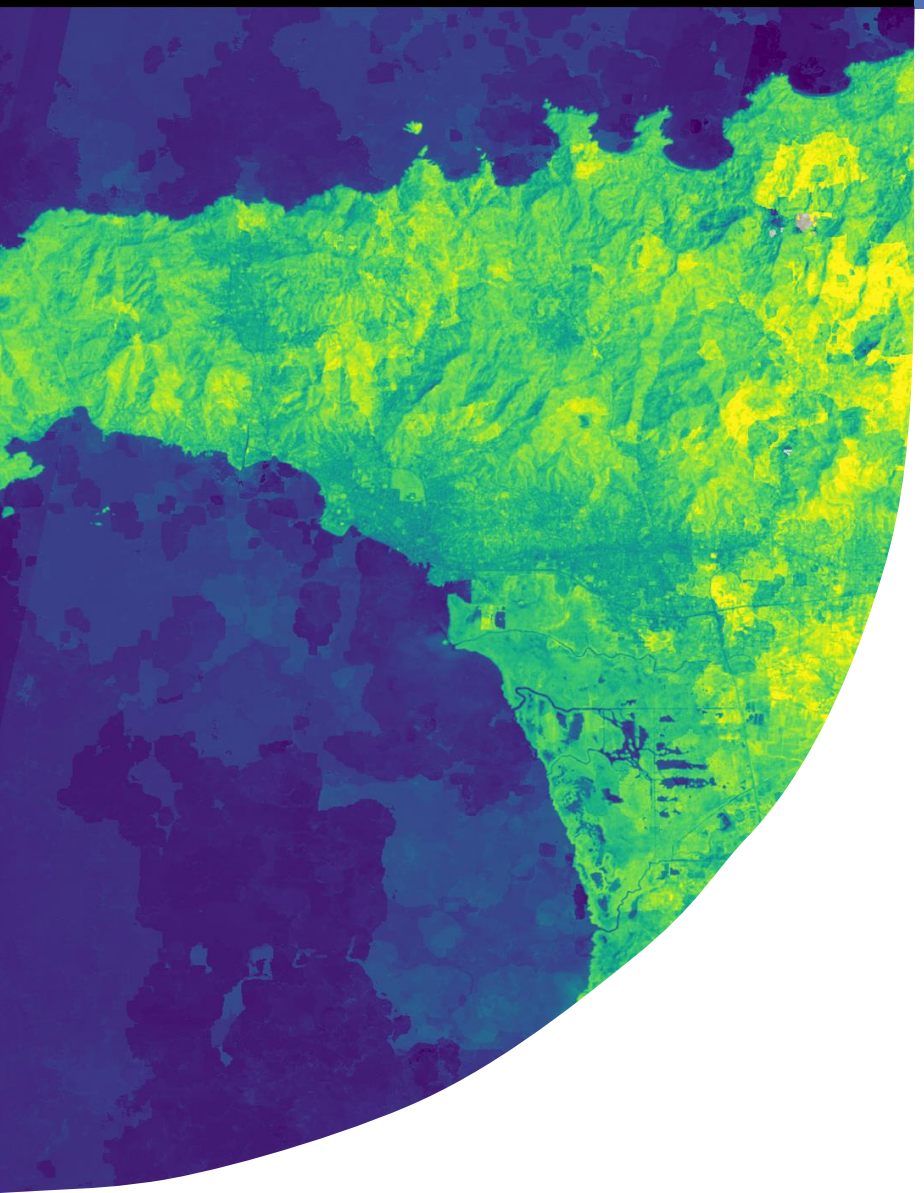
National Aeronautics and Space Administration



Trinidad & Tobago Climate

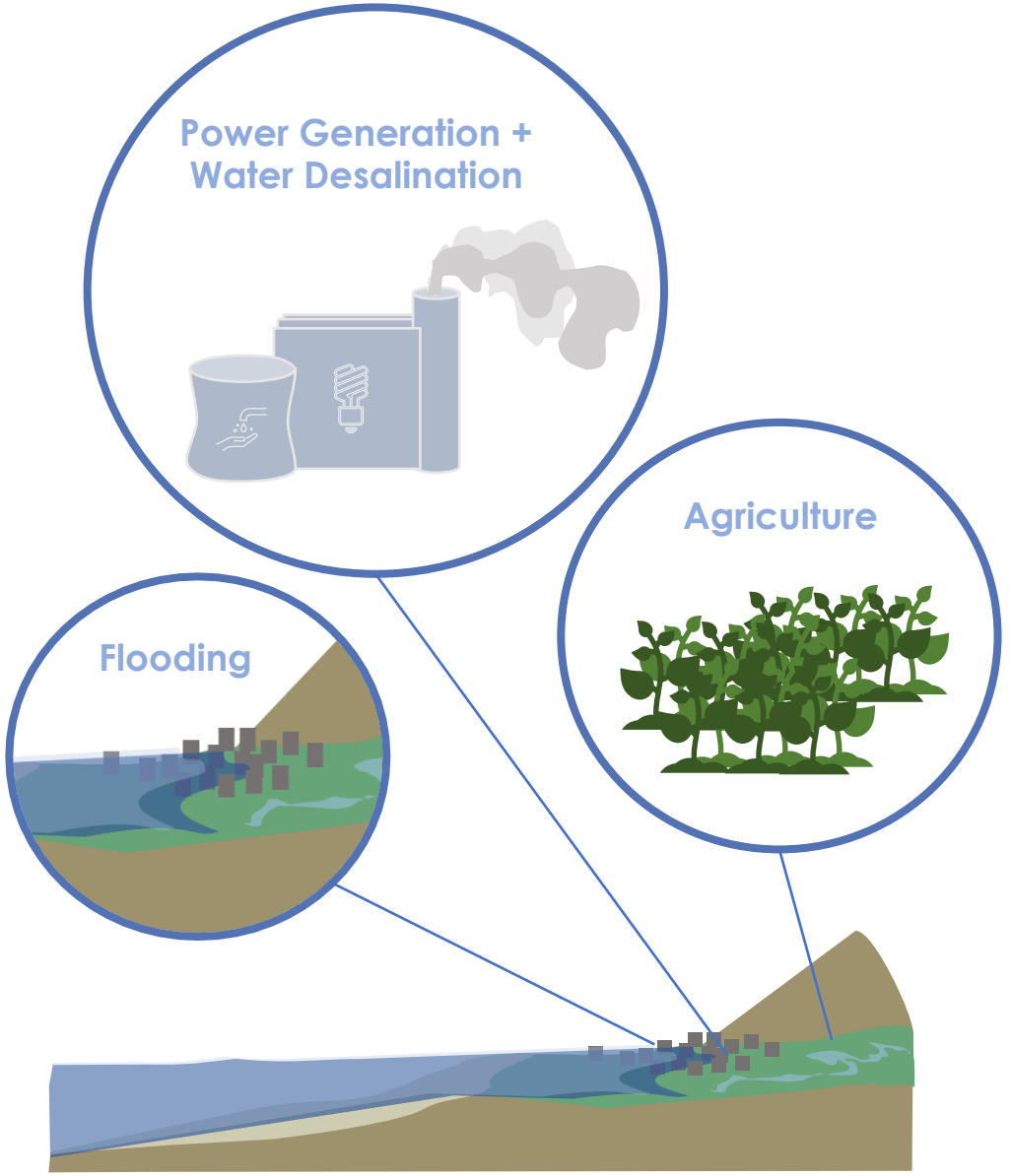
Using Earth Observations to Monitor Sea Level Rise and Identify Vulnerable Areas for Restoration Strategies in Trinidad & Tobago

