Leveraging Sentinel-6A interleaved mode to characterize High Resolution error budget over ocean

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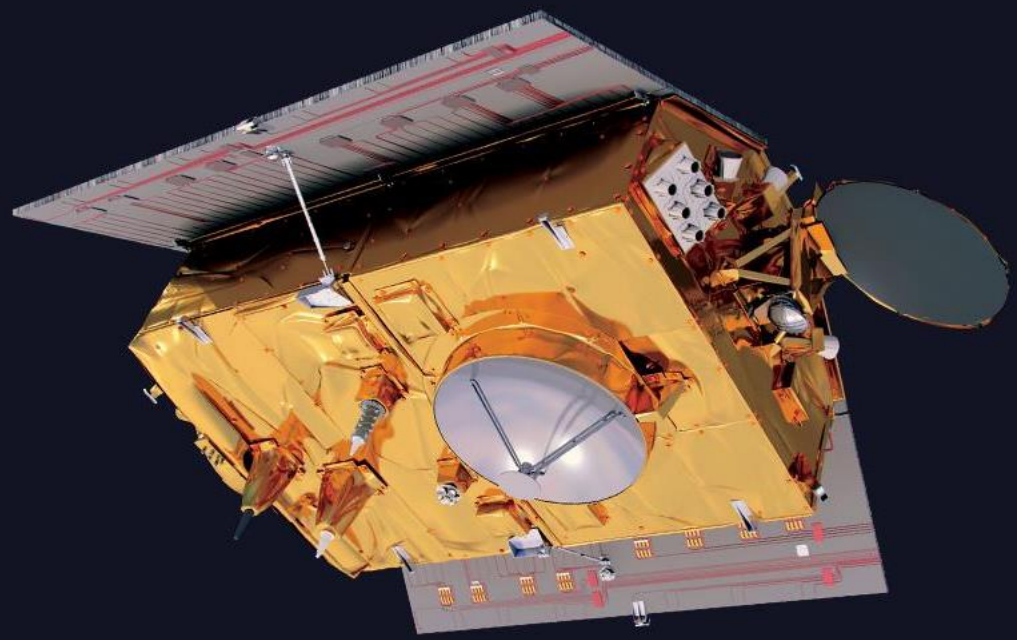
2022 OSTST, 2022-11-03



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Introduction

Goal: To review the known errors on HR/UF-SAR data over ocean, to present their current understanding and the possible solutions.

1. PTR shape evolution
2. Ocean vertical velocity effect
3. Along-track wind effect
4. Swell impact

Based on Sentinel-6A data during its tandem flight with Jason-3

Results from commissioning activities with CNES/Eumetsat and R&D activities with CNES.

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- Jason-3 GDR-F MLE4

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  → Allows to truly assess S6A HR performance

More details on CNES/CLS S6PP:

- *Dinardo S. et al, Sentinel-6 MF Poseidon-4 main results from the first year of mission from the S6PP LRM and UF-SAR chain, OSTST 2022, poster*
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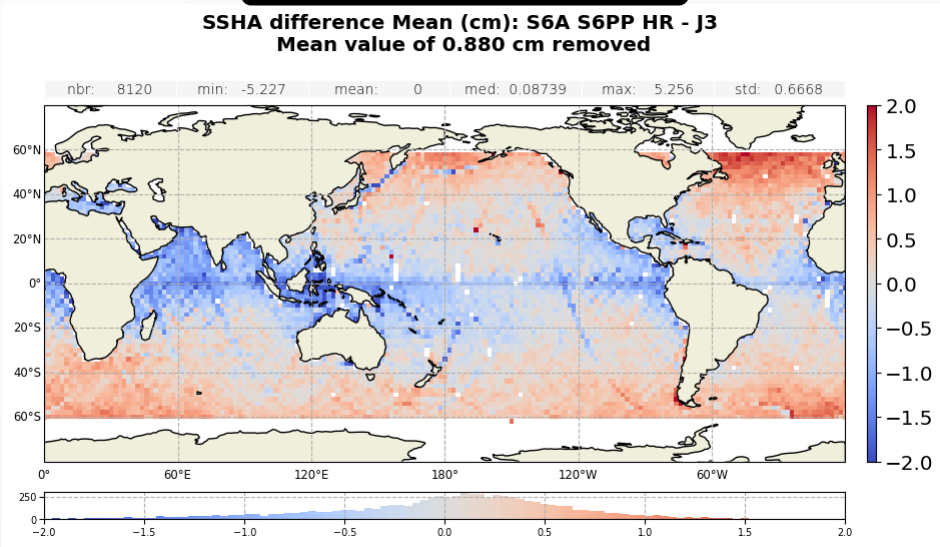
S6PP HR – J3



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Equatorial band

Equatorial band visible on « orbit – range – mss » comparison to J3

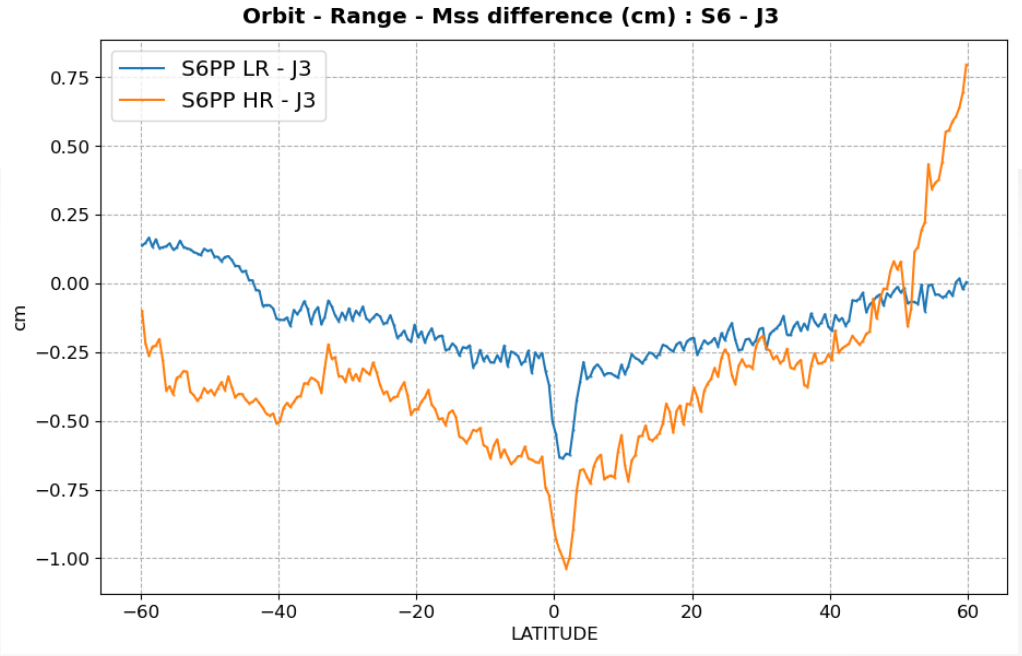
For LR and HR data, on S6PP and PDAP → **Not an HR error**

Amplitude of ~5 mm on range

A second (smaller, 1 mm) band is visible around 40°S

Not understood, but :

- Not coming from a geophysical correction,
- Not coming from the orbit,
- Not coming from echo centering issue,
- Not coming from temperature (S6)



