ESA Unclassified – For Official Use

DOCUMENT

S-1A TOPS Radiometric Calibration Refinement#1

Prepared by	**nuno miranda**
Reference	**ESA-EOPG-CSCOP-TN-0012**
Issue	**1**
Revision	**0**
Date of Issue	**24/11/2015**
Status	**Final**
Document Type	
Distribution	ESA Unclassified – For Official Use

European Space Agency
Agence spatiale européenne

APPROVAL

Title	S-1A TOPS Radiometric Calibration Refinement#1

Issue 1	**Revision** 0
Author	**Date** 24/11/2015
Approved by P. Potin	**Date** 24/11/2015

CHANGE LOG

Reason for change	Issue	Revision	Date

CHANGE RECORD

Issue 1		Revision 0	
Reason for change	**Date**	**Pages**	**Paragraph(s)**

Table of contents:

1 INTRODUCTION

Since the start of the mission, S-1A is impacted by unexpected radiometric and polarimetric channel imbalance. Those have been recently characterized through a recent calibration campaign over the DLR calibration site.

This technical note describes the current status and the performance achieved after the calibration improvements.

2 DOCUMENTS

[RD- 1] MPC Commissioning Phase report, issue 1.3,
[RD- 2] Sentinel-1 SAR Instrument Calibration and Characterisation Plan, issue 7.4, 09/09/2014

3 S-1A RADIOMETRIC RECALIBRATION PERFORMANCE

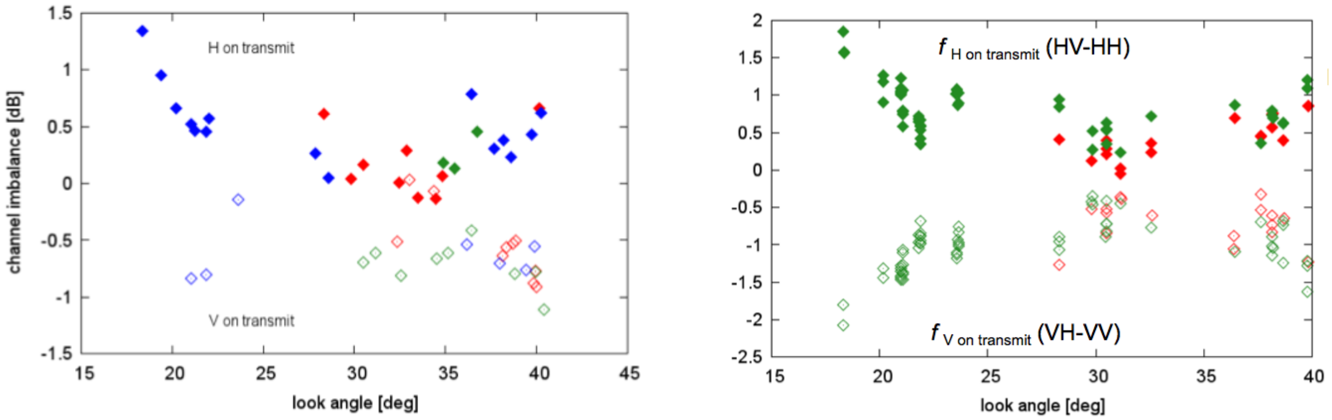
The S-1 IPF performs a number of radiometric corrections in order to achieve the expected radiometric accuracy. Some are well known and driven by the SAR radar equation like the Range Spreading Loss and the Elevation Antenna Pattern (EAP) correction. Others are specific to S-1 and are mostly related to the internal calibration approach [RD- 2]:

- instrument drift compensation
- polarimetric gain and phase imbalance
- gain variation over the receive window.

Even though these corrections are all active, it has been measured already during the Commissioning Phase an unexpected gain imbalance. Figure 1.a) shows the results obtained during the commissioning phase where it can be seen even with strip map (SM) acquisition (blue) that towards the near beams the gain imbalance increases. The gain imbalance is defined as the ratio between the signal power of the cross-polarized channel to the co-polarized channel measured over the transponders. In ideal conditions, no imbalance (0dB) is expected.

During spring/summer 2015, a calibration campaign took place over the DLR transponders to better characterize this effect and fine-tune the product calibration. The results of this calibration campaign are represented in the Figure 1.b) representing the polarimetric gain imbalance after applying all known corrections.

European Space Agency
Agence spatiale européenne



(a) IOCR status **(b) fall 2015 status**

Figure 1: Channel imbalance between cross- and co-polar channel derived from the transponder IRF for H- (filled diamonds) and V-polarization (open diamonds) on transmit for different modes (blue: SM, red: IW, green: EW).

