ESA COASTAL EROSION
'Coastal Erosion from Space'

Final Review Meeting

Olivier Arino

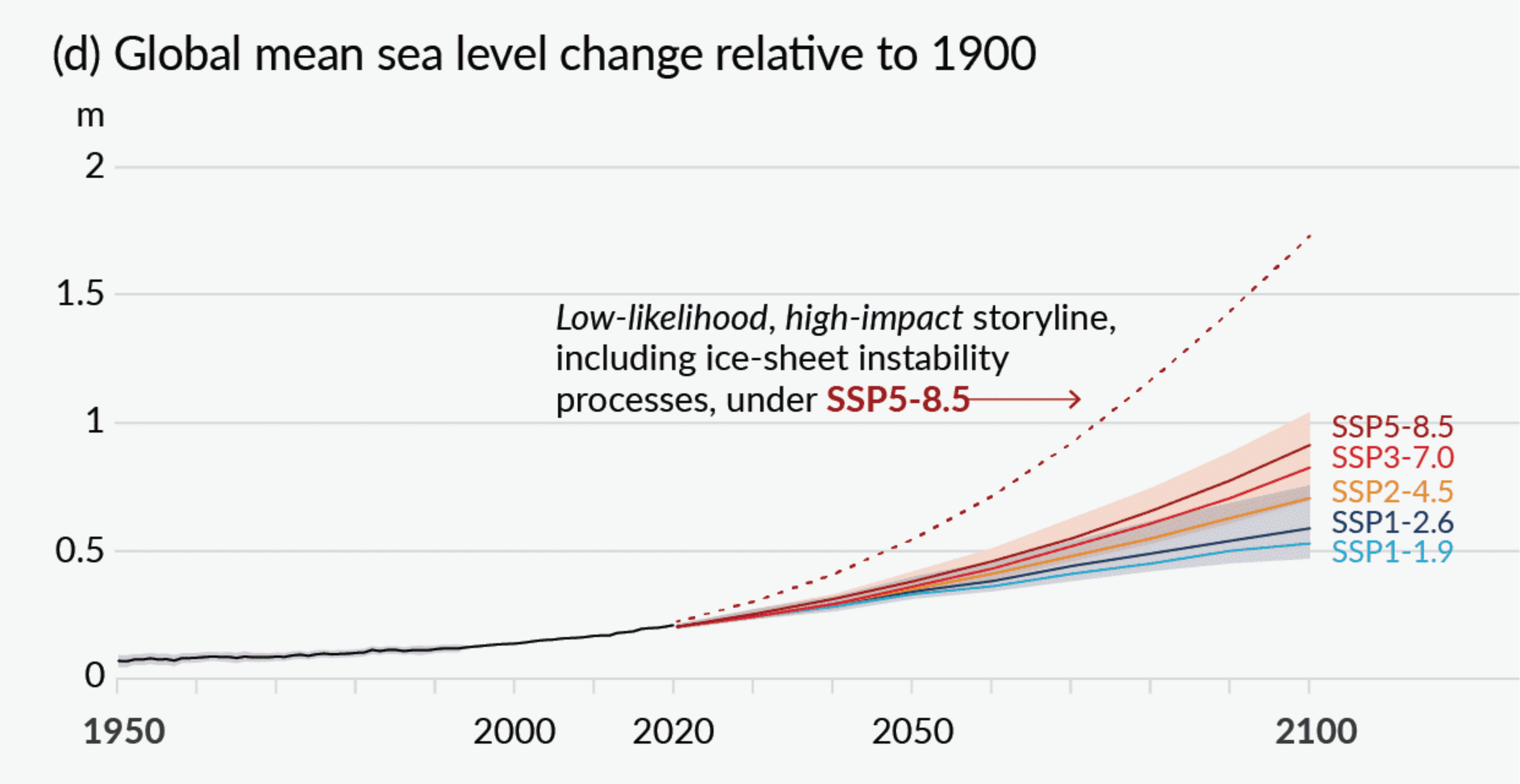
14/09/2022

ESA Coastal Erosion

Reason

The IPCC AR 6 report indicates a best estimated world sea level rise of 66 cm by end of this century. As a result, the coastal erosion process as visible and measured by satellite since the 80s could only increase in the near future. This session intends to provide a dedicated forum to scientists associated to public authorities to report on the use of satellite data to characterize this process over the past 30 to 40 years. To this purpose, the Agency placed in 2018 two contracts that studied the process in 9 ESA member states. Algorithms, methods and results will be presented together with other relevant studies in other part of the world.

Extract from IPCC AR6 Summary for Policymakers - Figure SPM.8



ESA Coastal Erosion

The studied sites

Coastal Erosion from Space – ARGANS

United Kingdom
- ✓ *Chesil Beach*
- ✓ *Start Bay*
- ✓ *Perranporth*
- ✓ *Spurn Head to Hunstanton*
- ✓ ***Cardigan Bay***

Ireland
- ✓ *Dublin Bay*
- ✓ *Ravens Point and Rosslare*
- ✓ *Waterford Estuary*
- ✓ *Cork Habour*
- ✓ ***Muir Eireann***

Spain
- ✓ *Barcelona and Tordera Delta*
- ✓ *Port of Castellón and Port of Sagunt*
- ✓ *Cadiz and Mazagón Beach*
- ✓ ***El Puntal de Santander***
- ✓ ***Bay of Biscay***

Canada
- ✓ *Pointe au Loup*
- ✓ *Pointe aux Outardes*
- ✓ *Longue Pointe de Mingan*
- ✓ ***Bylot Island***
- ✓ ***Baffin Bay***

Italy
- ✓ ***Lido di Jesolo***
- ✓ ***Catania, Sicily***

Space for Shore – i-Sea

France
- ✓ *Coast of the New Aquitaine*
- ✓ *Coast of Normandy*
- ✓ *Provence-Alpes-Côte d'Azur Region*
- ✓ ***Vendée Department***
- ✓ ***Morhiban Department***
- ✓ ***Charente-Maritime Department***
- ✓ ***Occitany Region (Roussillon)***

Greece
- ✓ *Eastern Macedonia & Thrace*
- ✓ *Peloponnese*
- ✓ ***Euboan Gulf***
- ✓ ***Rhodes Island***

Germany
- ✓ *North Sea*
- ✓ *Baltic Sea*
- ✓ ***Southern Schleswig-Holstein Wadden Sea tidal flats***

Portugal
- ✓ *Northwest coast*
- ✓ ***Peniche***
- ✓ ***Alentejo***
- ✓ ***Algarve***

Romania
- ✓ *Romanian Coast*
- ✓ ***Constanta***
- ✓ ***Chilia secondary delta***

Norway
- ✓ ***Svalbard***

ESA Coastal Erosion

Coastal Erosion from Space – Delivery Plan

As reported in the *'detailed proposal in reply to Contract Change Notice scope of work'* the due deliverables for the Final Review are listed below:

- *Technical Specifications Document* ☺
- *Product Validation Report* ☺
- *Final Report* ☺
- *Executive Summary* ☹
- *Product delivery* ☹

Coastal Erosion from Space

Final Review @ ESRIN

14th September 2022

AGENDA

- 0900 - 0915 Introduction and welcome from ESA/Argans
- 0915 – 1015 Products and Processes (Argans/IsardSAT)
- 1015 - 1030 Coffee break
- 1030 - 1130 User Requirement update/Validation/ Utility/application/Roll Out
- 1130 - 1200 ESA discussion and AOB.

Coastal Change Consortium

ARCTUS UQAR

in St Laurent mouth (Canada)

ARGANS

isardSAT

adwäisEO

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

in Kilkee (Ireland)

BGS British Geological Survey

Coastal Erosion events:

in Nerja (Spain)

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

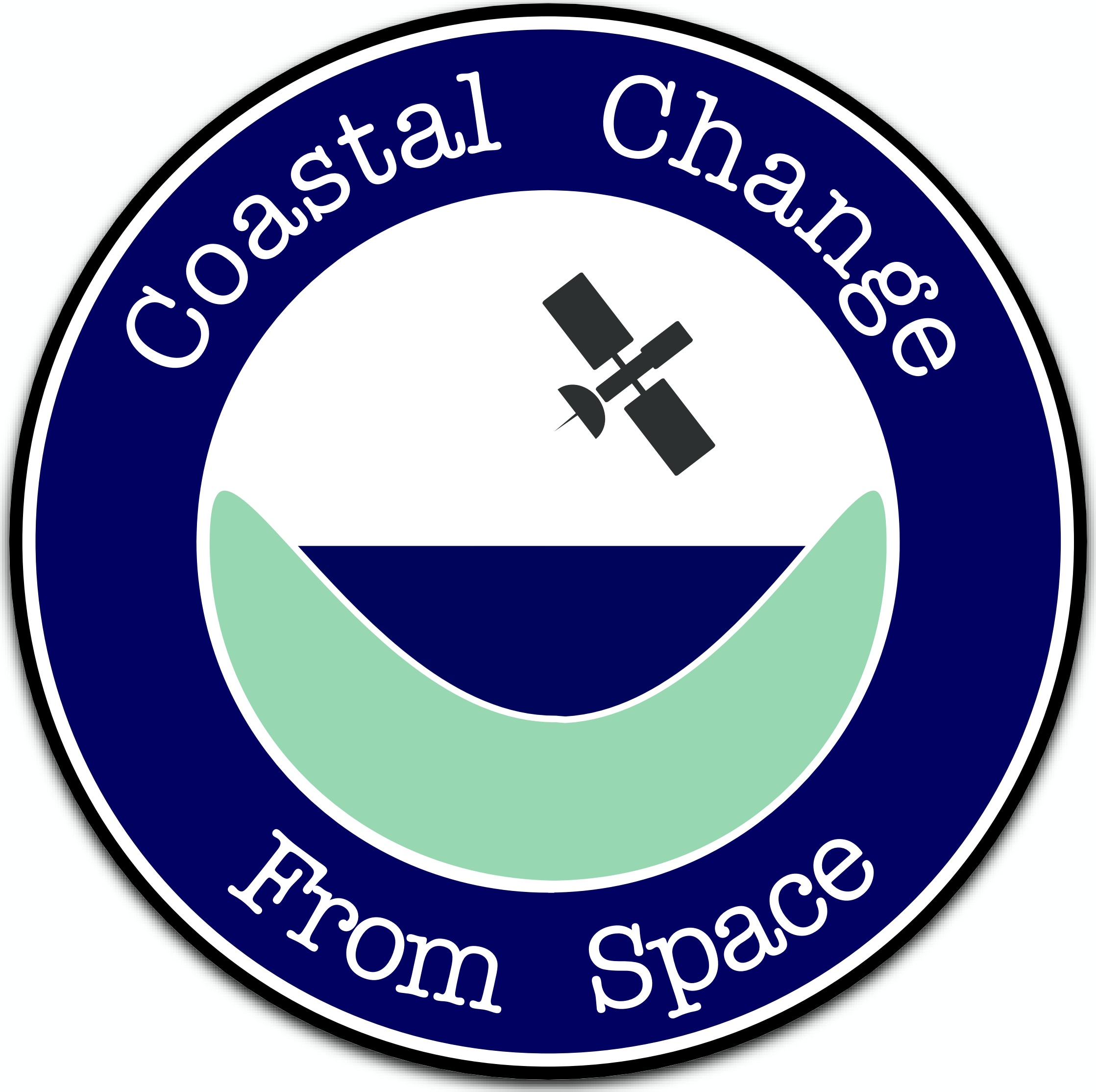
GOBIERNO DE ESPAÑA
VICEPRESIDENCIA CUARTA DEL GOBIERNO
MINISTERIO PARA LA TRANSICIÓN ECOLÓGICA Y EL RETO DEMOGRÁFICO

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

The Project Overview

- Phase 1 & 2 successfully concluded March 2021(the requirement was for 3 nations, 1000km of coastal products)

- Phase 3 (the CCN) added an additional partner with improvements to the products/processors based on User Need added and then the production of an additional 1500km plus updating the phase 2 data set to 2022.


Coastal Change
From Space

ARGANS

esa

COASTAL EROSION CCN final review

Processor & Products

Coastal Change From Space

ESA Frascati, Italy

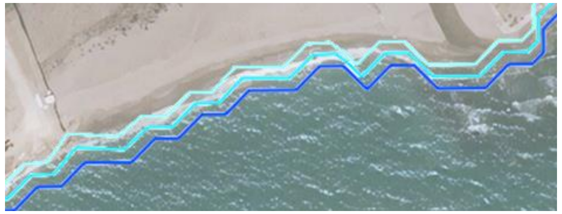
14 September 2022

Phase 1 & 2 summary

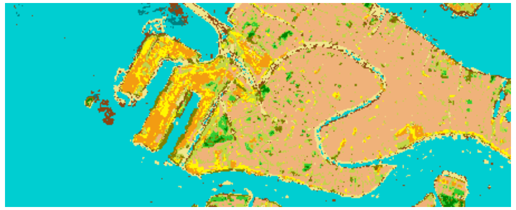
- Co-registration

- Optical Waterline

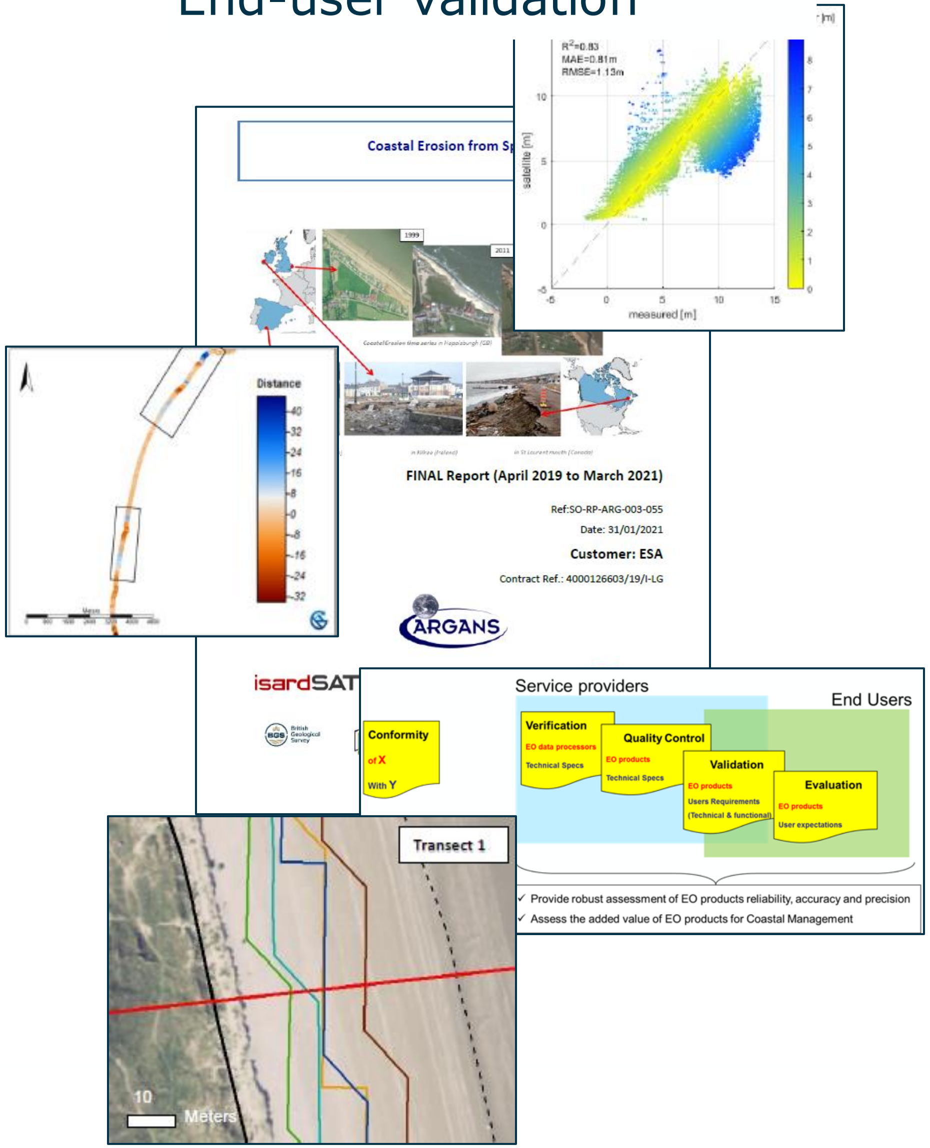
- Optical Shoreline



- Land use land cover map



End-user validation



- Time-series
- WL inter pixel position
- SL shape accuracy
- SL spatial extend

Pre-processing

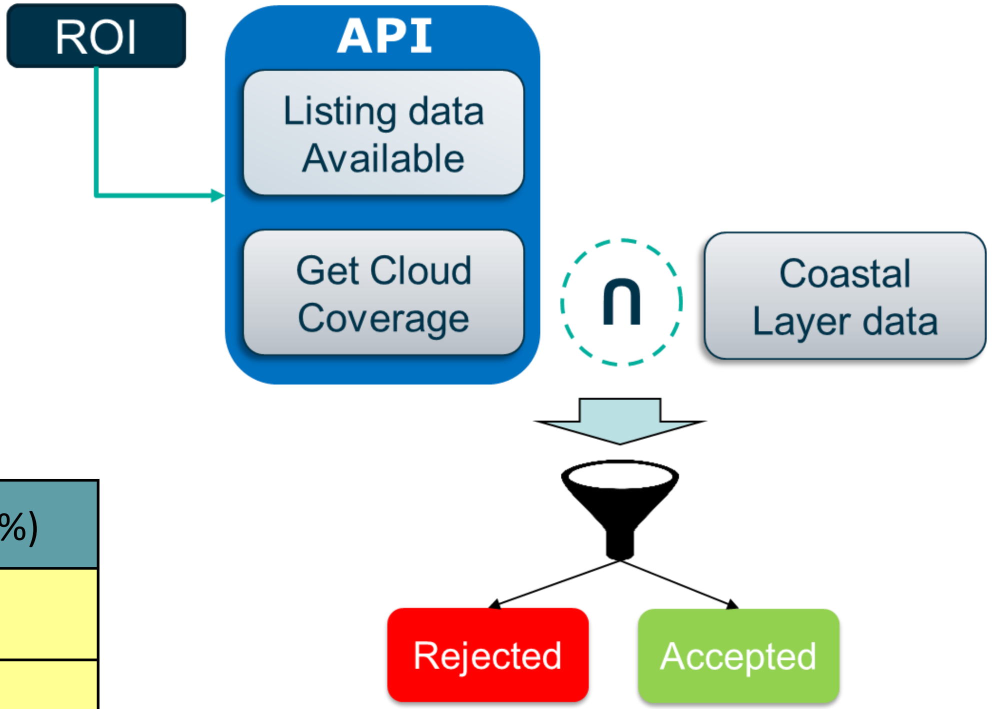
- Data selection
- Co-registration

Data Selection

Cloud cover : 0,21%

Cloud cover : 45,08%

Cloud cover : 20,11%

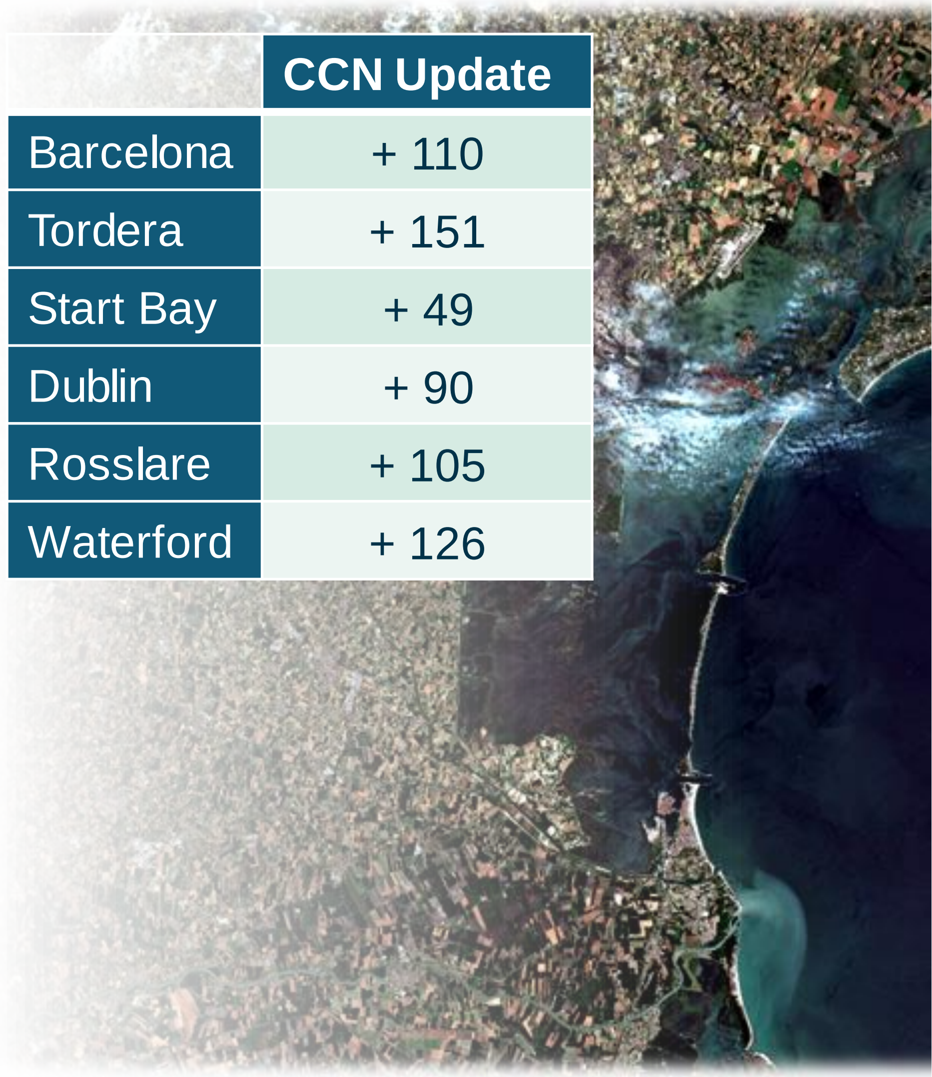


	Manual mode	Automatic mode	Evolution (%)
Barcelona (TDG)	92	96	4%
Start Bay	57	61	7%
Wales	55	63	13,56%
Venice	290	337	14%

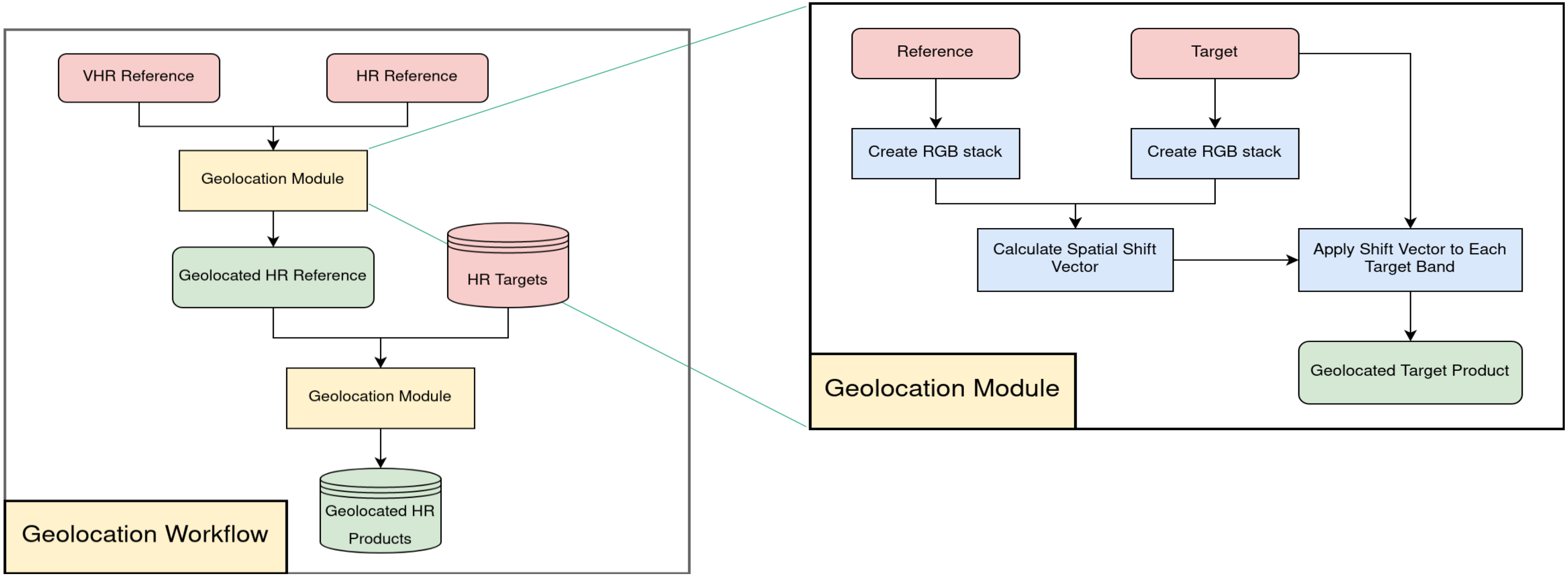
Co-registration

Co-registration	S2		L8	L5
Wales	T30UUD	70	107	93
	T30UVD	66		
Cantabria	T30TUP	121	90	123
	T30TVP	81		
Venice	T32TQR	200	154	231
	T33TUL	129		
Catane	T33SWB	279	58	59
Baffin Bay	T17XNA	32	15	9
	T17XPA	20		

	CCN Update
Barcelona	+ 110
Tordera	+ 151
Start Bay	+ 49
Dublin	+ 90
Rosslare	+ 105
Waterford	+ 126

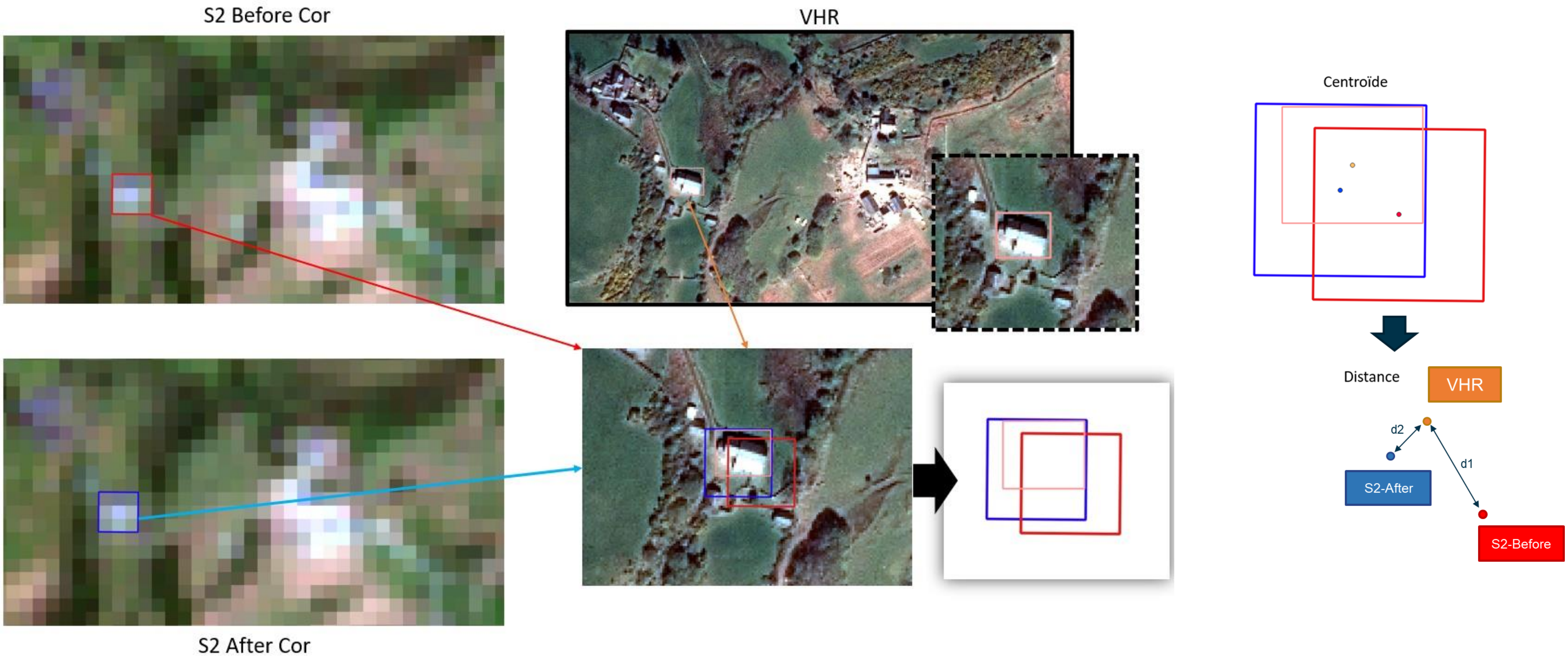


Co-registration

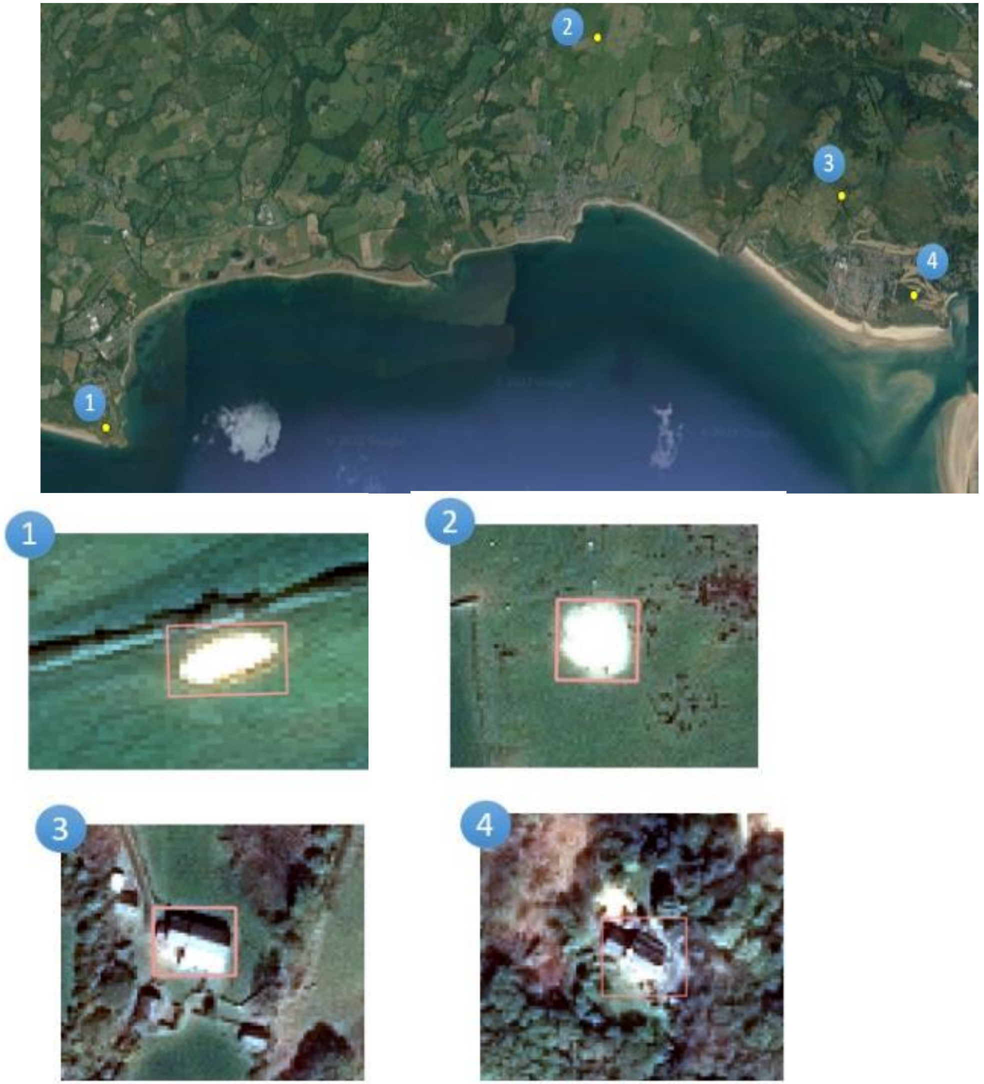


python /path/to/coregistration.py /path/to/reference/ /path/to/target/ /output/folder/ -p /path/to/optional_parameters.json

Co-Registration



Co-Registration



Object	d1 (Before co-reg)	d2 (After co-reg)	Correction
1	8,6 m	1,9 m	6,7 m
2	11,1 m	1,5 m	9,6 m
3	11,9 m	2,1 m	9,8 m
4	7,73 m	2,7 m	5,03 m

- The process has reduced the average horizontal error by **7,8m**.
- The average accuracy of the S2 image compared to the VHR after co-registration is of the order of **2m**.

