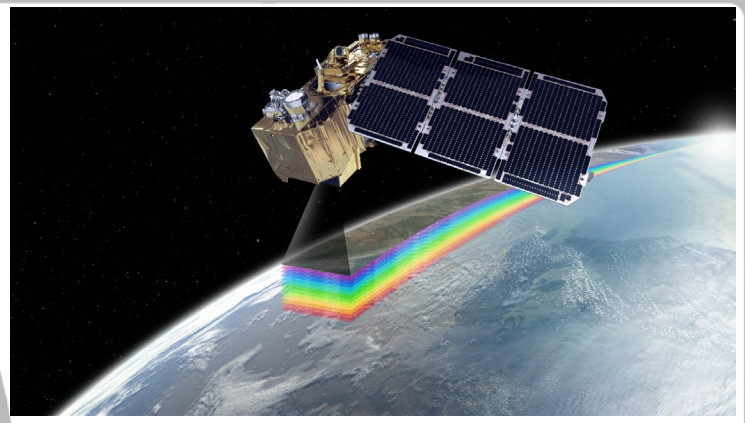
DEVELOPMENT OF A SATELLITE-BASED DISTRICT TOOL FOR QUANTIFYING COASTAL EVOLUTION AND PROJECT PERFORMANCE AT BEACHES



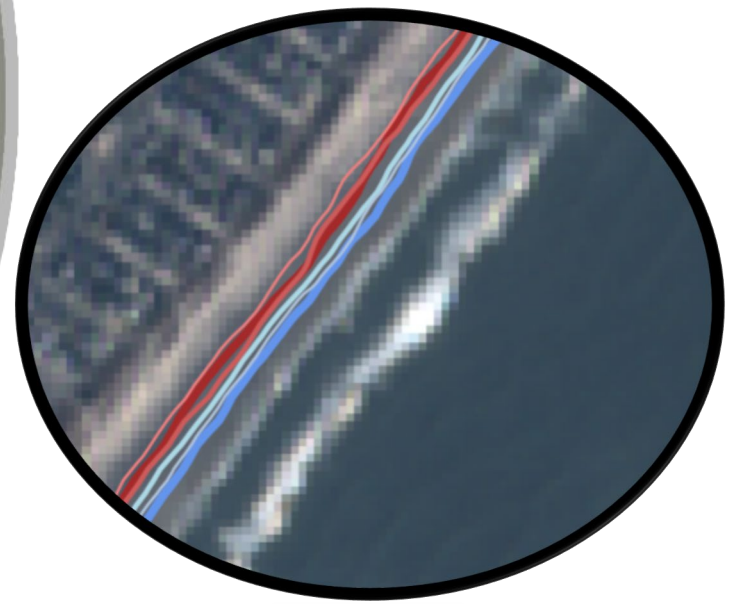
Ian Conery, Nicholas Olsen, Shannon Brown, Kate Brodie, Katherine DeVore, Mike Forte

District PDT Members

Monica Chasten (NAP), Jessica Podoski (POH), Jonathathan Waddell (LRE)

COASTAL INLETS RESEARCH PROGRAM

FY22 IN PROGRESS REVIEW



Tiffany Burroughs
HQ Navigation Business Line Manager

Eddie Wiggins
Technical Director, Navigation

Brian McFall
Acting Associate Technical Director, Navigation

CIRP: Mission Support, Technology Transfer, Research & Development

US Army Corps of Engineers®

CHL COASTAL & HYDRAULICS LABORATORY

ERDC ENGINEER RESEARCH & DEVELOPMENT CENTER

Problem Statement

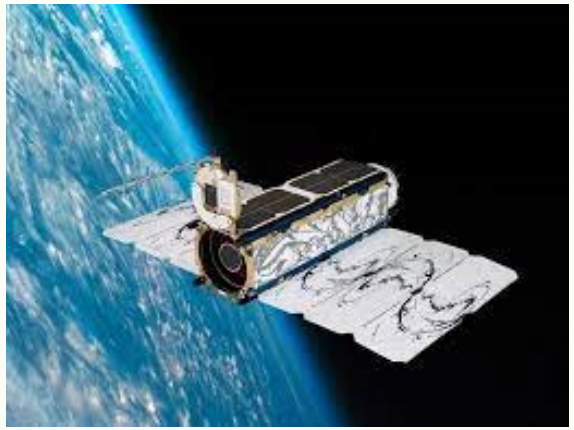
- **Existing coastal survey methods are often time-consuming and expensive**
  - **to conserve limited operational resources (e.g., personnel and vessels), USACE Districts are often forced to narrow areas of interest or monitoring frequency, decreasing the likelihood of making data-driven management decisions**

FY21 SoN
- Satellite Imagery for Coastal Monitoring (1731)

Capability and Strategic Impact Statement

Satellite-based tool is expected to provide USACE Districts access to a ***new data source***, enabling wide-spread ***frequent*** coastal data with ***low cost*** and personnel commitment.

Adds ability to examine shoreline variability (short and long term), "***now state***" of coastline and help with preliminary planning for districts managing beach projects and storm impacts (e.g., nourishments, nearshore berms, dredging, etc.)



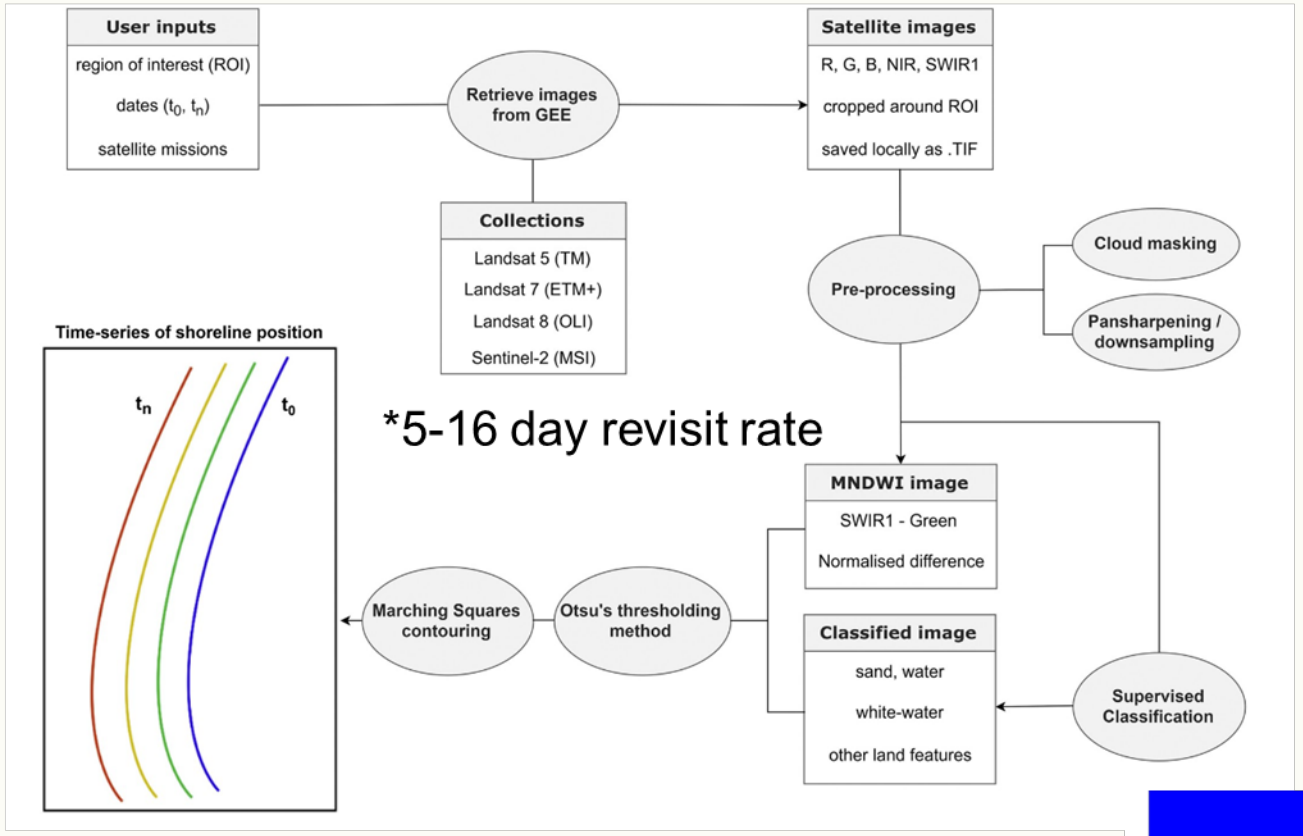
Project Objectives

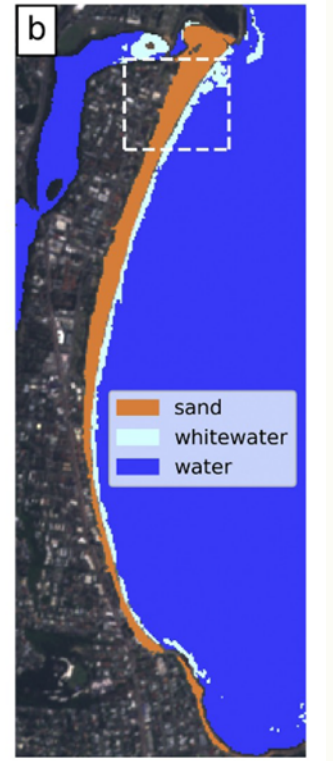
- Evaluate open-source satellite shoreline extraction algorithm accuracy at a range of test sites (CoastSat – UNSW; Vos et al., 2019)
- Assess how imagery can be used for management applications
- Create user-friendly ArcTool for USACE District use

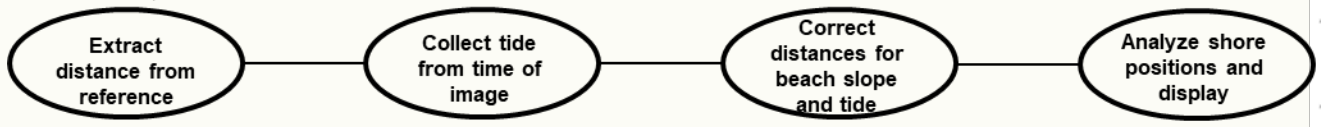
Approach

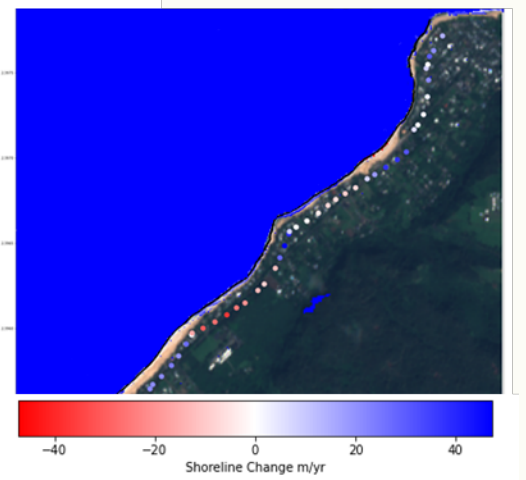
ERDC Technical Advancements:

- Tool migration to CoastSat 2.0
- Improved image sorting
- Continuing automated QA/QC for bad shorelines
- Shapefile tidal shifts



