

Assessing the direct aerosol impact on surface irradiance using satellite-based and surface reference data

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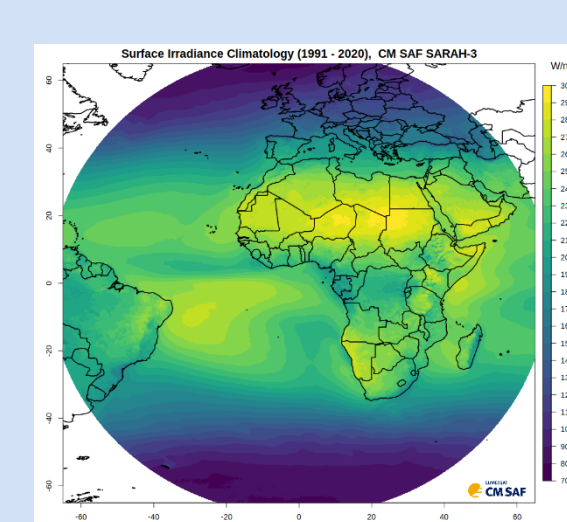
SARAH-3

→ Variables (selected)

- Surface Solar Irradiance
- Surface Direct Irradiance
- Sunshine Duration

→ Resolution / Coverage

- Spatial: $0.05^\circ \times 0.05^\circ$ / regional
- Temporal: 30-min, daily-, monthly mean / 1983 to date



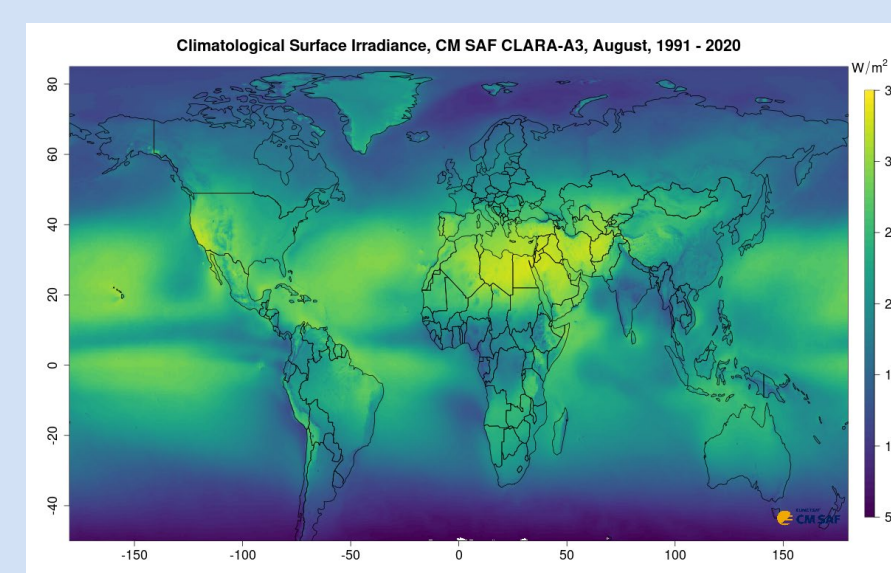
CLARA-A3

→ Variables (selected)

- Cloud properties
- Surface Radiation
- ToA Radiation

→ Resolution / Coverage

- Spatial: $0.25^\circ \times 0.25^\circ$ / global
- Temporal: daily-, pentad-, monthly mean / 1979 to date



HANNA

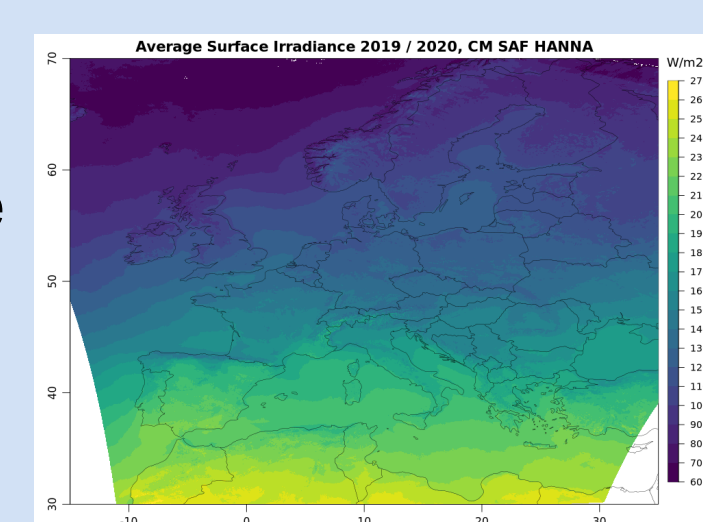
(Demo Dataset)