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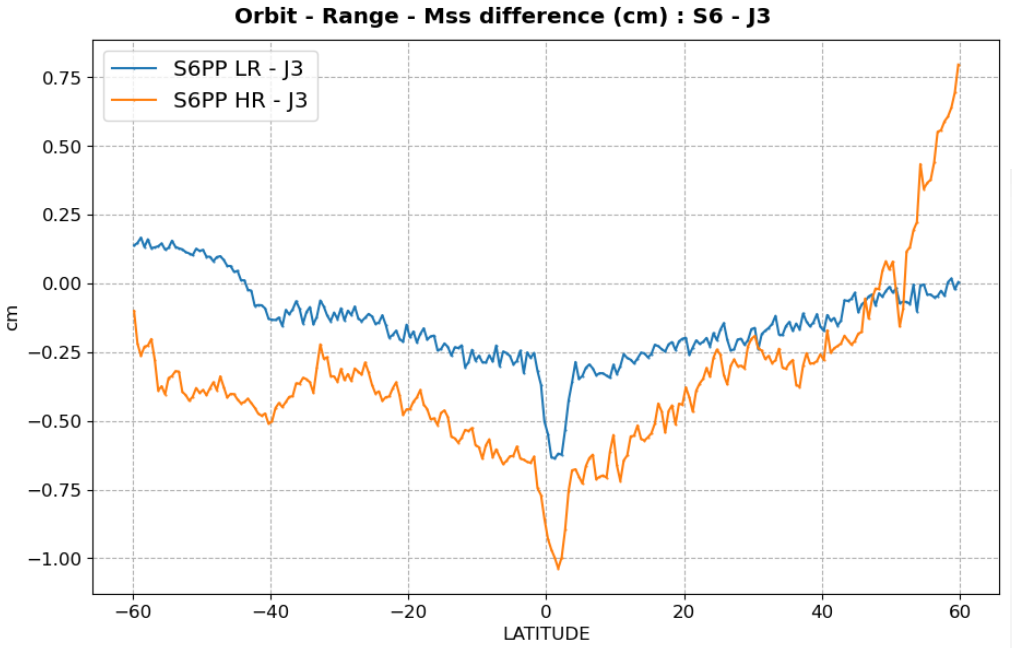
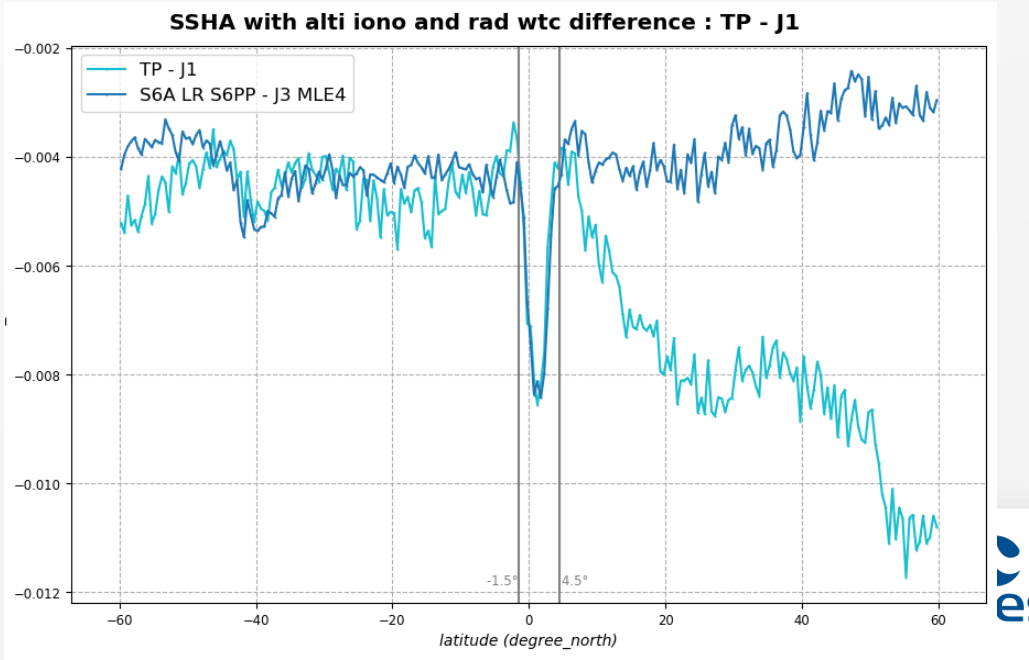
Same behavior seen between **Topex and Jason-1** over their tandem flight : same position and same amplitude.

Comparison to external products and missions (S3) → **This equatorial band likely comes from the Jason serie (ongoing CNES investigations)**





1/ PTR shape evolution

- **Evolution of PTR shape in range direction**
  - Impact range and SWH, LR and HR
  - Correction: **Numerical retracker** to account for in-flight PTR

- **Evolution of PTR shape in azimuth direction**
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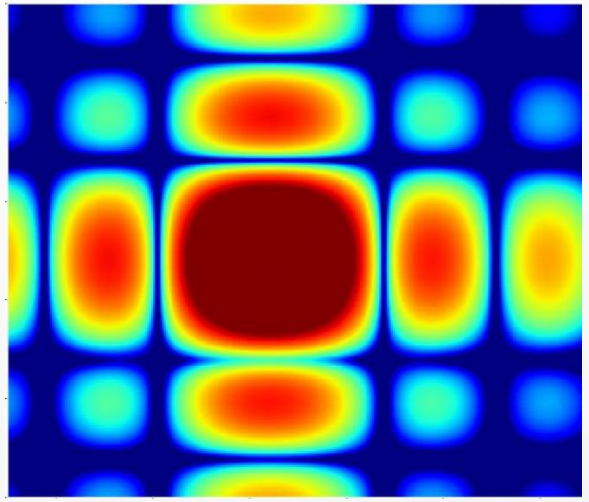

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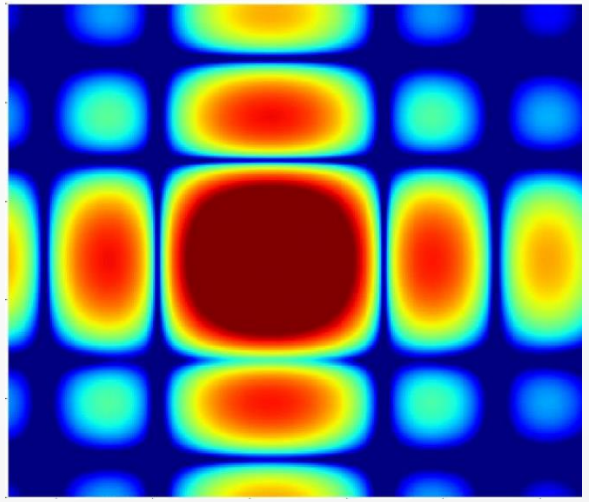

These 2 solutions have been implemented in CNES/CLS S6PP allowing to quantify the GMSL impact on S6A :

GMSL error on S6A HR	POS4-A	POS4-B
Due to absence of numerical rtk	0.7 mm/year	0.3 mm/year
Due to the absence range walk correction	1.8 mm/year	3.1 mm/year
Total	2.5 mm/year	3.4 mm/year

From Dinardo S. poster, Sentinel-6 MF Poseidon-4 main results from the first year of mission from the S6PP LRM and UF-SAR chain, OSTST 2022

