User Documentation for (A)ATSR 4th Reprocessing Level 1B Products

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This document provides a guide for users of (A)ATSR 4th reprocessing products, giving easily viewed format details, highlighting differences from previous reprocessed products, noting technical features inherent in the products, and giving notification of remaining Open Issues.

QA4EO-VEG-OQC-MEM-4538 *Issue 1.2* *12 October 2022*

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AMENDMENT POLICY

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

AMENDMENT RECORD SHEET

ISSUE	DATE	REASON
1.0	11/03/2019	First official version
1.1	10 August 2022	This document, previously **AATSRESL.SPE.005**, has now been transferred to the IDEAS-QA4EO project, and has been relabelled **QA4EO-VEG-OQC-MEM-4538** Changes for v1.1: • Updates to Further Notes for Users (Section 5), where changes to datasets, plans or product viewers have taken place. • Inclusion of Improvements within the 4th Reprocessing (Section 6). • Inclusion of Open Issues after completion of reprocessing (Section 7).
1.2	12 October 2022	Changes for v1.2: • Clearer explanation of the Bayesian and probabilistic cloud information (Sections 4.9.3 and 5.7).

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1. INTRODUCTION

1.1 Purpose and Scope

This document is intended to be used as a quick-look reference for the products that will be generated from the 4th reprocessing of (A)ATSR data, in terms of both the product specification and items to note within the v4 products.

The main focus of the 4th reprocessing is to harmonise the (A)ATSR data product format with the format from the follow-on instrument, SLSTR. The 4th reprocessing Level 1B (**L1B**) dataset is being released to users in 2022.

Users should note the following with regard to the products:

- The 4th reprocessing products are not in Envisat format.
- The 4th reprocessing product format will mimic that used for Sentinel-3 SLSTR products, but does not (and cannot) replicate it exactly.
- The 4th reprocessing will generate Level 1 products only. Level 2 Sea Surface Temperature (**SST**) and Land Surface Temperature (**LST**) products will be generated by ESA Climate Change Initiative (**CCI**) projects and made available alongside the Level 1 products.

If users should have any queries on the 4th reprocessing products that are not covered in this document, they are advised to contact the ESA Tellus service.

1.2 Structure of the Document

After this introduction, the document is divided into a number of major sections that are briefly described below:

2 4TH REPROCESSING PRODUCT SUMMARY

This section gives a summary of the 4th reprocessing products, including naming, types and product structure.

3 MANIFEST INFORMATION

The different sections that are contained within the manifest are described here, along with examples.

4 MEASUREMENT AND ANNOTATION DATASETS

Full details of the product specification with regard to the measurement and annotation datasets, including flag settings, are given in this section.

5 FURTHER NOTES FOR USERS

Useful notes for users are given here, including items on instrument channels, product differences, scientific and technical details.

6 IMPROVEMENTS WITHIN THE 4TH REPROCESSING

The improvements that have been noted within the 4th reprocessing dataset are given in this section.

7 OPEN ISSUES

Open issues with the 4th reprocessing products are listed here for reference; these are issues that may in the future be labelled as a Disclaimer and/or may be subject to correction.

8 ANNEX 1: PRODUCT NAMING CONVENTION

This section outlines the product naming convention for the 4th reprocessing products.

9 GLOSSARY

Table of abbreviated items.

1.3 Referenced Documents

The following is a list of documents with a direct bearing on the content of this report. Where referenced in the text, these are identified as RD.n, where 'n' is the number in the list below:

[RD.1] Sentinel-3 Product Data Format Specification - SLSTR Level 1 & 2 Instrument Products, S3IPF.PDS.005 (Issue 1.11, 28 May 2015)

[RD.2] (A)ATSR Expert Support Laboratory – FAST Level 1b Product Definition, PO-TN-RAL-AT-0568, v1.4, 19th March 2018: https://earth.esa.int/eogateway/documents/20142/37627/po-tn-ral-at-0568-fast-level-1b-product-definition-issue-1-4.pdf/b0a843d8-43b5-7905-26da-c53f3d3ec4ff

[RD.3] Sentinel-3 Toolbox: https://sentinel.esa.int/web/sentinel/toolboxes/sentinel-3/

[RD.4] Sentinel 3 PDGS File Naming Convention, EUM/LEO-SEN3/SPE/10/0070 GMES-S3GS-EOPG-TN-09-0009 (Issue 1.3): https://sentinel.esa.int/documents/247904/1964331/Sentinel-3_PDGS_File_Naming_Convention

[RD.5] ATSR-1/-2 User Guide: http://www.atsr.rl.ac.uk/documentation/docs/userguide/index.shtml

[RD.6] AATSR FAQ (dated 2016 so product relevance is related to the 3rd reprocessing): https://earth.esa.int/eogateway/documents/20142/37627/aatsr-frequently-asked-questions-faq-document.pdf/a3810659-9213-b828-aa41-374e6af6442f

[RD.7] AATSR Products Specification, PO-RS-MDA-GS-2009 (Volume 7), Issue 4/C, 5 September 2013: https://earth.esa.int/eogateway/documents/20142/37627/Vol-07-Aats-4C.pdf/f0ab7928-5517-d4f5-b0c7-2ab75620ce1c

[RD.8] IDEAS+-VEG-OQC-REP-2982 - AATSR Product Quality and Classification Flags, v1.0, 27 September 2018: https://earth.esa.int/eogateway/documents/20142/37627/AATSR%20Quality%20and%20Classification%20Flags.pdf?text=envisat+asar+im+medium+resolution+l1+%5Basa_imm_1p%5D

[RD.9] AATSR Handbook (dated 2007; no update will take place), and other documents: https://earth.esa.int/eogateway/documents/20142/37627/AATSR-product-handbook.pdf/5c3e92c6-a8fd-7d16-b0a8-2fe07bd9f39e and https://earth.esa.int/eogateway/search?text=about+aatsr&filter=envisat

[RD.10] Sentinel-3 – Land-Water Mask, Brockmann Consult, v1.2, 14 August 2015 (S-3 LWM S3_LandWaterMask_v1_2.pdf)

[RD.11] Calibration Activities, including AATSR 12 micron channel: https://earth.esa.int/eogateway/instruments/aatsr/cal-val

[RD.12] ATSR-2 in the ERS-2 Post Gyro Failure Period, IDEAS+-VEG-OQC-REP-2236, v1.0, 30 April 2015: https://earth.esa.int/eogateway/documents/20142/37627/QC19_IDEAS%2B-VEG-OQC-REP-2236+ATSR-2+in+the+ERS-2+Post+Gyro+Failure+Period+v1-0.pdf/12d1a6cd-f6ca-9c41-3aec-aca137ac432c

1.4 Definitions of Terms

The following terms have been used in this report with the meanings shown.

Term	Definition
(A)ATSR	Abbreviation used to refer specifically to all 3 instruments in the Along-Track Scanning Radiometer (**ATSR**) series: ATSR-1, ATSR-2 and AATSR.
IDEAS+/QA4EO	Instrument Data quality Evaluation and Analysis Service+, reporting to the ESA Data Quality and Algorithms Management Office (EOP-GMQ), responsible for quality of data provided to users including the data calibration and validation, the data processing algorithms, and the routine instrument and processing chain performances. The QA4EO QC Service followed on from IDEAS+.
SLSTR	Sea and Land Surface Temperature Radiometer (**SLSTR**): the follow-on instrument(s) to the ATSR series, being flown on the Sentinel-3 satellites.

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2. 4TH REPROCESSING PRODUCT SUMMARY

The 4th reprocessing product format will mimic that used for Sentinel-3 SLSTR products [RD.1], but is unable to replicate it exactly. The 4th reprocessing L1B product specification is given in [RD.2], on which the details given in this user documentation was largely based, with acknowledgement to T. Nightingale (RAL Space).

The Sentinel-3 Toolbox within the Sentinel Application Platform (**SNAP**) [RD.3] has been adapted to read 4th reprocessing (A)ATSR products. (With the caveat that not all ATSR-2 products can yet be read via the xfdumanifest.xml file; see Section 5.10.3.1)

2.1 Product Naming Convention

The naming convention for the 4th reprocessing products follows that for Sentinel-3 products [RD.4] and full details are given in ANNEX 1: PRODUCT NAMING CONVENTION. Note that the (A)ATSR 4th reprocessing products do not contain the absolute orbit number within the product names, unlike 3rd reprocessing products. The following are examples of 4th reprocessing product names for each instrument. ATSR-1. ATSR-2 and AATSR. respectively:

ER1_AT_1_RBT____19930113T231617_19930114T003307_20211213T151248_4609_009_172______DSI_R_NT_004.SEN3

ER2_AT_1_RBT____20011102T193853_20011102T212148_20220225T165412_6174_068_256______DSI_R_NT_004.SEN3

ENV_AT_1_RBT____20050311T022425_20050311T041000_20210408T073910_6334_035_246______DSI_R_NT_004.SEN3

2.2 Product Types

Only Level 1 products will be generated by the 4th reprocessing. The Product Type is specified within the product name by:

AT_*<level>*_*<mode>*

where there is only one Product Type for the 4th reprocessing:

AT_1_RBT___ (A)ATSR Thermal IR brightness temperatures and VIS SWIR radiances

This product type is an L1B product.

It can be noted that Level 2 SST and LST products will be generated by ESA CCI projects and subsequently made available alongside the Level 1 products.

2.3 Product Structure

The L1B product structure is an XML Formatted Data Unit (**XFDU**) package and is shown in Figure 2-1 (taken from [RD.1]). It comprises a Manifest section and a Components section, the latter is a set of NetCDF files. The product name (Section 2.1) is a folder within which the manifest file and components section are contained.

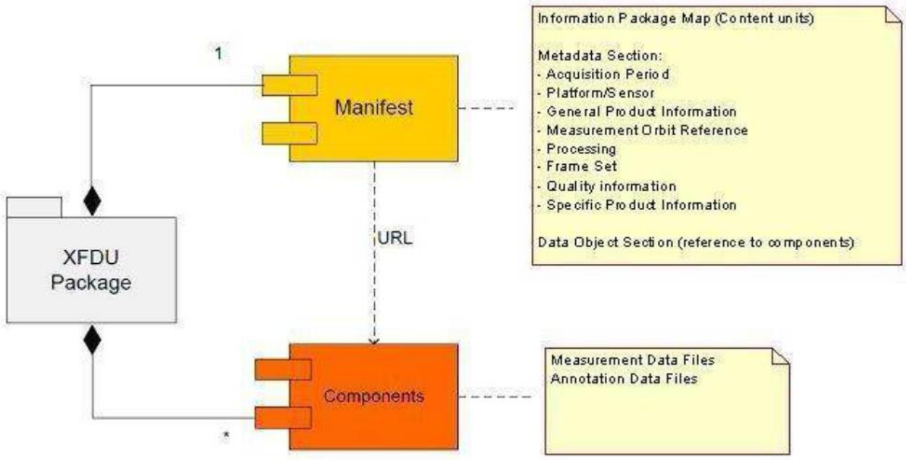


Figure 2-1. XFDU product package (taken from [RD.1]).

2.3.1 Manifest section

The manifest file is a set of metadata information, in XML format, related to the description of the product. It includes a common structure section (primary metadata), and a specific section (secondary metadata). It contains pointers to the components, quality information about the product, and checksum details.

Section 3 MANIFEST INFORMATION gives more information on the manifest file.

2.3.2 Component section

The components section comprises the measurement and annotation data files, in NetCDF-4 format.

Each file name has the format **<dataset ID>_<r><v>.nc**.

All files are individually named and detailed in Section 4 MEASUREMENT AND ANNOTATION DATASETS, but it can be noted that:

- **<dataset ID>** is a descriptive identifier, showing whether the file contains a measurement dataset (**MDS**) containing radiance or brightness temperatures (**BT**); or an annotation dataset (**ADS**) containing, for example, quality information.
- **<r>** shows the grid resolution of the data within the file, where
  - **i** is the 1-km x 1-km image grid
  - **t** is the 16-km x 16-km tie-point grid.
- **<v>** shows the view of the data within the file, where
  - **n** is the nadir view
  - **o** is the oblique view
  - **x** either applies to both views or there is no distinction.

3. MANIFEST INFORMATION

The manifest information within the product is the file named **xfdumanifest.xml**. Within SNAP, one can select the manifest file and see the component datasets displayed together. There is the current caveat that not all ATSR-2 products can yet be read via the xfdumanifest.xml file (Section 5.10.3.1). The manifest and component files can also be opened independently in SNAP or other appropriate viewers.

The manifest file is regulated by a hierarchy of schemas. The 4th reprocessing schemas closely follow those specified for Sentinel-3 and SLSTR. However, the 4th reprocessing schemas were necessarily shortened in places since information from the heritage missions is not as comprehensive as that from the Sentinel era.

The information in this section is largely taken from [RD.2], within which further details are given.

The manifest file has three main sections, as explained below.

3.1 Package Map

The package map section contains a logical description of each measurement and annotation dataset contained in the product, including its relationship to other datasets. An example block is:

```
<informationPackageMap>

<xfdu:contentUnit ID="packageUnit" unitType="Information Package"
textInfo="ENVISAT AATSR Level 1 Package" dmdID="acquisitionPeriod
platform generalProductInformation measurementOrbitReference
measurementQualityInformation measurementFrameSet atsrProductInformation"
pdiID="processing">

<xfdu:contentUnit ID="ATSR_GEODETIC_TX_Unit" unitType="Annotation Data
Unit" textInfo="16km geodetic coordinates">
<dataObjectPointer dataObjectID="ATSR_GEODETIC_TX_Data" />

</xfdu:contentUnit>
```

(continues…)

```
</informationPackageMap>
```

3.2 Metadata Section

The metadata section contains information about auxiliary files, data processing, data grids, instrument characteristics, annotations and other summary metadata.

The metadata section is the most varied section. It contains a number of different types of information, as given below.

- Processing resources, including descriptions of the origin and provenance of the level 1 dataset; of external products used to generate the level 1 dataset, including auxiliary files and (A)ATSR product files; and of supporting documentation
- The product acquisition period
- A summary platform description

- General product information
- Orbit reference data, including orbit number and orbit ephemeris data
- Quality information
- A frame set containing the coordinates of a product outline
- Summary instrument and product information, including surface classification statistics, data grid resolutions, image sizes (in pixels), detector temperatures and channel band descriptions.
- Annotation descriptors for each annotation dataset.

The metadata section contains rudimentary information on the input L1A product. The (A)ATSR QC team retains all input L1A header information and details can be requested from ESA via Tellus: ESA Tellus service.

3.3 Data Object Section

The data object section describes the physical characteristics of the dataset files, including their names, sizes and checksums. An example block is:

```
<dataObjectSection>
<dataObject ID="ATSR_S3_RADIANCE_IO_Data">
<byteStream mimeType="application/x-netcdf" size="27670030">
<fileLocation href="S3_radiance_io.nc" locatorType="URL"/>
<checksum checksumName="MD5">f370902f981b37de96d6e05a4e4985ae</checksum>
</byteStream>
</dataObject>
</dataObjectSection>
```

4. MEASUREMENT AND ANNOTATION DATASETS

Details within this section are from the 4th Reprocessing Product Specification [RD.2].

Background information for channels and instruments can be found in Section 5.2: Channel Terminology and Instrument Differences.

Table 4-1 gives the names of the measurement and annotation datasets contained within the product. All files are in NetCDF format. Table 4-1 contains links to a brief format descriptor that displays the variables available within the file; and relevant bitmask tables for flag information.

Users may note the following:

1. **Visible** and shortwave infrared channel measurements are given in radiance units, unlike previous (A)ATSR products that contained reflectances.
2. **Gridded** pixels correspond to the 512-pixel swath width, at 1-km resolution, the same image grid as previous (A)ATSR products.
3. **Orphan** pixels are now included in the L1B product, and are those pixels that previously failed to find a location on the image grid. As such, this is newly retained information and allows the user to reconstruct all data in the instrument space (using scan and pixel information in the indices ADS).
4. **Uncertainty** estimates are now available for most pixels in the product.
5. **Scan-based** datafiles are present in the product. These contain information from the original conical instrument scan, and so are not geographically compatible (in terms of rows and columns) with the equivalently placed pixels in the image grid. The information in each row of these files is relevant to certain instrument pixels that occupy the same row in the image grid. Sometimes, this is data that corresponds to the central pixel within the image grid, but not always. The product specification should be inspected closely.
6. **Not all channels** are populated for all instruments due to the heritage nature of the older data; see Table 5-2.

