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FRANÇAISE

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Earth observation lab

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SPACEBORNE COASTAL MONITORING

TOWARDS FULLY INTEGRATED MONITORING OF THE COASTAL ZONE

CNES DTN/CD/ LOT

Dr. Erwin W. J. Bergsma

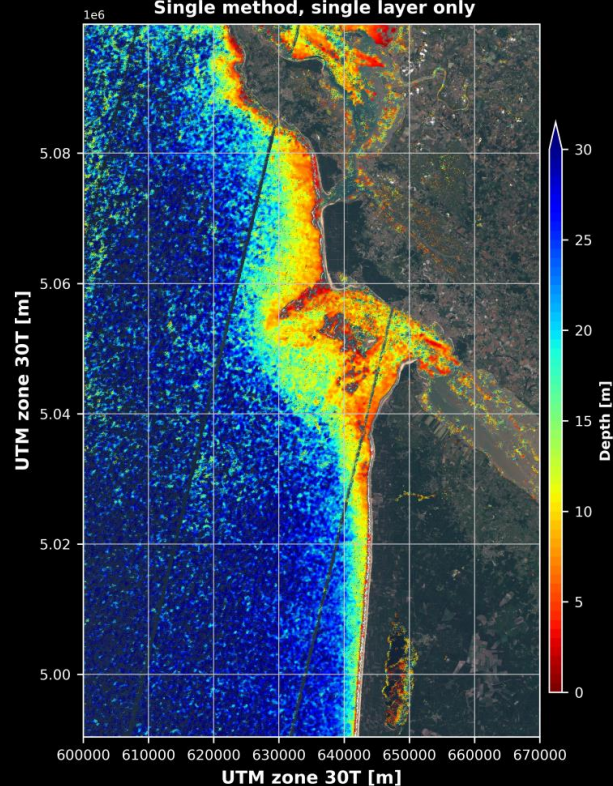
Erwin.Bergsma@cnes.fr

CONTEXT

DIGITAL REPLICA OF THE LITTORAL ZONE (GEOPHYSICAL)

Bathymetry

Unfiltered depth estimation result for 30TXR
Single method, single layer only



Examples here are realized with:



Inter-tidal zone



Shoreliner²

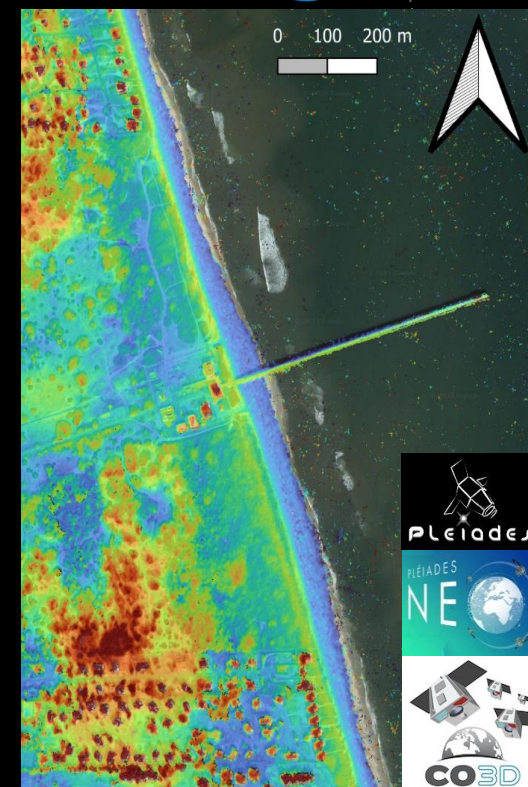


Time-average beach slopes



Topography of the inter-tidal zone

Topography



L'océan en référence

S2Shores¹

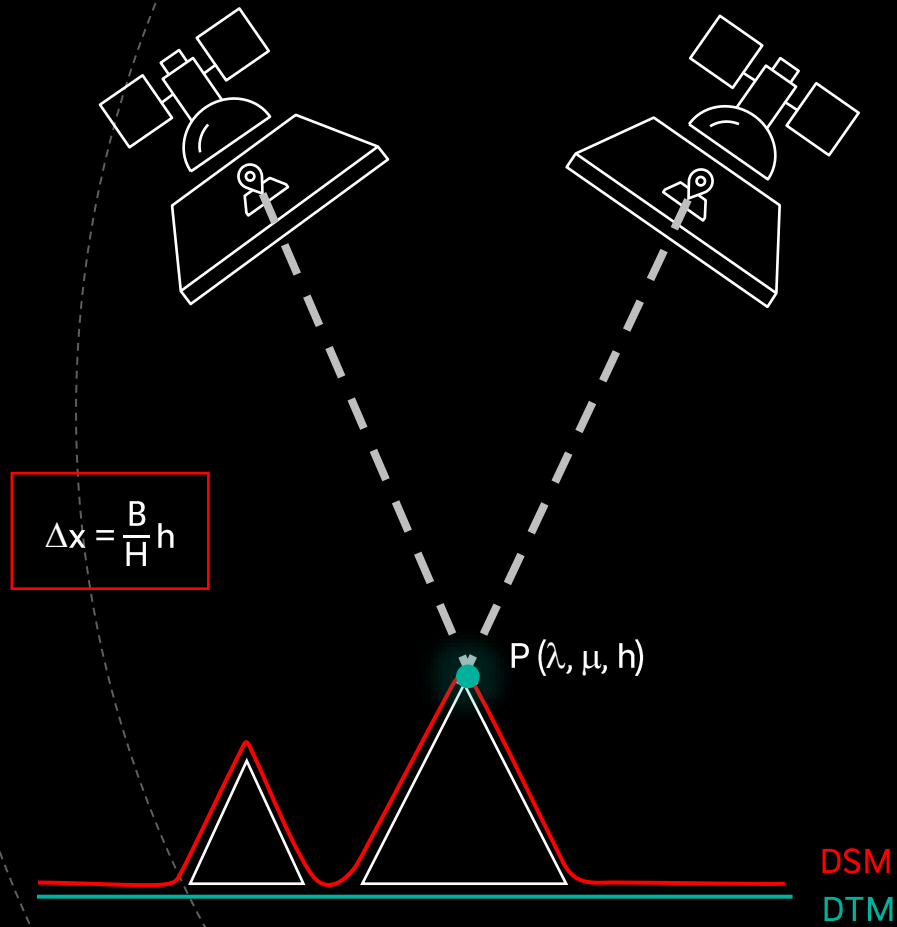
¹ Bergsma et al, 2019, 2021; Almar et al., 2019

² Bergsma et al, 2024

³ Youssefi et al., 2020

TOPOGRAPHY

STEREO PHOTOGRAMMETRY

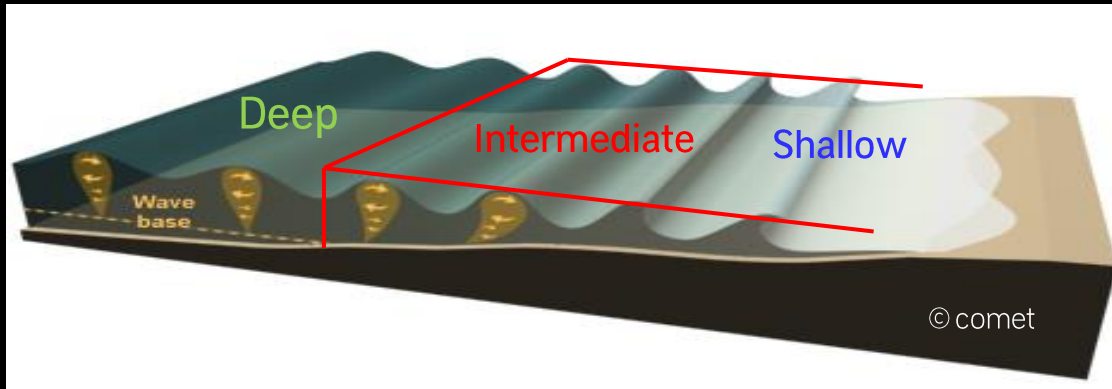


BATHYMETRY

BATHYMETRY THROUGH WAVE-KINEMATICS (SHELF TO NEARSHORE)

Waves are limited in depth in **intermediate to shallow waters**:

