EUMETSAT CM SAF CLIMATE MONITORING

Deutscher Wetterdienst
Wetter und Klima aus einer Hand
DWD

Four decades (and counting) of Satellite-based Surface Solar Radiation data

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The SARAH-3 and CLARA-A3 Data Records

Jörg Trentmann, Uwe Pfeifroth

Introduction

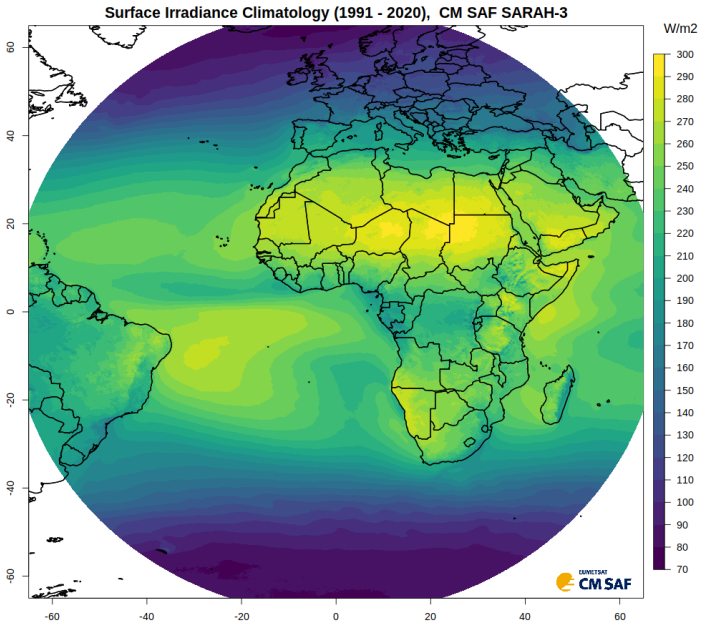
The EUMETSAT Satellite Application Facility on Climate Monitoring (CM SAF) is generating and providing satellite-based climate data records of surface solar radiation covering more than four decades (i.e, starting in the early 1980s).

Here, the newly released SARAH-3 and CLARA-A3 data records of high-quality regional and global surface solar radiation data are presented. The data quality in terms of accuracy and stability are assessed as well as the consistency of the identified trends.

CM SAF SARAH-3

Surface Solar Radiation Dataset – Heliosat

- **Variables**
  - Surface Solar Irradiance (SIS)
  - Surface Direct Irradiance (SID, DNI)
  - Sunshine Duration (SDU)
  - *Photosynthetic Active Radiation (PAR)*
  - *Daylight (DAL)*
  - Effective Cloud Albedo (CAL)
- **Resolution**
  - Spatial: 0.05° × 0.05°
  - Temporal: 30-min, daily-, monthly mean
- **Coverage**
  - Spatial: regional (±65°)
  - Temporal: 1983 to *date*
- Available at www.cmsaf.eu



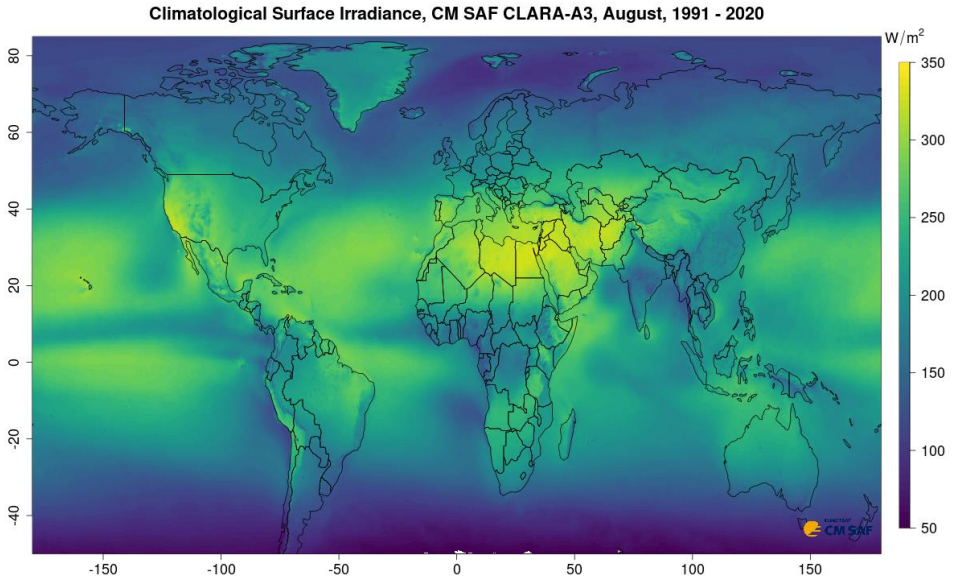
Müller, R. et al. (2015) *Remote Sens., 7*, 8067-8101, doi:10.3390/rs70608067
Pfeifroth, U. et al.. (2018) *J. Geophys, Res., 123,* 1735-1754, doi:10.1002/2017JD027418.

