Trends in U.S. Surface Radiation and Aerosol Optical Depth over the Past 20 Years

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Periods of solar dimming and brightening at the surface have been documented over the globe since the 1950s. In general, all-sky solar irradiance at the surface decreased (dimmed) from the 1950s to the 1980s and increased (brightened) from the 1990s through the first decade of the 21st century. According to Martin Wild's 2009 review, all continents experienced dimming and brightening except for parts of China and India, where dimming dominated. These trends have been linked to aerosol variability in Europe and Asia. For the U.S., high-quality measurements from the SURFRAD network document brightening of +7.2 Wm^{-2}/decade from 1995 to 2012, however, a quick retreat to normal levels has been observed from 2012 to 2017. Clear-sky short wave irradiance during the brightening period show an increase of +4.6 Wm^{-2}/decade, but almost all of that is in the diffuse, leading to speculation that ice in the stratosphere from increased airline traffic may be the cause. Aerosol optical depth (AOD) over the U.S. has steadily decreased by -.023/decade over the past 22 years, in agreement with other inventories. The change in the direct effect of aerosols corresponding to that decrease would account for only ~0.8 Wm^{-2}/decade of the measured brightening. Furthermore, decreasing AOD over the past five years is not consistent with the observed dimming during that period. In contrast, sky cover variability over the U.S. is inverse to that of surface irradiance over the past 20 years, suggesting that systematic changes in cloud cover have been mostly responsible for the recent brightening and dimming trends. Coincident with the systematic decrease of AOD is an *increase* in the network-wide annual AOD *minima* from 1998 through 2012, followed by a sharp decrease to 2017. That variability has been linked to northern hemisphere volcanic activity by comparing SURFRAD average annual AOD minima to the zonal average (30° to 60°N) of stratospheric AOD from the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO) space-lidar. The similarity in their variabilities demonstrates that area averaged surface-based annual AOD minima can be a proxy for stratospheric aerosol variability.

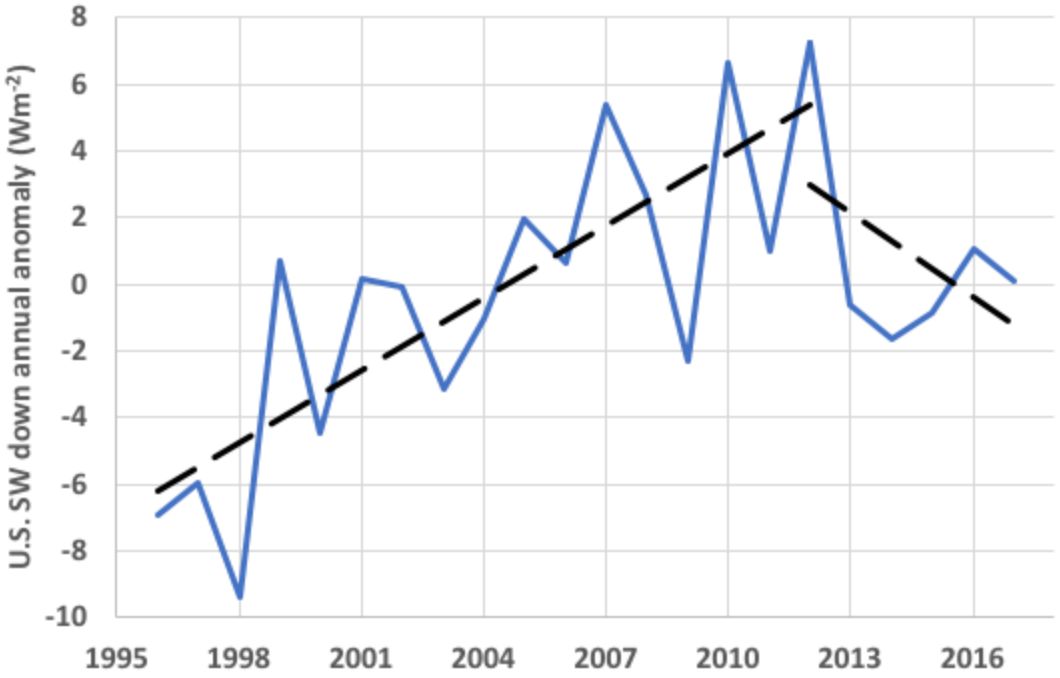

Figure 1. U.S. annual anomaly of downwelling short wave from the SURFRAD network. Dashed lines show trends for distinct periods of brightening and dimming.