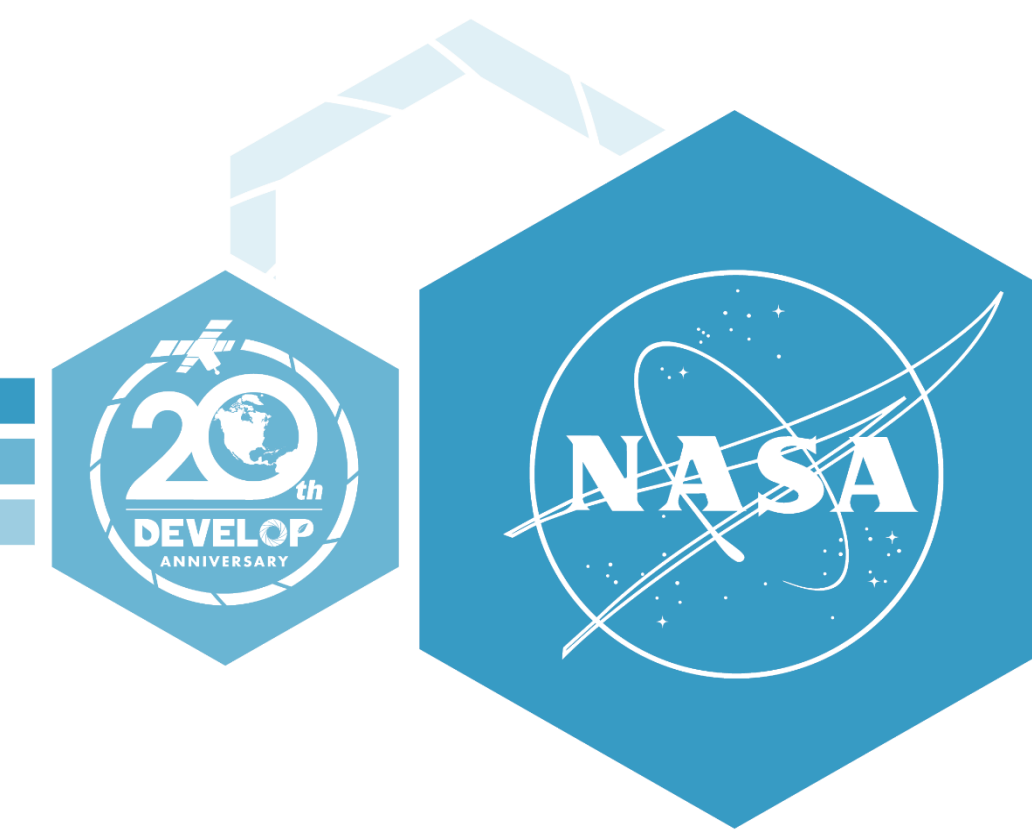# Analyzing Historical Hurricane Influences on Coastal Water Quality and their Impact to Marine Ecosystems

Abstract

Several major and small-scale hurricanes have swept over the US Virgin Islands (USVI) dating back to 1989. Often originating near the Cabo Verde islands near western Africa, these major hurricanes travel westward towards the USVI, leaving destructive impacts upon landfall. Nearshore marine ecosystems in the USVI have adapted to hurricane forces, but as urban development alters native vegetation and hurricanes intensify with the changing climate, marine ecosystems may not always withhold resilience. Increased sediment and nutrient loads from runoff adversely impact coral reefs and other marine organisms. These marine resources are vital to the economy of the USVI, accounting for 80% of the gross domestic product and attracting millions of tourists annually. Marine resources such as coral reefs help protect residents from floods, storms and maintain high levels of marine biodiversity. The project partner, the USVI Department of Planning and Natural Resources - Coastal Zone Management, currently uses in situ measurements and qualitative observations to monitor nearshore marine water quality. The analysis quantified water quality data post-hurricane season for Hurricane Hugo (1989), the 2017 hurricane season (Hurricanes Irma and Maria), and 2016 for baseline data using Landsat 5 Thematic Mapper (TM), Landsat 8 Operational Land Imager (OLI), and Sentinel-2 Multispectral Instrument (MSI) data. Using the select data, along with the 2017 NASA DEVELOP USVI Ecological Forecasting land use classifications (updated by Christopher McDonald), the team examined the complex interactions between hurricanes, land development, and water quality.

