

ILLIADA: Calibration and Validation of SWOT oceanographic products using Gavdos & Crete Permanent Satellite Altimeter Cal/Val infrastructure.

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1. Introduction & Objectives

Calibration and validation of the Surface Water and Ocean Topography (SWOT) mission has been recognized as a primary research priority for the SWOT Science Team for both hydrology and oceanography. The establishment of appropriate ground-based but also other infrastructures in various environments and worldwide, will contribute towards the accomplishment of the SWOT scientific and technological objectives.

The technological advancements of the SWOT mission pose critical questions to the international satellite altimetry Cal/Val community:

- How can the 2-D ground truth reference observations be established for sea-surface calibration for the SWOT mission?
- Are there any alternative approaches for calibrating this new altimetry mission?
- Can we provide post-launch calibration of the interferometric antennas baseline length and its orientation in space?

The main goal of this research is to answer these questions and carry out absolute calibration and validation (Cal/Val) of the SWOT products using the ESA Permanent Facility for Altimetry Calibration (PFAC) in west Crete, Greece.

The PFAC infrastructure has been continuously operational as of 2004. Since then, estimation of absolute altimeter bias for the Jason-1, Jason-2, Jason-3, SARAL/AltiKa, HY-2A, HY-2B, Sentinel-3A and Sentinel-6 altimetric missions has been continuously determined and results disseminated.

Currently, PFAC establishes new altimetry standards using the concept of fiducial reference measurements. This will act to serve as the “yardstick” for evaluating the performance of all altimetry missions with documented procedures, protocols, and with results tied to international SI standards and parameters in an open and transparent way.

2. Approach

2.1 Two dimensional ground truth fiducial reference measurements

The main problem for employing the conventional and standardized sea-surface calibration methodology for the calibration of the SWOT mission is its wide (~120 km) swath. This means that the permanent calibration sites primarily used for nadir altimeters are not that valuable for the SWOT calibration per se, as they provide a single point observation for the sea level. For nadir-looking altimeters this calibration point (or line) is satisfactory, because the satellite altimeter flies over the site. Nonetheless, this is not enough for wide swath altimeters. For the SWOT mission, in-situ sea-surface heights have to be obtained now over a large calibration surface area, extending up to 120 km.

The location of the existing PFAC sea-surface Cal/Val sites (such as Gavdos, CRS1, RDK1, SUG1) is

characterized by small tides, rather simple ocean current circulation, and sea depths which exceed 3500 meters in some regions. Based on our long-term experience and the specific characteristics of this PFAC location, it is accurate to estimate an effective calibrating region of 30 km for each Cal/Val site. A new sea-surface Cal/Val sites (SUG1) has already been established in 2021 whereas another sea-surface Cal/Val (KLM1) is currently under development. These five Cal/Val sites will provide 2-D in-situ measurements for both the SWOT ascending Pass No. 58 and its descending Pass No. 349 (Figure 1).

