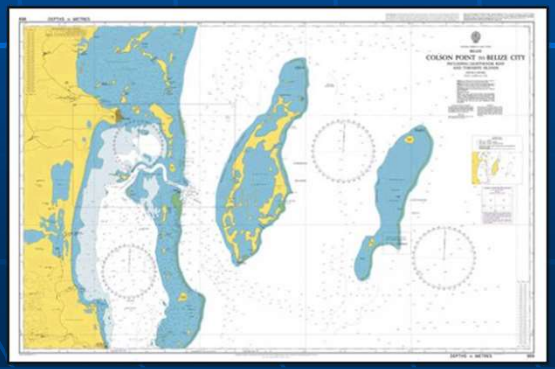
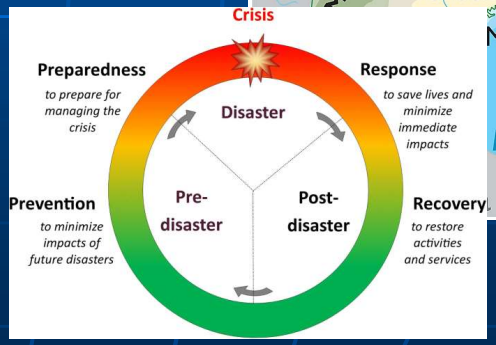
Modelling coastal vulnerability in Belize: an application of Satellite Derived Bathymetry for coastal management



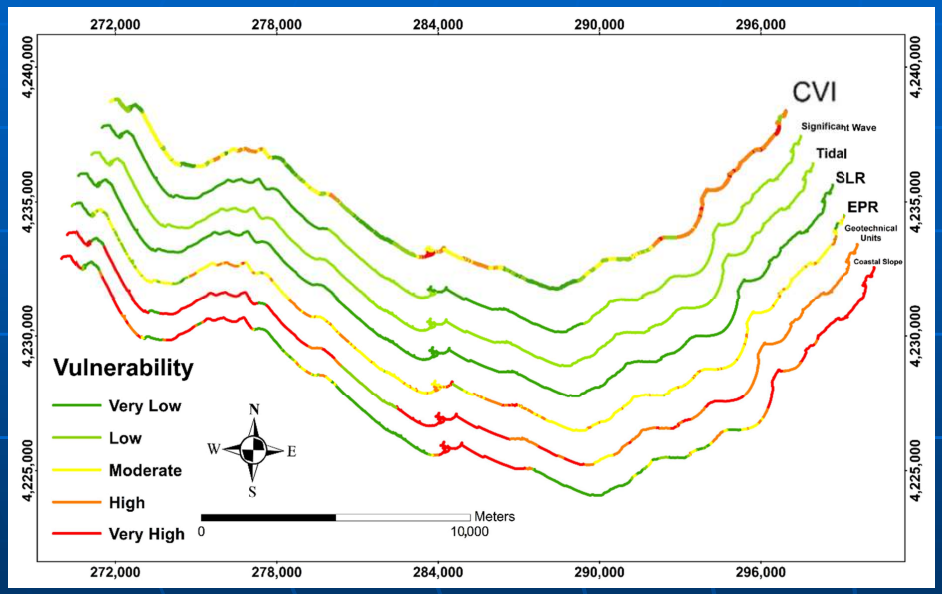
Integrated Coastal Zone Management

- Mesoamerican reef recently removed from IUCN List of World Heritage In Danger.
- It is important to have a strong characterization of the coastal zone to enhance protection and coral reef resilience to ensure this status is retained.
- Optically clear waters well suited to SDB.
- Contribute towards Integrated Coastal Zone Management through focus on coastal protection element.



https://link.springer.com/article/10.1007/s10712-020-09586-5

Project aims & objectives



Aim – provide merit for EO based approaches to evaluate coastal vulnerability in Belize for use in Integrated Coastal Zone Management to enhance resilience to climate change

