CMS Modeling of the North Coast of Puerto Rico

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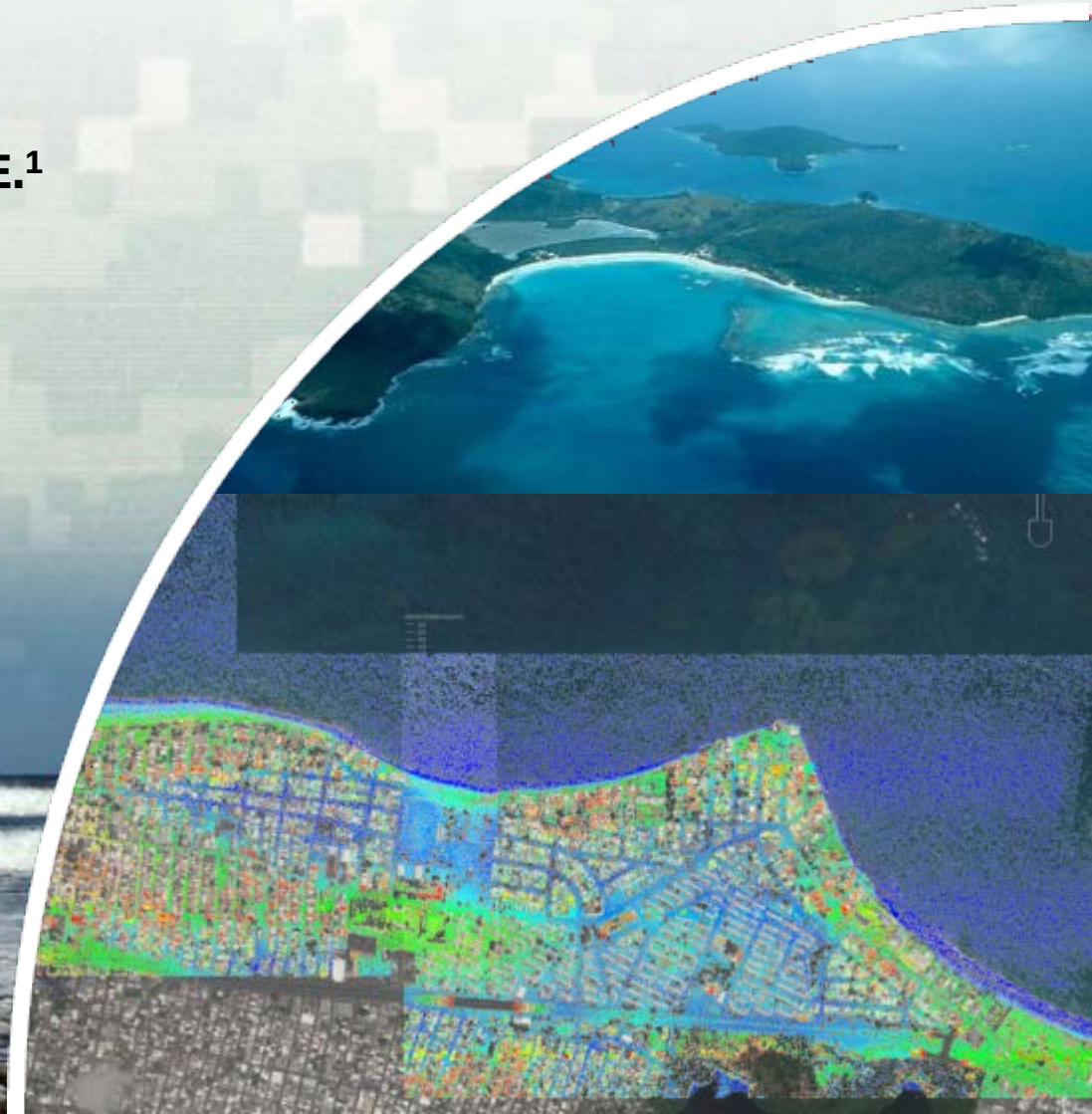

Beach Erosion in Puerto Rico

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PROBLEMS

- Erosion, storm surge (inundation) and wave attack
- Damage to coastal structures and infrastructure
- Loss of natural coastal habitat (beach, dunes, reef)
- Threatened recreational and tourism opportunities

OPPORTUNITIES

- Reduce storm damage to coastal structures and infrastructure
- Protect the hurricane evacuation route capability
- Restore dunes to function naturally
- Protect natural habitat
- Improve community resilience
- Maintain recreation and tourism opportunities

USACE RSM Program

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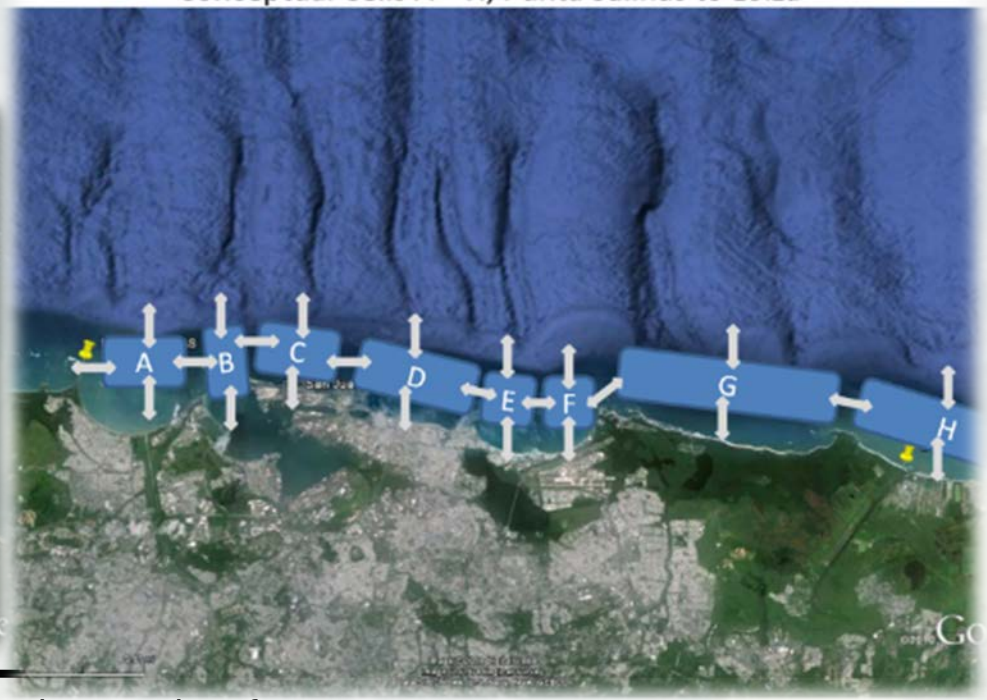
San Juan RSM Conceptual Sediment Budget

Transport Pathways

Conceptual Cells A—H, Punta Salinas to Loiza



Wave Climate – San Juan Region

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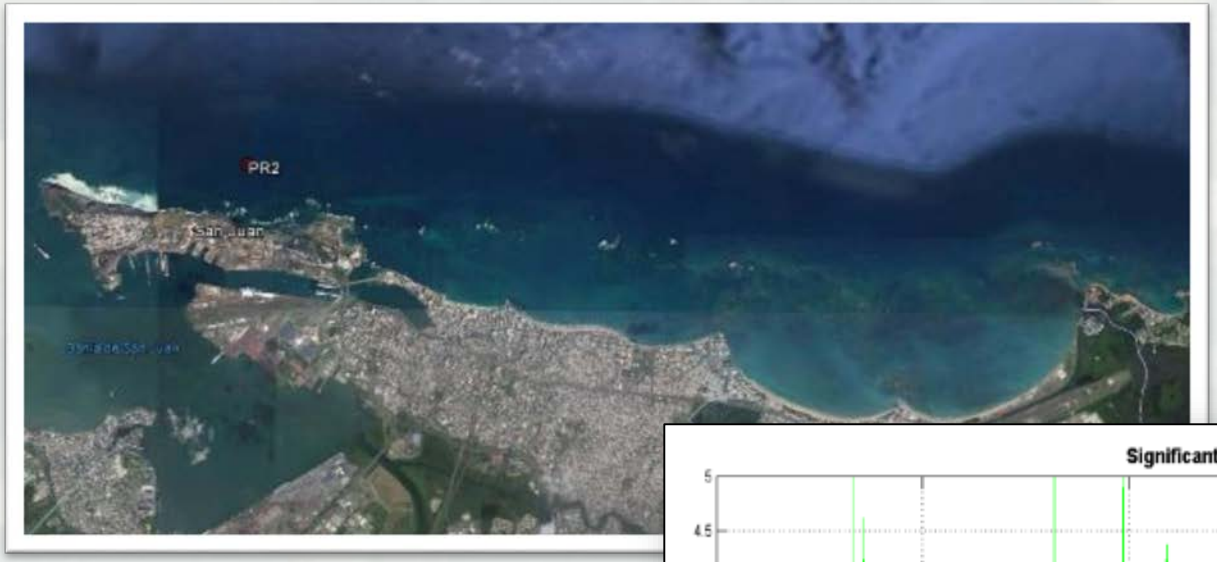
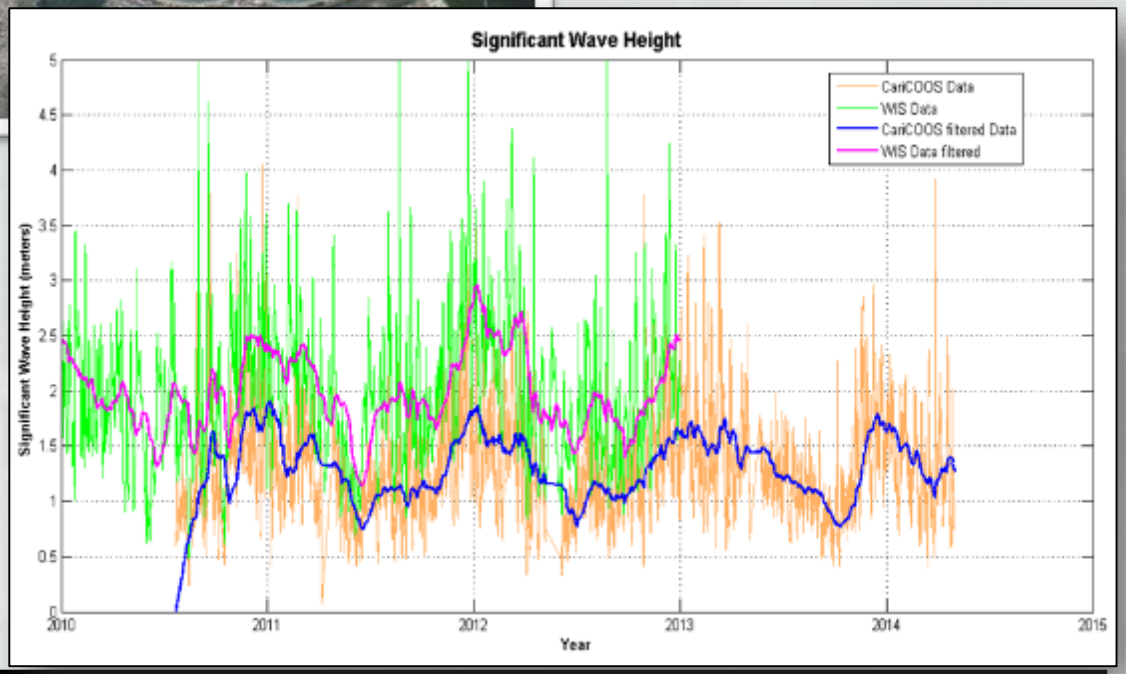


