(A)ATSR Validation Activities

Validation Issues Report

Space ConneXions Contract: 2004-03-001/CPEG10

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Document Control

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1B	24/09/2008	Updated draft following comments from H. Kelliher	H. Kelliher A. Chalmers
2A	16/04/2009	First public issue	QWG
3A	09/09/2009	Update of all validation issues following QWG in May 2009. Addition of new data quality issues, *AATSR missing orbits* (Section 2.1), and *ATSR-1 channel availability* (Section 2.2).	QWG
3B	23/09/2009	Update of issue *AATSR missing orbits* (Section 2.1) following comments received from Siân O'Hara	All
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5A	23/09/2014	Updated following completion of validation of V2.1/V3.0 dataset	H. Kelliher
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1   INTRODUCTION

1.1   The instrument

The Advanced Along-Track Scanning Radiometer (AATSR) is the third in a series of UK developed instruments, which along with its predecessors ATSR-2 and ATSR-1 are designed to provide a long time series of global Sea Surface Temperature (SST) data to an accuracy of < 0.3 K for the independent detection of climate change.

The AATSR instrument is an infrared, near-infrared and visible radiometer, which views the same location on the Earth's surface in both a nadir view and an oblique view at 55° to nadir. The instrument is self-calibrating through the use of two extremely stable on-board blackbody reference targets to calibrate the thermal channels and a Russian Opal diffuser to calibrate the visible and near-infrared channels.

1.2   The data products

The data collected from the instrument is routinely processed as part of the ENVISAT ground segment to Level 1b (calibrated, geolocated radiances) and Level 2 (geophysical products). The operational processing produces three operational products, namely SST, Land Surface Temperature (LST) and a Normalised Difference Vegetation Index (NDVI). There are two operational Level 2 AATSR products: a 1-km gridded product referred to as the ATS_NR__2P product and a spatially averaged product (at resolutions of 17 km, 50 km, 10´, and 30´), referred to as either the ATS_AR__2P product or the ATS_MET_2P product; the ATS_MET_2P product is reduced Level 2 product containing only 10´ resolution data for meteorological users.

Data from its predecessor instruments has been converted to ENVISAT data format by the Rutherford Appleton Laboratory (RAL) and the Natural Environmental Research Council (NERC) Earth Observation Data Centre (NEODC). These data products are identical in format although not in content to those from AATSR, and are prefixed AT2 for ATSR-2 and AT1 for ATSR-1. Further details on the complete ATSR data archive can be found on the NEODC website at http://www.neodc.rl.ac.uk/?option=displaypage&Itemid=91&op=page&SubMenu=91.

Data from the most recent reprocessing is designated as ATSR Version 3.0.

1.3   The validation programme

A comprehensive geophysical validation programme using ground based instrumentation on ships, buoys and on the land has been carried out to assess the accuracy of all operationally produced geophysical data sets produced from the AATSR instrument. All issues found are reported to the ATSR Quality Working Group (QWG) for subsequent evaluation and resolution.

1.4   Validation issues

This document summarises all known data quality issues with AATSR data that have been found through its validation programme. In addition, it includes data quality issues with ATSR-1 and ATSR-2 that have been found through analysis of the long-term ATSR archive.

Each data quality issue is described in one the following sections:

1. Ongoing investigations

    - Issues that potentially limit scientific exploitation of the ATSR dataset that are subject to ongoing work by the ATSR QWG.

2. Open issues

    - Issues identified in the ATSR dataset for which there is no scientific impetus to warrant further investigation at the date of this report.

3. Resolved

    - Issues for which solutions have been implemented in a previous reprocessing.

For each issue, a statement of the problem is given, actions defined to resolve it and the current status.

For further details, or to provide comments or feedback on the document, please contact the AATSR Validation Scientist (VS), Gary Corlett (gkc1@le.ac.uk).

2   ONGOING INVESTIGATIONS

2.1   Gross cloud test thresholds

Statement of the Issue

As part of the overlap analysis work, the AATSR Validation Scientist (VS) performed a detailed analysis of the current cloud screening algorithm applied to the Version 2.0 data in the ATSR archive. This work was complementary to the development of the new Bayesian scheme within the ATSR Reprocessing for Climate, or ARC, project (Merchant *et al.*, 2008).

The first cloud test investigated was the gross cloud test. The basic idea of the gross cloud test is to compare the estimated 12 μm Brightness Temperature (BT) to a predetermined threshold. If the estimated BT is below the threshold, then the pixel is likely to be cloudy. The thresholds are derived from an existing SST climatology, which has been adjusted for the effects of the atmosphere. A more complete description of the cloud test is given in Závody *et al* (2000). The first part of the analysis was to attempt to reproduce the operational gross cloud test.

The orbit ATS_TOA_1PNPDE20080501_012447_000048382068_00131_32249_4029.N1, from May 2008 was chosen for comparison, and software was written to perform the necessary analysis. However, it was soon apparent that the operational gross cloud test results were not reproducible for the chosen test orbit, over either land or ocean. Consequently, each step of the gross cloud test was investigated in further detail.

The first step was to analyse the gross cloud test thresholds from the ancillary file used in the operational processing of AATSR data. The cloud test thresholds are given in the following CL1 ancillary data file:

- ATS_CL1_AXNIEC20070223_102348_20010308_120446_20120801_235959

The gross cloud test thresholds for ocean pixels are shown in Figure 2-1.

As stated above, the gross cloud test thresholds are derived by adjusting an SST climatology for the effects of the atmosphere, so they are representative of the Top-Of-Atmosphere (TOA) BTs estimated from the TOA radiances measured by the instrument. However, visual inspection of Figure 2-1 suggests that the data stored in the CL1 file is partly incorrect, as the plot indicates a surprising increase in Southern Hemisphere temperatures in the period from June to September. To investigate this further, the NCEP OI V2.0 monthly SST climatology was plotted to see how the temperatures varied throughout the year. These data are shown in Figure 2-2.

As expected, the data shown in Figure 2-2 has a temperature increase in the Northern Hemisphere in the period from June to September. Moreover, the data in Figure 2-2 indicates a small seasonal cycle (the variation in temperature over the year at each latitude band) in mean temperatures in the Southern Hemisphere, with a much larger seasonal cycle in the northern Hemisphere. This observation is in agreement with Knudsen *et al.* (1996), and is in disagreement with the gross cloud test thresholds plotted in Figure 2-1.
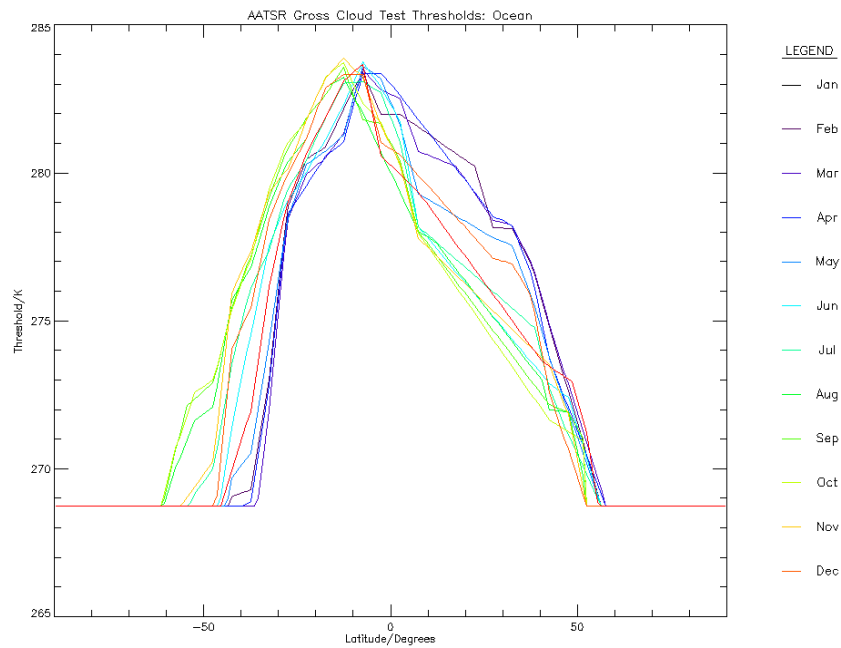
Figure 2-1: Monthly gross cloud test thresholds for ocean pixels
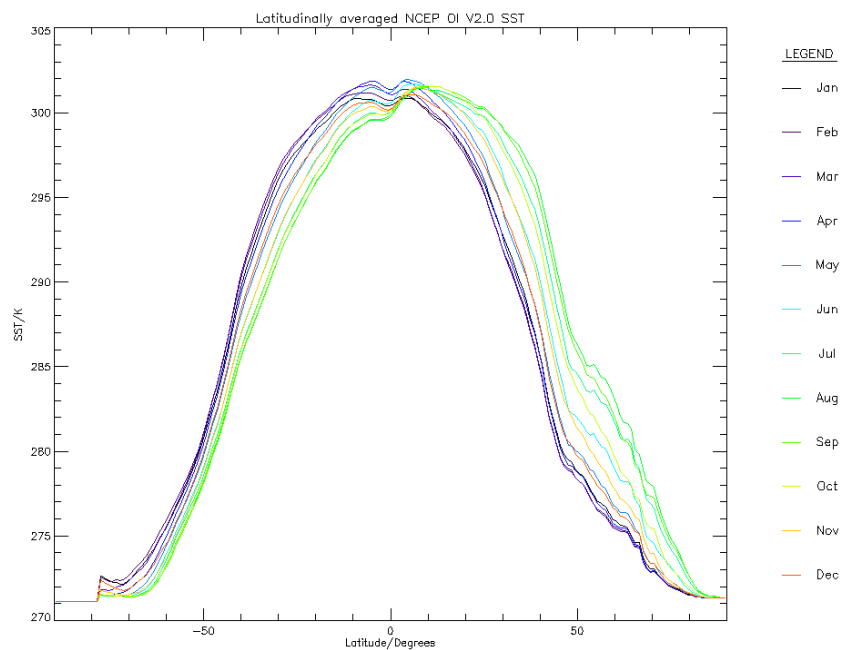
Figure 2-2: Latitudinally averaged NCEP OI V2.0 SST monthly climatologies

Action to resolve issue

The issue has been reported to the QWG and has been confirmed by the ESL at RAL. The generation of new thresholds and an updated CL1 file is required to resolve this issue.

Current status

An updated CL1 file was used to generate the AATSR V2.1 dataset. Updates were not applied to the V2.1/V3.0 ATSR-1 and ATSR-2 datasets and users may wish to evaluate alternate cloud masks contained with the L2P and UoL-LST-2P products. Updated CL1 files for ATSR-1 and ATSR-2 will be included in the 4th reprocessing.

References:

Knudsen, P., *et al.*, 1996: ATSR sea surface temperature data in a global analysis with TOPEX/POSEIDEN altimetry. *Geophys. Res. Lett.,* **23**, 821-824.

Merchant, C.J., *et al.*, 2008: Deriving a sea surface temperature record suitable for climate change research from the along-track scanning radiometers. *Adv. Space Res.*, **41**, 1-11.

Závody, A.M., *et al.*, 2000: Cloud Clearing over the Ocean in the Processing of Data from the Along-Track Scanning Radiometer (ATSR). *J. Atmos. Oceanic Tech.,* **17**, 595-615.
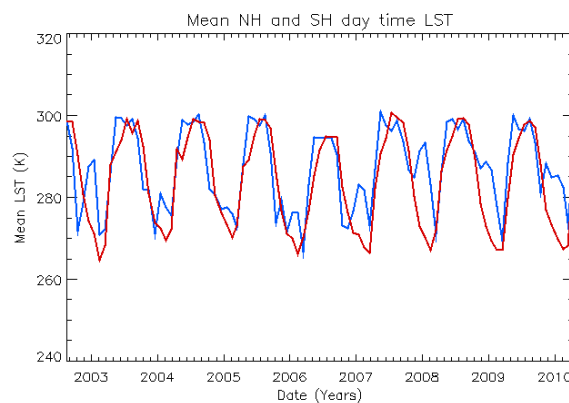
2.2 Land cloud mask

Statement of the issue

An analysis by Kogler et al. (2012) highlighted two issues with the current land surface temperature (LST) time series. There was:

1) A notable bias between ATSR-1 and ATSR-2 during daytime and

2) A 'dip' in the daytime AATSR record in 2006 (see Figure 2-3).

