FROM A REGIONAL WAVE HINDCAST DATABASE TO CHARACTERIZATION OF COASTAL SEDIMENT CELLS

The Guadeloupe island case study


CCI SEA STATES 2019
OCTOBER 8 & 9TH 2019
Introduction

Our general approach at BRGM: coastal flooding

- Historical events
- Field expertise
- Modeling (waves, storm surges, tide, flooding)
- Meta-modeling
- Extremes statistics
- Damage
- Prevention, previson, crisis management, adaptation

(Damages)

(Garcin et al., 2007)

(Lecacheux et al., 2013)

(Le Roy et al., in prep)

(André, 2013)
Introduction

• Questionning
  o Present wave climate and trends?
  o CC effect on future wave climate?
  o Effect on longshore and cross-shore sediment transport?

• Approach
  o Dynamical downscaling (Ex: Bobwa database)
  o Reanalyses & projections (IPCC scenarios, extra-probabilist approach)
  o Statistical downscaling
  o Multivariate extreme value analysis to populate wave models (SWAN, SWASH)
  o Meta-modelling for early warning systems

→ Also with extreme value analysis
Outline

• Introduction: General approach at BRGM

• An example of a policy support study using sea state conditions
  o Study area and data overview
  o Methodology
  o Validation
  o Clustering
  o Offshore to nearshore

• Our needs regarding satellite based products providing wave conditions

• Conclusion
### Study area and data overview

#### Summary of data sources

<table>
<thead>
<tr>
<th>Variable</th>
<th>Product</th>
<th>Source</th>
<th>Resolutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional Wave conditions (Hs, Tp, Dp)</td>
<td>IOWAGA-CRB</td>
<td>Ifremer/Lops</td>
<td>2min; 3h</td>
</tr>
<tr>
<td>Wind conditions (U, Du)</td>
<td>CFSR/ CFSv2</td>
<td>NCEP</td>
<td>0,312°/0,25°; 3h</td>
</tr>
<tr>
<td>Bathymetry</td>
<td>HOMONIM</td>
<td>Shom (France)</td>
<td>100 m</td>
</tr>
<tr>
<td><em>In-situ</em> wave time-series</td>
<td>Buoy time-series</td>
<td>Candhis (France)</td>
<td>1h or 30 min</td>
</tr>
</tbody>
</table>
Methodology

i. **Validation** of the dataset in our zone of interest

ii. **Clustering** offshore representative conditions using statistical clustering methods;
   
a. DBSCAN algorithm (density-based spatial clustering of applications with noise) to define the number of useful clusters and eliminate outliers (extreme waves coming from tropical storms and hurricanes)
   
b. K-means++ algorithm used for a well defined number of clusters

iii. Analysis of **associated winds**;

iv. **Offshore to nearshore modelling** using the the third generation wave model WAVEWATCH III® forced by all the clustered offshore conditions in order to obtain the sea states along the Guadeloupe coasts (100m resolution);

v. **Identify** the dominant direction of the sediment transfers and the homogeneous cells associated.
Validation

Example at Port-Louis (97101) in 1998

- Good reproduction of Hs by IOWAGA-CRB, overestimation for the highest values;
- The peak periods Tp are well reproduce in IOWAGA-CRB
- The main Dp (from E & ENE) are presents in IOWAGA-CRB
Validation of $H_s$

The model under-estimated the observations > to 2.5 m =>
Here IOWAGA is forced by ECMWF for 2008
Clustering

- Clustering algorithms applied on 5 offshore points around Guadeloupe island

- DBSCAN algorithm used in order to have an idea of main clusters and eliminate the outliers. Here the optimum is k=5 clusters and 11 outliers.

- Kmeans++ applied using k=5 clusters
Offshore to nearshore

Boundary conditions

<table>
<thead>
<tr>
<th>Class</th>
<th>Hs</th>
<th>Tp</th>
<th>Dp</th>
<th>Etal</th>
<th>Hs</th>
<th>Tp</th>
<th>Dp</th>
<th>Etal</th>
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<tbody>
<tr>
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<td>1.4</td>
<td>8.4</td>
<td>81</td>
<td>40.5</td>
<td>1.4</td>
<td>8.4</td>
<td>82</td>
<td>40.5</td>
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<td>2</td>
<td>1.9</td>
<td>8.1</td>
<td>89</td>
<td>36.8</td>
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<td>8.1</td>
<td>87</td>
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<td>42.4</td>
<td>2.5</td>
<td>9.1</td>
<td>73</td>
<td>42.4</td>
</tr>
</tbody>
</table>

Model setup

- Bathymetry: HOMONIM + Litto3D
- Unstructured grid: coastal grid (5km to 100m)

Spectral wave model WW3

Outputs: Sea states at the coast on a grid and at some points along the island (isobath 20 m)

- Step further:
  - Identify homogeneous cells knowing the dominant direction of the sediment transfers giving by the simulation for the wave contribution and mainly by expertise field for other contributions.
Our needs regarding satellite based products providing wave conditions

- For wave condition clustering

- To populate specific climate services (example of INSeaPTION)

- Working on uncertainties

- Have access to wave spectra for shoreline evolution in embayed beaches (LX-shore model)

- For flood induced by overtopping studies

- Wave conditions offshore leewar coasts (example: west coast of Caribbean islands)
• An example of a policy support study using sea state conditions:
  o Use a clustering methodology to feed a wave model;
  o Offshore to nearshore simulation in order to obtain the sea states along the Guadeloupe coasts (100 m resolution);
  o Identify the dominant direction of the sediment transfers and the homogeneous cells associated.

A possible alternative:
  o Use satellite data on the zone, in order to define the clusters using the DBSCAN algorithm. Indeed, DBSCAN was made especially for observations and to filter outliers. This way we can use directly the wave clustering. That could reduce sources of uncertainties?

• Interests and needs at BRGM for satellite based products:
  o For validation
  o Uncertainties reduction
  o As input for modelling
  o ...

Summary
THANK YOU
Example along the sat track 6

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Here IOWAGA is forced by ECMWF for the year 2008
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