

SATELLITE-DERIVED SHORELINES FOR COASTAL MONITORING

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COASTAL INLETS RESEARCH PROGRAM

FY23 IN PROGRESS REVIEW



U.S. ARMY



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ERDC



CIRP



PROBLEM STATEMENT



- **Existing coastal survey methods can be time-consuming, expensive and hazardous**
 - ...
 - **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)

FY23 was Year 3 of 3

FY21: Algorithm accuracy evaluation; FY22: Tool development and report writing; FY 23: Tool refinement and tech transfer

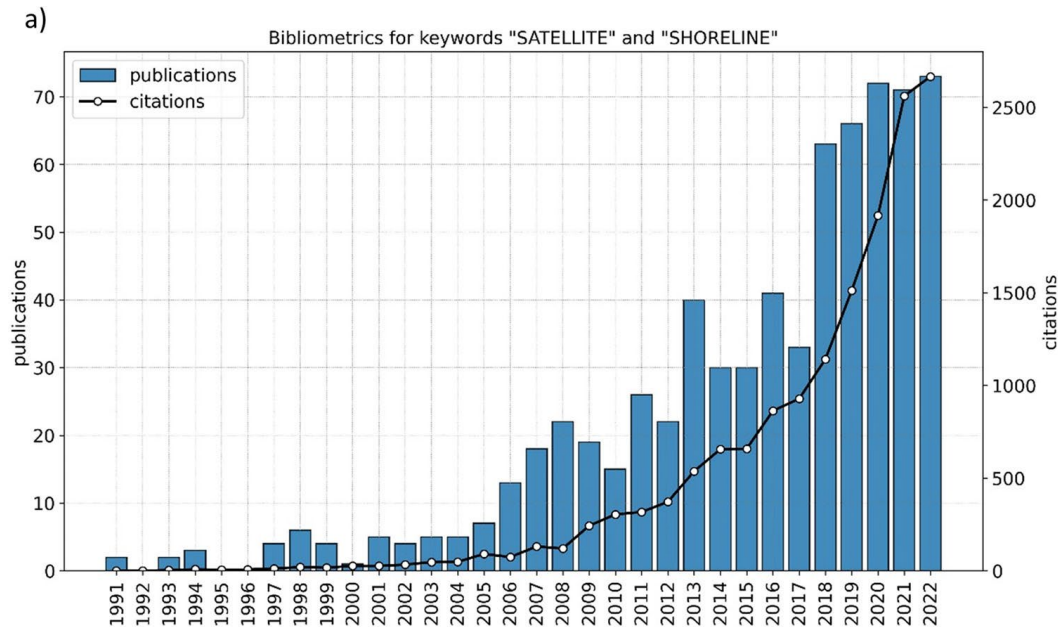


CAPABILITY AND STRATEGIC IMPACT



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

- 1) Evaluate open-source satellite shoreline extraction algorithm accuracy at a range of test sites (CoastSat – UNSW; Vos et al., 2019) (FY21-22)

Mean horizontal difference from ground truth = **11.32 m**; -3.51 m onshore bias

- 2) Assess how imagery can be used for management applications (FY21-22)

See technical report!

- 3) Create user-friendly ArcTool for USACE District use (FY22-23)

<https://cirp.usace.army.mil/products/ssm.php>

- 4) Journal Article (FY23-24)

ERDC Satellite Shoreline Mapper (SSM)

The screenshot displays the ERDC Satellite Shoreline Mapper (SSM) interface. On the left, a map shows a coastline with a dense orange and red line representing the shoreline timeseries output. A callout box labeled "Shoreline Timeseries Output" points to this line. Below the map is a table with the following data:

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

A callout box labeled "Shoreline Attribute Table" points to this table. On the right side of the interface is a "Geoprocessing" panel for the tool "DevelopSatelliteShorelinesSite". It contains several input parameters:

- Is this a repeated run? (checkbox)
- Sitename? (text field: TESTARC)
- Shore Polygon Filename? (text field: C:\Users\RDCHLNRO\Desktop\waves2021\site_shapefiles2\arctest.shp)
- Start Date (text field: 2021-10-01)
- End Date (text field: 2022-01-01)
- Contour? (text field: 0)
- Estimated Slope? (text field: 0.1)
- Tidal Gage Number? (text field: -1)
- Transect Spacing (text field: 70)

A callout box labeled "Input parameters" points to the "End Date" field.

Tool improvements



- Transects
- Shapefile tidal shift
- Created useful plots
- Sentinel 2 cloud threshold
- CoastSat slope over short intervals
- Blue border

Improvements on wrapper

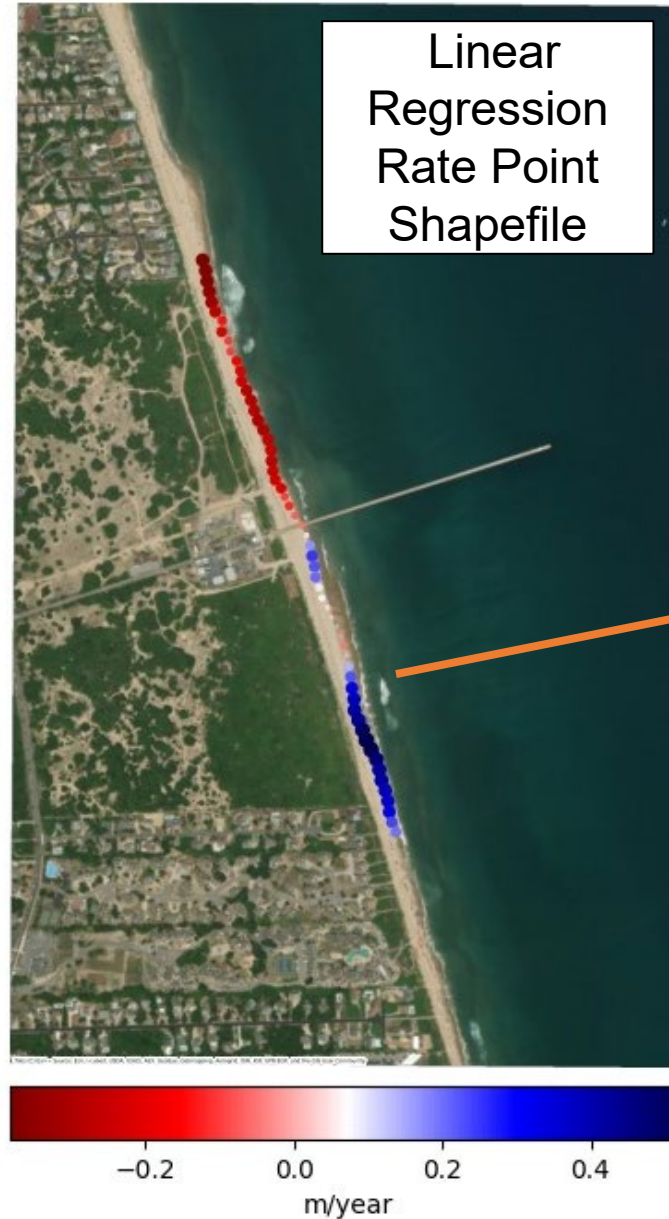
Update/Improve
CoastSat Algorithm

Tool Products

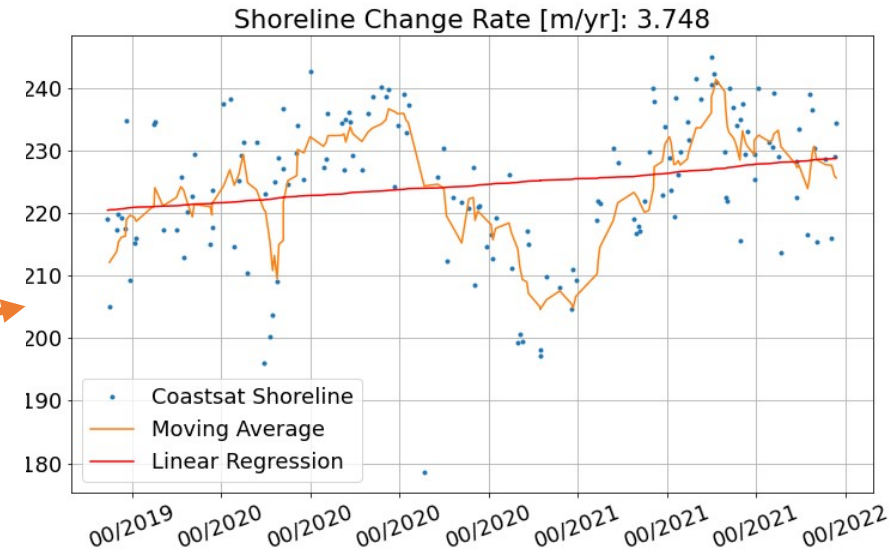
Summary .csv

	A	B	C	D	E
1	dates	tide	Transect 1	Transect 2	
2	0 2019-10-15 15:52:06+00:00	0.133	271.0521	270.4211	
3	1 2019-10-23 16:02:04+00:00	-0.077	277.6249	274.6783	
4	2 2019-10-24 15:40:16+00:00	-0.264	278.5828	271.9569	
5	3 2019-11-02 16:02:04+00:00	0.443			
6	4 2019-11-04 15:52:20+00:00	0.185	274.5704	272.4667	
7	5 2019-11-09 15:40:14+00:00	-0.261	276.6372	270.4311	
8	6 2019-11-09 15:52:08+00:00	-0.261	274.1979	269.7547	
9	7 2019-11-25 15:40:11+00:00	-0.291	276.0544	280.3004	
10	8 2019-11-29 15:52:19+00:00	0.325	252.4843	250.9596	
11	9 2019-12-12 16:01:57+00:00	-0.106	271.0976	267.4444	
12	10 2019-12-19 15:51:59+00:00	0.095	279.6316	274.5377	
13	11 2019-12-22 16:02:10+00:00	-0.423	270.033	268.5283	
14	12 2020-01-05 15:34:17+00:00	-0.229	276.964	270.5486	
15	13 2020-01-06 16:01:56+00:00	-0.333	271.8251	260.4234	
16	14 2020-01-08 15:52:00+00:00	-0.372	251.8553	258.9207	
17	15 2020-01-21 15:33:50+00:00	-0.437	276.612	268.725	
18	16 2020-01-21 16:01:59+00:00	-0.437	272.8194	271.3301	
19	17 2020-01-26 16:01:54+00:00	0.074	265.6532	263.2063	
20	18 2020-01-31 16:02:08+00:00	0.141	268.5693	265.5253	
21	19 2020-02-12 15:52:15+00:00	0.328	265.996	258.1539	
22	20 2020-02-15 16:01:57+00:00	0.099	271.0731	265.8477	
23	21 2020-02-17 15:51:59+00:00	-0.239	281.3595	277.6854	
24	22 2020-02-22 15:33:41+00:00	-0.202	281.0288	275.651	
25	23 2020-02-22 15:52:02+00:00	-0.202	279.7052	279.0967	
26	24 2020-02-27 15:52:15+00:00	0.204	270.1036	272.0576	
27	25 2020-02-29 15:39:50+00:00	0.171	279.6509	273.8794	
28	26 2020-03-01 16:01:56+00:00	0.116	285.7006	282.8834	
29	27 2020-03-08 15:52:16+00:00	-0.321	267.3256	259.4734	
30	28 2020-03-26 16:01:59+00:00	0.087	254.7096	250.9919	
31	29 2020-04-02 15:52:17+00:00	-0.127	265.9741	260.3019	
32	30 2020-04-07 15:52:17+00:00	-0.263	269.522	274.7061	