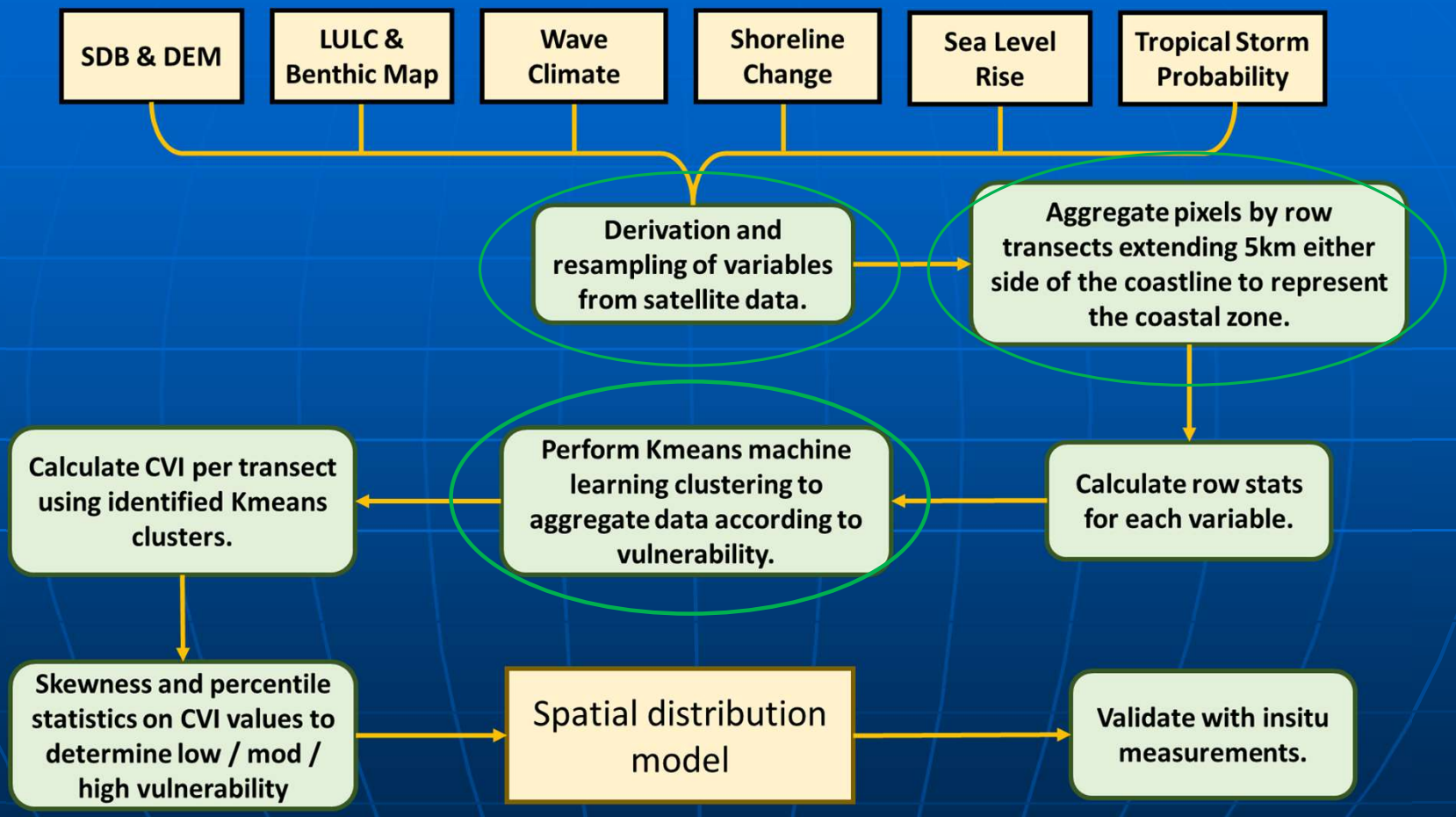
Objs –

1. Identify and quantify spatial variability of conditioning factors to coastal vulnerability in Belize
2. Synthesise into analytical Coastal Vulnerability Index model using vulnerability indices
3. Validate model

This project will specifically focus on the geographic indicators presenting coastal vulnerability to storm surges and therefore risk is not evaluated.

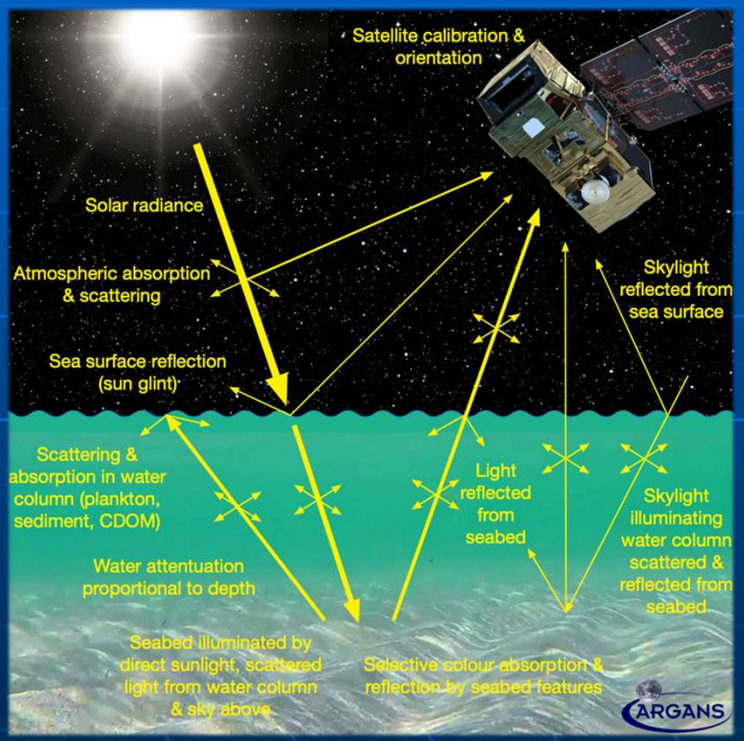
https://www.mdpi.com/2077-1312/9/4/423

Modelling Coastal Vulnerability



SDB: A reminder

Satellite Derived Bathymetry (SDB) is the estimation of ocean depth using multispectral sensors. A correlation exists between the amount of reflected energy received at the sensor and the water depth.



