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Patterns of surface solar radiation dimming and brightening at the turn of 21st century

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There has been observational evidence in the 20th century that surface solar radiation (SSR) has undergone climatologically significant decadal variations referred to as global dimming and brightening (GDB). Recent modelling and observational studies have documented a global brightening in the 1990s that was preceded by a global dimming from the 1960s up to the 1980s as shown by several studies based on surface measurements. Moreover, it has been shown that GDB has important implications for the Earth's energy budget and thus climate, and so it has to be continuously monitored and updated. Previous studies using data beyond 2000 examined tendencies of SSR up to 2004 at global/hemispherical/continental scales or station sites, separately, indicating a change from the 20th to the 21st century. In the present study, we investigate the evolution of GDB for the period 2000-2007 using a spectral radiative transfer model with input data from global satellite (International Satellite Cloud Climatology Project, ISCCP; Moderate Resolution Imaging Spectroradiometer, MODIS) and Reanalysis projects (National Center for Environmental Prediction/National Centers for Atmospheric Research, NCEP/NCAR), with the aim to provide local, regional and hemispherical aspects of the phenomenon and to identify possible causes.
An overall global dimming (based on coastal, land and ocean pixels) is found to have taken place on the Earth under all-sky conditions, from 2001 to 2006, arising from a stronger solar dimming in the SH (ΔSSR = -3.84 W m-2 or -0.64 W m-2/yr) and a slight dimming in NH (ΔSSR = -0.65 W m-2 or -0.11 W m-2/yr), thus exhibiting a strong inter-hemispherical difference. Dimming is observed over land and ocean in the SH, and over oceans in the NH, whereas a slight brightening occurred over NH land, with the SSR tendencies being larger in the SH than in the NH land and ocean areas. The regional patterns, however, have a patchy spatial structure, with opposite SSR tendencies in neighbouring areas, even on a continental scale. The model computed tendencies of SSR are supported to a large degree by surface station measurements taken from the GEBA and BSRN networks, which strengthens the validity of the post-2000 GDB findings of this study. As for the causes of the phenomenon, it appears that clouds have been primarily responsible for GDB beyond 2000, with aerosols playing a secondary role on a hemispherical/global basis. In the NH, the brightening resulting from a decreasing AOD tendency has been counterbalanced by the dimming produced by increased cloud cover, as shown by both ISCCP and MODIS data. The Southern Hemisphere has undergone significant dimming due to a larger increase in cloud cover than in NH, which has dominated the slight dimming from increased aerosols. The indicated SSR dimming of the Southern Hemisphere at the beginning of this century demonstrates that much remains to be learned about the responsible physical processes and climatic role of cloud and aerosol feedbacks.