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Meteosat MVIRI surface radiation dataset

Rebekka Posselt (MeteoSwiss)

With support from
J. Trentmann, R. Müller, R. Stöckli

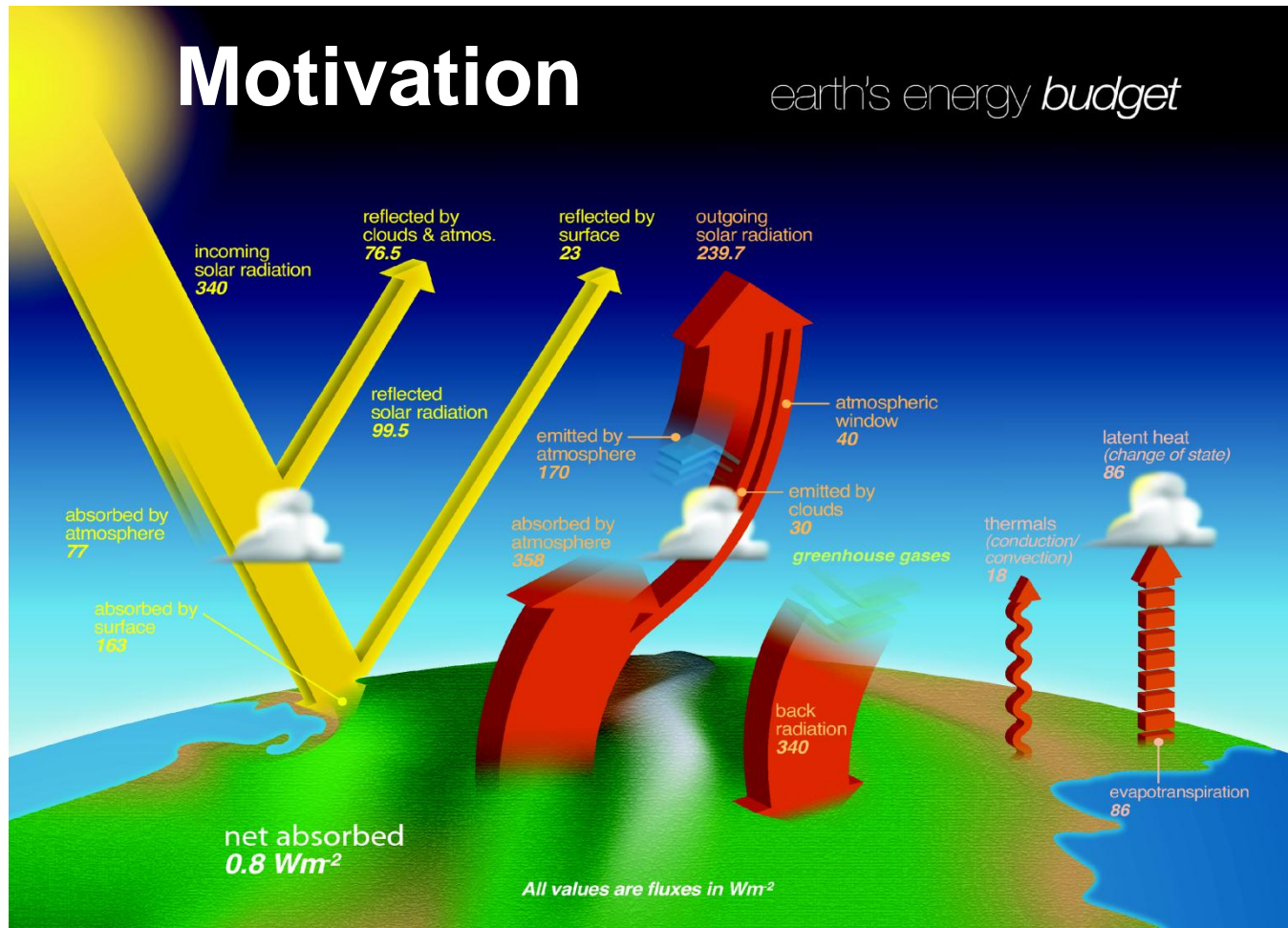
Contact me at: rebekka.posselt@meteoswiss.ch





Motivation

earth's energy *budget*

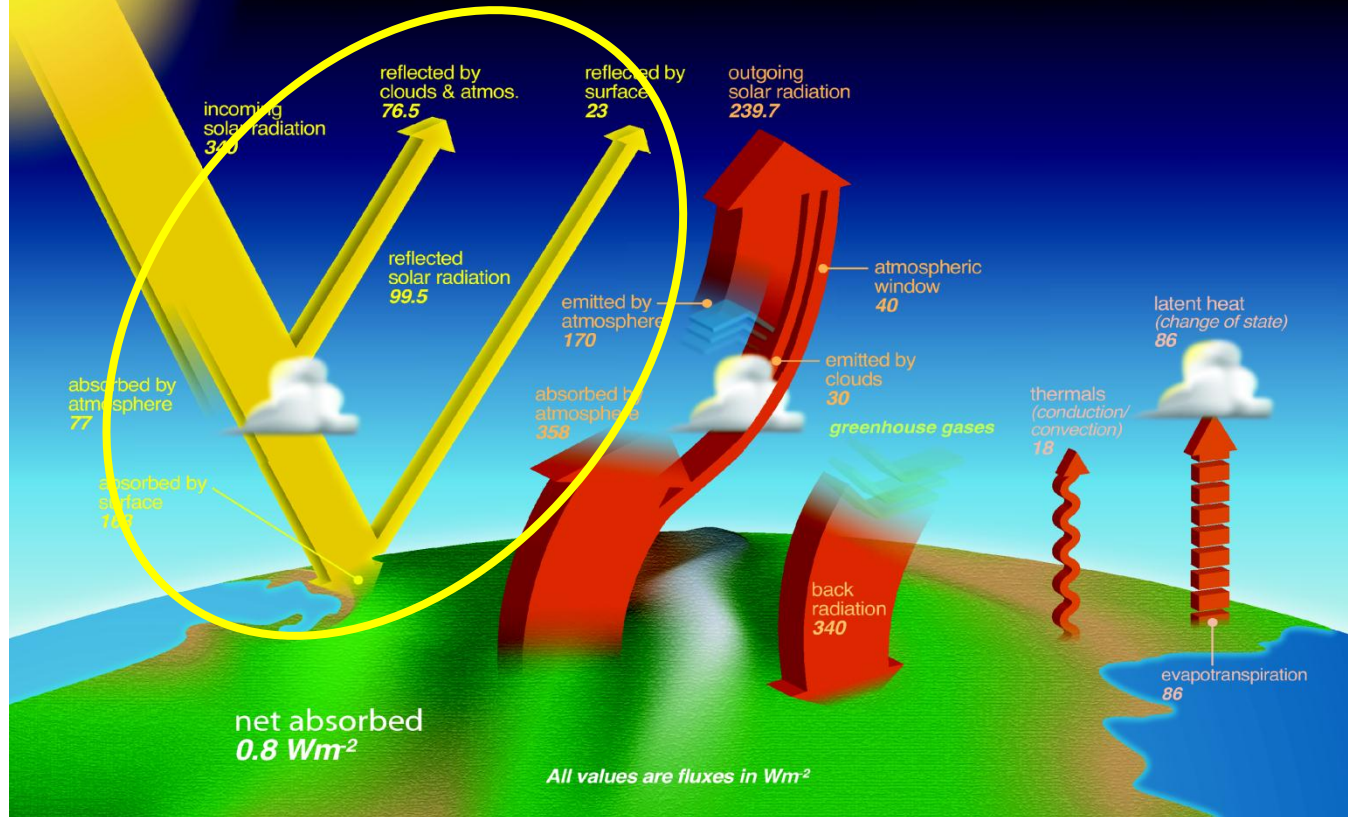


- Radiation is the driving force for all atmospheric processes.
→ Radiation budget is an essential climate variable (GCOS)
- Planning and monitoring of solar energy systems



Motivation

earth's energy *budget*



- Radiation is the driving force for all atmospheric processes.
→ Radiation budget is an essential climate variable (GCOS)
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Outline

- Motivation and Introduction
- Algorithm repetition
- **Meteosat MVIRI surface radiation dataset**
 - Validation
 - Homogeneity
 - Known Issues
- Applications
- Extension with SEVIRI data?

