AATSR Frequently Asked Questions (FAQ)

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IDEAS+-VEG-OQC-REP-2117 Issue 3 14 December 2016

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AMENDMENT RECORD SHEET

The Amendment Record Sheet below records the history and issue status of this document.

ISSUE	DATE	REASON
1	20 Dec 2005	Initial Issue (as AEP_REP_001)
2	02 Oct 2013	Updated with new questions and information (issued as IDEAS-VEG-OQC-REP-0955)
3	14 Dec 2016	General updates, major edits to Q37., new questions: Q17., Q25., Q26., Q28., Q32., Q38., Q39., Q48. Now issued as IDEAS+-VEG-OQC-REP-2117

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1. INTRODUCTION

The purpose of this FAQ is to act as a repository for common questions raised concerning the AATSR project. It includes questions raised with the AATSR Expert Support Laboratory, questions reported to the Quality Working Group or the ESA User Helpdesk, and questions of particular interest to new users.

The information contained within this document is supplementary to that contained within the AATSR Handbook, available from http://earth.esa.int/handbooks/.

The questions fall into four basic categories:

- General questions, covering background to the AATSR mission
- Common questions from new users
- Questions concerning the instrument
- Questions on data processing and products

Frequent updates to this document are expected as new questions arise and feedback on existing questions is collected from readers of the document. Any comments and questions on the document should be addressed via https://earth.esa.int/web/guest/contact-us.

1.1 The Third AATSR Reprocessing Dataset (IPF 6.05)

Users are strongly recommended to use the most recently generated AATSR dataset, which is from the Third AATSR Reprocessing. The (A)ATSR 3rd Reprocessing Information Pack, issued after full calibration assessments, validation and quality control had taken place, includes a summary that contains key information concerning the 3rd reprocessing dataset. The Pack also includes quality reports and auxiliary data lists.

Users can identify third reprocessing products using the following information:

- The IPF software version contained within the main product header of third reprocessing Envisat-format products is “AATS/6.05”.
- The Processing Stage Flag contained within the product name and main product header of third reprocessing Envisat-format products has been incremented to U, for example:
  ATS_TOA_1P**U**UPA20120308_005911_000065273112_00246_52415_6357.N1.
- L2P and L3U SST NetCDF products (based on ARC processing) were generated from the third reprocessing Level 1 dataset, and have product names as per the following example:
  20120122004543-UPA-{L2P|L3U}_GHRSST-SSTskin-**ARC**-AATSR-v02.0-fv01.0.nc.
- UOL LST NetCDF products were generated from the third reprocessing Level 1 dataset (see ESA News of 19 June 2014), and have product names as per the following example:
  ATS_LST_2P**UUOL**20080707_095243_000065272070_00093_33213_6456.nc.

Information on accessing AATSR third reprocessing products is available from the ESA EO Data Access webpage: https://earth.esa.int/web/guest/data-access.

1.2 References

References within this FAQ are posted as working links at the time of issue. Documents referenced are available in the ESA library: https://earth.esa.int/web/guest/document-library, unless explicitly stated otherwise.

2. GENERAL QUESTIONS

Q1. What does AATSR stand for?

AATSR stands for 'Advanced Along-Track Scanning Radiometer'.

Q2. What is AATSR and what does it do?

AATSR was one of the Announcement of Opportunity (AO) instruments on board the European Space Agency (ESA) satellite Envisat. It was the most recent in a series of instruments designed primarily to measure Sea Surface Temperature (SST), following on from ATSR-1 and ATSR-2 on-board ERS-1 and ERS-2. AATSR data have a resolution of 1 km at nadir, and are derived from measurements of reflected and emitted radiation taken at the following wavelengths: 0.55 µm, 0.66 µm, 0.87 µm, 1.6 µm, 3.7 µm, 11 µm and 12 µm. Additional information on the ATSR series of sensors is available from: http://atsrsensors.org/

Special features of the AATSR instrument include its use of a conical scan to give a dual-view of the Earth's surface, on-board calibration targets and use of mechanical coolers to maintain the thermal environment necessary for optimal operation of the infrared detectors. Further information on AATSR is available from the ESA AATSR webpages.

The AATSR instrument was funded by the predecessor departments of the UK Department of Business, Energy and Industrial Strategy (BEIS) and the Australian Department of Innovation, Industry and Science.

Q3. What is Envisat?

Envisat was launched in March 2002 by ESA, and was an advanced polar-orbiting Earth observation satellite providing measurements of the atmosphere, ocean, land, and ice (see https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/envisat).

Envisat continued the work of the ERS satellites, and its data supports Earth science research and allows monitoring of the evolution of environmental and climatic changes.

Following the loss of communications with Envisat on 8^{th} April 2012, ESA declared the official end of mission on 9^{th} May 2012.

Q4. What orbit does Envisat use?

Following its launch, Envisat was in a sun-synchronous polar orbit of about 800 km altitude. The repeat cycle of the reference orbit was 35 days.

In order to prolong the Envisat mission past its original planned end date, a set of orbit manoeuvres was performed at the end of October 2010 (user message from 2 November 2010).

After this date, Envisat's orbit was lowered by approximately 17.4 km and the inclination was allowed to drift. The repeat cycle in the new orbit configuration was 30 days.

Q5. What can AATSR data be used for?

AATSR primarily measured SST to the high levels of accuracy and precision required for monitoring and detecting climate change. Together with its predecessors, ATSR-1 and ATSR-2, AATSR established a unique SST dataset spanning almost 21 years (from 1991 to 2012), supporting oceanographic and climate research.

AATSR data can also be used for a number of land surface, cryosphere and atmospheric applications. Further information is available from: http://atsrsensors.org/applications.htm

Q6. If this FAQ does not answer my question, what should I do?

All queries regarding Envisat and AATSR should be directed to the ESA Earth Observation Help Team at https://earth.esa.int/web/guest/contact-us.

If your question relates to a particular problem with an AATSR product, then it may also be worthwhile checking the Product Quality Readme files, available from the SPPA AATSR Product Information webpage.

3. COMMON QUESTIONS FROM NEW USERS

Q7. Where can I find a 'user guide' to receiving and utilising AATSR data?

The AATSR Handbook is available either online or as a PDF download from http://earth.esa.int/handbooks/. Section 1 of the Handbook is designed as a Product User Guide, intended to help users familiarise themselves with AATSR and get started with using AATSR data. This is supported by later sections containing detailed information on the instrument, the products it produces and the algorithms used to generate them. Some Technical Notes have also been produced to accompany the Handbook, also available from the link given above. These provide updated or new information on specific aspects such as algorithm updates and data product detailed content/format descriptions.

Q8. How can I be kept up to date with events that might affect my use of AATSR data?

AATSR Cyclic Reports were made available by ESRIN to keep the AATSR community informed of any modifications to the processor, updates of auxiliary products, instrument anomalies, the status of data acquisition and processing, and the status of the calibration, validation, and quality control activities.

Daily Reports were also produced, providing an overview of the status of the instrument and data processing on each day.

The Cyclic and Daily Reports are still available from the ESA SPPA web site at: https://earth.esa.int/web/sppa/mission-performance/esa-missions/envisat/aatsr/quality-control-reports

See also Question 19. on how to locate information on instrument operations which may affect AATSR data.

ESA also issue Envisat news items at https://earth.esa.int/web/guest/missions/esa-operational-eo-missions/envisat/news and more general User Services news items can be found at https://earth.esa.int/web/guest/missions/user-services-news. These sources would provide information on any future data reprocessings.

Q9. What are the main differences between ATSR-1, ATSR-2 and AATSR?

ATSR-1 measured in the infra-red at 1.6 µm, 3.7 µm, 11 µm and 12 µm and had no visible channels. ATSR-2 and AATSR include the same four infra-red channels of ATSR-1 and three additional channels at 0.55 µm, 0.67 µm and 0.87 µm.

The ATSR-2 instrument was largely the same as ATSR-1, differing only in the inclusion of the extra channels and an on-board visible calibration system.

AATSR was functionally largely similar to ATSR-2, but components were redesigned to match the new platform environment of Envisat. The details of the scan, calibration systems, spatial resolution and swath were kept as close as possible to the earlier instruments to ensure data continuity. The major advantage of AATSR over ATSR-2 was in the downlinking of data. ATSR-2 had restrictions on the amount of data that could be downlinked, due to platform constraints, which particularly affected the visible channels, whereas AATSR could send down data from all the channels continuously at full 12-bit radiometric resolution. This also simplified the data processing for AATSR, since the processor did not have to cope with the wide range of instrument data formats that could be used for ATSR-2.

The specific differences between the ATSR-2 and AATSR source packets are discussed in Section 2.5.2 of the AATSR handbook (see Q7.).

Q10. How can I order AATSR data?