Emilie Flamme, Sambath Jayapregasham, Sarah Schneider, Sayona Turner (Analytical Mechanics Associates)

Alabama – Marshall | Spring 2025

Community Concerns

- Flooding
- Land Loss
- Brackish Water
- Ecological Concerns
- Risks to Critical Infrastructure



Illustrations by Emilie Flamme with Icons from Microsoft

Project Partner


Image Credit: IMA

The Institute of Marine Affairs (IMA)

- Research organization in Trinidad & Tobago
- Collects, analyzes, and disseminates information for program/project implementation

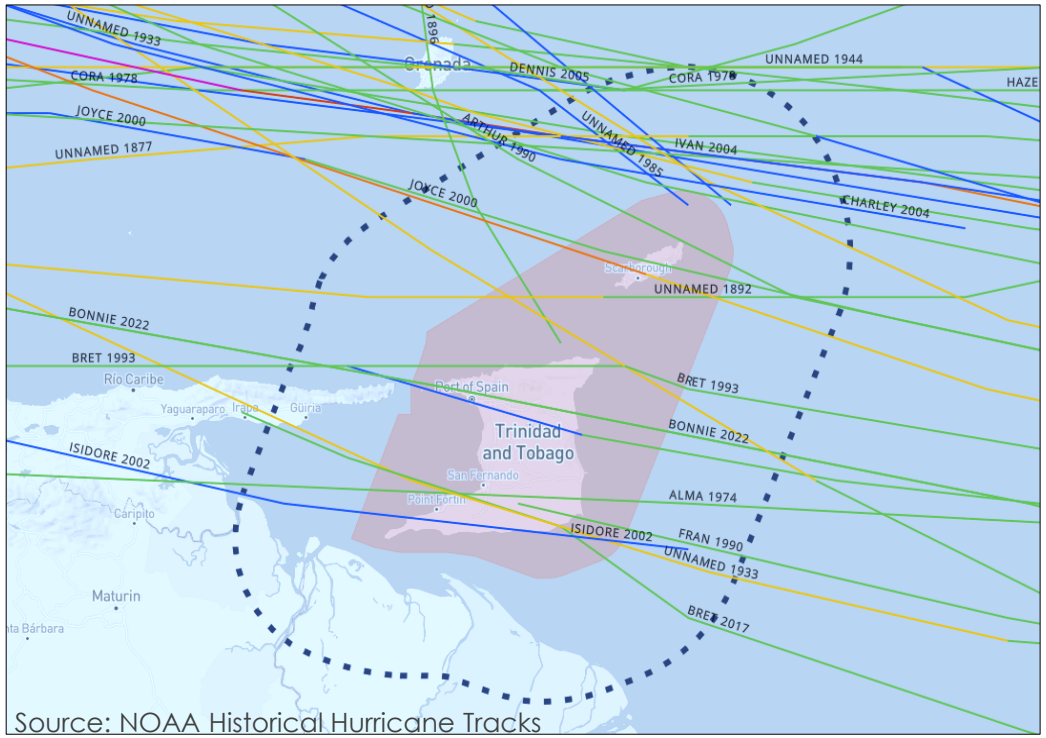
Environmental

Technological

Socioeconomic

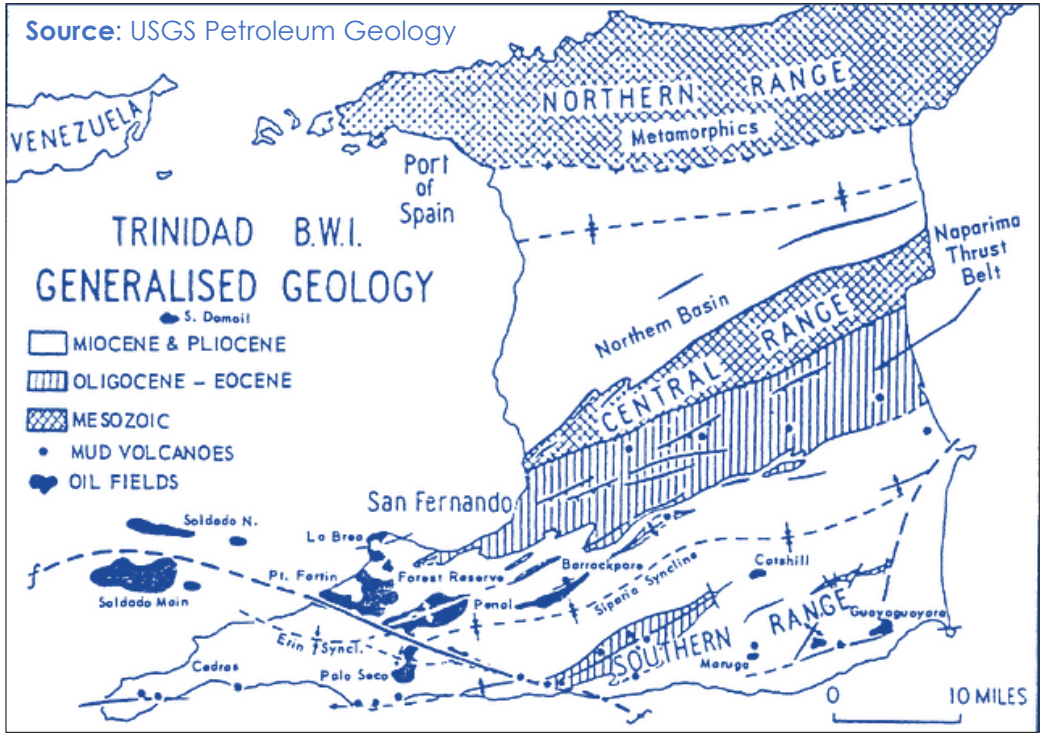
Background

Hurricanes + Tropical Storms



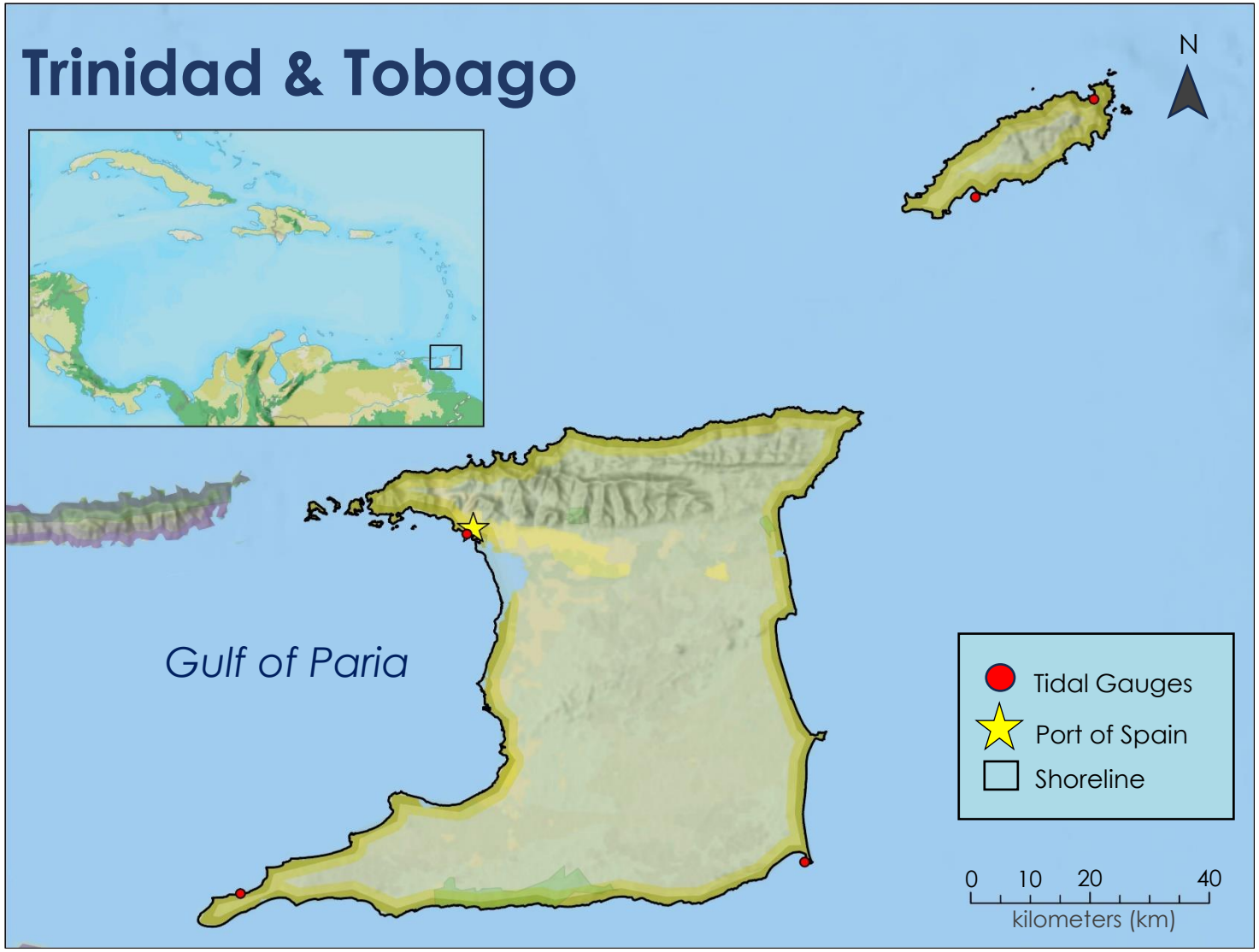
Historical hurricane paths crossing within 50 km of Trinidad & Tobago from 1856 to 2023.

