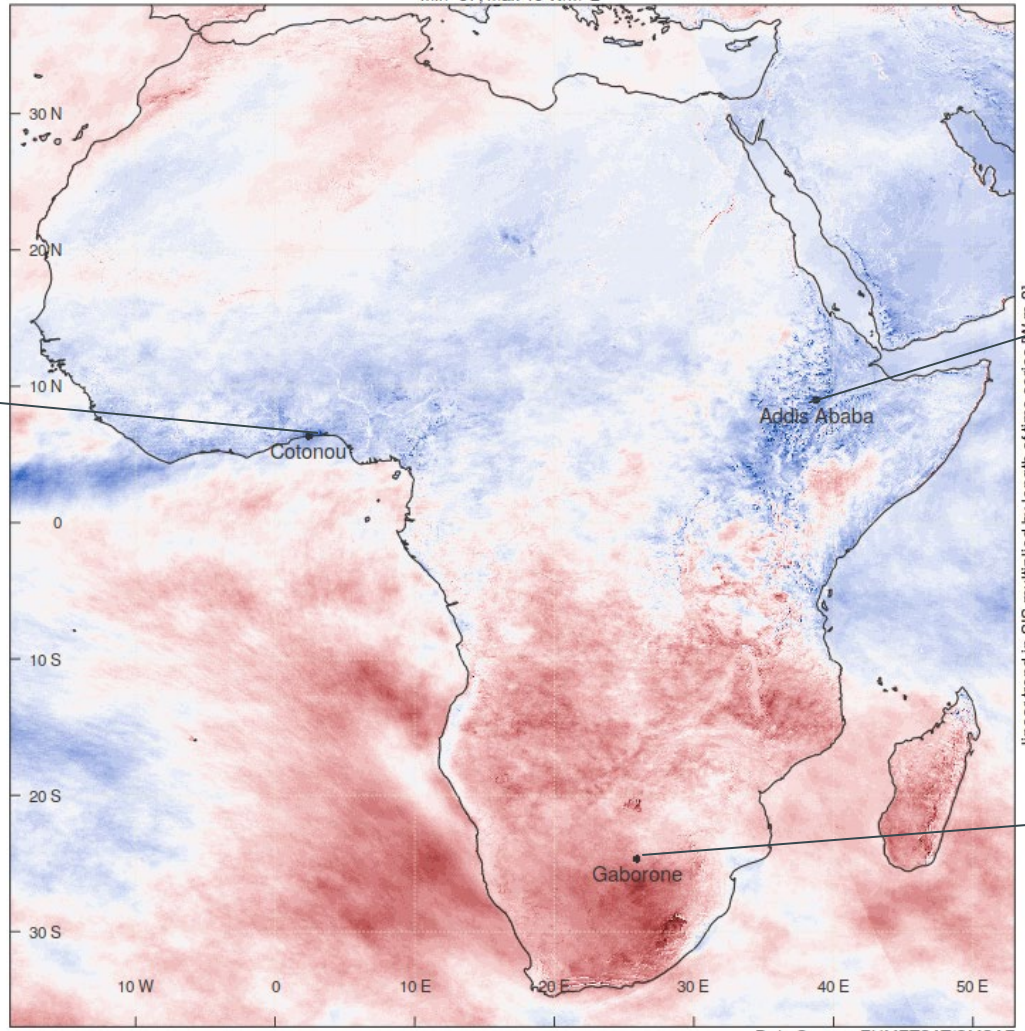
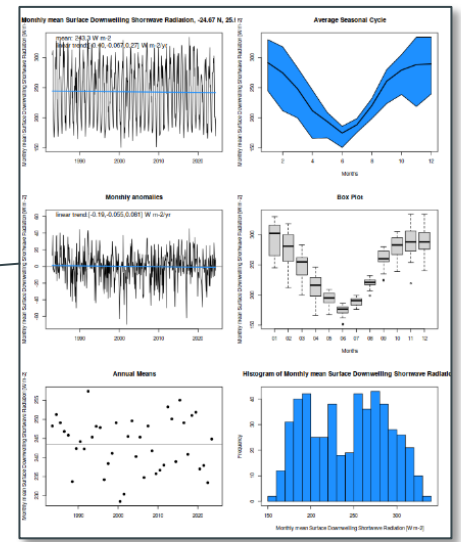
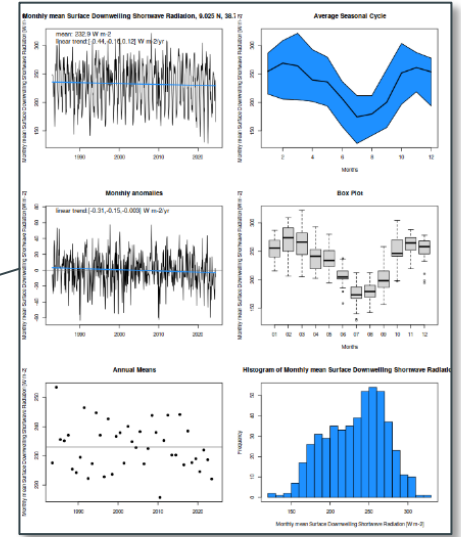
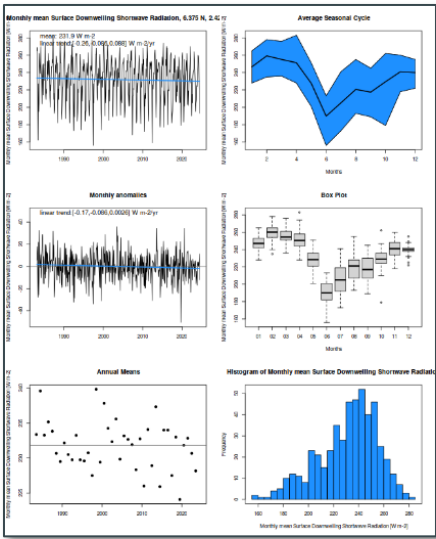




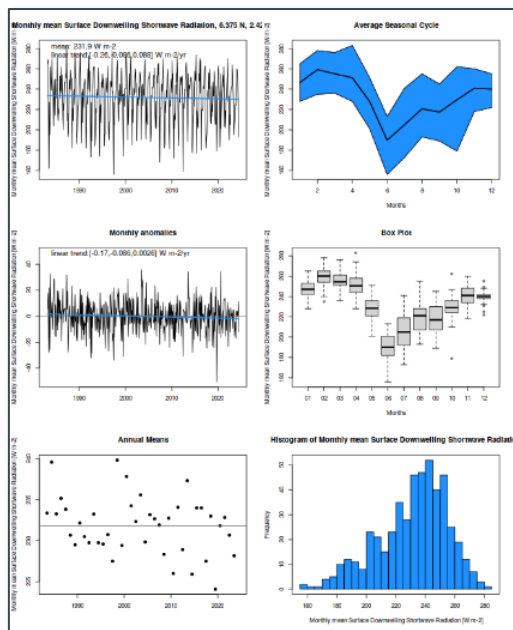
linear trend in SIS for SON 1983-2023
min -57; max 46 W/m²



linear trend in SIS multiplied by length of time series [W m⁻²]



Data Source: EUMETSAT/CMSAF

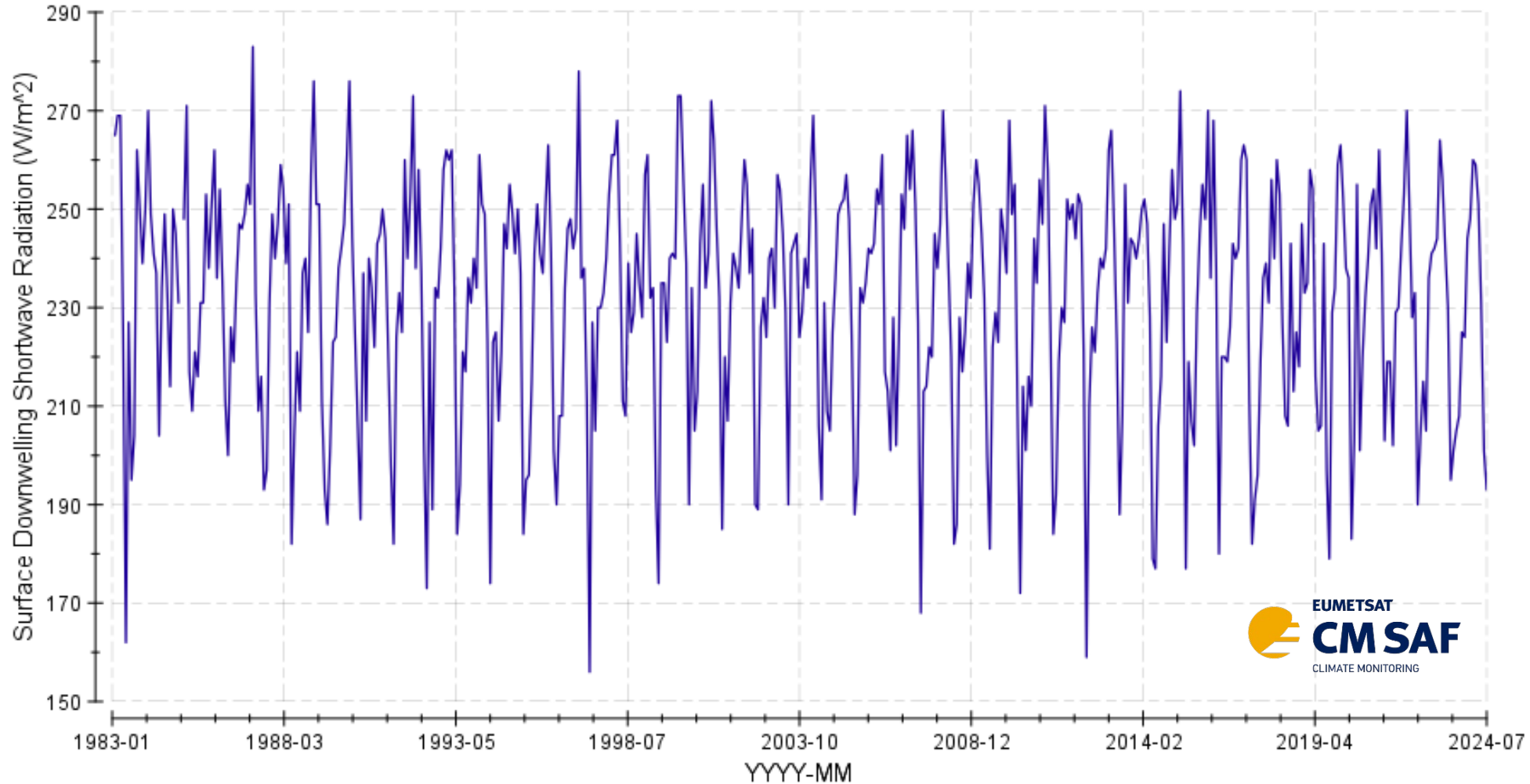


- **Resource Management:**
 - Agriculture: Optimizing planting schedules
 - Water Resources: Managing water supply
- **Disaster Preparedness:**
 - Extreme Weather Events: Early warnings for droughts, floods, and cyclones
 - Health Impacts: Monitoring and mitigating climate-related health risks
- **Economic Planning:**
 - Infrastructure: Resilient infrastructure
 - Insurance: Informing risk assessment



Monthly mean Surface Downwelling Shortwave Radiation for Cotonou

CM SAF SARA3: January 1983 to July 2024





- **Historical Insights:**
 - **Pattern Recognition:** Identify trends and anomalies
 - **Event Analysis:** Learning from past events to improve forecasting
- **Strategic Planning:**
 - **Policy Formulation:** Inform and develop effective climate policies
 - **Community Adaptation:** Tailoring local adaptation strategies
- **Innovative Solutions:**
 - **Data-Driven Decisions:** Sustainable development and disaster risk reduction



- Long-term, multi-satellite programmes, with service continuity
- Continuous improvement, expansion of portfolio of observations
- Unique archive: decades of observations
- Data rescue
- Recalibration and production of climate records
 - Physical parameters directly observed by satellites: level 1
 - Geophysical parameters: ECVs (ocean, atmosphere, land)
 - Estimation of uncertainties
- Data access
- Cooperation with users: validation, research, applications
- Training, support to climate-related capacity building initiative

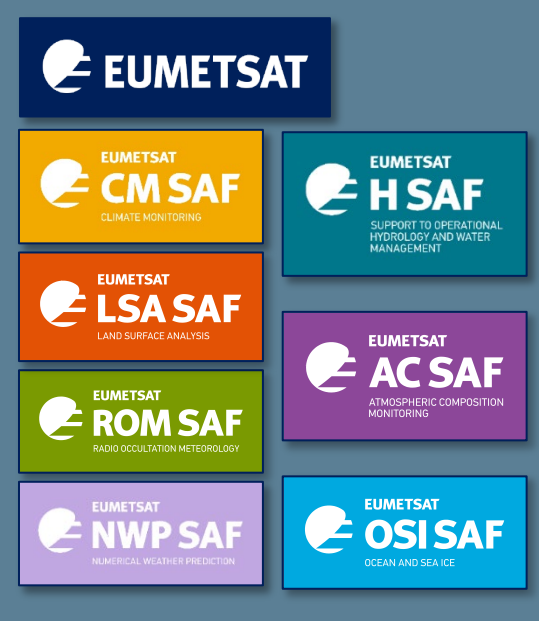
EUMETSAT Satellite Missions

DATA COLLECTION



EUMETSAT & SAFs

DATA PROCESSING



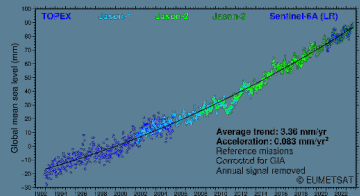
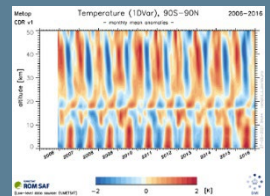
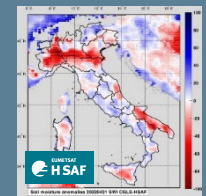
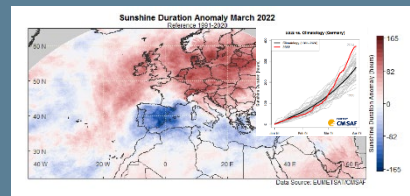
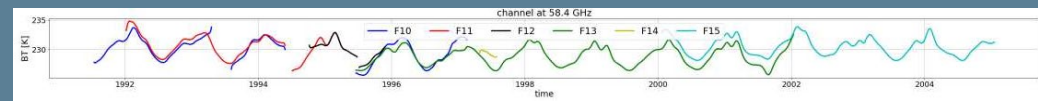
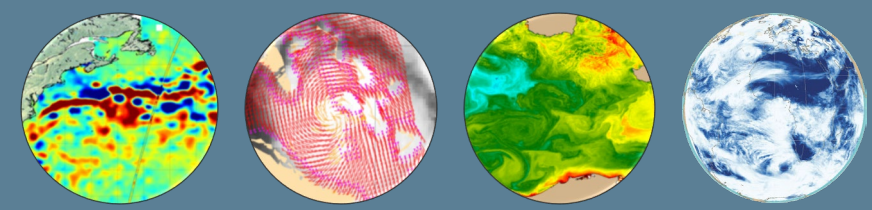
Application in Climate Services

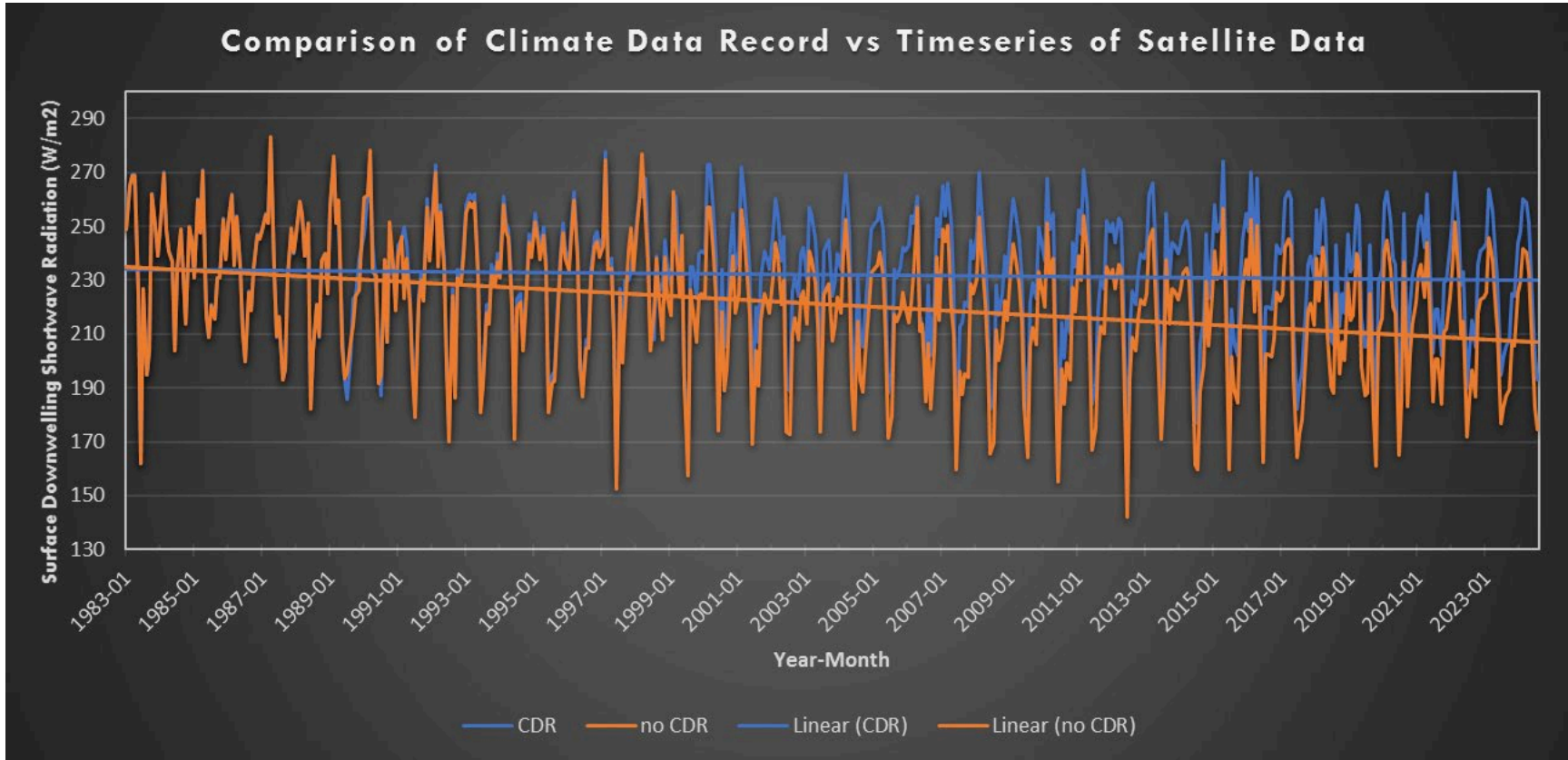


Policy



Climate Data Record Generation

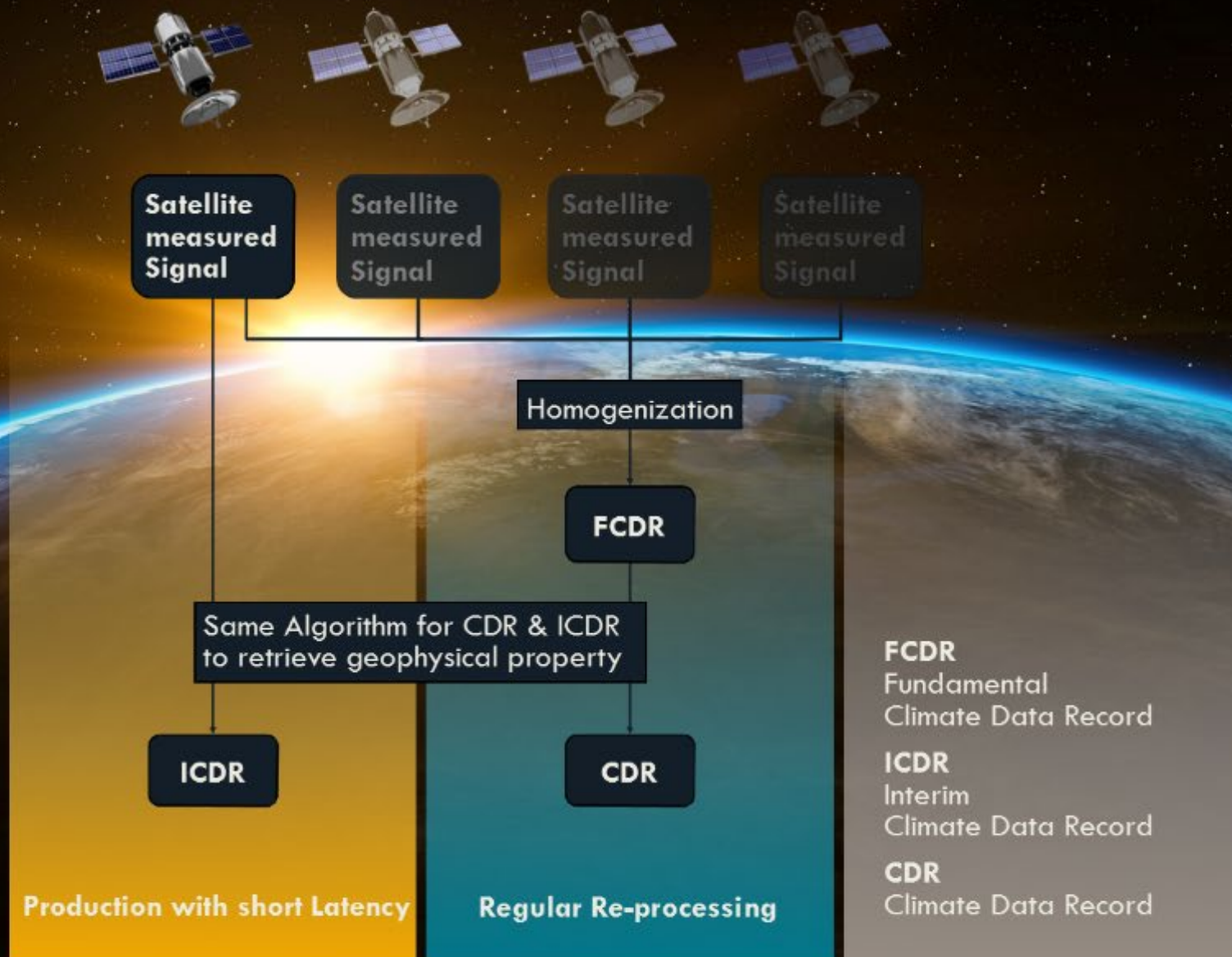




Account for:

- Satellite changes
- Instrument degradation
- Algorithm changes
- Satellite drift
- ...

