→ 8th COASTAL ALTIMETRY WORKSHOP

23–24 October 2014 | Lake Constance | Germany

A New SAR Altimetry waveform model in combination with phase information for coastal altimetry

Cristina Martin-Puig & Pablo García

isardSAT

Summary

- Introduction
- Methodology
- Wfm modelling improvements
- Verification of new modeling solution with CNES CPP
- Results processing SARin data
- Conclusions

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Introduction

- This investigation starts from the **CP4O project**.
  - **CP4O** (CryoSat Plus for Ocean): a project lead by SatOC, funded by ESA under the STSE (Support To Science Element) Programme.

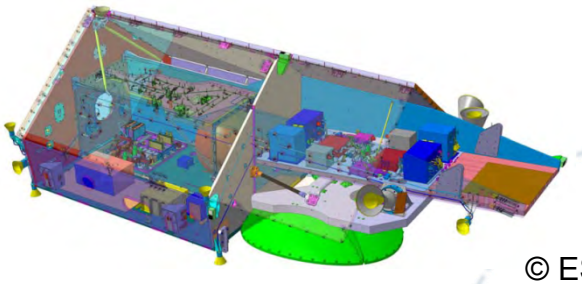
CP4O

SATOC · DTU Space National Space Institute · CLS · isardSAT · NOVELTIS · National Oceanography Centre · U.PORTO FC · TUDelft Delft University of Technology · Starlab Living Science

  - isardSAT investigates on **SARin capabilities on Coastal Ocean**

- isardSAT internally invested in this work by including L2 processing dedicated algorithms
- Now we will further develop this investigation under the framework of CP4O CCN

Introduction



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- The CryoSat-2 mission is designed to meet the requirements for Cryospheric applications. In addition, this mission is of great interest to the Hydrosphere and Oceanographic communities.
- One of the main Oceanographic communities is the **Coastal Altimetry** Community
- The CryoSat-2 mission is the first altimetric mission having on board a **SAR** Mode altimeter.

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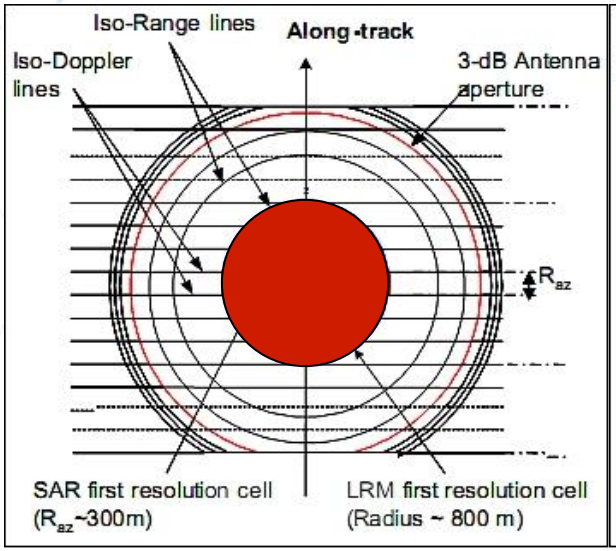
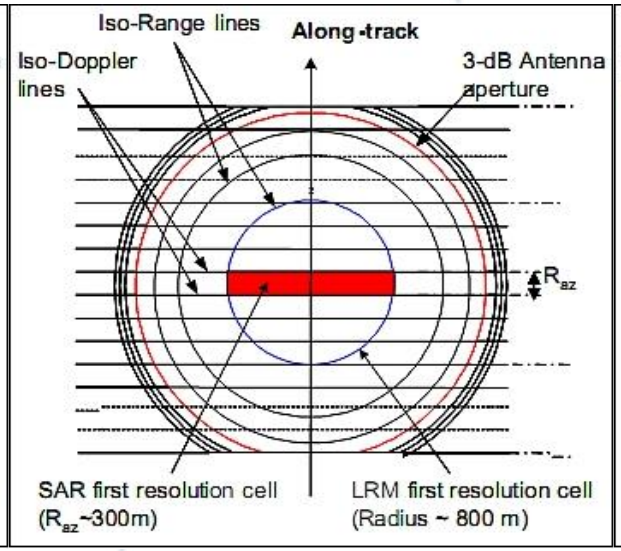
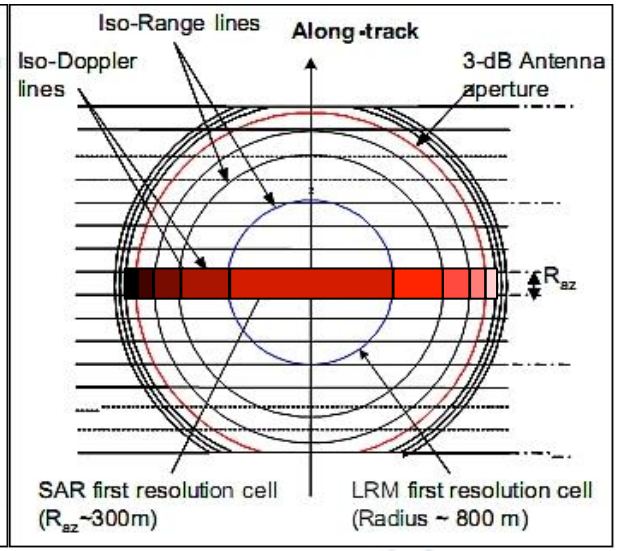
LRM