Figure 2-3: Mean Northern hemisphere (red) and Southern hemisphere (blue) LST derived from part of the AATSR mission. A clear 'dip' is seen in 2006 compared to other years.

Subsequent analysis revealed the likely cause as cloud contamination as a result of the failure of the current land cloud tests.
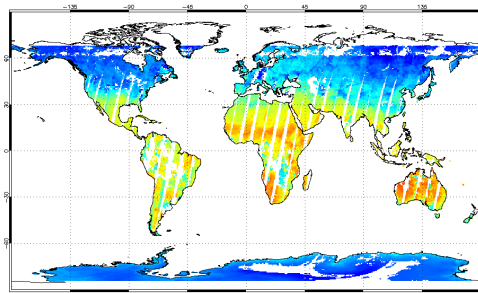
Figure 2-4: Monthly averaged AATSR LST for January 2006.

Specifically, for AATSR, the visible-channel cloud test appears to not be optimal during 2006 (see example in Figure 2-4, where notable 'cold' biases are seen, particularly in South America and Southern Africa). It is suspected that this is due to the fact that the correction for changes in the visible channel optical throughout the mission lifetime has not been applied to the data. Indeed, if it is the case it is also the likely cause for the large daytime offset between ATSR-1 and ATSR-2 observed by Kogler et al. (2012) as the ATSR-1 instrument did not have visible wavelength channels and so the test cannot be applied.

Action to resolve issue

Several AATSR test orbits were manually processed by the Expert Support Laboratory (ESL) using the correct visible channel calibration and significant improvements were seen in the cloud masking over land.

Current status

Updated visible calibration data have been applied to all three sensors during the reprocessing to V2.1/V3.0. However, this will not resolve the bias reported by Kogler et al. (2012) between ATSR-1 and ATSR-2 and has highlighted other notable failings with the current land cloud masking.

UoL developed a new land cloud mask for the V3.0 LST product based on radiative transfer model (RTM) simulations. On-going work within the GlobTemperature project will provide a new baseline from a round robin intercomparison activity. There are currently no planned developments to improve the ATSR land cloud mask for non-LST products. However, there are planned activities to improve the Sea and Land Surface Temperature Radiometer (SLSTR) cloud mask over land for non-LST products and it is expected that such developments can be translated into improvement for ATSR later on.

References

Kogler, C., S. Pinnock, O. Arino, S. Casadio, G. Corlett, F. Prata and T. Bras, 2012. Note on the quality of the (A)ATSR land surface temperature record from 1991 to 2009, International Journal of Remote Sensing, 33:13, 4178-4192.

2.3   Absolute geolocation accuracy

Statement of the issue

As part of the update to the LST retrieval algorithm a systematic offset was observed between gridded AATSR 11 µm BT images and coincident Globcover (Arino et al. 2007) biome types. An example, for a lake in Victoria, Australia, is shown in Figure 2-5, where a clear offset is seen between the 'lake' outline in the two images.
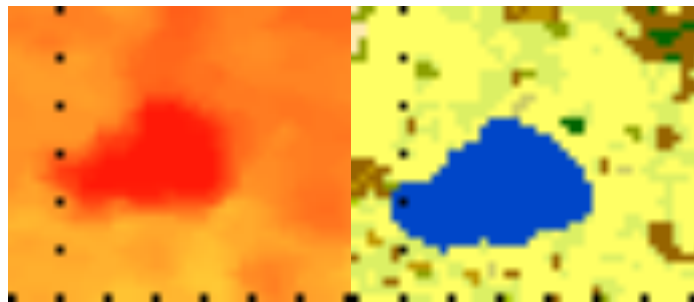
Figure 2-5: Plots showing night-time 11 µm BT (temperature range here is 275 – 285K) for an area of eastern Australia on the 19th September 2002 (left) and the Globcover biome of the chosen area whereby a lake is displayed as blue (right)

Action to resolve issue

Additional analysis by UoL (Zeller and Ghent, 2010) and by IDEAS (Marti Rocafull et al., 2011) confirmed a systematic offset of 1 pixel along-track and 1 pixel across-track between the AATSR and either Globcover or ground targets of known location. A new CH1 file is required that corrects for the observed offset as well as the alignment of the forward and nadir views (Section 2.3).

Current status

A new CH1 file for all three ATSR datasets has been prepared by the ESL and evaluated by both UoL and IDEAS. The new file has been used in generating the V2.1/V3.0 dataset.

References

Arino, O., Bicheron, P., F. Ranera ,D. Gross, Leroy, M., F. Nino, C. Brockmann, C. Vancutsem, P. Defourny, L. Bourg, F. Achard, L. Durieux, J.L. Weber, R. Witt, J. Latham, A. Di Gregorio, S. Plummer, C. Schmullius, M. Herold, H. Laur, P. Goryl, N. Houghton, 2007. ESA GlobCover DUE project, ENVISAT Symposium 2007, SP-636, ESA.

Marti Rocafull, P., Cocevar, P., and O'Hara, S., 2011. IDEAS – AATSR Geolocation assessment for new CH1 file, IDEAS-VEG-OQC-REP-0826, Issue 1 date 23/09/2011.

Zeller, O. and Ghent, D., 2010. ATSR Absolute Geolocation Accuracy: Observed shift between AATSR Brightness Temperature and Globcover biome structures, UoL-LST-P03, Issue 2A dates 11/11/2010.

2.4   ATSR-1 switching (1.6 and 3.7)

Statement of the Issue

Reprocessing of the ATSR-1 mission within the ARC project by Owen Embury (University of Reading) has highlighted issues with the on-board switching between the 1.6 µm and 3.7 µm channels. Basically, three downlink modes were used during the ATSR-1 mission. These were:

1) the 1.6 µm data was downlinked,
2) the 3.7 µm data was downlinked, or
3) either channel was downlinked based on a threshold applied to the 1.6 µm reflectance data.

Analysis of the data in the ATSR archive suggests that the switch mode was not successful and that only 1.6 µm or only 3.7 µm data were downlinked, and never both during the same orbit. This is shown below in Figure 2-6.
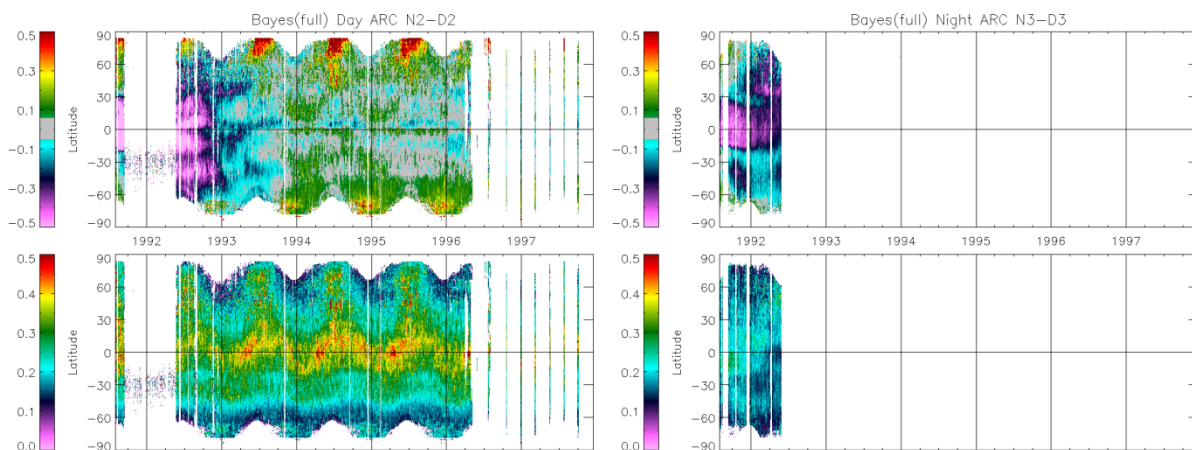
Figure 2-6: Hovmöller plot of ATSR-1 nadir SST minus dual SST differences for (left) daytime N2 minus D2 and (right) nighttime N3 minus D3. The day time plot (left) indicates where data from the 1.6 µm, 11 µm & 12 µm channels were all available, and the nighttime plot (right) indicates where the 3.7 µm, 11 µm & 12 µm channels were all available. The night time plot shows the loss of the 3.7 µm channel in May 1995, whereas the day time plot shows evidence of missing 1.6 µm channel data in the early part of the mission. (Images provided by Owen Embury, University of Edinburgh).

As a consequence, there is very little 1.6 µm data available for the early part of the mission prior to the failure of the 3.7 µm channel in May 1992. This will have an implication on the day time cloud screening, which relies on the 1.6 µm channel, and will therefore introduce an inconsistency into the long-term SST record.

Action to resolve issue

It has now been established that when the instrument was in its (standard) 1.6 µm / 3.7 µm channels threshold-switching-mode, the earth-viewing (uncalibrated) signal is indeed present in the telemetry for both channels and switching does occur as planned. This can be seen clearly in 'SADIST-2' processor Ucounts images. The 1.6 µm earth-view calibrated data is flagged as "calibration

unavailable" in the corresponding UBT products because the blackbody data (necessary for calibration) is correctly flagged as "missing/unavailable".

It was confirmed in 2014 that the 1.6 µm blackbody (BB) data is absent from UCOUNTS products when the 1.6µm Earth View data are present, for the period between launch and the 3.7µm channel failure (the true starting point is mid-Sept 1991). Absence of the BB data makes calibration of the 1.6µm data by the current processing software impossible.

In order to handle these data for the 4th reprocessing, it is necessary to define how to calibrate 1.6µm data when the BB data are absent and to reprocess the affected data from L0 to UBT.

The RAL Level 0 to UBT processing software is a Linux-ported version of the old SADIST-2 system, known as SUPPLE. The SUPPLE software was originally ported to process ATSR-2 data only. Following work done in early 2015, a version of the SUPPLE processor is now available which can generate UBT files from ATSR-1 L0 input data. This software update provides a baseline for further development to incorporate the new algorithm to cope with the absence of BB data. The SUPPLE software has been further updated to include visible channel calibration for ATSR-1.

Current status

The ESA disk-based process has now provided to RAL all the "fragmented" ATSR-2 products for the period from July 2003 onwards. ESA is providing all the ATSR-1 and -2 products in a disk-based L0 format. Once the ATSR-1 data is available, the processing to resolve the ATSR-1 switching issue can be done. The plan is for RAL to provide a look-up table to enable calibration for the missing blackbody data. This could then be built into ATSR-SLSTR processor planned for the 4th reprocessing.

At the October 2015 QWG meeting, Dave Smith (RAL) presented a suggested outline algorithm to handle the missing blackbody data, which involved interpolation between periods when the data are available. A software tool was then written to enable checking of the blackbody counts and other values from archived UBT files. Data values for the gains, offsets and blackbody counts were extracted from archived UBT products for August and September 1991, when the 1.6µm and 3.7µm channels were working, and May 1992, when the 3.7µm channel failed. These data and knowledge of the detector electronics were used to derive an algorithm to predict the missing blackbody count values. The derived algorithm uses a fit to the available data rather than the interpolation that was originally proposed. The predicted cold blackbody count values from the new algorithm are in good agreement with the measured counts where data are available for comparison. This new algorithm was presented to the QWG during the telecon on 5th May 2016.

