SPECTRAL RADIATION MODELING FOR THE ANTARCTIC PLATEAU: EFFECTS OF CLOUDS, OZONE AND CO_2 ON THE RADIATION BUDGET

(Abstract only)

by

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ABSTRACT

The radiation balance at and above a snow-covered surface is affected not only by the high general level of the surface albedo, but also by the strong spectral variation of that albedo. Furthermore, the fact that clouds and snow have highly correlated optical properties means that the radiative problem of clouds over a snow surface is a particularly difficult one.

Both for its own intrinsic interest, and because it is in many ways as clear an example of snow-atmosphere radiative interactions as one is likely to find, we have chosen to make spectrally detailed model calculations of solar and long-wave radiation over Antarctica using an atmospheric radiation model of Wiscombe (1975) coupled to the recent snow reflectivity model of Wiscombe and Warren (1980). Typical clear and cloudy situations are studied. Radiative fluxes are examined particularly at the surface and the top of the atmosphere since these are the locations of most past and future measurements.

Radiation budget calculations are compared with observations at Plateau station for various sun angles and cloud conditions. The effects on the radiation balance of a sub-visible ice-crystal cloud ("clear-sky ice-crystal precipitation"), as well as observed water clouds over the snow surface are investigated.

Because the snow of the Antarctic plateau is very clean, falls throughout the summer, and never melts, we can make accurate calculations of the surface albedo using our model for fine-grained snow. The absorbed solar radiation at the surface is almost entirely in the near-infrared where snow albedo is considerably lower than its visible values.

Snow-surface albedo increases with zenith angle for all sun angles. The spectrally integrated planetary albedo is about 10% less than the surface albedo and shows the same zenith-angle dependence for high sun. But for solar zenith angles greater than about 70° the planetary albedo may show a contrary trend because the increased atmospheric absorption in the long slant path overwhelms the zenith-angle dependence of the snow albedo.

Clouds raise the spectrally integrated planetary albedo because the cloud particles are smaller, on average, than the snow grains. Clouds raise the surface albedo by absorbing near-infrared radiation and thus altering the spectral distribution of the solar radiation reaching the surface.

The Antarctic atmosphere is so dry that more solar radiation may actually be absorbed by ozone than by water vapor, even for a water-vapor saturated troposphere, in contrast to the situation elsewhere.

As the solar absorption due to ozone is enhanced by the lack of water vapor, so is the absorption due to CO_2. Because some of the water-vapor absorption bands overlap CO_2 absorption bands, the radiation budget is more sensitive to CO_2 variations in the Antarctic than elsewhere. The radiation-budget effects of possible future increases as well as the likely Pleistocene reductions of atmospheric CO_2 are investigated.

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