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CCI Land Surface Temperature

LST CCI System Verification report

WP3.2 – DEL-D3.3

Ref.: LST-CCI-D3.3-SVR

Date: 15/10/2019

Organisation: ACRI-ST



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Change log

Version	Date	Changes
1.0	25/07/2019	First version
1.1	15/10/2019	Updated version taking into account ESA RIDs

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1. Executive Summary

This document reports the test results of the processing system verification designed for the Land Surface Temperature (LST) Climate Change Initiative (CCI) project. The LST CCI project aims to produce climate data records of LST, which is an Essential Climate Variable (ECV). LST is used for applications such as climate and land surface modelling, crop monitoring, and urban heat island studies. The LST ECV Products generated by LST CCI are also expected to be used by climate user communities for long-term analysis.

The LST climate data record (CDR) production system will allow the processing and reprocessing of consistent LST datasets over more than 25 years of satellite data issued from heterogeneous sensors, processing both single sensor ECV products and multi-sensors LST CDRs. It will use many different data sources stored in various existing data centres as well as building on the heritage of past projects. Periodical LST Climate Data Records (CDRs) will be provided as well as documentation conforming to URD LST-CCI-D1.1 [RD-1].

The LST testing reported in this document has been chosen with consideration of the LST System Requirements Document (SRD) [RD-2], LST CCI System Specification Document (SSD) [RD-4], User Requirements Document (URD) [RD-1] and the CCI Data Standards [RD-6].

2. Introduction

2.1. Purpose and scope

This Land Surface Temperature (LST) System Verification Report summarizes the results of tests executed in the verification frame of the LST-CCI project.

System verification is one component of the end-to-end processing system. The System Engineering Team supports the implementation of the whole processing system, ensuring it is designed and implemented with clear specification of its components, interfaces and dependencies. Verification of the output products will be carried out during the final processing stages of each processing cycle with results being communicated directly to the ECV production teams. Lessons learnt from Cycle 1 production and verification will be documented as updates to the System Requirements Document (SRD) and System Specification Document (SSD) respectively in preparation for Cycle 2 processing.

This document is based on the current versions of the System Requirement Document (SRD v1.0) [RD-2], the System Specification Document (SSD v1.0) [RD-4], the User Requirements Document (URD) [RD-1], the Data Standards requirements for CCI Data Producers and the Product Specification Document (PSD v1.6). This document is effectively a live document which will be updated throughout the project.

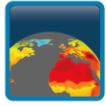
This version of the document is an initial version which reports on the first datasets generated at the end of year 1. The verification made and reported in this document relates to the compliance of the data format with the CCI standards [RD-4] (NetCDF-4 / CF 1.7 format) and the data consistency (data values vs data validity range).

For the current version of this document, we are still liaising with data producers in the LST CCI consortium to achieve a stable and CCI standards compliant climate data record production system. First results have shown a few non-critical discrepancies which are summarized in section 5.

2.2. References and applicable documents

The references used in this document are listed in document “References and Acronyms” (ref. LST-CCI-D6.5-REFACR [RD-3]). In addition, we have:

ID	Title	Reference	Issue	Date
[RD-1]	LST CCI User Requirement Document (URD)	LST-CCI-D1.1-URD	1.1	22/02/2019
[RD-2]	LST-CCI- System Requirement Document (SRD)	LST-CCI-D3.1-SRD	1.0	17/12/2018
[RD-3]	References and Acronyms (REFACR)	LST-CCI-D6.5-REFACR	1.1	08/10/2018
[RD-4]	LST-CCI- System Specification Document (SSD)	LST-CCI-D3.2-SSD	1.0	22/05/2019
[RD-5]	LST CCI Product Specification Document (PSD)	LST-CCI-D1.2-PSD	1.5	16/07/2019
[RD-6]	CCI Data Standards	CCI-PRGM-EOPS-TN-13-0009	2.0	17/09/2018
[RD-7]	Product Validation Plan (PVP)	LST-CCI-D2.5-PVP	1.0	17/06/2019



2.3. Acronyms

The list of references and acronyms is given in document “References and Acronyms” whose reference is LST-CCI-D6.5-REFACR [RD-3].

3. Verification of LST_cci products

3.1. Overview

The ESA CCI LST project aims to provide LST satellite data records meeting the requirements of the climate research community [RD-1]. The operational and technical descriptions of the processing system are available in the SRD [RD-2] and SSD [RD-4] and are illustrated in the following picture.

