MVIRI/SEVIRI TOA Radiation Datasets within the Climate Monitoring SAF

M. Urbain, N. Clerbaux, A. Ipe, E. Baudrez, A. Velazquez Blazquez, S. Nevens, S. 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, datasets 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 1982 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 (30 minutes) and spatial resolution (2.5km/3km) 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 variations in these fluxes and their small-scale spatial variations.

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) and the operational calibration have been used resp. for the SW and LW channels. It is foreseen to replace the latter by the EUMETSAT/GSICS recalibration of MVIRI using HIRS and the GSICS recalibration of SEVIRI using IASI. The CERES TRMM angular dependency models (ADMs) have been used to compute TRS fluxes while theoretical models are used for TET fluxes.

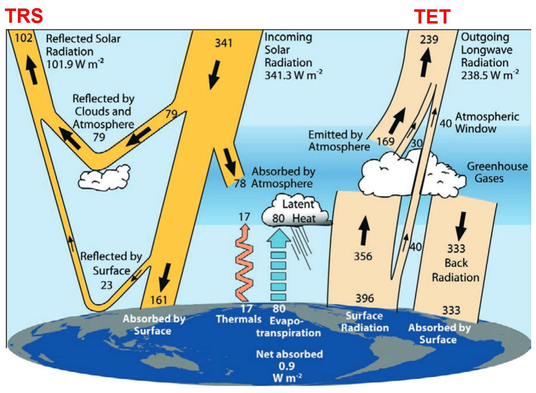

Figure 1: The Earth Radiation Budget (Trenberth et al., 2009)

1. Requirements

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

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 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

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 (CS VIS) 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 (CS VIS), 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 broadband 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).

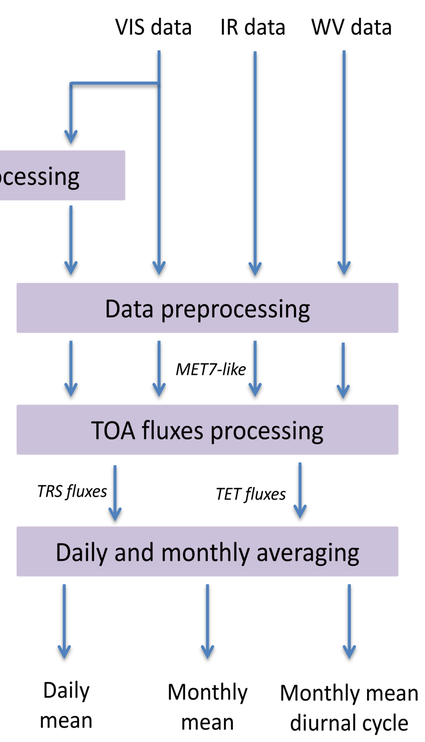

Figure 2: Processing flowchart

3. Products features

Covered period	32 years, from 1 February 1982 to 31 January 2014.
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 OLR, ISCCP-FD, NCDC daily OLR, etc.).
Format	A NetCDF file format following the CF convention.

4. Preliminary results

➢ Comparison with CERES EBAF Ed2.8

As an example, Figure 3 gives the comparison for June 2000 between Meteosat-7 CM SAF and CERES EBAF Ed 2.8 for TRS (left) and TET (right) MM fluxes. Mean values, RMS errors and standard deviations are shown (region 50°S-50°N-50°E-50°W). This gives a preliminary insight on the CM SAF MM accuracy at 1°x1° spatial scale.

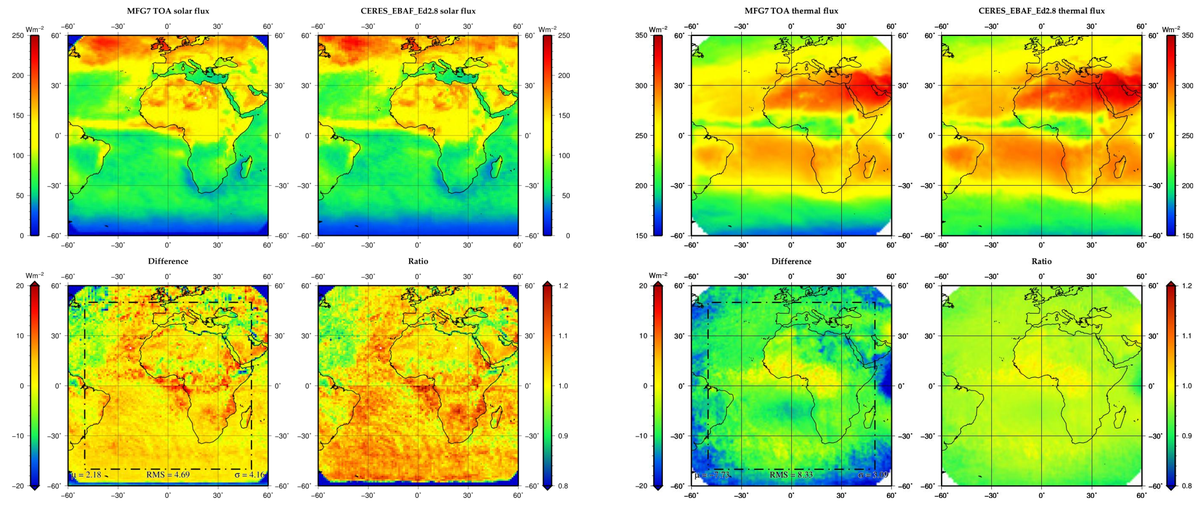

Figure 3: Comparison of June 2000 MM TRS (left) and TET (right) fluxes from MET-7 CM SAF and CERES EBAF

➢ Temporal stability with respect to CERES EBAF Ed2.8

Figure 4 shows the all-sky bias between the TRS and TET MM products and CERES EBAF Ed 2.8 for the months of June from 2000 to 2006. Variation of the bias is consistent with a stability of 2.5 W/m² for both TRS and TET fluxes.