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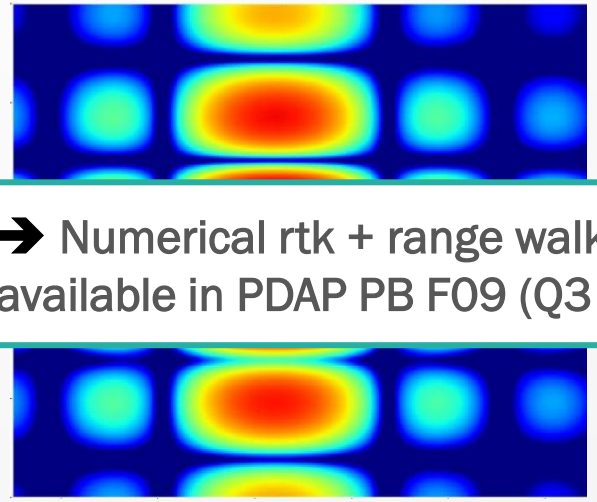

➔ Numerical rtk + range walk will be available in PDAP PB F09 (Q3 2023)

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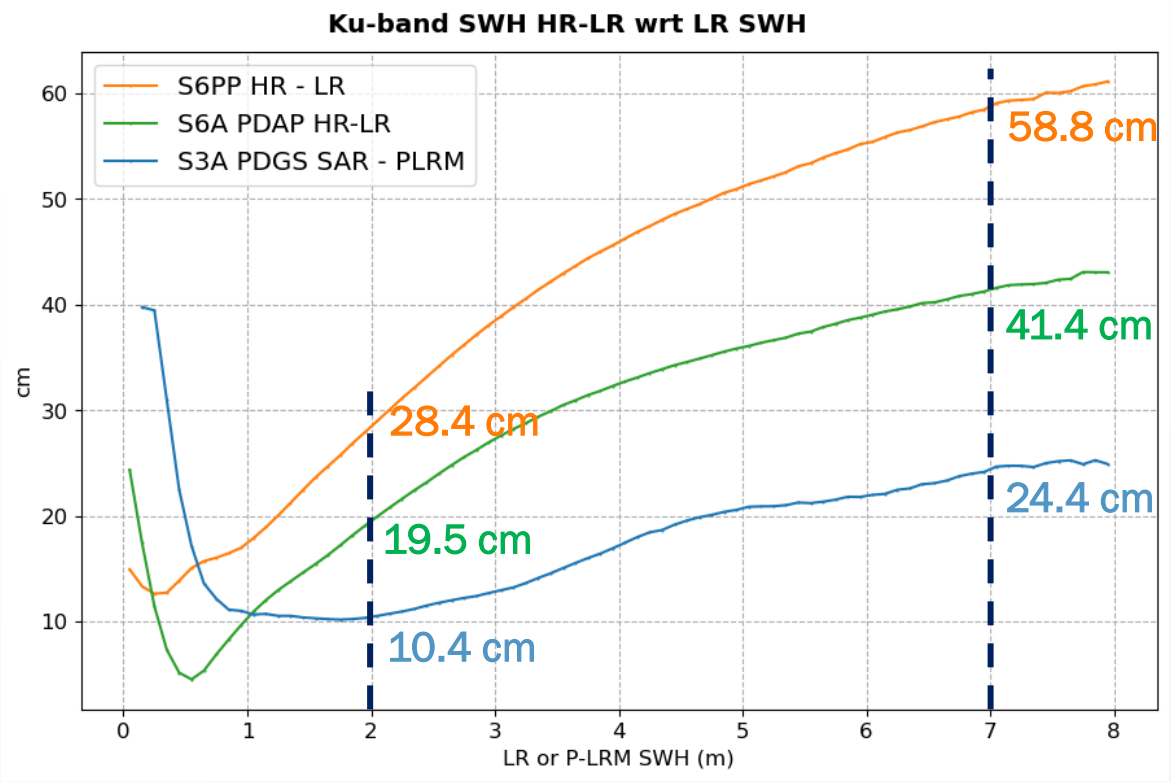
2/ HR SWH & Ocean vertical velocity



Known impact on SAR data

Induce strong bias on HR SWH.

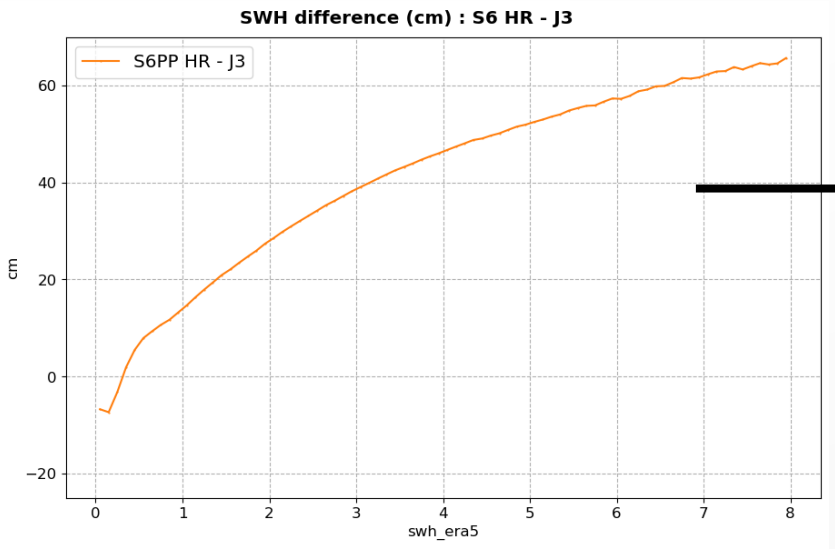
Impact stronger on S6A than on S3A due to longer burst duration and higher altitude

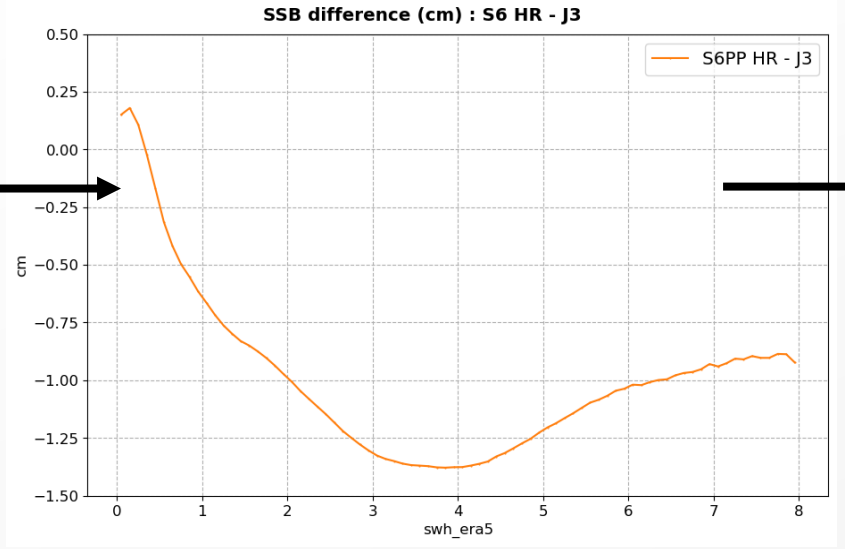
Impact reduced on PDAP thanks to the reduction of number of looks in PB F06 (HR SWH reduced by 16.5 cm in average)

