Global and local analysis of Surface Incoming Shortwave Radiation (SIS)

A decision guidance for the choice between

CLARA and SARAH datasets

Sarah Beuscher, October 21st 2022

Preface

In „Monthly Report of Surface Incoming Shortwave Radiation (SIS) - Application examples for the CM SAF R Toolbox using CM SAF Cloud, Albedo, Radiation (CLARA) datasets'' the CLARA dataset and it's application possibilities are introduced.

But there are some difficulties to consider while using the CLARA dataset or when looking for an alternative dataset like the Surface Solar Radiation Heliosat (SARAH) dataset to analyze radiation parameters.

This project is supposed to compare both datasets as well as giving tips on how to find the fitting CM SAF R Toolbox operators to each dataset.

All data used in this project are accessible from EUMETSAT CM SAF, https://wui.cmsaf.eu

- After ordering and downloading the data as .tar-files, you can combine multiple files by rename them with the same order number,
  for example:

  ORD44786.tar → ORD44786.tar

  ORD44787.tar → ORD44786_1.tar

  ORD44788.tar → ORD44786_2.tar

  .... → ....

Contents

1. The SARAH dataset

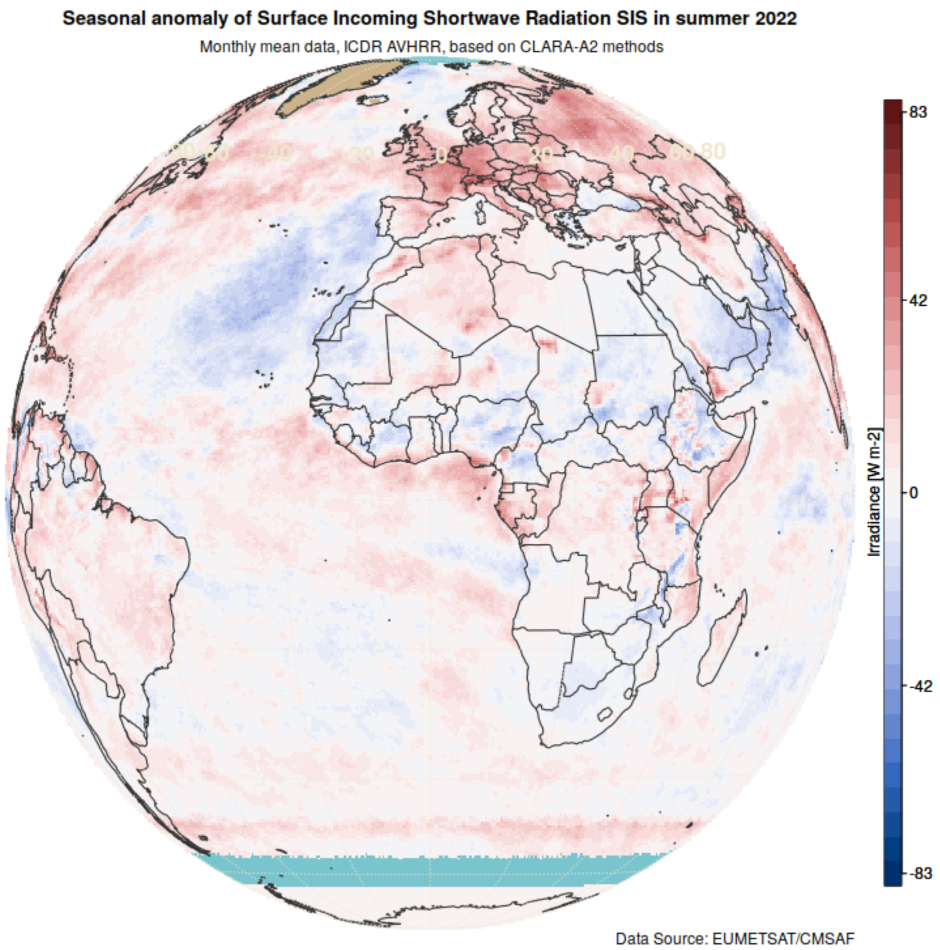
- The **S**urface Sol**a**r **Ra**diation **H**eliosat (SARAH) dataset is a CM SAF Surface Radiation data record covering the region ±65° longitude and ±65° latitude (also known as Meteosat disk).
- Data is retrieved from the visible channels of the **MVIRI** (Meteosat Visible and Infrared Imager) **and SEVIRI** (Spinning Enhanced Visible and Infrared Imager) **instruments** onboard the geostationary Meteosat satellites.
- **Temporal resolution**: Monthly, daily, instantaneous (every 30 minutes)
- **Spatial resolution**: 0.05°x 0.05°

