

Surface temperature patterns and lapse rates: implications for water resources and studies of mountain climate change

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Abstract. Mountains are the water towers of the western United States, and some of the greatest concerns about climate change in this region involve snowmelt timing and water supply. A realistic description of how temperatures vary with elevation is crucial for models of basin-scale snowmelt and spring streamflow. However, measurements at high elevations are scarce, and studies of long-term temperature trends have reached strikingly different conclusions about whether the high mountains are warming faster or slower than the lowlands (Beniston et al. 1997; Pepin 2000). More high-frequency observations of the spatial and temporal variations of mountain temperatures are needed before these long-term trends can be fully explained. For example, observed surface temperatures vary diurnally, synoptically, and seasonally and only sometimes increase linearly with elevation. Local inversions and cold air drainage may make a long-term measurement site unrepresentative of temperatures across most of the surrounding topography.

Fortunately, small, low-cost temperature loggers can now be deployed at high densities in complex mountain terrain. We use a prototypical array of over 40 such sensors in Yosemite National Park, California, combined with snow and streamflow measurements, to demonstrate 1) how temperature patterns and lapse rates vary with large-scale weather conditions, 2) how empirical orthogonal functions can be used to quantitatively determine these relationships, 3) how spatial forecasting can improve snowmelt modeling, and 4) how spatial hindcasting can improve interpretations of long-term climatic change. These results can be applied to improving snowmelt models and to interpreting how well long-term measurements represent the surrounding terrain.