Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project: SW fluxes

Akkermans, T., Clerbaux, N.

34th CERES Science Team Meeting
Virtual meeting, September 15-18, 2020

<tom.akkermans@meteo.be>
1. **Introduction**

2. **Validation results:**
   - 2.1. Instantaneous RSF (level-2)
   - 2.2. Daily and monthly mean RSF (level-3) + Monthly mean diurnal cycle
   - 2.3. Long term time series, stability
1. Introduction

What is CLARA? “CM SAF cLoud, Albedo and RAdiation dataset from AVHRR data” (=Similar to Patmos-X)

- Polar orbiting satellites NOAA and MetOp
- FCDR from NOAA (Heidinger et al., 2010)
- Currently released versions:

Some of the modifications in upcoming version CLARA-A3:

- Inclusion of AVHRR-1 sensor (TIROS-N, NOAA-6, -8, -10): extension of time range to 1978-2019 i.e. 42yr
- Updated FCDR: new calibration for visible channels (latest PATMOS-x coefficients)
- Updated cloud treatment algorithms (NWCSAF/PPS v.2018; Karlsson et al.)
- Addition of new product “TOA radiative fluxes” -> this presentation
**1. Introduction**

**Level-2 processing: instantaneous observations**

- AVHRR ch4: 11µm
- AVHRR ch5: 12µm

"all-in-one" conversion from narrowband directional brightness temp. to broadband hemispherical flux, based on database with coangular AVHRR-CERES obs.

- **OLR [W/m²]**
  - Aggregation from orbit to regular CMSAF grid (0.25°x0.25°)
  - Remapped OLR (0.25°)

**Broadband reflectance**

- **Albedo [%]** (hemispherical)

**Level-3 processing: daily mean**

- ERAS diurnal cycle OLR
- ERA5 diurnal cycle scaled to Level-2 observations, then interpolate

- Daily mean

**Level-3b processing**

- Monthly mean

**NB-to-BB regressions based on database with coangular AVHRR-CERES obs.**

**ADM's from CERES Ed2B: TRMM, +TERRA for snow/ice**

**Method: Young et al. ('98):**

- Match scene-dependent average diurnal cycle to observations, then interpolate
- Convert albedo to flux

**Daily mean RSF [W/m²]**

**Monthly mean RSF**

**Interpolate between diurnal cycles**

**Time (1 day, only during daylight)**

**Ongoing Longwave Radiation (OLR)**

**Reflective Solar Flux (RSF)**
1. Introduction

Narrowband-to-Broadband Conversions for Top-of-Atmosphere Reflectance from the Advanced Very High Resolution Radiometer (AVHRR)

Tom Akkermans * and Nicolas Clerbaux
Royal Meteorological Institute of Belgium, B-1180 Brussels, Belgium; nicolas.clerbaux@meteo.be
* Correspondence: tom.akkermans@meteo.be; Tel.: +32-(0)2-3730623

Received: 20 December 2019; Accepted: 14 January 2020; Published: 17 January 2020

Abstract: The current lack of a long, 30+ year, global climate data record of reflected shortwave top-of-atmosphere (TOA) radiation could be tackled by relying on existing narrowband records from the Advanced Very High Resolution Radiometer (AVHRR) instruments, and transforming these measurements into broadband quantities like provided by the Clouds and the Earth’s Radiant Energy System (CERES). This paper presents the methodology of an AVHRR-to-CERES narrowband-to-broadband conversion for shortwave TOA reflectance, including the ready-to-use Level-3 processing steps.

Level-3 processing:

- Monthly mean
- Daily mean
- Interpolate between diurnal cycles
- Monthly mean RSF
- Daily mean RSF [W/m²]
- Convert albedo to flux based on database with coangular AVHRR-CERES obs
- NB-BB regressions based on database with coangular AVHRR-CERES obs

Time (1 day, only during daylight)

Development of an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

1. Introduction

Level-2 processing: instantaneous observations

- AVHRR ch4: 11 µm
- AVHRR ch5: 12 µm

"all-in-one" conversion from narrowband directional brightness temp. to broadband hemispherical flux, based on database with co-angular AVHRR-CERES obs.

