Investigation into ATSR-1 uncalibrated brightness temperatures

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Change Record

Issue	Date	Description
0.1	27-Jul-2016	First draft completed
0.2	03-Aug-2016	Reviewed by Space ConneXions Limited. Suggested changes accepted. New plots added where they were not included previously, for several cases where saturation is not present and other instrument anomalies appear to have affected the data.
1.0	05-Aug-2016	All updates accepted, prepared for issue.

Table of Contents

1 Scope of Document

This Technical Note describes the work performed by RAL Space to investigate and deal with the causes of un-calibrated brightness temperature values, which were reported to be present in certain ATSR-1 UBT products. This work is performed as Work Package 4.4 of the proposal described in [AD 1].

2 Terms, Definitions and Abbreviations

2.1 Acronyms

APP	Archive Product Processor (RAL ATSR-1&2 processor)
ATSR	Along-Track Scanning Radiometer
DSI	Data Services Initiative
IDL	Interactive Data Language (data manipulation and graphics software)
LRDAF	Low-Rate Data acquisition Facility (TBC)
QC	Quality Control
SADIST(-2)	Synthesis of ATSR(-2) Data Into Sea surface Temperature (RAL software to process Level 0 ATSR data from tape into UBT products)
SUPPLE	Sadist UBT Processor Linux Environment. Linux-ported version of the SADIST L0 to UBT processor software
TOA	Top of Atmosphere
UBT	Ungridded Brightness Temperature (Level 1 ATSR product, generated at single-scene spatial coverage, 512x512km)

3 Documents

3.1 Applicable Documents

Ref	Title	Document code	Version	Date
AD 1	ATSR Satellite Dataset Supporting Activities, 2014 - 2017	Proposal 2014-07-001 (response to DECC ITT : TRN 829/06/2014)	2	28-Jul-2014
AD 2	(A)ATSR Validation Activities, validation Issues Report	UL-AATSR-VIR	5B	29/11/2014
AD 3	The Architecture of the SADIST-2 VT100 Level-1 subsystem	ER-TN-RAL-AT-2166		10th October 1995
AD 4	SADIST-2 v100 Products	ER-TN-RAL-AT-2164		06-Sep-1995
AD 5	ATSR-1 anomaly log	http://www.atsr.rl.ac.uk/satellite/logs/anomaly/archive/ers-1/index.shtml	n/a	n/a

3.2 Reference Documents

Ref	Title	Document code	Version	Date
RD 1				

4 Introduction and background

[AD 1] describes the proposed work package, while [AD 2] gives a more detailed description of the problem. The following paragraphs summarise the information from the two documents.

This work package addresses the problem of a small number of incorrectly calibrated ATSR-1 Brightness Temperatures (BTs). 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 11μm and 12μm BTs was not seen.

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.

In the current APP approach, used in all ATSR reprocessings to date, the input UBTs are already calibrated (even if, as in the affected orbits, incorrectly). So, as there is no thermal infrared calibration done by the APP with this current approach, the problem could be addressed only by the SUPPLE processor once it has been extended to process ATSR-1 data. Even within SUPPLE, the best that could 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.). The affected orbits can be reprocessed once the corresponding L0 data is supplied by ESA, and the SUPPLE extensions for ATSR-1 include trapping and accounting for the saturated hot blackbody situation.

The work performed therefore concentrated on three main areas as follows:

1. Investigation of the extent of the problem, i.e. the time range within which products are affected
2. Investigation of the source of the problem in the SUPPLE processing code.
3. Attempted reprocessing of the affected products from Level 0 data, i.e. validation of flagging of affected products by the SUPPLE code and feasibility of bulk reprocessing to replace affected products.

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5 Investigations performed

5.1 Contents of affected UBT products

An IDL tool was written to read in a set of UBT product files and plot (1) blackbody count values from the hot and cold blackbodies (2) the blackbody temperatures (3) the brightness temperature values for the 11µm and 12µm channel nadir views, from a sample pixel near the centre of each scan, (4) the ratio of the brightness temperatures in the 11µm and 12µm channels, from a sample pixel near the centre of each scan.

[AD 2] presents an example of the problem, seen in data from 09-Apr-1996. Data from this date were extracted from the NEODC archive for use as a sample day. The IDL tool generated the plots in Figure 1 from data for the orbit with ascending node crossing time 12:23.

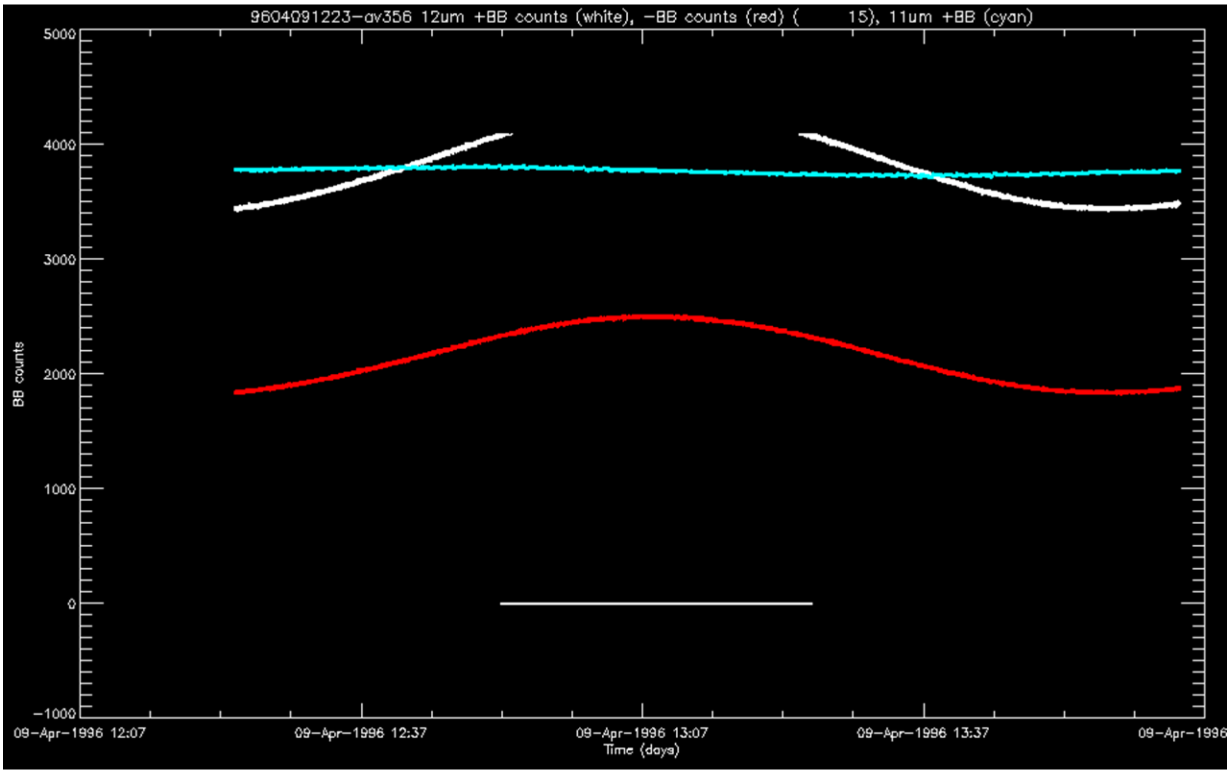

Figure 1: Counts from the 12µm channel warm (white) and cold (red) blackbodies and from the 11µm channel warm blackbody (cyan), for the orbit at 12:23 09-Apr-1996.

The black-body counts plotted in Figure 1 show that the 12µm warm blackbody saturates during the middle part of the orbit and that values during this period are correctly flagged (negative values close to 0 in the centre part of the plot). The cold blackbody (red curve) does not saturate. The 11µm warm blackbody (cyan curve) is plotted for comparison. The blackbody temperature plots were checked but no strong, discernible variation was found, so they are not included here.

Figure 2 shows the values of brightness temperatures in a sample pixel close to the centre of each scan, for the 11µm and 12µm channels. For most of the orbit, the two curves are close in value but the divergence during the period of blackbody saturation can clearly be seen. (The separate white trace with negative values is caused by flagging of the 12µm brightness temperatures where the blanking pulse is present, and can be ignored).

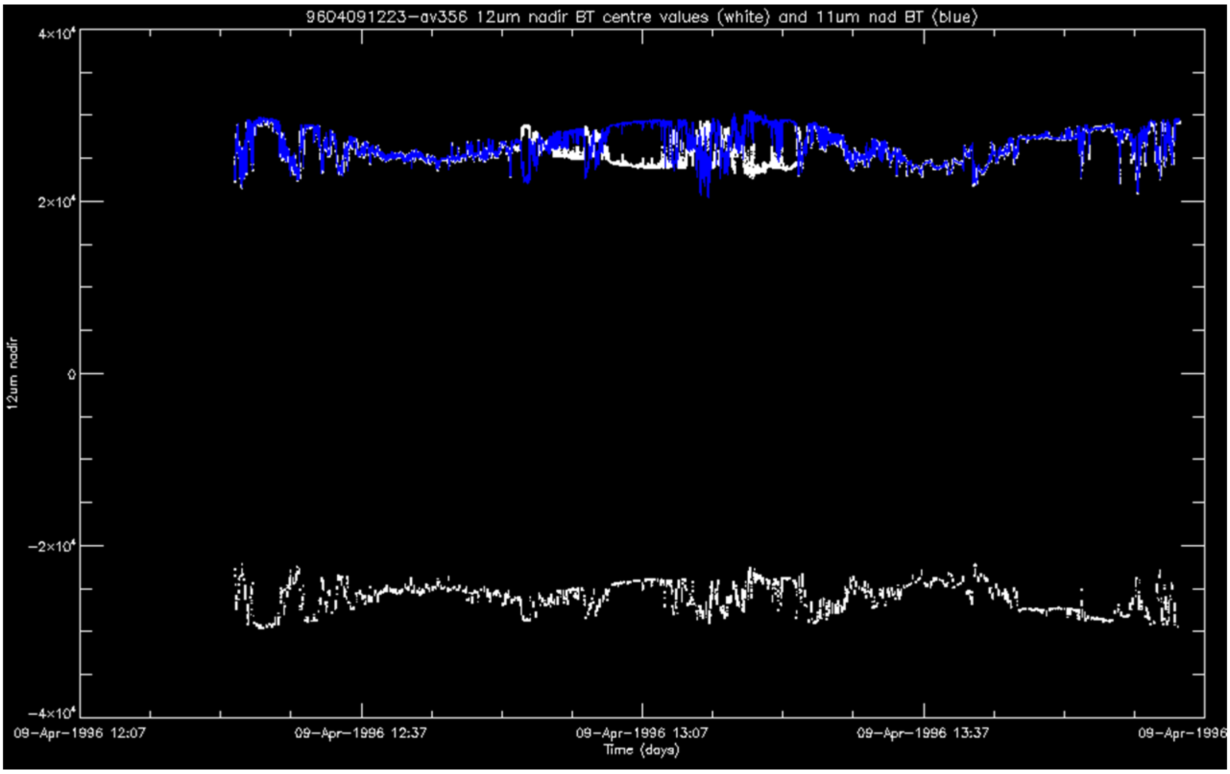

Figure 2: Brightness temperature values from (approximately) the centre of scan for orbit at 12:23 09-Apr-1996. 12µm values in white, 11µm in blue. The lower white trace with negative values is caused by blanking pulse flags in the data.

The divergence of the 11µm and 12µm brightness temperature values is also seen in Figure 3, where the ratio of the pixel values in the two channels is plotted. The ratio is close to 1 for most of the orbit but varies during the mid-part of the orbit where blackbody saturation occurs. This ratio may provide a way to identify periods affected by the problem if an automated scan of archived UBTs is performed, although a reasonable threshold value needs to be identified.