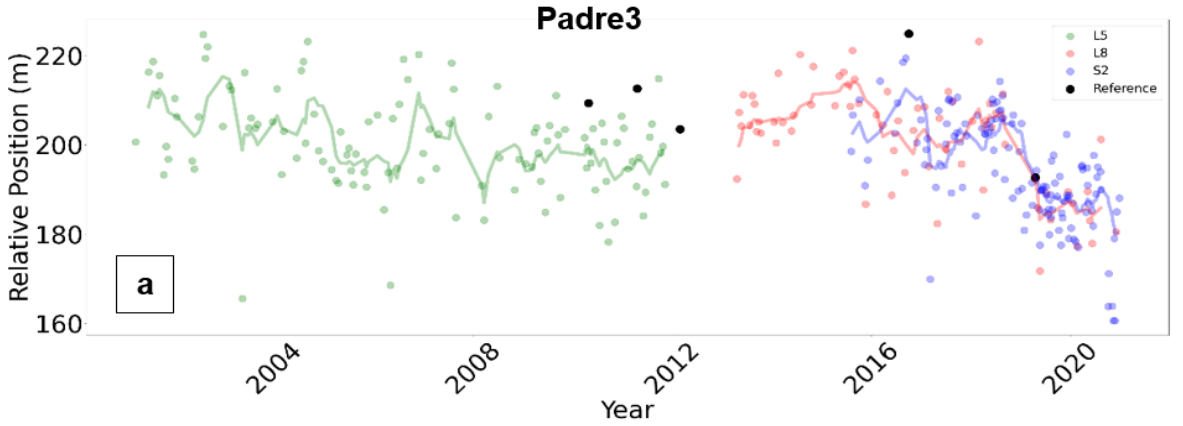


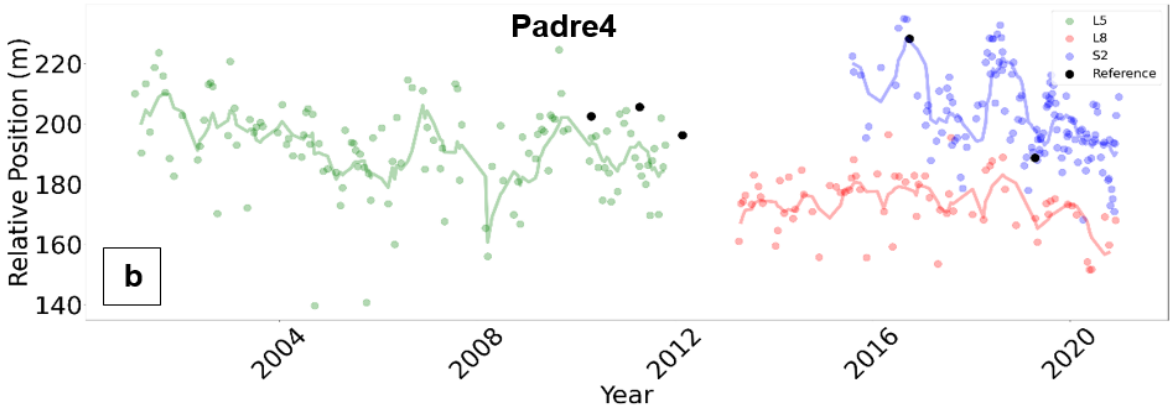


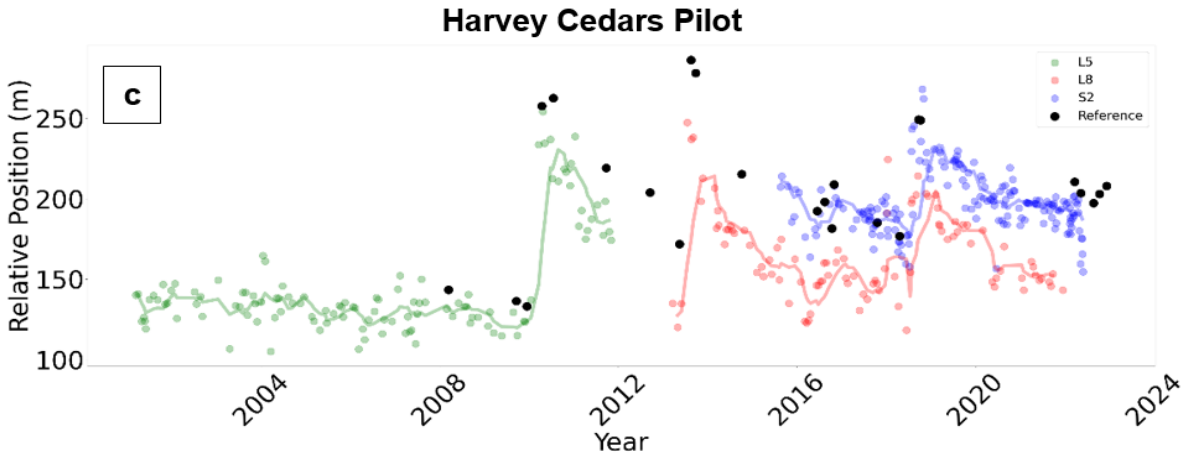


Google Earth Engine Issue

- Vos et al. validations on individual transects, small spatial scales
- Modified recently in CoastSat 2.1
- With focus on performance of ML shoreline selection algorithm, these sites were discarded







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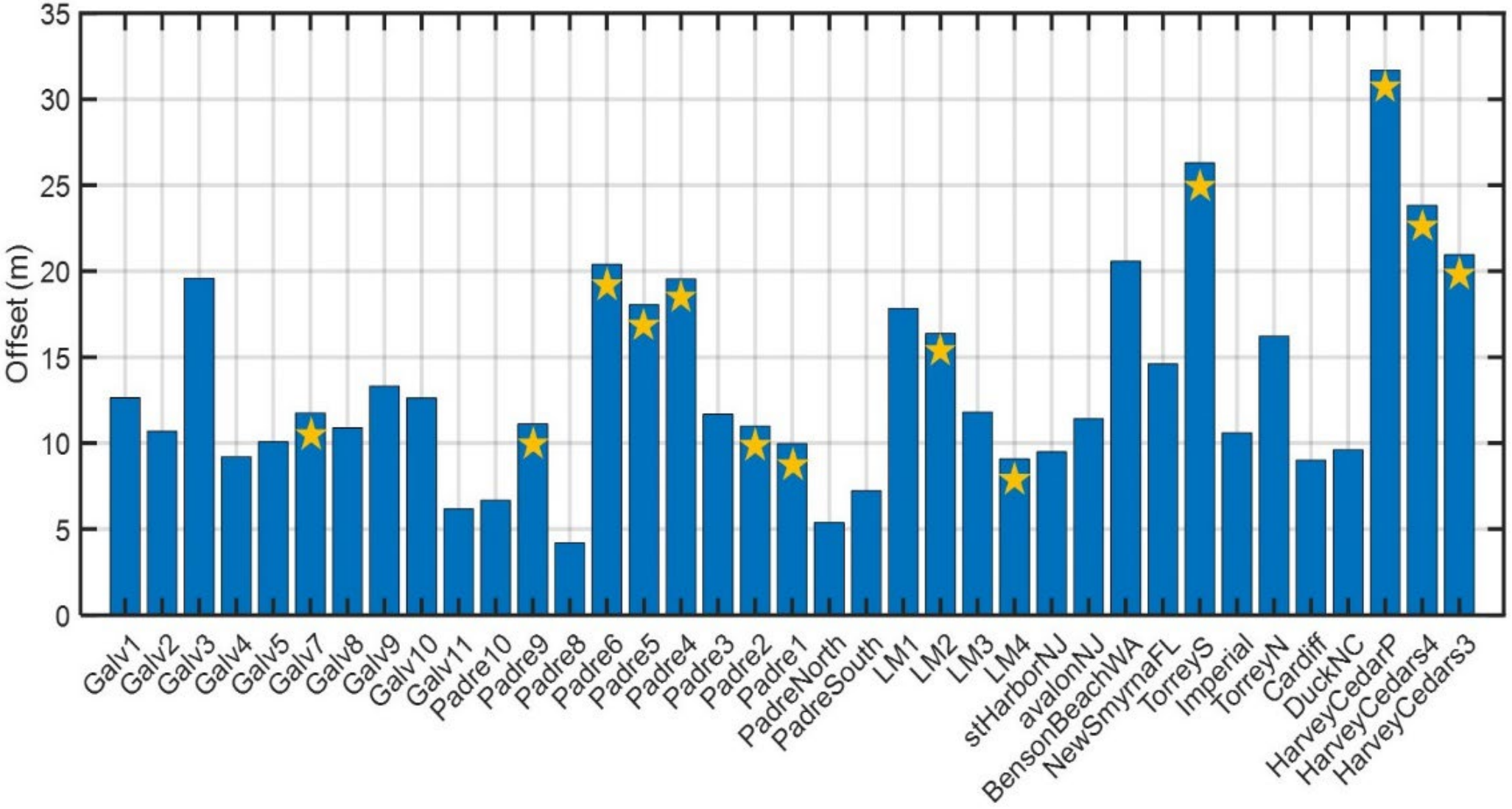
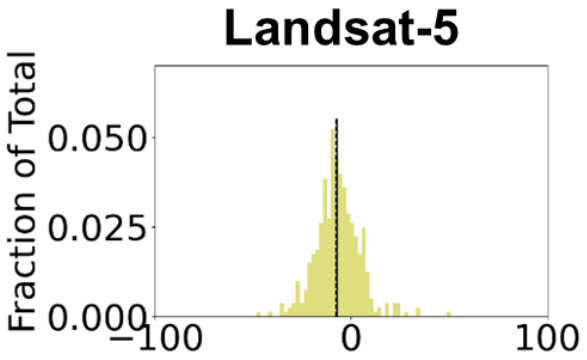
Instantaneous Shoreline Comparison Results

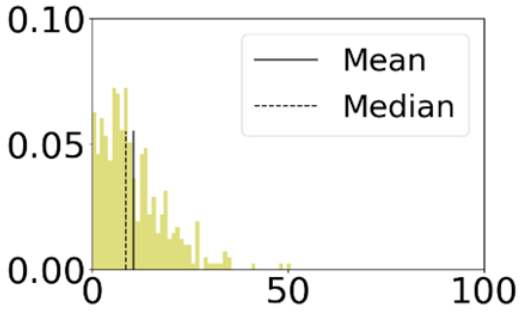


- Google Earth Engine image registration issue (★); corrected in CoastSat 2.0
- Mean horizontal offset from ground truth = **11.32** m; -3.51 m onshore bias