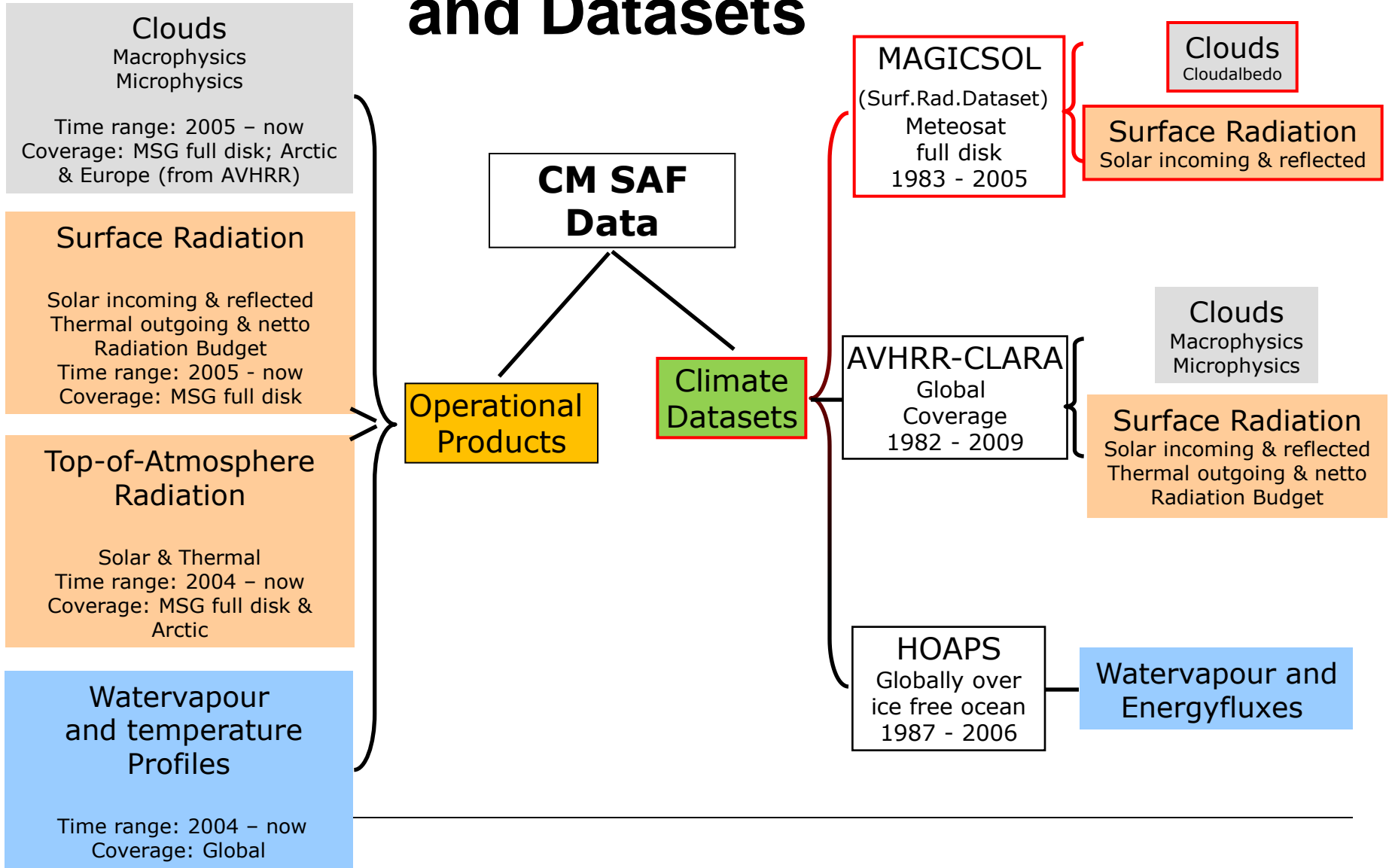


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Available operational Products and Datasets



**CM SAF
Data**

**Operational
Products**

**Climate
Datasets**

Clouds
Macrophysics
Microphysics

Time range: 2005 - now
Coverage: MSG full disk; Arctic & Europe (from AVHRR)

Surface Radiation

Solar incoming & reflected
Thermal outgoing & netto
Radiation Budget
Time range: 2005 - now
Coverage: MSG full disk

Top-of-Atmosphere Radiation

Solar & Thermal
Time range: 2004 - now
Coverage: MSG full disk & Arctic

Watervapour and temperature Profiles

Time range: 2004 - now
Coverage: Global

MAGICSOl
(Surf.Rad.Dataset)
Meteosat full disk
1983 - 2005

Clouds
Cloudalbedo

Surface Radiation
Solar incoming & reflected

AVHRR-CLARA
Global Coverage
1982 - 2009

Clouds
Macrophysics
Microphysics

Surface Radiation
Solar incoming & reflected
Thermal outgoing & netto
Radiation Budget

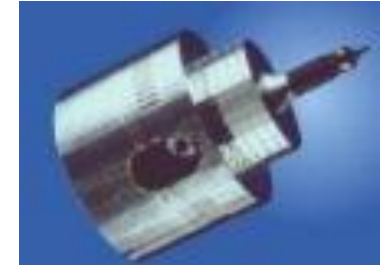
HOAPS
Globally over ice free ocean
1987 - 2006

Watervapour and Energyfluxes

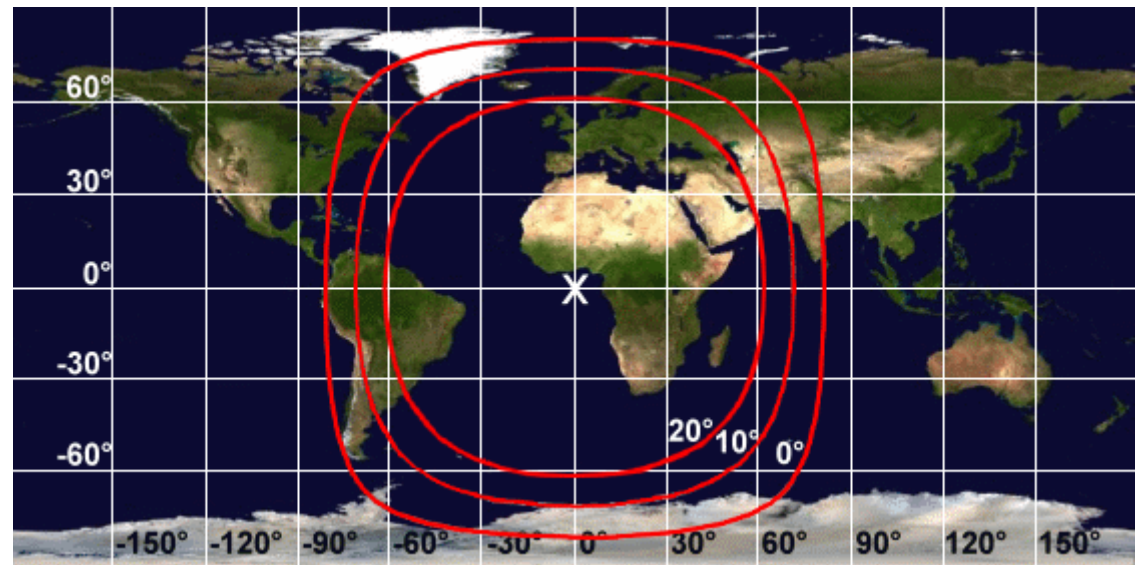
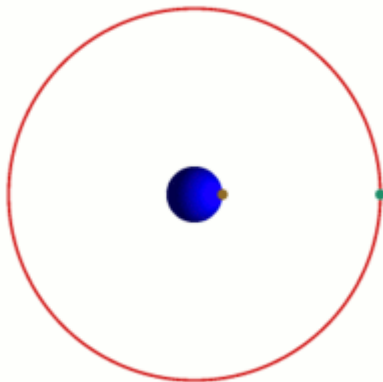


Meteosat MVIRI

- MVIRI = Meteosat Visible and Infrared Imager
- Instrument on Meteosat First Generation (or Meteosat Transition Period) Satellites
 - 1977-2005 = Meteosat 1-7
- Covers Africa and Europe (positioned at 0°)



© <http://www.eumetsat.int>

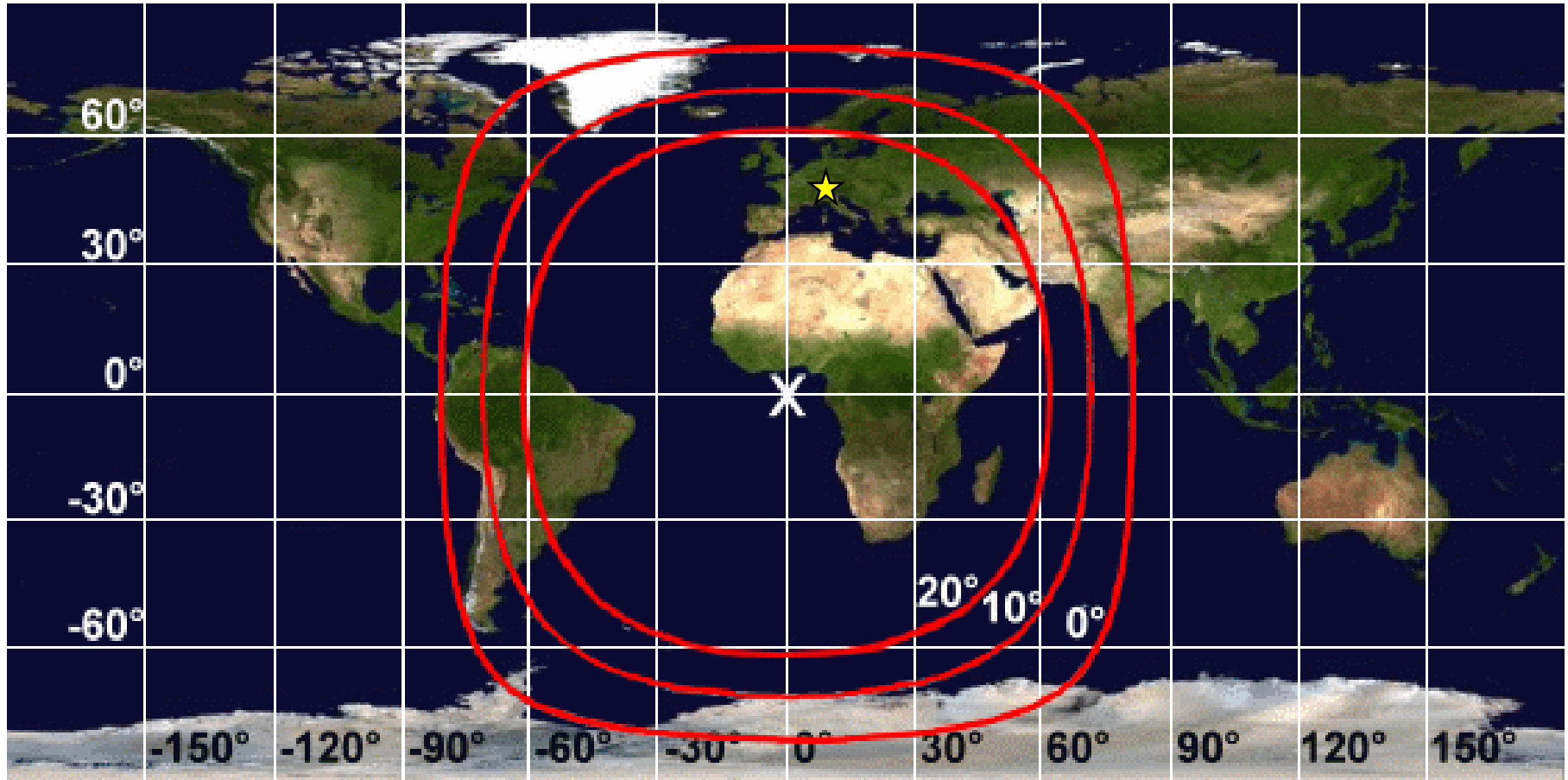


Graphics from: http://de.wikipedia.org/wiki/Geosynchrone_Umlaufbahn



Meteosat MVIRI

Where are you on the Meteosat disc? (use the ★)



Graphics from: http://de.wikipedia.org/wiki/Geosynchrone_Umlaufbahn



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MagicSol

Retrieval for historical radiation datasets

- Retrieval scheme
 1. Get cloud information
 - “Effective Cloud Albedo” (CAL)
 - From satellite
 2. Get clear sky information
 - “Clear Sky Radiation” (Rad_{cs})
 - From LookUpTables
 3. Combine 1. & 2.