Benefits:-

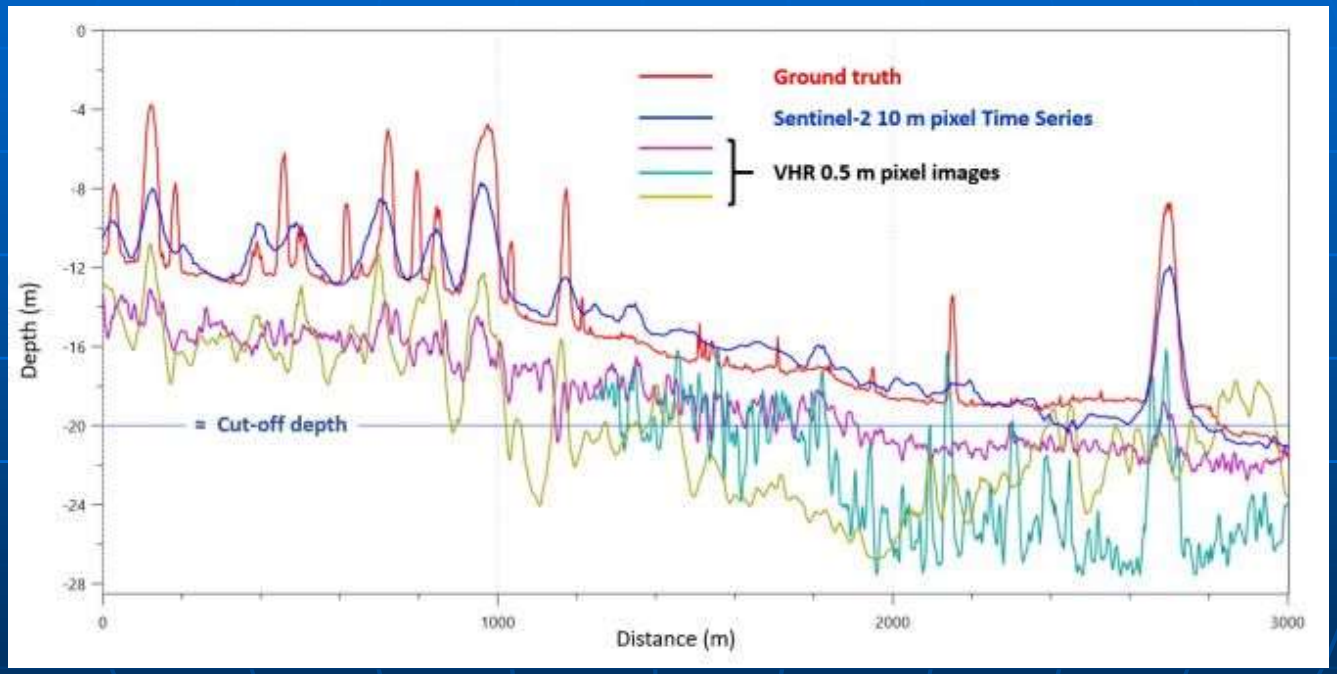
- Cost effective.
- Fast production.
- High resolution results.
- Remote areas become accessible.
- Side products (seabed classifications).

'Sentinel Coastal Charting Worldwide'

The objective of the project was to prove the capability of Sentinel-2 to produce reliable SDB reducing gaps within navigational charting at appropriate scales and an affordable price.

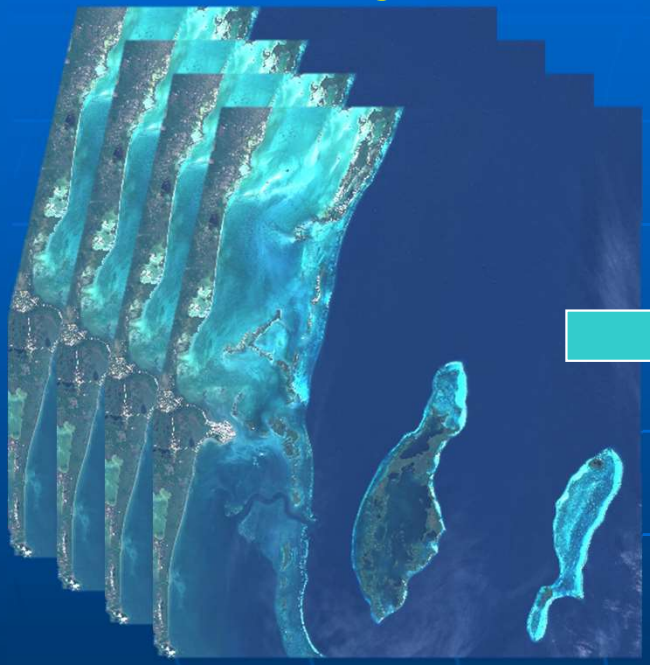
SDB: ARGANS' research findings

Sentinel-2 or VHR Sensors?