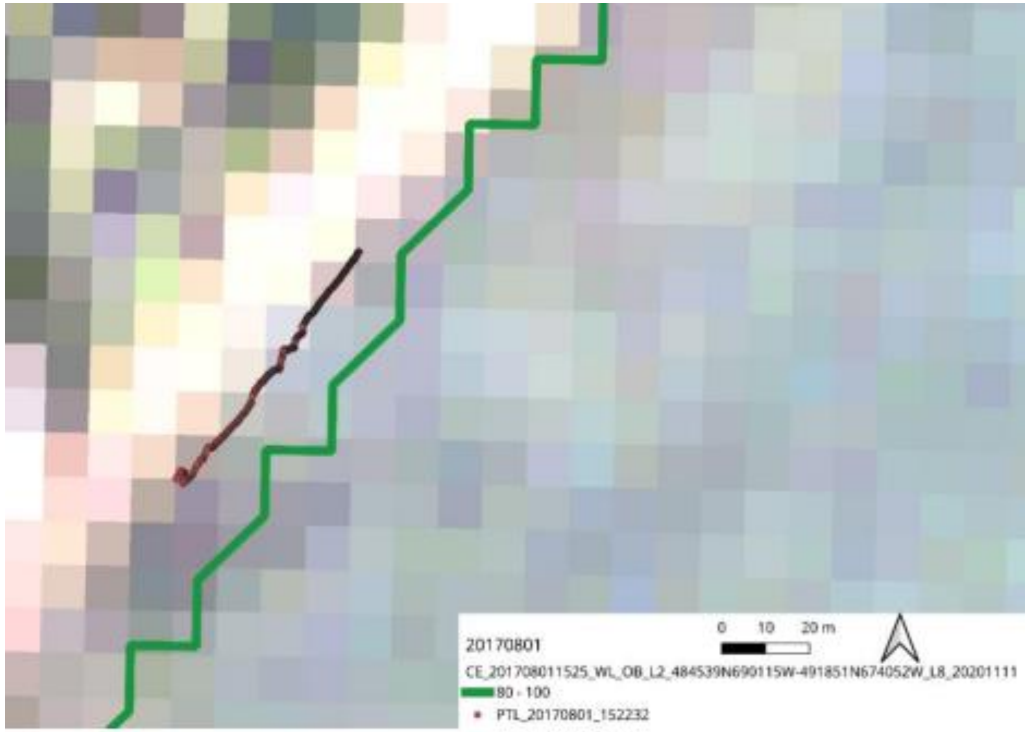
Waterline

- V2 Production
- V3 process
- V3 Production

Waterline V2 process

Waterline	S2		L8	L5
Wales	T30UUD	70	107	93
	T30UVD	66		
Cantabria	T30TUP	121	90	123
	T30TVP	81		
Venice	T32TQR	200	154	231
	T33TUL	129		

Waterline V2 process



Landsat-8 Waterline (01/08/2017) Validation for Pointe-aux-Outardes
ARCTUS product validation report

Sentinel-2 Waterline (02/02/2019) Validation at Dublin (Dunleary),
GSI product validation report

Waterline process

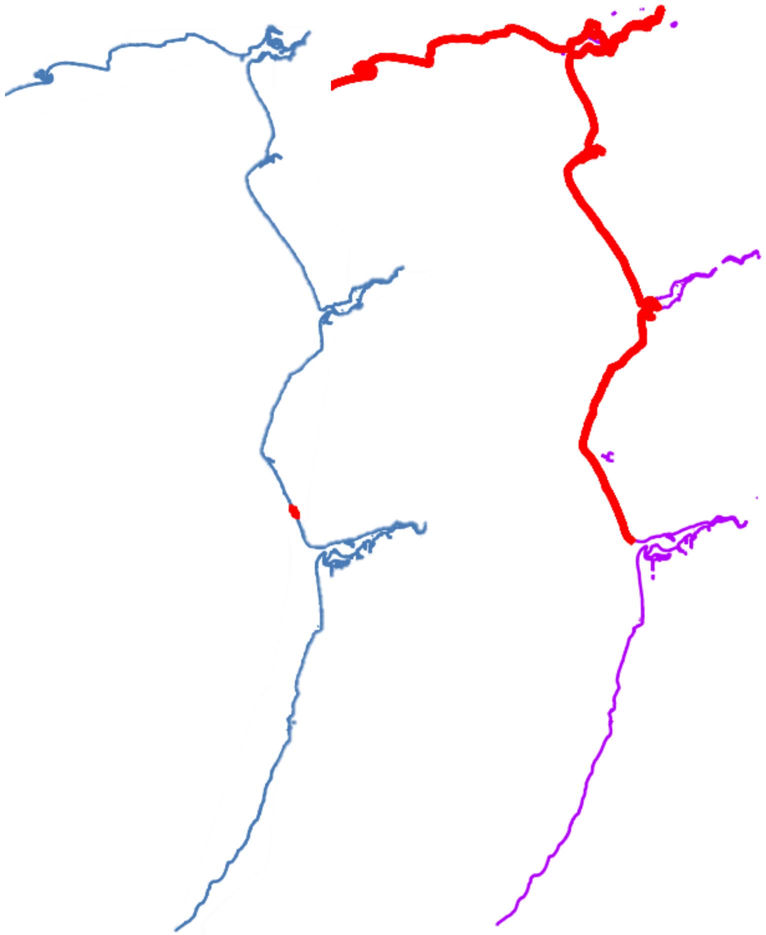
	Sep 2021	Oct	Nov	Dec	Jan 2022	Feb	Mar	Apr	May	Jun	Jul	Aug
Wales												
Cantabria												
Venice												
Catane												
Baffin Bay												
Muir Eireann												
UK CE sites												
Spain CE sites												
Canada CE sites												

V2 waterline process

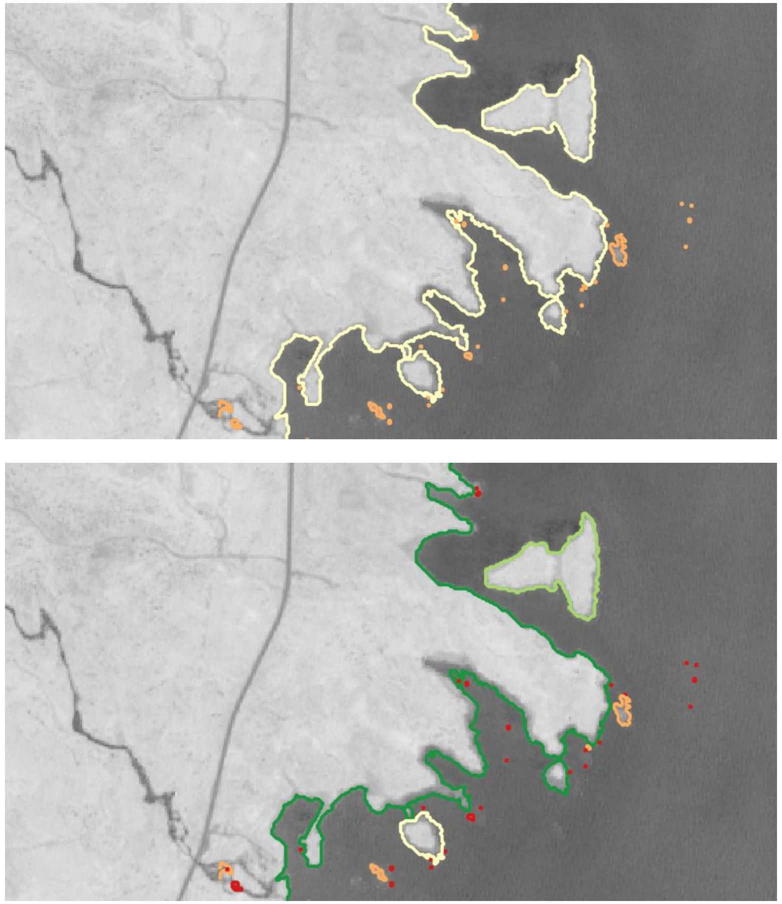
V3 waterline process

V3 waterline process CE sites re-processing

Waterline V3 process



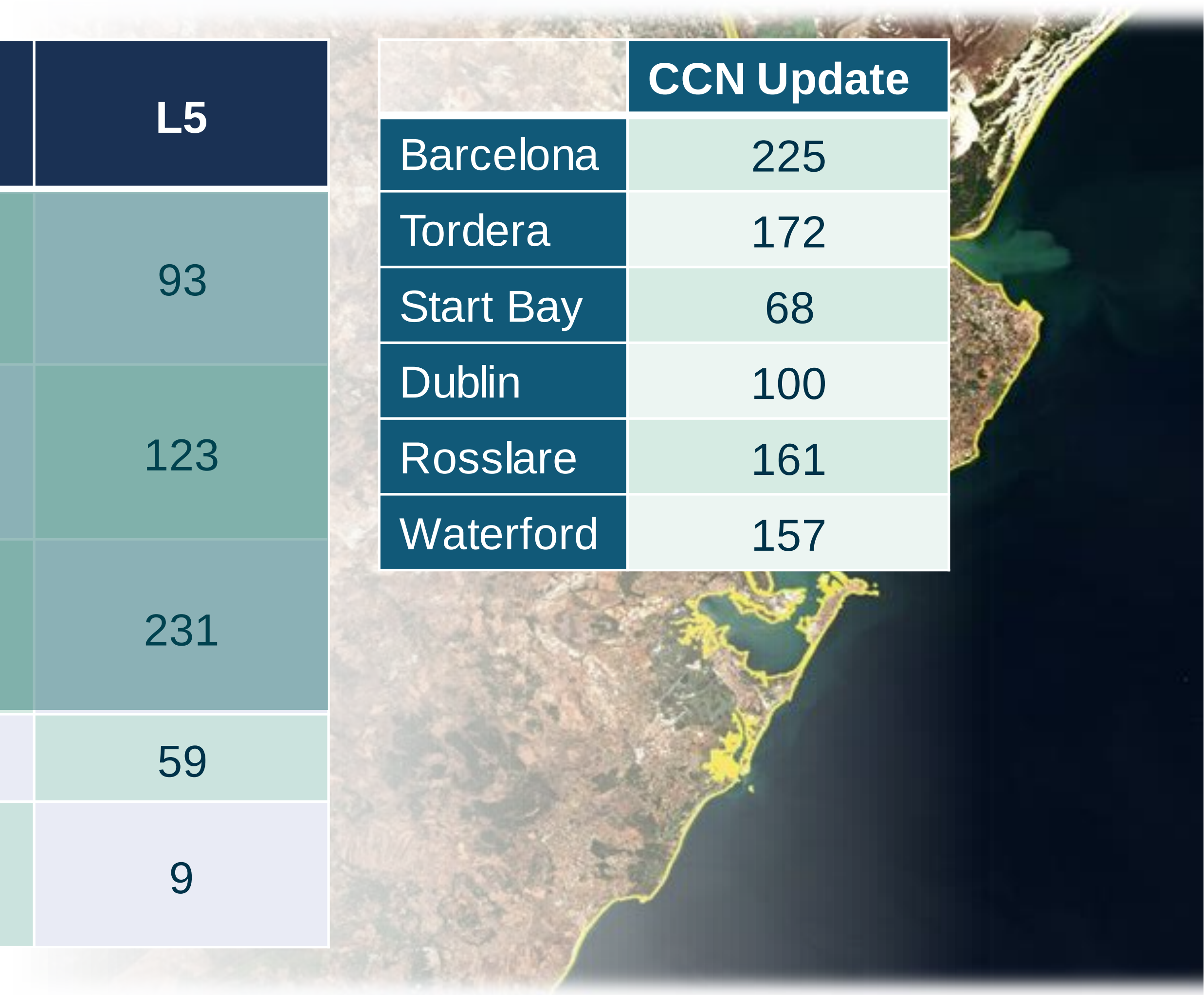
V2 waterline, V3 waterline



QC Score	
0 – 20 (Very Low Confidence)	40 – 60 (Fair Confidence)
20 – 40 (Low Confidence)	60 – 80 (High Confidence)
	80 – 100 (Very High Confidence)

Waterline V3 process

Waterline	S2		L8	L5
Wales	T30UUD	70	107	93
	T30UVD	66		
Cantabria	T30TUP	121	90	123
	T30TVP	81		
Venice	T32TQR	200	154	231
	T33TUL	129		
Catane	T33SWB	279	58	59
Baffin bay	T17XNA	32	15	9
	T17XPA	20		

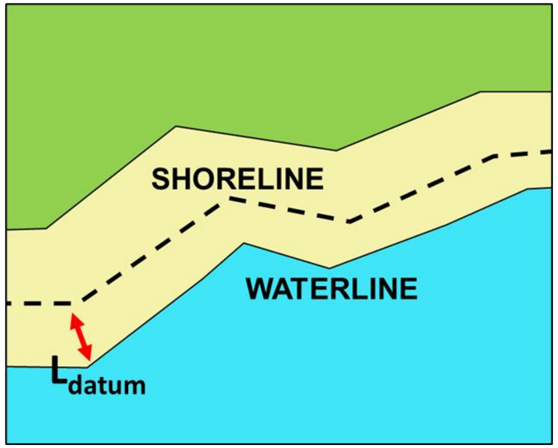


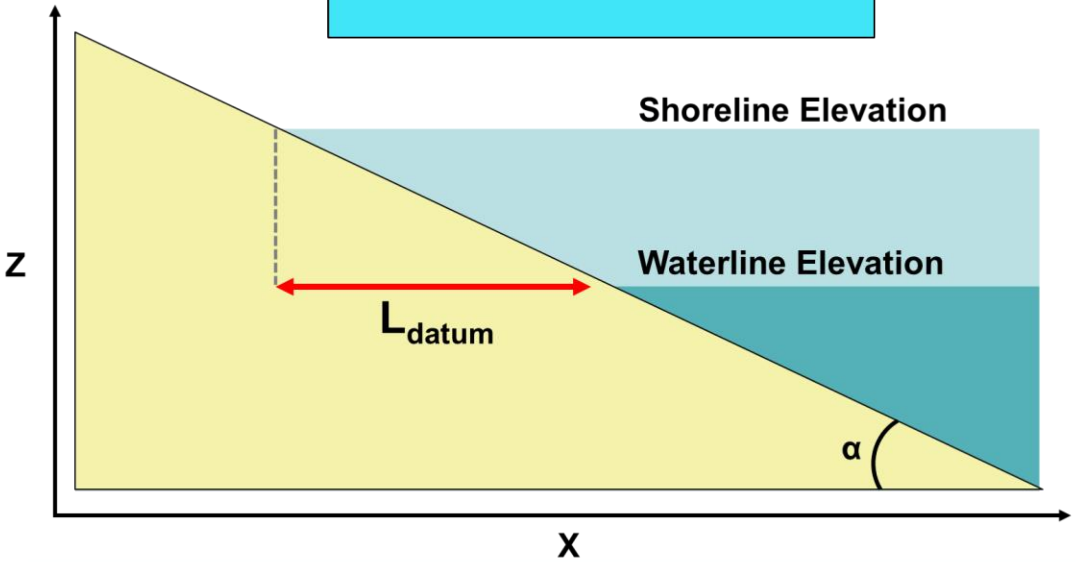
	CCN Update
Barcelona	225
Tordera	172
Start Bay	68
Dublin	100
Rosslare	161
Waterford	157

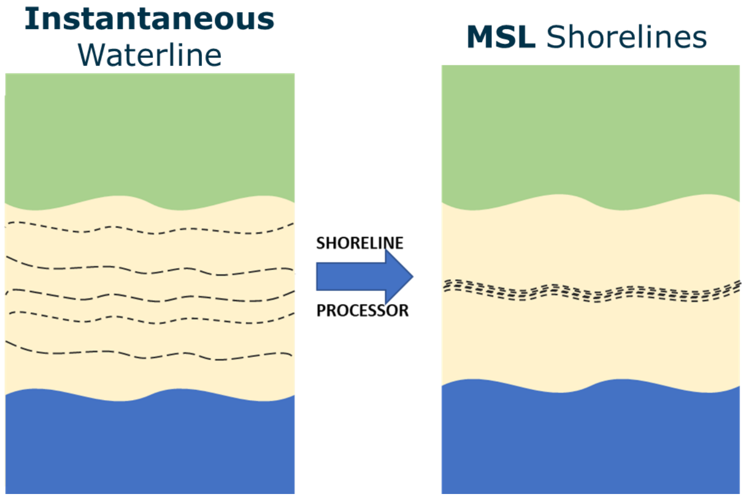
Shoreline

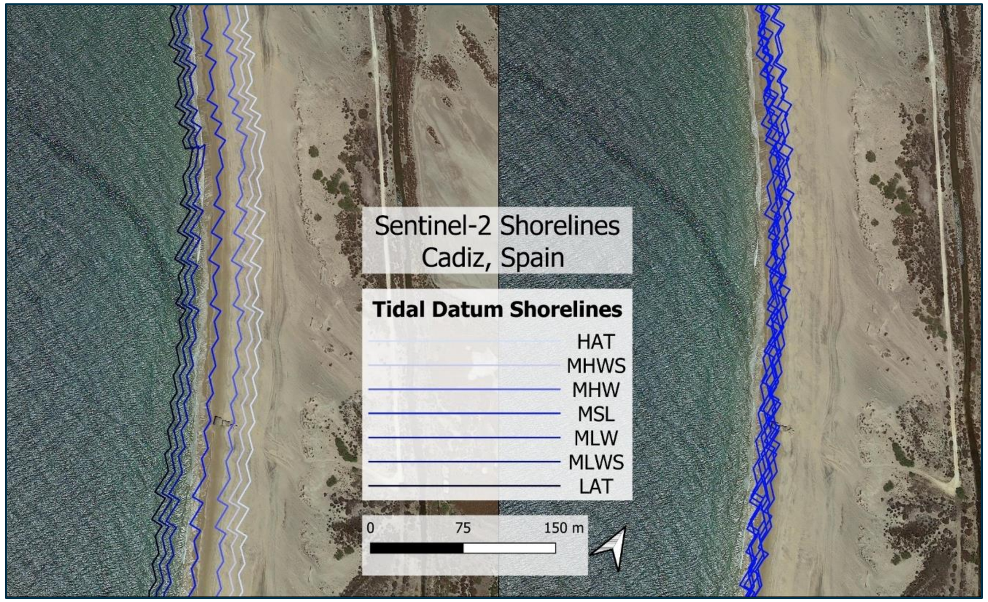
- Shoreline process
- Challenges
- V2 Process

Shoreline process

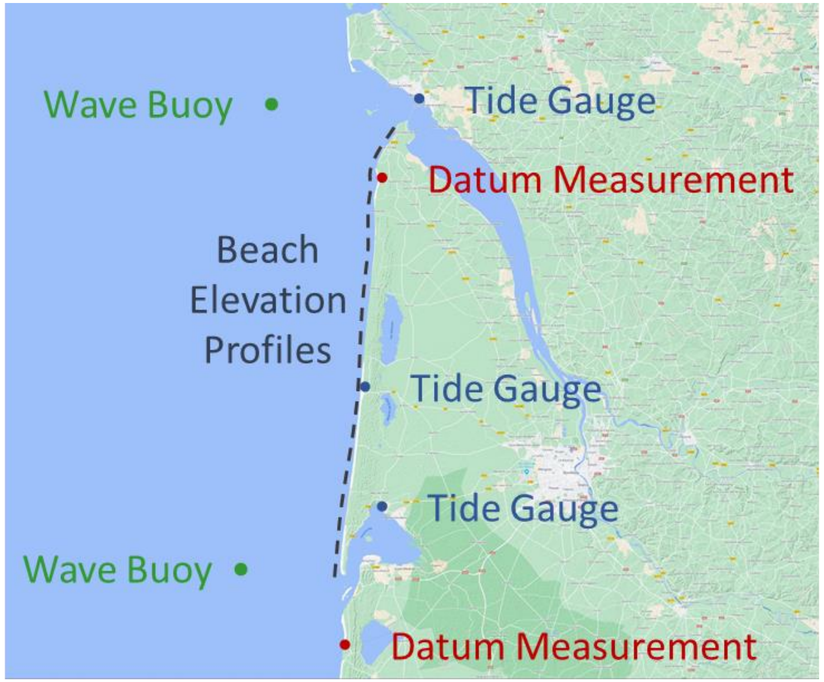


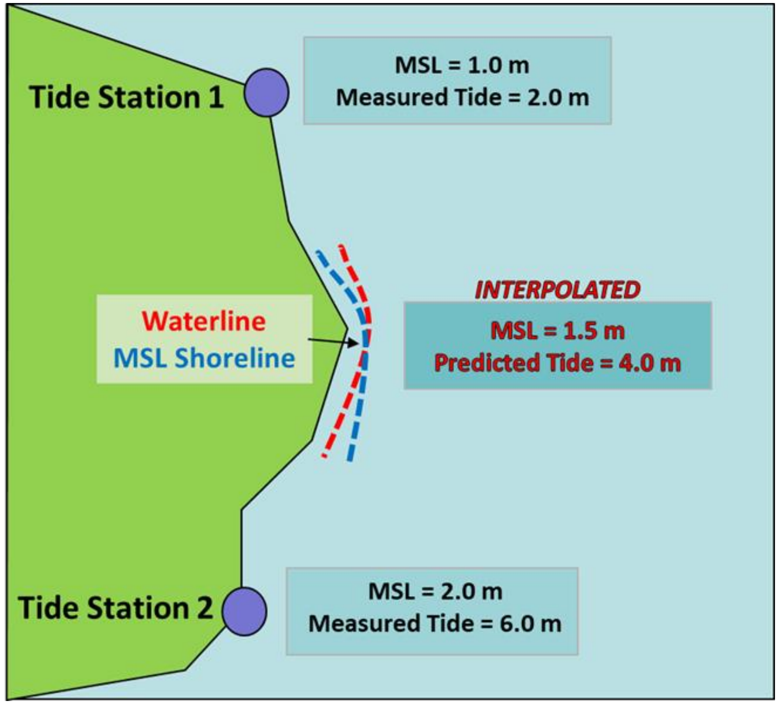






Shoreline process

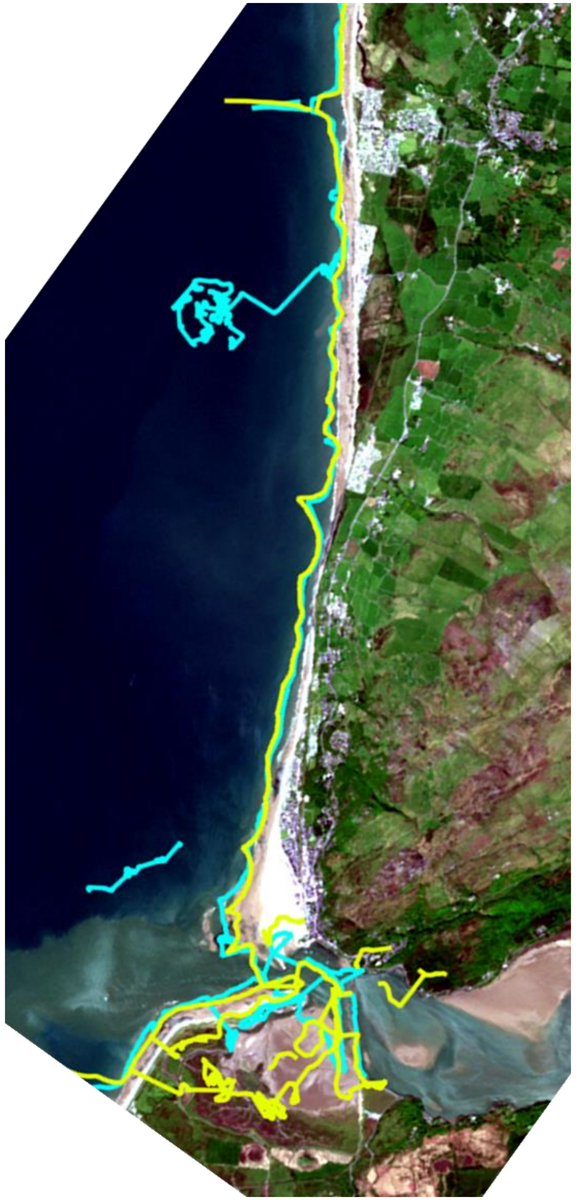




Shoreline process

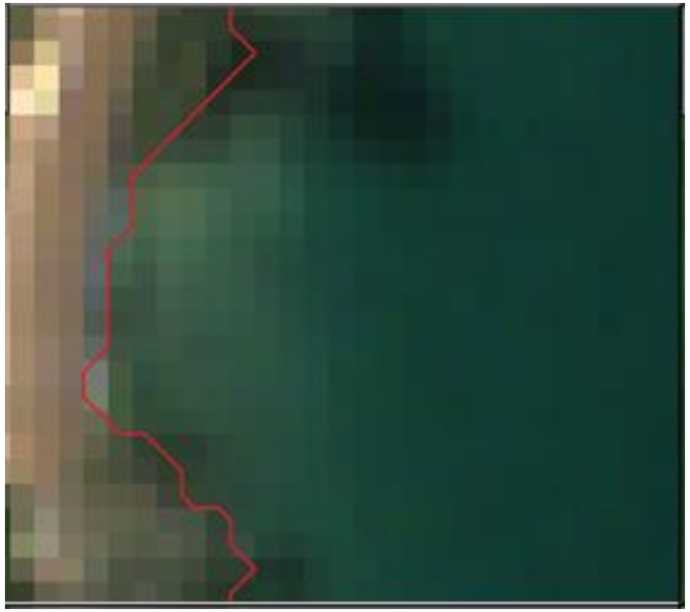
Waterline	S2		L8	L5
Wales	T30UUD	68	86	75
	T30UVD	65		
Cantabria	T30TUP	No aux. data	52	57
	T30TVP	80		
Venice	T32TQR	195	150	182
	T33TUL	128		
Catane	T33SWB	278	58	4
Baffin Bay	T17XNA	96	15	No aux. data
	T17XPA	60		