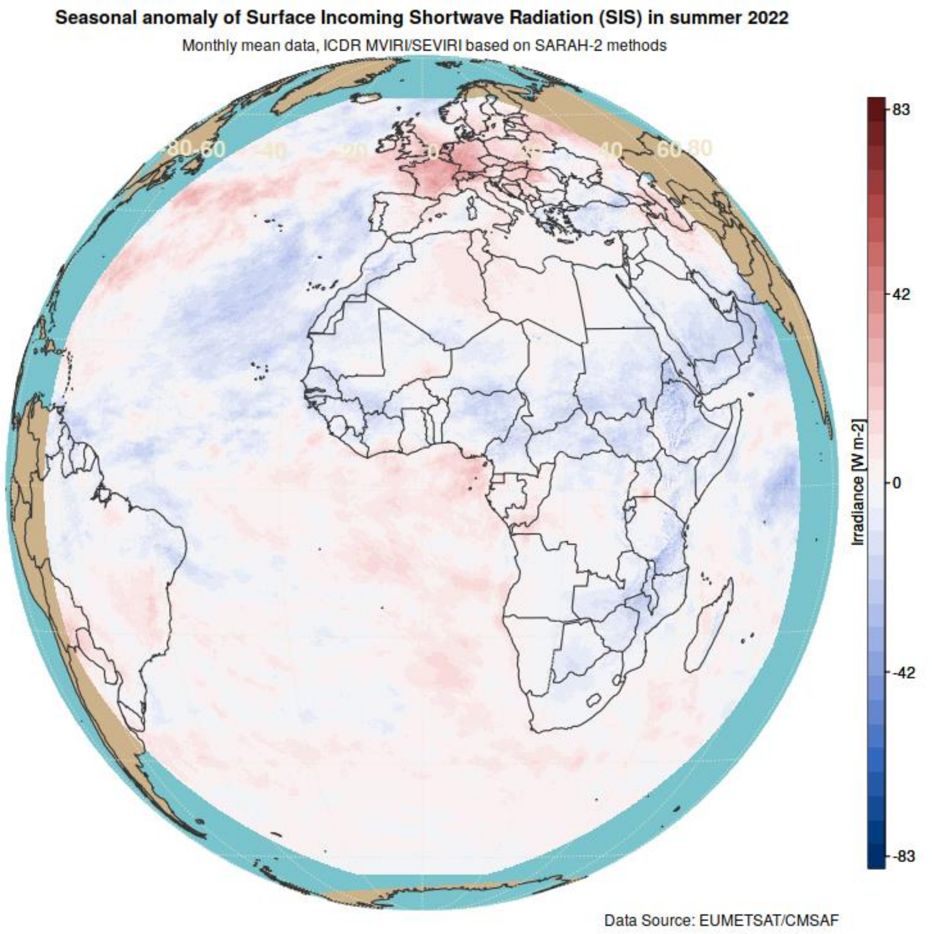
2. Comparison SARAH vs. CLARA dataset

	CLARA	SARAH
Temporal coverage	CLARA-A2: 1982-01-01-2019-06-01, ICDR* AVHRR (based on CLARA-A2 methods): 2019-01-01- „two days ago“	SARAH-2: 1983-01-01-2017-12-01, ICDR* MVIRI/SEVIRI (based on SARAH-2 methods): 2018-01-01- „two days ago“
Temporal resolution	Monthly mean, daily mean, pentad mean	Monthly mean/sum, daily mean/sum, instantaneous (every 30 min.)
Spatial coverage	global	Meteosat disk up to a scanning angle of 65°
Spatial resolution	0.25° x 0.25° (0.05° x 0.05° for daily subsampled products)	0.05° x 0.05°
Products	(CLARA-A2): ▪ Fractional Cloud Cover (CFC) ▪ Cloud Mask (CMA) ▪ Joint Cloud property Histogram (JCH) ▪ Cloud Top Height, Temperature, Pressure (CTO) ▪ Cloud Phase (CPH) ▪ Liquid Water Path (LWP) ▪ Ice Water Path (IWP) ▪ Cloud Optical Thickness (COT) ▪ Surface Albedo (SAL) ▪ Surface Incoming Shortwave Radiation (SIS) ▪ Surface Outgoing Longwave Radiation (SOL) ▪ Surface Downward Longwave Radiation (SDL)	(SARAH-2.1): ▪ Surface Incoming Shortwave Radiation (SIS) ▪ Surface Incoming Diredct Radiation (SID) ▪ Surface Incoming Direct Normalized Radiation (DNI) ▪ Spectral Resolved Irradiance (SRI) ▪ Sunshine Duration (SDU) ▪ Effective Cloud Albedo (CAL)

* ICDR: Interim Climate Data Records

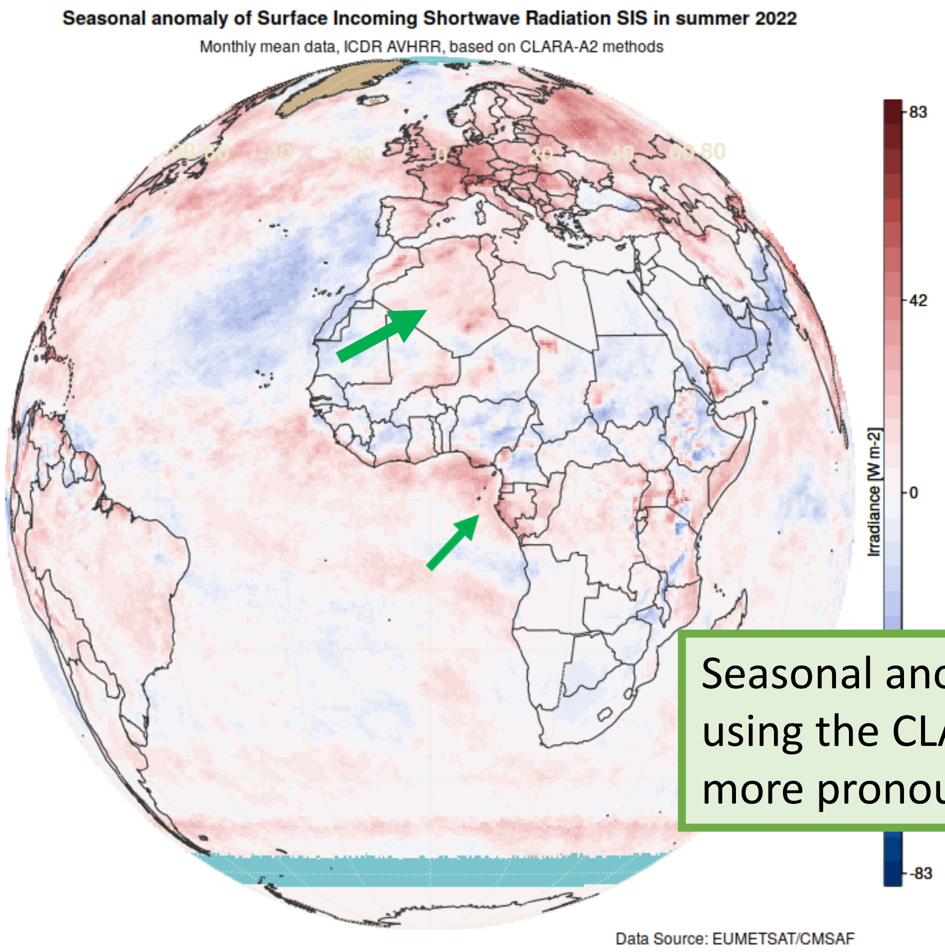
3. Seasonal anomaly of SIS in summer 2022

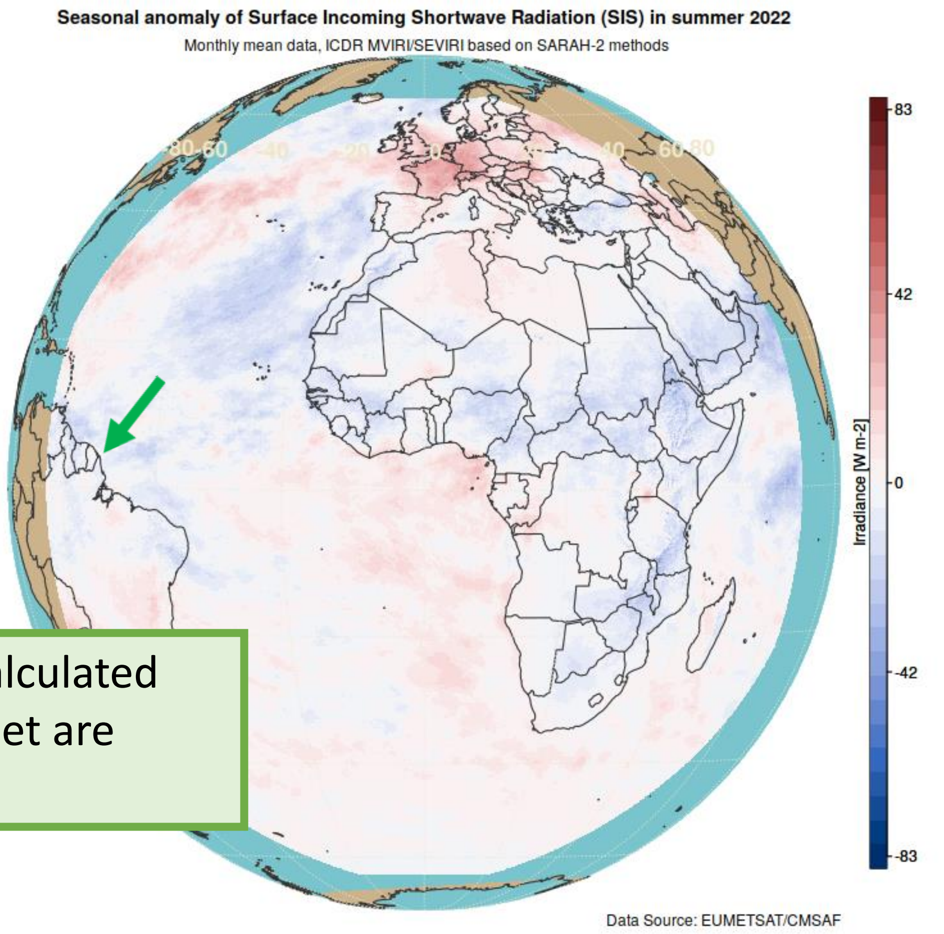




Seasonal anomaly of Surface Incoming Shortwave Radiation (SIS) between summer 2022 and the reference time period 1991-2020. Monthly mean data of the CLARA dataset (map on the left) and SARAH dataset (map on the right) were used.

