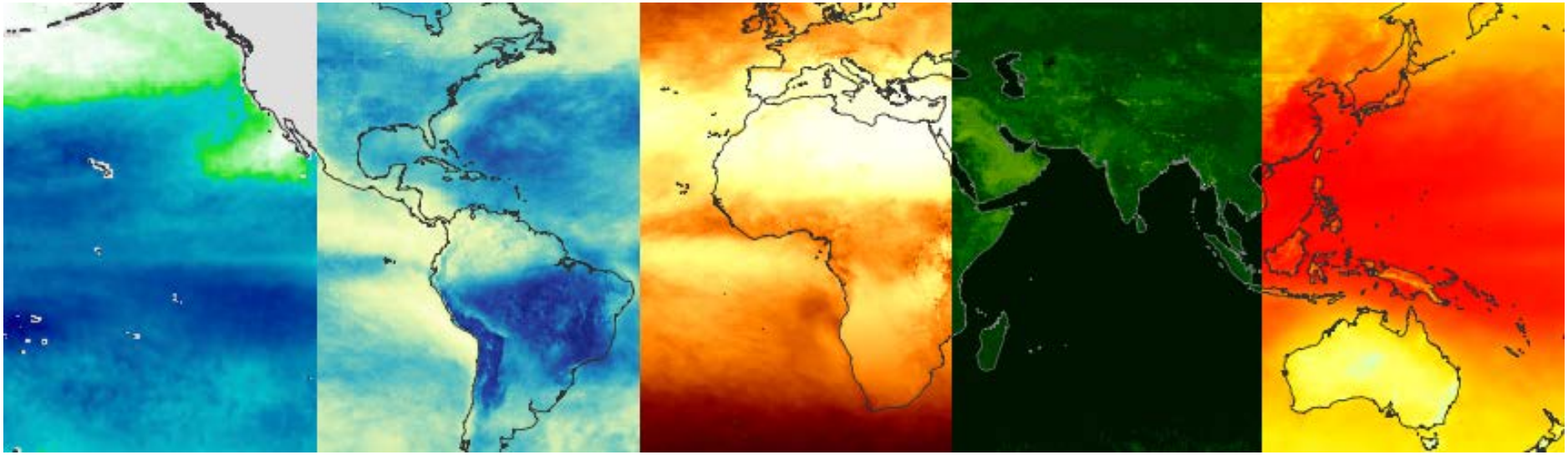
Climate Monitoring SAF
- Climate data records and services-

Rainer Hollmann
and the CM SAF team

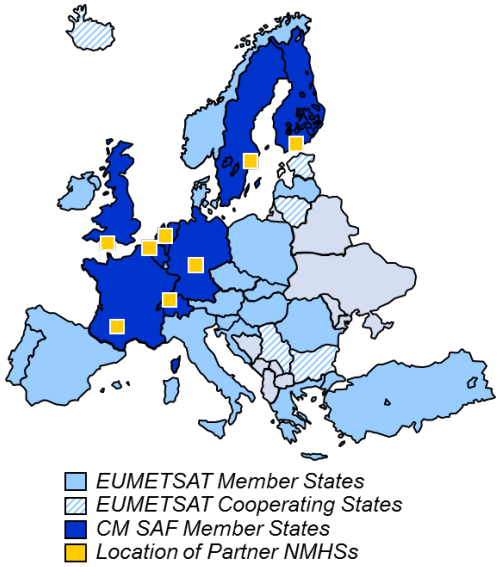


Overview

- CM SAF background
- Using CM SAF CDRs for assimilation
- Using CM SAF CDRs to support process studies
- Using CM SAF CDRs for model evaluation
- CM SAF services
- Conclusion and outlook

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.



Partner:

Deutscher Wetterdienst
Wetter und Klima aus einer Hand

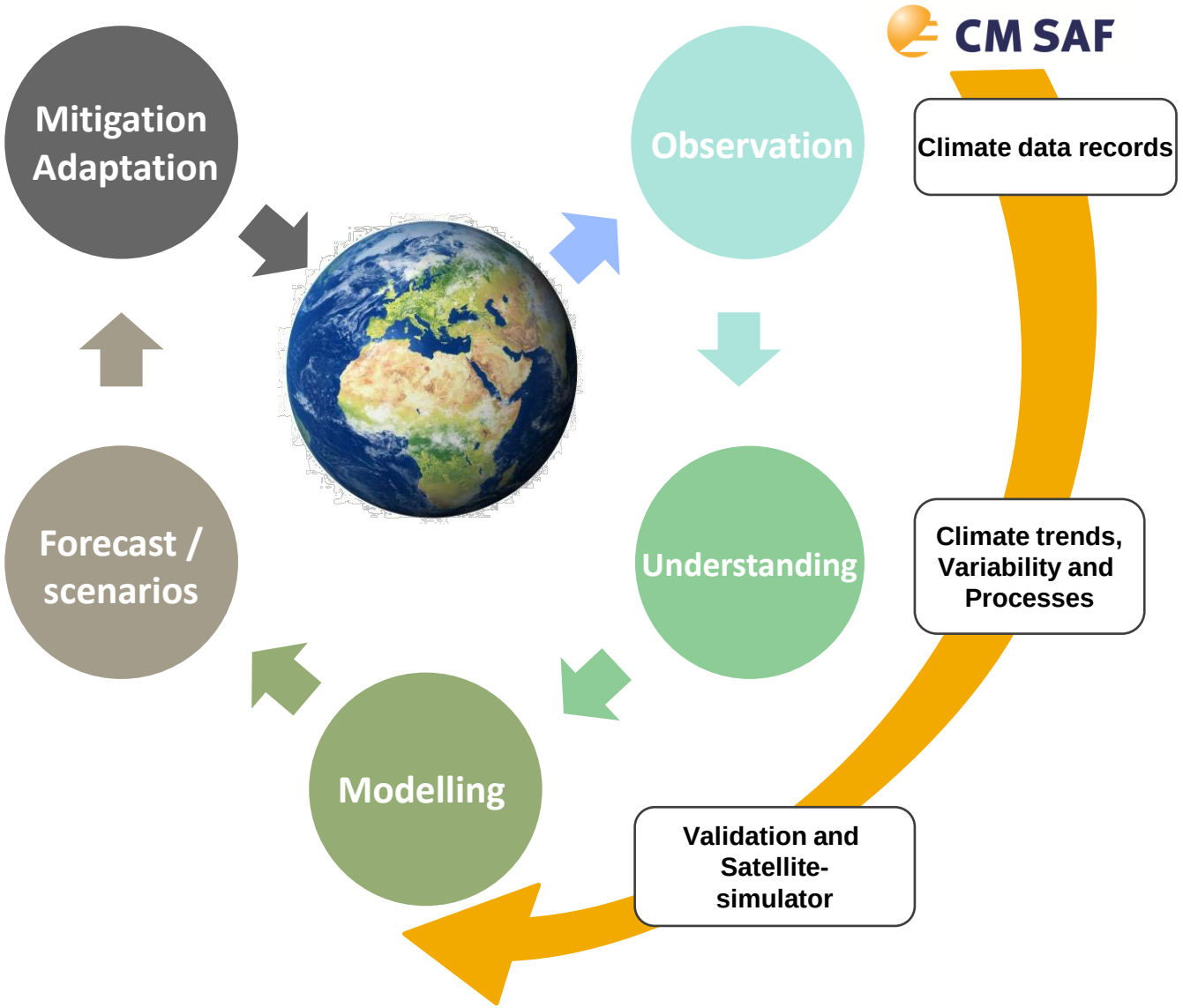
SMHI

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

Met Office

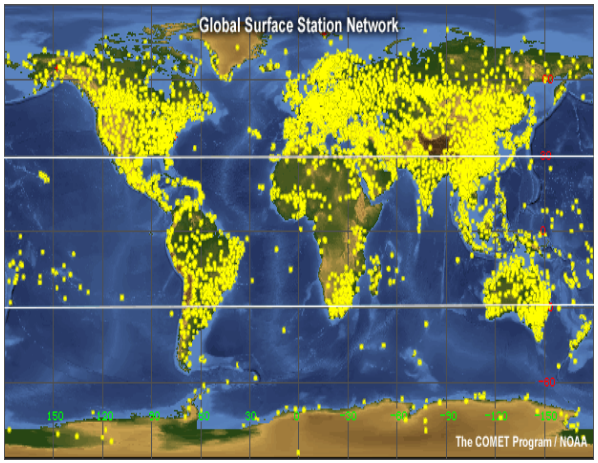
RMI

Centre National de la recherche scientifique (2017)


CM SAF
Mitigation
Adaptation
Observation
Climate data records
Forecast /
scenarios
Understanding
Climate trends,
Variability and
Processes
Modelling
Validation and
Satellite-
simulator

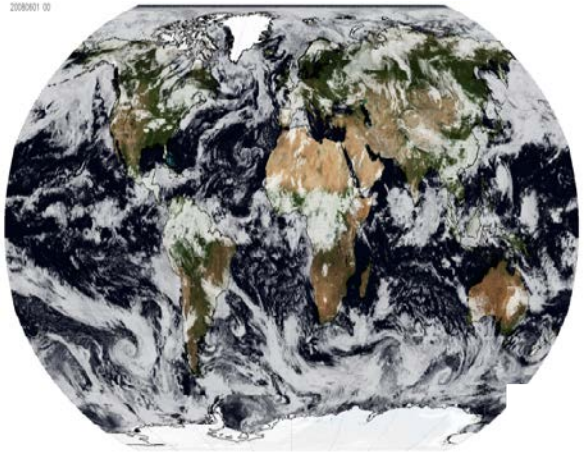
Climate Monitoring

- Status of climate system
- Improved understanding of climate change
- Basis usually are in situ observations but increasingly data from remote sensing with satellites



Global network of surface stations

Global network of radiosondes



Global coverage of satellites

Overview

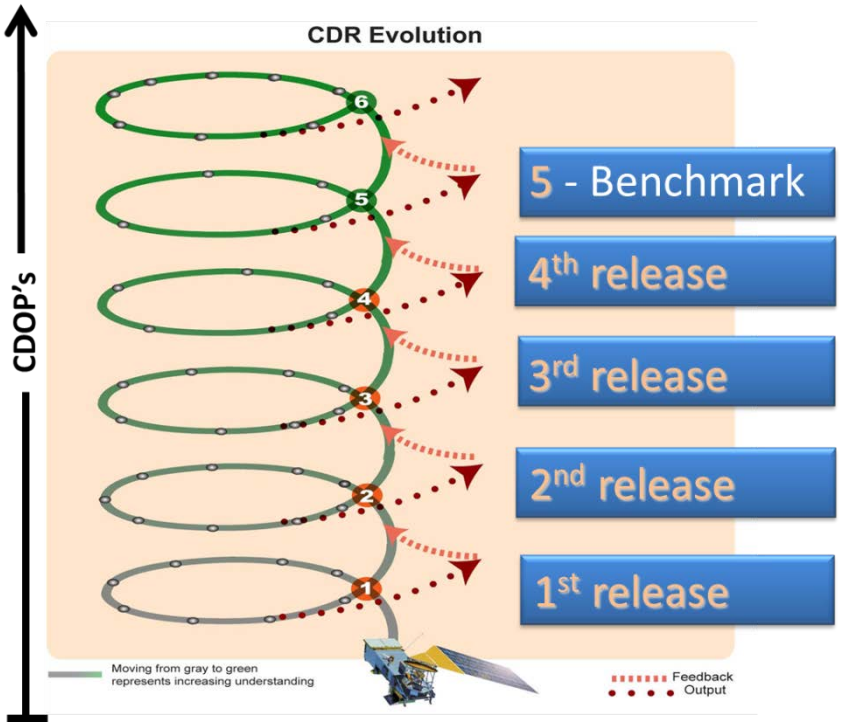
- **CM SAF background**
  - CM SAF and its CDR Portfolio
  - Cyclic approach & Quality assurance