Outgoing Longwave Radiation (OLR)

- OLR [W/m²]

Aggregation from orbit to regular CMSAF grid (0.25° x 0.25°)

remapped OLR (0.25°)

Level-3 processing: daily mean

- ERA5 diurnal cycle OLR

ERAS diurnal cycle OLR scaled to Level-2 observations, then interpolate:

Daily mean

Method: Young et al. (’98): match scene-dependent average diurnal cycle to observations, then interpolate

Convert albedo to flux

Daily mean

RSF [W/m²]

Level-3b processing

Monthly mean RSF

NB-to-BB regressions based on database with co-angular AVHRR-CERES obs.

Broadband reflectance

ADM’s from CERES Ed2B: TRMM, +TERRA for snow/ice

Albedo [%] (hemispherical)

Aggregation from orbit to regular CMSAF grid (0.25° x 0.25°)

remapped Albedo (0.25°)

Interpolate between diurnal cycles

Time (1 day, only during daylight)
1. Introduction

Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Level-2 processing: instantaneous observations

**Part 1**
- AVHRR ch4: 11µ
- AVHRR ch5: 12µ
  - "all-in-one" conversion from narrowband directional brightness temp. to broadband hemispherical flux, based on database with co-angular AVHRR-CERES obs.
  - OLR [W/m²]

**Part 2**
- Outgoing Longwave Radiation (OLR)
  - Remapped OLR (0.25°)
  - Aggregation from orbit to regular CMSAF grid (0.25°x0.25°)

**Part 3**
- ERA5 diurnal cycle OLR
  - Daily mean

- NOAA17 overcast
  - NOAA16 clearsky

**P4**
- OLR
- Monthly mean

**Level-2 observations with scene type**

- ALB %
- Time (1 day, only during daylight)
- Interpolate between diurnal cycles:
  - NB-to-BB regressions based on database with co-angular AVHRR-CERES obs.
  - ADM’s from CERES Ed2B: TRMM, +TERRA for snow/ice

- ALB %
  - NOAA17 overcast
  - NOAA16 clearsky

- Convert albedo to flux based on database with co-angular AVHRR-CERES obs.

- Brightness temp. to broadband hemispherical flux, (1 day, only during daylight)

**Level-3 processing:**
- Daily mean ERA5 diurnal cycle scaled to Level-2 observations, then interpolate.

**Level-3b processing:**
- Broadband reflectance
- Albedo [%] (hemispherical)
1. Introduction

AVHRR ch4: 11µ
AVHRR ch5: 12µ

"all-in-one" conversion from narrowband directional brightness temp. to broadband hemispherical flux, based on database with coangular AVHRR-CERES obs.

OLR [W/m²]

Aggregation from orbit to regular CMSAF grid (0.25° x 0.25°)

remapped OLR (0.25°)

Albedo [%] (hemispherical)

Broadband reflectance

Remapped OLR for snow/ice

Level-3 processing:

ADM’s from CERES Ed2B: TRMM, +TERRA

Interpolation following Young et al. ('98): match scenetype-dependent average diurnal cycle to observations.

Convert albedo to flux based on database with coangular AVHRR-CERES obs.

NB-to-BB regressions based on database with coangular AVHRR-CERES obs.

ERS diurnal cycle OLR

ERA5 diurnal cycle scaled to Level-2 observations, then interpolate:

Interpolate between diurnal cycles.

Convert albedo to flux based on database with coangular AVHRR-CERES obs.

1. Introduction

Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project
1. Introduction

Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

**Level-2 processing: instantaneous observations**

- **AVHRR ch4**: 11µ
- **AVHRR ch5**: 12µ

"all-in-one" conversion from narrowband directional brightness temp. to broadband hemispherical flux, based on database with coangular AVHRR-CERES obs.

