Sentinel 3 Sigma0 Calibration with Transponder

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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.

The backscatter from a radar altimeter σ0 is a measure of the surface roughness at scales of a few radar wavelengths; over the ocean, this is used to infer wind speed, which is an essential parameter used in weather forecasting. Over the ice, it gives information about the ice characteristics, which is crucial to understand the dynamics of the sea-ice and ice-sheets.

Some discrepancies have been observed between Envisat and Sentinel-3 for the open ocean backscatter σ0 coefficient. In addition, the Ice Community is requesting to get an accurate absolute knowledge of the backscatter coefficient to within 0.1 dB ideally. In order to cover both points, ESA/ESRIN decided to refurbish the Envisat σ0 transponder so that it can be used operationally for current and future altimetry missions.

The RF of the transponder is switched on upon detection of the Radar pulses. In addition, it is thermally controlled and its gain is accurately measured/monitored. All these features make this transponder fully relevant to properly validate the Radar Altimeter link budget for a point target. However, it must be emphasised that the transponder has an internal optical fiber delay line of 16.5 kilometers (representing a delay of 55 µs). As such, even very minor temperature change could impact the delay. This is why it is not advised to use this transponder as a range transponder but only as a σ0 transponder.

Before implementing operationally the transponder, a field test campaign has been carried out. A total of 6 acquisitions over a preliminary location have been performed. The final operation site will be selected at a later stage once the transponder commissioning is successful.

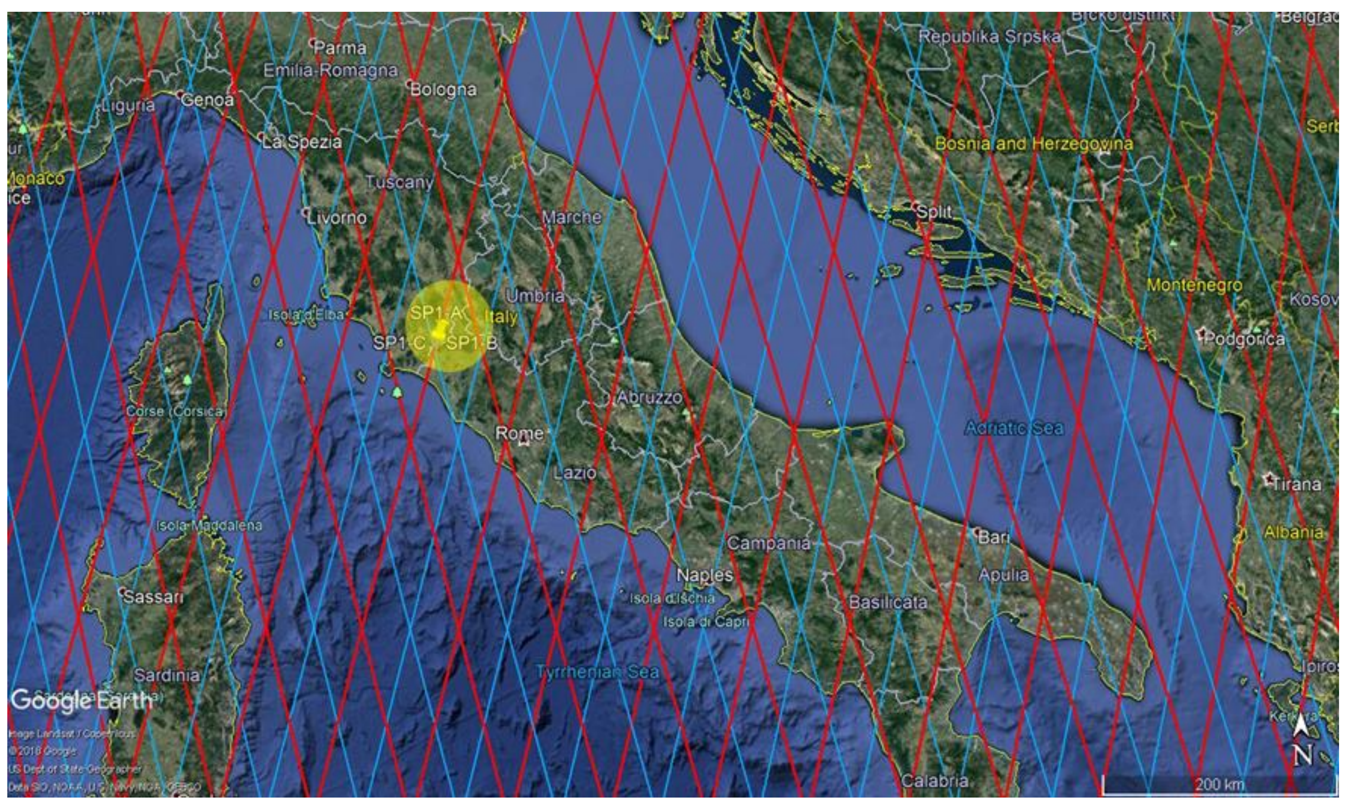
The σ0 results obtained during this first stage are shown in this presentation.

