



Seasonal evaluation of morphological indexes in quantifying snow cover patterns in the Zugspitze area

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The spatiotemporal distribution of snow cover affects several processes at different scales, such as the Earth's energy balance, the hydrological cycle and ecosystems functions, with important implications on many aspects of human life. Topography, meteorological conditions in general and wind in particular affect the evolution of seasonal snow cover patterns during snow accumulation and ablation. With the help of remote sensing techniques, such as Sentinel-2 imagery, it is feasible to study snow cover patterns also in complex terrain. Satellite based morphological analysis of snow cover patterns may provide i) information on snow cover and its connection to morphology and alpine topography ii) a valuable complement to ground-based data and snow-hydrological simulations. In this study, we evaluate the effectiveness of two types of geometric indexes, i) MN, Minkowsky numbers (representing area, perimeter and Euler characteristic), and ii) CL, Average chord length, in quantitatively describing the morphology of Sentinel-2 derived snow cover patterns within the high-alpine area of Zugspitze at the boarder of Germany and Austria for a five-year period. MN and CL have been used previously in different fields, e.g. soil sciences, but to the authors' knowledge, these measures have never been applied in the field of snow cover pattern monitoring before. We present the seasonal evolution of MN and CL, as well as their correlation to topographic features (e.g., aspect, slope, curvature) and meteorological and snow variables. The individual indexes show distinct differences during snow accumulation and ablation and a clear annual periodicity. MN and CL can effectively quantify some aspects of the dynamic of snow cover patterns, although further analysis are necessary to conclude if such morphologic pattern descriptors can substantively improve the accuracy of the understanding and the modelling of snow-related processes.