Satellite-based Climate Data Records



The EUMETSAT SAF Network



The EUMETSAT SAF Network



Satellite Application Facility on Climate Monitoring

What we do

Satellite-derived Products
of Energy & Water Cycle

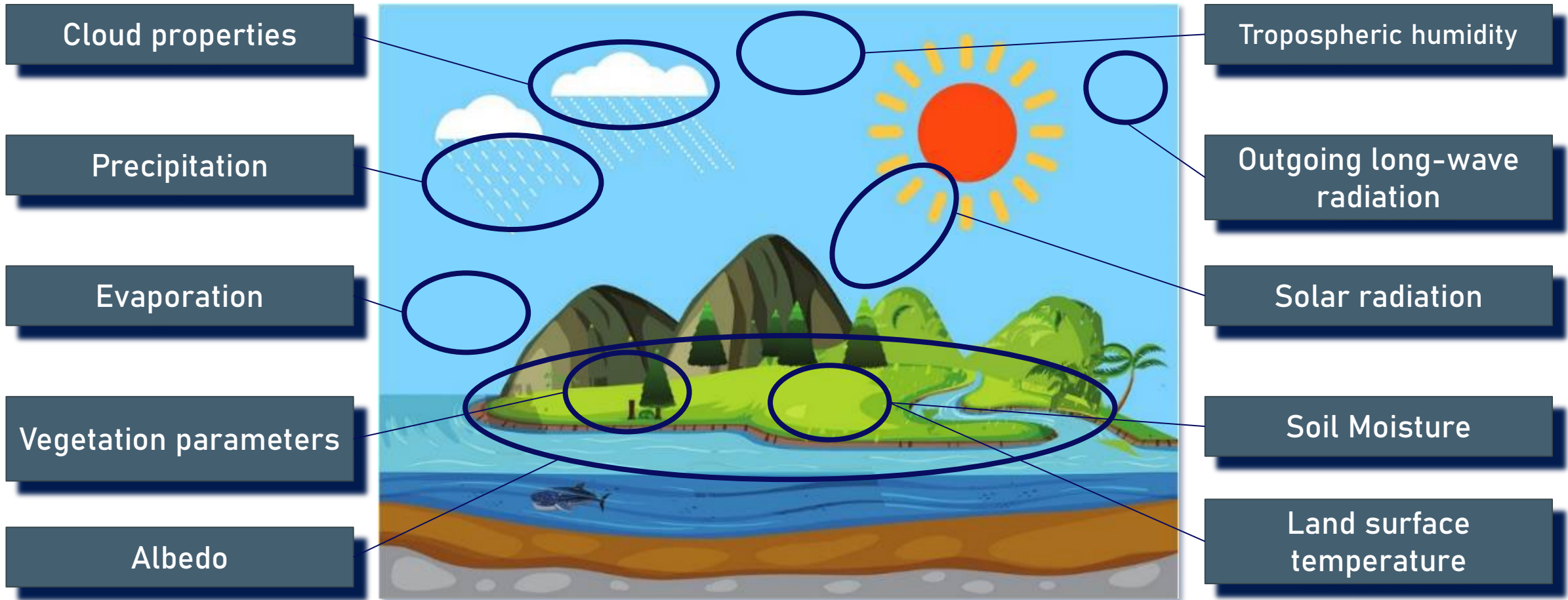
Why we do it

Develop
Generate
Archive
Distribute



Monitor
Understand
Adapt
Climate Variability
&
Climate Change





CLARA-A3

Variables

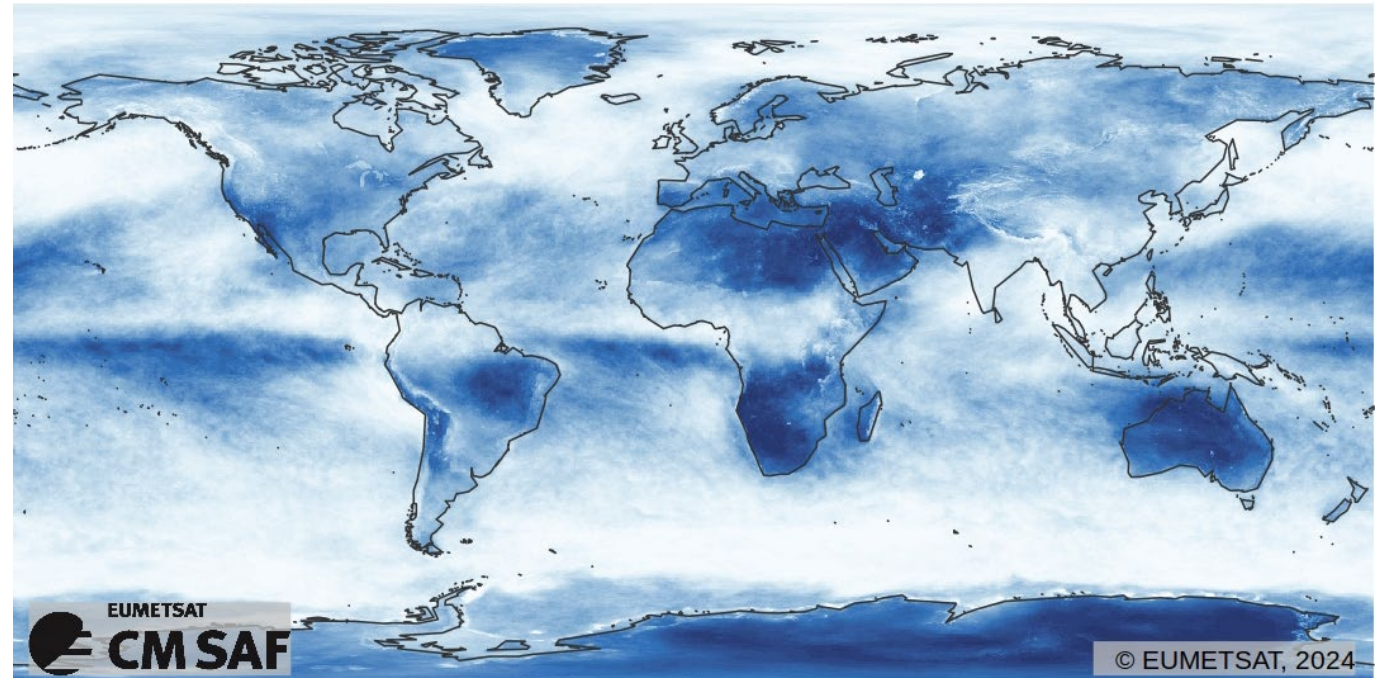
- Cloud properties
- Surface albedo
- Radiation

Resolution

- Spatial: $0.25^\circ \times 0.25^\circ$
- Temporal: daily, pentad, monthly

Coverage

- Spatial: global
- Temporal: 1979 to present



DOI:10.5676/EUM_SAF_CM/CLARA_AVHRR/V003
Cloud Fractional Coverage (CFC)

CLARA-A3

Variables

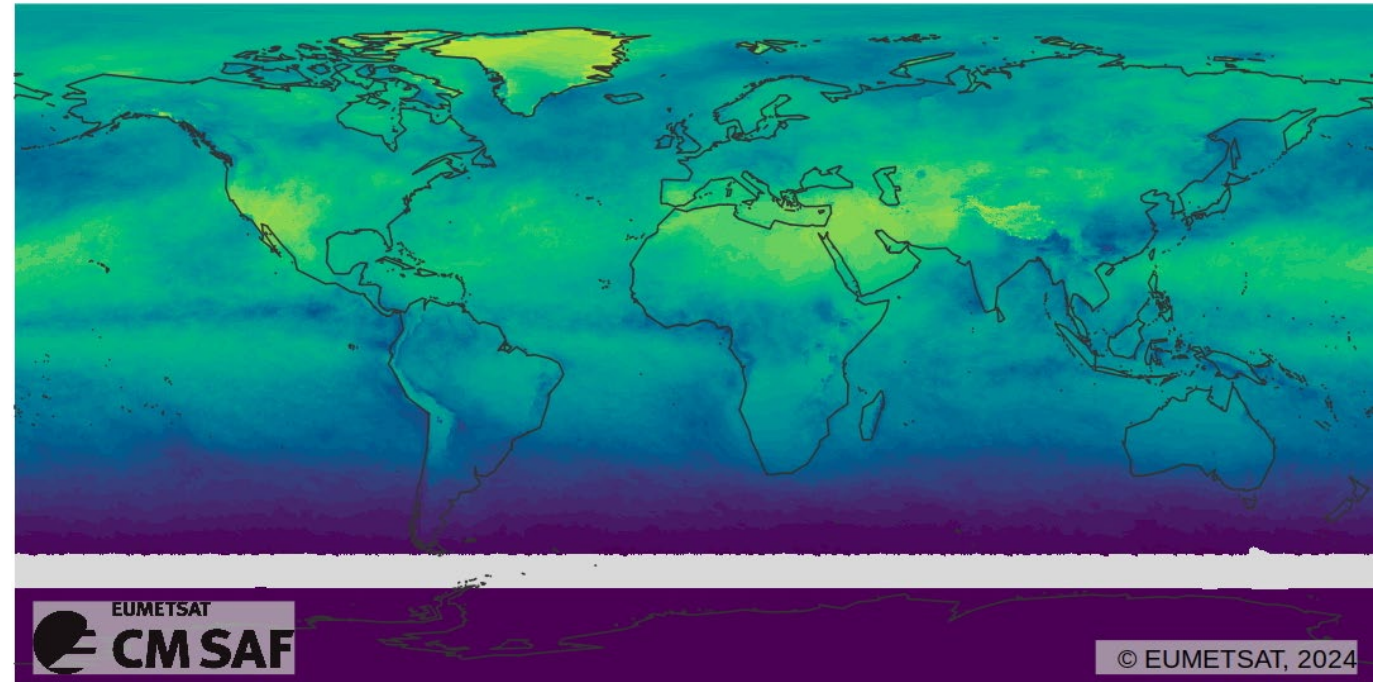
- Cloud properties
- Surface albedo
- Radiation

Resolution

- Spatial: $0.25^\circ \times 0.25^\circ$
- Temporal: daily, pentad, monthly

Coverage

- Spatial: global
- Temporal: 1979 to present



DOI:10.5676/EUM_SAF_CM/CLARA_AVHRR/V003
Surface incoming shortwave radiation (SIS)

CLARA-A3

Variables

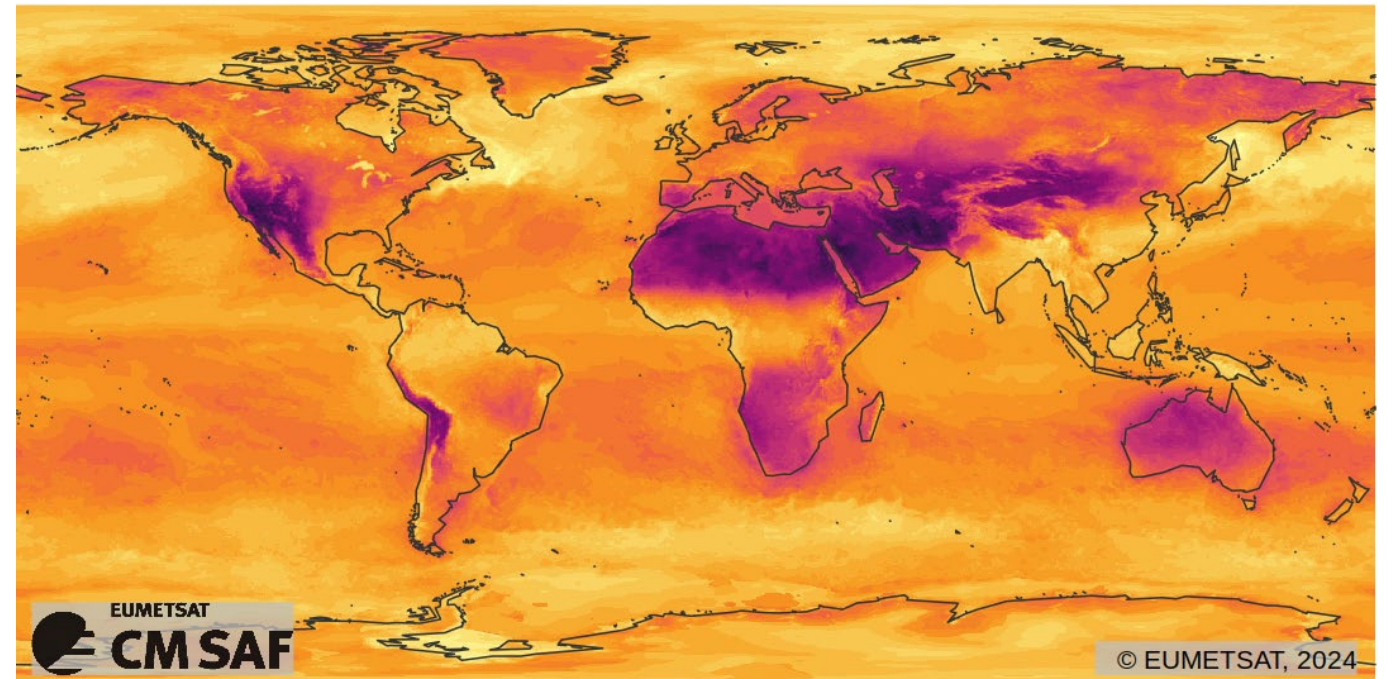
- Cloud properties
- Surface albedo
- Radiation

Resolution

- Spatial: $0.25^\circ \times 0.25^\circ$
- Temporal: daily, pentad, monthly

Coverage

- Spatial: global
- Temporal: 1979 to present



DOI:10.5676/EUM_SAF_CM/CLARA_AVHRR/V003
Surface Net Longwave Radiation(SNL)

CLAAS-3

Variables

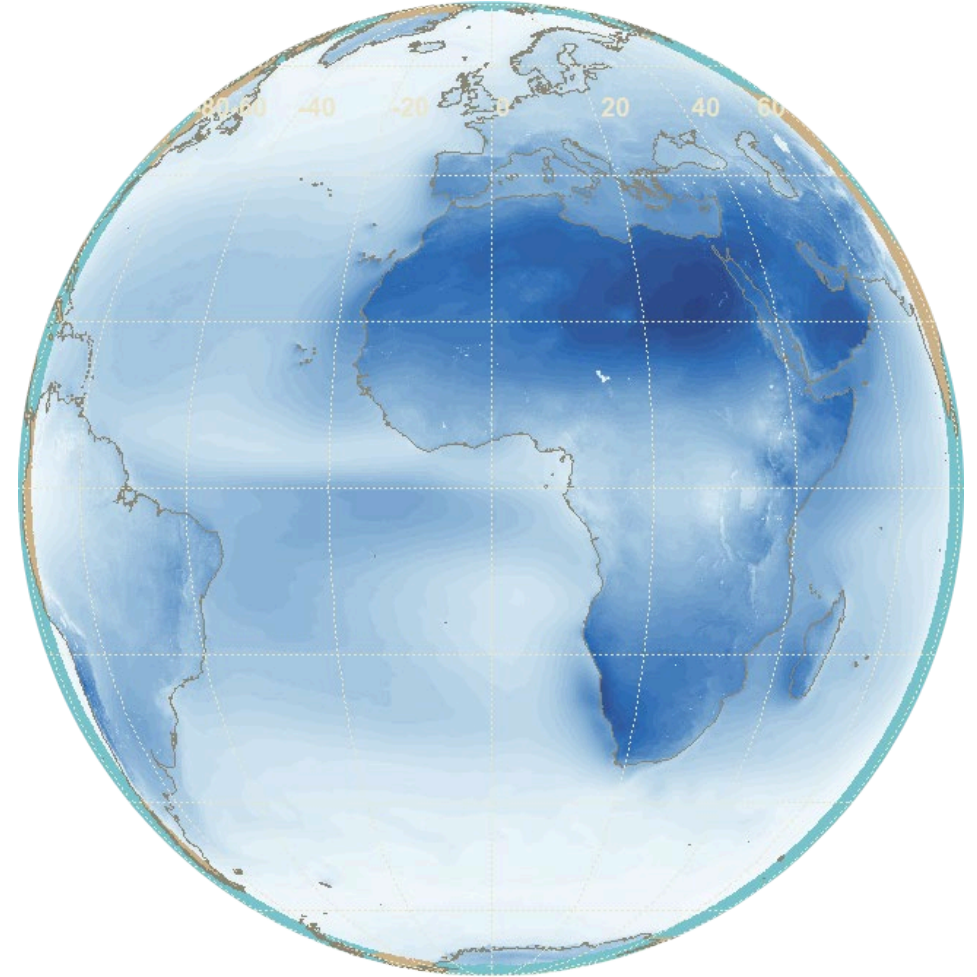
- Cloud properties
- Liquid and ice water path

Resolution

- Spatial: native, $0.05^\circ \times 0.05^\circ$
- Temporal: 15 min, hourly, daily, monthly, mean diurnal cycle

Coverage

- Spatial: Meteosat disk
- Temporal: 2004 to present



DOI:10.5676/EUM_SAF_CM/CLAAS/V003
Cloud Fractional Coverage (CFC)

CLAAS-3

Variables

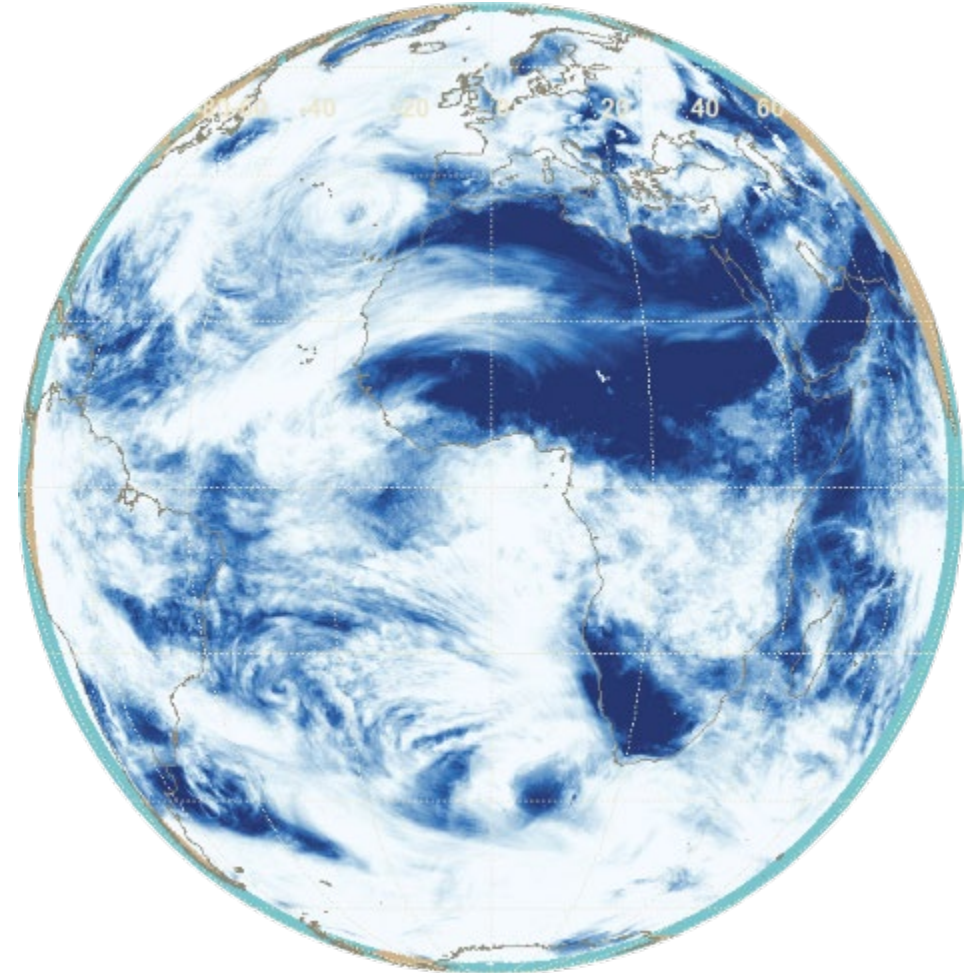
- Cloud properties
- Liquid and ice water path

Resolution

- Spatial: native, $0.05^\circ \times 0.05^\circ$
- Temporal: 15 min, hourly, daily, monthly, mean diurnal cycle

Coverage

- Spatial: Meteosat disk
- Temporal: 2004 to present



DOI:10.5676/EUM_SAF_CM/CLAAS/V003
Cloud Fractional Coverage (CFC)