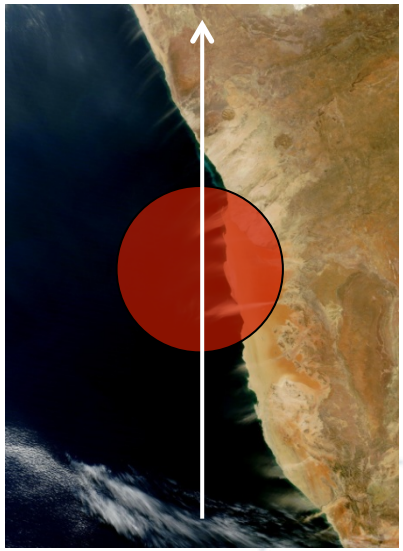


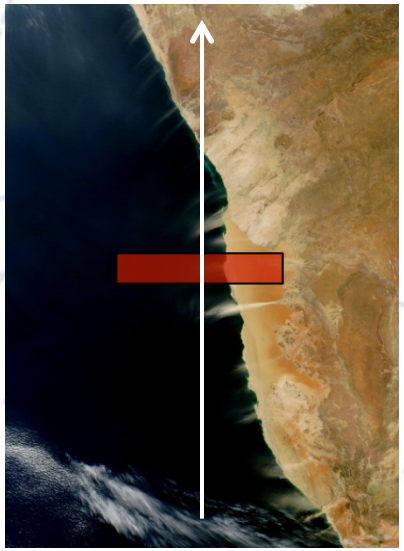
HRM - SARM

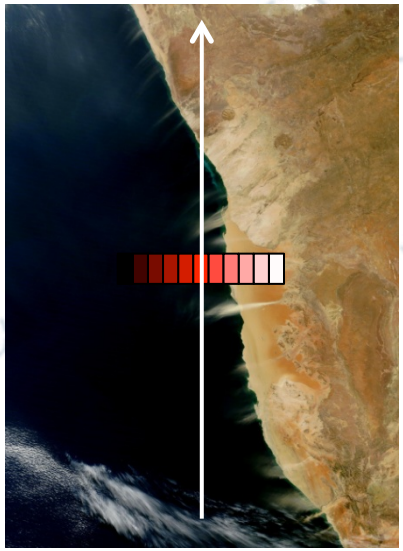


HRM - SARin









Courtesy of THALES

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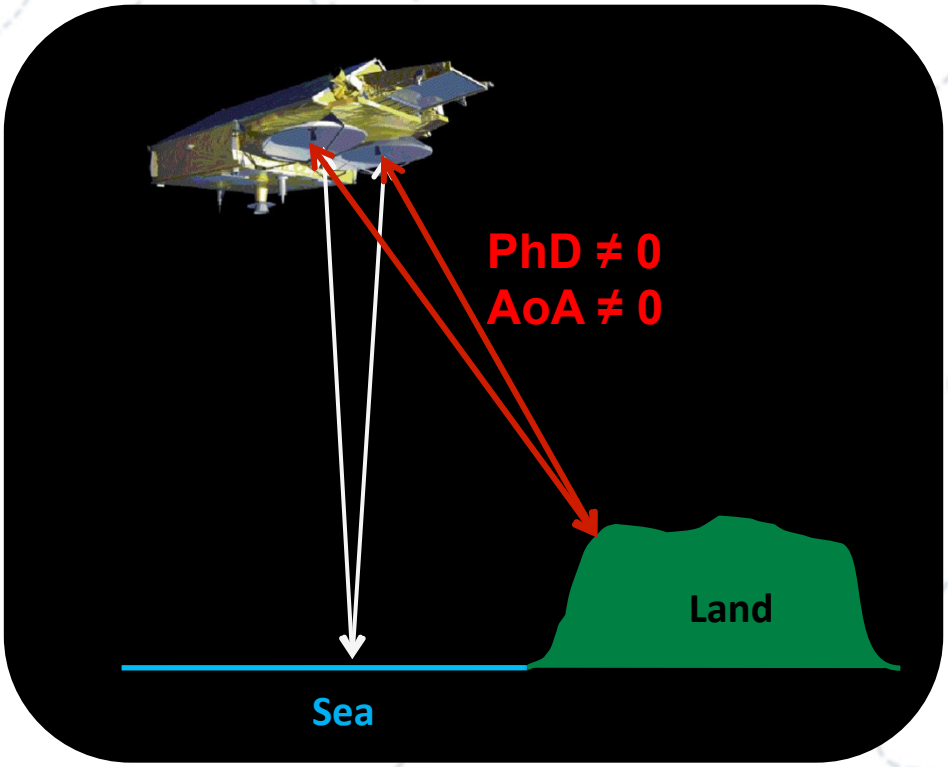
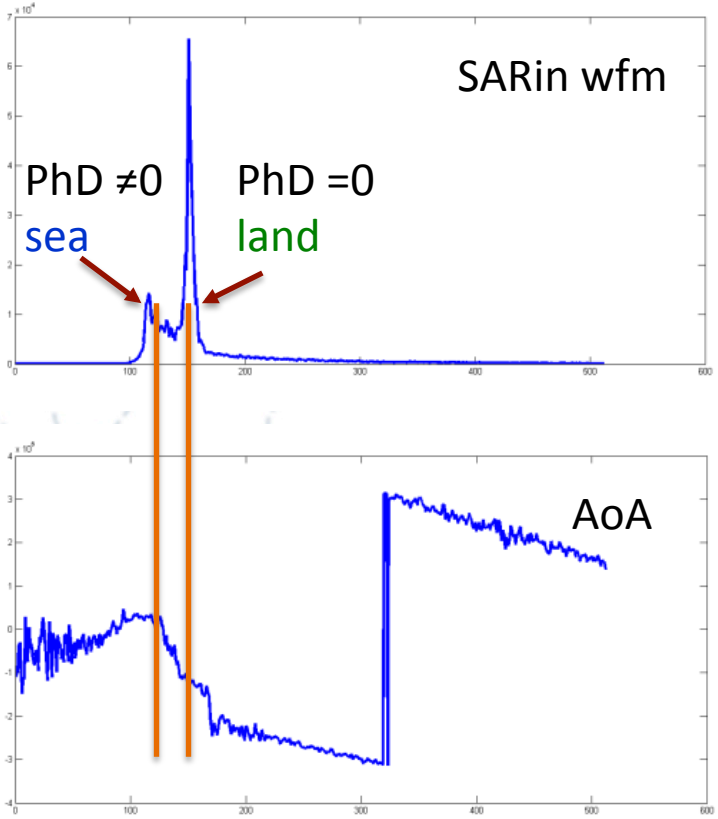
CryoSat-2 & Coastal Altimetry

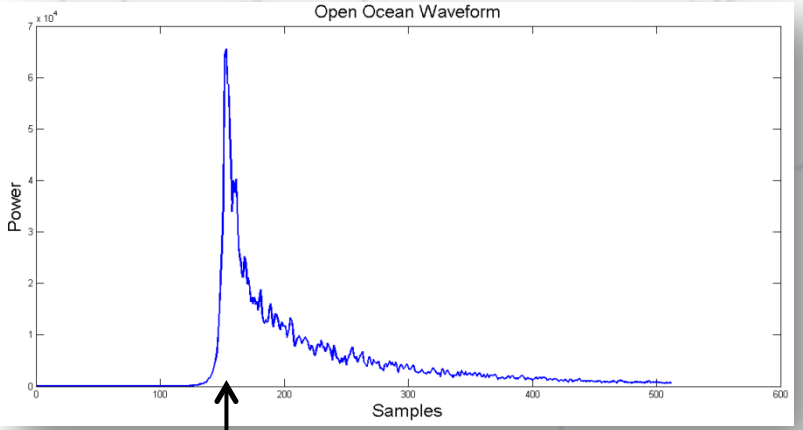
SARinM: The Across-Track discrimination is based in the Phase Difference (PhD) → Angle of Arrival (AoA)



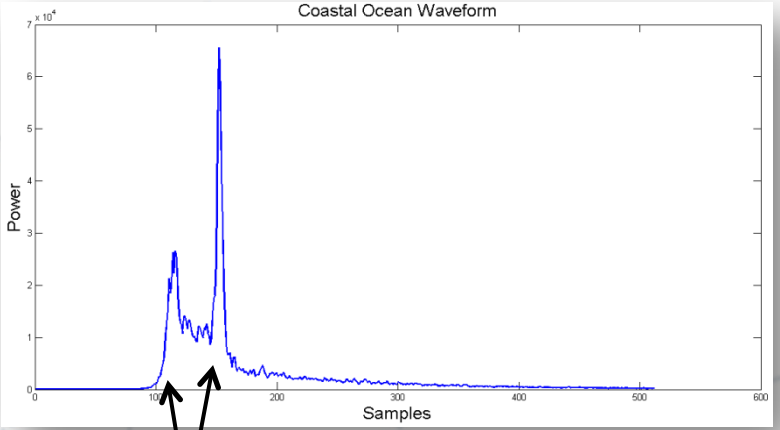


What happens in Altimetry near the coast?

- Coastal signals are not ocean like waveforms, but contaminated by land and calm waters reflections → the retracking processing needs some help.



Retracked range bin



Retracked range bin**?**

- It is necessary to avoid all the “non ocean” (Off-Nadir) information when retracking.

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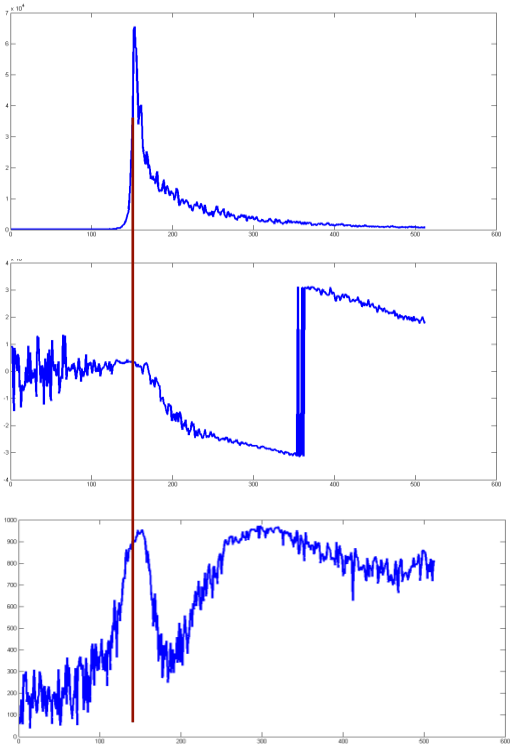
Proposed solution

- Main L1B information used for the analysis:
  - Power wfm →
  - Phase difference →
  - Coherence →
  - Non-fit parameters: v, pitch, roll, h, …



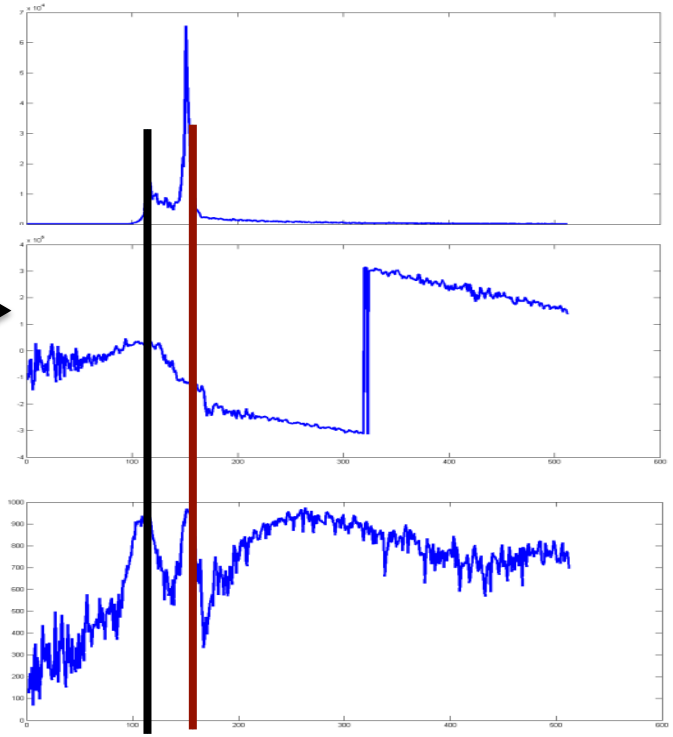
LEP

AoA = nadir

Max coherence

Proposed solution

- Main L1B information used for the analysis:
  - Power wfm
  - Phase difference
  - Coherence