DATA

Date	Mission	Track Distance [m]
12/06/2020	S3A	384.44
23/06/2020	S3B	801.33
09/07/2020	S3A	53.47
20/07/2020	S3B	420.35
01/09/2020	S3A	683.33
28/09/2020	S3A	52.71

L1A data processed with IPF-SR-1 version 6.11

- Geophysical Corrections:
  - Atmospheric corrections extracted from L2
- TRP information
  - Location (**Lat: 42.5736; Lon: 11.6253; Alt: 284.249**)
  - Internal delay provided by RAME (**16518.564 m**)
  - Geometric Offset of TRP and its platform (**1.263 m**)



The location of the crossover of S3A and S3B for the field testing of sigma0 TRP in Italy

THE PRELIMINARY SITE

Deployment of the TRP with pedestal unit and platform on truck.

The sigma0 TRP with both antennas pointing to the sky.

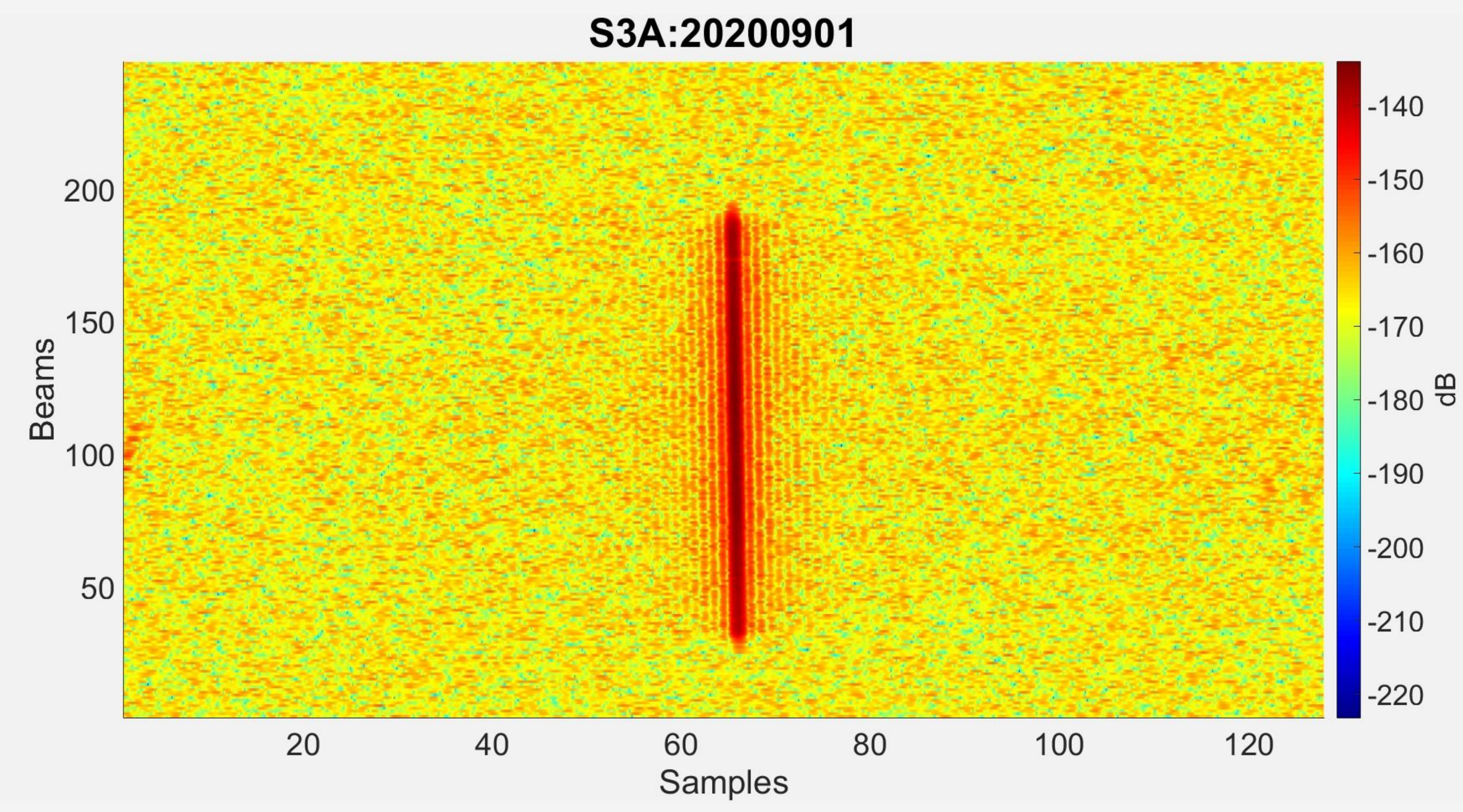
The Sigma0 transponder was developed at ESA ESTEC for the Envisat mission. One of the objectives of the SeRAC project was to refurbish and upgrade the existing ESA sigma-0 transponder for calibrating the backscatter coefficient of Setinel-3 SRAL instrument.