CariCOOS San Juan buoy wave data



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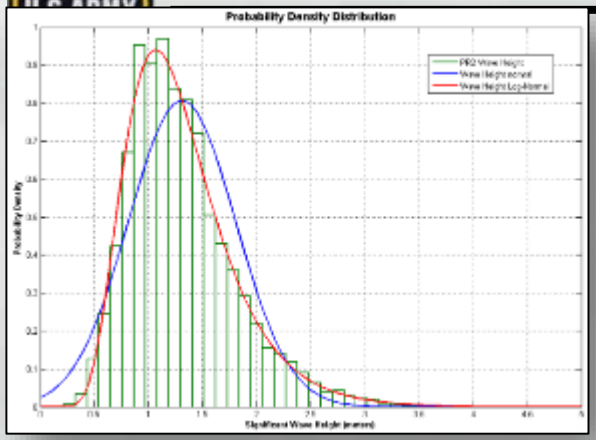
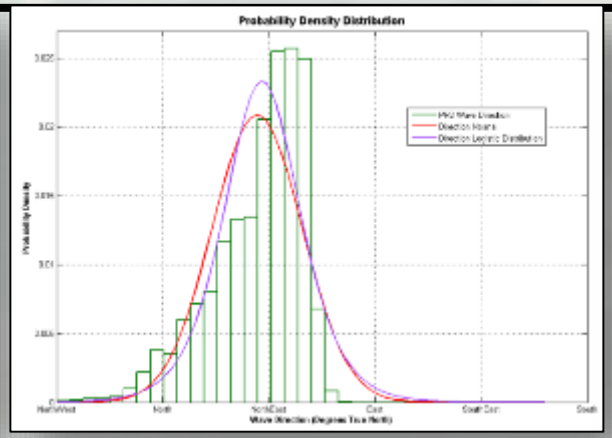
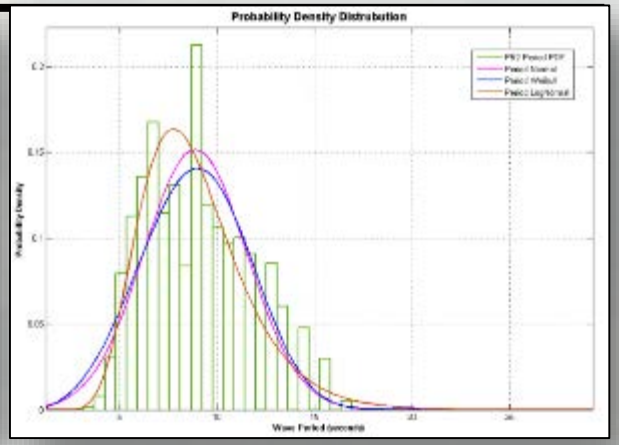


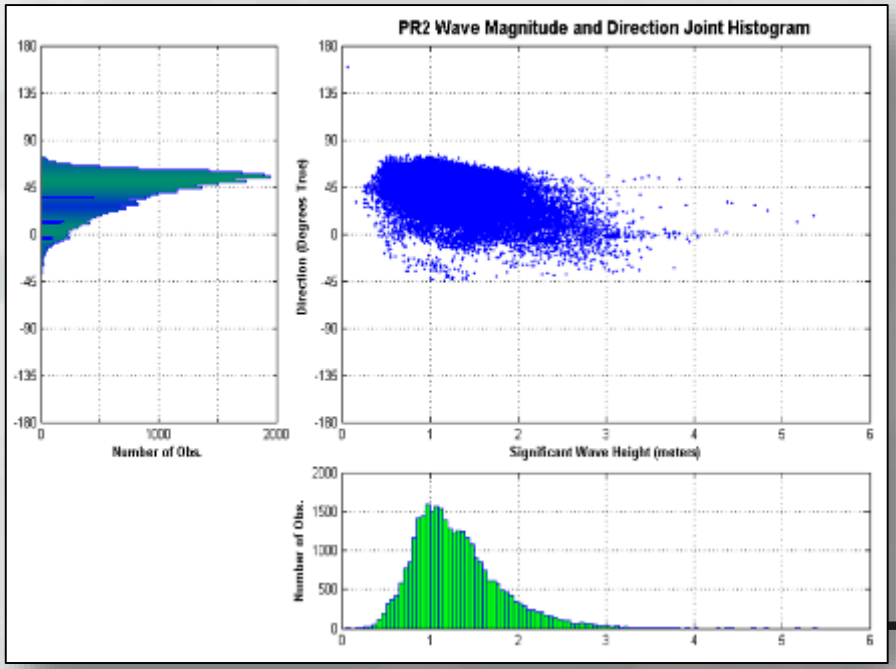
Significant Wave Height

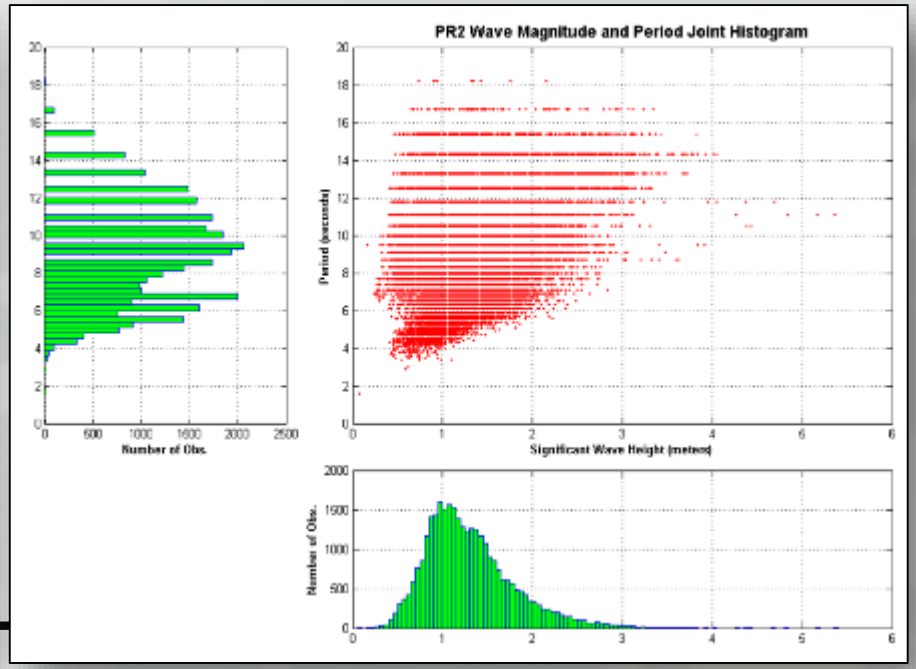


Mean Wave Direction



Peak Wave Period





CariCoos San Juan Buoy Wind Data

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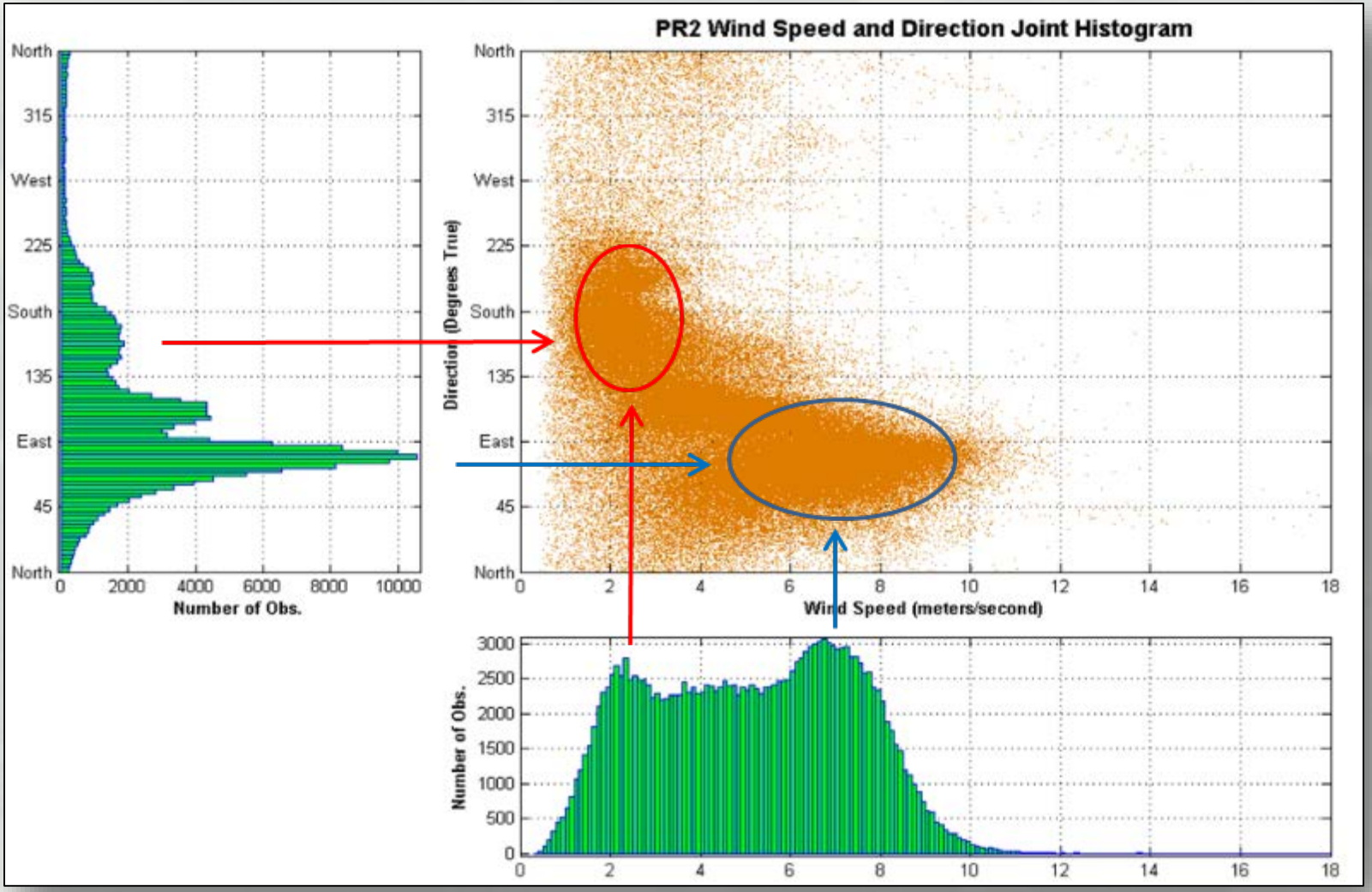

