DeDop

Fully Adaptable and Configurable Altimeter Delay Doppler Processor

Sentinel 3 For Science – SAR Altimetry Studies

SEOM Study 1. SARAE

DeDop Case Study Report TRANSPONDER

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1 Introduction

1.1 Purpose

This document provides the Transponder analysis done with DeDop processor. The results have been used to validate the different modules and a comparison between them and other processor is presented.

1.2 Document structure

This section provides a brief overview of the outline structure of the document.

Section 1. Introduction

Section 2. Case Study Description

Section 3. Analysis of Case Study Output

Section 4. Conclusions / Recommendations

1.3 Acronyms

AD	Applicable Document
QWG	Quality Working Group
DDP	Delay-Doppler Processor
DMP	Data Management Plan
ESA	European Space Agency
HRM	High Resolution Mode
ISP	Instrument Source Packet
L1A	Input file with geo-located bursts of Ku echoes. The calibrations are not applied. Each record contains 1 SAR burst of aligned but not-calibrated echoes
L1B-S	Output file with fully processed and calibrated SAR complex echoes, arranged in stacks after slant range correction and prior to echo multi-looking.
L1B	Output file with fully calibrated multi-looked power echoes (SAR)
RD	Reference Document
SAR	Synthetic Aperture Radar

S3MPC   Sentinel 3 Mission Performance Centre

1.4 References

1.4.1 Applicable Documents

1.4.2 Reference Documents

RD. 1	Sentinel-3 Surface Topography Mission L0 and L1B SRAL Input Output Data Definition SY-04/SY-21. S3-IF-CLS-SY-00006-11-1_SRAL_L0_L1_IODD.
RD. 2	Sentinel-3 Mission Requirements, EOP-SMO/1151/MD-md, issue 2, rev. 0, 19 February 2007.
RD. 3	SIRAL2 Calibration using TRP: Detail Processing Model – DPM; ISARD_ESA_CR2_TRP_CAL_DPM.

2 Case Study Description

In this section, we provide an overview of the Transponder Case Study

Section 2.1 Technical Context

Section 2.2 Objective

Section 2.3 Input Data Sets (including auxiliary and validation data sets)

Section 2.4 DeDop Tool Processing Specifications

2.1 Technical Context

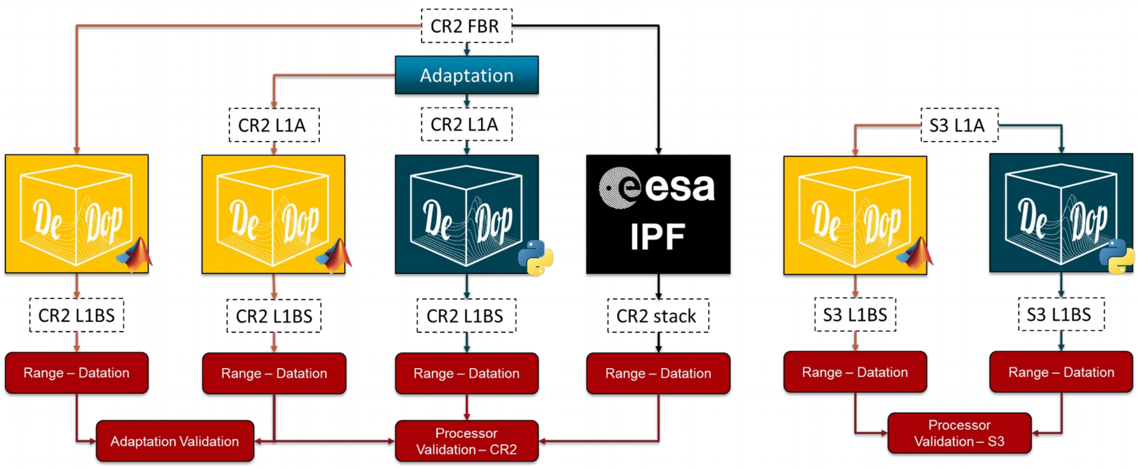
The particularities of the transponder case make it ideal for cross comparison with internal validation purposes. For that reason, three different exercises has been set up in order to validate the different modules that have been implemented in the DeDop project. Outputs from other processing chains, such the CR2 ESA IPF or our development Matlab DeDop code, is used.

