EUMETSAT

OSI SAF

OCEAN AND SEA ICE

Scientific Validation Report for the Geostationary Satellite Radiative fluxes

GOES-16	OSI-305-b	OSI-306-b
Meteosat-11	OSI-303-a	OSI-304-a
Meteosat-8	OSI-IO-DLI	OSI-IO-SSI

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Document Change record

Document version	Date	Authors	Change description
0.1	31/10/2019	MF/CMS	Initial submitted version
1.0	19/02/2020	MF/CMS	Minor changes in Table 1 and [AD.1] date, in response to rids 08 and 09

Contents

1. Introduction

The EUMETSAT Satellite Application Facilities (SAFs) are dedicated centres of excellence for processing satellite data. They form an integral part of the distributed EUMETSAT ApplicationGround Segment. The Ocean and Sea Ice SAF, led by Météo-France/Centre de Météorologie Spatiale (MF/CMS), has the responsibility of developing, validating and distributing near real time products of Sea Surface Temperature, radiative fluxes, wind and Sea Ice for a variety of platforms/sensors.

In this context OSI SAF is processing radiative flux products from geostationary satellites from the EUMETSAT Meteosat Second Generation program and the US program of NASA and the National Oceanic and Atmospheric Administration (NOAA), Geostationary Operational Environment Satellite (GOES) in East position.

The radiative fluxes are the Surface Solar Irradiance (SSI) and the Downward Longwave Irradiance (DLI) The satellites presently used are GOES-16 located at 75°W, Meteosat-11 at 0° and Meteosat-8 at 41.5°E. The satellite and product characteristics are summarized in table 1. All products have a spatial sampling of 0.05° in latitude and longitude and two temporal frequencies, hourly and daily.

Product id	Product name	Satellite	Information	Spatial coverage
OSI-305-b	GOES-East DLI	GOES-16 *located at 75°W*	1st satellite of GOES Third Generation	135W -15W-60S-60N
OSI-306-b	GOES-East SSI			
OSI-303-a	Meteosat DLI	Meteosat-11 *located at 0°*	4th satellite of Meteosat Second Generation	60W-60E-60S-60N
OSI-304-a	Meteosat SSI			
OSI-IO-DLI	Meteosat IO DLI	Meteosat-8 *located at 41.5°E*	1st satellite of Meteosat Second Generation	19.5W-101.5E-60S-60N
OSI-IO-SSI	Meteosat IO SSI			

Table 1: satellites and products summary.

1.1. Purpose and scope of the document

This document is a scientific validation report for the OSI SAF geostationary radiative fluxes products. It follows an upgrade of the processing chain responsible for producing SST and radiative fluxes products. The upgrade of the chain mostly consisted in technical updates: the code is now using Python3 as the primary language, it is adapted to the new version of the dispatcher system used at Météo-France.

The intention of this report is to evaluate the quality of the OSI SAF geostationary products and their compliance with the product requirement of the third Continuous Development and Operation Phase (CDOP-3) which are summarized in table 2.

	Target accuracy		Threshold accuracy	
	Hourly product bias,SD	Daily product bias,SD	Hourly product bias,SD	Daily product bias,SD
SSI	10% , 30%	10% , 15%	20% , 50%	20% , 25%
DLI	5% , 10%	5% , 5%	10% , 20%	10% , 10%

Table 2: Threshold and target accuracies define respectively the lower limit of usefulness and the main reference for assessment at EUMETSAT. Bias is the monthly relative bias, SD the monthly relative standard deviation. Extracted from [AD.1].