**Outgoing Longwave Radiation (OLR)**

- **OLR [W/m²]**

Aggregation from orbit to regular CMSAF grid (0.25° x 0.25°)

**Reflected Solar Flux (RSF)**

- **Broadband reflectance**
- **Albedo [%] (hemispherical)**

**ADM’s from CERES Ed2B: TRMM, +TERRA for snow/ice**

**Scale diurnal cycle: match observation**

- **ALB %**
- **NOAA17 overcast**

**Time** (1 day, only during daylight)

**Monthly mean**

**Daily mean**

**P4**

**Monthly mean**

**ERAS diurnal cycle OLR**

ERAS diurnal cycle scaled to Level-2 observations, then interpolate:

**Angular AVHRR - CERES obs.**

**Brightness temp. to broadband hemispherical flux, (1 day, only during daylight)**
## 1. Introduction

### Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

### Level-2 processing: instantaneous observations

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Part 1</td>
<td>AVHRR ch4: 11µ</td>
</tr>
<tr>
<td>Part 2</td>
<td>Outgoing Longwave Radiation (OLR)</td>
</tr>
<tr>
<td>Part 3</td>
<td>Remapped OLR (0.25°)</td>
</tr>
<tr>
<td>P4</td>
<td>OLR</td>
</tr>
</tbody>
</table>

### Albedo [%] (hemispherical)

- **NB**-to-**BB** regressions based on database with co-angular AVHRR-CERES obs.
- ADM's from CERES Ed2B: TRMM, +TERRA for snow/ice

### Level-3 processing:

#### Daily mean

- ERA5 diurnal cycle OLR scaled to Level-2 observations, then interpolate:
- Interpolate following Young et al. ('98): match scenetype-dependent average diurnal cycle to observations.
- Convert albedo to flux based on database with co-angular AVHRR-CERES obs. brightness temp. to broadband hemispherical flux, (1 day, only during daylight)

#### Time (1 day, only during daylight)

- NOAA17 overcast
- NOAA16 clearsky
1. Introduction

Level-2 processing: instantaneous observations

**Part 1**
- AVHRR ch4: 11μ
- AVHRR ch5: 12μ

"all-in-one" conversion from narrowband directional brightness temp. to broadband hemispherical flux, based on database with coangular AVHRR-CERES obs.

**OLR [W/m²]**

Outgoing Longwave Radiation (OLR)

Aggregation from orbit to regular CMSAF grid (0.25° x 0.25°).

**Part 2**

Remapped OLR (0.25°)

**Part 3**

ERAS diurnal cycle OLR

ERA5 diurnal cycle scaled to Level-2 observations, then interpolate:

**Daily mean**

**Monthly mean**

**Level-3 processing:**
- Daily mean ERA5

*ADM’s from CERES Ed2B: TRMM, +TERRA for snow/ice*

Custom regressions based on database with co-angular AVHRR-CERES obs.

Broadband reflectance

Albedo [%] (hemispherical)

Scale diurnal cycle: match observation

**Time** (1 day, only during daylight)

---

Tom Akkermans
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project
1. Introduction

Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Part 1
Level-2 processing: instantaneous observations

- AVHRR ch4: 11µ
- AVHRR ch5: 12µ

"all-in-one" conversion from narrowband directional brightness temp. to broadband hemispherical flux, based on database with co-angular AVHRR-CERES obs.

Part 2
Outgoing Longwave Radiation (OLR)

- OLR [W/m²]

Aggregation from orbit to regular CMSAF grid (0.25° x 0.25°)

remapped OLR (0.25°)

Part 3
Level-3 processing: daily mean OLR

- ERAS diurnal cycle OLR

ERAS diurnal cycle scaled to Level-2 observations, then interpolate:

Daily mean

Monthly mean

P4

Interpolate between diurnal cycles

Interpolate following Young et al. ('98): match scenetype-dependent average diurnal cycle to observations. Convert albedo to flux based on database with co-angular AVHRR-CERES obs. brightness temp. to broadband hemispherical flux.

