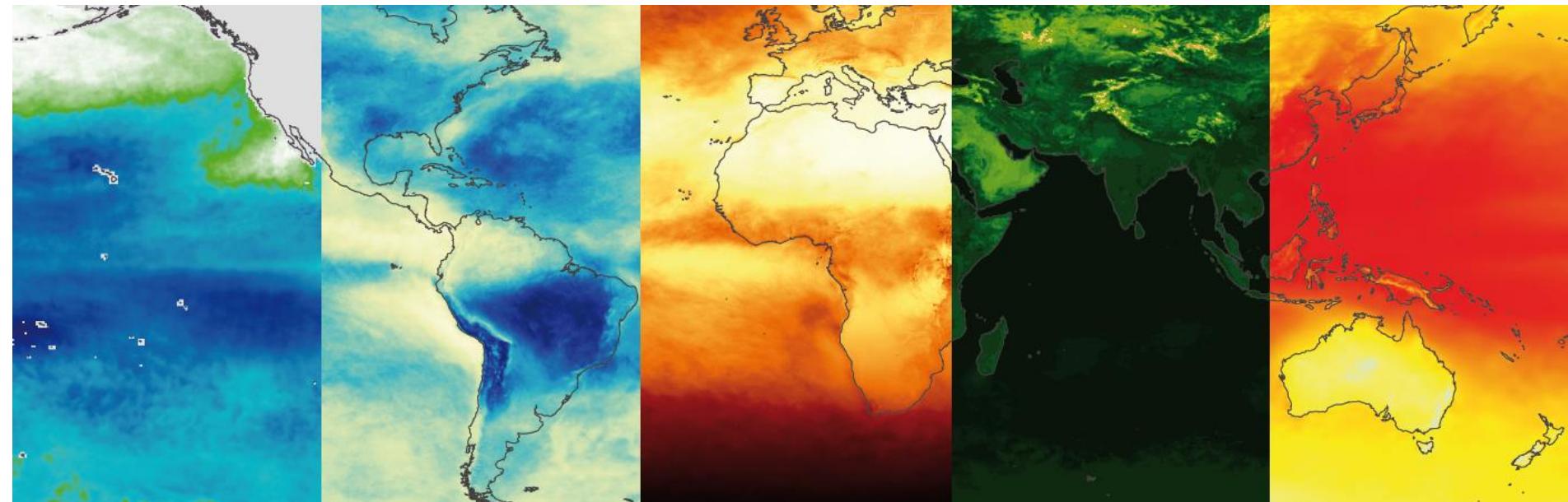


# Satellite Application Facility on Climate Monitoring

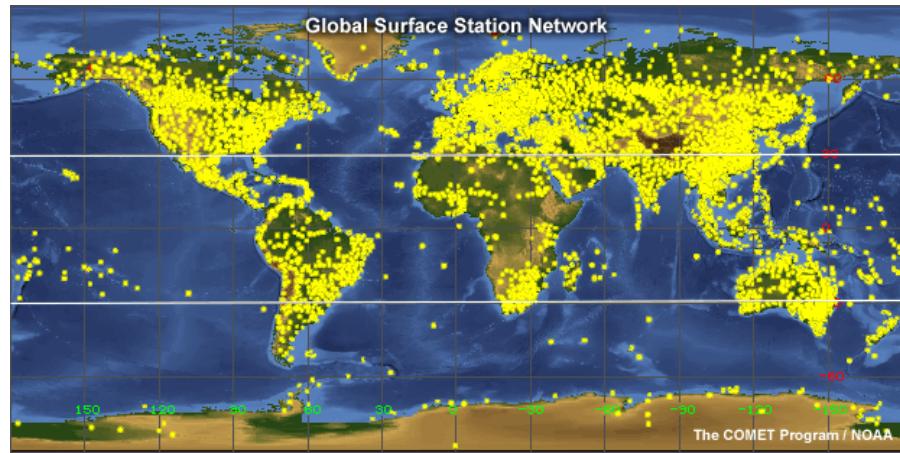
## - Climate Data Records and Services -

Steffen Kothe and CM SAF Team

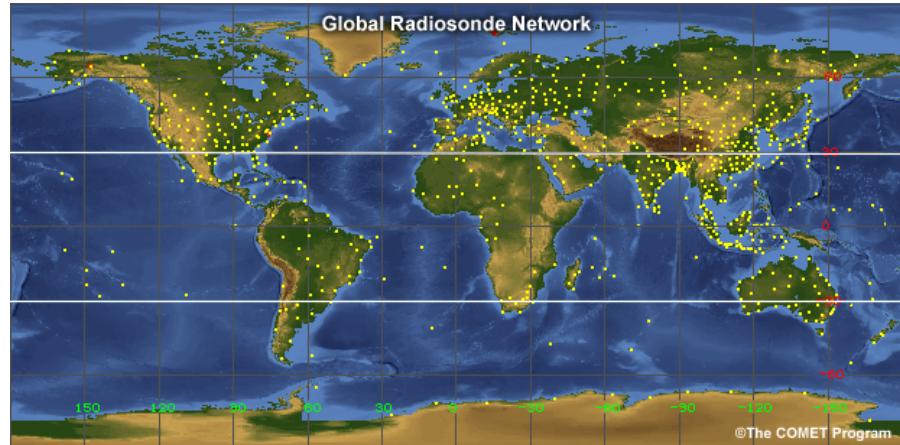


# Climate Monitoring

- State of climate system
- Better understanding of climate change



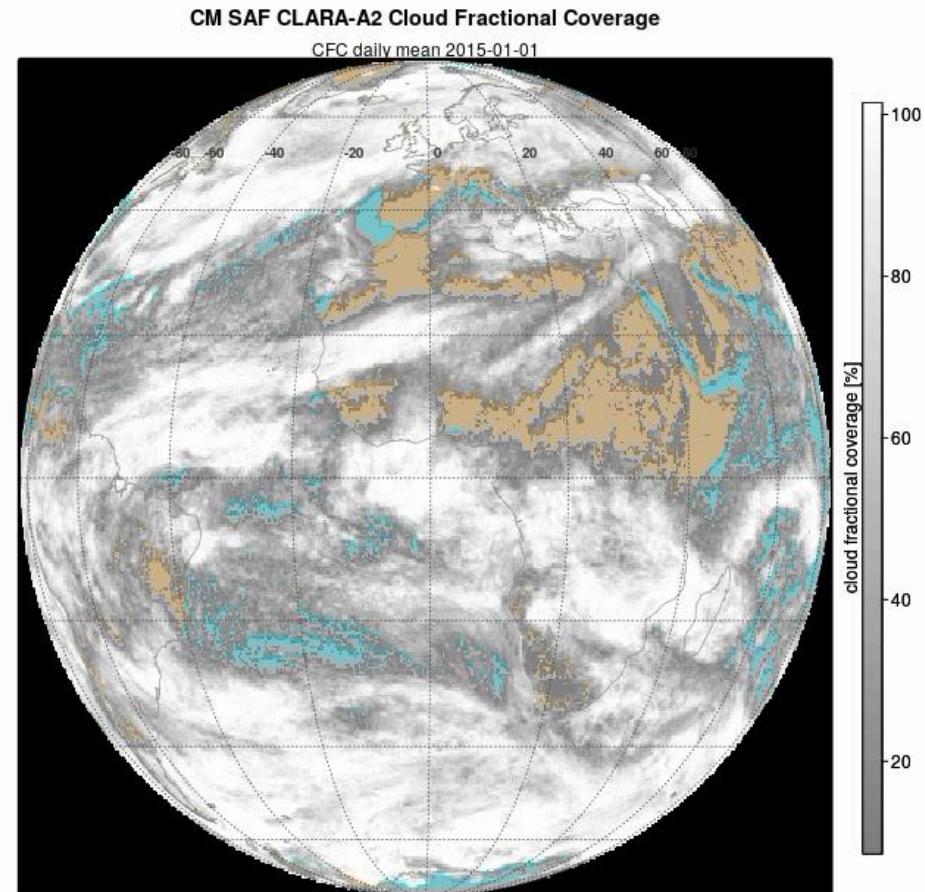
Global Station Network



Global Radiosonde Network

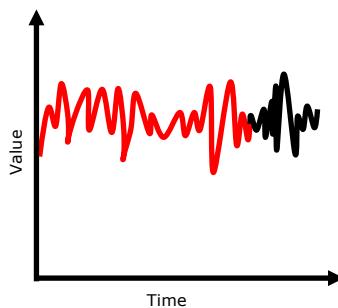
# Climate Monitoring

- State of climate system
- Better understanding of climate change
- Basis are in situ measurements and more and more satellite-based data