For more details refer to the previous “Surface Radiation Retrieval” session

$$Rad = f(CAL) \cdot Rad_{cs} \approx (1 - CAL) \cdot Rad_{cs}$$



MagicSol

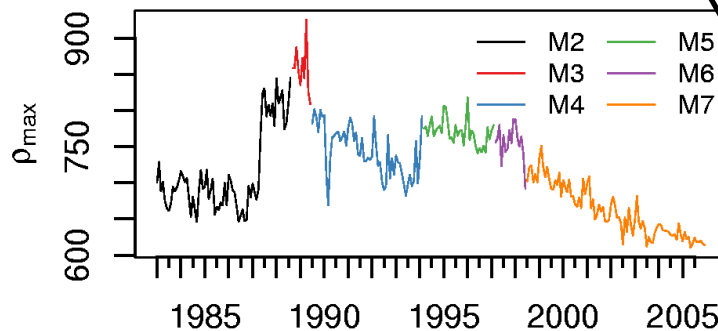
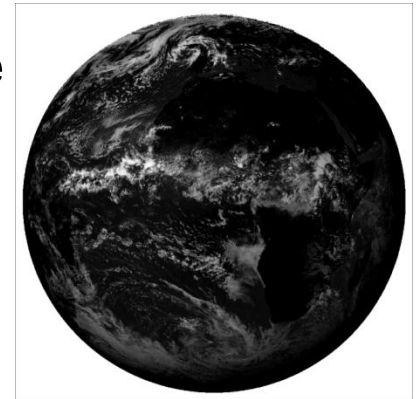
Retrieval for historical radiation datasets

1. Get cloud information

- All information together give the “effective cloud albedo” (CAL, a.k.a. cloud index) → Heliosat method

$$CAL = \frac{\rho - \rho_{min}}{\rho_{max} - \rho_{min}}$$

Cloud image



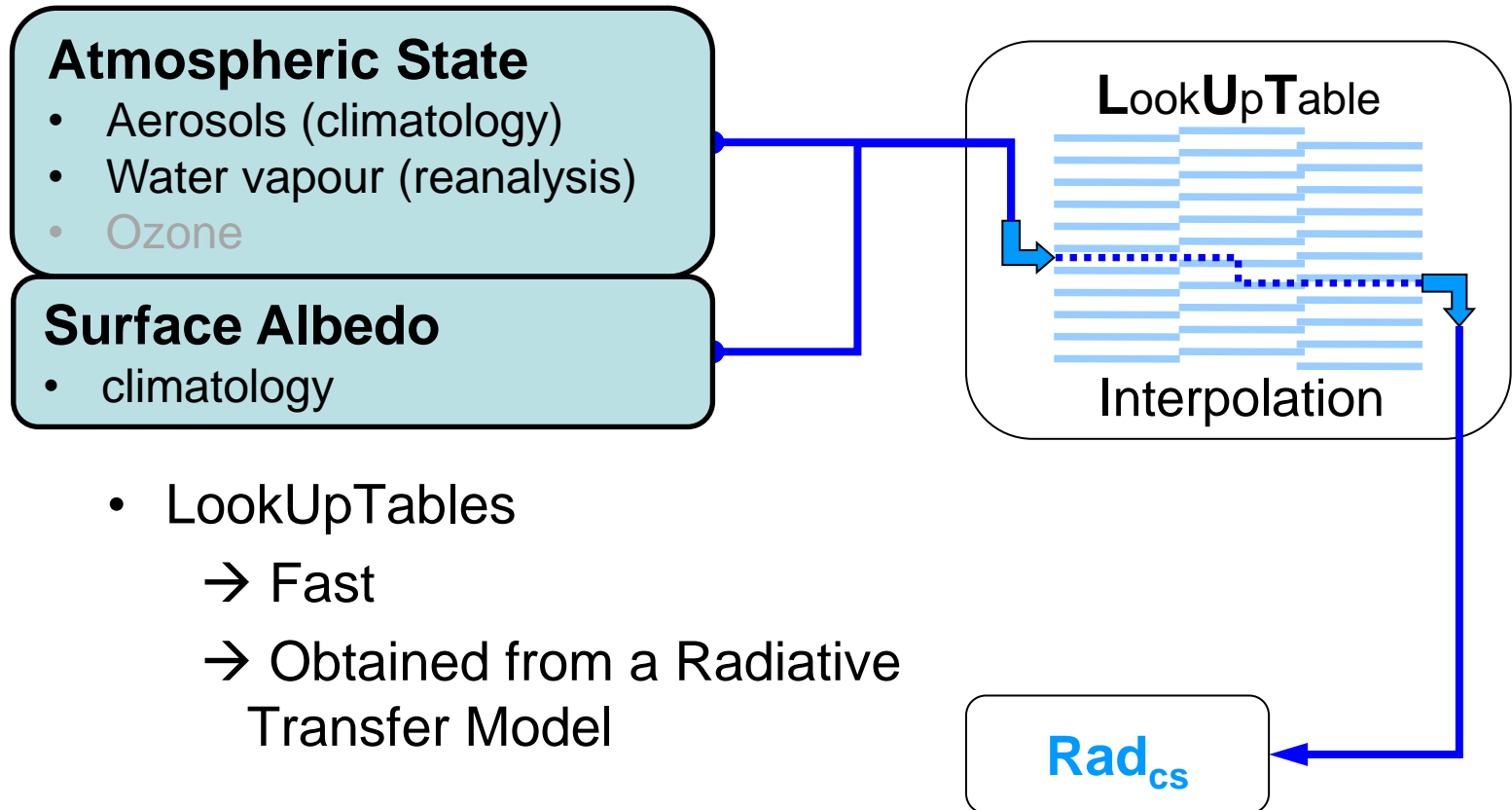
~ Maximum range of pixel brightnesses



MagicSol

Retrieval for historical radiation datasets

2. Get clear sky radiation (clear sky gnu-magic)



- LookUpTables
 - Fast
 - Obtained from a Radiative Transfer Model



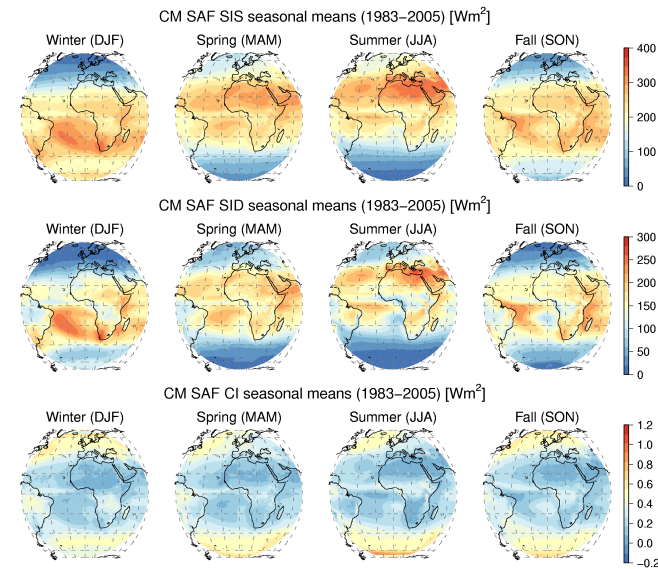
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MVIRI Surface Radiation CDR

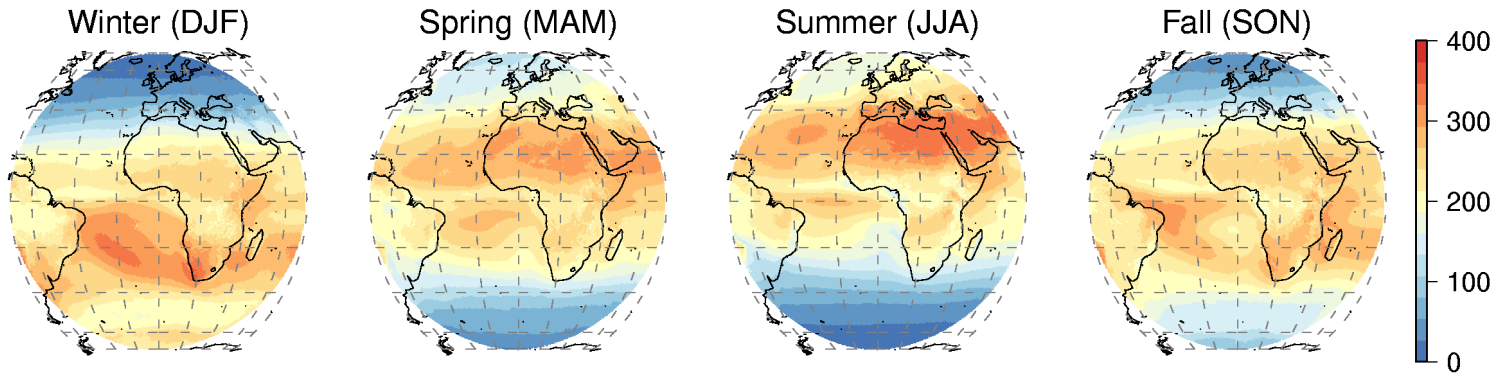
- Available variables:
 - SIS – global radiation
 - SID – direct radiation
 - CAL – cloud albedo (also CI – Cloud index)
- Available coverage
 - 1982 – 2005 (= Meteosat 2 – 7)
 - Meteosat Full Disc
- Available resolutions:
 - hourly, daily and monthly means
 - 0.03° regular lon-lat-grid



