Environment SYSTEMS
evidence and insight

# Vulnerability Mapping in the Caribbean

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JNCC Joint Nature Conservation Committee

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# The project

- Using marine and terrestrial data to map the vulnerability / risks of 4 of the UK Overseas Territories in the Caribbean to natural disasters
- Newly available satellite imagery data sets to produce
    - Risk modelling
    - Validation against actual storm events
- Developing methodologies that the islands could use themselves to monitor risk into the future.
- Working at the land-sea interface to demonstrate the importance of Natural Capital

# The importance of the coastal zone and shallow water marine areas

- Economic value of beaches to tourism and island GDP. Beach erosion is an increasing problem
- The coastal zone is under pressure from storm events, exacerbated by climate change and rise in sea level
- Marine features such as coral reefs, sea grass beds and mangroves provide resistance to natural hazards – often referred to as Natural Capital

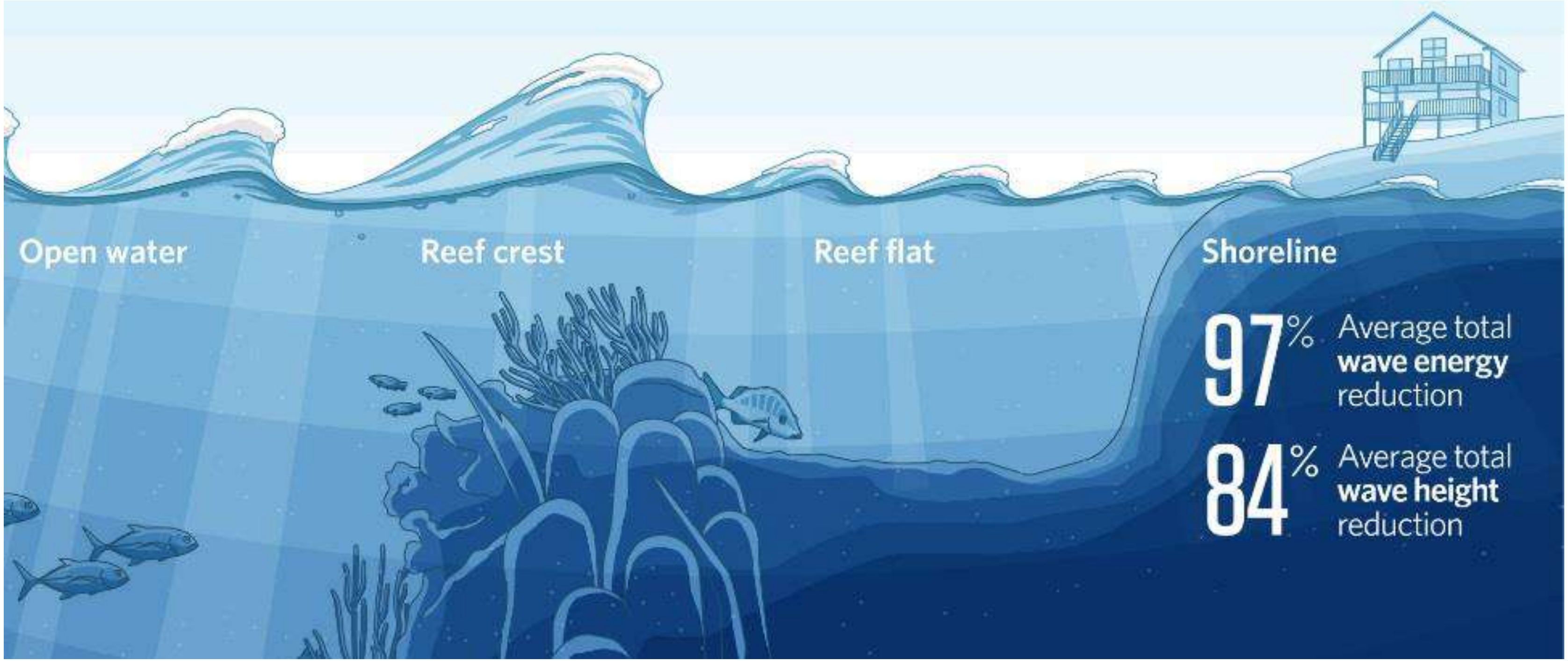
Gwen’s beach bar Anguilla 2013

Site of Gwen’s beach bar Anguilla 2014 post hurricane Gonzalo

# Marine natural capital

- Helps stabilise beaches
- Maintain good water quality
- Supports fish nurseries
    - Young fish often require specific environmental conditions – these are often met in coastal waters

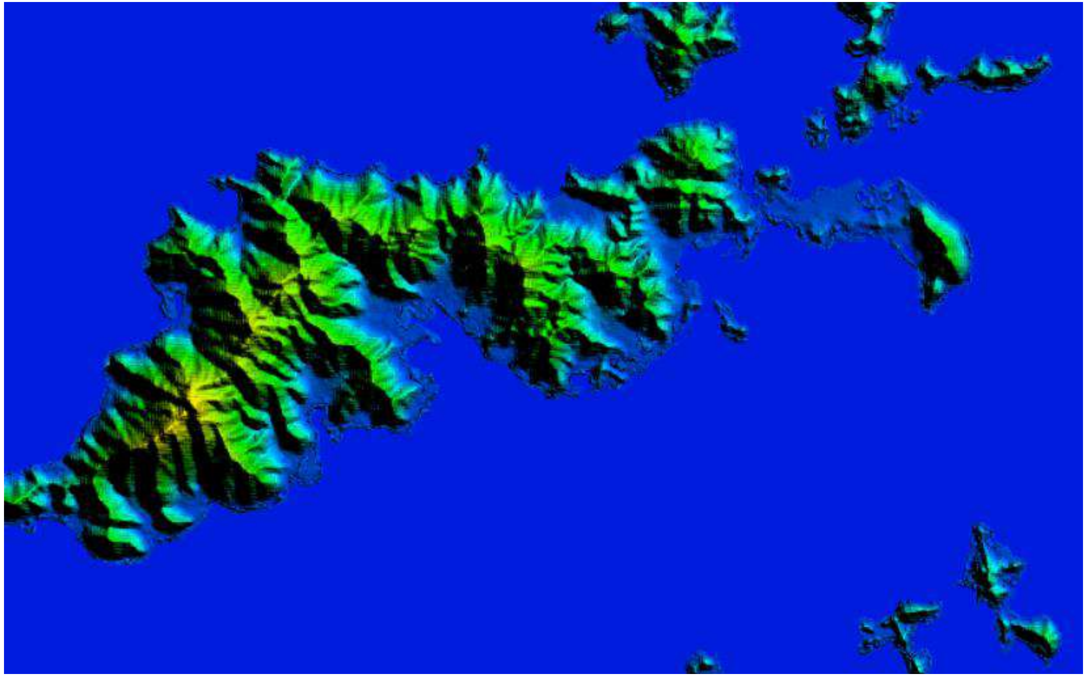
# Marine natural capital helps reduce wave energy and height.