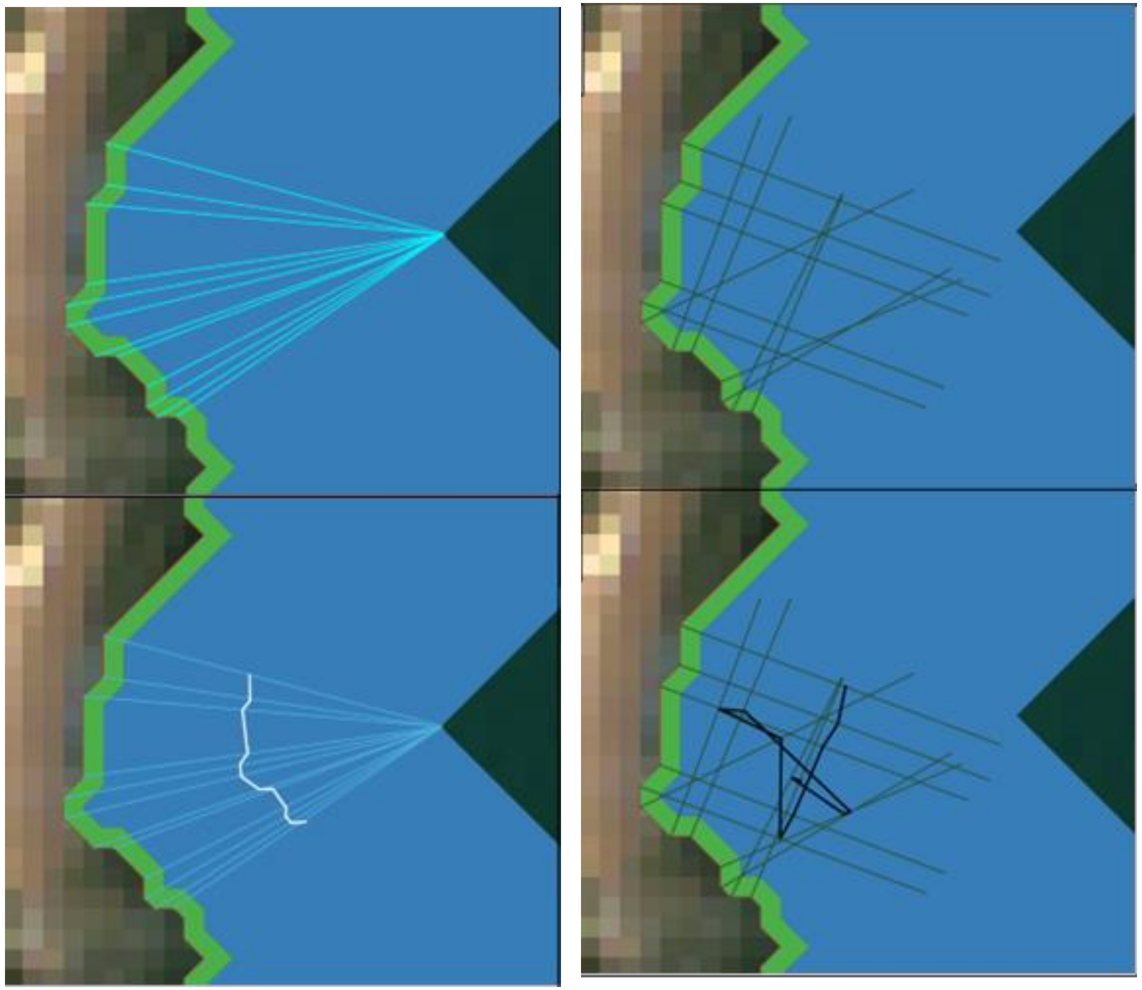
Challenges



V2 process

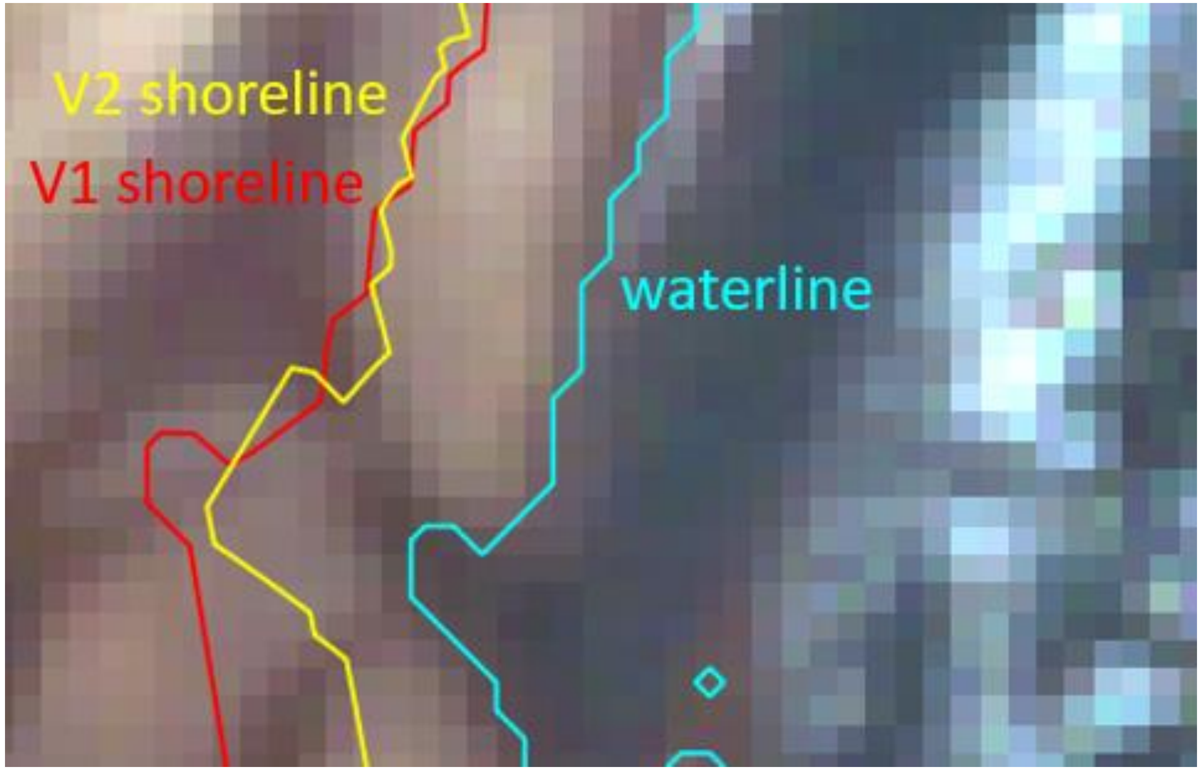
Point by point transformation

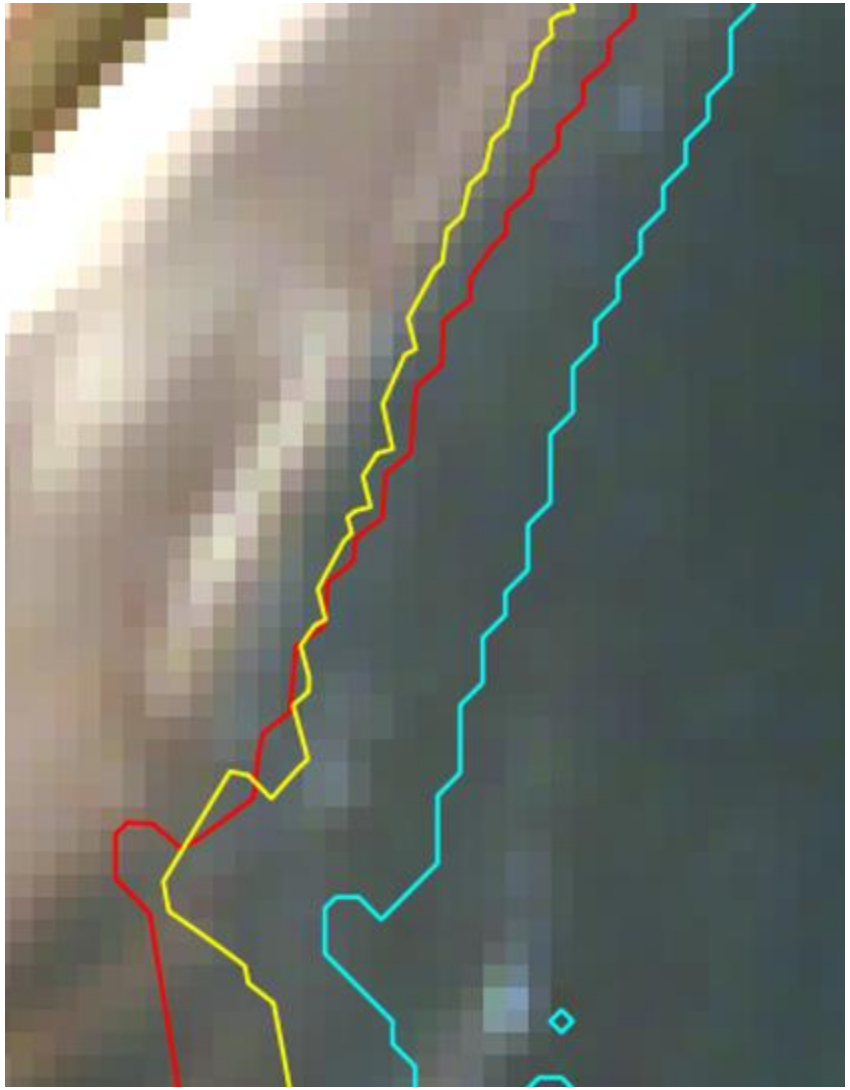




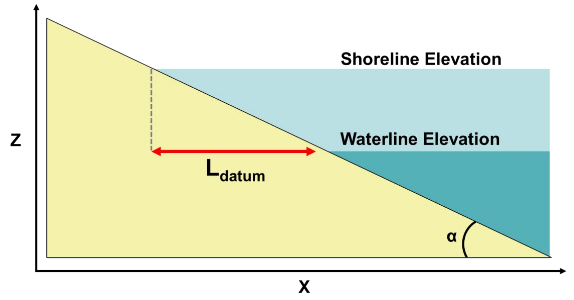
V2 process

Point by point transformation

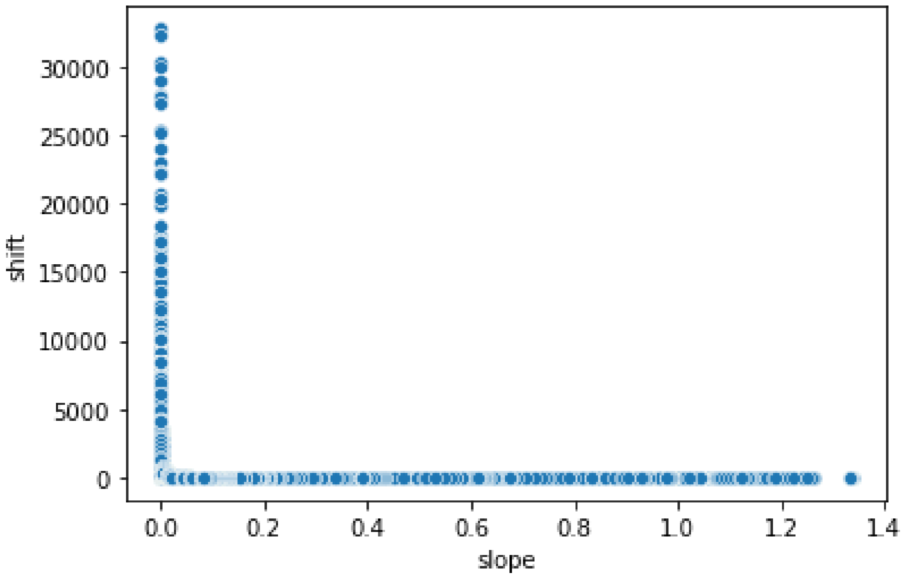


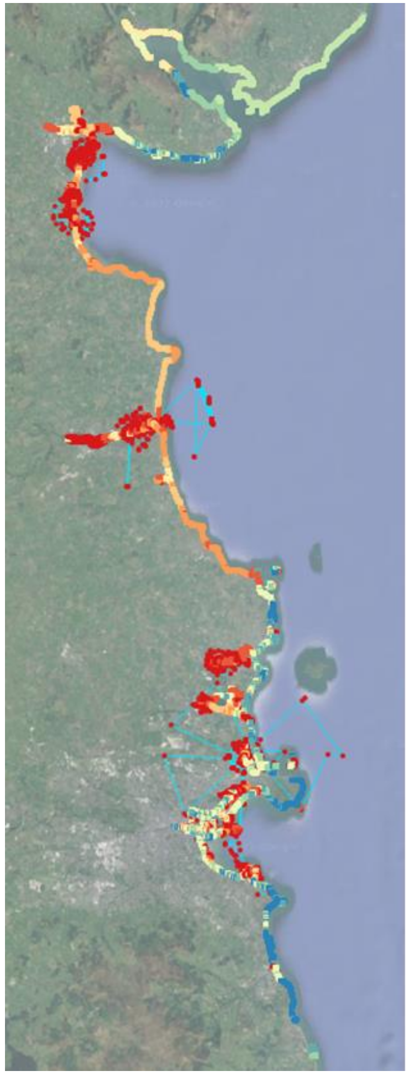


Shift calculation



$$L_{datum} = \frac{h_{wl} - h_{datum}}{\alpha}$$

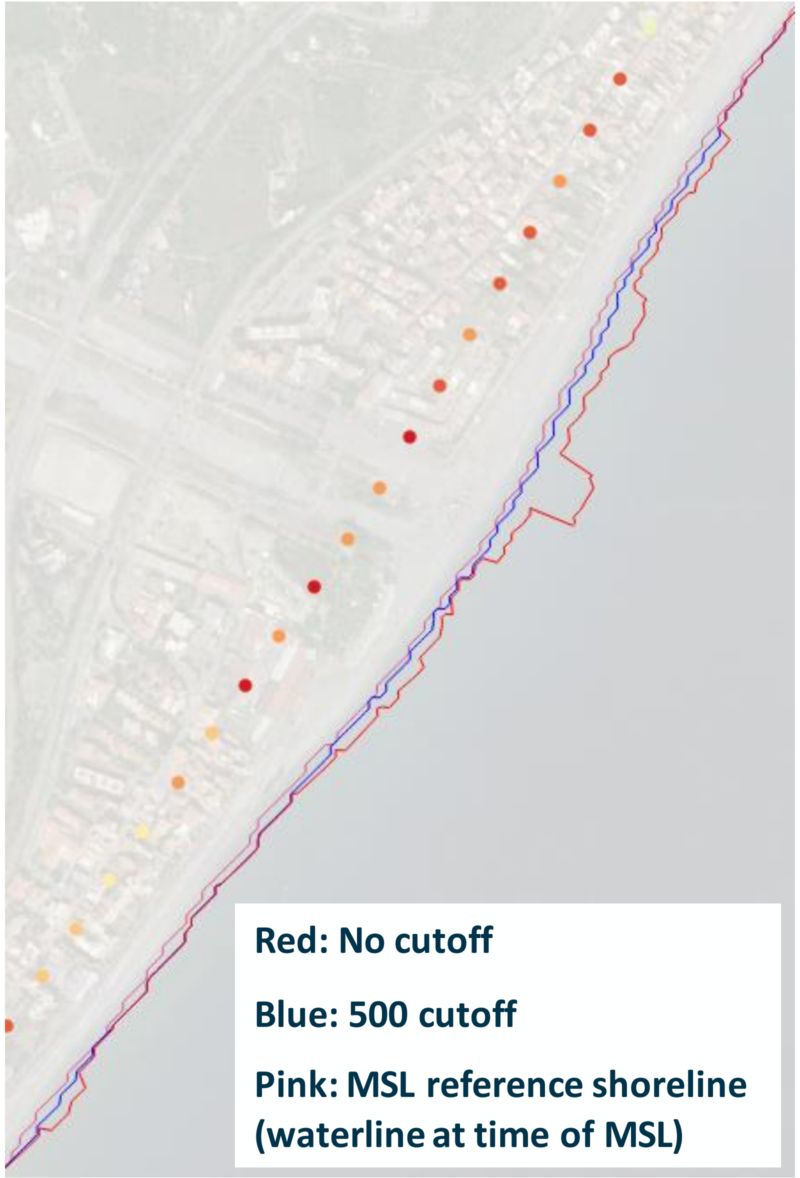


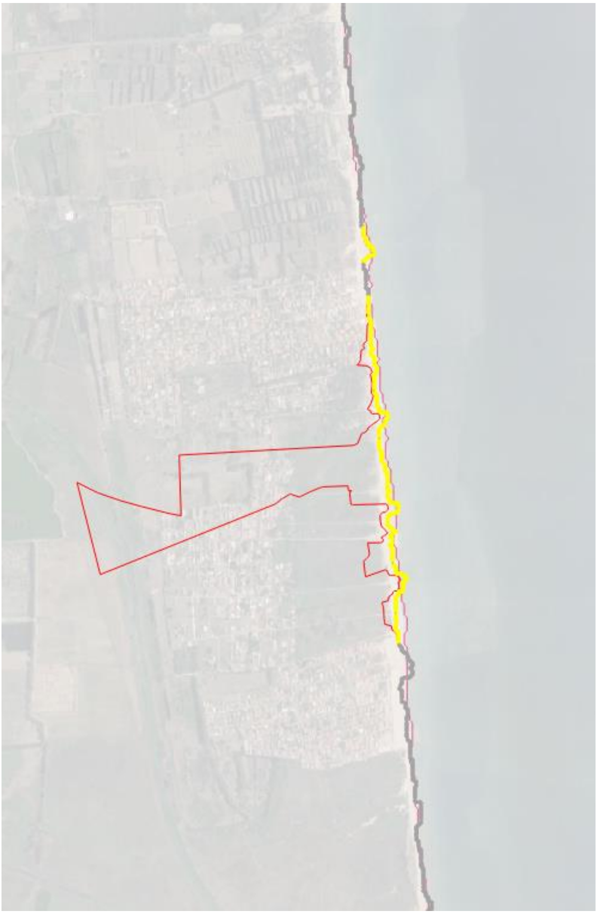


Slope Value

- 0.0002 - 0.0081
- 0.0081 - 0.0153
- 0.0153 - 0.0217
- 0.0217 - 0.0305
- 0.0305 - 0.0538
- 0.0538 - 0.0775
- 0.0775 - 0.0804
- 0.0804 - 0.1076
- 0.1076 - 0.1741
- 0.1741 - 1.3362

V2 process


Red: No cutoff
Blue: 500 cutoff
Pink: MSL reference shoreline (waterline at time of MSL)

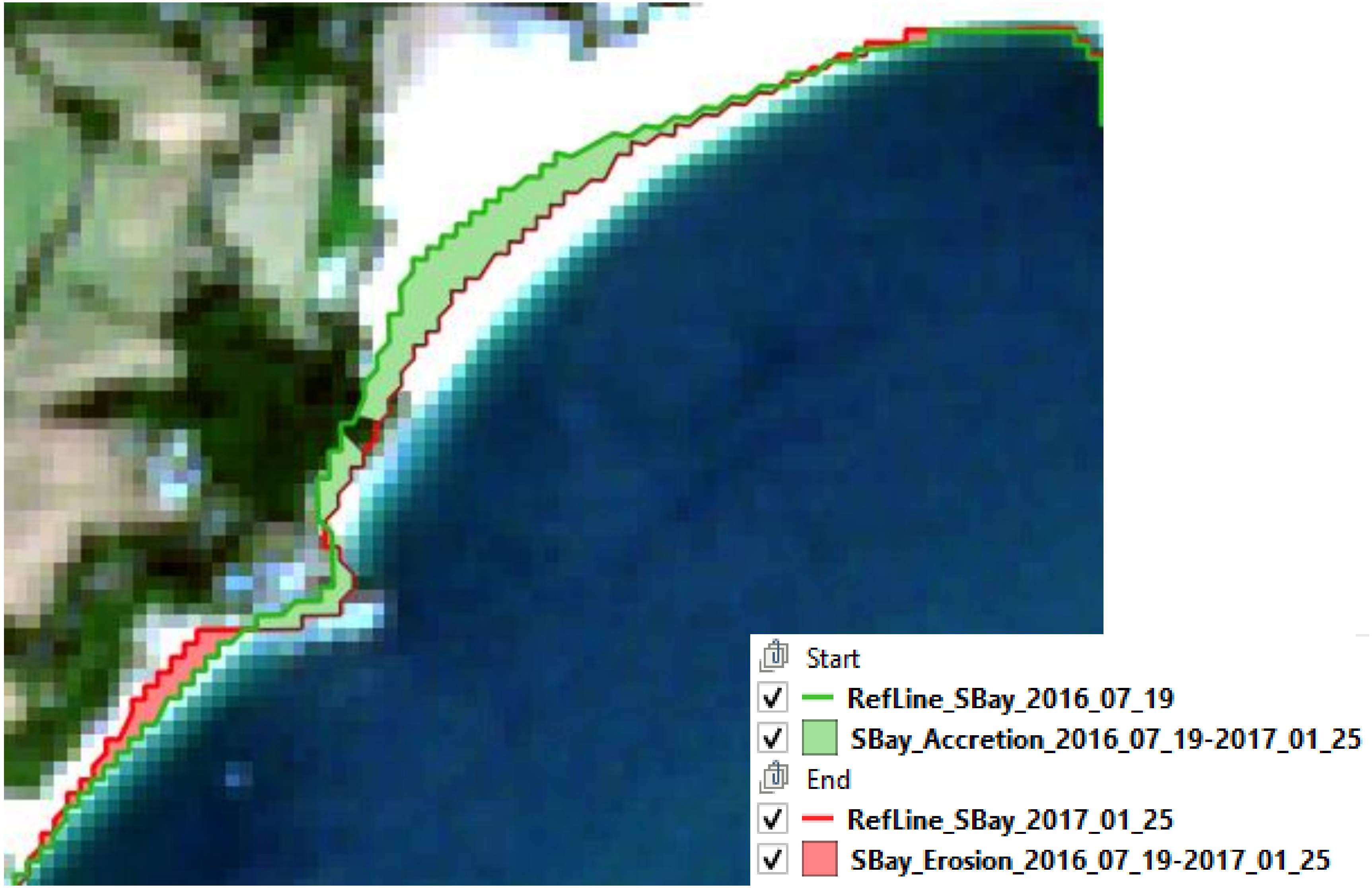


Shoreline quality control

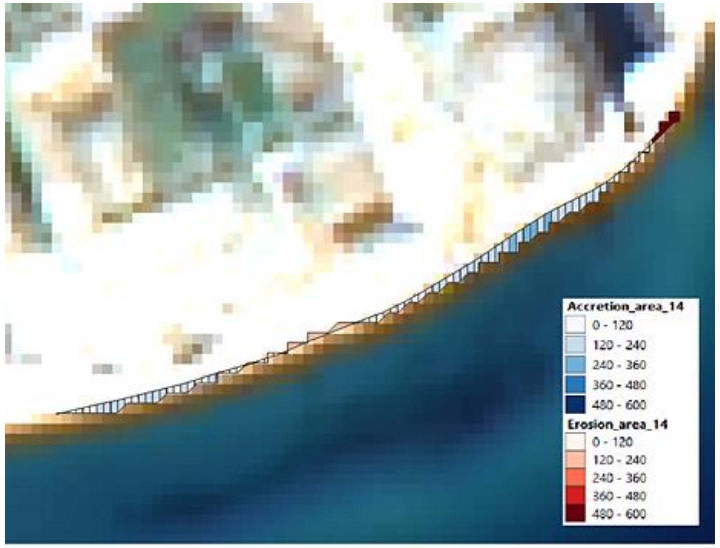
Time Series

Time series

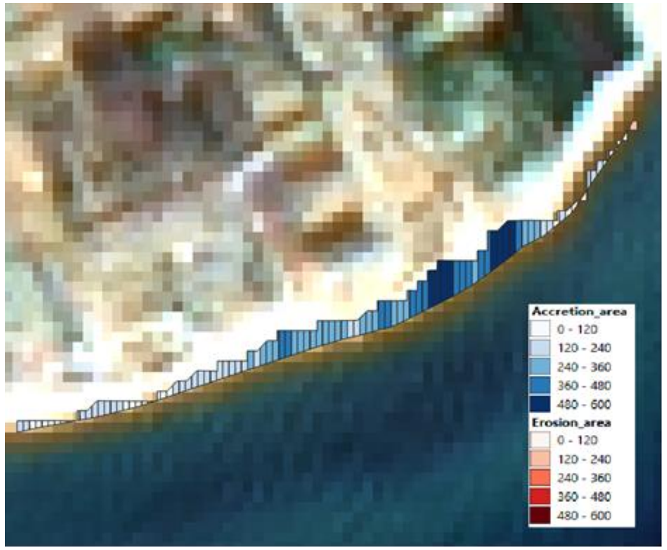
Change area mapping



Shoreline Time series

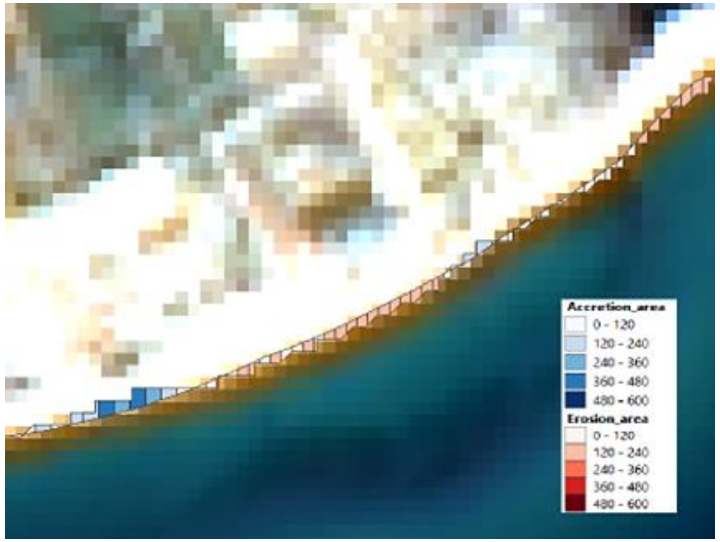


2014

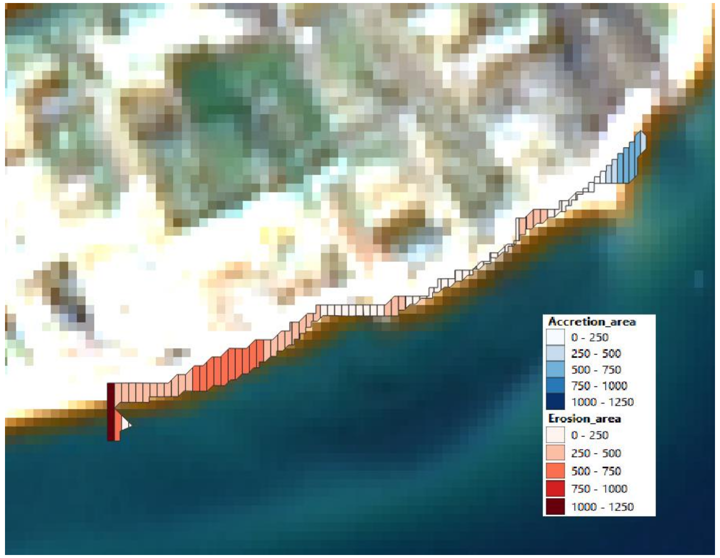


2015

March- July time series

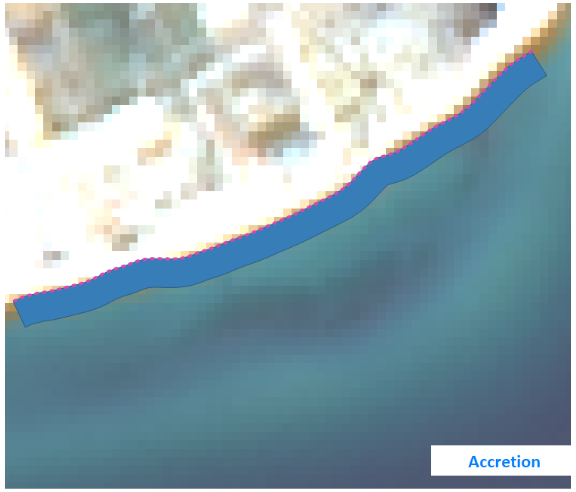


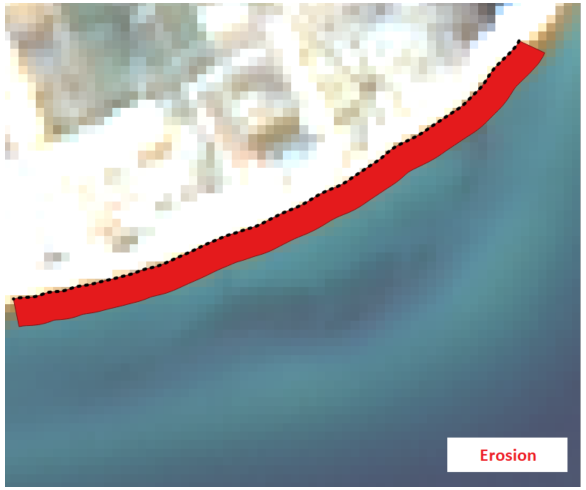
2016

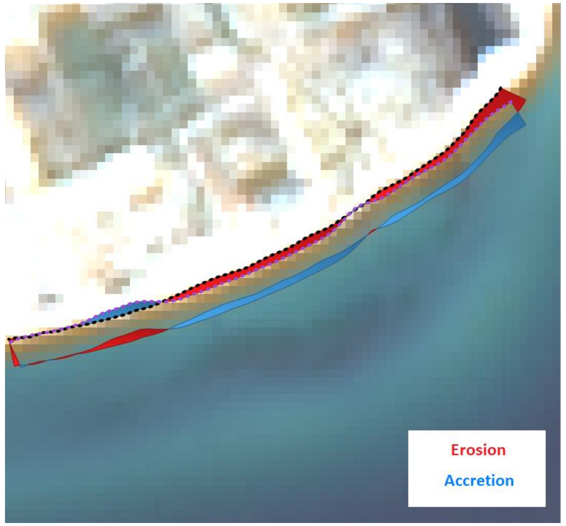


2017

Shoreline Time series



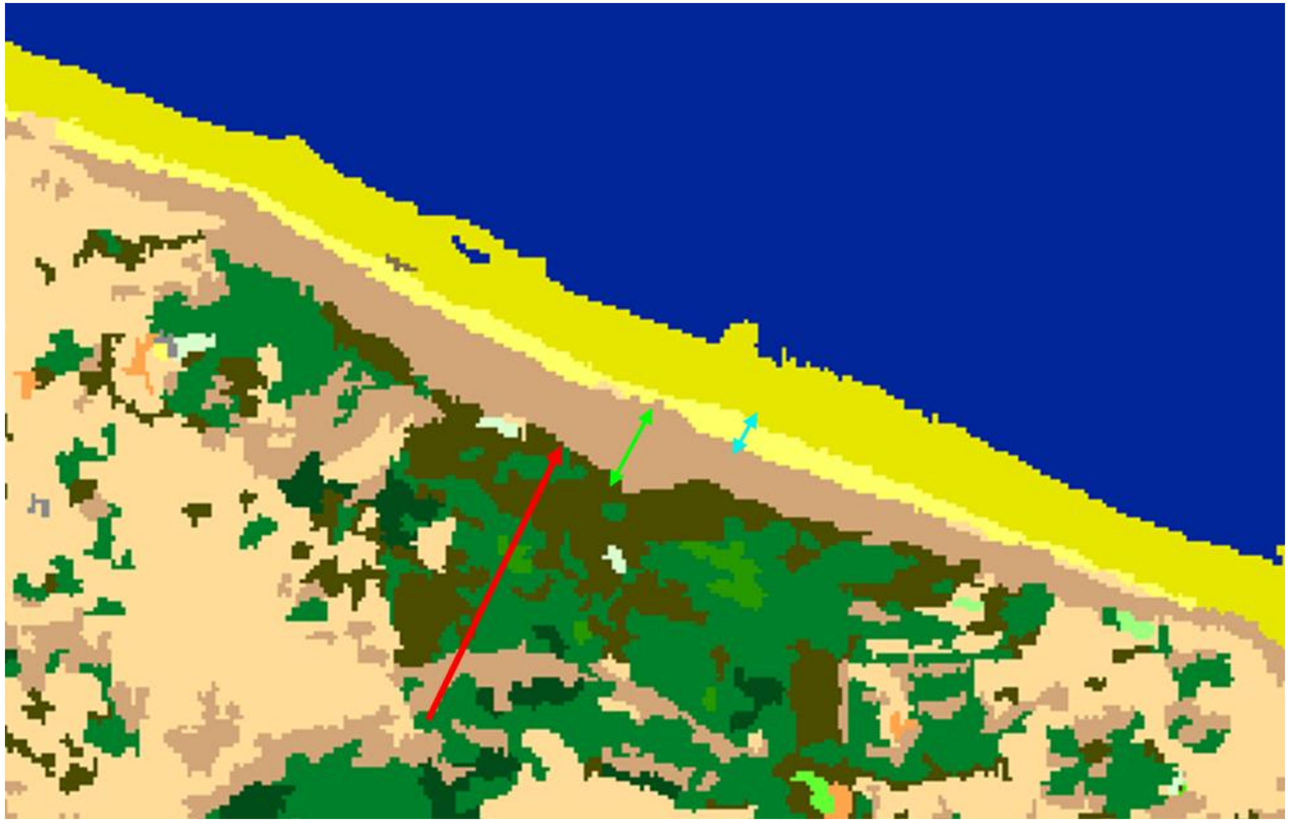




Land classification

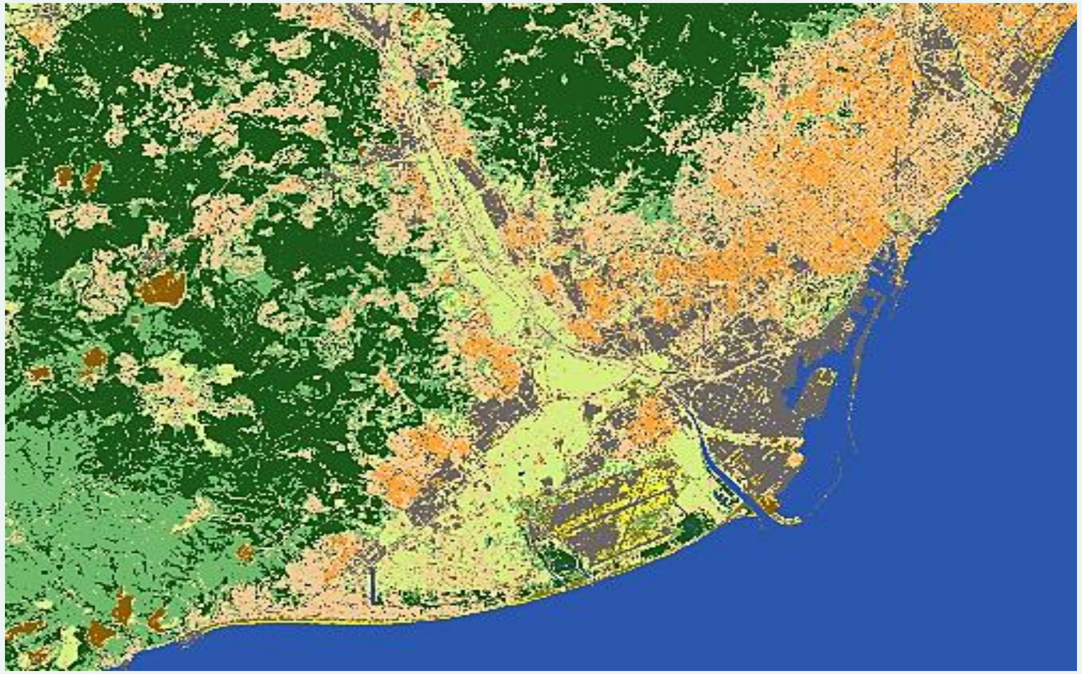
- Temporal classification
- Final product
- Internal & External QC
- Dynamic areas

Temporal classification

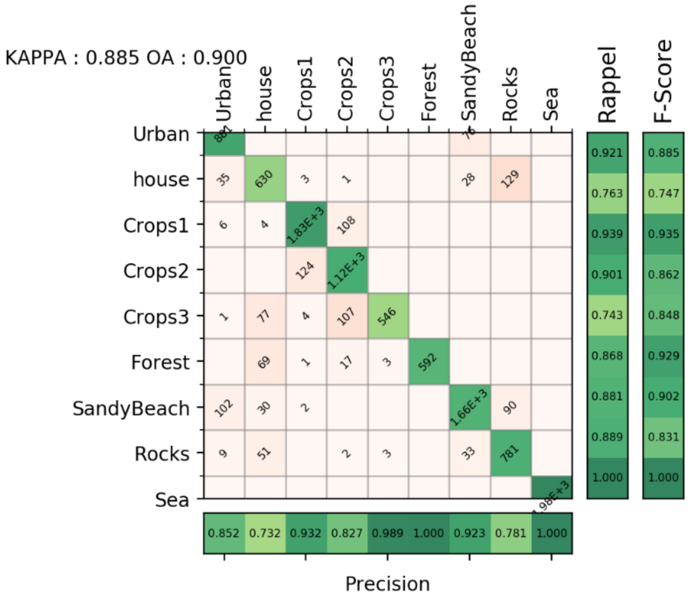


Temporal classification

Random forest from a single image	Random forest from 12 images



Delivered product



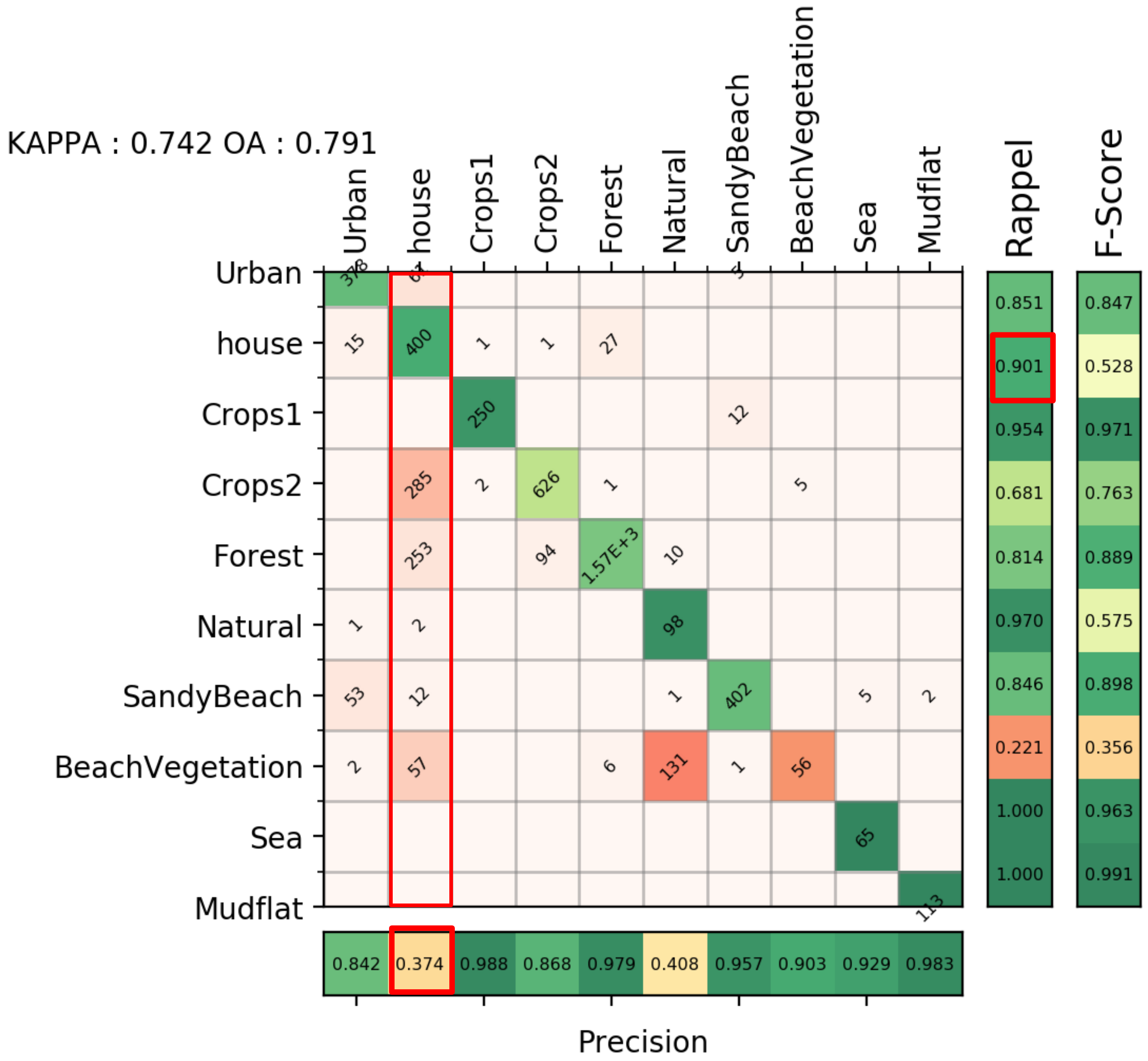
Cork_nomenclature.txt

Cork_QGIS_style.qml

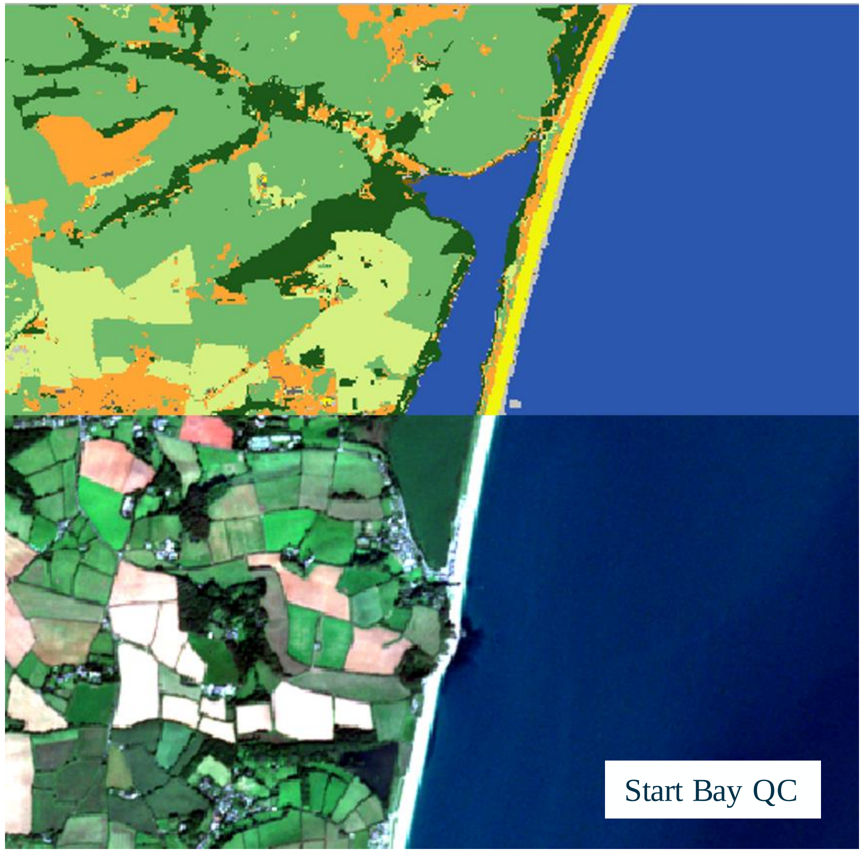
Classification map Internal QC

OA & KAPPA	F-Score	Recall & Precision	Message
< 0,70	/	/	Insufficient quality of the training data set, classification aborted
0,70 > X > 0,80	< 0,7	Recall < Precision	Underestimation of the class, need to review training data set (the sample selected are not enough – too selective)
		Recall > Precision	Over-estimation of the class, training data set is not selective enough, too many variability in a class, or two class that need to be grouped
0,80 > X > 0,90	/	/	External QC process needed
> 0,90	/	/	Classification accepted