The new algorithm was applied to the SUPPLE code and tested by processing Level 0 files from a more recent re-transcription of data from tape. As found during development of the algorithm, the predicted cold blackbody counts are in good agreement for periods where the measured data are present, both before and after the gap. For the period of missing data, the predicted count values are significantly lower than the values seen at either end of the gap. IDL software tools have been developed further to study detector temperatures, instrument voltages, gains and reflectance values, in order to understand the behaviour during this period. It appears that there may have been other changes in the instrument configuration during the gap period, which affect the predicted counts.

Attempts have been made to find detailed mission log information for the gap period, but this work has been unsuccessful. It appears that logging was not performed in sufficient detail at this stage of the mission.

2.5 Data availability (ATSR-1 and ATSR-2)

Statement of the issue

Noticeable gaps have been reported at the start of the ATSR-1 mission (during the eruption of Mount Pinatubo) and also at the start and end of the ATSR-2 mission.

Most of the data gaps appear in the commissioning phase of the parent spacecraft (ERS-1 for ATSR-1 and ERS-2 for ATSR-2) when both platform and instrument operations were highly variable. Consequently, the observed data gaps may be times when the instrument was off or in a non-standard mode.

Action to resolve issue

ESA, IDEAS and RAL are checking data logs so see if current data gaps are really missing data or data that has not yet been processed. This requires analysis of original ESA data tapes to check whether the data is genuinely missing or has simply not been transcribed to the archive.

Current status

ESA are providing all the ATSR-1 and -2 products in a disk-based L0 format. Once the data is available, any gaps in the archive can be identified by comparing the L0 data with a detailed log file produced by RAL in the 3rd reprocessing. Data missing from the archive, as identified by the logs, can then be processed from the L0 data. Note: Even if several orbits are recovered, the data quality cannot be guaranteed during the commissioning phase.

During the 3rd reprocessing, the logging of UBT to Level 1 processing was significantly improved. The processing logs are archived by NEODC along with the Level 1B data products. It should therefore be possible to develop a utility to scan the processing logs to determine which UBT products were processed. The resulting listing could be compared with the available ESA Level 0 archive.

A software tool has been created to descend through the NEODC data archive directories, locate the v3.0 processing log files and list the UBT file inputs to each orbit. A further listing was created by dumping the contents of the NEODC's Postgres data base of UBT products. However, comparison of listings of UBT product dates and times with those of Level 0 products are not straightforward due to the different time scales of the two types of product.

Comparison of the Level 0 data from the DSI data transcription for ESA and the NEODC UBT archives has been discussed with Gareth Davies of DSI.

Checks have been focussed on the commissioning period and first two years of operation for each instrument. There are outstanding questions regarding the quality of the Level 0 data set and the availability of multiple versions of data, which are awaiting responses from ESA.

The investigation has identified a possible 21 days' ATSR-1 data in 1991 and 19 days in 1992 that might be recoverable by reprocessing from Level 0. For ATSR-2 a period of up to a month's data might be recoverable at the start of the mission, although only 8 to 9 days of this period are likely to contain science measurements. All these data are subject to the caveat that the data must be used with caution due to instrument commissioning.

For further details, see Smith (2016).

References
Smith, A, 2016. Investigation into ATSR-1 and ATSR-2 data availability, Technical Note PO-TN-RAL-AT-0573, RAL Space, Issue 1.0 dated 26/08/2016.

2.6 ATSR-1 uncalibrated BTs

Statement of the issue

Analysis of the ATSR-1 mission as part of the ARC project by Owen Embury (University of Reading) highlighted several orbits towards the end of the ATSR-1 mission where the expected pseudo linear relationship between 11 µm and 12 µm BTs was not seen. An example for one ATSR-1 orbit from 9th April 1996 is shown in Figure 2-7.

AT1_TOA_1PTRAL19960409_122311_000000008012_00223_24760_0000.E1
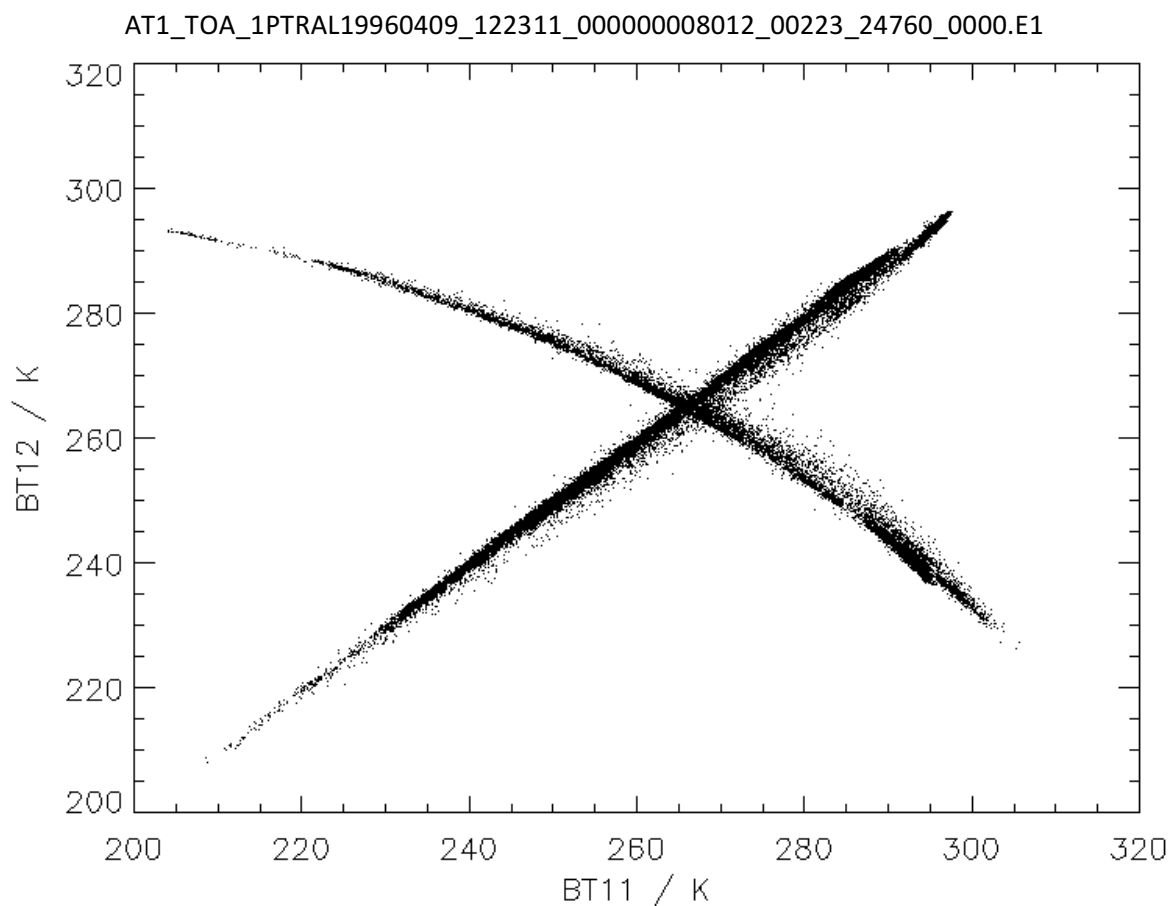
Figure 2-7: Plot of 11 µm and 12 µm BTs for one orbit of ATSR-1 data from 9th April 1996 (orbit 24760). The two curves are from difference part of the same orbit. The linear curve that increases from around 210 K towards 300 K is from the night time part of the orbit processed with valid calibration data; the second non-linear curve is from the day time part of the orbit processed with invalid calibration data for the 12 µm channel.

Action to resolve issue

In the few examples seen to date, this apparent inversion is due to occasional saturation of the warm BB signal towards the end of the ATSR-1 mission. In these circumstances, the data cannot be calibrated and ideally should be flagged as such by the SADIST-2 processor that generates the UBTs.

There is no clear idea of how much data is affected and what impact there is on the SSTs. So far, this only seems to be occurring towards the end of the mission, and it is only in daytime data.

Current status

The non-linear relationship between the 11 μm and 12 μm BTs in Figure 2-7 is due to invalid calibration data being used during the day time to calibrate the 12 μm BTs.

In the current processor, used in all ATSR-1 and ATSR-2 reprocessings to date, the input data is already calibrated (even if, as in the affected orbits, incorrectly). So, as there is no thermal infrared calibration done by the current processor with this current approach, only a new processor can address this issue. Even then, the best that can be done is to flag the affected pixels with "calibration unavailable". (The current consensus is that, when the hot blackbody is saturated, calibration is not possible.)

Subsequent investigations by Andy Smith (Smith, 2016) has shown that the period affected is from 03-Apr-1996 until 02-Jun-1996. All reported suspected cases for other dates have been checked and have been shown not to be due to blackbody saturation. However, no exhaustive check of the archive has been performed so other instances may exist.

The source of the brightness temperature "inversion" has been traced to an error in the SUPPLE software's calculation of thermal calibration values and has been corrected. It should be noted that the affected pixel values are flagged as "calibration unavailable" by the updated processor. It is not currently possible to recover the measured values.

Bulk reprocessing of the affected 2-month period should be possible if and when a suitable Level 0 data set can be transferred to RAL, although the SUPPLE processing is not well-automated.

References
Smith, A, 2016. Investigation into ATSR-1uncalibrated brightness temperatures, Technical Note PO-TN-RAL-AT-0572, RAL Space, Issue 1.0 dated 05/08/2016.

2.7   Filling of ATSR data gaps

Statement of the Issue

Analysis of the V3.0 ATSR-1 and ATSR-2 by Andy Smith (RAL) identified infilling of known data gaps in the time series. An example, for the same orbit of ATSR-1 data from the V2.0 and V3.0 archives is shown in Figure 2-8. Analysis of the entire V3.0 ATSR-1 and ATSR-2 archives showed the issue to be present throughout.
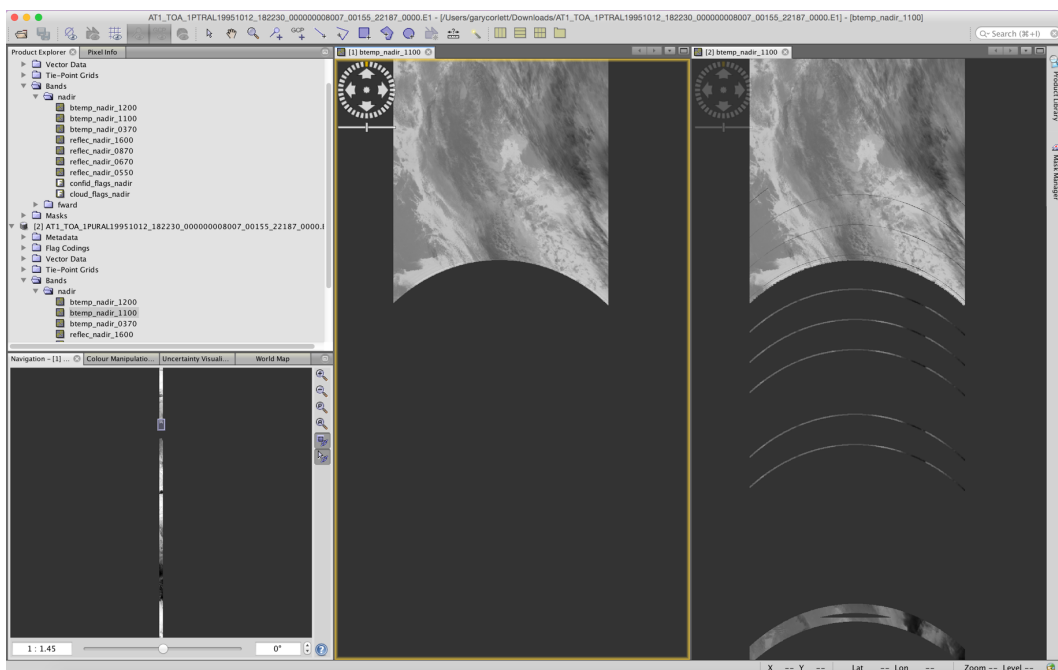
Figure 2-8: Example of data gap infilling for the same ATSR-1 orbit from the (left) V2.0 and (right) V3.0 archives.