Wave and Wind Climate Summary

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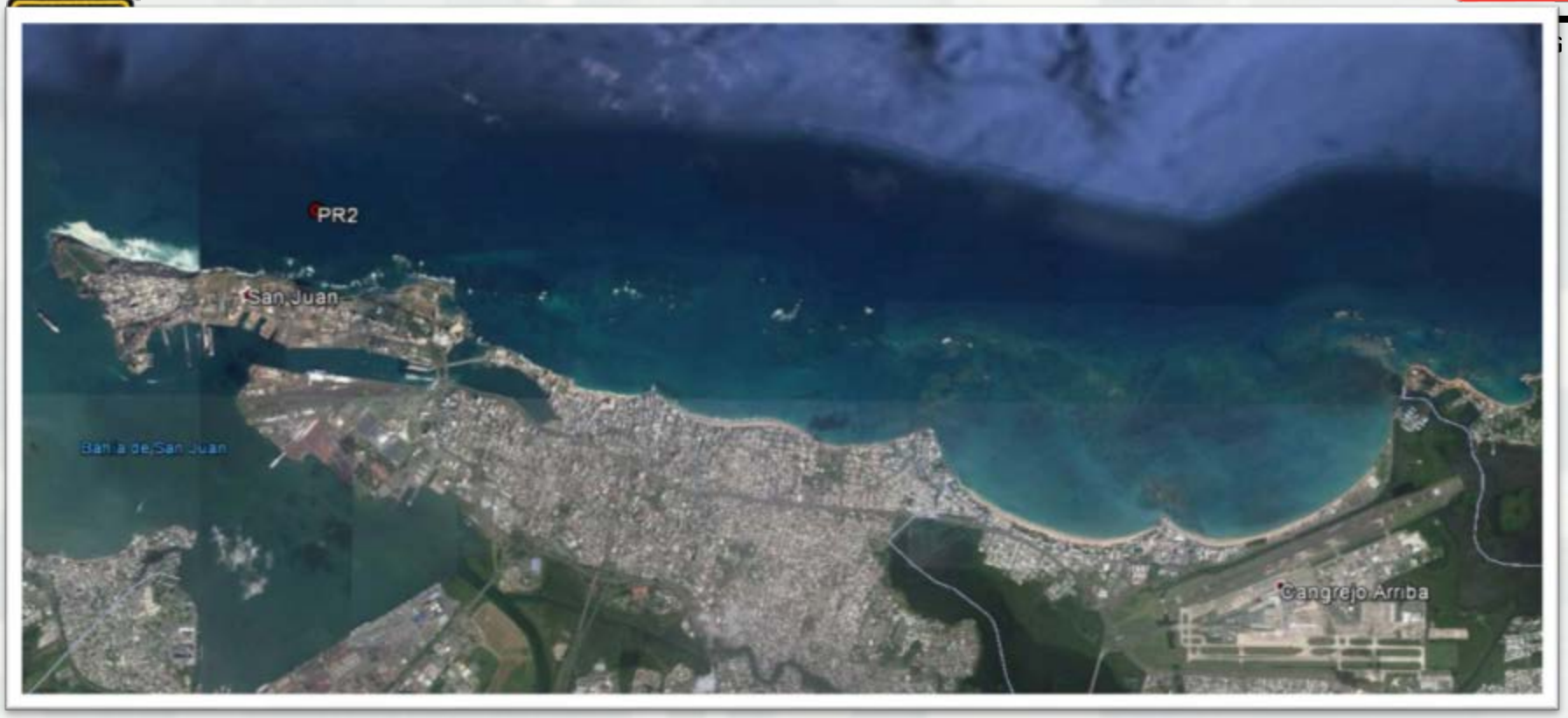
- Bi-modal wave climate:
- larger, longer period swell in winter, mostly from the northeast, but with some forcing from the west
- Smaller, shorter period wind waves in summer, with a more easterly component

- Bi-modal wind climate:
- Fairly consistent east-northeast trade winds
- Weaker more southerly winds in fall

- Net Result:
- “winter regime” wave dominated (more northerly forcing)
- “summer regime” wind dominated (more easterly forcing)

North Coast Morphology



The beaches of San Juan are Headland-Bay beaches…Headland-Bay beaches occur in coastal systems with a ***limited*** sand supply…

North Coast Morphology

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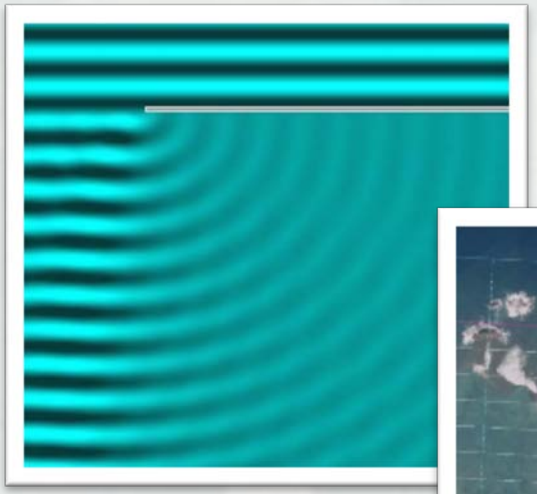
Wave diffraction plays a key role in the dynamics of Headland-Bay beaches…



The curved wave fronts lead to a stable beach that does not require a continuous sand supply in the alongshore

North Coast Morphology

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A second defining characteristic of the beaches of San Juan is the presence of fringing reefs…

North Coast Morphology

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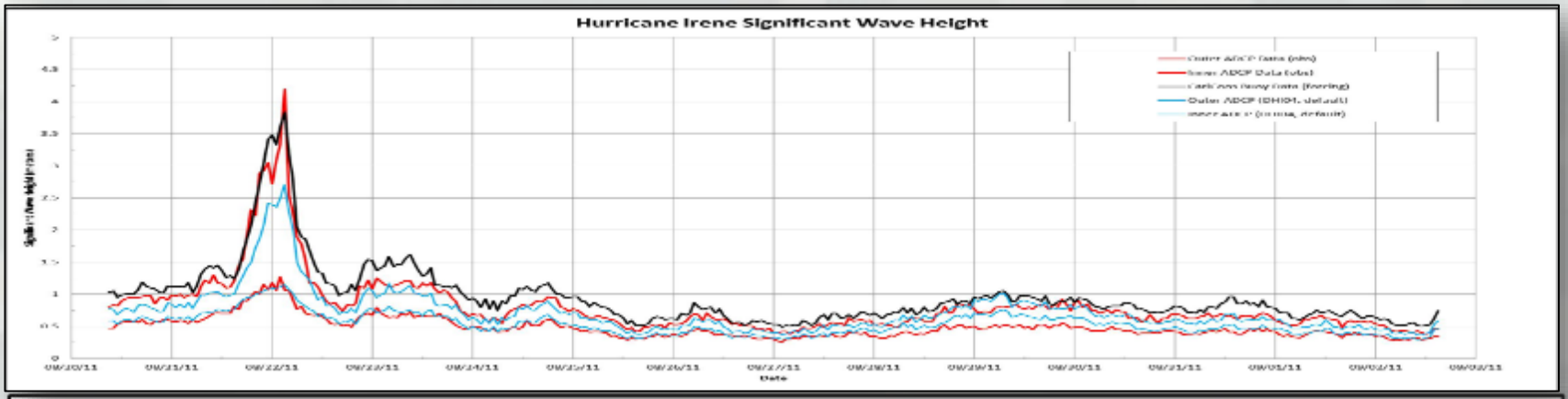
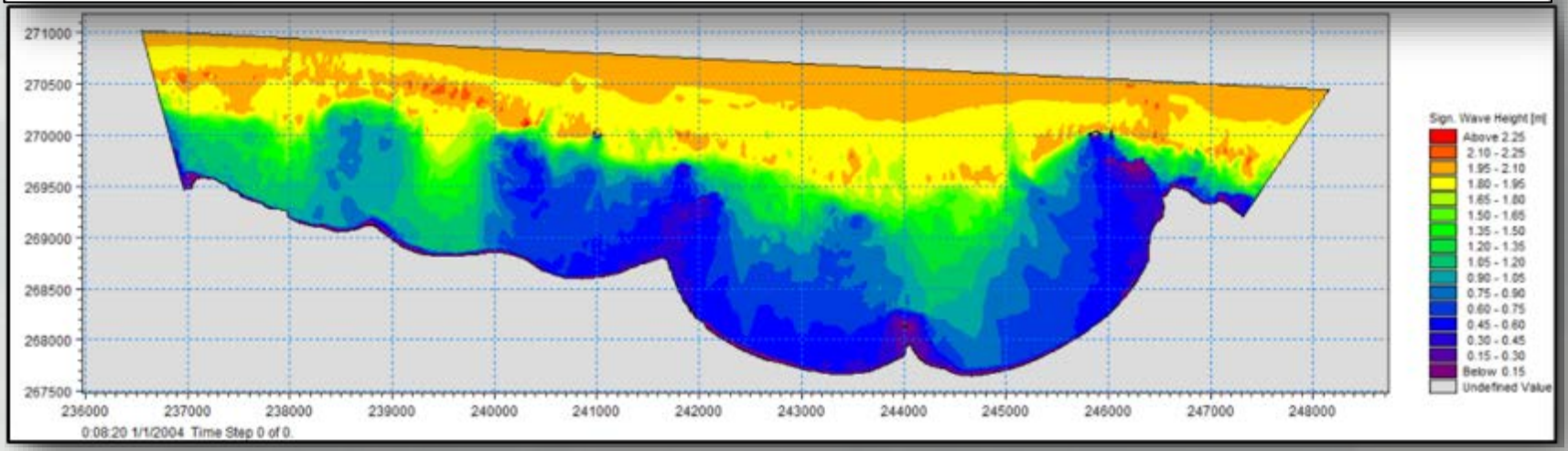
On the positive side, the fringing reefs dissipate the majority of large wave energy, protecting the beaches…





