

Baird.

Innovation Engineered.

Coastal Flood Risk Assessment for Arterial Road Construction on Grand Cayman, Cayman Islands

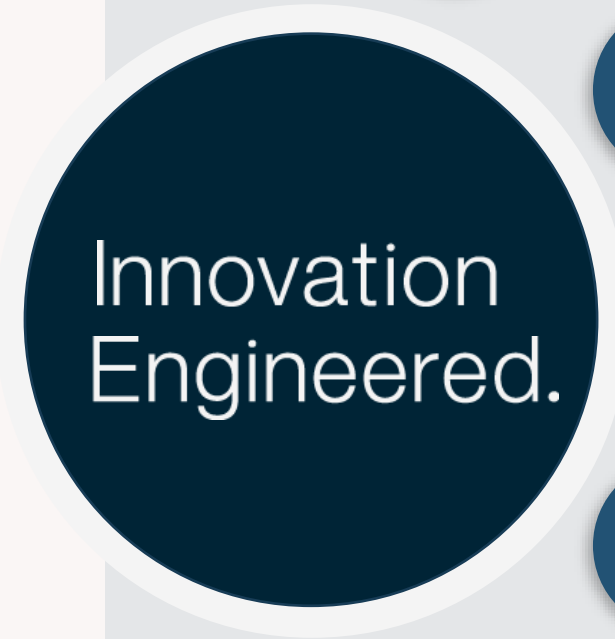
Keith Roberts, Onur Kurum, Derek Williamson, Dave Anglin

2023-10-02

- Founded in 1981
- ~ 105 Employees
- Employee Owned
- 12 Offices Worldwide
- ISO 9001 Certified

B.

Our Sectors



Ports, Terminals & Vessel Operations



Coastal & Marine Structures



Waterfronts, Marinas & Resorts



Coastal & River Environmental



Shoreline & Coastal Restoration



Hazards, Risk & Resilience

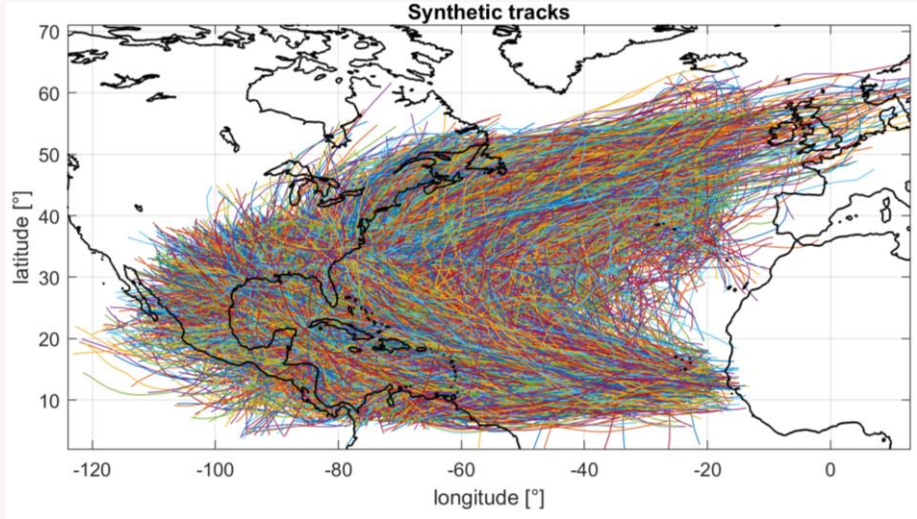


Metocean Studies & Offshore Renewable Energy

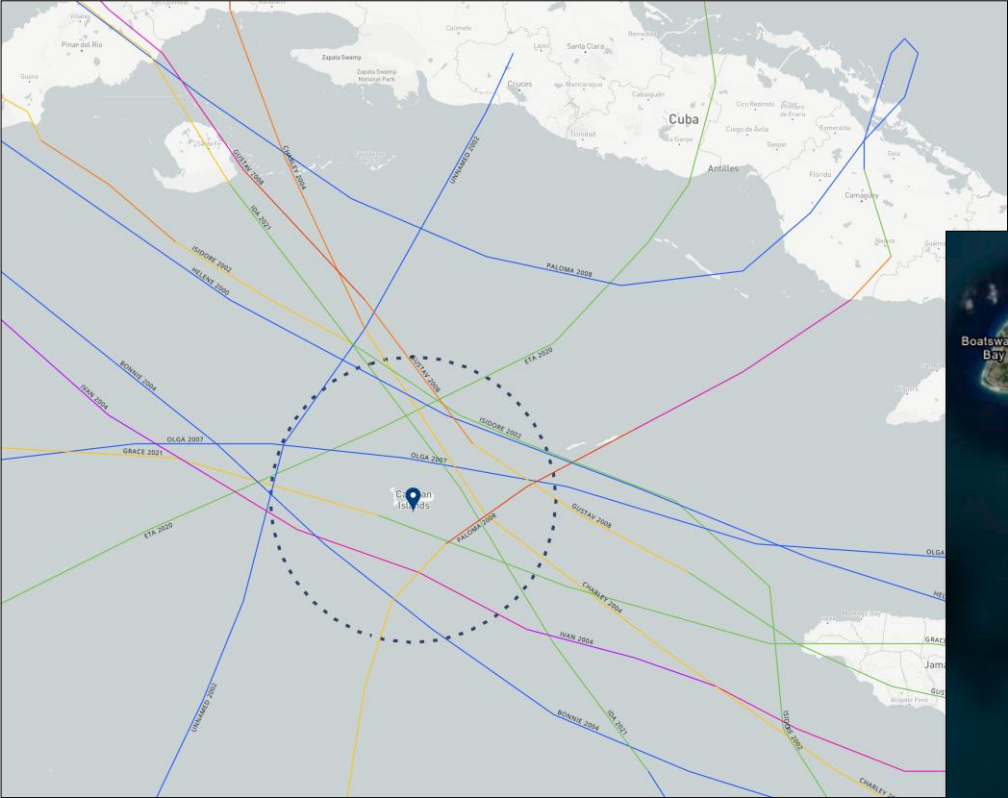
Content



- Grand Cayman Island
- Inform preliminary design of road
- Synthetic hurricane track generator
- Vortex Model
- TELEMAC+TOMAWAC



Coastal Processes



- Storm surge through north bay



- Limited wave overtopping along southern shoreline
- Rainfall runoff

Modeling with TELEMAC + TOMAWAC

- Open-source since 2010 (with many in-house Baird modifications) dozens of features and model coupling capabilities.

