

## Southeast Coast Ecological Conservation

Investigating the Development of Ghost Forests Due to Saltwater Intrusion  
along the Savannah River, Georgia Coastline of the United States

Emma Cheriegate • Eleri Griffiths • Quintin Munoz • Vivienne von Welczeck

California – JPL | Summer 2023

25<sup>TH</sup> DEVELOP  
ANNIVERSARY

# Background



Image Credit: NOAA



- **↑ Saltwater intrusion (SWI) into freshwater** systems
  - Ghost forest formation



- **Natural and anthropogenic drivers intensifying SWI**



# Community Concerns

- Loss of biodiversity
- Inhibited carbon sequestration
- Declining drinking water quality and supply
- Dangerous storm surges
- Climate change adaptation strategies



Image Credit: Dr. William Conner, USGS

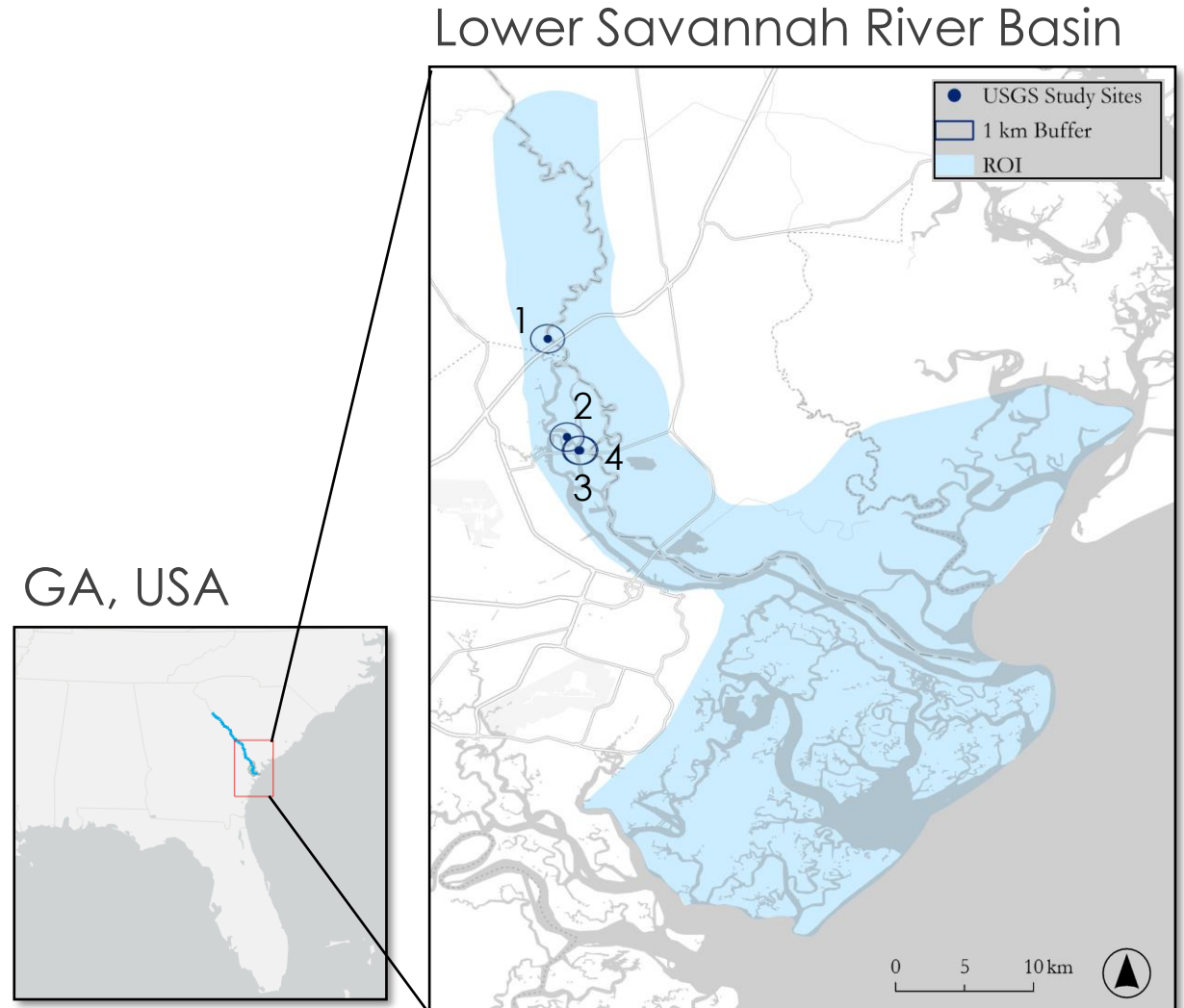


# Study Area & Period

- Lower Savannah River, Georgia
  - HUC10 Watershed
  - Savannah National Wildlife Refuge
- Time Frame: Growing Season of 2013 – 2023 (March – Sept)



Image Credit: U.S. Fish & Wildlife Service. Bald cypress in bottomland hardwood forest at Savannah National Wildlife Refuge.