DOI:10.5676/EUM_SAF_CM/SARAH/V003

CM SAF CLARA-A3

CM SAF Clouds, Albedo and Radiation dataset from AVHRR

- **Variables**
  - Cloud properties
  - Surface albedo
  - Surface Radiation
  - *ToA Radiation*
- **Resolution**
  - Spatial: 0.25° × 0.25°
  - Temporal: daily-, pentad-, monthly mean
- **Coverage**
  - Spatial: global
  - Temporal: *1979 to date*
- Available at www.cmsaf.eu



Karlsson, K.-G. et al., (2017), *Atmos. Chem. Phys., 17*, 5809-5828, doi:10.5194/acp-17-5809-2017

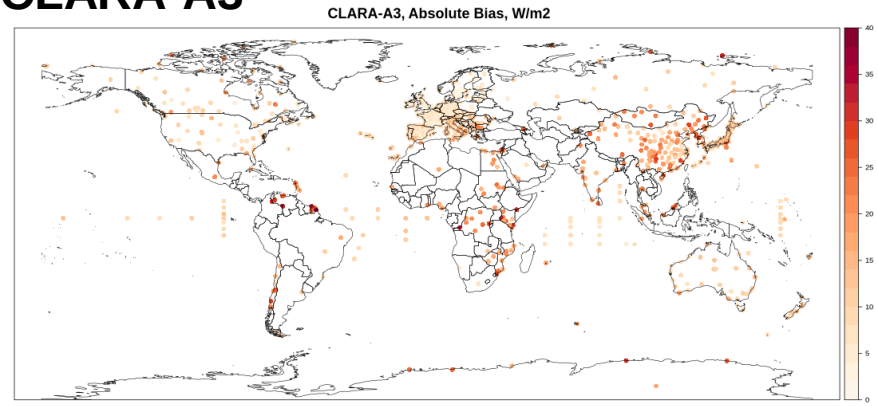
DOI:10.5676/EUM_SAF_CM/CLARA_AVHRR/V003

Reference Data

- **BSRN**: global GCOS Recognized Network: https://bsrn.awi.de
- **GEBA**: global monthly data, provided by ETH Zürich: https://geba.ethz.ch
- **Buoys**: Global Tropical Moored Buoy Array (provided by PMEL): https://www.pmel.noaa.gov/gtmba/
- **MeteoSwiss**: homogenisierte Daten, Switzerland, provided by MeteoSwiss