SARAH-3

Variables

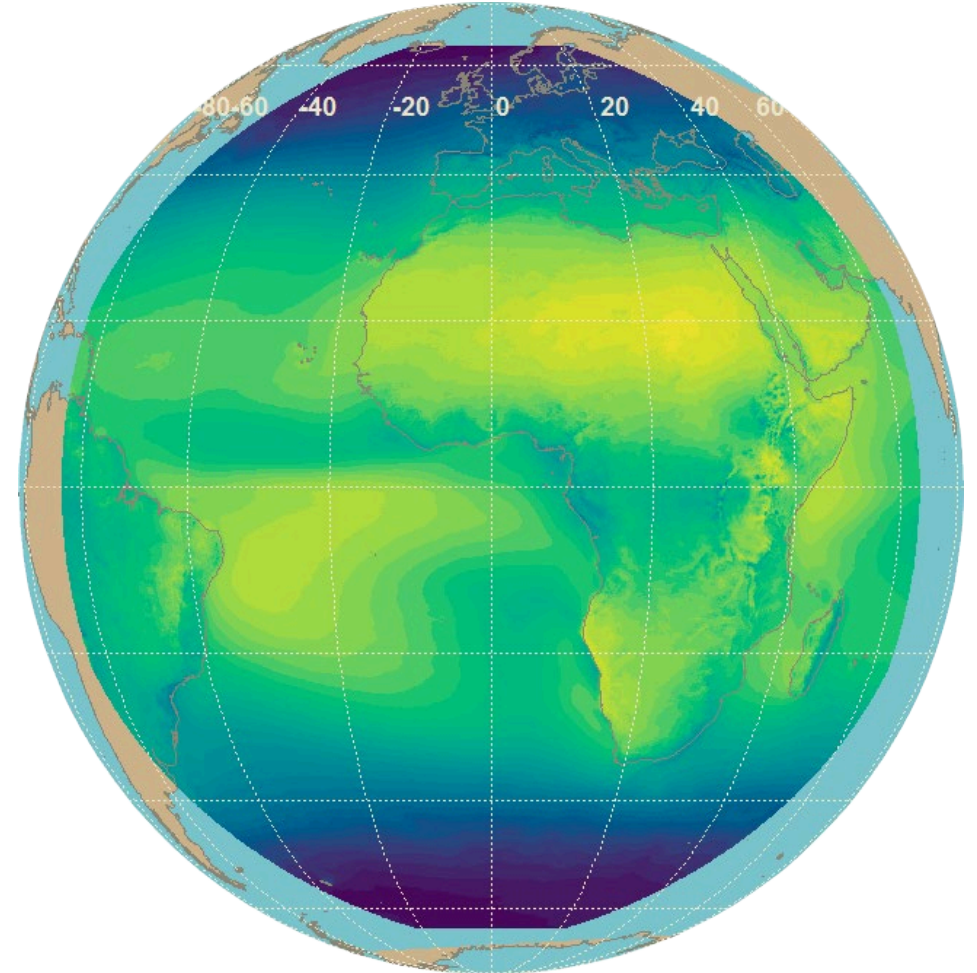
- Surface radiation
- Sunshine duration
- PAR

Resolution

- Spatial: $0.05^\circ \times 0.05^\circ$
- Temporal: 30 min, daily, monthly

Coverage

- Spatial: Meteosat disk
- Temporal: 1983 to present



DOI:10.5676/EUM_SAF_CM/SARAH/V003
Surface incoming shortwave radiation (SIS)

SARAH-3

Variables

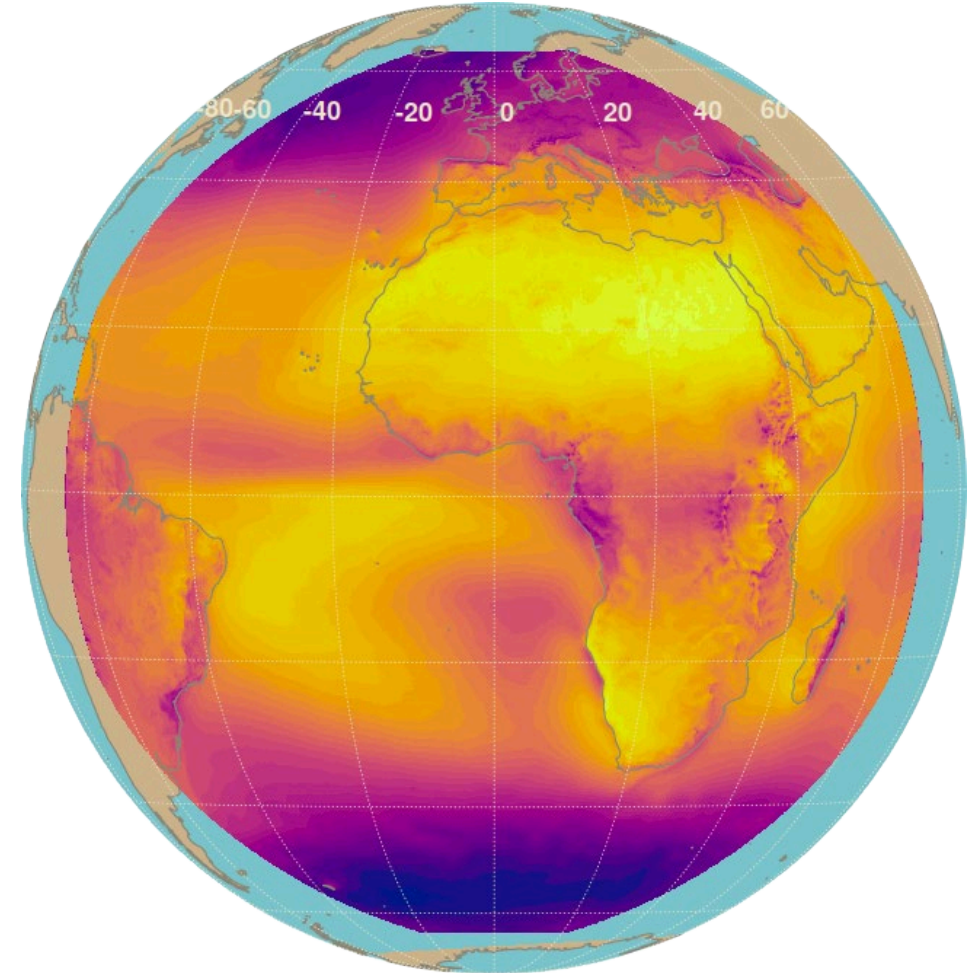
- Surface radiation
- Sunshine duration
- PAR

Resolution

- Spatial: $0.05^\circ \times 0.05^\circ$
- Temporal: 30 min, daily, monthly

Coverage

- Spatial: Meteosat disk
- Temporal: 1983 to present



DOI:10.5676/EUM_SAF_CM/SARAH/V003
Sunshine Duration (SDU)

GIRAFE

Variables

→ Precipitation

Resolution

→ Spatial: 1°×1°

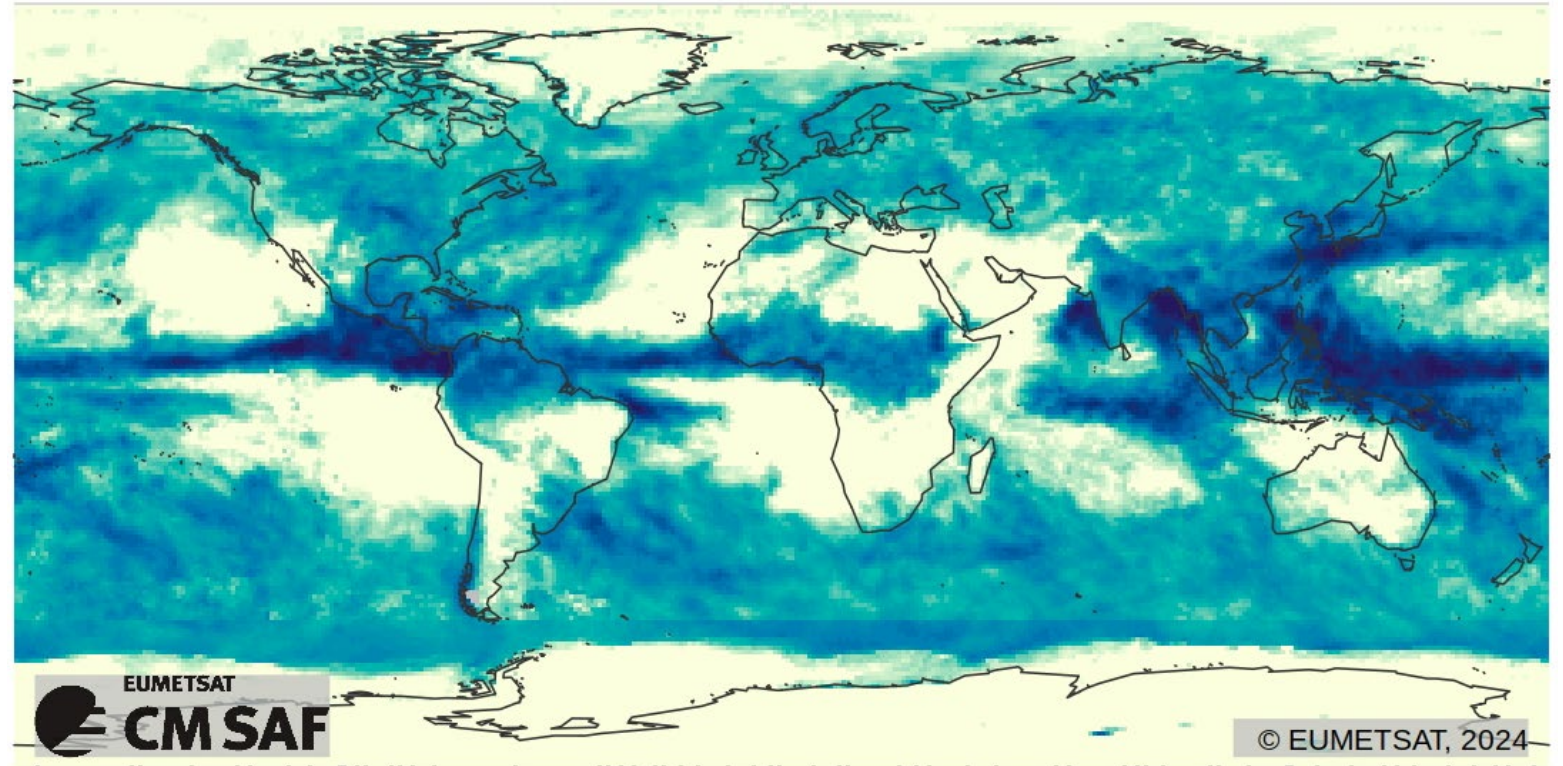
→ Temporal: daily, monthly

Coverage

→ Spatial: global

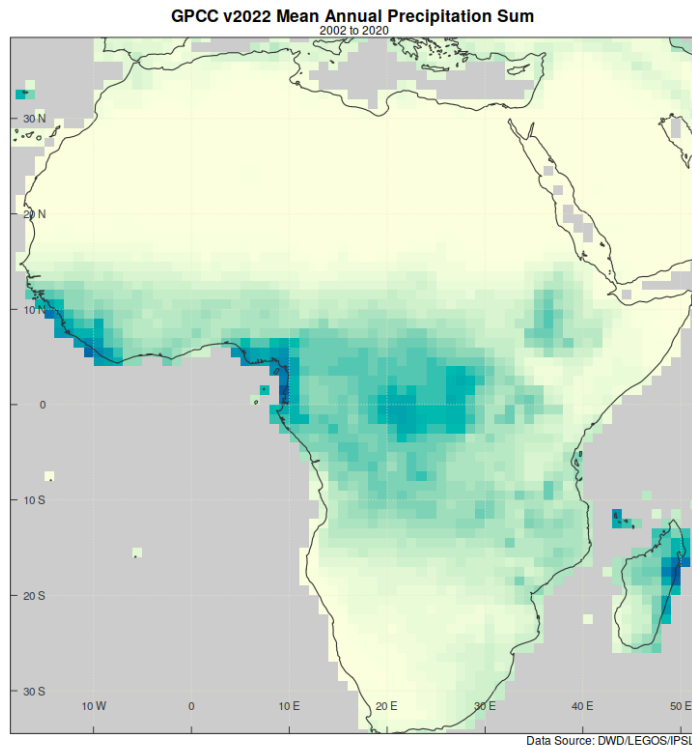
→ Temporal: 2002 to 2022

→ ICDR release in 2025

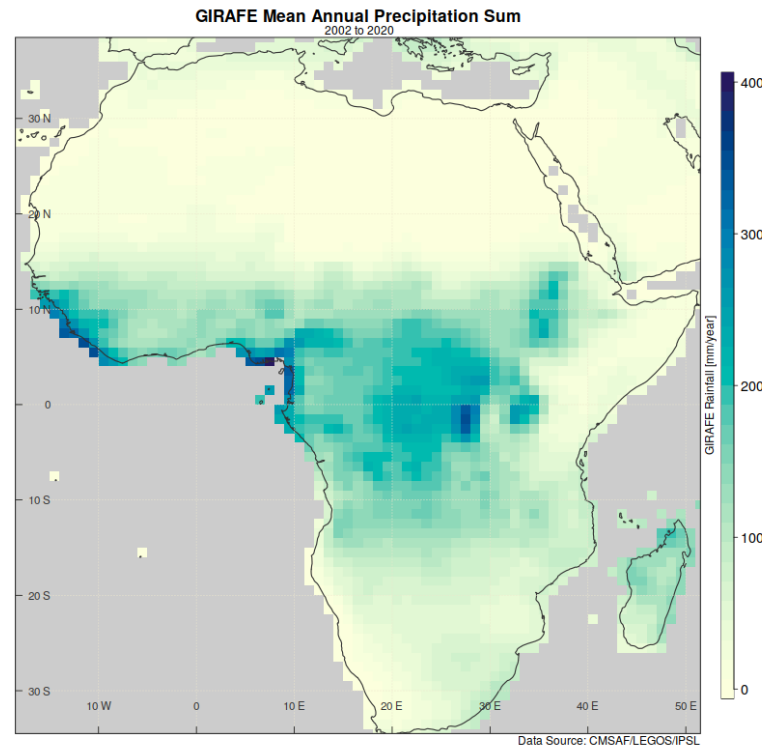


DOI:10.5676/EUM_SAF_CM/GIRAFE/V001
Precipitation (PRE)

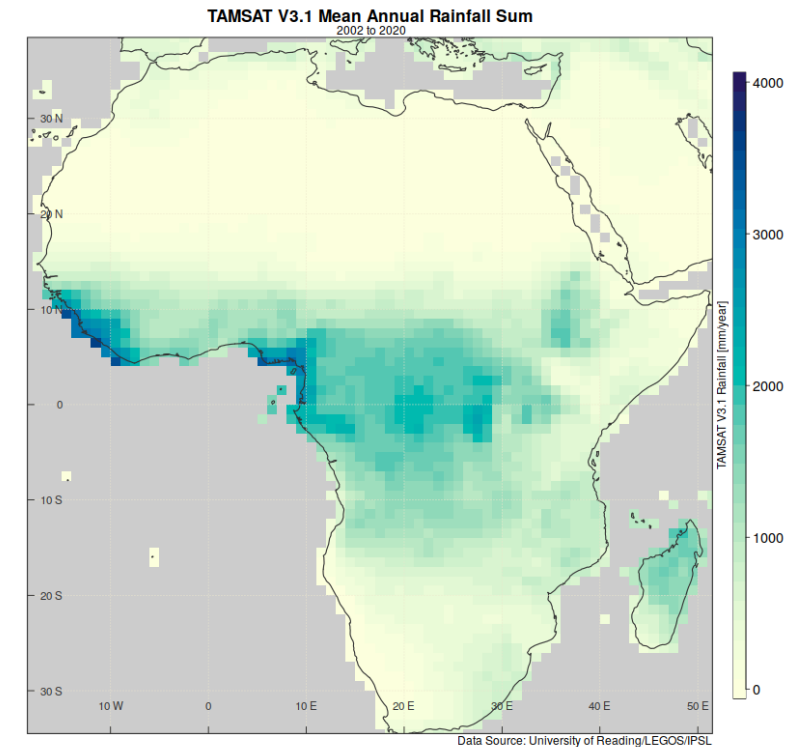
Mean Annual Sum 2002 to 2020



GPCC

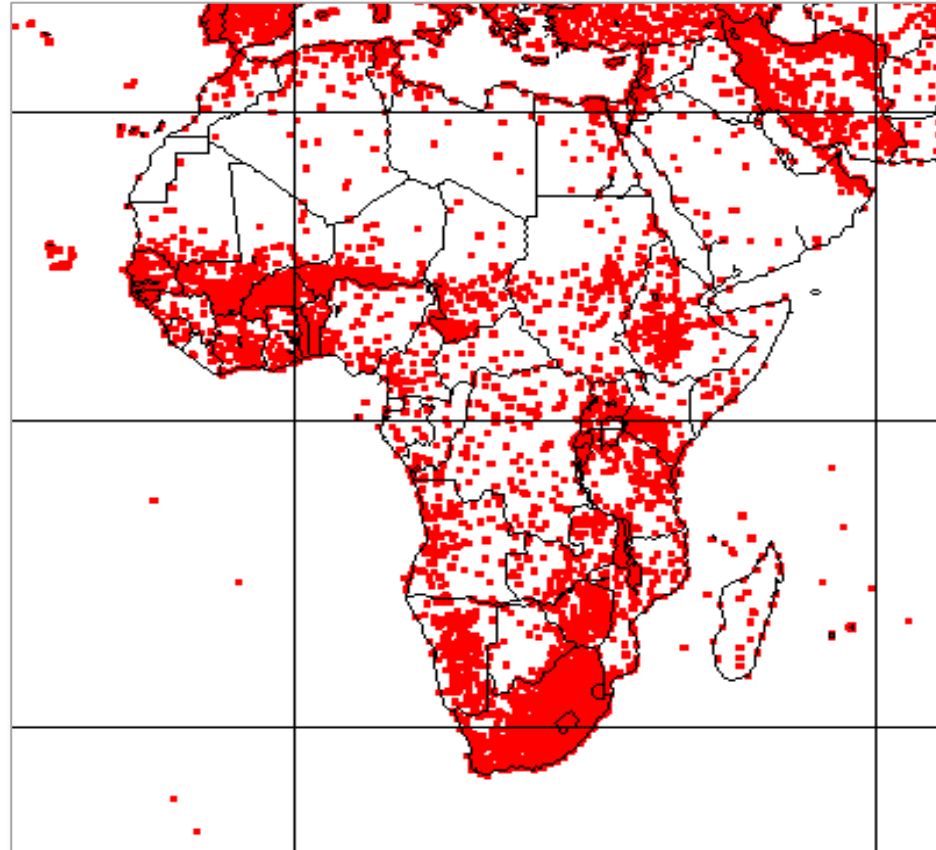


GIRAFE



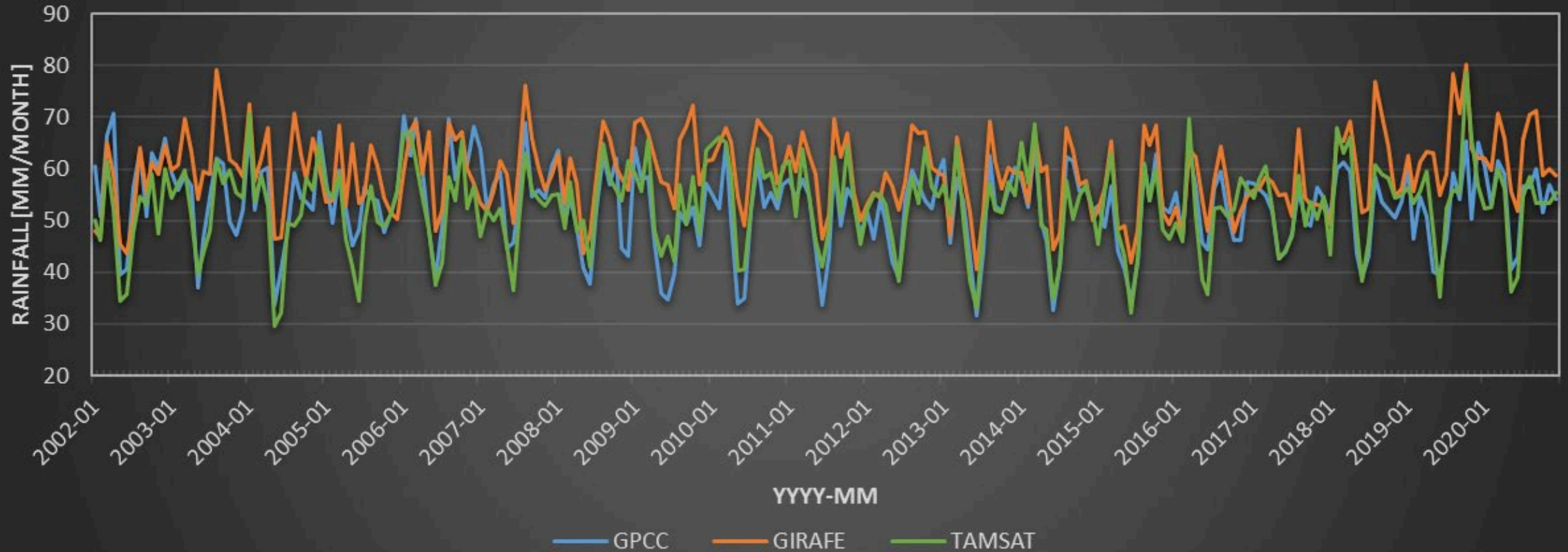
TAMSAT

What is the Truth?