# Objectives



## Investigate Changes

in sea level rise (SLR) and vegetative health



## Synthesize & Analyze

trends in saltwater intrusion (SWI)



## Validate and Correlate

NASA Earth observations (EO) with in-situ (field-derived) data



# Project Partners



- Southeast Regional Climate Hub



- Wetland and Aquatic Research Center (WARC)
- Florence Bascom Geoscience Center (FBGC)



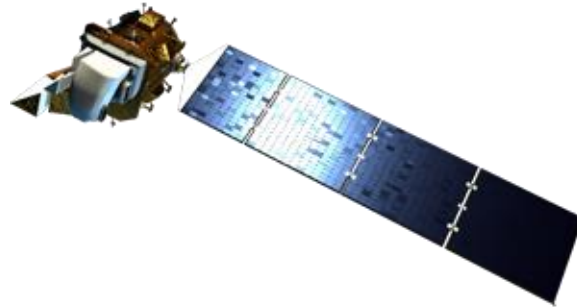
- Department of Biology, Georgia Southern University



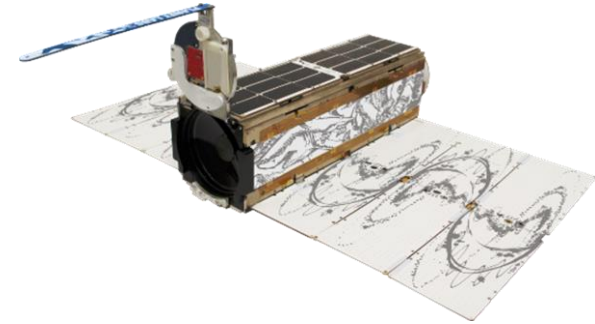
# Earth Observations (EOs)



