Geophysical Research Abstracts
Vol. 20, EGU2018-3650, 2018
EGU General Assembly 2018

Modelling snow load from historical snow depth series

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Long-term measurements of daily snow depths do exist in many regions, sometimes for more than 100 years. These precious data can be used for extreme value analyses and climate studies. Still, long-term measurements of snow water equivalent and snow load are scarce. Historical data before 1960 virtually do not exist at all. But extreme value analyses of snow loads and trend investigations of snow water equivalent would greatly benefit from these data. So, how to derive historical snow load information from snow depth data?

Sophisticated snow models solve processes in snow packs on a physical basis. Snow water equivalent and snow load, respectively, can be derived satisfactorily. However, these models need meteorological forcing and, therefore, are not applicable to historical snow depth series, where adequate point information of e.g. temperature and radiation are often missing.

Some methods provide snow loads from snow depths using parametrizations of bulk snow density based on actual snow depth, altitude, time of year, region etc. Within this framework sufficient results are gained by regression analysis. However, the transferability of the results is questionable since physical mechanisms are mostly ignored. How can the gap be bridged between meteorologically-driven, process-based snow pack models and basic statistical approaches?

We introduce a semi-empirical snow model to derive historical snow loads and water equivalents from snow depths series with focus on extreme values. In principle the model is independent from geographical parameters and time of year, and it encompasses not only actual snow depth, but also snow depth evolution, basic settlement mechanisms, possible rain-on-snow-events and periods of ablation. In its basic version the model does not depend on meteorological information and is therefore especially valuable for long-term observations of snow depth. The new semi-empirical layer-model assesses different settlement properties of individual snow pack layers. Therefore, we argue that it can be the requested piece between sophisticated process-based and basic statistical models.