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Global Trends in Downward Surface Solar Radiation from Spatial Interpolated Ground Observations during 1961-2019

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Downward surface solar radiation (SSR) is a crucial component of the Global Energy Balance. Many studies have examined SSR trends; however, they are often concentrated on specific regions due to limited spatial coverage of ground based observation stations. To overcome this spatial limitation, this study performs a spatial interpolation based on a machine learning method, Random Forest, to interpolate monthly SSR anomalies using a number of climatic variables (various temperature indices, cloud coverage, etc.), time point indicators (years and months of SSR observations), and geographical characteristics of locations (latitudes, longitudes, etc). The predictors that provide the largest explanatory power for interannual variability are *diurnal temperature range* and *cloud coverage*. The output of the spatial interpolation is a $0.5^{\circ} \times 0.5^{\circ}$ monthly gridded dataset of SSR anomalies with complete land coverage over the period 1961-2019, which is used afterwards in a comprehensive trend analysis for i) each continent separately, and ii) the entire globe.

The out-of-sample cross-validation shows that the applied machine learning method is able to capture 49% of the interannual long-term variations in observed SSR, which demonstrates the robustness of the method and shows that the interpolated dataset could serve as a foundation for further SSR research.

The current research was published in *Journal of Climate* (Yuan, Leirvik, and Wild, 2021). Based on the established work, we propose to carry out more extensions:

- We will evaluate the model's forecasting accuracy. Yuan, Leirvik, and Wild (2021) validated the model against the Global Energy Balance Archive (GEBA) over the period from the 1950s until 2013. The recent update of GEBA until 2019 makes possible the forecast validation over the more recent period 2014-2019. Not only is the validation an out-of-sample verification, but it will also test the model's ability in predicting future values.

- We further propose to use external SSR data to cross validate our interpolated dataset. By external, we mean these data are not included in the GEBA and therefore not used in training the model. This validation will provide further proof for the robustness of our method and the reliability of our dataset. We aim to use World Radiation Data Center (WRDC) and Baseline Surface Radiation Network (BSRN) in this application. In particular, we will conduct a correlation analysis and calculate spatial sampling errors that arise from estimating the temporal variability of SSR for a grid box ($0.5^{\circ}\times0.5^{\circ}$) from a point observation.
- Following the aforementioned in-depth validation of our interpolated dataset, we aim to use it as a reference to assess the performance of the global climate models in CMIP6. Based on our constructed dataset, we aim to implement a comprehensive evaluation of the extent of the discrepancy between CMIP6 model simulations and our synthetic observations. A weighted-average ensemble series could be further developed by giving the better performing models larger weights and less competent models lower weights.