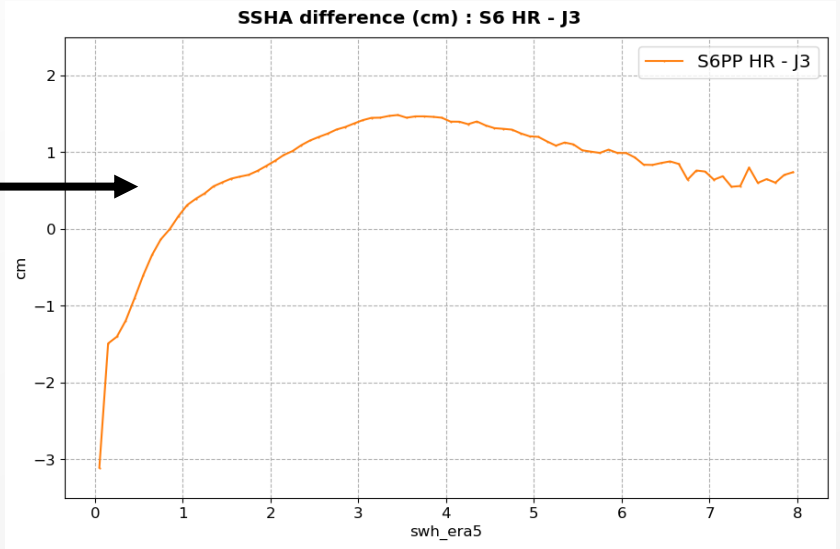
→ impact S6A HR SSHA through SSB

2/ HR SWH & Ocean vertical velocity

S6PP HR – J3 difference wrt to ERA5 SWH







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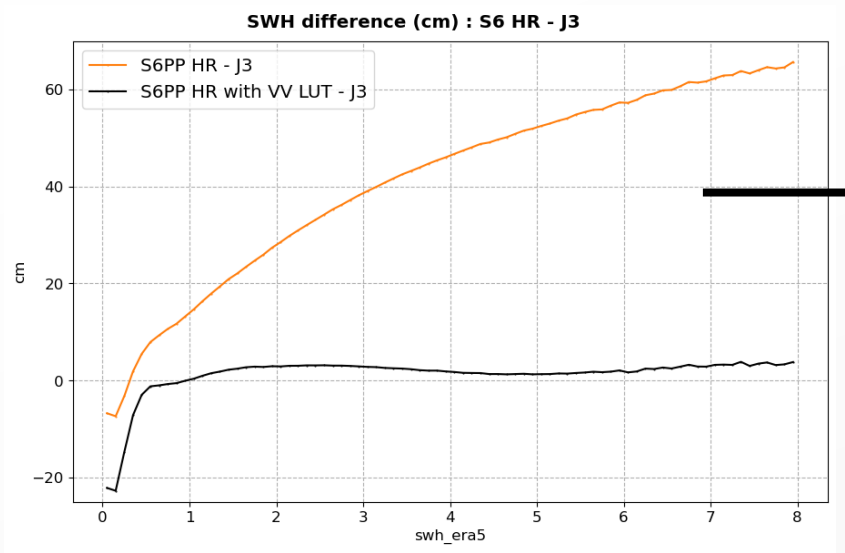
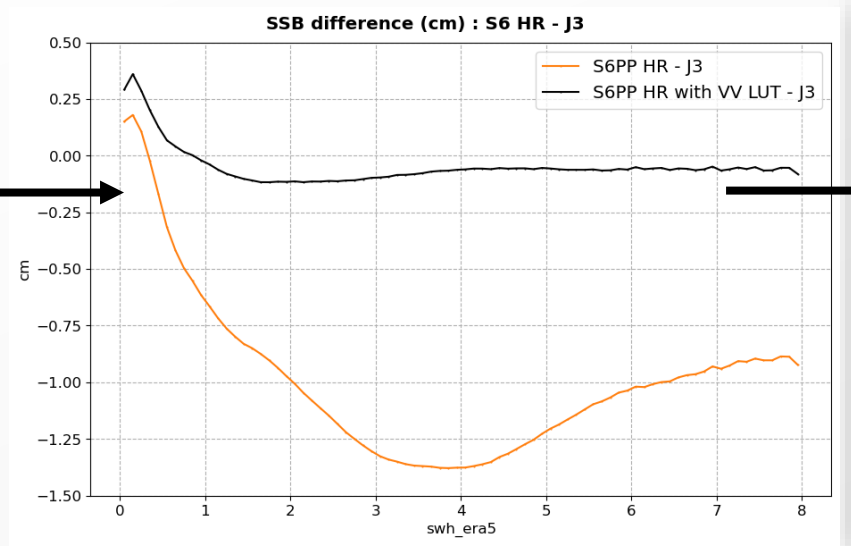
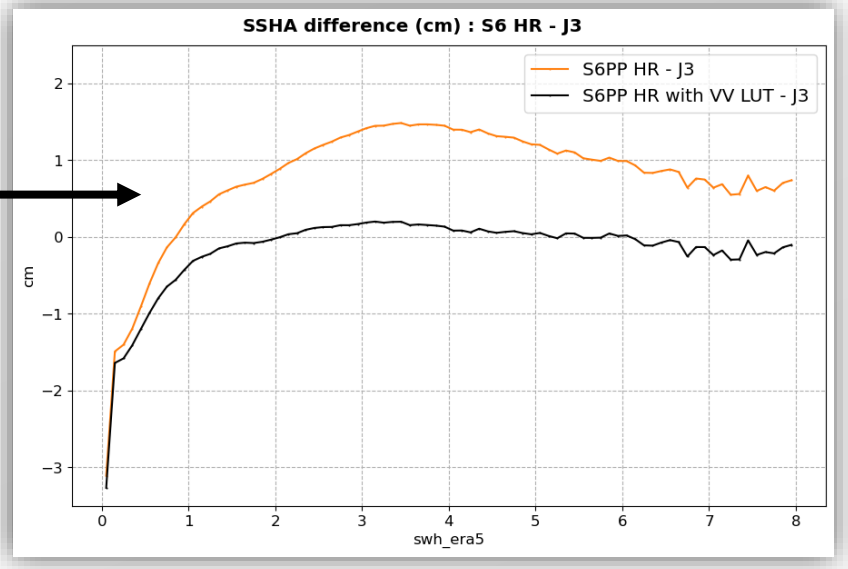






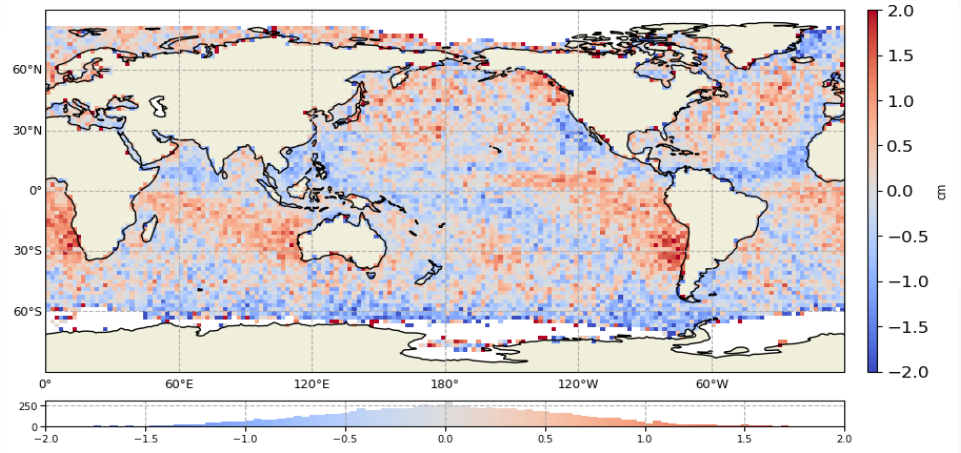
To reduce OVV effect in S6PP HR dataset: Application of LUT built by NOAA on S6PP HR SWH (*see Egido A. et al presentation, A Significant Wave Height Correction to Account for Vertical Wave Motion Effects in SAR Altimeter Measurements, OSTST 2022*).
Correction applied using S6PP LR SWH and MFWAM mean wave period

