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Detailed analysis of the Global Dimming & Brightening from 1980 to 2020 based on MERRA-2 reanalysis data

Michael Stamatis¹, Nikolaos Hatzianastassiou¹, Marios Bruno Korras Carraca^{1,2}, Christos Matsoukas², Martin Wild³, and Ilias Vardavas⁴

¹University of Ioannina, Department of Physics, Neochoropoulon, Ioannina, Greece (mixstam1453@gmail.com)

²Department of Environment, University of the Aegean, Mytilene, Greece

³Institute for Atmospheric and Climate Science, ETH Zurich, 8092 Zurich, Switzerland

⁴Department of Physics, University of Crete, Heraklion, Greece

The incident solar radiation on the Earth's surface (SSR) varies on a decadal scale and this phenomenon is called Global Dimming & Brightening (GDB). GDB is known to be caused by anthropogenic and natural climate agents, with clouds and aerosols being the most significant.

This study examines the GDB using Modern-Era Retrospective Analysis for Research and Applications v.2 (MERRA-2) reanalysis data, that is originally provided on a $0.5^\circ \times 0.625^\circ$ horizontal grid resolution, for the 41-year period 01/1980 – 12/2020. The mean monthly SSR fluxes and their deseasonalized anomalies are computed and validated against ground truth measurements from two major reference station networks, namely the Global Energy Balance Archive (GEBA), and the Baseline Surface Radiation Network (BSRN). The changes of SSR anomalies (Δ SSR or GDB) are calculated on global (land & ocean), hemispherical and regional scales, over the entire period and for sub-periods too. In each case, it has been examined whether the sign of MERRA-2 GDB (dimming or brightening) agree or disagree with the corresponding GDB sign of stations lying within the MERRA pixel.

Using SSR deseasonalized anomalies, the computed Δ SSR for the 41-year period 1/1980-12/2019 for the Globe is equal to $-6.307 \pm 0.193 \text{ W/m}^2$ (on an annual basis), $-5.716 \pm 0.281 \text{ W/m}^2$ for the Northern Hemisphere and $-6.161 \pm 0.379 \text{ W/m}^2$ for the Southern Hemisphere, indicating an overall dimming, which has counteracted the anthropogenic greenhouse warming. Stronger dimming is found over oceans, equal to $-7.805 \pm 0.244 \text{ W/m}^2$, against a weaker dimming over land, equal to $-2.582 \pm 0.249 \text{ W/m}^2$, pointing to a less transparent atmosphere over the oceans than over land. A brightening is found over Europe and E. Asia, opposite to a dimming over India. The agreement between the estimated GDB from MERRA-2 and GEBA/BSRN stations ranges from 50% to 77%, either for the entire study period as well or the examined sub-periods (1980-1985, 1986-2000, 2001-2010, 2011-2020), revealing a reasonable agreement adding confidence about the conclusions drawn from this MERRA-2 based analysis.