MVIRI/SEVIRI TOA Radiation Datasets within the Climate Monitoring SAF

Manon URBAIN, Nicolas CLERBAUX, Alessandro IPE, Edward BAUDREZ, Almudena VELAZQUEZ BLAZQUEZ, Johan MOREELS, Stijn NEVENS, Steven DEWITTE
Royal Meteorological Institute of Belgium, Department of Observations, Section Remote Sensing from Space, Avenue Circulaire 3, B-1180 Brussels, Belgium.
manon.urbain@meteo.be - Tel :+32.2.373.06.26

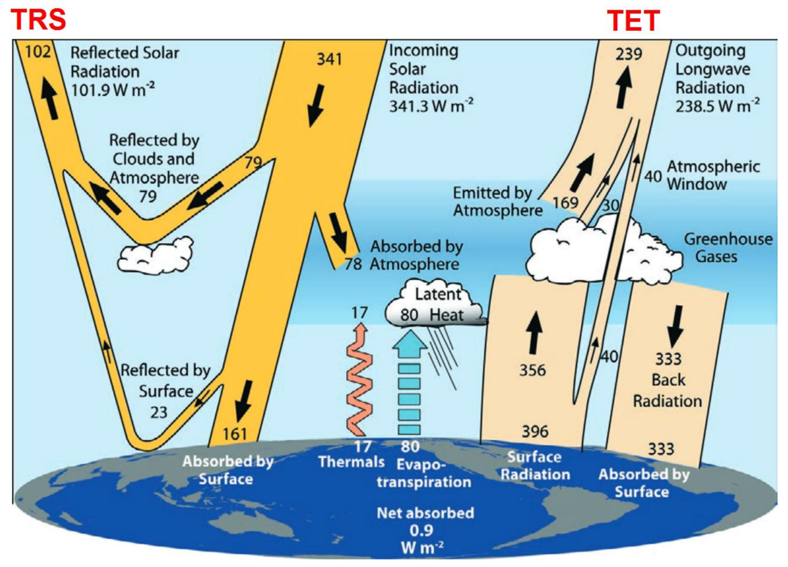
Abstract

Within CM SAF, Interim Climate Data Records (ICDR) of Top-Of-Atmosphere (TOA) radiation products from the Geostationary Earth Radiation Budget (GERB) instruments on the Meteosat Second Generation (MSG) satellites have been released in 2013. Since no GERB instruments were available on the Meteosat First Generation (MFG) satellites, they only cover the time period 2004-2011.

As an alternative, it is proposed to rely on the Meteosat Visible and InfraRed Imager (MVIRI - from 1983 until 2004) and the Spinning Enhanced Visible and Infrared Imager (SEVIRI - from 2004 onward) to generate a Thematic Climate Data Record (TCDR) from Meteosat instruments covering more than 30 years. Combining MVIRI and SEVIRI allows an unprecedented temporal (30min/15min) and spatial (2.5km/3km) resolution compared to the Clouds and the Earth's Radiant Energy System (CERES) products. This is a step forward as it helps to increase the knowledge of the diurnal cycle and the small-scale spatial variations of radiation.

The MVIRI/SEVIRI datasets (referred to as CM-23311 and CM-23341, resp. for shortwave (SW) and longwave (LW) radiation) will provide daily and monthly averaged TOA Reflected Solar (TRS) and Emitted Thermal (TET) radiation in "all-sky" conditions, as well as monthly averaged of the hourly integrated values. The SEVIRI Solar Channels Calibration (SSCC) has been used for the SW channels while the EUMETSAT/GSICS recalibration of MVIRI using HIRS and the SEVIRI operational calibration have been used for the LW channels. The CERES TRMM angular dependency models (ADMs) have been used to compute TRS fluxes while theoretical models have been used for TET fluxes.

Figure 1: The Earth Radiation Budget (Trenberth et al., 2009)



1. Requirements

Table 1 summarizes the user requirements in terms of stability and Table 2 in terms of accuracy.