CM SAF: Long-term sustained effort for climate

PP	IOP	CDOP-1	CDOP-2	CDOP-3	CDOP-4	CDOP-5
1999-2004	2004-2007	2007-2012	2012-2017	2017-2022	2022-2027	2027-2032

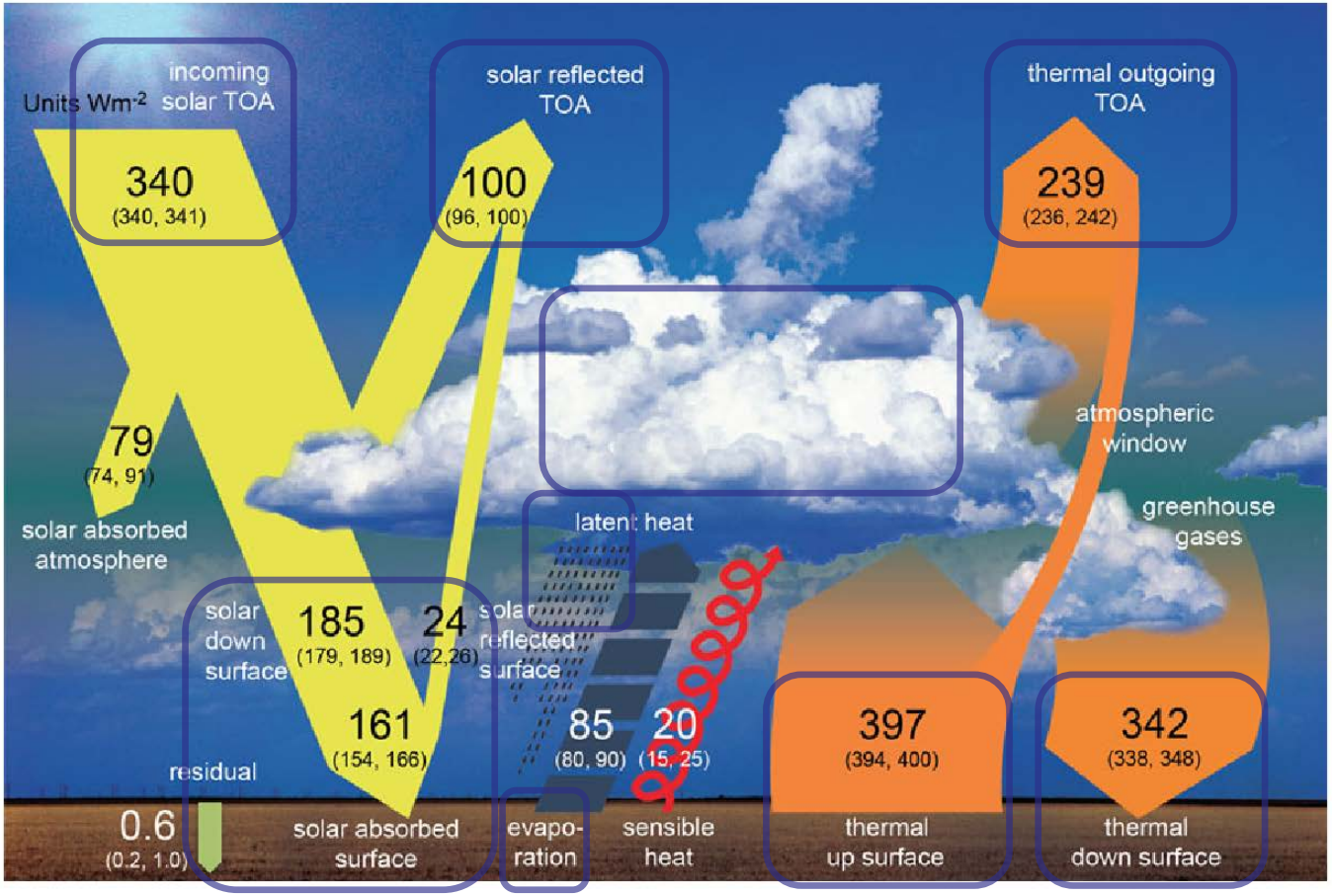
PP (Project Phase), IOP (Initial Operations Phase), CDOP (Continuous Development and Operations Phase)

- **Main topics for 2012 – 2017**
  - Cyclic update of CDR's of variables related to GCOS and the E & W cycle
  - Comprehensive user support and training
  - Continued data provision
  - Co-leading GDAP Assessment
- In an agile framework using opportunities and chances



www.cmsaf.eu **www.cmsaf.eu/tools**

CM SAF Products and application examples



Source:
Wild et al., 2013

Available CM SAF CDR's

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

Committed CM SAF CDR's until 2022

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

Available CM SAF CDR's

Sensor, Satellite resp.	Parameter	CDR Period	Coverage
Fundamental **C**limate **D**ata **R**ecord (FCDR)			
SMMR, SSM/I, SSMIS	**Microwave Radiances**	1978 – 2013	global
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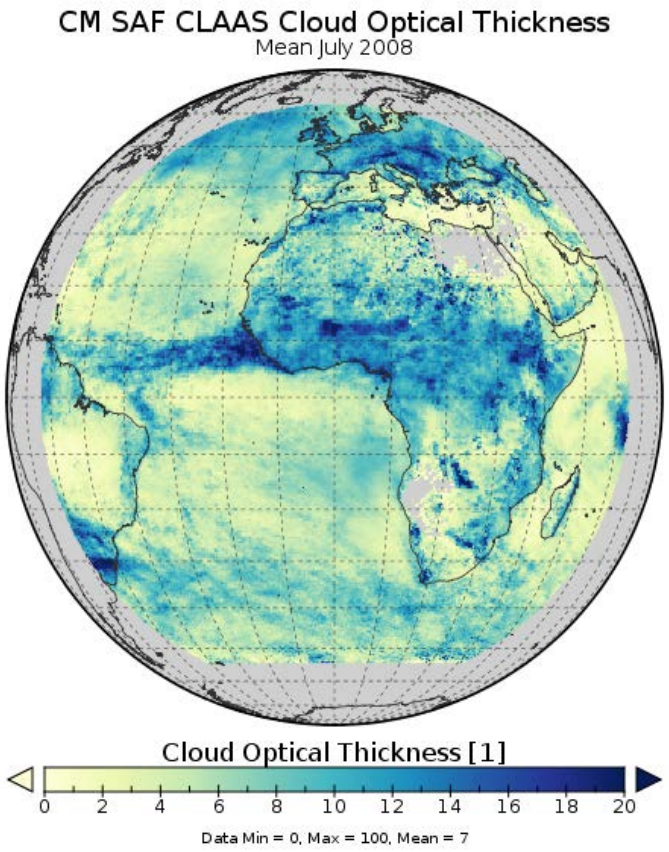
MSU, AMSU, SSM/T2, MHS	**Upper troposphere humidity**	1993 – 2013	

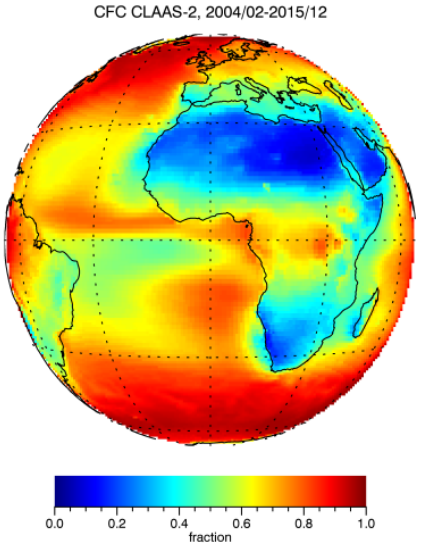
CLAAS / CLAAS-2 released in autumn 2016

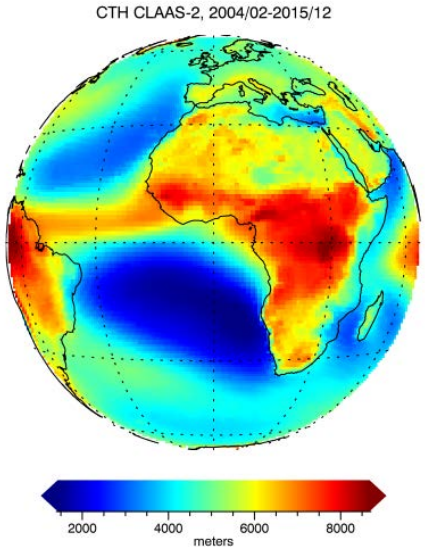
- **Variables**
  - Cloud properties
  - Surface albedo (only CLAAS)
  - Radiation (only CLAAS)
- **Grid**
  - spatial: 0.05° × 0.05° (0.25° × 0.25°)
  - temporal: hourly-, daily-, monthly-means, monthly mean diurnal cycle
- **Coverage**
  - spatial: Meteosat disk
  - temporal: 2004 to 2011 (2015)
- **Satellites**
  - Meteosat Second Generation (SEVIRI)