Study Area

- Study Area
- US Virgin Islands
- Maritime Boundary
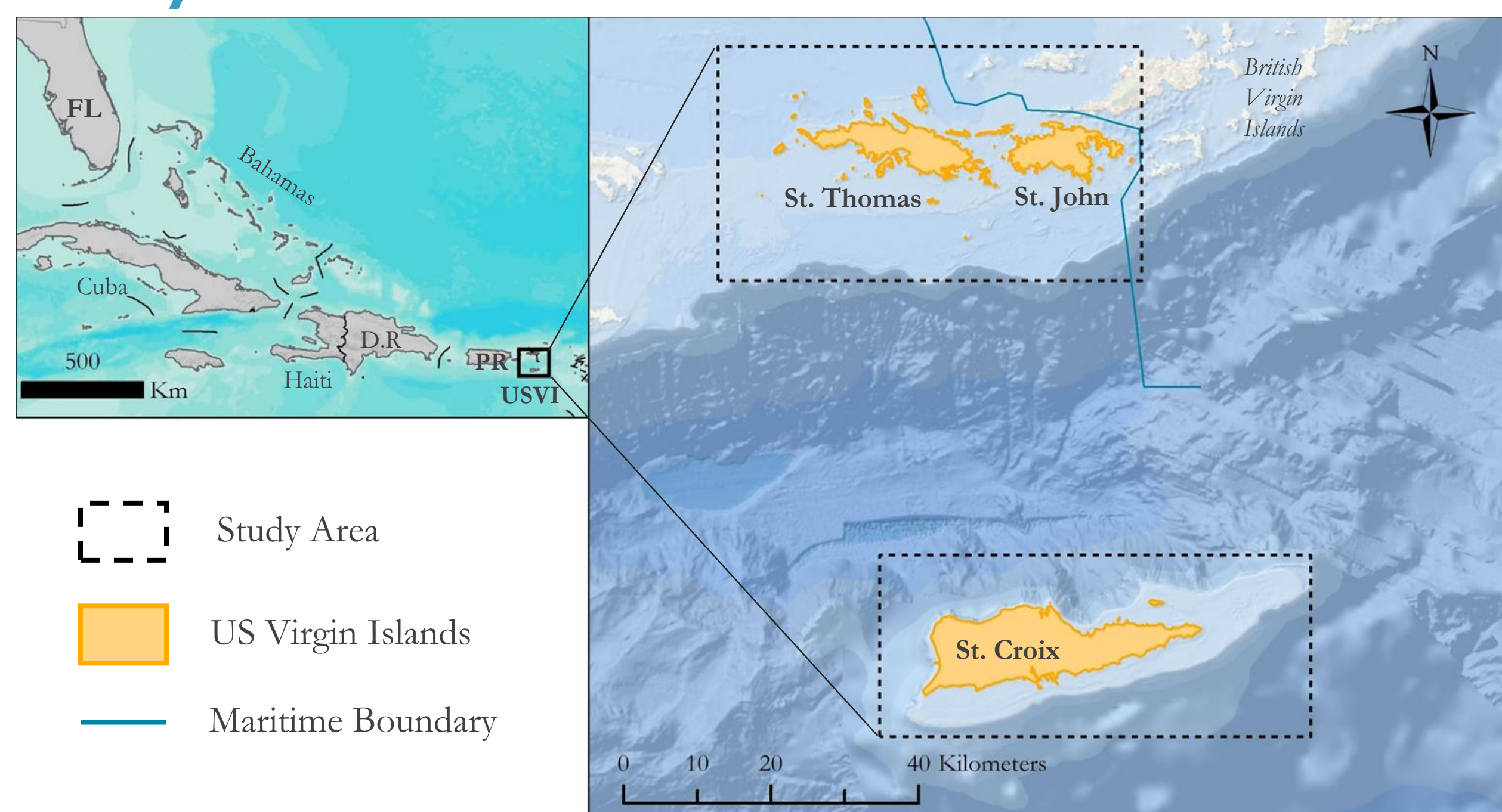
Objectives