Suggested action to resolve

The issue was not present in the V2.0 dataset so a software glitch has been introduced in the set-up used to generate the V3.0 dataset. This requires further investigation by the expert team at RAL.

Current status

A software bug was identified by Andy Smith and a new processor was generated. A new version (V3.1) of the entire ATSR-1 and ATSR-2 data records will be generated.

Note: The V3.0 post-2003 ATSR-2 was not affected by this issue as it was processed with the SUPPLE processor and not the APP.

3   OPEN ISSUES

3.1   Unexpected offset between AATSR and ATSR-2 12 μm BTs

Statement of the Issue

An initial analysis of the AATSR/ATSR-2 overlap period was carried out by Tim Nightingale and Andrew Birks (Nightingale and Birks, 2004). The conclusion of their report was that there is an unexpected offset between coincident BTs at 12 μm. The initial analysis of Nightingale and Birks (2004) compared six orbits of data across one month, October 2002, and used ENVISAT format AATSR data with SADIST format ATSR-2 data. Following the creation of the ATSR multi-mission archive, six months of data (covering the period from January 2003 to June 2003) from ATSR-2 was processed into ENVISAT format for further analysis.

The AATSR instrument on ENVISAT has an equatorial crossing time in the descending node of 10:00 am, with the ATSR-2 instrument on ERS-2 following 30 minutes later at 10:30 am. For the purposes of this comparison, it is assumed that geophysical conditions are consistent and have not changed during the 30 minutes. Estimates of diurnal warming from SEVIRI suggest that this assumption is valid for the overlap times of AATSR and ATSR-2. A complete analysis of the overlap period will consider both the Brightness Temperatures (BT) and the SSTs. At this stage, only BT comparisons are given.
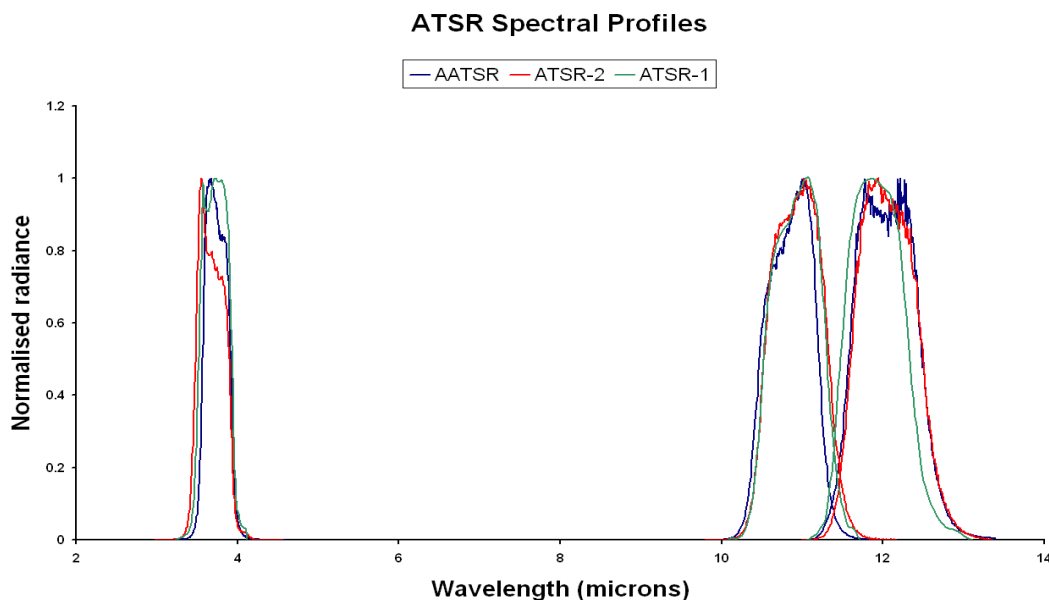

Figure 3-1: Comparison of spectral profiles of ATSR-1, ATSR-2 and AATSR, for the three thermal channels. The data was provided by Dave Smith (RAL).

It is important to recognise first of all that the two instruments are not necessarily going to provide the same BT values, even if the two instruments were looking at identical scenes at the same time.

This is because the two instruments have different spectral profiles. The profiles for all three ATSR instruments are plotted in Figure 3-1.

Visual inspection of Figure 3-1 shows that for AATSR compared to ATSR-2, the best agreement should be at 12 microns, as this channel has very similar spectral profiles for both sensors. This statement is supported by theoretical calculations using a radiative transfer model, shown below.
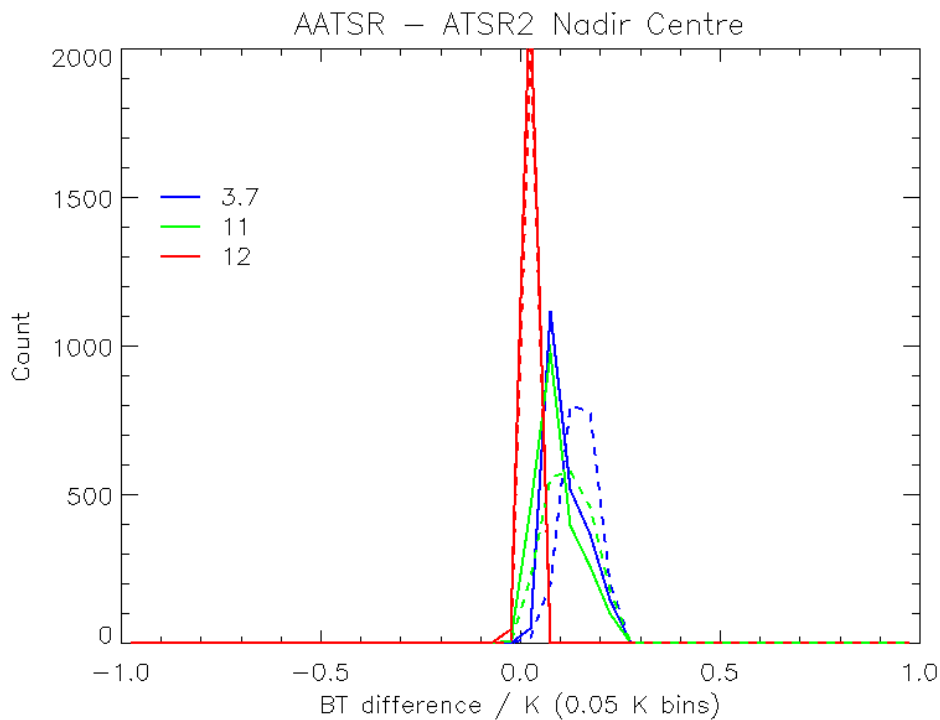
Figure 3-2: Simulated AATSR minus ATSR-2 BT differences. The solid lines represent a global profile set; the dashed lines are a subset over the Atlantic region (0-30 lat) scaled vertically by a factor x20. The plot was provided by Owen Embury (University of Reading).

The data shown in Figure 3-2 supports the earlier comment that the best agreement between AATSR and ATSR-2 should be at 12 microns, as there is only a very small positive bias (+0.01 K). A slightly larger bias (+0.1 K) is seen for both the 11 and 3.7 micron channels. This subset of data over the Atlantic region demonstrates that even when larger regional biases are observed at 11 and 3.7 microns, there is still good agreement at 12 microns. Furthermore, the global comparison shows that the shift in the peak of the 11 and 3.7 micron channel differences is consistent although the mean is different owing to the asymmetry of the distributions.

Two orbits from 1st January 2003 and 12th January 2003 were compared by subtracting co-located 10′ spatially averaged BTs at 3.7, 11 and 12 microns. Comparisons were done in both forward and nadir views. The results are given on the next page in Figure 3-3.
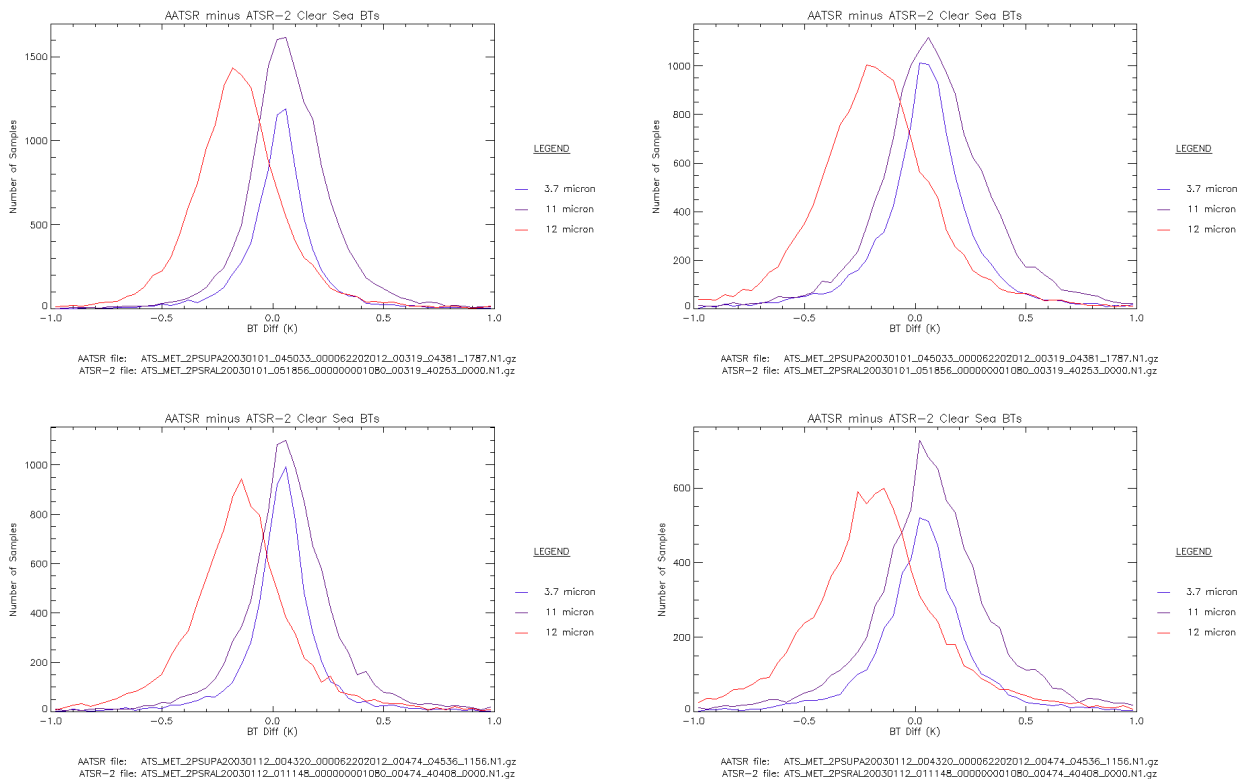
Figure 3-3: Comparison of AATSR minus ATSR-2 BTs for two orbits in January 2003.
The upper left is the nadir view on 1st January; upper right is the forward view from 1st January;
lower left is nadir view from 12th January; lower right is the forward view from 12th January.

Inspection of Figure 3-3 shows that the plots are very similar in both views and on both days. There are small positive shifts in both the 11 and 3.7 micron channels, the shift of the peak of the distributions is similar and the distributions show the predicted asymmetry seen in Figure 3-2. However, at 12 microns, we see a slightly more symmetric distribution (as expected) but we also see a substantial shift of ~ -0.2 K, which is not what was predicted from the theoretical analysis shown in Figure 3-2.