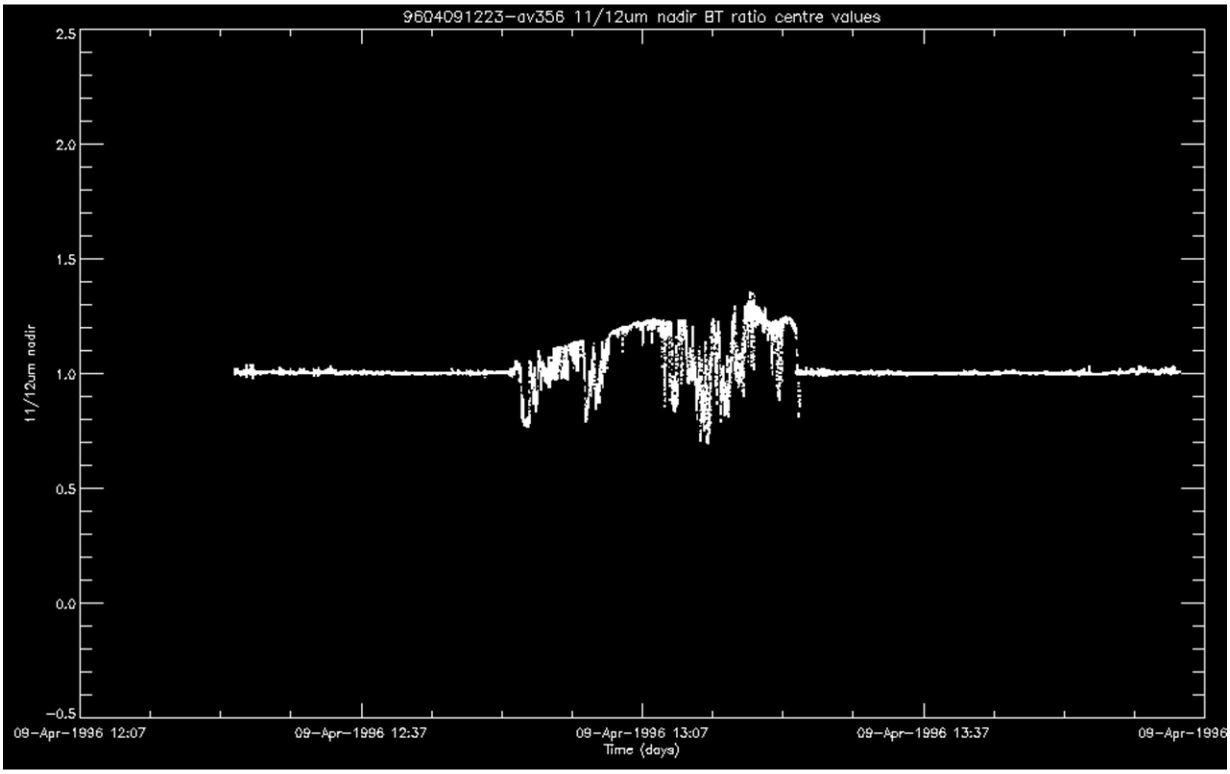

Figure 3: Ratio of the centre-scan brightness temperatures in the 11µm and 12µm channels, for the orbit from 09-Apr-1996 12:23.

5.2 Extent of the problem

Owen Embury provided a list of affected products found during his validation work. This list is incomplete as it does not represent the results of an exhaustive check on the full archive. The filenames for these products represent the first day's data included. The affected products listed below represent 3-day segments in the data set (although only ocean pixels were checked). The effect may therefore persist for 2 days following the date in the filename.

AT1_PDF_3PAARC19920723_T.bin
AT1_PDF_3PAARC19921111_T.bin
AT1_PDF_3PAARC19941008_T.bin
AT1_PDF_3PAARC19960110_T.bin
AT1_PDF_3PAARC19960331_T.bin
AT1_PDF_3PAARC19960403_T.bin
AT1_PDF_3PAARC19960406_T.bin
AT1_PDF_3PAARC19960409_T.bin
...
AT1_PDF_3PAARC19960509_T.bin
...
AT1_PDF_3PAARC19960530_T.bin

5.2.1 Previous analysis

In September 2010 Owen Embury reported 2 specific orbit cases to Jack Abolins at RAL. These orbits were checked and Jack's analysis is reported in the following two paragraphs (extracts from e-mail).

AT1_TOA_1PTRAL19960409_122311_000000008012_00223_24760_0000.E1: inspection of the input UBT products, with respect to the BB data, shows that the warm BB saturates for the duration of the apparent inversion of the 12µm BTs. This means that these inverted data *should* be absent from the products and flagged instead as "calibration unavailable" with corresponding exception values.

AT1_TOA_1PTRAL19920222_062904_000000002020_00005_03155_0000.E1: inspection of the input UBT's shows no BB saturation conditions - the BB counts data look more-or-less nominal in this respect. That's more than can be said for the overall visual appearance of the earth-view images for *both* 11µm and 12µm channels. In both these channels, the odd- and even-pixel gains/offsets appear to be showing intermittent disparate behaviour. On the evidence seen to date, in my opinion, this orbit suffers from the "UBT blemish" problems reported recently to the QWG. This *might* give rise to calibration problems which would not be due, in such cases, to inherent on-board conditions (TBC).

Hence it may be the case that periods reported in 1992 and 1994 are actually the result of some form of data corruption rather than blackbody saturation.

5.2.2 Early reported cases, 1992-94

All cases in 1992 and 1994 listed above were checked using the IDL tool and by inspecting UBT scene images, to determine whether these cases were genuinely un-calibrated brightness temperatures or the result of some other problem in the data. In each case a sample orbit, or a few orbits, were extracted from the archive and plotted. Checks were extended into the following 1-2 days if necessary to find representative values for the maximum blackbody counts.

In each case, 12µm warm blackbody saturation has been discounted as the possible cause.

5.2.2.1 19920723

The data for 19920723 are patchy in coverage and the plot of blackbody counts (Figure 4) looks unusual.

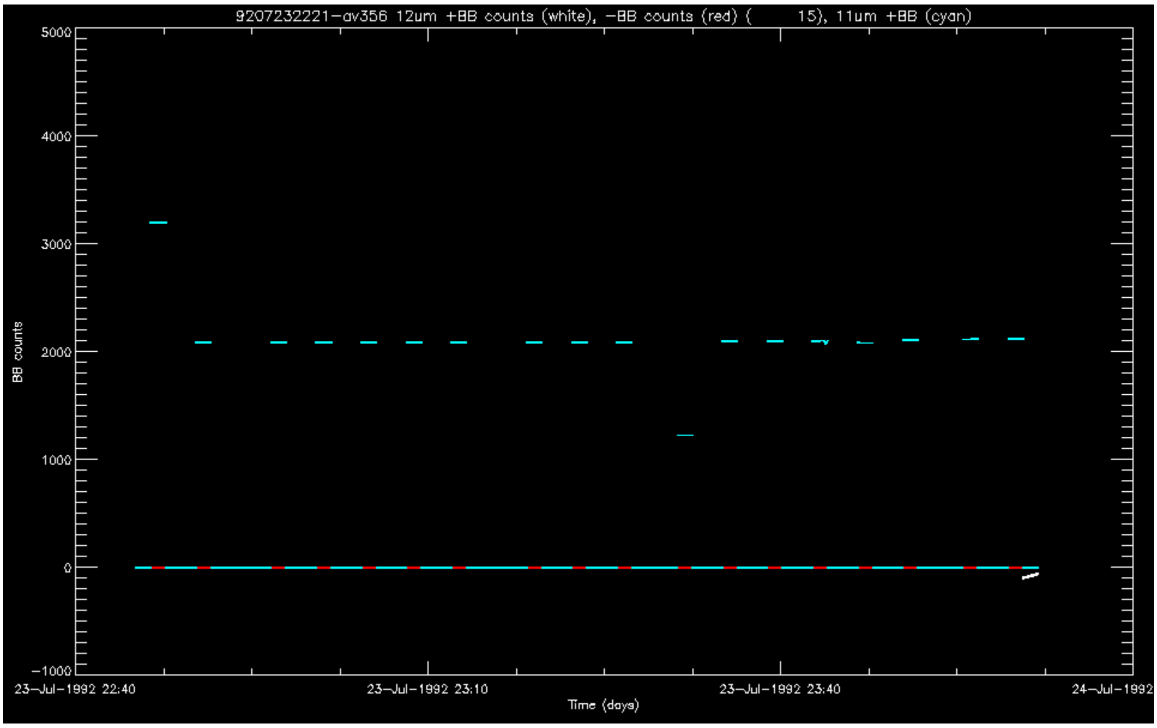

Figure 4: Blackbody counts from the 12µm channel warm (white) and cold (red) blackbodies and from the 11µm channel warm blackbody, for the orbit from 23-Jul-1992 22:21

The ATSR-1 Anomaly Log [AD 5] reports that the instrument was in standby from 19-23 July following a ‘bit flip’ in the ERS-1 non-vital data store. The blackbody count plot for 24-Jul-1992 (Figure 5) shows that the values are well below the saturation point.

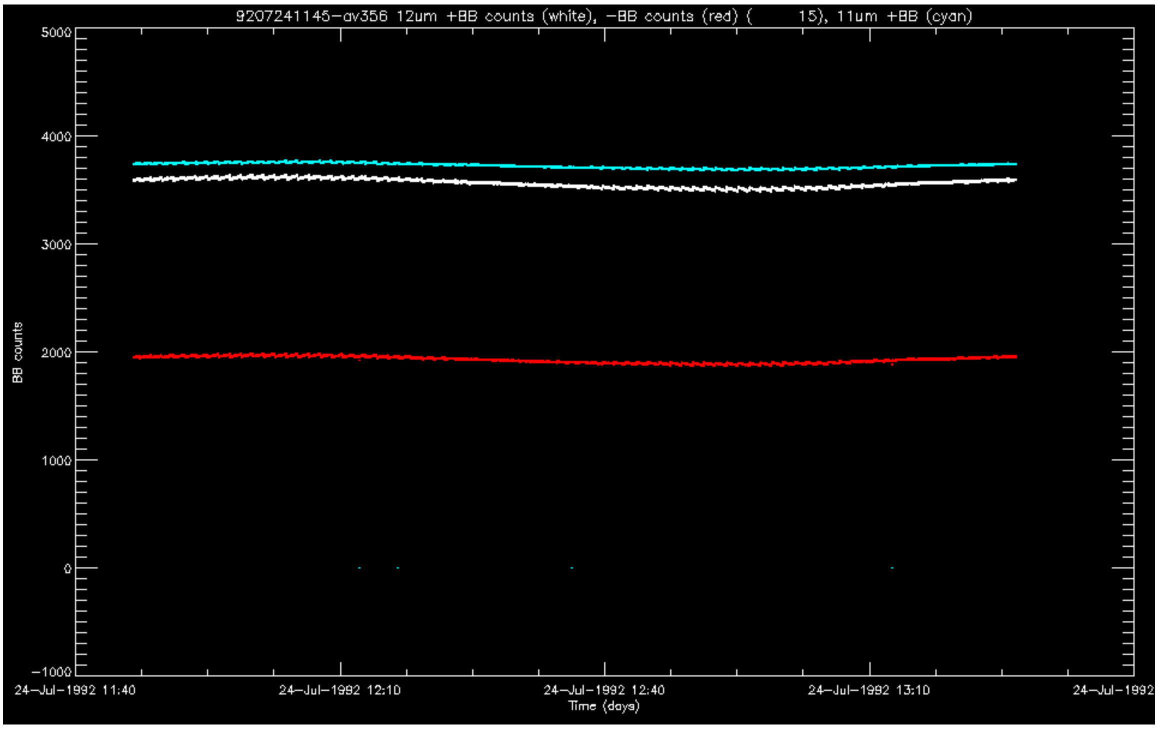

Figure 5: Blackbody counts from the 12µm channel warm (white) and cold (red) blackbodies and from the 11µm channel warm blackbody, for the orbit from 24-Jul-1992 11:45.

5.2.2.2 19921111

The data for 19921111 are patchy in time coverage. [AD 5] logs that ATSR data were unavailable for a period overnight on 12 and 13-Nov-1992. The log also reports that “Due to a procedural discrepancy, on reconfiguration the wrong compression mode was selected AND the 1.6/3.7 AUTOCAL was turned ON”. Whether this has any effect on the observed problems is not known.

The plotted brightness temperatures and blackbody counts do not show any inversion or saturation.

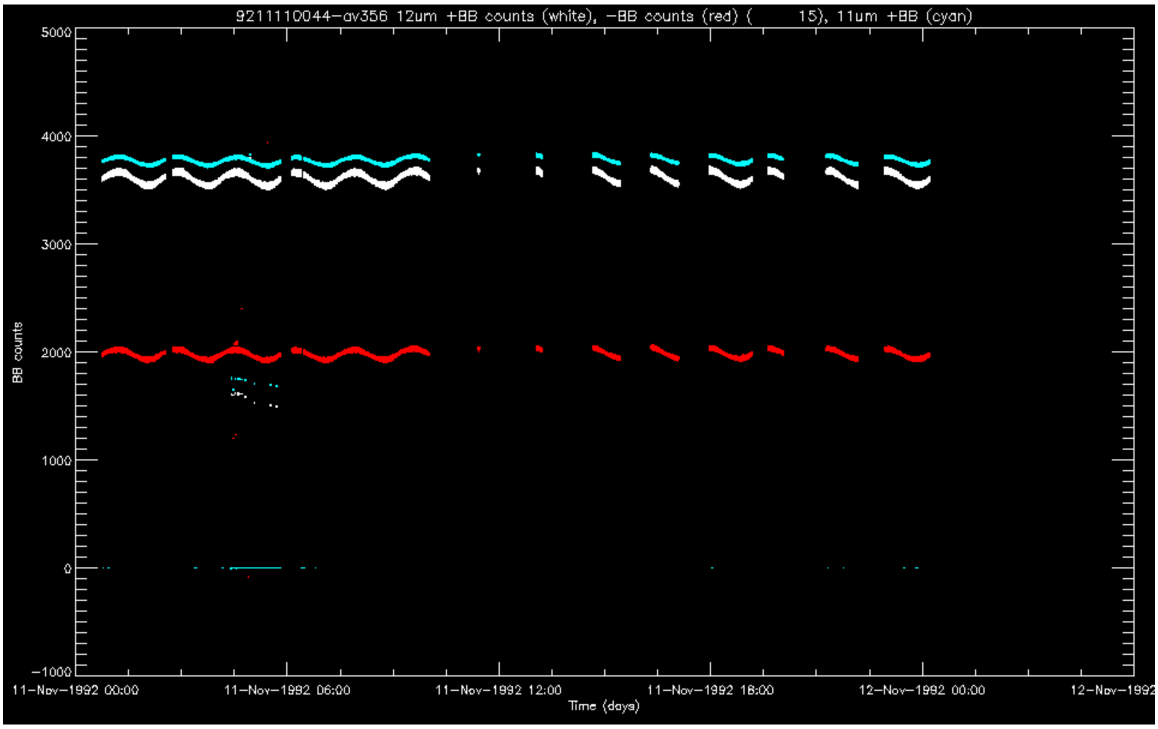

Figure 6: Counts from the 12μm channel warm (white) and cold (red) blackbodies and from the 11μm channel warm blackbody, for all available UBT files on 11-Nov-1992