3. Seasonal anomaly of SIS in summer 2022

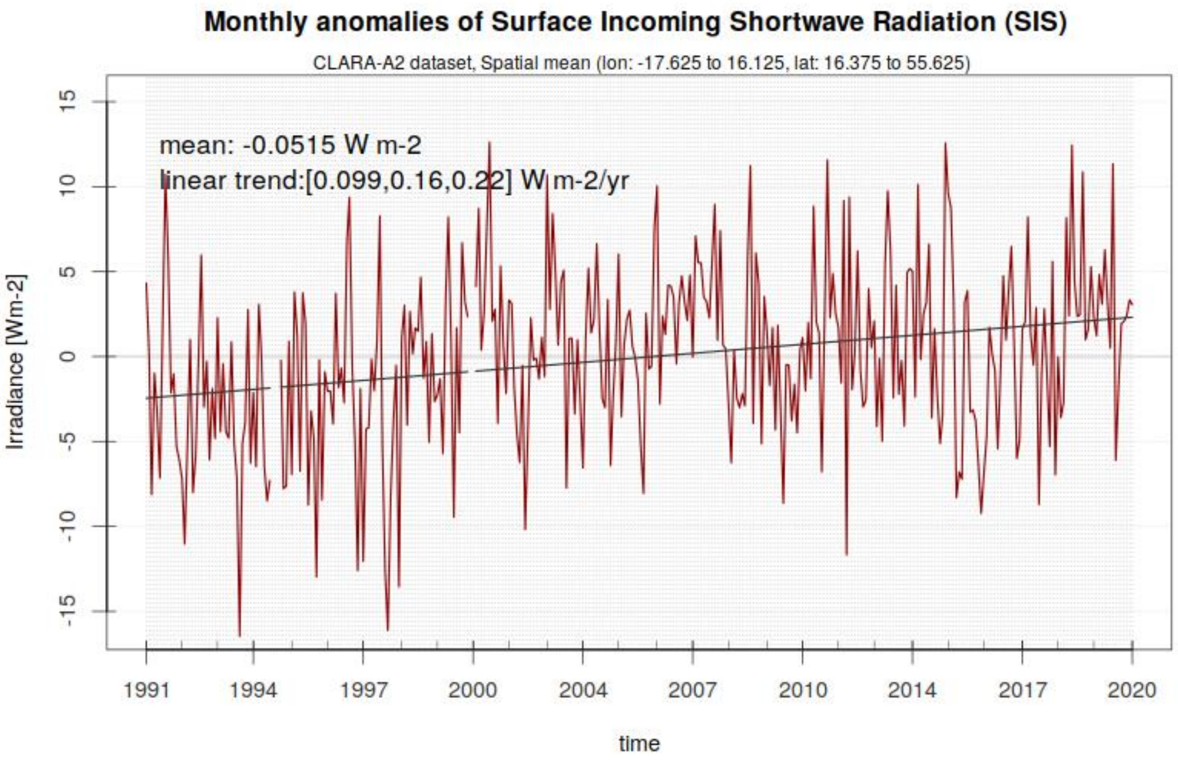


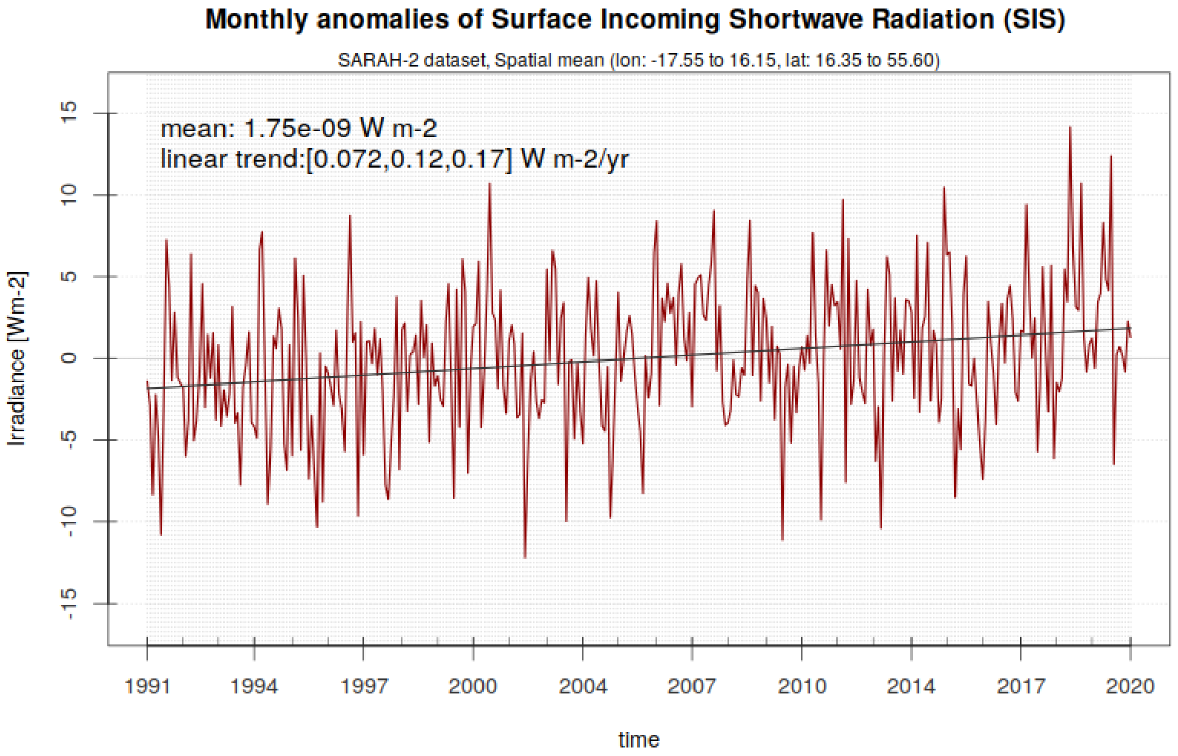


Seasonal anomalies calculated using the CLARA dataset are more pronounced

Seasonal anomaly of Surface Incoming Shortwave Radiation (SIS) between summer 2022 and the reference time period 1991-2020. Monthly mean data of the CLARA dataset (map on the left) and SARAH dataset (map on the right) were used.

