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Project : **SST-CCI-Phase-II**

Title : **SST CCI System Verification Report - CDR 2.1 Update**

Abstract : This document describes the verification of SST-CCI products CDR version 2.1. It is an addendum to the System Verification Report SST_CCI-SVR-BC-201_Issue-3B.

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CONTRACT REPORT

The work described in this report was done under ESA contract. Responsibility for the contents resides in the author or organisation that prepared it.

AMENDMENT RECORD

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 FOR CHANGE
A	27.08.2019	Initial version for ESA review
1	09.10.2019	First issue

RECORD OF CHANGES IN THIS ISSUE

Issue	Section	Reason	Change

EXECUTIVE SUMMARY

The SST-CCI project is part of the ESA Climate Change Initiative, which aims to produce long-term sea surface temperature (SST) essential climate variable (ECV) products.

This document contains a description of the quality assessment chores applied to verify the correct format and content of the CDR 2.1 release of the SST-CCI dataset. It covers the description of automated test routines and manual inspection tasks.

A detailed description of the test results is presented and an evaluation of the formal correctness of the data is given.

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1. INTRODUCTION

1.1 Purpose and scope

This Sea Surface Temperature (SST) System Verification Report gives a complete report of the data quality and the compliance with the specification document [AD.2] of the version 2.1 SST climate data record. It covers an introduction of the tools used for the verification, a concise description of the tests applied to the data and the results of the complete verification task for data of processing levels L2P and L3U.

1.2 References

The following documents are applicable to this document:

ID	Title	Issue	Date
[AD.1]	ESA Climate Change Initiative Phase II – Scientific User Consultation and Detailed Specification Statement of Work (SoW), including Annex G: Sea Surface Temperature ECV	1	2013-07-02
[AD.2]	Sea Surface Temperature CCI Phase-II Product Specification Document, SST_CCI-PSD-UKMO-201 (PSD)	2	2017-05-09
[AD.3]	Sea Surface Temperature CCI Phase-II System Specification Document, SST_CCI-SSD-BC-201 (SSD)	2	2016-02-10
[AD.4]	Sea Surface Temperature CCI Phase-II User Requirements Document, SST_CCI-URD-UKMO-201 (URD)	2.1	2017-01-13
[AD.5]	Sea Surface Temperature CCI Phase-II Data Access Requirements Document, SST_CCI-DARD-UOL-201 (DARD)	2	2017-02-24
[AD.6]	CCI System Requirements, CCI-PRGM-EOPS-TN-12-0031	1	2013-07-02
[AD.7]	Data Standards Requirements for CCI Data Producers, CCI-PRGM-EOPS-TN-13-0009	1.2	2015-03-09
[AD.8]	GHRSST Science Team, cited 2010: The Recommended GHRSST Data Specification (GDS) Revision 2.0 Technical Specifications.	2.0	2010-10-01

The following documents are referenced in this document:

ID	Title
RD.184	Embury, O., C. J. Merchant and G. K. Corlett (2012), A Reprocessing for Climate of Sea Surface Temperature from the Along-Track Scanning Radiometers: Initial validation, accounting for skin and diurnal variability, Rem. Sens. Env., pp62 – 78 DOI:10.1016/j.rse.2011.02.028

ID	Title
RD.232	SST_CCI Multi-Sensor Match-up Dataset Specification, SST_CCI-REP-UoL-001
RD.258	SST CCI System Requirements Document, SST_CCI-SRD-BC-001 (SRD)
RD.305	ESA SST CCI Algorithm Theoretical Basis Document, SST-CCI-ATBD-UOR-203 (ATBD)
RD.329	ESA SST CCI System Verification Report, SST_CCI-SVR-UOR-001 (SVR)
RD.330	ESA SST CCI Product User Guide, SST_CCI-PUG-UKMO-201
RD.331	Pearson, K., Merchant, C., Embury, O. and Donlon, C. (2018) The role of Advanced Microwave Scanning Radiometer 2 channels within an optimal estimation scheme for sea surface temperature. Remote Sensing, 10 (1). 90. ISSN 2072-4292 doi: https://doi.org/10.3390/rs10010090 (special issue 'Sea Surface Temperature Retrievals from Remote Sensing')
RD.332	Bulgin, C. E., Mittaz, J. P.D., Embury, O., Eastwood, S. and Merchant, C. J. (2018) Bayesian cloud detection for 37 Years of Advanced Very High Resolution Radiometer (AVHRR) Global Area Coverage (GAC) data. Remote Sensing, 10 (1). 97. ISSN 2072-4292 doi: https://doi.org/10.3390/rs10010097

1.3 Acronyms

The following SST-specific acronyms are used in this report.

Acronym	Definition
ARC	ATSR Reprocessing for Climate
(A)ATSR	(Advanced) Along-Track Scanning Radiometer
AVHRR	Advanced Very High Resolution Radiometer
CCI	Climate Change Initiative
CF	Climate Forecast
CMIP5	Coupled Model Intercomparison Project Phase 5
DARD	Data Access Requirements Document
ECDF	Edinburgh Compute and Data Facility
ECMWF	European Centre for Medium-Range Weather Forecasts
ECV	Essential Climate Variable
ESA	European Space Agency
GBCS	Generalised Bayesian Cloud Screening
GDS	GHRSST Data Processing Specification
GHRSST	Group for High-Resolution SST
GMPE	GHRSST Multi Product Ensemble

Acronym	Definition
IR	Infrared
MetOp	Meteorological Operational (EUMETSAT)
MMD	Multi-sensor Match-up Dataset
MMS	Multi-sensor Match-up System
NOAA	National Oceanic and Atmospheric Administration
NWP	Numerical weather prediction
OSTIA	Operational Sea Surface Temperature and Sea Ice Analysis
PMW	Passive Microwave
SEVIRI	Spinning Enhanced Visible and Infrared Imager
SNAP	SentiNel Application Platform
SST	Sea Surface Temperature

2. SEA SURFACE TEMPERATURE SYSTEM OVERVIEW

2.1.1 SST-CCI processing

Between the production of the CDR2.0 and CDR2.1 products the major change to the ARC CCI processor was a rewrite of the output module. This was required to support the updated file format required for CDR2.1. There were improvements to pixel quality level assignment to reduce instances of mask inconsistencies following the results of the CDR2.0 SVR. In addition support for PWM processing (AMSRE/AMSR2) was integrated into the ARC CCI code base, along with various bug fixes and updates from the ongoing Copernicus Climate Change Service (C3S) work

2.2 Subsystems of the SST-CCI processing

2.2.1 Level-2 and Level-3 (ARC CCI) processors

The Level-2 and Level-3 processors consist of the optical and infrared (ARC) SST processor, the diurnal variability (DV) model, and the microwave SST processor. Level-1b AVHRR GAC and ATSR satellite data are the main input of the optical and microwave SST, with ECMWF Interim and sea ice concentration auxiliary data. The outputs of the processors are SST-CCI L2P and L3U SST. The DV model uses the same inputs as the SST processor in order to modify the L2P and L3U SST. All inputs required for the processing are hosted in the Scale-Out File System (SOF) storage at JASMIN.

2.3 Requirements review

Table 2-1 below provides a review of all SST-CCI requirements for Phase-II and how these have been addressed as part of the work conducted in the project, and within the SVR, where applicable. Where appropriate, readers are referred to other project documents where requirements are addressed.

The list of requirements below is a subset of the complete list as defined by the agency, tailored to cover the content of this add-on SVR and to the quality assessment chores executed to cover the CDR2.1 data quality.

Table 2-1: SST-CCI requirements (Phase-II) addressed during the data verification process

Relevant Requirements	How addressed	SVR section or reference
Cardinal requirements		
CR-2 Produce and validate the most complete and consistent possible time series of multi-sensor global satellite data products for climate research and modelling, for the period where data are available including up to the present day. This will include at least one full ECV reprocessing.	Verification that the products contain SSTs that are faithful implementations of the scientific algorithms selected for climate products.	4.1 4.2
Framework		

Relevant Requirements	**How addressed**	**SVR section or reference**
SST-TR-1 The CCI SST ECV project shall use netCDF CF compliant definitions of ‘SSTskin’, ‘SSTsub-skin’, ‘SSTfnd’ and ‘SSTdepth’ […] the misleading term ‘Bulk SST’ […] shall not be used	The SST-CCI Product Specification Document (PSD) has adopted the required netCDF CF compliant definitions of SSTs. The products produced in SST-CCI comply with the PSD by design and are verified here	4.1 4.2
SST-TR-3 SST data products shall comply with the GHRSST Data Processing Specification […]	The SST-CCI Product Specification Document (PSD) has adopted GHRSST compliant definitions of SSTs. The products produced in SST-CCI comply with the PSD and GHRSST by design and are verified here	4.1.1 4.2.1
SST-TR-5 SST-CCI Phase-II shall produce sea-surface temperature products for the baseline time period of 1981-2016	This has been implemented in Phase II for L2P and L3U data	4.1.1 4.2.1
General product requirements		
SST-TR-6 SST-CCI shall produce integrated sea-surface temperature analyses based on SST-CCI L2/L3 satellite data records from 1981-2016. Products shall push as far as scientifically and technically possible to address GCOS user requirements using both IR and MW data, within the time and resource constraints of the project	L2P and L3U SST products have been produced for the period 1981-2016 and are verified here	4.1.1 4.1.2 4.2.1 4.2.2
SST-TR-7 SST-CCI shall produce L2/L3 SST products from the AVHRR series of satellite infrared radiometers for the period 1981 – 2016	L2P and L3U SST products have been produced for the period 1981-2016 and are verified here	4.1.1 4.1.2 4.2.1 4.2.2
SST-TR-8 SST-CCI shall produce L2/L3 SST products from the (A)ATSR series of satellite infrared radiometers for the period 1991-2012	L2P and L3U SST products have been produced for the period 1991-2012 and are verified here	4.1.1 4.1.2 4.2.1 4.2.2
SST-TR-10 IR satellite FCDR data products shall provide an ‘SSTskin’ measurement as single sensor orbital swath/scene products	This is done as defined in PSD	4.2.1
SST-TR-13 All SST-CCI SST products shall include an estimate of uncertainty rigorously propagated from known instrument uncertainties, measurements and retrieval/merging models	The inclusion of uncertainty estimates in the products has been ensured by design. The consistency checking is a validation activity (uncertainty is a part of the product to be validated in its own right) and will be described in the PVIR. The presence of per-pixel uncertainties in the products is verified here	4.1.1 4.1.2 4.2.1 4.2.2

Relevant Requirements	How addressed	SVR section or reference
SST-TR-14 Appropriate communication tools to help users understand uncertainty estimates how to apply them shall be provided	Addressed via Products User Guide (PUG)	N/A
SST-TR-15 SST retrievals shall be provided for all conditions that may potentially provide a useful SST in all L2P products	SST retrievals are supplied for all potentially clear-sky pixels in L2P	N/A
SST-TR-16 Quality Flags shall be provided in all L2P products that allow users to select the quality of SST data to use for their application	Quality level flags are provided for all L2P and L3U products. The presence and consistency of per-pixel quality flags is verified here.	4.1.1 4.1.2 4.2.1 4.2.2
Product performance		
SST-TR-21 The SST-CCI sea-surface temperature products shall target a stability of 0.03 K per decade over 100 km scales, assessed to the extent possible using the SST-CCI Independent Reference Data Set (SIRDS)	Full CDR results are not available at the time of writing this report. Global trend of preliminary ATSR data against reference data is: ATSR vs GTMBA (tropical Pacific) (1992 – 2012) Day: -2.1 mK/year < trend < 2.3 mK/year Night: -2.6 mK/year < trend < 0.4 mK/year AVHRR vs GTMBA (tropical Pacific) (1990 – 2010) Day: 3.6 mK/year < trend < 15.5 mK/year Night: -2.1 mK/year < trend < 9.8 mK/year	N/A
Requirements management		
SST-TR-25 In addition to the Product Specification Document (PSD) requirements set […] the SST ECV PSD shall include for all products: 1. File metadata format and structure specifications, 2. Community data discovery metadata and structure specifications, 3. Long-term document revision control procedures for the PSD, 4. Any other requirements relevant to SST ECV product specification	These are already included in the Phase-I PSD and will be updated as appropriate in Phase-II. The products produced in SST-CCI comply with the PSD by design and are verified here	4.1.2 4.2.2
Algorithm development		

Relevant Requirements	How addressed	SVR section or reference
SST-TR-35 ATSR-1, ATSR-2 and AATSR sensor overlap periods shall be reanalysed using the latest available L1b data to improve stability	Scientific developments were incorporated in the Phase-II reprocessing and are implicitly tested herein.	[RD.305]
SST-TR-36 Synergy techniques […] shall be developed/tested to re-assess Pinatubo and other stratospheric aerosol events for impact on the SST record stability	Scientific developments were incorporated in the Phase-II reprocessing and are implicitly tested herein.	[RD.305]
SST-TR-37 […] overlap techniques for harmonising AVHRRs pre-1991 shall be developed and applied to pre-1991 sensors	AVHRR data were harmonised at BT level using FIDUCEO techniques. SST harmonisation of Phase-II products used in situ SST for pre-1991 AVHRRs.	[RD.305]
SST-TR-39 Improved probabilistic cloud detection and flagging algorithms shall be tested and/or developed in routine and marginal situations that have increased sensitivity and performance […]	Probabilistic cloud detection is used for AVHRR	[RD.332]
SST-TR-40 Cloud flag definitions within SST-CCI data products shall be reviewed and updated as required	Reviewed, but no changes made with respect to Phase-I	N/A
SST-TR-41 Improved atmospheric aerosol detection and flagging algorithms shall be tested and/or developed that have increased sensitivity and performance […]	Scientific developments towards this are ongoing. No system verification yet	N/A
SST-TR-42 Aerosol contamination flag definitions within SST-CCI data products shall be reviewed and updated […]	Quality-level definitions have been updated to better account for atmospheric aerosol in Phase-II.	RD.330
SST-TR-43 Algorithms shall be tested and/or developed that improve the discrimination of ice-free and ice-covered water (i.e. clear/cloud/ice) classification in the MIZ to improve SST-CCI data products	Methods have been developed and implemented for AVHRR but no system verification has been undertaken yet.	In next major versions of this document
System evolution		
SST-TR-45 The SST-CCI system prototype system shall be implemented on a sustainable cost effective platform (e.g. the JASMIN platform) enabling multiple re-processing of SST-CCI data building on the SRD developed in Phase-I	Testing of the OSTIA system revealed that the processing capacity of JASMIN is not sufficient to enable re-processings of the SST-CCI data so the Met Office HPC system will need to be used for this. The JASMIN implementation is, however, suitable for extending the SST-CCI dataset under the C3S project.	N/A
SST-TR-49 SST-CCI shall implement more integrated and consistent radiative transfer modelling across IR and MW wavelengths	RTTOV v11.3 is now used for all fast radiative transfer.	N/A

Relevant Requirements	How addressed	SVR section or reference
Product generation		
SST-TR-51 At least two re-processing runs shall be performed during Phase-II SST-CCI activities. One of these shall deliver a data set (1981-2016) in sufficient time for the climate assessment work to be completed in good time prior to the end of the project	The Phase-II data covers 1982-2016 and is currently undergoing climate assessment work. L4 products were delivered to the team performing climate assessment; this work is ongoing.	N/A
SST-TR-52 An interim re-processing shall be performed that tests the functionality of the sustainable SST-CCI system and provides a data set suitable for validation of the system and data sets produced	An interim re-processing “EXP1.2” covering 1991-2015 was performed to test the production and validation.	N/A
SST-TR-55 The SST-CCI system shall be upgraded to address new requirements subject to scientific and technological constraints, Agency approval and available resources	The SST CCI system is in continuous development	N/A
Climate assessment		
SST-TR-57 An approach shall be established and implemented to assess, on a regular basis, the performance of satellite SST climate data records. The approach shall be developed in close cooperation with relevant international activities	Developments towards an automatic system for production of a comprehensive suite of diagnostics are ongoing	N/A
SST-TR-58 Validation of CCI SST satellite data products shall include global and regional aspects (spatially and in time series analysis) and at daily, weekly, seasonal, annual and inter-annual timescales	Methods to do this were developed and implemented in Phase-I. They have been adapted in Phase-II to align with the measures defined in the GHRSST CDAF	N/A
SST-TR-60 The SST-CCI validation of SST products shall include the use of methods developed in Phase-I (i.e. including the validation of uncertainty information)	The methods developed and implemented in Phase-I (including validation of uncertainty information) will be applied in Phase-II	N/A

3. DESCRIPTION OF VERIFICATION ACTIVITIES

For each of the verified components, a description of verification activities and associated criteria is provided in the following subsections.

3.1 Description of the verification tools

For verifying the content of the L2P and L3U products the automated verification procedure developed in Phase-I has been re-implemented from scratch. The new Python scripts have improved the verification procedure in several aspects:

- The verification procedure has fully been integrated into the JASMIN environment, using the p-monitor intermediate layer to control and monitor individual processing jobs. The source code has been integrated into the source code tree of the MMS. Verification procedures are executed massively parallel. Improvements of the p-monitor software have been implemented that allow a better integration into the LSF scheduling system installed at JASMIN, resulting in an even higher achievable parallel performance.
- A verification report is generated for each product file checked. The report is written in JSON format, which is easily readable by humans and machines. Python supports the JSON format natively. Verification reports translate into Python dictionaries, where the keys are text and the values are either numbers or text. Checks for all product types (L2P, L3U) have been implemented and updated to reflect the format changes introduced with the version 2.1 SST dataset.
- Product verification reports are accumulated into summary reports; one summary report per product type and sensor. For each check, the summary report traces failures back to individual product files. The format of the summary report again is JSON.
- For each summary report a set of bar charts is generated. The format of the bar charts is PDF.

Figure 3-1 below illustrates the workflow of the content verification procedure, which is split into daily chunks per product type and sensor.

Content verification is comprised of checks that are conducted per product or per pixel, which are listed and explained in Table 3-1 and Table 3-2 for product checks and Table 3-3 and Table 3-4 for pixel checks below. Checks conducted per pixel count the number of pixels in a product where an asserted condition fails. Individual checks in the verification procedure that have been added or modified with respect to the previous SVR checks have been iterated with the production team.

A summary of verification activities is given in Table 3-5 and Table 3-6. A detailed verification and validation of SST will be summarised in the “Product Verification and Intercomparison Report” (PVIR).

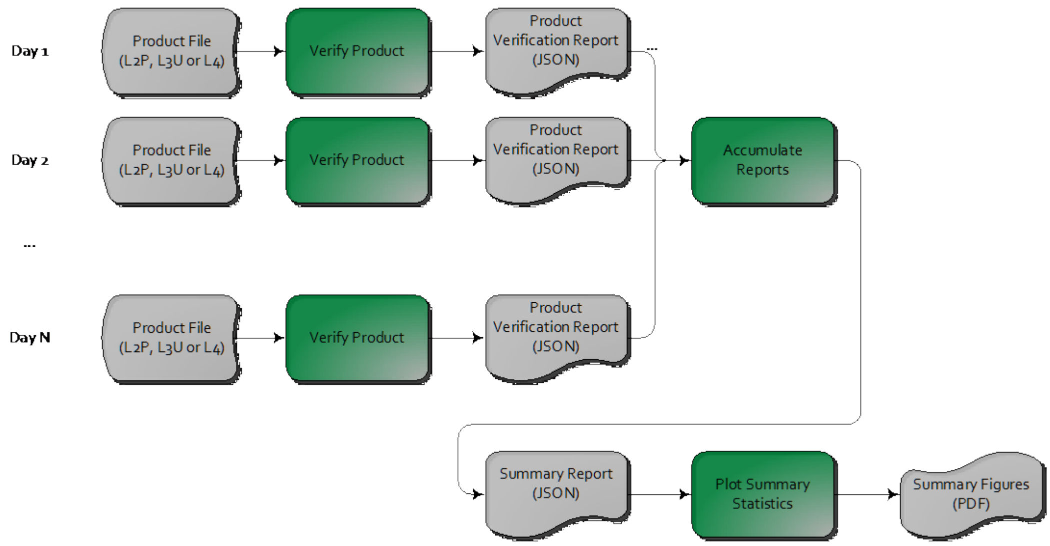

Figure 3-1: Processing workflow of the content verification procedure

Table 3-1: Checks conducted per product file for L2P and L3U

Name	Description
Is File	Fails if a product file is not a regular file (but e.g. a link or a directory)
Filename	Fails if the name of a product file does not comply with the naming convention defined in the PSD
Can Open	Fails if a product file is not readable or not a valid netCDF file
Has Version	Fails if a product file does not contain a global field “product_version”
Lat Exists	Fails if the ‘lat’ variable does not exist
Lon Exists	Fails if the ‘lon’ variable does not exist
SST Exists	Fails if the ‘sea_surface_temperature’ variable does not exist
Time Exists	Fails if the ‘time’ variable does not exist
SST DTime Exists	Fails if the ‘sst_dtime’ variable does not exist
SSES Bias Exists	Fails if the ‘sses_bias’ variable does not exist
SSES St Dev Exists	Fails if the ‘sses_standard_deviation’ variable does not exist
Correlated Unc Exists	Fails if the ‘uncertainty_correlated’ variable does not exist
Random Unc Exists	Fails if the ‘uncertainty_random’ variable does not exist
Systematic Unc Exists	Fails if the ‘uncertainty_systematic’ variable does not exist
SST Depth Exists	Fails if the ‘sea_surface_temperature_depth’ variable does not exist
SST Depth Unc Exists	Fails if the ‘sea_surface_temperature_depth_total_uncertainty’ variable does not exist
SST Depth DTime Exists	Fails if the ‘sst_depth_dtime’ variable does not exist
Wind Speed Exists	Fails if the ‘wind_speed’ variable does not exist

Name	Description
L2P Flags Exist	Fails if the l2p_flags' variable does not exist
Quality Level Exists	Fails if the 'quality_level' variable does not exist
Adj Alt Exists	Fails if the 'adjustment_alt' variable does not exist
Alt SST Retr Exists	Fails if the 'alt_sst_retrieval_type' variable does not exist (only for L2P)
Depth Adj Exists	Fails if the 'depth_adjustment' variable does not exist
Emp Adj Exists	Fails if the 'empirical_adjustment' variable does not exist
SST Depth Anom Exists	Fails if the 'sea_surface_temperature_depth_anomaly' variable does not exist
SST Depth Tot Unc Exists	Fails if the 'sea_surface_temperature_depth_total_uncertainty' variable does not exist
SST Ret Type Exists	Fails if the 'sea_surface_temperature_retrieval_type' variable does not exist
SST Total Unc Exists	Fails if the 'sea_surface_temperature_total_uncertainty' variable does not exist
SST Sens Exists	Fails if the 'sst_sensitivity' variable does not exist
Unc Corr Alt Exists	Fails if the 'uncertainty_correlated_alt' variable does not exist
Unc Corr TD Exists	Fails if the 'uncertainty_correlated_time_and_depth_adjustment' variable does not exist
Unc Rand Alt Exists	Fails if the 'uncertainty_random_alt' variable does not exist
Unc Sys Alt Exists	Fails if the 'uncertainty_systematic_alt' variable does not exist
SST Corrupt	Fails if all values of the 'sea surface temperature' variable are invalid

Table 3-2: Additional checks conducted per product file for L3U

Name	Description
Lat Bounds Exists	Fails if the 'lat_bnds' variable does not exist
Lon Bounds Exists	Fails if the 'lon_bnds' variable does not exist
Time Bounds Exists	Fails if the 'time_bnds' variable does not exist

Table 3-3: Checks conducted per pixel for L2P and L3U

Name	Description
Lat Min	Counts the number of pixels where the value of the 'lat' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
Lat Max	Counts the number of pixels where the value of the 'lat' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.

Name	Description
Lon Min	Counts the number of pixels where the value of the 'lon' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
Lon Max	Counts the number of pixels where the value of the 'lon' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
SST DTime Min	Counts the number of pixels where the value of the 'sst_dtime' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
SST DTime Max	Counts the number of pixels where the value of the 'sst_dtime' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
SST Min	Counts the number of pixels where the value of the 'sea_surface_temperature' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
SST Max	Counts the number of pixels where the value of the 'sea_surface_temperature' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
SST Geophysical Min	Counts the number of pixels where the 'SST – SST depth' difference is less than -5 K. Fails if number counts are greater than zero.
SST Geophysical Max	Counts the number of pixels where the 'SST – SST depth' difference is greater than 10 K. Fails if number counts are greater than zero.
Quality Level Min	Counts the number of pixels where the value of the 'quality_level' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
Quality Level Max	Counts the number of pixels where the value of the 'quality_level' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
SSES Bias Min	Counts the number of pixels where the value of the 'sses_bias' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
SSES Bias Max	Counts the number of pixels where the value of the 'sses_bias' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
SSES St Dev Min	Counts the number of pixels where the value of the 'sses_standard_deviation' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
SSES St Dev Max	Counts the number of pixels where the value of the 'sses_standard_deviation' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.

Name	Description
Correlated Unc Min	Counts the number of pixels where the value of the ‘uncertainty_correlated’ variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
Correlated Unc Max	Counts the number of pixels where the value of the ‘uncertainty_correlated’ variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
Random Unc Min	Counts the number of pixels where the value of the ‘uncertainty_random’ variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
Random Unc Max	Counts the number of pixels where the value of the ‘‘uncertainty_random’ variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
Systematic Unc Min	Counts the number of pixels where the value of the ‘uncertainty_systematic’ variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
Systematic Unc Max	Counts the number of pixels where the value of the ‘uncertainty_systematic’ variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
SST Depth Min	Counts the number of pixels where the value of the ‘sea_surface_temperature_depth’ variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
SST Depth Max	Counts the number of pixels where the value of the ‘sea_surface_temperature_depth’ variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
SST Depth Unc Min	Counts the number of pixels where the value of the ‘sea_surface_temperature_depth_total_uncertainty’ variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
SST Depth Unc Max	Counts the number of pixels where the value of the ‘sea_surface_temperature_depth_total_uncertainty’ variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
Wind Speed Min	Counts the number of pixels where the value of the ‘wind_speed’ variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
Wind Speed Max	Counts the number of pixels where the value of the ‘wind_speed’ variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
L2P Flags Min	Counts the number of pixels where the value of the ‘l2p_flags’ variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.

Name	Description
L2P Flags Max	Counts the number of pixels where the value of the 'l2p_flags' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
Adj Alt Min	Counts the number of pixels where the value of the 'adjustment_alt' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
Adj Alt Max	Counts the number of pixels where the value of the 'adjustment_alt' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
Sens Min	Counts the number of pixels where the value of the 'sst_sensitivity' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
Sens Max	Counts the number of pixels where the value of the 'sst_sensitivity' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
Alt SST Retr Min	Counts the number of pixels where the value of the 'alt_sst_retrieval_type' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
Alt SST Retr Max	Counts the number of pixels where the value of the 'alt_sst_retrieval_type' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
Depth Adj Min	Counts the number of pixels where the value of the 'depth_adjustment' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
Depth Adj Max	Counts the number of pixels where the value of the 'depth_adjustment' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
Emp Adj Min	Counts the number of pixels where the value of the 'empirical_adjustment' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
Emp Adj Max	Counts the number of pixels where the value of the 'empirical_adjustment' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
SST Depth Anom Min	Counts the number of pixels where the value of the 'sea_surface_temperature_depth_anomaly' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
SST Depth Anom Max	Counts the number of pixels where the value of the 'sea_surface_temperature_depth_anomaly' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.

Name	Description
SST Depth DTime Min	Counts the number of pixels where the value of the 'sst_depth_dtime' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
SST Depth DTime Max	Counts the number of pixels where the value of the 'sst_depth_dtime' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
SST Ret Type Min	Counts the number of pixels where the value of the 'sea_surface_temperature_retrieval_type' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
SST Ret Type Max	Counts the number of pixels where the value of the 'sea_surface_temperature_retrieval_type' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
SST Total Unc Min	Counts the number of pixels where the value of the 'sea_surface_temperature_total_uncertainty' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
SST Total Unc Max	Counts the number of pixels where the value of the 'sea_surface_temperature_total_uncertainty' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
Unc Corr Alt Min	Counts the number of pixels where the value of the 'uncertainty_correlated_alt' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
Unc Corr Alt Max	Counts the number of pixels where the value of the 'uncertainty_correlated_alt' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
Unc Corr TD Min	Counts the number of pixels where the value of the 'uncertainty_correlated_time_and_depth_adjustment' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
Unc Corr TD Max	Counts the number of pixels where the value of the 'uncertainty_correlated_time_and_depth_adjustment' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
Unc Rand Alt Min	Counts the number of pixels where the value of the 'uncertainty_random_alt' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
Unc Rand Alt Max	Counts the number of pixels where the value of the 'uncertainty_random_alt' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.

Name	Description
Unc Sys Alt Min	Counts the number of pixels where the value of the 'uncertainty_systematic_alt' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
Unc Sys Alt Max	Counts the number of pixels where the value of the 'uncertainty_systematic_alt' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
Quality Level Mask N	For each quality level L ∊ {2, 3, 4, 5} counts the number of pixels where the value of the 'sea_surface_temperature' variable is equal to the fill value (i.e. is masked) but the value of the 'quality level' variable is equal to L (i.e. is not masked). Fails if number counts are greater than zero.
Quality Level Mask P	Counts the number of pixels where the value of the 'sea_surface_temperature' variable is not equal to the fill value (i.e. is not masked) but the value of the 'quality level' variable is equal to 0. Fails if number counts are greater than zero.
SSES Bias Mask N	For each quality level L ∊ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'sea_surface_temperature' variable is equal to the fill value (i.e. is masked) but the value of the 'sses_bias' variable is not equal to the fill value (i.e. is not masked). Fails if number counts are greater than zero.
SSES Bias Mask P	For each quality level L ∊ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'sea_surface_temperature' variable is not equal to the fill value (i.e. is not masked) but the value of the 'sses_bias' variable is equal to the fill value (i.e. is masked). Fails if number counts are greater than zero.
SSES St Dev Mask N	For each quality level L ∊ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'sea_surface_temperature' variable is equal to the fill value (i.e. is masked) but the value of the 'sses_standard_deviation' variable is not equal to the fill value (i.e. is not masked). Fails if number counts are greater than zero.
SSES St Dev Mask P	For each quality level L ∊ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'sea_surface_temperature' variable is not equal to the fill value (i.e. is not masked) but the value of the 'sses_standard_deviation' variable is equal to the fill value (i.e. is masked). Fails if number counts are greater than zero.
Depth Adj Mask N	For each quality level L ∊ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'sea_surface_temperature' variable is equal to the fill value (i.e. is masked) but the value of the 'depth_adjustment' variable is not equal to the fill value (i.e. is not masked). Fails if number counts are greater than zero.