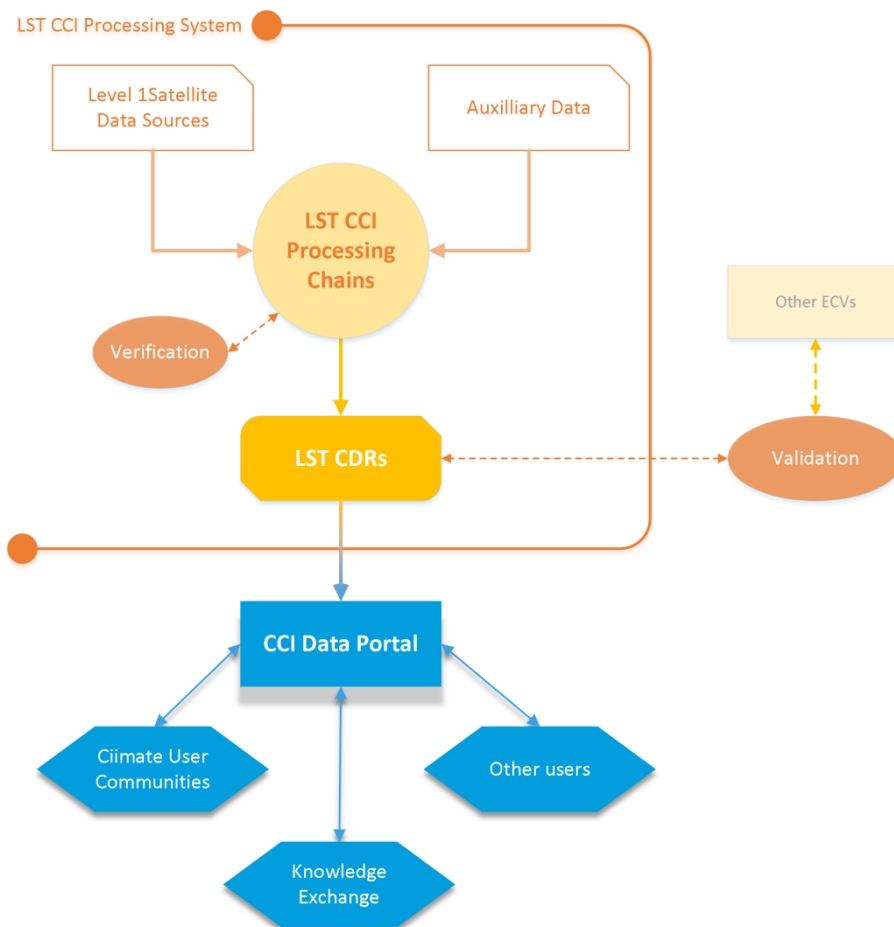


Figure 1: LST CCI Processing System.

The LST ECV Products will be generated from satellite data spanning nearly 25 years and multiple sensors, which are stored across different computing centres (JASMIN, IPMA, ESTELLUS).

The validation of the generated LST ECV products will be performed later (managed by Karlsruhe Institute of Technology as specified in the PVP [RD-7]), and will be provided in a Product Validation and Intercomparison Report (PVIR)), but this will be facilitated by guaranteeing a common understanding of the format of the data file and input files. The first version of this document reports the file format validation.

3.2. Verification work logic

The work logic of the verification is displayed in Figure 2 and is split in different stages:

- ❖ The EO teams, in charge of producing the LST_cci datasets, have developed their processing chains in order to comply with the PSD [RD-5].
- ❖ Before starting the production, they generate a few samples which are then tested.
- ❖ Verification consists of checking the compliance with the PSD [RD-5], with the CCI Data Standards format [RD-6] and the file naming convention, also defined in the CCI Data Standards [RD-6]. Minimum / maximum value tests check that there are no anomalous data stored in the data files.
- ❖ If the tests are unsuccessful, the applicable EO team is advised, and requested to make corrections. If necessary, the PSD may be adjusted to reflect a difference which is deemed to be more appropriate in the output data files. New samples are then supplied to the engineering team.
- ❖ If the tests are successful, the generation of LST_cci products can start. These products are then checked again. In case of anomalies or persistent discrepancies with the PSD, the EO team is informed. In such cases, corrections are made in the processing chains, and production is performed again. Though unlikely at this stage, an update of the PSD may still be needed.