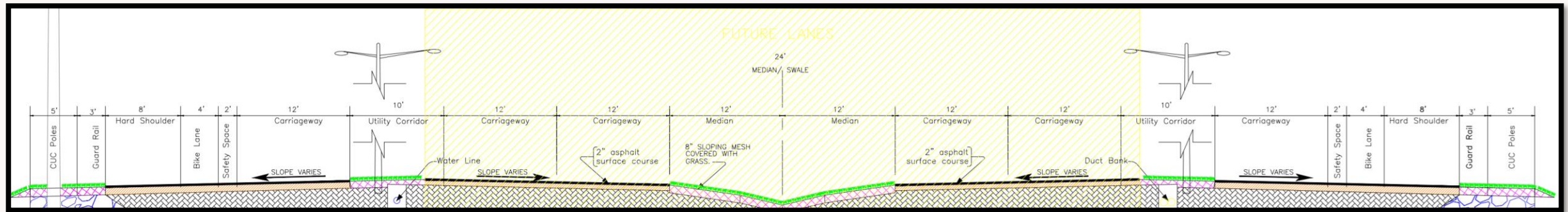
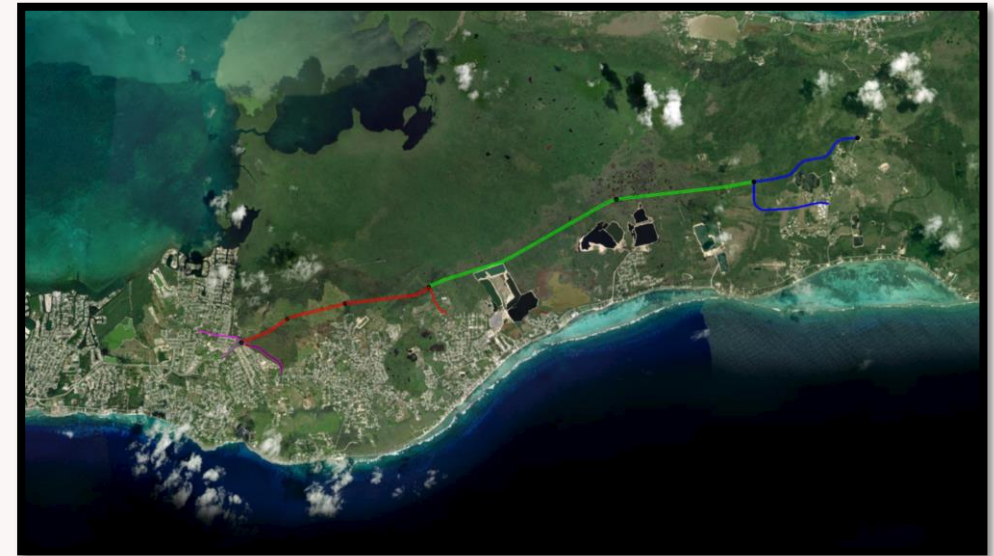
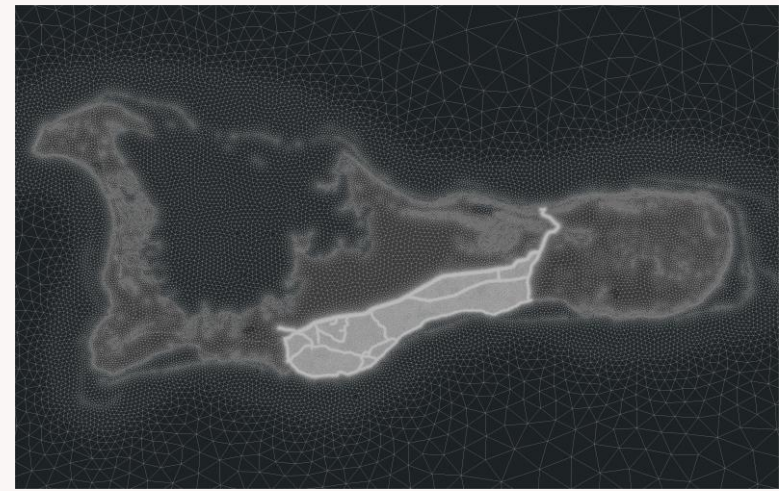
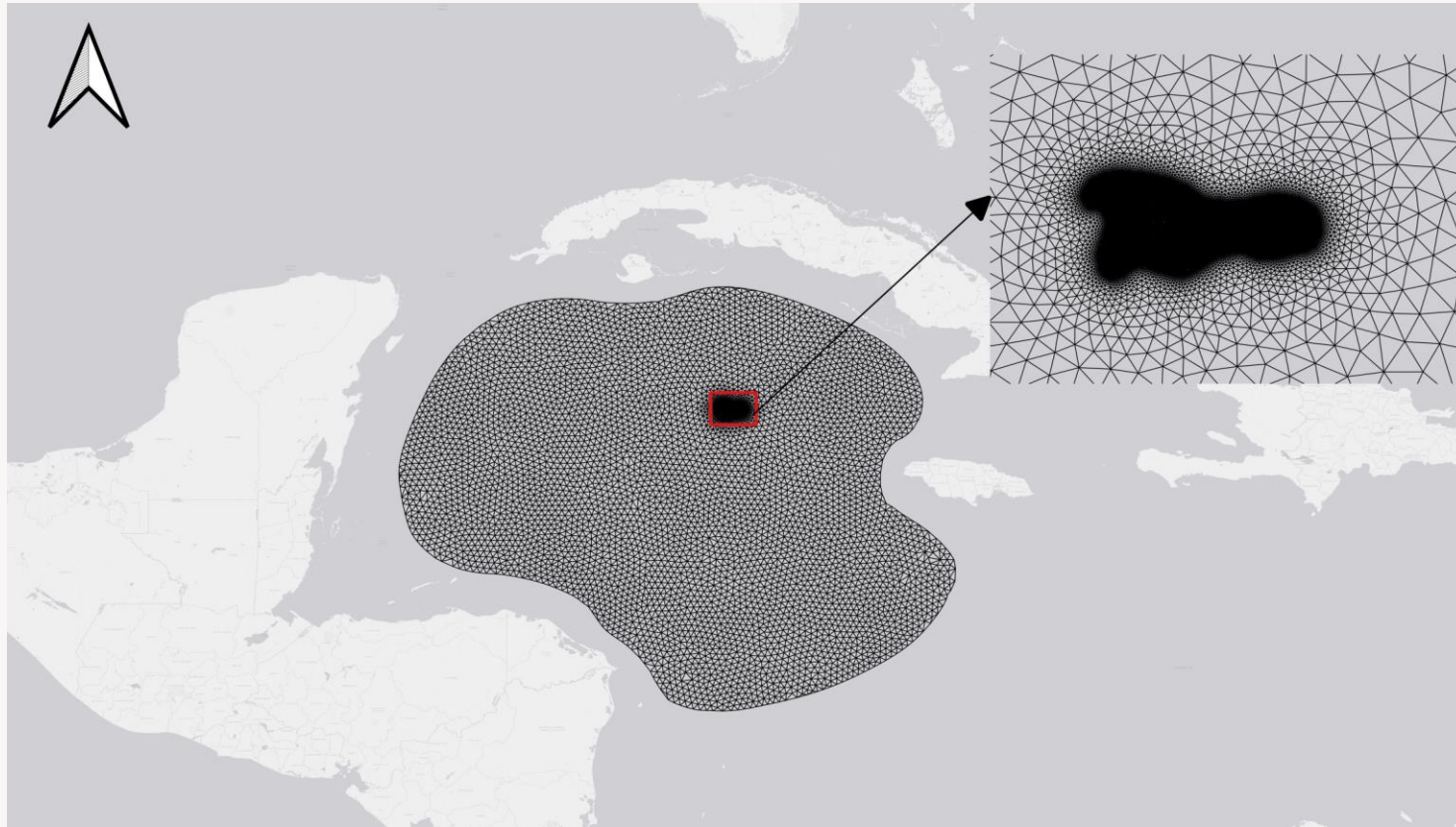
Numerics

- **Physics:** non-linear shallow water equations & Navier stokes (RANs). Conserves mass.
- **Discretization:** Finite element
- **Mesh:** 2D triangular unstructured or 3D triangular prismatic.

Select features

- Time and space varying wind and pressure (parametric or measured).
- Time and space varying rainfall (synthetic or measured).
 - Infiltration: Curve Number (CN) or Green and Ampt (GA) .
- Tides
- Waves

