Coastal Remote Sensing Applications for Disaster Recovery

Hurricane Irma's Impact on Antigua and Barbuda

MACHC XIX| Cartagena, Colombia |27 Nov, 2018

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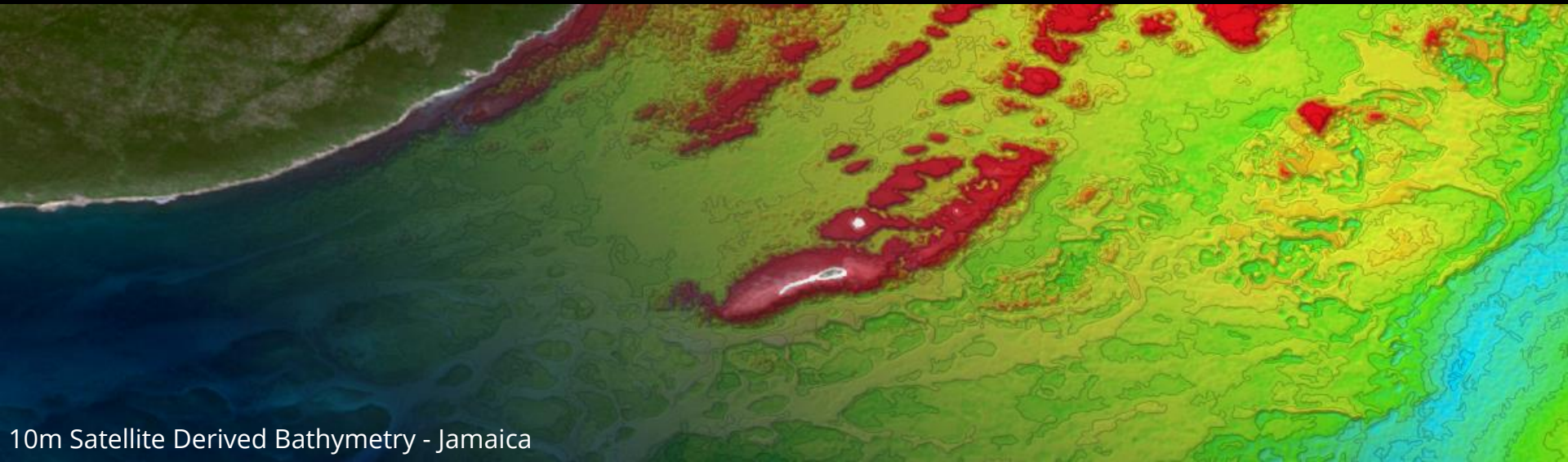


10m Satellite Derived Bathymetry - Jamaica

Marine Remote Sensing Applications for Disaster Recovery

Tsunami Modeling
Storm Surge Modeling
Coastal Resilience Planning
Updated bathymetry

Ship Groundings
Hurricanes and tropical storms
Earthquake / Tsunami

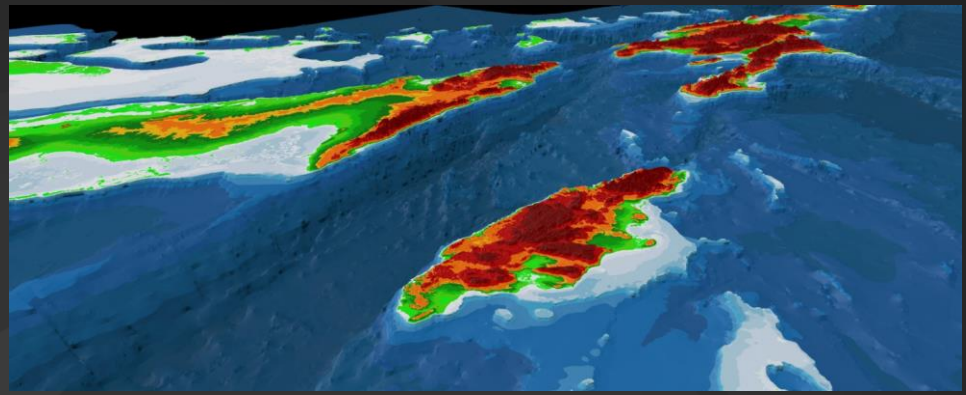
Tasked satellite imagery
Satellite-based hydrography
Amphibious landing planning
object/ hazard detection