The first comparison validates the first part of the chain, the adaptation. For that reason, we use our **Matlab development** code that is able to process data directly from CR2-FBR and CR2 data adapted to S3 L1A format.

The second comparison validates the **DeDop processor**. It consists on a triple comparison between the results retrieved from L1BS file generated with the ESA IPF processor, the results from the Matlab development code and the results from the Python DeDop released code with adapted data.

Finally, DeDop is used to process S3 L1A data and the results between the Python DeDop and the Matlab development versions is compared.

Figure 2-1 Transponder Case Study Data flow diagram



2.2 Objective of Case Study

The proposed activity directly addresses the calibration of the main scientific parameters of the altimeter. In particular, those parameters are the range, which is used to derive the surface elevations and the datation, which has a direct implication in the geo-location of the scatters and in turn the elevation itself.

Using a transponder, we can derive the absolute errors on these measurements, therefore retrieving the biases. If the measurement is continuously performed all through the mission, we are able to monitor the drifts of these measurements, which is a mandatory exercise for the Mean Sea Level rise estimation, especially with the accuracies that scientists are achieving and requesting these days.

The objective of a transponder processing exercise is to calibrate the main altimetric scientific parameters. In particular they are:

1. retrieve the **range bias**, with which one derives the surface elevations;
2. retrieve the **datation bias**, which has a direct implication in the geo-location of the scatters and in turn the elevation itself; and

In these calibrations, we will use three different types of data: L1A (equivalent to CryoSat-2 Full Bit Rate data); the L1B-S (RD. 1) and L2 (to get the geophysical corrections needed in the case of S3 inputs).

To calibrate these parameters and meet the Sentinel-3 mission requirements (RD. 2), we have used two transponders: the transponder in Svalbard (which ESA deployed for the CryoSat-2 project) and the one in Crete.

The objective of this case-study in particular is the demonstration that such a dedicated and specific exercise, can be performed using only the low levels of processing data (e.g. L1A) and using DeDop on top of it for further processing.

2.3 Input Data Sets (including auxiliary and validation data sets)

As shown in Figure 2 -1, we have used CryoSat-2 data adapted to Sentinel-3 format for the first two comparison exercises and also data directly from Sentinel-3 for the third exercise. Additionally the location of the transponder is needed during the surface generation. The L1BS data generated by DeDop is analysed and the range and datation biases are computed. The geophysical corrections needed in the absolute computation of the range are extracted from the CR2 products, as the adapted ones do not contain them (nor at L1A neither at L1BS/L1B). In the S3 case, they are extracted from the corresponding L2 product.

2.4 DeDop Tool Processing Specifications and Description

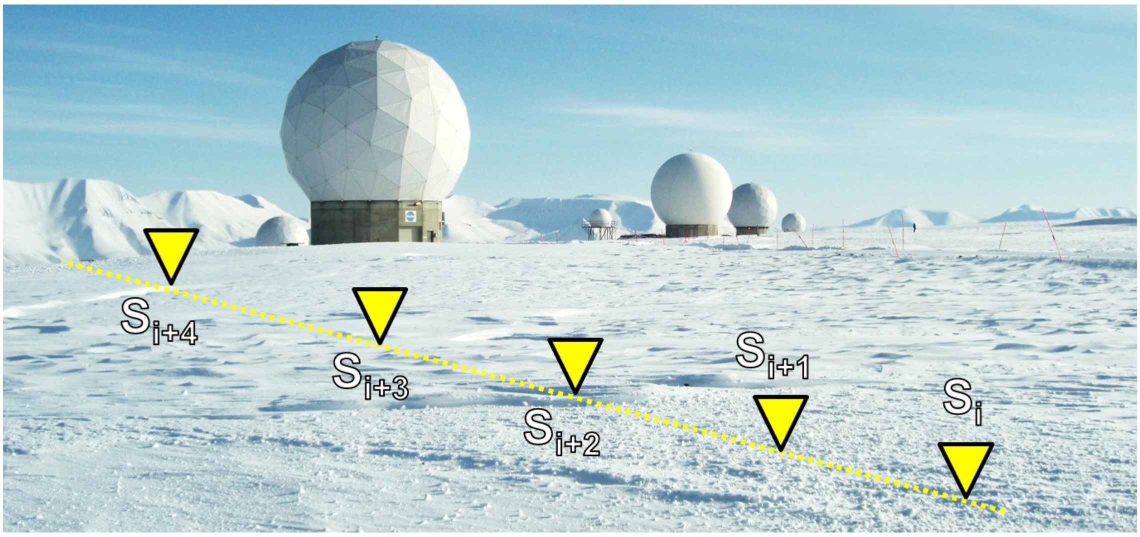
Three configuration parameters have been modified from the default ones:

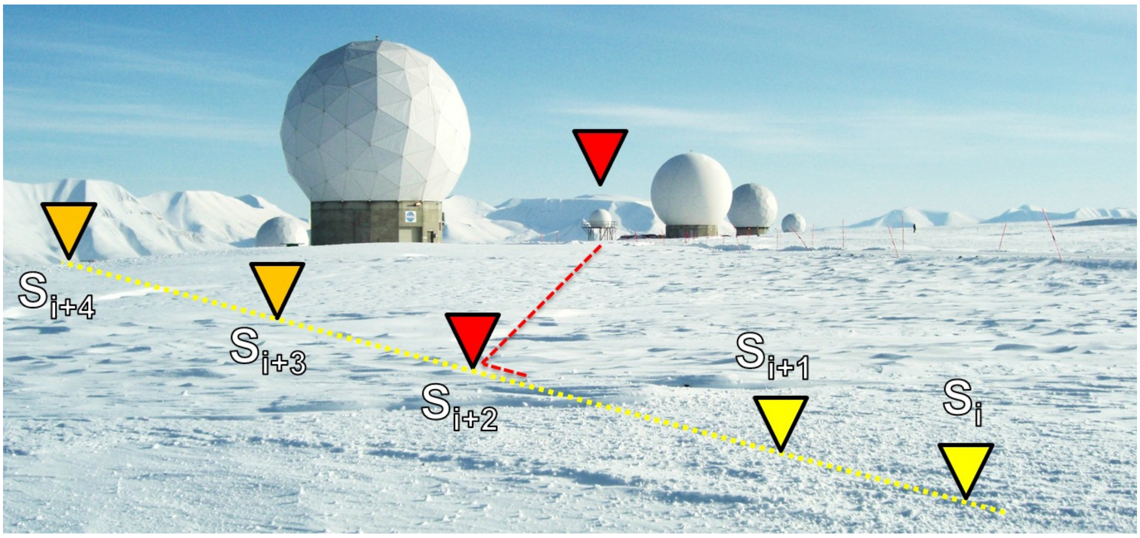
1. Surface location

In order to process and focus properly the TRP beams, the L1B location needs to be computed in the orthogonal projection of the real TRP location to the ground track (see Figure 2 -2) The additional input needed is the TRP location.

Expected change: Surface moved to a new location along the ground track in the closest point to the specified location. The surface_flag parameter should include a value to indicate TRP type.

Figure 2-2 Surface Location Transponder. Top plot shows the nominal surface locations generated and bottom the surfaces after having changed the closest (i+2 in this case) one to the projection of the TRP location to the ground track.





2. Azimuth processing method

The azimuth method is the exact, as the approximate one will not perform the steering of the beams Range zero padding and the stacks will be misaligned, generating a bad range and datation performance.

Expected change: Stacks perfectly aligned.

3. Range zero padding

It has been set to 512 in order to get enough range resolution (from 0.47 meters to 0.9 mm) to measure the biases very precisely.