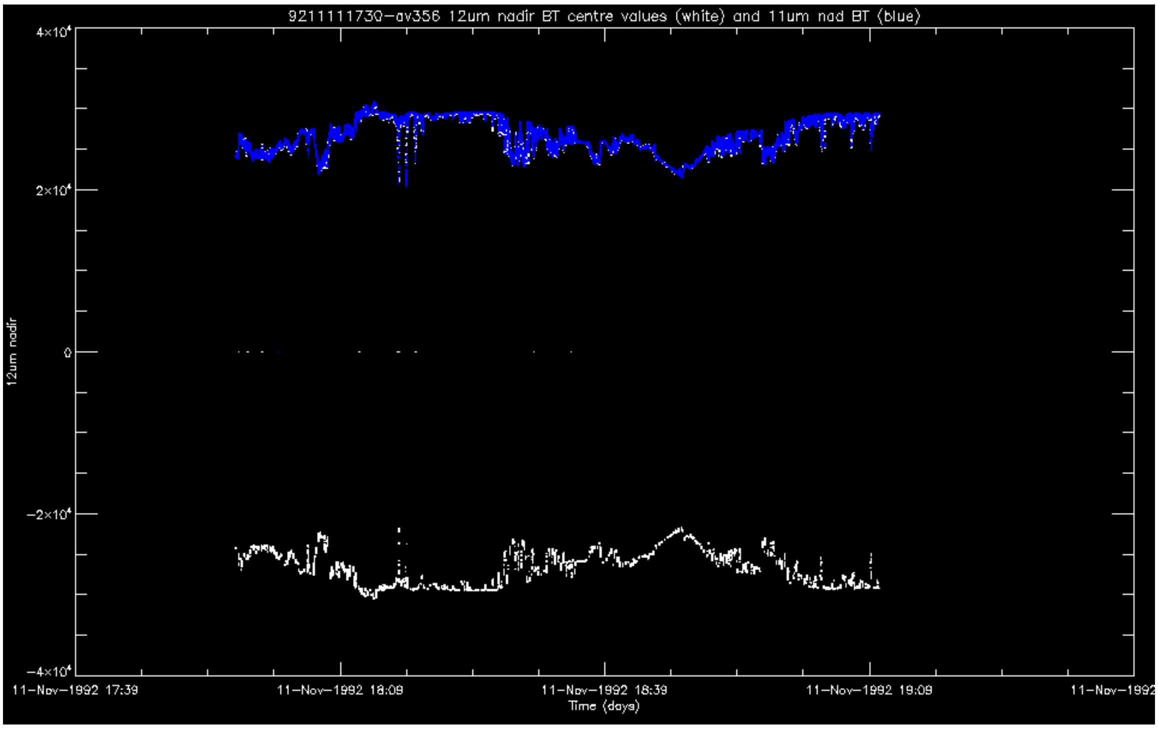

Figure 7: Brightness temperature values from (approximately) the centre of scan for orbit at 17:30 11-Nov-1992. 12μm values in white, 11μm in blue.

5.2.2.3 19941008

[AD 5] notes that on 08-Oct-1994 ATSR resumed "Nominal" operation, which followed a shutdown caused by an anomaly. The FPA was running at this time 2-3 degree warmer than just prior to the shut down.

The plotted brightness temperatures (Figure 8) and blackbody counts (Figure 9) do not show any inversion or saturation.

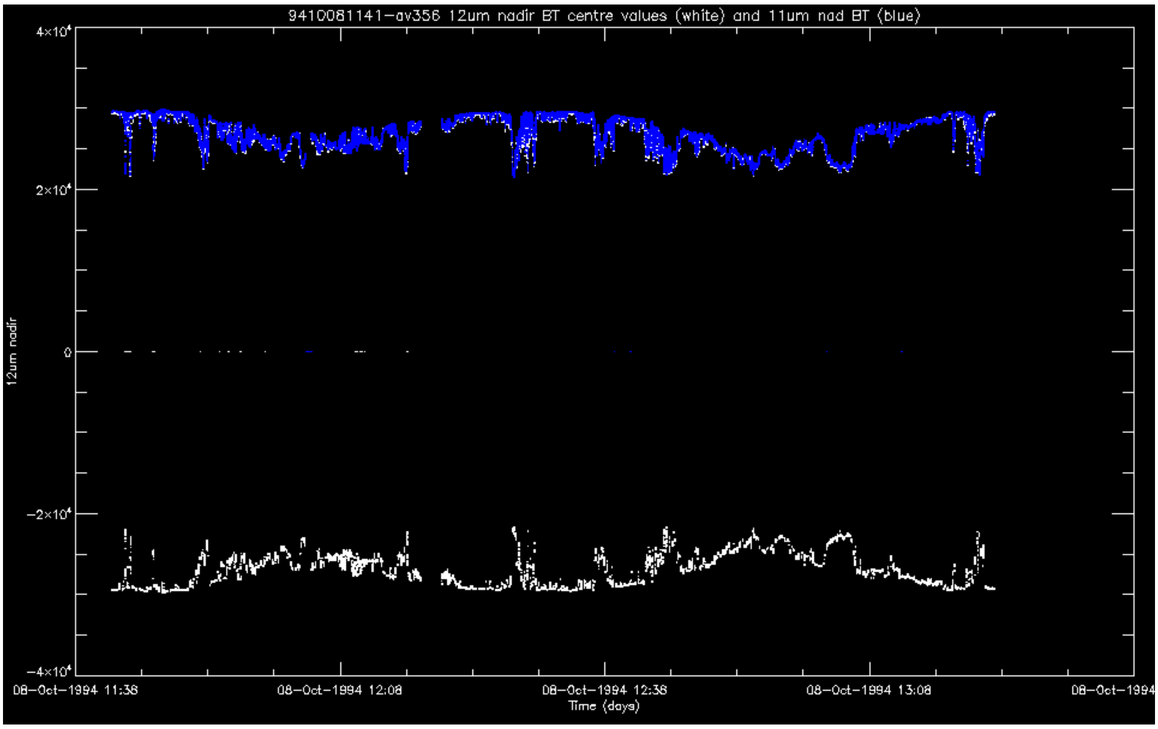

Figure 8: Brightness temperature values from (approximately) the centre of scan for orbit at 11:41 08-Oct-1994. 12µm values in white, 11µm in blue.

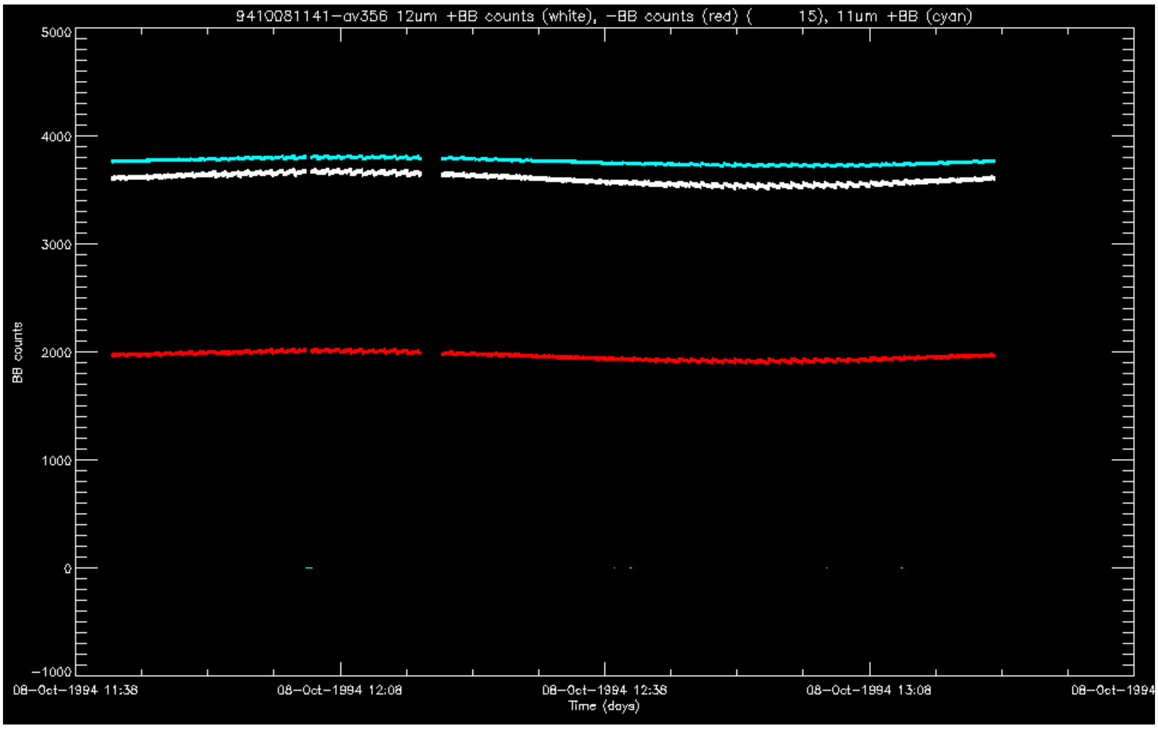

Figure 9: Counts from the 12µm channel warm (white) and cold (red) blackbodies and from the 11µm channel warm blackbody, for the orbit at 11:41 08-Oct-1994

5.2.3 Reported cases in January to May 1996

5.2.3.1 19960110

The blackbody plot for the two orbits at 19960110 11:11 and 12:51 (Figure 10) shows unusual behaviour of the 12µm blackbody counts, warm and cold. The log entries in [AD 5] for 10-Jan-1996 and 21-Jan-1996 report that detector temperatures were rising and that the 12µm auto gain/offset control was lost. A fixed gain and offset were subsequently commanded.

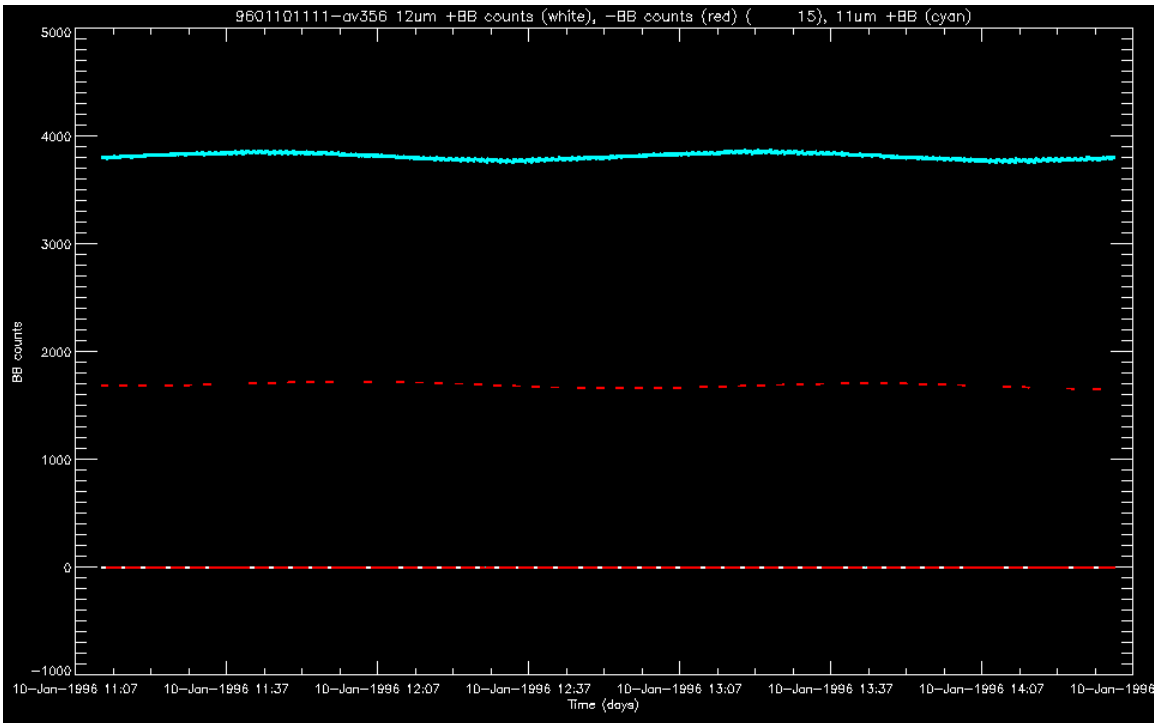

Figure 10: Counts from the 12µm channel warm (white) and cold (red) blackbodies and from the 11µm channel warm blackbody, for the orbit at 1996-01-10 11:11

5.2.3.2 19960331

Blackbody plots for several orbits on 19960331 (Figure 11) showed no indication of saturation in the 11µm or 12µm blackbodies. The data appeared to be well behaved, although there are gaps in the day's coverage. The brightness temperature plots also appeared well behaved. No anomalies are logged in [AD 5] for this day. Inspection of UBT scene images does not reveal any obvious problem due to data artefacts.