Suggested action to resolve issue

Comparison of AATSR and ATSR-2 BTs during January 2003 indicates an unexpected offset of ~ 0.2 K for the 12 micron channel, and confirms the initial finding of Nightingale and Birks (2004). This indicates that there is a calibration error in either AATSR or ATSR-2. However, the results do not indicate which sensor has the calibration error. Therefore, the calibration of both sensors should be revisited by the instrument support team at RAL.

Closer inspection of the AATSR 12 micron filter suggests there may be residual out of band leakage above the specification (Smith, 2007). The instrument support team at RAL has examined the spare AATSR Focal Plane Assembly (FPA) and found no convincing explanation for the discrepancy.

Current status

The discrepancy has been rigorously investigated by a specially convened Anomaly Review Board (ARB), which identified the most likely causes and has made specific recommendations for reprocessing to take into account these anomalies (IDEAS-VEG-OQC-REP-1274).

As an interim solution, users should proceed as follows:

1. **If using AATSR Level 1B data (TOA files):**

   a) Adjust the 12 μm brightness temperatures by subtracting the values provided in the Technical Note "Empirical Nonlinearity Correction" (PO-TN-RAL-AT-0562)

   b) For subsequent processing, use the current AATSR 12 μm 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.

2. **If using AATSR level 2 data (NR and AR files):** No direct correction is possible; for highest accuracy SST we recommend the use of the L2P products.

   a) For users of the NR *SST products* the effect has been minimised for data produced as part of the V2.1 reprocessing; for earlier versions it is estimated to be between 0.05 K - 0.15 K depending on the exact retrieval used.

   b) For users of the NR *LST products* it is estimated to be between 0.02 K - 0.35 K depending on the pixel biome classification and scene temperature.

3. **If using the AATSR L2P products (V2.1 or later[1]):** An empirical adjustment factor to the 12 μm BT values has already been incorporated into the processor; estimates of uncertainty are provided in the L2P products.

Subsequent to the original ARB finding, recommending both a spectral filter shift and a non-linearity correction, it was found in ESA SST_CCI studies that the recommended adjustments overcorrected the observed differences between AATSR and ATSR-2 12 micron BTs. 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 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 blackbody temperatures. At these points the non-linearity correction is zero and so any differences will solely be due to spectral effects.

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[1] Previous L2P products were a repackaging of the NR SST product; see point 2a above for an indication of the effect of the discrepancy on these products.

Following the meeting, the University of Reading agreed to carry out an initial evaluation of this new hypothesis as part of their FIDUCEO activities (Desmons et al., 2016). The result was confirmation 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 μm channel of AATSR. This was tested using a 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.

References

Desmons M., Mittaz J. P. D., Merchant C. J. and Embury O., 2016. Feasibility study for improvement of the Advanced AlongTrack Scanning Radiometer 12 micron channel correction, Technical Report, University of Reading.

Nightingale, T.J., and A.R. Birks, 2004. AATSR Algorithm Verification: Comparison of AATSR and ATSR-2 Data, AATSR Technical Note, Rutherford Appleton Laboratory.

O'Hara, S., et al., 2013. AATSR 12 Micron Anomaly Review Board - Final Report, AATSR Technical Note, IDEAS-VEG-OQC-REP-1274, Telespazio VEGA.

Smith, D.L., 2007. Effect of long wavelength response in AATSR filters on brightness temperature measurements, AATSR Technical Note, PO-TN-RAL-AT-0541, Issue 1.0, Rutherford Appleton Laboratory.

Smith, D.L., 2014. Empirical Nonlinearity Correction for 12um Channel, AATSR Technical Note, PO-TN-RAL-AT-0562, RAL Space.

3.2   ATSR-1 pick-up noise

Statement of the Issue

Comparison of ATSR-1 gridded 1 km SST images with equivalent ATSR-2 images from the ATSR-1/ATSR-2 overlap period in 1995 indicates significant increased noise within the ATSR-1 image. An example of the increased noise is shown in Figure 3-4.
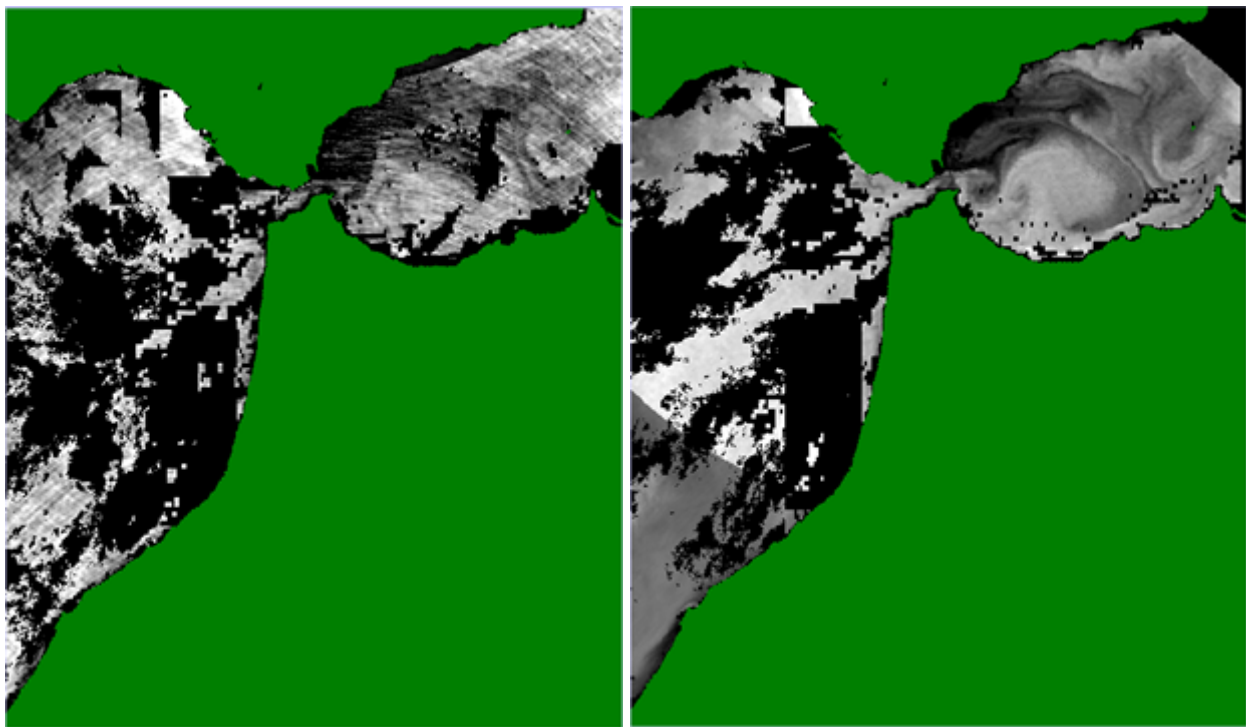
Figure 3-4: Comparison of (left) ATSR-1 and (right) ATSR-2 1 km resolution BT images taken on the 1st and 2nd of July 1995, respectively, showing and area around the Strait of Gibraltar. Increased noise is apparent in the eddy features within the western Mediterranean Sea in the ATSR-1 image compared to the ATSR-2 image.

The higher than usual noise in the ATSR-1 1 km images was first reported by Harris and Saunders (1996), who suggested it was caused by pick-up noise from the cooler.

Action to resolve issue

The issue has been reported to the QWG and has been reviewed by the ATSR instrument experts at RAL. The noise is caused by pick-up of the cooler drive on the detector signals. Further analysis has shown the signal is consistent over time and the apparent increase in noise over the mission is actually a decrease in signal to noise ratio due to the increased detector temperature resulting in a lower gain.

No actions to resolve the issue have been formulated at this stage.

Current status

The noise has been shown to be constant with time and currently no solution for reducing the noise signal has been identified. The impact of the noise will be minor on the long term SST record but may impact other studies that rely on imagery data such as ocean front detection.

No additional work will be done to resolve this issue until a clear scientific justification is identified by the ATSR Science Advisory Group (SAG).
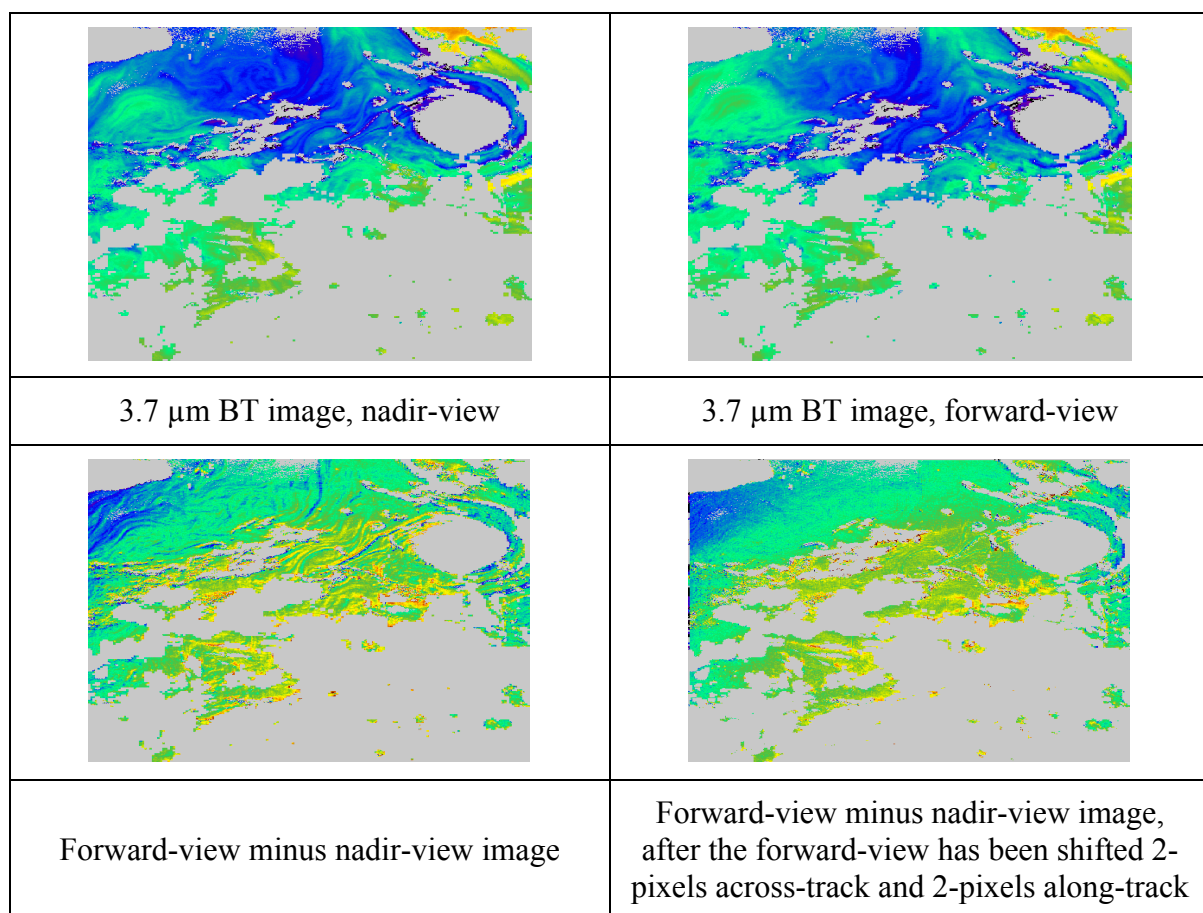
References:

Harris, A. R., and M. A. Saunders, 1996: Global validation of the along-track scanning radiometer against drifting buoys. *J. Geophys. Res.*, **101**, 12,127-12,140.

4   RESOLVED

4.1   Relative alignment between forward and nadir views

Statement of the Issue

Analysis of 1 km AATSR images by Owen Embury of the University of Reading (and several other data users) suggests that there is a consistent offset of roughly 2 pixels along-track, and 2 pixels across-track, between the forward and nadir views. This is shown below in Figure 4-1.