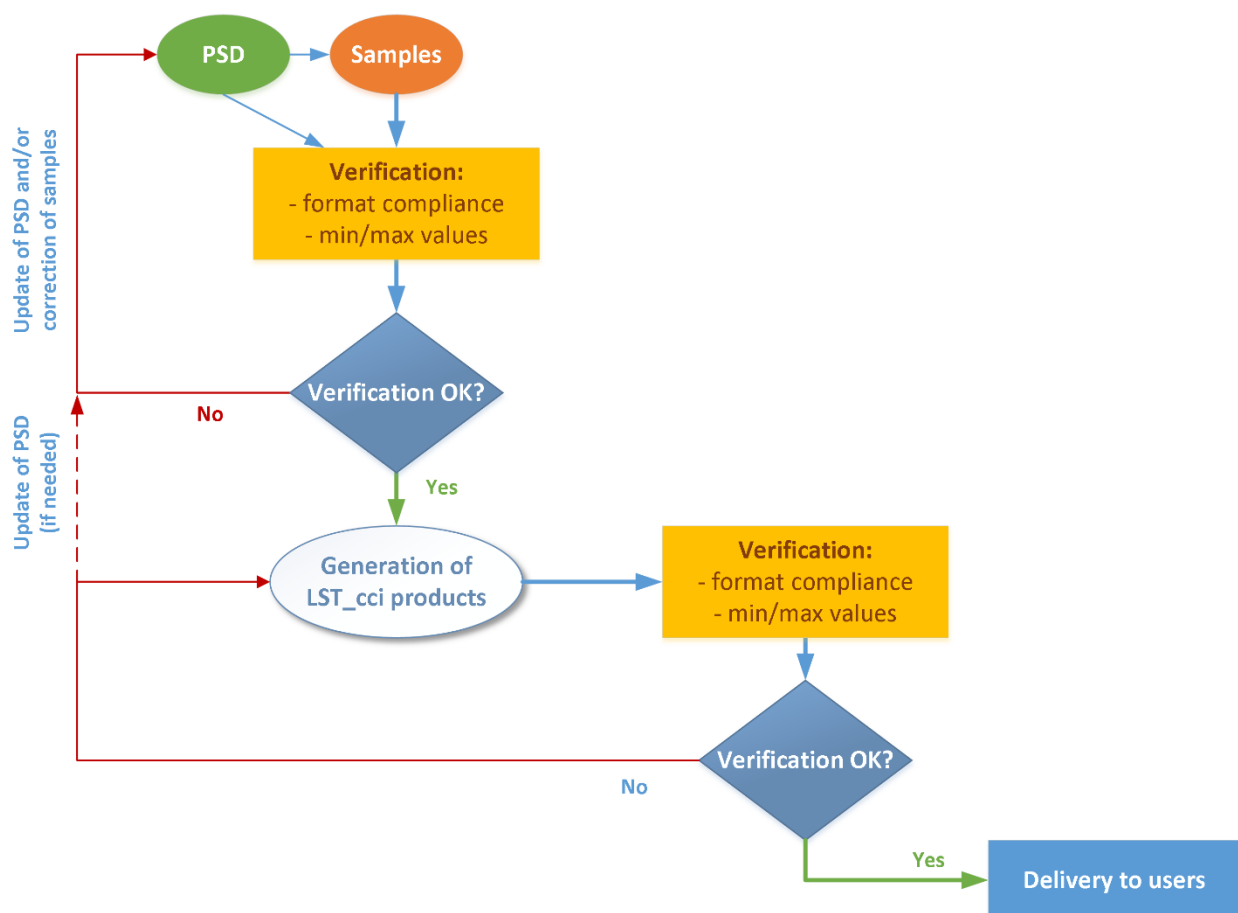



Figure 2: Verification work logic

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The verification is done offline and this is a change with respect to the very initial plan (in which we expected this to be done in real-time). We have considered this slightly different approach (verification remains identical) for the following reasons:

- ❖ The time needed to generate a set of global products is generally quite short. As an example, generating a 10-year time series of AATSR-based LST products takes less than one day. 10 years of MW products only takes a few days. It means that, in case an anomaly is found, it is very quick to generate again the full time series
- ❖ Decoupling the processing from the verification also minimizes time for the generation itself and allows the verification to target dataset from various location in both time and space.

If it emerges that, for other LST_cci products, processing time increases substantially (e.g. several weeks), we could always split the processing per period (e.g., by processing the full time series in periods of 5 years), the verification being performed after each period of time.