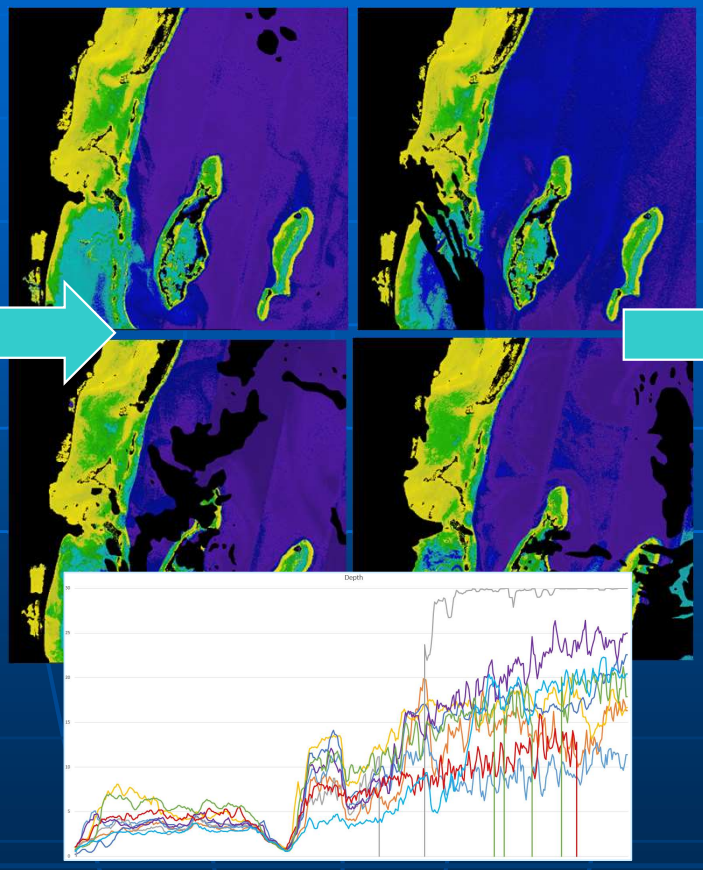


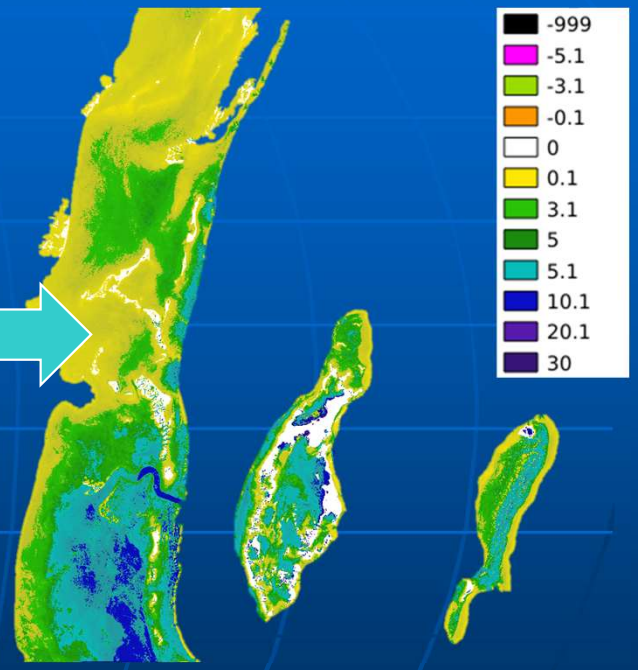
SDB: ARGANS' research findings

Time-series Merge



Normalised time-series of Sentinel-2 images





The "perfect image"

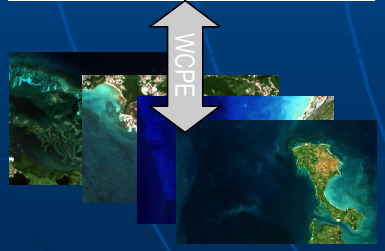
SDB Software Developments

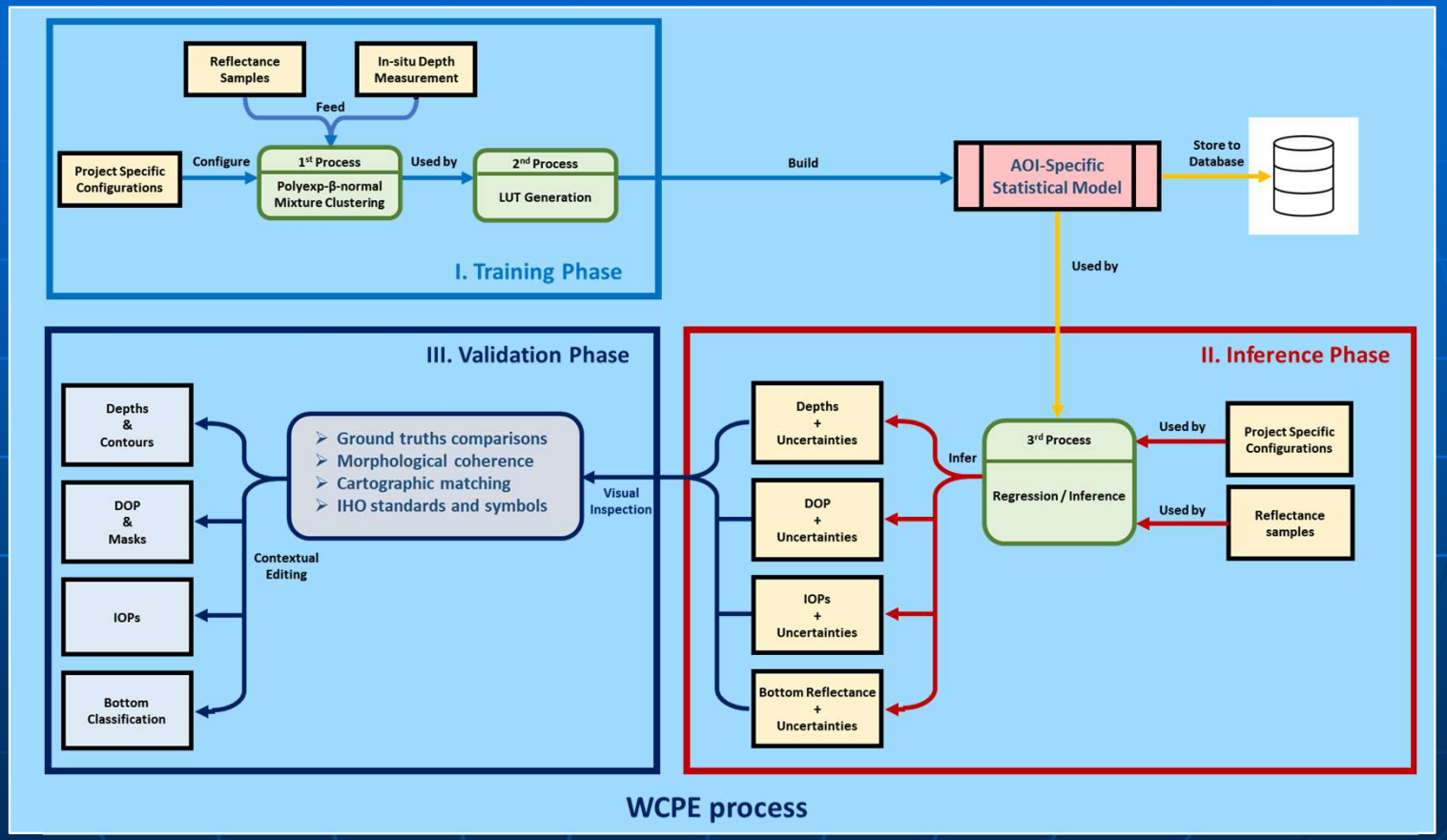
The main physical equations don't scale by themselves.