Table 1: Stability requirements for CM-23311 and CM-23341

Products	Threshold	Target	Optimal
TRS all sky MM	4 W/m²/dec	0.6 W/m²/dec	0.3 W/m²/dec
TET all sky MM	4 W/m²/dec	0.6 W/m²/dec	0.3 W/m²/dec

Stability refers to the maximum acceptable change of the systematic error (primarily caused by switches of instrument and instrumental drift) from monthly mean products and over a period of 10 years.

Requirements referring to error:

- at 1 standard deviation (RMS error)
- at 1° x 1° scale
- taking only Viewing Zenith Angle (VZA) <60°
- does not include error (bias) due to the absolute calibration

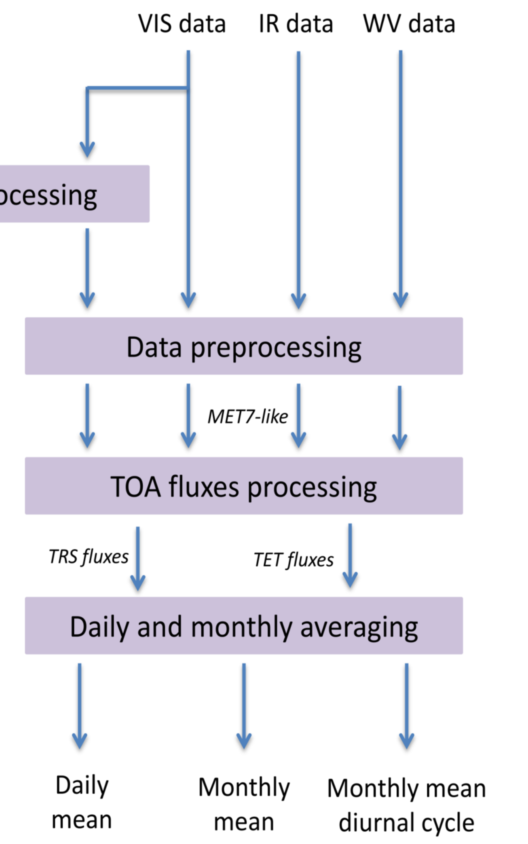
Table 2: Accuracy requirements for CM-23311 and CM-23341 and for the MM, DM and the MMDC

Products		Threshold	Target	Optimal
TRS CM-23311	MM	8 W/m²	4 W/m²	2 W/m²
	DM	16W/m²	8 W/m²	4 W/m²
	MMDC	16W/m²	8 W/m²	4 W/m²
TET CM-23341	MM	4 W/m²	2 W/m²	1 W/m²
	DM	8 W/m²	4 W/m²	2 W/m²
	MMDC	8 W/m²	4 W/m²	2 W/m²

2. Processing overview

- The **visible clear-sky processing** subsystem aims at generating the clear-sky visible data which are an important input for cloud detection and characterization. In those images, the cloud effect has been filtered by image processing techniques, based on series of input VIS images covering a period of 61 days around the day of interest.
- The **data preprocessing** subsystem performs several corrections of the input clear-sky visible, visible (VIS), water vapour (WV) and infrared (IR) data, such as calibration, ageing correction and conversion to equivalent Meteosat-7 (MET7-like) observations.
- In the **TOA fluxes processing**, the TRS and TET instantaneous radiative fluxes are generated at time of the imager acquisition from the MET7-like observations through various stages: a scene identification (performed only during daytime, i.e. for Solar Zenith Angle (SZA) < 80°), narrowband-to-broadband relations to "unfilter" the MET7-like radiances, and ADMs to convert broad-band radiances into fluxes.
- Finally, the **daily and monthly averaging** subsystem performs the averaging of the TRS and TET fluxes in hourly boxes, from which the daily mean (DM), monthly mean (MM) and monthly mean diurnal cycle (MMDC) are estimated. The data are then re-gridded from the geostationary grid onto a common regular grid with a spatial resolution of (0.05°)² (consistent with other CM SAF products).