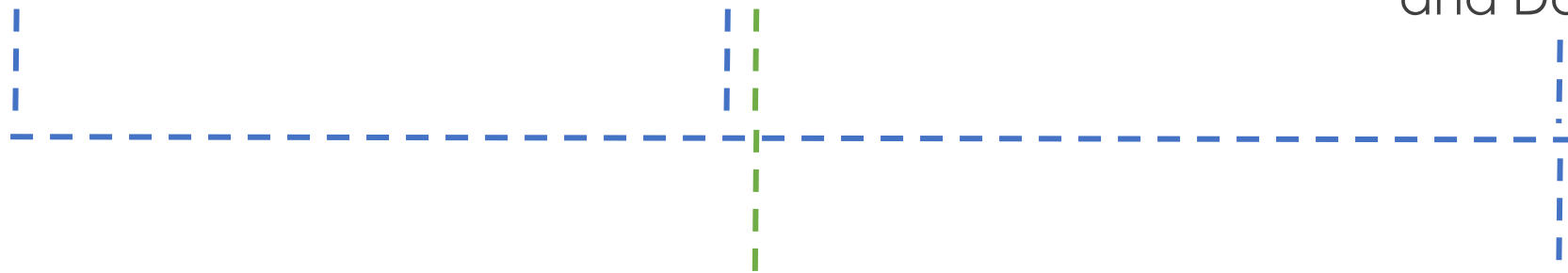
Landsat 7 ETM+



Landsat 8 OLI



Planet Scope Rapid Eye  
and Dove



Land Classification

NDVI Parallel Processing



# Methodology – NDVI Parallel Processing

Inputs

Landsat 8 OLI

PlanetScope  
Dove

Processing

Filter by date and ROI  
Water Mask  
Cloud Mask

Filter by date and ROI  
Water Mask

Analysis

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

ee.ReducerMean

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

ee.ReducerMean

Output

12 Month  
Mean NDVI

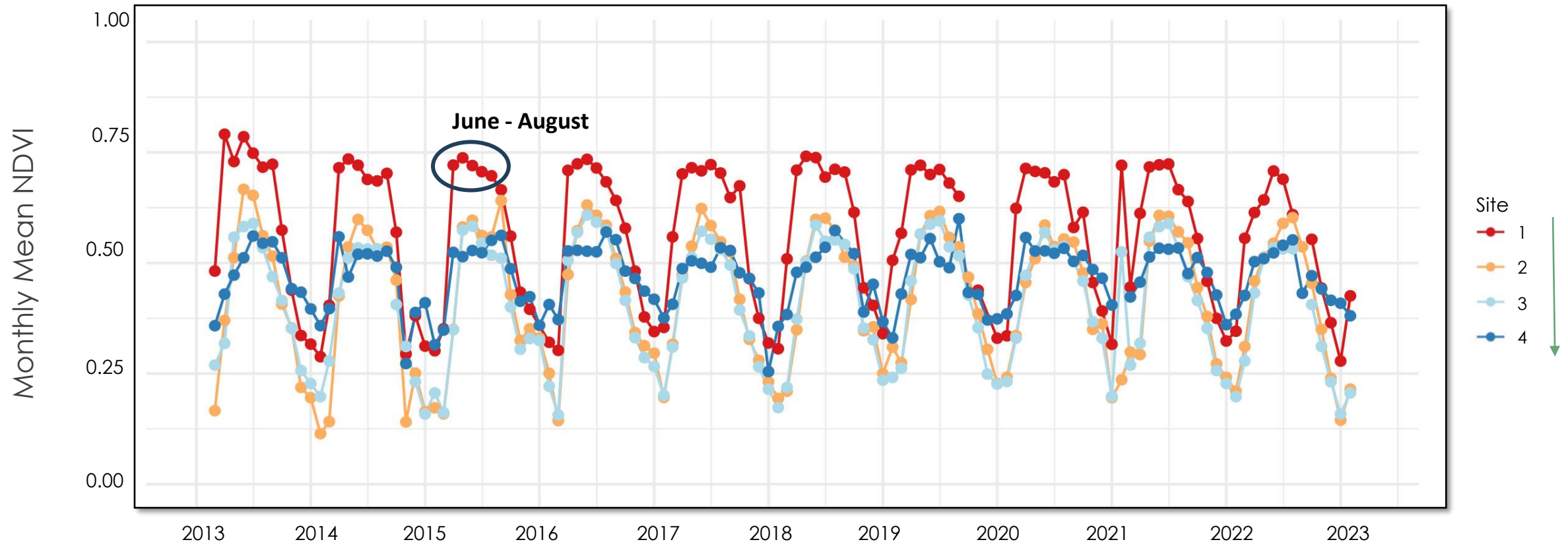
Mean NDVI  
per month





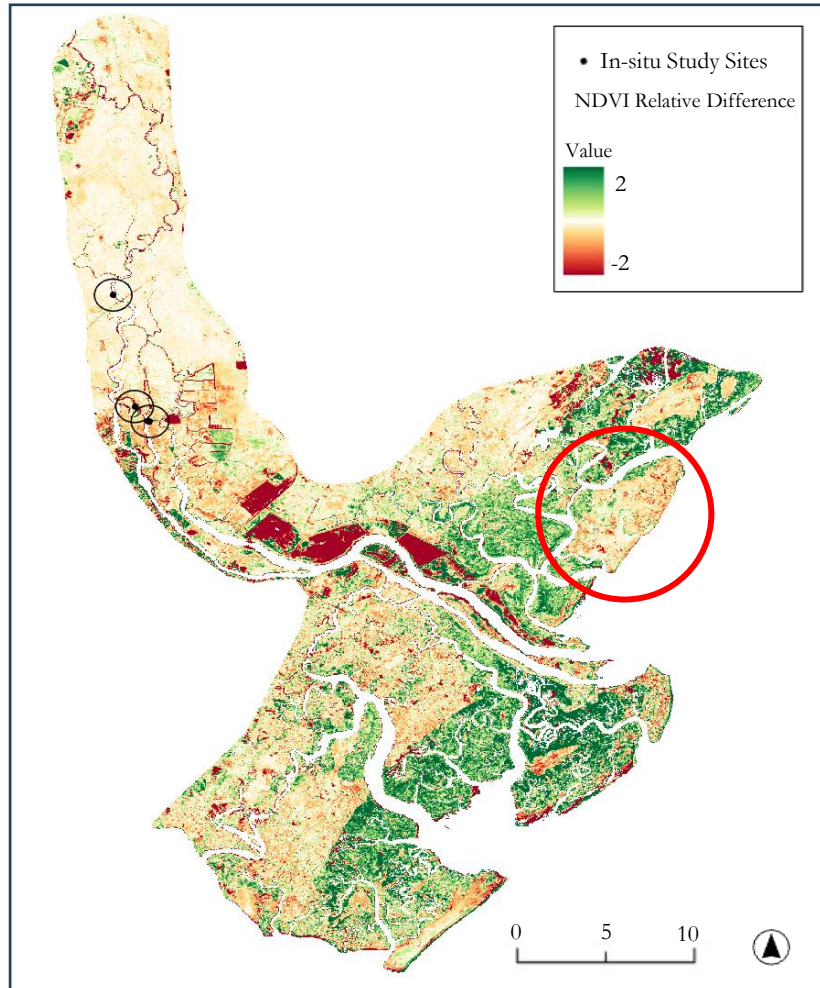
# Results – NDVI Time Series (Landsat 8)