Name	Description
Depth Adj Mask P	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'sea_surface_temperature' variable is not equal to the fill value (i.e. is not masked) but the value of the 'depth_adjustment' variable is equal to the fill value (i.e. is masked). Fails if number counts are greater than zero.
SST Depth Anom Mask N	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'sea_surface_temperature' variable is equal to the fill value (i.e. is masked) but the value of the 'sea_surface_temperature_depth_anomaly' variable is not equal to the fill value (i.e. is not masked). Fails if number counts are greater than zero.
SST Depth Anom Mask P	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'sea_surface_temperature' variable is not equal to the fill value (i.e. is not masked) but the value of the 'sea_surface_temperature_depth_anomaly' variable is equal to the fill value (i.e. is masked). Fails if number counts are greater than zero.
SST Depth Unc Mask N	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'sea_surface_temperature' variable is equal to the fill value (i.e. is masked) but the value of the 'sea_surface_temperature_depth_total_uncertainty' variable is not equal to the fill value (i.e. is not masked). Fails if number counts are greater than zero.
SST Depth Unc Mask P	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'sea_surface_temperature' variable is not equal to the fill value (i.e. is not masked) but the value of the 'sea_surface_temperature_depth_total_uncertainty' variable is equal to the fill value (i.e. is masked). Fails if number counts are greater than zero.
SST Ret Type Mask N	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'sea_surface_temperature' variable is equal to the fill value (i.e. is masked) but the value of the 'sea_surface_temperature_retrieval_type' variable is not equal to the fill value (i.e. is not masked). Fails if number counts are greater than zero.
SST Ret Type Mask P	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'sea_surface_temperature' variable is not equal to the fill value (i.e. is not masked) but the value of the 'sea_surface_temperature_retrieval_type' variable is equal to the fill value (i.e. is masked). Fails if number counts are greater than zero.

Name	Description
SST Total Unc Mask N	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the ‘quality_level’ variable is equal to L, the value of the ‘sea_surface_temperature’ variable is not equal to the fill value (i.e. is masked) but the value of the ‘sea_surface_temperature_total_uncertainty’ variable is equal to the fill value (i.e. is masked). Fails if number counts are greater than zero.
SST Total Unc Mask P	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the ‘quality_level’ variable is equal to L, the value of the ‘sea_surface_temperature’ variable is equal to the fill value (i.e. is not masked) but the value of the ‘sea_surface_temperature_total_uncertainty’ variable is not equal to the fill value (i.e. is not masked). Fails if number counts are greater than zero.
SST Sens Mask N	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the ‘quality_level’ variable is equal to L, the value of the ‘sea_surface_temperature’ variable is equal to the fill value (i.e. is masked) but the value of the ‘sst_sensitivity’ variable is not equal to the fill value (i.e. is not masked). Fails if number counts are greater than zero.
SST Sens Mask P	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the ‘quality_level’ variable is equal to L, the value of the ‘sea_surface_temperature’ variable is not equal to the fill value (i.e. is not masked) but the value of the ‘sst_sensitivity’ variable is equal to the fill value (i.e. is masked). Fails if number counts are greater than zero.
Unc Corr Mask N	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the ‘quality_level’ variable is equal to L, the value of the ‘sea_surface_temperature’ variable is equal to the fill value (i.e. is masked) but the value of the ‘uncertainty_correlated’ variable is not equal to the fill value (i.e. is not masked). Fails if number counts are greater than zero.
Unc Corr Mask P	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the ‘quality_level’ variable is equal to L, the value of the ‘sea_surface_temperature’ variable is not equal to the fill value (i.e. is not masked) but the value of the ‘uncertainty_correlated’ variable is equal to the fill value (i.e. is masked). Fails if number counts are greater than zero.
SST Depth Mask N	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the ‘quality_level’ variable is equal to L, the value of the ‘sea_surface_temperature’ variable is equal to the fill value (i.e. is masked) but the value of the ‘sea_surface_temperature_depth’ variable is not equal to the fill value (i.e. is not masked). Fails if number counts are greater than zero.
SST Depth Mask P	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the ‘quality_level’ variable is equal to L, the value of the ‘sea_surface_temperature’ variable is not equal to the fill value (i.e. is not masked) but the value of the ‘sea_surface_temperature_depth’ variable is equal to the fill value (i.e. is masked). Fails if number counts are greater than zero.

Name	Description
Unc Corr Alt Mask N	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'alt_sst_retrieval_type' variable is equal to the fill value (i.e. is masked) but the value of the 'uncertainty_correlated_alt' variable is not equal to the fill value (i.e. is not masked). Fails if number counts are greater than zero.
Unc Corr Alt Mask P	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'alt_sst_retrieval_type' variable is not equal to the fill value (i.e. is not masked) but the value of the 'uncertainty_correlated_alt' variable is equal to the fill value (i.e. is masked). Fails if number counts are greater than zero.
Adj Alt Mask N	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'alt_sst_retrieval_type' variable is equal to the fill value (i.e. is masked) but the value of the 'adjustment_alt' variable is not equal to the fill value (i.e. is not masked). Fails if number counts are greater than zero.
Adj Alt Mask P	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'alt_sst_retrieval_type' variable is not equal to the fill value (i.e. is not masked) but the value of the 'adjustment_alt' variable is equal to the fill value (i.e. is masked). Fails if number counts are greater than zero.
Unc Corr TD Mask N	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'sea_surface_temperature' variable is equal to the fill value (i.e. is masked) but the value of the 'uncertainty_correlated_time_and_depth_adjustment' variable is not equal to the fill value (i.e. is not masked). Fails if number counts are greater than zero.
Unc Corr TD Mask P	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'sea_surface_temperature' variable is not equal to the fill value (i.e. is not masked) but the value of the 'uncertainty_correlated_time_and_depth_adjustment' variable is equal to the fill value (i.e. is masked). Fails if number counts are greater than zero.
Unc Rand Mask N	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'sea_surface_temperature' variable is equal to the fill value (i.e. is masked) but the value of the 'uncertainty_random' variable is not equal to the fill value (i.e. is not masked). Fails if number counts are greater than zero.
Unc Rand Mask P	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'sea_surface_temperature' variable is not equal to the fill value (i.e. is not masked) but the value of the 'uncertainty_random' variable is equal to the fill value (i.e. is masked). Fails if number counts are greater than zero.

Name	Description
Unc Rand Alt Mask N	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'alt_sst_retrieval_type' variable is equal to the fill value (i.e. is masked) but the value of the 'uncertainty_random_alt' variable is not equal to the fill value (i.e. is not masked). Fails if number counts are greater than zero.
Unc Rand Alt Mask P	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'alt_sst_retrieval_type' variable is not equal to the fill value (i.e. is not masked) but the value of the 'uncertainty_random_alt' variable is equal to the fill value (i.e. is masked). Fails if number counts are greater than zero.
Unc Sys Mask N	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'sea_surface_temperature' variable is equal to the fill value (i.e. is masked) but the value of the 'uncertainty_systematic' variable is not equal to the fill value (i.e. is not masked). Fails if number counts are greater than zero.
Unc Sys Mask P	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'sea_surface_temperature' variable is not equal to the fill value (i.e. is not masked) but the value of the 'uncertainty_systematic' variable is equal to the fill value (i.e. is masked). Fails if number counts are greater than zero.
Unc Sys Alt Mask N	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'alt_sst_retrieval_type' variable is equal to the fill value (i.e. is masked) but the value of the 'uncertainty_systematic_alt' variable is not equal to the fill value (i.e. is not masked). Fails if number counts are greater than zero.
Unc Sys Alt Mask P	For each quality level L ∈ {0, 1, 2, 3, 4, 5} counts the number of pixels where the value of the 'quality_level' variable is equal to L, the value of the 'alt_sst_retrieval_type' variable is not equal to the fill value (i.e. is not masked) but the value of the 'uncertainty_systematic_alt' variable is equal to the fill value (i.e. is masked). Fails if number counts are greater than zero.

Table 3-4: Checks conducted per pixel only for L3U

Name	Description
Lat Bnds Min	Counts the number of pixels where the value of the 'lat_bnds' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
Lat Bnds Max	Counts the number of pixels where the value of the 'lat_bnds' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
Lon Bnds Min	Counts the number of pixels where the value of the 'lon_bnds' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
Lon Bnds Max	Counts the number of pixels where the value of the 'lon_bnds'

Name	Description
	variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.
Time Bnds Min	Counts the number of pixels where the value of the 'time_bnds' variable is not equal to the fill value but less than the minimum valid value. Fails if number counts are greater than zero.
Time Bnds Max	Counts the number of pixels where the value of the 'time_bnds' variable is not equal to the fill value but greater than the maximum valid value. Fails if number counts are greater than zero.

3.2 Verifying the ARC CCI processor (L2P)

For verifying the content of the L2P products the all applicable verification checks were conducted as described in the previous section 3.1. A summary of verification activities is given in Table 3-5 below.

Table 3-5: Summary of activities for verifying L2P products

Component and mode of use	ARC CCI processor when processing AVHRR GAC inputs to L2P SST outputs.	
Requirements Addressed	CR-2, SST-TR-1,3,8,13,16,25,33	
Summary description of testing	• A sample of L2P output files are checked for completeness of content and consistency with product specification • All files are checked for content ensuring that all variables have values within the specified limits or fill value	
L2P content verification	Files	All SST-CCI L2P files (not listed)
	Verification activities	• Scripting the automated verification • Checking file name complies with naming convention • Checking file is a netCDF file and can be read • Checking following fields are present and have values within valid range or correct fill values o SST skin o SST depth o All flags o Uncertainty fields • Verifying geophysical validity of key fields within plausible ranges • Verifying mask consistency
L2P sample verification	Files	• One early and one late L2P file per sensor (listing in Section 4.2.2).
	Verification activities	• Manual inspection of all fields against PSD.

3.3 Verifying the ARC CCI processor (L3U)

For verifying the content of the L3U products the all applicable verification checks were conducted as described in the previous section 3.1. A summary of verification activities is given in Table 3-5 below.

Table 3-6: Summary of activities for verifying L3U products

Component and mode of use	ARC CCI processor when processing ATSR-series inputs to L3U SST outputs	
Requirements Addressed	CR-2, SST-TR-1,3,8,13,16,25,33	
Summary description of verification	• A sample of L3U output files are checked for completeness of content and consistency with product specification • All files are checked for content ensuring that all variables have values within the specified limits or fill values	
L3U content verification	Files	All SST-CCI L3U files (not listed)
	Verification activities	• Scripting the automated verification • Checking file name complies with naming convention • Checking file is a netCDF file and can be read • Checking following fields are present and have values within valid range or correct fill values o SST skin o SST depth o All flags o Uncertainty fields • Verifying geophysical validity of key fields within plausible ranges • Verifying mask consistency
L3U sample verification	Files	• One early and one late L3U file per sensor (listing in Section 4.1.2)
	Verification activities	• Manual inspection of all fields against PSD

4. RECORD OF VERIFICATION RESULTS

4.1 ARC CCI processor (L2P)

4.1.1 Content verification

Content verification checks have been carried out for all L2P products obtained from all flavours of ATSR and AVHRR-GAC sensors. The results of the L2P product and pixel checks are represented in horizontal bar charts shown in Figure 4-1 to Figure 4-28 below.

For all bar charts the left vertical axis lists the names of the checks conducted as defined in Table 3-1 and Table 3-3. The right vertical axis lists the number of occurrences where the check named on the left vertical axis has failed. For each check, a horizontal bar visualises the failure permillage (failure rate measured per thousand). If there is no bar drawn for a check, the check has been passed completely, without any failures. The number of product files (or pixels) checked in total is given in the label of the horizontal axis at the bottom.

The mask consistency tests defined in Table 3-3 are conducted per quality level. The results for these tests are visualised per quality level in form of a stacked bar. The total lengths of the stacked bar corresponds to the total permillage of failures for all quality levels. If the check does not distinguish between quality levels, the colour for "all" is used. The failure counts appearing on the right vertical axis also refer to the total number of failures.

In summary, the product checks have been passed without failures, except for 'SST Corrupt'. The overall number of affected L2P products is 23 out of 465302 for the total dataset. This is a significant improvement with respect to the previous version CDR 2.0 dataset.

Masking inconsistencies are expected at quality_level 1 (bad_data). These are pixels where some data (which can include retrieval, uncertainty, sensitivity, or cloud probabilities) are outside valid limits and the pixel is not useful for quantitative studies. The permillage of pixels affected by masking inconsistencies has improved by a factor of approximately 2 with respect to the previous version.