Tsunami Modeling

CARIBBEAN SEA TOPO/BATHY MODEL

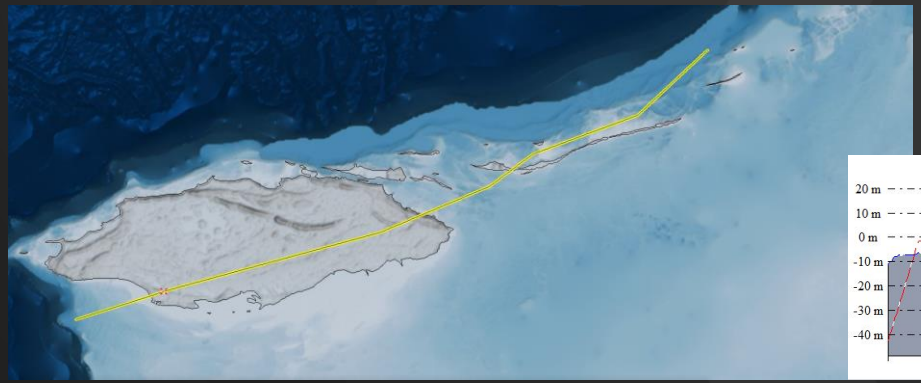
Combined TCarta 30m SDB,90m Bathymetry Model with infilled NASA 30m SRTM DEM

1:20,000 scale Sentinel 2 based MSL shorelines used as land/water break
("0" elevation) in gridding process

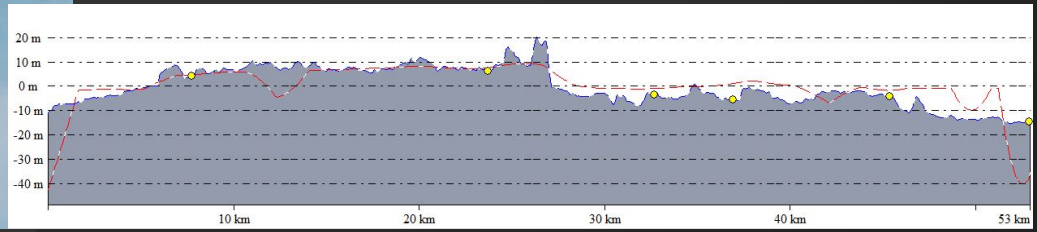


Caribbean Topo/Bathy : Jamaica, Cuba, Haiti

30m Topo/Bathy : Nassau, Bahamas



Elevation Profile: ETOPO =red, TCarta = grey

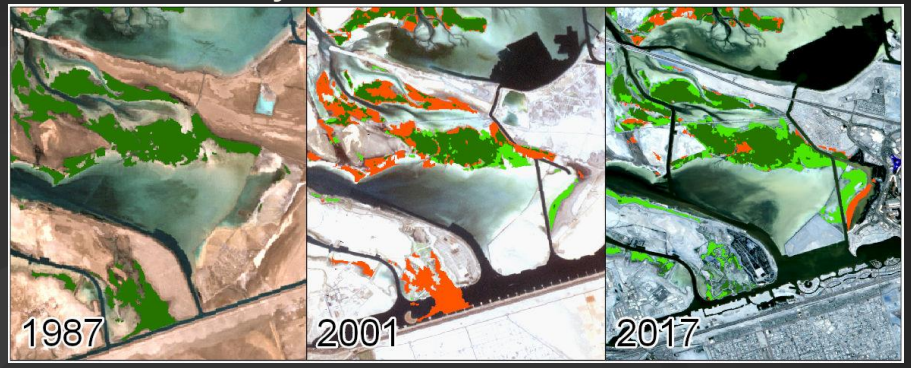


Coastal Resilience and Surge Modeling

Natural Shoreline Resilience – Mangrove Health Indexing

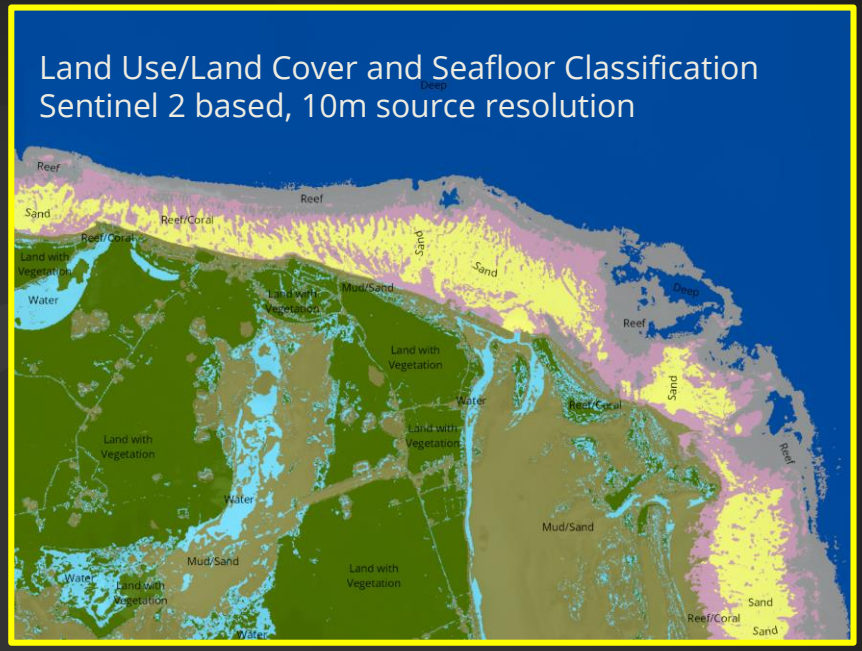
- Established baseline mangrove and vegetative health
- Comparison using archive imagery and tasked WorldView
- Mangrove and habitat loss has direct influence on coastal resilience to storms
- Mangroves are the key wave dissipative measures on many small island economies and during bad storms or hurricanes they suffer severe and often fatal damage and do not recover without human intervention.
- Mangrove mapping through multiple months and years provides a health index for each mangrove crown or stand.
- Targeted regeneration programs helps maintain storm and flood resilience as well as a tourist attraction opposed to unattractive heavy duty seawalls.