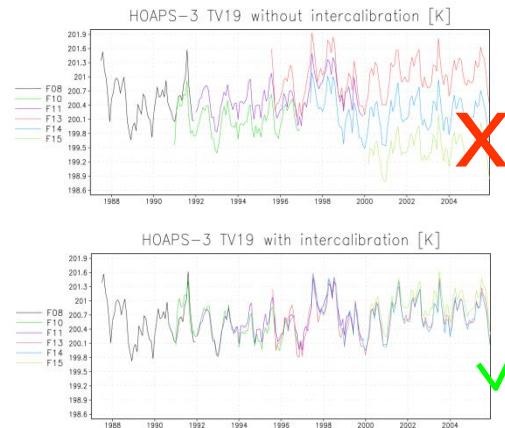


Global Coverage of Satellites

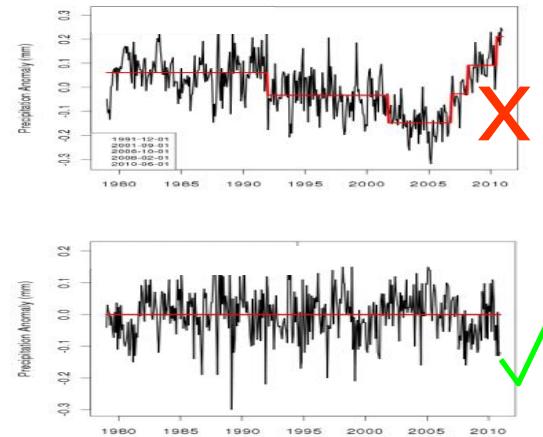
# Requirements for Climate Data



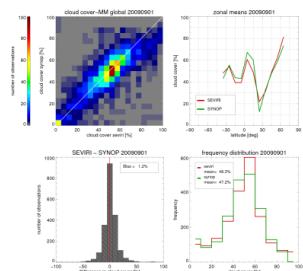
Long-term time series



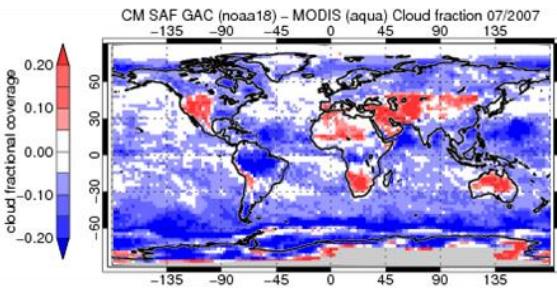
Calibration



Homogeneity

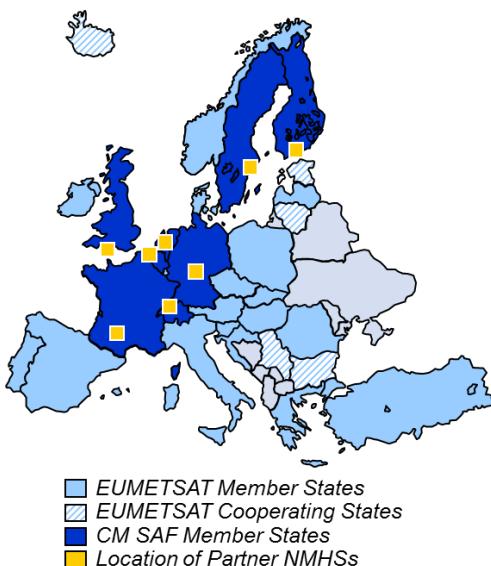


Quality control



## Mandat

*The EUMETSAT Satellite Application Facility on Climate Monitoring develops, generates, archives and distributes high-quality satellite-derived products of the energy & water cycle in support to monitor, understand and adapt to climate variability and climate change.*



### Partners:

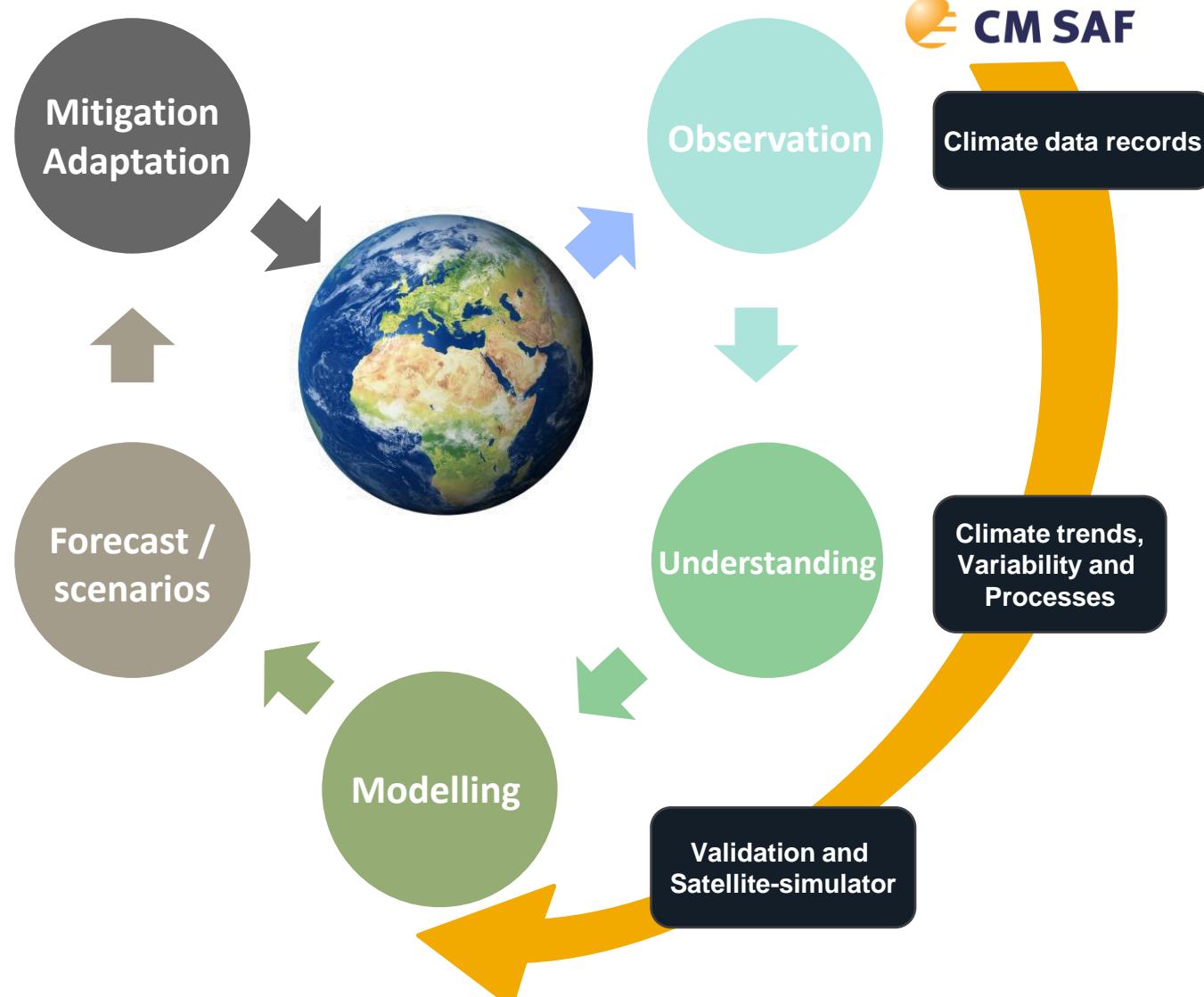
**Deutscher Wetterdienst**  
Wetter und Klima aus einer Hand



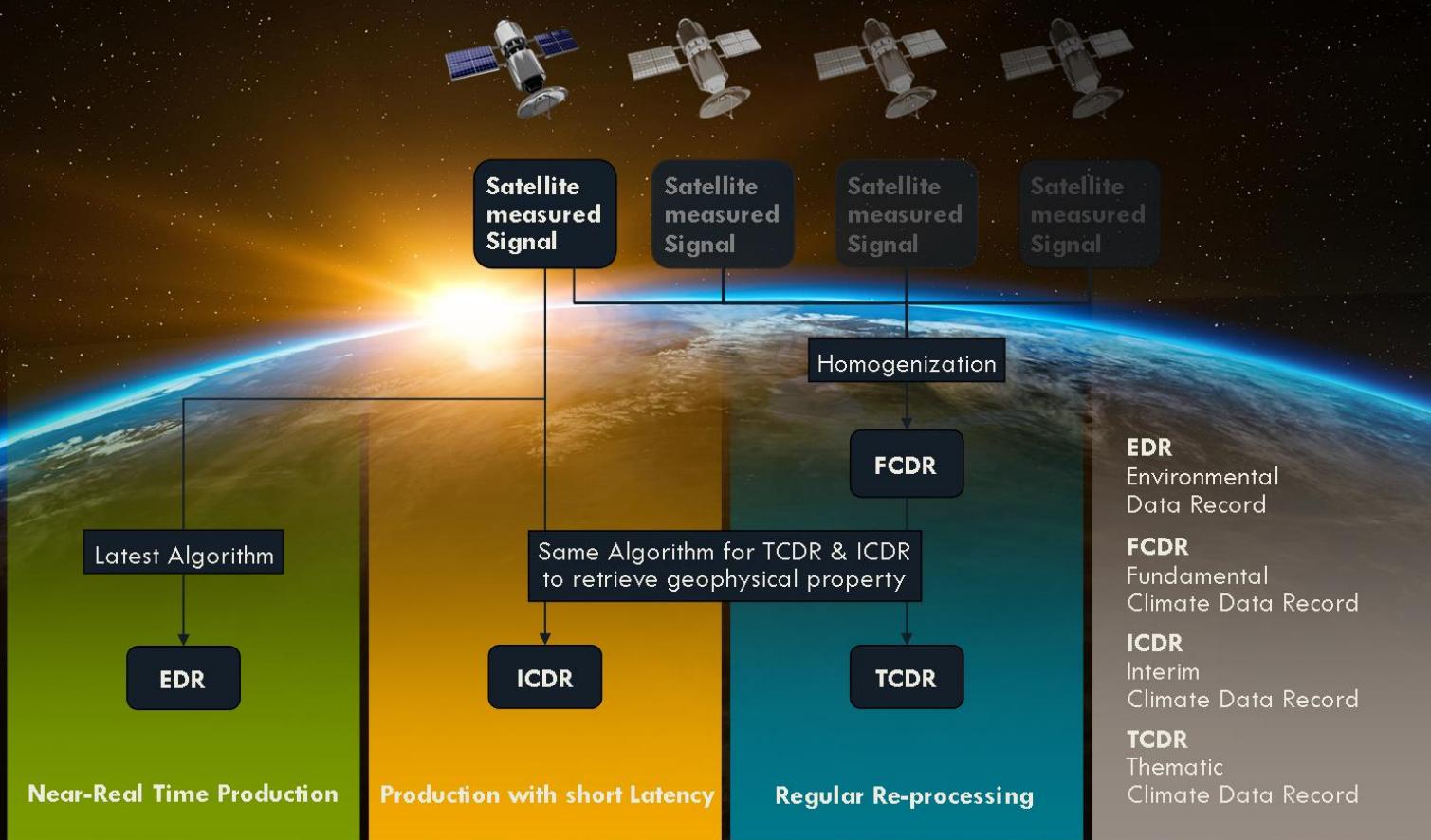
Royal Netherlands  
Meteorological Institute  
Ministry of Transport, Public Works  
and Water Management