Table 4-1. Measurement and annotation datasets within the L1B product

File name	File name	Contents of file
Measurement datasets		
S1_radiance_in.nc	S1_radiance_io.nc	Nadir and oblique 1 km radiance measurement datasets For full content details, see Table 4-2
S2_radiance_in.nc	S2_radiance_io.nc	
S3_radiance_in.nc	S3_radiance_io.nc	
S5_radiance_in.nc	S5_radiance_io.nc	
S7_BT_in.nc	S7_BT_io.nc	Nadir and oblique 1 km brightness temperature measurement datasets For full content details, see Table 4-3
S8_BT_in.nc	S8_BT_io.nc	
S9_BT_in.nc	S9_BT_io.nc	
Quality annotation datasets		
S1_quality_in.nc	S1_quality_io.nc	Nadir and oblique 1 km quality annotation datasets for

File name	File name	Contents of file
S2_quality_in.nc	S2_quality_io.nc	radiance channels For full content details, see Table 4-4
S3_quality_in.nc	S3_quality_io.nc	
S5_quality_in.nc	S5_quality_io.nc	
S7_quality_in.nc	S7_quality_io.nc	Nadir and oblique 1 km quality annotation datasets for the thermal channels For full content details, see Table 4-5
S8_quality_in.nc	S8_quality_io.nc	
S9_quality_in.nc	S9_quality_io.nc	
Global flags annotation datasets		
flags_in.nc	flags_io.nc	Nadir and oblique 1 km global flags annotation dataset For full content details, see Table 4-6
ATSR additional information annotation datasets		
atsr_in.nc	atsr_io.nc	Nadir and oblique 1 km ATSR additional information annotation datasets For full content details, see Table 4-7
Coordinate annotation datasets		
indices_in.nc	indices_io.nc	Nadir and oblique 1 km scan, pixel and detector number annotation datasets For full content details, see Table 4-10
cartesian_in.nc	cartesian_io.nc	Nadir and oblique 1 km Cartesian coordinates annotation datasets For full content details, see Table 4-11
cartesian_tx.nc		16 km Cartesian coordinates annotation dataset For full content details, see Table 4-12
geodetic_in.nc	geodetic_io.nc	Nadir and oblique 1 km geodetic coordinates annotation datasets For full content details, see Table 4-13
geodetic_tx.nc		16 km geodetic coordinates annotation dataset For full content details, see Table 4-14
time_in.nc		Nadir *and oblique* combined 1 km time coordinate annotation dataset For full content details, see Table 4-15
Solar and satellite geometry annotation datasets		
geometry_tn.nc	geometry_to.nc	Nadir and oblique 16 km solar and satellite geometry annotation datasets For full content details, see Table 4-16
Meteorological parameters auxiliary dataset		
met_tx.nc		16 km meteorological parameters auxiliary dataset For full content details, see Table 4-17

4.1 Visible and Shortwave Infrared MDS

The visible and shortwave infrared MDS contain 1-km resolution pixel radiances, radiance total uncertainties and exception flags. There are values for both gridded and orphan pixels, although orphan pixels do not have uncertainties assigned to them. There is one NetCDF file for each of the nadir and oblique views for each channel: 8 files in total. The format for each is identical but the array sizes and the values of some attributes will differ.

Table 4-2 displays information for the variables contained within the radiance MDS. Notes on dimensions are given in Section 5.5.

Table 4-2. Visible and shortwave infrared MDS variables (1-km resolution)

Element name	Description	Unit	Dimensions
<b>_radiance_i<v>	Gridded pixel radiance	mW m^{-2} sr^{-1} nm^{-1}	rows, columns
<b>_ radiance _uncert_i<v>	Gridded pixel radiance total uncertainty estimates	mW m^{-2} sr^{-1} nm^{-1}	rows, columns
<b>_exception_i<v>	Gridded pixel exception flags (Table 4-18)	-	rows, columns
<b>_ radiance _orphan_ i<v>	Orphan pixel radiance	mW m^{-2} sr^{-1} nm^{-1}	rows, orphan pixels
<b>_ radiance _orphan_uncert_i<v>	Orphan pixel radiance total uncertainty estimates (Not assigned)	mW m^{-2} sr^{-1} nm^{-1}	rows, orphan_pixels
<b>_orphan_exception_i<v>	Orphan pixel exception flags (Table 4-18)	-	rows, orphan_pixels
where: <**b**> is the channel identifier: **S1**, **S2**, **S3** or **S5**, and <**v**> is the instrument view: **n** or **o**			

(return to *Measurement datasets*)

4.2 Thermal Infrared MDS

The thermal infrared MDS contain 1-km resolution pixel brightness temperatures, BT total uncertainties and exception flags. There are values for both gridded and orphan pixels, although orphan pixels do not have uncertainties assigned to them. There is one NetCDF file for each of the nadir and oblique views for each channel: 6 files in total. The format for each is identical but the array sizes and the values of some attributes will differ.

Table 4-3 displays information for the variables contained within the brightness temperature MDS. Notes on dimensions are given in Section 5.5.

Table 4-3. Thermal infrared MDS variables (1-km resolution)

Element name	Description	Unit	Dimensions
<b>_BT_i<v>	Gridded pixel brightness temperatures	K	rows, columns

<b>_BT_uncert_i<v>	Gridded pixel brightness temperature total uncertainty estimates	K	rows, columns
<b>_exception_i<v>	Gridded pixel exception flags (Table 4-18)	-	rows, columns
<b>_BT_orphan_ i<v>	Orphan pixel brightness temperatures	K	rows, orphan_pixels
<b>_BT_orphan_uncert _i<v>	Orphan pixel brightness temperature total uncertainty estimates (Not assigned)	K	rows, orphan_pixels
<b>_orphan_exception _i<v>	Orphan pixel exception flags (Table 4-18)	-	rows, orphan_pixels
where: <**b**> is the channel identifier: **S7**, **S8** or **S9**, and <**v**> is the instrument view: **n** or **o**			

(return to *Measurement datasets*)

4.3 Quality ADS

4.3.1 Visible and shortwave infrared quality

The visible and shortwave infrared quality ADS contains estimates of detector noise measured at the black bodies and visible calibration unit (VISCAL), if available for the instrument. It also contains the ancillary information required to scale these to estimates of radiance noise for each pixel in the visible and shortwave infrared channels (S1 – S3, S5). There are two NetCDF files for each channel, one each for the nadir and oblique views. The format for each is identical but the across-track array size and the values of some attributes may differ. Also, the along-track array size will be dependent on the number of scans in the L0 data.

Table 4-4 displays information for the variables contained within the visible and shortwave infrared quality ADS. Please note that not all quality descriptors will be populated for all instruments due to the heritage nature of the older data. Notes on array dimensions are given in Section 5.5.

Table 4-4. Visible and shortwave infrared quality ADS variables (1-km resolution)

Element name	Description	Unit	Dimensions
<b>_scene_radiance_i<v>	Scene radiance for VIS-SWIR channel type B uncertainty estimate LUT	mW m^{-2} sr^{-1} nm^{-1}	uncertainties
<b>_band_centre_i<v>	Detector filter band centre	m	detectors
<b>_bandwidth_i<v>	Detector filter bandwidth	m	detectors
<b>_solar_irradiance_i<v>	Solar spectral irradiance at top of atmosphere	mW m^{-2} nm^{-1}	detectors

Element name	Description	Unit	Dimensions
<b>_radiometric_ uncertainty_i<v>	Radiometric calibration uncertainty estimates. These are provided as a tabulated function of scene radiance. They are estimates of uncertainties due to systematic effects in the radiometric calibration, e.g. VISCAL reflectance factor, degradation, non-linearity	mW m^{-2} sr^{-1} nm^{-1}	detectors, uncertainties
<b>_dL_BB_i<v>	Cold black body radiance noise	mW m^{-2} sr^{-1} nm^{-1}	rows, detectors, integrators
<b>_dL_VISCAL_i<v>	VISCAL radiance noise	mW m^{-2} sr^{-1} nm^{-1}	detectors, integrators
<b>_L_BB_i<v>	Black body radiance from cold BB	mW m^{-2} sr^{-1} nm^{-1}	rows, detectors
<b>_L_VISCAL_i<v>	VISCAL radiance	mW m^{-2} sr^{-1} nm^{-1}	detectors
<b>_T_det_i<v>	Detector temperature	K	rows
<b>_cal_gain_i<v>	Scale factor multiplying detector count	-	detectors, integrators
<b>_cal_offset_i<v>	Offset added to scaled detector count	-	rows, detectors, integrators
<b>_SCP_gain_i<v>	Electronic gain applied to detector signal	-	rows, detectors
<b>_SCP_offset_i<v>	Electronic offset applied to detector signal	-	rows, detectors
where: <**b**> is the channel identifier: **S1**, **S2, S3** or **S5**, and <**v**> is the instrument view: **n** or **o**			

(return to *Measurement datasets*)
(return to *Quality annotation dataset*

4.3.2 Thermal infrared quality

The thermal infrared quality ADS contains estimates of detector noise measured at the black bodies and the ancillary information required to scale this to estimates of NEΔT for each pixel sample for each thermal infrared channel (S7, S8 and S9). There are two NetCDF files for each channel, one each for the nadir and oblique views. The format for each is identical but the across-track array size and the values of some attributes may differ. Also the along-track array size will be dependent on the number of scans in the L0 data.

Table 4-5 displays information for the variables contained within the thermal infrared quality ADS. Please note that not all quality descriptors are populated for all instruments due to the heritage nature of the older data. Notes on array dimensions are given in Section 5.5.

Table 4-5. Thermal infrared quality ADS variables (1-km resolution)

Element name	Description	Unit	Dimensions
<b>_band_centre_i<v>	Detector filter band centre	m	detectors
<b>_bandwidth_i<v>	Detector filter bandwidth	m	detectors
<b>_scene_temperature_i<v>	Scene temperature for IR channel uncertainty estimates	K	uncertainties
<b>_radiometric_ uncertainty_i<v>	Radiometric calibration uncertainty estimates. These are provided as a tabulated function of scene brightness temperature. They are estimates of uncertainties due to systematic effects in the radiometric calibration, e.g. BB thermometry, BB emissivity, non-linearity	K	detectors, uncertainties
<b>_dT_BB1_i<v>	Black body 1 noise equivalent brightness temperature	K	rows, detectors, integrators
<b>_dT_BB2_i<v>	Black body 2 noise equivalent brightness temperature	K	rows, detectors, integrators
<b>_T_BB1_i<v>	Black body temperature 1	K	rows
<b>_T_BB2_i<v>	Blackbody temperature 2	K	rows
<b>_T_det_i<v>	Detector temperature	K	rows
<b>_cal_gain_i<v>	Scale factor multiplying detector count	-	rows, detectors, integrators
<b>_cal_offset_i<v>	Offset added to scaled detector count	-	rows, detectors, integrators
<b>_SCP_gain_i<v>	Electronic gain applied to detector signal	-	rows, detectors
<b>_SCP_offset_i<v>	Electronic offset added to detector signal	-	rows, detectors
<b>_ADC_cal_i<v>	ADC reference measurement	V	rows
where: <**b**> is the channel identifier: **S7**, **S8** or **S9**, and <**v**> is the instrument view: **n** or **o**			

(return to *Measurement datasets*)
(return to *Quality annotation dataset*)

4.4 Global Flags ADS

The global flags ADS contains the product quality flags which are applicable across all measurement datasets sharing the same view and detector geometry. There are two global flag files at 1-km resolution, one each for the nadir and oblique views. The format for each is identical but the array sizes and the values of some attributes will differ.

Table 4-6 displays information for the variables contained within the global flags ADS. Notes on array dimensions are given in Section 5.5.

Further information on the different cloud parameters, and available subsets, is given in Section 5.7.

Table 4-6. Global flags ADS variables (1-km resolution)

Element name	Description	Unit	Dimensions
probability_cloud_single_i<v>	Probability of cloud in pixel as estimated by Bayesian cloud detection on a single view	-	rows, columns
probability_cloud_dual_i<v>	Probability of cloud in pixel as estimated by Bayesian cloud detection on both views	-	rows, columns
cloud_i<v>	Global cloud flags (Table 4-19)	-	rows, columns
bayes_i<v>	Bayesian/probabilistic cloud flags (Table 4-20)	-	rows, columns
pointing_i<v>	Global pointing flags (Table 4-21)	-	rows, columns
confidence_i<v>	Global confidence flags (Table 4-22)	-	rows, columns
probability_cloud_single_orphan_i<v>	Probability of cloud in pixel as estimated by Bayesian cloud detection on a single view (subset)	-	rows, orphan_pixels
probability_cloud_dual_orphan_i<v>	Probability of cloud in pixel as estimated by Bayesian cloud detection on both views (subset)	-	rows, orphan_pixels
cloud_orphan_i<v>	Orphan pixel global cloud flags (Table 4-19)	-	rows, orphan_pixels
bayes_orphan_i<v>	Orphan pixel global cloud flags (subset) (Table 4-20)	-	rows, orphan_pixels
pointing_orphan_i<v>	Orphan pixel global pointing flags (Table 4-21)	-	rows, orphan_pixels
confidence_orphan_i<v>	Orphan pixel global confidence flags (Table 4-22)	-	rows, orphan_pixels

where:

<**v**> is the instrument view: **n** or **o**

(return to *Measurement datasets*)

(return to *Global flags annotation datasets*)

4.5 ATSR Additional Information ADS

This ADS contains additional information required mainly for **ATSR-2**. There are two datasets at 1-km resolution, one each for the nadir and oblique views. The format for each is identical but the array sizes and the values of some attributes will differ.

Table 4-7 displays information for the variables contained within the ATSR additional information ADS, with further information in the sections following. Notes on array dimensions are given in Section 5.5.

Table 4-7. ATSR additional information ADS variables (1-km resolution)

Element name	Description	Unit	Dimensions
TLM_rate_i<v>	Telemetry data rate (see section 4.5.1)	-	rows
PSM_ID_i<v>	Pixel selection map ID - ATSR-2 only (see section 4.5.2)	-	rows
where: <**v**> is the instrument view: **n** or **o**			

(return to *Measurement datasets*)
(return to *ATSR additional information annotation datasets*)

4.5.1 Telemetry data rate

The telemetry (**TLM**) data rate information is needed mainly for ATSR-2, which could not transmit high-rate data when other ERS-2 instruments were deployed. Therefore, the ATSR-2 data rate varies with time.

ATSR-1 had different fixed rates for different channels (see table 8 of [RD.5]), but was constant with time, and AATSR transmitted high-rate data at all times.

Table 4-8. ATSR data rate information

Code	Text code	Description
0	fixed_rate	ATSR-1, AATSR: fixed-rate data
2519	high_rate	ATSR-2: low-rate data
60304*	low_rate	ATSR-2: high-rate data

*Please note the consequences of the Java –NetCDF-4 unsigned data type issue outlined in Section 5.10.1

4.5.2 Pixel selection map

The ATSR-2 pixel selection map (**PSM**) information contains the scope of the pixel mapping that was carried out, dependent on the TLM data rate. More information on both ATSR-2 TLM data rate and PSM is given in section 5.3 of [RD.5]. There are up to 14 PSMs, but commonly PSM 13 and 14 are used.

It is the use of the PSM that shows what seem to be data missing in ATSR-2 visible channel products, when reduced swath-width maps are transmitted. Table 4-9 (table 9 from [RD.5]) shows the routine pixel maps used for ATSR-2.