This document is complemented by the Algorithm Theoretical Basis Document [RD.1] and the Product User Manual [RD.2]

1.2. Reference documents

[RD.1] Algorithm Theoretical Basis Document for the Geostationary Satellite Radiative Fluxes Version 1.0, 6 May 2019, SAF/OSI/CDOP3/MF/SCI/MA/343

[RD.2] Product User Manual for the Geostationary Satellite Radiative Fluxes SAF/OSI/CDOP3/MF/TEC/MA/182

1.3. Applicable documents

[AD.1] OSI SAF CDOP 3 Product Requirement Document, version 1.4, 20/12/2018 SAF/OSI/CDOP3/MF/MGT/PL/2-001

1.4. Acronyms

BSRN	Baseline Surface Radiation Network
CMS	Centre de Météorologie Spatiale
DLI	Downward Longwave Irradiance
CDOP	Continuous Development and Operation Phase
GOES	Geostationary Operational Environmental Satellite
GOES-E	GOES East
MDS	Match up Data Set
MF/CMS	Météo France/Centre de Météorologie Spatiale
MSG	Meteosat Second Generation
NOAA	National Oceanic and Atmospheric Administration
OSI SAF	Ocean and Sea Ice Satellite Application Facility
SAF	Satellite Application Facility
SD	Standard Deviation
SIRTA	Site Instrumental de Recherche par Télédétection Atmosphérique
SSI	Surface Solar Irradiance
SURFRAD	Surface Radiation Budget

2. Validation scheme summary

This section presents the main features of the validation scheme, a more detailed description is given in [RD.1]. The validation is based on Match-up Data Set (MDS) gathering coincident satellite data and in situ measurements, from pyranometer for shortwave flux or pyrgeometer for longwave flux. The measured flux in the MDSs is a value centered on the time of the satellite data, obtained from the original in situ data by integration or interpolation. The satellite flux in the MDBs is the average on a 9-pixel square box centered on the measurement station. The SSI or DLI error is defined as the satellite value minus measured value.

The validation stations belong to different networks, they are not well distributed in the area and some stations make their data available only after a long delay. Four subsets of stations, well distributed and producing data rather rapidly, have been selected for the routine validation of the SSI and DLI products. Theses subsets of stations are presented in figure 1 and listed in tables 3 and 4.

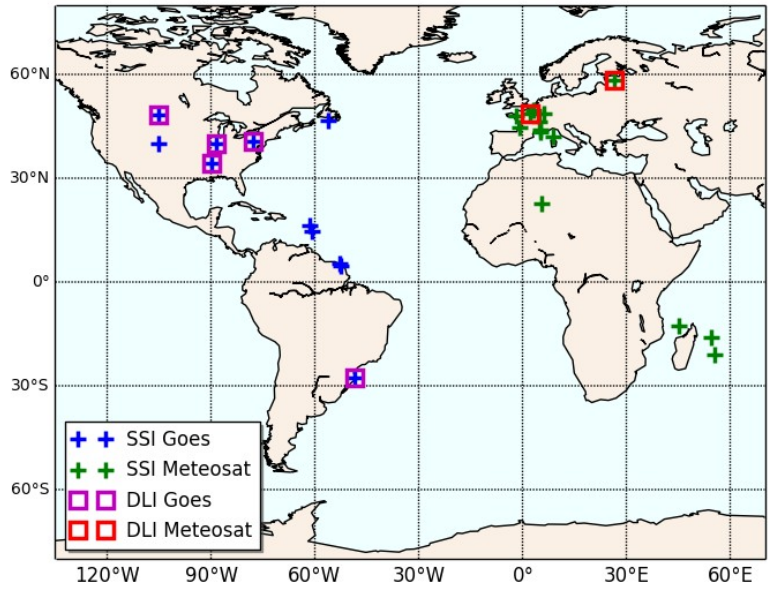

Figure 1: map of the measurement stations used to validate SSI and DLI in the present study

station name	*id*	*longitude*	*latitude*	*network*
Bondville_IL	bon	-88.37	40.05	SURFRAD
Goodwin_Creek_MS	gwn	-89.87	34.25	SURFRAD
Penn_State_PA	psu	-77.93	40.72	SURFRAD
Boulder_CO	tbl	-105.24	40.13	SURFRAD
Fort_Peck_MT	fpk	-105.10	48.31	SURFRAD
Le_Lamentin	lla	-61.00	14.59	METEOFRANCE
Kourou_CSG	kou	-52.77	5.19	METEOFRANCE
Le_Raizet	lra	-61.52	16.26	METEOFRANCE
Rochambeau	roc	-52.37	4.83	METEOFRANCE
Saint-Pierre	spr	-56.18	46.76	METEOFRANCE
Florianopolis	flo	-48.52	-27.53	BSRN

