Sentinel-3 SEOM study 2 “Ocean and Coasts”

SCOOP

WP3000/4000: Delay-Doppler Processor & L2

Phase 2

isardSAT®

Outline

- Status and activities
- Performance analysis (Phase 2 vs GPOD: Phase 1)
- L1B coastal processing
- L2 coastal study on Sentinel-3 data

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Status and Activities

- L1B processing:
  - Understand the source of *radial velocity dependency* on SSH → **Phase 2 complete data set** (available at ftp "/test_data/SAR_Phase2")
  - Proposal of a *new processing to recover waveforms* in coastal areas (flying from land to ocean) → **Subset Coastal data set** (available at ftp "/test_data/SAR_Phase2_coastal_L1B_proc/")

- L2 processing:
  - *Minimize differences w.r.t GPOD* (biases SWH and sigma0)
  - Integration of atmospheric attenuation correction on sigma0
  - *Coastal study case* (Sentinel-3 data): optimised selection of waveform return from ocean exploiting jumps on tracker range in coastal areas

- Documentation
  - PSD for L2 isardSAT products (approved)
  - ATBD for L2 processor
  - Executable code L2 processor and IUM

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L1B Processing baseline

- Phase-2a isardSAT analysis → zero-padding of 2 & intra-burst Hamming individually provide improvements in SSH and SWH precision for low and high SWH regions, respectively

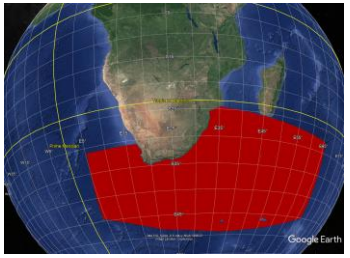
- L1B processing baseline for Phase-2
  - Zero-padding (factor 2) in range
  - Intra-burst windowing (Hamming)
  - Zeros in multilooking
  - Approximate beamforming (azimuth processing)
  - Cut of stack edges (keeping looks below $\pm 0{,}6\ degrees$)
  - No intra-burst alignment → removed effect on radial velocity dependency

L2 processor

- isardSAT SAR ocean retracker based on Chris et al. 2015
  - **Aligned with L1B processing**: zero-padding of 2 and zeros in mulitlooking
  - **Fixed PTR setting** to minimize bias w.r.t GPOD: $\sigma_{al} = 0.65$ & $\sigma_{ac} = 0.54351$
  - **Atmospheric attenuation correction** of sigma0 (not available for all 2012 data sets: missing original maps from NCEP GFS)
  - Sigma0 bias correction around 2 dB to align w.r.t GPOD data

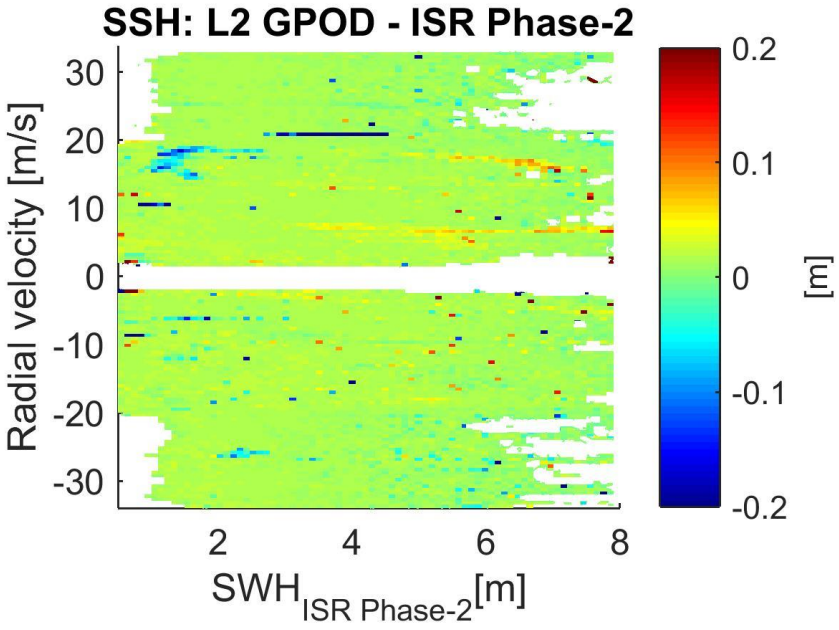
Phase-2: Performance analysis (I)

- Performance analysis against Phase-1 GPOD data
  - **Accuracy:** biases on geophysical retrievals w.r.t GPOD data
  - **Precision:** noise performance on the geophysical retrievals
- AOIs:
  - North East Atlantic (2012-2013) → Mask to avoid land
  - Agulhas (2012-2013) → Mask to avoid land
  - West Pacific (2012-2013)
  - Central Pacific (2012-2013)
  - East Pacific (2012-2013)

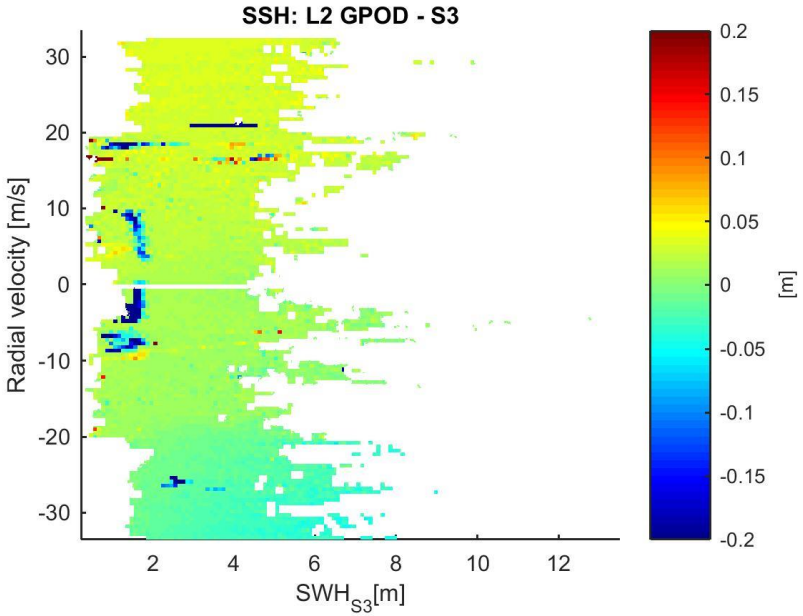


North East Atlantic and Agulhas

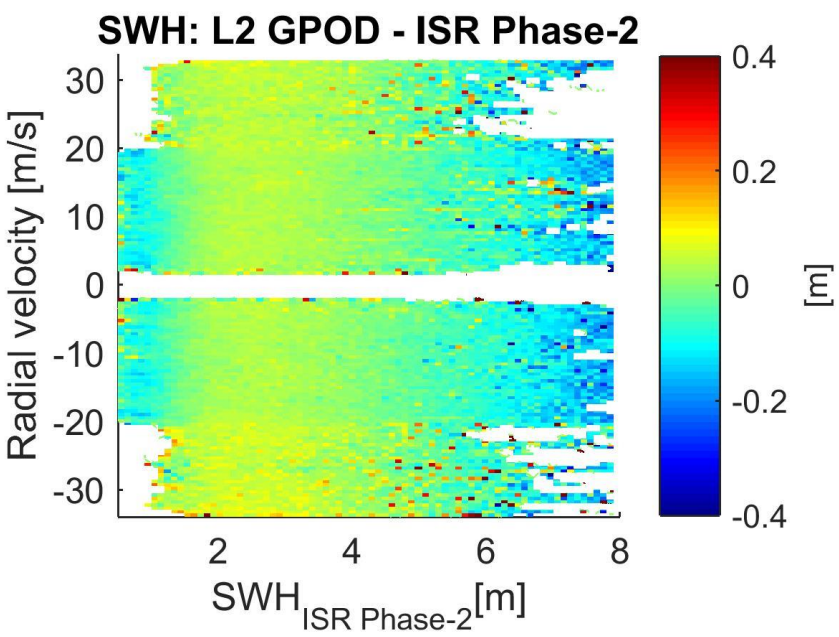
ACCURACY (AGAINST GPOD DATA)

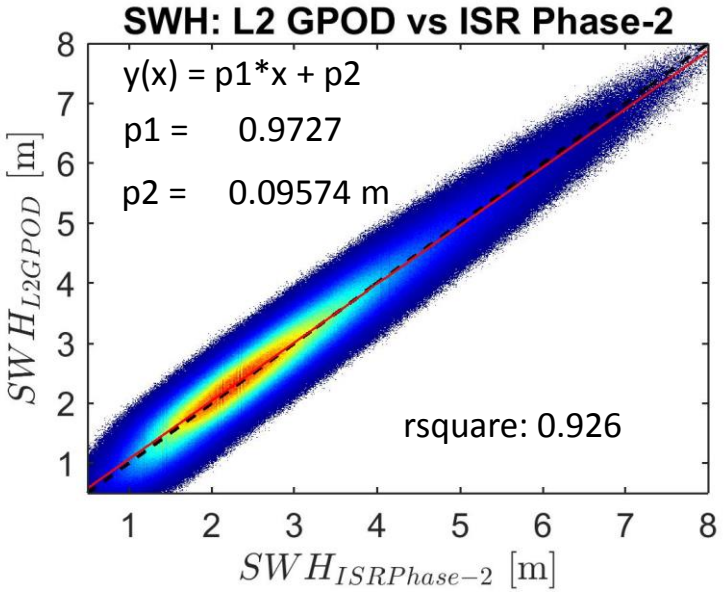


Phase-2 data SSH doesn't show a clear dependency on radial velocity → no intra-burst alignment has been applied



