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Assessment of radiative fluxes in IPCC AR4 GCMs using observations from GEBA and BSRN

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Substantial uncertainty still exists regarding the distribution of solar energy within the global climate system, and its representation in General Circulation Models. Compared to a comprehensive set of surface observations, the majority of the state-of-the art GCMs participating in the latest IPCC forth assessment report (AR4) overestimate the surface insolation, by 6 Wm-2 on average, while the bias is smaller at the TOA. This is in line with an analysis of 20 earlier GCMs participating in the Atmospheric Model Intercomparison Project AMIP II and suggests that the GCM atmospheres are still overly transparent for solar radiation. Based on newly derived observational clear-sky climatologies at worldwide distributed anchor sites from the Baseline Surface Radiation Network (BSRN) and the Atmospheric Radiation Measurement Program (ARM) it is shown, that the surface insolation is also overestimated under cloud-free conditions in many GCMs with comparatively low atmospheric clear-sky solar absorption (around 60 Wm-2 in the global mean). This identifies an overly transparent cloud-free atmosphere as a key error source for the long known problem of excessive surface insolation in GCMs. However, there are now several models participating in IPCC-AR4 with higher atmospheric clear-sky absorption (70 Wm-2 and up, globally averaged) and more realistic aerosol treatment, which are in excellent agreement with the newly-derived observational clear-sky climatologies. This underlines the progress made in radiative transfer modeling as well as in the observation and diagnosis of solar radiation under cloudless atmospheres. The most difficult component to model in the longwave is the downward longwave flux at the surface. Accordingly, large discrepancies exist in the global means of this component in the GCMs, both under all sky and clear sky conditions. A comparison with available observations from GEBA and BSRN suggests that the IPCC AR4 GCMs tend to underestimate the longwave

downward flux.

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