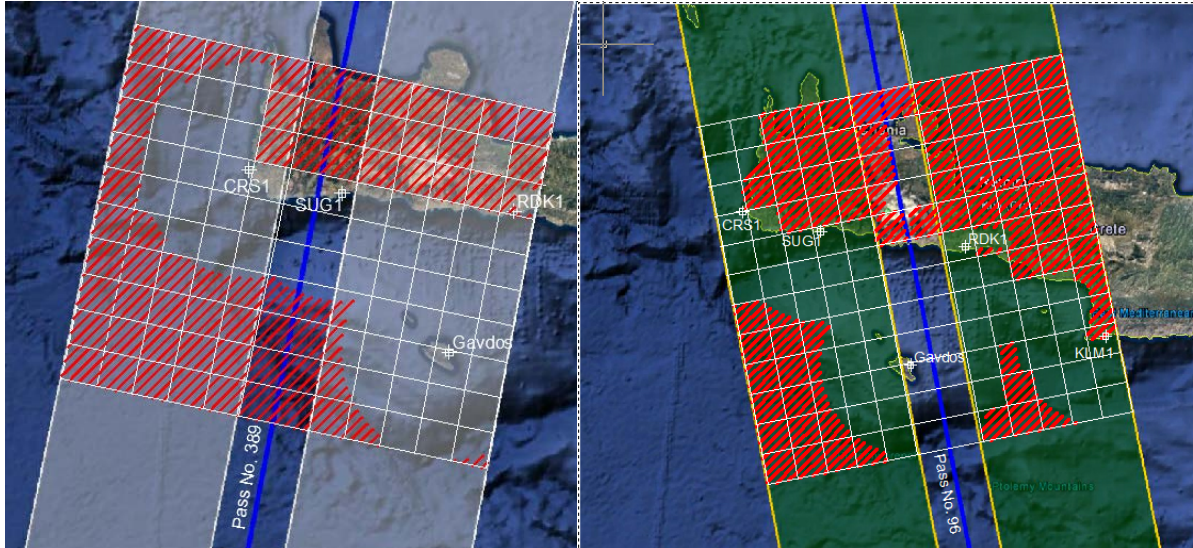


Figure 1. The PFAC geographical areas that will provide valid ground truth observation for the SWOT mission sea-surface calibration from its current (Gavdos-GVD8, CRS1, RDK1, SUG1) and future (KLM1) Cal/Val sites. Each square is 10 km×10km. Shaded areas are more than 30 km from Cal/Val sites. The blue line in the center gives the SWOT nadir track and the green lines its swath. **Left:** ascending Pass No. 58, **Right:** descending Pass No. 349.

2.2 Alternative approaches for SWOT calibration

Two alternative approaches are investigated under the framework of this project provided that availability of support is secured to perform appropriate software and hardware modifications in the PFAC infrastructure and instrumentation.

2.2.1 Transponder Calibrations

The CDN1 transponder Cal/Val site established on the mountains of Crete, Greece has been operating continuously since Sept. 2015 for the calibration of Ku-band altimeters on-board the Jason-2, Jason-3, Sentinel-3A, Sentinel-3B, CryoSat-2 and Sentinel-6A/Jason-CS missions using a prototype microwave transponder (Fig. 2). A second transponder is ready to be deployed in Gavdos in 2021 (GVD1 Cal/Val site).



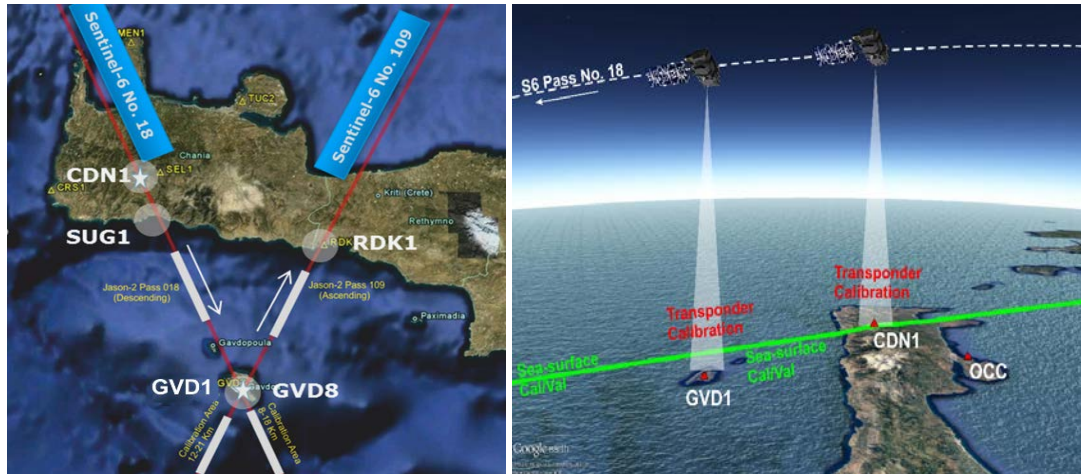


Figure 2. Upper Left: The existing Ku-band range transponder operating at the CDN1 Cal/Val site is ready to provide absolute range bias of the SWOT's nadir altimeter Pass No. 389. Cross-calibration with other missions such as Sentinel-3A & -3B and Sentinel-6/Jason-CS will be also performed. **Upper Right:** The CDN1 transponder Cal/Val site established on the mountains of Crete, Greece.

