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The global land surface energy balance and its representation in CMIP5 models

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The energy budget over terrestrial surfaces is a key determinant of the land surface climate and governs a variety of physical, chemical and biological surface processes. The purpose of the present study is to establish new reference estimates for the different components of the energy balance over global land surfaces.
Thanks to the impressive progress in space-based observation systems in the past decade, we now know the energy exchanges between our planet and the surrounding space with unprecedented accuracy. However, the energy flows at the Earth's surface have not been established with the same accuracy, since they cannot be directly measured from satellites. Accordingly, estimates on the magnitude of the fluxes at terrestrial surfaces largely vary, and latest climate models from the Coupled Model Intercomparison Project Phase 5 (CMIP5) still show significant differences in their simulated energy budgets on a land mean basis, which prevents a consistent simulation of the land surface processes in these models. In the present study we use to the extent possible direct observations of surface radiative fluxes from the Global Energy Balance Archive (GEBA) and the Baseline Surface Radiation Network (BSRN) to better constrain the simulated fluxes over global land surfaces. These model-calculated fluxes stem from the comprehensive set of more than 40 global climate from CMIP5 used in the latest IPCC report AR5. The CMIP5 models overall still show a tendency to overestimate the downward solar and underestimate the downward thermal radiation at terrestrial surfaces, a long standing problem in climate modelling. Based on the direct radiation observations and the bias structure of the CMIP5 models we infer best estimates for the downward solar and thermal radiation averaged over global land surfaces. They amount to 184 Wm-2 and 306 Wm-2, respectively. These values closely agree with the respective quantities independently derived by recent state-of-the-art reanalyses (ERA-Interim) and satellite-derived products (surface CERES EBAF). This remarkable consistency enhances confidence in the determined flux magnitudes, which so far caused large uncertainties in the energy budgets and often hampered an accurate simulation of surface climates in models. Using in addition a land mean surface albedo estimate of 0.26, we determine an average absorbed solar radiation at land surfaces of 136 Wm-2. Our best estimate for the upward thermal radiation at land surfaces (essentially based on the Stefan Boltzmann law) is 372 Wm-2, and combined with the above best estimate of 306 Wm-2 for the downward thermal radiation, this results in a net thermal radiation of -66 Wm-2 averaged over global land surfaces. Adding the absorbed solar and net thermal radiation, our best estimate of the land mean surface net radiation amounts to 70 Wm-2, which is the energy available for the sensible and latent heat fluxes. Latest estimates of terrestrial latent heat fluxes indicate a land mean value slightly below 40 Wm-2. In our best estimate of the global land mean energy balance we thus adopt a land mean latent heat flux of 38 Wm-2, leaving a land mean sensible heat flux of 32 Wm-2 as residual to close the energy balance over terrestrial surfaces. A diagram of the global land mean energy balance including these new estimates and the related discussion has recently been published in Climate Dynamics (Wild et al. 2015).

Related reference:

Wild, M., Folini, D., Hakuba, M., Schär, C., Seneviratne, S.I., Kato, S., Rutan, D., Ammann, C., Wood E.F. ·and König-Langlo, G., 2015: The energy balance over land and oceans: An assessment based on direct observations and CMIP5 climate models, Climate Dynamics, DOI 10.1007/s00382-014-2430-z