Nadir LEP / flat sea

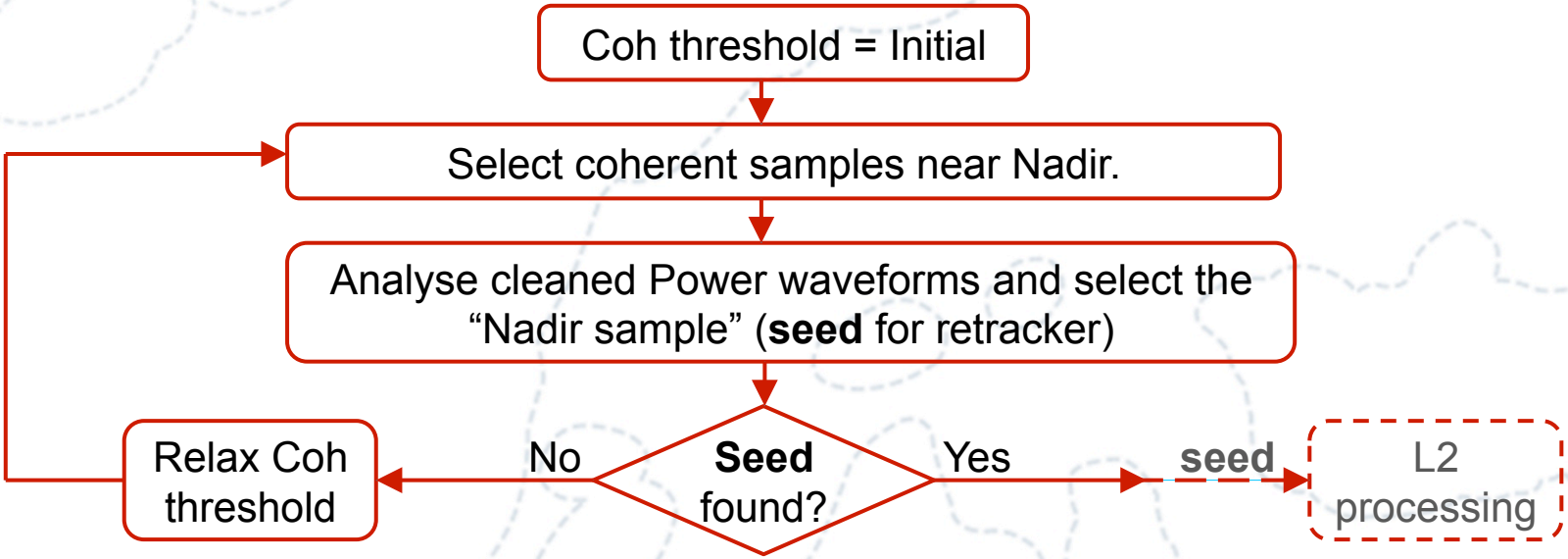
Nadir / off-nadir

Both show high coherence

  - Non-fit parameters: v, pitch, roll, h, …

Proposed solution

- Algorithm developed:
  Iterative process for each L1b echo



The next step is at L2 processing → SARin waveforms retracking (ingesting the **seed**)

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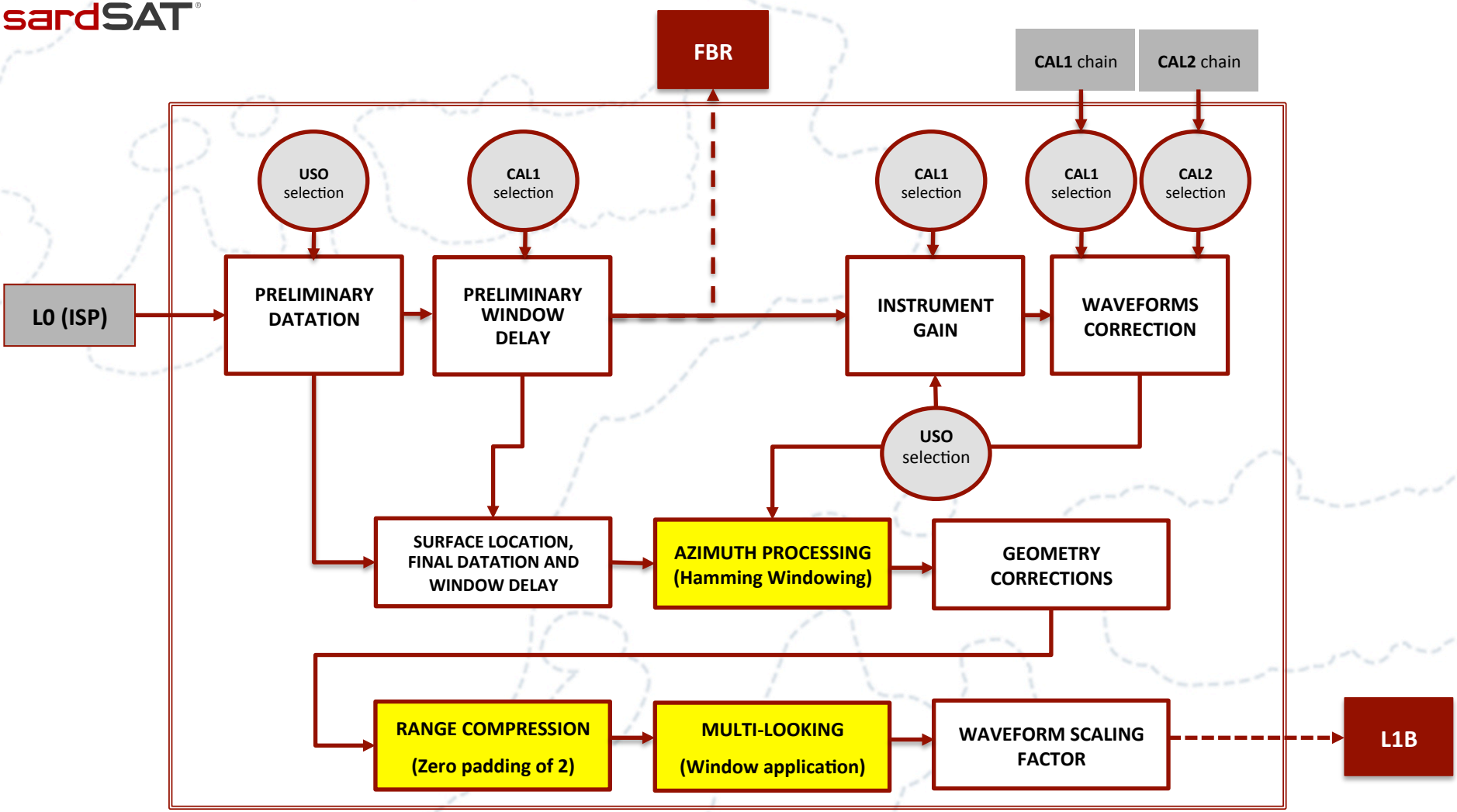
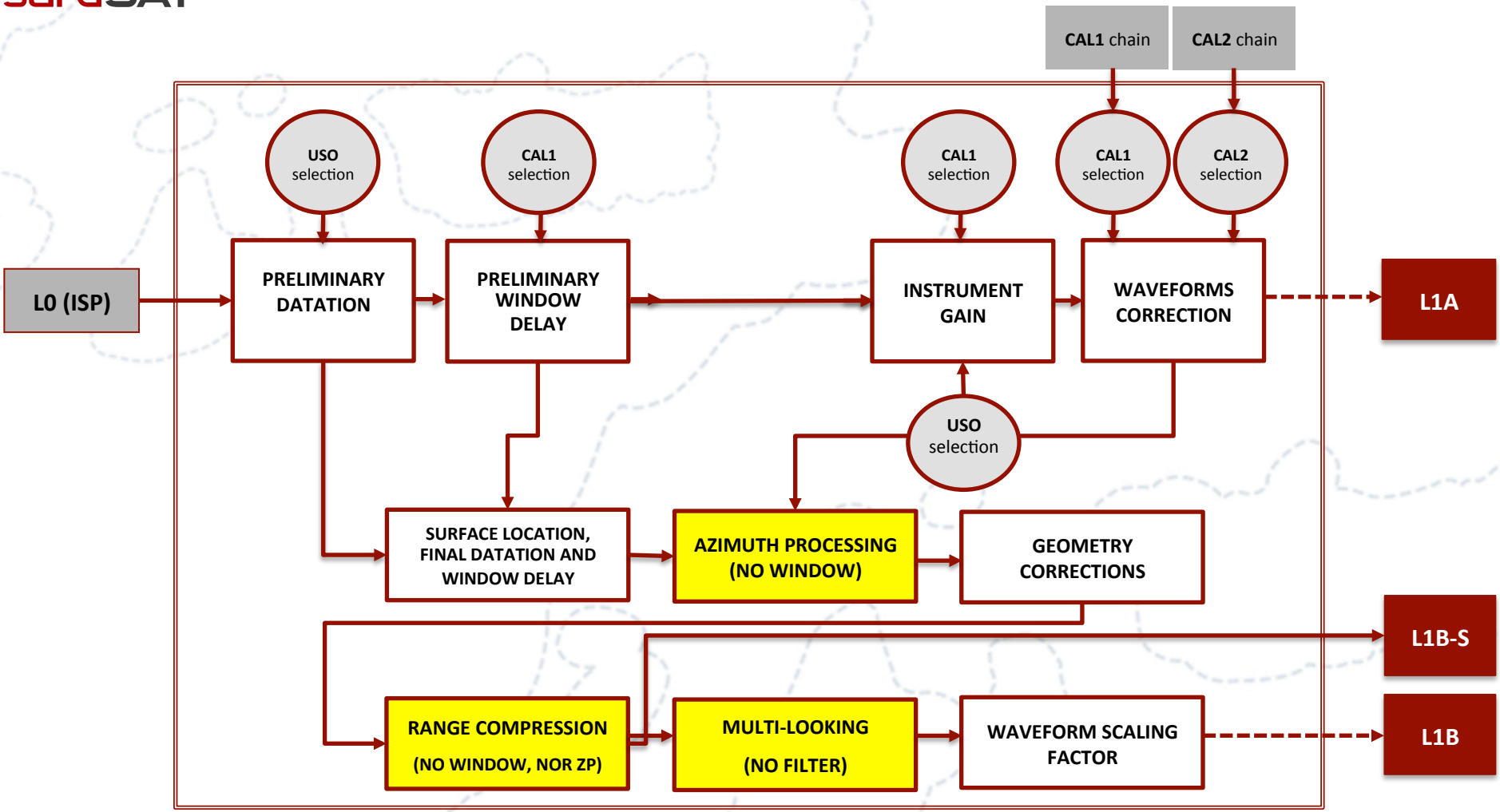
wfm modeling improvements