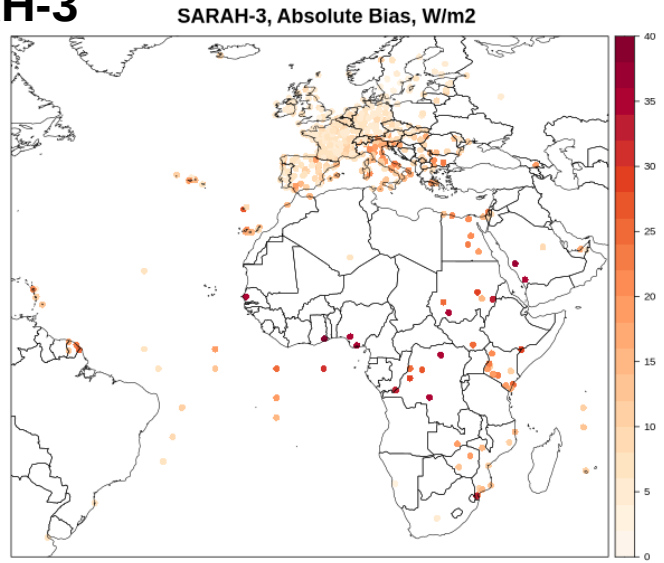
Accuracy, 1979 / 1983 - 2023

CLARA-A3



Mean absolute difference of monthly surface irradiance, CLARA-A3

SARAH-3



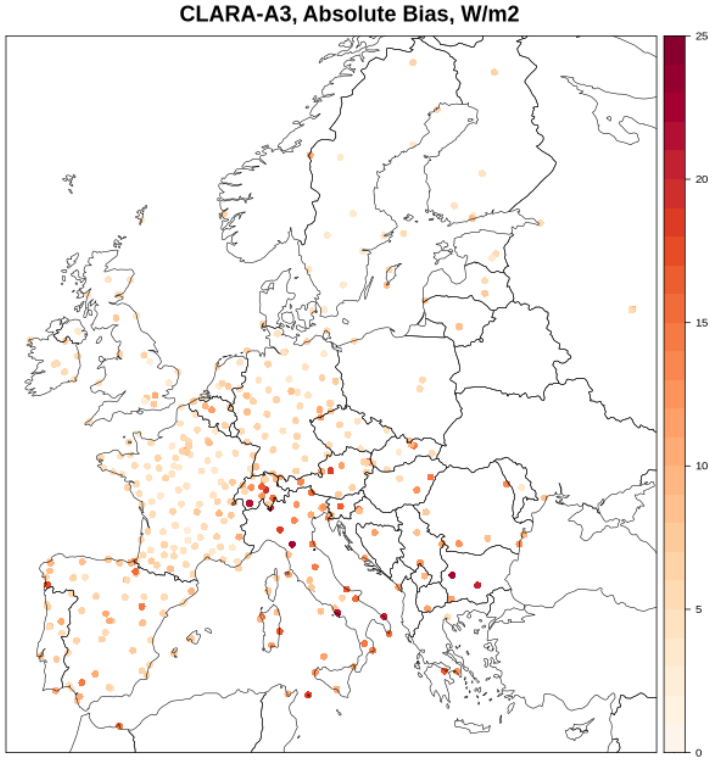
Mean absolute difference of monthly surface irradiance, SARAH-3

- ➔ High accuracy of surface irradiance by CM SAF data records (MAD about 10 W/m^2)
- ➔ High quality of satellite data in Europe / North America
- ➔ Tendency for larger deviations in Africa, Asia

Data Set	# stations	#months	bias [W/m^2]	MAD [W/m^2]	bc-rms [W/m^2]
CLARA-A3	730	169,878	5.5	10.6	14.7
SARAH-3	370	83,909	4.8	8.7	11.8
CLARA-A3 (as SARAH-3)	371	83,736	3.1	8.0	12.1

