CMSAF AVHRR-based CDR of TOA radiative fluxes (CLARA-A3): results and validation

Tom Akkermans, Nicolas Clerbaux

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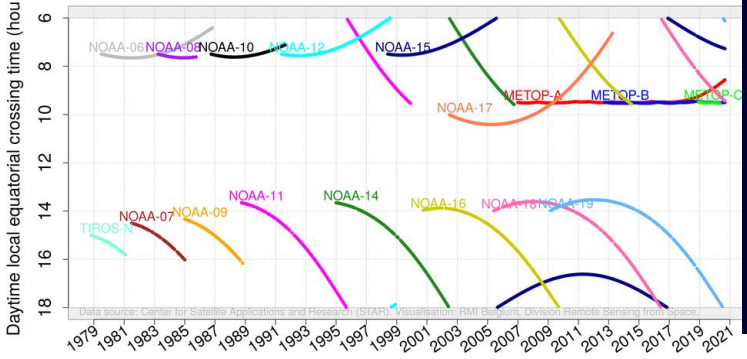
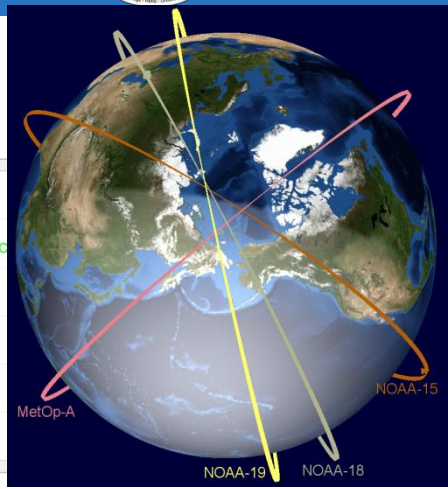
1. Introduction

- **What is CLARA?** "**C**M SAF c**L**oud, **A**lbedo and **RA**diation dataset from AVHRR data" (≈similar to Patmos-X):
  - Polar orbiting : NOAA and MetOp
  - FCDR from NOAA (Heidinger,2010)
  - L3 products on 0.25°x0.25°
  - Currently released versions:
    - CLARA-A1 (1982-2009)
    - CLARA-A2 (1982-2015)

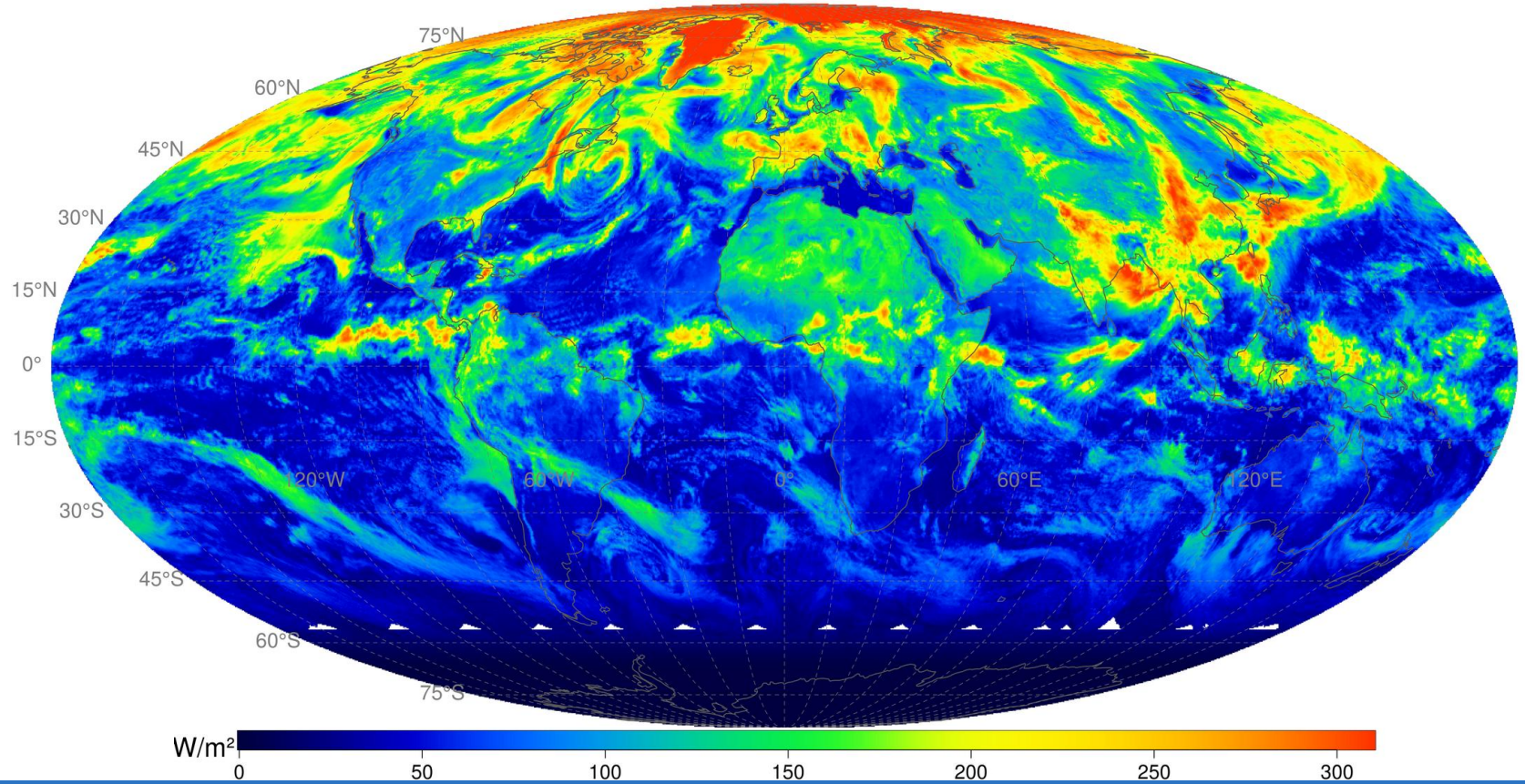




- **Some of the modifications in the upcoming version CLARA-A3:**
  - Inclusion of the AVHRR-1 sensor (TIROS-N, NOAA-6,-8,-10): extension of time range to 1979-2020, which is 42 years
  - Updated FCDR: new calibration for visible channels (latest PATMOS-x coefficients)
  - Updated cloud treatment algorithms (NWC SAF / PPS v.2018; Karlsson et al.)
  - Addition of new product "TOA radiative fluxes" → this presentation

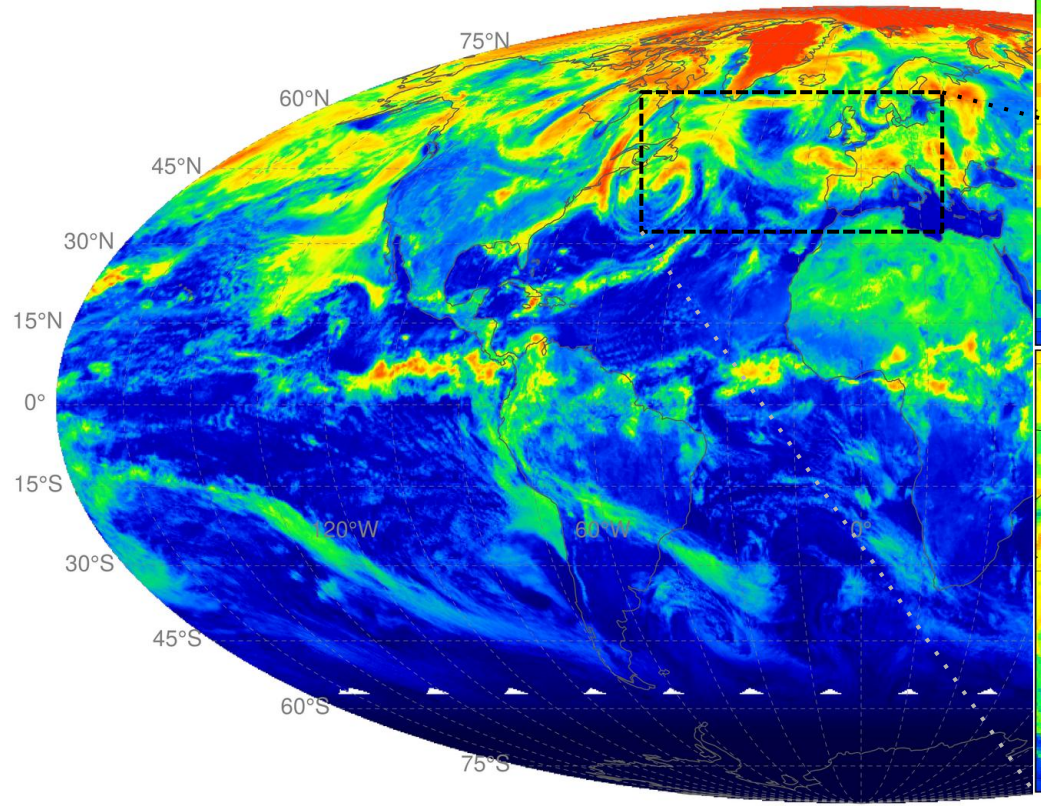
2. Results

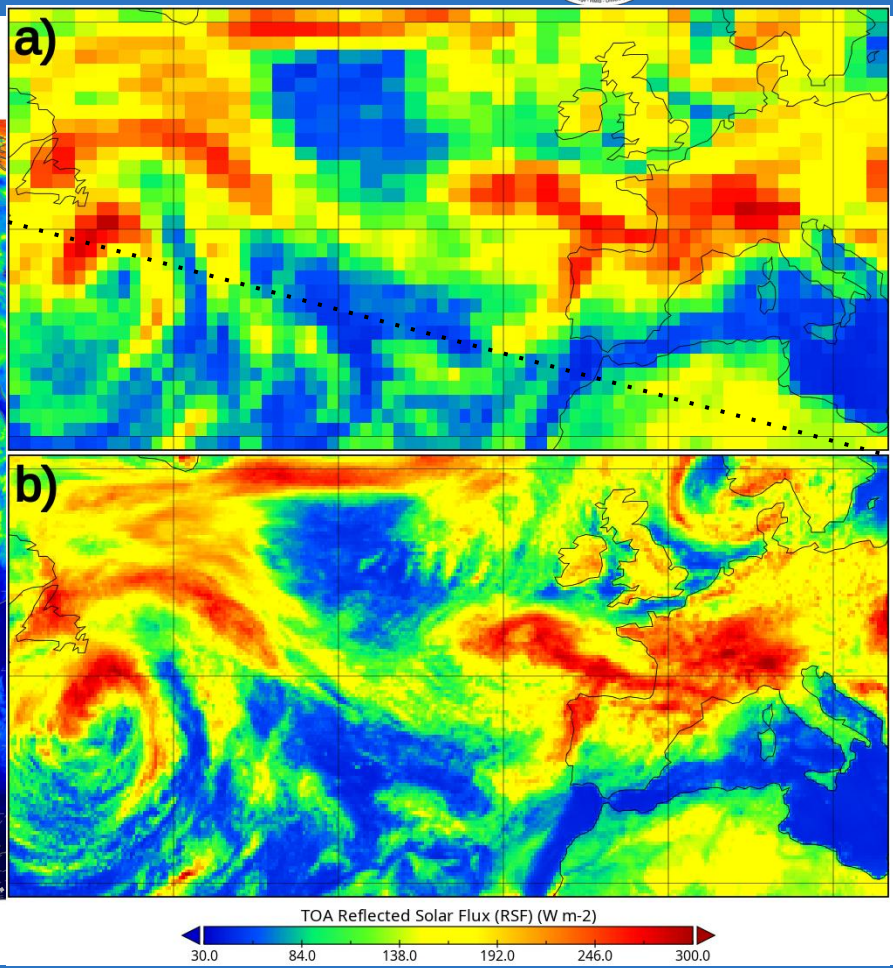
- Example: daily mean RSF (15/6/2008)



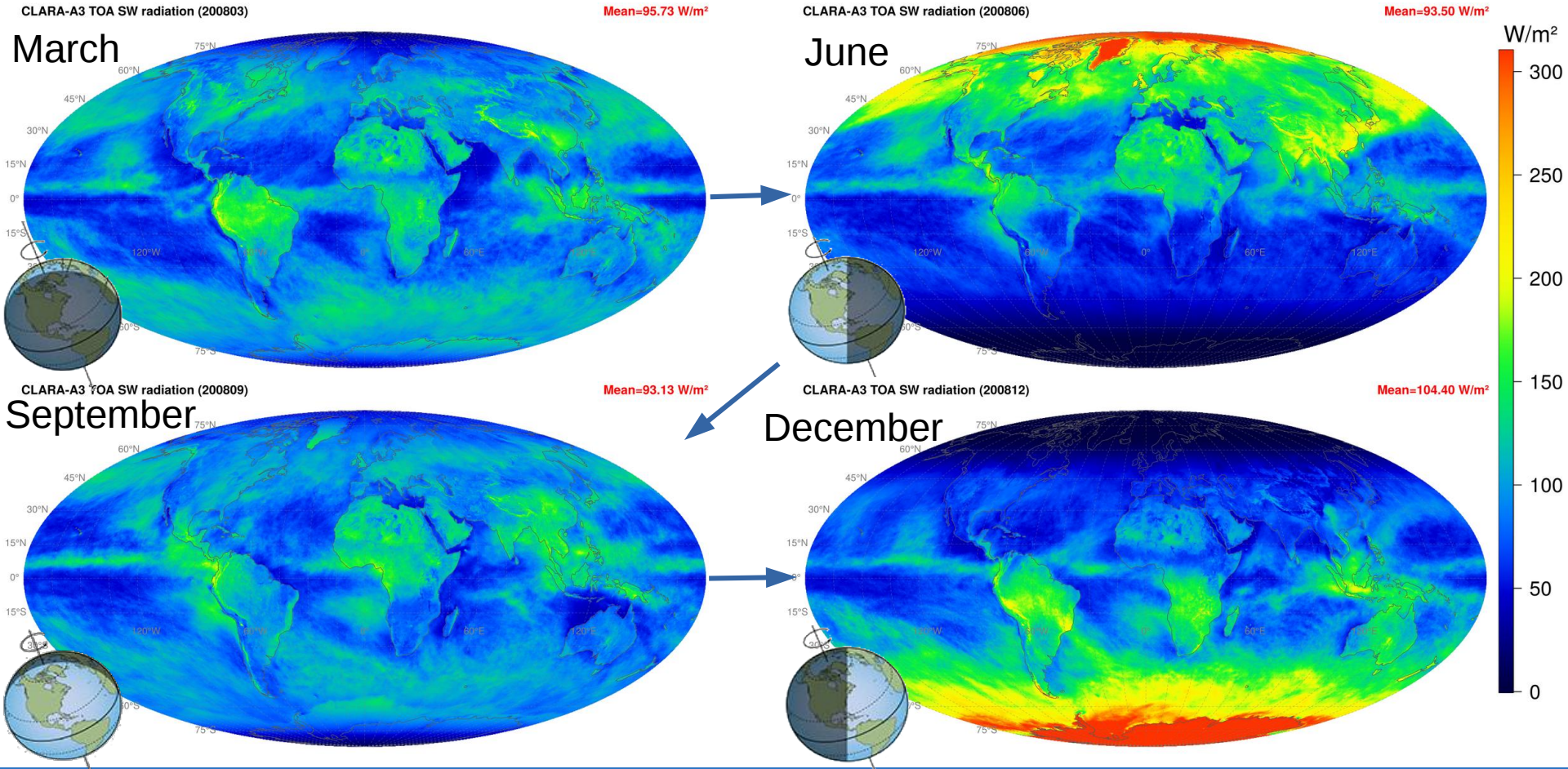
2. Results

- Example: daily mean RSF (15/6/2008)

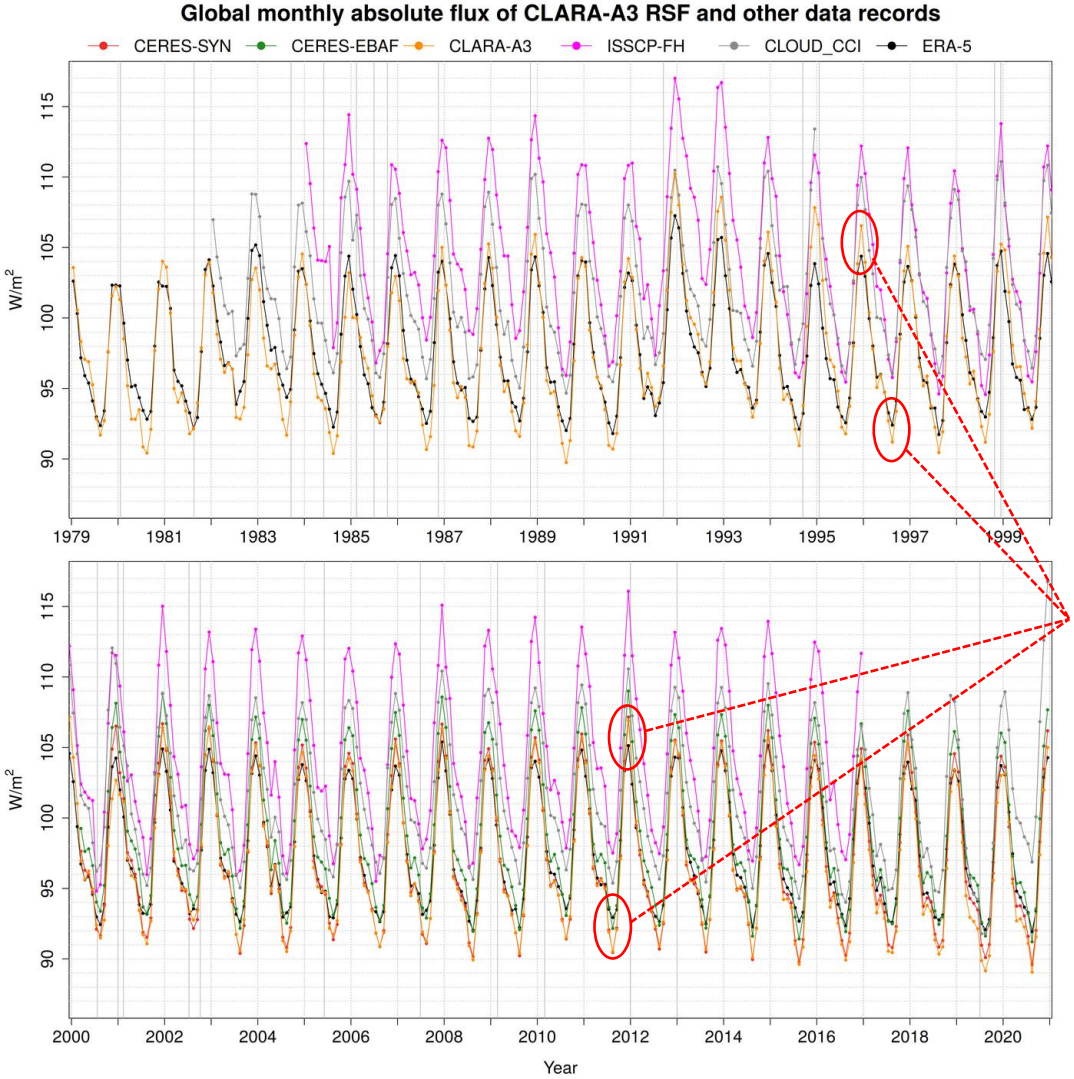




2. Results


CLARA-A3 TOA SW radiation (200803)
Mean=95.73 W/m²
March
CLARA-A3 TOA SW radiation (200806)
Mean=93.50 W/m²
June
CLARA-A3 TOA SW radiation (200809)
Mean=93.13 W/m²
September
CLARA-A3 TOA SW radiation (200812)
Mean=104.40 W/m²
December
W/m²
300
250
200
150
100
50
0

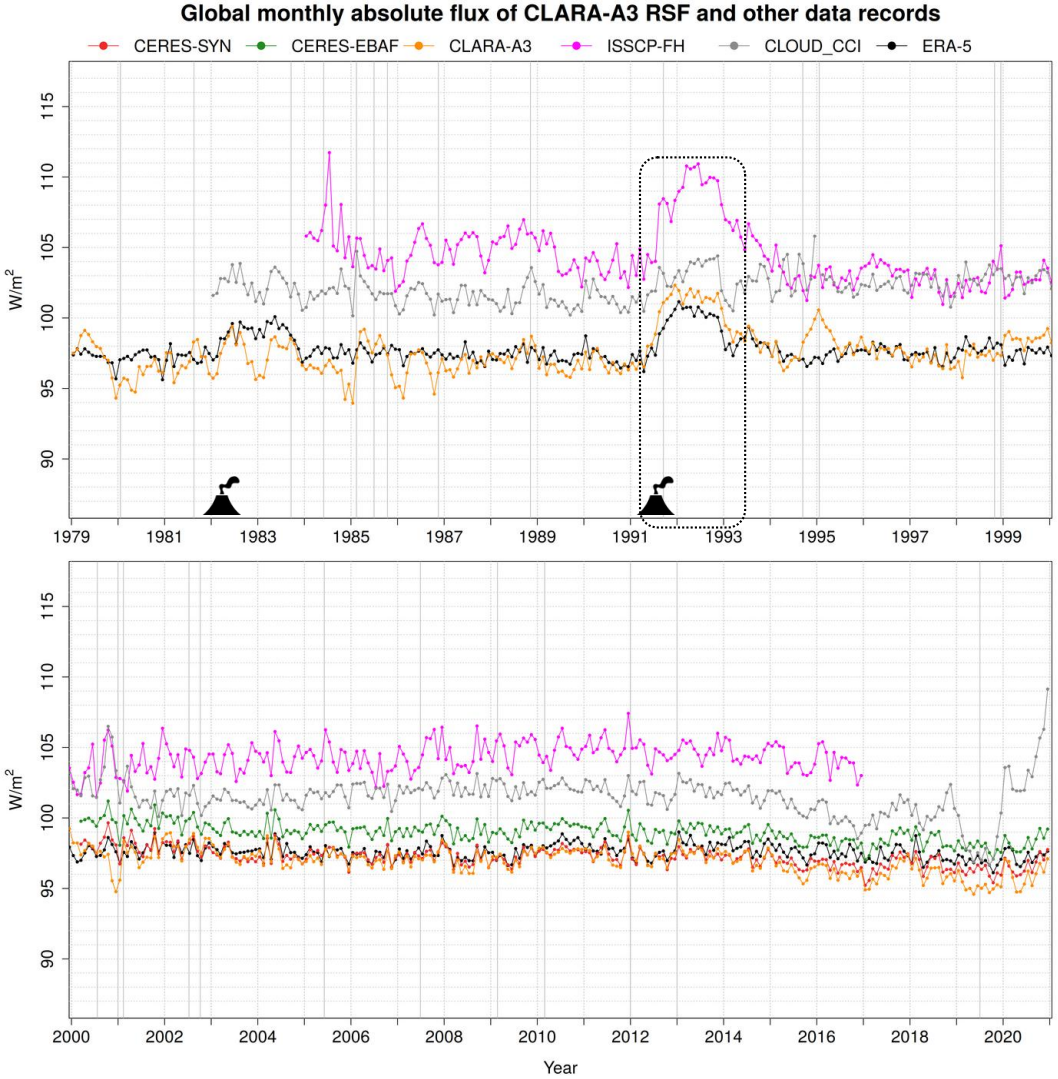
- **Global** Monthly Mean RSF:



Systematic seasonal biases, e.g. from ERA5 w.r.t. CERES and CLARA-A3: underestimated amplitude of annual cycle

- **Global** Monthly Mean RSF:

- Deseasonalized



Major volcanic events

Trends (W/m²/dec):

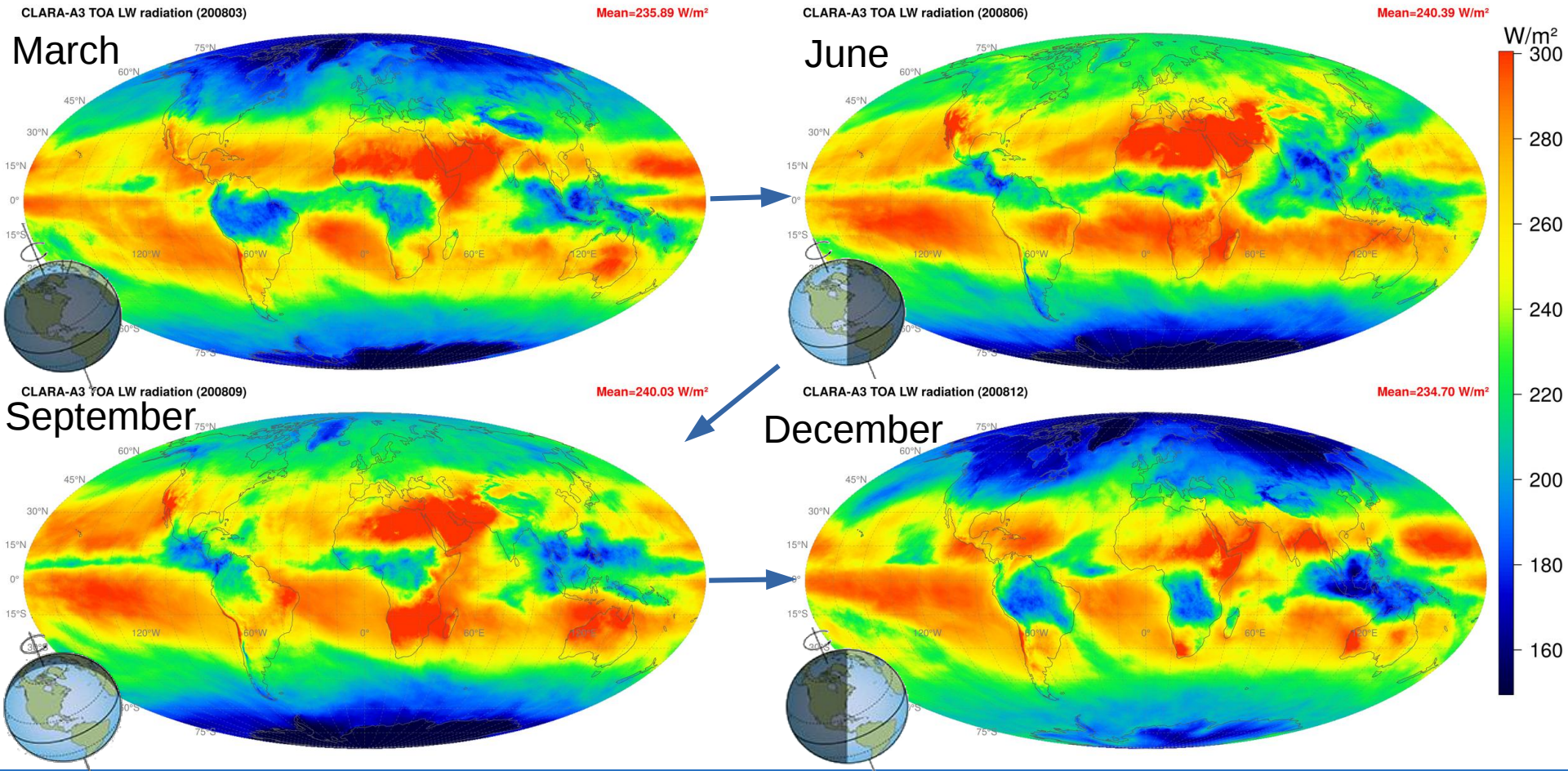
Full series:

ERA5:	-0.0769
CLARA-A3:	-0.2318

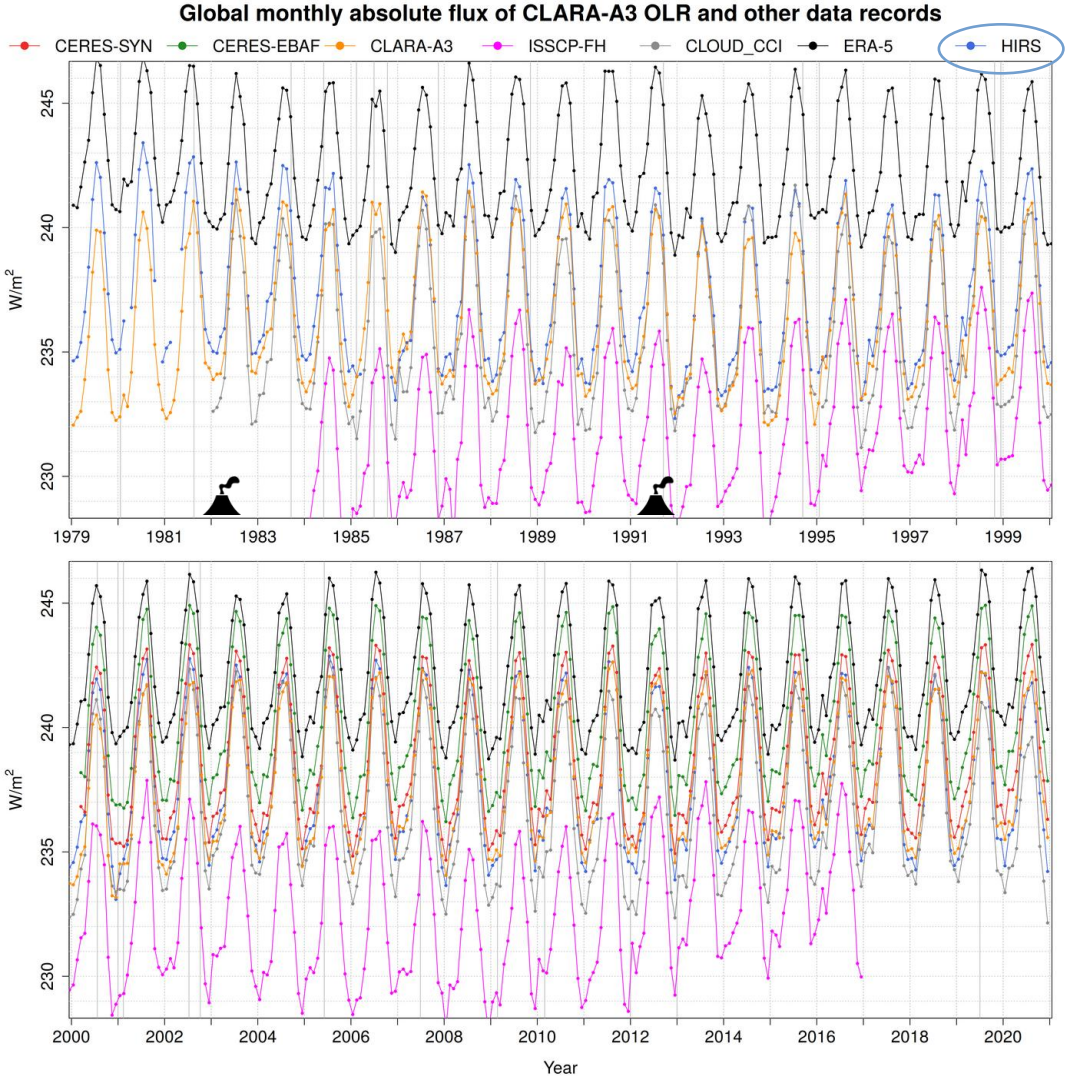
Since 2000:

ERA5:	-0.2024
CLARA-A3:	-0.9645
CERESSYN:	-0.6451
CERESEBAF:	-0.7023

2. Results

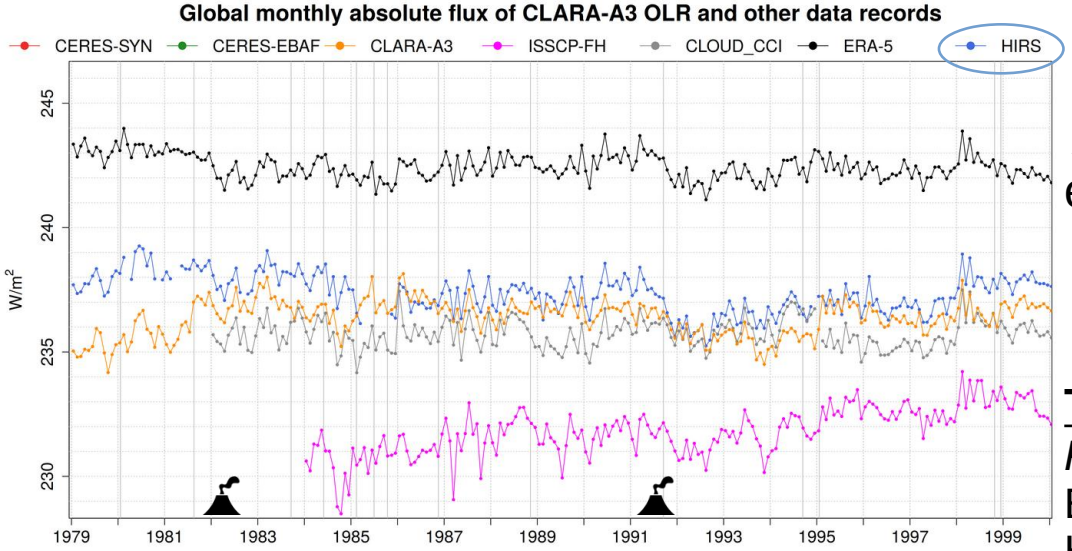

CLARA-A3 TOA LW radiation (200803)
Mean=235.89 W/m²
March
CLARA-A3 TOA LW radiation (200806)
Mean=240.39 W/m²
June
CLARA-A3 TOA LW radiation (200809)
Mean=240.03 W/m²
September
CLARA-A3 TOA LW radiation (200812)
Mean=234.70 W/m²
December
W/m²
300
280
260
240
220
200
180
160

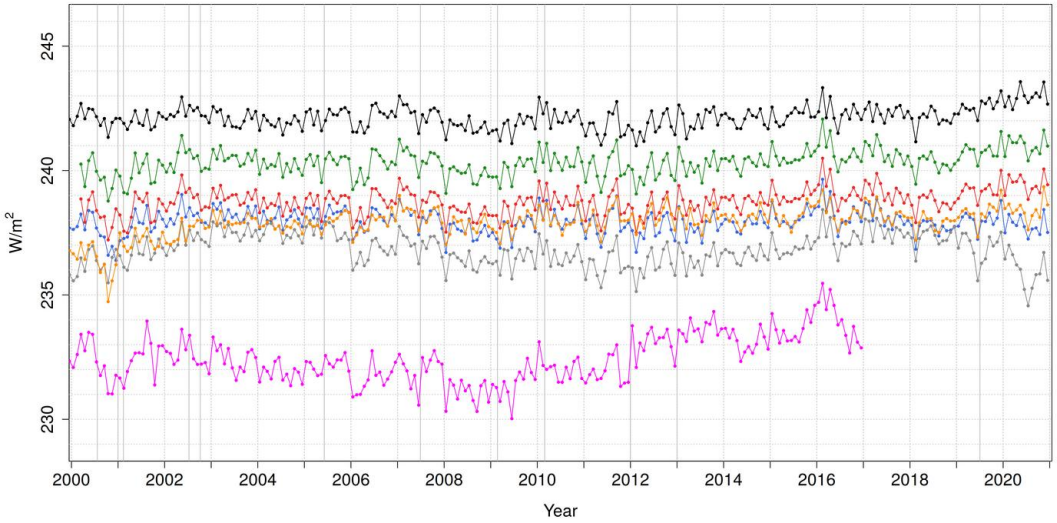
- **Global** Monthly Mean OLR:



- **Global** Monthly Mean OLR:

- Deseasonalized





Major volcanic events

Trends (W/m²/dec):

Full series:

ERA5:	-0.1125
HIRS:	+0.1461
CLARA-A3:	+0.6321

Since 2000:

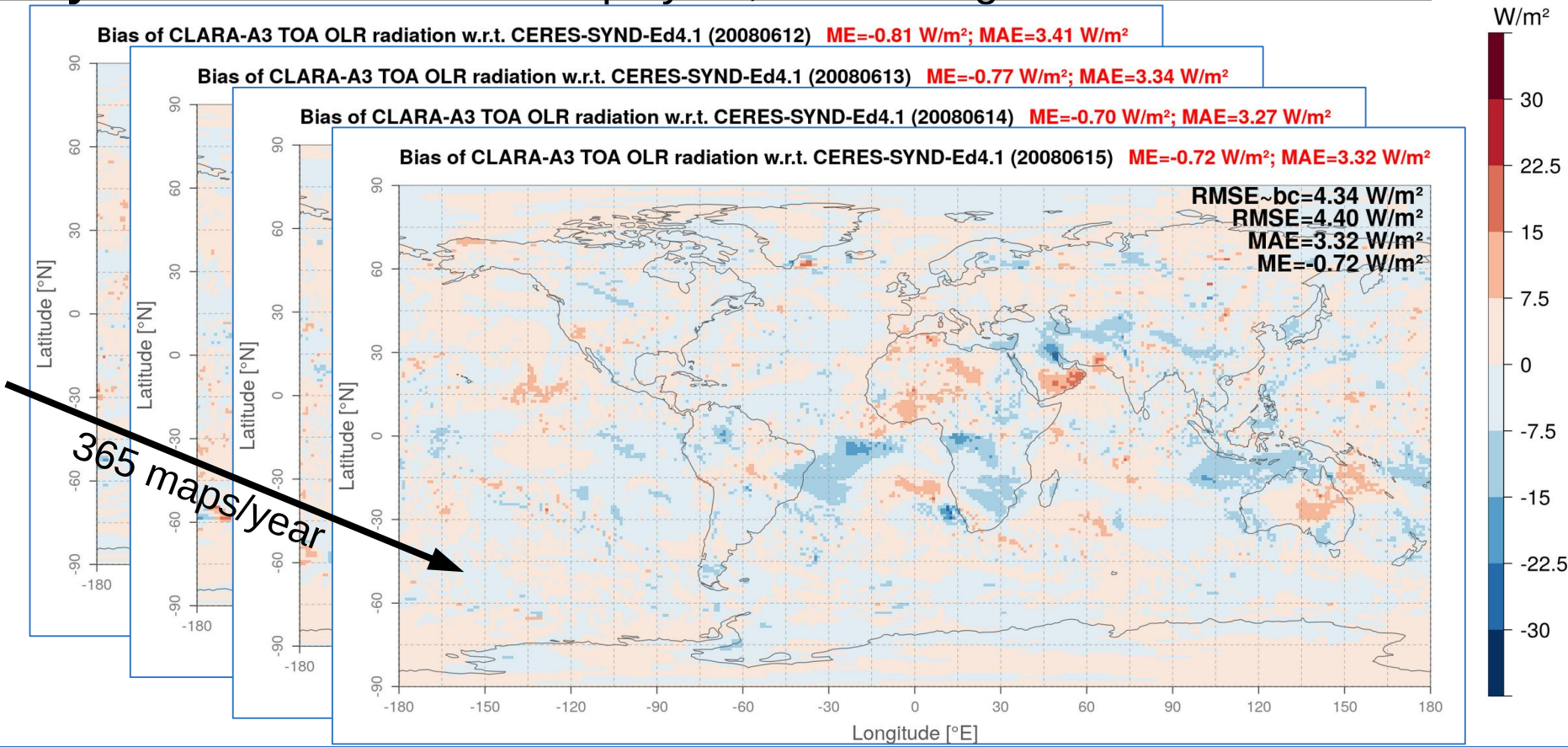
ERA5:	+0.2295
HIRS:	-0.0679
CLARA-A3:	+0.3800
CERESSYN:	+0.2825
CERESEBAF:	+0.2839

3. Validation

- ***Longwave: Outgoing Longwave Radiation :***
  - **Bias:**
    - Daily mean OLR
    - Monthly mean OLR
  - **RMSE (bias corrected):**
    - Daily mean OLR
    - Monthly mean OLR
- ***Shortwave: Reflected Solar Flux :***
  - **Bias:**
    - Daily mean RSF
    - Monthly mean RSF
  - **RMSE (bias corrected):**
    - Daily mean RSF
    - Monthly mean RSF

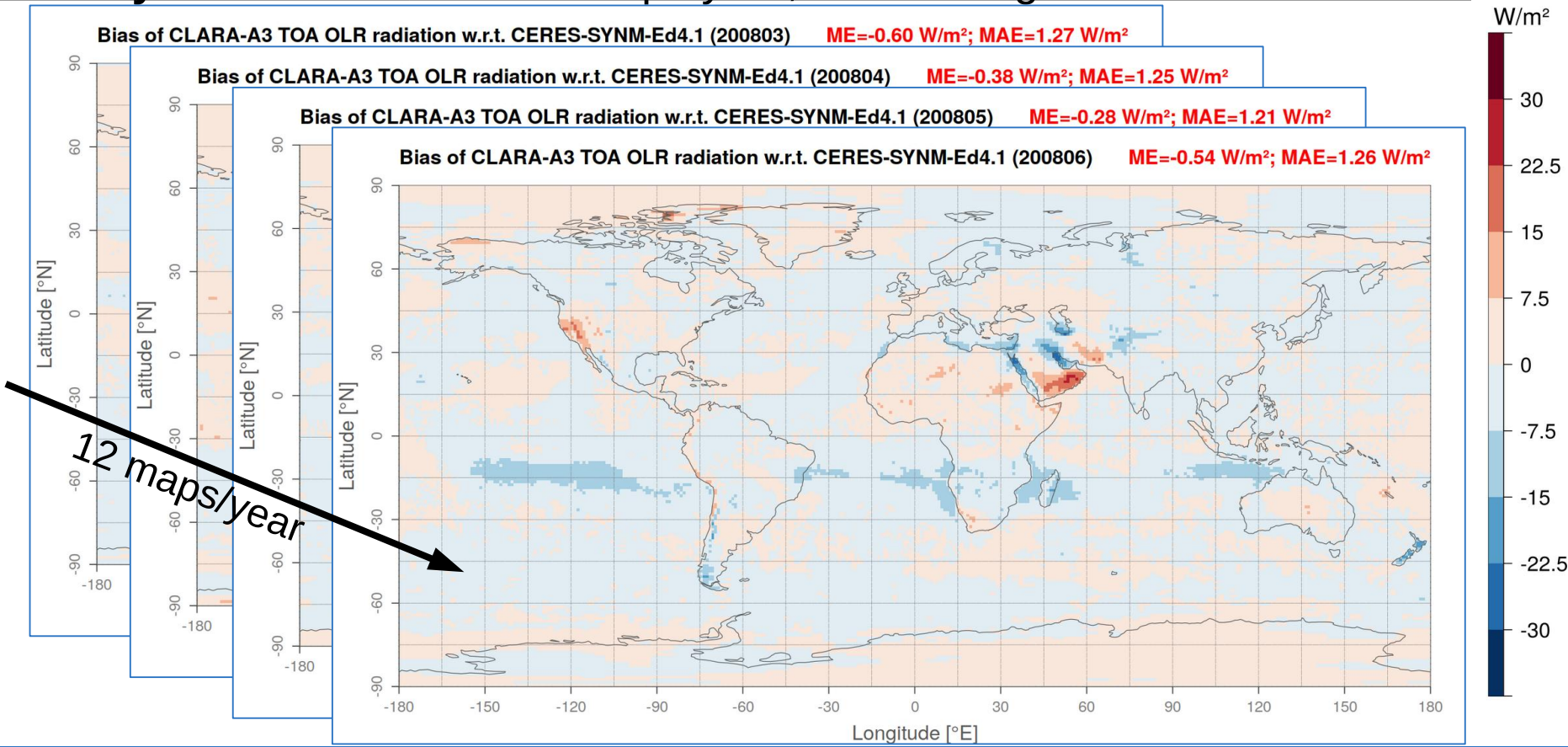
3. Validation

- **Daily mean OLR:** 365 bias maps/year, each with global bias and RMSE:

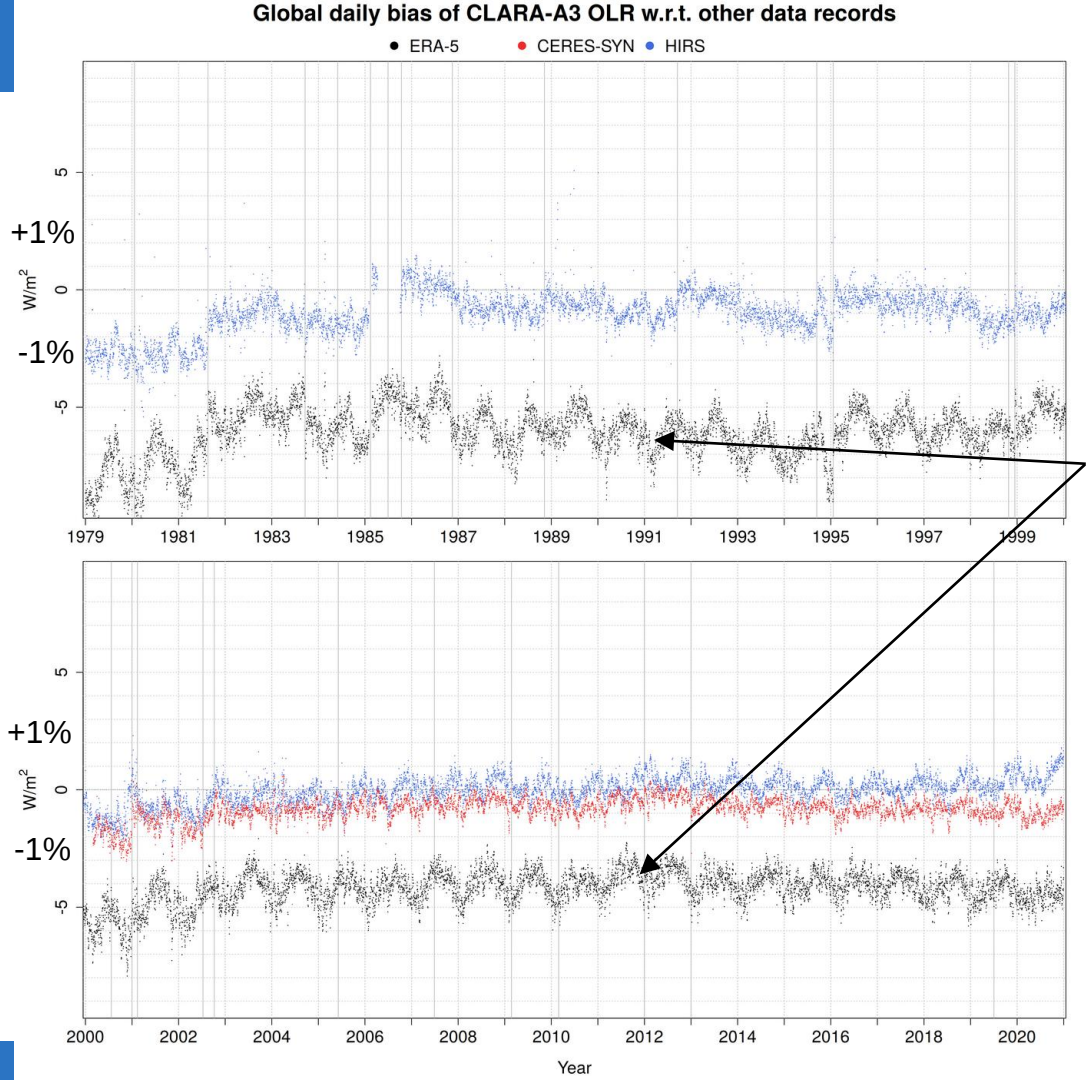


3. Validation

- **Monthly mean OLR:** 12 bias maps/year, each with global bias and RMSE:



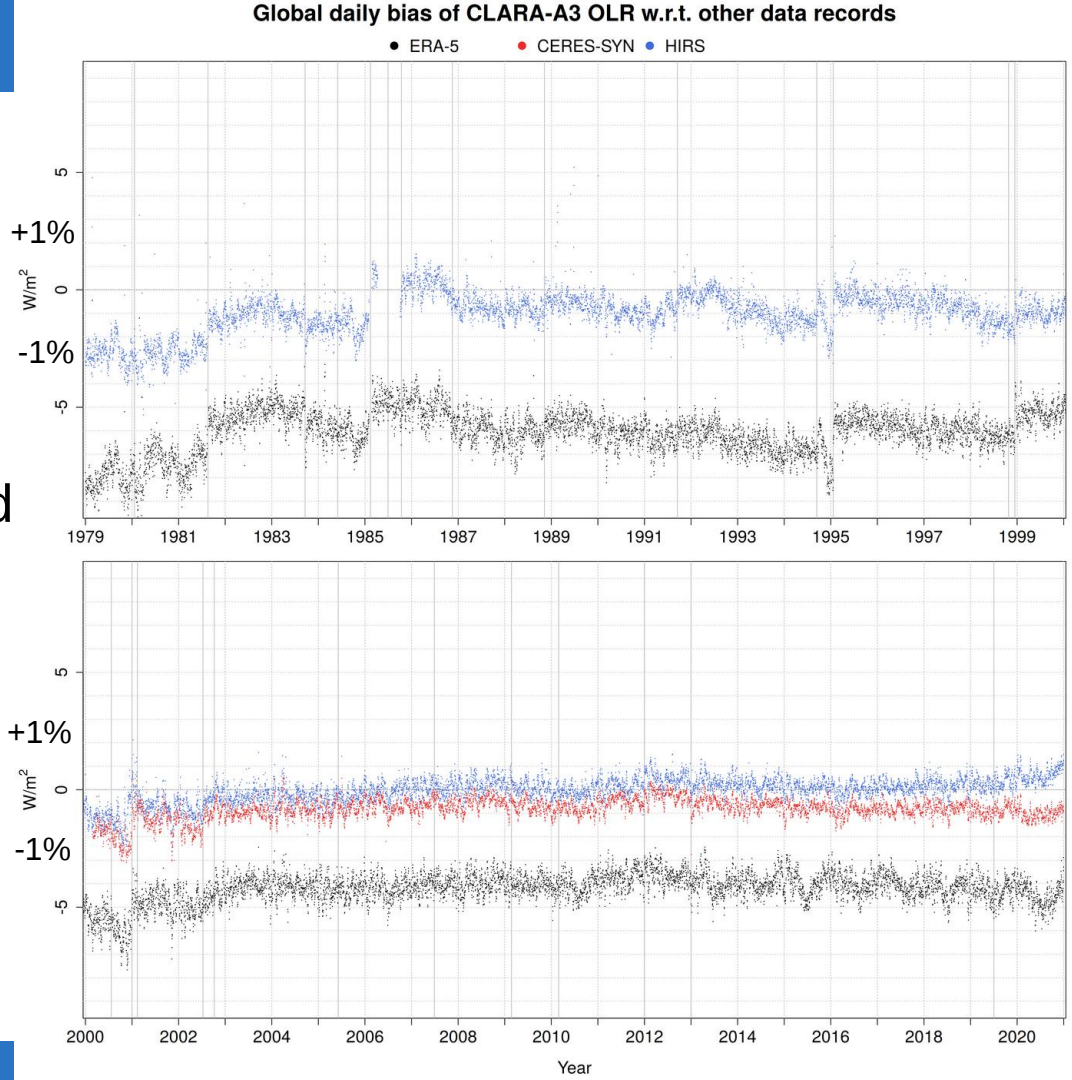
- **Global mean bias** of Daily Mean OLR:



Bias w.r.t. **ERA5** has a systematic seasonal pattern, not visible in biases w.r.t. CERES and HIRS.