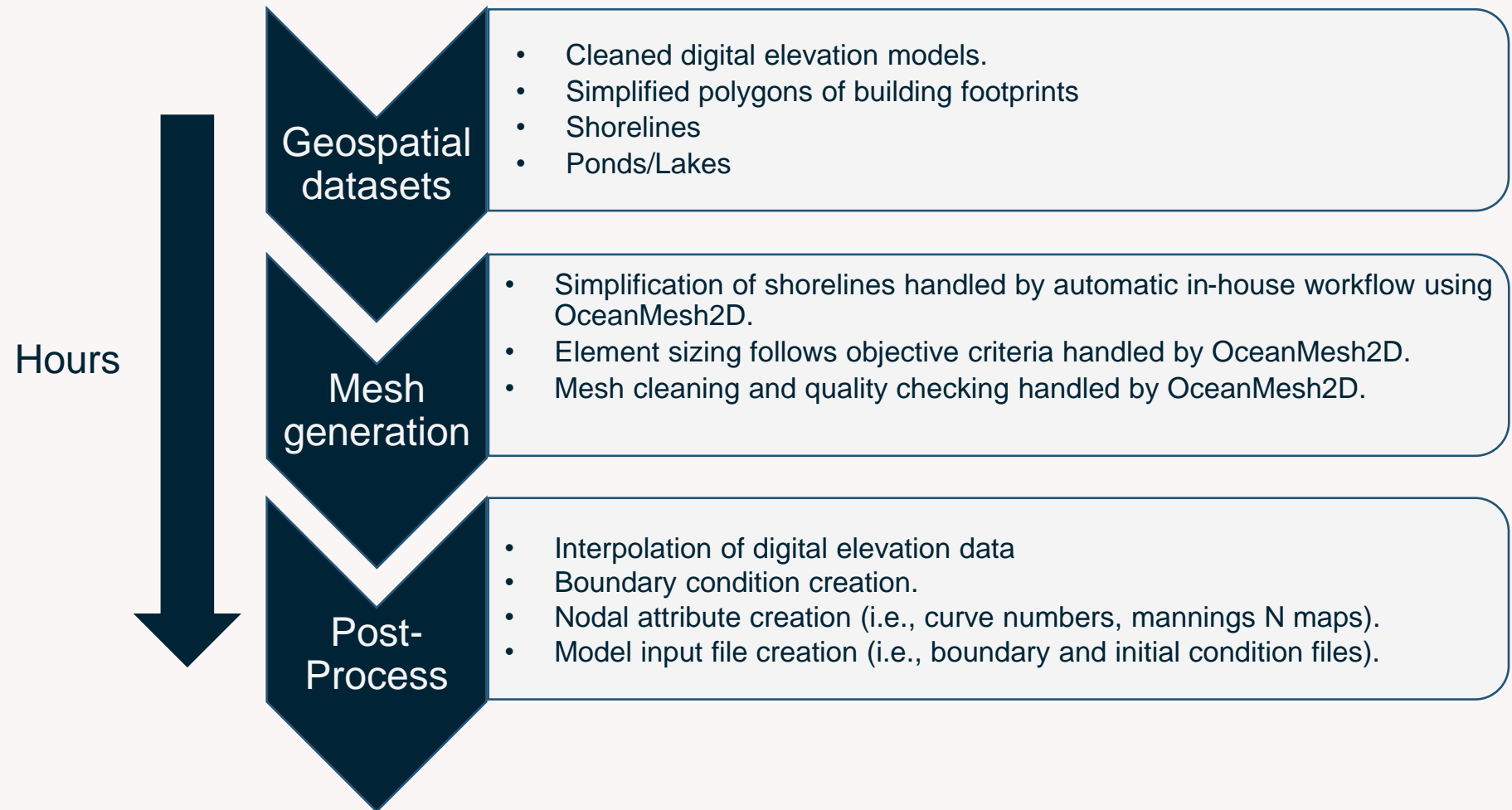
Developed model



B. 1515

Automatic unstructured mesh generation

- In-house Baird workflows using script-based mesh generation tools (**OceanMesh2D**) reduce model development times and increase reproducibility of model generation.



Datasets used to create the model...

- Elevation datasets

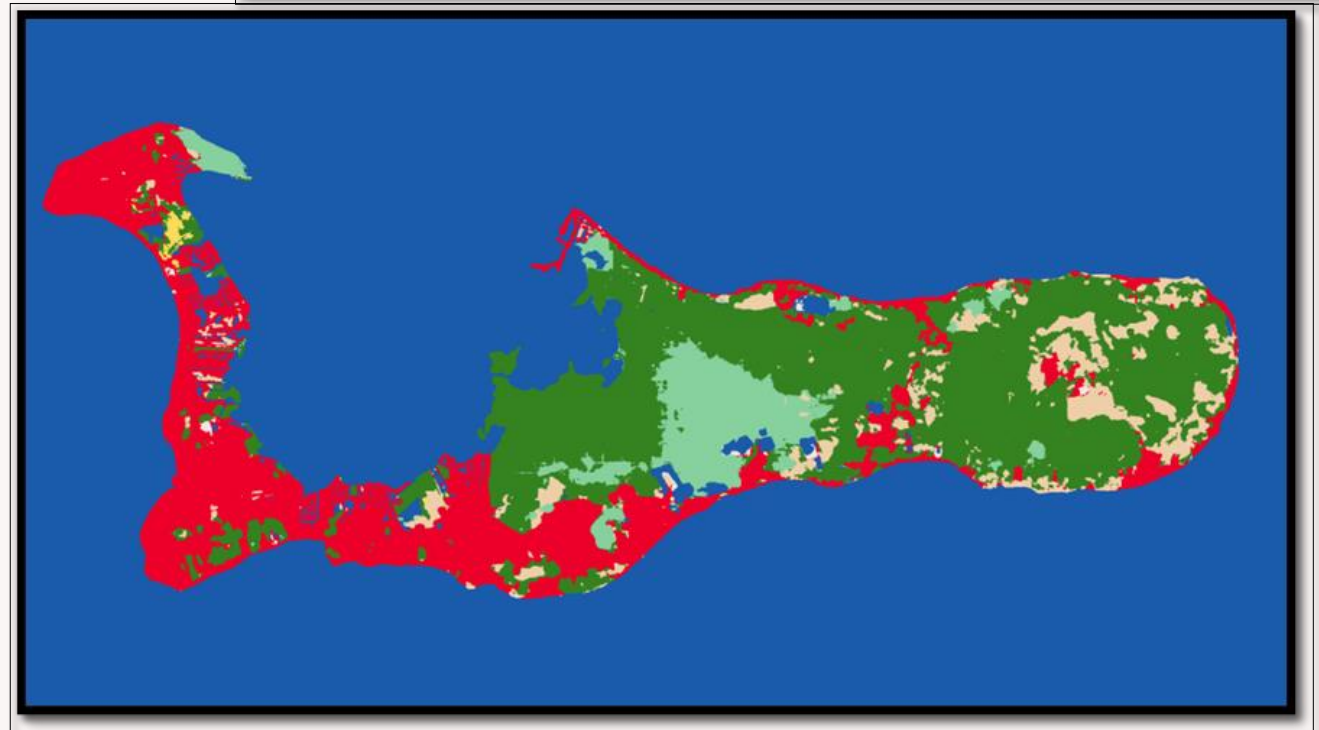
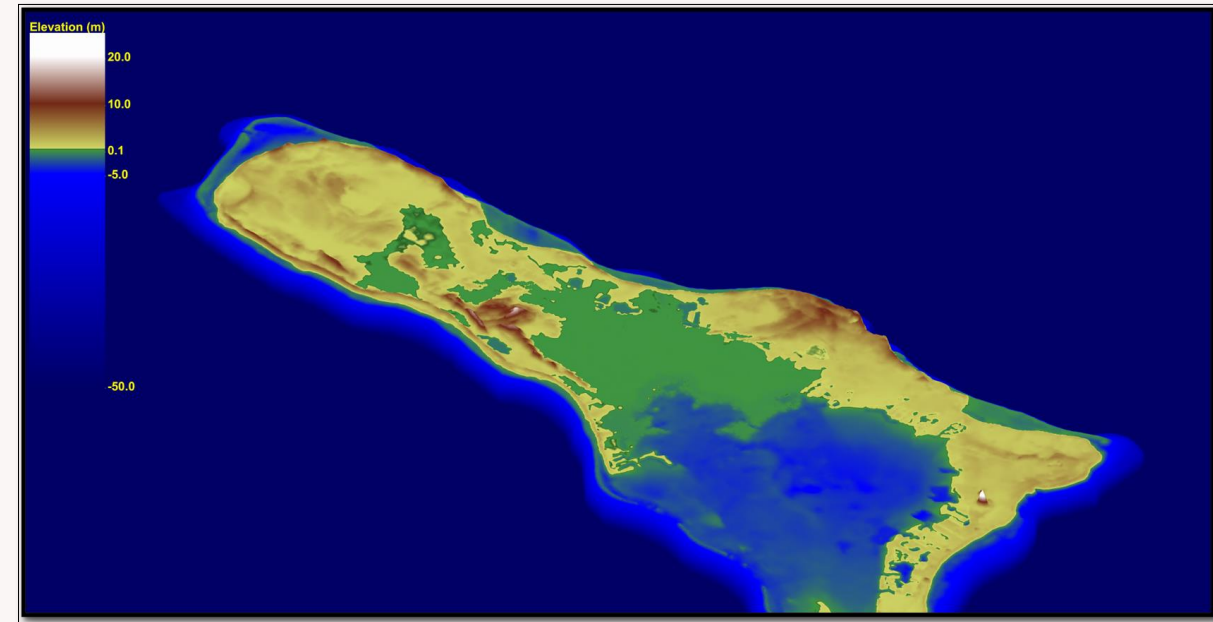
- The UK Hydrographic Office (UKHO) has completed a seabed mapping survey for the Cayman Islands
 - Data was gathered over the land and in the sea around the islands to depths of around 40 metres.