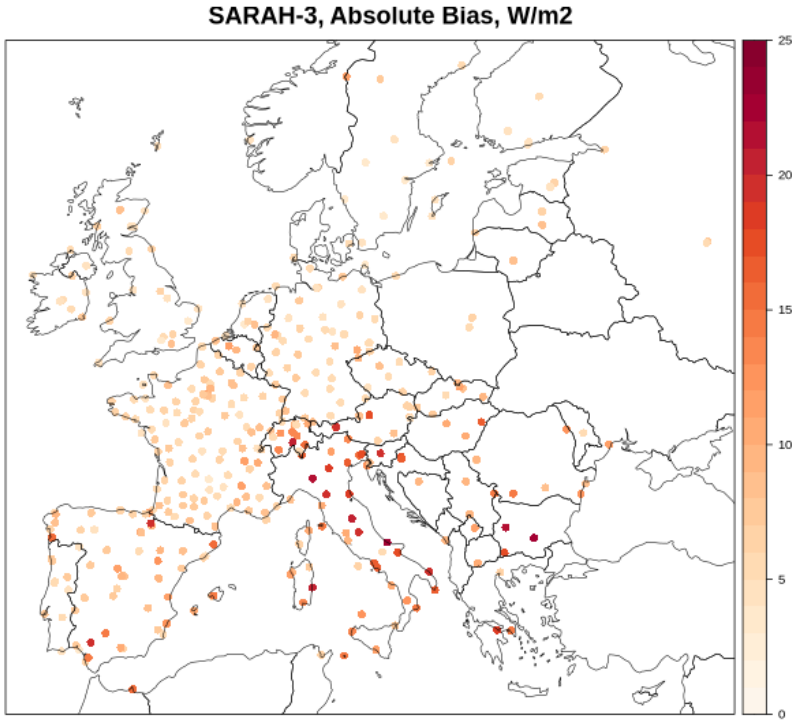
Europe

CLARA-A3



Mean absolute difference of monthly surface irradiance, CLARA-A3

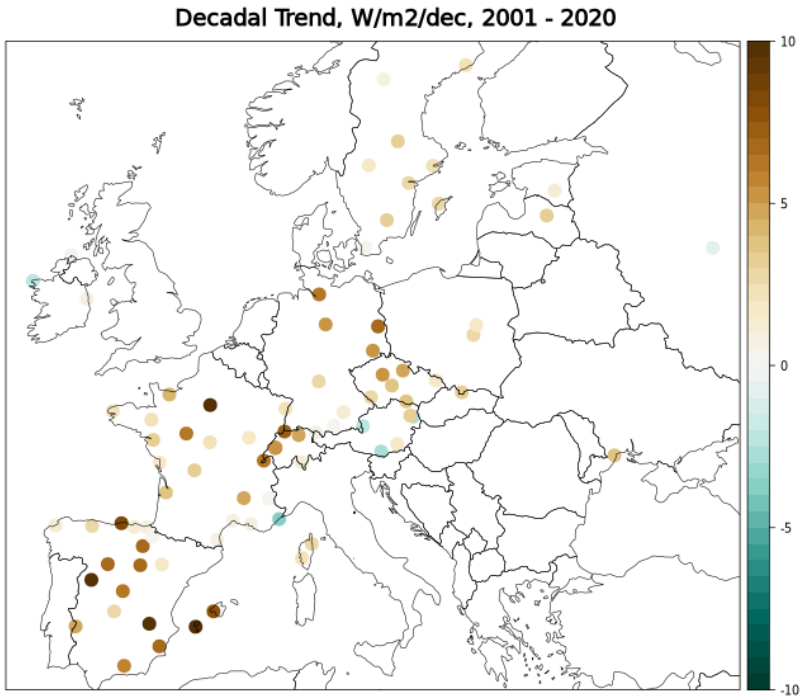
SARAH-3



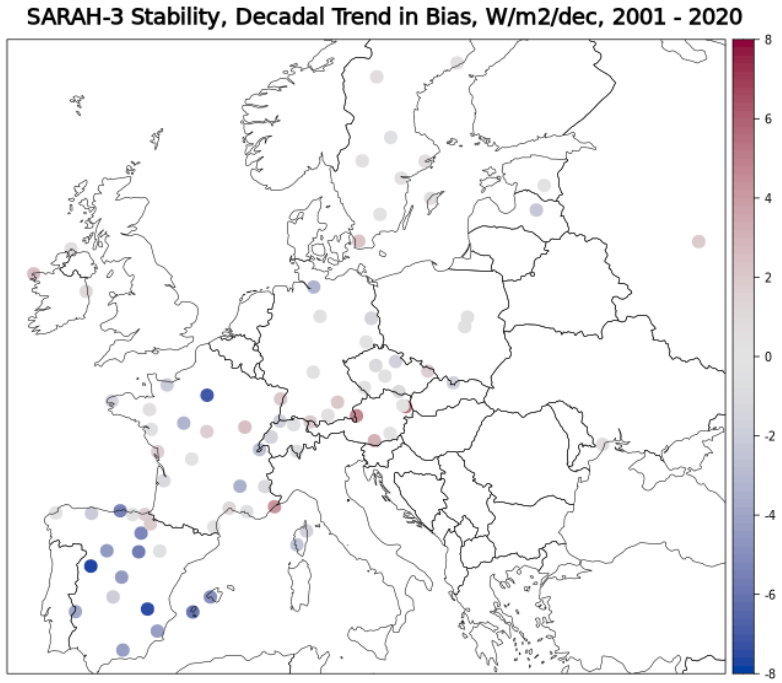
Mean absolute difference of monthly surface irradiance, SARAH-3