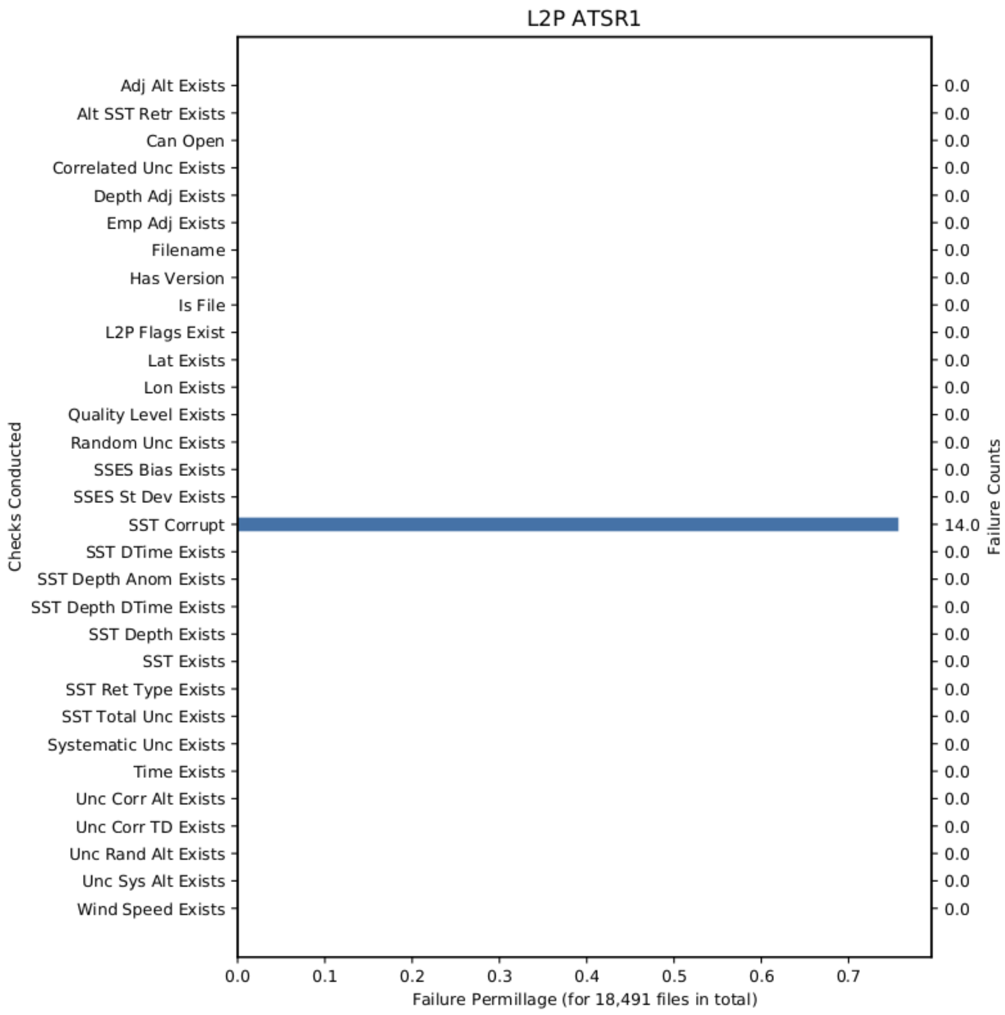

Figure 4-1: Results of L2P product checks for ATSR1

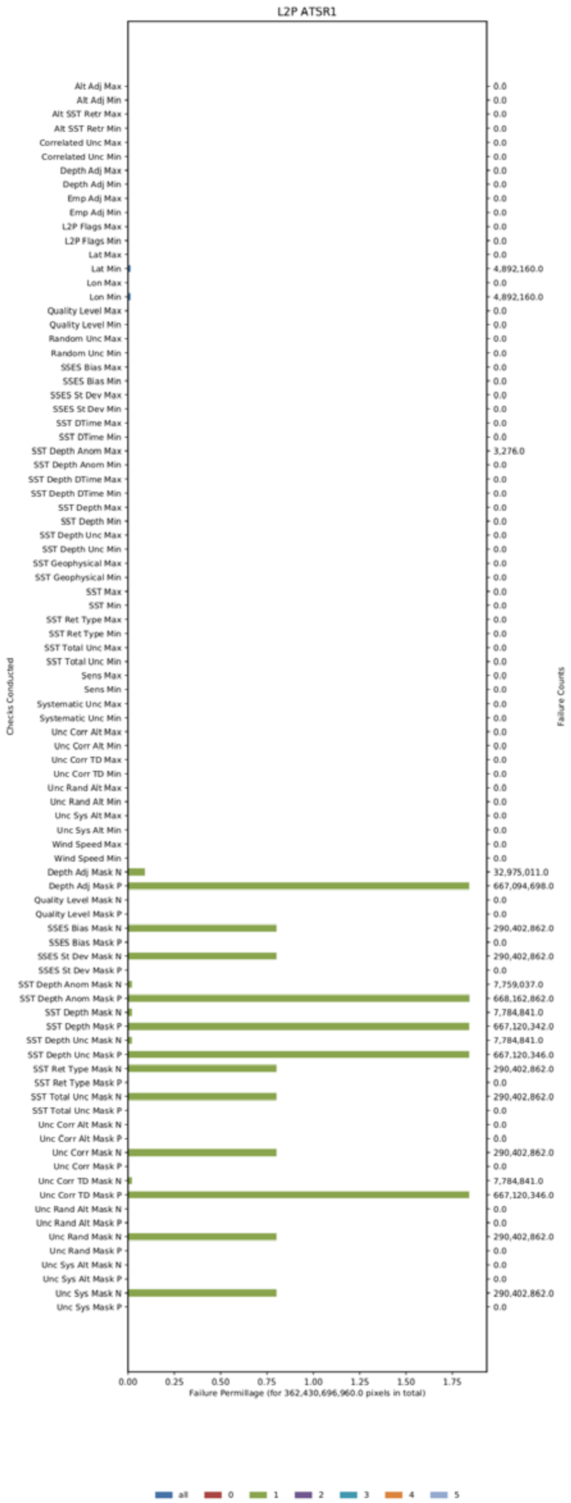

Figure 4-2: Results of L2P pixel checks for ATSR1

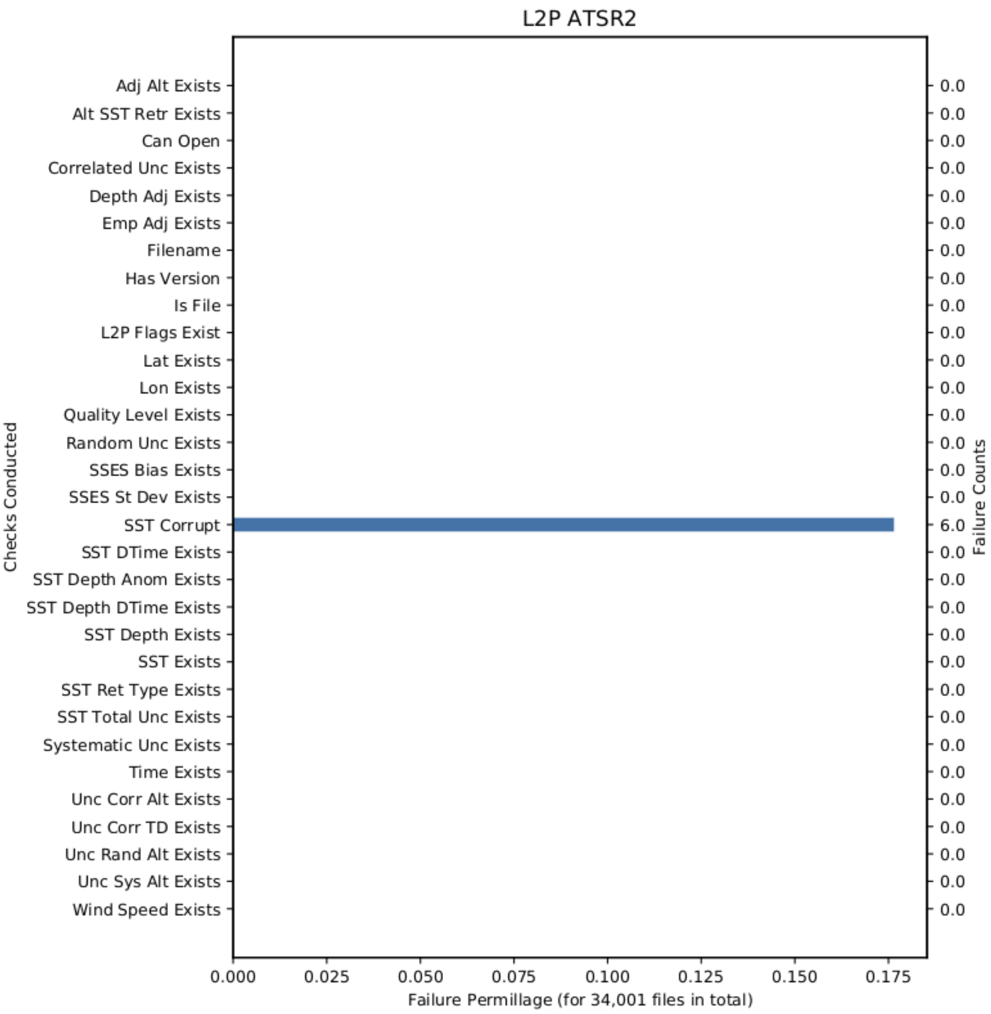

Figure 4-3: Results of L2P product checks for ATSR2

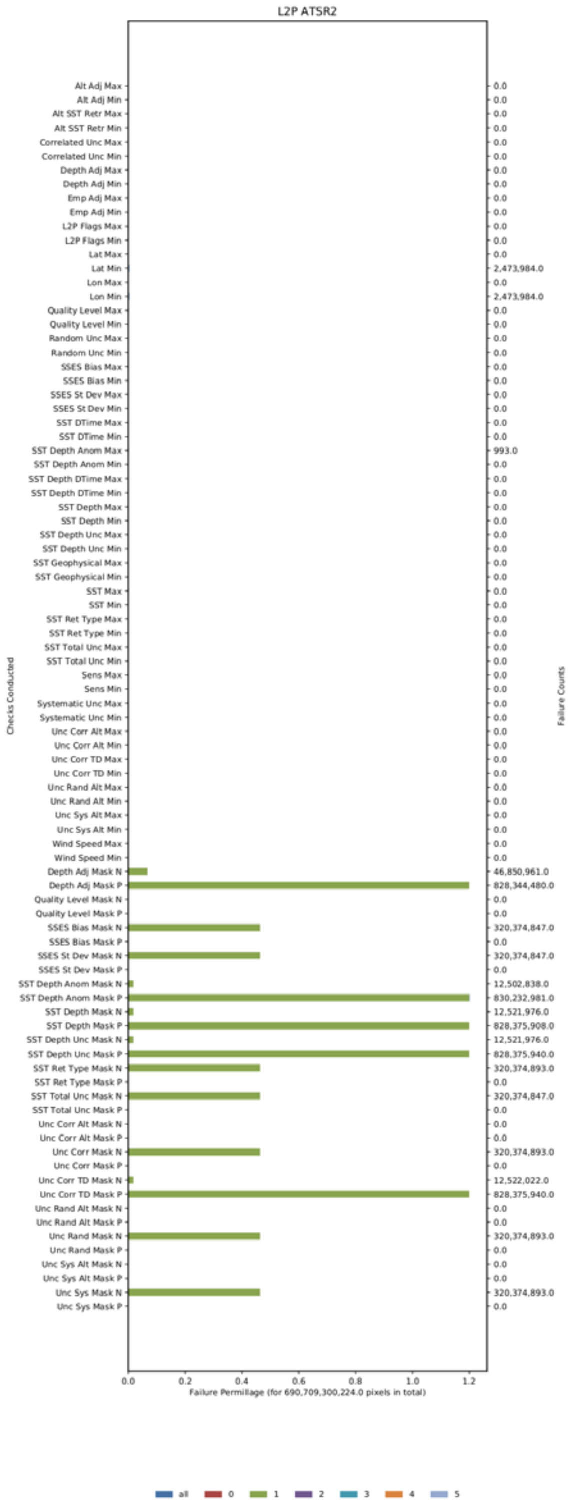

Figure 4-4: Results of L2P pixel checks for ATSR2

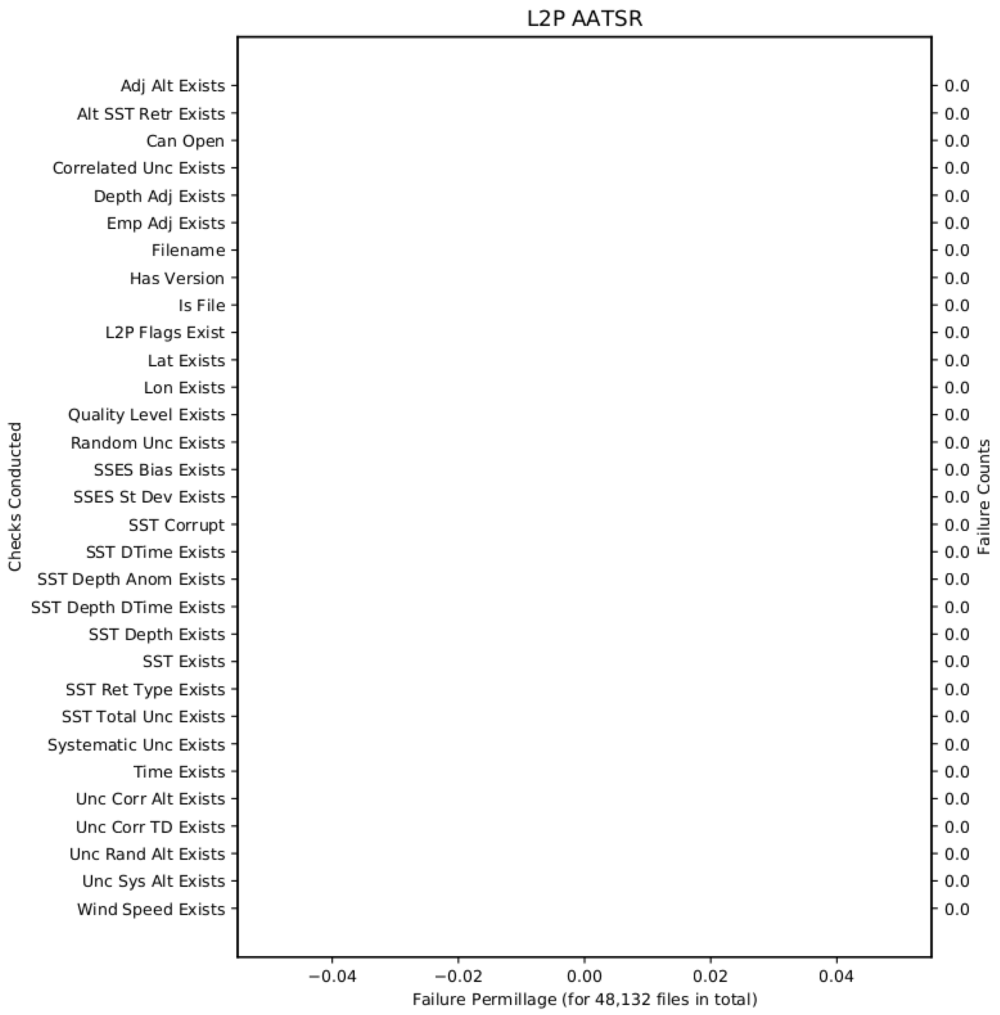

Figure 4-5: Results of L2P product checks for AATSR

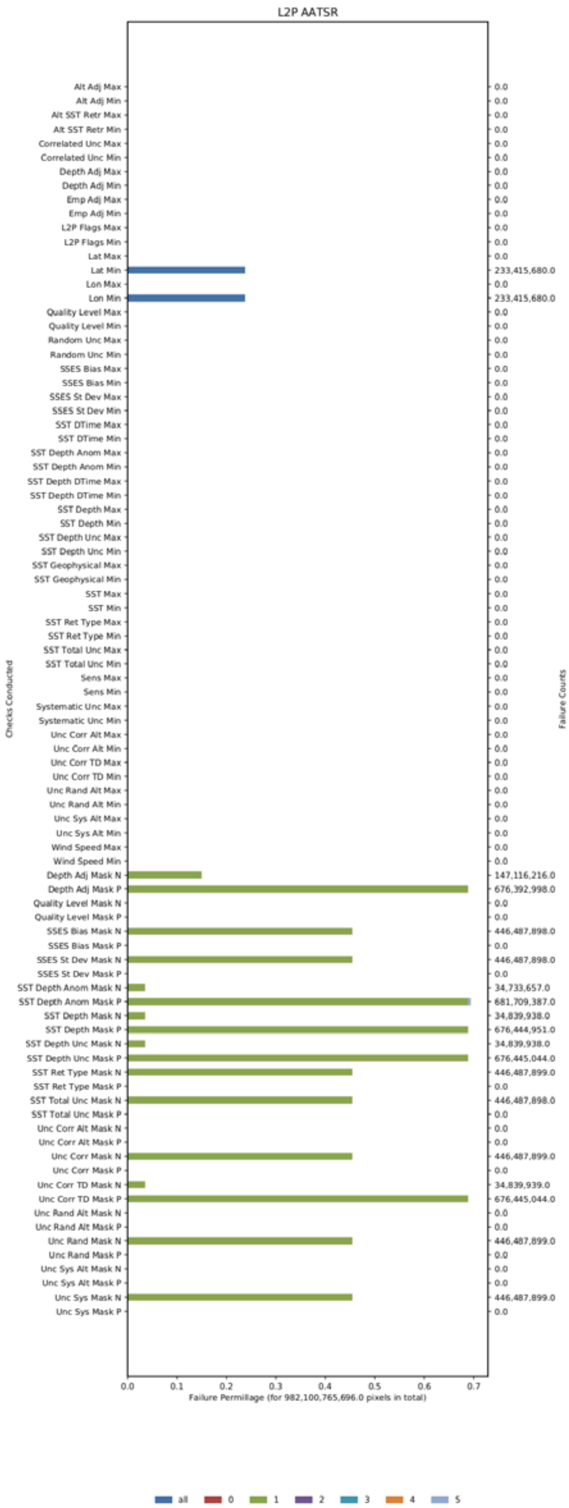

Figure 4-6: Results of L2P pixel checks for AATSR

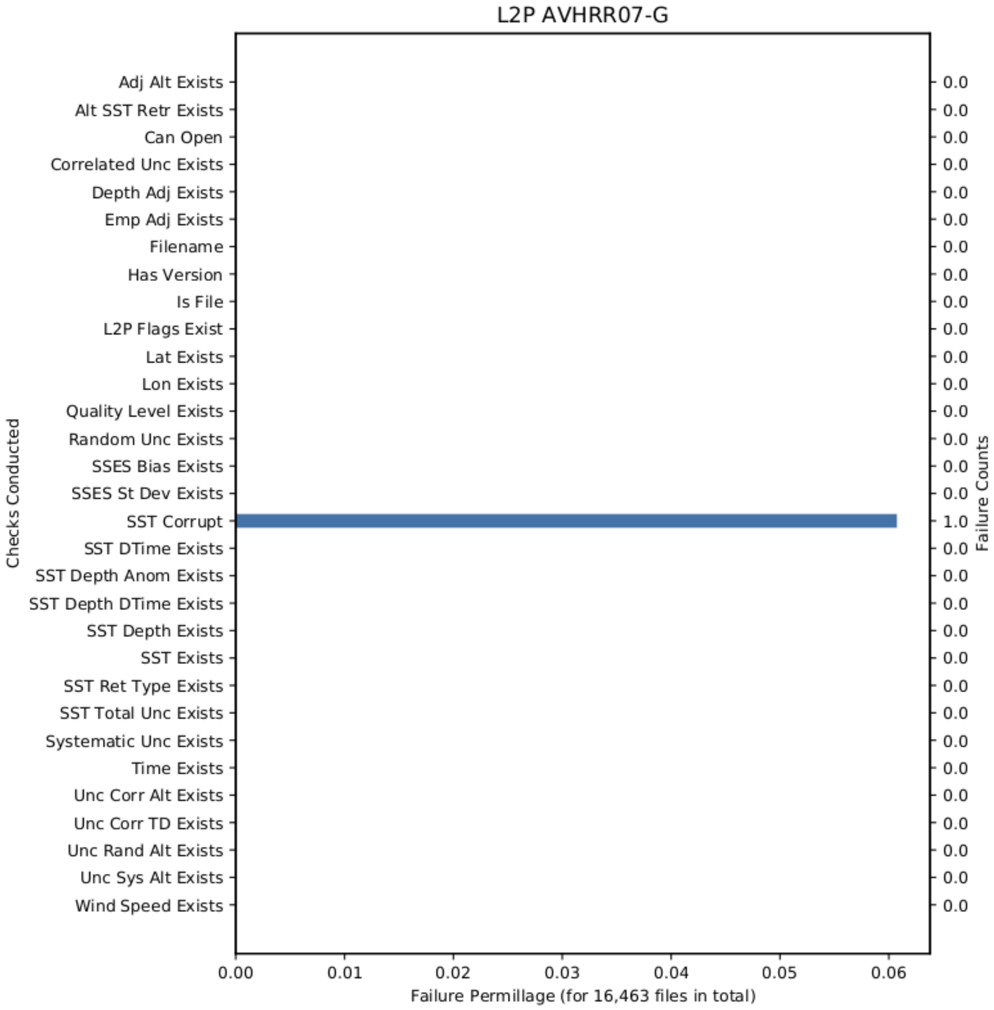

Figure 4-7: Results of L2P product checks for AVHRR07 GAC

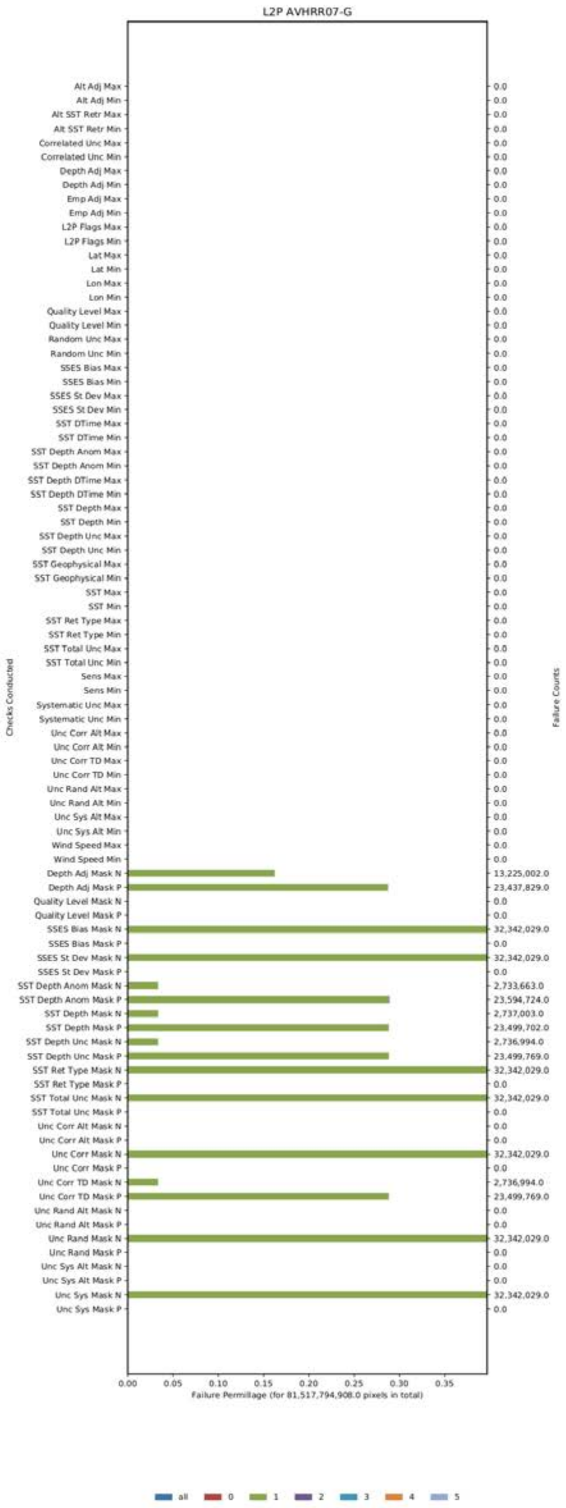

Figure 4-8: Results of L2P pixel checks for AVHRR07 GAC

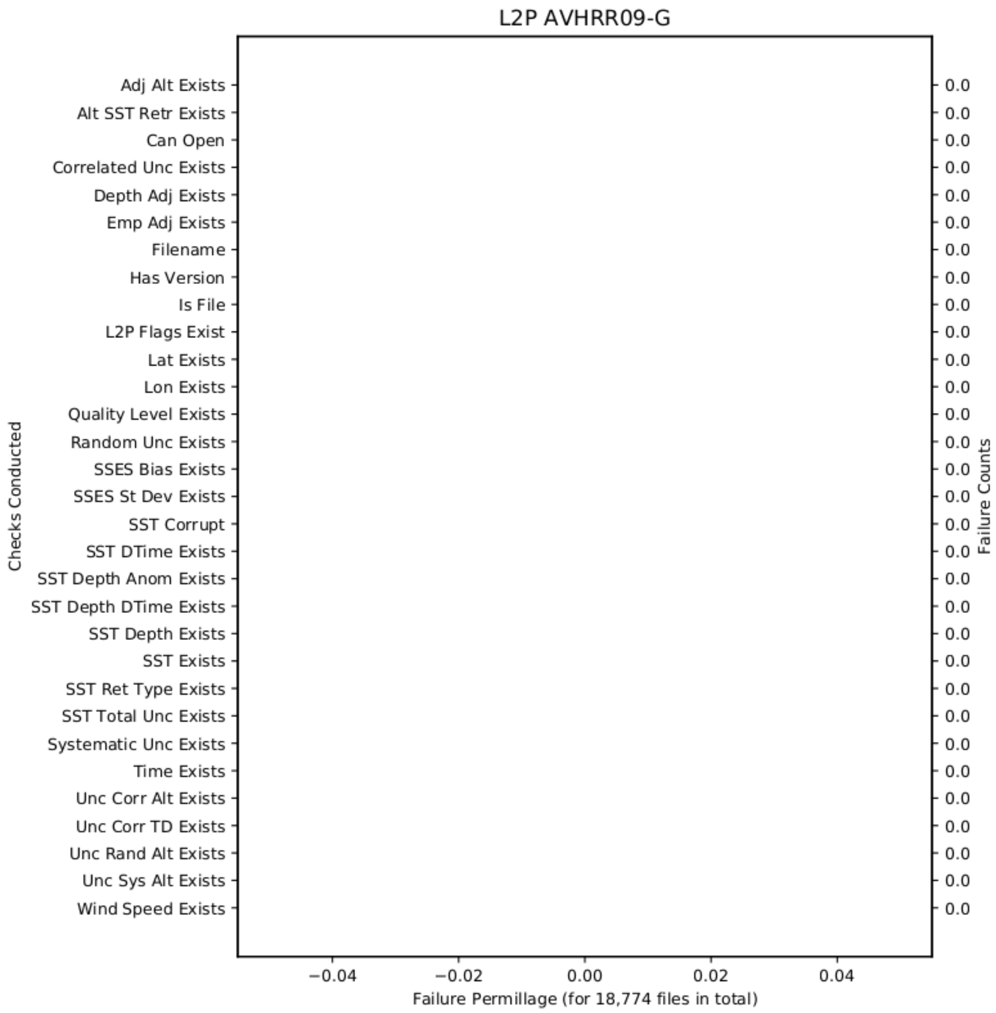

Figure 4-9: Results of L2P product checks for AVHRR09 GAC

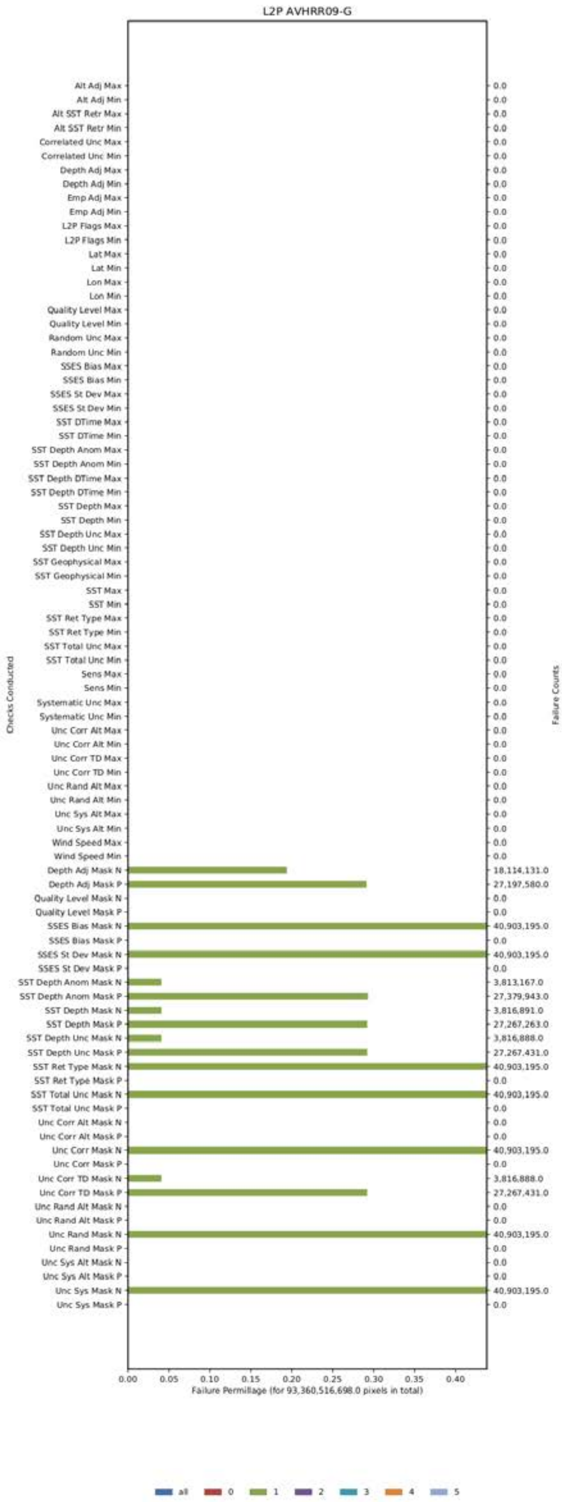

Figure 4-10: Results of L2P pixel checks for AVHRR09 GAC

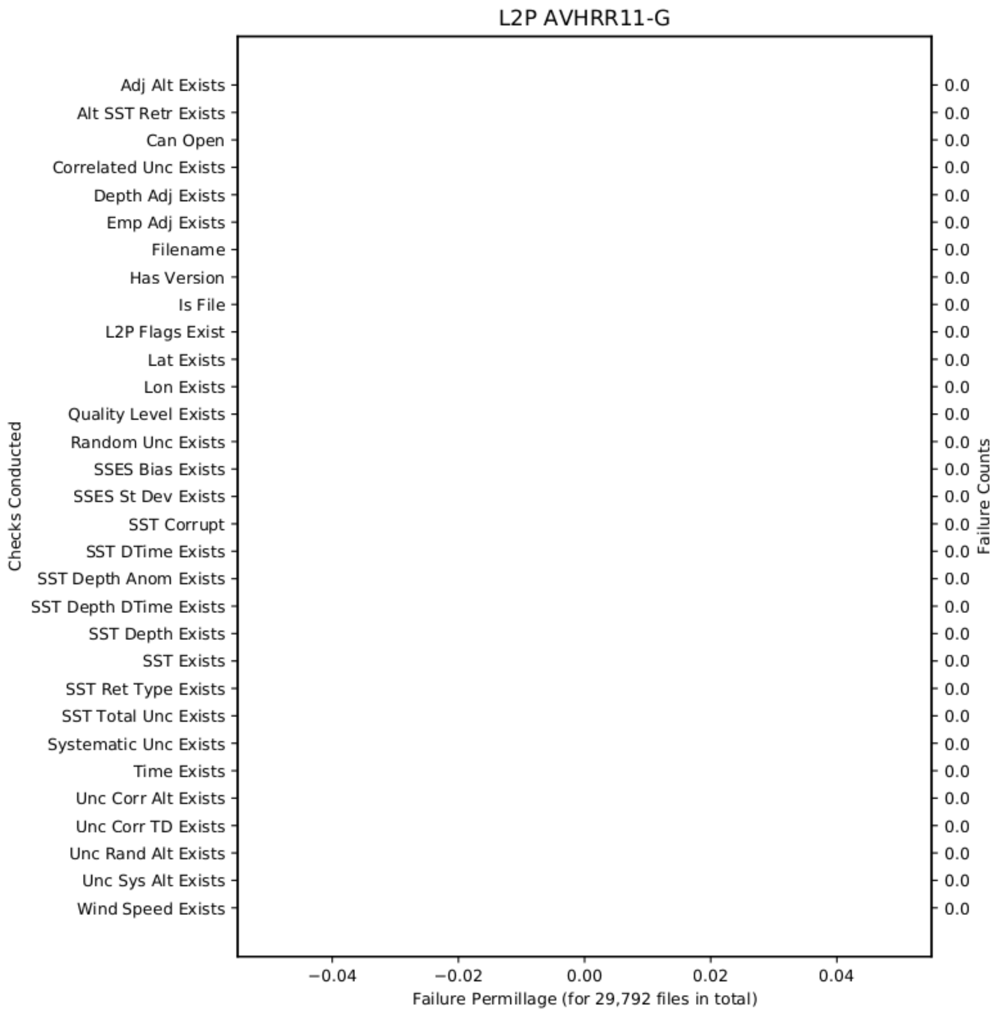

Figure 4-11: Results of L2P product checks for AVHRR11 GAC

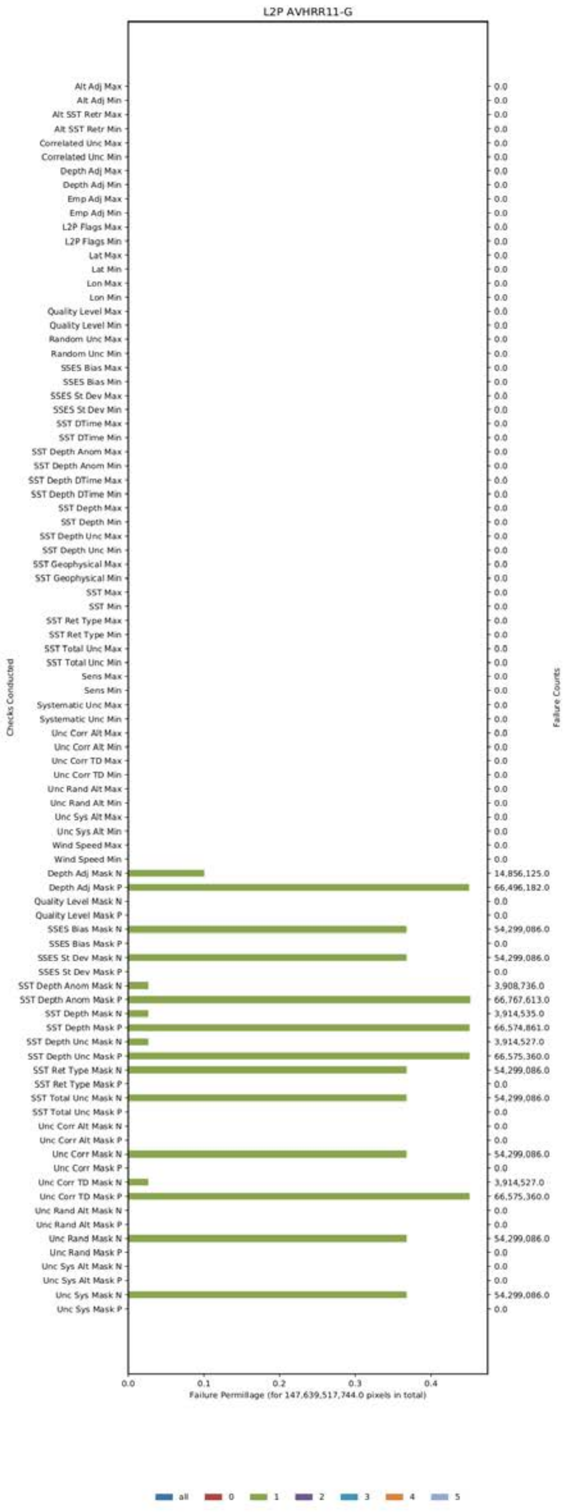

Figure 4-12: Results of L2P pixel checks for AVHRR11 GAC

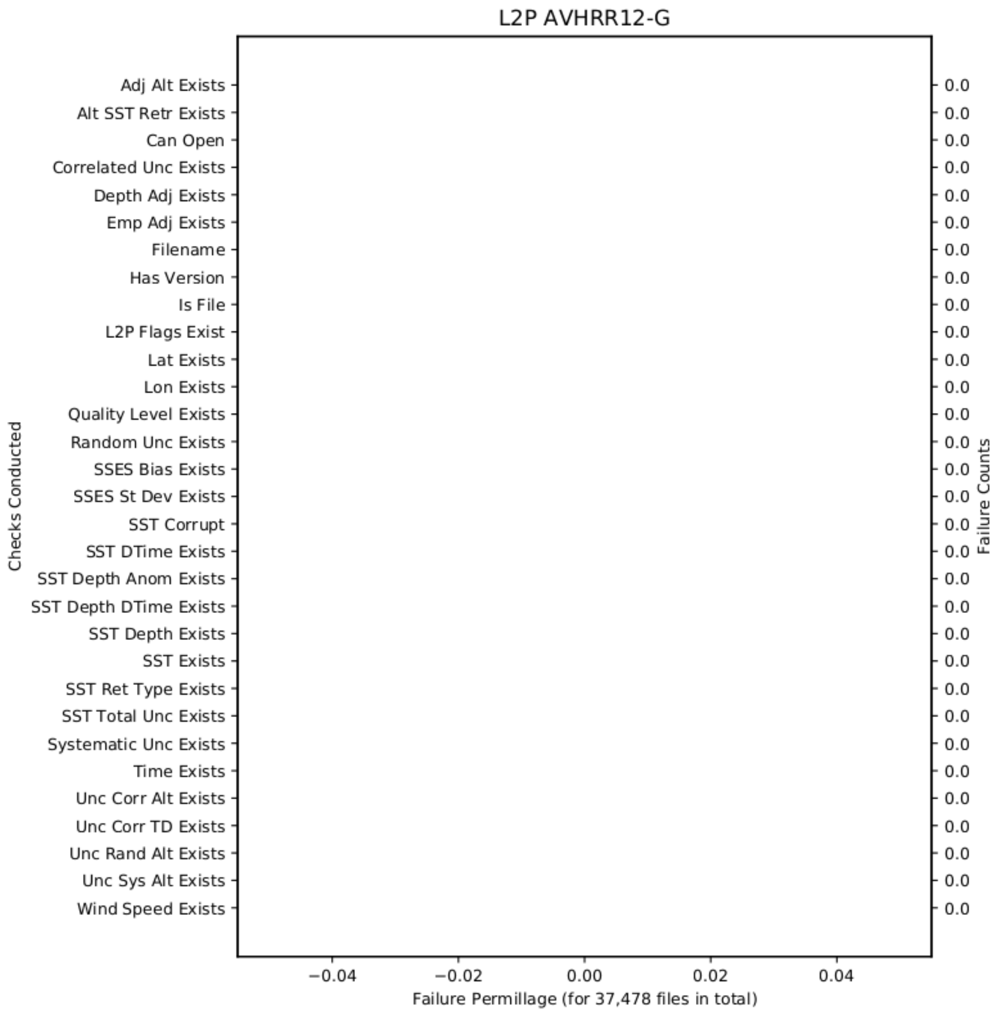

Figure 4-13: Results of L2P product checks for AVHRR12 GAC

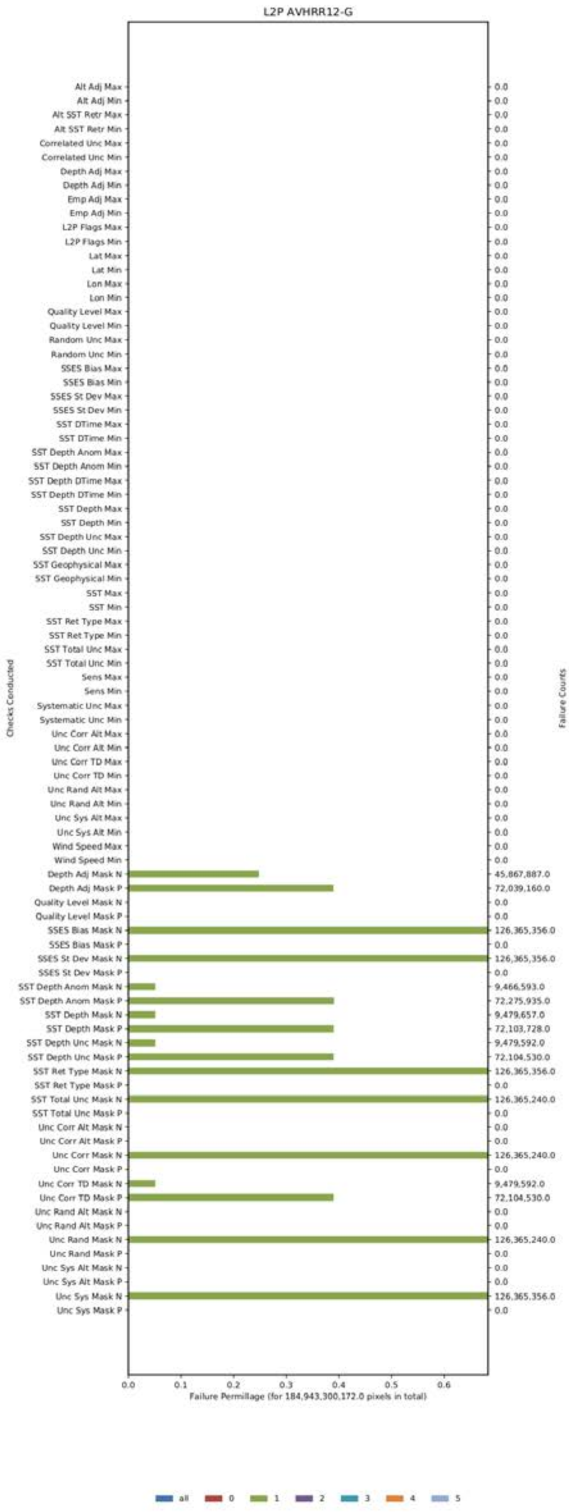

Figure 4-14: Results of L2P pixel checks for AVHRR12 GAC

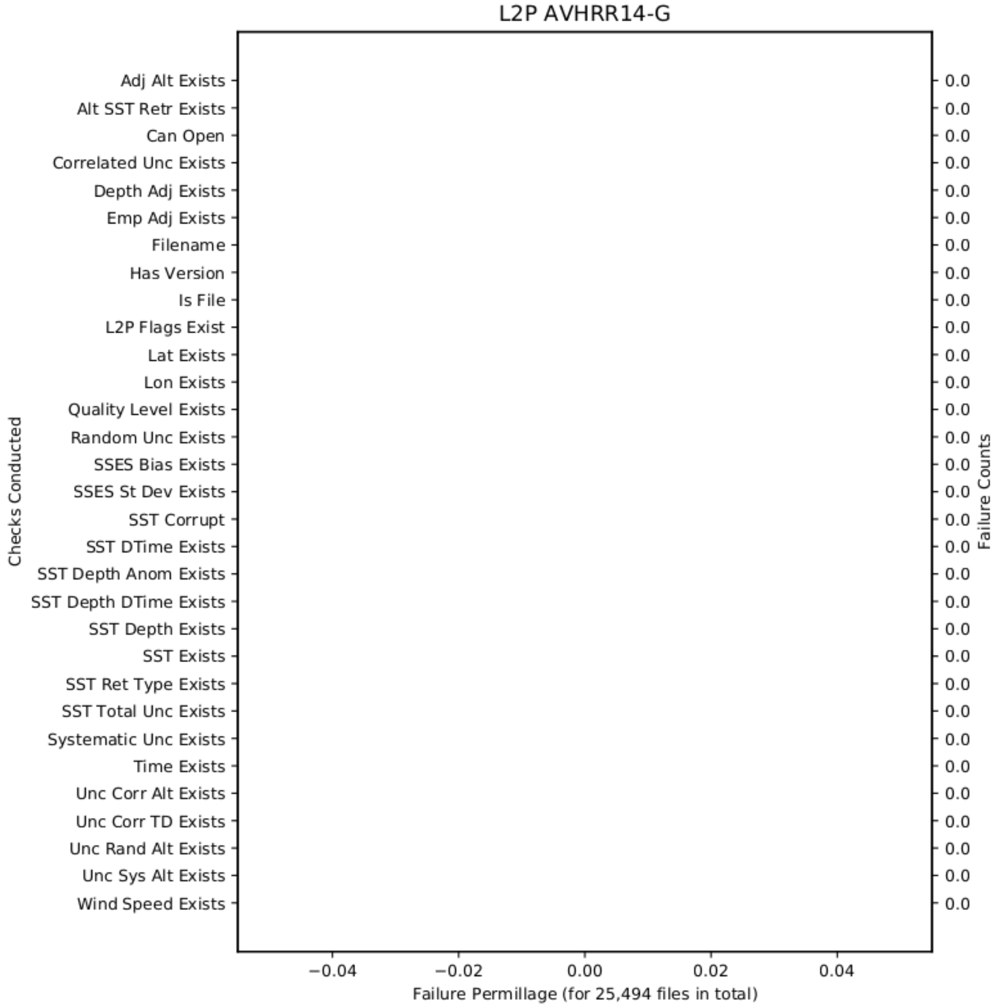

Figure 4-15: Results of L2P product checks for AVHRR14 GAC

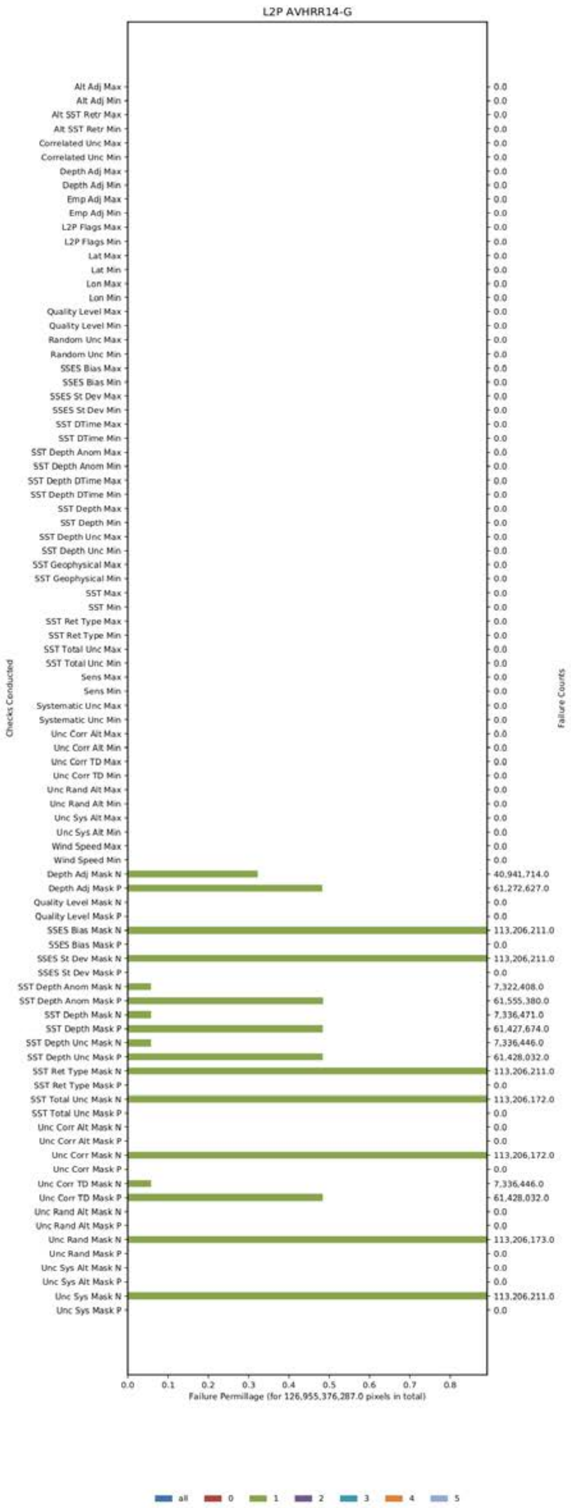

Figure 4-16: Results of L2P pixel checks for AVHRR14 GAC

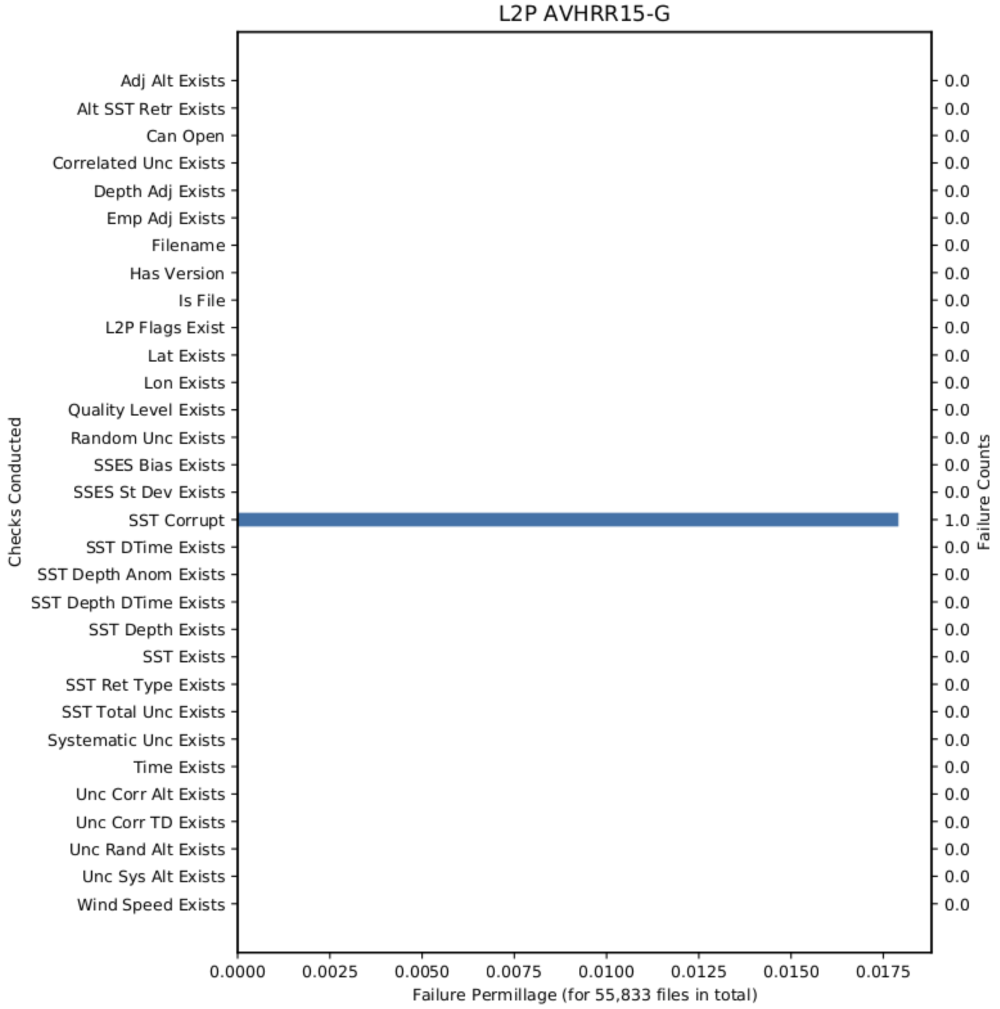

Figure 4-17: Results of L2P product checks for AVHRR15 GAC

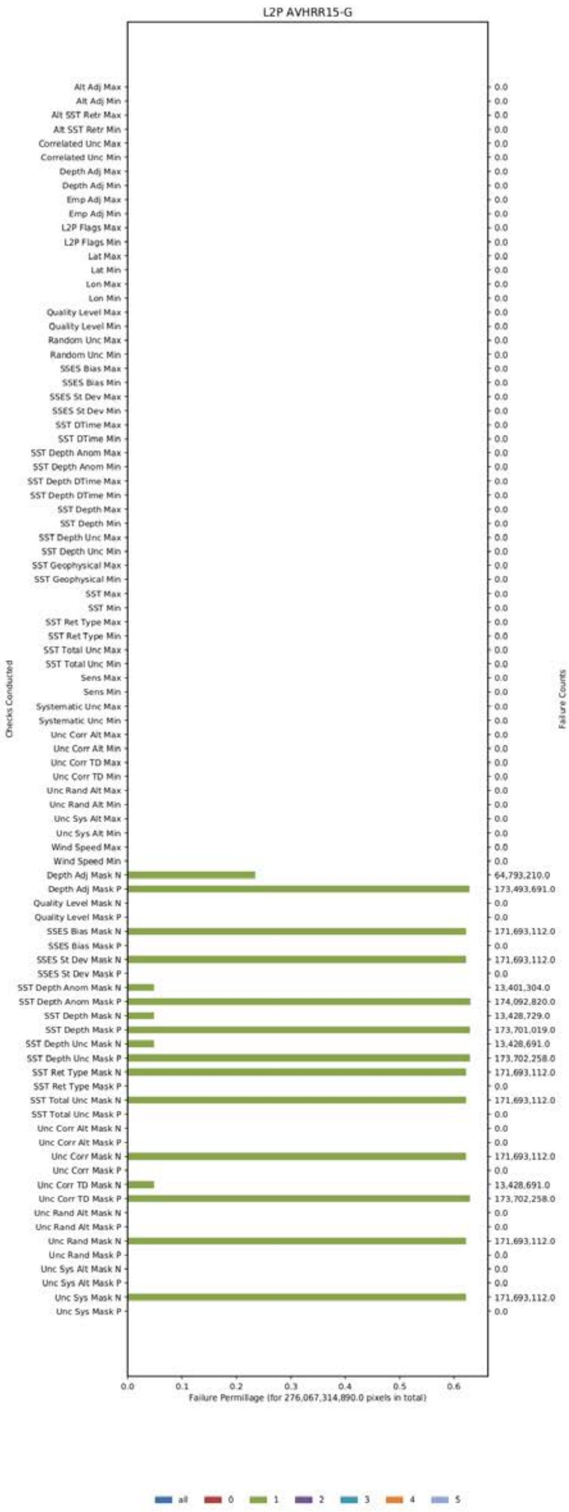

Figure 4-18: Results of L2P pixel checks for AVHRR15 GAC

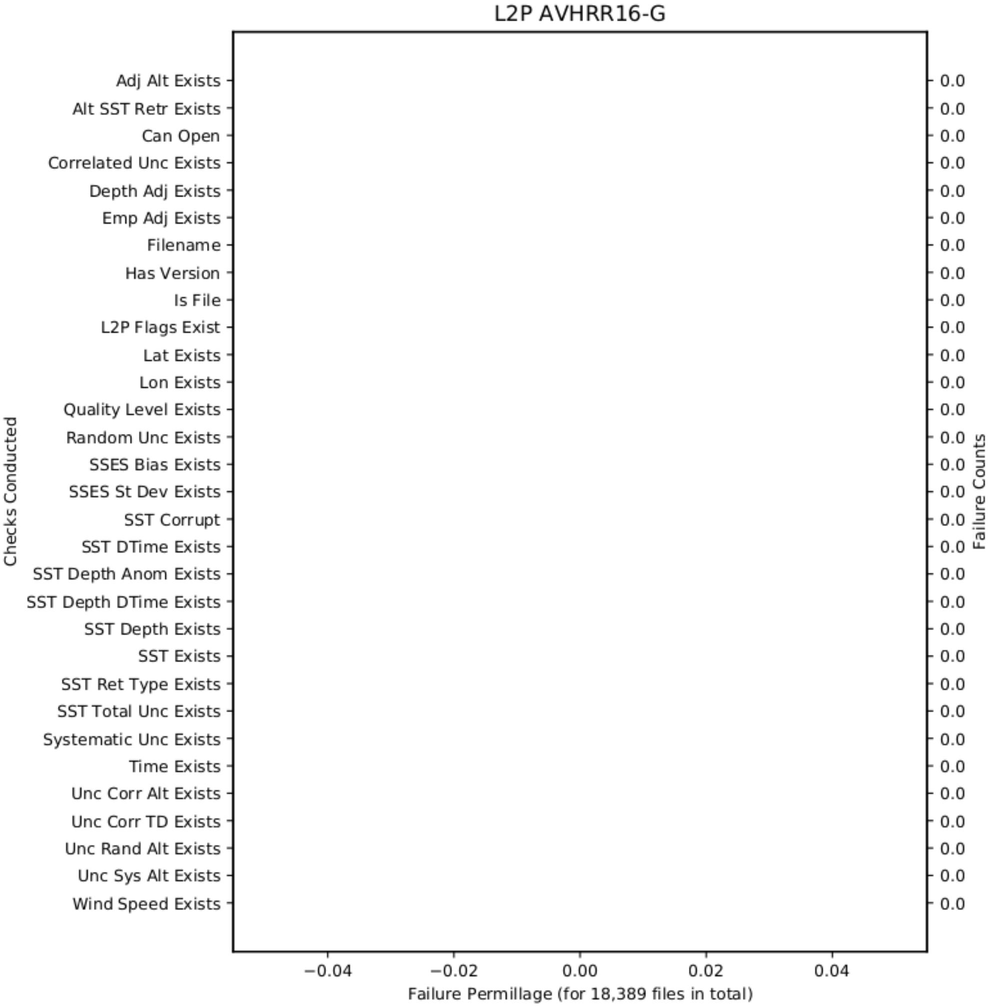

Figure 4-19: Results of L2P product checks for AVHRR16 GAC

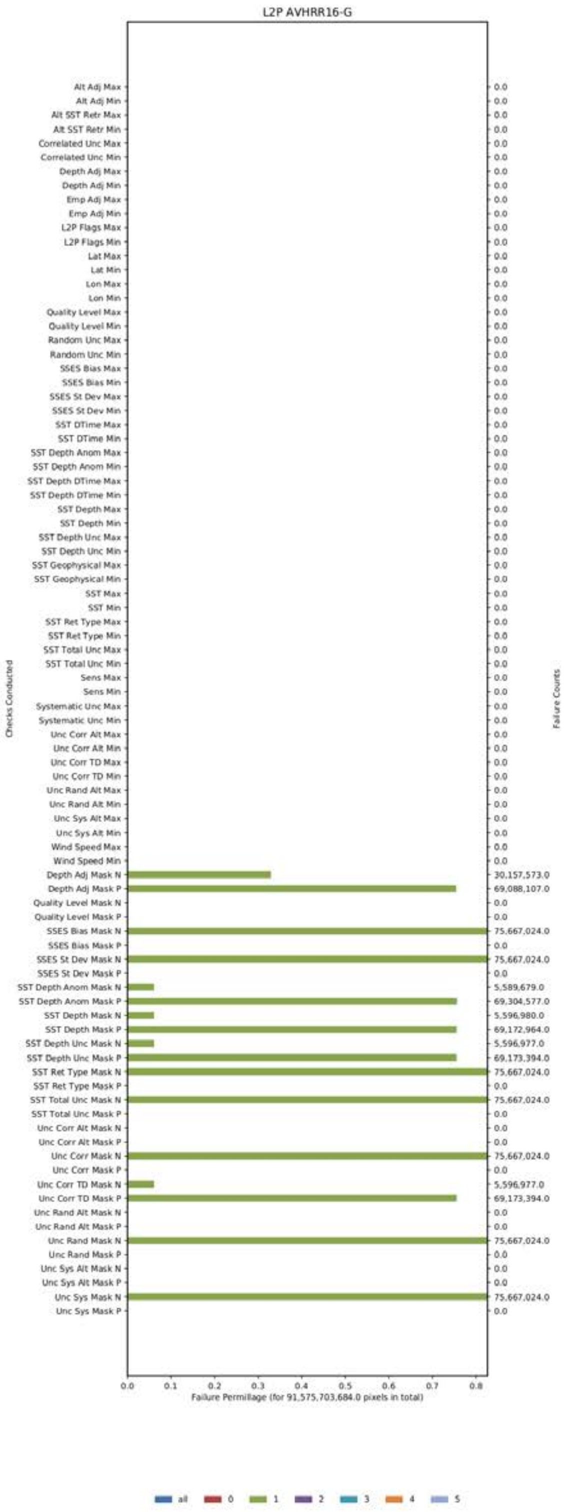

Figure 4-20: Results of L2P pixel checks for AVHRR16 GAC

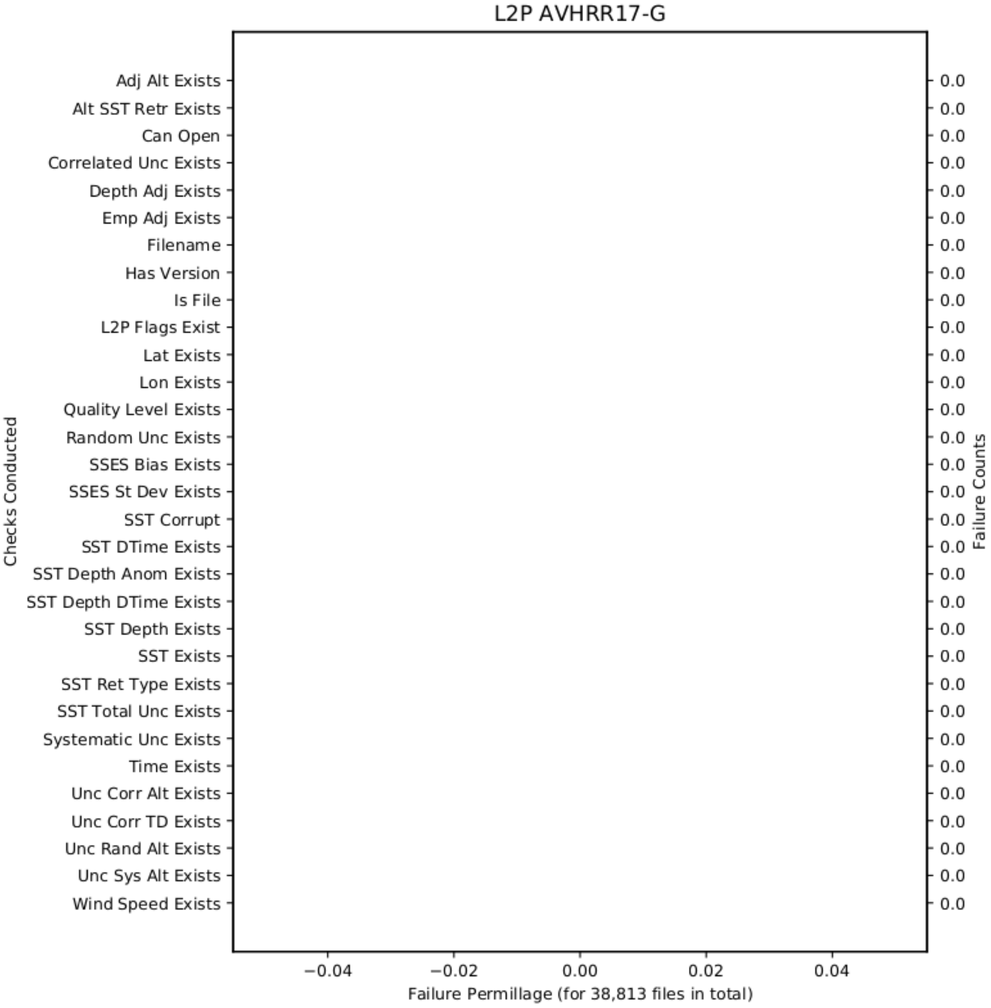

Figure 4-21: Results of L2P product checks for AVHRR17 GAC

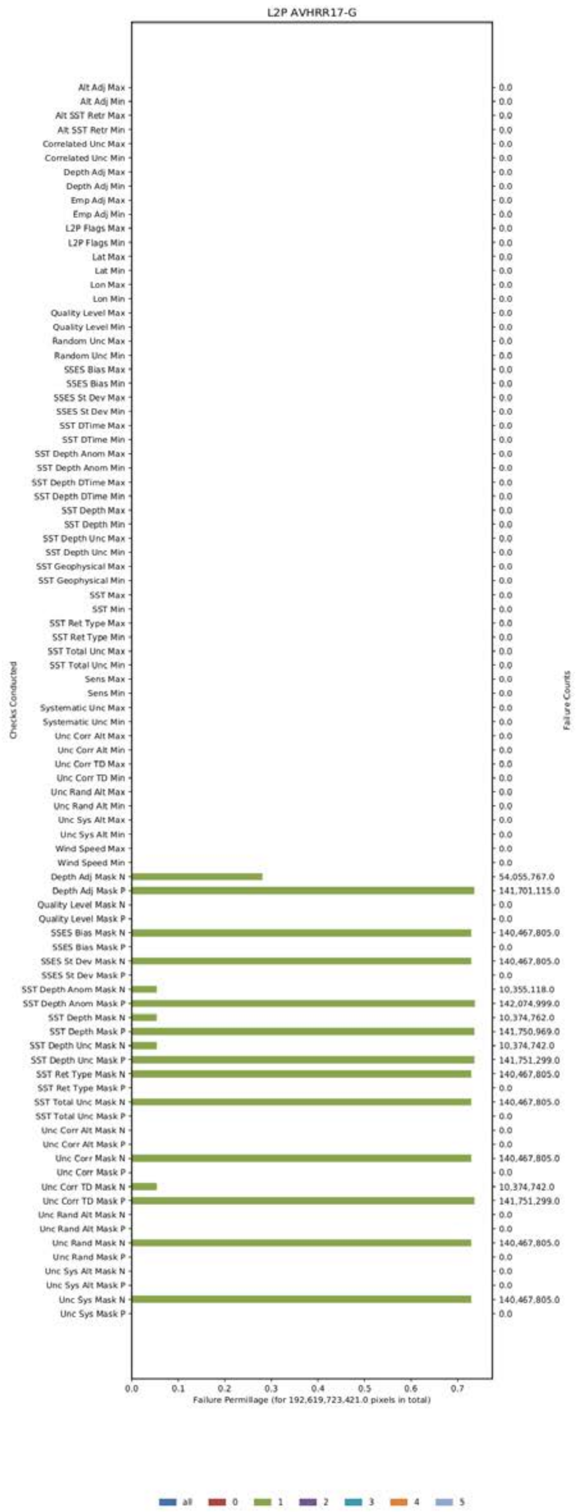

Figure 4-22: Results of L2P pixel checks for AVHRR17 GAC

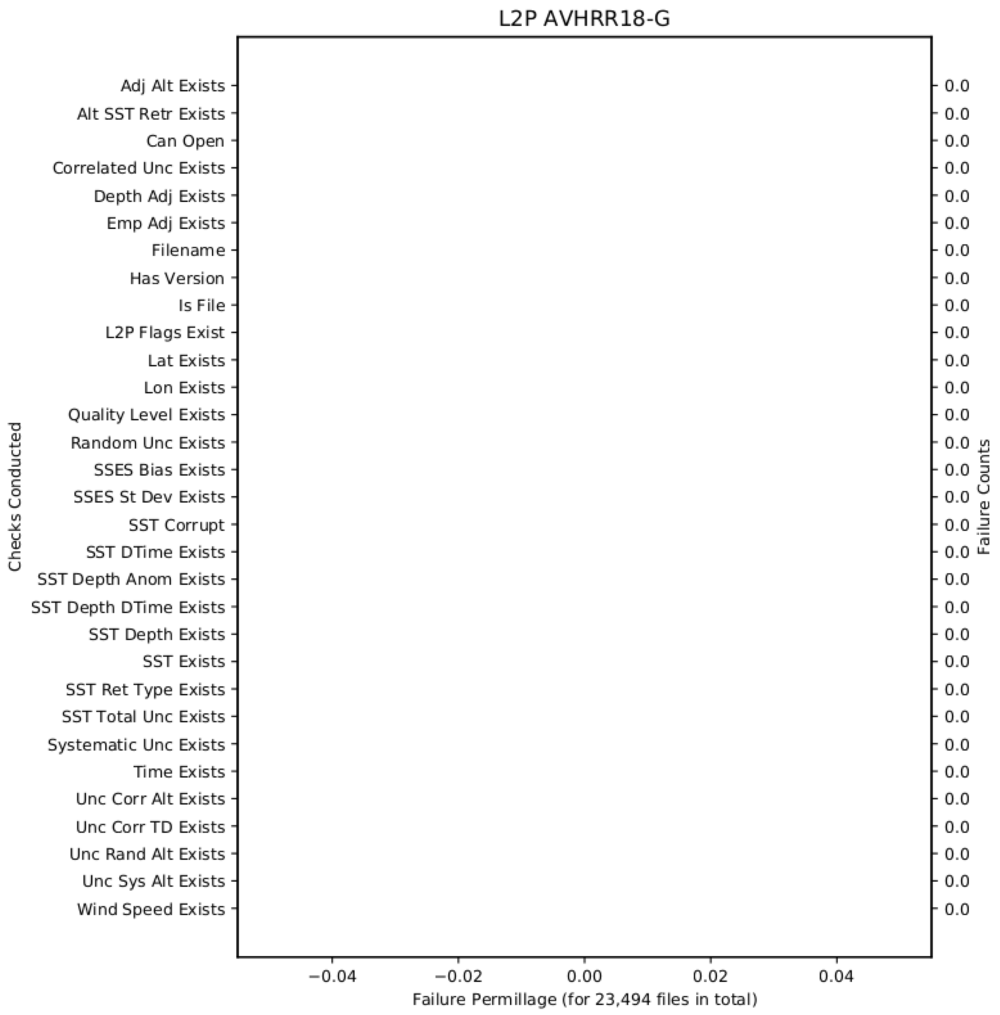

Figure 4-23: Results of L2P product checks for AVHRR18 GAC

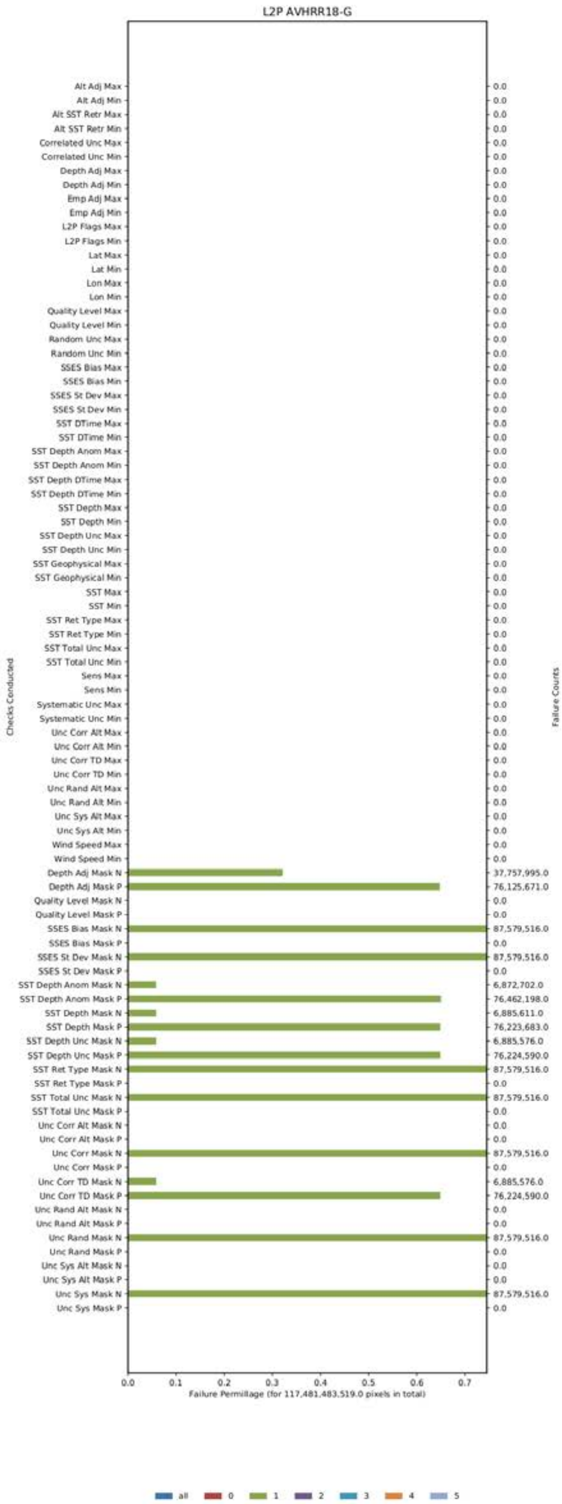

Figure 4-24: Results of L2P pixel checks for AVHRR18 GAC

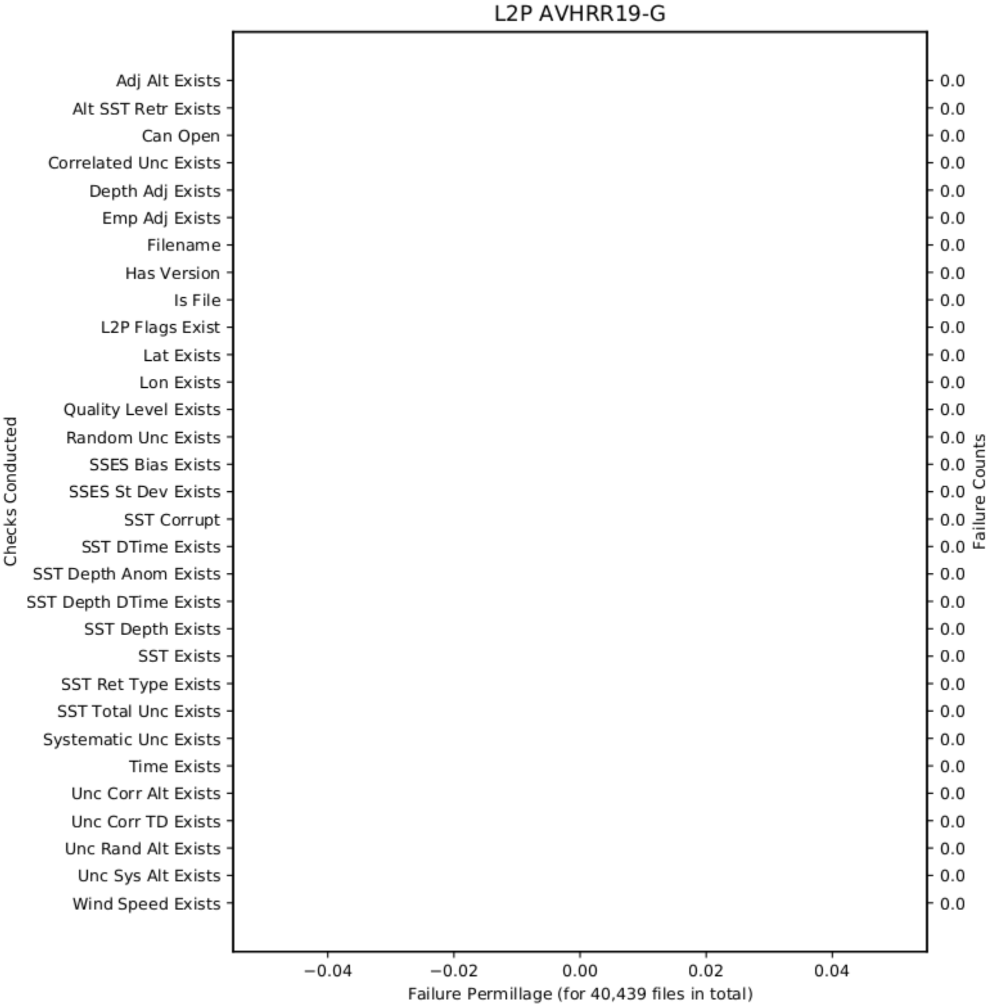

Figure 4-25: Results of L2P product checks for AVHRR19 GAC

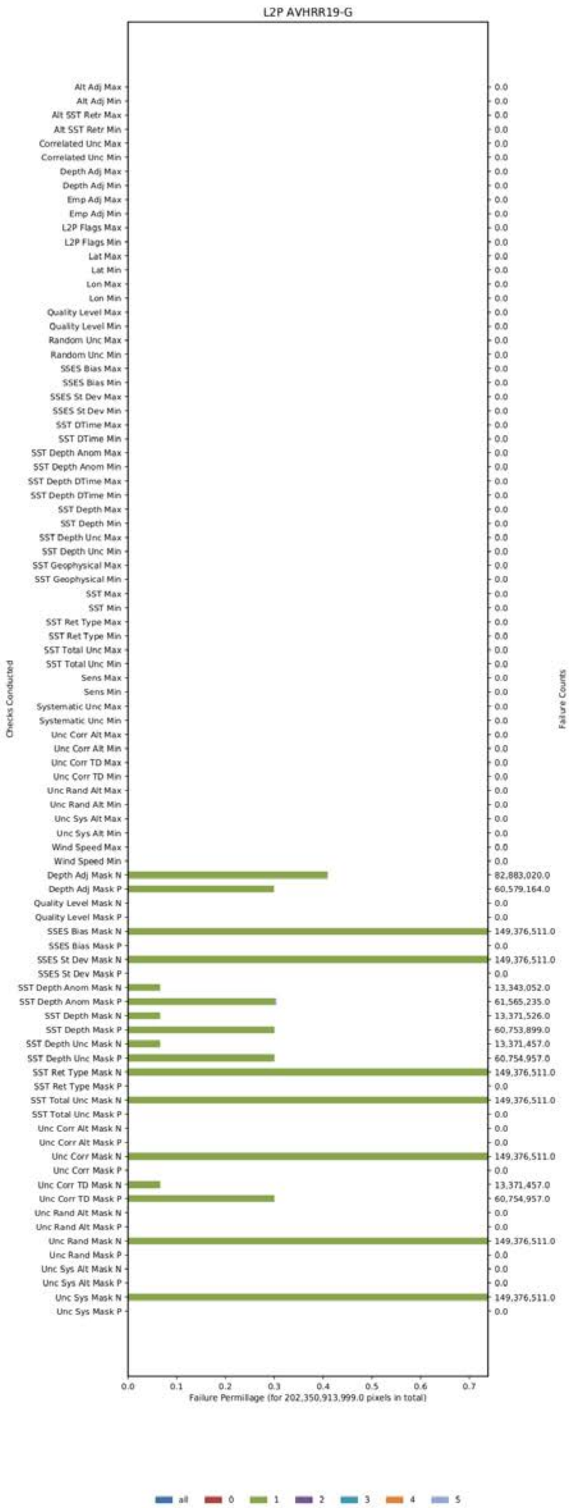

Figure 4-26: Results of L2P pixel checks for AVHRR19 GAC

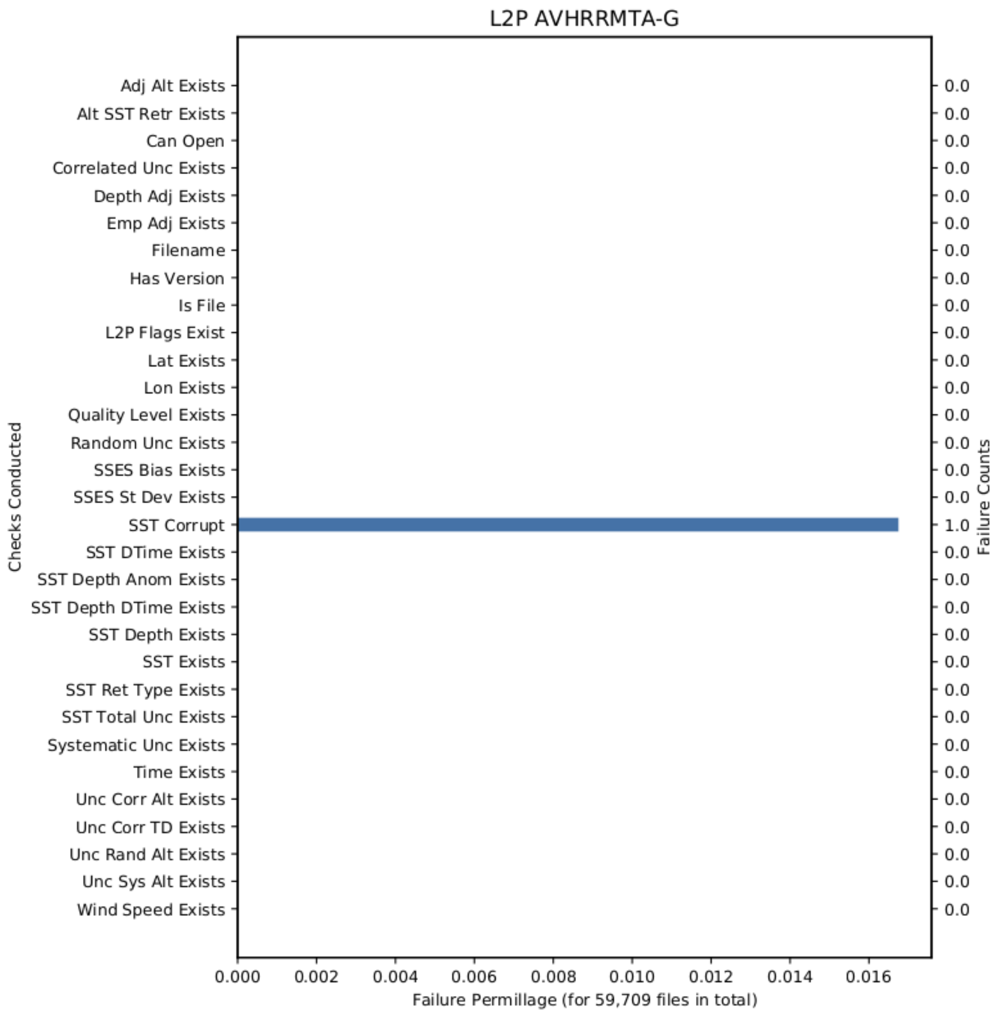

Figure 4-27: Results of L2P product checks for AVHRR MetOp-A GAC

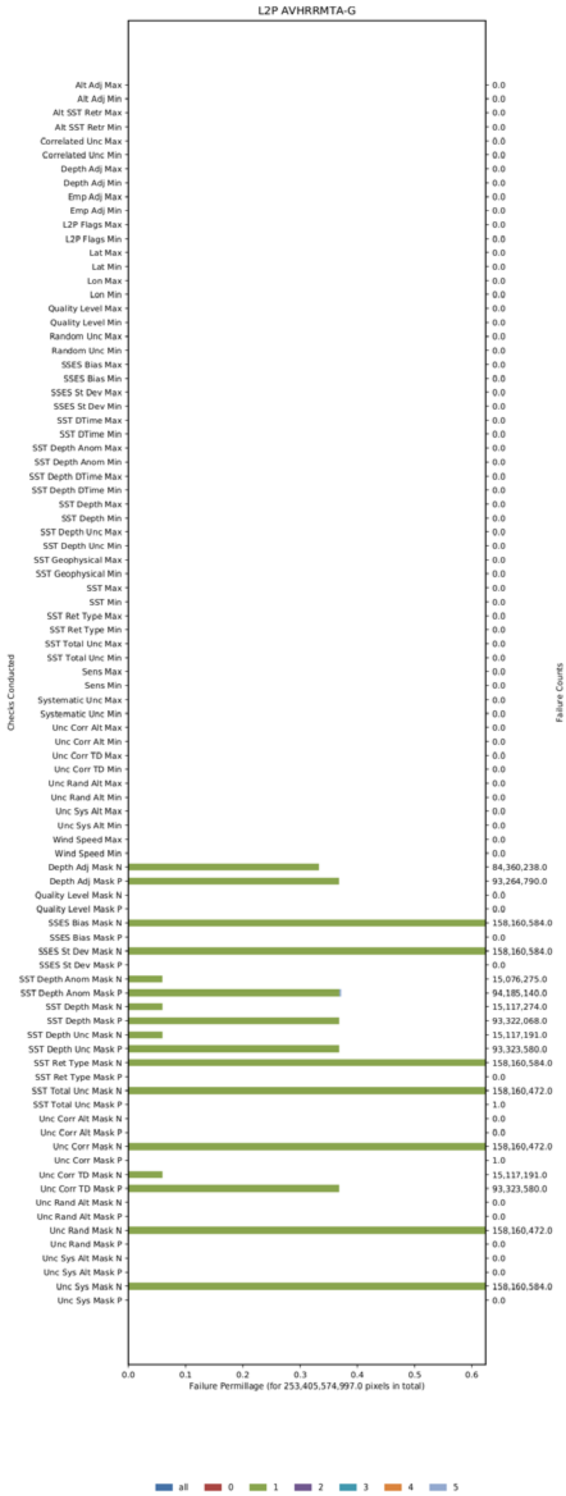

Figure 4-28: Results of L2P pixel checks for AVHRR MetOp-A GAC

4.1.2 Sample verification

A sample of L2P files consisting of one early and one late product from each of the (A)ATSR and AVHRR sensor periods, selected at random, were verified by manual inspection of the data fields. One randomly selected product of these files was also used for the verification of all metadata against the Product Specification Document (PSD) [AD.2]. The files manually inspected are detailed in Table 4-1 below, the file used for metadata verification is marked in boldface.

The metadata verification against the product specification included both global and variable attributes. A few discrepancies found between the file content and the product specification, which are listed in Table 4-3 further below.

The manual inspection of the data fields within the L2P file sample included the following checks:

- Applying a map-projection to the data and verify that the bounding geometry covers the expected orbit geometry
- Plotting sea_surface_temperature data and checking data coverage and histogram
- Plotting sea_surface_temperature_depth data and checking data coverage and histogram
- Plotting sea_surface_temperature_depth_anomaly data and checking data coverage and histogram
- Plotting sst_dtime data and checking data coverage and histogram
- Plotting sst_depth_dtime data and checking data coverage and histogram
- Plotting sses_bias and checking data coverage and histogram (bias always equal to zero)
- Plotting sses_standard_deviation and checking data coverage and histogram
- Plotting sst_total_uncertainty and checking data coverage and histogram
- Plotting sst_depth_total_uncertainty and checking data coverage and histogram
- Plotting depth_adjustment and checking data coverage and histogram
- Plotting wind_speed data and checking data coverage and histogram
- Plotting l2p_flags and checking data coverage and histogram
- Plotting quality_level and checking data structure coverage and histogram
- Plotting large_scale_correlated_uncertainty and checking data coverage and histogram
- Plotting synoptically_correlated_uncertainty and checking data coverage and histogram
- Plotting uncorrelated_uncertainty and checking data coverage and histogram
- Plotting adjustment_uncertainty and checking data coverage and histogram
- Plotting aerosol_dynamic_indicator and checking data coverage and histogram
- Plotting probability_clear and checking data coverage and histogram
- Plotting sensitivity and checking data coverage and histogram

File #1 contained some patches in sea_surface_temperature, sea_surface_temperature_depth, sea_surface_temperature_depth_anomaly variables (see Figure 4-29 below).

Figure 4-29: Patches in ATSR1 SST data

These artefacts could be identified as results of a retrieval type switch from D3 to D2 that was not applied to the atmospheric correction smoothing. The problem is understood and will be corrected in the next version of the CDR, an issue tracker item was created.