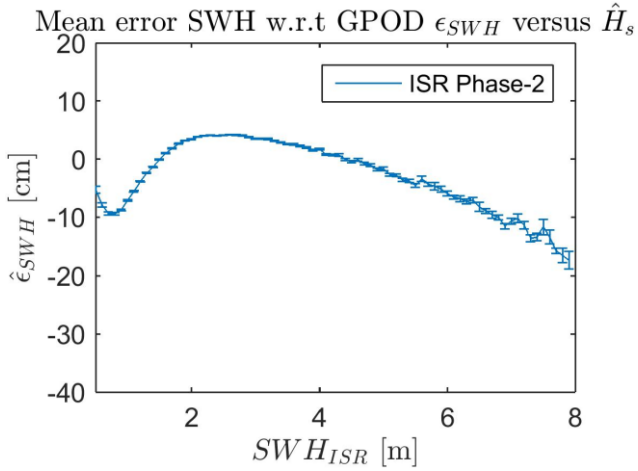
Phase-2a isardSAT processed data (L1+L2) with Sentinel-3 baseline [Agulhas, Central Pacific & North Sea, 2013-year]

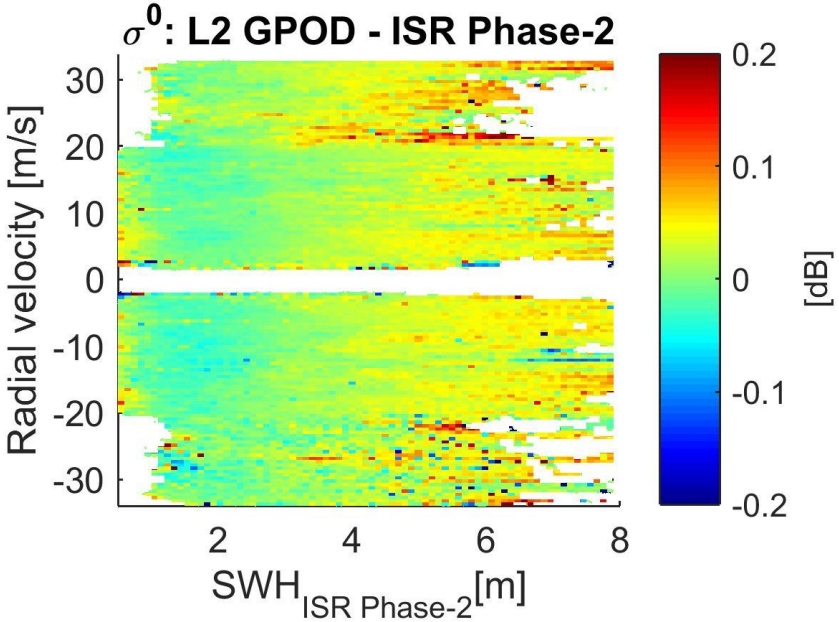


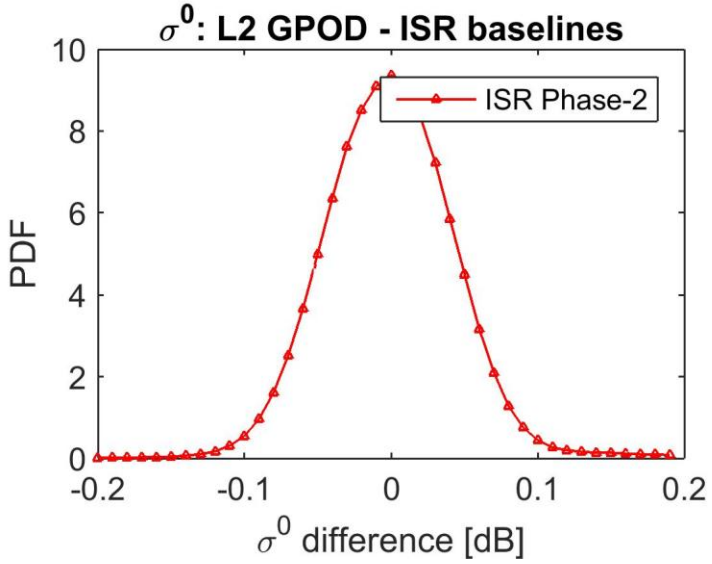


SWH differences doesn't show a clear dependency on radial velocity

SWH error versus SWH ISR Phase-2 shows a slight dependency below 20 cm (below requirement on SWH error for Sentinel-6): GPOD uses an adaptive LUT on PTR while ISR Phase-2 uses a fixed value



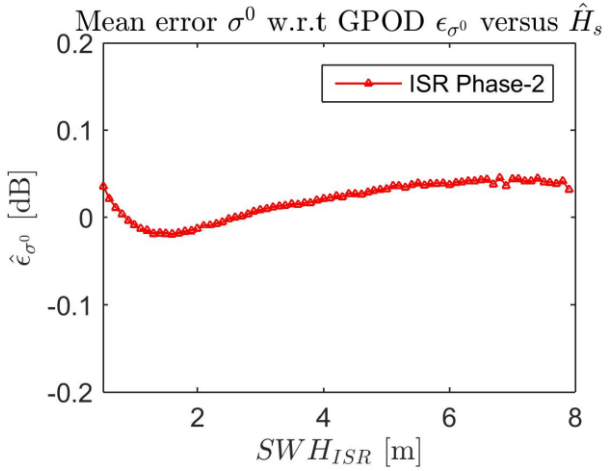




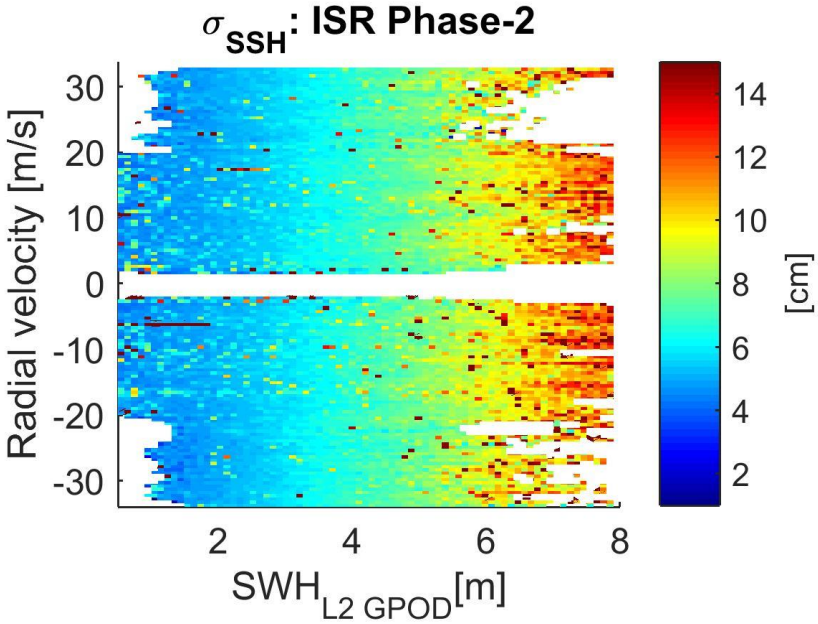
No clear dependency on radial velocity is observed

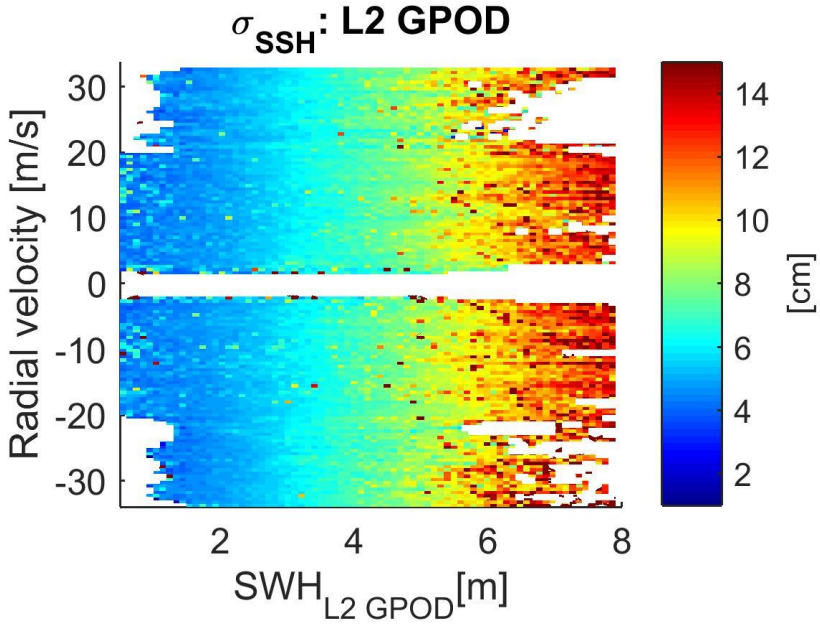
Sigma0 discrepancies as function of SWH are correlated with SWH differences (dilation term is modulating the amplitude of the backscattered waveform)

A bias correction around 2 dB has been considered on the Phase-2 data



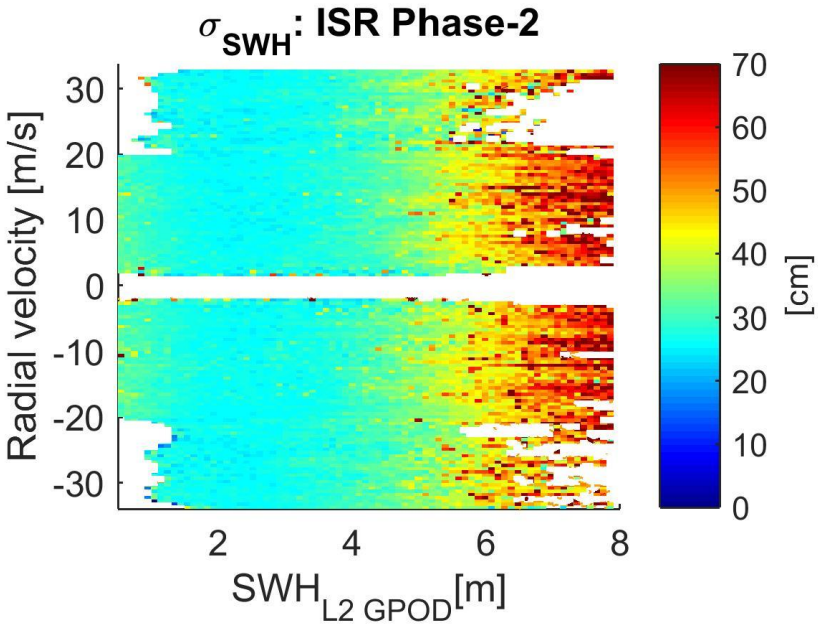
PRECISION (AGAINST GPOD DATA)