NOAA1 overcast

NOAA16 clearsky

Time (1 day, only during daylight)
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

1. Introduction

Level-2 processing: instantaneous observations

- AVHRR ch4: 11µm
- AVHRR ch5: 12µm

“all-in-one” conversion from narrowband directional brightness temp. to broadband hemispherical flux, based on database with coangular AVHRR-CERES obs.

- OLR [W/m²]

Aggregation from orbit to regular CMSAF grid (0.25°x0.25°)

Level-3 processing: daily mean

- ERA5 diurnal cycle OLR

Daily mean

Method: Young et al. ('98): match scene-dependent average diurnal cycle to observations, then interpolate

Convert albedo to flux

Daily mean RSF [W/m²]

Level-3b processing

Monthly mean RSF

Time (1 day, only during daylight)

ADM’s from CERES Ed2B: TRMM, +TERRA for snow/ice

Albedo [%] (hemispherical)

Broadband reflectance

NB-to-BB regressions based on database with coangular AVHRR-CERES obs.

Aggregation from orbit to regular CMSAF grid (0.25°x0.25°)

remapped Albedo (0.25°)

remapped OLR (0.25°)

Monthly mean OLR

Daily mean OLR

Monthly mean NOAA18 daily cycle

NOAA18 diurnal cycle

Interpolate between diurnal cycles
1. **Introduction**

2. **Validation results:**
   - 2.1. Instantaneous RSF (level-2)
   - 2.2. Daily and monthly mean RSF (level-3) + Monthly mean diurnal cycle
   - 2.3. Long term time series, stability
2.1. Validation instantaneous L2

**Level-2 processing: instantaneous observations**

- **AVHRR ch4: 11µ**
- **AVHRR ch5: 12µ**

  "all-in-one" conversion from narrowband directional brightness temp. to broadband hemispherical flux, based on database with coangular AVHRR-CERES obs.

  - OLR [W/m²]
  - Aggregation from orbit to regular CMSAF grid (0.25° x 0.25°)
  - remapped OLR (0.25°)

---

**Level-2 validation**

- Broadband reflectance
- ADM’s from CERES Ed2B: TRMM, +TERRA for snow/ice

---

**Level-3 processing: daily mean**

- **ERAS diurnal cycle OLR**
  - ERA5 diurnal cycle scaled to Level-2 observations, then interpolate:
  - OLR [W/m²]
  - Interpolation between diurnal cycles

  - Method: Young et al. ('98): match scene-dependent average diurnal cycle to observations, then interpolate

  - Convert albedo to flux

  - Daily mean RSF [W/m²]

---

**Level-3b processing**

- **Monthly mean RSF**
• Validation is done on AVHRR-CERES “matched observations”, i.e. that are collocated, co-angular, and simultaneous. Those conditions are met when orbital planes from Terra/Aqua and NOAA-17/18/19 coincide (2004, 2005, 2007, 2008, 2011, 2012).

• Method: TOA albedo+RSF is calculated for each AVHRR pixel. Subsequently, for each CERES-SSF footprint the matching AVHRR pixel values are averaged and the bias is calculated.

• Number of matched observations: about 66 million

• Biases are gridded in 5°x5° lat-lon boxes. Spatial spread of bias is quantified by bias-corrected RMSE.
2.1. Validation instantaneous L2

Broadband reflectance bias (%):

Bias due to NB-to-BB (%):

Bias due to NB-to-BB and ADM (W/m²):

Bias due to ADM (W/m²):
1. Introduction

2. Validation results:
   - 2.1. Instantaneous RSF (level-2)
   - 2.2. Daily and monthly mean RSF (level-3) + Monthly mean diurnal cycle
   - 2.3. Long term time series, stability
2.2. Validation daily/monthly L3

Level-2 processing: instantaneous observations

- AVHRR ch4: 11µ
- AVHRR ch5: 12µ

"all-in-one" conversion from narrowband directional brightness temp. to broadband hemispherical flux, based on database with co-angular AVHRR-CERES obs.

