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Long-term changes in net radiation at the Earth's surface: uncertainties and implications

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Net radiation at the earth's surface plays a key role in terrestrial water, energy and carbon fluxes, but there is large uncertainty in its variation over decadal time scales. Globally, surface and satellite measurements indicate global dimming in solar radiation over many regions since the mid-20th century and then brightening over recent decades due to changes in cloudiness and aerosols. Changes in longwave radiation are driven by long-term increases in greenhouse gases and inter-annual variations in short-lived constituents such as dust and black carbon. These increases are partially offset, however, by increases in surface temperature. Current estimates of these components of the net radiation balance from satellite remote sensing are inconsistent because of inhomogeneities from changes in satellites, sensor calibration, retrieval algorithms, and so on, in addition to systematic biases. Estimates from direct ground observations are hampered by sparse spatial networks and often short-term records, and estimates based on denser networks of meteorological data are affected by errors in empirical radiation models. Some of the largest uncertainties are in the characterization of the global distribution and temporal changes in surface shortwave albedo and infrared emissivity, especially in regions with seasonal and patchy snow cover. This paper presents comparisons of legacy satellite-derived datasets (e.g. ISCCP, GEWEX/SRB) and recently developed datasets based on updated algorithms and homogenized data sources (e.g. NASA Princeton-Measures, HIRS) in the context of long-term changes in the net radiation balance at the earth's surface. We compare these with ground observations and empirical estimates based on meteorological data from in-situ sources and reanalysis. In particular we focus on the uncertainties in the magnitude and variation in surface albedo and emissivity, and their contribution to uncertainties in net radiation. We discuss the implications of these uncertainties on estimates of long-term changes in the terrestrial water cycle and trends in drought severity.