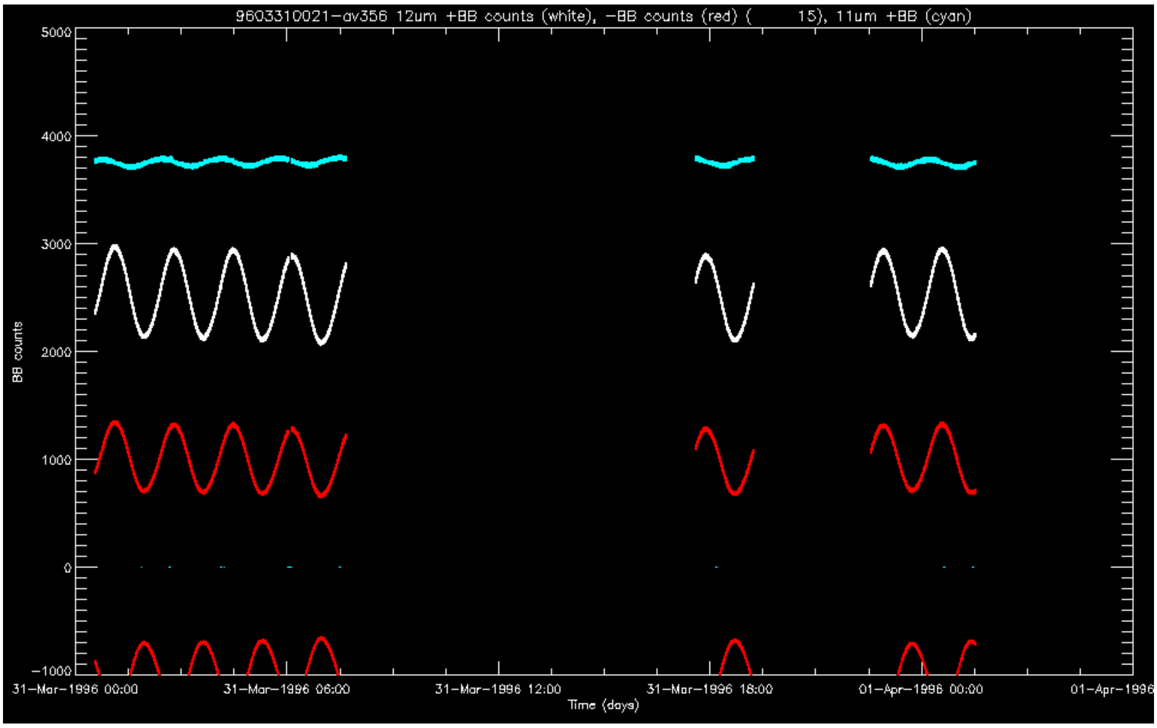

Figure 11: Counts from the 12µm channel warm (white) and cold (red) blackbodies and from the 11µm channel warm blackbody, for several orbits on 1996-03-31

5.2.3.3 April and May 1996

Analysis by Jack Abolins showed that the 09-Apr-1996 12:23 orbit included a period where the 12µm blackbody counts were saturated. During debugging and testing of the possible solution applied to the SUPPLE processor a full day's blackbody data for 09-Apr-1996 was plotted using the IDL tool, as shown in Figure 12. The figure clearly shows that saturation occurs in every orbit for this day.

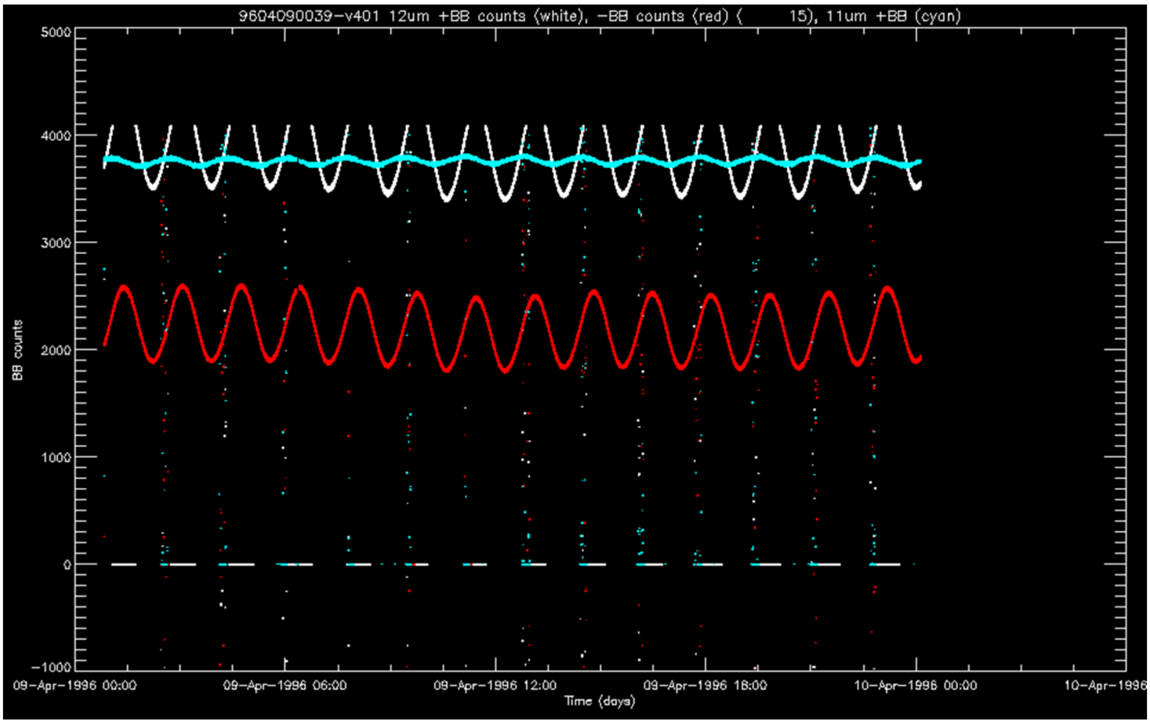

Figure 12: Blackbody values from the full day's data for 09-Apr-1996, showing the extent of blackbody saturation. (Same colours as Figure 1, 12µm warm blackbody counts are shown in white)

Further checks on archived UBT products from sample orbits on 03, 05, 08, 10, 20 and 30-Apr-1996 show that these days are also affected.

03-Apr-1996 appears to be the start point for this particular set of affected data. The blackbody plot for 02-Apr-1996 12:43 (see Figure 13) shows that the 12µm warm blackbody count is not saturated. The 11µm blackbody counts plot on 02-Apr-1996 appears odd, which is consistent with the information recorded in [AD 5], that "the 11µm auto gain/offset control was lost from 093:05:54:02 UTC through 093:15:03:00 UTC. 11µm data through this period will be unusable".

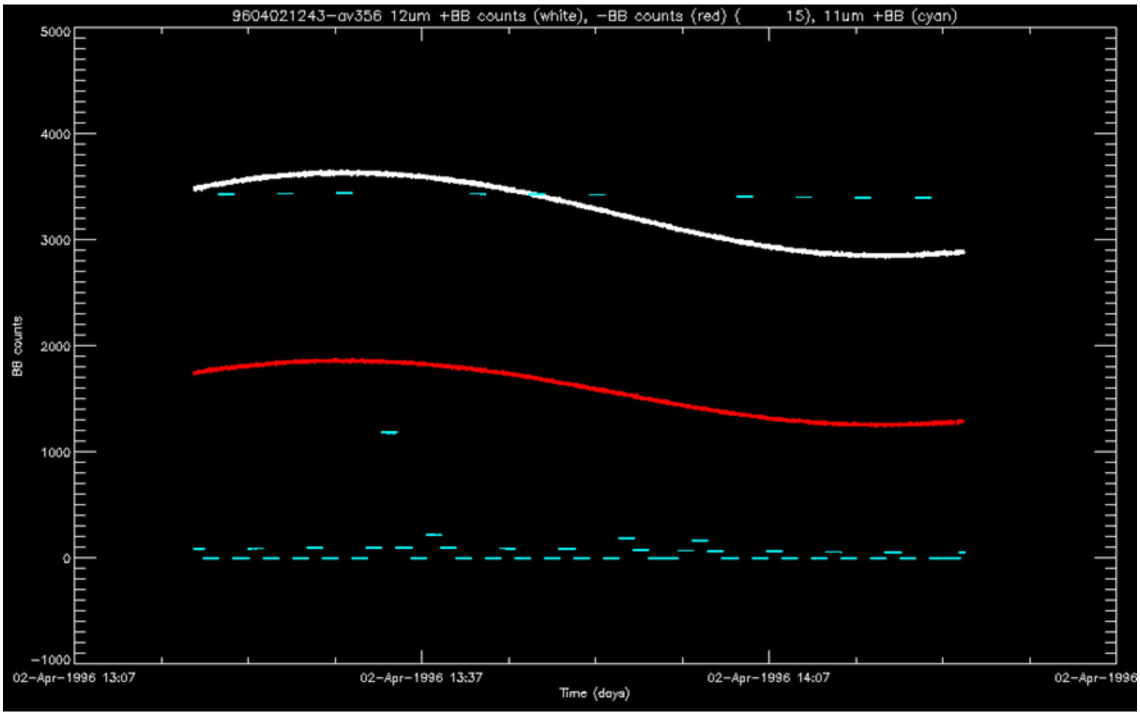

Figure 13: Counts from the 12µm channel warm (white) and cold (red) blackbodies and from the 11µm channel warm blackbody, for the orbit at 02-Apr-1996 12:43.

Data from several days in May 1996 were checked, including the specific dates for which possible affected products were reported. UBT files are available for only one orbit (approx.) on 09-May-1996. The earliest product available is 9605092143-09856, i.e. at along-track distance 9856 into the orbit with ascending node crossing at 21:43. Products spanning 1-2 orbits were checked on the 09, 10, 20 and 30-May-1996. As seen in Figure 14, Figure 16, Figure 17 and Figure 18 the period of saturation of the 12µm warm blackbody signal becomes progressively longer over time until effectively the entire orbit's data are saturated. Figure 15 shows that the associated brightness temperatures are equally badly affected.

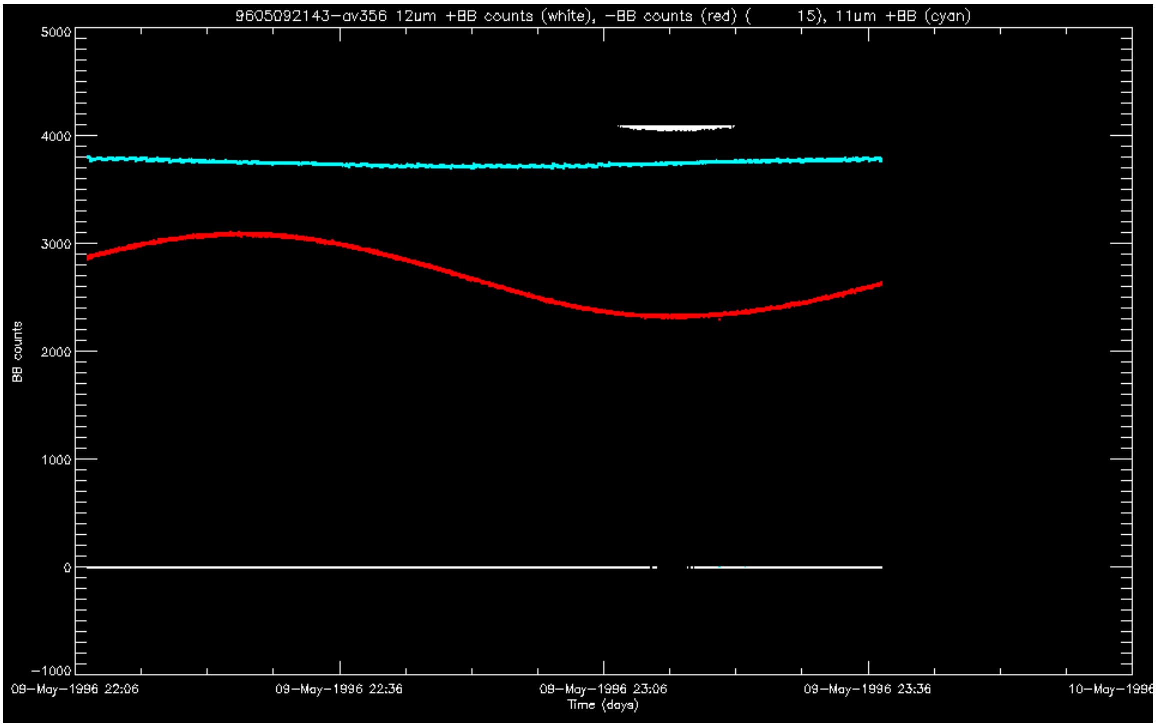

Figure 14: Counts from the 12µm channel warm (white) and cold (red) blackbodies and from the 11µm channel warm blackbody, for the orbit at 21:43 09-May-1996