Instantaneous Accuracy by Satellite

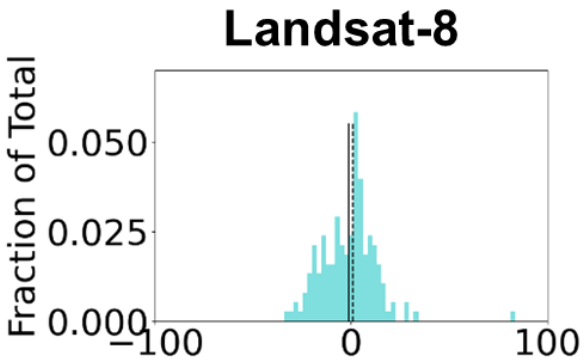
-6.93 m bias

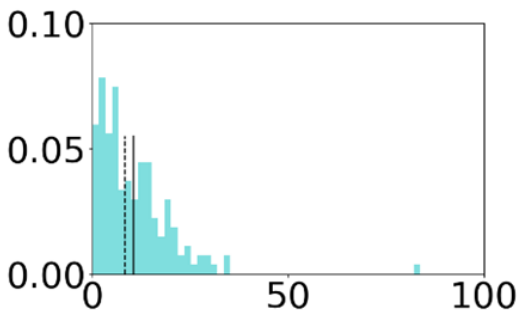




10.52 m error

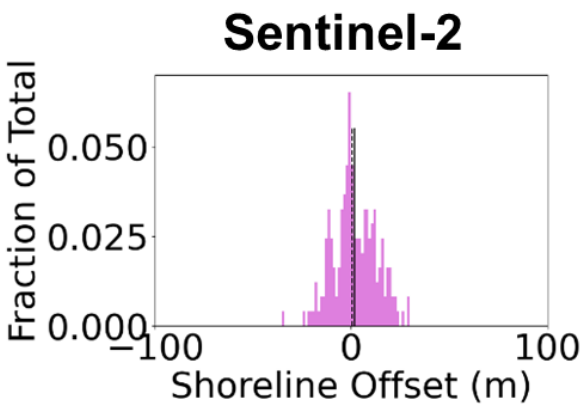
-1.21 m bias

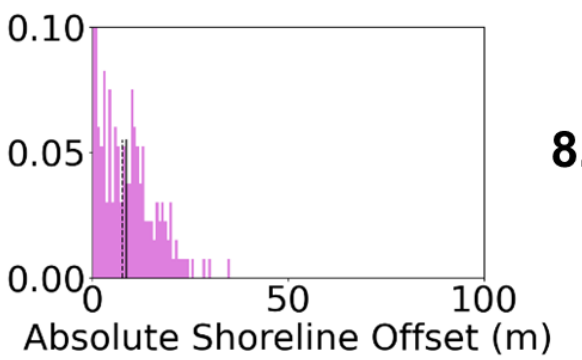




10.57 m error

1.9 m bias

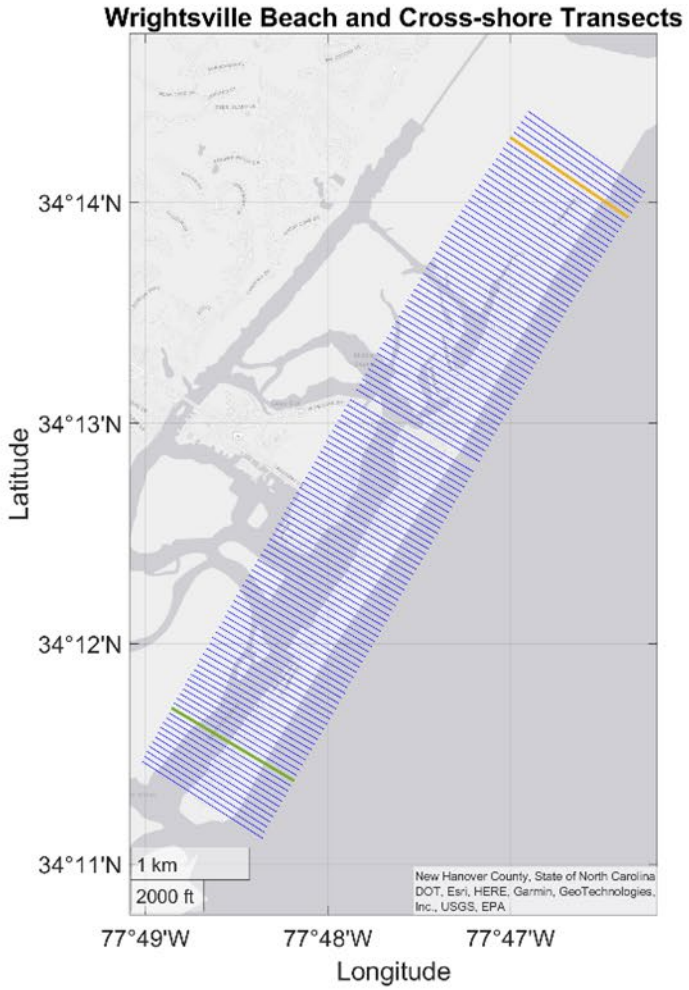


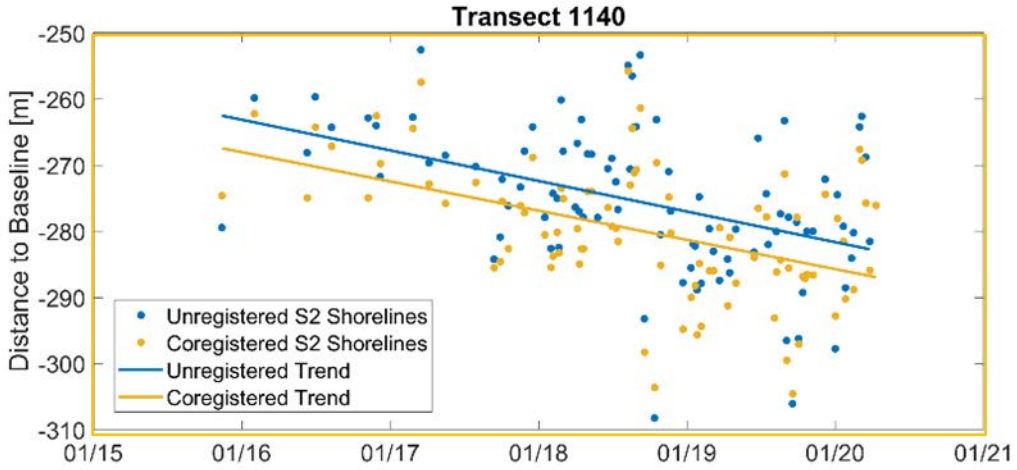


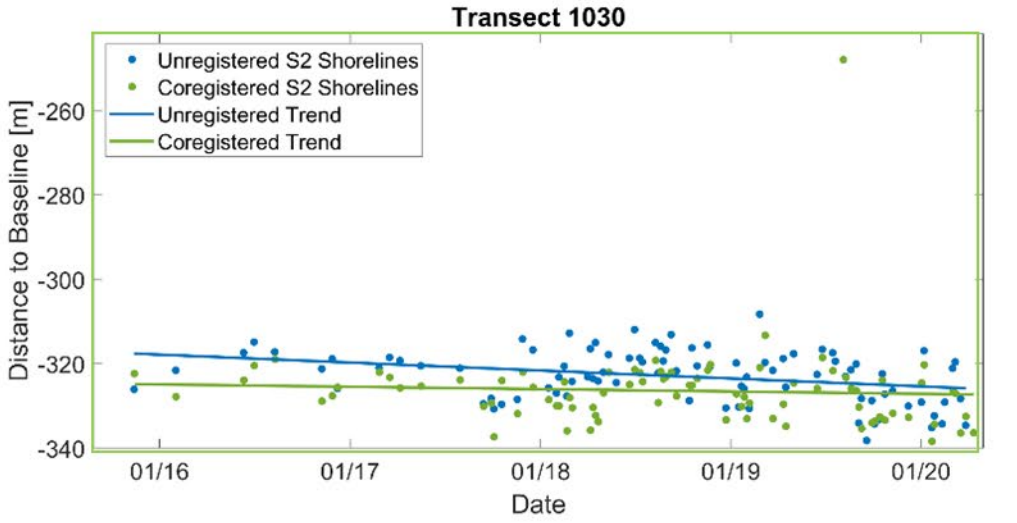
8.86 m error

Image Coregistration: AROSICS and ArcPy

- Workflow integration challenges. ArcPy faster.
- Detrended std. dev. reduction of ~1-3 m at Wrightsville transects.
- Sentinel-2 co-registration only improved Duck shorelines by 6 cm.
- Mission to mission registration stronger influence.

