SENTINEL-6 MF POSEIDON-4 RADAR ALTIMETER IN-FLIGHT CALIBRATION AND PERFORMANCES MONITORING

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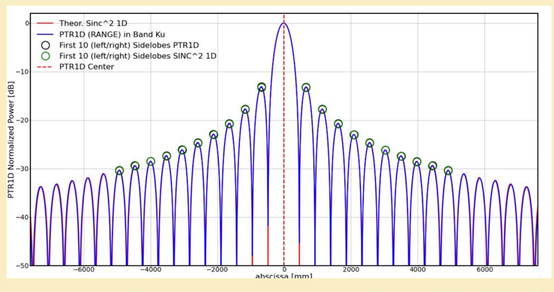
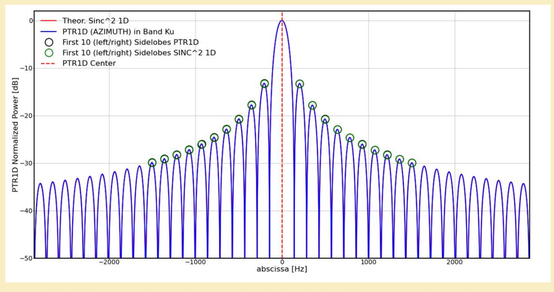
Introduction

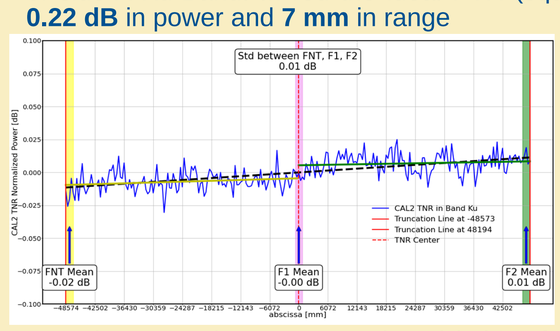
Poseidon-4 is a dual frequency redundant radar altimeter, embarked on board of European Commission Copernicus Programme Sentinel-6 Michael Freilich satellite, which represents a significant breakthrough with respect to its predecessors Jason-class altimeters thanks to its digital architecture (based on an on-board digital matched-filtering) and to novel internal calibrations modes as EchoCal and InstrCal. In this work, we assess Poseidon-4 main instrumental improvements and performances, with the presentation of the more important outcomes from the In-Flight internal calibration modes and housekeeping telemetries monitoring (as internal temperatures and ADAC flags).
The altimeter has been powered-on on 30th November 2020 (side-A) and it has been switched to Side-B on 14th September 2021