➔ Europe: Satellite data tend to overestimate in Central / Eastern Mediterranean

Stability 2001 - 2020

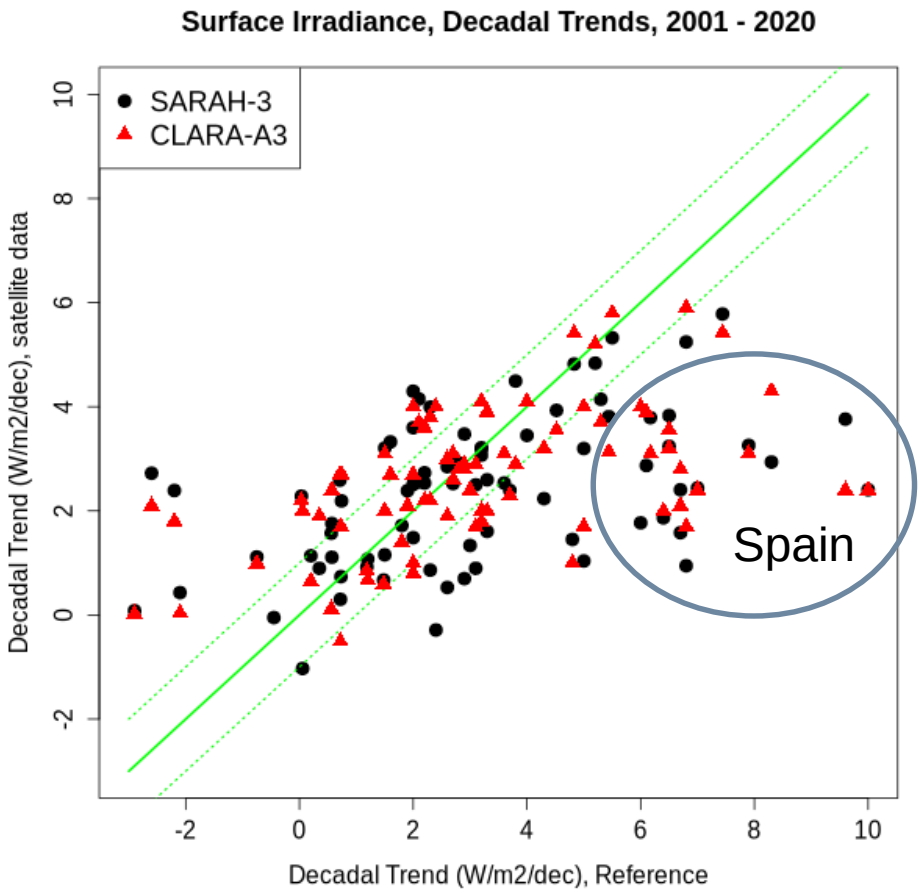


Decadal Trend of Surface Irradiance (2001 – 2020), Reference Stations



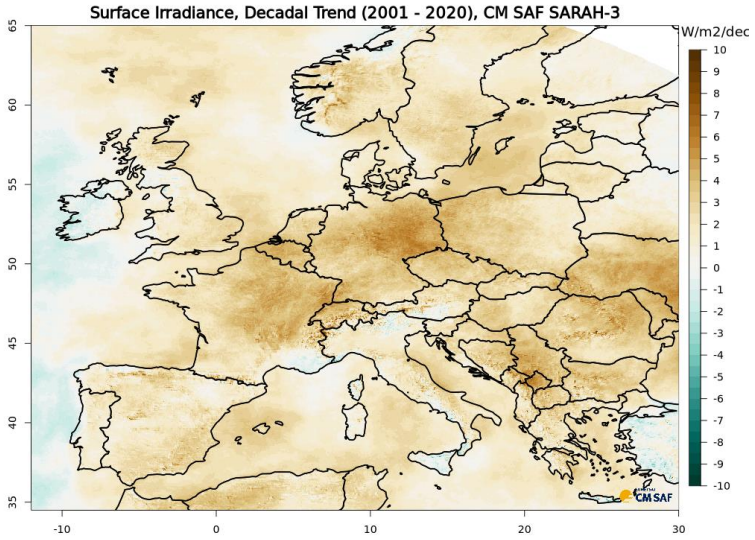
Decadal Trend of the difference SARAH-3 and reference data, 2001 - 2020

- Increase in surface irradiance (2001 – 2020) in Central Europe (1 – 5 W/m^2/dec) in surface and satellite data
- No / small change in Northern and Eastern Europe
- Underestimation of strong solar radiation increase in Spain by satellite data

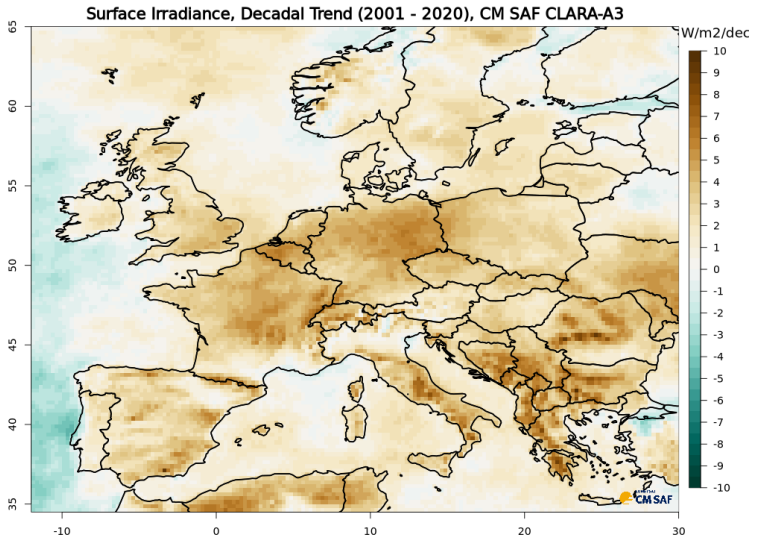


Comparison of the decadal trend derived from CM SAF and reference data, 2001 - 2020