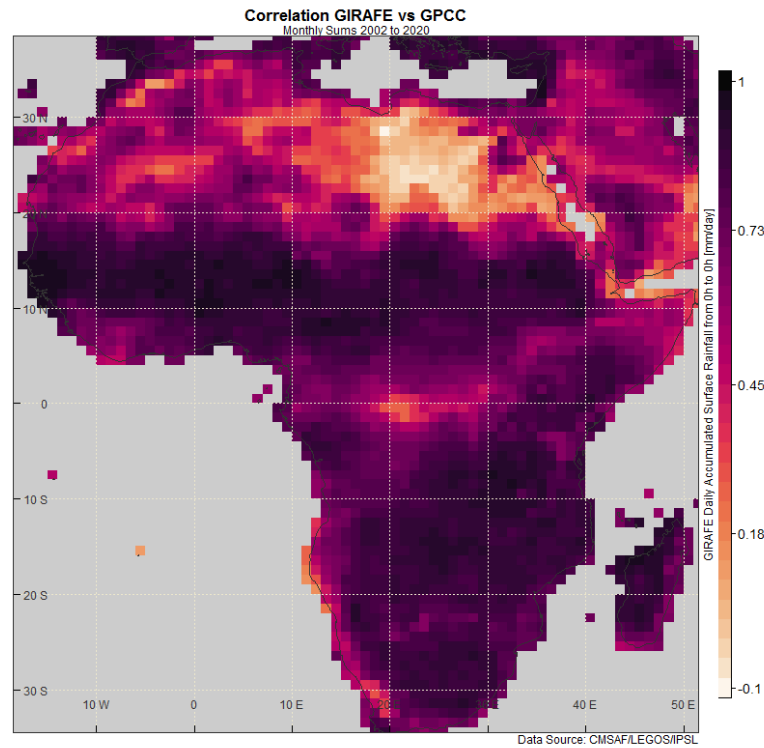


GPCP station distribution

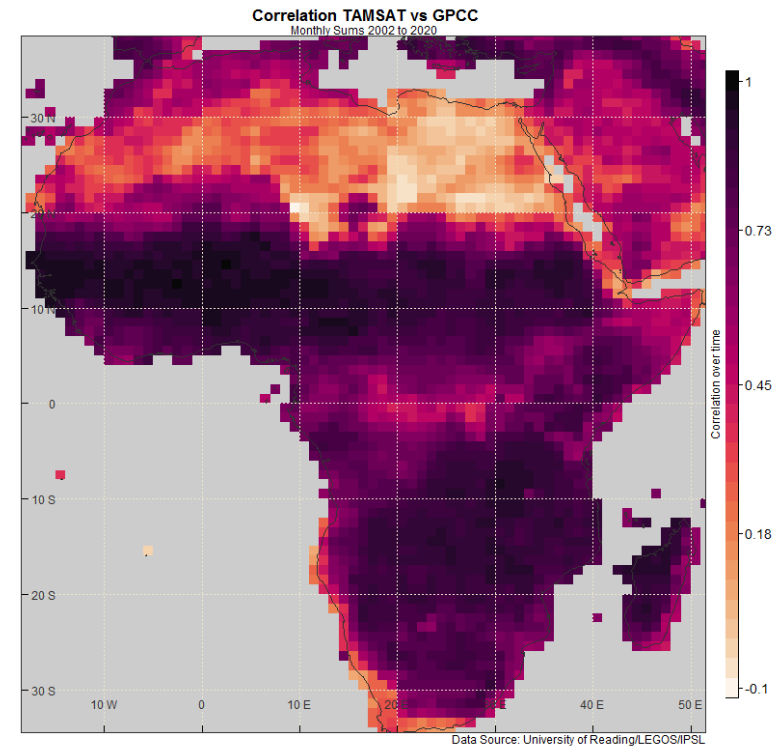
Monthly Mean Precipitation in Africa



Correlation vs GPCC

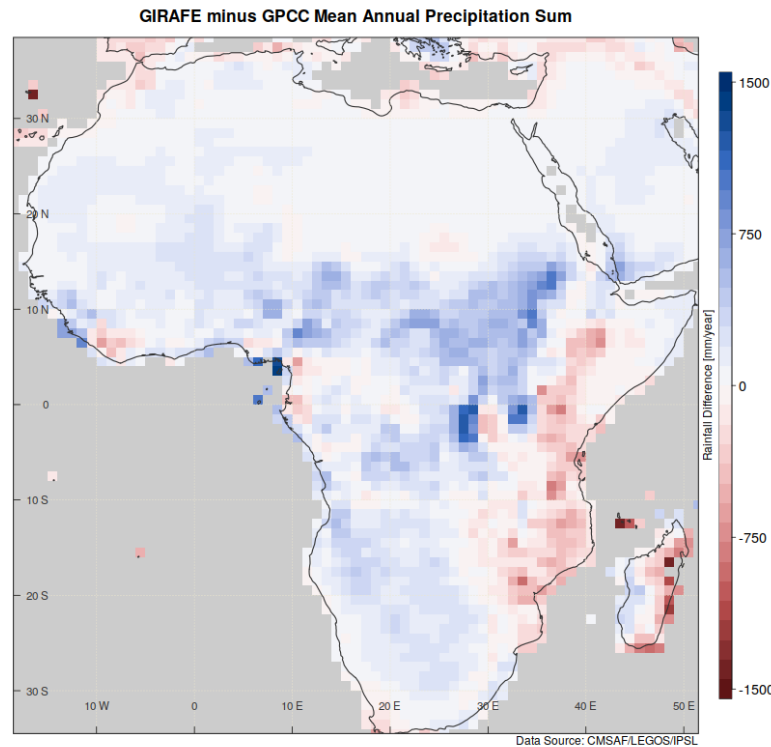


GIRAFE

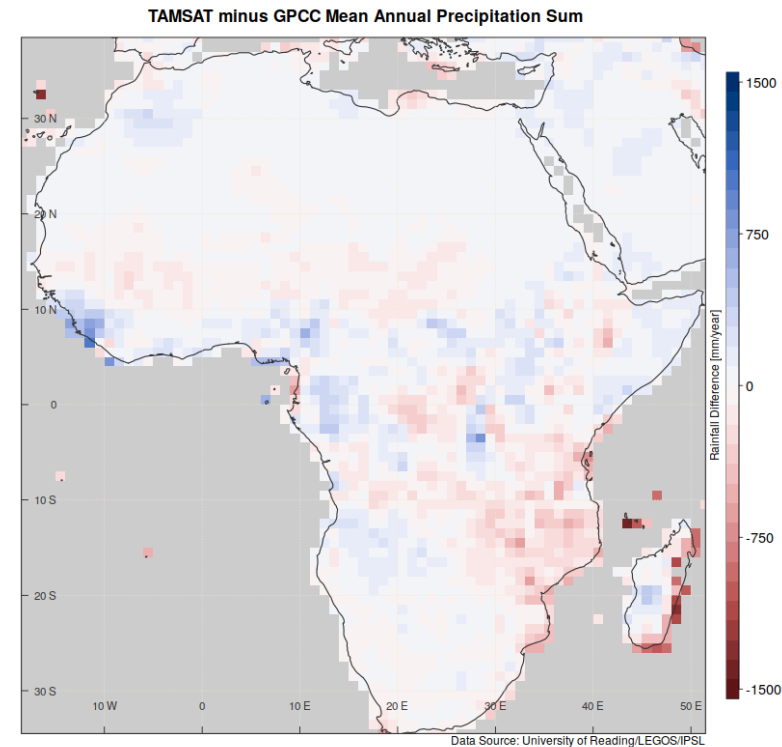


TAMSAT

Difference vs GPCC

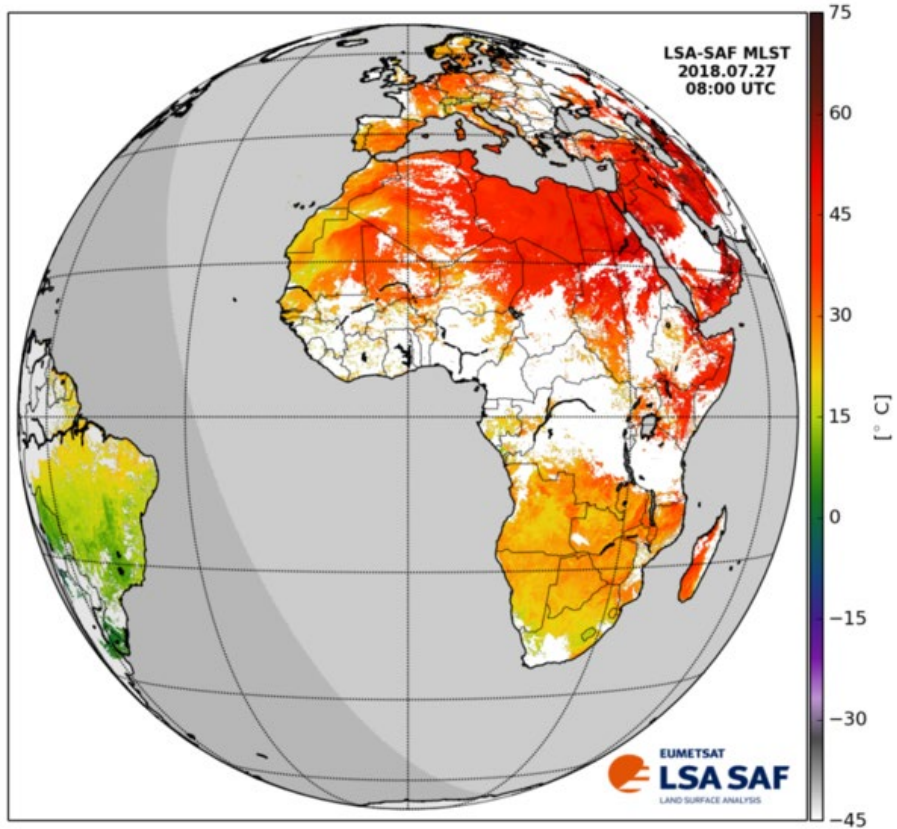


GIRAFE minus GPCC



TAMSAT minus GPCC

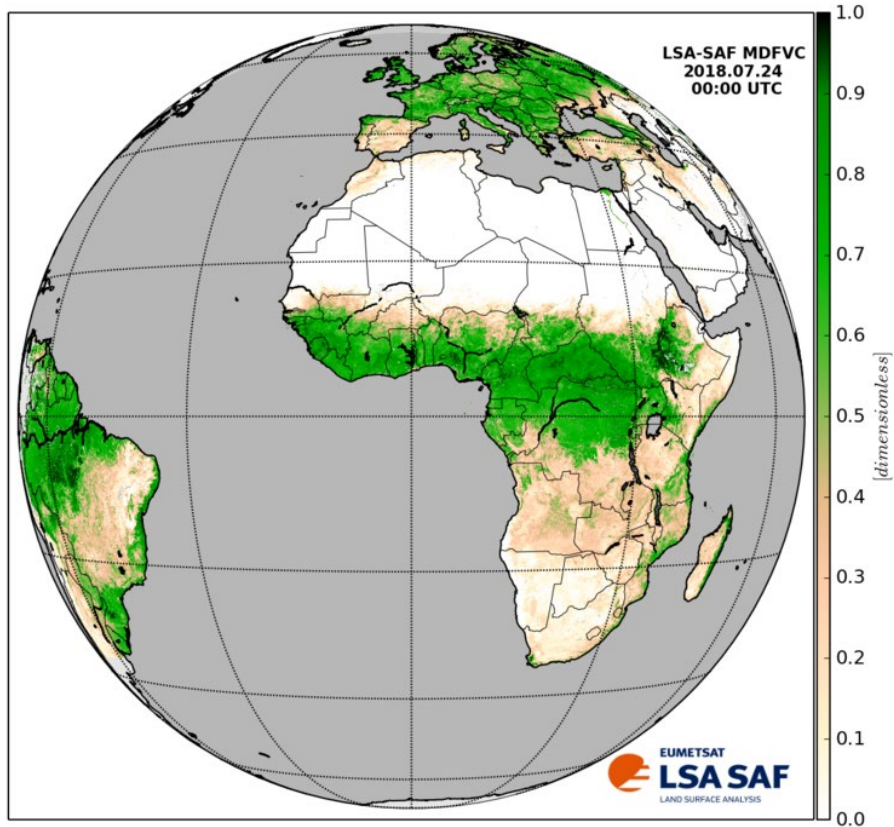




Land Surface Temperature (LST)

- Radiative skin temperature over land
- Available ≥ 2004
- Frequency: 15 min.

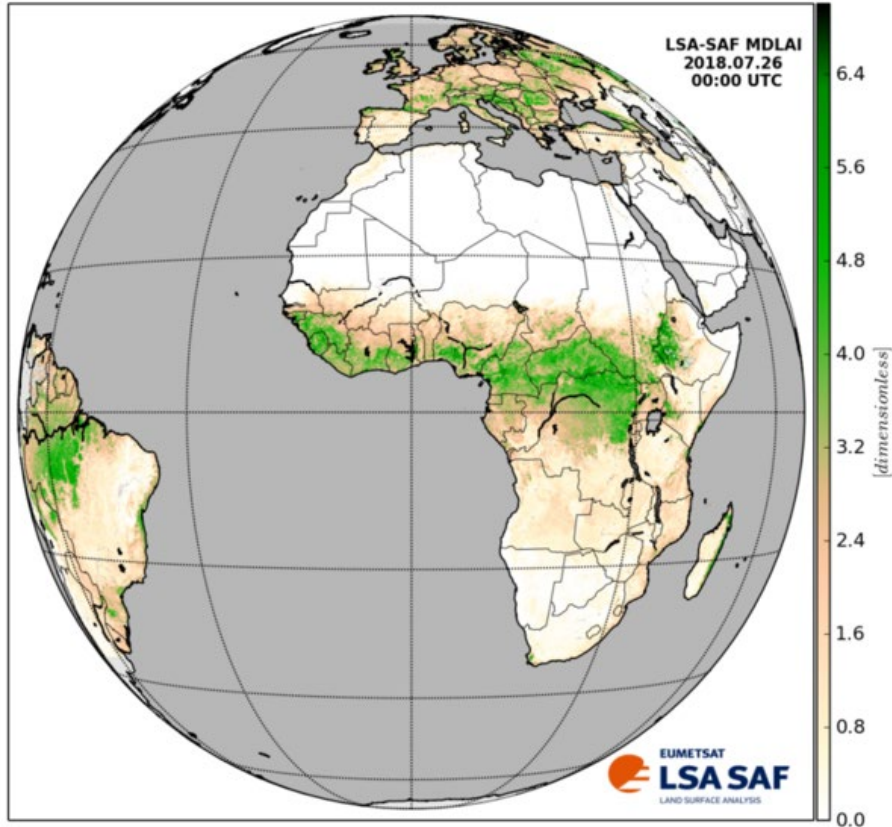
<https://lsa-saf.eumetsat.int>



Fraction of Vegetation Cover (FVC)

- Amount of vegetation distributed on a flat background
- Available ≥ 2004
- Frequency: daily & 10-days

<https://lsa-saf.eumetsat.int>

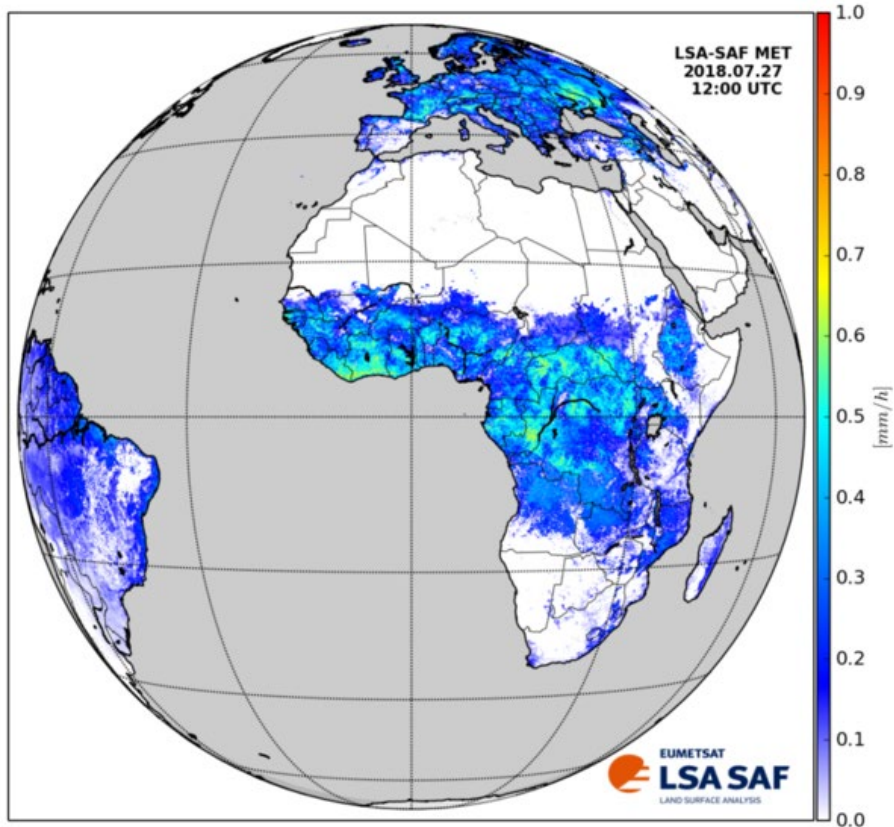


Leaf Area Index (LAI)

Fraction of Absorbed Photosynthetically Active Radiation (FAPAR)

- Together with FVC information on vegetation density, canopy density & vegetation health
- Available ≥ 2004
- Frequency: daily & 10-days

<https://lsa-saf.eumetsat.int>



Evapotranspiration (ET)

Reference evapotranspiration (ETREF)

- combined process of water evaporation from soil and other surfaces and the transpiration of water from plants, representing the total water loss to the atmosphere from land surfaces
- Available ≥ 2004
- Frequency: 30 min. & daily

<https://lsa-saf.eumetsat.int>



Some other SAF Climate Data Records



Meet the SAFs

<p>AC SAF Atmospheric Composition Monitoring</p>	<p>CM SAF Climate Monitoring</p>	<p>LSA SAF Land Surface Analysis</p>
<p>The AC SAF processes satellite data on ozone, other trace gases, aerosols and ultraviolet data.</p>	<p>The CM SAF generates and archives high-quality climate datasets.</p>	<p>The LSA SAF exploits remotely-sensed data on land, land-atmosphere interactions and biosphere applications.</p>
<p>Learn more about AC SAF</p>	<p>Learn more about CM SAF</p>	<p>Learn more about LSA SAF</p>
<p>OSI SAF Ocean and Sea Ice</p>	<p>NWP SAF Numerical Weather Prediction</p>	<p>ROM SAF Radio Occultation Meteorology</p>
<p>The OSI SAF provides comprehensive information on the ocean-atmosphere interface.</p>	<p>The NWP SAF supports the interface between satellite data and European activities in NWP.</p>	<p>The ROM SAF generates and archives high-quality GNSS Radio Occultation (RO) data for NWP and specific climate application areas.</p>
<p>Learn more about OSI SAF</p>	<p>Learn more about NWP SAF</p>	<p>Learn more about ROM SAF</p>
<p>NWC SAF Nowcasting and Very Short Range Forecasting</p>	<p>H SAF Operational Hydrology and Water Management</p>	
<p>Nowcasting is a weather forecast for the next few hours, based on current information.</p>	<p>The H SAF generates and archives datasets and products for operational hydrological applications.</p>	

<https://www.eumetsat.int/about-us/satellite-application-facilities-safs>

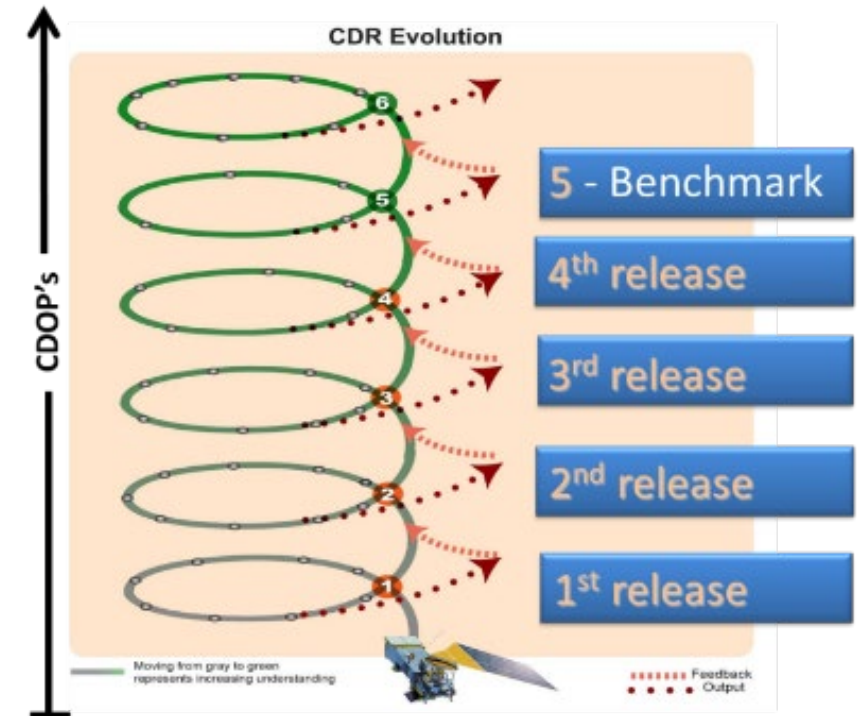
- Review cycle applied before publishing CDRs
- DOI is assigned
- CDR comes with comprehensive documentation and publications
- CDR with uncertainty estimates
- Participation in international assessments and retrieval evaluations





PP (Project Phase), IOP (Initial Operations Phase), CDOP (Continuous Development and Operations Phase)

- Sustained, long-term and reliable climate monitoring
- Continuous development and generation
- Cyclic improvements of CDRs to increase maturity



- **Web User Interface**

- CM SAF Climate Data
- <https://wui.cmsaf.eu>

- **EUMETCast**

- Selected Climate Data
- <https://eoportal.eumetsat.int>

- **EUMETSAT Data Store**

- EUMETSAT and some SAF data
- <https://eoportal.eumetsat.int>





The CM SAF R Toolbox





Prepare

Analyze

Visualize

EXIT

View or edit the user directory.

The CM SAF R TOOLBOX 3.5.1 -- 'Of Course I Still Love You'

The intention of the CM SAF R Toolbox is to help you using CM SAF NetCDF formatted climate data

This includes:

1. Preparation of data files.
2. Analysis and manipulation of prepared data.
3. Visualization of the results.

To begin, choose a .tar file or a .nc file in the prepare section or jump right in and analyze or visualize a .nc file.

Suggestions for improvements and praise for the developers can be sent to contact.cmsaf@dwd.de.