Shallower = waves propagate slower & wave crests are closer together



Linear dispersion relation : $\sigma^2 = gk \tanh(kh) + k\vec{U}$

$$h = L \operatorname{arctanh}\left(\frac{c^2}{gL}\right) \leftrightarrow h = \frac{2\pi}{k} \operatorname{arctanh}\left(\frac{c^2 k}{g}\right)$$

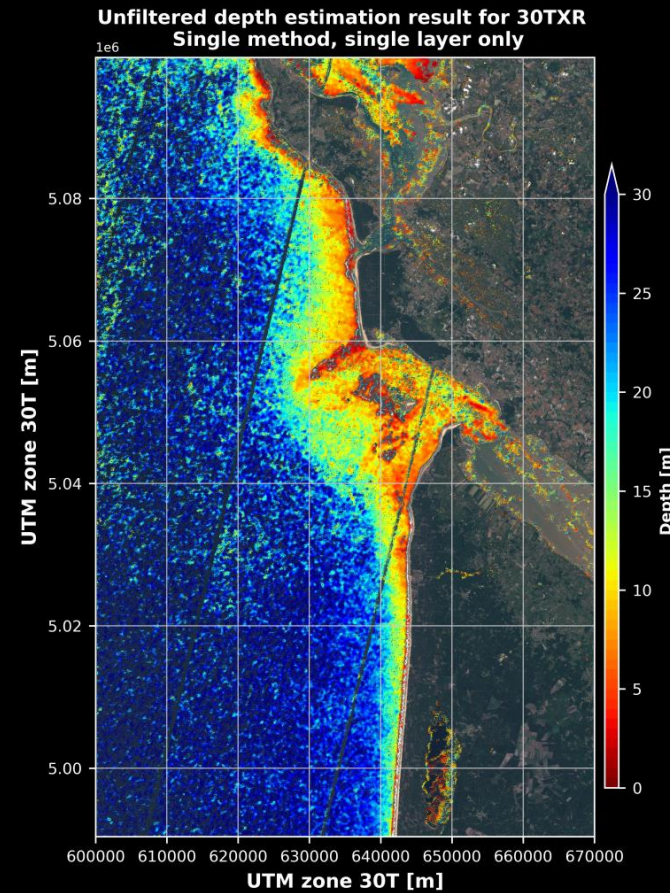
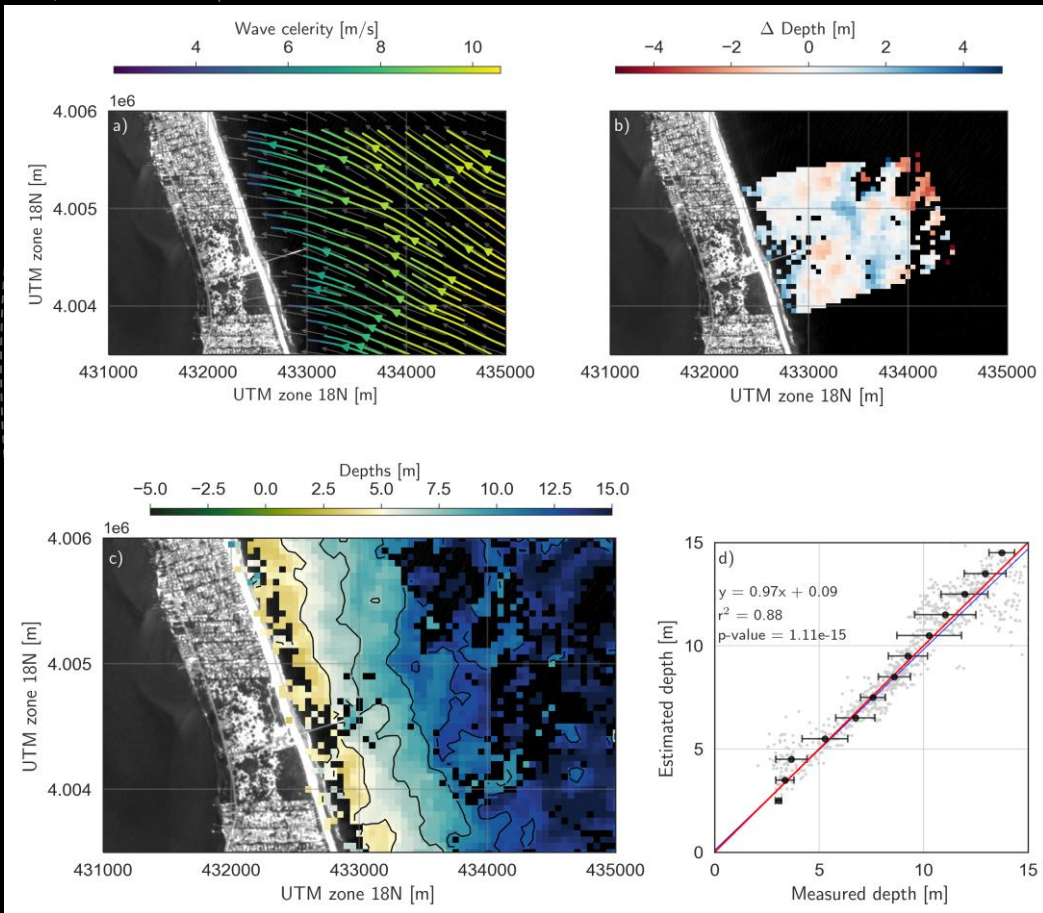
All we need to do is measure the wavelength (L) and celerity (c) of the swell to determine the depth.



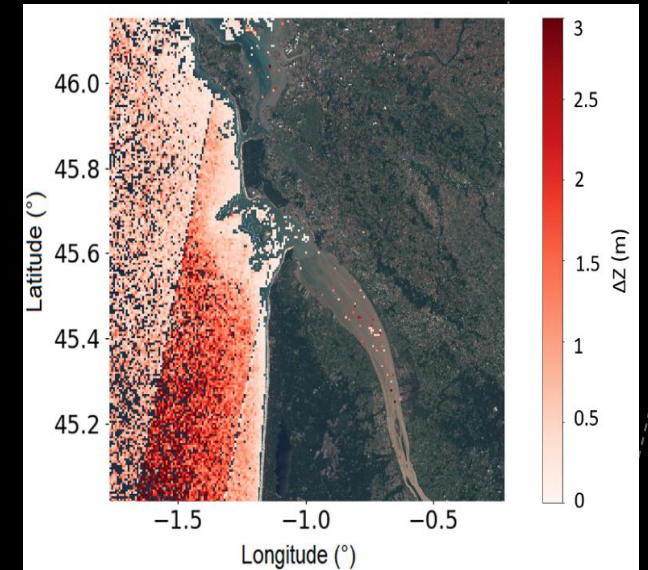
BATHYMETRY

BATHYMETRY THROUGH WAVE-KINEMATICS (SHELF TO NEARSHORE)

Local validation using the VENμS satellite
USACE ERDC FRF. Duck, NC USA (Bergsma et al. 2021)



Effect of the time-delay on the depth estimation
ESA manual – time delay following (Binet et al. 2022)