Earthquakes + Land Subsidence



Geological map of Trinidad depicting fault lines.

Study Area



Study Period

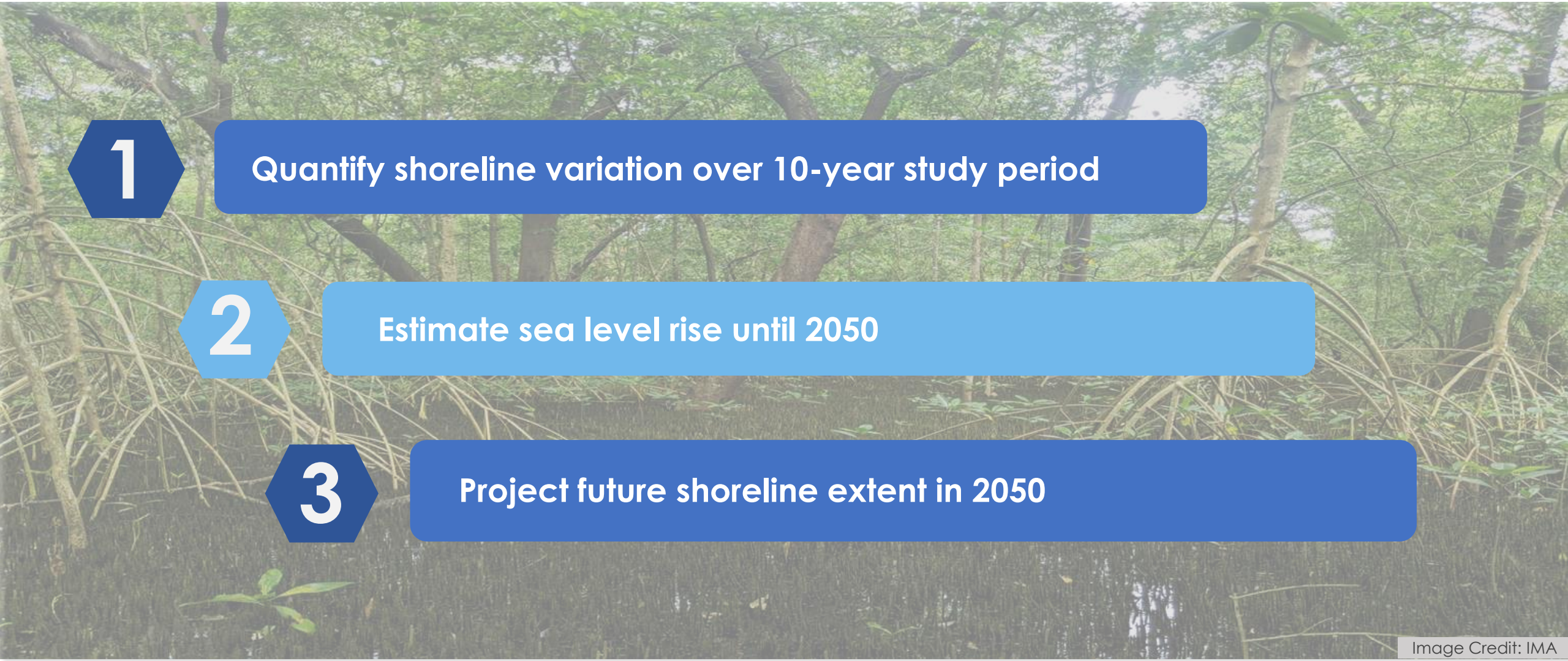
- **10-year Span** (2015, 2020, 2024)
- **Dry Season** (5 months):
  - January – April
  - December
- **Study Focus** (7 months):
  - January – June
  - December

Basemap Credits: Esri, TomTom, Garmin, FAO, NOAA, Maxar, Airbus DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstaat, GSA, Geoland, FEMA, Intermap, © OpenStreetMap contributors, and the GIS user community

Case Study Areas

Basemap Credits: Map tiles by CartoDB, under CC BY 3.0. Data by OpenStreetMap, under ODbL.
Cutout Credits: PlanetScope Dove

Project Objectives



1. Quantify shoreline variation over 10-year study period
2. Estimate sea level rise until 2050
3. Project future shoreline extent in 2050