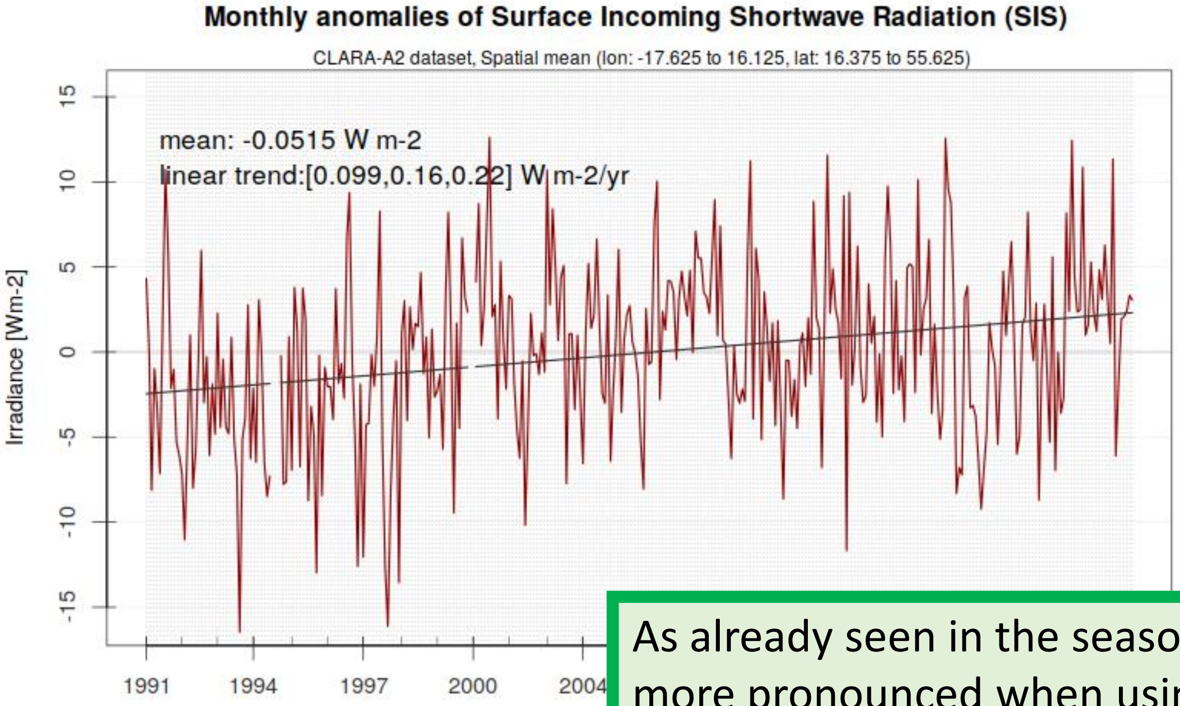
4. Monthly anomalies of SIS, 1991-2020

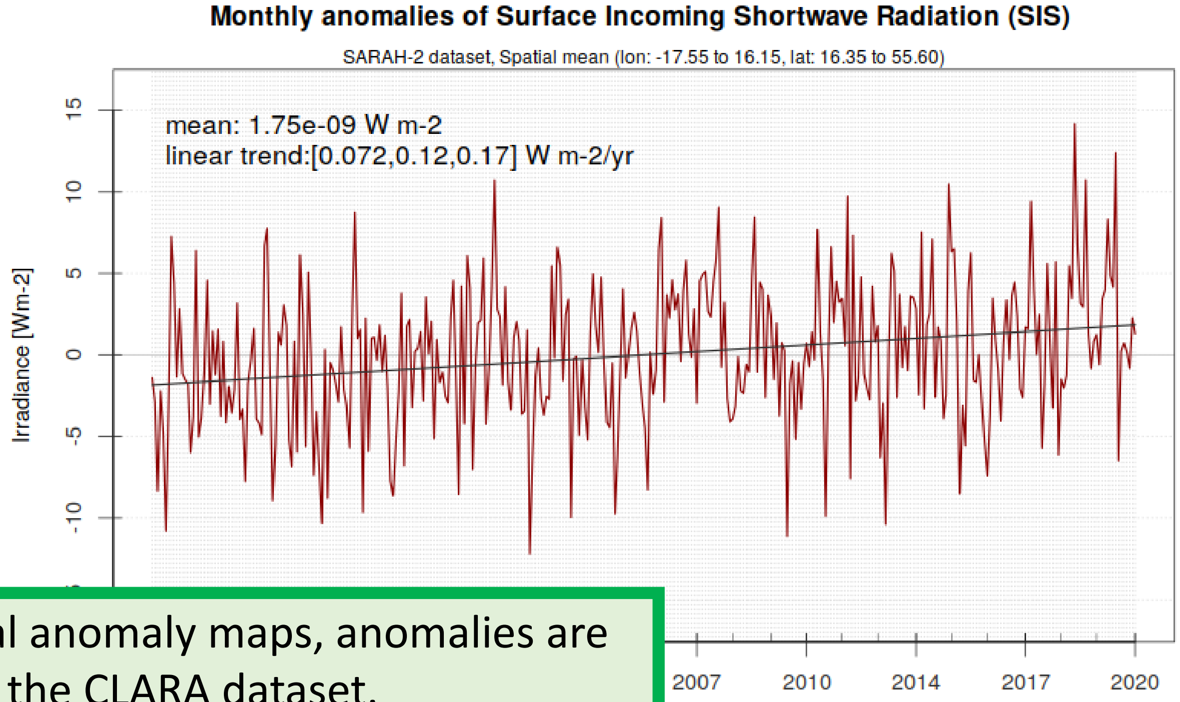




Time series: Monthly anomalies of SIS in the time period 1991-01-01 to 2020-12-01 calculated with the CLARA-A2 (plot on the left) and the SARAH-2 (plot on the right) datasets

