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Measurements and modelling of the effect of a fringing reef and upperbeach vegetation on runup behaviour - A Caribbean Context

T. Laigre, Y. Balouin, D. Villarroel-Lamb, M. Moisan

Site description

Pocket beach with a small lagoon and a fringing reef

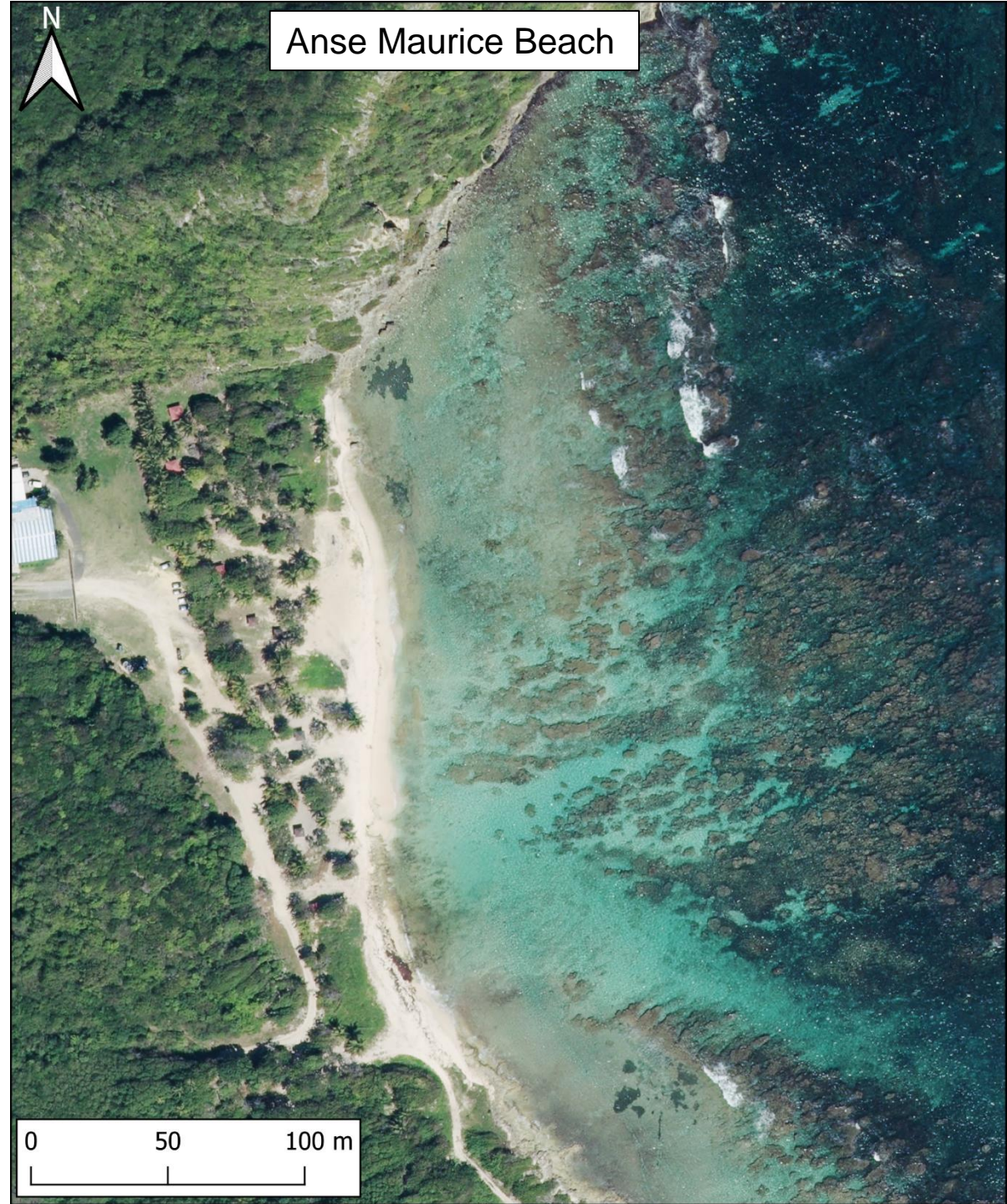
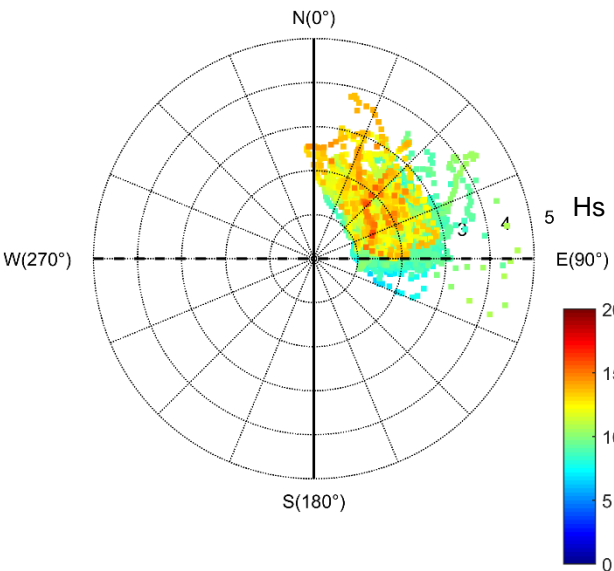
- ~300 m long
- 5-20 m wide

Hydrodynamic :