- Model parameters

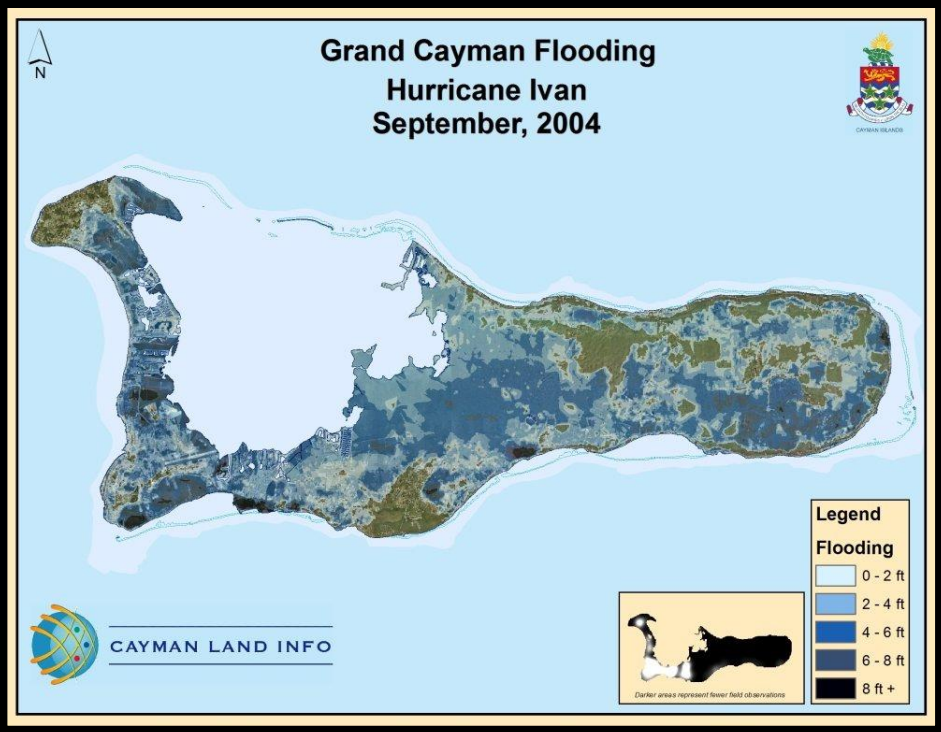
- Bottom roughness – Infiltration (Curve Number CN)
- Sentinel 2 10m Land Use
- Global Mangrove Watch (1996-2020)

- Meteorological Datasets

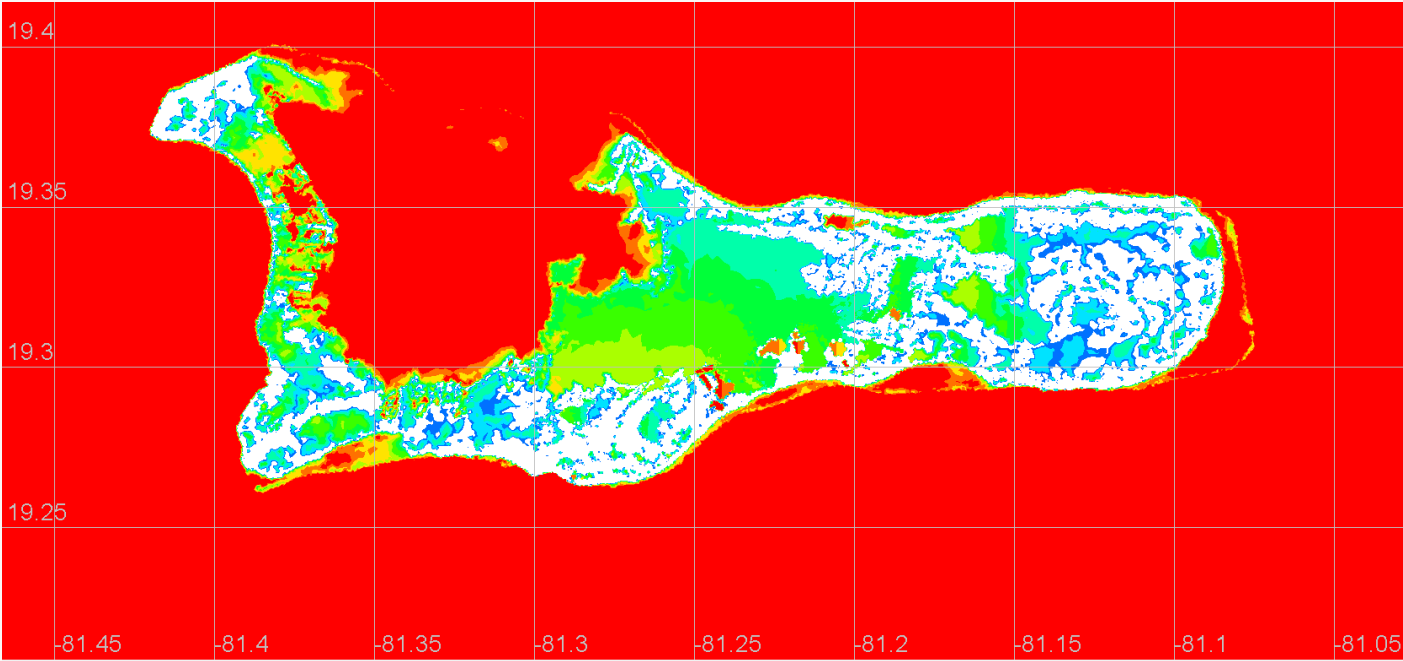
- Parametric Tropical Cyclone Rainfall Model
- Parametric Tropical Cyclone Wind Model



Hurricane Ivan Floodmap Comparison



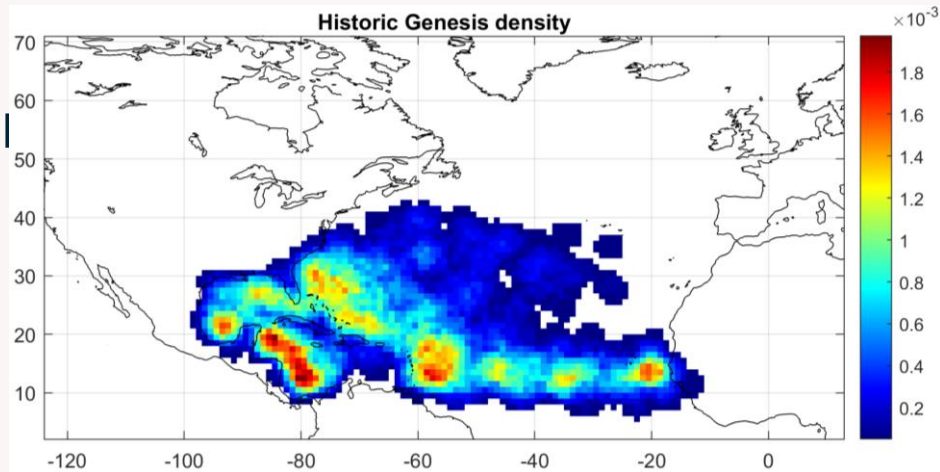
Modeled Ivan flood depth



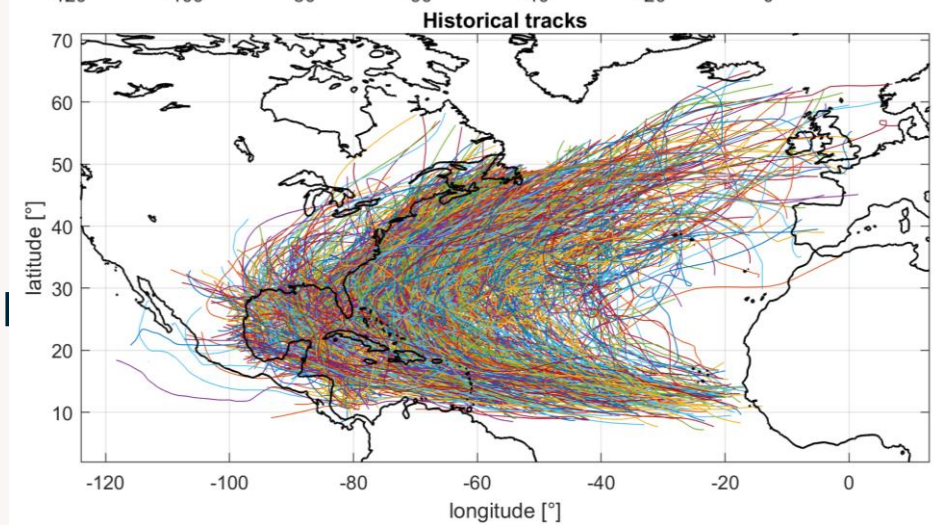
Synthetic track generation

- Augment historical record - Monte Carlo with Markov Chain model
 - Synthetic track generation ~1000yrs

