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A conceptual snow model with an analytic resolution of the heat and phase change equations

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Compared to degree-day snow models, physically-based snow models resolve more processes in an attempt to achieve a better representation of reality. Often these physically-based models resolve the heat transport equations in snow using a vertical discretization of the snowpack. The snowpack is decomposed into several layers in which the mechanical and thermal states of the snow are calculated. A higher number of layers in the snowpack allow for better accuracy but it also tends to increase the computational costs.

In order to develop a snow model that estimates the temperature profile of snow with a lower computational cost, we used an analytical decomposition of the vertical profile using eigenfunctions (i.e. trigonometric functions adapted to the specific boundary conditions). The mass transfer of snow melt has also been estimated using an analytical conceptualization of runoff fingering and matrix flow.

As external meteorological forcing, the model uses solar and atmospheric radiation, air temperature, atmospheric humidity and precipitations. It has been tested and calibrated at point scale at two different stations in the Alps: Col de Porte (France, 1325 m) and Weissfluhjoch (Switzerland, 2540 m). A sensitivity analysis of model parameters and model inputs will be presented together with a comparison with measured snow surface temperature, SWE, snow depth, temperature profile and snow melt data.

The snow model is created in order to be ultimately coupled with hydrological models for rainfall-runoff modeling in mountainous areas. We hope to create a model faster than physically-based models but capable to estimate more physical processes than degree-day snow models. This should help to build a more reliable snow model capable of being easily calibrated by remote sensing and in situ observation or to assimilate these data for operational forecasting purposes.