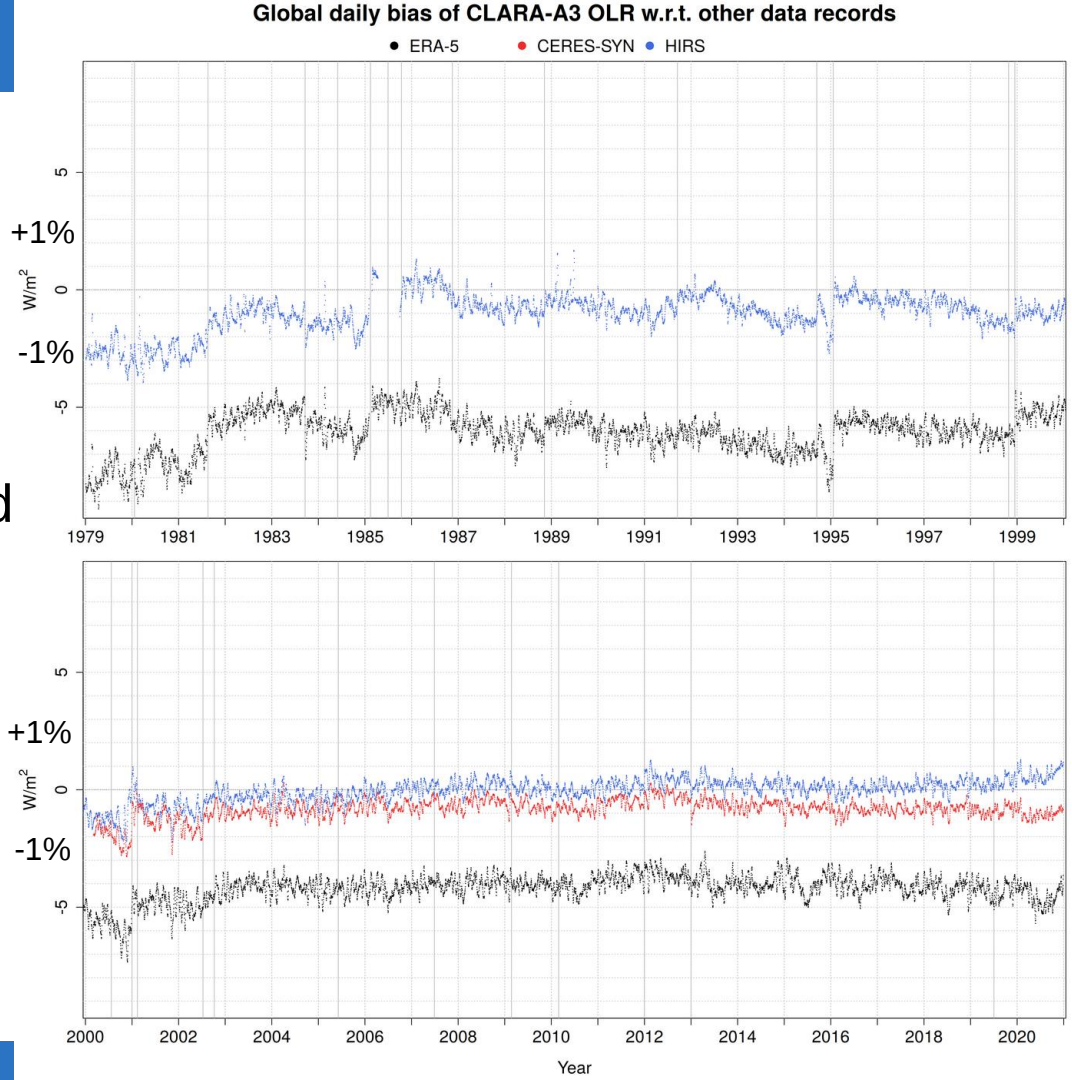
- **Global mean bias** of Daily Mean OLR:

- Deseasonalized



- **Global mean bias** of Daily Mean OLR:

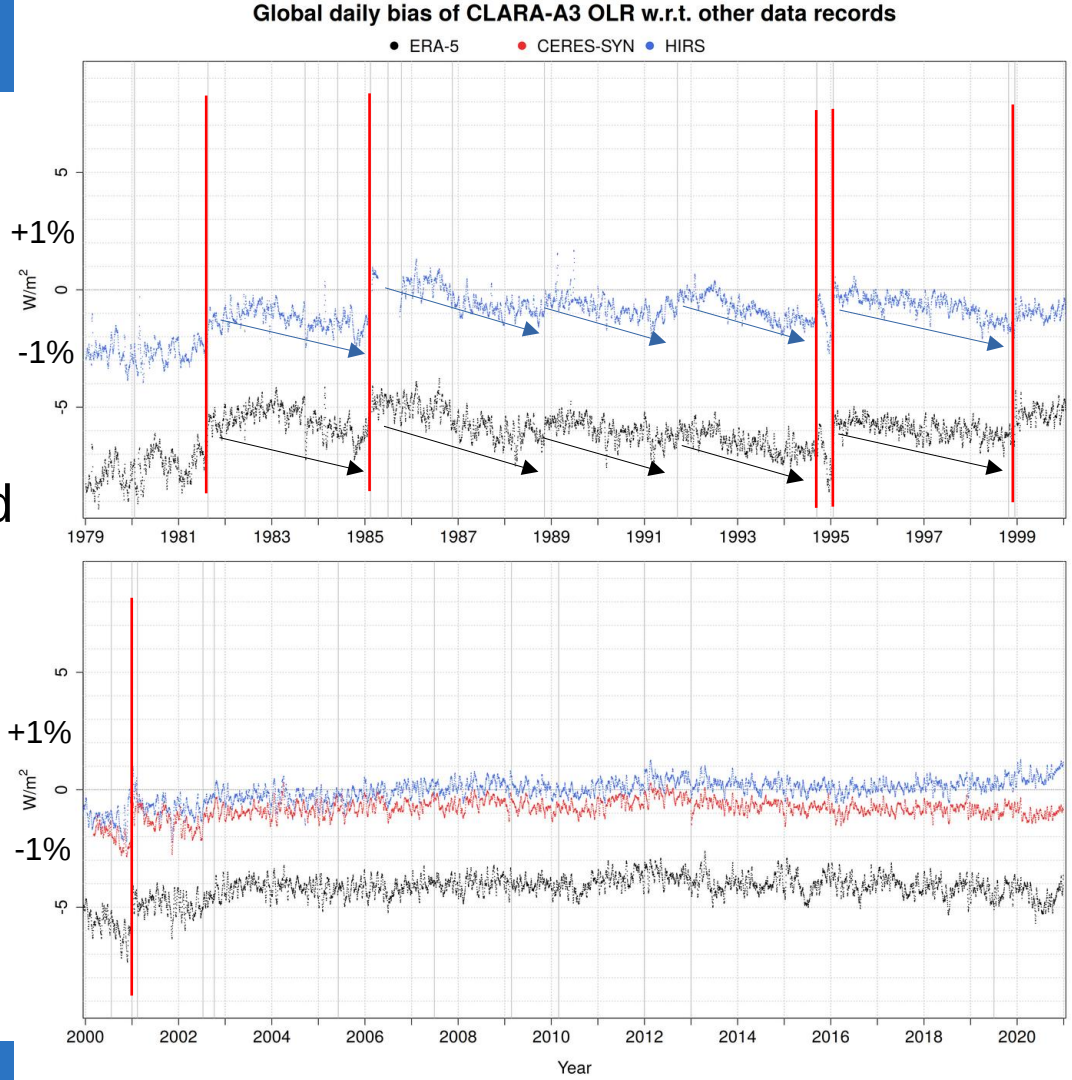
- Deseasonalized
- Weekly running average



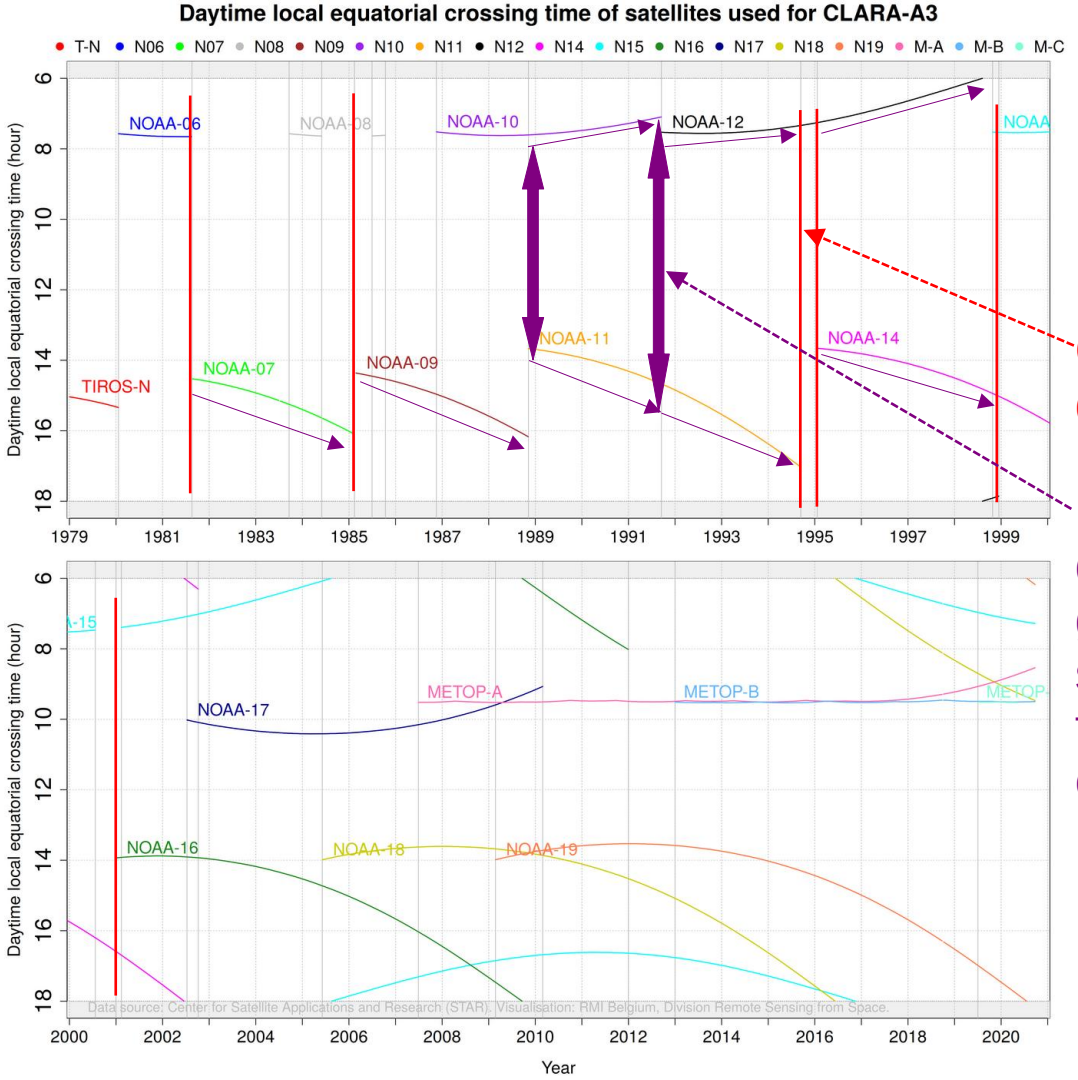
Overall: good: within +/-1% w.r.t. HIRS

- **Global mean bias** of Daily Mean OLR:

- Deseasonalized
- Weekly running average



Discontinuities related to changes in orbital configuration?



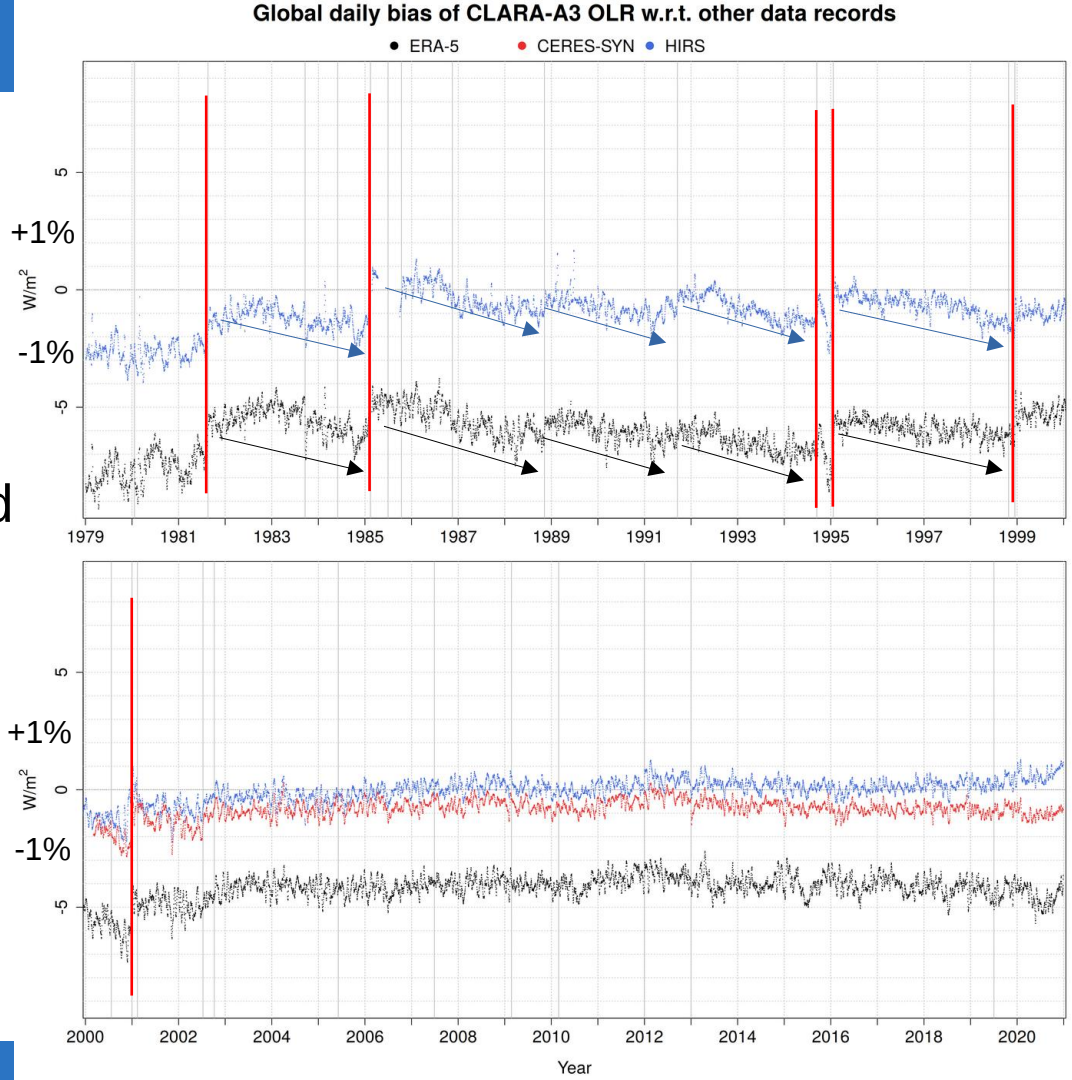
Orbital discontinuities

+

Between the discontinuities are gradients from small to large temporal spread of observations

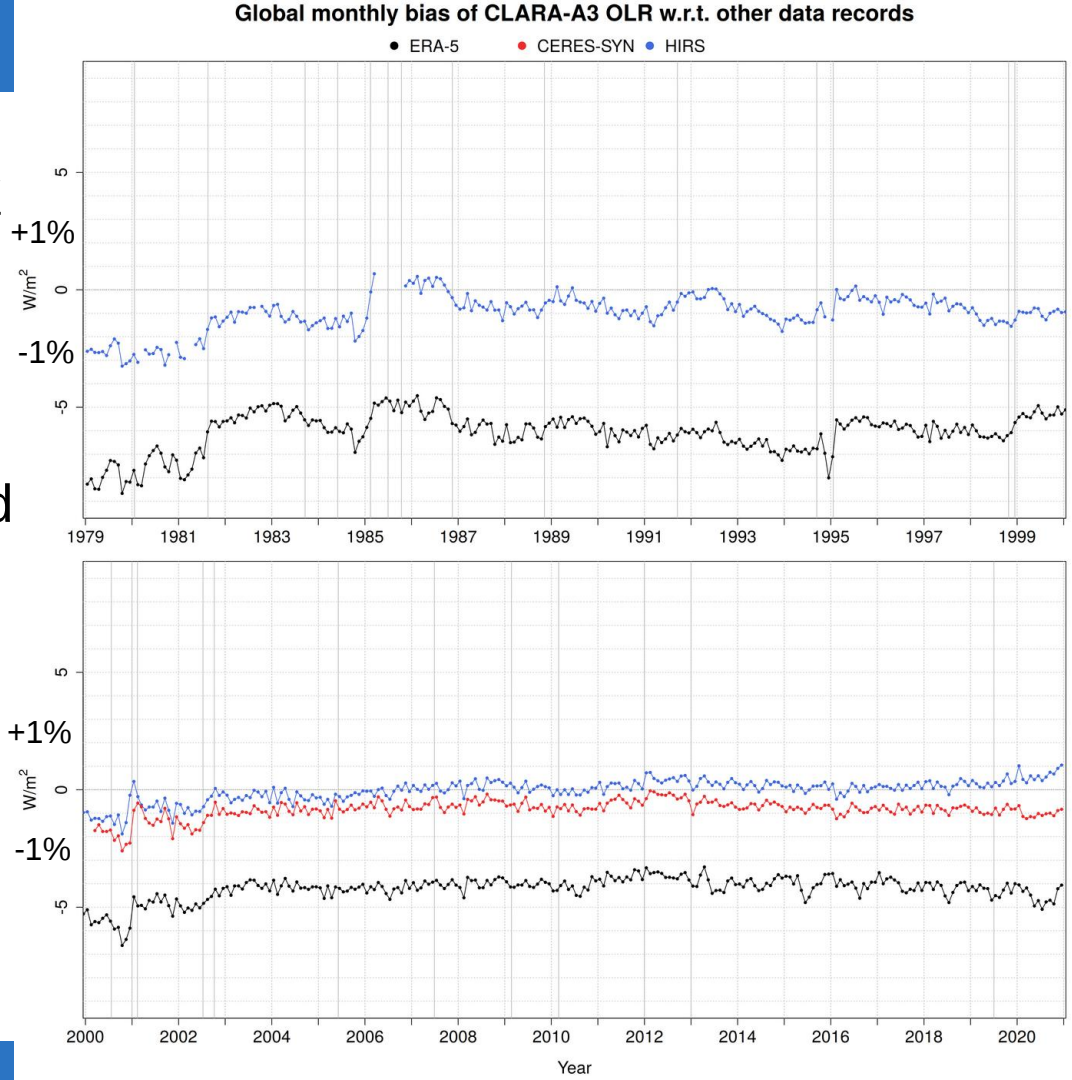
- **Global mean bias** of Daily Mean OLR:

- Deseasonalized
- Weekly running average



- **Global mean bias** of Monthly Mean OLR:

- Deseasonalized

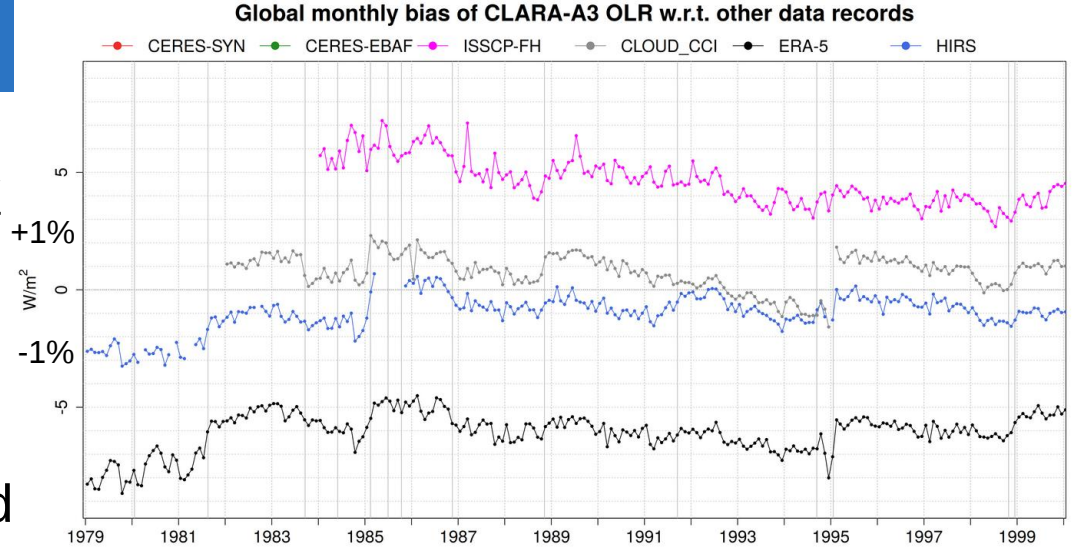


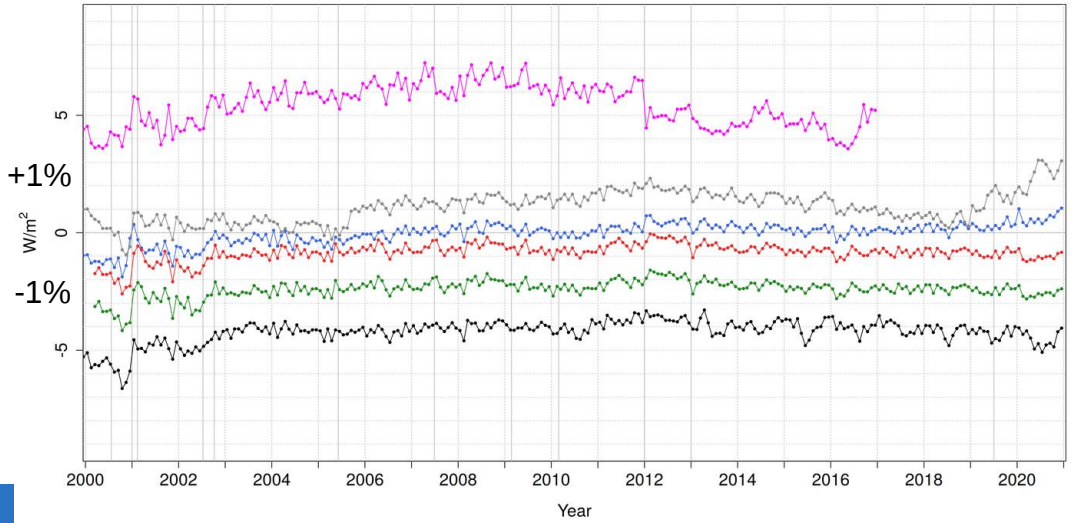
Monthly pattern same as daily.

Stable w.r.t. HIRS

- **Global mean bias** of Monthly Mean OLR:

- Deseasonalized



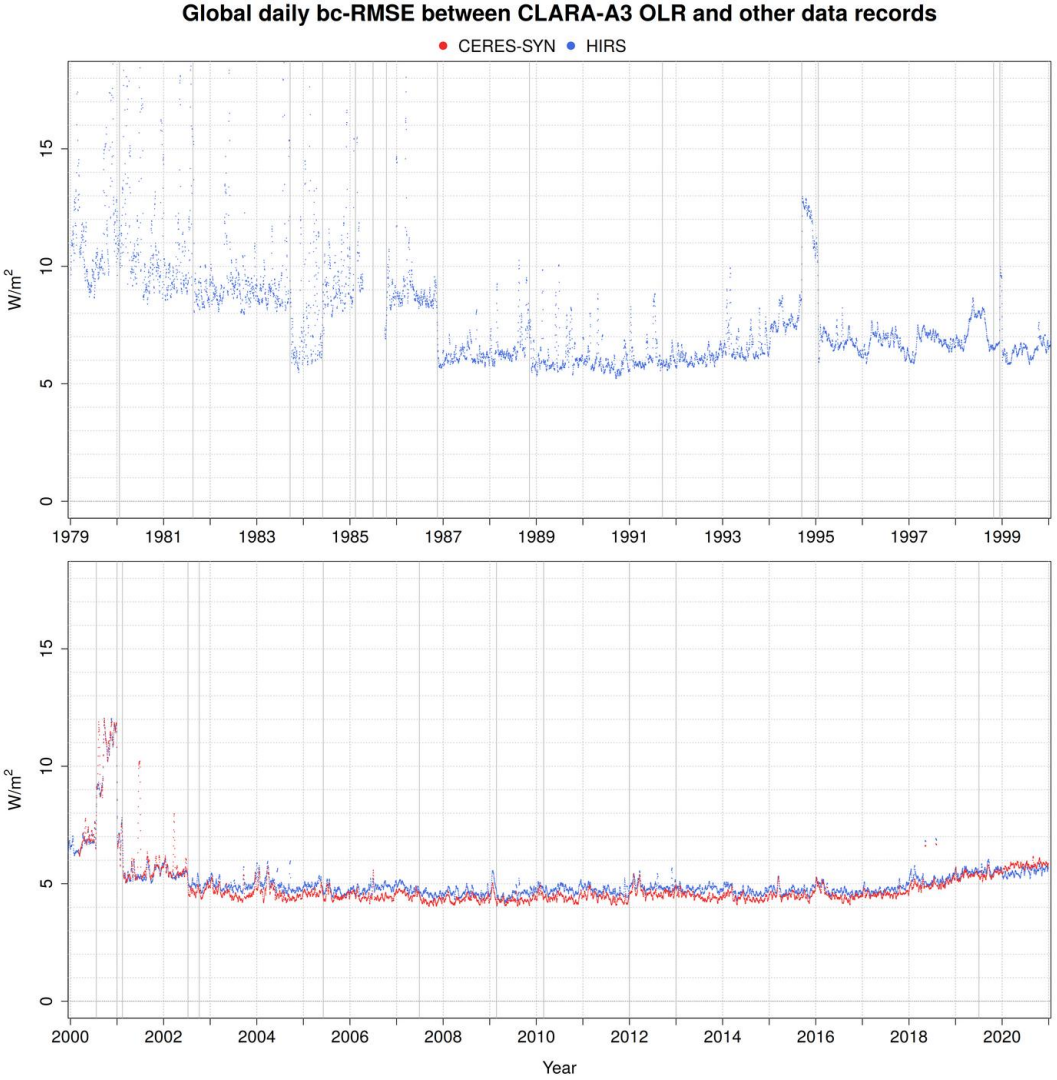


Monthly pattern same as daily.

