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Spatio-Temporal Representativeness of Ground-Based Downward Solar Radiation Measurements

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Motivation

The climatological mean amount of solar radiation absorbed in the atmosphere has recently been estimated using a combined data-set of ground based measurements and satellite derived products. [Hakuba et.al, 2014].

Studies on surface solar radiation (SSR) revealed significant variations of SSR on decadal timescales. [e.g. Wild, 2012; Sanchez-Lorenzo et.al. 2015]

→ Analysis of temporal variations of atmospheric absorption is pending.

→ Before addressing atmospheric absorption, spatio-temporal representativeness of ground-based SSR measurements has to be inferred.

Data

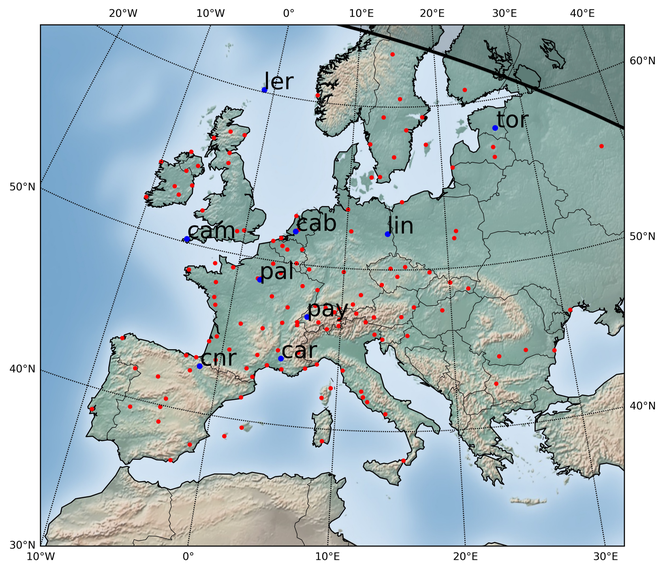
Data from 1983 to 2015 (we use deseasonalized monthly mean time-series)

- World Radiation Data Center (WRDC)

  140 Stations selected according to homogeneity criteria developed in [Hakuba et.al., 2013]

- Baseline Surface Radiation Network (BSRN) – 9 Stations
- Satellite Application Facility on Climate monitoring: Surface Solar Radiation Data Set - Heliosat (CM-SAF SARAH) - Edition 2 (resolution 0.05°x0.05°, [Müller et.al 2015]): Surface incoming shortwave (SIS, Monthly mean).

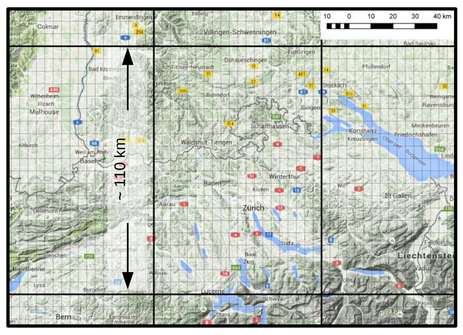
  Homogeneity of CM-SAF SIS SARAH V002 has been examined



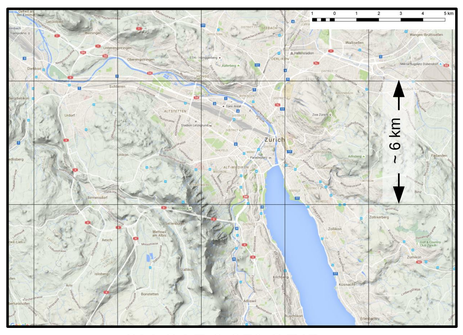
Objectives

When comparing ground-based point measurements with satellite derived gridded datasets (target grid = CERES Standard 1°x1° grid), representation errors occur. In order to do a proper time-series analysis, this error has to be quantified.