(86% - 92% wave energy reduction during Hurricane Irene, as per *R. Calzada's Masters Thesis*)

North Coast Morphology

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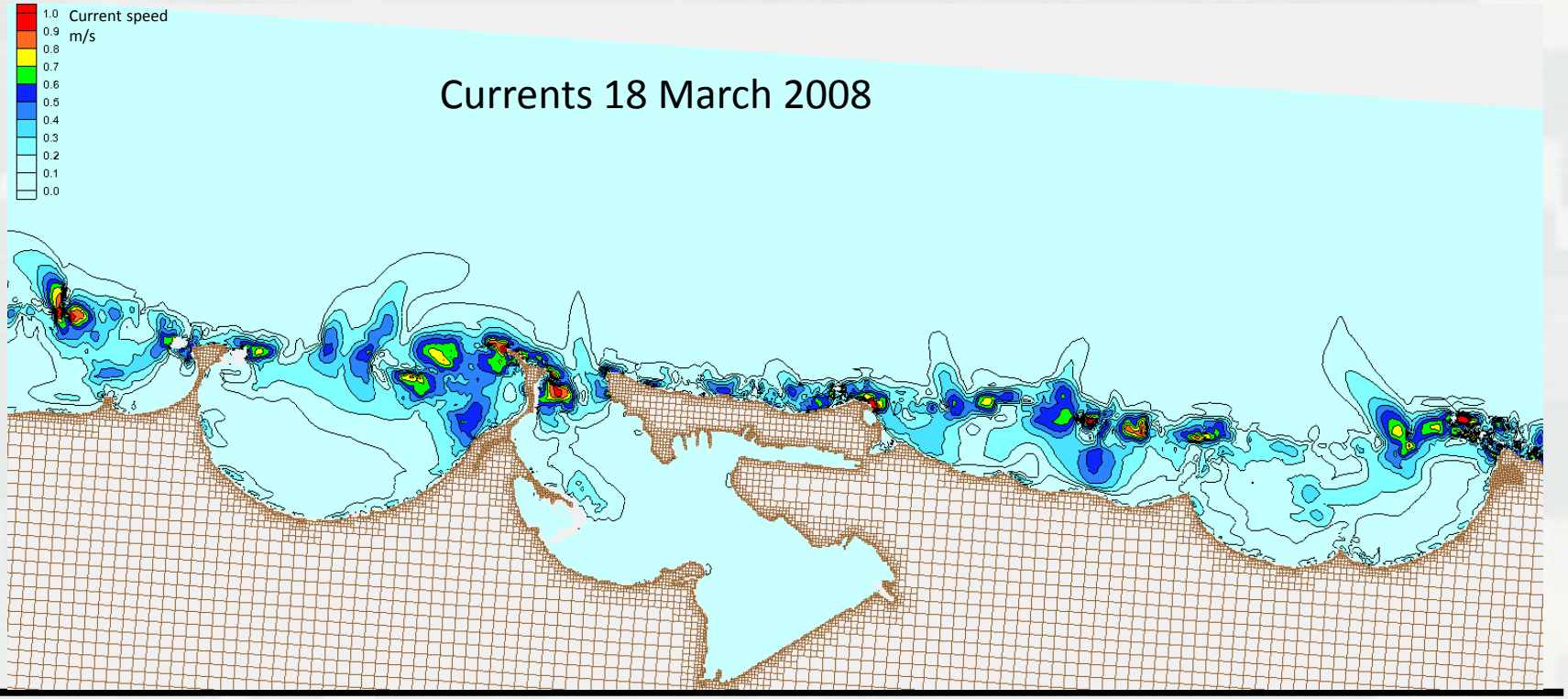
On the negative side, the fringing reefs generate strong currents and infra-gravity waves during swell events that may contribute to long term sand loss from the system…



Coastal Modeling System (CMS) Flow and Wave

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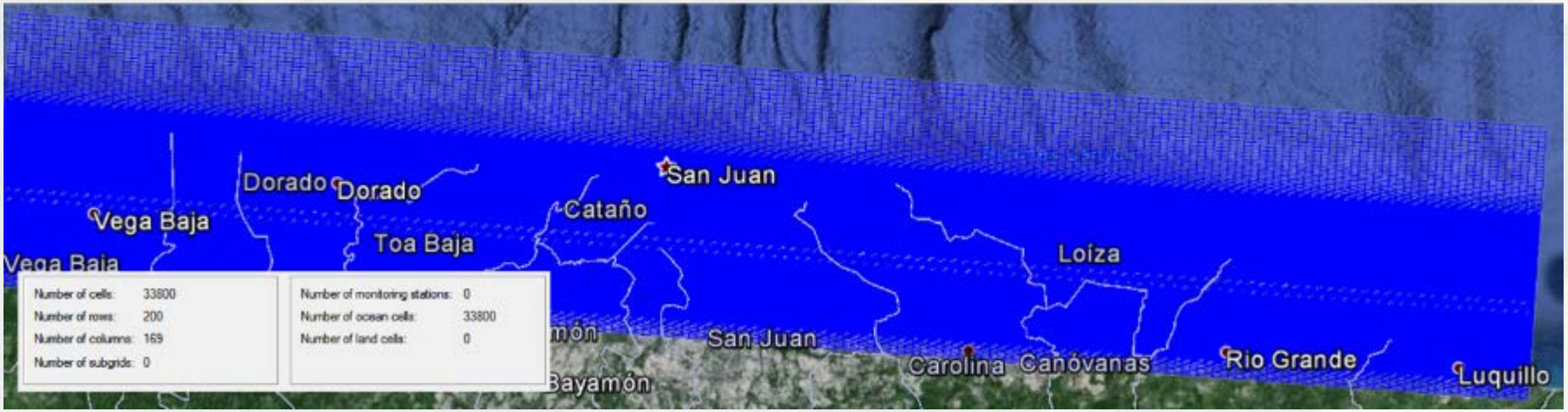

Coastal Modeling System (CMS) Flow and Wave

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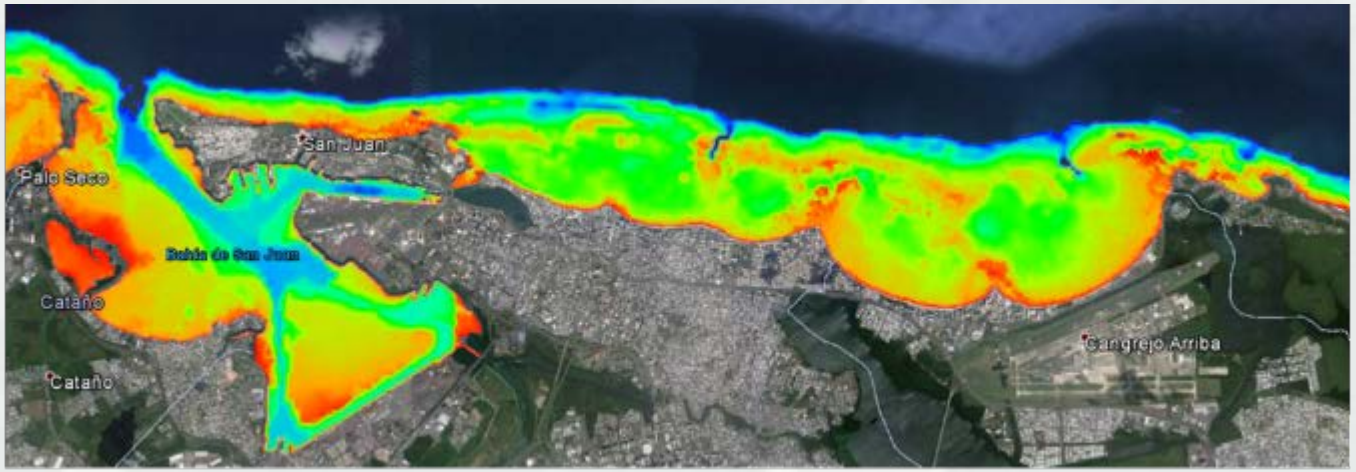
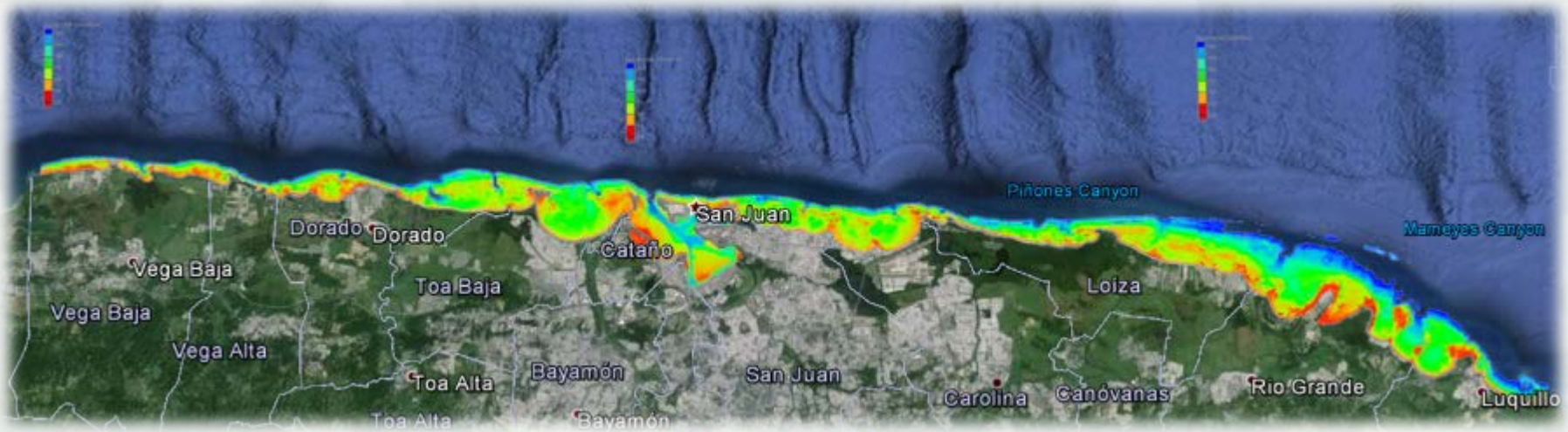
Bathymetry (2008 NOAA DEM, Local Surveys)