4. Monthly anomalies of SIS, 1991-2020

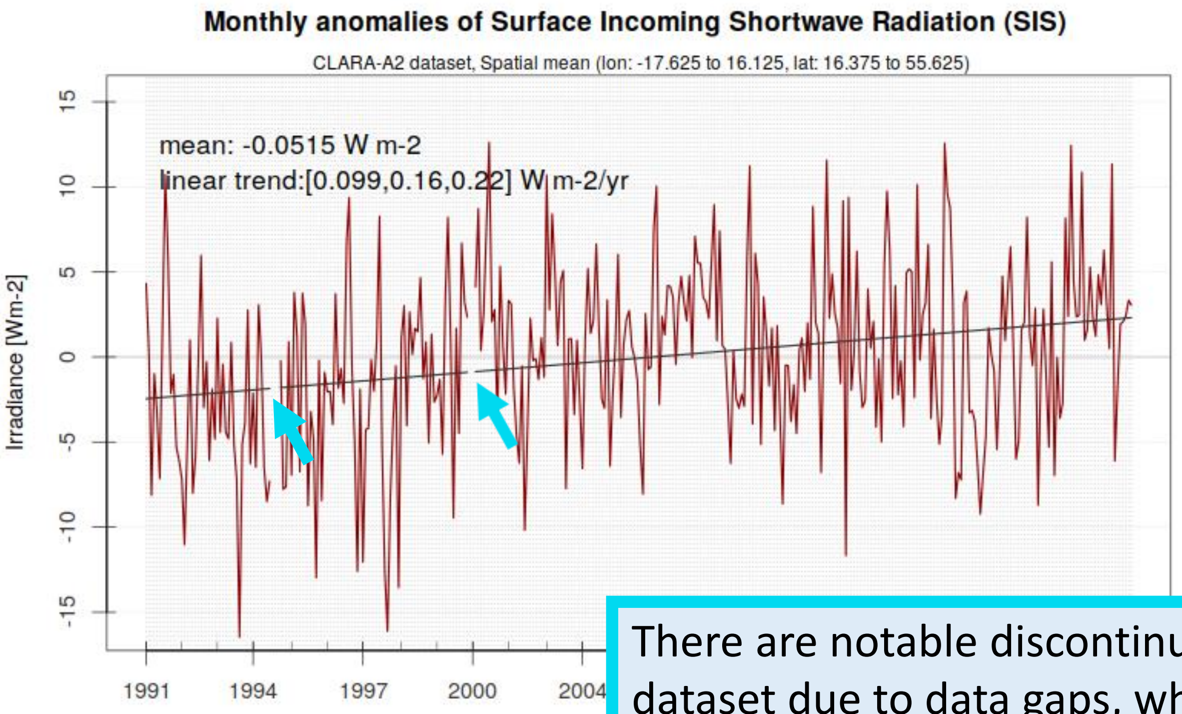


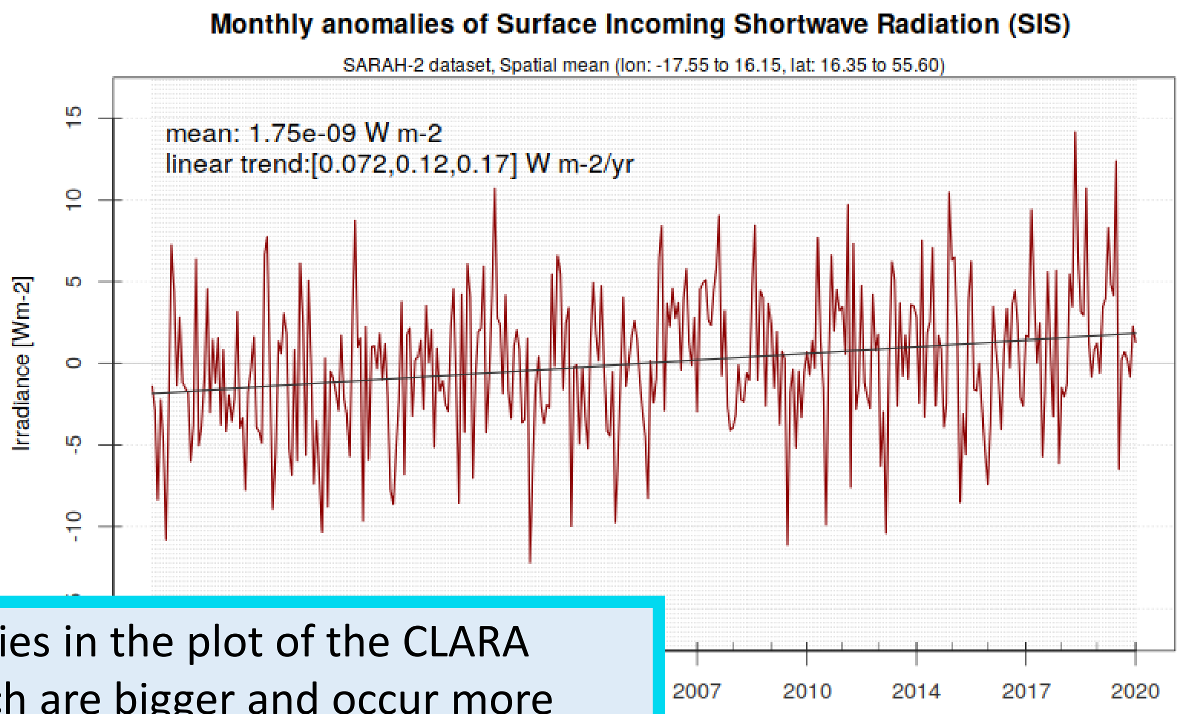


As already seen in the seasonal anomaly maps, anomalies are more pronounced when using the CLARA dataset.
Especially the negative anomalies in the 1990s are way more striking in the CLARA-A2 plot resulting in a slightly negative long-term mean. However both datasets verify a positive linear trend of monthly anomalies in this area.

Time series: Monthly … culated with
the CLARA-A2 (plot o…

4. Monthly anomalies of SIS, 1991-2020





There are notable discontinuities in the plot of the CLARA dataset due to data gaps, which are bigger and occur more often than in the SARAH dataset. They are caused by the fact that in the 90s only one NOAA satellite was used to collect data.

Time series: Monthly … culated with the CLARA-A2 (plot o…

5. Calculating diurnal variations of SIS using the SARAH dataset

- Using SARAH instantaneous data (30 minute temporal resolved) you can also analyze daily variations of surface radiation parameters like Surface Incoming Shortwave Radiation (SIS). This is also an advantage over the CLARA dataset (lower temporal resolution).
- In the following example the daily variation of SIS on a September day in Toulouse (France) is analyzed.

5. Calculating diurnal variations of SIS using the SARAH dataset

Prepare

Required data:

(SARAH) instantaneous data of the preferred time period and area

Important:

- If multiple data sets are needed: all data sets need to have the same spatial and temporal resolution
- Avoid temporal overlap of the data

THEN: **Unzip and untar** the data for the preferred time period (here: 2022-09-03 to 2022-09-03)

5. Calculating diurnal variations of SIS using the SARAH dataset

- **Group of operators:** Hourly statistics
- **Operator**: Hourly means

THEN: tick the box „do you want to apply another operator afterwards?", apply operator and continue with the second operator:

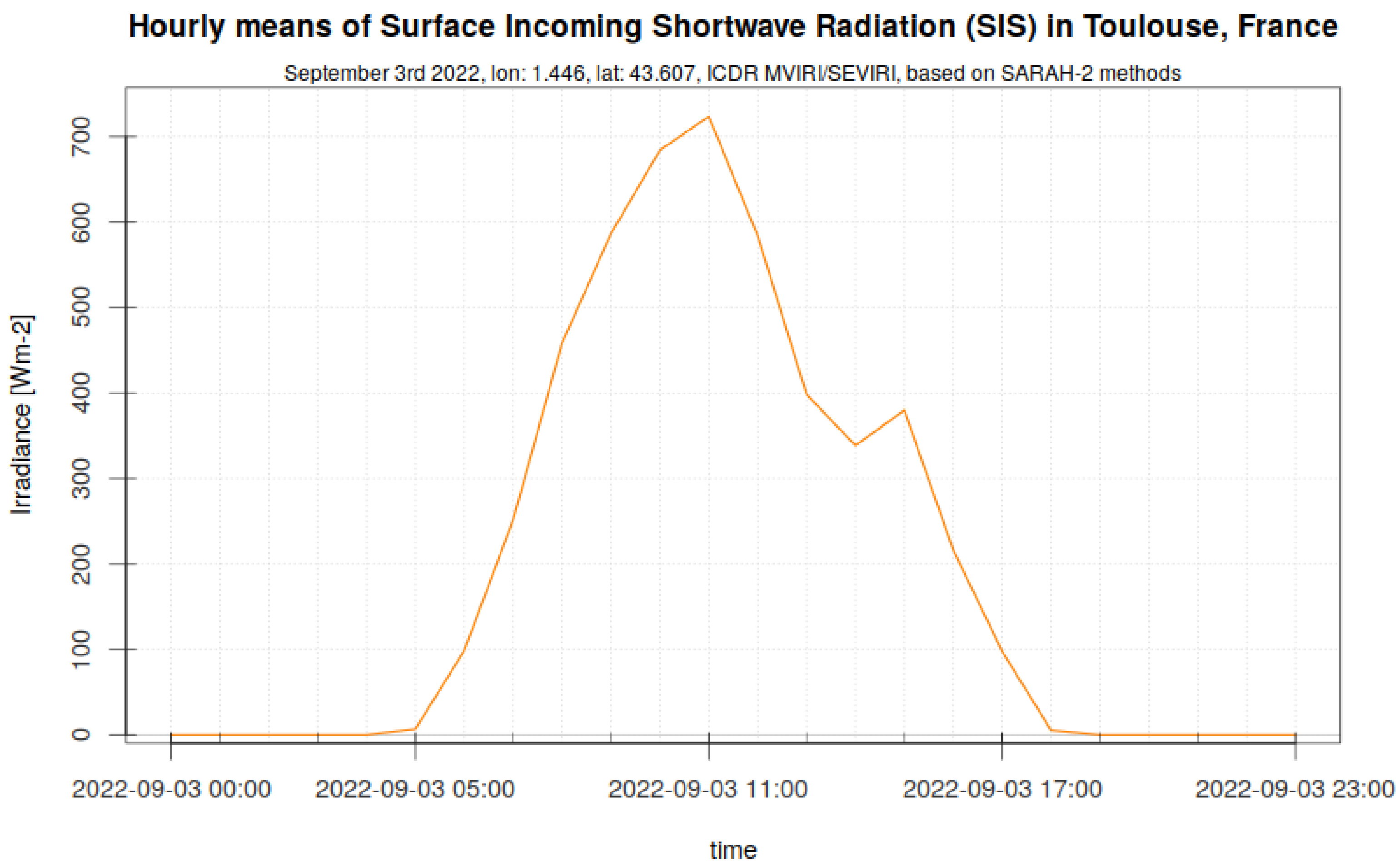
- **Group of operators**: Selection
- **Operator**: Select data at given point

Enter the coordinates of the location you want to analyze (here: Toulouse: lat: 43.607, lon: 1.446), untick the box „do you want to apply another operator afterwards?" and apply the operator

5. Calculating diurnal variations of SIS using the SARAH dataset

Visualize

- The highest peak (global maximum) of SIS occured around midday at 11:00 MEZ as well as a local maximum in the afternoon around 15:00 MEZ.



