ICCE 2018
36TH INTERNATIONAL CONFERENCE ON COASTAL ENGINEERING 2018
Baltimore, Maryland | July 30 – August 3, 2018
The State of the Art and Science of Coastal Engineering

Hurricanes Irma/Maria In the USVI: Joint JSCE-NSF Field Reconnaissance and the use of UAVs for Geospatial Disaster Data

Dan Cox[1], Andre Barbosa[1], Greg Guannel[2], Andrew Kennedy[3], Chase Simpson[1], Richie Slocum[1], Nobuhito Mori[4], Taro Arikawa[5], Daisuke Inazu[6], Tomoya Shimura[4], Takenori Shimozono[7], Tracy Kijewski-Correa[3], Chris Parrish[1]

[1]Oregon State Univ., [2]Univ. Virgin Islands , [3]Notre Dame Univ.,
[4]Kyoto Univ., [5]Chuo Univ., [6]Tokyo Univ. Marine Sci. Tech., [7]Univ. Tokyo

IRMA

Sept 6, 2017

BVI

St. Thomas

St. Johns

USVI

Puerto Rico

St. Croix

MARIA

Sept 20, 2017

30 km

Survey Teams

November 8-12, 2017
(approx. 2 months after Irma)

JSCE– Coastal Engineering

- Nobuhito Mori (lead), Kyoto U.
- Taro Arikawa, Chuo U.
- Daisuke Inazu, TUMST
- Tomoya Shimura, Kyoto U.
- Takenori Shimozono, U. Tokyo
- Eisuke Shimakawa (NHK)
- Shinya Kimura (NHK)

NSF – Wind Engineering

- David Prevat (lead), U. Florida
- David Roueche, Auburn U.
- Kwasi Perry, UAV Survey Inc.

NSF – Coastal Engineering

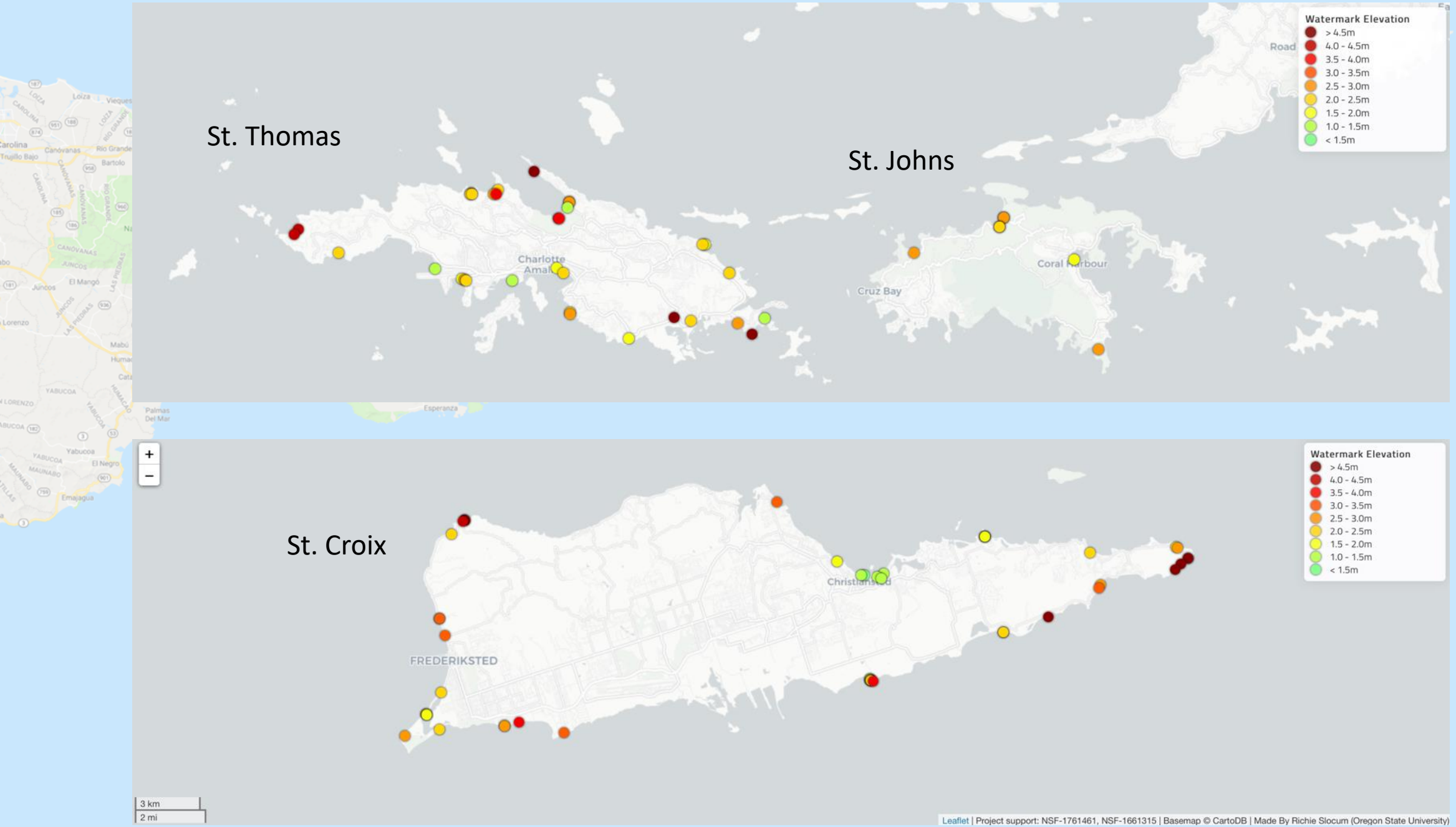
- Dan Cox (lead), Oregon State U.
- Andre Barbosa, Oregon State U.
- Greg Guannel, U. VI
- Andrew Kennedy, Notre Dame U.
- Chase Simpson, Oregon State U.
- Richie Slocum, Oregon State U.