- Under the framework of the **Sentinel-6/Jason-CS** we have revisited the work I did in SAMOSA wfm model derivation
- This work has allowed us to also adapt the model to:
  - CryoSat-2 Baseline B configuration, and Baseline-C
  - And a few improvements also benefit Sentinel-3

Different missions different L1 processors


FBR
CAL1 chain
CAL2 chain
USO selection
CAL1 selection
CAL1 selection
CAL1 selection
CAL2 selection
L0 (ISP)
PRELIMINARY DATATION
PRELIMINARY WINDOW DELAY
INSTRUMENT GAIN
WAVEFORMS CORRECTION
USO selection
SURFACE LOCATION, FINAL DATATION AND WINDOW DELAY
AZIMUTH PROCESSING (Hamming Windowing)
GEOMETRY CORRECTIONS
RANGE COMPRESSION (Zero padding of 2)
MULTI-LOOKING (Window application)
WAVEFORM SCALING FACTOR
L1B


CAL1 chain
CAL2 chain
USO selection
CAL1 selection
CAL1 selection
CAL1 selection
CAL2 selection
L0 (ISP)
PRELIMINARY DATATION
PRELIMINARY WINDOW DELAY
INSTRUMENT GAIN
WAVEFORMS CORRECTION
L1A
USO selection
SURFACE LOCATION, FINAL DATATION AND WINDOW DELAY
AZIMUTH PROCESSING (NO WINDOW)
GEOMETRY CORRECTIONS
L1B-S
RANGE COMPRESSION (NO WINDOW, NOR ZP)
MULTI-LOOKING (NO FILTER)
WAVEFORM SCALING FACTOR
L1B

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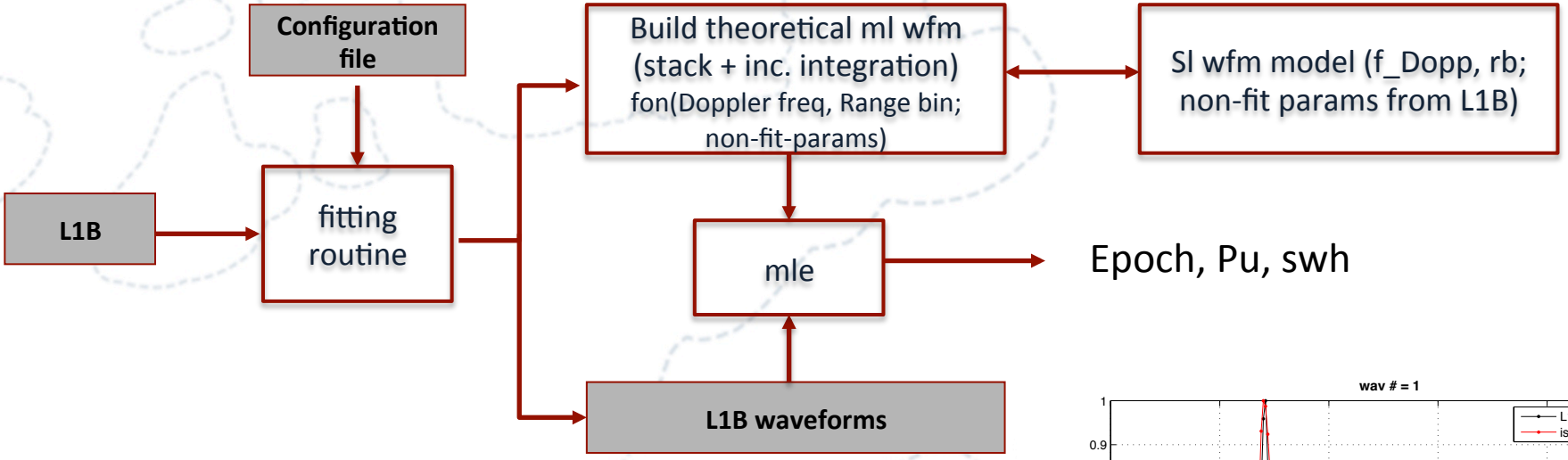
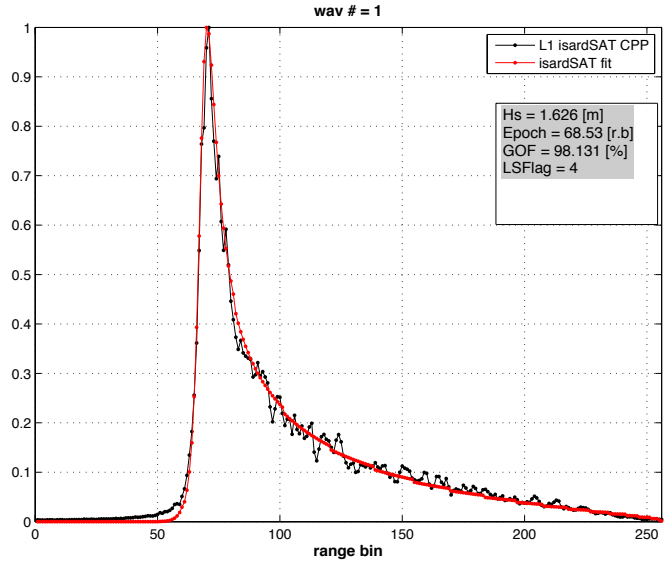
L2 wfm model block diagram





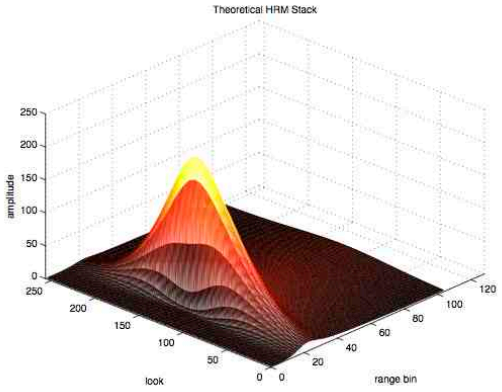
Different L1 blocks in CS-2 and S-3 → revisit model

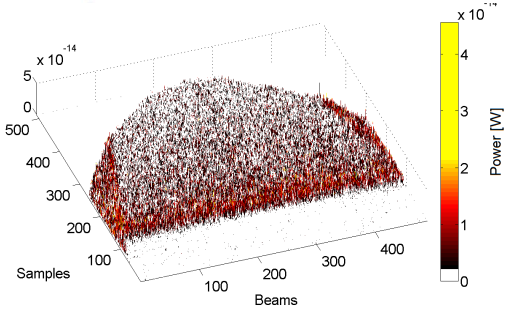
- **Windowing along or across track**
  - SAMOSA was built under the assumption that the **same windowing was applied along and across-track**. Any variation to this assumption requires to revisit the theoretical model
- **Zero Padding**
  - The effect of zero padding in Fourier transforms is well known, by this technique the resulting sampling sequence resolution is reduced proportional to the number of zero padded samples, which usually tends to be a power of two for simplicity
- **Stack Masking**
  - Real stacking vs theoretical stacking
    - Range cell migration and corse information from the window delay

Solution to previous slide

- **Windowing along and across track**
  - new solution for g_l [1]
- **Zero Padding**
  - Revisit the model [1] to distinguish between BW_{rx} (related to footprint resolution) vs sampling frequency(ZP)
- **Stack Masking**

[1] Ray, C., Martin-Puig, C. ; Clarizia, M.P. ; Ruffini, G. ; Dinardo, S. ; Gommenginger, C. and Benveniste, J., 2014(on-line), 2015(in print), SAR Altimeter Backscattered Waveform Model, Geoscience and Remote Sensing, Vol. 53, Iss. 2., pp 911 – 919, Doi: 10.1109/TGRS.2014.2330423





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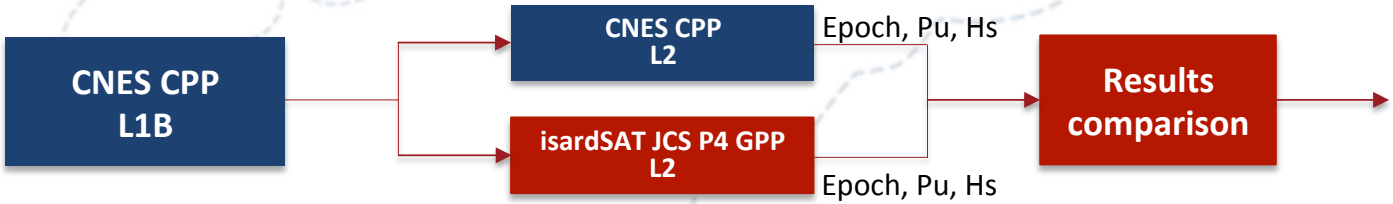
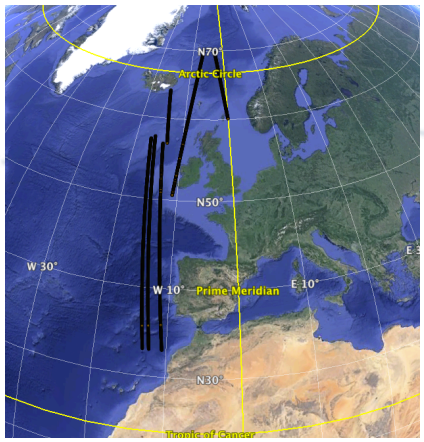
Comparison with CNES CPP