➔ **Suppression of the bias in SSHA for SWH > 1.5 m**

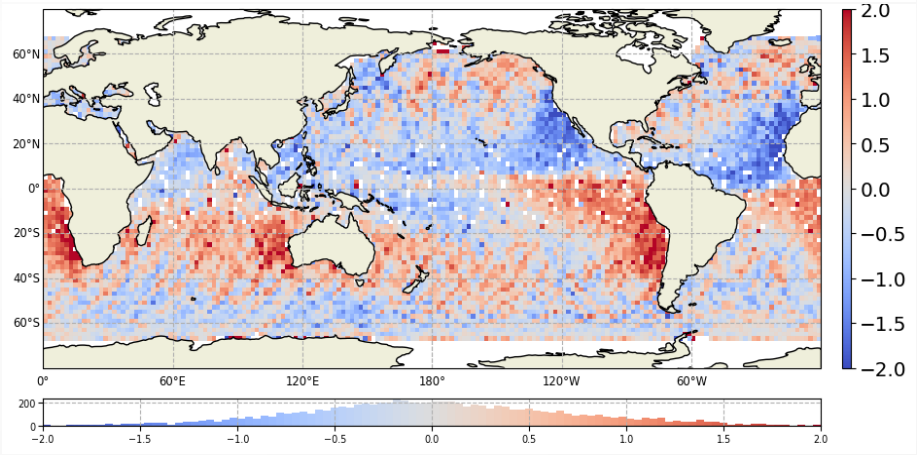
➔ OVV LUT in PDAP PB F10 foreseen for end Q4 2023

3/ Along-track Wind

S3A PDGS



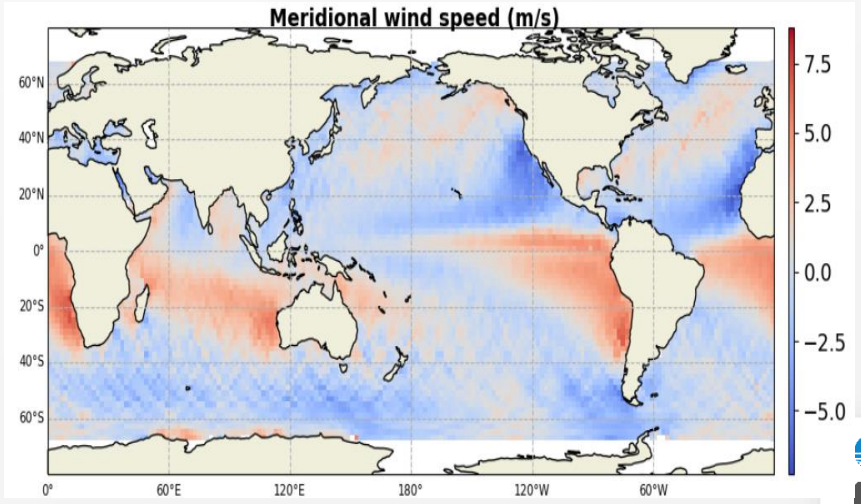
S6A PDAP – original data



HR–LR Range difference, ascending tracks–descending tracks

As already observed on Sentinel-3 (Raynal OSTST 2019), a correlation to along track wind is also visible on Sentinel-6 (Boy OSTST 202203)

→ PDAP and S6PP : same impact of ~3cm of amplitude (asc+dsc)
→ S6 vs S3 : higher amplitude for S6



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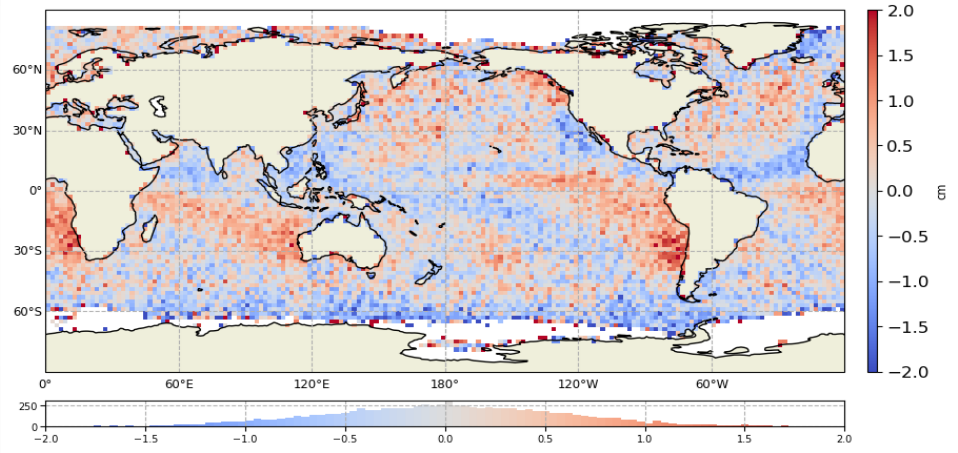

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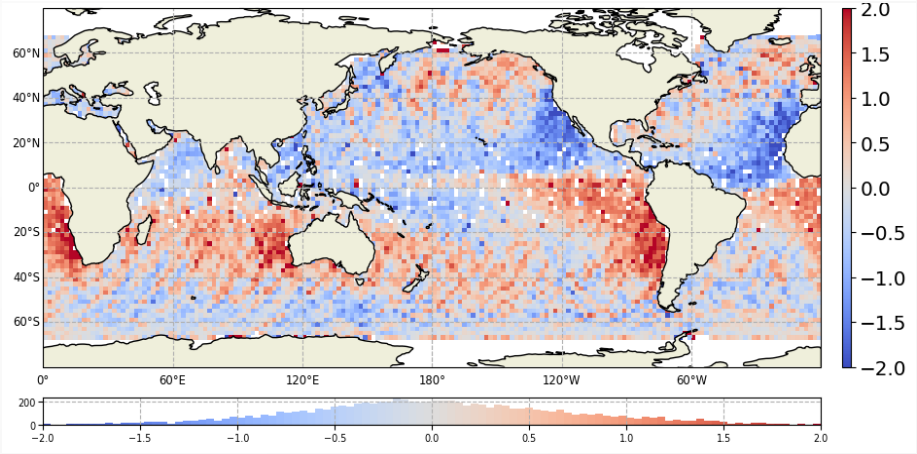

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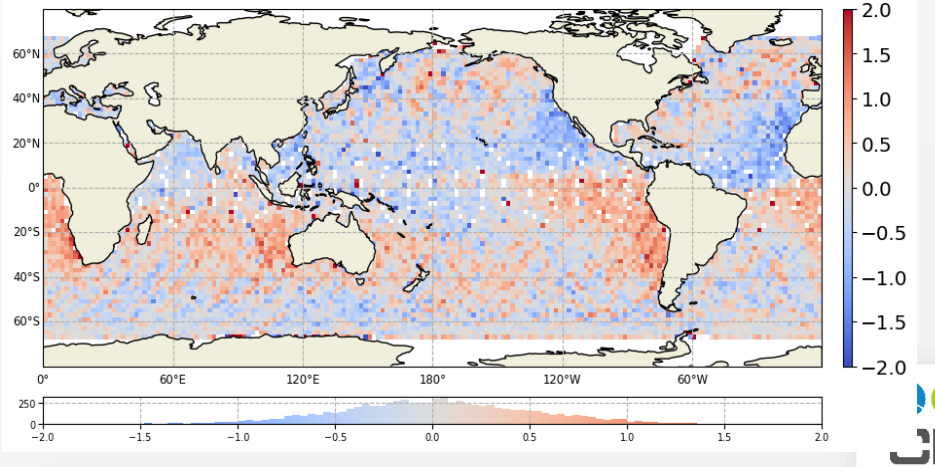
Impact reduced in PDAP PB F06 with the reduction of nb of looks

S6A PDAP – PB F06



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<u>Recent study by N. Tran:</u>
Performed on S3A data.