Figure 2: Processing flowchart



3. Products features

Covered period	32 years, from 1 February 1983 to 31 January 2015.
VIS ageing correction	Coarse correction of the MVIRI and SEVIRI ageing using SSCC and J.F. Meirink (KNMI) latest calibration slopes updates.
Spectral response correction	MET7-like VIS, WV and IR channels are simulated using regressions from narrowband channels which are theoretical for MVIRI and empirical for SEVIRI.
Unfiltering (NB→BB)	Empirical narrowband-to-broadband regressions are used to "unfilter" the MET7-like channel observations. GERB is used "off-line" to tune the regressions.
Fluxes computation (ADM)	Using CERES TRMM ADMs for the TRS and theoretical models for the TET.
Output quantities	TRS and TET fluxes in "all sky" conditions (no clear-sky fluxes datasets in this first version of the datasets).
Temporal characteristics	Fluxes provided as DM, MM and MMDC.
Spatial Resolution	Datasets provided on a regular lat-lon grid with a spatial resolution of (0.05°)², i.e., about (5.5 km)².
Validation	Validation performed at lower resolution (e.g. 1°x1°) by intercomparison with several other datasets (CERES EBAF, CERES SYN 1deg-day, HIRS NCDC OLR, ISCCP FD-TOA, etc.).
Format	A NetCDF file format following the CF convention.

4. Results

➢ MM product: Comparison with CERES EBAF Ed2.8

As an example, Figure 3 gives an insight on the CM SAF MM accuracy at a 1°x1° spatial scale for TRS (left) and TET (right) by comparing with CERES EBAF Ed 2.8. Mean values, RMS errors and standard deviations are shown (region 50°S-50°N-50°E-50°W).

Figure 3: Comparison of June 2002 MM TRS (left) and TET (right) fluxes from MET-7 CM SAF and CERES EBAF

