Top-of-Atmosphere Radiative flux from MSG

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1. Project Introduction
2. LW/SW approaches
3. Preliminary results
4. Conclusions & Outlook
CM SAF project: *Cloud property dAtAset using SEVIRI*

*Previous dataset: MVIRI/SEVIRI (Urbain et al., 2015) & SEVIRI/GERB (Clerbaux et al., 2015)*

**Parameters**
- SW/LW TOA all and clear-sky

**Sensor & Coverage**
- SEVIRI / Meteosat disk (60°N-60°S; 60°W-60°E)

**Spatial resolution**
- 0.05°

**Temporal resolution**
- Monthly mean diurnal cycle, daily and monthly

**Period**
- 2005 - 2022
Preliminary processing chain

**Inputs**
- SEVIRI narrowband Reflectance

**NB-BB**
- Clerbaux et al., 2005 (based on CERES)
- SEVIRI/GERB approach

**ADMs**
- CERES-TRMM (Loeb et al., 2003)
- CERES Terra-ed2b (Loeb et al., 2005)
- CERES ed4 (Su et al., 2015)

**Albedo to Broadband SW hemispherical flux**

**NB-BB**
- Theoretical regression in radiance Clerbaux et al., 2007

**ADM**
- Velazquez et al, in prep

**Broadband LW hemispherical flux**
CERES-TRMM (Tropical Rainfall Measuring Mission)

- 38°S-38°N with a resolution of ~10km
- Up to 592 scene types (from VIRS measurements)
- Discrete angular bins:
  - $\theta_0$: 9 angular bins (0° to 90° in 10° steps)
  - $\phi$: 10 angular bins (0° to 180° in 10° or 20° steps)
  - Full range $\theta_0$ of acquired every 46 days.
- Samples each grid box at all local time of days over a 46 days period

Gristey et al., 2021
SW ADMs

CERES-Terra (Ed2b)
- 2 years of RAPS data from Terra satellite.
- 20km resolution / scene identification via MODIS.
- More scene types and increase in angular bin resolution:
  - e.g., 2° in solar zenith, viewing zenith, and relative azimuth angles for cloud-free ocean scenes.
- Add mid-latitude and polar observations.

BUT over land:
- Does not provide observation of the angular radiation fields over the full range of $\theta_0$.
  - We can’t use it due to the limited $\theta_0$ range for each grid-box.

CERES-Terra (Edition 4; v2013-11-30)
- 5 years of RAPS data from the Terra satellite.
- Segregated by:
  - AOD in glint regions (3 classes).
  - Both AOD (3 classes) and two aerosol types (rural and urban) in non-glint regions.
- Same method than CERES-Terra Ed2b to develop the ADM cloudy ocean.
Ed2b: Good opportunity to test the impact of AOD inputs from MERRA-2
Comparisons with CERES SSF TOA flux

*CERES SSF SW TOA flux (Ed4.1)*

vs.

TOA flux by applying local ADM implementations on radiance

No glint - Clear sky ocean

- Better result with Ed4 while using MERRA-2.
- Higher MAD with Aqua:
  - Not the last ADM version.
- MAD of 0 if the similar AOD case than Ed4 is used (no MERRA-2 anymore).

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**Introduction**  |  **Approaches**  |  **Validation**  |  **Conclusions**
LW ADM (Velazquez et al., in prep)

Night cases

Needed MODIS PSF weighted BT only available during night

**Polynomial fit**

- Database: LibRadtran 1.4 and SBDART radiative transfer models
  \[
  R(\theta) = a_0 + a_1 z_1 + a_2 z_2 + a_3 z_1^2 + a_4 z_1 z_2 + a_5 z_2^2
  \]
- \( z_1 = T_b(10.8 \mu m) \) and \( z_2 = T_b(12 \mu m) - T_b(10.8 \mu m) \)
- Bins:
  - 5° VZA
  - 25 -> 135 Wm\(^{-2}\)sr\(^{-1}\); 5 Wm\(^{-2}\)sr\(^{-1}\) step
Characterize the products in terms of accuracy, precision and stability.

1 month of test data -> June 2011

Today

01 Comparisons of CDR outputs with CERES reference dataset:
   - CERES SYN Ed4.1 (various SW ADMs)
   - CERES EBAF Ed4.2

02 Comparisons with other CDRs (CDOP2):
   - SEVIRI/GERB
   - MVIRI/SEVIRI

03 Specific analysis of the stability:
   - Monthly mean deseasonal bias
Short-wave flux

Monthly mean diurnal cycle (FOV < 60° SZA < 84°)
Monthly mean (from daily mean with minimum 27 days)
SW$_{CERES SYN}$ relative bias

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Hypothesis:
SEVIRI underestimates the impact of absorbing aerosols over SEA persistent mid-level clouds and so induces an overestimation.
$SW_{CERES \ SYN}$ relative uRMSD

### All Map

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SW$_{CERES\ SYN}$ vs. CDRs

CERES SYN Comparisons
FOV < 60°
All map

- CLAAS4
- GERB/SEVIRI
- MVIRI/SEVIRI

- SW RBias (%)
- Number of pixels

Land

Water

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SW\textsubscript{CERES SYN} vs. CDRs

CERES SYN Comparisons
FOV < 60°
All map

- CLAAS4
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- MVIRI/SEVIRI

SW RuRMSD (%)

Number of pixels

0 5000 10000 15000

Land

SW RuRMSD (%)

Number of pixels

0 1000 2000 3000 4000 5000

Water

SW RuRMSD (%)

Number of pixels

0 2000 4000 6000 8000 10000

Hours
Monthly bias with SW_{CERES-EBAF}

- Improvement as compared to previous CM SAF versions at the border of the disk.
- Overestimation over land
  - Need to improve the NB to BB relation?