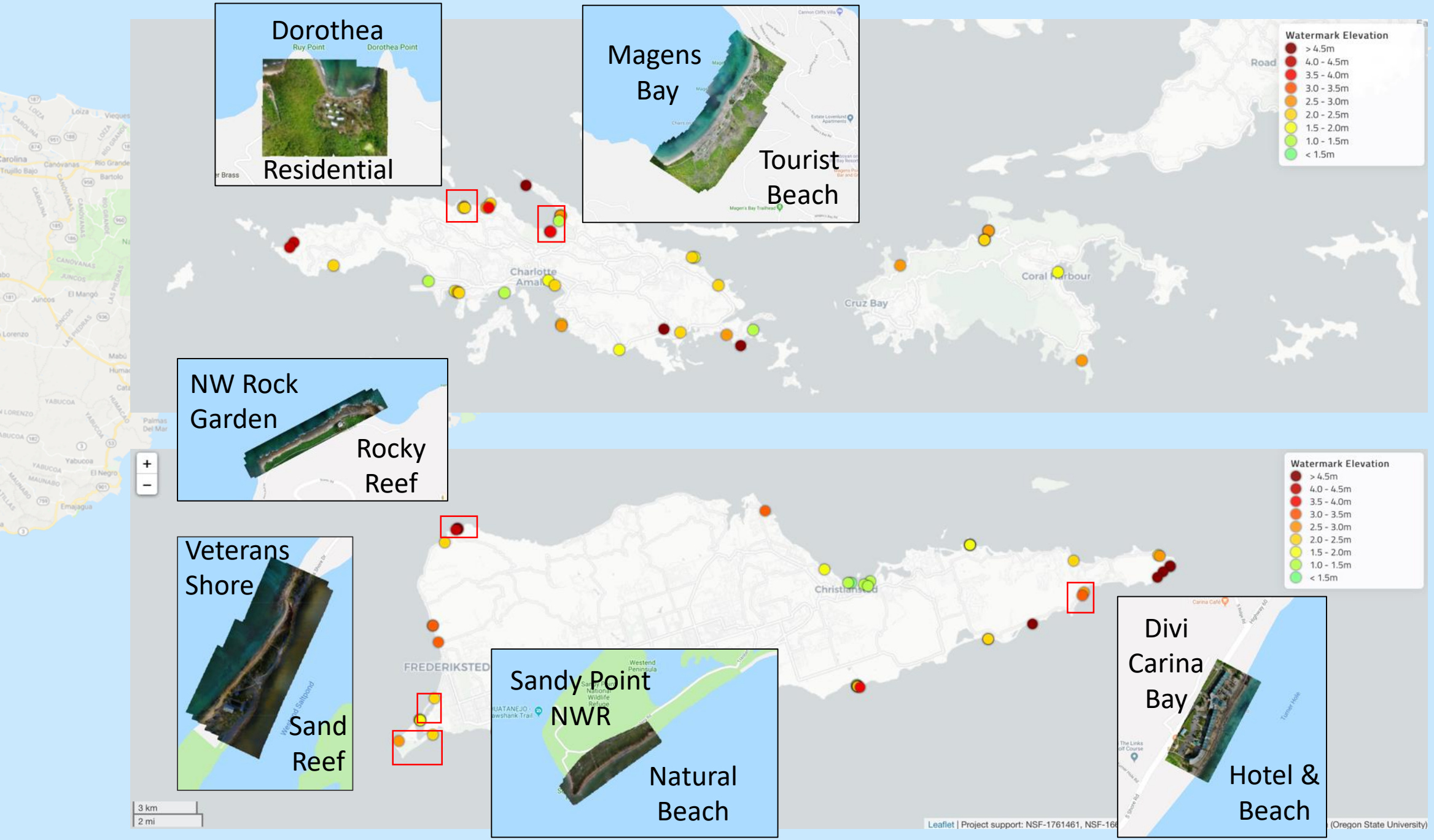
Remote Coordinator/Collaborator

- Tracy Kijewski-Correa (NSF PI), Notre Dame U.
- Andrew Bartolini, Notre Dame U.
- Chris Parrish, Oregon State U.

Purpose

- Collect perishable coastal disaster data related to
  1. Surge levels
  2. Damage to built environment
     - Buildings
     - Lifelines (power, water, transportation, communications)
     - Combined surge/wave and wind
  3. Total sediment transported between the two hurricanes
  4. Ecosystems services provided by reef and vegetation
- Use of newer technology for disaster data collection
  1. UAV survey data
  2. File sharing for photos and metadata (FULCRUM)
  3. Data archive (DesignSafe.org)
- Possible future testbed for disaster recovery and resilience


St. Thomas
St. Johns
St. Croix
Watermark Elevation
> 4.5m
4.0 - 4.5m
3.5 - 4.0m
3.0 - 3.5m
2.5 - 3.0m
2.0 - 2.5m
1.5 - 2.0m
1.0 - 1.5m
< 1.5m
Charlotte Amalie
Cruz Bay
Coral Harbour
Christiansted
FREDERIKSTED
Road
Esperanza
Palmas Del Mar
Yabucoa
Emajagua
El Negro
Juncos
El Mangó
Canóvanas
Carolina
Trujillo Bajo
Río Grande
Bartolo
Loíza
Vieques
Mabú
3 km
2 mi
Leaflet | Project support: NSF-1761461, NSF-1661315 | Basemap © CartoDB | Made By Richie Slocum (Oregon State University)


Dorothea
Residential
Magens Bay
Tourist Beach
NW Rock Garden
Rocky Reef
Veterans Shore
Sand Reef
Sandy Point NWR
Natural Beach
Divi Carina Bay
Hotel & Beach
Watermark Elevation
> 4.5m
4.0 - 4.5m
3.5 - 4.0m
3.0 - 3.5m
2.5 - 3.0m
2.0 - 2.5m
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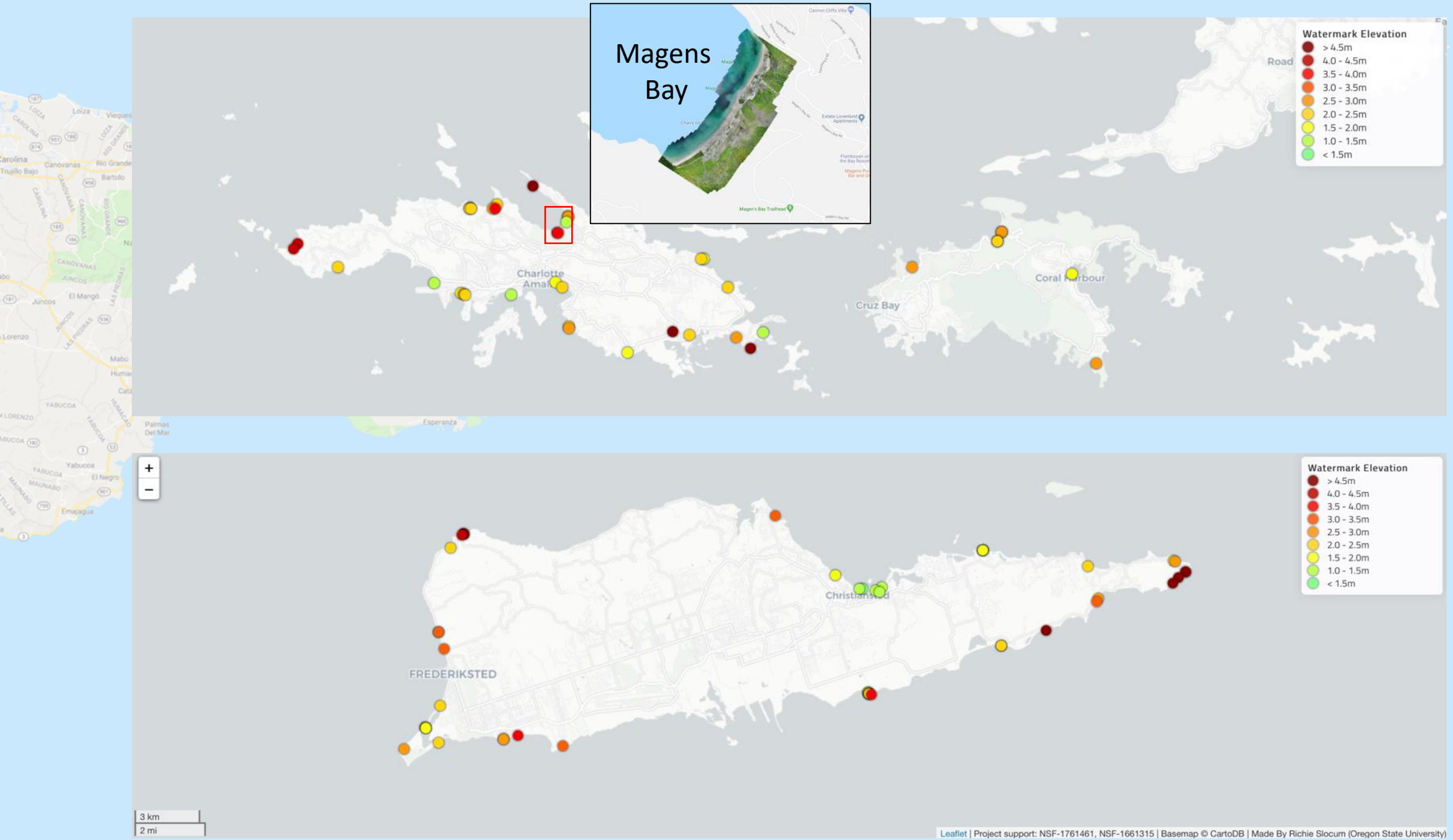
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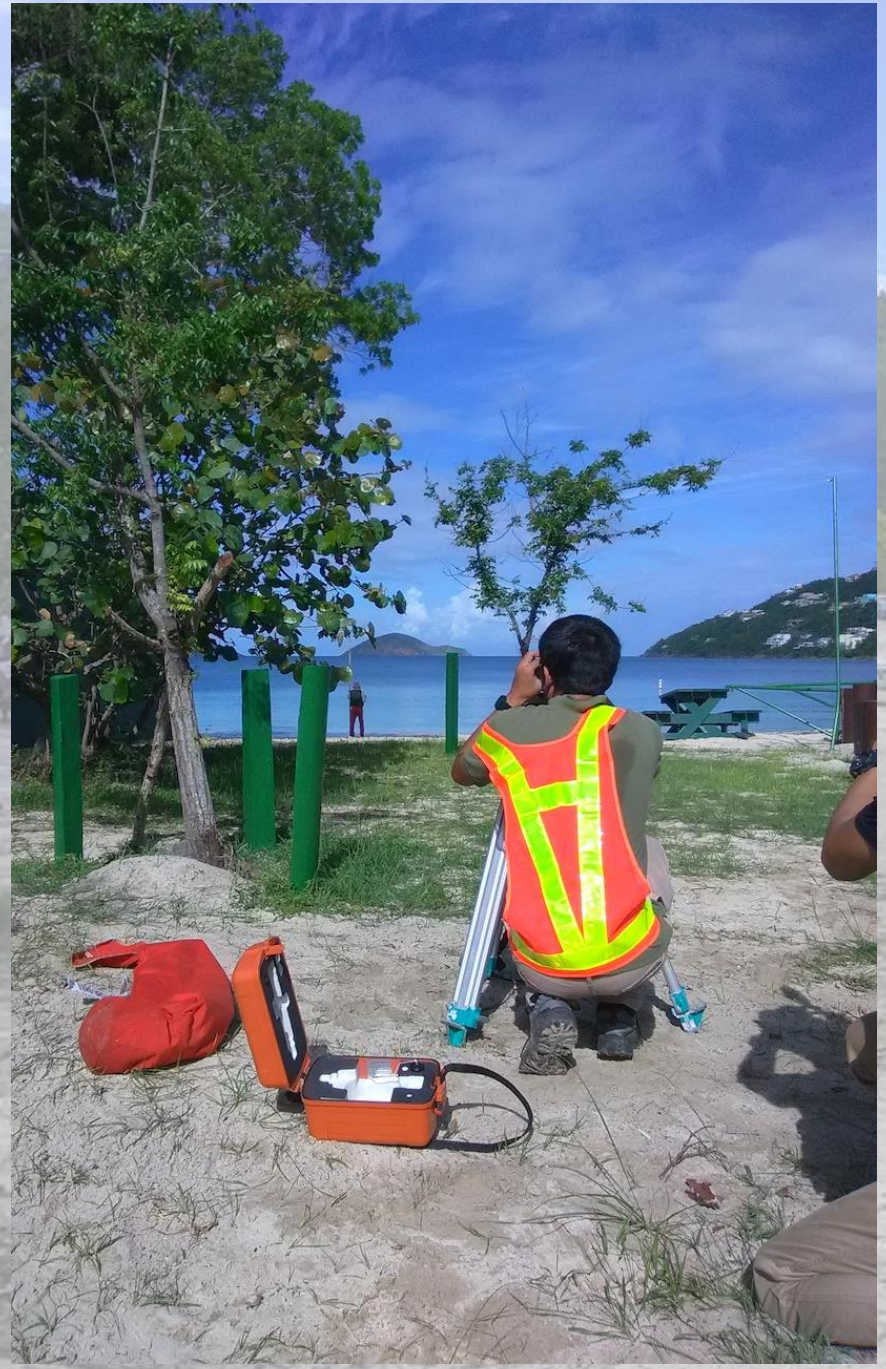