Along-track wind effect :

- Cannot be corrected with SSB (2D or 3D)
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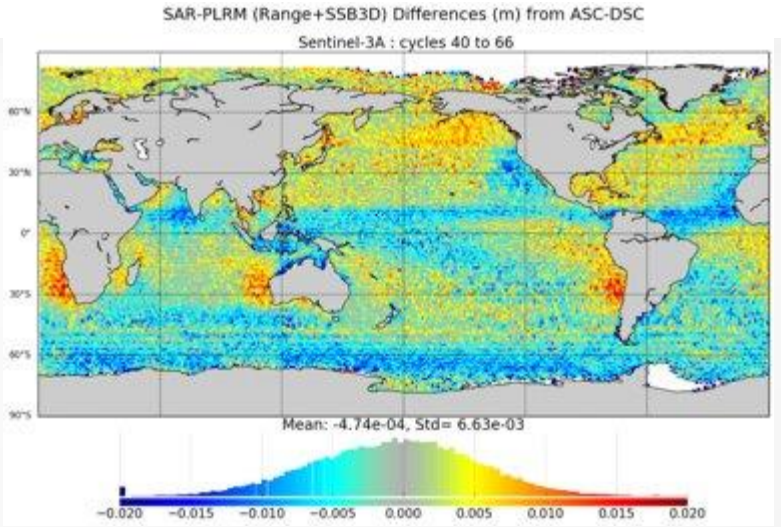

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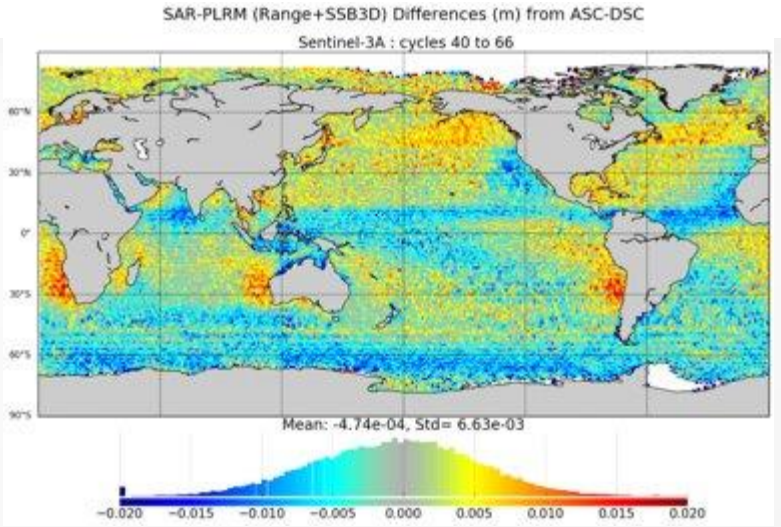

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Correlation with along-track wind through **wind waves** propagation direction:

	↓ Swell ↓ WW		← Swell ← WW		→ Swell ↓ WW	
	↑ asc	↓ dsc	↑ asc	↓ dsc	↑ asc	↓ dsc
SAR-PLRM range	0.4 cm	1.6 cm	1.19 cm	1.15 cm	0.54 cm	1.54 cm
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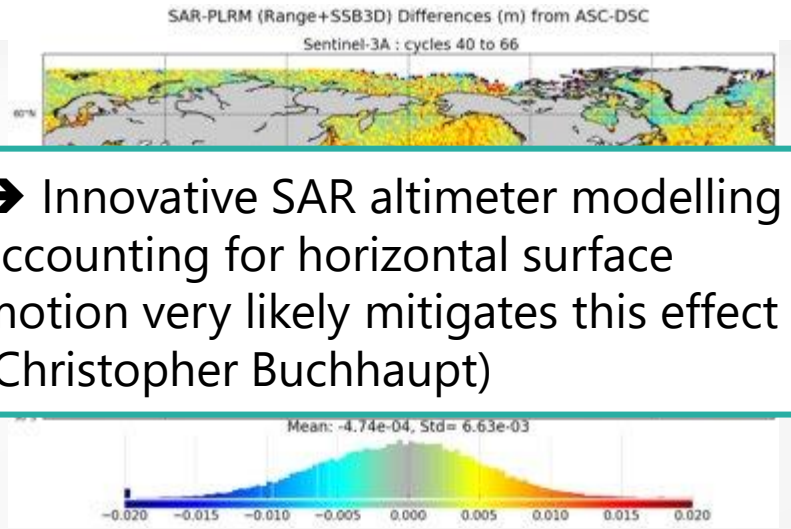

➔ Innovative SAR altimeter modelling accounting for horizontal surface motion very likely mitigates this effect (Christopher Buchhaupt)

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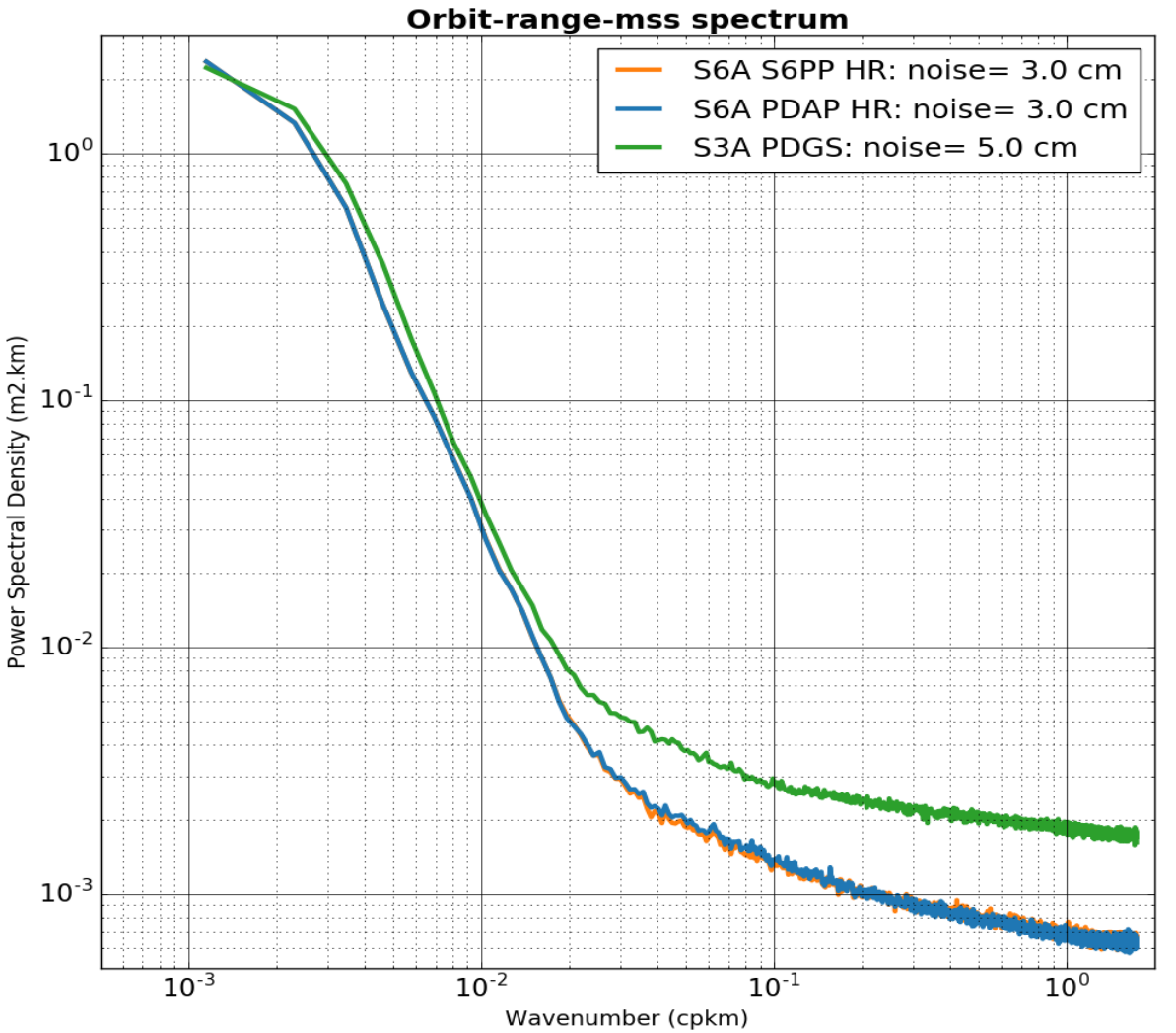
Sentinel-6 data present a lower level of noise than Sentinel-3 by 2 cm.