Image Credit: IMA

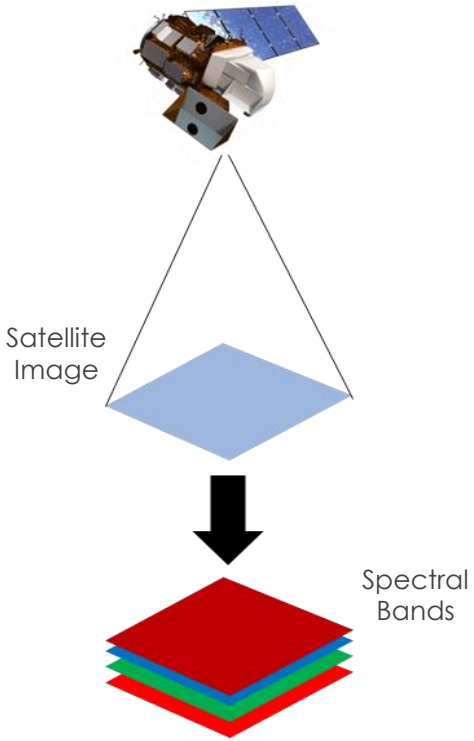
Data Types

Ground-level Data

Image Credit: Travelling Steve, Flickr

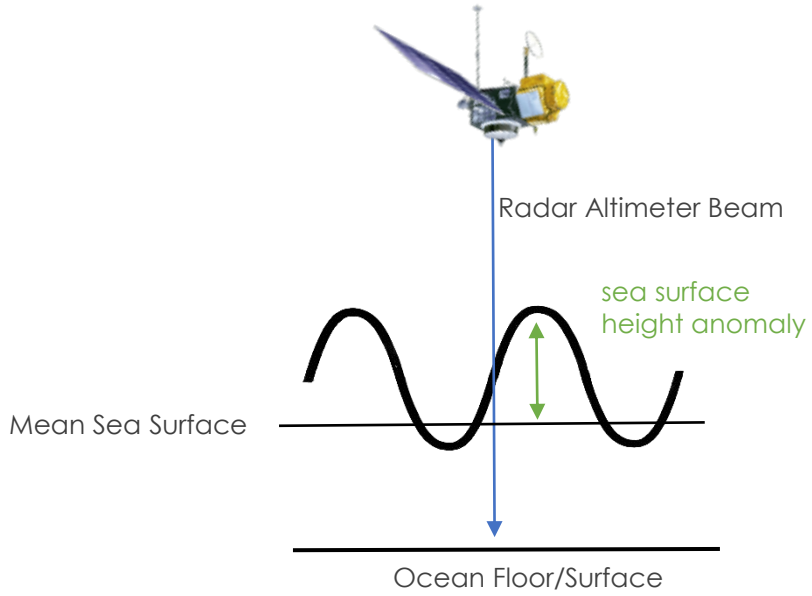
Tidal gauge data from UNESCO's Intergovernmental Oceanographic Commision (IOC) captures sea surface height from Earth's surface

Multispectral Imagery Data



Multispectral EO data consists of spectral bands. The NIR band is ideal for shoreline delineation.

Radar-based Altimetry Data

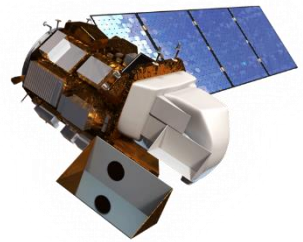


Altimetry captures the height of the sea surface by measuring the difference between the water's surface, and the height of the Earth's ellipsoid.

