CLARA-A3 data record released: 40 years of shortwave and longwave TOA fluxes

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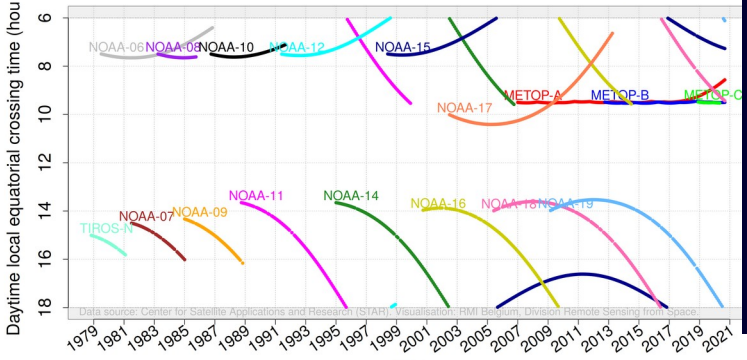
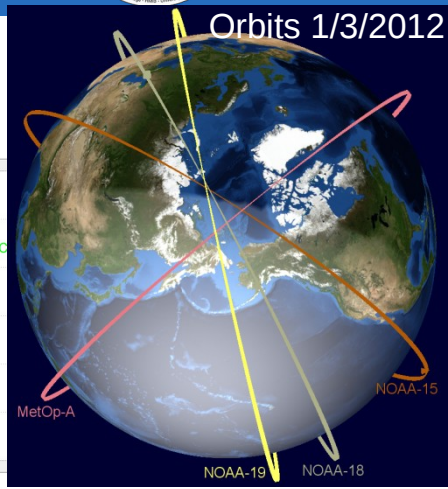
1. Introduction

- **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)



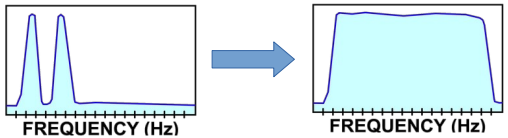


- **Some of the modifications in the upcoming version CLARA-A3:**
  - Inclusion of the AVHRR-1 sensor (TIROS-N, NOAA-6,-8,-10): extension of time range to 1979-2020, which is 42 years
  - Updated FCDR: new calibration for visible channels (latest PATMOS-x coefficients)
  - Updated cloud treatment algorithms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

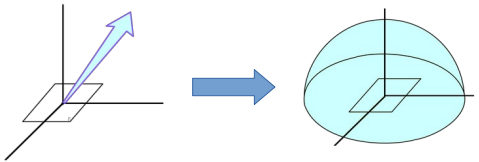
1. Introduction

Simplified version of processing chain:

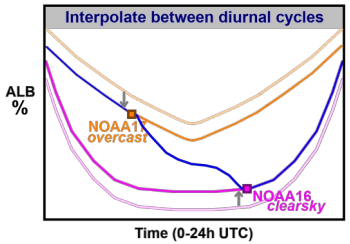
- Starting point : Reflectances (RSF) or brightness temperatures (OLR) in 2 narrowband channels from AVHRR instrument
- Narrowband-to-broadband conversion (using empirical regressions) :



- Directional-to-hemispherical conversion (using Angular Dependency Models):



- Instantaneous-to-dailymean conversion (using temporal interpolation models):



2. Overview of the products

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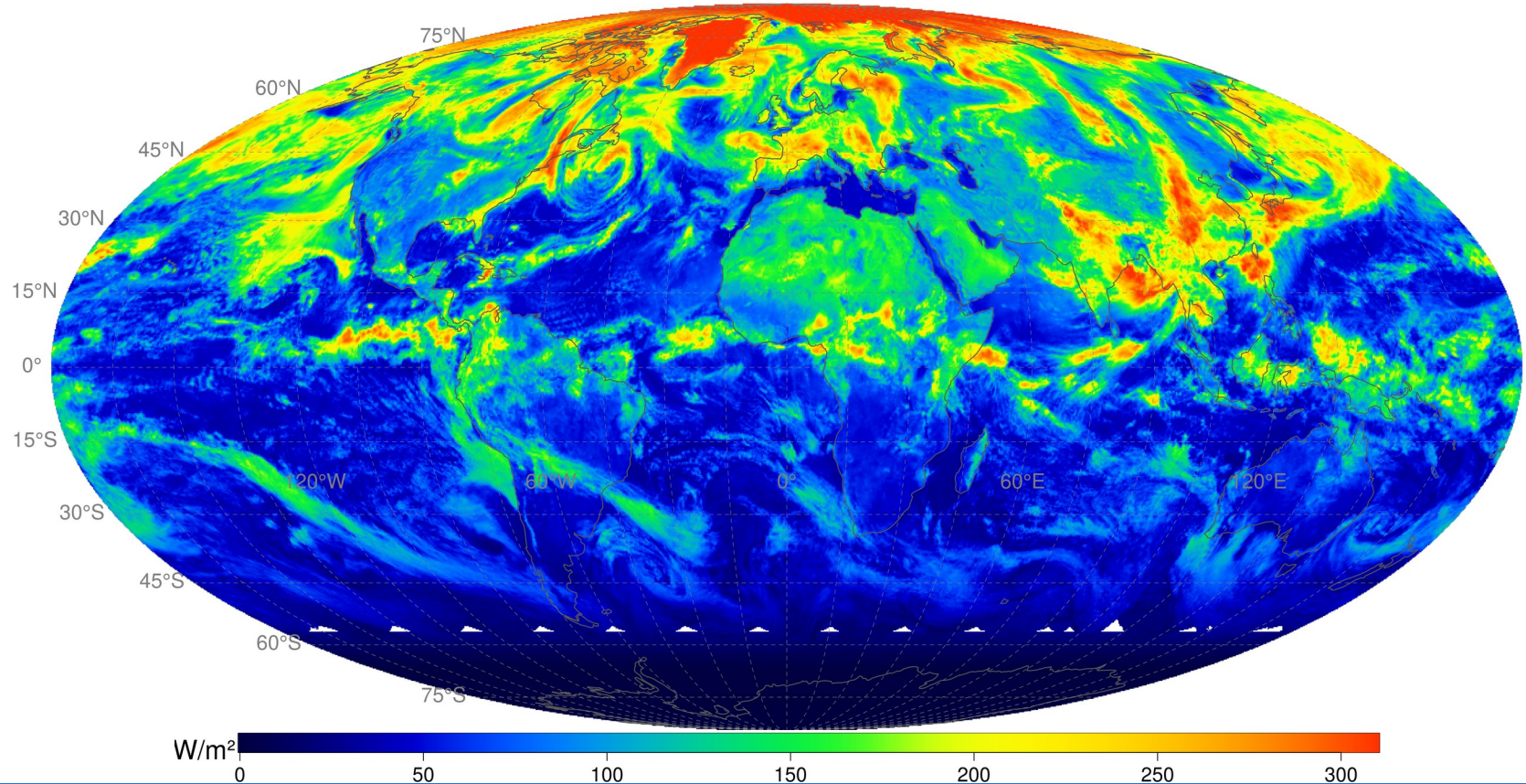
- Example: daily mean RSF (15/6/2008)



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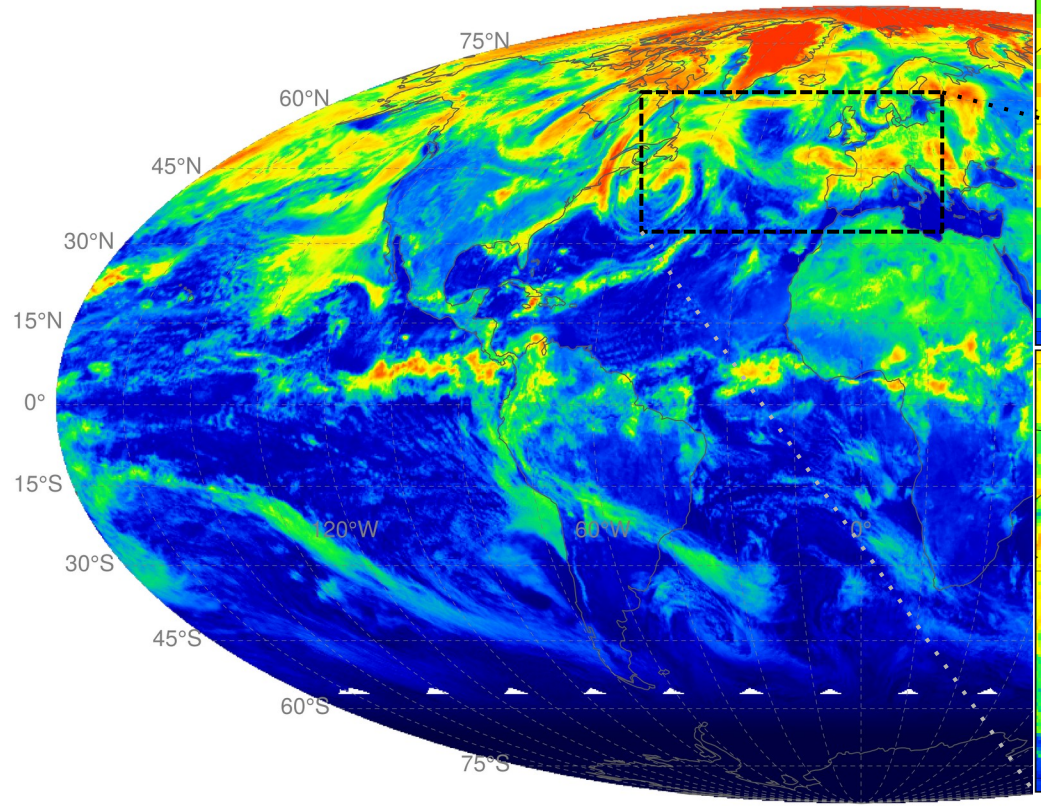