- Need to train on real world data
- Infer all relevant water-column properties

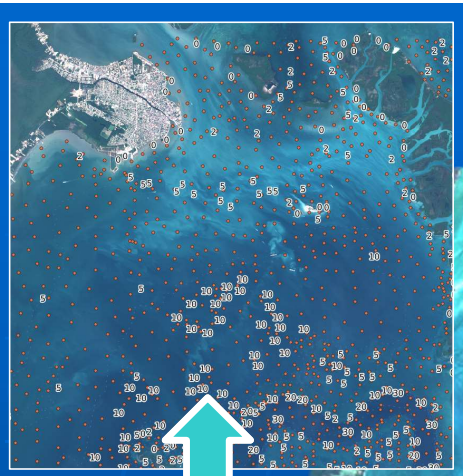
Water Column Parameter Estimator (WCPE) pertains to solve the gap between equations and available satellite data.

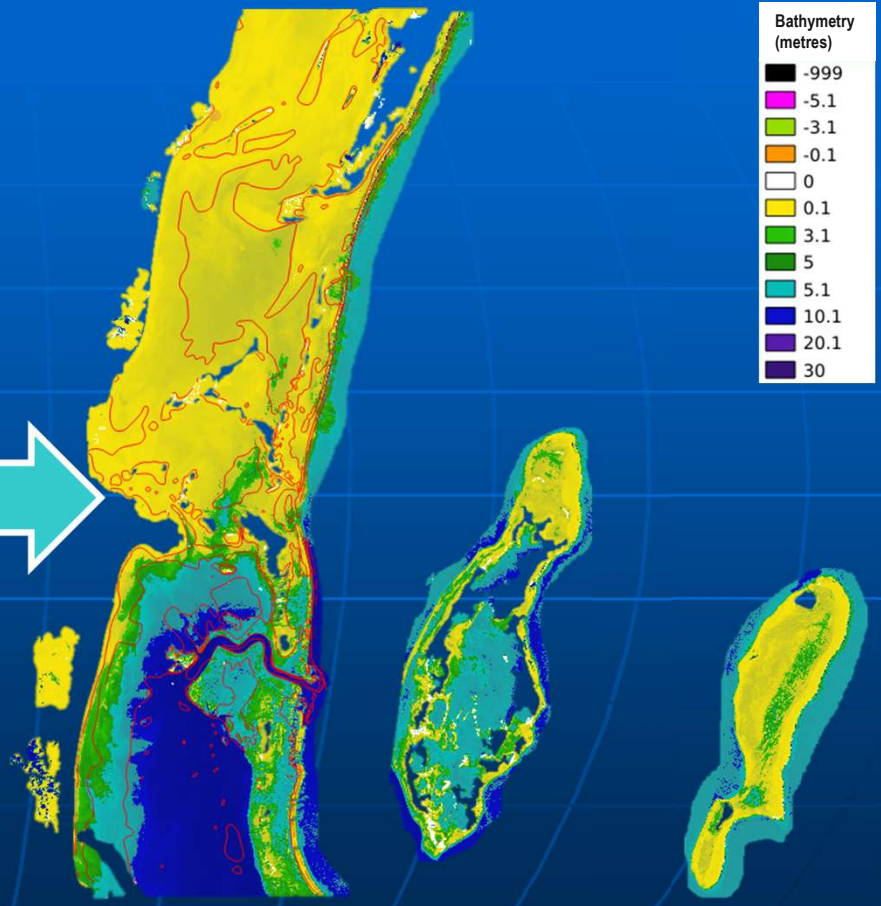
$$R_s = e^{-c\,d\,\alpha}\left(R_b(\psi_r) - \frac{\omega(\psi_r)}{\alpha}\right) + \frac{\omega(\psi_r)}{\alpha}$$