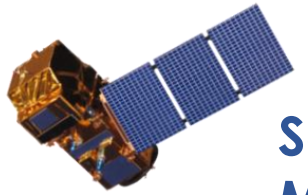
Earth Observations

Publicly Accessible Satellites

Landsat 7 ETM+



Landsat 8 OLI



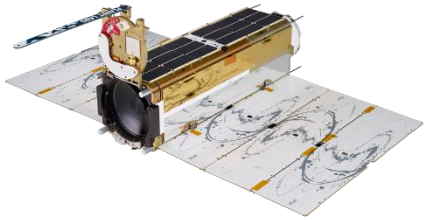
Sentinel-2 MSI

JASON-1

TOPEX

Altimetry Satellites

ICESat-2



PlanetScope Dove

Commercial Satellite

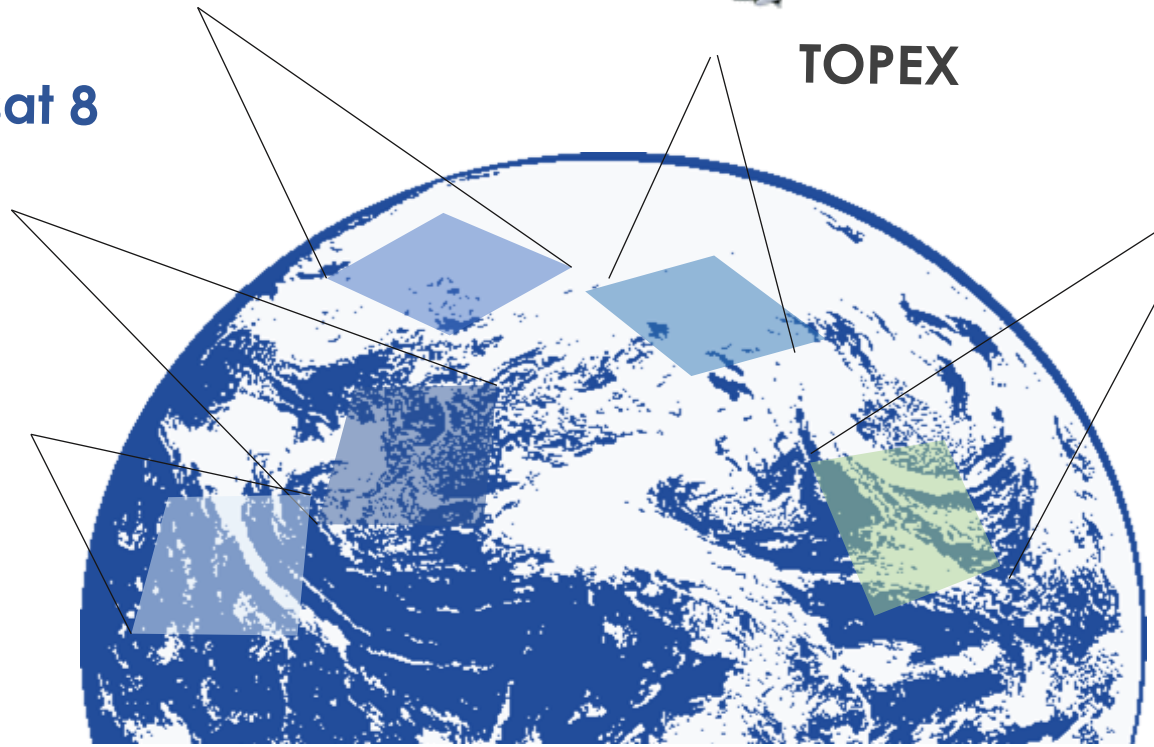
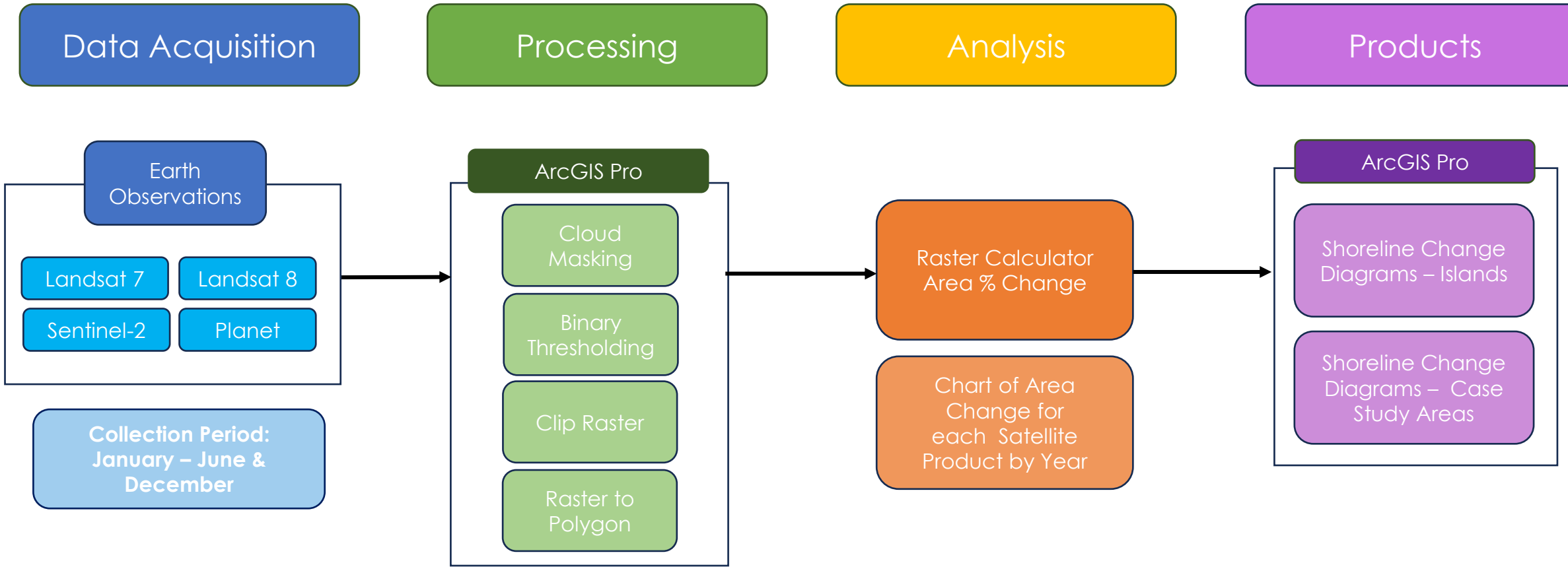
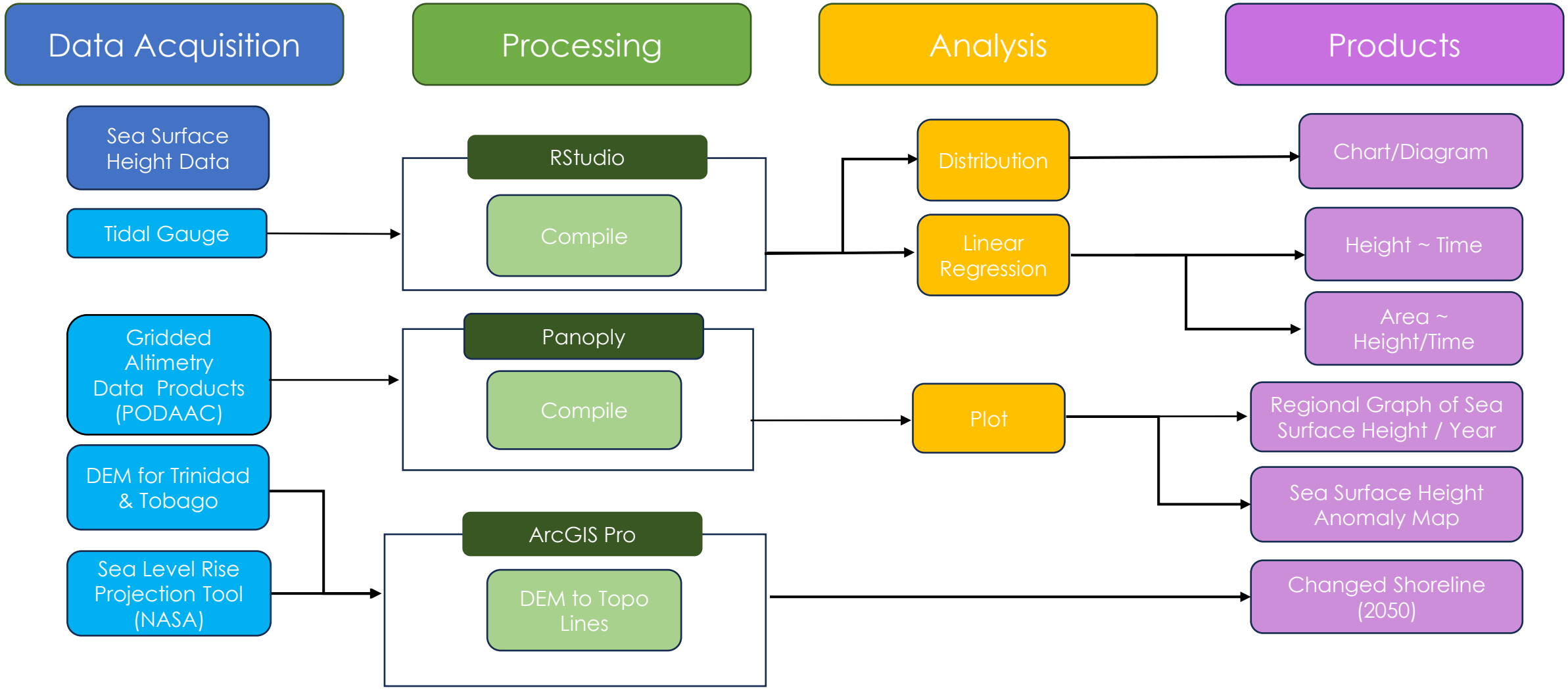