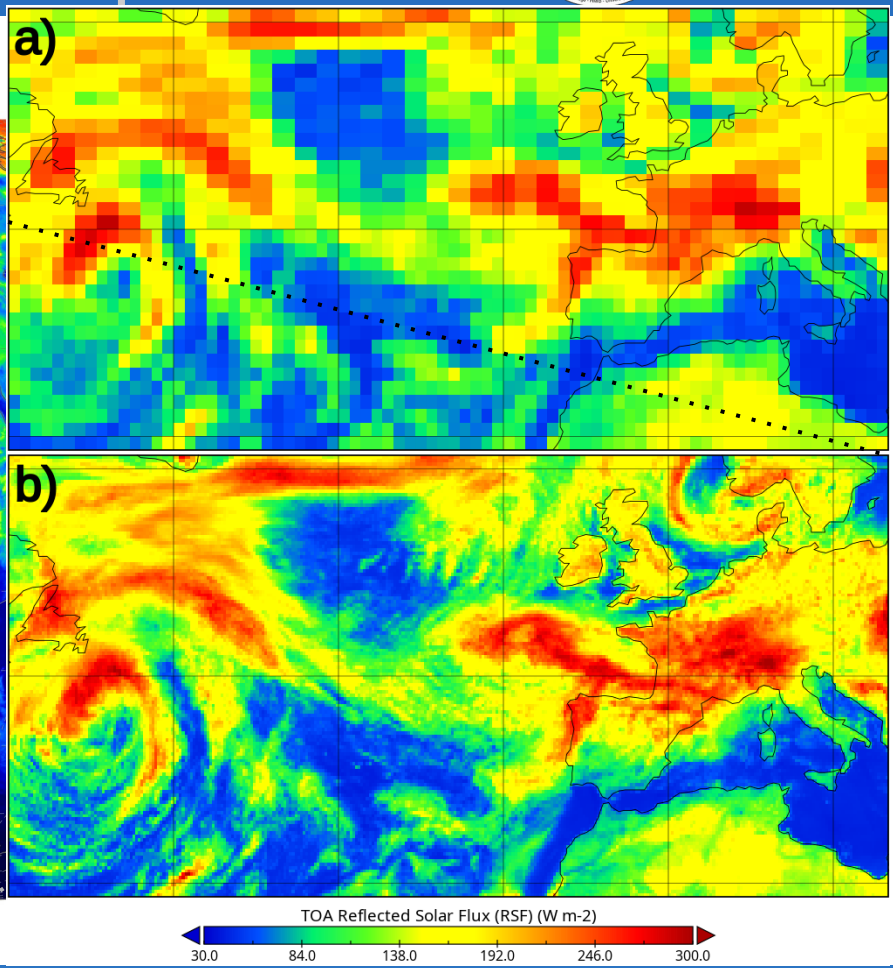

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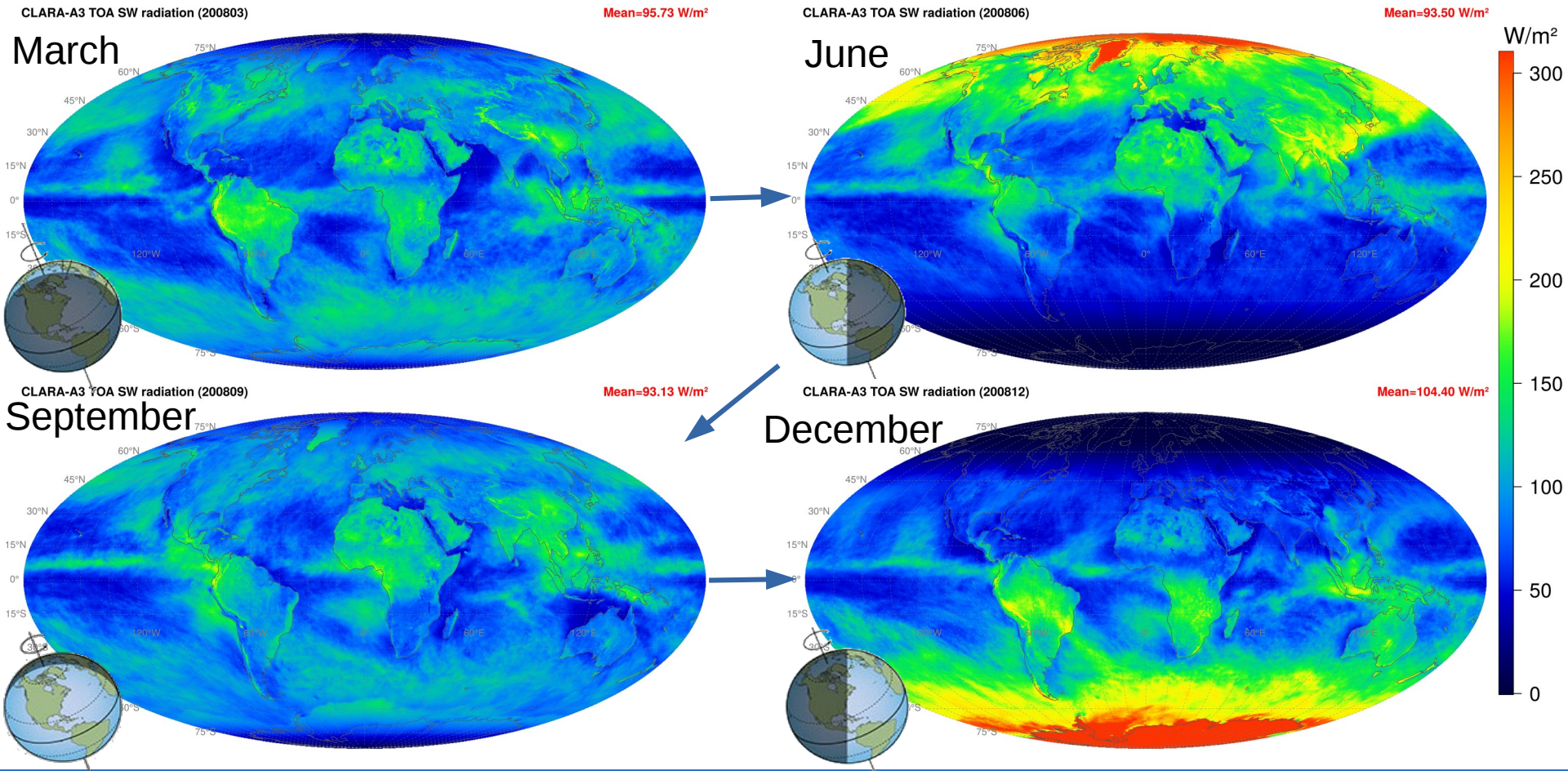
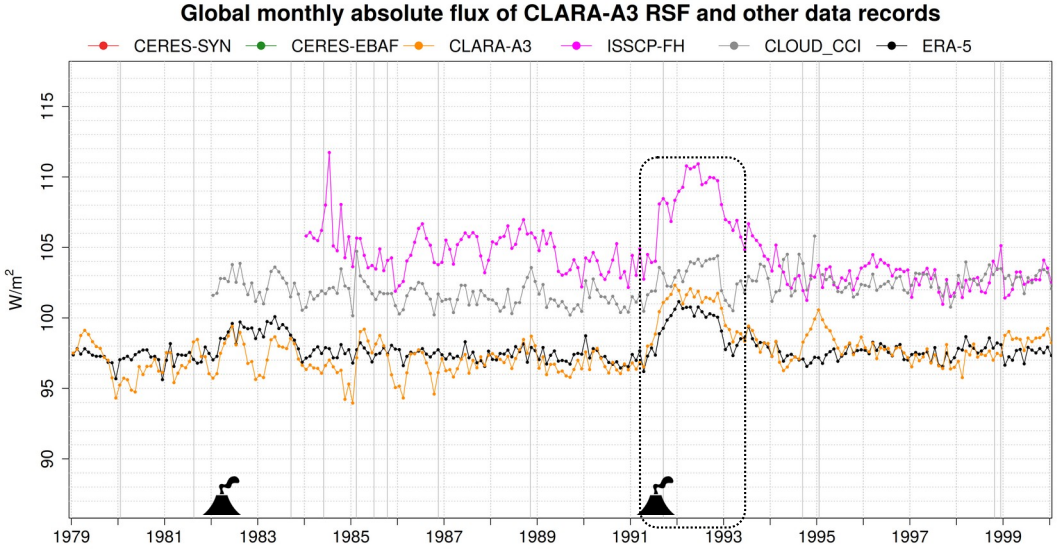


- **Global** Monthly Mean RSF:



- Deseasonalized

Major volcanic events

Trends (W/m²/dec):

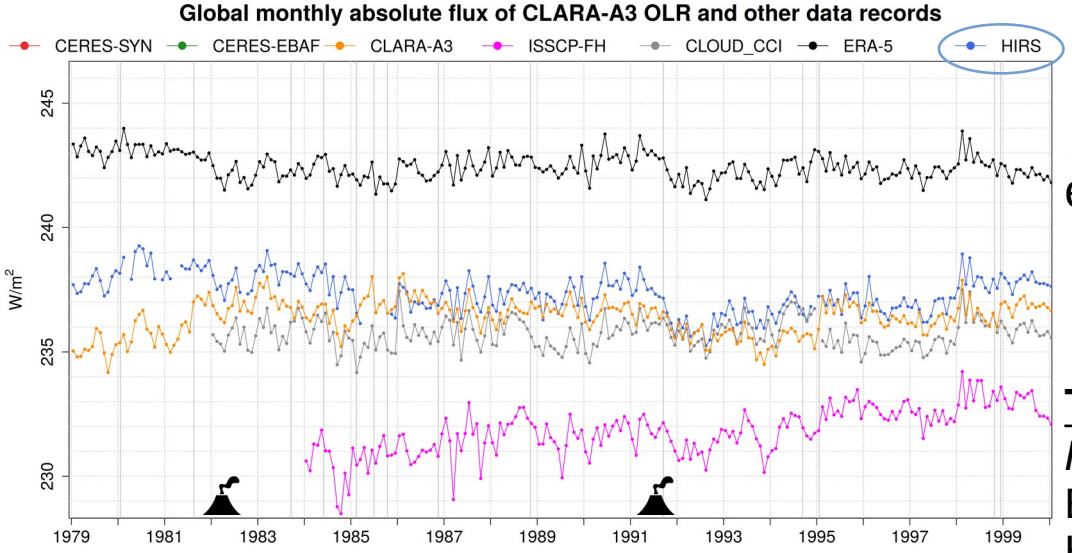
Full series:

ERA5:	-0.0769
CLARA-A3:	-0.2318

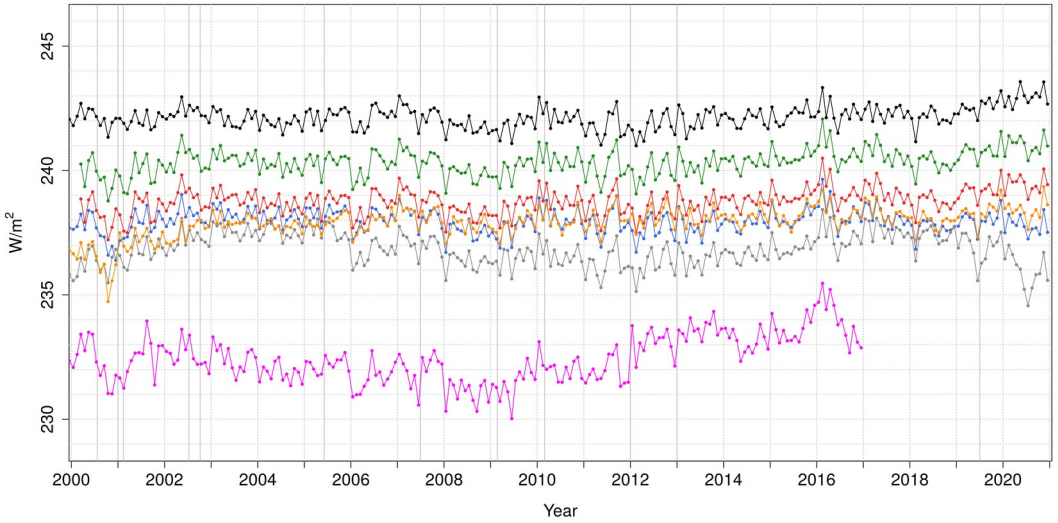
Since 2000:

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

- **Global** Monthly Mean OLR:



- Deseasonalized



Major volcanic events

Trends (W/m²/dec):

Full series:

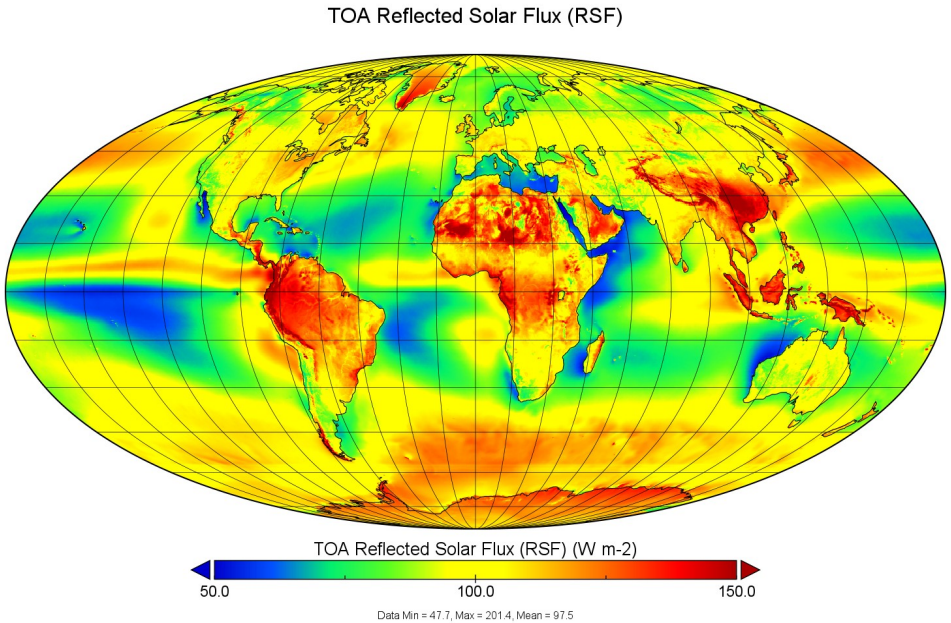
ERA5:	-0.1125
HIRS:	+0.1461
CLARA-A3:	+0.6321

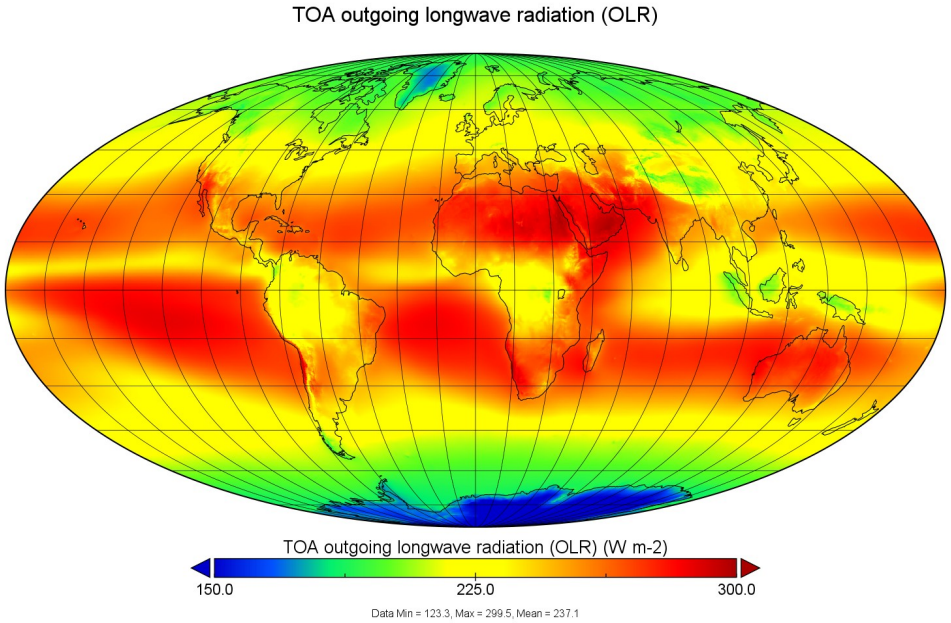
Since 2000:

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

2. Overview of the products

- Long-term average TOA fluxes (1979-2020) from CLARA-A3:

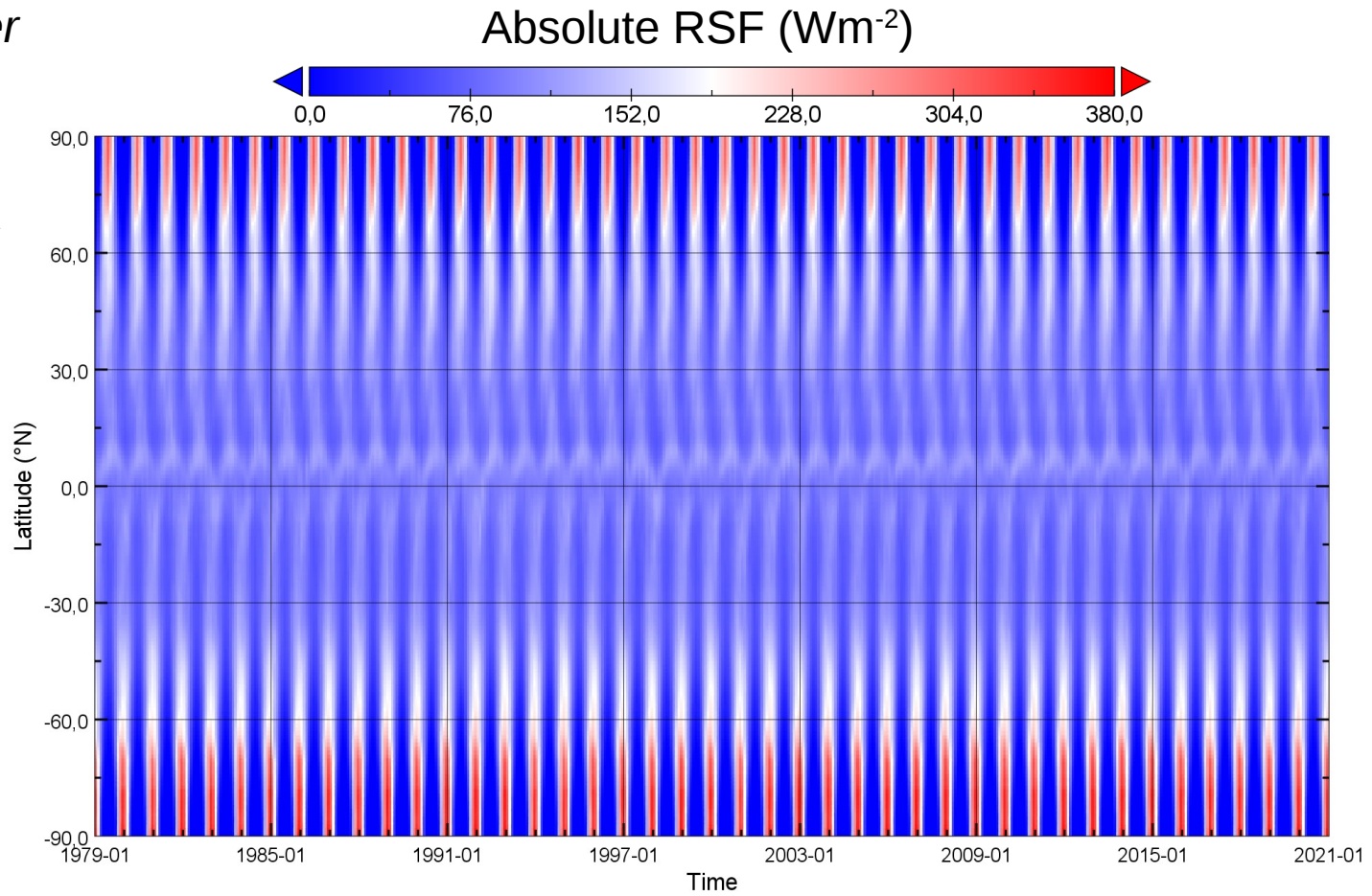




3. Some spatio-temporal insights in the data record

3. Some spatiotemporal insights

Hovmöller diagram: time vs zonal averages



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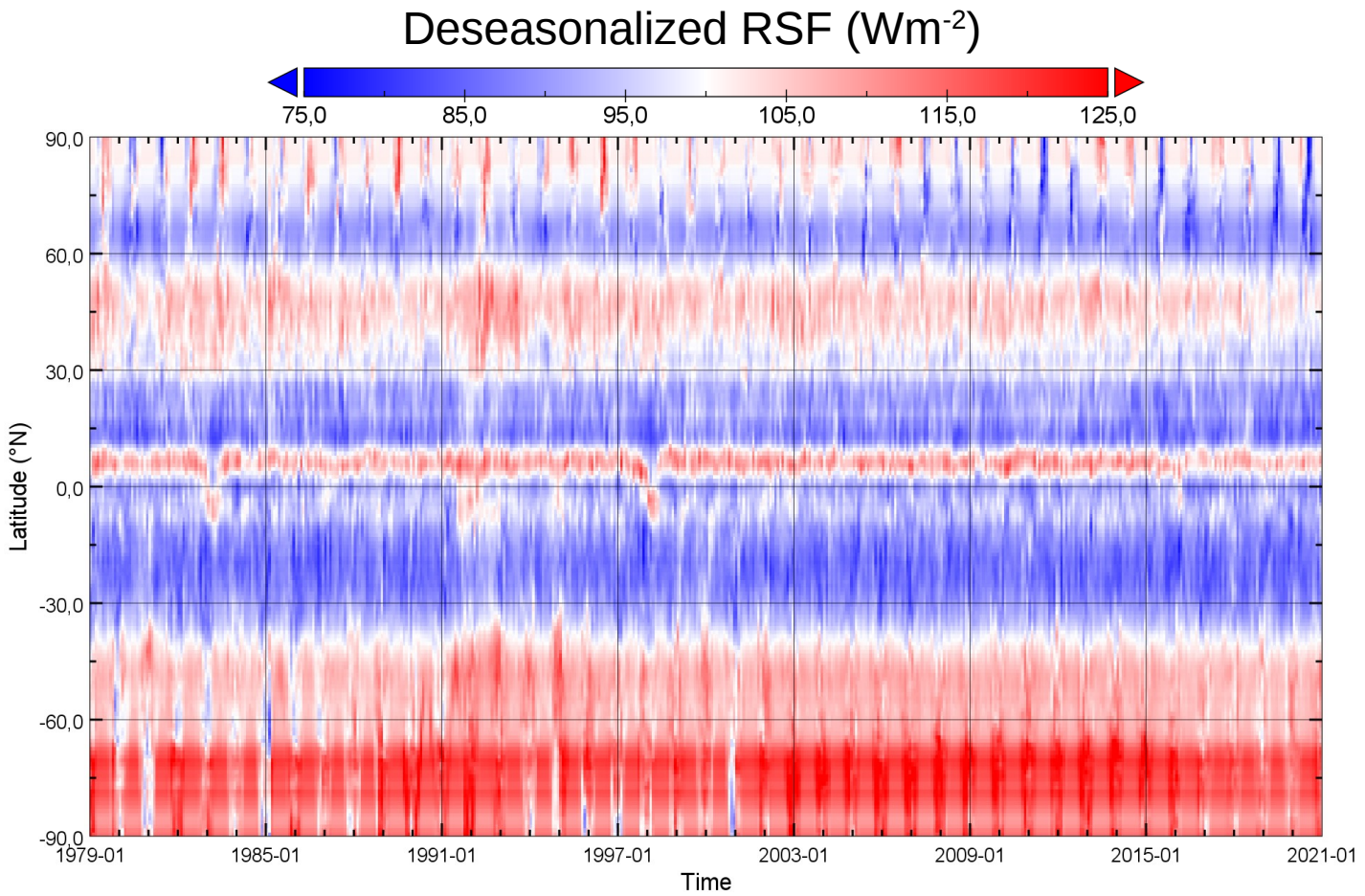

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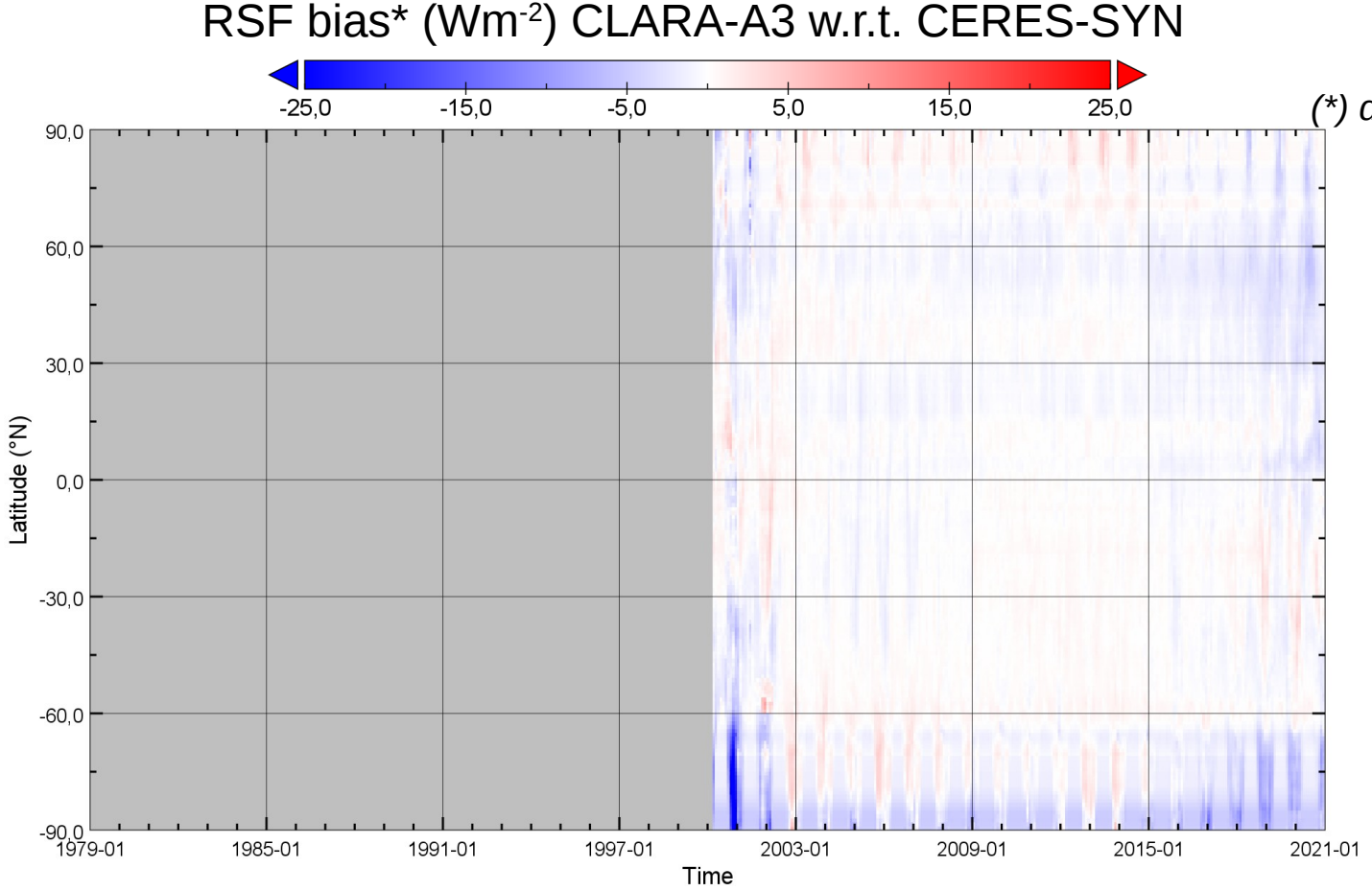

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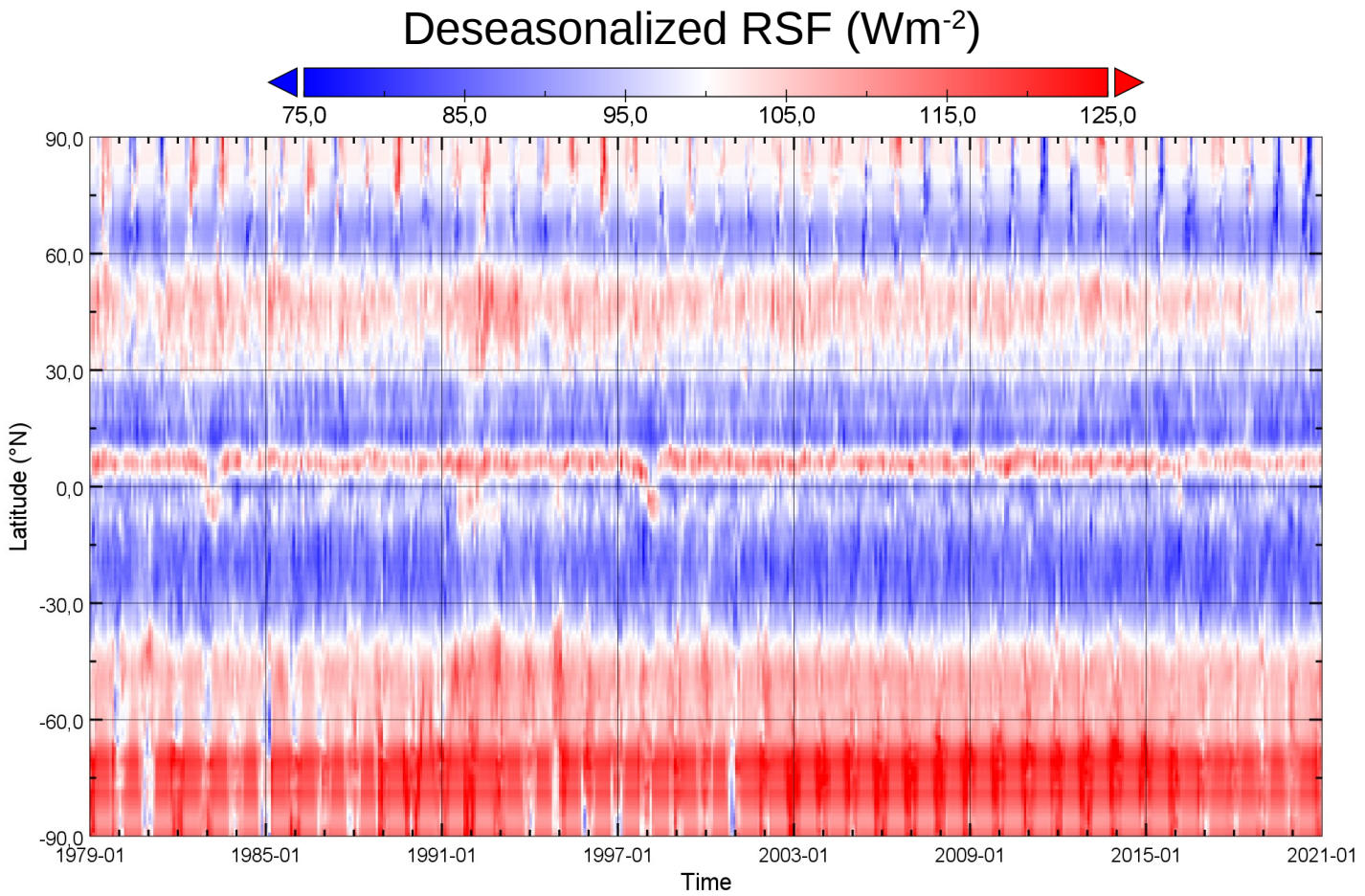