→ Variable

- Surface Solar Irradiance

→ Resolution / Coverage

- Spatial: $0.01^\circ \times 0.01^\circ$ / Europe
- Temporal: 15-min / daily-, monthly mean / 2019 + 2020



The EUMETSAT Satellite Application Facility on Climate Monitoring (CM SAF) is providing satellite-based climate data records of surface solar radiation covering more than four decades. The SARAH-3 and CLARA-A3 data records provide high-quality surface solar radiation data from the 1980s onwards. The 2-year demonstrational HANNA data set (2019 / 2020) provides spatially and temporally high resolution data for Europe.

Here, we assess the performance of the clear-sky irradiance as provided by CM SAF and the impact of aerosol on monthly clear-sky radiation.

Evaluation of CM SAF data, all-sky and clear-sky irradiance

Data Set	# stations	# months	bias [W/m ²]	MAD [W/m ²]	bc-rms [W/m ²]	
CLARA-A3	43	~9000	1.5	7.3	10.5	all-sky
			-5.3	7.2	9.4	clear-sky
SARAH-3	16	~3150	3.1	5.8	7.4	all-sky
			-2.8	6.0	8.4	clear-sky

→ BSRN data allow the estimation of monthly mean clear-sky irradiance

→ CM SAF data records tend to overestimate all-sky surface irradiance and to underestimate clear-sky irradiance

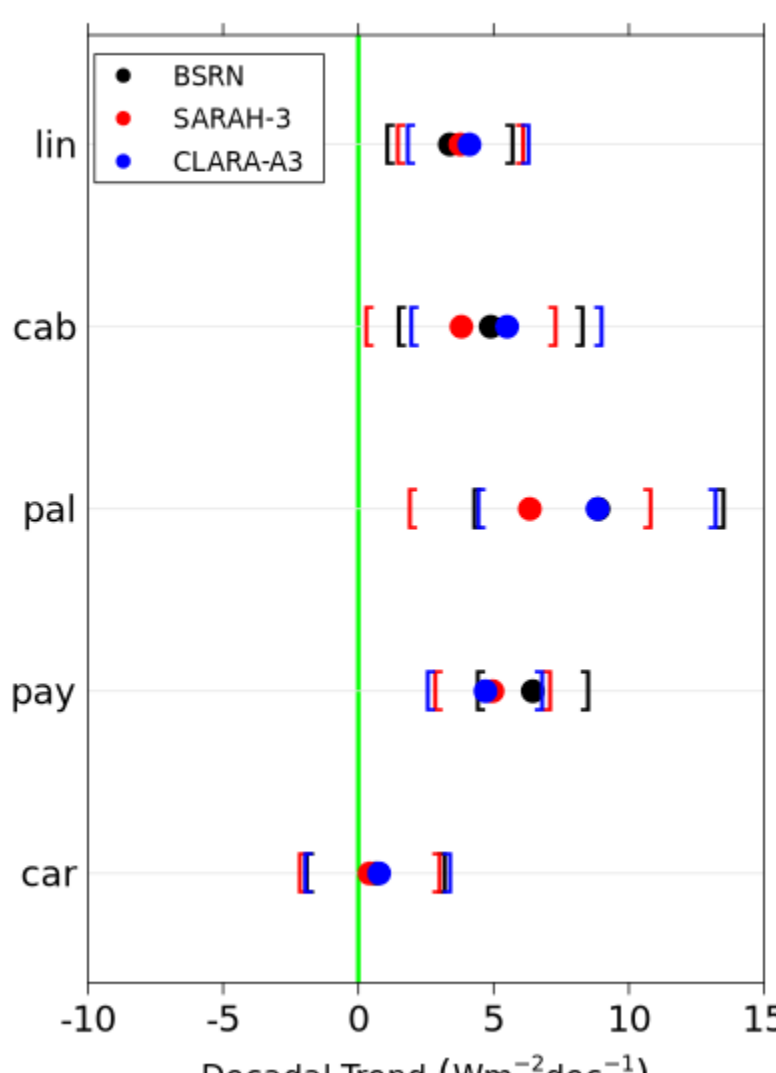
→ Likely reason: Inconsistent aerosol and water vapour information