2.2.2 Relative Calibration

The conventional sea-surface calibration methodology constitutes an **absolute indirect** technique. This team investigates the relative calibration of SWOT mission products against baseline altimetry missions such as the Sentinel-6/Jason-3 series (Fig. 3).

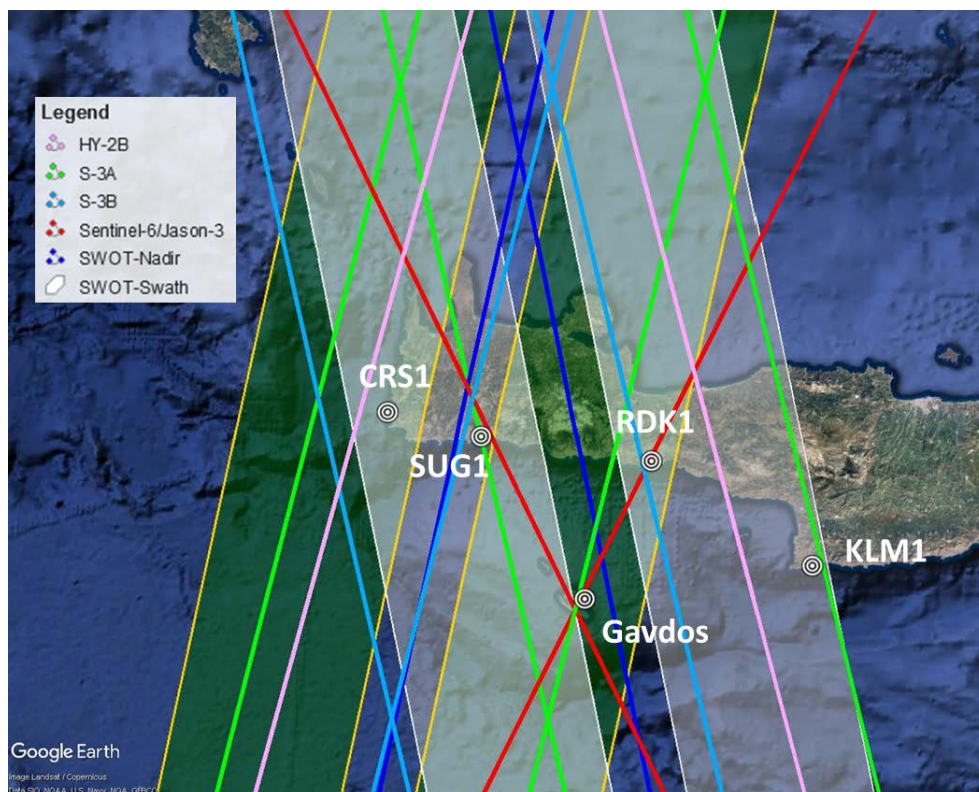


Figure 3. The SWOT ascending Pass No. 58 and descending Pass No. 349 nadir track (blue) and swath (white) with the Sentinel-6-MF/Jason-CS (red), Sentinel-3A (green), Sentinel-3B (light blue) and HY-2B (pink) missions. Relative direct calibration with all these missions is possible in west Crete, Greece.

3. Analysis & Anticipated Results

The main results of this research proposal may be summarized as follows:

1. Determination of absolute calibration bias and their drifts for SWOT nadir and KaRIN altimeters, as well as, for existing and future altimetric missions. These bias results will be determined twice a year, using three independent calibration methodologies (sea-surface, transponder and cross-calibration) at the same infrastructure, location and setting;
2. Any directional errors could be revealed (ascending/descending passes) at the same reference calibration sites in PFAC;
3. Cross-calibration of various satellite altimeters will be achieved using six Cal/Val sites and sea-surface calibration methodologies;
4. Near-real time access to local data will be granted to authorized users;
5. Design of a prototype Ka-band transponder

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