EMS Annual Meeting Abstracts
Vol. 18, EMS2021-128, 2021
https://doi.org/10.5194/ems2021-128
EMS Annual Meeting 2021

Merging of satellite and ground measurements of hourly surface solar radiation variables in Germany

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Measurements of the surface solar radiation have a high importance for the fields of meteorology, climatology, solar energy, agriculture, forestry and other applications. Radiation measurements at ground stations using high quality instruments such as pyranometers began in the second half of the nineteenth century. From the 1980s onward, satellite imagery in the visible radiation spectrum has been used to calculate gridded data of cloud information and, subsequently, of solar radiation at the Earth's surface. Compared to station data, satellite data have the advantage of spatial continuity, but have disadvantages in temporal resolution and data accuracy.

As part of a restructuring of the radiation measurement network, the German Meteorological Service (DWD) is pursuing the goal of expanding its high-quality surface measurements using pyranometers (to 42 stations) and largely discontinuing other radiation measurements, such as direct measurements of sunshine duration. At the same time, surface solar radiation products from satellite data are progressively improving in quality and can be used to compensate for the reduction of ground measurements and increase the spatial coverage of radiation information over Germany. For this purpose, the project DUETT aims at a merging between solar radiation data from the 42 pyranometer stations and near-real-time data based on measurements from METEOSAT-SEVIRI. As products, hourly values of the parameters global horizontal irradiance (GHI) and sunshine duration (SDU) will be provided on a 1x1km grid for Germany with a time delay of 15 minutes after each full hour.

Merging is performed in three main steps, which are described in the following for the parameter GHI. First, the hourly mean values of both data sources are calculated. In the case of the satellite data, this step involves the use of an 'optical flow' technique to generate intermediate images to increase the original time resolution from 15 minutes to virtually 1 minute. Using this technique, the displacement of fast-moving clouds is better reflected. In the second step, systematic deviations between the two data sources are determined and corrected for by using predictors. Preliminary research suggests that cloudiness (or clearness index) is one such appropriate predictor. In the final step, the local differences between the corrected satellite data and the station data are interpolated to the target grid using Universal Kriging and the results are added to the corrected satellite data.

We present the first results of the merging procedure to be developed for both radiation parameters GHI and SDU. Analyses of the systematically occurring radiation differences between the two data sources are shown as well as the related correction functions. Furthermore, first results of the validation of the combined radiation products will be presented. This includes comparisons with measurements at validation stations as well as analyses based on cross-validation.