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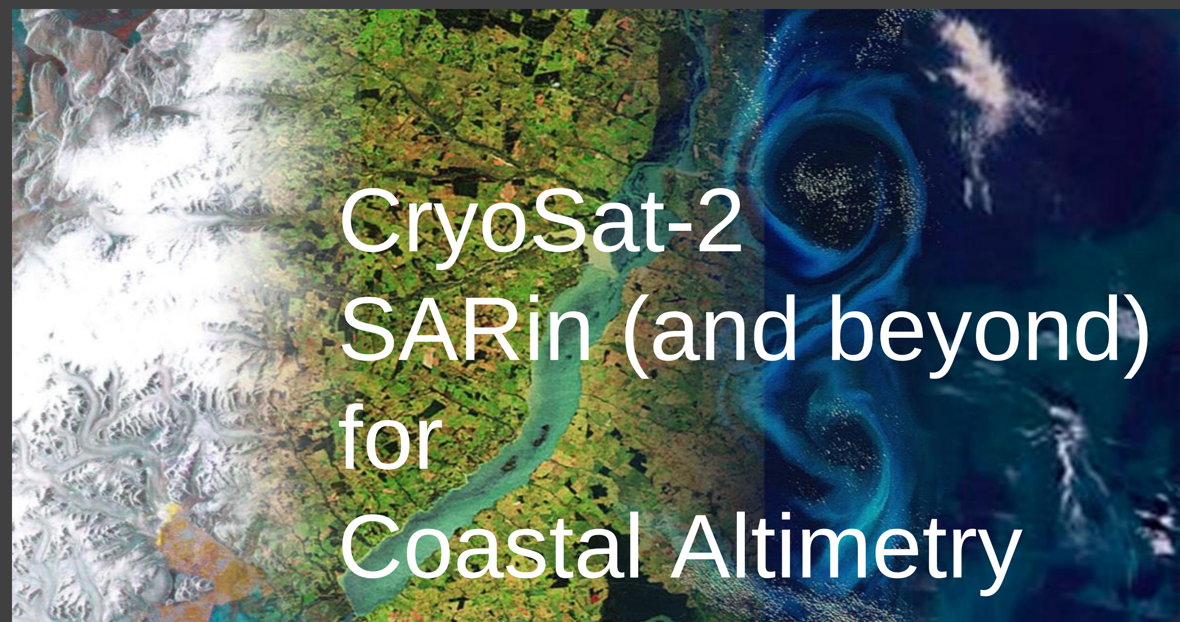

CryoSat-2 SARin (and beyond) for Coastal Altimetry

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Table of Contents

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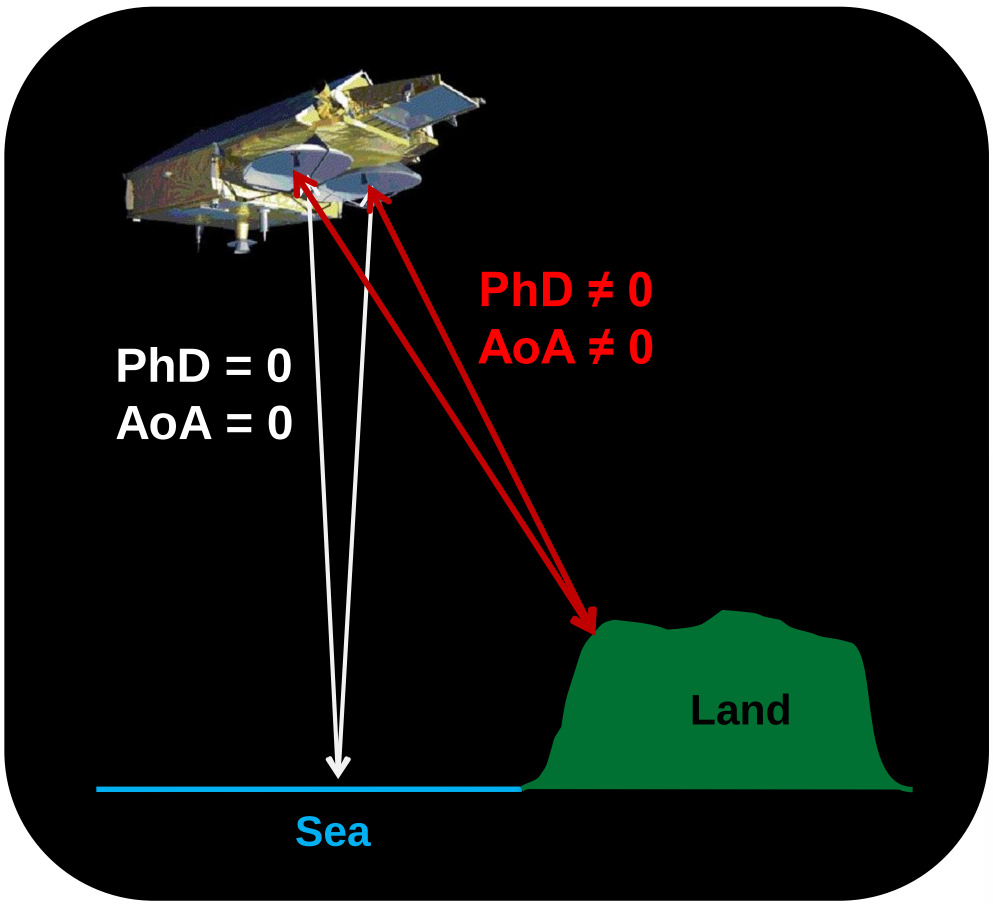
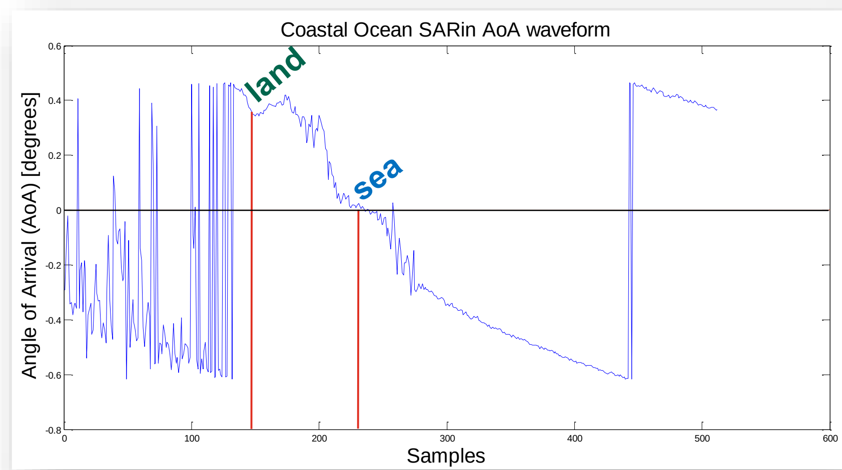
Phase I investigation

SARinM: The Across-Track discrimination is based in the Phase Difference (PhD) → Angle of Arrival (AoA)



SARin Mode allows discrimination of coastal echoes between **sea** and **land**



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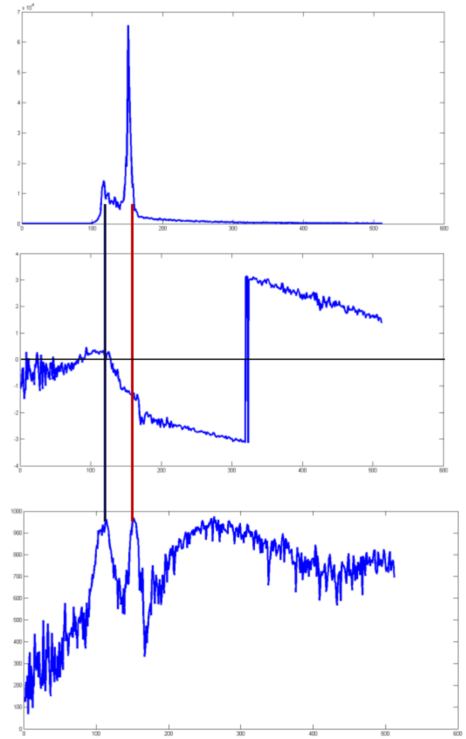
Phase I investigation

- L1 data used in the processing:



black / red line:

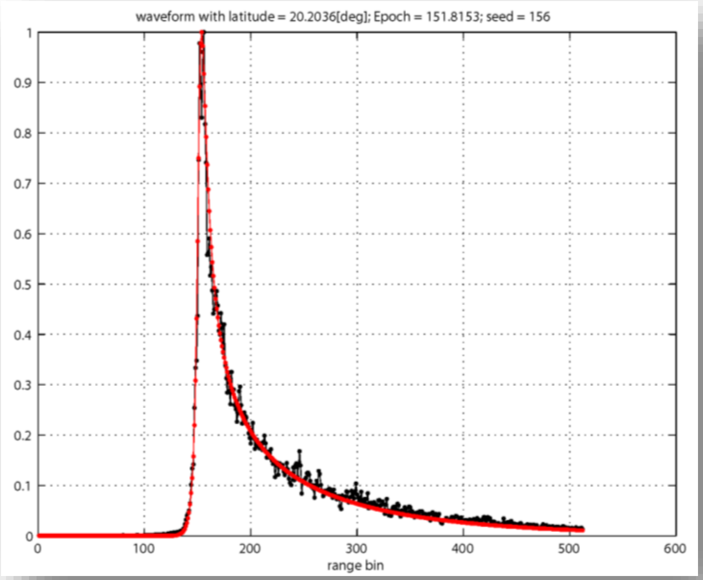
  - Power waveforms — Nadir LEP / flat sea
  - Phase Difference waveforms — Nadir / Off-Nadir
  - Coherence waveforms — High Coherence / High Coherence
  - Plus: geolocation, Roll, Altitude, Window_delay…

Phase I investigation

- Algorithm developed:

1. Iterative process to find a seed for the L2 retracker avoiding off-nadir targets.

2. The L2 processing consists in a retracking method, inherited from the SAMOSA model.



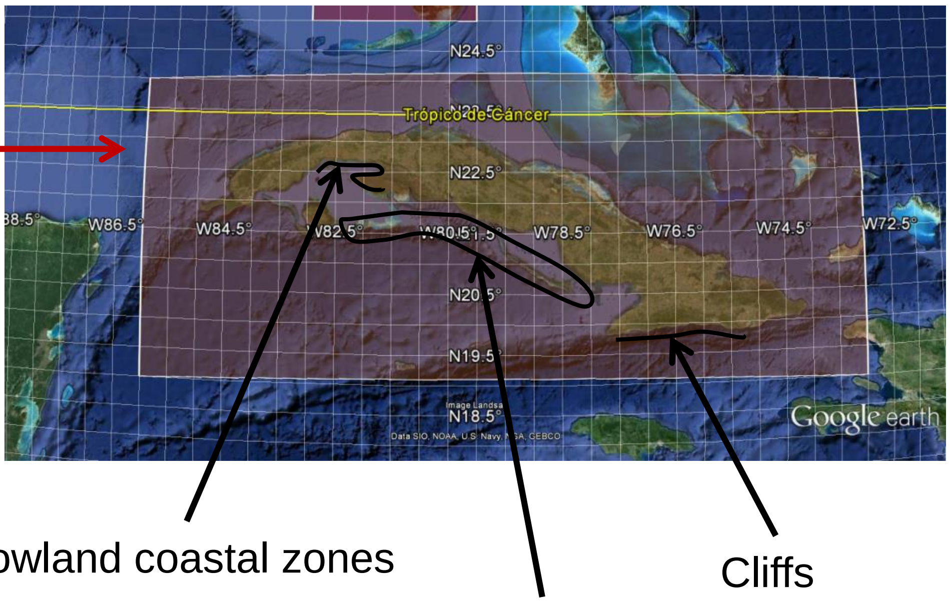
SAMOSA Model Adapted:
- **SARin** Mode
- Baseline B
- Modifications of the model

(Cristina Martin-Puig, isardSAT)

Phase I investigation

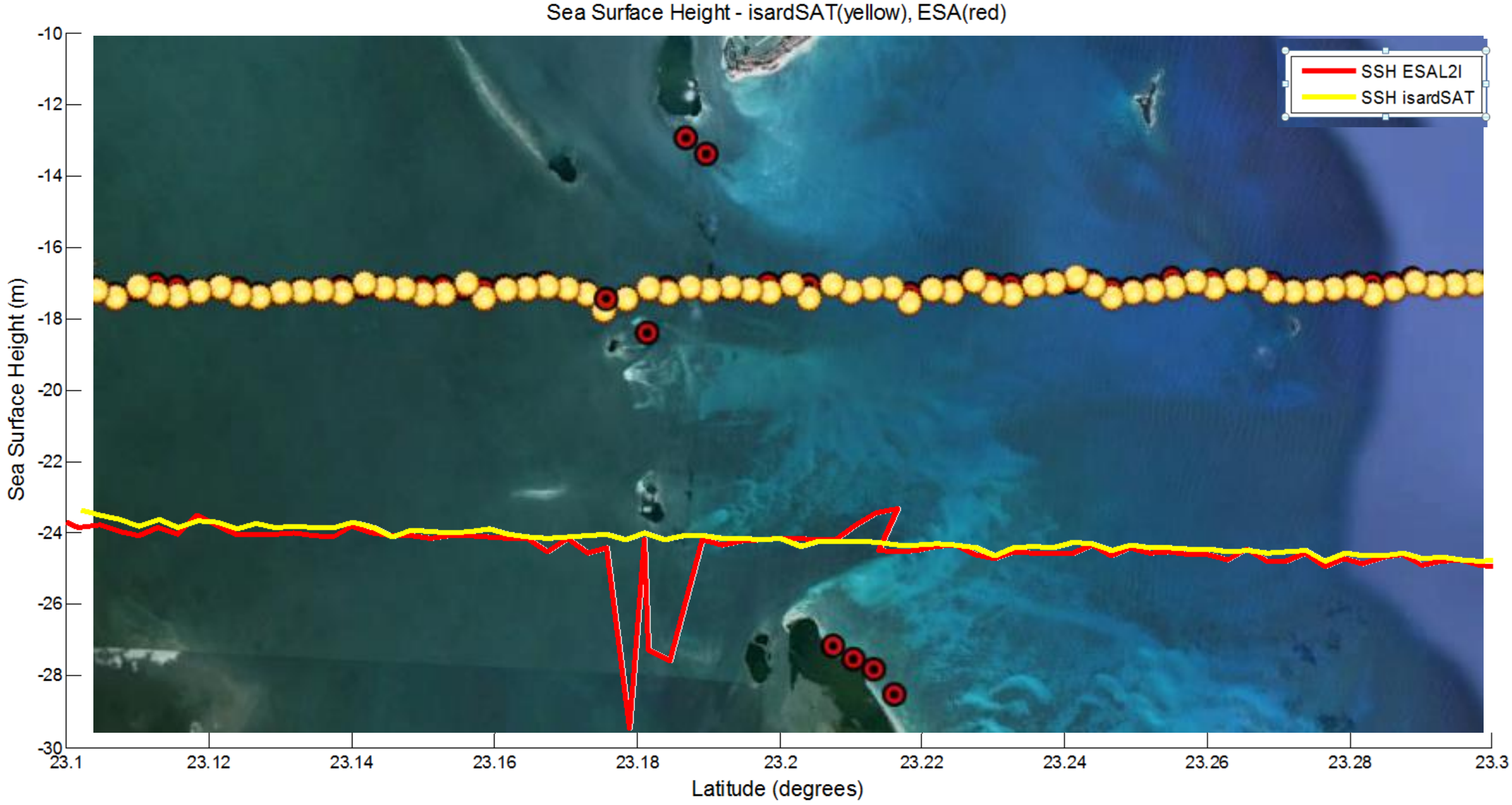
Zones of interest for this investigation:

- CP4O request for specific SARin mode area: **The Cuban Archipelago**



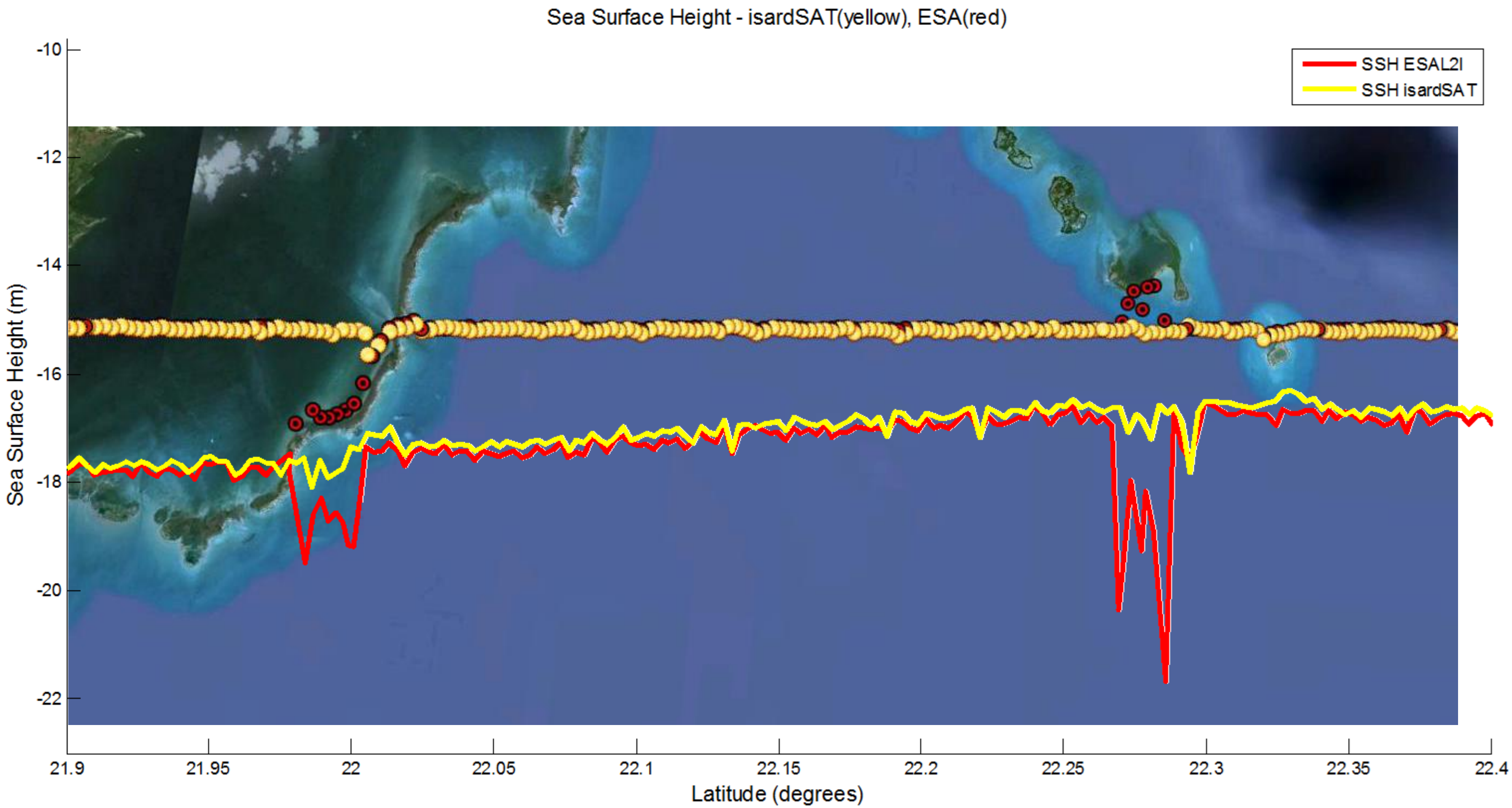
Phase I results

Example 1: CUBA, pass over North cays

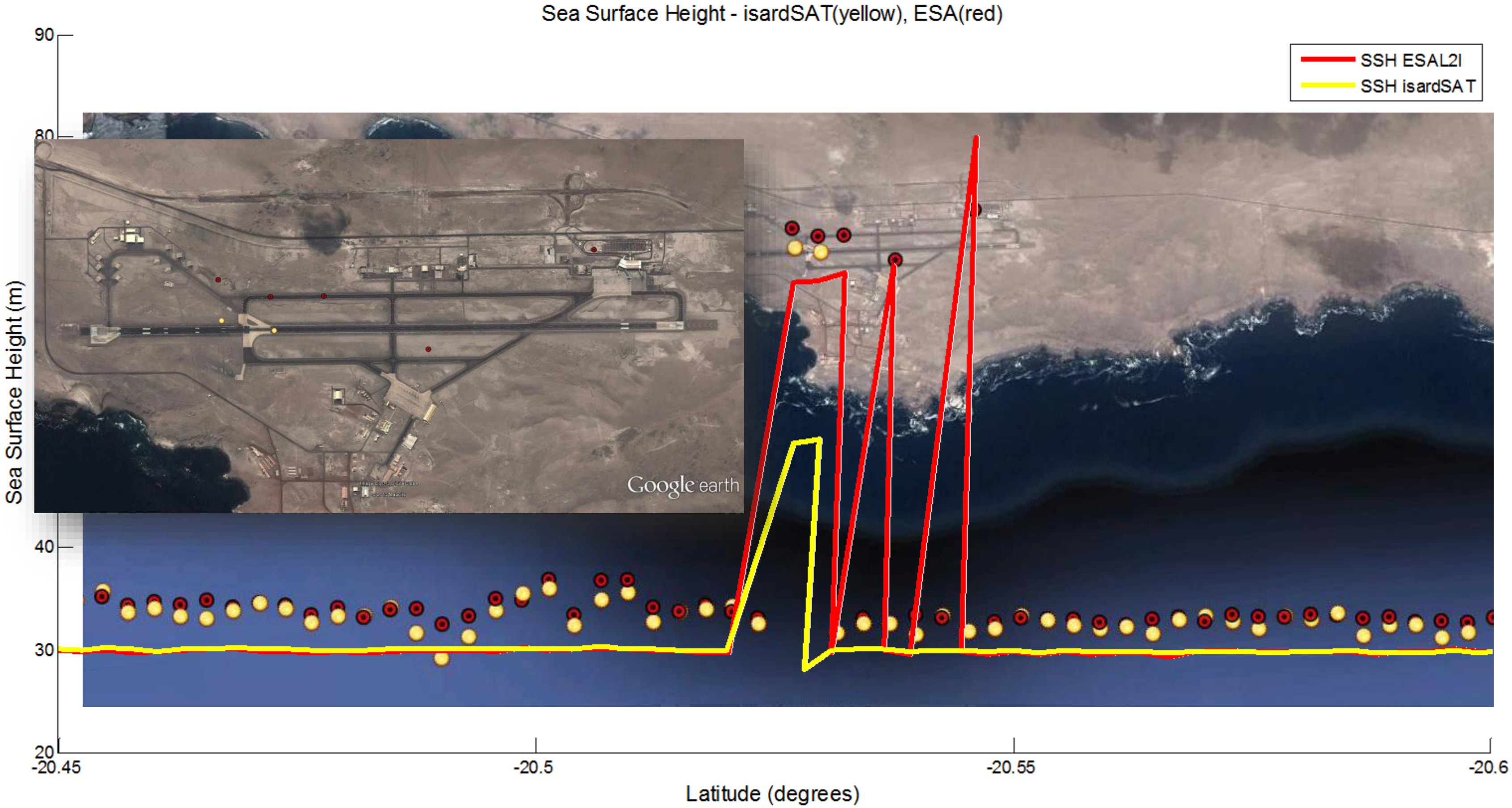


Phase I results

Example 2: CUBA, pass over SW cays

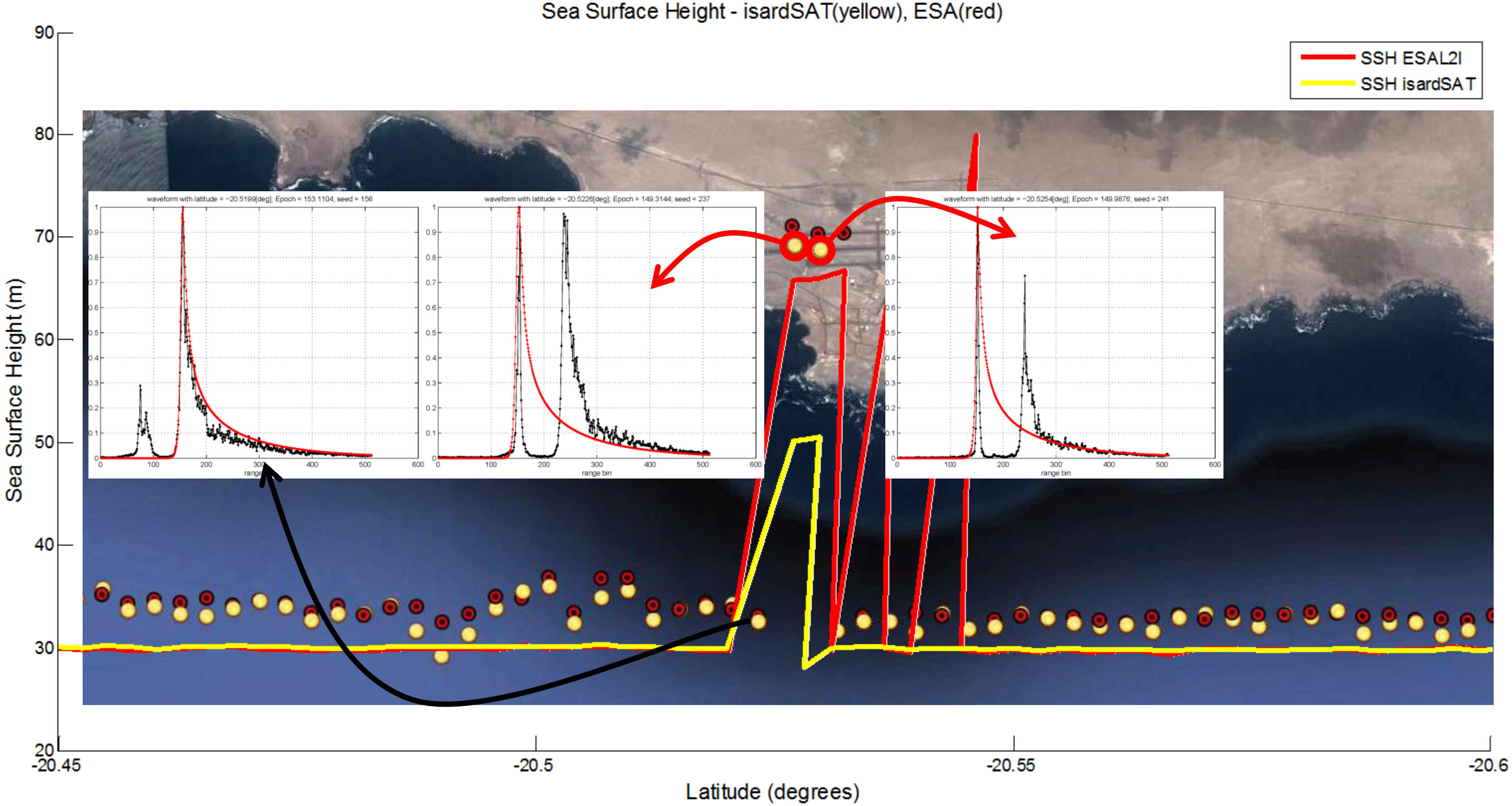


Example 3: CHILE, parallel track wrt to coast line



Phase I results

Example 3: CHILE, parallel track wrt to coast line



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Aim of Phase II work

The aim of this Phase II work is about to improve the Phase I results by:

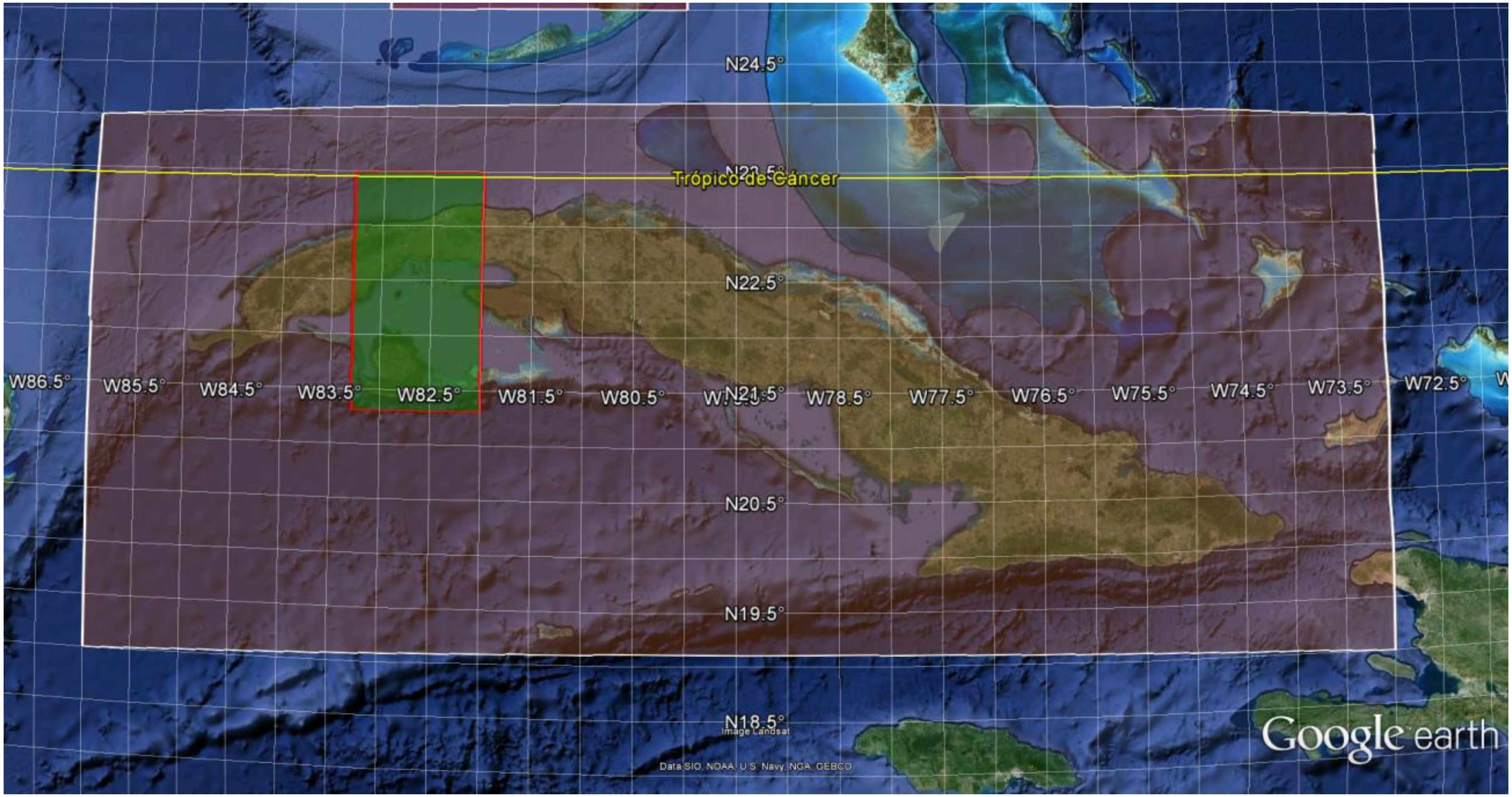
- Modifying the retracker seed production algorithms
- Working on the waveform shape
- Fine tuning of the retracking solution

Extensive assessment of the method’s results in a subset data sample

Produce a test data set to be considered in coastal zones

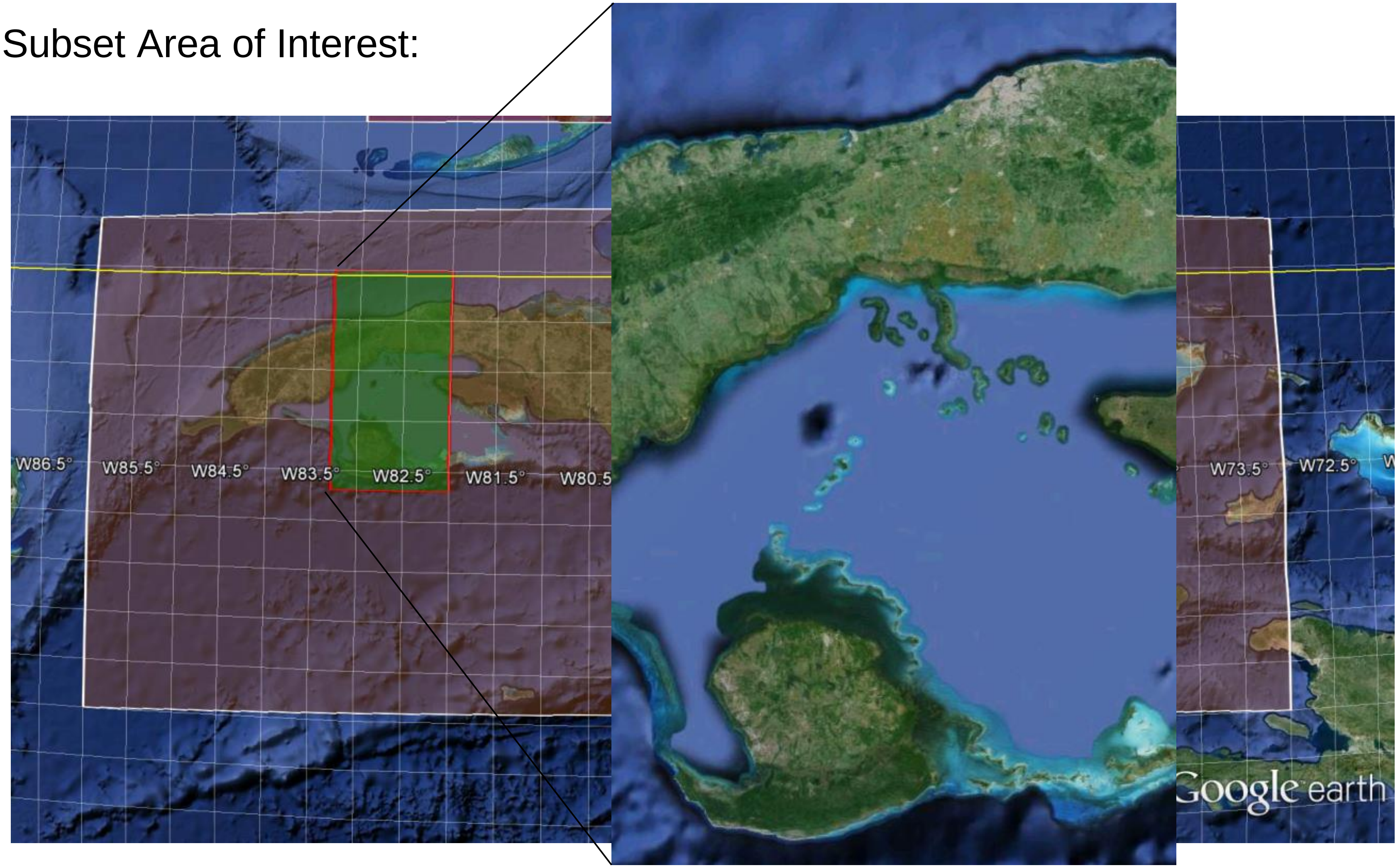
Aim of Phase II work

Subset Area of Interest:



Aim of Phase II work

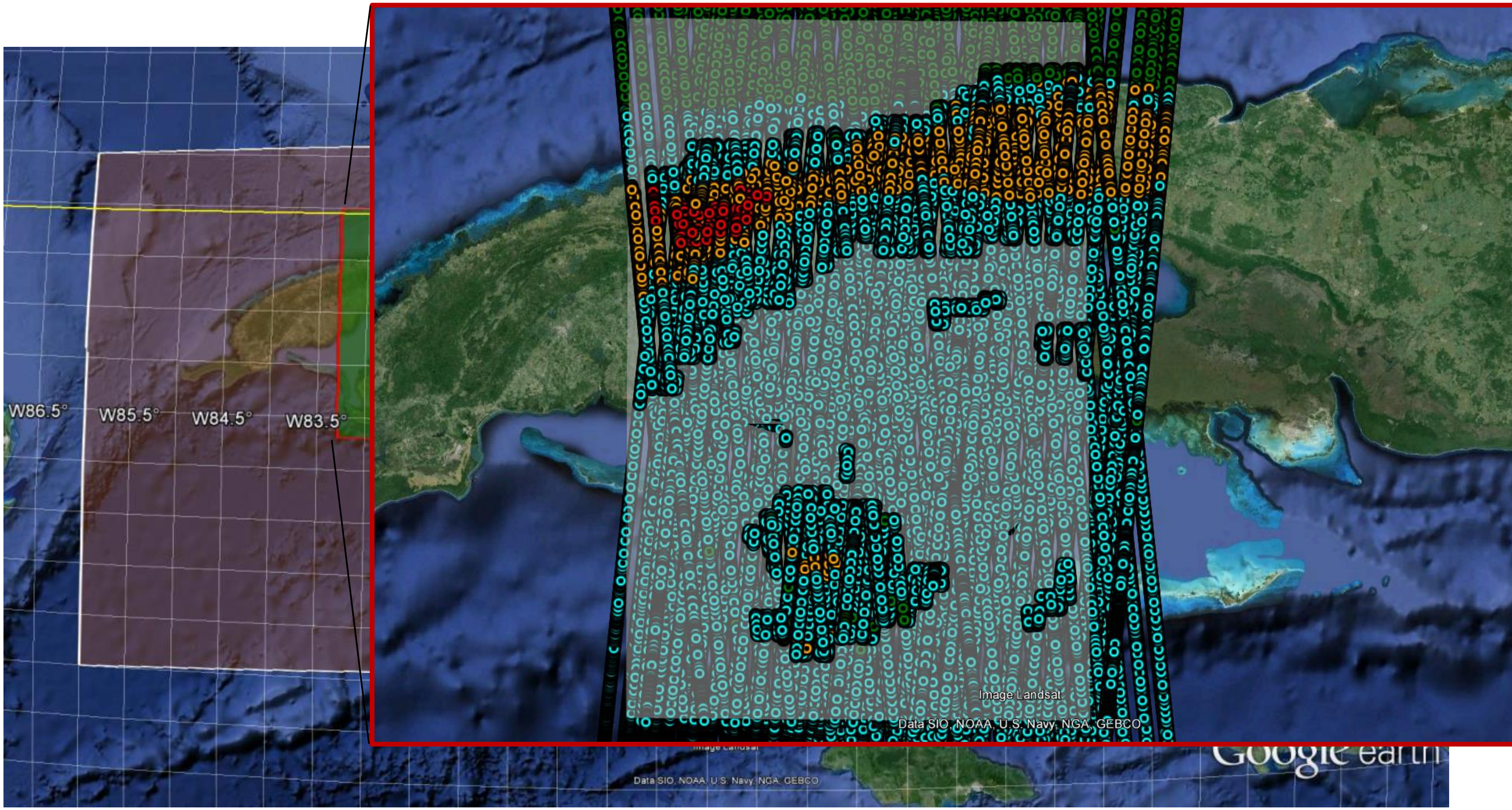
Subset Area of Interest:



Aim of Phase II work

Subset Area of Interest:

104 tracks over the subset area, 46 each cycle:



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Proposed improvement solution (I)

First solution consists in:

- Analysing the AoA waveform and detecting range bins far from Nadir
- Avoiding off-Nadir range bins (waveform gaps) by interpolating them
- Retracking the new rebuilt waveform

Results:

- Good results in waveforms with clear interferences far from the ocean echo
- Undesired results in more contaminated ocean waveforms (some waveforms are too much degraded after interpolation)

Proposed improvement solution (II)

Second solution consists in:

- Analysing the 3 SARin waveforms and detecting range bin closest to Nadir with coherent and high power return → seed
- Selecting a number of range bins around the seed (cut the waveform: 25 before the seed, 10 after the seed)
- Adapt the retracking routine for retracking only the selected waveform section

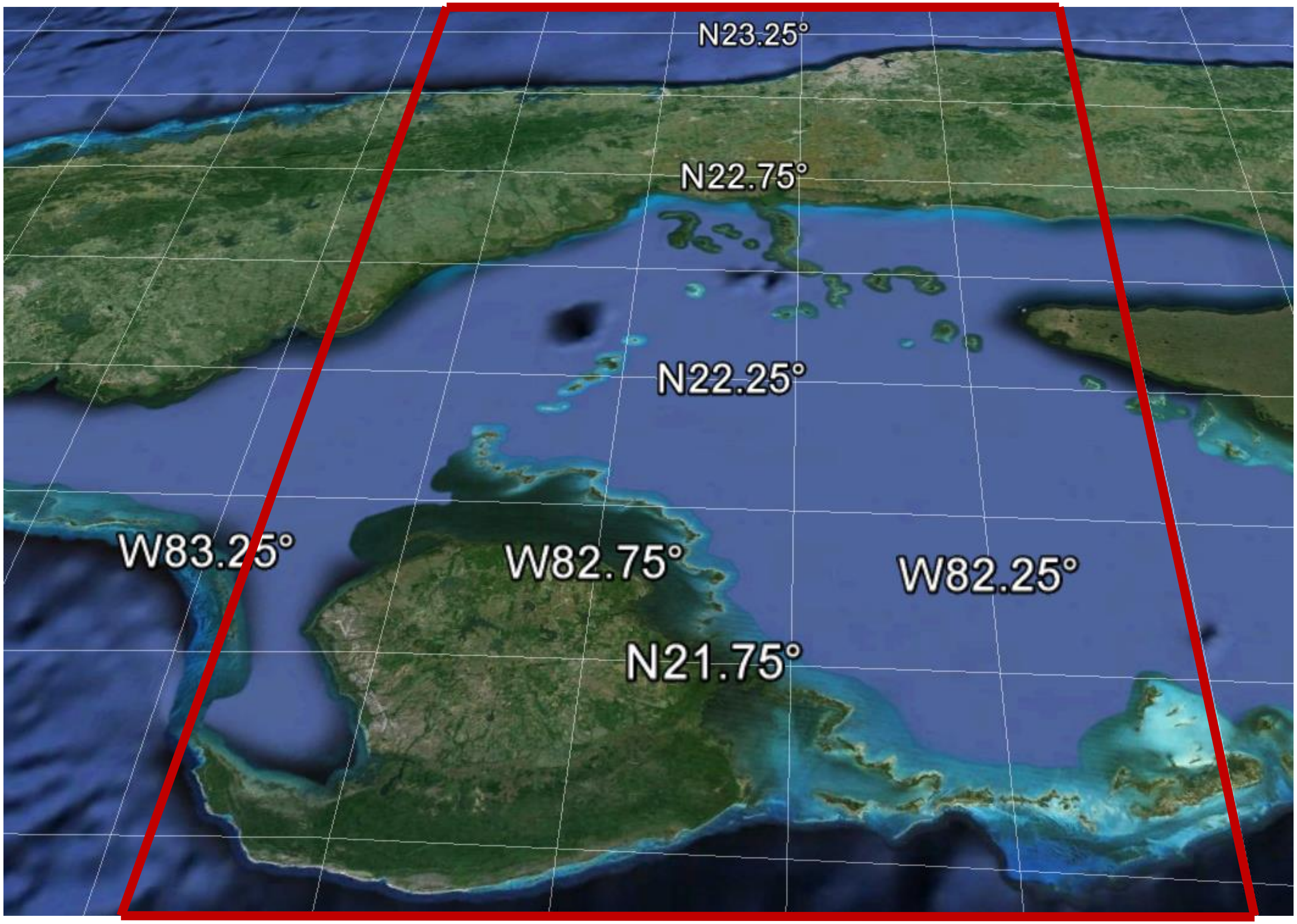
Results:

- Good results in waveforms with clear interferences far from the ocean echo
- Improved results in contaminated ocean waveforms wrt to first approach
- But …

Proposed improvement solution (II)

Results:

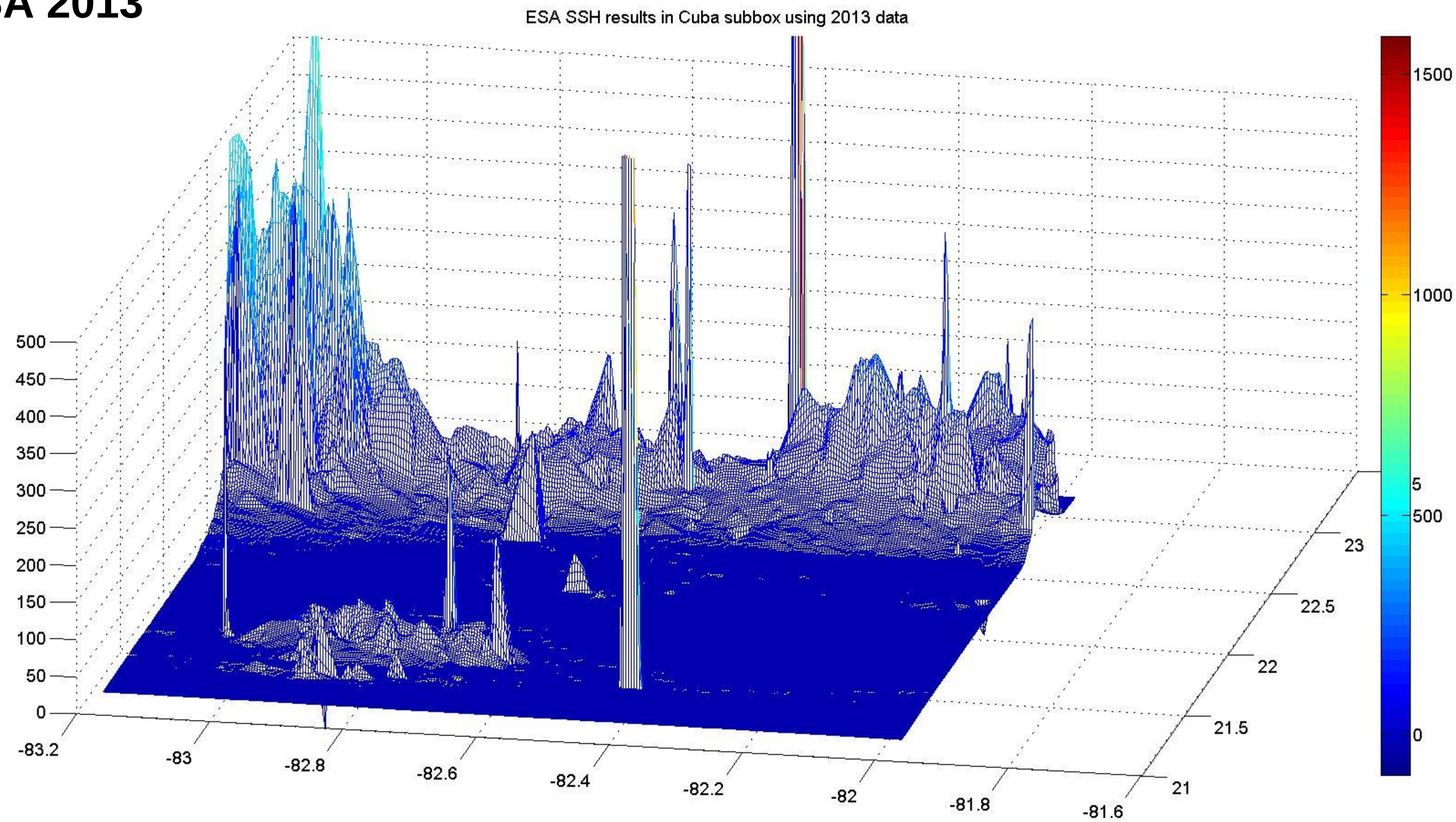
AoI



Proposed improvement solution (II)

Results:

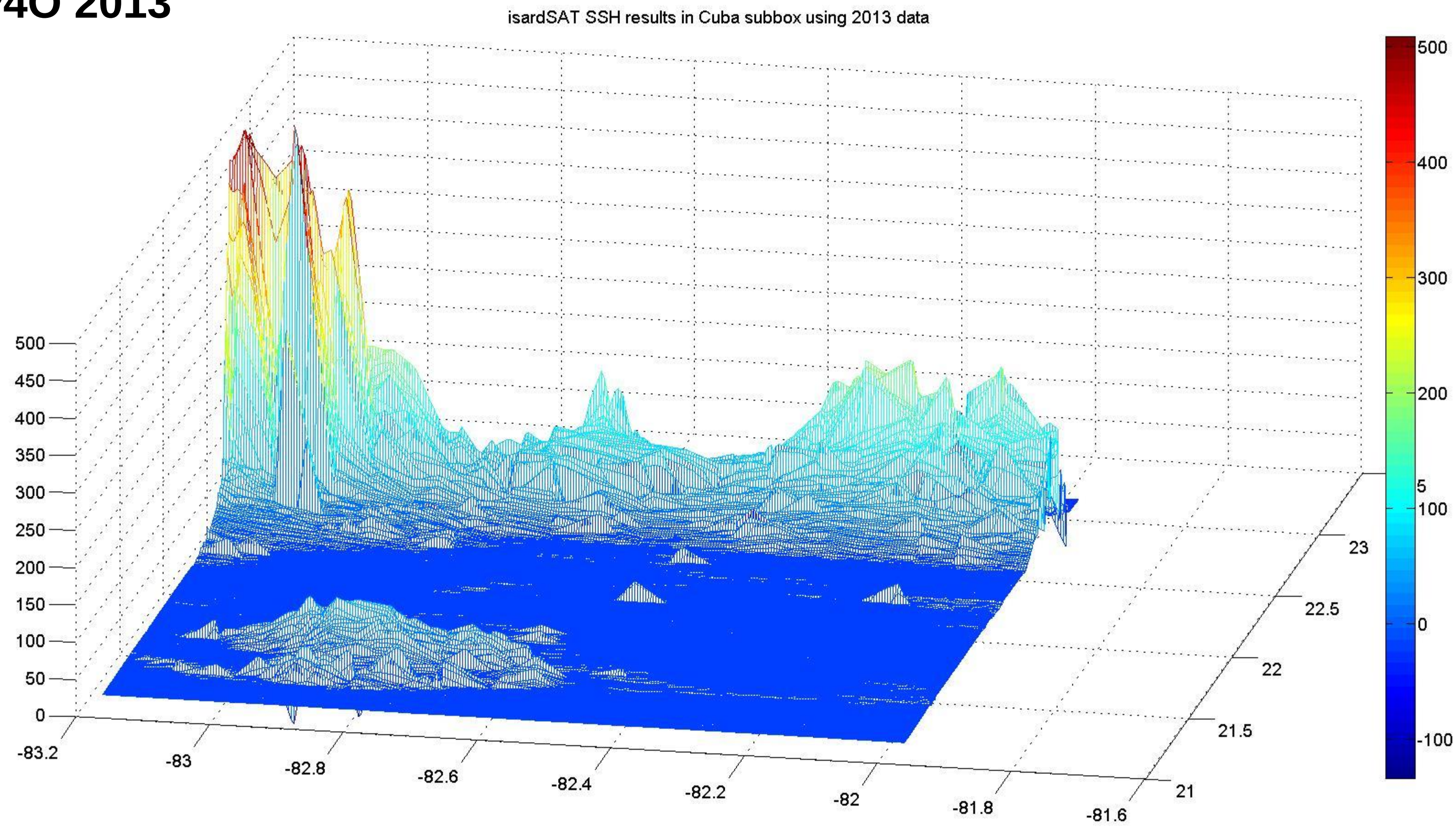
ESA 2013



Proposed improvement solution (II)

Results:

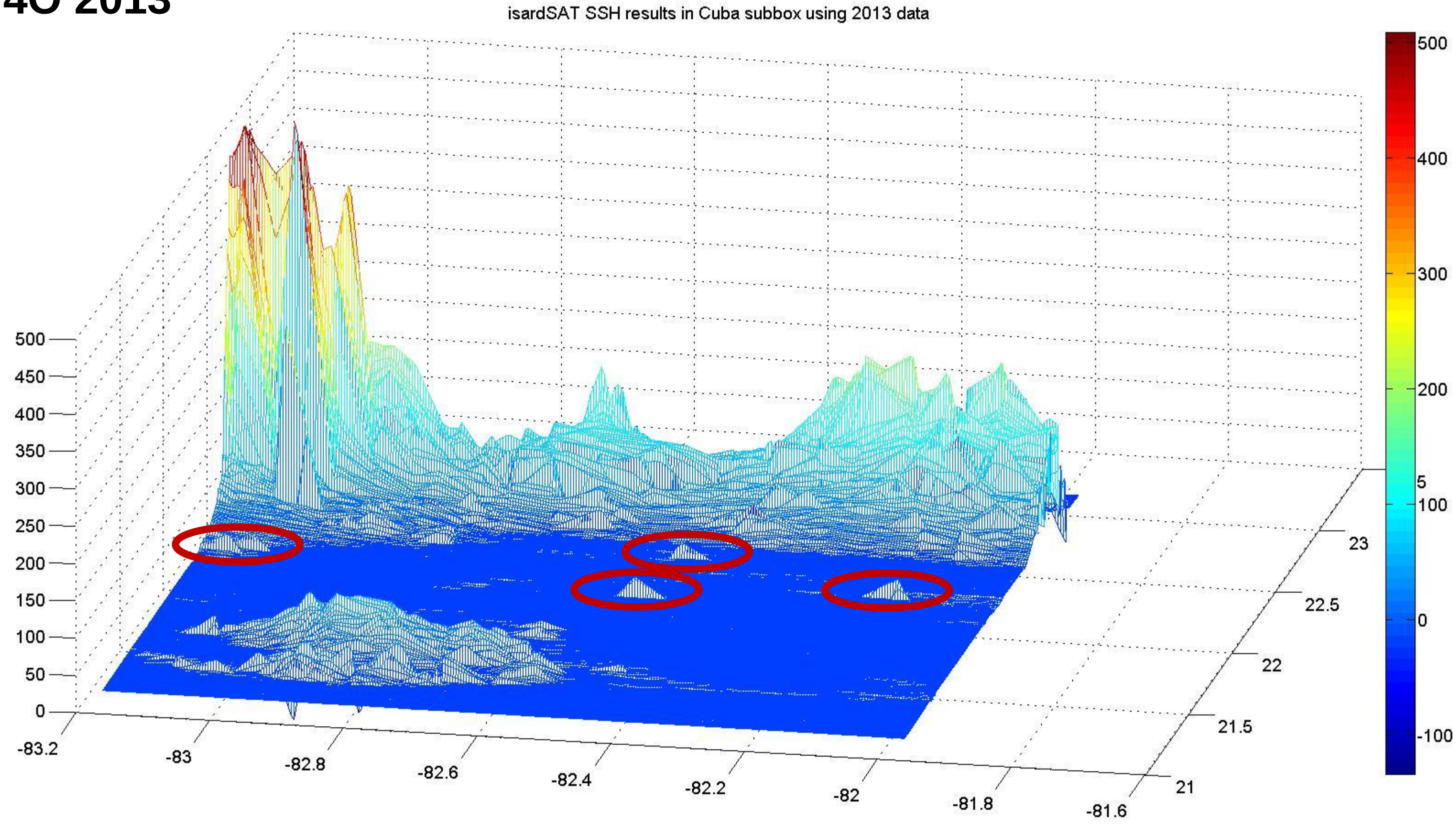
CP4O 2013



Proposed improvement solution (II)