Stable w.r.t. CERES SYN/EBAF

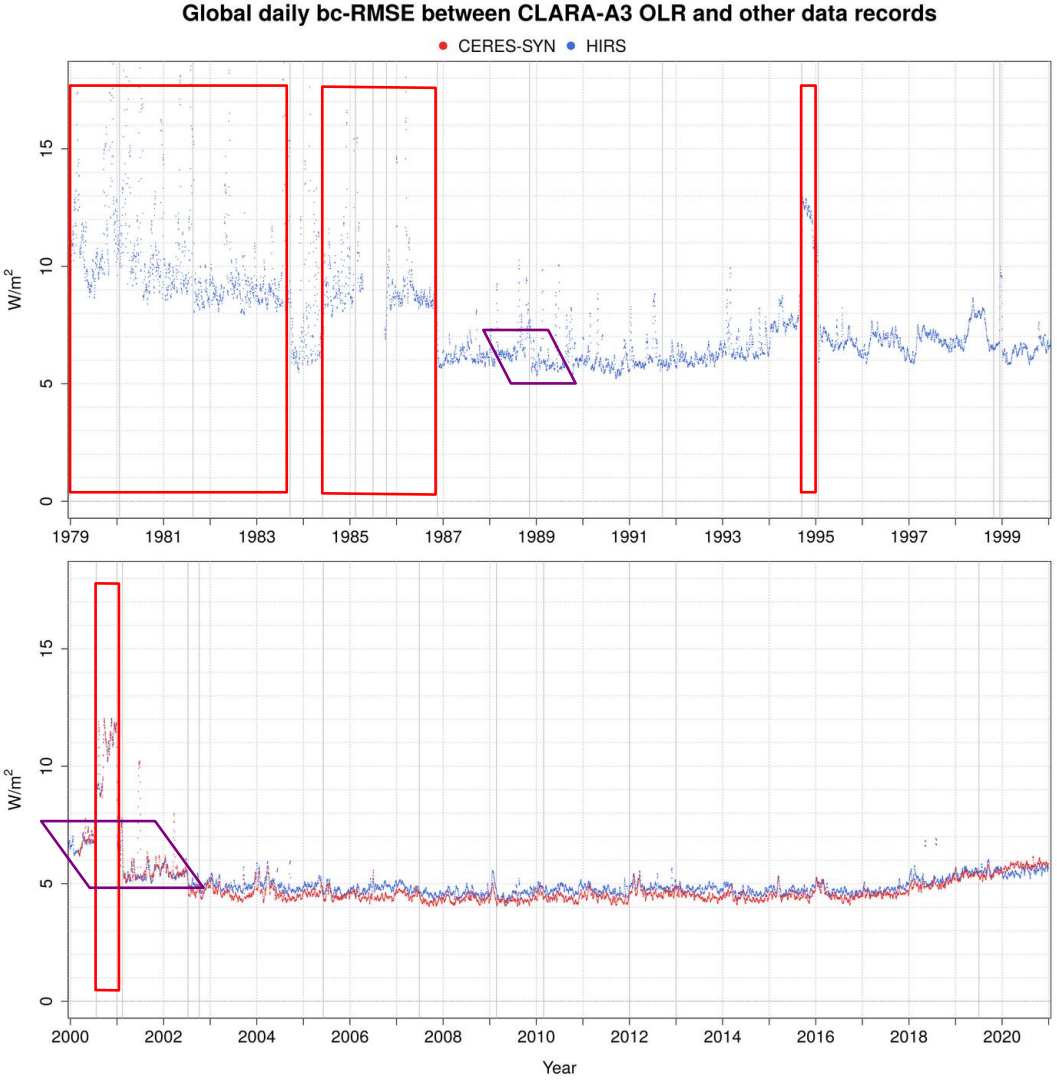
- **Global RMSE (bias-corrected)** of Daily Mean OLR:

- Weekly running average



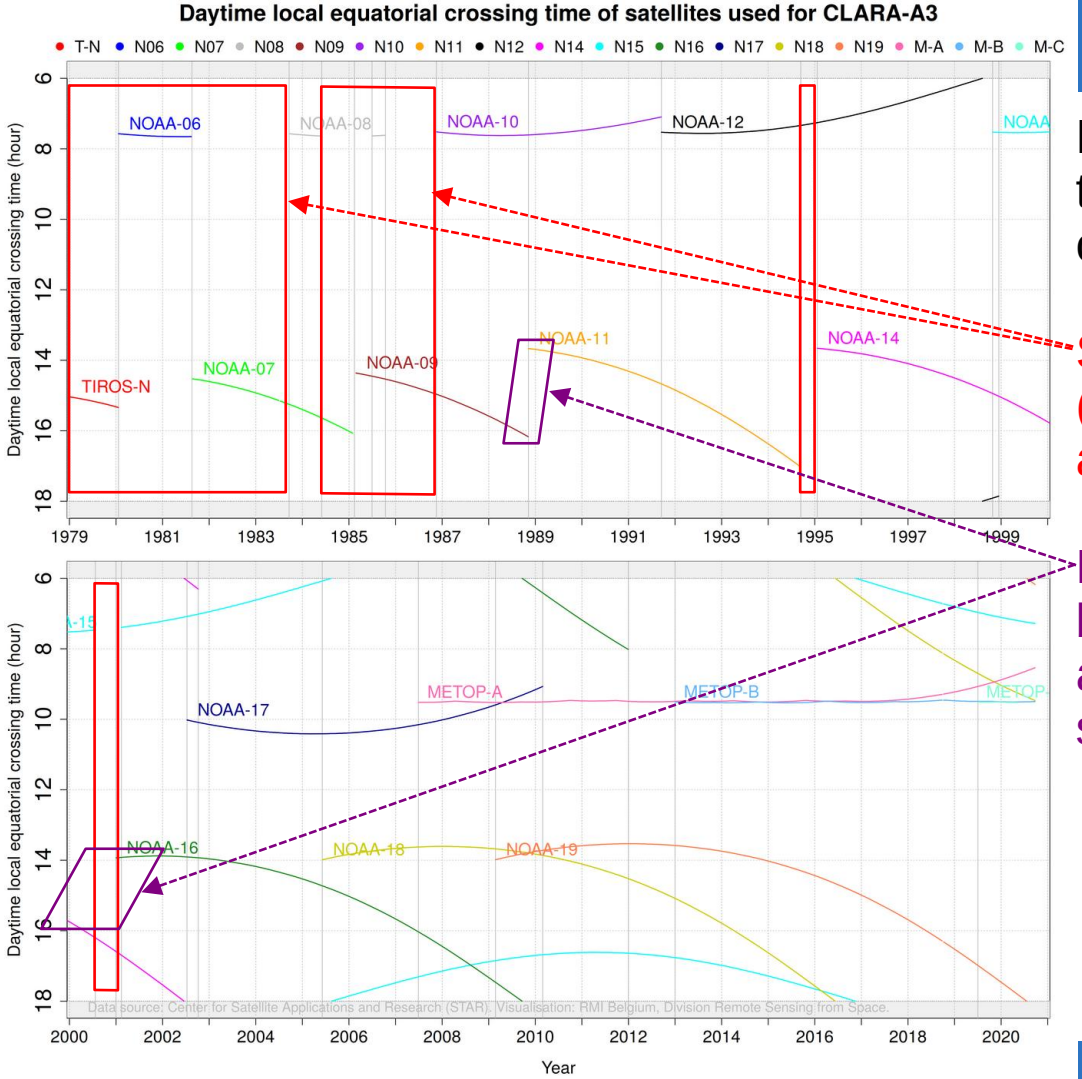
- **Global RMSE (bias-corrected)** of Daily Mean OLR:

- Weekly running average



Discontinuities due to changed orbital configuration.

- **Orbital configuration** of CLARA-A3:



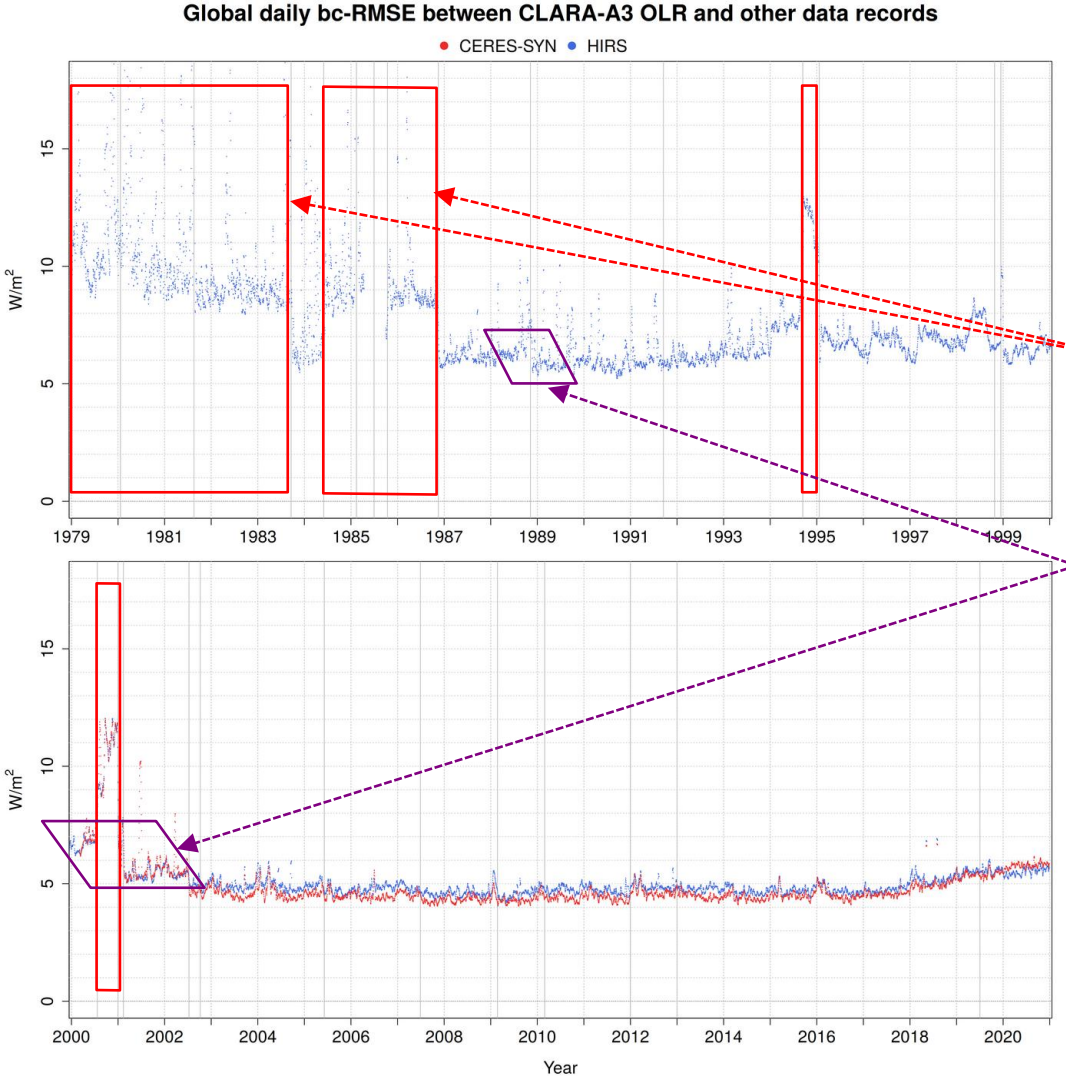
Discontinuities due to changed orbital configuration:

Single-orbit periods (either morning or afternoon)

Discontinuities between satellites and hence local solar time

- **Global RMSE (bias-corrected)** of Daily Mean OLR:

- Weekly running average



Discontinuities due to changed orbital configuration:

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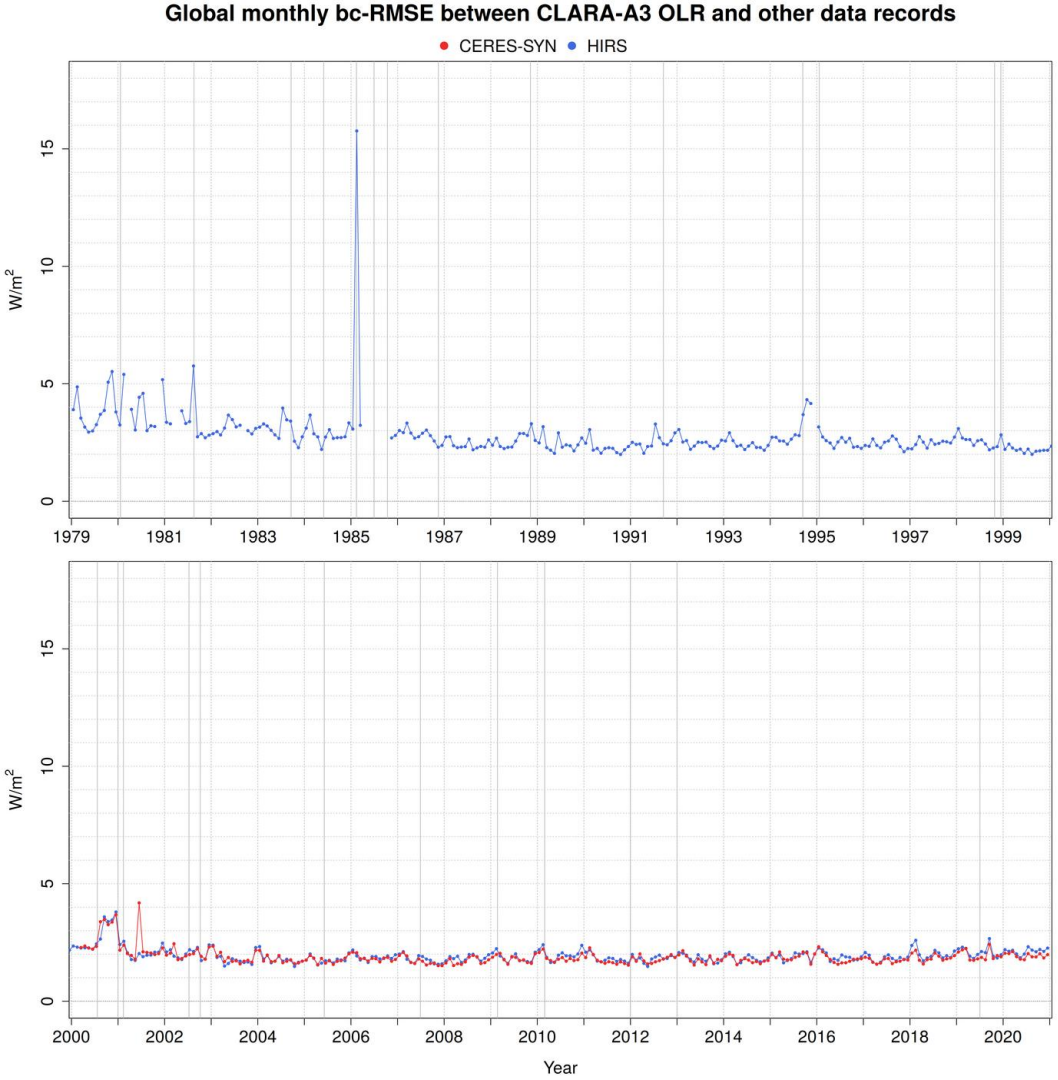
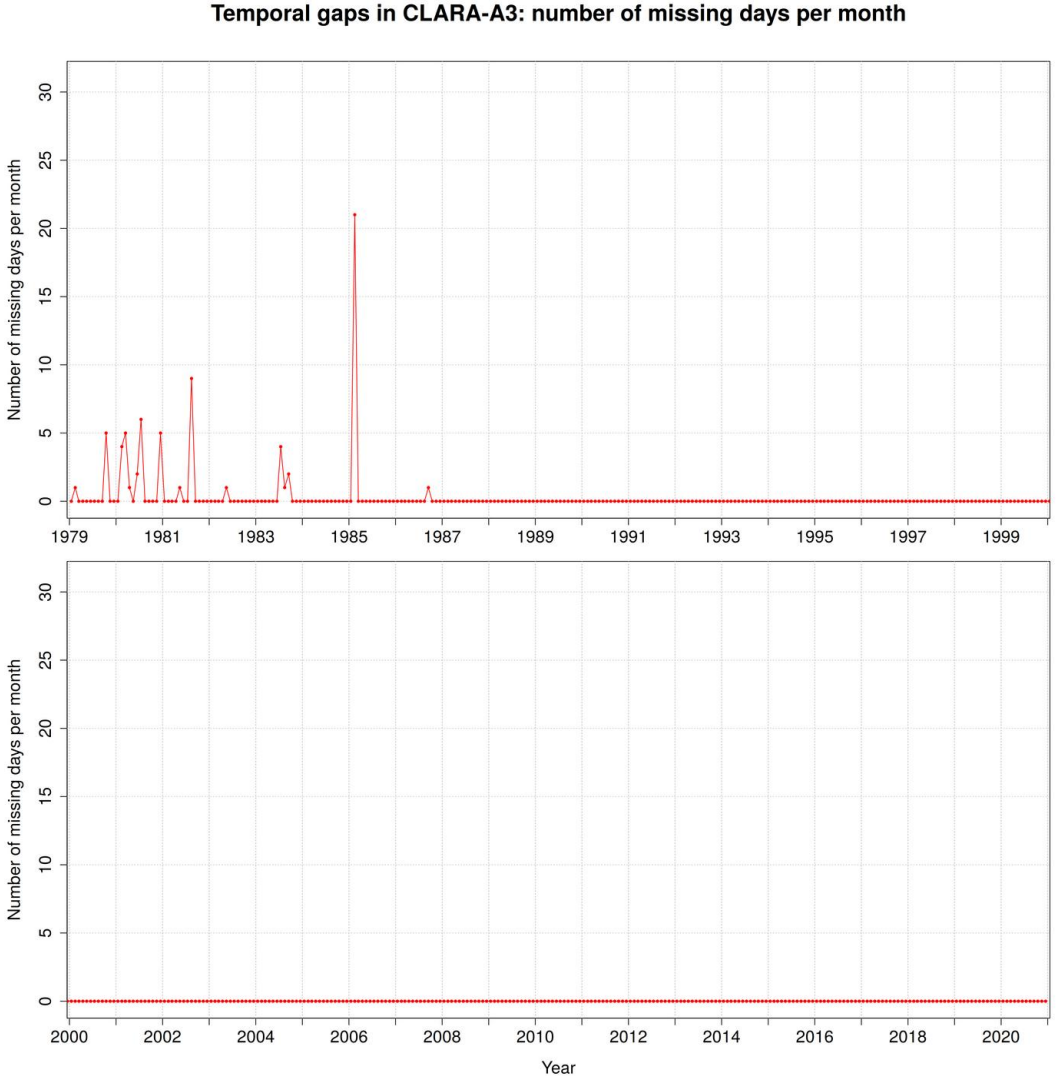
Discontinuities between satellites and hence local solar time

- **Global RMSE (bias-corrected)** of Monthly Mean OLR:



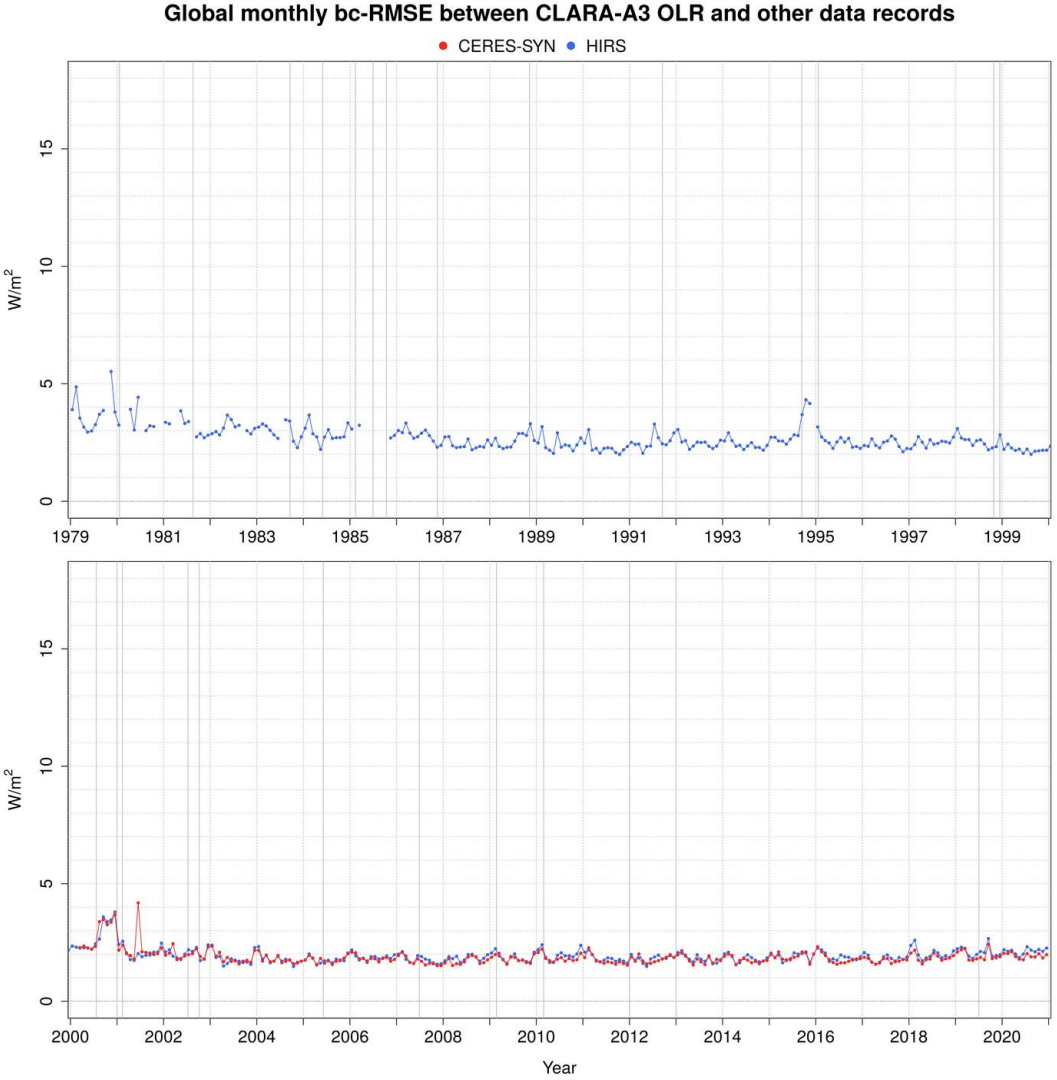
On monthly scale, impact of orbital configuration is much smaller.