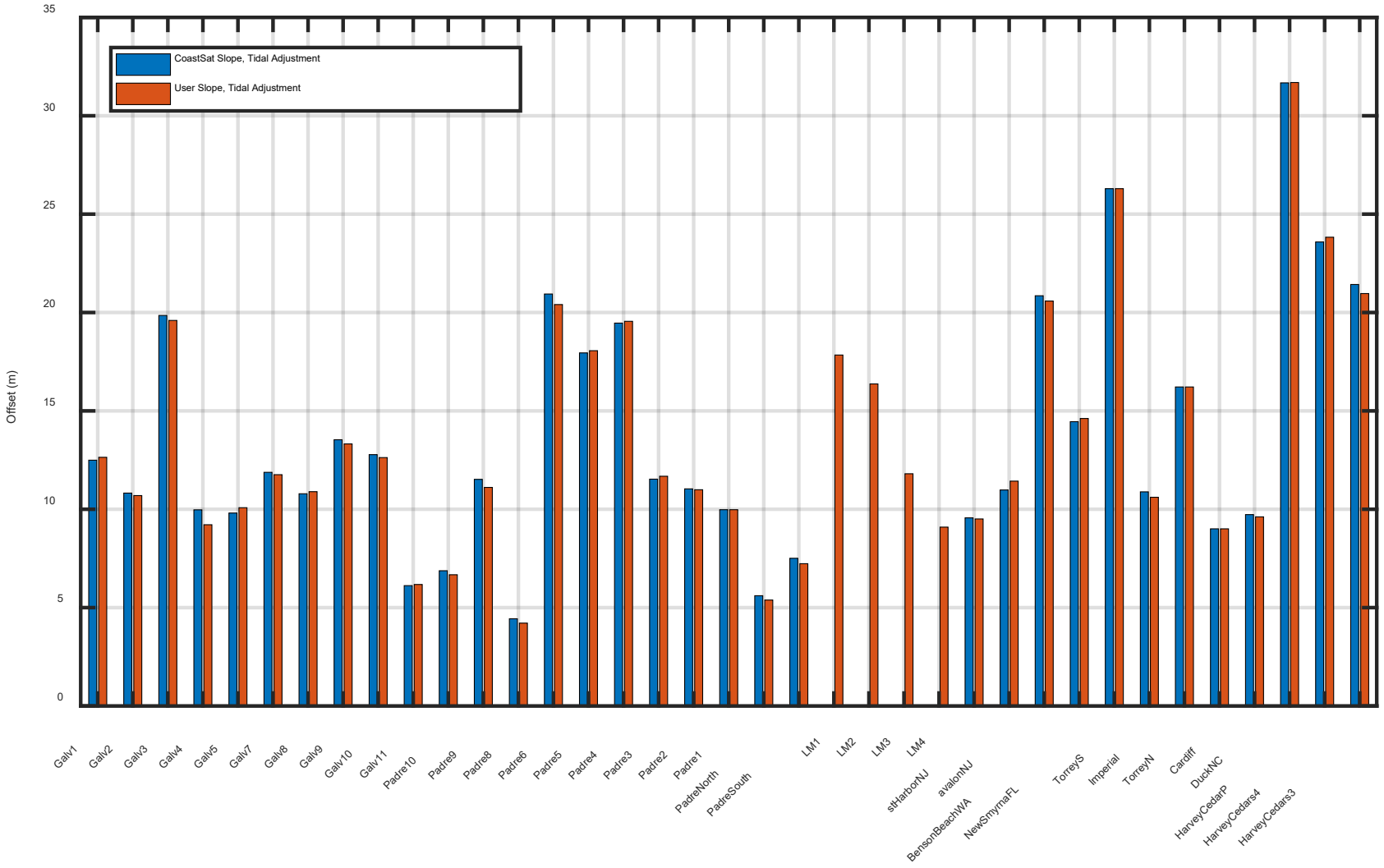




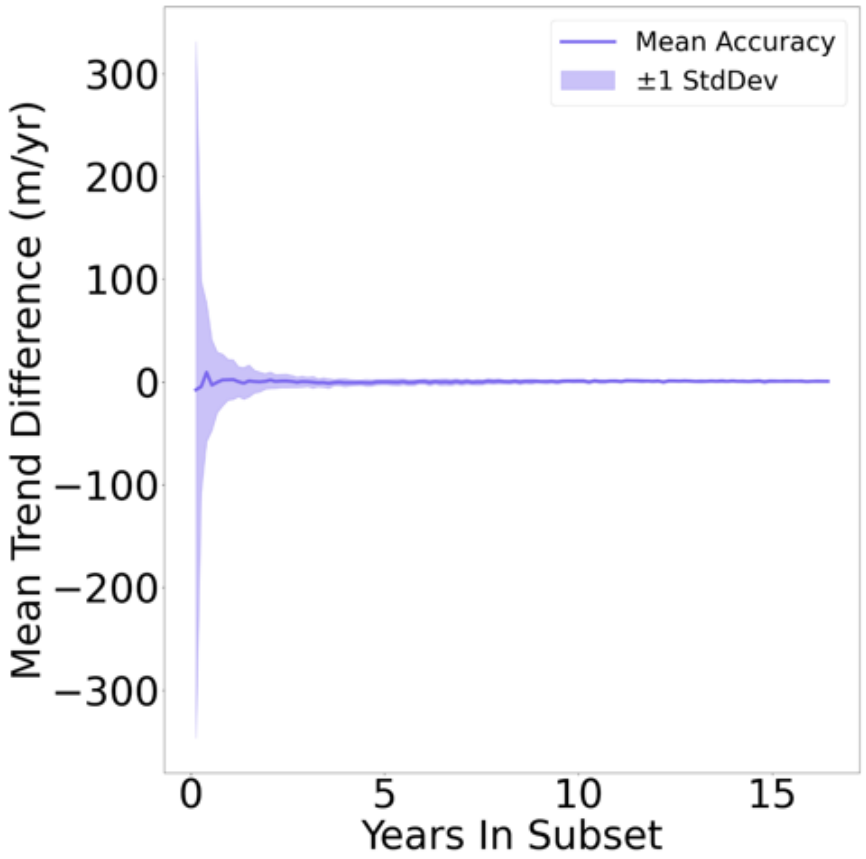


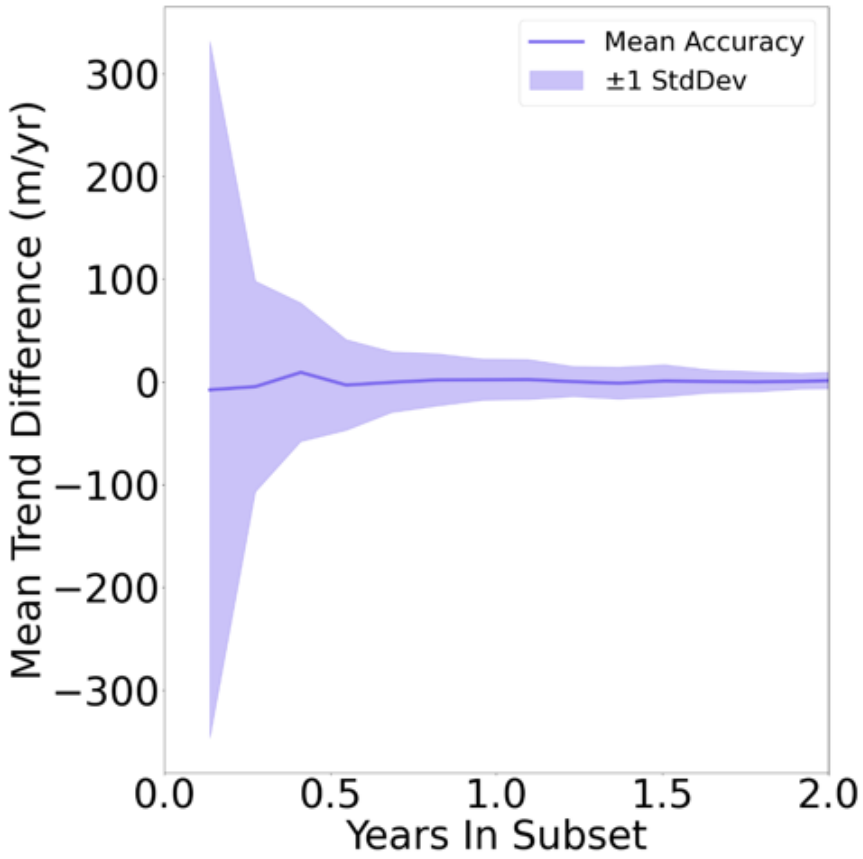
CoastSat Slope vs. User Slope

- Vos et al., 2022: Gentle and steep beaches have best predicted slopes; intermediate beaches worst
- Benson Beach, WA
  - CoastSat slope = 0.08
  - User-defined slope = 0.025
- Galveston, TX
  - CoastSat slope = 0.035
  - User-defined slope = 0.04
- Lake Michigan
  - CoastSat slope = 0.25
  - User-defined slope = 0.25



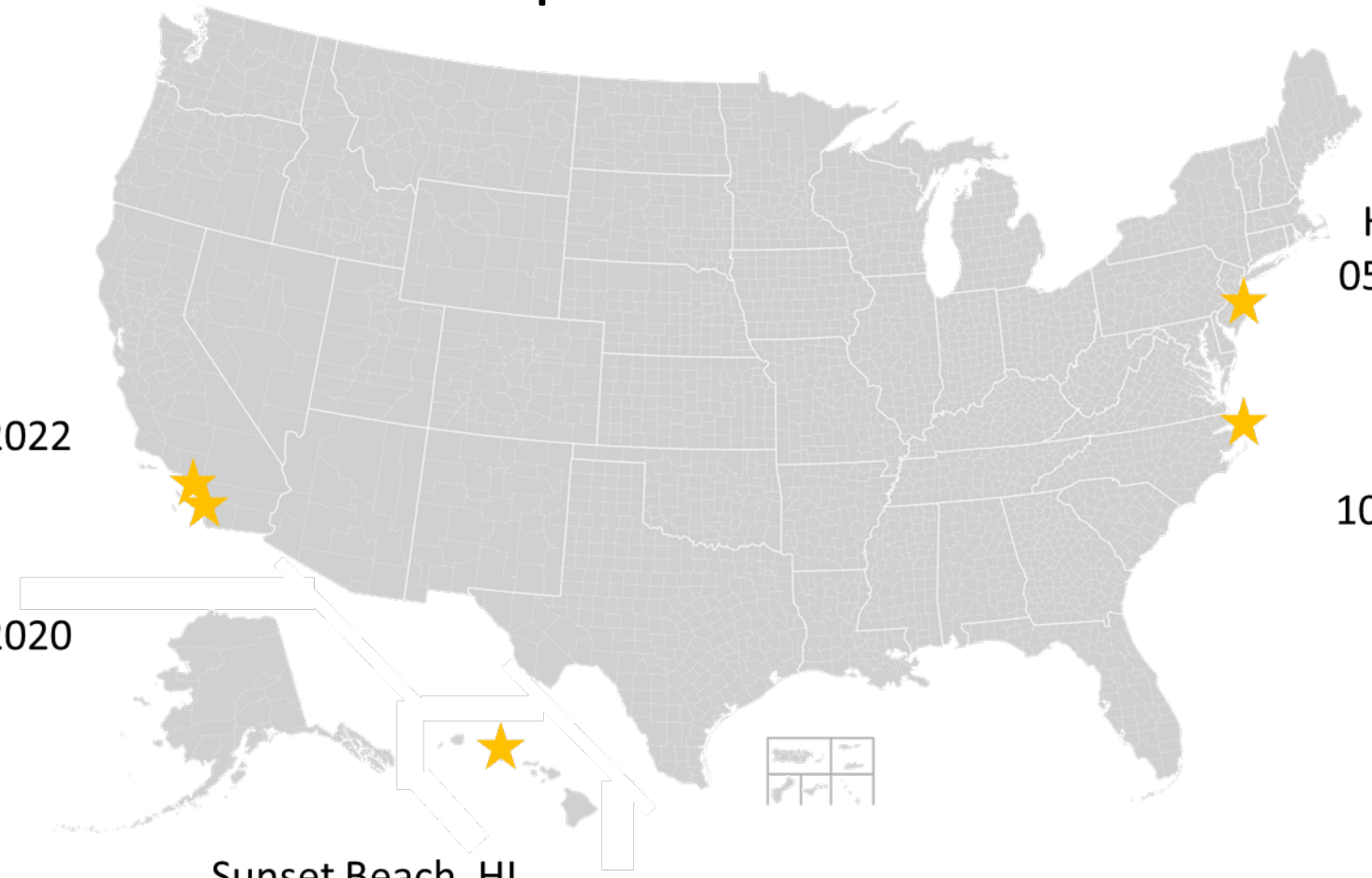
Decadal Trends





- Good trend agreement with ground truth
- 200 days data mean difference = -3.10 m/yr; 650 days of data mean difference = -0.04 m/yr

CoastSat.PlanetScope Sites



Encinitas, CA
06/2018 – 05/2022
176 Images

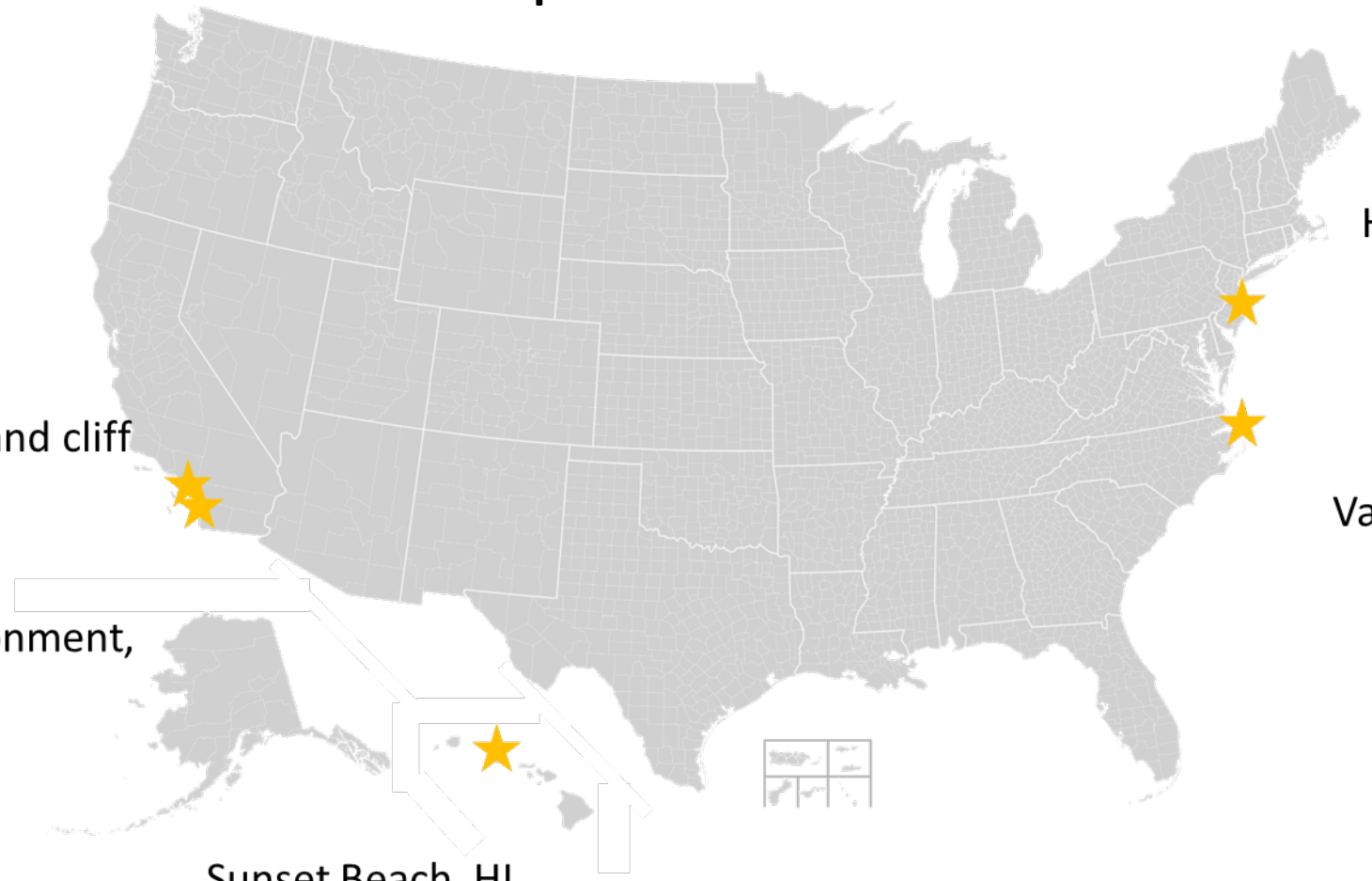
Ponto, CA
10/2018 – 03/2020
62 Images

Harvey Cedars, NJ
05/2021 – 02/2022
43 Images

Duck, NC
10/2016 – 07/2022
475 Images

Sunset Beach, HI
03/2017 – 03/2020
74 Images

CoastSat.PlanetScope Sites



Encinitas, CA
Narrow beach and cliff erosion

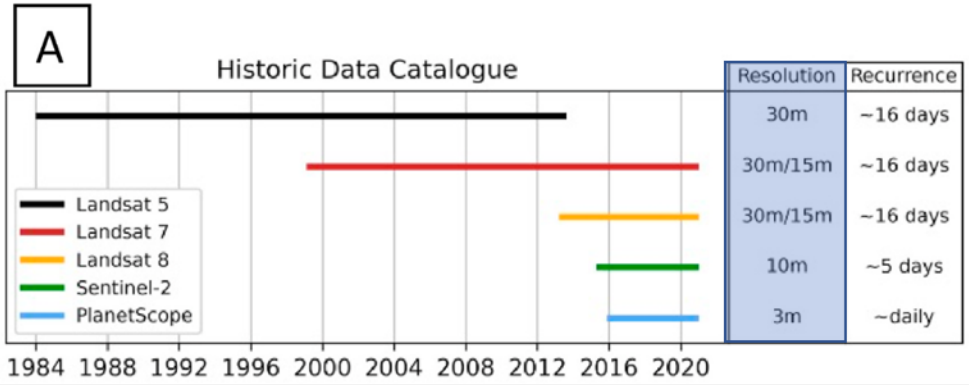
Ponto, CA
Different environment, cobble beach

