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A snowfall downscaling scheme for mountainous terrain

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In mountainous terrain, the spatial and temporal variability of the snow cover is driven by the interaction of meteorological processes with the underlying topography. Typically, terrain-precipitation-wind interactions predominantly shape the spatial snow depth distribution during the accumulation season through drifting snow and preferential deposition of snowfall. While a suspension model forced with fine-scale three-dimensional wind fields can generate spatial preferential deposition patterns, fine-scale three-dimensional wind fields or the necessary computational demands cannot be met by most model applications over larger areas.

We present an efficient statistical snowfall downscaling scheme over complex topography reproducing preferred fine-scale snowfall deposition patterns. Towards this we generated several thousands of spatial new snow distributions on artificial topographies by modeling preferential deposition with a suspension model and pre-computed Advanced Regional Prediction System (ARPS) wind fields. To systematically analyze spatial preferential deposition patterns, we chose artificial topographies covering a broad range of real terrain characteristics as well as controlled conditions for the model runs. We developed two statistical downscaling schemes using several millions of distributed fine-scale snowfall values. With one parameterization, we scale coarse-scale snowfall with fine-scale surface vertical wind components and topographic parameters. If fine-scale vertical wind components are not available, a second parameterization can be used to scale coarse-scale snowfall with coarse-scale wind direction and fine-scale topographic parameters. The spatial patterns of preferential snowfall deposition were well reproduced by the parameterizations, indicating that the downscaling scheme can be used for various model applications such as hydrological, avalanche, weather, and climate forecasts or hazard mapping.