EUMETSAT OSI SAF
OCEAN AND SEA ICE

Scientific Validation Report for Atlantic High Latitudes level 3 Radiative Flux products

OSI-301-c and OSI-302-c

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Document Change record

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2.0-draft	5.3	05-12-2019	Amélie Neuville	New document to report the validation of the OSI-301-b and OSI-302-b products
2.0	5.3	12-02-2020	Steinar Eastwood	Minor updates after ORR review.
2.1	5.4	14-01-2022	Steinar Eastwood	New document to report the validation of the OSI-301-c and OSI-302-c products
2.2	5.4	08-11-2022	Steinar Eastwood	Updates after ORR review

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1. Introduction

1.1. The EUMETSAT Ocean and Sea Ice SAF

The Satellite Application Facilities (SAFs) are dedicated centres of excellence for processing satellite data – hosted by a National Meteorological Service – which utilise specialist expertise from institutes based in Member States. EUMETSAT created Satellite Application Facilities (SAFs) to complement its Central Facilities capability in Darmstadt. The Ocean and Sea Ice Satellite Application Facility (OSI SAF) is one of eight EUMETSAT SAFs, which provide users with operational data and software products. More on SAFs can be read at www.eumetsat.int.

The objective of the OSI SAF is the operational near real-time production and distribution of a coherent set of information, derived from earth observation satellites, and characterising the ocean surface and the energy fluxes through it: sea surface temperature, radiative fluxes, wind vector and sea ice characteristics. For some variables, the OSI SAF is also aiming at providing long term data records for climate applications, based on reprocessing activities.

The radiative fluxes products includes longwave and shortwave downward irradiance at the surface. The longwave product is labelled Downward Longwave Irradiance (DLI) product, with identificator OSI-301-c. The shortwave product is labelled Surface Shortwave Irradiance (SSI) product, with identificator OSI-302-c. These two products replace the OSI-301 and OSI-302 products, motivated by algorithm improvements and new cloud mask (cf [RD.1]).

The OSI SAF consortium is hosted by Météo-France. The Atlantic High Latitude (AHL) radiative processing is performed at the High Latitude processing facility (HL centre), under the responsibility of the Norwegian Meteorological Institute.

1.2. Disclaimer

Note: The comments that we get from our users are important inputs when defining development activities and updates, and user feedback to the OSI SAF project team is highly valued.

Acknowledgement and citation

Use of these products should be acknowledged with the following citations:

OSI SAF (2022): Product User Manual for Atlantic High Latitude level 3 Radiative Flux, EUMETSAT SAF on Ocean and Sea Ice. https://osi-saf.eumetsat.int/products/radiative-fluxes-products

1.3. Scope of this document

The quality assessement of the OSI SAF OSI-301-c and OSI-302-c products is done before becoming an operational/pre-operational product distributed by the OSI SAF. This first assessement is explained in this scientific validation report. Then continuous monitoring of the product quality is done by

the OSI SAF team and presented in the half-yearly operations reports available on the OSI SAF web site project documentation.

1.4. Overview

The high latitude radiative flux products have been produced since 2002. In the start the products were merged with the low/mid latitude products for a complete Atlantic coverage. Since 2011 the high latitude products have been distributed separately, as OSI-301 for DLI and OSI-302 for SSI. OSI-301 and OSI-302 are daily products in 5km resolution, based on orbit data gridded to fixed tiles before cloud masking and processing.

The major changes for this update are:

- Including VIIRS data from S-NPP and NOAA-20
- Replacing Metop-A with Metop-C AVHRR data
- Replacing the cloud type product from PPS v2014 with v2021.

1.5. Target accuracy

The required accuracy of the Flux products are defined as monthly mean difference and standard deviation of the flux values compared with in situ measurements. Three requirement levels are defined in [AD.2].

- *Threshold* – The model user community gain no improved model performance using data of worse quality than this.
- *Target* – This is an intermediate quality level, between the two extremes (Threshold and Optimal), at which the product quality aim at.
- *Optimal* – The model user community can not gain from improvements in product quality beyond this level.

The validation of the OSI-301-b and OSI-302-b products will be compared with the target accuracy requirement.

	Treshold accuracy (%)		Target accuracy (%)		*Optimal accuracy* (%)	
	Mean diff	*Std*	Mean diff	Std	*Mean diff*	*Std*
DLI, OSI-301-c	*10*	*20*	5	10	*0*	*3*
SSI, OSI-302-c	*20*	*50*	10	30	*0*	*10*

Table 1: DLI and SSI quality requirements thresholds (from [AD.2]).