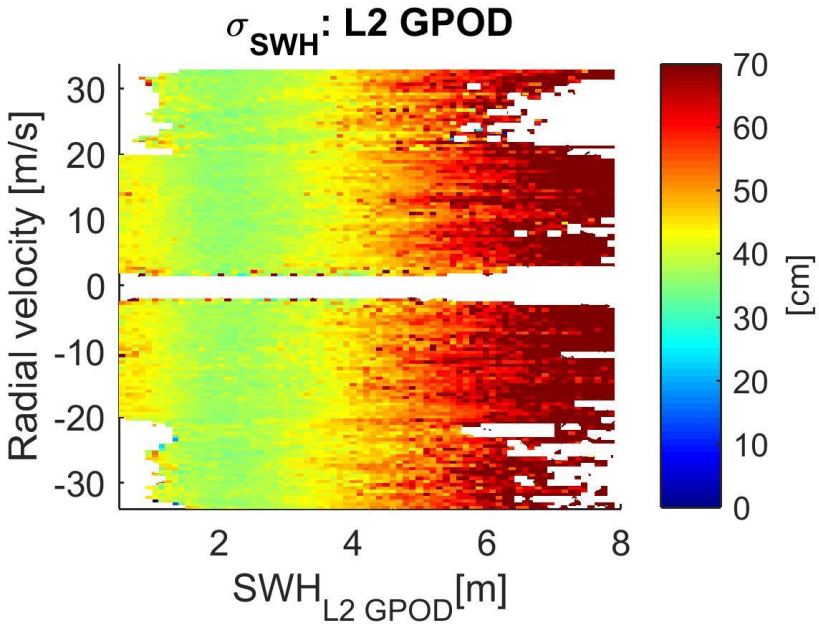




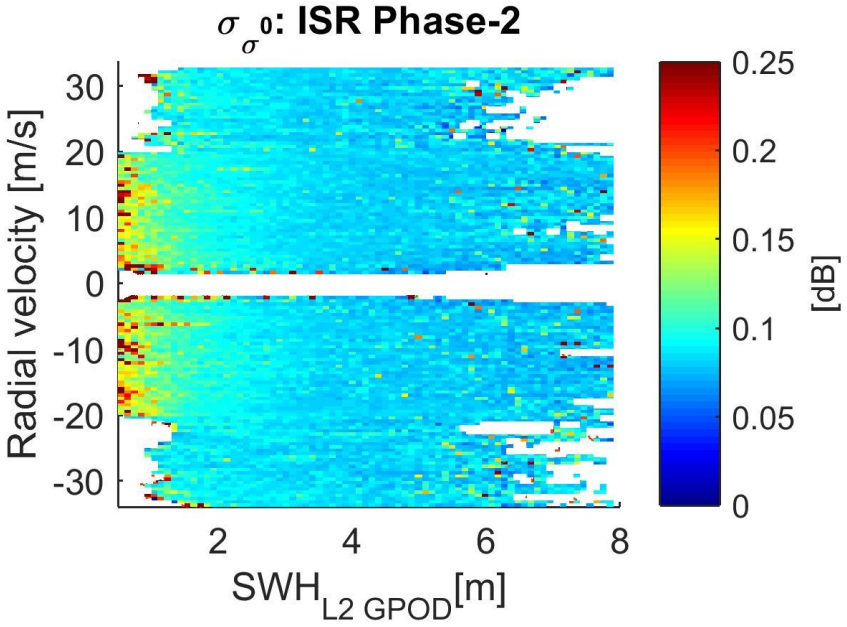
Very similar noise performance is obtained for both GPOD data and ISR Phase-2, except for a small degradation for low SWH in the case of ISR data due to potential overestimation of SWH compared to GPOD case

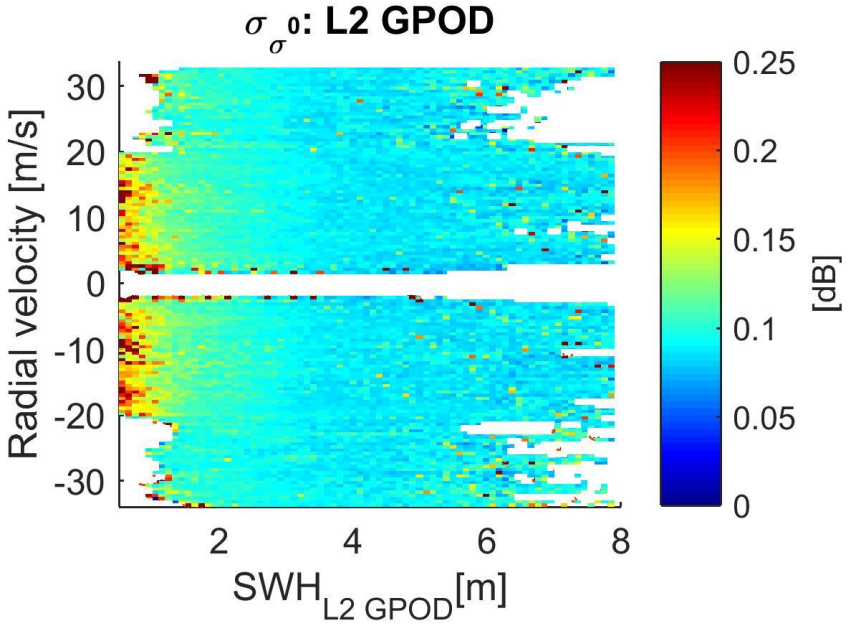
Slight improvement of noise performance compared to GPOD for SWH above 4 m due to the presence of intra-burst Hamming (as analyzed in Phase-2a)





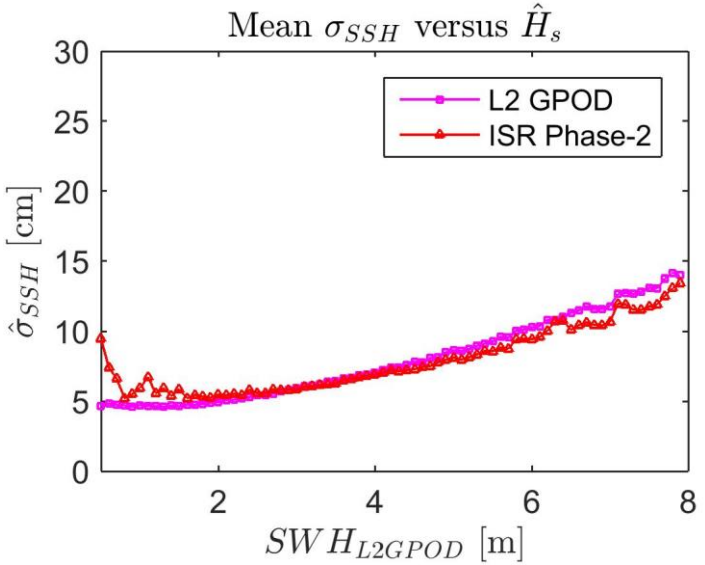
ISR Phase-2 shows an improved noise performance in SWH compared to GPOD with a consistent improvement around 10 cm over all SWH range

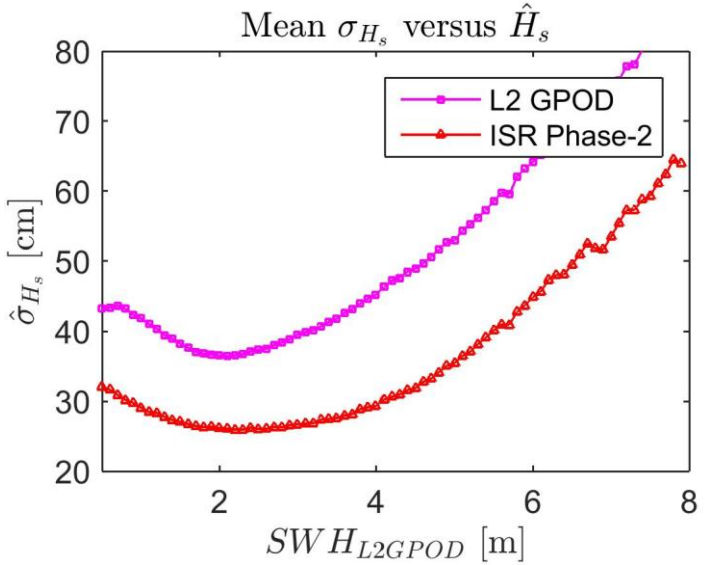


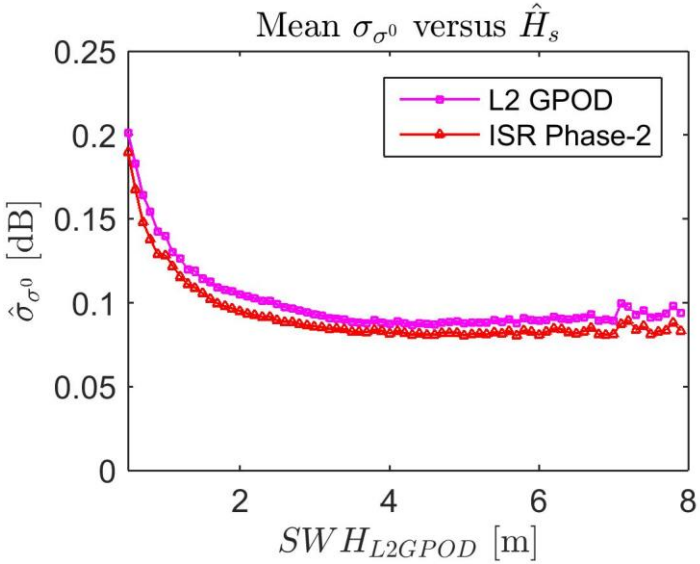


ISR Phase-2 shows a slight improvement in noise performance for SWH compared to GPOD with a consistent improvement around 0.01 dB over all SWH range