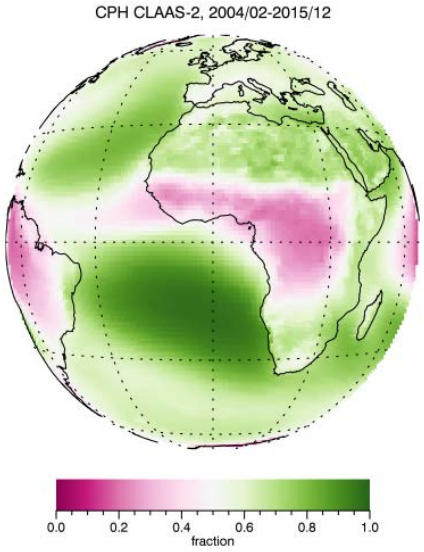


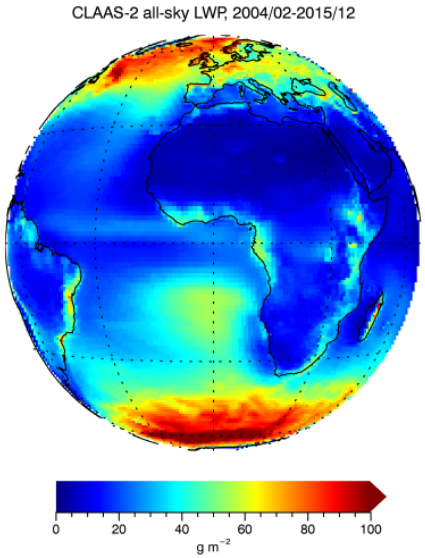
DOI:10.5676/EUM_SAF_CM/CLAAS/V001

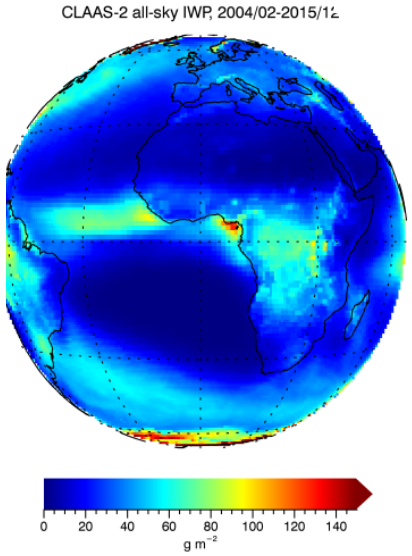
CLAAS-2: CDR examples

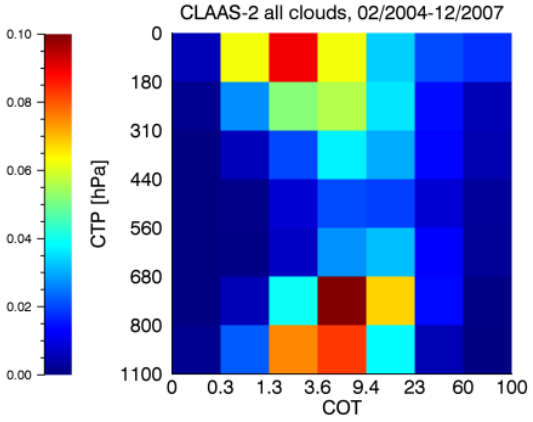






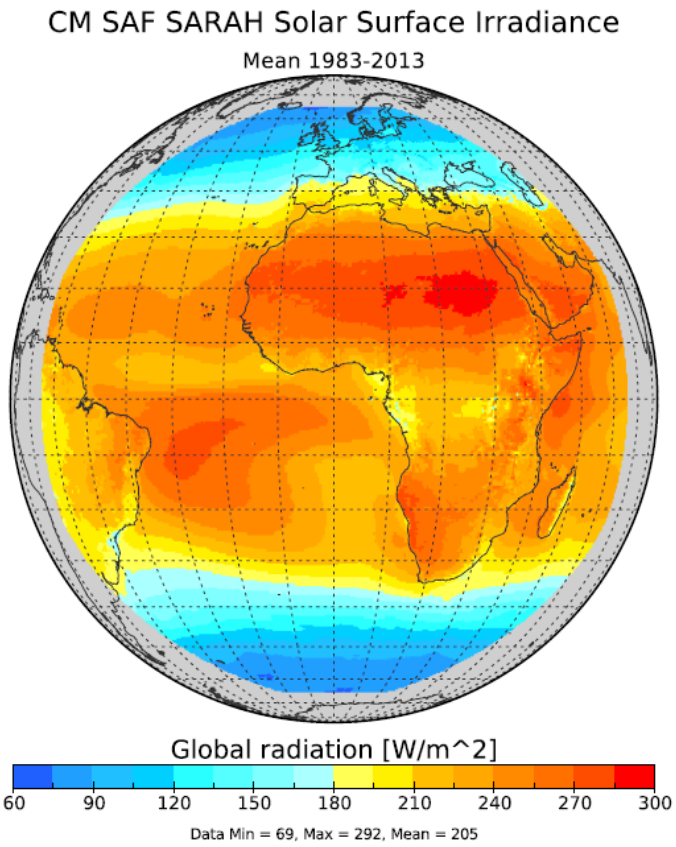






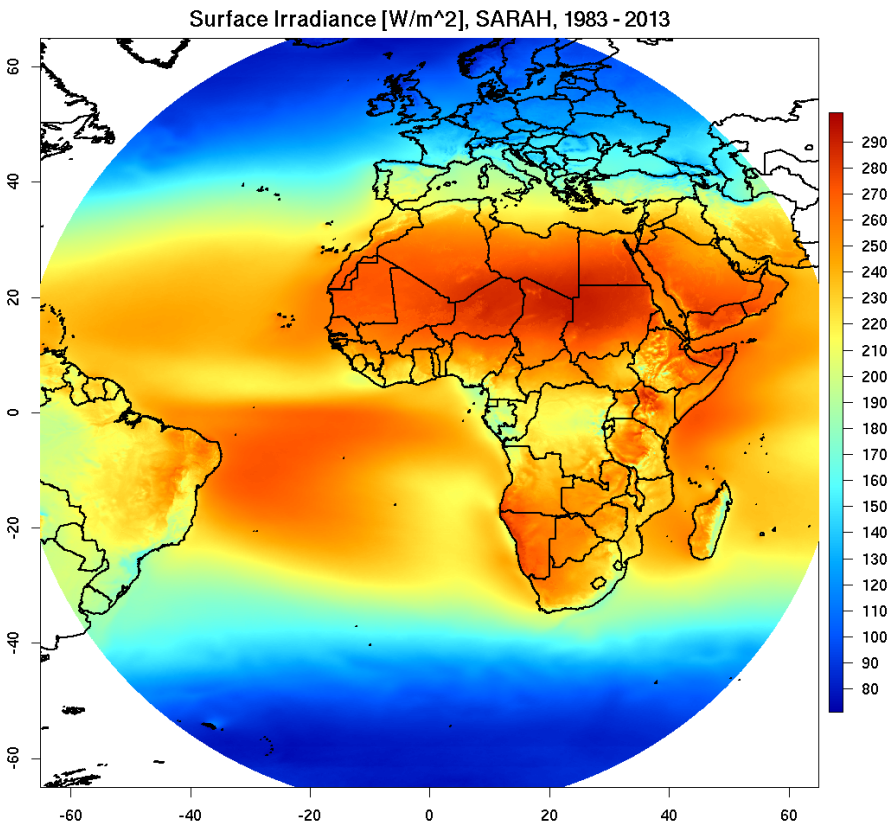
SARAH, SARAH-2 available Dec. 2016

- **Variables**
  - Global radiation
  - Normalized direct radiation
  - Effective cloud albedo
  - (sunshine duration)
- **Grid**
  - Spatial: 0.05° × 0.05°
  - temporal: hourly, daily, monthly means
- **Coverage**
  - spatial: Meteosat disk
  - temporal: 1983 to 2013 (2015)
- **Satellites**
  - Meteosat 2 to 10 (MVIRI/SEVIRI)

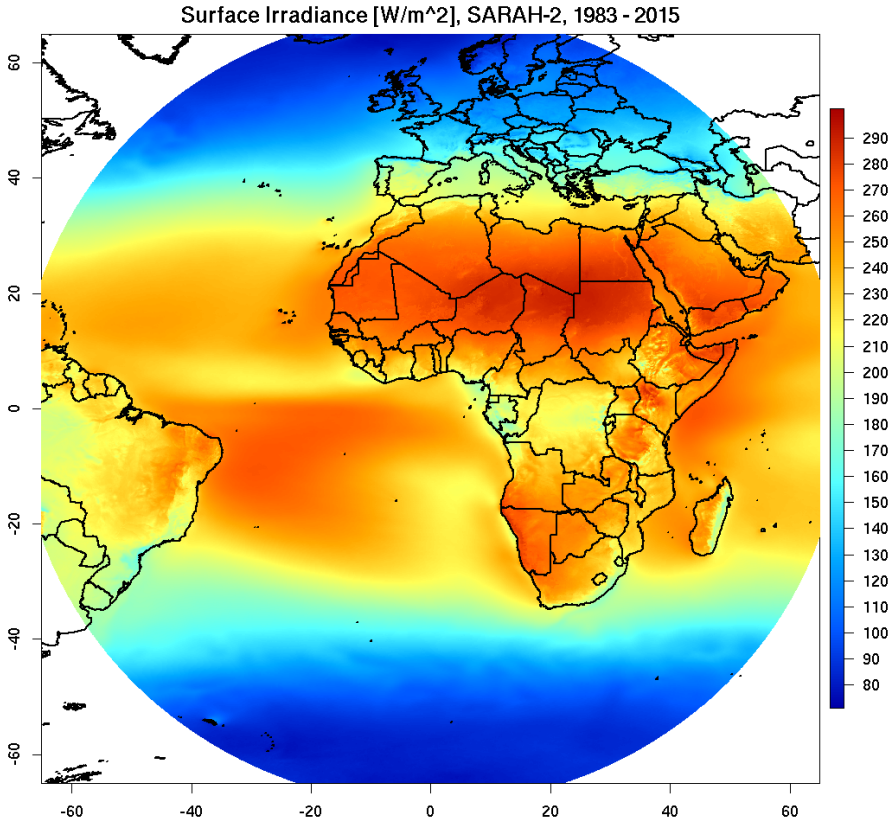


DOI:10.5676/EUM_SAF_CM/SARAH/V001

SARAH and SARAH-2 (I)



SARAH

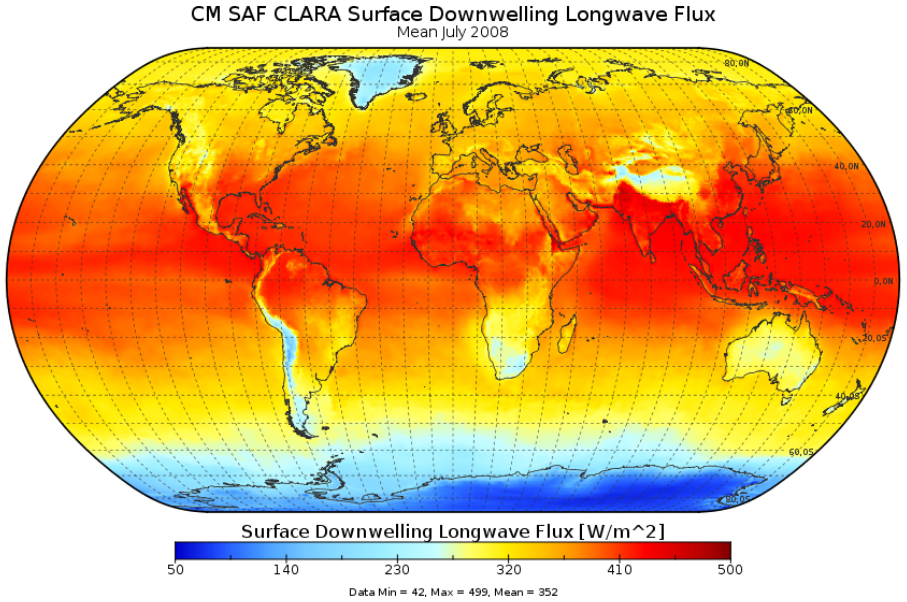


SARAH-2

- improved homogenization (transition from MFG to MSG)
- Viewing geometry correction in case of large satellite zenith angles
- Improved treatment of water vapor through topographic downscaling
- Improved quality control of input data for MFG data

CLARA-A1 / CLARA A2 to be released in Dec. 2016

- **Variables**
  - Cloud properties
  - Surface albedo
  - Surface radiation
- **Grid**
  - spatial: 0.25° × 0.25°
  - temporal: daily-, Pentad-, Monthly
- **Coverage**
  - spatial: Global
  - Temporal: 1982 to 2009 (2015)
- **Satellites**
  - NOAA, Metop (AVHRR)