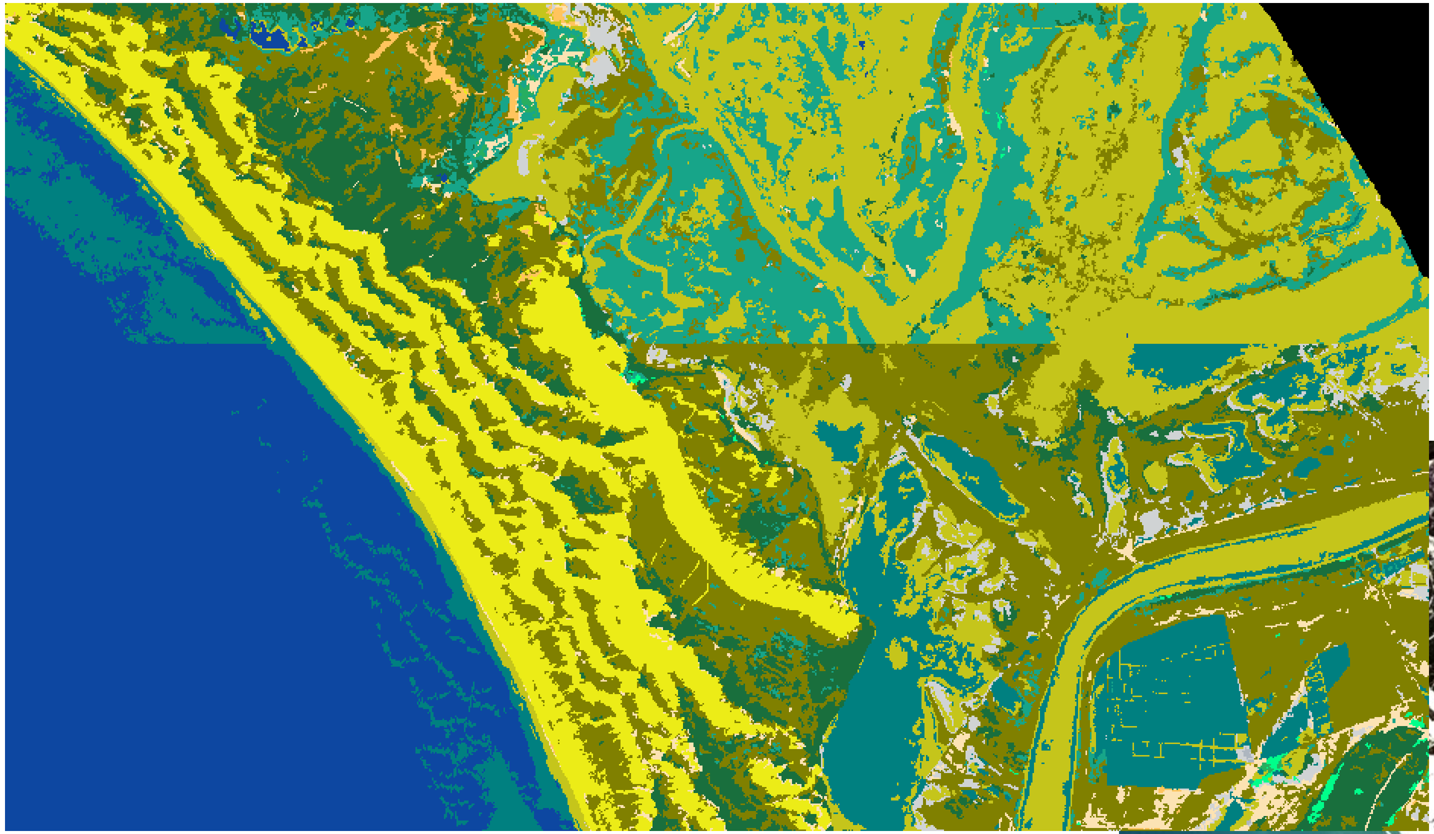
Classification map Internal QC



Classification External QC



Classification map External QC



Spur Head

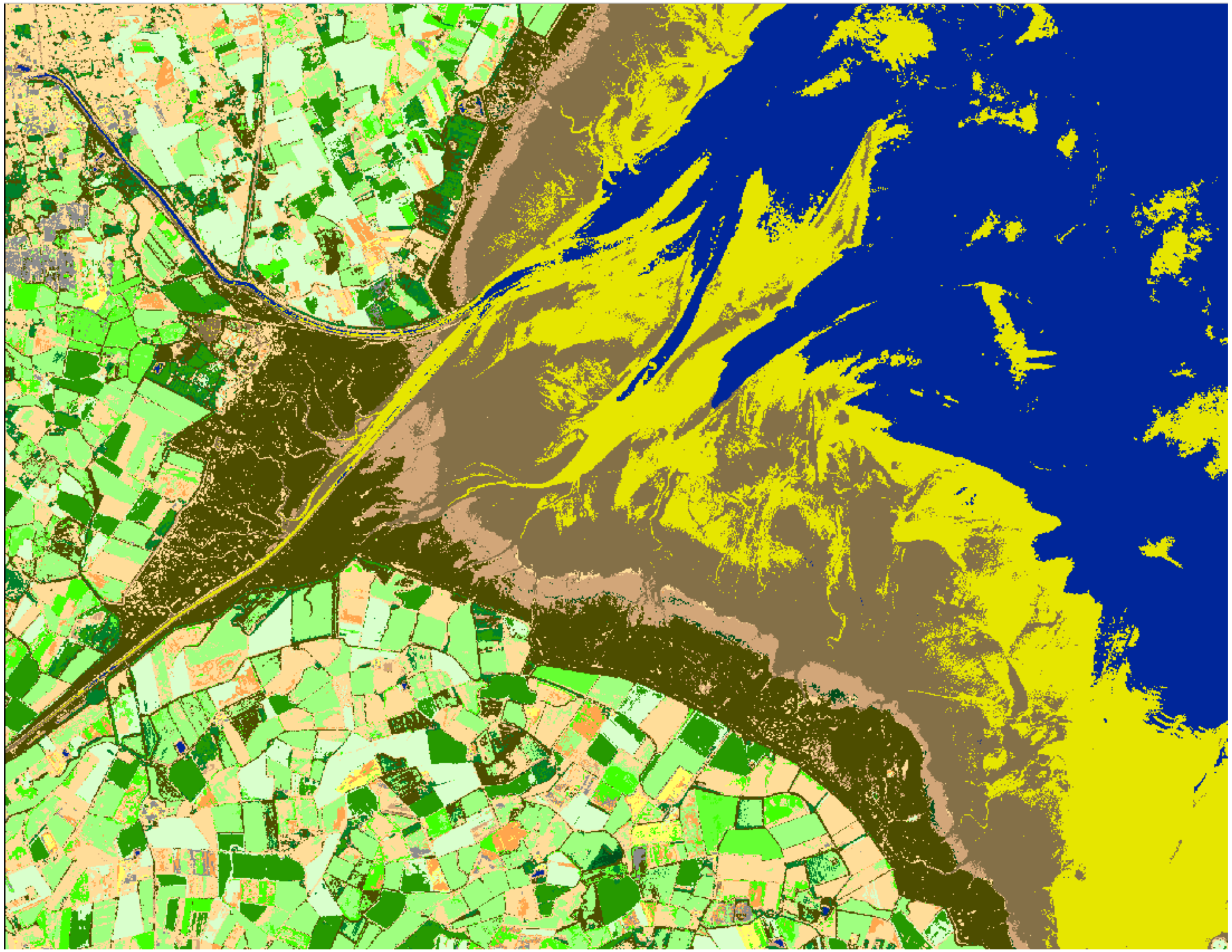
- Industrial
- Build up type 1
- Build up type 2
- Crop 1
- Crop 2
- Crop 3
- Crop 4
- Crop 5
- Crop 6
- Forest type 1
- Forest type 2
- Soft Cliff
- SaltMarshes
- Sandy Beach
- Tidal areas
- Sea

Dynamic areas




Dynamic areas

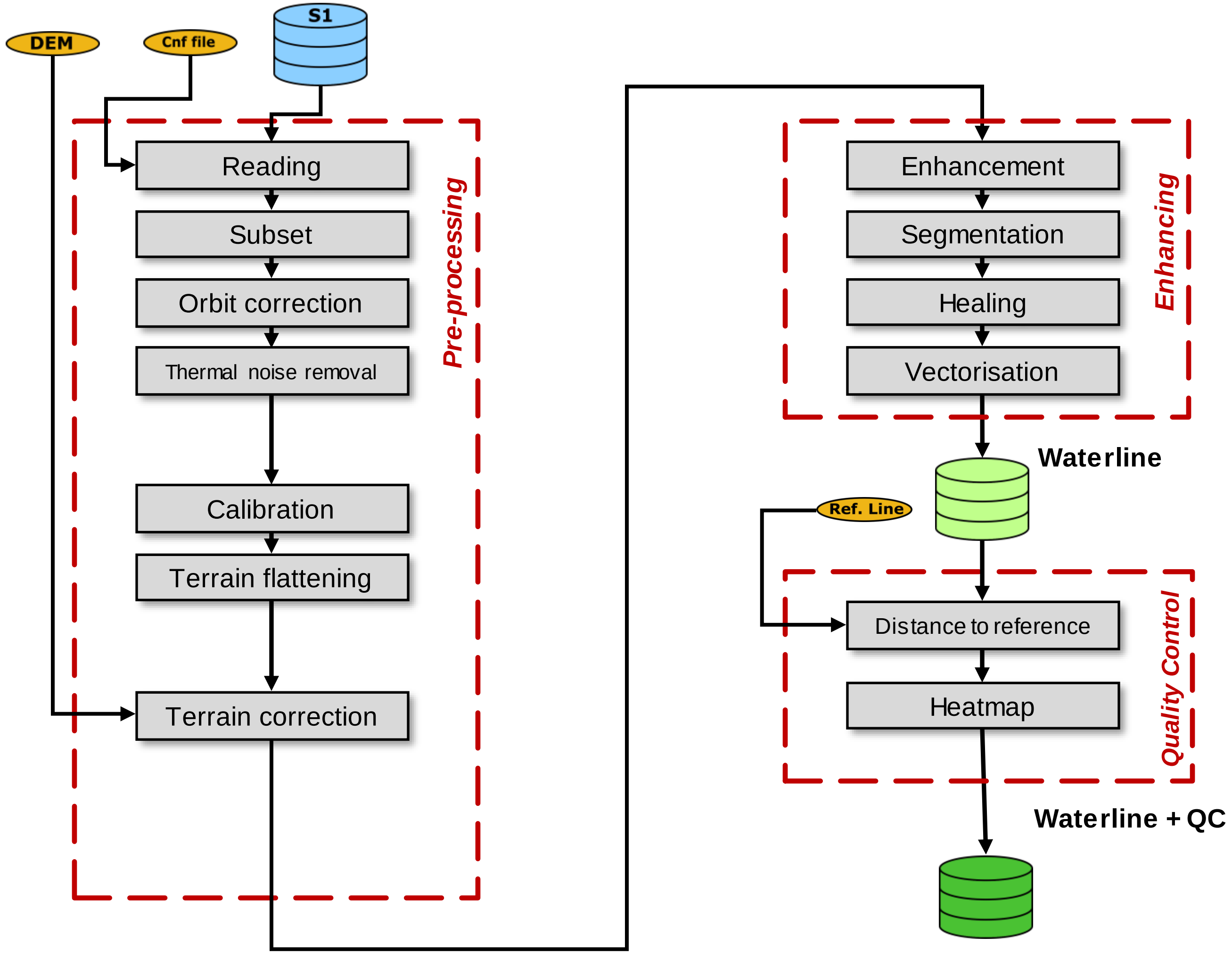
- Industrial
- Build-Up area 1
- Build-Up area 2
- Crop type 1
- Crop type 2
- Crop type 4
- Crop type 5
- Crop type 6
- Forest type 1
- Forest type 2
- Soft Cliff
- Salt Marshes
- Mudflat
- Sandy Beach
- Tidal area
- Sea



SAR change rates

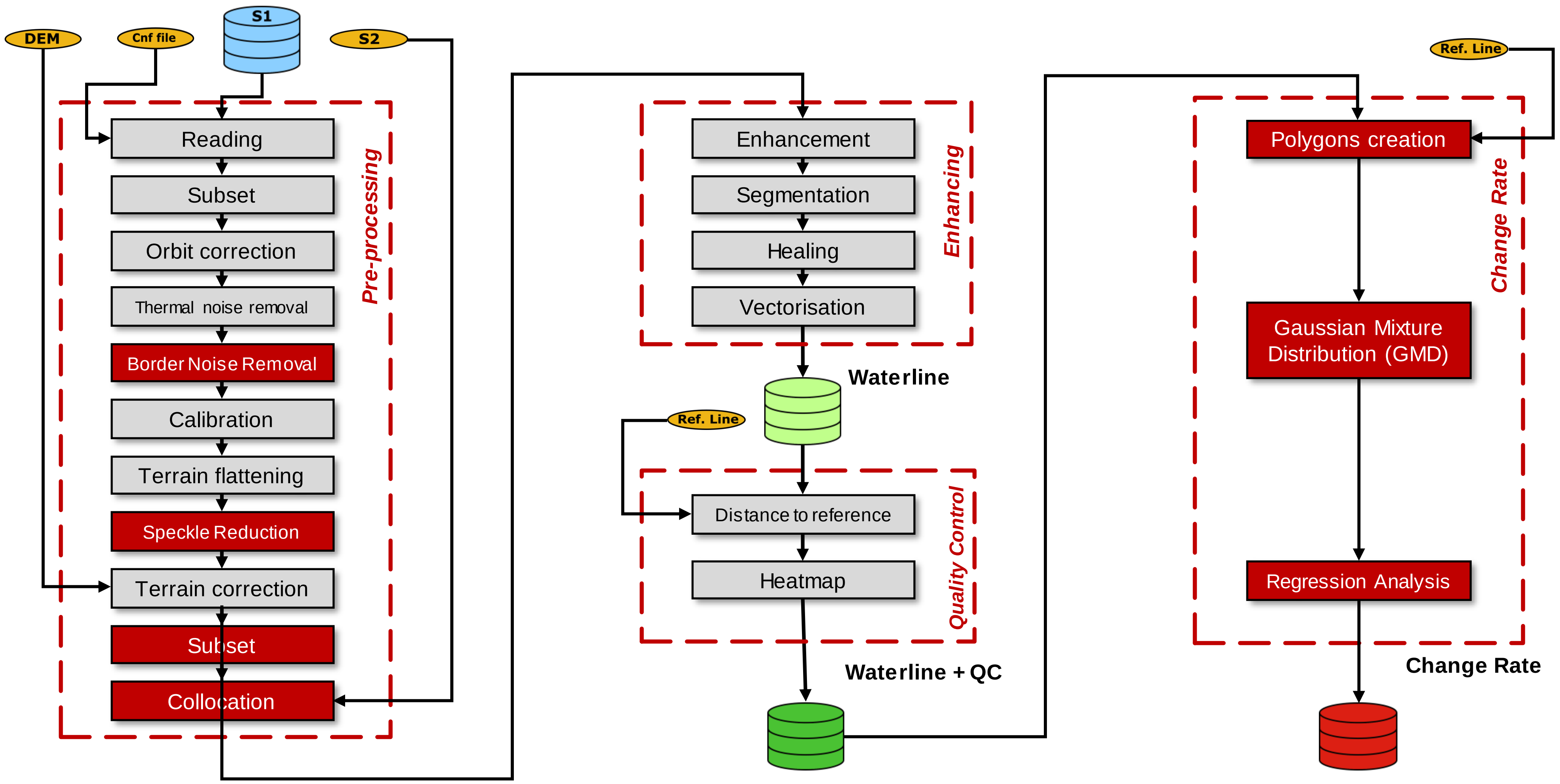
- Improvements
- Change Rates products
- Results
- Conclusions

SAR Processing Chain at the end of the project



starting

isardSAT SAR Processing Chain improvements

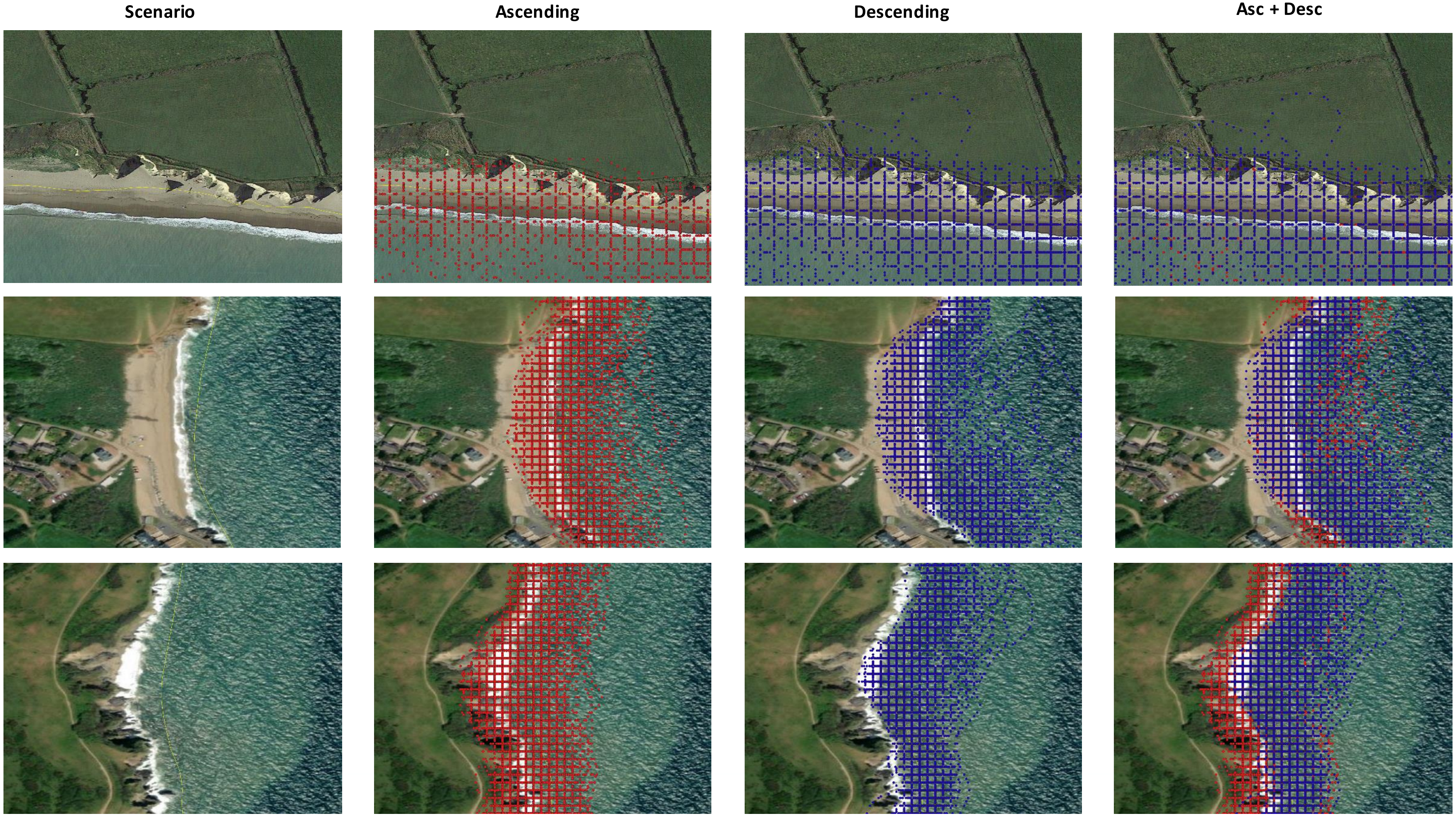


SAR Geometric distortions

Example 1 - Wexford (scene on the South coast from East to West including a beach and cliff)

Example 2 - Start Bay (scene on the East coast from South to North including a beach)

Example 3 - Start Bay (scene on the East coast from South to North including a cliff)



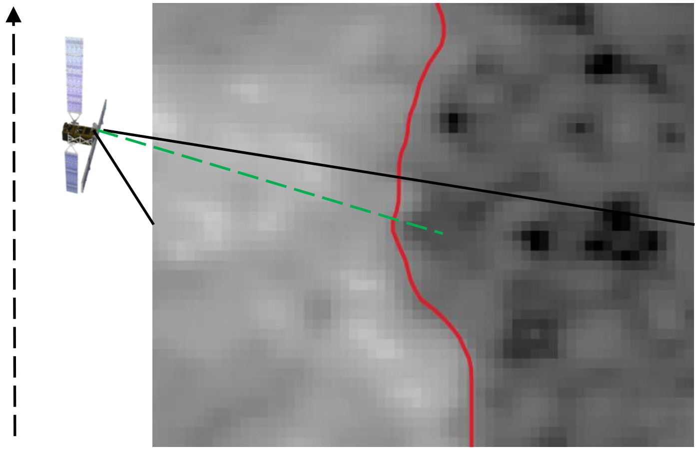
WLs ascending vs descending tracks

Scenario

WLs ascending vs descending tracks

Scenario

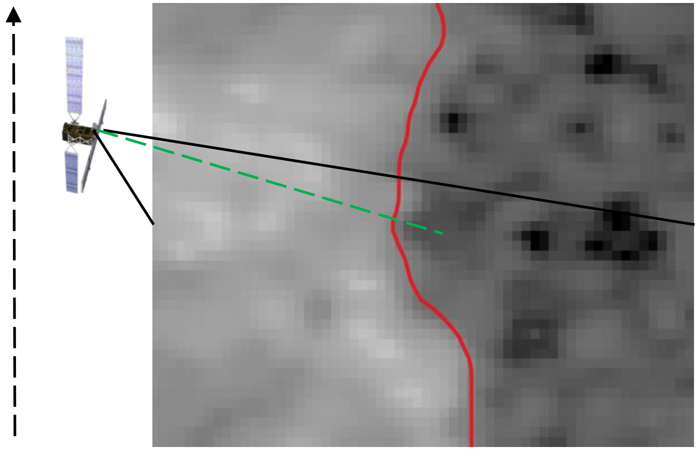
Ascending



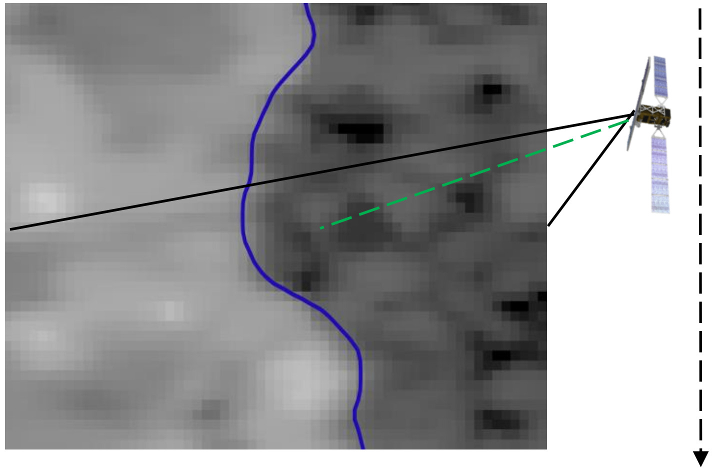
WLs ascending vs descending tracks

Scenario

Ascending



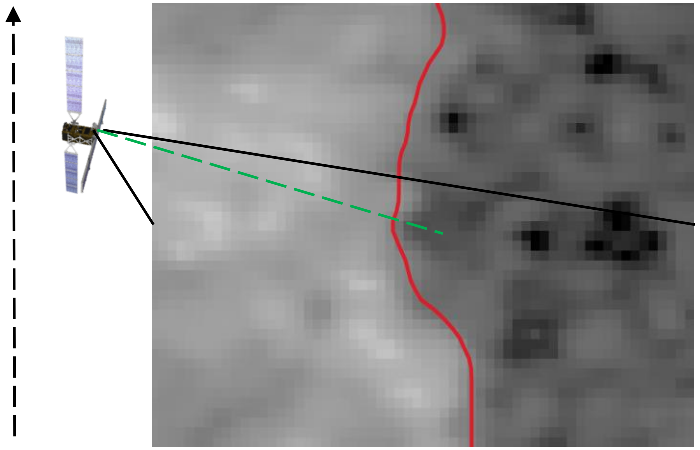
Descending



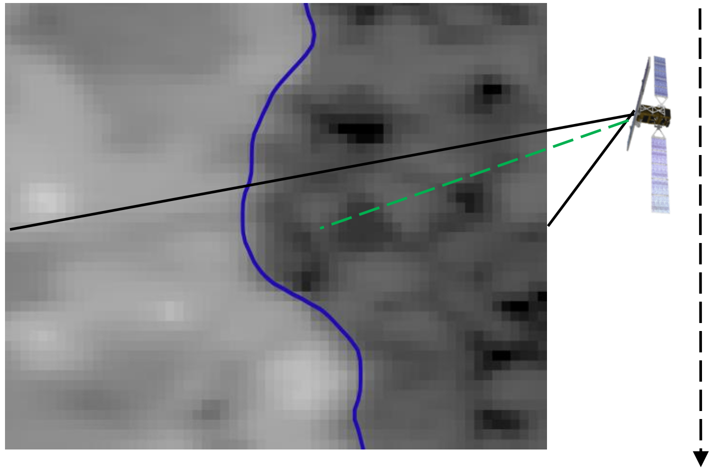
WLs ascending vs descending tracks

Scenario

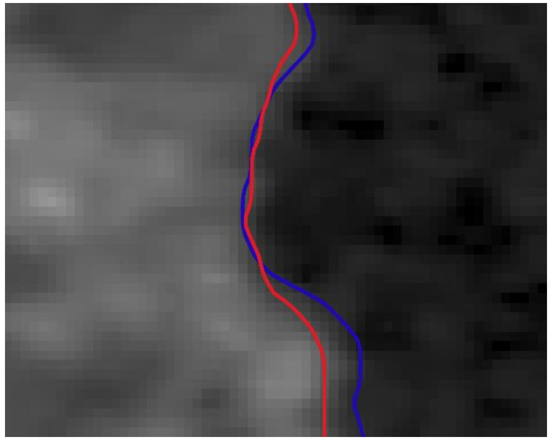
Ascending



Descending



Ascending - Descending

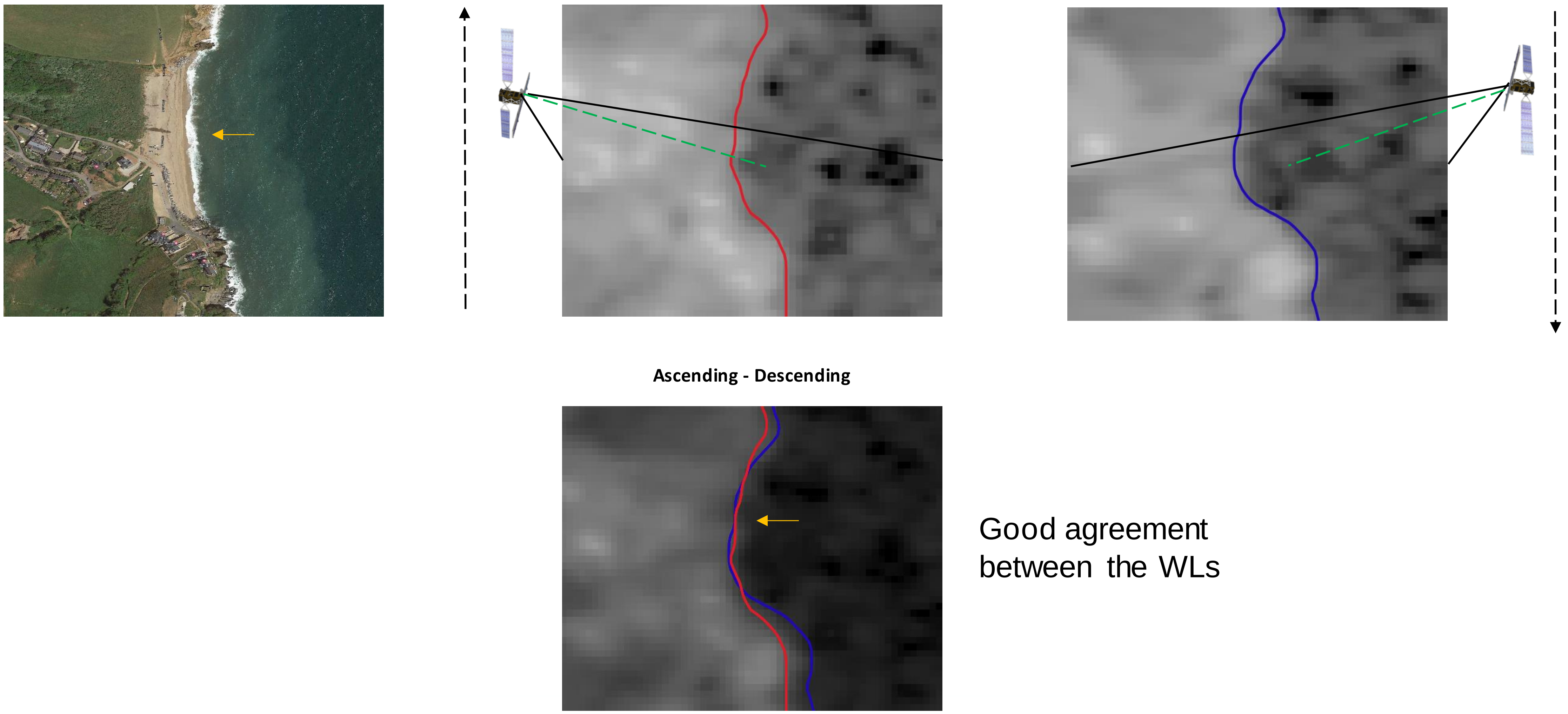


WLs ascending vs descending tracks

Scenario

Ascending

Descending



Ascending - Descending

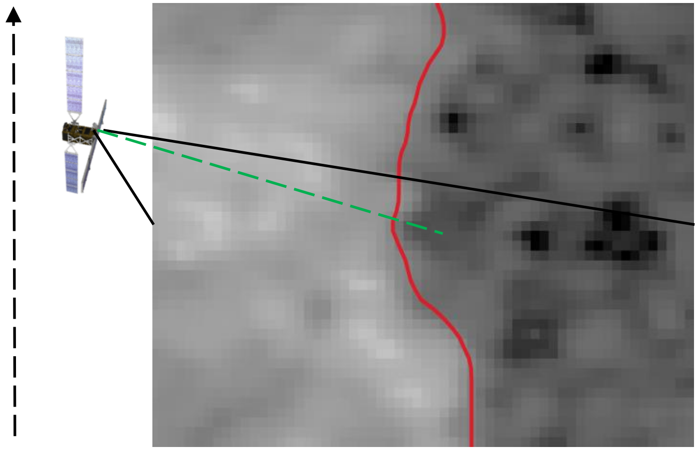
Good agreement between the WLs

isardSAT

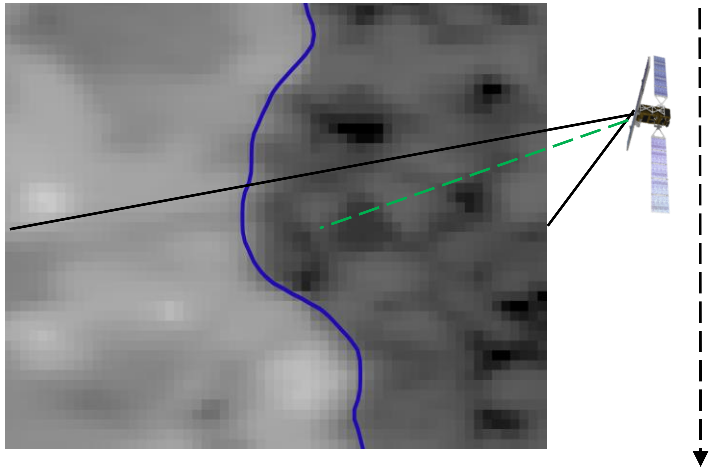
WLs ascending vs descending tracks

Scenario

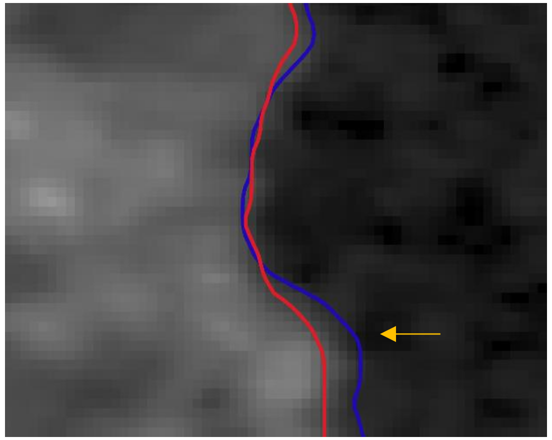
Ascending



Descending

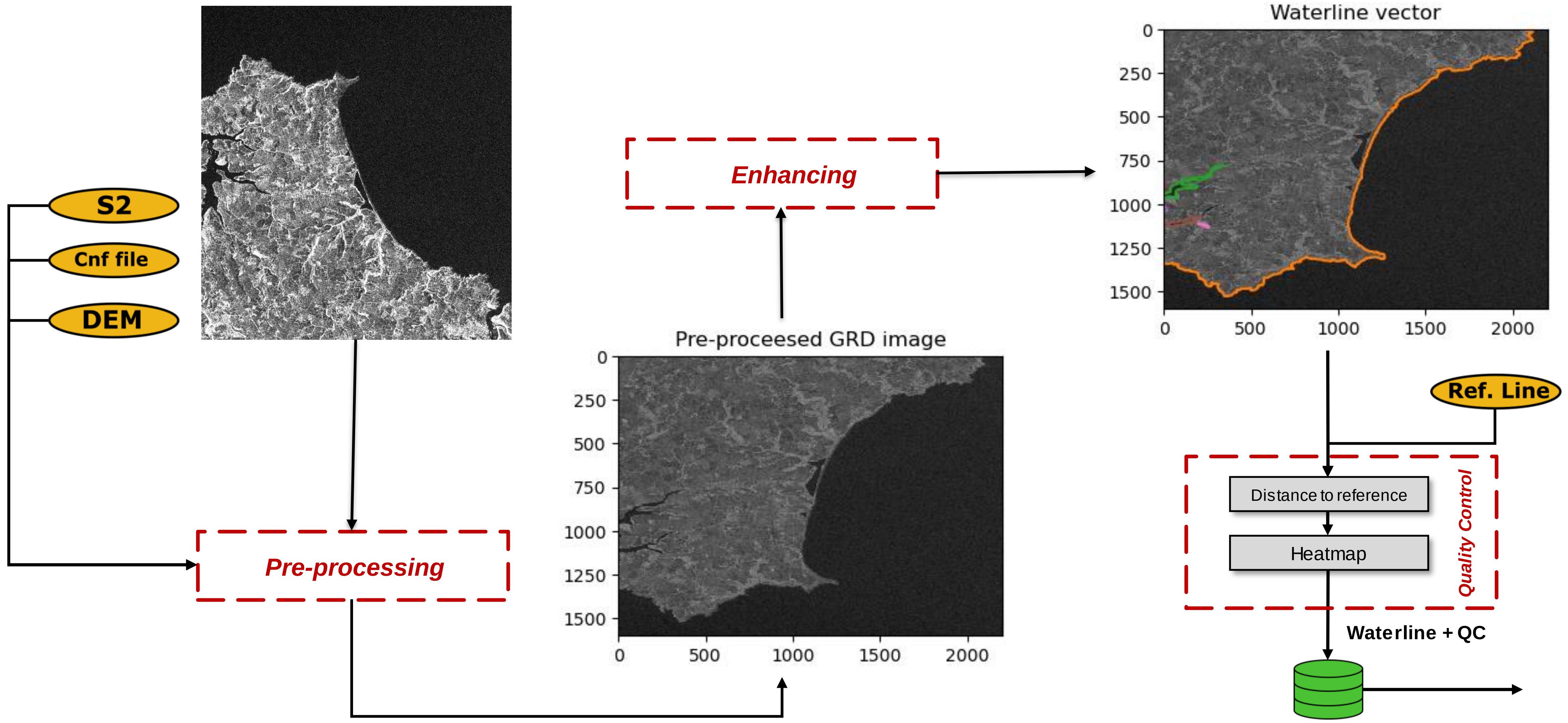


Ascending - Descending



The darker area between the two WLs is the shadow effect.

