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The effect of snow cover roughnesses on angular structure of reflected solar radiation

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The improvement of the quality of retrieving the snow cover characteristics from remote sensing data involves the use of more accurate information on the spectral-angular characteristics of the reflected solar radiation (snow reflection function, SRF). The experimental data and numerical simulation results, accumulated to date, show that, besides the snow grain shape and size, pollution of the snow cover, etc., the albedo and SRF also depend on the surface roughnesses.

In the present study, we considered the snow roughnesses, characteristic for certain polar regions, where under impact of prevailing wind direction, snow is eroded into meter-scale longitudinal dunes (sastrugi). To study the 3D (3-dimensional) effects of sastrugi, we used the statistical approach, making it possible to draw practice-important conclusions about the average (over ensemble of realizations of surface inhomogeneities) characteristics of reflected radiation, i.e. to determine and analyze the interrelation between the statistical characteristics of inhomogeneous underlying surface and radiation. The albedo and angular radiative characteristics were numerically simulated in the framework of the statistically homogeneous model on the basis of Poisson point fluxes on the straight lines. The reflected radiation was simulated taking into account the effects associated with random roughness geometry (shadowing, radiation can leave through lateral non-horizontal surfaces and can be multiply scattered by surrounding elements).

The model input parameters are optical characteristics of snow (extinction coefficient, single scattering albedo SSA, and scattering phase function) and data, characterizing the geometrical sizes and density of the roughnesses. The smooth snow surface, on which the sastrugi are located, is approximated by flat semi-infinite snow layer, whose bidirectional reflectance was simulated beforehand using the solution of the 1-D radiative transfer equation.

The results of the numerical simulation showed that the 3D effects of rough snow surface affect most appreciably the albedo and angular characteristics of the brightness field of the “flat snow - sastrugi” system at moderate sastrugi densities and under conditions when the direct solar rays are incident perpendicular to the sastrugi elongation direction. It was found that the albedo of snow layer is reduced (in particular, in the infrared region), if 3D effects are taken into account. The 3D effects may increase or decrease SRF depending on the sastrugi fraction and illumination/observation conditions.

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