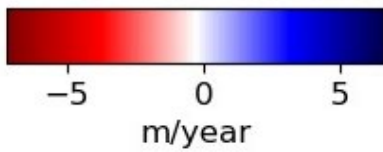
LRR [2008 - 2023] Satellite Derived Shorelines



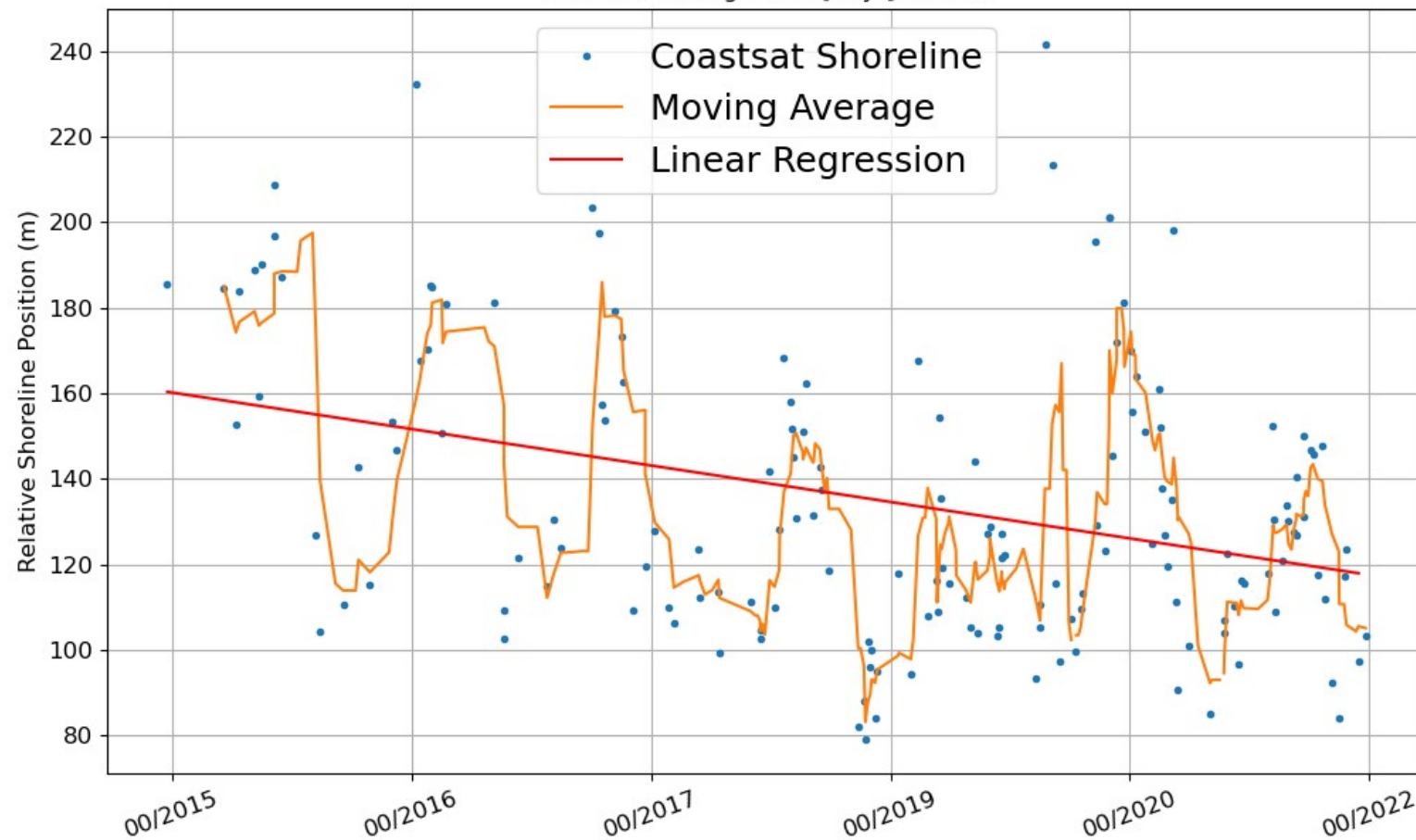
Individual Transect Trend Plots



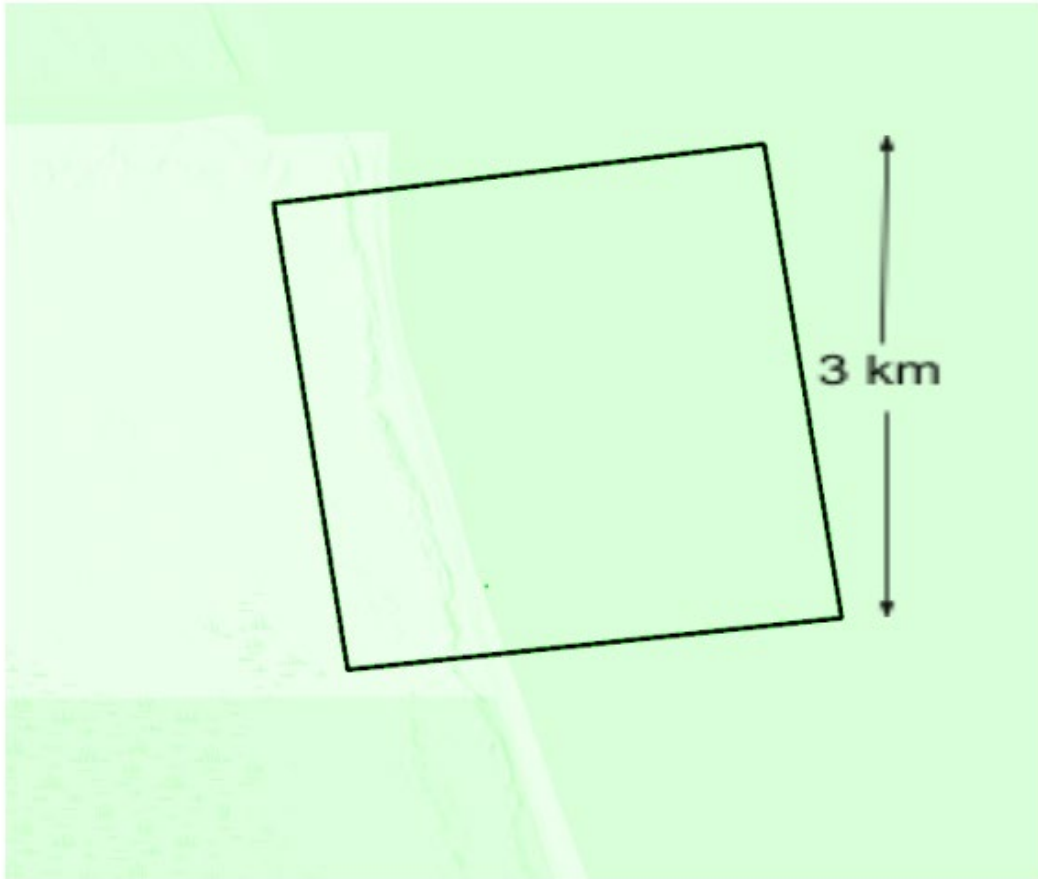
Satellite Derived Shorelines Linear Regression Rate 2015-2021



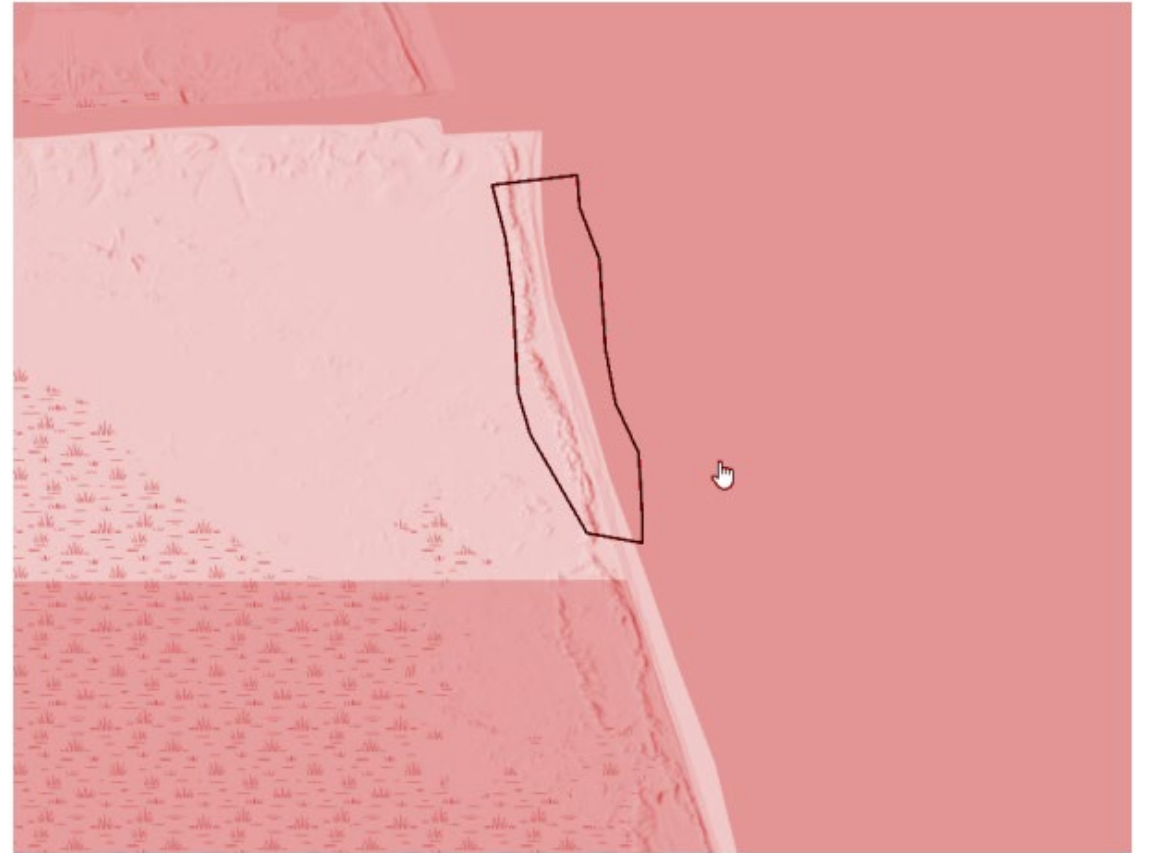
bensonbeach_long2 Transect 36
Shoreline Change Rate [m/yr]: -6.223