As for Sentinel-3 data, a **red noise** correlated to swell is detected.



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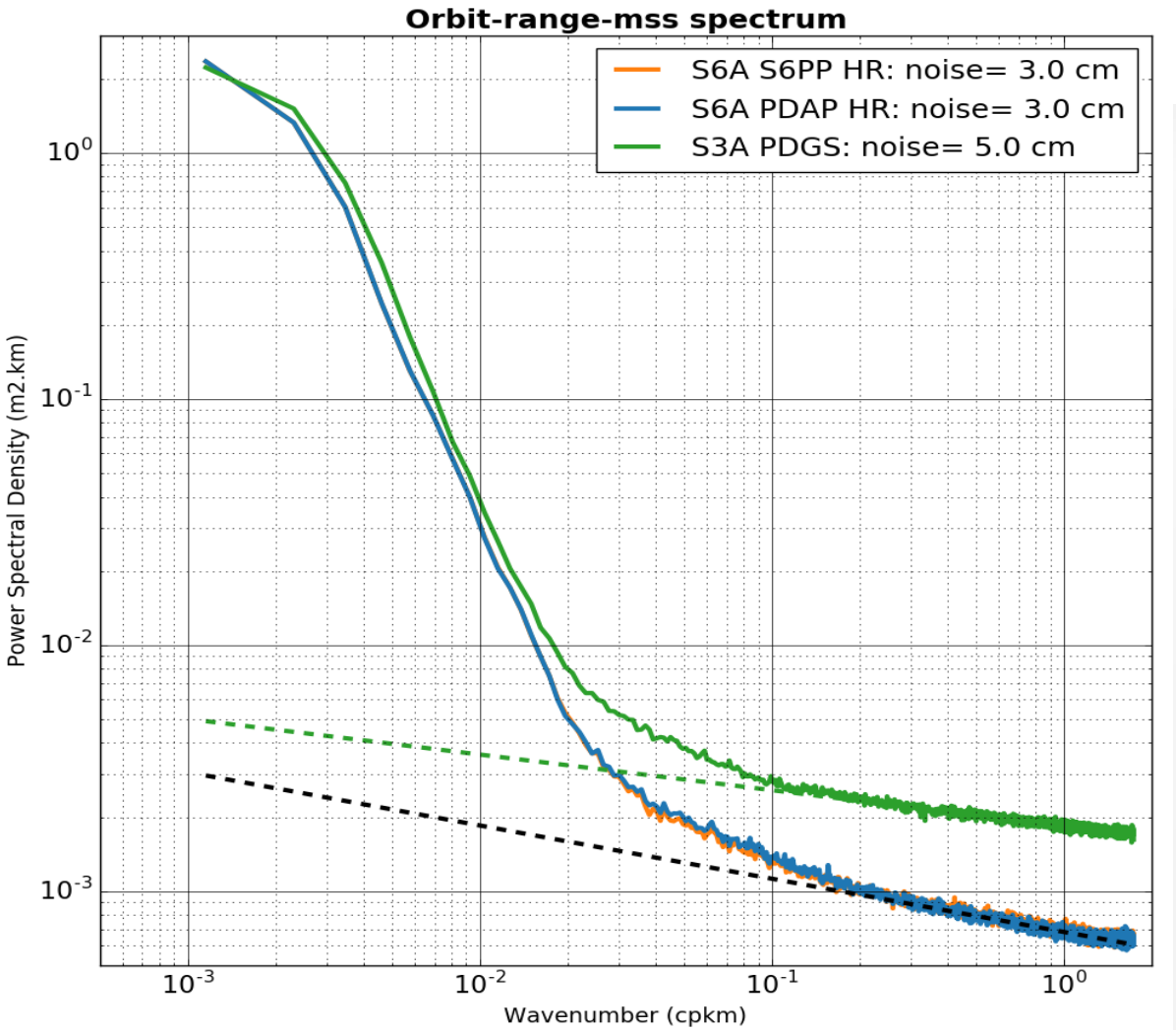