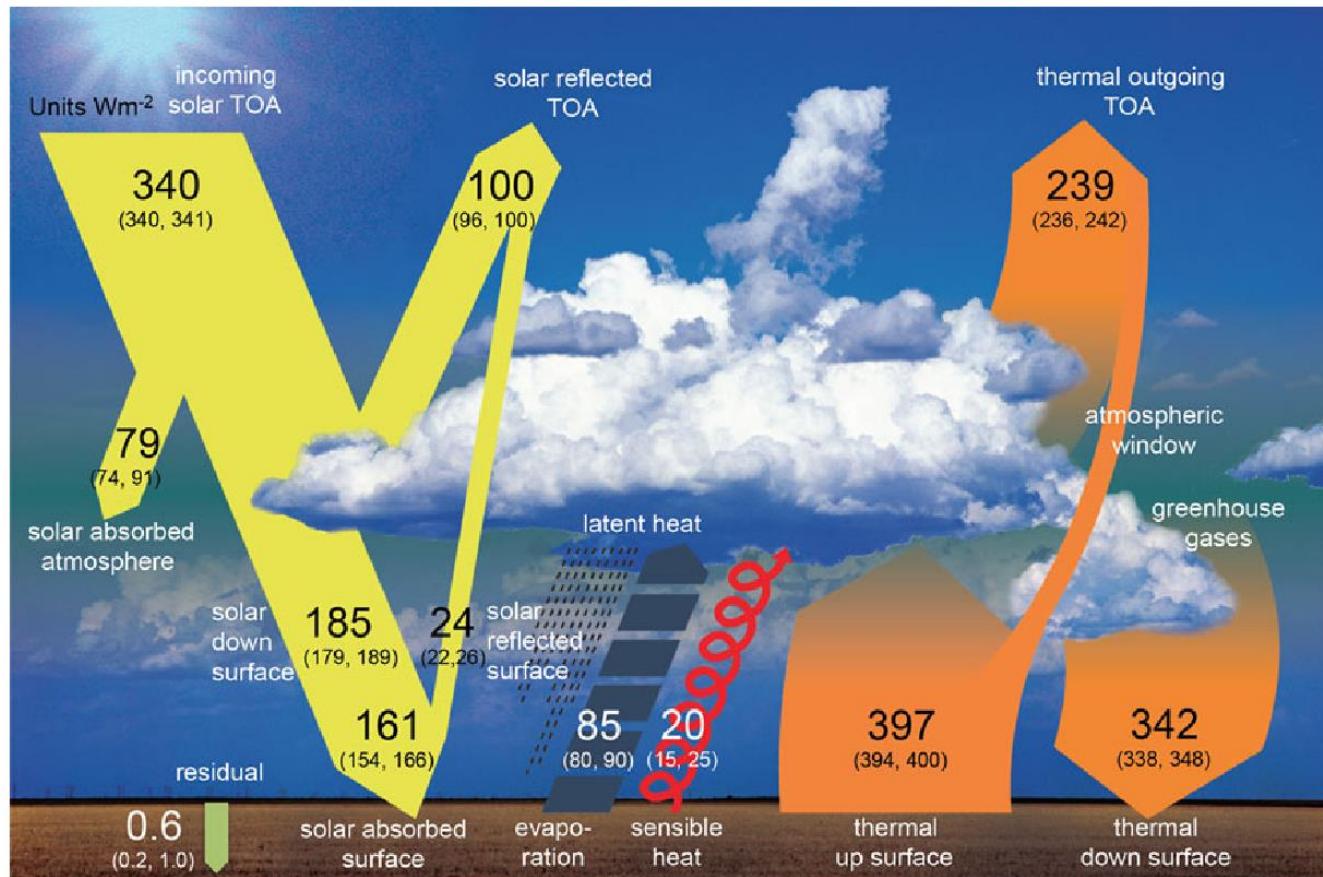
Centre National de la recherche scientifique



## Satellite-based Climate Data Records

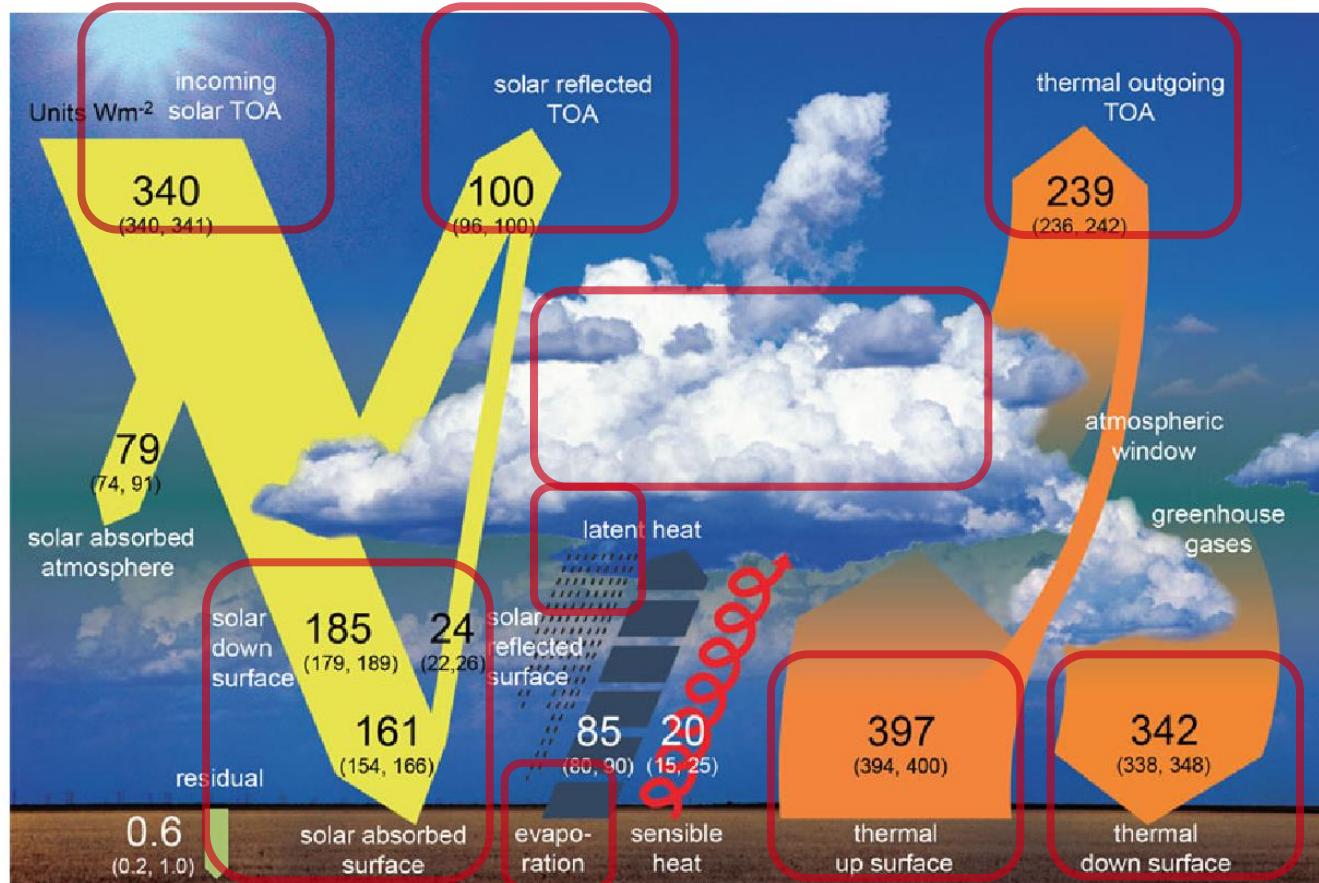


# Global Energy and Water Cycle



Source:  
Wild et al., 2013

# Global Energy and Water Cycle



Source:  
Wild et al., 2013

## CLAAS-2

### → Variables

- Cloud properties
- Liquid and ice water path

### → Resolution

- Spatial: native,  $0.05^\circ \times 0.05^\circ$  ( $0.25^\circ \times 0.25^\circ$ )
- Temporal: 15 min, hourly-, daily-, monthly means, mean monthly diurnal cycle

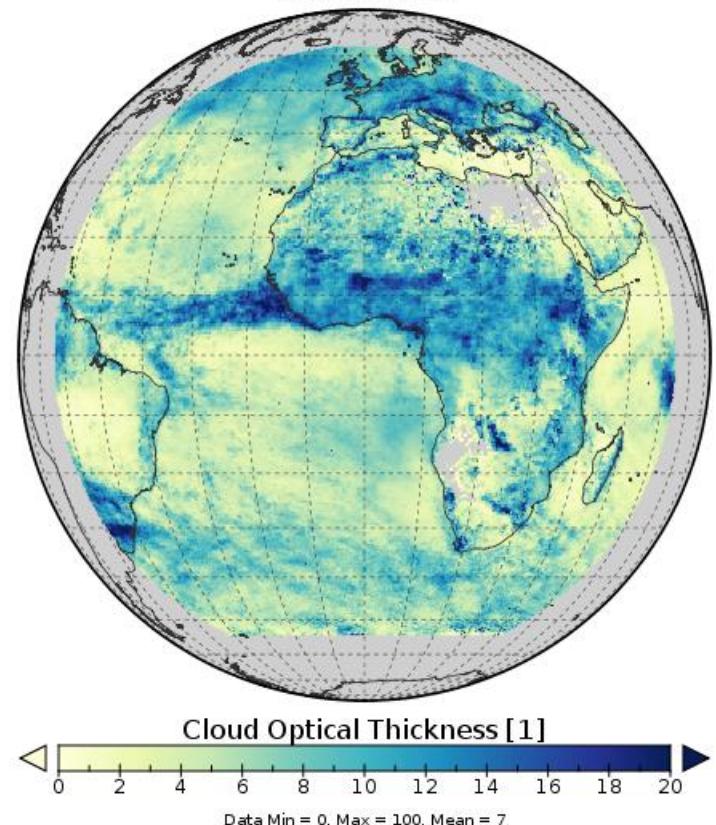
### → Coverage

- Spatial: Meteosat disk
- Temporal: 2004 to 2015

### → Satellites

- Meteosat Second Generation (SEVIRI)

CM SAF CLAAS Cloud Optical Thickness  
Mean July 2008



DOI:10.5676/EUM\_SAF\_CM/CLAAS/V002

# CLARA-A2

## → Variables

- Cloud properties
- Surface albedo
- Radiation

## → Resolution

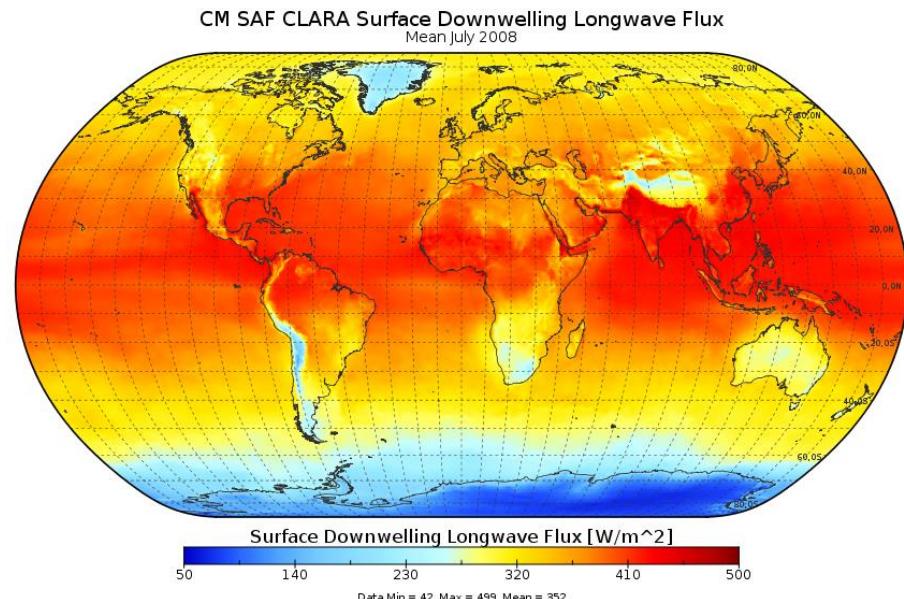
- Spatial:  $0.25^\circ \times 0.25^\circ$
- Temporal: daily-, pentad-, monthly mean

