Geophysical Research Abstracts
Vol. 17, EGU2015-10328, 2015
EGU General Assembly 2015

Why Do Analytical Snow Models Succeed? Why Do They Fail?

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Seasonal snowpack storage exerts a major influence on water resources for millions of people; these snowpacks are currently changing, and are expected to change further in response to climate changes. Analytical models of snowpack storage are one possible technique for improving our understanding of the sensitivity of snowpacks to changes in climate. Such models have the benefit of being parsimonious and easily understood, but they rely on very strong assumptions which may not be valid.
A previous study (Woods, 2009, Advances in Water Resources) indicated that an analytical model was able to capture the long-term average seasonal accumulation and melt of the snowpack in 6 widely differing sites in the western USA. Here I report on further tests using a large sample of snow data (more than 700 stations in the USA's SNOTEL network) which expose some weaknesses in the model, though these do not appear sufficiently systematic to completely reject the model. However, the model fails comprehensively when used in a semi-distributed application to predict the seasonal snowmelt pulse in streamflow records of 100 snow-dominated catchments from the MOPEX data set.
Finally, I will report on an investigation of several of the assumptions underlying the analytical model (e.g. deterministic climate inputs, temperature-index method, universal values of model parameters), to determine the dominant causes of model failure, and propose alternative formulations and appropriate hypothesis tests.