Allows validation of numerical model
- Allows monitoring of wave climatology
- Gives trend during extreme event



Description of altimetric measure by satellite



Example of tracks follow by Jason 2 around Jamaica

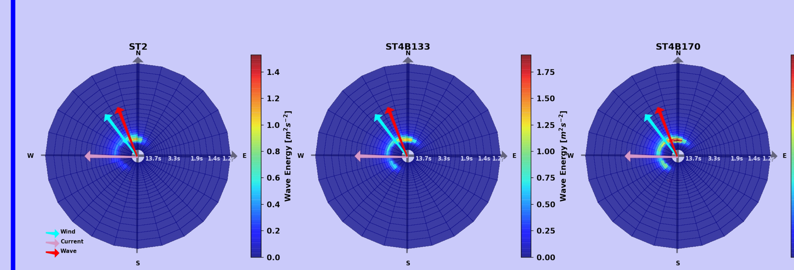
Need of Numerical Model

Wave Watch III

3rd generation of energy wave propagation model

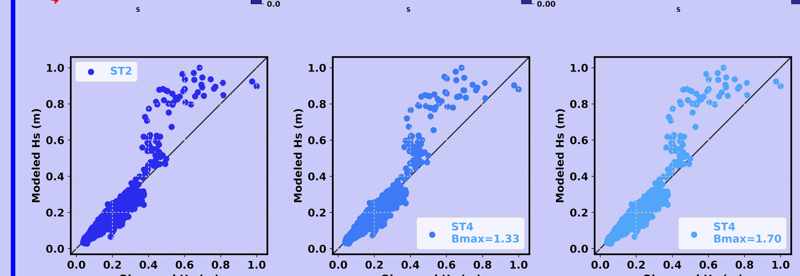
$$\frac{\partial N}{\partial t} + \nabla_x \dot{x} N + \frac{\partial}{\partial k}\dot{k}N + \frac{\partial}{\partial \theta}\dot{\theta}N = \frac{S}{\sigma}$$

$$S = S_{source} + S_{sink} = \underbrace{S_{in} + S_{ln} + S_{xx}}_{\text{Source}} + \underbrace{S_{ds} + S_{nl} + S_{bot} + S_{db} + S_{tr} + S_{sc} + S_{ice} + S_{ref}}_{\text{Sink}}$$



Simulation of November 2012

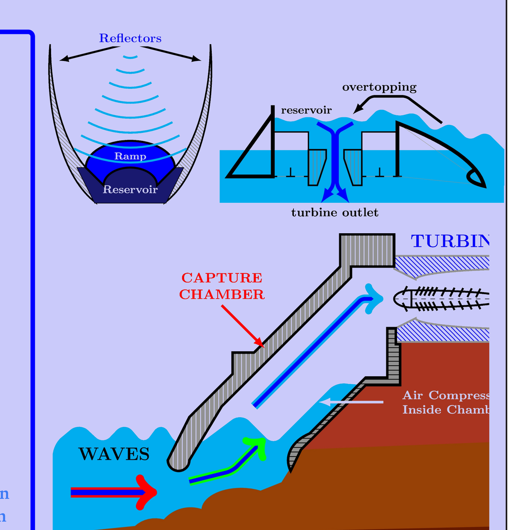
Spectrum representation in frequency (*f*) and direction (*theta*) with wind, water current and wave direction

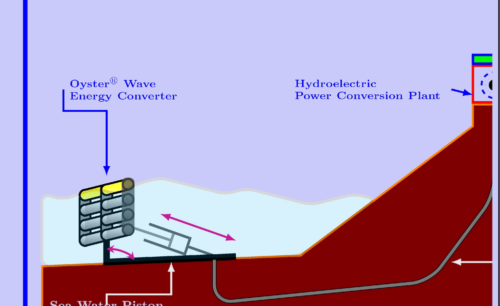


Relative average error between observation and modelling during Hurricane Mattew 2016 (H5) October 1st to 5th

- Hs 17.4 - 20.5 %
- Tp 33.3- 40.9 %
- Dir 14.7- 16.3 %

Example of simulation of Hurricane Mattieuw (*H5 - 2016*) in the ROI. Comparison between simulation and observation of Hs for three configurations





Example of Wave Energy Converter
From top to bottom
Dragon 2006
Polinder 2005
Oyster 2019

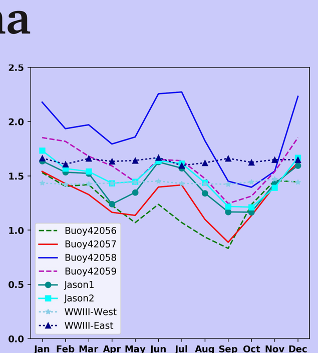
Seasonal variability

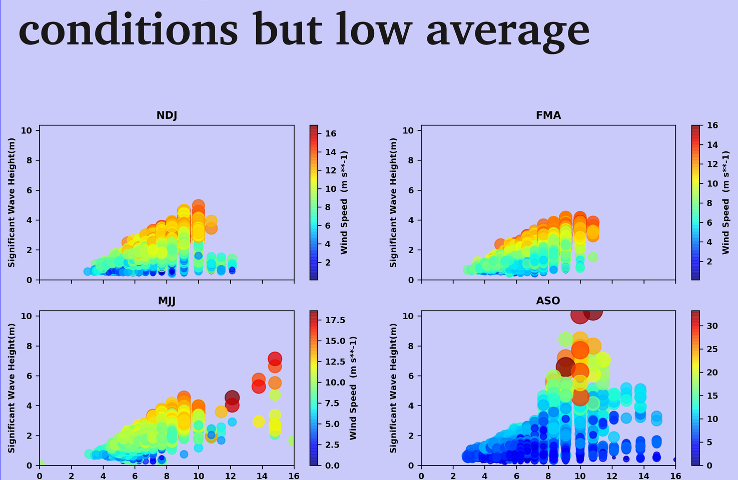
Hurricane season (ASO) has effect on extreme Hs values with episodic phenomena

