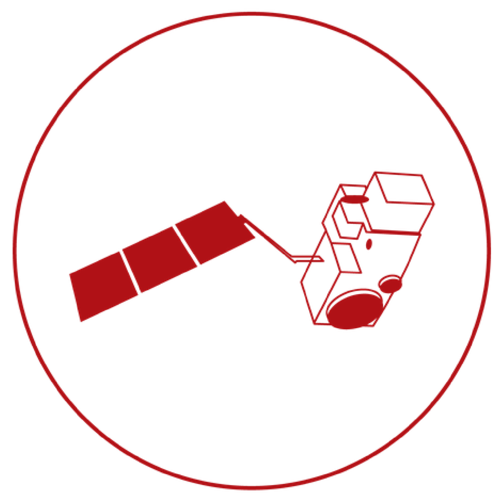
# Sentinel-3 Transponder Calibration Results



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## ABSTRACT

**Sentinel-3 is the Earth observation satellite mission designed to ensure the long-term collection and operational delivery of high-quality measurements of, among others, the sea surface topography. Post-launch calibration and validation of the satellite measurements is a prerequisite to achieve the desired level of accuracy and ensure the return of the investment.**

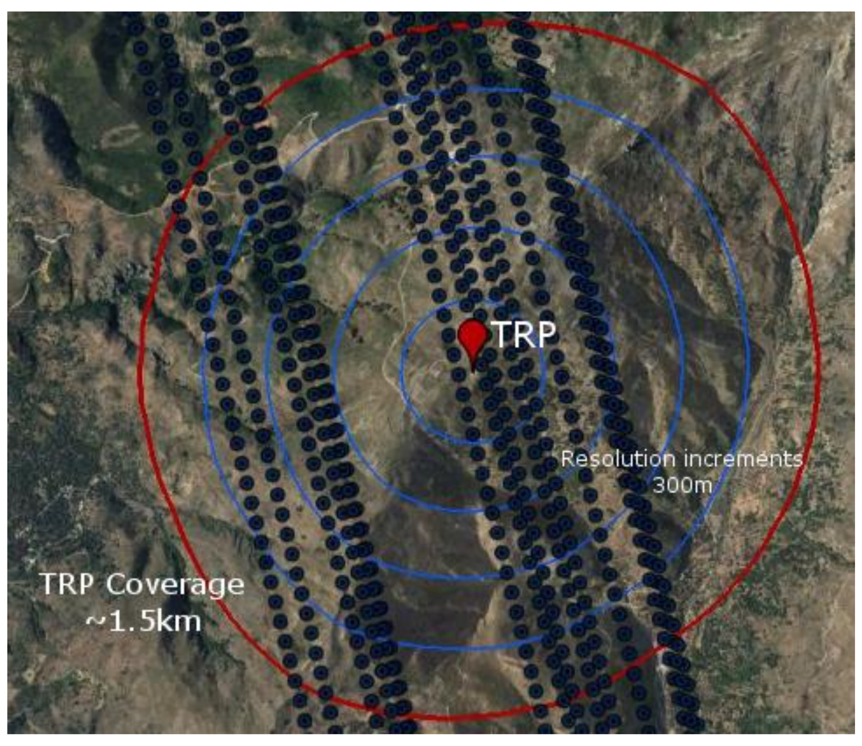
These Calibration/Validation (Cal/Val) services are provided by independent, external Cal/Val facilities that determine the error in satellite measurements, using known and controlled signal inputs on the ground. The Sentinel-3 altimeter calibration site was established in West Crete, Greece. This site has been named 'CDN1 Cal/Val site' and is located at an elevation of 1050m on the western mountains of Crete.

The transponder is used to calibrate SRAL's range and datation to meet the mission requirements. For this calibration, the S-3 L1A data is processed with a specialised transponder processor. Atmospheric delays are acquired directly from the calibration site, providing better accuracy to the final range measurement. Ideally, the comparison between the theoretical values provided by the well-known target and the measurement by the instrument to be calibrated provides us with the error that the instrument is introducing when performing its measurement. When this error can be assumed to be constant regardless the conditions, it will provide the bias of the instrument. If the measurements can be repeated after a certain period of time, it can also provide an indication of the instrument drift.