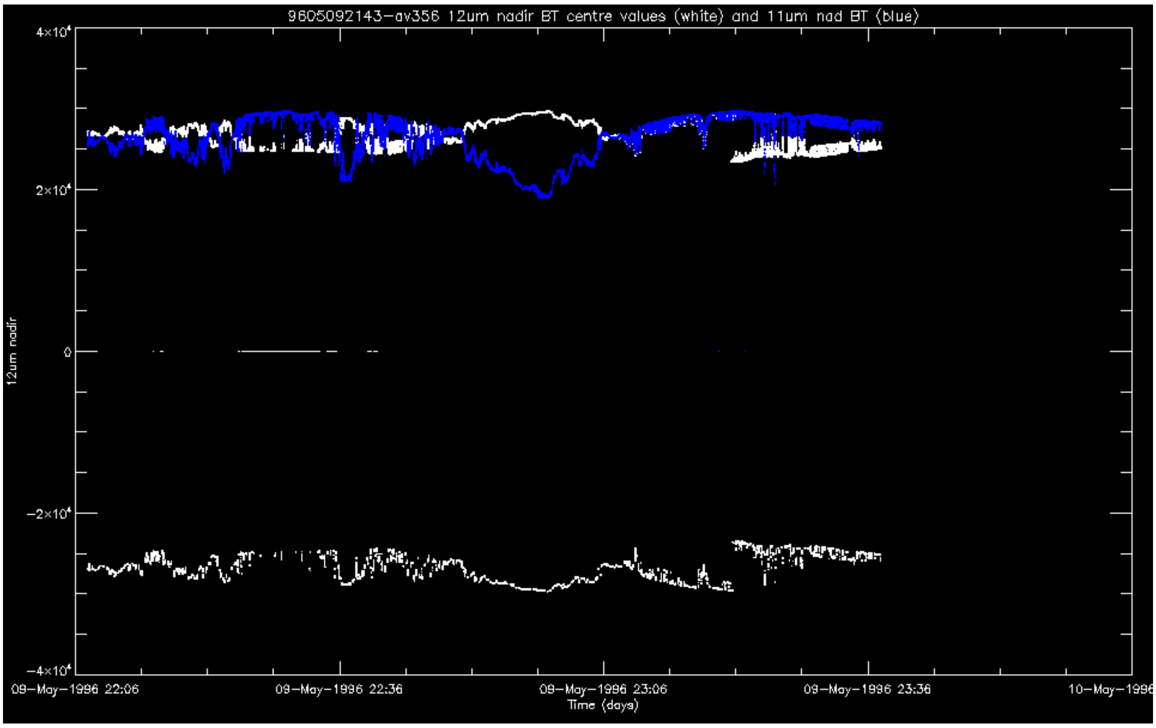

Figure 15: Brightness temperature values from (approximately) the centre of scan for orbit at 21:43 09-May-1996. 12µm values in white, 11µm blue

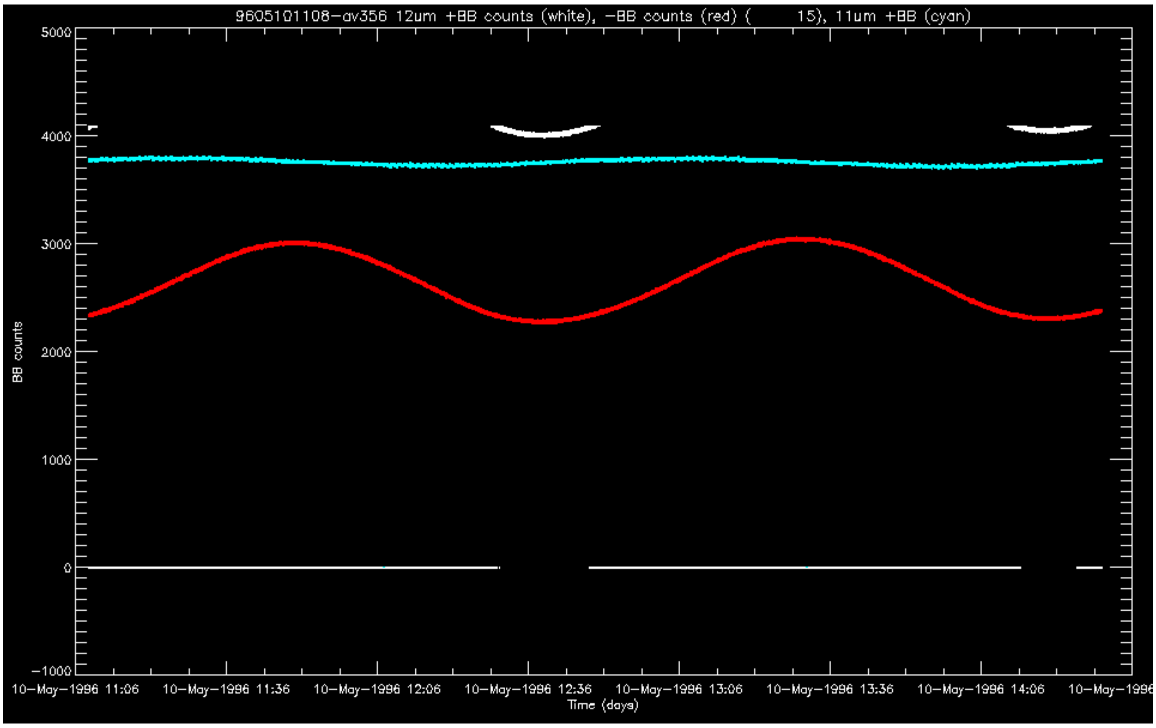

Figure 16: Counts from the 12µm channel warm (white) and cold (red) blackbodies and from the 11µm channel warm blackbody, for the 2 orbits at 11:08 10-May-1996

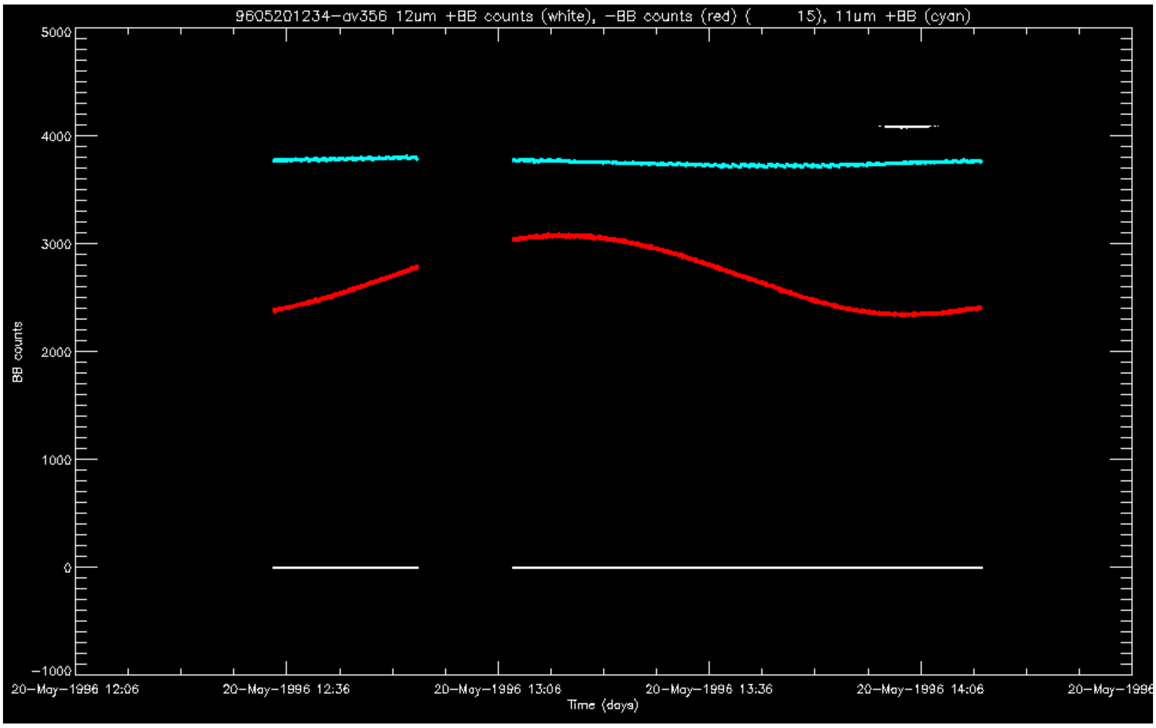

Figure 17: Counts from the 12µm channel warm (white) and cold (red) blackbodies and from the 11µm channel warm blackbody, for the orbit at 12:34 20-May-1996

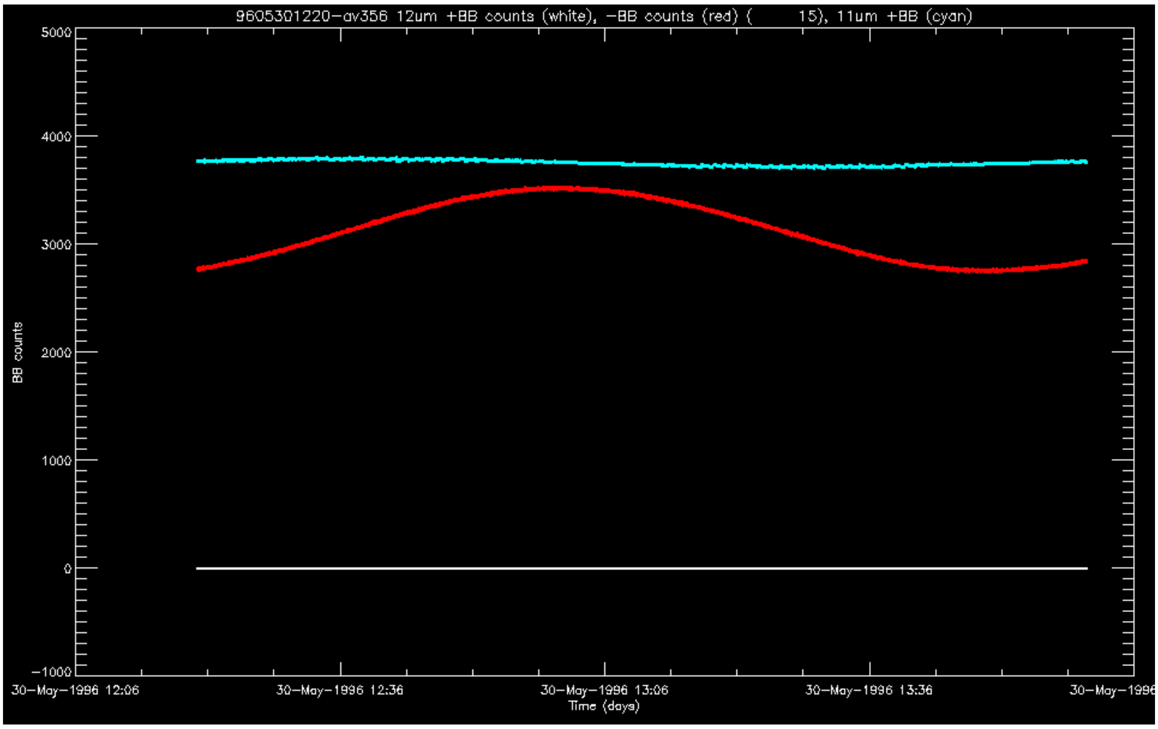

Figure 18: Counts from the 12µm channel warm (white) and cold (red) blackbodies and from the 11µm channel warm blackbody, for the orbit at 12:20 30-May-1996

5.2.4 June to August 1996

From 02-Jun-1996 [AD 5] reports that science data gathering was effectively stopped in preparation for instrument hibernation. The anomaly log then reports that during July and August 1996 there was occasional downlinking of data during the MUBEX-96 campaign. Only 287 UBT products are archived for July 1996, equivalent to fewer than 4 complete orbits. Sample orbits from 11-Jul-1996 and 26-Jul-1996 were checked to see whether the saturation persisted.

The data from 11-Jul-1996 covered only a fraction of an orbit, not including the peak 12µm warm blackbody count, but all values present were valid.