- OLR [W/m²]

Aggregation from orbit to regular CMSAF grid (0.25° x0.25°)

- remapped OLR (0.25°)

Level-3 processing: daily mean

- ERA5 diurnal cycle OLR

ERS diurnal cycle OLR

- Daily mean

Method: Young et al. ('98): match scene-dependent average diurnal cycle to observations, then interpolate

Convert albedo to flux

Daily mean RSF [W/m²]

Level-3b processing

- OLR

Monthly mean

Level-3 validation

- Monthly mean RSF

Level-3 validation
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Validation Level -3 (daily mean)
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Relative bias (%)
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Validation Level - 3 (daily mean)

RMSE - 2.48 W/m²
MAE = 1.84 W/m²
ME = -0.09 W/m²

RMSE - 2.67 W/m²
MAE = 1.90 W/m²
ME = -0.31 W/m²

RMSE - 2.71 W/m²
MAE = 1.94 W/m²
ME = -0.17 W/m²

RMSE - 2.36 W/m²
MAE = 1.74 W/m²
ME = -0.08 W/m²
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Validation Level -3 (daily mean)
Mean diurnal cycle (0-24h UTC); Region: OCEAN-ATL, g-10 (10 gridboxes between -20.5°E-20.5°E,-14.5°N-5.5°N); Month: 2008-10

- CLARA-A3
- GERB-CMSAF
- SYN1deg-M-Hour

NOAA-17
NOAA-18
NOAA-16
NOAA-15
Metop-A

UTC (hours)
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Mean diurnal cycle (0-24h UTC); Region: OCEAN-ATL_g-10 (10 gridboxes between -20.5°E,-20.5°E,-14.5°N,-5.5°N); Month: 2008-10

-10 0 10 20 30
Flux bias (W/m²)

0 2 4 6 8 10 12
LST (hours)

Observations (bias gridbox per hour)

-10 -5 0 5 10
Flux bias (W/m²)

0 2 4 6 8 10
bias CLARA-A3 - SYN1deg-MHour (-4.4W/m²)

bias GERB-CMSAF - SYN1deg-MHour (0.5W/m²)

Mean diurnal cycle (0-24h UTC); Region: OCEAN-ATL_g-10 (10 gridboxes between -20.5°E,-20.5°E,-14.5°N,-5.5°N); Month: 2008-10

-30 -20 -10 0 10 20 30
Flux bias (W/m²)

0 2 4 6 8 10
LST (hours)

Observations (bias gridbox per hour)

-30 -20 -10 0 10
Flux bias (W/m²)

0 2 4 6 8 10
bias CLARA-A3 - SYN1deg-MHour (-4.4W/m²)

bias GERB-CMSAF - SYN1deg-MHour (0.5W/m²)

Mean diurnal cycle (0-24h UTC); Region: OCEAN-ATL_g-10 (10 gridboxes between -20.5°E,-20.5°E,-14.5°N,-5.5°N); Month: 2008-10

-30 -20 -10 0 10 20 30
Flux bias (W/m²)

0 2 4 6 8 10
LST (hours)

Observations (bias gridbox per hour)

-30 -20 -10 0 10
Flux bias (W/m²)

0 2 4 6 8 10
bias CLARA-A3 - SYN1deg-MHour (-4.4W/m²)

bias GERB-CMSAF - SYN1deg-MHour (0.5W/m²)
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Validation Level - 3 (daily mean)

Metop-A

NOAA-17

NOAA-18

NOAA-16

NOAA-15

Mean diurnal cycle (0-24h UTC); Region: OCEAN-ATL_g-10 (10 gridboxes between -20.5°E,-20.5°E,-14.5°N,-5.5°N); Month: 2008-10
Validation Level - 3 (daily mean)