- **Global RMSE (bias-corrected)** of Daily Mean OLR:



- **Global RMSE (bias-corrected)** of Monthly Mean OLR:

- Max 2 missing days per month



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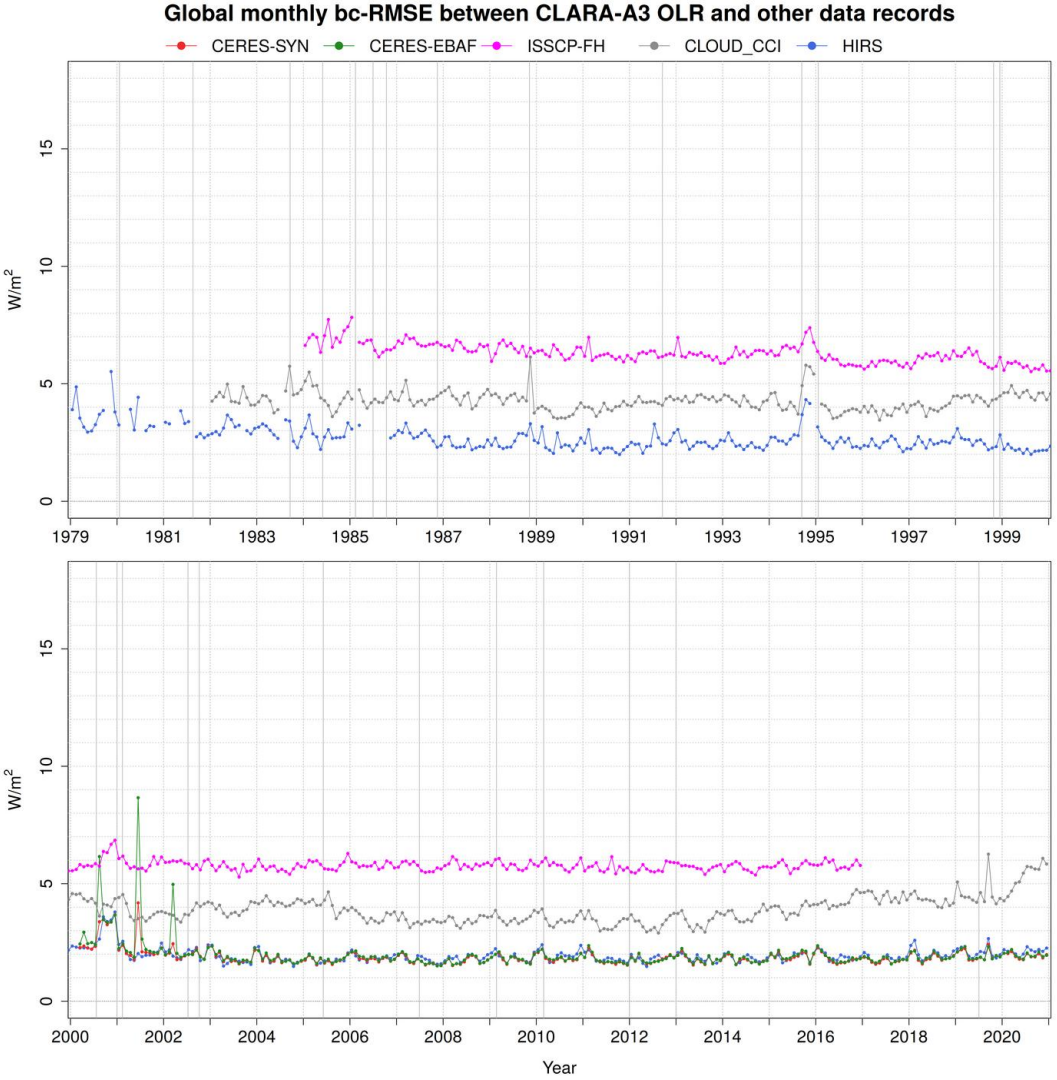

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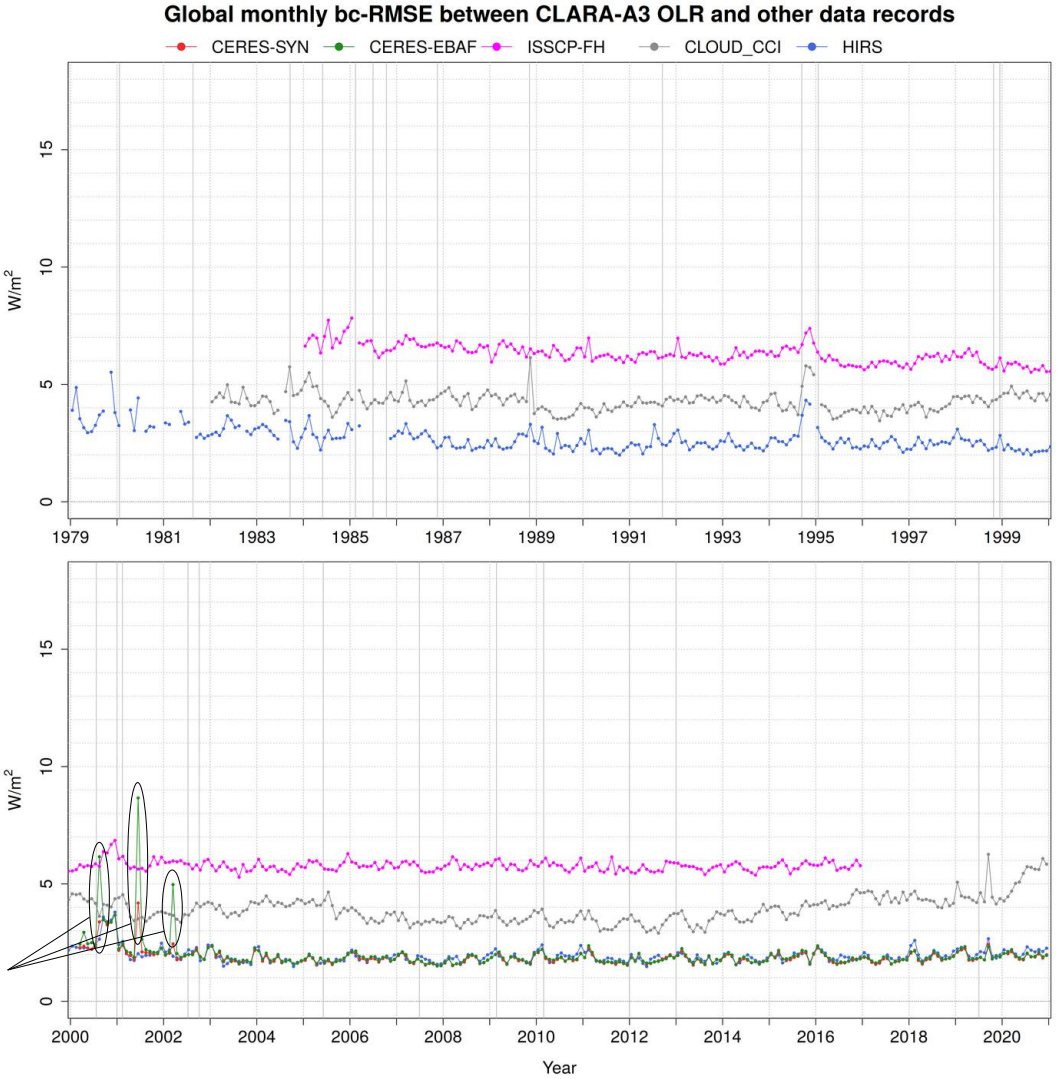
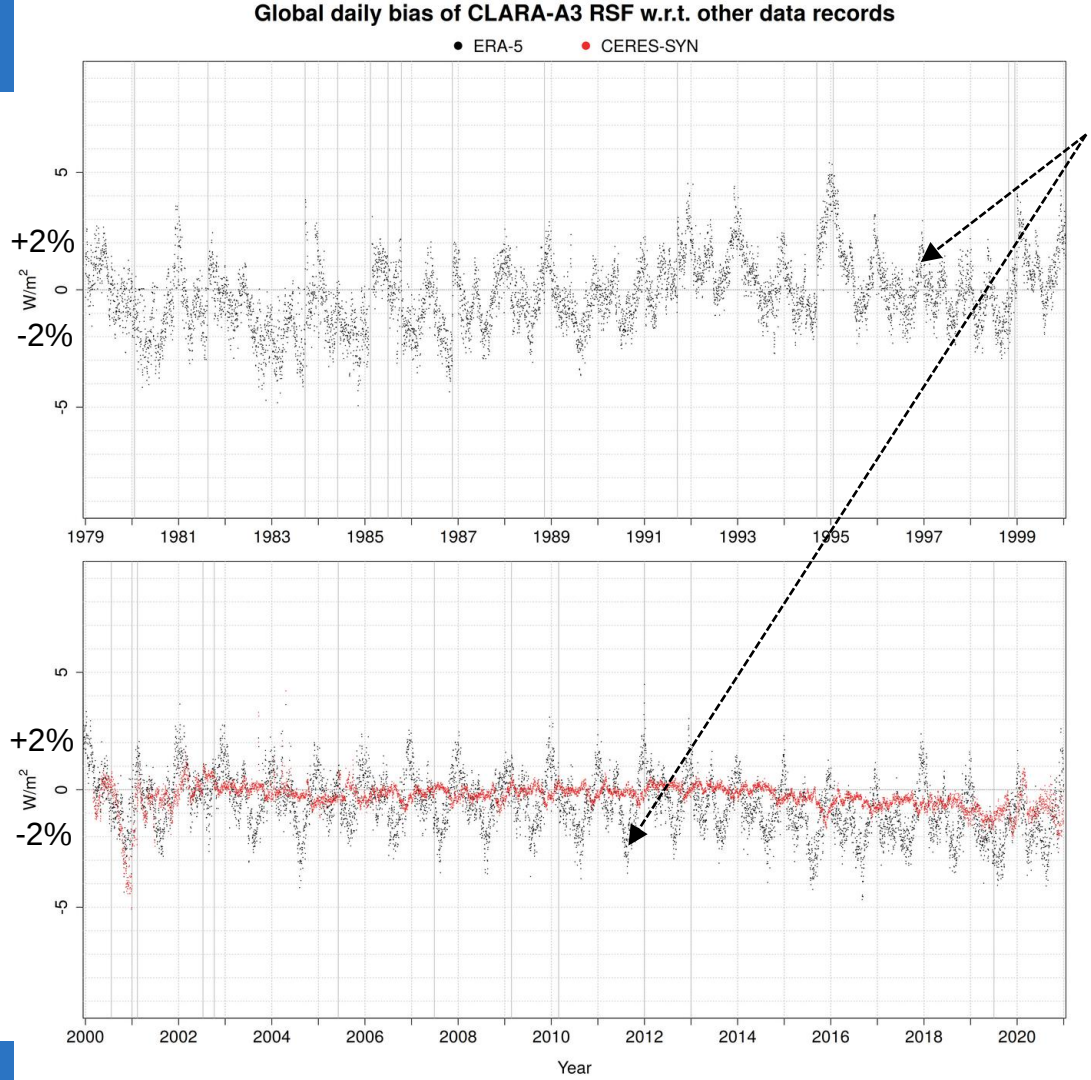


Strange artifacts in CERES Ed4.1

3. Validation

- ***Longwave: Outgoing Longwave Radiation :***
  - **Bias:**
    - Daily mean OLR
    - Monthly mean OLR
  - **RMSE (bias corrected):**
    - Daily mean OLR
    - Monthly mean OLR
- ***Shortwave: Reflected Solar Flux :***
  - **Bias:**
    - Daily mean RSF
    - Monthly mean RSF
  - **RMSE (bias corrected):**
    - Daily mean RSF
    - Monthly mean RSF

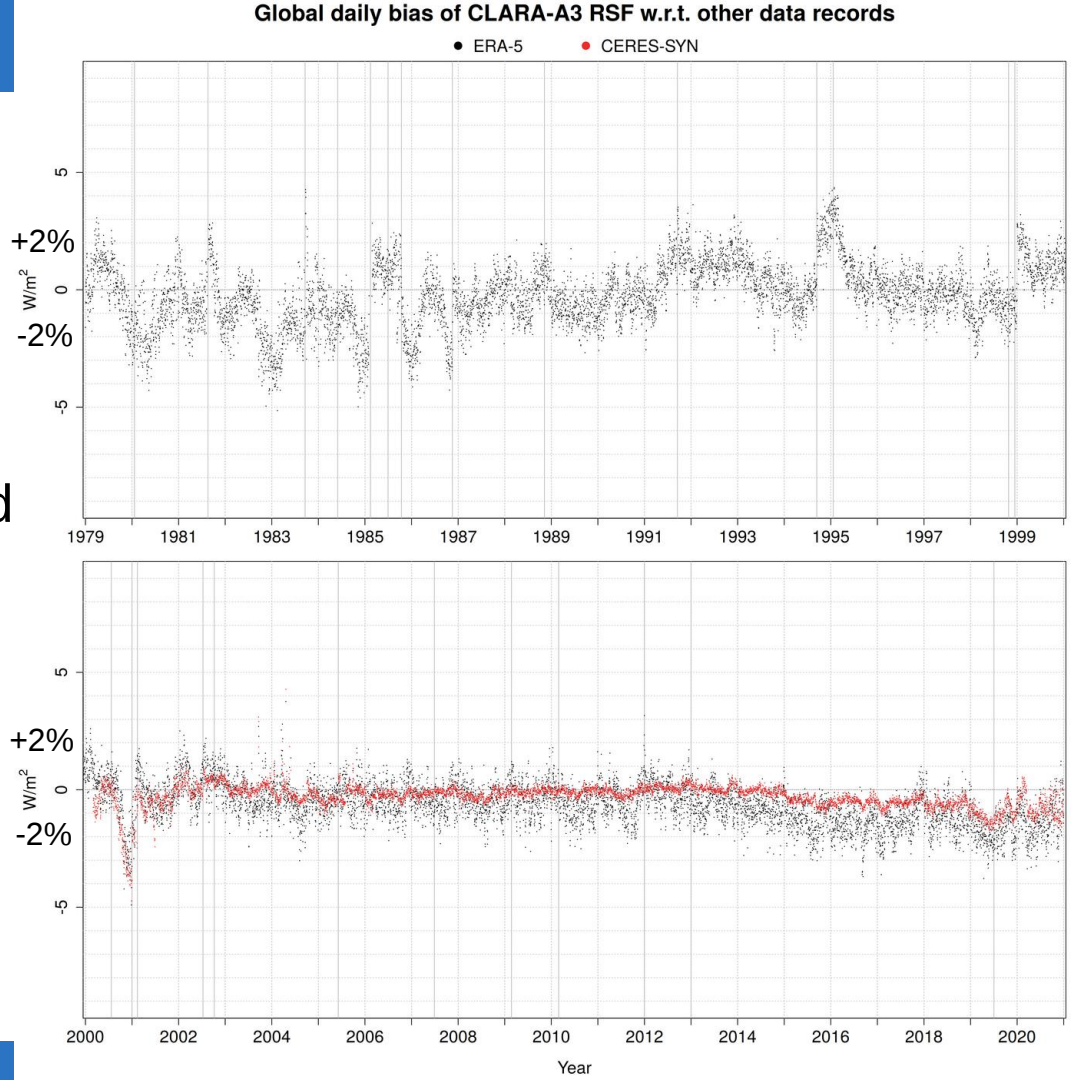
- **Global mean bias** of Daily Mean RSF:



ERA5 has a systematic seasonal bias w.r.t. CERES and CLARA-A3.

- **Global mean bias** of Daily Mean RSF:

- Deseasonalized

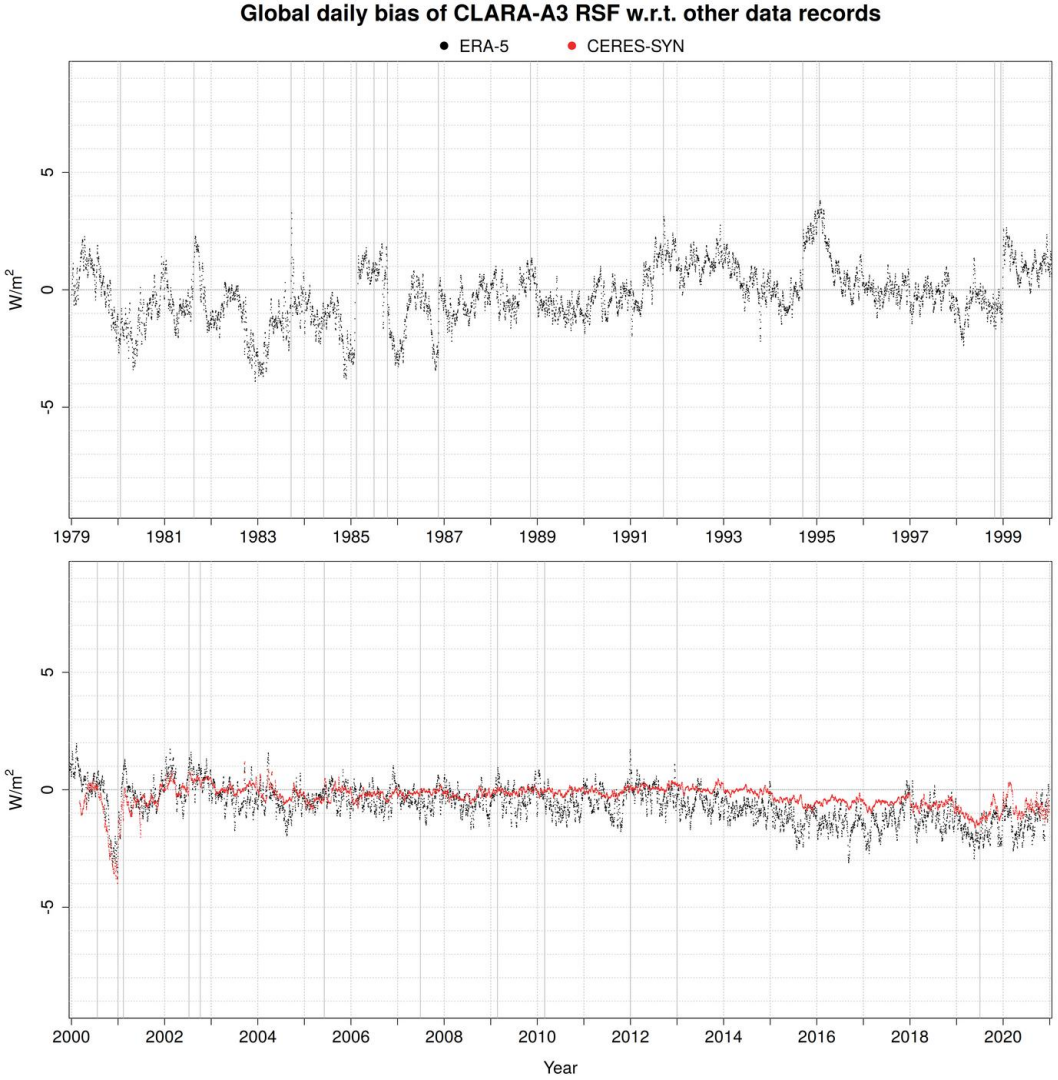


ERA5 has a systematic seasonal bias w.r.t. CERES and CLARA-A3.

This is removed by deseasonalizing.

- **Global mean bias** of Daily Mean RSF:

- Deseasonalized
- **Weekly running average**

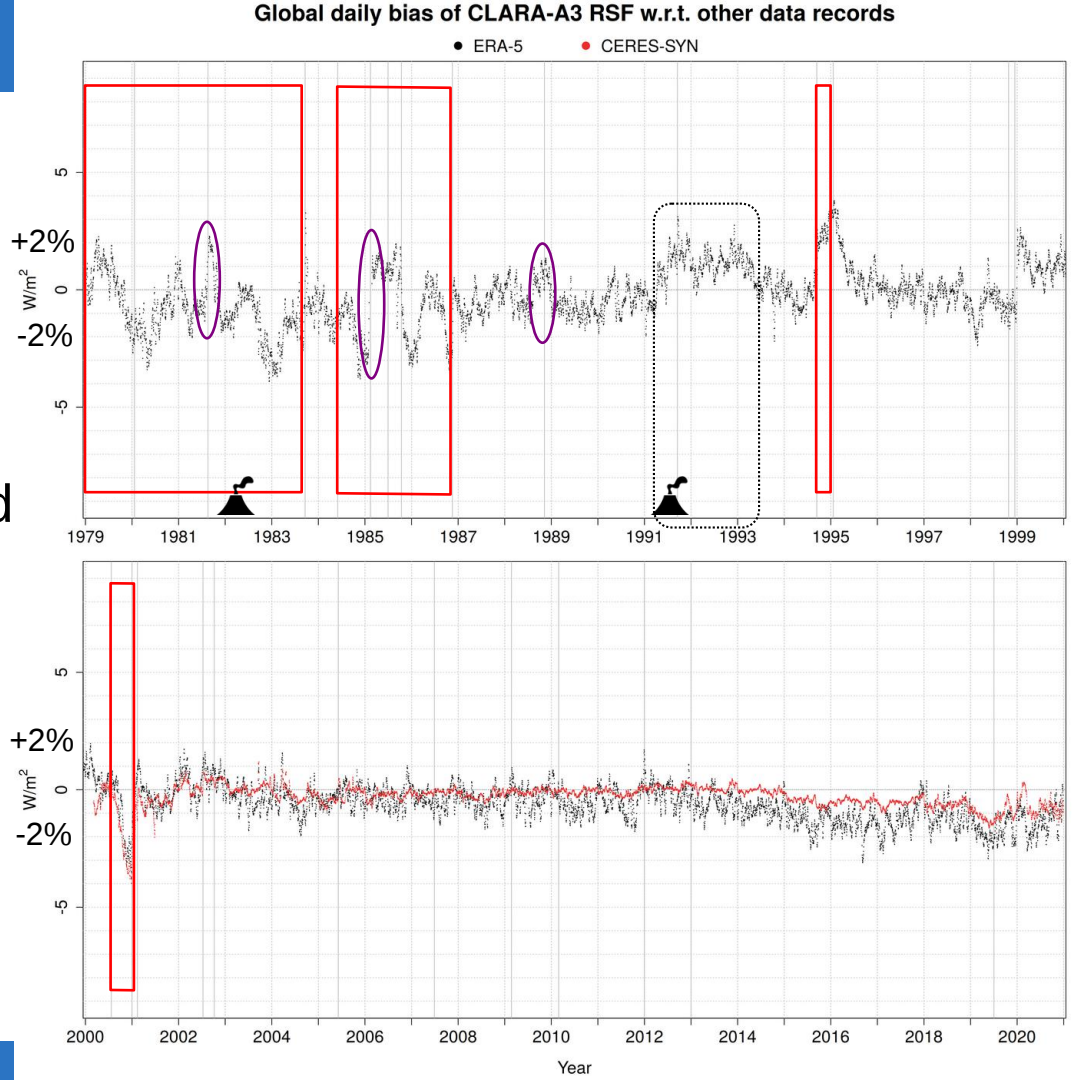


ERA5 has a systematic seasonal bias w.r.t. CERES and CLARA-A3.

This is removed by deseasonalizing.

- **Global mean bias** of Daily Mean RSF:

- Deseasonalized
- Weekly running average

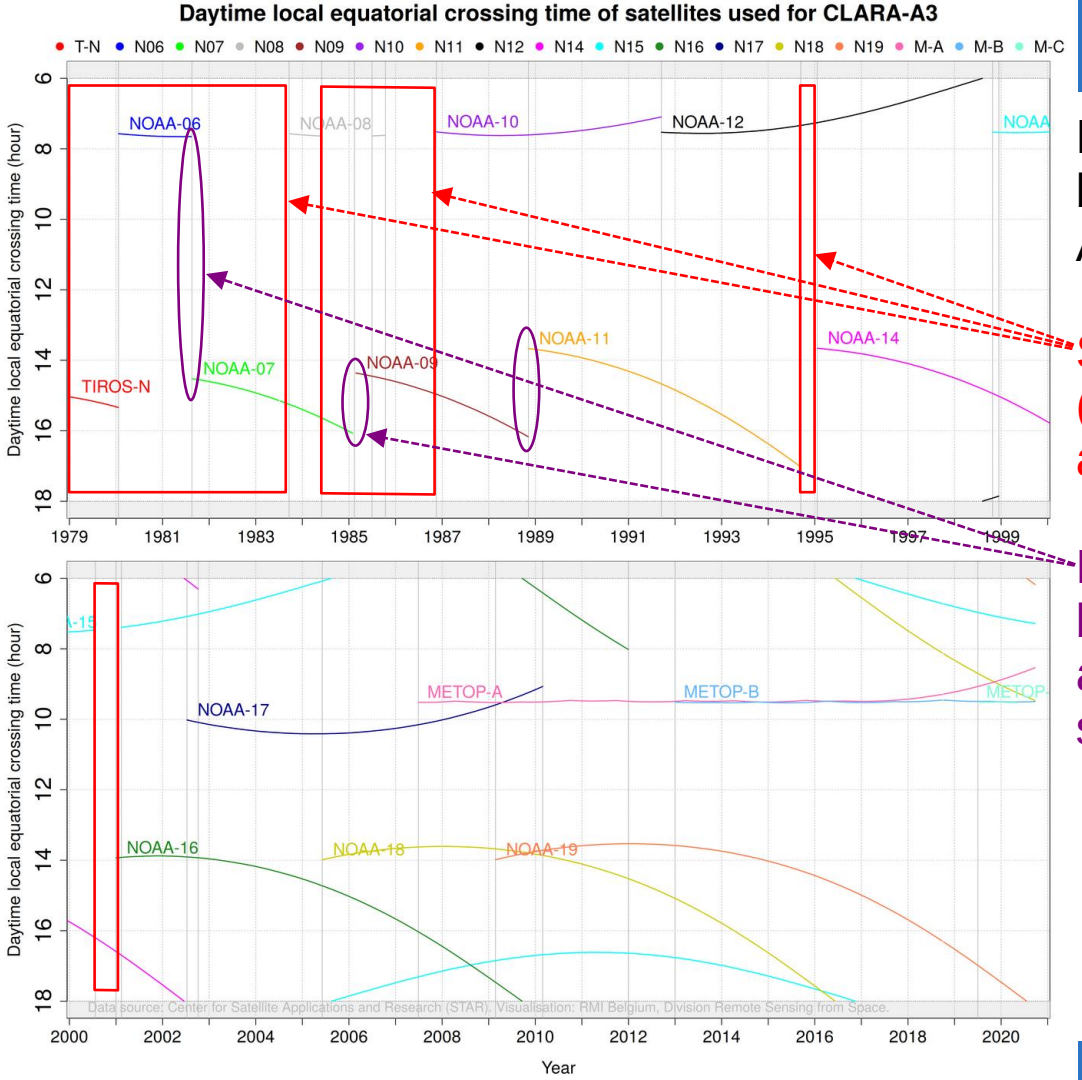


ERA5 has a systematic seasonal bias w.r.t. CERES and CLARA-A3.

This is removed by deseasonalizing.

The remaining bias is due to non-systematic biases in CLARA-A3.

