Downward shortwave radiation trends in Europe since the 20th century: what we know from direct measurements and sunshine duration records?

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The first part of this work presents results based on the longest series measuring downward shortwave radiation (DSR) available at the Global Energy Balance Archive (GEBA) over Europe, some of them available since the 1920s. Particular emphasis is placed upon the quality control and homogenization of the dataset, which has been checked for temporal homogeneity by means of different relative homogeneity tests. The mean annual DSR series show an increase from the 1930s to the early 1950s (i.e. early brightening period), followed by a reduction until mid-1980s (i.e., dimming period), and ending with an increase up to the present (i.e., brightening period). Overall, the trend from the 1930s to the present is negative and significant on annual basis. Unfortunately, there exists a substantial gap in direct measurements of DSR as few stations in Europe provide records before the 1960s. To overcome the lack of direct measurements, the analysis can be supported with other proxy variables more widely measured, such as sunshine duration (SD) records. Thus, in this work we also present the reconstructed DSR variations since late 19th century in Europe based on the SD series over Europe with around one century of records, some of them starting in the 1880s. The reconstructed DSR variations have been estimated by using the relationship found between the SD sunshine duration series and a satellite-derived DSR dataset (0.03 x 0.03 of spatial resolution), provided by the EUMETSAT Satellite Application Facility on Climate Monitoring (CM SAF), during the common 1983-2005 subperiod. The reconstructed records have been validated by using the GEBA series described in the first part of this work. The temporal evolution of the mean DSR annual series since the 1950s is characterized by the well-known dimming and brightening periods. Moreover, an early brightening period is also detected during the first half of the 20th century, although regional differences are observed with areas over Europe where the DSR show no increase in this subperiod. Interestingly, the reconstructed DSR also highlight an absolute minimum in 1912, which should be the signal of the Katmai volcanic eruption (i.e., largest volcanic eruption in the 20th century) as the consequence of the direct effect of the volcanic sulphur aerosols released in the volcanic eruption. The results highlight the suitability of SD records to detect changes in DSR under all-sky and clear-sky conditions (e.g., due to aerosol changes).