ESA has defined a new Earth Observation Data Policy which was approved by the ESA Earth Observation Programme Board in May 2010. The new data policy applies to the ESA missions, i.e. to **ERS-1, ERS-2, Envisat, GOCE, SMOS, CryoSat** and **future Earth Explorer missions**. It is derived from the full and open access approach established in the Sentinel Data Policy.

More information on EO data distributed by ESA is available at:
https://earth.esa.int/web/guest/data-access/how-to-access-eo-data/earth-observation-data-distributed-by-esa

Further information on accessing EO data can be found at:
https://earth.esa.int/web/guest/data-access/how-to-access-eo-data/how-to-access-earth-observation-data-distributed-by-esa

In their capacity as AO Instrument Provider, BEIS have the right to make and distribute copies of AATSR data for its own use, for use by other funding entities of AATSR and for research groups designated by BEIS. Users with links to BEIS or the other AATSR programme partners should consult their local contacts within these agencies.

Q11. I have used ATSR-1 and ATSR-2 data before – are the contents of the ATSR-1 & 2 products and those from AATSR identical?

A summary of the relationship between the AATSR and ATSR-1/-2 products is given in Section 2.2.3 of the AATSR Handbook (see Q7.).

Information on ATSR-1 and ATSR-2 data in Envisat format is also available in a separate Technical Note: Envisat-style products for ATSR-1 and ATSR-2 data.

Q12. I want to look at data from ATSR-1 and ATSR-2 data as well as from AATSR. How do I get ATSR-1 and ATSR-2 data?

BEIS, NERC and ESA have developed an (A)ATSR series archive in which data from ATSR-1, ATSR-2 and AATSR are reprocessed and stored together in an identical format (the Envisat product format). This is available via the MERCI interface.

Users with approved projects for ATSR data should contact the EO Helpdesk referring to relevant project ID for detailed access coordinates. New users can submit a registration on EOPI (EO Principal Investigator portal). See also Q10.

Q13. Where can I find articles/papers on the exploitation of (A)ATSR data?

The following list provides links to proceedings and publications available online.

MERIS and (A)ATSR Workshops
- ESRIN (15–19 October 2012) http://www.sen3symposium.org/
- ESRIN (22–26 September 2008) http://earth.esa.int/workshops/meris_aatsr2008/
- ESRIN (26–30 September 2005) https://earth.esa.int/workshops/meris_aatsr2005/

Envisat/ERS Symposia; which evolved into the Living Planet Symposia from 2010
- Edinburgh (09–13 September 2013) http://www.livingplanet2013.org/index.asp
- Bergen (28 June – 2 July 2010) https://earth.esa.int/web/guest/document-library/browse-document-library/-/article/esa-living-planet-symposium-7438
- Montreux (23–27 April 2007) http://envisat.esa.int/envisatsymposium/
- Salzburg (6–10 September 2004) http://earth.esa.int/salzburg04/
- Gothenburg (16–20 October 2000 https://earth.esa.int/web/guest/document-library/browse-document-library/-/asset_publisher/lDo6/content/ers-envisat-symposium-4558

Envisat MERIS and AATSR Validation Team (MAVT) Workshops
- MAVT-2006 (20–24 March 2006) http://envisat.esa.int/workshops/mavt_2006/
- MAVT-2003 (20–24 October 2003) http://envisat.esa.int/workshops/mavt_2003/

Envisat Validation Workshop (9-13 December 2002)
http://envisat.esa.int/pub/ESA_DOC/envisat_val_1202/proceedings/

Envisat Calibration Review (9-13 September 2002)
http://earth.esa.int/documents/10174/1591138/ENVI55

ESA Data User Element (DUE) Projects
http://due.esrin.esa.int/

ESA EO PI Projects
https://earth.esa.int/web/guest/pi-community

AATSR PI Team at Leicester University
http://www.leos.le.ac.uk/aatsr/

ATSR Project Web Site – Documentation Section
http://www.atsr.rl.ac.uk/documentation/index.shtml

ESA User Services Library
https://earth.esa.int/web/guest/document-library

Remote Sensing of the Environment Special Issue on AATSR:
http://www.sciencedirect.com/science/journal/00344257/116

A list of scientific literature referencing ATSR data is maintained:
https://earth.esa.int/documents/10174/663411/ATSR_Scientific_Document_Listing

The ATSR Exploitation Board website also gives a list of recent ATSR science publications at: http://atsrsensors.org/publications.htm

Q14. What tools are available for reading AATSR products?

There are some generic tools available from the ESA SPPA Software Tools section (https://earth.esa.int/web/sppa/mission-performance/esa-missions/envisat/aatsr/sensor-description, see lower right hand corner):

- **SNAP/Sentinel-3 Toolbox (following on from BEAM)** consisting of visualisation, analysis and processing tools for the exploitation of SLSTR (and OLCI) data from Sentinel-3. It also supports (A)ATSR Envisat-format products. The tools can be run from an intuitive desktop application or via a command-line interface. A rich application programming interface (API) allows for development of plugins using Java or Python.

EnviView is an old application for Envisat data products that is no longer freely available. If users still have this, note that it is no longer supported.

Most users write their own routines in C, IDL or other languages to read and process AATSR data. The detailed AATSR product specifications (PO-RS-MDA-GS-2009, Volume 7, available at https://earth.esa.int/web/guest/document-library/browse-document-library/-/article/aatsr-product-specifications) will assist with this task.

The providers of a number of COTS image processing packages such as ERDAS, ENVI and Geomatica also planned to extend their products to directly support the AATSR product format. The individual packages/providers should be consulted for details of each tool's capabilities.

There are a number of important concepts associated with the AATSR products that should be understood before trying to read and interpret the data. These are discussed in Section 2.12.1 of the AATSR handbook (see Q7.).

Q15. Why can't one of the recommended tools open my data product?

In the first instance, users should check whether the tool they are using can open the product in question. The two most commonly used tools listed above (Sentinel-3 Toolbox and EnviView) have some restrictions in this regard:

- EnviView only supports data in Envisat format; it will not open NetCDF format products (affecting the L2P/L3U SST and the UOL LST products). EnviView opens AATSR and ATSR-2 products but ATSR-1 products cannot be viewed without modifications to a field within the MPH. For details, contact the EO Help team via https://earth.esa.int/web/guest/contact-us.
- Sentinel-3 Toolbox does not support averaged data products and so will not open (A)ATSR Level 2 averaged data or meteo products (AT*x*_AR__2P and AT*x*_MET_2P). It will open the L2P/L3U SST and the UOL LST NetCDF format products.

If a tool reports an error with an AATSR product it is supposed to be able to read, then the likely cause is that the file has been corrupted somehow. This can be avoided via the following means:

- When downloading AATSR data products, or transferring via FTP, then this must always be done as a binary (not ASCII) transfer.
- If WinZip is used to extract data from a tar archive (compressed folder with extension such as .tar, .tar.gz or .tgz), then ensure the option "TAR file smart CR/LF conversion" is unchecked.

If none of the above resolves the issue with the file, then there may be a problem with the data within the file. In which case, contact the EO Help team via https://earth.esa.int/web/guest/contact-us for further assistance.

4. QUESTIONS ABOUT THE INSTRUMENT

4.1 Instrument Characteristics

Q16. What is the range of nadir and forward view incidence angles for (A)ATSR?

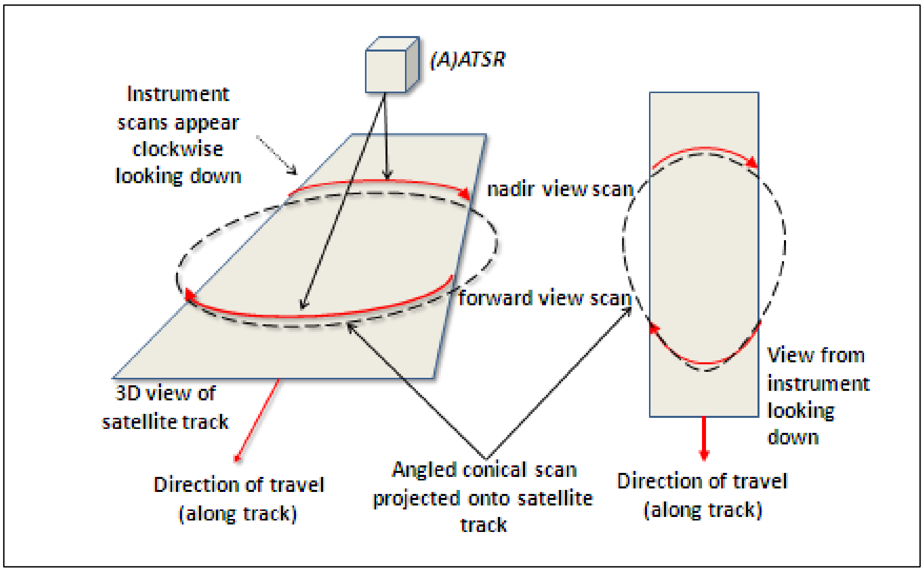
The range of incidence angles between the swath centre and edge was an input to the SST coefficients generation process. The values that are used in the current Radiative Transfer Modelling code, in degrees, are:

- nadir 0.0 (swath centre) 21.732 (swath edge)
- forward 55.587 (swath centre) 53.009 (swath edge)

Strictly the value depends on which instrument is being considered (because the cone angles differ slightly), but in practice the differences are small.