Image sources: NASA, Planet, Wikimedia Commons

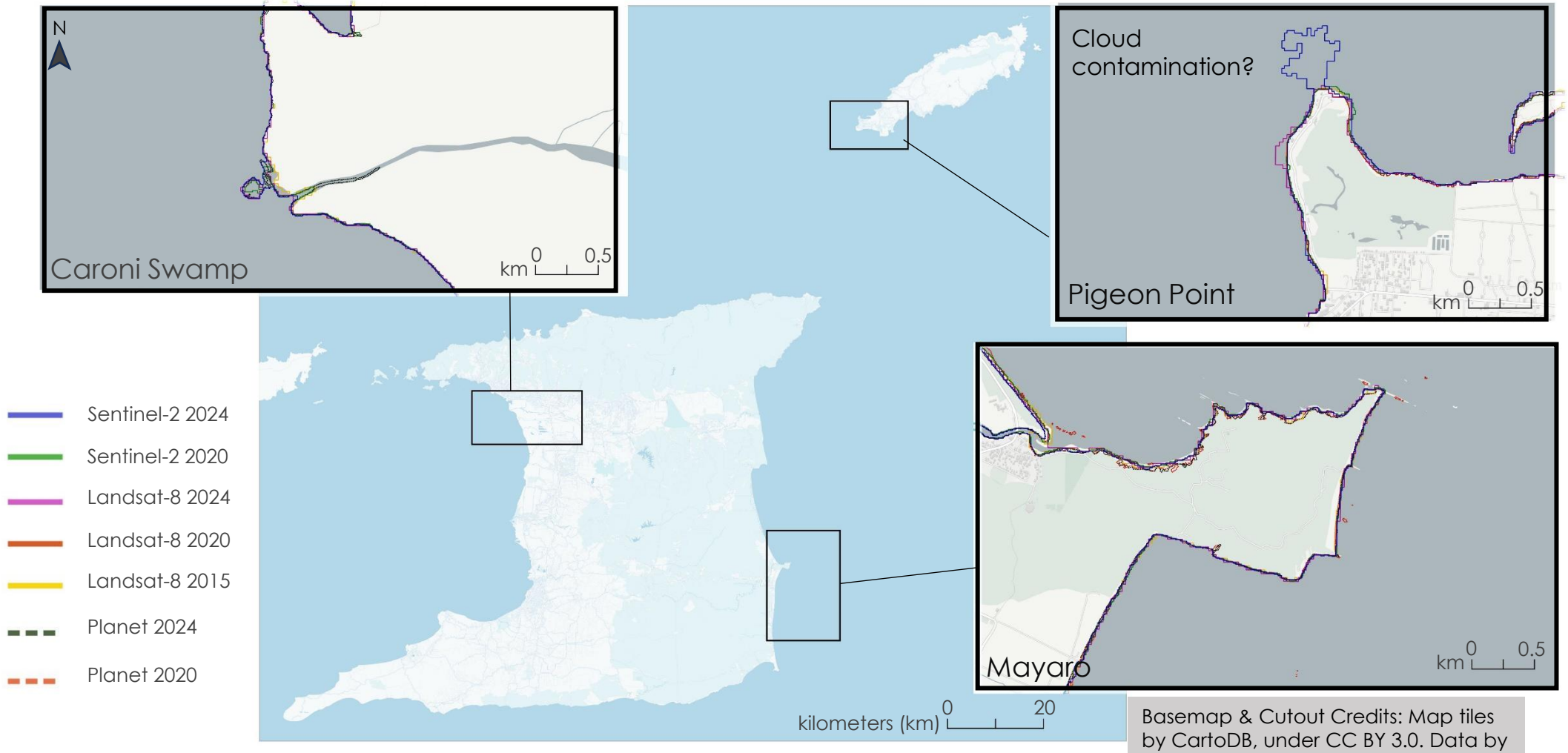
Methodology – Shoreline Delineation



Methodology – Sea Level Rise + Change in Surface Extent



Shoreline Delineation



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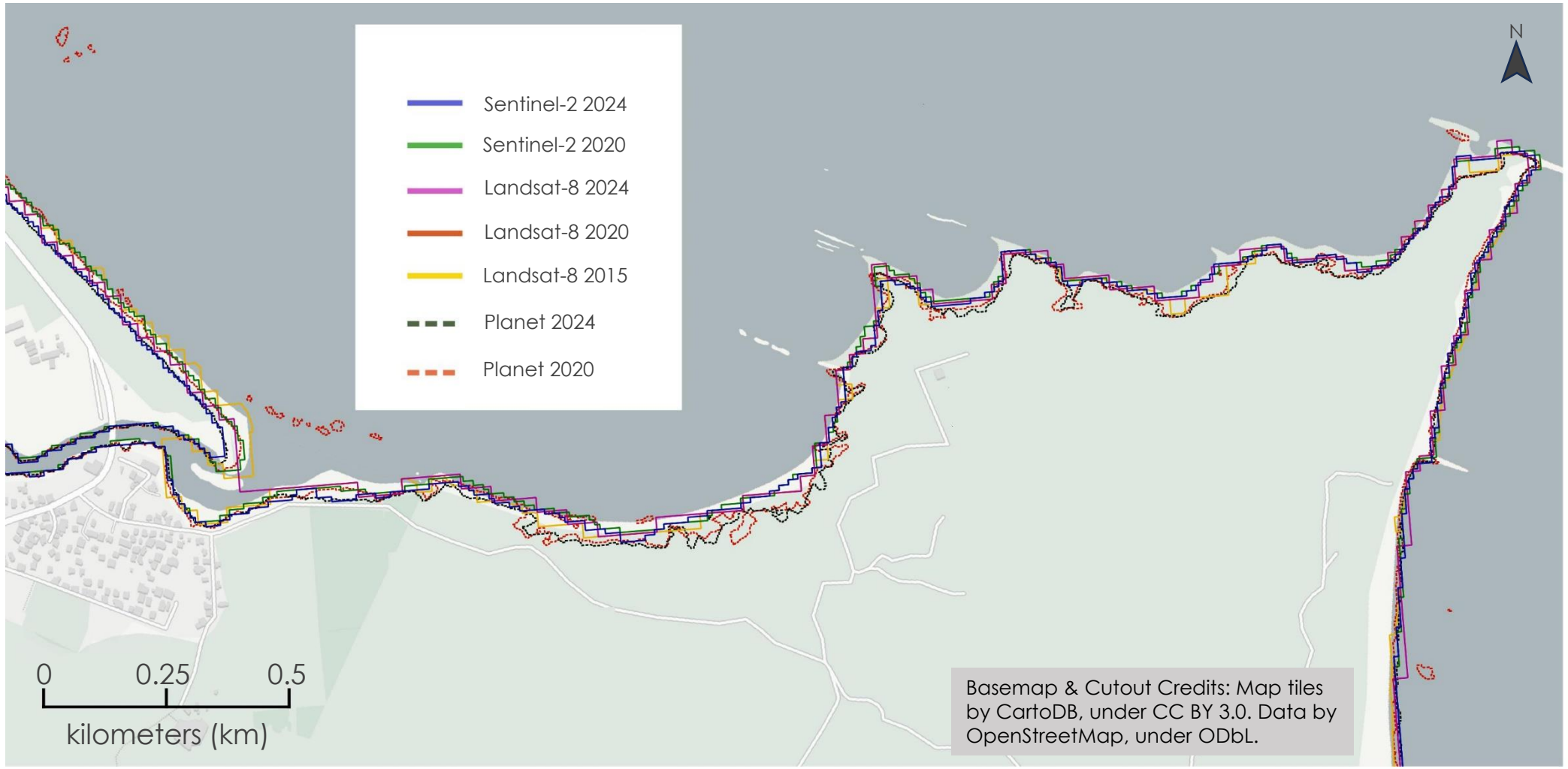
Shoreline Delineation – Mayaro



Shoreline Delineation – Area Change

	Area Change Between 2015-2024					
Year	**2015**	**2015 – 2020**	**2020**	**2020 – 2024**	**2024**	**2015 – 2024**
Landsat 8	4987.277 km^2	2.472%	5110.574 km^2	0.476%	5134.888 km^2	2.960%
Sentinel-2	N/A	N/A	5129.157 km^2	0.029%	5130.629 km^2	N/A