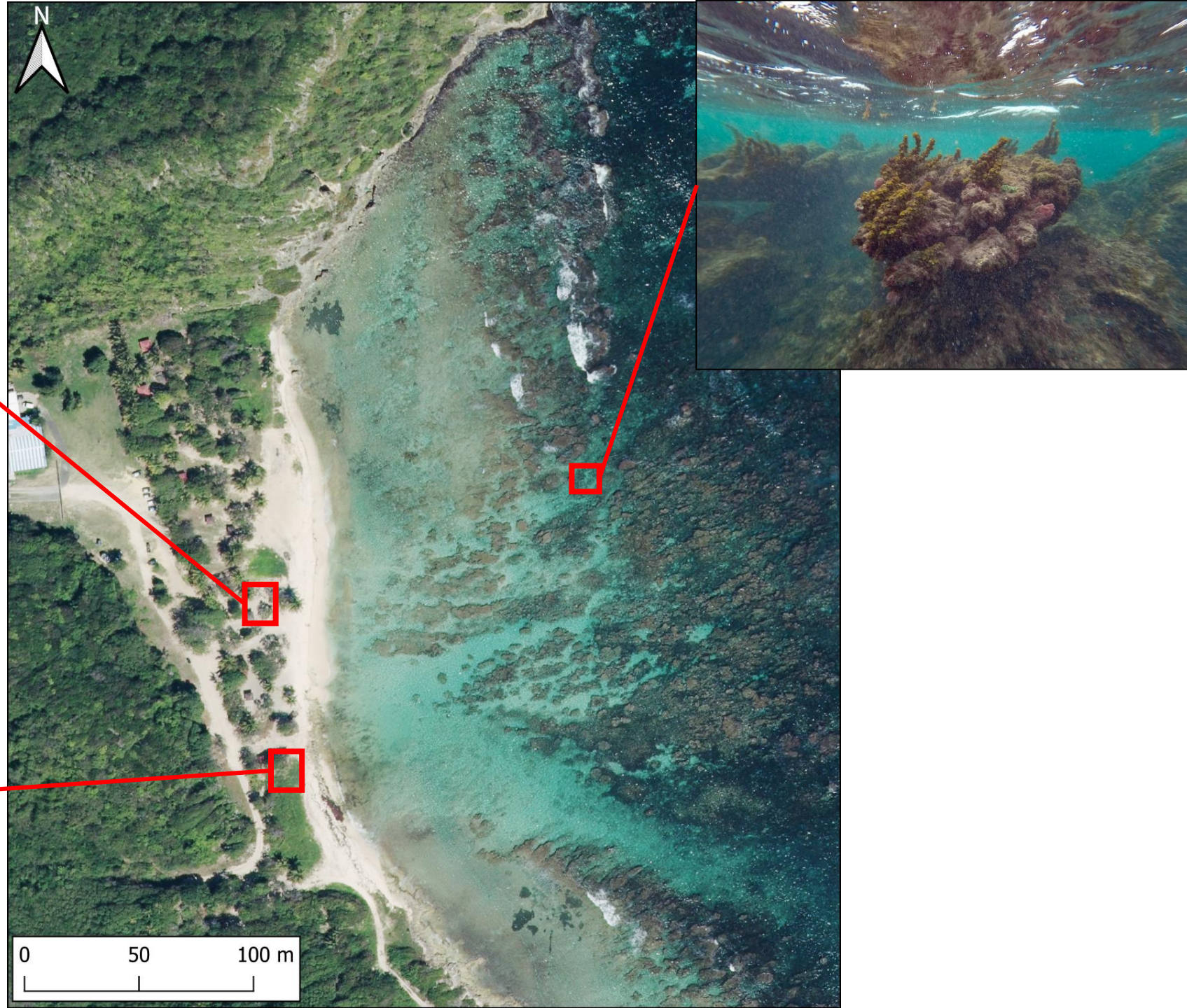
- Exposed to Atlantic winter storms (December-March)
- Episodically exposed to Cyclone (July-November)

Revegetation enclosure from the French forestry agency

Subject to sargassum beaching since 2012



Site description



Methodology : Field monitoring

2 permanent low-cost video systems :

- Short term (Storm scale) :
 - Identification of swash events
 - Identification overall agitation offshore and on the lagoon
- Mid/long-term :
 - Upper beach vegetation limit monitoring
 - Swash maximum excursion monitoring

Pre and post-storm RTK-GPS monitoring :

- Ground truth for extractions from cameras
- Morphological evolution

Local hydrodynamic monitoring:

- Calibration and validation of numerical modelling experiment



Numerical modelling

WW3 MARC model outputs (From Ifremer)

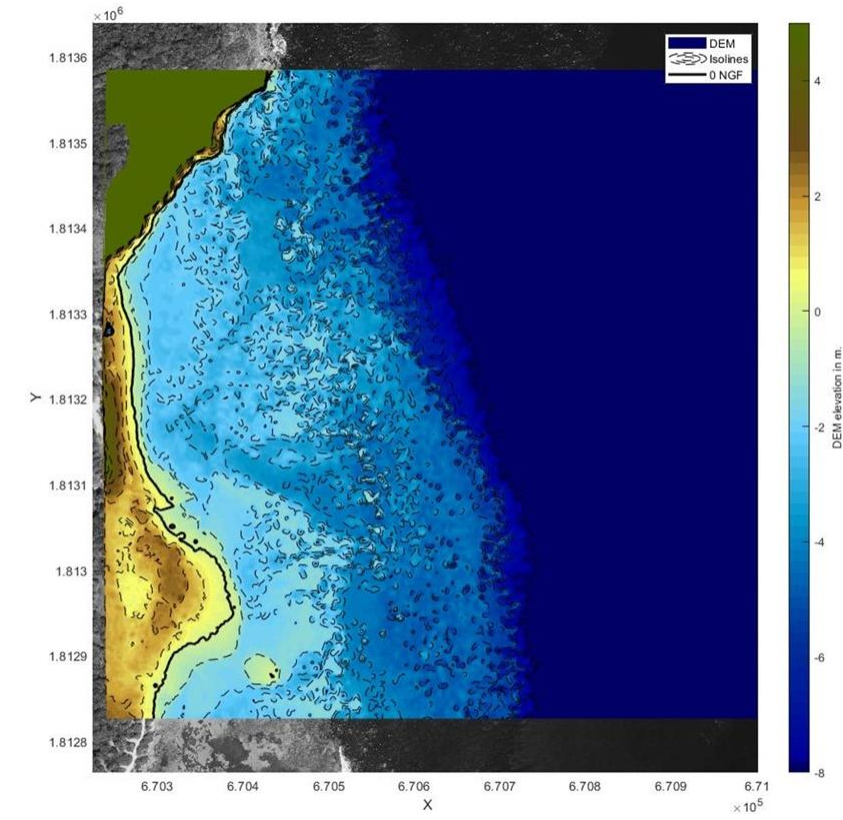
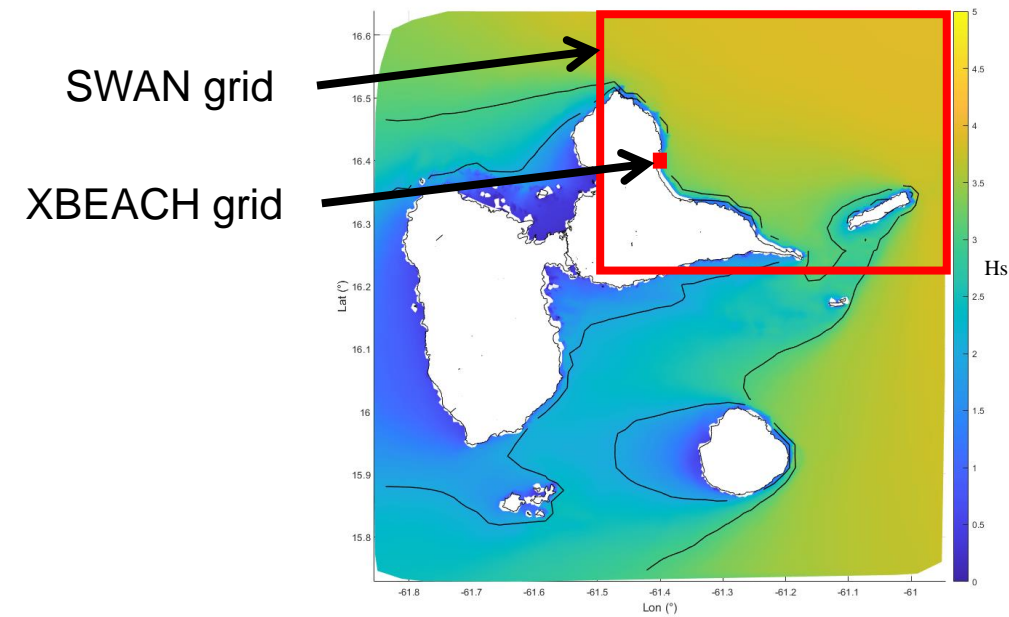
- Inputs for SWAN model