Q17. In which direction did AATSR scan?

The AATSR scan mirror rotated clockwise when viewed from the satellite looking downwards towards the earth. This is clearly illustrated in the diagram below.



Some diagrams of the AATSR instrument may seem to show the scan direction in the opposite sense. Whilst these may seem contradictory, this is actually because such diagrams are drawn from the point of view of looking toward the instrument from outside rather than looking at the earth through the instrument.

Q18. Where can I obtain the full set of AATSR spectral response functions?

There is a link to these data from Section 3.2.1.1.2 of the AATSR handbook (see Q7.)

Q19. How can I obtain information about any interruptions to AATSR data acquisition or identify periods of special instrument operations?

Envisat End of Mission reports were produced for the AATSR instrument, highlighting particular events that took place and giving a summary of AATSR performance throughout the mission. The AATSR Mission Event history and associated periods of special instrument operations are available from the EO SPPA website at: https://earth.esa.int/web/sppa/mission-performance/esa-missions/envisat/aatsr/mission-highlights

The AATSR Events Report is available at:
https://earth.esa.int/documents/10174/437508/Envisat_AATSR_Events_Report.pdf

The AATSR Performance Report is available at:
https://earth.esa.int/documents/10174/437508/Envisat_AATSR_Performance_Report.pdf

Background information on issues relating to AATSR Flight Operations can be found in Sections 1.1.3.2 and 3.2.2.2.1 of the AATSR handbook (see Q7.).

5. QUESTIONS ON DATA PROCESSING AND PRODUCTS

5.1 Data Processing

Q20. Which version of the AATSR IPF was used to produce my data?

The AATSR IPF version number is a field within the Main Product Header of the Envisat data. Volume 5 of the Envisat Product Specification (Product Structures) details the contents of the product headers: https://earth.esa.int/pub/ESA_DOC/ENVISAT/Vol05_Structures_3d_20071122.pdf.

Differences between the various IPF versions, and the date of their introduction, are given in the AATSR IPF Change Log, available from: https://earth.esa.int/web/sppa/mission-performance/esa-missions/envisat/aatsr/products-and-algorithms/processor-releases

Q21. What differences are there between data processed in Near-Real-Time and Off-Line (Consolidated)?

NRT and off-line products were identical except for the auxiliary files used in their production (ref. Section 2.10.1 of the AATSR Handbook (see Q7.)) and coverage. Updates to most AATSR auxiliary files were infrequent, with the exception of the ATS_VC1_AX files containing visible channel calibration coefficients. The version of this file used for NRT processing does not contain the exact coefficients for that orbit. A file from one or two days previous to the acquisition of the orbit in question was used instead. For more information on this, see Section 2.11.2 of the AATSR Handbook (see Q7.). Under normal circumstances VC1 files used for off-line processing should correspond to that orbit (assuming that visible calibration information could be extracted from the L1b product). NRT data were also processed with predicted rather than restituted Orbit State Vectors, but this does not have a significant effect on geolocation/colocation for AATSR.

Q22. Is there a repository of known problems with the AATSR data processing/products that can be consulted before raising queries with the helpdesk?

Product Quality Readme files addressing issues affecting AATSR product quality are published on the SPPA AATSR Product Information webpage.

Q23. What value of cone angle was used to define the edge of the swath air mass when the AATSR SST coefficients were derived? Could differences in this parameter between datasets explain discrepancies in retrieved SST?

The auxiliary file of SST coefficients used by the Level 2 processor includes distinct coefficients for each of 38 across-track distances. The process by which these 38 sets of coefficients are generated involves first deriving two sets of coefficients, for the swath centre and swath edge, and then computing intermediate values by linear interpolation with respect to air mass. (Here the air mass refers to the normalised length of the atmospheric path traversed by the line of sight - essentially the secant of the angle of incidence at the pixel.)

The air mass at the swath centre is unity (that is the normalisation), but that at the edge depends on factors such as the cone angle of the AATSR scan and the satellite height.

A study of the sensitivity of the edge of swath air mass to changes in the cone angle and the satellite height has been conducted. In general, the results are very insensitive to cone angle; satellite height is a slightly more significant parameter, but as it varied around the orbit there is not much that can be done about it other than to use a suitable average value.

Further details can be obtained from the AATSR Expert Support Laboratory team at RAL (initial contact to be made through https://earth.esa.int/web/guest/contact-us).

Q24. What visible channel calibration corrections have been applied to my data?

Different modifications for the visible calibration have been implemented in the operational processing since launch. Briefly, these include a non-linearity correction for the 1.6 micron channel (introduced by updating the ATS_GC1_AX auxiliary file in 2004), and several versions of a drift correction for the visible channels.

The corrections for the visible channel calibration drift which were applied during operations were not the best representation of the instrument behaviour. Instead, a look-up table containing actual drift values and a set of instructions and tools on how to apply these have been produced. These, and further information, can be found at: http://www.aatsrops.rl.ac.uk/PERFCAL/OtherInfo/

This table of measured drift values was used in the visible channel corrections applied during the third reprocessing of AATSR data. See the INTRODUCTION for further details on the third reprocessing.

Q25. Are there any other corrections to be applied to the data?

A discrepancy within AATSR's 12 μm channel has been characterised since the completion of the third reprocessing. User recommendations and a Technical Note (PO-TN-RAL-AT-0562) containing empirical correction values are available: https://earth.esa.int/documents/10174/663411/AATSR_12micron_User_Recommendations

Note that the L2P and L3U third reprocessing products already contain a correction for this discrepancy, so no further processing needs to be carried out on them.

Q26. What is known about the calibration of the AATSR 3.7 and 11 micron channels?

As part of the investigation into the AATSR 12-micron anomaly (see Q25.) the calibration of the 3.7 and 11 micron channels was also considered. Results for simulated and observed BT differences for the 3.7 and 11 micron channels are shown in Figure 1 as a function of total column water vapour (TCWV).

For the 3.7-micron channel, the results are outside the expected uncertainty for such a comparison (0.1 K) and a notable dependence on TCWV is seen. Additional analysis (not shown) looking at each sensor individually suggests the disagreement is due to a calibration error with the ATSR-2 3.7-micron channel. During the ATSR-2 pre-flight calibration an unexpected non-linearity was observed with the 3.7-micron channel and a spectral shift was introduced to minimise the effect (see Smith *et al.,* Test and Calibration of the Along Track Scanning Radiometer 2, ER-RP-OXF-AT-2001, Issue 2, 21st December 1993).

For the 11-micron channel the results for both views are within the expected uncertainty (0.1 K) and no notable TCWV dependence is seen.

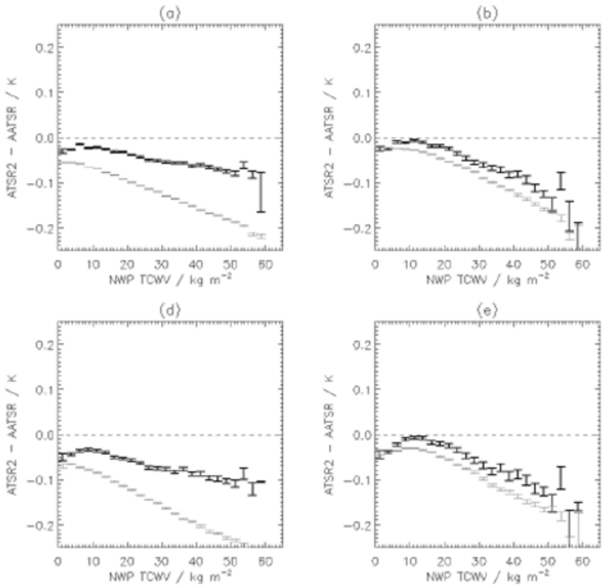


Figure 1. Simulated (grey lines) and observed (black lines) difference between colocated AATSR and ATSR-2 brightness temperatures for (a) nadir 3.7 micron, (b) nadir 11 micron), (d) forward 3.7 micron) and (e) forward 11 micron) as a function of total column water vapour.

5.2 Products

Q27. How do I interpret the information in the filename of my AATSR data?