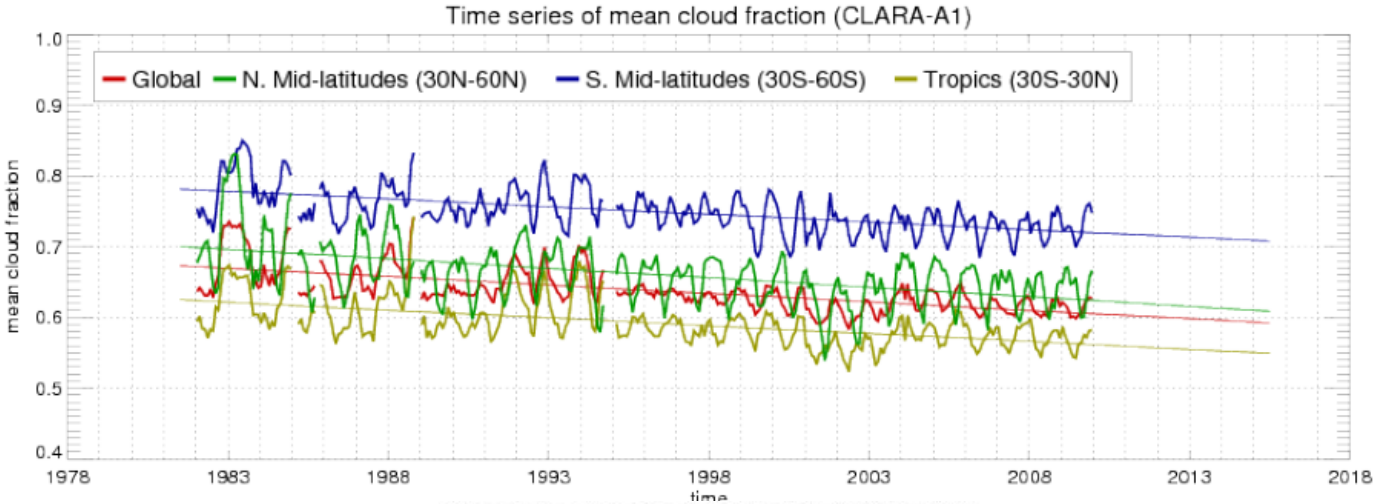


DOI:10.5676/EUM_SAF_CM/CLARA_AVHRR/V0011

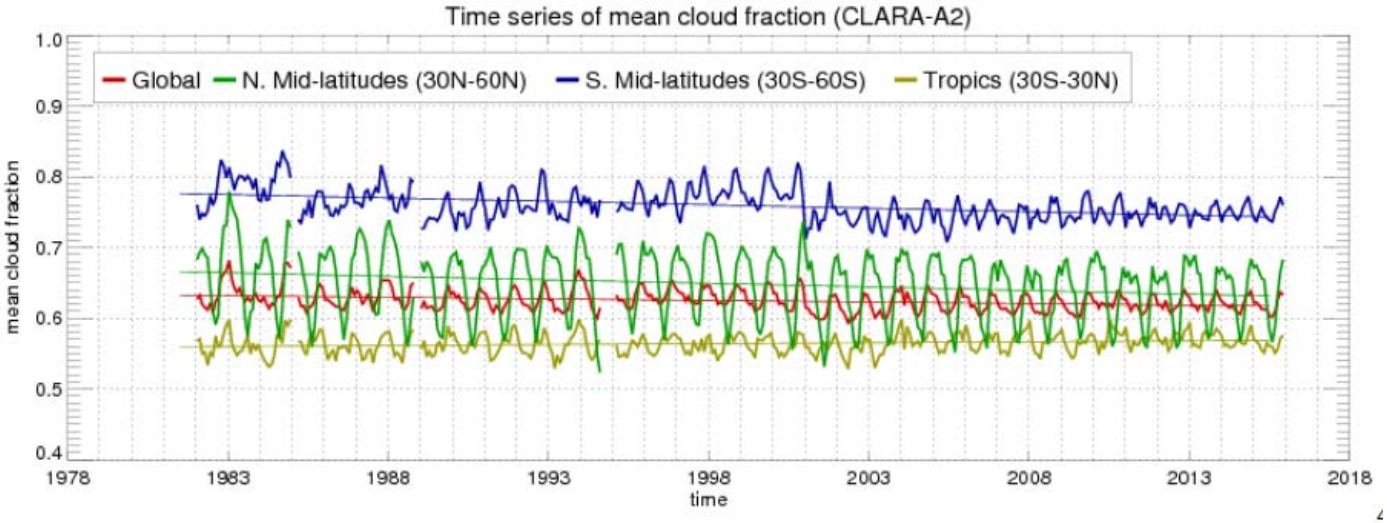
CLARA-A1 vs CLARA-A2

Global mean cloud fraction

CLARA-A1



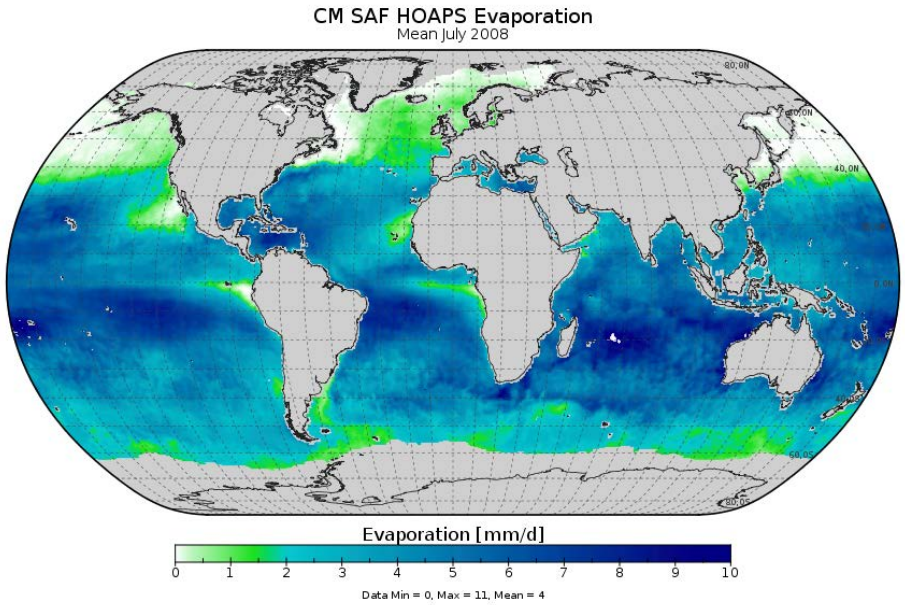
CLARA-A2



... due to improved algorithms and Level 1 data screening

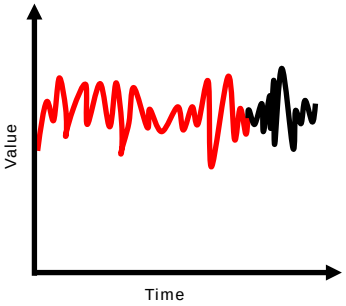
HOAPS, HOAPS-4 to be released Dec. 2016

- **Variables**
  - Wind, humidity (surface)
  - Precipitation, Evaporation
  - Latent heat flux
  - Freshwater flux
- **Grid**
  - spatial: 0.5° × 0.5°
  - temporal: 6- hourly-, monthly mea
- **Coverage**
  - spatial: Global ice-free Ocean
  - temporal: 1987 to 2008 (2014)
- **Satellites**
  - DMSP (SSM/I), DMSP (SSMIS), SMMR

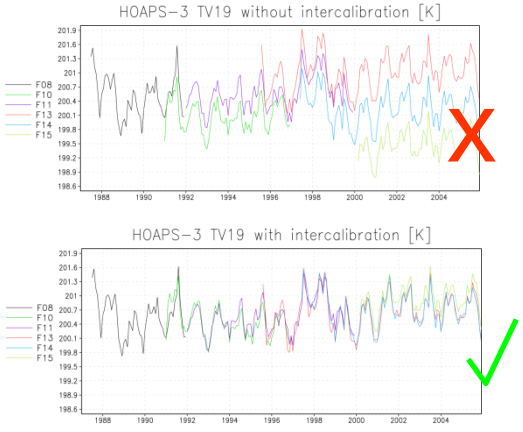


DOI:10.5676/EUM_SAF_CM/HOAPS/V001

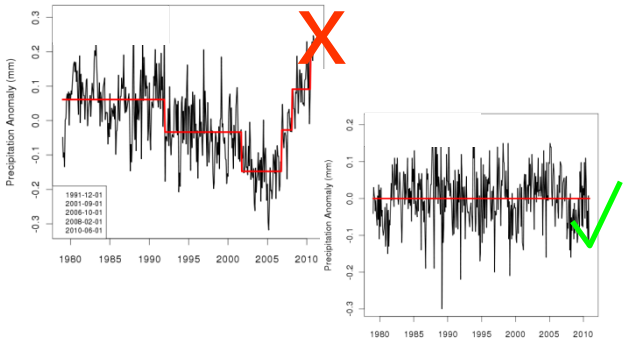
Requirements Climate data records



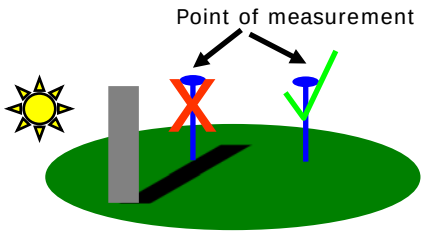
Sufficient long temporal coverage



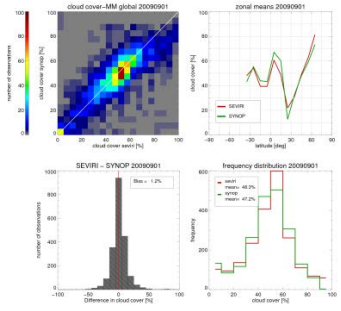
Calibration

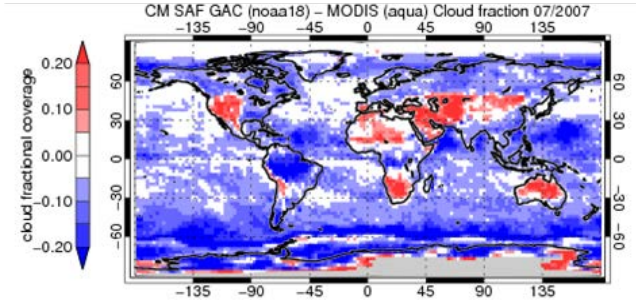


Homogen



representative



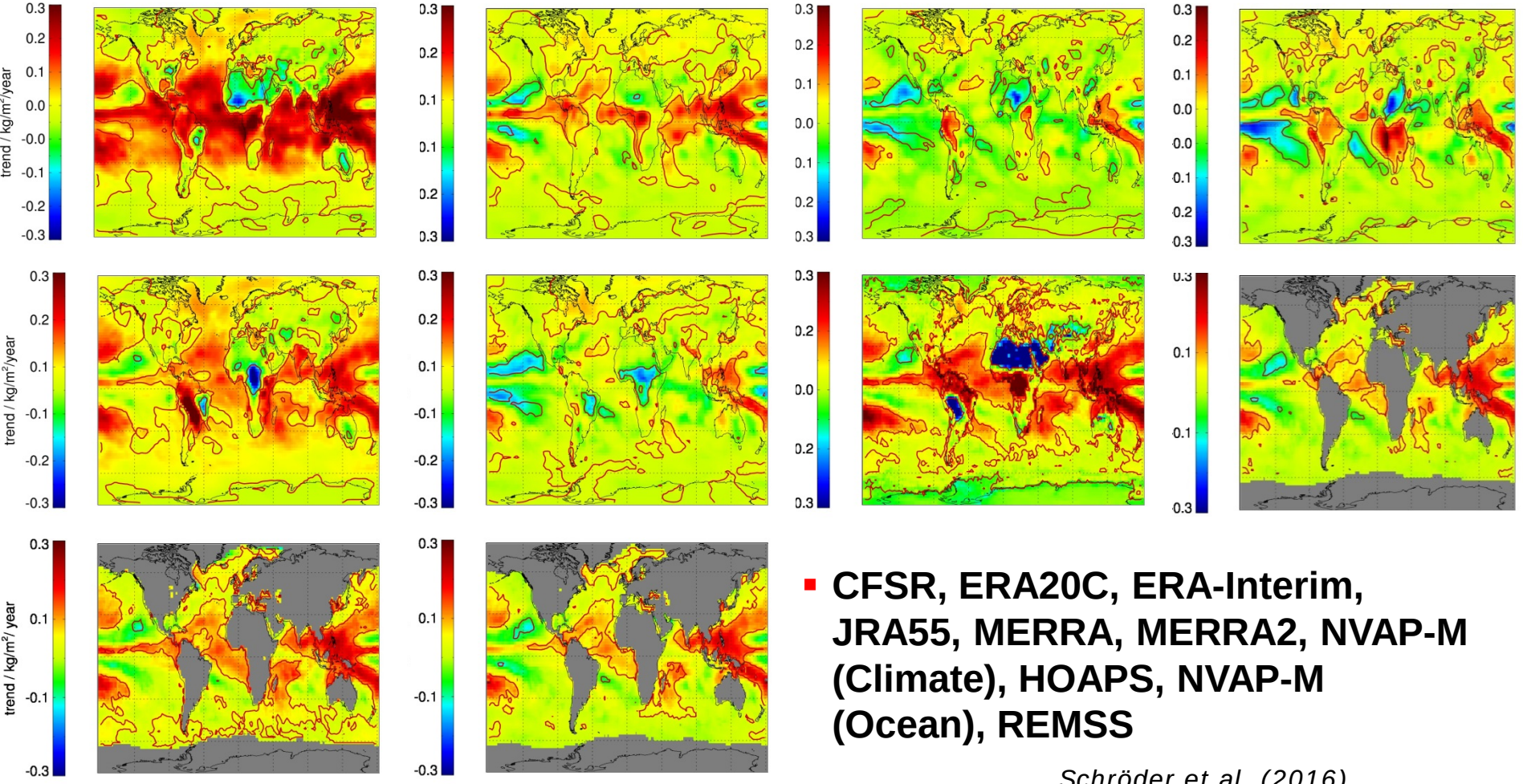


Quality controlled and assessed

Quality assurance

- Rigorous review cycle is applied before publishing CDRs:
  - Starting with reviewed user tailored indiv. Product requirements (fit for purpose)
  - Selection of suitable algorithm to realize CDR
  - Final review of data record assuring that requirements are met
- DOI is assigned; CDR comes with comprehensive documentation and publications
- CDR with uncertainty estimates
- Participation in assessments and retrieval evaluation (e.g. GVAP, IWCG)