Coastal Modeling System (CMS) Waves and Current Measurements

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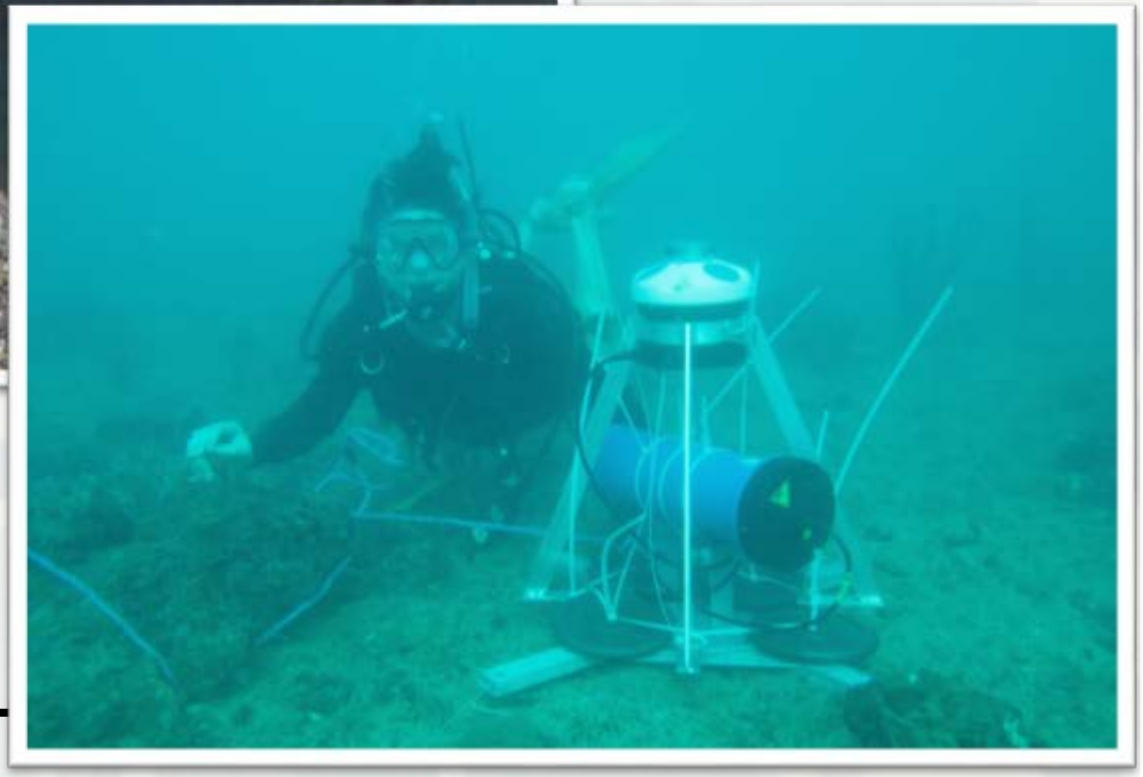

Calibration Feb 2015

WWIII waves and San Juan Tide Forcing

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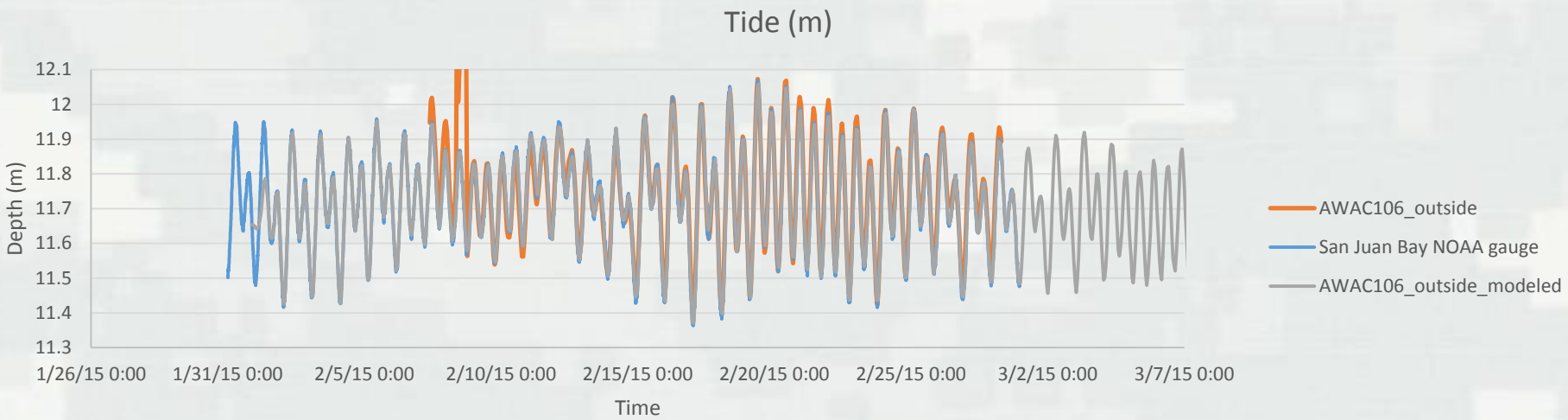

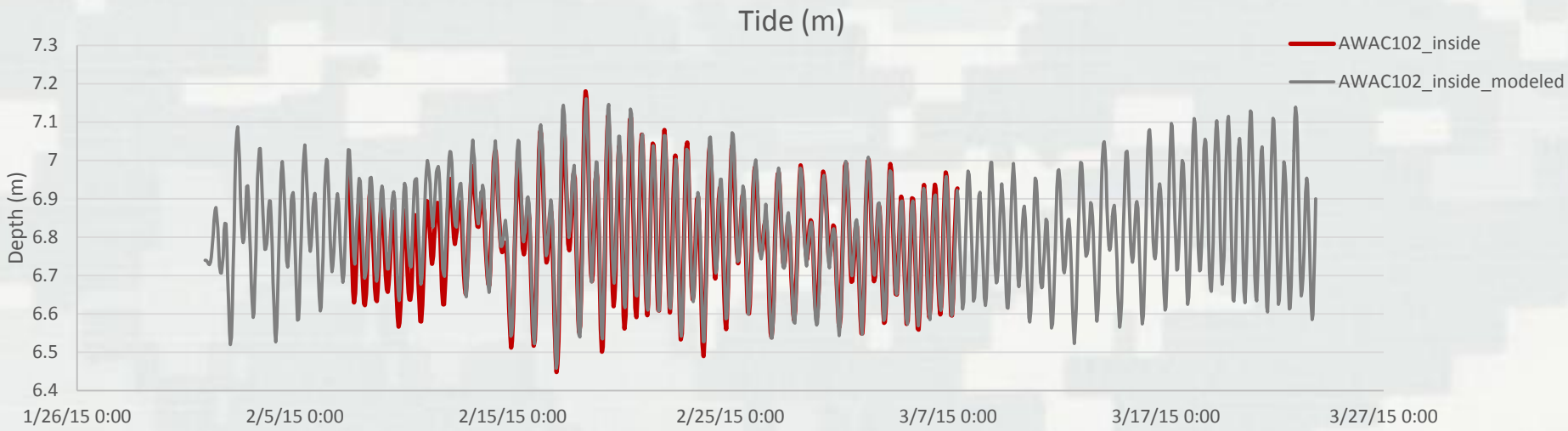

Calibration Feb 2015

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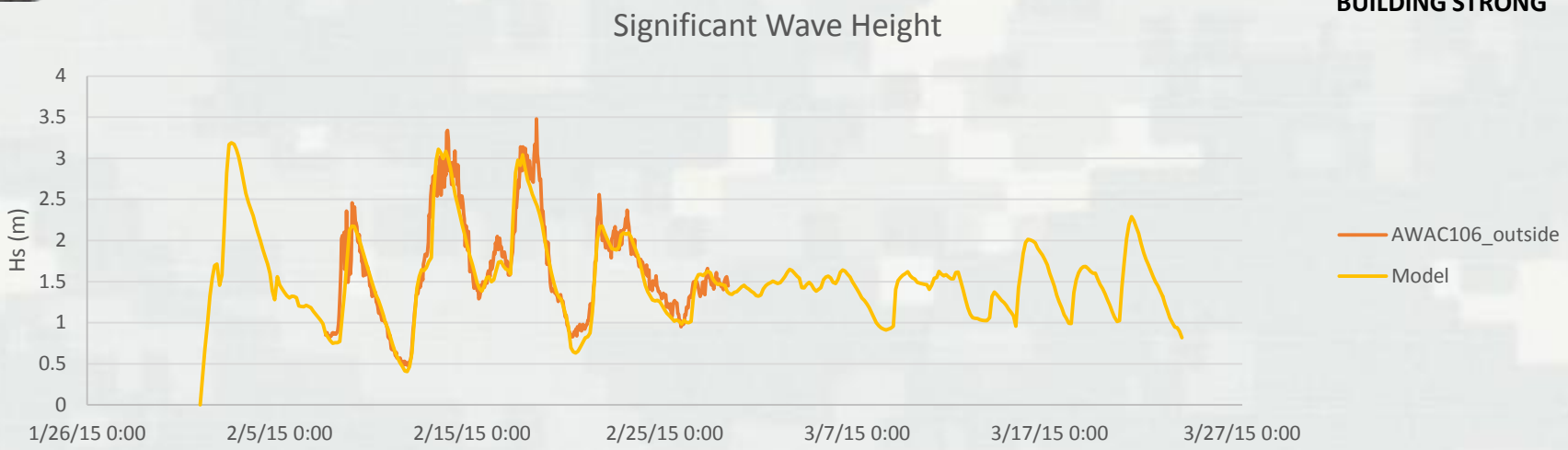