Refurbishment was carried out by RAME. The different field test campaigns of the sigma0 TRP have been deployed in **Tuscany**, Italy.

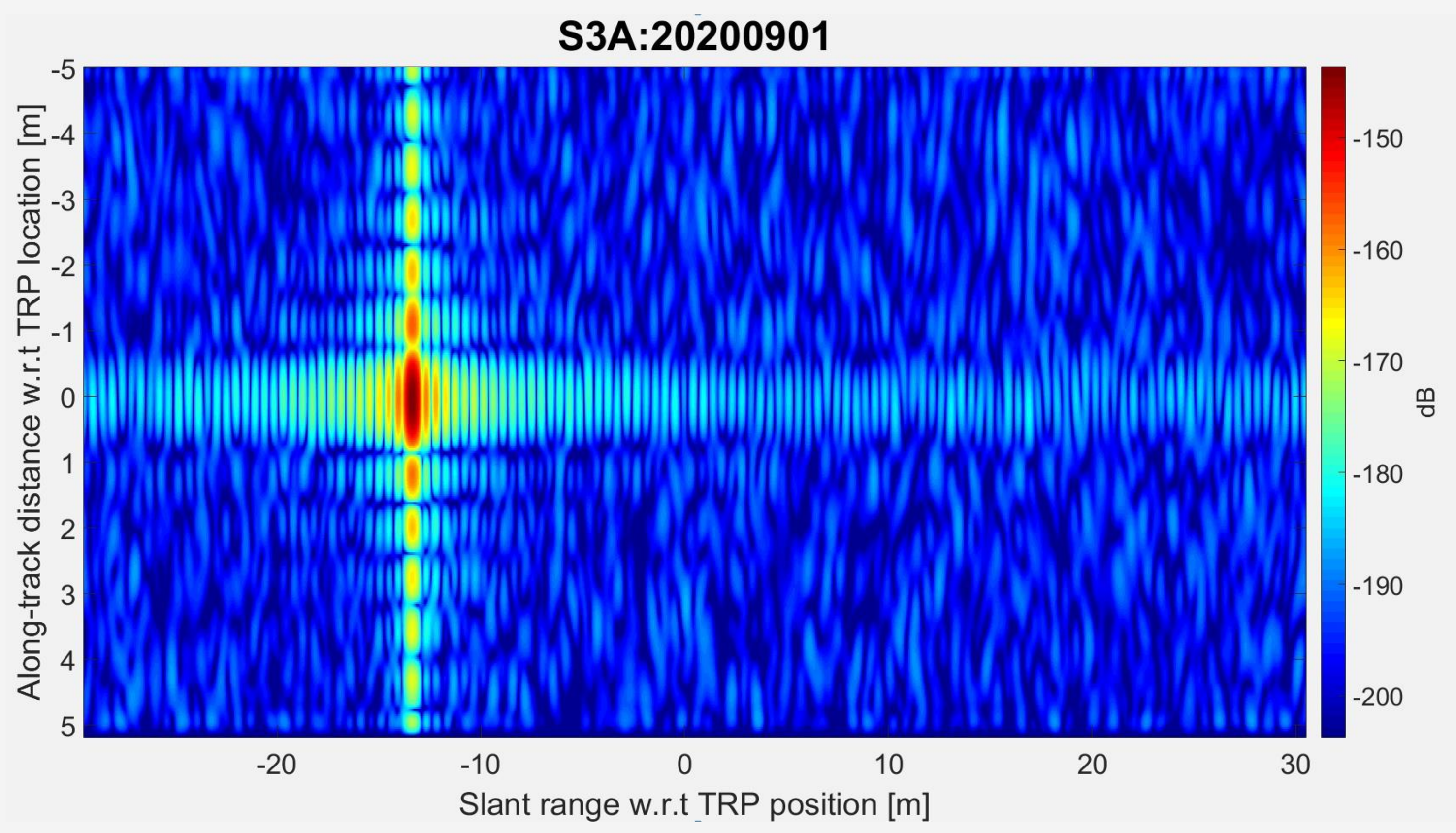
Sigma Naught Transponder Link budget

Radar Cross Section	67.89 dB
Frequency	13.575 GHz
Rx TRP antenna gain	33.8 dB
Rx Cable Attenuation	2.83 dB
RF Unit Gain	54.60 dB
Tx Cable Attenuation	2.40 dB
Tx Antenna Gain	33.77 dB
Optical delay line	55.075 µs
TRP Latitude	42° 34' 25.26960" N
TRP Longitude	11° 37' 31.11714" E
TRP Ellipsoidal Altitude	284.249 m

DELAY-DOPPLER and FULLY FOCUSED RESULTS



Transponder signal after **Delay Doppler processing** for the 1st of September 2020 acquisition. The figures shows the aligned waveforms (Zero padding 32) for each of the contribution Doppler Beams steered at the TRP surface.



Transponder signal after **Fully Focused processing** for the 1st of September 2020 acquisition. The figure shows the 2D impulse response of the TRP showing a very good SNR and Peak to secondary lobes ratios.

Date	Mission	AGC (dB)	Atmospheric Correction 1-way (dB)	Delay Doppler SAR		FULLY FOCUSED SAR	
				RF Unit Input power (dB)	RCS (dBm^2)	RF Unit Input power (dB)	RCS (dBm^2)
12/06/20	S3A	13.2	0.52	-142.4	69.65	-142.77	69.28
