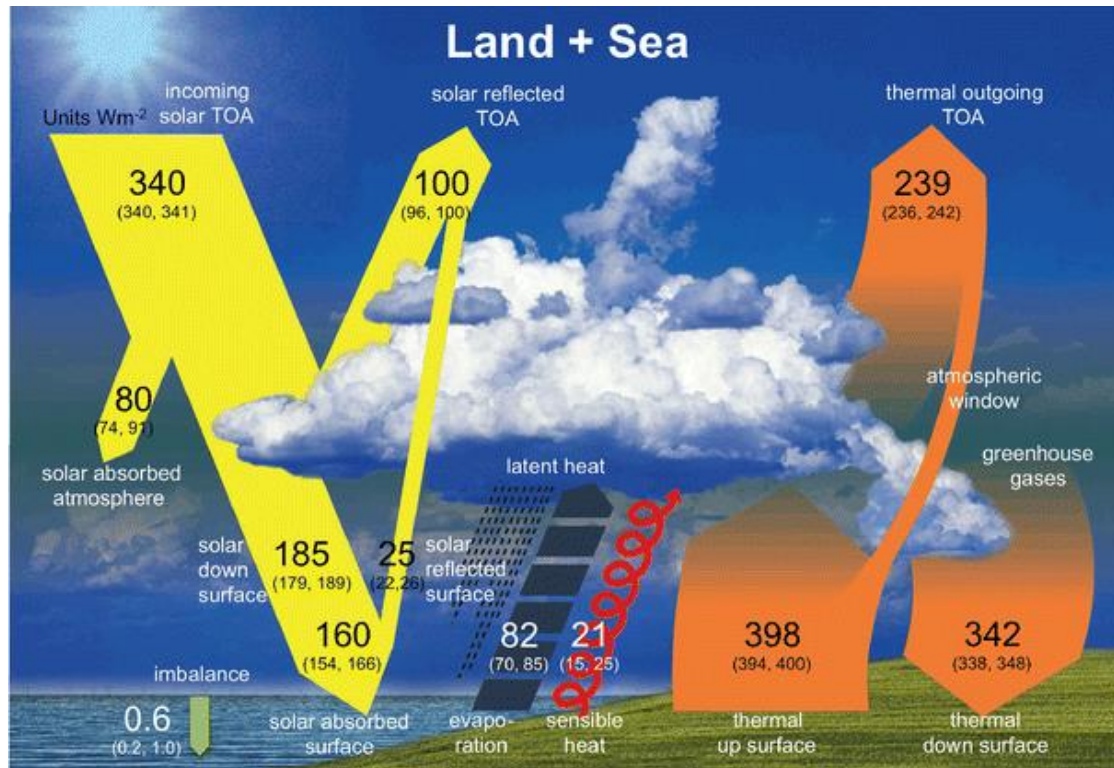


Variability and Trends of Surface Solar Radiation in Europe based on satellite- and surface-based data

Uwe Pfeifroth and **Jörg Trentmann**

Deutscher Wetterdienst, Satellite-based Climate Monitoring, Offenbach, Germany



Source: Wild et. al, 2015

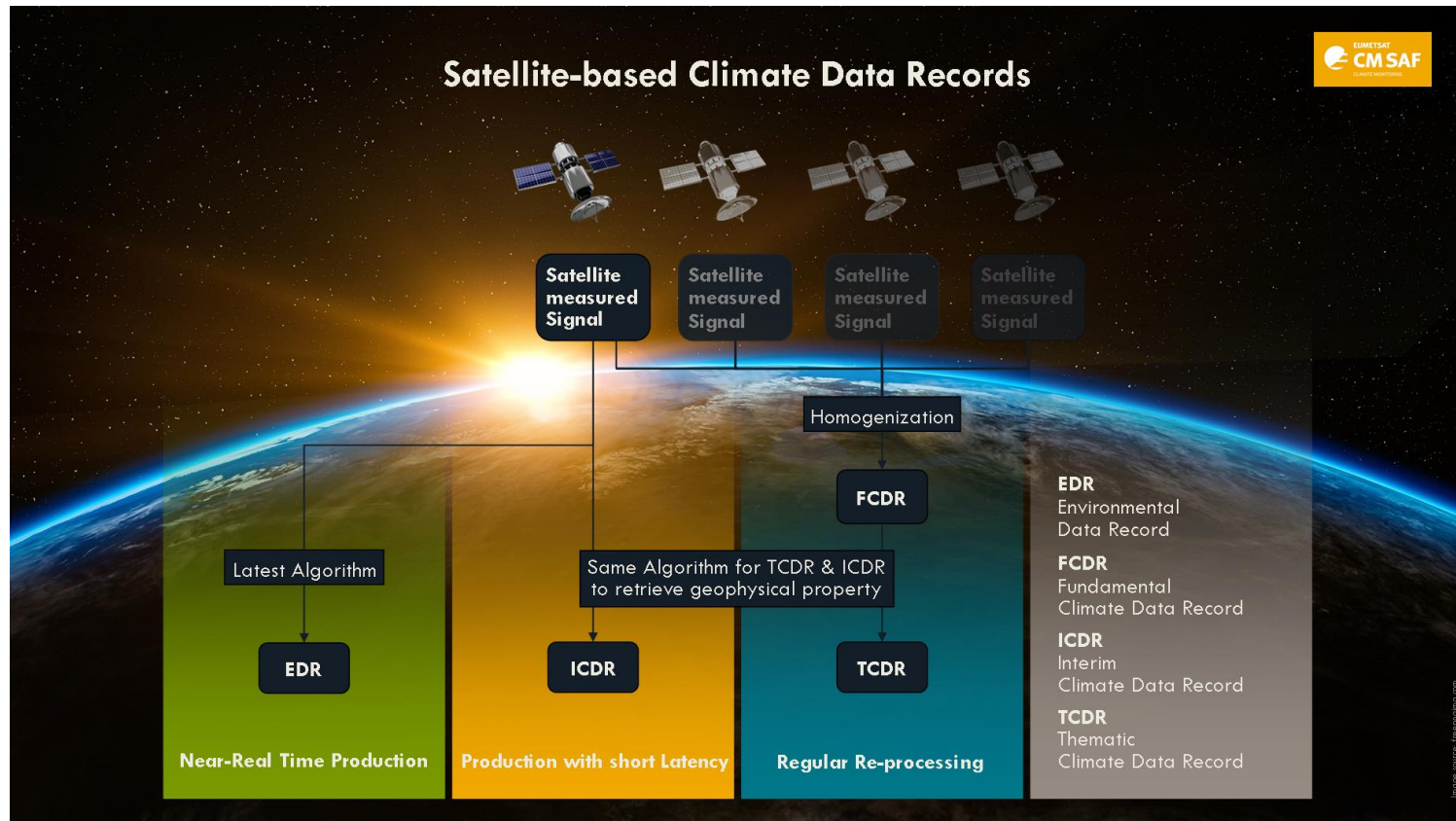
- Solar radiation drives the Earth's climate
- Changes in radiation fluxes impact our climate

CM SAF – Satellite Application Facility on Climate Monitoring

Mission: “develop, 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”



www.cmsaf.eu -> *get the Data*



➤ TCDR + ICDR data records enable climate monitoring with high reliability

Surface Solar Radiation Dataset – Heliosat (SARAH-2.1)

→ Variables

- **Global irradiance (SIS)**
- Sunshine Duration (SDU)
- Surface Direct Irradiance (SDI)
- Effective cloud albedo (CAL)

→ Resolution

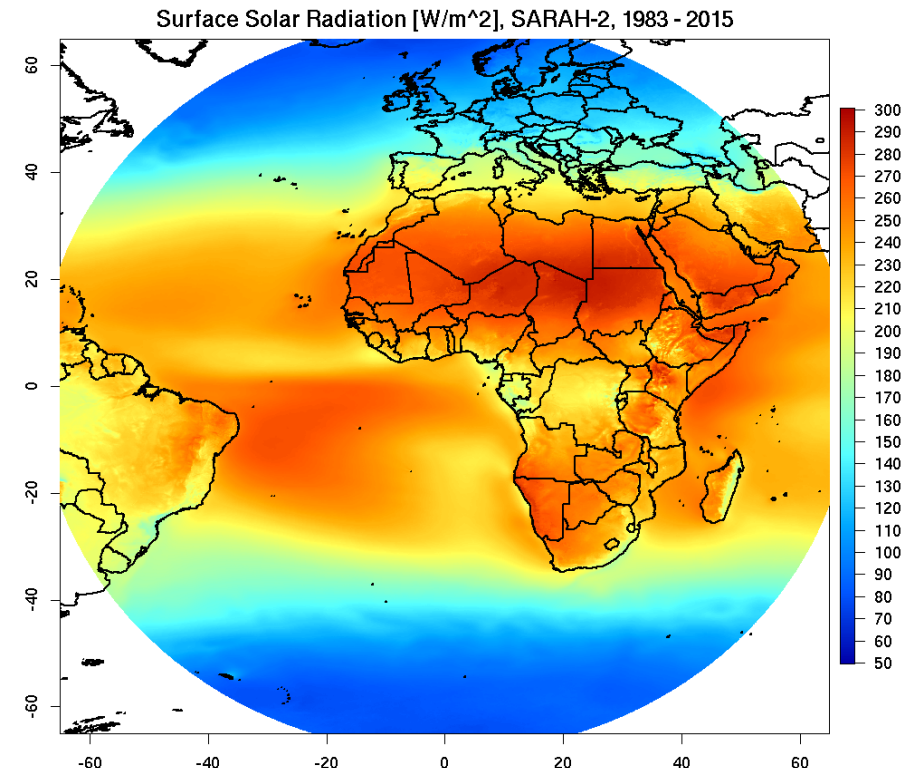
- Spatial: $0.05^\circ \times 0.05^\circ$
- Temporal: 30min-instantaneous, daily means, **monthly means**

→ Coverage

- Spatial: METEOSAT-Prime Full disk
- Temporal: 1983 to 2017

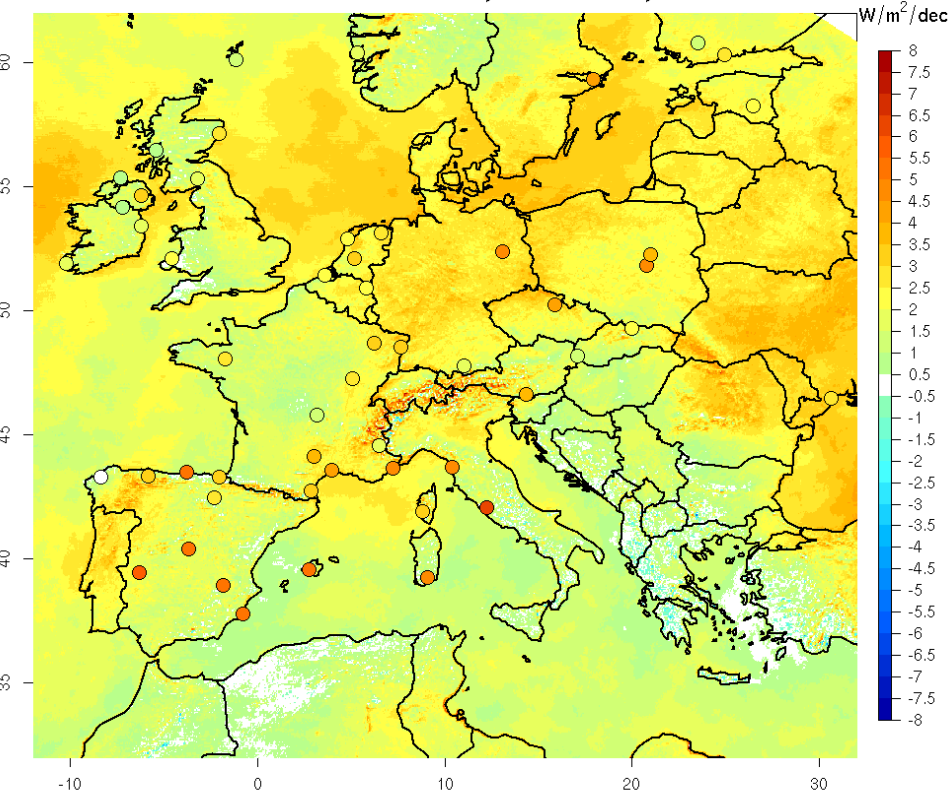
→ Satellites / Instruments

- METEOSAT series (MVIRI/SEVIRI)



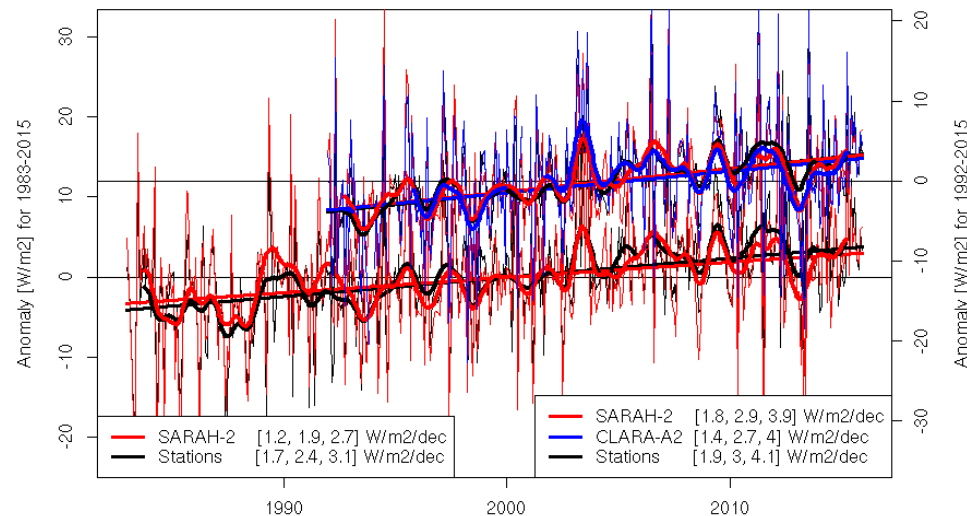
Trends of **SARAH-2** (and CLARA-A2) Surface Solar Radiation (SSR) agree well with surface measurements !

Trend in Surface Radiation, SARAH-2, 1983-2015



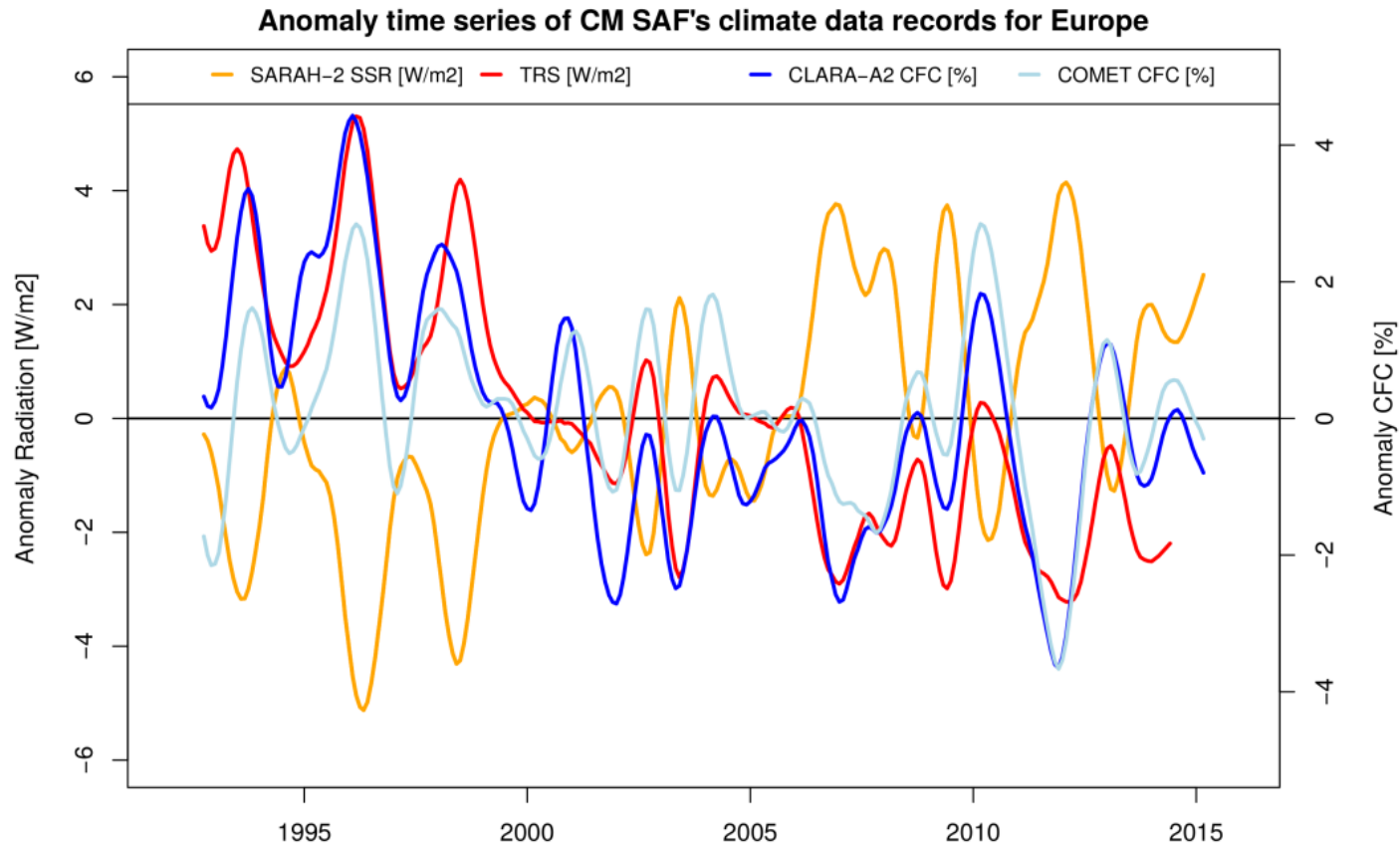
Increase in solar surface radiation in Europe in the past +30 years

Anomaly Time Series for SARAH-2, CLARA-A2 and Stations



Pfeifroth et al. 2018, JGR

High level of consistency between different CM SAF data records

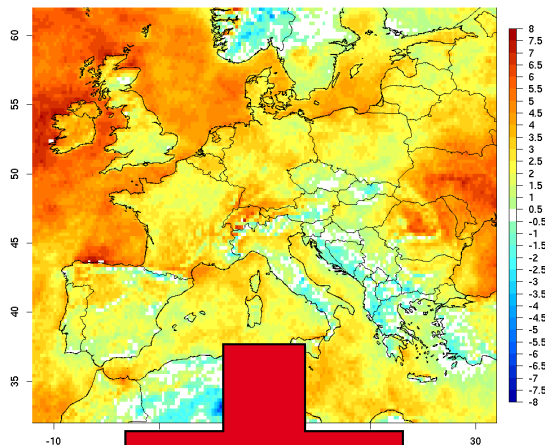


Pfeifroth et al. 2018, Adv. Science and Research

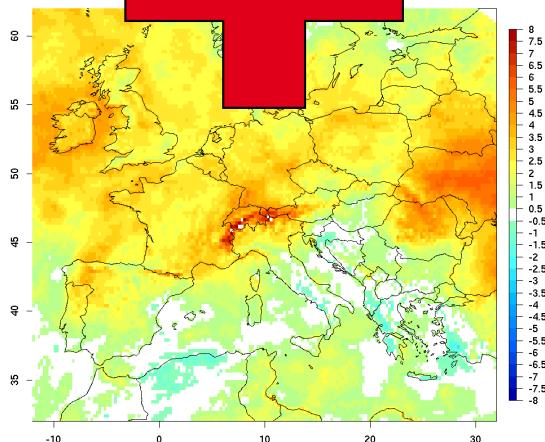
Overview of Trends of the analyzed CM SAF climate data records (1992-2015)

SSR

CLARA-A2_SIS, Trend [W/m2/dec], 1992-2015

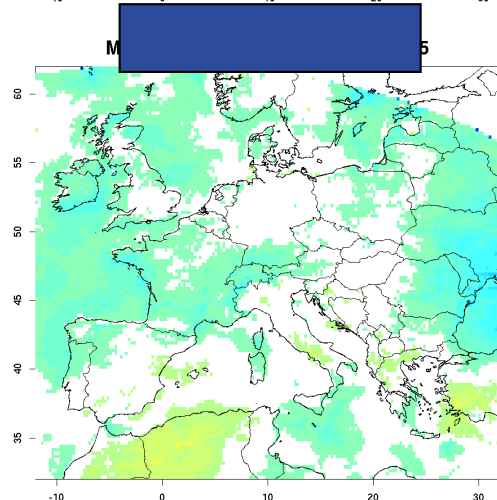
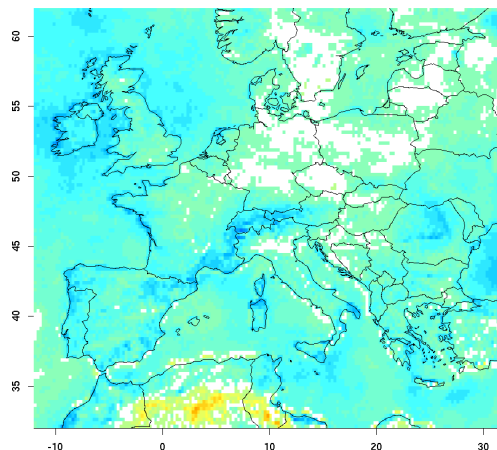


SARAH, Trend [W/m2/dec], 1992-2015



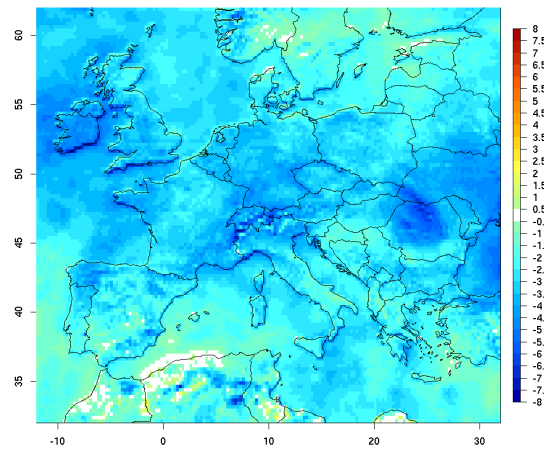
CFC

CLARA-A2_CFC, Trend [CFC/dec], 1992-2015



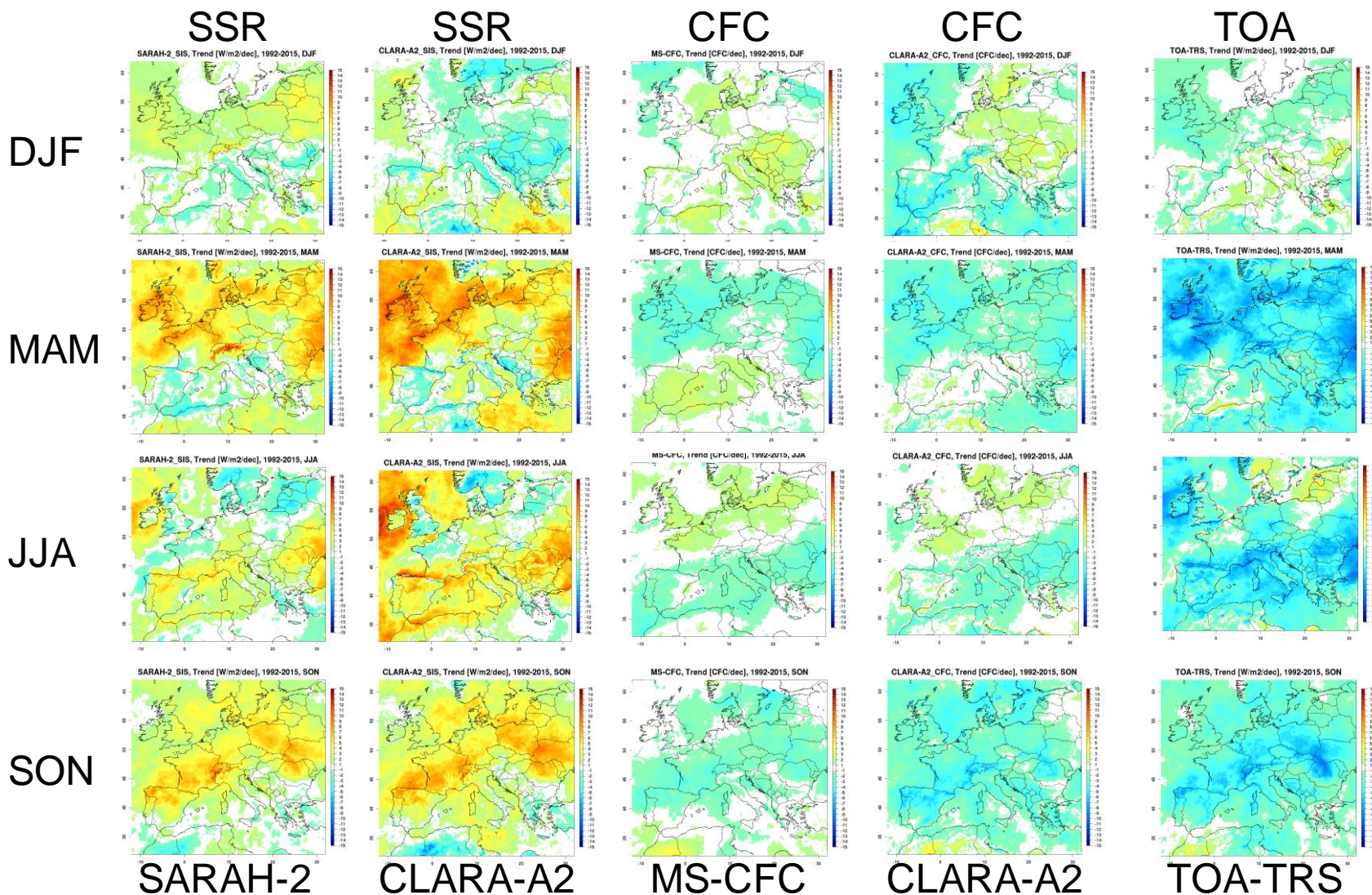
TOA-TRS

TOA-TRS, Trend [W/m2/dec], 1992-2015

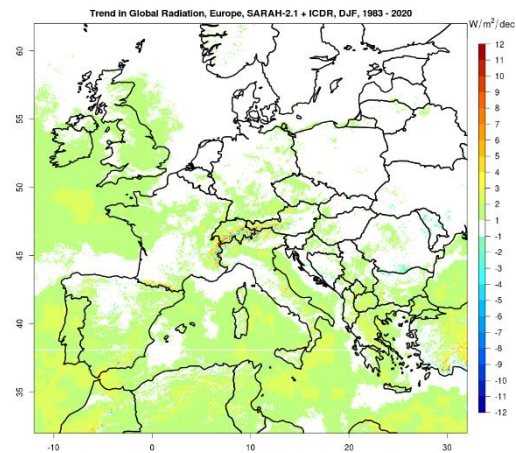
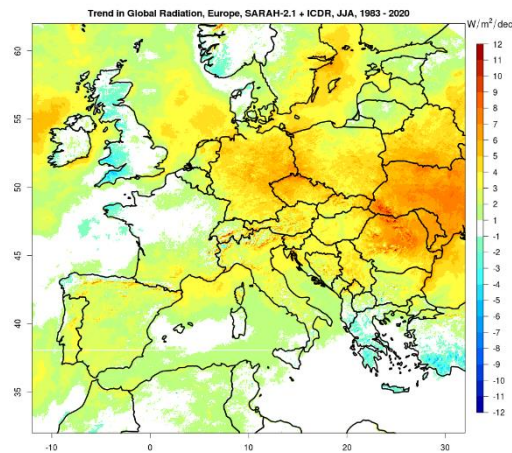
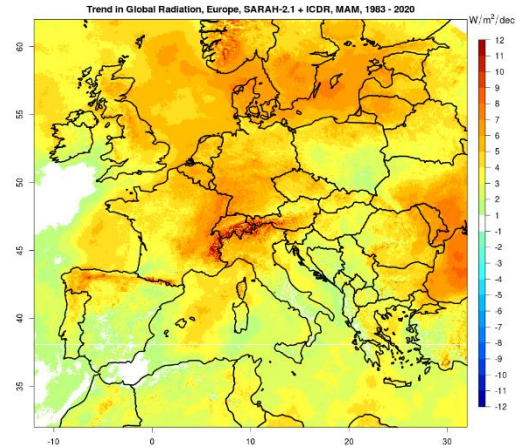
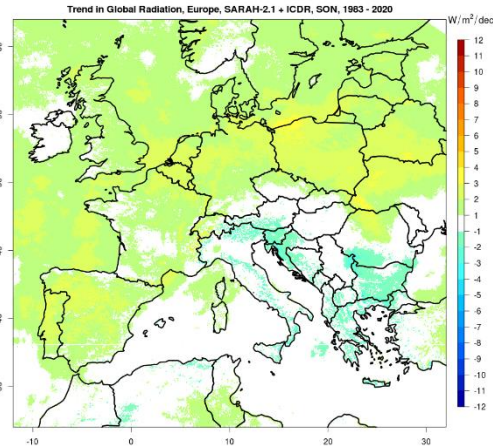
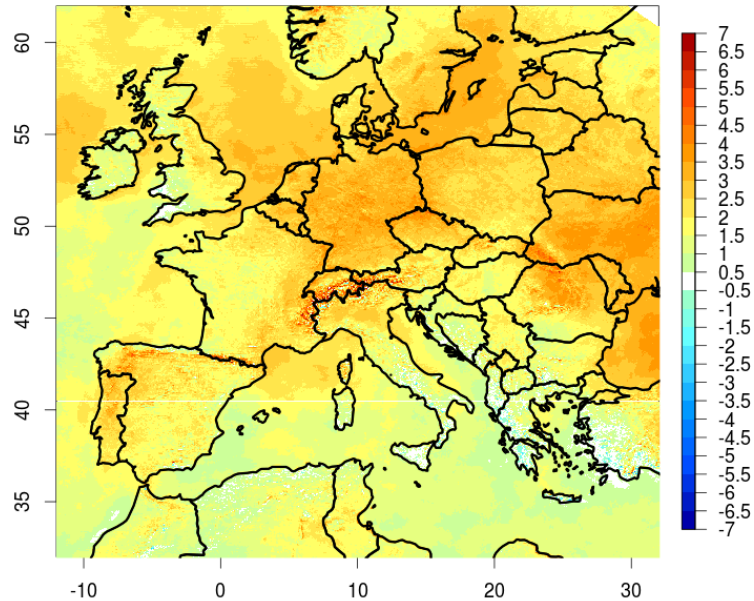


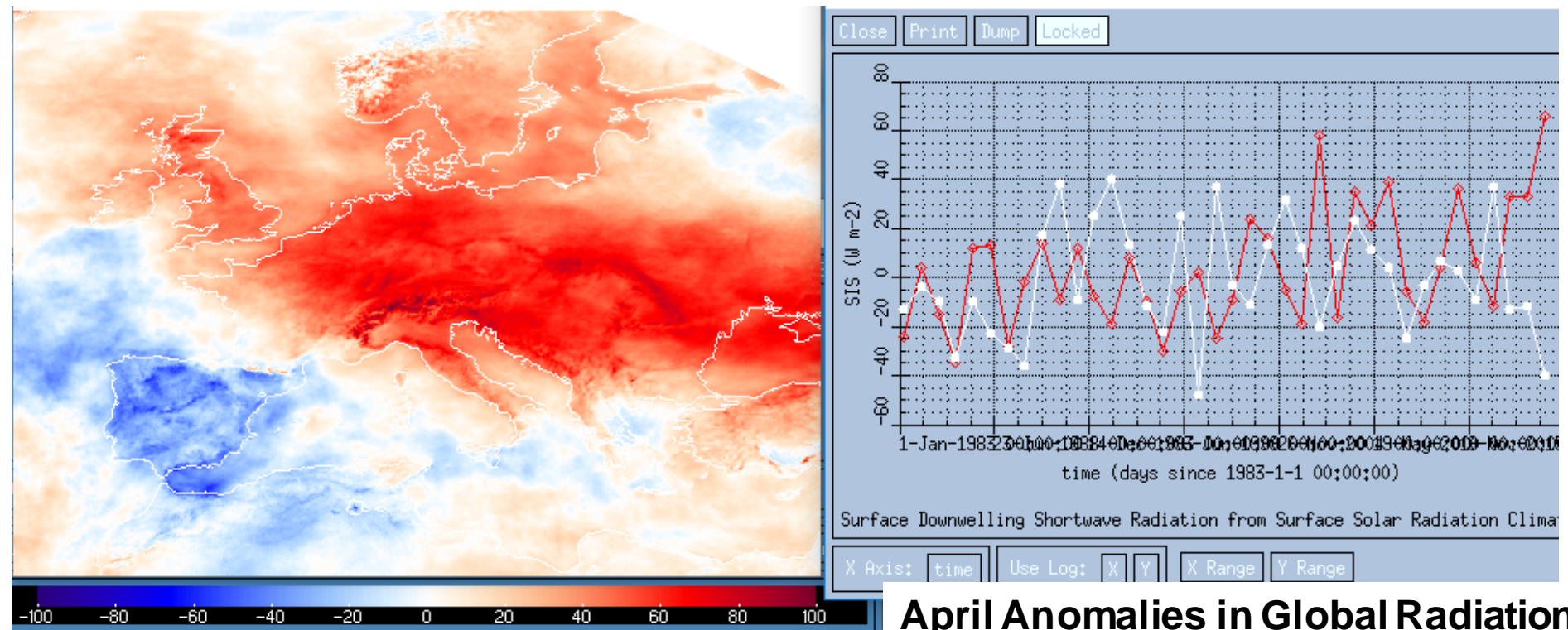
Pfeifroth et al. 2018, Adv. Science and Research

Seasonal trends of the analyzed CM SAF climate data records (1992-2015)



Trend [W/m²/dec] in Global Radiation, SARAH-2.1 + ICDR, 1983-2020





April Anomalies in Global Radiation

Red line: Point in Central Germany

White line: Point in Central Spain

- **Positive trend in global radiation in Europe** is continued (1983-2020)
 - especially in spring
- **High correlations** between SSR, CFC and TOA-reflected solar radiation
- Data records show **increasing SSR and decreasing CFC** during 1992-2015 in Europe
- Strong **coherence in temporal and spatial patterns** of SSR, CFC and TOA-radiation (on the annual and seasonal scale)
- CM SAF's data records are overall **consistent** concerning trends and variability in radiation and cloud parameters
- **Remaining challenges**, e.g. bright surfaces

- **Changes in clouds** likely main reason for changes in surface solar radiation in Europe (changes in **aerosols are not explicitly considered by the algorithms**)
 - This finding is partly in **contradiction** to the majority of past studies which conclude that changes in **aerosols** to be the main driver for trends in SSR (e.g. Norris and Wild, 2007; Philipona et al., 2009; Zubler et al., 2011; Nabat et al., 2014)
 - However change of **aerosol indirect effect** is covered by the satellite data, changes of **aerosol direct effect** not
- Changes in the aerosol direct effect might play a larger role in the **Mediterranean region in summer** (-> disagreements of station and satellite)
- Remaining data inhomogeneities (station and satellite) cannot be excluded
- Indications of **changing Circulation Patterns** in Europe as a main reason for trends in clouds and surface radiation

Journal of Geophysical Research: Atmospheres

RESEARCH ARTICLE

10.1002/2017JD027418

Key Points:

- CMSAF's satellite climate data record of surface solar radiation have high accuracy and stability
- Surface solar radiation trends given by the satellite data and the station data agree well for Europe, except for the Mediterranean summer
- The main reason for the observed trends of surface solar radiation in Europe is changes in clouds

Trends and Variability of Surface Solar Radiation in Europe Based On Surface- and Satellite-Based Data Records

Uwe Pfeifroth¹ , Arturo Sanchez-Lorenzo^{2,3} , Veronica Manara⁴ , Jörg Trentmann¹, and Rainer Hollmann¹

¹Satellite-Based Climate Monitoring, Deutscher Wetterdienst, Offenbach, Germany, ²Pyrenean Institute of Ecology, Spanish National Research Council (CSIC), Zaragoza, Spain, ³Department of Physics, University of Extremadura, Badajoz, Spain, ⁴Now at Institute of Atmospheric Sciences and Climate, ISAC-CNR, Bologna, Italy

Abstract The incoming solar radiation is the essential climate variable that determines the Earth's

Adv. Sci. Res., 15, 31–37, 2018

<https://doi.org/10.5194/asr-15-31-2018>

© Author(s) 2018. This work is distributed under the Creative Commons Attribution 4.0 License.



Advances in
Science & Research
Open Access Proceedings

Satellite-based trends of solar radiation and cloud parameters in Europe

Uwe Pfeifroth¹, Jędrzej S. Bojanowski², Nicolas Clerbaux³, Veronica Manara⁴, Arturo Sanchez-Lorenzo⁵, Jörg Trentmann¹, Jakub P. Walawender¹, and Rainer Hollmann¹