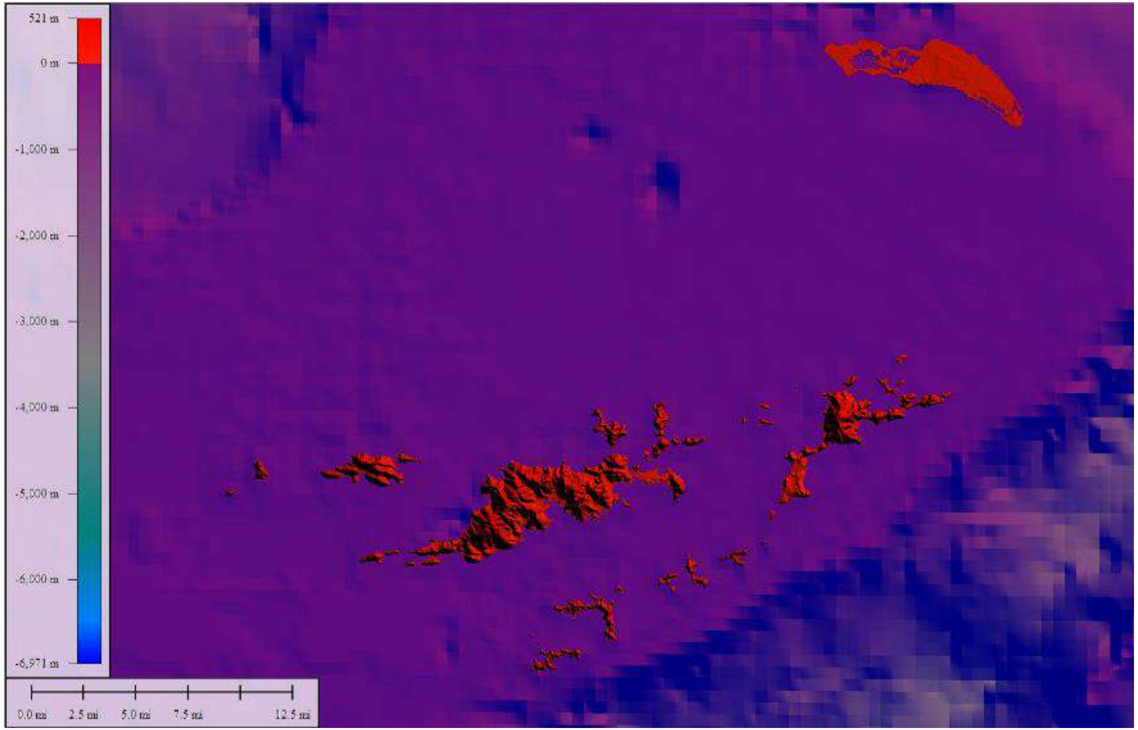

Coastal protection by coral reefs (Ferrario *et al* 2014)

# Modelling the vulnerability of areas at risk from storm surge and how natural capital is helping to protect these areas

# Radar satellite data (WorldDEM™) allowed the creation of a detailed digital terrain model



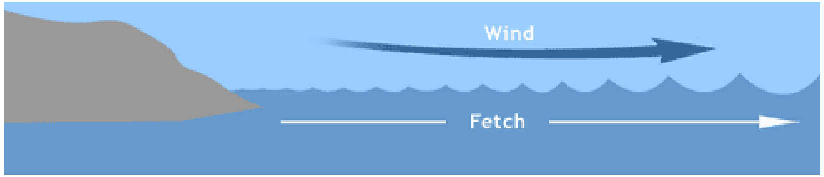
# Creating a seamless bottom of ocean to top of island model