## → Coverage

- Spatial: global
- Temporal: 1982 to 2015

## → Satellites

- NOAA, Metop (AVHRR)



DOI:10.5676/EUM\_SAF\_CM/CLARA\_AVHRR/V002

# HOAPS

## → Variables

- Wind, humidity (close to surface)
- Precipitation, evaporation
- Latent heat flux
- Fresh water flux

## → Resolution

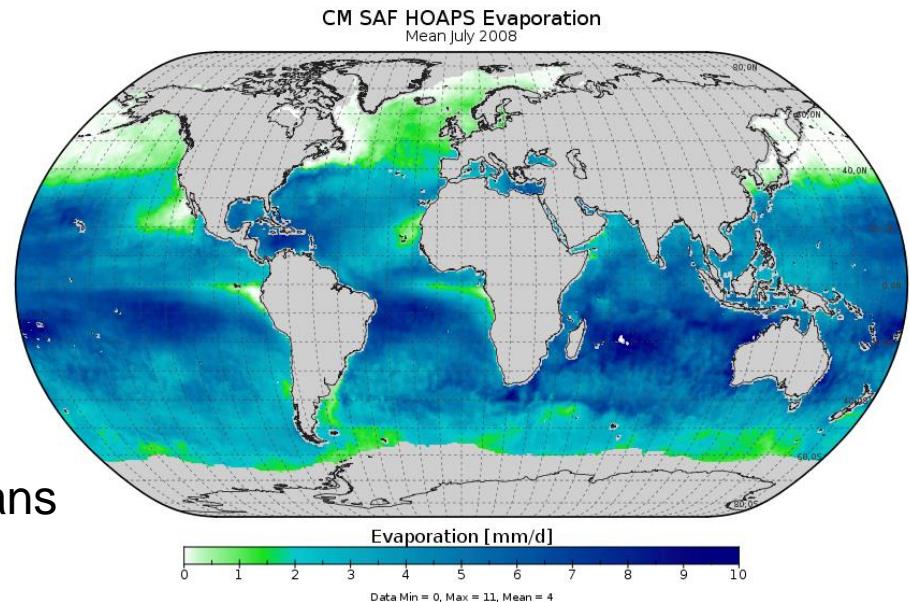
- Spatial:  $0.5^\circ \times 0.5^\circ$
- Temporal: 6-hourly-, monthly means

## → Coverage

- Spatial: global ice free ocean
- Temporal: 1987 to 2014

## → Satellites

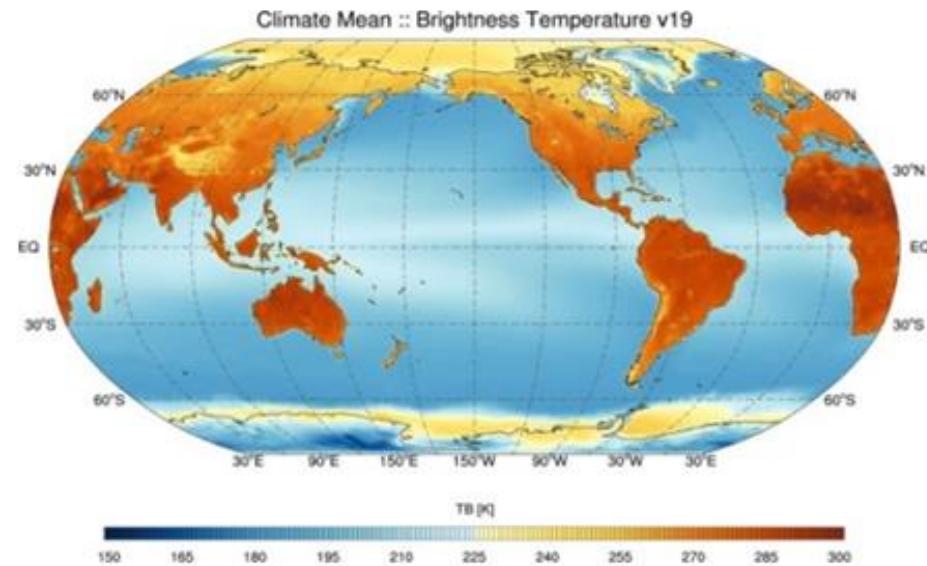
- DMSP (SSM/I, SSMIS), SMMR



DOI:10.5676/EUM\_SAF\_CM/HOAPS/V002

# FCDR SSM/I

- **Variables**
  - Brightness temperature
- **Resolution**
  - Spatial: native SSM/I
  - Temporal: native SSM/I
- **Coverage**
  - Spatial: global
  - Temporal: 1978 to 2013
- **Satellites**
  - DMSP (SSM/I, SSMIS), SMMR



DOI:10.5676/EUM\_SAF\_CM/FCDR\_MWI/V002

# SUMET

## → Variables

- Land surface temperature basing on physical model (LTP)
- Land surface temperature basing on statistical model (LTS)

## → Resolution

- Spatial:  $0.05^\circ \times 0.05^\circ$
- Temporal: hourly instantaneous, monthly mean diurnal cycle

## → Coverage

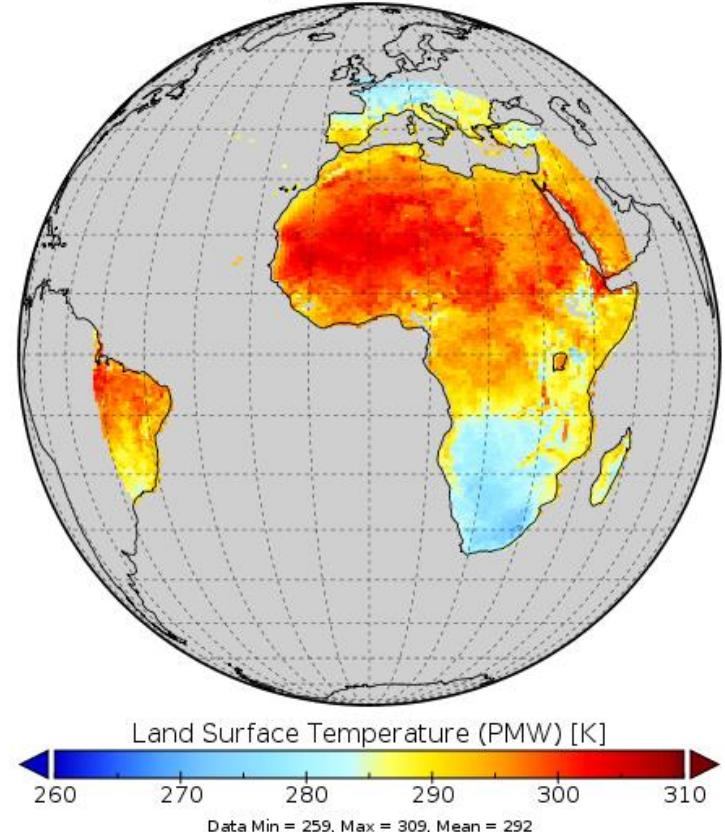
- Spatial: Meteosat disk
- Temporal: 1991 to 2015

## → Satellites

- Meteosat (M VIRI/SEVIRI)

CM SAF SUMET Land Surface Temperature

Monthly Mean June 1991 00:00



DOI:10.5676/EUM\_SAF\_CM/LST\_METEOSAT/V001

# COMET

## → Variables

→ Fractional cloud cover (CFC)

## → Resolution

→ Spatial:  $0.05^\circ \times 0.05^\circ$

→ Temporal: hourly instantaneous,  
daily and monthly means,  
monthly mean diurnal cycle

## → Coverage

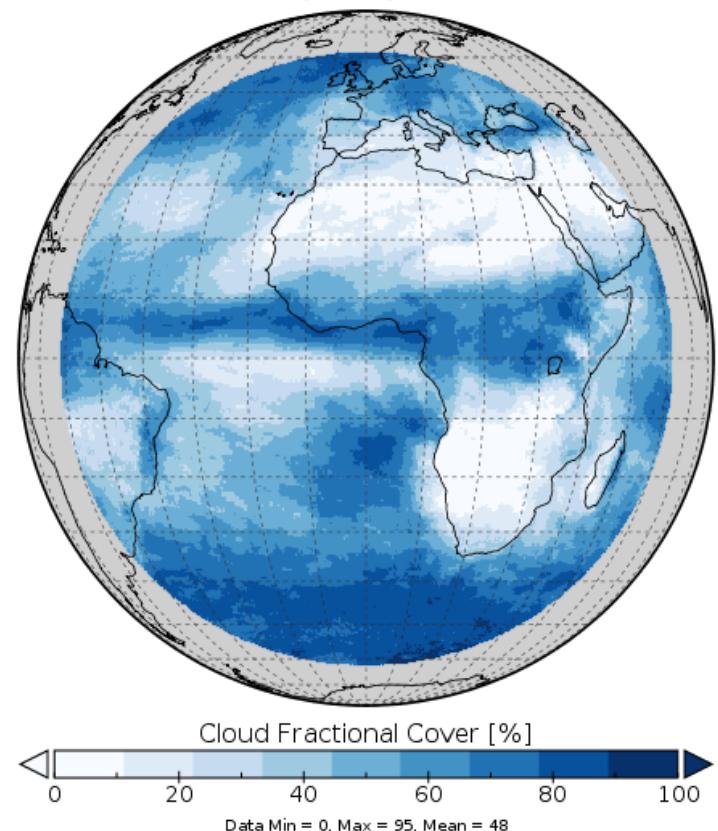
→ Spatial: Meteosat disk

→ Temporal: 1991 to 2015

## → Satellites

→ Meteosat (M VIRI/SEVIRI)