NOAA-18

NOAA-16

Mean diurnal cycle (0-24h UTC); Region: OCEAN-ATL_g-10 (10 gridboxes between -20.5°E,-20.5°E,-14.5°N,-5.5°N); Month: 2008-10
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Validation Level - 3 (daily mean)

NOAA-18

NOAA-16
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Bias of CLARA-A3 TOA RSF radiation w.r.t. CERES-SYNME-Ed4.1 (200601)

RMSE - bc = 2.48 W/m²
RMSE = 2.48 W/m²
MAE = 1.84 W/m²
ME = -0.09 W/m²

Bias of CLARA-A3 TOA RSF radiation w.r.t. CERES-SYNME-Ed4.1 (200604)

RMSE - bc = 2.67 W/m²
RMSE = 2.69 W/m²
MAE = 1.90 W/m²
ME = -0.31 W/m²

Bias of CLARA-A3 TOA RSF radiation w.r.t. CERES-SYNME-Ed4.1 (200607)

RMSE - bc = 2.71 W/m²
RMSE = 2.72 W/m²
MAE = 1.74 W/m²
ME = -0.17 W/m²

Bias of CLARA-A3 TOA RSF radiation w.r.t. CERES-SYNME-Ed4.1 (200610)

RMSE - bc = 2.36 W/m²
RMSE = 2.36 W/m²
MAE = 1.74 W/m²
ME = -0.08 W/m²
Validation Level - 3 (daily mean)
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Validation Level - 3 (daily mean)

Metop-A
NOAA-17
NOAA-18
NOAA-16
NOAA-15

Mean diurnal cycle (0-24h UTC); Region: LAND-AFR_e10 (10 gridboxes between 22.5°E,22.5°E,5.5°N,14.5°N); Month: 2008-01
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Validation Level -3 (daily mean)

NOAA-18

NOAA-17

NOAA-16

NOAA-15

Mean diurnal cycle (0-24h UTC); Region: LAND-AFR_e10 (10 gridboxes between 22.5°E, 22.5°E, 5.5°N, 14.5°N); Month: 2008-01

bias CLARA-A3 - SYN1deg-M-hour (5.5W/m²)

bias GERB-CMSAF - SYN1deg-M-hour (3.5W/m²)
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Validation Level - 3 (daily mean)

NOAA-18

NOAA-17

NOAA-16

NOAA-15

Mean diurnal cycle (0-24h UTC); Region: LAND-AFR_e10 (10 gridboxes between 22.5°E, 22.5°E, 5.5°N, 14.5°N); Month: 2008-01

Bias of CLARA-A3 TOA RSF radiation w.r.t. CERES-SYNEd4.1 (200801)

RMSE_bc=2.48 W/m²
RMSE=2.48 W/m²
ME=-0.09 W/m²

Bias of CLARA-A3 TOA RSF radiation w.r.t. CERES-SYNEd4.1 (200804)

RMSE_bc=2.67 W/m²
RMSE=2.69 W/m²
MAE=1.90 W/m²
ME=-0.31 W/m²

NOAA-18

NOAA-17

NOAA-16

NOAA-15
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Validation Level - 3 (daily mean)
1. **Introduction**

2. **Validation results:**
   - 2.1. Instantaneous RSF (level-2)
   - 2.2. Daily and monthly mean RSF (level-3) + Monthly mean diurnal cycle
   - 2.3. Long term time series, stability
Global monthly RSF CLARA-A3, ERA-5 and CERES (RSF)
2.3. Validation longterm timeserie

Global monthly RMS bias CLARA-A3 w.r.t. ERA-5 and CERES (RSF)
2.3. Validation longterm timeserie

Global monthly RMS bias

CLARA-A3 w.r.t. ERA-5 and CERES (RSF)

