Analyzing the Contribution of Aerosols to an Observed Increase in Direct Normal Irradiance

Contributors

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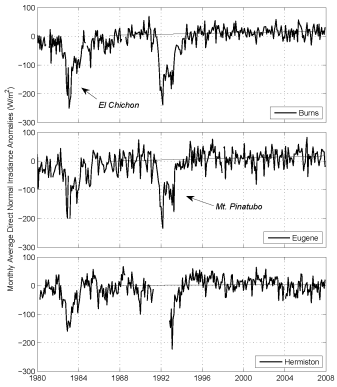
Research Highlight

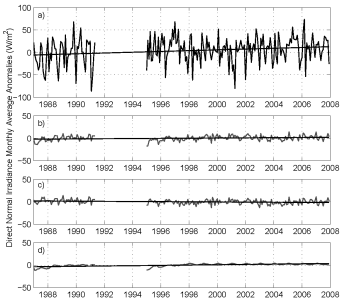
Analyses of surface solar irradiance reported a decrease in total irradiance until around 1990 and a following increase at many monitoring stations worldwide. One of the hypothesized causes for the #dimming# and following #brightening# is changing concentrations of anthropogenic aerosols. Studies show that calculated global emissions of sulfur dioxide and black carbon between 1980 and 2000, which peaked in 1988#1989 and were at a minimum in 2000, are consistent with the observed trends of changes from dimming to brightening. Determining how much of the change seen in surface solar irradiance is due to anthropogenic aerosols would help reach better conclusions about anthropogenic climate forcing. If the observed decrease in surface irradiance caused by anthropogenic aerosols is signicant, then the global warming from increased greenhouse gases might be underestimated.

Annual average total irradiance increases by 1#2 percent per decade at three monitoring stations in Oregon over the period from 1980 to 2007. Direct normal irradiance measurements increase by 5 percent per decade over the same time period. The measurements show no sign of a dimming before 1990. The impact of high concentrations of stratospheric aerosols following the volcanic eruptions of El Chichon and Mt. Pinatubo are seen clearly in the measurements. Removing these years from the annual average all#sky time series reduces the trends in both total and direct normal irradiance.

Clear#sky periods from this long direct normal time series are used in conjunction with radiative transfer calculations to test whether part of the increase could be caused by anthropogenic aerosols. All three sites show relatively low clear#sky measurements before the eruption of El Chichon in 1982, suggesting higher aerosol loads during this period. After removing the periods most strongly impacted by volcanic eruptions, two of the sites show statistically signifcant increases in clear#sky direct normal irradiance from 1987 to 2007. Radiative transfer calculations of the impact of volcanic aerosols and tropospheric water vapor indicate that only about 20 percent of that clear#sky increase between background aerosol periods before and after the eruption of Mt. Pinatubo can be explained by these two factors. Thus, a statistically significant clear#sky trend remains between 1987 and 2007 that is consistent with the hypothesis that at least some of the increase in surface irradiance could be caused by a reduction of anthropogenic aerosols.



Clear#sky monthly average anomalies of direct normal irradiance measurements for three ground sites at solar zenith angles of 65#75 degrees.



Monthly average anomalies of measured (a) and modeled data sets (b#d) for the period from 1987 to 2007, excluding the eruption of Mt. Pinatubo (June 1991#Dec 1994). Modeled data include interannual variability in both stratospheric aerosol optical depths and water vapor profiles (b), only changes in water vapor profiles (c), and only interannual variability in stratospheric aerosols (d). Linear regression lines are plotted for each time series.

Reference(s)

Riihimaki L, FE Vignola, and CN Long. 2009. "Analyzing the contribution of aerosols to an observed increase in direct normal irradiance in Oregon." Journal of Geophysical Research – Atmospheres, 114, D00D02, doi:10.1029/2008JD010970.

Working Group(s)

Aerosol, Radiative Processes