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Decoupling the effects of clouds and clear atmosphere to compute the solar irradiance at surface

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This work contributes to the research of fast calculations of the surface solar irradiance (SSI) I and proposes a general equation that decouples the effects of the clear atmosphere on I and its direct (B) and diffuse (D) components from those due to the clouds. These effects are studied numerically in the case of infinite plane-parallel atmosphere and single-layered cloud. The dependency of the ratios I / Ic and B / Bc is studied as a function of the clear-sky parameters, where Ic and Bc are the global and direct SSI under clear-sky. To that extent, a large set of atmosphere, clouds and surface properties has been created, which statistically represent conditions encountered worldwide with their respective probabilities. Many possible combinations are randomly extracted and are input to the radiative transfer model libRadtran, yielding a corresponding series of I, B, D, Ic and Bc. The influence of the clear-atmosphere properties on the ratios in cloudy conditions are studied to quantify how small this influence is compared to that of the clouds. It is found that the SSI can be approximated by the product of the irradiance under clear-sky for a null ground albedo and a modification factor due to cloud properties and ground albedo only with no influence of the clear-atmosphere properties. The errors made are mapped against ground albedo, cloud optical depth and solar zenith angle, where the latter is the most prominent variable. The maximum error (percentile 95%) is less than 5% of the irradiance under clear-sky for solar zenith angles less than 70° and in all cases less than 15 W/m2 for ground albedos less than 0.7. This practical approximation is convenient in developing any computational chain since the whole processing can be separated in two independent models whose inputs are different.