This poster presents the range and datation results using the Crete transponder for the first 23 cycles. This work is been carried out within the Sentinel-3 Mission Performance Center activity S3MPC.

## DATA

**Sentinel-3 uses SRAL (SENTINEL-3 Ku/C Radar Altimeter), which is capable of both LRM (Low Resolution Mode) and SAR (Synthetic Aperture Radar) modes of operation.**




| Cycle | Date | Track distance [m] | L1 Timeliness |
|---|---|---|---|
| 3 | 09/04/2016 | 605.74 | NT |
| 4 | 06/05/2016 | 914.23 | NT |
| 5 | 2016/06/02 | 239.71 | NT |
| 6 | 29/06/2016 | 55.56 | NT |
| 7 | 26/07/2016 | 571.89 | NT |
| 8 | 22/08/2016 | 520.32 | NT |
| 9 | 18/09/2016 | 1028.32 | NT |
| 10 | 2016/10/15 | 521.73 | NT |
| 11 | 2016/11/11 | 366.16 | NT |
| 12 | 08/12/2016 | 232.22 | NT |
| 14 | 31/01/2017 | 91.80 | NT |
| 15 | 27/02/2017 | 548.91 | NT |
| 16 | 26/03/2017 | 622.00 | NT |
| 17 | 22/04/2017 | 47.83 | NT |
| 18 | 19/05/2017 | 736.04 | NT |
| 19 | 15/06/2017 | 663.76 | NT |
| 20 | 12/07/2017 | 363.34 | NT |
| 22 | 04/09/2017 | 178.81 | ST |
| 23 | 01/10/2017 | 280.97 | ST |
| 13 | 04/01/2017 | TRP switched off | |
| 21 | 09/08/2017 | TRP switched off | |

**L1A data processed with IPF-SR-1 version 6.11**

- Geophysical Corrections:
  - Dry & Wet Tropospheric + Ionospheric delays measured at the TRP site provided by the Technical University of Crete
  - Solid Earth + Geocentric Tide + Ocean Loading corrections extracted from L2
- TRP information
  - Location
  - Internal delay (4.954 m)