Processing chain flowchart (1/2) (Pre-processing, Enhancing and Quality Control)

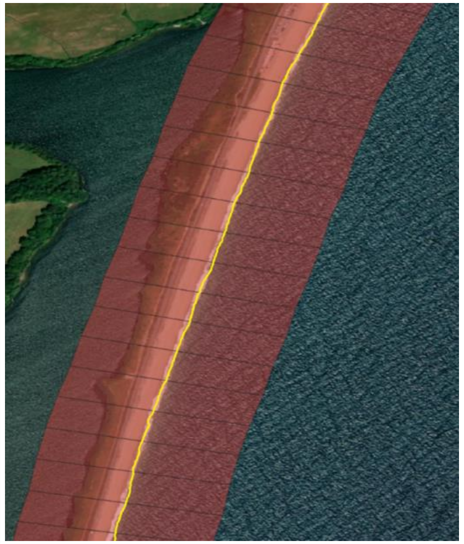


Processing chain flowchart (2/2) (Change Rate)

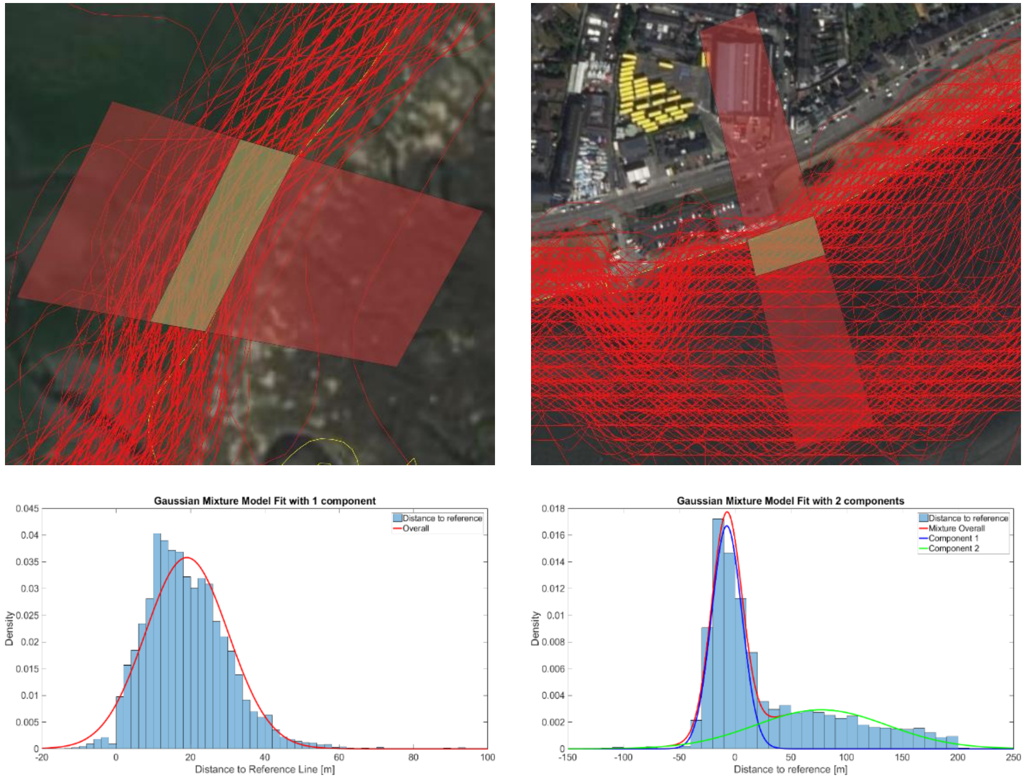
Change Rate

Ref. Line

Polygons creation

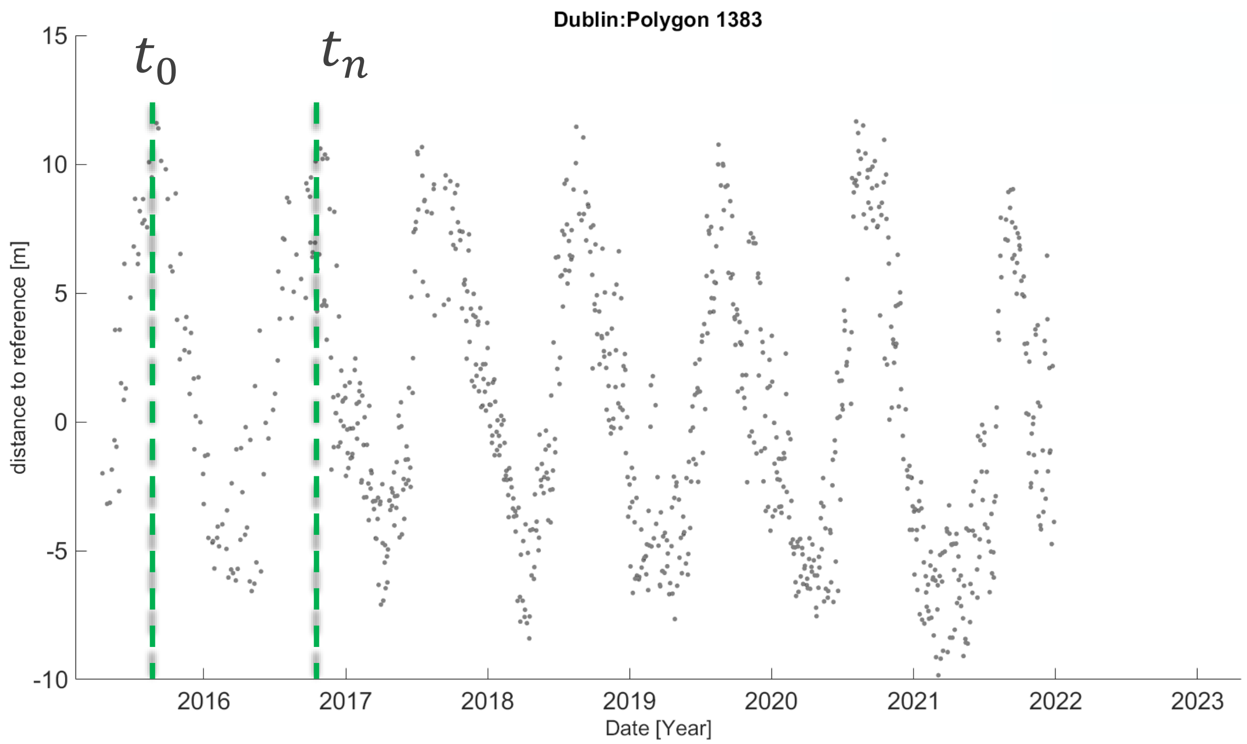


Gaussian Mixture Distribution (GMD)

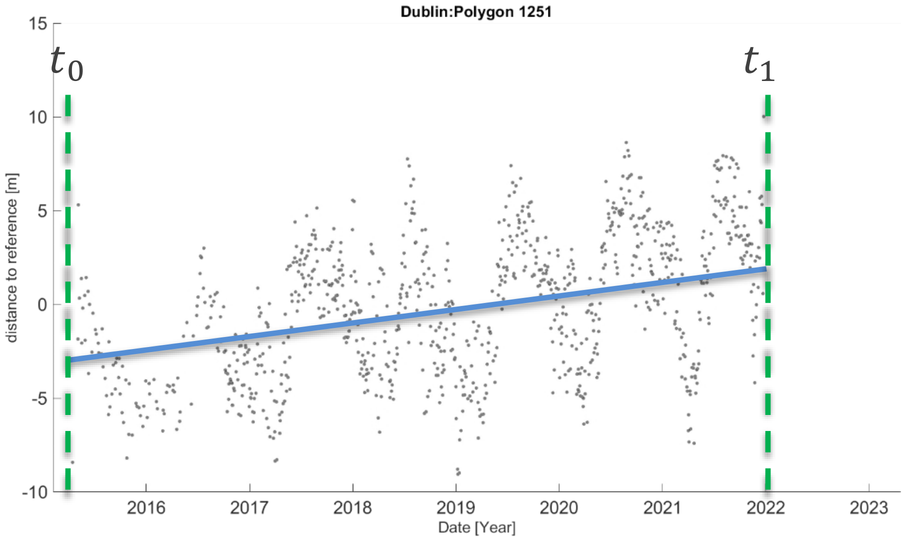


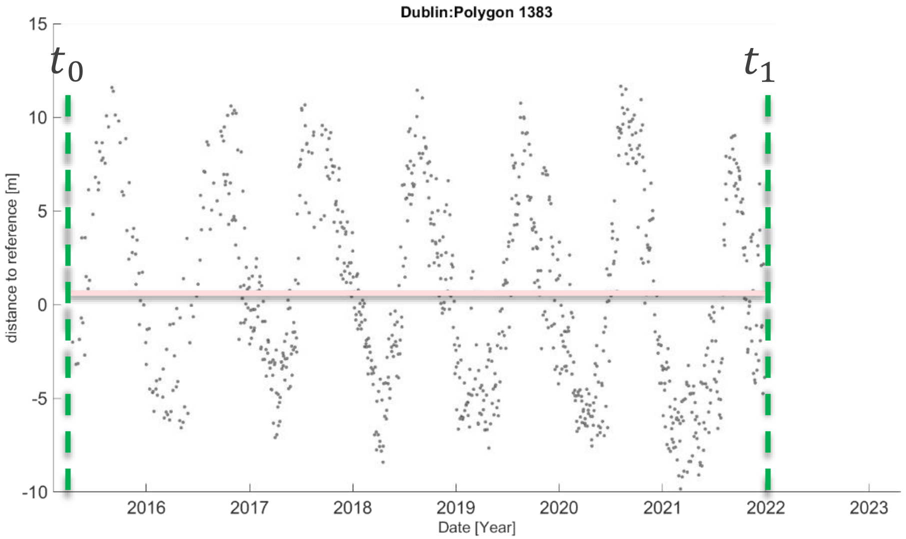
Regression Analysis

SAR Change Rate Product



Change rates products can be configured by specifying
- the polygon width (w)
- the observation time ($t_0, \ldots, t_n$)

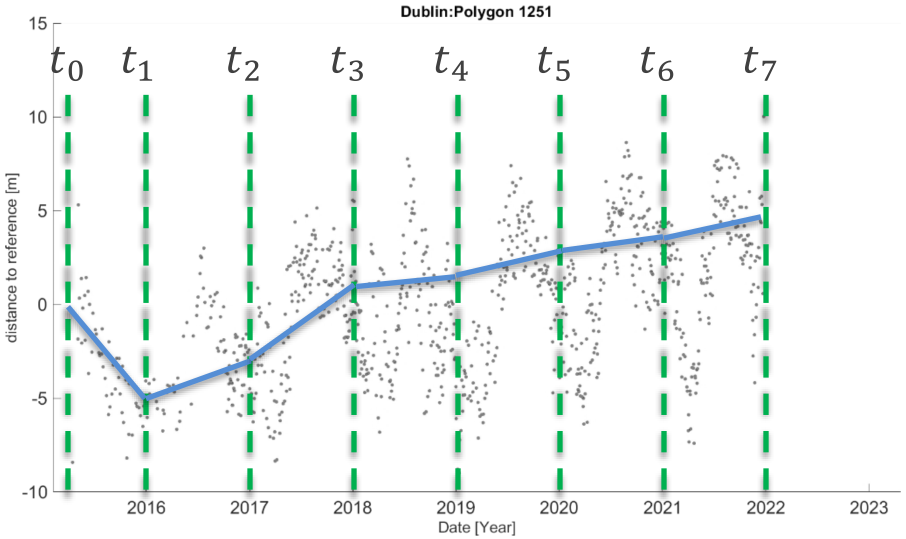


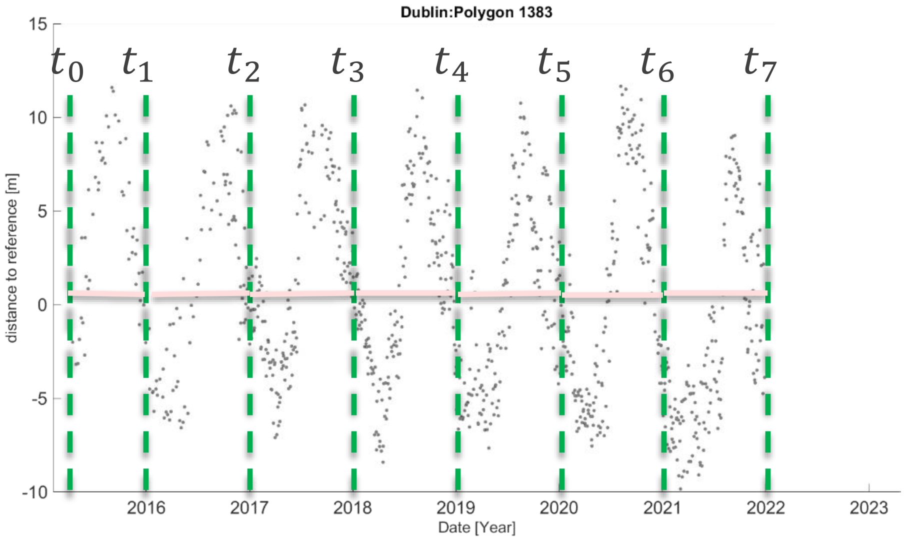


Change rates products can be configured by specifying

- the polygon width
- the observation time
  - **Overall**

SAR Change Rate Product

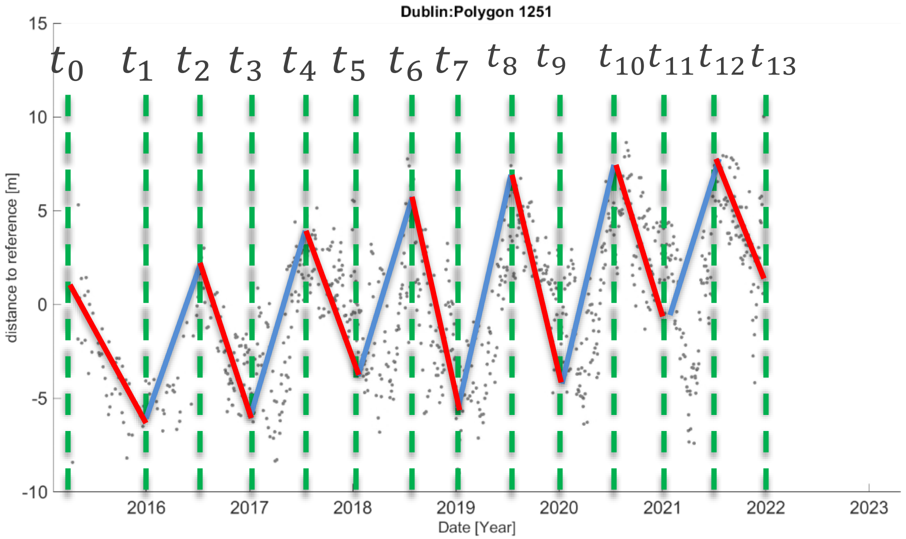


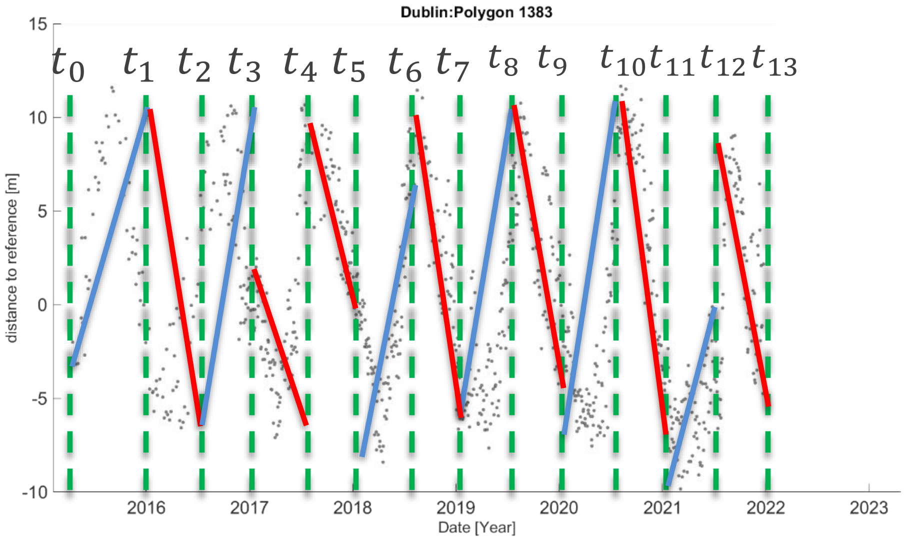


Change rates products can be configured by specifying

- the polygon width
- the observation time
    - Overall
    - **Yearly**

isardSAT SAR Change Rate Product



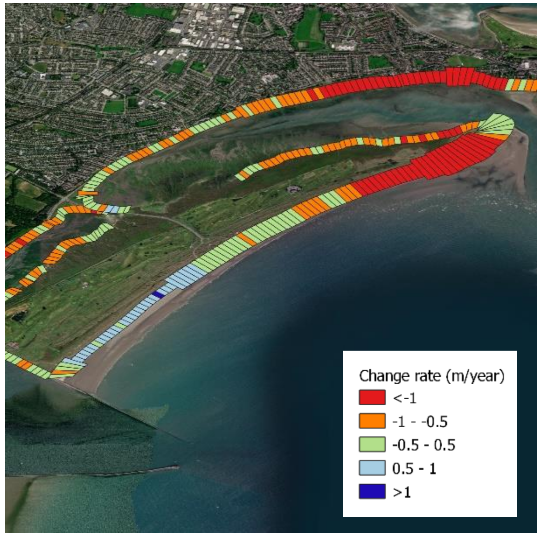


Change rates products can be configured by specifying

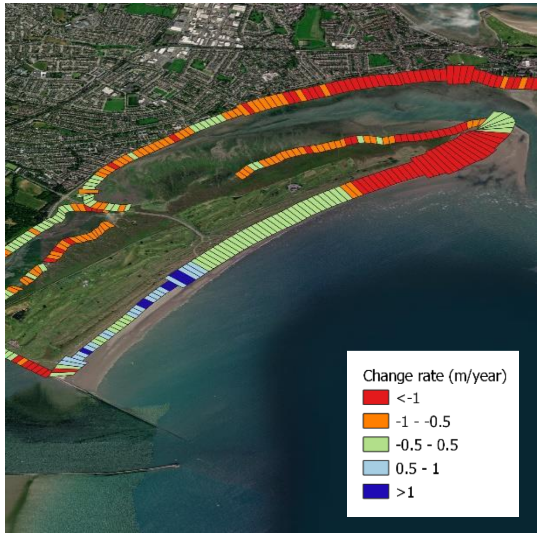
- the polygon width
- the observation time
  - Overall
  - Yearly
  - **Half-yearly**
  - Monthly

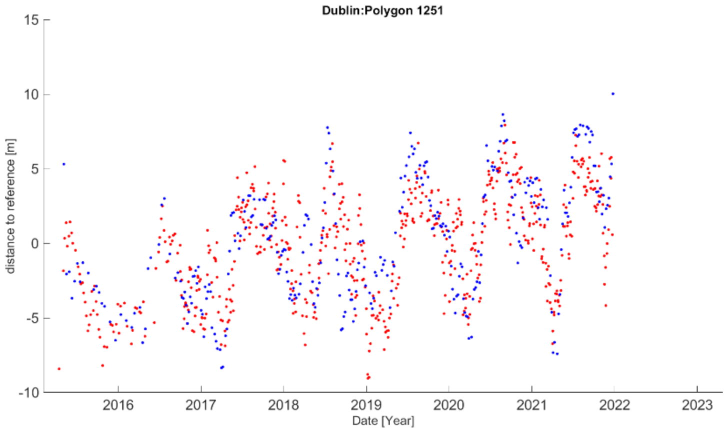
Results for Bull Island

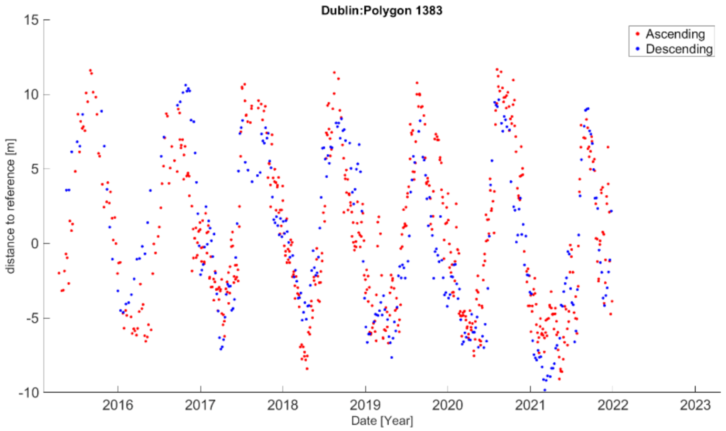
Ascending

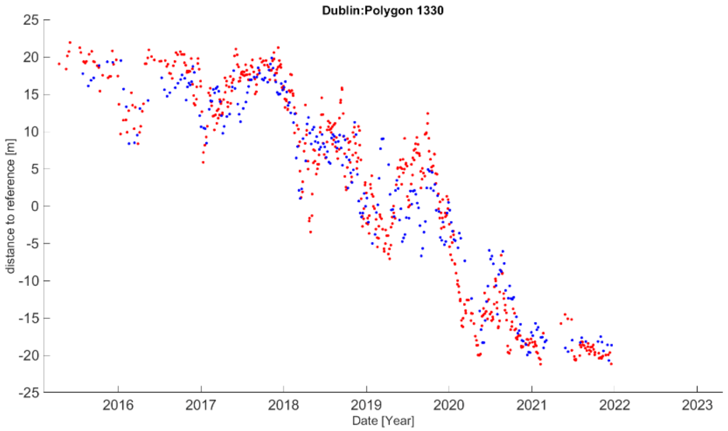


Descending



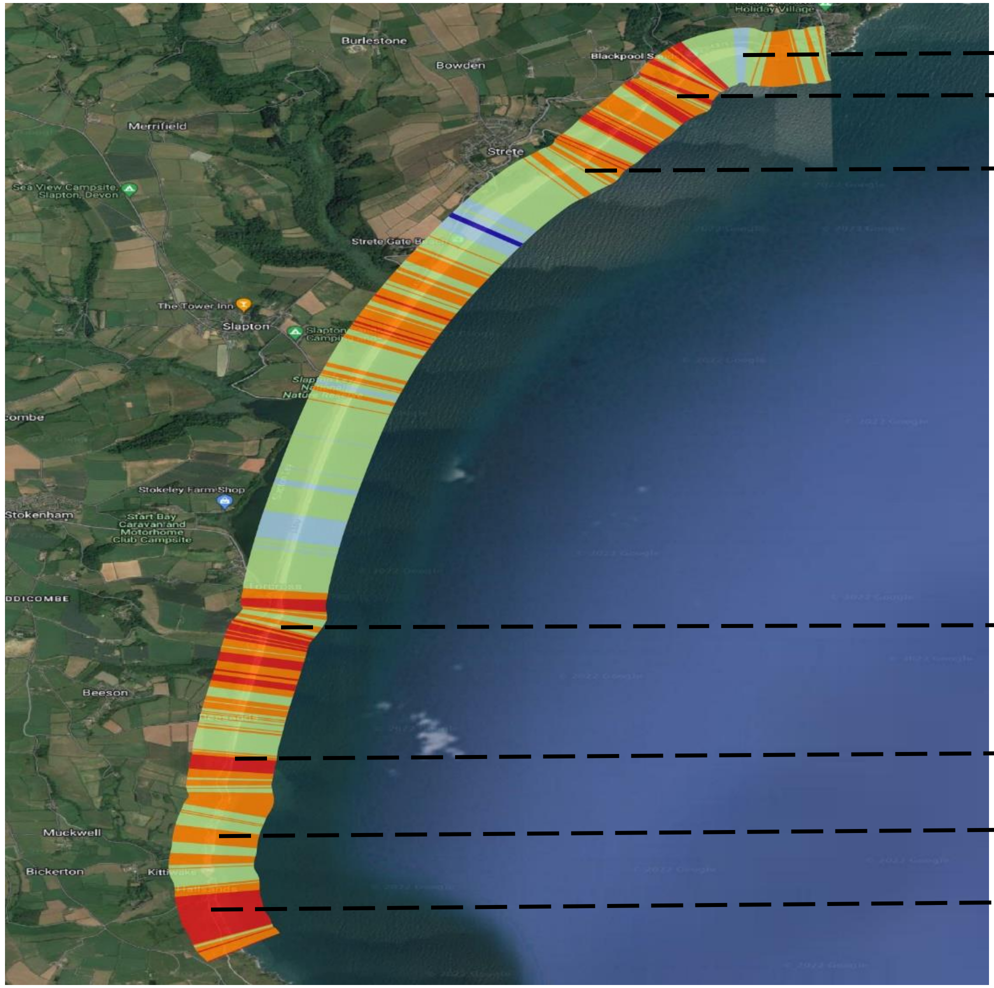




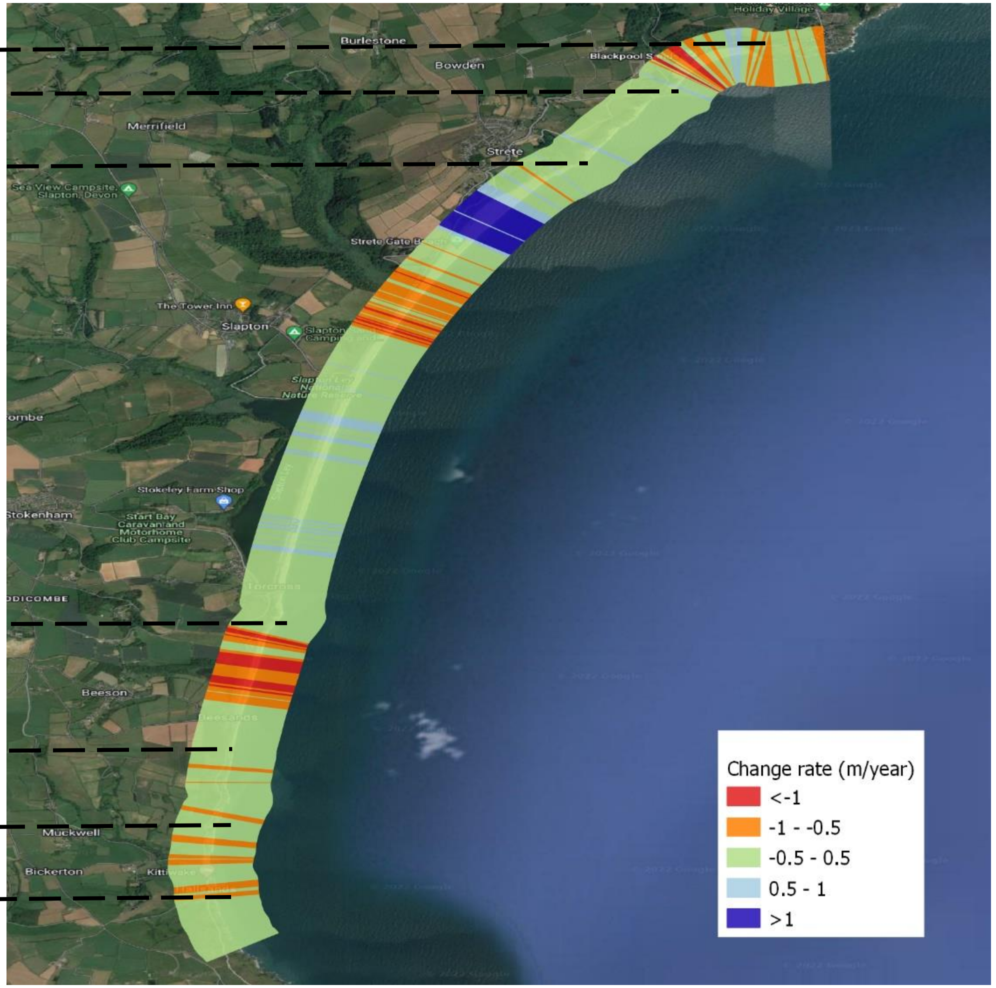


Results for Start Bay (1/2)

Ascending



Descending



Blackpool Sands

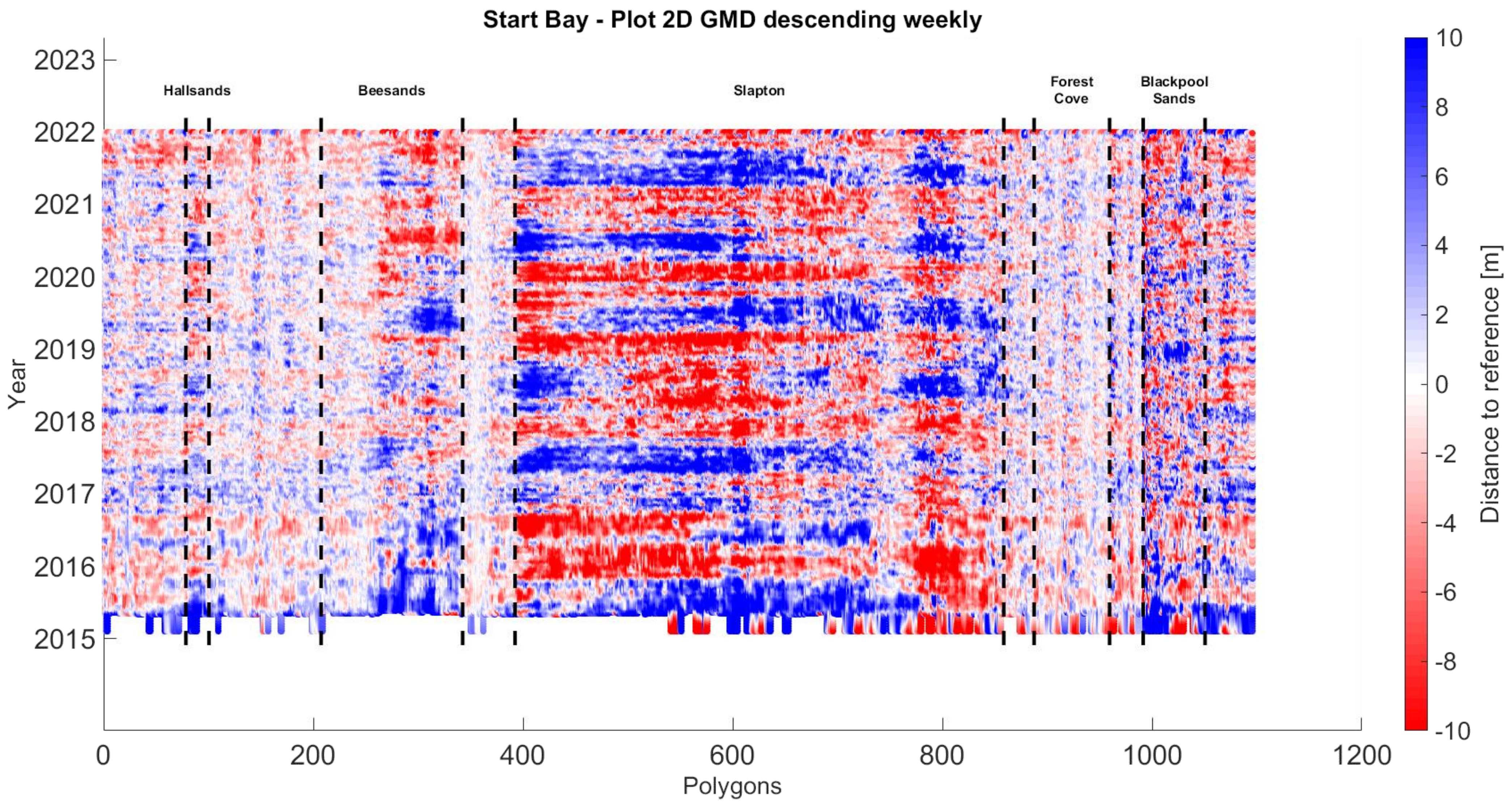
Forest cove

Slapton sands

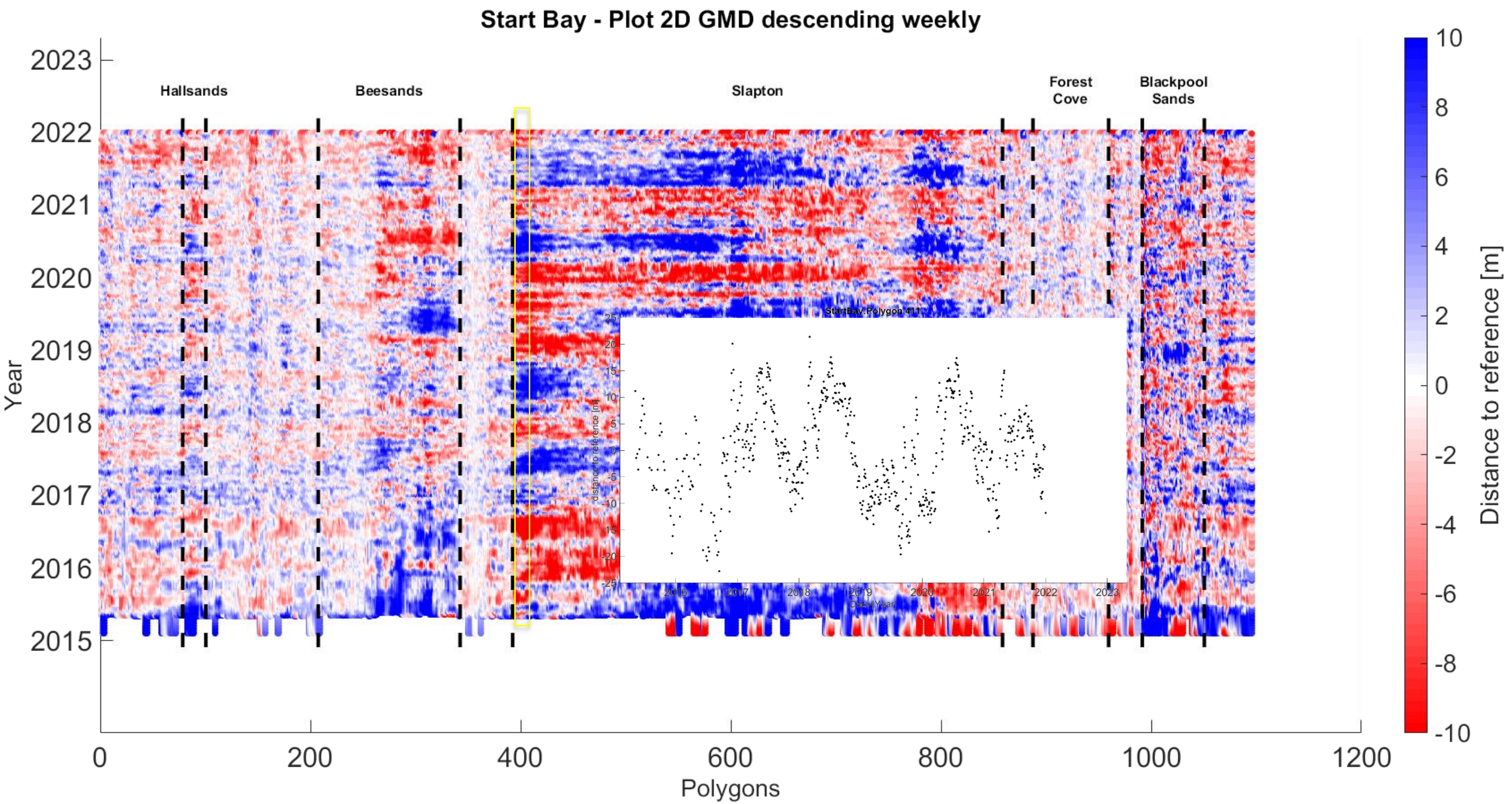
Beesands

Hallsands

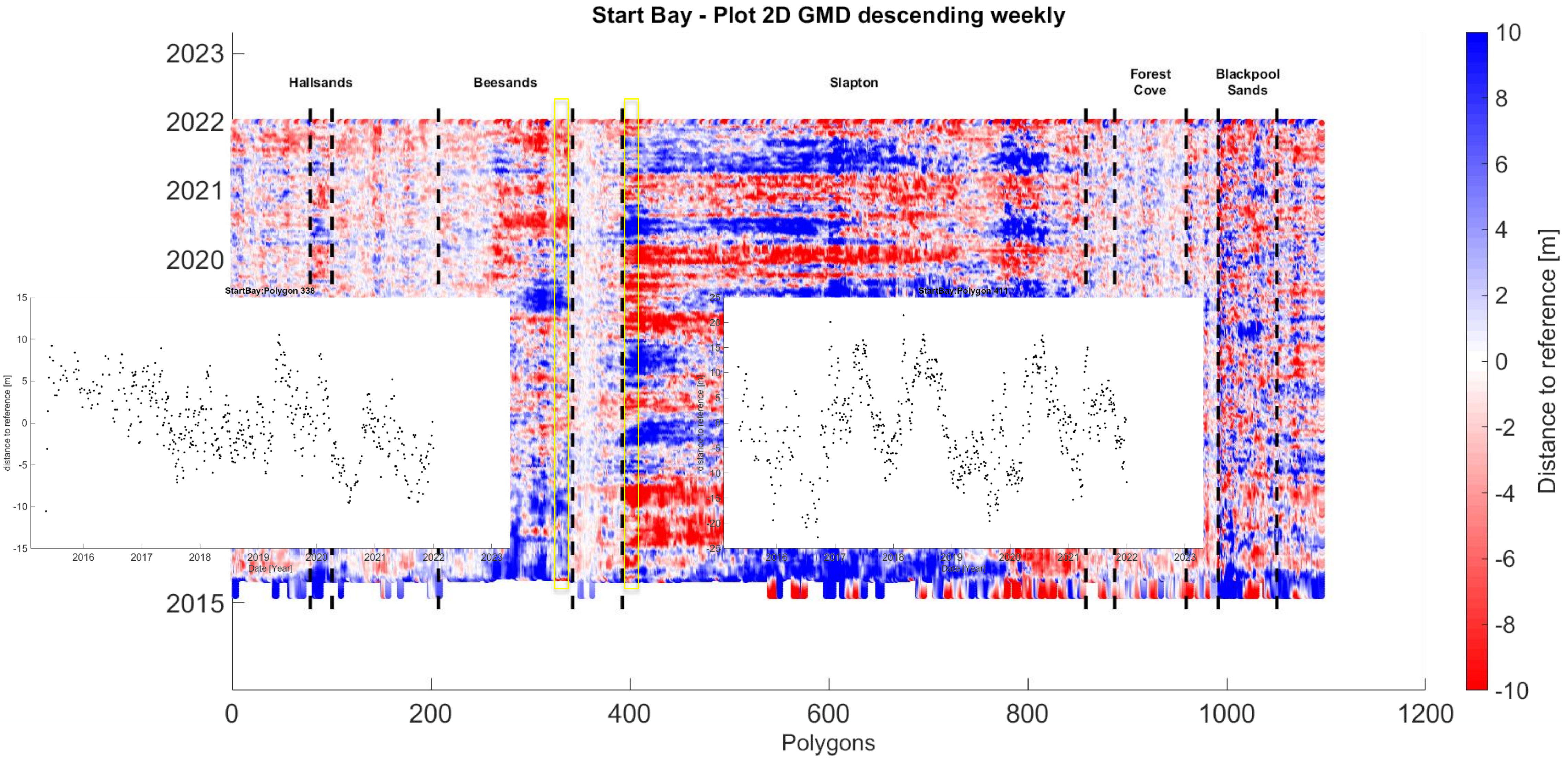
Results for Start Bay (2/2) Beach rotation