- Steffen Kothe - 2024-05-07 -

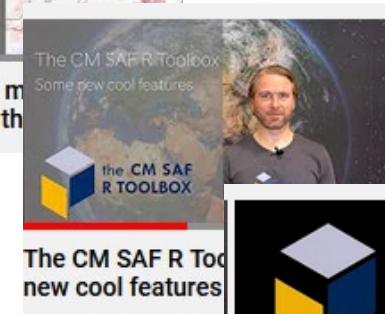
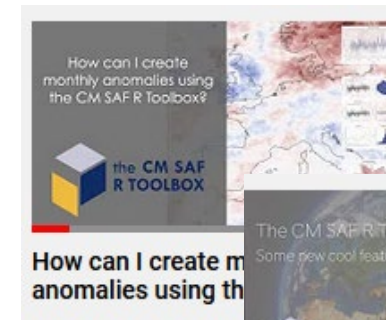
www.cmsaf.eu/R_toolbox

Support

→ If you need help using the Toolbox have a look at our manuals, Youtube videos, the Toolbox paper, Tutorial, Q&A document, Cheat Sheets, flyer, etc.

→ www.cmsaf.eu/R_toolbox

→ contact.cmsaf@dwd.de





EUMETSAT TrainHub

Discover and explore EUMETSAT data, products and services, including Copernicus data provided by EUMETSAT in an interactive and hands-on way.

The EUMETSAT TrainHub provides you access to Jupyter notebook training resources offered by EUMETSAT. You can browse and discover notebooks for different thematic application domains, such as Atmosphere, Climate, Land Surface, Marine or Weather.

Discover our notebooks



<https://catalog.trainhub.eumetsat.int/>



EUMETSAT USER PORTAL

Dashboard | Data catalogue | Using data | Data access | News & events

Themes | Satellites | Resources | Search user portal

Atmospheric composition | Climate | Emergency | Marine | Weather

Satellites provide a wide array of Earth observation data for **atmospheric composition, climate, emergency, marine and weather monitoring**.

In this section you can explore, discover and download our satellite data using the following themes:

- **Atmospheric composition** – aerosols, air quality and greenhouse gases and ozone.
- **Climate** – climate system monitoring for atmosphere, cryosphere, oceans and terrestrial, plus NWP-based analysis.
- **Emergency** – Fires, floods and severe storms

V2, 8 Feb 2024 **User guide**

Getting started using data

How to find, view, download and use our satellite data.

Go to EUMETSAT website

EUMETSAT User Portal
<https://user.eumetsat.int/dashboard>

EUMETSAT | HOME | COURSES & WORKSHOPS | More | English (en)

Participate in virtual trainings

Welcome to the EUMETSAT virtual classroom.

Most of our training activities are designed to support users in the member states and among the World Meteorological Organization (WMO) members in the application of EUMETSAT data, products, and services, including Copernicus data provided by EUMETSAT.

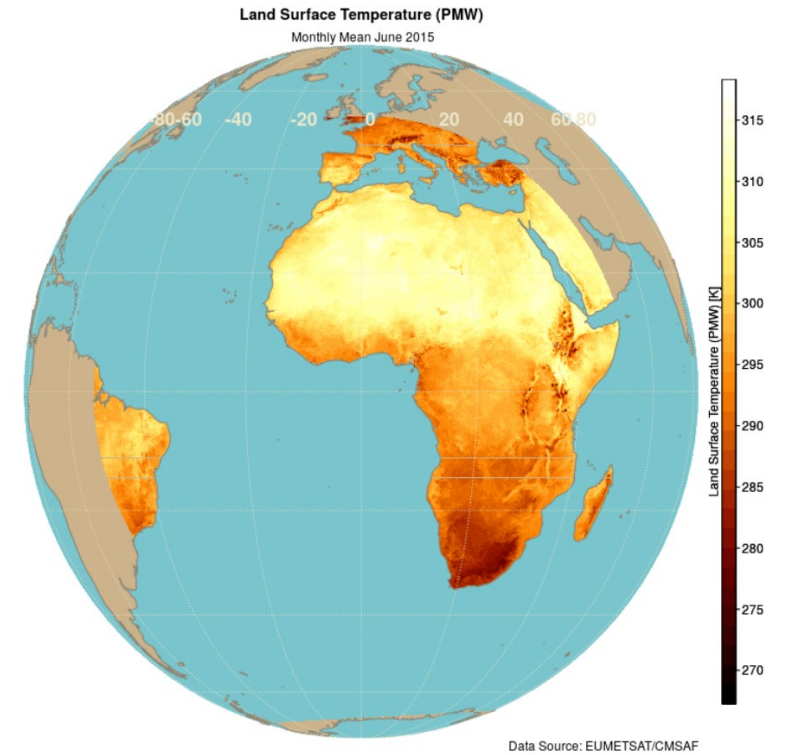
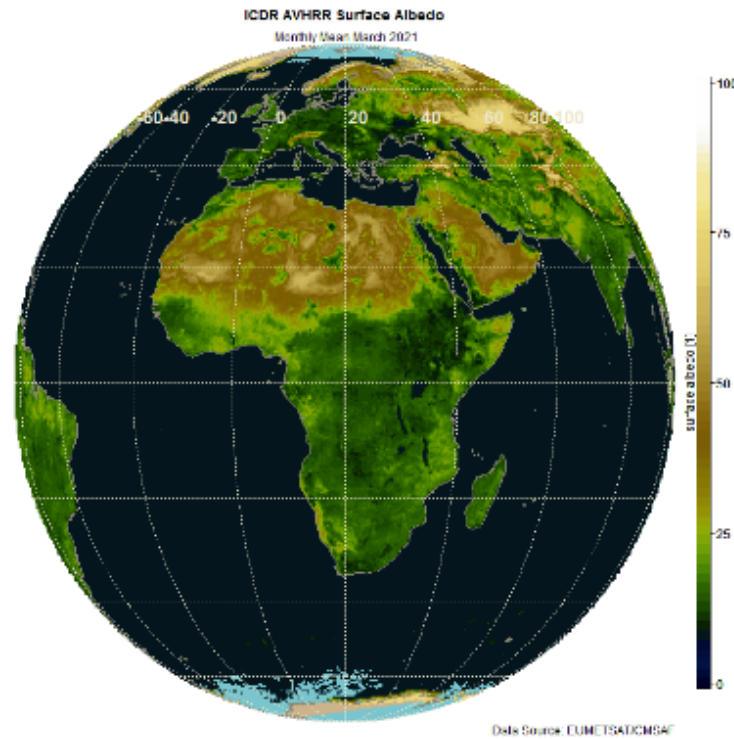
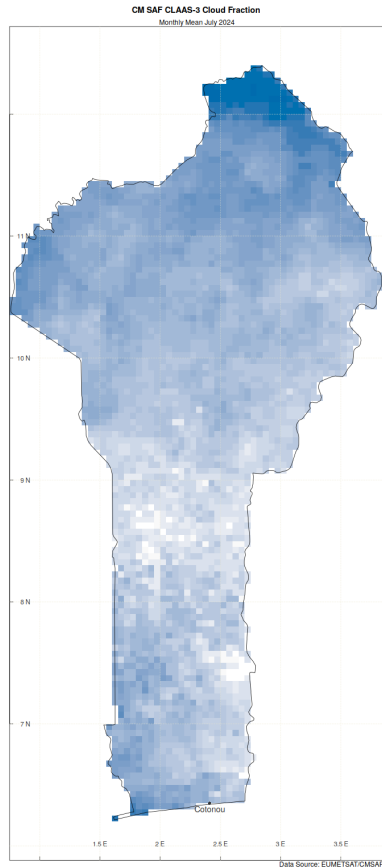
To participate in most of our courses, you will first need to send an Application and, in some cases, you will also need a Nomination from your institution. Find out more under [Search and Apply for courses](#).

In the **Open Learning** section, you will find a number of self-paced resources you can use to start learning at any time. Please note that you will need to log in or register on this platform before accessing these resources.

If you have questions or suggestions, we are happy for you to **contact us**.

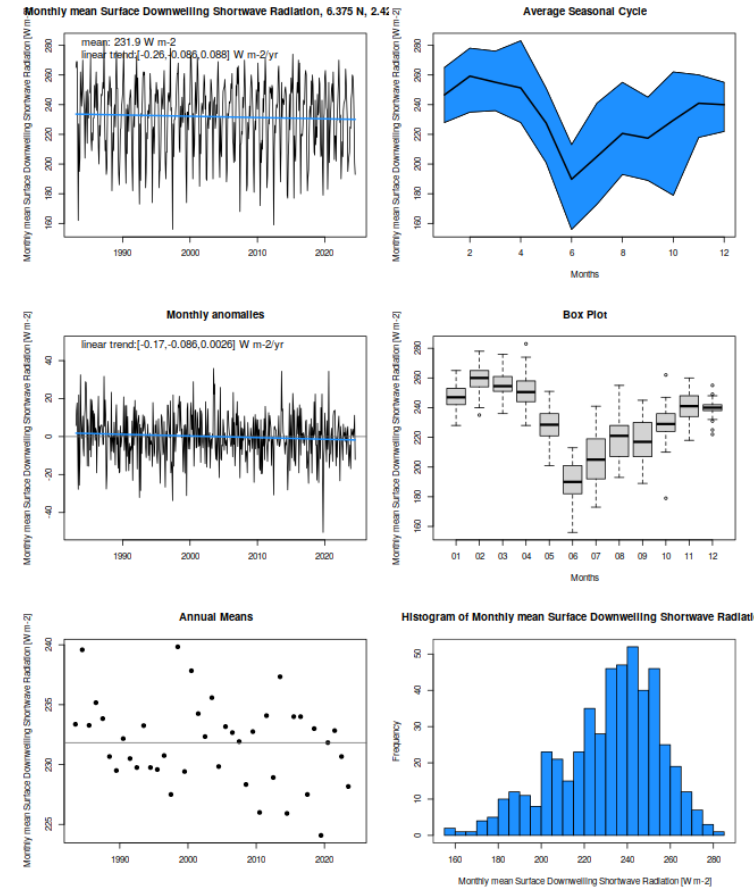
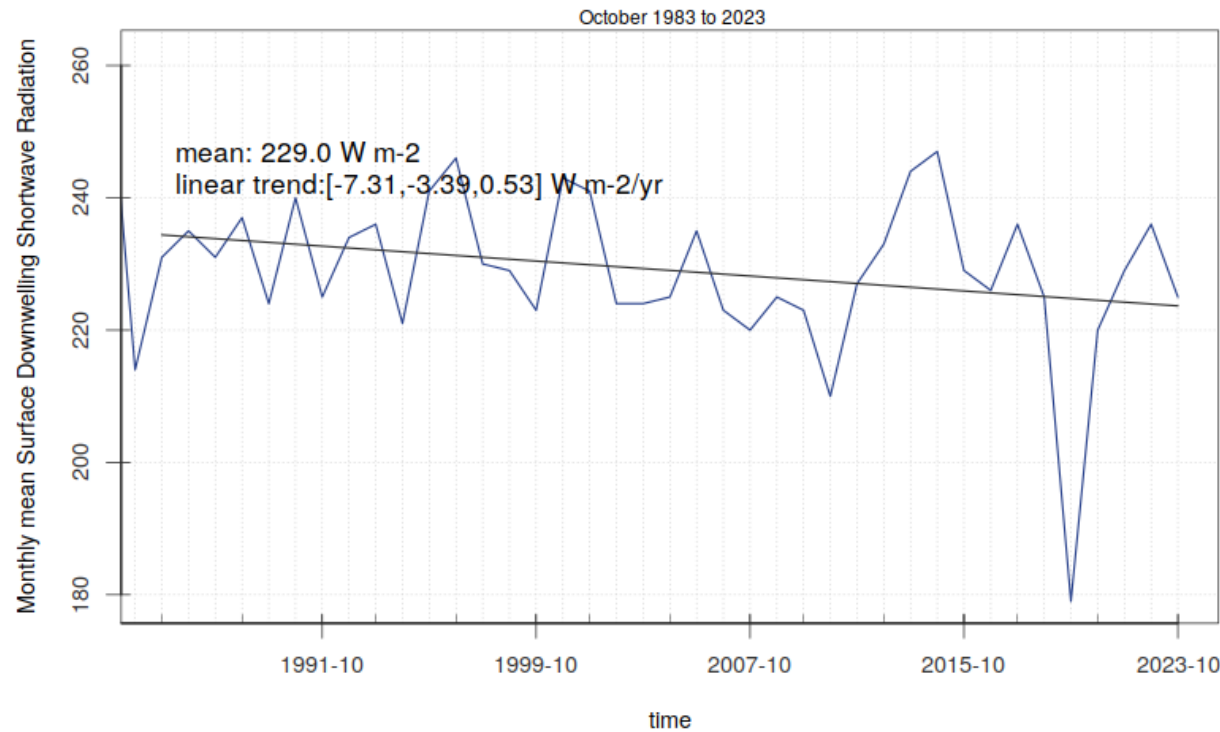
Training Activities
<https://training.eumetsat.int>

It's easy to work with the data!



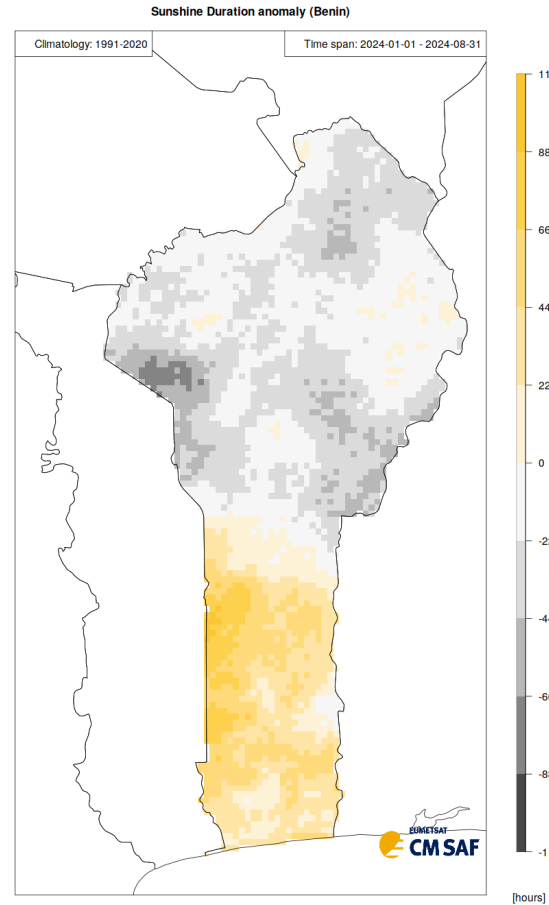
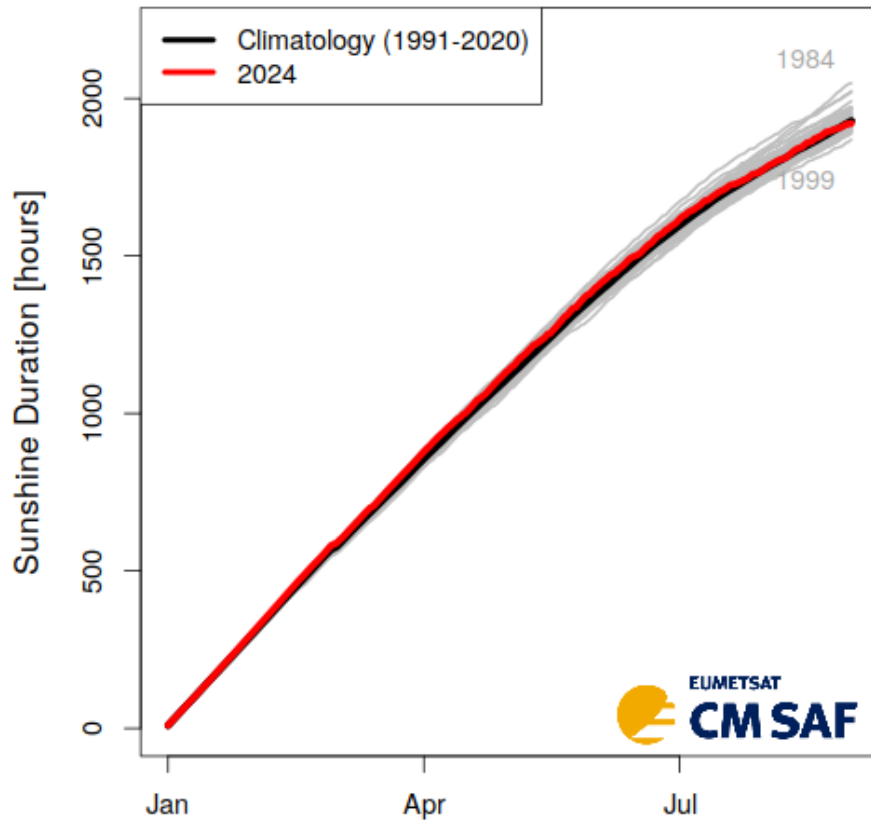
It's easy to work with the data!

Monthly mean Surface Downwelling Shortwave Radiation for Cotonou



Example: Sunshine Duration in 2024

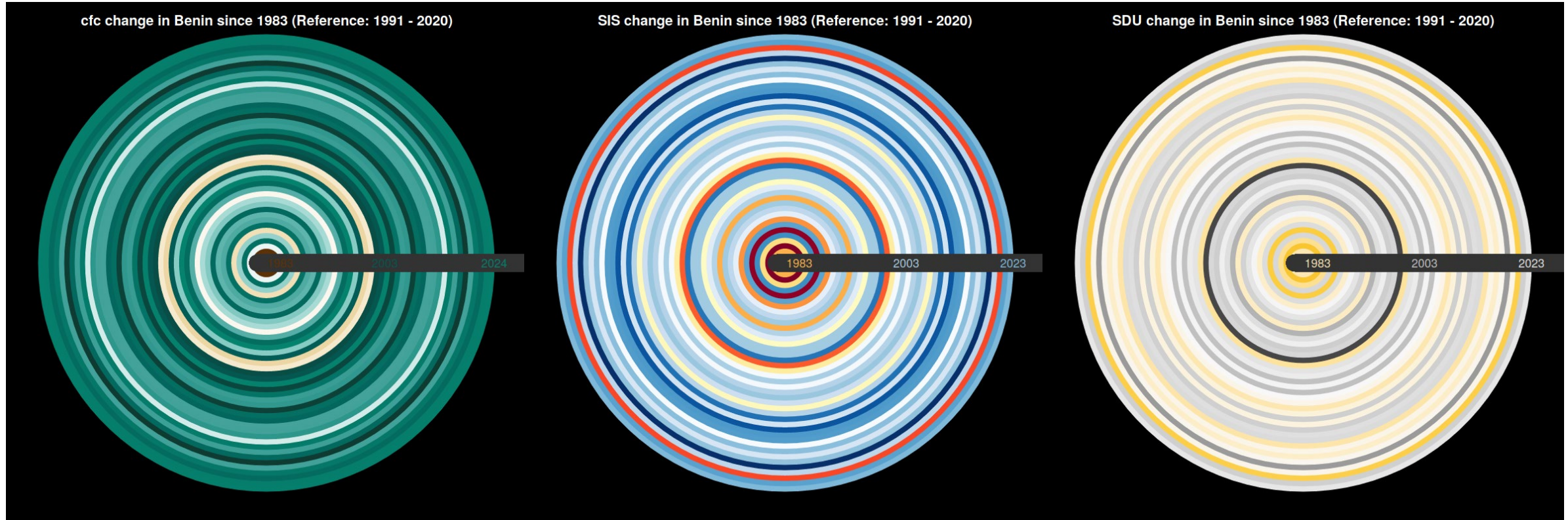
2024 vs. Climatology (Benin)



