Meteosat MVIRI/SEVIRI TOA radiation data records within the Climate Monitoring SAF

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Introduction

TOA radiation in CM SAF

- Operational GERB EDR product (since 2004)
- GERB/SEVIRI dataset ed01
- Meteosat (MVIRI/SEVIRI) datasets ed01
- GERB/SEVIRI dataset ed02
- TOA radiation in CLARA-A3 (AVHRR)

- Generation of a TCDR from Meteosat instruments covering more than 30 years
- An unprecedented temporal (30min/15min) and spatial (2.5km/3km) resolution (compared to other ERB products)
- A better knowledge of the diurnal cycle and the small-scale spatial variations of radiation

<table>
<thead>
<tr>
<th>CM SAF identifier</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM-23311</td>
<td>TOA Reflected Solar radiative flux All Sky (TRS_AS)</td>
</tr>
<tr>
<td>CM-23341</td>
<td>TOA Emitted Thermal radiative flux All Sky (TET_AS)</td>
</tr>
</tbody>
</table>
### Main products features

<table>
<thead>
<tr>
<th>Covered period</th>
<th>32 years → from 1 February 1983 to 31 January 2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output quantities</td>
<td>TRS and TET fluxes in all-sky conditions → TIS provided as ancillary field of the TRS product</td>
</tr>
<tr>
<td>Temporal characteristics</td>
<td>Fluxes provided as Daily Mean (DM), Monthly Mean (MM) and Monthly Mean Diurnal Cycle (MMDC, 24 hourly intervals)</td>
</tr>
<tr>
<td>Spatial resolution</td>
<td>Data records provided on a regular grid with a spatial resolution of $(0.05°)^2$, i.e., about $(5.5 \text{ km})^2$ at sub-satellite point</td>
</tr>
<tr>
<td>Format</td>
<td>NetCDF file format following the CF convention</td>
</tr>
</tbody>
</table>
User requirements

Stability requirements for CM-23311 and CM-23341

<table>
<thead>
<tr>
<th>Products</th>
<th>Threshold</th>
<th>Target</th>
<th>Optimal</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRS all sky MM</td>
<td>4 W/m²/dec</td>
<td>0.6 W/m²/dec</td>
<td>0.3 W/m²/dec</td>
</tr>
<tr>
<td>TET all sky MM</td>
<td>4 W/m²/dec</td>
<td>0.6 W/m²/dec</td>
<td>0.3 W/m²/dec</td>
</tr>
</tbody>
</table>

- Maximum acceptable change (max-min) of the systematic error over a period of 10 years
- Primarily caused by switches of instruments and instrumental drift
- Only defined for the MM products but also representative of the DM and MMDC products
- Should be met over most of the scene types

Accuracy requirements for CM-23311 and CM-23341

<table>
<thead>
<tr>
<th>Products</th>
<th>Threshold</th>
<th>Target</th>
<th>Optimal</th>
<th>CM-113 and CM-115 accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRS CM-23311</td>
<td>MM</td>
<td>8 W/m²</td>
<td>4 W/m²</td>
<td>2 W/m²</td>
</tr>
<tr>
<td></td>
<td>DM</td>
<td>16W/m²</td>
<td>8 W/m²</td>
<td>4 W/m²</td>
</tr>
<tr>
<td></td>
<td>MMDC</td>
<td>16W/m²</td>
<td>8 W/m²</td>
<td>4 W/m²</td>
</tr>
<tr>
<td>TET CM-23341</td>
<td>MM</td>
<td>4 W/m²</td>
<td>2 W/m²</td>
<td>1 W/m²</td>
</tr>
<tr>
<td></td>
<td>DM</td>
<td>8 W/m²</td>
<td>4 W/m²</td>
<td>2 W/m²</td>
</tr>
<tr>
<td></td>
<td>MMDC</td>
<td>8 W/m²</td>
<td>4 W/m²</td>
<td>2 W/m²</td>
</tr>
</tbody>
</table>

Requirements referring to error:
- at 1 standard deviation (RMS error)
- at 1° x 1° scale
- taking only VZA<60°
- does not include error (bias) due to the absolute calibration
Processing overview

- **Visible clear-sky processing:**
  - Generates the clear-sky VIS data
  - Cloud effect filtered by image processing techniques (based on a series of 61 days of input VIS images)

- **Data preprocessing:**
  - Calibration & ageing correction
  - Stripes’ interpolation
  - Conversion to “MET7-like” using theoretical regressions from NB channels