Precision (vs SWH)

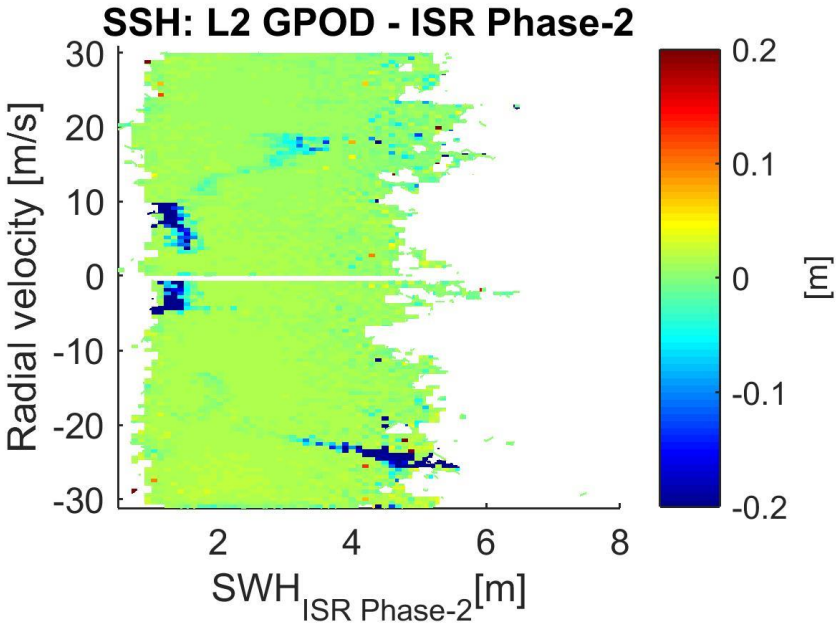




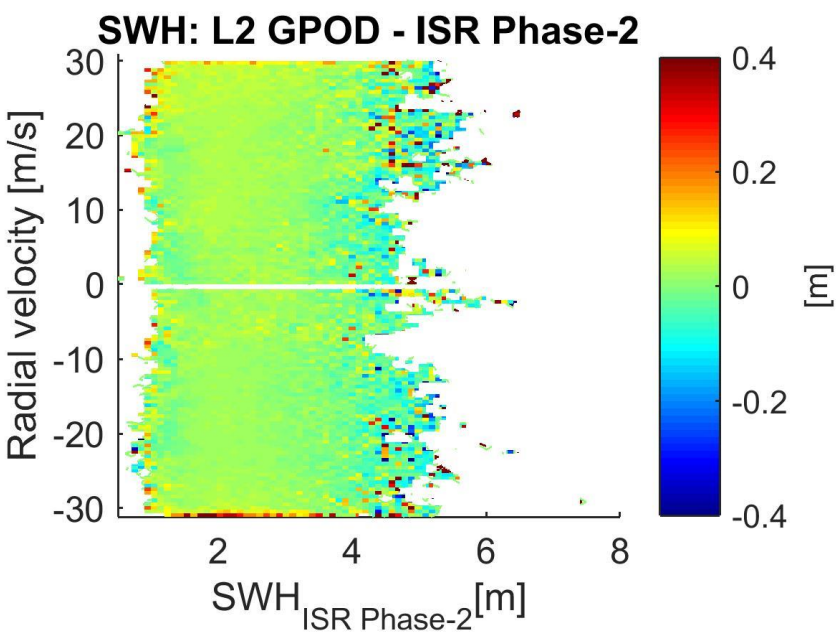


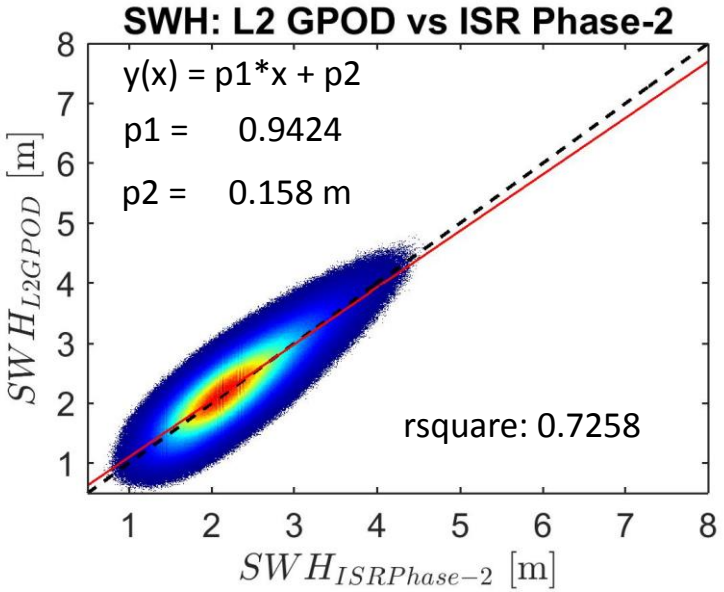
Pacific Regions: West, Central and East

ACCURACY (AGAINST GPOD DATA)



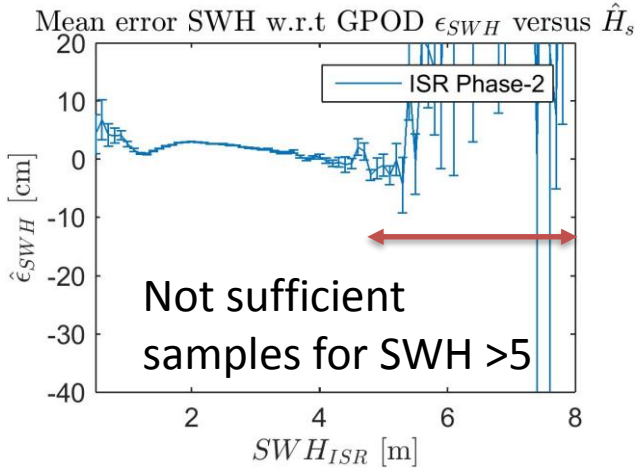
Phase-2 data SSH doesn't show a clear dependency on radial velocity → no intra-burst alignment has been applied



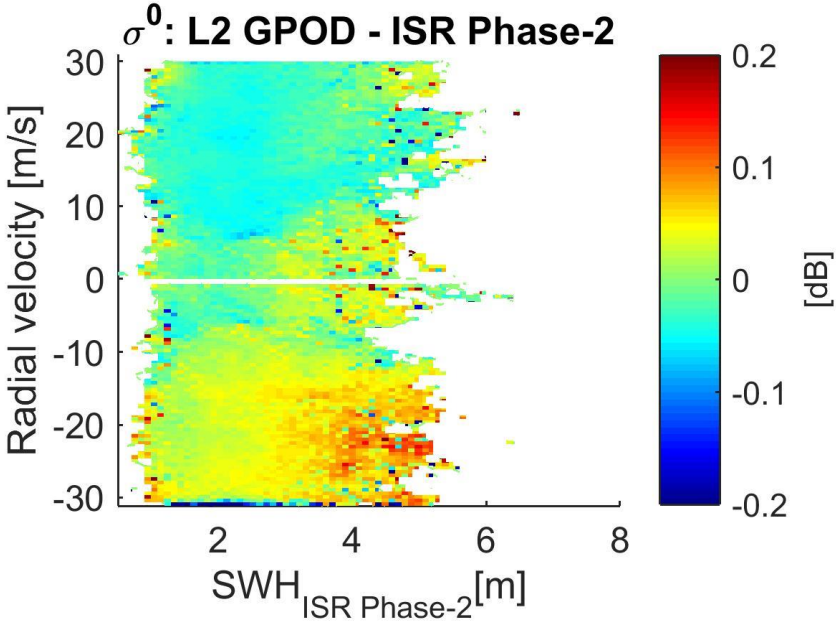


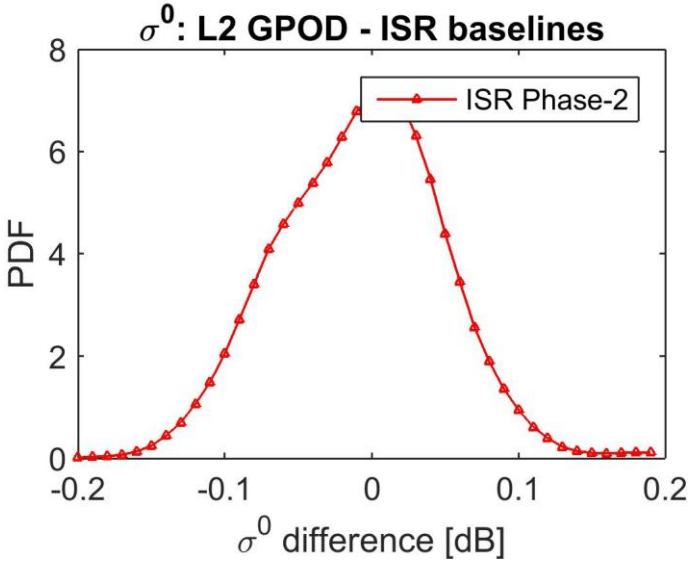
SWH differences doesn't show a clear dependency on radial velocity

SWH error versus SWH ISR Phase-2 shows a slight dependency

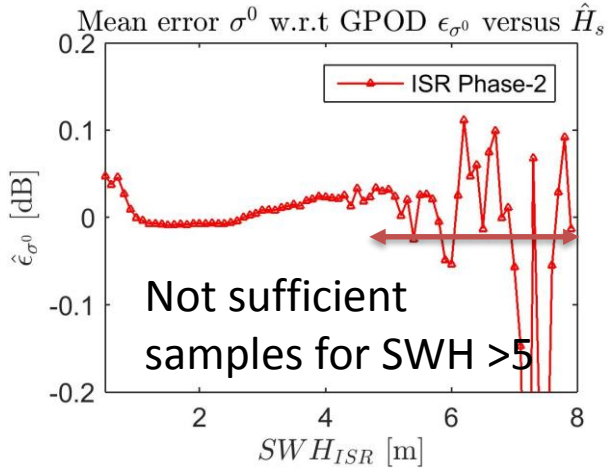


Sigma0 (I)