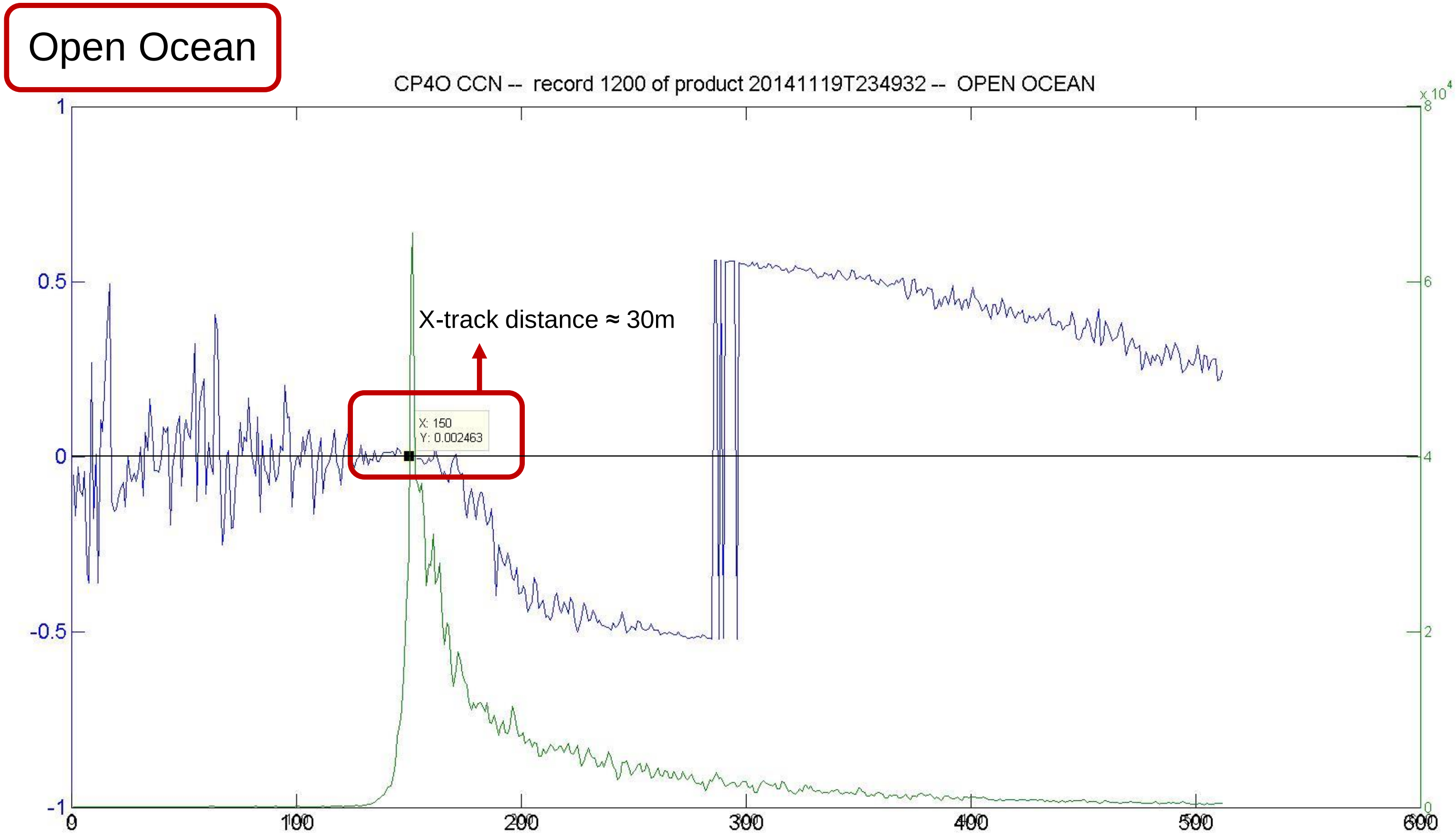
Results:

CP4O 2013



Proposed improvement solution (II)

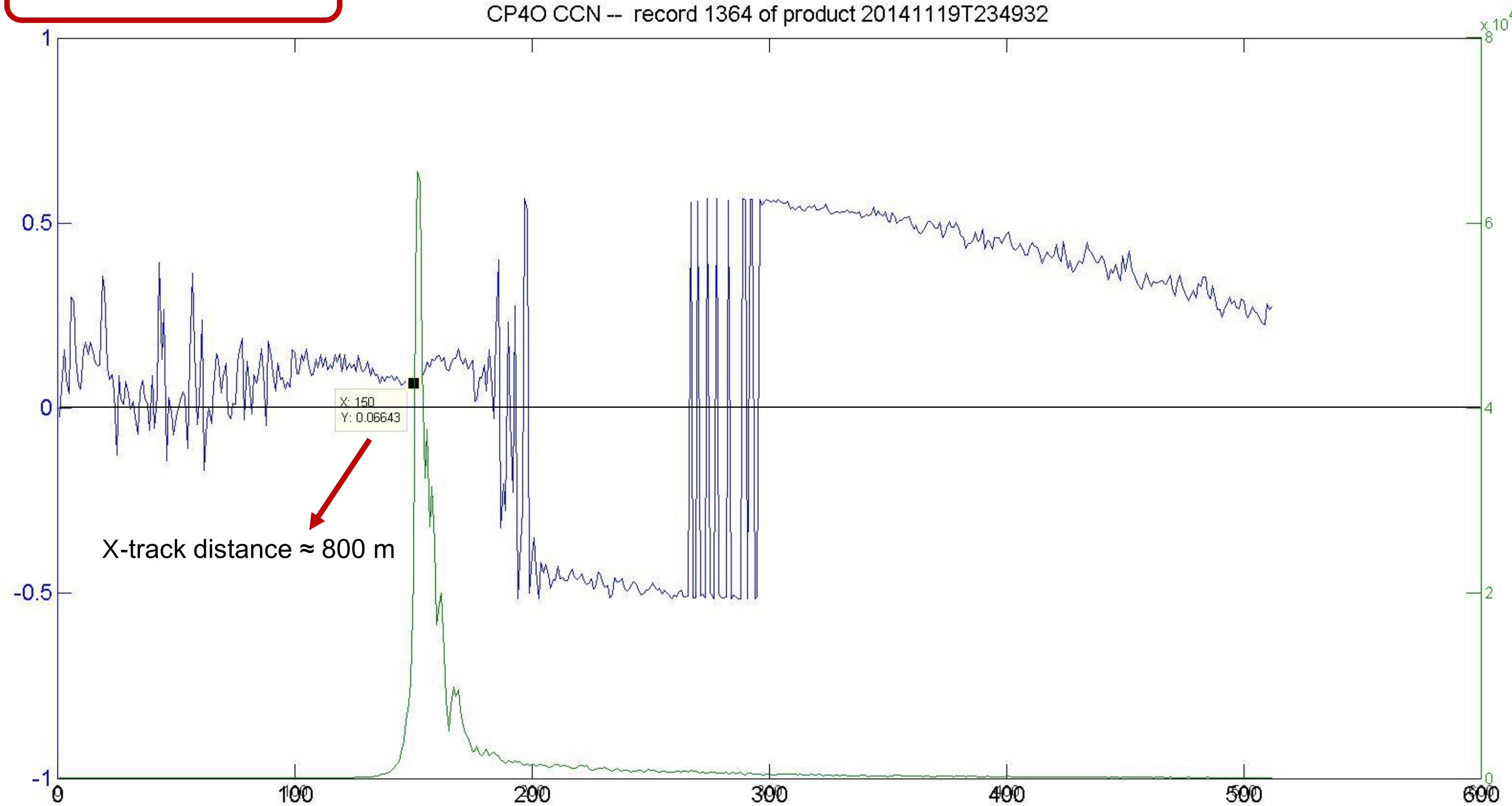
AoA problems: noisy data and sometimes not reliable in coastal zones



Proposed improvement solution (II)

AoA problems: noisy data and sometimes not reliable in coastal zones

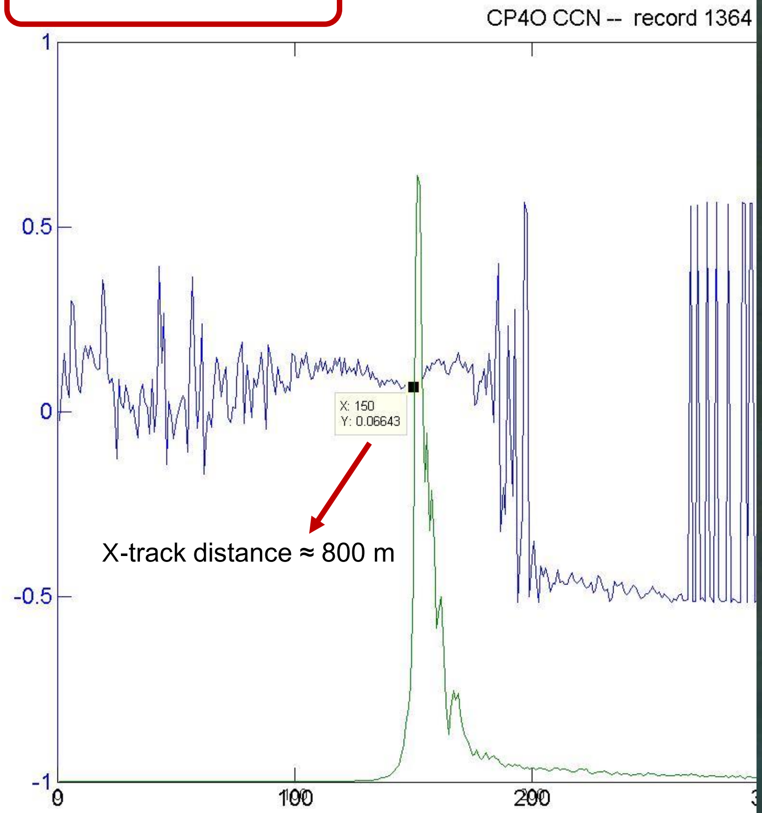
Coastal Ocean



Proposed improvement solution (II)

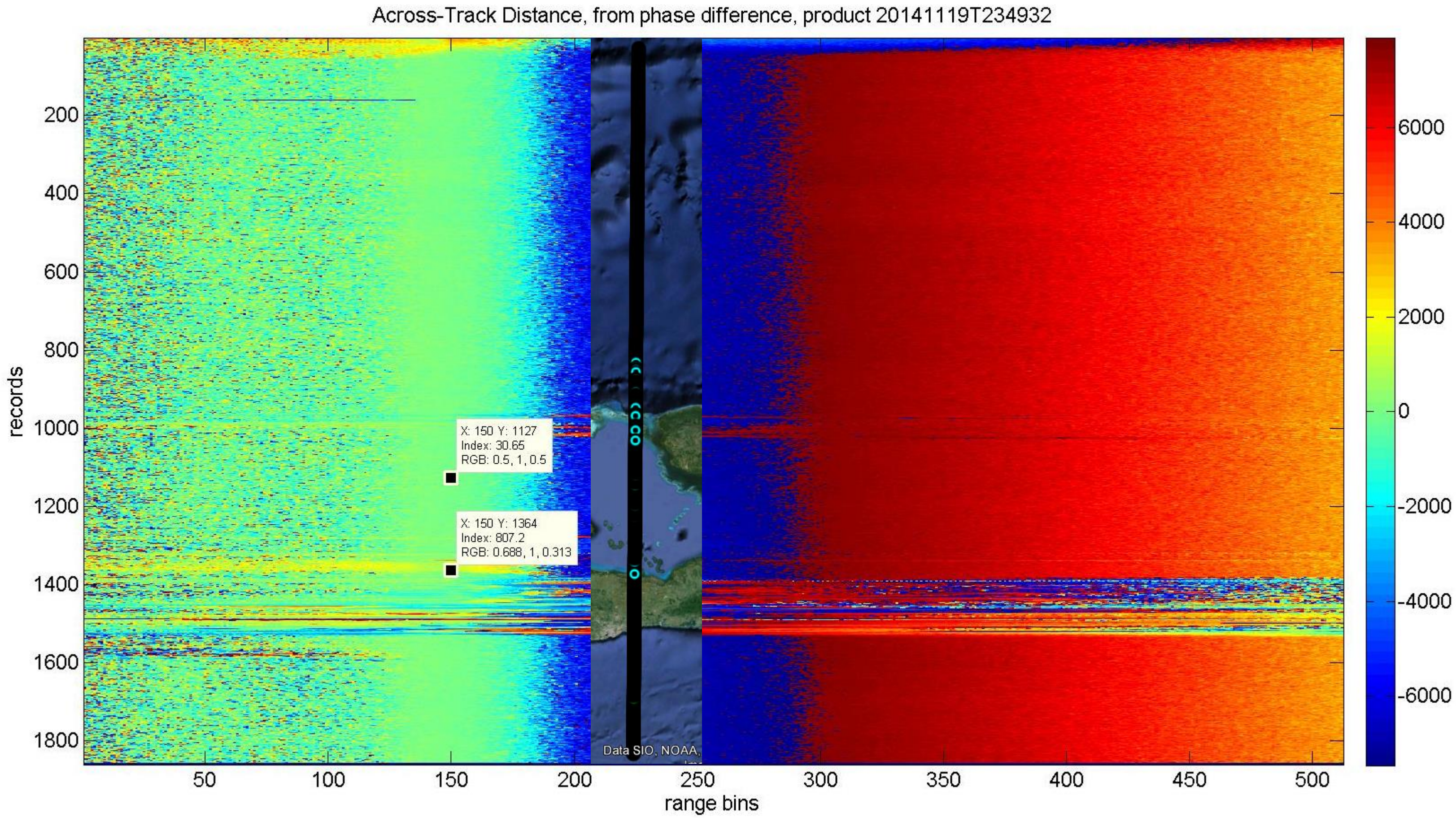
AoA problems: noisy data and sometim

Coastal Ocean



Proposed improvement solution (II)

AoA problems: noisy and sometimes not reliable data



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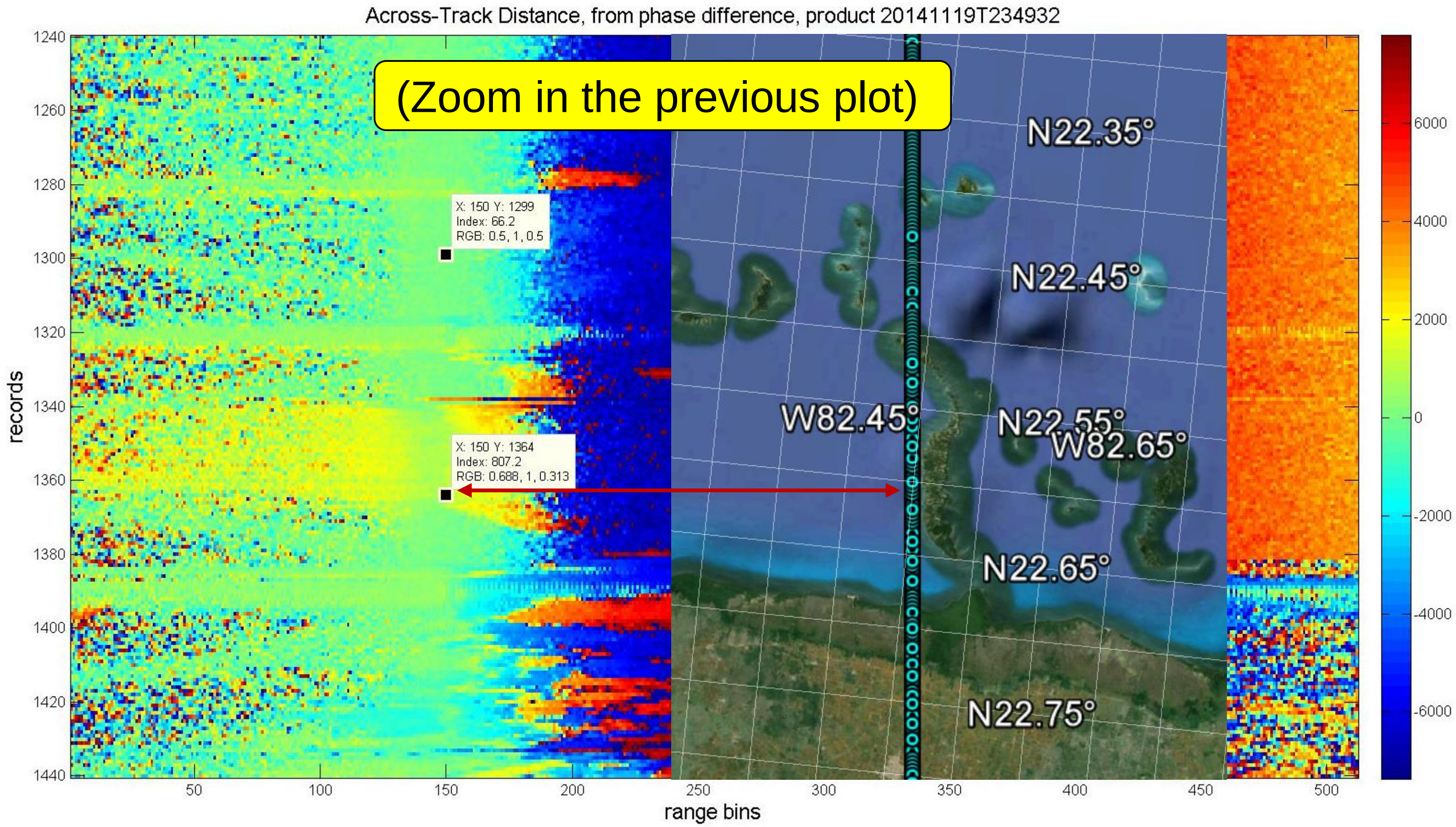
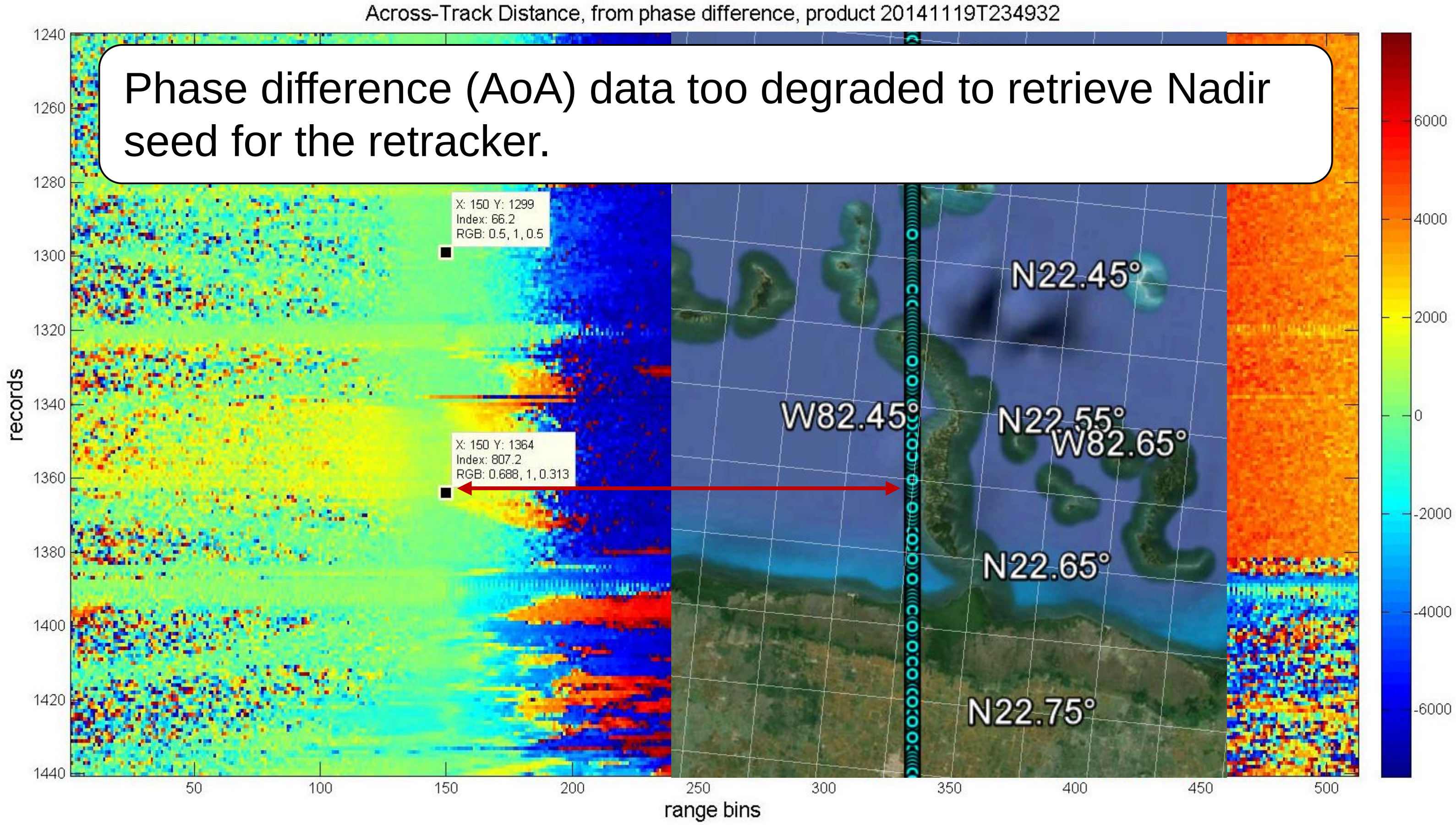
AoA problems: noisy and sometimes not reliable data