3.3. Verification

The verification process aims to validate the common CCI Standard file format, which is NETCDF-4 format and CF 1.7 compliant, to be used along the LST_cci project, and to secure the processing with data consistency checks. The data checks are the following (cf. [RD-4]):

- ❖ NetCDF/CF File format (variables names, attributes, units, dimensions, versions)
- ❖ Data range of values versus data valid range
- ❖ File naming and location (*manually verified, a script is to be written for future processing Cycles*)

The verification process is performed in two steps:

- ❖ First a validation tool is used to validate the file format (cfchecker tool)
- ❖ A reference file is produced and used as a template to compare with the produced files and list the deviations (nc-validate tool). This comparison will be included in the production chain to automatically detect format errors and raise warnings.

During Cycle 1, the validation is performed with the cfchecker tool.

3.3.1. Cfchecker tool

The cfchecker script tools exist in two versions:

- ❖ Downloadable <https://github.com/cedadev/cf-checker>
- ❖ Online version <http://pumatest.nerc.ac.uk/cgi-bin/cf-checker.pl>

The cfchecker tool was originally developed by the Hadley Centre for Climate Prediction and Research, UK Met Office. Development and maintenance of the tool has now been taken over by the NCAS Computational Modelling Services (NCAS-CMS).

The cfchecker tool checks that the contents of a NetCDF file complies with the Climate and Forecasts (CF) Metadata Convention (<http://cfconventions.org/>).

The errors found by the cfchecker are categorized according to Table 1:


	<p style="text-align: center;">LST CCI System Verification report</p> <p style="text-align: center;"><i>WP3.2 – DEL-D3.3</i></p>	<p>Ref.: LST-CCI-D3.3-SVR Version: 1.1 Date: 15/10/2019 Page: 7</p>
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Table 1: Error classification

Error type	Meaning
Error	Error which could make the file not usable and should be analyzed and stated rapidly for correction ex: Invalid variables format or names
Warning	Errors that should be analyzed but has no impact on the processing. Ex. missing CF convention tag
Information	Deviation from the expectation that does not affect the file consistency Ex. Missing unit

Known limitation

- ❖ cfchecker is mainly for meta-information
- ❖ If the `_FillValue` is set incorrectly, this cannot be checked automatically because the checker has no way of knowing in advance which cells should be marked in this way.
- ❖ There is no check made on the dimensions of variables of a ragged array representation.
- ❖ The global attribute “featureType” is required for all discrete geometry representations, however, it is only possible to identify the ragged array representation by the presence of “sample_dimension” or “instance_dimension” attributes.
- ❖ The count variable must have the instance dimension as its sole dimension.
- ❖ The index variable must have the sample dimension as its sole dimension.

The verification tools give a good confidence level into the file format attenuated by these limitations. Free existing tools (ESA CCI Toolbox, SNAP or ncview) can be manually used to verify the file consistency.

The cfchecker version used for verification is latest stable version 3.1.0 (CF compliance up to and including CF-1.7).

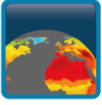
3.3.2. Nc-validate tool

Nc-validate is a python module for comparing one or more NetCDF files against a known NetCDF template. Results are printed to STDOUT and errors (i.e.: missing dimensions, variables, global and variable attributes) are printed to STDERR.

The template file is read and then compared to the structure of each of the files specified on the command line. The following items are checked:

- ❖ Inclusion of proper dimension variables
- ❖ Inclusion of global attributes
- ❖ Inclusion of proper variables
- ❖ Datatypes of included variables
- ❖ Attributes of included variables

It will be used to automatically verify the produced files once the production chain is established: during cycle 1, data producers converge altogether toward a common LST_cci file format, from which a template

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will be generated and used in cycle 1.5. This template will be produced with respect to the latest PSD version (currently 1.5). It will be used to automatically verify the produced files once the production chain is established.

The output data format applied to the datasets generated in production will also need to be compliant with the obs4MIPs initiative in the final Cycle: the file format verification will be studied at this moment thanks to project experience acquired during cycle 1.

4. Tests and results

At the time this document was written, the PSD was still actively evolving and some elements related to the CCI file format (e.g. Quality flags) are still under discussion. The content of this SVR presents the state of the CCI LST file production at the beginning of the project: the format is verified with the cfchecker tool and results are presented in this document, according to PSD v1.5 [RD-5]. In that context, the tested files are picked up from different locations as summarized in Table 2.