1.6. Reference and applicable documents

1.6.1. Reference documents

[RD.1] EUMETSAT OSI SAF
ATBD for Atlantic High Latitudes level 3 Radiative Flux products.
SAF/OSI/CDOP3/MET-Norway/SCI/MA/255, version 1.2, 05.11.2022

[RD.2] EUMETSAT OSI SAF
PUM for Atlantic High Latitudes level 3 Radiative Flux products.
SAF/OSI/CDOP3/MET-Norway/TEC/MA/373, version 2.1, 05.01.2022

[RD.3] EUMETSAT OSI SAF
Half-Yearly Operations report H1 2019
SAF/OSI/CDOP3/MF/TEC/RP/31, version 1.0, 04/09/2019

1.6.2. Applicable documents

[AD.1] EUMETSAT OSI SAF
Product Requirements Document
SAF/OSI/CDOP3/MF/MGT/PL/2-001, version 1.9, 31.12.2021

[AD.2] EUMETSAT OSI SAF
Service Specification Document
SAF/OSI/CDOP3/MF/MGT/PL/003, version 1.12, 31.12.2021

2. Validation data and method

The validation of the flux products OSI-301-c and OSI-302-c products is performed using a matchup data set containing in situ observations collocated with the satellite flux products in time and space.

The quality assessement is done against the target accuracy requirement defined in 1.5. The target accuracy corresponds to the desired preformance level (the breakthrough accuracy). If the values are not compliant to the target accuracy requirement, we consider that the product is still useful/useable as long as the values are compliant to the threshold requirement. The validation presented her is done for the period September 2021 to January 2022.

The validation results for the products OSI-301-b and OSI-302-b are also shown, for reference, as the «-c» products will replace the «-b» products. The period with overlapping production and available in situ observations is from 22.09.2021 to 10.01.2022. This is a relative short period for a validation exercise, but should be sufficient since no algorithm changes have been made, only changes in input data. Furthermore this period spans the complexity of creating these products at high latitudes by including the polar night.

2.1. In situ data

2.1.1. Station description

The stations used in this validation are owned and operated by the Norwegian Meteorological Institute, Norwegian Institute of Bioeconomy Research (NIBIO) and the Finnish Meteorological Institute (FMI). Data are received by email or through direct extraction from the authoritative data repository. Note that we plan to include more stations in our validation at a later stage.

There are some differences in the stations used for SSI validation compared to DLI. The reason for this is partly the observation programme at stations, but also that SSI validation is more sensitive to station characteristics than DLI.

All stations with available flux measurements are shown in the following table and those used for this quality assessment of the AHL flux products are marked « In use »:

Station	StId	Latitude	Longitude		Status
Apelsvoll	11500	60.70°N	10.87°E	SSI	In use
Løken	23500	61.12°N	9.07°E	SSI	Not used currently
Landvik	38140	58.33°N	8.52°E	SSI	In use
Særheim	44300	58.78°N	5.68°E	SSI	Not used currently
Fureneset	56420	61.30°N	5.05°E	SSI	In use
Tjøtta	76530	65.83°N	12.43°E	SSI	Not used currently
Holt	90400	69.67°N	18.93°E	SSI	In use
Bjørnøya	99710	74.52°N	19.02°E	SSI, DLI	In use, Arctic station with snow on ground much of the year.
Hopen	99720	76.51°N	25.01°E	SSI, DLI	Not used currently
Jan Mayen	99950	70.93°N	-8.67°E	SSI, DLI	In use, Arctic station with snow on ground much of the year, volcanic ash deteriorates instruments in periods.
Schleswig	10035	54.53°N	9.55°E	SSI, DLI	Not used currently
Hamburg-Fuhlsbuettel	10147	53.63°N	9.99°E	SSI, DLI	Not used currently
Jokioinen	1201	60.81°N	23.501°E	SSI, DLI	In use
Sodankylä	7501	67.37°N	26.63°E	SSI, DLI	In use, temporarily disabled for SSI validation. Problems likely to be connected with snow on ground.
Kiruna	02045	67.85°N	20.41°E	SSI, DLI	Not used currently
Visby	02091	57.68°N	18.35°E	SSI, DLI	Not used currently
Svenska Högarna	02492	59.45°N	19.51°E	SSI, DLI	Not used currently

Table 2: Validation stations that are currently used for AHL radiative fluxes quality assessment.

2.1.2. Computation of the daily in-situ radiative fluxes

We average the hourly station records to daily values. The station measurements may be disinterrupted, which lead to missing values. This usually happens during the night, but also during daytime. For each day, a linear interpolation was done to obtain those missing data, providing that at least 21 hourly data exist during this day. For SSI, days where hourly data are missing around the sunrise or sunset, are also rejected. The 24 hourly data per day are then averaged, so daily flux observation data are obtained.

2.1.3. List of the DLI stations and missing data

The pyrgeometer stations used for quality assessment of the AHL DLI product are selected stations from Table 2. The stations that are currently used are listed below.