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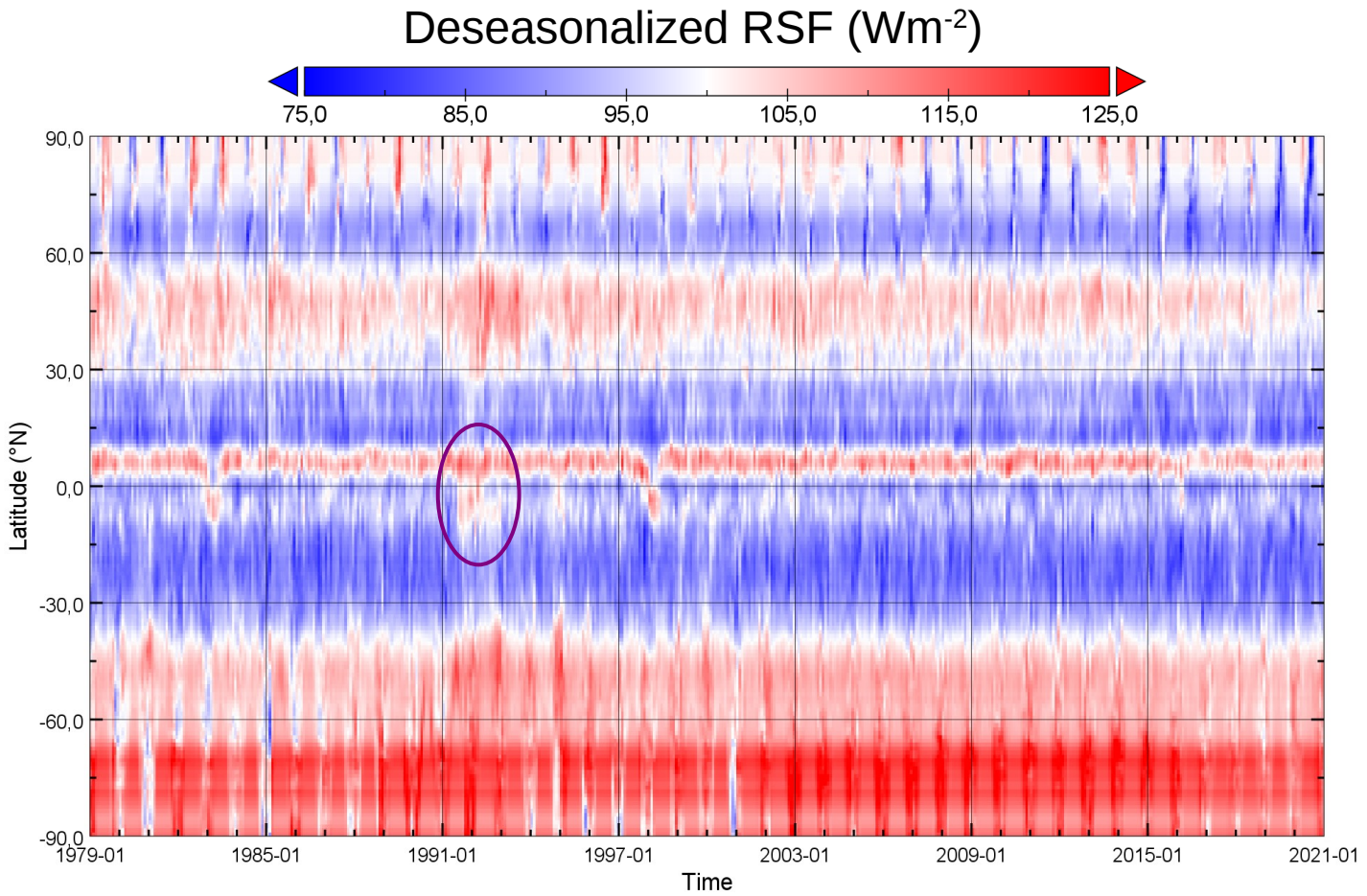
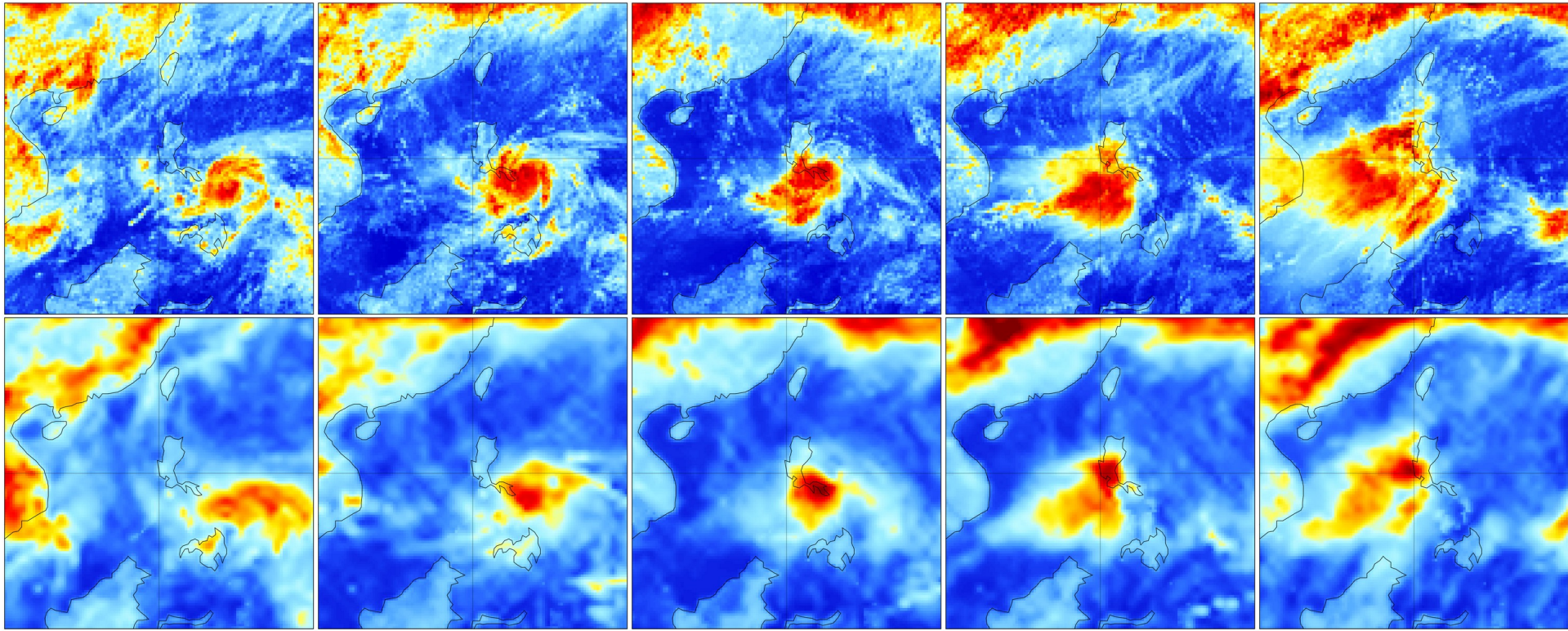


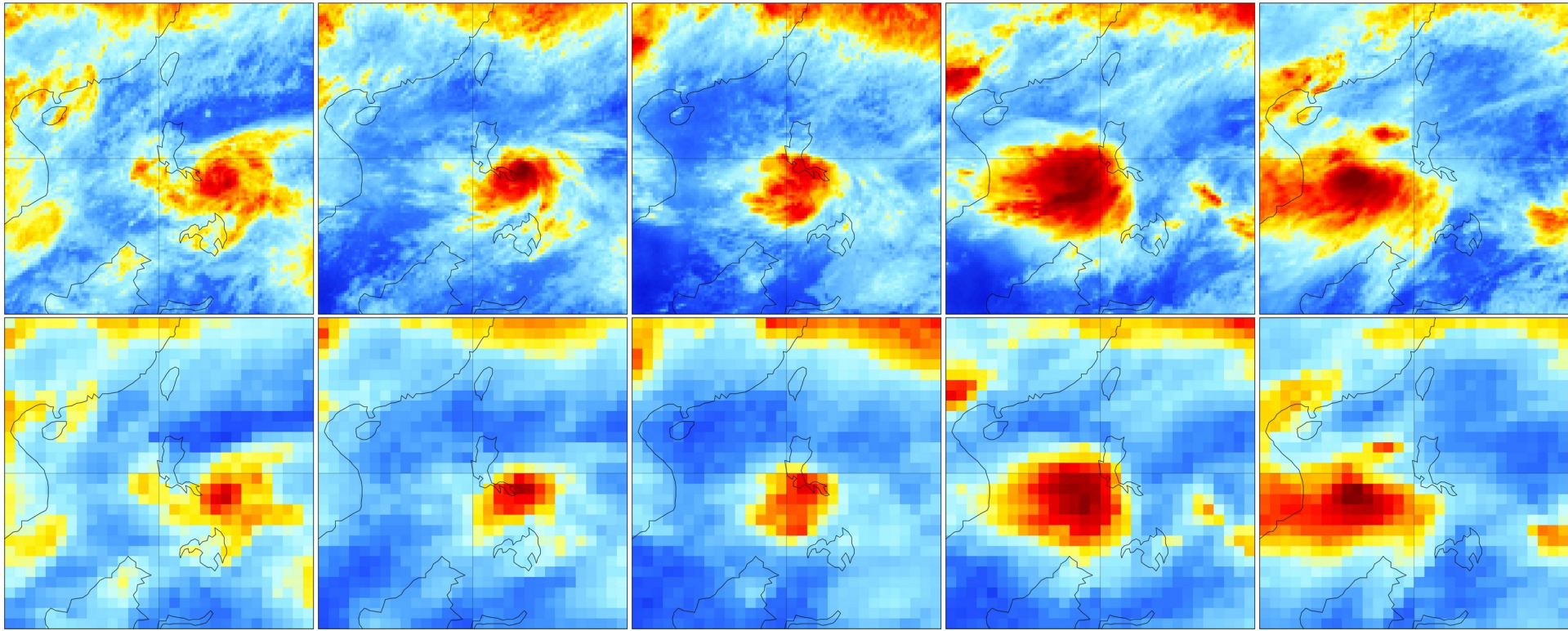
3. Some spatiotemporal insights

Typhoon Yunya + Pinatubo eruption: Daily mean **RSF** (W/m²) from CLARA-A3 (top) and ERA5 (bottom)



3. Some spatiotemporal insights

Typhoon Yunya + Pinatubo eruption: Daily mean **OLR** (W/m²) from CLARA-A3 (top) and HIRS* (bottom)

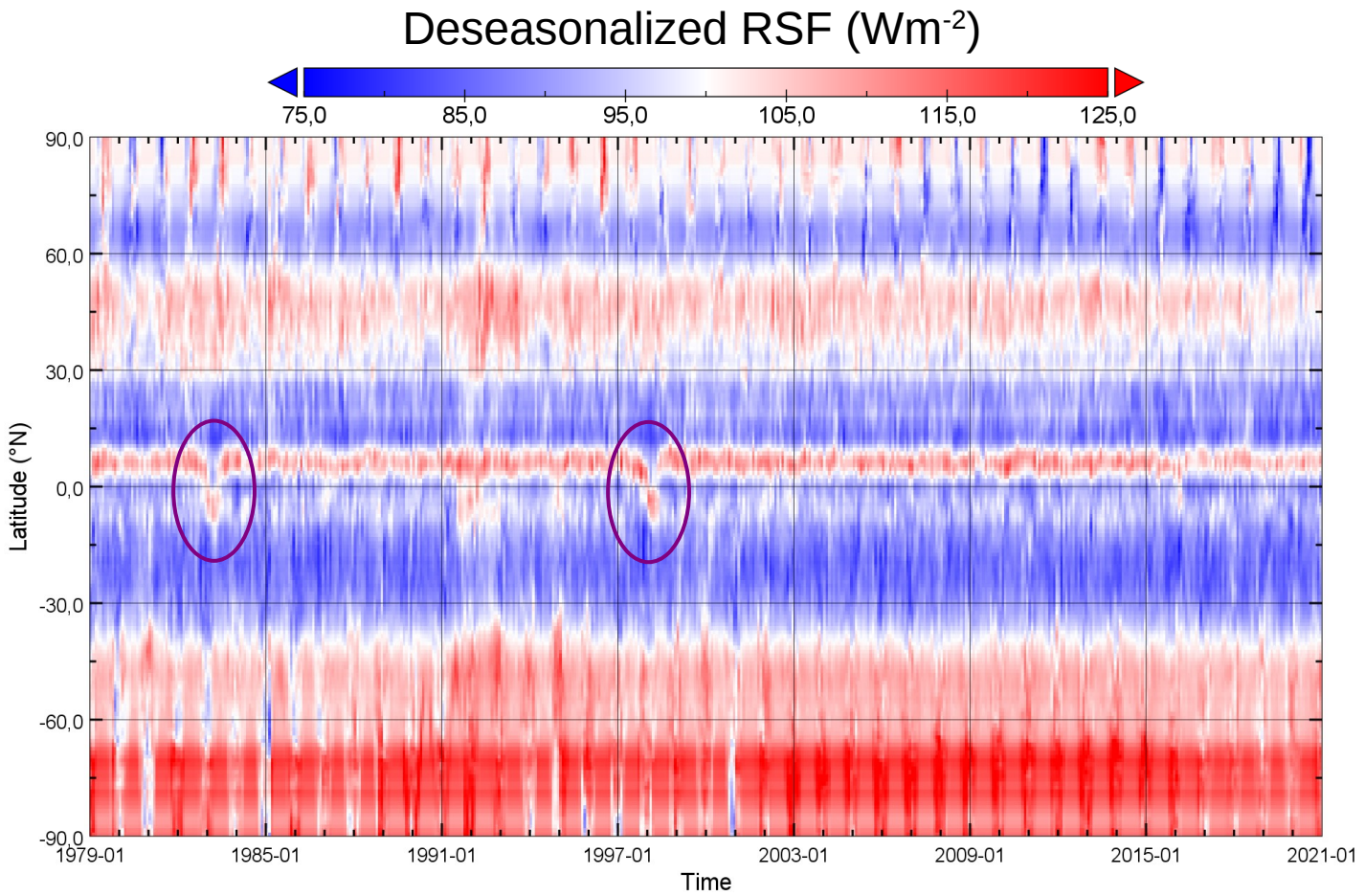


12-06-1991 **13**-06-1991 **14**-06-1991 **15**-06-1991 **16**-06-1991

(*) NOAA HIRS OLR v01r02

100,0 140,0 180,0 220,0 260,0 300,0

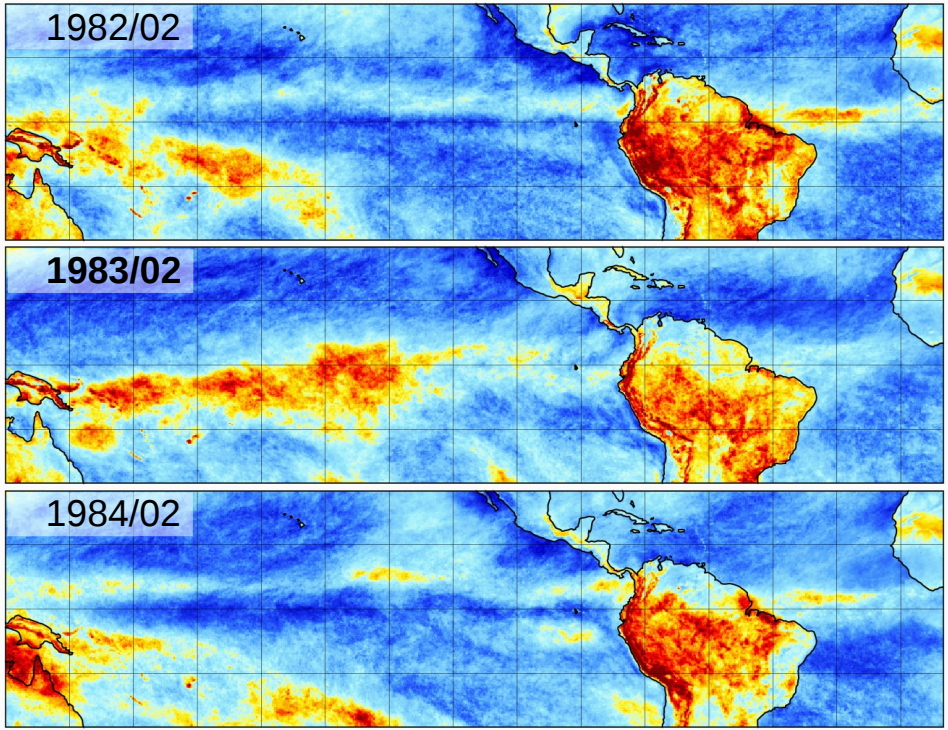
3. Some spatiotemporal insights



3. Some spatiotemporal insights

"For the 1983 and 1998 El Niño's, warm equatorial SSTs (>27 °C) persisted from November to June, and these warm SSTs replaced the climatic cold tongue. Accompanying the disappearance of the cold tongue during March-April, the northern ITCZ and southern ITCZ migrated to each other." (Chen et al., 2021*).

(*) Chen, Y., Yan, L., Li, G., Xu, J., Long, J., & Zheng, S. (2021). Contrasting Impacts of Three Extreme El Niños on Double ITCZs over the Eastern Pacific Ocean. Atmosphere, 12(4), 424.