**CLAAS4**

**CM SAF CLAAS4 ed4 v6 vs. CERES EBAF**
- Bias: 0.6 W m^{-2} (0.7%)
- MAD: 2.8 W m^{-2} (3.1%)
- bc-RMSD: 3.9 W m^{-2} (4.3%)
- bc-MAD: 2.8 W m^{-2} (3.1%)

**SEVIRI/GERB vs. CERES EBAF**
- Bias: -1.2 W m^{-2} (-1.3%)
- MAD: 2.9 W m^{-2} (3.2%)
- bc-RMSD: 4.4 W m^{-2} (4.8%)
- bc-MAD: 2.9 W m^{-2} (3.2%)

**MVIRI/SEVIRI vs. CERES EBAF**
- Bias: 0.7 W m^{-2} (0.7%)
- MAD: 3.2 W m^{-2} (3.5%)
- bc-RMSD: 4.6 W m^{-2} (5.0%)
- bc-MAD: 3.1 W m^{-2} (3.4%)
Monthly bias with SW$_{\text{CERES-SYN}}$

- **CM SAF CLAAS4 ed4 v8 vs. CERES SYN**
  - Bias: 2.1 W m$^{-2}$ (2.4%) MAD: 3.5W m$^{-2}$ (3.9%)
  - bc-RMSE: 4.5 W m$^{-2}$ (5.0%) bc-MAD: 3.4 W m$^{-2}$ (3.8%)

- **SEVIRI/GERB vs. CERES SYN**
  - Bias: 0.3 W m$^{-2}$ (0.4%) MAD: 2.9W m$^{-2}$ (3.3%)
  - bc-RMSE: 4.3 W m$^{-2}$ (4.8%) bc-MAD: 2.9 W m$^{-2}$ (3.2%)

- **MVIRI/SEVIRI vs. CERES SYN**
  - Bias: 2.2 W m$^{-2}$ (2.4%) MAD: 3.5W m$^{-2}$ (3.9%)
  - bc-RMSE: 4.1 W m$^{-2}$ (4.9%) bc-MAD: 2.9 W m$^{-2}$ (3.3%)

### CLAAS4
- Same conclusions than for EBAF
- Larger overestimation as compared to CERES$_{\text{EBAF}}$
Monthly rbias with SW CERES-SYN

CM SAF CLAAS4 ed4 v8 vs. CERES SYN
bias 2.1 W m\(^{-2}\) (2.4%) MAD 3.5 W m\(^{-2}\) (3.9%)
bc-RMSD 4.5 W m\(^{-2}\) (5.0%) bc-MAD 3.4 W m\(^{-2}\) (3.8%)

SEVIRI/GERB vs. CERES SYN
bias 0.3 W m\(^{-2}\) (0.4%) MAD 2.9 W m\(^{-2}\) (3.3%)
bc-RMSD 4.3 W m\(^{-2}\) (4.8%) bc-MAD 2.9 W m\(^{-2}\) (3.2%)

MVIRI/SEVIRI vs. CERES SYN
bias 2.2 W m\(^{-2}\) (2.4%) MAD 3.5 W m\(^{-2}\) (3.9%)
bc-RMSD 4.4 W m\(^{-2}\) (4.9%) bc-MAD 2.9 W m\(^{-2}\) (3.3%)
Long-wave flux
Monthly mean diurnal cycle
Monthly mean
LW$_{\text{CERES SYN}}$ vs. CDRs

CERES SYN Comparisons
FOV $< 60^\circ$
All map

LW RBias (%)

Land

Water

Hours

-1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

-1 -0.5 0 0.5 1

CLAAS4
GERB/SEVIRI
MVIRI/SEVIRI
CERES SYN Comparisons
FOV < 60°
All map

LW RuRMSD (%)

CLAA4
GERB/SEVIRI
MVIRI/SEVIRI

Land

Water

Hours

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Monthly bias with LW\textsubscript{CERES-EBAF}

**CLAAS4**

- Global Underestimation
- Lower impact of the VZA

*Improvement as compared to previous CM SAF versions over water*
Monthly bias with LW\textsubscript{CERES-SYN}

- **CM SAF CLAAS4 ed4 v8 vs. CERES SYN**
  - Bias: -1.7 W m\textsuperscript{-2} (0.7\%)
  - MAD: 2.2 W m\textsuperscript{-2} (0.9\%)
  - bc-RMSD: 2.2 W m\textsuperscript{-2} (0.9\%), bc-MAD: 1.5 W m\textsuperscript{-2} (0.6\%)

- **SEVIRI/GERB vs. CERES SYN**
  - Bias: -3.9 W m\textsuperscript{-2} (1.6\%)
  - MAD: 4.0 W m\textsuperscript{-2} (1.6\%)
  - bc-RMSD: 2.5 W m\textsuperscript{-2} (1.0\%), bc-MAD: 1.8 W m\textsuperscript{-2} (0.7\%)

**CLAAS4**
- Same trend than comparison with CERES\textsubscript{EBAF}
- Lower global bias
Conclusions & Outlook

**Conclusions**

- Good agreements with CERES data:
  - Monthly Bias of $-1.7 \, \text{W m}^{-2} \, (\text{LW})$ and $2.1 \, (\text{SW})$ with CERES SYN.
  - Overestimation over land for the SW.
- Improvement as compared to previous CDR for the LW.
  - Better bias and no clear impact of the VZA anymore.

**Future tasks**

- Test with 2 years of data.
- New NB to BB relation will be tested.
- Test CERES-LW ADM
- Test for the CS with a time windows of 61 days.
Thank you for your attention