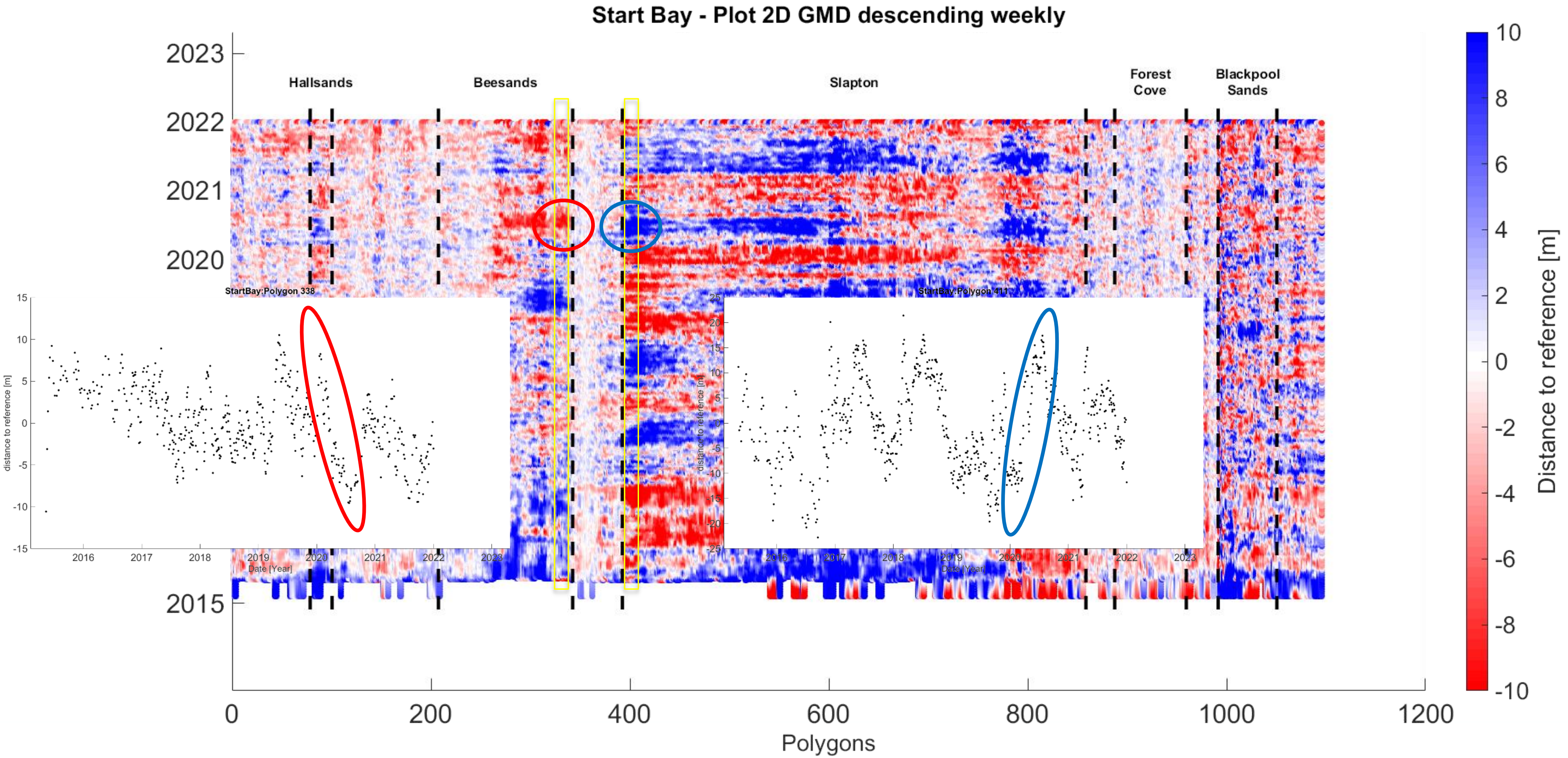
Results for Start Bay (2/2) Beach rotation



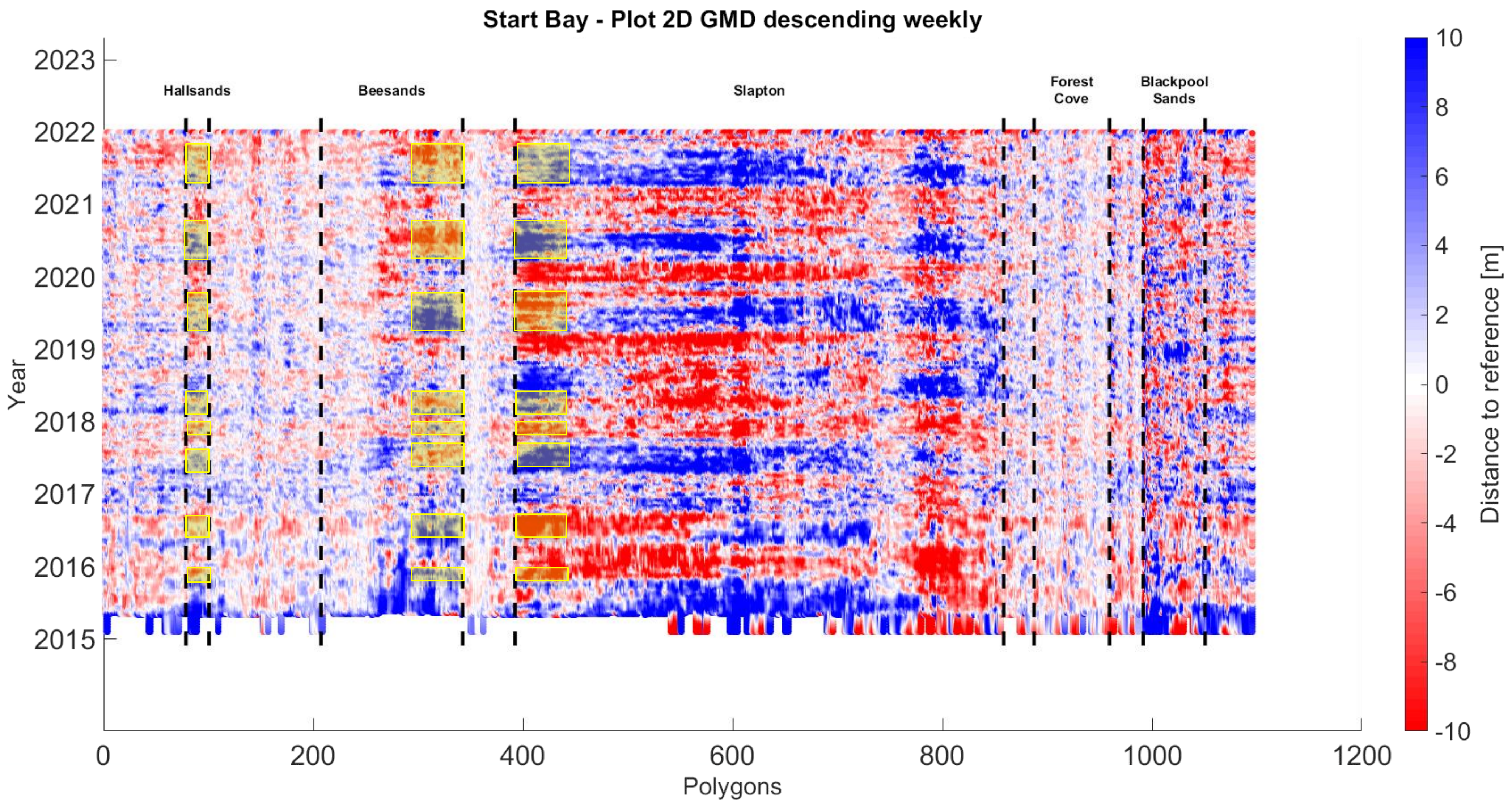
Results for Start Bay (2/2) Beach rotation



Results for Start Bay (2/2)
Beach rotation

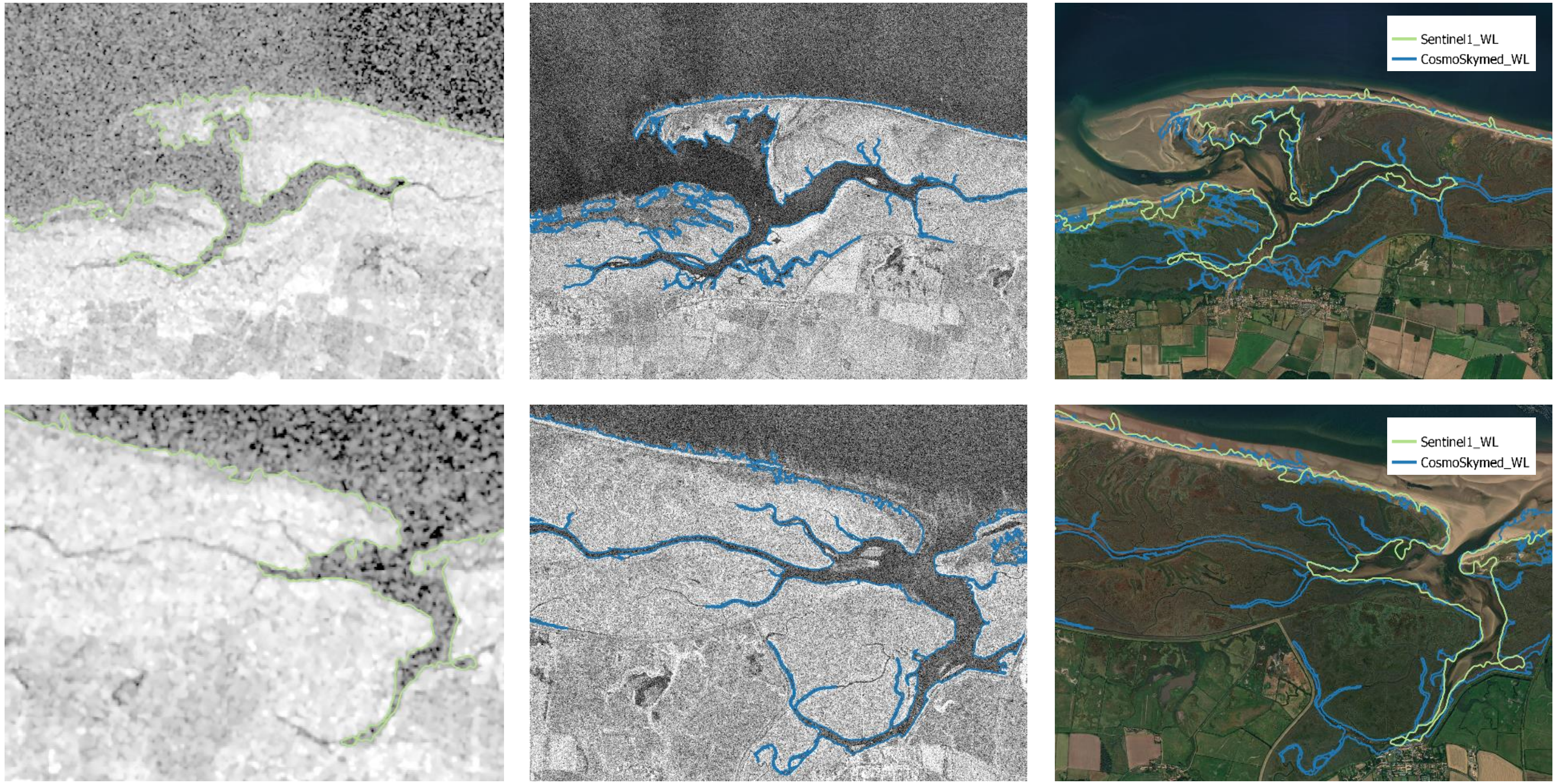


Results for Start Bay (2/2) Beach rotation



COSMO-SkyMed and new constellations

Sentinel-1 WL | CosmoSkymed WL | Cosmo vs Sentinel-1 WL



New SAR constellations we are interested to work for: Capella, ICEYE, NovaSAR-S, etc.

isardSAT Conclusions

- New modules has been implemented in the processing chain in order to get more reliable results.
- We have produced improved waterlines for two different validation sites (Start Bay and Bull Island) and the results confirm that the SAR waterlines are aligned with the expected changes.
  - In Bull Island (IRL), the change rate from SAR has been fully validated by GSI, comparing it with the Vegetation Line, showing an agreement (<~1 m/year) in both acquisition geometries (ascending and descending), as it will presented later in the end users session.
  - In Start Bay (UK), the WLs from SAR show also the well known Coastal embayment rotation while the numerical validation from BGS is still pending.
- Although the success in these two cases, there are scene conditions that do not allow the coast to be monitored properly by SAR and some work is still needed to better estimate the product limitations.
- The processing chain inputs are not restricted only to Sentinel-1 data. It is extendable also to other sensors and isardSAT is working to explore to apply its methodology to these last.
- isardSAT (via its services group company Lobelia) offers its coastal products in the EO products OCRE catalogue - https://www.ocre-project.eu/eo-catalogue.

Thank you

Any questions ?

Validation and Application

End Users perspective

ARCTUS

British Geological Survey

ISPRA

Istituto Superiore per la Protezione e la Ricerca Ambientale

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

IH cantabria
INSTITUTO DE HIDRÁULICA AMBIENTAL
UNIVERSIDAD DE CANTABRIA

Coastal Change From Space

Outline

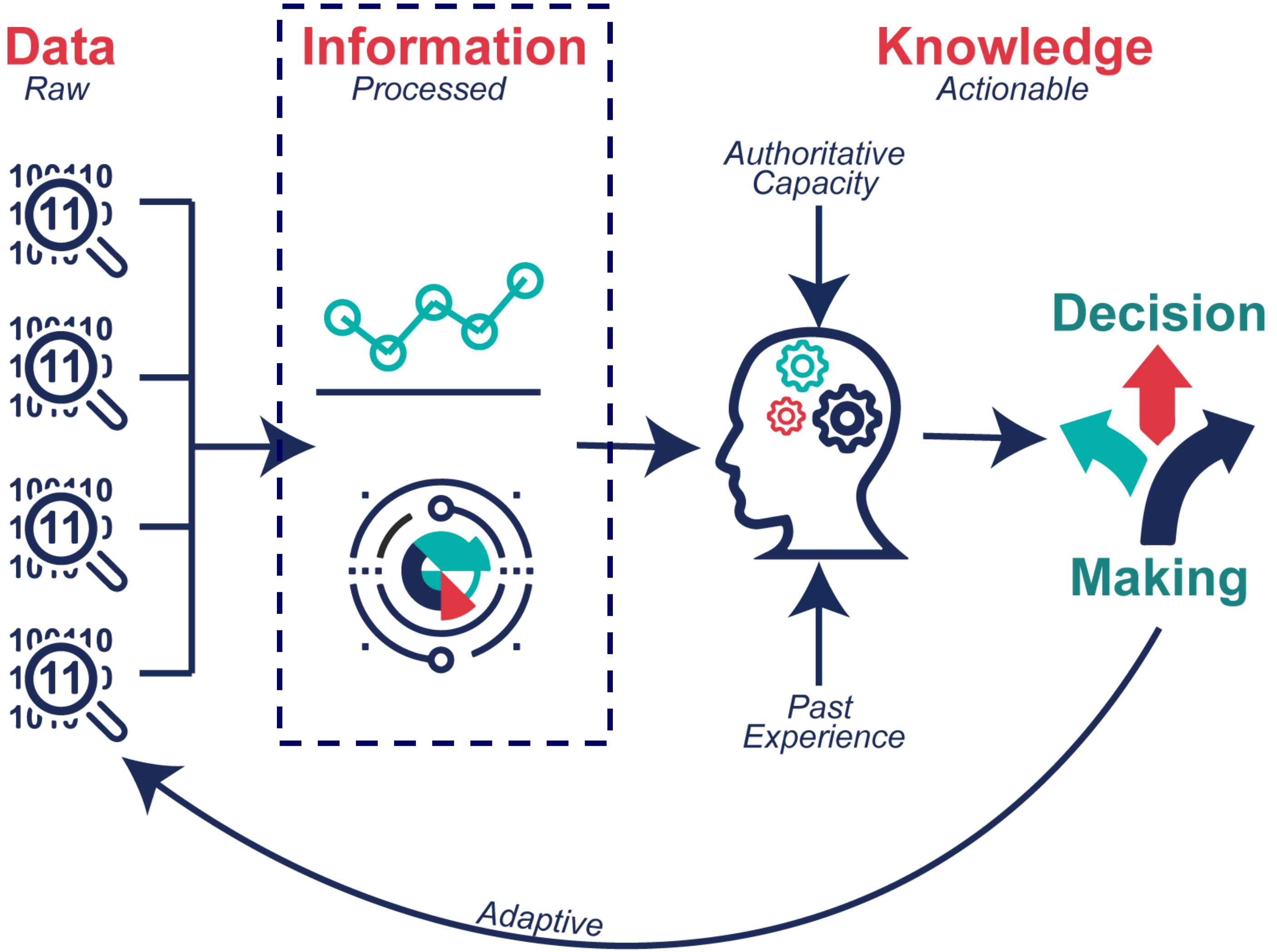
1. Overview of End Users Validation and Application analysis
2. From data to information: in depth uncertainty analysis
3. Technology Readiness Level for all EO products and services
4. Roll-out plans

1. **Overview of End Users Validation and Application analysis**
2. From data to information: in depth uncertainty analysis
3. Technology Readiness Level for all EO products and services
4. Roll-out plans

Validated in a large number of different environments

Providing evidences for decision makers

Collaboration between End-Users and Service providers filled in the gap between Data and actionable Knowledge for coastal erosion risk management.



Example: monitoring of the dry beach in Spain

Motivation Coastal protection strategies (regional and national scope) considering the effects of climate change by the General Directorate of the Coast and the Sea (DGCM) - MITECO

Input data:

Beach width lost/gain rate at all beaches in the country (national) o region and at various timescales

Results:

Hazard level at each beach

Indicator	Thresholds	Hazard level	
		Management Unit with beach	Management Unit with no beach
Dry beach width (m)	≤ 10	High 5	None 0
	> 10 y ≤ 20	Medium 3	
	>20 y ≤ 30	Low 2	
	>30 y ≤ 40	Very low 1	
	> 40	None 0	

Example: Monitoring of the dry beach in Spain

Backshore from LC maps

Shoreline evolution from SDS timeseries

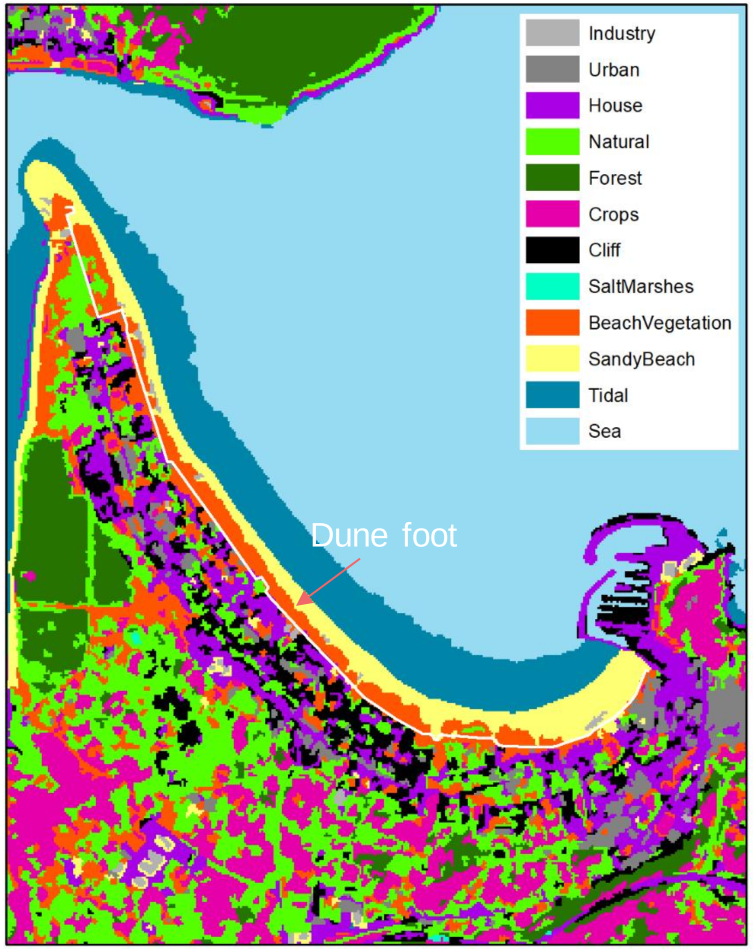
Laredo

Sopelana

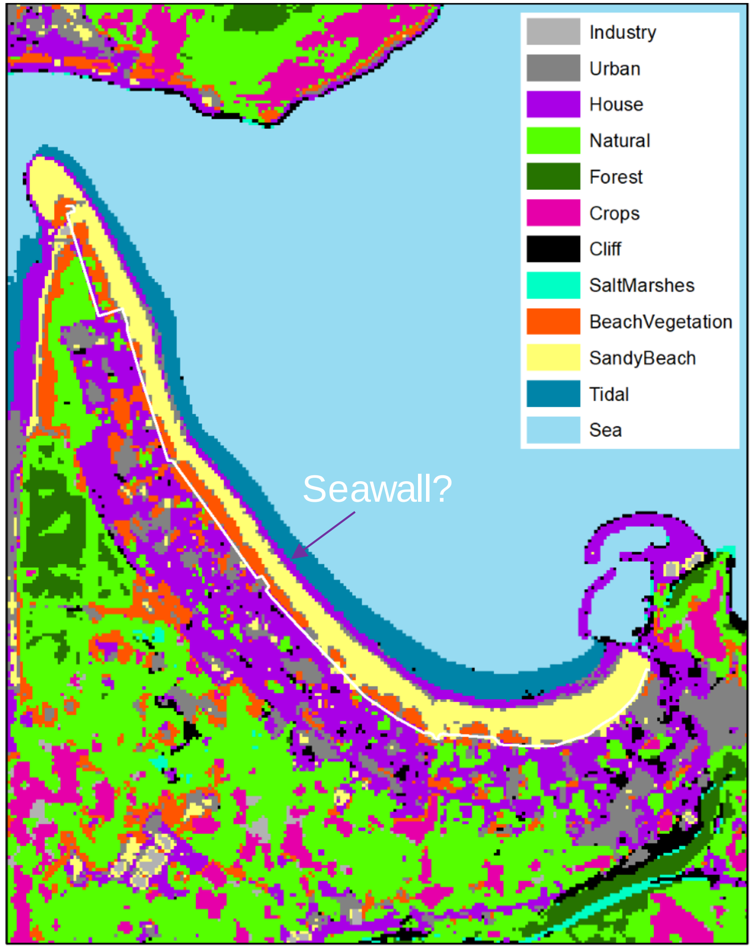
Data to information: Beach backshore identification

Laredo

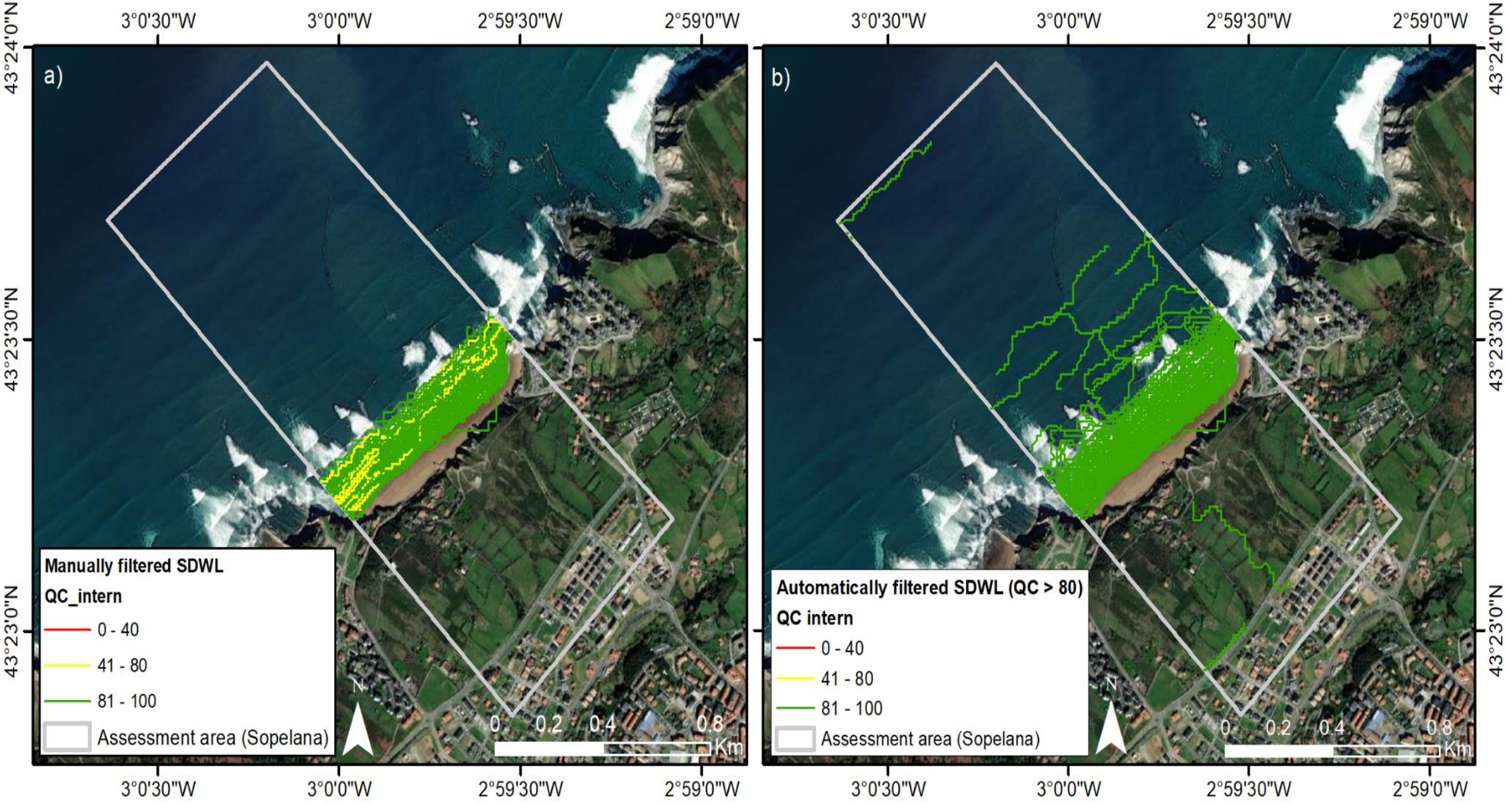
2018 ☺



2015 ☹



Data to information: noise to signal by using the Quality Control indeces



- ✓ Sopelana

2% of SDWL with LOW QC were OK

3% of SDWL with HIGH QC were NOT OK

We have shown how EO has a key role on as monitoring tool of the health our coastlines

ARCTUS

British Geological Survey

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

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UNIVERSIDAD DE CANTABRIA

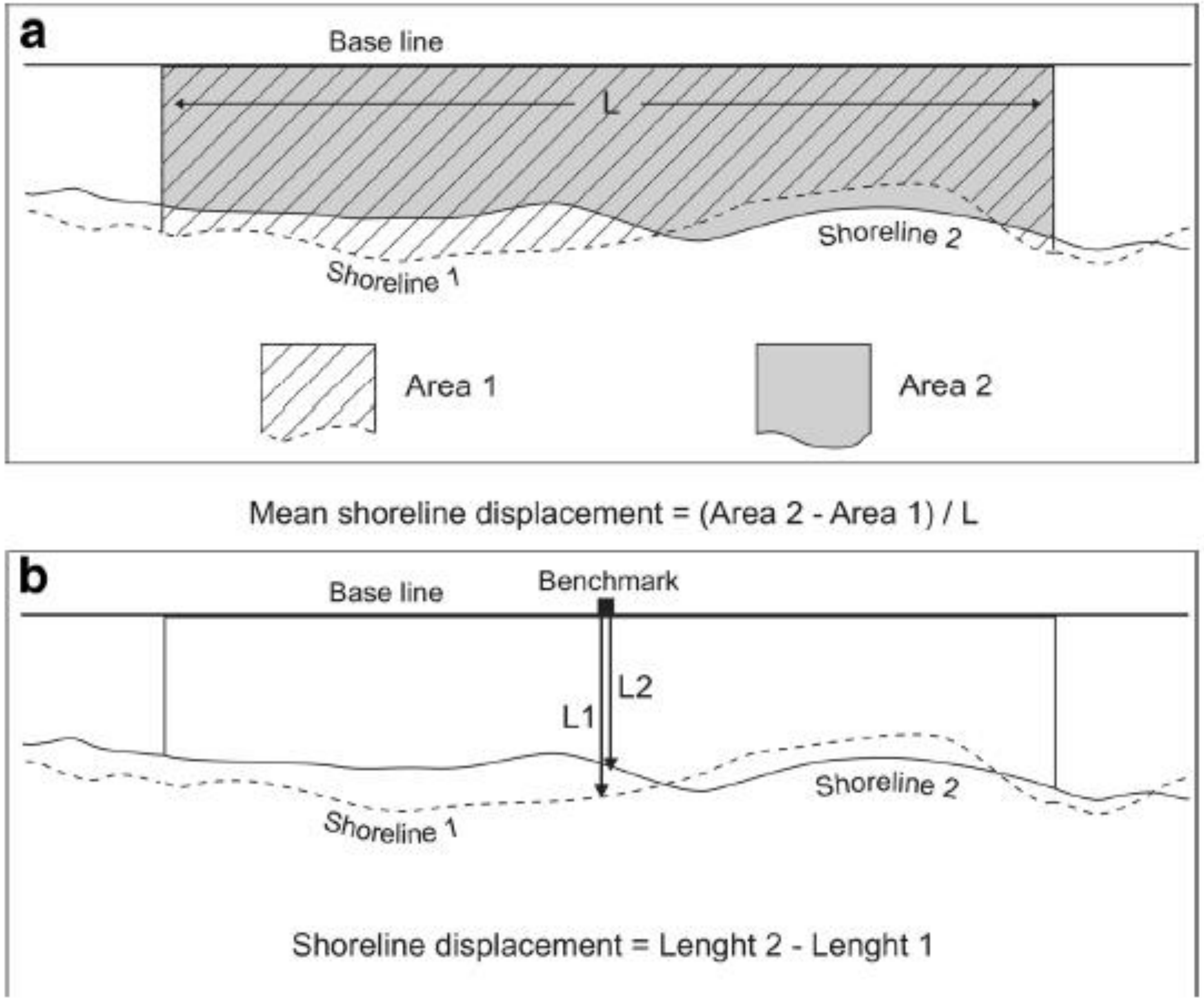
1. Overview of End Users Validation and Application analysis

2. **From data to information: in depth uncertainty analysis in**
    1. Metrics of change
    2. Coastlines databases

3. Technology Readiness Level for all EO products and services

4. Roll-out plans

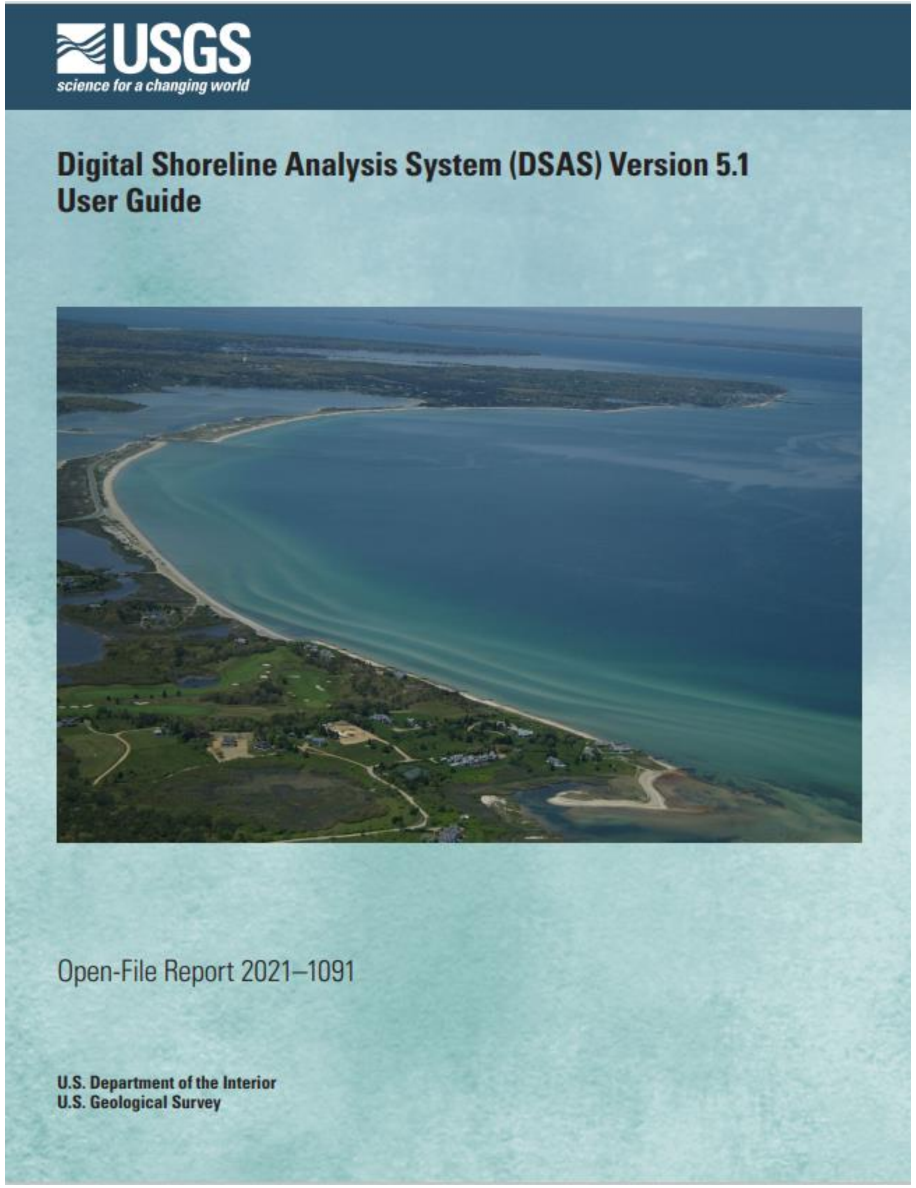
Different stakeholders uses different metrics of change & all are subject to uncertainties



Area change method

Transect and baseline method

The Digital Shoreline Analysis System is the transect-baseline software tool more broadly used

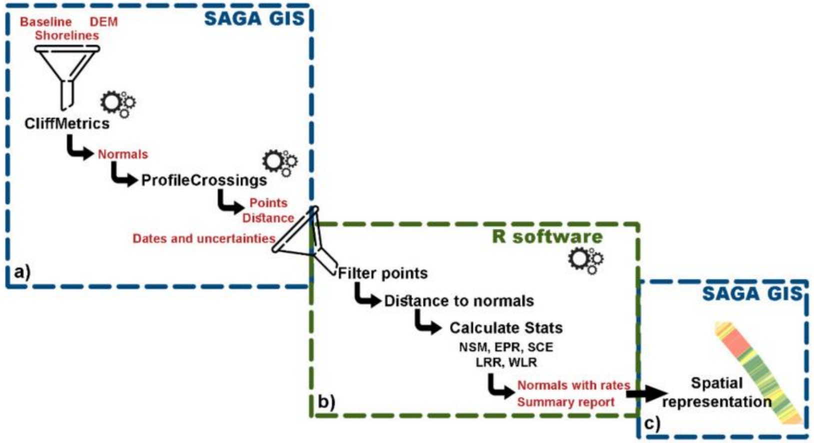


The DSAS version 5 software is an add-in to Esri ArcGIS Desktop version 10.4–10.7 that enables a user to calculate rate-of-change statistics from a time series of vector shoreline positions.

