Geophysical Research Abstracts, Vol. 8, 08706, 2006
SRef-ID: 1607-7962/gra/EGU06-A-08706

Simulation of internal snow properties and retention of liquid water

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The complexity of a model should be appropriate for its application. Highly complex snow models may be needed for remote sensing applications, where accurate simulation of surface temperature is needed. Less computationally intensive snow models are essential to examine changes in the water budget over large scales. A good understanding of the physical processes within the snow can be used to enhance simple models, whilst keeping within the computational requirements for the application. A complex model, tested against detailed observations, can be used to examine where our understanding of the physics is good, and in turn can be used to develop simpler models.

Only within the last decade have physically-based models been developed to simulate the evolution of snow beneath a forest canopy. We have previously shown how a physically-based, multi-layer snow model, coupled to an optical and thermal canopy radiation model, could be used to simulate snow depth beneath several different canopy types. However, the model, SNOWCAN, had only been tested against radiation measurements. Here, we evaluate SNOWCAN against internal snowpack measurements, both at an open site, and beneath a fir canopy.

Meteorological data from an open field site in Reynolds Mountain East, Idaho, USA, were used to drive SNOWCAN. The coupling between the canopy radiation component and the snow component (based on SNTHERM) includes multiple reflections between the canopy and snow surface, so that the albedo both affects, and is affected by the radiation balance, through growth in the snow grains. SNOWCAN was eval-

uated against radiation observations and measurements of the snow temperature and density profiles. Simulation of the snowpack properties was reasonable prior to significant melt. However, once substantial melt had occurred liquid water was retained in the simulated snowpack, but in reality was drained or refroze in the natural snowpack.

Drainage in SNOWCAN is assumed to be gravitational and is represented by a Darcy's Law formulation. In a natural snowpack, removal of liquid water is much more complex and is spatially variable. Drainage channels may form, which rapidly remove water from the snowpack. The impact of a gravitational drainage assumption is examined through a comparison of SNOWCAN with another model, SNOBAL, which assumes instantaneous drainage to the irreducible saturation limit. SNOBAL is a simpler, two-layer model that has been used to simulate the water balance over a range of scales (point to basin). One set of diurnal meteorological data was repetitively used to drive SNOWCAN to enable a uniform response. Fluxes output from SNOWCAN were used to drive SNOBAL to ensure the same energy inputs to both models. However, a very different response occurred between the models as a result of the different representations of liquid water. This highlights the need for a better understanding of liquid water processes within snow.