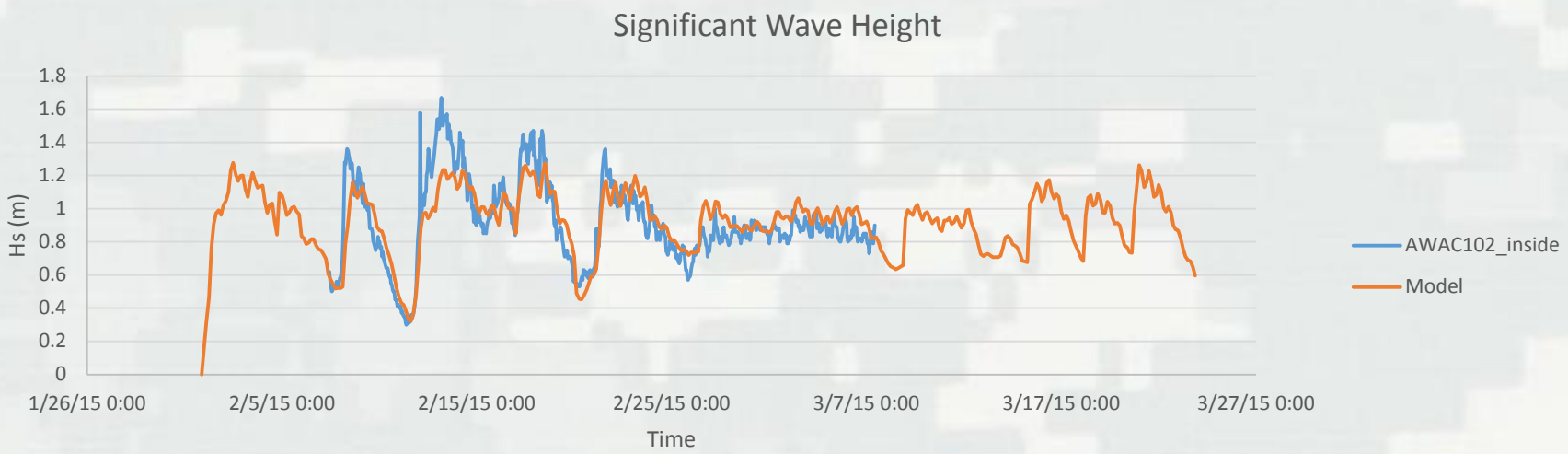

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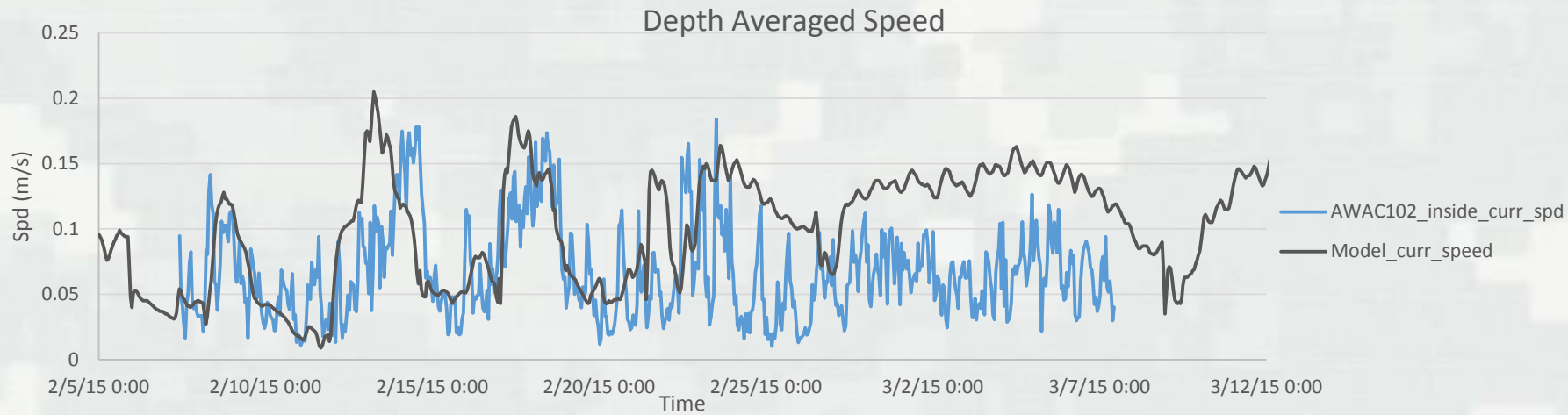

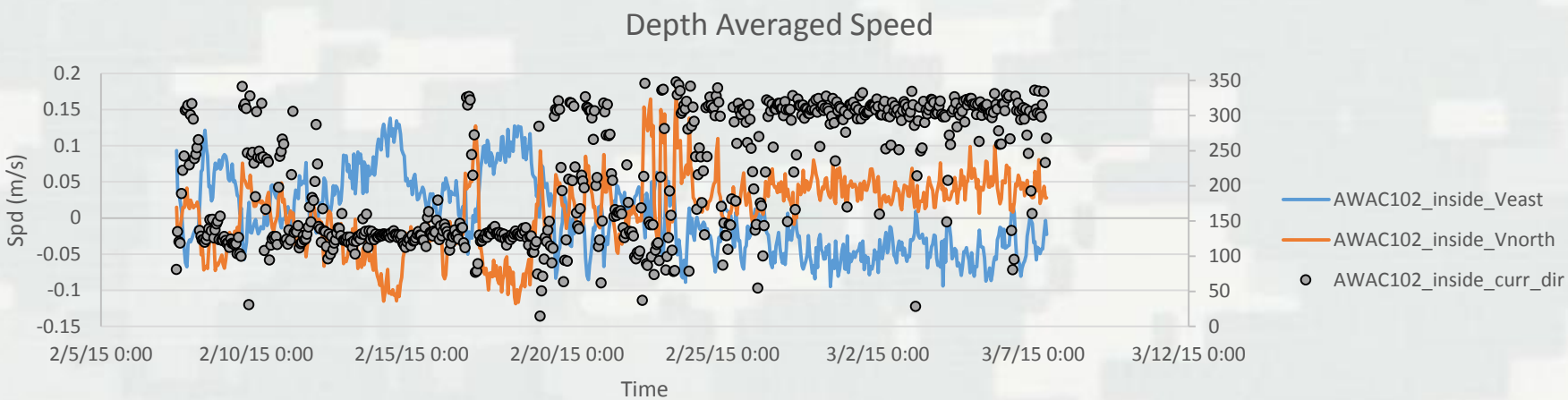

Model Run
WWIII forcing – 6 months

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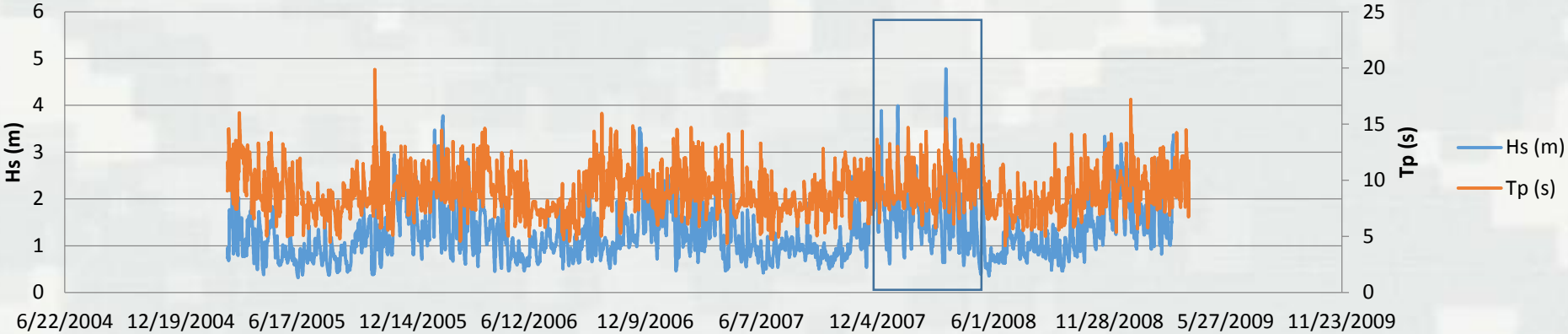
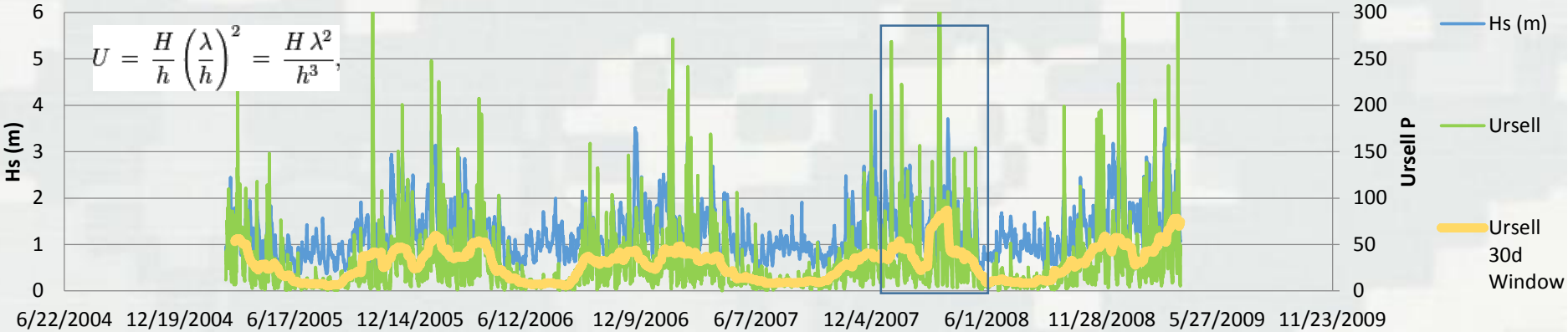
Sig Wave Height and Peak Spectral Period