SDU Anomaly Jan – Aug

2024:	1920.8 h
1991 – 2020:	1929.2 h
Max 1984:	2048.5 h
Min 1999:	1869.6 h

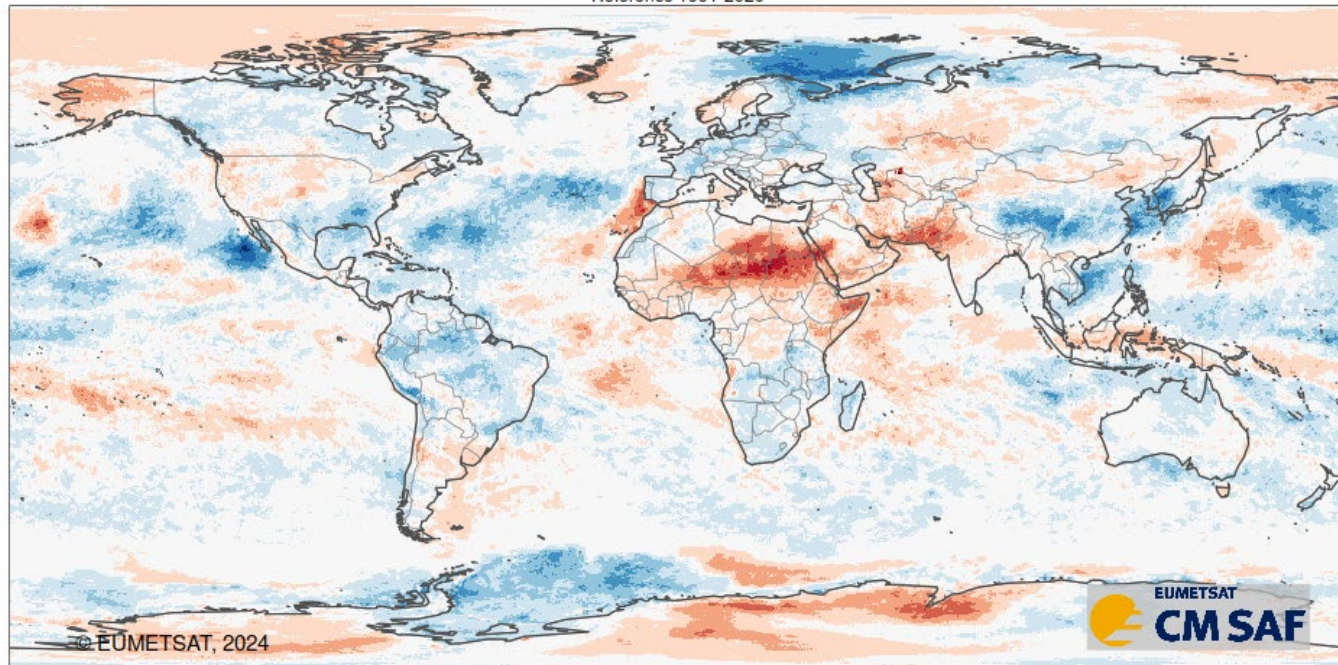
Example: 41 Years of Anomalies





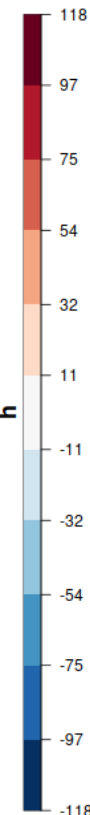
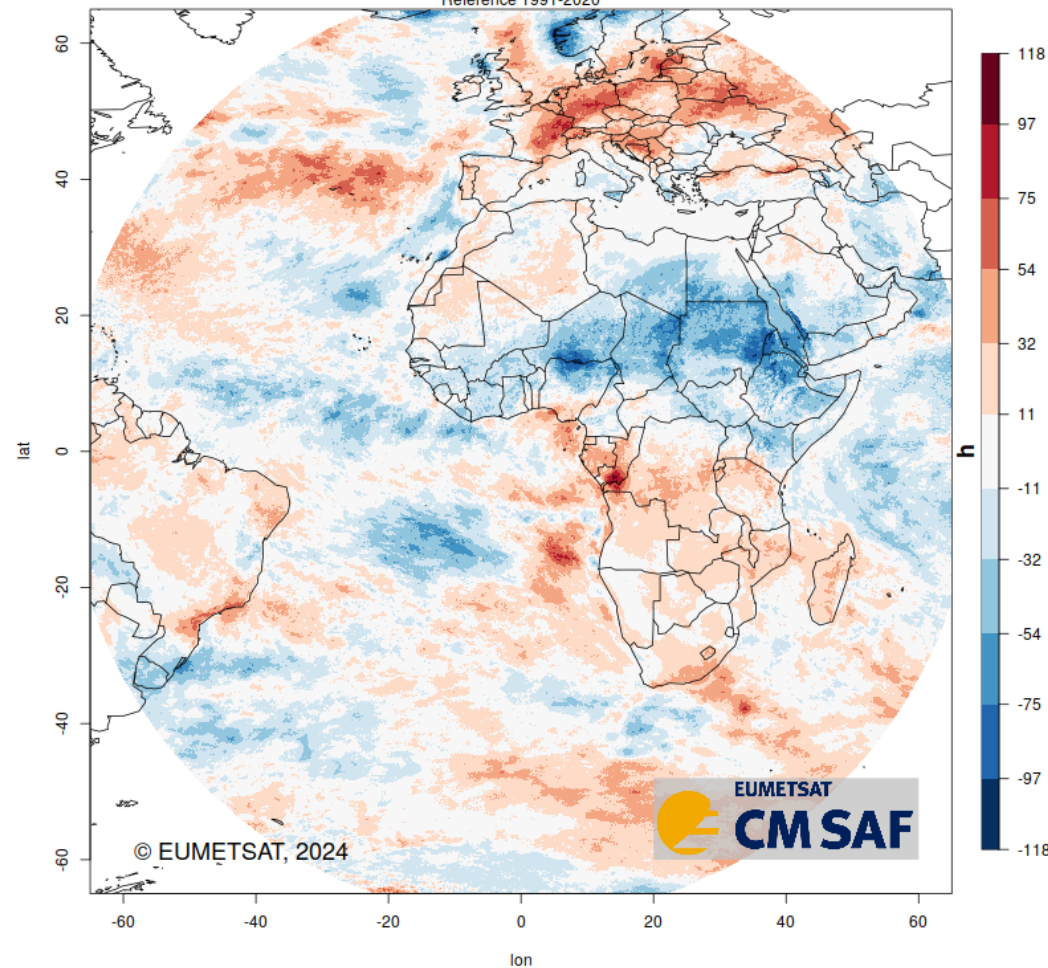
CLARA-A3 CFC Anomaly Aug 2024

Reference 1991-2020

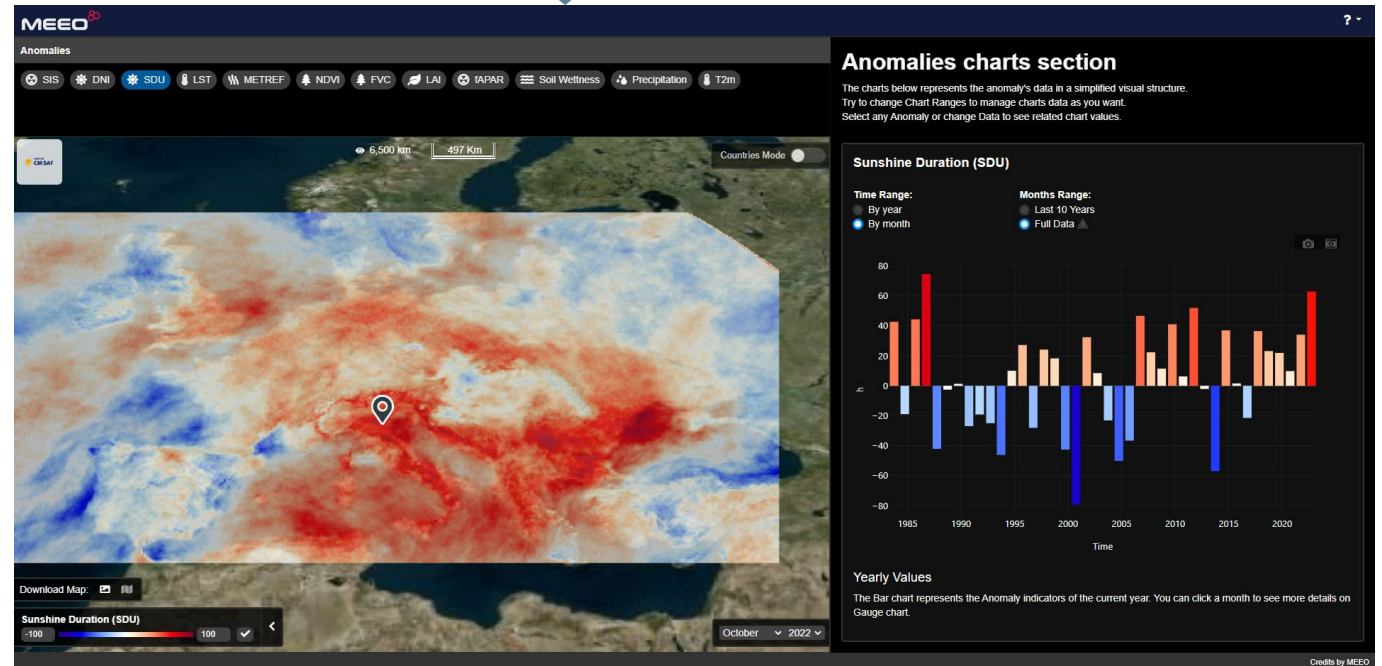
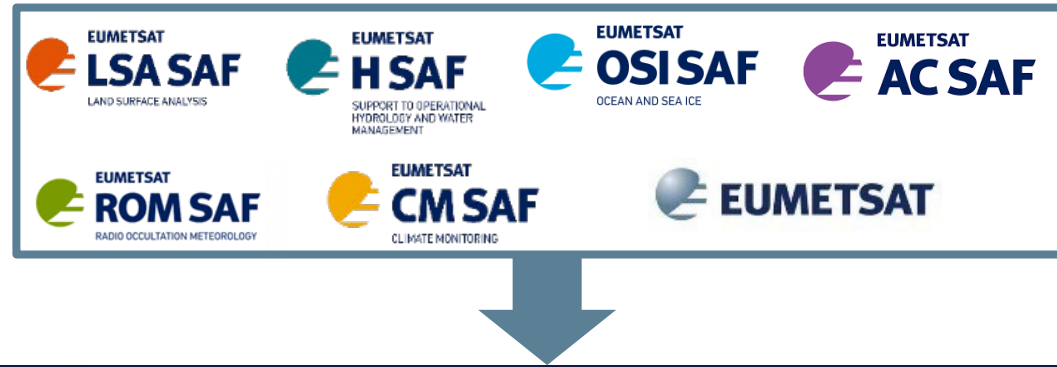


SARAH-3 SDU Anomaly Aug 2024

Reference 1991-2020



- Web-based service
- Monthly anomaly maps
- Barplot of anomaly time series for each pixel
- Anomaly maps & plots for download
- Anomaly data files for download
- Scripts to create own maps and barplots



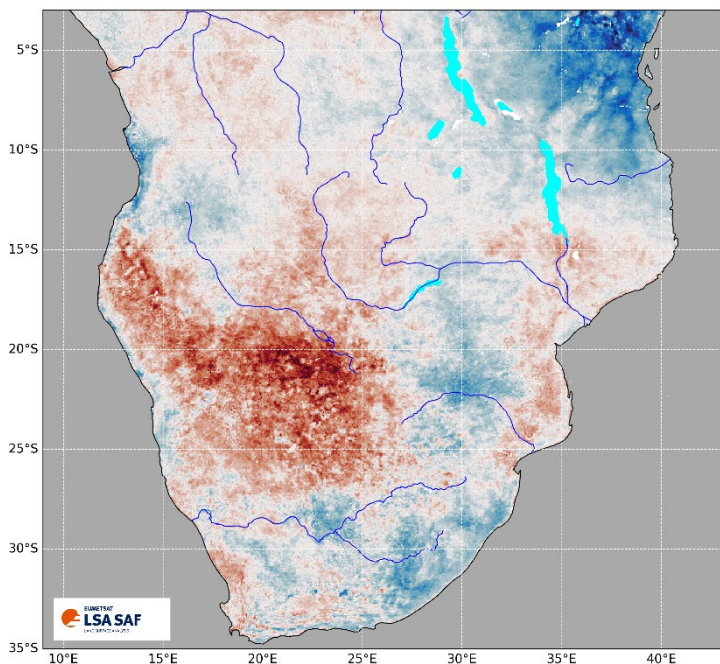
CAN Service v0 expected in summer 2025, please reach out to ops@eumetsat.int if you are interested in being a test-user.



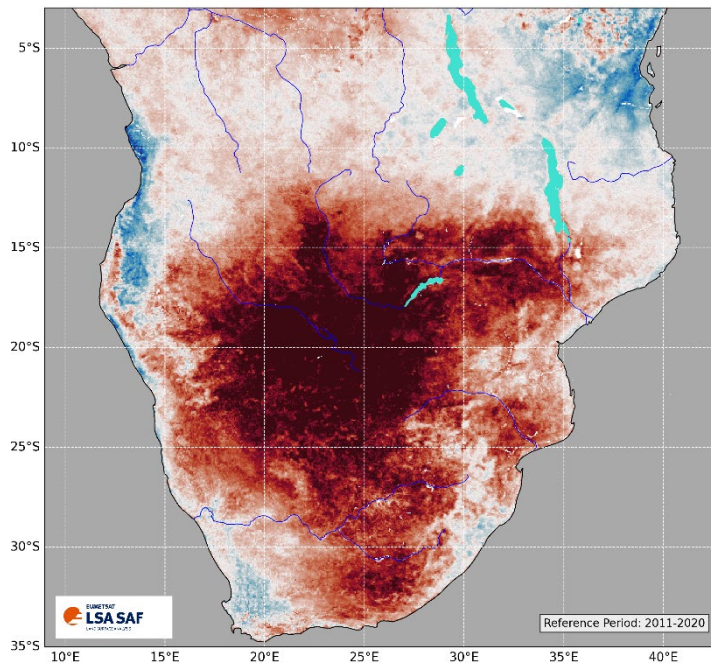
- **LST Anomalies**
 - Monthly anomaly of daily maximum Land-Surface-Temperature
- **Root Zone Soil Moisture Anomalies**
 - Monthly anomaly of root-zone-soil-moisture index
- **Leaf Area Index Anomalies**
 - Monthly anomaly of daily LAI
- **Reference Evapotranspiration Anomalies**
 - Monthly anomaly of monthly sum of daily METREF
- **Sunshine Duration Anomalies**
 - Monthly anomaly of monthly sum of SDU



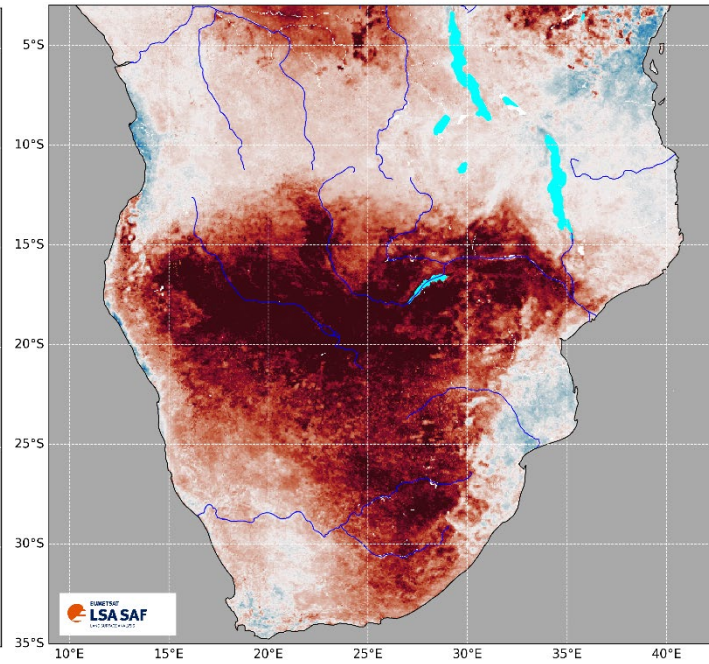
Monthly anomaly of max LST- All Sky in January 2024



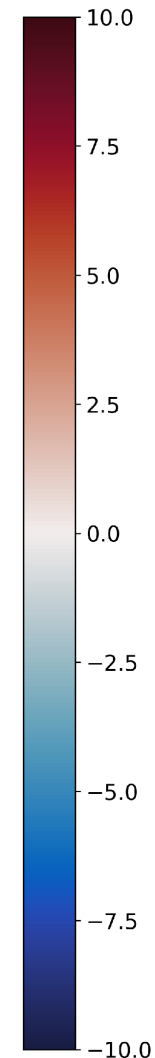
Anomaly of max LST-All Sky for February 2024



Monthly anomaly of max LST- All Sky in March 2024



LST[°C]



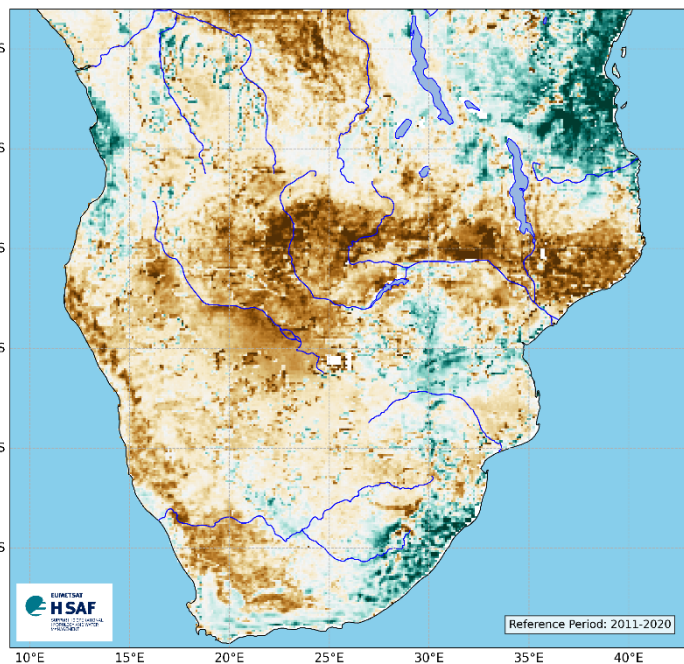
V† · Đ† - Ğ† Æ†

Èπ⁻ - Đ† - Ğ† Æ†

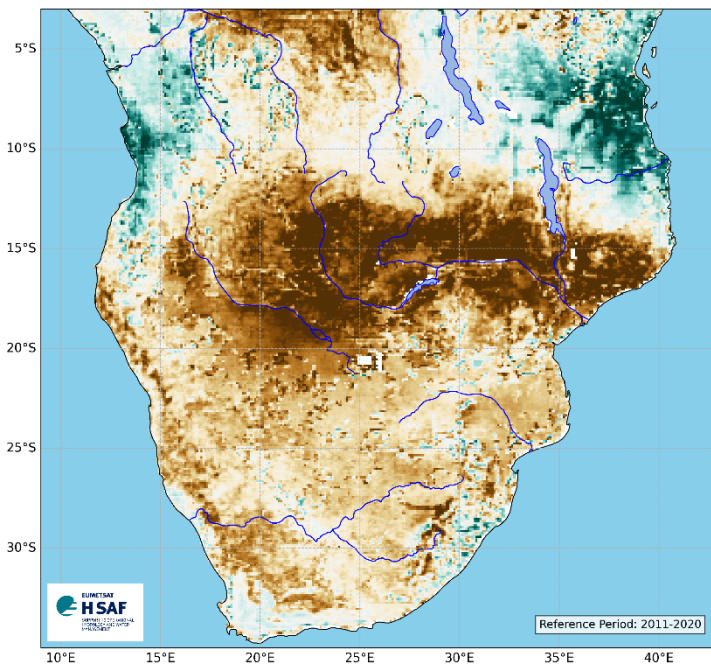
_ † - Æ† Æ† Æ†



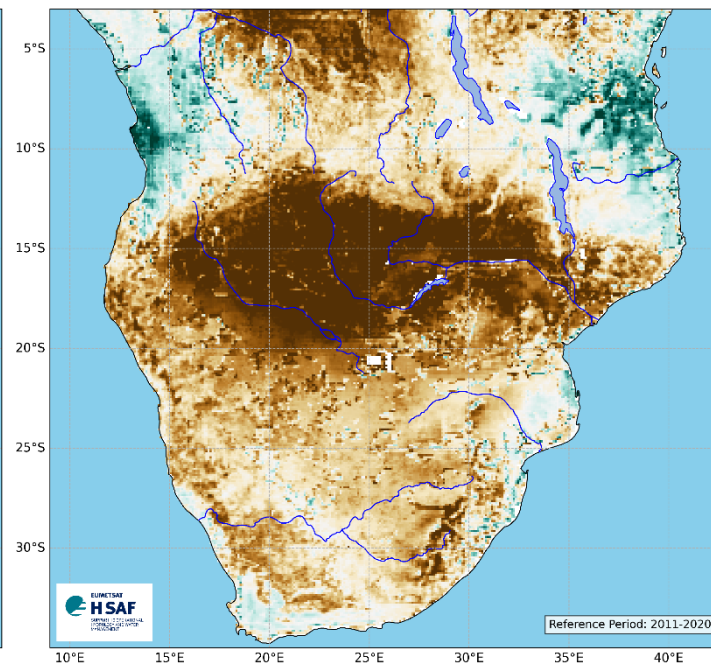
Monthly anomaly of RZSM in January 2024



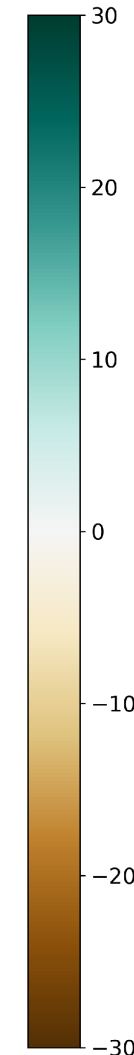
Monthly anomaly of RZSM in February 2024



Monthly anomaly of RZSM in March 2024



RZSM[%]