3.7 µm BT image, nadir-view	3.7 µm BT image, forward-view
Forward-view minus nadir-view image	Forward-view minus nadir-view image, after the forward-view has been shifted 2-pixels across-track and 2-pixels along-track

Figure 4-1: Plots showing (upper left) uncorrected 3.7 µm image from the nadir view,
(upper right) equivalent uncorrected 3.7 µm image from the forward view,
(lower left) BT difference image of uncorrected forward-view minus uncorrected nadir-view difference, and
(lower right) forward-view minus nadir-view BT difference image after the forward view has been shifted 2 pixels across-track and 2 pixels along-track. The images were provided by Owen Embury (University of Edinburgh)

The uncorrected forward-view minus nadir-view image in Figure 4-1 shows significant edge effects around the eddy structures and also at the edges of clouds. Although some edge effects do remain, the shifted image reduces these effects, which suggest the alignment of the two views has been improved.

Suggested action to resolve issue

A detailed histogram analysis of similar 1 km AATSR images by the ESL has concluded that there is a small error in the measured scan angle, which equates roughly to a consistent offset of 2 pixels along track, and 1 pixel across track between the forward and nadir views. An updated CH1 file is required to resolve this issue.

Current status

An updated CH1 file has been produced for all three ATSR sensors and was implemented in generating the V2.1/V3.0 dataset.

4.2   Banding in spatially averaged SST data

Statement of the Issue

During the production of monthly Level 3 products, it was observed that there is missing data in consolidated spatially averaged data for December 2002, December 2003 and December 2004. An example is shown below in Figure 4-2.
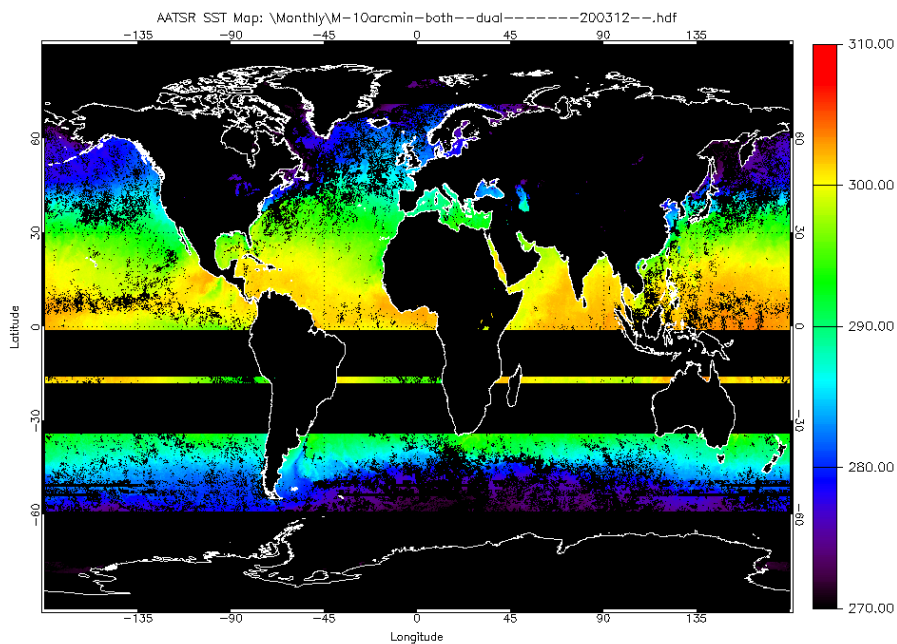
Figure 4-2: Plot of monthly averaged SST for December 2003 showing the banding caused by the error in reading the cloud screening auxiliary data file

Action to resolve issue

This issue was reported to the QWG, and was identified by the ESL as being caused by an error in reading the cloud test auxiliary data file for the month of December each year. A patch to the Integrated Processing Facility (IPF), which is used to provide operational AATSR data, to correct for the banding was written and has been installed in the operational processor.

Current status

The issue has been resolved.

4.3 Strange values in 1km data

Statement of the Issue

The issue here is that internal diagnostic tests have identified incorrect SST values in the 1km data. The incorrect values appear to occur in every row that is a multiple of 480.

Action to resolve issue

The issue was reported to the QWG and then to ELCA, the company responsible for producing the operational processor. A response on this issue was received from ELCA who were unable to reproduce the problem in simulation. Subsequently, the issue appears to have resolved itself as the problem has not been seen in data since it was originally identified. However, routine checks will continue to be carried out on random orbits.

Current status

The issue has been resolved.

4.4   Missing ATSR-2 Orbits

Statement of the Issue

Visual inspection of day/night monthly cloud masks for the ATSR archive has shown that the ATSR-2 data record has missing SST records that are consistently "cloudy" across the same geographic region over many months. This "cloudy" data appears to be consistently missing orbits, as the data gaps have the appearance of orbital swaths.
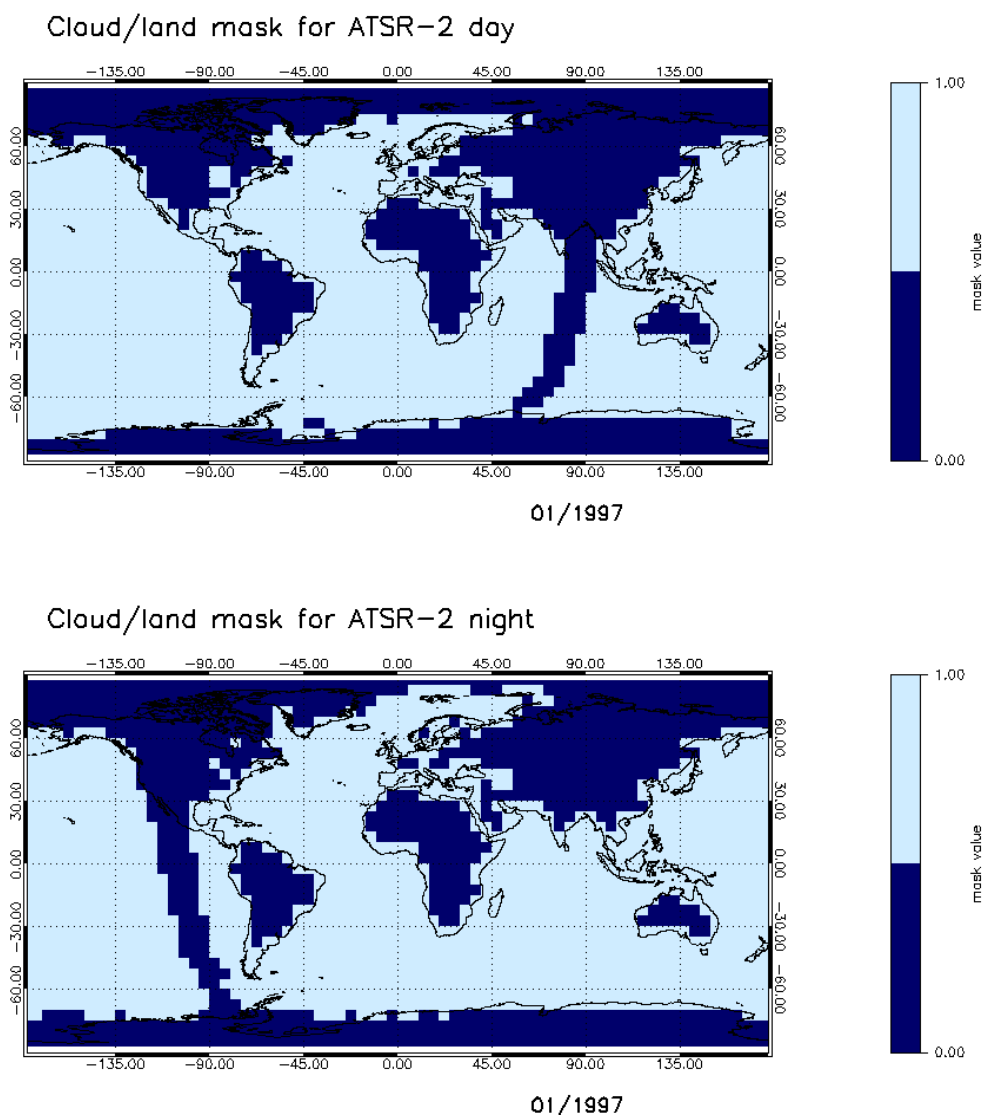
Figure 4-3: Masks of 'no data' constructed from monthly average ATSR-2 day-time SST on a 5° x 5° grid for January 1997 day time (above) and night time (below). Images provided by Karen Veal (University of Leicester).

The plots in Figure 4-3 indicate where, for example in January 1997, a 5 degree spatially averaged pixel is either "clear" (light blue in colour, at least one valid sea 10 arcmin product within the month), or "cloudy" (dark blue, no valid sea 10 arcmin products during the month).

Further analysis of the original 10 arcmin ATSR-2 data has revealed that there are consistent data gaps in the ATSR-2 record. The next plots in Figure 4-4 are an example of the total number of data samples (clear and cloudy) within a month, this time for July 1997.
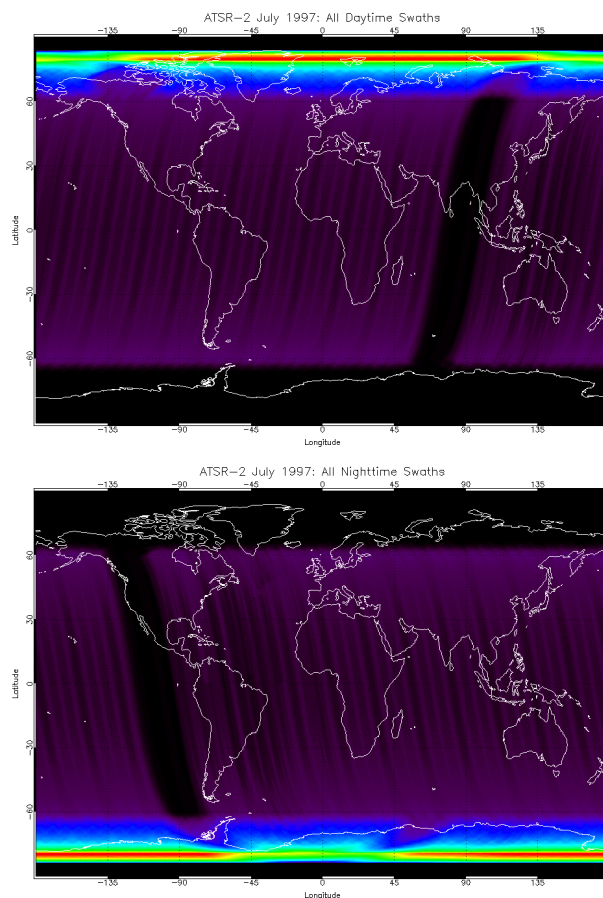
Figure 4-4: Number of available 10 arcmin data samples for July 1997 daytime (above) and nighttime (below).

The plots in Figure 4-4 show the total number of 10 arcmin data points available within the month, and indicate that the cause of the consistent "cloudy" data in the 5 degree averages is indeed missing data, and not data that has been consistently flagged as cloudy.