Open Access | Feature Paper | Editor's Choice | Article

Open Digital Shoreline Analysis System: ODSAS v1.0

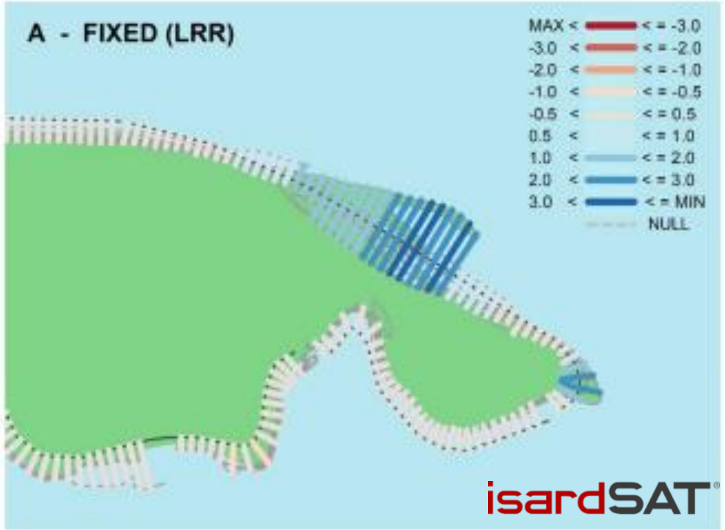
by Alejandro Gómez-Pazo [1,*], Andres Payo [2,*], María Victoria Paz-Delgado [3] and Miguel A. Delgadillo-Calzadilla [4]

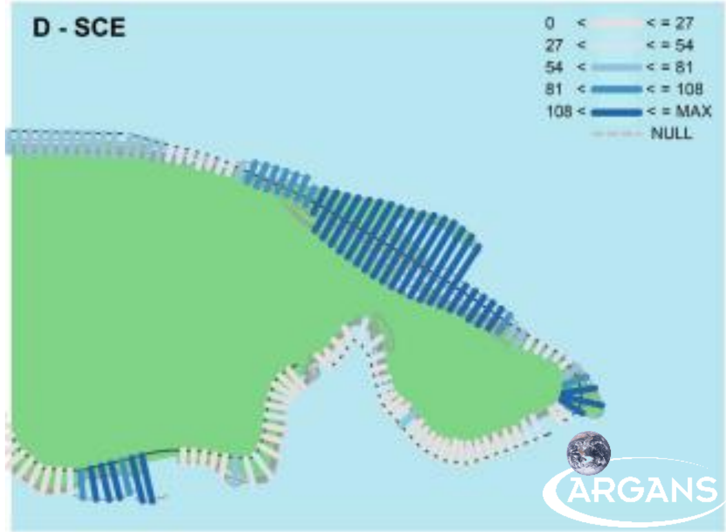


Journal of *Marine Science and Engineering*

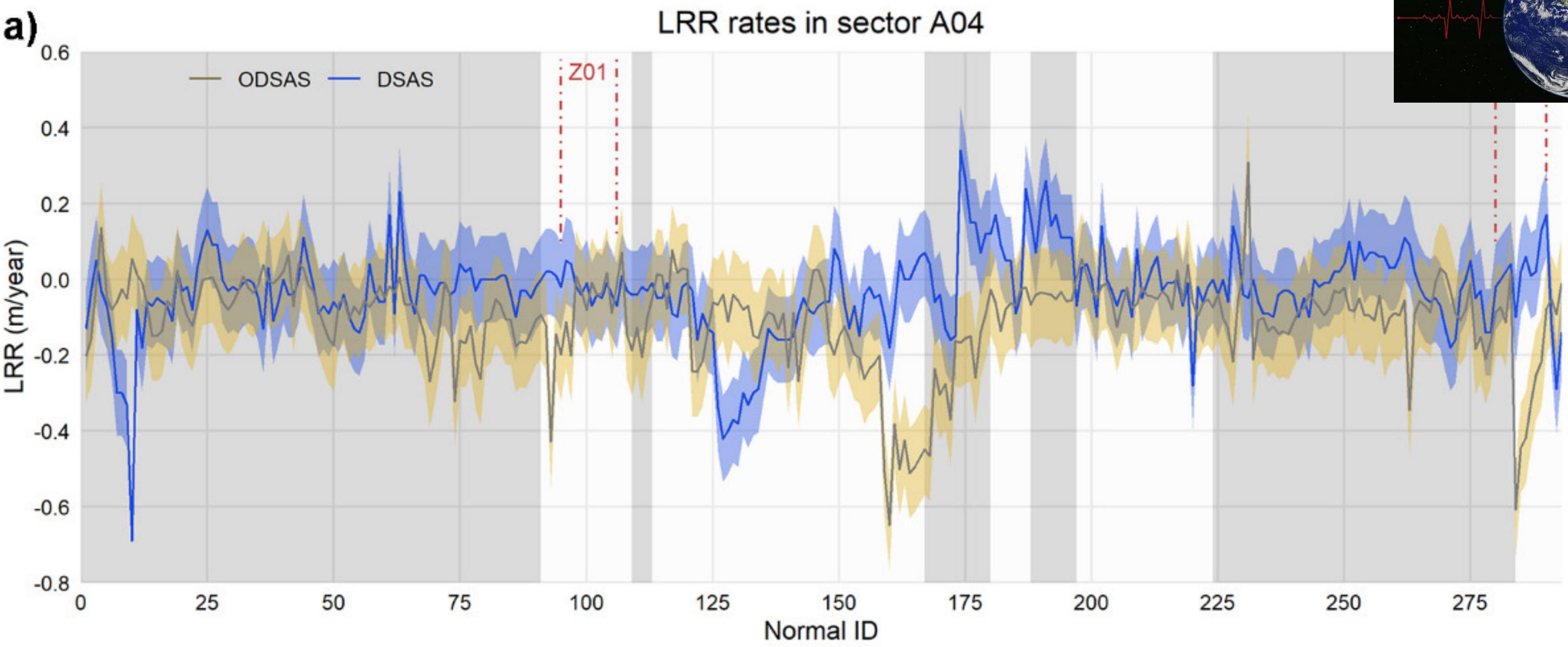
The same data can be used to calculate different metrics of change

Parameter	Name	Definition	Units
NSM	Net Shoreline Movement	Oldest—Youngest coastline	m
SCE	Shoreline Change Envelope	Greatest distance between coastlines	m
EPR	End Point Rate	NSM/timespan	m/year
LRR	Linear Regression Rate	Slope of regression line by the sum of the squared residuals	m/year
WLR	Weighted Linear Regression Rate	Considers the variance in the uncertainty	m/year





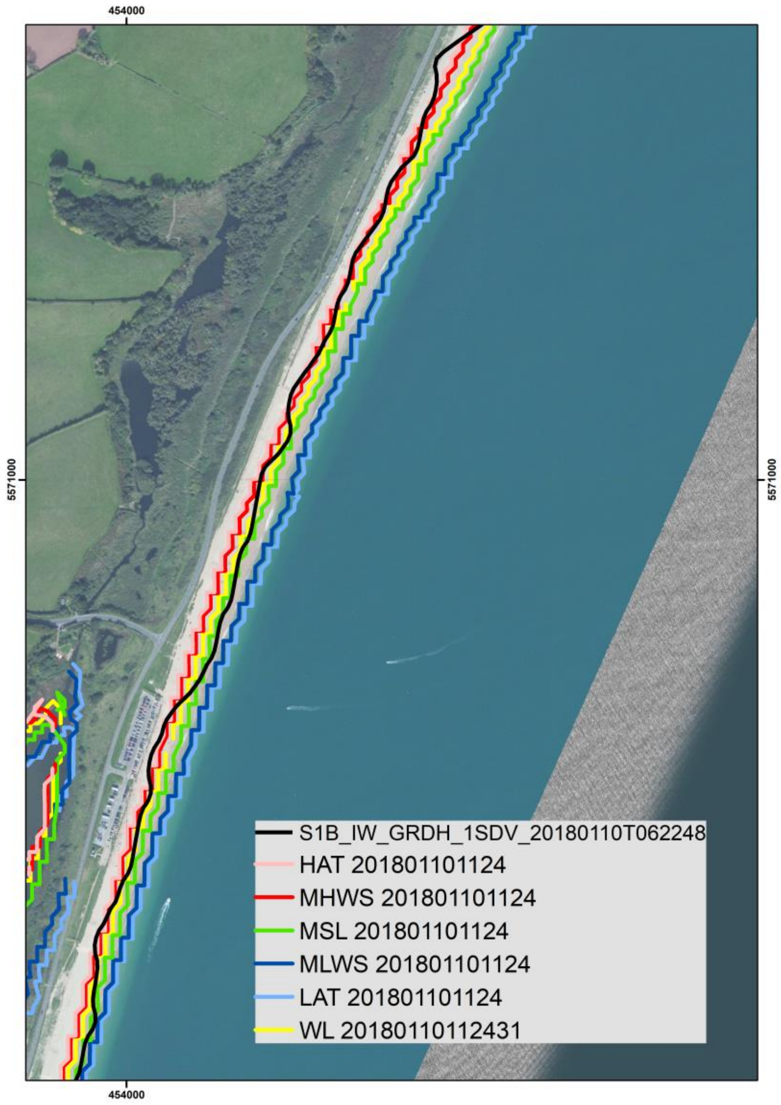
Small transect orientation results in significant differences in the metrics of change

iSARDSAT change rate is comparable to erosion rates derived from vegetation lines

S1 SAR Slope (2015-2020)
Vs.
Shoreline change rate 2013-2020
(vegetation line)

Comparison	N	R2	AIC	MAE Total (m/yr)	MAE Erosion (ER< 0) (m/yr)	MAE Accretion (ER> 0) (m/yr)
VG ER /S1 SAR Descending	94	0.89	260	0.85	0.84	0.86
VG ER / S1 SAR Ascending	94	0.91	232	0.77	0.58	0.94
S1 SAR Asc /S1 SAR Desc	*94*	*0.95*	*151*	-	-	-



20180110
Narrow shallow slope-bound beach

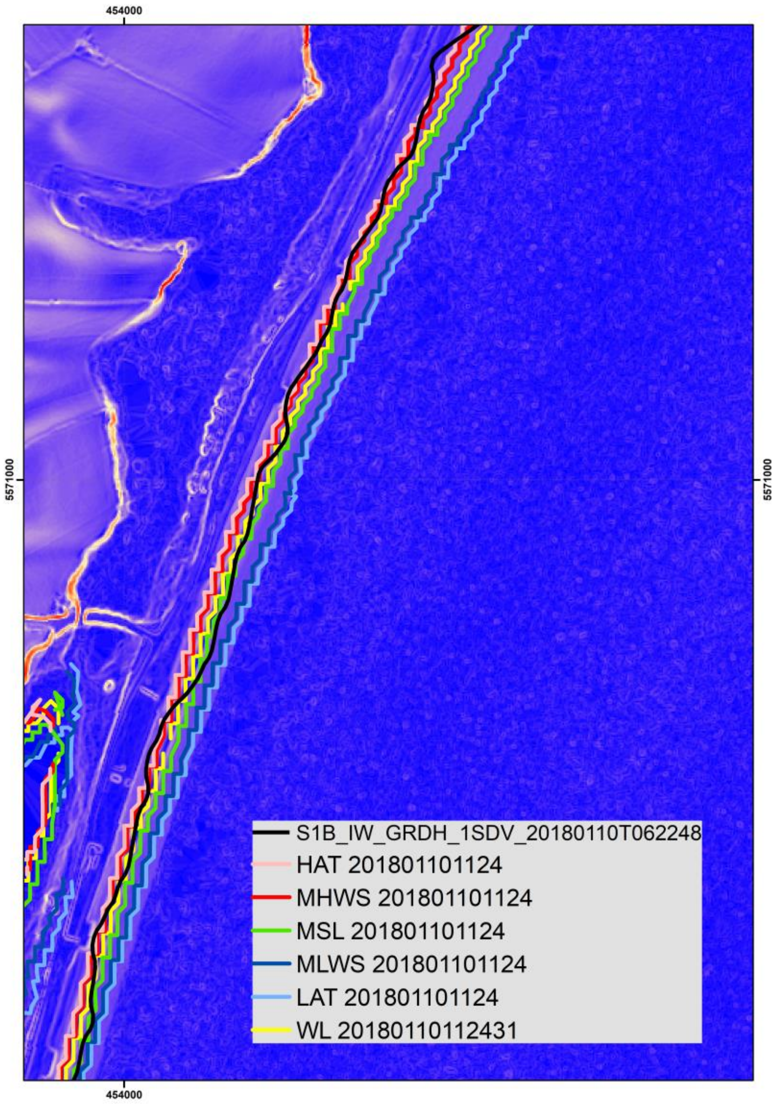
Context: low slope angle beach bounded by low slope angle land (blues)

Consistency in optical-derived shorelines from LAT, MLWS, MSL, MHWS and HAT on a landward progression

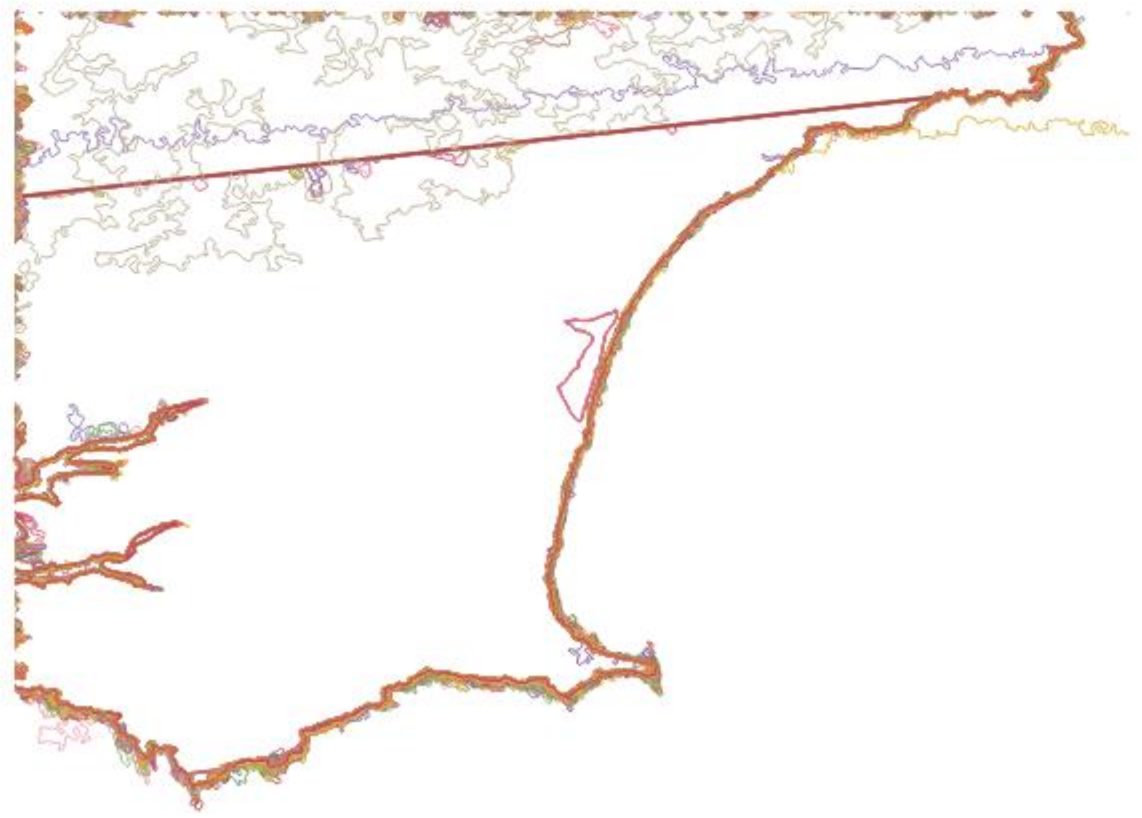
Optical-derived WL consistently between MSL and MHWS

Optical shorelines consistently marks the boundary between the sand and water

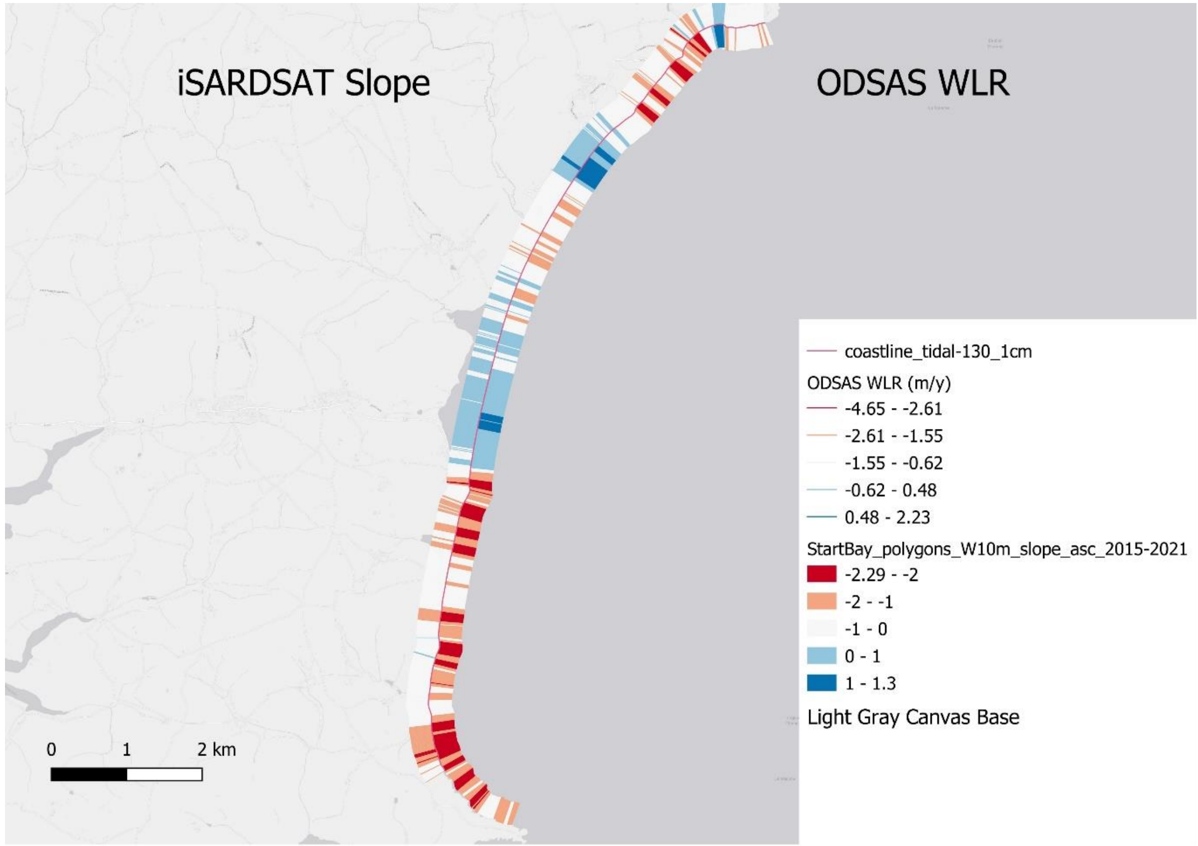
SAR waterline (IW) consistently landward of MSL shoreline bounded by landward low slopes



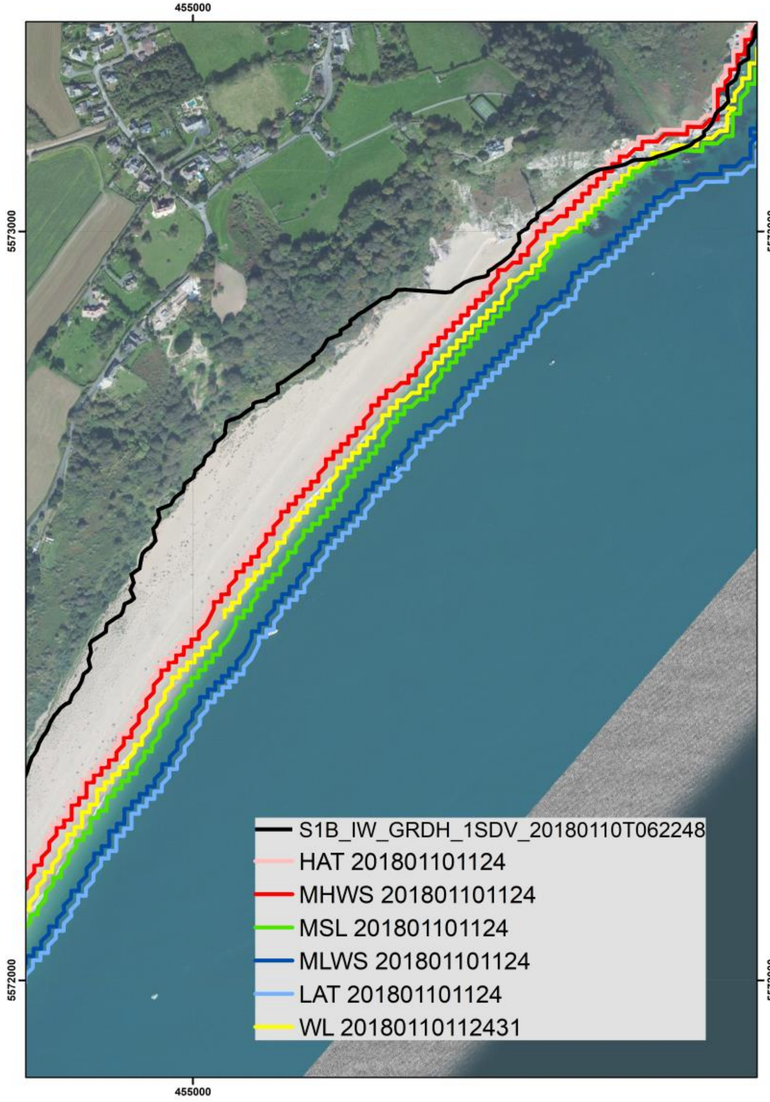
iSARDSAT change rate is comparable to erosion rates derived from transect-baseline



701 Lines for ASC between 2015 to 2021



Similar patterns of erosion and accretion derived from using ODSAS and the same baseline at 10 meters spacing



20180110
Wide cliff-bound beach

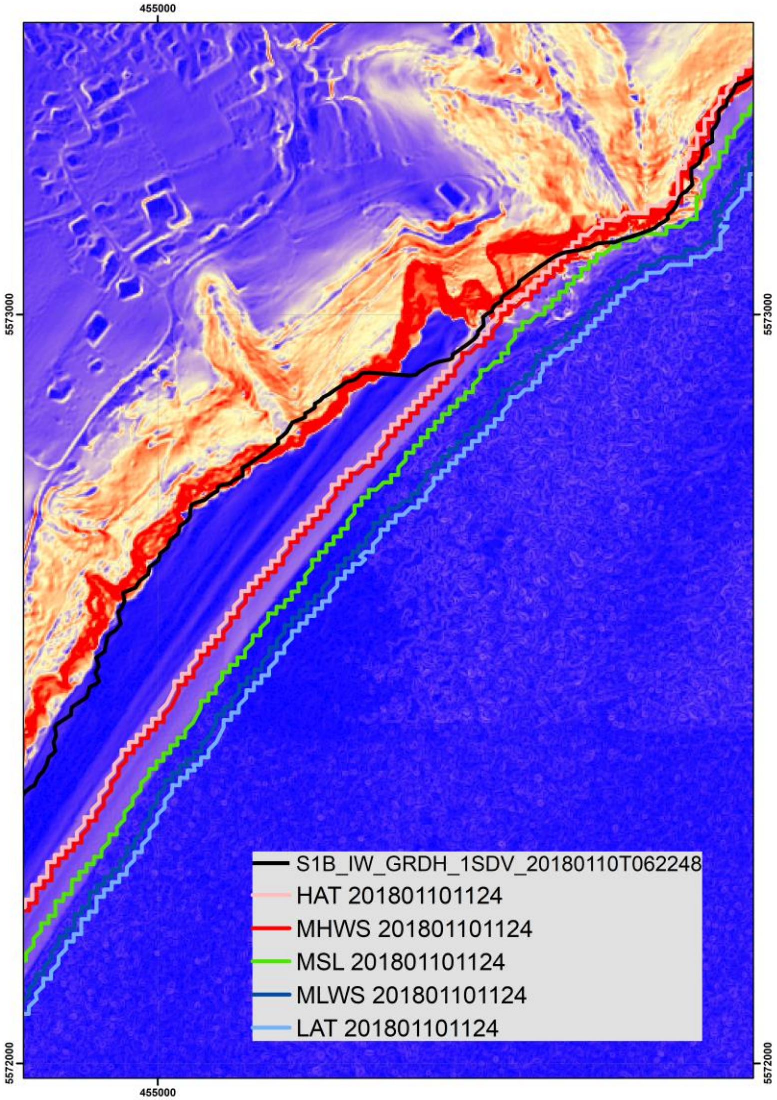
Context: steep-slopes (reds) bounding low slope angle beach (blues)

Consistency in optical-derived shorelines from LAT, MLWS, MSL, MHWS and HAT on a landward progression

Optical-derived WL consistently between MSL and MHWS

Optical-derived shorelines mark boundary between sand and water

SAR waterline (IW) consistently landward of MSL shoreline bounded by landward steep slopes



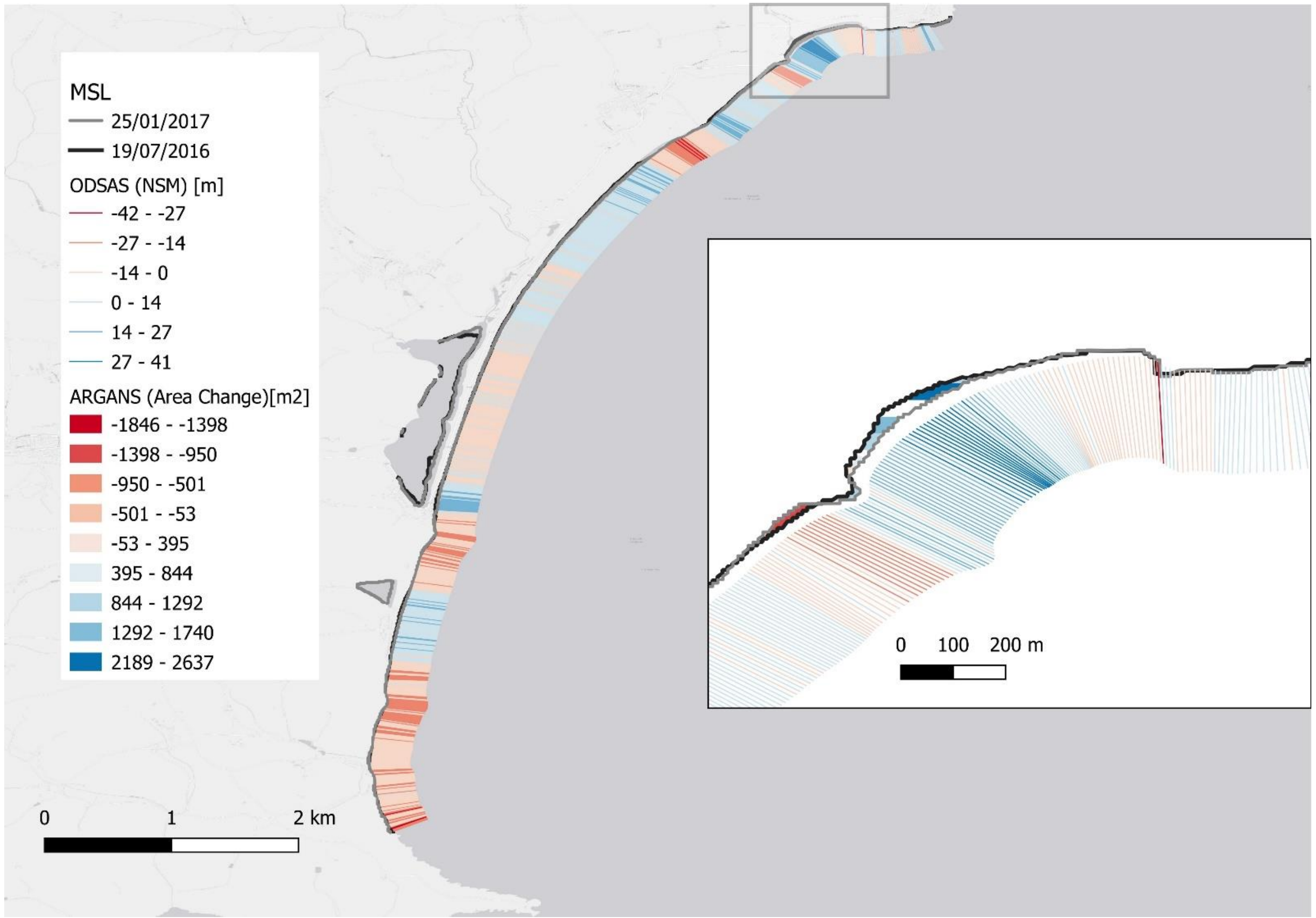
ARGANS Time Series change rate are comparable to transect-baseline SCE

1300 ODSAS transects compared with 3799* polygons created by ARGANS Time Series

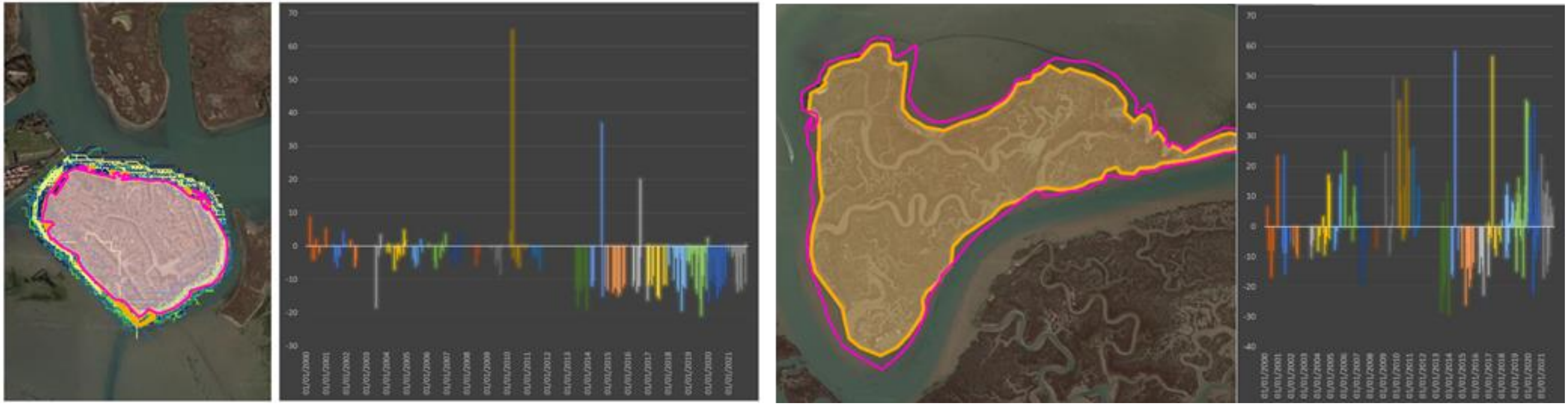
*Reduced to 454 objects if filtered by area larger than 0.0001 m^2

Only two MSL SLs from S2 used (e.g. not a composite of multiple lines for start and end)

	ARGANS	ODSAS (NSM)	ARGANS (Filtered)
Num Objects	3799	1302	454
Num acretion	2465	530	220
Num erosion	1334	773	234
% acretion	65	41	48
% erosion	35	59	52
% TOTAL	100	100	100

