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A 24-year climatology of cloud effects on the Earth's longwave radiation budget

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A longwave (LW) radiative transfer model (RTM) was used together with monthly mean climatological data from global datasets to compute the global distribution of LW cloud radiative effect (CRE) at the top of atmosphere (TOA), within the atmosphere and at the Earth's surface, at 2.5°x2.5° latitude-longitude resolution, for the 24-year period 1984-2007. The cloud data, namely cloud cover and optical depth, were derived from the latest D2 series of the International Satellite Cloud Climatology Project (ISCCP) Project, which includes 9 cloud types, distinguishing between low-, mid- and high-level and liquid and ice clouds. Supplementary data for surface and atmospheric parameters were taken from NCEP/NCAR, ECMWF, ISCCP-D2, and TOVS datasets.

On a mean annual basis and global scale, clouds are found to warm the planet, by decreasing the outgoing LW radiation at TOA, by 17.8 W/m2, to cool the atmosphere, by decreasing the LW atmospheric absorption, by 11.9 W/m2 and to heat the surface by 29.7 W/m2. Nevertheless, there is a significant spatial variability of CREs. Thus, at pixel level and on year mean basis, clouds generally decrease the thermal emission of our planet by up to about 50 W/m2 but also induce planetary cooling, by up to about 2 W/m2 over central Antarctica's regions. The presence of low and middle clouds in the atmosphere induces an atmospheric cooling, by up to about 50 W/m2, while atmospheric warming is produced by high clouds along the inter-tropical convergence zone (by up to about 30 W/m2). The net LW radiation emitted by the surface is found to be reduced by clouds by up to 55 W/m2.

The model CREs were validated at TOA through comparisons against high-quality ERBE-S4 CRE values over the 5-year period 1985-1989 and also against high-quality CERES-S4 CREs over the 7-year period 2001-2007. Model CREs were found to reasonably agree with both CERES and ERBE ones, with biases equal to -9.9 W/m2 and -7.1 W/m2, standard deviations of differences equal to 4.7 W/m2, and correlation coefficients equal to 0.89.

Further analysis revealed significant differences between CREs for low-, mid- and high-level clouds, consisting not only in changing magnitude but also sometimes in opposite sign. For example, high-level clouds produce atmospheric warming, opposite to atmospheric cooling produced by mid- and low-level clouds. Besides, the largest/smallest surface warming is caused by low/high clouds, whereas the biggest/smallest planetary warming is induced by high/low clouds. Noticeable differences are also identified between the two hemispheres, with larger values in SH for low clouds against greater CREs in NH for high clouds. Finally, the time series of monthly mean CREs indicate a significant year by year variability as well as decadal scale variations which are mostly attributed to corresponding changes of ISCCP low-level clouds.