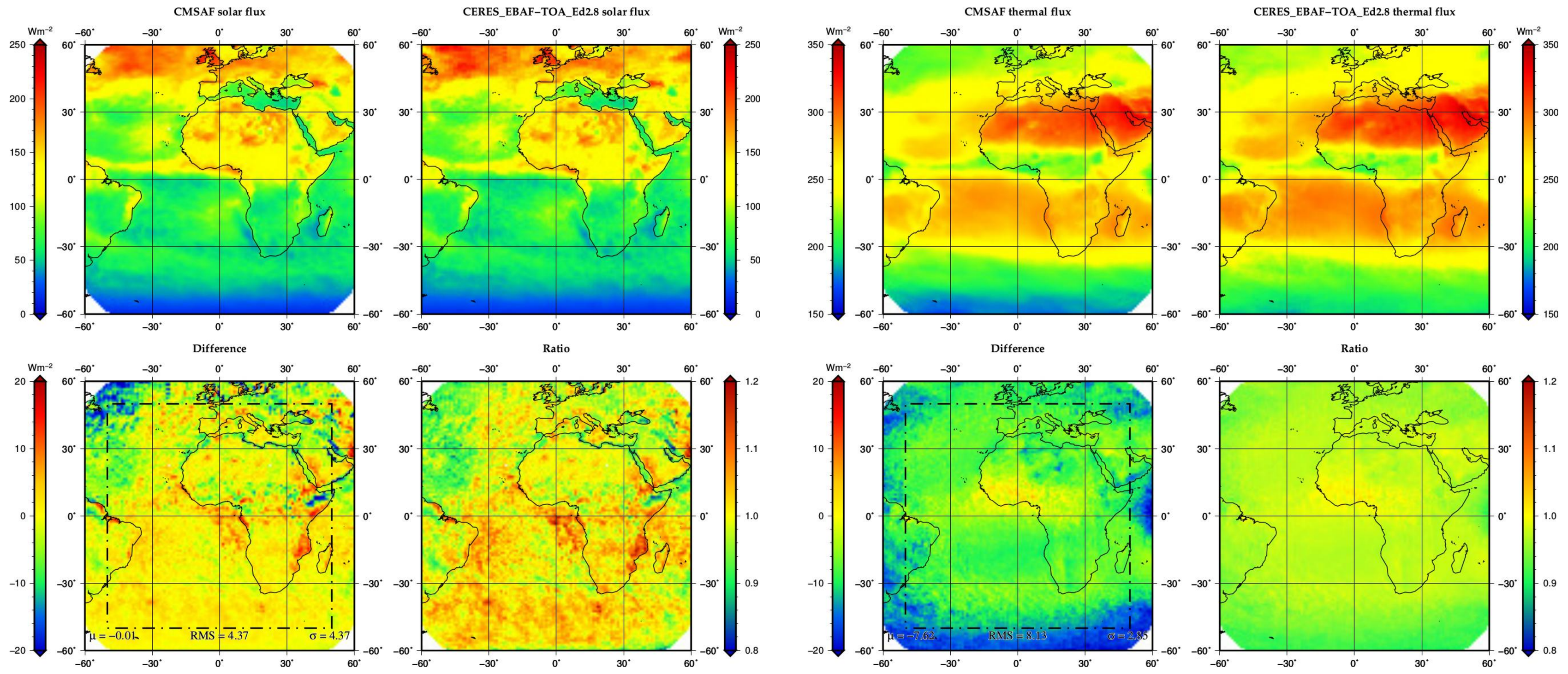


Figure 4 shows the temporal evolution of the residual RMS difference (bias corrected) w.r.t. CERES EBAF Ed 2.8. Average levels (red dotted lines) are consistent with the threshold accuracy for the TET and even with the target for the TRS.