- *Bjørnøya*
- *Jan Mayen*
- *Sodankylä*
- *Jokioinen*

2.1.4. List of the SSI stations

The pyranometer stations used for validation of the AHL SSI product are selected stations from Table 2. The stations that are currently used are listed below.

- *Bjørnøya*
- *Jan Mayen*
- *Jokioinen*
- *Apelsvoll*
- *Landvik*
- *Fureneset*
- *Holt*

2.2. Satellite data product

The radiative fluxes that are validated in this report, are retrieved from AVHRR and VIIRS data collected by Metop-B, Metop-C, S-NPP and NOAA-20 satellites between 22.09.2021 and 10.01.2022. The radiative fluxes are computed on the satellite swath for each satellite passage (method described in [RD.1]). These radiative flux products are then resampled to a polar stereographic map projection with 5 km grid resolution. During this gridding process only the data which have confidence levels as excellent, good or acceptable are kept. The map projected passage products are then averaged into daily products in the same map projection, i.e. the OSI SAF Atlantic High Latitude DLI (OSI-301-c) and SSI (OSI-302-c) products. These products are the ones validated below.

These products have been run with the PPS v2018 software, which is similar to the v2021 that will be used by OSI-301/2-c. The reason for this is that the release of PPS v2021 was delayed and was not released before mid November. The processing of OSI-301/2-c using PPS v2018 in parallel to OSI-301/2-b was done until end of 2021, after that OSI-301/2-c were using PPS v2021.

2.3. Validation method

For a given day of the validation period and a given observation station, averages of the satellite estimates (OSI-301-c and OSI-302-c) for the grid points located within a radius of 5km around the observation station are created. These daily values for the OSI SAF radiative fluxes are compared to the daily values observed for all stations.

The monthly statistics that are presented in Table 3 and Table 4 are for all stations together (ungrouped data statistics).

3. Validation results

3.1. Downward Longwave Irradiance validation results

The processing chains for OSI-301-c and OSI-301-b have been run in parallel and show very similar values in the daily products. The OSI-301-c chain has been run since 22-09-2021, with PPS v2018 cloud type as input up to end of 2021 and then with PPS v2021 as input since start of 2022. The input satellite data are the same for the runs with PPS v2018 and PPS v2021.

Table 3 provides the validation results for September 2021 to January 2022, with both the new product OSI-301-c and the old OSI-301-b. Typical examples of the three daily products from one day are shown in Figure 1 below. To illustrate the minor difference between PPS v2018 and PPS v2021, a typical cloud type product for the same segment from the two versions is shown in Figure 2.

As shown in Table Table 3, the OSI-301-c are within target requirement for both mean difference and standard deviation for all months. OSI-301-c has better score/higher margin than OSI-301-b for about half the months for both mean difference and standard deviation.

AHL DLI quality results for OSI-301-c Sep 2021 to Jan 2022						
Month	Number of cases	Mean DLI in Wm^{-2}	Mean diff. in Wm^{-2}	Mean diff. margin in % (*)	SD in Wm^{-2}	SD margin in % (**)
Sep 2021	34	314.41	-5.84	62.86	13.99	55.51
Oct 2021	122	299.65	-2.69	82.08	15.89	46.97
Nov 2021	110	269.70	0.74	94.48	17.28	35.94
Dec 2021	122	256.68	-3.05	76.20	18.08	29.55
Jan 2022	40	252.12	-2.32	81.60	21.21	15.88
AHL DLI quality results for OSI-301-b Sep 2021 to Jan 2022						
Sep 2021	34	314.41	-7.95	49.44	15.00	52.30
Oct 2021	122	299.65	-2.90	80.67	15.90	46.95
Nov 2021	110	269.70	-0.03	99.81	16.05	40.48
Dec 2021	122	256.68	-0.44	96.57	19.79	22.90
Jan 2022	40	252.12	-2.90	76.99	20.06	20.43

(*) Mean diff. margin = 100 * (1 - (|mean diff. in %/ mean diff. req. in %|))
with mean diff. in % = 100*Mean diff/Mean DLI
and mean diff. req. = 5 %
100 refers then to a perfect product, 0 to a quality just as required, without margin.
A negative result indicates that the product quality does not fulfil the requirement.

(**) SD margin = 100 * (1 - (SD / SD req.))

Table 3: OSI-301-c and OSI-301-b validation results from 21-09-2021 to 10-01-2022.