Table 3a: pyranometer stations used to validate GOES-16 SSI (called OGS subset)

station name	*id*	*longitude*	*latitude*	*network*
Tamanrasset	tam	5.51	22.78	BSRN
Toravere	tor	26.46	58.25	BSRN
Saint_Quentin	sqt	3.20	49.81	METEOFRANCE
Nancy	nan	6.22	48.68	METEOFRANCE
Rennes	ren	-1.71	48.06	METEOFRANCE
Macon	mac	4.79	46.29	METEOFRANCE
Bordeaux	bor	-0.68	44.83	METEOFRANCE
Marignane	mgn	5.21	43.45	METEOFRANCE
Ajaccio	aja	8.80	41.92	METEOFRANCE
Palaiseau	pal	2.21	48.71	SIRTA
Gillot_Aeroport	gla	55.53	-20.89	METEOFRANCE
Pamandzi_Aeroport	pmz	45.28	-12.81	METEOFRANCE

Table 3b: pyranometer stations used to validate Meteosat-11 and Meteosat-8 SSI (called OMS subset)

station name	id	longitude	latitude	network
Bondville_IL	bon	-88.37	40.05	SURFRAD
Goodwin_Creek_MS	gwn	-89.87	34.25	SURFRAD
Penn_State_PA	psu	-77.93	40.72	SURFRAD
Fort_Peck_MT	fpk	-105.10	48.31	SURFRAD
Desert_Rock_NV	dra	-116.02	36.63	SURFRAD
Florianopolis	flo	-48.52	-27.53	BSRN

Table 4a: pyrgeometer stations used to validate GOES-16 DLI (called OGD subset)

station name	id	longitude	latitude	network
Toravere	tor	26.46	58.25	BSRN
Palaiseau	pal	2.21	48.71	SIRTA

Table 4b: pyrgeometer stations used to validate Meteosat-11 and Meteosat-8 DLI (called OMD subset)

3. Validation results

The validation statistic presented here cover a 5-month time period, from 1 May to 30 September 2019. The statistics are computed on the validation subsets presented in section 2.

3.1. Overall statistics

The overall statistics are computed on the 5-month period, for each satellite. Table 4 present SSI statistics and table 5 DLI statistics. Meteosat-11 and Meteosat-8 results are rather close, they are obtained with satellites of the same series and on the same validations stations.

The hourly and daily SSI biases are rather low, ranging from -1.7% to 1.3% The hourly|daily SSI error standard deviation is higher for GOES-16, 17.9%|10.1%, than for Meteosat-11, 13.9%|6.8% and Meteosat-8, 14.4%|7.4%. This does not indicate a worse quality of GOES-16 product but is related to the validation stations more widely distributed geographically.

The DLI results are rather close for the three satellites . The hourly and daily DLI biases range from 0.2% to 2.4%, with higher values for Meteosat-11 and Meteosat-8, however only two stations are used these satellites. The DLI error standard deviation range from 4.1% to 5.2% (hourly products) and from 1.8% to 2.4% (daily products), with no significant differences between satellites.

		mean error		error std		mean flux	cor	nbc
GOES-16	hourly	-0.8	-0.2 %	82.9	17.9 %	462.1	0.955	30731
Meteosat-11	hourly	-6.7	-1.4 %	65.1	13.9 %	467.1	0.969	41201
Meteosat-8	hourly	-5.8	-1.2 %	67.7	14.4 %	469.1	0.967	41593
GOES-16	daily	2.7	1.3 %	21.3	10.1 %	211.2	0.958	688
Meteosat-11	daily	-3.9	-1.7 %	15.9	6.8 %	233.0	0.977	1727
Meteosat-8	daily	-3.3	-1.4 %	17.2	7.4 %	233.6	0.973	1748