<table>
<thead>
<tr>
<th>Instrument</th>
<th>TRS</th>
<th>TET</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVIRI</td>
<td>SEVIRI Solar Channel Calibration (Govaerts et al., 2004)</td>
<td>MFG-2 and -3 : operational calibration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MFG-4 to -7 : GSICS/EUMETSAT recalibration using HIRS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(R. Stöckli and A. Tetzlaff, pers. comm.)</td>
</tr>
<tr>
<td>SEVIRI</td>
<td>Meirink et al. (2013)</td>
<td>Operational calibration</td>
</tr>
</tbody>
</table>
• **TOA fluxes processing:**
  - Scene identification (daytime only; Ipe, 2011 & Ipe et al., 2010, 2004)
  - Empirical NB to BB regressions (GERB used “off-line”)
  - Instantaneous fluxes computation:
    ▪ TRS: using CERES TRMM angular dependency models (Loeb et al., 2003)
    ▪ TET: using theoretical models (Clerbaux et al., 2003)

• **Daily and monthly averaging:**
  - Averaging of the instantaneous fluxes in hourly boxes from which the DM, MM and MMDC are estimated

- Maximum **3 hours** of successive missing data in the daily averaging (otherwise DM not issued)
- Minimum **15 days** required in the monthly averaging (MM and MMDC)
- Seasonal change in insolation taken into account in the monthly averaging
- Regridding onto a regular grid at 0.05° x 0.05°
Validation methodology

No “Ground Truth” observations for the TOA fluxes

- intercomparison with other satellite-based data (polar satellites observations are preferred)

<table>
<thead>
<tr>
<th>Source</th>
<th>Version</th>
<th>Variable</th>
<th>Temporal resolution</th>
<th>Spatial resolution</th>
<th>Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>CERES EBAF</td>
<td>2.8</td>
<td>TRS TET</td>
<td>MM</td>
<td>1° x 1°</td>
<td>March 2000 onward</td>
</tr>
<tr>
<td>CERES SYN1deg-Day</td>
<td>3A</td>
<td>TRS TET</td>
<td>DM</td>
<td>1° x 1°</td>
<td>March 2000 onward</td>
</tr>
<tr>
<td>CERES SYN1deg-M3Hour</td>
<td>3A</td>
<td>TRS TET</td>
<td>MMDC in 3-hourly intervals</td>
<td>1° x 1°</td>
<td>March 2000 onward</td>
</tr>
<tr>
<td>HIRS OLR CDR - Monthly</td>
<td>2.7</td>
<td>TET</td>
<td>MM</td>
<td>2.5° x 2.5°</td>
<td>1979 onward</td>
</tr>
<tr>
<td>HIRS OLR CDR - Daily</td>
<td>1.2</td>
<td>TET</td>
<td>DM</td>
<td>1° x 1°</td>
<td>Jan. 1979 to Dec. 2013</td>
</tr>
<tr>
<td>Univ. Reading ERBS WFOV-CERES (DEEP-C)</td>
<td>2</td>
<td>TRS TET</td>
<td>MM</td>
<td>0.7° x 0.7°</td>
<td>Jan. 1985 to May 2015</td>
</tr>
<tr>
<td>ISCCP FD</td>
<td>-</td>
<td>TRS TET</td>
<td>MM</td>
<td>2.5° x 2.5°</td>
<td>July 1983 to Dec. 2004</td>
</tr>
</tbody>
</table>

Three sources of error:

- Temporal stability of the data records
  - Evaluated by computing time series of overall bias between CM SAF and reference products
- Accuracy (processing error)
  - Quantified by computing the RMS against CERES
  - CERES considered as the best reference, especially for the MM and MMDC products
  - cover the area 50°S-50°N and 50°W – 50°E (approx. VZA<60°).
- Effect of missing input data (not shown here)
  - Due to missing instantaneous fluxes for the DM (interpolation) and missing days in the MM and MMDC
Validation results
Stability
Monthly mean products

Wrt CERES EBAF

TRS

Wrt ERBS WFOV-CERES

Wrt CERES EBAF

TET

Wrt HIRS NCDC OLR – Monthly

Validation results
Stability
Monthly mean products

Wrt CERES EBAF

TRS

Wrt ERBS WFOV-CERES

Wrt CERES EBAF

TET

Wrt HIRS NCDC OLR – Monthly
Stability
Daily mean products

TRS  WrC CERES SYN1deg-Day

Wwr CERES SYN1deg-Day  TET  WrH HIRS NCDC OLR – Daily
Stability
Monthly mean diurnal cycle products

Wrt CERES SYN1deg-M3Hour

Bias CMSAF - CERES SYN1deg-M3Hour

Solar

Time

00 UTC
03 UTC
06 UTC
09 UTC
12 UTC
15 UTC
18 UTC
21 UTC

Jan 03
Jan 06
Jan 09
Jan 12
Jan 15

Bias in W/m²

TRS

RMIB

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Validation
• Methodology
• Results
Summary of the errors
Conclusion
Data access and documentation