Proposed improvement solution (II)

AoA problems: noisy and sometimes not reliable data



Proposed improvement solution (III): New solution for every modes

This third solution follows a **different approach**, not based in the SARin AoA data, but taking advantage of the previous algorithms.

Hence, it could work for all modes (also SAR and LRM), and for all altimeters (need of adapting the processing for each mission case).

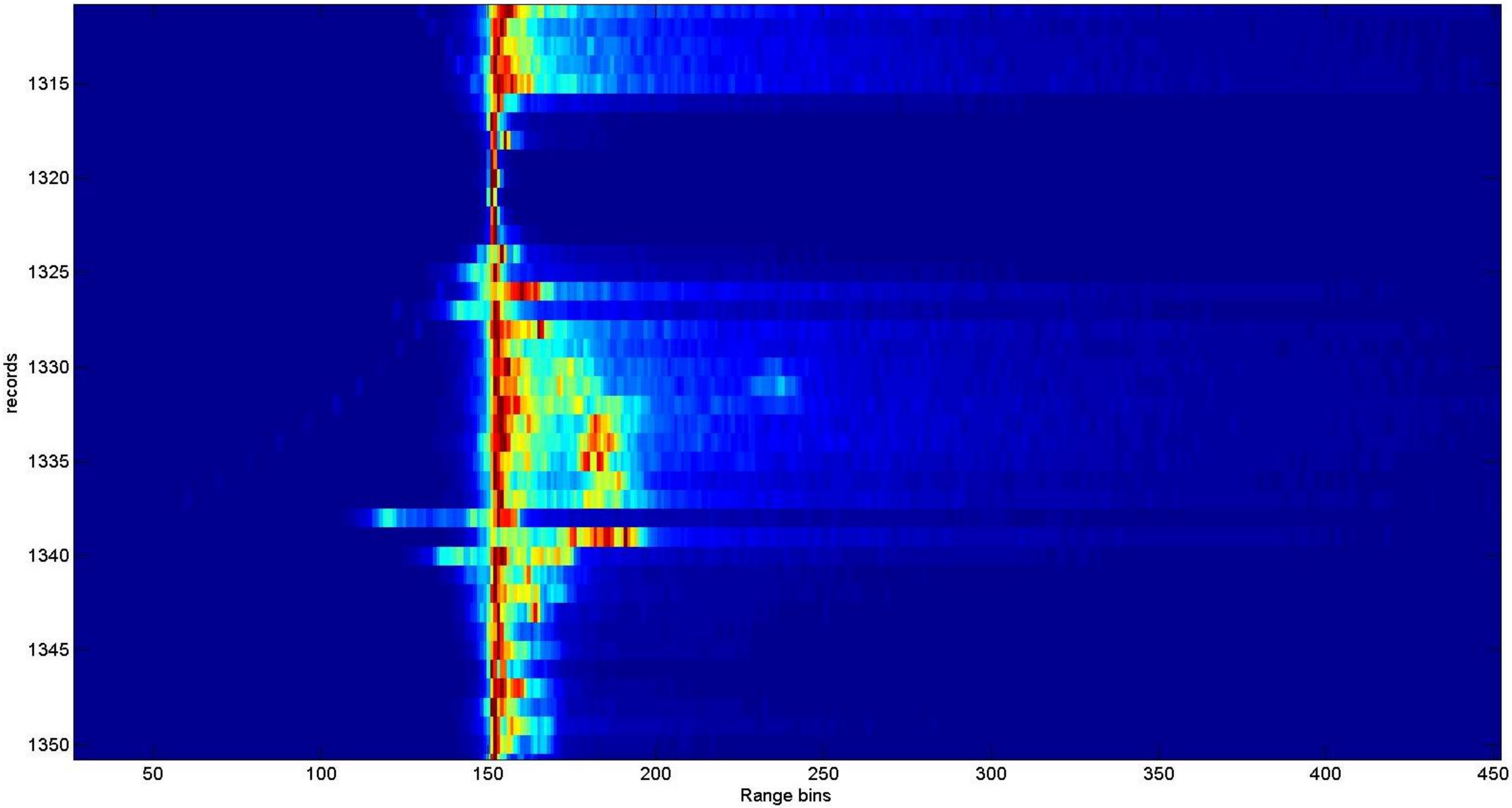
The third solution consists in:

- Analysing the **Window Delay** behavior along the track for avoiding jumps while over the ocean (open or coastal)
- Cutting the waveforms around the stable Window Delay driven potential LEP.
- Retracking the new “cut waveform”

Proposed improvement solution (III): New solution for every modes

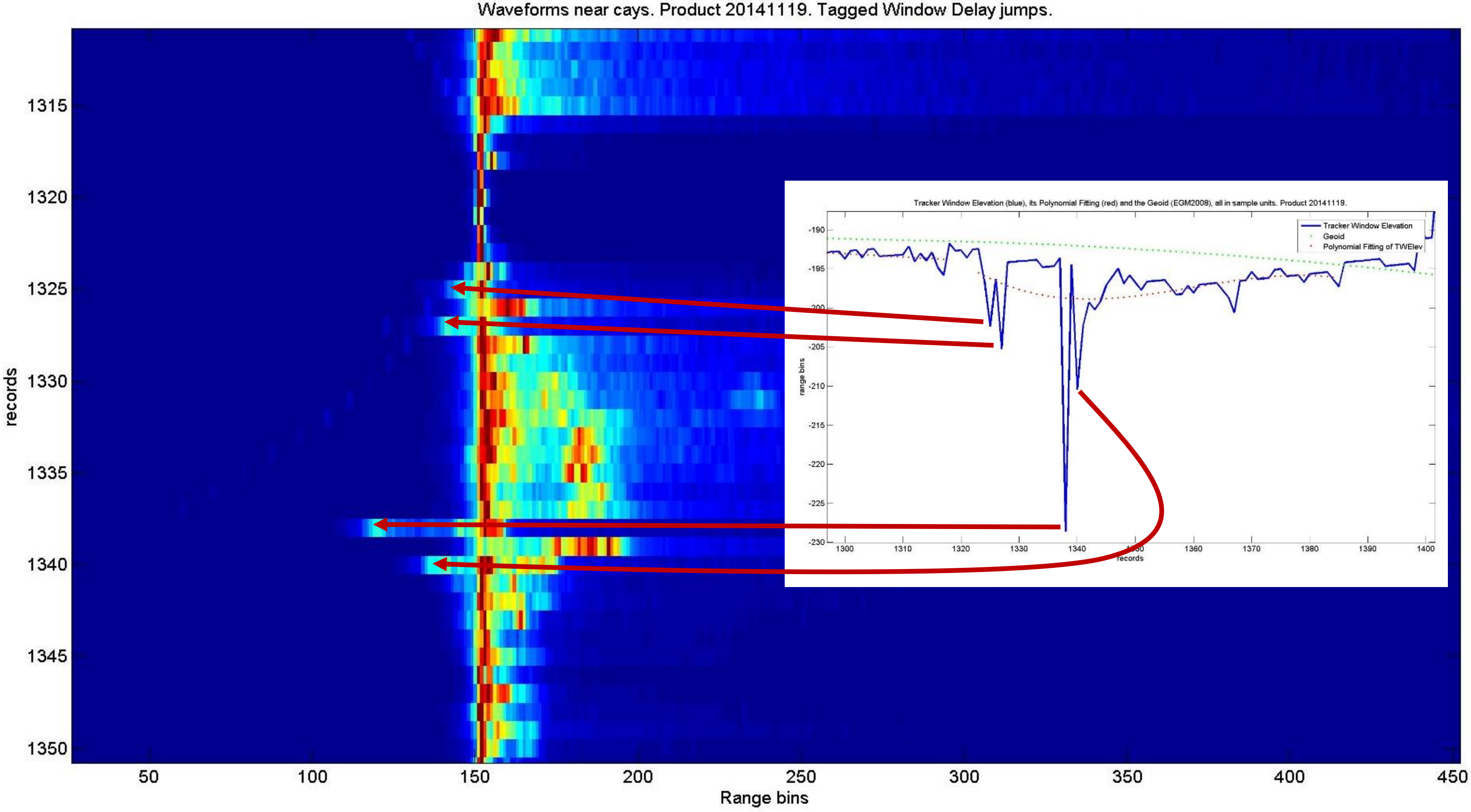
Example of Window Delay jumps in a single track:

Waveforms near cays. Product 20141119. Tagged Window Delay jumps.



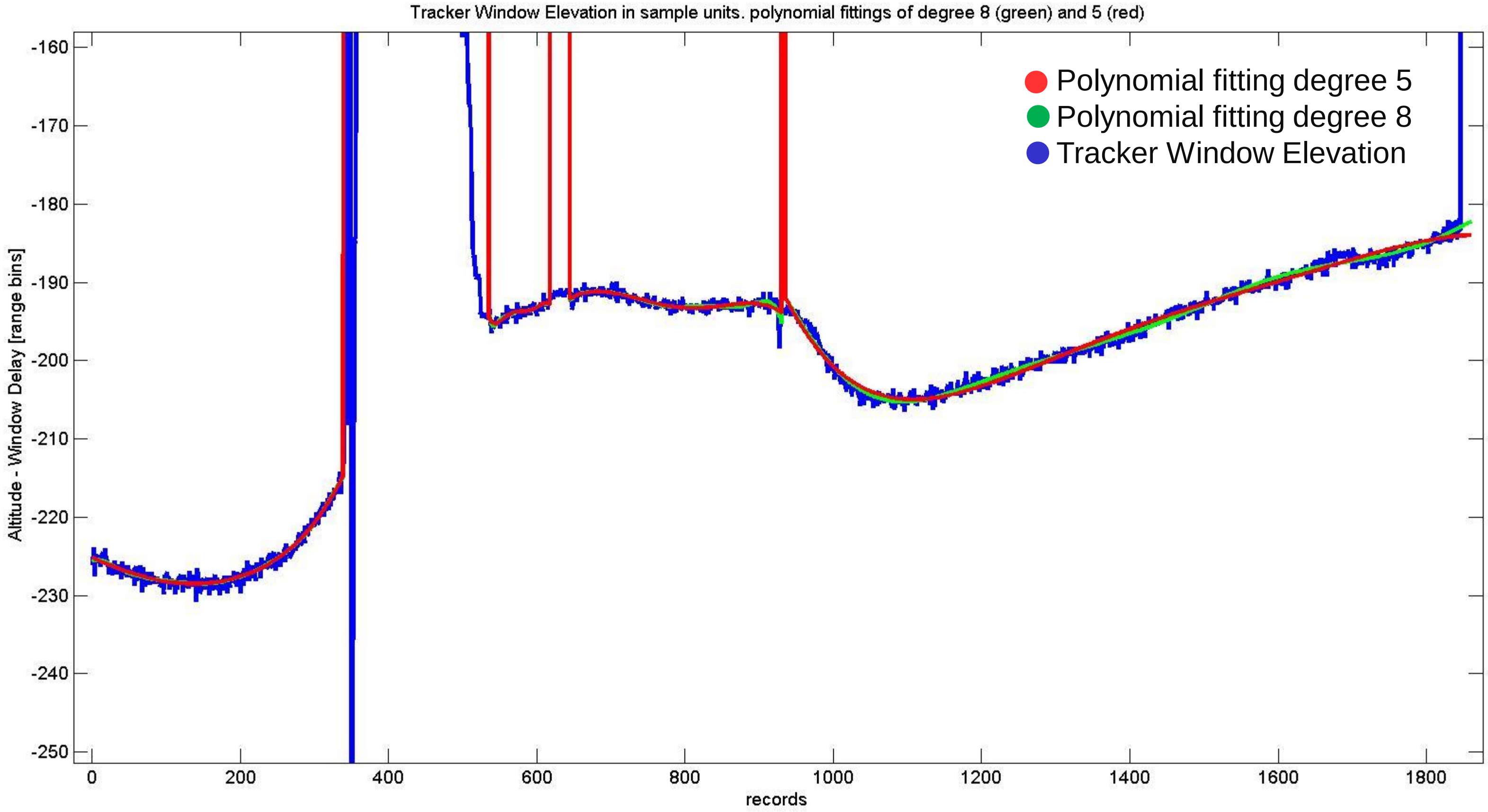
Proposed improvement solution (III): New solution for every modes

Example of Window Delay jumps in a single track:



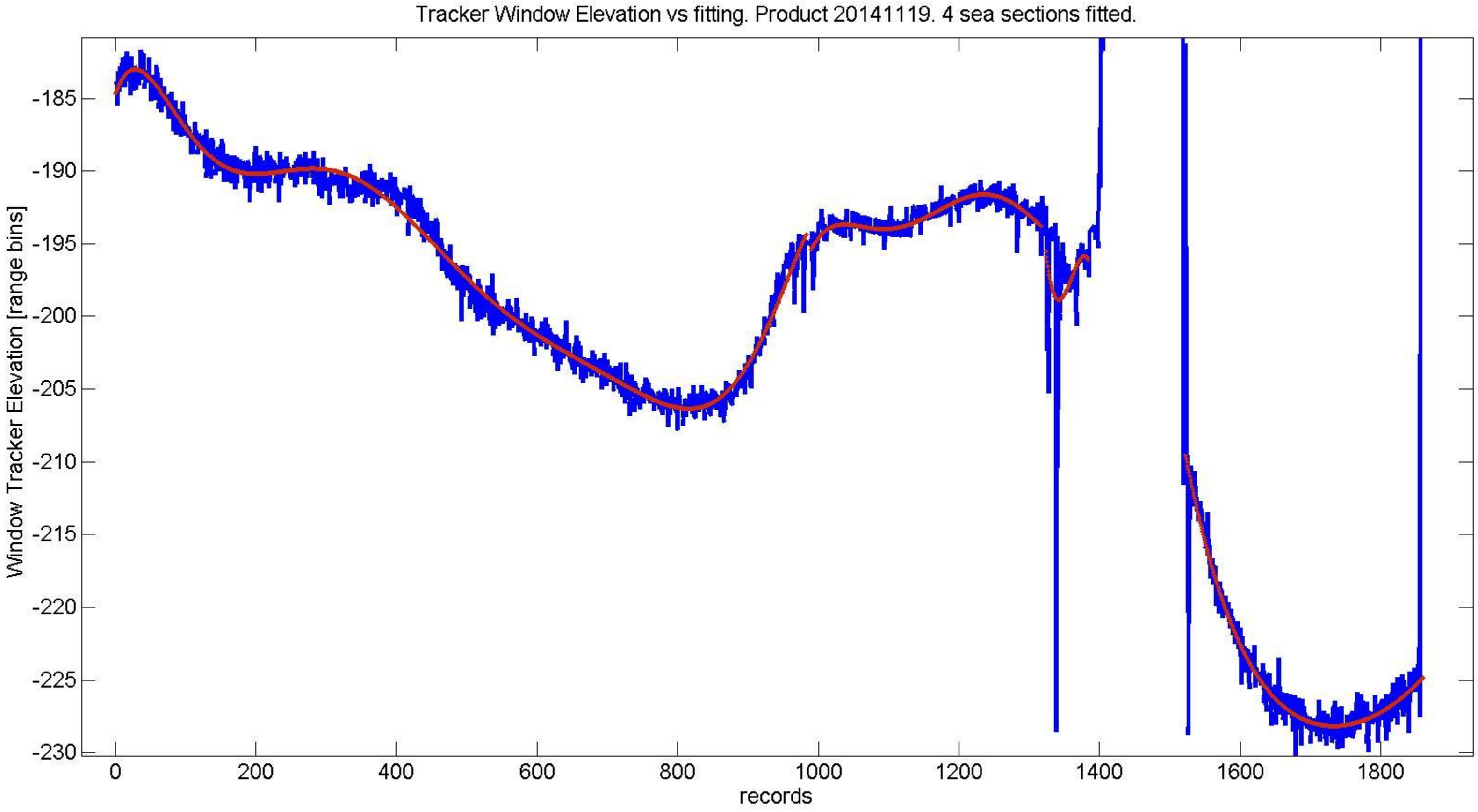
Proposed improvement solution (III): New solution for every modes

Polynomial fitting of each Window Delay sea section along track (which polyfit degree?)



