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**Title** : **AATSR 12 Micron Anomaly Review Board – Final Report**  
**ADDENDUM**

**Abstract** : This document is an ADDENDUM to the final report from the AATSR 12 micron Anomaly Review Board.

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## AMENDMENT POLICY

This document shall be amended by releasing a new edition of the document in its entirety. The Amendment Record Sheet below records the history and issue status of this document.

### AMENDMENT RECORD SHEET

ISSUE	DATE	REASON
1.0	03 Nov 2016	Initial Issue of this Addendum

## 1. EXECUTIVE SUMMARY

An Anomaly Review Board (ARB) was convened in 2013 to consider the differences in signal response when similar scenes were viewed by both the ATSR-2 and AATSR instruments. The original reports focussed on discrepancies in brightness temperatures for the two respective 12  $\mu\text{m}$  channels with much closer agreement observed at 11  $\mu\text{m}$ . The ARB examined the evidence and was able to confirm the likely origins as being a spectral filter shift and an improved application of the non-linearity correction.

New analyses in 2015 identified that the two components of correction had been estimated separately and concluded that the co-application of both resulted in an over-correction. Overall, the evidence is that empirical non-linearity correction should be applied together with use of a 12  $\mu\text{m}$  spectral response shifted by 40 nm. We estimate an associated uncertainty of 0.05 K in absolute 12  $\mu\text{m}$  BTs.

Advice to users should be updated to make this clear for users of the **AATSR level 1B data (TOA files)** as follows:

1. Adjust the 12  $\mu\text{m}$  brightness temperatures by subtracting the values provided in the Technical Note "Empirical Nonlinearity Correction" (*PO-TN-RAL-AT-0562*, v1.1) [RD.1].
2. For subsequent processing, use the current AATSR 12  $\mu\text{m}$  spectral response function but shifted by 40 nm towards longer wavelengths. This value is refined through additional work (see below) from the original recommendation of 50 nm; the difference in values is indicative of the level of confidence in knowledge of the spectral shift.

For level 2 data, the advice remains the same. For users of level 2 data (NR and AR files), no empirical correction is possible. The recommendation is to use the AATSR L2P products (V2.1 or later) in which an empirical correction has been made.

## 2. INTRODUCTION

The Advanced Along Track Scanning Radiometer (AATSR) was an instrument on-board ESA's ENVISAT satellite, which was launched on 1 March 2002 and ceased to function on 8 April 2012. During the mission it became clear that there were discrepancies between brightness temperatures (BTs) measured by the 12  $\mu\text{m}$  channel of AATSR and those from the corresponding channel on ATSR-2.

Following a recommendation from the AATSR Exploitation Board (AEB) and Quality Working Group (QWG), an Anomaly Review Board (ARB) was convened in 2013 to consider the differences in signal response which have been consistently observed between the ATSR-2 and AATSR signal channels, particularly though perhaps not exclusively, in the 12  $\mu\text{m}$  wavelength signal channels of the two instruments. The findings of the ARB have been published in a final report [RD.2] and in a recommendation for users [RD.3], that has been subsequently updated (now v1-2).

Subsequent to the original ARB finding, recommending both a spectral filter shift and a non-linearity correction, it was found in the ESA SST\_CCI studies that the recommended adjustments overcorrected the observed differences between AATSR and ATSR-2 12 micron BTs. One reason is that the optimisation for each effect was assessed independently in the original work but the practical application to BTs combines both. Further work was then initiated as described below.

The results were considered at the 32<sup>nd</sup> AATSR Quality Working Group meeting in October 2015 at which revised recommendations were agreed.

### 3. EVALUATION OF ARB RECOMMENDATION BY ESA SST\_CCI PROJECT

The ESA SST\_CCI project team evaluated the recommendations of the ARB in their recent (2015) reprocessing of all ATSR datasets. Their results were presented in a supporting document [RD.4]. The key findings from the ESA SST\_CCI project team were:

1. The recommendation of the ARB did not provide an optimal reduction of the observed discrepancy between AATSR and ATSR-2 12 micron BTs.
2. That a shorter wavelength shift of ~40 nm is used with the published non-linearity correction.
3. That the recommended spectral shift of ~50 nm be used without the additional non-linearity correction.

The ESA SST\_CCI project team held a meeting to review their findings and proposed some additional work to better understand these differences. The meeting was also attended by members of the ATSR QWG. The findings of the meeting were:

1. The published non-linearity correction (URL) was not the same correction that was used by the ARB to estimate the optimal combination of non-linearity correction and spectral shift.
2. It was hypothesised that it might be possible to separate out the non-linearity and spectral parts by considering the difference between AATSR and ATSR-2 at the on board black-body temperatures. At these points the non-linearity correction is zero and so any differences will solely be due to spectral effects.

Following the meeting, the University of Reading agreed to carry out an initial evaluation of this new hypothesis as part of their FIDUCEO activities.

### 4. SUMMARY OF FIDUCEO WORK

The evaluation of the ARB recommendations in the ESA SST\_CCI project suggested that the simulated correction was over-compensating by 0.05 K (see Figure 1).