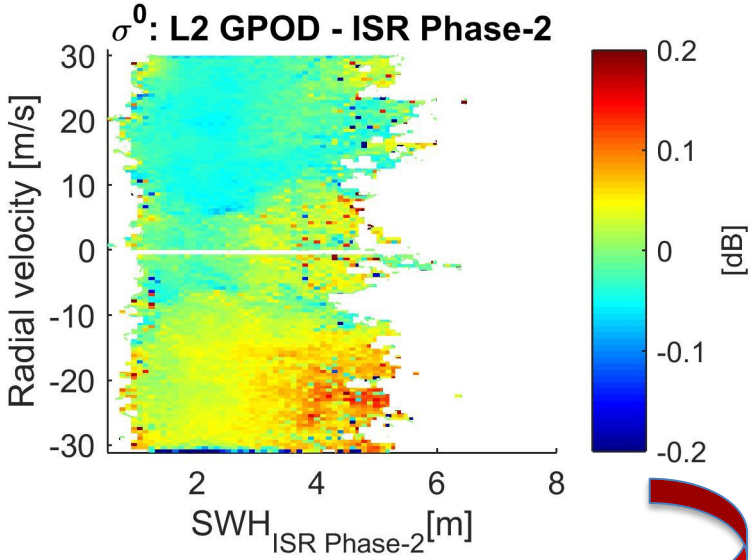


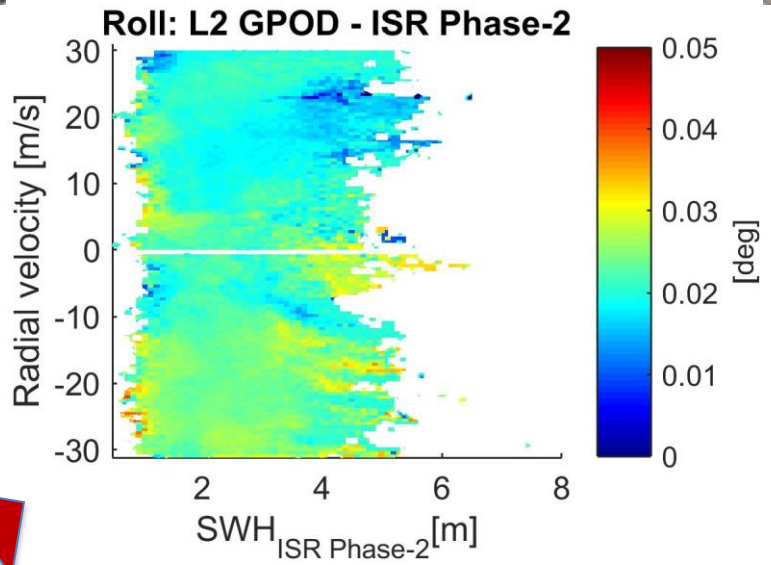


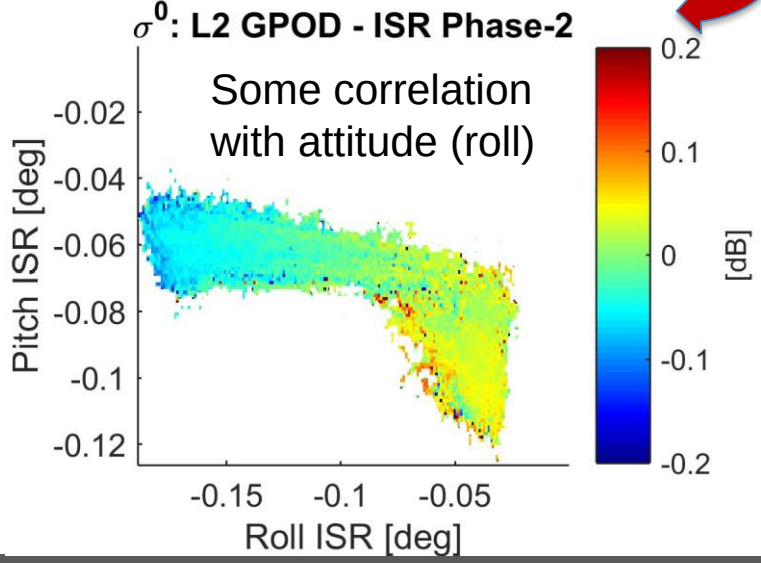
Sigma0 discrepancies show some correlation or dependency with the radial velocity, is it radial velocity or attitude dependency?



Sigma0 (II)

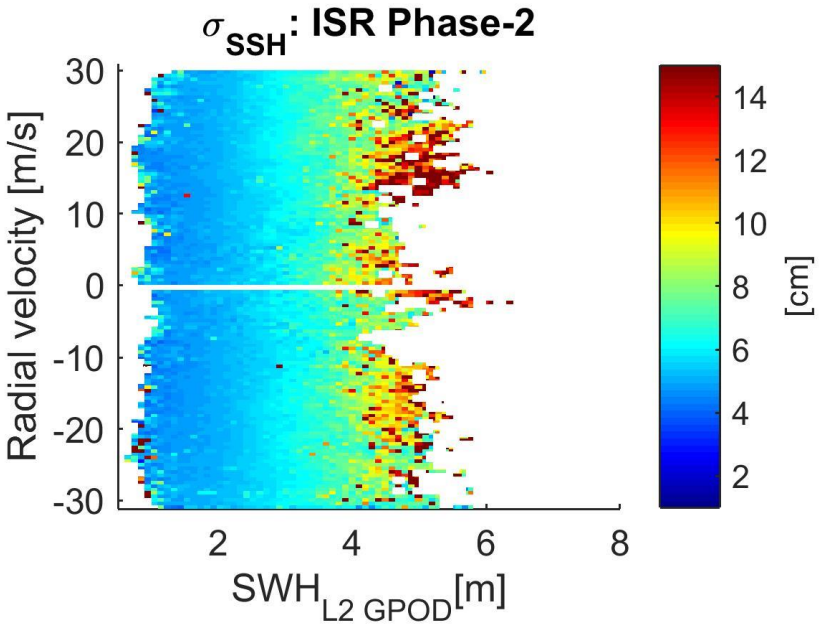


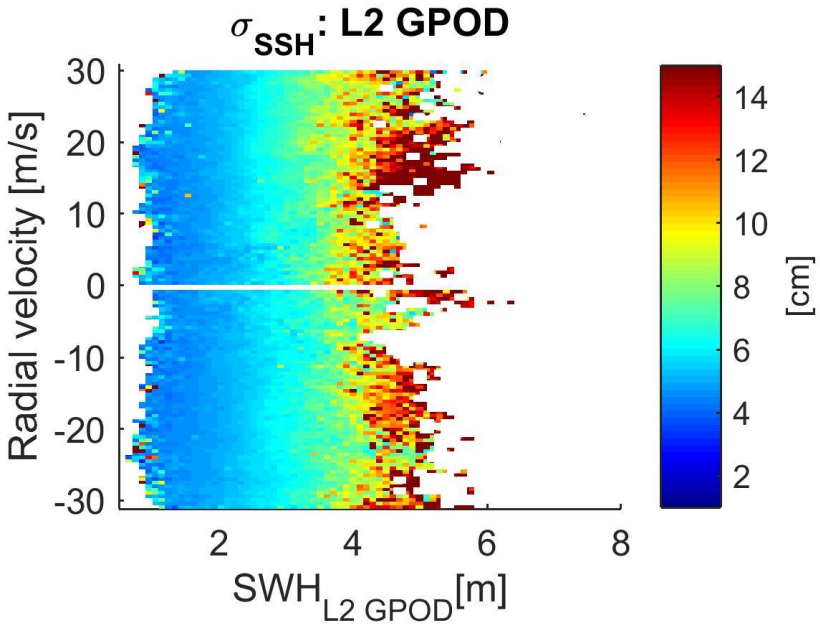




Differences in the Roll information between GPOD and ISR Phase-2 have “similar” patterns as the discrepancies in the sigma0 → roll modulates the amplitude of the modelled waveform

PRECISION (AGAINST GPOD DATA)