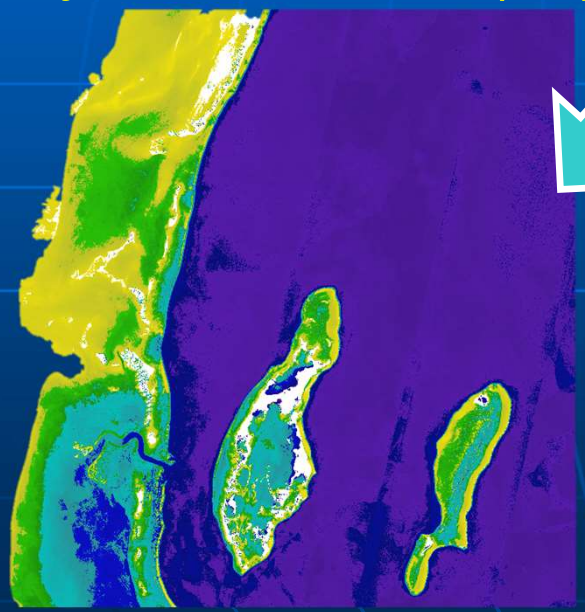
Training and inference

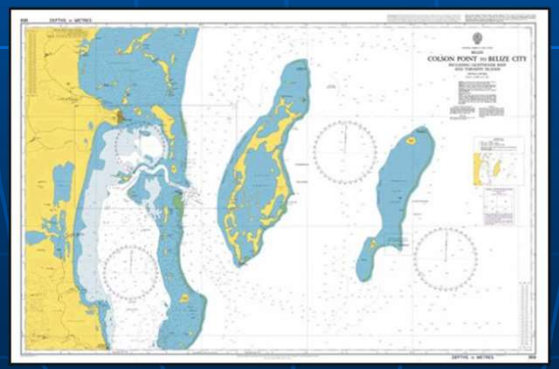




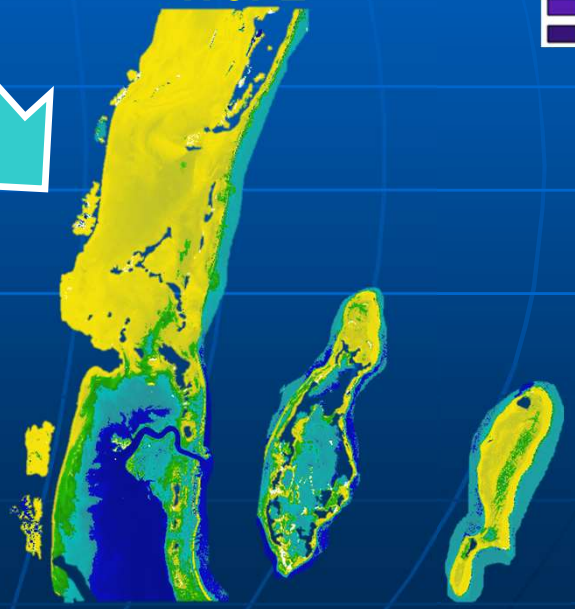
Validation of SDB results in Belize

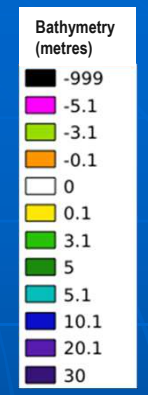
Physics-Based Method (IDA)





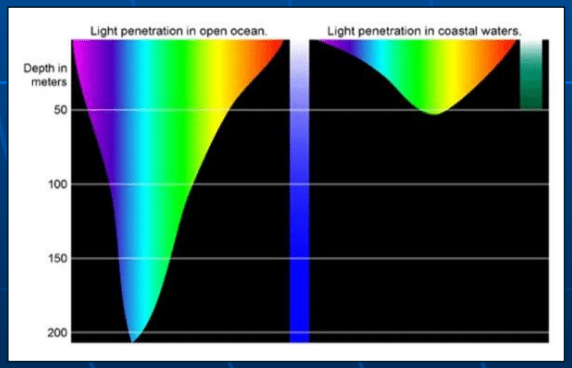
WCPE



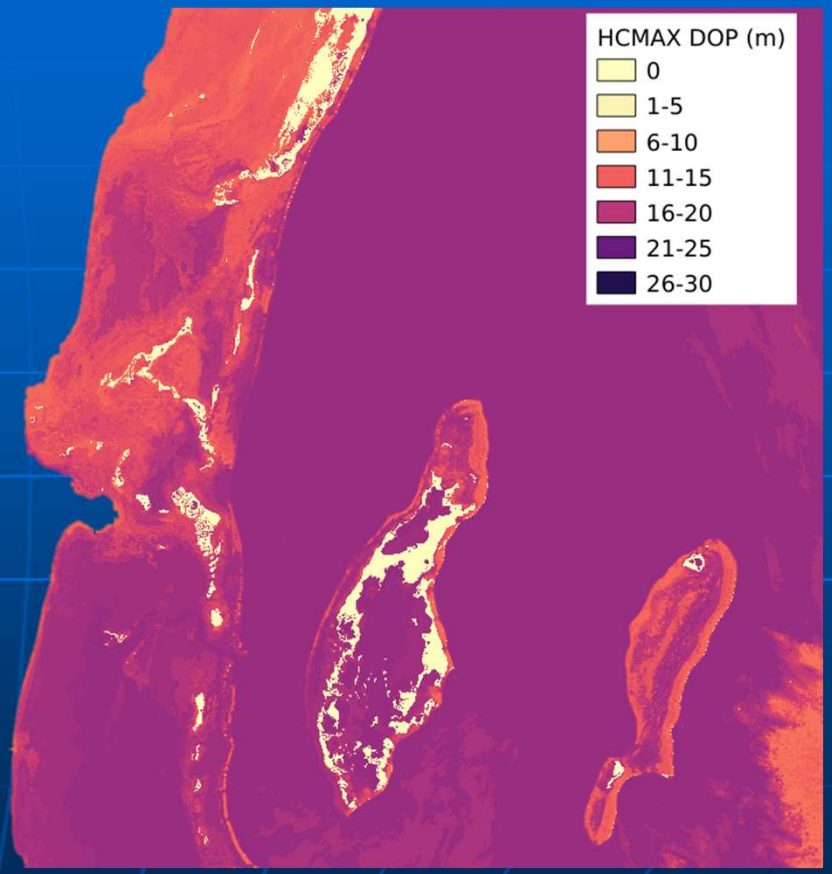


Belize Water Quality

- Consideration of turbidity must be made to mask out areas where seabed may be obscured.
- Masking achieved using Han et al (2016) algorithm with Depth of Penetration (DoP) in house software.
- More turbid waters observed in the north resulting in smaller HCMax.