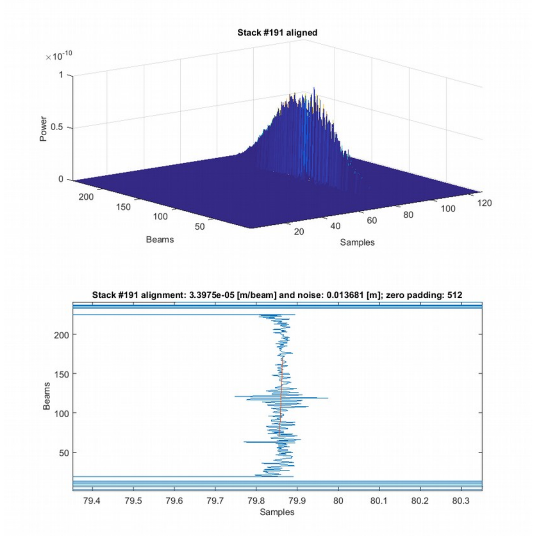
Expected change: Waveforms with 512 times more samples and 512 better.

3 Analysis of Case Study Output

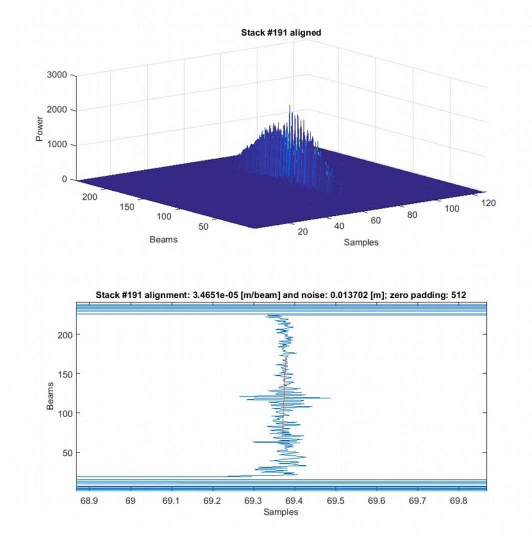
3.1 Technical / Scientific Results

3.1.1 Visual inspection

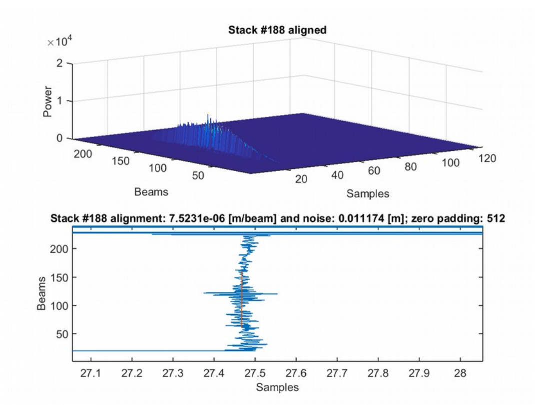
Figure 3-3 Transponder stack after alignment (top) .and the retracked epoch for each beam (bottom) with a regression performed to measure the alignment and noise performances for each of the examples



