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The Earth Energy Budget inferred from direct observations and climate models

Martin Wild
ETH Zurich, Institute for Atmospheric and Climate Science, Zurich, Switzerland (martin.wild@env.ethz.ch)

Despite the central importance of the Earth energy budget for the genesis and evolution of Earth's climate, the adequate quantification of its components is still a major issue. While the net radiative energy fluxes in and out of the climate system at the top of atmosphere (TOA) are now known with considerable accuracy from major satellite programs such as CERES and SORCE, a challenge remains the accurate determination of the energy distribution within the climate system. This applies for example for the partitioning of shortwave energy absorption between the atmosphere and surface, and within the atmosphere between cloudy and cloud-free parts, as well as for the longwave energy exchanges at the surface/atmosphere interface. Uncertainties in the energy balance components at the surface have therefore traditionally been larger and less well quantified than at the TOA. This is reflected in greatly diverging global estimates of the surface energy balance components that have been published over the years. Accordingly, also state of the art global climate models still largely differ in their representation of these components. Since the mid-1990s, accurate direct measurements become increasingly available from the networks of surface radiation stations, such as the Baseline Surface Radiation Network (BSRN), which allow to better constrain the energy fluxes at the Earth's surface. The high temporal resolution of the BSRN observations (minute data) further allows the construction of clear-sky reference climatologies, based on composites of cloud-free episodes identified by clear-sky detection algorithms. These clear-sky climatologies allow a quantification of the surface cloud radiative effect through a comparison with the corresponding all-sky climatologies. Combined with the cloud radiative effects at the TOA inferred from satellite observations, this allows then also a characterization of the cloud radiative effect within the atmosphere. Some of the remaining challenges in the quantification of the Earth energy balance include the accurate determination of large-scale surface albedo estimates, and the adequate representation of the surface skin temperatures in the estimation of the surface upward longwave radiation. Considerable uncertainties remain also in the partitioning of the surface net radiation into the non-radiative fluxes of sensible and latent heat, and accordingly in the consistent representation of the energy and water cycles.

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