Year


W/m²

-20 -10 0 10 20
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

2.3. Validation longterm timeseries bias CLARA-A3 w.r.t. CERES (RSF)

Global monthly bias CLARA-A3 w.r.t. CERES (RSF)

- SYNM Bias
- SYNM RMSEbc
- EBAF Bias
- EBAF RMSEbc


W/m²: -4, -2, 0, 2, 4
Thanks for your attention!
Extra slides
1. Introduction

– 1.1. CLARA-A3 TOA reflected solar flux (‘RSF’)
– 1.2. improvements/changes during last year

2. Validation results:

– 2.1. Instantaneous RSF (level-2)
– 2.2. Daily and monthly mean RSF (level-3) + Monthly mean diurnal cycle
– 2.3. Long term time series, stability
1. Introduction

1.2. Additions/improvements implemented during last year:

- **Spectral response corrections:**

<table>
<thead>
<tr>
<th>AVHRR</th>
<th>Channel 1</th>
<th>Channel 2</th>
<th>Channel 4</th>
<th>Channel 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>satellite</td>
<td>slope</td>
<td>offset</td>
<td>slope</td>
<td>offset</td>
</tr>
<tr>
<td>tirosn</td>
<td>1.023</td>
<td>-1.449</td>
<td>1.006</td>
<td>0.085</td>
</tr>
<tr>
<td>noaa5</td>
<td>1.009</td>
<td>-0.174</td>
<td>1.011</td>
<td>-0.102</td>
</tr>
<tr>
<td>noaa6</td>
<td>1.012</td>
<td>-0.027</td>
<td>1.003</td>
<td>-0.052</td>
</tr>
<tr>
<td>noaa7</td>
<td>1.009</td>
<td>-0.036</td>
<td>1.007</td>
<td>-0.007</td>
</tr>
<tr>
<td>noaa8</td>
<td>1.010</td>
<td>-0.009</td>
<td>1.003</td>
<td>-0.048</td>
</tr>
<tr>
<td>metop</td>
<td>1.000</td>
<td>0.013</td>
<td>1.002</td>
<td>0.014</td>
</tr>
</tbody>
</table>

- **ADM interpolation between SZA,VZA,RAA bins now done on fluxes, not on anisotropic factors.**

- **ADM interpolation bias correction (Loeb et al. 2003):**

\[
\hat{F}^\prime(\theta_o, \theta, \phi; h_{sfc}) = \frac{\pi I(\theta_o, \theta, \phi; h_{sfc})}{\hat{R}(\theta_o, \theta, \phi; h_{sfc})} + \delta F_j(\theta_o, \theta, \phi; h_{sfc}),
\]

- **ADM: weighted scene types from discretized bins with cloudcover and COT:**
  - E.g. cloud cover is 20%, so the anisotropic factor is calculated as weighted mean from anisotropic factors corresponding to the discretized scenetypes with respectively 0-25% and 25-50% cloud cover.
2.2. Validation daily/monthly L3

- 2011
Validation Level - 3 (daily mean)
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Validation Level -3 (daily mean)

Relative bias (%)
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Bias of CLARA-A3 TOA RSF radiation w.r.t. CERES-SYN-MEd4.1 (201101)

RMSE = 2.59 W/m²
RMSE = 2.60 W/m²
MAE = 1.98 W/m²
ME = -0.21 W/m²

Bias of CLARA-A3 TOA RSF radiation w.r.t. CERES-SYN-MEd4.1 (201107)

RMSE = 2.91 W/m²
RMSE = 2.91 W/m²
MAE = 2.10 W/m²
ME = -0.21 W/m²

Relative bias (%)
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Validation Level - 3 (daily mean)

NOAA-18
NOAA-16
NOAA-15
NOAA-19
Metop-A

Mean diurnal cycle (0-24h UTC); Region: OCEAN-ATL_b40 (10 gridboxes between -20.5°E, -20.5°E, 35.5°N, 44.5°N); Month: 2011-07
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Validation Level - 3 (daily mean)

