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Modeling the impacts of solar radiation partitioning into direct and diffuse fractions for the global water cycle

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Incident solar radiation at the Earth's surface affects plant photosynthesis and evapotranspiration, and consequently the global water budget. Observations from 1960-1990's across the Northern Hemisphere suggest that increased aerosol loadings from industrialization led not only to a decline in the intensity of solar radiation at the surface (global dimming), but also to a higher fraction of scattered light, which enhanced plant photosynthesis and the land carbon sink, with probable concurrent impacts on the water cycle. Thus, we used the NCAR Community Land Model (version 3.5) to perform global offline simulations and study the effects of the imposition of changes to radiation partitioning in diffuse and direct fractions on trends in evapotranspiration and runoff.

We find that most modeled land surface variables respond to an increased-diffuse simulation where the relative fraction of radiation is changed globally at a high rate of increased diffuse as reported by some observation stations. Increased-diffuse partitioning causes a rise in total ET in all regions, an effect of opposite sign but smaller absolute value than that resulting from global dimming. Evapotranspiration rises by over 0.5 watt/m2 per decade in the tropics, due to increased shaded leaf stomatal conductance, with an opposite effect noted elsewhere due to lower ground evaporation. In the eastern U.S.A. and the Amazon basin, decadal trend anomalies in evapotranspiration for increased-diffuse radiation change reach 25-30% the absolute magnitude of those caused by dimming. Reductions to river runoff are modest nearly everywhere outside the Amazon. Understanding the mechanisms behind the interactions between solar radiation and the various land-surface components will help the development of climate models, improving predictions, in particular regarding changes in terrestrial hydrologic resources.