CM SAF COMET Cloud Fractional Cover  
Monthly Mean June 2015



DOI:10.5676/EUM\_SAF\_CM/CFC\_METEOSAT/V001

## CM SAF AOD

### → Variables

→ Aerosol Optical Depth (AOD)

### → Resolution

→ Spatial: native

→ Temporal: daily and monthly means

### → Coverage

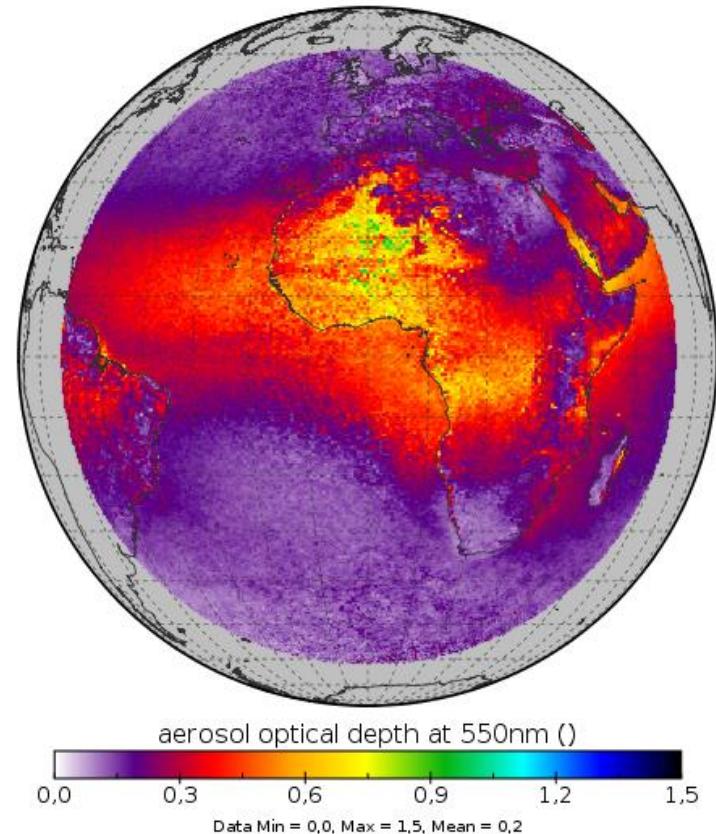
→ Spatial: Meteosat disk

→ Temporal: 02/2004 to 12/2012

### → Satellites

→ Meteosat Second Generation (SEVIRI)

CM SAF aerosol optical depth at 550nm  
Mean 2012



DOI:10.5676/EUM\_SAF\_CM/MSG\_AOD/V001

# TOA Radiation

## → Variables

- TOA reflected solar (TRS)
- TOA emitted thermal (TET)

## → Resolution

- Spatial:  $0.05^\circ \times 0.05^\circ$
- Temporal: daily and monthly means,  
monthly means of hourly means

## → Coverage

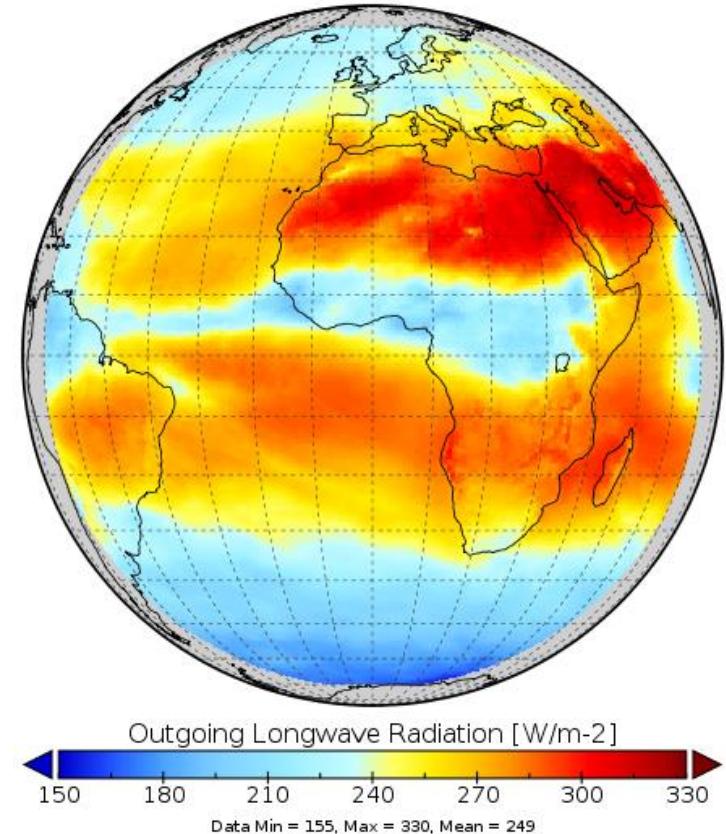
- Spatial: Meteosat disk
- Temporal: 2004 to 2015

## → Satellites

- Meteosat (GERB/SEVIRI)

CM SAF TOA Outgoing Longwave Radiation

Monthly Mean June 2014



DOI:10.5676/EUM\_SAF\_CM/CFC\_METEOSAT/V001

# SARAH-2

## → Variables

- Global radiation (SIS)
- Surface direct irradiance (SDI)
- Spectral resolved irradiance (SRI)
- Effective cloud albedo (CAL)

## → Resolution

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

## → Coverage

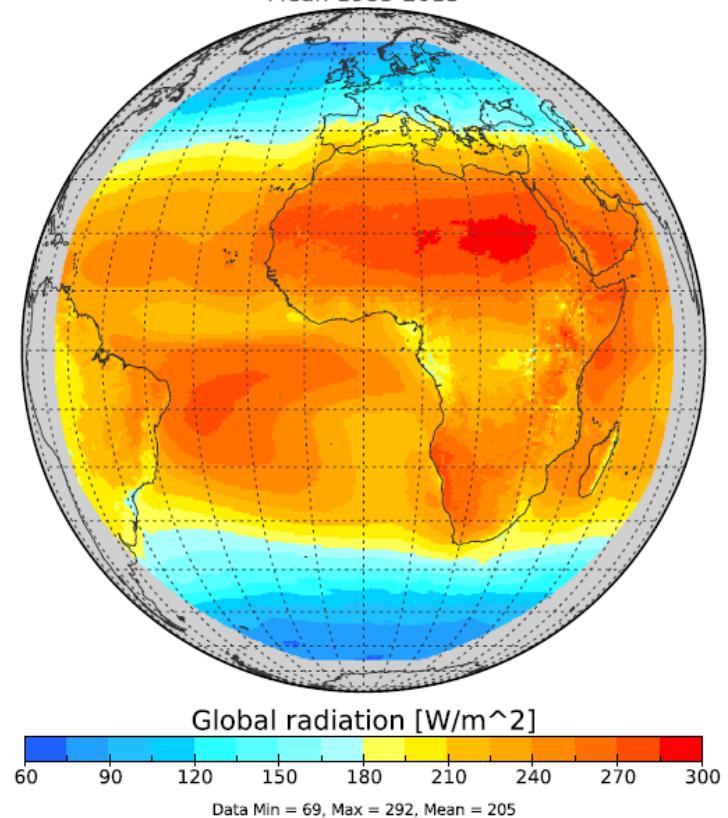
- Spatial: Meteosat disk
- Temporal: 1983 to 2015

## → Satellites

- Meteosat 2 to 10 (M VIRI/SE VIRI)

CM SAF SARAH Solar Surface Irradiance

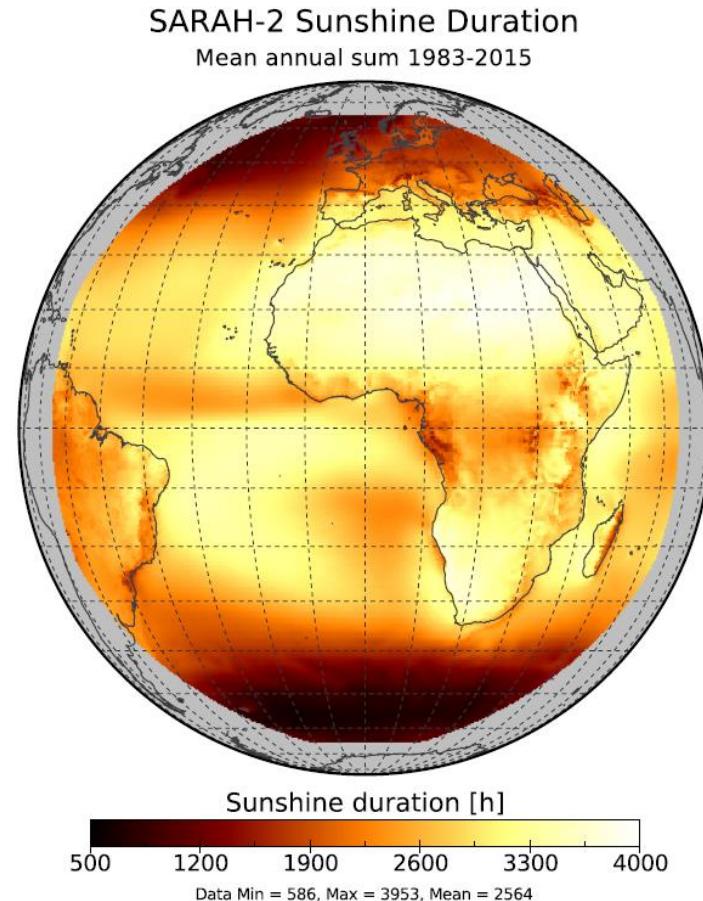
Mean 1983-2013



DOI:10.5676/EUM\_SAF\_CM/SARAH/V002

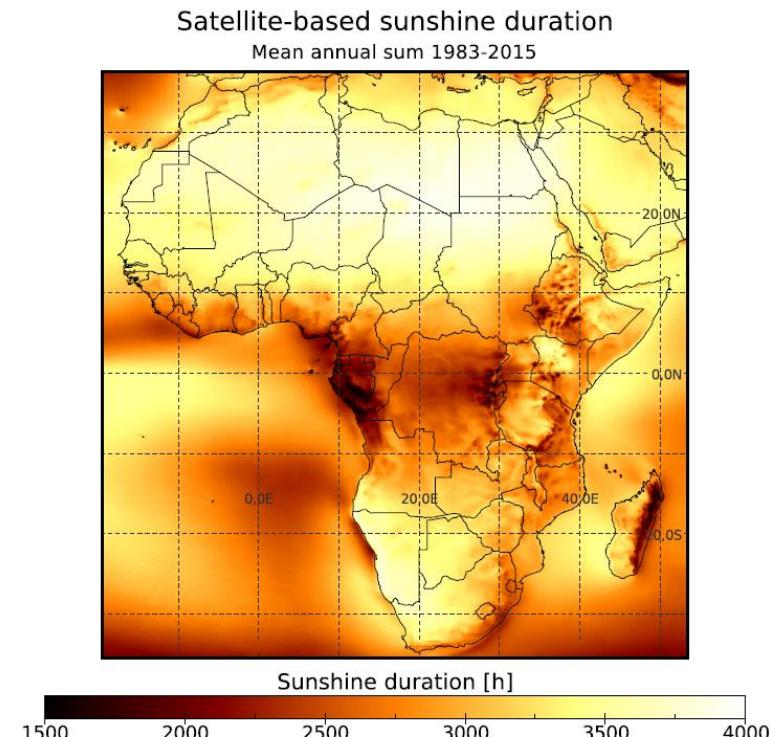
# SARAH-2 Sunshine Duration

- Sunshine duration important parameter
  - Tourism
  - Health Sector
  - Agriculture
  - Vegetation modelling
  - Solar energy