Table 4-9. ATSR-2 routine pixel maps
(table 9 from [RD.5])

Pixel map	IR data	Visible data*	
High-rate	All 12-bit	0.55, 0.67 & 0.87 µm	All channels full 500 km swath with 12-bit digitisation

Pixel map	IR data	Visible data*	
Map 12	Not sent	0.55, 0.67 & 0.87 µm	Full 500 km swath with 12-bit digitisation
Map 13	As ATSR-1	0.55, 0.67 & 0.87 µm	Reduced 180 km swath width with 12-bit digitisation
Map 14	As ATSR-1	0.55 µm	Reduced 300 km swath with 8-bit digitisation in nadir
		0.67 & 0.87 µm	Full 500 km swath with 8-bit digitisation in nadir & alternate (interlaced) pixels in forward with 8-bit digitisation

*Bands 0.55, 0.67 and 0.87 µm correspond to channels S1, S2 and S3, respectively.

4.6 Coordinate ADS

This set of annotation datasets contains coordinate information for the product, both in instrument space, quasi-Cartesian and geodetic coordinates, as well as time information. This set consists of the following data files, and full details are given in the referenced sections.

- Indices (Section 4.6.1)
- Cartesian (Section 4.6.2)
- Geodetic (Section 4.6.3)
- Time (Section 4.6.4)

4.6.1 Indices: Scan, pixel and detector number

The scan, pixel and detector number description table contains arrays of indices which map both gridded and orphaned pixels to their original positions in the instrument measurement frame. There are two scan, pixel and detector number datasets at 1-km resolution, one each for the nadir and oblique views. The format for each is identical but the array sizes and the values of some attributes will differ.

Table 4-10 displays the variables within the Indices ADS. Notes on array dimensions are given in Section 5.5.

Table 4-10. Indices ADS variables (1-km resolution)

Element name	Description	Unit	Dimensions
scan_i<v>	Gridded-pixel scan number	-	rows, columns
pixel_i<v>	Gridded-pixel pixel number	-	rows, columns
detector_i<v>	Gridded-pixel detector number	-	rows, columns
scan_orphan_i<v>	Orphan-pixel scan number	-	rows, orphan_pixels
pixel_orphan_i<v>	Orphan-pixel pixel number	-	rows, orphan_pixels
detector_orphan_i<v>	Orphan-pixel detector number	-	rows, orphan_pixels

Element name	Description	Unit	Dimensions
where: <**v**> is the instrument view: **n** or **o**			

(return to *Measurement datasets*)
(return to *Coordinate annotation datasets*)

4.6.2 Cartesian: Full and 16-km resolution Cartesian coordinates

The Cartesian coordinates dataset contains the orthogeolocated quasi-Cartesian coordinates x and y of the centre of each pixel field of view on the earth's surface, determined from a digital elevation model (**DEM**), where x is the across-track distance on the ellipsoid, locally perpendicular to the sub-satellite track and y is the distance along the sub-satellite track. The dataset is generated in the instrument frame.

There are two datasets at full 1-km resolution, one each for the nadir and oblique views. The format for each is identical but the array sizes and the values of some attributes will differ. Table 4-11 displays the variables contained within the Cartesian orthogeolocation ADS at full resolution.

The 16-km Cartesian coordinates dataset contains the quasi-Cartesian swath coordinates of the tie-points on the ellipsoid. Table 4-12 displays the variables contained within the Cartesian orthogeolocation ADS at 16-km resolution.

Notes on array dimensions are given in Section 5.5.

Table 4-11. Cartesian orthogeolocation ADS variables (1-km resolution)

Element name	Description	Unit	Dimensions
x_i<v>	Geolocated x (across track) coordinate of detector FOV centre	m	rows, columns
y_i<v>	Geolocated y (along track) coordinate of detector FOV centre	m	rows, columns
x_orphan_i<v>	Orphan geolocated x (across track) coordinate of detector FOV centre	m	rows, orphan_pixels
y_orphan_i<v>	Orphan geolocated y (along track) coordinate of detector FOV centre	m	rows, orphan_pixels
where: <**v**> is the instrument view: **n** or **o**			

(return to *Measurement datasets*)
(return to *Coordinate annotation datasets*)

Table 4-12. Cartesian orthogeolocation ADS variables (16-km resolution)

Element name	Description	Unit	Dimensions
x_tx	Geolocated x (across track) coordinate of detector FOV centre	m	rows, columns

Element name	Description	Unit	Dimensions
y_tx	Geolocated y (along track) coordinate of detector FOV centre	m	rows, columns

(return to *Measurement datasets*)
(return to *Coordinate annotation datasets*)

Information relevant to the 16-km file can be found in Section 5.10.6: Grid differences and offset values.

4.6.3 Geodetic: Full and 16-km resolution geodetic coordinates

The geodetic ADS contains the orthogeolocated geodetic coordinates, for both gridded and orphan pixels, in latitude and longitude. The 1-km geodetic ADS also contains surface elevation of the centre of each pixel in the field of view on the earth's surface, determined from a DEM. The dataset is generated in the image frame.

There are two datasets at 1-km resolution, one each for the nadir and oblique views. The format for each is identical but the array sizes and the values of some attributes will differ. Table 4-13 displays the variables contained within the Geodetic orthogeolocation ADS at full resolution.

The 16-km geodetic coordinates dataset contains the geodetic coordinates, in latitude and longitude, of the tie-points on the ellipsoid. Table 4-14 displays the variables contained within the Geodetic orthogeolocation ADS at 16-km resolution.

Notes on array dimensions are given in Section 5.5.

Table 4-13. Geodetic orthogeolocation ADS variables (1-km resolution)

Element name	Description	Unit	D
latitude_i<v>	Latitude of detector FOV centre on the earth's surface	degrees	rows, columns
longitude_i<v>	Longitude of detector FOV centre on the earth's surface	degrees	rows, columns
elevation_i<v>	Surface elevation of detector FOV above reference ellipsoid	m	rows, columns
latitude_orphan_i<v>	Orphan latitude of detector FOV centre on the earth's surface	degrees	rows, orphan_pixels
longitude_orphan_i<v>	Orphan longitude of detector FOV centre on the earth's surface	degrees	rows, orphan_pixels
elevation_orphan_i<v>	Orphan surface elevation of detector FOV above reference ellipsoid	m	rows, orphan_pixels
where: <**v**> is the instrument view: **n** or **o**			

(return to *Measurement datasets*)
(return to *Coordinate annotation datasets*)

Table 4-14. Geodetic orthogeolocation ADS variables (16-km resolution)

Element name	Description	Unit	D
latitude_tx	Latitude of detector FOV centre on the earth's surface	degrees	rows, columns
longitude_tx	Longitude of detector FOV centre on the earth's surface	degrees	rows, columns

(return to *Measurement datasets*)
(return to *Coordinate annotation datasets*)

Information relevant to the 16-km file can be found in Section 5.10.6: Grid differences and offset values.

4.6.4 Time

The 1-km time coordinate dataset contains measurement times for certain pixels on each image row. The main time information is the scan acquisition time associated with the sub-satellite point included on each line (time_stamp_i). Other parameters are included that enable the retrieval of the exact acquisition time of each instrument pixel.

Table 4-15 displays the variables within the Time ADS.

Notes on array dimensions are given in Section 5.5. Please take note of the time-specific information given in Section 5.10.7.

Table 4-15. Time ADS variables (1-km resolution)

Element name	Description	Unit	D
time_stamp_i	Acquisition time of the sub-satellite point included in this line	µs	rows
SCANSYNC	Scan period defined as a complete rotation of the scan mirrors	µs	1
PIXSYNC_i	Frequency at which the pixels are sampled on each scan	µs	1
Nadir_First_scan_i	Scan number of the first nadir scan contributing to each line	-	rows
Nadir_Last_scan_i	Scan number of the last nadir scan contributing to each line	-	rows
Oblique_First_scan_i	Scan number of the first oblique scan contributing to each line	-	rows
Oblique_Last_scan_i	Scan number of the last Oblique scan contributing to each line	-	rows
Nadir_Minimal_ts_i	Acquisition time of the first nadir scan contributing to each line	µs	rows
Nadir_Maximal_ts_i	Acquisition time of the last nadir scan contributing to each line	µs	rows
Oblique_Minimal_ts_i	Acquisition time of the first oblique scan contributing to each line	µs	rows

Element name	Description	Unit	D
Oblique_Maximal_ts_i	Acquisition time of the last oblique scan contributing to each line	µs	rows

(return to *Measurement datasets*)
(return to *Coordinate annotation datasets*)

4.7 Geometry: Solar and Satellite Geometry

The 16-km solar and satellite geometry ADS contains the solar and satellite azimuth and zenith angles at earth's surface and the corresponding distances to the surface, on a tie point grid. There are two datasets, one each for nadir and oblique viewing geometries. The format for each is identical.

Table 4-16 displays the variables within the Geometry ADS. Notes on array dimensions are given in Section 5.5.

Table 4-16. Geometry ADS variables (16-km resolution)

Element name	Description	Unit	D
sat_azimuth_t<v>	Satellite azimuth angle	degrees	rows, columns
sat_path_t<v>	Distance from satellite to surface	m	rows, columns
sat_zenith_t<v>	Satellite zenith angle	degrees	rows, columns
solar_azimuth_t<v>	Solar azimuth angle	degrees	rows, columns
solar_path_t<v>	Distance from sun to surface	m	rows, columns
solar_zenith_t<v>	Solar zenith angle	degrees	rows, columns
where: <**v**> is the instrument view: **n** or **o**			

(return to *Measurement datasets*)
(return to *Solar and satellite geometry annotation datasets*)

Information relevant to this 16-km file can be found in Section 5.10.6: Grid differences and offset values.

4.8 Met: Meteorological Parameters Auxiliary Dataset

The meteorological parameters dataset contains ECMWF ERA-Interim analysis fields, regridded onto 16-km tie points. The dataset contains three types of field:

- single surface or near-surface values
- surface time series
- profiles.

The preferred synoptic time is the time nearest to the product centre time. For most parameters, the analysis field is used, but for integrated parameters, the values are only available on the forecast fields.

Table 4-17 displays the variables within the Meteorological parameters auxiliary dataset. Notes on array dimensions are given in Section 5.5.

Table 4-17. Meteorological variables (16-km resolution)

Element name	Description	Unit	D
cloud_fraction_tx	Fractional cloud cover	1	t_single,rows,columns
dew_point_tx	2-m dew point	K	t_single,z_atmos,rows ,columns
east_west_stress_tx	East–west integrated surface wind stress	N m^{-2} s	t_series,rows,columns
latent_heat_tx	Integrated surface latent heat flux	W m^{-2} s	t_series,rows,columns
north_south_stress_tx	North–south integrated surface wind stress	N m^{-2} s	t_series,rows,columns
sea_ice_fraction_tx	Sea ice fraction	1	t_single,rows,columns
sea_surface_temperature_tx	Sea surface temperature	K	t_single,rows,columns
sensible_heat_tx	Integrated surface sensible heat flux	W m^{-2} s	t_series,rows,columns
skin_temperature_tx	Skin temperature	K	t_single,rows,columns
snow_depth_tx	Snow liquid water equivalent depth	m	t_single,rows,columns
snow_albedo_tx	Snow broadband albedo	1	t_single,rows,columns
soil_wetness_tx	Volumetric soil water layer 1	m^3 m^{-3}	t_single,rows,columns
solar_radiation_tx	Integrated surface solar radiation	W m^{-2} s	t_series,rows,columns
specific_humidity_tx	Specific humidity profile (kg/kg)	kg kg^{-1}	t_single,p_atmos,rows ,columns
surface_pressure_tx	Surface pressure	hPa	t_single,rows,columns
temperature_profile_tx	Atmospheric temperature profile	K	t_single,p_atmos,rows ,columns
temperature_tx	2-m air temperature	K	t_single,z_atmos,rows ,columns
thermal_radiation_tx	Integrated surface solar radiation	W m^{-2} s	t_series,rows,columns
total_column_ozone_tx	Total column ozone	kg m^{-2}	t_single,rows,columns
total_column_water_vapour_tx	Total column water vapour	kg m^{-2}	t_single,rows,columns
u_wind_tx	10-m U wind component	m s^{-2}	t_series,z_wind,rows,columns
v_wind_tx	10-m V wind component	m s^{-2}	t_series,z_wind,rows,columns
t_bound	Start and stop times for integrated products	hours since	t_series,n_bound

Element name	Description	Unit	D
t_forecast	For forecast parameters, the time of the analysis from which the forecast was made	hours since	1
t_series	Synoptic times of time series fields	hours since	t_series
t_single	Synoptic time of single time fields	hours since	t_single
p_atmos	Pressure level coordinates	Pa	p_atmos
z_atmos	Height of atmospheric field above surface	m	z_atmos
z_bound	Soil wetness level depth bounds	m	z_soil,n_bound
z_soil	Depth of soil wetness level	m	z_soil
z_wind	Height of wind field above surface	m	z_wind

(return to *Measurement datasets*)
(return to *Meteorological parameters auxiliary dataset*)

Information relevant to this 16-km file can be found in Sections 5.10.6: Grid differences and offset values and 5.10.15: Meteorological file (met_tx.nc).

4.9 Flag Tables

This section displays the meanings of the bit settings for all the flag tables within the product. Users should note that actual bit values are assigned as signed bytes, with further details given in Section 5.10.1.

4.9.1 Pixel exception values (within Measurement MDS)

Table 4-18 displays the pixel exception values for the radiance and brightness temperature MDS.

Users should also note one relevant high-priority open issue (see Section 7.1):

Open Issue
Measurement data: The exception word for cosmetically filled pixels has not been copied over from the natural pixels.

Table 4-18. Radiance and brightness temperature pixel exception values

Bit number	Text code	Description
0	ISP_absent	ISP/scan absent
1	pixel_absent	Pixel absent
2	not_decompressed	Not decompressed

3	no_signal	No signal in channel
4	saturation	Saturation in channel
5	invalid_radiance	Derived radiance outside calibration
6	no_parameters	Calibration parameters unavailable
7	unfilled_pixel	Unfilled pixel

(return to *Measurement datasets*)
(return to Visible and Shortwave Infrared MDS)
(return to Thermal Infrared MDS)

It should be noted that, as in the previous Envisat-format products, noise in the radiance (visible−shortwave infrared) channels at night-time can cause both the radiance field and the exception values to be filled with non-valid data.

4.9.2 Global cloud word definitions (within Global flags ADS)

Table 4-19 displays the global cloud word definitions contained within the Global flags ADS. It is intended that the assigned cloud flags match those contained within the (A)ATSR products from the 3rd reprocessing as far as possible. The cloud word *definitions* match those from SLSTR, although it can be seen that not all SLSTR cloud tests are applicable to the (A)ATSR data.

Global cloud flags will not be assigned to the orphan pixels.

Table 4-19. Global cloud word definitions

Bit	Text code	Meaning if set	Comment
0		Visible channels cloud test	Day time only
1		(not implemented)	
2		1.6 µm small-scale histogram test (*previously referred to as the 1.6 µm spatial coherence test*)	Day time only
3		1.6 µm large-scale histogram test (*previously referred to as the 1.6 µm reflectance histogram test*)	Day time only
4		(not implemented)	
5		(not implemented)	
6		11 µm spatial coherence test	
7		12 µm gross cloud test	
8	thin_cirrus	11 µm/12 µm thin cirrus test	
9		3.7 µm/12 µm medium/high level test	
10	fog_low_stratus	11 µm/3.7 µm fog/low stratus test	
11		11 µm/12 µm view difference test	Uses both views
12		3.7 µm/11 µm view difference test	Uses both views
13	thermal_histogram	11 µm/12 µm thermal histogram test	

Bit	Text code	Meaning if set	Comment
14		spare	
15		spare	

(return to *Global flags annotation datasets*)
(return to *Global flags ADS variables*)

Further information on cloud is given in Section 5.7.

4.9.3 Bayesian/probabilistic cloud word definitions (within Global Flags ADS)

Table 4-20 displays the definitions for the Bayesian (ocean and inland water) and probabilistic (land) cloud word definitions.

Bit 7 remains set if a pixel is not analysed by the Bayesian or probabilistic cloud processors. (This was likely to have been the case around coastlines and inland water edges.)

- **However**, to follow SLSTR's operational decision in 2022, the 4th reprocessing L1B products will **not** now contain Bayesian or probabilistic cloud information, which is considered better placed in the SST and LST Level 2 products. Therefore, the struck-out parameters in Table 4-20 demonstrate that, while the Product Specification [RD.2] and products contain descriptors for these items, they will not be filled for the released L1B datasets.