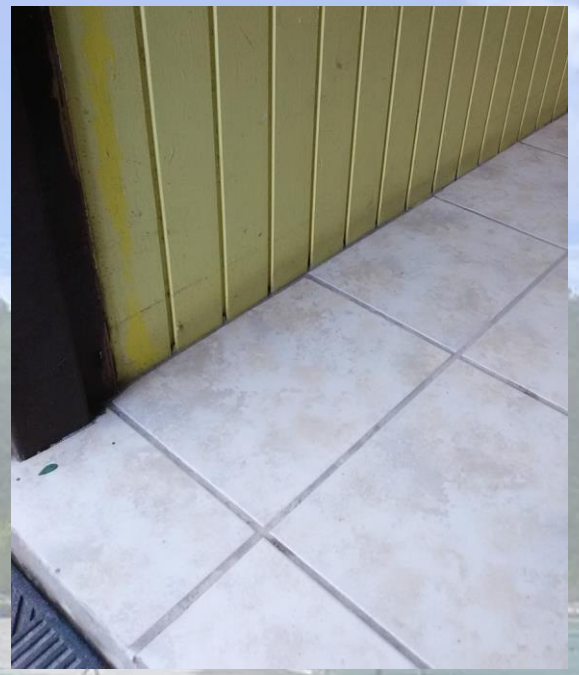

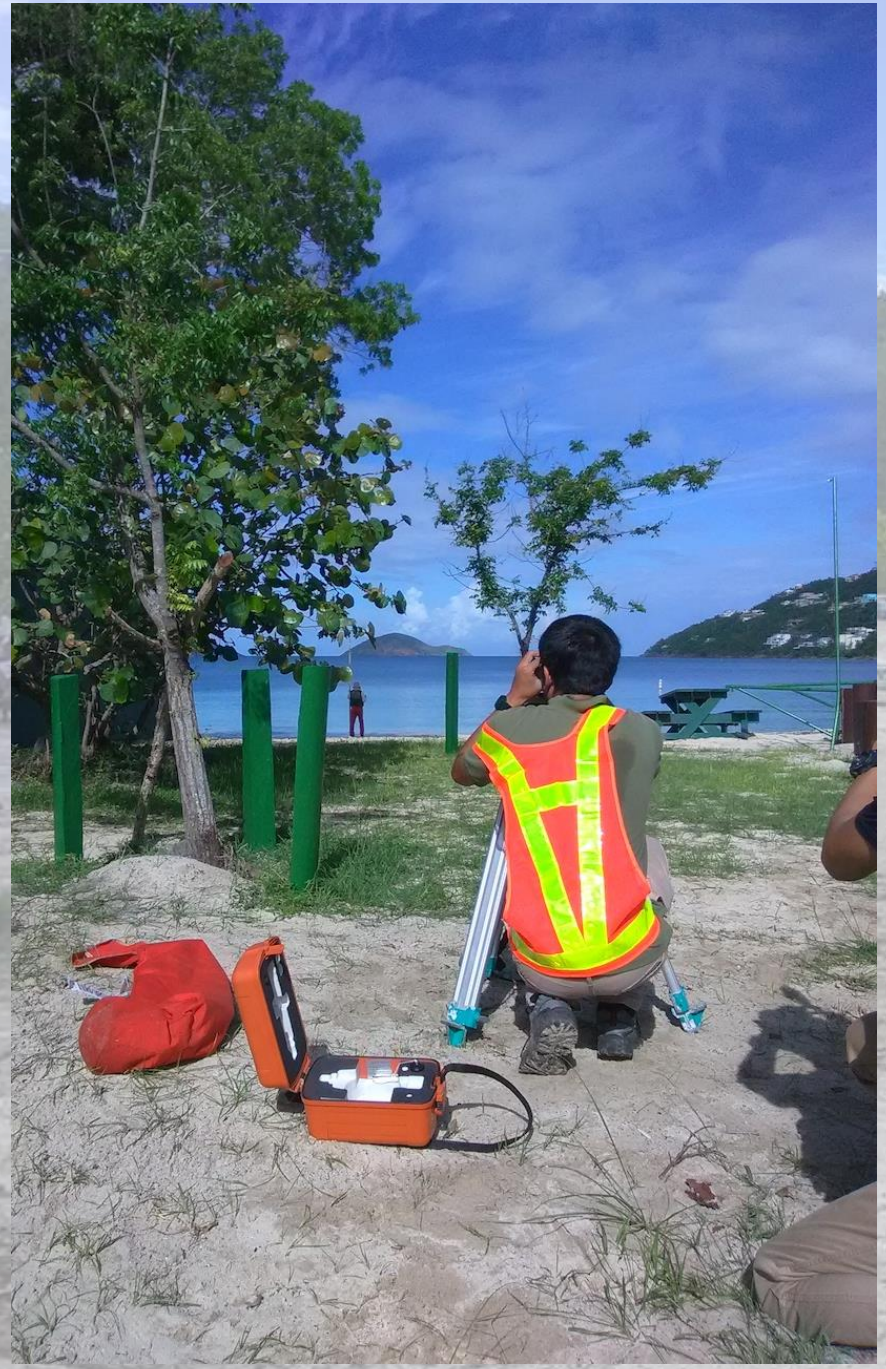

Oregon State University

USVI, November 8-15, 2017

Geospatial Data Products

Location	Island	Date	Time	OrthoPhoto	DSM	Pointcloud	meta
Magens Bay	STT	Nov 10, 2017	12:10 PM	link	link	link	link
Dorothea Beach	STT	Nov 11, 2017	09:39 AM	link	link	link	link
Divi Carina Bay	STX	Nov 13, 2017	08:35 AM	link	link	link	link
Sandy Point	STX	Nov 13, 2017	11:42 AM	link	link	link	link
Veterans Shore Washout	STX	Nov 13, 2017	05:02 PM	link	link	link	link
Veterans Shore Washout Bathy	STX	Nov 13, 2017	05:21 PM	link	n/a	n/a	link
Northwest Rock Garden (All)	STX	Nov 14, 2017	10:24 AM	link	link	link	link
Northwest Rock Garden (Detail)	STX	Nov 14, 2017	10:38 AM	link	link	link	link

