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Domain-averaged snow depth over complex terrain from flat field measurements

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Snow depth is an important parameter for a variety of coarse-scale models and applications, such as hydrological forecasting. Since high-resolution snow cover models are computational expensive, simplified snow models are often used. Ground measured snow depth at single stations provide a chance for snow depth data assimilation to improve coarse-scale model forecasts. Snow depth is however commonly recorded at so-called flat fields, often in large measurement networks. While these ground measurement networks provide a wealth of information, various studies questioned the representativity of such flat field snow depth measurements for the surrounding topography.

We developed two parameterizations to compute domain-averaged snow depth for coarse model grid cells over complex topography using easy to derive topographic parameters. To derive the two parameterizations we performed a scale dependent analysis for domain sizes ranging from 50m to 3km using highly-resolved snow depth maps at the peak of winter from two distinct climatic regions in Switzerland and in the Spanish Pyrenees. The first, simpler parameterization uses a commonly applied linear lapse rate. For the second parameterization, we first removed the obvious elevation gradient in mean snow depth, which revealed an additional correlation with the subgrid sky view factor. We evaluated domain-averaged snow depth derived with both parameterizations using flat field measurements nearby with the domain-averaged highly-resolved snow depth. This revealed an overall improved performance for the parameterization combining a power law elevation trend scaled with the subgrid parameterized sky view factor. We therefore suggest the parameterization could be used to assimilate flat field snow depth into coarse-scale snow model frameworks in order to improve coarse-scale snow depth estimates over complex topography.