Table 5: SSI validation statistics from 1 May to 30 September 2019. GOES-16 statistics are calculated with the OGS subset, Meteosat-11 and Meteosat-8 statistics with the OMS subset. The mean error and error standard deviation (“error std”) are expressed in Wm^{-2} and in percentage of the mean measure (“mean flux”, expressed in Wm^{-2}), “nbc” is the number of cases and “cor” is the correlation coefficient.

		mean error		error std		mean flux	cor	nbc
GOES-16	hourly	0.7	0.2 %	16.4	4.5 %	366.7	0.920	28572
Meteosat-11	hourly	5.1	1.5 %	13.9	4.1 %	335.7	0.918	11680
Meteosat-8	hourly	8.1	2.4 %	17.4	5.2 %	335.6	0.871	11615
GOES-16	daily	1.0	0.3 %	8.9	2.4 %	366.9	0.968	590
Meteosat-11	daily	5.2	1.5 %	6.0	1.8 %	335.6	0.975	246
Meteosat-8	daily	8.2	2.4 %	7.8	2.3 %	335.6	0.956	246

Table 6: DLI validation statistics from 1 May to 30 September 2019. Similar to table 5, but GOES-16 statistics are calculated with the OGD subset, Meteosat-11 and Meteosat-8 statistics with the OMD subset .

3.2. Temporal variations

Figures 2 to 5 show the temporal variations of the SSI and DLI validation statistics for the three satellites from 1 May to 30 September 2019. Data are missing during this period when the chain was running in test environment (various reasons are responsible due to the non-operational status of the chain). The most obvious problem is the missing 10-day period, July 21 to 31.

The temporal variations in figures 2 to 5 are not very important, but the studied period is only 5 months. Higher variations are commonly observed on a whole year.