Table 4-20. Bayesian/probabilistic cloud word definitions

Bit number	Meaning if set	Comment
~~0~~	~~Single view low probability threshold~~	~~Climate-quality clearing~~
~~1~~	~~Single view moderate probability threshold~~	~~Operational-quality clearing~~
~~2~~	~~Dual view low probability threshold~~	~~Climate-quality clearing~~
~~3~~	~~Dual view moderate probability threshold~~	~~Operational-quality clearing~~
4	spare	
5	spare	
6	spare	
7	No Bayesian probabilities available	Default setting

(return to *Global flags annotation datasets*)
(return to *Global flags ADS variables*)

Further information on cloud is given in Section 5.7.

4.9.4 Pointing word definitions (within Global Flags ADS)

Table 4-21 displays the pointing word definitions within the Global Flags ADS. There are only two switches possible:

scan_mirror_integrated_error: for AATSR only, is an indication of 'jitter', whereby the number of pixels within the instrument scan is not nominal due to a non-smooth sweep of the scanning mirror, and therefore the relationship between (odd/even) pixel and integrator has been lost. Consideration of uncertainties for AATSR can bear this in mind, although no such information exists for ATSR-1 or ATSR-2 within the products.

platform_mode: will be always set to 0. Information on non-nominal products, including any satellite control manoeuvres, can be found in the quality section of the manifest (Section 5.9).

Table 4-21. Pointing word definitions

Bit number	Text code	Meaning if set	Comment
0		(not implemented)	
1		(not implemented)	
2		(not implemented)	
3		(not implemented)	
4	scan_mirror_integrated_error	Pixel counter not equal to 2000	AATSR only
5		(not implemented)	
6		(not implemented)	
7	platform_mode	Platform mode	0 if nominal, else 1

(return to *Global flags annotation datasets*)
(return to *Global flags ADS variables*)

4.9.5 Confidence word definitions (within Global Flags ADS)

Table 4-22 displays the confidence word definitions within the Global Flags ADS, showing details of surface type, daytime, and summaries of cloud tests and pointing flags.

Some flags are not set for orphan pixels. Users can infer the likely flag by inspecting neighbouring image-grid pixels via inspection of the scan and pixel information given in the indices datafiles (see Section 4.6.1).

Users should also note two relevant high-priority open issues (see Section 7.1):

Open Issue

Measurement data: The exception word for cosmetically filled pixels has not been copied over from the natural pixels

Open Issue

Confidence word: The duplicate pixel flag has not been raised to show an orphan pixel exists

Table 4-22. Confidence word definitions

Bit number	Text code	Meaning if set	Comment
0	coastline	Coastline in field of view	
1	ocean	Ocean in field of view	
2	tidal	Tidal zone in field of view	
3	land	Land in field of view	
4	inland_water	Inland water in field of view	
5	unfilled	Unfilled pixel (1 if this pixel is never tested or filled)	
6	spare	spare	
7	blanking_pulse	RADAR active	
8	cosmetic	Cosmetic fill pixel	
9	duplicate	Pixel has a duplicate	
10	day	Pixel in daylight	Not set for orphans
11	twilight	Pixel in twilight	Not set for orphans
12	sun_glint	Sun glint in pixel	Not set for orphans
13	snow	Snow	Not set for orphans
14	summary_cloud	Summary cloud test	Not set for orphans
15	summary_pointing	Summary pointing	

(return to *Global flags annotation datasets*)
(return to *Global flags ADS variables*)

5. FURTHER NOTES FOR USERS

This section gives further information for users, both on the measured data within the products, and the technical features of the NetCDF files.

5.1 AATSR 12 micron discrepancy

Users are advised that the corrections for the AATSR 12 micron channel discrepancy, explained in [RD.11] and links within, have been incorporated into the 4th reprocessing products.

5.2 Channel Terminology and Instrument Differences

Users of 3rd reprocessing (A)ATSR products may be interested to note the difference in channel and view terminology between the 3rd and 4th reprocessing datasets, and these are given in Table 5-1.

Table 5-1. Differences in terminology between the 3rd and 4th reprocessing products

Third Reprocessing	Fourth Reprocessing
Forward view	Oblique view
0.55 µm channel	S1 radiance channel
0.66 µm channel	S2 radiance channel
0.87 µm channel	S3 radiance channel
1.6 µm channel	S5 radiance channel
3.7 µm channel	S7 BT channel
11 µm channel	S8 BT channel
12 µm channel	S9 BT channel

Note that each of the (A)ATSR instruments have different channel availability. Table 5-2 shows the channels fitted in each of the three instruments and whether or not these channels are continuously available. Although 4th reprocessing products contain files for all channels, they are not all populated with data.

Table 5-2. Instrument differences regarding channel availability

Channel	ATSR-1		ATSR-2		AATSR	
	Fitted?	Always on?	Fitted?	Always on?	Fitted?	Always on?
S1	no	-	yes	no	yes	yes
S2	no	-	yes	no	yes	yes
S3	no	-	yes	no	yes	yes
S5	yes	no	yes	no	yes	yes
S7	yes	no	yes	no	yes	yes
S8	yes	yes	yes	yes	yes	yes
S9	yes	yes	yes	yes	yes	yes

5.3 Mapping of Information between the 3rd and 4th Reprocessings

The location of information has changed between the 3rd and 4th reprocessing products, due to their very different specifications. The 3rd reprocessing product specification is available in [RD.7].

Table 5-3 shows the mapping of L1B information between the two reprocessings, by using table 6.6 from [RD.7] as a reference.

Table 5-3. L1B information mapping between the 3rd and 4th reprocessings

Information	3rd Reprocessing Location (with section number from [RD.7])	4th Reprocessing Location (with filename; reference)
Envisat MPH	MPH 6.6.1.	xfdumanifest.xml; section 3
Level 1B SPH	SPH 6.6.50.	xfdumanifest.xml; section 3
Summary Quality ADS	SUMMARY_QUALITY_ADS 6.6.45.	*Various* Quality information: xfdumanifest.xml; section 3 Jitter information: flags_in/_io.nc; section 4.4 Scan number information: indices_in/_io.nc; section 4.6.1
Grid pixel latitude and longitude, topographic corrections ADS	GEOLOCATION_ADS 6.6.43.	cartesian_tx.nc; section 4.6.2 geodetic_in.nc; section 4.6.3 geodetic_io.nc; section 4.6.3 geodetic_tx.nc; section 4.6.3
Scan pixel x and y ADS	SCAN_PIXEL_X_AND_Y_ADS 6.6.44.	indices_in.nc; section 4.6.1 indices_io.nc; section 4.6.1
Nadir view solar angles ADS	NADIR_VIEW_SOLAR_ANGLES_ADS 6.6.64.	geometry_tn.nc; section 4.7
Forward view solar angles ADS	FWARD_VIEW_SOLAR_ANGLES_ADS 6.6.64.	geometry_to.nc; section 4.7
Visible channel calibration parameters GADS	VISIBLE_CALIB_COEFS_GADS 6.6.51.	S*_quality_in.nc; section 4.3.1 S*_quality_io.nc; section 4.3.1
Scan and pixel number nadir view ADS	NADIR_VIEW_SCAN_PIX_NUM_ADS 6.6.62.	indices_in.nc; section 4.6.1
Scan and pixel number forward view ADS	FWARD_VIEW_SCAN_PIX_NUM_ADS 6.6.62.	indices_io.nc; section 4.6.1
12 micron nadir view MDS	11500_12500_NM_NADIR_TOA_MDS 6.6.47.	S9_BT_in.nc; section 4.2
11 micron nadir view MDS	10400_11300_NM_NADIR_TOA_MDS 6.6.47.	S8_BT_in.nc; section 4.2
3.7 micron nadir view MDS	03505_03895_NM_NADIR_TOA_MDS 6.6.47.	S7_BT_in.nc; section 4.2
1.6 micron nadir view MDS	01580_01640_NM_NADIR_TOA_MDS 6.6.49.	S5_radiance_in.nc; section 4.1
0.87 micron nadir view MDS	00855_00875_NM_NADIR_TOA_MDS 6.6.49.	S3_radiance_in.nc; section 4.1
0.66 micron nadir view MDS	00649_00669_NM_NADIR_TOA_MDS 6.6.49.	S2_radiance_in.nc; section 4.1

Information	3rd Reprocessing Location (with section number from [RD.7])	4th Reprocessing Location (with filename; reference)
0.55 micron nadir view MDS	00545_00565_NM_NADIR_TOA_MDS 6.6.49.	S1_radiance_in.nc; section 4.1
12 micron forward view MDS	11500_12500_NM_FWARD_TOA_MDS 6.6.46.	S9_BT_io.nc; section 4.2
11 micron forward view MDS	10400_11300_NM_FWARD_TOA_MDS 6.6.46.	S8_BT_io.nc; section 4.2
3.7 micron forward view MDS	03505_03895_NM_FWARD_TOA_MDS 6.6.46.	S7_BT_io.nc; section 4.2
1.6 micron forward view MDS	01580_01640_NM_FWARD_TOA_MDS 6.6.48.	S5_radiance_io.nc; section 4.1
0.87 micron forward view MDS	00855_00875_NM_FWARD_TOA_MDS 6.6.48.	S3_radiance_io.nc; section 4.1
0.66 micron forward view MDS	00649_00669_NM_FWARD_TOA_MDS 6.6.48.	S2_radiance_io.nc; section 4.1
0.55 micron forward view MDS	00545_00565_NM_FWARD_TOA_MDS 6.6.48.	S1_radiance_io.nc; section 4.1
Confidence words nadir view MDS	NADIR_VIEW_CONFIDENCE_MDS 6.6.65.	flags_in.nc; section 4.4
Confidence words forward view MDS	FWARD_VIEW_CONFIDENCE_MDS 6.6.65.	flags_io.nc; section 4.4
Cloud flag nadir view MDS	NADIR_VIEW_CLOUD_MDS 6.6.63.	flags_in.nc; section 4.4
Cloud flag forward view MDS	FWARD_VIEW_CLOUD_MDS 6.6.63.	flags_io.nc; section 4.4

Other points of difference between the 3rd and 4th reprocessings are itemised in Table 5-4.

Table 5-4. Other points of difference between the 3rd and 4th reprocessings

Information	3rd Reprocessing	4th Reprocessing
Exception value placement	Within channel MDS, replacing invalid measurement pixel	Within channel MDS as a separate parameter, leaving a fill value in MDS pixel
Exception value allocation	One exception value duplicated in all channels, regardless of applicability	Channel-dependent exception value
Ungridded measurement locations	External information was needed to calculate the ungridded location of the pixel measurement	All information to make this calculation is now within the product
Visible/short-wave IR channels	Measurements in reflectance	Measurements converted to radiance units
(A)ATSR data rate	Not available	atsr_in / _io; section 4.5
ATSR-2 pixel selection map ID	Not available	atsr_in / _io; section 4.5

5.3.1 Quality and classification flags

A technical note on the quality and classification flags in both the 3rd and 4th Reprocessing products is available in [RD.8].

5.4 Differences between (A)ATSR and SLSTR Products

The 4th reprocessing is designed to follow the specification of SLSTR products. Of course, differences between the instruments mean this is not possible in every case. This section outlines where users may expect to find differences.

The SLSTR format used at the time of the 4th reprocessing initiation is specified in [RD.1]. It can easily be noted that the SLSTR products contain more information than is available for (A)ATSR. Therefore, some sections will be absent and some will contain fill values.

Table 5-5 outlines the main differences between SLSTR and (A)ATSR instruments and 4th reprocessing products.

Table 5-5. Main differences between SLSTR and (A)ATSR products

SLSTR	(A)ATSR
Oblique view: backwards facing	Oblique view: forwards facing
Vis – SWIR channel resolution 500 m	Vis – SWIR channel resolution 1 km
Spectral channels S1–S9 Fire channels F1, F2	No spectral channels S4, S6 No fire channels
No files atsr_in / atsr_io	atsr_in / atsr_io included
Swath widths are 1420 km (nadir), 750 km (oblique)	Swath width for both views is 512 km
‘i’, ‘a’, ‘b’, ‘c’ and ‘t’ stripe grids available	‘i’ and ‘t’ stripe grids available (‘i’ applies to both BT and radiance channels)
Tie point data is computed per line	Tie point data is computed every 16 lines
viscal.nc file included	No viscal.nc for (A)ATSR
soil wetness parameter in met_tx is specified to be code 140 (soil wetness (level1))	soil wetness parameter in met_tx is code 39 (volumetric soil water layer 1)
Differences in settings and definitions:	
Global cloud word definitions	Certain tests unable to be implemented; see Table 4-19
Bayesian and probabilistic cloud word definitions	Bit 7 added for no Bayesian or probabilistic flag available; see Table 4-20
Pointing word definitions	Certain flags unable to be set; see Table 4-21
Confidence word definitions	Bit 7 added as blanking_pulse; see Table 4-22
NetCDF settings	Differences necessarily exist due to instrument and dynamic range differences Users are recommended <u>not</u> to use hard-coded scale factors or offsets
Bit allocation for flags	Differences due to signed/unsigned byte

SLSTR	(A)ATSR
	assignation; see section 5.10.2

Table 5-6 shows information that has been retained from the 3rd reprocessing products, or retrieved from the original data, and transferred to the 4th reprocessing products, but that have no equivalents in the SLSTR format. The extra information will be stored either in spare fields in the 4th reprocessing products (noted in the table), or in an extra NetCDF file within the product.

Table 5-6. Extra information added to 4th reprocessing products (no equivalent exists in SLSTR)

Information	Placing in 4th reprocessing products
Blanking pulse	Bit 7 of the Confidence word (Table 4-22)
(A)ATSR telemetry downlink rate	To go in extra data file (section 4.5)
ATSR-2 pixel selection map	To go in extra data file (section 4.5)

5.5 Dimensions and Grids

The dimensions and grids specified in the NetCDF files are outlined more closely in this section.

5.5.1 Dimensions

The following list gives information on the dimensions that are listed in the dataset descriptor tables:

- **rows**: the number of pixels in the along-track direction within the dataset. Note that not all rows are filled with valid measurement data.
- **columns**: the number of pixels in the across-track direction within the dataset. Note that not all columns are filled with valid measurement data.
- **orphan_pixels**: the dimension for 'orphan_pixels' is set at 100 before regridding, since it is not known how many orphans will be collected. The number of filled data values will be lower.
- **uncertainties**: This dimension is dependent on how many data values are present in the look-up table that is used to set uncertainty values.
- **detectors**: for (A)ATSR data, this dimension is always 1, since there is only one detector.
- **integrators**: for (A)ATSR data, this dimension is always 2, since there are two integrators. This allows instrument pixel data to be labelled as 'odd' or 'even' pixels, depending on which integrator was used to generate the measurement.
- **For meteorological data,** the dimensions used for variables (other than rows and columns) are specified within the file itself, and are generally as follows:
    - single surface and near-surface values with a single time dimension (t_single)
    - surface and near-surface values time series with 5 time values (t_series)
    - profile values at a single time with 25 pressure levels (p_atmos)

  - near-surface values are bounded by the height of the atmospheric field above the surface (z_atmos), by the height of wind field above surface (z_wind), or by depth boundaries (z_soil, n_bound)

5.5.2 Grids

The following terminology and dimensions are used for the grids available in the 4th reprocessing products:

- **Image grid**, full resolution (1 km x 1 km); dimensions are (rows, columns)
- **Orphan pixel grid**, full resolution (1 km x 1 km); dimensions are (rows, orphan_pixels)
- **Tie-point grid**, tie-point resolution (16 km x 16 km); dimensions are (rows, columns)

5.6 Uncertainties

The inclusion of total uncertainties within the measurement datasets are a new feature of the (A)ATSR reprocessing dataset, and are an initial attempt at quantifying the total uncertainties inherent in each pixel measurement.

The uncertainty in the calibration for each pixel is the root sum-square of the uncertainties due to random effects (noise) and the uncertainties in systematic effects (i.e. calibration). Calibration uncertainties for each channel are provided as a function of scene temperature/radiance in an auxiliary data file. The values provided in these tables are based on the pre-flight calibration results and account for known degradation effects, e.g. diffuser drift model, blackbody thermometer drifts, and were generated by D. Smith, RAL Space. Constants used within the uncertainty calculations, and LUT information, can be found in the Quality ADS (Section 4.3).