- **Orbital configuration** of CLARA-A3:



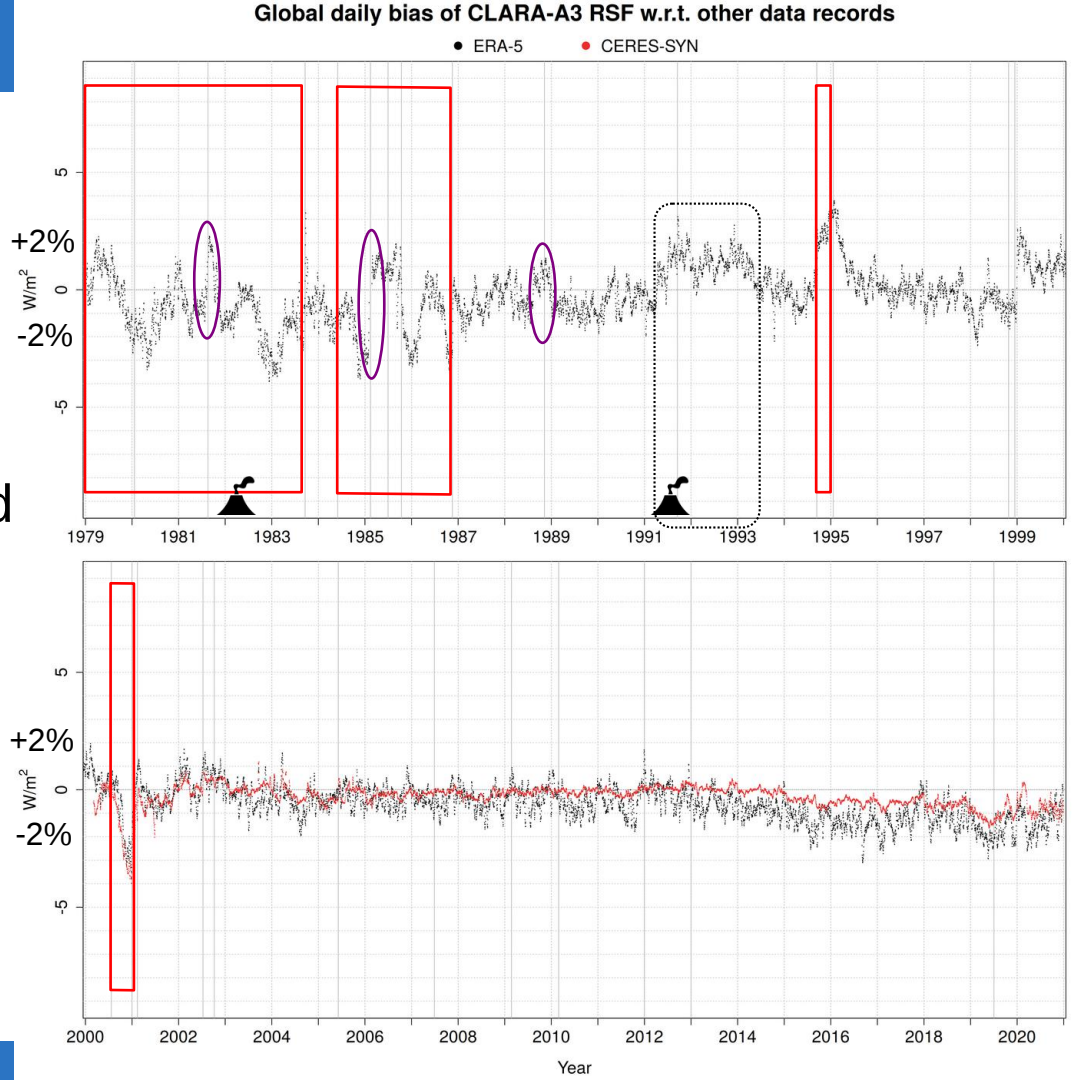
Non-systematic biases in CLARA-A3:

Single-orbit periods (either morning or afternoon)

Discontinuities between satellites and hence local solar time

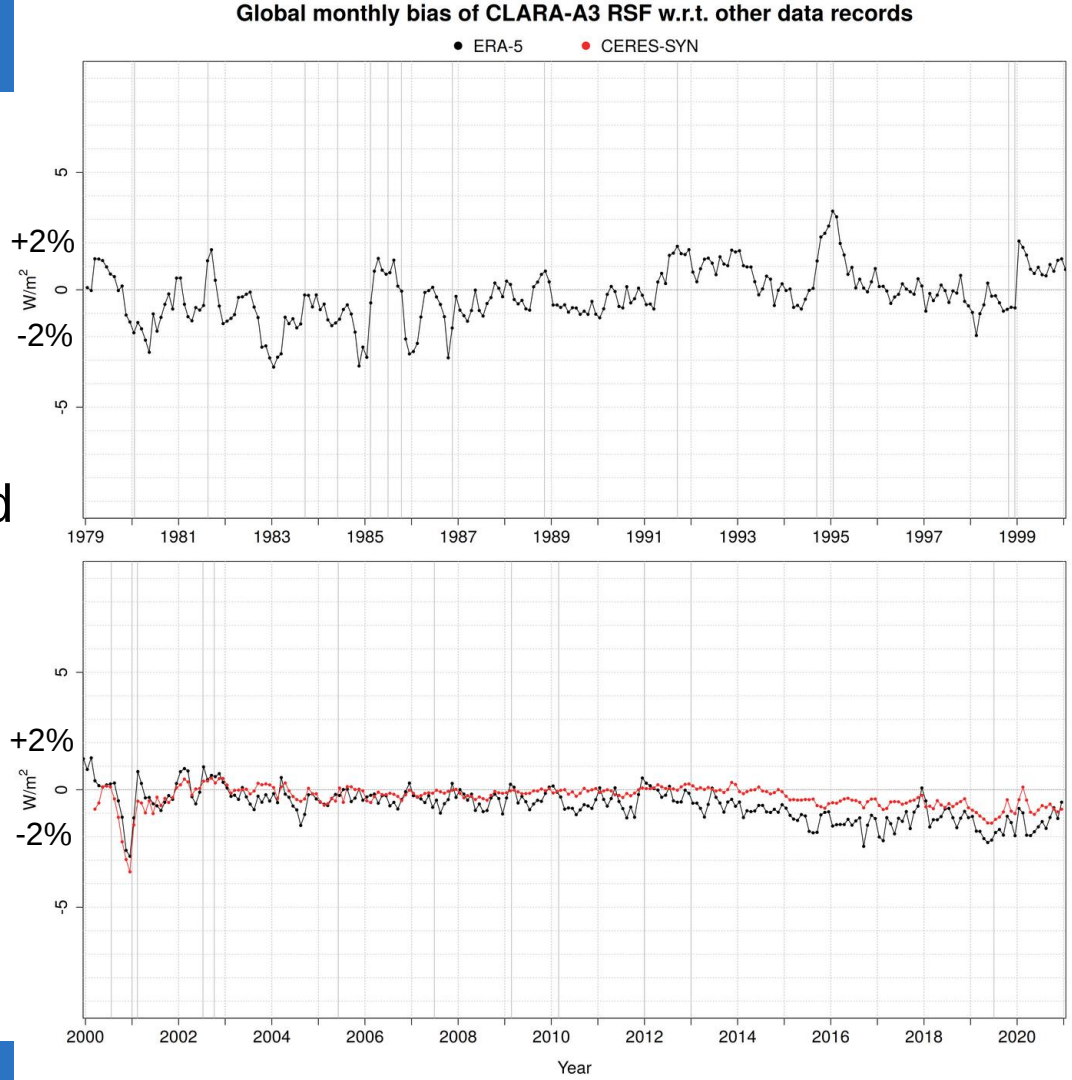
- **Global mean bias** of Daily Mean RSF:

- Deseasonalized
- Weekly running average



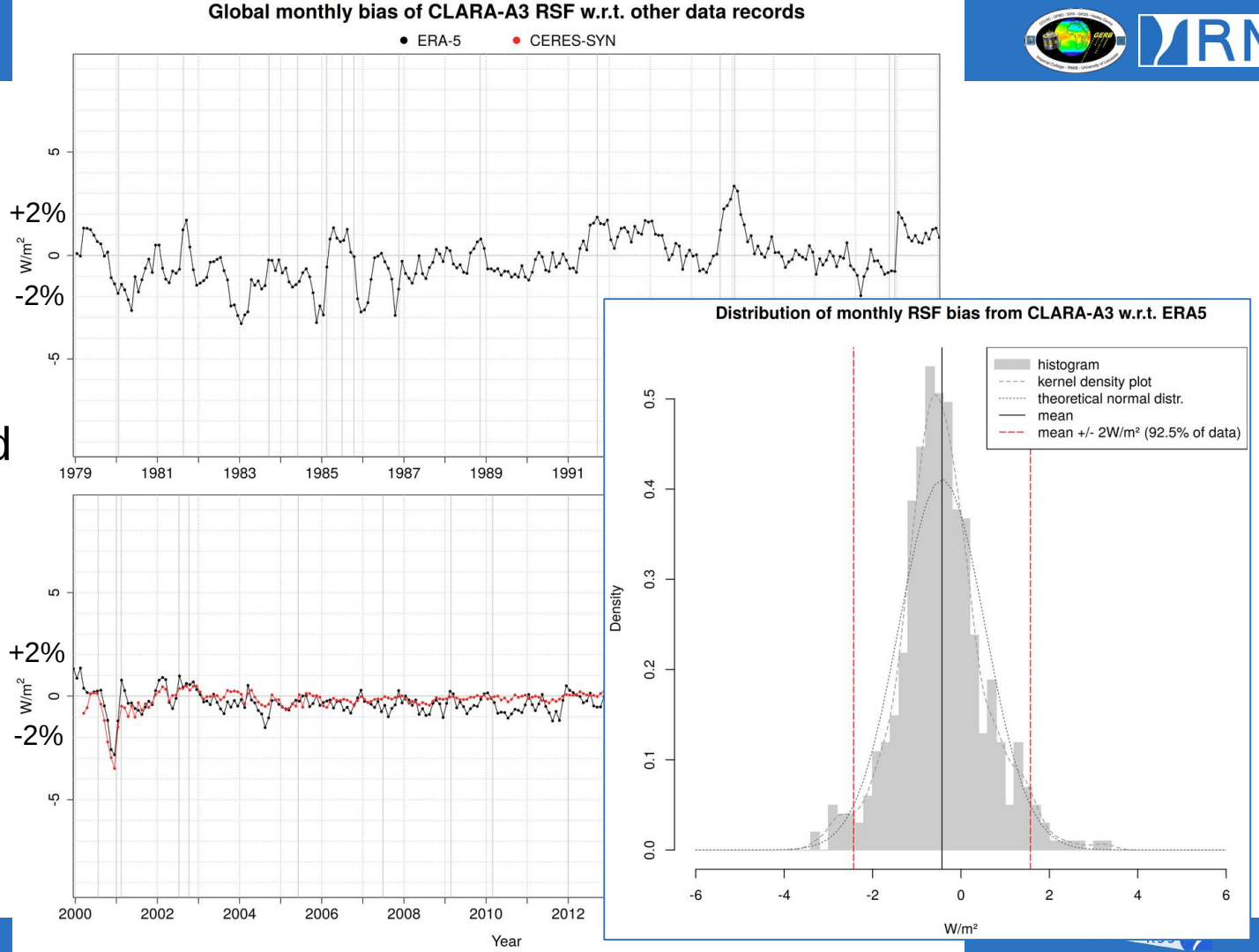
- **Global mean bias** of Daily Mean RSF:

- Deseasonalized

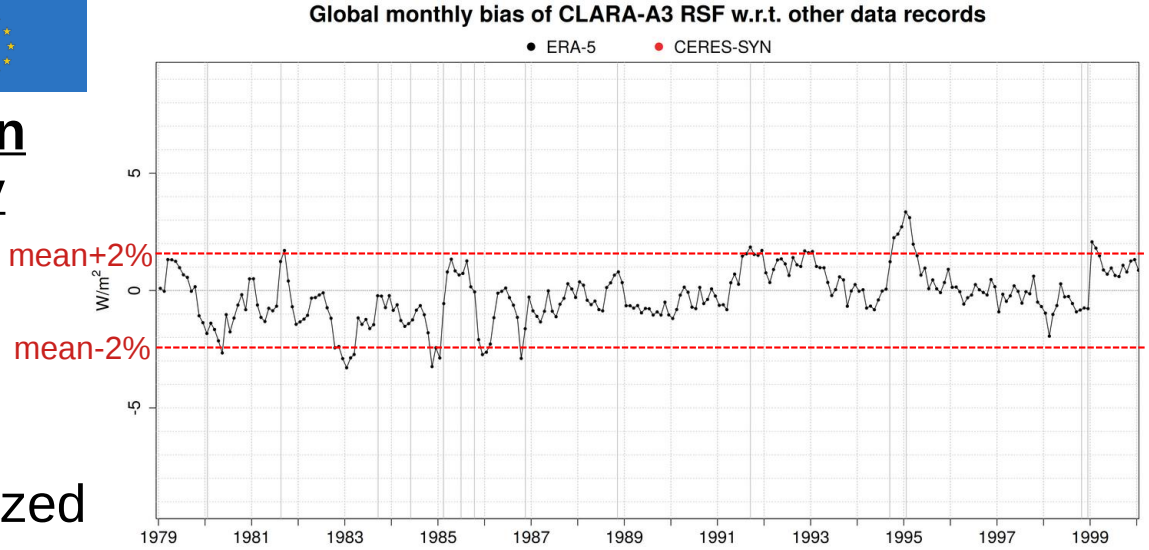


- **Global mean bias** of Daily Mean RSF:

- Deseasonalized

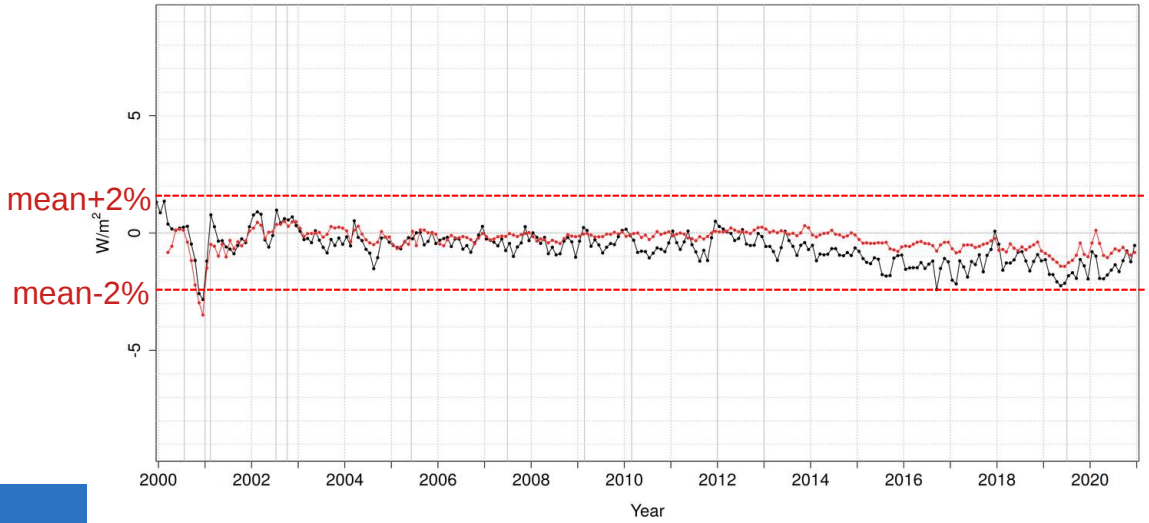


- **Global mean bias** of Daily Mean RSF:



93% of months are within mean +/- 2W/m² (about +/-2%)

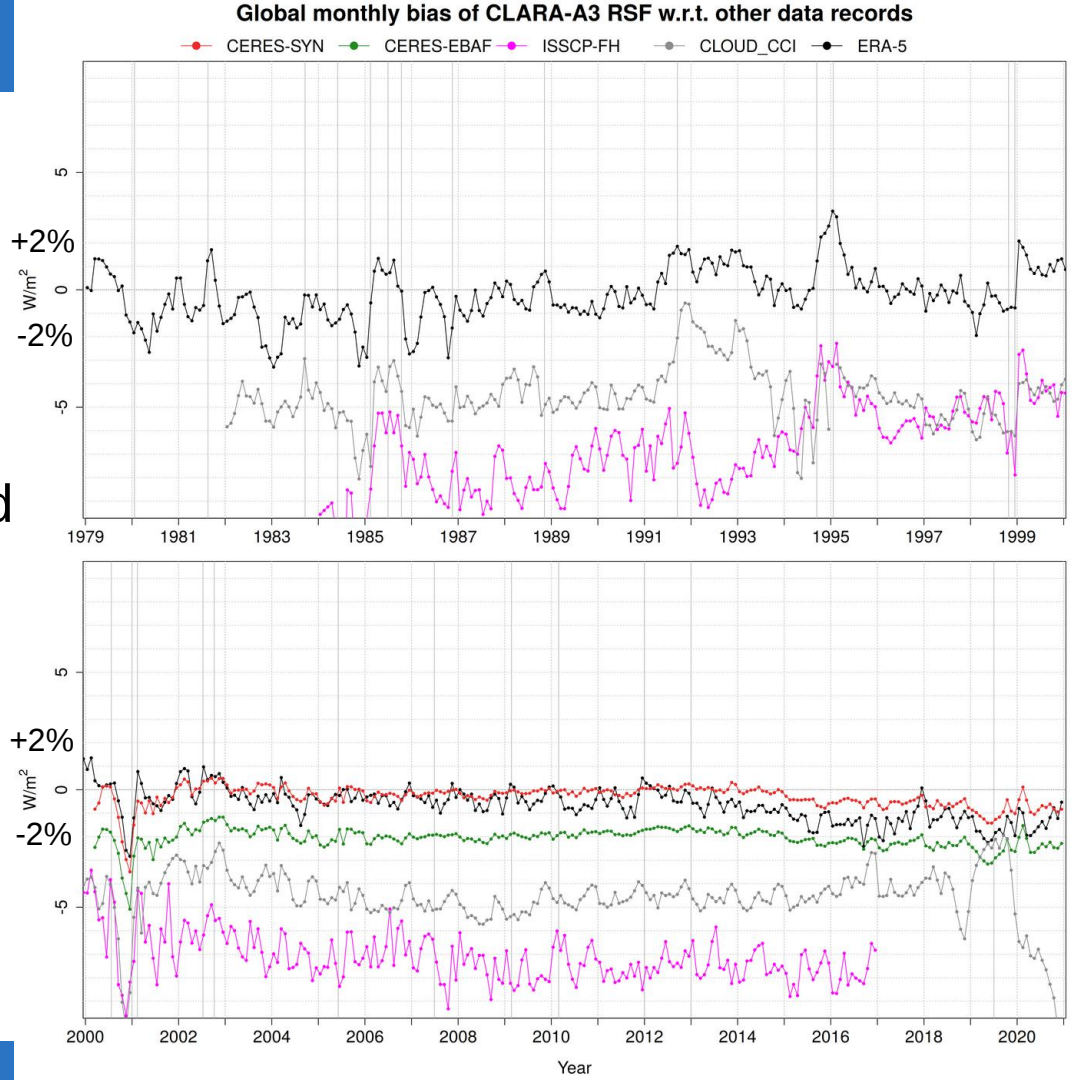
- Deseasonalized



Trend of bias: -0.1547 W/m²/dec

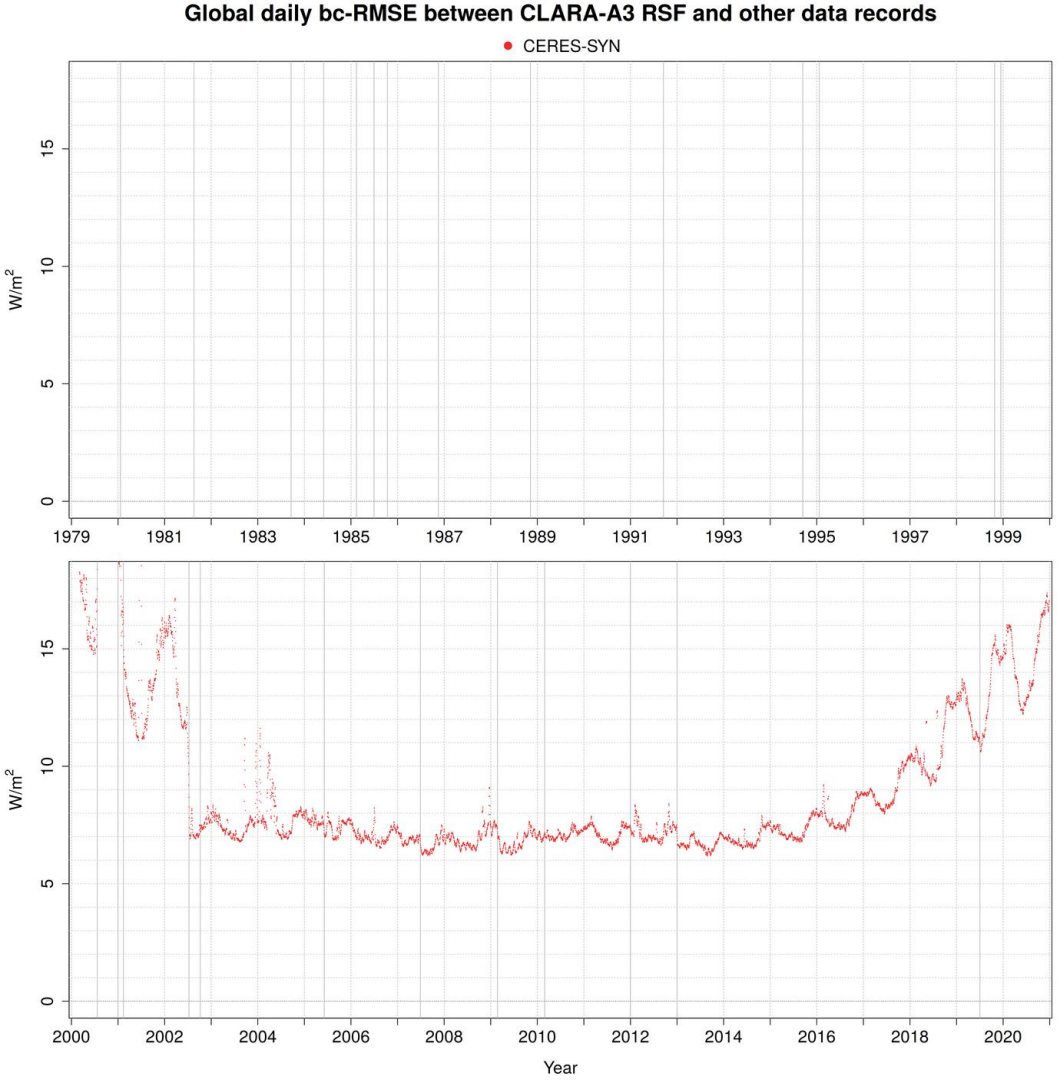
- **Global mean bias** of Daily Mean RSF:

- Deseasonalized



- **Global RMSE (bias-corrected)** of Daily Mean RSF:

- Weekly running average



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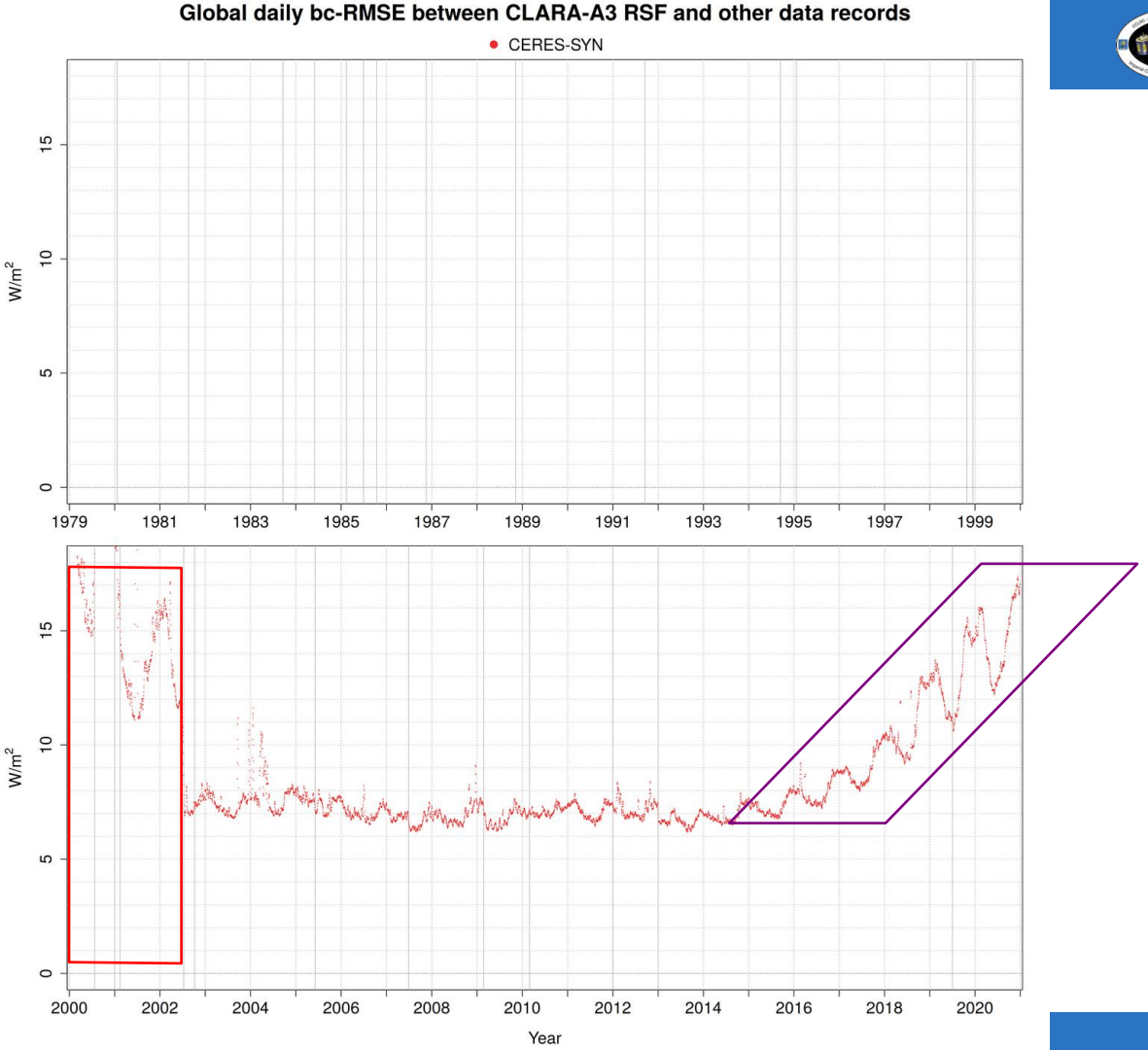
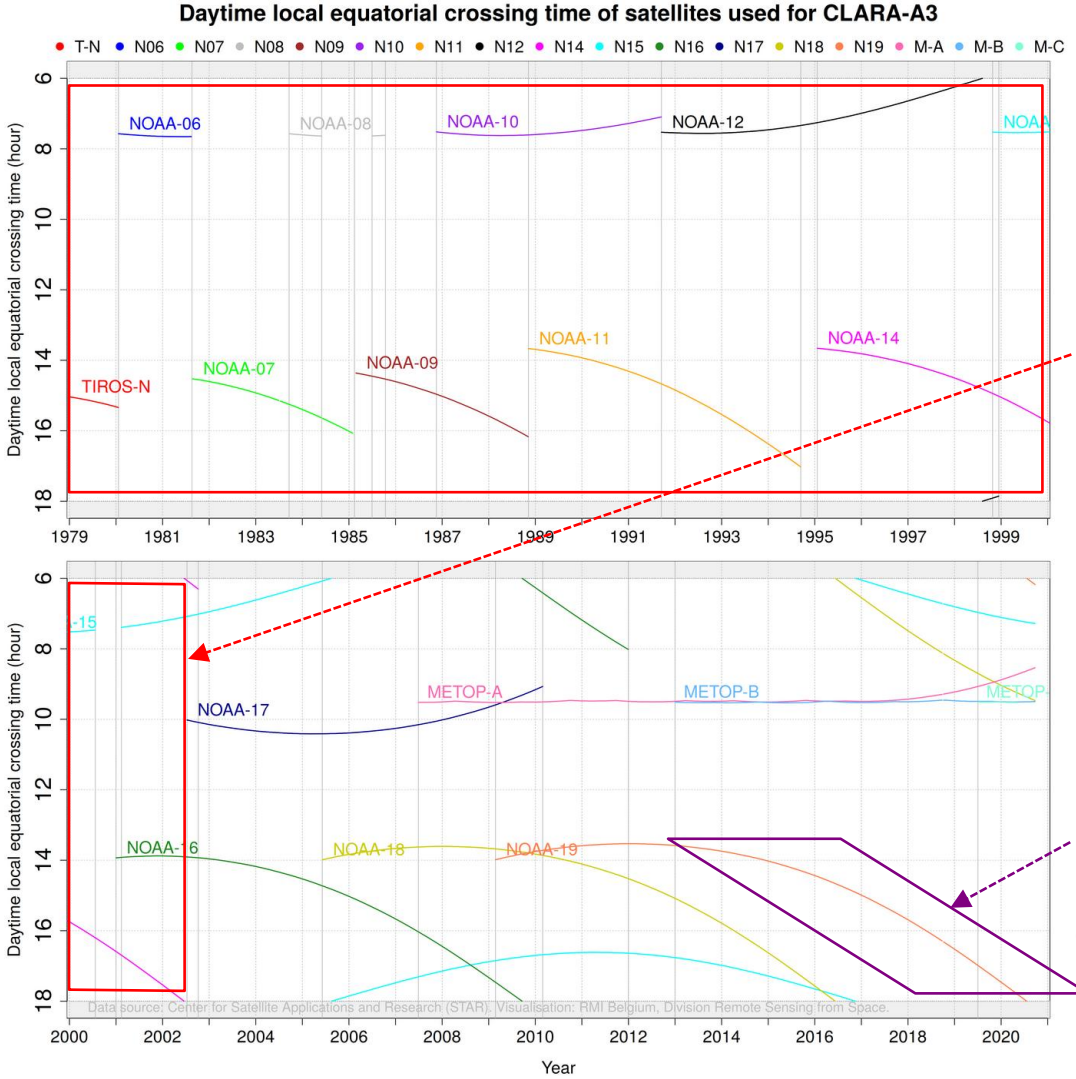
- Weekly running average