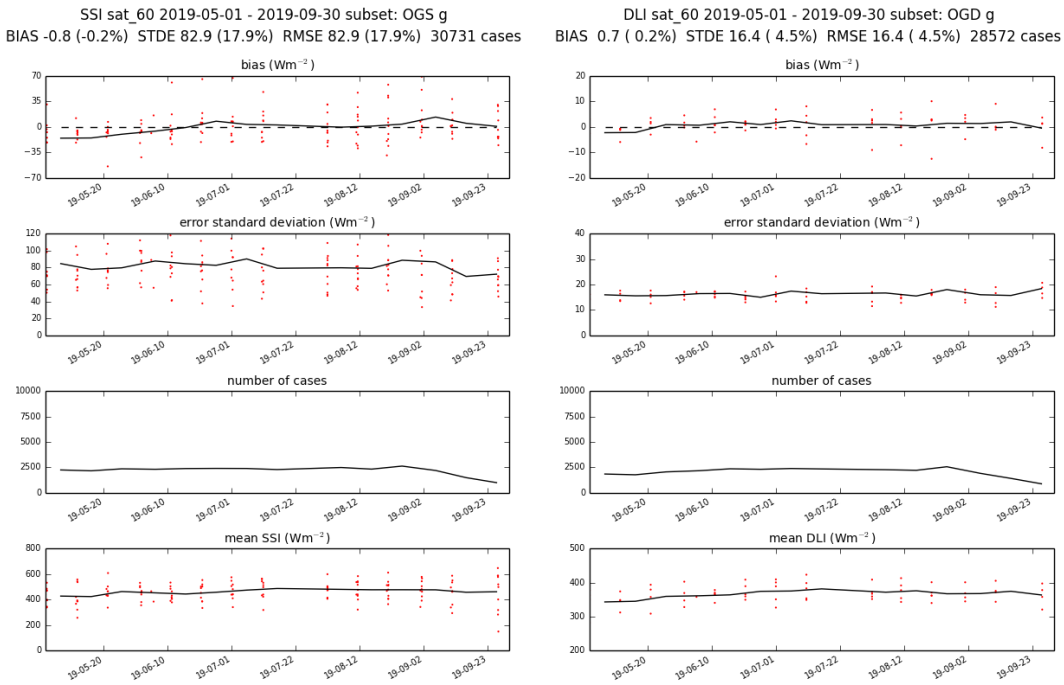

Figure 2: GOES-16 validation results for the hourly SSI (left) and for hourly DLI (right) from 1 May to 30 September 2019. The basic data of the validation are the differences between the satellite hourly SSI or DLI and the measured value. The plots present statistics calculated with a 10-day time step. The dots show the satistics for each station of the validation subset, the solid lines the statistics for the validation subset (OGS subset for SSI and OGD subset for DLI).

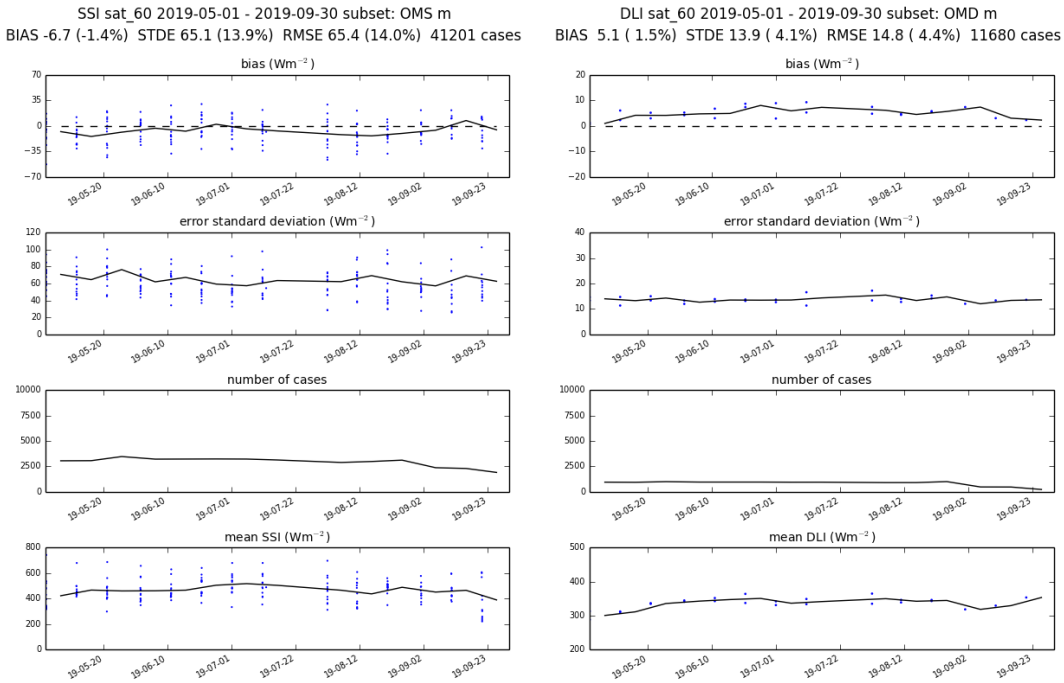

Figure 3: Meteosat-11 validation results for the hourly SSI (left) and for hourly DLI (right) from 1 May to 30 September 2019. Similar to figure 2, but using OMS subset for SSI and OMD subset for DLI.