This section aims to inform users on what to expect in the products. It should be noted that the AATSR products contain the most reliable uncertainty estimates due to more comprehensive auxiliary information.

5.6.1 Items to note

- Thermal uncertainty values can be seen to follow the pattern of the instrument curved scan.
- The across-track alternate pixel banding that can sometimes be seen in thermal uncertainty values is due to different uncertainties calculated from the two integrators, which each deal with alternate (“odd” and “even”) pixels in the scan.
- Along-track pixel banding (in bands of 10) that can be seen in thermal uncertainty values, when these values are low, is due to the calibration period, which encompasses 10 instrument scans, and applies the calculated signal noise to each of those scans.
- Thermal uncertainty values are only calculated in the range 200 K < BT < 330 K. Occasional small negative uncertainty values can be generated for BT values ~200.01 K; these can be disregarded.
- Radiance uncertainties are not calculated above an equivalent reflectance value of 1.2; values so high are usually affected by sun glint.
- Noise present in the radiance measurement data at night can also give rise to the generation of uncertainty values; these can be disregarded.
- Radiance uncertainties for ATSR-1 and ATSR-2 are based only on the measured signal and LUTs; no external visible calibration has been incorporated into the pixel uncertainty calculation.
- There is no uncertainty information available for orphan pixels.

- Note that ATSR-1 radiance channel *measurements* are not calibrated.
- Note that ATSR-2 measurements for July 2003 onwards, if available in the 4th reprocessing release, are not calibrated.

5.7 Cloud information

The cloud information available within the Global Flags ADS (Section 4.4) contains the **basic cloud** information only. Table 5-7 gives the details.

Table 5-7. Cloud flag information

Cloud parameter	Type	Source	Application
~~probability_cloud_single_i<v>~~	~~%~~	~~SST_cci (Bayesian)~~	~~Over ocean and inland water~~ ~~No values for orphan data~~
~~probability_cloud_dual_i<v>~~		~~LST_cci (probabilistic)~~	~~Over land~~ ~~Values for orphan data possible~~
cloud_i<v>	flag (Table 4-19)	RAL Space (in line with 3rd reprocessing)	All surface types No values for orphan data
~~bayes_i<v>~~	~~flag (Table 4-20)~~	~~SST_cci (Bayesian)~~	~~Over ocean and inland water~~ ~~No values for orphan data~~
		~~LST_cci (probabilistic)~~	~~Over land~~ ~~Values for orphan data possible~~

The "cloud" flag is closely related to the cloud information available in the 3rd reprocessing products, but does not replicate it exactly. This is because the ATSR-1/-2 cloud auxiliary data files (**ADF**) have been corrected, and also because the 3rd and 4th reprocessing products are likely to have measurements placed into a slightly different pixel due to regridding changes. Details on cloud processing are given in the AATSR Handbook [RD.9].

The 4th reprocessing L1B dataset will not now contain Bayes or probabilistic cloud information; this cloud information will be contained within the Level 2 products (and generated by the ESA SST and LST CCI teams). This follows SLSTR's operational decision in 2022. The struck-out parameters in Table 5-7 demonstrate that, while the Product Specification [RD.2] and products contain descriptors for these items, they will not be filled for the released L1B datasets.

5.8 ADF usage in processing

Information on ADF usage is incorporated into the manifest of each product. This subsection flags abnormal situations, and highlights where ADFs have changed from the 3rd reprocessing.

5.8.1 Orbit state vector ADFs

The standard ESA set of restituted orbit state vector (**OSV**) ADFs are used for each instrument, with the following exception:

- The ERS-1 hibernation period (27/07/1996–17/12/1997) uses predicted OSVs generated by RAL Space, since no files exist in the ESA archive for this period.

5.8.2 Attitude ADFs

Geolocation processing now makes use of dynamic attitude ADFs. However, the following highlight the times for which **no** dynamic attitude ADFs were used:

- AATSR: Launch to 27/01/2005, and on 08/04/2012
- ATSR-2: Launch to 12/02/2001, which was when the last gyro failed
- From this time, ERS-2 HEY data was used to account for yaw drift
  - There was the intention to use ERS-2 HEY data from 12/2/2001, but the initial released dataset may not have used this option. Users can check by searching the xfdumanifest.xml file for the string "AUX_FRA". If it is not found, then attitude ADFs were not used for that product.
- ATSR-1: Whole mission (no dynamic information available)

5.8.3 ADF changes from 3rd reprocessing

The ADFs that have been changed between the 3rd and 4th reprocessing are given in Table 5-8.

Table 5-8. ADF changes between the 3rd and 4th reprocessings

ADF change	Reason
AATSR General Calibration	Incorporation of 12 micron (S9) nonlinearity correction
AATSR Characterisation	Improvement of colocation
ATSR-1/-2 Cloud test LUT	Correction of latitudes
(A)ATSR Land water mask	Improved information
(A)ATSR Digital Elevation model	Improved information

5.9 Product Quality Information

The 3rd (A)ATSR reprocessing contained a segregated area within the data archives for products that were of non-nominal or unknown quality. The 4th reprocessing will not make use of a segregated archive, but instead will include information in the quality section of the product manifest.

Users should also note two relevant high-priority open issues for ATSR-2 (see Section 7.1):

Open Issue
ATSR-2 Manifest xml: Quality-check tag in manifest should be changed from "passed" to

“degraded” for time period after the loss of the ERS-2 gyros:16 January 2001 at 06:32:30 (product orbit 30019) to 05 July 2001 at 22:34:40 (product orbit 32462).

Open Issue

ATSR-2 Manifest xml: Quality-check tag in manifest should be changed from “passed” to “degraded” for all time periods when HEY attitude file data should have been used (from 12 February 2001 to June 2003).

5.9.1 Nominal product

If a product has no known issues associated, then the following setting will be active:

```
<sentinel3:onlineQualityCheck>PASSED</sentinel3:onlineQualityCheck>
```

5.9.2 Non-nominal or unknown quality product

The following overall setting will be active for a non-nominal or unknown quality product:

```
<sentinel3:onlineQualityCheck>DEGRADED</sentinel3:onlineQualityCheck>
```

5.9.2.1 Satellite manoeuvre

Further information will then be given, so for a satellite manoeuvre:

```
<sentinel3:satelliteManoeuvre>
    <sentinel3:startTime>2011-01-07T12:40:09.000Z</sentinel3:startTime>
    <sentinel3:stopTime>2011-01-07T14:03:36.000Z</sentinel3:stopTime>
    <sentinel3:type>out-of-plane</sentinel3:type>
</sentinel3:satelliteManoeuvre>
```

and the following flag will be set:

```
<sentinel3:degradationFlags>MANOEUVRES</sentinel3:degradationFlags>
```

5.9.2.2 Other situations

For other situations, the following flag will be set (it could also be set in addition to the satellite manoeuvre flag):

```
<sentinel3:degradationFlags>NON_NOMINAL_INPUT</sentinel3:degradationFlags
>
```

The NON_NOMINAL_INPUT degradation flag covers the following situations:

- Commissioning Phases or tests carried out during commissioning
- Instrument operations: outgassings and blackbody cross-over tests
- Other low-quality products that have been identified during quality control procedures
- Products of unknown quality that have not been adequately assessed, e.g. data recovered after the mission ended

If users require further information on the likely reason for a non-nominal classification, details can generally be found via the ESA EO website:

https://earth.esa.int/eogateway/missions/heritage-missions for Envisat and ERS missions.

5.10 Technical Features

This section contains details on technical features of the products that may give rise to problems; these concern the product format, and not the scientific data within the products.

Very useful work by Brockmann Consult for the update required for SNAP to read 4th reprocessing products via the manifest file have rendered some of the items below transparent to the user. They will be more readily seen if using other applications or command-line enquiries to inspect the NetCDF files independently.

5.10.1 NetCDF-4, Java and Unsigned Data Types

At the time of 4th reprocessing initiation, the Java NetCDF-4 library did not contain an assignation for unsigned byte, or unsigned short. Discussion on this issue can be found on the internet, e.g.
https://github.com/Unidata/netcdf4-python/issues/656.

A consequence was that variables defined as unsigned in [RD.2] were stored as signed in the NetCDF files, but with an '_Unsigned' attribute that allowed some viewers and readers to display the stored values as the user expects (i.e. unsigned), while others would still display the signed value. See Section 5.10.1.1 for further explanation.

For version 1.1 of this User Document, the situation with viewers appears to have improved. Users can note the change from version 1.0 by the example given in Section 5.10.1.2. The metadata may still contain the signed byte value (Table 5-9) but printouts of values are giving the expected unsigned value.

Table 5-9. Metadata containing signed flag mask (highlighted in blue) from Panoply

```
netcdf file:
ENV_AT_1_RBT____20050311T022425_20050311T041000_20210408T073910_6
334_035_246______DSI_R_NT_004.SEN3/atsr_io.nc {
  dimensions:
    rows = UNLIMITED;   // (43137 currently)
  variables:
    ushort TLM_rate_io(rows=43137);
      :long_name = "telemetry data rate";
      :flag_masks = 0S, 2519S, -5232S; // short
      :flag_meanings = "fixed_rate low_rate high_rate";
      :_Unsigned = "true";
      :_ChunkSizes = 4096U; // uint
```

5.10.1.1 Byte flag values: Java and the norm

As background, for parameters consisting of byte flag values, **(A)ATSR** 4th reprocessing flags are stored as Java signed bytes, and have the following bit values:

For a **Java** 1-byte flag:

1	2	4	8	16	32	64	-128

For a **Java** 2-byte flag:

1	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	-32768

For comparison, flags within **SLSTR** are set as unsigned bytes, and have the commonly accepted bit values shown below:

For a 1-byte flag:

1	2	4	8	16	32	64	128

For a 2-byte flag:

1	2	4	8	16	32	64	128	256	512	1024	2048	4096	8192	16384	32768

This meant that the maximum possible values in 4th reprocessing NetCDF files did not correspond to the pixel value if all bits were set:

	Maximum possible value in 4th reprocessing NetCDF files	Value of flag if all bits are set
1 byte	127	-1 (NOT 255)
2 bytes	32767	-1 (NOT 65535)

A further consequence was that, in unassigned pixels with no available measurement data, all flags (bits) are set to "true", and the pixel value therefore be given as -1. Since there were no measured data corresponding to these pixels, this fact would not have an impact on users, however, it is wise to be aware of this effect.

The situation described above appears to have been resolved, and the following section gives an example of the evolution from v1.0 of this document to v1.1.

5.10.1.2 Illustration of evolution using JavaToolsUI/NetCDF (5.0) Tools

The atsr_i<v>.nc file contains a variable (Section 4.5) specified in Java with the '_unsigned' attribute:

- PSM_ID_i<v>, byte, _unsigned, fill value=255.

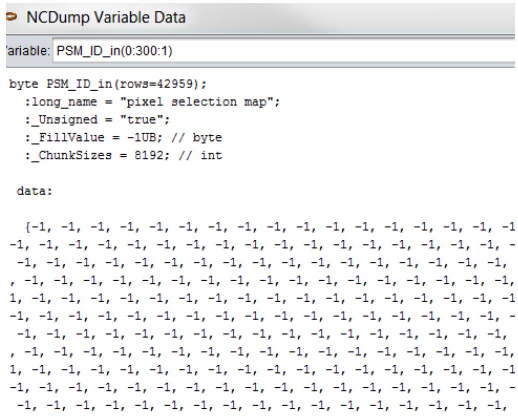
The time_in.nc file contains variables such as (Section 4.6.4):

- Oblique_First_Scan_i, short, _unsigned, fill value=65535

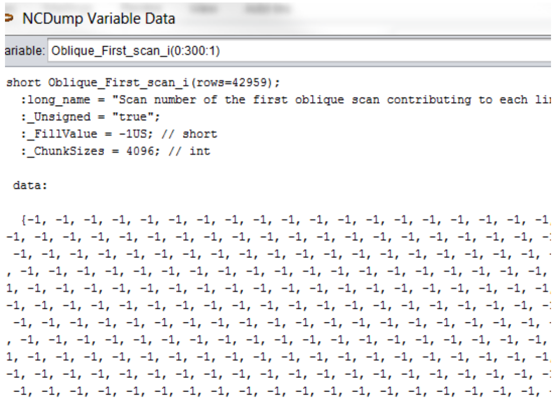
The outputs below illustrate the evolution regarding the display of fill values. Note that the metadata has also changed but in some cases still displays the signed fill value or mask value (depending on the viewer; Table 5-9).

Table 5-10: Change between v1.0 and v1.1 of this document, showing evolution of display of Java unsigned bytes

JavaToolsUI displayed signed fill values for version 1.0 of this document:

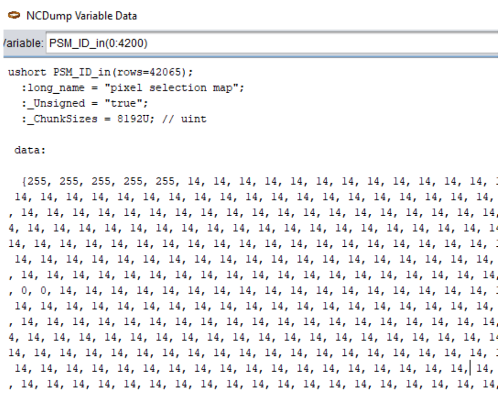


JavaToolsUI: PSM_ID for AATSR in v1.0, displaying signed fill value (-1)

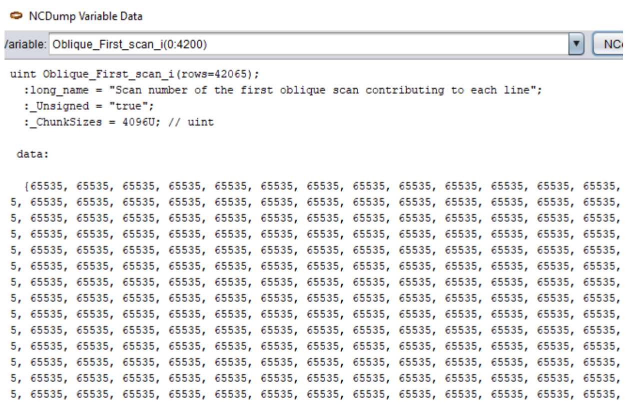


JavaToolsUI: Oblique_First_scan for AATSR in v1.0, displayed signed fill value (-1)

__**NetCDF (5.0) Tools**__ displays accepted fill values for version 1.1 of this document:



__**NetCDF (5.0) Tools**__: PSM_ID for ATSR-2 in v1.1, displaying accepted fill value (255)



__**NetCDF (5.0) Tools**__: Oblique_First_scan for ATSR-2 in v1.1, displaying accepted fill value (65535)

5.10.2 Whole-orbit, segmented-orbit products and product overlaps

For the 3rd reprocessing, a reconsolidation exercise for all existing near-real time (**NRT**) AATSR Level 0 products was undertaken. This resulted in a largely consistent set of AATSR whole-orbit L0, and therefore L1B, products, with small overlaps at the ANX. The ATSR-1 and ATSR-2 datasets were truncated at the ANX with no overlaps between products.

For the 4th AATSR reprocessing, a L0 gap recovery exercise was undertaken, and several new NRT L0 products were found. These were consolidated in isolation from the remaining consolidated L0 dataset. This has resulted in many segmented-orbit L1B products that can have quite sizeable overlaps with adjacent products. If overlaps are undesirable, users are reminded to check the start and stop times of the data within the products, and use advice such as given in [RD.6] (Q.32 in Issue 3) on how to remove overlaps between products.

For the 4th ATSR-1/-2 reprocessing, the use of a new L1A to L1B processor has meant that the L1B products now have overlaps with adjacent products. Users are referred to the removal method outlined in the previous paragraph.

5.10.3 SNAP/Sentinel-3 Toolbox and 4th reprocessing products

5.10.3.1 Use of manifest file for display

SNAP/Sentinel-3 Toolbox version 9 allows the display of the 4th reprocessing products via the use of the manifest for AATSR and ATSR-1. However, most ATSR-2 products **cannot** yet be viewed this way due to a mismatch between the number of image rows stated in the manifest and the number of actual rows in the image-resolution data files. Users can view the NetCDF files individually in SNAP or via other readers or viewers until this facility becomes available.