This is explained in Section 2.2.1 of the AATSR handbook (see Q7.). Volume 5 (Product Structures) of the Envisat Product Specification (see Q28.) also addresses this and other issues related to Envisat product conventions.

Q28. Where can I find information on product specification?

Envisat Product Specification documents that may be of use to AATSR users are listed below and are contained within the ESA library and from https://earth.esa.int/web/sppa/mission-performance/esa-missions/envisat:

- Volume 1: Introduction
- Volume 2: Overview of Instruments
- Volume 3: Product Terms and Definitions
- Volume 4: Products Overview
- Volume 5: Product Structures
- Volume 6: Level 0 Products Specifications
- Volume 7: AATSR Products Specifications
- Volume 16: Auxiliary Data Files
- Volume 17: Extracted Instrument Headers
- Annex A: Product Data Conventions

Volume 7 contains details of L2P and L3U SST products but not UOL LST products. The User Guides for these NetCDF products also contain product specifications:

  - L2P and L3U SST: L2P_Product_Description

- UOL LST: ATSR_UOL_LST_L2_User_Guide_v1-0

Q29. Why does my AATSR image appear to contain negative temperatures?

Small negative values (-1 to -8) are 'exception values' used to flag errors and other special conditions in the data. These are listed in Sections 2.6.2.1.1 of the AATSR Handbook (see Q7.) for L1b data.

Q30. Why can some instances of exception values (-999999) rather than zeros be seen in the topographic correction fields in a clear sea image?

Most topographic correction tie points over sea are set to zero (as the sea is at sea level). However, exception values (notably –999999) can arise in the current algorithm if no pixel at a given across-track position regrids to a particular topographic correction tie point. This occurs because there is no cosmetic fill in the topographic correction and the array is initialised to –999999 before calculations commence.

Q31. Why does the orbit number in the filename of AATSR data files claiming to be over a particular location sometimes differ from the orbit number returned by software tools or other instrument products for the same location?

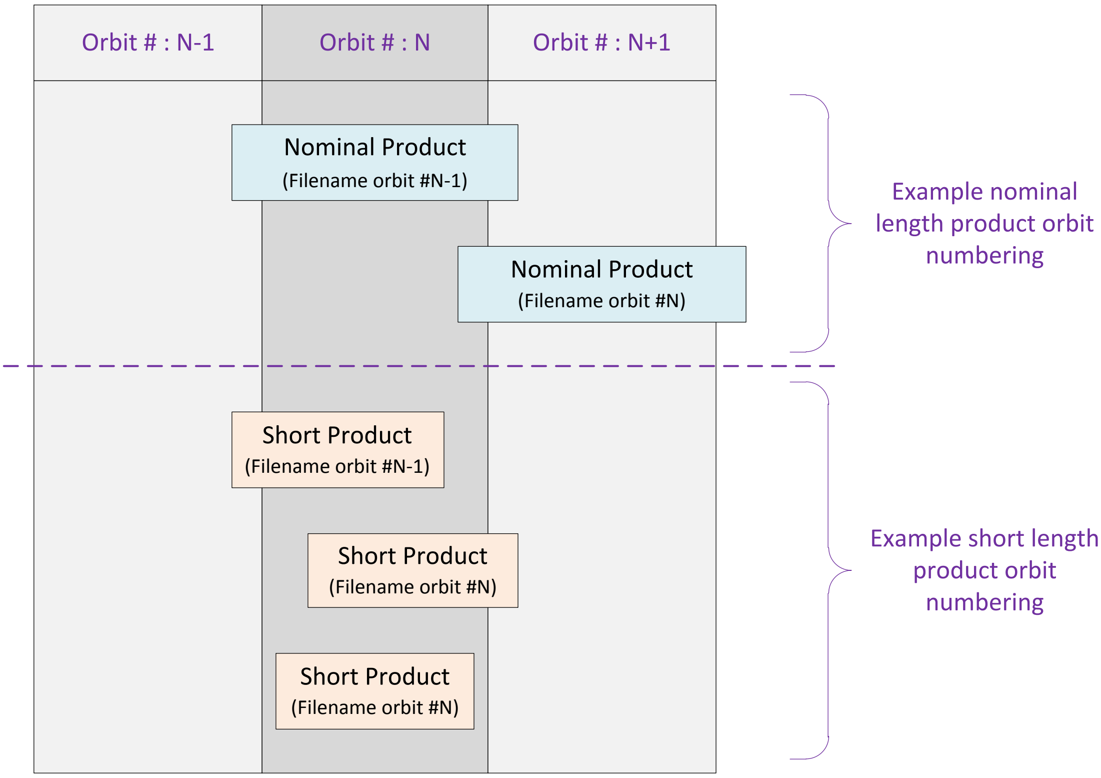
The orbit number in the product file name is that in which the first data contributing to the product falls. This was not a problem for NRT data, as NRT products are not expected to begin exactly at ascending node crossing point (ANX).

However, in the case of consolidated data (orbits defined from ANX to ANX), the first data records usually precede the ascending node, and so the product is named with an orbit number one lower than one might expect.

Taking the following file as an example:
ATS_TOA_1PRUPA20040605_001218_000065272027_00259_**11836**_4472.N1

The start of data (00:12:18, 5 June 2004) is very close to, but before, the ascending node at the start of absolute orbit 11837 (00:14:48, 5 June 2004). Therefore, although the product predominantly represents orbit **11837**, the start of data falls within the preceding orbit and so the filename contains the orbit number **11836**.

This is further illustrated in the diagram below:



This is of particular importance when identifying which data products to order by querying a catalogue such as EOLI-SA.

To be absolutely safe, one should never rely on just the orbit number to identify AATSR data, instead date and time information should be used to ensure the product identified contains the desired data.

Q32. How do I remove overlap between successive consolidated products?

A fully consolidated complete orbit of (A)ATSR data should run from the ascending node crossing point (ANX) to the next ANX one orbit later; the ANX point is the location at which the satellite transits the Earth's Equator in the South to North direction. Successive consolidated full orbits of (A)ATSR data may contain measurements from the immediate orbits before and after. This is due to the dual-view nature of the (A)ATSR instruments meaning there is a timing difference that needs to be corrected between the nadir and forward views to correctly align them in the final product.

Two methods are suggested to remove the extra data:

1. ANX detection

In this approach the user can detect the location of any ANX points by identifying where the latitude changes from negative to positive at the centre of the swath. Three possible outcomes are (i) two ANX positions are found, (ii) only one ANX position is found or (iii) no ANX positions are found. For case (i) the user should reject data before the first ANX and after the second ANX. For case (ii) the product is missing data at either the beginning or end. In this case the user should look at the line number within the orbit. If the line number for the ANX is < 2000 then this means the user should reject data before the ANX position; if not, then the user should reject data after the ANX. Note: It is theoretically possible to have a very short orbit where the first data is just before the 2nd ANX position. However, no such products are to be found in the archive. For case (iii) all data lies between the two ANX points so no rejection is needed.

2. ANX time lookup

In this approach the user can use an external file of ANX transit times, and remove any data with a time flag outside the acceptable time range for each orbit (defined as greater than or equal to the ANX time for the orbit to less than the ANX time for the subsequent orbit). ANX time files for the operational segments of the satellites are available for ENVISAT: http://tinyurl.com/hsrj5uv, ERS-2: http://tinyurl.com/zs7zjgj, ERS-1: http://tinyurl.com/gwln4uv. It should be noted that the Mission orbit number within these files does not always coincide with the Product orbit number, for the reason stated in Q31.

Q33. When comparing the AST product with the average of the full resolution (GST) product, differences are observed that correlate with differences between the two calculations in respect of the number of pixels that contributed to the average in a given cell. Which average is correct?

There is no unambiguous answer to this. Both the AST and GST products are derived from the same set of L1b data, just using different algorithms, so they are, in effect, both 'right'. The real issue is the exact definition of the 'number of pixels' field in the AST product.

The field of the AST record designated 'Number of pixels in dual view average' contains the smallest of the numbers of pixels contributing to the averaged brightness temperatures (in the 11 and 12 micron channels and in the nadir and forward views) that were used in the SST retrieval.

In an ideal world the same number of pixels would contribute to each of the averaged brightness temperatures in the cell, and this number would appear in the field, but in practice the numbers may differ for different channel/view combinations. In particular, although the numbers of 11 and 12 micron values contributing are likely to be the same in each view, the nadir and forward views may differ because of missing scans, for example. As the number of pixels is supplied as an indicator of SST quality, the smallest is chosen. Similarly the field 'Number of pixels in nadir-only average' would contain the smaller of the numbers of pixels in the 11 and 12 micron averages where these differ. The 3.7 micron channel numbers are ignored because this channel may or may not contribute to the SST retrieval.