During this manual inspection, no further artefacts that could be hints for erroneous processing settings could be detected.

The issue of extremely high SST and SST_depth values for some products that was reported in the last version of the SVR could be resolved by the production team and does not occur anymore.

A comparison was also made between the square root of the sum of the squares of the uncertainty values and total uncertainty provided in the file. In the L2P products, the total uncertainty standard deviation is given with a precision of about 0.005 K, whereas for all other uncertainties the precision is about 0.0001 K. Propagating these numbers gives an expected accuracy of about 0.0011 for the difference in sea surface temperature total uncertainties and of about 0.0011 for the difference in sea surface temperature depth total uncertainty. In the files checked manually the differences found (see

Table 4-2) are in excellent agreement with the expected accuracies.

Table 4-1: Files verified manually for data content. The filename listed in boldface was used for the verification of the complete metadata.

Sensor	Filename	File number
ATSR1	19911208201847-ESACCI-L2P_GHRSST-SSTskin-ATSR1-CDR2.1-v02.0-fv01.0.nc	1
ATSR1	19960103131202-ESACCI-L2P_GHRSST-SSTskin-ATSR1-CDR2.1-v02.0-fv01.0	2
ATSR2	19960803052624-ESACCI-L2P_GHRSST-SSTskin-ATSR2-CDR2.1-v02.0-fv01.0	3
ATSR2	20021205193235-ESACCI-L2P_GHRSST-SSTskin-ATSR2-CDR2.1-v02.0-fv01.0	4
AATSR	20021106155431-ESACCI-L2P_GHRSST-SSTskin-AATSR-CDR2.1-v02.0-fv01.0	5
AATSR	20110322070627-ESACCI-L2P_GHRSST-SSTskin-AATSR-CDR2.1-v02.0-fv01.0	6
AVHRR 07	19811019114956-ESACCI-L2P_GHRSST-SSTskin-AVHRR07_G-CDR2.1-v02.0-fv01.0	7
AVHRR 07	19850124150917-ESACCI-L2P_GHRSST-SSTskin-AVHRR07_G-CDR2.1-v02.0-fv01.0	8
AVHRR 09	19860601203817-ESACCI-L2P_GHRSST-SSTskin-AVHRR09_G-CDR2.1-v02.0-fv01.0	9
AVHRR 09	19920102213545-ESACCI-L2P_GHRSST-SSTskin-AVHRR09_G-CDR2.1-v02.0-fv01.0	10
AVHRR 11	19890314212728-ESACCI-L2P_GHRSST-SSTskin-AVHRR11_G-CDR2.1-v02.0-fv01.0	11
AVHRR 11	19930919014902-ESACCI-L2P_GHRSST-SSTskin-AVHRR11_G-CDR2.1-v02.0-fv01.0	12
AVHRR 12	19911103053320-ESACCI-L2P_GHRSST-SSTskin-AVHRR12_G-CDR2.1-v02.0-fv01.0	13
AVHRR 12	19971113094448-ESACCI-L2P_GHRSST-SSTskin-AVHRR12_G-CDR2.1-v02.0-fv01.0	14
AVHRR 14	19960418112501-ESACCI-L2P_GHRSST-SSTskin-AVHRR14_G-CDR2.1-v02.0-fv01.0	15
AVHRR 14	19990726132025-ESACCI-L2P_GHRSST-SSTskin-AVHRR14_G-CDR2.1-v02.0-fv01.0	16
AVHRR 15	19990208193933-ESACCI-L2P_GHRSST-SSTskin-AVHRR15_G-CDR2.1-v02.0-fv01.0	17
AVHRR 15	20081226203159-ESACCI-L2P_GHRSST-SSTskin-AVHRR15_G-CDR2.1-v02.0-fv01.0	18

Sensor	Filename	File number
AVHRR 16	20030729003226-ESACCI-L2P_GHRSST-SSTskin-AVHRR16_G-CDR2.1-v02.0-fv01.0.nc	19
AVHRR 16	20060704105707-ESACCI-L2P_GHRSST-SSTskin-AVHRR16_G-CDR2.1-v02.0-fv01.0.nc	20
AVHRR 17	20021011072352-ESACCI-L2P_GHRSST-SSTskin-AVHRR17_G-CDR2.1-v02.0-fv01.0.nc	21
AVHRR 17	20090119164419-ESACCI-L2P_GHRSST-SSTskin-AVHRR17_G-CDR2.1-v02.0-fv01.0.nc	22
AVHRR 18	20060612160853-ESACCI-L2P_GHRSST-SSTskin-AVHRR18_G-CDR2.1-v02.0-fv01.0.nc	23
AVHRR 18	20091002174612-ESACCI-L2P_GHRSST-SSTskin-AVHRR18_G-CDR2.1-v02.0-fv01.0.nc	24
AVHRR 19	20100318225612-ESACCI-L2P_GHRSST-SSTskin-AVHRR19_G-CDR2.1-v02.0-fv01.0.nc	25
AVHRR 19	**20151105010653-ESACCI-L2P_GHRSST-SSTskin-AVHRR19_G-CDR2.1-v02.0-fv01.0.nc**	**26**
AVHRR-MTA	20061215033727-ESACCI-L2P_GHRSST-SSTskin-AVHRRMTA_G-CDR2.1-v02.0-fv01.0.nc	27
AVHRR-MTA	20160927143904-ESACCI-L2P_GHRSST-SSTskin-AVHRRMTA_G-CDR2.1-v02.0-fv01.0.nc	28

Table 4-2: Differences between total uncertainties absolute min and max values and mean value provided in the L2P product and the total uncertainty calculated by combining individual uncertainty components

File num.	Min SST Uncert delta	Max SST Uncert. delta	Mean SST Uncert. delta	Min SST_depth Uncert delta	Max SST_depth Uncert. delta	Mean SST_depth Uncert. delta	Num Pixels
1	0.0	9.78e-4	2.84e-4	0.0	9.93e-4	2.74e-4	1699397
2	0.0	9.84e-4	2.76e-4	0.0	0.001	2.84e-4	1949187
3	0.0	0.0011	3.05e-4	0.0	0.0012	3.06e-4	2267027
4	0.0	0.0011	3.1e-4	0.0	0.0012	3.1e-4	2062666
5	0.0	0.0011	2.93e-4	0.0	0.0012	3.07e-4	2032555
6	0.0	0.001	3.11e-4	0.0	0.0012	3.12e-4	623464
7	0.0	0.001	2.87e-4	0.0	0.0011	2.89e-4	399154
8	0.0	0.001	3.03e-4	0.0	0.0011	3.06e-4	242012
9	0.0	0.0011	3.11e-4	0.0	0.0011	3.12e-4	680979
10	0.0	0.0011	3.1e-4	0.0	0.0011	3.13e-4	301450
11	0.0	0.0011	3.09e-4	0.0	0.0011	3.11e-4	897466
12	0.0	0.0011	3.15e-4	0.0	0.0012	3.16e-4	586152

13	0.0	0.001	3.04e-4	0.0	0.0011	3.07e-4	416537
14	0.0	0.0011	3.16e-4	0.0	0.0012	3.17e-4	515719
15	0.0	0.0011	3.16e-4	0.0	0.0012	3.16e-4	433692
16	0.0	0.0011	3.14e-4	0.0	0.0012	3.17e-4	527225
17	0.0	0.001	3.1e-4	0.0	0.0011	3.11e-4	1070112
18	0.0	0.001	3.21e-4	0.0	0.0011	3.22e-4	377567
19	0.0	0.0011	3.29e-4	0.0	0.0012	3.27e-4	804529
20	0.0	0.0011	3.29e-4	0.0	0.0012	3.25e-4	623625
21	0.0	0.0011	3.28e-4	0.0	0.0011	3.28e-4	608546
22	0.0	0.0011	3.31e-4	0.0	0.0012	3.32e-4	660148
23	0.0	0.0011	3.3e-4	0.0	0.0012	3.26e-4	412039
24	0.0	0.0011	3.25e-4	0.0	0.0012	3.28e-4	431504
25	0.0	0.0011	3.26e-4	0.0	0.0011	3.28e-4	504674
26	0.0	0.0011	3.25e-4	0.0	0.0012	3.27e-4	716463
27	0.0	0.001	3.23e-4	0.0	0.0011	3.25e-4	643960
28	0.0	0.0011	3.25e-4	0.0	0.0011	3.26e-4	406887

4.1.2.1 Meta Data Issues

Table 4-3: Discrepancies between L2P metadata and the PSD. Shaded cells indicate true discrepancies, while the non-shaded cells indicate where the PSD is mistaken

Variable name or *global*	**Attribute or property**	**File content**	**Product specification**
