





CAL VAL Activities Performed by the MPWG

Cristina Martin-Puig (EUMETSAT) on behalf of:

Rob Cullen (ESA) Jean Damien Desjonqueres (NASA/JPL) Eric Leuliette (NOAA) Claire Maraldi (CNES) Marco Meloni (EUMETSAT)

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Ce The Mission Performance Working Group (MPWG)

What is the MPWG:

- The MPWG is a body composed of experts from EUMETSAT, NASA, ESA, NOAA and CNES.
- The group meets on a regular basis, and it is aiming at monitoring the Sentinel-6MF overall altimetry mission performance.
- The group assesses on mission and payload performance budgets, data products quality, algorithm development, new processor verification and validation performance, calibration and validation planning, as well as provides scientific support to the reprocessing calibration and validation, key mission instrument meetings and mission performance meetings.
- The MPWG activities are similar to those done by the MSEs as per previous Jason mission.



Cyclic monitoring

- S6 MF NTC Altimeter products cyclic Cal/Val reports are available to the user community
- S6 POS4 Instrument Calibration report is also made available per cycle to the user community
- https://eumetsatspace.atlassian.net/wiki/spac es/PQ/pages/1773928450/Sentinel-6+cyclic+reports
- Specifications of the Sentinel-6 processors are available here:
 - https://www.eumetsat.int/altimetry-resources



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Important differences between missions 6

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What	Jason-3	Sentinel-3	Sentinel-6
Delay/Doppler altimeter	N/A	Closed Burst (1/3 time we are tx while 2/3 time we are rx)	Open Burst
Reception pattern, and what is available in a radar cycle	90 Ku and 15 C band echoes	64 * 4 Ku band echoes 4 * 4 C band echoes	64 * 7 Ku band echoes 4 * 7 C band echoes
Calibration	Traditional calibration over specific areas CAL1, CAL2, other	Traditional calibration over specific areas CAL1, CAL2, other	ECHO CAL CAL1 Calibration along the orbit only for Ku band + traditional calibration
For modellers	deramp BW_Rx = sampling frequency	deramp BW_Rx = sampling frequency	Match filtering BW_Rx diff to sampling frequency
Radiometer	AMR	AMR	 AMR-C Supplemental Calibration System (SCS) – maintain mm/yr stability High Resolution Microwave Radiometer (HRMR) – provide coastal path delay to 1cm at 5km from land

POS4 Temperature Sensitivity – ECHO CAL

- Sentinel-6 allows for CAL1 acquisitions along the orbit.
- This CAL1 mode is known as ECHO CAL.
- Using these data, the altimeter range and backscatter measurements can be calibrated along the orbit and all short term variations removed (without any impacts on noise level).



- 5). Geographical maps of Range differences (standard CAL1 vs ECHO CAL) show patterns that highly correlate with variations of the temperature of the instrument along each orbit.
- Sentinel-6's ECHO CAL is the first to capture this of any altimeter mission.
- As expected, the impact on LR and HR is identical as they rely on the same calibration values.
- Differences are within millimeters for SSHA and Range, and negligible for SWH and sigma0.



ECHO CAL Ku



Performance Assessment vs Requirements

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- Altimeter LR range noise ([1.2, 1.5, 2.4, 3.2] cm at [1, 2, 5, 8] m SWH):
 - Side-A: [1.25, 1.44, 1.93, 2.41]
 - Side-B: [1.24, 1.45, 1.94, 2.41]



 To be re-assessed by means of data processed with the LR Numerical Retracker (PB F08 Q1 2023)

- Altimeter HR range noise ([0.7, 0.8, 1.3, 2.0] cm at [1, 2, 5, 8] m SWH):
 - Side-A: [0.62, 0.75, 1.46, 2.42]
 - Side-B: [0.62, 0.75, 1.45, 2.43]
 - **<u>NEW</u>**: 322 looks L1 CONF: [0.61, 0.77, 1.45, 2.41]
- To be re-assessed by means of data processed with the HR Numerical Retracker (PB F09 TBC Q3 2023)

 Altimeter HR SWH (Uncertainty < 15 cm + 5% of SWH): same effects of vertical waves motion observed on both Side-A and Side-B.



To be re-assessed by means of data processed with the VV correction to HR SWH (PB F09/F10 TBC Q3/Q4 2023)



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Known anomalies that have a planned and approved way forward



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Orbit-Range-MSS for LR compared to Jason-3

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- J3 and S6 LR are in line with Bias of only 0.76 cm
- Observations:

- To be re-assessed by means of data processed with the LR Numerical Retracker (PB F08 Q1 2023)
- SWH dependency of the bias. Will be improved with LR numerical retracking
- Equatorial band. First investigations have shown that this behavior is most likely coming from Jason-3. Still under investigation





Crbit-Range-MSS for HR compared to Jason-3

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- We saw a high dependency of LR-HR as a function of SWH → this was considerably reduced by means of reducing the number of Doppler beams in the Stack (PB F06 used for reprocessing)
- Still there is a residual dependency



RANGE difference (cm): S6A HR-LR wrt LR SWH (m)

• Skewness or meridional winds or both?