- **Create** a database of water quality parameters post-hurricane season to assess the effect major (Category 4/5) hurricanes have on the US Virgin Islands nearshore habitat.
- **Characterize** the temporal and spatial influence of hurricanes on suspended particulate matter, turbidity, and chlorophyll-a concentration.
- **Identify** coral reef communities at risk of poor water quality and assess the combined influence of development and hurricanes on nearshore marine habitat water quality indices.
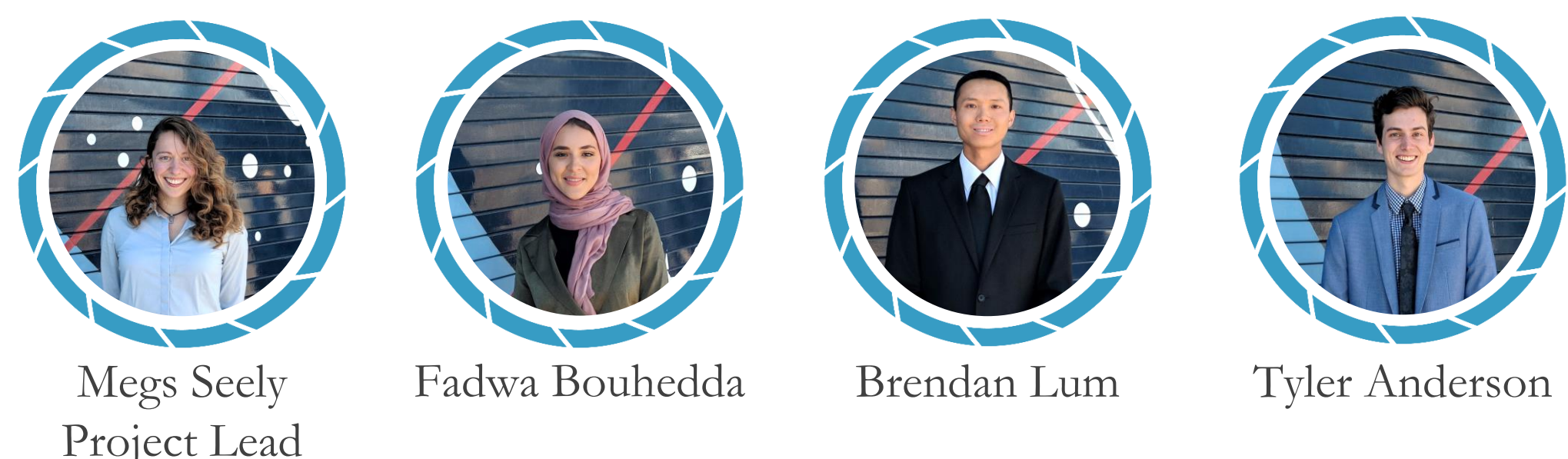
Earth Observations

Landsat 5 TM
Landsat 8 OLI
Sentinel-2 MSI
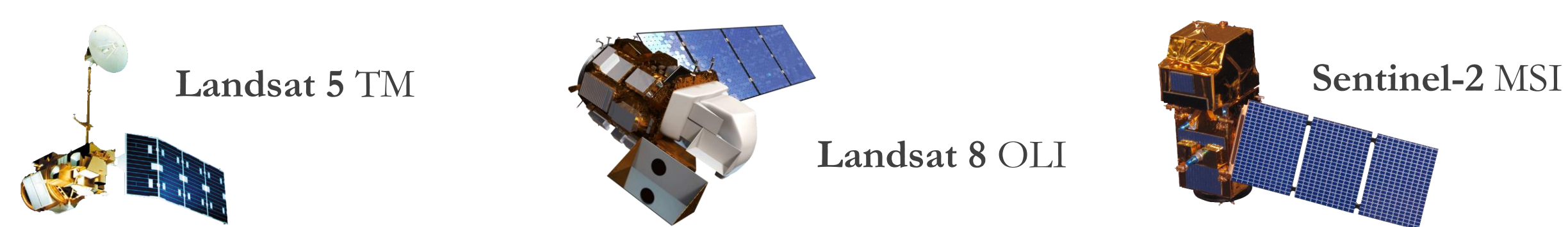
Project Partners

US Virgin Islands Department of Planning and Natural Resources, Coastal Zone Management