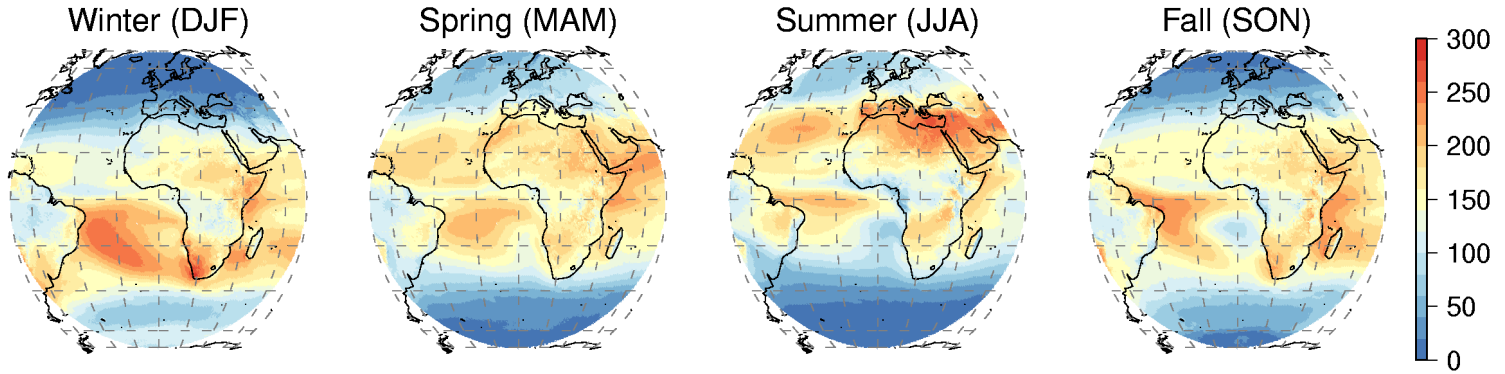


MVIRI Surface Radiation CDR

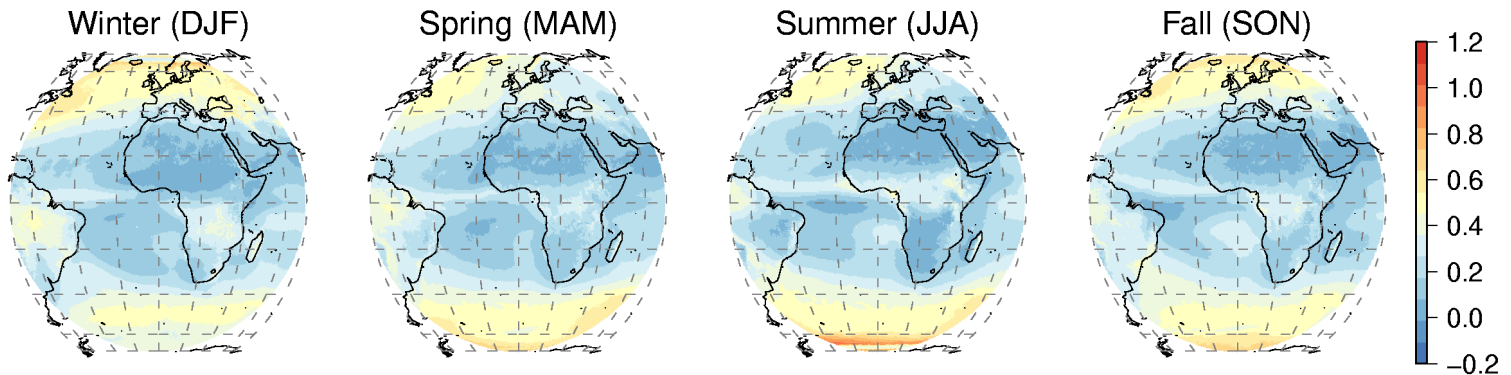
CM SAF SIS seasonal means (1983–2005) [Wm^2]



CM SAF SID seasonal means (1983–2005) [Wm^2]



CM SAF CI seasonal means (1983–2005) [Wm^2]





Validation Dataset

- Quality of dataset is validated using **Baseline Surface Radiation Network (BSRN)** data
- BSRN is a project of the GEWEX Radiation Panel under the World Climate Research Programme (WCRP).
- Currently about 40 stations in contrasting climatic zones
- Support of the validation and confirmation of satellite and computer model estimates





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Accuracy requirements	SIS [W/m ²]	SID [W/m ²]	CAL
Monthly	15	20	0.15
Hourly/Daily	25	30	0.2



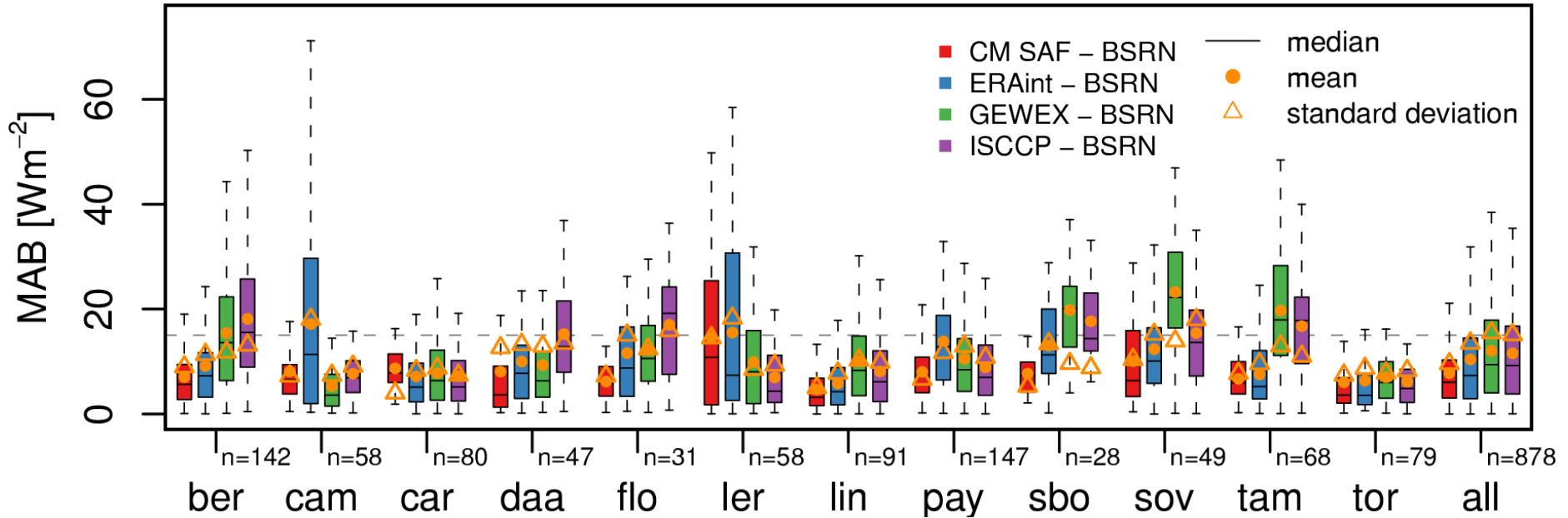
Intercomparison datasets

- **ERAinterim** (ECMWF Re-Analysis Project)
 - 6-hourly means, 1989 - present
 - Global coverage on a $1^\circ \times 1^\circ$ global grid
- **GEWEX** (Global Energy and Water-cycle Experiment)
Surface Radiation Budget dataset
 - 3-hourly/daily/monthly means, July 1983 - Dec. 2007
 - Global coverage on a $1^\circ \times 1^\circ$ global grid
- **ISCCP** (International Satellite Cloud Climatology Project)
Flux dataset
 - 3-hourly means, July 1983 - Dec 2007
 - Global coverage on a 280 km equal-area global grid