• Skewness could be introduced with HR NR (PB F09)

Orbit - Range - Mss difference Mean (cm): S6A HR - J3 Mean value of -1.125 cm removed



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SWH LR vs HR only S6

- The difference between SWH was considerably reduced after F06
- Remaining differences are understood and linked to Vertical Velocity Motion effect
 VVM effects correction is foreseen for E09 or E1





VVM effects correction is foreseen for F09 or F10 in 2023

SWH difference (cm): S6A HR-LR Operational, Mean SWH difference (cm): S6A HR-LR Reprocessing, Mean

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VVM effects correction tested in CNES' S6PP

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- LUT correcting for SWH VV effects computed by NOAA, and correction added to CNES' S6PP
- HR SWH is more in line with LR SWH when the correction is applied.
- SWH dependency of the difference is reduced.
- Noise is reduced on S6 LR wrt J3. HR SWH is now in line with LR SWH for long wavelengths.
- Important Note: SWH improvement has also an impact on SSHA via the SSB correction.



Sigma0 all resolutions S6 compared to Jason-3

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- Different S6 LR / J3 mean value
- Same patterns than for J3
- Alignment is done before wind computation



Sigma0 histograms (dB)





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HRMR Coastal Path Delay Performance

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- HRMR data now available in products
- HRMR+AMR has up to 50% reduction in variance from AMR only coastal PD to coast
- HRMR+AMR excess error globally less
 than 1 cm to 5km from land
- HRMR algorithm work on-going and further improvement expected (OSTST input encouraged)



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Pending to be further studied



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Impact of orbit on height signal as a function of latitude

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Use of JPK orbit slightly reduces the amplitude of the difference signal \rightarrow the product orbit is a contributor to this difference.



Wet Tropospheric Correction – Not fully understood jumps

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WTC difference: Radiometer - ECMWF - mean per day (m)

WTC difference: Radiometer - ECMWF - mean per day (m)





SSHA (HR – LR) Asc – Des Orbit differences

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HR - LR SSHA difference - Descending

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SSHA HR – LR Difference

The **bias between HR & LR in SSHA** is linked to the **relative wind direction** with respect to the satellite heading...**the bias is in the HR data!**

The source of this SSHA bias is attributed to a Doppler shift associated to the cross-correlation between waves orbital velocity and waves slopes, showing up as an apparent horizontal wave motion.

The bias is stronger and with **opposite sign for upwind and down-wind, zero for cross-wind,** and **SWH dependent.**

This explains the bias between asc. and des. passes for persistent meridional wind regions...

However, local wind a waves conditions drive the biases between the HR and LR SSH measurements.



2D-retracker for VV and Meridional Wind removal effects on SWH

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Sentinel-6A Cycle 44 SWH LR-HR Differences



Sentinel-6MF HR – Jason-3 intermission bias: slope dependence

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North Pacific Trenches and Seamounts



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1-2 cm bias over areas over trenches

S6 – J3 Range differences vs Latitude



Range for Ku MLE-4 presents significant V-shape discrepancy Range for C presents large V-shape discrepancy For all, unexplained bump at the equator is present → this is now under investigation by the J3 CNES' team Ku MLE-4 and MLE-3 present slight differences around lat = -40 deg (~1mm)

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Very good SWH agreement for Ku MLE-4 Significant differences for Ku MLE-3 Large differences for C-band (25 cm)

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Conclusions

- S6 MF data quality is showing high quality and ensures Jason's continuity.
- Instrument and products are within requirements with a few marginal exceptions.
- HRMR allows radiometer corrections to be improved up to 5km to the coast.
- Evolutions are planned along this and next year to overcome most of the issues observed \rightarrow we hope that requirements are then all met.
- Open point from this OSTST:
 - No correction is available today for the meridional winds induced differences in SSHA.
 - 2D retacking solution to this problem is not operational feasible and a computational less demanding solution shall be investigated.
 - Slope dependencies are not understood yet, and will be investigated.
 - Ku retrackers different behaviour as a function of latitude is under investigation.
 - C band behaviours are known to MPWG, and investigations are ongoing.



Thank you!

Questions are welcome.

For questions or findings please contact us at: OPS@eumetsat.int

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