Creating AOI Shapefile



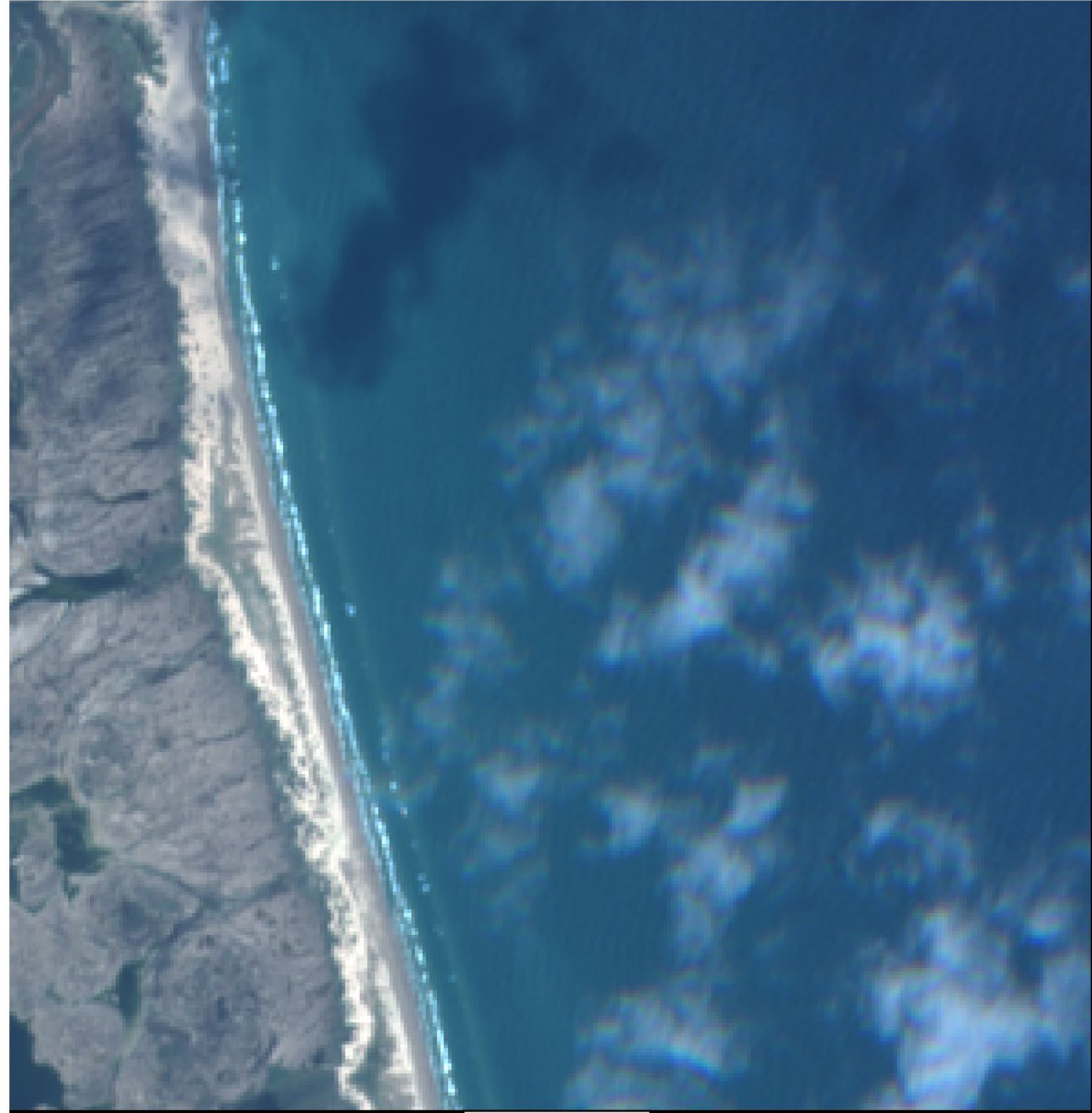
Bad shapefile example:



Creating Reference Shorelines

Press <right arrow> if image is clear enough to digitize the shoreline.
If the image is cloudy press <left arrow> to get another image

↩ skip



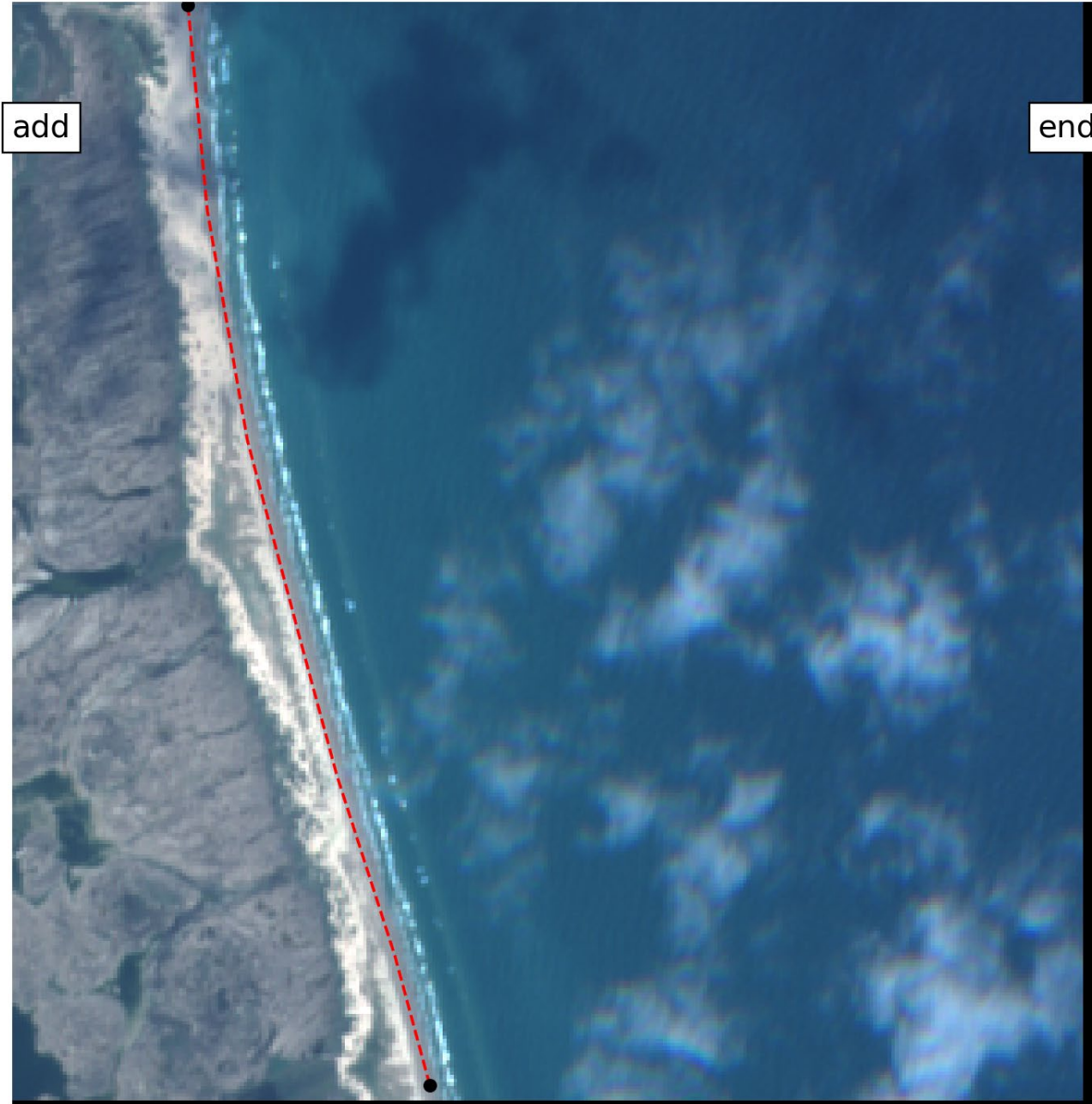
keep →

<esc> to quit

Activ
Go to :

Creating Reference Shorelines

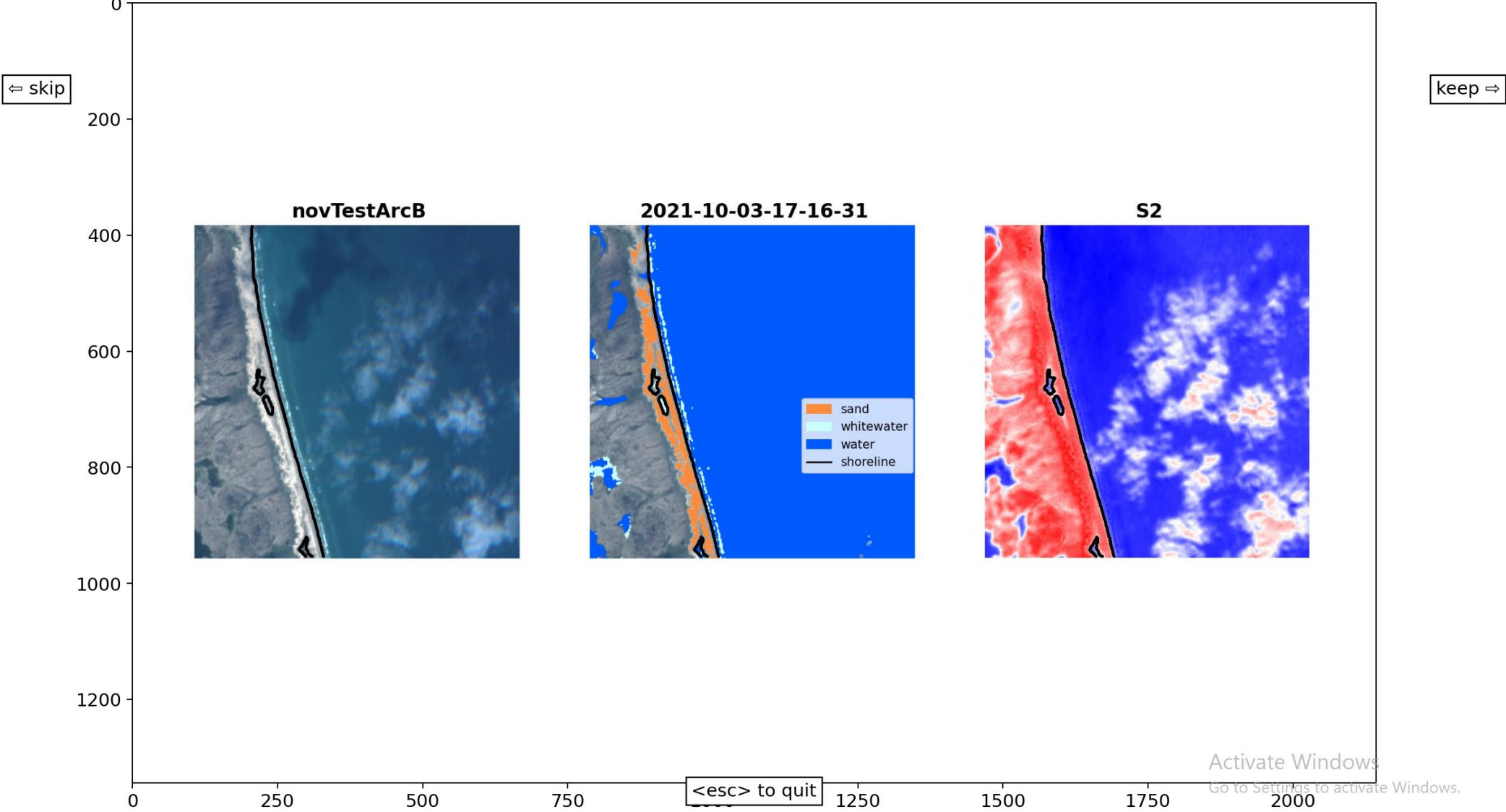
click on <add> to digitize another shoreline or on <end> to finish and save the shoreline(s)