Validation

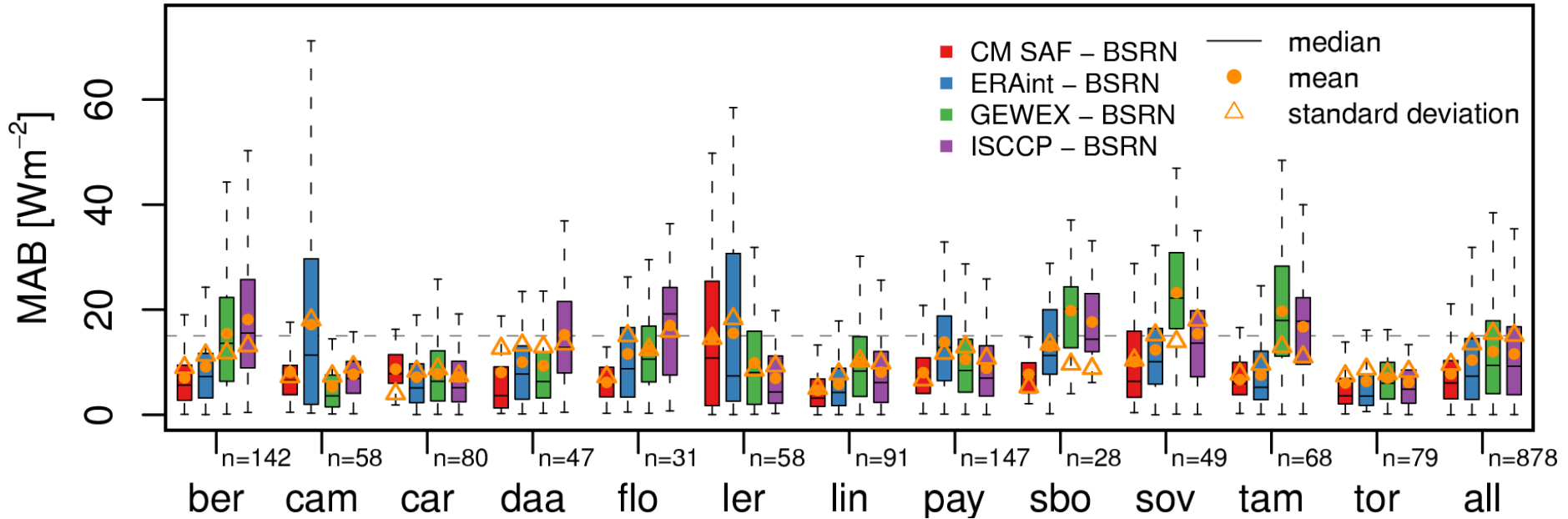
Monthly mean SIS





Validation

Monthly mean SIS

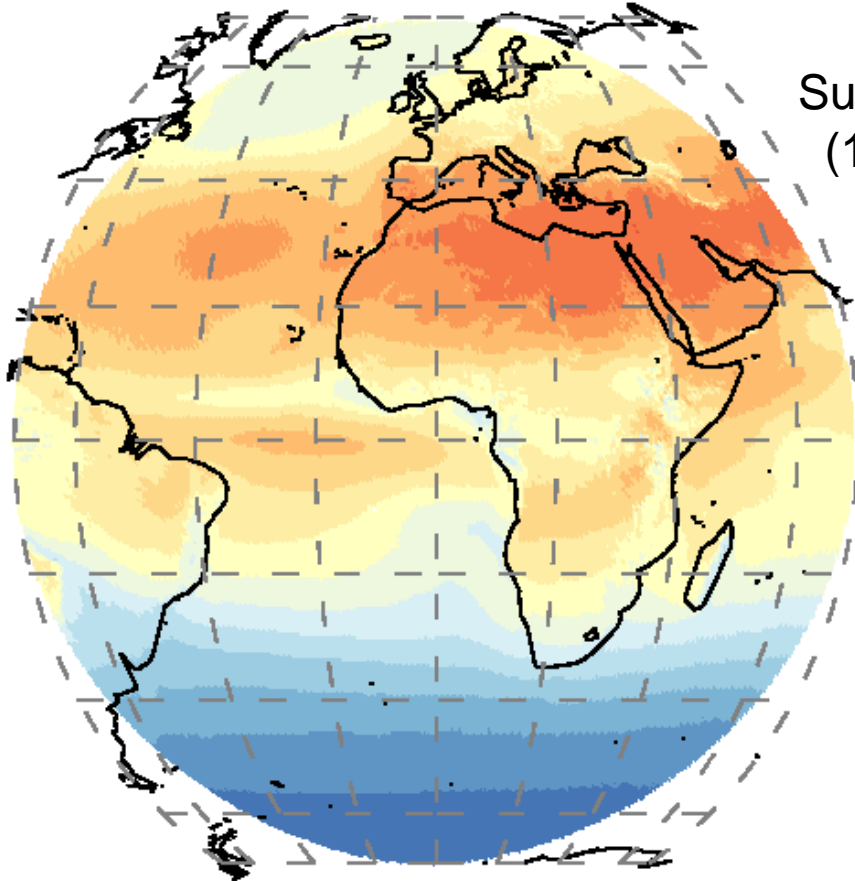


SIS	N _{mon}	Bias [W/m ²]	MAB [W/m ²]	SD [W/m ²]	AC	Frac _{mon} > 15 W/m ² [%]
CM SAF	878	4.24	7.76	8.23	0.89	10.71
ERAinterim	878	5.48	10.41	12.15	0.8	24.6
GEWEX	878	-2.42	12.03	11.03	0.82	31.89
ISCCP	878	-0.02	11.56	11.25	0.78	29.16

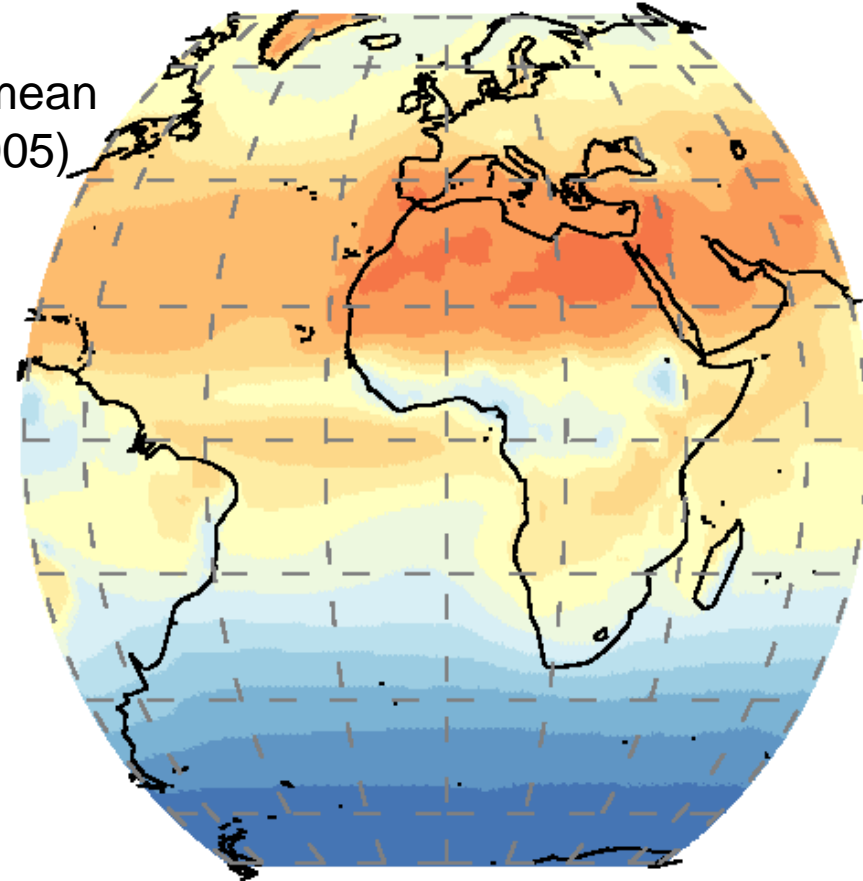


Intercomparison

CM SAF



ERA interim



Summer mean
(1983-2005)

- Find the differences! (use the★)



Intercomparison

SIS seasonal means (1983–2005) [Wm^2]

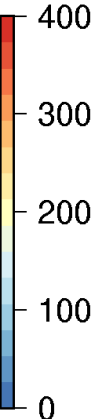
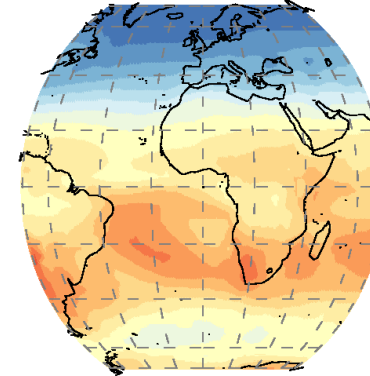
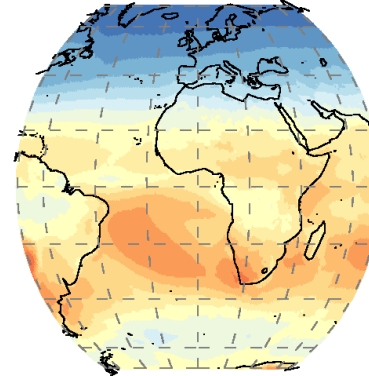
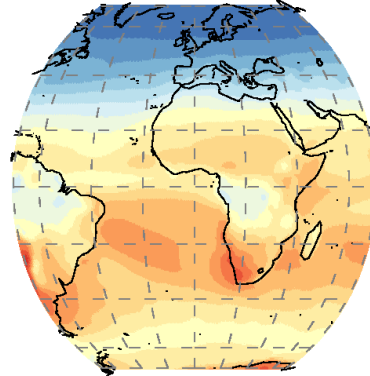
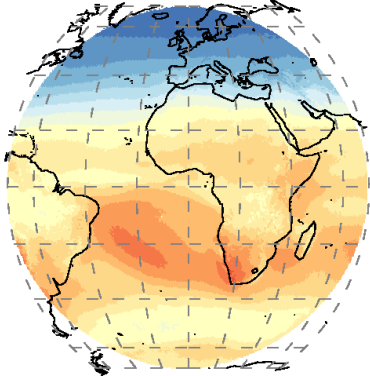
CM SAF

ERAint

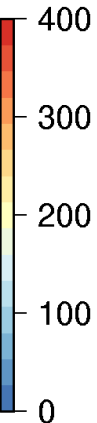
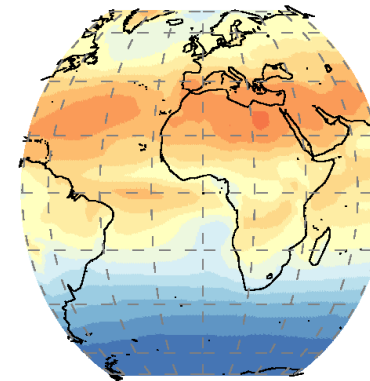
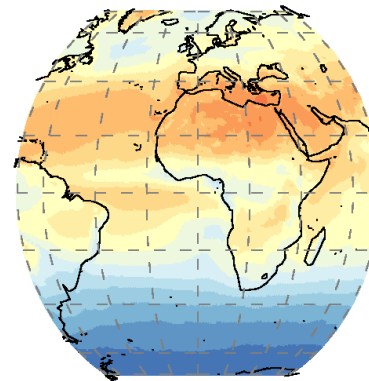
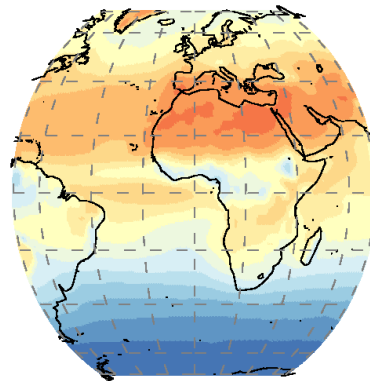
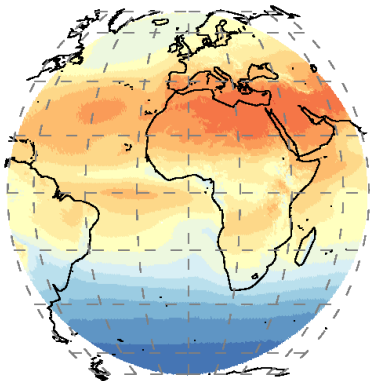
GEWEX

ISCCP

Winter (DJF)



Summer (JJA)