Time series: Hourly means of Surface Incoming Shortwave Radiation over a time period of 24 hours on September 3rd 2022 in Toulouse, France.

6. Application example: Vitamin D_3 effective radiation

Solar UV-B radiation with wavelenghts between 280 and 315 nm initiates cholecalciferol (vitamin D_3) production in the human skin.

The Vitamin D_3 effective radiation (VID) describes the part of shortwave UV radiation in just this wavelength range.

- ➢This radiation parameter is not included in the recent version of the SARAH datasets but the following application example can easily be applied on other solar and radiation products.

6a) Generating a stripes plot of VID

Prepare

Required data: - Monthly, mean data (.tar files) for the preferred area

- Temporal coverage: 1991-01-01 to 2020-12-01

Important:

- If multiple data sets are needed: all data sets need to have the same spatial and temporal resolution
- Avoid temporal overlap of the data

THEN: **Unzip and untar** the data for the time range 1991-01-01 to 2020-12-01

6a) Generating a stripes plot of VID

Analyze

- **Group of operators:** Climate Analysis
  - **Operator**: Stripes Plot

↓

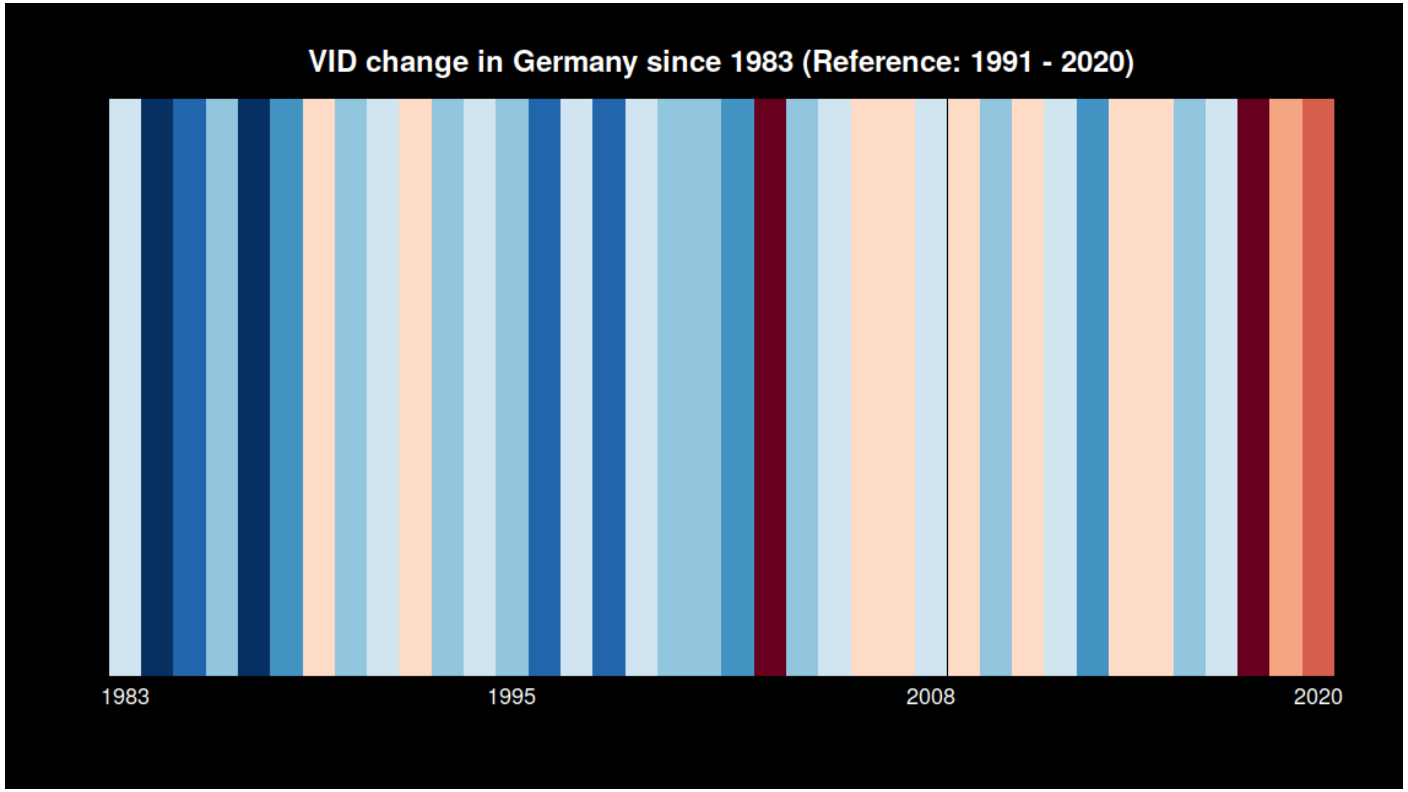
THEN: Enter the time range „12“ for monthly mean data

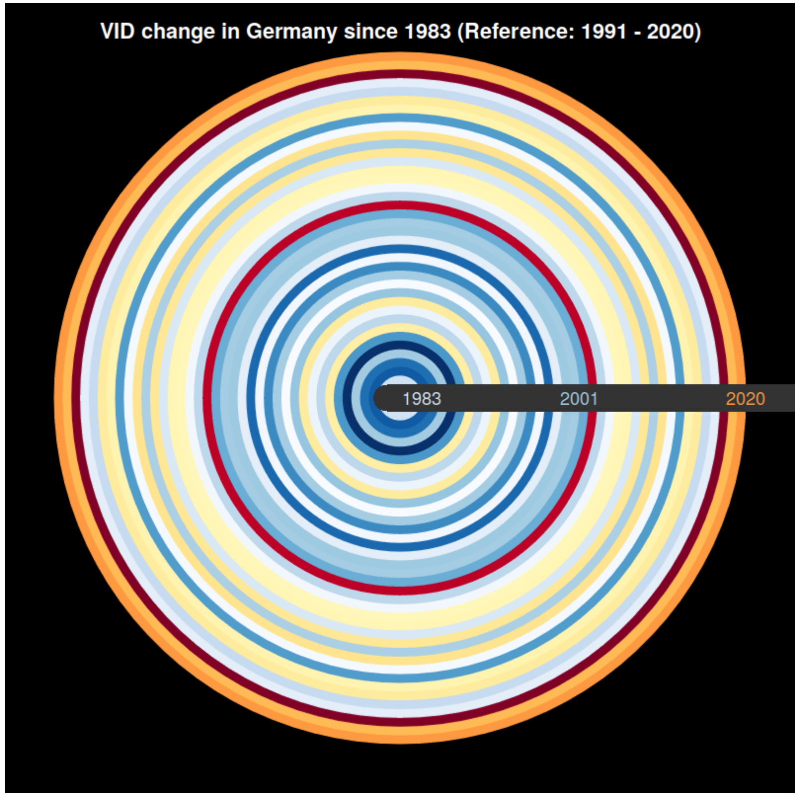
↓

Select the area you want to analyze,
the Climatology start year „1991“, the Climatology end year „2020“
(optional: tick the box „Circular plot“)
and apply the operator