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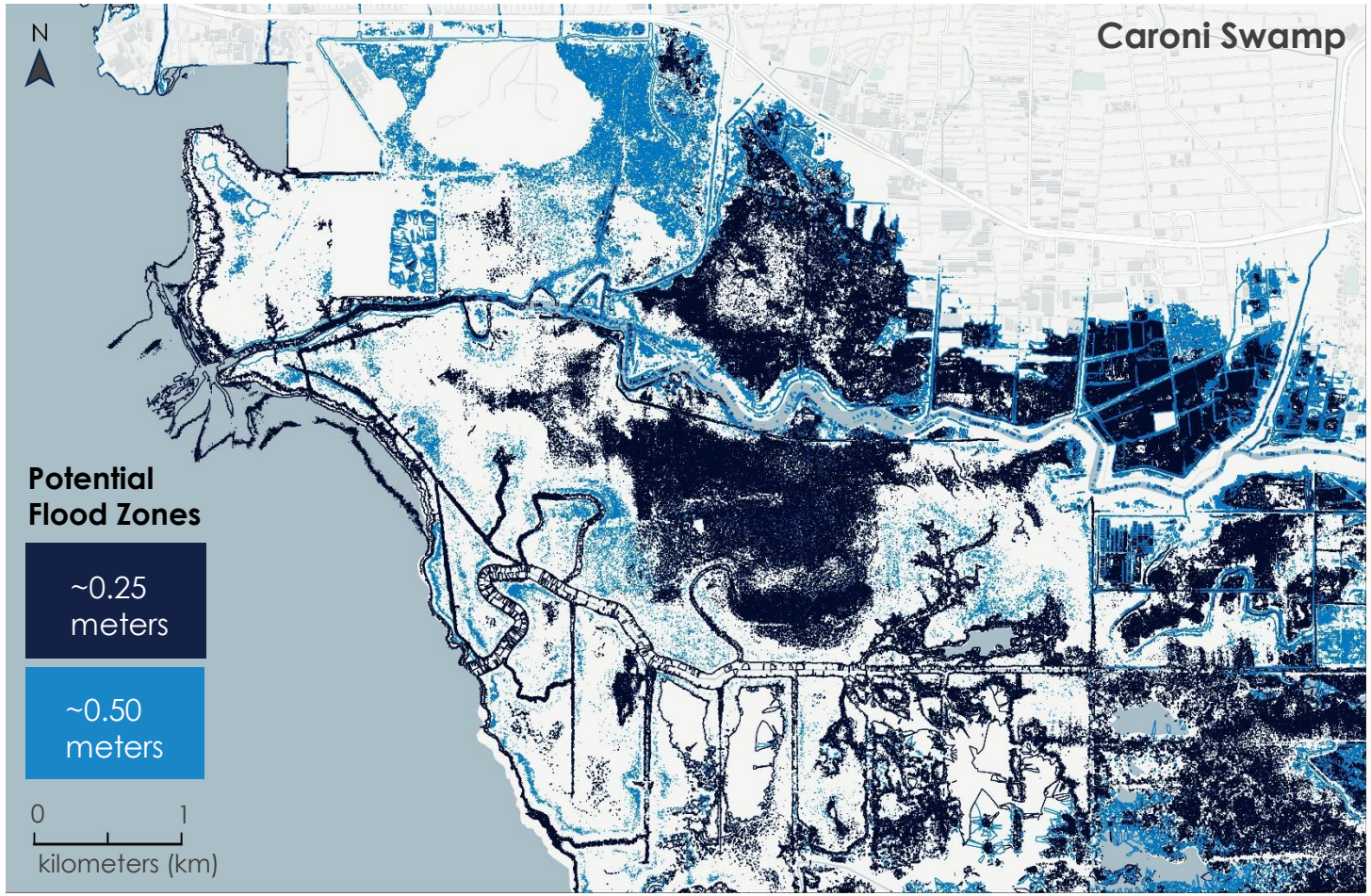
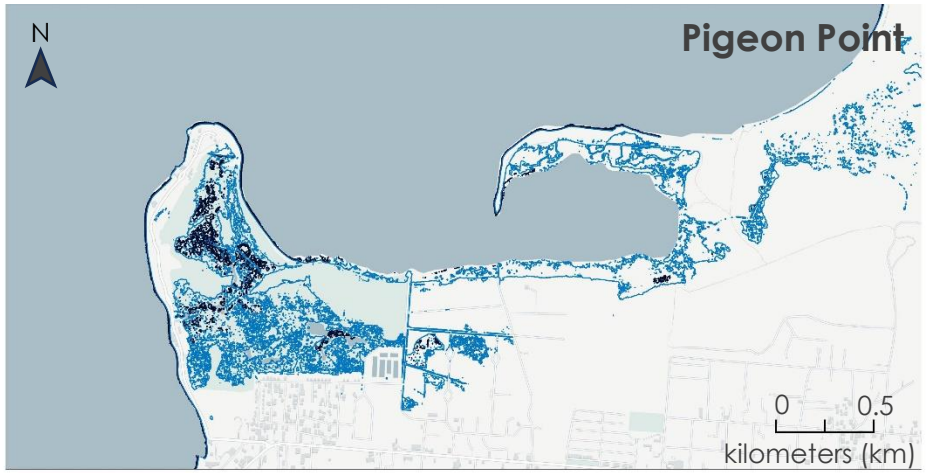
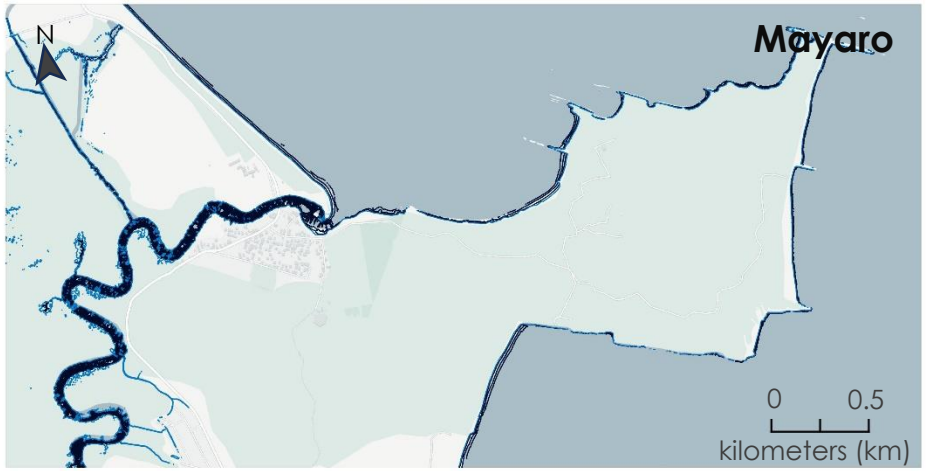
Data Analysis – Change in Sea Surface

Tidal gauge data used to estimate relative sea level change over study period from 2015-2024.