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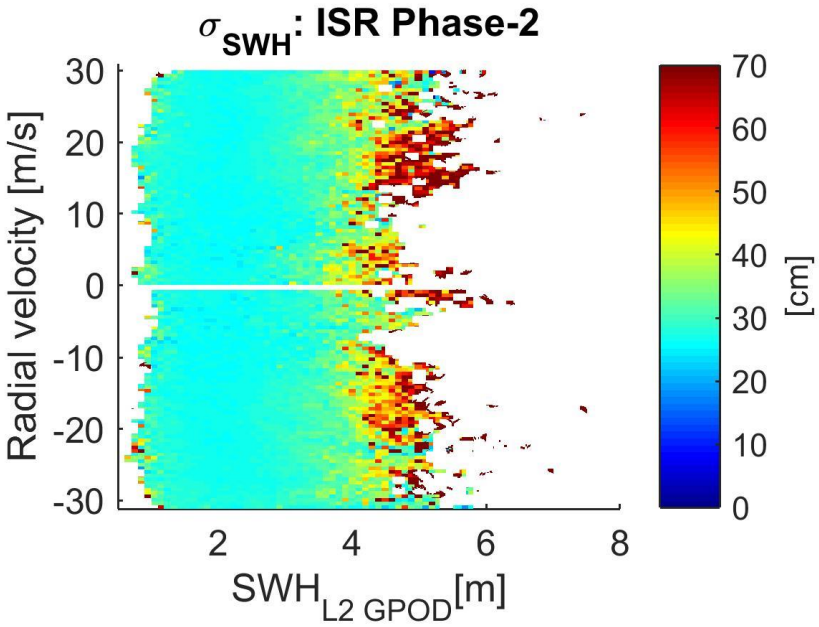
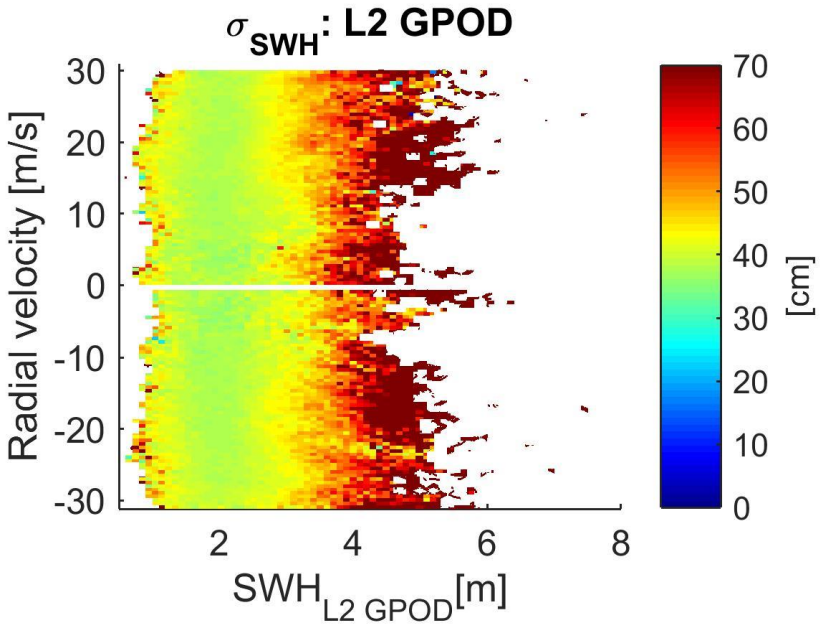
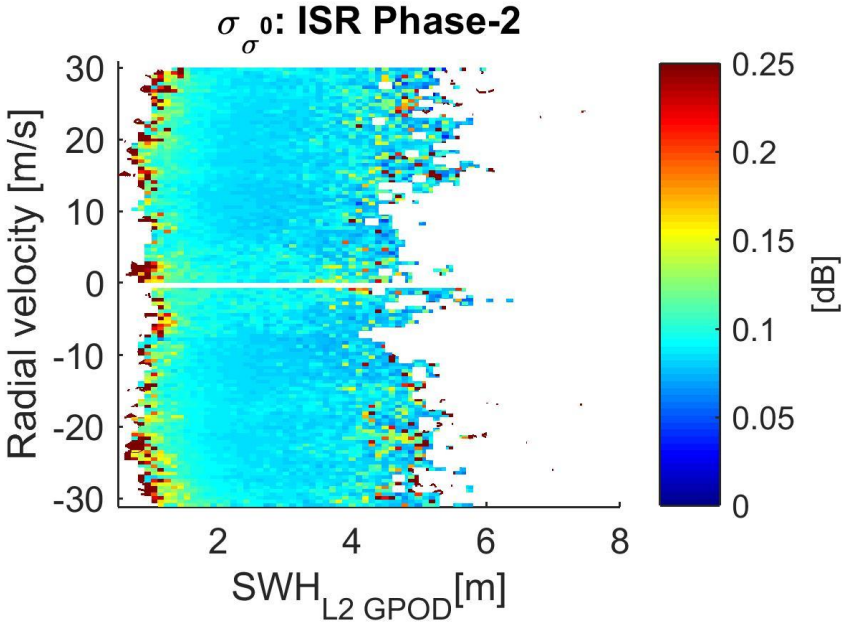
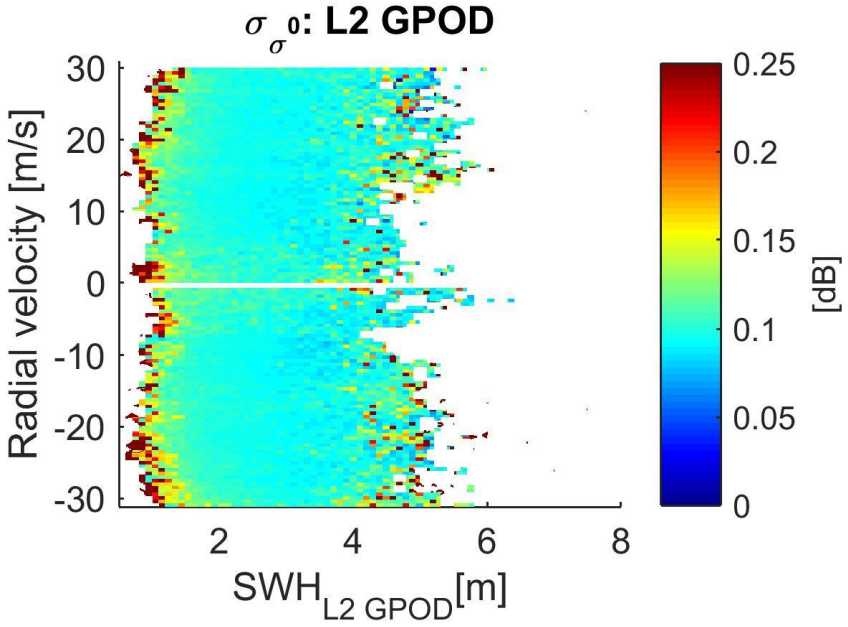




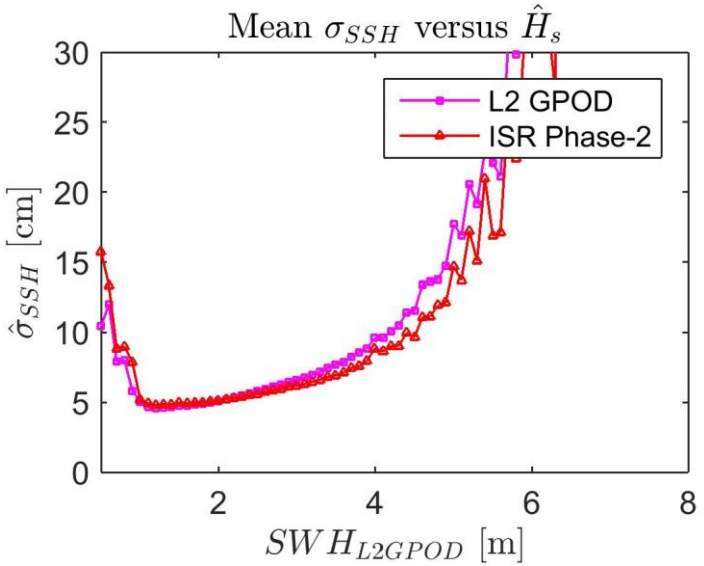
ISR Phase-2 shows an improved noise performance in SWH compared to GPOD with a consistent improvement around 10 cm over all SWH range

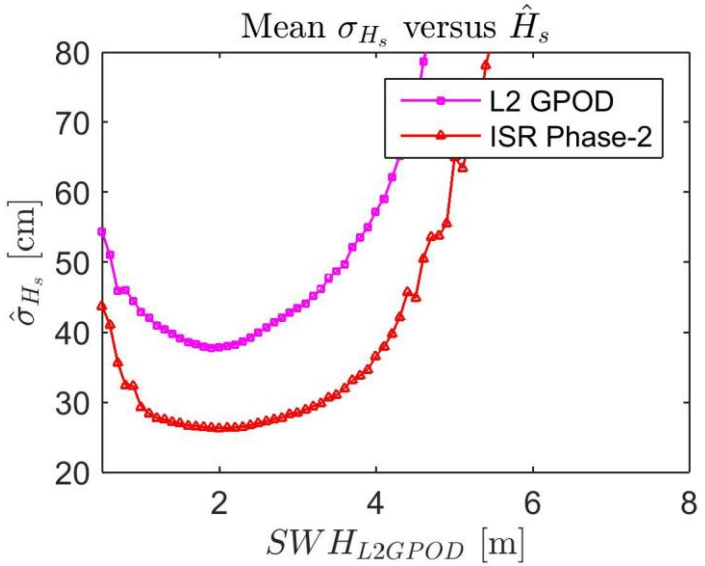


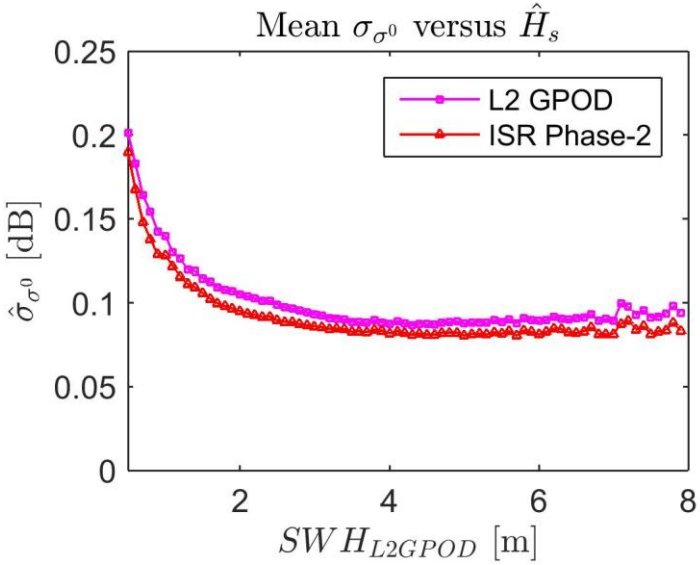


ISR Phase-2 shows a slight improvement in noise performance for SWH compared to GPOD with a consistent improvement around 0.01 dB over all SWH range

Precision (vs SWH)