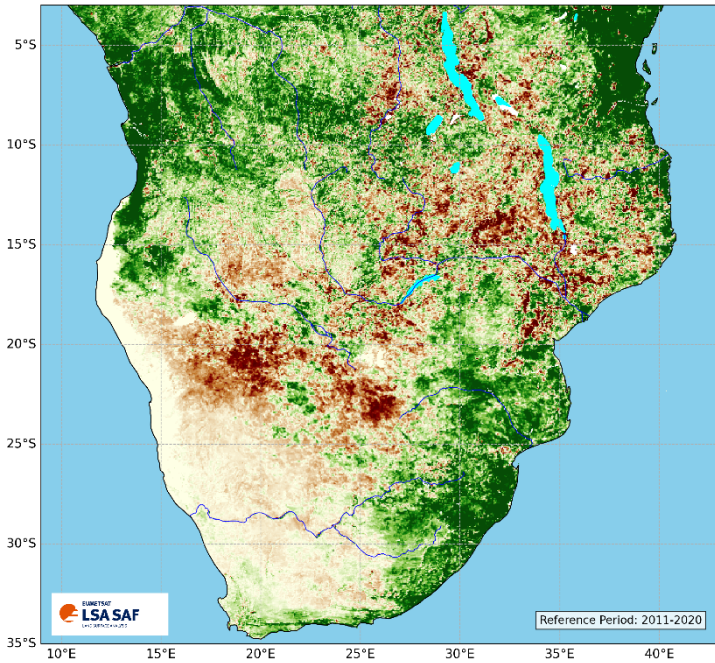
V†· Đ†-ĞİÖİÖ

Επ¨-Đ†-ĞİÖİÖ

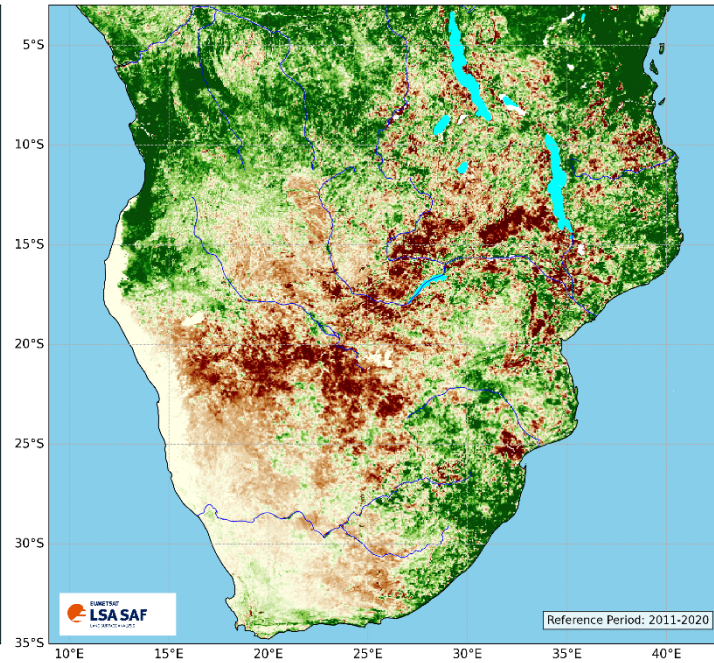
- †-ĂĂİÖİÖ



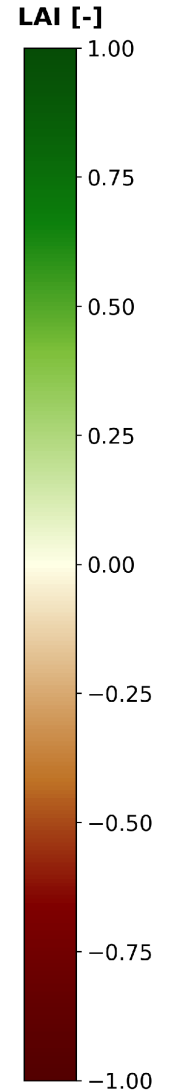
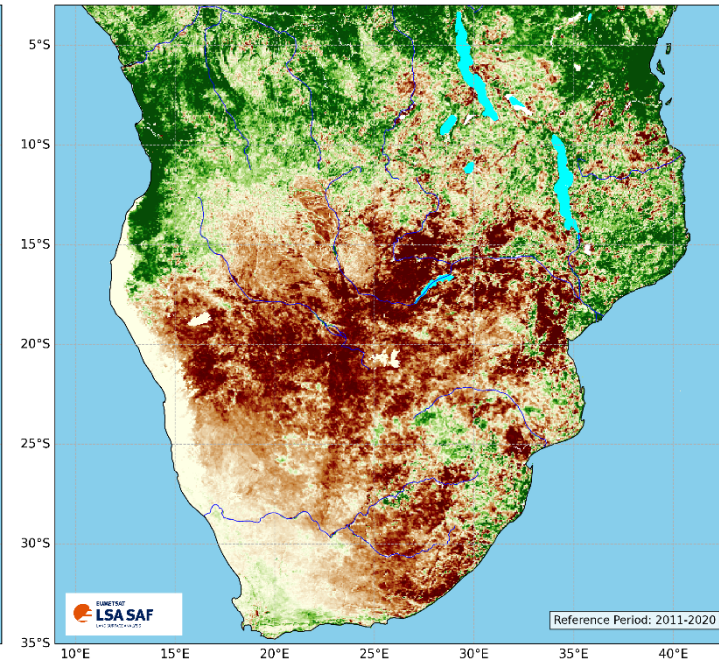
Monthly anomaly of LAI in Jan 2024



Monthly anomaly of LAI in February 2024



Monthly anomaly of LAI in MARCH 2024



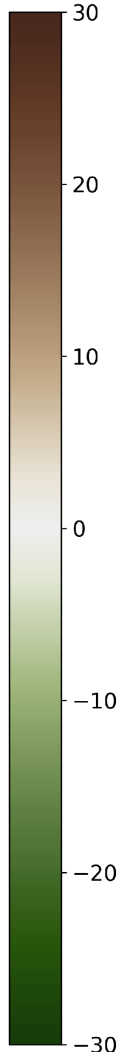
V† · D† - G† O† I† Ö

E† π - D† - G† O† I† Ö

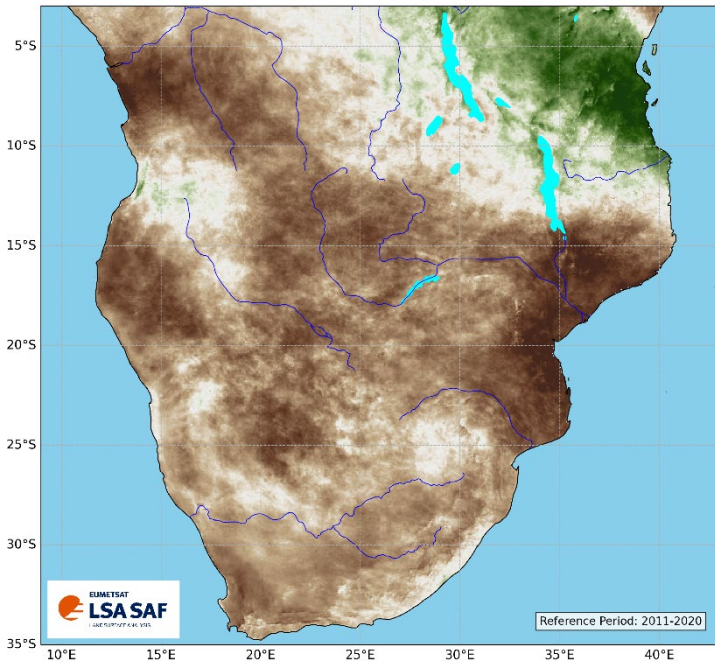
- † - A† A† O† I† Ö



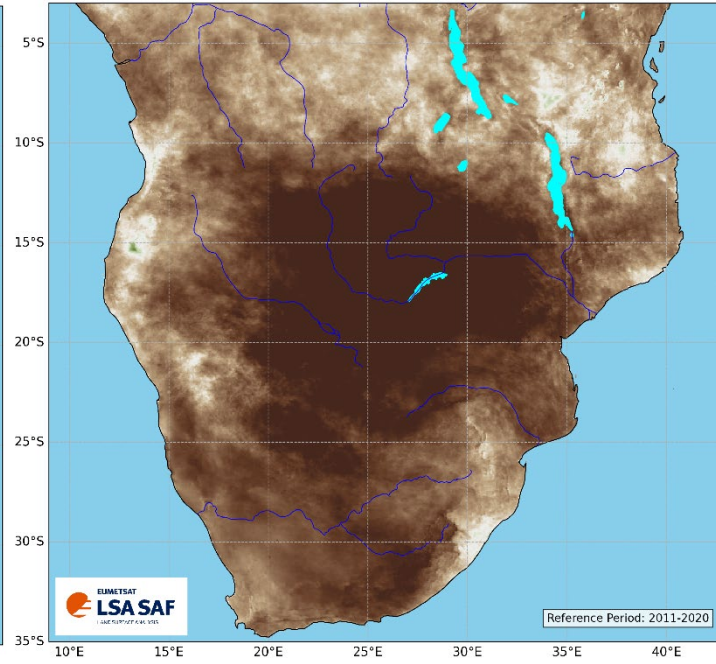
[mm/month]



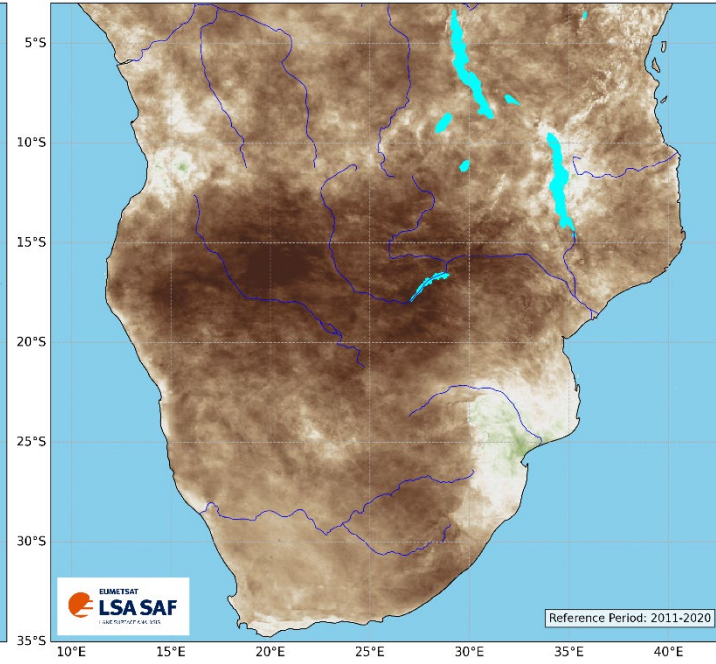
Monthly anomaly of METREF in January 2024



Monthly anomaly of METREF in February 2024



Monthly anomaly of METREF in March 2024



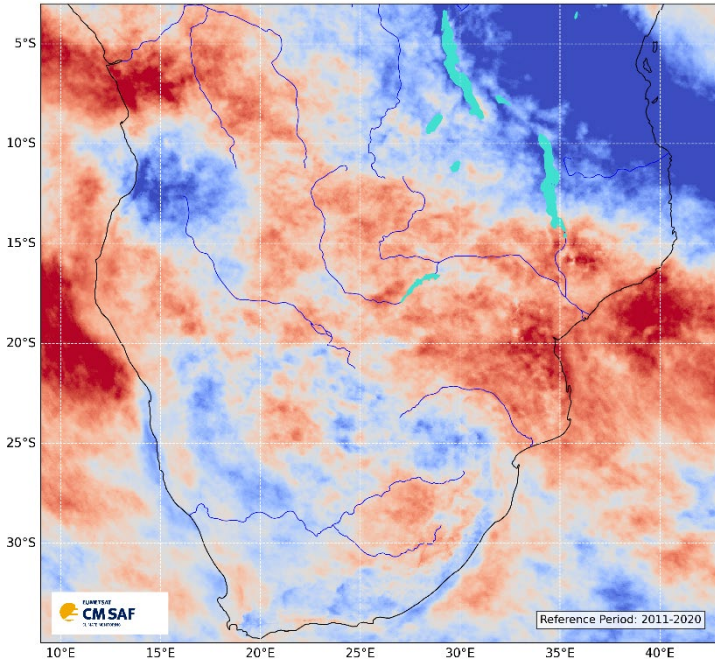
V̇ · Ḋ · Ğ̇ · İ̇ · Ö̇

Ė π̇ · Ḋ · Ğ̇ · İ̇ · Ö̇

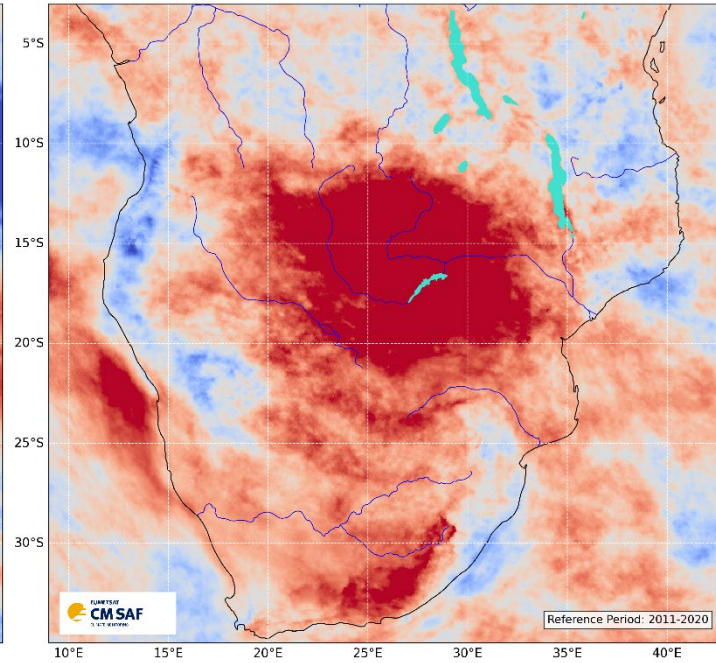
_ · † · Ā̇ · İ̇ · Ö̇



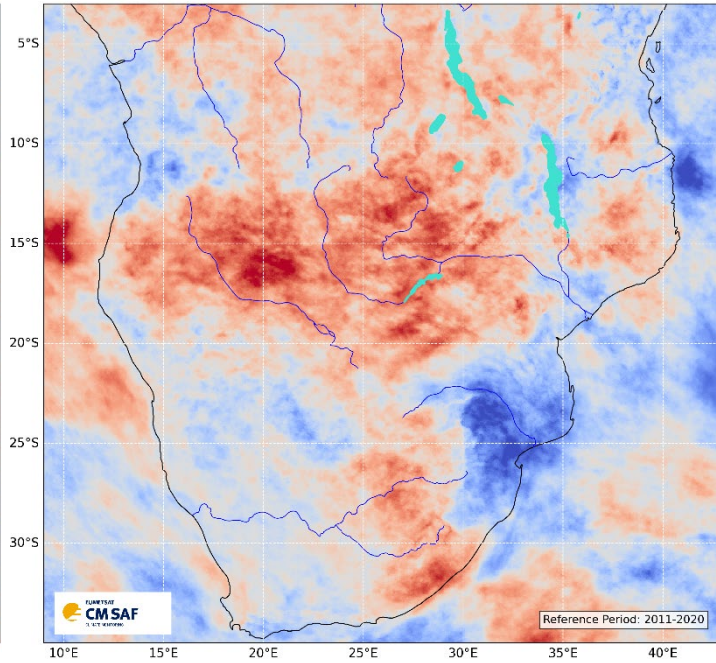
Anomaly of Sunshine Duration for January 2024



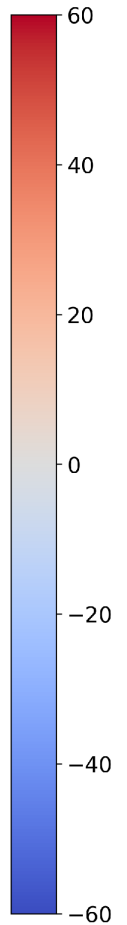
Anomaly of Sunshine Duration for February 2024



Anomaly of Sunshine Duration for March 2024



SDU[h]



V† · D† - ĞŦICÖ

Eπ · D† - ĞŦICÖ

_ † - ÆÄICÖ

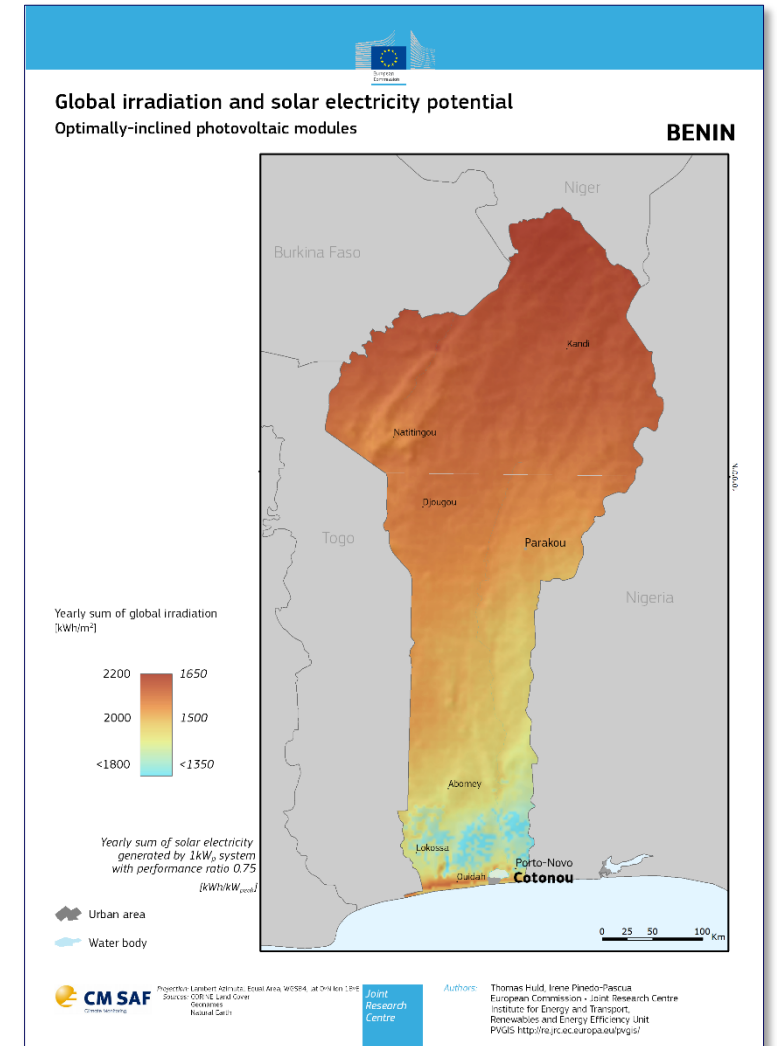
- Temperature increases in Africa slightly above global average
- Multi-year droughts continued in northwest Africa in 2023
- Extreme floods caused severe losses and damages
- African countries face increasing climate change bill
- Investment in early warnings will protect lives and economies

<https://wmo.int/publication-series/state-of-climate-africa-2023>



Application Example

- ➔ Photovoltaic Geographical Information System (**PVGIS**)
- ➔ Provides information on solar radiation and photovoltaic system performance for any location in the world
- ➔ Applies CM SAF SARA solar radiation data



Application Example: PV GIS

PHOTOVOLTAIC GEOGRAPHICAL INFORMATION SYSTEM

European Commission

European Commission > EU Science Hub > PVGIS > Interactive tools

Home Tools Downloads Documentation Contact us

Cursor: 6.348, 2.405
 Selected: 6.348, 2.405
 Elevation (m): 4
 PVGIS ver.: 5.2

Use terrain shadows:
 Calculated horizon
 Upload horizon file

Buttons: csv, json, Durchsuchen..., Keine Datei ausgewählt, Switch to version 5.1

PERFORMANCE OF GRID-CONNECTED PV

GRID CONNECTED

TRACKING PV OFF-GRID MONTHLY DATA DAILY DATA HOURLY DATA TMY

Solar radiation database* PVGIS-SARAH2
 PV technology* Crystalline silicon
 Installed peak PV power [kWp]* 1
 System loss [%]* 14

Fixed mounting options

Mounting position* Free-standing
 Slope [°]* 35
 Azimuth [°]* 0
 Optimize slope
 Optimize slope and azimuth

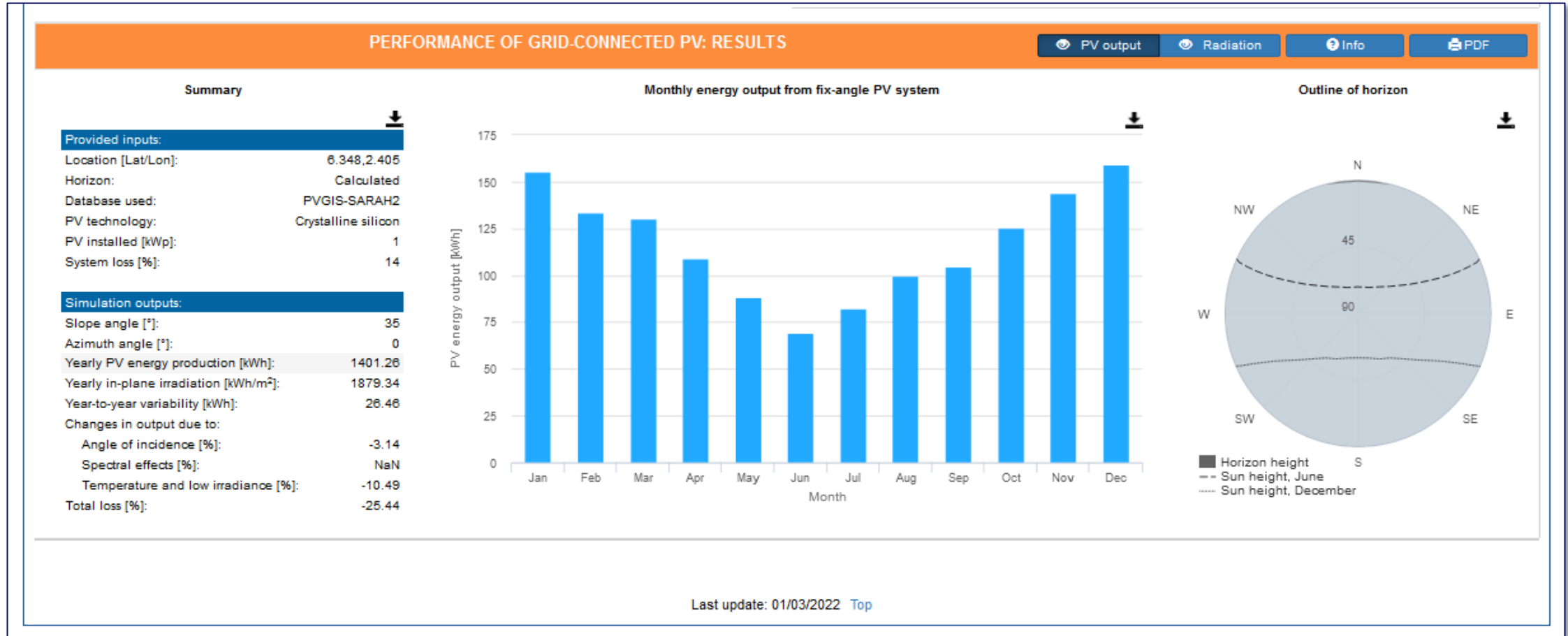
PV electricity price

PV system cost (your currency)
 Interest [%/year]
 Lifetime [years]

Address: Eg. Ispra, Italy Go! Lat/Lon: Eg. 45.815 Eg. 8.611 Go!