- Test A



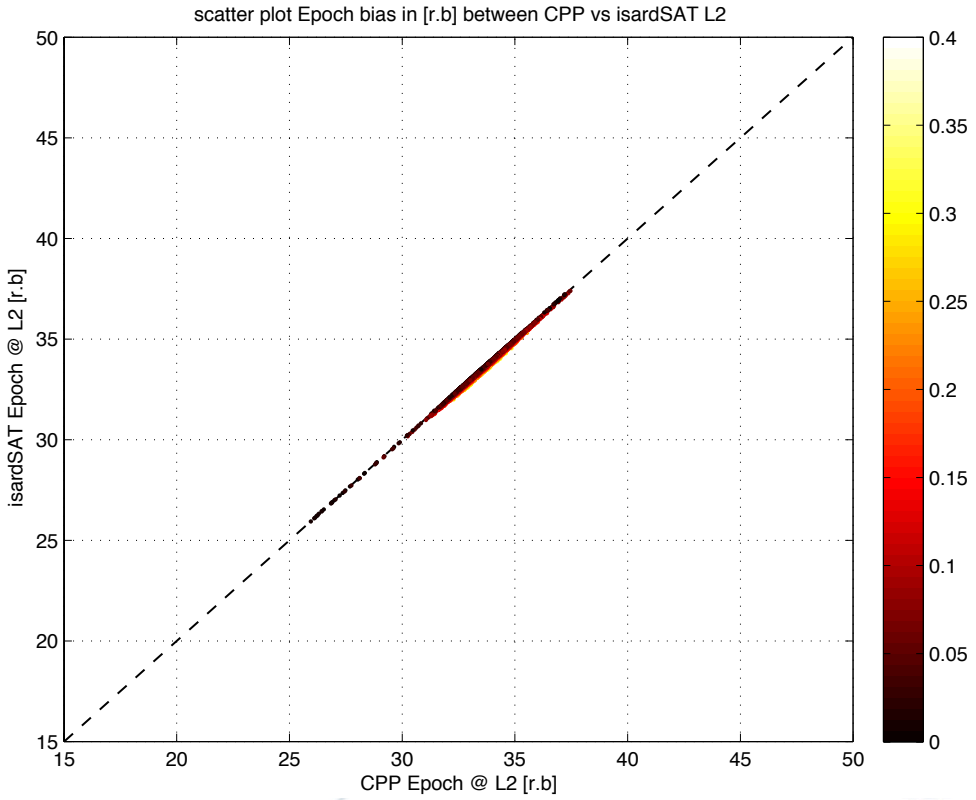
Model as it is today @ isardSAT is in both solution (equivalent to SAMOSA2, and what is equivalent to **SAMOSA 3**).

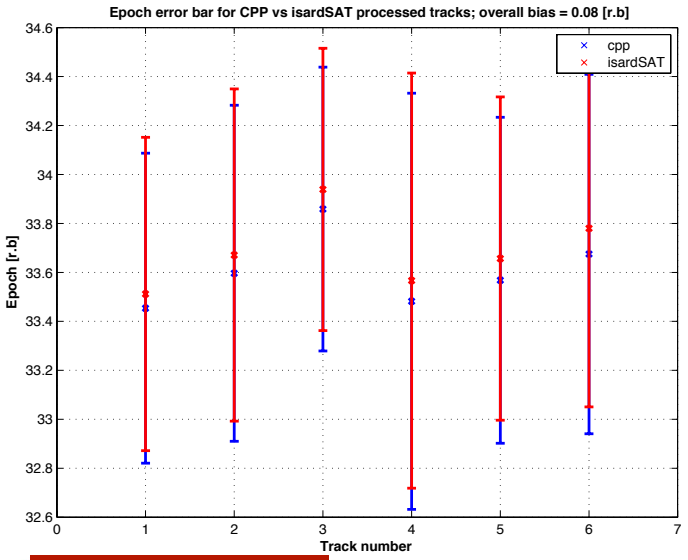


20Hz Epoch comparison

FIGs DESCRIPTION

20Hz Scatter and error bar plots comparing performance of CPP vs isardSAT epoch for identical L1B processed by CNES CPP





Track num	Bias Epoch [r.b]
1	0.0581
2	0.0747
3	0.0802
4	0.0846
5	0.0886
6	0.1051

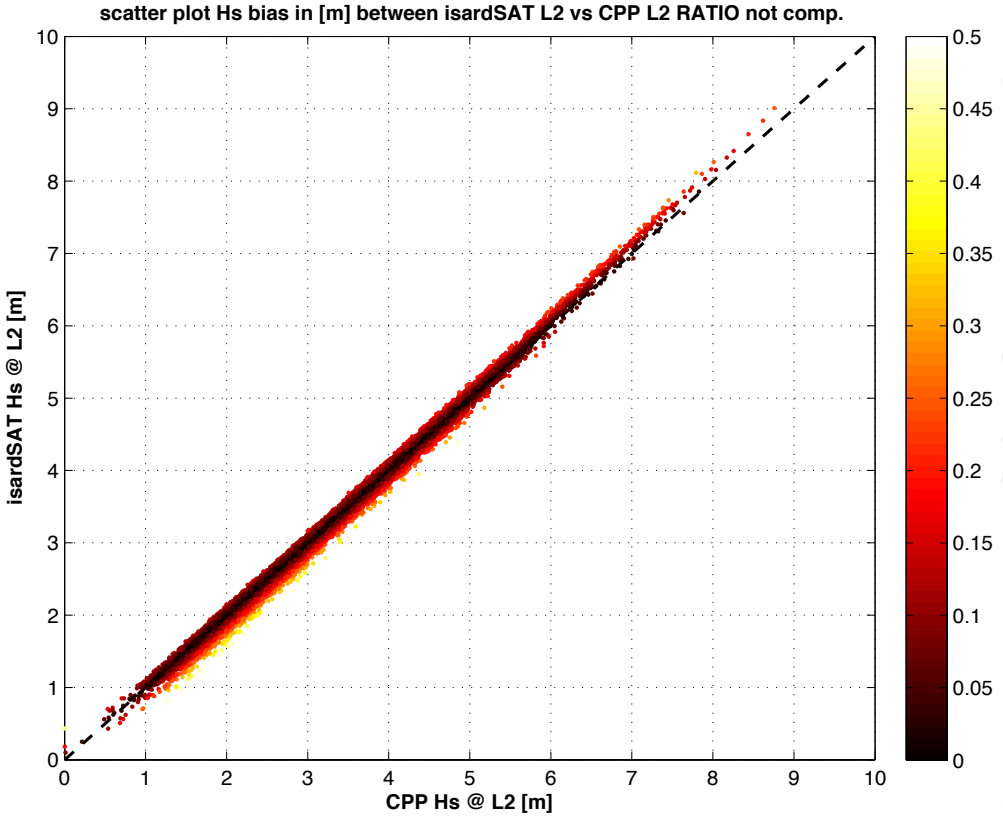
We quantify a ~0.07 range bins bias between CPP and isardSAT L2 solutions → 3.28 [mm]

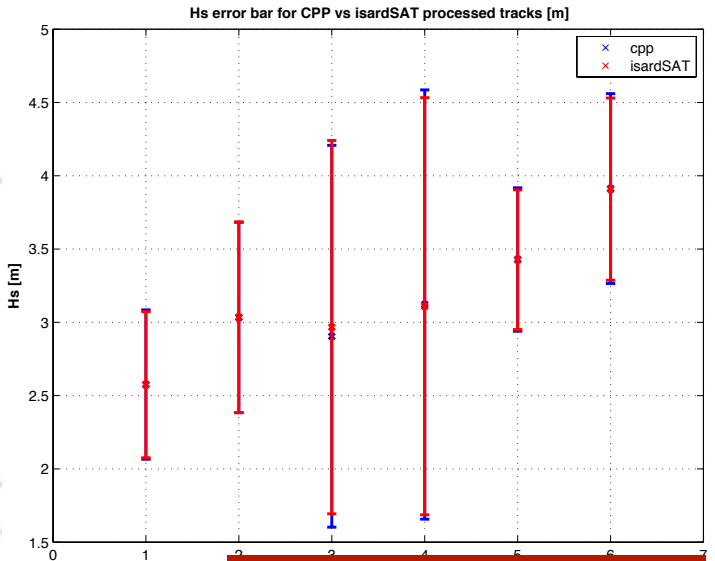
With delta_rb = 0.5*c/BW_r

20Hz Hs comparison

FIGs DESCRIPTION

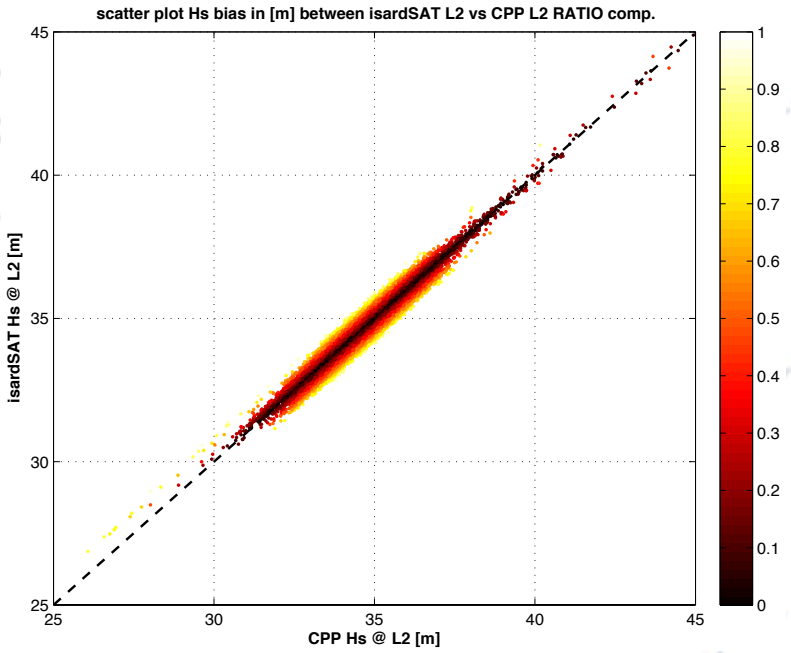
Scatter and error bar plots comparing performance of CPP vs isardSAT Hs @ L2 for identical L1B processed by CNES CPP