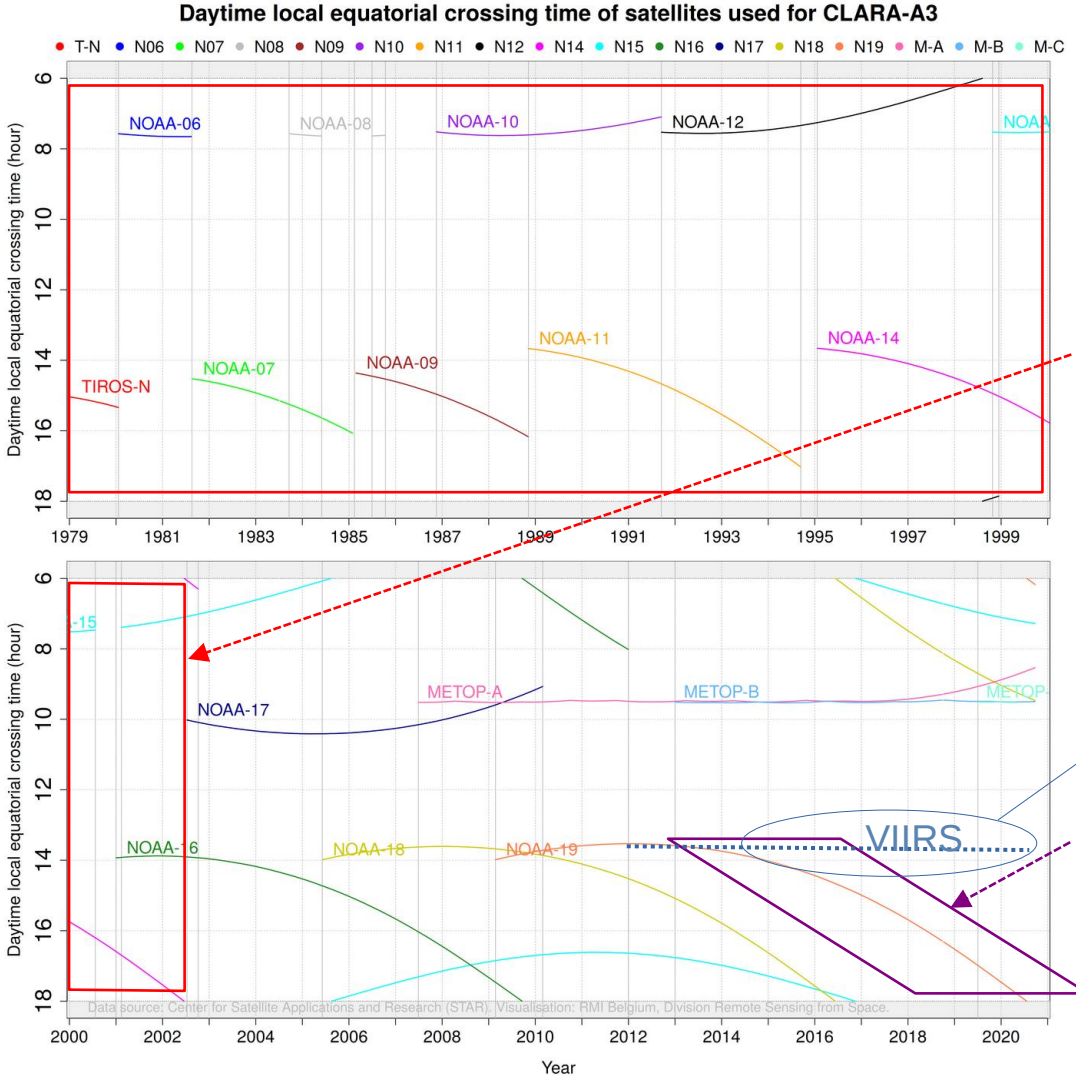
- **Orbital configuration** of CLARA-A3:



No mid-morning orbit available (NOAA-17, MetOp)

Orbital drift of afternoon satellite towards evening

- **Orbital configuration** of CLARA-A3:



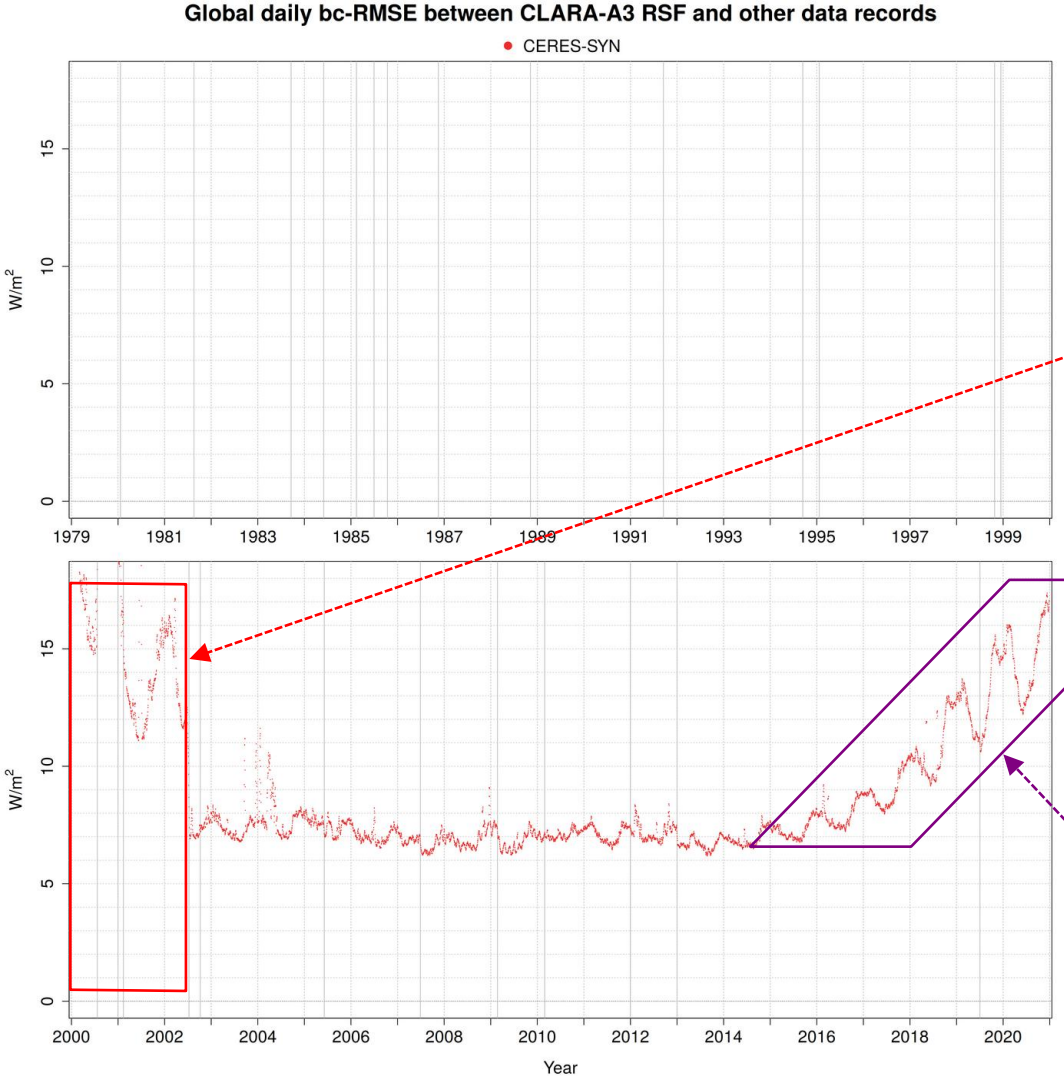
No mid-morning orbit available (NOAA-17, MetOp)

Next CLARA update includes VIIRS

Orbital drift of afternoon satellite towards evening

- **Global RMSE (bias-corrected)** of Daily Mean RSF:

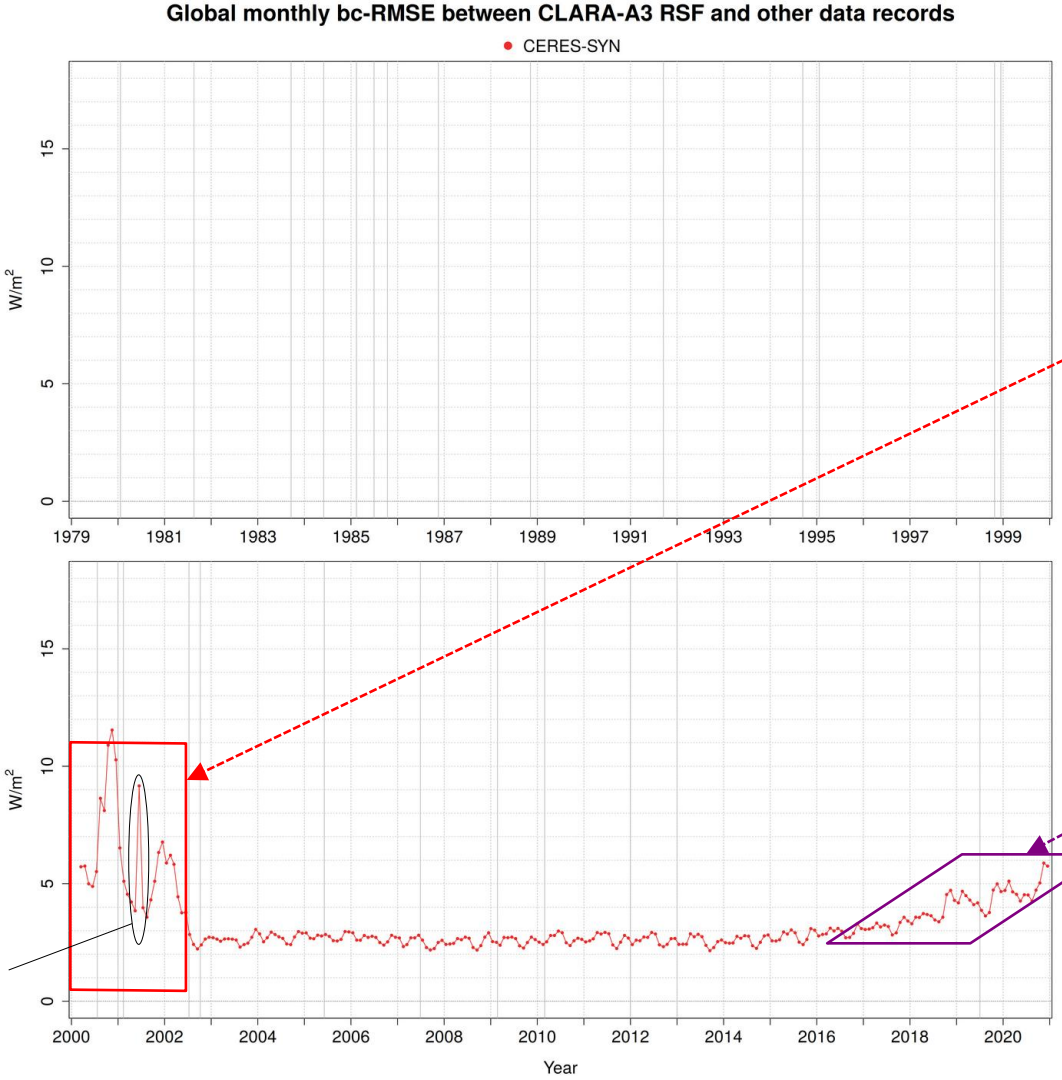
- Weekly running average



No mid-morning orbit available (NOAA-17, MetOp)

Orbital drift of afternoon satellite towards evening

- **Global RMSE (bias-corrected)** of Monthly Mean RSF:



Strange artifacts in CERES Ed4.1

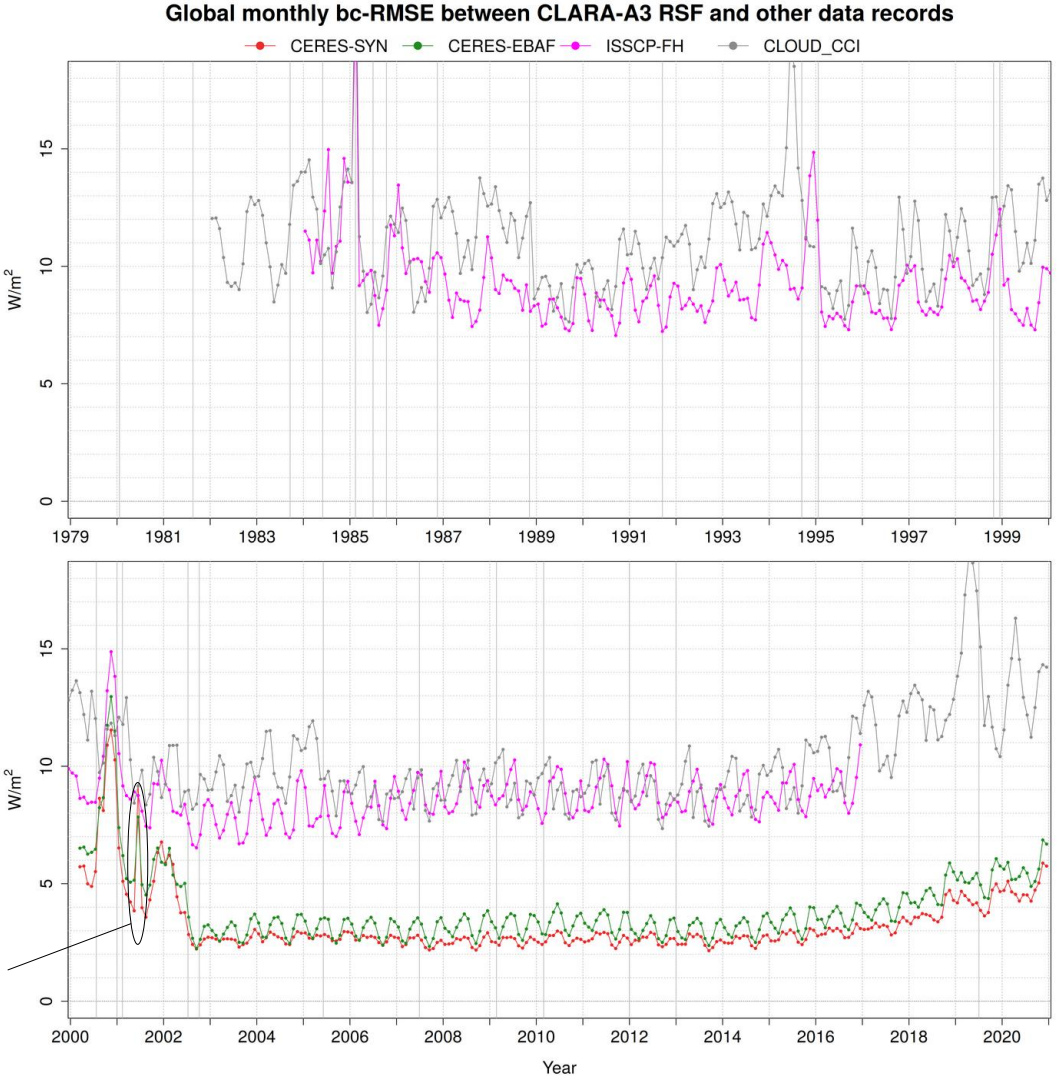
On monthly scale, same effects but less pronounced.

No mid-morning orbit available (NOAA-17, MetOp)

Orbital drift of afternoon satellite towards evening

- **Global RMSE (bias-corrected)** of Daily Mean RSF:

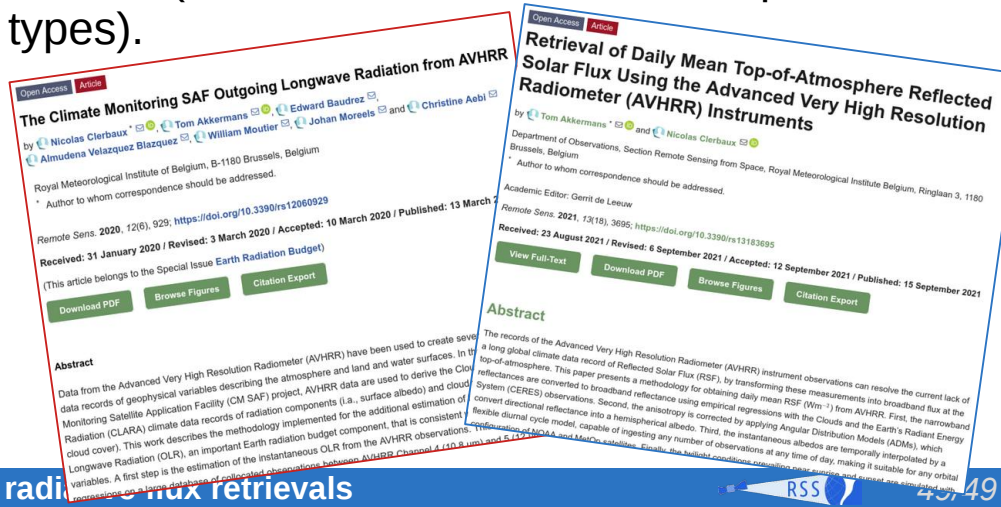
- Weekly running average



Strange artifacts in CERES Ed4.1

4. Future outlook

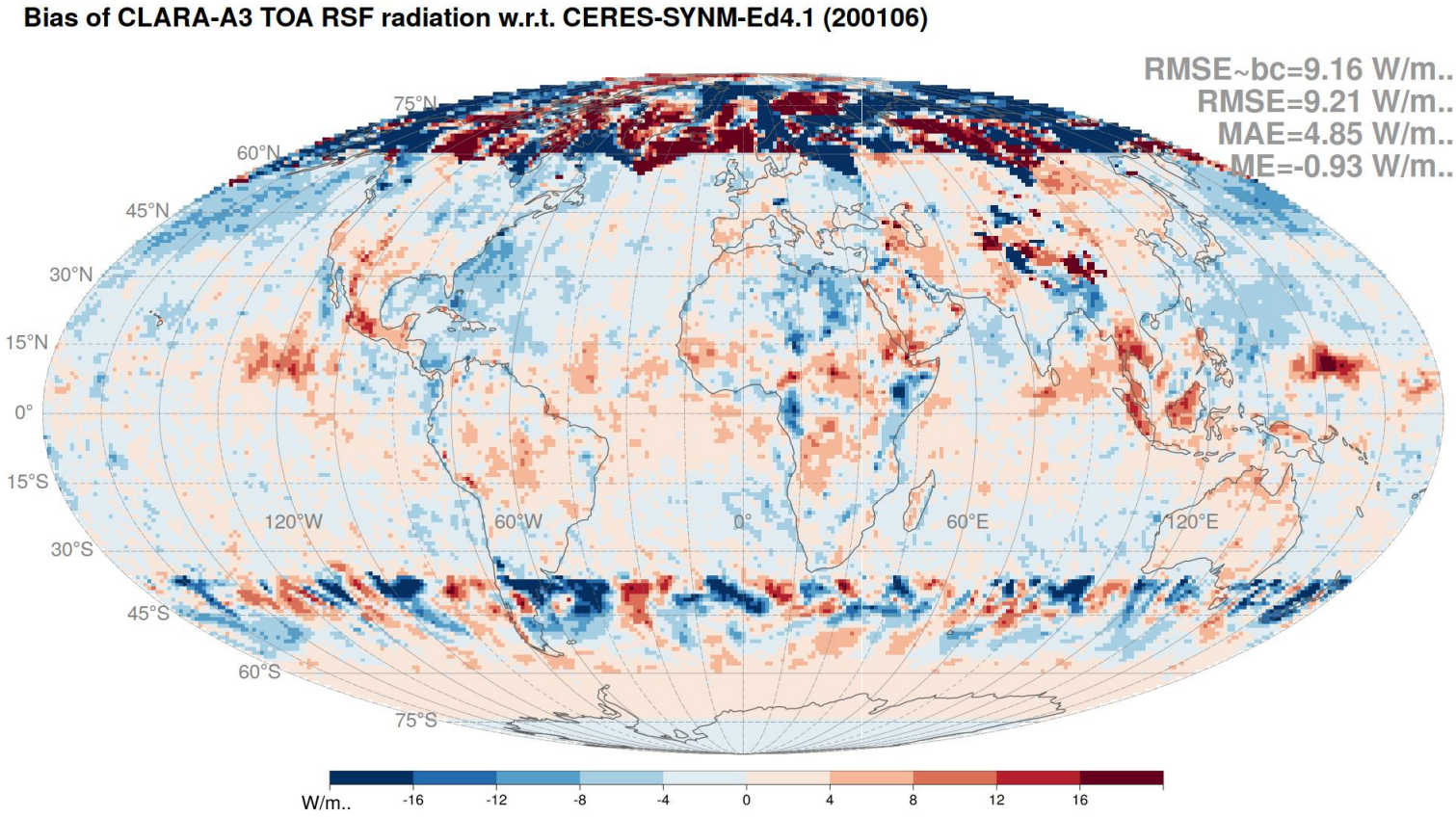
- Full data record of **CLARA-A3** has just been generated. After validation, release is foreseen around Q1 2023; an ICDR will also be developed
- Update **CLARA-A3.5** will include VIIRS instrument (S-NPP and NOAA-20) without any code changes (i.e. to be used as extension to CLARA-A3)
- Potential code updates will be done as part of **CLARA-A4** (within CMSAF), or as stand-alone data record (within RMIB), including:
  - Use of new CERES ADM's Ed4 (currently being implemented and tested at RMIB)
  - Use of new Narrowband-to-broadband regressions (based on reflectances with updated calibration coefficients, and updated scene types).



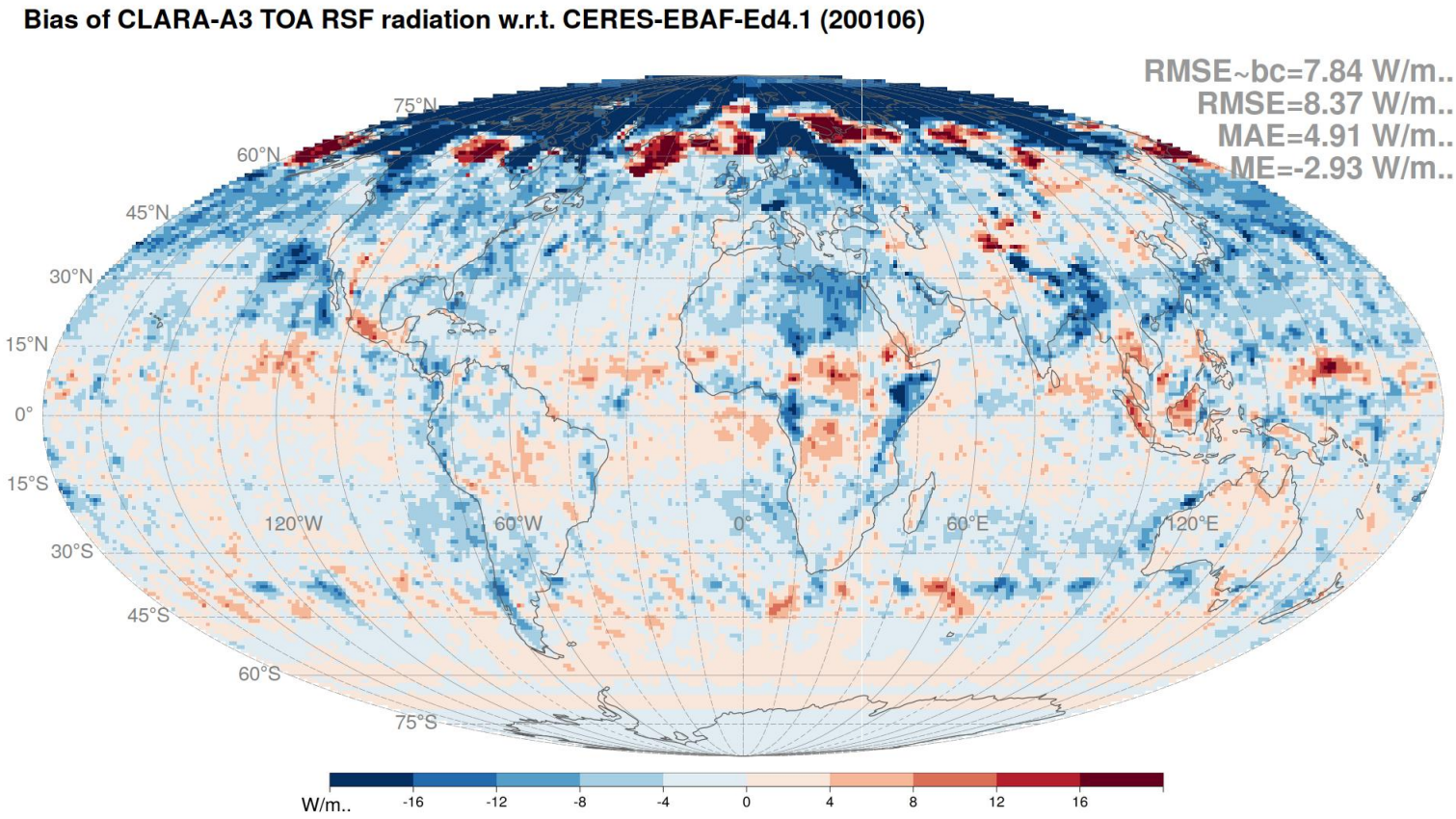
Thanks for your attention!