Q34. There appears to be something wrong with my calculations when I use the values for visible channel bandwidth in ATS_PC1_AX as defined in EnviView and the Envisat Product Specifications.

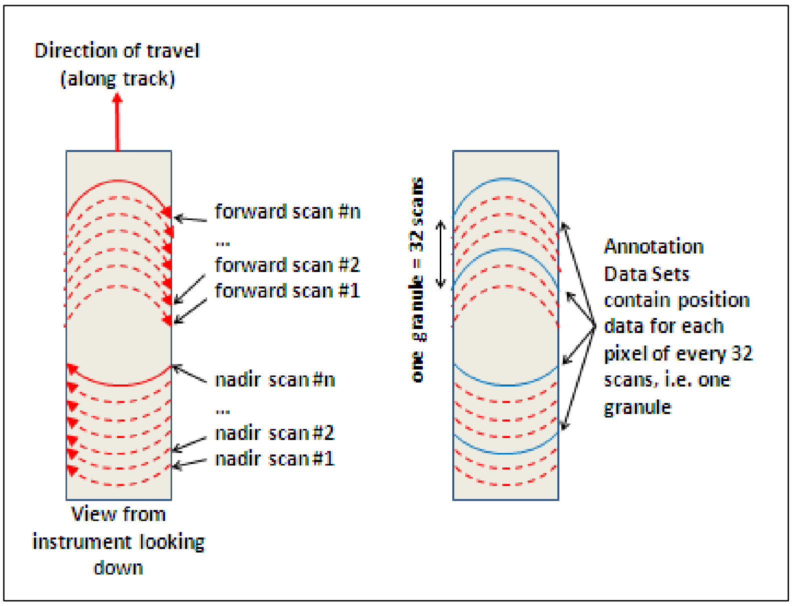
The units for the visible channel bandwidth in the IODD, in the Envisat Product Specifications and in EnviView are given as microns, but the actual numerical value is in nm.

Q35. What are the units for integrated solar irradiance values in the visible channel calibration auxiliary file ATS_VC1_AX and in the GBTR VISCAL GADS, as they do not appear anywhere in the documentation?

The units for the integrated solar irradiance values are microwatts/cm^2.

Q36. What is the relationship between the contents of the geolocation ADS and the latitudes and longitudes of the pixels in the MDSs of the AATSR gridded products?

The geolocation ADS contains position data for each pixel within every 32nd scan (where a block of 32 scans is termed a "granule"); see the diagram below for a visual representation:



To obtain the positions of the pixels in the intervening scans, information within the geolocation ADS needs to be interpolated. Instructions on how to do this can be found in the AATSR Technical note entitled "Interpolation of Pixel Geolocation in AATSR Full Resolution Products" referenced in Section 2.12.1.3.1 of the AATSR handbook (see Q7.). The contents of this note are also contained in APPENDIX A of this FAQ.

Visualisation software will usually automatically apply this step so that each imaged pixel has a position associated with it.

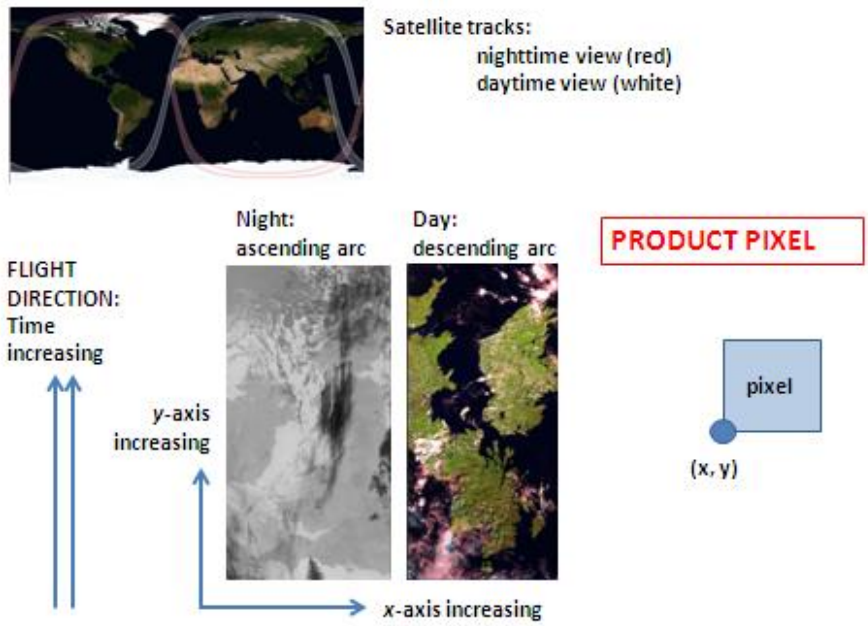
Q37. Do the resulting across-track co-ordinates associated to each pixel after interpolation refer to the left-hand edge of the pixel? Similarly, do the along-track tie points refer to the centre of the pixel or to one pixel edge (i.e. does the line of tie points go through the centre of the associated line of pixels in the image)?

The pixel co-ordinate resulting from the interpolation (as described in the technical note referenced above in Q36.) corresponds to the lower left corner of the pixel within the gridded product.

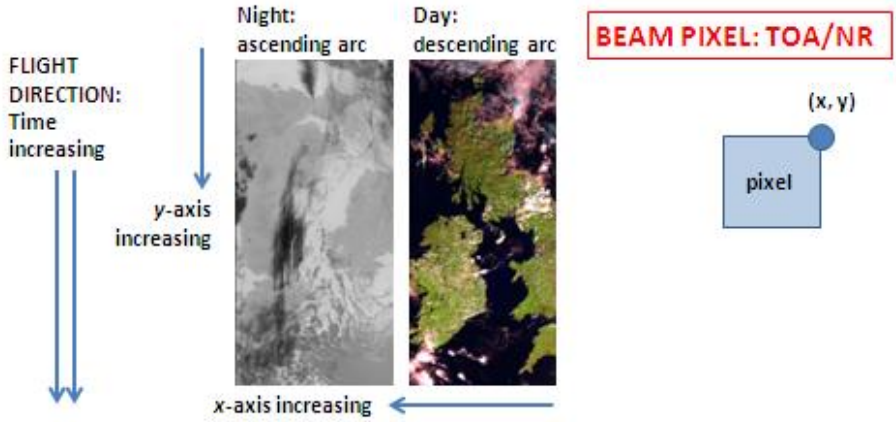
In the across-track direction the co-ordinate corresponds to the left-hand edge, while in the along-track direction, the sampling of the tie points is such that the tie points correspond to the lower edge of the pixel (i.e. the edge corresponding to the lower *y* co-ordinate).

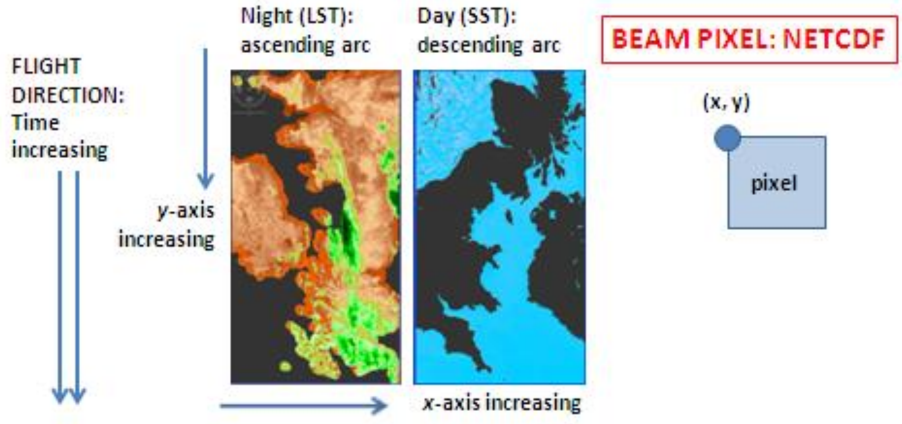
Note that the Cartesian *x* and *y* co-ordinates used for AATSR are instrument related and are measured in the across-track and along-track directions, respectively. The *x*-axis is at right angles to the satellite ground track, and the *x* co-ordinate increases towards the right (looking forwards from above). The *y*-axis is parallel to the satellite direction of motion, and the *y* co-ordinate increases in the forward direction.

The diagram below shows how the resulting interpolated co-ordinates relate to the pixel within the gridded product; it gives examples for both night-time and daytime views of the British Isles, and clearly demonstrates the axes of increasing *x* and *y*, and the flight direction. Thus, the co-ordinates are placed at the lower left corner of the product pixel.