Sunset Beach, HI
Large erosion event

Harvey Cedars, NJ
Monitoring berm placement

Duck, NC
Validation data and storm impact

PlanetScope vs. CoastSat



(Doherty et al. 2022)

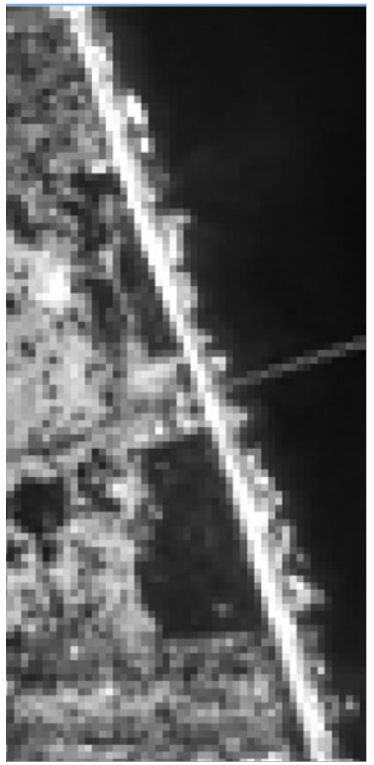
Traditional CoastSat

- 1 shoreline/ week
- Longterm change

PlanetScope

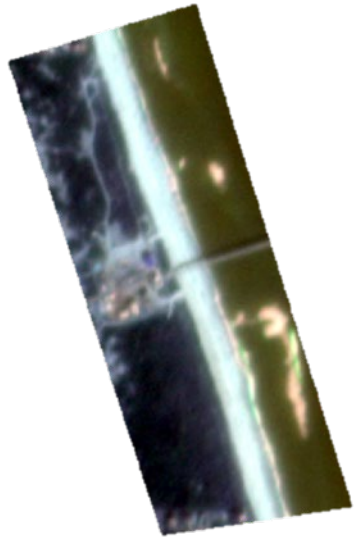
- 1 shoreline/ day
- Enables storm response
- Smaller management projects monitoring