Landsat's 30yr archive and tasked WorldView



Mangrove Disturbance Index – Abu Dhabi

LULC and Seafloor Classification – Turks and Caicos

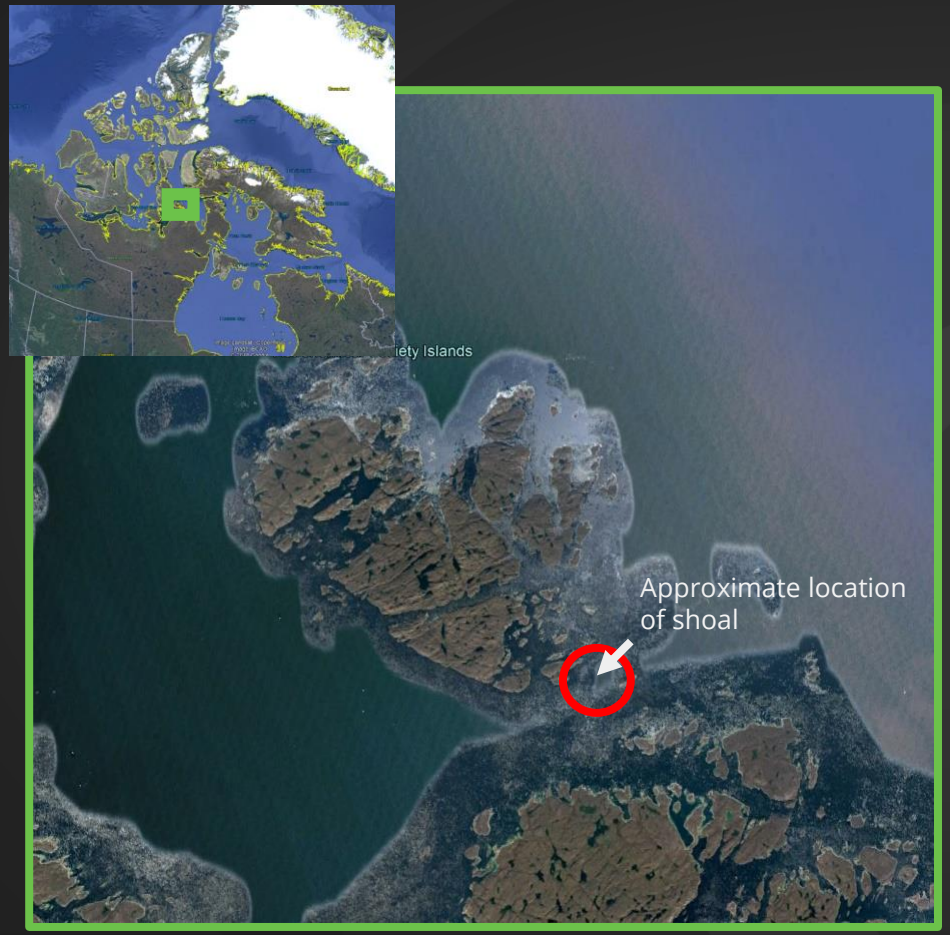


Seamless Land Use/ Land Cover and Seafloor Classification provides before/after event quantification of habitat change

Provides more accurate seabed friction modeling and Manning coefficients overland for storm surge modeling

Ship Groundings and Hazard Detection

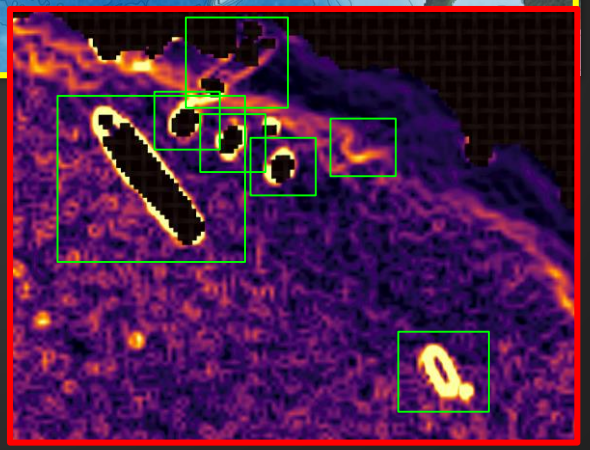
Case in Point: Grounding of Akademik Ioffe




https://oceanconservancy.org/blog/2018/09/03/ship-runs-aground-arctic-ocean/

- Ran aground on a shoal in late August 2018
- Within secondary NW Passage Route
- No injuries and no indication of oil spill
- TCarta tasked this location but bad weather for collection prevented collection prior to ice
- < 2 % of U.S. Arctic waters surveyed with MBES[1]