Summary of Phase-2 data

- **SSH**:
  - Accuracy analysis doesn't show a clear dependency on radial velocity (as in previous Phase-2a data)
  - Very similar noise performance compared to GPOD, with slight improvement on higher SWH provided by intra-burst Hamming
- **SWH**:
  - In terms of accuracy a dependency on SWH exits below 20 cm (GPOD applies an adaptive PTR and ISR Phase-2 uses a fixed PTR) → in-situ data would be required to calibrate SWH properly (out of scope of SCOOP)
  - Improved noise performance (10 cm better) compared to GPOD over the range of 0.5 to 8-m SWH
- **Sigma0:**
  - Accuracy analysis shows a *dependency on radial velocity only for analysed Pacific patch areas* → might be correlated with differences on roll between GPOD and ISR
  - Improved precision (around 0.01 dB) compared to GPOD over the range of 0.5 to 8-m SWH

Outline

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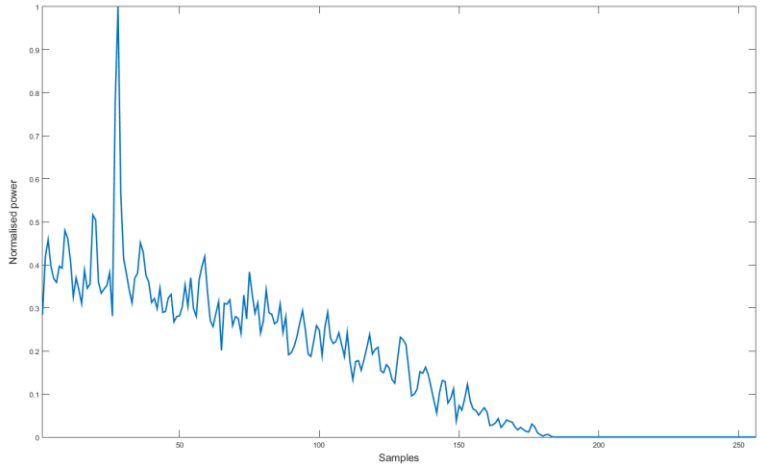
- L1B coastal processing
- L2 coastal study on Sentinel-3 data

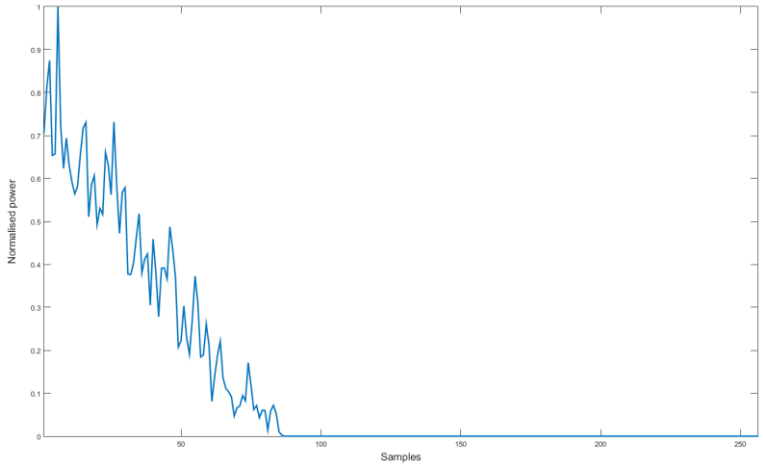
L1B coastal processing

Close to the coast, it has been observed a degradation of the L1B waveforms, which could impair the performance in L2.

Waveform #1134



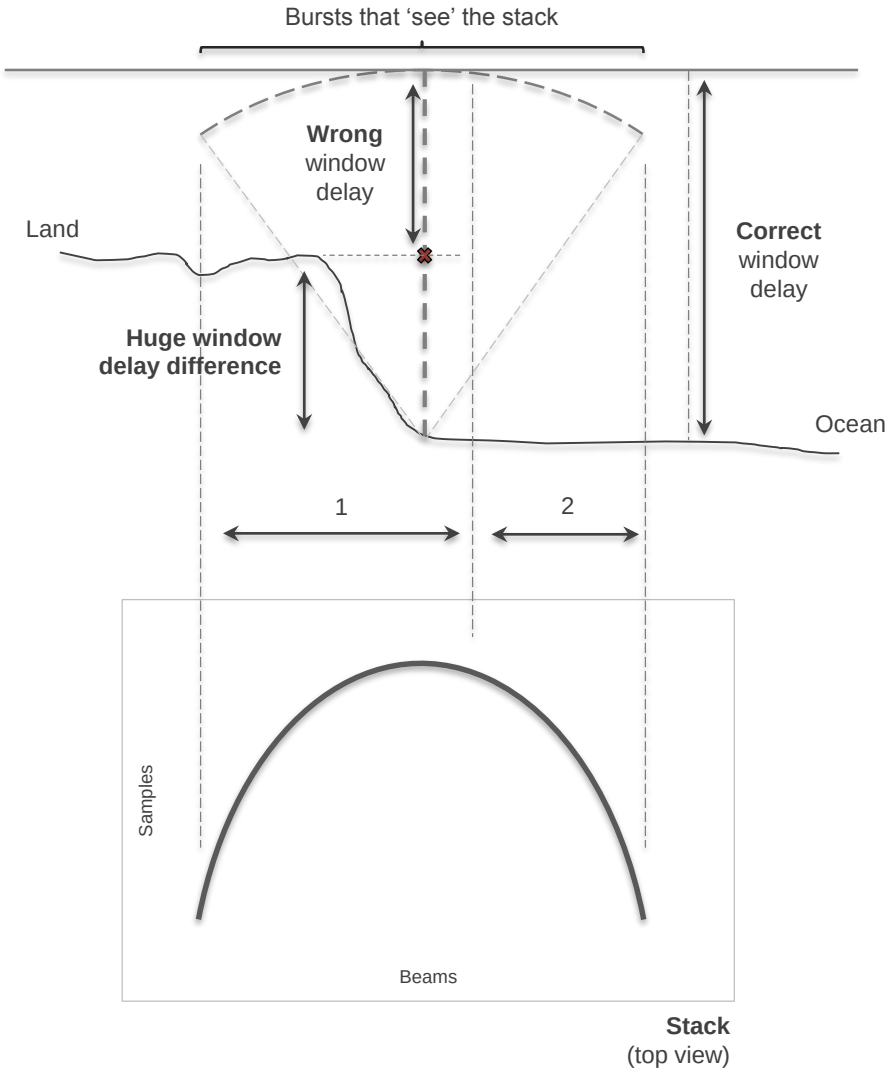
Waveform #1135



CR2_SR_1_SRA____20130224T115652_20130224T115932.nc

(Agulhas region)

L1B coastal processing



1. Waveforms coming from these bursts were lost because the on-board tracker did not position the window correctly.
2. The on-board tracker was already tracking the ocean so waveforms were not lost.

However, since our window delay reference was wrong, waveforms coming from '2' were lost when aligning the stack due to the huge window delay difference*.

*All waveforms that suffer more than a window size shift are masked to avoid undesired wraps.

L1B coastal processing

- Following GPOD's approach that takes the window delay that minimises "*altitude – (window delay*c/2)*" as the reference, we decided to take the first *ocean* window delay, as sometimes the first solution did not work.

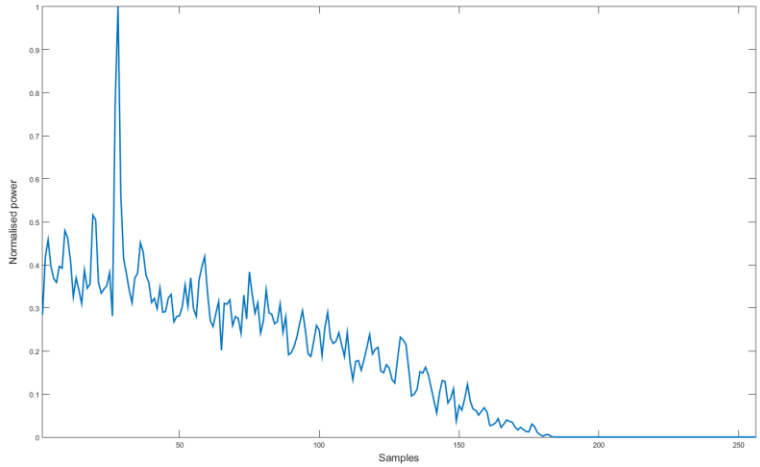
- This *ocean* decision is based on the rough ocean/land mask from the FBR at burst level.

- With this, waveforms from '2' are aligned with respect to the first burst or look in the stack marked as *ocean* and thus not lost.

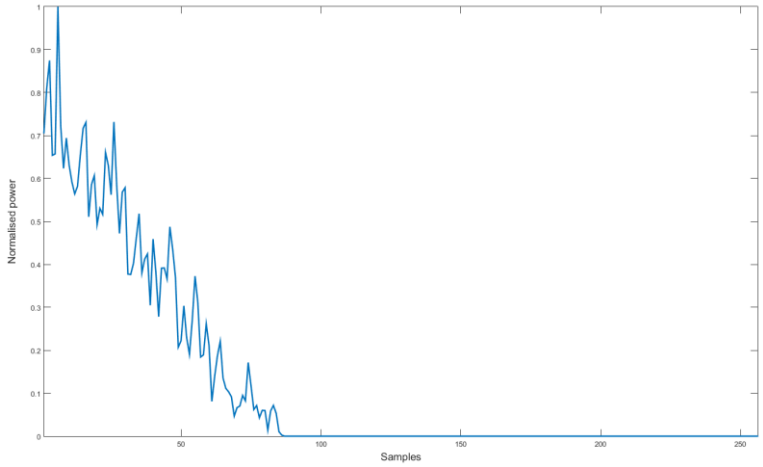
L1B coastal processing

Our final solution yields useful information near the coast…

Waveform #1134



Waveform #1135



CR2_SR_1_SRA____20130224T115652_20130224T115932.nc

(Agulhas region)