Activ
Go to

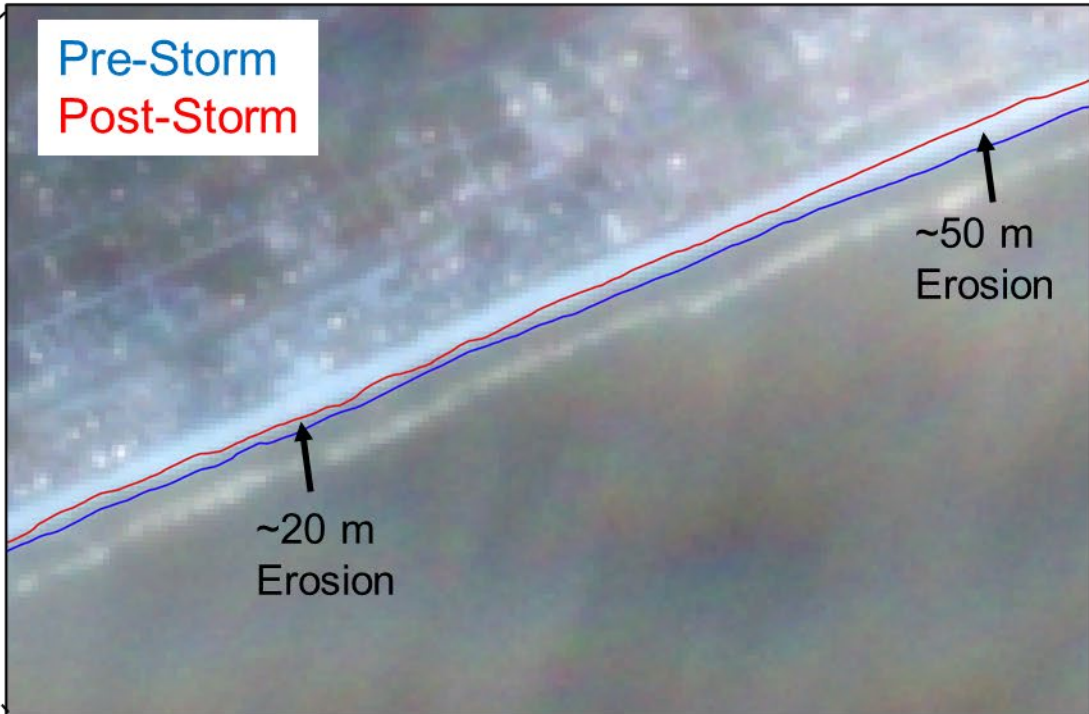
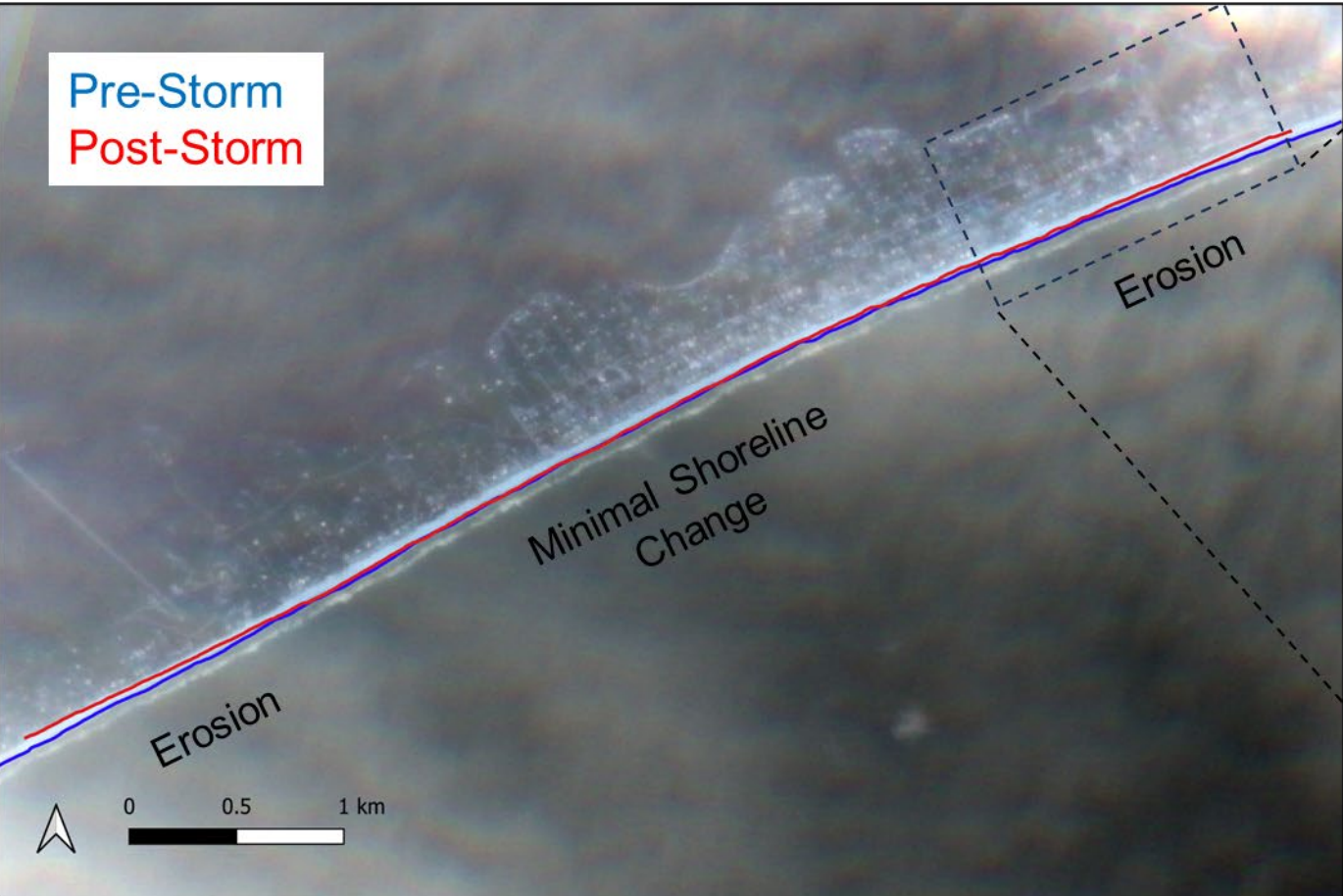
Image Sorting

Press <right arrow> if image is the shoreline is drawn well.
If the shoreline is bad press <left arrow> to get another image



Applications of ERDC Satellite Shoreline Mapper : Rapid Storm Impact Assessment

Hurricane Idalia, Aug. 30, 2023: St. George, FL

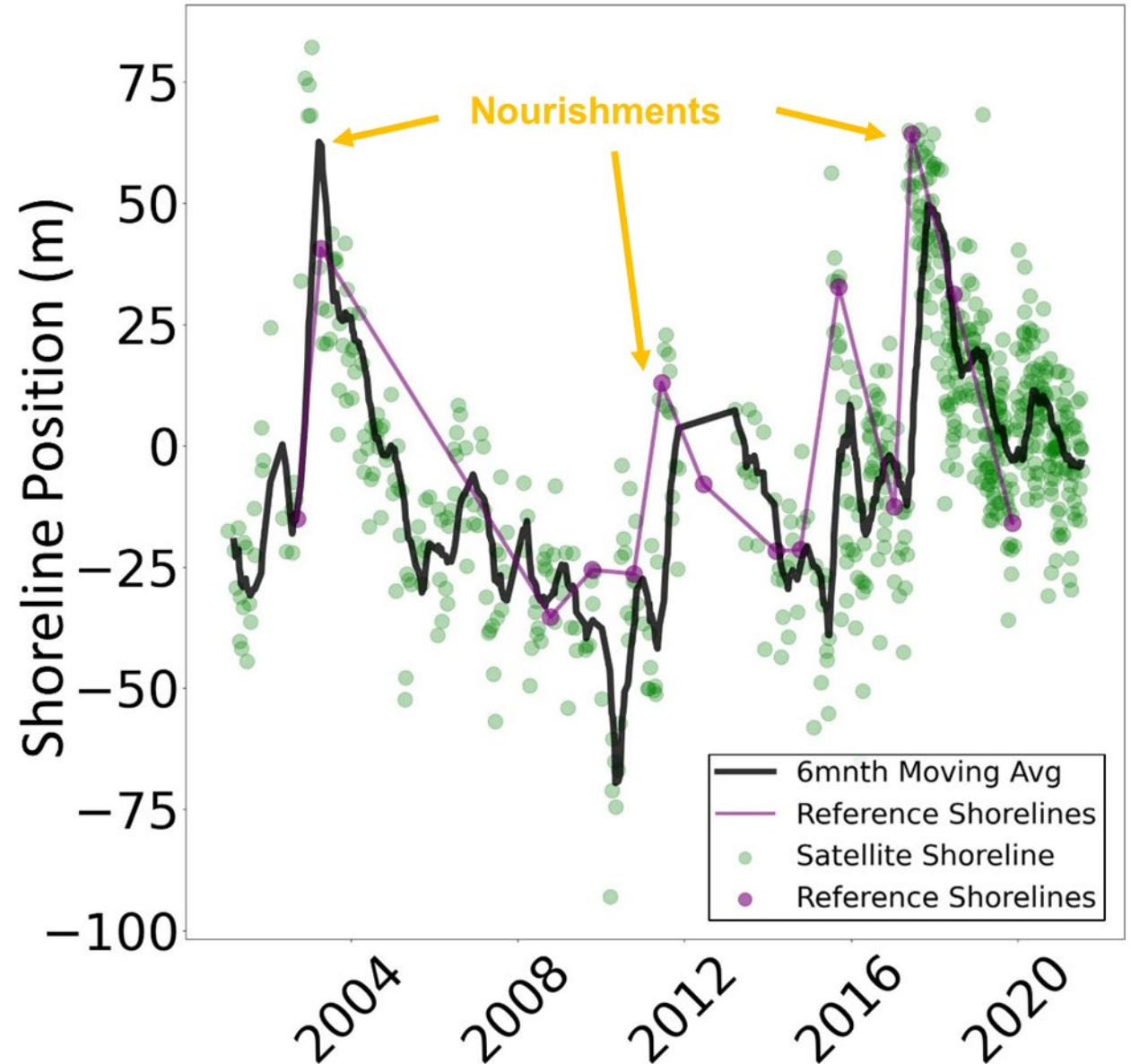


BLUF: Automated algorithms detected shoreline in pre (3 days) & post-storm (4 days) imagery, indicating up to 50-m of erosion and dune collision along eastern end of study site, minimal change in the center, and 20-m of beach erosion (half the pre-storm beach) to the west.

Applications of ERDC Satellite Shoreline Mapper : Decadal Trends and Nourishment Monitoring, Avalon, NJ

Example takeaways:

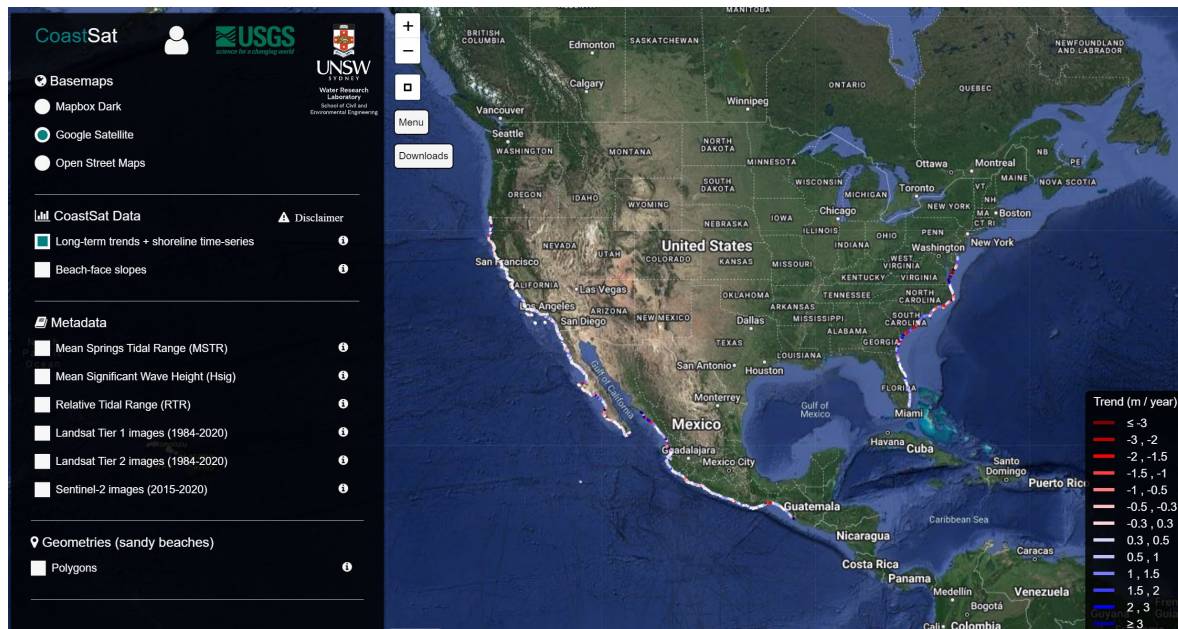
- After 2003 nourishment, equilibration occurred resulting in shoreline recession at a rate of ~ 37.6 m/yr; likely attributable to active 2004 hurricane season which included impacts from four storms: Bonnie (August), Charlie (August), Gaston (August) and Ivan (September).
- Prior to the next major nourishment in 2011, the erosion from Hurricane Barry in May 2007 is clear (8 m shoreline retreat).
- The last notable nourishment of 1,636,685 CY was conducted in 2017. Over the next 2.25 years, the beach equilibrated to pre-project width, at a recession rate of 23.2 m/yr.