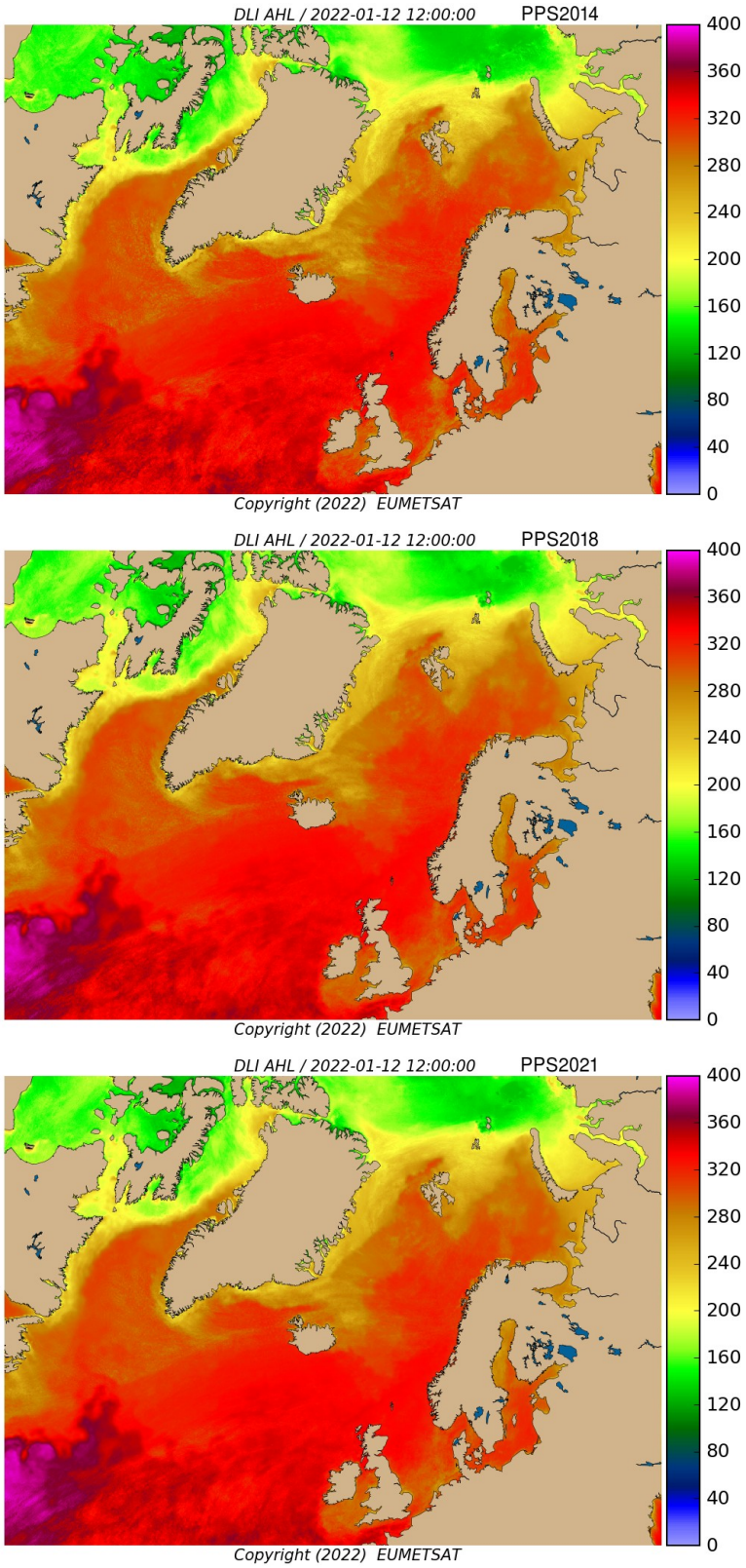

Figure 1: DLI from three different runs : OSI-301-b using PPS v2014 (top), OSI-301-c with v2018 (middle) and OSI-301-c with v2021 (bottom), all for 2022-01-12. The unit are W/m².