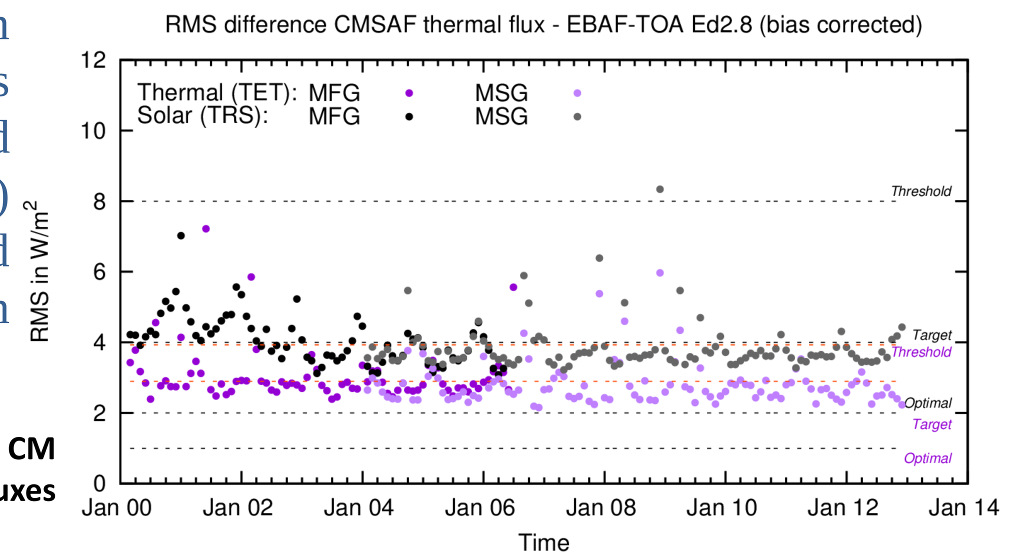


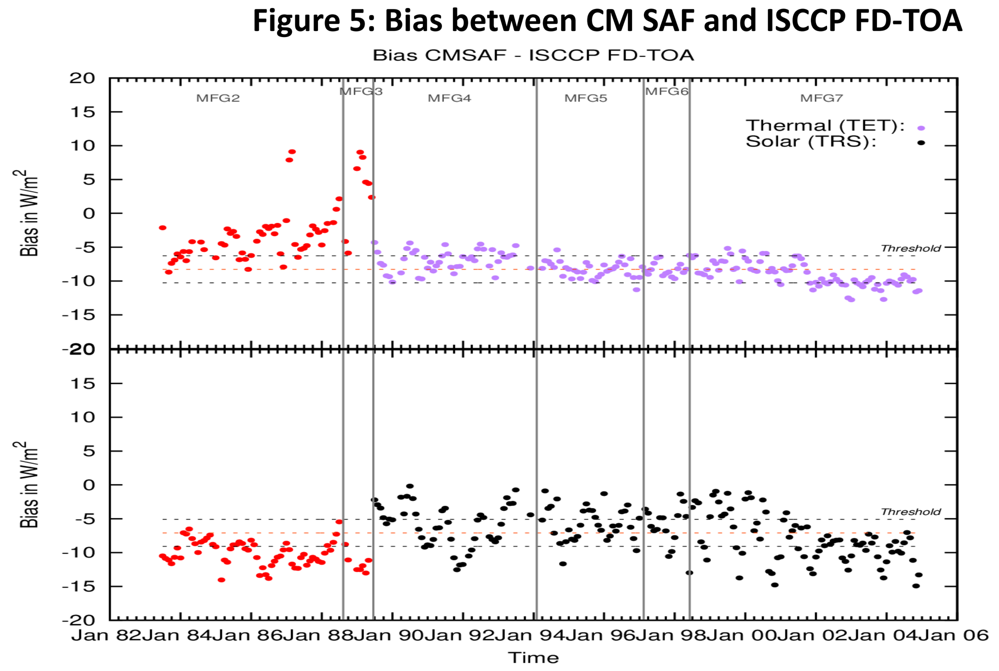
Figure 4: RMS (bias corrected) between CM SAF and CERES EBAF MM fluxes

➢ MM product: Temporal stability w.r.t ISCCP FD-TOA

Figure 5 shows the temporal evolution of the overall bias w.r.t. ISCCP FD-TOA. This gives an insight into the stability of the CM SAF MM product at a 1°x1° spatial scale.

Since the EUMETSAT recalibration of MVIRI using HIRS is not available yet for MFG2 and MFG3 (red dots), the operational calibration has been used meanwhile but shows obvious problems.

Figure 5: Bias between CM SAF and ISCCP FD-TOA



➢ DM product: Comparison with CERES SYN1deg-day

Figure 6 shows the temporal evolution of the residual RMS difference (bias corrected) w.r.t. CERES SYN1deg-day. Average levels (red dotted lines) are consistent with the threshold accuracy for the TET and even with the target for the TRS.