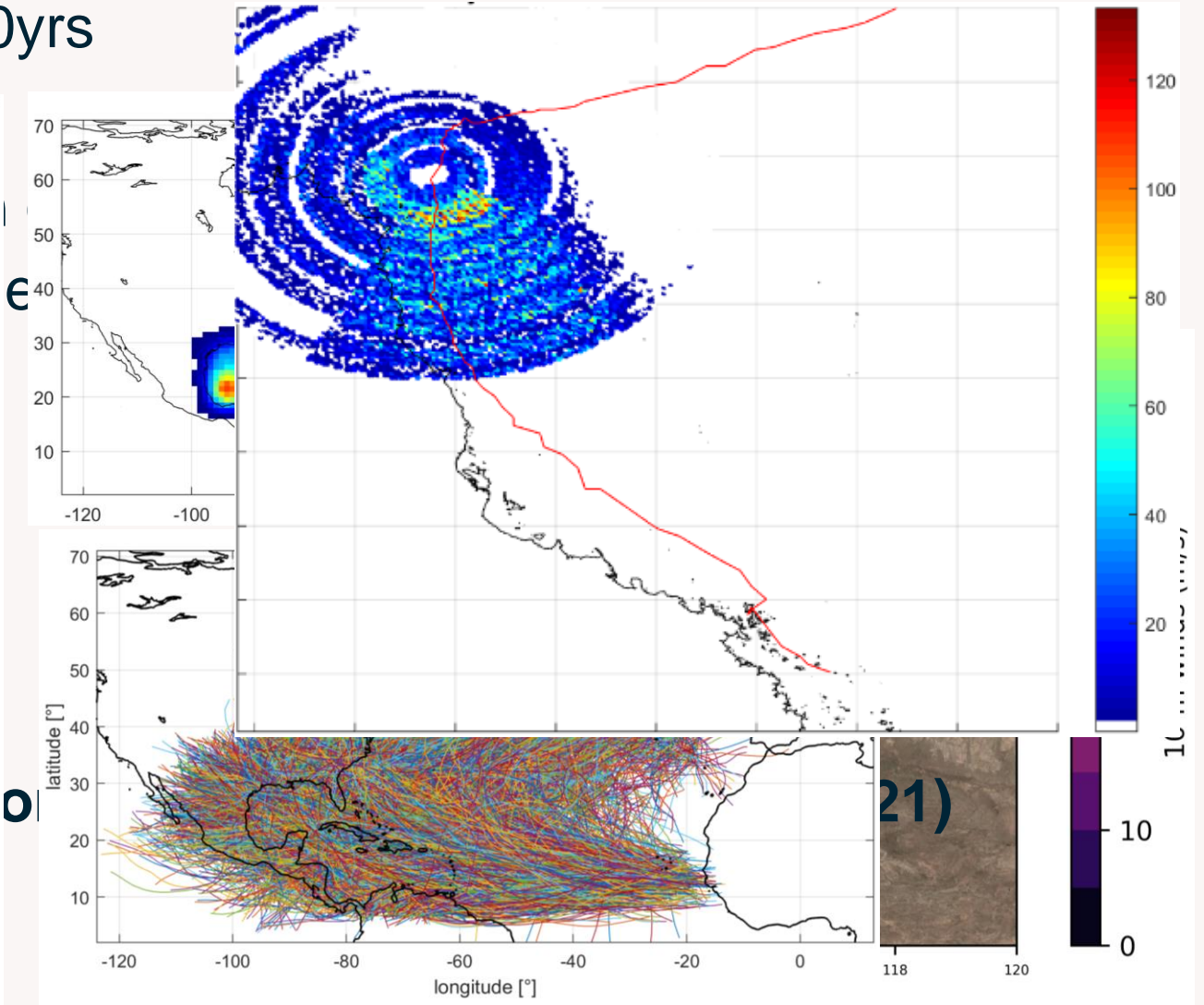
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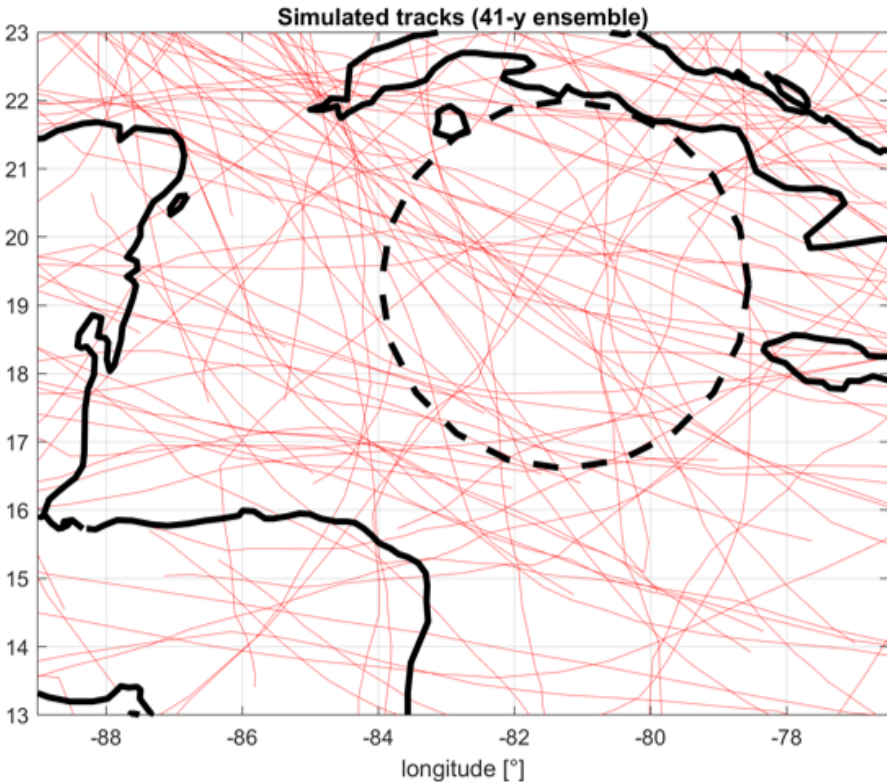
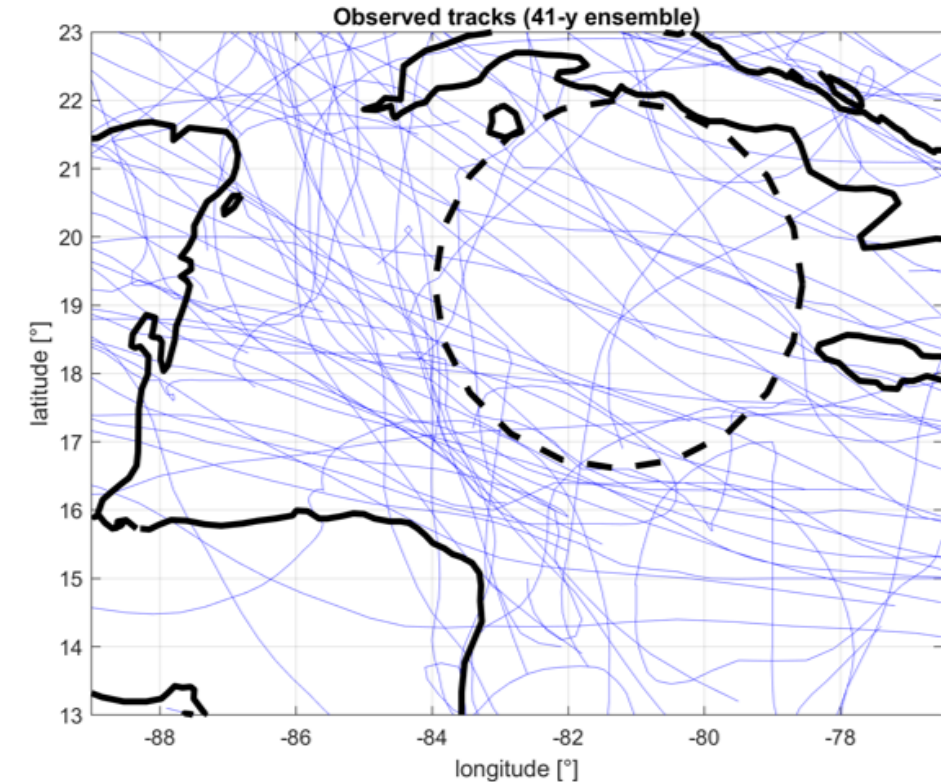