SWAN model

- Wave propagation up to ~20 depth
- Shows better skills than MARC at nearshore

XBEACH Non-hydrostatic

- Phase resolving model
- Wave propagation from ~20 depth to shoreline
- Validated with sensors data



Experimental methodology

Runup comparison on two profiles

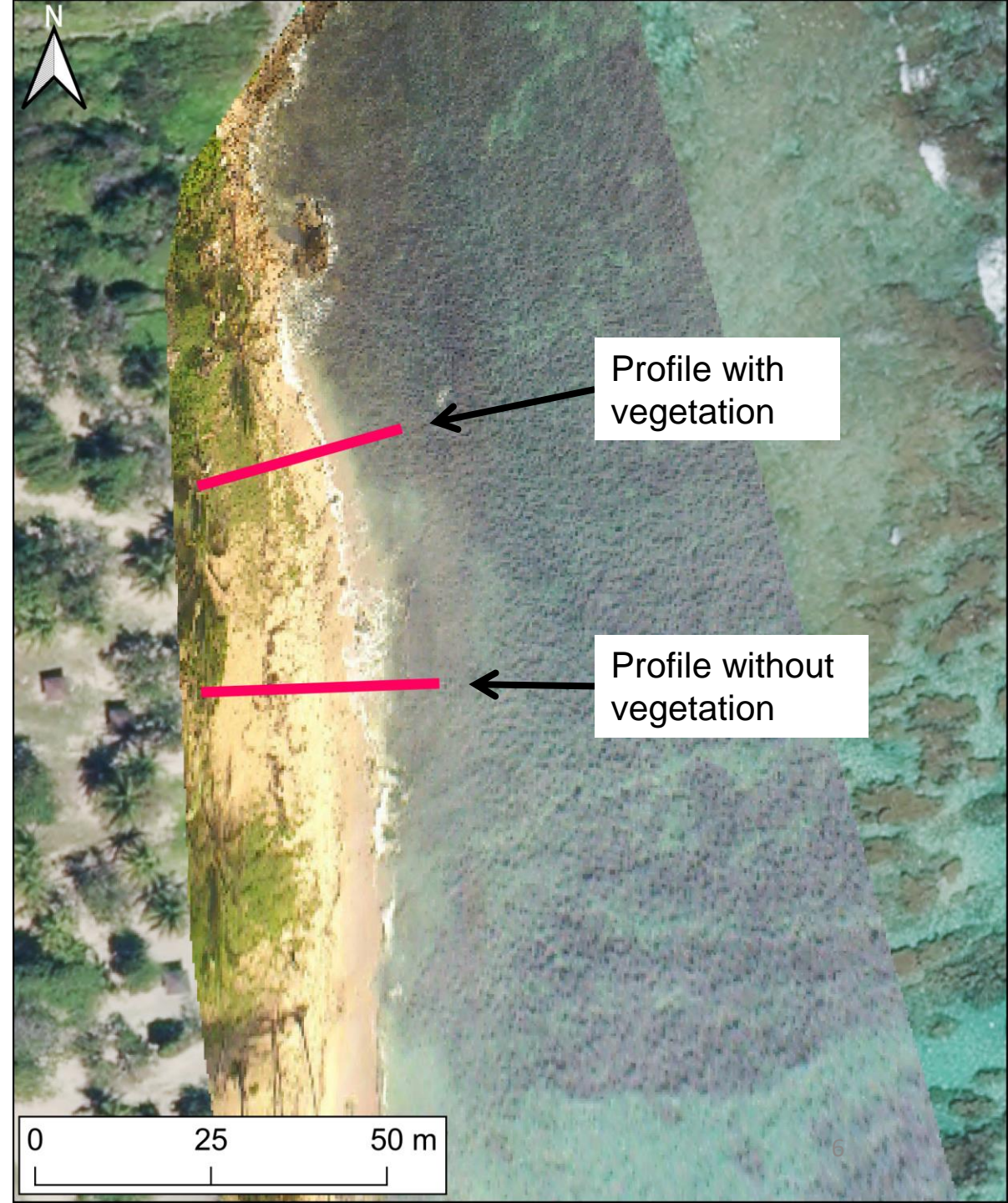
- One with dense upperbeach vegetation
- One without vegetation