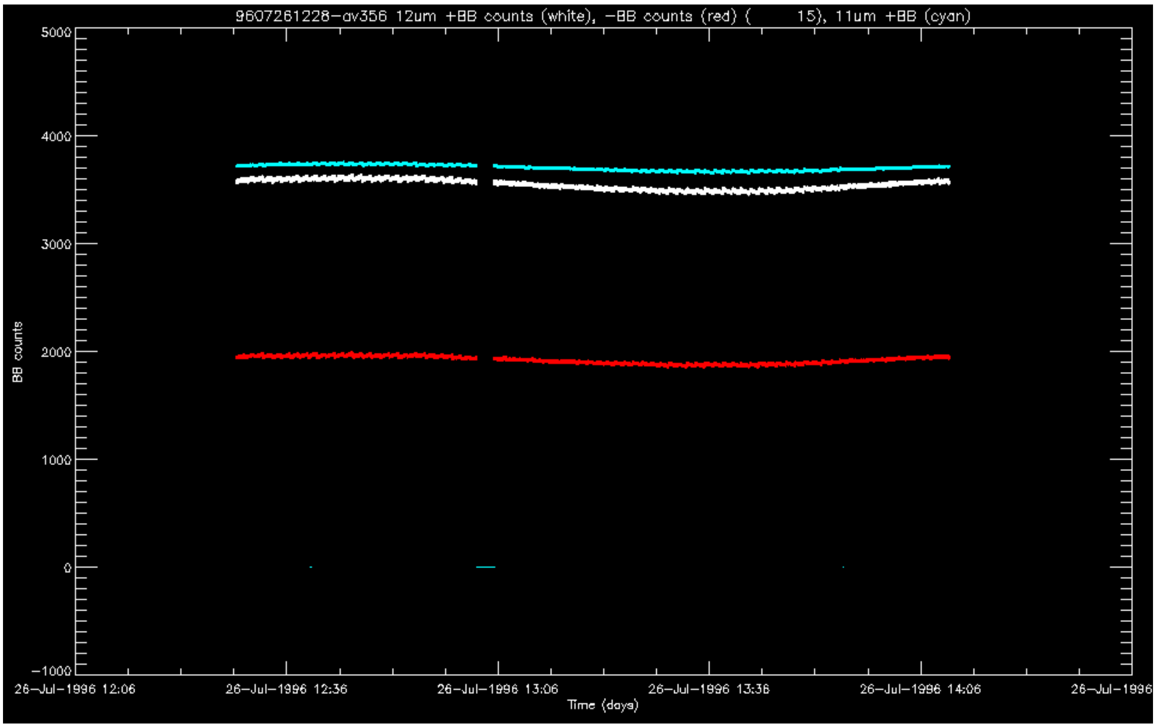

Figure 19: Counts from the 12µm channel warm (white) and cold (red) blackbodies and from the 11µm channel warm blackbody, for the orbit at 12:28 26-Jul-1996.

As illustrated by Figure 19, the blackbody counts on 26-Jul-1996 are not saturated. The corresponding brightness temperatures and those on 11-Jul-1996 appear unaffected by any saturation problems.

5.2.5 Summary of reported and affected periods

The table below summarises the findings for each of the reported data products or periods in 5.2.

Product date / period	Uncalibrated BT?	Comments
19920723	No	Instrument started up after standby
19921111	No	Data unavailable for 12-13-Nov, procedural error on ATSR reconfiguration
19941008	No	ATSR resumed operation following anomaly. FPA warm
19960110	No	Detector temperatures rising, 12µm auto gain/offset control lost
19960331	No	Problems on 02-Apr: 11µm auto gain/offset control lost
19960403	Yes	12µm warm blackbody count saturated regularly throughout Apr 1996
19960406	Yes	As above
19960409	Yes	As above
19960509	Yes	12µm warm blackbody saturated over large fraction of orbit

19960520	Yes	As above
19960530	Yes	12μm warm blackbody saturated over entire orbit
19960726	No	Not reported – additional check on data after May 1996. No saturation.

5.3 Inspection and debugging of SUPPLE

The SUPPLE processing code was inspected and executed in the Eclipse debugger over sample data sets in order to investigate why the flagged blackbody values did not lead to brightness temperatures being flagged as uncalibrated.

To summarise briefly, the problem was traced to the calculation of calibration parameters from blackbody values. The difference between the warm and cold blackbody counts is used to calculate a gradient. A check for a 0 difference is made in order to prevent a divide by 0, but there is no trapping of the case when the detector count values for either individual blackbody are 0 (i.e. no valid data available; the count values used in this calculation are means over the array of available values per scan, for several scans). Full details are given in the following paragraphs.

Level 0 data from two sample days was used as an input, to determine indicative values for the warm and cold blackbody counts when the signal was saturated and when within the nominal range. The Level 0 data files were obtained from the ongoing re-transcription of Matera data on behalf of ESA by DSI.

In data from 01-Sep-1991, sample warm and cold 12µm blackbody values were found to be of the order of 3600 and 1900, respectively. In data from 09-Apr-1996, the values were -5 (flag value for PIXEL_COUNT_SATURATED, as noted in [AD 4]) and approximately 2400, while the 11µm warm blackbody values were approximately 3790. The value at which saturation occurs depends on the data compression mode used, i.e. the number of bits available to store each data value e.g. the 12-bit saturation mask is 0x0FFF, or 4095 counts. These test values confirm what was already seen in the plots of UBT data.

It is noted that, based on a small data sample checked during debugging, although the warm blackbody values are flagged as saturated, the associated nadir-view pixel counts are not saturated.

The blackbody values are used in the derivation of calibration values. [AD 3] describes the calibration, which is based on a linear relationship between the brightness temperature and the pixel counts from the two blackbodies (see Figure 20). The slope and offset are calculated separately for each channel (The calibration values are applied to the pixel values much later in the sequence of function calls than the point at which they are calculated).

Processing is done over a “calibration period” of 10 scans. For each scan, the data is unpacked into a data structure, which contains pixel arrays including 36 warm and 36 cold blackbody values (only the centre part of each array views the blackbody itself). These values are averaged over the calibration period to give a mean warm and cold blackbody value, excluding any flagged values. (Separate averages are calculated for odd and even-numbered pixels as there are two different integrators in the signal processing chain). If all values are flagged the resulting mean count is 0.

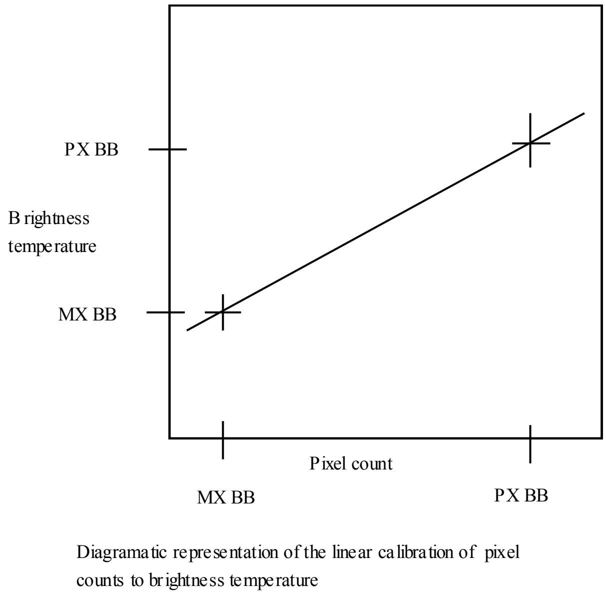

Figure 20: Relationship between blackbody counts and brightness temperature as illustrated in [AD 3]

The function to calculate slope and intercept includes trapping for a possible divide by 0 (i.e. when the difference between the warm and cold blackbody counts is 0). The original code contained no trapping for cases where one or other of the blackbody mean counts is 0. Hence a 0 in the mean warm blackbody count resulted in a negative difference between the warm and cold blackbody counts.

5.3.1 Results and validation of the updated SUPPLE processor

Additional conditions were applied to the SUPPLE processor's calculation of calibration slope and intercept, to exclude mean counts of 0 in either blackbody. The entire day's data from 09-Apr-1996 was then reprocessed from Level 0 data. Plots were made from the resulting UBT products, denoted version 401 for test purposes.

Figure 21 shows the centre of scan data for the same orbit as Figure 2. The same broad features are present, giving confidence that the change has not introduced any unintended side-effects. The 12µm values in the middle part of the orbit are flagged out, hence the horizontal white trace at brightness temperature values close to 0. Small differences from the brightness temperatures in Figure 2 may arise as the new data may be derived from different input Level 0 data with differing time range, different, missing and corrupted source packets etc. The "spikes" in the 12µm trace in the early part of the flagged data period may be a result of some corrupted data values which are not excluded by the processing.

Figure 22 shows the blackbody data from the new "version 401" UBT products and allows comparison of the timing of flagged data in Figure 21 with the blackbody data from the same UBT products.

Figure 23 shows the centre of scan values for the whole day from the test output data.

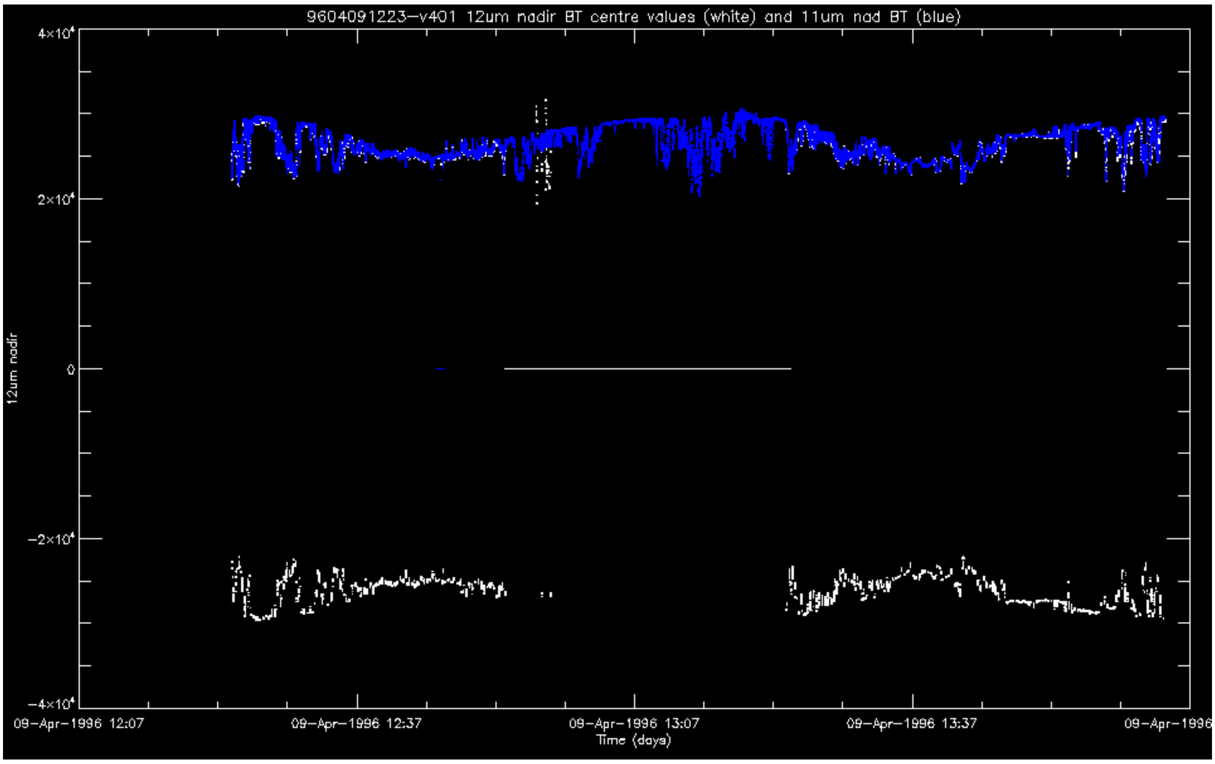

Figure 21: Centre of scan brightness temperatures for the 12µm and 11µm channels, from the updated SUPPLE processor.

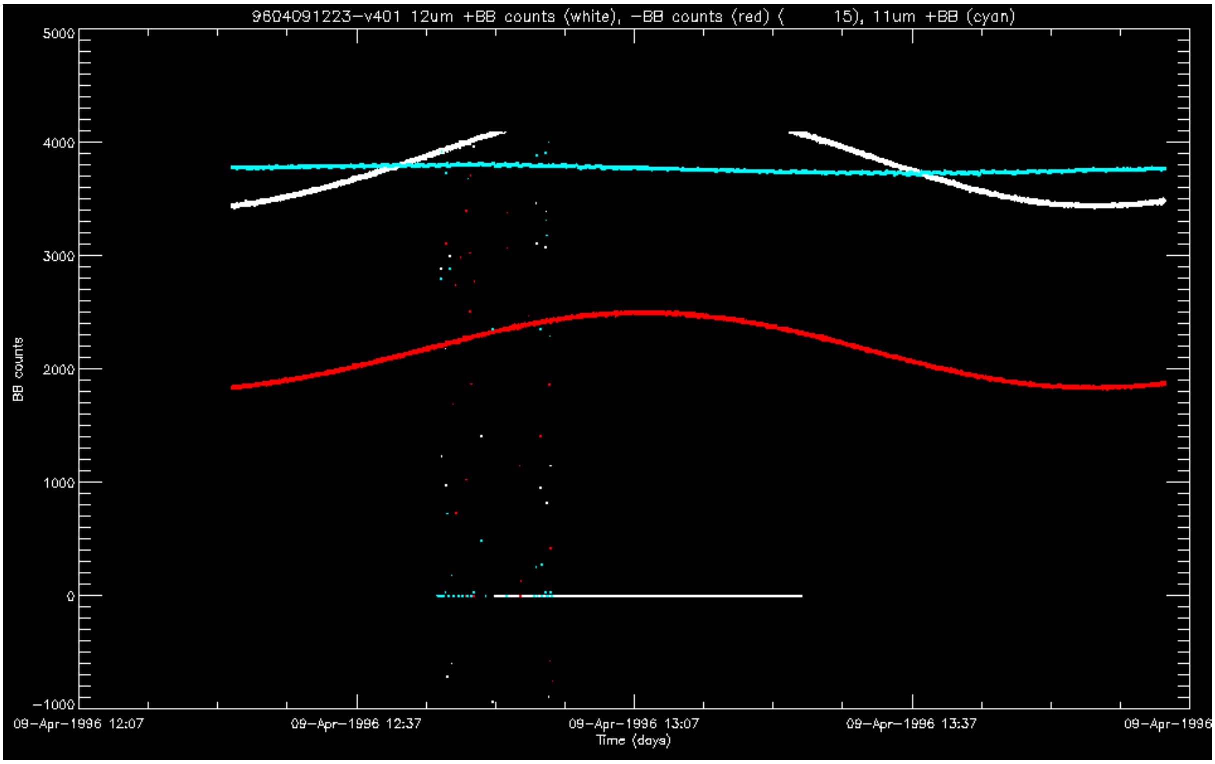

Figure 22: Blackbody counts for the orbit with ascending node time 09-Apr-1996 12:23, from the updated SUPPLE processor.