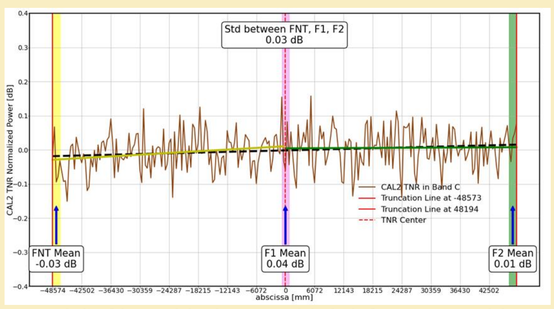
PTR & TNR





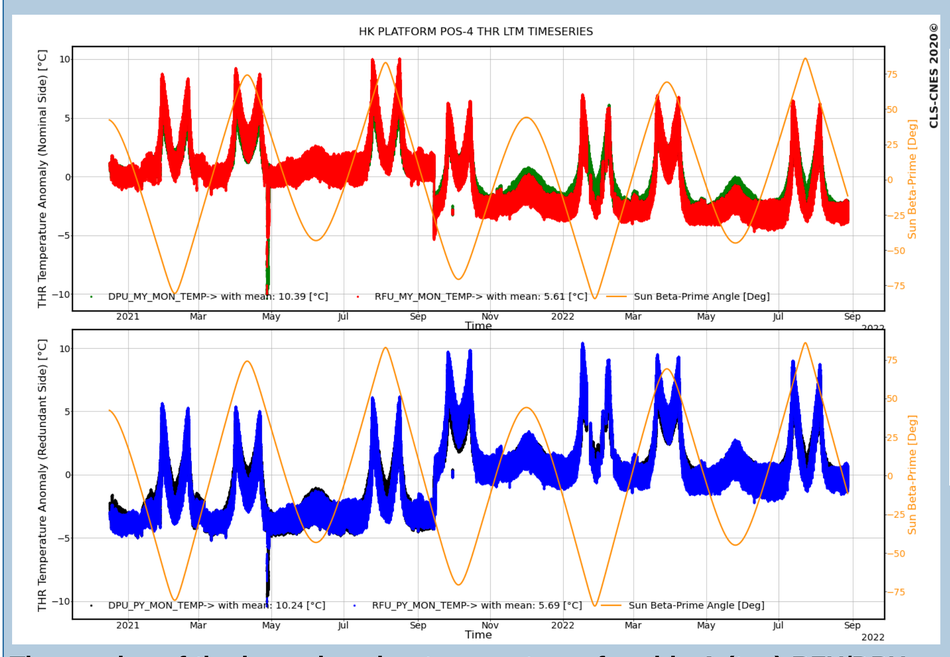
CAL1 Point Target Response (PTR) in blue for **range** (left) and **azimuth** (right) dimension in case of side-A Ku-Band. In red the ideal PTR (squared sinc) is displayed. Max side-lobe deviation is **0.22 dB** in power and **7 mm** in range



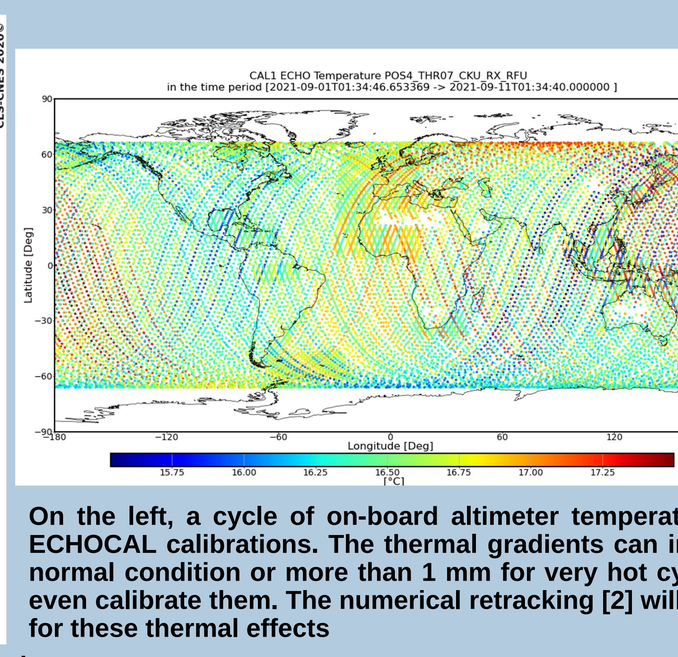


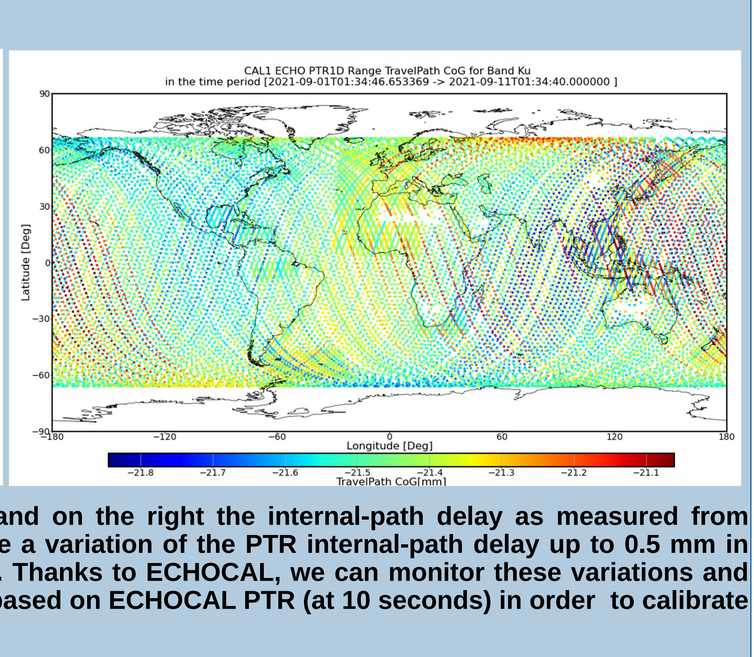
CAL2 Thermal Noise Response (TNR) in blue for Ku-Band (left) and in brown (right) for C-Band in case of side-A. The slope of the TNR is only **0.02 dB** end-to-end and **std around 0.01 dB**