Sig Wave Height and Ursell Parameter



Mean Nearshore Currents

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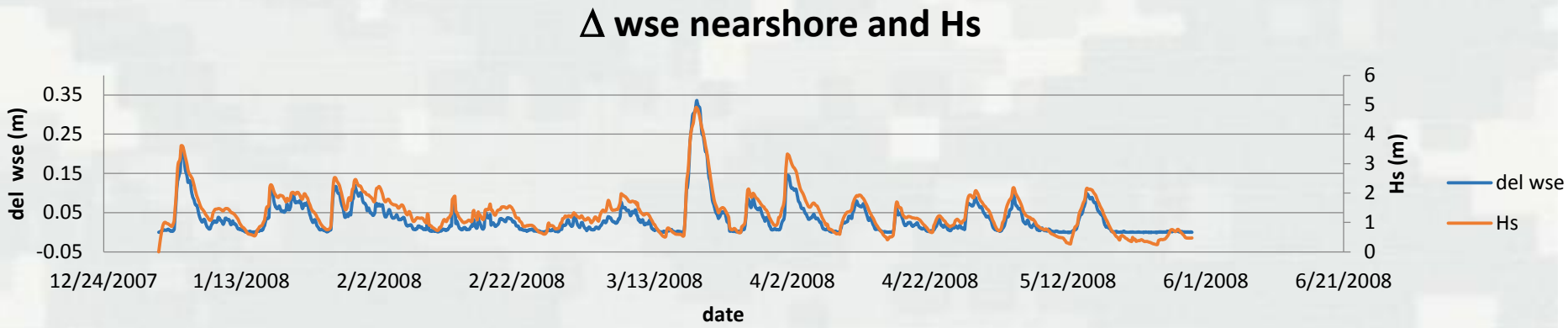

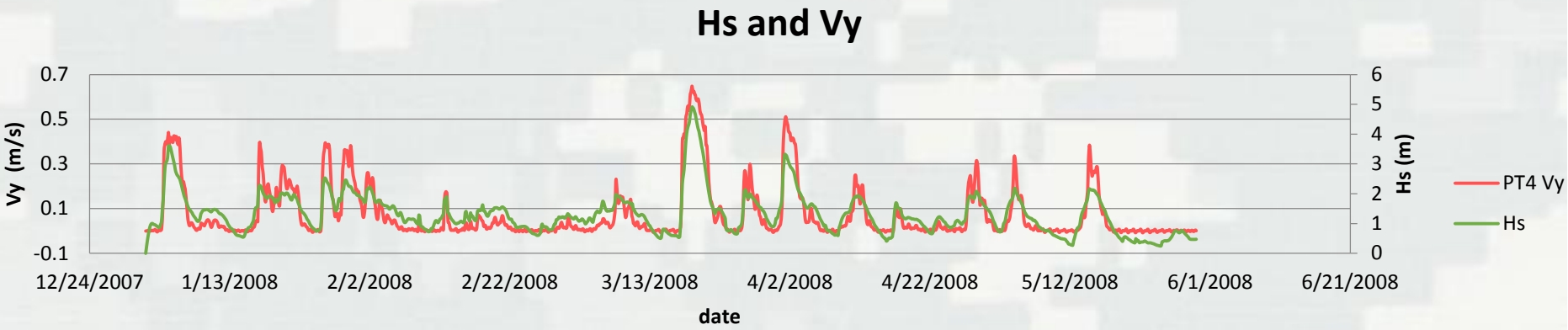

Mean Crosshore Currents

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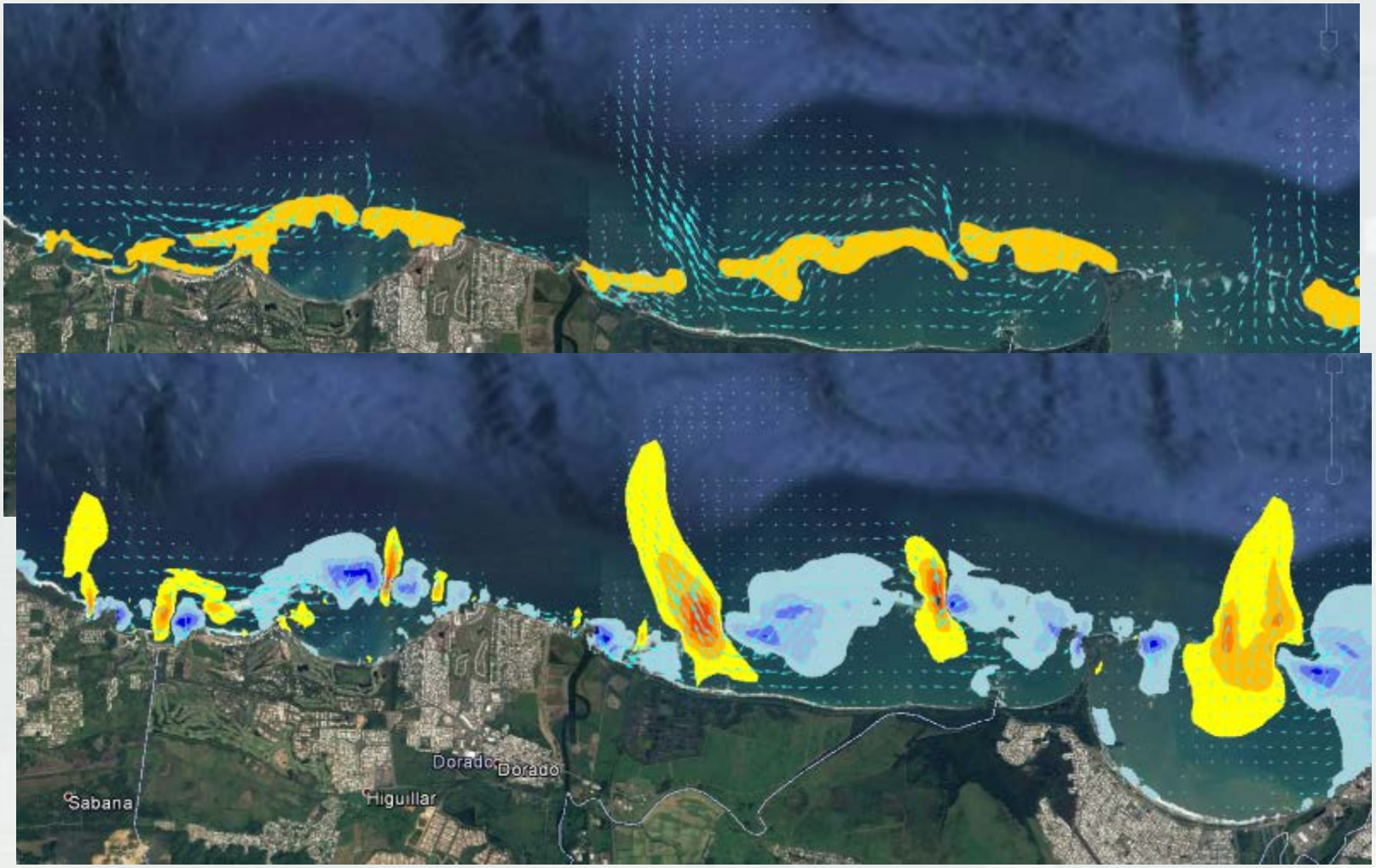
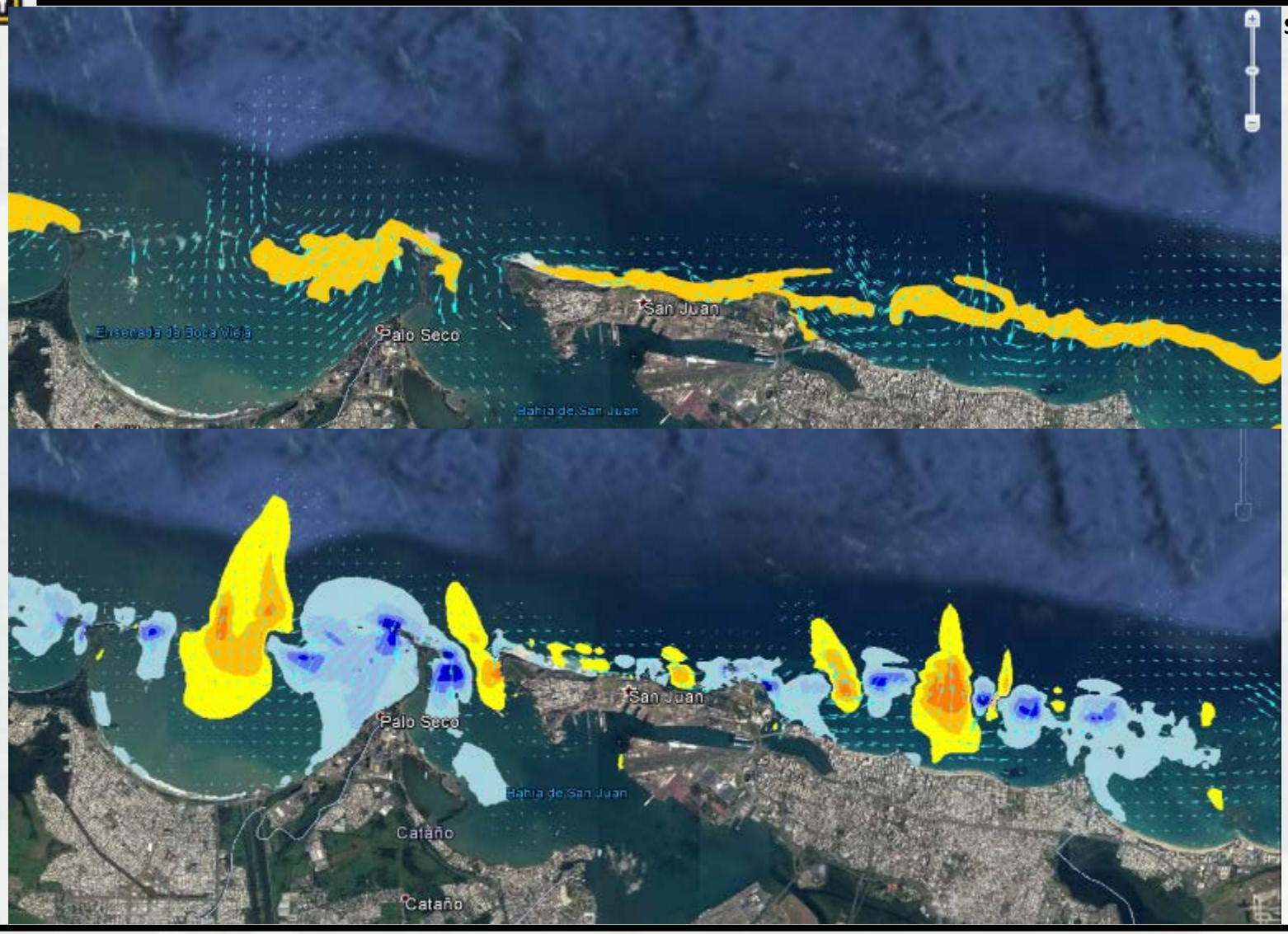