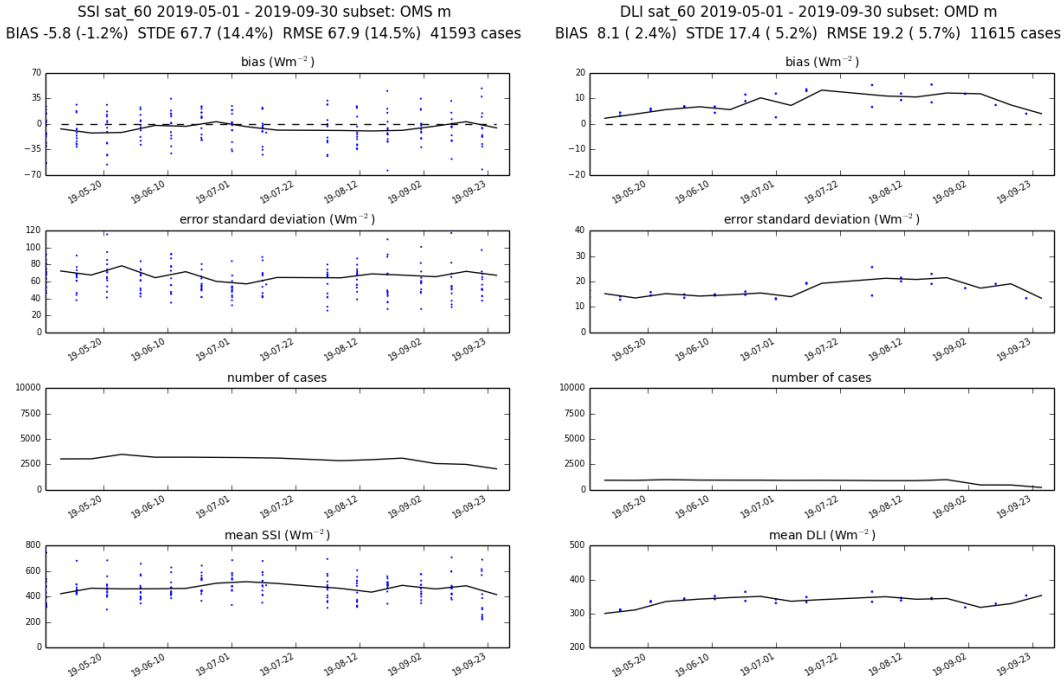

Figure 4: Meteosat-8 validation results for the hourly SSI (left) and for hourly DLI (right) from 1 May to 30 September 2019. Similar to figure 2, but using OMS subset for SSI and OMD subset for DLI.

3.3. Monthly statistics

	month	statistics on hourly products				statistics on daily products			
		bias	SD	flux	nbc	bias	SD	flux	nbc
GOES-16	2019-05	-3.1 %	18.4 %	438.7	6780	-4.0 %	10.1 %	213.4	155
GOES-16	2019-06	0.1 %	18.8 %	451.4	7110	2.2 %	9.9 %	199.2	145
GOES-16	2019-07	0.6 %	17.7 %	480.7	4687	4.3 %	9.5 %	208.1	97
GOES-16	2019-08	0.3 %	17.3 %	478.4	7455	2.6 %	9.5 %	216.2	185
GOES-16	2019-09	1.7 %	16.8 %	467.5	4699	2.8 %	9.1 %	218.6	106
Meteosat-11	2019-05	-2.3 %	15.8 %	450.3	9589	-2.5 %	7.8 %	227.9	389
Meteosat-11	2019-06	-0.6 %	13.2 %	477.5	9676	-0.7 %	6.1 %	251.4	387
Meteosat-11	2019-07	-1.1 %	11.8 %	511.0	6359	-1.2 %	5.3 %	267.1	256
Meteosat-11	2019-08	-2.6 %	13.9 %	464.1	8995	-3.0 %	6.8 %	227.3	382
Meteosat-11	2019-09	-0.3 %	14.5 %	438.1	6582	-0.7 %	7.8 %	195.5	313
Meteosat-8	2019-05	-2.3 %	16.3 %	450.1	9579	-2.5 %	8.3 %	227.9	389
Meteosat-8	2019-06	-0.2 %	13.8 %	476.8	9611	-0.3 %	6.4 %	251.4	387
Meteosat-8	2019-07	-1.2 %	12.0 %	510.2	6295	-1.3 %	5.6 %	265.0	248
Meteosat-8	2019-08	-2.0 %	14.5 %	462.7	8954	-2.3 %	7.5 %	227.5	383
Meteosat-8	2019-09	-0.4 %	15.0 %	455.9	7154	-0.7 %	8.6 %	203.7	341