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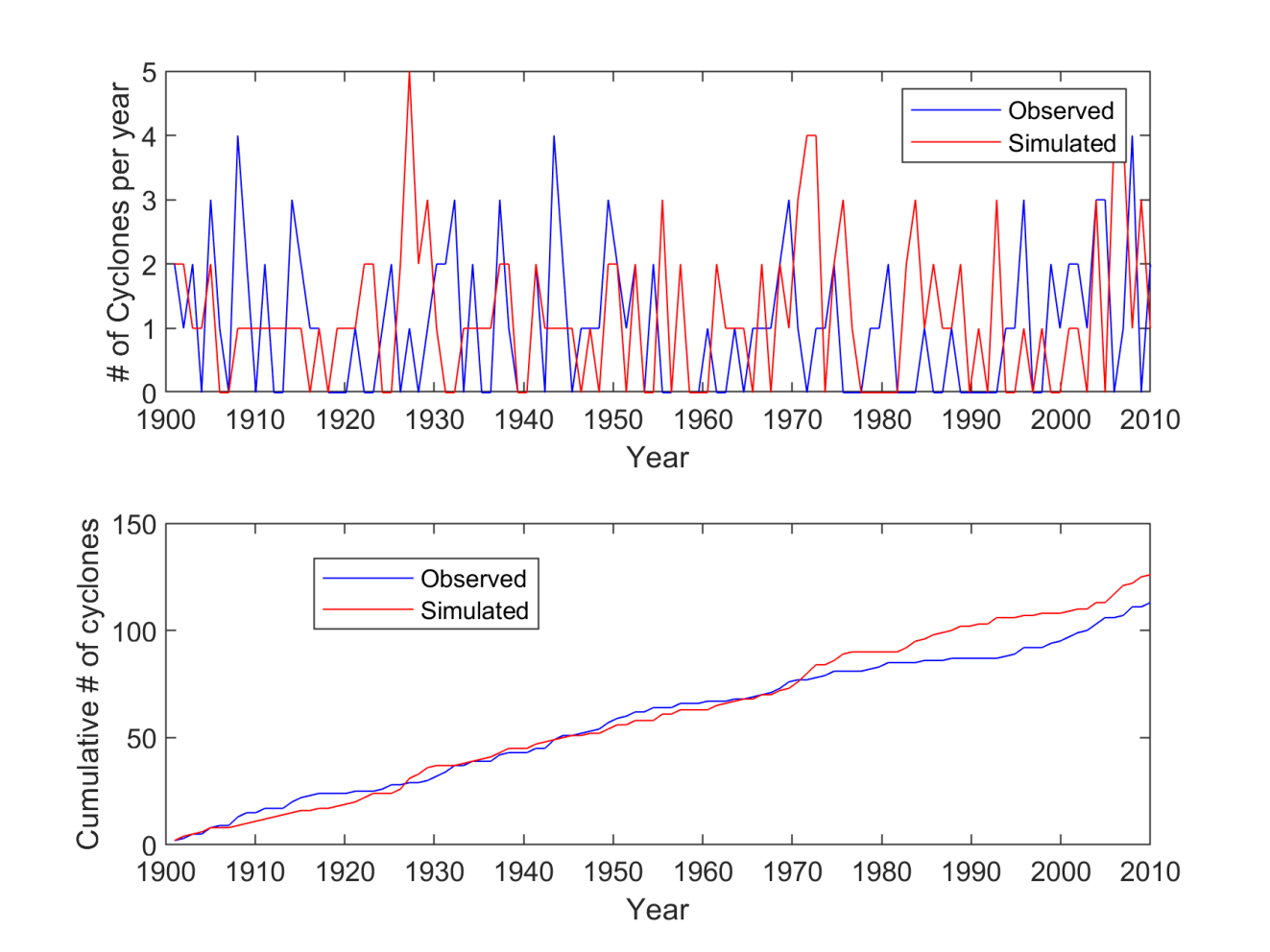
Generating synthetic storms

- Comparing modeled versus synthetic data over similar length periods.



Generating synthetic storms

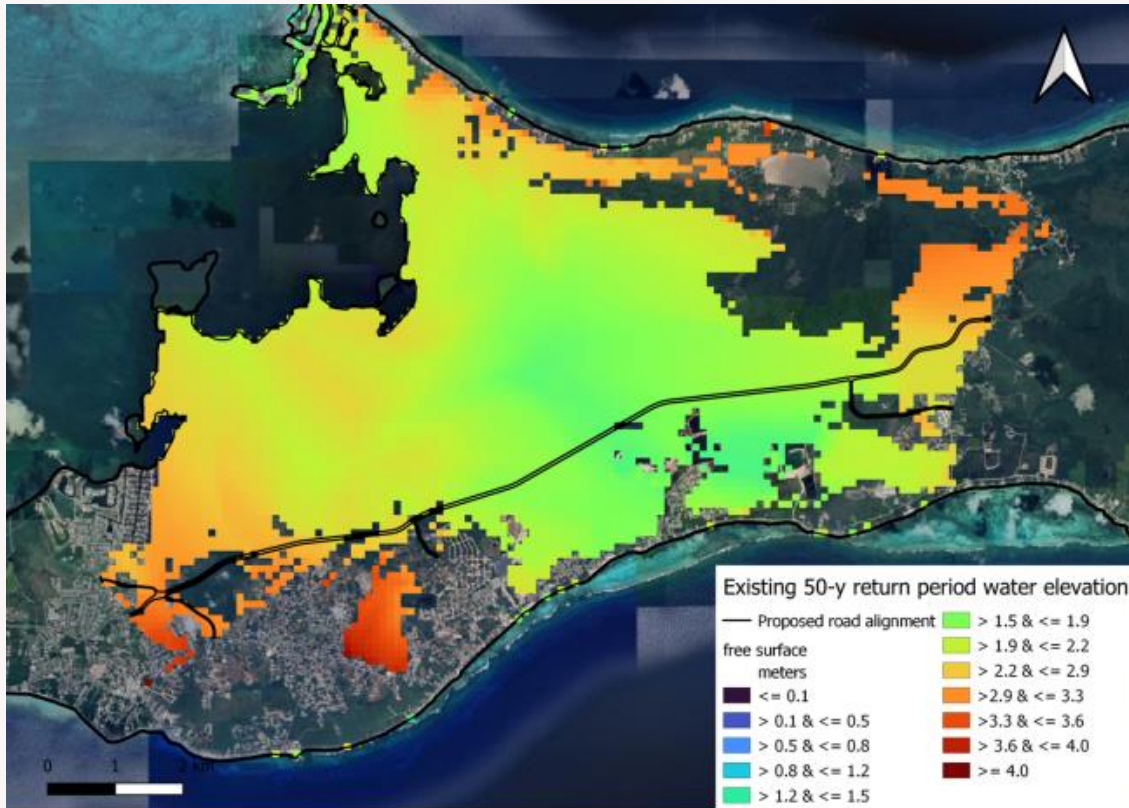
- Comparing annual rates of occurrence in a 600 km radius around Cayman.



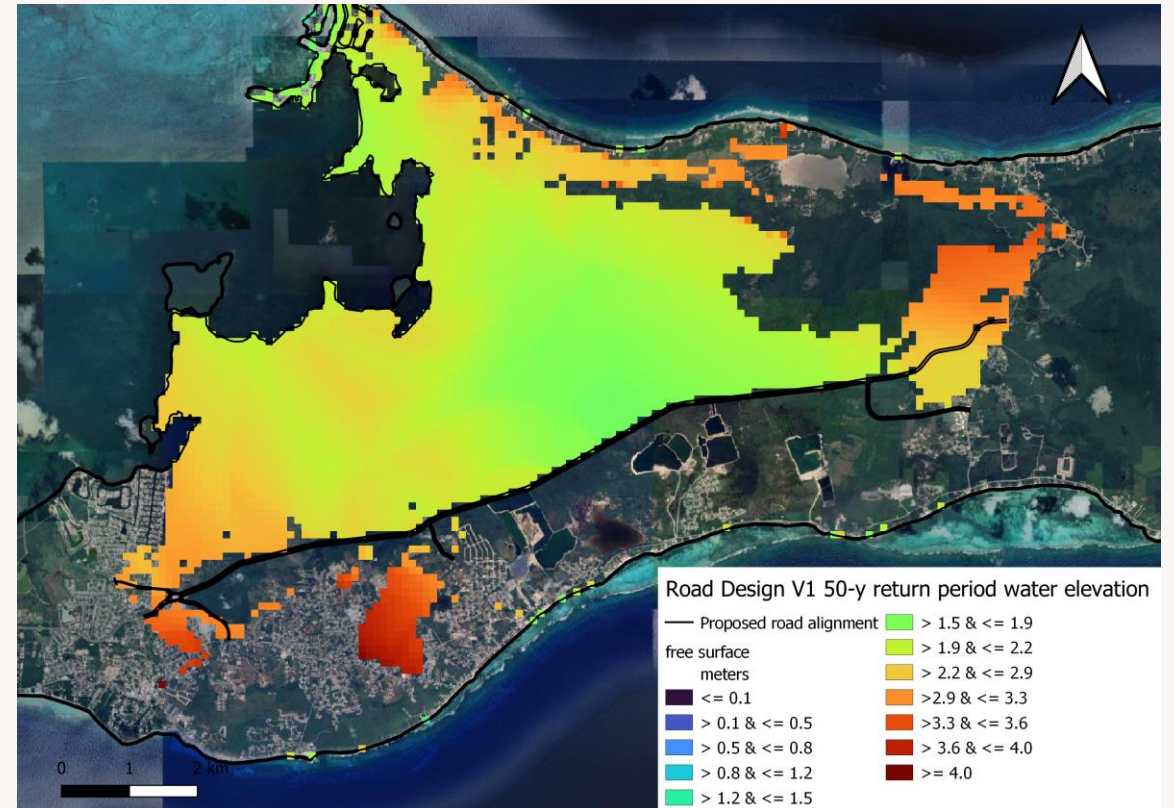
10-, 25-, and 50-y return periods

- Simulating coastal flooding and fitting extreme value distributions to all nodes

