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A coupled melt-freeze temperature index approach in a one-layer model to predict bulk volumetric liquid water content dynamics in snow

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Liquid water in snow rules runoff dynamics and wet snow avalanches release. Moreover, it affects snow viscosity and snow albedo. As a result, measuring and modeling liquid water dynamics in snow have important implications for many scientific applications. However, measurements are usually challenging, while modeling is difficult due to an overlap of mechanical, thermal and hydraulic processes. Here, we evaluate the use of a simple one-layer one-dimensional model to predict hourly time-series of bulk volumetric liquid water content in seasonal snow. The model considers both a simple temperature-index approach (melt only) and a coupled melt-freeze temperature-index approach that is able to reconstruct melt-freeze dynamics. Performance of this approach is evaluated at three sites in Japan. These sites (Nagaoka, Shinjo and Sapporo) present multi-year time-series of snow and meteorological data, vertical profiles of snow physical properties and snow melt lysimeters data. These data-sets are an interesting opportunity to test this application in different climatic conditions, as sites span a wide latitudinal range and are subjected to different snow conditions during the season. When melt-freeze dynamics are included in the model, results show that median absolute differences between observations and predictions of bulk volumetric liquid water content are consistently lower than 1 vol%. Moreover, the model is able to predict an observed dry condition of the snowpack in 80% of observed cases at a non-calibration site, where parameters from calibration sites are transferred. Overall, the analysis show that a coupled melt-freeze temperature-index approach may be a valid solution to predict average wetness conditions of a snow cover at local scale.