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Investigating surface hoar spatial distributions in complex topography

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Knowledge about the spatial distribution of weak snowpack layers is of great importance for avalanche forecasting. A common weak snowpack layer consists of buried surface hoar and is often associated with snow avalanches. We investigate if spatial variations of surface hoar in mountainous terrain can be modeled based on terrain characteristics. Distributed radiation over an ensemble of 1800 simulated topographies, covering a wide range of terrain characteristics, was computed using a detailed radiation balance model. Light winds and increased relative humidity were assumed to be favorable for surface hoar formation. To describe surface hoar formation, laboratory measurements were performed to derived a sky view factor threshold associated with the minimum snow surface cooling necessary for surface hoar formation. To describe surface hoar destruction, we assumed that surface hoar only survives on shaded slopes. Using these two simple thresholds, we investigated spatial patterns of surface hoar in complex topography. Our results show that the spatial distribution of surface hoar is greatly affected by large scale terrain roughness and sun elevation angle. Spatial correlation ranges, on the order of several hundred meters, were closely related to the typical spacing between mountains and decreased with increasing sun elevation angle. Furthermore, the modeled spatial patterns of surface hoar were in line with previously published field observations. Overall, the results suggest that simple terrain parameters can very well be used to describe the predominant surface hoar layer patterns in complex topography. On the practical side, our results show that for a thorough field study of spatial variability of surface hoar, it is thus necessary to consider for both the change of sun elevation angles over the course of the winter and for the large scale terrain characteristics of the field site.