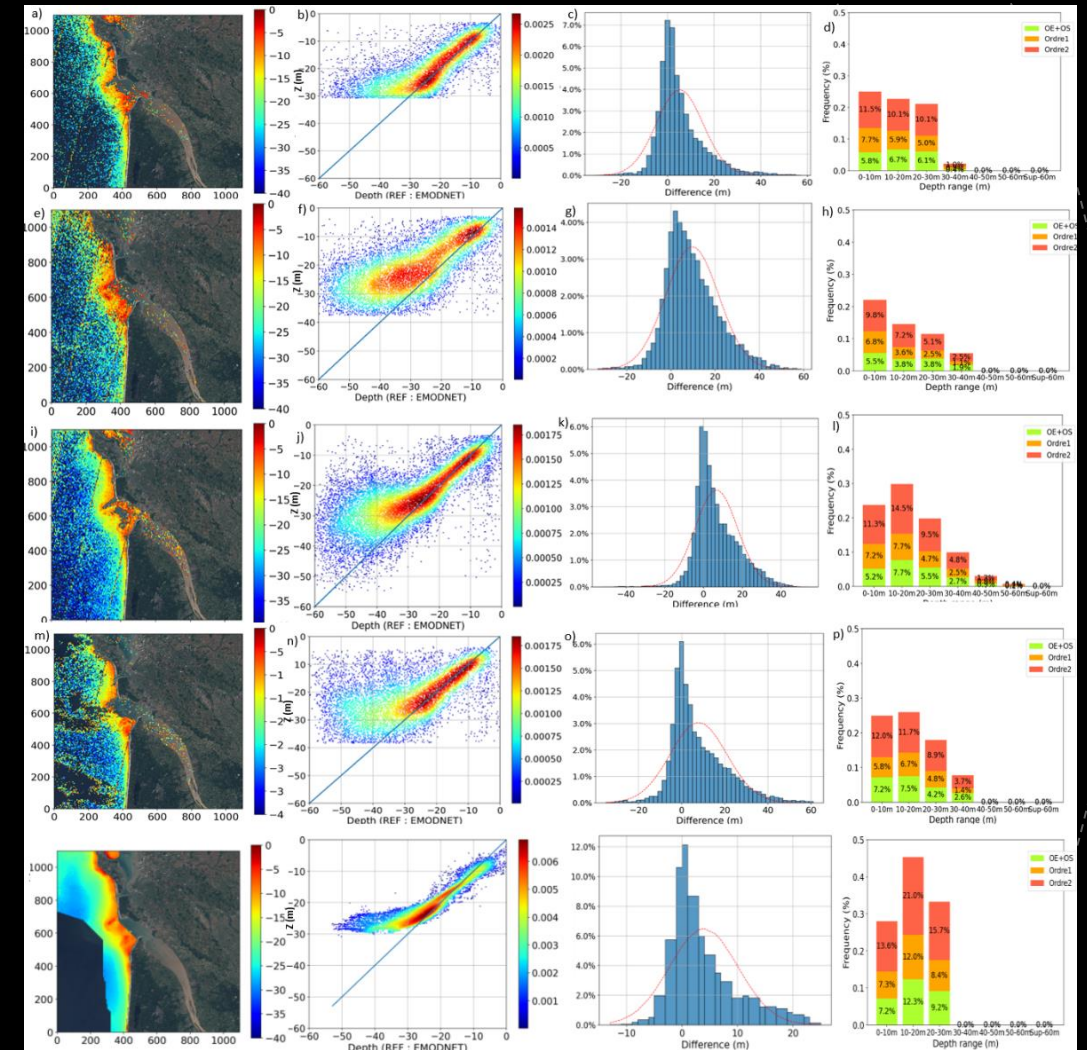
BATHYMETRY DEPLOYMENT AT CNES

HPC 6th generation :

- All Sentinel data to our disposal
- Large scale applications (time and space).
- S2Shores
 - Bergsma et al., 2019 : principle Radon based Fourier slicing approach
 - Bergsma et al., 2021 : updated approach including the topography – single orbit topo/bathy
 - Almar et al., 2019: spatial correlation method
 - Klotz et al., 2024. : temporal correlation method (also applied to UAV sensors)

Processing chain S2Shores v7.1

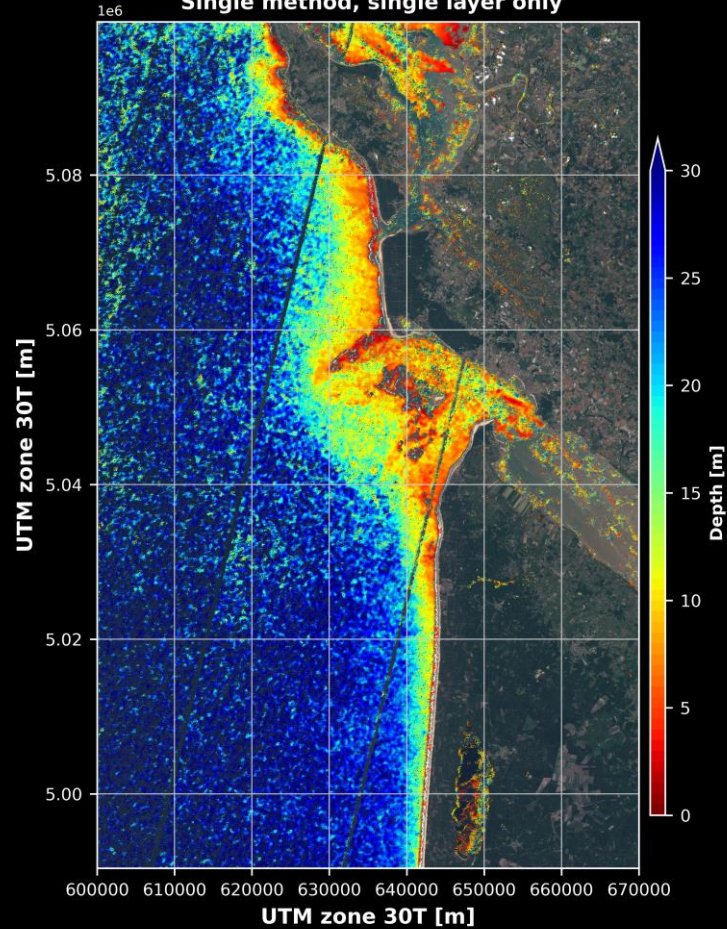
- Tide correction FES2022
- Time-delay optimisation (Binet et al. 2022)
- IHO classification of the performance