However, users need to be aware that visualisation software may automatically invert the gridded product to provide a user-friendly display in the daytime view, and then take this into consideration when associating co-ordinates with the pixels in such an image. The diagrams below show the default displays within BEAM (this will be switchable within the S-3 Toolbox) for the TOA and NR Envisat-format products, and for the NetCDF products. Note the changed directions of increasing *x* and *y*, and the subsequent altered placement of the interpolated co-ordinates in the pixel imaged in the software.





Q38. What are the consequences of the curved-swath instrument data being transferred onto a quasi-Cartesian grid?

The transfer of curved-swath instrument data, in two different views and retrieved at different times, to a quasi-Cartesian 1 x 1 km gridded product with colocated nadir and forward views necessitates a certain amount of data processing, since the sampling and spatial resolution of AATSR does not match the required grid. The main consequences of the transfer of the measured instrument data to the gridded product are as follows:

- A nearest-neighbour approach to remapping means that the original instrument measurement **value** is retained in the gridded product but it is shifted with respect to its true position.
- The nearest-neighbour approach results in many unfilled pixels in the forward view; these are then *cosmetically filled* by neighbouring pixel data. Therefore, a 1-km gridded pixel value does not always represent actual measured data; see Figure 2 (right) which shows the forward-view measured data on the gridded product. The cosmetically filled pixels have been blacked out, which reveals the true sampling of the forward view when viewed on a 1-km grid.
- Since the instrument pixel size and field of view is much larger in the forward view than in the nadir view, due to the oblique angle of sight for the forward view, any identified feature will be smeared, or blurred, over a larger number of 1-km pixels in the forward view than in the nadir view; see Figure 2 and compare the nadir-view image (left) with the forward-view images (centre and right). When users are comparing nadir data with forward data, these characteristics need to be taken into account.

Figure 2. Lough Neagh, Northern Ireland. Left: nadir view; centre: forward view; right: forward view with cosmetically filled pixels in black

Q39. Can the instrument co-ordinates be regenerated from the gridded product?

Yes. A TN is available describing the steps needed to determine the instrument pixel co-ordinates, and measurement times, using information within an AATSR TOA L1B gridded product:

http://earth.esa.int/pub/ESA_DOC/ENVISAT/AATSR/Instrument_Pixel_Coordinates_and_Measurement_Time.pdf.

The Level L1B Characterisation (CH1) auxiliary data file is also needed in order to determine the first pixel numbers of the nadir and forward scans, and is available at https://earth.esa.int/web/sppa/mission-performance/esa-missions/envisat/aatsr/products-and-algorithms/products-information/aux.

The interpolation technique using the method in APPENDIX A is also then required, using the new geolocation ADS (pixel position data for every 32 scans) that has been generated for the instrument co-ordinates. This interpolation thereby results in the regeneration of instrument co-ordinates for all pixels.

Key points to note:

- The instrument pixel co-ordinates derived using the TN above are referenced to the instrument pixel centre (this is not explicit in the TN). An additional conversion step may be required to convert the reference to the lower left corner (or other position, depending on viewing software; see Q37.).
- The gridded product contains cosmetically filled pixels (as explained in Q38.), and so regenerating instrument pixel co-ordinates will reveal the true sampling characteristics of the instrument.
- Third reprocessing AATSR products are longer than one standard full orbit (measured from equator to equator). They continue with empty pixels for several minutes after passing the equator in the ascending node. (This can be seen in the satellite ground track diagram in Q37.) Users should note that ADS metadata is available for both views within the standard full orbit, and the next sequential product should be used once the equator has been passed in the ascending node.
- The field of view of all AATSR measurements extends into neighbouring pixels (see Section 2.12.1.7 of the AATSR handbook,Q7.), therefore care should be taken when conducting analysis on instrument co-ordinate data, or on gridded products, on the pixel resolution (~1 km) scale.
- The regeneration of instrument co-ordinate data may reveal pixels where data was lost in the transfer to the gridded product and unfortunately these cannot be regained. These will be mostly apparent at the centre of the swath in the nadir view. The next (fourth) reprocessing of AATSR data will retain this information in the output products.

Q40. In EnviView and the Formats section of the AATSR handbook, why are there three different fields (one in the Meteo product and two in the AST product) all called "pix_nad"? How do these relate to the fields pix_ss_nad and clpix_ss_nad in the AST product?

The short field names, such as pix_nad, used in EnviView and the Formats sections of the AATSR handbook (see Q7.) have not been assigned uniquely; the same names have been used, in different products and MDS, for different things.

The data definition document for the AATSR processing software defines a unique parameter ID for each AATSR product field. The unique parameter names of the values referred to are as follows:

Product	Parameter ID	EnviView name
Meteo	[ECM-MDS1-8]	pix_nad
AST	[AST-MDS3-8]	pix_nad

Product	Parameter ID	EnviView name
AST	[AST-MDS15-7]	pix_nad
AST	[AST-MDS15-8]	pix_ss_nad
AST	[AST-MDS15-9]	clpix_ss_nad

The Level 2 processor generates the averaged brightness temperatures by averaging all of the valid image pixels from the Level 1b product that fall in each 10 arc minute cell. Image pixels in the Level 1b product are classifiable into three mutually exclusive types: NATURAL, COSMETIC, and UNFILLED; every pixel is one of these types, and this classification is purely geometrical, and independent of whether or not the pixel contains valid data in any channel.

Essentially, NATURAL pixels are those to which a measured instrument pixel has been mapped during regridding (the majority of image pixels should be of this type.) A pixel to which no instrument pixel maps during regridding is either COSMETIC or UNFILLED. A COSMETIC pixel has been filled by the cosmetic fill algorithm; it will have at least one natural pixel as a neighbour. Otherwise the pixel is UNFILLED.

In the BT/TOA MDS, the quantity [AST-MDS15-7] (pix_nad) is the total number of filled (i.e. NATURAL or COSMETIC) pixels in the 10 arc minute sub-cell, regardless of whether or not the brightness temperatures are valid. Similarly [AST-MDS15-8] (pix_ss_nad) is the number of filled pixels that are over sea, and [AST-MDS15-9] (clpix_ss_nad) is the fraction of these that have been flagged as cloudy. (Since the cloud clearing algorithms depend upon the pixel data, the last of these quantities has some dependence on whether or not the pixel data is valid.) [AST-MDS15-7] (pix_nad) should equal [AST-MDS15-8] (pix_ss_nad) if the sub-cell is entirely sea, but not if it is intersected by coastline.

The quantities [ECM-MDS1-8] and [AST-MDS3-8], both designated pix_nad in EnviView, are identical; that in the Meteo product, [ECM-MDS1-8], is a copy of [AST-MDS3-8]. They represent the number of valid pixels that contribute to the nadir SST in the cell. This number cannot exceed, but may be less than, pix_ss_nad, since some of the filled sea pixels may contain invalid data. Its detailed definition is the smaller of the number of valid pixels that contribute to the averaged brightness temperatures at 11 and 12 microns; this definition reflects the theoretical possibility that a given pixel might have a valid BT in one channel but not in the other, although this is unlikely over clear sea.

Q41. Why is the forward/nadir view sometimes missing at the start/end of the products when the other one is present?

AATSR products are generated from instrument source packets, each of which contains a single scan incorporating both nadir and forward view pixels. As such a product will start with a nadir view portion of the scan. The forward view data from the same scan is offset by approximately 1000 km hence the forward view data appears to start after the nadir view data (in terms of ground location). Likewise at the end of the product, the nadir view ends at the geographical point contained in the scan from the last contributing source packet, and the corresponding forward view data appears to continue for approximately 1000 km.

Q42. Why do pixel exception values and corresponding confidence flags appear to be set in some visible channel data at night?

At night, noise in the visible channels cannot be distinguished from pixel exception values, and can therefore be masked into the confidence flags. This is not strictly an error in the AATSR processing scheme, but rather an unexpected result of adopting the ATSR-

2 processing scheme for AATSR (ATSR-2 visible channel data were not available at night).

The AATSR pixel exception values are small negative numbers (ranging from -1 to -8). At night, the noise in the visible channels can mimic these exception values, so that the interpretation of negative visible channel reflectances is ambiguous. Also, because the confidence flags are derived from the union of the exception values across all channels, this can cause the confidence flags to be wrongly set. Note that the latter effect affects any user who is using the confidence flags to filter the data, regardless of whether the user is interested in the visible channels or not.

Users are advised to take note of this effect and to take into account these effects if using the confidence flags or visible channel reflectances in night-time data.

Q43. Why does NDVI appear to be generated for night-time data (when there are no valid visible channel data)?

This is also due to the presence of noise in the visible channel data at night.

NDVI values are calculated whenever visible channel data are present, and as visible channels were present in the AATSR telemetry at all times, the NDVI is calculated for both day and night data. There is no trap for night-time data.

However, at night, the visible channels are dominated by noise, making these NDVI values essentially meaningless. Users are therefore advised to disregard the values in the AATSR NDVI field at night.