NOAA-18
NOAA-19
NOAA-16

Bias of CLARA-A3 TOA RSF radiation w.r.t. CERES-SYNEd.4 (201107)

RMSE-bc=2.91 W/m²
MAE=2.10 W/m²
ME=-0.21 W/m²

Mean diurnal cycle (0-24h UTC): Region: OCEAN-ATL_b40 (10 gridboxes between -26.5°E, 20.5°E, 35.5°N, 44.5°N); Month: 2011-07

CLARA-3 SYN_d1deg_MHour (-4.98 W/m²)
GERB-CMSAF-SYN_d1deg_MHour (0.11 W/m²)

NOAA-15
Metop-A

Bias of CLARA-A3 TOA RSF radiation w.r.t. CERES-SYNEd.4 (201101)

RMSE-bc=2.59 W/m²
RMSE=2.60 W/m²
MAE=1.88 W/m²
ME=-0.21 W/m²

CLARA-3 SYN_d1deg_MHour (-4.98 W/m²)
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Validation Level - 3 (daily mean)

NOAA-19
NOAA-16
NOAA-18
NOAA-15
Metop-A
NOAA-17

Bias of CLARA-A3 TOA RSF radiation w.r.t. CERES-SYN-M4 Ed4.1 (201107)

RMSE-bc=2.91 W/m²
RMSE=2.91 W/m²
MAE=2.10 W/m²
ME=-0.21 W/m²
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Mean diurnal cycle (0-24h UTC); Region: OCEAN-ATL_b40 (10 gridboxes between -20.5°E, -20.5°E, 35.5°N, 44.5°N); Month: 2011-07
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Validation Level - 3 (daily mean)

NOAA-19
NOAA-18

Mean diurnal cycle (0-24h UTC): Region: OCEAN-ATL_b40 (10 gridboxes between -20.5°E, 20.5°E, 35.5°N, 44.5°N); Month: 2011-07

Bias of CLARA-A3 TOA RSF radiation w.r.t. CERES-SYNEd4.1 (201101)

RMSE-bc=2.59 W/m²
RMSE=2.60 W/m²
MAE=1.88 W/m²
ME=-0.21 W/m²

Bias of CLARA-A3 TOA RSF radiation w.r.t. CERES-SYNEd4.1 (201107)

RMSE-bc=2.91 W/m²
RMSE=2.91 W/m²
MAE=2.10 W/m²
ME=-0.21 W/m²
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Validation Level - 3 (daily mean)

NOAA-18

NOAA-19

NOAA-16

Metop-A

NOAA-15

Mean diurnal cycle (0-24h UTC); Region: LAND-AFR_e10 (10 gridboxes between 22.5°E,22.5°E,5.5°N,14.5°N); Month: 2011-07

RMSE-bc=2.59 W/m²
RMSE=2.60 W/m²
MAE=1.88 W/m²
ME=-0.21 W/m²

RMSE-bc=2.91 W/m²
RMSE=2.91 W/m²
MAE=2.10 W/m²
ME=-0.21 W/m²
2.2. Validation daily/monthly L3

- 2008
• 2008
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Validation Level -3 (daily mean)
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Validation Level - 3 (daily mean)

Metop-A

NOAA-17

NOAA-18

NOAA-16

NOAA-15

Mean diurnal cycle (0-24h UTC); Region: OCEAN-ATLE_100 (10 gridboxes between 0.5°E,0.5°E,-4.5°N,4.5°N); Month: 2008-10
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Validation Level - 3 (daily mean)
Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project

Tom Akkermans

Global daily statistics CLARA-A3 w.r.t. ERA-5 and CERES (RSF)
Global daily statistics CLARA-A3 w.r.t. CERES (RSF)

- SYND Bias
- SYND RMSEbc

Year


W/m²

-15 -10 -5 0 5 10 15

Tom Akkermans  Developing an AVHRR-based CDR of TOA radiative fluxes within the CMSAF Project  63/40