Existing



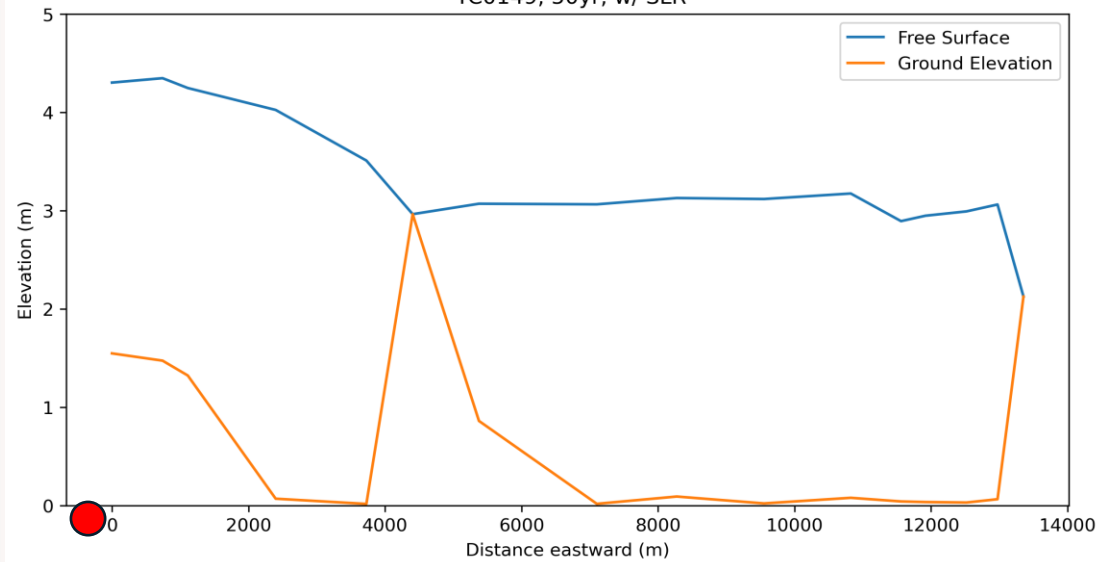
With Road as a 6 ft berm



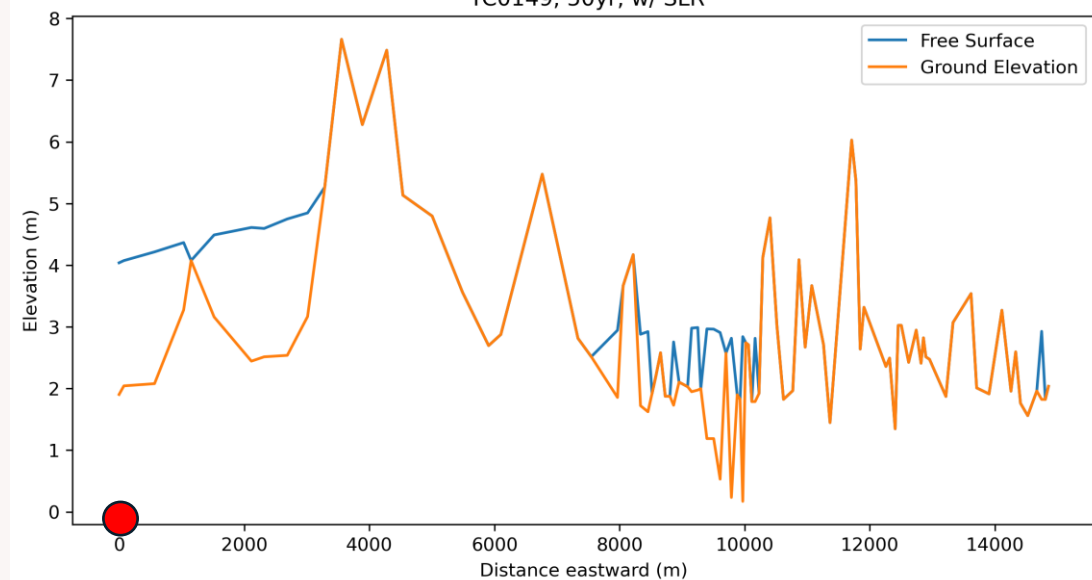
Results – Storm event maximum free surface 50-y RP + w/ SLR, TC0149