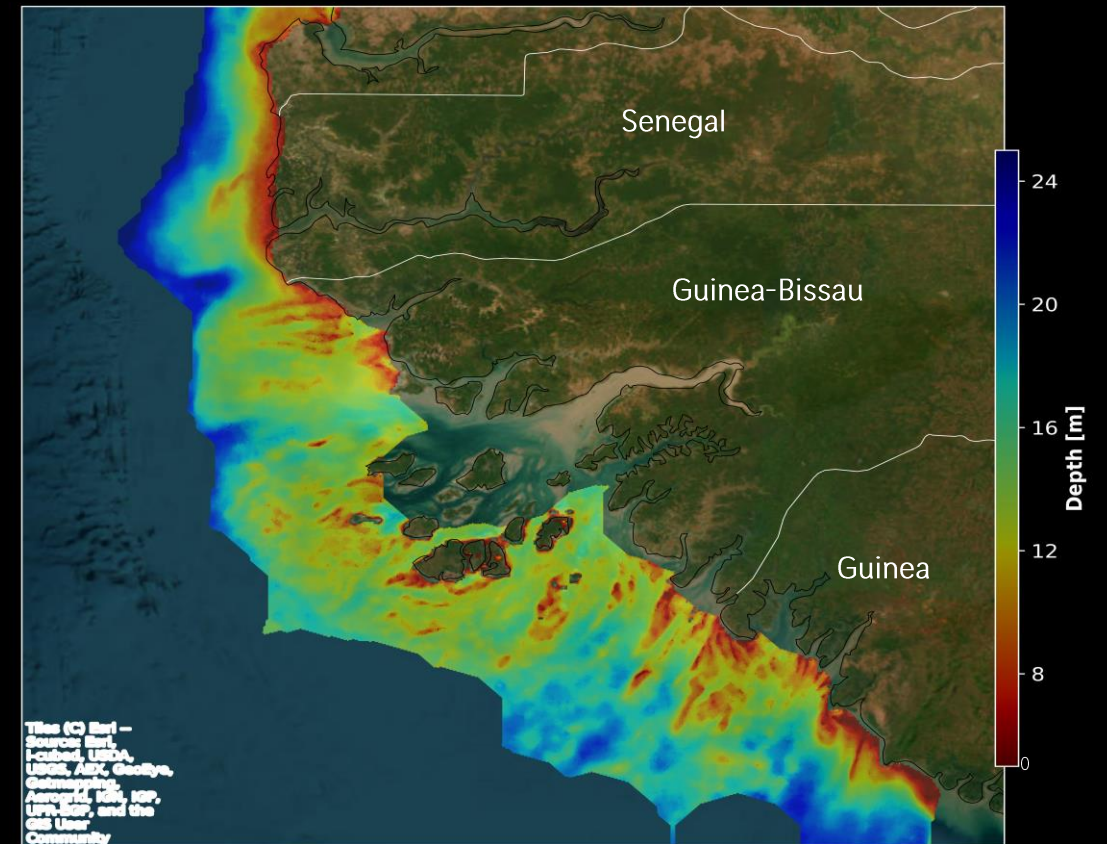
BATHYMETRY

LARGE SCALE WITH SENTINEL 2

Unfiltered depth estimation result for 30TXR
Single method, single layer only

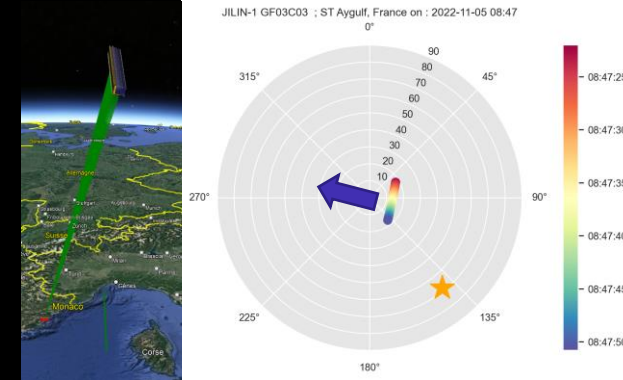
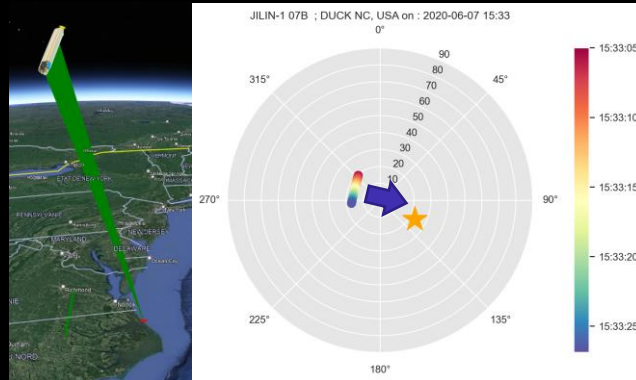
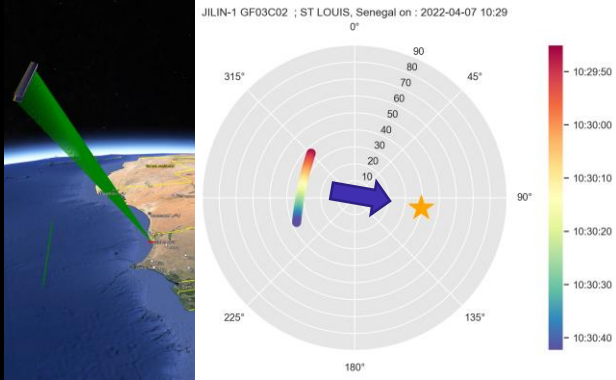
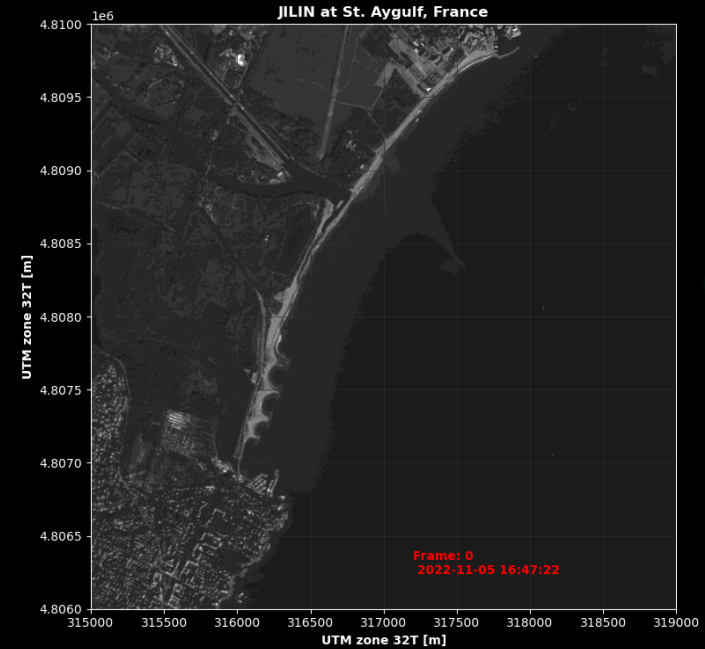
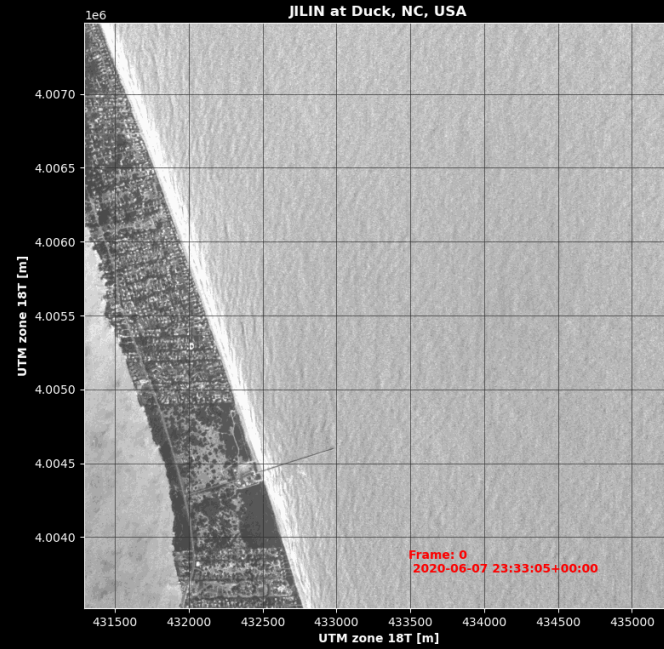
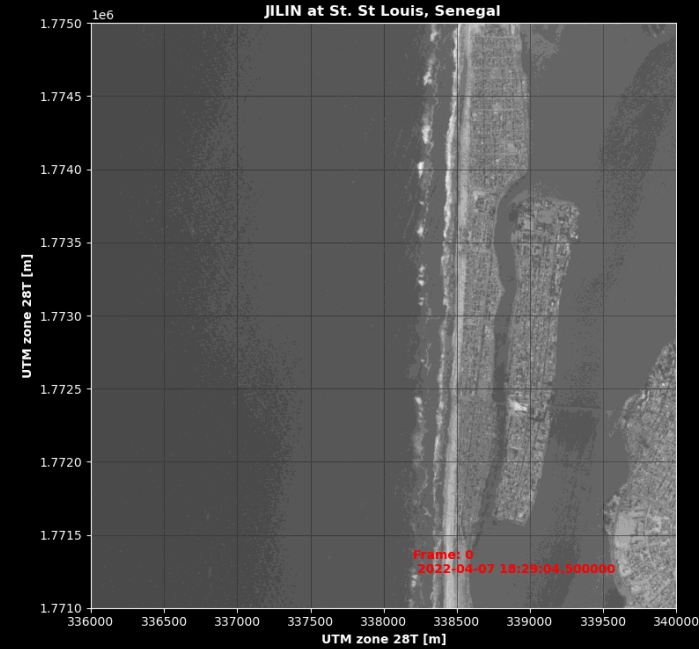