CAL1 Calibration Monitoring (ECHOCAL)

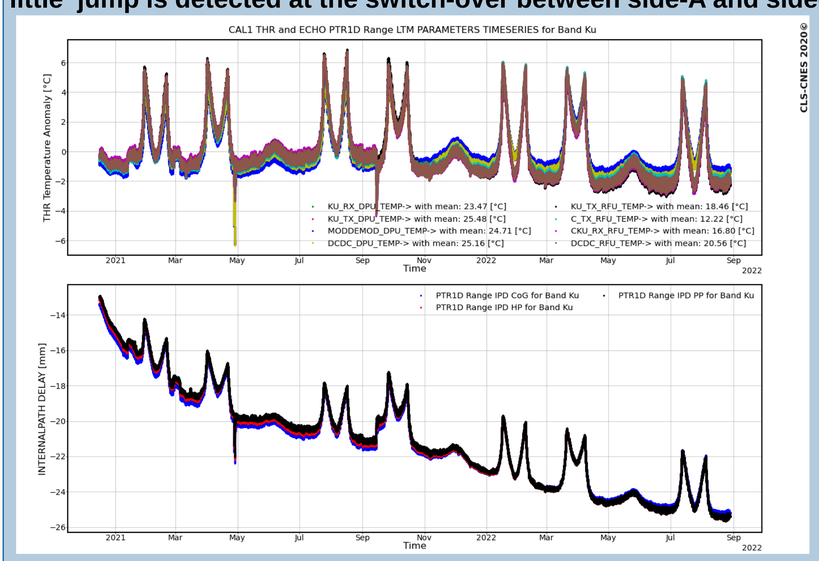


Time-series of the housekeeping temperatures for side-A (top) RFU/DPU and side-B (bottom) RFU/DPU. The sun beta-prime angle is shown in orange. The temperature increase (“M Pattern”) are in sync with sun beta-prime angle. A little jump is detected at the switch-over between side-A and side-B