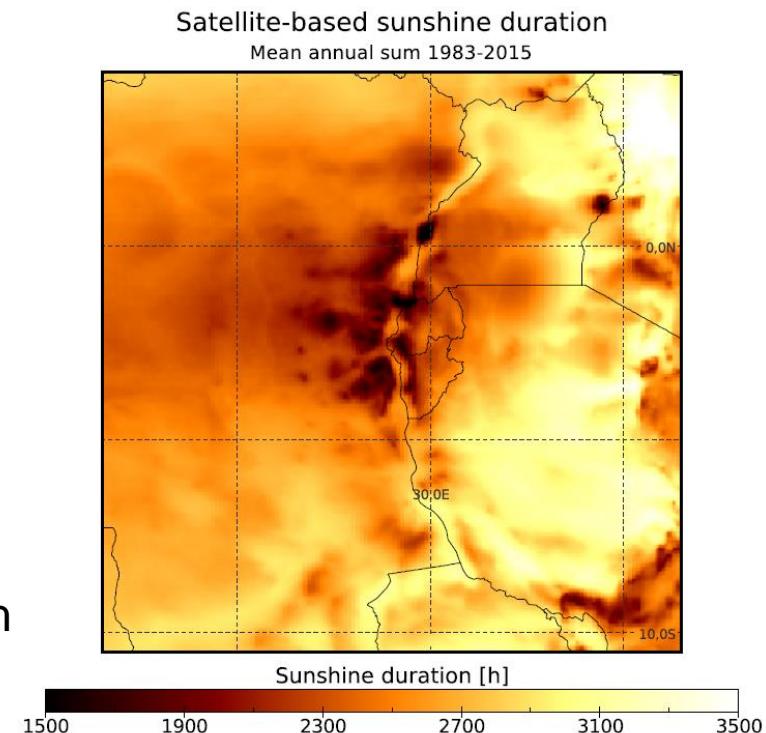
# SARAH-2 Sunshine Duration

- Sunshine duration important parameter
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- First satellite-based sunshine duration dataset for Europe and Africa



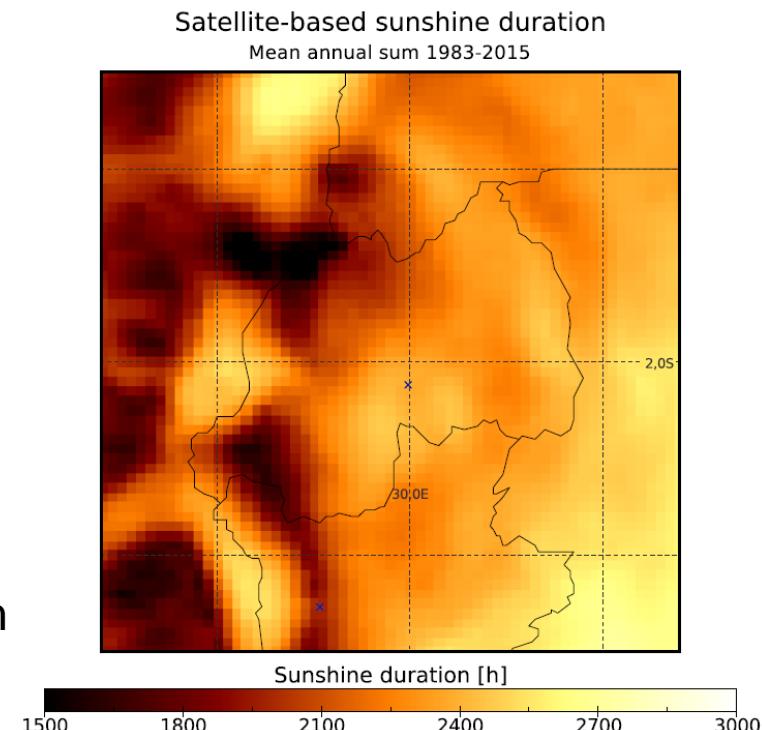
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- Sunshine duration important parameter
  - Tourism
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  - Agriculture
  - Vegetation modelling
  - Solar energy
- First satellite-based sunshine duration dataset for Europe and Africa
  - Basis SARAH-2 DNI data
  - Evaluation showed good agreement with station data (< 9 %)



# SARAH-2 Sunshine Duration

- Sunshine duration important parameter
  - Tourism
  - Health Sector
  - Agriculture
  - Vegetation modelling
  - Solar energy
- First satellite-based sunshine duration dataset for Europe and Africa
  - Basis SARAH-2 DNI data
  - Evaluation showed good agreement with station data (< 9 %)
  - Suitable for many applications



## Available CM SAF CDR's

Sensor, Satellite resp.	Parameter	CDR Period	Coverage
<b>Fundamental Climate Data Record (FCDR)</b>			
<b>SMMR, SSM/I, SSMIS</b>	<b>Microwave Radiances</b>	1978 – 2013	global
<b>Climate Data Record (CDR)</b>			
<b>SEVIRI</b>	<b>Cloud parameters (frac., height, opt. dep., phase, eff. Rad., LWP, IWP), AOD</b>	2004 – 2015	Regional
<b>GERB/SEVIRI</b>	<b>Top of atmosphere radiative fluxes</b>	2004 – 2015	
<b>MVIRI/SEVIRI</b>	<b>TOA, surface radiation &amp; Cloud frac. Land Surface Temp Free tropospheric humidity</b>	1983 – 2015 1991 – 2015 1983 – 2009	
<b>AVHRR GAC</b>	<b>Cloud parameters, surface radiation parameters, incl. albedo</b>	1982 – 2015	Global
<b>SSM/I, SSMIS, SMMR</b>	<b>HOAPS 4 (precip, evap, hum., wind, ..) (Ice free ocean only)</b>	1987 – 2014	
<b>ATOVS</b>	<b>Water vapour and Temperature profile</b>	1998 – 2008	
<b>MSU, AMSU, SSM/T2, MHS</b>	<b>Upper troposphere humidity</b>	1993 – 2013	



## Committed CM SAF CDR's until 2022

Sensor, Satellite resp.	Parameter	CDR Period	Coverage
<b>Fundamental Climate Data Record (FCDR)</b>			
<b>SMMR, SSM/I, SSMIS</b>	<b>Microwave Radiances</b>	1978 – 2013	global
<b>Climate Data Record (CDR)</b>			
<b>Updated edition of SEVIRI</b>	Cloud parameters (frac., height, opt. dep., phase, eff. Rad., LWP, IWP)	2004 – 2020	Regional
<b>NEW: Global Precipitation</b>	Precipitation rate	2002 – 2019	
<b>Updated edition of MVIRI/SEVIRI</b>	TOA, surface radiation & Cloud frac. land surface temp, evapo. Free tropospheric humidity	1983 – 2020 1991 – 2020 1983 – 2020	
<b>Updated edition of AVHRR GAC</b>	Cloud parameters, surface radiation parameters, incl. albedo	1982 – 2020	Global
<b>Updated edition of SSM/I, SSMIS, TMI, GMI, AMSR-2</b>	HOAPS 4 (precip, evap, hum., wind, ..) <b>Ice free ocean only</b>	1987 – 2019	
<b>NEW: HIRS cloud properties</b>	Cloud fraction, cloud top pressure	1980 – 2013	
<b>Updated edition of MSU, AMSU, SSM/T2, MHS</b>	Upper troposphere humidity	1993 – 2020	