Monthly mean RSF (W/m²) from CLARA-A3

40,0 72,0 104,0 136,0 168,0 200,0

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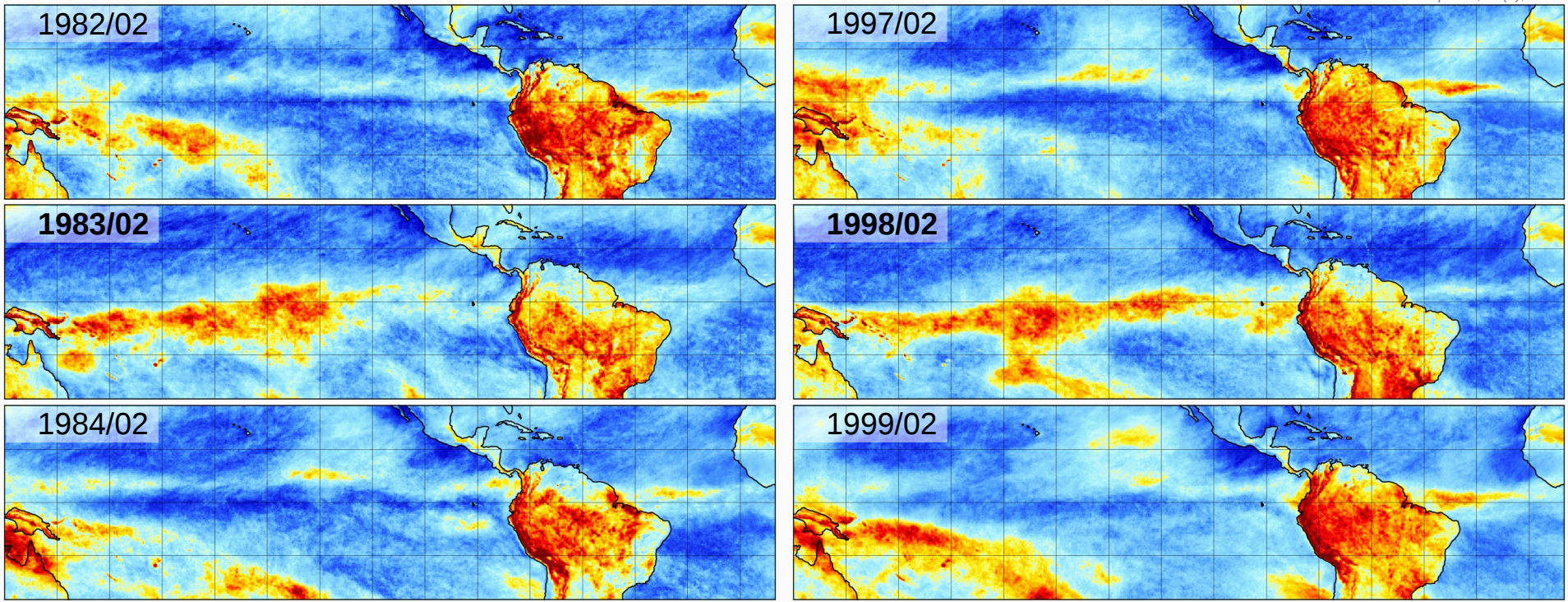

4. Trend analysis

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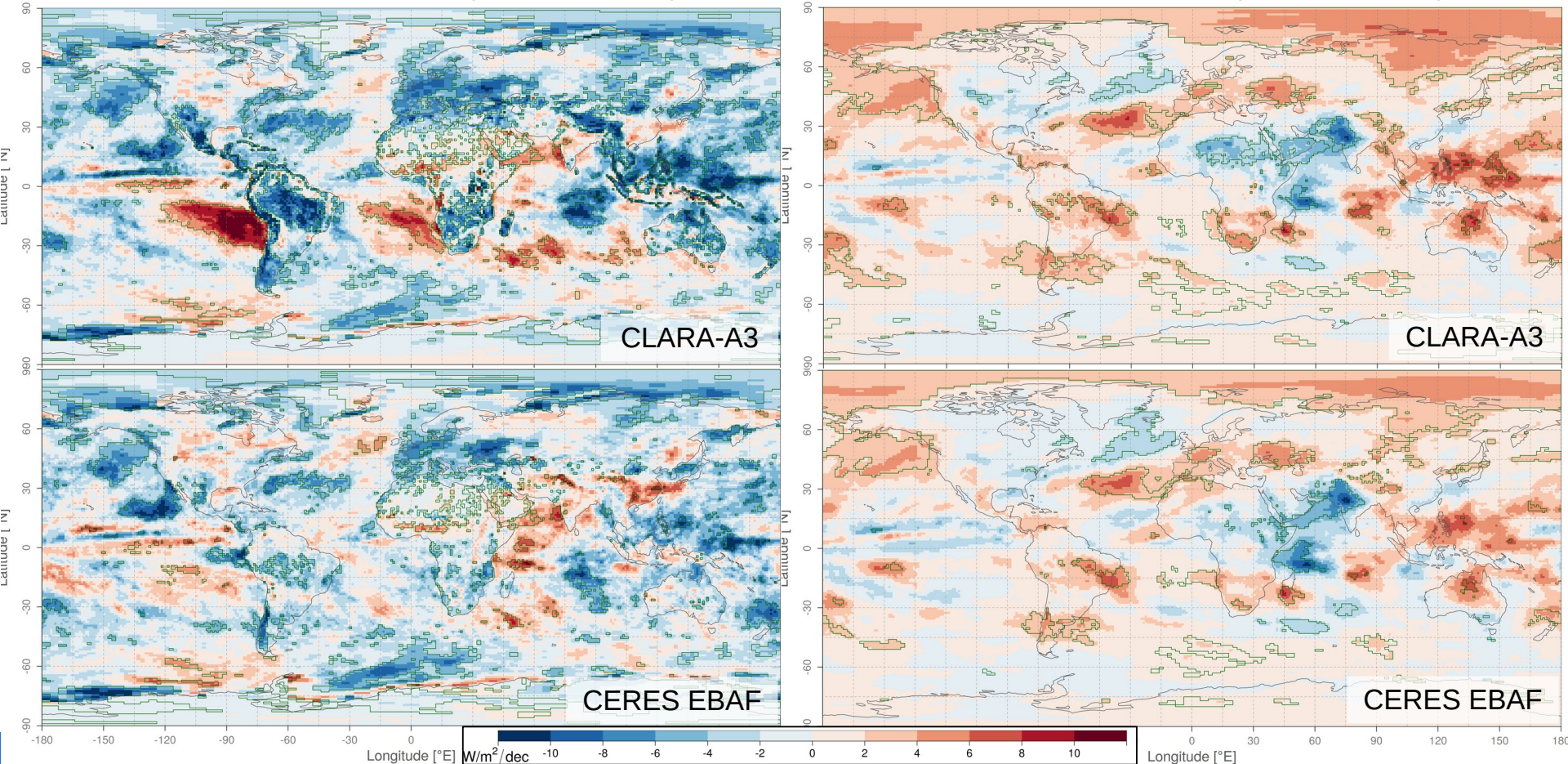
RSF trend 2000-2020 (W/m²/decade)

OLR trend 2000-2020 (W/m²/decade)



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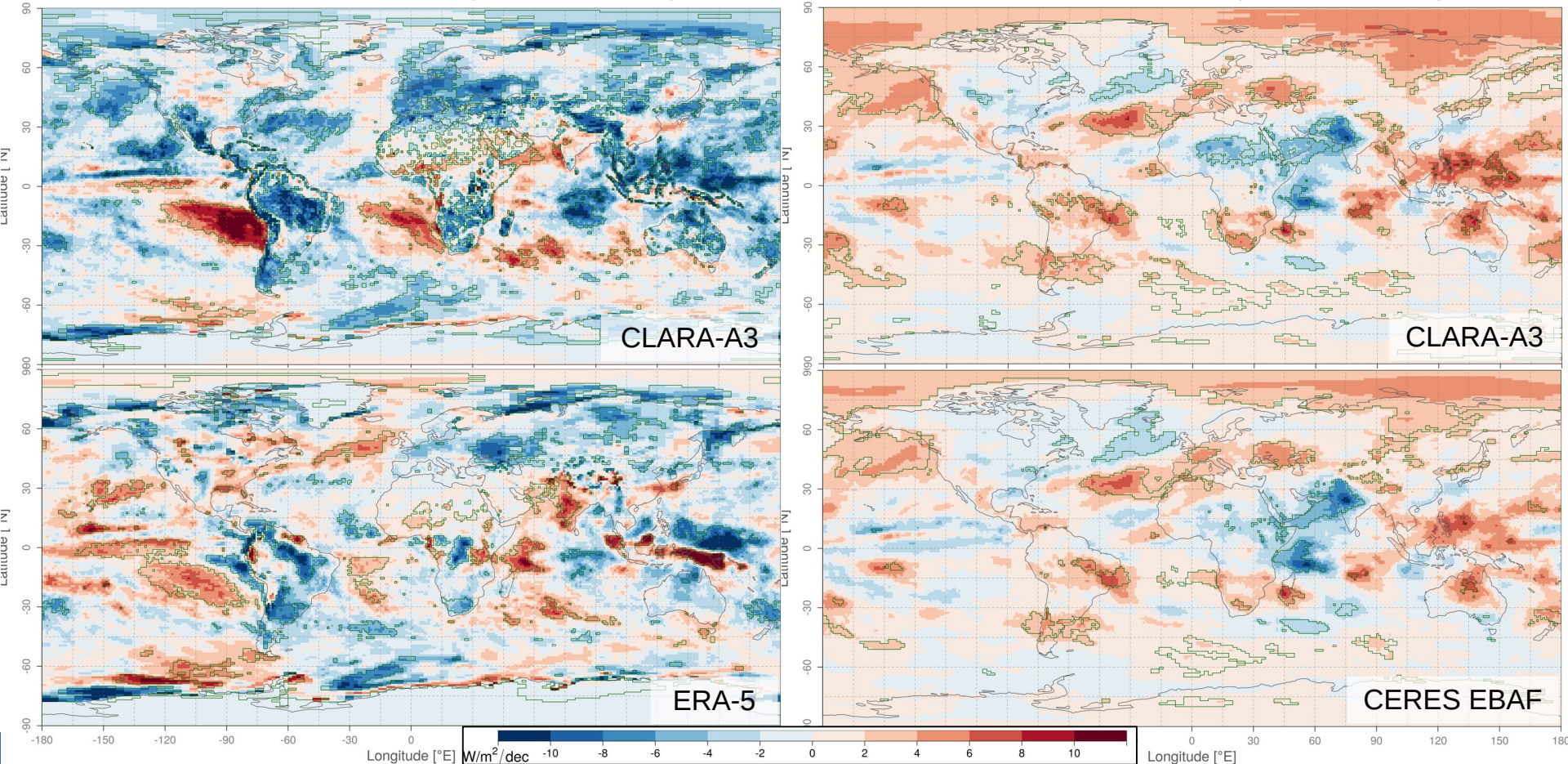

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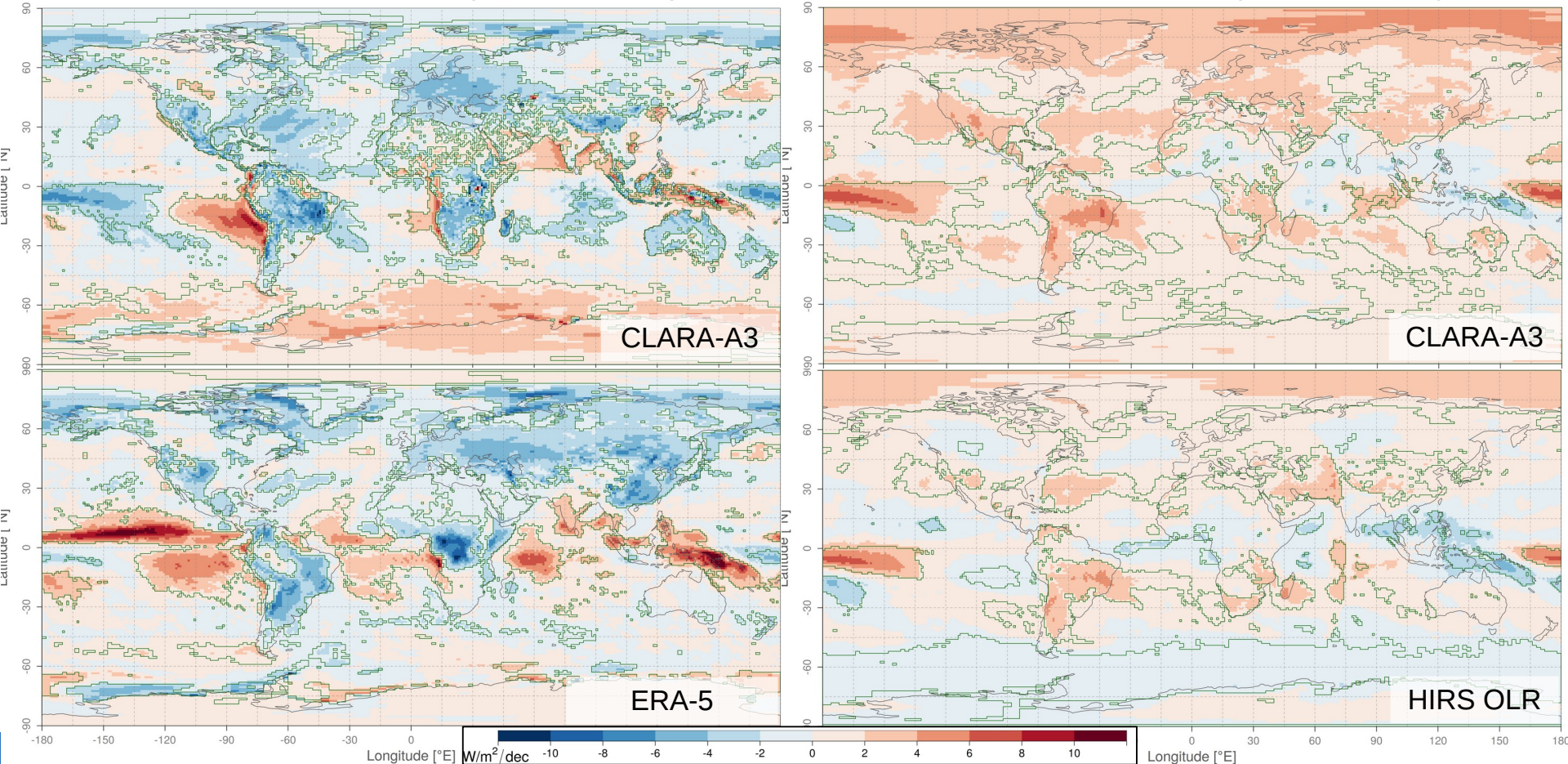
OLR trend 1979-2020 (W/m²/decade)