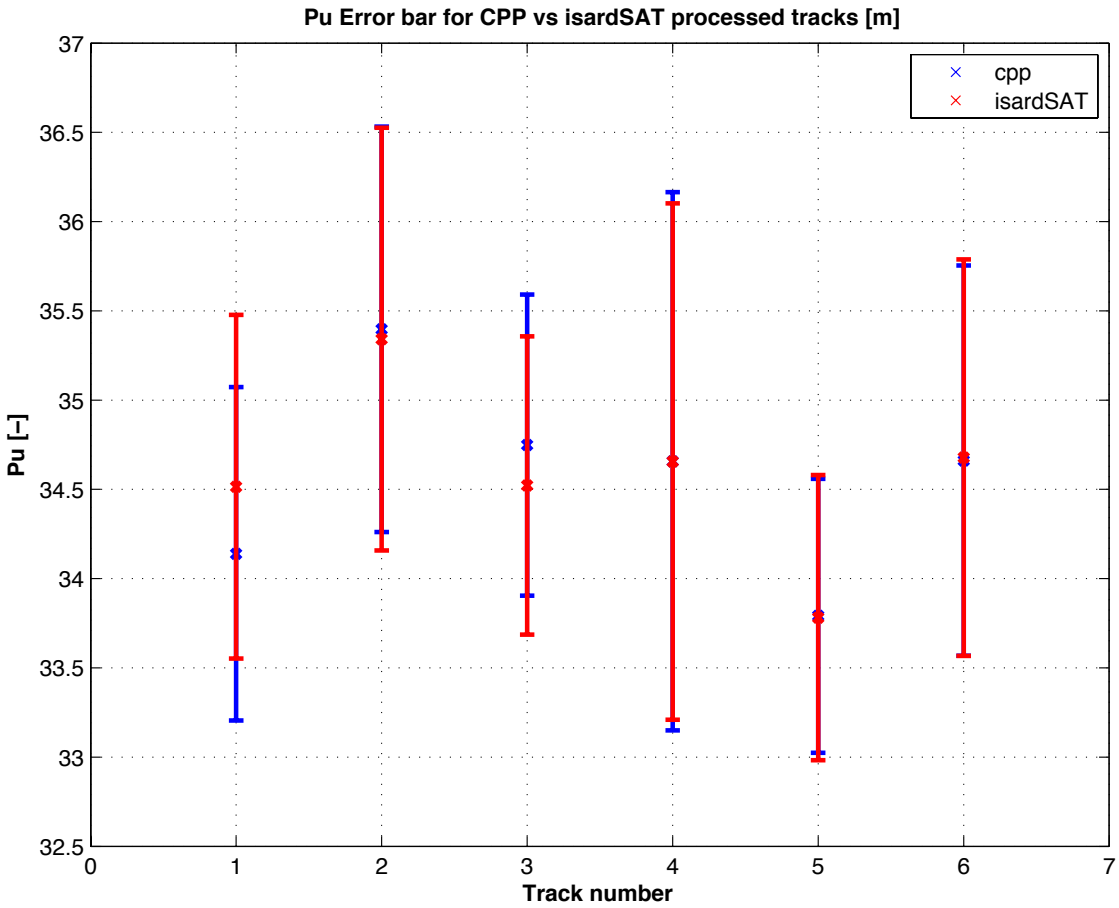
Track num	Mean value Bias Hs [mm]
1	1.4
2	1.4
3	62.2
4	11.3
5	1.2
6	3.6

20Hz Pu comparison

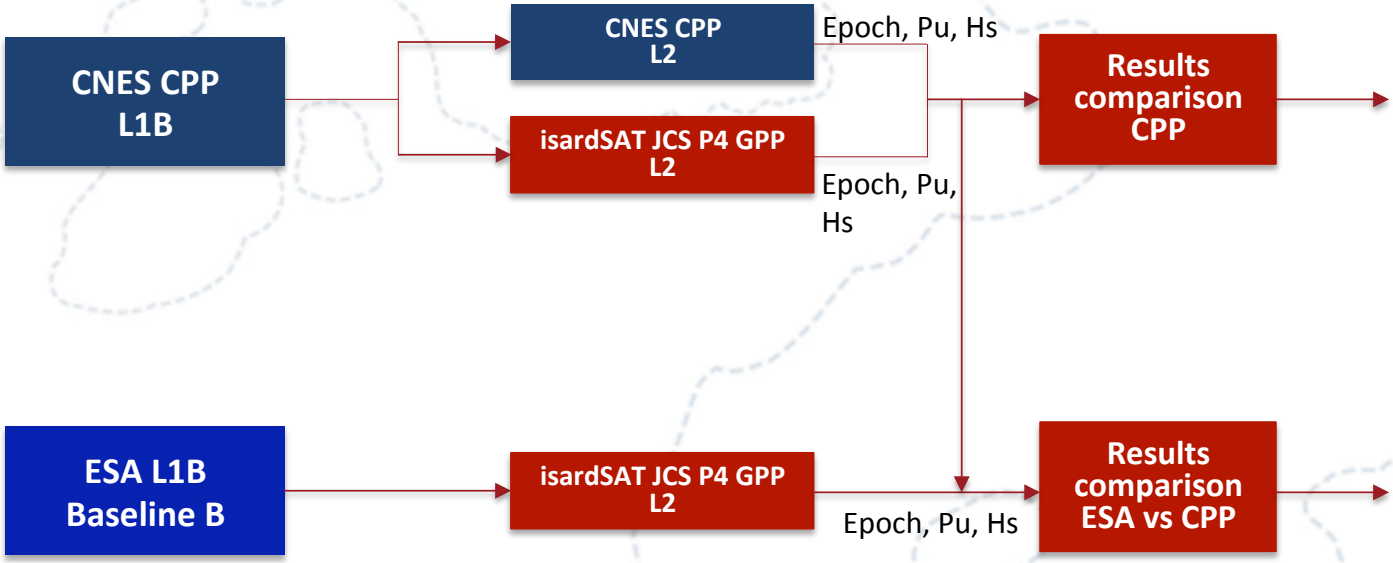


FIGs DESCRIPTION

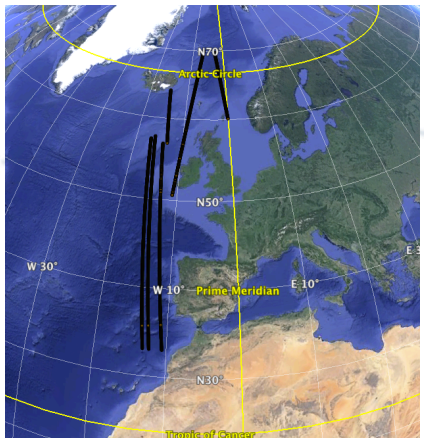
These graphs show in the form of scatter plot and error bar the comparison of results achieve from isardSAT L2 processor compared to CNES CPP L2 processor for the same input data L1B from CNES CPP