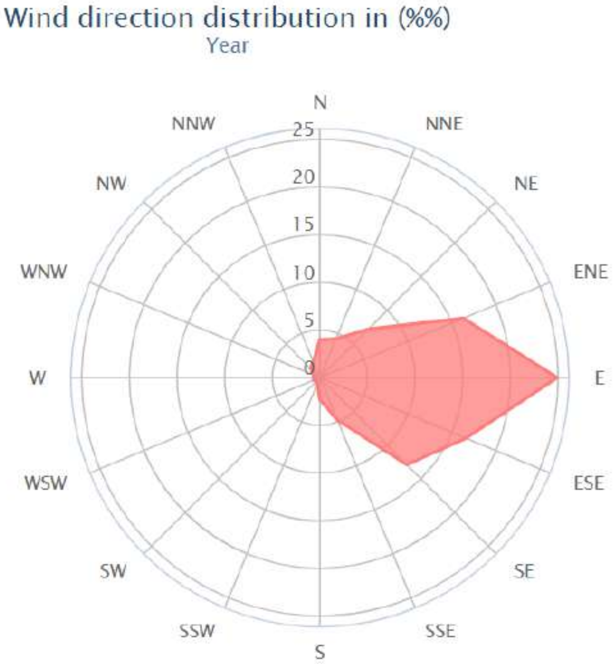


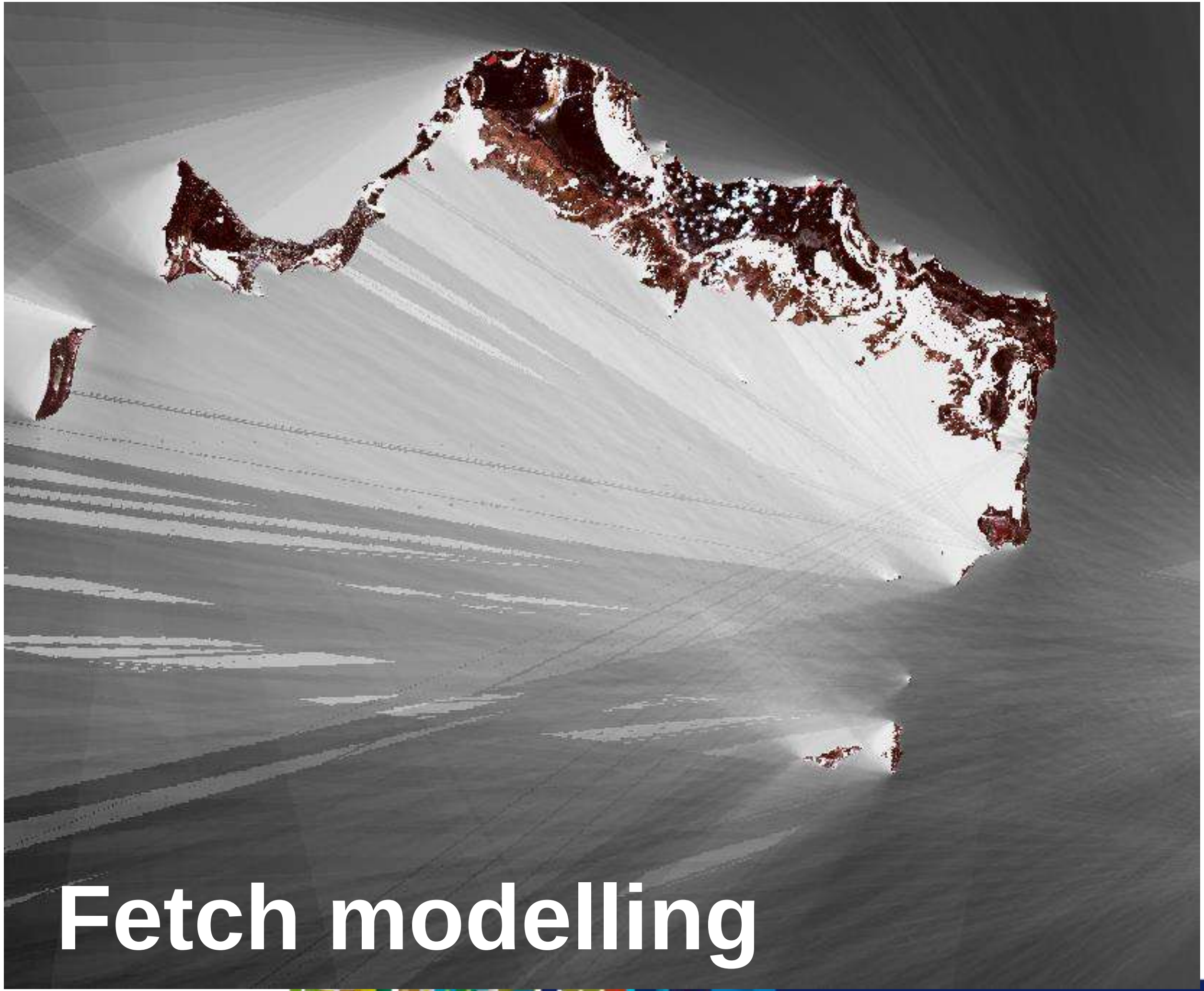

Using existing bathymetry data, it was then possible to produce a Seamless DTM (bathymetry and elevation)

- Sea Zone bathymetry
- WorldDEM produced terrestrial model

# Fetch modelling



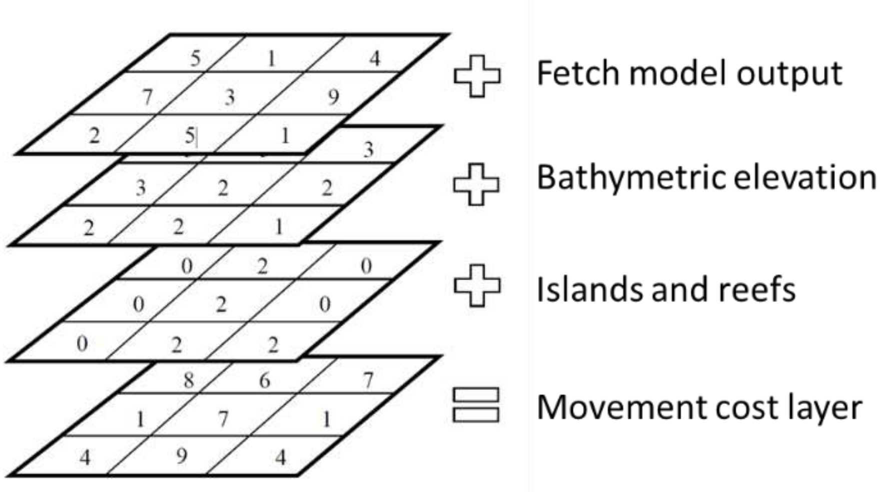





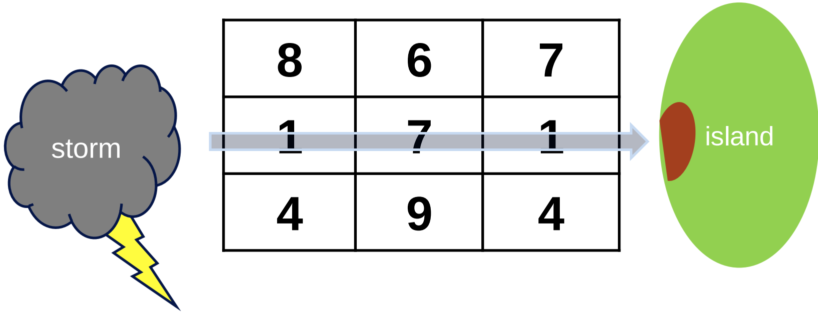
# Fetch modelling

- Fetch provided an indication of sheltered and exposed conditions
- Used the USGS Wind Fetch Model, along with average wind directions.
- Premise: the longer the distance a wave has travelled, as a result of wind and uninterrupted waters, the larger the wave and the greater the exposure of the underlying near-surface sea bed cover.
- To validate the model, the actual storm track (obtained from NOAH) was used