Assessment of CDR's



- **CFSR, ERA20C, ERA-Interim, JRA55, MERRA, MERRA2, NVAP-M (Climate), HOAPS, NVAP-M (Ocean), REMSS**

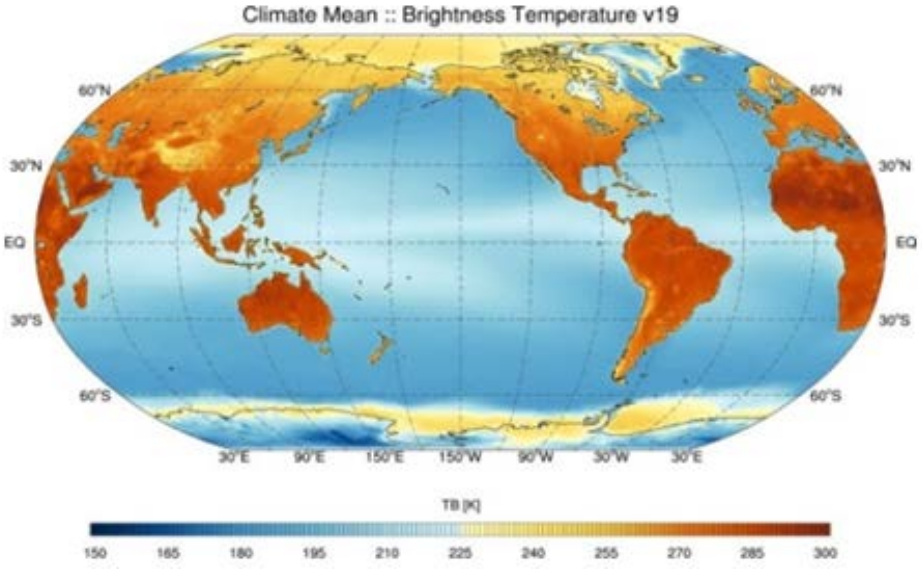
Schröder et al. (2016)

Overview

- CM SAF background
- Using CM SAF CDRs for assimilation
- Using CM SAF CDRs to support process studies
- Using CM SAF CDRs for model evaluation
  - From regional to multidecadal

FCDR on SSMR, SSM/I, SSMIS

- **Variable**
  - Brightness temperature
- **Grid**
  - spatial: Native SSM/I (SSMIS)
  - temporal: Native SSM/I (SSMIS)
- **Coverage**
  - spatial: Global
  - temporal: 1987 to 2014 (2008)
- **Satellites & instruments**
  - DMSP (SSM/I), DMSP (SSMIS), SMMR



DOI:10.5676/EUM_SAF_CM/FCDR_MWI/V002

Reanalyses

- The value of the CM SAF SSM/I FCDR has been assessed in a ECMWF pre-assimilation feedback study*. SMMR and SSMIS is planned/ongoing
- Poli et al.: "…such a detailed interaction, although it may only occur rarely between a data provider and its users, proved to be extremely beneficial"* (for both sides).
- CM SAF FCDR will be utilized in future reanalyses (e.g., ERA5) at ECMWF**.

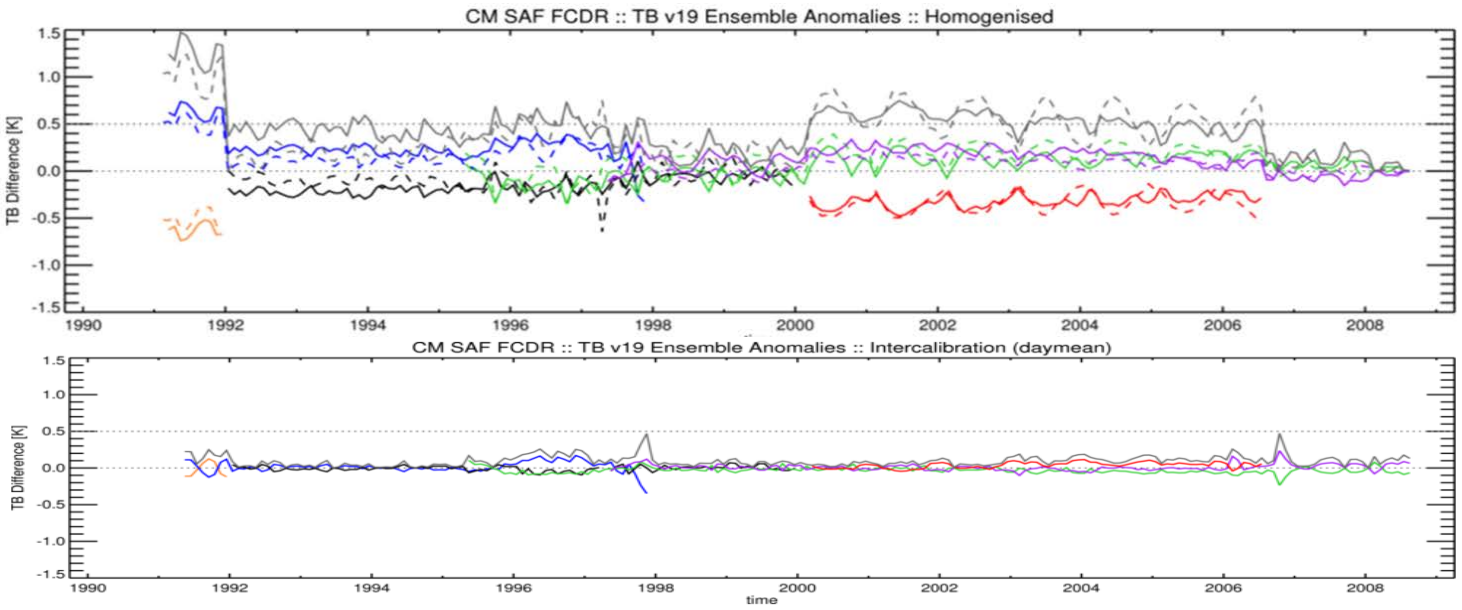


Fig.: Inter-satellite brightness temperature differences.

Top: After Earth incidence angle and diurnal cycle correction.

Bottom: Fully inter-calibrated. Remaining differences are below ~0.3 K.

** Poli, P., et al., ERA report series, No. 19, August 2015.*

*** http://www.ecmwf.int/sites/default/files/ Dee_ECMWF_Seminar2014_nomovies.pdf*

Using CM SAF CDRs for Process understanding

Objective:
Identify benefits of Convective permitting scale simulations through comparison with CLAAS

- CPS allows to capture diurnal cycle
- Low bias in OSR
- More clear sky in model
- Too reflective clouds correlates then with surface radiation budget and temperature

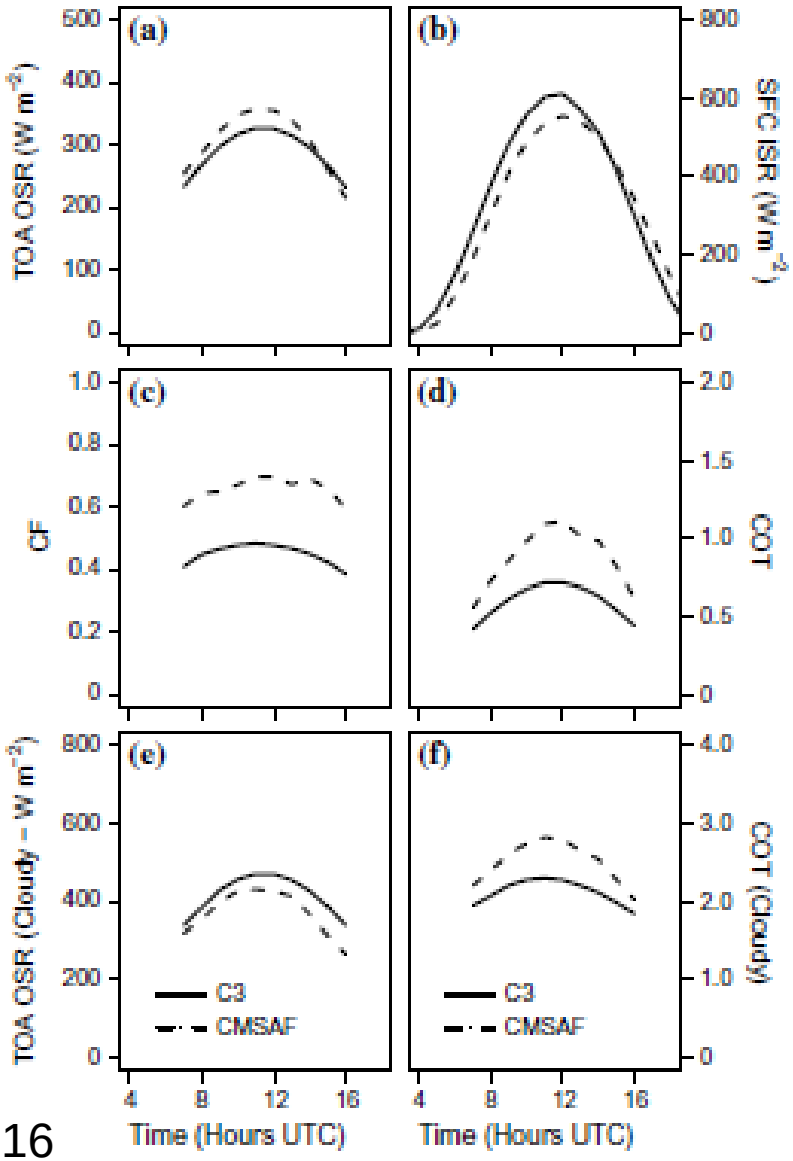


Figure: Domain and time averaged diurnal cycles as observed and simulated with COSMO CLM