Hazard Detection and Feature Extraction Example - Bermuda



- Shallow water reconnaissance from satellite imagery
- Multi-modal hazard detection and feature extraction
- Through-the-water Stereo photogrammetry techniques used for validation
- Objects as small as <1m can be detected from WorldView, up to 25m depths
- Natural and Manmade hazards distinguished

Satellite Derived Bathymetry Use Case: Hurricane Irma Recovery

Commonwealth Marine Economies Program (CME)

Enabling Safe and Sustainable Marine Economies across Commonwealth Small Island Developing States (SIDS)

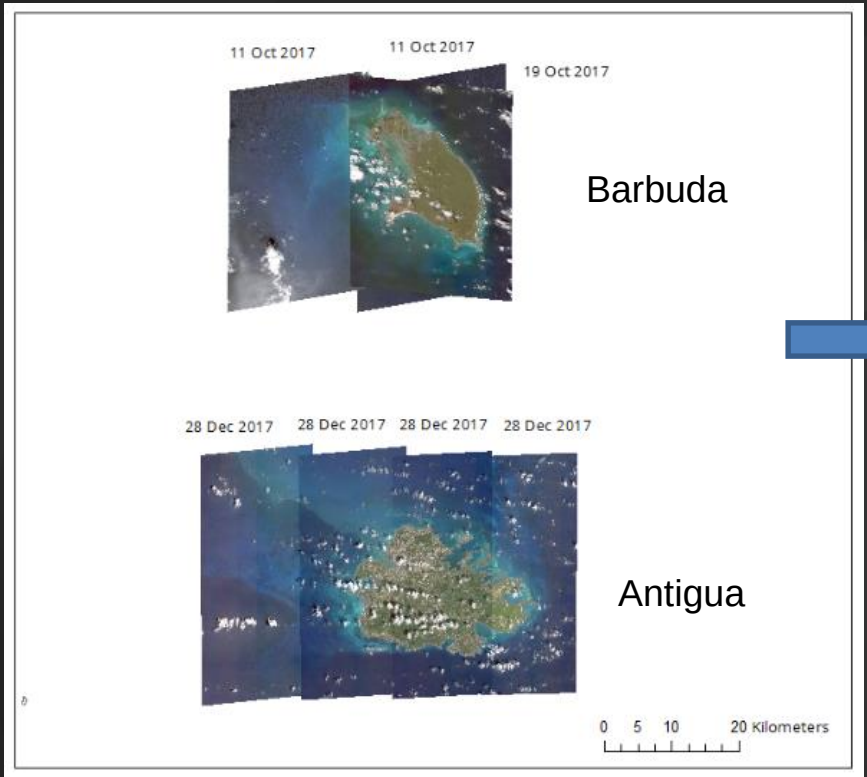
PROJECT SCOPE

- Centre for Environment, Fisheries and Aquaculture Science (Cefas) commissioned work with Antigua and Barbuda under CME Program (UK)
- Objective to model both overland and storm surge flooding
- Project completed 100% remotely
- Estimated less than 10% cost of traditional survey
- Completed in a fraction of the time of local survey