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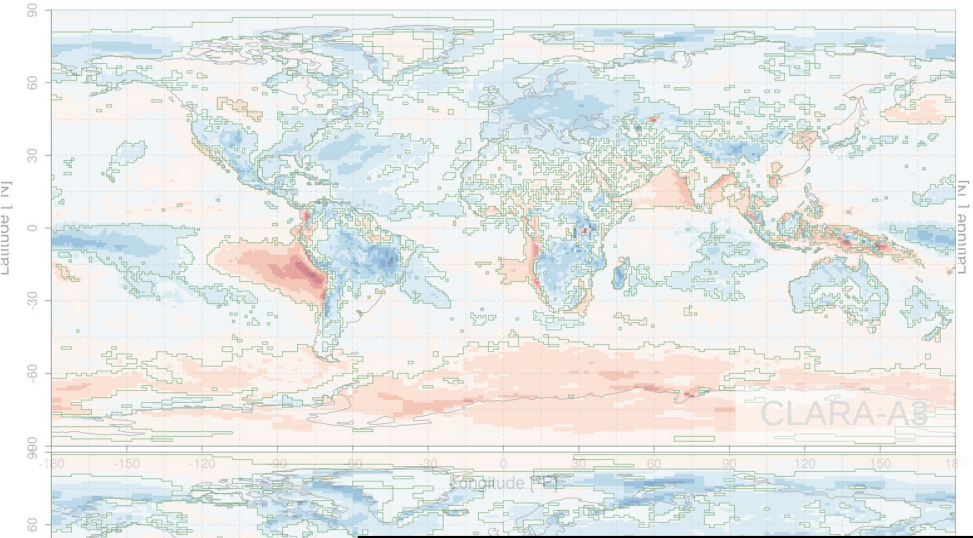
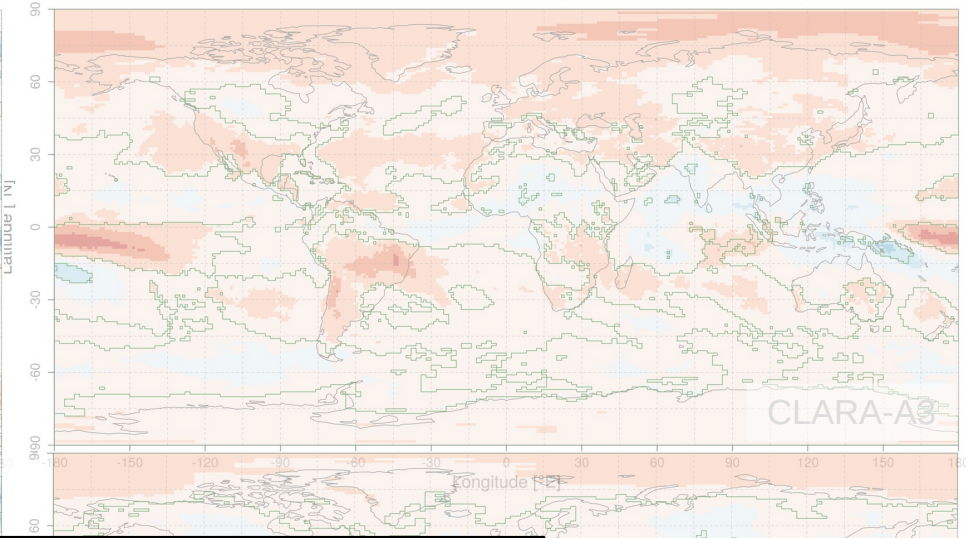
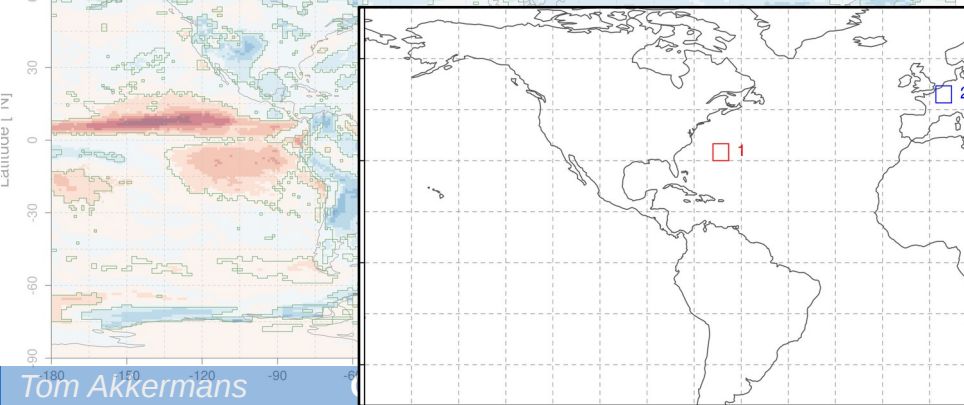
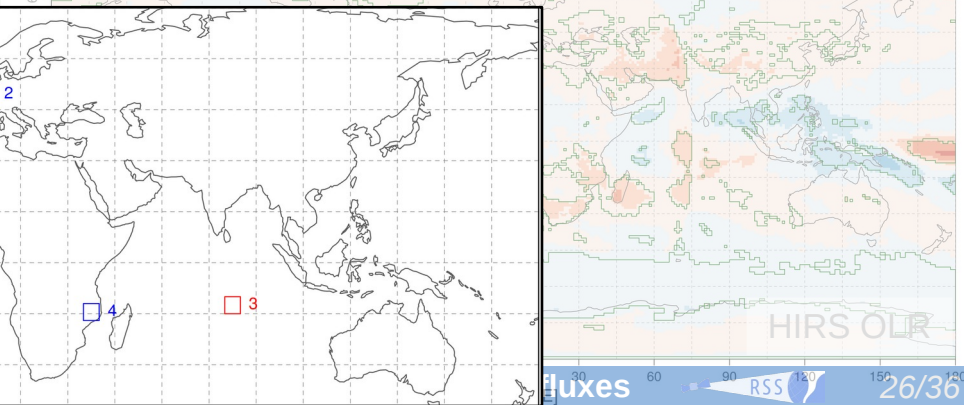
RSF trend 1979-2020 (W/m²/decade)



OLR trend 1979-2020 (W/m²/decade)







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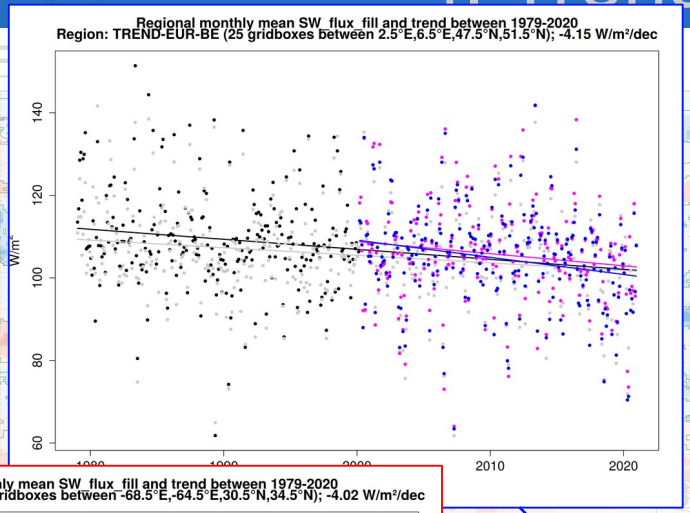

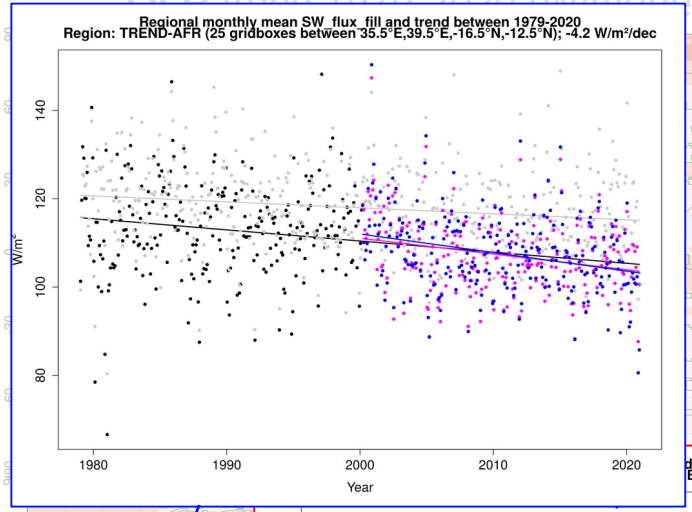

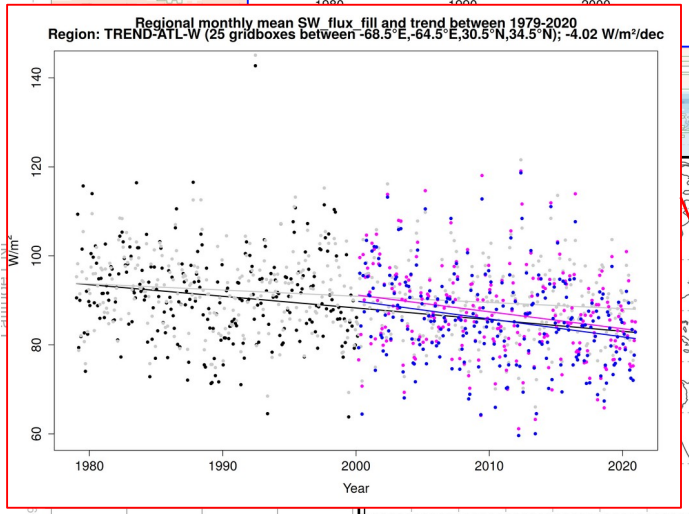

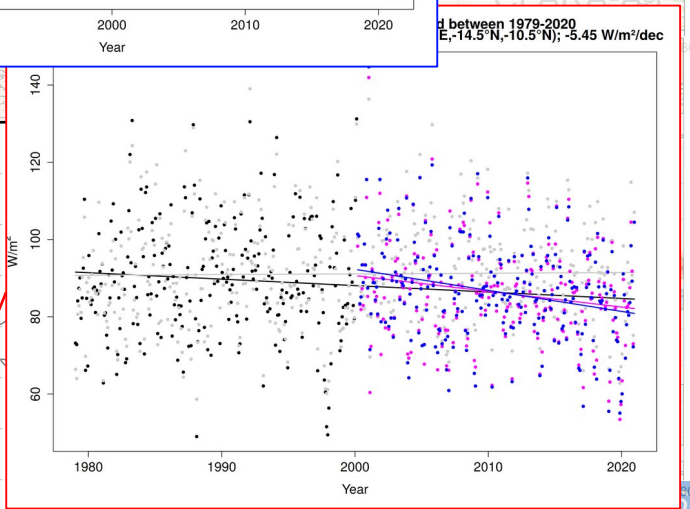

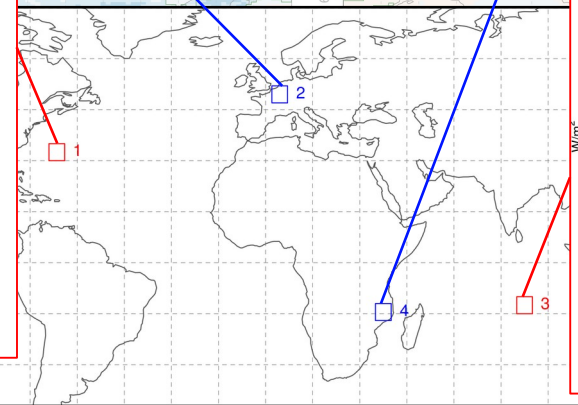

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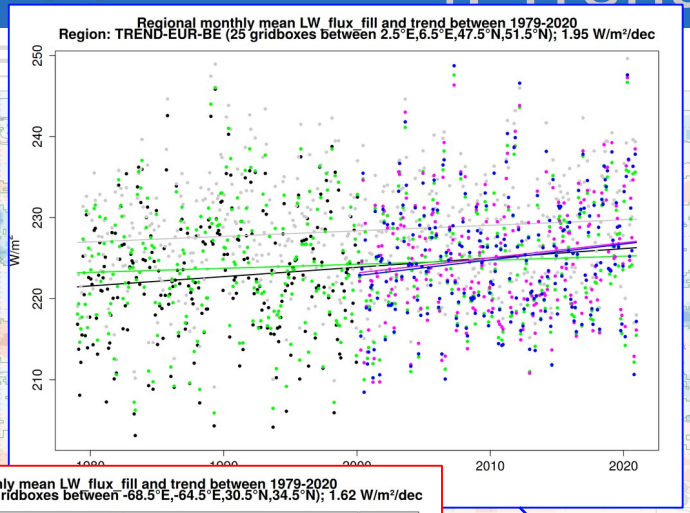

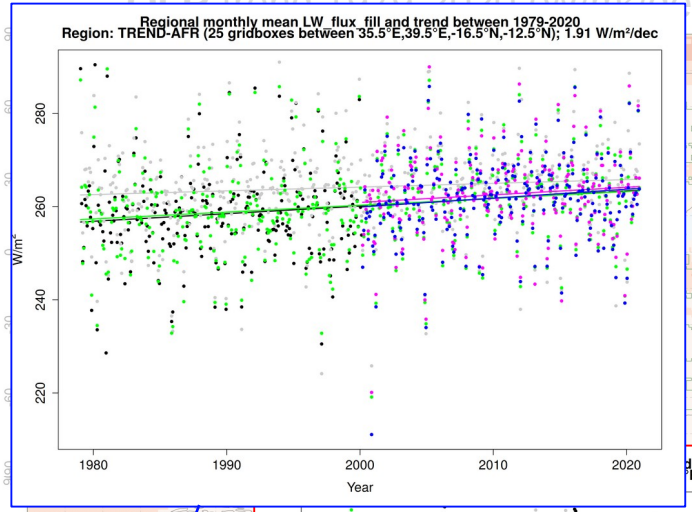

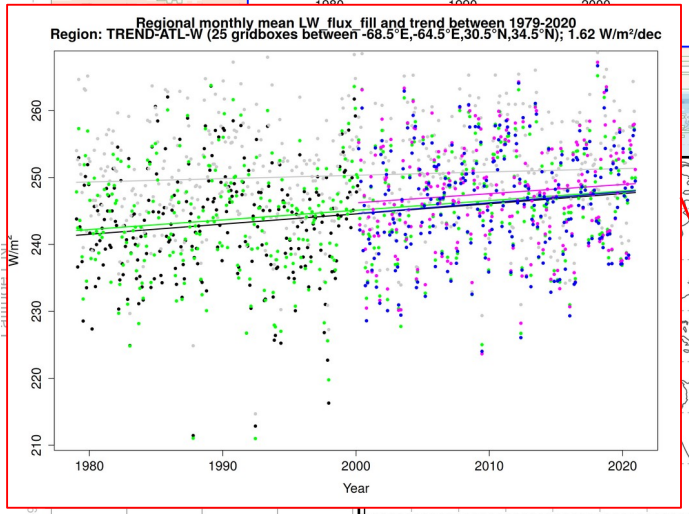

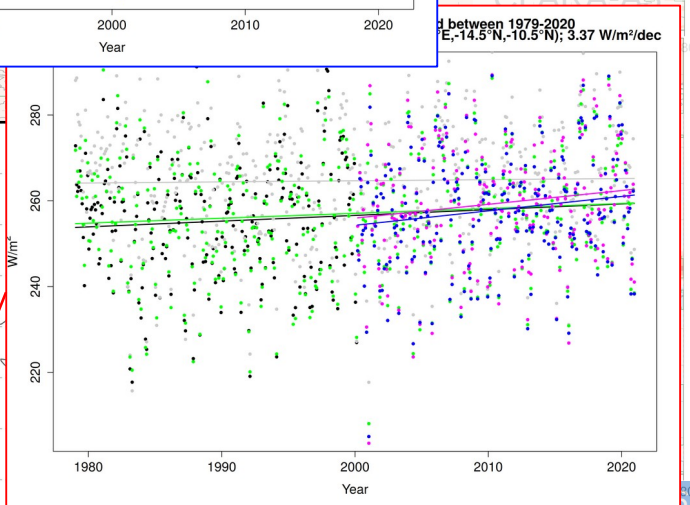

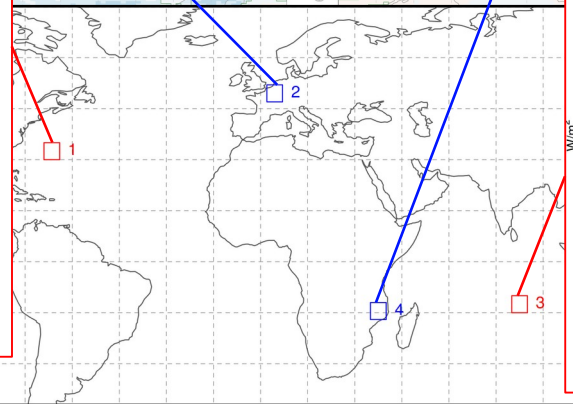

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5. Where to find the data?