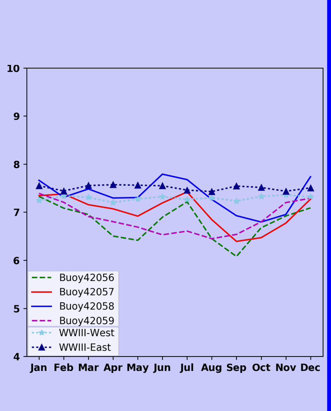
=> MJJ is the best season for Wave Energy

=> NDJ provide longest Wave Lenght (Tp) North Swell

=> ASO provide extreme conditions but low average



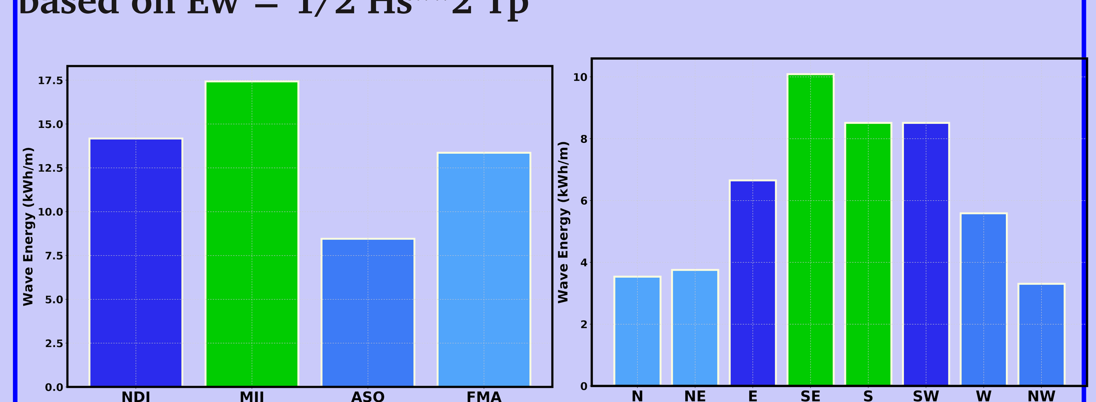




Wave Energy Potential

Wave energy (Ew) is computed using WaveWatchIII data form 1999 to 2018

based on Ew = 1/2 Hs**2 Tp



Average Wave Energy potential is defined from 3.31 to 10.1 kW / m around Jamaica

Sector SE received best wave energy.

Best *season* period are in the order MAJ, FMA, NDJ and ASO (*i.e.*, hurricane season)

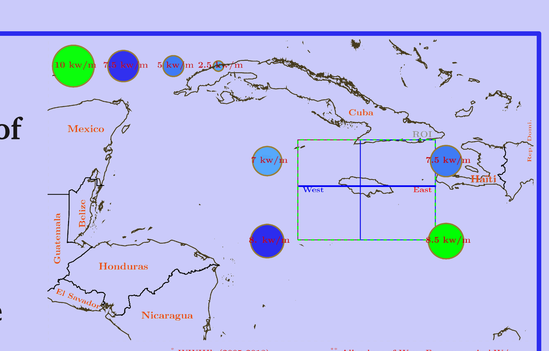
Best *month* during the last twenty years is June with 20 kW / m.

Conclusion

Wave Potential of 3.306 – 10.089 kW/m equivalent to a maximum of 5 households

30 MW Wave Energy farm is proposed for the SE area of Jamaica (St. Thomas) with 30 - 40 WEC with rated power ranging from 750 kW-1 MW

Energy cost estimation of 7.6 c/kWh - 10.8 c/kWh with Oyster device on 20 years



Abstract :

Jamaica a medium sized island of 1022 km of coastline located in the Greater Antilles Arc of the Caribbean has made significant strides in achieving its goal of 30 % renewables on the electricity grid by 2030. The renewable energy sources harnessed by the country at this moment includes: wind, solar and hydro. Presently some consideration has been given to exploiting the power from the waves that constantly wash ashore the islands coastline. This study aims to highlight the behaviour of the sea state of the water mass surrounding the island. Access to this information should allow officials and investors to make a more conscious decision on the appropriate type of renewable energy source.

The study uses a combination of in-situ (NOAA/NDBC buoys), satellite (altimetric) and modelled data (NCEP/NOAA/WW3) to develop an understanding of the behaviour of the main wave variables: significant wave height (Hs), wave period (Tp) and wave direction (Dirm) both spatially and temporally. All of which are necessary to create a comprehensive picture of the wave energy potential of Jamaica. The study also highlights an investigation into the distribution of Hs, Tp, and Dirm datasets provided by NDBC buoys, NCEP/NOAA/WW3 simulation and Jason 1&2 satellites. Finally each of these variables provided by the datasets was divided into four geographic sectors (NE, SE, NW, SW) and there distribution scrutinized.

The results show that the SE coast of the island produces the best waves conditions (Hs > 1.5 m and Tp < 7.5 s) equivalent to 10.089 kW/m. The best periods for production are in the order May-July, February-April and November-January, with May-June affected by tropical storms and hurricanes. The assessment carried out on the variables from each dataset showed that the variables in question were from a population with similar distribution.

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Numerical Model : WRF, WaveWatch III

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