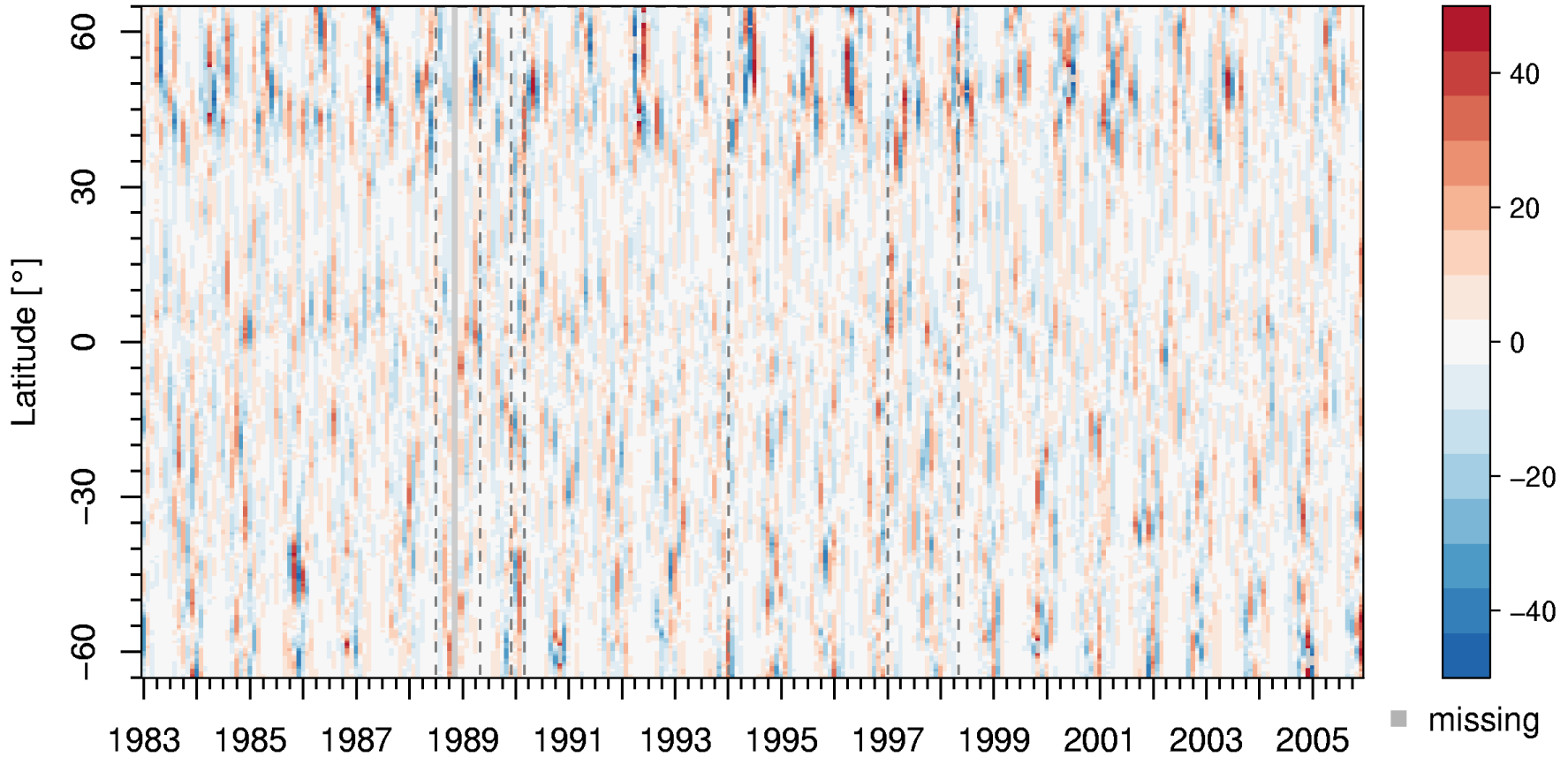


- Overall pattern are in good agreement, but significant regional differences are visible
→ especially Tropics and Southern and Northern Atlantic



Homogeneity

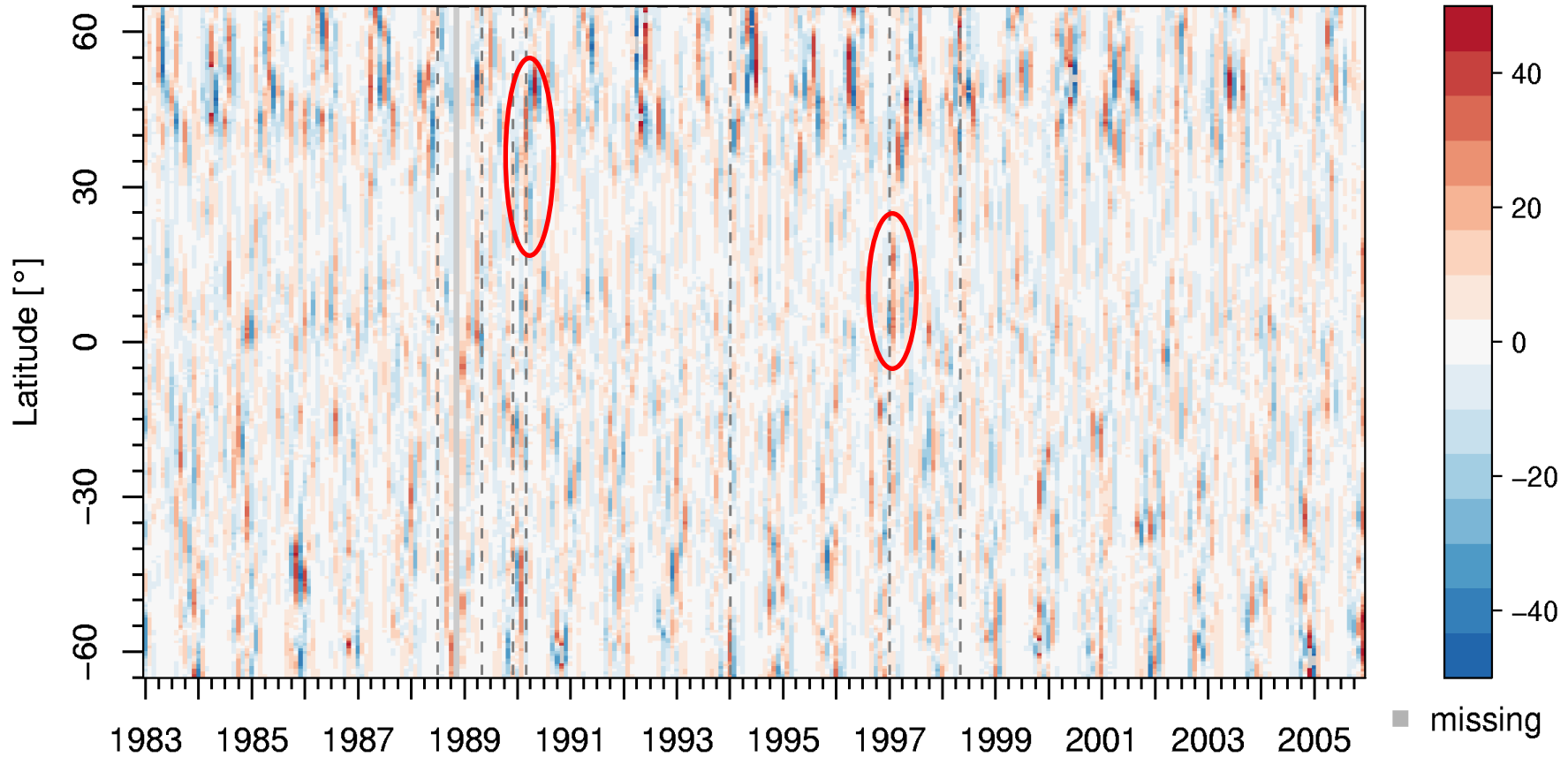
zonal (10°W–30°E) monthly mean anomaly derivation of SIS [Wm^{-2}]





Homogeneity

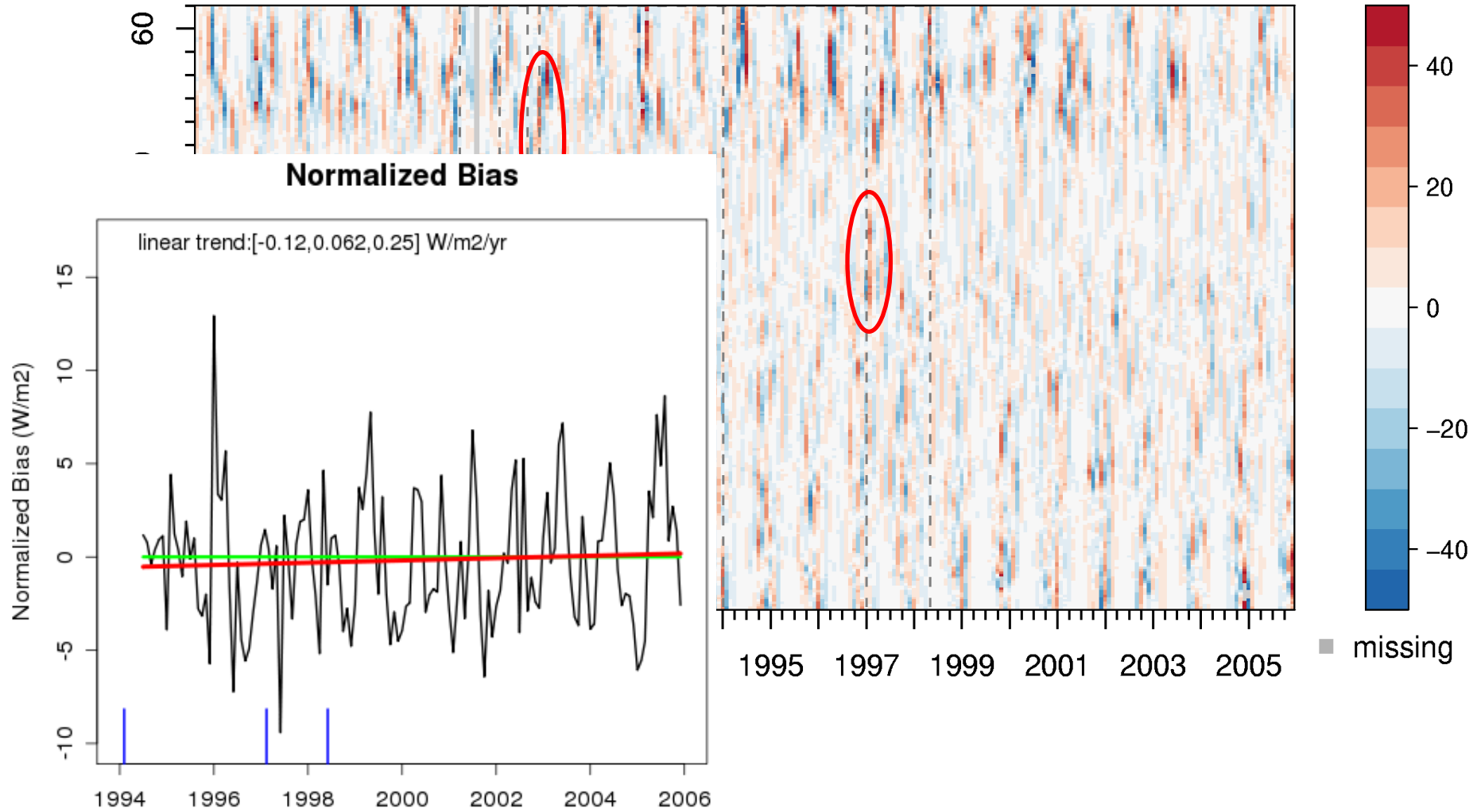
zonal (10°W–30°E) monthly mean anomaly derivation of SIS [Wm^{-2}]





Homogeneity

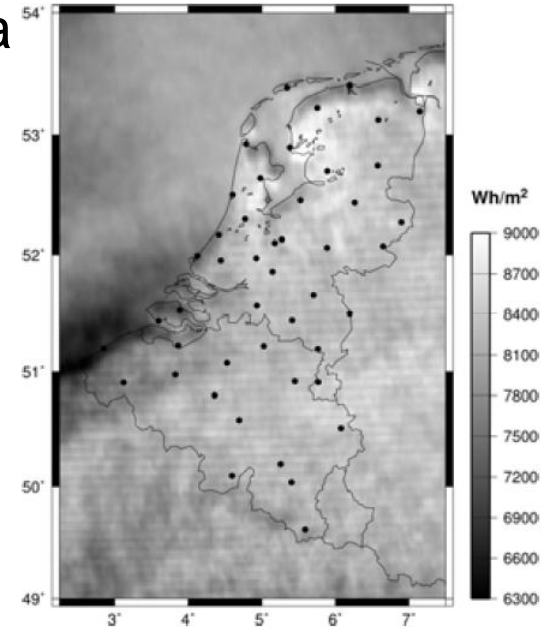
zonal (10°W–30°E) monthly mean anomaly derivation of SIS [Wm^{-2}]





Known Issues

- Stripping pattern in Meteosat 2 and 3 data (1982 – 1989; partly up to 1994, if Meteosat 3 was used as backup)
 - Due to uncorrected missing lines during night
 - Consequence: means are too low (order of 5 Wm^{-2} for daily means)
 - Cannot be corrected at the moment, wait for next dataset release (CDOP2)



Courtesy of M. Journée (RMIB)

- Radiation over bright surfaces (e.g., snow and deserts)
 - ρ_{\min} retrieval complicated and, thus, unreliable
 - Consequence: Handle radiation fields in this areas with care!