Regional products, towards a global atlas
S2Shores v7.1



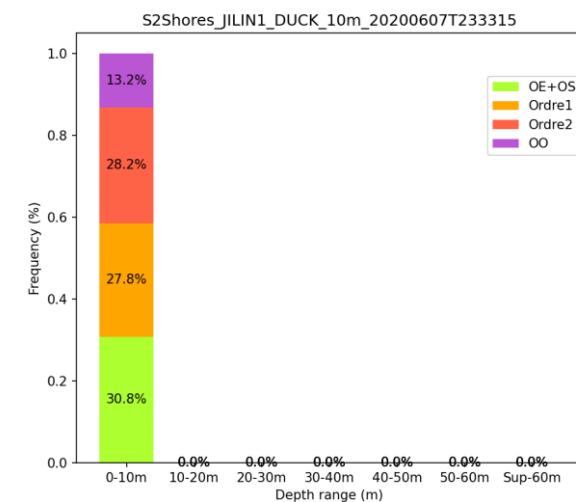
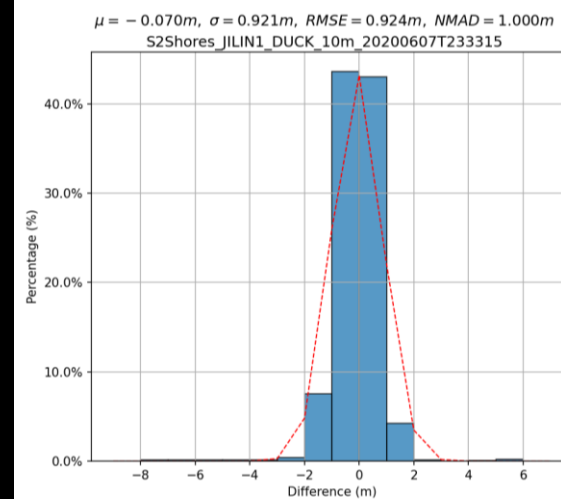
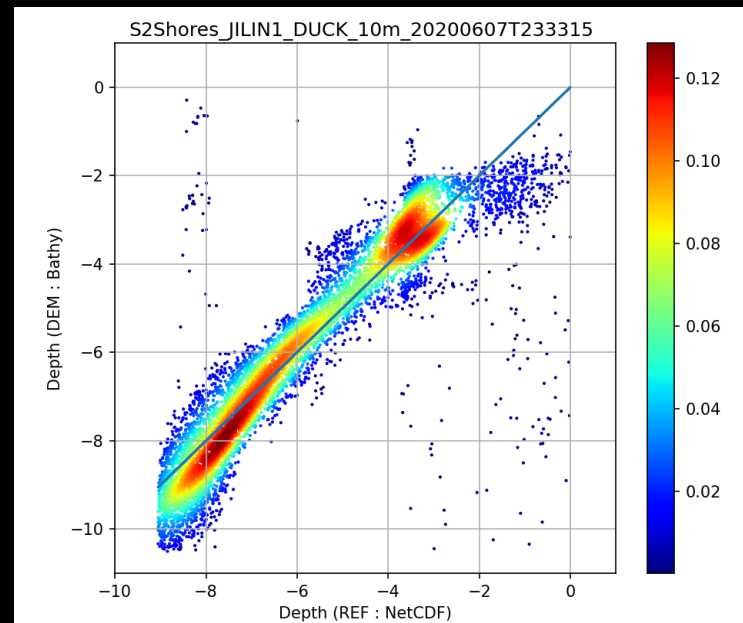
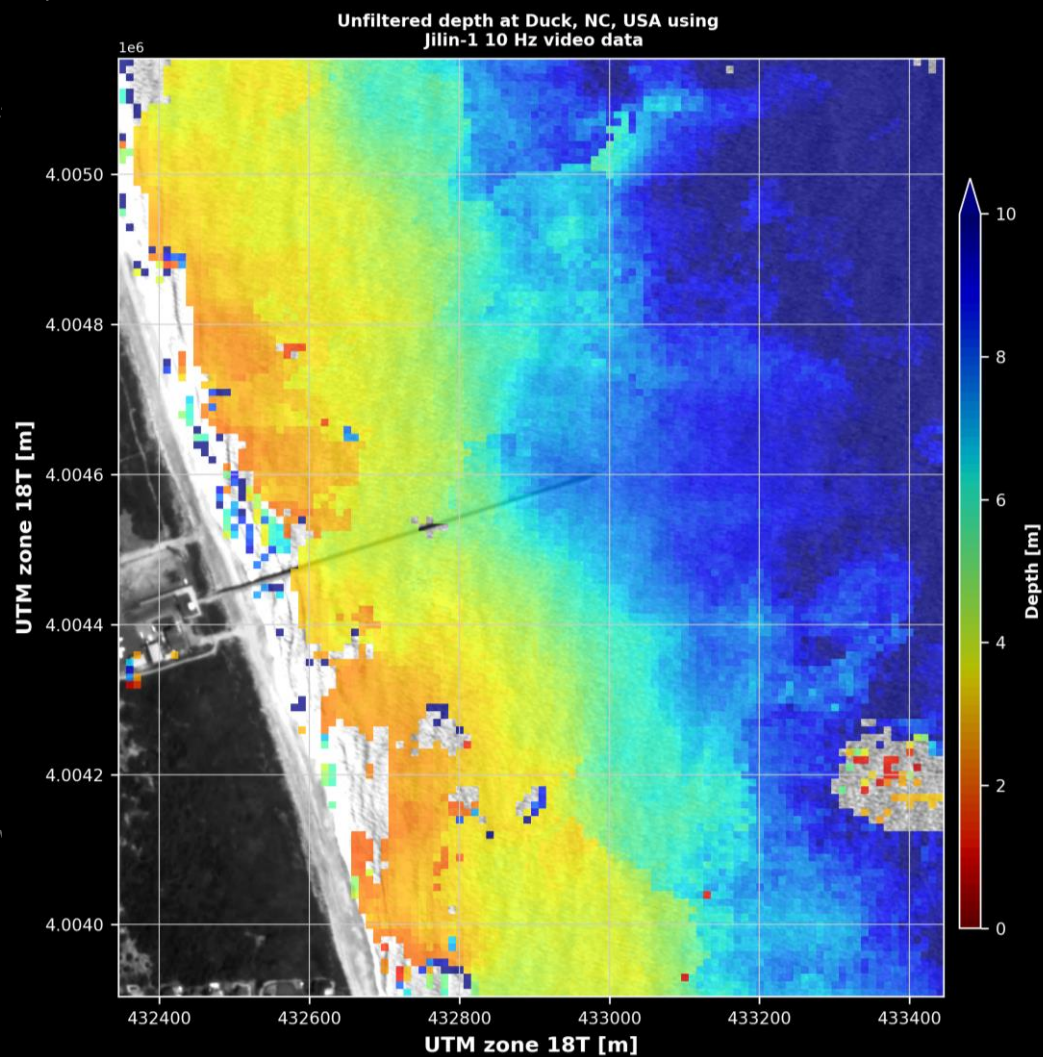
EXPLORATORY VIDEO DATA (PREPARATION CO3D)