Baseline B vs CNES CPP



- Test B



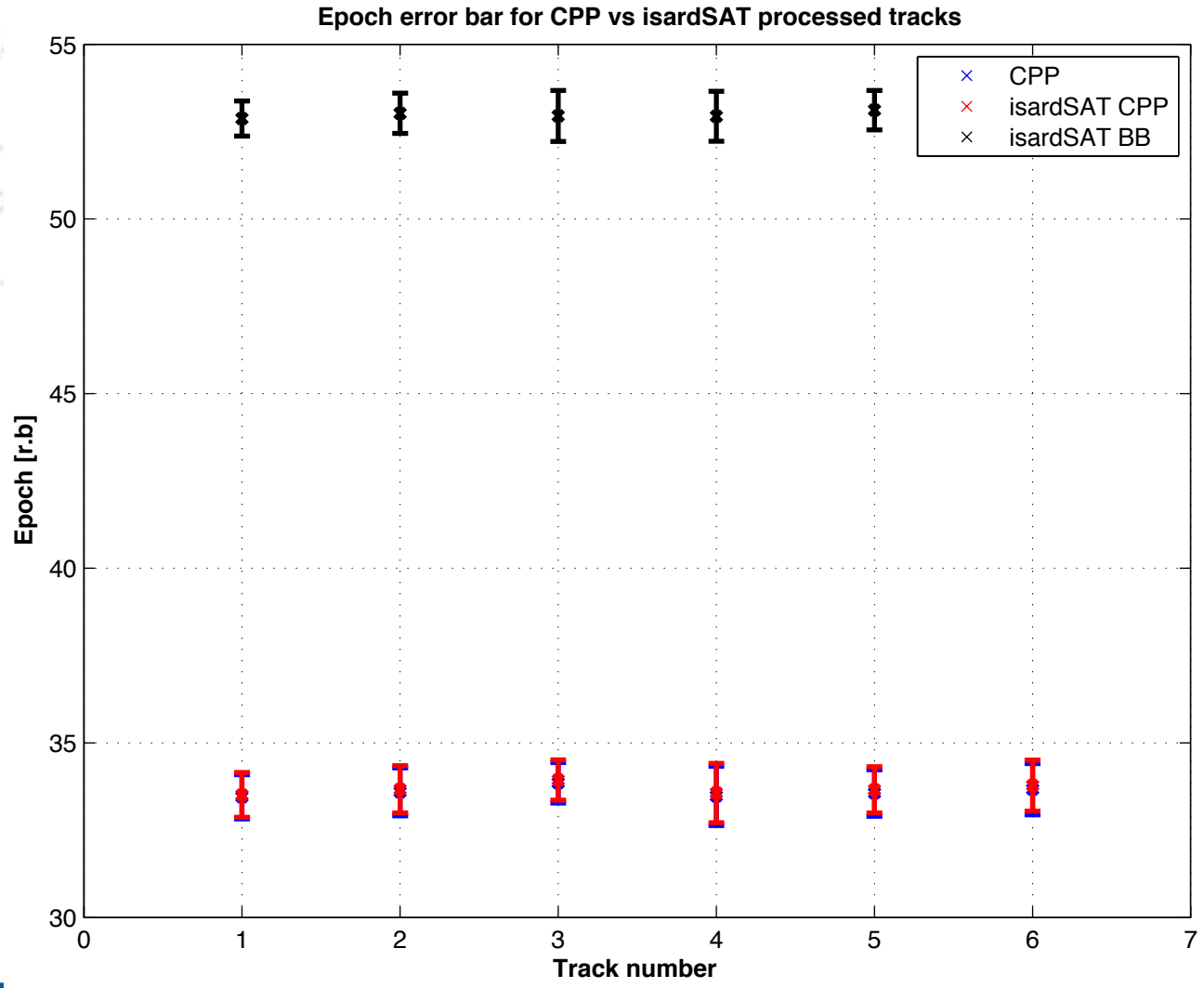
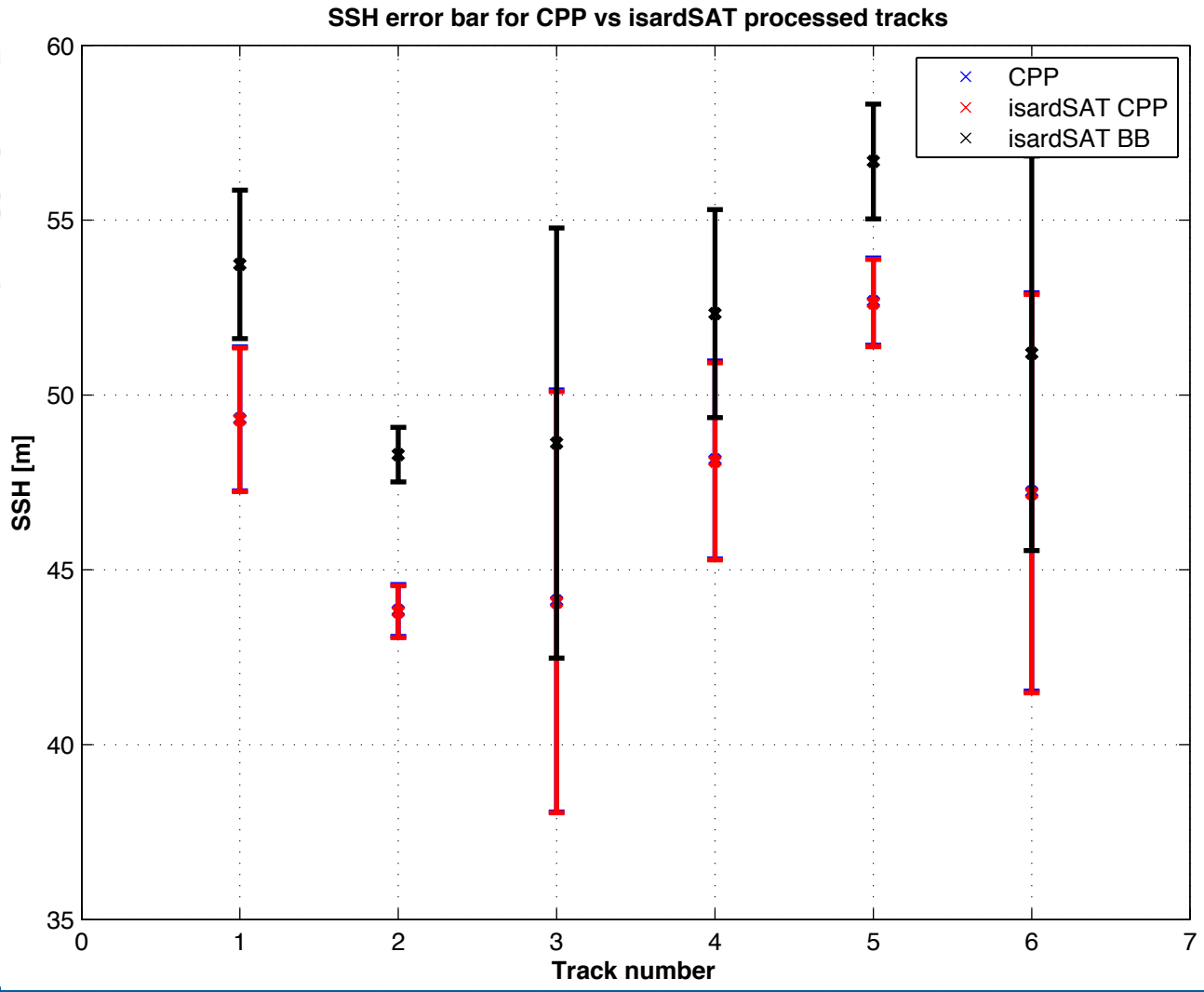


FIG DESCRIPTION

This graphs shows in the form of error bars the statistical performance of CPP, and isardSAT Epoch @ L2 for identical L1B processed by CNES CPP vs the performance of isardSAT L2 processing Baseline B L1B

isardSAT

SSH results now comparing to ESA Baseline B

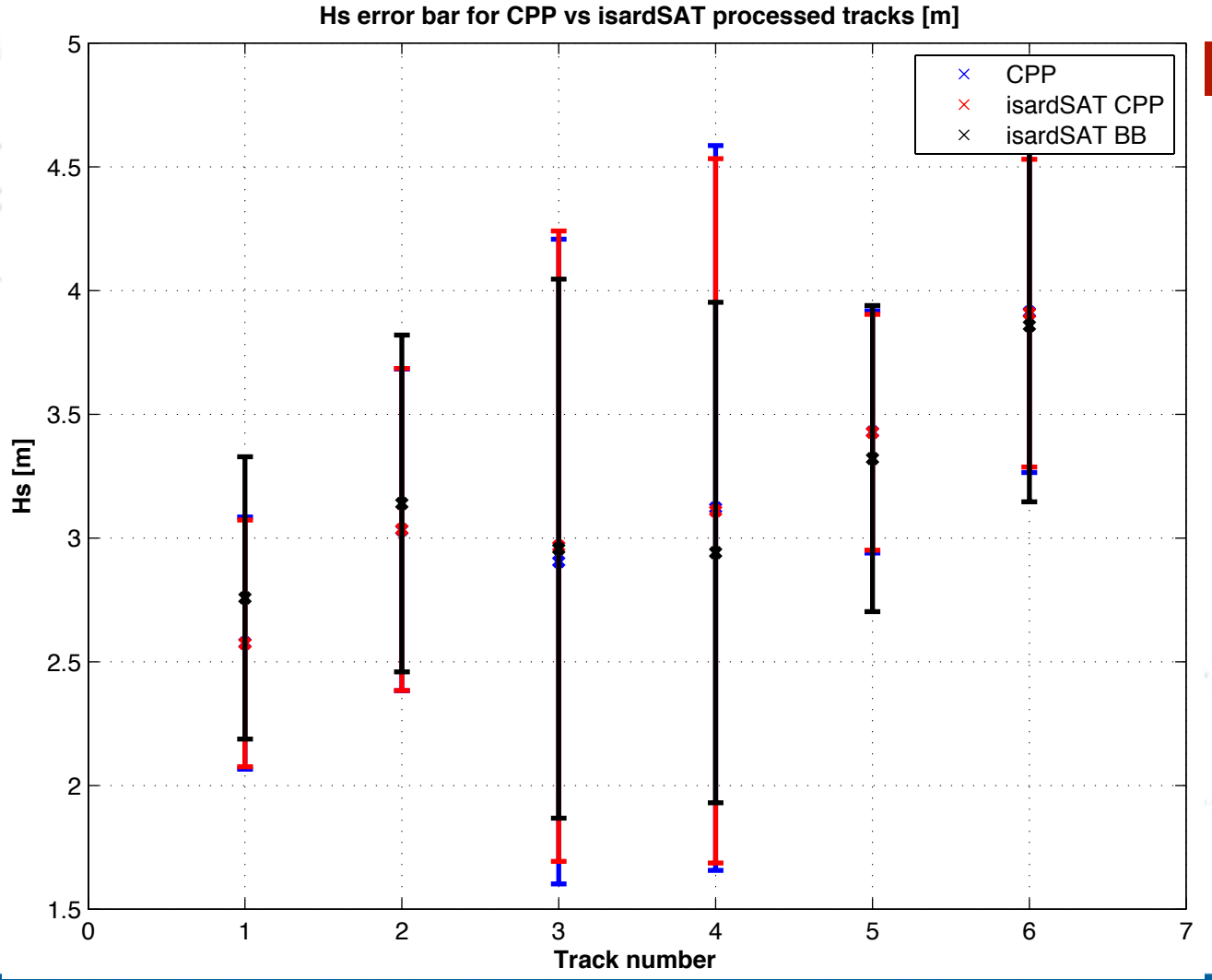


Track num	Bias SSH [m]
1	4.41
2	4.45
3	4.51
4	4.18
5	4.00
6	3.96

After cross calibration with Jason-2, CPP applies the following bias:
For SAR => Range - 4.51 m
For PseudoLRM => Range - 4.48 m

isardSAT

Hs results now comparing to ESA Baseline B



Track num	Bias Hs [cm]
1	18.22
2	10.66
3	5.25
4	18.03
5	10.71
6	5.47

FIG DESCRIPTION

This graphs shows in the form of error bars the statistical performance of CPP, and isardSAT Hs @ L2 for identical L1B processed by CNES CPP vs the performance of isardSAT L2 processing Baseline B L1B