6a) Generating a stripes plot of VID

Visualize

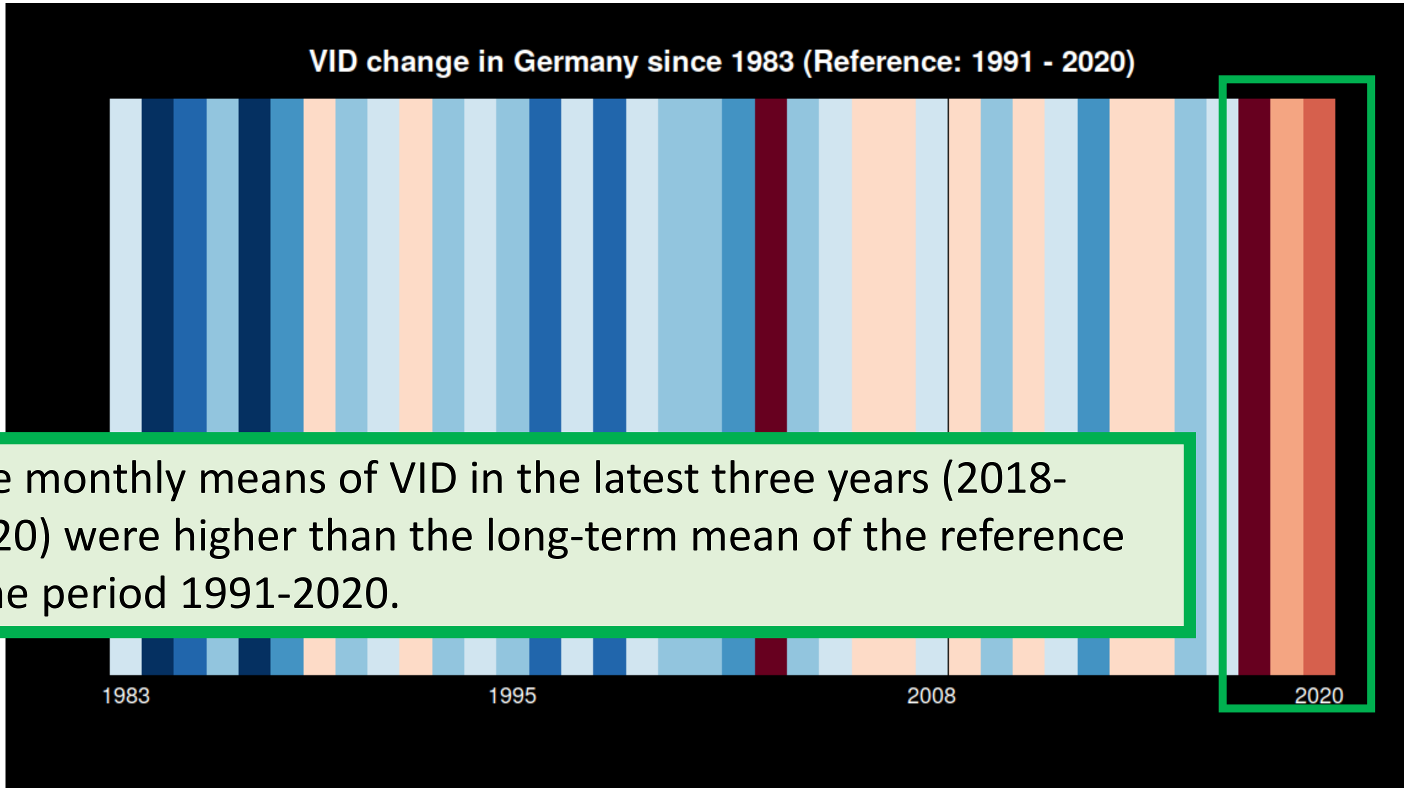




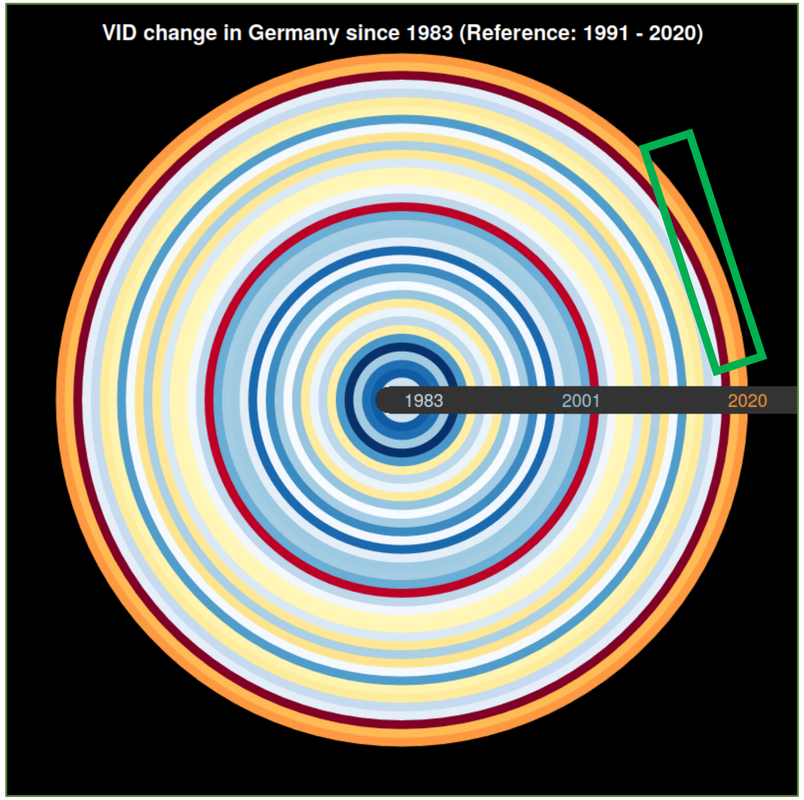
Result: Rectangular (left) and circular (right) stripes plot of monthly anomalies of VID in Germany since 1983.
Red stripes represent positive anomalies compared to the long-term mean of the reference time span 1991-2020 while blue stripes represent negative anomalies.

6a) Generating a stripes plot of VID

Visualize



The monthly means of VID in the latest three years (2018-2020) were higher than the long-term mean of the reference time period 1991-2020.