Observations

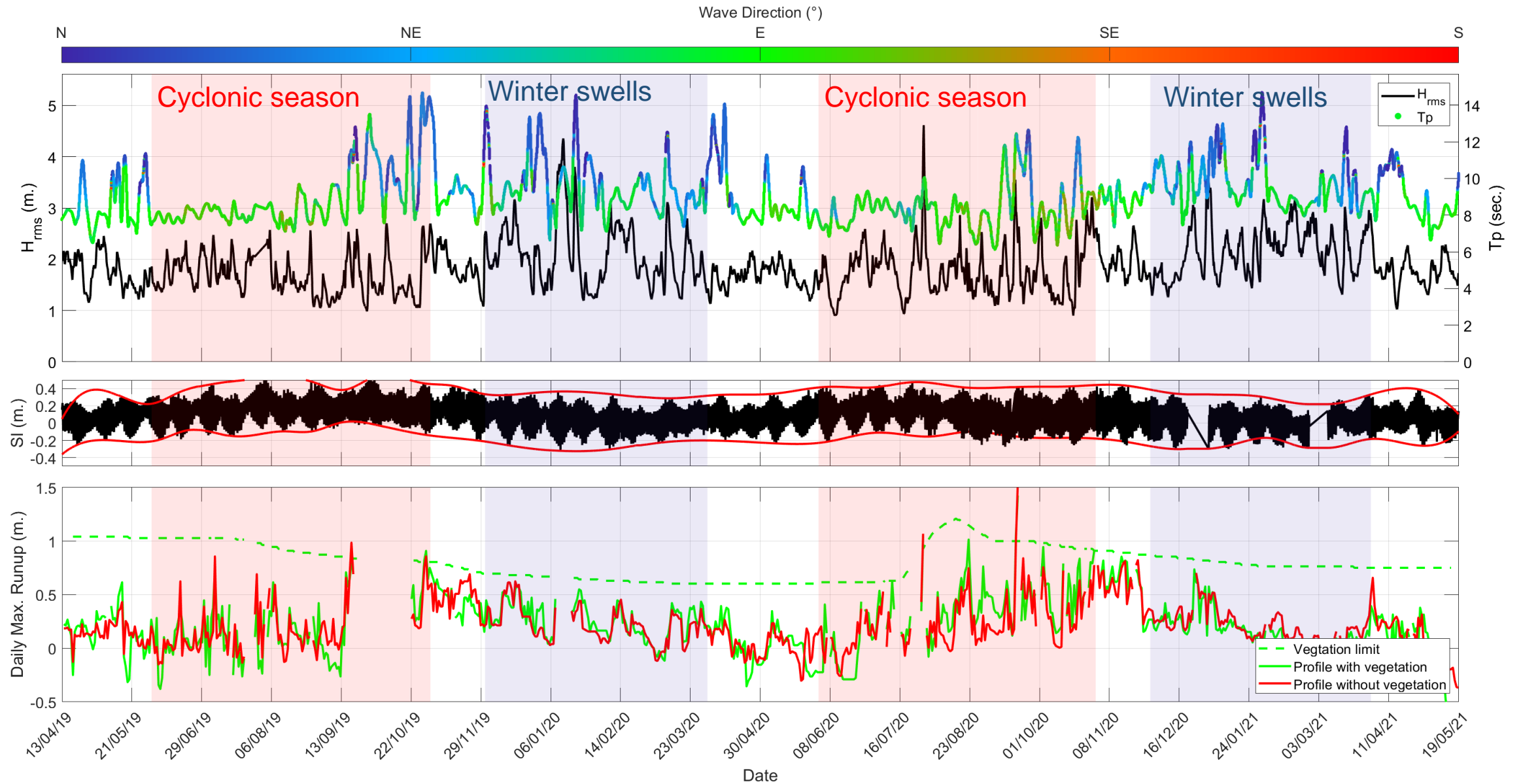
- Daily extraction of maximum swash on images from camera over mid/long term (768 days)

Numerical modelling

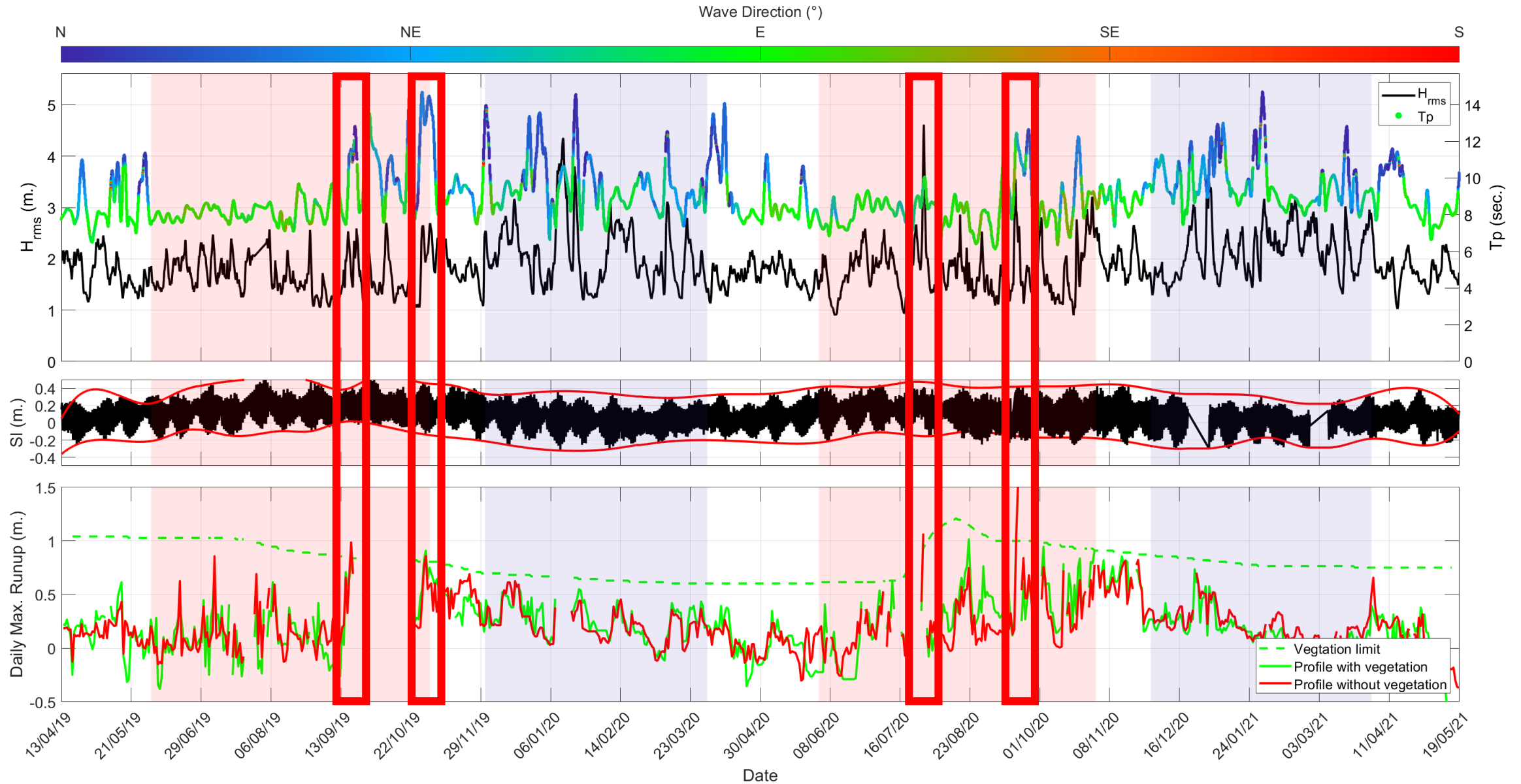
- Runup analysis on a specific storm event