SARAH-3



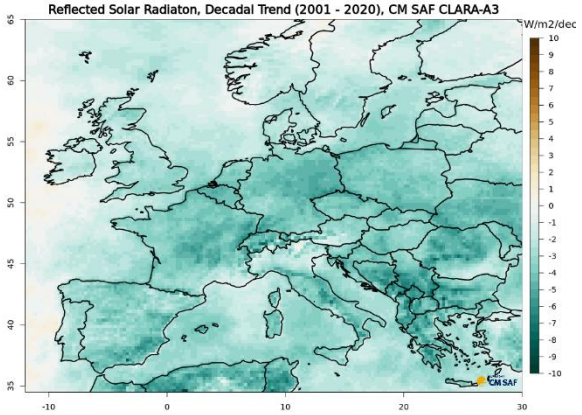
CLARA-A3



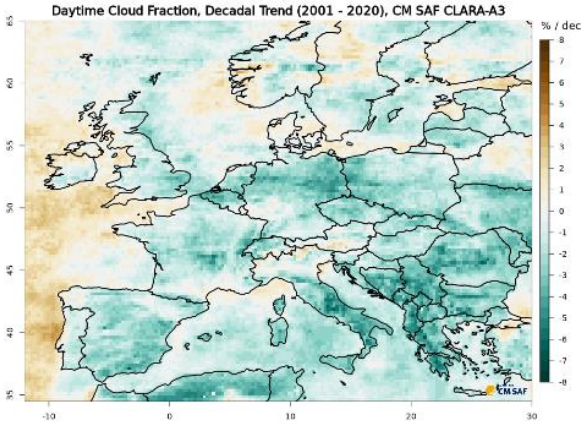
- ➔ Consistent spatial distribution of surface irradiance trends between SARAH-3 and CLARA-A3
- ➔ CLARA-A3 indicates larger increase in Italy / South Eastern Europe than SARAH-3

CLARA-A3

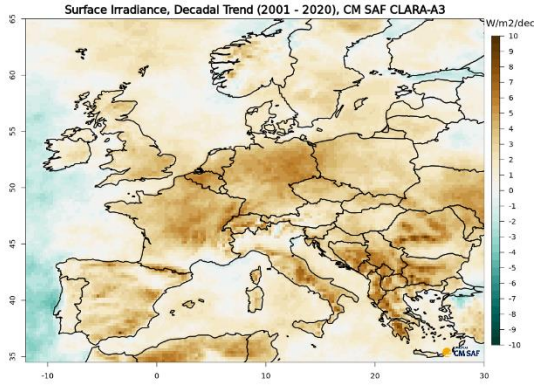
TOA refl. flux



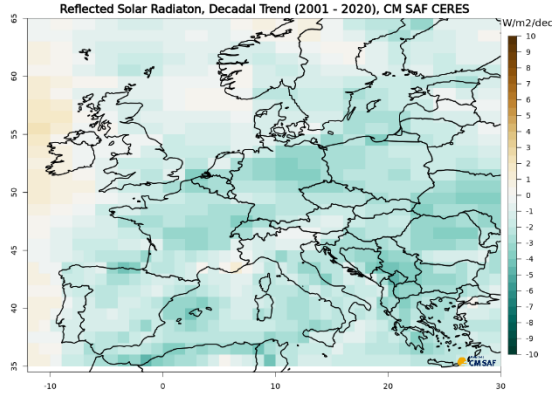
Daytime cloud coverage



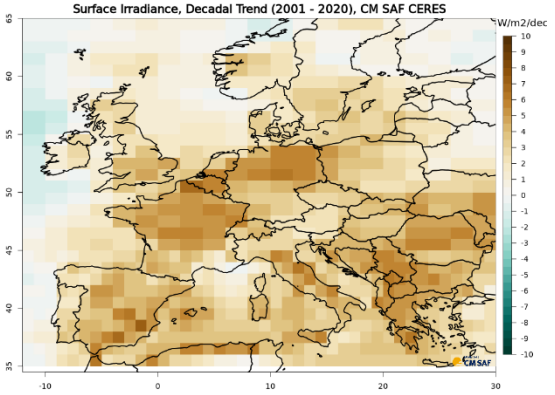
Surface irradiance



CERES



➔ Spatial distribution of surface irradiance trends consistent with trends in cloud coverage and reflected solar flux at top-of-atmosphere



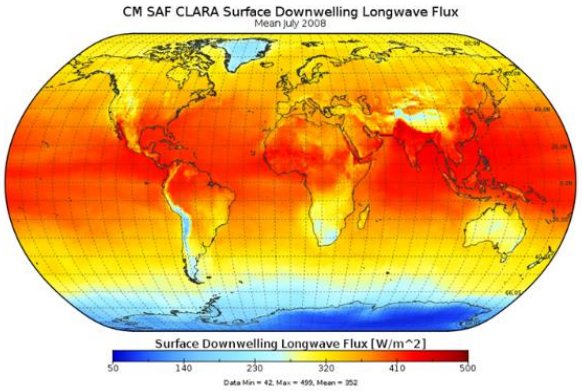
Summary

- CM SAF provides high-quality surface irradiance data records: SARAH + CLARA
- Collection of surface reference data available for validation
- Very comparable quality of SARAH-3 and CLARA-A3 compared to reference data
- Observed increase in surface irradiance in Central Europe well represented in satellite data
- Surface irradiance increase consistent with cloud coverage decrease (2001 – 2020)