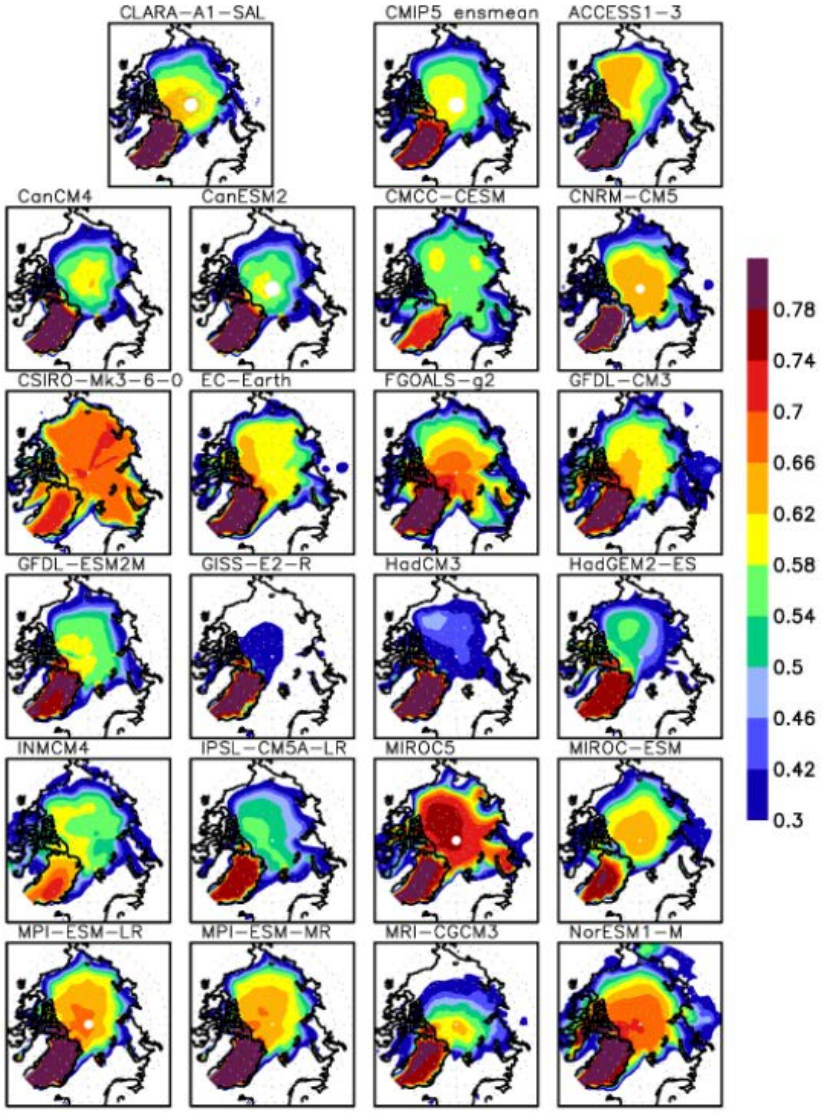
Brisson et al. 2016

CMIP5 model evaluation

Summer Sea ice

- Summer-averaged (JJA) surface albedo in CLARA-SAL, the CMIP5 ensemble mean and the individual CMIP5 models. Shown is the time average over the period 1982–2005.

- Koenigk et al. 2014, Atmos. Chem. Phys., 14, 1987–1998, 2014



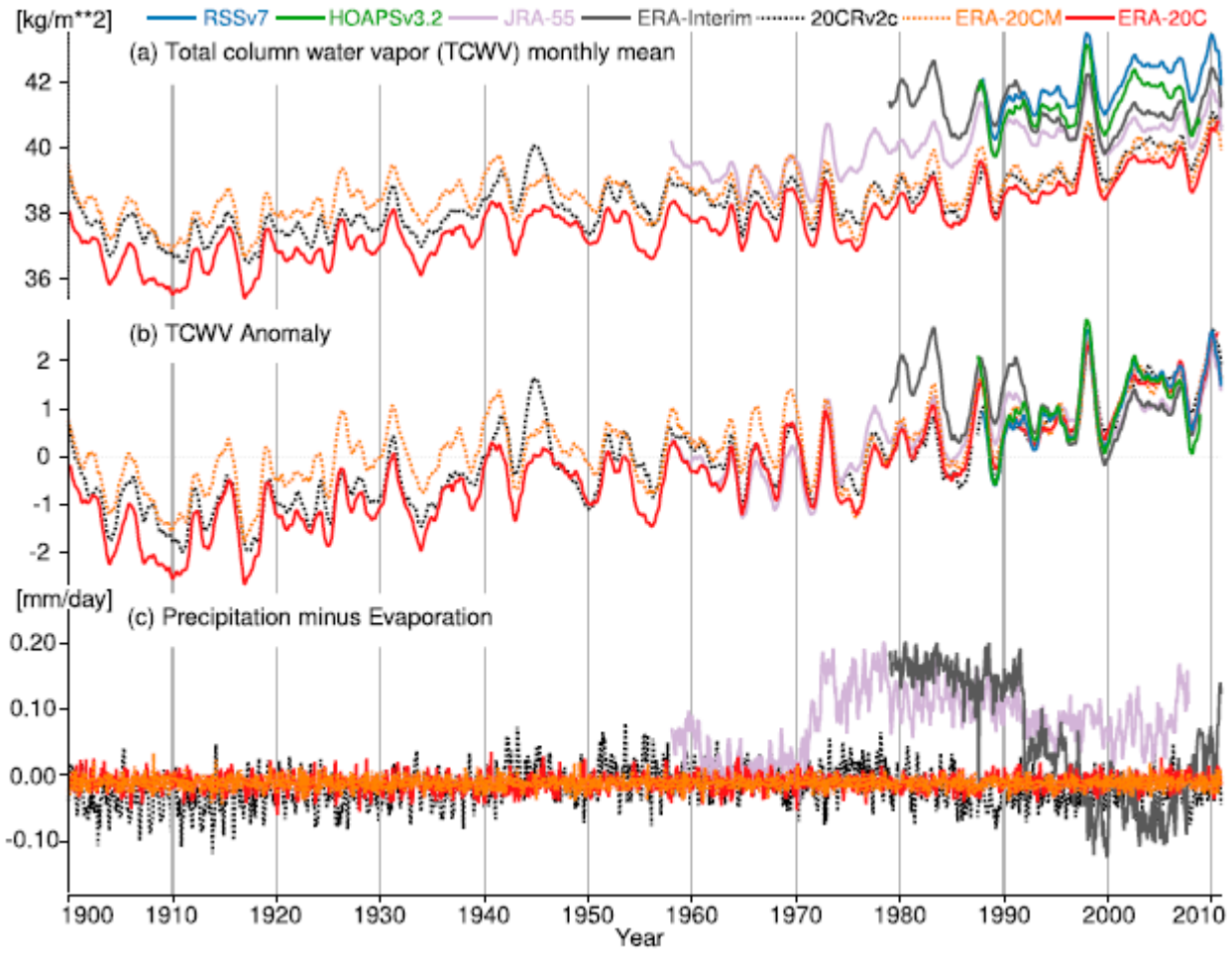
Evaluation of Water cycle in ERA-20C

(a) monthly total column water vapor over oceans and latitude 20° S–20° N.

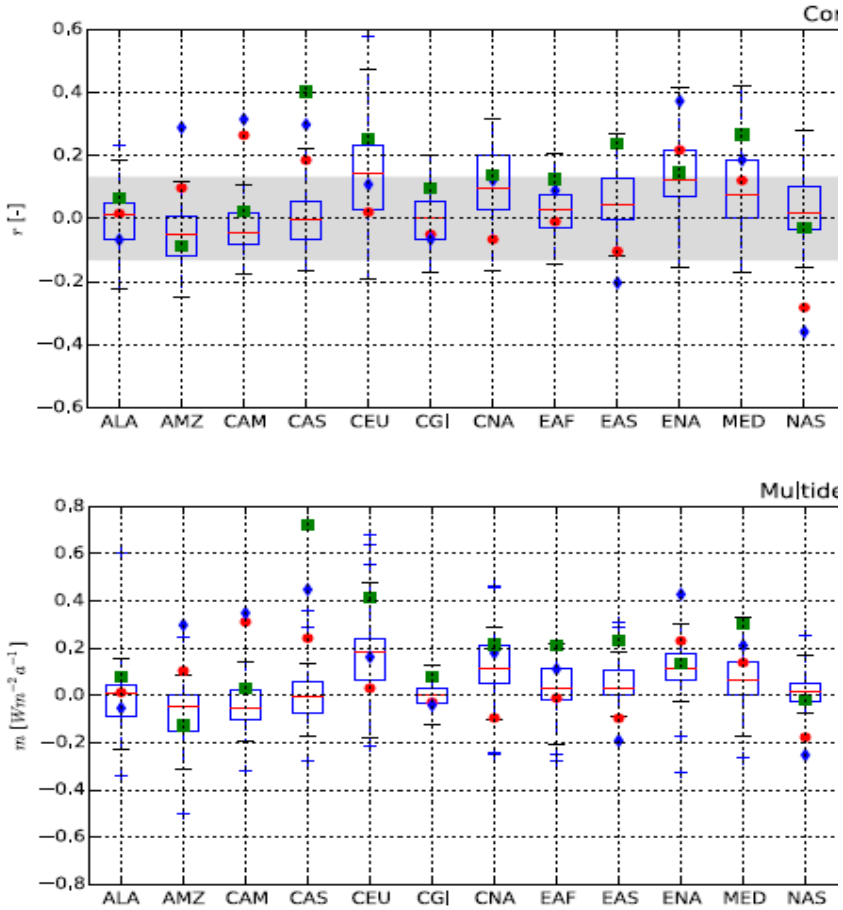
(b) Anomalies relative to years 1988–2008.

(c) Time series of monthly anomalies of global averages of precipitation minus evaporation relative to the mean annual cycle (1981–2010) but with the inclusion of the mean annual climate.

Poli et al. 2016,



CMIP5 model evaluation (1)



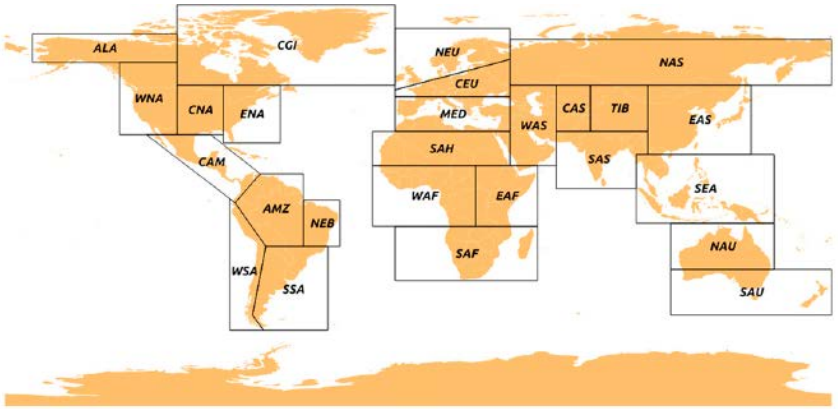


FIG. B1. Definition of regions used for the analysis. The regions are based on those of IPCC (2012), in which the latitude–longitude coordinates of individual regions are also defined.

Multidecadal regional trends of RY: (top) The Pearson product moment correlation coefficient and (bottom) multidecadal trend for IPCC regions. Shaded areas not significant.
Box plots represent model results from AMIP experiment, where the box corresponds to the IQR. ISCCP (red dots), SRB3.0 (blue diamonds), and CLARA-A1 (green rectangle).

Löw et al. DOI: 10.1175/JCLI-D-14-00503.1

CMIP5 model evaluation (2)

Assessing Surface Solar Radiation Fluxes

- Accuracy of CMIP models, when the **multimodel mean**, in general**, outperforms the individual models**.

- **Choice of observational reference matters** since the relative model ranking depends on the choice of the observational reference dataset. It is therefore **recommended that a multitude of observations** is always used when evaluating model simulations.

- CMIP models **underestimate multidecadal trends** of radiation fluxes. The CMIP **model ensemble underestimates** observed multidecadal trends in surface solar radiation fluxes. Significant **changes observed in in situ and satellite observations are not reproduced** by the CMIP models.