Mean Nearshore Currents



Mean Crosshore Currents

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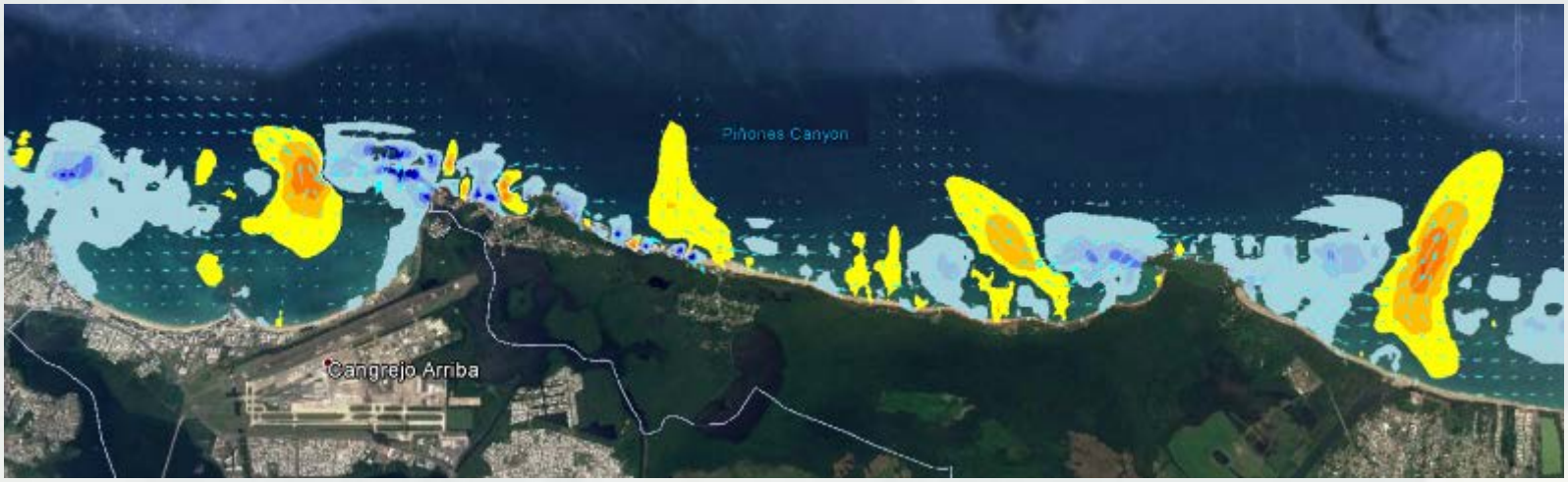

Mean Onshore Currents

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Mean Offshore Currents

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Coastal Modeling System (CMS) Flow and Wave

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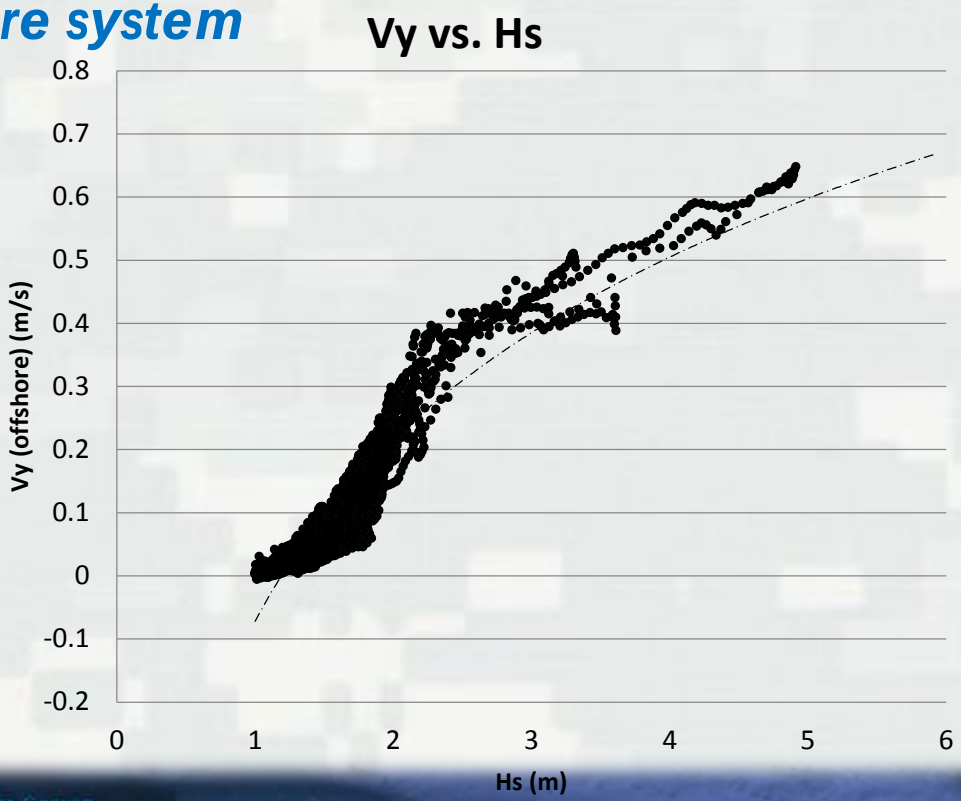
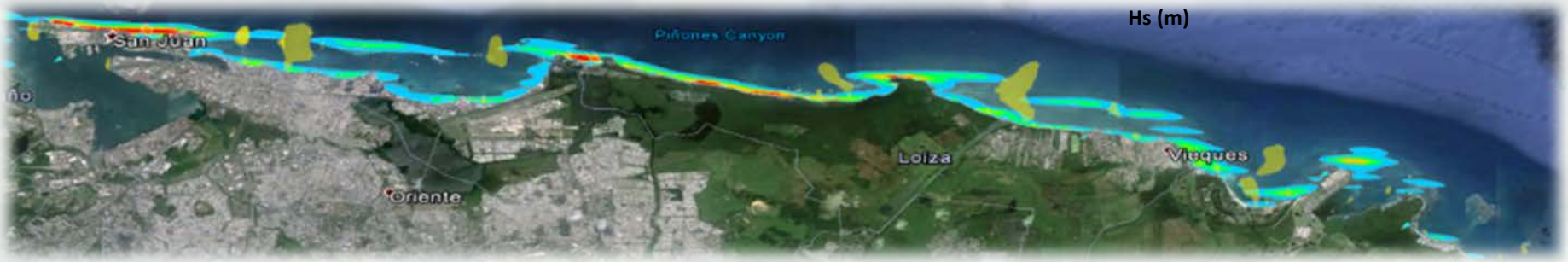
Incident Wave Energy and Coastal Currents – CMS is likely to be an appropriate model to simulate the nearshore system

METHODOLOGY

- Strength of coastal currents are strongly correlated with incoming wave energy
- Examine offshore flows and low frequency wse in the nearshore
- Examine distribution and volume of sediments in the nearshore, mass flux of sediments being driven offshore.





Conclusions

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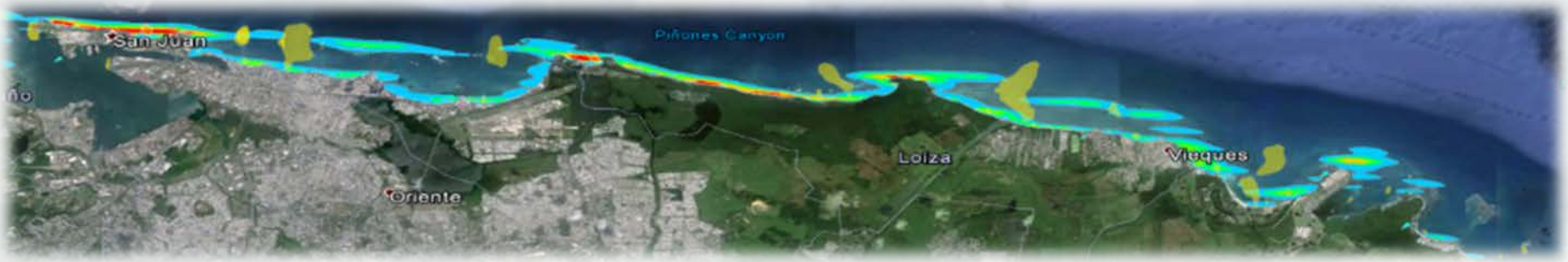
- Strength of coastal currents are strongly correlated with incoming wave energy
- The beaches of San Juan are Headland-Bay beaches, a sign of a sand starved system.
- The beaches of San Juan are in short term and medium term equilibrium.
- The long term beach erosion is likely due to sand being pumped out of the system through the reef passes during swell events, possibly exacerbated by infra-gravity waves.
- More research is needed (and is in the pipeline!) to determine the thickness of the sand layer in the bays, as well as the dynamics of the sediment throughout the year.