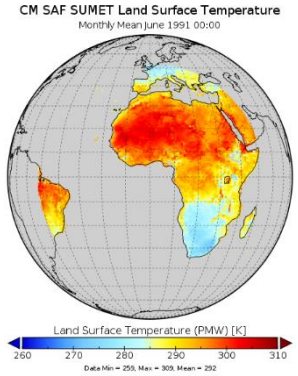
CM SAF Climate Data Records

- CM SAF provides a variety of global and regional climate data records on clouds, radiation, surface parameters (e.g., LST), precipitation (ocean only)
- Availability: 1979 to date
- Resolution: Daily, monthly / 0.05°, 0.25°, 1°
- All data are freely available at www.cmsaf.eu

CLARA-A3 / ICDR



SUMET 1.0



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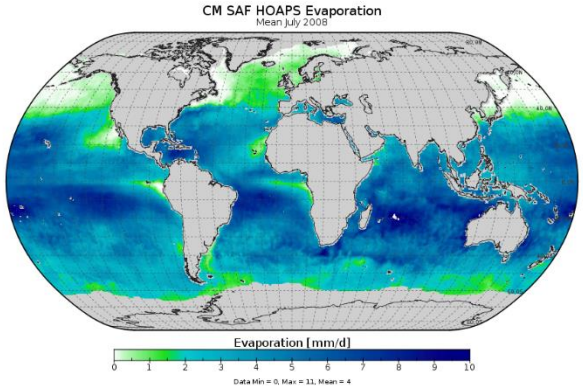
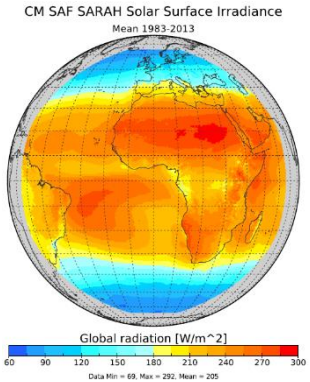
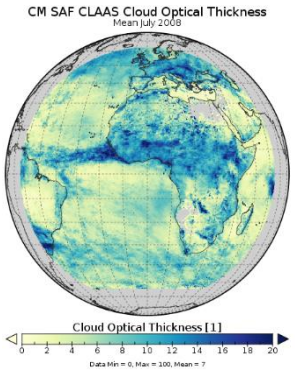


SARAH-3 / ICDR



CLAAS-3 / ICDR



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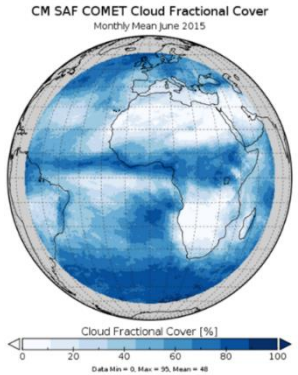
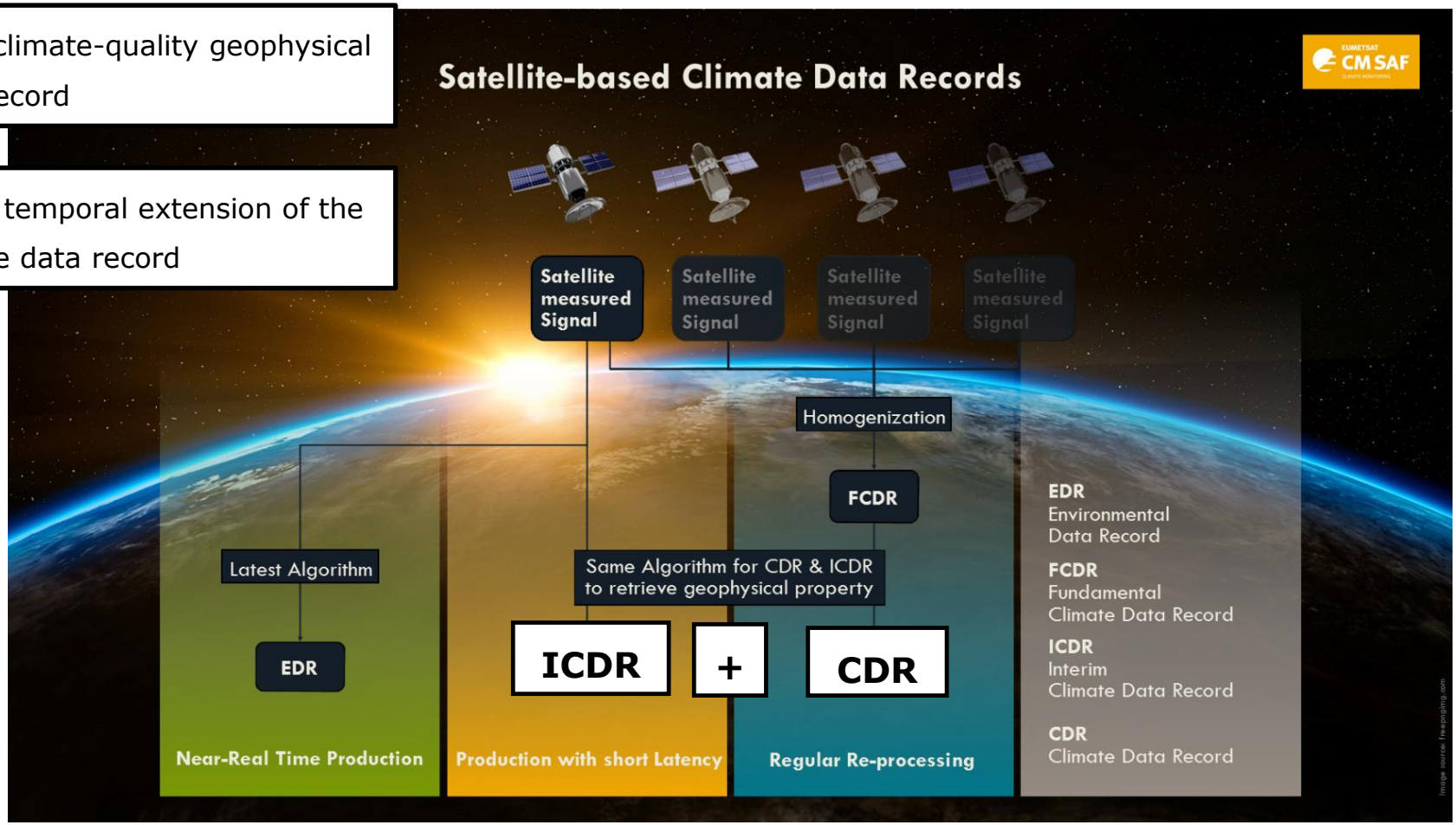