→ The increase in all-sky surface irradiance in the CM SAF data broadly agrees with BSRN measurements

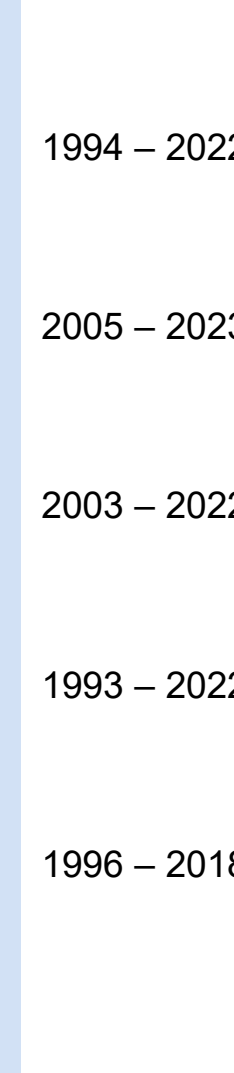
→ Trend in clear-sky irradiance underestimated by CM SAF data records

→ Variability and change in AOD not explicitly considered in CM SAF data

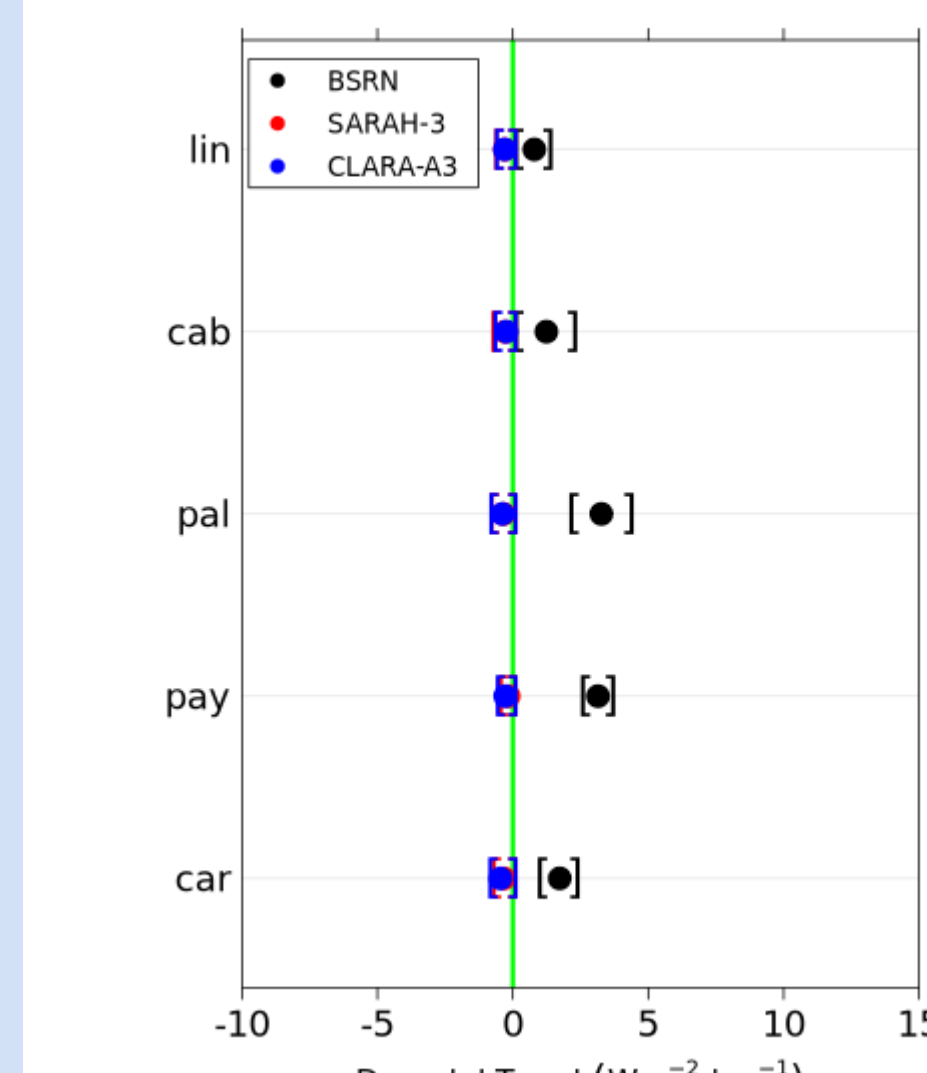
Trend, Surface Irradiance



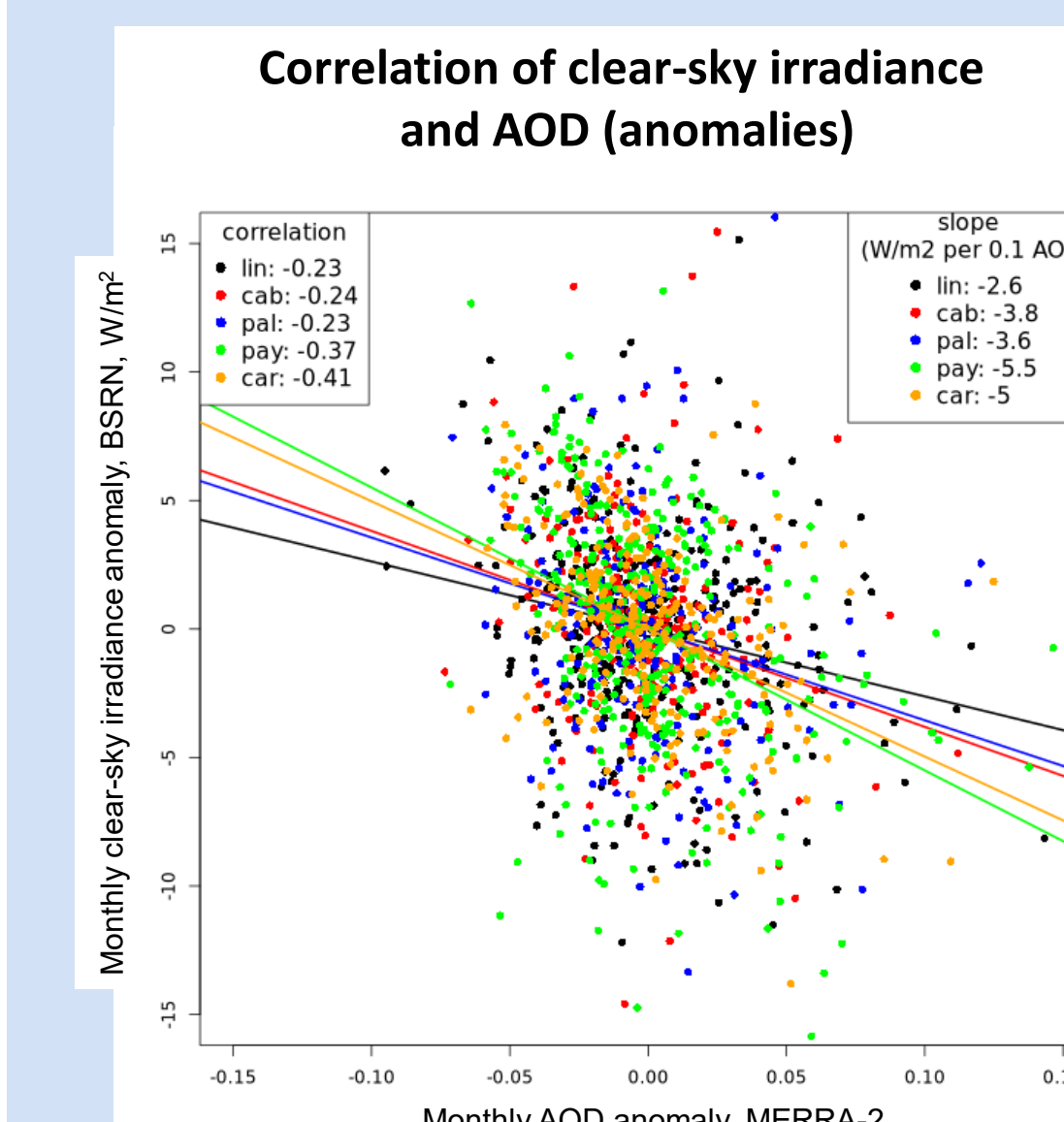
Coverage



Trend, Clear-sky Surface Irradiance