Global	geospatial_vertical _max	-1.0E-5	-10^{-6} or -0.001 or -0.2 (update PSD)
Global	keywords	Attribute name starts with a small "k"	Attribute name starts with a capital "K" (update table 14)
Global	license	Creative Commons Licence by attribution (http://creativecommons.org/licenses/by/4.0/)	GHRSST protocol describes data use as free and open (update PSD)
Global	platform	Attribute name starts with a small "p"	Attribute name starts with a capital "P" (update table 14)
Global	sensor	Attribute name starts with a small "s"	Attribute name starts with a capital "S" (update table 14)
Global	source_file	The data source file	Missing (update PSD)

Variable name or *global*	Attribute or property	File content	Product specification
lat	standard_name	latitude	Latitude (update PSD)
lat	least_significant_digit	0.001	Not present (update PSD)
lon	standard_name	longitude	Longitude (update PSD)
lon	least_significant_digit	0.001	Not present (update PSD)
time	standard_name	time	Time (update PSD)
sea_surface_temperature	units	kelvin	Kelvin (update PSD)
sst_dtime	units	seconds	Seconds (update PSD)
sses_bias	units	kelvin	Kelvin (update PSD)
sses_standard_deviation	units	kelvin	Kelvin (update PSD)
l2p_flags	valid_max	511	255 (update PSD)
l2p_flags	flag_meanings	microwave land ice lake river spare views channels day	microwave land ice lake river spare views channels aerosol (update PSD)
quality_level	_FillValue	0	-128 (update PSD)
sea_surface_temperature_retrieval_type	flag_meanings	n.a.	Rename attribute from retrieval_type_meanings to flag_meanings (update PSD)
sea_surface_temperature_retrieval_type	flag_values	n.a.	Rename attribute from retrieval_type_values to flag_values (update PSD)
uncertainty_random	units	kelvin	Kelvin (update PSD)
uncertainty_correlated	units	kelvin	Kelvin (update PSD)
uncertainty_systematic	units	kelvin	Kelvin (update PSD)
sea_surface_temperature_total_uncertainty	units	kelvin	Kelvin (update PSD)
depth_adjustment	units	kelvin	Kelvin (update PSD)
depth_adjustment	standard_name	None	Remove attribute from PSD
depth_adjustment	source	None	Remove attribute from PSD
depth_adjustment	references	None	Remove attribute from PSD
uncertainty_correlated_depth_adjustment	None	None	Remove variable from PSD

Variable name or *global*	Attribute or property	File content	Product specification
sea_surface_temperature_depth	units	kelvin	Kelvin (update PSD)
daymean_time	None	None	Remove variable from PSD
uncertainty_correlated_time_and_depth_adjustment	units	kelvin	Kelvin (update PSD)
sea_surface_temperature_depth_total_uncertainty	units	kelvin	Kelvin (update PSD)
sea_surface_temperature_depth_anomaly	units	kelvin	Kelvin (update PSD)
alt_sst_retrieval_type	flag_meanings	n.a.	Rename attribute from retrieval_type_meanings to flag_meanings (update PSD)
alt_sst_retrieval_type	flag_values	n.a.	Rename attribute from retrieval_type_values to flag_values (update PSD)
adjustment_alt	units	kelvin	Kelvin (update PSD)
adjustment_alt	standard_name	None	Remove attribute from PSD
adjustment_alt	source	None	Remove attribute from PSD
adjustment_alt	references	None	Remove attribute from PSD
sst_sensitivity	valid_max	1100	1000 (update PSD)
sst_sensitivity	units	K/K	Attribute missing (update PSD)
empirical_adjustment	units	kelvin	Kelvin (update PSD)
empirical_adjustment	standard_name	None	Remove attribute from PSD
empirical_adjustment	source	None	Remove attribute from PSD
empirical_adjustment	references	None	Remove attribute from PSD
sst_depth_dtime	Complete variable	Present	Missing (update PSD)

4.2 ARC CCI processor (L3U)

4.2.1 Content verification

Content verification checks have been carried out for all L3U products obtained from ATSR1, ATSR2, AATSR and AVHRR series of sensors. The results of the L3U product and pixel checks are represented in horizontal bar charts shown in Figure 4-30 to Figure 4-57 below.

For all bar charts the left vertical axis lists the names of the checks conducted as defined in Table 3-2, Table 3-2 and Table 3-4. The right vertical axis lists the number of occurrences where the check named on the left vertical axis has failed. For each check, a horizontal bar visualises the failure permillage (failure rate measured per thousand). If there is no bar drawn for a check, the check has been passed completely, without any failures. The number of product files (or pixels) checked in total is given in the label of the horizontal axis at the bottom.

The mask consistency tests defined in Table 3-3 are conducted per quality level. The results for these tests are visualised per quality level in form of a stacked bar. The total lengths of the stacked bar corresponds to the total permillage of failures for all quality levels. If the check does not distinguish between quality levels, the colour for “all” is used. The failure counts appearing on the right vertical axis also refer to the total number of failures.

In summary, the product checks have been passed without failures, except for ‘SST Corrupt’. The same significant improvement for the L2P data, stated in 4.1.1, applies to the L3U dataset.

The same masking issues detected during L2P quality assurance are present in the L3U data, see in chapter 4.1.1. for a detailed description.

There have been five ATSR1 L3U files marked as “can_open” failed which means that the QA software was not able to correctly read the complete NetCDF file. All five products have been manually checked with SNAP 7.0 and HdfView and found to be correctly formatted. It is supposed that this erroneous triggering of “can_open” may be caused by a short-time mounting issue on the JASMIN file system.