THE IMPACT OF VIEW-ANGLES ON THE OBSERVED SIGNAL



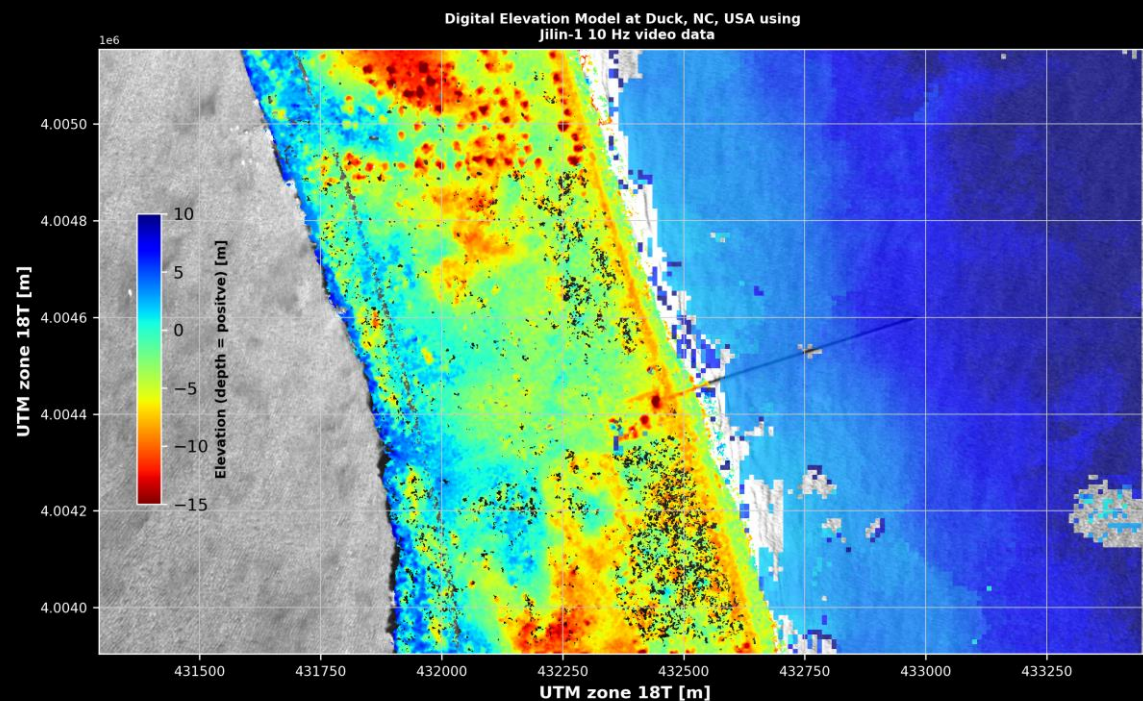
SOME RESULTS

BATHYMETRY

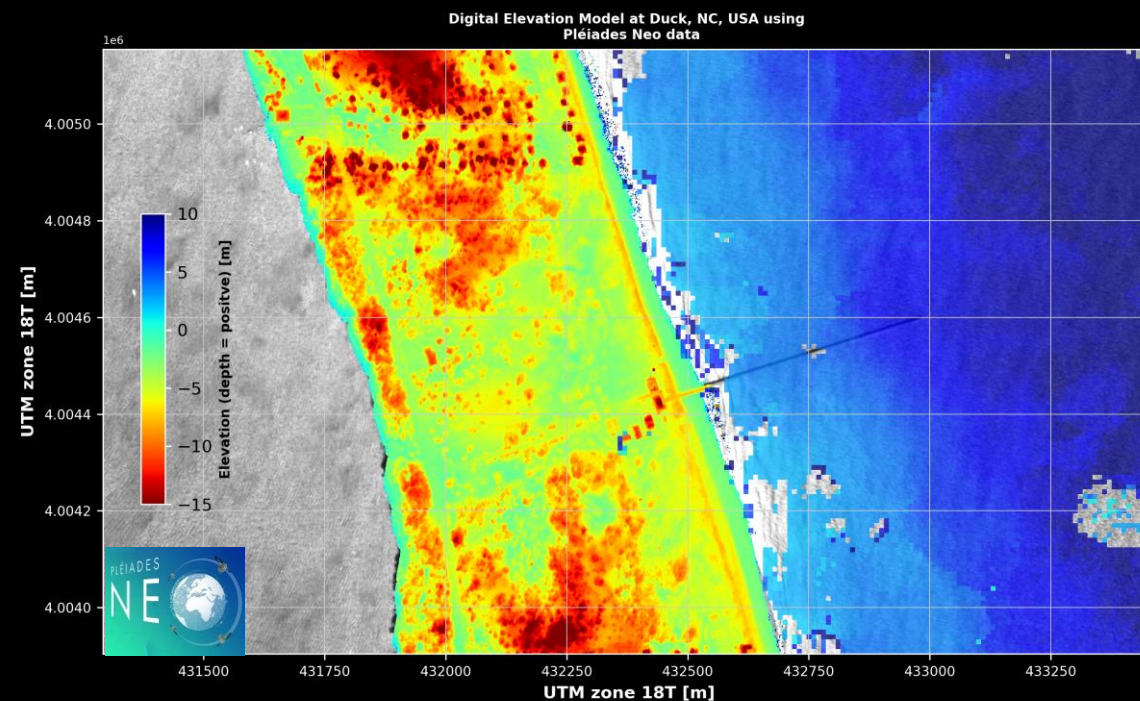


RESULTS

TOPOGRAPHY (+ BATHYMETRY)



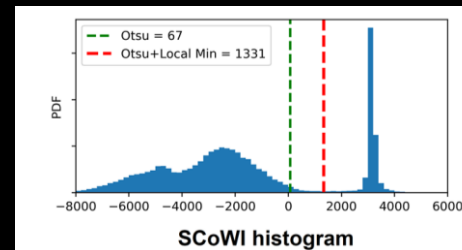
Jilin-1 (90 cm resolution ?)



Pleiades Neo (30 cm resolution -- confirmed)

SHORELINE DETECTION

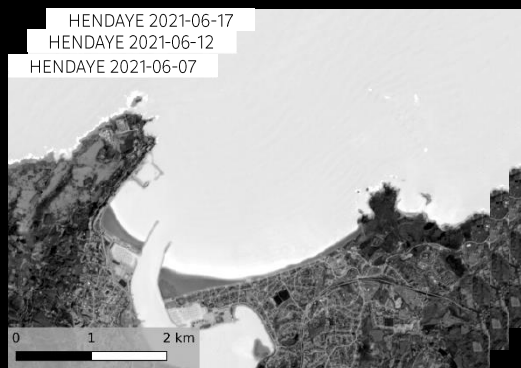