# Modelling the risk of storm surge using a least cost model to trace the waters movement inland

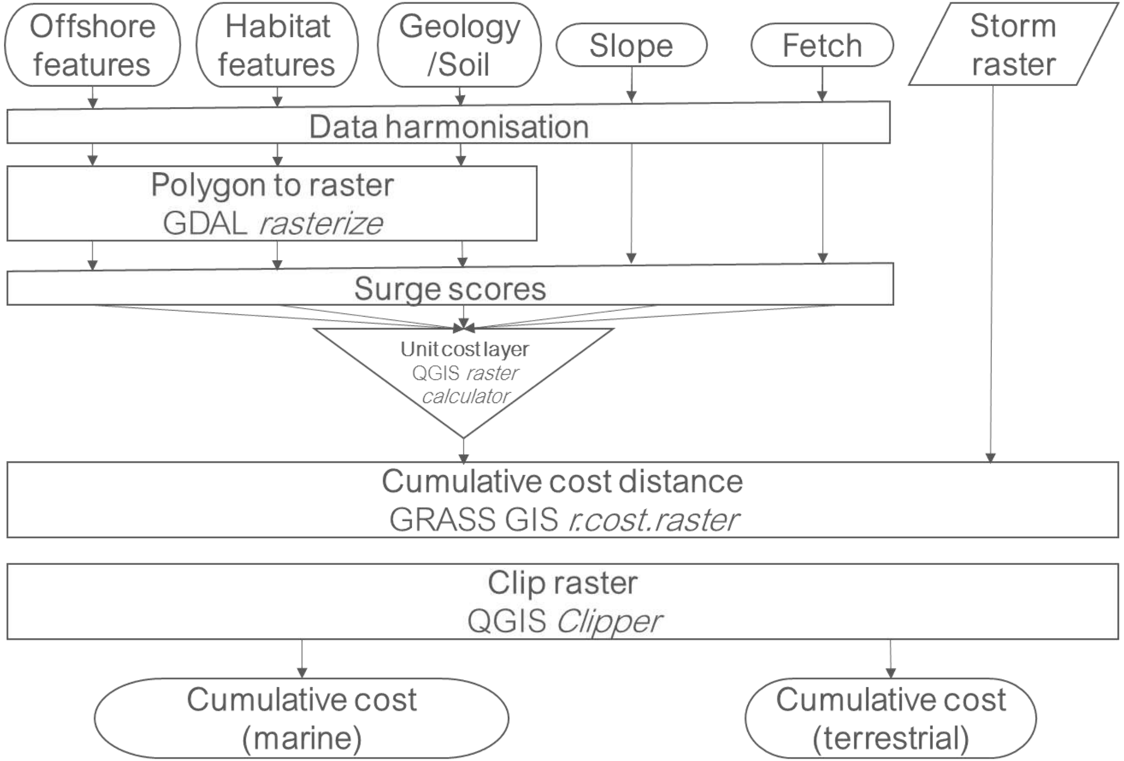



Conceptual diagram of additive raster model, creating the movement cost layer

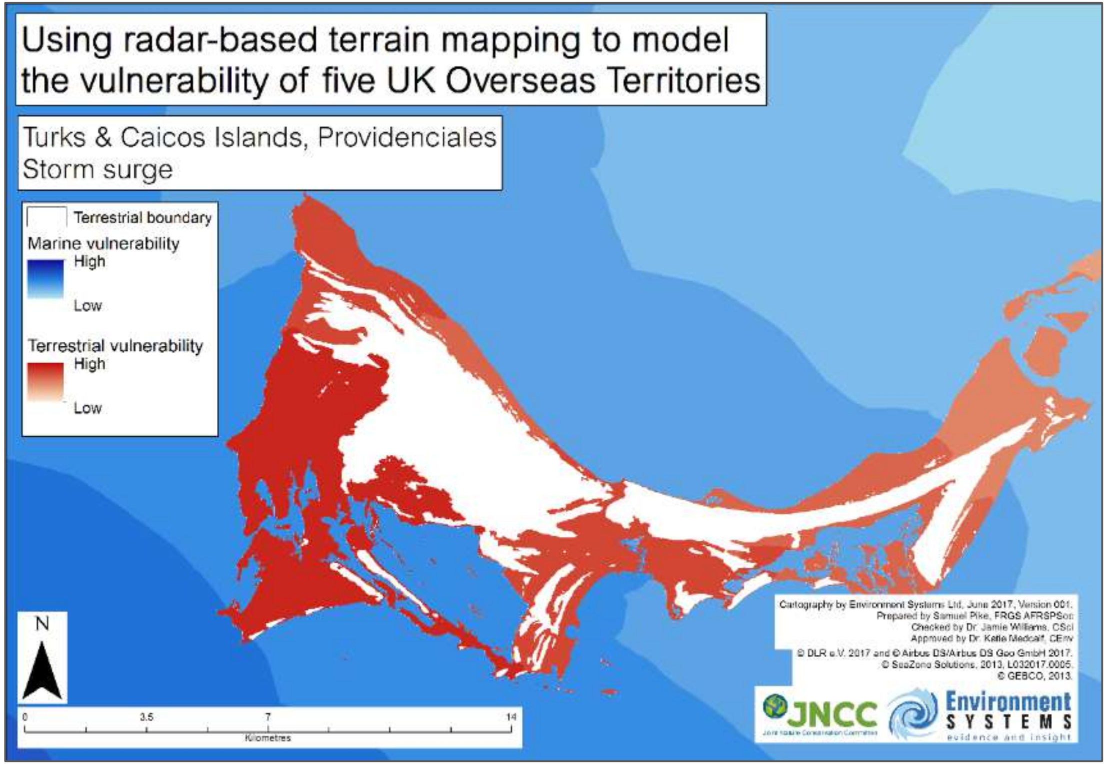



Conceptual diagram of least cost model

# Putting the model together



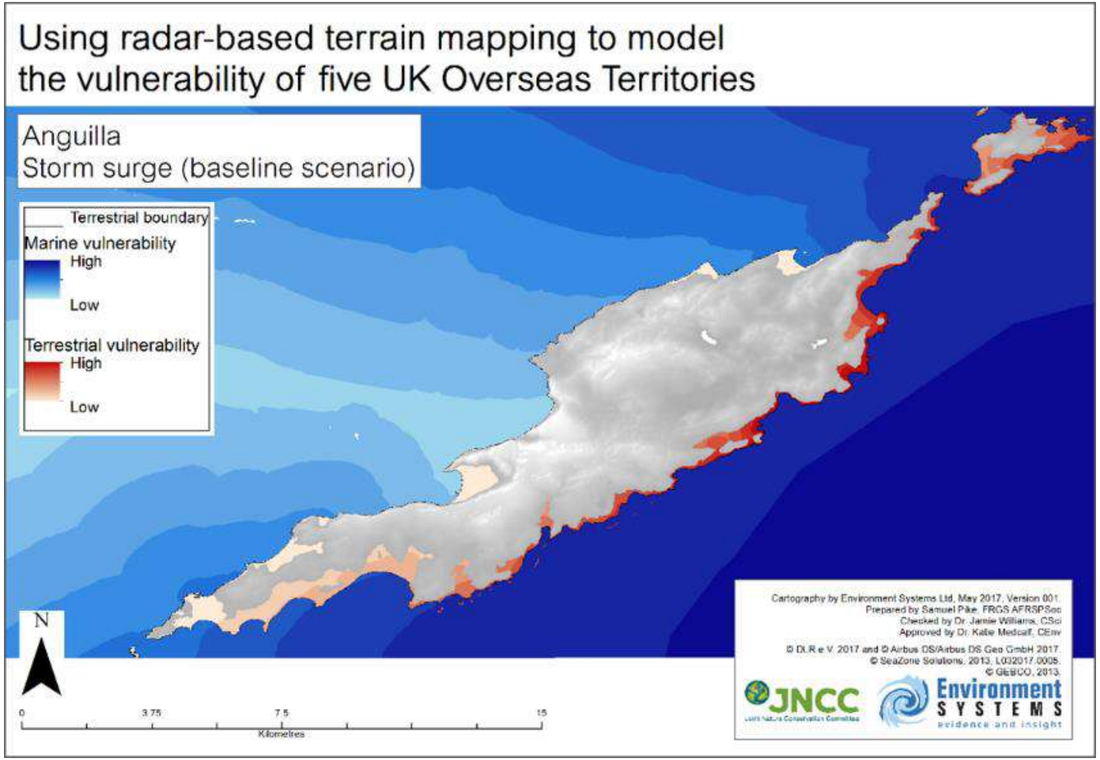
# Task 5. Application of the procedure
## Storm surge risk




