Significant Decadal Brightening over the Continental United States

Contributors

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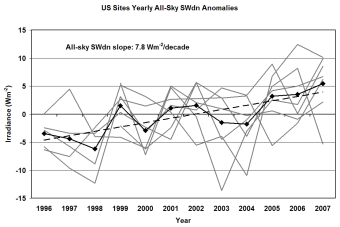
Research Highlight

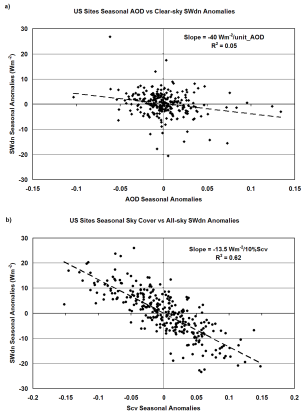
We conduct analyses of all-sky and clear-sky surface downwelling shortwave radiation and bulk cloud properties using data from several Department of Energy Atmospheric Radiation Measurement (ARM) Climate Research Facility (ACRF) and National Oceanic and Atmospheric Administration Surface Radiation (SURFRAD) Network sites spanning the years 1995 through 2007. Five ACRF sites are aggregated to study downwelling shortwave tendencies on global circulation model grid scales, then six SURFRAD sites plus the central ACRF site are aggregated to study the wider scale of the continental United States.

We show that wide-spread brightening has occurred over the continental United States as represented by these measurements over the 12 years of the study, averaging about 8 Wm-2/decade for the all-sky shortwave and 5 Wm-2/decade for the clear-sky shortwave. This all-sky increase is substantially greater than the 2 Wm-2/decade previously reported over much more of the globe as represented by data from the Global Energy Balance Archive (GEBA) spanning 1986-2000, and is more than twice the magnitude of the corresponding 1986-2000 2-3 Wm-2/decade increase in downwelling longwave. Our results show that changes in dry aerosols and/or direct aerosol effects alone cannot explain the observed changes in surface SW radiation, but it is likely that changes in cloudiness play a significant role. These SW increases are accompanied by decreasing tendencies in cloudiness, and an increasing tendency in the clear-sky SW diffuse/direct ratio that is often associated with atmospheric turbidity. However, given the many local influences, evidence presented here suggests that the determination of the causes of decadal changes in the downwelling solar radiation at the surface are better studied locally and regionally, rather than on a global or continental scale.

Arguments have been made that the decades of dimming from 1960-1990 may have, to some extent, offset expected global warming due to greenhouse gases, with the more recent brightening starting in the 1990s now contributing to more rapid manifestations of global greenhouse warming effects and possibly to the recent acceleration of the land-based hydrological cycle. The significant all-sky brightening we show here is almost three times the magnitude of the reported wide-spread 2-3 Wm-2/decade increase in downwelling longwave over much more of the globe deduced from GEBA records, presumably due to greenhouse warming. We note that documented dimming and brightening are to date not well represented in climate models, as noted in comparing Intergovernmental Panel on Climate Change (IPCC) models with measurements from baseline surface radiation



Yearly averages of downwelling all-sky SW anomalies (gray) for the ACRF Southern Great Plains (SGP) Central Facility and SURFRAD sites used in this study as well as the all-sky (black with diamonds) aggregate average and the corresponding least-squares linear fit showing an increasing trend of 8 Wm-2/decade.



Seasonal anomalies of 500-nm aerosol optical depth versus clear-sky SW (a) and SW total daylight sky cover (Scv) versus all-sky SW for the ACRF Southern Great Plains (SGP) Central Facility and SURFRAD sites and the corresponding least-squares linear fits showing a far greater relationship between sky cover and SW than aerosols and SW, despite the average magnitude of clear-sky SW being about twice that of all-sky.

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network (BSRN) sites and International Satellite Cloud Climatology Program (ISCCP) satellite-derived surface downwelling SW, and as such denotes a significant unresolved problem for climate change prediction.

Reference(s)

Long CN, EG Dutton, JA Augustine, W Wiscombe, M Wild, SA McFarlane, and CJ Flynn. 2009. "Significant Decadal Brightening of Downwelling Shortwave in the Continental US." Journal of Geophysical Research – Atmospheres, , . ACCEPTED.

Working Group(s)

Radiative Processes