Monthly Mean NDVI 2013 – 2023

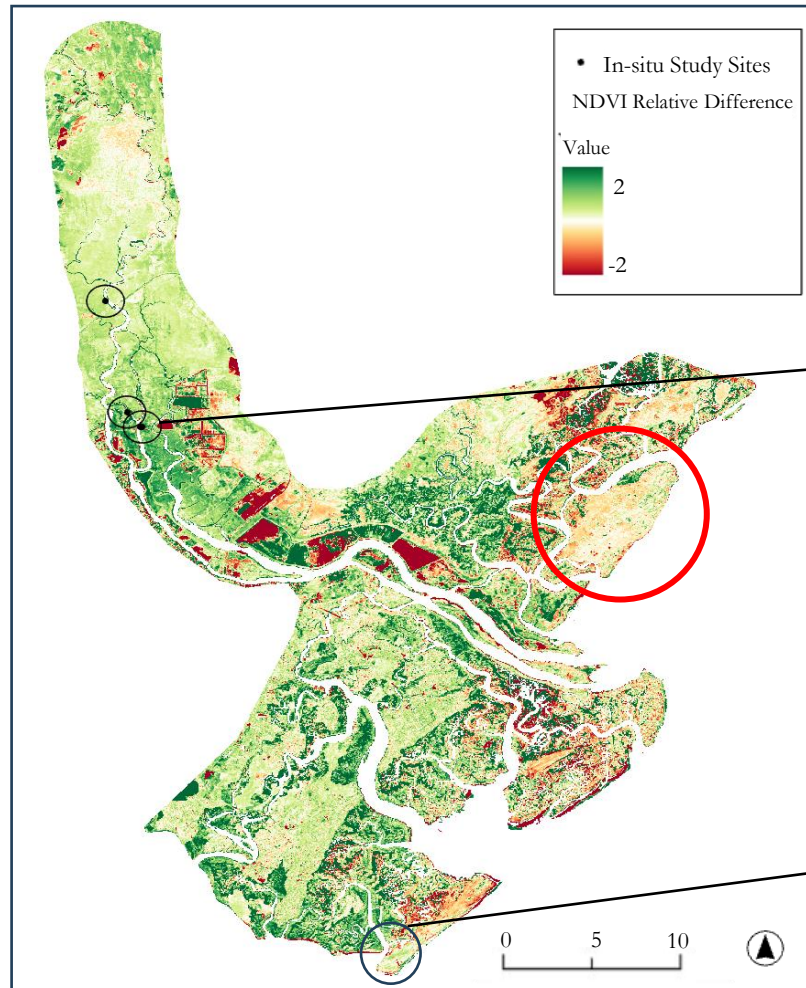


# Results – NDVI Parallel Processing (Landsat 8)

$\Delta$  NDVI = June 2022 – June 2014



$\Delta$  NDVI = March 2023 – March 2013

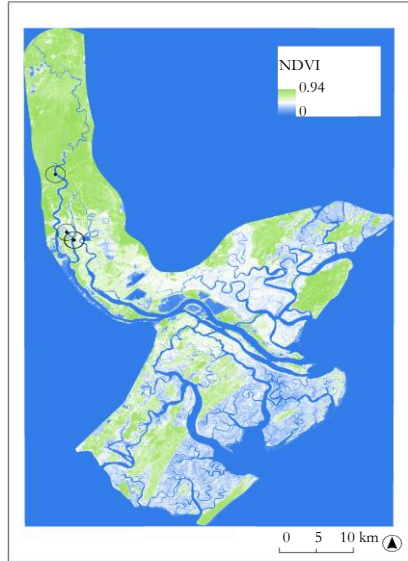


Images Credit: Maxar, ESRI

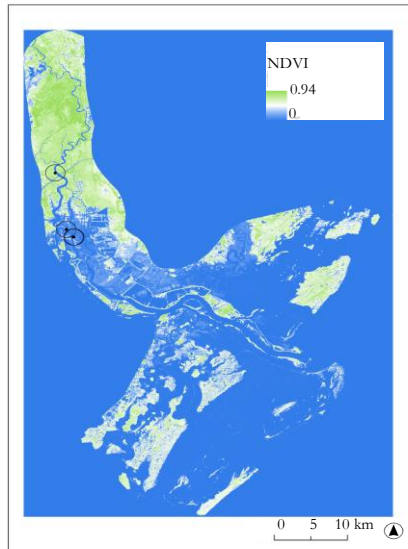


# Results – NDVI Parallel Processing (Planet)

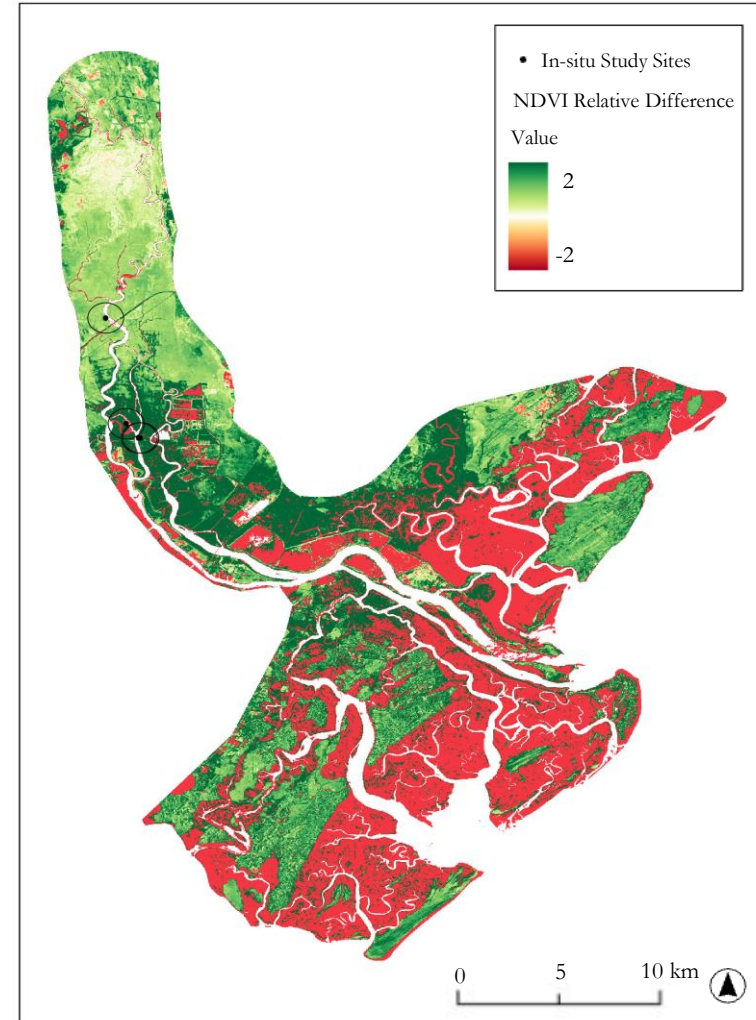
April 2023  
Planet NDVI  
for Overall  
Study Site



April 2013  
Planet NDVI  
for Overall  
Study Site



$\Delta$  NDVI = April 2023 – April 2013



# Results – NDVI Parallel Processing (Planet)

Planet NDVI  
Plot Maps  
for USGS Sites  
(April 2023)