Beach

Structures

Structures

Beach

Reef/Beach

Reef

http://research.engr.oregonstate.edu/lidar/pointcloud/20171107_USVI/

Location	Island	Date	Time	OrthoPhoto	DSM	Pointcloud	meta
Magens Bay	STT	Nov 10, 2017	12:10 PM	link	link	link	link

```
   Magens Bay
------------------------------
Station ID                    : MagensBay
Date                          : 10 Nov, 2017
Local Time                    : 1210-1602
UTC Time                      : 1610-2002 UTC
Location                      : "Magens Bay", St Thomas, USVI, USA
Latitude                      : 18°21'44.11"N
Longitude                     : 64°55'26.29"W

UAS Platform                  : DJI Mavic Pro with Polarizing Lens Filter
Type Of UAS Flight            : RECREATIONAL

------------------------------
   RAW DATA
------------------------------
Mapping Nadir Images          : 490 (186+152+152)
Mapping Oblique Images        : 171
Overview Images               : 64
Overview Video                : 0

------------------------------
   MAPPING PRODUCTS
------------------------------
Processing Software           : Agisoft Photoscan 1.3.3 build 4827 (64 Bit)
OrthoPhoto                    : YES
DSM                           : YES
KMZ                           : YES
Textured Model                : YES
Pointcloud                    : YES
PoTree                        : YES

------------------------------
   MAPPING DATUM/ACCURACY
------------------------------
Horizontal Datum              : WGS-84 / NAD83 UTM 20N
Absolute Horizontal Accuracy  : *+/- 10cm
Vertical Datum                : "Above Sea Level" from DJI Mavic GPS in exif data
Absolute Vertical Accuracy    : *+/- 10cm