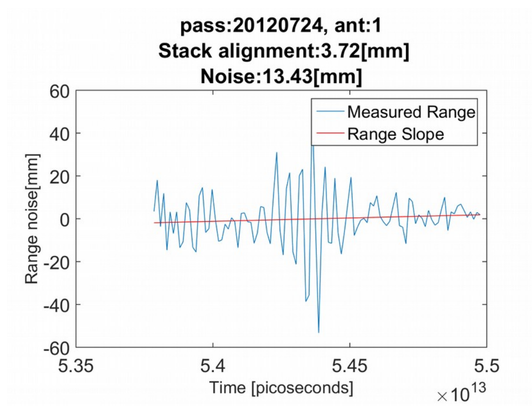
1. CR2 FBR > Matlab



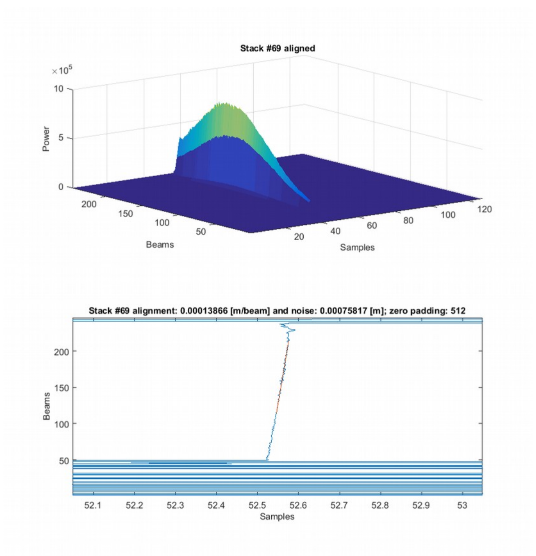
2. CR2 FBR > Adaptor > Matlab



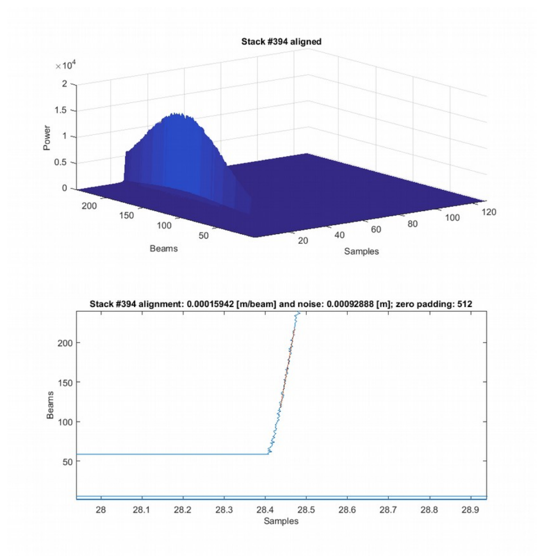
3. CR2 FBR > Adaptor > Dedop



4. CR2 FBR > ESA IPF



5. S3 L1A > Matlab



6. S3 L1A > DeDop

3.1.2 Numerical results

In Table 3 -1 the results for all five different runs are presented.

Table 3-1 Results summary

Test	Range Bias [mm]	Datation bias [microseconds]	Range noise within stack [mm]	Range alignment within stack [mm/beam]
1.CR2 + Matlab	55.76	-47.17	13.68	0.0339
2.CR2 + Adaptor + Matlab	-4856.10	-47.17	13.70	0.0346
3.CR2+ Adaptor + DeDop	-4846.75	-11.79	11.17	0.0075
4.CR2+ ESA IPF	30.54	-54.24	13.43	0.0365
5.S3 + Matlab	-3.53	-216.48	0.76	0.1386
6.S3 + DeDop	-4.32	-203.73	0.92	0.1594

The comparisons should be done grouping 1-2, 5-6, and 2-3-4. The first comparison (1-2) shows us the performances of the CR2 adaptation block. The second comparison (2-3-4) shows us the performances of the DeDop processor with S3 data and any difference with the Matlab development code. The last comparison is made to validate the DeDop processor using CR2, comparing the results against the Matlab development and the CR2 IPF processors.

It can be appreciated a bias of about 4.9 meters associated with a missing internal delay correction not applied in the Adaptation block in 2. The rest of the performances are practically identical giving very similar and very good results in datation, range noise and range alignment for both CR2 and Sentinel 3 data.

3.2 Impact of Different DeDop Processing Configurations

Three configuration changes explained in section 2.4. The zero padding allowed increasing the range resolution from 468.75 mm up to 0.9 mm. The precise surface determination and the exact azimuth processing allowed focussing and aligning the beams properly.

3.3 DeDop Processor and Tool Performance

Apart from the bias introduced in the adaptation block, the performances have a very good agreement with the official processors (CR2 ESA IPF and Matlab Development) being used in the official Cal-Val activities within the CryoSat-2 Quality Working Group and the S3 Mission Performance Centre.

4 Conclusions / Recommendations

The Transponder case study is a very useful validation activity to analyse the performances of the instrument and ground processing. In the case of DeDop, it has helped to identify issues in the implementation that have been corrected and are not present in the current release.

We have also demonstrated that such a dedicated and specific exercise, can only be performed starting from the low levels of data processing (e.g. L1A). Moreover, DeDop provides, on top of the classic Delay Doppler Processing, the possibility to process and analyse the specific case of the transponder data, where a particular configuration and algorithms are required.

The main results show a very good agreement between the CR2 ESA IPF and the Matlab development code, validating the use of DeDop for processing S3 L1A data and CR2 FBR adapted.

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