Results : Mid/long-term observations

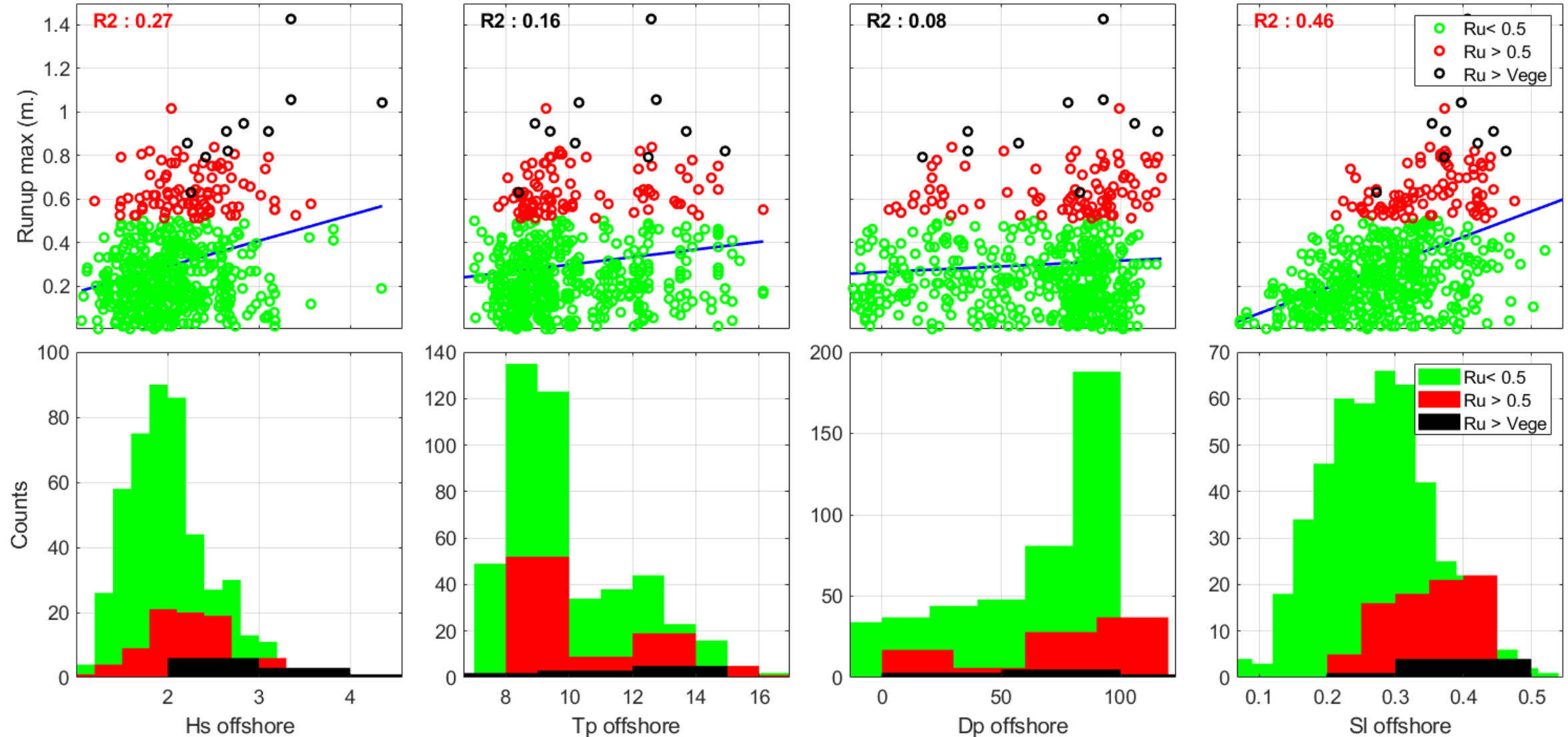


Results : Mid/long-term observations



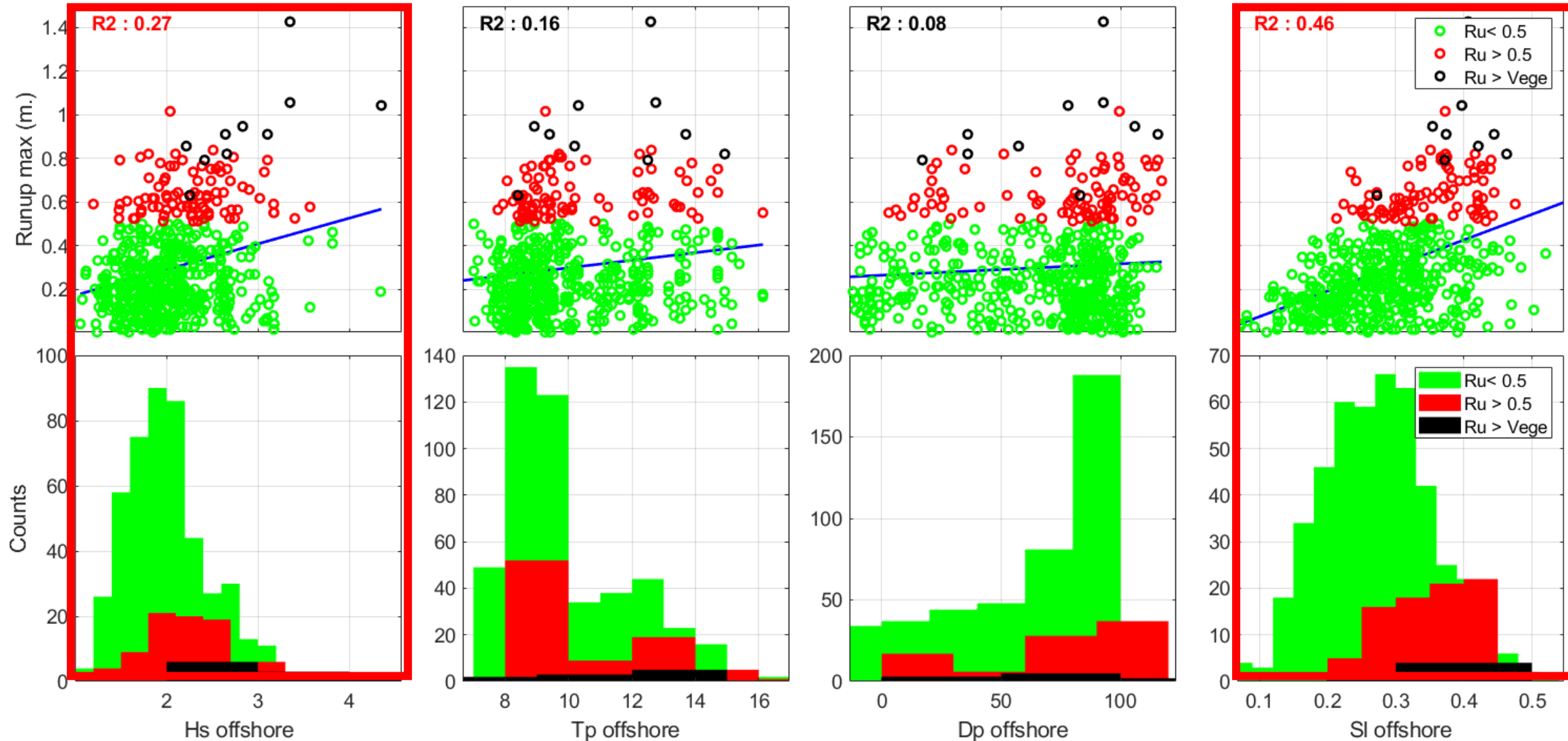
Results : Mid/long-term observations

Correlation between daily max. Runup and offshore hydrodynamic



Results : Mid/long-term observations