L8 Image
30 m
10/15 m

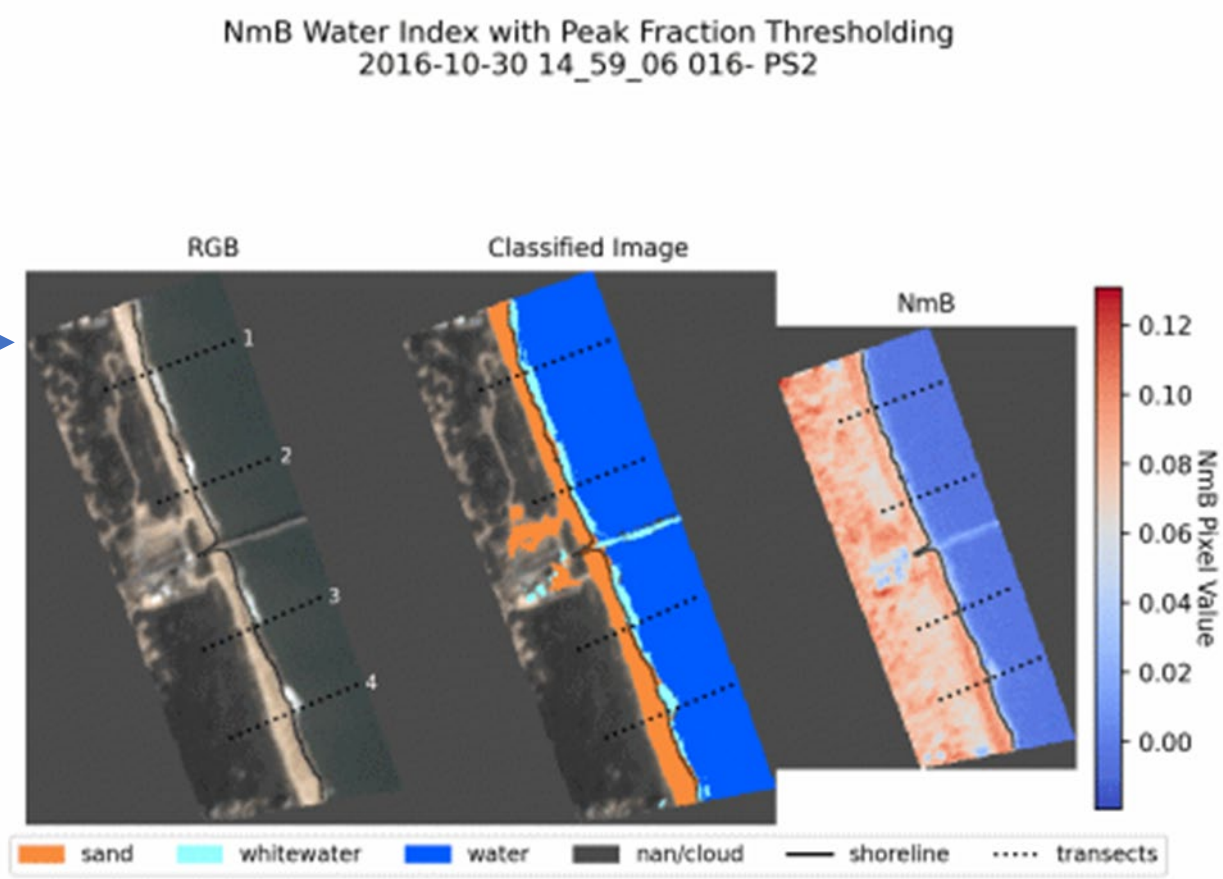


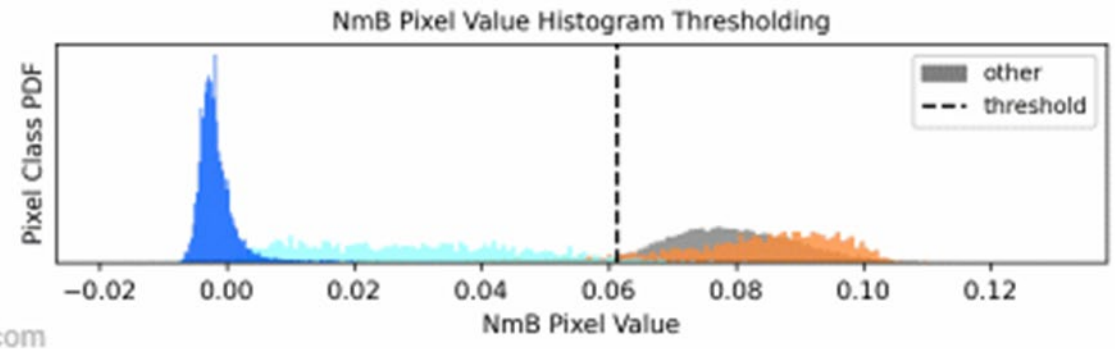
S2 Image
10m
10/15 m

PS Image
3.7 m
3.5/5 m

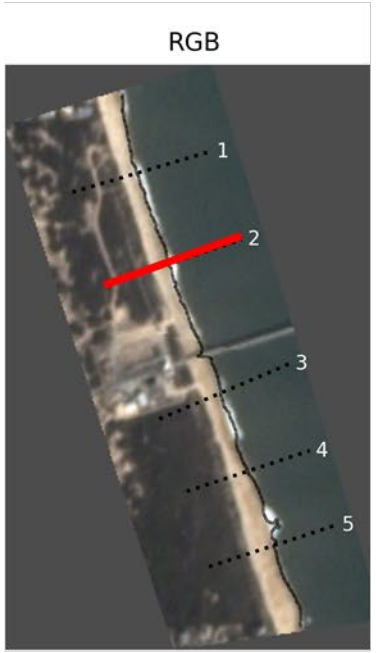


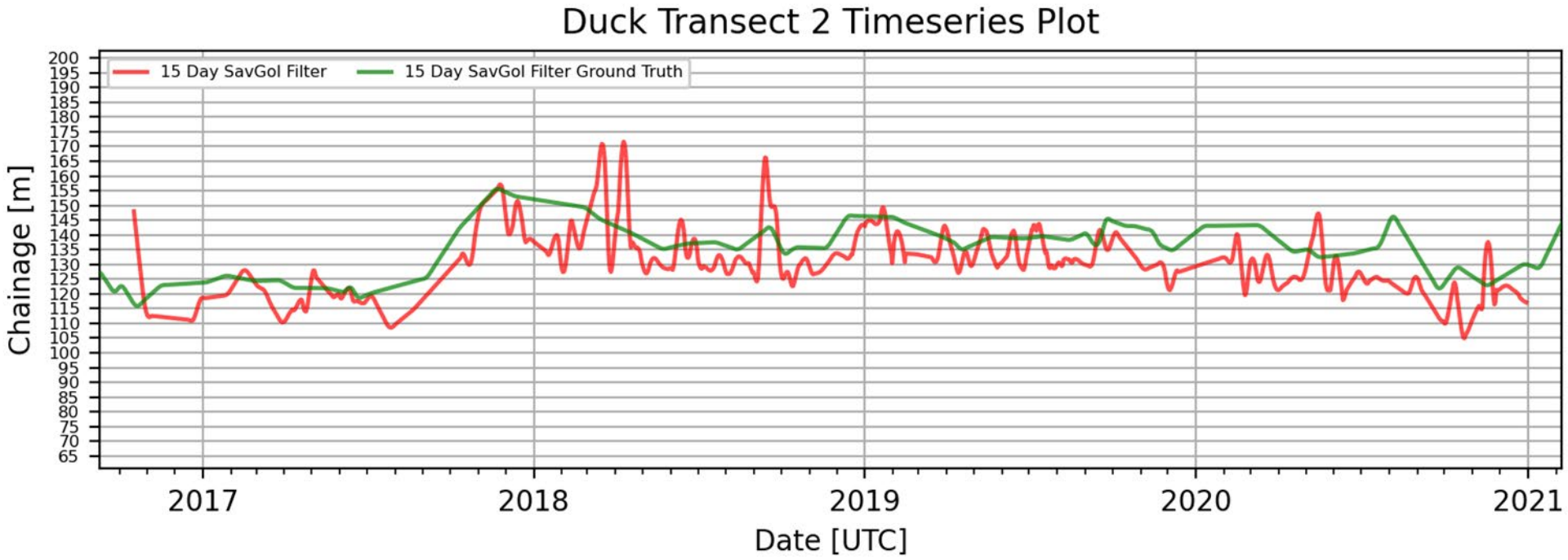
Edge of Nourishment





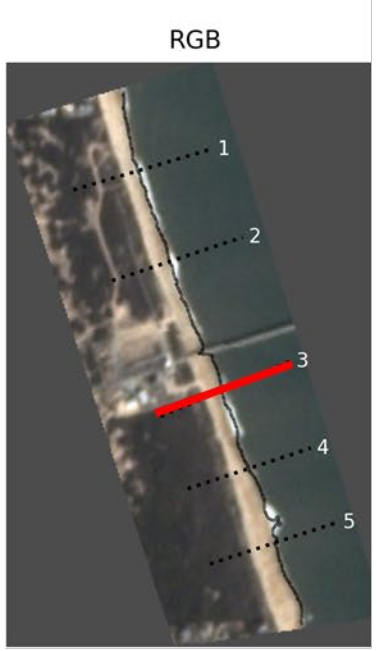
Duck, NC Ground Truth

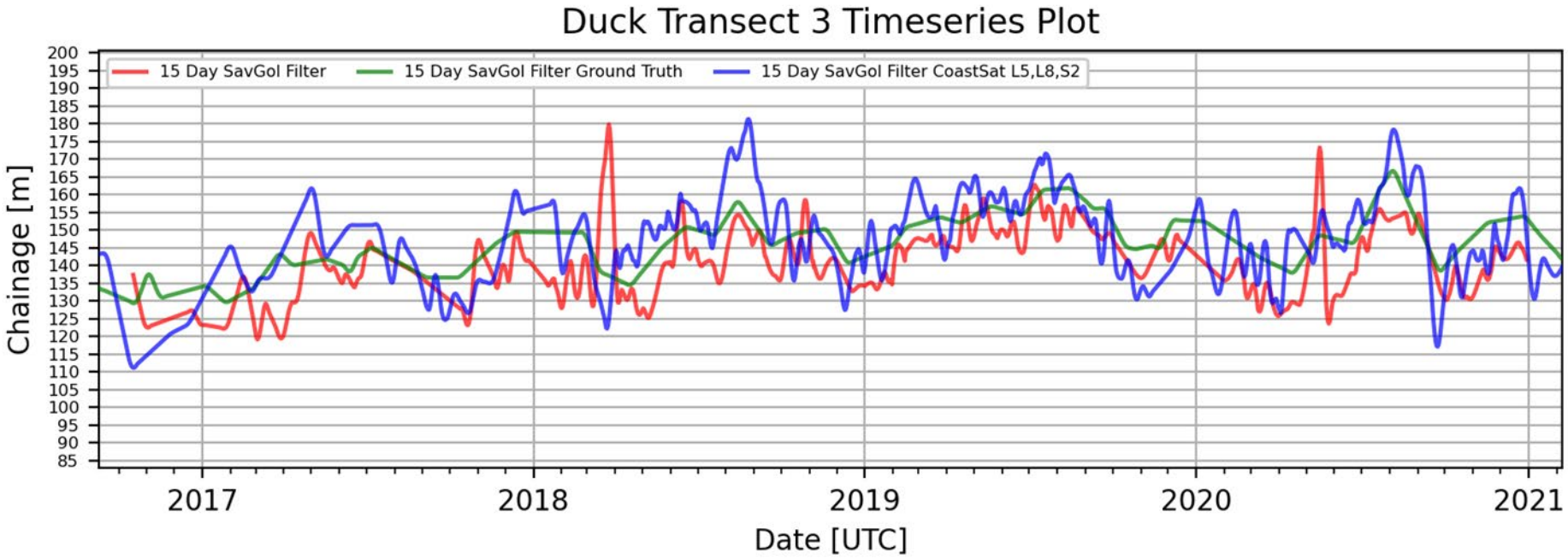




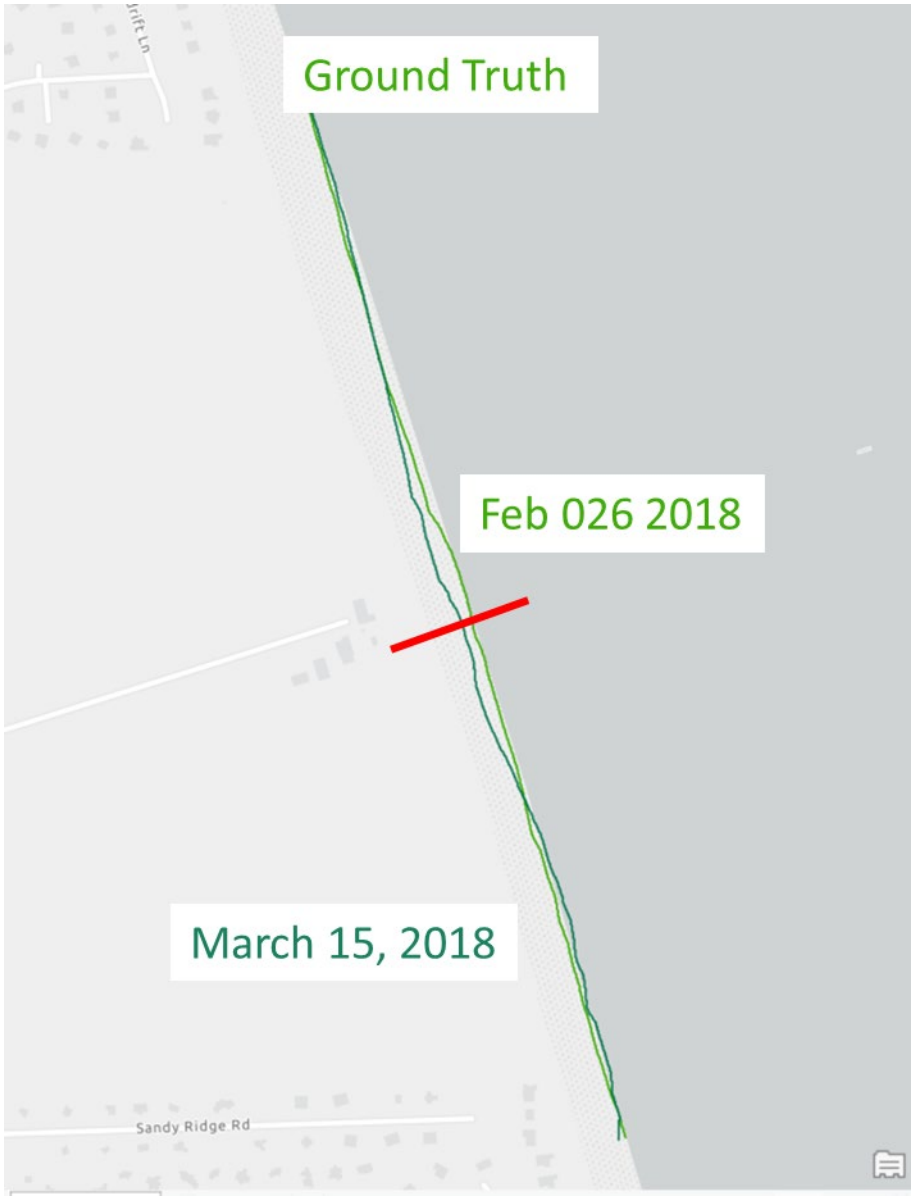
- 430 CoastSat.Planetscope shorelines (red) compared to 97 LARC shorelines (green)
- RMSE = 4.7 m
- Bias = -0.01 m
- Can see seasonal fluctuations in Coastsat.Planetscope

Duck, NC Ground Truth



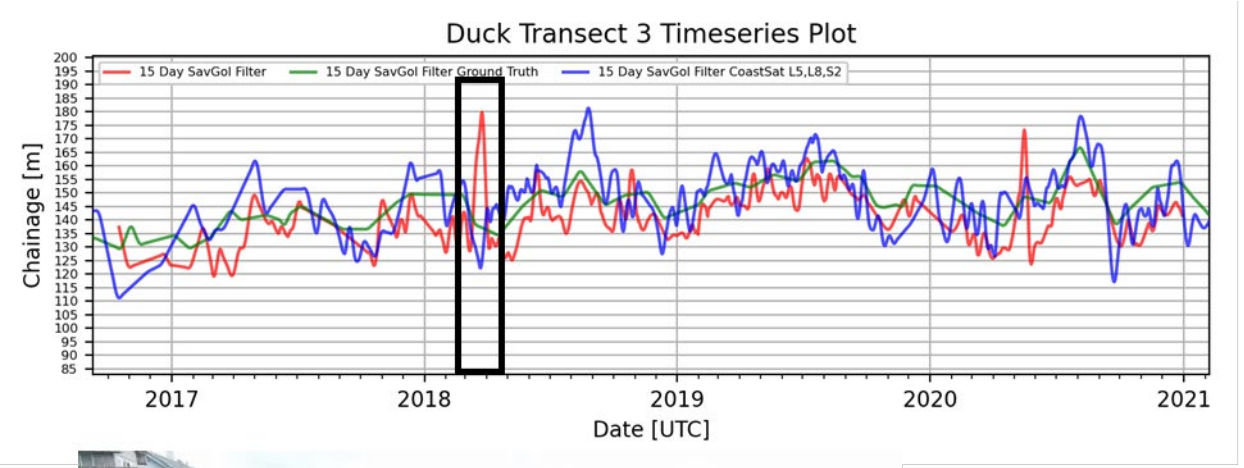


- 387 CoastSat shorelines (blue) compared to 97 LARC shorelines (green)
- RMSE = 8.5 m
- Bias = -0.4 m



