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Snow storage modelling in the Lake Pukaki Catchment, New Zealand: An investigation of enhancements to the SnowSim model

The quantity of seasonal snow stored in the Lake Pukaki catchment, New Zealand has a significant impact on the country's economy through its influence on hydroelectricity generation, tourism, agriculture and conservation. SnowSim is a snow storage model developed for New Zealand conditions that may be used to quantify the catchment's frozen water resource and the melt water derived from that resource. Through implementation on a geographic information system, SnowSim has been applied and optimised to the Lake Pukaki catchment. The optimal parameters found were: temperature-elevation lapse rate of 0.005 $^{o}C\ m^{-1}$, snow/rain temperature threshold of 2.5 ^{o}C, and a melt to temperature relationship factor ranging from 1 to 6 mm $^{o}C^{-1}\ d^{-1}$. The melt to temperature relationship factor is significantly reduced from that previously used for a New Zealand wide application of SnowSim. Use of a daily measured lapse rate was found to provide no improvement to the model, considered to be because of the spatial variability of lapse rates. Inclusion of a radiation component also provided no improvement in the model. This is contrary to the experience found in similar model applications in other regions of the world. The lower relative importance of radiation melt (with regard to total melt) in the region compared to continental locations may explain this result. The use of a new precipitation distribution system did improve model results. Daily precipitation measurements were related to a new annual average precipitation surface prior to interpolating them across the region, without any elevation to precipitation relationship. Model free water results required an offset adjustment to bring them into line with measured lake inflows limiting the application of the model to estimation of seasonal variation, relative magnitudes and event frequencies of snow storage. Over four years of data a model output quality criterion of 0.61 (where a value of 1 is a perfect model) was returned. This increased to 0.76 for monthly values indicating a high quality of output at the seasonal scale. Model parameters and output quality are in line with those found using comparable models for various applications around the world. The variety of outputs available from the model provide a valuable resource for applications in the electricity, tourism, conservation and agriculture industries as well as for climate, glacier, snow and mountain research.
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Tim Kerr
Department of Geography
University of Canterbury
Private Bag 4800
Christchurch

Ph +64 3 364 2987 ext. 7925
Email trk21@student.canterbury.ac.nz