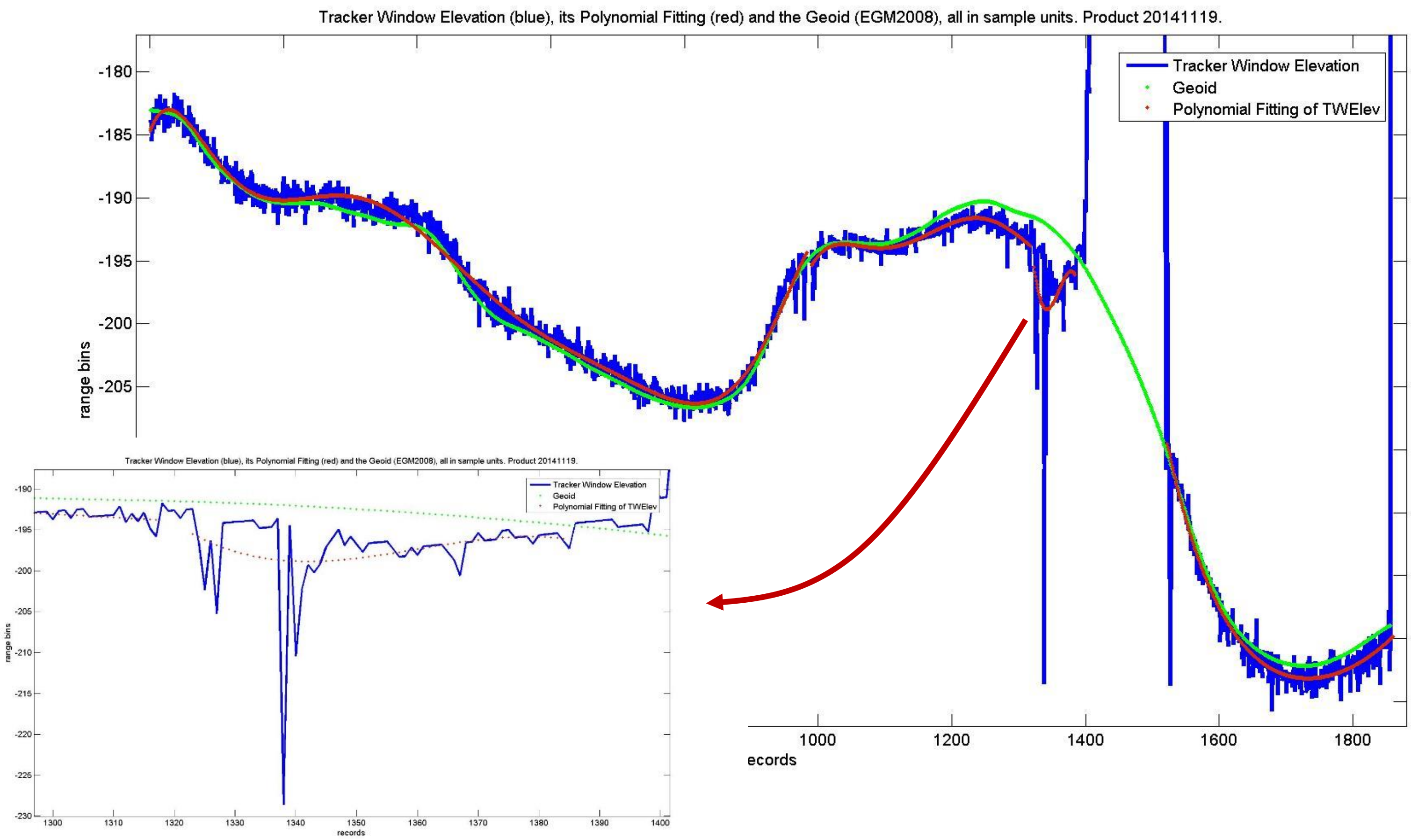
Proposed improvement solution (III): New solution for every modes

Polynomial fitting of each Window Delay sea section along track **(dynamic polyfit degree)**



Proposed improvement solution (III): New solution for every modes

What about following the Geoid? (more stable, good for noisy short sea sections)



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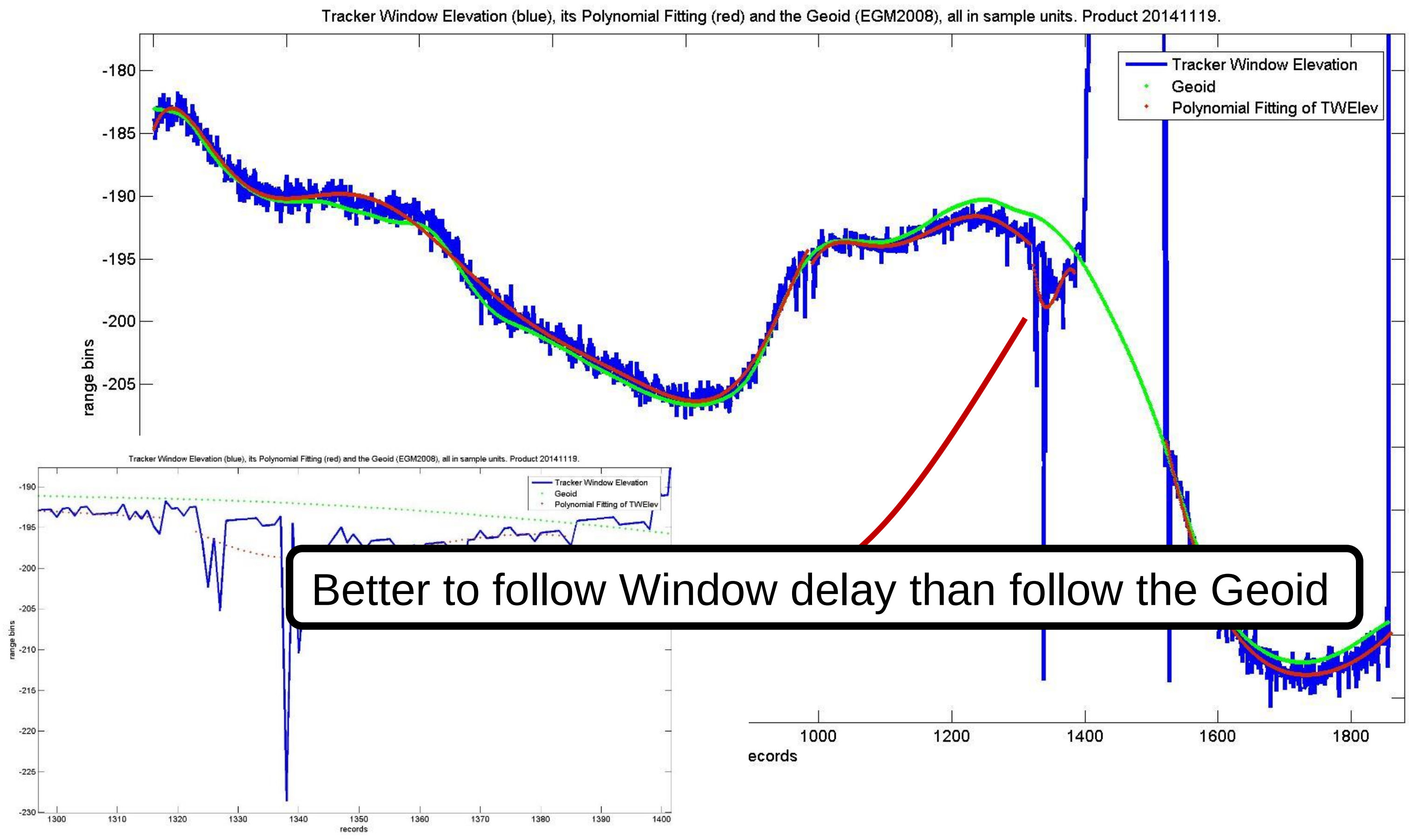
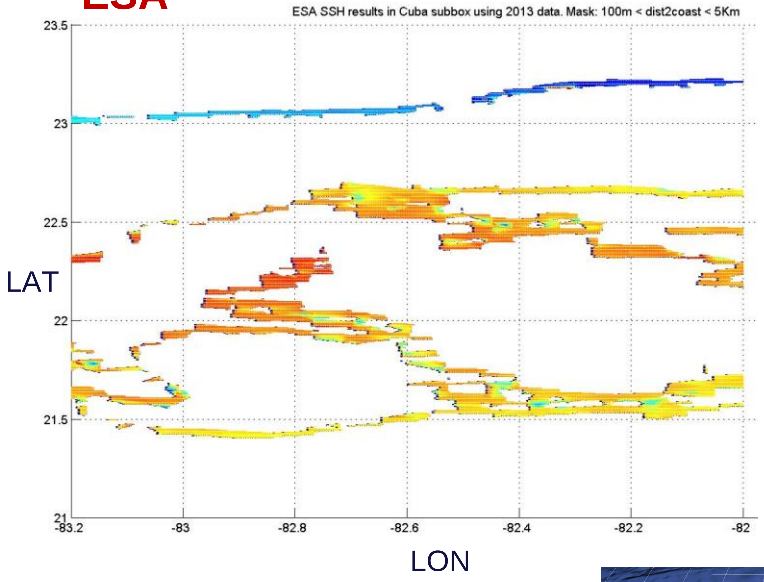


Proposed improvement solution (III): New solution for every modes

New SSH figures: Only Coastal SSH retrievals (100m to 5Km offshore)

ESA



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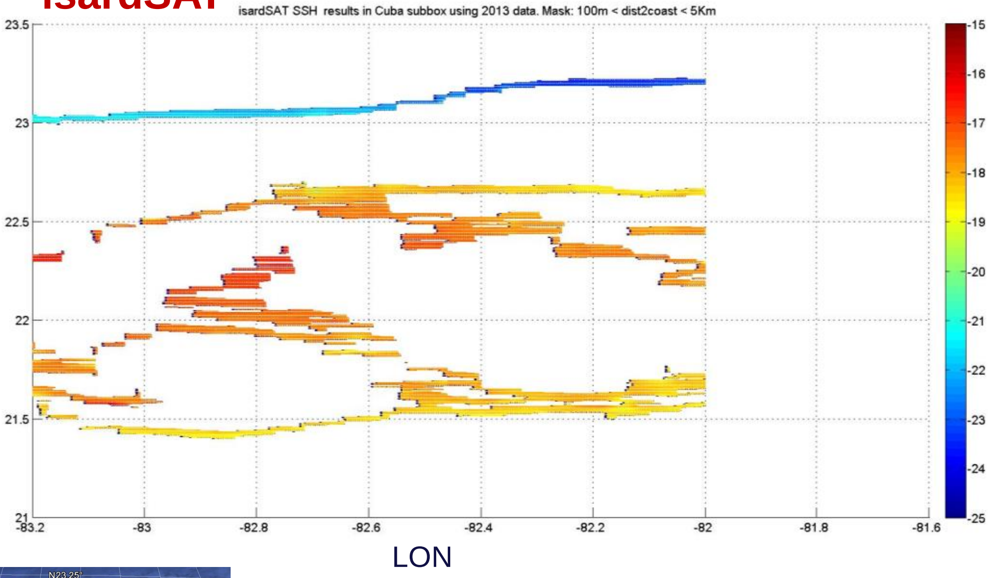

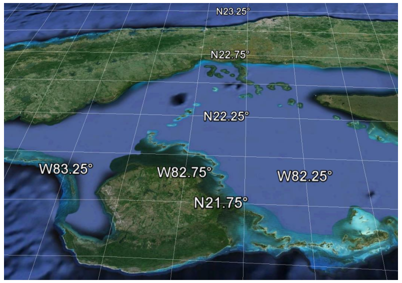

Proposed improvement solution (III): New solution for every modes

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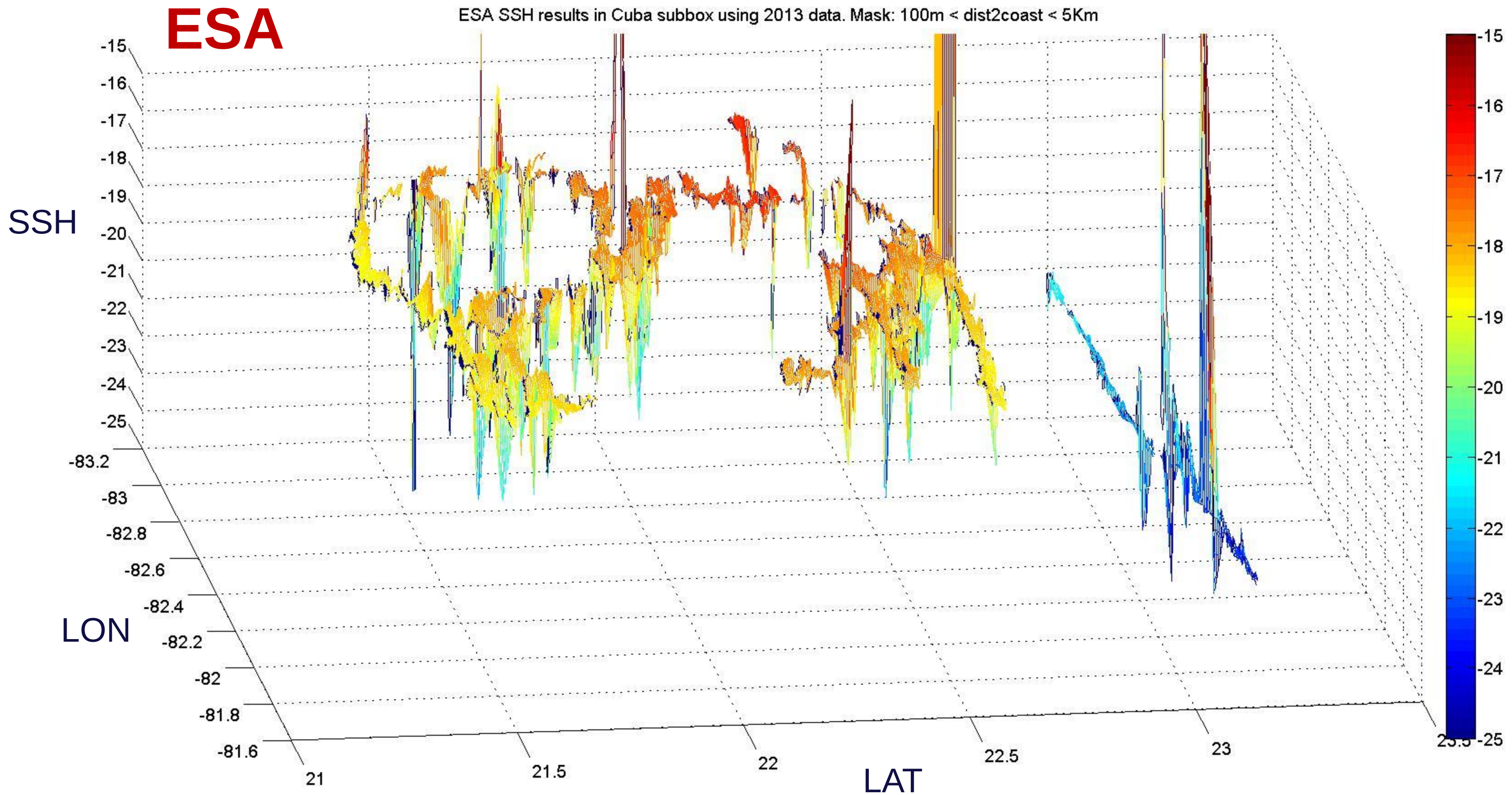
New figures: Only Coastal SSH retrievals (100m to 5Km offshore)