5.10.3.2 Geolocation display

Geolocation information displayed via the Pin Manager is the geolocation of the pixel inferred (interpolated) from the 16-km tie-grid geodetic files.

Users are reminded that the precise latitude and longitude of the measurement that is contained within the 1-km pixel can be found in the geodetic_in and geodetic_io files.

Cartesian parameters x_in/x_io and y_in/y_io from the cartesian_in/io files cannot be displayed fully in SNAP as they were intended, rather SNAP divides the x and y parameters into 'lsb' (least significant bit) and 'msb' (most significant bit).

5.10.3.3 Time display

The time information given in SNAP cannot be considered to be exact, since the originating time files have a flaw in the time stamp; see Section 5.10.7: Time file (time_in.nc).

5.10.3.4 ATSR additional information file (atsr_in.nc/atsr_io.nc)

The reading of these files is not enabled in SNAP currently, so independent file viewing is advised.

5.10.4 Comparison of gridded pixel measurements between the 3rd and 4th reprocessing products

If users attempt to engage in a side-by-side comparison of gridded measurements between the 3rd and 4th reprocessing products, they will find that there is not always an exact match. The use of dynamic attitude information, and/or the geolocation to a DEM, can result in a slightly different latitude/longitude calculation for each scanned instrument pixel. The measurement chosen to fill a gridded pixel can therefore be different to that within the 3rd reprocessing, due to either the location change, or the fact that the processor finds a different instrument pixel to fill the image pixel. This would be expected to apply to only a few pixels scattered within the product, and not be a large-scale effect.

Comparison line differences in the 11 µm (S8) channel of up to 50 K have been seen due to changes in either (or both of) the cloud processing or allocation of different instrument measurements to the image grid.

5.10.5 Spurious accuracy in measurement values

Users who use other NetCDF viewers (e.g. Java toolsUI) to display data, may observe spurious accuracy in some data points. For example, a data readout of pixel BT values might show as follows:

223.62, 236.74, 248.35, 251.63, 252.76000000000002, 251.73000000000002, 252.88,….

However, BT values are valid to two decimal places only. This phenomenon may appear in other data points, so users are advised to be aware.

5.10.6 Grid differences and offset values

This section contains notes on grid differences and the along- and across-track offset values assigned to them. For a visual reference, figures 4-1 and 4-2 in [RD.2] show the grid structures; figure 4-1 is reproduced here as Figure 5-1. Note that the instrument pixel location is represented by the small pink circle inside the grid lines; it is not sitting on the grid lines, as is the case for many other instruments.

5.10.6.1 Tie-point grid data differences

Tie-point grid data coverage is different for view-specific and view-agnostic tie-point grids.

- View-agnostic files, geodetic_tx.nc and cartesian_tx.nc, are generated on a tie-point grid that encompasses the image grid, as seen in Figure 5-1 for the nadir view.
- View-specific files, geometry_tn.nc and geometry_to.nc, are calculated initially at the instrument pixel locations (every 10 scans) and are then interpolated to the image grid. This means that they span the width of the image grid but do not encompass it.

In order to maintain consistency of grid dimensions and offset values, the geometry tie grids have been extended to match the view-agnostic tie grid, and in some cases shifted along-track. However, it can be noted that the files then contain empty pixels or filled-value pixels after this extension, rather than a coherent set of full information.

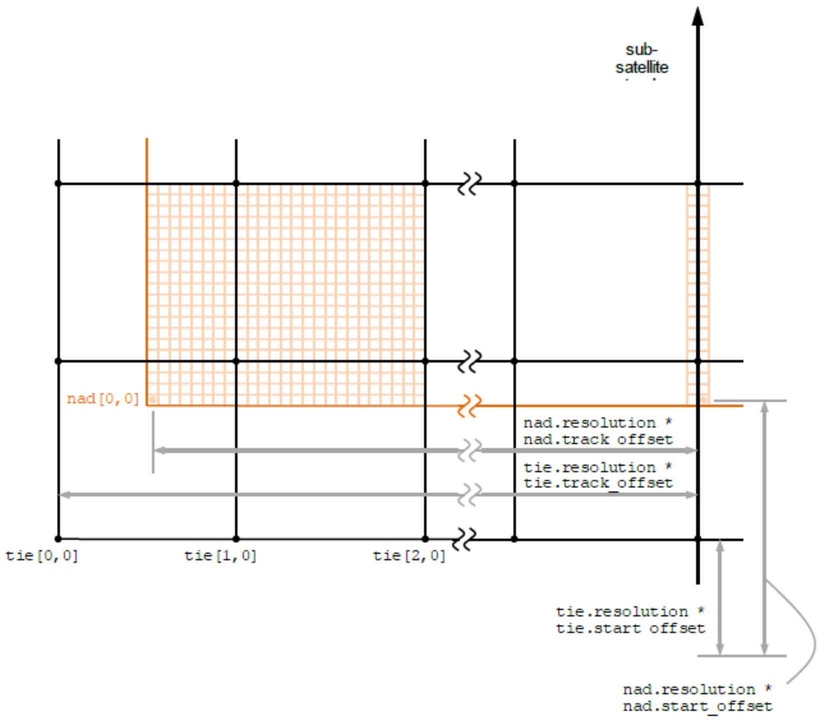


Figure 5-1. The relative alignments of generic 16km tie point and 1km nadir grids (figure 4-1 from [RD.2]).

5.10.6.2 Geometry tie-point data misalignment with instrument pixel locations

The geometry parameters were calculated at the instrument pixel locations (every 10 scans). Once the geometry data have been interpolated to the image grid locations, they are now valid at the grid location and not the instrument pixel location (which is inside the grid lines). Therefore, subsampling the image-grid geometry data to obtain tie-point geometry data misaligns slightly the geometry values from the instrument pixel. For slowly varying variables such as the parameters in the geometry files, this is considered acceptable.

5.10.6.3 startOffset and trackOffset values discrepancy with instrument pixels

The offset values are required to align the different grids in relation to each other, by reference to the start of the image grid and the distance across track from the subsatellite track. At the time of 4th reprocessing development, SLSTR used whole pixel number offsets, even though the instrument pixels themselves are not aligned with the grid, but are inside the pixel gridlines. The 4th reprocessing products have aligned with (old) SLSTR in this respect, while noting this discrepancy exists.

5.10.6.4 startOffset and trackOffset parameters not set correctly

Work undertaken by Brockmann Consult for the update of SNAP provided clarity and correction on the use of the offset parameters.

The colocation of image and tie-point data (i.e. interpolation of the 16-km grid data to match the 1-km image grid data) cannot easily be made since the startOffset and trackOffset values for both grids are not correctly stated in the manifest file. Helpful investigations by Brockmann Consult generated an equation that aligns the grids initially, after which the usual interpolation can take place. This is done automatically within SNAP, but users who are dealing with the product data independently will find the following useful.

For SNAP, an offset is required which defines the location of the first tie-point in relation to the image grid, which are X-Offset and Y-Offset, and shown in Figure 5-2.

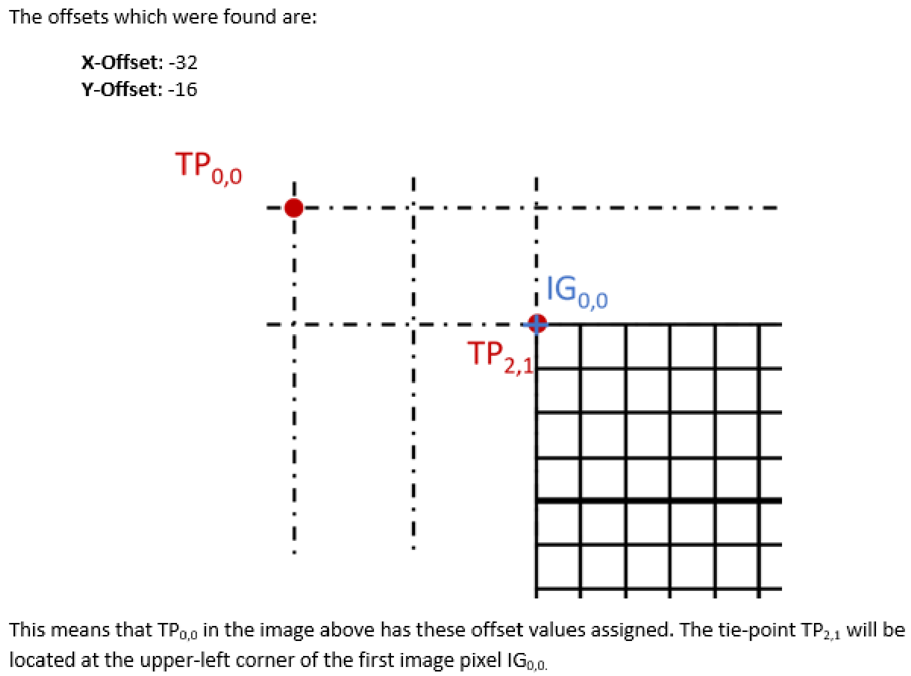


Figure 5-2. Offsets that initially pin the image and tie-point grids.
(Acknowledgement: M. Peters, Brockmann Consult)

The values are as given in Figure 5-2, or users can use the relationship below to generate the X-Offset and Y-Offset, where `tp` are tie-point and `img` are nadir image grid values for offsets and resolutions as already stated in the manifest metadata:

```
X-Offset= imgTrackOffset - ((tpTrackOffset - 1) *
        (tpResolution / imgResolution))

Y-Offset= (tpStartOffset - 1) * (tpResolution /
        imgResolution) - imgStartOffset
```

Once the corners of the grids are aligned correctly, as stated above, then the usual relationship between the grids regarding interpolation of the 16-km grid data to match the 1-km grid data can take place as usual.

5.10.7 Time file (time_in.nc)

The data content of the time_in.nc file is as shown in Section 4.6.4, but users are cautioned to take note of the technical features outlined below. The information that is contained within the indices files (Section 4.6.1) is also very relevant to the time file, and it can help to view those files in SNAP when considering the parameters in the time file.

The time_in.nc file is characterised here for ATSR-1 but the features are applicable to all instruments. The contents of the time file (which contains both nadir and oblique information) are given in Table 5-11.

Table 5-11. Contents of the time_in.nc file (via Panoply)

Name	Long Name
time_in.nc	time_in.nc
Nadir_First_scan_i	Scan number of the first nadir scan contributing to each line
Nadir_Last_scan_i	Scan number of the last nadir scan contributing to each line
Nadir_Maximal_ts_i	Acquisition time of the last nadir scan contributing to each line
Nadir_Minimal_ts_i	Acquisition time of the first nadir scan contributing to each line
Oblique_First_scan_i	Scan number of the first oblique scan contributing to each line
Oblique_Last_scan_i	Scan number of the last oblique scan contributing to each line
Oblique_Maximal_ts_i	Acquisition time of the last oblique scan contributing to each line
Oblique_Minimal_ts_i	Acquisition time of the first oblique scan contributing to each line
PIXSYNC_i	Frequency at which the pixels are sampled on each scan
SCANSYNC	Scan Period defined as a complete rotation of the scan mirrors
time_stamp_i	Acquisition time of the sub-satellite point included in each line

The following can be noted:

1. Each row of the time file corresponds to the equivalent row in the gridded dataset.
2. The units for time are “microseconds since 2000-01-01T00:00:00Z”.
3. A value of 0 for scan number is a legitimate value.

The particular characteristics of the time file are listed below.

1. Nadir_First_Scan_i is not filled (NaN) until after the curved part of the nadir scan, and the corresponding value for Nadir_Minimal_ts_i is 0.
2. Nadir_Last_Scan_i and Nadir_Maximal_ts_i are filled correctly.
3. Oblique_First_Scan_i is not filled (NaN) until after the curved part of the nadir scan, and the corresponding value for Oblique_Minimal_ts_i is 0.
4. Oblique_Last_Scan_i is filled correctly.
5. Oblique_Maximal_ts_i is almost filled correctly, except for the very first value, which is set to 0.
6. **time_stamp_i** is not filled correctly. It should be the time of the subsatellite point (i.e. nadir view) in the corresponding grid row, but is set to Nadir_Minimal_ts_i for the grid row.

With the caveats above, especially for time_stamp_i, users need to be cautious in the use of the Time parameter within SNAP (in Pixel Info). While the time given therein is largely correct it is not absolutely precise.

Example nadir time data can be viewed in Table 5-12 from the ATSR-1 product:

ER1_AT_1_RBT____19910901T194319_19910901T212606_20191107T075209_6167_014_013______TPZ_R_NT_004.SEN3.

Example oblique time data can be viewed in Table 5-13. A reminder of the curved views and scan numbering can be seen in Figure 5-3.

Most issues can be considered minor, since nominal values will be present for all rows after the first complete grid row (i.e. after the curved scan section of each of the views).

Given the ancillary information that is available (pixel number and scan number in indices_in.nc, PIXSYNC_i and SCANSYNC_i in the time_in.nc), a legitimate **time_stamp_i** can be calculated from existing information if required.

Table 5-12. Nadir time information example

Row	Nadir_First_ Scan_i	Nadir_Last_ Scan_i	Nadir_Minimal_ts_i	Nadir_Maximal_ts_i	time_stamp_i
1	NaN	1	0	-262930600737522	-262930600885959
2	NaN	2	0	-262930600589084	-262930600885959
3	NaN	3	0	-262930600436741	-262930600885959
4	NaN	4	0	-262930600288303	-262930600885959
(continue)					
109	NaN	109	0	-262930584538316	-262930600885959
110	0	110	-262930600885959	-262930584385972	-262930600885959
111	0	111	-262930600885959	-262930584237534	-262930600885959
112	1	112	-262930600737522	-262930584085191	-262930600737522
113	2	113	-262930600589084	-262930583936754	-262930600589084
114	3	114	-262930600436741	-262930583784410	-262930600436741

Table 5-13. Oblique time information example

Row	Oblique_First_ Scan_i	Oblique _Last_ Scan_i	Oblique _Minimal_ts_i	Oblique _Maximal_ts_i
1	NaN	NaN	NaN	NaN
2	NaN	NaN	NaN	NaN
(continue)				
791	NaN	NaN	NaN	NaN
792	NaN	1	0	0
793	NaN	1	0	-262930600737522
794	NaN	2	0	-262930600589084
795	NaN	3	0	-262930600436741
796	NaN	4	0	-262930600288303
797	NaN	5	0	-262930600135960
(continue)				
907	NaN	115	0	-262930583635972
908	NaN	116	0	-262930583487535
909	0	117	-262930600885959	-262930583335191
910	0	118	-262930600885959	-262930583186753
911	1	119	-262930600737522	-262930583034409
912	2	120	-262930600589084	-262930582885973
913	3	121	-262930600436741	-262930582737536

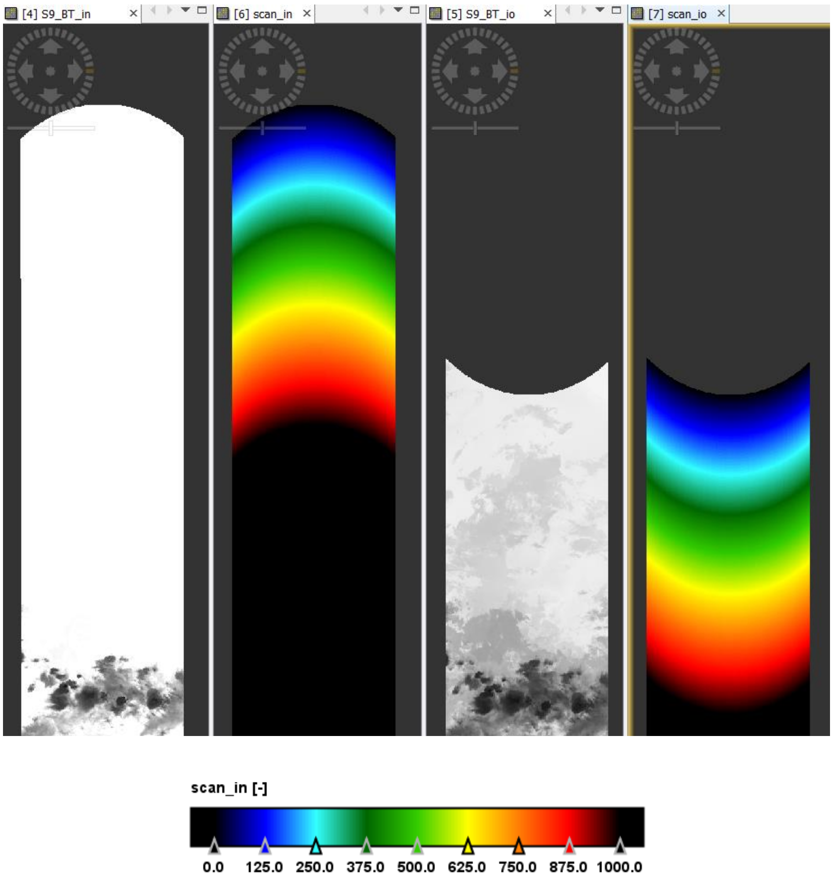


Figure 5-3. Scan number information in the indices_in/_io files with corresponding measurement data in S9_BT

5.10.7.1 Time transformation to UTC

Some of the times from Table 5-12 are given in UTC in Table 5-14, confirming the validity of the values.