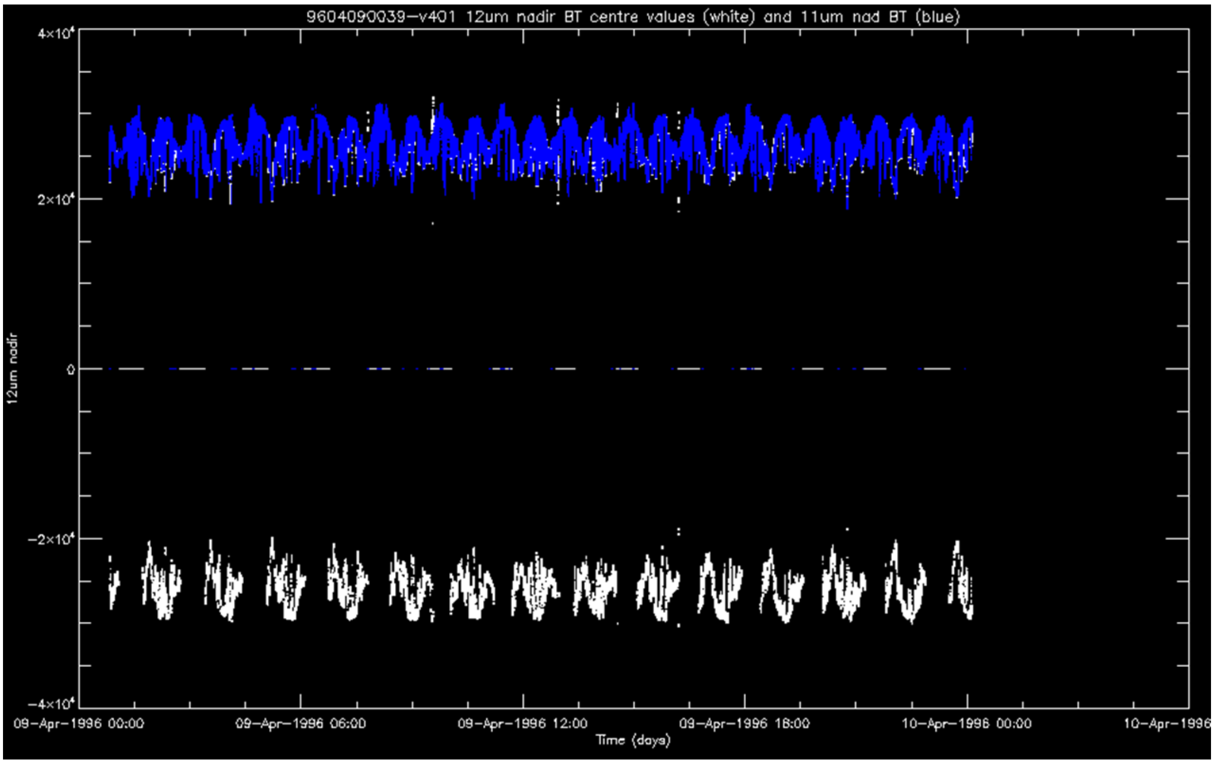

Figure 23: Centre of scan brightness temperatures for the whole day of 09-Apr-1996, 12µm and 11µm channels, from the updated SUPPLE processor.

Figure 24, Figure 25 and Figure 26 show individual nadir scenes from the 11µm and 12µm channels at different along-track distances within the 09-Apr-1996 12:23 orbit. In the earliest scene the acquisition time of 12:40 is before the onset of blackbody saturation and the 12µm brightness temperatures are not flagged out. In the second scene the 12µm brightness temperatures have been flagged by the updated processor.

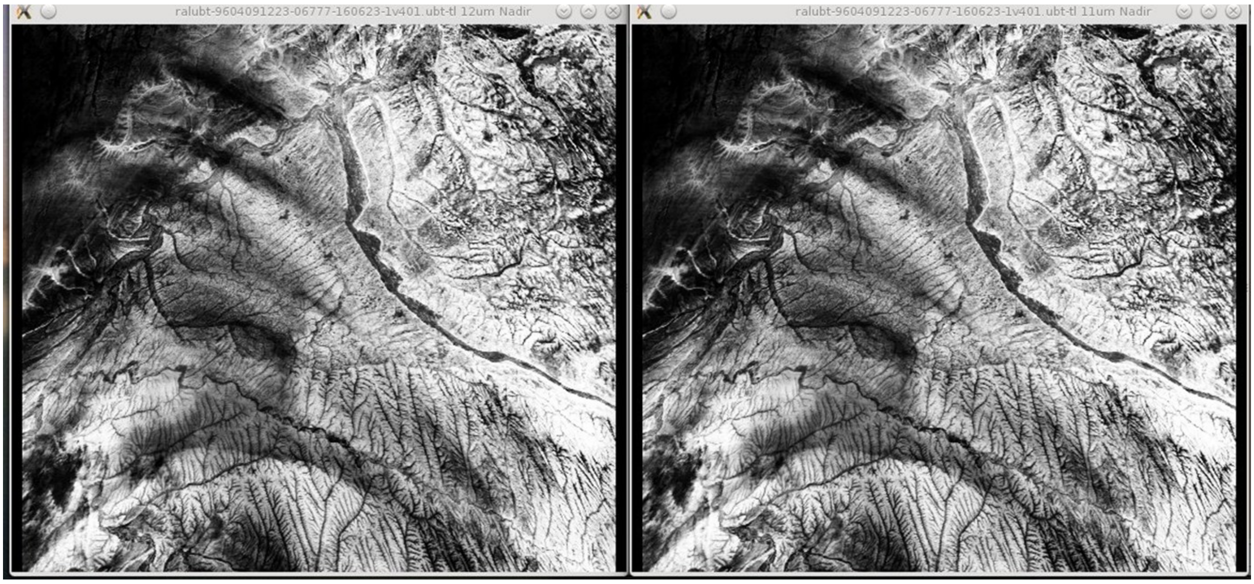

Figure 24: 12µm (left) and 11µm (right) nadir brightness temperatures from reprocessed data for orbit with ascending node time 09-Apr-1996 12:23, scene at along-track distance 06777, acquisition time 12:40:08.

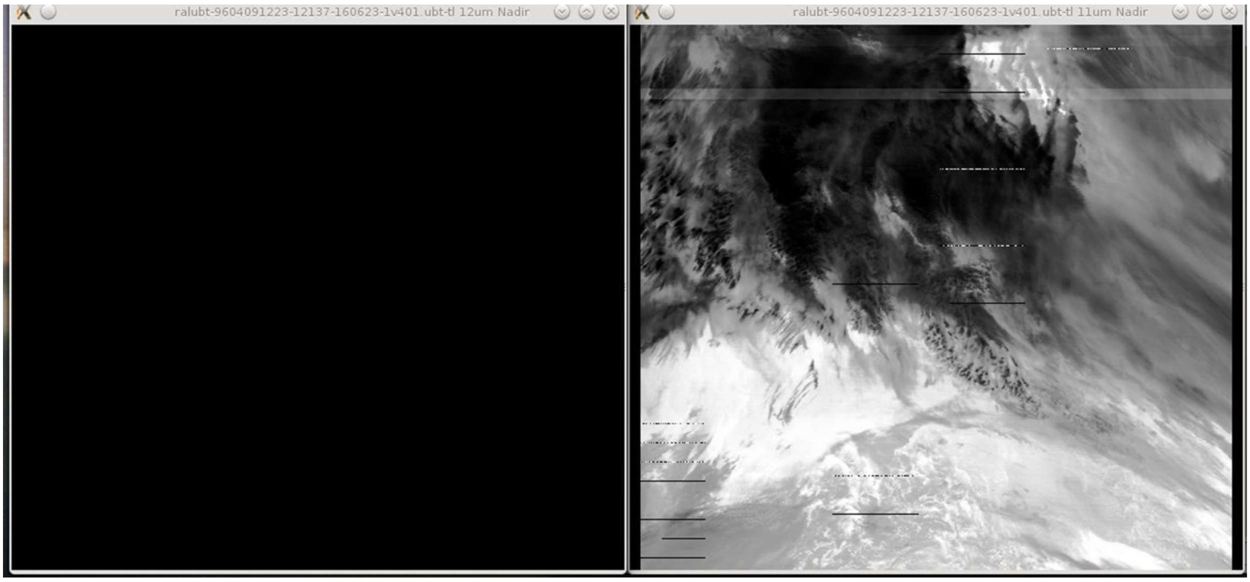

Figure 25: 12µm (left) and 11µm (right) nadir brightness temperatures from reprocessed data for orbit with ascending node time 09-Apr-1996 12:23, scene at along-track distance 12137, acquisition time 12:53.

The scene in Figure 26 falls within the flagged period. The presence of visible data artefacts in the 11µm image suggests that some form of data corruption may have resulted in some 12µm blackbody values not being flagged in this case. The next scene in the orbit is similarly affected. Later scenes have their 12µm brightness temperatures flagged out, up to along-track distance 23050, acquisition time 13:20.

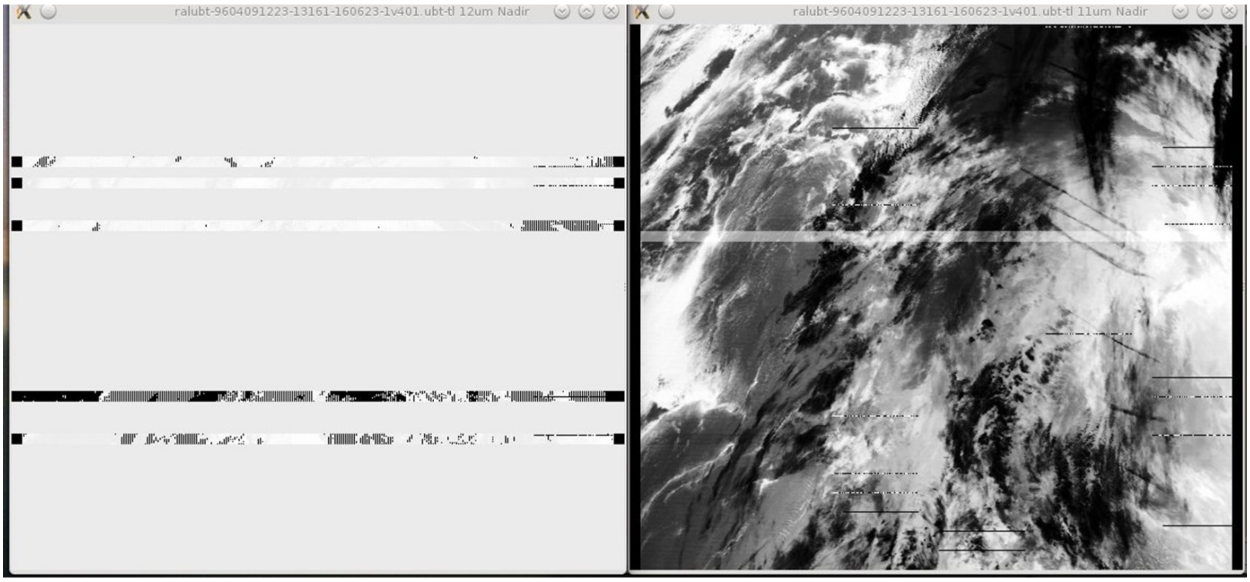

Figure 26: 12µm (left) and 11µm (right) nadir brightness temperatures from reprocessed data for orbit with ascending node time 09-Apr-1996 12:23, scene at along-track distance 13161, acquisition time 12:56.

As well as making visual checks by inspecting plots, an IDL tool, compUBT, was written to allow numerical comparison of the nadir pixels in the 11µm and 12µm channels from two UBT products. This tool effectively allows (partial) “differencing” of UBT products generated before and after applying the update to SUPPLE. CompUBT subtracts the 11µm and 12µm nadir pixel arrays and prints the number of differences found. In products where no flagging is expected, a 0 difference is seen. In flagged products, compUBT records differences in the 12µm channel as expected and confirms that the 11µm is unchanged.

As additional diagnostic information compUBT logs the number of scan groups (10 successive scans) in which all 12µm blackbody values flagged and the number of groups where the blackbody counts are flagged and un-flagged brightness temperatures are present. 10 scans matches the size of a "calibration period" used in processing of Level 0 data to UBT in the SUPPLE code. The check proved to be inconclusive when applied to UBT products since the synchronisation between the start of a scan group or calibration period and the start of a Level 0 product is lost when the data are written out to individual UBT scenes.