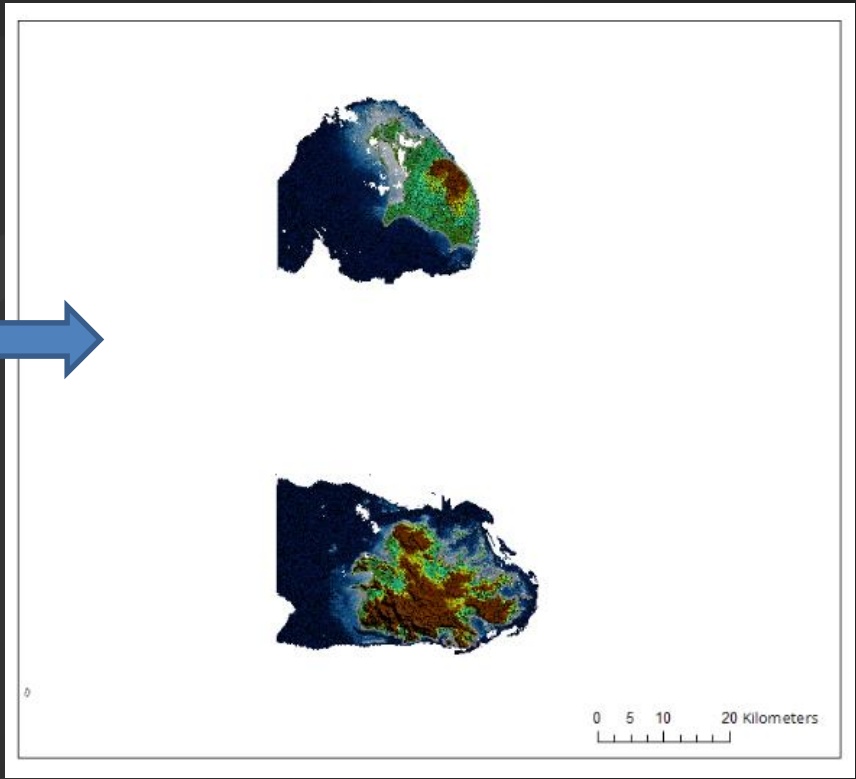
SPECIFICATION

- Seamless land and marine surface
- Pre and post hurricane analysis
- Bathymetry at 2 meter spacing, vertical accuracy of 12% of depth (CE90)
- DSM provided at 0.5 meter spacing (accuracy of 3m CE90 LE90)
- Vegetation removed from terrestrial component for overland flow analysis

Antigua and Barbuda - Pre and Post Hurricane Irma



Source Imagery – WorldView3



2m Satellite Derived Bathymetry

Satellite-Based Hydrography

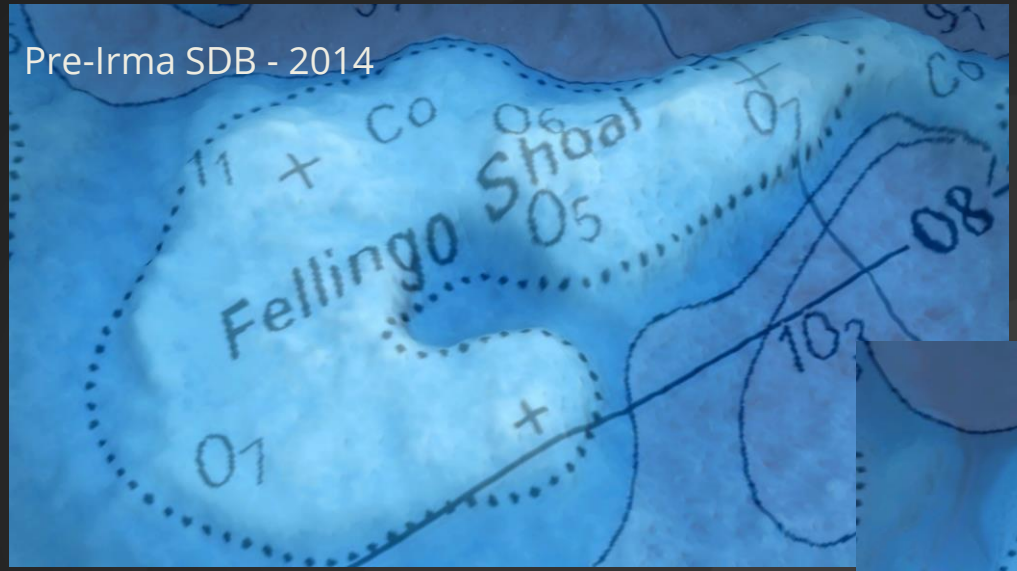
DISADVANTAGES

- Optical method requires clear water
- 25-30m maximum achievable depth
- At present no standards exist for SDB
- Cloud cover, wavy conditions are challenging
- Ports and boat traffic are difficult
- Physics-based approach requires understanding of seabed types and spectral response

ADVANTAGES

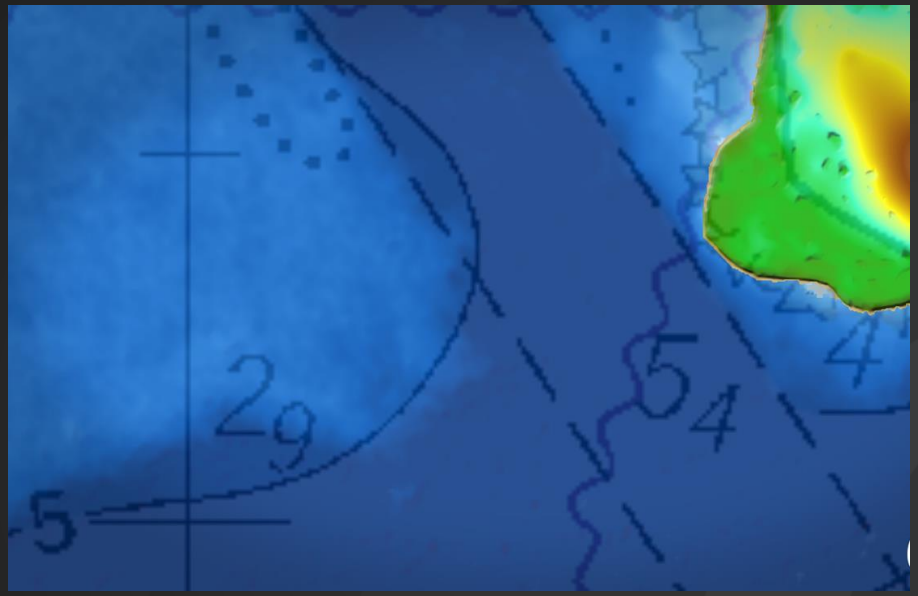
- Large coverage and rapid production
- Project completed remotely
- <10% cost of traditional survey
- No mobilization cost, time delay, and risk
- Eliminates risk to safety and environment
- Seafloor classification produced simultaneously
- Reconnaissance tool for MBES planning
- Archive imagery allows for before/after event analysis