The output dataset indicates those shorelines that are likely more susceptible to storm surge events

This analysis resulted in the indication of relative risk potential at the coastline

# Storm surge risk



# Phase 2: Validation of the models

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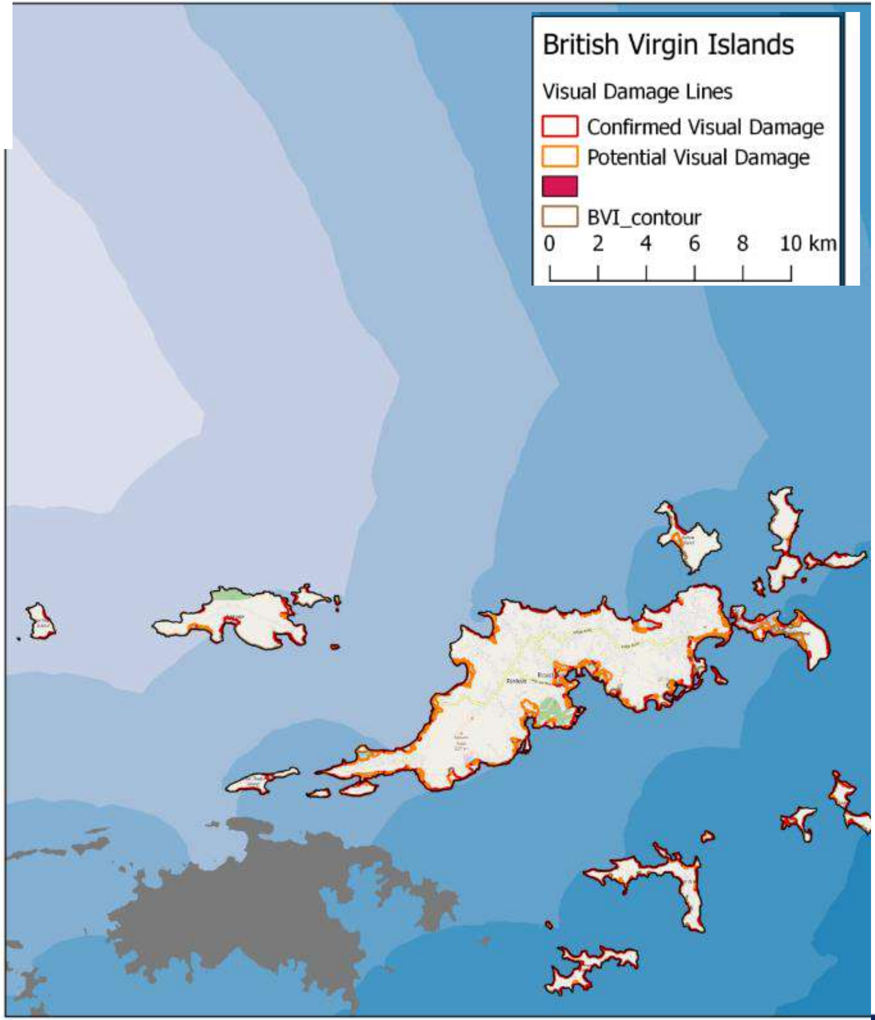
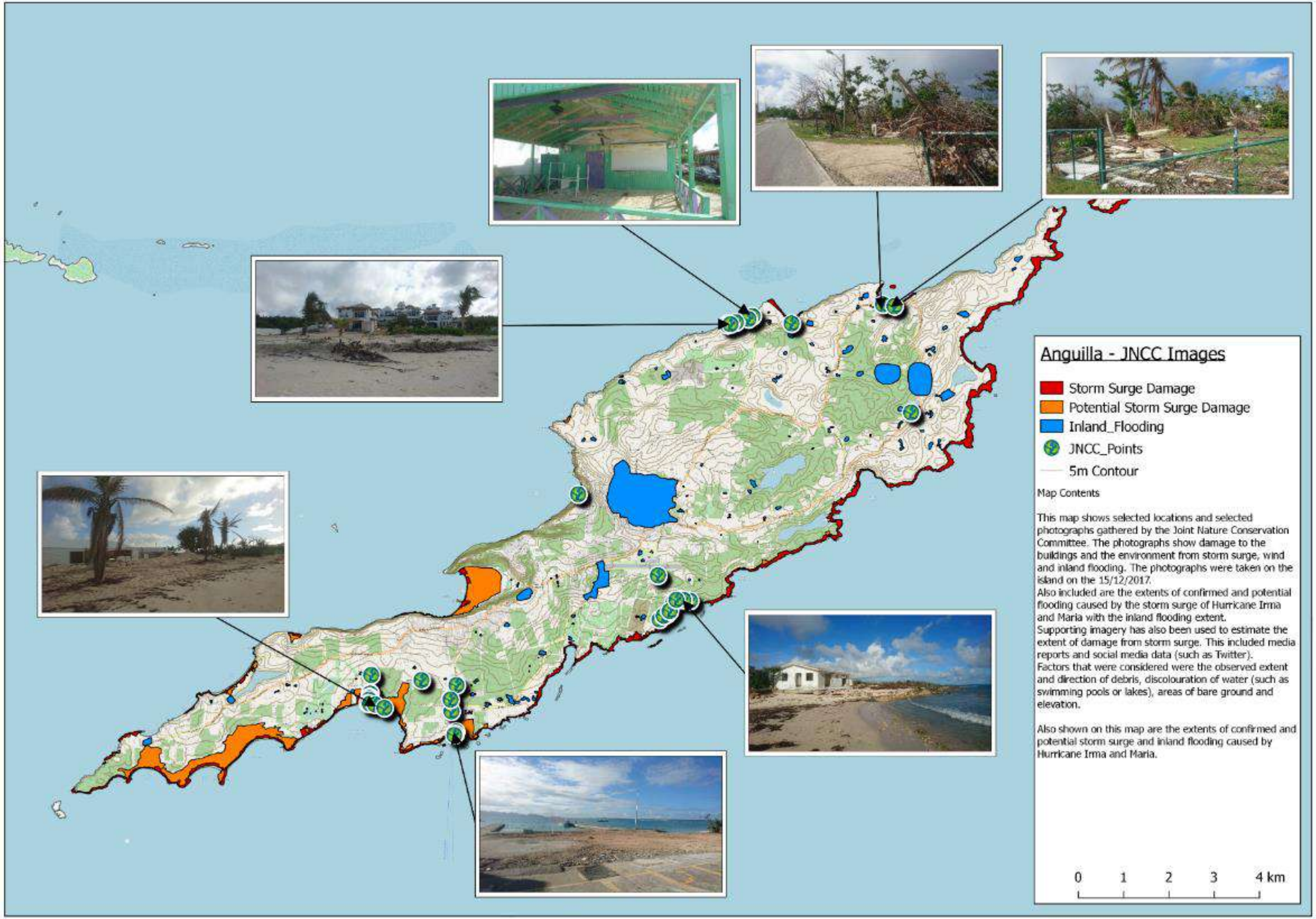
- Used Social Media, information gathered by JNCC and interpretation of satellite imagery taken between Irma and Maria and afterwards to designate damage lines
- Compared the damage lines to the risk zones
- Considered actual damage against expected risk