Nonetheless, the numerical check gave confidence that no side-effects had been introduced by the change, as no differences were seen in the small number of non-flagged scenes checked.

Inspection of the UBT pixel arrays in IDL also helped explain the appearance of bands of non-flagged pixels in Figure 26, e.g. scans 118:127 are "calibrated" because the blackbody values in scan 126 contain a short sequence of "non-flagged" values: -3580, 3196, 3328, 1152, 1792, 3460. The wide variation from one value to the next suggests that these are not measured detector counts and may be the result of data corruption. These values are not trapped by the validity checks in the SUPPPLE code as they fall within the valid range of counts and they are therefore used in "calibration" processing.

5.4 Re-processing of affected UBT products from Level 0

Section 5.3.1 describes the results of a test reprocessing of Level 0 data to UBT for an affected day. Is it therefore feasible to replace all the affected UBT products in the archive by reprocessing the entire period, 3rd April to 2nd June 1996?

At present, although the updated SUPPLE processor is now available, processing requires a degree of manual operation, which makes it impractical to perform bulk processing on long periods of data. In this case, the affected period is relatively short and continuous so while the processing would be time-consuming it is probably feasible.

Replacement of UBT products in the NEODC archive is also difficult to automate, although again the operation will be simplified if all products can be replaced over a continuous period.

Level 0 data are available from the DSI re-transcription for the affected period. Access to the data is currently restricted to the CEMS (commercial) FTP server and transfers are therefore difficult to automate. Bulk transfer of the data for the relevant period to the Jasmin system is planned for the near future, since the original data will be repatriated to ESA.

The Level 0 data set contains files with several different version numbers, e.g. on the test day for which data have been reprocessed, 09-Apr-1996, there are 3 versions. The version numbers refer to the extraction software, which, it is thought, has been applied to the same tape source in each case.

Initially it was assumed that the most recent version, 9120, would be the best available. When processing of this version resulted in the generation of far fewer UBT products than expected a brief test processing of all the available Level 0 versions was performed. The results are listed in Table 1. The processing problem was subsequently traced to an error in the SUPPLE software rather than the data. An error in the adaptation of the SUPPLE pre-processor to handle ATSR-1 source packets led to the wrong size of null packet being inserted to replace a missing packet. The test processing of each available version by the patched SUPPLE processor demonstrated the necessity of further supporting information to help determine the best version for reprocessing.

Version	Station ID	Generation date	Number of files	Source packets	Missed packets	Comments
9120	2: Fucino	08-Apr-2015	13	519,927	11,586	Time range matches v8700 but files are generally smaller by, e.g. 1%. File for period 211126 – 225121 is missing.
8700	2: Fucino	23-Nov-2006	14	564,626	5,206	Largest number of Level 0 files available.
6400	2: Fucino	26-Jul-1996	10	403,603	1,998	The first 3 files and the last file for the day are missing c.f. v8700. Files are larger than the v8700 equivalents by a small fraction, e.g. 0.05%.

Table 1: Available Level 0 file versions for 09-Apr-1996. “Missed packets” represents the totals for the day as logged by the SUPPLE pre-processor.

Inspection of UBT images showed that in the short periods processed to date there is a higher number of missing scans in the UBTs produced from versions 9120 and 8700 than in the archived products, typically 1-5 missing scans per scene. It is possible that the data are also affected by other quality issues, e.g. corruption, which may have less immediately obvious effects. Reprocessing would therefore result in flagging of the 12µm pixels affected by saturated blackbody counts, but would give a slight reduction in data quality in all channels.

The log output from the SUPPLE pre-processor was used to generate a total number of null packets inserted to replace missing source packets for the full day, which is listed as “Missed packets” in Table 1.

Improvements in the tape transcription software which generated each product version would be expected to lead to improved time coverage and a larger number of packets in each successive version. However, there are smaller numbers of source packets in the most recent version 9120 files, compared with the version 8700 equivalents, suggesting that there may also have been some degradation of the data tapes between transcriptions. Figure 27 compares 4 examples of the same scene, taken from UBT products generated from different Level 0 versions and from the NEODC archive.

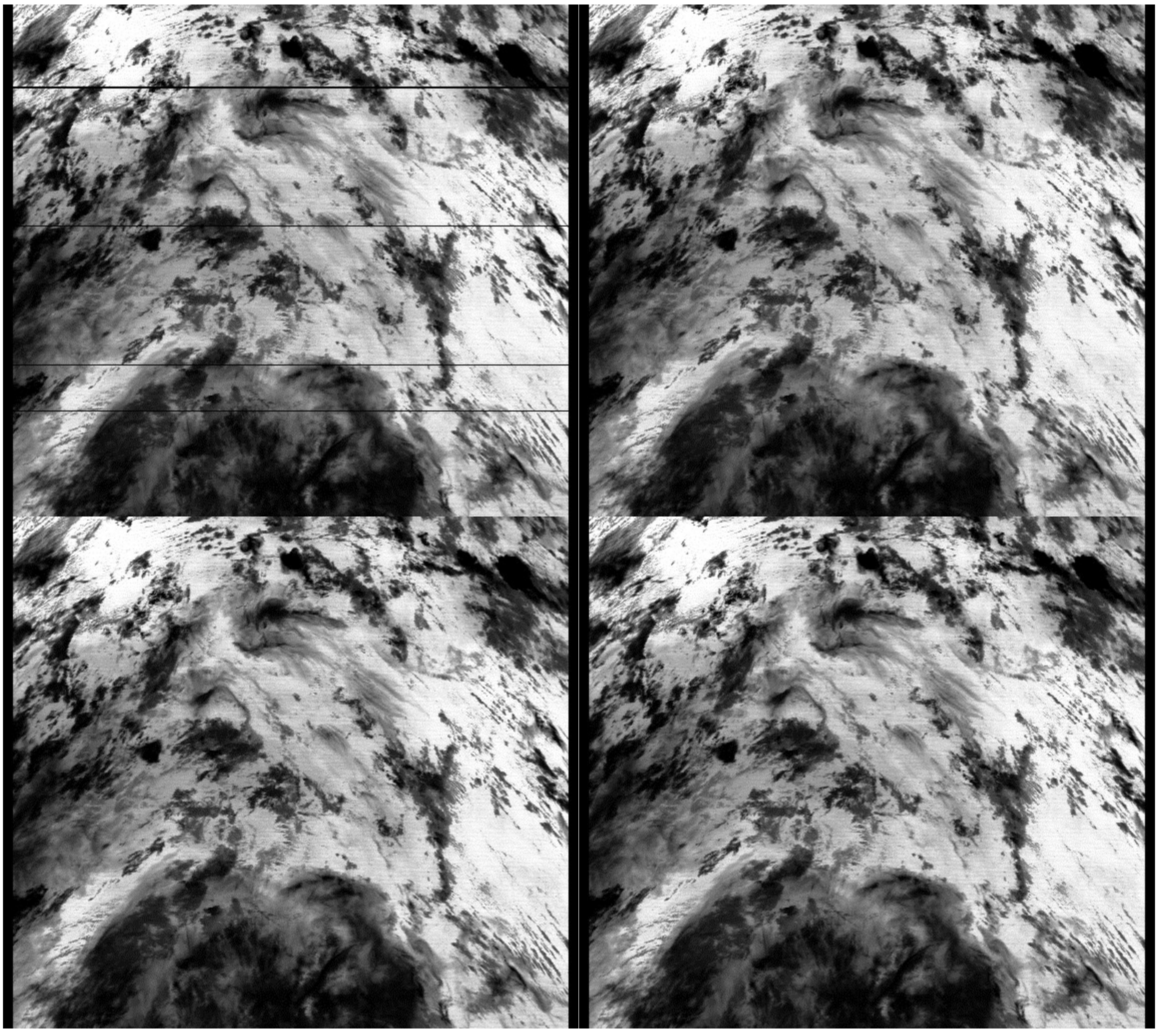

Figure 27: UBT product 9604091042-00008 (11µm nadir view) from Level 0 file version 9120 (top left), version 8700 (top right), version 6400 (bottom left) and from the NEODC archive, SADIST version 356 (bottom right).

Scenes have been found in which the version 9120 data appears to be more strongly corrupted, i.e. a set of contiguous scans is either missing or corrupted, rather than the more typical handful of missing scans per scene, as shown in Figure 28.

One example scene has been found in which the version 8700 data appear to be corrupted while the version 9120 data are not (Figure 29).

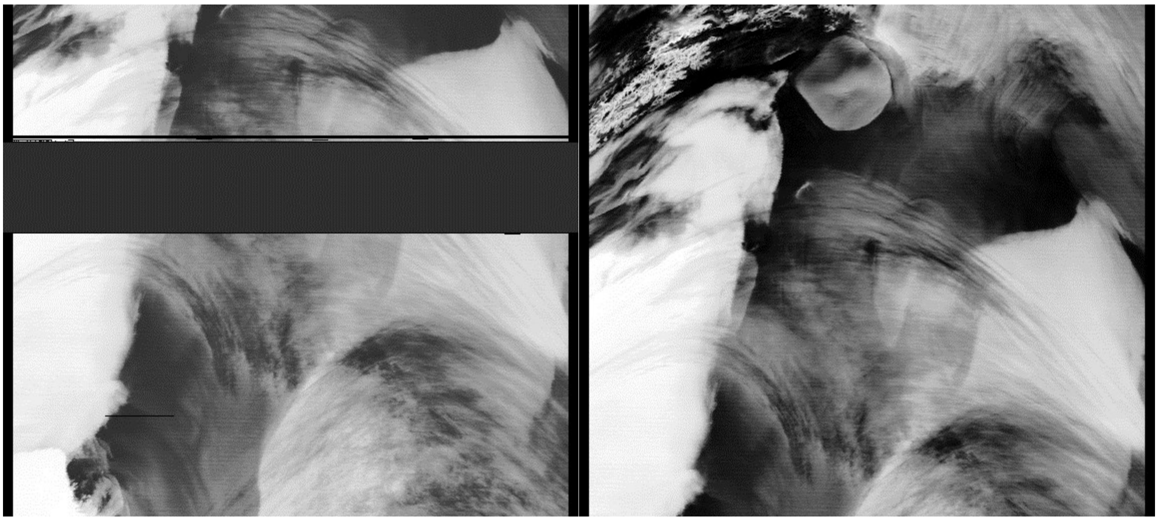

Figure 28: 11µm nadir scene 9604091042-29095 from Level 0 version 9120 (left) and version 8700 (right)

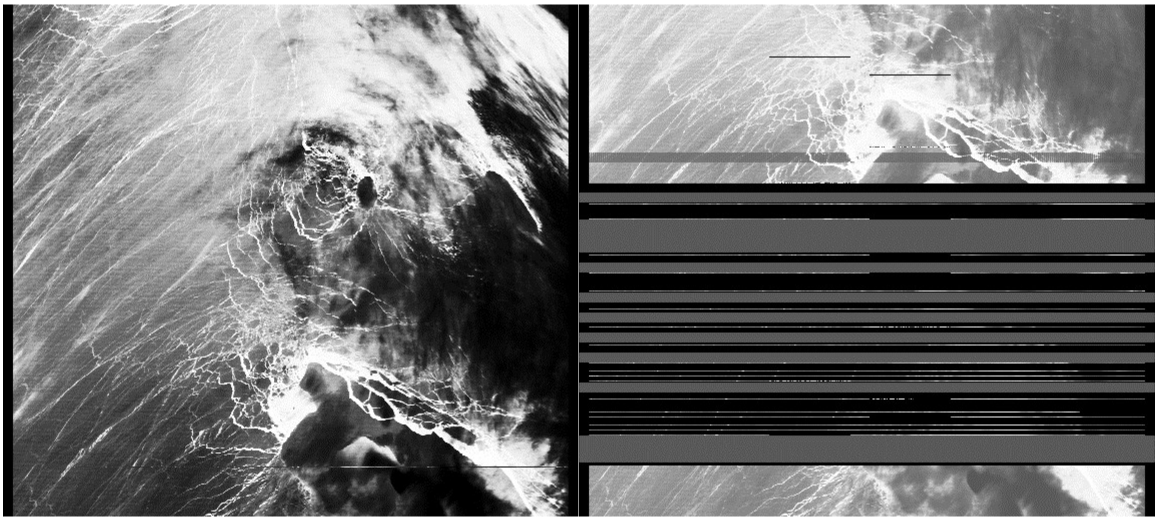

Figure 29: 11µm nadir scene 9604091042-09736 from Level 0 version 9120 (left) and version 8700 (right). In version 8700-derived UBTs the feature near the centre of the scene is shifted into the next product, which has along-track distance 09985, only 249 different from the preceding scene rather than the usual 512.

6 Conclusions

6.1 Dates of affected products

The full extent of the period of affected data appears to be 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.

It is possible that there are other occurrences in the archived data set since only a handful of cases have been checked. No exhaustive check of the archive has been performed. The 11/12µm brightness temperature ratio may provide a useful signature for any automated archive check performed in future.

6.2 Processing software: debugging and correction

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.

6.3 Processing of corrected UBTs from Level 0

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.

Differences in data quality between the available Level 0 product versions have been reported to DSI and ESA. Processing will be delayed pending investigation by ESA and advice on the most suitable Level 0 version. The advice of the ATSR SAG will also be sought before replacement of any archived UBT products.