AN ASSESSMENT OF MEASUREMENTS AND MODELING OF TURBULENT
FLUXES OVER SNOW BY EDDY COVARIANCE AT TWO COMPLEX
MOUNTAIN SITES

by
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Snow is a major component of the annual water balance in many locations across
the globe, including the mountainous regions of the interior western U.S. and Canada. As
water is scarce and over-allocated in many parts of this region, it is of the utmost
importance to accurately model the amount and timing of spring runoff. Most
components of snow cover energy and mass balance models are validated through direct
measurements such as snow water equivalent, density, temperature, and net radiation.
However, validation data for turbulent fluxes are generally limited. Eddy covariance
(EC) is the most direct method to measure turbulent fluxes. Findings from this research
are based on EC and ancillary meteorological measurements from two mountain sites,
wind-exposed and sheltered sub-canopy, during the 2004, 2005, and 2006 snow seasons.
EC systems have been used successfully over snow in mountain regions but
detailed analysis of post-processing and data quality is lacking. The first component of
this research focuses on the viability of EC technology over snow in mountainous terrain
and makes a detailed analysis of data quality and the influence post-processing has on
turbulent fluxes. Post-processing and data quality analysis of these data indicate that
application of EC-technology at these sites was viable and data quality parameters were
comparable to other reported research.
As detailed analysis of site characteristics on EC measurements over snow is
limited, this research then generalizes findings at two contrasting sites and highlights
challenges of measuring EC over snow. The exposed site yielded measured sensible and
latent heat fluxes that were five and two times, respectively, the magnitude of those at the
sheltered site. There was less inter-annual variability in EC-measured turbulent fluxes at
the sheltered compared to the exposed site. Differences between sites are explored at
seasonal, monthly and event based temporal scales. These findings highlight the

importance of careful review of over
-snow EC
-measured fluxes and the meteorological
conditions during which those measurements were conducted.

Lastly, measured turbulent fluxes are used to determine key model parameters and
update the stability functions of an existing snow cover and energy balance model while
retaining accuracy of simulated snow water equivalent. Improved modeling of the snow
cover that is
 based on physical processes instead of on empirical relationships between
climate and snowcover dynamics should better predict responses to climatic variability
and trends. The adjustable parameters of roughness length and active layer depth
influenced the accuracy with which the model simulated mass and latent heat flux. At the
exposed site shorter roughness lengths and a thicker active layer was optimal, while
longer roughness lengths and a thinner active layer was optimal at the sheltered site.

These outcomes are related to the site characteristics and can be readily incorporated into
a distributed snowmelt model.