SCOWI + SHORELINER



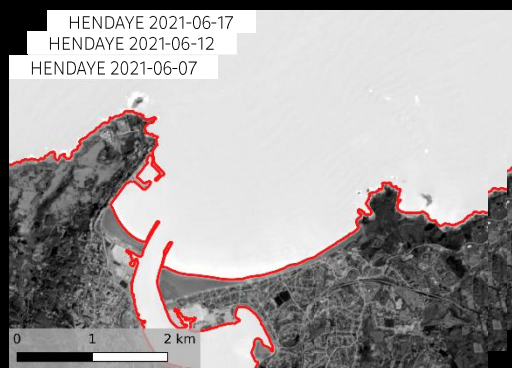
Shoreliner



Sentinel-2 (L1C)



SCoWI



Thresholding SCoWI land/sea



Instantaneous and/or sea boundary



Multi-date shorelines synthesis

Bergsma et al, 2024



Intertidal topography

Post-processing

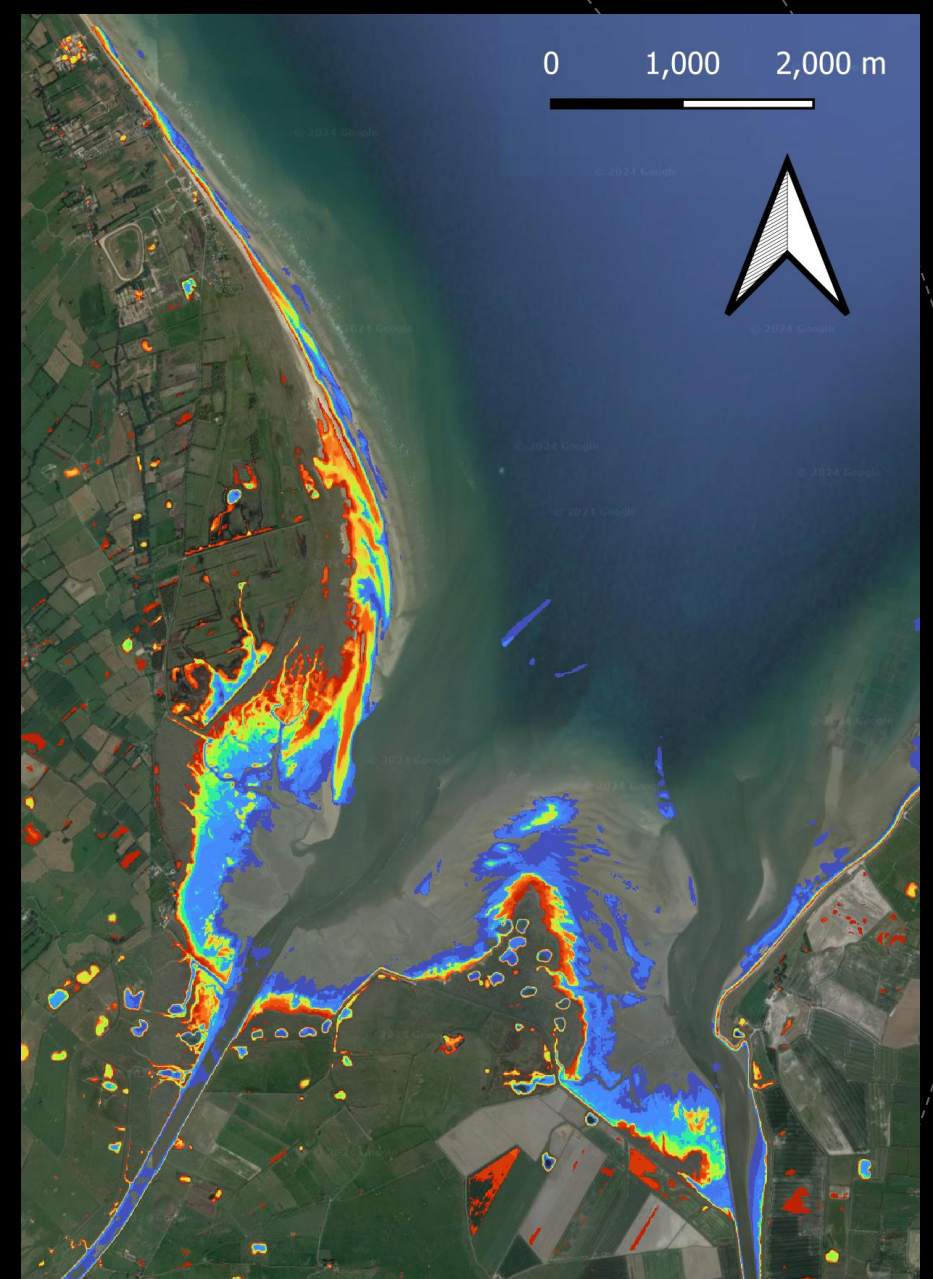
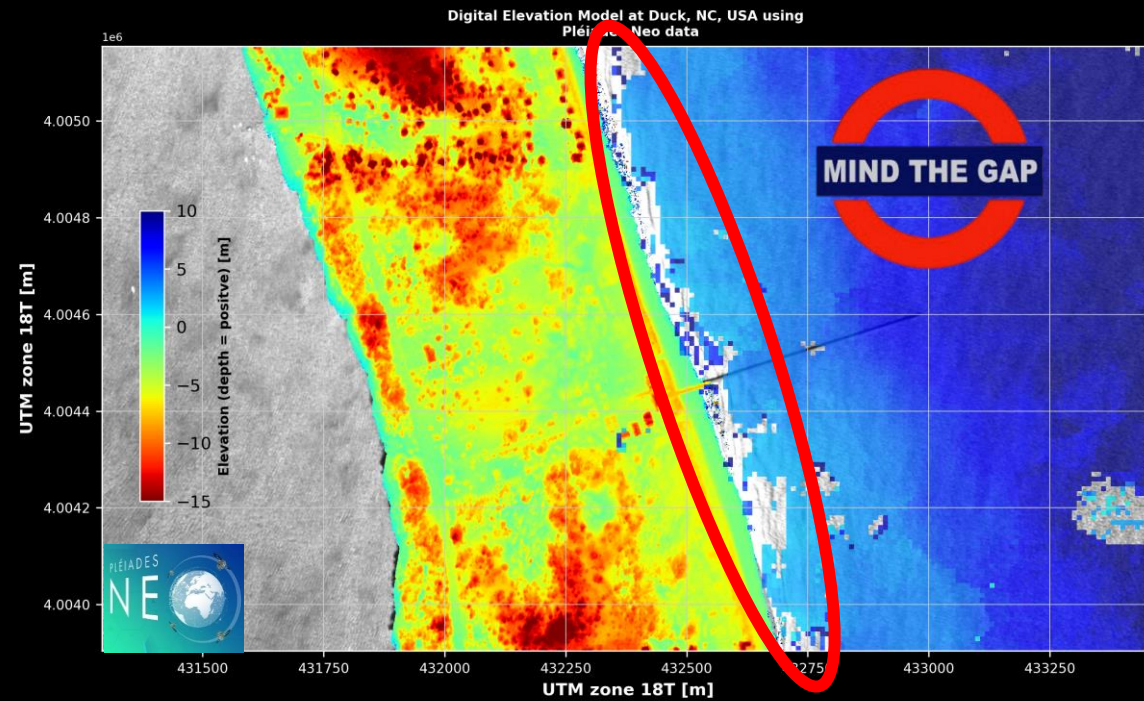


