

2000. *Bulletin of the American Meteorological Society* 81(10), 2367-2392.

Snow avalanche climatology of the western United States mountain ranges

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ABSTRACT. The snow avalanche climate of the western United States has long been suspected to consist of three main climate zones that relate with different avalanche characteristics: coastal, intermountain, and continental. The coastal zone of the Pacific mountain ranges is characterized by abundant snowfall, higher snow densities, and higher temperatures. The continental zone of Colorado Rockies is characterized by lower temperatures, lower snowfall, lower snow densities, higher snow temperature gradients, and a more persistently unstable snowpack resulting from depth hoar. The intermountain zone of Utah, Montana, and Idaho is intermediate between the other two zones. We conducted a quantitative analysis of snow avalanche climate of the region based on Westwide Avalanche Network data from 1969-1995. A binary avalanche climate classification, based on well-known thresholds and ranges of snowpack and climatic variables, illustrate the broad-scale climatology of the three major zones, some spatially heterogeneous patterns, and variations with elevation. Widespread spatial shifts towards more coastal conditions occurred during 1985-86 and 1991-92, and shifts towards more continental conditions occurred during 1976-77 and 1987-88. Height anomalies at 500 mb explain many of these shifts, but daily plots of climate and avalanche variables during seasonal extremes for sites in northern Utah also illustrate the importance of understanding snowpack and weather variations that occur at daily to weekly timescales. Data from several central Rocky Mountain sites indicate some relationships with the Pacific North American teleconnection pattern and the Pacific Decadal Oscillation, illustrating the importance of applying long-term climate records in an avalanche hazard assessment.