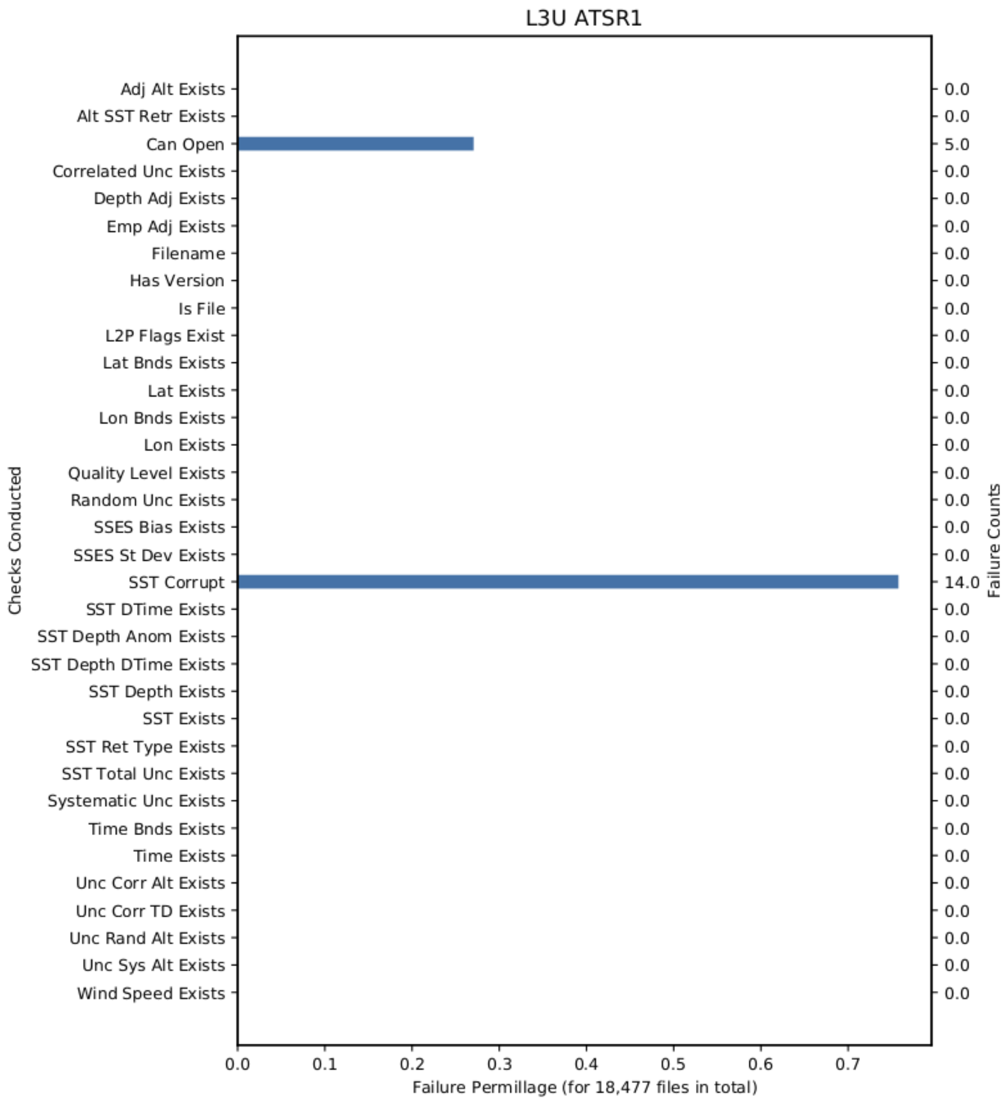

Figure 4-30: Results of L3U product checks for ATSR1

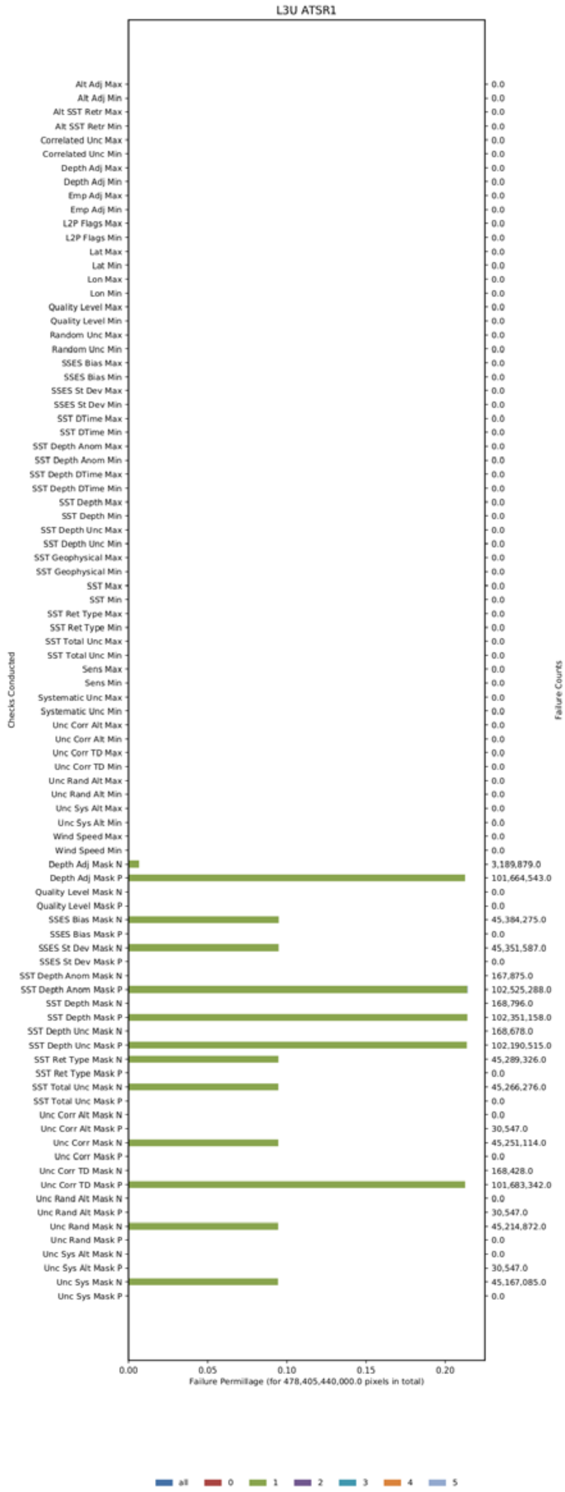

Figure 4-31: Results of L3U pixel checks for ATSR1

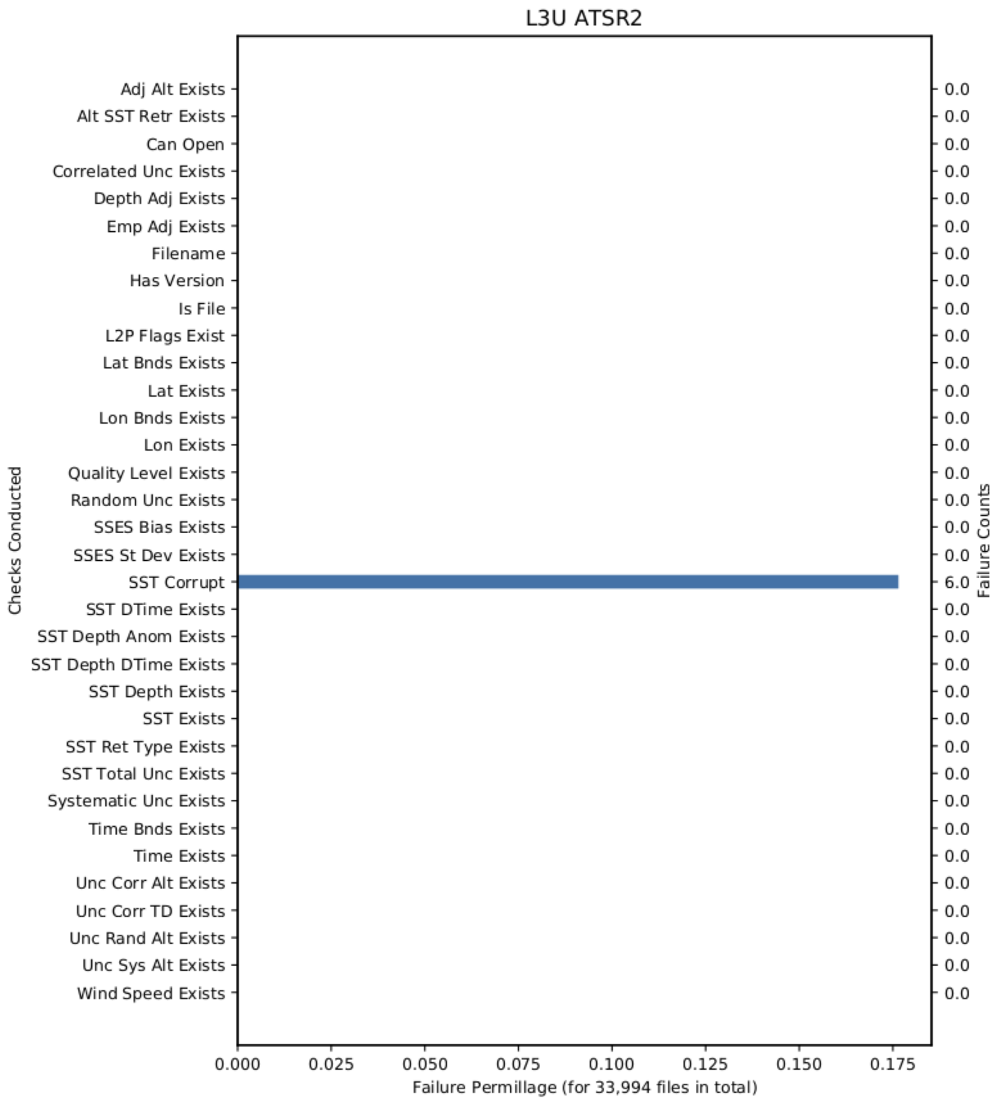

Figure 4-32: Summary of L3U product checks for ATSR2

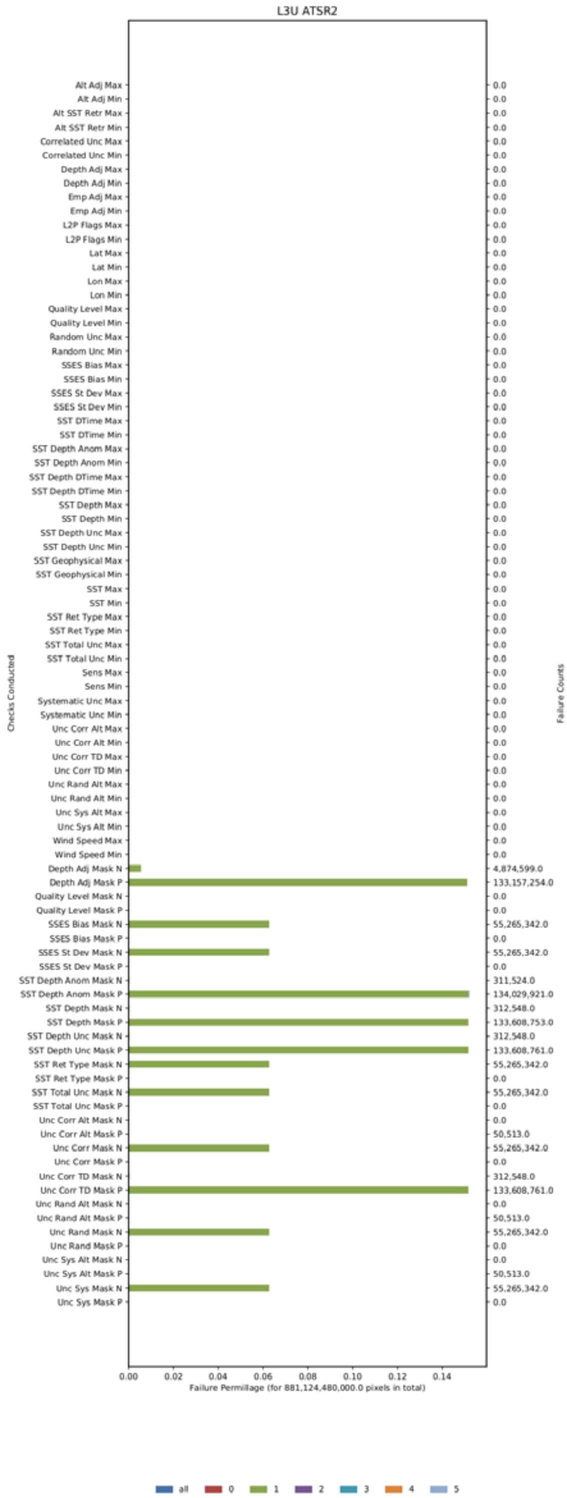

Figure 4-33: Results of L3U pixel checks for ATSR2

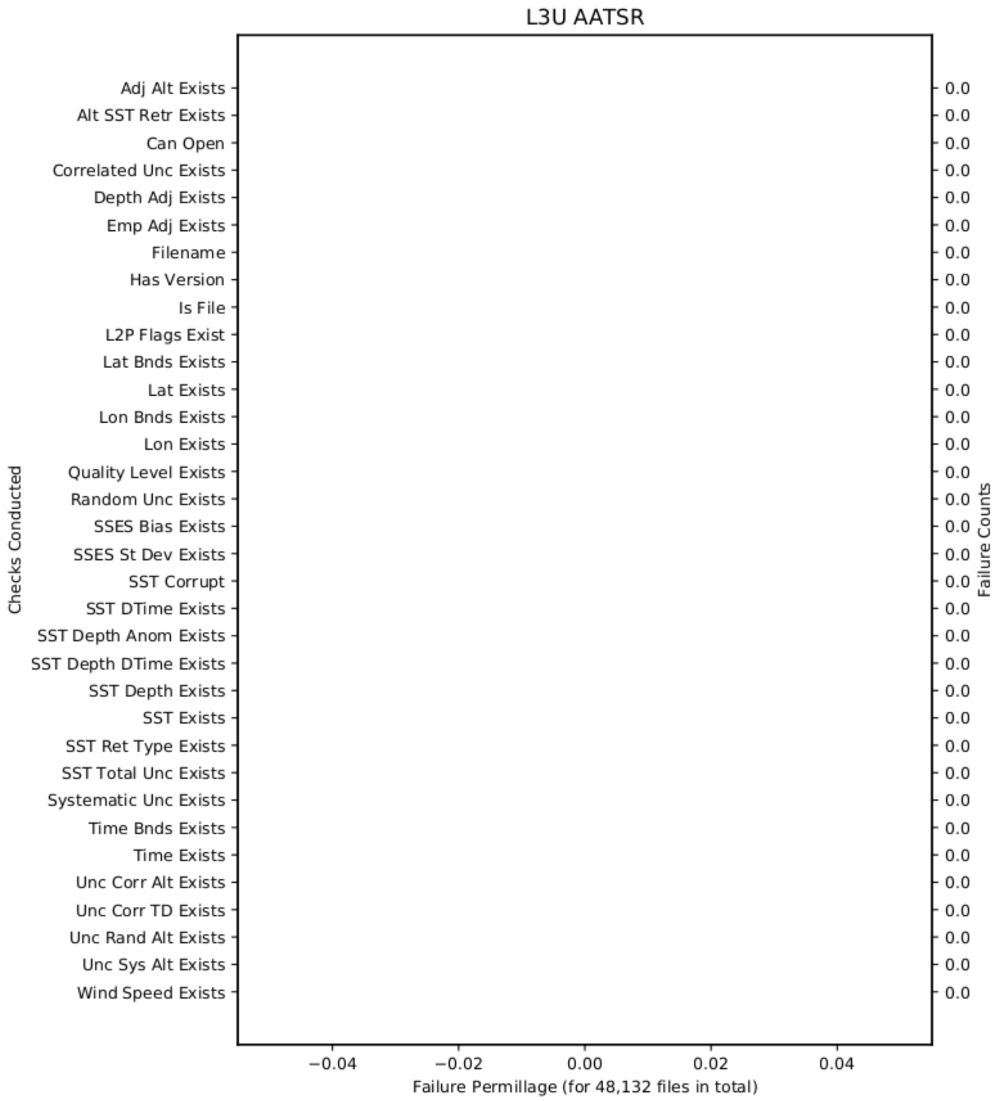

Figure 4-34: Summary of L3U product checks for AATSR

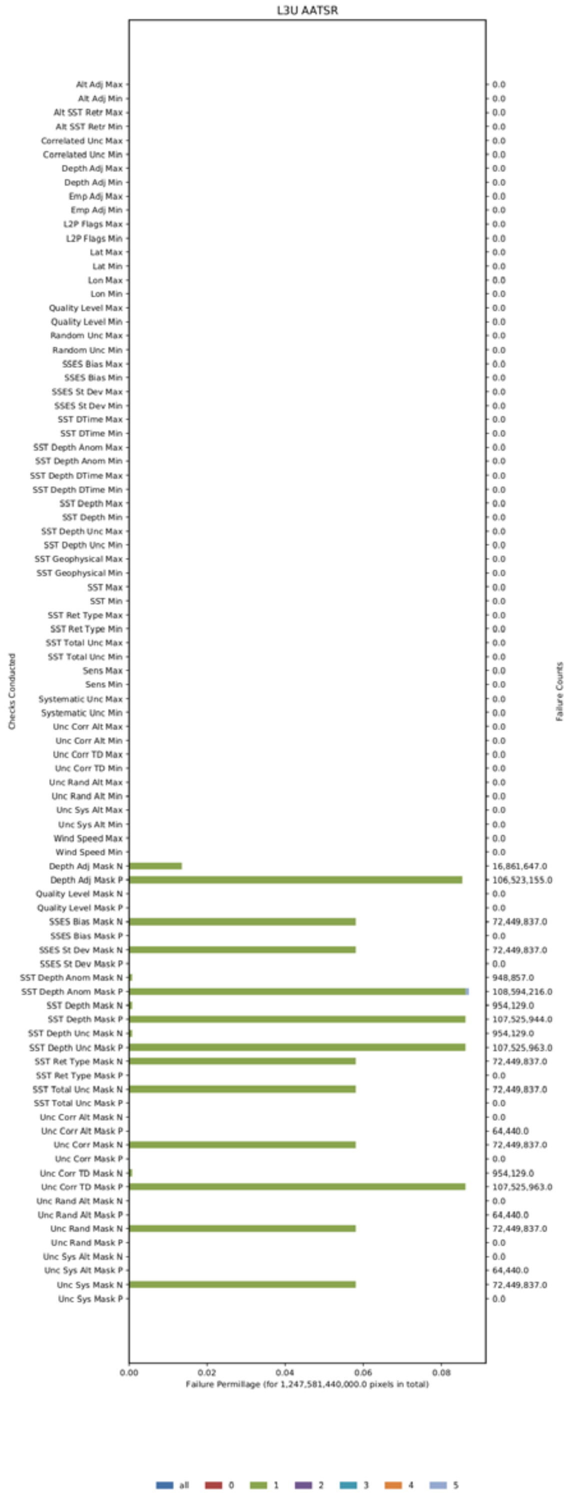

Figure 4-35: Results of L3U pixel checks for AATSR

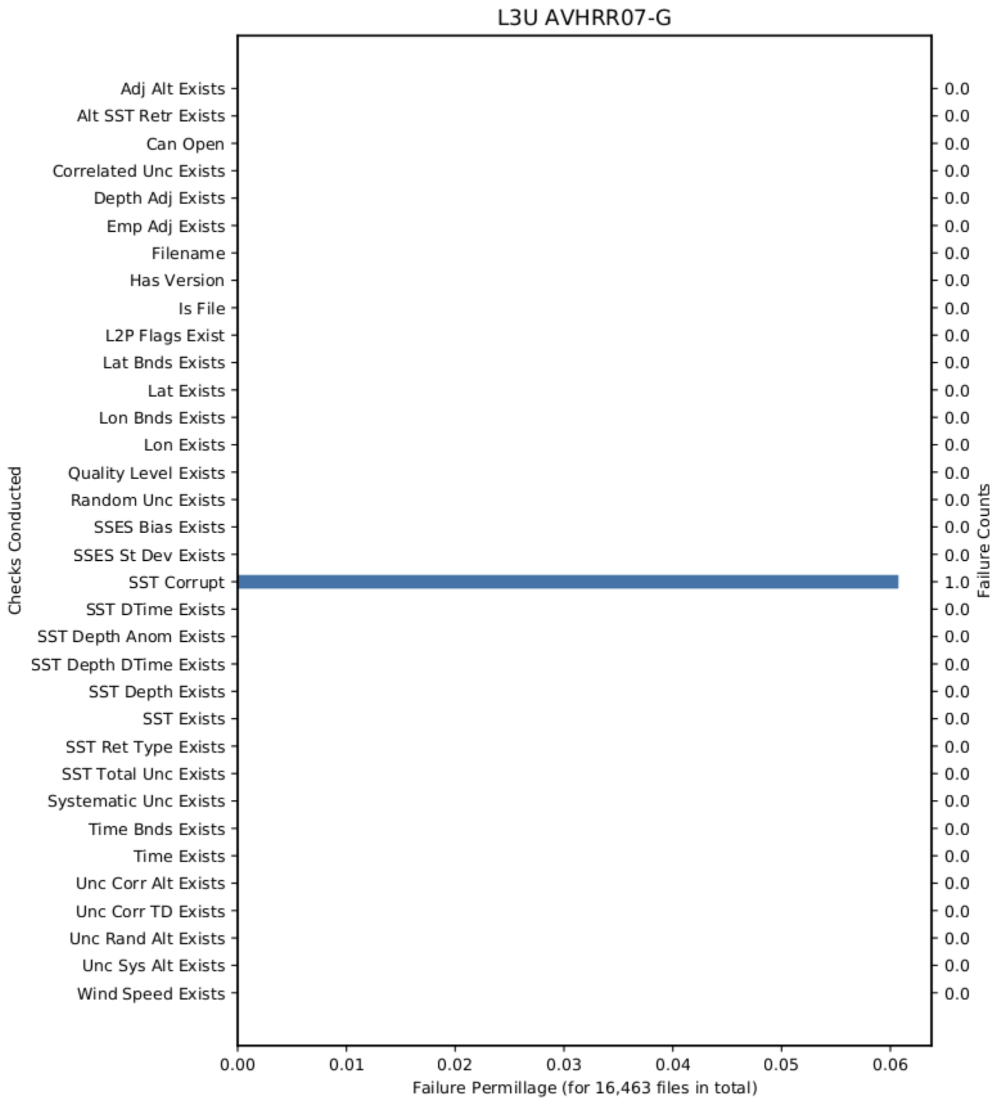

Figure 4-36: Summary of L3U product checks for AVHRR07_G

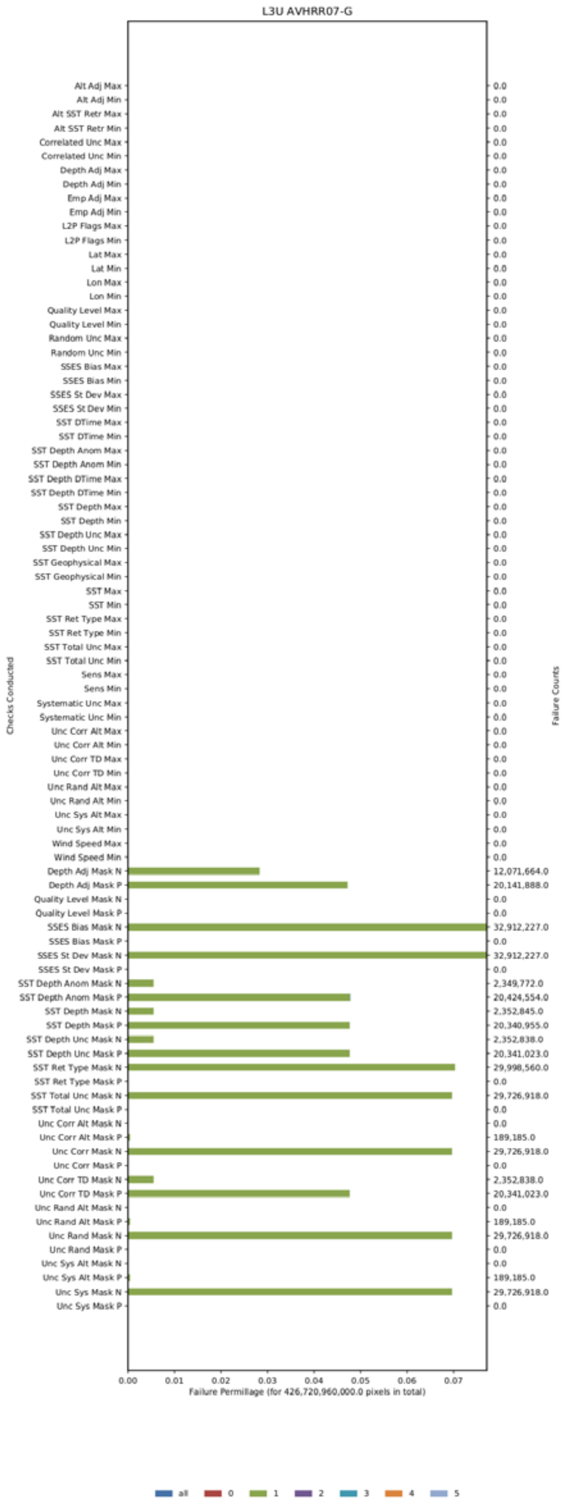

Figure 4-37: Results of L3U pixel checks for AVHRR07_G

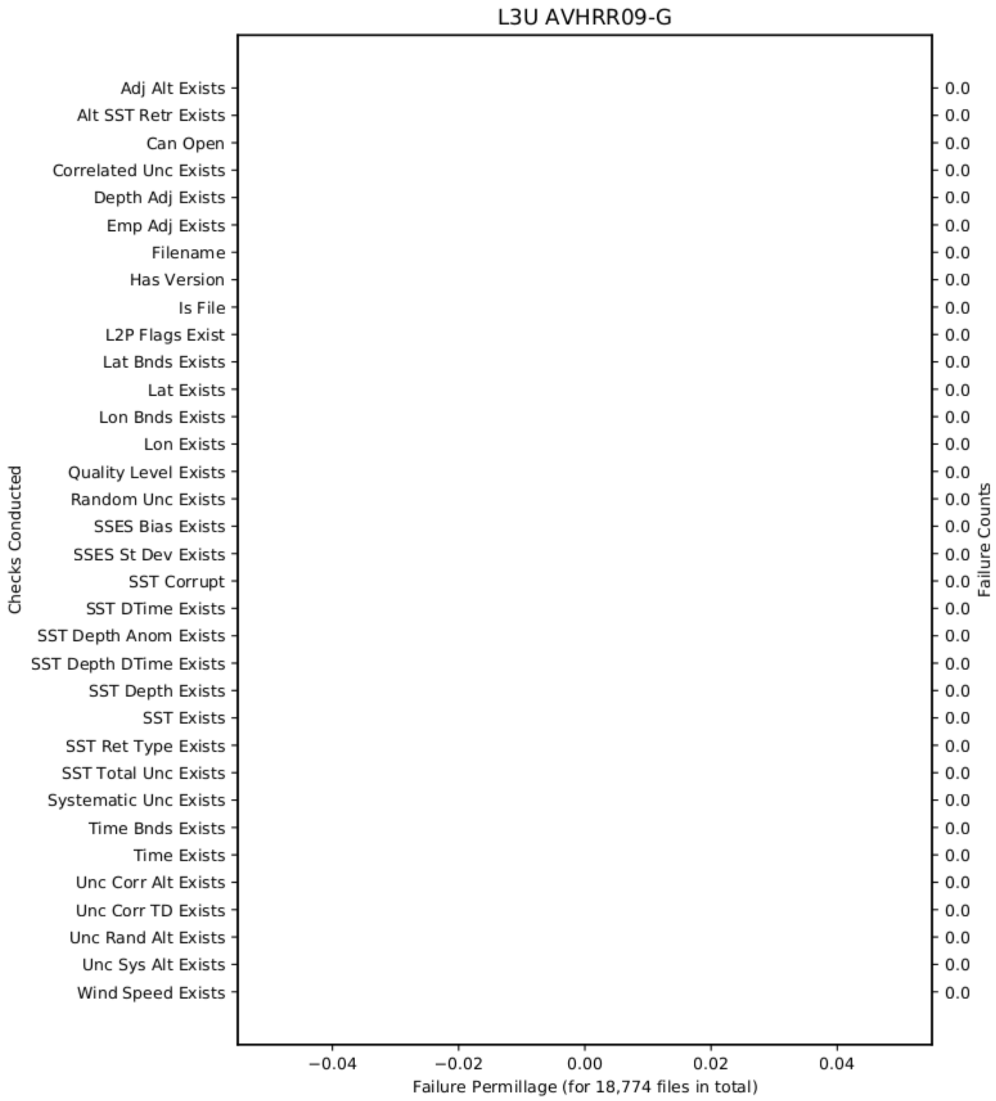

Figure 4-38: Summary of L3U product checks for AVHRR09_G

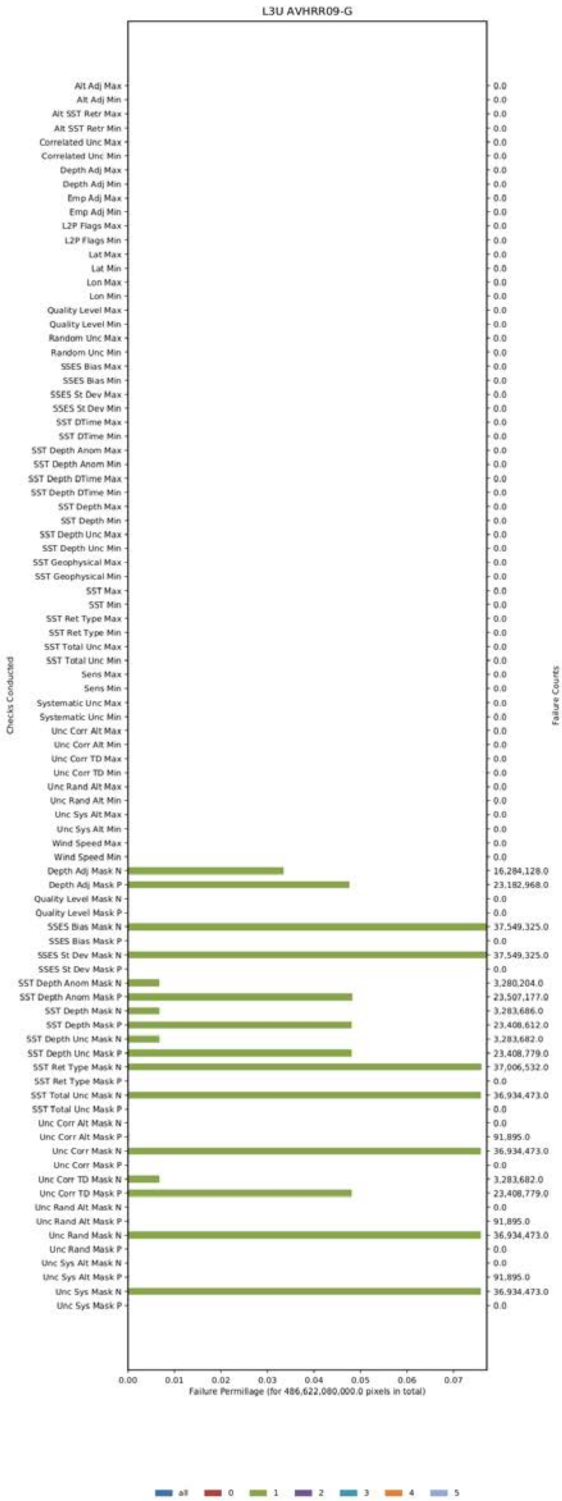

Figure 4-39: Results of L3U pixel checks for AVHRR09_G

Figure 4-40: Summary of L3U product checks for AVHRR11_G

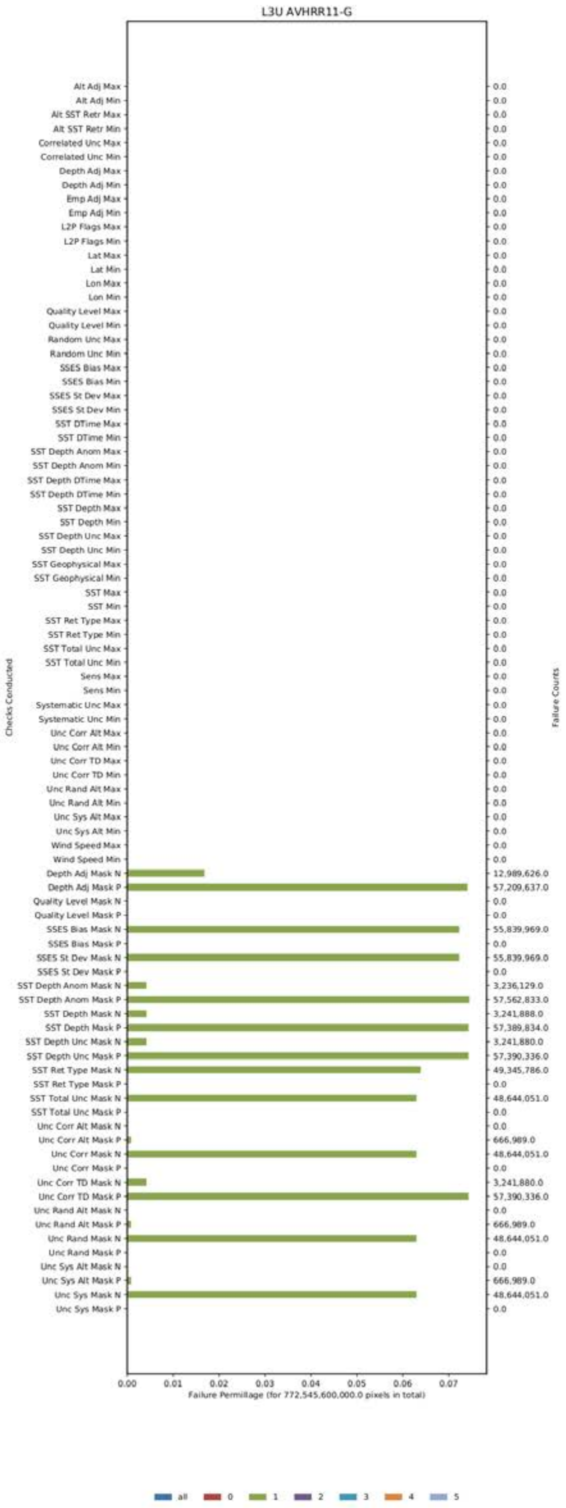

Figure 4-41: Results of L3U pixel checks for AVHRR11_G

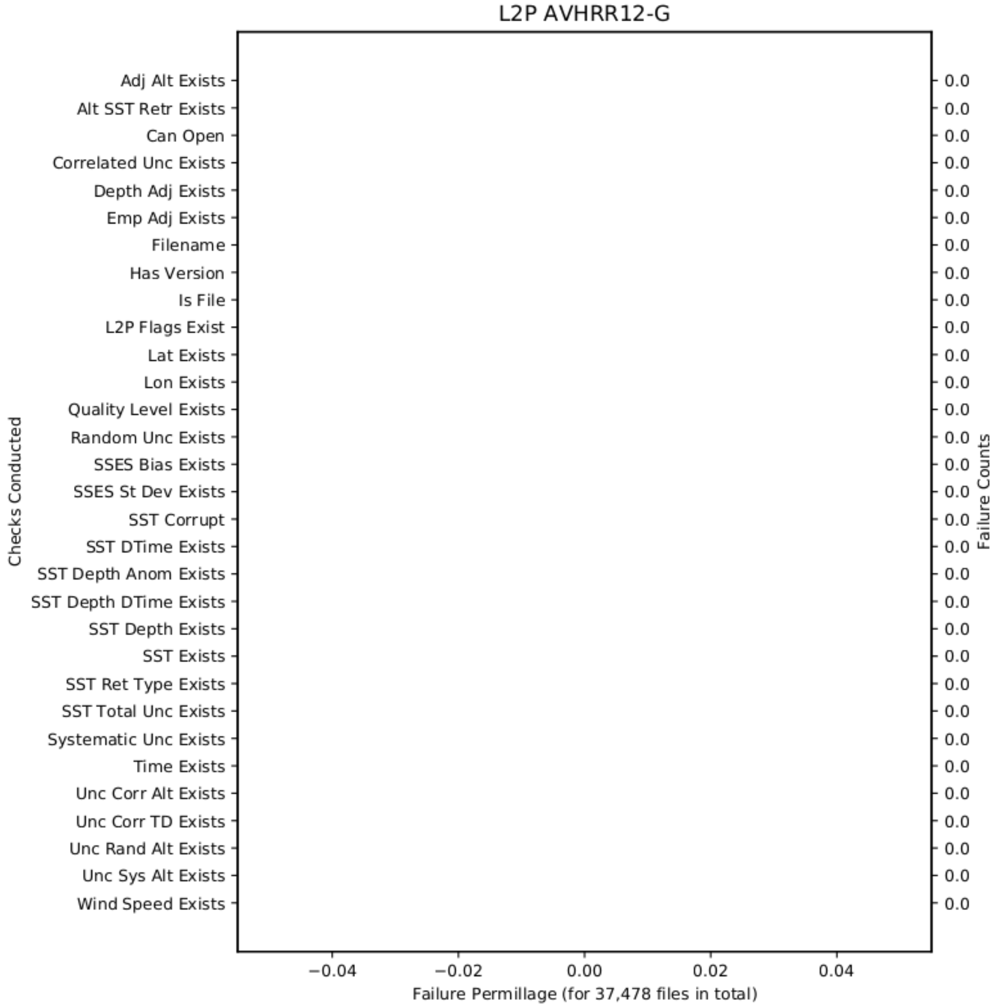

Figure 4-42: Summary of L3U product checks for AVHRR12_G

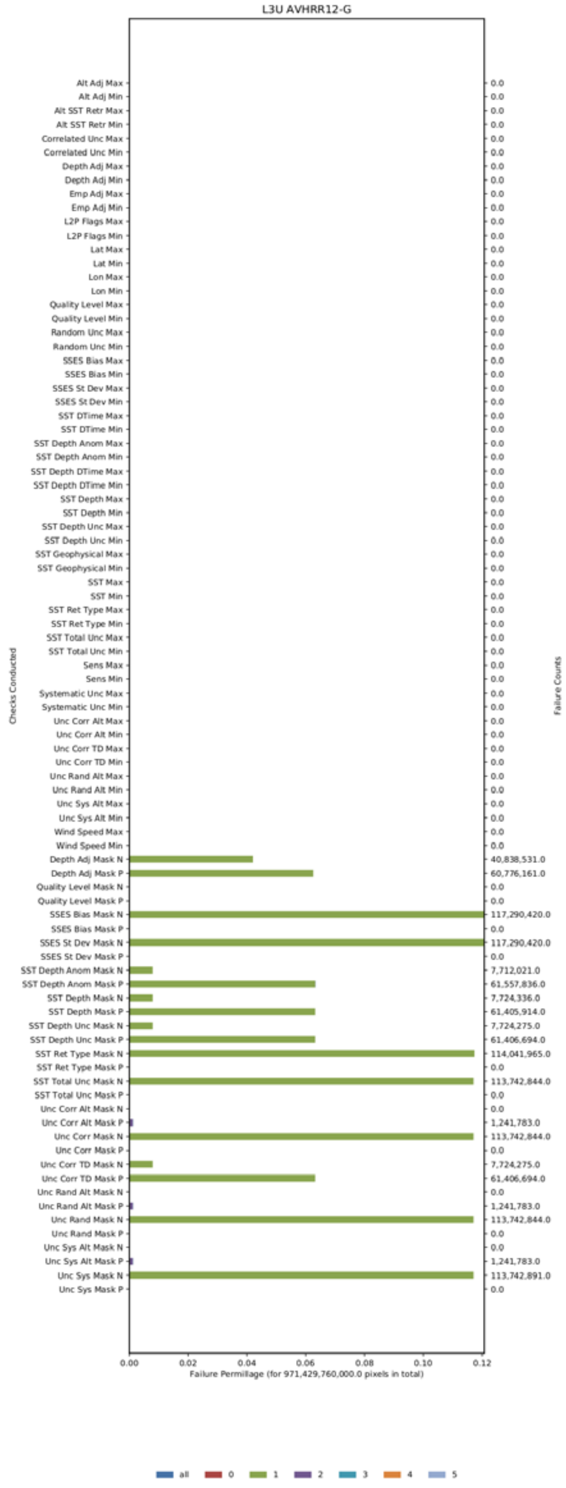

Figure 4-43: Results of L3U pixel checks for AVHRR12_G

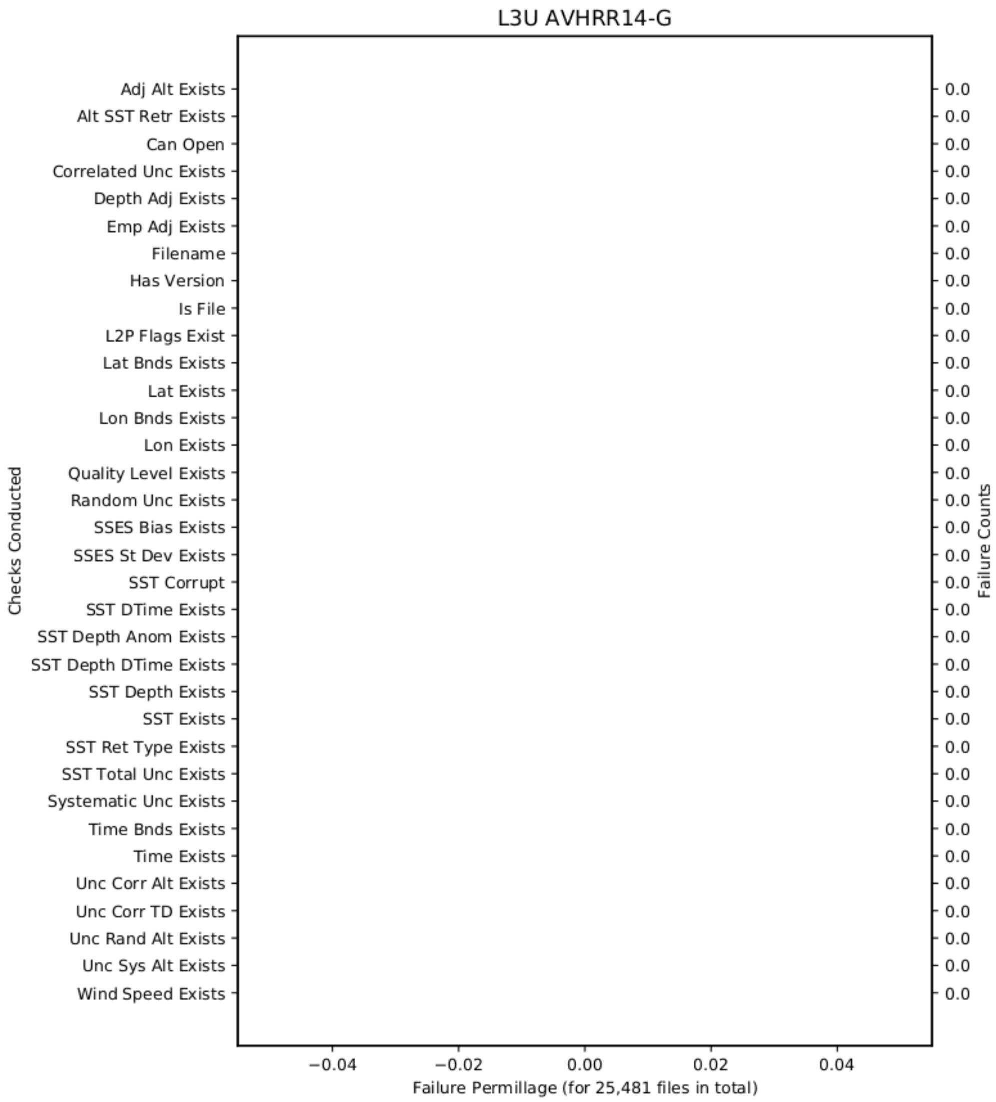

Figure 4-44: Summary of L3U product checks for AVHRR14_G

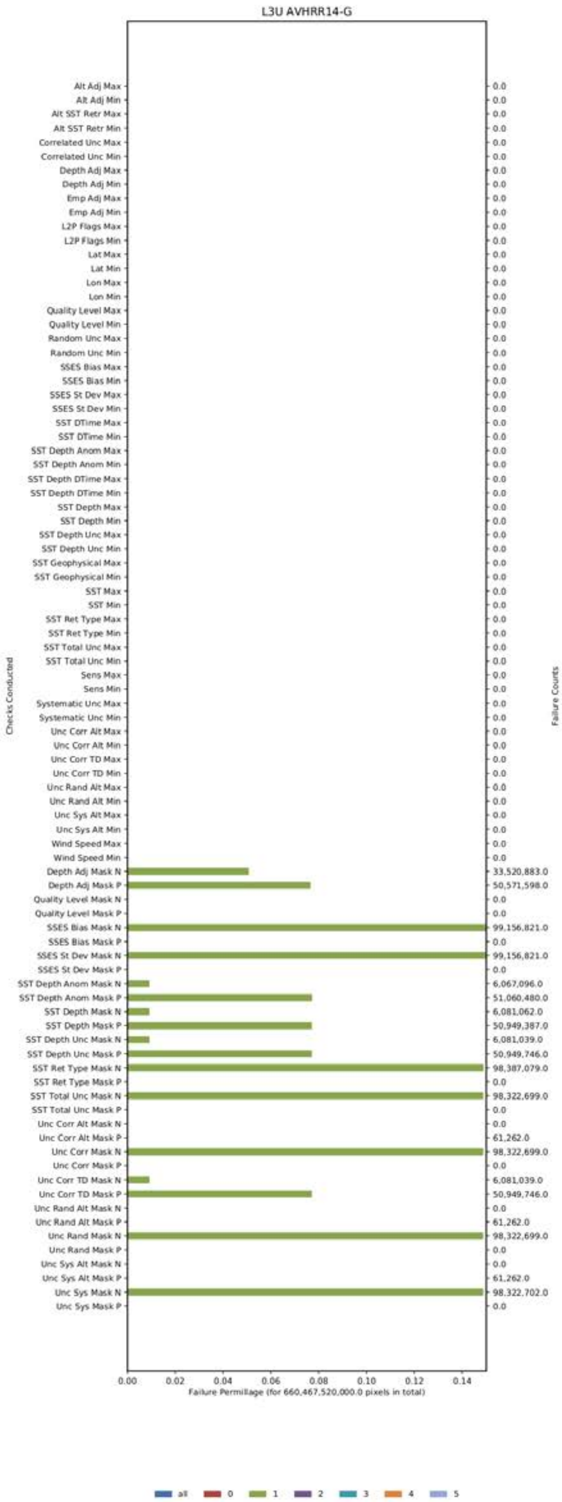

Figure 4-45: Results of L3U pixel checks for AVHRR14_G

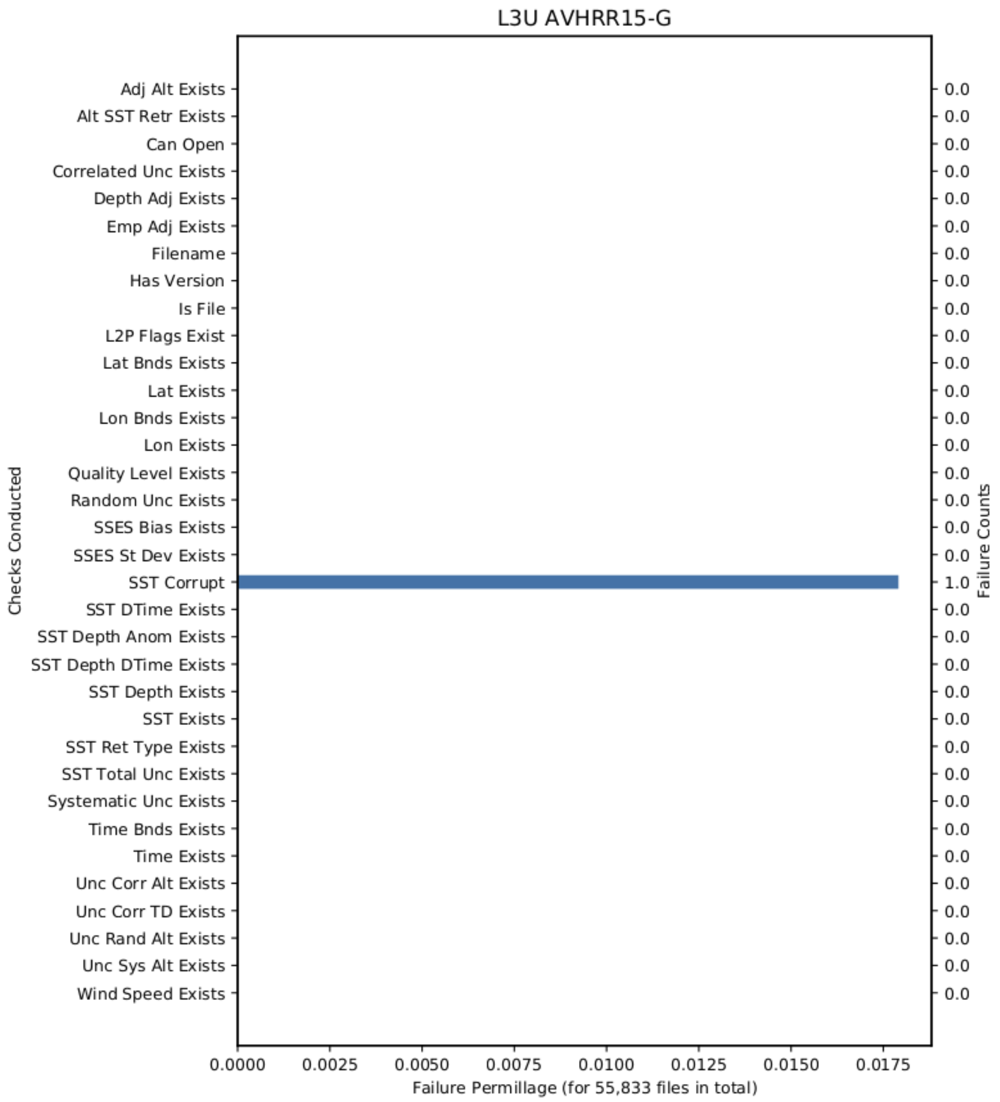

Figure 4-46: Summary of L3U product checks for AVHRR15_G

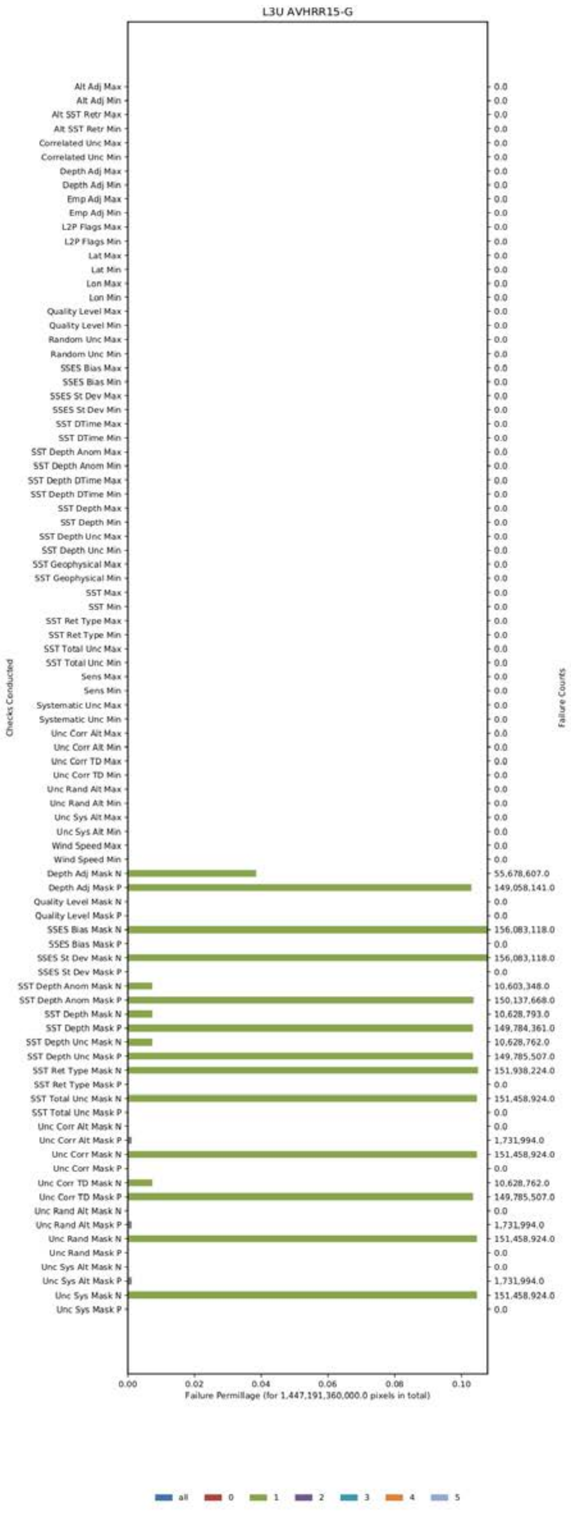

Figure 4-47: Results of L3U pixel checks for AVHRR15_G

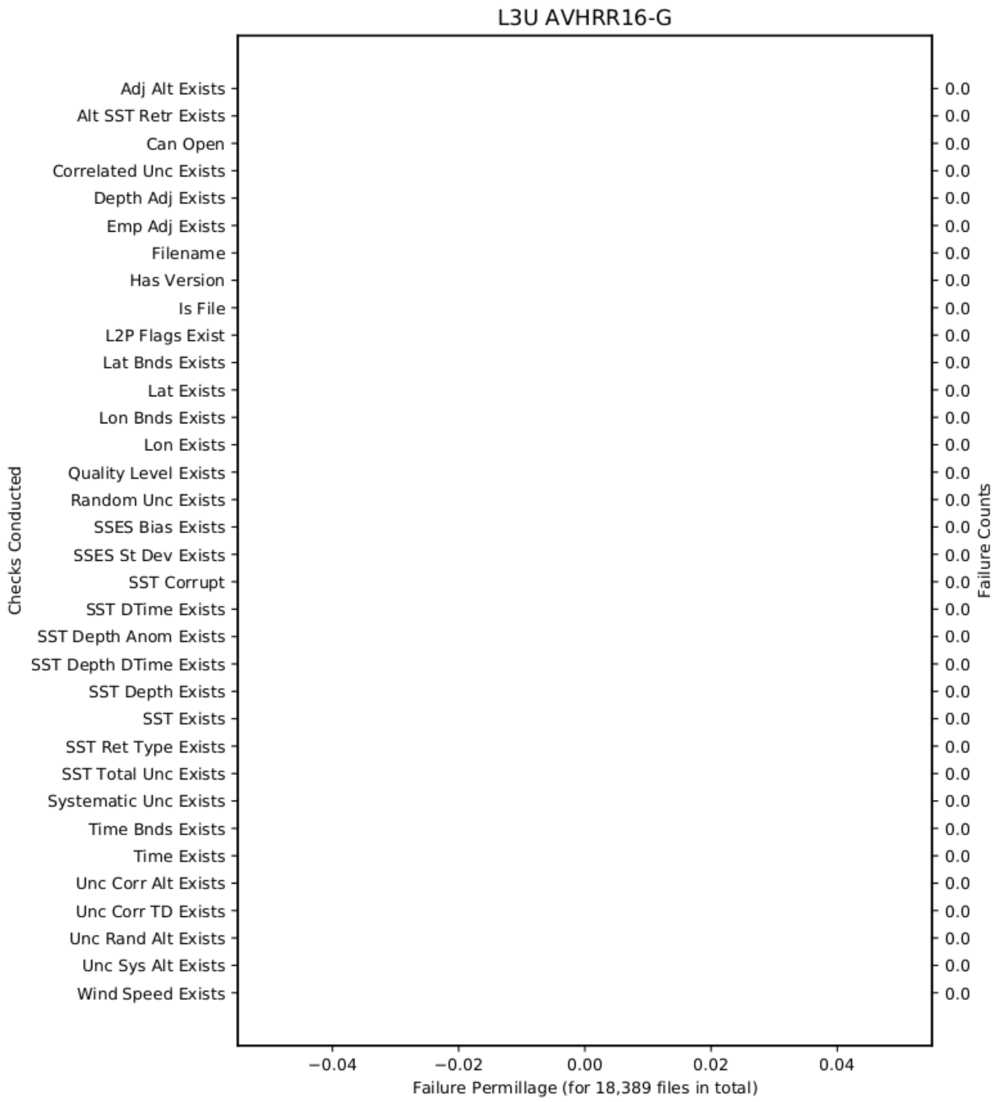

Figure 4-48: Summary of L3U product checks for AVHRR16_G

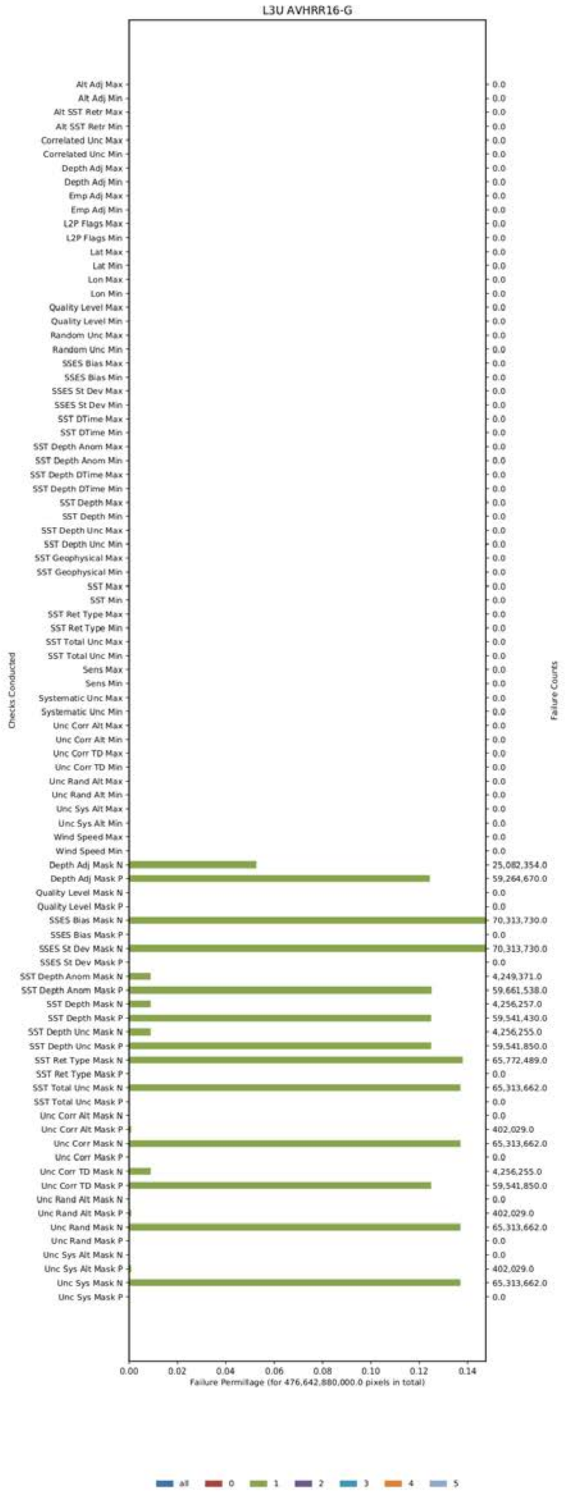

Figure 4-49: Results of L3U pixel checks for AVHRR16_G

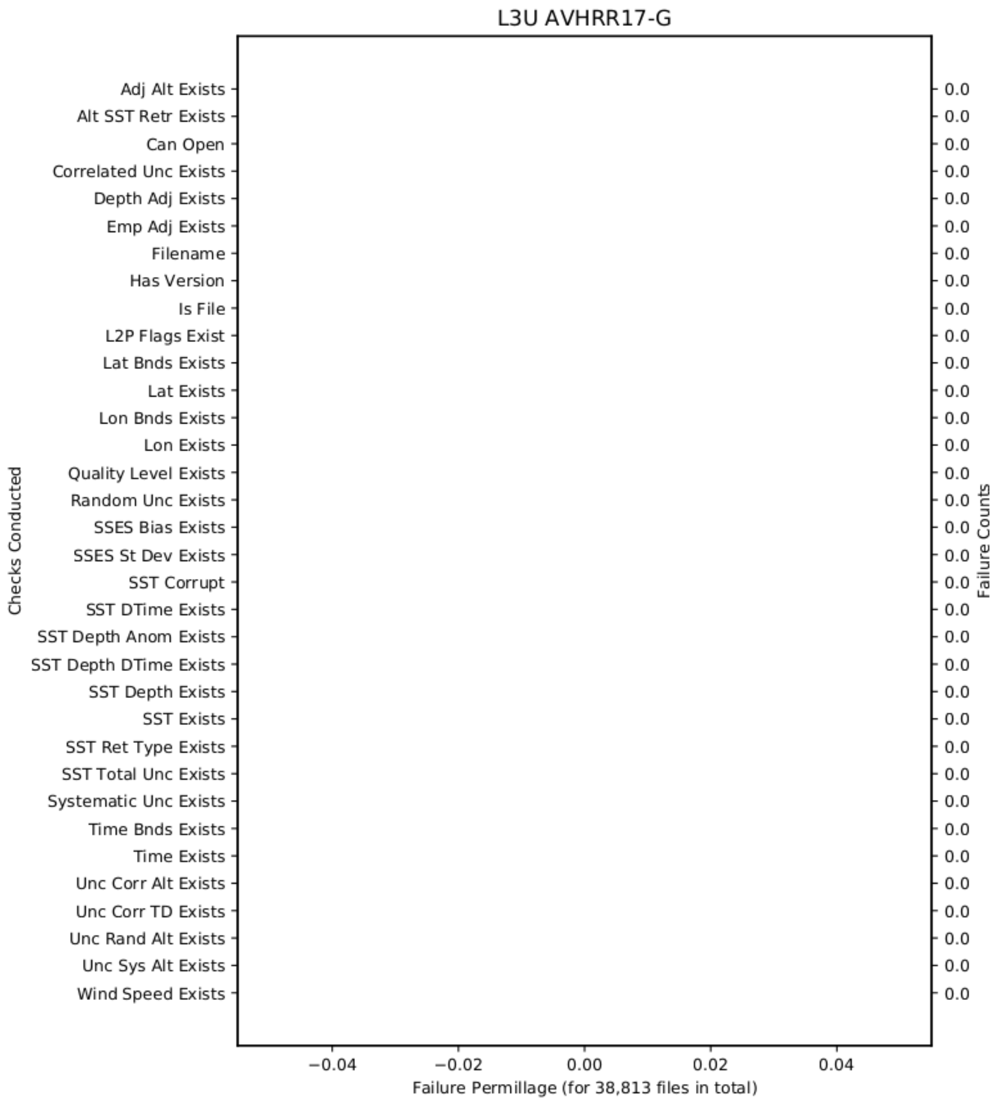

Figure 4-50: Summary of L3U product checks for AVHRR17_G

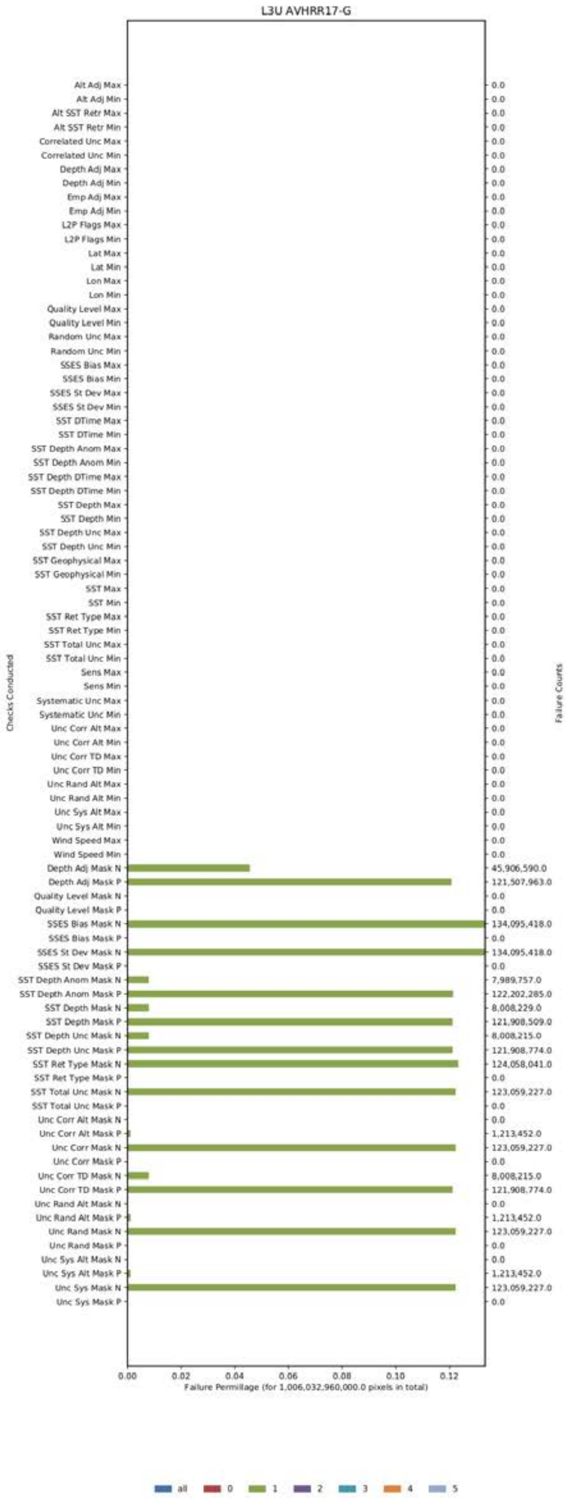

Figure 4-51: Results of L3U pixel checks for AVHRR17_G

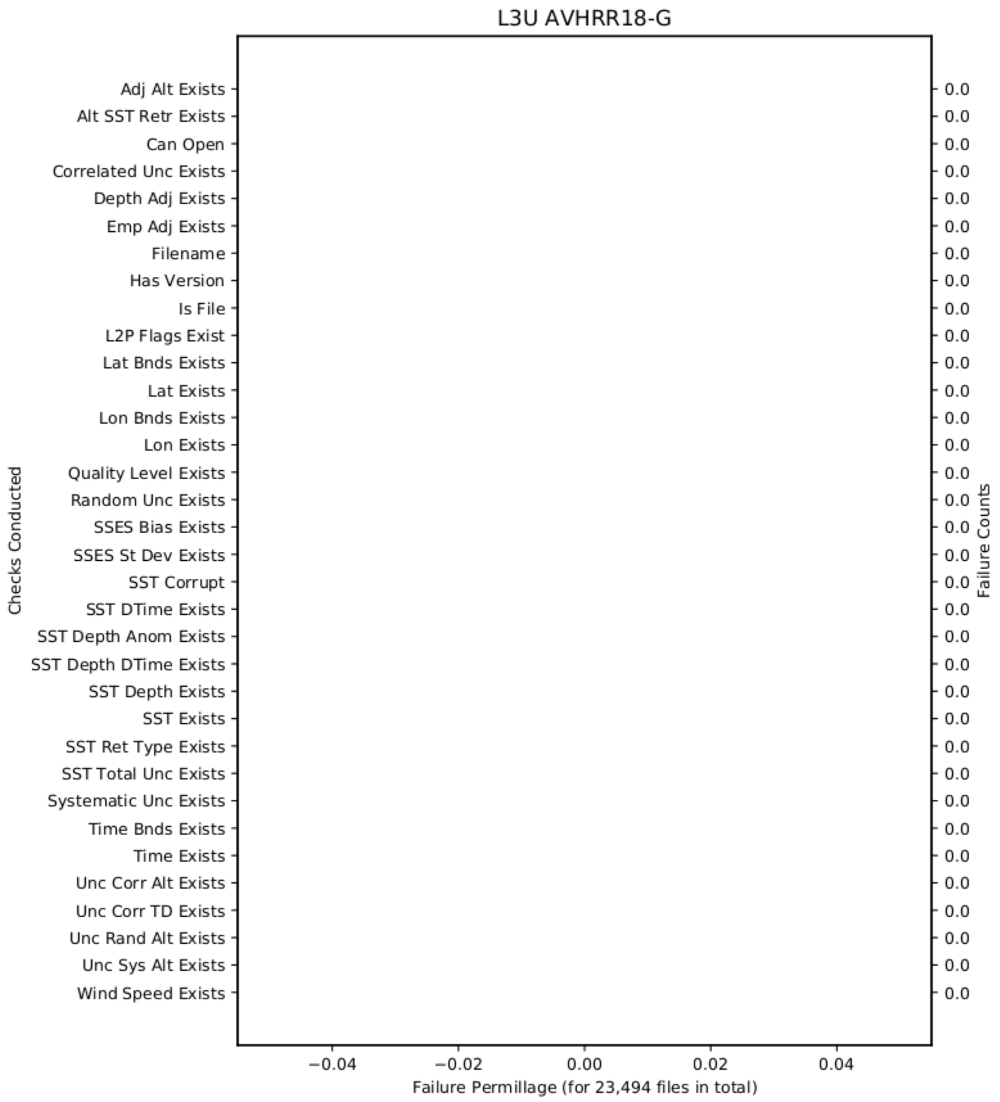

Figure 4-52: Summary of L3U product checks for AVHRR18_G

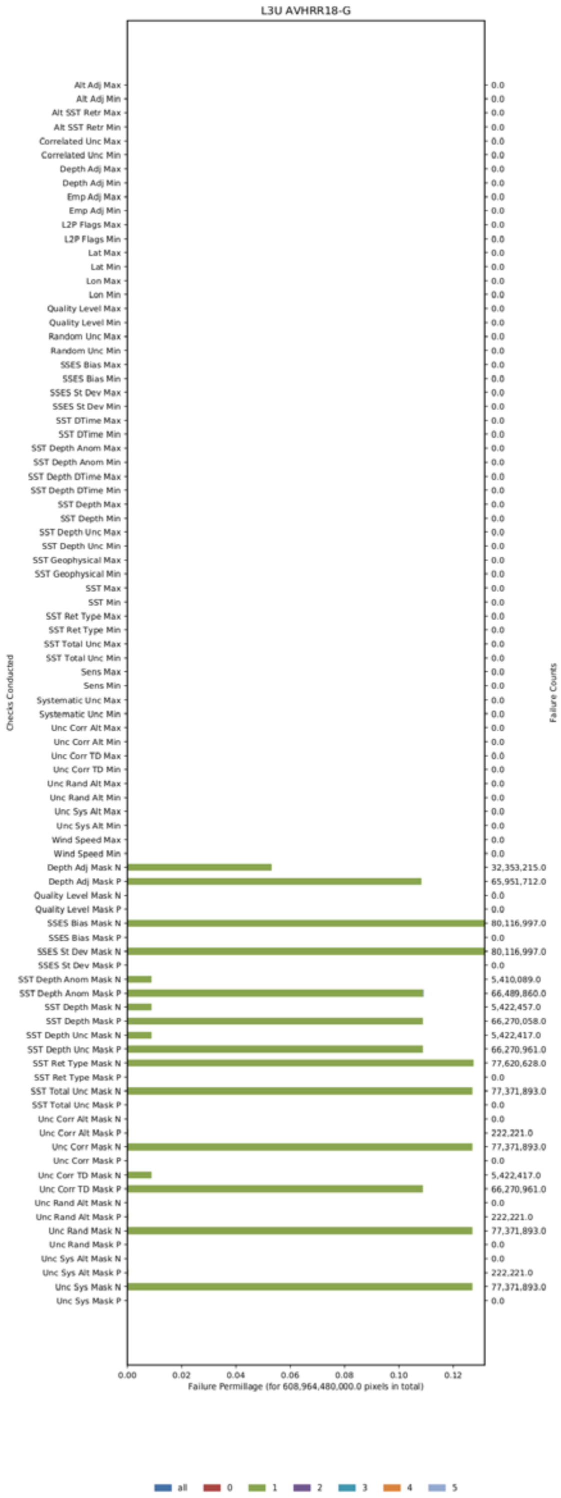

Figure 4-53: Results of L3U pixel checks for AVHRR18_G

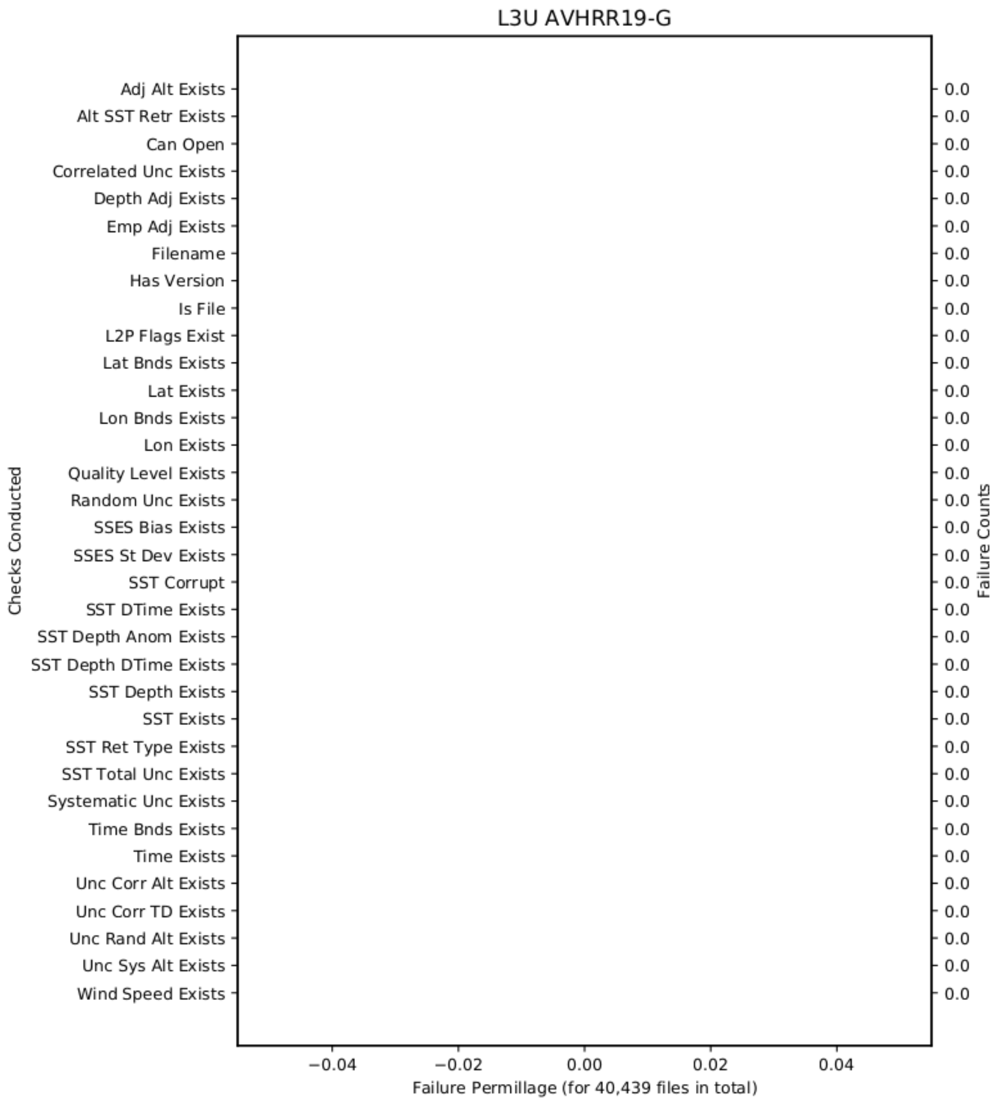

Figure 4-54: Summary of L3U product checks for AVHRR19_G

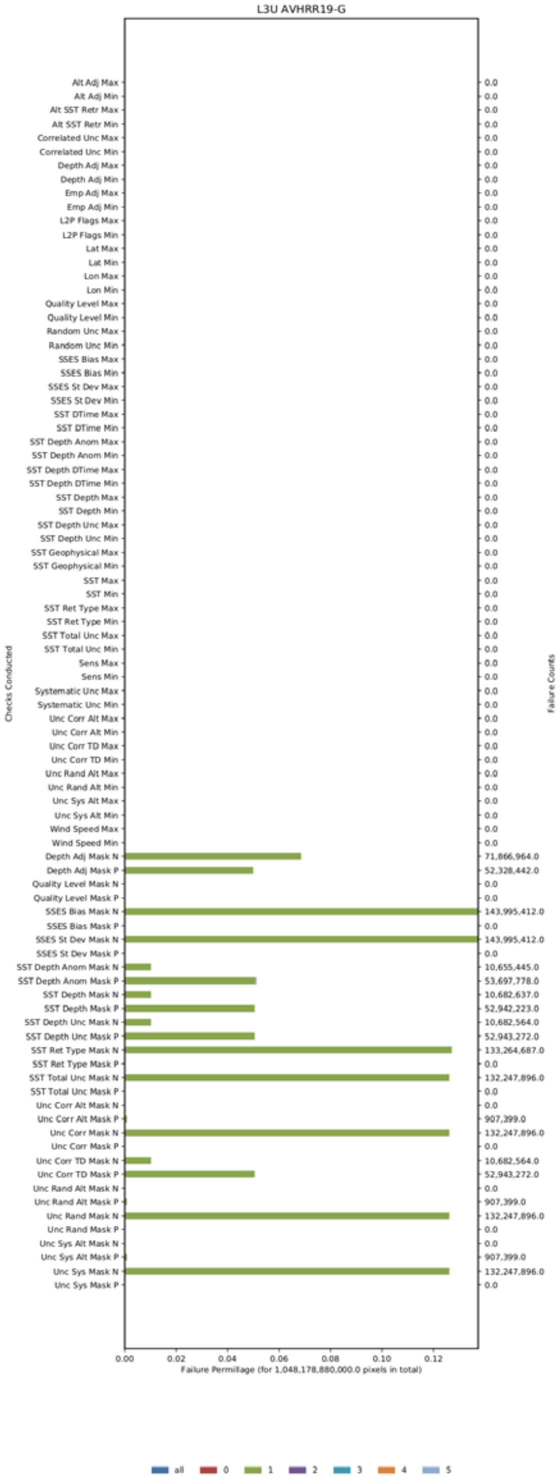

Figure 4-55: Results of L3U pixel checks for AVHRR19_G

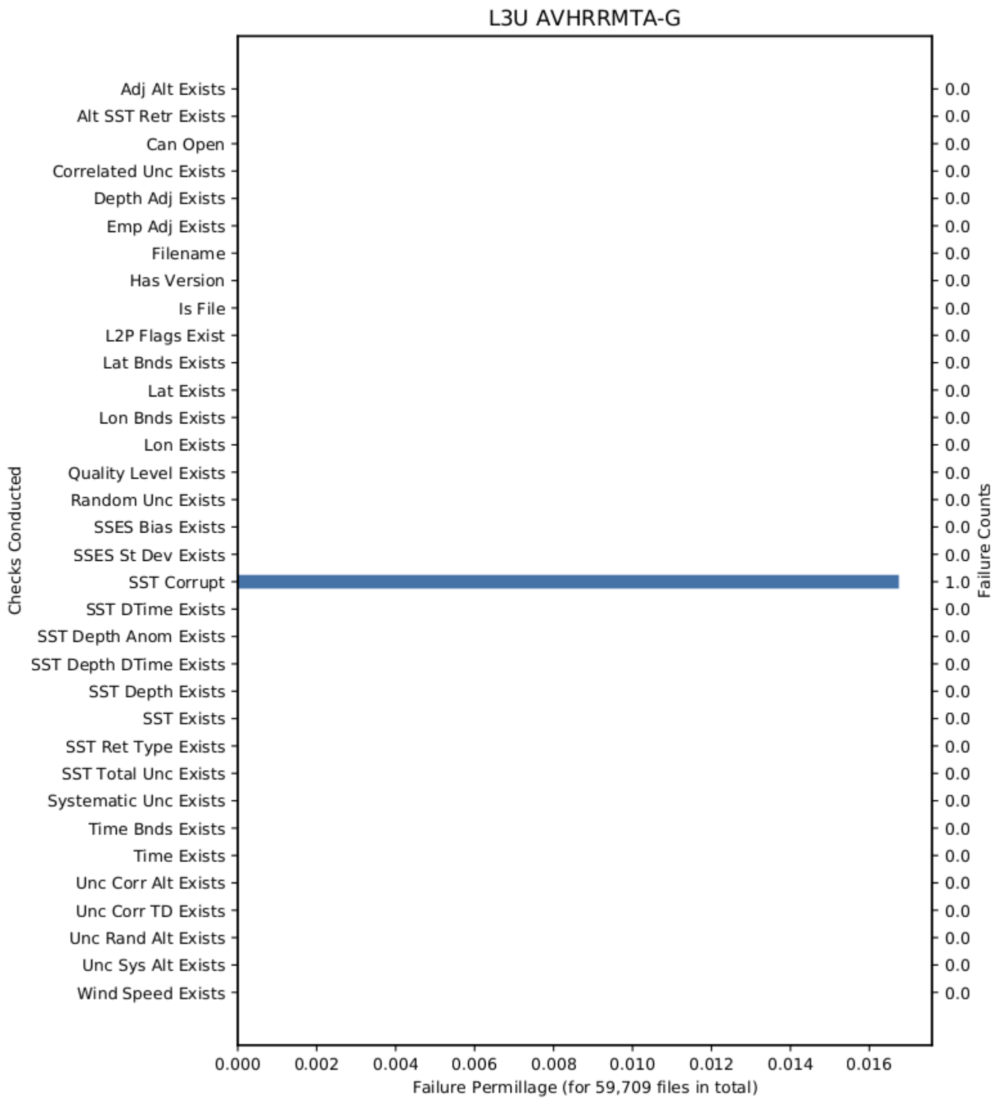

Figure 4-56: Summary of L3U product checks for AVHRRMTA_G

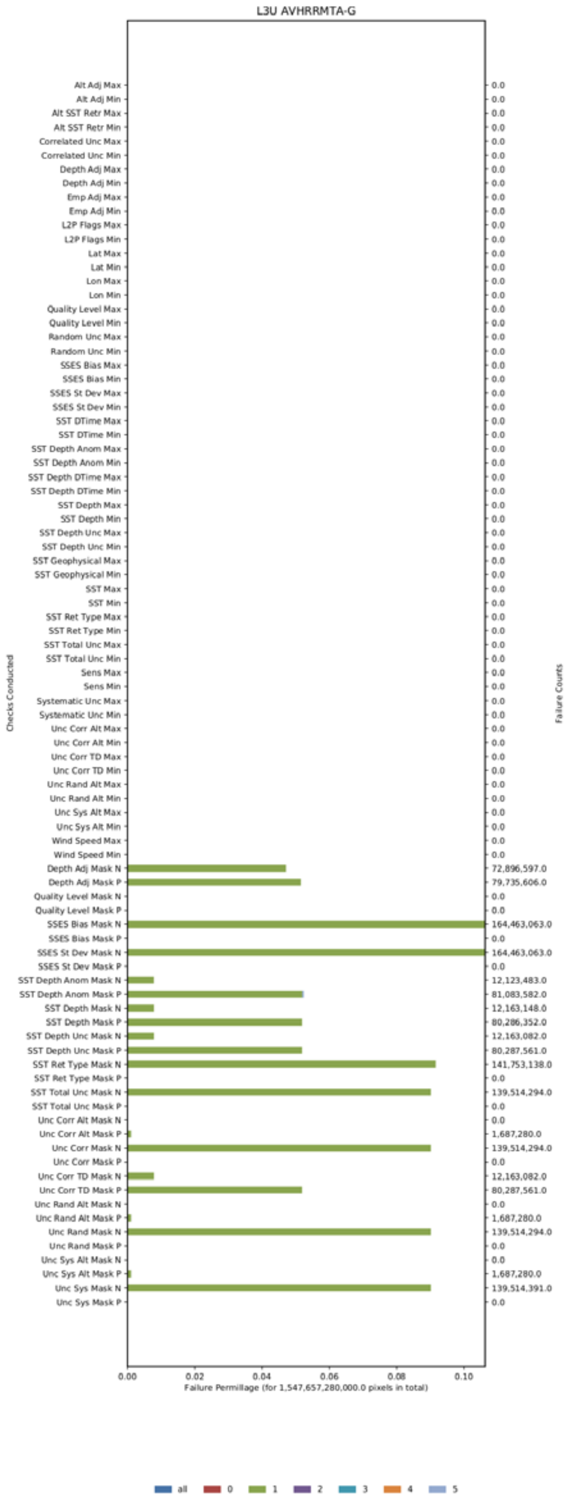

Figure 4-57: Results of L3U pixel checks for AVHRRMTA_G

4.2.2 Sample verification

A sample of L3U files consisting of one early and one late product from each of the (A)ATSR/AVHRR sensors, selected at random, were verified by manual inspection of the data fields. A randomly selected product of these files was also used for the verification of all metadata against the Product Specification Document (PSD) [AD.2]. The files manually inspected are listed in Table 4-4 below, the file used for metadata verification is marked in boldface.

The metadata verification against the product specification included both global and variable attributes. Some discrepancies were found between the file content and the product specification as listed in Table 4-5 further below.

The manual inspection of the data fields within the L3U file sample was carried out with the ESA Sentinel Toolbox (SNAP) (see Figure 4-58) and included the following checks:

- Plotting sea_surface_temperature data and checking data coverage and histogram
- Plotting sea_surface_temperature_depth and checking data coverage and histogram
- Plotting sst_dtime data and checking data coverage and histogram
- Plotting sses_bias and checking data coverage and histogram (always equal to zero)
- Plotting sses_standard_deviation and checking data coverage and histogram
- Plotting sst_depth_total_uncertainty and checking data coverage and histogram
- Plotting wind_speed data and checking data coverage and histogram
- Plotting l2p_flags and checking data coverage and histogram
- Plotting quality_level and checking data coverage and histogram
- Plotting large_scale_correlated_uncertainty and checking data coverage and histogram
- Plotting synoptically_correlated_uncertainty and checking data coverage and histogram
- Plotting uncorrelated_uncertainty and checking data coverage and histogram
- Plotting adjustment_uncertainty and checking data coverage and histogram
- Plotting aerosol_dynamic_indicator and checking data coverage and histogram
- Plotting sensitivity and checking data coverage and histogram

These checks did not reveal any major issues on the data. No erroneous structural artefacts have been found in any of the data fields plotted.

The issues of negative wind-speed and extremely high SST and SST_depth values reported in the last SVR have been resolved and could not be detected anymore.