## THE CRETE SITE

**Crete Transponder developed by the Technical University of Crete in 2011.**

**Transponder site being cleared, with GNSS receiver, solar panels and wind generators.**

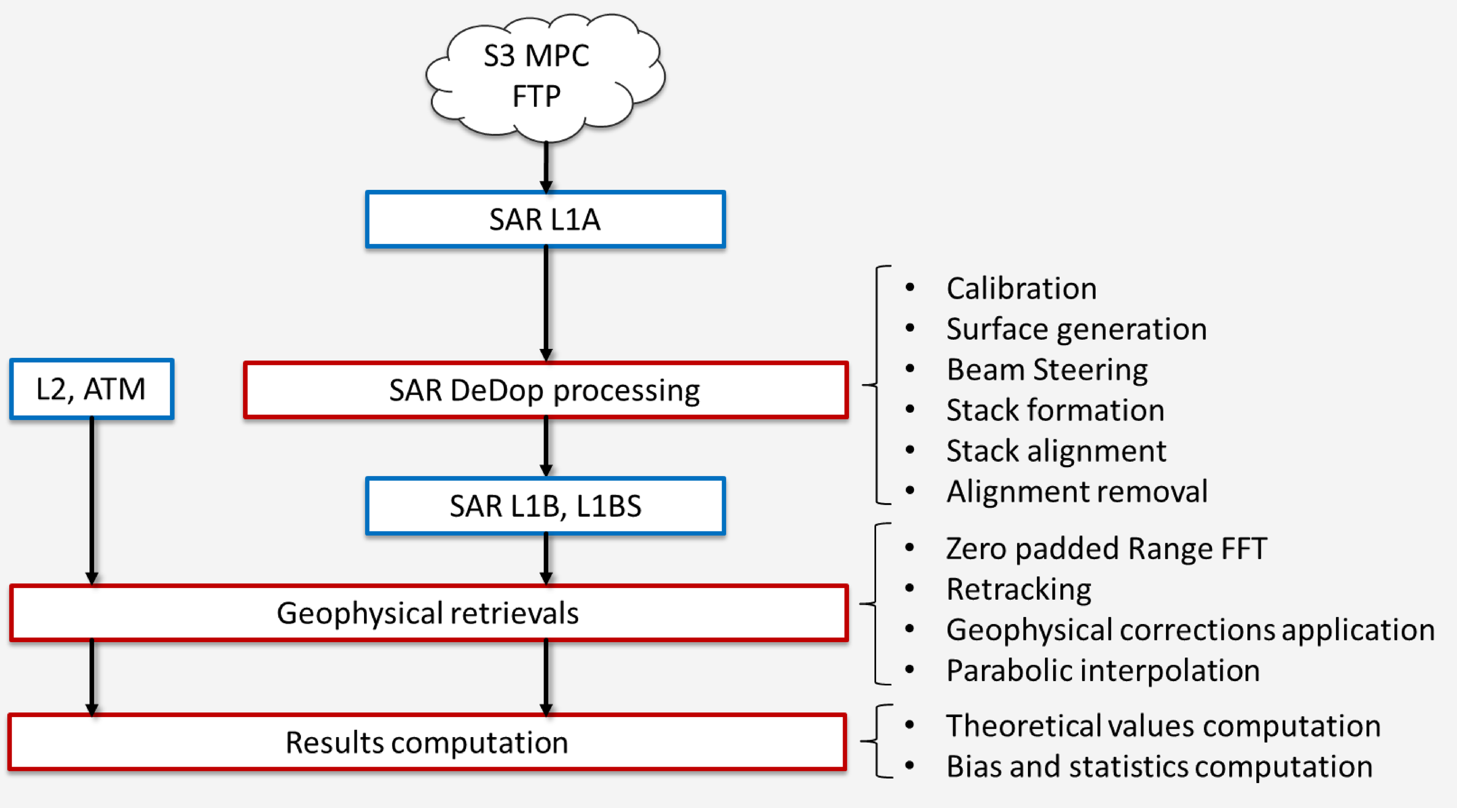
The Crete transponder was developed at the Technical University of Crete for ESA's Copernicus earth observation programme. As well as the Sentinel-3 project, it services the Jason missions as an additional transponder site.

With a ground coverage of approximately 1.5 km, Sentinel-3-A's planned passes are directly overhead (with some slight variation due to orbital manoeuvres), and a repeat cycle of 27 days. The TRP site, along with the transponder itself, contains a Global Navigation Satellite Systems (GNSS) receiver to accurately track the TRP's position over time.

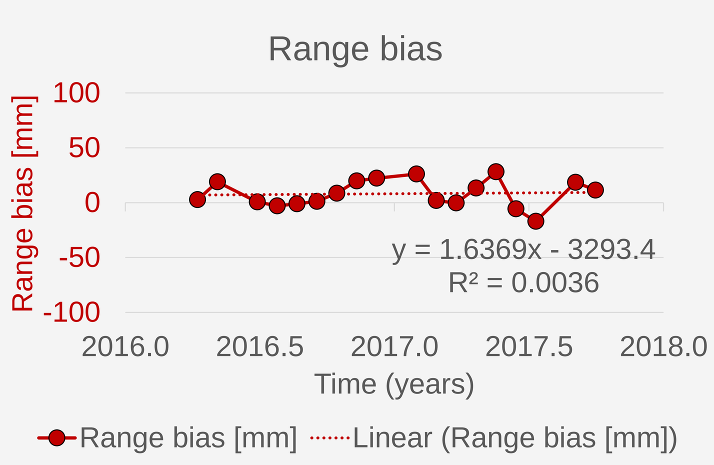
### TRP CHARACTERISTICS

| | |
|---|---|
| Antenna diameter | 0.90 m |
| Frequency | 13.575 GHz with a bandwidth of 350 MHz |
| Gain stability | 3 dB BW of 1.5 dB |
| Gain | 60 dB – stable gain design |
| Receiver noise figure | < 8 dB |
| Group delay | < 70 psec ± 10 psec over temperature |
| Phase linearity | 0.1 radians |
| Internal gain calibration accuracy | 0.5 dB |
| Receiver to transmitter isolation | 100 dB |
| TRP Latitude | 35° 20' 16.549011" N |
| TRP Longitude | 23° 46' 46.265833" E |
| TRP Ellipsoidal Altitude | 1048.8184 m |