Correlation between daily max. Runup and offshore hydrodynamic



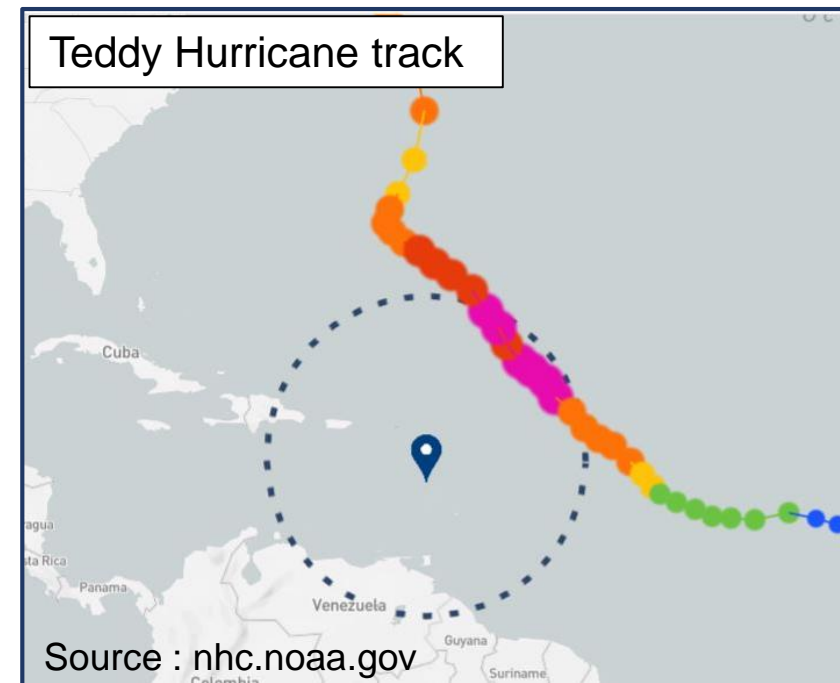
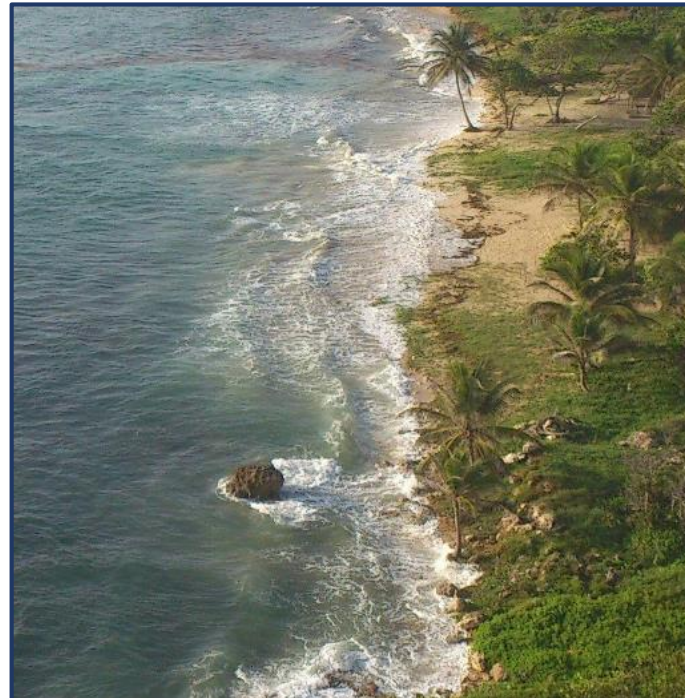
Results : Short-term modelling

Zoom on major hurricane Teddy (cat. 4) :

- Peak waves in Guadeloupe:
 - Date : 17-18/09/2020
 - Distance : 800 km
 - Hs : 4.5 m Tp: 14 sec
- Massive swash observed on cameras



