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Earth radiation balance as observed and represented in CMIP5 models

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The genesis and evolution of Earth's climate is largely regulated by the Earth radiation balance. Despite of its key role in the context of climate change, substantial uncertainties still exist in the quantification of the magnitudes of its different components, and its representation in climate models. While the net radiative energy flows in and out of the climate system at the top of atmosphere are now known with considerable accuracy from new satellite programs such as CERES and SORCE, the energy distribution within the climate system and at the Earth's surface is less well determined. Accordingly, the magnitudes of the components of the surface energy balance have recently been controversially disputed, and potential inconsistencies between the estimated magnitudes of the global energy and water cycle have been emphasized. Here we summarize this discussion as presented in Chapter 2.3 of the 5th IPCC assessment report (AR5).

In this context we made an attempt to better constrain the magnitudes of the surface radiative components with largest uncertainties. In addition to satellite observations, we thereby made extensive use of the growing number of surface observations to constrain the radiation balance not only from space, but also from the surface. We combined these observations with the latest modeling efforts performed for AR5 (CMIP5) to infer best estimates for the global mean surface radiative components. Our analyses favor global mean values of downward surface solar and thermal radiation near 185 and 342 Wm-2, respectively, which are most compatible with surface observations (Wild et al. 2013). These estimates are on the order of 10 Wm-2 lower and higher, respectively, than in some of the previous global energy balance assessments, including those presented in previous IPCC reports. It is encouraging that these estimates, which make full use of the information contained in the surface networks, coincide within 2 Wm-2 with the latest satellite-derived estimates (Kato et al. 2013), which are completely independently determined. This enhances confidence in these recent surface flux estimates.

IPCC AR5 further presents increasing evidence from direct observations that the surface radiative fluxes undergo significant changes on decadal timescales, not only in their thermal components as expected from the increasing greenhouse effect, but also in the amount of solar radiation that reaches the Earth surface. In the thermal range, surface observations suggest an overall increase of downward thermal radiation in line with latest projections from the CMIP5 models and expectations from an increasing greenhouse effect. On the other hand the strong decadal changes in surface solar radiation seen in the observations ("dimming/brightening") are not fully captured by current climate models. These decadal changes in surface solar radiation may largely affect various aspects of climate change.

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