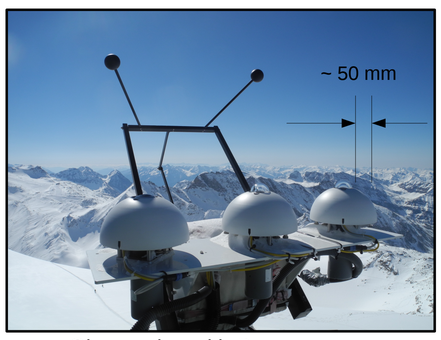
- Quantifying spatial and temporal representativeness of ground based monthly mean SSR observations.
- Quantifying representation error of single stations



CERES 1° GRID



CM-SAF 0.05° GRID



Observation with Pyranometer

Results

- **Correlation analysis European SSR-Stations vs. CM-SAF SSR**

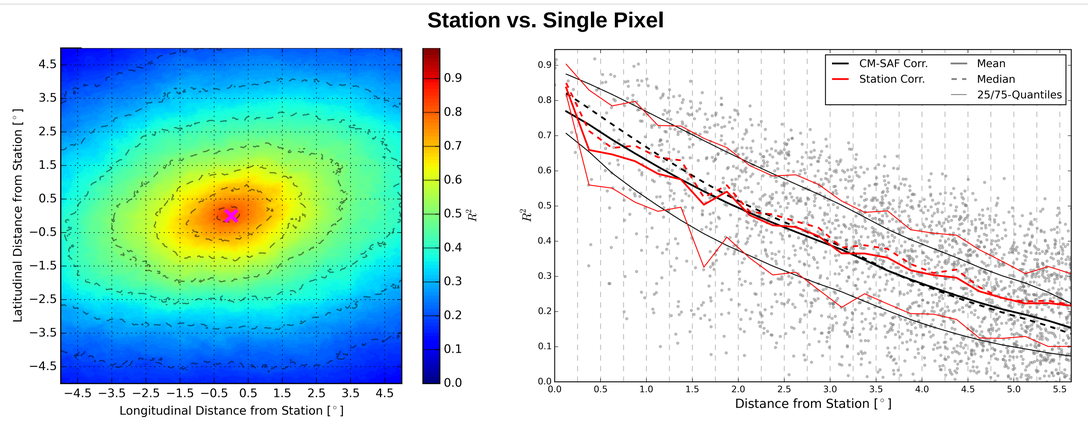


Fig.1: Map of median correlation between ground based SSR stations (center point of map) and single pixels of the CM-SAF SSR-dataset for all European station

Fig.2 Correlation between European SSR stations depending on their distance. Each gray point represents one station pair. Red lines are computed from stations only. Black lines represent correlation patterns as computed from CM-SAF (see left panel)

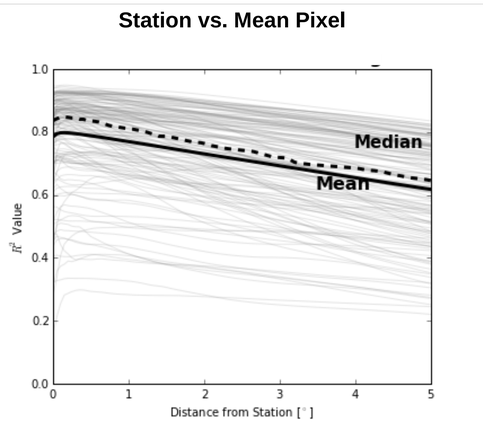


Fig.3: Correlation between European SSR stations and a spatially averaged series of CM-SAF pixels with maximum latitudinal and longitudinal distance to stations as indicated in the x-axis.