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Applications

- “Brainstorming”
→ “What applications can you imagine for the MVIRI surface radiation Dataset?”



Applications

JRC CM SAF Photovoltaic Geographical Information System - Interactive Maps

EUROPA > EC > JRC > IE > RE > SOLAREC > PVGIS > Interactive maps > europe

Contact Important legal notice

Europe Africa e.g., "Ispra, Italy" or "45.256N, 16.9589E" Zürich cursor position: 41.706, 28.916 selected position: 47.369, 8.539

PV Estimation Monthly radiation Daily radiation

Performance of Grid-connected PV

Radiation database: Climate-SAF PVGIS [What is this?]

PV technology: Crystalline silicon

Installed peak PV power 1 kWp

Estimated system losses [0;100] 14 %

Fixed mounting options:

Mounting position: Free-standing

Slope [0;90] 35 ° Optimize slope

Azimuth 0 ° Also optimize azimuth

Tracking options:

Vertical axis Slope [0;90] 0 ° Optimize

Inclined axis Slope [0;90] 0 ° Optimize

2-axis tracking

Horizon file

Output options

Show graphs Show horizon

Web page Text file PDF

[help]

Solar Energy potential

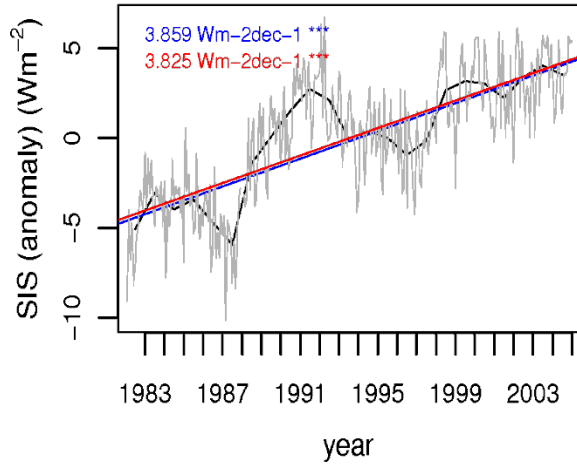
- PVGIS (<http://re.jrc.ec.europa.eu/pvgis/>)
 - Geographical Assessment of Solar Resource and Performance of Photovoltaic Technology



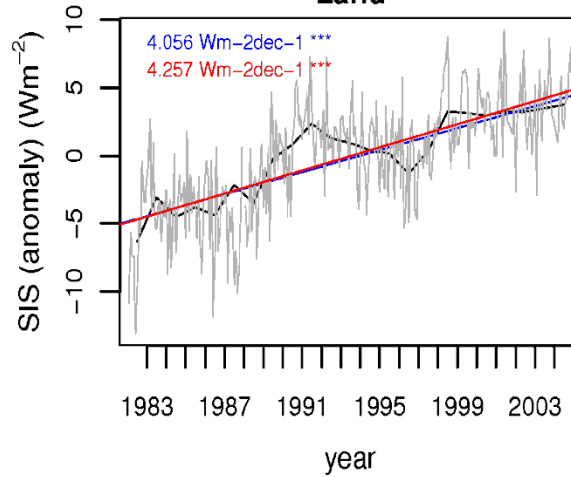
Applications

Trend Analysis

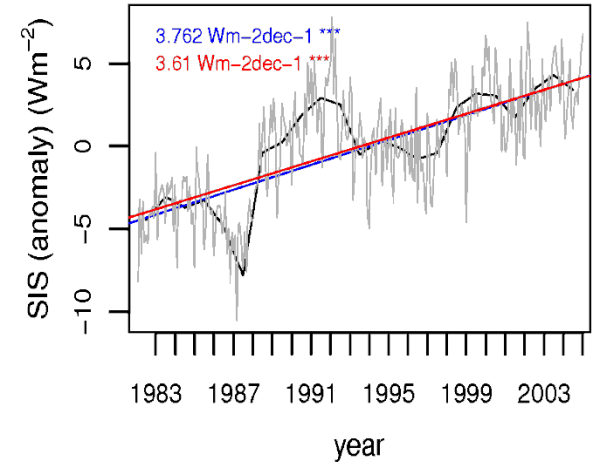
World



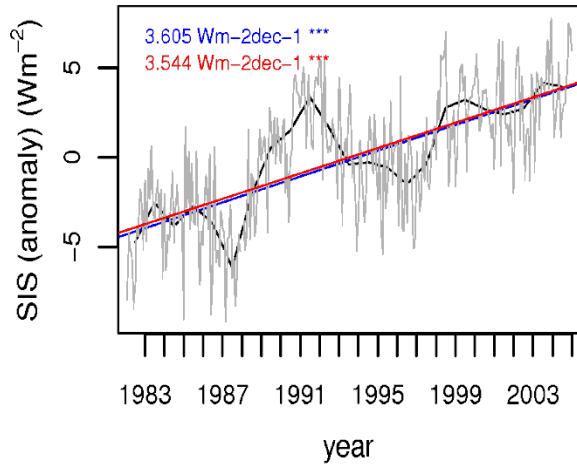
Land



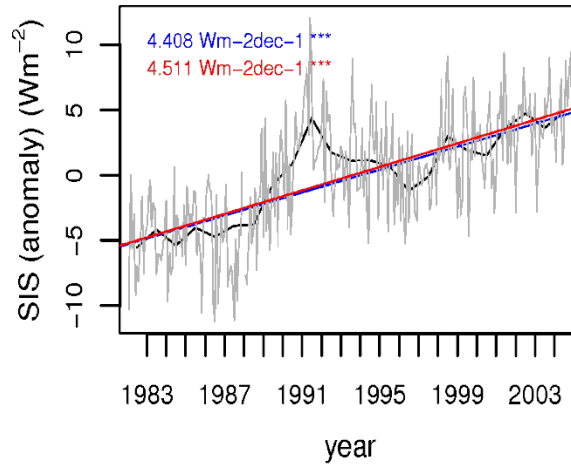
Ocean



NH



SH



- yearly anomaly
- monthly anomaly
- trend ym
- trend mm



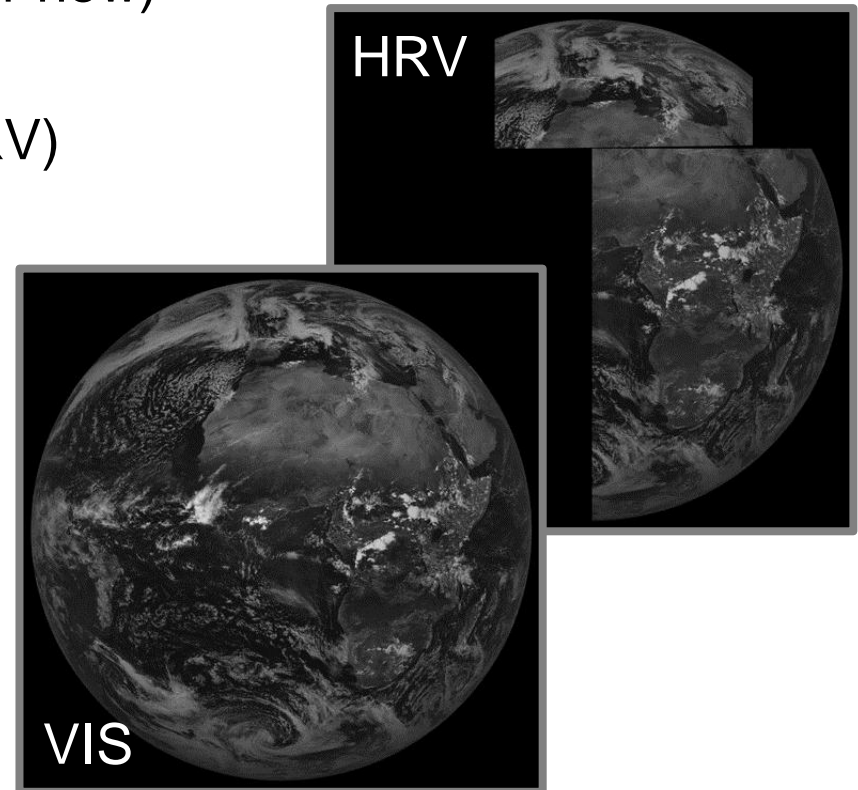
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Extension with SEVIRI data?