# BVI Tortola – Comparison after hurricanes Irma and Maria

- The visual damage lines of the storm surges from Irma and Maria were compared to the 6.2 meter elevation contour.
- The visual extents of confirmed / potential flooding were created from worldview2 and 3 data.
- Supporting imagery, including media reports, social media data (such as Twitter) and images from Joint Nature Conservation Committee were used to help confirm damage lines.
- Factors that were considered were the observed extent and direction of debris, discolouration of water (such as swimming pools or lakes), areas of bare ground and elevation.
- In some areas, the habitats present prevent visual inspection of damage due to factors such as tree cover.




Anguilla - JNCC Images
Storm Surge Damage
Potential Storm Surge Damage
Inland_Flooding
JNCC_Points
5m Contour
Map Contents
This map shows selected locations and selected photographs gathered by the Joint Nature Conservation Committee. The photographs show damage to the buildings and the environment from storm surge, wind and inland flooding. The photographs were taken on the island on the 15/12/2017.
Also included are the extents of confirmed and potential flooding caused by the storm surge of Hurricane Irma and Maria with the inland flooding extent.
Supporting imagery has also been used to estimate the extent of damage from storm surge. This included media reports and social media data (such as Twitter).
Factors that were considered were the observed extent and direction of debris, discolouration of water (such as swimming pools or lakes), areas of bare ground and elevation.
Also shown on this map are the extents of confirmed and potential storm surge and inland flooding caused by Hurricane Irma and Maria.
0 1 2 3 4 km

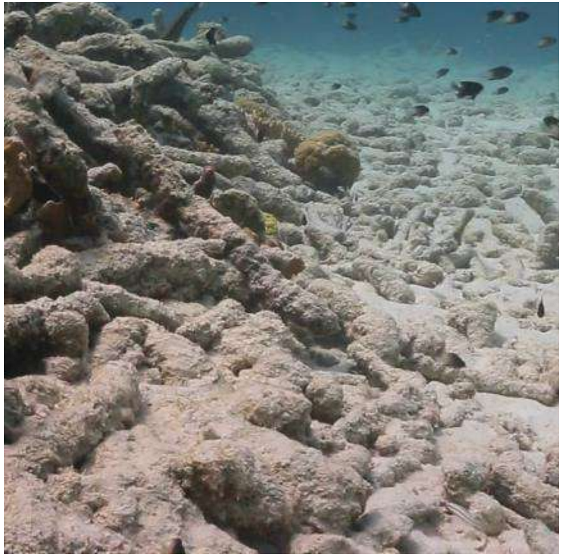
# Results of the validation showed a good fit between actual damage and the model