L1B coastal processing

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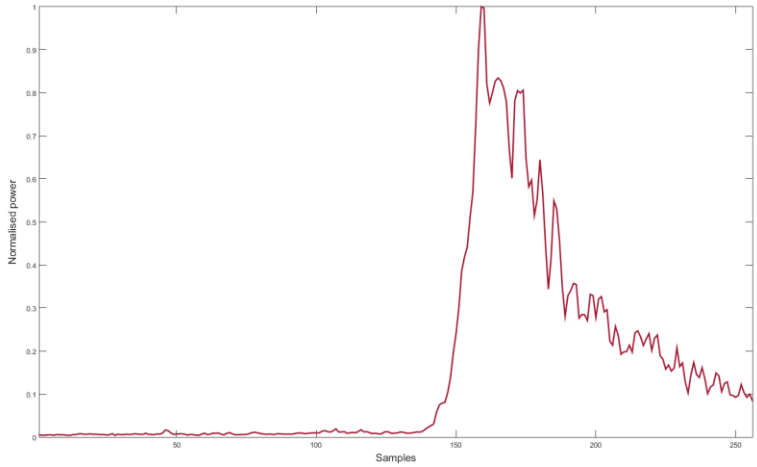
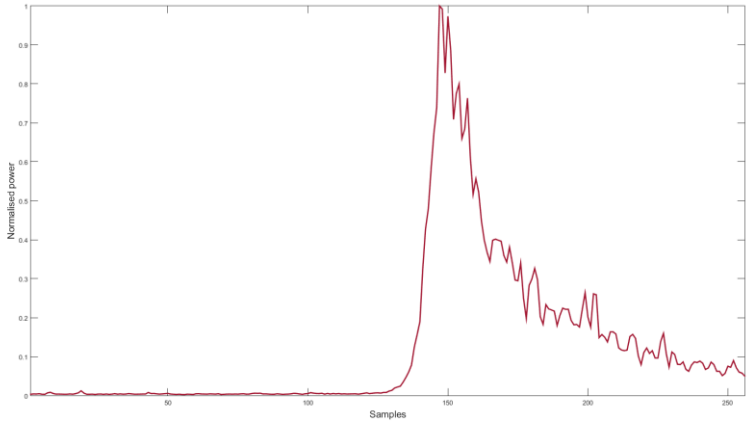
Waveform #1134



Waveform #1135

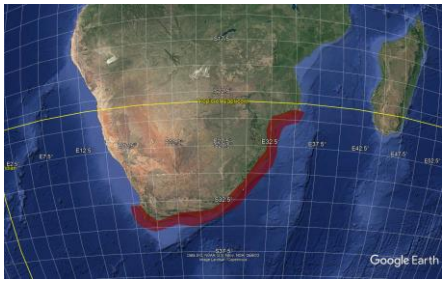


CR2_SR_1_SRA____20130224T115652_20130224T115932.nc

(Agulhas region)

L1B coastal processing

- A **reduced data set generated** with this new L1B processing approach over:
  - North East Atlantic
  - North Sea
  - Agulhas
  - Harvest
  - North Indian Coast
  - Indonesia
- **L2 processing** considered with specific **masks** around the coast to **reduce computational load**:
  - North East Atlantic
  - North Sea
  - Agulhas



THANK YOU !!

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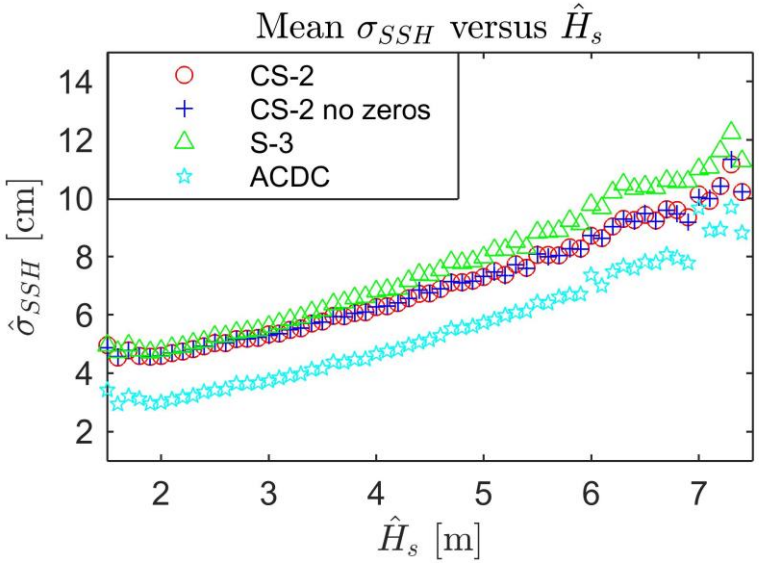
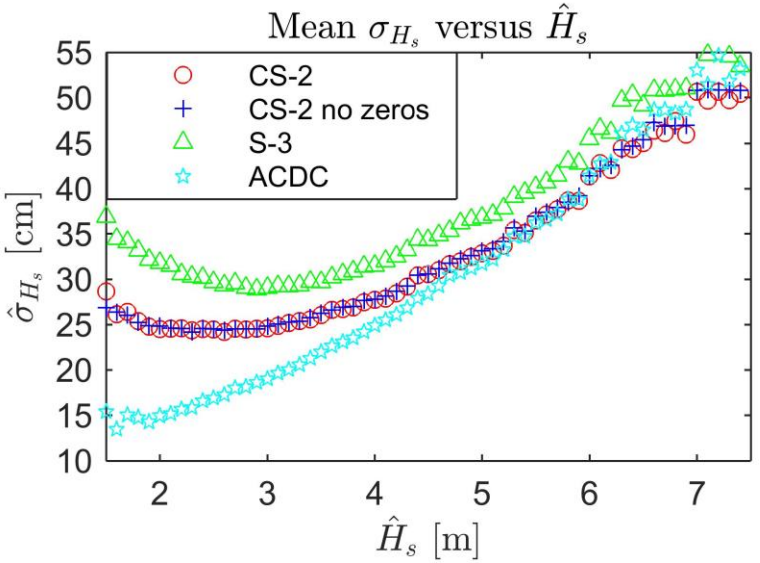
Performance: DDP and ACDC

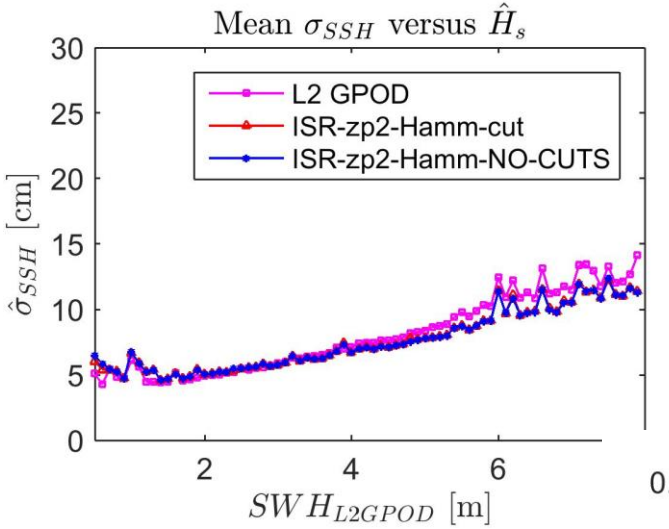
- isardSAT aside study comparing Sentinel-3, CryoSat-2 and ACDC processing approaches over Agulhas region: Indicates that CS-2 baseline with cut on the edges of stack combined with Hamming and zero-padding of 2 provides improved performance compared to S-3

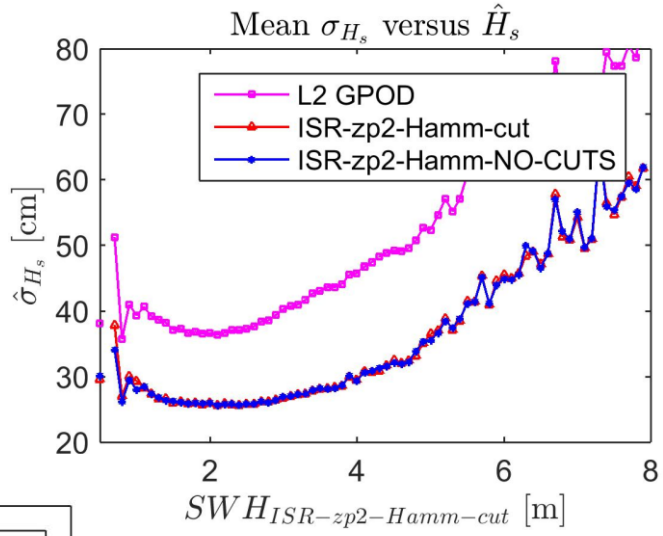


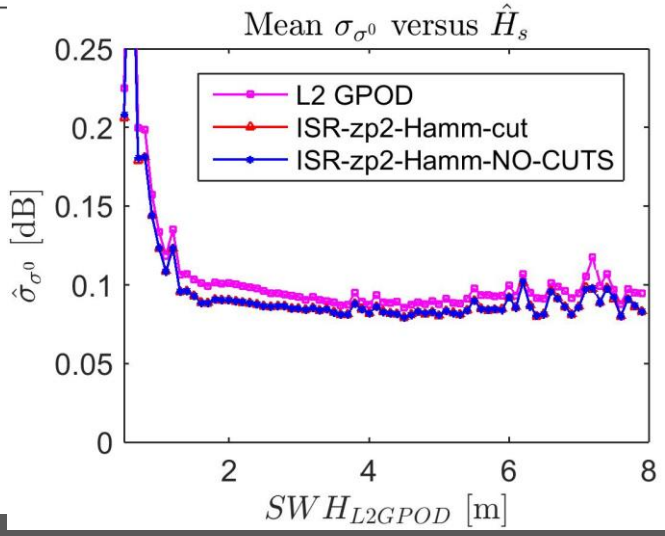


Impact of stack cuting at edges: $\pm 0{,}6\ degrees$

- Comparison considering or not the cut of the stack at the edges (as per CryoSat-2 approach) no significant differences are appreciated (Agulhas region 2013)







Attitude differences w.r.t GPOD