Geophysical Research Abstracts
Vol. 20, EGU2018-1968-4, 2018
EGU General Assembly 2018

A New Global Energy Budget Poster, with Flux Integer Tables for Clear, Cloudy and All-sky Conditions

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Within the CERES (Clouds and the Earth's Radiant Energy System) data sets, direct top-of-atmosphere – surface energetic connections can be recognized, separately for clear-sky and all-sky conditions. Utilizing different graphical representations of the global energy flow system and published high-resolution clear-sky radiative transfer computations as well, a coherent set of internal flux relationships reveals itself. A possible physical explanation refers to an idealized greenhouse model and helps to deduce the observed flux structure from that model geometry. Longwave cloud radiative effect (LWCRE) seems to play a central role in organizing the energy flow system, where a simple physical hypothesis helps to understand the resulted integer ratios: assuming that the function of the observed cloud cover in the longwave is to effectively close the open mid-infrared atmospheric window, a 'modulo-LWCRE' energy flow system can be expected. This model-geometry explains the unexpected energetic connection between the top-of-atmosphere (TOA) fluxes and the total energy absorbed by the surface. The form of this connection (the total shortwave plus longwave energy absorbed by the surface is twice the outgoing longwave radiation at TOA in the cloudless part of the system, and twice the outgoing longwave radiation at TOA plus one surface longwave cloud radiative effect in the all-sky case) is apparent in the LWCRE-modulated flux system. The all-sky equality is valid within 1 W/m2 in the previous (Ed2.8) and within 2.6 W/m2 in the current (Ed4.0) versions of the CERES EBAF products; the clear-sky equality is valid with a difference of EEI (Earth Energy Imbalance) = 0.59 W/m2 in the Ed2.8 product, and with 8.2 W/m2 in Edition 4.0 (the latter is a consequence of the increased outgoing longwave flux in the current version). Note that the known satellite instrument calibration error (the difference between the absorbed shortwave and emitted longwave radiation) is about 4.5 W/m2. Another important flux interconnection is that the clear-sky greenhouse effect (the difference of surface terrestrial upward emission and TOA LW emission) is completely equilibrated by the surface net (turbulent) fluxes; a relationship valid within 1 W/m2 in both CERES EBAF editions. Weighted by the effective single-layer infrared-opaque cloud area fraction (defined as the observed cloud area fraction multiplied by the average cloud emissivity), the cloudy fluxes can be computed from the known clear-sky and all-sky values. Here we show the resulting radiative and non-radiative global mean surface and atmospheric energy flow distribution as integer multiples of a unit flux, separately for clear-sky, cloudy-sky and all-sky conditions. It is shown how the energy balance conditions for the cloud-free and the cloudy atmospheric regions work together to satisfy the all-sky requirements. Our results are arranged into a new global energy budget diagram where the integer flux tables and the surface and atmospheric energy balance equations are also indicated.