QAQC                          : Minimal

*Note: The horizontal and vertical accuracies are estimated based on the
accuracy of the control network, and the processing teams experience with SfM
software.  With SfM, regions with low texture, high presence of vegetation,
and clear water will have much higher uncertainties.  Also, the North-Eastern
side of the beach had no control points, and is expected to have errors up to
a few orders of magnitude larger than the South-Western side.

------------------------------
   CONTROL NETWORK
------------------------------
Number of GCPs                : 9
GPS Equipment Used            : Trimble R8
Total Station Used            : Leica TS15
Estimated Control Accuracy    : * Approximately +/- 1cm

*Note: Uncertainty per point is computed, see raw data

------------------------------
   SUMMARY
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Magens Bay was mapped in detail using multiple UAS flights.  A control network
of Ground Control Points was generated using L1/L2 Carrier Phase GPS and a
Total Station.  The control network was focused solely on the South-West half
of the beach. Independent topography and bathymetry shots were measured using
a prism pole, and could be utilized to perform an accuracy assessment if
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~ $ 1,200

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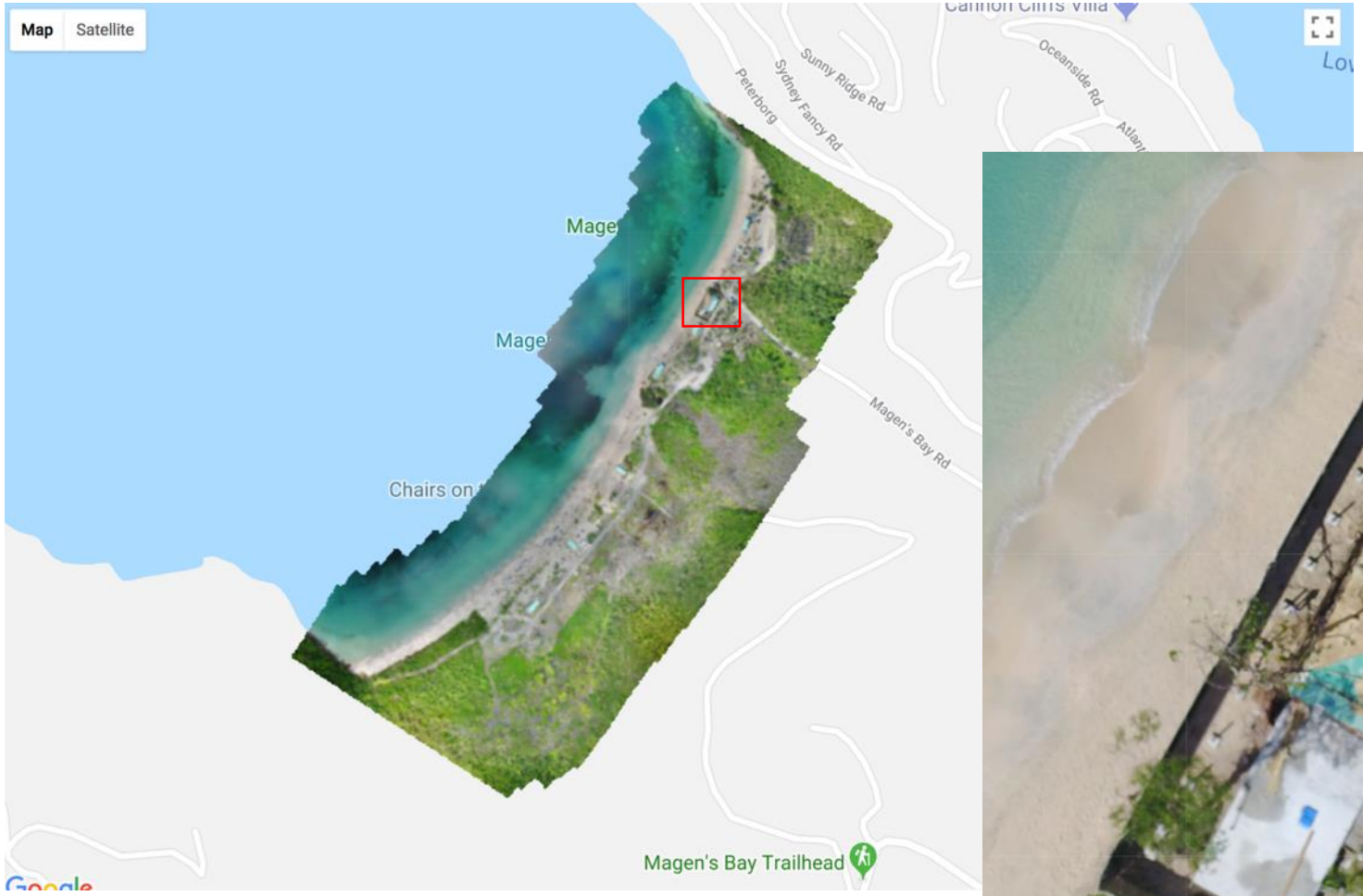

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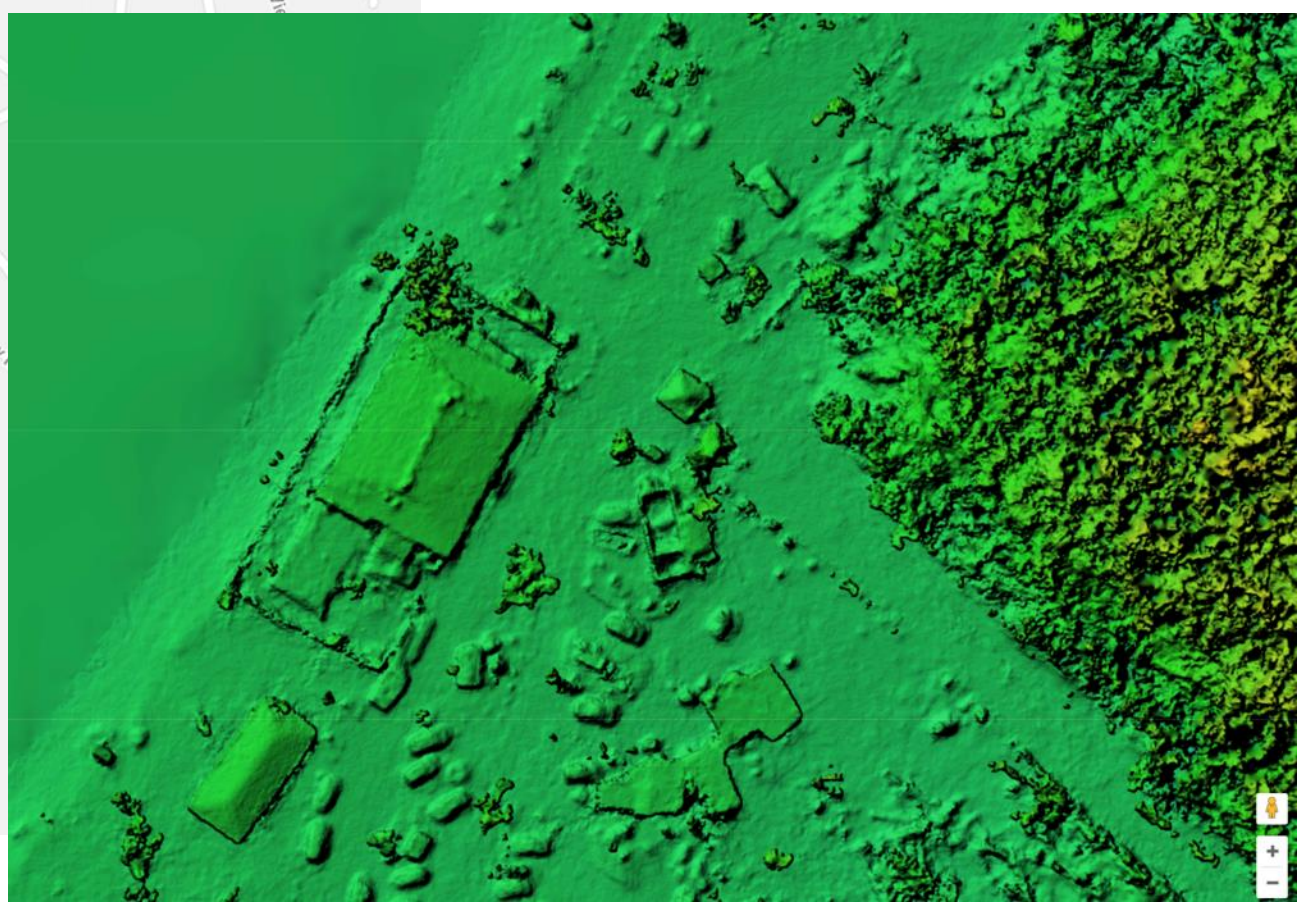

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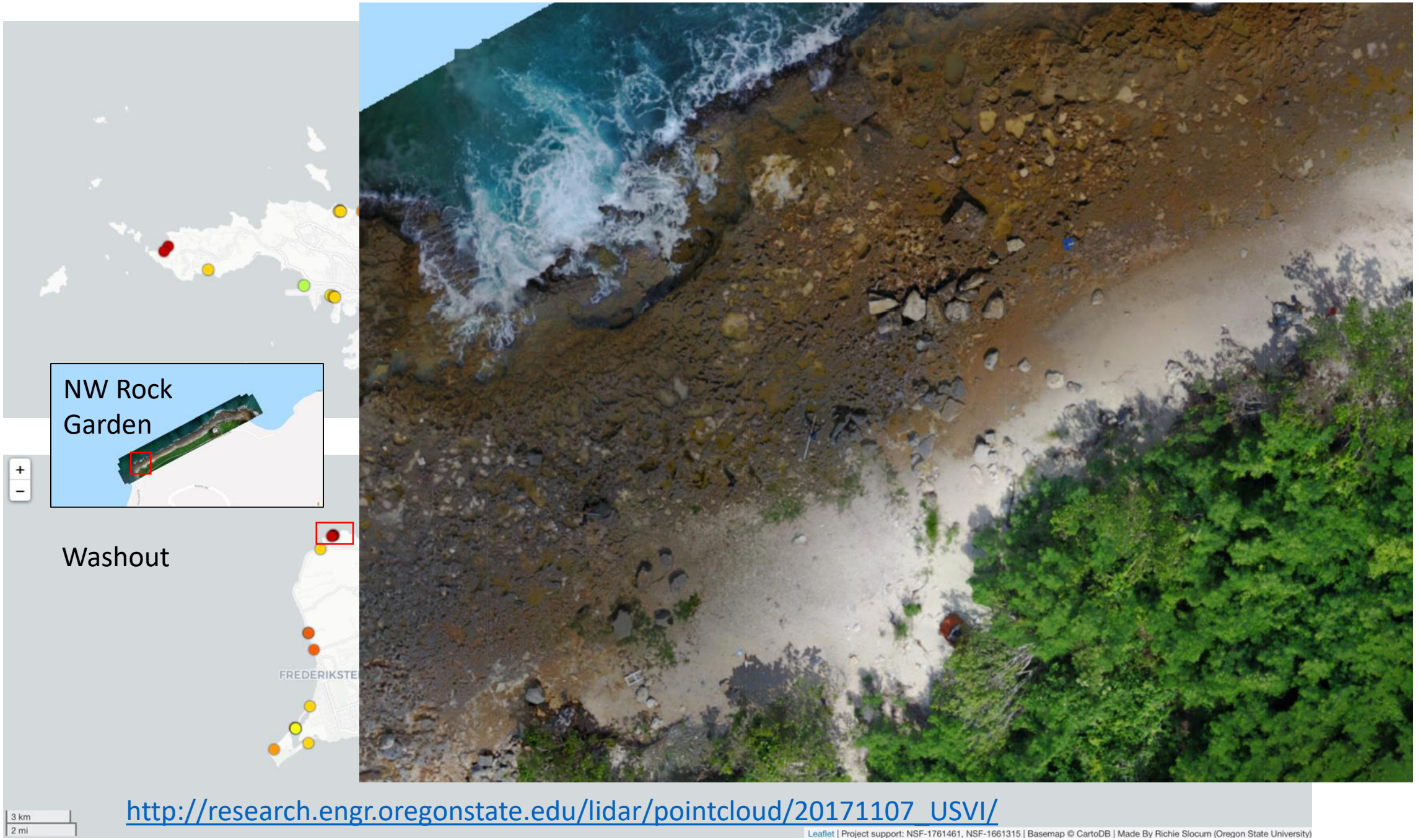