FUTURE ENVISIONED PRODUCT

- **Vision:** Build a continuously updated national repository of satellite-derived shoreline position along our Nation's coastlines accessible via web portal
 - Allows historical shoreline available for all US Coastlines with each satellite pass (5 to 16-day interval)
 - In parallel a rapid response data pipeline can be setup for acute events where commercial satellites are tasked as priority and resources are directed.
 - Produces:
 - Shoreline change, beach width (e.g., shorelines cross-referenced with Dune position from JALBTCX)
 - Flooding extent
 - Flooding depth estimates (extent cross-referenced with latest topo DEM)

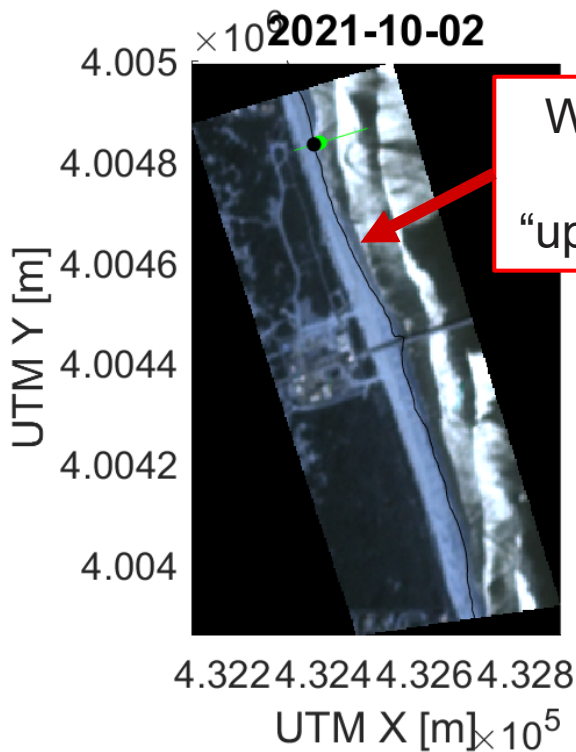




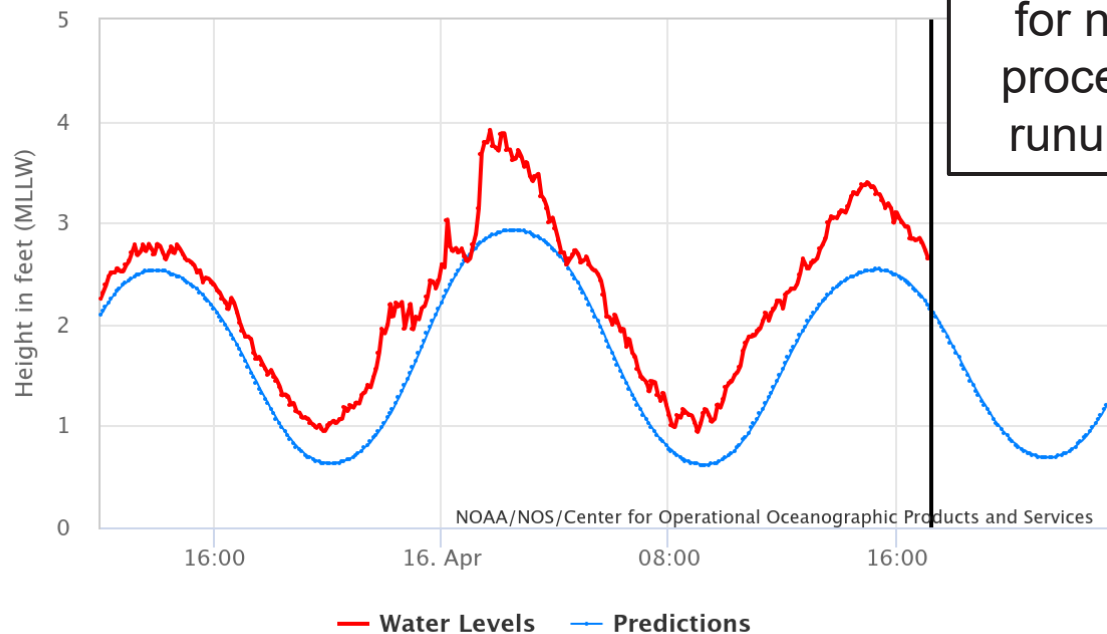
Water Level Correction



Elevation Based
Shoreline



NOAA/NOS/CO-OPS
Observed Water Levels at 8651370, Duck NC
From 2024/04/15 12:00 LST_LDT to 2024/04/16 23:59 LST_LDT



Doesn't account
for nearshore
processes (i.e.
runup, setup).



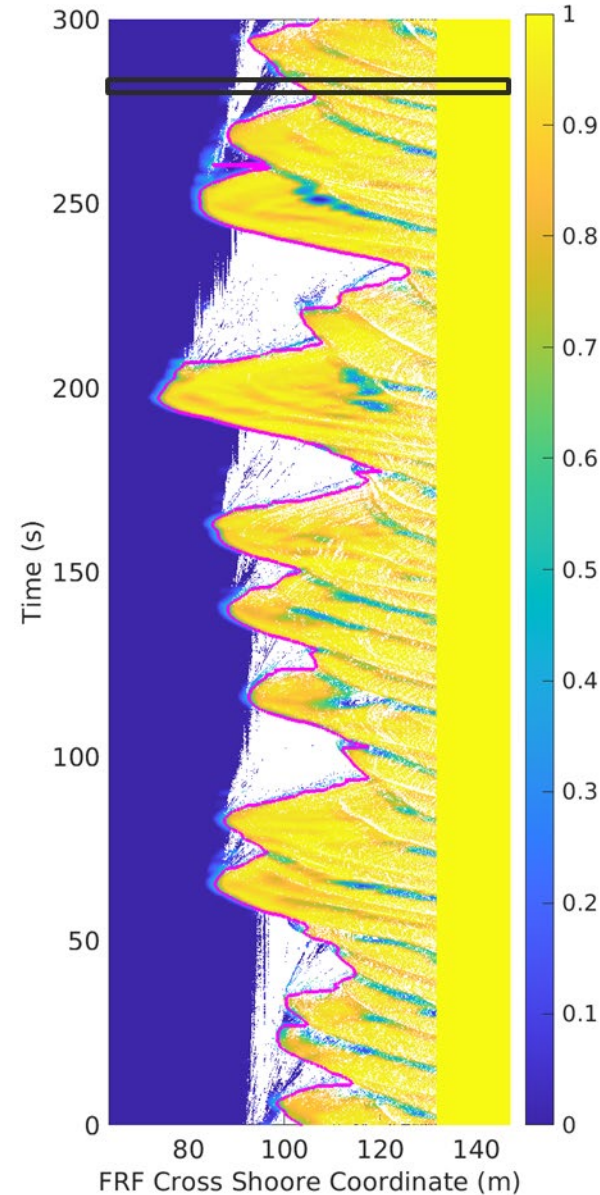
Dune Lidar

Reigl VZ-1000 | Collecting 7 Hertz

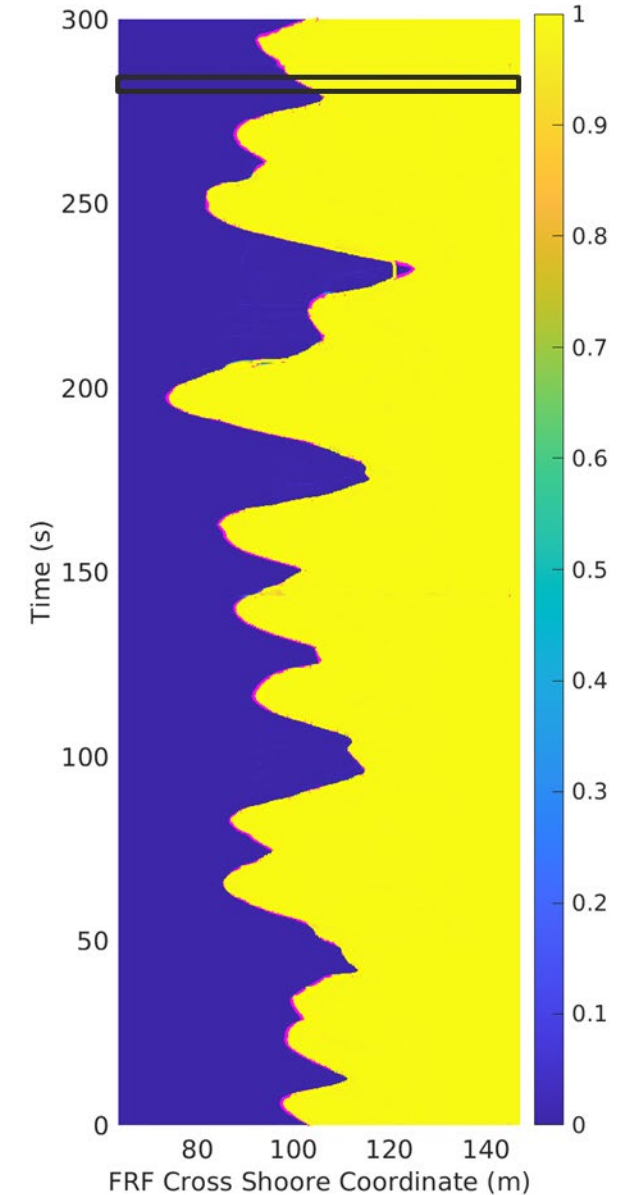


Can now compare coincident water level elevations and CoastSat shoreline location to better define “upper swash”.