## METHODOLOGY

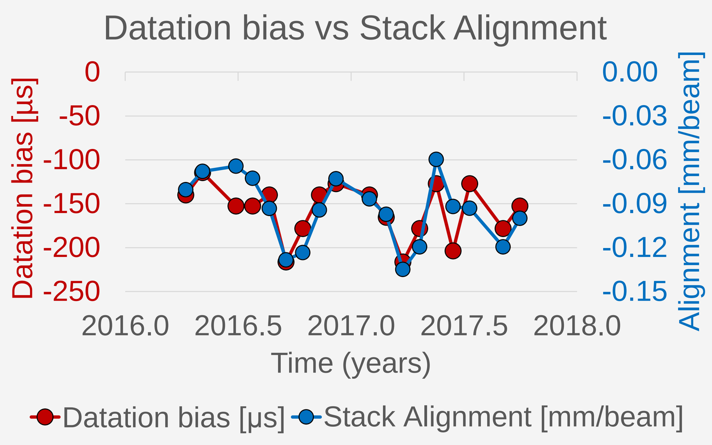



## RESULTS



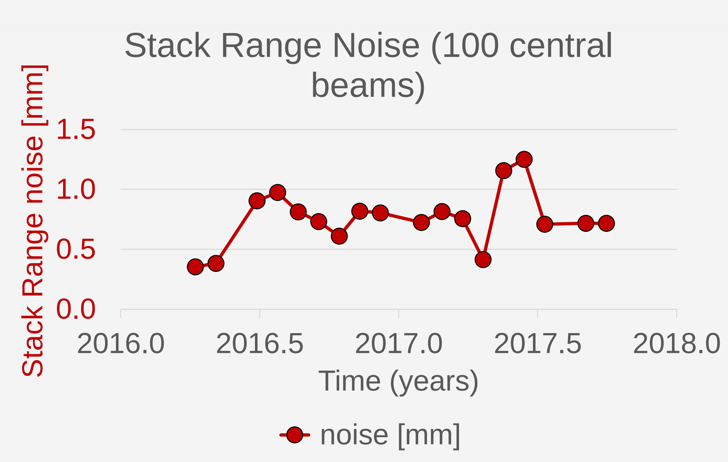

**RANGE RESULTS**

The range bias is generally very low, with a mean of only 8.19 mm, and a maximum of just under 3 cm. There is an increase per year of 1.63 mm, but with a low fitting coefficient ($R^2$), so this has not been considered strongly.




**DATATION RESULTS**

The datation bias for the S-3 results is quite variable, with a standard deviation of 33.3 µs and an average of -158.75 µs. It also, however, shows some correlation with the alignment of the beams, where the worst aligned results also tend to have worse datation bias.




**RANGE NOISE RESULTS**

The range noise results are calculated based on the standard deviation of the TRP range errors, which includes the noise from both the instrumental and geophysical corrections.

Average noise performance is very good, with none over 2 mm, a majority below 1 mm, and a low standard deviation.

| | Range bias [mm] | Alignment [mm/beam] | Datation bias [µs] | Noise [mm] |
|---|---|---|---|---|
| Mean | 8.19 | 0.09 | -158.47 | 0.76 |
| Std | 12.36 | 0.02 | 30.95 | 0.23 |

## CONCLUSIONS

- **Mean Range bias is 8.19 mm with 12 mm of noise between measurements.**
- **Mean Datation bias is -158 ms with 31 ms of noise between measurements.**
- **Stack range noise lower than 1 mm (7.5 mm with CryoSat-2 over Svalbard TRP).**
- **The datation bias is causing a stack misalignment of 0.09 mm/beam.**
- **The effect of this misalignment is an increase of the width (22 mm wider) of the L1B waveform and probably a very little overestimation of the SWH in L2.**