Table 2: files tested during the verification

File type	Origin
ENVISAT_ATSR_L2P	Jasmin workspace
ERS-2_ATSR_L3U	Jasmin workspace
MODIS_L3U	Jasmin workspace
SEVIRI	Email
MW	Jasmin workspace
ENVISAT_ATSR__L3U	Jasmin workspace

Note several files have been tested in each category (see each test report below) and results are identical category by category. For that reason, only one report of each type is presented in this document.

4.1. SEVIRI

Number of files tested: 107 SEVIRI files have been tested out of the year 2008 processing (files have been chosen randomly). All reports are identical.

File name :	ESACCI-LST-L3U-LST-SEVIRI-20081205060000-fv1.00.nc	File Date : 25/06/2019
		Origin : Email
Report	 ESACCI-LST-L3U-LST-SEVIRI-20081205060000-fv1.00.nc.log.zip	
Summary:	<ul style="list-style-type: none"> ❖ ERRORS detected: 2 ❖ WARNINGS given: 0 ❖ INFORMATION messages: 0 	

Errors and explanations:

ERROR: (2.6.1): This netCDF file does not appear to contain CF Convention data.

Explanation: The files have been generated with CF version 1.8 (which is not officially released yet)

ERROR: (3.5): Invalid syntax for 'flag_meanings' attribute


variable: lcc

Recommendation: The flag mask should be checked against section 3.5 of the convention documentation. According to the convention documentation, the flag_meanings should not contain ',' nor '>' characters.

Mitigation: The PSD 1.5 has been updated to 1.6 to remove the forbidden characters from the definition. A new file must be generated with respect to the new PSD 1.6

4.2. Microwave

Number of files tested: 285 SSMI_SSMIS_L2P files have been tested out of the year January 2013 processing (files have been chosen randomly). All reports are identical.

File name :	ESACCI-LST-L2P-LST-SSMI-F13-20080101101428-fv1.11.nc	File Date : 17/07/2019
		Origin : Jasmin workspace
Report	 ESACCI-LST-L2P-LST-SSMI-F13-20080101101428-fv1.11.nc.log.zip	
Summary: <ul style="list-style-type: none"> ❖ ERRORS detected: 4 ❖ WARNINGS given: 0 ❖ INFORMATION messages: 0 		

Errors and explanations:

Checking variable: satze

ERROR: (2.5.1): Second element of actual_range must equal maximum data value of variable after scale_factor/add_offset applied (53.129997)

Checking variable: sataz


ERROR: (2.5.1): First element of actual_range must equal minimum data value of variable after scale_factor/add_offset applied (-179.98999)

Checking variable: solaz

ERROR: (2.5.1): First element of actual_range must equal minimum data value of variable after scale_factor/add_offset applied (-108.509995)

Checking variable: lst

ERROR: (2.5.1): First element of actual_range must equal minimum data value of variable after scale_factor/add_offset applied (221.29999)

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Explanation: In every of the four cases, the error raised is false and due to floating point precision issue. For example, the max value of satze variable is 5313, which gives 53.13 after application of scale factor (=0.01) and add offset (0).

Mitigation: The cfchecker producer has been informed of the issue on 19/07/2019.

The explanation of the issue has been provided by the cfchecker producer: *“Variable satze data is type int16 and add_offset and scale_factor type float32. So you are unpacking an int into a float.”*


The cfchecker producer offered the proposal: *“Further to this I have also found a bug in the checker as it should flag warnings in your file to state the recommendation that “if scale_factor & add_offset are type float, the variable should not be of type int”. See section 8.1 of the convention document. I will fix this and try and release a new version for you next week.”*

This solution has not been provided yet, but data producers have been informed. The feedback is: *“Unpacking the integer into a float is needed if we want to keep packing as integer or reduce file size. If a variable saved as an integer cannot use float scale factors, we cannot apply e.g. a 0.01 for the satellite zenith angle, so the whole trick is compromised. I’m surprised about this, as this float->integer packing and integer->float unpacking seems very common in many established datasets, e.g., ECMWF products.”*

The tool mitigation solution solves the problem partially only and the issue is still opened and under investigation.

4.3. MODIS

Number of files tested: 275 MODIS files have been tested out of the year April 2018 processing (files have been chosen randomly). All reports are identical.