scan @ 03-08-2020 15:00:01
Analytical alg - Digitized Runup

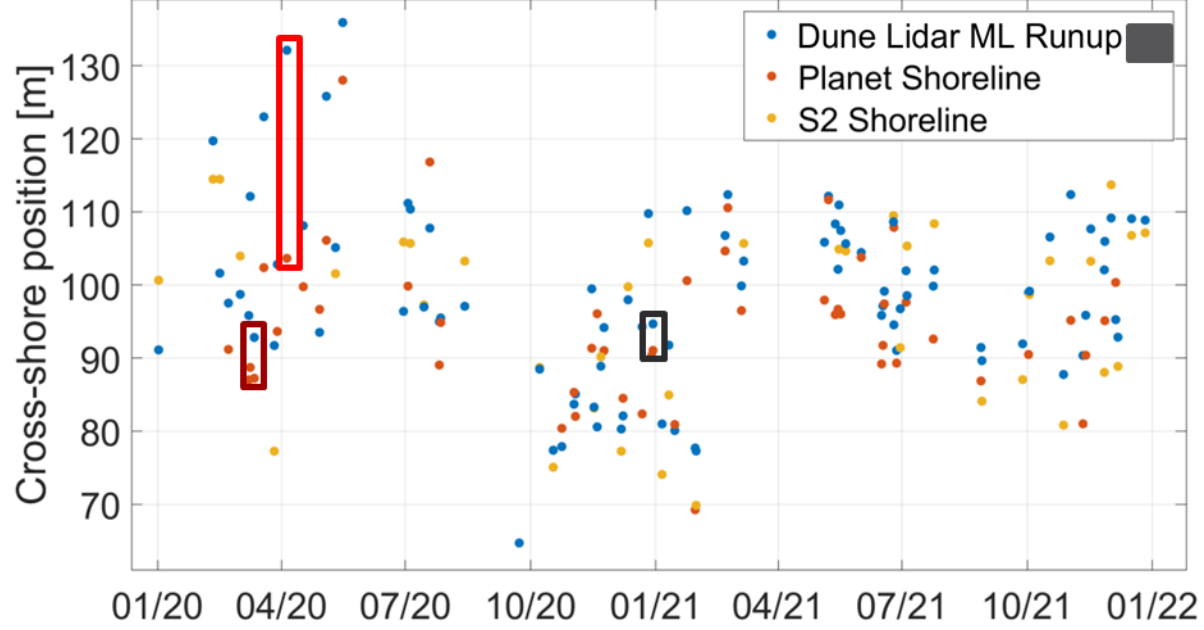


scan @ 03-08-2020 15:00:01
ML alg - Digitized Runup





Shoreline Location Variability at Dune Lidar Location

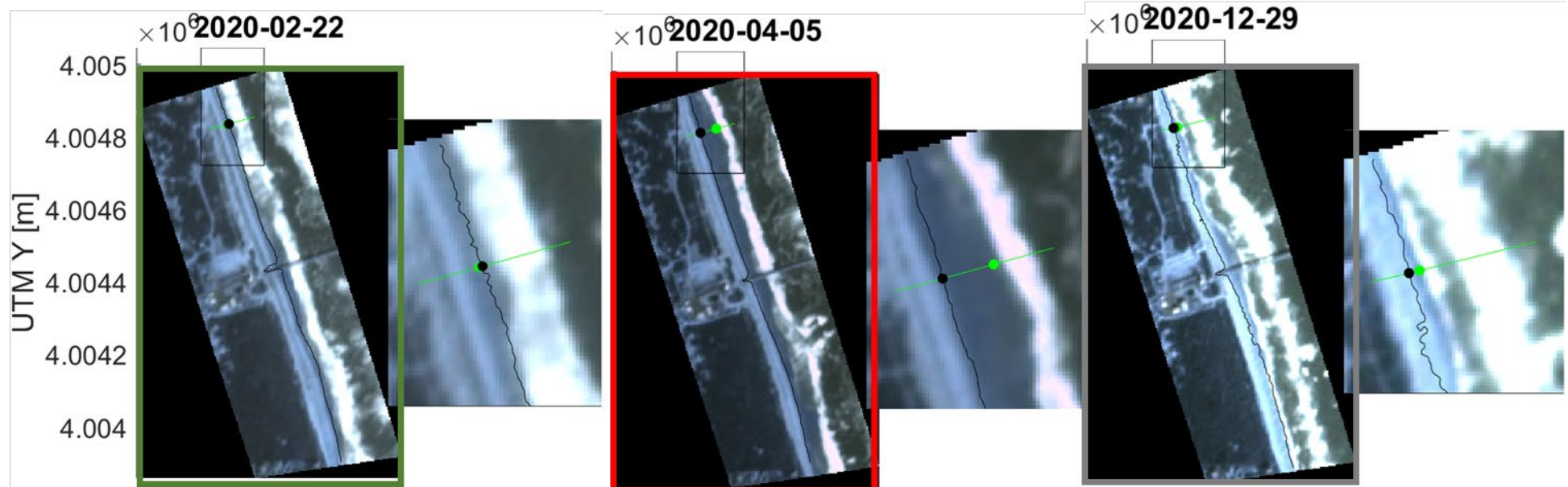


Agreement

Disagreement

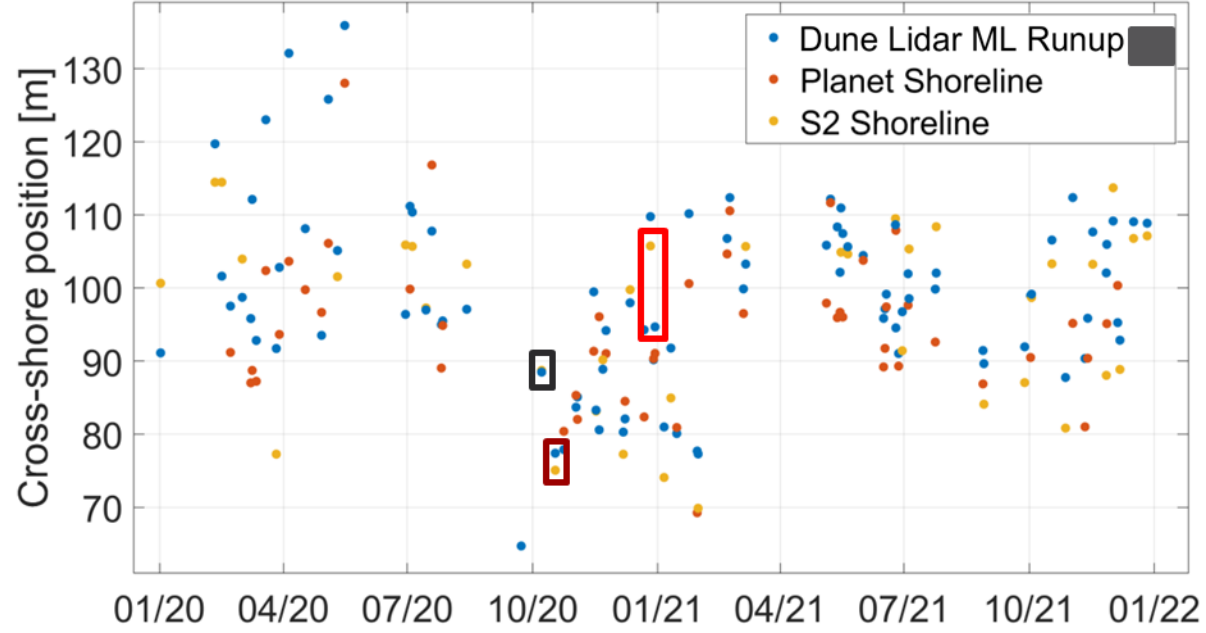
Storm Scenario

Planet Imagery



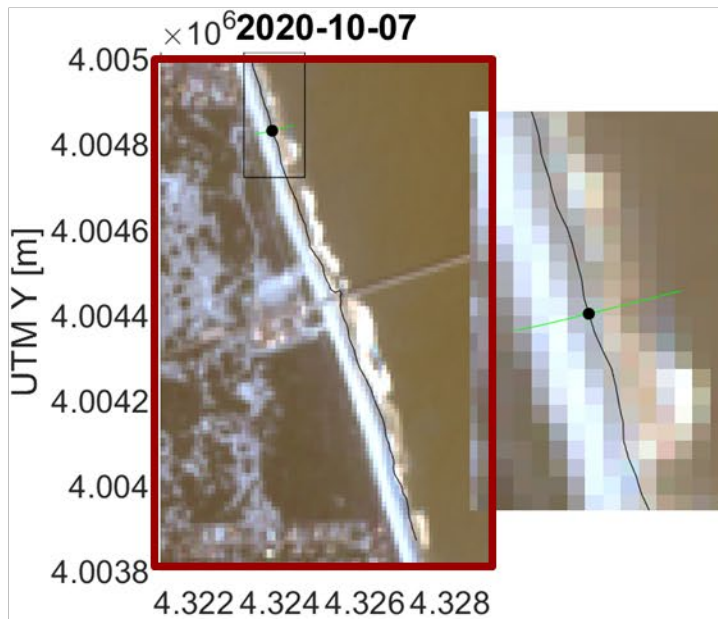


Shoreline Location Variability at Dune Lidar Location

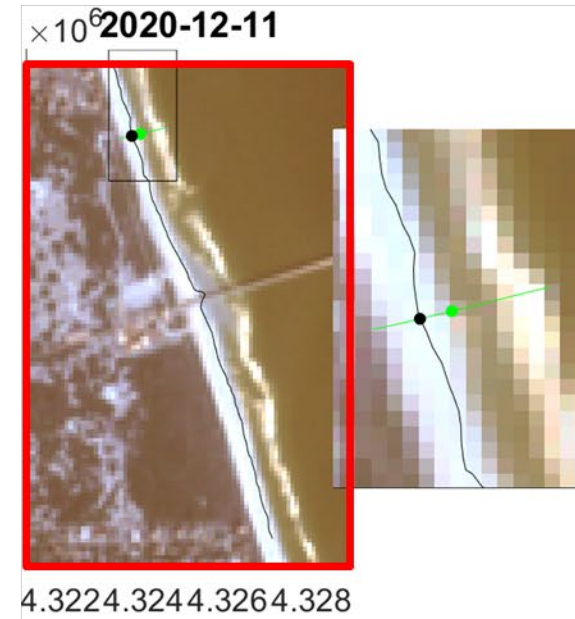


Sentinel-2 Imagery

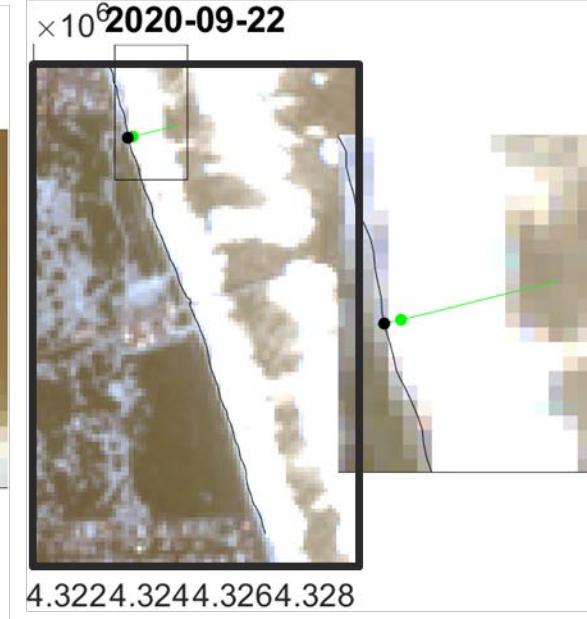
Agreement



Disagreement

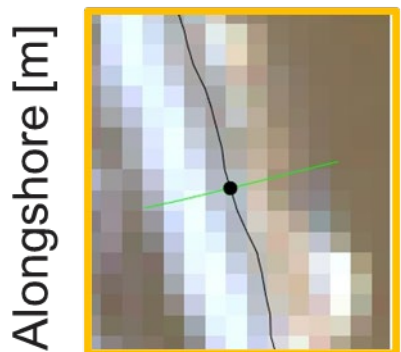
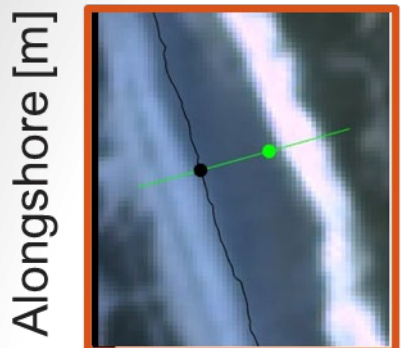