Proposed improvement solution (III): New solution for every modes

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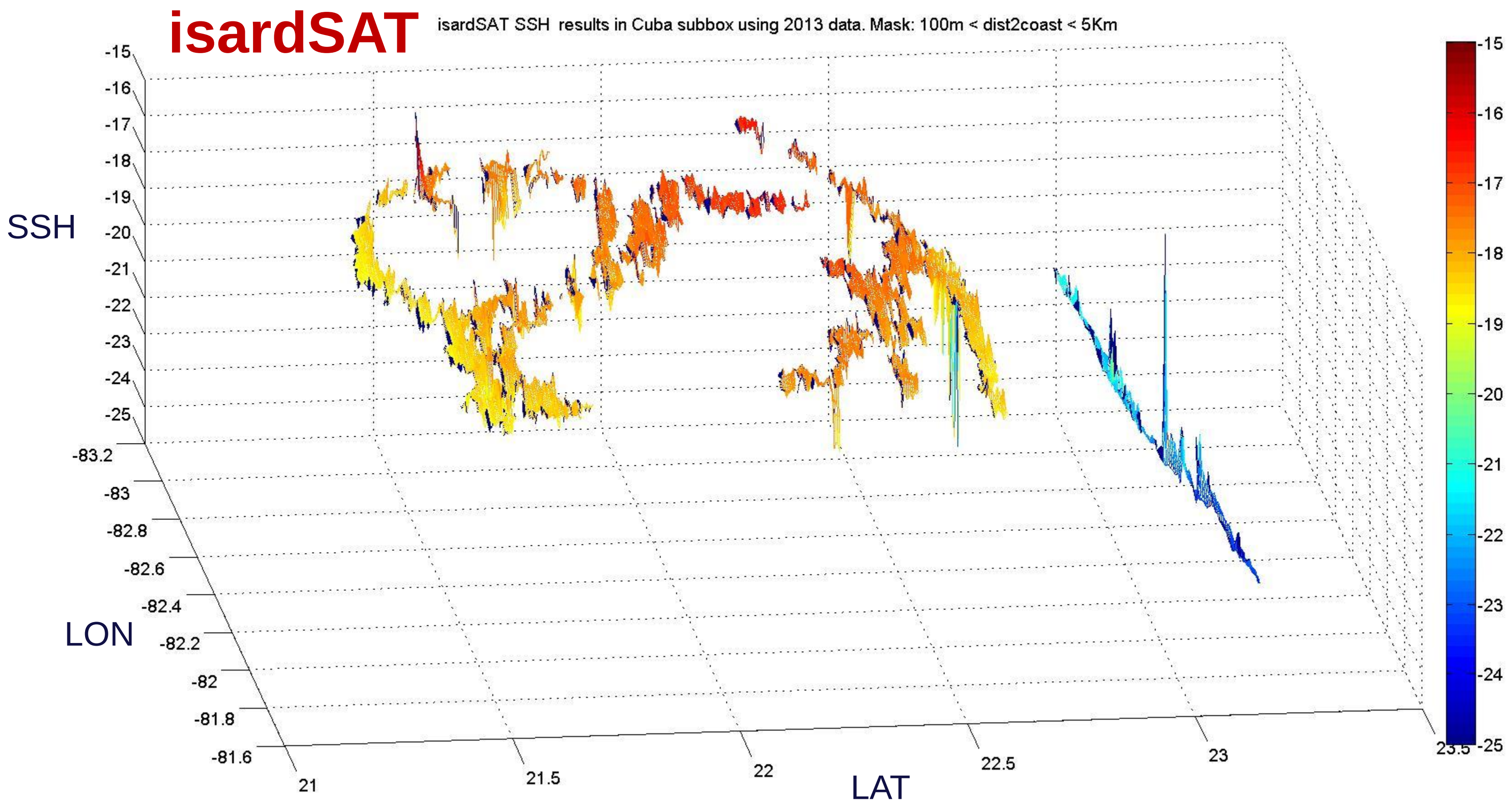
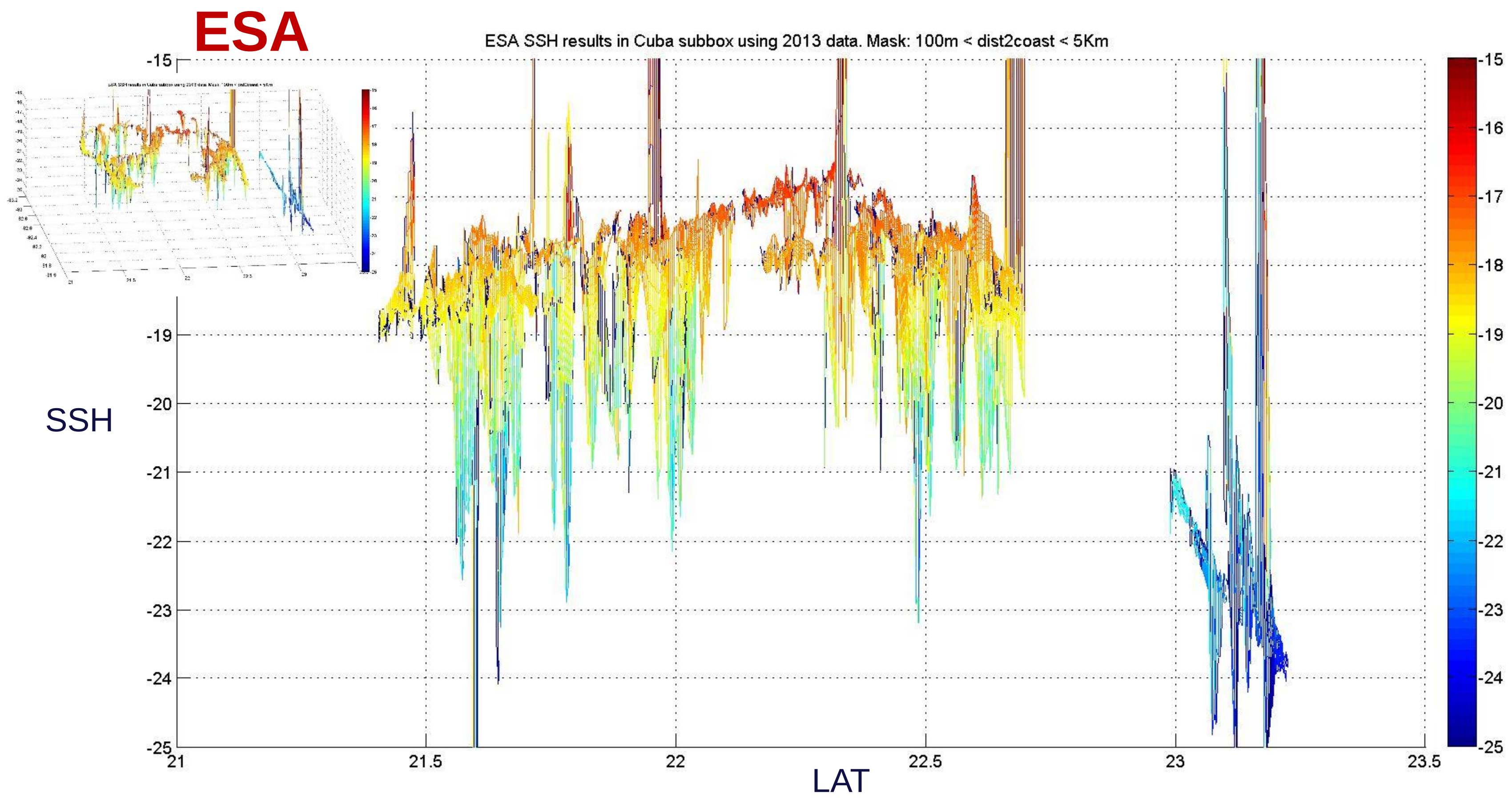


Proposed improvement solution (III): New solution for every modes

New figures: Only Coastal SSH retrievals (100m to 5Km offshore)



Proposed improvement solution (III): New solution for every modes

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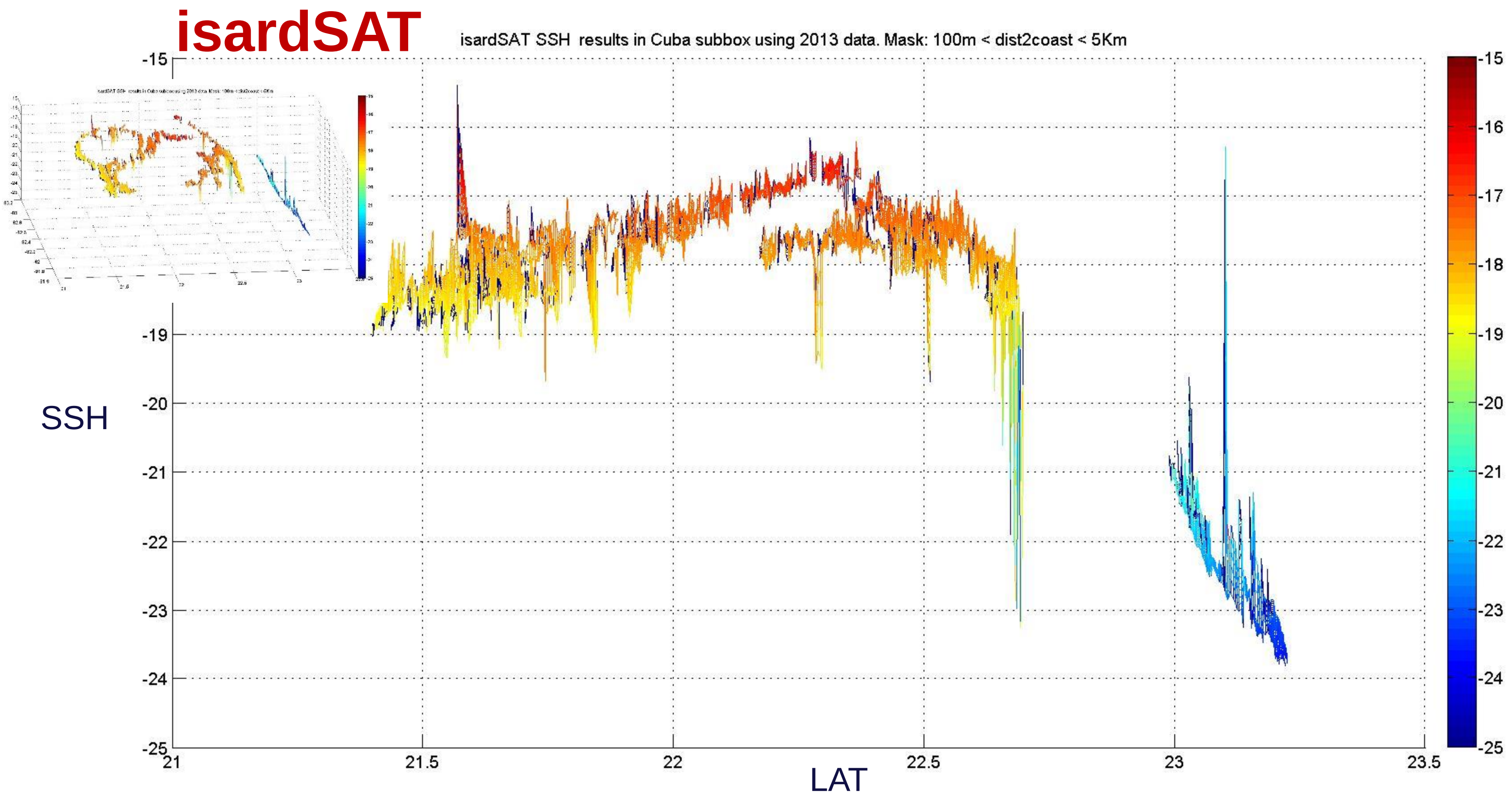


Proposed improvement solution (III): Assessment

Statistics of improvement

Overall standard deviation of the dataset:

Comparison of overall SSH standard deviation	
ESA dataset	**CP4O dataset**
2.6985 m	1.5671 m

Individual track sections standard deviation:

Averaged SSH stdev by track section	
ESA dataset	**CP4O dataset**
0.5819 m	0.2345 m

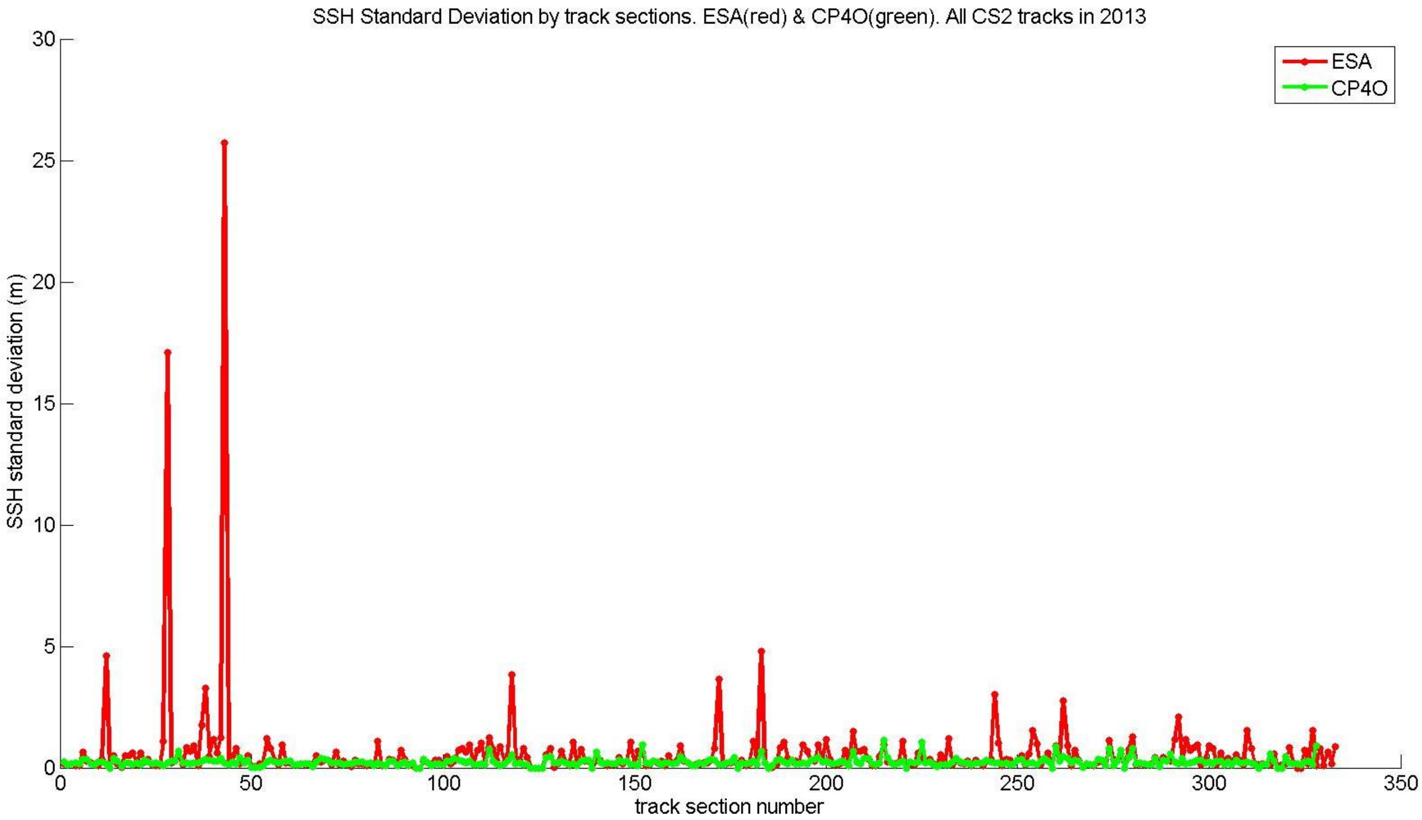
(more than 300 track sections)

→ **59,7% IMPROVEMENT**

Proposed improvement solution (III): Assessment

Statistics of improvement

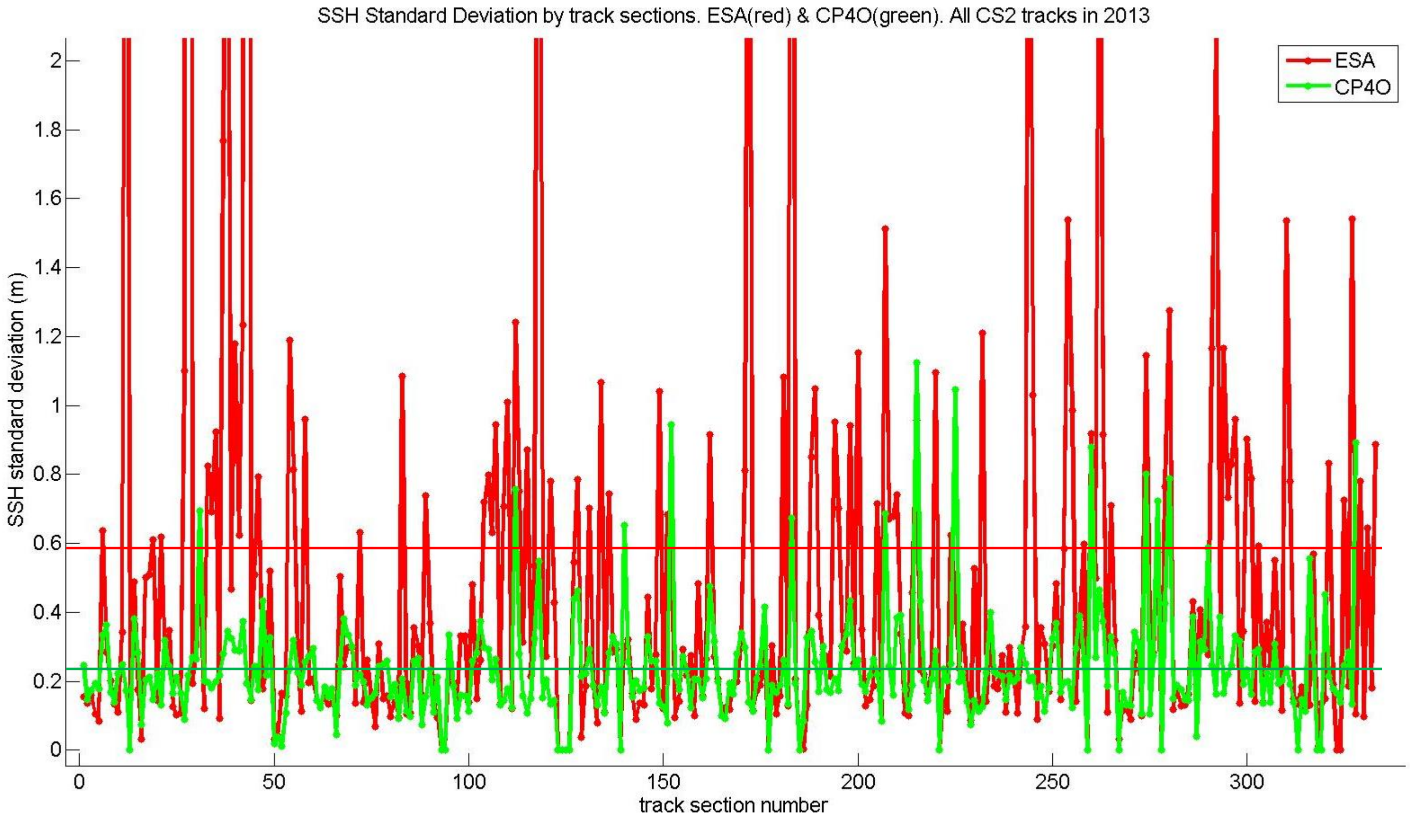
Individual track sections standard deviation:



Proposed improvement solution (III): Assessment

Statistics of improvement

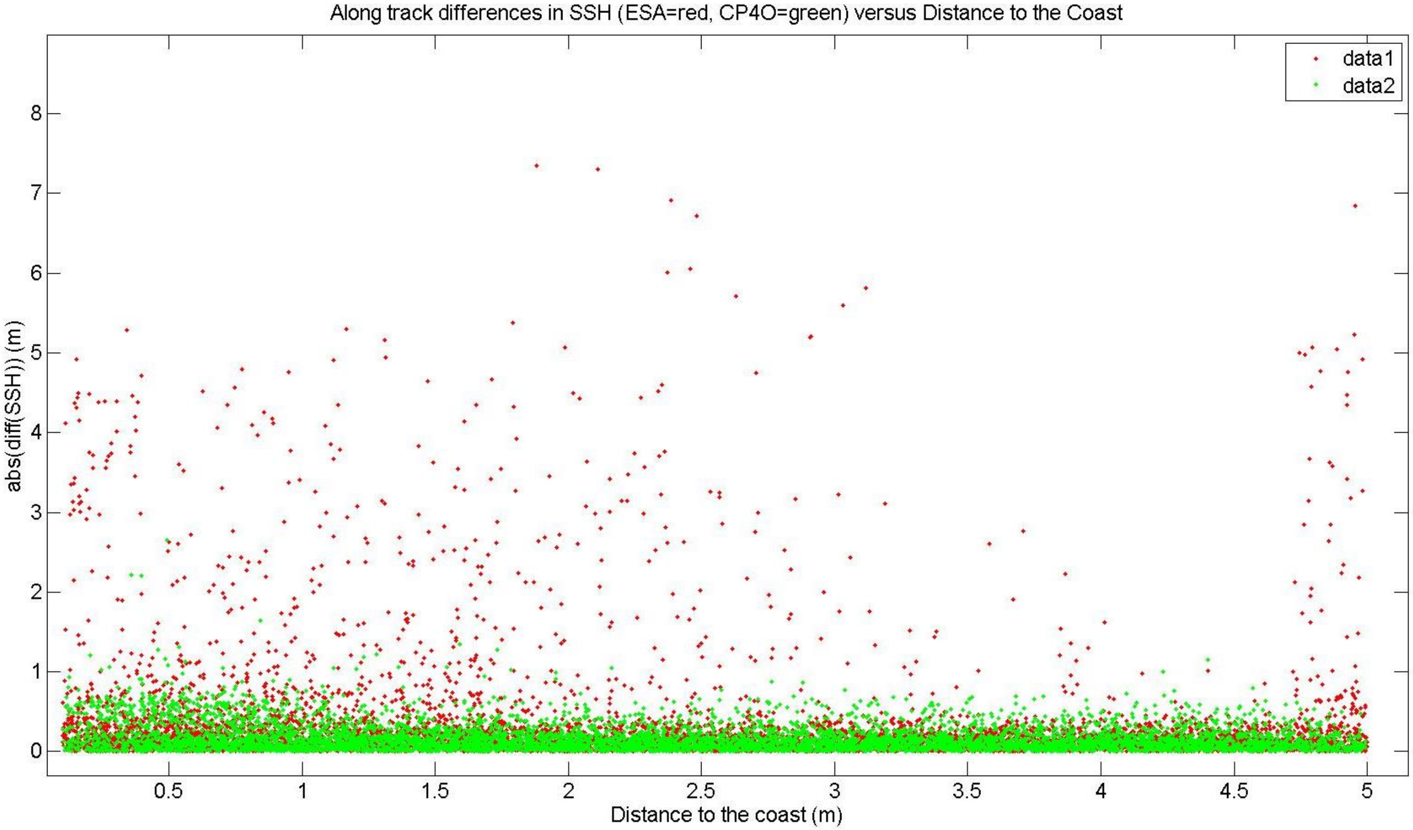
Individual track sections standard deviation:



Proposed improvement solution (III): Assessment

Statistics of improvement

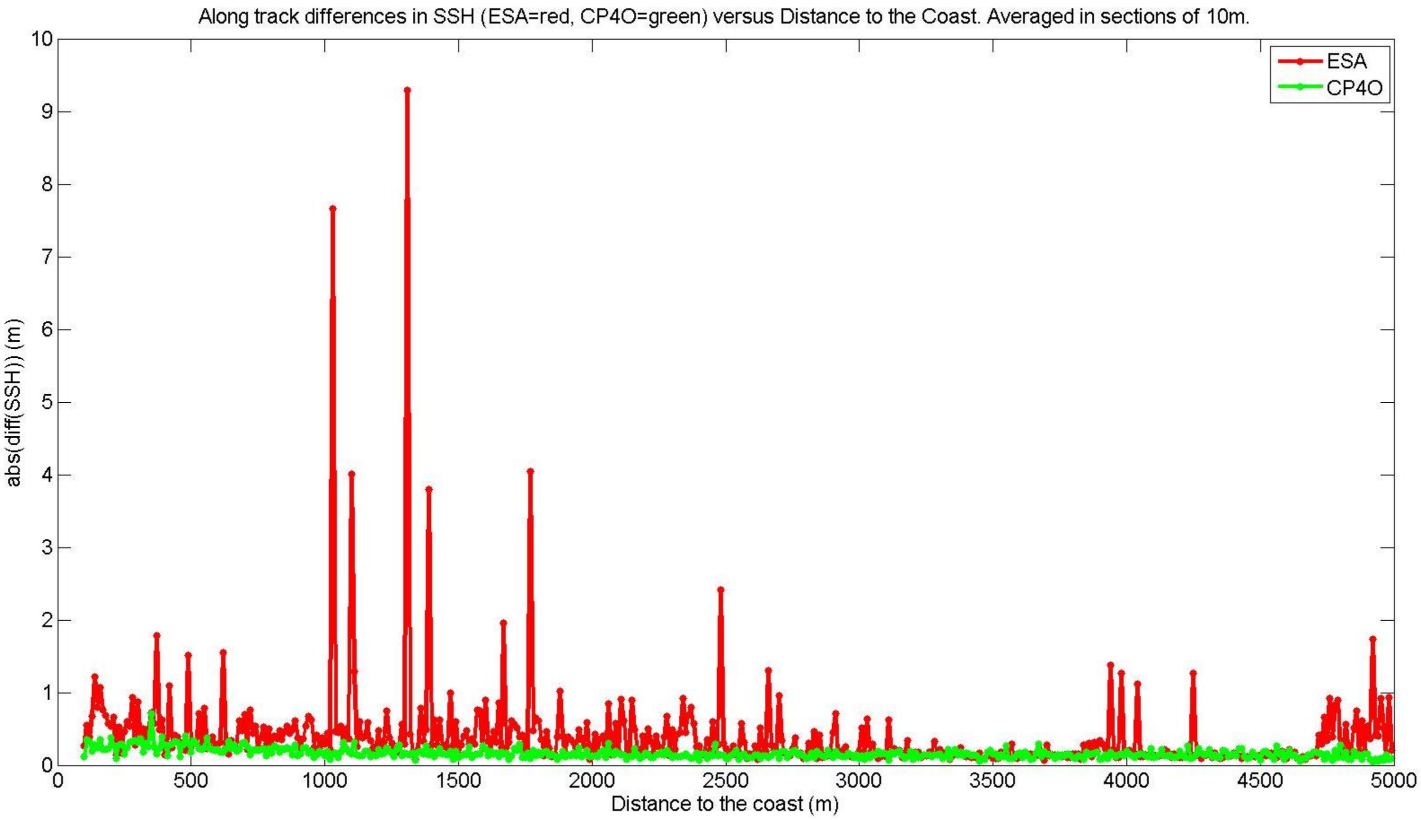
SSH diff vs distance to the coast (abs(diff(SSH))):



Proposed improvement solution (III): Assessment

Statistics of improvement

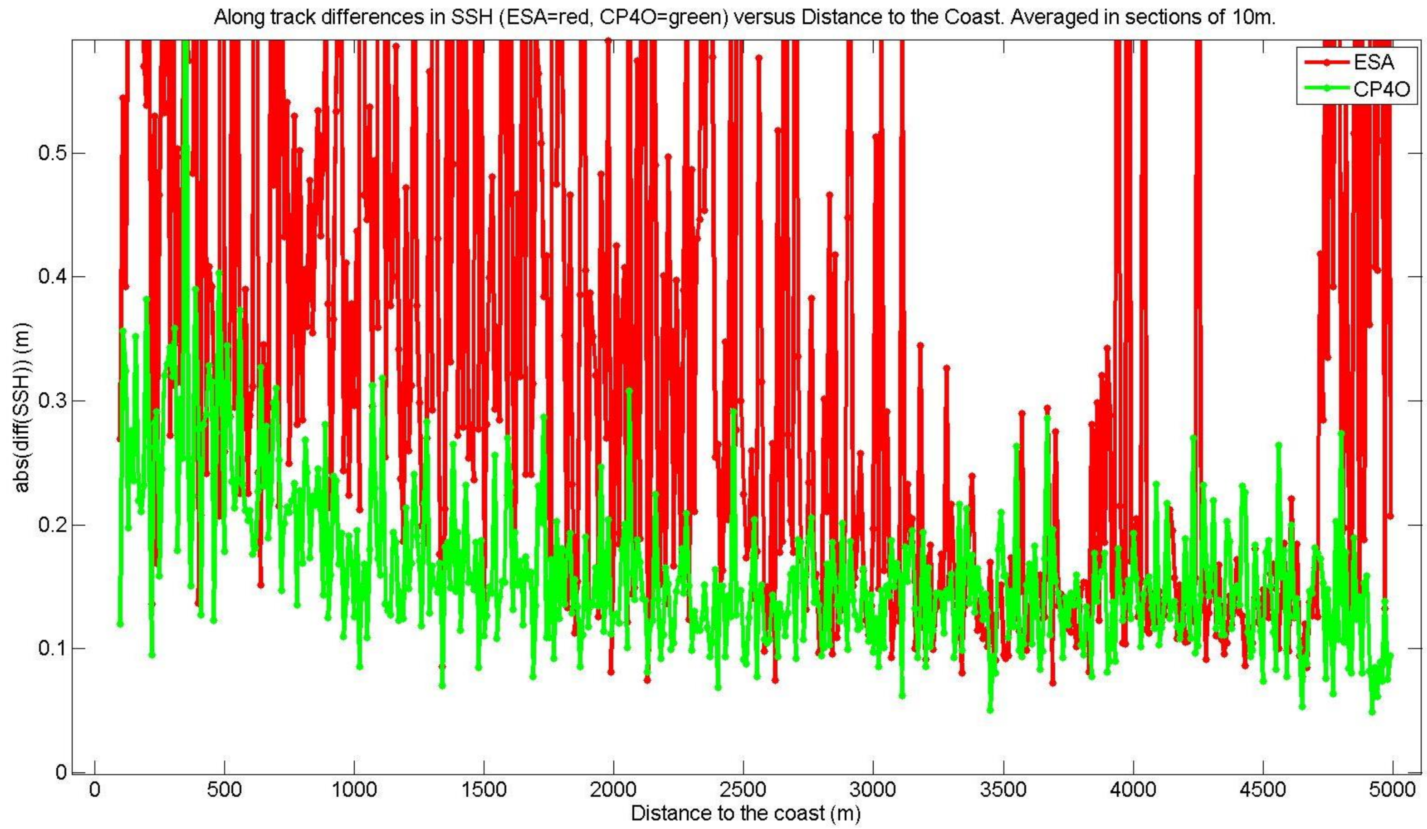
SSH diff vs distance to the coast: average **10m**



Proposed improvement solution (III): Assessment

Statistics of improvement

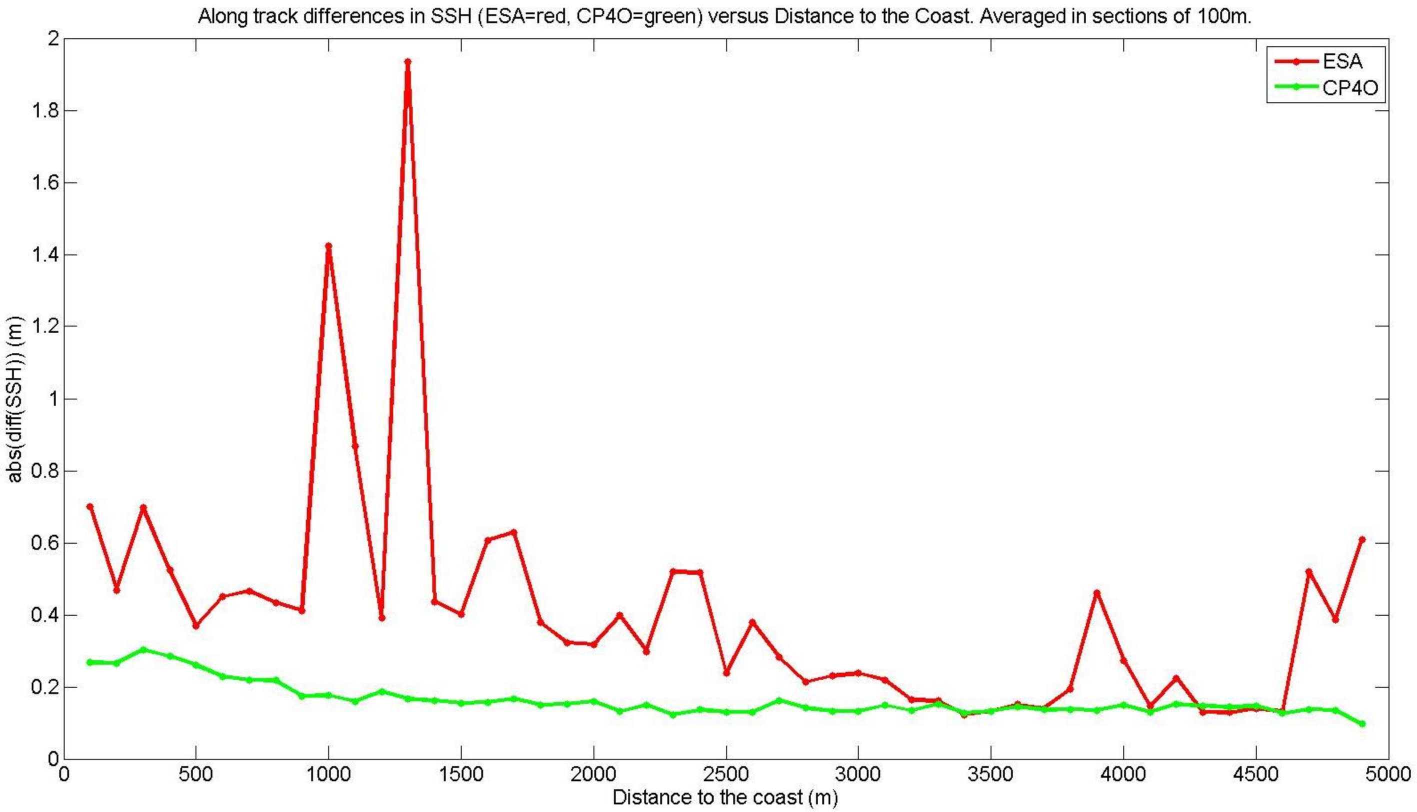
SSH diff vs distance to the coast: average **10m**



Proposed improvement solution (III): Assessment

Statistics of improvement

SSH diff vs distance to the coast: average **100m**



Proposed improvement solution (III): Assessment

Statistics of improvement

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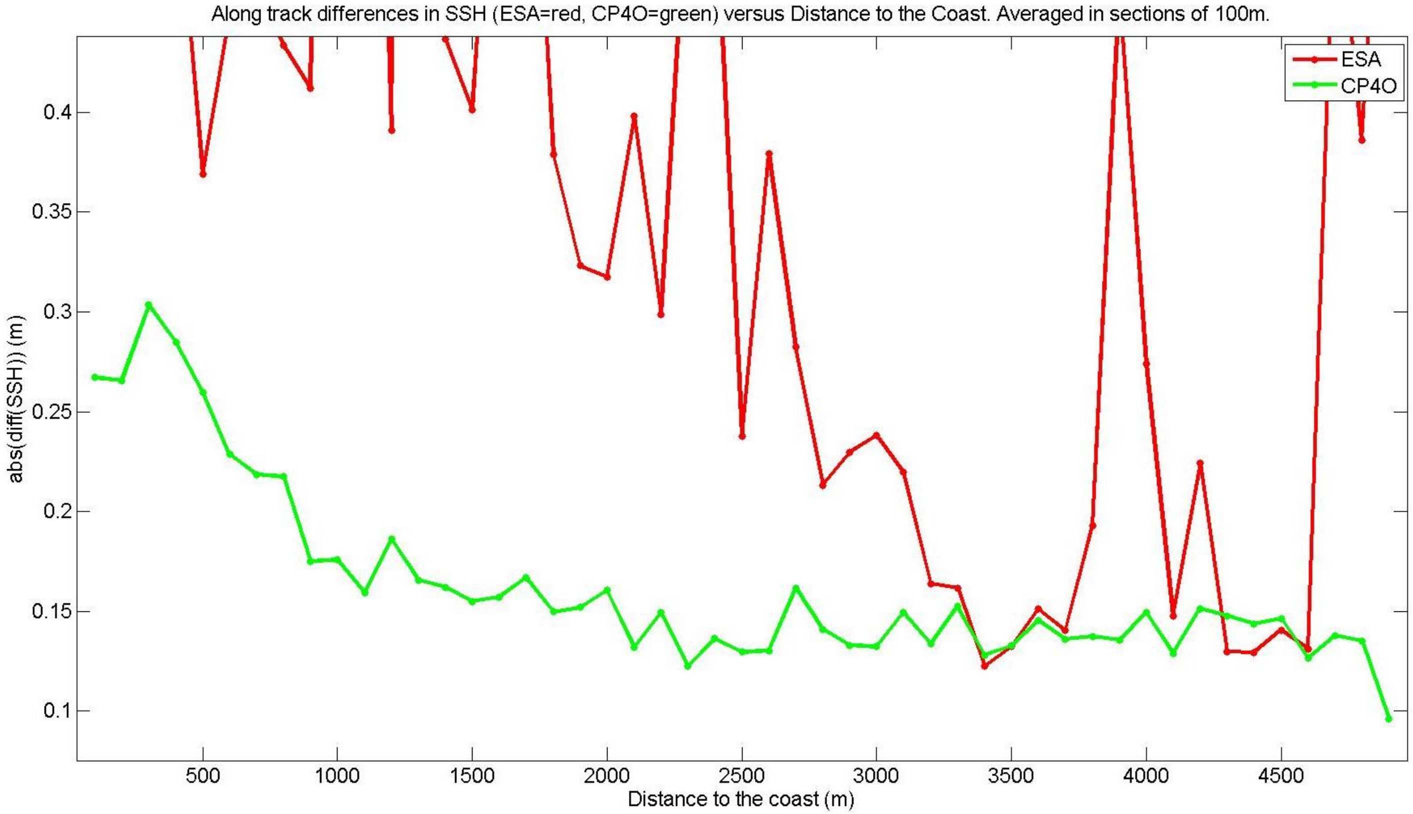

CONCLUSIONS:

- In some scenarios it is very difficult to retrieve Nadir information (AoA≈0). Hence, no possible seed production for the retracker from the AoA.
- The methodology applied for SARin coastal has been exploited for a general approach using the Window Delay, valid for all modes → CryoSat SAR/LRM, S-3, EnviSat, etc.
- Improved (60%) coastal SSH retrievals throughout the AoI.
- Yet some SSH spikes to be solved.
- Some coastal waveforms are impossible to be solved due to its level of contamination.
- Open Street Map has showed to be of great value for land/sea masking in complex coastal topography areas.

Looking Forward:

- The method here developed starts from L1b products.
  SAR/SARin L1b **stack** dedicated processing could be of great benefit for Coastal Ocean SSH estimations.

- A combination of the AoA & Window Delay solutions could be adopted, taking the best from both (synergic approach).

- The code here developed could be adapted to the soon starting Sentinel-3 mission coastal processing.

- Also it could be adapted to previous missions (EnviSat, Jason-2, etc).

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END

Thank You