- **Regression analysis: Interquartileranges of slopes in 1° Box**

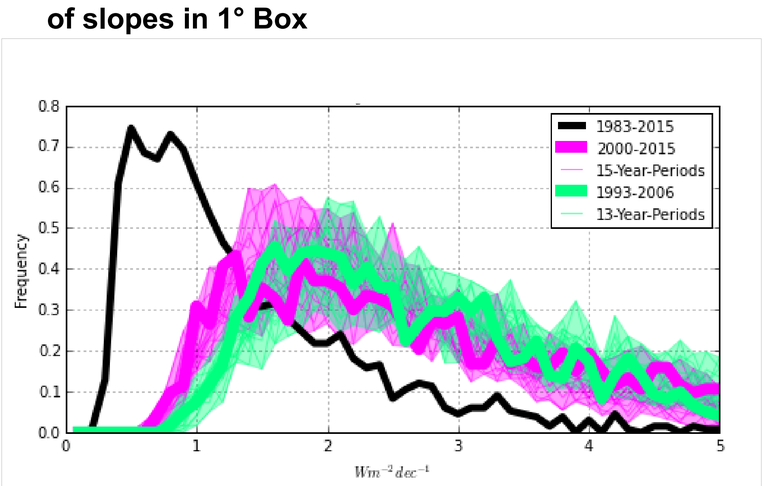


Fig.7: Range of regression slopes of individual CM-SAF pixels within 1°x1° Boxes:
Histogram of 95%-Interquantileranges over all 1° Boxes. The black line indicates the longest possible period. Magenta indicated 15-Year Periods. Green indicates 13-Year periods.

- **Synthetic Correlations (CM-SAF vs. CM-SAF)**

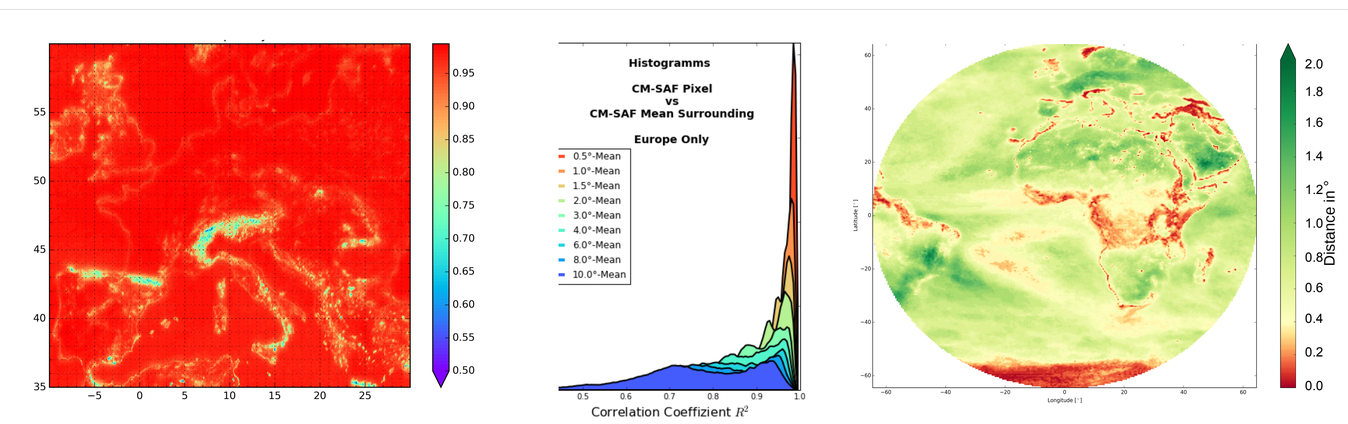


Fig.4: Synthetic correlation in Europe: R^2 for each CM-SAF Pixel with its 1° surrounding gridbox.
Fig.5: Histogram of R^2 values for different surrounding Boxes (0.5° - 10°) in Europe.
Fig.6: Distance at which the median correlation between each individual CM-SAF pixel and its single surrounding pixels drops below $R^2 < 0.7$ for the whole meteosat disk

Summary and Conclusion:

Ground Based monthly mean SSR measurements correlate well with 1-Degree-Surrounding:

Fig.1: High spatial correlation of SSR ground based measurements up to a few degrees distance

Fig.2: Correlation pattern from CM-SAF agree well with correlation pattern from ground based observations.

Fig.3: Correlation for spatially averaged time-series show higher correlations than single pixel correlations.

Fig. 4+5+6: Synthetic correlation analysis reveals spatial pattern

→ Complex and changing topography leads to lower correlations

Fig.7: CM-SAF homogenous period (1993-2006) has no significantly lower interquartileranges of regression slopes.

Regression slope differences between SSR stations in close proximity show that CM-SAF is smoother (factor 2) than ground based observations (not shown). → From Fig.7: Mean Sampling Error is relatively small!