Team Members

Megs Seely — Project Lead
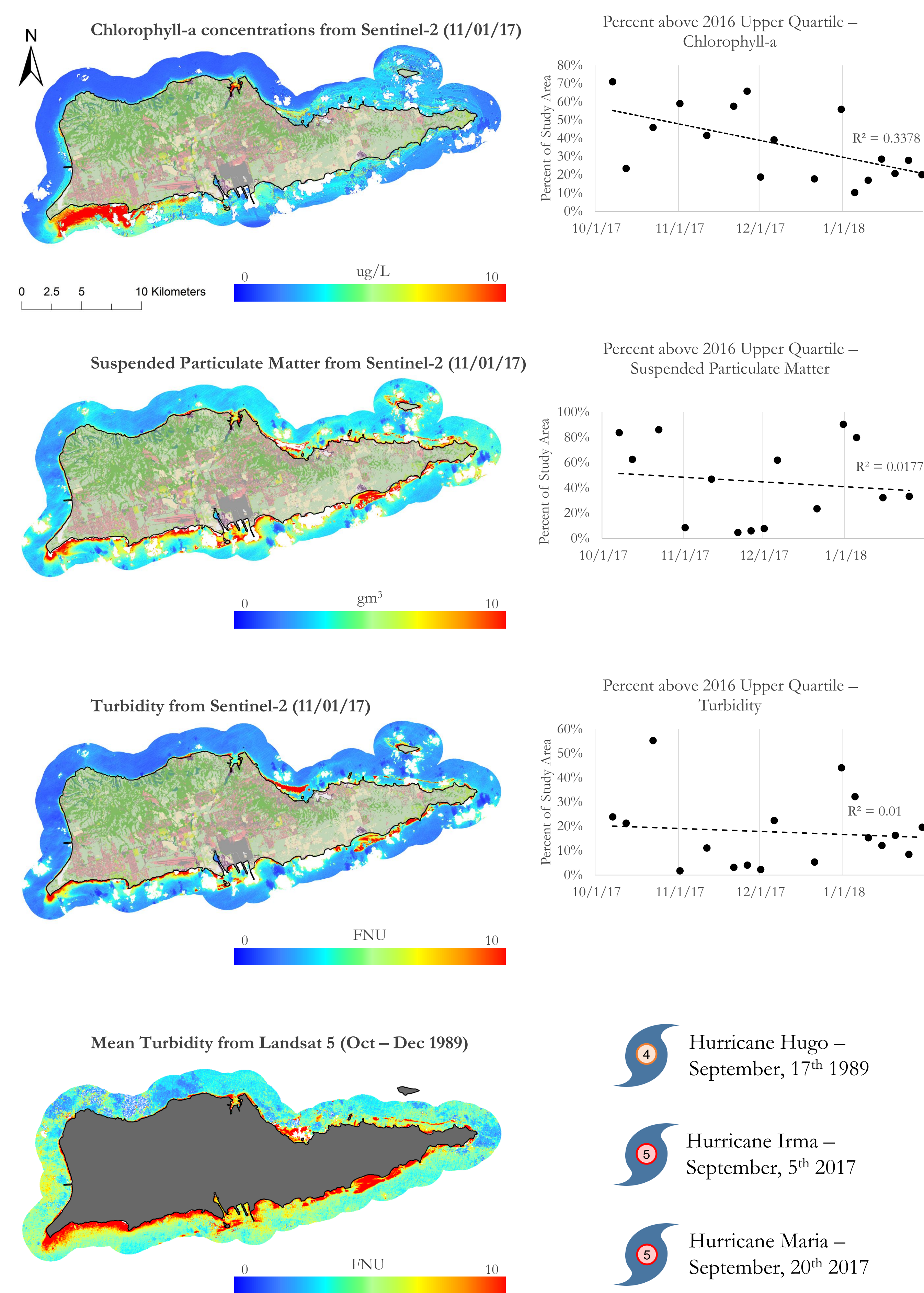Fadwa Bouhedda
Brendan Lum
Tyler Anderson

Acknowledgements

Methodology

Acquire Data — Landsat 4/5/8 and Sentinel-2 data for 1989, 2016 - 2018

Quantify Water Quality — SPM, Turbidity, Chlorophyll-a

Create 2016 Baseline — Median values and quartiles of water quality indices

Evaluate Change — Change in water quality post-hurricanes over space and time

Results

Chlorophyll-a concentrations from Sentinel-2 (11/01/17)

Percent above 2016 Upper Quartile – Chlorophyll-a — $R^2 = 0.3378$

Suspended Particulate Matter from Sentinel-2 (11/01/17)

Percent above 2016 Upper Quartile – Suspended Particulate Matter — $R^2 = 0.0177$

Turbidity from Sentinel-2 (11/01/17)

Percent above 2016 Upper Quartile – Turbidity — $R^2 = 0.01$

Mean Turbidity from Landsat 5 (Oct – Dec 1989)

- Hurricane Hugo – September, 17th 1989
- Hurricane Irma – September, 5th 2017
- Hurricane Maria – September, 20th 2017

Conclusions

- Post-hurricane water quality parameters exhibit strong spatial patterns, with the southern coast of St. Croix having the poorest water quality.
- Post-hurricane water quality indices tend to decrease over time, with chlorophyll-a having the strongest decreasing trend.
- Turbidity patterns remained consistent between the 1989 and 2017 hurricane seasons.
- Further investigations of how development and precipitation events impact water quality response to and recovery from hurricanes may provide further insight to water quality spatial and temporal patterns.