Löw et al. DOI: 10.1175/JCLI-D-14-00503.1

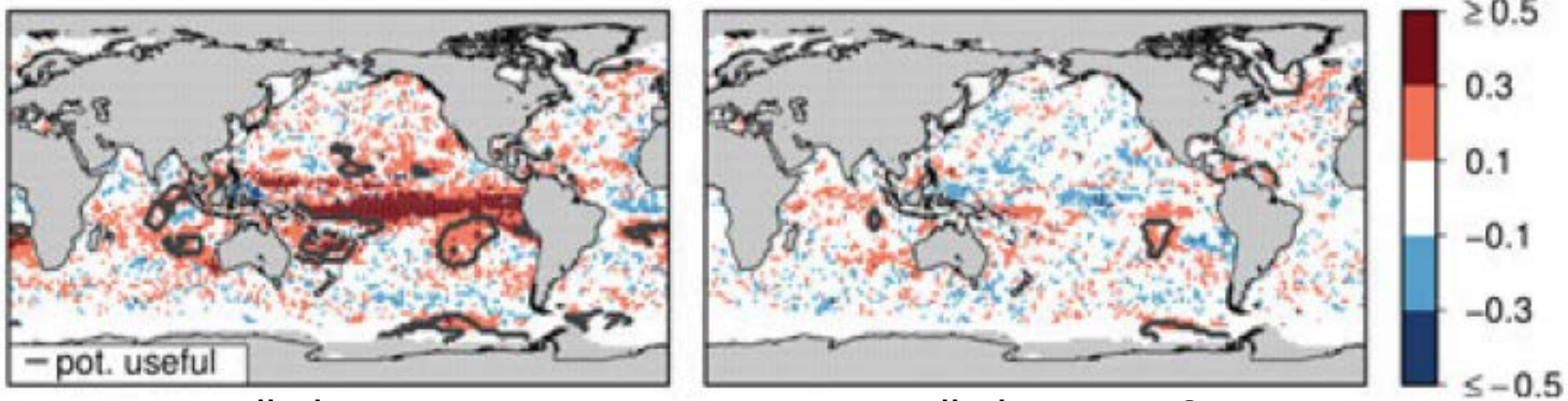
Probabilistic evaluation of decadal predictions using satellite-based data.

The Hamburg Ocean Atmosphere Parameters and Fluxes from Satellite Data - HOAPS-3" (Andersson et al., 2010).

Freshwater Flux (Evaporation - Precipitation)

Mean Square Error Skill Score

MSESS



Prediction year 1 Prediction year 2

VECAP/PROVESIMAC

Deutscher Wetterdienst Wetter und Klima aus einer Hand DWD

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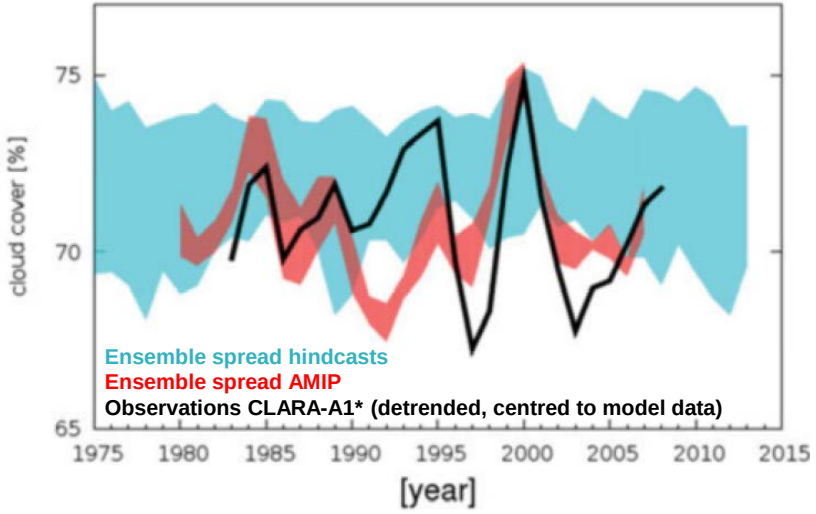
Stolzenberger et al. (2015)

Probabilistic evaluation of decadal predictions using satellite-based data.

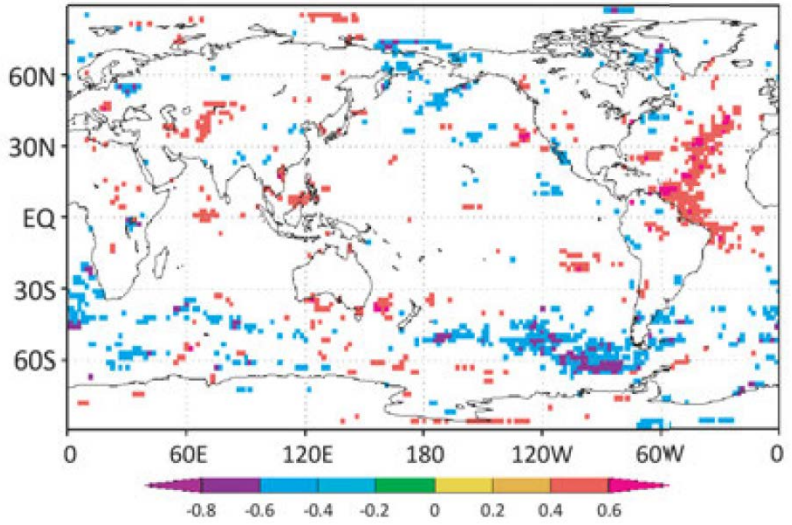
- „CM SAF Cloud, Albedo and Radiation dataset from AVHRR data – CLARA-A1" (Karlsson et al., 2013)

Cloud cover, averaged over lead years 2-4 (left) / 2-5 (right)

Area Averages for Tropical Warm Pool



Deterministic Correlation Coefficient



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Spangehl et al. (2015)

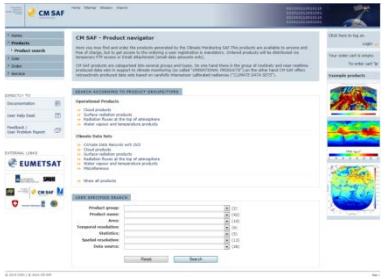
Overview

- CM SAF background
- Using CM SAF CDRs for assimilation
- Using CM SAF CDRs to support process studies
- Using CM SAF CDRs for model evaluation
- CM SAF services
- Conclusion and outlook

CM SAF Services

- **Simulator for model comparisons**
- **Obs4Mips**
- **Tools** www.cmsaf.eu/tools
  'cmsaf' R-package includes Functions for simple analyses and CM SAF netcdf Data

- **Comprehensive User service (e.g. User help desk, training exercises and workshops)**



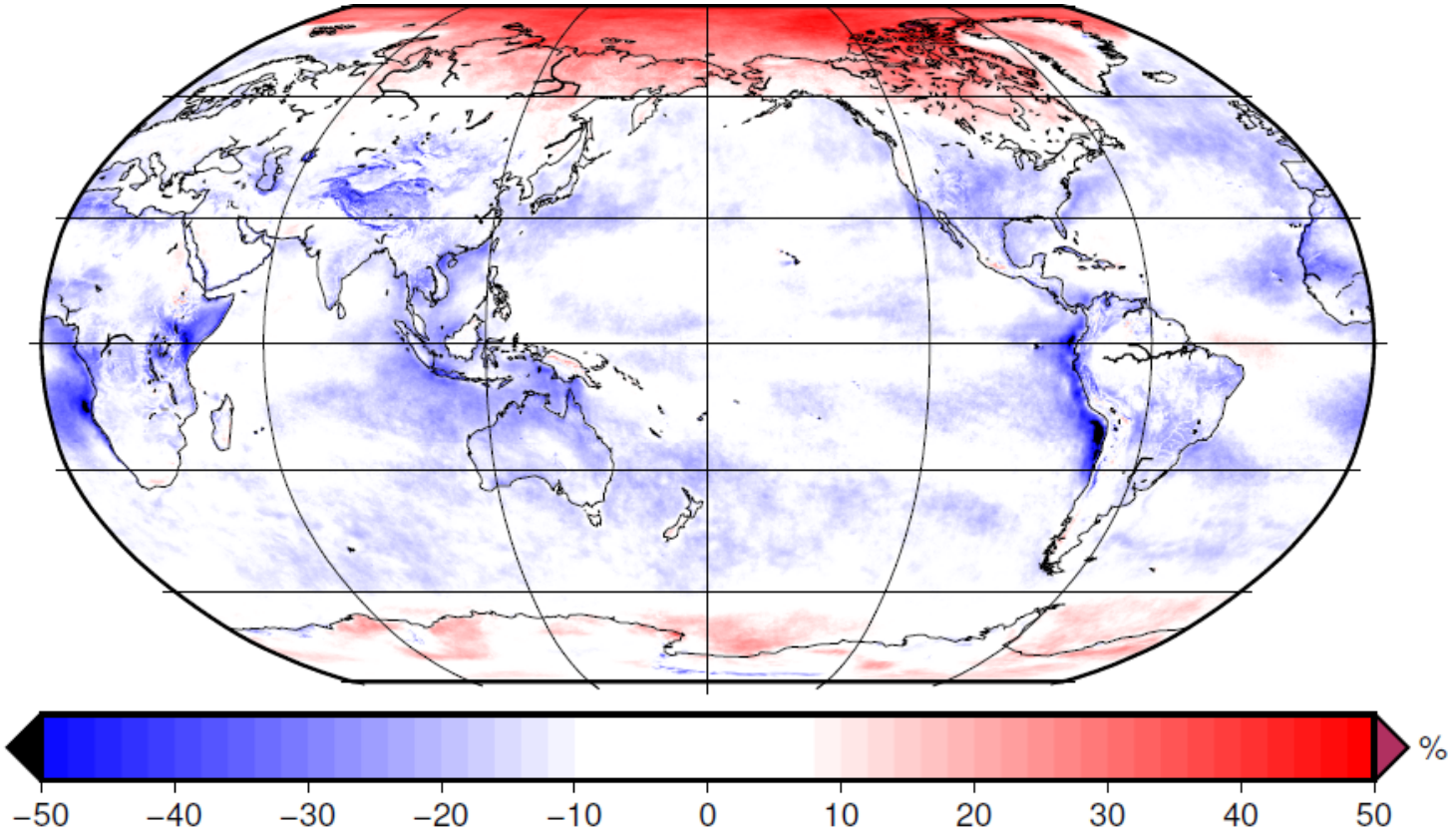
- **Simple, fast, free ordering tool via the Web**
- **Climate service TCDR + ICDR**

https://wui.cmsaf.eu

CLARA Simulator application

Cloud fraction

Simulated - observed

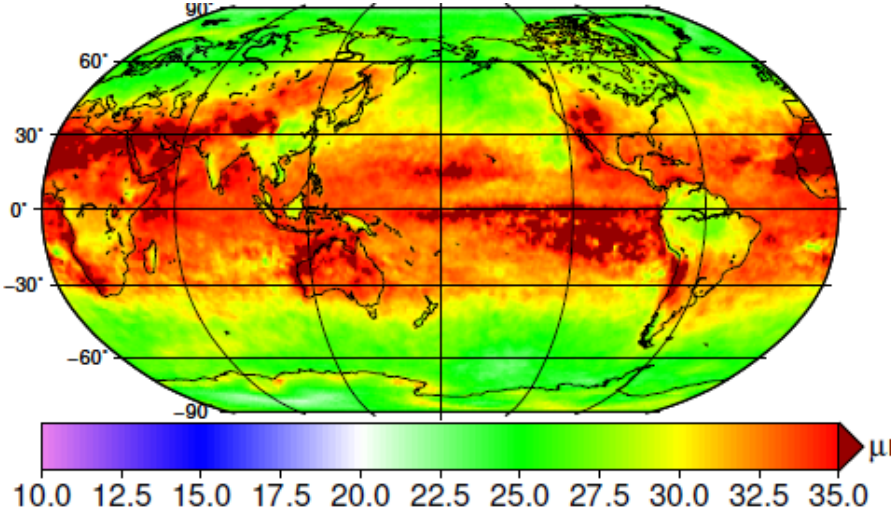


2008, NOAA-18. Large discrepancies in Arctic and Wester coastlines seen between CLARA and EC Earth (CLARA simulator-applied)