From Figure 1, it can be seen that for:

- IW: it mainly consists of an offset that is slightly different for Dual H (DH) and Dual V (DV).
- EW: similar offset as for IW except that it can be also be noticed that there is a range variation exhibiting higher imbalance towards the lower and higher look angles.

In addition, for IW it has been seen using the transponders and verified against CMOD-5 predicted NRCS that there is an overall offset of the order of 0.66dB w.r.t. the expected RCS (this offset is for all polarisations).

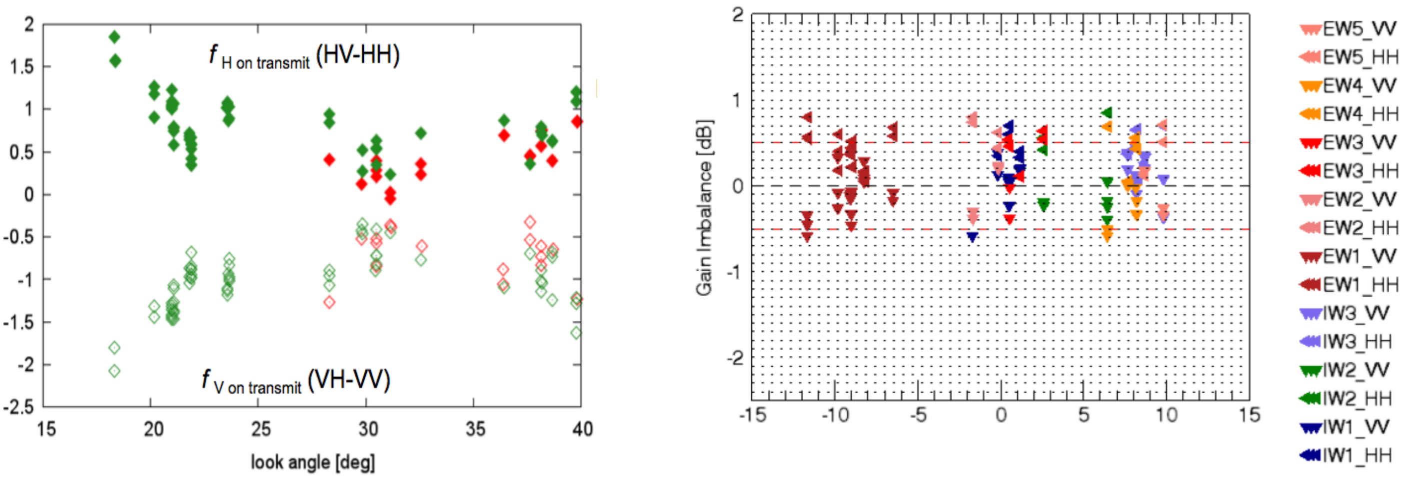
The purpose of this enhancement is to improve the correction for the polarimetric channel imbalance and IW absolute calibration. The calibration is applicable for TOPS SLC and GRD products.

In order to achieve those, Elevation Antenna Patterns (EAPs) have been refined using the Amazonian rain-forest and the processing gains adjusted.

The results obtained are provided in the next section where the left plots represents the status since launch and the right plot represents the status after the fine-tuning.

3.1 Polarimetric amplitude imbalance results

As it can be seen in Figure 2, the polarimetric imbalance has been mostly reduced. The strong dependency with the incidence angle has been reduced. The overall IW/EW accuracy is of 0.036dB (1σ) with no bias. Taking separately IW and EW, the 1σ accuracy is of 0.31dB and 0.4db respectively.



(a) before recalibration (b) after recalibration

Figure 2: EW/IW polarimetric gain imbalance before a) and after recalibation b)

3.2 Absolute calibration results

The absolute calibration is measured over the DLR calibration targets composed of three precision transponders and three corner reflectors. The absolute calibration is assessed by the mean of the relative RCS defined as:

$$RCS_{relative} = RCS_{measured} - RCS_{expected}$$

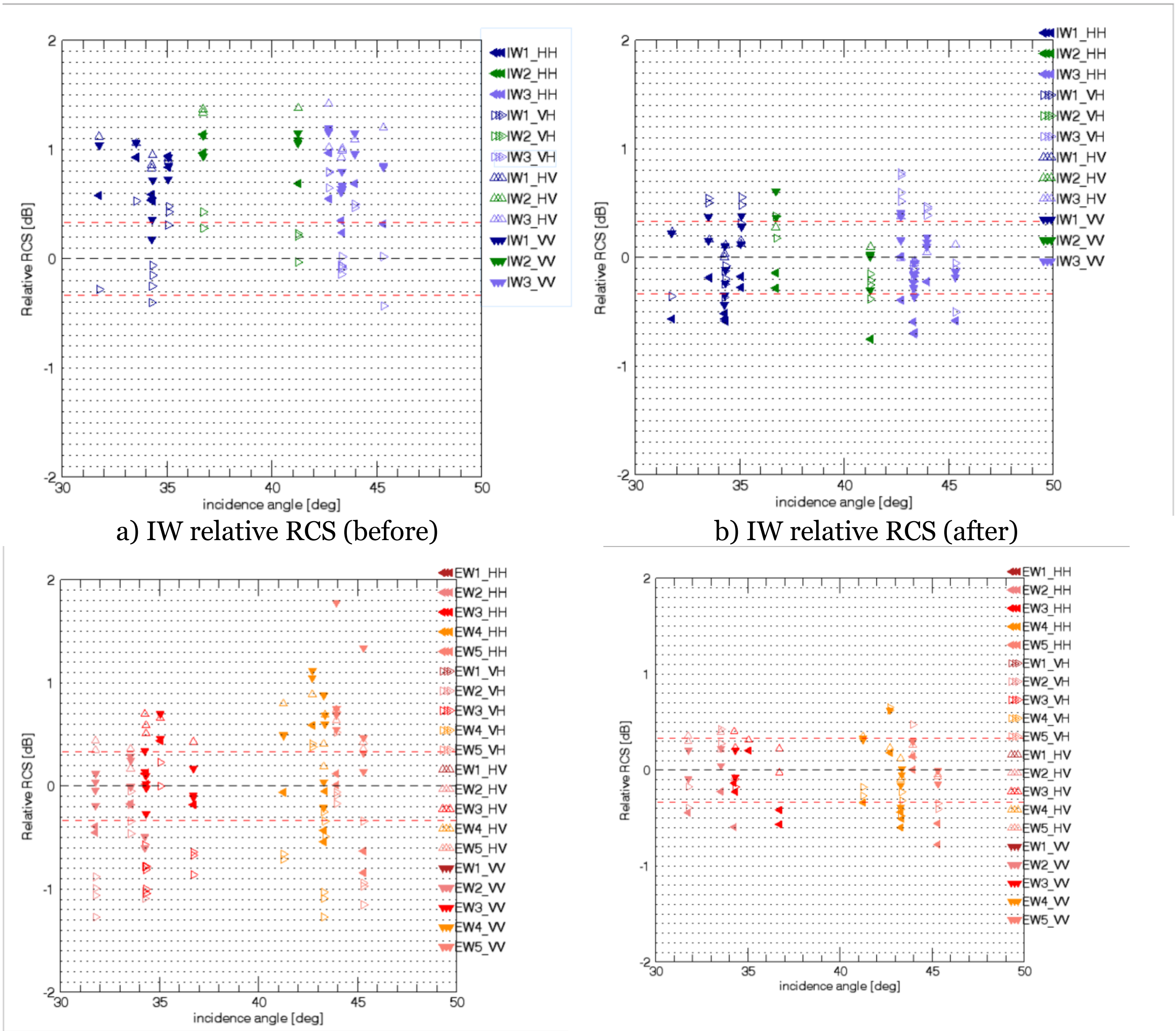
Before recalibration, the TOPS overall radiometric precision/accuracy measured by the transponders was:

- IW: 0.67±0.45dB (1σ)
- EW: 0.00 ±0.66dB (1σ)

The relatively high accuracy was essentially due to the polarimetric gain imbalance creating a difference between the Rx V and H measurements directly impacting the accuracy.

Taking the measurements separately by beam and polarisation the standard deviation was very close to 0.2dB indicating a very good system stability. After recalibration, the results significantly improved (see also Figure 3, right plots):

- IW: 0.0±0.34dB (1σ)
- EW: 0.00 ±0.38dB (1σ)



a) IW relative RCS (before) b) IW relative RCS (after)

c) EW relative RCS (before) d) EW relative RCS (after)