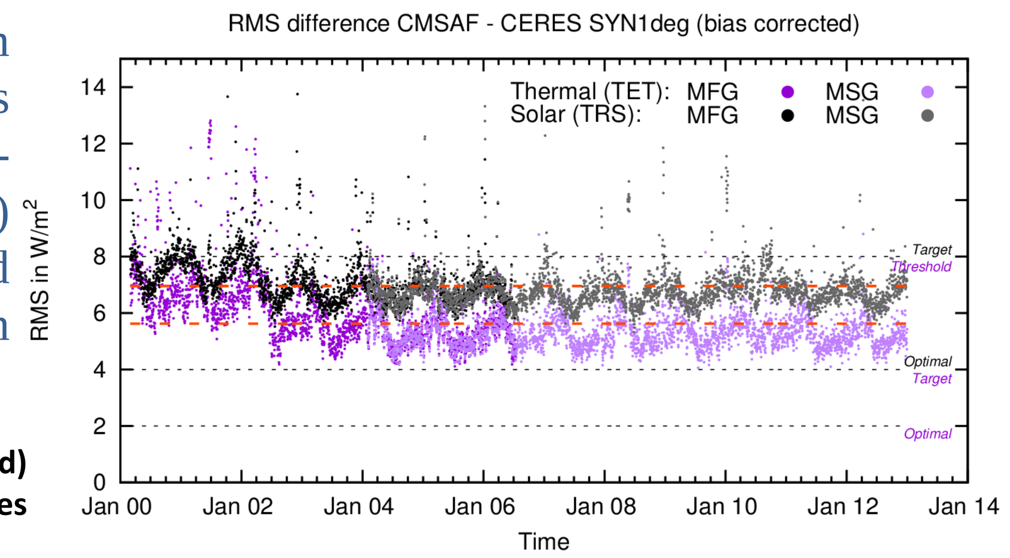


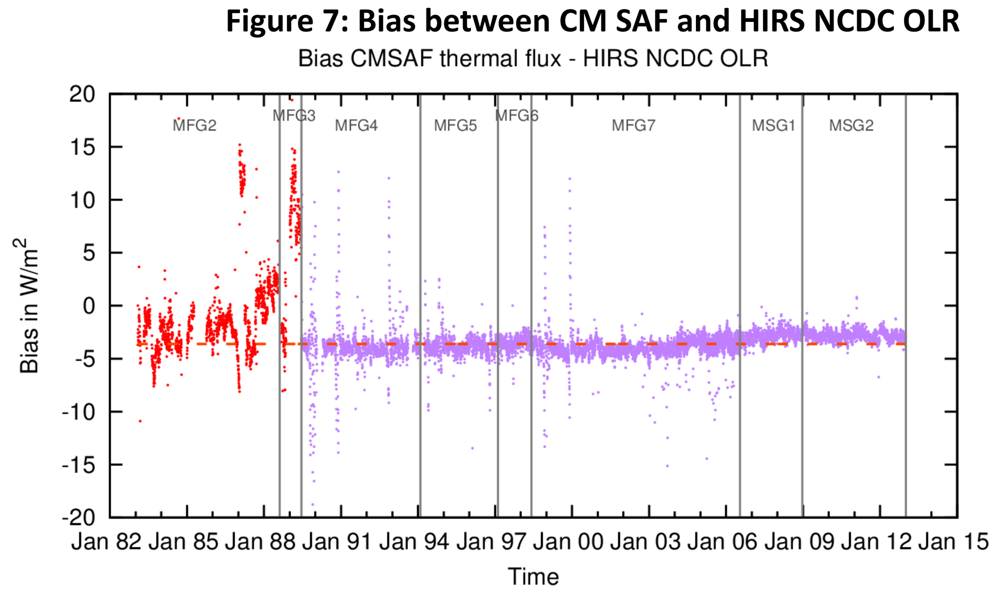
Figure 6: RMS (bias corrected) between CM SAF and CERES SYN1deg-day fluxes

➢ DM product: Temporal stability w.r.t HIRS NCDC OLR

Figure 7 shows the temporal evolution of the overall bias between CM SAF DM TET products and HIRS NCDC OLR. This gives an insight into the stability of the CM SAF DM TET product at a 1°x1° spatial scale.

Again, the (problematic) operational calibration has been used for MFG2 and MFG3 (red dots).

Figure 7: Bias between CM SAF and HIRS NCDC OLR



➢ MMDC product : upcoming

5. Discussion

In view of this preliminary validation, it is expected that the MM and DM products will fulfill the threshold accuracy requirements for the TET and even the target accuracy requirements for the TRS. In terms of stability, the threshold requirements seem feasible for the TET, however further investigation is needed for the TRS. Forthcoming validation activities will consolidate these results and consider the MMDC products. Improvements are expected for MGF2 and MFG3 once the EUMETSAT/GSICS recalibration of MVIRI using HIRS will be available.