A comparison was also made between the square root of the sum of the squares of the uncertainty values and total uncertainty provided in the file. In the L3U products, the total uncertainty standard deviation is given with a precision of about 0.005 K, whereas for all other uncertainties the precision is about 0.0001 K. Propagating these numbers gives an expected accuracy of about 0.0011 for the difference in sea surface temperature total uncertainties and of about 0.0011 for the difference in sea surface temperature depth total uncertainty.

Table 4-4: Files verified manually for data content. The filename listed in boldface was used for the verification of the complete metadata.

Sensor	Filename	File number
ATSR 1	19920327023440-ESACCI-L3U_GHRSST-SSTskin-ATSR1-CDR2.1-v02.0-fv01.0.nc	1
ATSR 1	19960103081014-ESACCI-L3U_GHRSST-SSTskin-ATSR1-CDR2.1-v02.0-fv01.0.nc	2
ATSR 2	19951104114844-ESACCI-L3U_GHRSST-SSTskin-ATSR2-CDR2.1-v02.0-fv01.0.nc	3
ATSR 2	20020911140213-ESACCI-L3U_GHRSST-SSTskin-ATSR2-CDR2.1-v02.0-fv01.0.nc	4
AATSR	**20020729213927-ESACCI-L3U_GHRSST-SSTskin-AATSR-CDR2.1-v02.0-fv01.0.nc**	**5**
AATSR	20120219020145-ESACCI-L3U_GHRSST-SSTskin-AATSR-CDR2.1-v02.0-fv01.0.nc	6
AVHRR 07	19820424000740-ESACCI-L3U_GHRSST-SSTskin-AVHRR07_G-CDR2.1-v02.0-fv01.0.nc	7
AVHRR 07	19850123040206-ESACCI-L3U_GHRSST-SSTskin-AVHRR07_G-CDR2.1-v02.0-fv01.0.nc	8
AVHRR 09	19850902202853-ESACCI-L3U_GHRSST-SSTskin-AVHRR09_G-CDR2.1-v02.0-fv01.0.nc	9
AVHRR 09	19920106032406-ESACCI-L3U_GHRSST-SSTskin-AVHRR09_G-CDR2.1-v02.0-fv01.0.nc	10
AVHRR 11	19881208145056-ESACCI-L3U_GHRSST-SSTskin-AVHRR11_G-CDR2.1-v02.0-fv01.0.nc	11
AVHRR 11	19931129004603-ESACCI-L3U_GHRSST-SSTskin-AVHRR11_G-CDR2.1-v02.0-fv01.0.nc	12
AVHRR 12	19911028150415-ESACCI-L3U_GHRSST-SSTskin-AVHRR12_G-CDR2.1-v02.0-fv01.0.nc	13
AVHRR 12	19980601210924-ESACCI-L3U_GHRSST-SSTskin-AVHRR12_G-CDR2.1-v02.0-fv01.0.nc	14
AVHRR 14	19950426203306-ESACCI-L3U_GHRSST-SSTskin-AVHRR14_G-CDR2.1-v02.0-fv01.0.nc	15
AVHRR 14	19980929034211-ESACCI-L3U_GHRSST-SSTskin-AVHRR14_G-CDR2.1-v02.0-fv01.0.nc	16
AVHRR 15	19990211115501-ESACCI-L3U_GHRSST-SSTskin-AVHRR15_G-CDR2.1-v02.0-fv01.0.nc	17
AVHRR 15	20081207164308-ESACCI-L3U_GHRSST-SSTskin-AVHRR15_G-CDR2.1-v02.0-fv01.0.nc	18
AVHRR 16	20030929210124-ESACCI-L3U_GHRSST-SSTskin-AVHRR16_G-CDR2.1-v02.0-fv01.0.nc	19
AVHRR 16	20060702004737-ESACCI-L3U_GHRSST-SSTskin-AVHRR16_G-CDR2.1-v02.0-fv01.0.nc	20

Sensor	Filename	File number
AVHRR 17	20021104064648-ESACCI-L3U_GHRSST-SSTskin-AVHRR17_G-CDR2.1-v02.0-fv01.0.nc	21
AVHRR 17	20090619093213-ESACCI-L3U_GHRSST-SSTskin-AVHRR17_G-CDR2.1-v02.0-fv01.0.nc	22
AVHRR 18	20060428154023-ESACCI-L3U_GHRSST-SSTskin-AVHRR18_G-CDR2.0-v02.0-fv01.0.nc	23
AVHRR 18	20090214175601-ESACCI-L3U_GHRSST-SSTskin-AVHRR18_G-CDR2.1-v02.0-fv01.0.nc	24
AVHRR 19	20090713200527-ESACCI-L3U_GHRSST-SSTskin-AVHRR19_G-CDR2.1-v02.0-fv01.0.nc	25
AVHRR 19	20160511161944-ESACCI-L3U_GHRSST-SSTskin-AVHRR19_G-CDR2.1-v02.0-fv01.0.nc	26
AVHRR-MTA	20070314194603-ESACCI-L3U_GHRSST-SSTskin-AVHRRMTA_G-CDR2.1-v02.0-fv01.0.nc	27
AVHRR-MTA	20161017210756-ESACCI-L3U_GHRSST-SSTskin-AVHRRMTA_G-CDR2.1-v02.0-fv01.0.nc	28

4.2.2.1 Meta Data Issues

Table 4-5: Discrepancies between L3U metadata and the PSD. Shaded cells indicate true discrepancies, while the non-shaded cells indicate where the PSD is mistaken

Variable name or *global*	Attribute or property	File content	Product specification
Global	license	Creative Commons Licence by attribution (http://creativecommons.org/licenses/by/4.0/)	GHRSST protocol describes data use as free and open (update PSD)
Global	keywords	Attribute name starts with a small "k"	Attribute name starts with a capital "K" (update table 14)
Global	geospatial_vertical_max	-1.0E-5	-10^{-6} or -0.001 or -0.2 (update PSD)
Global	platform	Attribute name starts with a small "p"	Attribute name starts with a capital "P" (update table 14)
Global	sensor	Attribute name starts with a small "s"	Attribute name starts with a capital "S" (update table 14)
Global	source_file	The data source file	Missing (update PSD)

Variable name or *global*	Attribute or property	File content	Product specification
sea_surface_temperature	units	kelvin	Kelvin (update PSD)
sst_dtime	units	seconds	Seconds (update PSD)
sses_bias	units	kelvin	Kelvin (update PSD)
sses_standard_deviation	units	kelvin	Kelvin (update PSD)
l2p_flags	valid_max	511	255 (update PSD)
l2p_flags	flag_meanings	microwave land ice lake river spare views channels day	microwave land ice lake river spare views channels aerosol (update PSD)
quality_level	_FillValue	0	-128 (update PSD)
sea_surface_temperature _retrieval_type	flag_meanings	n.a.	Rename attribute from retrieval_type_meanings to flag_meanings (update PSD)
sea_surface_temperature _retrieval_type	flag_values	n.a.	Rename attribute from retrieval_type_values to flag_values (update PSD)
uncertainty_random	units	kelvin	Kelvin (update PSD)
uncertainty_correlated	units	kelvin	Kelvin (update PSD)
uncertainty_systematic	units	kelvin	Kelvin (update PSD)