Q44. How can I ensure that I do not include any data from non-nominal instrument operations such as outgassings and blackbody crossover tests?

The acquisition date of the data product in question can be cross-checked against the instrument operations at the time; a comprehensive list of outgassing periods and times of blackbody crossover tests (along with other operations and unavailabilities) can be found at the RAL AATSR Ops site: http://www.aatsrops.rl.ac.uk/status.html and the EO SPPA AATSR site: https://earth.esa.int/web/sppa/mission-performance/esa-missions/envisat/aatsr/mission-highlights (see Housekeeping Activities and Non-Nominal Data Periods).

After the third reprocessing, products generated during non-nominal instrument operations have been placed within clearly-marked segregated sections of the archive (since their quality cannot be guaranteed). Therefore, products within the main archive are unaffected by any known quality issues.

Q45. Why do pixels in the nadir and forward view appear to be offset from one another?

Previous assessments of the AATSR colocation (meaning co-registration between the nadir and forward views) showed that the forward view was shifted in relation to the nadir view by around 3 pixels in the along-track direction and by around 1 pixel in the across-track direction. A correction for this was identified and incorporated into a modified CH1 auxiliary file. All data products from the third AATSR reprocessing incorporate this improvement, with an average shift of 1 pixel in the along-track direction still existing. (See the INTRODUCTION for further details on the third reprocessing.) There will be measures contained within the fourth AATSR reprocessing to improve this further.

It should be noted that the geolocation, and hence the colocation, of the instrument pixels is dependent on several input parameters, including the satellite orbit. Small errors in assumptions about the yaw, pitch and roll of the spacecraft translate to relocation errors. This is particularly true for the along-track view where, due to the high view-zenith-angle, there is a greater sensitivity to pointing errors.

See Q38.for further information on geolocation and colocation in the context of dual-view curved swath instrument data.

Q46. Why do the co-ordinates from my AATSR data not match with reference data for the same point?

Comparisons with other data (GlobCover and MERIS Full Resolution, which have both been independently assessed to be accurate to the order of 150 m) showed evidence of a systematic AATSR geolocation offset of 1 AATSR pixel along track and 1 AATSR pixel across track. There was no evidence of variation around the orbit.

Subsequent modifications made to the CH1 auxiliary file (see Q45.) incorporated a 1x1 pixel shift in order to improve the absolute nadir geolocation of AATSR products. All data products from the third AATSR reprocessing incorporate this improvement. The AATSR nadir geolocation accuracy for third reprocessing data is to within 1 km (1 pixel). (See the INTRODUCTION for further details on the third reprocessing.)

The third reprocessing improved the AATSR geolocation performance to within 1 km; future activities may aim to improve this to a sub-pixel scale assessment and define further improvements thus identified.

Q47. Why do the following problems occur with the AATSR NR product LST retrieval?

Known problems with the AATSR NR product LST retrieval are listed below. Users are encouraged to access the LST dataset now available in NetCDF format, as this contains LST data of higher quality (see Q48.).

Poor cloud clearing

The current AATSR cloud clearing scheme is optimised for use over oceans and its performance cannot be guaranteed over land. Land pixels may be wrongly flagged as cloud and, prior to the introduction of IPF v6.0 (see Q20. for IPF version information), when a pixel is flagged as cloud no LST retrieval is applied. Instead, pixels flagged as cloud were set to Cloud Top Temperature in the nadir view field (filled with 11 µm BT as a placeholder) and Cloud Top Height in the combined view field (set to zero, as a placeholder).

With IPF version 6.0 onwards, the approach was adopted of always performing LST retrieval, regardless of the contents of the cloud flag, and land pixels which were identified as cloudy are defined as being marginal cloud, with the Level 2 cloud flags modified to indicate such pixels.

As well as retrieving LST for cloudy land pixels, improvements to the cloud flagging were also introduced. Briefly, these were to implement the gross cloud test over land; to disable the spatial coherence test over land; to implement a test using the visible channels, based on NDVI; and to define a snow test based on NDSI.

Further information on the changes made with IPF v6.0 is available from the Technical Note “IPF Improvements in Land Surface Temperature Retrieval and Cloud Clearing over Land”, which accompanies the AATSR Product Handbook:
http://envisat.esa.int/handbooks/

A "blocky" appearance with discontinuities at surface classification cell boundaries.

No spatial smoothing of the LST has been included in the current implementation of the LST algorithm. Therefore the outline of the 0.5 degree cells used in the underlying land surface type classification map may be visible in the retrieved LST field. While there may be merit in using an interpolation scheme to smooth such discontinuities at the cell boundaries, it might also distort the land surface temperatures in an unquantifiable way so has not been included in the current LST algorithm.

No Lake Surface Temperature retrieval

IPF version 6.0 also introduced changes to the LST retrieval over lakes. Prior to this, as most large and medium-sized lakes are flagged as sea in the Level 1b land/sea mask, SSTs were calculated over these regions and the lake surface temperature calculation was never invoked despite the land surface type file containing a class for lakes and lake surface temperature coefficients being included in the coefficients set.

With IPF v6.0, the Level 2 algorithm was modified so that the surface type mask is interrogated for each sea pixel, to detect cases where the pixel is identified as sea by the land/sea flag but is shown as inland water in the surface type file. A new flag, extended land, has been defined to include these "sea" pixels which are lakes as well as land pixels. The LST algorithm is then applied to all pixels flagged as extended land.

Problems with the calculation of LST in coastal regions

Clear land pixels over validation sites close to the coast have been seen to contain the 11 micron BT, rather than LST. This occurs where pixels are identified as land in the Level 1b land/sea mask, but are flagged as sea in the Level 2 LST surface type file used by the LST algorithm.

An AATSR pixel is identified as land or sea during Level 1b processing with reference to the AATSR land/sea mask. This is an auxiliary file classifying points on the Earth's surface as land or sea at 1 km resolution. When a Level 1b product is presented for processing to Level 2, the SST retrieval algorithms are invoked for pixels flagged as sea and the LST/NDVI algorithms are invoked for pixels flagged as land. As part of the Level 2 LST algorithm land pixels are then further categorised into 13 biomes with reference to a land surface type file.

The Level 2 land surface type file is provided at 0.5 degree resolution. All of the AATSR (1 km) pixels that fall within each 0.5 degree cell are deemed to be either land (including lakes) or sea according to the surface type associated with these cells. However, it is possible for some 0.5 degree cells that cross the boundary between land and sea to be classified as sea when they also contain land. For these cells no surface type or biome is defined for the land pixels that they contain. In this instance the LST algorithm is unable to make a valid LST retrieval; it therefore fills the pixel with the 11 micron BT and sets the pixel status to invalid in the confidence word. [Note that bits 0 and 2 in the confidence word are currently labelled "Nadir-only SST is valid" and "Dual-view SST is valid" respectively, but they are also applicable to LST. They should really be re-named "Nadir field is valid" and "Combined field is valid".]

Average LST retrieval in the AST product

With IPF v6.0, the Level 2 processing has been upgraded to calculate the averaged LST in the AST product (ATS_AR__2P) There is no change required to the product format; the averaged LST replaces the 11 micron BT that was previously used as a placeholder in this LST field.

Q48. Are there any other AATSR LST data available?

The AATSR third reprocessing dataset incorporates LST products in NetCDF format generated by the University of Leicester. See ESA news from 19 June 2014 for details and user guide.

With regard to the problems raised in Q47., the new LST dataset incorporates the following improvements:

- Cloud clearing: a probabilistic cloud identification algorithm has been used, thereby improving cloud masking.
- Blocky surface classifications: the use of improved high-resolution auxiliary datasets has removed these features.
- Lake surface temperature: the improved auxiliary datasets now enable a clear demarcation of inland water, so that the lake surface temperature retrieval is more consistent.
- LST in coastal regions: the high-resolution auxiliary data more accurately flags the land and sea in the coastal regions, therefore sea pixels are not treated as land pixels.

LST are generated for all available non-ocean pixels. An uncertainty associated with each measurement is contained within this dataset, along with a quality flag. Users are advised to apply the Version 3 (probabilistic) cloud mask (where QC bit value of 16 is set) for best LST quality. Furthermore, LST where the corresponding uncertainty is greater than 2.0 K should be treated with caution.

Q49. Where can I find examples of AATSR Level 3 products?

Details of all AATSR products and how to obtain examples can be accessed from https://earth.esa.int/web/guest/data-access/browse-data-products.

Q50. Why does the archive of AATSR data start where it does?

The AATSR archive originally contained data for the operational phase from July 2002 to April 2012. Although Envisat was launched in March 2002, AATSR had to be thoroughly tested, completing what is known as its commissioning phase, before the quality of the data it was acquiring could be assured.