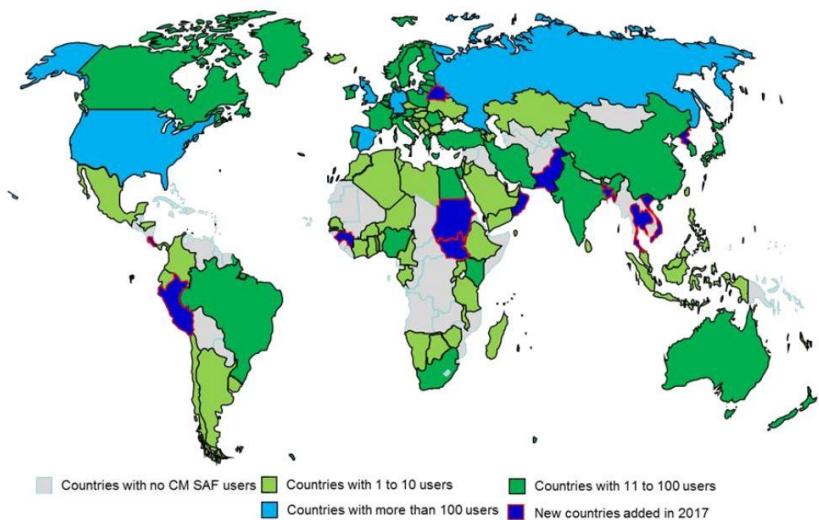
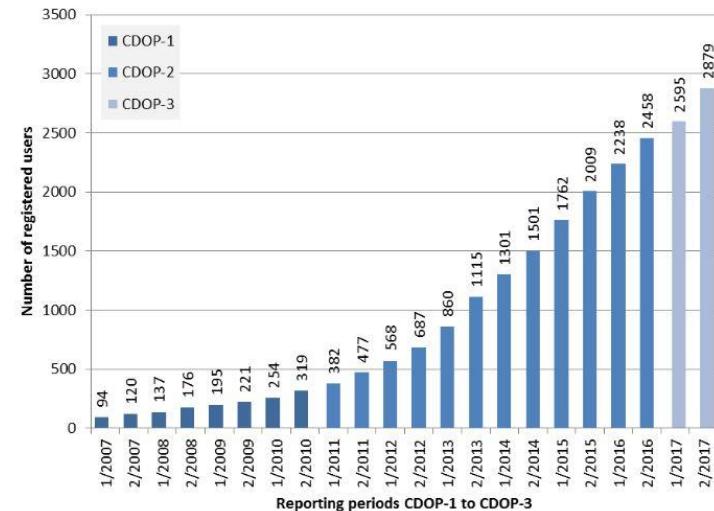
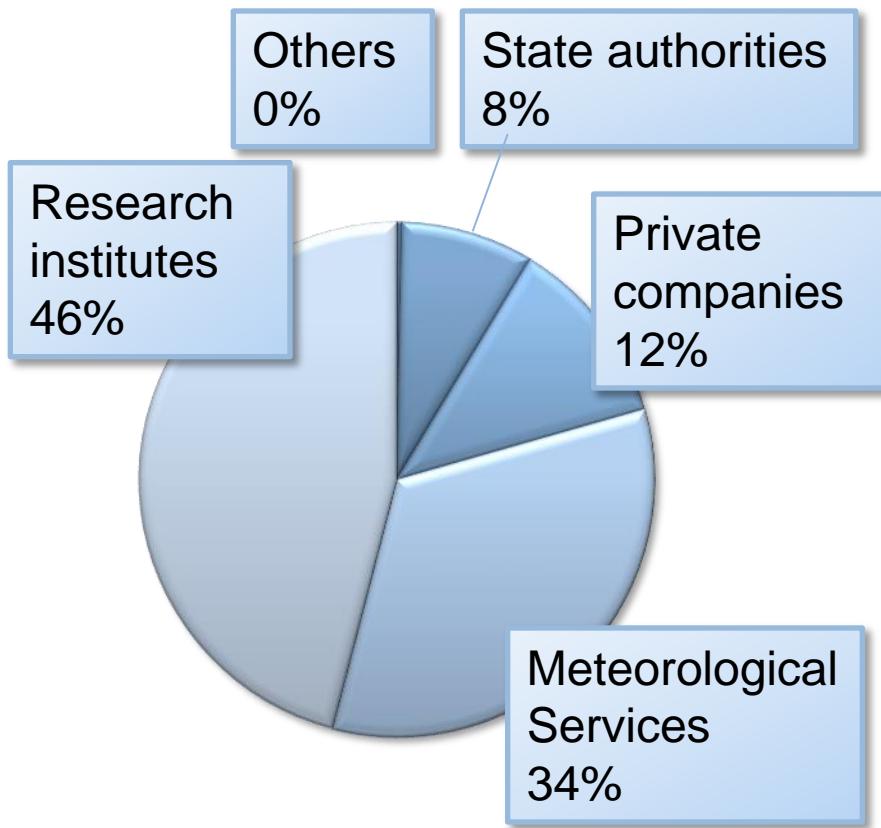


## Quality assurance

- Rigorous review cycle is 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



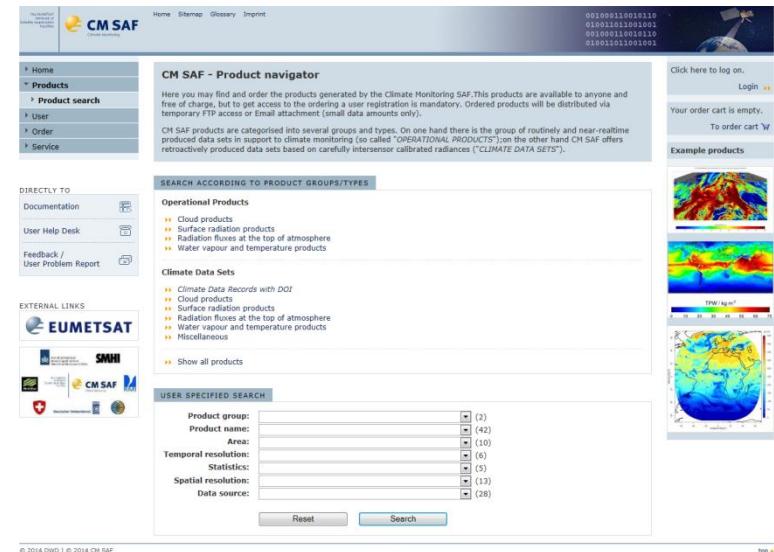
## CM SAF Users



# 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
- User Help Desk



<https://wui.cmsaf.eu>

## Data Access

### → EUMETCast

→ The following CM SAF products are disseminated via EUMETCast:

→ Monthly mean fractional cloud cover

→ Monthly mean surface incoming shortwave radiation

→ Product format is NetCDF

→ EUMETCast Africa:

→ Channel: SAF-Africa  
PID: 301

Multicast Address:  
224.223.222.33



<https://eoportal.eumetsat.int>

## R-Toolbox

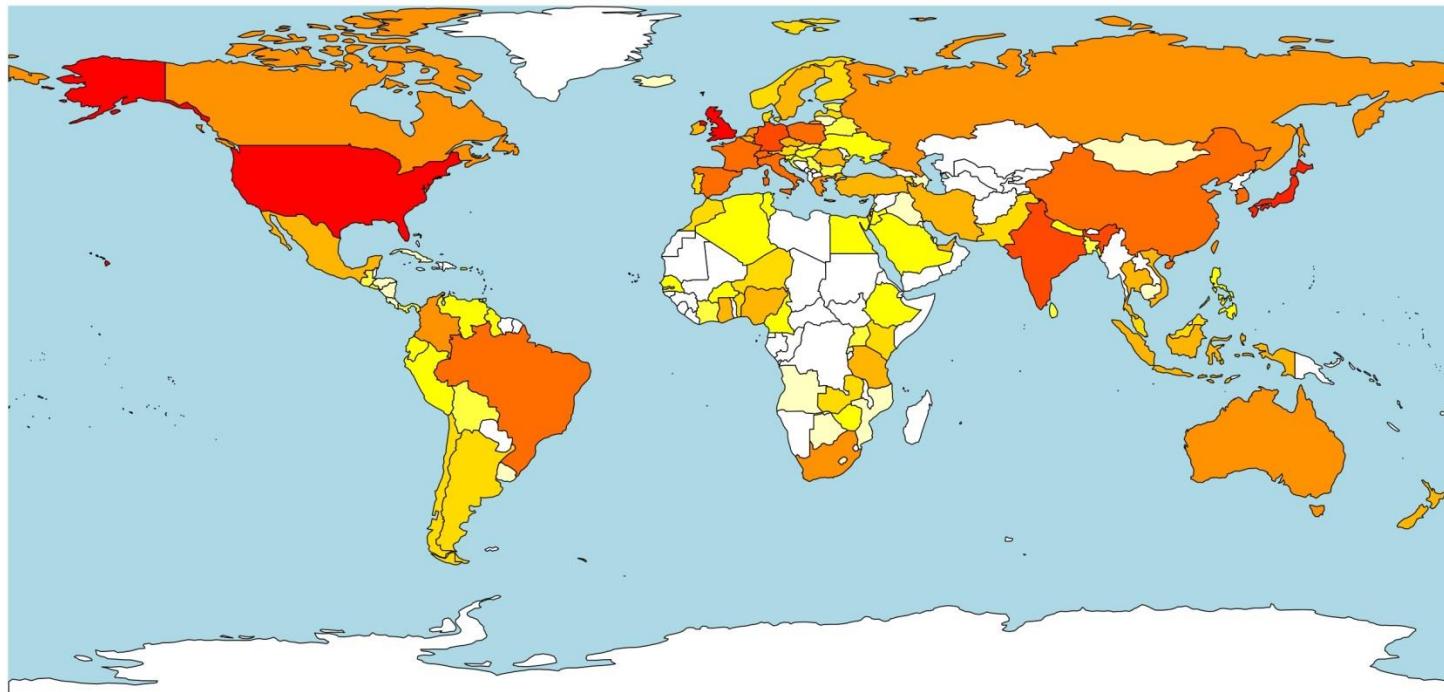
- CM SAF provides CM SAF R Toolbox for free
- **Prepare**
  - Preparation of ordered CM SAF data (extract, choose time & region, merge)
- **Analyze**
  - ‘cmsaf’ R-package collection of functions for easy analysis and manipulation of CM SAF NetCDF data (see cran.r-project.org)
- **Visualize**
  - R-scripts for visualization of CM SAF data
  - R-scripts, which help unexperienced R-users to apply functions of ‘cmsaf’ R-package (no R or scripting experiences needed)



[www.cmsaf.eu/tools](http://www.cmsaf.eu/tools)

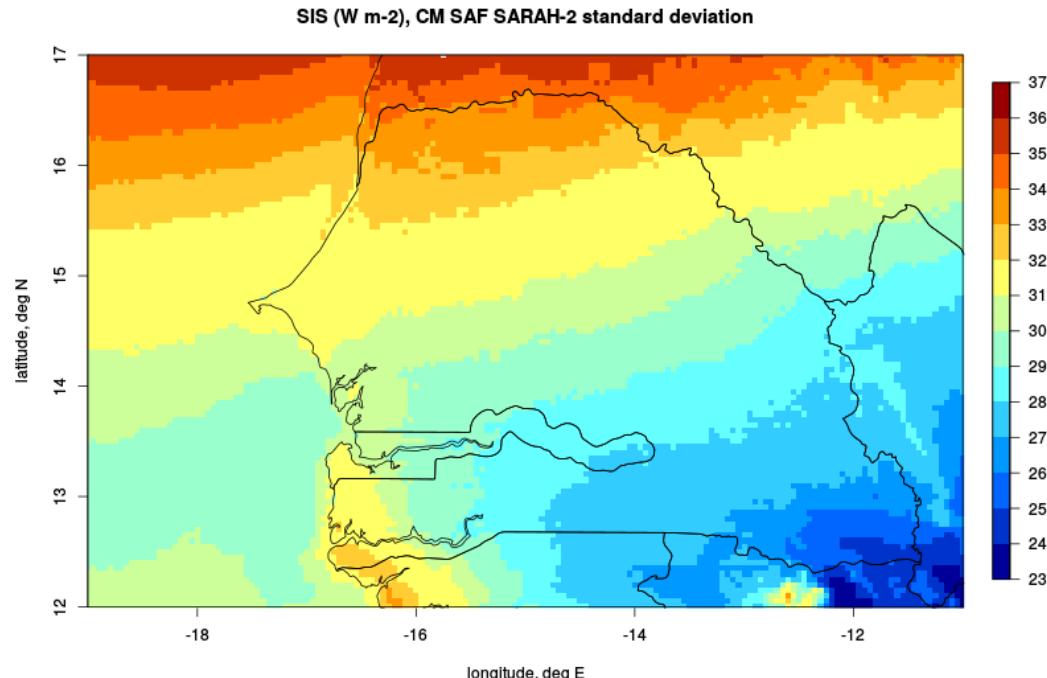
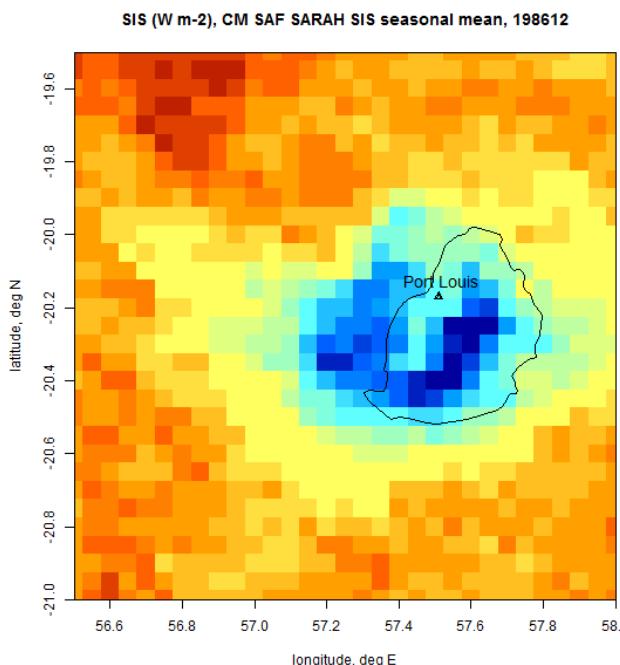
## 'cmsaf' R-package downloads since 26-06-2015