# Storms and water quality

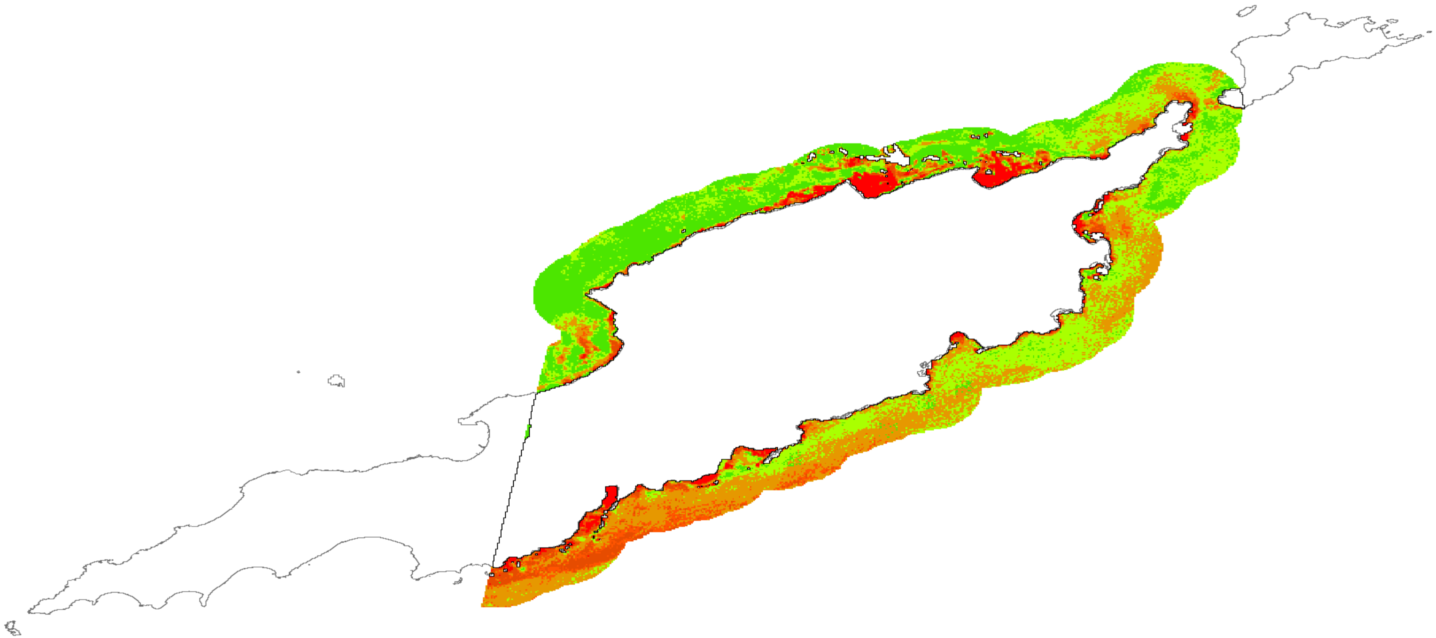
Suspended sediment

Nutrient enrichment leads to increase chance of algal blooms

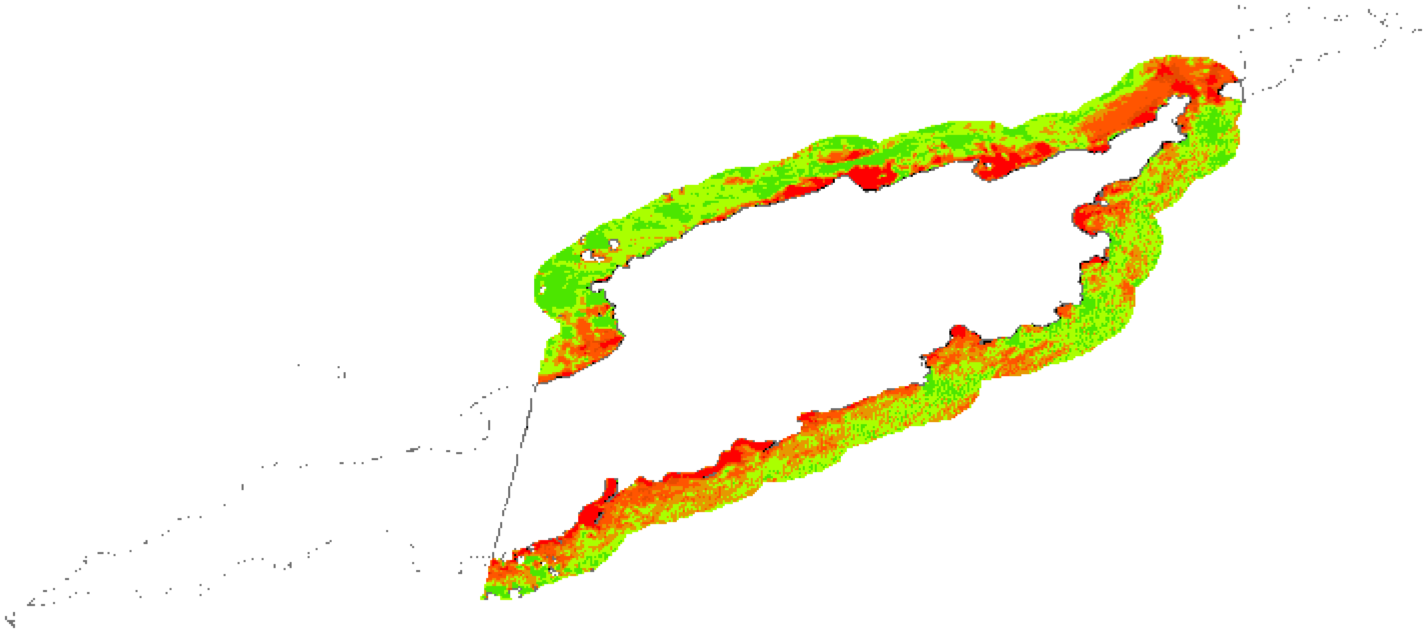
Change in shallow aquatic physical and vegetation features



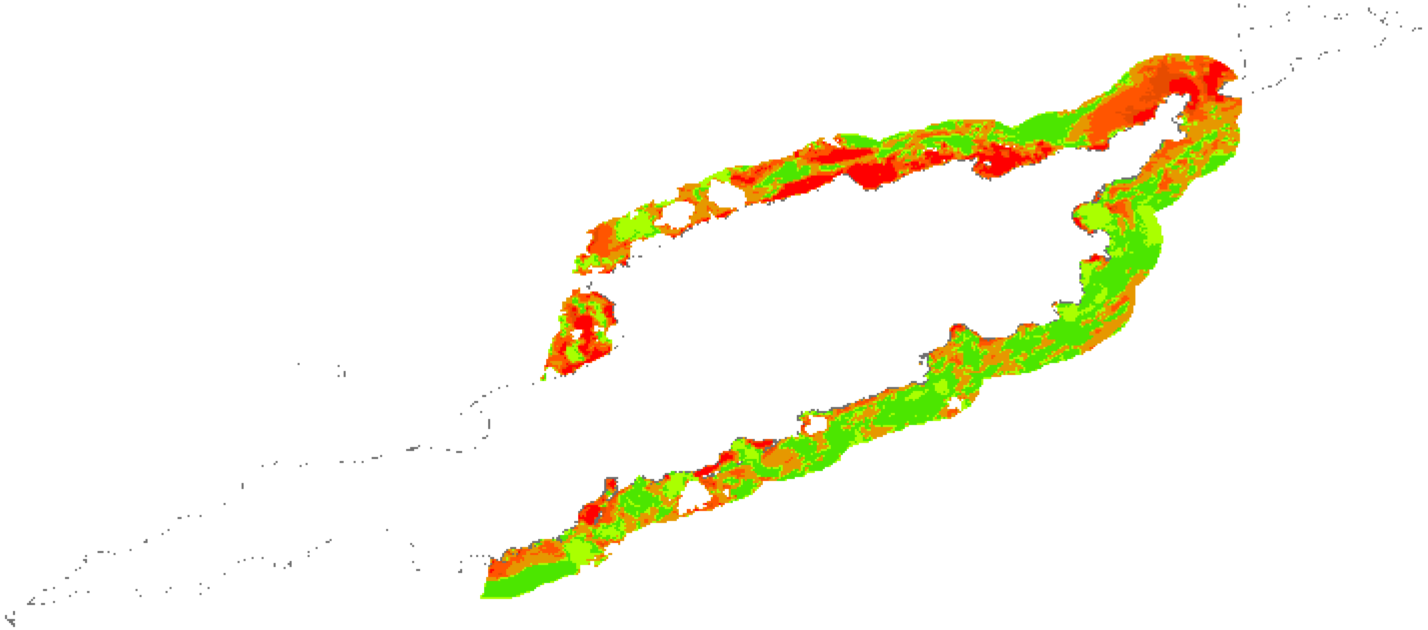
# Suspended Sediments (from Landsat) 1984