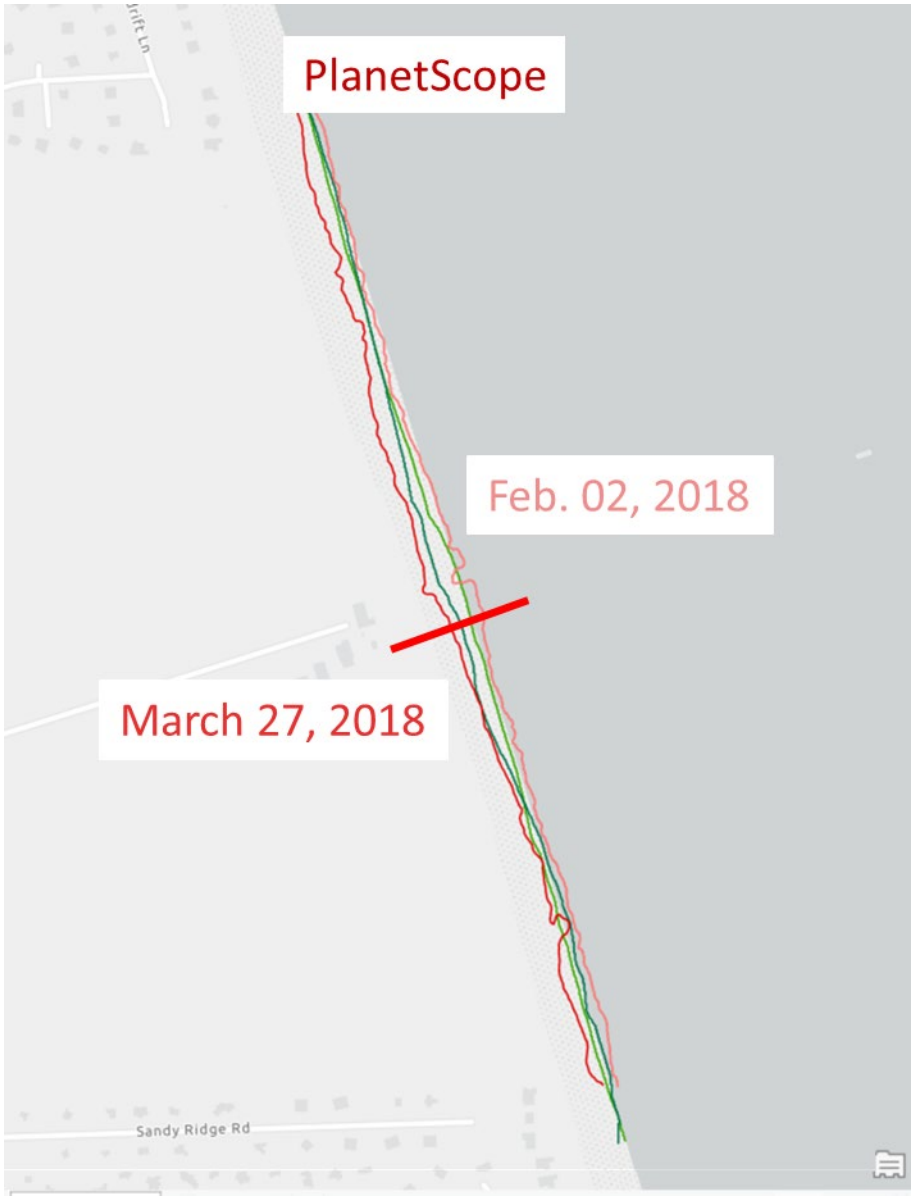
Duck, NC

Nor'Easter March 4, 2018



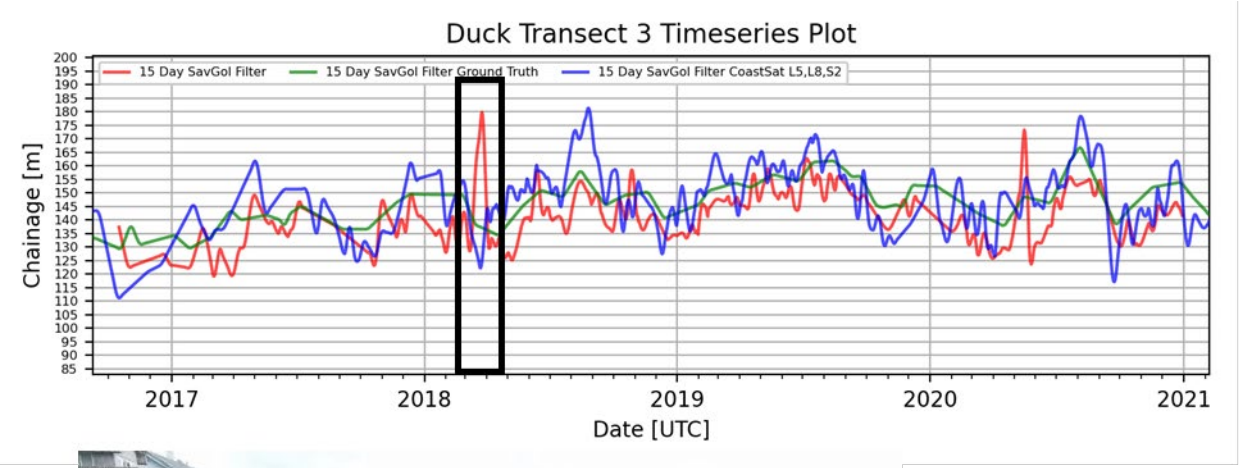
https://www.wral.com/nor-easter-leaves-some-outer-banks-islands-inaccessible/17391444/

https://www.thecoastlandtimes.com/2018/10/13/michael/



Duck, NC

Nor'Easter March 4, 2018



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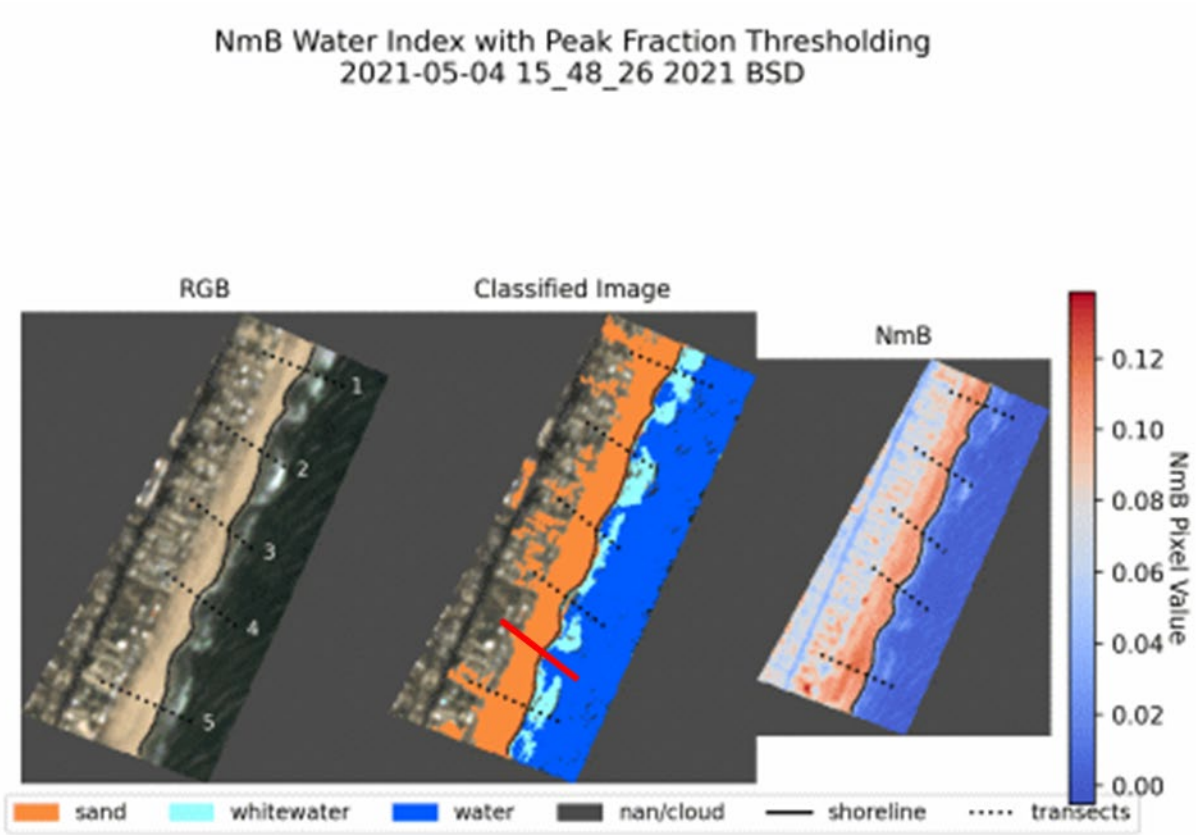
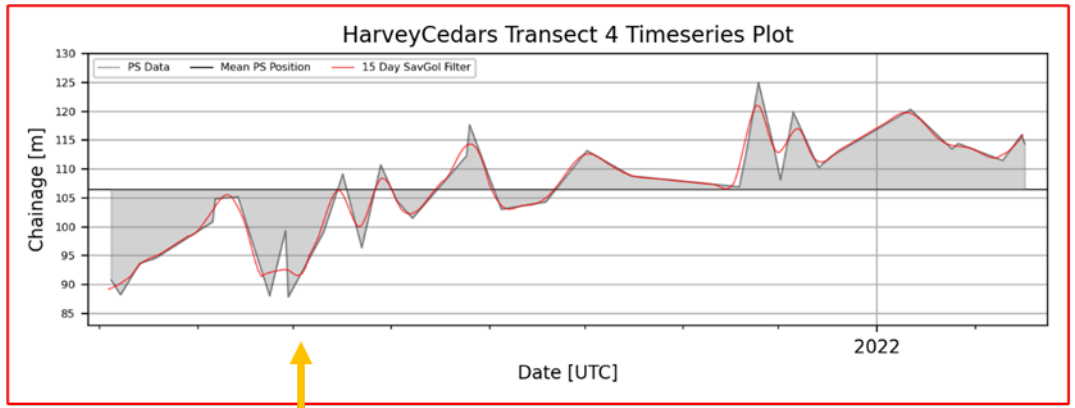
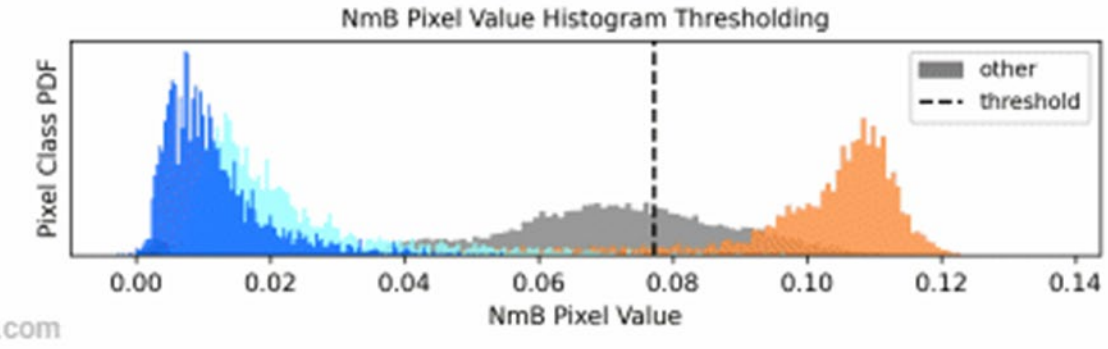


Harvey Cedars, NJ



Nearshore Berm Placement



*McGill et al. 2022

Maxar Sites

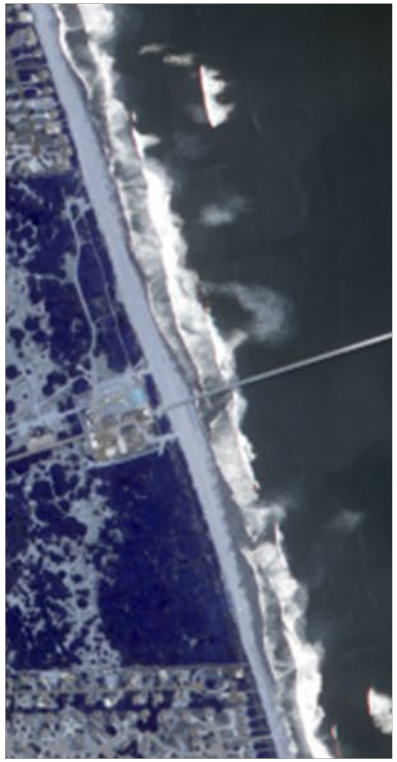
Benson Beach, WA
03/2022 – 09/2022
3 Images