NB: GERB-2 SW channel calibration update included.

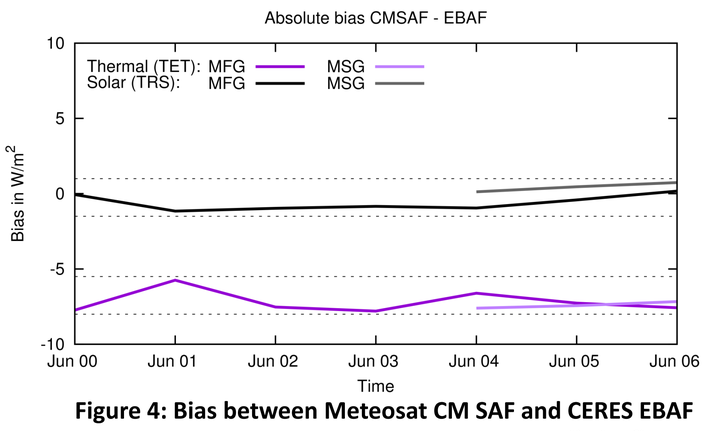

Figure 4: Bias between Meteosat CM SAF and CERES EBAF MM all-sky fluxes

➢ Overall time series stability on main surface types

The TOA fluxes processing has been applied in a CS mode to process the 12 UTC repeat cycle over the full dataset. Figure 5 shows the time series of the CS TRS fluxes averaged over 5 scene types.

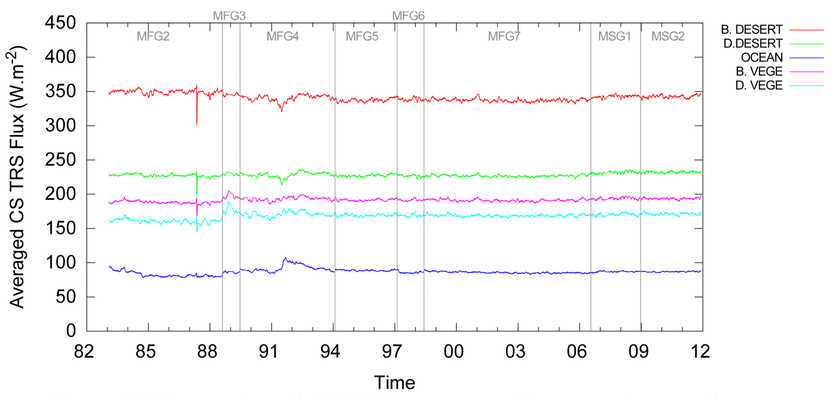

Figure 5: Time series of CS TRS fluxes according to various surface types

Figure 6 gives the 12 UTC all-sky TRS fluxes for "deep convective clouds" (DCC), i.e. the percentile 99.5% over the whole Meteosat disk. Resulting fluxes have been smoothed by taking the local mean from inside a moving window of 60 days.

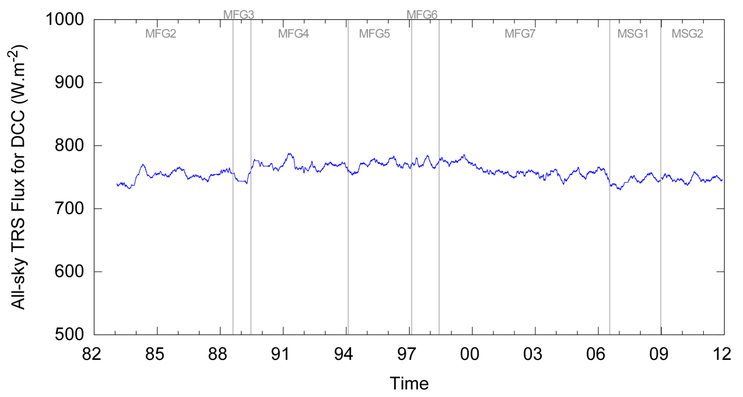

Figure 6: Time series of the all-sky TRS fluxes for "DCC"

5. Discussion

In view of the comparison with CERES EBAF, it is expected that the MM products will fulfill the threshold accuracy and also likely the target accuracy requirements. Forthcoming validation activities will consolidate these first results and also consider the DM and MMDC products. In terms of stability, the target requirement will most likely not be met, at least for the MFG era, but the threshold requirement seems feasible for both MFG and MSG eras. The merging of MFG and MSG data seems not introduce a discontinuity in the TET data record (similar bias of about -7.5 W/m² are observed for Met-7 and Met-8) as well as in the TRS data record (similar bias of about -0.5 W/m²).

Obviously, improvements of the stability are expected once the recalibration of the MVIRI WV and IR channel recalibration will be available.