Table 5-14. Sample times from Table 5-12 transformed into UTC

Row	Nadir_Minimal_ts_i	Nadir_Minimal_ts_i (UTC)	Nadir_Maximal_ts_i	Nadir_Maximal_ts_i (UTC)
1	0		-262930600737522	01/09/1991 19:43:19.262
2	0		-262930600589084	01/09/1991 19:43:19.411
109	0		-262930584538316	01/09/1991 19:43:35.462
110	-262930600885959	01/09/1991 19:43:19.114	-262930584385972	01/09/1991 19:43:35.614
111	-262930600885959	01/09/1991 19:43:19.114	-262930584237534	01/09/1991 19:43:35.762
112	-262930600737522	01/09/1991 19:43:19.262	-262930584085191	01/09/1991 19:43:35.915

5.10.8 Surface, day/twilight, sun glint and snow classification

Note that surface and day/twilight classification exists for every natural or cosmetic pixel, but not for invalid, orphan or unfilled pixels. This is because these classifications use the orthogeolocated pixel latitude and longitude, which only exist for measured pixels on the image grid.

Sun glint and snow classification exist only for pixels on the image grid, since these classifications were made by the basic cloud post-processor, which processes information on the image grid only.

5.10.9 Cosmetic fill pixels

Users are reminded of the existence of cosmetically filled pixels, duplicates of near-neighbour measured pixels that fill empty gridded pixels. It is advisable to check the cosmetic fill flag within the confidence words if original data only is required.

In particular, there exist a line of cosmetically filled pixels at the starts and ends of the curved nadir and forward views. These pixels can be discounted in processing by identifying cosmetically filled pixels.

5.10.10 Parameters in geometry_tn and geometry_to files

Users can note that there are fixed parameter values in the ‘empty’ curved part of the conical scan that mimic real parameter values. There are no instrument measurements in these segments, and the values themselves vary with product.

For example, in one particular product these fixed values are 771399.84 m for satellite path, and 147111547601.362 m for solar path. For other variables, these values are fixed in the along-track direction.

5.10.11 ATSR-1/-2 band centres and bandwidths in the quality files

Users should be aware that some band centre and bandwidth values for ATSR-1 and ATSR-2 in the quality files are not correct. Correct values are available in the manifest if required.

ATSR-1: S5 bandwidth should be 0.075

ATSR-2: S1, S2, S3 bandwidths should all be 0.022

5.10.12 Detector temperatures in the quality files

The scale factor is not set correctly for values of T_detector in the quality files, and the values are 3 orders of magnitude too large, which can be seen clearly. For example:

T_detector = 80075 K

Cold detector temperatures in quality files should be ~80 K, therefore the above value should be 80.075 K.

5.10.13 Non-legitimate fill values

Some parameters in some files, contain values in non-measurement data pixels that do not conform either to the official fill values, or contain fill values when there is not expected to be any. The following gives a list of known instances:

- None specified in product specification:

- atsr files
- indices files
- time file
- "Extra" fill values:
  - cal_offset in quality files
  - SCP_gain and SCP_offset in quality files
  - Parameters within geometry tie-point and image files

5.10.14 Tags in the xfdu manifest file

Even though the 4th reprocessing products mimic the SLSTR products, the tags within the xfdumanifest.xml file contain tags appropriate to atsr (not slstr) and sentinel3. Users are advised to be aware if there is any particular usage where the tags are interrogated in the manifest file.

For example:

```
<atsr:classificationSummary grid="1 km">
   <sentinel3:salineWaterPixels percentage="39.61416" />
   <sentinel3:landPixels percentage="55.783974" />
   <sentinel3:coastalPixels percentage="0.491877" />
   <sentinel3:freshInlandWaterPixels percentage="0.711009" />
   <sentinel3:tidalRegionPixels percentage="1.284091" />
   <sentinel3:cloudyPixels percentage="63.555334" />
</atsr:classificationSummary>
```

5.10.15 Meteorological file (met_tx.nc)

The meteorological file contains single surface or near-surface values, surface time-series parameters, and temperature and specific humidity profile information, all on the tie-point grid; see Section 4.8: Met: Meteorological Parameters Auxiliary Dataset. This section notes some technical features related to the met_tx file.

1. Approximately 600 AATSR L1B products have been released without full meteorological information. It was considered that, as the measurement datasets were nominal, incomplete met_tx.nc should not block release. The cause was that the input meteorological data was corrupt, truncated or did not cover all future t_series times (see Section 5.5.1: Dimensions), and so not all parameters for all times could be filled in the L1B product. Affected time spans are:

   a) 17–20 December 2008

   b) 27–30 December 2008

   c) 1–31 January 2010

   d) 22–31 October 2010.

2. Eight ATSR-1 L1B have been released without full meteorological information. The affected time span is:

   a) 1 October 1992, 0853 to 2038 h (start times).

3. Meteorological <u>profile</u> parameters do not contain required fill values towards the end of the product (where there are no related measurements), apart from the very first profile (p_atmos_1). This effect can clearly be seen if viewing met_tx as a stand-alone file in SNAP.

6. IMPROVEMENTS WITHIN THE 4TH REPROCESSING

Notwithstanding some of the Technical Features (Section 5.10) and the Open Issues still remaining (Section 7), the 4th reprocessing datasets contain a number of improvements. A summary is presented here.

6.1 Improved and Extended Datasets

The use of improved and extended consolidated ATSR-1, ATSR-2 and AATSR **Level 0** datasets, and the generation and use of new ATSR-1, ATSR-2 and AATSR **Level 1A** datasets (through a number of projects funded by ESA) took place. These improvements fed into the L1B generation.

Completeness assessments for L1B products have shown:

AATSR

- A L1A to L1B success rate of 99.7%, with potential to recover some of the processing failures, if required.
- Recovery of 32 hours of measurement data due to the removal of 40 inter-product gaps (when compared with the 3rd Reprocessing).

ATSR-2

- A L1A to L1B success rate of 94.5%, with potential to recover some of the processing failures, if required.
    - The decision was made to curtail the dataset at June 2003 (when the ERS-2 data recorder failed), due to uncertainty in geolocation quality after the ERS-2 gyroscope problems. These products are currently available at NEODC, although AATSR covers the time period involved.
    - There are 1883 fewer 4th reprocessing products when compared with the 3rd reprocessing, as some input L1A displayed issues that cannot be dealt with at the present time.

ATSR-1

- A L1A to L1B success rate of 94.7%, with potential to recover some of the processing failures, if required.
- The recovery and improvement of data due to historic processing issues (period of missing 1.6 µm (S5) channel data due to channel switching between 1.6 and 3.7 µm (S7) channels, uncalibrated brightness temperatures, etc.) has been incorporated such that the 4th Reprocessing now mirrors ATSR-1 v3.0.1 (available at NEODC)

6.2 Improved AATSR Colocation

An updated ADF generated by RAL Space has been used to provide an improvement for AATSR nadir−oblique view colocation. AATSR had retained an along-track shift of 1 pixel within the 3rd Reprocessing. The improvement is demonstrated in Figure 6-1, which shows an example of the nadir−oblique reflectance and radiance view differences for the 1.6 µm (S5) channel; there are “cleaner”, less shadowed, land edges provided by the 4th Reprocessing (right), indicating an improvement in colocation.

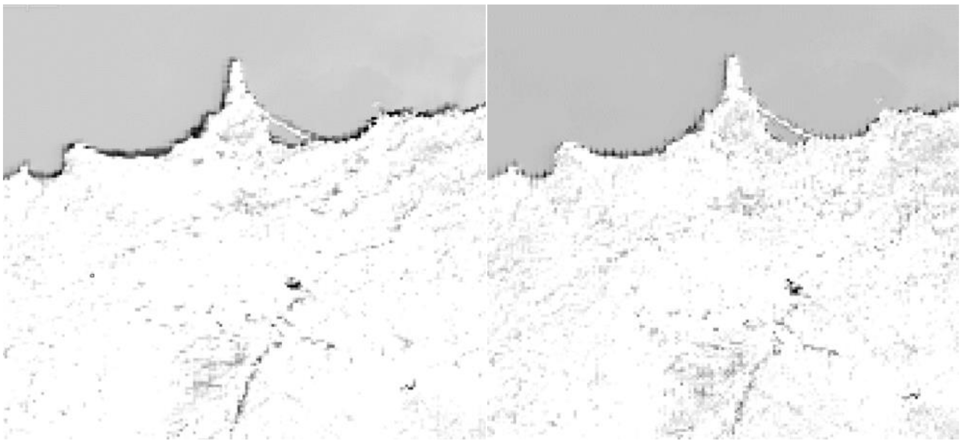


Figure 6-1. AATSR, Morocco, nadir–oblique 1.6 µm (S5) radiance difference images: 3rd (left) and 4th (right) Reprocessings

6.3 Improved Surface Classification

Improved surface classification via use of the Sentinel-3 Land Water Masks has been achieved for all instruments. Figure 6-2 gives an example for ATSR-1.

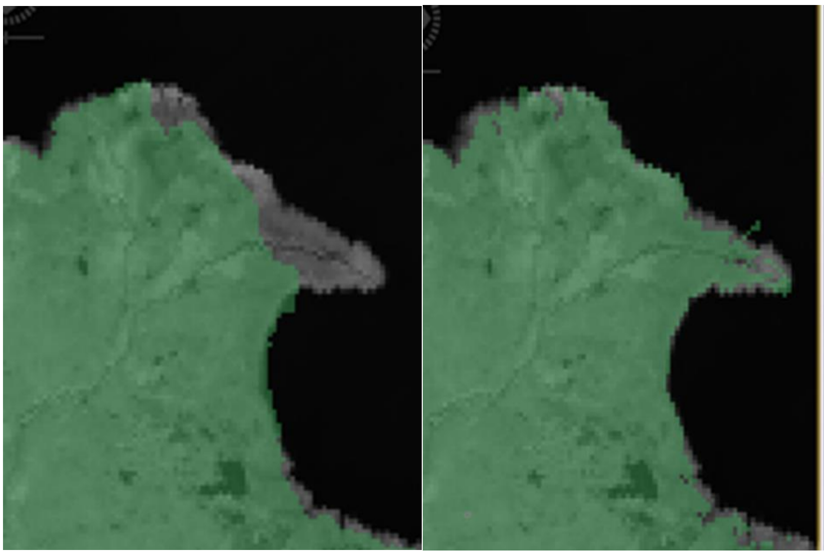


Figure 6-2. ATSR-1, Laizhou Bay, China. 3rd (left) and 4th Reprocessings (right). Land flag is green.

6.4 New Uncertainty Estimates

In line with the product format, the 4th reprocessing contains new uncertainty estimates (Section 4).

The 4th Reprocessing (A)ATSR L1B products contain uncertainty estimates (Figure 6-3) composed of random and systematic effects (e.g. blackbody calibration, spectral response), for each pixel. The random noise estimates are provided per pixel as a function of scene temperature, while the systematic noise estimates use “fixed” uncertainty estimates based on pre-launch data and knowledge of the instrument stability. Figure 6-3 shows the differing uncertainties in the 3.7 and 12 µm (S7 and S8) channels (same scale). The contribution of the 10-scan average and the contribution from the blackbody detectors (alternating values within the scan arc) can be seen in low uncertainty parts of the image (blue areas). In high uncertainty areas, the calculation is dominated by the contribution from the measurements and so scan/pixel contributions can no longer be seen.

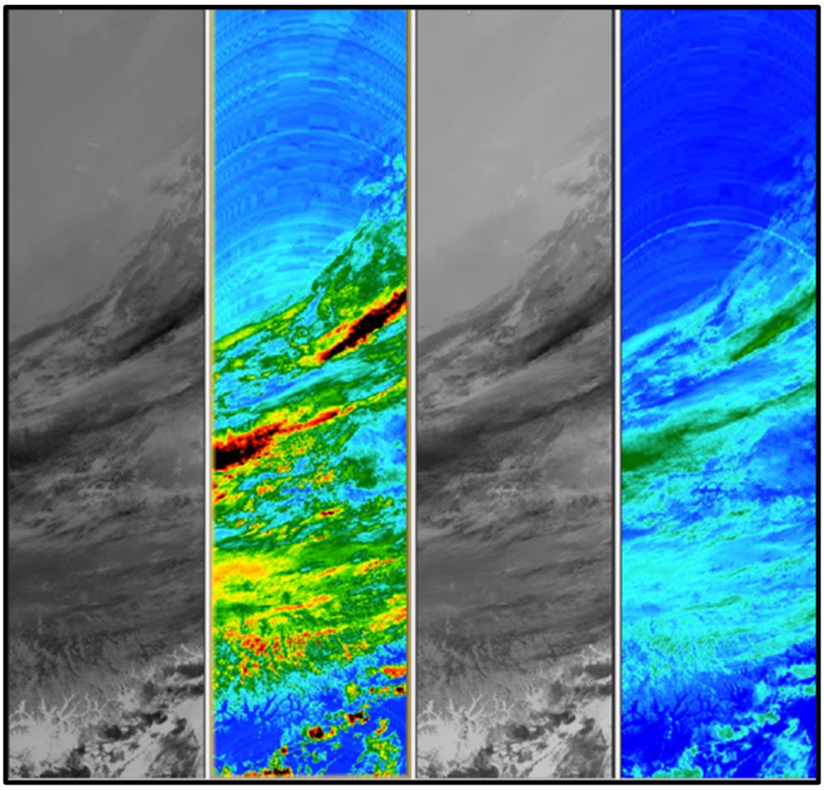


Figure 6-3. An example of the per-pixel uncertainty estimates contained in the L1B product for AATSR. Left to right: S7 brightness temperature (BT), S7 uncertainty, S8 BT, S8 uncertainty (as viewed in SNAP).

6.5 Orthogeolocation Enabled

For the first time, (A)ATSR L1B products are orthogeolocated to a DEM. The geometric processing is enabled by the (A)ATSR L1B processor, developed especially for the 4th Reprocessing, and is assisted by the use of the ESA EO CFI.

6.6 Geolocation Assessment

AATSR

- The mean offset to reference coordinates over 22 predetermined sites improved from 0.67 km in the 3rd Reprocessing to **0.62 km** in the 4th Reprocessing.

ATSR-2

- Seventeen independent sites display a mean offset of **0.69 km** from reference coordinates; note there is a caveat for edge-of-swath geolocation during the ERS-2 no-gyroscope period and so the stated assessment does not include any assessments during that time.

ATSR-1

- Twenty-two independent sites display a mean offset of **0.79 km**.

- Figure 6-4 shows a comparison example for ATSR-1 for Isla Cariba, Venezuela, which has an improved offset from 1.07 km in the 3rd Reprocessing to 0.75 km in the 4th Reprocessing.