Site 1



Site 2

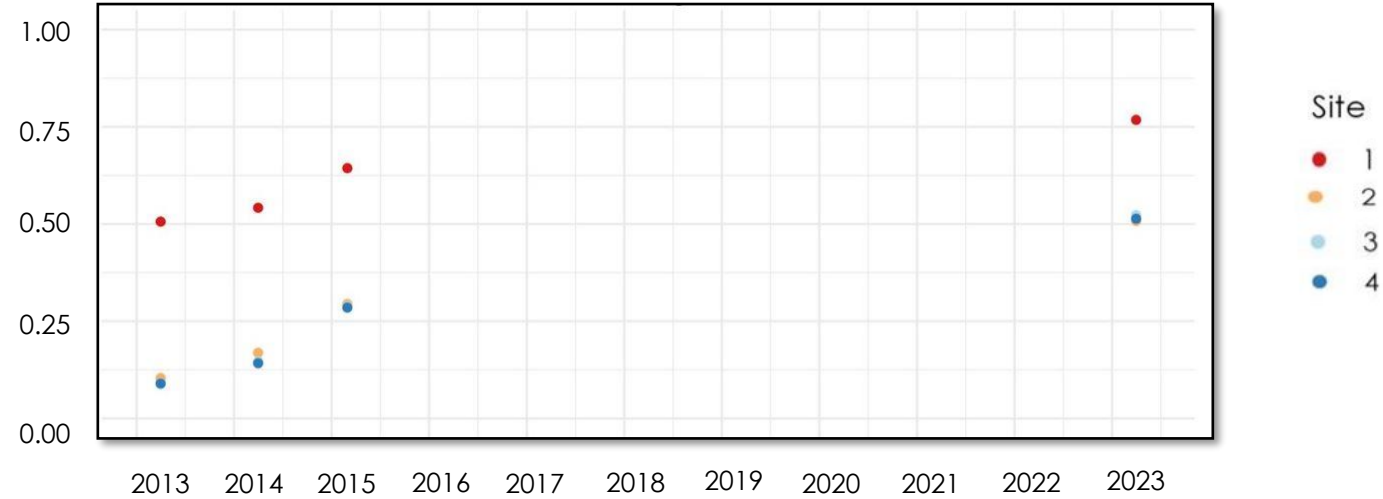


Site 3

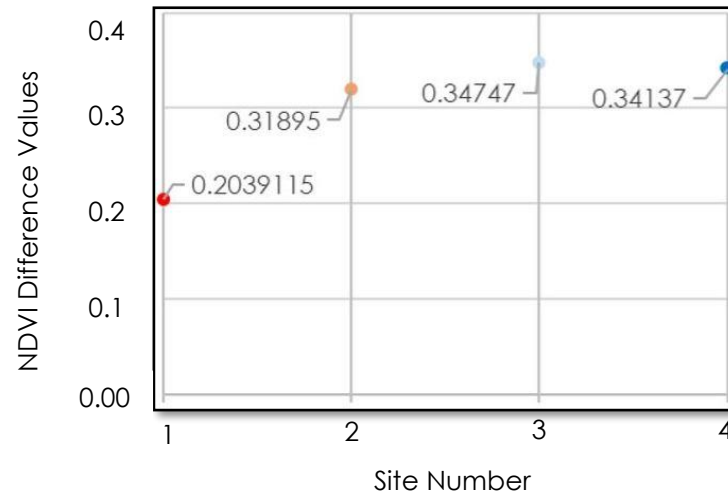


Site 4

(2013 – 2015 & 2023) Planet NDVI Values for USGS Plot Sites



Planet NDVI Plot Site Difference Calculation  
(2023) NDVI – av mean (2013,2014,2015) NDVI



# Methodology – Random Forest Land Classification

Inputs

Processing

Analysis

Output

Landsat 8 OLI

Seasonal  
composite  
(May – Sept)

Urban Mask  
Cloud Mask  
Water Mask

Delineate  
training  
points

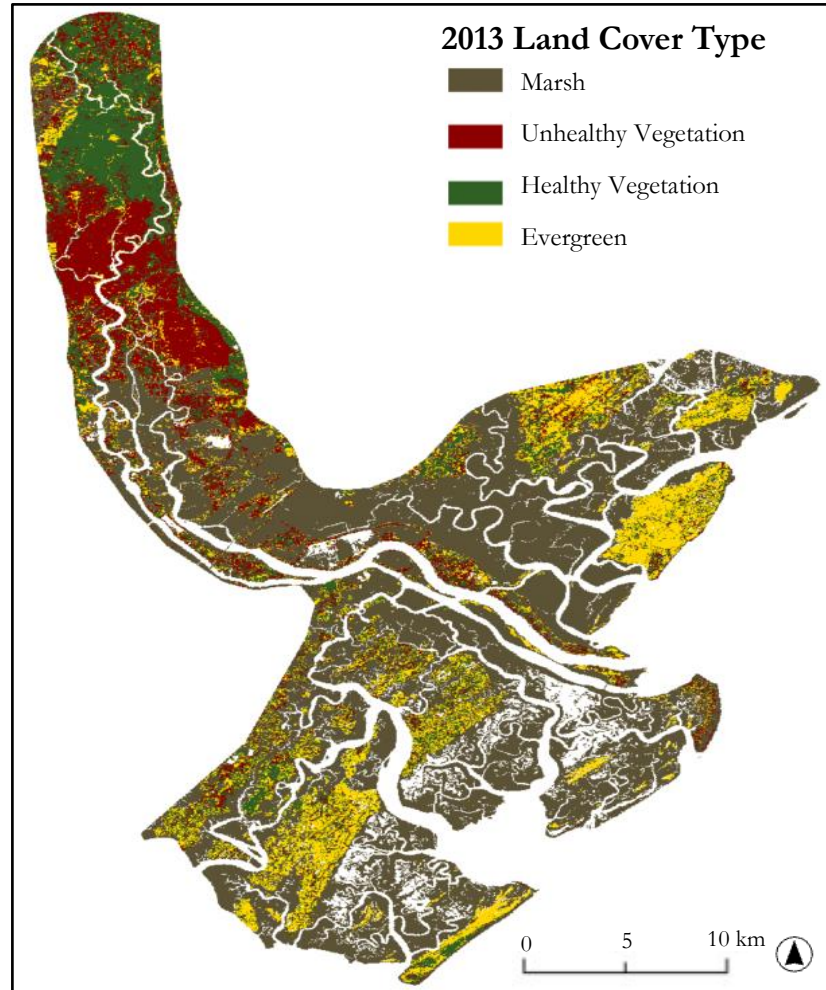
Random  
Forest Land  
Cover  
Classification

10 land cover  
images (1 per  
year)