File name :	ESALST-CCI-L3U-LST-MODIST-20091231000000-fv1.00.nc	File Date : 31/05/2019 Origin : Jasmin
Report	 ESACCI-LST-L3U-LST-MODIST-20091231000000-fv1.00.nc.log.zip	
Summary: <ul style="list-style-type: none"> ❖ ERRORS detected: 5 ❖ WARNINGS given: 0 ❖ INFORMATION messages: 2 		

Errors and explanations:

ERROR: (2.6.1): This netCDF file does not appear to contain CF Convention data.

Explanation: The files have been generated with CF version 1.8 (which is not officially released yet)

ERROR: (3.1): Invalid units: unitless

Explanation: section 3.1 of the CF conventions should give the explanation [*The `units` attribute is required for all variables that represent dimensional quantities [...]*]

ERROR: (3.5): Invalid syntax for 'flag_meanings' attribute

variable: lcc

Recommendation: The flag mask should be checked against section 3.5 of the convention documentation. According to the convention documentation, the flag_meanings should not contain ‘,’ nor ‘>’ characters. The PSD should be updated removing the forbidden characters from the definition.

INFO: (3.1): No units attribute set. Please consider adding a units attribute for completeness.


variable: ncd, n

Explanation: section 3.1 of the CF conventions should give the explanation [*The `units` attribute is required for all variables that represent dimensional quantities [...]*]

Mitigation: The PSD 1.5 has already been updated and issued and data producers informed. The new PSD 1.6 includes a new definition of the flag_meaning attribute and the correct CF version 1.7. A new file generation is expected in accordance with the new PSD

4.4. ERS-2_ATSR_L3U

Number of files tested: 609 ERS-2_ATSR_L3U files have been tested out of the March 2003 processing (files have been chosen randomly). All reports are identical.

File name :	ESACCI-LST-L3U-LST-ATSR_2-20030308040801-fv1.00.nc	File Date 09/07/2019
		Origin : Jasmin
Report	 ESACCI-LST-L3U-LST-ATSR_2-20030308040801-fv1.00.nc.log.zip	
Summary:	<ul style="list-style-type: none"> ❖ ERRORS detected: 5 ❖ WARNINGS given: 0 ❖ INFORMATION messages: 2 	

Errors and explanations:

ERROR: (2.6.1): This netCDF file does not appear to contain CF Convention data.

Explanation: The files have been generated with CF version 1.8 (which is not officially released yet)

ERROR: (3.1): Invalid units: unitless

Explanation: section 3.1 of the CF conventions should give the explanation [*The `units` attribute is required for all variables that represent dimensional quantities [...]*]

ERROR: (3.5): Invalid syntax for 'flag_meanings' attribute

variable: lcc

Recommendation: The flag mask should be checked against section 3.5 of the convention documentation. According to the convention documentation, the flag_meanings should not contain ',' nor '>' characters.

INFO: (3.1): No units attribute set. Please consider adding a units attribute for completeness.


variable: ncd, n

Explanation: section 3.1 of the CF conventions should give the explanation [*The `units` attribute is required for all variables that represent dimensional quantities [...]*].

Mitigation: The PSD 1.5 has already been updated and issued and data producers informed. The new PSD 1.6 includes a new definition of the flag_meaning attribute and the correct CF version 1.7. A new file generation is expected in accordance with the new PSD

4.5. ENVISAT_ATSR_L2P

Number of files tested: 854 ENVISAT_ATSR_L2P files have been tested out of the years 2002, 2003, and July 2006 processing (files have been chosen randomly). All reports are identical.

File name :	ESALST-CCI-L2P-LST-ATSR_3-20060718015838-fv1.00.nc	File Date : 04/06/2019
		Origin : Jasmin
Report	 ESACCI-LST-L2P-LST-ATSR_3-20060718015838-fv1.00.nc.log.zip	
Summary: <ul style="list-style-type: none"> ❖ ERRORS detected: 4 ❖ WARNINGS given: 0 ❖ INFORMATION messages: 2 		

Errors and explanations:

ERROR: (2.6.1): This netCDF file does not appear to contain CF Convention data.

Explanation: The files have been generated with CF version 1.8 (which is not officially released yet).

ERROR: (3.1): Invalid units: unitless

Explanation: section 3.1 of the CF conventions should give the explanation [*The units attribute is required for all variables that represent dimensional quantities [...]*].