Storm Scenario

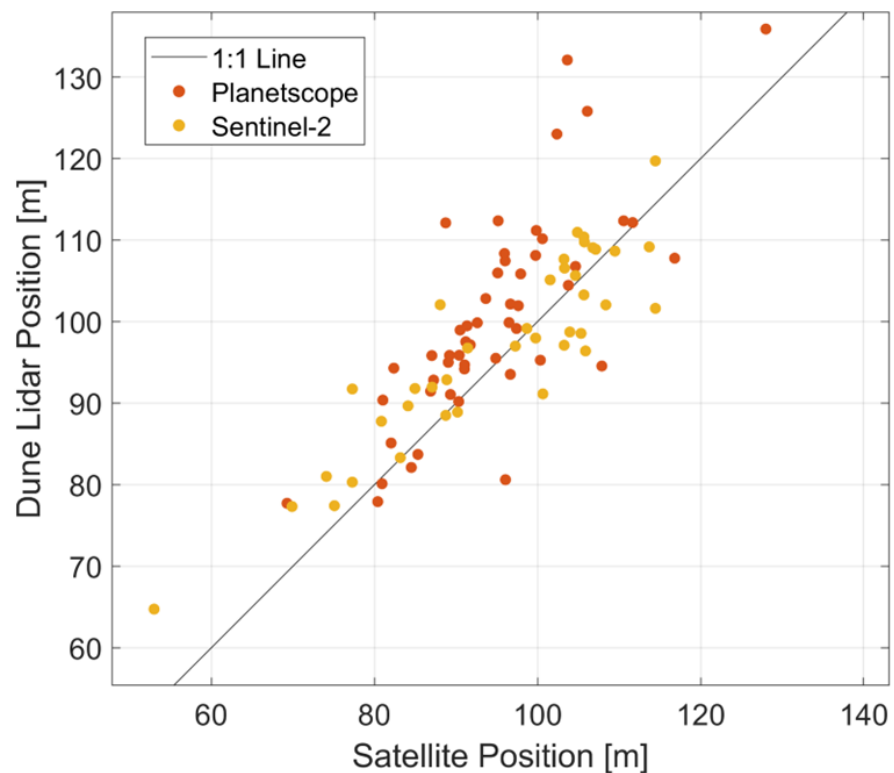




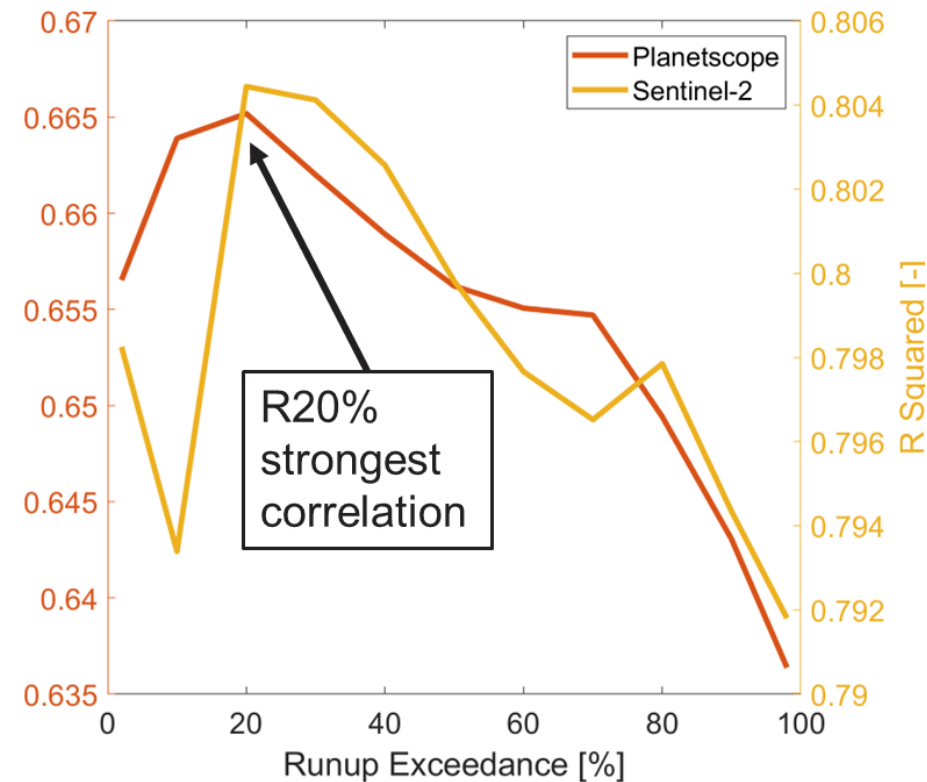
COMPARING PLANETSCOPE AND SENTINEL-2



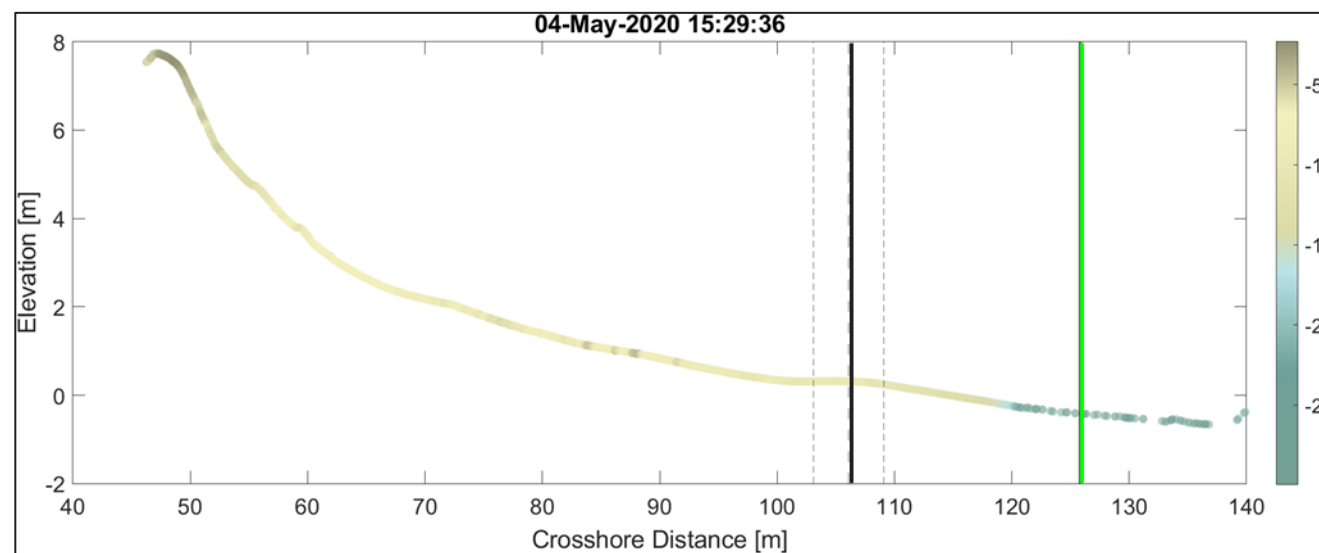
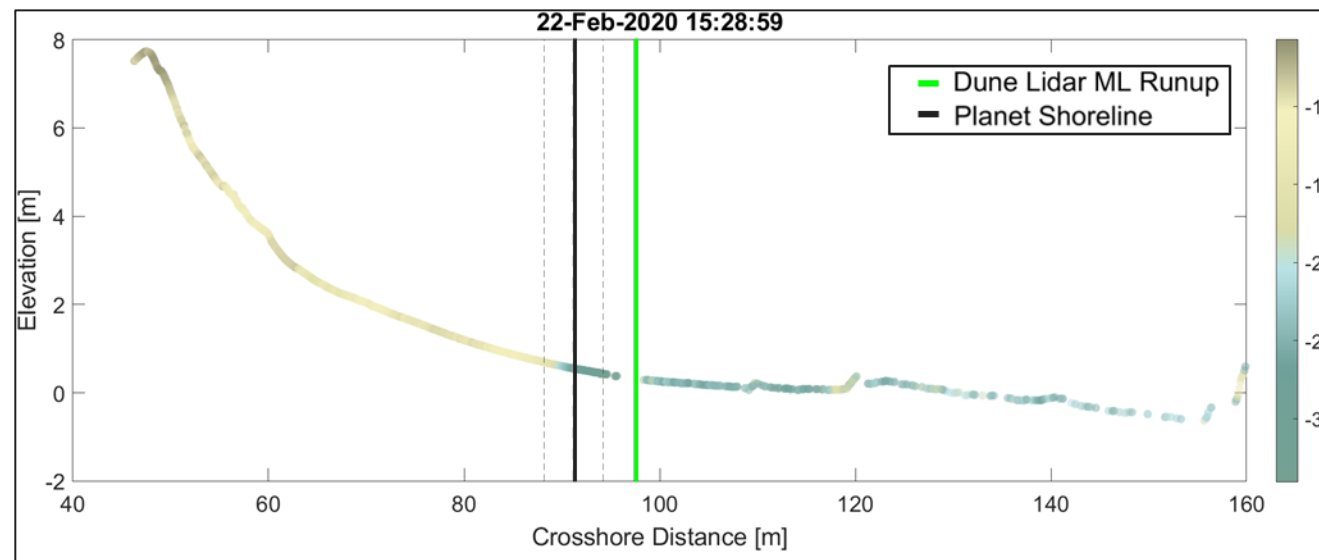
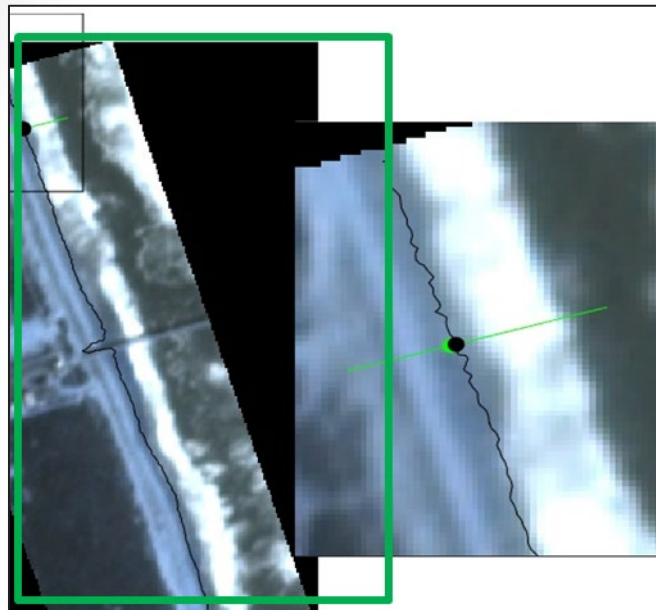
Cross-shore Position Agreement