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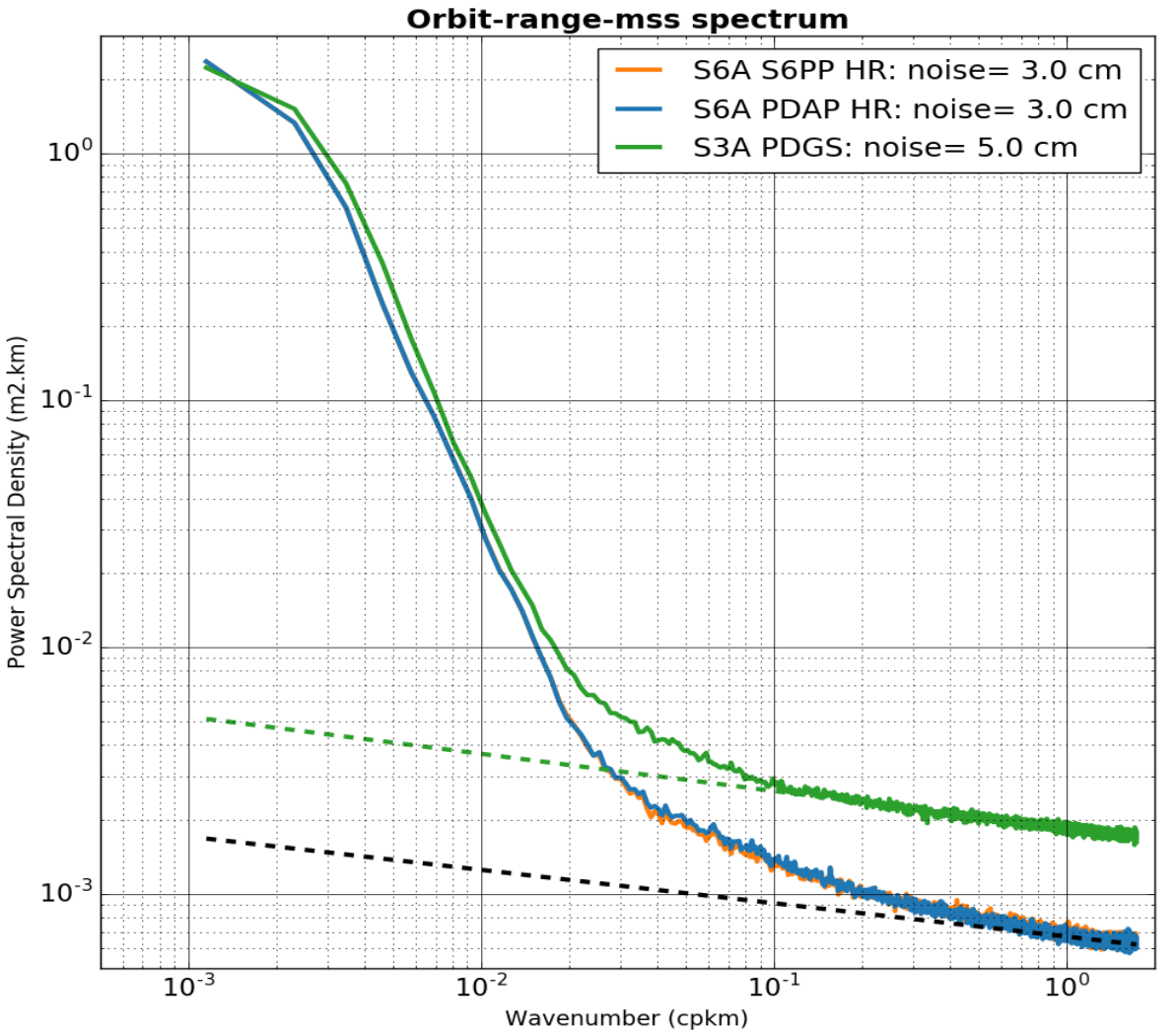

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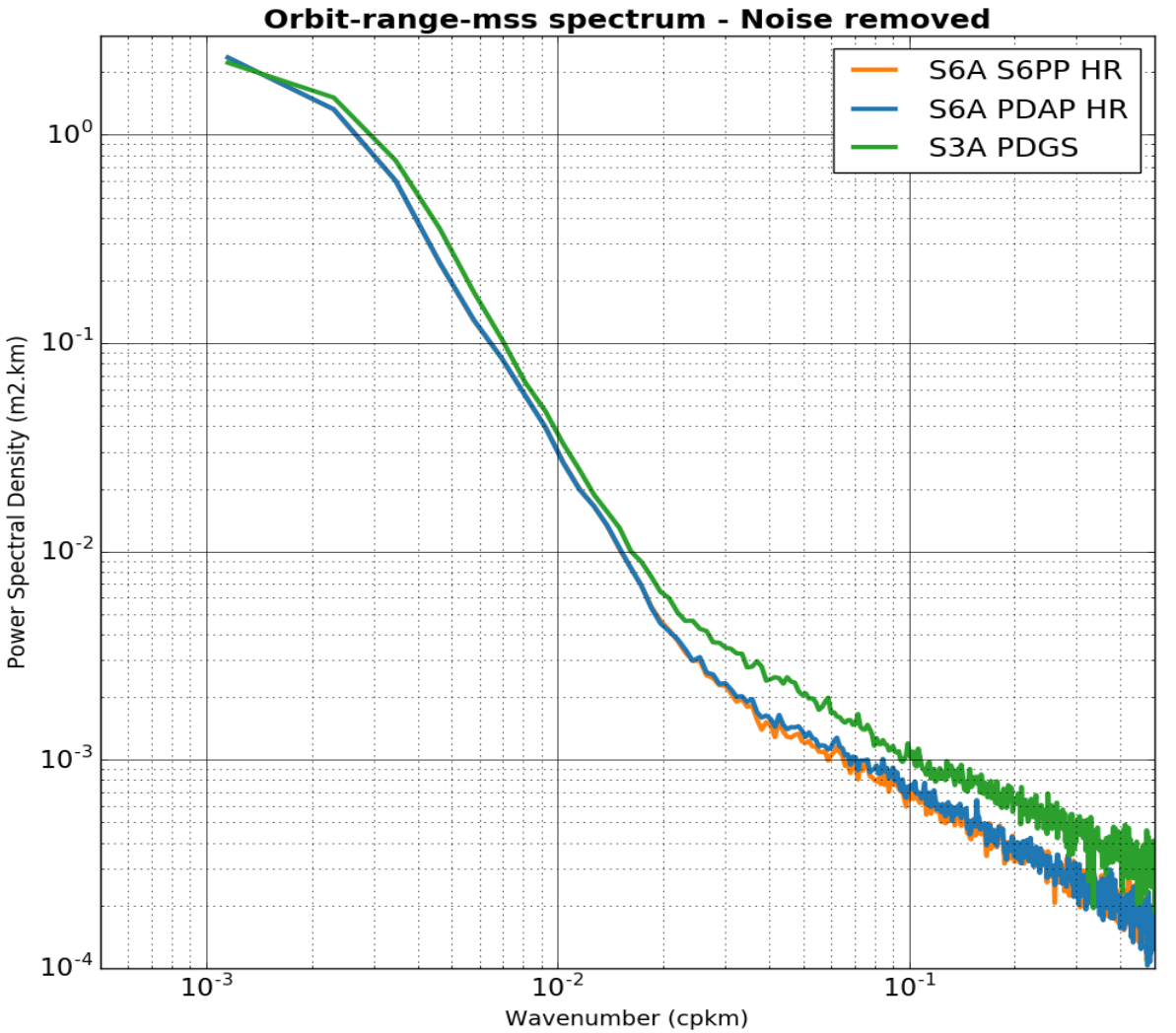
Confirm when removing the white noise level.

→ Same swell impact between S3 and S6.



Conclusion

➔ Lots of **progress** have been made in our understanding of HR processing.
➔ There are still some open issues, but some **solutions** have been found and will be implemented in a near future in S6A official ground segment (PDAP).

Error	Impact	Amplitude	Solution	PDAP Plan
PTR shape evolution	Drift on range	3.4 mm/year on GMSL (POS4-B)	**Numerical retracking + Range walk**	**PB F09 (Q3 2023)**
Ocean vertical velocity	SWH bias (impacting SSHA through SSB)	+30 cm at 2m-wave	**NOAA LUT** *2D retracking ?*	**F10 (end Q4 2023)**
Along-track wind	Range	2 cm	*2D retracking ?*	
Swell impact	Red noise on range and SWH	~several cm		
Others	?	?		

➔ Future L2P S6A aims at correcting the explained errors using CNES/CLS S6PP through a LUT function of SWH
(see Kocha C. poster, Homogeneous multi-mission along-track Sea Level Anomalies, Wave and Wind (Level-2P) : implementation of Sentinel-6A/Jason-CS, OSTST 2022)

Conclusion

➔ Tandem flight with Jason-3 has allowed to detect potential issue on the Jason serie (equatorial band)

➔ CNES/CLS S6PP data release:

- plan for November 2022
- HR and LR data
- Available at : https://doi.org/10.24400/527896/a01-2022.015
- See Maraldi C. poster : *Sentinel-6 Processing prototype Data Release, OSTST 2022*

Thank you

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