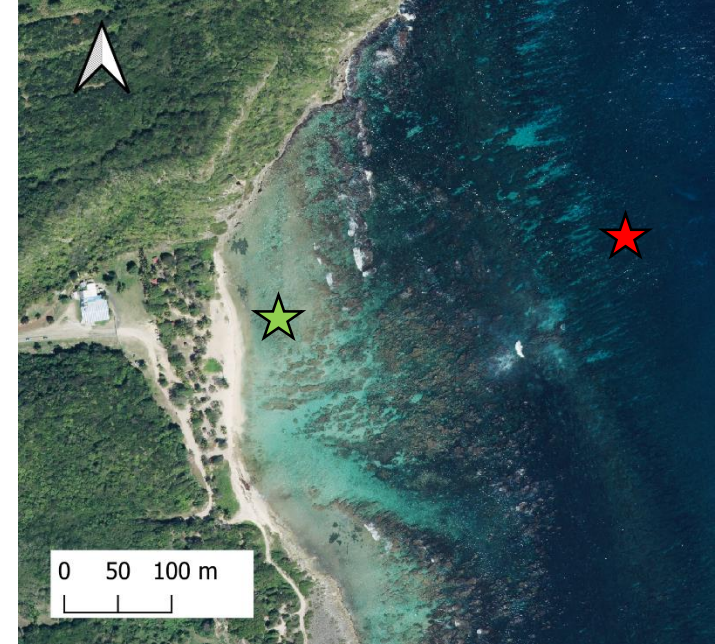
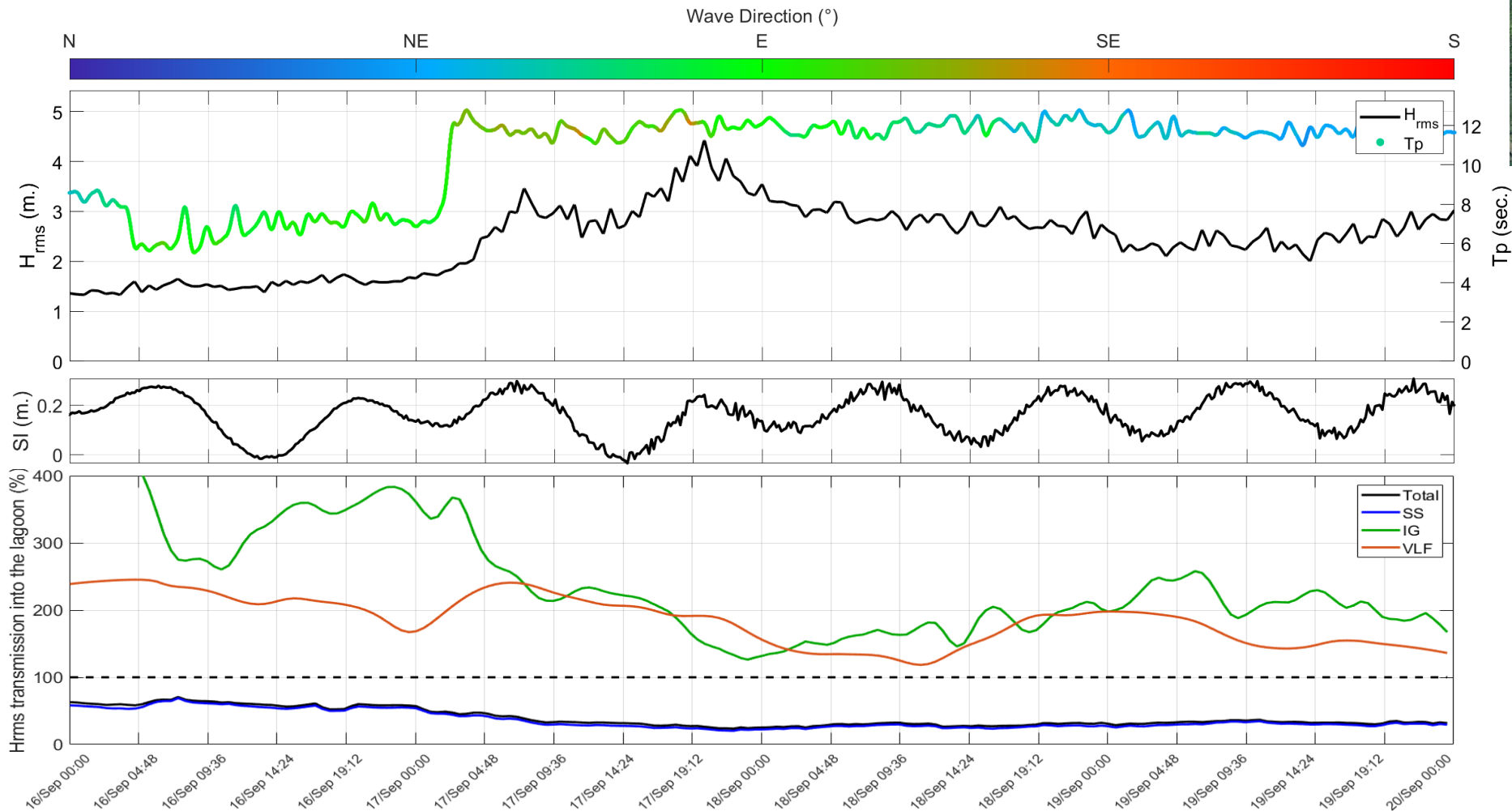
Cameras snapshots (17/09/2020)