Clear-Sky Irradiance (BSRN) and Aerosol Optical Depth (MERRA-2)

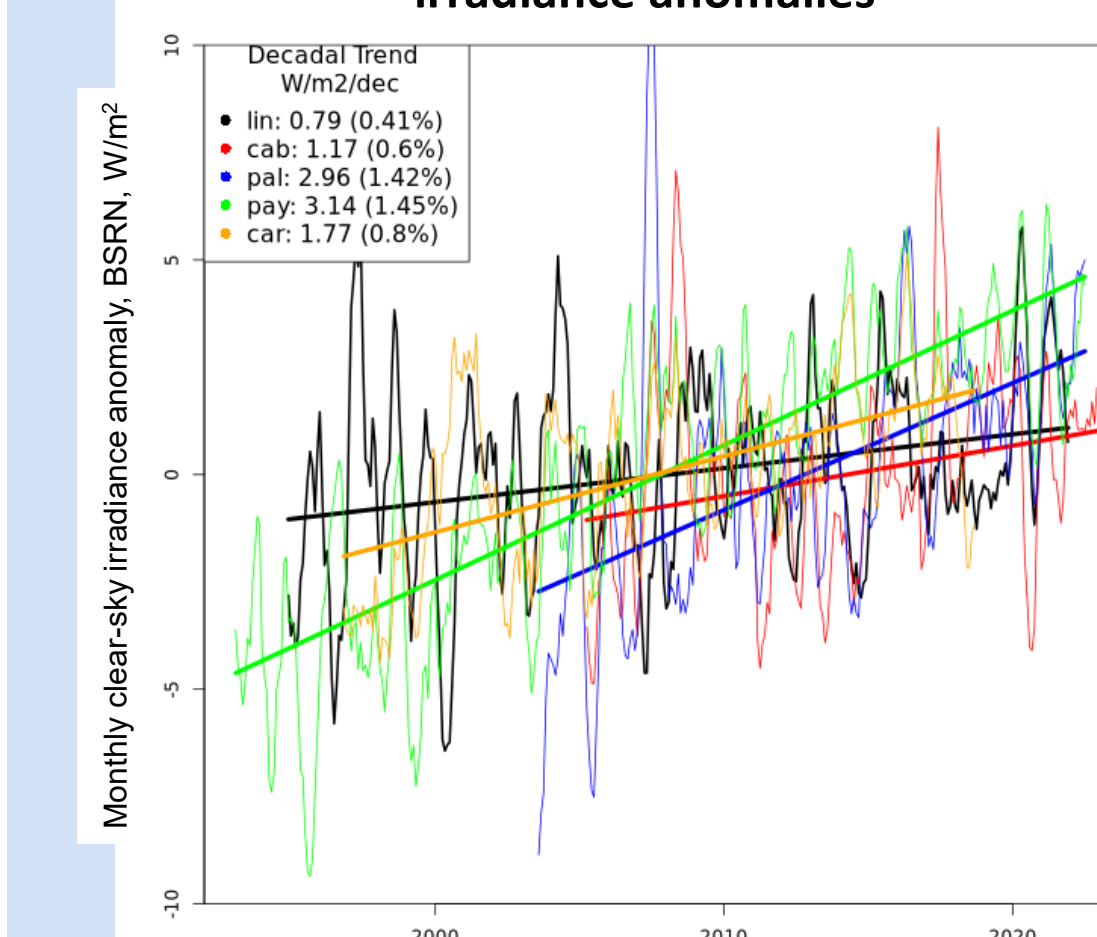


→ Anomalies of clear-sky radiation are negatively correlated with AOD anomalies (correlation coefficients between -0.2 and -0.5)