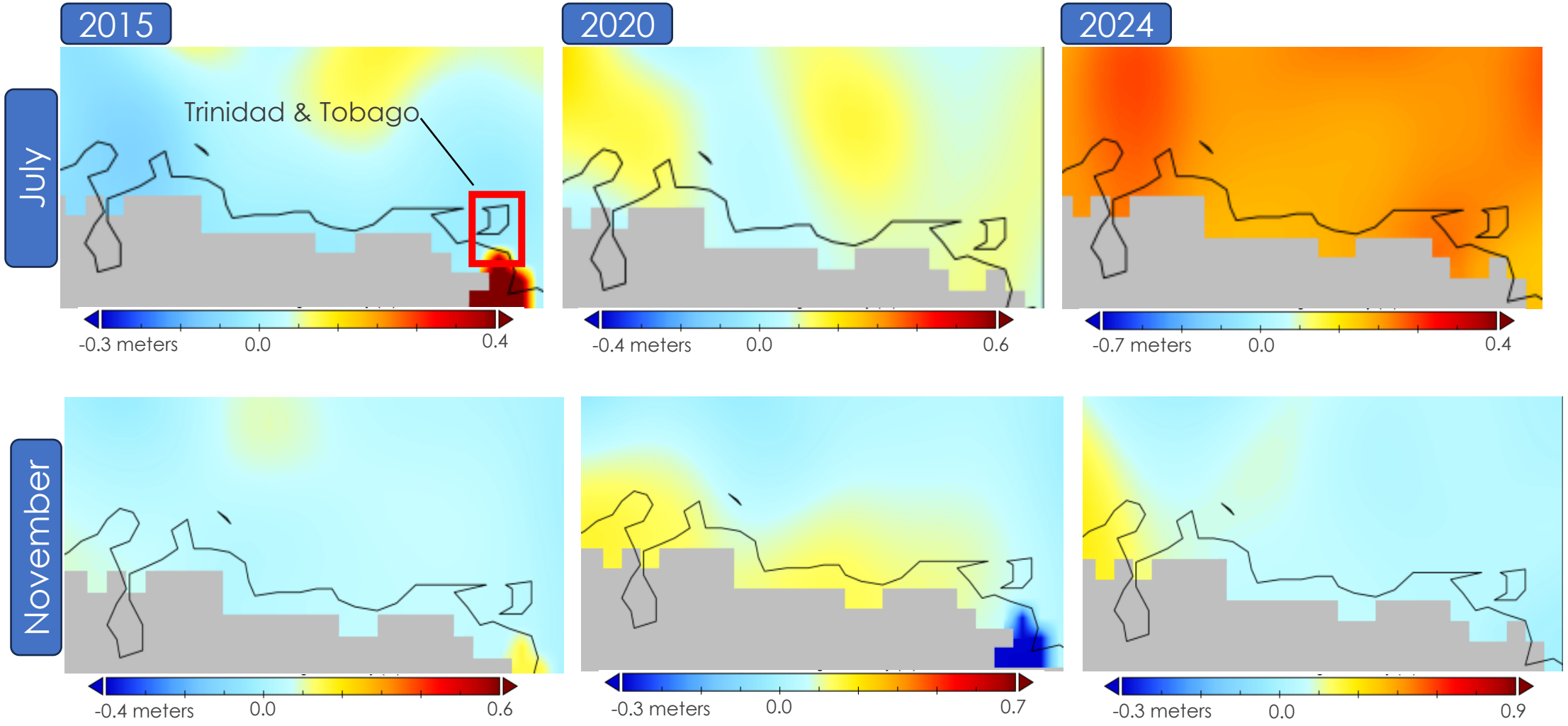
2050 Sea Level Rise Projection + Impact Areas







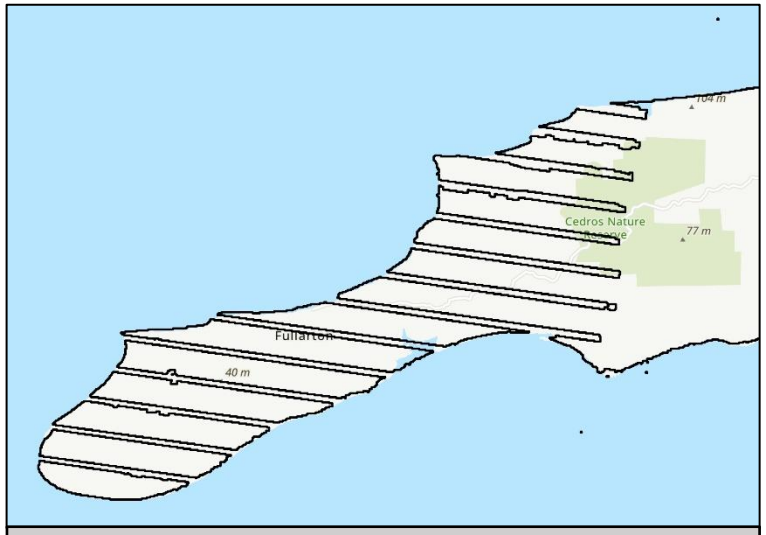
Data Analysis – Altimetric Sea Surface Anomaly



Errors + Uncertainties

Limited reliability of tidal gauge data limited due to gaps created by tidal gauge inactivity.

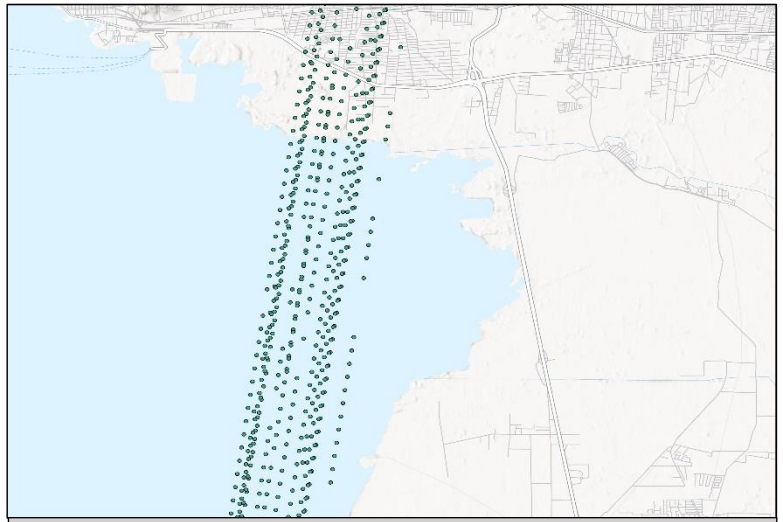
Tidal Gauge	% Availability of Tidal Gauge between 2015-2024
Port of Spain	92%
Scarborough	76%
Cedros Bay	48%
Galeota	34%
Charlottesville	23%



Credits: Esri, TomTom, Garmin, FAO, NOAA, USGS, OpenStreetMap contributors, and the GIS User Community

Landsat 7 scanline error shown in shoreline result for 2015 shoreline.

Altimetry data with noise and gaps in the photon data.



Credits: Esri, , USGS, OpenStreetMap contributors, and the GIS User Community

Conclusions

1. **The feasibility of shoreline delineation is dependent upon sufficient imagery, with limited cloud-cover, covering the spatial and temporal extent of the study.**

2. **Linear regression results predict rise in sea level consistent with the global model estimates. Altimetry is an adequate compliment to tidal gauge information and can supplement gaps in the data.**

3. **Future shoreline extent in 2050 will be impacted by sea level rise, however this will not impact the coast evenly in Trinidad and Tobago.**

*Overall, we emphasize the role **publicly accessible earth observation data** can play in generating results for decision-makers in Trinidad & Tobago as they address the impacts of a changing climate.*

Future Recommendations

- **Harmonized Landsat and Sentinel (HLS) imagery** can be evaluated to generate **more reliable** shoreline composites for shoreline delineation.
- Publicly available **Sentinel-1 Synthetic Aperture Radar (SAR)** imagery and commercial LiDAR imagery (if available) can be used to **avoid cloud cover** issues that affect both shoreline delineation and area change calculations.
- Future feasibility studies should include and develop processes to **include altimetry data** to measure changes in sea surface height. Altimetry data can be evaluated in a timeseries to **encapsulate sea level rise** over decades.
- Continued focus on **publicly accessible data** and satellites should remain a critical component of any future feasibility studies for Trinidad & Tobago or similar geographies.

Acknowledgements

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- Isabel Tate (Project Coordination Fellow)

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