Along B1 Transect
TC0149, 50yr, w/ SLR

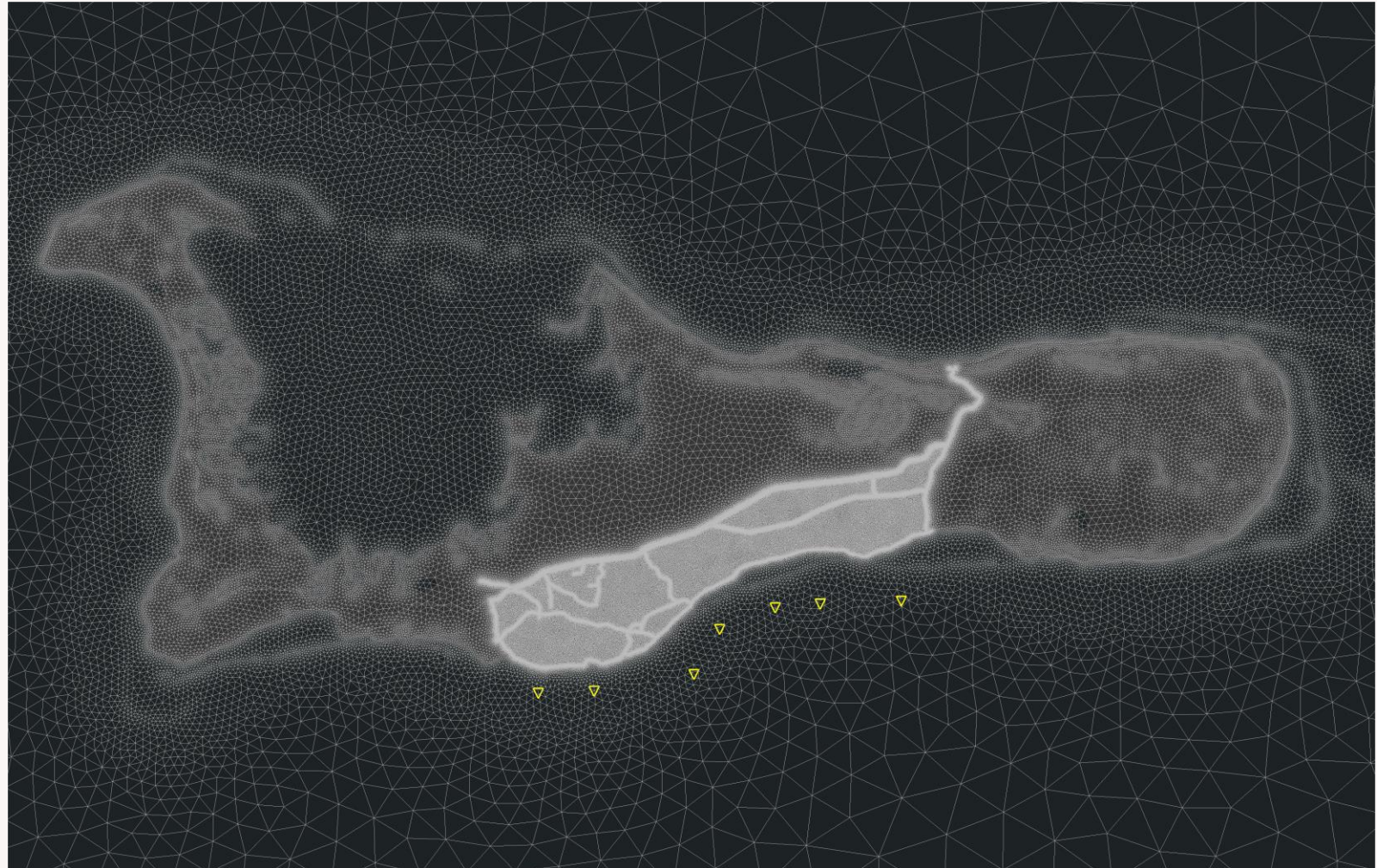


Along C1 Transect
TC0149, 50yr, w/ SLR



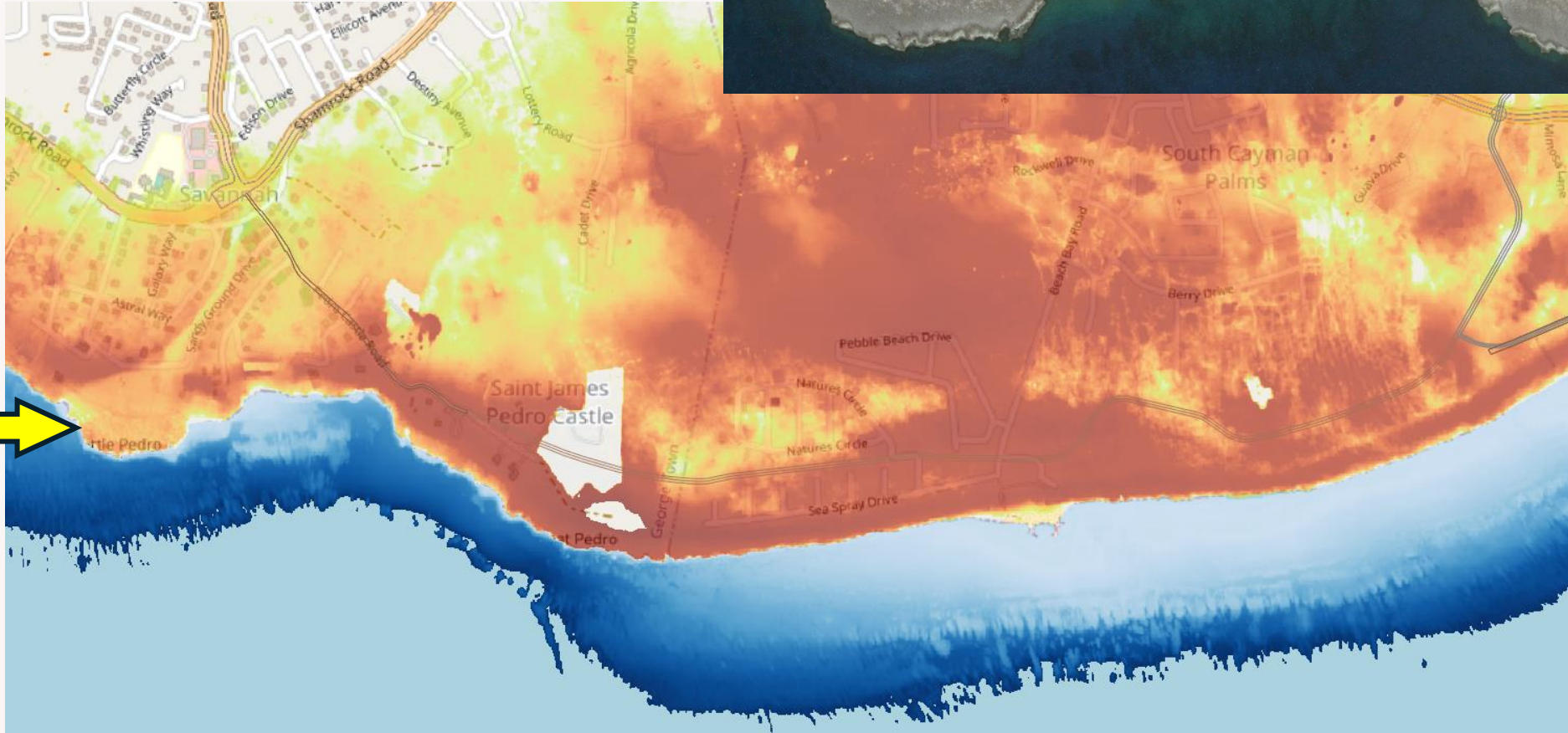
Results – Wave Overtopping

- Runup and overtopping using EurOtop
 - No storm wave overtopping predicted on extracted profile
 - Could be some minor pockets with overtopping



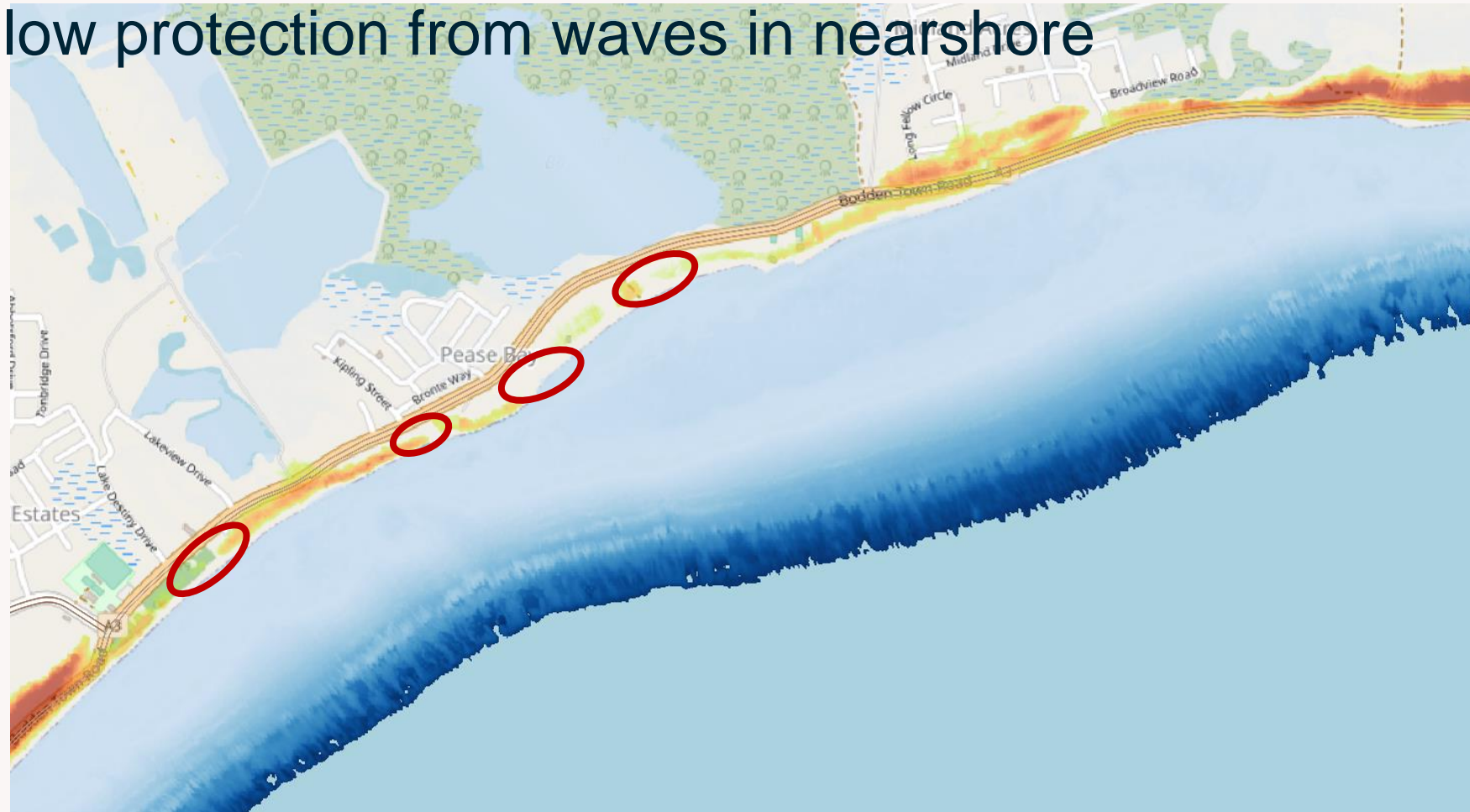
South Shore Topography - West

- Significant ridge elevation in most areas
- One past trouble spot
 - Deep offshore
 - Break in the ridge
 - Not on road alignment



South Shore Topography - East

- Shoreline becomes somewhat lower to the east
- Significant reef/shallow protection from waves in nearshore
- Some localized low areas may need to be addressed in future phase



Post-Ivan Example of Overtopping

- Examples of some isolated areas where inland flow is evident
- Limited in number and severity but would need to be addressed



Design considerations



- Flood protection
 - Road acts like a flood barrier
 - Developing housing communities in currently exposed locations on the island

Thank you for listening
Questions & Comments
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