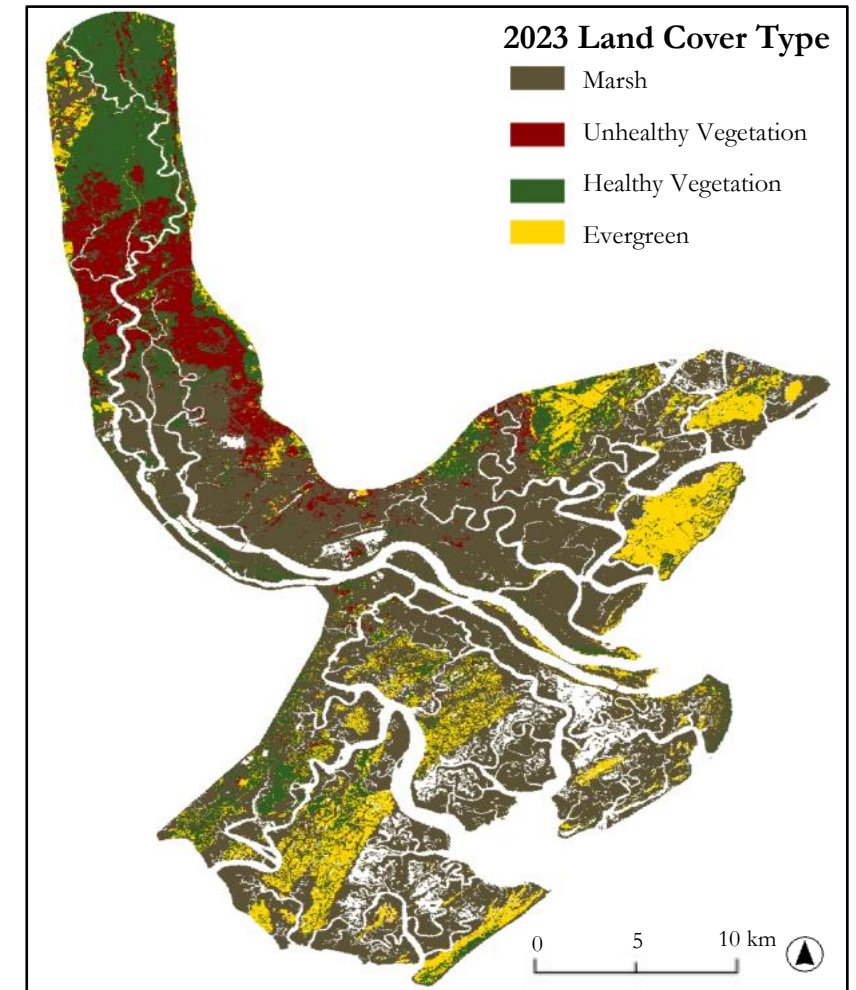


# Results – Land Cover Classification (Landsat 8)

Growing Season Composite = May to Sept 2013

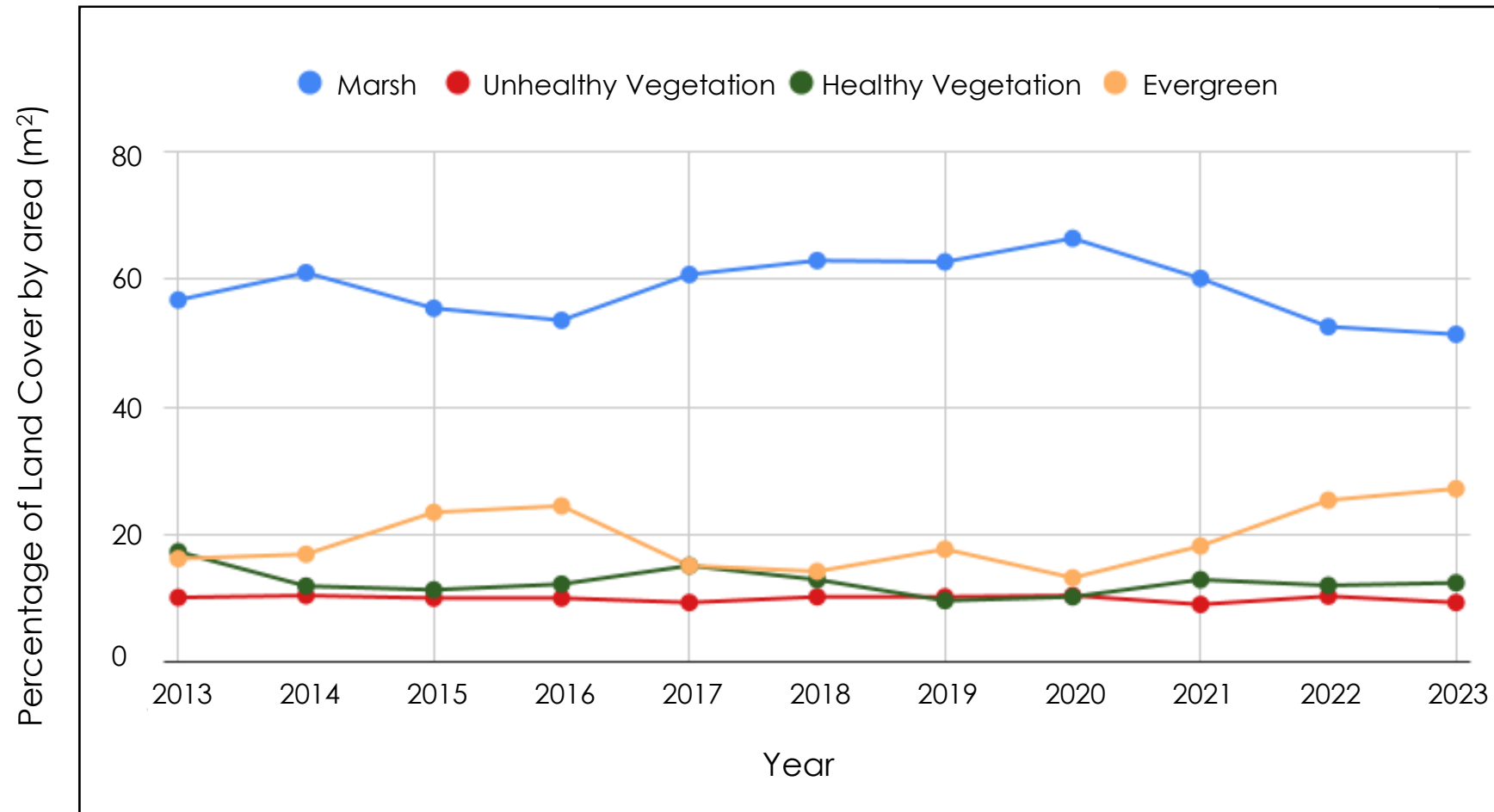


Growing Season Composite = May to Sept 2023



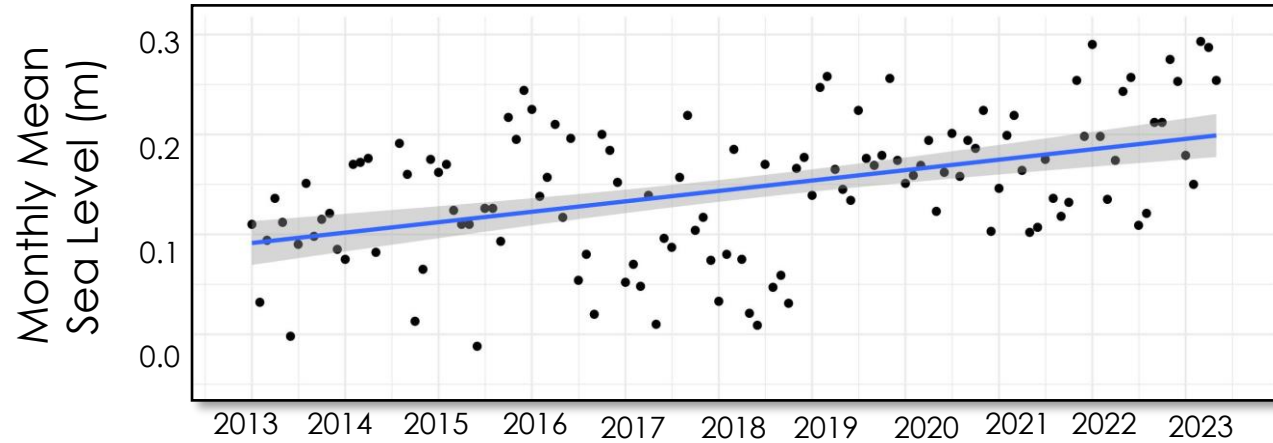
# Results – Land Cover Classification

Land Cover Classification Time Series 2013 – 2023

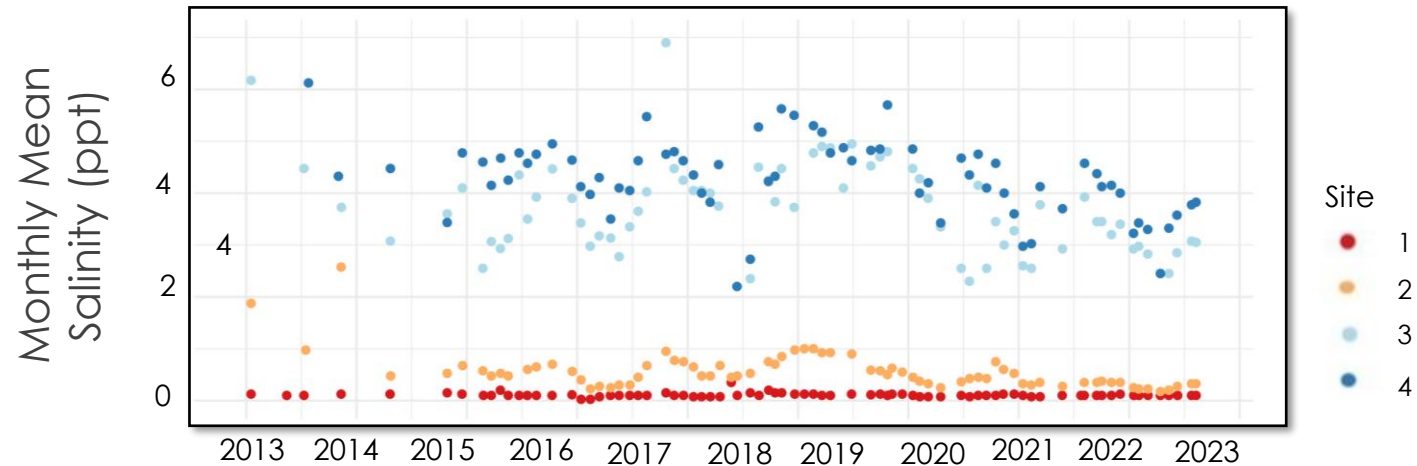


# Results – In Situ Data

## Sea Level Rise Trend 2013 – 2023



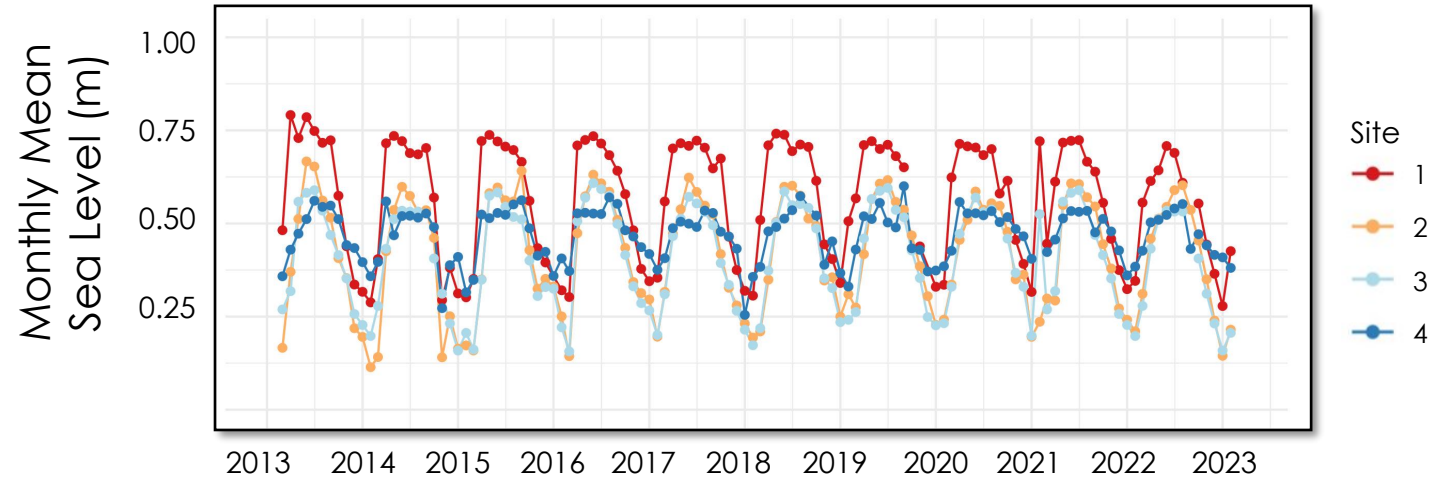
## USGS Porewater Salinity Measurements 2023 – 2021



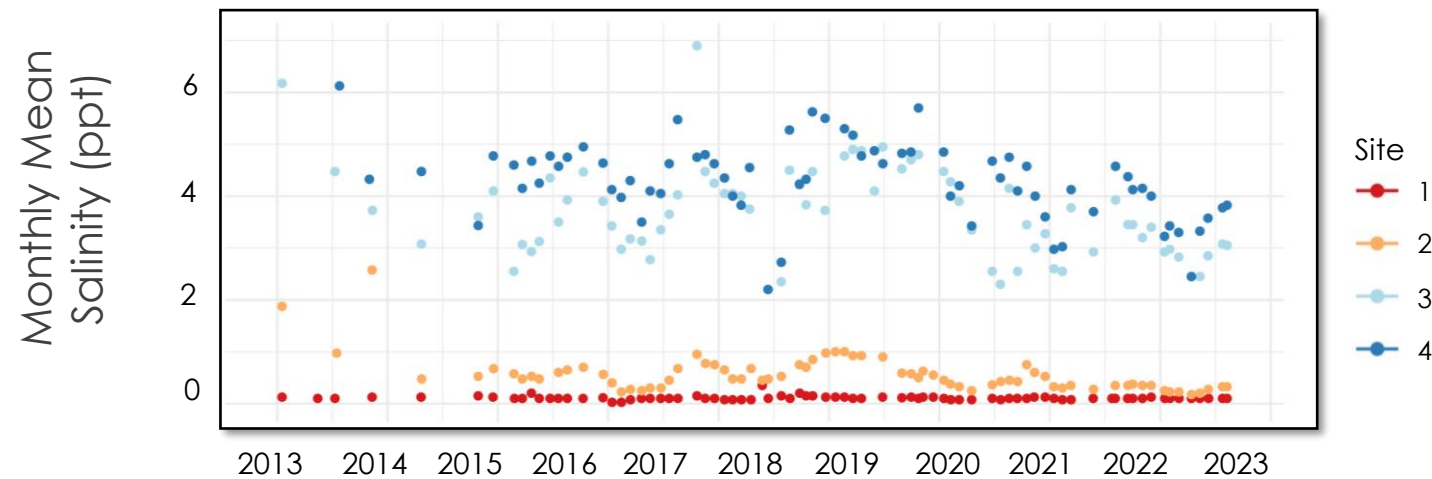


# Results – Long Term Trends

## Monthly Mean NDVI 2013 – 2023



## USGS Porewater Salinity Measurements 2013 – 2021





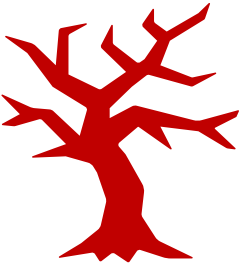