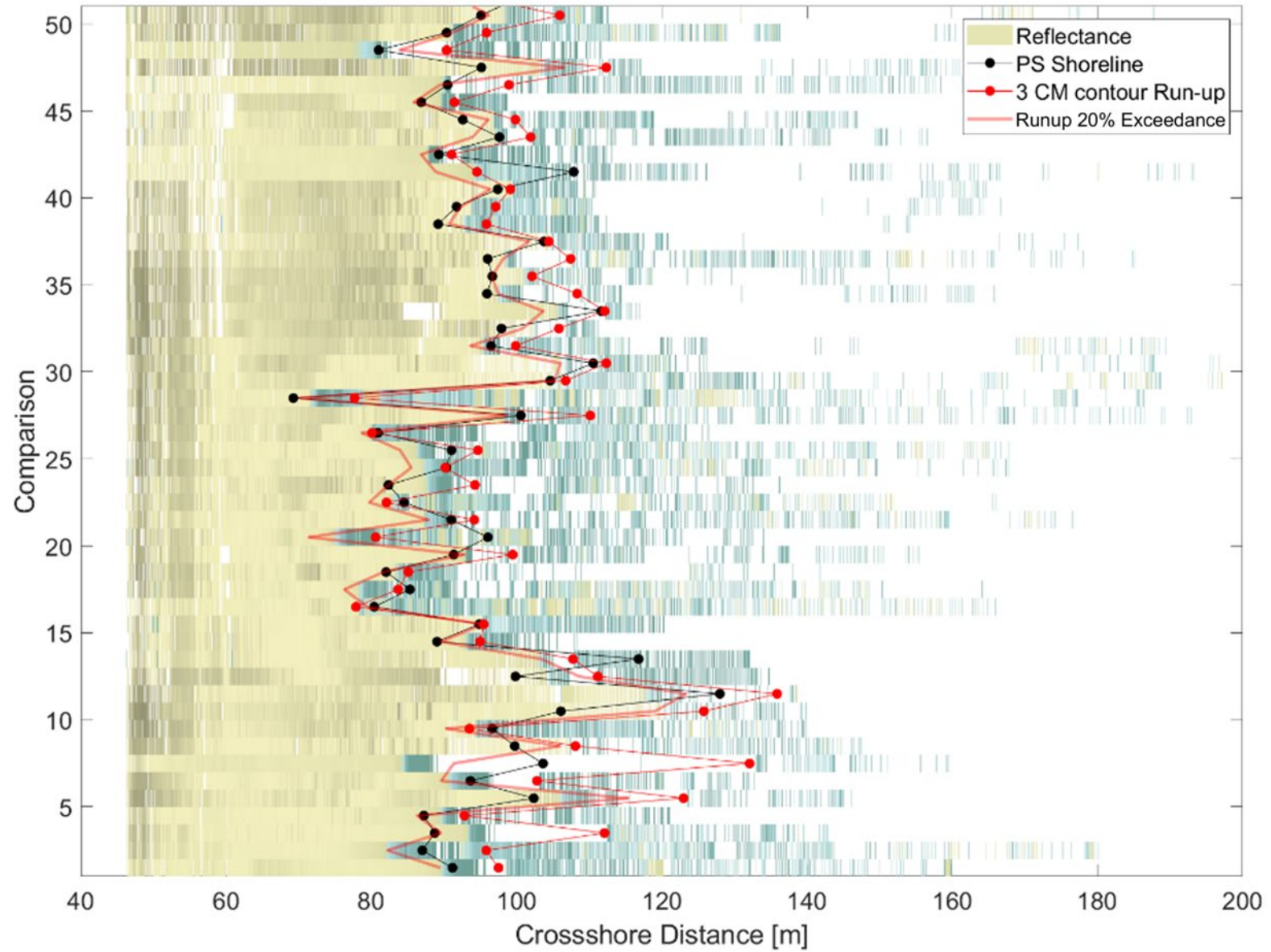
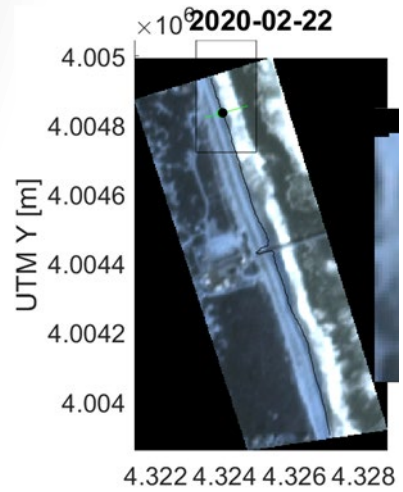
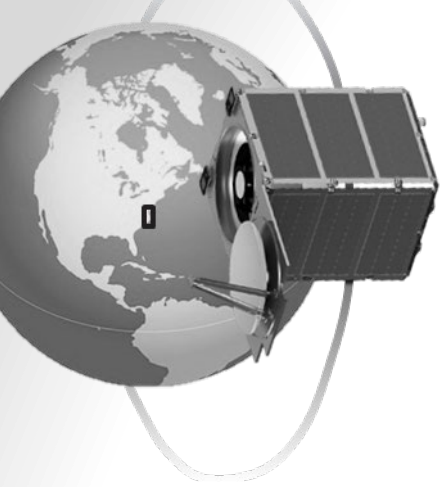
Correlation to Varying Runup Exceedances



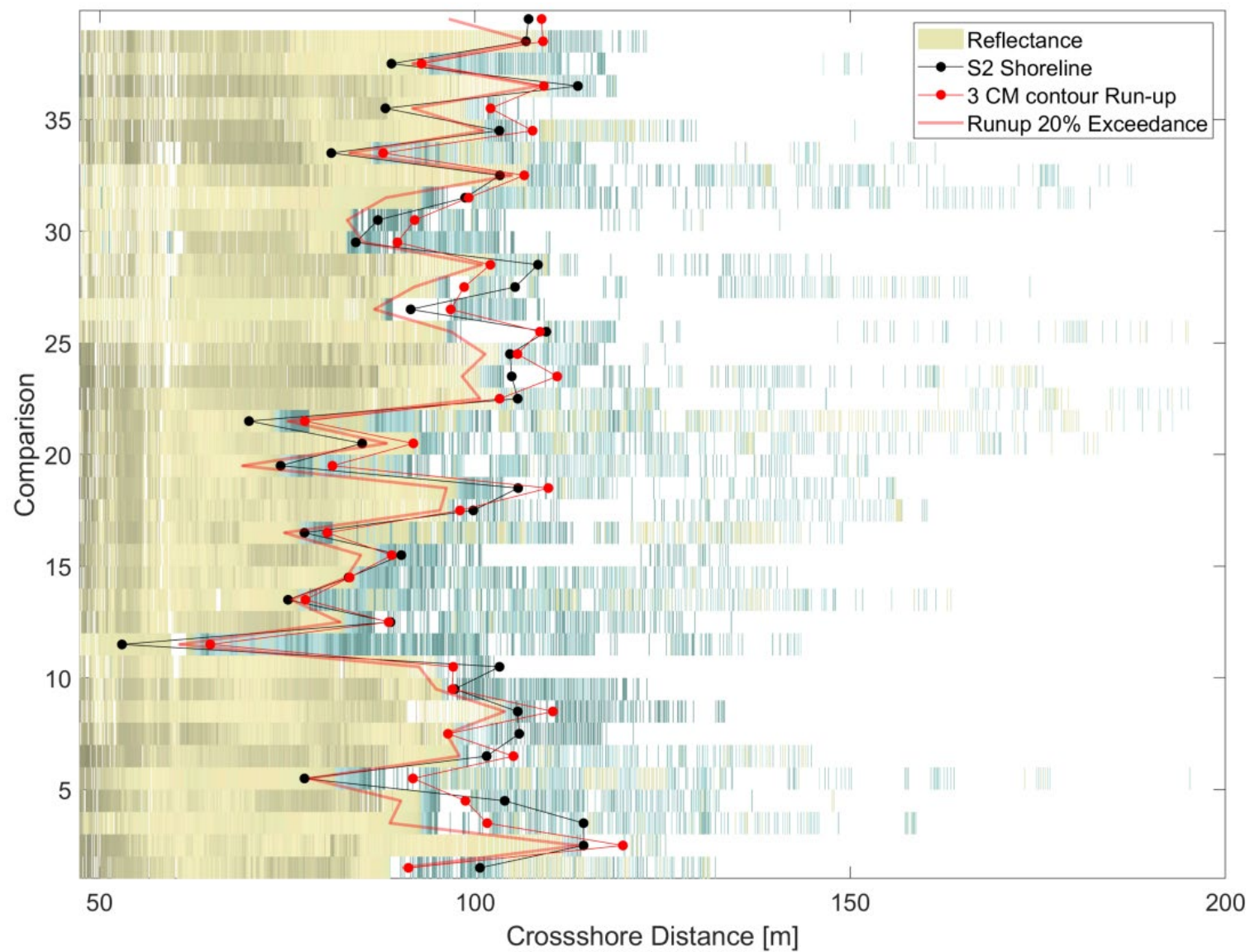
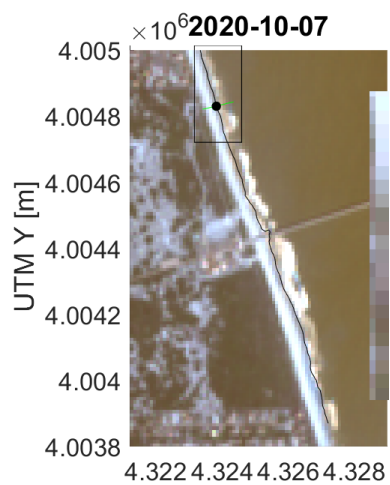
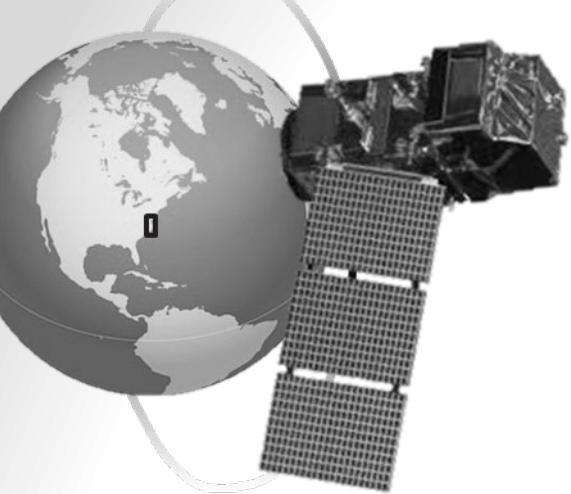
Reflectance



Planetscope



Sentinel-2





SUMMARY



FY23 Major Advancements in Capability

- Improvements to SSM workflow
 - Transect generation
 - Shapefile tidal shift
 - Sentinel-2 cloud mask
 - Small AOI fix
- Expanded SSM automated output analysis plots/tables

FY23 Major Products & Collaborations

- SSM user manual and SSM tool release
- Internal ERDC SSM tool testing and feedback implementation
- Coastal Working Group (CWG) SSM workshop and tech transfer to district users
- CIRP TD
- Coastal Prospect Course Presentation

FY24 Products & Advancements

- Streamline SSM install process
- Submit runup journal article

Coastal Inlets Research Program
US Army Corps of Engineers

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Satellite Shoreline Mapper (SSM)

The ERDC Satellite Shoreline Mapper is a user-friendly ArcGIS tool that automatically extracts historic shorelines along sandy coastlines from publicly available satellite imagery dating back to 1984 (Landsat missions and Sentinel-2). The tool was created using the open-source CoastSat algorithm, developed by Vos et al. (2019, J. Coastal Eng.) at the University of New South Wales (UNSW). The user specifies an AOI and time interval, along with a few other parameters (i.e., transect spacing, contour, slope, folder location), then Google Earth Engine requests imagery every 5 to 16 days, image pre-processing

<https://cirp.usace.army.mil/products/ssm.php>