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Quantification of the radiative effect of optically thin clouds on the surface energy budget based on two years of lidar and radiation measurements at the SIRTA observatory

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The radiative effects of high altitude clouds on the surface energy budget, in both the solar and infrared spectrum, are well known but not well quantified. Precise quantification of radiative effects of clouds requires precise reference solar and infrared irradiance values for the cloud free atmosphere. Such reference values can be obtained from radiative transfer calculation if the temperature, water vapor, ozone, and aerosol profiles are known at each time step. In this study, we present two parametric representations that use ground-based surface and integration information on temperature, water vapor and aerosols to estimate clear-sky values of solar and infrared irradiances with rms uncertainties below 5 W/m2. Clear-sky model calculations are evaluated against measurements for cloud free conditions determined by combined analysis of lidar and broadband flux measurements. We analyze two years of solar and infrared irradiance measurements, cloud and aerosol Lidar backscattering profiles, microwave radiometer brightness temperatures, radiosonde profiles, and sunphotometer extinctions gathered at the SIRTA Observatory (BSRN Station, Paris, France) to estimate the radiative effects of high altitude clouds (cloud base above 7 km). Because of persistent significant aerosol loading in the Paris area, we perform parallel analyses of the effects of semi-transparent (OD$<$0.3) and subvisible (OD$<$0.03) clouds and the effects of coincident aerosol layers on the surface solar irradiance. Cloud and aerosol effects are compared. In the infrared spectrum we evaluate the radiative impact of clouds as high as 11 km for various atmospheric conditions (dry and moist).