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The role of decadal changes in incident radiation for trends in global evapotranspiration and runoff

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Incident solar radiation has changed in the last 50 years, where a dimming trend from 1960 to approximately 1990 was followed by an ongoing brightening period that was observed in several regions. Concomitantly to the solar dimming, radiation partitioning between direct and diffuse fractions has also changed in favour of a higher relative proportion of the latter. Such radiation changes are expected to significantly affect the global water cycle. Thus, we used the NCAR Community Land Model (version 3.5) to perform global offline simulations of land-atmosphere processes to study the effects of the imposition of extreme and realistic radiation signals on trends in evapotranspiration and runoff.

We find that the modeled components of the hydrologic cycle respond strongly to strong radiation changes, especially in the tropics as a result from increased plant transpiration. In Europe and in the Eastern U.S.A. an imposed realistic 1960-1990 solar dimming decreases evapotranspiration by 1.5 watt/m2, rising runoff by nearly 4.5% of its mean; trends with stronger but opposite signals are also shown for the subsequent brightening period. Similarly, a higher imposed diffuse fraction of radiation raises evapotranspiration by over 0.5 watt/m2 per decade in the tropics due to increased photosynthesis from shaded leaf stomatal conductance, with an opposite effect noted elsewhere due to lower ground evaporation. Validation of the model runoff output is also performed using streamflow data from over 700 small European catchments with no direct anthropogenic influence. Understanding the mechanisms underlying the impacts of solar radiation on the hydrologic cycle will help the development and parameterization of the land-surface components of climate models, improving predictions, in particular regarding changes in terrestrial water resources.