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Uncertainties in the long-term surface radiation balance and its impact on hydrologic variability and changes in drought occurrence

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Radiation at the earth's surface is a key driver and feedback with the terrestrial hydrologic cycle. Changes in the long-term radiation budget manifest in changes in hydrologic response via evaporation, sublimation and snowmelt, which propagate to the rest of the water cycle. Over the past 50 years, global dimming and then brightening is likely to have had an impact on the hydrologic cycle but there are uncertainties in the magnitude of the trends and their impacts at global scale. The magnitude of changes in longwave radiation globally are also uncertain but can be characterized by long-term increases in incoming longwave driven mostly by increased water vapour. These are offset to some extent by increases in outgoing longwave from a warming surface. The balance of these individual components as net radiation is therefore uncertain, and especially in its long-term trends, but better estimates are crucial for understanding the response and feedbacks of the hydrologic cycle. This paper presents results from simulations with a land surface hydrologic model forced by an ensemble of estimates of the global surface radiation budget (and best estimates of other meteorological forcings) for 1948-2008. The radiation components are derived from multiple reanalysis products with corrections for spurious jumps at the pre/post-satellite transition and unrealistic trends due to, for example, poor representation of clouds. These are blended with multiple remote sensing based and empirical estimates for the past 30 years. Comparisons with measurements from sparse radiation networks indicate that some products are better at characterizing long-term trends than others, although their biases may be larger. The ensemble of estimates shows generally decreasing global surface net radiation for 1950-1980 dominated by decreasing solar radiation, but a mixed picture of mainly increases and some decreases since the 1980s depending on the combination of individual radiation components. The direct impact of these changes on the hydrologic cycle is small globally but in recent years there is a tendency for increased evaporation and drying, and a contribution to increased drought occurrence. These changes are put in the context of competing influences on evaporation from atmospheric stilling, increased atmospheric demand and decadal changes in precipitation.