Time-average beach slopes

Post-processing on transects

SHORELINE DETECTION

INTERTIDAL TOPOGRAPHY:



SHORELINE DETECTION

LARGE SPATIO-TEMPORAL SCALES

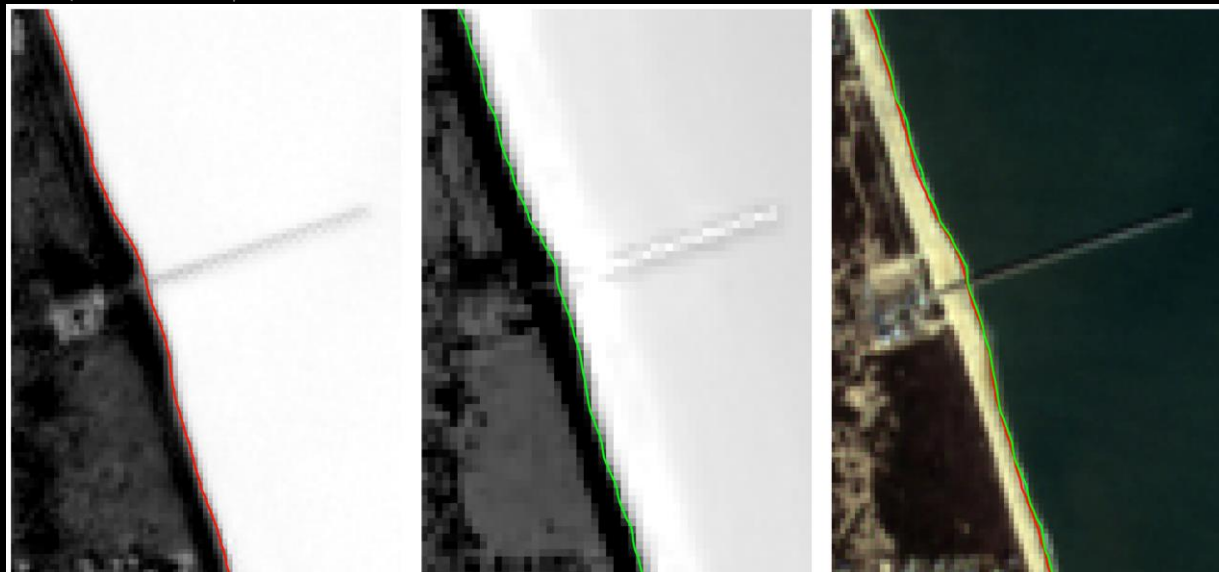
Sentinel-2

Landsat 8

overlay

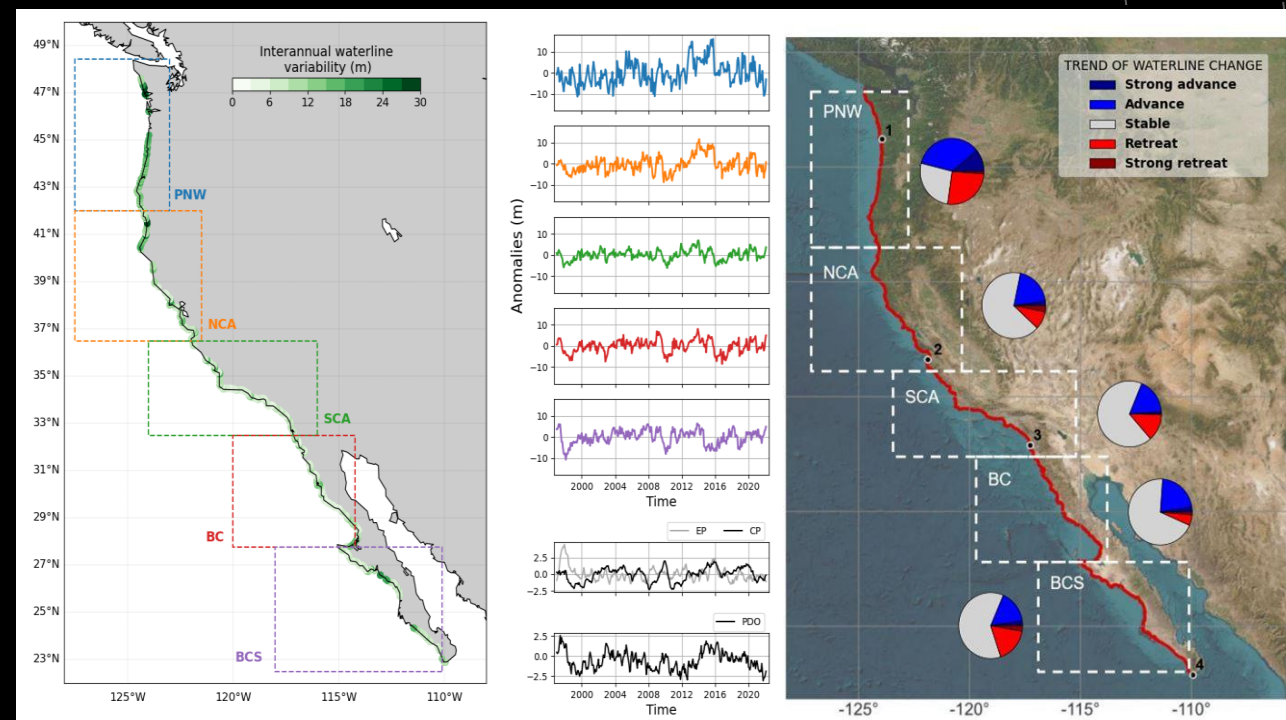
21 Février 2023 at 15h50

21 Février 2023 at 15h41



Bergsma et al, 2024

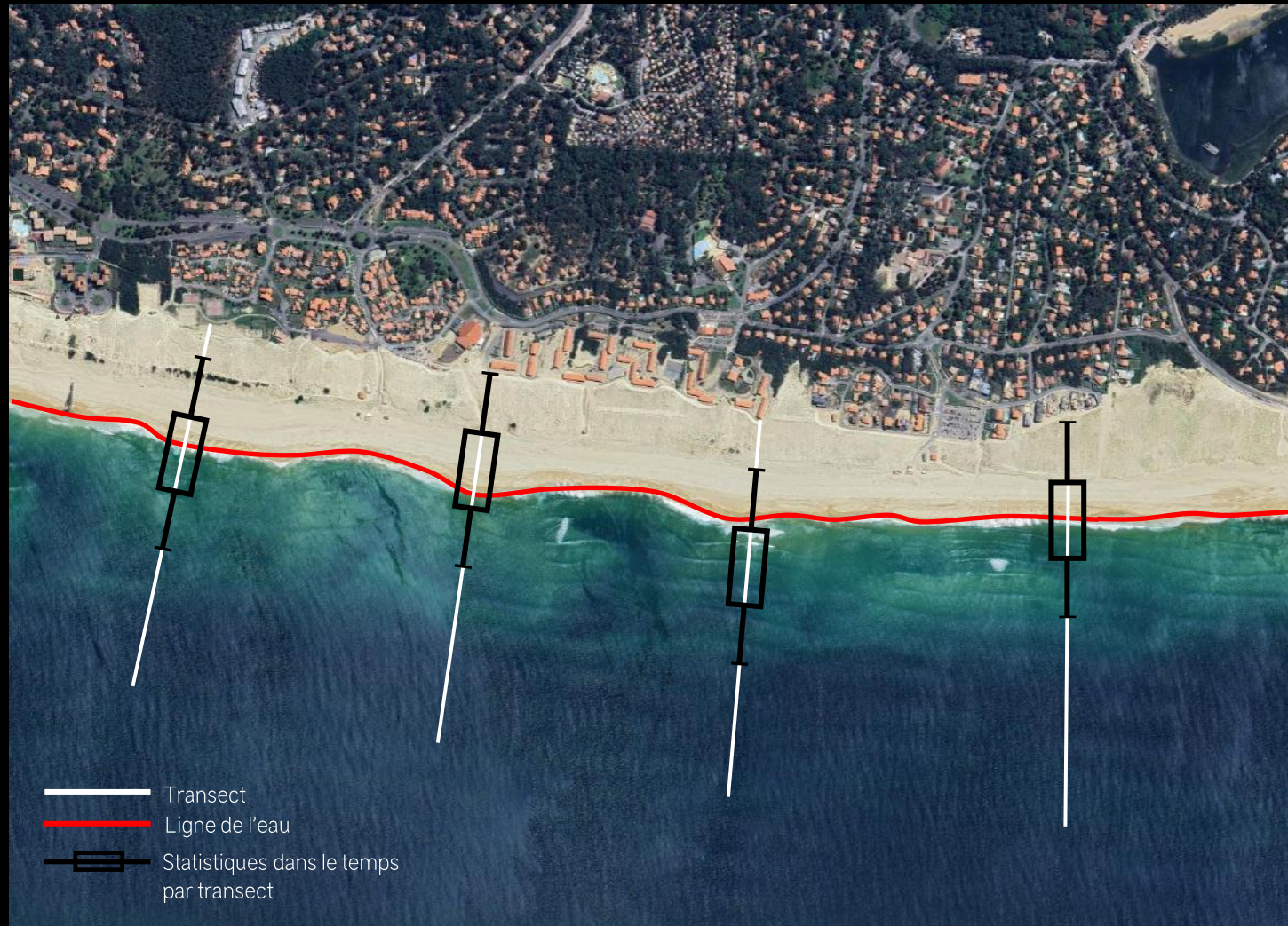
Large spatio-temporal application (climate scale)



Graffin et al, under review

SHORELINE DETECTION

TOOL DEVELOPMENT

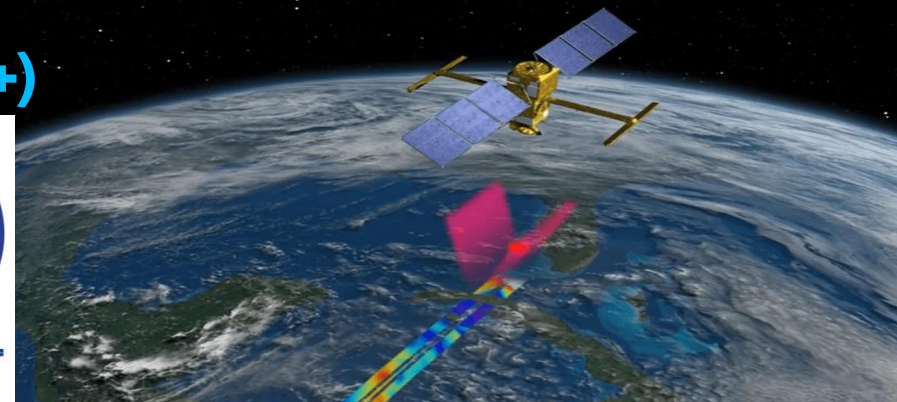


NEAR FUTURE

SIMULTANEOUS STEREO / SWOT / SAR (S1 ++)

4 satellites

4 bands : Blue, Green, Red,
Near Infra Red at 50 cm



SPACE OF CLIMATE OBSERVATORY

YEARLY CALL, VARIETY OF SCO PROJECTS

2020

- SCO LITTOSCOPE

2021

- SCO TAHATAI
- SCO OSS St. Louis

2022

- SCO LittoSAT

2023

- SCO WACA-VAR
- SCO EO4InterTidalTopo
- SCO TAHATAI Neo

2024

- SCOast-DT

2030



SCO LITTOSAT



SCO WACA-VAR



SCOAST-DT

VARIETY OF COASTAL ZONES AND APPLICATIONS



- Project labelled SCO and fully financed
- FR-US collaboration
- 2024-2026
- Construction and operation of digital twins
- Representative areas and issues
- Climate projection and impact analysis
- Response to local issues
- Free results

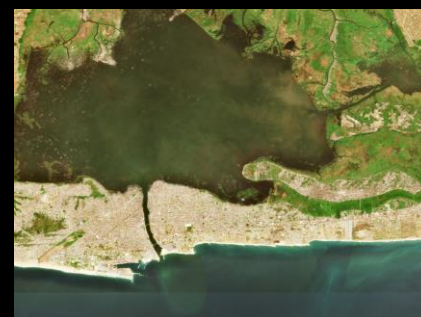


France métropolitaine

Coastline, erosion/accretion, intertidal zone

~ 40 years of satellite data

Validation at multiple sites



Bay of Nokoué

Water quality, pollution

Satellite + in-situ

Hydrodynamic modeling



New Caledonia

Marine submersion and coastal flooding

Satellite + in-situ

Hydrodynamic modeling

2024

2025

2026

Project kickoff
Start of development
Data identification & collection

Bathymetry and
shoreline tools
release

Digital replica V1 available
internally to the project partners
on some ROI

Open digital replicas
available on all ROI

Open digital replicas available for each region of interest, including
use cases specific outputs
Open tools available
Web portal to explore the data and use cases
Added value communication material (virtual reality, movies...)

Project end

Data collection from
local authorities.
Need refinement

Workshop : presentation
to local authorities and
public institutions

What if and what next
scenarios fine definition in
collaboration with decision
takers

Restitution to local
authorities

Implication of local authorities

Communication in international conferences
(EGU, AGU, IGARSS, DITTO...)

Preliminary schedule

Stabilization of ROI
and local contact
points.
End of financial round
table. Contract.