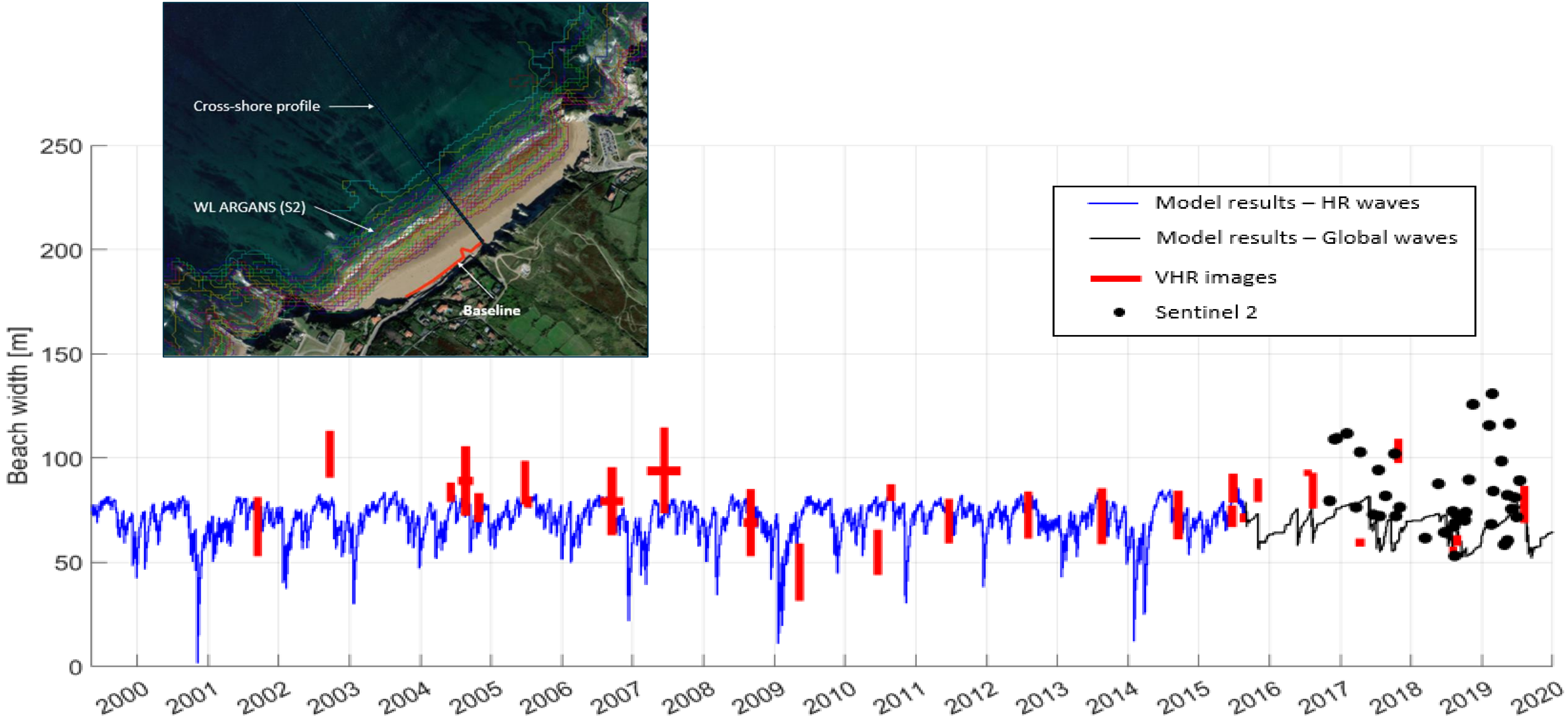


Developed the WL envelope method to assess area changes of small islands



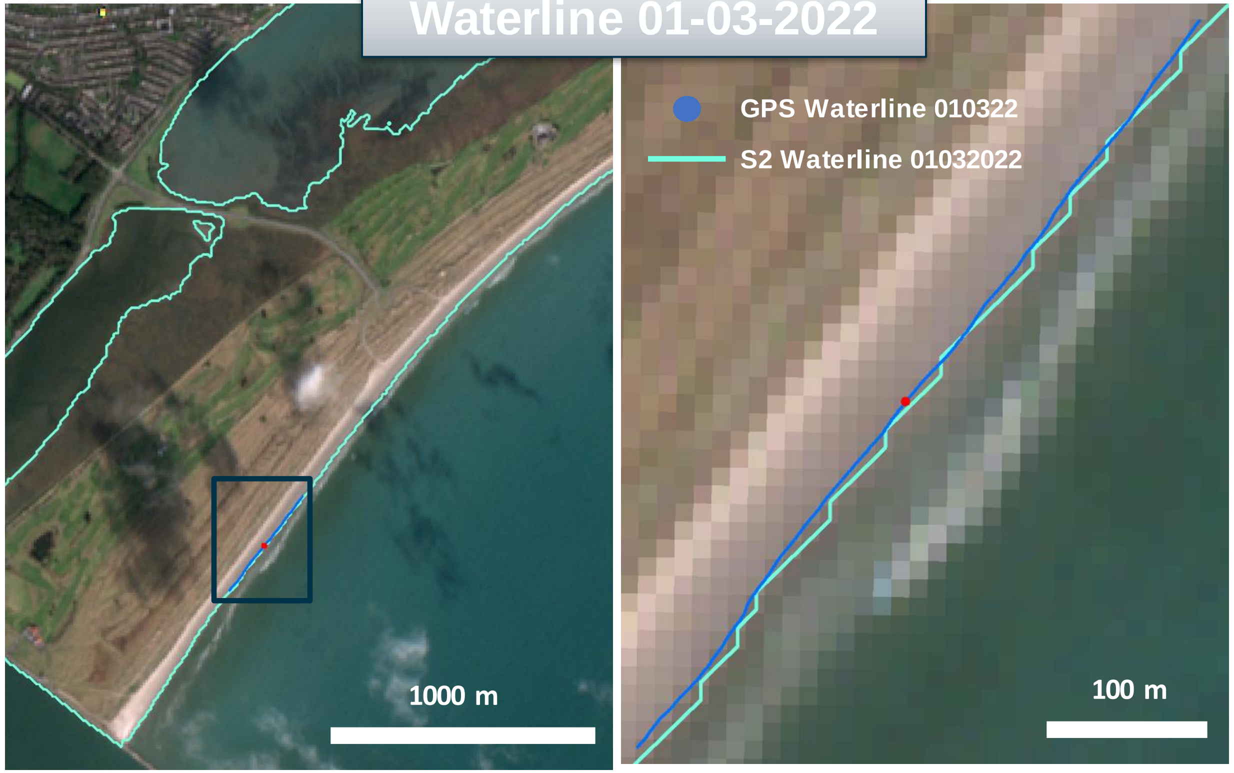
plots of the results of the calculations on the fully artificial island of Burano (left) and a fully natura Barena “Sicily” (right).

Illustrated how can be used to enrich shoreline evolution modelling



S2 WL are typically sited to the offshore side relative to the GPS waterline on sandy beaches

Waterline 01-03-2022



Tide (Going Down)

Clear sky

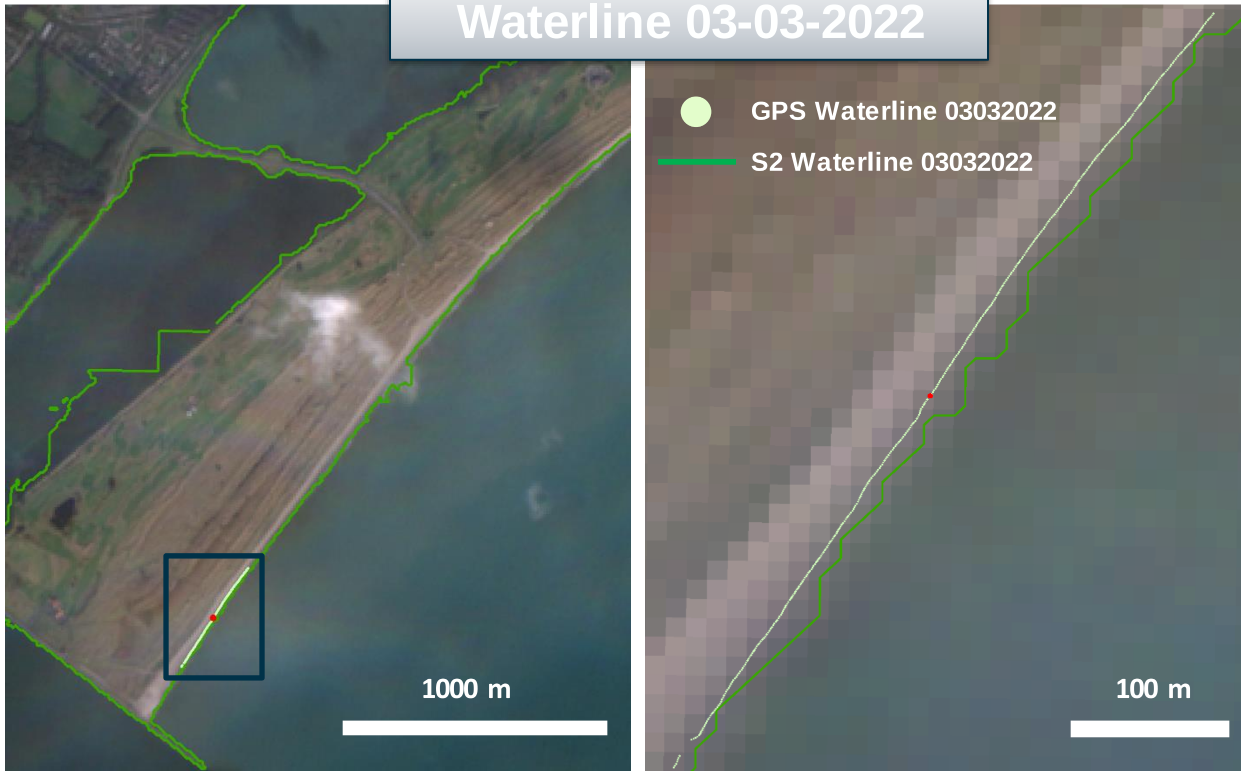
Small waves

Tide (Going Up)

Cloudy

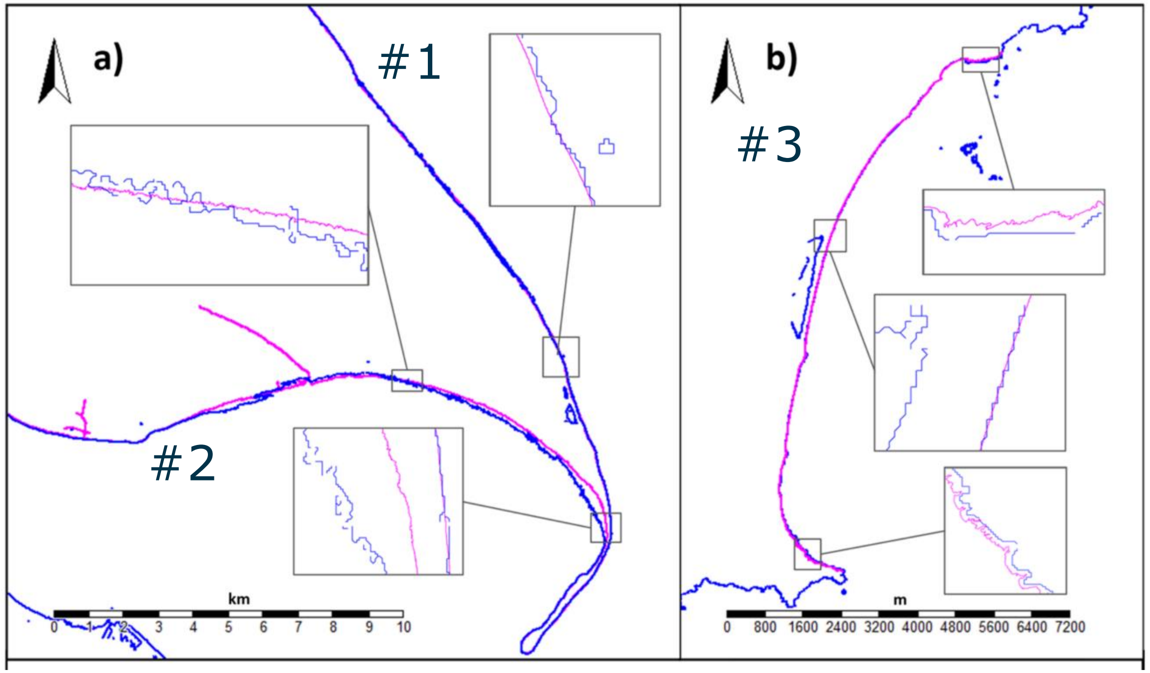
Small waves

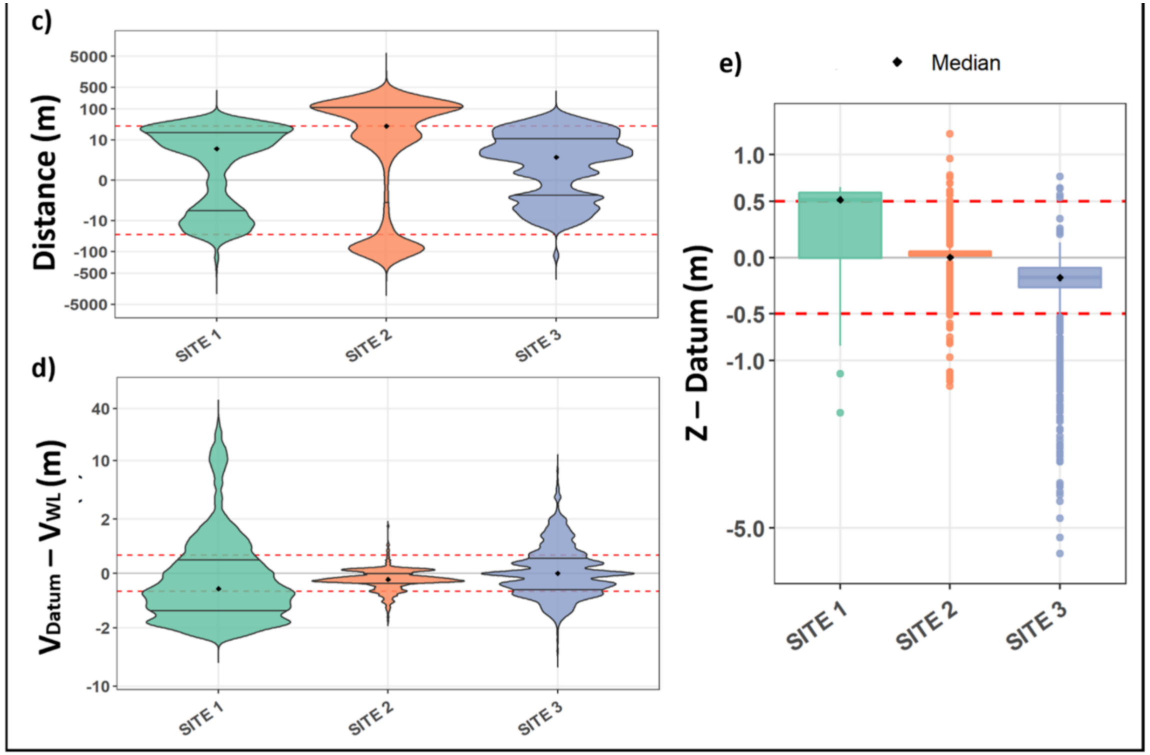
Waterline 03-03-2022



S2 WL are typically sited to the offshore side relative to the tidal shoreline

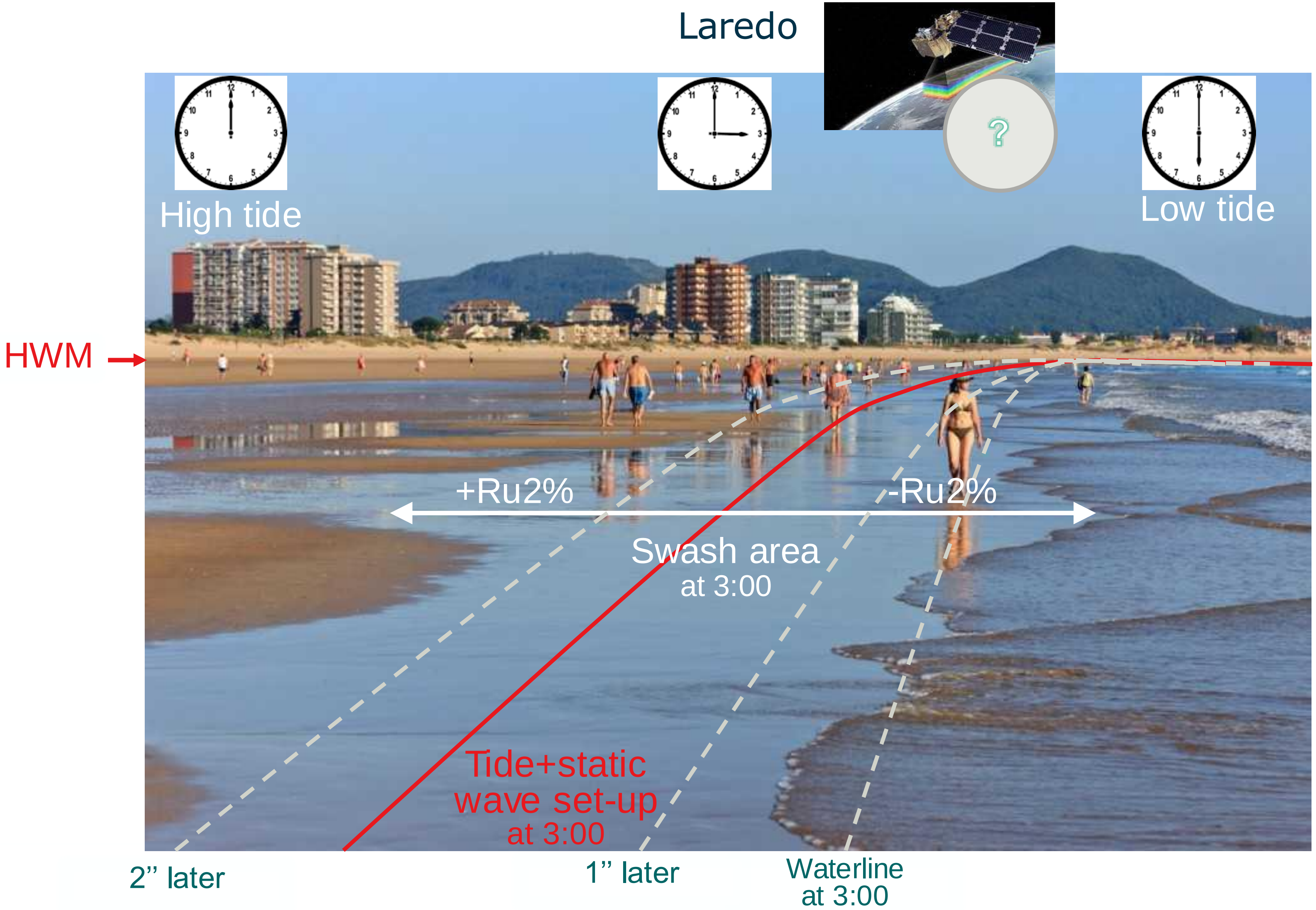
map showing the location of the datum-based tideline (magenta) and S2-WL (blue) for Sites #1 & #2; #3…





Bias implications when combined with other coastline databases

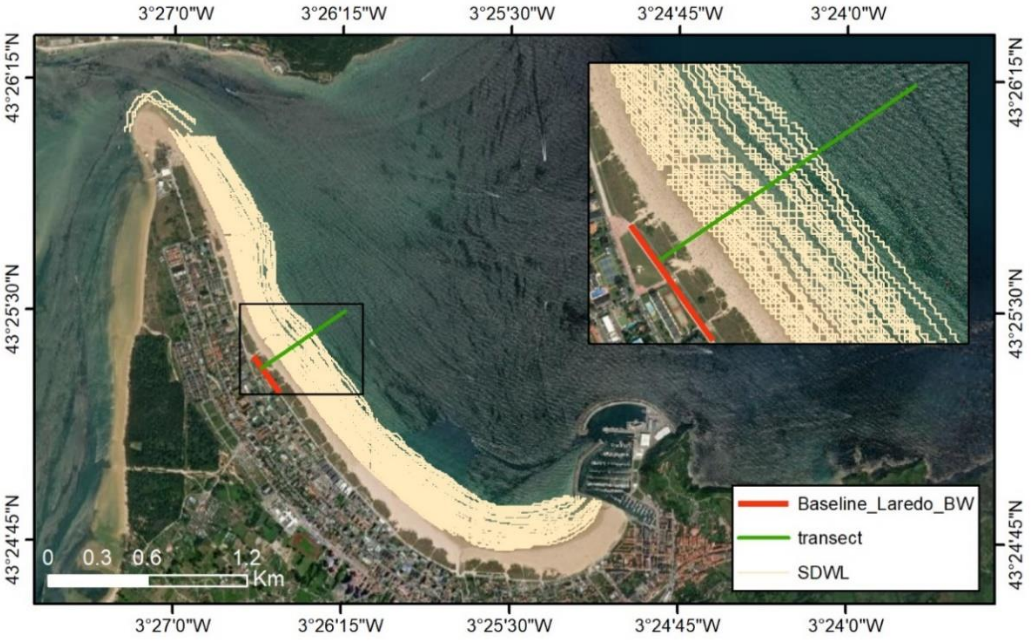
Uncertainty on beach slope is propagated forward to shoreline position

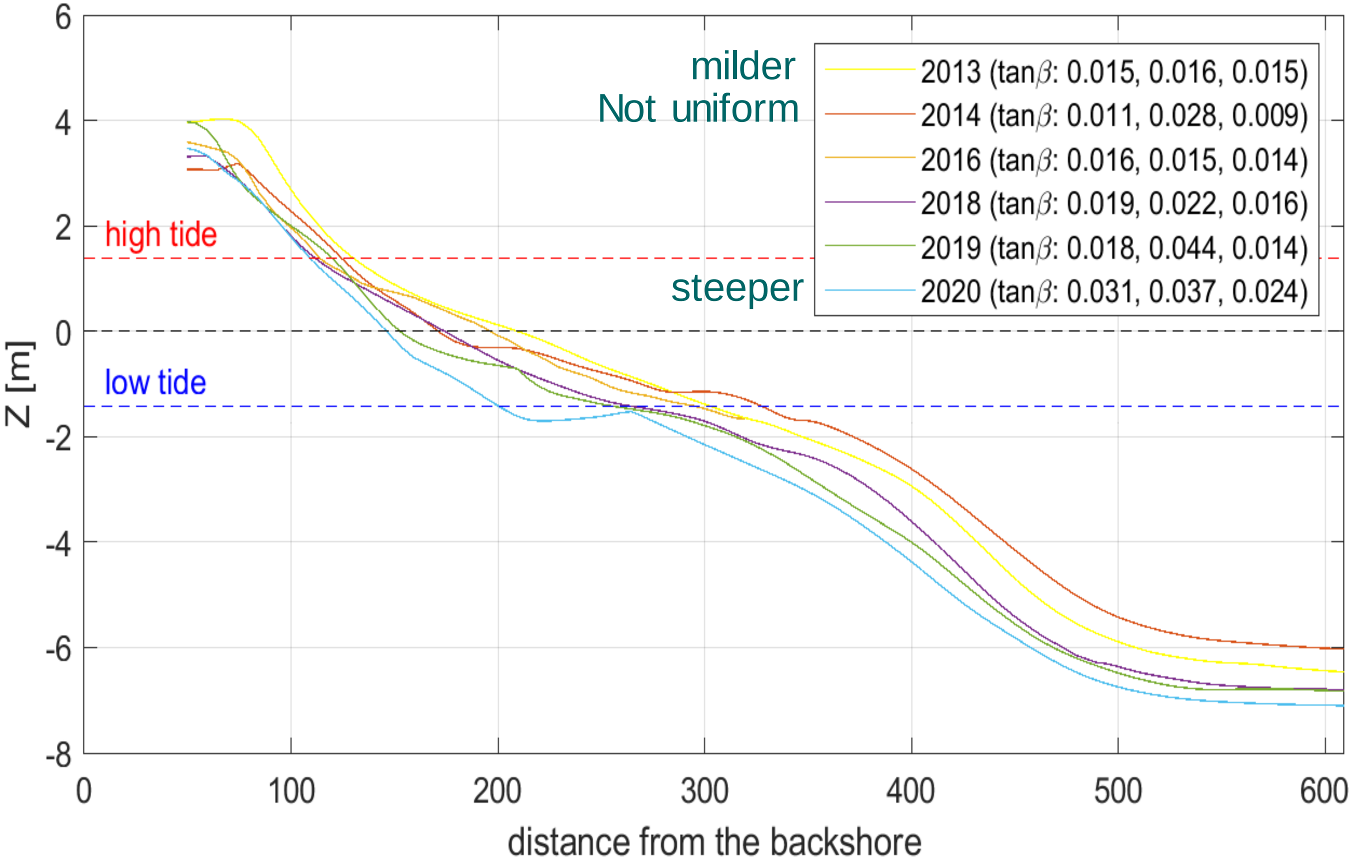


Uncertainty on beach slope is propagated forward to shoreline position

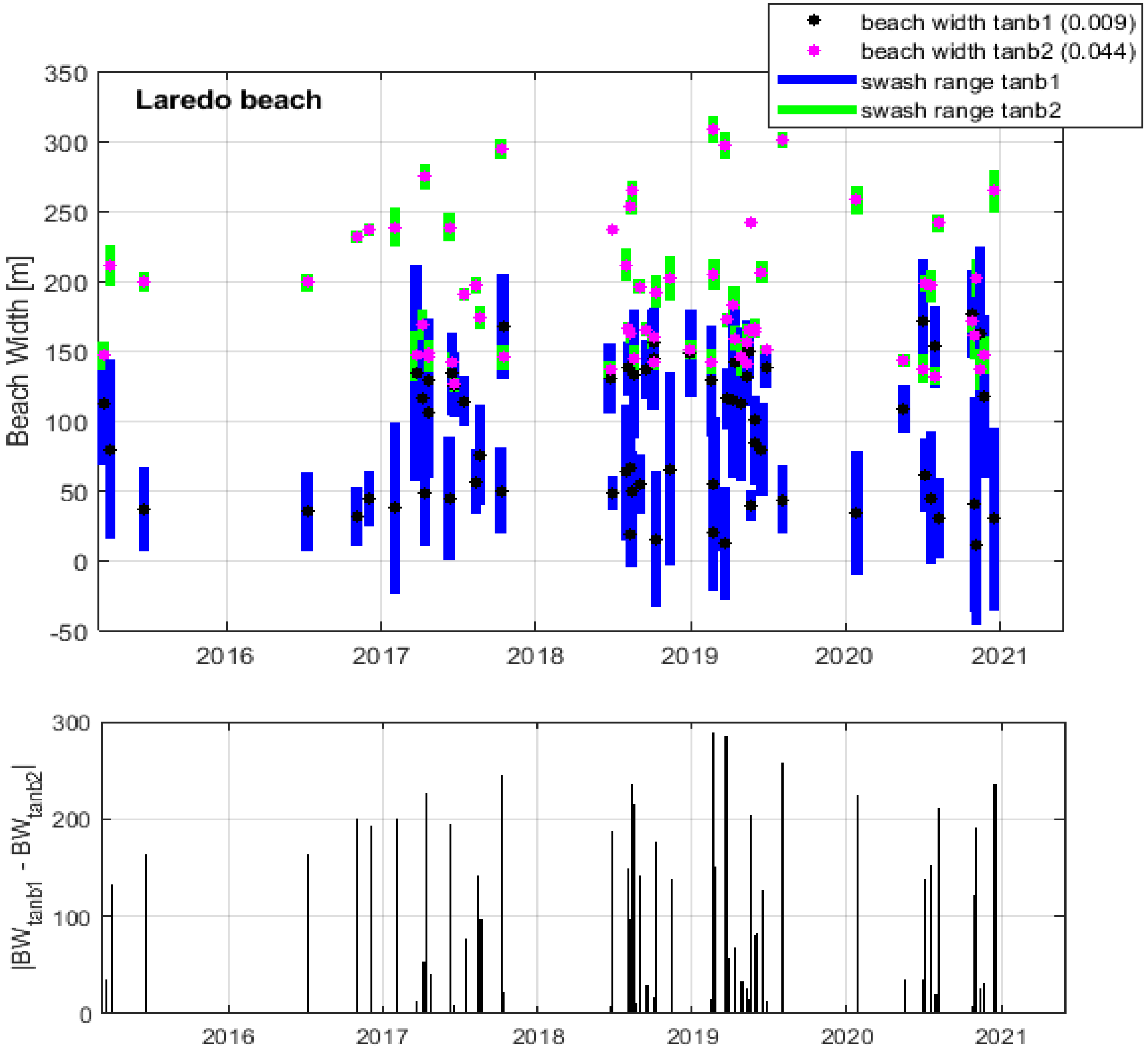
Beach slope influence

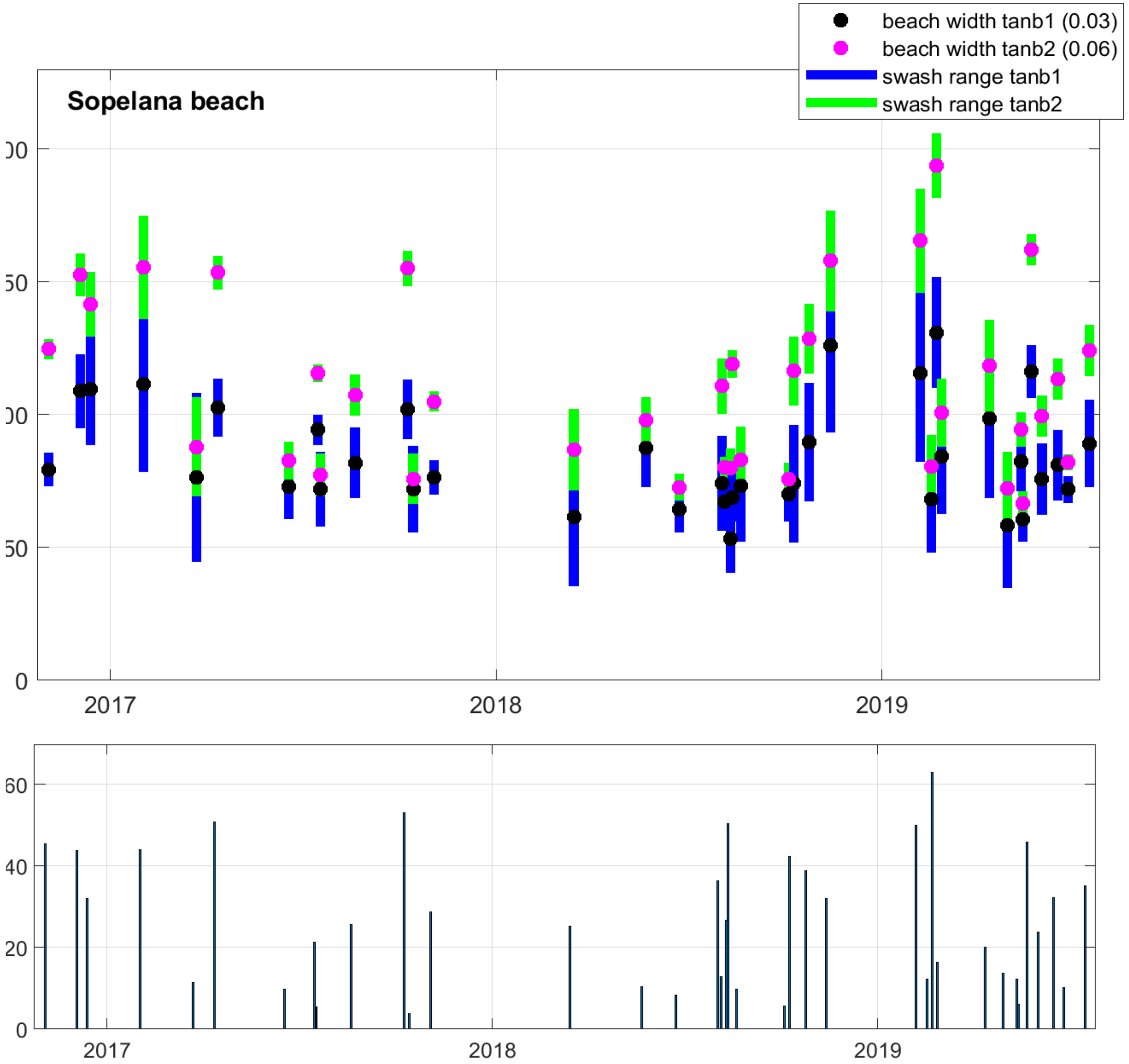
- ✓ Changes with time
- ✓ Not uniform





3c. Shoreline uncertainty analysis



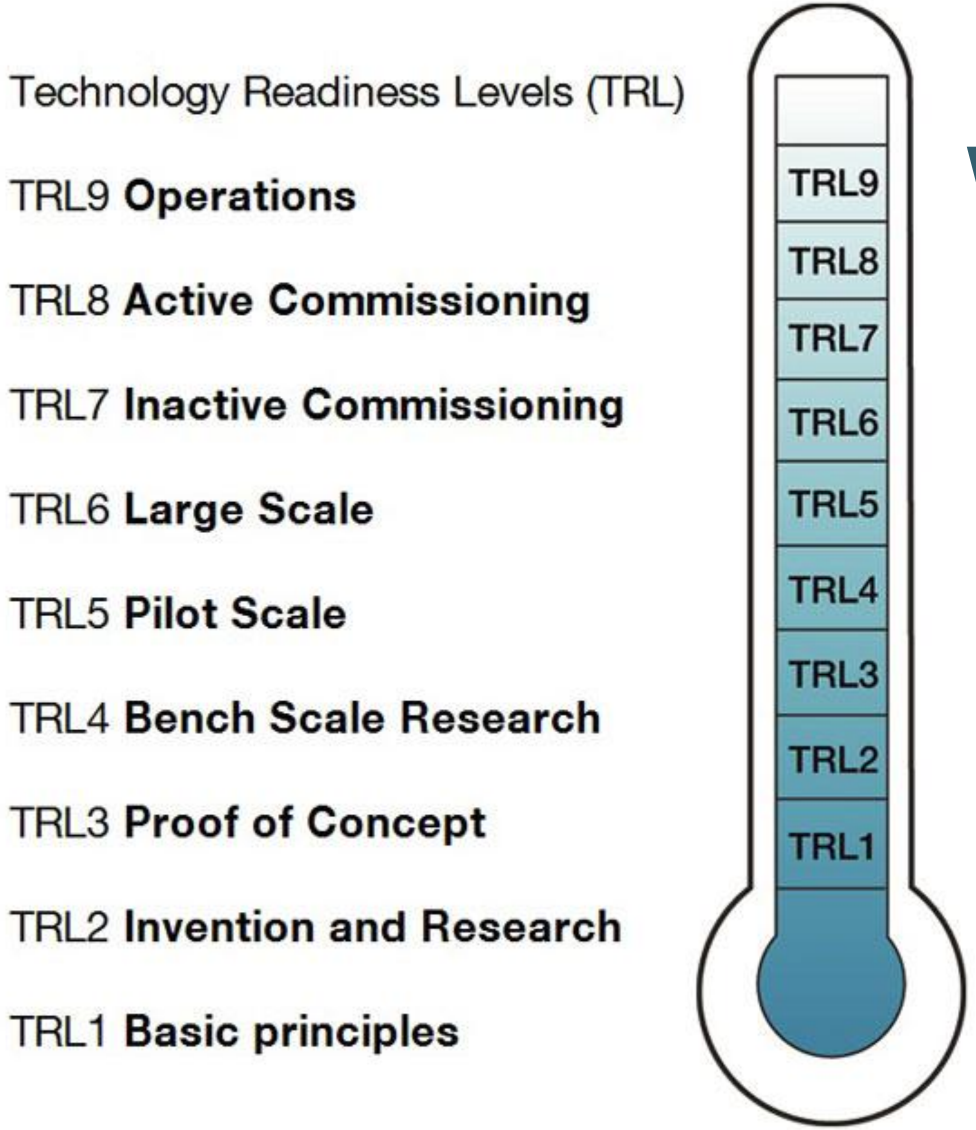


1. Overview of End Users Validation and Application analysis

2. From data to information: in depth uncertainty analysis

3. Technology Readiness Level for all EO products and services

4. Roll-out plans



WL Optical (QC)

SL Optical

LC lines

TS Optical & SAR

WL SAR

1. Overview of End Users Validation and Application analysis

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4. **Roll-out plans**

ARCTUS

BGS British Geological Survey

ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

Geological Survey
Suirbhéireacht Gheolaíochta
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