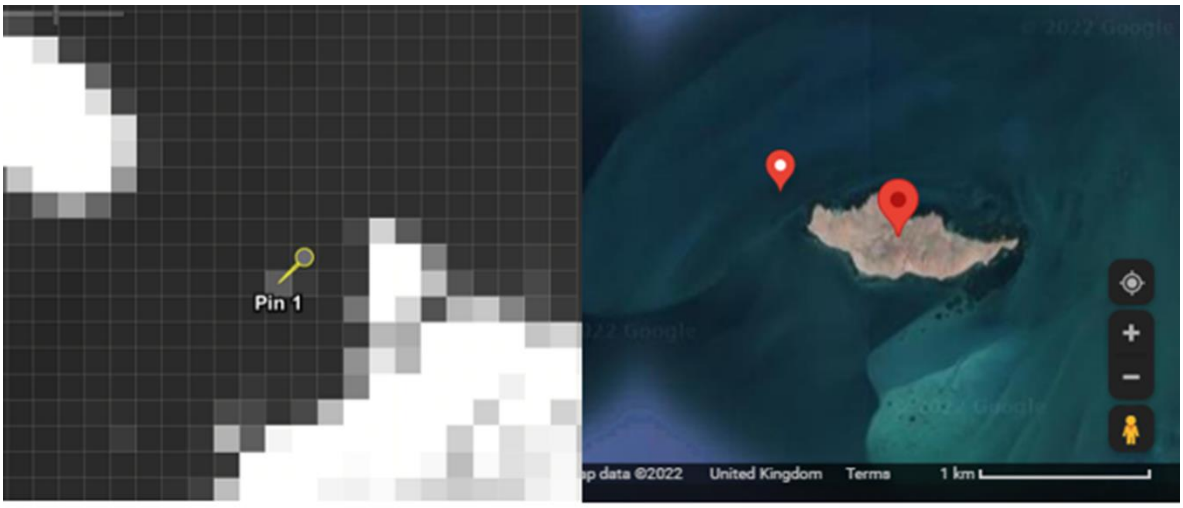


Figure 6-4. Isla Cariba, Venezuela, seen by ATSR-1 S5 1-km grid in SNAP (left), and Google maps (right), with the ATSR-1 image pin superimposed (red pin with white circle).

6.7 AATSR 12 Micron Channel Discrepancy

An updated general calibration ADF, generated by RAL Space, has been used to incorporate the adjustment to the 12 µm (S9) channel, which showed evidence of a small temperature-dependent discrepancy. Previously, users had to apply the correction themselves. See Section 5.1.

6.8 Objectives of the 4th Reprocessing

Figure 6-5 displays the original objectives of the 4th Reprocessing. It can be seen that all were achieved, apart from the inclusion of the Bayesian/probabilistic cloud flags which have been, to follow the lead of SLSTR, deferred for inclusion in Level 2 products.

Generate (A)ATSR L1B **products** in an **SLSTR-like** format	✓
Implement Orthogeolocation to a DEM for (A)ATSR	✓
Improve (A)ATSR **geolocation** via new and/or updated ADFs	✓
Improve AATSR **colocation** via use of updated ADF	✓
Generate Uncertainty estimates for the first time	✓
Improve Surface classification via use of Sentinel LSM	✓
Carry forward v3.0.1 **improvements** for ATSR-1 and ATSR-2	✓
Incorporate Bayesian/probabilistic Cloud masking – expected in L2	⌛

Figure 6-5. Objectives for the 4th Reprocessing.

7. OPEN ISSUES

The 4th reprocessing main datasets of AATSR, ATSR-2 and ATSR-1 are scheduled for release in 2022. There are, however, a number of open issues that arose during reprocessing. These issues were all classified as being non-blocking, but they have been collected as part of a possible evolution of the datasets in the future.

There is a general **caution** for **ATSR-2 Geolocation**: the failure of the ERS-2 gyroscopes resulted in non-optimal geolocation, especially for pixels that are far from the centre of the swath, which has been exacerbated in the 4th reprocessing due to the non-use of yaw correction attitude data; more information can be found in [RD.12] (applicable to 3rd reprocessing products) .

7.1 Open-issue Priority Tables

This section contains details of the open issues that relate to the released L1B products, some of which have already been mentioned in previous sections. The issues have been classified as High (Table 7-1), Medium (Table 7-2) or Low (Table 7-3) priority. Users are advised to scan these tables if they have noted any anomaly within the product. If there is any other concern, please contact the ESA Tellus service.

Table 7-1. High-priority open issues in the 4th (A)ATSR reprocessing

Instrument	Category/Files	Description	Comment
All	Measurement data	Exception word for cosmetic pixels has not been copied over from the natural pixels	
All	Flags	Duplicate pixel flag has not been raised to show an orphan pixel exists	
All	cartesian_in	Image grid starts before the tie point (geodetic location data does not always show this)	
All	cartesian_tx	There are equal spatial intervals between tie points in the along-track direction when they should be equal in time	
All	tie point and image grid headings and metadata	Start and track offsets do not contain the correct information to allow alignment	Correction advice exists: section 5.10.6.4
ATSR-2	Configuration: ADF database	Processor was not configured to use HEY attitude data from 12 February 2001, so geolocation is likely impaired	Section 5.8.2
ATSR-2	Manifest xml	The manifest file is not certain to state the correct number of rows within the image data files. The mismatch means that currently ATSR-2 products cannot be opened via the manifest within SNAP. Files can be viewed individually	Section 5.10.3.1
ATSR-2	Manifest xml	Quality-check tag in manifest should be changed from “passed” to “degraded” for time period after the loss of the ERS-2 gyros:16 January 2001 at 06:32:30 (product orbit 30019) to 05 July 2001 at 22:34:40 (product orbit 32462)	Section 5.9

Instrument	Category/Files	Description	Comment
ATSR-2	Manifest xml	Quality-check tag in manifest should be changed from “passed” to “degraded” for all time periods when HEY attitude file data should have been used (from 12 February 2001 onwards).	Sections 5.8.2 and 5.9

Table 7-2. Medium-priority open issues in the 4th (A)ATSR reprocessing

Instrument	Category/Files	Description	Comment
ATSR-2	S1–S9	Some missing scan lines within product have not been cosmetically filled	
ATSR-1	S5_quality	No fill value is defined for solar irradiance, scene radiance or radiometric uncertainty	
ATSR-2	S5_quality	No fill value is defined for solar irradiance, scene radiance or radiometric uncertainty	
ATSR-2	S3_quality/S1_quality	There are no values for dL_BB, cal gain, cal offset	
ATSR-2	Flags: cloud	1.6 histogram test is masking missing data as cloud in places. Cloud test not ignoring NaNs, as would be expected	
All	General	Time period of data not exactly matching original v3 products for ATSR-1/-2. This is due to no-slicing at the ANX	Section 5.10.2
All	manifest xml	xml html links to ESA SAFE format are no longer active	
All	time_in.nc	time_stamp_i is not filled correctly. It should be the time of the subsatellite point (i.e. nadir view) in the corresponding grid row, but is set to Nadir_Minimal_ts_i for the grid row	Section 5.10.7
ATSR-1	Quality files	S5 bandwidth should be 0.075	Section 5.10.11
ATSR-2	Quality files	S1, S2, S3 bandwidths should all be 0.022	Section 5.10.11
All	Quality files	The scale factor is not set correctly for values of T_detector in the quality files, and the values are 3 orders of magnitude too large	Section 5.10.12
ATSR-1	L1B name, Manifest and metadata for all files	QC showed L1B Sentinel-SAFE name violation (more than 3 digits in the relative orbit section) for more than 3000 products (currently segregated)	
ATSR-2	Orphan data files	NaN value measurements have been saved within the orphan files, unlike	

Instrument	Category/Files	Description	Comment
		ATSR-1/AATSR. This could be related to previous issues with exception values (and the cloud processor ignoring NaN)	

Table 7-3. Low-priority open issues in the 4th (A)ATSR reprocessing

Instrument	Category/Files	Description	Comment
ATSR-1	S*_radiance	No measurement data exists, but exception word could be set to provide confirmation, or files removed	Section 5.2
ATSR-2	Exception flags	Pixel absent flag is set where it appears that entire scans are missing; scan absent flag preferable	
All	Geodetic_i	Incorrect 'no data' value used. The value of -0.000999 appears at the end of the nadir view, and start of the oblique view. In the file, the no data value is described as -9.99E8	Section 5.10.13
All	All	Format of resolution string inconsistent with SLSTR. [1000 1000] instead of [1000 1000] used in SLSTR	
All	Tie point files	Tie point grid not symmetric about origin	
All	Geodetic	Incorrect fill value used. Product Spec says -99999999; used is -9.9999999E8	Section 5.10.13
All	Meteo files	Profile parameters should contain fill value at no-data ends of products after the first profile (which is fine)	
AATSR	manifest xml	Change quality assessment from 'passed' to 'degraded' for eight products if keeping in archived dataset	Note 1 below
AATSR	manifest xml	Correct the manifest orbit number of five products	Note 2 below
Note 1: These products are: ENV_AT_1_RBT____20020702T021837_20020702T040416_20210228T093548_6338_007_203______DSI_R_NT_004.SEN3 ENV_AT_1_RBT____20020828T004635_20020828T030631_20210308T180834_8396_009_016______DSI_R_NT_004.SEN3 ENV_AT_1_RBT____20020908T014112_20020908T034748_20210310T181905_7596_009_174______DSI_R_NT_004.SEN3			

Instrument	Category/Files	Description	Comment
ENV_AT_1_RBT____20030209T142544_20030209T161401_20210317T145510_6497_013_382______DSI_R_NT_004.SEN3			
ENV_AT_1_RBT____20030209T160757_20030209T174931_20210317T151107_6094_013_383______DSI_R_NT_004.SEN3			
ENV_AT_1_RBT____20030209T180700_20030209T192528_20210317T151650_4708_013_385______DSI_R_NT_004.SEN3			
ENV_AT_1_RBT____20030209T194453_20030209T202955_20210317T152133_2701_013_386______DSI_R_NT_004.SEN3			
ENV_AT_1_RBT____20030209T202017_20030209T212023_20210317T153038_3605_013_386______DSI_R_NT_004.SEN3			
Note 2: These products are:			
ENV_AT_1_RBT____20061216T093525_20061216T100328_20210423T122923_1682_053_466______DSI_R_NT_004.SEN3			
ENV_AT_1_RBT____20070928T144845_20070928T163421_20210520T054533_6335_062_054______DSI_R_NT_004.SEN3			
ENV_AT_1_RBT____20071206T083755_20071206T102330_20210521T225633_6334_064_036______DSI_R_NT_004.SEN3			
ENV_AT_1_RBT____20101124T012619_20101124T031133_20210718T022234_6313_096_391______DSI_R_NT_004.SEN3			
ENV_AT_1_RBT____20110406T165450_20110406T184004_20210701T233342_6313_101_156______DSI_R_NT_004.SEN3			

7.2 SLSTR Advances

SLSTR products have been subject to ongoing improvements since the initiation of the 4th reprocessing. Table 7-4 lists the items for improvement that could be considered for (A)ATSR.

Table 7-4. (A)ATSR possible improvements to follow SLSTR

Instrument	Category/Files	Description
All	Regridding	(A)ATSR L1 products use Envisat era regridding algorithm: cosmetic fill values use copy of nearest adjacent filled pixel. SLSTR L1 products use ‘ortho’ geolocation to perform regridding (Products are ‘ortho-rectified’): Cosmetic fill values use true nearest available pixel from all surrounding pixels including orphan pixels
All	Uncertainty estimates	(A)ATSR provides per pixel uncertainty estimates as combined standard uncertainty = Random + Correlated Effects. Splitting to random and correlated effects could be done for (A)ATSR. Note we would need to use tables in quality datasets to extract the data
AATSR	Uncertainty estimates	SLSTR L1 products have uncertainty information quality datasets. Correlated Effects and Random Noise Separated. Python Script MapNoisS3 developed to remap to L1 products. Could be used for AATSR, but not ATSR-1 or ATSR-2 due to missing parameters

All	Cloud screening	Improvements to SLSTR L1 basic cloud screening are being investigated that could also apply to (A)ATSR L1 products. • Sunglint Tests • Fog test: currently not good over land (switched off when used in the LST) • Visible tests: will improve over land/ocean (Not possible for ATSR-1)
All	Surface classification	Existing surface classification scheme uses position of the centre of the pixel to determine the scene type. This approach does not allow for 'mixed' scenes including land + water and often mis-classifies coastline pixels. Revised scheme accounts for pixel footprint and improves flagging of mixed pixels. It also improves identification of inland waters that are missed under the existing scheme

8. ANNEX 1: PRODUCT NAMING CONVENTION

The 4th reprocessing product names will follow the naming convention for Sentinel-3 products, given in [RD.4], which is:

MMM_SS_L_TTTTTT_yyyymmddThhmmss_YYYYMMDDTHHMMSS_YYYYMMDDTHHMMSS_<instance ID>_GGG_<class ID>.<extension>

The product names consist of 99 characters; details of the naming convention are given in Table 8-1. The "Product Type" is specified by the characters SS_L_TTTTTT.

It can be noted that the absolute orbit number does not appear in the filenames for the 4th reprocessing products. The 4th reprocessing products will take their data start and data stop times from the sensing start and stop data contained within the header of the parent Level 0 product.

Example

Comparisons of the name formats are given below, using a 3rd reprocessing example:

Envisat format:

ATS_TOA_1PUUPA20120406_145752_000065273113_00240_52840_6782.N1

Sentinel format:

ENV_AT_1_RBT____20120406T145752_20120406T164306_20210711T085052_6313_113_240______DSI_R_NT_004.SEN3

Table 8-1. Sentinel-3 product naming convention details and options for the 4th reprocessing products

Field	Length	Purpose	SLSTR L1B value	(A)ATSR L1B value	Comment
MMM	3	Mission ID	S3A, S3B, S3_	ER1, ER2, ENV	
SS	2	Instrument	SL	AT	AT since MMM differentiates instruments
L	1	Processing Level	1	1	
TTTTTT	6	Data Type ID	RBT___, (RBT_BW)	RBT___	
yyyymmddThhmmss	15	Data Start Time	<yyyymmdd**T**hhmmss>	<yyyymmdd**T**hhmmss>	
YYYYMMDDTHHMMSS	15	Data Stop Time	<YYYYMMDD**T**HHMMSS>	<YYYYMMDD**T**HHMMSS>	
YYYYMMDDTHHMMSS	15	Creation Time	<YYYYMMDD**T**HHMMSS>	<YYYYMMDD**T**HHMMSS>	
<instance ID>	17	<Duration>_ <Cycle>_ <Relative Orbit>	<DDDD>_<CCC>_ <LLL>_____	<DDDD>_<CCC> _<LLL>_____	Variable by stripes, tiles or frames: 4th reprocessing follows "stripes" pattern

Field	Length	Purpose	SLSTR L1B value	(A)ATSR L1B value	Comment
GGG	3	Product Generating Centre	LN2, MAR	DSI	
<class ID>	8	<Processing platform>_ <Timeliness>_ <Free Text>	<P>_<XX>_<NNN>	R_NT_*nnn*[3]	[1]P = O, F, D, R or _ [2]XX = NR, ST, NT or __ NNN can be anything, such as baseline collection
<extension>	≤ 4	Filename extension	SEN3	SEN3	To show it is S3 format, as first 6 characters (MMM_SS) show it is (A)ATSR data not SLSTR

[1]O = operational, F = reference, D = development, R = reprocessing
[2]NR= Near Real Time, ST = Short Time Critical, NT = Non Time Critical
[3]*nnn=an identifier specifying the reprocessing version*

9. GLOSSARY

The following acronyms and abbreviations have been used in this report.

ADF	auxiliary data files
ADS	annotation dataset
ATSR	Along-Track Scanning Radiometer
BT	brightness temperatures
CCI	Climate Change Initiative
DEM	digital elevation model
L1B	Level 1B
LST	Land Surface Temperature
MDS	measurement dataset
NRT	near-real time
OSV	orbit state vector
PSM	pixel selection map
RD	Reference Document
SLSTR	Sea and Land Surface Temperature Radiometer
SNAP	Sentinel Application Platform
SST	Sea Surface Temperature
TLM	telemetry
XFDU	XML Formatted Data Unit

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