Buttons: Visualize results, csv, json

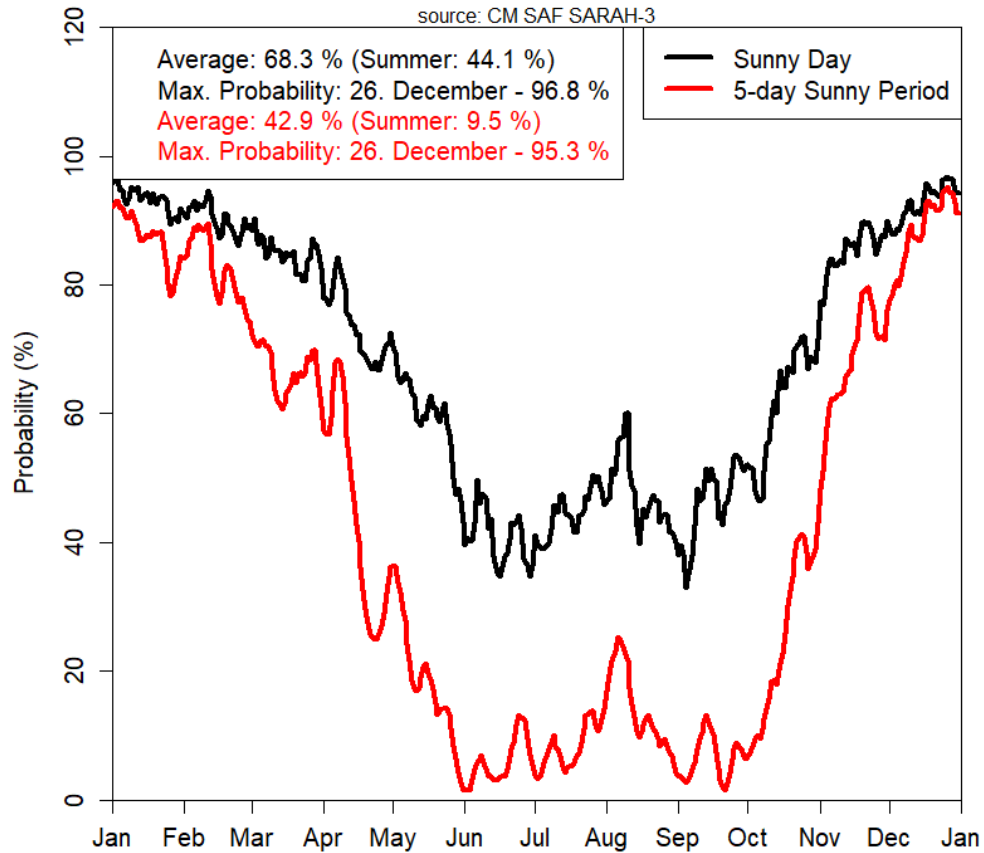
Application Example: PV GIS



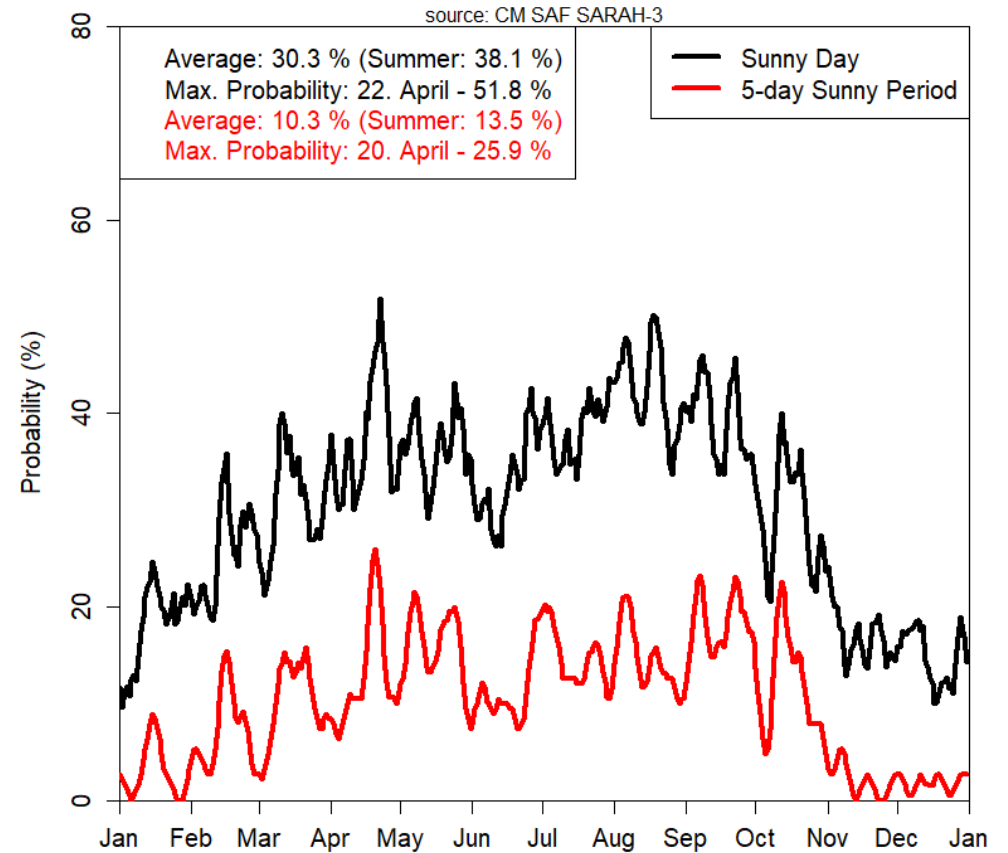
Application Example: Sunny Days

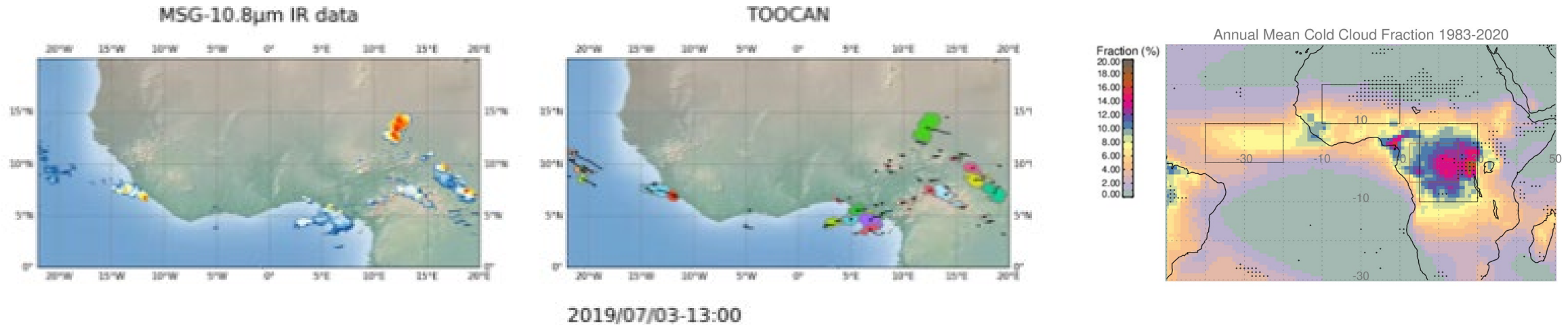
www.cmsaf.eu/SunnyDays

Probability of Sunny Days / Periods, Cotonou



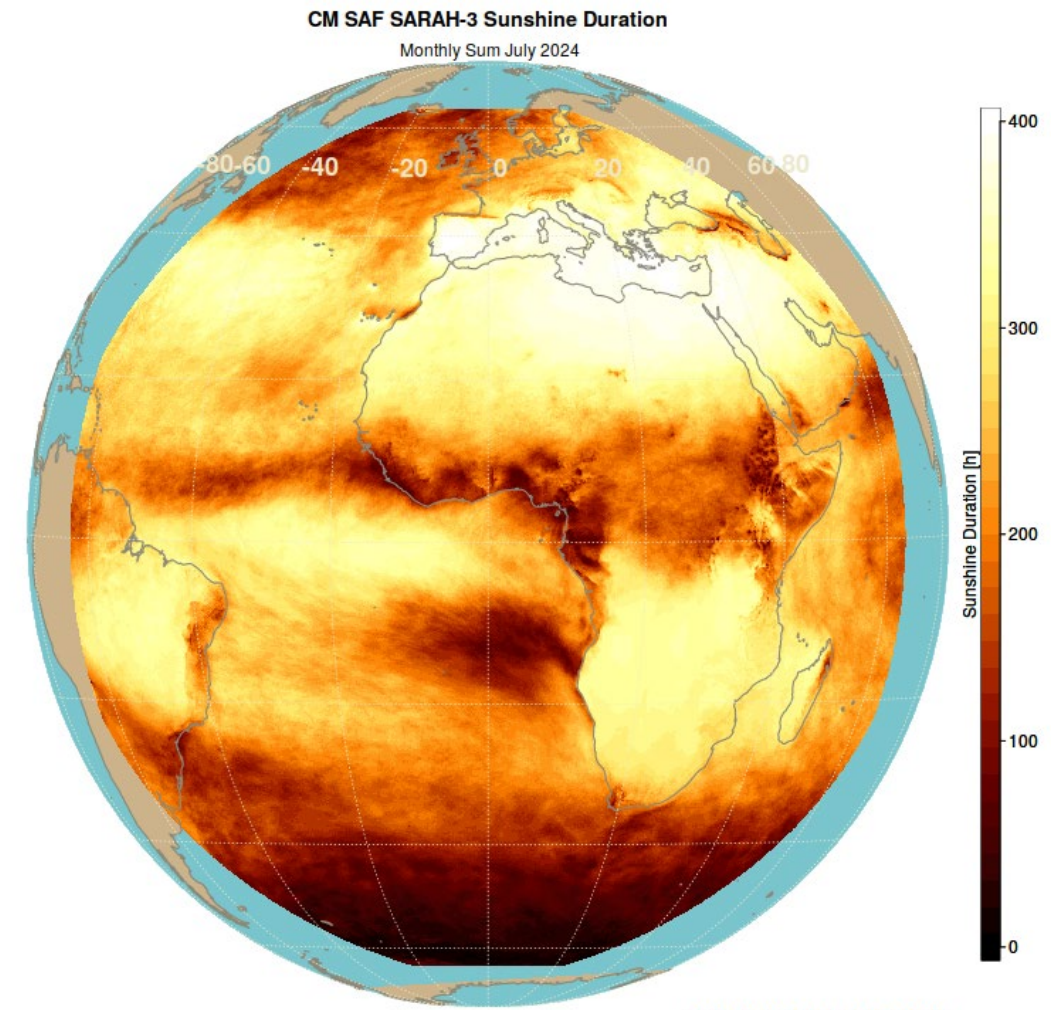
Probability of Sunny Days / Periods, Frankfurt



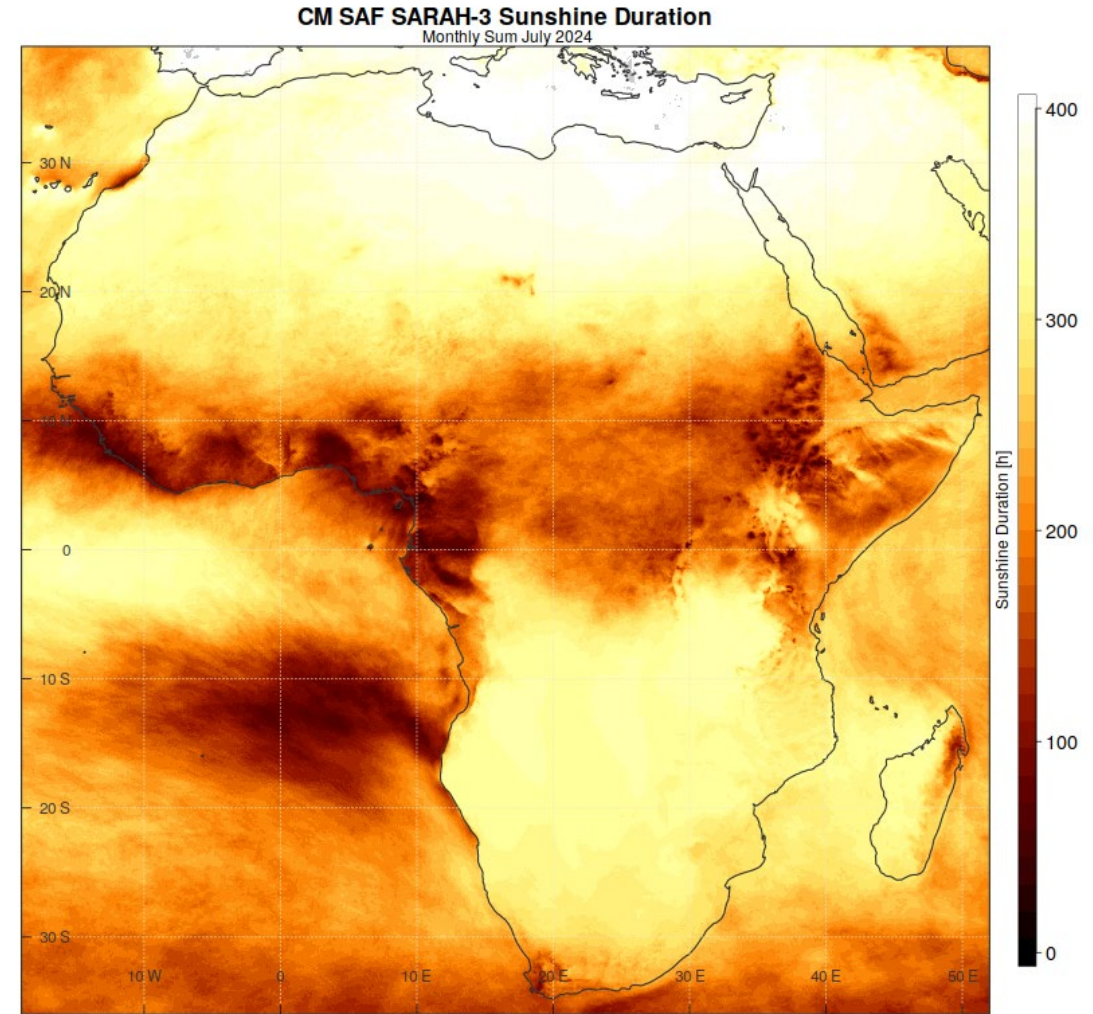


- 40+ year Meteosat data based climatology of Mesoscale Convective Systems
- TOOCAN algorithm was developed to track and characterise MCSs
- Found redistribution of the MCS occurrences towards shorter and smaller MCS?

- High quality data with excellent spatial and temporal coverage of the African continent

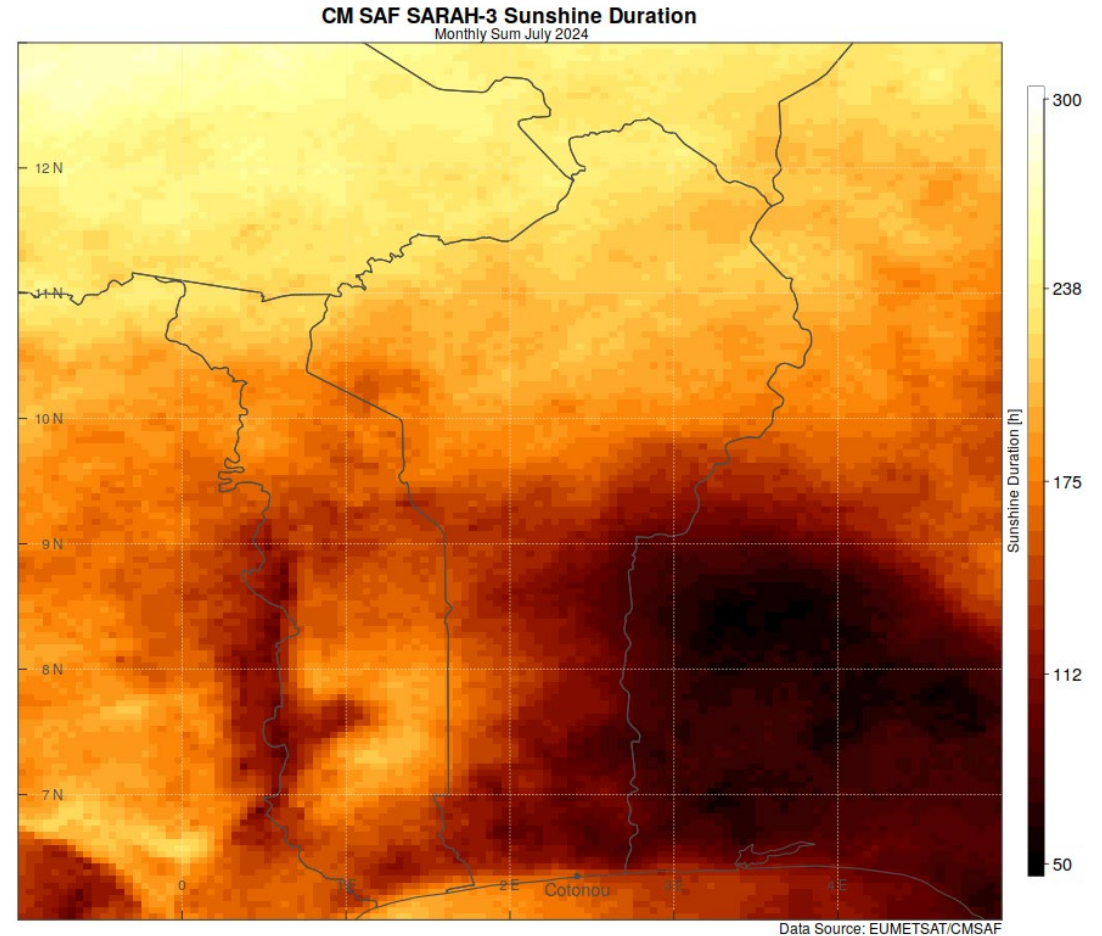


- High quality data with excellent spatial and temporal coverage of the African continent
- Seamless coverage
 - Complement station data
 - Evaluate station data
 - Suitable for many applications

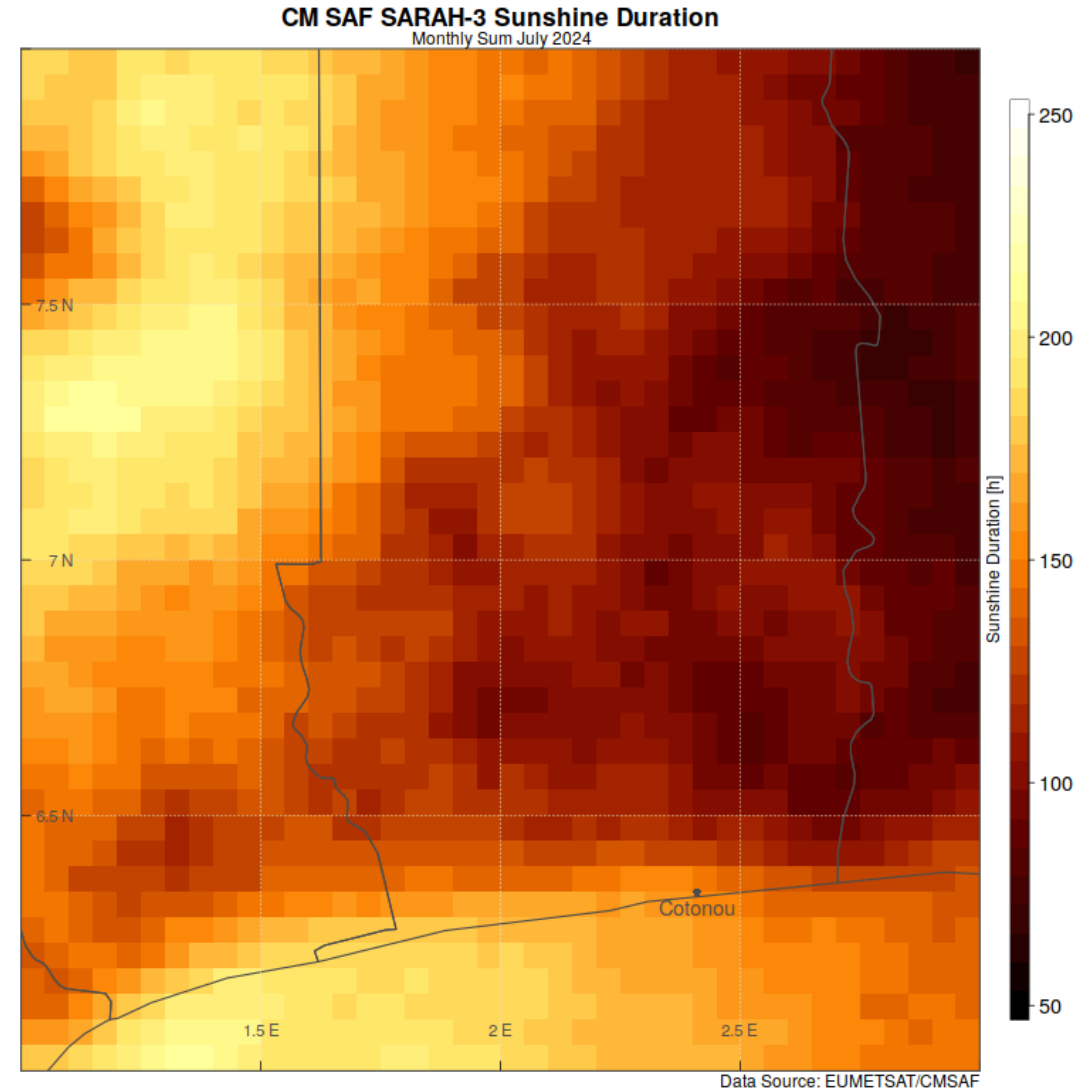


Data Source: EUMETSAT/CMSAF

- High quality data with excellent spatial and temporal coverage of the African continent
- Seamless coverage
 - Complement station data
 - Evaluate station data
 - Suitable for many applications
- Easy to get and to work with



- High quality data with excellent spatial and temporal coverage of the African continent
- Seamless coverage
 - Complement station data
 - Evaluate station data
 - Suitable for many applications
- Easy to get and to work with
- Support and training



Summary

- EUMETSAT and its SAFs offer a wide range of Climate Data Records
- Thoroughly quality assurance and control mechanisms
- Extensive exchange and support with / of users
- Free and uncomplicated data access + free tools to work with data
- Data excellent suited for applications in Africa

Contact data:

www.cmsaf.eu

contact.cmsaf@dwd.de

Steffen.Kothe@dwd.de