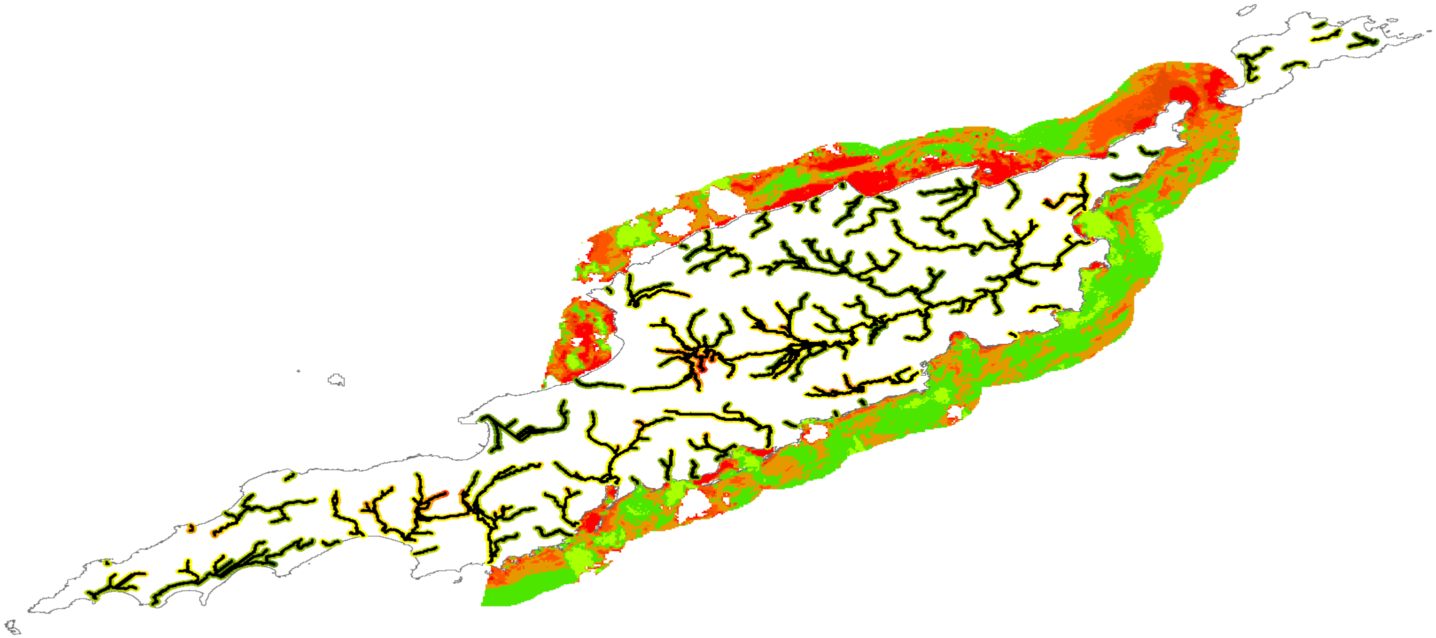
# Suspended Sediments (from Landsat) 2013



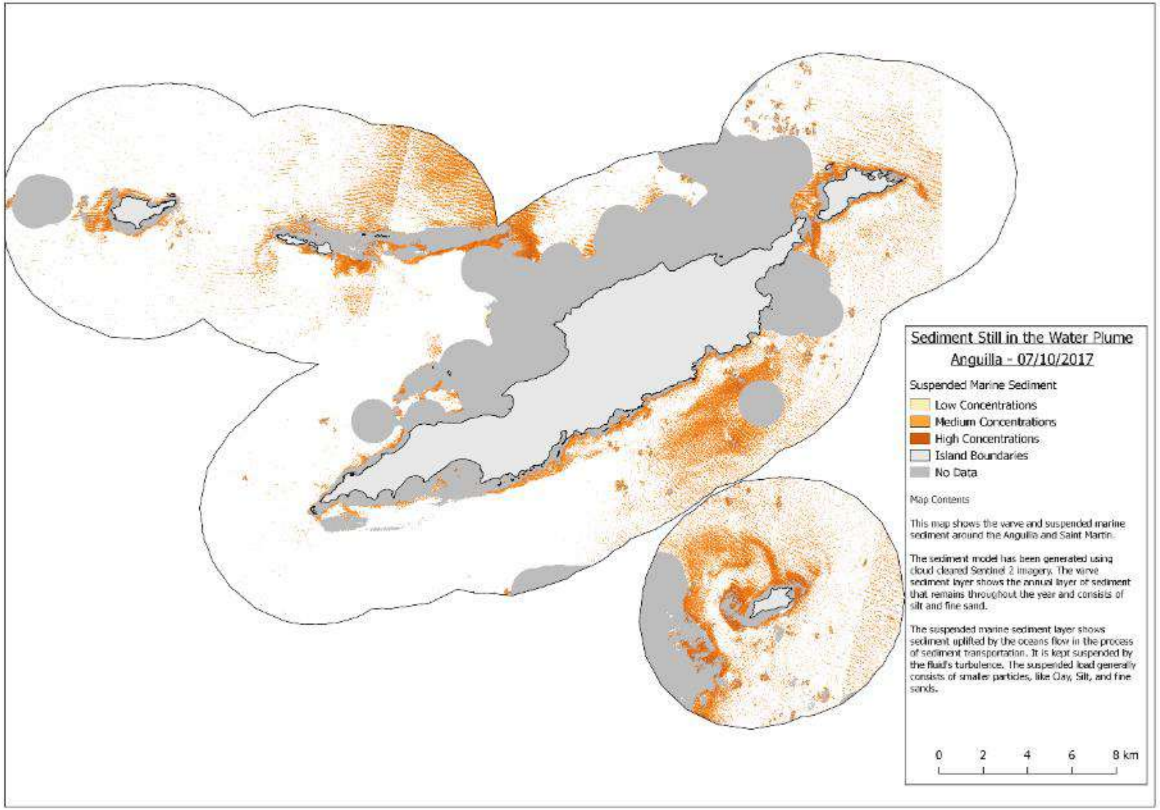
# Suspended sediments (from Landsat) October 2014 (2 days post Gonzalo)



# Erosion channels (from SciMap) LiDAR DTM and Suspended Sediments 2014 (2 days post Gonzalo)



# Sediments out to sea




Post Hurricane Irma

Sedimentation analysed from Sentinel 2 Imagery

Sediment damages coral degrading the environment, reducing the coastal protection role the reefs have.

# Conclusion

By understanding and modelling the key environmental factors relating to storm surge we have

- Quantified the risks
- Produced data that was validated against actual storm events

This can then be used to:

- Provide evidence to back policy choices, such as restoration activities and coastal protection
- Provide evidence to formulate resilient planning legislation
- Help formulate accurate disaster management plans.

Environment SYSTEMS evidence and insight

# Thank you

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