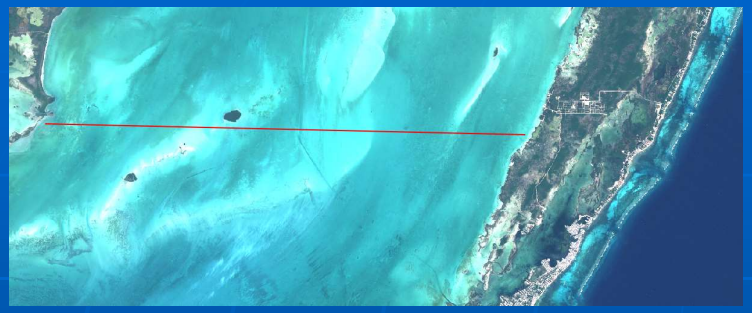


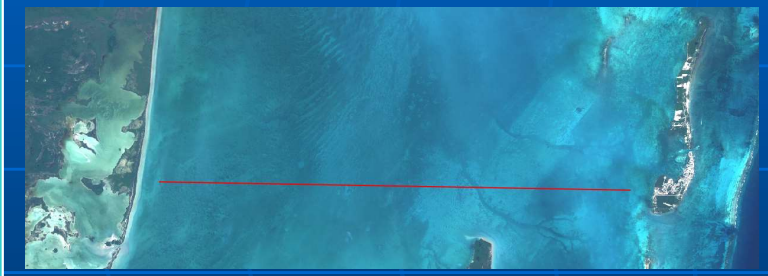
Light penetration (source: NOAA)