NAVIGATION

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- Products
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- Service

DIRECTLY TO

- Documentation
- User Help Desk
- CM SAF Service Messages
- CM SAF FAQs
- CM SAF Accessibility Declaration

EXTERNAL LINKS

Digital Object Identifier
Entry information for CLARA_AVHRR_V003

Here you find the details of your selected DOI acronym and the links to order the described products.

Title
CLARA-A3: CM SAF cLoud, Albedo and surface RAdiation dataset from AVHRR data - Edition 3

Citation
Karlsson, Karl-Göran; Riihelä, Aku; Trentmann, Jörg; Stengel, Martin; Solodovnik, Irina; Meirink, Jan Fokke; Devasthale, Abhay; Jääskeläinen, Emmihenna; Kallio-Myers, Viivi; Eliasson, Salomon; Benas, Nikos; Johansson, Erik; Stein, Diana; Finkensieper, Stephan; Håkansson, Nina; Akkermans, Tom; Clerbaux, Nicolas; Selbach, Nathalie; Schröder, Marc; Hollmann, Rainer (2023): CLARA-A3: CM SAF cLoud, Albedo and surface RAdiation dataset from AVHRR data - Edition 3, Satellite Application Facility on Climate Monitoring, DOI:10.5676/EUM_SAF_CM/CLARA_AVHRR/V003, https://doi.org/10.5676/EUM_SAF_CM/CLARA_AVHRR/V003. [BibTeX entry]

Publisher
Satellite Application Facility on Climate Monitoring (CM SAF)

Publication year
2023

Author(s)
Karlsson, Karl-Göran; Riihelä, Aku; Trentmann, Jörg; Stengel, Martin; Solodovnik, Irina; Meirink, Jan Fokke; Devasthale, Abhay; Jääskeläinen, Emmihenna; Kallio-Myers, Viivi; Eliasson, Salomon; Benas, Nikos; Johansson, Erik; Stein, Diana; Finkensieper, Stephan; Håkansson, Nina; Akkermans, Tom; Clerbaux, Nicolas; Selbach, Nathalie; Schröder, Marc; Hollmann, Rainer

Description
The CLARA-A3 record provides cloud properties and radiation parameters derived from the AVHRR sensor onboard polar orbiting NOAA and METOP satellites. CLARA-A3 is the latest edition of CLARA with previous editions documented in Karlsson et al. (2013) and Karlsson et al. (2017). CLARA-A3 covers the time period 1979/01/01 until 2020/12/31 as climate data record (CDR), but is operationally extended as interim climate data record (ICDR) to the present with a latency of 10 days. The AVHRR measurement input to the CLARA-A3 retrieval algorithms is the EUMETSAT PyGAC AVHRR Fundamental Data Record (FDR) Release 1 (DOI:10.15770/EUM_SEC_CLM_0060). CLARA-A3 features a range of cloud products: cloud mask, cloud top temperature/pressure/height, cloud thermodynamic phase, and (for liquid and ice clouds separately) cloud optical thickness, particle effective radius and cloud water path. Additionally, cloud droplet number concentration and cloud geometrical thickness are provided for liquid clouds. Furthermore, a range of radiation products are included in CLARA-A3: surface black-sky, white-sky and blue-sky albedo; surface downwelling short- and longwave radiation as well as surface net radiation; top-of-atmosphere (TOA) upwelling short- and longwave radiation. Cloud products are available as monthly and daily averages and histograms, as well as daily resampled global products (Level 2b) for individual satellites. Surface albedo is presented as monthly and pentad (5 day) averages. Surface and TOA radiation products are provided as daily and monthly averages. All averages are available on a 0.25° x 0.25° global grid. Surface albedo and selected cloud products are also provided on two equal area grids with a resolution of 25 km x 25 km covering the polar regions. Daily resampled cloud products (level 2b) are provided in a global grid with a resolution of 0.05°x0.05°. CLARA-A3 features a comprehensive set of documentation including User Manuals, Validation Reports and Algorithms Theoretical Baseline Documents (see links below).

Format
NetCDF-4

Version
3.0

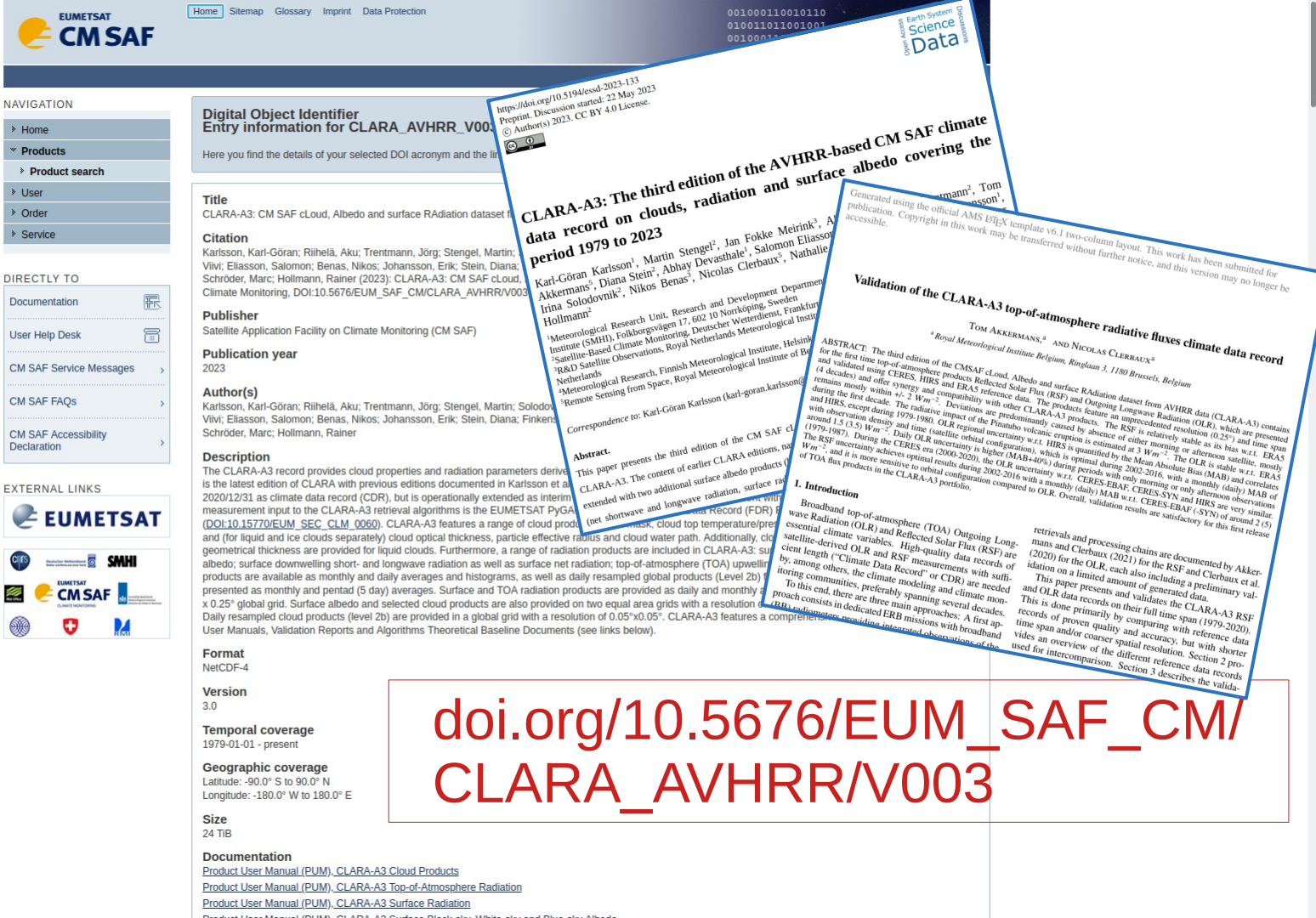
Temporal coverage
1979-01-01 - present

Geographic coverage
Latitude: -90.0° S to 90.0° N
Longitude: -180.0° W to 180.0° E

Size
24 TiB

Documentation
Product User Manual (PUM), CLARA-A3 Cloud Products
Product User Manual (PUM), CLARA-A3 Top-of-Atmosphere Radiation
Product User Manual (PUM), CLARA-A3 Surface Radiation

doi.org/10.5676/EUM_SAF_CM/CLARA_AVHRR/V003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Title
CLARA-A3: CM SAF cLoud, Albedo and surface RAdiation dataset f
Citation
Karlsson, Karl-Göran; Riihelä, Aku; Trentmann, Jörg; Stengel, Martin;
Viivi; Eliasson, Salomon; Benas, Nikos; Johansson, Erik; Stein, Diana;
Schröder, Marc; Hollmann, Rainer (2023): CLARA-A3: CM SAF cLoud,
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Publisher
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Author(s)
Karlsson, Karl-Göran; Riihelä, Aku; Trentmann, Jörg; Stengel, Martin; Solodov
Viivi; Eliasson, Salomon; Benas, Nikos; Johansson, Erik; Stein, Diana; Finkens
Schröder, Marc; Hollmann, Rainer
Description
The CLARA-A3 record provides cloud properties and radiation parameters derive
is the latest edition of CLARA with previous editions documented in Karlsson et a
2020/12/31 as climate data record (CDR), but is operationally extended as interim
measurement input to the CLARA-A3 retrieval algorithms is the EUMETSAT PyGA
(DOI:10.15770/EUM_SEC_CLM_0060). CLARA-A3 features a range of cloud prod
and (for liquid and ice clouds separately) cloud optical thickness, particle effective radius and cloud water path. Additionally, clo
geometrical thickness are provided for liquid clouds. Furthermore, a range of radiation products are included in CLARA-A3: su
albedo; surface downwelling short- and longwave radiation as well as surface net radiation; top-of-atmosphere (TOA) upwellir
products are available as monthly and daily averages and histograms, as well as daily resampled global products (Level 2b)
presented as monthly and pentad (5 day) averages. Surface and TOA radiation products are provided as daily and monthly a
x 0.25° global grid. Surface albedo and selected cloud products are also provided on two equal area grids with a resolution o
Daily resampled cloud products (level 2b) are provided in a global grid with a resolution of 0.05°x0.05°. CLARA-A3 features a comprehensi
User Manuals, Validation Reports and Algorithms Theoretical Baseline Documents (see links below).
Format
NetCDF-4
Version
3.0
Temporal coverage
1979-01-01 - present
Geographic coverage
Latitude: -90.0° S to 90.0° N
Longitude: -180.0° W to 180.0° E
Size
24 TiB
Documentation
Product User Manual (PUM), CLARA-A3 Cloud Products
Product User Manual (PUM), CLARA-A3 Top-of-Atmosphere Radiation
Product User Manual (PUM), CLARA-A3 Surface Radiation
https://doi.org/10.5194/essd-2023-133
Preprint. Discussion started: 22 May 2023
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Earth System Science Data
CLARA-A3: The third edition of the AVHRR-based CM SAF climate data record on clouds, radiation and surface albedo covering the period 1979 to 2023
Karl-Göran Karlsson[1], Martin Stengel[2], Jan Fokke Meirink[3], A
Akkermans[5], Diana Stein[2], Abhay Devasthale[1], Salomon Eliasso
Irina Solodovnik[2], Nikos Benas[3], Nicolas Clerbaux[5], Nathalie
Hollmann[2]
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Netherlands
[4]Meteorological Research, Finnish Meteorological Institute, Helsink
[5]Remote Sensing from Space, Royal Meteorological Institute of Be
Correspondence to: Karl-Göran Karlsson (karl-goran.karlsson@
Abstract.
This paper presents the third edition of the CM SAF cl
CLARA-A3. The content of earlier CLARA editions, na
extended with two additional surface albedo products (
(net shortwave and longwave radiation, surface ra
Validation of the CLARA-A3 top-of-atmosphere radiative fluxes climate data record
Tom Akkermans,[a] and Nicolas Clerbaux[a]
[a]Royal Meteorological Institute Belgium, Ringlaan 3, 1180 Brussels, Belgium
ABSTRACT. The third edition of the CMSAF cLoud, Albedo and surface RAdiation dataset from AVHRR data (CLARA-A3) contains for the first time top-of-atmosphere products Reflected Solar Flux (RSF) and Outgoing Longwave Radiation (OLR), which are presented and validated using CERES, HIRS and ERA5 reference data. The products feature an unprecedented resolution (0.25°) and time span (4 decades) and offer synergy and compatibility with other CLARA-A3 products. The RSF is relatively stable as its bias w.r.t. ERA5 remains mostly within +/- 2 Wm⁻². Deviations are predominantly caused by absence of either morning or afternoon satellites, mostly during the first decade. The radiative impact of the Pinatubo volcanic eruption is estimated at 3 Wm⁻². The OLR is stable w.r.t. ERA5 and HIRS, except during 1979-1980. OLR regional uncertainty w.r.t. HIRS is quantified by the Mean Absolute Bias (MAB) and correlates with observation density and time (satellite orbital configuration), which is optimal during 2002-2016, with a monthly (daily) MAB of around 1.5 (3.5) Wm⁻². Daily OLR uncertainty is higher (MAB+40%) during periods with only morning or only afternoon observations (1979-1987). During the CERES era (2000-2020), the OLR uncertainty w.r.t. CERES-SYN and HIRS are very similar. The RSF uncertainty achieves optimal results during 2002-2016 with a monthly (daily) MAB w.r.t. CERES-EBAF (-SYN) of around 2 (5) Wm⁻² and it is more sensitive to orbital configuration compared to OLR. Overall, validation results are satisfactory for this first release of TOA flux products in the CLARA-A3 portfolio.
1. Introduction
Broadband top-of-atmosphere (TOA) Outgoing Long-wave Radiation (OLR) and Reflected Solar Flux (RSF) are essential climate variables. High-quality data records of satellite-derived OLR and RSF measurements with sufficient length ("Climate Data Record" or CDR) are needed by, among others, the climate modeling and climate monitoring communities, preferably spanning several decades. To this end, there are three main approaches: A first approach consists in dedicated ERB missions with broadband
retrievals and processing chains are documented by Akkermans and Clerbaux (2021) for the RSF and Clerbaux et al. (2020) for the OLR, each also including a preliminary validation on a limited amount of generated data.
This paper presents and validates the CLARA-A3 RSF and OLR data records on their full time span (1979-2020). This is done primarily by comparing with reference data records of proven quality and accuracy, but with shorter time span and/or coarser spatial resolution. Section 2 provides an overview of the different reference data records used for intercomparison. Section 3 describes the valida-
doi.org/10.5676/EUM_SAF_CM/CLARA_AVHRR/V003