When the day and night coverage maps are viewed together, it looks like the missing data are possibly related to unused/unprocessed ERS-2 tape dumps, as the data gaps start and end in locations close to the ERS-2 ground station at Gatineau, in Canada, as shown in Figure 4-5.
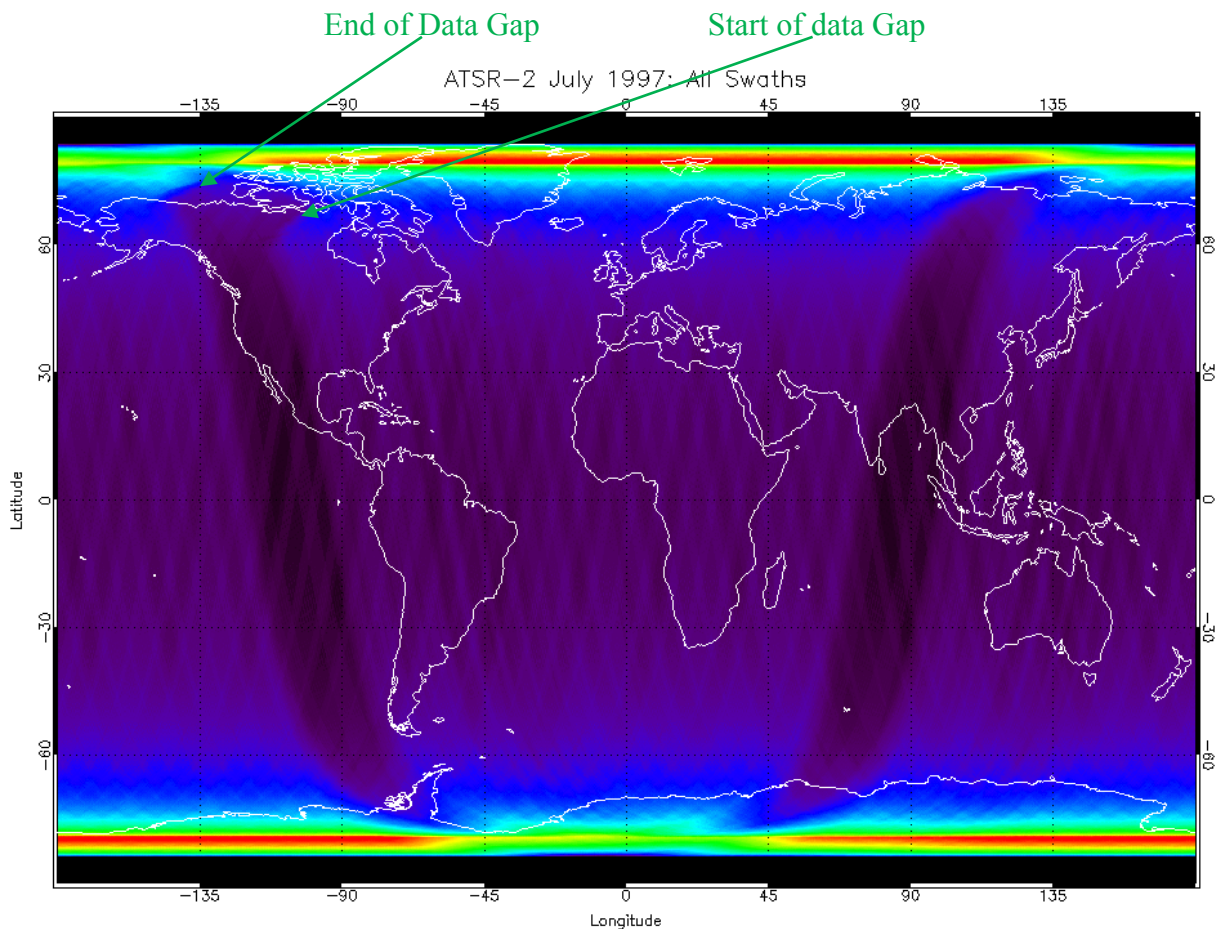
Figure 4-5: Number of available 10 arcmin ATSR-2 data samples for July 1997.

Action to resolve issue

The issue was investigated by the QWG and was found to be caused by missing information on the platform mode for data collected at certain ground stations. The solution found was to switch off the filter that checks the platform mode in the product processor and then reprocess all the data. An assumption is made that the platform was in nominal yaw steering mode for cases where the platform mode is missing. Affected orbits are identified by appending a "u" to the processing centre field in the Main Product Header (MPH).

Current status

The issue has been resolved.

4.5 Missing AATSR orbits

Statement of the Issue

Visual inspection of day/night monthly cloud masks for the ATSR archive has shown that the AATSR data record has missing SST records that are consistently "cloudy" across the same geographic region over many months. The appearance is similar to that reported for ATSR-2, see Section 4.4, but is only found in one month of data, namely March 2007. Although similar in appearance to the ATSR-2 missing orbits, the cause of the missing AATSR orbits is completely different.

Action to resolve issue

The issue was reported to the QWG in May 2009, and was also identified by IDEAS as part of their work to identify the cause of all data gaps in the AATSR record. Further analysis revealed the issue was due to data that was lost in transmission from Kiruna to the processing centre at the UK-MM-PAF. The missing data was resent from Kiruna to the UK-MM-PAF, has been reprocessed and is now available from the ATSR archive.

Current status

The issue has been resolved.

4.6 ATSR-2 invalid SSTs

Statement of the issue

An issue was reported by a user of invalid SSTs when viewing an ATSR-2 orbit file in BEAM. The issue has only been noticed in one orbit file so far.

Action to resolve issue

Further investigation of the orbit identified two issues: (1) the default flag configuration in BEAM was incorrect and invalid SSTs were not being masked correctly; (2) the issue was compounded by missing calibration data in alternate scenes for both views.

The issue was reported to the BEAM developers and a correct flag checking scheme was provided.

Current status

The default configuration in BEAM has been updated to correctly check the appropriate flags. The issue is resolved.

4.7   D2-D3 latitudinal bias correction

Statement of the Issue

Calculated differences between the night time dual-view 3-channel retrieval (D3) and an equivalent dual-view 2-channel (D2) retrieval produced using pre-launch SST retrieval coefficients indicates a latitudinal bias and offset that is attributable to prior and non-linearity errors within the retrieval scheme (Merchant *et al.* 2006). Subsequently, updated retrieval coefficients and a latitudinal correction were issued in December 2005 (Birks 2005); the updated coefficients are referred to as the "December 2005 Case C" coefficients.

The updated coefficients and the latitudinal correction were applied to several years of AATSR data. The resulting difference between coincident night time D2 and D3 retrievals are shown without the latitudinal correction in Figure 4-6 and with the latitudinal correction in Figure 4-7.

The data shown in Figure 4-6 indicates the presence of a latitudinal bias after the updated coefficients has been applied to the AATSR brightness temperatures (BT). The residuals are consistent in shape and size across several years, and are similar in shape to that reported by Merchant *et al.* (2006).

The data in Figure 4-7 indicates that the application of the latitudinal correction has reduced the magnitude of the D2-D3 bias at many latitudes, but some consistent residual structure still remains, which requires further investigation. Results for other months (not shown) indicate similar consistent year-on-year residual features.

Action to resolve issue

A presentation from Chris Merchant at a GHRSST meeting and discussion during subsequent meetings, suggested that combining a temperature dependent emissivity and updated spectroscopy in the production of new coefficients would account for a large proportion of the observed differences; the remaining difference (very small) is possibly due to a limitation of the retrieval scheme. These hypotheses were assessed within the ARC project and as a result, the ATSR QWG agreed to update the SST retrieval coefficients based on the ARC findings.

Current status

A new set of SST retrieval coefficients based on updated radiative transfer theory from the ARC project has been generated and have been implemented for the V2.1/V3.0 reprocessing. A report summarising the new coefficient generation and evaluation is available (Embury and Corlett, 2010).

The issue is resolved.

References:

Merchant C. J., *et al.*, 2006. Retrievals of sea surface temperature from infra-red imagery: origin and form of systematic errors, *Quart. J. Royal Met. Soc.*, **132**, 1205-1223.

Birks, A., 2006. Latitude Dependent Bias Correction, AATSR Technical note, Rutherford Appleton Laboratory.

Embury, O., and G.K. Corlett, 2010. AATSR SST Retrieval: Updated retrieval coefficients based on ARC project findings, UL-SST-P04, Issue 1A dated 15/11/2010.
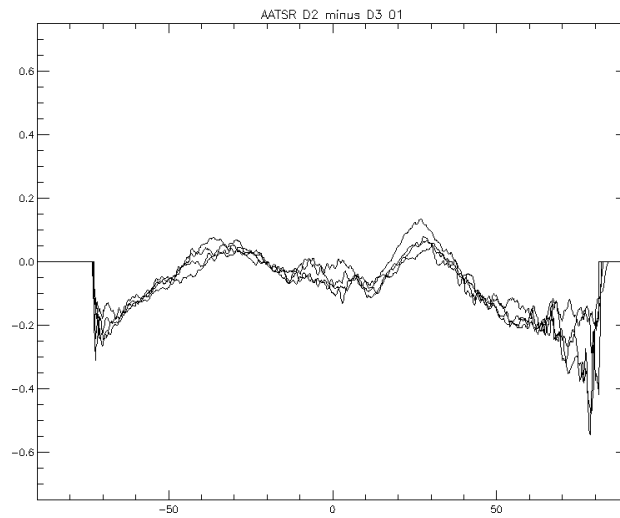
Figure 4-6: Residual difference between D2 and D3 SST retrieval as a function of latitude for the month of January in the years 2003 to 2006. Each point is an average difference across all longitudes.
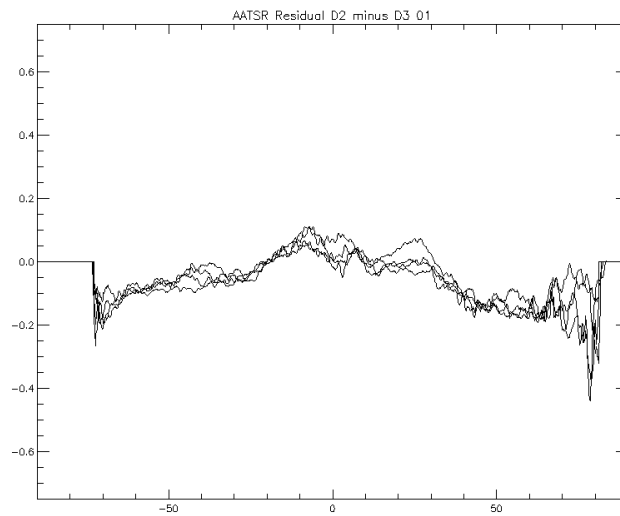
Figure 4-7: Residual difference between D2 and D3 SST retrieval, as a function of latitude for the month of January in the years 2003 to 2006, following application of the latitudinal correction. Each point represents in an average difference across all longitudes.

4.8 Possible emissivity effect on the SST retrieval

Statement of the Issue

Measurements from an aircraft-based interferometer by the Met Office (Newman *et al.* 2005) have shown that there is a temperature dependence on sea water emissivity that will affect AATSR estimates of SST where the SST is below 10 ºC.

Action to resolve issue

As part of the ARC project, the University of Edinburgh implemented an updated emissivity model to account for temperature dependence below 10 ºC. As a result of the ARC findings, the QWG has approved a new set of retrieval coefficients that will resolve the issue.

However, the QWG has recognised that there is limited validation data in cold waters to verify the effect on AATSR SSTs. Consequently, the validation programme, with funding from ESA, are seeking to address this issue through routine autonomous deployments of the SISTeR radiometer.

Tim Nightingale (RAL) has successfully carried out two autonomous deployments of the SISTeR radiometer and the initial analysis of the data collected in these deployments resulted in a very low number of match-ups in what are predominantly cloudy areas. Consequently, further work is needed to look at each match-up individually but this is a very low priority activity. Other opportunities for long-term deployments in regions of cold water (SST < 10 ºC) are currently being assessed.

Current status

A new set of SST retrieval coefficients based on updated radiative transfer theory from the ARC project has been generated and have been implemented for the V2.1/V3.0 reprocessing. A report summarising the new coefficient generation and evaluation is available (Embury and Corlett, 2010).

The issue is resolved.

