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Features and causes of recent surface solar radiation dimming and brightening patterns

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Incoming solar radiation at the Earth's surface has undergone substantial decreases/increases on decadal timescales in the second half of 20th century. More specifically, surface measurements have indicated a widespread decrease of surface solar radiation (SSR) from the 1950s to the 1980s, described as global dimming, followed by a period with either no more decrease or even an increase at various locations worldwide till the end of 1990s, namely a global brightening. These measured patterns of SSR are, in general, in line with SSR fluxes computed with radiative transfer models (RTMs) using satellite input data, while efforts are currently being made to reproduce them with regional or global climate models. The advantage of reproducing SSR dimming/brightening with RTMs is that an almost complete coverage of the globe is possible, whereas dimming/brightening patterns are obtained under both clear- and all-sky conditions. Moreover, an even more important and incomparable advantage of the use of RTMs for reproducing SSR dimming/brightening, is that it makes possible the identification of their causes in terms of specific radiative forcing agents, and the assessment and quantification of their relative contribution to GDB, which is of major importance for understanding current and future climate changes.

In the present study, first an update of SSR dimming/brightening at global scale beyond 2000 is attempted using a spectral RTM along with a variety of satellite and reanalyses input data. The results are obtained at scales varying from the regional to continental/hemispherical/global, and are validated through comparisons against quality surface measurements from reference global networks such as GEBA (Global Energy Balance Archive) and BSRN (Baseline Surface Radiation Network). An inter-hemispherical difference is revealed up to 2007, consisting in a clear dimming in the South Hemisphere (SH), against a no clear dimming/brightening signal in North Hemisphere (NH), under all-sky conditions. Clouds and aerosols are identified to be the main contributors to the post 2000 dimming/brightening global patterns, with the former exerting a solar radiative forcing that is larger than the forcing of aerosols by about factor of 8 in SH, against factor of 2 for NH. In SH, both clouds and aerosols have increased after 2000, leading to SSR dimming, whereas in NH aerosols have decreased, producing a brightening that partly counteracts the dimming due to increasing clouds. However, the role of aerosols is predominant in specific world regions, like the Mediterranean and Amazonian basins, sub-Sahel Africa, Indonesia, Europe or North America. Contribution of other parameters, namely incoming solar radiation at the top of atmosphere, water vapor or ozone, has been evaluated as being of relatively minor importance for SSR dimming/brightening after 2000. The increase in cloudiness, in both hemispheres, is mainly attributed to mid-level clouds, and also to high clouds for NH, against decreasing low-level clouds in both hemispheres. Our results prove the complexity of concurrent actions of natural and anthropogenic solar radiative forcing agents, that can induce strong spatial temperature gradients and finally affect physical processes such as evaporation from the Earth's surface or even the hydrological cycle, atmospheric circulation and climate.