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SEARCH ACCORDING TO PRODUCT GROUPS/TYPES

Operational Products

- Cloud products
- Surface radiation products
- Miscellaneous

Climate Data Records

- *Climate Data Records with DOI*
- Cloud products
- Surface radiation products
- Radiation fluxes at the top of atmosphere
- Water vapour and temperature products
- Miscellaneous

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Product family:	CLARA-A ed. 3.0	(19)
Product name:		(16)
Area:		(3)
Temporal resolution:		(4)
Statistics:		(3)
Spatial resolution:		(4)
Platform:		(21)
Temporal coverage:	from	to

Result: 207 Reset Show

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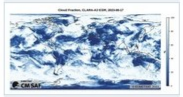

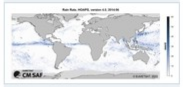

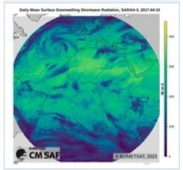

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Show all products

ADVANCED SEARCH

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Product name:		(16)
Area:		(3)
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Spatial resolution:		(4)
Platform:		(21)
Temporal coverage:	from	to

Result: 207 Reset Show

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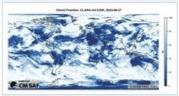

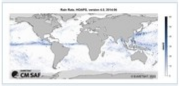

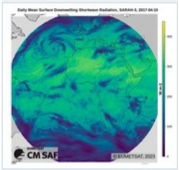

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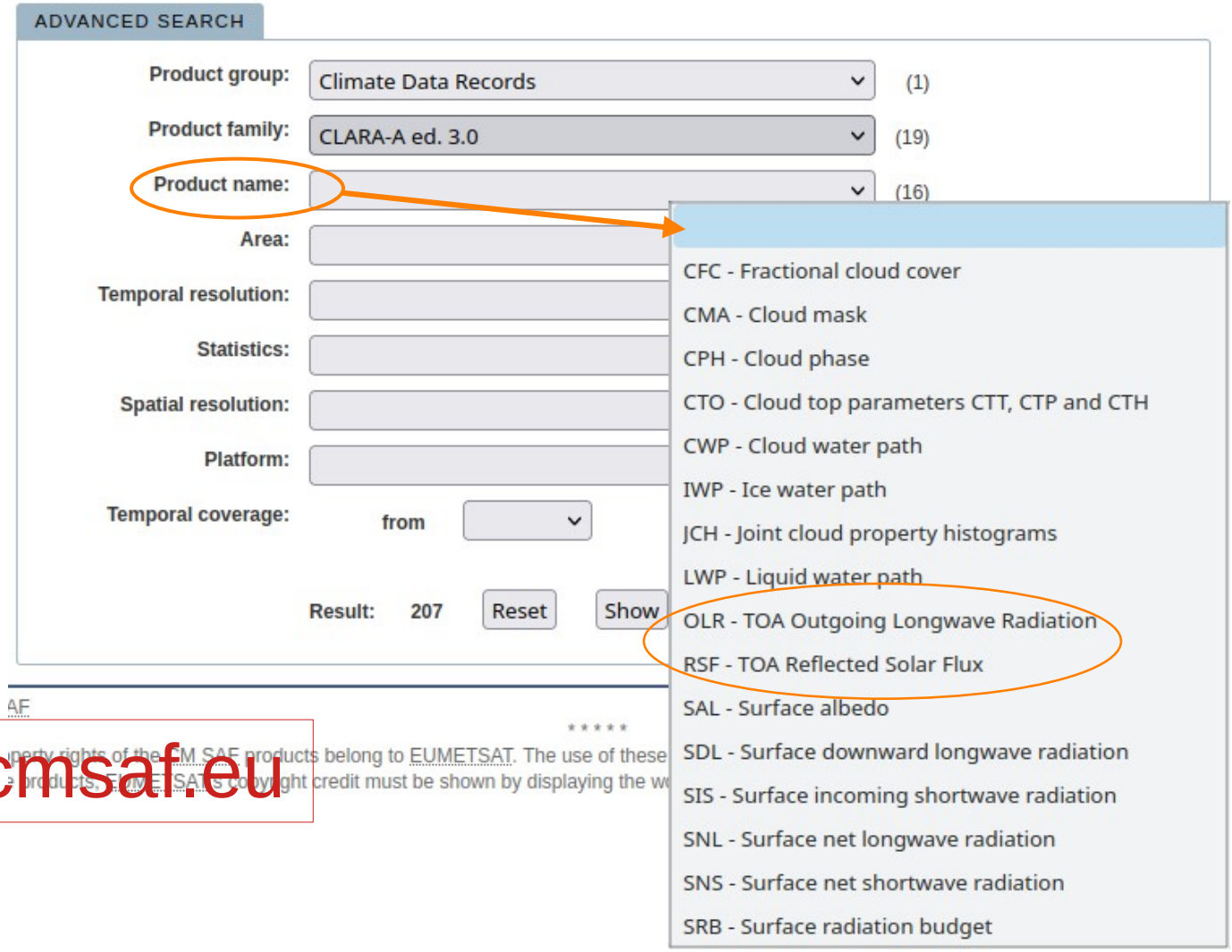
ADVANCED SEARCH
Product group:
Climate Data Records
(1)
Product family:
CLARA-A ed. 3.0
(19)
Product name:
(16)
Area:
Temporal resolution:
Statistics:
Spatial resolution:
Platform:
Temporal coverage:
from
Result: 207
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CFC - Fractional cloud cover
CMA - Cloud mask
CPH - Cloud phase
CTO - Cloud top parameters CTT, CTP and CTH
CWP - Cloud water path
IWP - Ice water path
JCH - Joint cloud property histograms
LWP - Liquid water path
OLR - TOA Outgoing Longwave Radiation
RSF - TOA Reflected Solar Flux
SAL - Surface albedo
SDL - Surface downward longwave radiation
SIS - Surface incoming shortwave radiation
SNL - Surface net longwave radiation
SNS - Surface net shortwave radiation
SRB - Surface radiation budget

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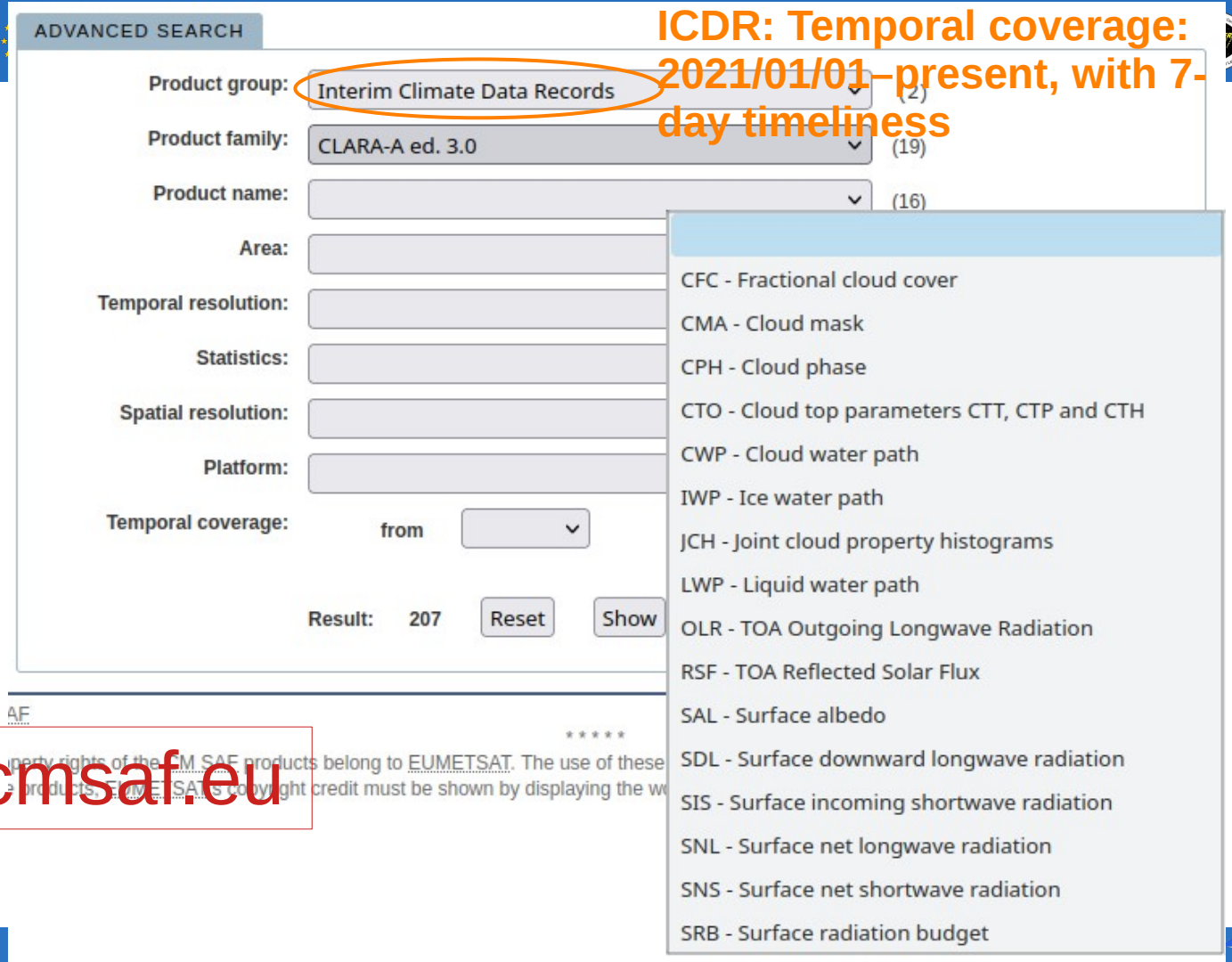

ICDR: Temporal coverage: 2021/01/01–present, with 7-day timeliness

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5. Where to find the data?

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Details of product

PRODUCT CHARACTERISTICS

Product group: Interim Climate Data Records
Product family: CLARA-A ed. 3.0
Product name: RSF - TOA Reflected Solar Flux
Area: Global
Temporal resolution: Daily
Statistics: Mean
Spatial resolution: Latitude/longitude grid (0.25x0.25 degree)
Data source: AVHRR on polar orbiting satellites
Temporal coverage: 2021-01-01 – 2023-09-29
Geographic coverage: Latitude: -90.0° S to 90.0° N
Longitude: -180.0° W to 180.0° E
Version(s): V003 [ICDR]
Citation: Karlsson, Karl-Göran; Riihelä, Aku; Trentmann, Jörg; Stengel, Martin; Solodovnik, Irina; Meirink, Jan Fokke; Devasthale, Abhay; Jääskeläinen, Emmihenna; Kallio-Myers, Viivi; Eliasson, Salomon; Benas, Nikos; Johansson, Erik; Stein, Diana; Finkensieper, Stephan; Håkansson, Nina; Akkermans, Tom; Clerbaux, Nicolas; Selbach, Nathalie; Schröder, Marc; Hollmann, Rainer (2023): CLARA-A3: CM SAF cLoud, Albedo and surface RAdiation dataset from AVHRR data - Edition 3, Satellite Application Facility on Climate Monitoring, DOI:10.5676/EUM_SAF_CM/CLARA_AVHRR/V003, https://doi.org/10.5676/EUM_SAF_CM/CLARA_AVHRR/V003.

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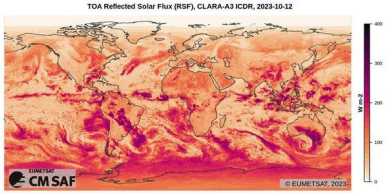

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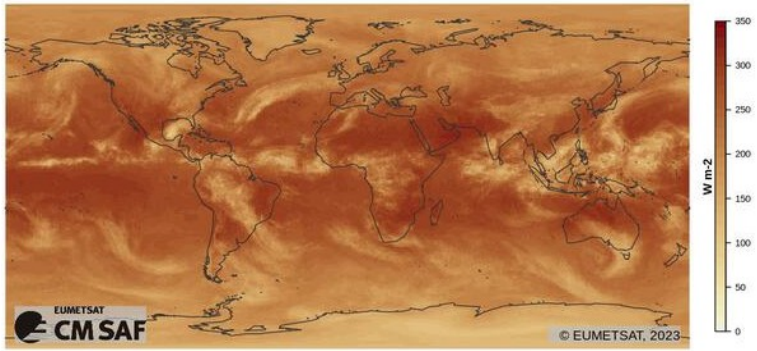

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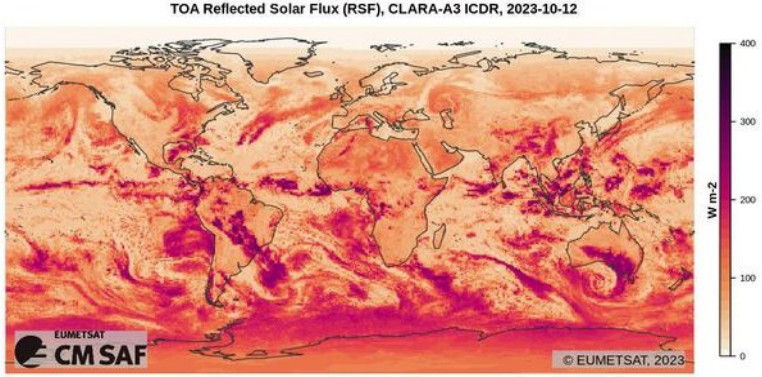

Date [YYYY-MM-DD]: 2023-10-12

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Royal Meteorological Institute Belgium

Thanks for your attention!

<tom.akkermans@meteo.be>

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