Table 7: SSI monthly validation statistics from May to September 2019. GOES-16 statistics are calculated with the OGS subset, Meteosat-11 and Meteosat-8 statistics with the OMS subset. The mean error ("bias") and error standard deviation ("SD") are expressed in percentage of the mean measure ("flux"), "nbc" is the number of cases.

	month	statistics on hourly products				statistics on daily products			
		bias	SD	flux	nbc	bias	SD	flux	nbc
GOES-16	2019-05	-0.3 %	4.5 %	349.6	5688	-0.3 %	2.0 %	349.8	123
GOES-16	2019-06	0.3 %	4.4 %	366.6	6858	0.3 %	2.1 %	366.6	146
GOES-16	2019-07	0.4 %	4.5 %	378.4	4743	0.4 %	2.8 %	378.5	100
GOES-16	2019-08	0.2 %	4.5 %	371.4	7059	0.4 %	2.8 %	371.2	154
GOES-16	2019-09	0.3 %	4.4 %	369.1	4224	0.4 %	2.1 %	371.8	67
Meteosat-11	2019-05	1.0 %	4.4 %	315.9	2892	1.0 %	2.1 %	315.9	61
Meteosat-11	2019-06	1.7 %	3.8 %	346.7	2880	1.7 %	1.4 %	346.7	60
Meteosat-11	2019-07	1.9 %	4.1 %	338.7	1898	2.0 %	1.6 %	338.6	40
Meteosat-11	2019-08	1.6 %	4.2 %	345.4	2824	1.7 %	1.8 %	345.3	60
Meteosat-11	2019-09	1.4 %	4.0 %	329.4	1186	1.5 %	1.6 %	329.2	25
Meteosat-8	2019-05	1.2 %	4.7 %	315.9	2884	1.2 %	2.1 %	315.9	61
Meteosat-8	2019-06	2.2 %	4.3 %	346.7	2865	2.1 %	1.7 %	346.7	60
Meteosat-8	2019-07	3.0 %	5.1 %	338.6	1874	3.1 %	2.2 %	338.6	40
Meteosat-8	2019-08	3.3 %	6.1 %	345.4	2806	3.3 %	2.5 %	345.3	60
Meteosat-8	2019-09	2.6 %	5.4 %	329.4	1186	2.6 %	2.3 %	329.2	25

Table 8: DLI monthly validation statistics May to September 2019. GOES-16 statistics are calculated with the OGD subset, Meteosat-11 and Meteosat-8 statistics with the OMD subset. Same notations as in table 7.

Monthly statistics have been calculated in order to compare them with the accuracy requirements (table 2). These statistics fulfill the target accuracy requirements:

- SSI: in table 7, the mean error (absolute value) and error standard deviation of the hourly products are lower than 10% and 30%, respectively, and the same quantities of the daily products are lower than 10% and 15%
- DLI: in table 8, the mean error (absolute value) and error standard deviation of the hourly products are lower than 5% and 10%, respectively, and the same quantities of the daily products are lower than 5% and 5%

4. Conclusion

The OSI SAF radiative flux products of GOES-16, Meteosat-11 and Meteosat-8 have been validated against in situ data, with error statistics calculated on a 5-month period

Considering the overall statistics, the SSI and DLI results are satisfying with low mean errors. For the hourly products of GOES-16| Meteosat-11| Meteosat-8, the error standard deviations are 17.9%| 13.9%| 14.4% for the SSI and 4.5%| 4.1%| 5.2% for the DLI (expressed in percentage of the mean measure,

The monthly statistics fulfill the target accuracy requirements.