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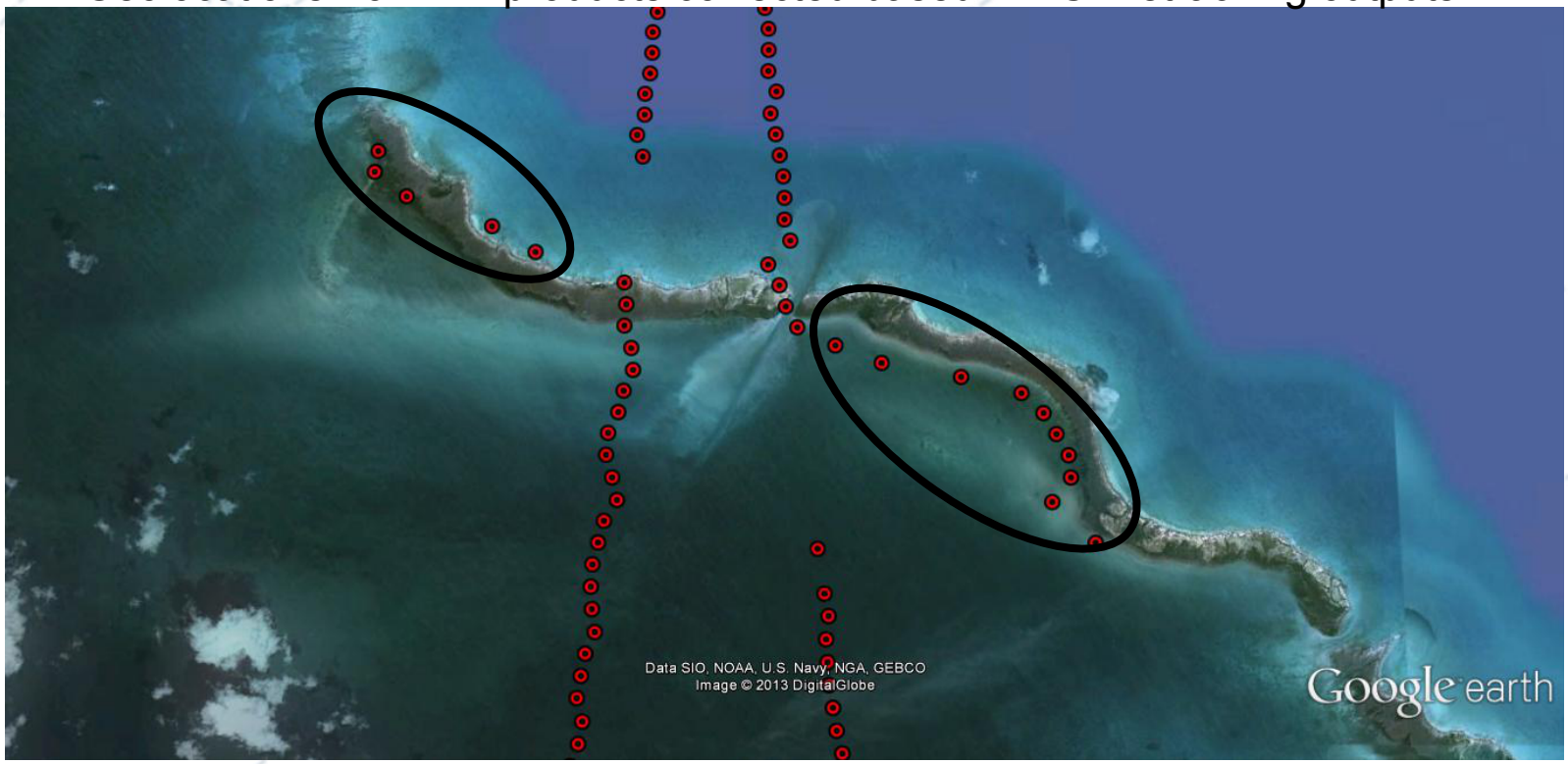
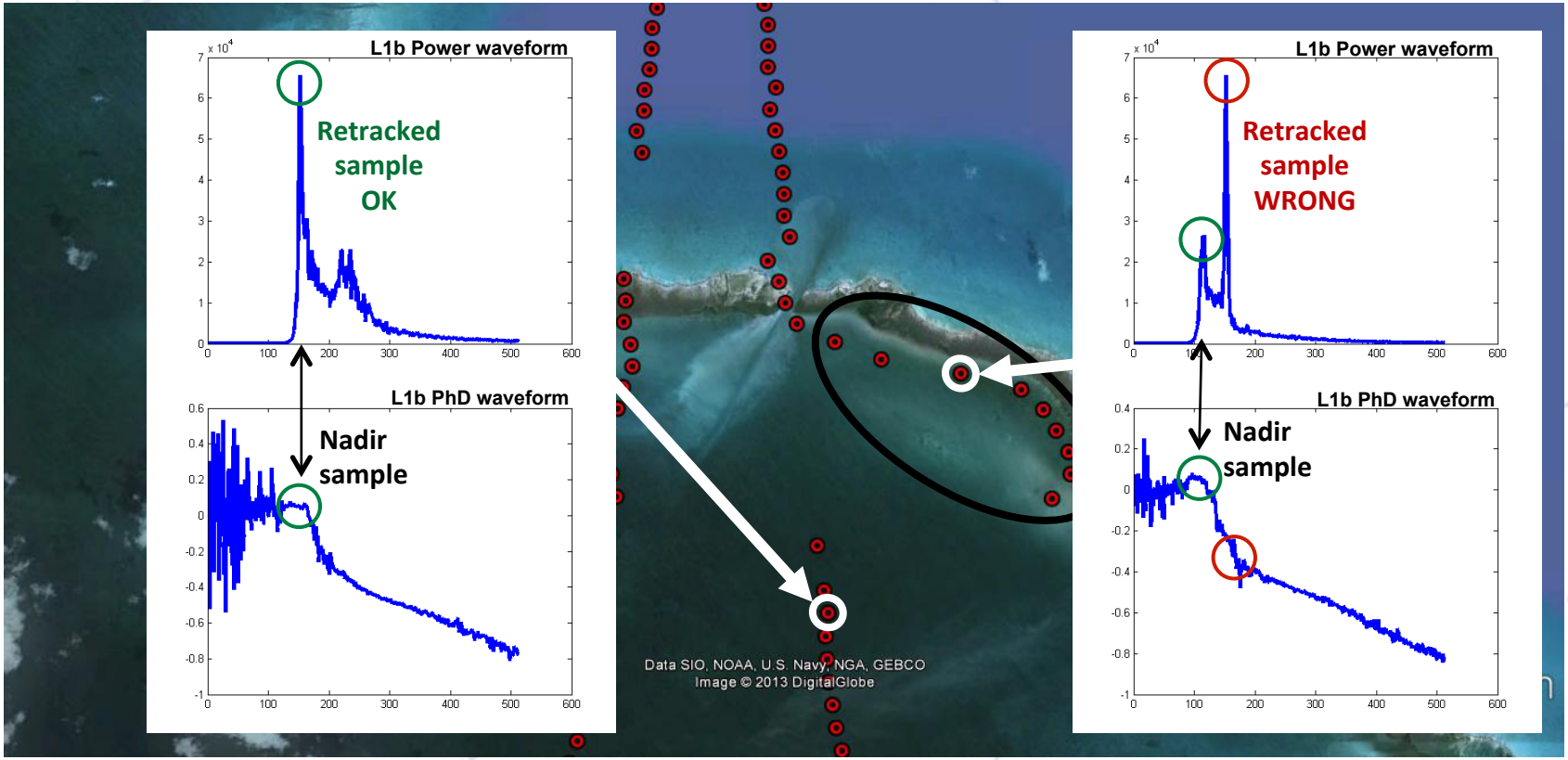
Performance of the adopted Solution

Example of how the current L2 products lose the Nadir signal near the coast.

Geolocations from L2I products corrected based in ESA retracking outputs.



Performance of the adopted Solution



SARin performance over coast

- Video 1 available @:
  - http://www.satoc.eu/projects/CP4O/docs/isardSAT_CP4O_video_20121204T110520.mp4
- Video 2 available @:
  - http://www.satoc.eu/projects/CP4O/docs/isardSAT_CP4O_video_20121208T231245.mp4

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Conclusions

- Coastal zones are very likely to produce contaminated waveforms, affecting the SSH retrieval.
- Nadir determination can be solved from AoA, useful in coastal waveforms.
- An adapted Retracking method, seeded by a post-L1b dedicated algorithm, improves the SSH results in coastal areas.
- Coastal Altimetry Community could be highly benefited from this solution, that also can be applied in inland waters.
- This investigation shows the SARin specific potential to improve the SSH results in problematic scenarios as coastal zones.

For further information

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