sea_surface_temperature _total_uncertainty	units	kelvin	Kelvin (update PSD)
depth_adjustment	units	kelvin	Kelvin (update PSD)
depth_adjustment	standard_name	None	Remove attribute from PSD
depth_adjustment	source	None	Remove attribute from PSD
depth_adjustment	references	None	Remove attribute from PSD
uncertainty_correlated_d epth_adjustment	None	None	Remove variable from PSD
sea_surface_temperature _depth	units	kelvin	Kelvin (update PSD)
daymean_time	None	None	Remove variable from PSD
uncertainty_correlated_ti me_and_depth_adjustme nt	units	kelvin	Kelvin (update PSD)
sea_surface_temperature _depth_total_uncertainty	units	kelvin	Kelvin (update PSD)
sea_surface_temperature _depth_anomaly	units	kelvin	Kelvin (update PSD)

Variable name or *global*	Attribute or property	File content	Product specification
alt_sst_retrieval_type	flag_meanings	n.a.	Rename attribute from retrieval_type_meanings to flag_meanings (update PSD)
alt_sst_retrieval_type	flag_values	n.a.	Rename attribute from retrieval_type_values to flag_values (update PSD)
adjustment_alt	units	kelvin	Kelvin (update PSD)
adjustment_alt	standard_name	None	Remove attribute from PSD
adjustment_alt	source	None	Remove attribute from PSD
adjustment_alt	references	None	Remove attribute from PSD
sst_sensitivity	Complete variable	Present	Missing (update PSD)
empirical_adjustment	units	kelvin	Kelvin (update PSD)
empirical_adjustment	standard_name	None	Remove attribute from PSD
empirical_adjustment	source	None	Remove attribute from PSD
empirical_adjustment	references	None	Remove attribute from PSD
sst_depth_dtime	Complete variable	Present	Missing (update PSD)

Table 4-6: Differences between total uncertainties absolute min and max values and mean value provided in the L3U product and the total uncertainty calculated by combining individual uncertainty components

№	Min SST Uncert delta	Max SST Uncert. delta	Mean SST Uncert. delta	Min SST_depth Uncert delta	Max SST_depth Uncert. delta	Mean SST_depth Uncert. delta	Num Pixels
1	0.0	9.98e-4	2.89e-4	0.0	9.97e-4	2.83e-4	87060
2	0.0	9.87e-4	2.97e-4	0.0	9.87e-4	2.96e.4	68816
3	0.0	0.0011	3.07e-4	0.0	0.0011	3.07e-4	98784
4	0.0	0.0011	3.1e-4	0.0	0.0011	3.11e-4	84617
5	0.0	0.0011	3.08e-4	0.0	0.0011	3.08e-4	126634
6	0.0	0.0011	3.04e-4	0.0	0.0011	3.04e-4	149229
7	0.0	0.0011	3.12e-4	0.0	0.0011	3.13e-4	303982
8	0.0	0.0011	3.1e-4	0.0	0.0011	3.11e-4	350051
9	0.0	0.0011	3.15e-4	0.0	0.0011	3.15e-4	384933
10	0.0	0.0011	3.09e-4	0.0	0.0011	3.09e-4	411193
11	0.0	0.0011	3.18e-4	0.0	0.0012	3.18e-4	337407
12	0.0	0.0011	3.18e-4	0.0	0.0012	3.18e-4	343692
13	0.0	0.0011	3.16e-4	0.0	0.0011	3.16e-4	345503
14	0.0	0.0011	3.17e-4	0.0	0.0011	3.17e-4	295548
15	0.0	0.0011	3.22e-4	0.0	0.0011	3.22e-4	521402
16	0.0	0.0011	3.18e-4	0.0	0.0011	3.16e-4	419964
17	0.0	0.0011	3.17e-4	0.0	0.0011	3.18e-4	272443
18	0.0	0.0011	3.22e-4	0.0	0.0011	3.22e-4	427674
19	0.0	0.0011	3.31e-4	0.0	0.0011	3.29e-4	393698
20	0.0	0.0011	3.28e-4	0.0	0.0011	3.3e-4	361420
21	0.0	0.0011	3.31e-4	0.0	0.0011	3.31e-4	343547
22	0.0	0.0012	3.29e-4	0.0	0.0011	3.29e-4	438468
23	0.0	0.0011	3.29e-4	0.0	0.0011	3.28e-4	345145
24	0.0	0.0011	3.29e-4	0.0	0.0011	3.3e-4	349603
25	0.0	0.0011	3.28e-4	0.0	0.0012	3.27e-4	309869
26	0.0	0.0011	3.27e-4	0.0	0.0011	3.27e-4	387035
27	0.0	0.0011	3.28e-4	0.0	0.0011	3.28e-4	404176
28	0.0	0.0011	3.27e-4	0.0	0.0011	3.27e-4	483341

5. CONCLUSIONS

The SST CCI CDR version 2.1 dataset has been exhaustively tested using automated inspections by dedicated software-modules and manual checks verifying compliancy with the PSD. Additionally, a visual inspection of a randomly selected product subset ensured that no visible artefacts remained in the data. The verification procedures conducted for writing this document have shown to be effective. No major defects could be detected during the execution of the numerous QA exercises.

With respect to the data content, a small number of L2P and L3U products are affected by mask inconsistencies, only appearing at pixels flagged with quality level 1 (bad_data). These masking inconsistencies do not affect the general usability of the data record.

The overall state of the data is remarkably mature and error free. With respect to the previous version, significant improvements can be stated. The number of products raising the “sst-corrupt” check (all SST data is fill value) has almost dropped to zero. In addition, the number of pixels affected by masking inconsistencies has dropped to about the half.

The lessons learned from the SVR version 2.0 have been successfully implemented in the processes used to generate the new CDR version 2.1. An exhaustive consolidation of the input data quality and the removal of weak missions (e.g. AVHRR NOAA 6) from the processing input have raised the general quality of the SST dataset noticeably.

Data issues detected and discrepancies between user guide and the CDR 2.1 dataset have been recorded with the standard issue tracking system of the project and will be corrected by the teams responsible.