Total downloads: 12923 (01 June 2018)

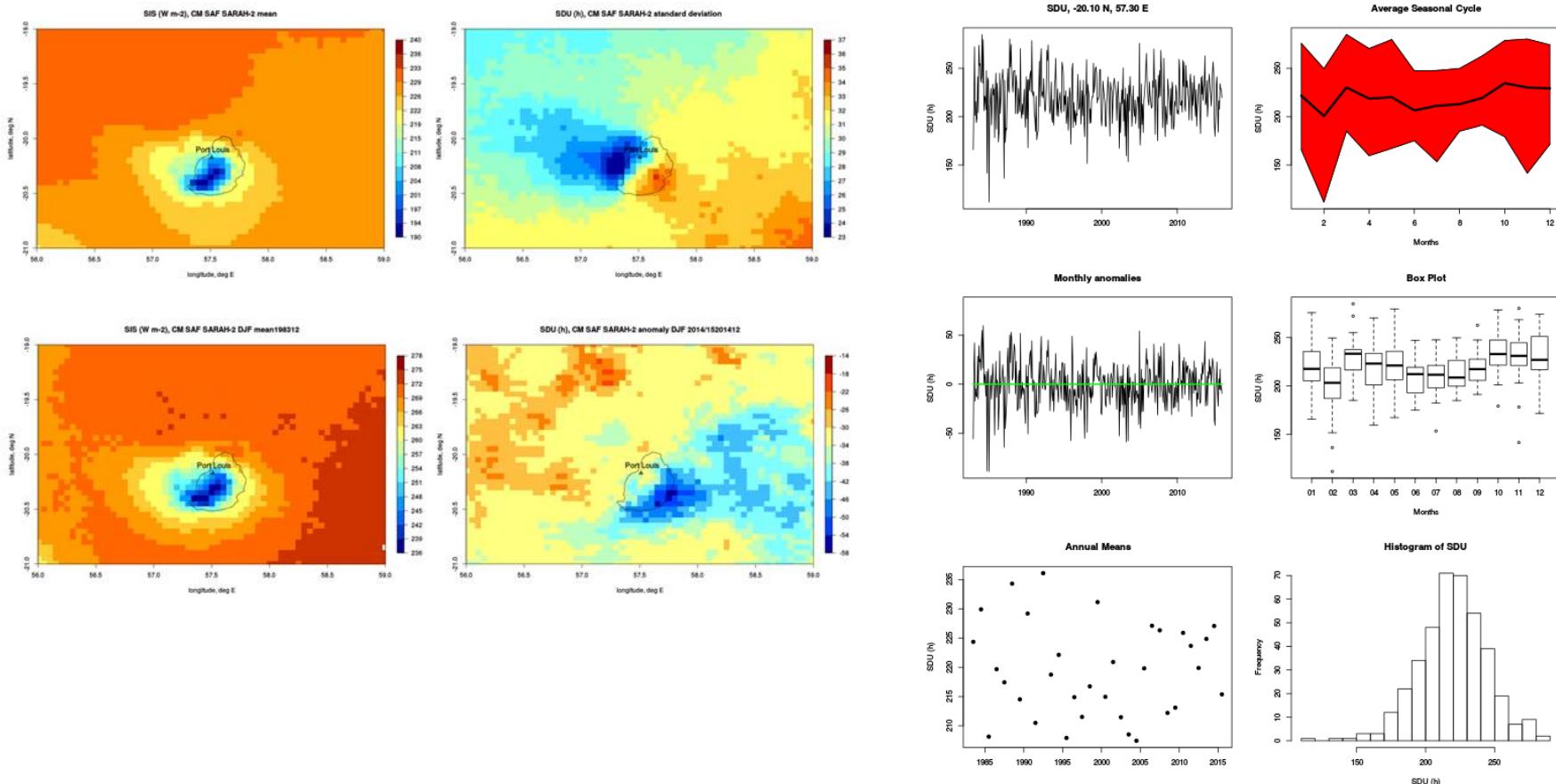


## R-Toolbox

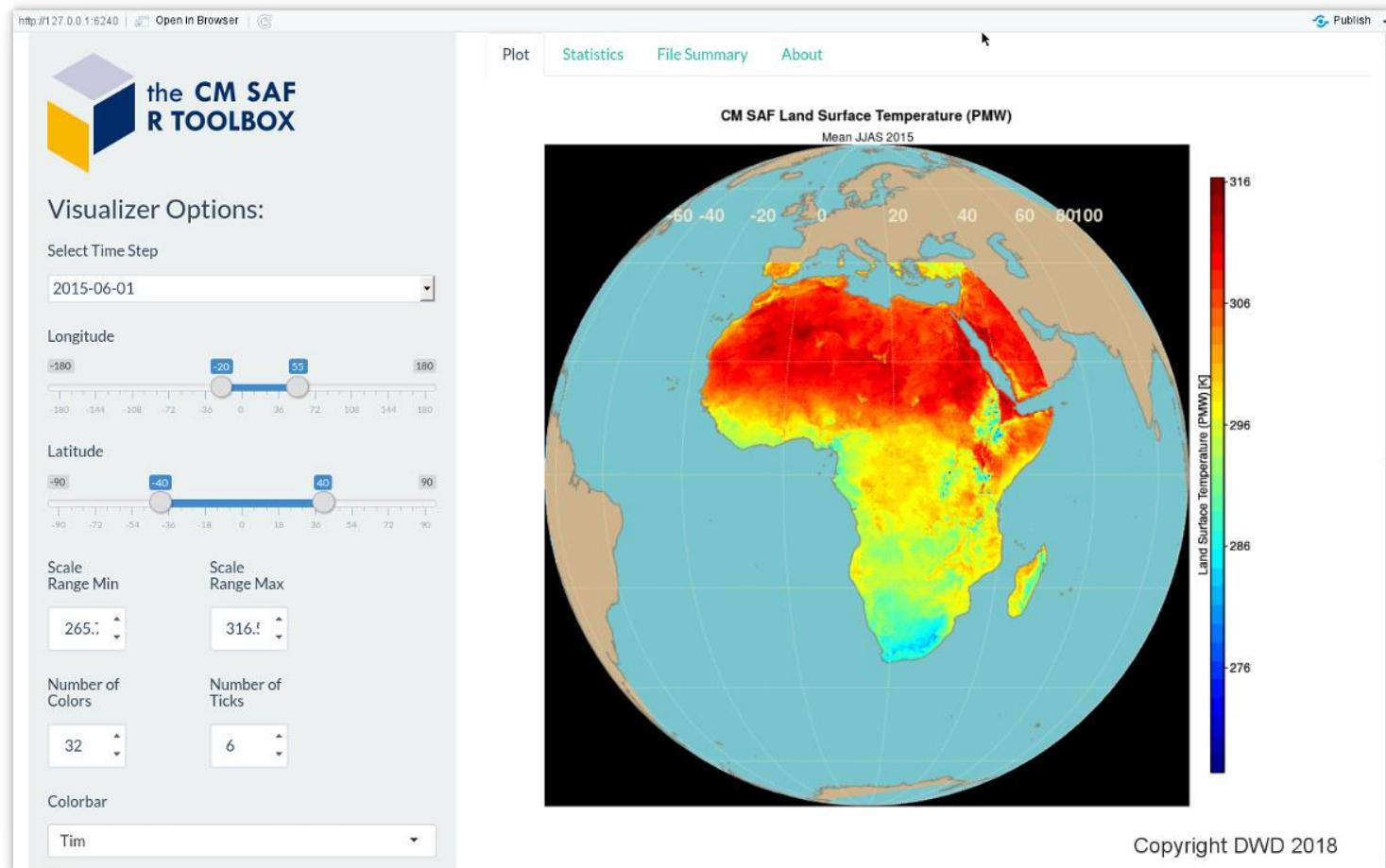
- Examples by UFA participants
- Interesting seasonal patterns over Mauritius
- Solar energy potential in Senegal



## R-Toolbox



# R-Toolbox



# Training

- Training workshops in cooperation with EUMETSAT
- Practical exercises with CM SAF data
- To learn more about EUMETSAT training workshops see:

**<https://training.eumetsat.int>**



## Summary

- Products and services in connection with global energy and water cycle
- Especially geostationary products excellent suitable for Africa
- Thoroughly quality assurance and control mechanisms
- Extensive exchange and support with / of users
- Free and uncomplicated data access
- So far more than 140 peer-reviewed publications using CM SAF data
  - [http://www.cmsaf.eu/EN/Documentation/Journal\\_Articles/Journal\\_Articles\\_node.html](http://www.cmsaf.eu/EN/Documentation/Journal_Articles/Journal_Articles_node.html)

Contact data:

[www.cmsaf.eu](http://www.cmsaf.eu)

Contact.cmsaf@dwd.de