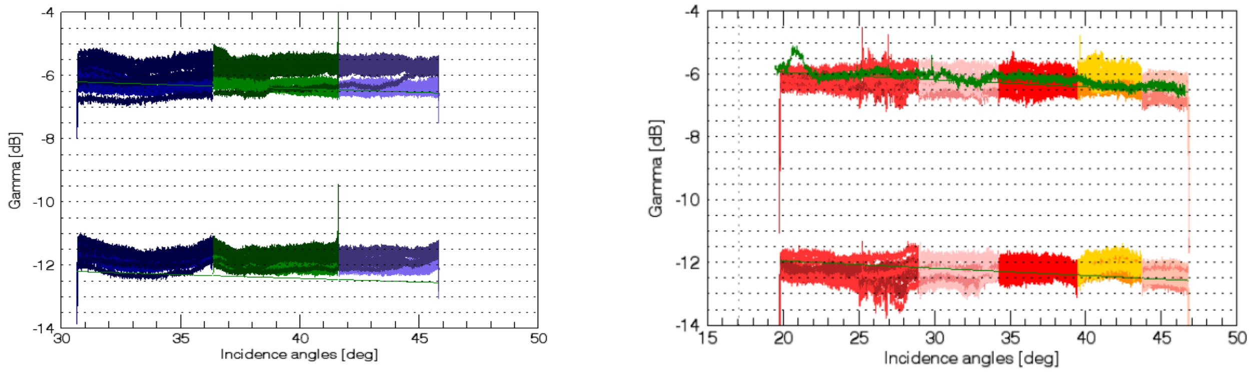
Figure 3: IW and EW absolute radiometric calibration results before (left) and after (right) the recalibration

3.3 Verification over the rain-forest

The Amazonian rainforest is used to verify the beam relative calibration and also the absolute calibration by comparing the derived gamma with the expected gamma over the

European Space Agency
Agence spatiale européenne

Amazonian Rainforest which between -6.2 and -6.5dB for VV and HH. However, being the rain-forest presenting seasonal and diurnal reflectivity changes, it can only be considered as a qualitative assessment. Figure 4 shows a flat gamma response and no discontinuities between sub-swaths.



(a) IW gamma profiles b) EW gamma profiles

Figure 4: S-1A mean gamma profiles over the Amazonian rainforest for DH and DV after the recalibration

3.4 Impact on time series

The product calibration enhancement has been achieved by using a new set of auxiliary files to generate the S1 L1 core user products (see section 4) since 25/11/2015 at 10h40 UTC approximately.

All S1 Level-1 (SLC and GRD) user products with a sensing time after 25/11/2015 10:40 UTC are processed with the radiometric performance enhancement.

Some L1 products with an earlier sensing time may also include the calibration enhancement (depending on their processing time). User can verify if a given Level-1 product includes the enhancement by checking in the product manifest which set of auxiliary files has been used for processing. In case the generation date of the S1A_AUX_CAL and S1A_AUX_PP1 file reported in the manifest is greater or equal to “G20151125”, then product includes the calibration enhancement.

The table below is an extract of the manifest file showing how the auxiliary data files are annotated.

```
<safe:resource
name="S1A_IW_SL1__1_DV_20151029T053435_20151029T053507_008363_00BCE7_8BBE.SAFE"
role="Level-1 Intermediate SLC Product">
       <processing name="SLC Processing" start="2015-11-02T14:23:01.000000" stop="2015-
11-02T14:28:15.000000" xmlns="http://www.esa.int/safe/sentinel-1.0">
       <facility country="France" name="MPC_" organisation="CLS" site="Brest">
         <software name="Sentinel-1 IPF" version="002.60"/>
       </facility>
       <resource name=”S1A_AUX_PP1_V20150722T120000_G20151125T104803.SAFE"
role="AUX_PP1"/>
       <resource name=”S1A_AUX_CAL_V20150722T120000_G20151125T104733.SAFE"
role="AUX_CAL"/>
       <resource name="S1A_AUX_INS_V20150722T120000_G20150720T091909.SAFE"
role="AUX_INS"/>
       <resource
name="/S1A_IW_RAW__0SDV_20151029T053434_20151029T053506_008363_00BCE7_7A5A.SAFE"
role="Level-0 Product">
       <processing xmlns="http://www.esa.int/safe/sentinel-1.0" name="Generation of
Sentinel-1 L0 SAR Product, dual polarisation" start="2015-10-29T07:53:45.589907"
stop="2015-10-29T07:53:45.731682">
    <facility country="United Kingdom" name="UPA_" organisation="Airbus DS"
site="Farnborough">
```


4 APPLICABILITY

The new auxiliary data files are in operations for data processed since 25/11/2015 10h40 UTC.

The calibration fine-tuning is applicable for all data acquired since the end of the commissioning phase. As a consequence several Auxiliary Data Files (ADFs) have been updated. Any products processed with these auxiliary files will include the calibration enhancement.

RDB3:
S1A_AUX_PP1_V20140915T100000_G20151125T102627.SAFE
S1A_AUX_CAL_V20140915T100000_G20151125T103928.SAFE

RDB4:
S1A_AUX_PP1_V20150519T120000_G20151125T102820.SAFE
S1A_AUX_CAL_V20150519T120000_G20151125T104142.SAFE

RDB5:
S1A_AUX_PP1_V20150722T120000_G20151125T104803.SAFE
S1A_AUX_CAL_V20150722T120000_G20151125T104733.SAFE