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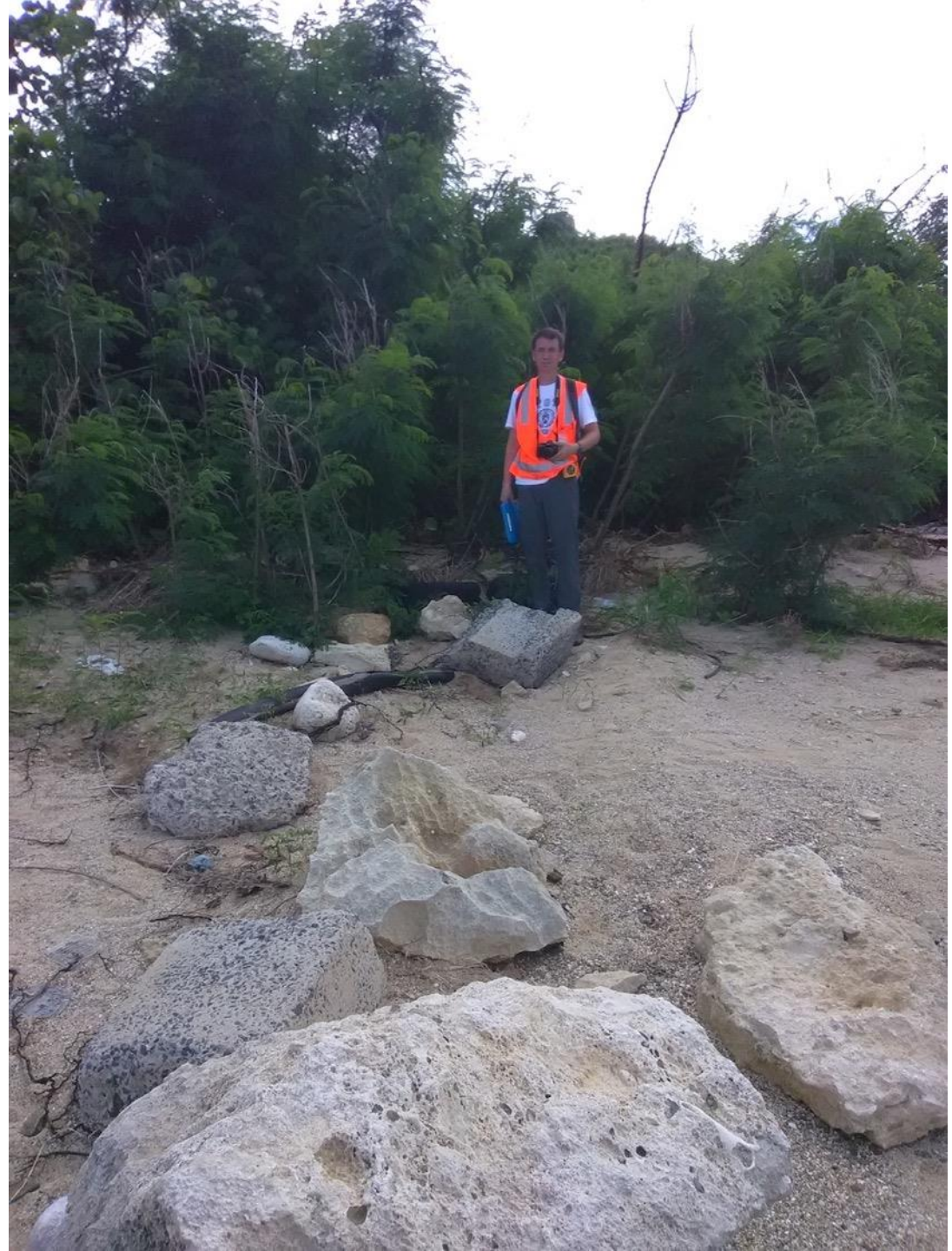
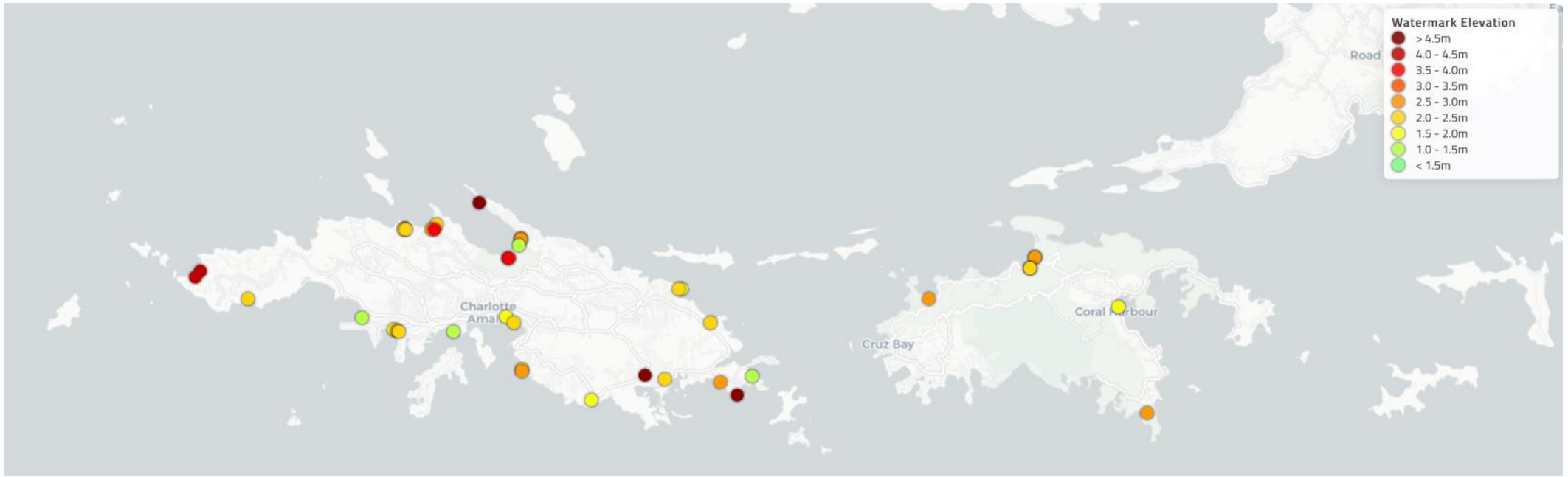



potree.org - github - twitter
1.4RC
Appearance
Point Budget: 1,000,000
Point Size: 3.00
Field of View: 60
Opacity: 1.00
Point Sizing
Fixed
Quality
Squares
Skybox
Eye-Dome-Lighting
enable
radius: 2.0
strength: 1.0
Navigation
keep above ground
move speed 24.3
Tools
Measurements
Material
Scene
Classification Filter
Settings
Littlebay Point, St. Croix, USVI. November 14, 2017
Data collection performed by Oregon State University following 2017 Hurricane Ir
Maria. Project support: NSF-1761461, NSF-1661315
NSF
Oregon State University
College of Engineering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1.0 - 1.5m
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Veterans Shore
Westend Saltpond
FREDERIKSTED
Christiansted
3 km
2 mi
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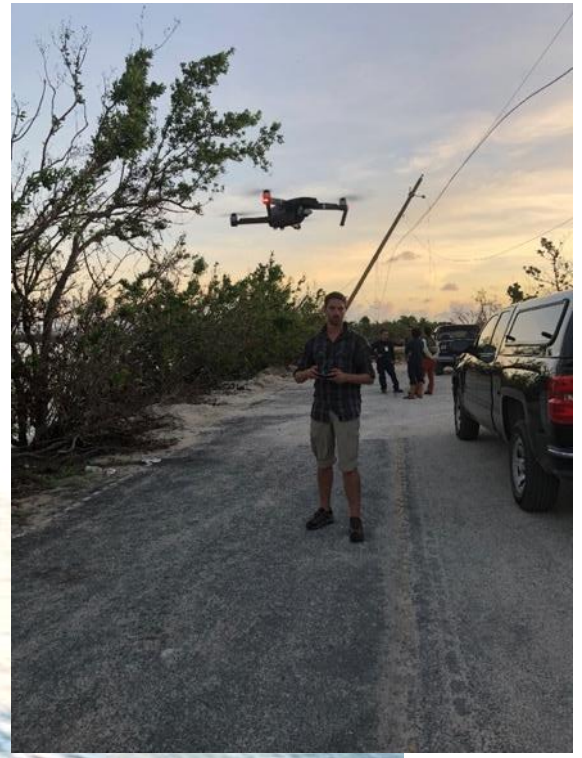

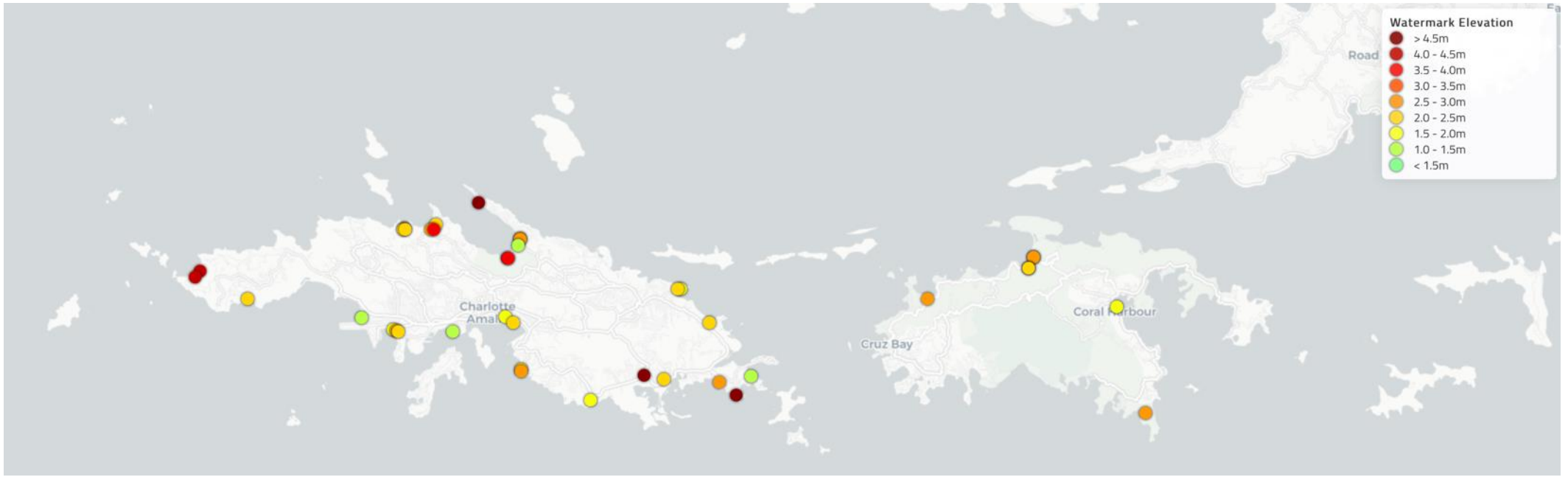
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3.0 - 3.5m
2.5 - 3.0m
2.0 - 2.5m
1.5 - 2.0m
1.0 - 1.5m
< 1.5m
Road
Charlotte
Amal
Cruz Bay
Coral Harbour


Watermark Elevation
> 4.5m
4.0 - 4.5m
3.5 - 4.0m
3.0 - 3.5m
2.5 - 3.0m
2.0 - 2.5m
1.5 - 2.0m
1.0 - 1.5m
< 1.5m
FREDERIKSTED
Christiansted
3 km
2 mi
Leaflet | Project support: NSF-1761461, NSF-166
(Oregon State University)
Divi
Carina
Bay

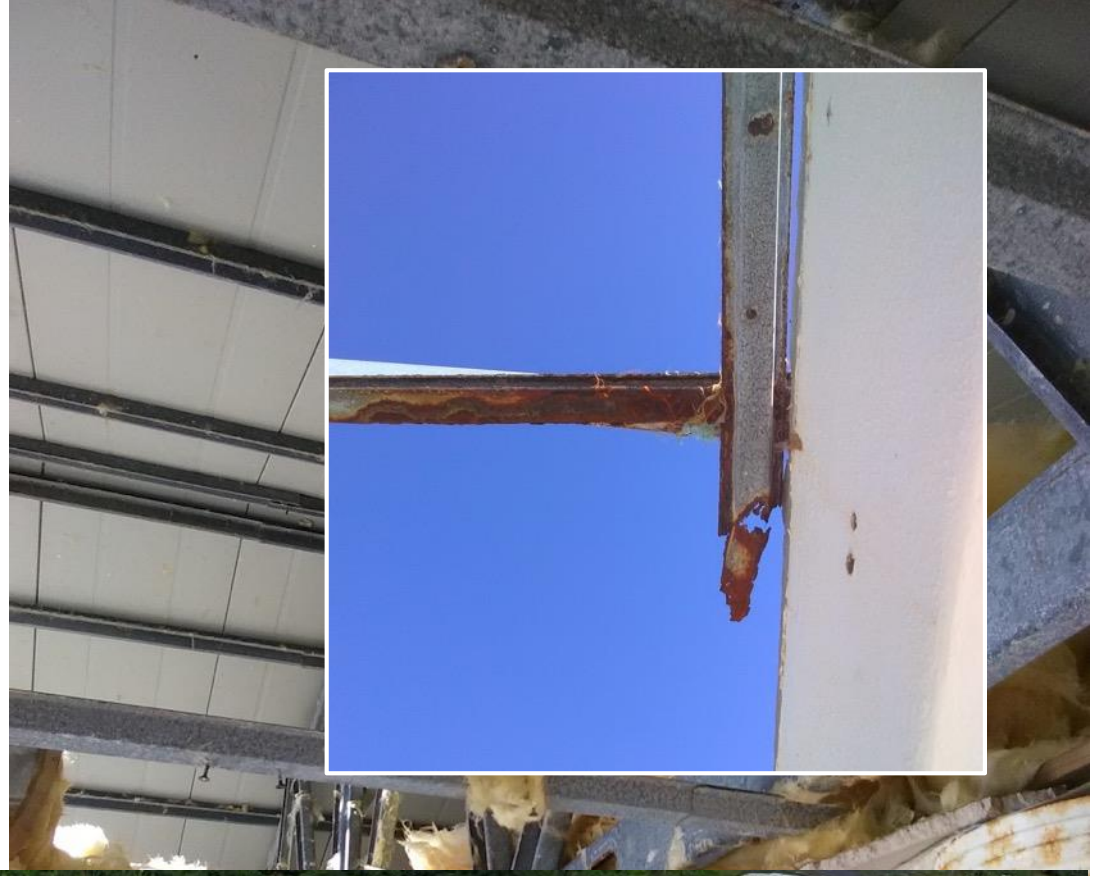
Wind Damage

Almost No Damage

Surge/Wave Damage


OSU
Oregon State
College of Engineering


OSU
Oregon State
College of Engineering
School of Civil and Construction Engineering



Divi Carina Bay	STX	Nov 13, 2017	08:35 AM	link	link	link	link

