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Diurnal surface albedo parametrization

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Surface albedo, the fraction of incoming solar radiation reflected hemispherically by the surface, is an essential climate variable (ECV) directly related to the energy budget of the Earth. The diurnal variation of the surface albedo is dominated by the varying incidence angle of incoming solar radiation. Therefore, the diurnal variation of the surface albedo is usually parametrized with the cosine of the solar zenith angle. However, when the surface material characteristics vary markedly during the day, as in the case of melting snow, the diurnal albedo variation is asymmetric. During the day, the metamorphosis of snow reduces the albedo value, often almost linearly with time. The difference between the morning and afternoon value corresponding to the same solar zenith angle value can easily be as large as 0.25, when the diurnal variation of the albedo is in the range 0.28 … 0.58. As the cosine of the solar zenith angle value is symmetric versus local midday, it can't describe this phenomenon. There is a simple analytic relationship between the solar azimuth angle and the solar zenith angle. Hence, the driver of the diurnal variation in a surface albedo parametrization can easily be changed from solar zenith angle to solar azimuth angle. The advantage gained is that the azimuth angle of morning and afternoon differ, so that the asymmetry of the surface albedo diurnal variation can be described with the azimuth angle, without loss of accuracy in the case of materials with noon-symmetric diurnal cycle in surface albedo.
In situ measurements carried out at Fort Peck station, belonging to the Baseline Surface Radiation Network (BSRN), are used to demonstrate the new parametrization of surface albedo diurnal cycle using the solar azimuth angle. To generalize the relationship between the azimuth angle and albedo, the azimuth angle was normalized to vary in the range -1 … 1 so that at midday it is zero and at sunrise and sunset -1 and 1, respectively. The analytic relationship between the solar azimuth and zenith angles is too complicated to be practical in linear regression and a simple relationship based on the hyperbolic cosine and linear terms of the azimuth angle was found to be a suitable form to describe the daily variation of snow covered surface in both midwinter and melting season conditions.