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Earth radiation budget – An integer system

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The energy from the sun arrives to the Earth in continuous flow of electromagnetic radiation. There is no indication that this energy should be divided into discrete building blocks when reaching the Earth's atmosphere or the surface. On the contrary, any small change in the gaseous constituents of the atmosphere will have its proportionally small change in the corresponding energetic fluxes, and tenth of a watt per square meter is important as net flux at the top of atmosphere. Still, here we show that the annual global mean energy flow system exhibits a peculiar feature: after interacting with the Earth's atmosphere, the incoming continuous solar radiation field is reflected, absorbed and emitted by the Earth in surprisingly large energy packages. This quantal feature can be recognized in surface- (Wild et al. 2018) and satellite-based (Kato et al. 2018) global energy budget estimates, and proved to be valid within measurement uncertainty. Here we relate the shortwave, longwave and non-radiative fluxes in the annual global mean energy flow system, both for all-sky and clear-sky, to the total solar irradiance TSI = 1360.68 $\pm$ 0.5 Wm-2 and point out that the size of one energy unit is TSI/51 = 26.68 Wm-2. After weighting to the spherical surface of the planet (division factor 4), quarters of a unit appear. We show that from the total incoming energy of 51 units, 15 units are reflected and 36 units are absorbed by the system (planetary albedo = 15/51). In spherical geometry, incoming solar radiation at TOA will be ISR = 51/4 = $12\frac{3}{4}$ units = 340.17 Wm-2, from which reflected RSR = 15/4 = $3\frac{3}{4}$ units = 100.05 Wm-2 and absorbed ASR = 9 units = 240.12 Wm-2; the latter is partially absorbed by the atmosphere (3 units = 80.04 Wm-2), the remaining by the surface (6 units = 160.08 Wm-2), with surface downward and reflected solar radiation of 7 units = 186.76 Wm-2 and 1 unit = 26.68 Wm-2 (all-sky surface albedo = 1/7). According to observations, surface upward and downward longwave radiations are 15 units = 400.20 Wm-2 and 13 units = 346.84 Wm-2, resp., allowing 4 units = 106.72 Wm-2 for surface non-radiative fluxes. Under clear-skies, satellite measurements (Loeb et al. 2018) give 53.3 Wm-2 for TOA solar reflection, being identical to 2 units = 53.36 Wm-2, allowing $10\frac{3}{4}$ units = 286.81 Wm-2 of solar absorption, from which $2\frac{3}{4}$ units = 73.37 Wm-2 are absorbed by the atmosphere and 8 units = 213.44 Wm-2 by the surface; downward and reflected surface solar irradiances are $9\frac{1}{4}$ units = 246.79 Wm-2 and $1\frac{1}{4}$ units = 33.35 Wm-2, resp. (clear-sky surface albedo = $1\frac{1}{4}/9\frac{1}{4}$). OLR(clear-sky) is 10 units = 266.8 Wm-2; $\frac{3}{4}$ unit = 20.0 Wm-2 goes to the cloudy part of the atmosphere. LWCRE = 1 unit = 26.68 Wm-2; TOA and surface SWCRE = $-1\frac{3}{4}$ units and –2 units (–46.69 Wm-2 and –53.36 Wm-2); surface net CRE = –1 unit = –26.68 Wm-2, TOA net CRE = $-\frac{3}{4}$ unit = –20.0 Wm-2.