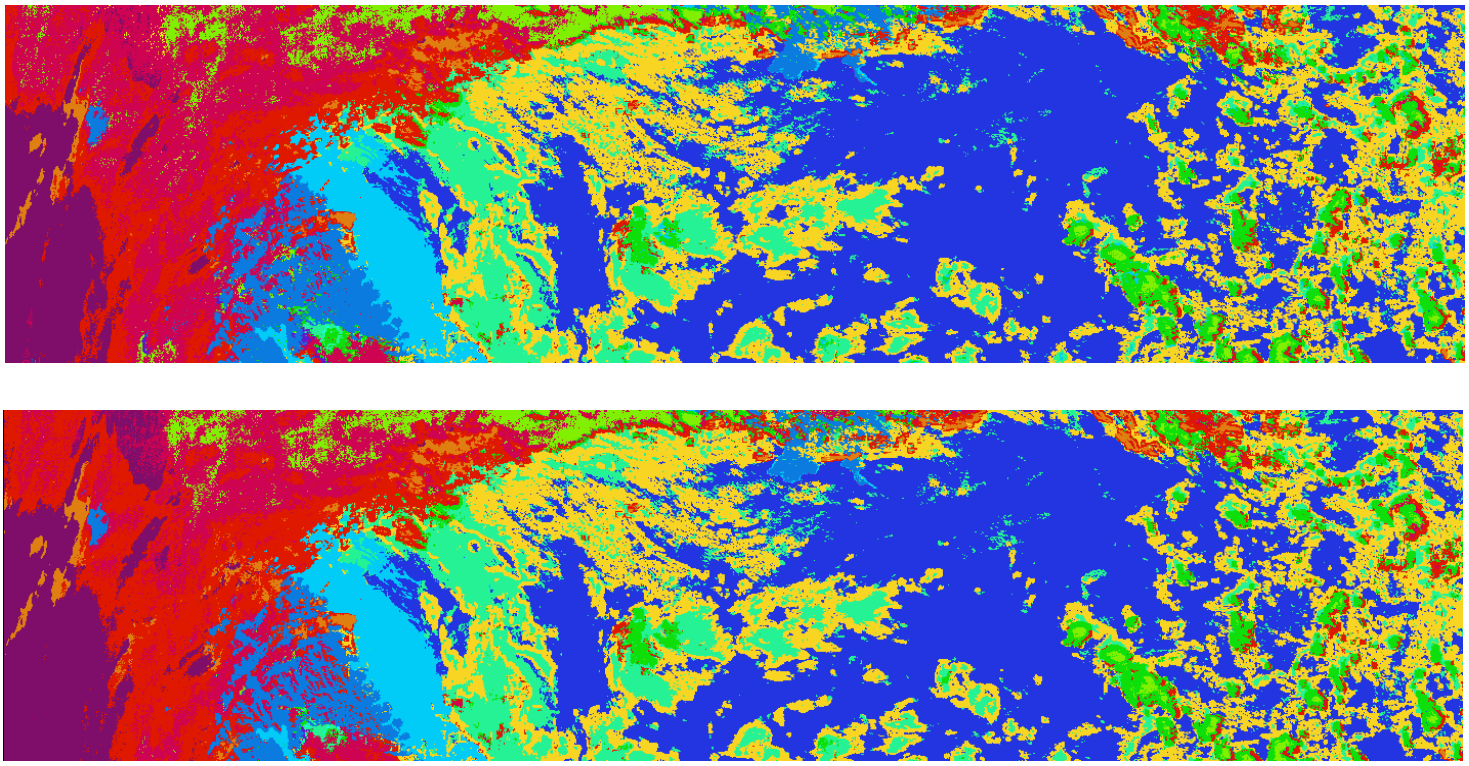

Figure 2 : Cloud type product from PPS v2018 (top) and PPS v2021 (bottom) for AVHRR Metop-B on 2022-02-17 11:36 UTC, between Greenland and Norway, just north of Iceland. The different colors represent the 14 different cloud type classes.

3.2. Surface Shortwave Irradiance validation results

The first validation of OSI-302-c was done on the same data as for OSI-301-c, and the results showed that there was a systematic difference between performance of AVHRR and VIIRS data. This identified a need to update the processing chain by intercalibrating the AVHRR and VIIRS visible data, as described in the ATBD [RD.1]. The validation results presented here for OSI-302-c are therefore for a different period than OSI-301-c. The period February – July 2022 has been used, which covers both winter and summer conditions.

Table 4 provides the validation results for February 2022 to July 2022, with both the new product OSI-302-c and the old OSI-302-b. Typical examples of daily products with the different inputs from one day are shown in Figure 3 and Figure 4 below.

As shown in Table 4, the OSI-302-c are within target requirement for mean difference in all month. For standard deviation OSI-302-c is within target requirement except February and March. OSI-301-c has better score/higher margin than OSI-301-b for all month except June, both for mean difference and standard deviation.

AHL SSI quality results for OSI-302-c Feb to Jul 2022							
Month	Number of cases	Mean SSI in Wm^{-2}	Mean diff. in Wm^{-2}	Mean diff. margin in % (*)		SD in Wm^{-2}	SD margin in % (**)
Feb 2022	142	37.37	-5.63	43.71		12.95	-15.51
Mar 2022	240	84.33	-5.81	41.86		26.2	-3.57
Apr 2022	238	152.16	-4.83	51.65		32.31	29.22
May 2022	246	187.52	-9.22	7.85		38.01	32.43
Jun 2022	238	206.96	4.64	53.57		51.91	16.39
Jul 2022	242	181.5	-0.6	94.05		32.59	40.16
AHL SSI quality results for OSI-302-b Feb to Jul 2022							
Feb 2022	135	30.13	-8.08	19.15		16.10	-40.46
Mar 2022	240	75.21	-9.11	8.86		29.72	-17.48
Apr 2022	238	141.14	-11.02	-10.20		33.16	27.36
May 2022	246	173.85	-13.67	-36.73		41.72	25.84
Jun 2022	238	209.88	2.92	70.85		51.38	17.25
Jul 2022	215	172.45	-1.1	88.95		34.86	32.62

(*) Mean diff. margin = 100 * (1 - (|mean diff. in %/ mean diff. req. in %|))
with mean diff. in % = 100*Mean diff/Mean SSI
and mean diff. req. = 10 %
100 refers then to a perfect product, 0 to a quality just as required, without margin.
A negative result indicates that the product quality does not fulfil the requirement.