23/06/20	S3B	0	0.55	-142.0	69.27	-142.36	68.91
09/07/20	S3A	0	0.55	-143.2	68.86	-143.17	68.89
20/07/20	S3B	0	0.57	-141.8	69.45	-142.4	68.85
01/09/20	S3A	0	0.51	-144.8	67.26	-143.67	68.39
28/09/20	S3A	0	0.48	-143.9	68.07	-143.47	68.5
Average				-143.01	68.76	-142.97	68.80
Expected values from SeRAC09 doc				-143.45	67.89	-143.45	67.89
Bias				**0.44 dB**	**0.87 dB**	**0.36 dB**	**0.91 dB**
Standard deviation				**1.1 dB**	**0.92 dB**	**0.55dB**	**0.32 dB**

Summary table of passes acquired for both Sentinel 3A and S3B, comparing the results for both DDP and FF with the expected values from SeRAC document.

CONCLUSIONS

- Successful results obtained for both Delay Doppler and Fully Focused methods showing good agreement between them.
- Results from Pierdicca et. al. using the Sigma0 transponder with Envisat data are aligned with the ones obtained (bias of 1 dB and std of 0.1 dB over 67 passes).
- Altough the atmospheric attenuation is taken directly from the L2 product and not measured by an in-situ radiometer, the standard deviation of the RCS is better than one computed at the RF input power level (which is affected by atmospheric attenuation and other geometry factors).