Provincetown, MA
03/2021 – 06/2022
17 Images

Duck, NC
02/2021 – 07/2022
9 Images

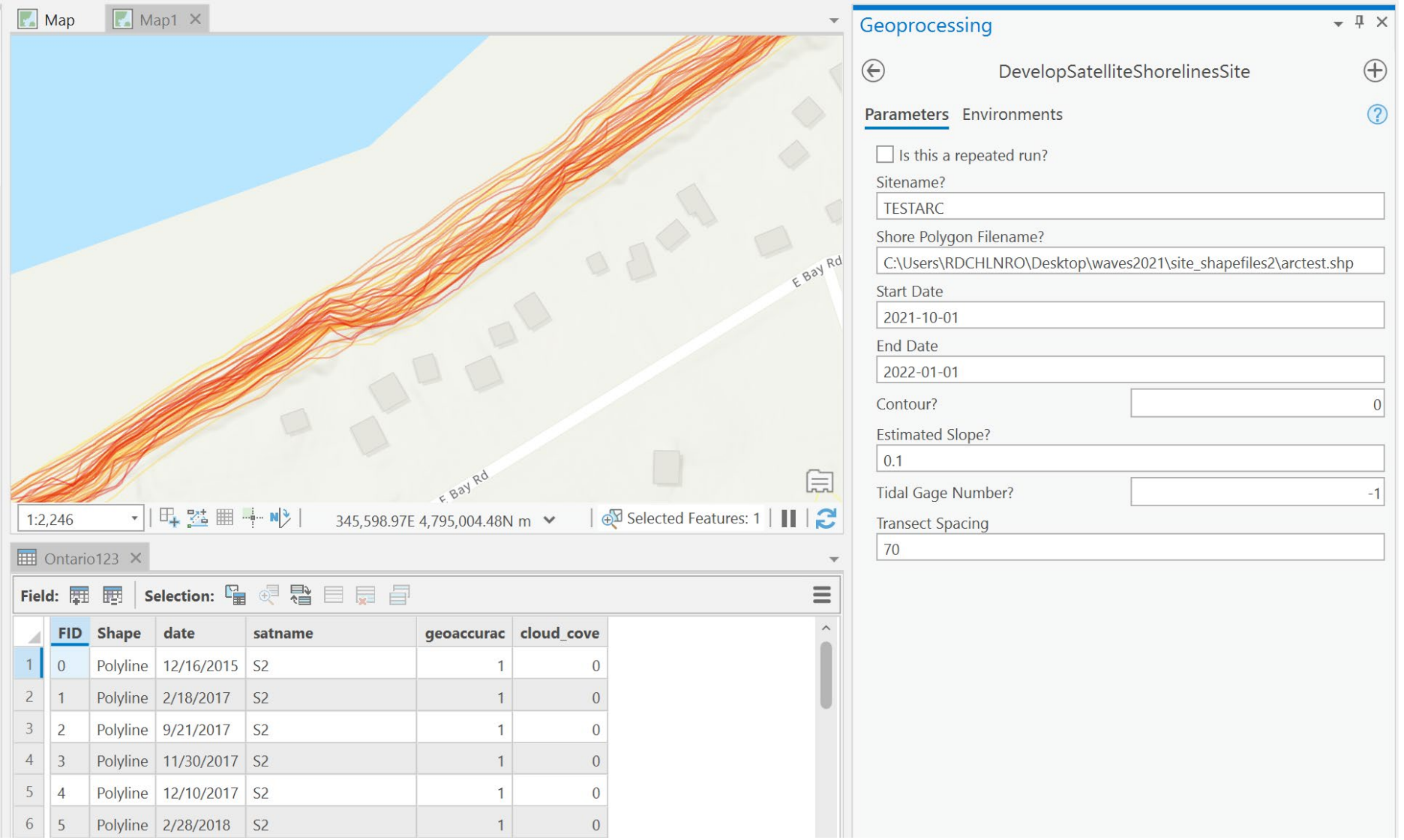
Sunset Beach, HI
04/2021 – 12/2022
61 Images

WorldView 2
1.8 m



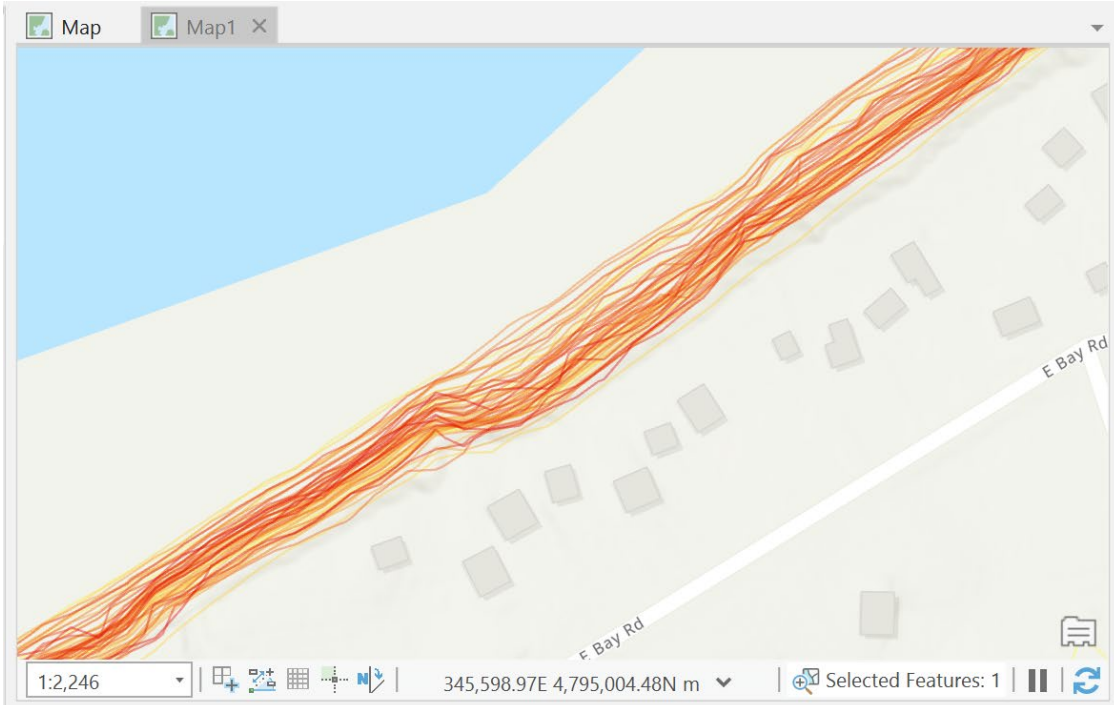
***Free to Districts with justification**

Tool Development and Analysis Products



- Beta tool version
- M. Forte Arc
- User manual
- District Training Webinar in summer
- Potential to incorporate PlanetScope and Maxar in future

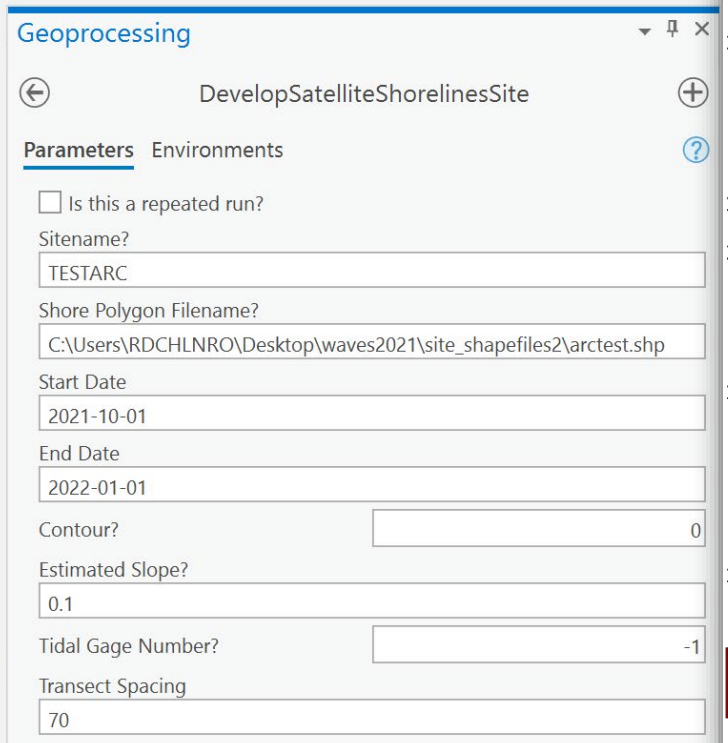
Tool Development and Analysis Products

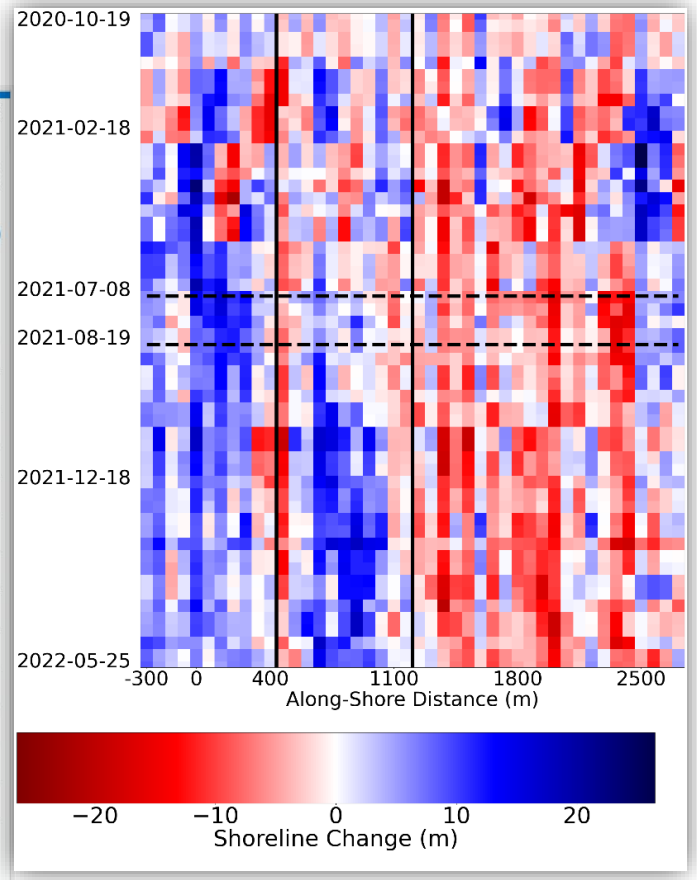


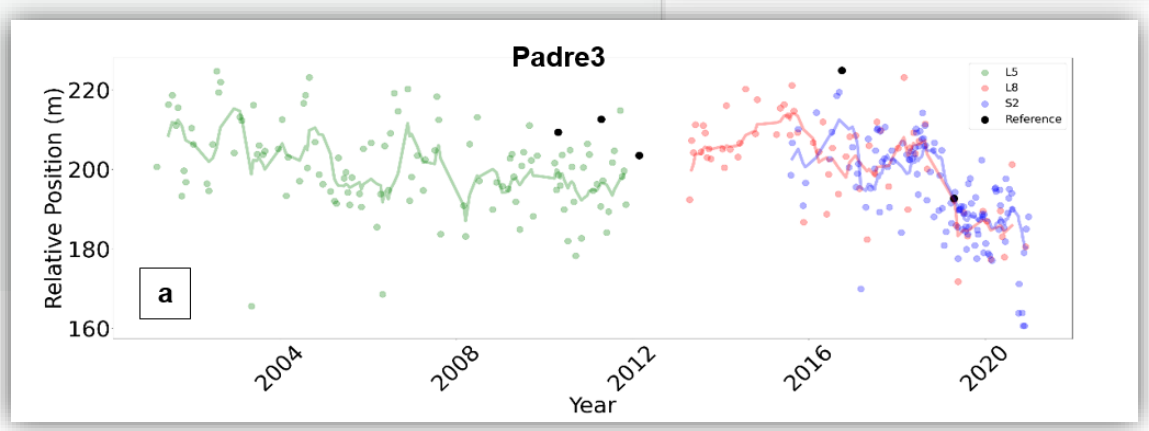
Ontario123

Field: Selection:

	FID	Shape	date	satname	geoaccurac	cloud_cove
1	0	Polyline	12/16/2015	S2	1	0
2	1	Polyline	2/18/2017	S2	1	0
3	2	Polyline	9/21/2017	S2	1	0
4	3	Polyline	11/30/2017	S2	1	0
5	4	Polyline	12/10/2017	S2	1	0
6	5	Polyline	2/28/2018	S2	1	0







* Open to suggestions!

Summary

FY22 Major Advances in Capability

- Tool upgrade to CoastSat version 2.0, bug fixes
- Improved analysis products for management
- PlanetScope imagery acquisition at 5 sites, troubleshooting and runs at 4 sites
- Maxar imagery acquisition at 4 sites, 2 attempted runs
- Team re-structuring FY23

FY22 Major Products & Collaborations

- **TR on CoastSat Accuracy (in pub.)**
- **CHL seminar**
- **CIRP TD**
- **Ocean Sciences Conference Presentation**
- **CODS IPR and meetings**
- **Lake Ontario Reimbursable (25%)**
- **Y. Ding Probablistic Shoreline Modeling (CODS)**
- **S. McGill Water Level Cameras (CODS)**
- **USGS and NOAA discussions**

Planned Outyear Products/Advances

- **Runup correction paper using FRF lidar tower data (FY24/Q1)**
- **Submit PlanetScope TN**
- **District Training Webinar**
- **Incorporate tool feedback**
- **Tool release**