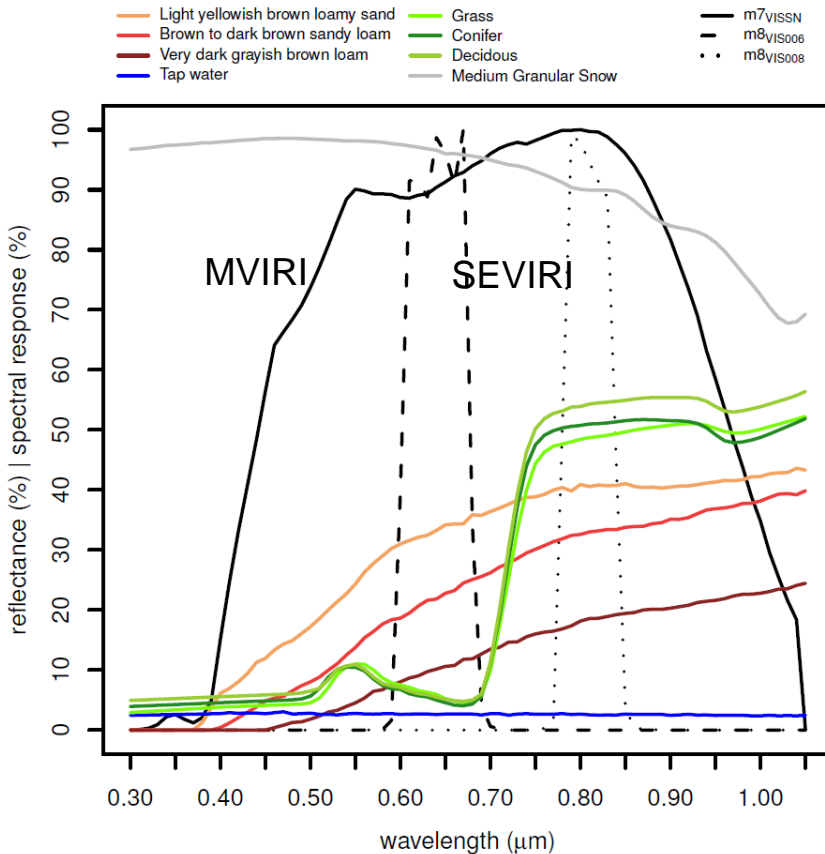
- SEVIRI = Spinning Enhanced Visible and InfraRed Imager
 - Onboard Meteosat Second Generation satellites (Meteosat 8-10 → 2004-now)
- High resolution visible (HRV) channel:
 - Differences in spatial coverage
 - Only useful for subsets (e.g., Europe, Africa)
 - Similar spectral properties





Extension with SEVIRI data?

- SEVIRI = Spinning Enhanced Visible and InfraRed Imager
 - Onboard Meteosat Second Generation satellites (Meteosat 8-10 → 2004-now)

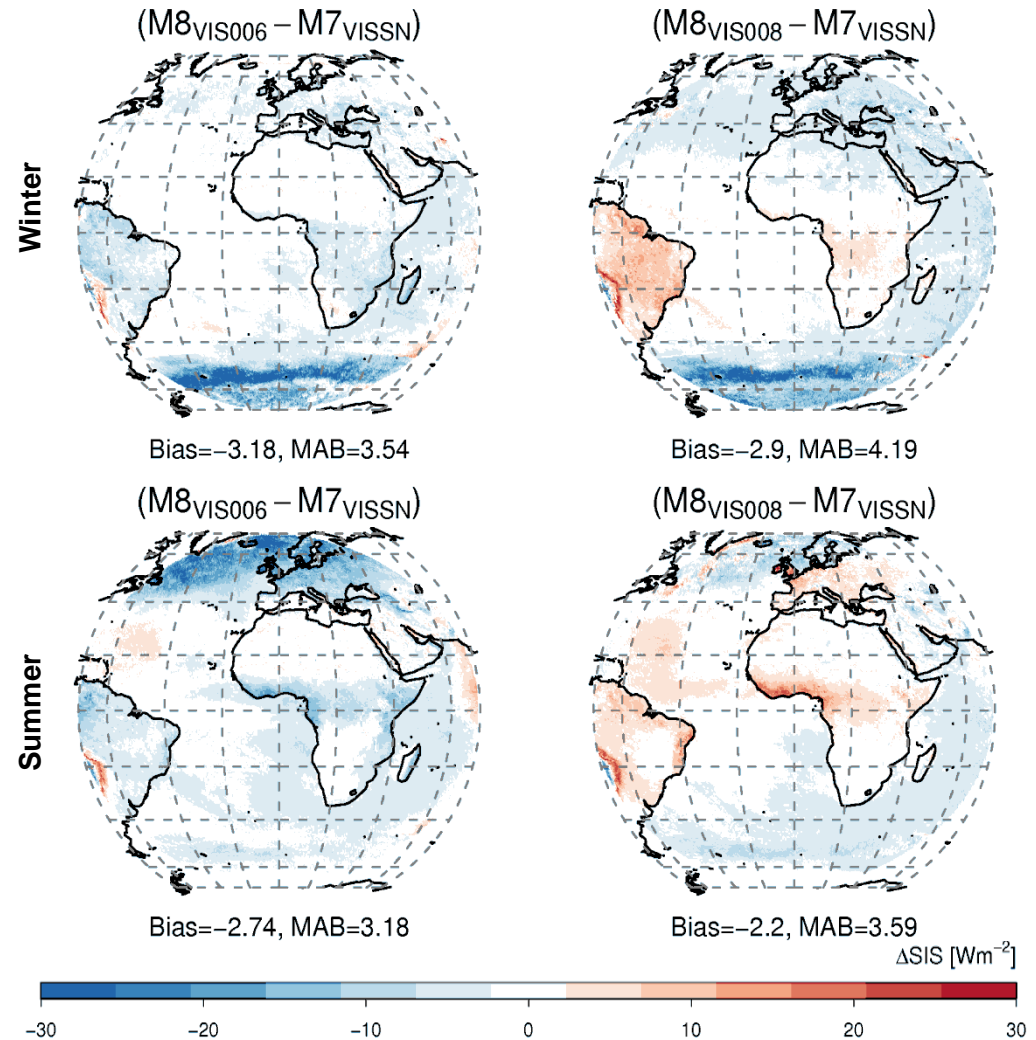


- Narrowband VIS channels
 - Differences in spectral characteristics (broadband vs. narrowband)
 - Large differences especially for vegetation
 - Similar spatial coverage



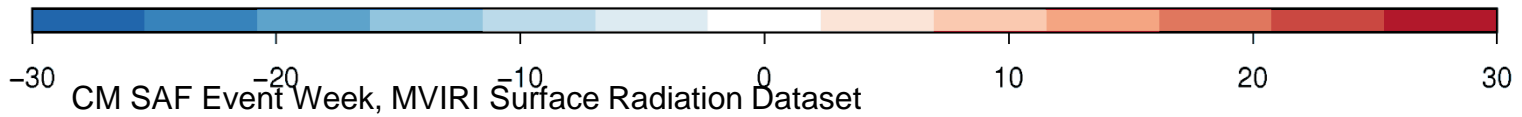
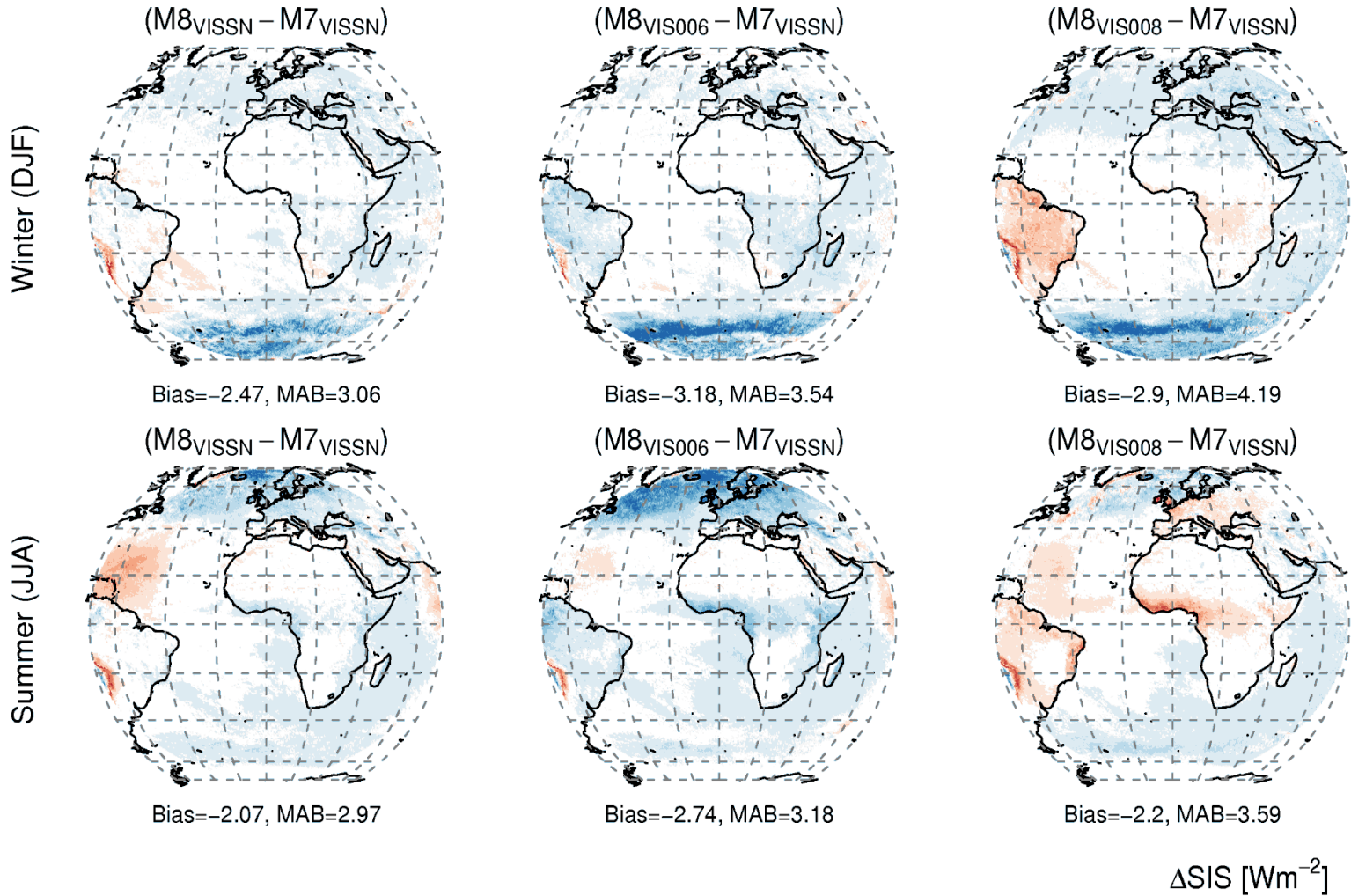
Extension with SEVIRI data?

- How to solve? (use the ★)
 - **Combination of the SEVIRI VIS channels** to generate a broadband channel similar to MVIRI
 - **Average SIS of the SEVIRI VIS channels** to even out the differences





Extension with SEVIRI data?





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