ERROR: (3.5): Invalid syntax for 'flag_meanings' attribute


variable: lcc

Recommendation: The flag mask should be checked against section 3.5 of the convention documentation. According to the convention documentation, the flag_meanings should not contain ',' nor '>' characters.

Mitigation: The PSD 1.5 has already been updated and issued and data producers informed. The new PSD 1.6 includes a new definition of the flag_meaning attribute and the correct CF version 1.7. A new file generation is expected in accordance with the new PSD

4.6. ENVISAT_ATSR__L3U

Number of files tested: 660 ENVISAT_ATSR_L3U files have been tested out of the February 2004 processing (files have been chosen randomly). All reports are identical.

File name :	ESACCI-LST-L3U-LST-ATSR_3-20040102010253-fv1.00.nc	File Date : 14/07/2019
		Origin : Jasmin
Report	 ESACCI-LST-L3U-LST-ATSR_3-20040102010253-fv1.00.nc.log.zip	
Summary:	<ul style="list-style-type: none"> ❖ ERRORS detected: 1 ❖ WARNINGS given: 0 ❖ INFORMATION messages: 2 	

Errors and explanations:

ERROR: (3.5): Invalid syntax for 'flag_meanings' attribute


variable: lcc

Recommendation: The flag mask should be checked against section 3.5 of the convention documentation. According to the convention documentation, the flag_meanings should not contain ',' nor '>' characters.

INFO: (3.1): No units attribute set. Please consider adding a units attribute for completeness.

variable: ncd, n

Explanation: section 3.1 of the CF conventions should give the explanation [*The units attribute is required for all variables that represent dimensional quantities [...]*].

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Mitigation: The PSD 1.5 has already been updated and issued and data producers informed. The new PSD 1.6 includes a new definition of the flag_meaning attribute and the correct CF version 1.7. A new file generation is expected in accordance with the new PSD

5. Conclusion

No blocking point identified: the NetCDF files could have been generated with respect to LST_cci format as described in PSD [RD-5], with minor discrepancies. The format errors raised with PSD 1.5 have been corrected in the PSD 1.6 and new files will be issued, except for the actual_range issue which is still under investigation.

The file format verification tests showed that the format is not 100% [NetCDF-4 / CF-1.7] compliant. Yet, the file format is mature enough to begin processing, although we recommend that corrections are made before the delivery of products to the CCI community. A new test campaign will be completed to check for full compliance before delivery of LST ECV products to the community.

Any modification will be reflected in the documentation, in particular in the PSD.

Table 3: tests results

Sample File name	File date	status	Number of Errors	Number of Warnings	Number of Information	Is blocking	mitigation
SEVIRI							
ESALST-CCI-L3U-LST-SEVIRI-20080101120000-fv1.00.nc	18/06/19	To be validated with new file generation	2	0	2	-	Generate a new file in accordance with latest PSD 1.6
Identical result for 107 tested files							

Microwave							
ESACCI-LST-L2P-LST-SSMI-F13-20080101101428-fv1.11.nc	17/07/19	Under investigation	4	0	0	Might break the processing chain if the verification is included in an automated process and false positive are detected	Under investigation
Identical result for 285 tested files							




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Sample File name	File date	status	Number of Errors	Number of Warnings	Number of Information	Is blocking	mitigation
MODIS							
ESALST-CCI-L3U-LST-MODIST-20091231000000-fv1.00.nc	31/05/19	To be validated with new file generation	5	0	2	-	Generate a new file in accordance with latest PSD 1.6
Identical result for 275 tested files							
ERS-2_ATSR_L3U							
ESALST-CCI-L2P-LST-ATSR_2-19951128023105-fv1.00.nc	31/05/19	To be validated with new file generation	4	0	2	-	Generate a new file in accordance with latest PSD 1.6
Identical result for 609 tested files							
ENVISAT_ATSR_L2P							
ESALST-CCI-L2P-LST-ATSR_3-20060718015838-fv1.00.nc	04/06/19	To be validated with new file generation	4	0	2	-	Generate a new file in accordance with latest PSD 1.6

	<p>LST CCI System Verification report</p> <p><i>WP3.2 – DEL-D3.3</i></p>	<p>Ref.: LST-CCI-D3.3-SVR</p> <p>Version: 1.1</p> <p>Date: 15/10/2019</p> <p>Page: 19</p>
---	--	---

Sample File name	File date	status	Number of Errors	Number of Warnings	Number of Information	Is blocking	mitigation
Identical result for 854 tested files							