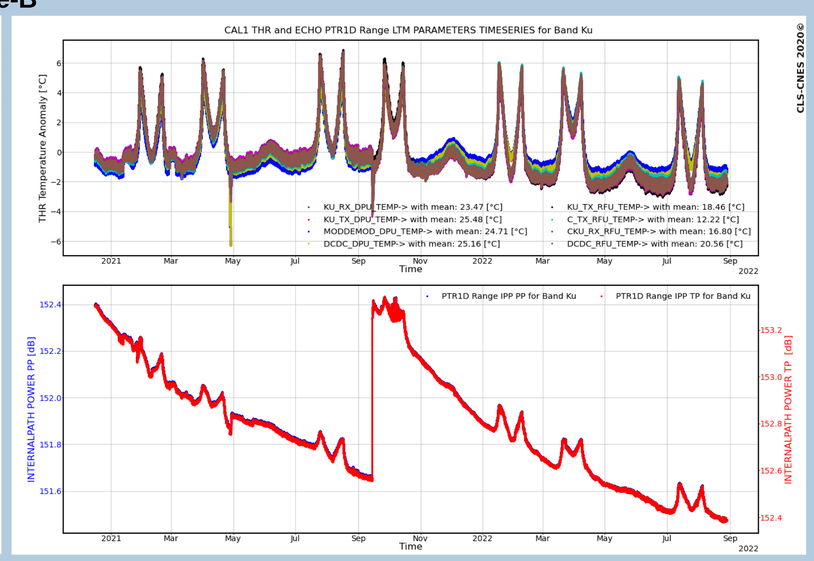




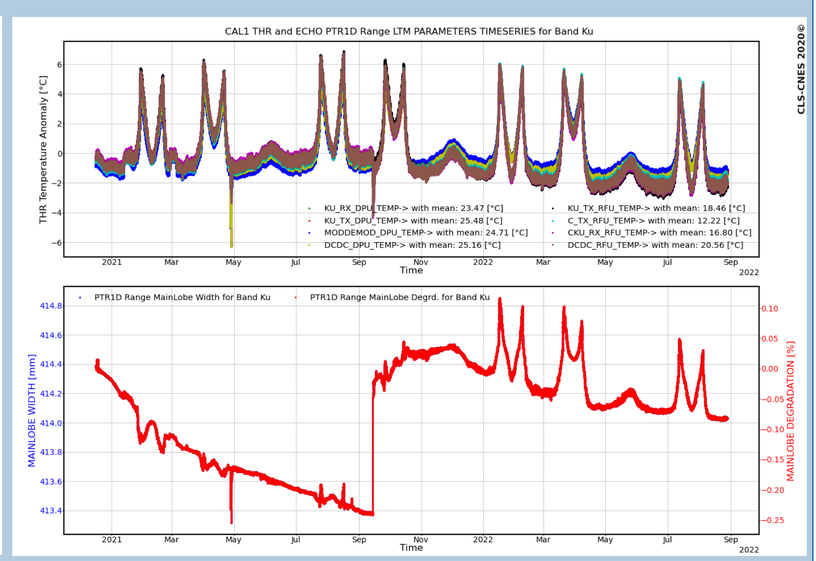
On the left, a cycle of on-board altimeter temperature and on the right the internal-path delay as measured from ECHOCAL calibrations. The thermal gradients can induce a variation of the PTR internal-path delay up to 0.5 mm in normal condition or more than 1 mm for very hot cycles. Thanks to ECHOCAL, we can monitor these variations and even calibrate them. The numerical retracking [2] will be based on ECHOCAL PTR (at 10 seconds) in order to calibrate for these thermal effects



Time-series of the PTR internal-path delay (for Center-of-Gravity, Half-Power and Peak-Position methods). A little jump is visible at the switch-over between side-A and side-B. Also, the temperature-driven “M-shape” patterns are visible and they are in sync with temperatures (top plot)



Time-series of the PTR internal-path power (for Total Power and Peak-Power methods). A jump is visible at the switch-over between side-A and side-B. Also, the temperature-driven “M-shape” patterns are visible and they are in sync with temperatures (top plot)



Time-series of the PTR main-lobe width. A jump is visible at the switch-over between side-A and side-B. Also, the temperature-driven “M-shape” patterns are visible.

These variation of the PTR main-lobe is uncalibrated in the MLE4 retracker. It will be taken in account in the numerical retracker

Conclusions

The instrumental performances of the radar altimeter are **excellent**: Poseidon-4 delivers a range/azimuth instrument impulse response with the highest **quality and fidelity** in the age of space-borne radar altimetry and its thermal noise response is almost at level of random noise, and this both for its nominal and redundant side.
A significant power decay of the level of the transmitted power in Ku Band has been detected both for the nominal and redundant side, which will not lead to a violation of the mission requirement of the minimum signal-to-noise ratio over ocean at the end of the expected satellite life (5.5 years).
The novel CAL1 ECHO-CAL calibration mode allows to characterize very precisely the sensitivity of the instrument impulse response to the in-orbit temperature variations: this has been estimated to be of +0.3 mm/deg for the range and of +0.01 dB/deg for the power in Ku Band.

The PTR sidelobes in Ku Band do not evolve in a perfect symmetrical manner between the left-hand side and right-hand side but some deviations have been registered for side-A (0.5 mm and 0.025 dB after 10 months). Also, the PTR main-lobe width shows some sort of evolutions and “M-shape” patterns. The impact of these dis-symmetries on the range measurement stability will be analyzed in a separate work [2] (see S6PP poster results).

References

[1] Dinardo S. , Maraldi C., Daguze J.A. , Amraoui S., Boy F., Moreau T., Fornari M., Cullen R., Picot N. (2023): “*Sentinel-6 MF Poseidon-4 Radar Altimeter In-Flight Calibration and Performances Monitoring*” submitted to IEEE TGRS Journal

[2] Dinardo S., Maraldi C., Cadier E., Rieu P., Aublanc J., Guerou A., Boy F., Moreau T., Picot N. (2023): ”*Sentinel-6 MF Poseidon-4 Radar Altimeter: Main Scientific Results from S6PP LRM and UF-SAR chains in the first year of the mission*. Submitted to Advances in Space Research