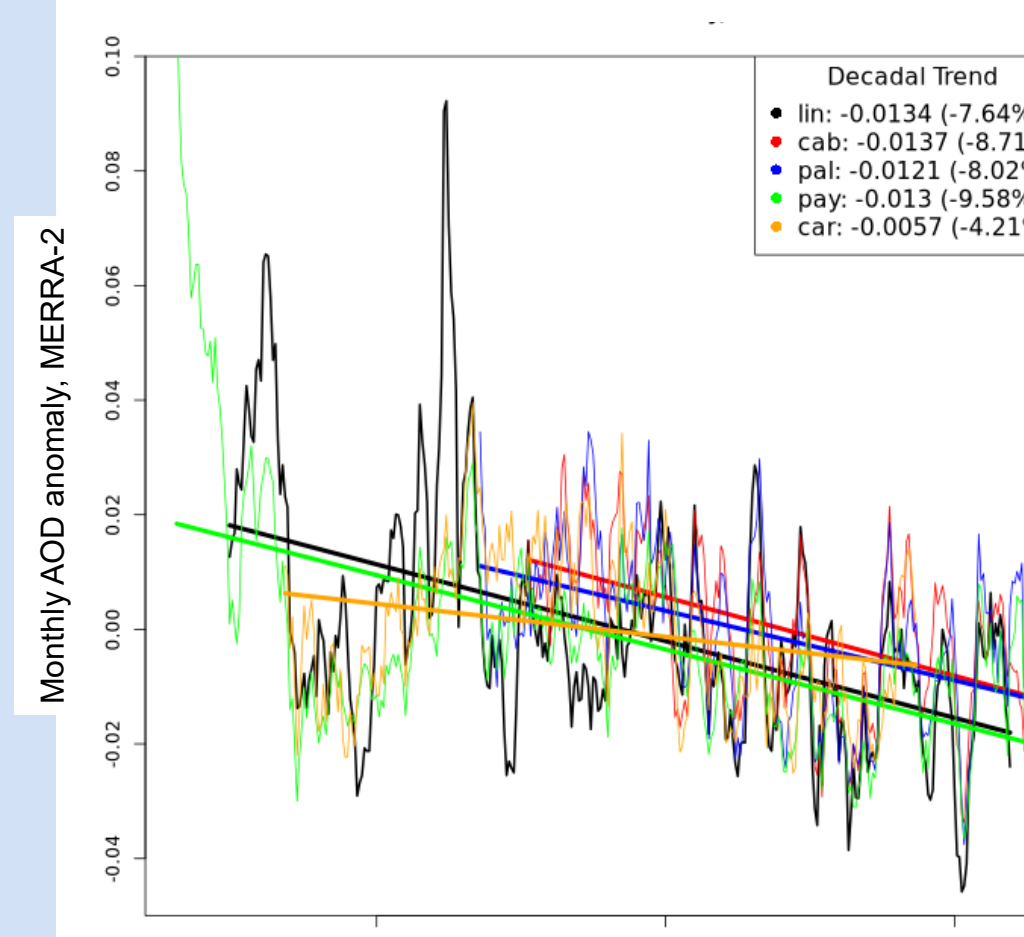
→ A change of 0.1 in AOD induces a change in clear-sky irradiance between about 2 and 6 W/m²

→ No correlation between the anomalies of all-sky irradiance and AOD (not shown)

Time Series and Trends of clear-sky irradiance anomalies



Time Series and Trends of AOD anomalies



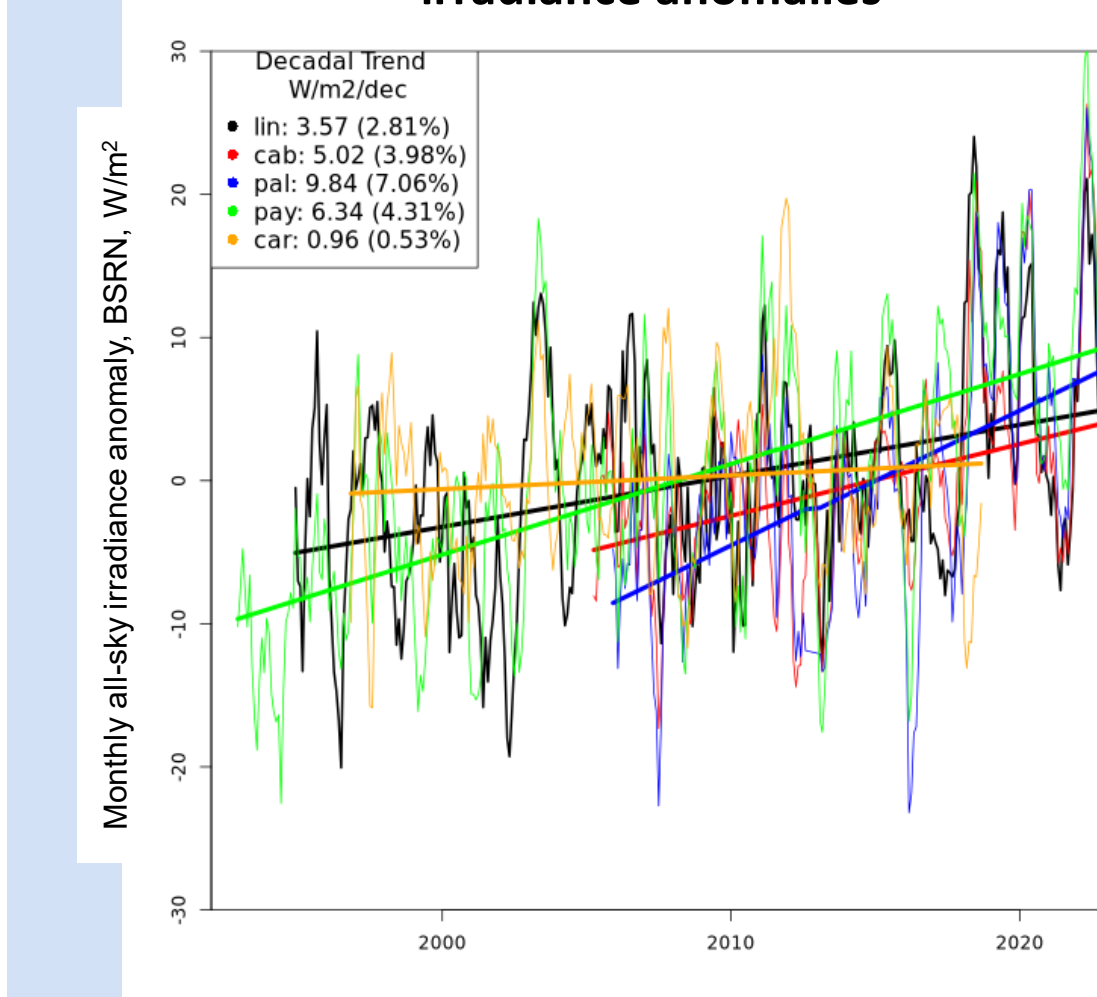
→ Positive trends in clear-sky irradiance are consistent with decreasing trends in AOD

→ Decrease in AOD appears to be too small to fully explain increase in SISCLS:

- 0.015 trend in AOD results in < 1 W/m² change in SISCLS
- Other factors might also contribute, e.g. change in water vapor

→ Moderate (< 20 %) direct aerosol effect on increasing surface irradiance (global brightening) since mid-1990s.

Time Series and Trends of all-sky irradiance anomalies



Data

- BSRN: global GCOS Recognized Network: <https://bsrn.awi.de>
- All-sky surface irradiance, clear-sky surface irradiance derived using the method of Long and Ackerman, 2000
- Detailed analyses based on data from 5 BSRN station (> 18 yrs data availability): Lindenberg (lin), Cabauw (cab), Palaiseu Cedex (pal), Payerne (pay), Carpentras (car)
- MERRA-2 monthly data of aerosol optical depth (AOD)

Summary

- CM SAF data records underestimate the levels and the trends in clear-sky irradiance
- Based on 5 locations in Europe:
 - Clear-sky irradiance anomalies are correlated with AOD anomalies
 - Trends in clear-sky irradiance appear larger than expected from change in AOD (based on MERRA-2)