Climate Data Record + Interim Climate Data Record

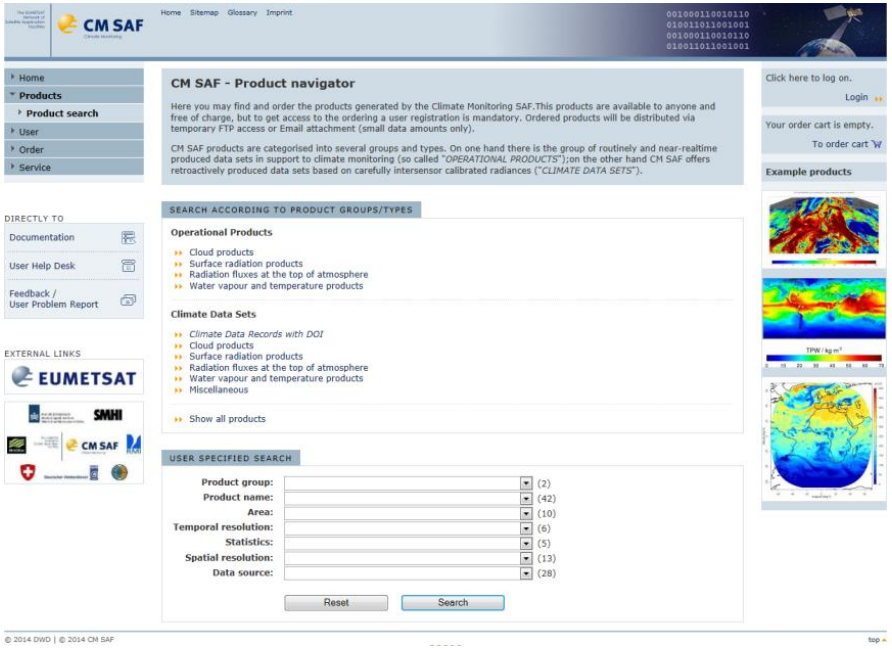
CDR: climate-quality geophysical data record

ICDR: temporal extension of the climate data record



Data Access

- **Web User Interface**
  - Easy selection and online ordering
  - Possibility of regular data delivery
  - Postprocessing
    - Spatial, temporal selection
  - Data format (NetCDF)
  - Download via https or sftp
  - All data free of charge
- **EUMETCast**
- **User Help Desk**



https://wui.cmsaf.eu

CM SAF R Toolbox

www.cmsaf.eu/R_toolbox

- CM SAF provides the CM SAF R Toolbox (based on the open source software R)
- Designed to access, analyse, and visualize CM SAF (and other SAF) data
- No programming skills required
- Can be used within scripts or as a stand-alone GUI
- (Video-)Tutorials available