Antigua - Shifting Shoals



- Sandy and unconsolidated shoals show flattening
- Changes to seafloor type distribution
- Potential impact on local fisherfolk and tourism related activities

Antigua - Shifting Channel Edges



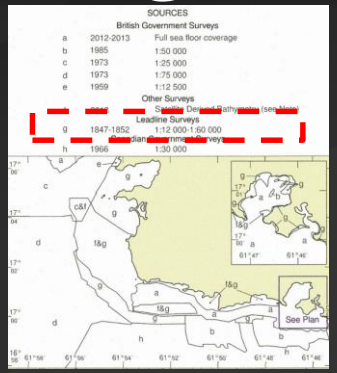
- Dredged channel shows in-fill effect from hurricane
- Affected navigation channel.
- Assisting port authority management.
- Prioritize engineering works for shipping.

Antigua - Infilled Channels

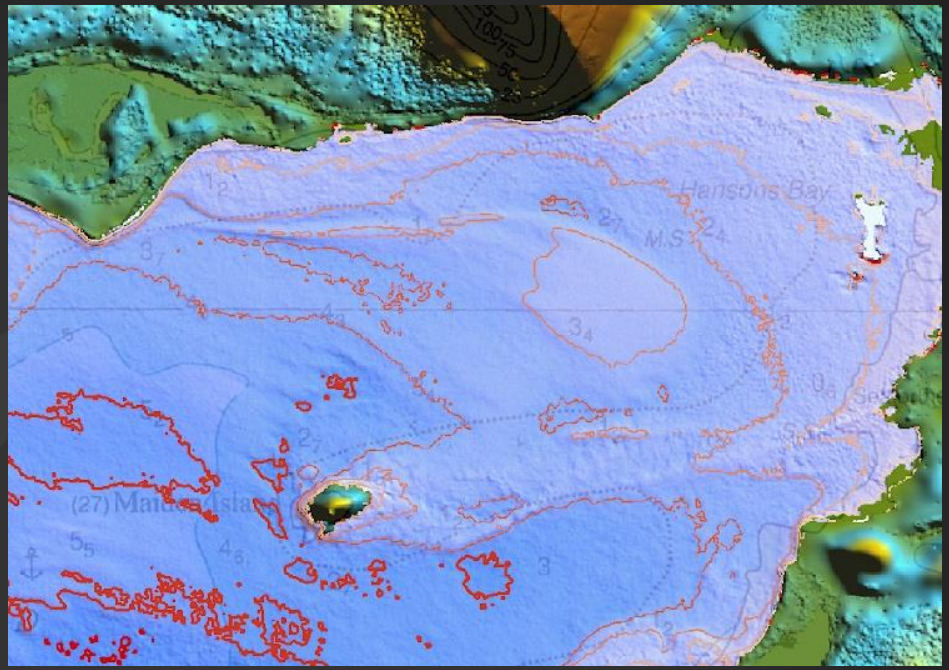
- Dredged channel shows in-fill affect from hurricane
- SDB indicated ~1.5m of infilling
- Not a major Harbour but important for local economy