After the third reprocessing, data from the commissioning period was added to the archive of available data, and the archive now starts from 20 May 2002. However, products from data acquired before 22 July 2002 23:42 UTC are segregated, since the quality of this data cannot be guaranteed. It is therefore recommended that any such data are treated with caution.

Q51. Why can't I process my entire AATSR Child Product?

For users who are in receipt of child products that were generated by submitting an order via EOLI, a known problem existed, such that the number of Annotation Data Set (ADS) records included with the child product was not sufficient to process the entire child product. This meant that ADS information could not be interpolated for the last record and so the last granule of the MDS could not be processed. To circumvent this problem, users were advised to order child products one granule (32 rows) longer than they needed in order to include an extra ADS record so that information was present for the entire region of interest.

Note that this workaround applied to all ADS records apart from the Summary Quality (SQADS) and Scan Pixel X and Y ADS as these are not provided on a per-granule basis. If the user requires the information from these particular ADSs for their purposes, then they are advised either to order the parent (full orbit) product, or contact the EOHelp team at https://earth.esa.int/web/guest/contact-us for advice on how to proceed.

Users who have received MERCI-generated child products should not encounter this problem, but are advised to contact the EOHelp team if similar problems do occur.

APPENDIX A INTERPOLATION OF PIXEL GEOLOCATION IN AATSR FULL RESOLUTION PRODUCTS

A.1 Introduction

The AATSR full resolution products are the Gridded Brightness Temperature and Reflectance (GBTR) product ATS_TOA_1P, and the Gridded Surface Temperature (GST) product ATS_NR__2P. In both of these products the information from which the geolocation of the image pixels can be determined is given in an Annotation Data Set (ADS), the Grid Pixel Latitude and Longitude and Topographic Corrections ADS.

This note sets out the method of interpolating the latitude and longitude values from the ADS to give the co-ordinates of the image pixels in these products.

A.2 Notation

The notation used in this document is summarised below:

i_g	index to tie rows (or ADS records)
j_g	index to tie point pixels (j_g = 0, 22)
i	index to records (or image rows)
j	index to image pixels (j = 0, 511)
$\varphi_g(i_g,j_g)$	tie point latitude
$\lambda_g(i_g,j_g)$	tie point longitude
$\varphi(i, j)$	image latitude
$\lambda(i, j)$	image longitude
w_x	interpolation weight in x
w_y	interpolation weight in y
φ_1, φ_2	intermediate latitude value
λ_1, λ_2	intermediate longitude value

A.3 X and Y Co-ordinates

The Cartesian *X* and *Y* co-ordinates used for AATSR are instrument related and are measured in the across-track and along-track directions respectively. The *X* axis is at right angles to the satellite ground track, and the *X* co-ordinate increases towards the right (looking forwards from above). The *Y* axis is parallel to the satellite direction of motion, and the *Y* co-ordinate increases in the forward direction.

A.4 Product Structure

The Measurement Data Sets (MDS) of each full resolution (GBTR or GST) product consist of a series of pixels arranged on a rectangular grid. Each record of the product contains 512 pixels in a line across track, at a sampling interval of 1 km. Let the records in the MDS be numbered by i (i = 0, 1, 2, …) and let the pixels in each record be indexed by j (j = 0, ... 511). The pixels in each record are arranged in order of increasing X co-ordinate, and so the X co-ordinate of the pixel indexed by j is

$$X = (j - 256) \text{ km.} \quad (1)$$

(As in the case of ATSR-2, a pixel can be thought of as a small quadrilateral, and its nominal co-ordinates are those of its lower left hand corner, and so this co-ordinate refers to the left-hand edge of the pixel.)

The along-track co-ordinate $Y(i)$ of the pixels on record i is specified on the record, in the field designated 'image scan y co-ordinate', in units of metres. The increment $Y(i + 1) - Y(i)$ is approximately equal to 1 km, but varies around the orbit owing to the equal time interval sampling adopted in AATSR products.

The geolocation information can be found in the Grid Pixel Latitude and Longitude ADS, and comprises latitude and longitude at a series of tie points spaced by 25 km across track and by 1 product granule (32 records, or approximately 32 km) along-track.

Each record of the ADS contains latitude and longitude values at 23 tie points whose X co-ordinates are X = -275, -250, … +275 km. There is one ADS record for every 32 MDS records, such that the first ADS record corresponds to the first MDS record (that is, they have the same Y co-ordinate). For simplicity we adopt the convention that records in an MDS or ADS are numbered so that the first record in the data set is record zero (although EnviView numbers records from 1). Thus if k (k = 0, 1, 2, …) is the number of the record in the ADS, the ADS record identified by k corresponds to the MDS record numbered

$$i = 32k. \quad (2)$$

The y co-ordinates of these two records should be identical.

A.5 Bilinear Interpolation of Geolocation Information

Given the (geodetic) latitudes and longitudes of the tie points from the Grid Pixel Latitude and Longitude ADS, the latitude and longitude of each image pixel may be derived by interpolation between these tie points in two dimensions. In the case of longitude account must be taken of the possibility that the 180 degree meridian intersects the image row.

Suppose we wish to find the latitude and longitude of a point whose image co-ordinates are X and Y. Then the index of the tie point to the left of the point (X, Y) is

$$j_g = 11 + \text{int}[X/25] = \text{int}[(X + 275)/25], \quad (3)$$

where int[x] represents the integer part of x. Calculate

$$w_x = (X + 275)/25 - j_g. \quad (4)$$

The point with along-track co-ordinate Y lies between the tie rows indexed by i_g, $i_g + 1$, where

$$Y(i_g) \le Y < Y(i_g + 1) \quad (5)$$

and where $Y(i_g)$ is the image scan y co-ordinate of ADS record i_g. The interpolation weight for use in the Y direction is then

$$w_y = \left(Y - Y(i_g)\right) / \left(Y(i_g + 1) - Y(i_g)\right) \qquad (6)$$

In the particular case that X and Y are the co-ordinates of the pixel indexed by i, j, then substitution of Equation (1) in Equations (3) and (4) respectively gives

$$j_g = \mathrm{int}[(j + 19)/25] \qquad (7)$$

$$w_x = (j + 19)/25 - j_g \qquad (8)$$

Similarly for the Y co-ordinate, from Equation (2) with $k = i_g$,

$$i_g = \mathrm{int}[i/32] \qquad (9)$$

$$w_y = (i/32) - i_g \qquad (10)$$

The geocentric latitude of the pixel is then calculated by interpolation as follows:

$$\varphi(i,j) = \varphi_1 + w_y\{\varphi_2 - \varphi_1\}, \qquad (11)$$

where

$$\varphi_1 = \varphi_g(i_g, j_g) + w_x\left\{\varphi_g(i_g, j_g + 1) - \varphi_g(i_g, j_g)\right\}, \qquad (12)$$

$$\varphi_2 = \varphi_g(i_g + 1, j_g) + w_x\left\{\varphi_g(i_g + 1, j_g + 1) - \varphi_g(i_g + 1, j_g)\right\} \qquad (13)$$

and where the tie point latitudes φ_g are taken from ADS records i_g and i_{g+1}.

Longitude is treated similarly unless the 180 degree meridian is present:

$$\lambda(i,j) = \lambda_1 + w_y\{\lambda_2 - \lambda_1\}, \qquad (14)$$

where

$$\lambda_1 = \lambda_g(i_g, j_g) + w_x\left\{\lambda_g(i_g, j_g + 1) - \lambda_g(i_g, j_g)\right\}, \qquad (15)$$

$$\lambda_2 = \lambda_g(i_g + 1, j_g) + w_x\left\{\lambda_g(i_g + 1, j_g + 1) - \lambda_g(i_g + 1, j_g)\right\} \qquad (16)$$

and the tie point longitudes λ_g are taken from ADS records i_g and i_{g+1}.

However, if the position to be interpolated is close to longitude 180 degrees, special treatment is required because the longitude values in the ADS are specified in the range -180 to +180 degrees. Thus if longitude 180 degrees falls between the tie points it will give rise to a discontinuity in the longitude. This is the case if

$$\left(\lambda_{\max} - \lambda_{\min}\right) > 180.0 \qquad (17)$$

where $\lambda_{\max}$ and $\lambda_{\min}$ are respectively the greatest and least of

$$\lambda_g(i_g, j_g),\ \lambda_g(i_g, j_g + 1),\ \lambda_g(i_g + 1, j_g),\ \lambda_g(i_g + 1, j_g + 1). \qquad (18)$$

In this case 360.0 should be added to each of the tie point longitudes λ_g that is initially negative before it is substituted in equations (14) to (16) above. On completion of the interpolation the resultant interpolated longitude λ may be translated back into the range -180.0 to 180.0 degrees by subtracting 360.0 if its value exceeds 180.0.