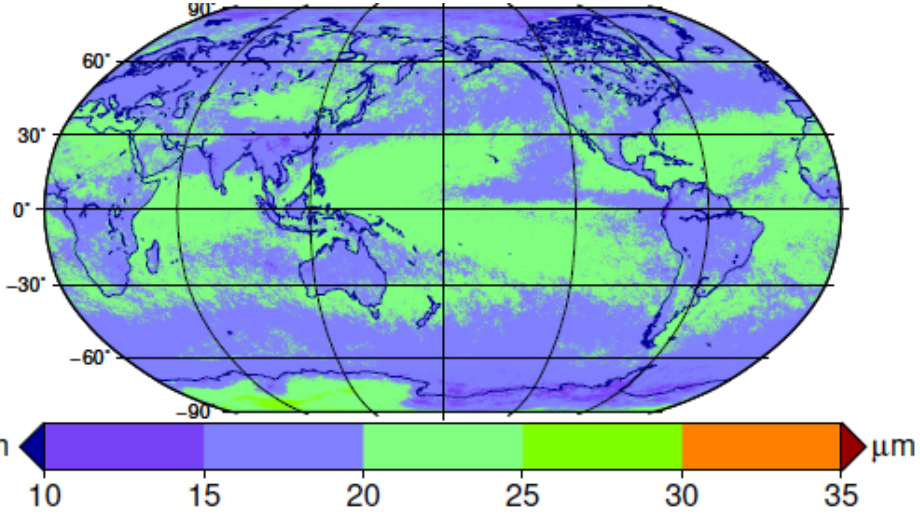
CLARA Simulator application

Effective radius (ice)

Model ice re

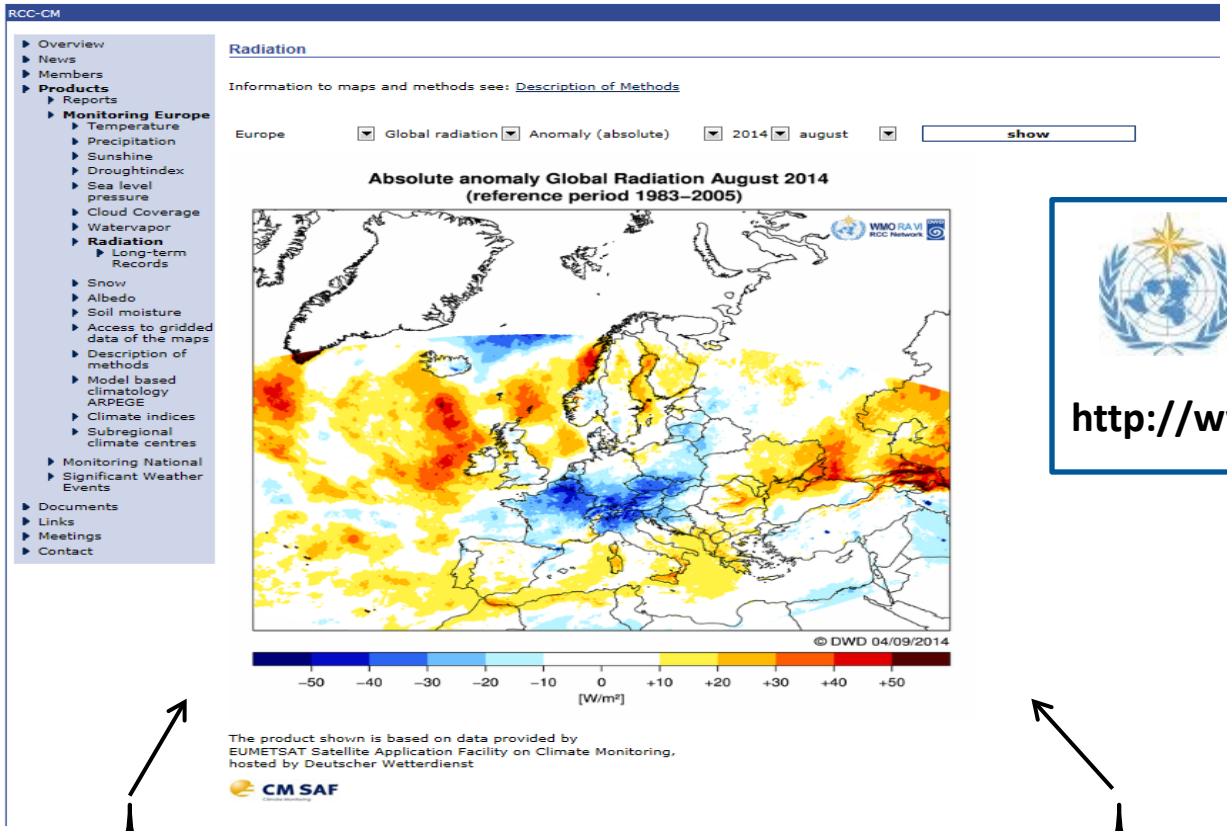


Ice re



2008, NOAA18, ascending. Quite different effective radius for ice clouds between CLARA-A2 and EC Earth (using simulator)

Application: WMO RCC RA VI



WMO RA VI RCC Network

http://www.dwd.de/rcc-cm

TCDR Long time series of ECVs

+

ICDR Regular & consistent updates of TCDRs

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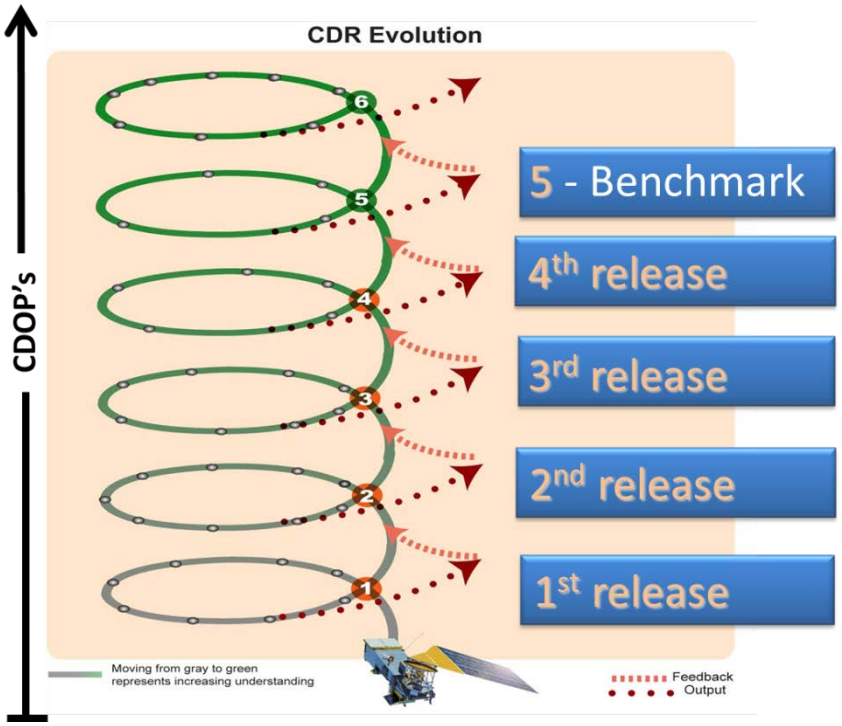
CM SAF: Long-term sustained effort for climate

PP	IOP	CDOP-1	CDOP-2	CDOP-3	CDOP-4	CDOP-5
1999-2004	2004-2007	2007-2012	2012-2017	2017-2022	2022-2027	2027-2032

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

- **Objectives for 2017 – 2022**
  - Continuation with the overall successful data records
  - Extended CDR portfolio:
    - Global Precipitation CDR
    - Regional Evapotranspiration CDR
  - Support to SCOPE-CM & GSICS
- In an agile framework using opportunities and chances



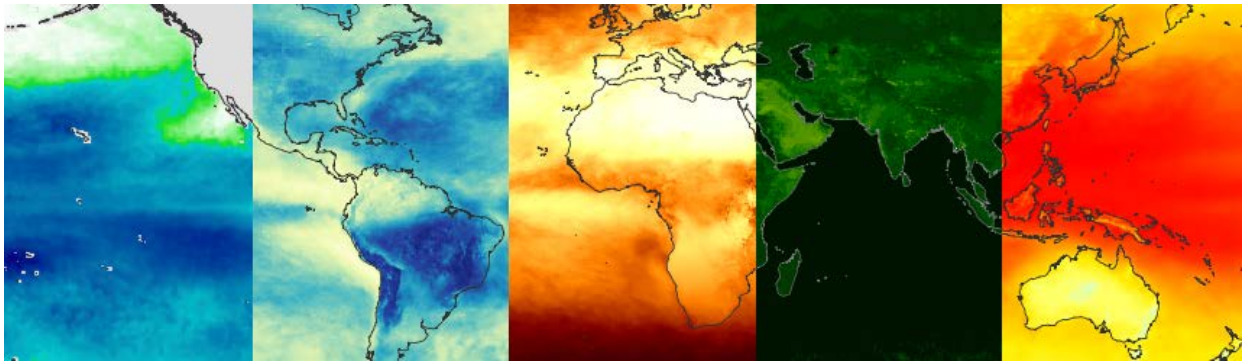
Conclusion and outlook

- Products and Services connected with CDRs of the global Energy- and water cycle
- CDR generation in an sustained operational environment
- Quality control and monitoring and reviews before publishing data
- Extensive services, training and support to User
- Free and easy direct data access
- Successful: about 140 peer-reviewed papers using CM SAF Data

Contact data:

www.cmsaf.eu

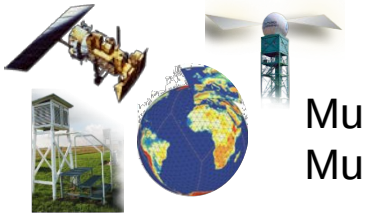
Contact.cmsaf@dwd.de



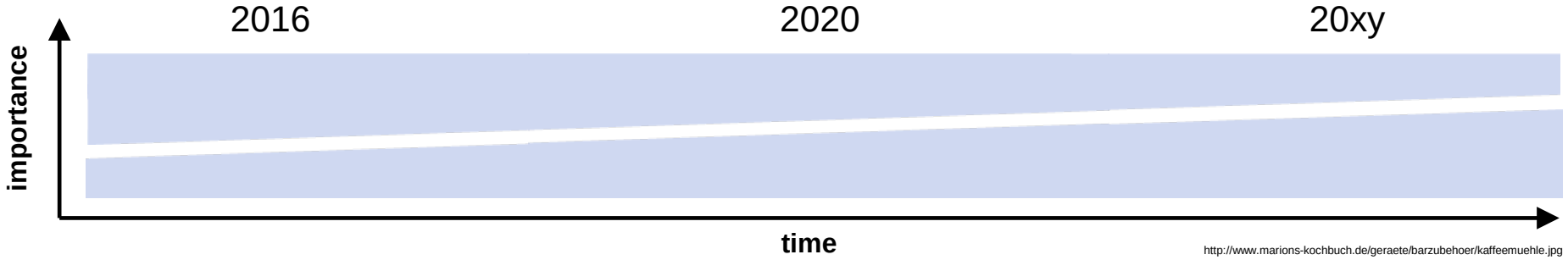
Changing the paradigm?

Multi Sensor
Multi Satellite

Multi Sensor
Multi Source



Multi Sensor
Multi Source



http://www.marions-kochbuch.de/geraete/barzubehoer/kaffeemuehle.jpg