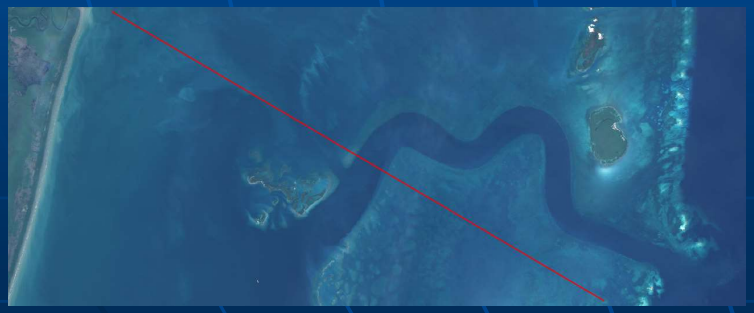


Coastal Slope Assessment

N

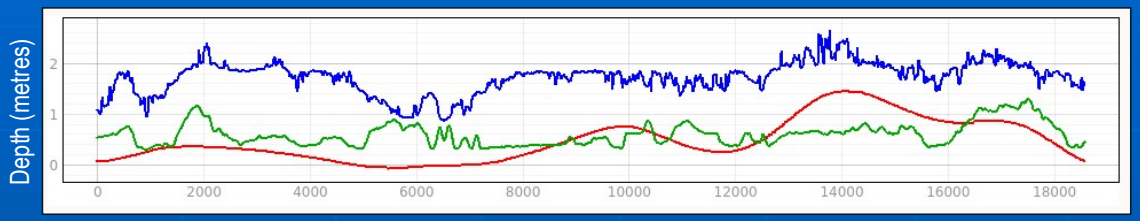


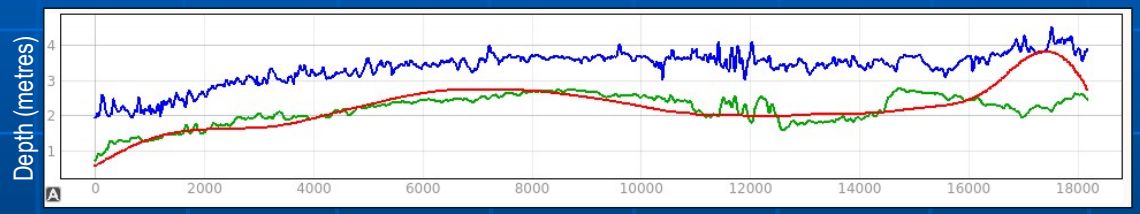


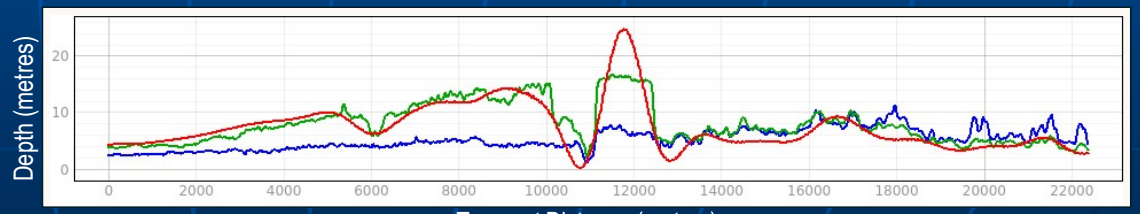


S

WCPE Bathymetry | Interpolated ENC | IDA Bathymetry



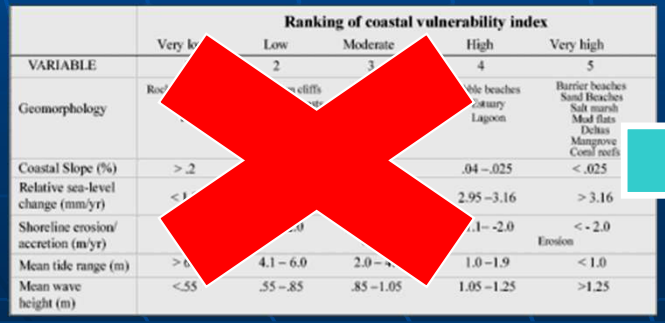


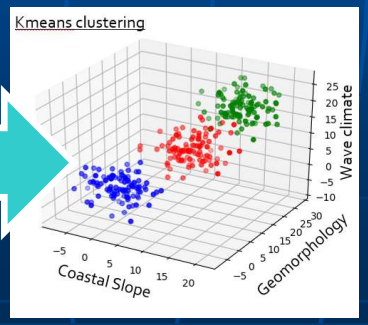


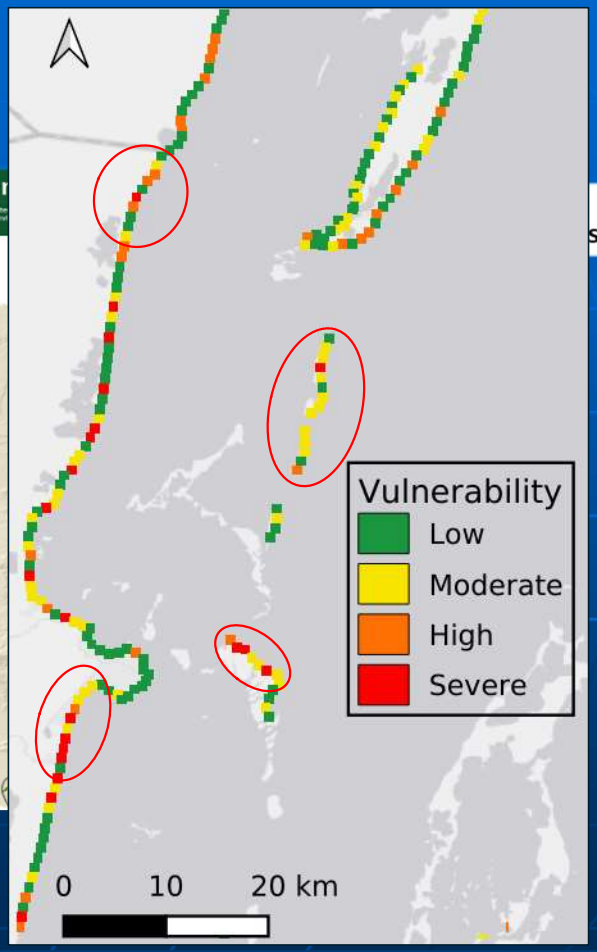
Modelling Coastal Vulnerability

$$CVI = \sqrt{\frac{(a * b * c * d * e * f)}{6}}$$

- Remote sensing risk parameters synthesised into bespoke Coastal Vulnerability model to determine areas of coast most susceptible to storm surges.
- First test following Koroglu et al. (2019) method showing promising results and agreement with existing InVEST models in absence of insitu data.
- Improve definition of risk groups with machine learning and characterisation of vulnerability through continued mapping.

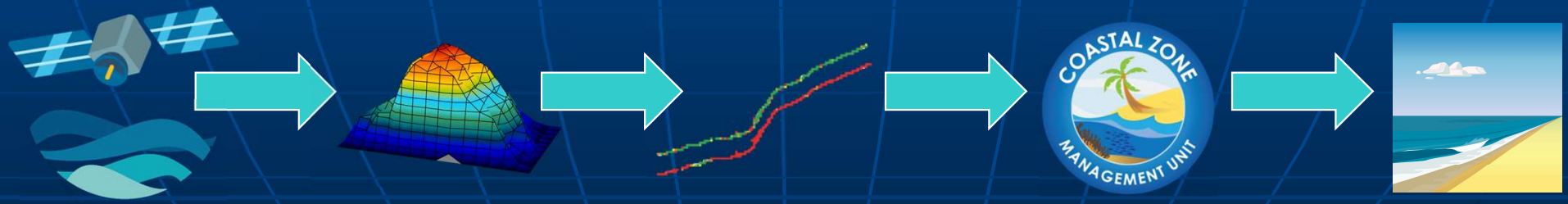






Closure

- Coastal areas can be surveyed cheaply, regularly and efficiently using Satellite Derived Bathymetry from Sentinel-2. These datasets can be implemented into coastal models for cheap and efficient decision-making tools for coastal managers.
- Data can be optimised through utilisation of a time-series of images and machine learning of water quality properties associated with depth.
- The WCPE method demonstrates clear advantages of being transferable across multiple Sentinel-2 tiles in regions with morphological similarities with minimal human intervention to train models.
- Looking for opportunities to progress research through provision of insitu data for validation.



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Thanks for listening!!

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