# Limitations and Uncertainties

- **Landsat 8 NDVI:** Cloud coverage
- **Planet Imagery:** API accessibility
- **Land cover classification:**
  - # of training points
  - Temporal variation
  - Mixed pixels/resolution limitations
  - Edge effects
- **Salinity:** Data availability

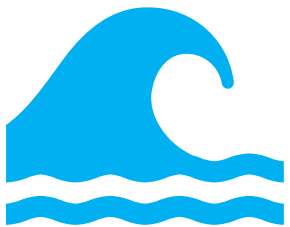
# Conclusions



- **Landsat 8 NDVI values decreased over time while Planet NDVI values increased**, potentially due to varying spatial resolutions



- **Marshes were stable and dominant over time**, possibly due to ecological saline adaptation
- **Evergreen areas experienced the highest fluctuations and increased over time**, leading to potential ecological effects



- **Salinity levels were highest at the southernmost study sites** closest to the coast
- **As salinity increased, NDVI decreased**



# Future Work



Image Credit: USDA Forest Service



- ↑ temporal/spatial resolution
- ↑ Scale & number of variables
- Investigate other drivers of SWI



- **Attempt different classification algorithms, ↑ # of training points**



- ↑ porewater salinity data & sites



# Acknowledgments

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- NASA Jet Propulsion Laboratory, California Institute of Technology

## Fellow

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