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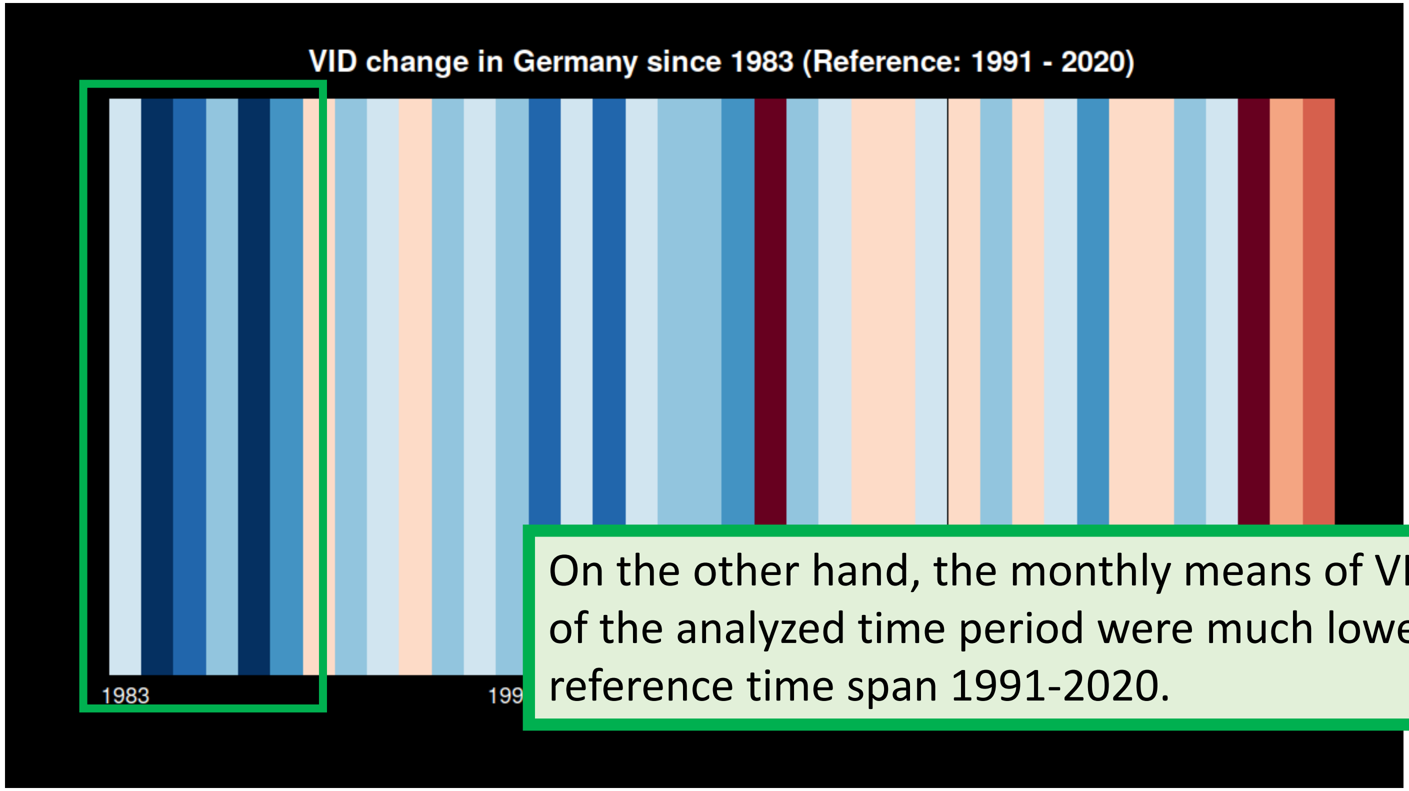
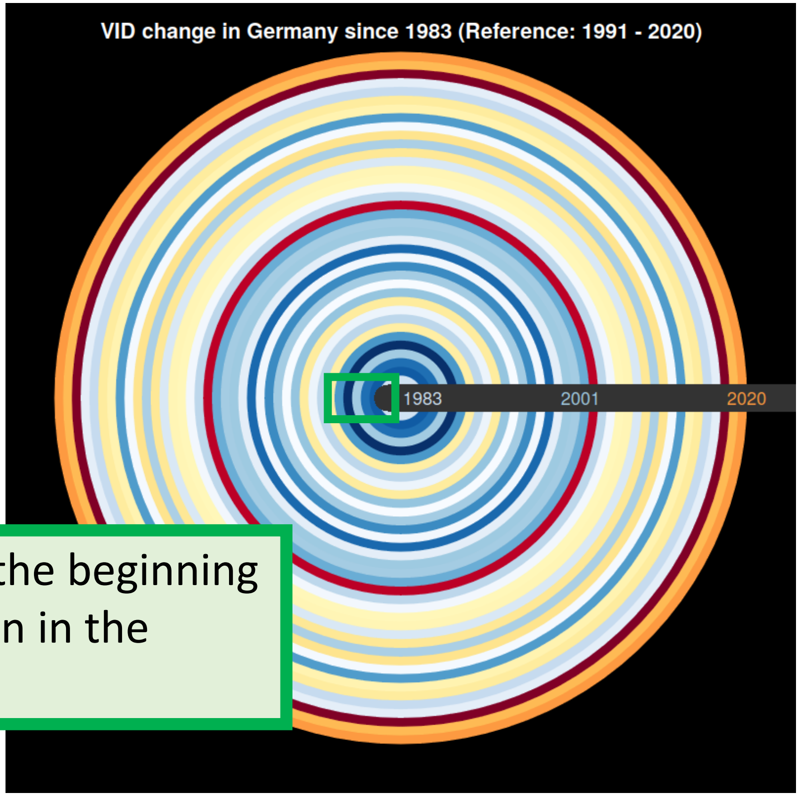
6a) Generating a stripes plot of VID

Visualize





On the other hand, the monthly means of VID in the beginning of the analyzed time period were much lower than in the reference time span 1991-2020.

Result: Rectangular (left) and circular (right) stripes plot of monthly anomalies of VID in Germany since 1983.
Red stripes represent positive anomalies compared to the long-term mean of the reference time span 1991-2020 while blue stripes represent negative anomalies.

7. Conclusion

- SARAH:
  - preferred used when variations over short time periods are analyzed
    (➡ higher temporal resolution (30min) for e.g. diurnal variations)
  - Ideal for analysis of small areas due to higher spatial resolution than CLARA
  - Better data situation for applications using the „Climate Analysis“ operators

- CLARA:
  - Ideal for a global overview of different cloud/radiation parameters
  - Lower spatial resolution ➡ less memory needed, faster computation
  - Due to data gaps, applying specific operators of the „Climate Analysis“ group may result in error messages

  ➡ Time series of monthly anomalies for example should rather be created using the SARAH dataset

8. Accessed data

CLARA datasets:

- ”SIS-Surface incoming shortwave radiation, AVHRR on polar orbiting satellites, Monthly, Mean, Global” (TCDR) with temporal coverage 1991-01-01 to 2019-06-01
- ”SIS-Surface incoming shortwave radiation, AVHRR on polar orbiting satellites, Monthly, Mean, Global” (ICDR) with temporal coverage 2019-07-01 to 2022-08-01

SARAH datasets:

- ”SIS-Surface incoming shortwave radiation, MVIRI/SEVIRI on METEOSAT, Monthly, Mean, METEOSAT full disk (includes Europe, Afrika, Atlantic Ocean)” (TCDR) with temporal coverage 1991-01-01 to 2017-12-01
- ”SIS-Surface incoming shortwave radiation, MVIRI/SEVIRI on METEOSAT, Monthly, Mean, METEOSAT full disk (includes Europe, Afrika, Atlantic Ocean)” (ICDR) with temporal coverage 2018-01-01 to 2022-08-01
- ”SIS-Surface incoming shortwave radiation, MVIRI/SEVIRI on METEOSAT, Instantaneous, METEOSAT full disk (includes Europe, Afrika, Atlantic Ocean)” (ICDR) with temporal coverage 2022-09-03 to 2022-09-03

Not published yet:

- VID-Vitamin D effective radiation, MVIRI/SEVIRI on METEOSAT, Monthly, Mean, METEOSAT full disk (includes Europe, Afrika, Atlantic Ocean)” (TCDR and ICDR) with temporal coverage 1983-01-16-2020-01-16