ENVISAT_ATSR__L3U							
Sample File name	File date	status	Number of Errors	Number of Warnings	Number of Information	Is blocking	mitigation
ESACCI-LST-L3U-LST-ATSR_3-20040102010253-fv1.00.nc	14/07/19	To be validated with new file generation	1	0	2		Generate a new file in accordance with latest PSD 1.6
Identical result for 660 tested files							

6. Appendix A: Cfchecker log

This log is provided as example and is not part of the results reported in this document

```
CHECKING NetCDF FILE: /home/hnabedrik/lst_files/sofia//ESACCI-LST-L3U-LST-SEVIRI-20080115120000-  
fv1.00.nc
```

```
=====
```

```
Using CF Checker Version 3.1.1
```

```
Checking against CF Version CF-1.7
```

```
Using Standard Name Table Version 66 (2019-05-15T13:20:50Z)
```

```
Using Area Type Table Version 9 (07 August 2018)
```

```
Using Standardized Region Name Table Version 4 (18 December 2018)
```

```
ERROR: (2.6.1): This netCDF file does not appear to contain CF Convention data.
```

```
-----  
Checking variable: time
```

```
-----  
Checking variable: dtype
```

```
-----  
WARN: (2.4): space/time dimensions appear in incorrect order
```

```
-----  
Checking variable: lat
```

```
-----  
Checking variable: lon
```

```
-----  
Checking variable: satze
```

```
-----  
WARN: (2.4): space/time dimensions appear in incorrect order
```

```
-----  
Checking variable: sataz
```

```
-----  
WARN: (2.4): space/time dimensions appear in incorrect order
```

```
-----  
Checking variable: solze
```

```
-----  
WARN: (2.4): space/time dimensions appear in incorrect order
```

```
-----
```


Checking variable: solaz

WARN: (2.4): space/time dimensions appear in incorrect order

Checking variable: qual_flag

WARN: (2.4): space/time dimensions appear in incorrect order

Checking variable: domain_flag

WARN: (2.4): space/time dimensions appear in incorrect order

Checking variable: lst

WARN: (2.4): space/time dimensions appear in incorrect order

Checking variable: lst_uncertainty

WARN: (2.4): space/time dimensions appear in incorrect order

Checking variable: lst_unc_ran

WARN: (2.4): space/time dimensions appear in incorrect order

Checking variable: lst_unc_loc_atm

WARN: (2.4): space/time dimensions appear in incorrect order

Checking variable: lst_unc_loc_sfc

WARN: (2.4): space/time dimensions appear in incorrect order

Checking variable: lst_unc_sys

Checking variable: lcc

WARN: (2.4): space/time dimensions appear in incorrect order

ERROR: (3.5): Invalid syntax for 'flag_meanings' attribute

ERROR: (3.5): Number of flag_masks values must equal the number or words/phrases in flag_meanings

Checking variable: fv

WARN: (2.4): space/time dimensions appear in incorrect order
ERROR: (3.1): Invalid units: unitless

Checking variable: tcwv

WARN: (2.4): space/time dimensions appear in incorrect order

Checking variable: ndvi

WARN: (2.4): space/time dimensions appear in incorrect order
ERROR: (3.1): Invalid units: unitless

Checking variable: emis

WARN: (2.4): space/time dimensions appear in incorrect order
ERROR: (3.1): Invalid units: unitless

Checking variable: t2m

WARN: (2.4): space/time dimensions appear in incorrect order

Checking variable: sh2m

WARN: (2.4): space/time dimensions appear in incorrect order
ERROR: (3.1): Invalid units: unitless

Checking variable: ws2m

WARN: (2.4): space/time dimensions appear in incorrect order

Checking variable: n

WARN: (2.4): space/time dimensions appear in incorrect order
ERROR: (3.1): Invalid units: unitless

Checking variable: nclد

WARN: (2.4): space/time dimensions appear in incorrect order
ERROR: (3.1): Invalid units: unitless

Checking variable: lwm

WARN: (2.4): space/time dimensions appear in incorrect order
ERROR: (3.1): Invalid units: unitless

Checking variable: variance

WARN: (2.4): space/time dimensions appear in incorrect order

Checking variable: channel

INFO: attribute coordinates is being used in a non-standard way
INFO: attribute add_offset is being used in a non-standard way

ERRORS detected: 10

WARNINGS given: 24

INFORMATION messages: 2

End of document