<tom.akkermans@meteo.be>

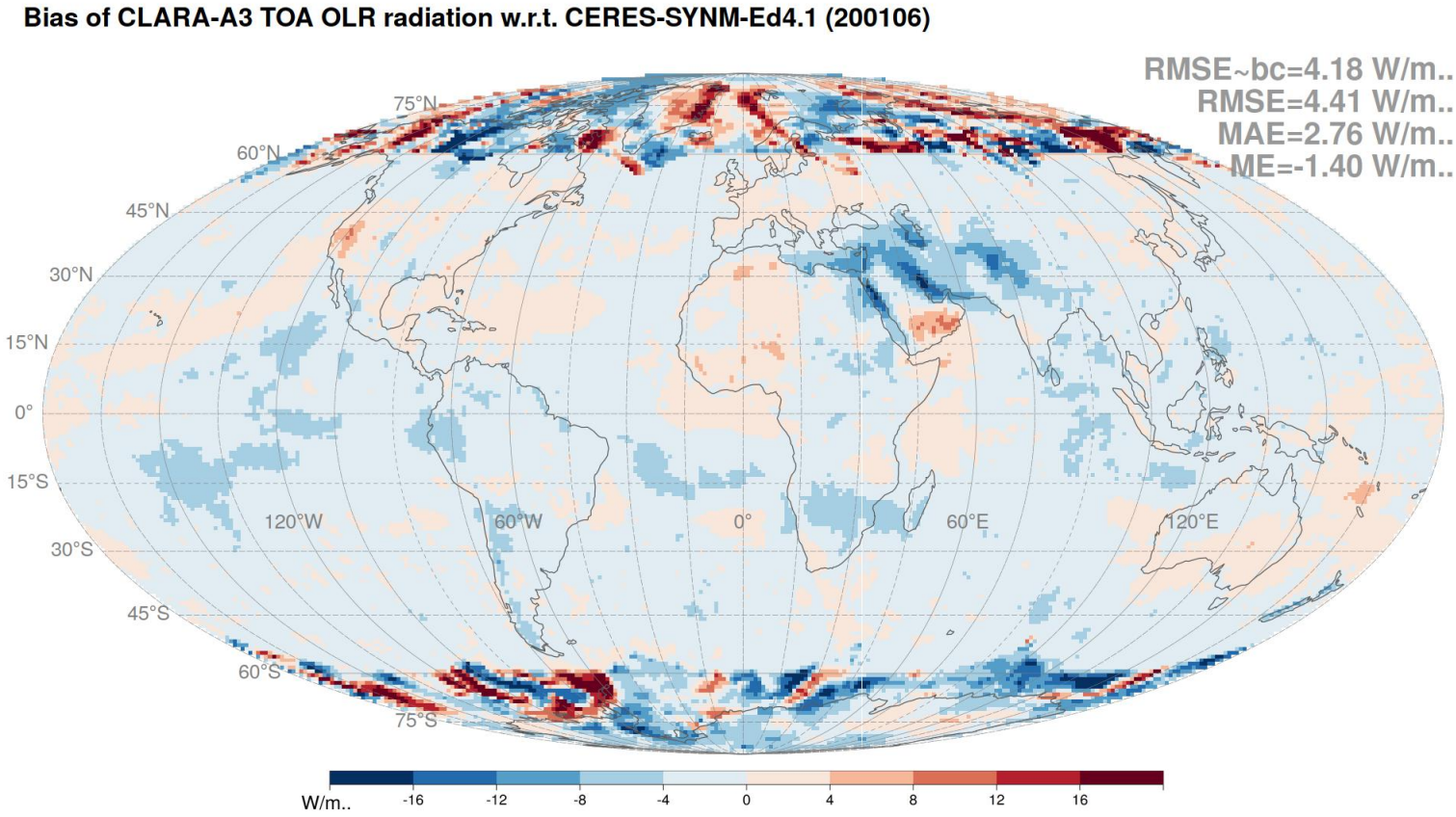
- Strange artefacts in CERES-SYN (RSF):



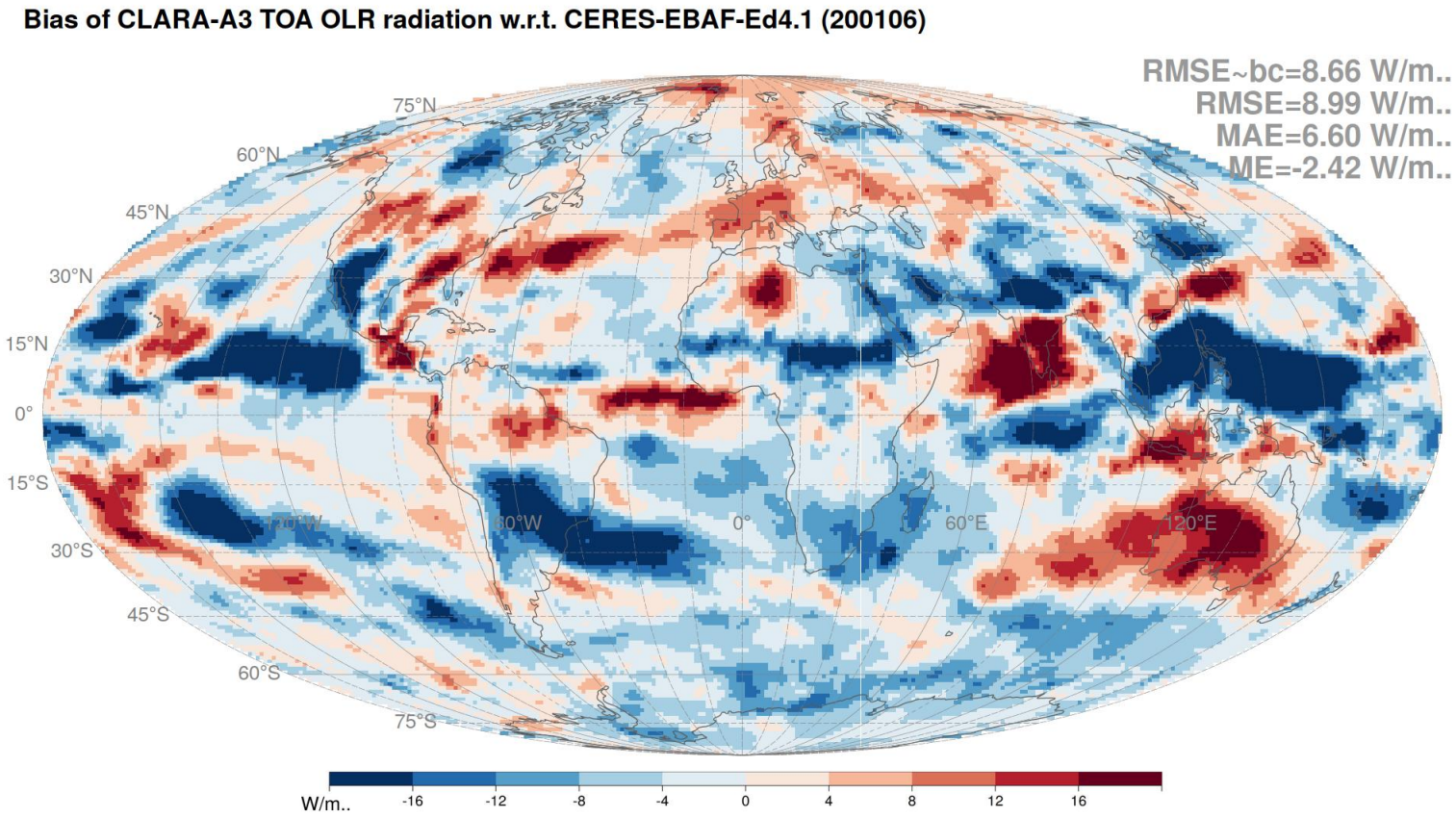
- Strange artefacts in CERES-EBAF (RSF):



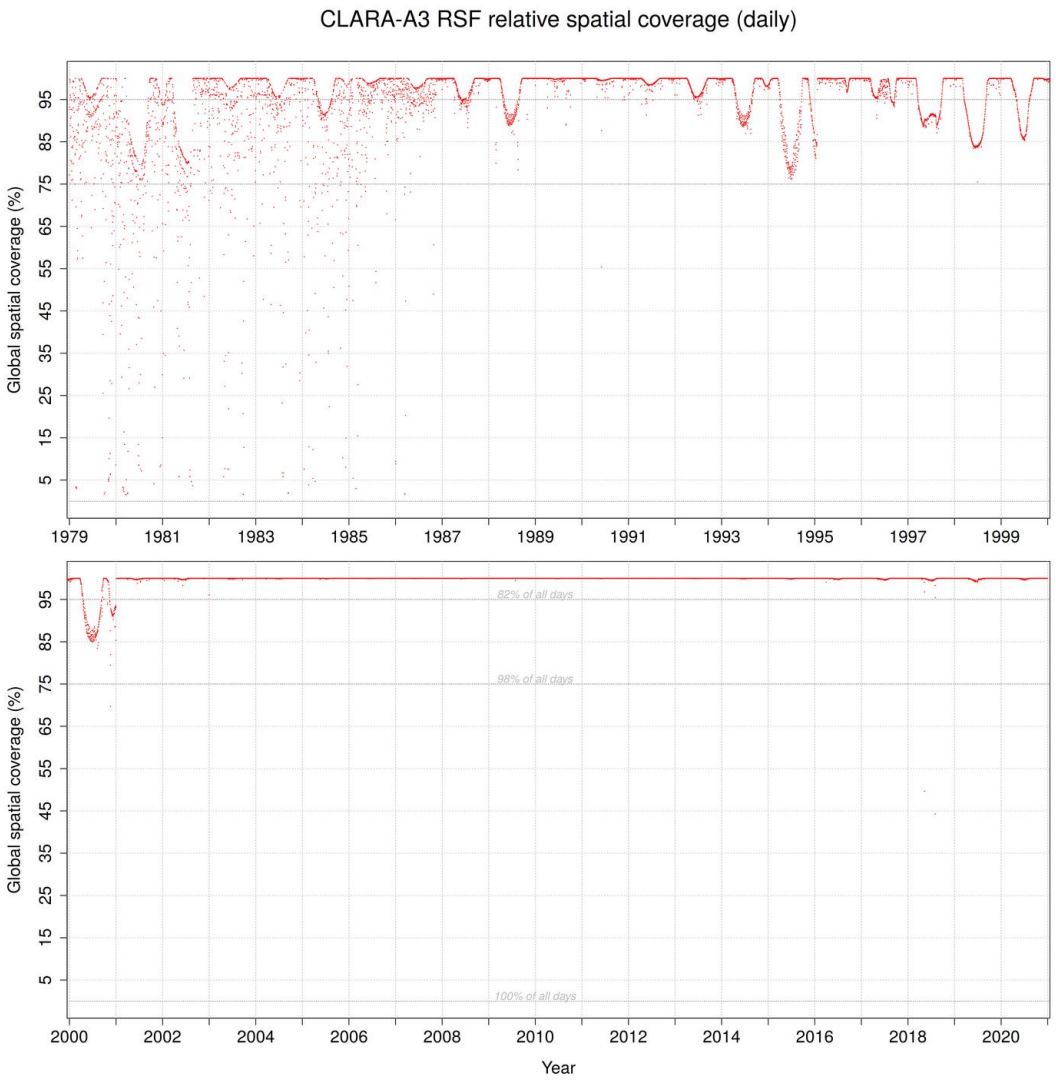
- Strange artefacts in CERES-SYN (OLR):



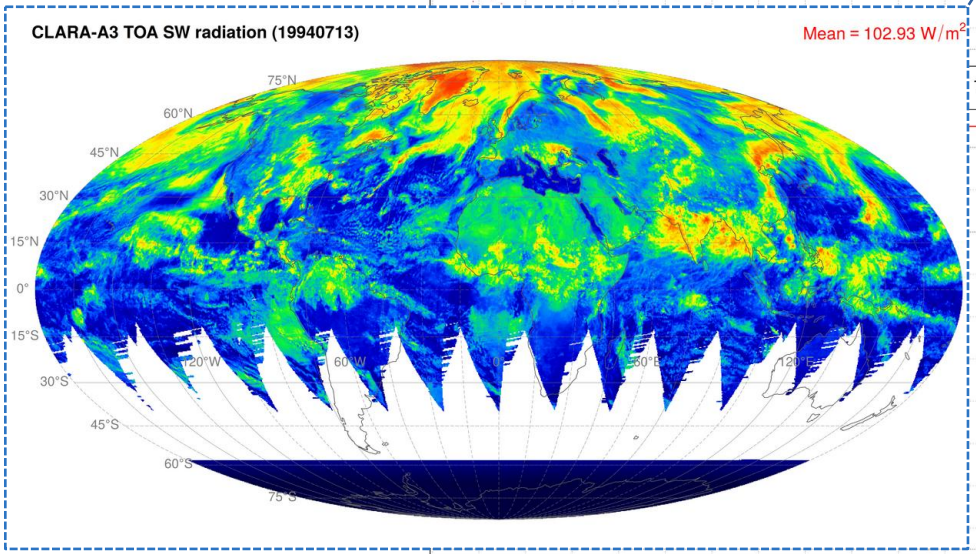
- Strange artefacts in CERES-SYN (OLR):

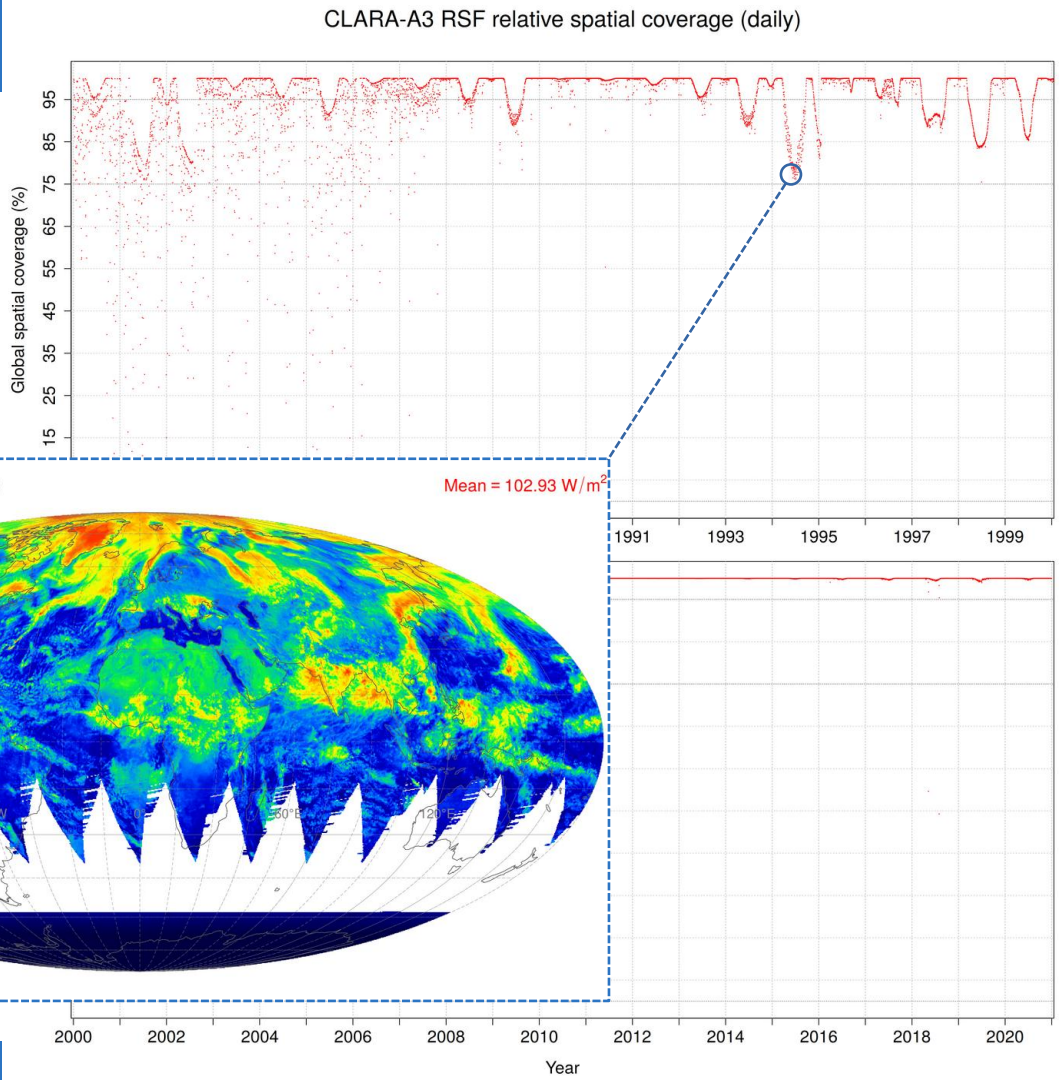


- **Global spatial coverage** of each RSF daily mean (%).

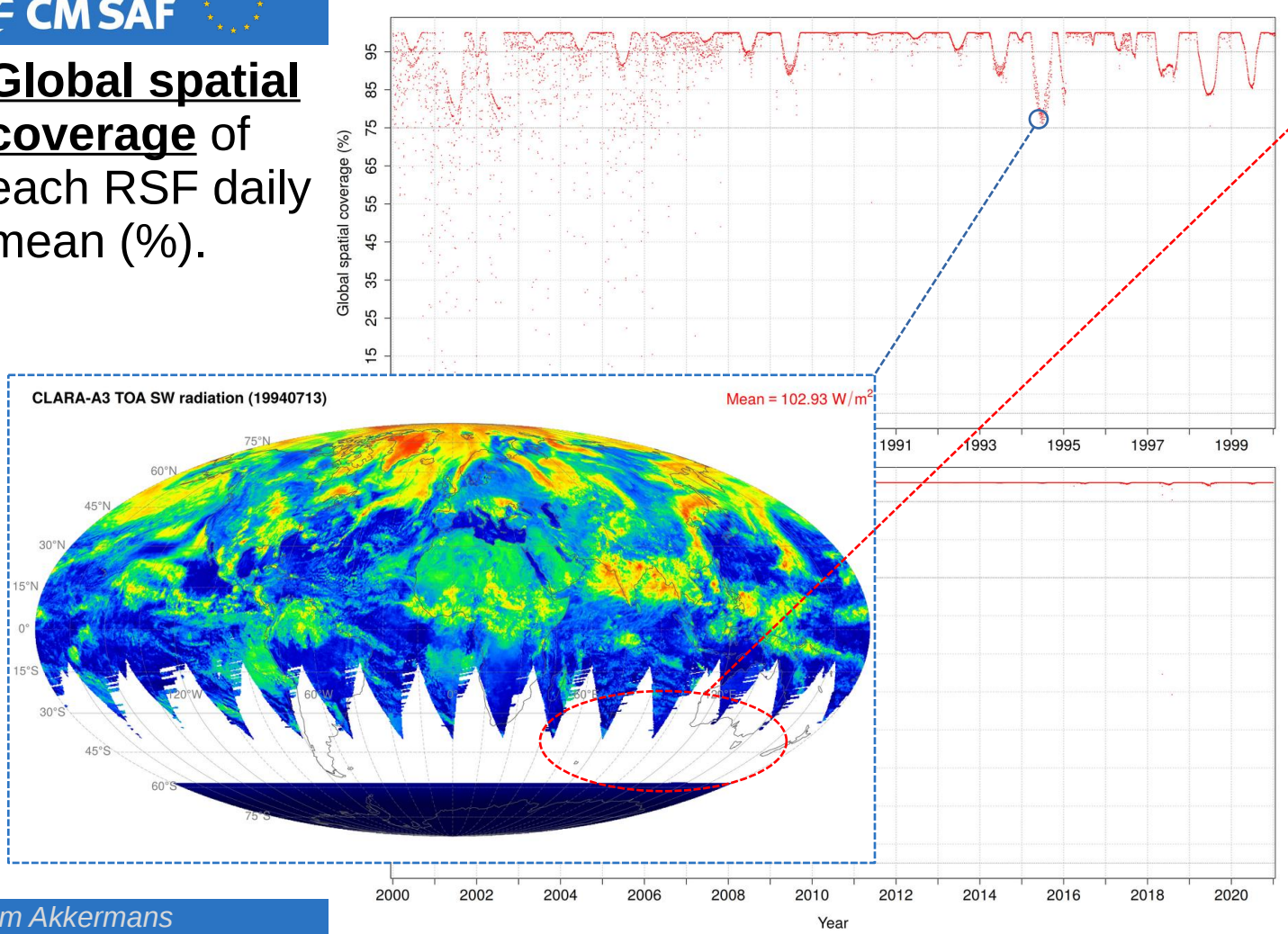


- **Global spatial coverage** of each RSF daily mean (%).

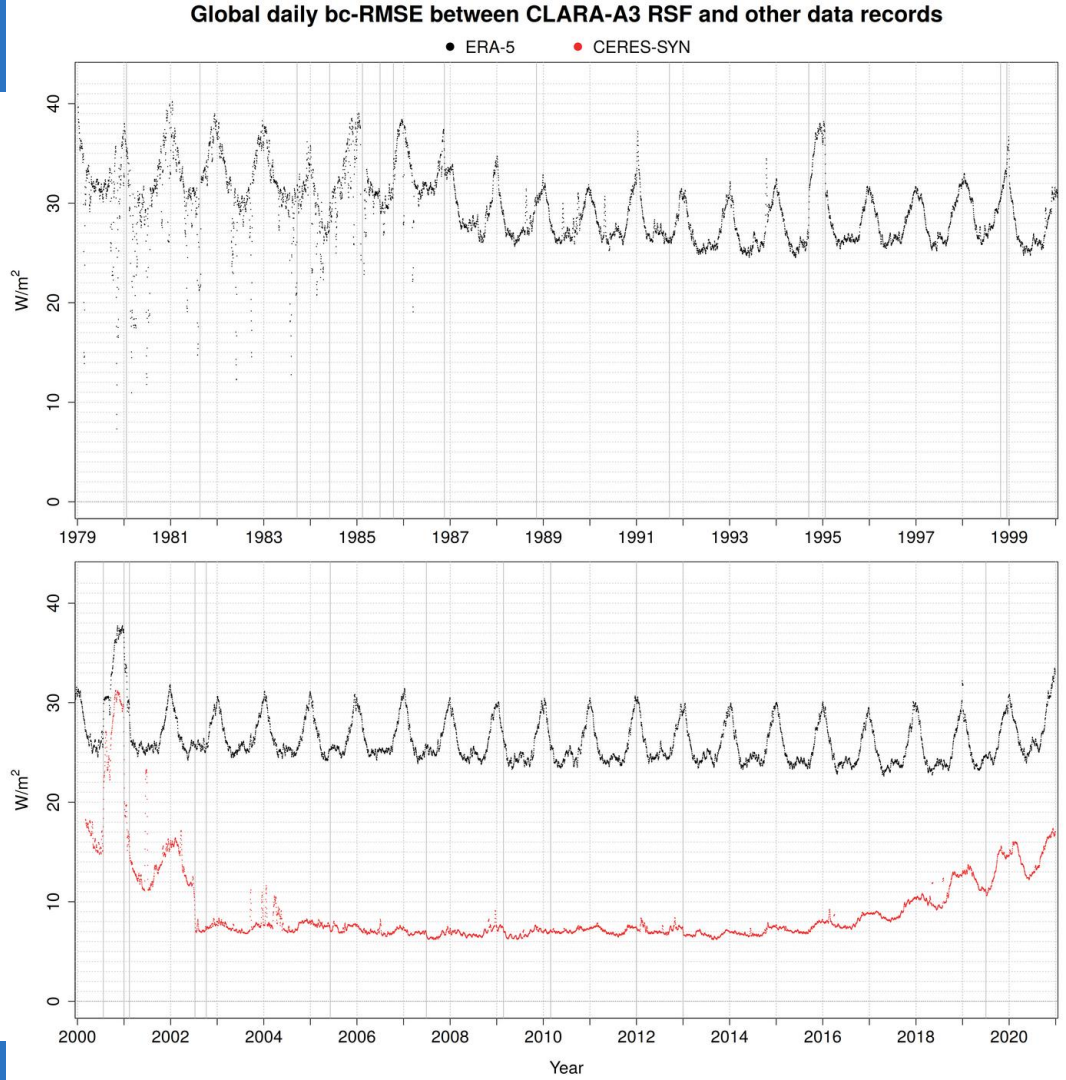




- **Global spatial coverage** of each RSF daily mean (%).



- Missing areas are filled with ERA5.
- If entire day is missing (i.e. 0% coverage), then no filling is done.


Global daily bc-RMSE between CLARA-A3 RSF and other data records
ERA-5
CERES-SYN
W/m2
0
10
20
30
40
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
Year

4. Validation

- **ERA5** annual mean OLR: