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Solar dimming and brightening in the second half of 20th century based on ERA-40 Reanalysis Project

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Solar radiation is the single most important energy source for the Earth. It governs a broad range of physical and chemical processes and atmospheric phenomena, determining the radiation budget and hence the Earth's climate. In particular, the solar radiation reaching the Earth's surface (surface solar radiation, SSR) is the major heating source that generates pressure gradients, drives evaporation and controls the water cycle. Therefore, monitoring SSR and its potential modifications is of great importance for the Earth's climate.

Recently, surface observations have indicated that SSR has undergone significant decadal variations, comprising periods of decreases (dimming) or increases (brightening), referred to as global dimming and brightening (GDB). The local/global nature of GDB as well as its long-term patterns, are still the subject of ongoing discussions. The inability of stations to reproduce GDB all over the globe, especially over the oceans, has stimulated studies that use satellite measurements and models. Another alternative for investigating GDB is to use global reanalysis radiation products. These approaches can offer advantages such as complete global coverage, realistic reproduction of the state of the atmosphere, validation by surface observations and the possibility of extended study periods that allow assessments of long-term GDB.

In the present study, we examine the GDB patterns as reproduced by reanalysis data from the European Centre for Medium-Range Weather Forecasts (ECMWF) covering the period 1958–2001 (ERA-40). All-sky daily SSR data were used to produce monthly and annual fluxes, computed at the geographical cell, regional, and hemispherical/global levels, in order to discern SSR spatial and temporal fluctuations.

An overall solar dimming is revealed at the global scale, which is however divided into two subperiods characterized by consecutive dimming and brightening. Thus, globally, SSR is found to have decreased from the late 1950s through to the late 1970s, having then increased until the early 1990s, and subsequently decreased during the 1990s, with similar features in the North and South hemispheres as well as in most world regions. The overall linearly decreasing mean global SSR in the second half of 20th century has been observed in all seasons at a comparable strength. However, the declining SSR, which is slightly stronger in SH than NH, has been mainly observed in winter and spring in NH and in summer and autumn in SH. The identified ERA-40 GDB features seem to be different than those reported from observations, indicating a dimming from the 1950s to the 1980s, and a brightening thereafter, i.e. during the 1990s. Nevertheless, given that observed GDB is rather representative of specific locations, emphasis was given to ERA-40 SSR tendencies at the local scale through comparisons against observational reference data taken from 433 Global Energy Balance Archive (GEBA) stations with more than 10 years data distributed over most of the globe. It is found that ERA-40 SSR fluxes are in good agreement with GEBA (correlation coefficients larger than 0.9 in 350 stations) while the ERA-40 trends have the same sign as those of 269 (62%) GEBA stations.