TOA radiation data records

MVIRI/SEVIRI

CERES SYN1deg-M3Hour

M3Hour

TRS

TET

Wrt CERES SYN1deg-M3Hour

Bias CMSAF - CERES SYN1deg-M3Hour

Thermal

Time

00 UTC
03 UTC
06 UTC
09 UTC
12 UTC
15 UTC
18 UTC
21 UTC

Jan 03
Jan 06
Jan 09
Jan 12
Jan 15

Bias in W/m²
Regional comparison
Monthly mean products

TRS

Wrt CERES EBAF

TET

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MVIRI/SEVIRI TOA radiation data records

RMIB

TRS

Wrt CERES SYN1deg-M3Hour

TET
Accuracy
Monthly mean products

TRS
Wrt CERES EBAF

TET
Wrt CERES EBAF
Accuracy
Daily mean products

TRS
Wrt CERES SYN1deg-Day

Wrt CERES SYN1deg-Day
TET
Wrt HIRS NCDC OLR – Daily
Accuracy
Monthly mean diurnal cycle products

Wrt CERES SYN1deg-M3Hour

RMS difference CMSAF - CERES SYN1deg-M3Hour (bias corrected)

Solar

RMS in W/m²

Time

Jan 00 Jan 03 Jan 06 Jan 09 Jan 12 Jan 15

TRS

00 UTC 03 UTC 06 UTC 09 UTC 12 UTC 15 UTC 18 UTC 21 UTC

0

5

10

15

20

25

MFG7 MSG1 MSG2 MSG3

Threshold

Optimal

Target

TRS

00 UTC 03 UTC 06 UTC 09 UTC 12 UTC 15 UTC 18 UTC 21 UTC

0

1

2

3

4

5

6

7

8

9

MFG7 MSG1 MSG2 MSG3

Threshold

Optimal

Target

TET

Summary of the errors

Conclusion

Data access and documentation
### Summary of the errors

<table>
<thead>
<tr>
<th>Error sources</th>
<th>MM</th>
<th>DM</th>
<th>MMDC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TRS</td>
<td>TET</td>
<td>TRS</td>
</tr>
<tr>
<td>Stability error</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stability of all the products better than 4 W/m² (max-min) except for the TET during a given period in 1987 (MFG2) (4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Processing error (at 1 std. dev.)</td>
<td>3.6 W/m²</td>
<td>2.6 W/m²</td>
<td>6.5 W/m²</td>
</tr>
<tr>
<td>Additional error due to missing input data (1)(2)</td>
<td>0.3 W/m²/day</td>
<td>0.2 W/m²/day</td>
<td>0.5 W/m²</td>
</tr>
</tbody>
</table>

**Remarks**

1. The reported errors due to missing data do not affect the products without missing data. For the DM products, the missing data error is the 0.9 percentile of the error over days affected by missing repeat cycles of image acquisition.
2. The missing data error must be added to the processing error (not a root mean summation of these errors).
3. The reported errors for the MMDC of the TRS are estimated for the time intervals with the highest illumination of the Meteosat FOV (e.g. [11-12] and [12-13] UTC).
4. Those months are January, February and March 1987.
Conclusion

• Validation mainly performed by intercomparison with the CERES products from 2000 onward

• Quality of the early part of the data records verified against other data records (e.g. HIRS OLR CDR - Daily/Monthly, ERBS WFOV-CERES)

• **In terms of accuracy**, validation indicates that:
  - threshold requirements are fulfilled
  - target requirements are fulfilled for most of the products and periods

• **In terms of stability**, validation indicates that:
  - optimal and target requirements far from being achieved
  - threshold requirements are however fulfilled for most of the products and periods
  - systematic error shows a relatively good stability in time, without sharp transitions between satellites and generations of instruments
  - no instrumental drift (i.e. ageing effect) is apparent
Data access and documentation

• Data ordering via the Web User Interface through the CM SAF homepage: [www.cmsaf.eu](http://www.cmsaf.eu)

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• Algorithm Theoretical Basis Document, version 1.3: SAF/CM/RMIB/ATBD/MET_TOA

• Dataset Generation Capability Description Document, version 1.1: SAF/CM/RMIB/DGCDD/MET_TOA

• Product User Manual, version 1.1: SAF/CM/RMIB/PUM/MET_TOA

• Scientific Validation Report, version 1.1: SAF/CM/RMIB/VAL/MET_TOA
Thank you for your attention!
References