Antigua – Five Island Harbour

Existing data source – Leadline surveys from 1847-1852



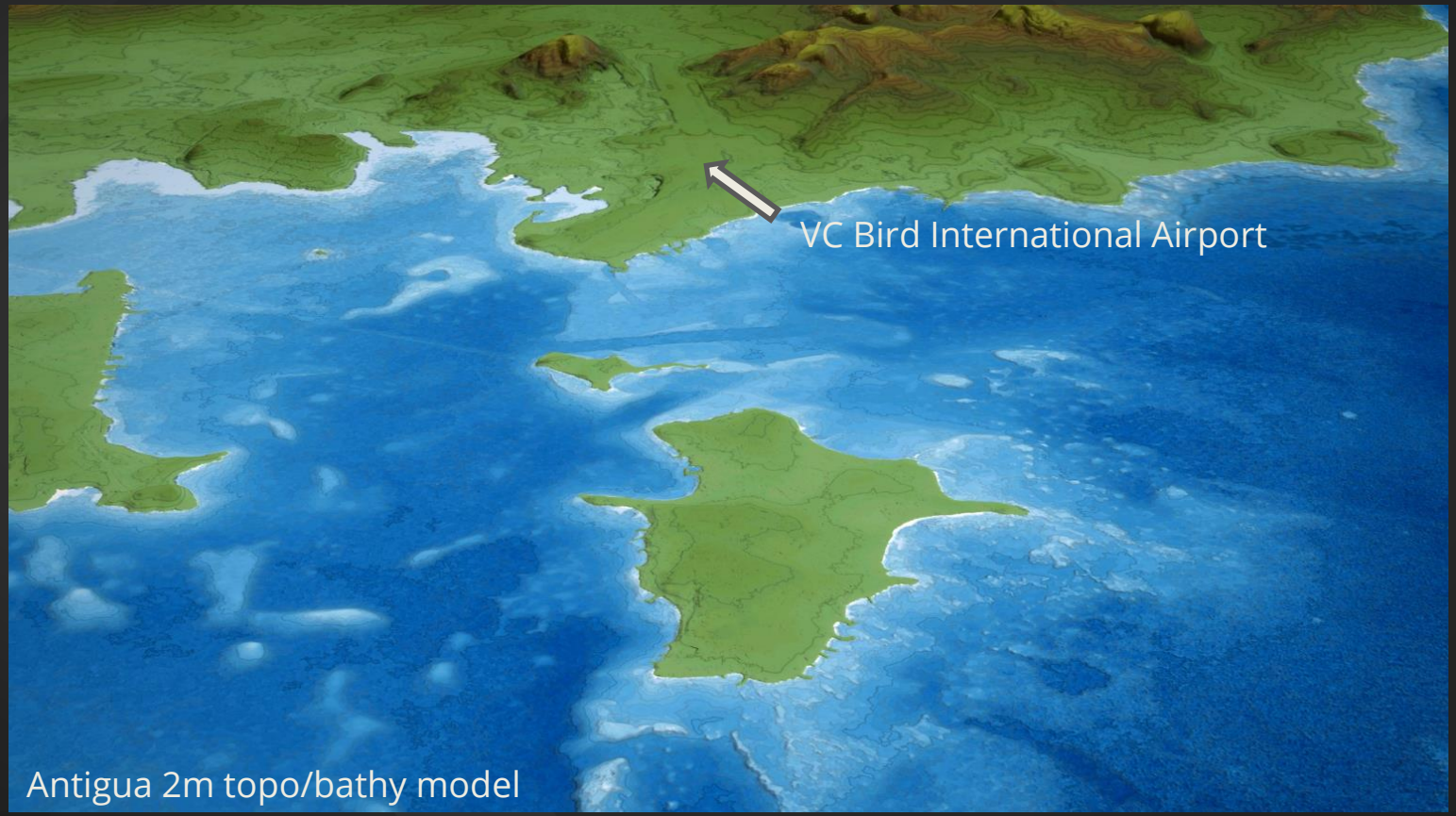
Post-Irma WorldView 2m SDB - 2017



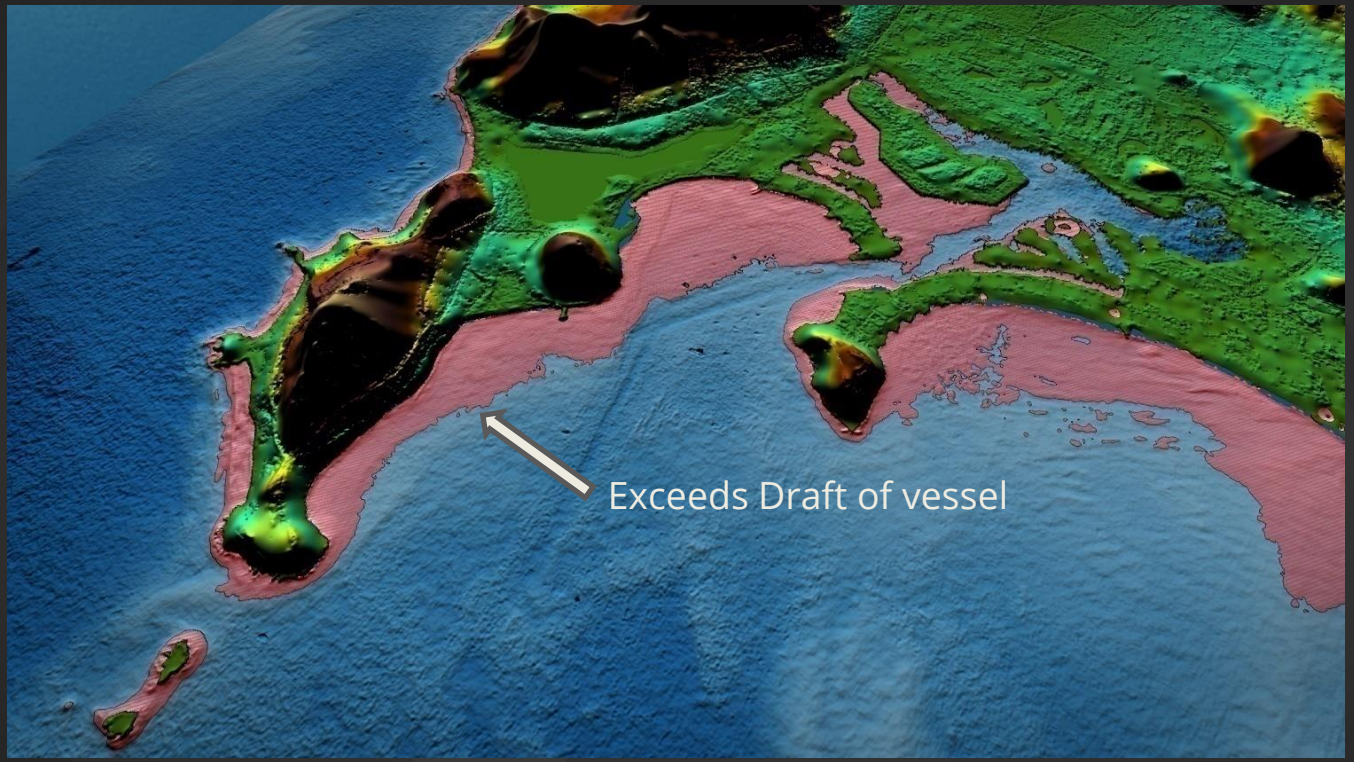
Using modern satellite imagery and physics-based SDB with stereo photogrammetric bathymetry validation, source bathymetry for Five Island Harbour was updated by ~170 years. Remote validation at +-12% of depth

Seamless Topography and Bathymetry

100% derived from DigitalGlobe WorldView High Resolution Optical Satellites



Amphibious Landing Planning

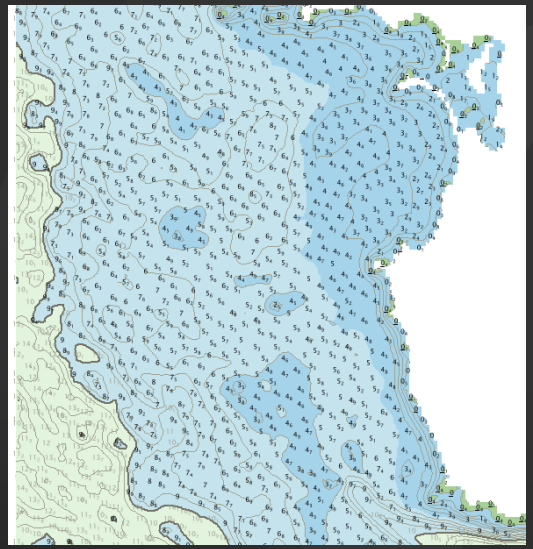


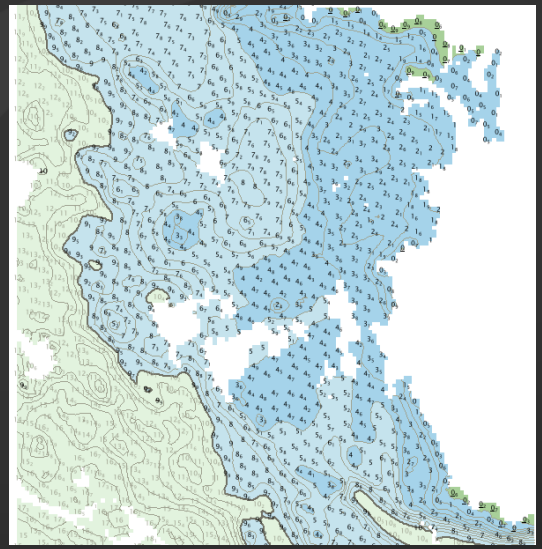
Facilitate landing diagram creation, using hydrographic observations to identify hazards, optimal boat lanes and landing beaches based on craft capabilities and seafloor classification.

S-57 Delivery Standards

- Remote Locations. Rapid delivery, <1 week from tasked imagery to bENC
- Seafloor classification, navigation features and bENC are produced side by side
- Complex shallow weighted smoothing for conservative charts.
- Visualization of S-57 in free software such as EasyView (free), CARIS Base Editor (proprietary), or NaAVIC (IIC Technologies).

Pre-Hurricane bENC





Post-Hurricane bENC

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10m Satellite Derived Bathymetry – Isla Grande, Colombia