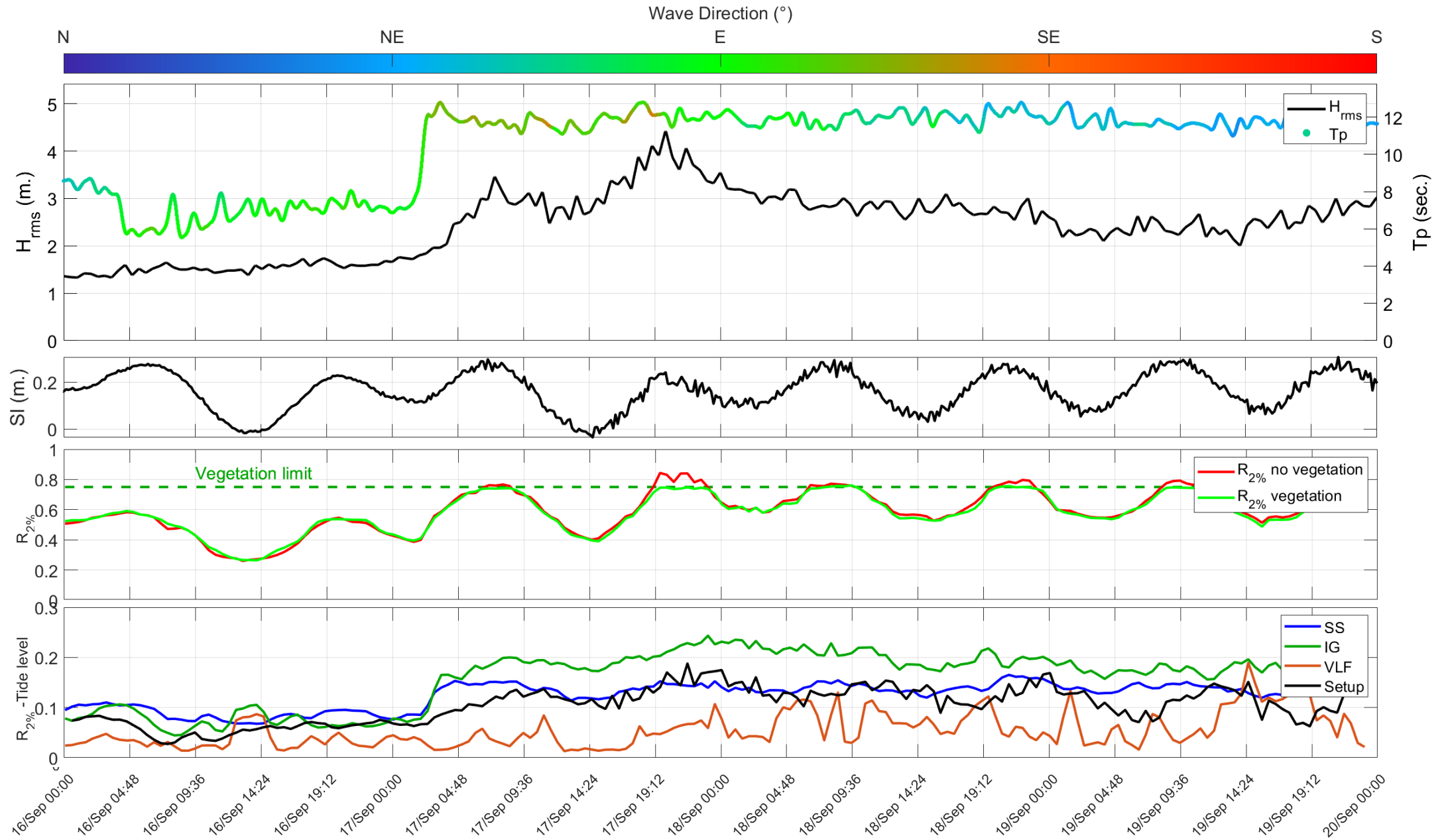
Source : nhc.noaa.gov

Results : Short-term modelling

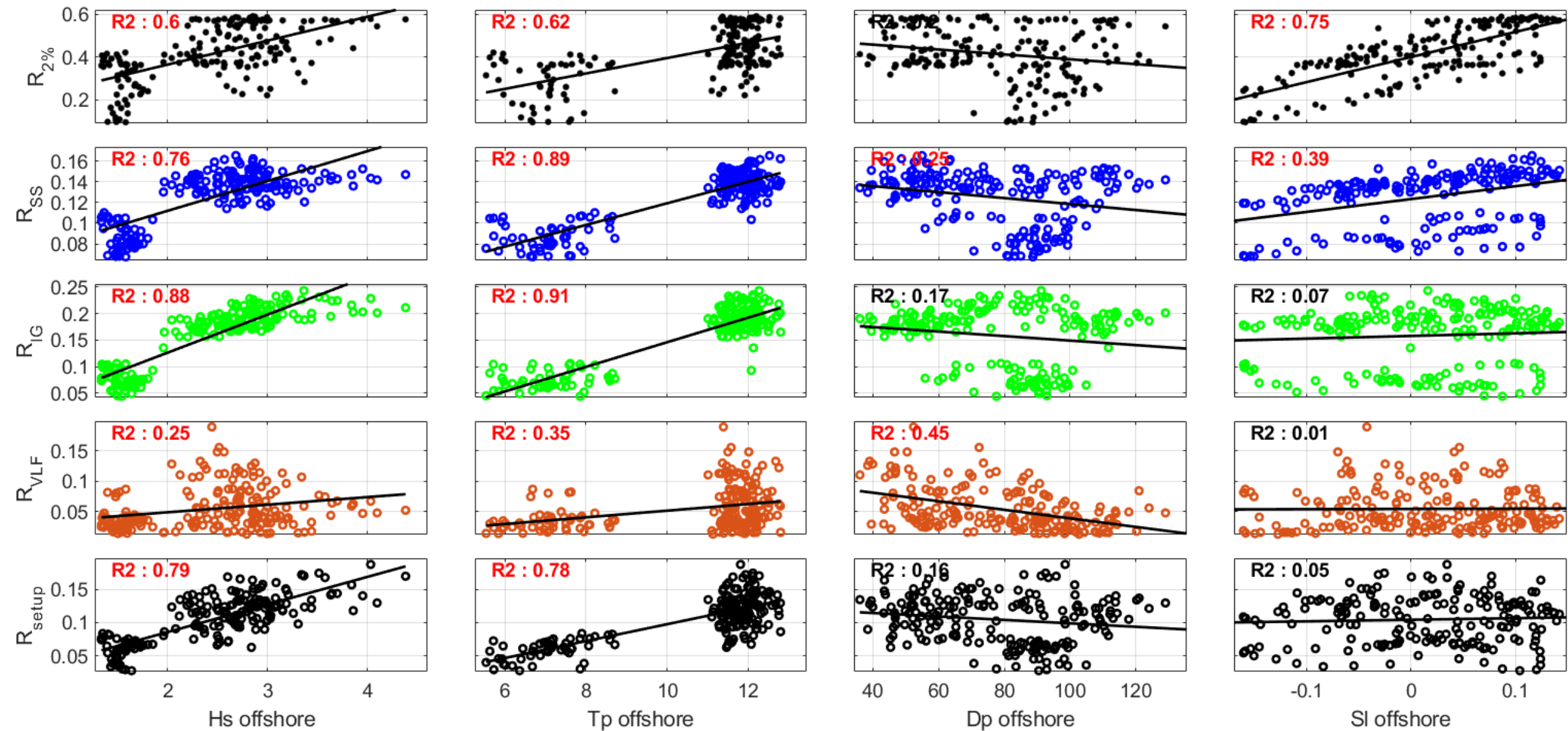
- SS waves attenuation by the reef
- IG and VLF waves amplification by the reef
- Between 30 to 70 % of incident wave height is reduced



Results : Short-term modelling



Results : Short-term modelling



Conclusions & Perspectives

Observations

- Runup mostly correlated to Sea level on the mid/long-term
- Low Correlation with Hs and Tp excepted during storms
- Upperbeach vegetation seems to reduce maximum runup
- Extrem runup = High sea level + strong swell

Numerical modelling during storm :

- Between 30 to 70 % of the incident wave height is dissipated by the reef
- Sea level dominates Runup signal globally
- IG waves are the second most important parameter on runup
- Upperbeach vegetation reduce maximum runup

Perspectives :

- Numerical modelling sensitivity test with varying reef and vegetation properties in order to quantify the benefits (loss) of ecosystem state of health changes.
- Modelling probabilistic events : 5,10,100... years return storms +sea level rise scenarios (IPCC)



Vegetation enclosure at Anse-Maurice