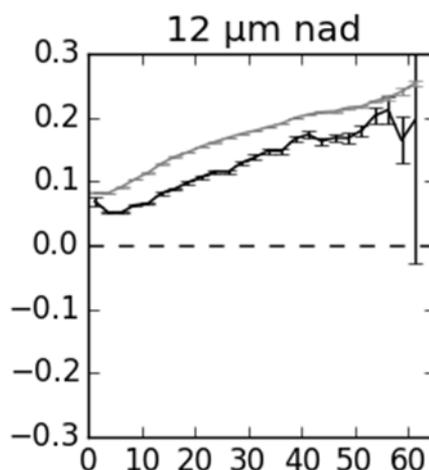
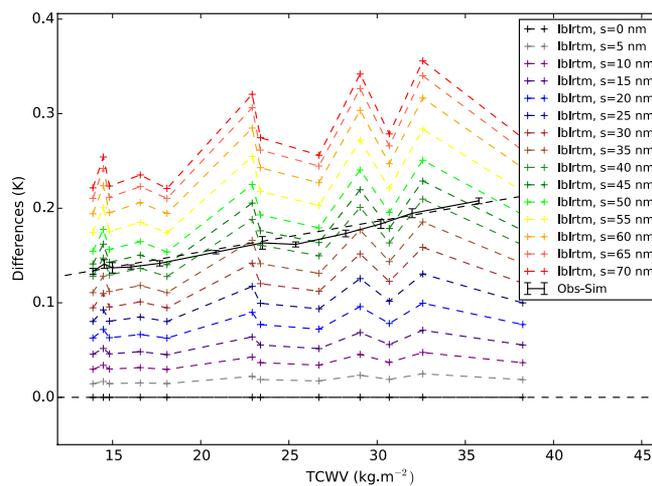


Figure 1: Observed (black) and simulated (grey) ATSR-2 minus AATSR nadir-only 12 micron BT differences as a function of TCWV ( $\text{kg/m}^2$ ) after applying the ARB recommendations

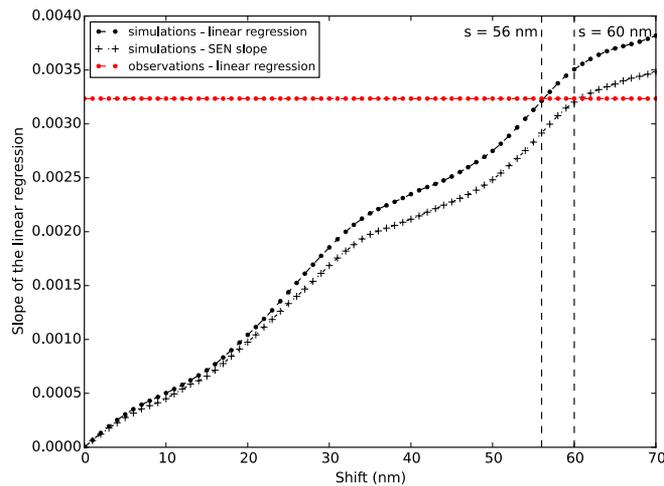
A feasibility study was carried out as part of FIDUCEO [RD.5] to improve the correction. Double-difference simulations were carried out for a range of spectral filter shifts at temperatures close to 300 K (at which any non-linearity of range of spectral filter shifts is minimised as it is the approximate on-board temperature of the “hot” internal blackbody). A total of twelve profiles were used with total column water vapour (TCWV) ranging from 13.85 kg/m<sup>2</sup> to 38.25 kg/m<sup>2</sup>. Both observation and simulations were limited to cases where the 12 micron BT was within 2 K of the blackbody temperature. The resulting simulations are shown in Figure 2 where a shift of 40 nm gives the closest agreement between observed and simulated differences.

Applying a 40 nm shift to the full ESA SST\_CCI overlap dataset (including observations for all clear-sky open-ocean conditions) also improved agreement between observation and simulation when the non-linearity correction is included.



**Figure 2: Double differences between ATSR2 and AATSR nadir-only 12 micron BTs as a function of TCWV at T=300+/-2 K**

A further observation by the FIDUCEO team was a small difference in the slope between the observed and simulated results (Figure 2). To investigate this in more detail the FIDUCEO team plotted the slope of the two sets of differences as a function of the spectral shift. These results are shown in Figure 3.



**Figure 3: Slope of the linear regression for the observed double differences (red line) and for the FIDUCEO simulated differences (black lines) as a function of the shift applied to AATSR SRF**

From this it can be seen that while a shift of 39 nm gives the best agreement in terms of the absolute difference between the observed and simulated cases, the shift where the slope as a function of TCWV matches the observations is larger. Indeed, calculating the slopes with a linear regression gives a best shift value that is closer to 56 nm. This finding shows that the observed differences are not just a simple shift and implies a change in shape albeit as a second-order effect.

## 5. UPDATED ARB RECOMMENDATION

The updated ARB recommendation is that the empirical non-linearity correction coupled to a 40 nm shift of the spectral response function is most likely to give the best correction to the 12  $\mu\text{m}$  channel of AATSR. This has been tested using an ATSR dataset limited to observations close to the hot blackbody temperature (where non-linearity effects should be near-zero), and for a full dataset of clear-sky ocean scenes (which covers temperatures between the hot and cold blackbody temperatures).

However, the observed differences cannot be solely explained by a spectral shift – when considering just the slope of the differences and not the absolute difference, the best agreement is seen for a larger shift implying that there is also a change in the shape of the spectral response function. We consider that 0.05 K represents the best simple estimate of the uncertainty in BT in this channel after the adjustments have been applied within the temperature range of the on-board black bodies (260 K to 300 K).

## 6. REFERENCES

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