(**) SD margin = 100 * (1 - (SD / SD req.))

Table 4: OSI-302-c and OSI-302-b validation results from 01-02-2022 to 31-07-2022.

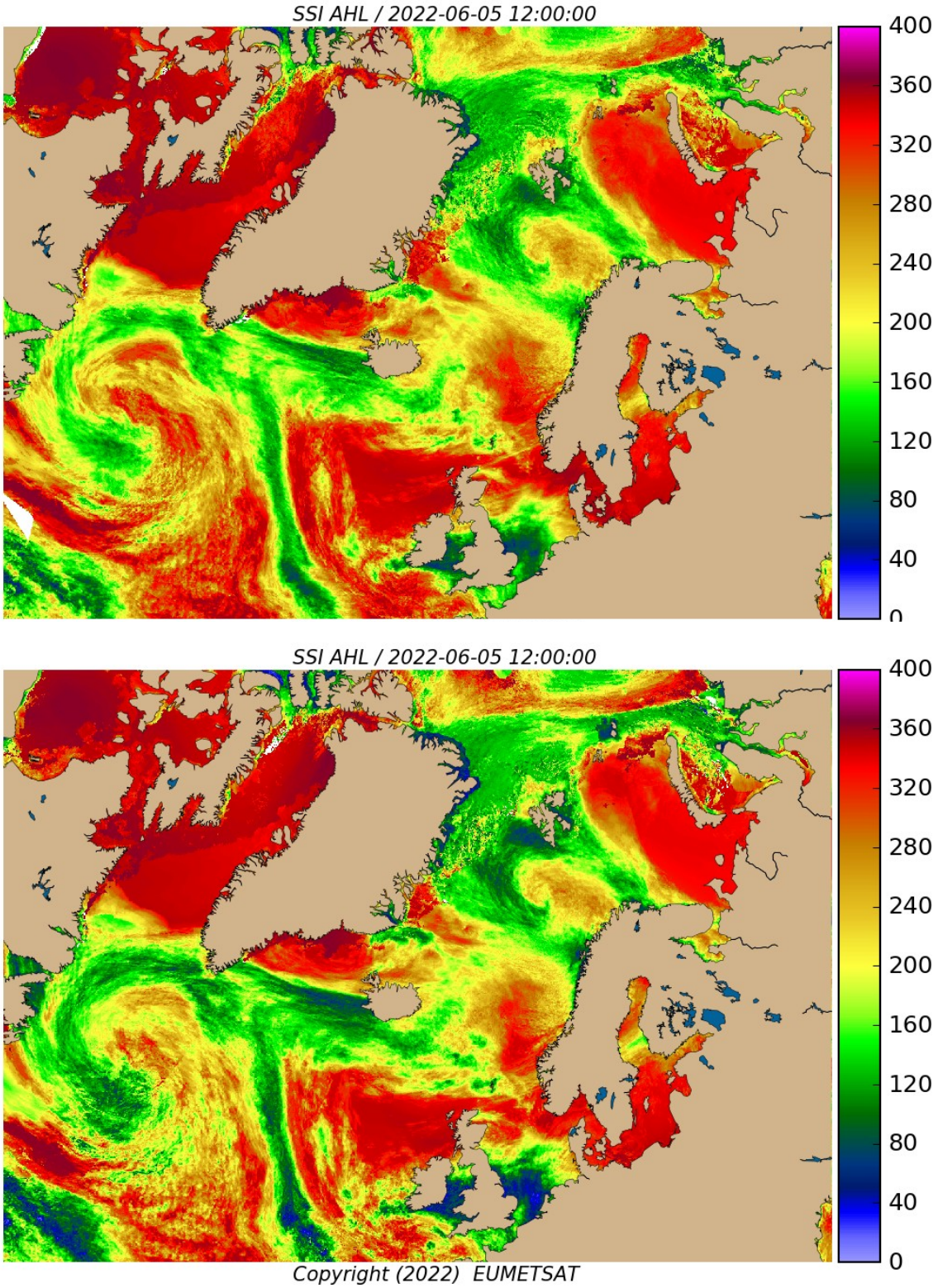

Figure 3: SSI from two different runs : OSI-302-c with v2018 (top) and OSI-302-b using PPS v2014 (bottom), all for 2022-06-05. The units are W/m².

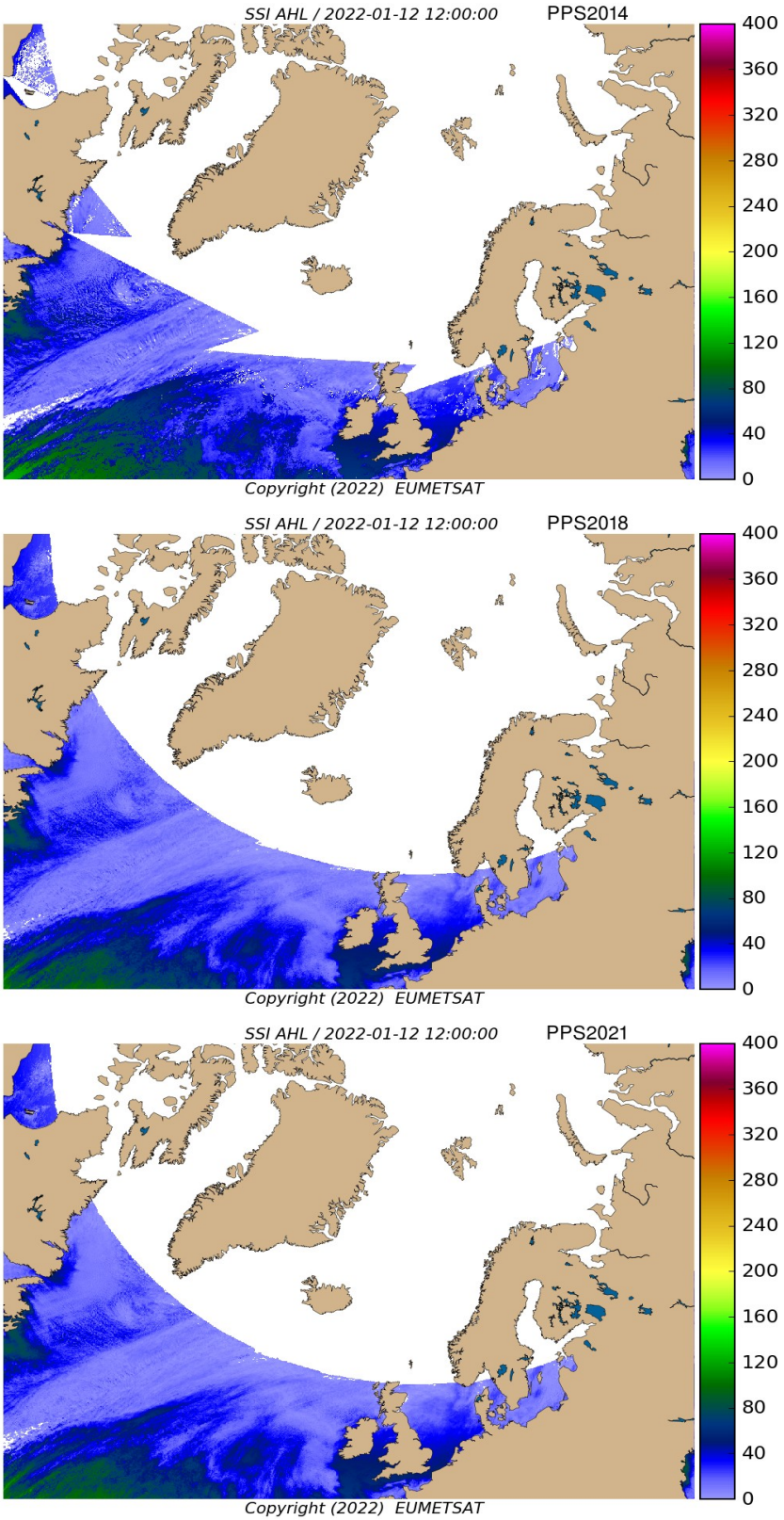

Figure 4: SSI (in W/m²) from three different runs: OSI-302-b using PPS v2014 (top), OSI-302-c with v2018 (middle) and OSI-302-c with v2021 (bottom), all for 2022-01-12.

4. Discussion

The main difference between the products that are compared in chapter 3 are the use of new satellite data (Metop-C, S-NPP and NOAA-20) and the change of PPS version for cloud type classification. Since Metop-A has been decomissioned in autumn 2021, the current operational product only uses Metop-B and NOAA-19. The addition of Metop-C, S-NPP and NOAA-20 will therefore give an increase in the number of available data. The effect of more available input data is not directly assessed, as the validation is done on the daily integrated product.

4.1. Downward Longwave Irradiance

As shown in 3.1 the DLI OSI-301-c product fulfils the target requirement for all months, both for mean difference and standard deviation. When the validation results of OSI-301-c product is compared to those of OSI-301-b product, the OSI-301-c product is better than OSI-301-b in about half of the months, and OSI-301-b better in the other half. This indicates that the two products are equally good, even though the validation period is not a full year.

4.2. Surface Shortwave Irradiance

As shown in 3.2 the SSI OSI-302-c product fulfils the target requirement for most of the months, both in mean difference and standard deviation. The OSI-302-c SSI also performs better than OSI-302-b for all months expect June. These results are for the period covering February to July 2022. This is not a full year that would be optimal for a product with a strong seasonal variability such as SSI, but it covers both winter, spring and summer months. Therefore, the validation period and results should be sufficient to conclude that the OSI-302-c is a better product than OSI-302-b.

Figure 4 also shows an improvement in the new product in terms of coverage. The SSI is only processed when the sun has lower sun zenith angle than 85 degrees (see RD.1). PPS v2014 is run with full orbit files, while PPS v2018 and v2021 with segmented files (granules). Due to a quality control step that rejects files with very few valid data for the daily gridding, some data around twilight are rejected. Less data are rejected when the granule input files are used, as in the new product, and the daily gridded SSI product gives a continuous circle where the input data reaches sun zenith angle of 85 degrees.

5. Conclusion

The OSI-301-c and OSI-302-c products have been validated and compared with the target requirement, as well as with the current operational OSI-301-b and OSI-302-b products. The overall validation results for OSI-301-c and OSI-302-c shows that they are of similar quality as OSI-301-b and OSI-302-b, respectively.

It is therefore suggested to replace OSI-301-b/OSI-302-b with OSI-301-c/OSI-302-c.

6. Annex

Validation tables for OSI-301-b and OSI-302-b for the full year of 2021 are recalled hereafter, for reference.

AHL DLI quality results for Jan to Dec 2021						
Month	Number of cases	Mean DLI in Wm^{-2}	Mean diff. in Wm^{-2}	Mean diff. margin in % (*)	SD in Wm^{-2}	SD margin in % (**)
JAN. 2021	152	266.50	-7.23	45.71	18.59	30.26
FEB. 2021	137	255.10	-6.09	52.24	19.03	25.41
MAR. 2021	147	259.42	2.76	78.72	18.09	30.26
APR. 2021	142	271.47	0.25	98.13	14.52	46.50
MAY 2021	151	286.44	-2.63	81.63	13.68	52.24
JUN. 2021	122	316.07	-8.46	46.44	19.58	38.06
JUL. 2021	137	333.43	-0.35	97.92	18.39	44.86
AUG. 2021	122	331.54	-3.28	80.23	14.65	55.80
SEP. 2021	118	313.04	-5.49	64.90	15.19	51.47
OCT. 2021	122	299.65	-2.90	80.67	15.90	46.95
NOV. 2021	118	272.14	-0.48	96.45	16.19	40.51
DEC. 2021	122	256.68	-0.44	96.57	19.79	22.90

(*) Mean diff. margin = 100 * (1 - (|mean diff. in %/ mean diff. req. in %|))
with mean diff. in % = 100*Mean diff/Mean DLI
and mean diff. req. = 5 %
100 refers then to a perfect product, 0 to a quality just as required, without margin.
A negative result indicates that the product quality does not fulfil the requirement.

(**) SD margin = 100 * (1 - (SD / SD req.))
with SD req. = 10%

Table 5: OSI-301-b (AHL DLI) validation results for Jan to Dec 2021.

AHL SSI quality results from Jan to Dec 2021						
Month	Number of cases	Mean SSI in Wm^{-2}	Mean diff. in Wm^{-2}	Mean diff. margin in % (*)	SD in Wm^{-2}	SD margin in % (**)
JAN. 2021	26	19.95	-4.44	-122.77	17.05	-184.80
FEB. 2021	121	34.64	-4.31	-24.45	18.44	-77.47
MAR. 2021	220	64.80	-11.79	-82.00	20.31	-4.50
APR. 2021	229	135.60	-7.76	42.78	38.46	5.45
MAY 2021	245	182.90	-11.83	35.35	42.07	23.32
JUN. 2021	218	197.19	1.00	94.93	36.23	38.76
JUL. 2021	210	192.92	4.43	77.06	40.08	30.75
AUG. 2021	215	141.93	1.73	87.83	32.95	22.62
SEP. 2021	208	75.13	-3.31	55.91	20.08	10.91
OCT. 2021	160	35.08	-2.63	24.98	12.20	-15.94
NOV. 2021	72	19.69	-4.53	-130.21	7.13	-20.65
DEC. 2021	-	-	-	-	-	-

(*) Mean diff. margin = 100 * (1 - (|mean diff. in %/ mean diff. req. in %|))
with mean diff. in % = 100*Mean diff/Mean DLI
and mean diff. req. = 10 %
100 refers then to a perfect product, 0 to a quality just as required, without margin.
A negative result indicates that the product quality does not fulfil the requirement.

(**) SD margin = 100 * (1 - (SD / SD req.))
with SD req. = 30%

Table 6: OSI-302-b (AHL SSI) validation results for Jan to Dec 2021.