```
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   RAW DATA
------------------------------
Mapping Nadir Images          : 415 (369+46)
Mapping Oblique Images        : 855 (37+295+197+102+74+150)
Overview Images               : 15
Overview Video                : 5
```

```
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   SUMMARY
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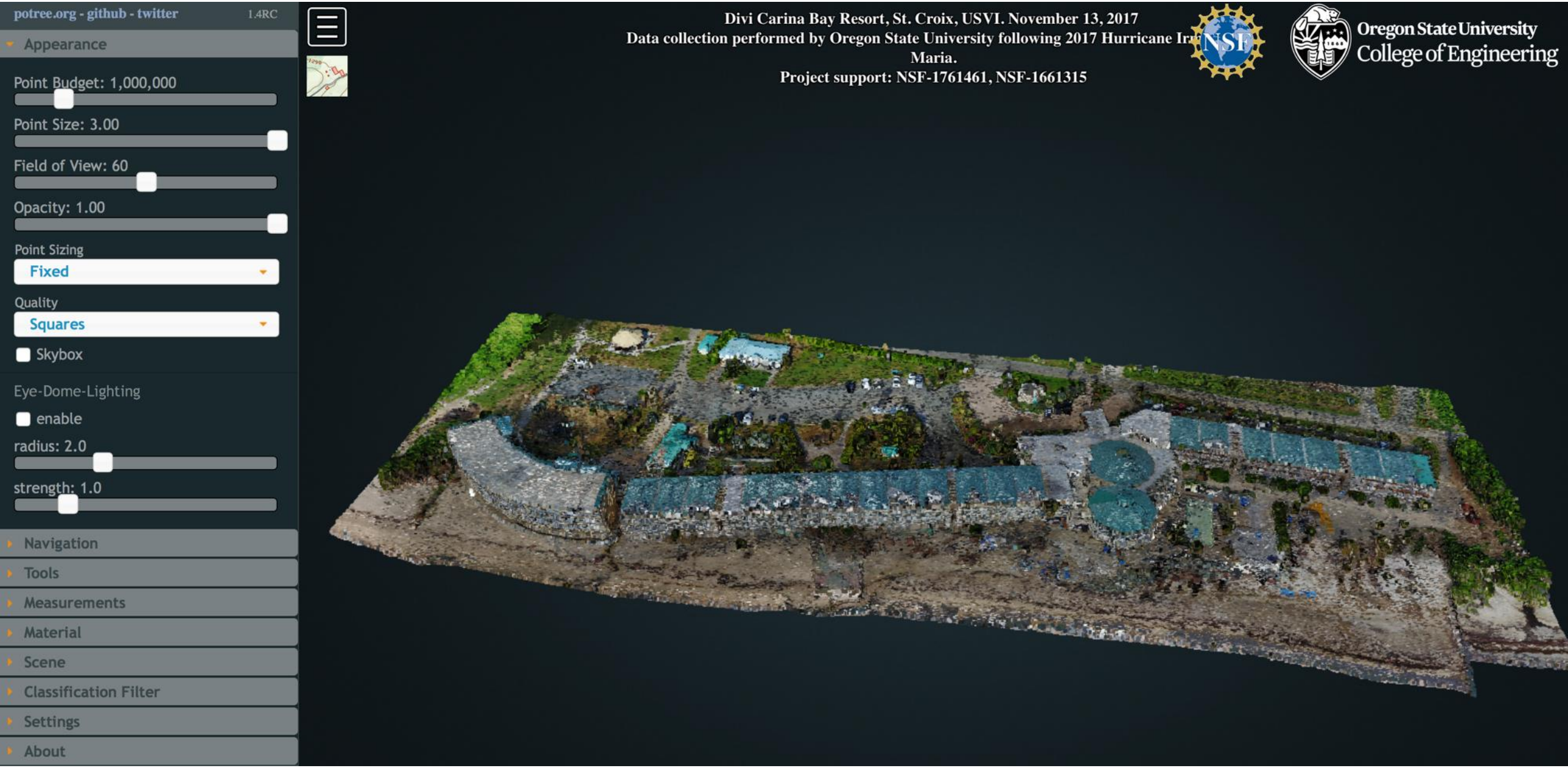
```

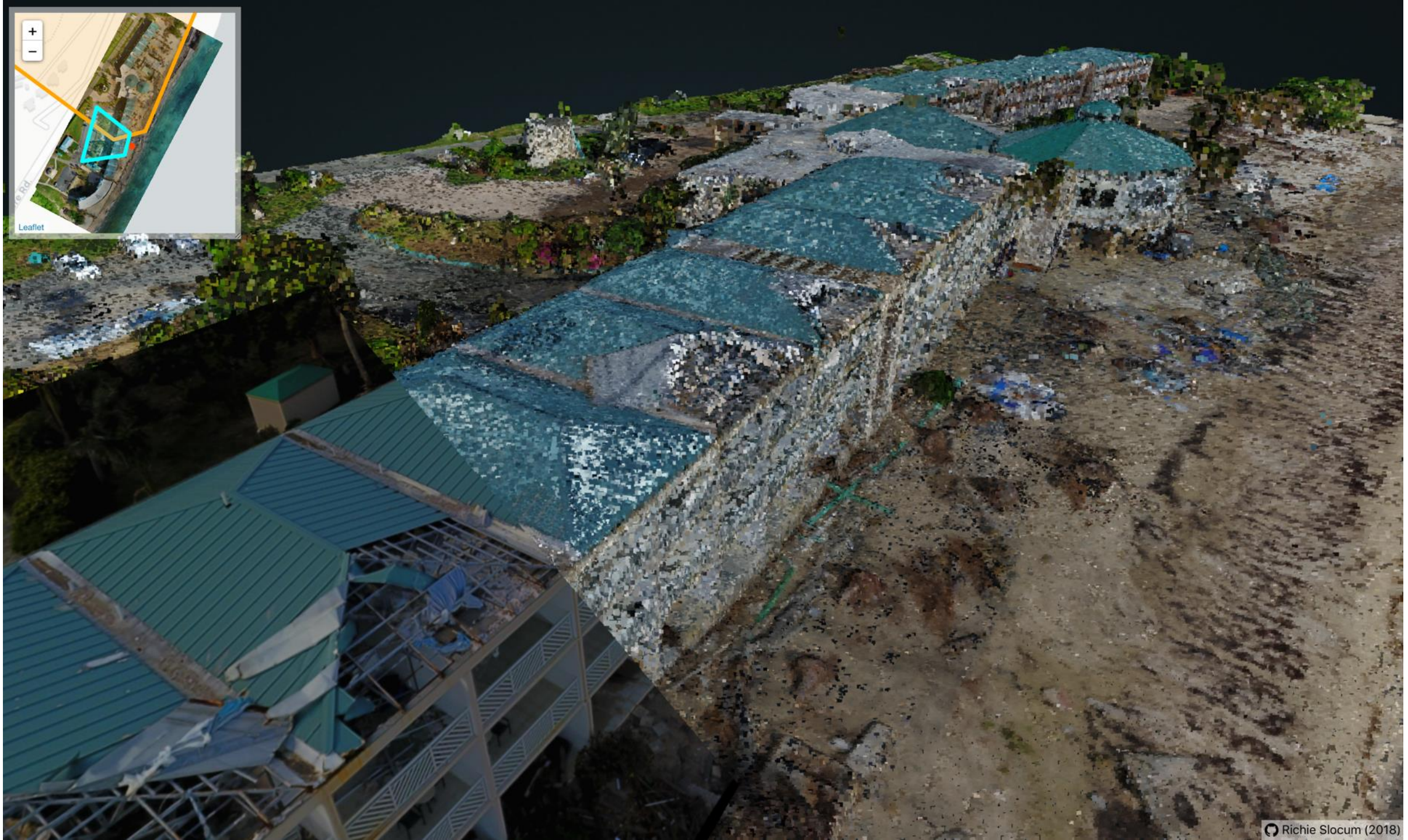
Data was acquired at Divi Carina Bay Resort on two consecutive days. The hotel was badly damaged from the storm, and the acquisition was performed with the goal of generating a high resolution 3D model and capturing the stuctural damage to the building. Multiple nadir and oblique flights were performed in an effort to capture data from all sides of the building. Note that the videos at this location were causing the drone to overheat, and are therefore limited in duration, unfortunately.

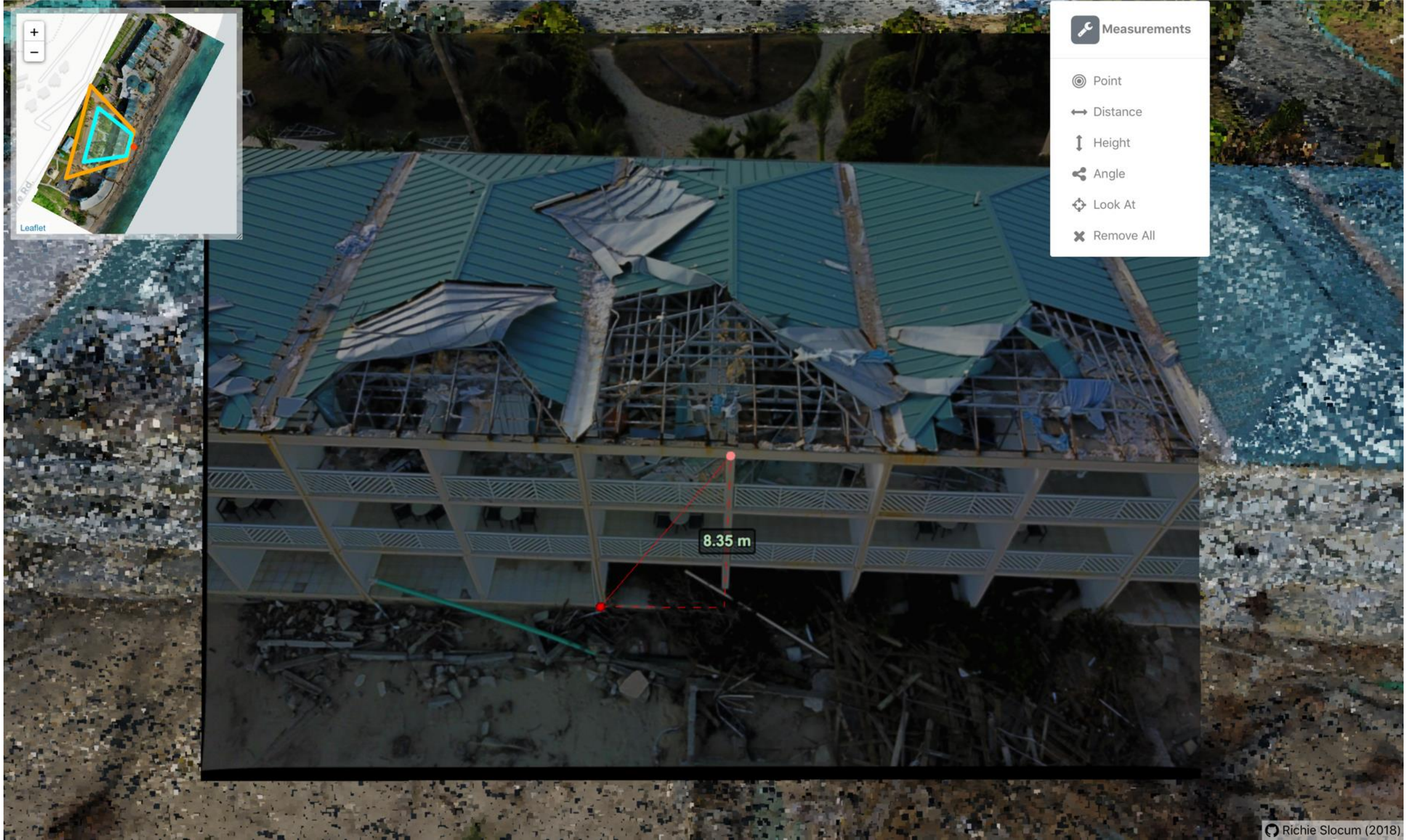


http://research.engr.oregonstate.edu/lidar/pointcloud/20171107_USVI/

Divi Carina Resort, USVI


+
−
Leaflet
Richie Slocum (2018)


+
−
Leaflet
Richie Slocum (2018)


Measurements
Point
Distance
Height
Angle
Look At
Remove All
8.35 m
Leaflet
Richie Slocum (2018)

Drone Accuracy

- ❖ Qualitative UAS data can be acquired relatively quickly
- ❖ Quantitative UAS data acquisition takes more time, and requires a survey with Ground Control Points
  - Improved scale
  - Improved orientation
  - Enables repeat surveys for change detection

Drone Legality / Safety

- ❖ If in the United States, follow FAA Part 107 rules
  - Class G airspace (away from airports)
  - Not over unwilling participants
  - Remain within Line of Sight
- ❖ If outside of US
  - Depends on the county
- ❖ Disaster areas can require special clearance
  - Safety issue to avoid any low flying helicopters

Summary

- Overall Goals
  - Successful mission to document Irma/Maria storm surge in USVI
  - Documented several examples of damage to built environment
- Drone survey data
  - Qualitative data
    - relatively cheap, easy
    - requires some planning
  - Quantitative data
    - Requires additional equipment & time for ground control points
    - Requires post processing, expertise
- Data sharing (images)
  - Phone apps (eg FULCRUM)
    - relatively cheap, easy
    - requires cell/internet eventually
    - Excellent for short metadata description, geolocation

Thank you!

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