References:

Newman, S. M., *et al.*, 2005. Temperature and salinity dependence of sea surface emissivity in the thermal infrared, *Quart. J. Royal Met. Soc.*, **131**, 2539-2557

Embury, O., and G.K. Corlett, 2010. AATSR SST Retrieval: Updated retrieval coefficients based on ARC project findings, UL-SST-P04, Issue 1A dated 15/11/2010.

4.9   Difference between 10' validation results and 1 km validation results

Statement of the Issue

Validation of the AATSR 10´ SST product against buoys and the AATSR 1 km SST product give different biases. UoL can now show that the biases have a strong regional dependence, and that the large differences observed are most likely due to undetected cloud in the 10´ SST product. The reason the undetected cloud affects the 10´ SSTs and not the 1km product is that the 10´ SSTs are produced using a single SST retrieval on spatially averaged 1km BTs, and not produced by spatially averaging the 1 km SSTs. The affected 1 km SST data can be more effectively identified and removed using the D-N difference test, prior to averaging to 10´.

Suggested action to resolve issue

The effect of cloud contamination requires further quantification by spatially averaging 1 km SSTs to produce a revised 10´ product, in order to perform a direct comparison with the original 10´ product.

Current status

Analysis of ARC validation results (Embury et al. 2012; Merchant et al. 2012) at different resolutions does not show similar findings (ARC 0.1º products are derived from the 1 km data), where consistent biases are observed for both the 1 km and 0.1º resolution products confirming undetected cloud as the primary cause of this issue. Users are advised to use the L2P and UoL-LST-2P level 2 products, which use alternate and improved cloud masking algorithms.

The issue has been resolved.

4.10 Cloud masking failures in sun-glint regions

Statement of the Issue

Incorrect SST values have been observed in SST imagery across several latitudes. Analysis of the incorrect SSTs suggests that they are due to a failure of the day-time cloud screening, which is fairly unusual, as the day-time cloud screening is usually too stringent rather than too lax.

The failure appears to primarily occur in areas of sun-glint, and is most likely due to the 1.6 histogram test not automatically adjusting for the higher radiances measured due to the sun-glint off the ocean surface.

Suggested action to resolve issue

The 1.6 test requires further investigating and updating in regions of sun-glint.

Current status

The failure of the cloud test in sun-glint areas has been reported to the QWG and work to investigate the issue is ongoing at the ESL. No decision has yet been taken on further action.

Users of the ARC-based L2P product do not need to consider this issue as this uses the Bayesian clear-sky algorithm developed by the University of Edinburgh, which does not show the same failures.

The issue has been resolved.

4.11 Poor performance of N2 retrieval coefficients

Statement of the Issue

Validation results from comparing all four AATSR SST retrievals (D2, D3, N2 and N3) to both shipborne radiometers and drifting buoys suggest the N2 retrieval is far from optimal as a significant bias is observed. An example set of results, from comparison to the M-AERI radiometer mounted on the *Explorer of the Seas* is shown in Table 4-1.

	Dual-view			Nadir-only		
	No.	Bias (K)	St. Dev. (K)	No.	Bias (K)	St. Dev. (K)
2-channel Day	400	+0.14	0.40	400	+0.99	0.45
2-channel Night	936	+0.14	0.39	936	+1.00	0.47
3-channel Night	936	+0.09	0.30	936	+0.10	0.26

Table 4-1: Summary of M-AERI validation result from August 2002 to June 2007. Note the significantly higher bias for the nadir-only 2-channel retrievals.

Action to resolve issue

The VS has recommended that the QWG consider updating the SST retrieval coefficients based on the improved knowledge gained in the ARC project.

Current status

A new set of SST retrieval coefficients based on updated radiative transfer theory from the ARC project has been generated and have been implemented for the V2.1/V3.0 reprocessing. A report summarising the new coefficient generation and evaluation is available (Embury and Corlett, 2010).

The issue is resolved.

References

Embury, O., and G.K. Corlett, 2010. AATSR SST Retrieval: Updated retrieval coefficients based on ARC project findings, UL-SST-P04, Issue 1A dated 15/11/2010.

4.12 ATSR-1 and ATSR-2 N3 SSTs do not use correct latitudinal banding below the Equator

Statement of the issue

As part of the routine validation processing an in-house written 'replica' of the AATSR IPF SST retrieval algorithm is run on the ATSR L2P MD to generate night time 2-channel SSTs as these are not provided in the ENVISAT format files. To test the accuracy of the code, the software also directly outputs the daytime 2-channel and night time 3-channel SSTs. Usually differences are of order 0.01 K or the least significant bit.

However, when the same code was run on ATSR-1 and ATSR-2 orbit files, larger than expected differences (up to 0.6 K) were observed for night time 3-channel nadir-only SSTs (N3) in the Southern hemisphere.

The nadir-only retrievals use latitude-banded coefficients and it is speculated that the banding is not working correctly for the N3 retrievals. If the latitude banding is ignored in the Southern hemisphere (such that the tropical coefficients are used everywhere) then the UoL processor reproduces the N3 retrievals in the ENVISAT-format ATSR-1 and ATSR-2 files.

Action to resolve issue

The issue has been reported to the QWG and a Software Problem Report (SPR 19) has been raised against the Archive Product Processor (APP) subject to confirmation of the issue by RAL. If confirmed, the IPF will need to be modified.

Current status

A bug was found in the APP and a fix has been implemented prior to generating the V2.1/V3.0 dataset.

The issue is resolved.

4.13 Asymmetry of air-mass for SST retrieval / orbit height variations

Statement of the issue

Analysis by Owen Embury (University of Reading) as part of the ARC project has shown that there is a small asymmetry to the satellite view angle as determined from the pixel level angles provided in the AATSR orbit files. A symmetric across-track interpolation from centre to edge is used within the SST retrieval within the IPF.

The asymmetry is shown in Figure 4-8, which plots the theoretical (black line) and measured (red curve) along-track view angles as a function of across-track position for each match-up in the ATSR L2P MD for AATSR. Similar results are seen for ATSR-1 and ATSR-2.
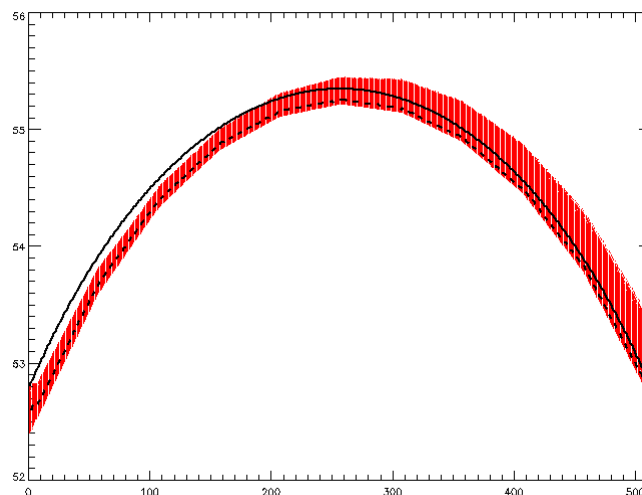
Figure 4-8: Theoretical (black line) versus measured (red curve) along-track view angles as a function of across-track position for AATSR for each match-up in the ATSR L2P MD. Image provided by Owen Embury (University of Reading).

Action to resolve issue

The appropriate way to resolve this issue is to not use the symmetric across-track interpolation of retrieval coefficient as a function of view angle but to use the angles given for each pixel in the ATSR orbit files.

Current status

It is not possible to implement such a change in the IPF without considerable redesign of the algorithm and processing code. Consequently, no further action will be taken.

Users of the ARC project and the ARC-based L2P should note that this issue is not applicable as pixel level view angles are implemented.

The issue is resolved.

4.14 ATSR-1 SSES during Mount Pinatubo

Statement of the issue

The ATSR L2P format provides Single Sensor Error Statistics (SSES) for each pixel, comprising a bias and standard deviation compared to the reference data set, drifting buoys. In addition, a proximity confidence value (PCV), or quality level, is provided. For AATSR data, it is recommended to only use data with a PCV of 5.

The SSES scheme applied to ATSR-1 is that derived for Medspiration/AATSR data (Corlett and Poulter, 2008). This scheme uses distributions of dual minus nadir SST difference (D-N) to set upper and lower thresholds that can subsequently be used to remove data that is subject to cloud contamination. Owing to the dual-view capability of AATSR, cloud contamination can have both a positive and negative effect on the retrieved SST.

A consequence of applying the D-N filter is that valid data affected by the presence of aerosol is likely to be removed; of course the whole point of the dual-view is to correct for aerosol, so large D-N differences are to be expected. However, the test removes far more invalid cloud contaminated dual-view retrievals than it false flags valid aerosol affected dual-view retrievals. This compromise was felt to be a significant benefit for operational users of the L2P data.

The compromise of losing valid aerosol affected dual-view retrievals is not suitable for the start of the ATSR-1 mission, which is dominated by stratospheric aerosol from Mount Pinatubo. A consequence of using the current ATSR-1 SSES scheme is that the amount of data with PCV=5 will be very little at the start of the mission but will then increase as the influence of the Mount Pinatubo aerosol diminishes as it disperses throughout the atmosphere. The cause of the change in number of PCV=5 data is that the upper and lower D-N thresholds shift as the distribution of D-N changes.

The Met Office has raised the question as to whether the data that has been flagged with a PCV of 5 is actually useable or is it likely to be poor quality data has 'slipped through' due to the shift of the thresholds.

Action to resolve issue

To assess the performance of the PCV=5 data, we use the ATSR L2P match-up dataset (M0, which contains matches of ATSR-1 data to drifting buoys, moored buoys and ships. The reference data are provided by the Met Office Hadley Centre, and contain ICOADS (Woodruff et al., 2011) data to 1997 and NCEP GTS data from 1997 onwards, and are quality controlled by the Met Office Hadley Centre prior to ingestion into the MD.

Current status

No definite statement of PCV=5 data quality can be made as the relative effects of Mount Pinatubo and the 12 μm detector temperature drift cannot be separated from the impact of the changing time difference due to the low number of match-ups found during the ATSR-1 period. The findings are summarised in Corlett (2012).

The L2P product in the V2.1 dataset is no longer based on the IPF-produced AATSR data but instead will be produced from a modification of the ARC processor. As a consequence, no additional work

will be done to correct the IPF L2P products in the ATSR archive. Users are advised to use the ARC-based L2P products instead.

The issue is resolved.

References

Corlett, G.K., 2012. ATSR SST time-series: The effect of Mount Pinatubo on the Version 2.0 dataset, UL-SST-P05, Issue 1A dated 26/09/2011.

Corlett, G.K., and Poulter, D.J.S., 2008. An updated confidence flagging scheme for medspiration AATSR L2P files, MED-UL-REP-002, Issue 1D, dated 17/03/2008.

Woodruff, S. D., and co-authors, 2011: ICOADS Release 2.5: extensions and enhancements to the surface marine meteorological archive. *International Journal of Climatology*, **31**, 951 – 967, DOI: 10.1002/joc.2103.

4.15 ATSR-2 channel availability

Statement of the issue

Several users have noticed what they thought was missing data in ATSR-2 orbit files in ENVISAT format. The data is indeed missing due to limitations in downlink bandwidth forcing flexible formats to be used for the ATSR-2 mission (also for ATSR-1). As a result, not all channels are present for every ATSR-2 pixel and there are several different pixel maps as described on the ATSR webpage (see Section 5.3 in the ATSR user guide for further details, which can be found by following the URL given below). This is particularly noticeable for visible channel data during daytime.

It is not possible to tell from an ATSR-2 orbit file in ENVISAT format which pixel map is applicable for each and every pixel within the file.

Action to resolve issue

No action is required to resolve this issue, other than to ensure that users are aware that all data features described for SADIST-format ATSR data in the SADIST ATSR documentation are applicable to ATSR-1 and ATSR-2 data in ENVISAT format

Current status

No further action is necessary. The issue is resolved.

References

http://www.atsr.rl.ac.uk/documentation/docs/userguide/index.shtml