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The influence of topographic setting and weather type on the correlation between elevation and daily temperature measures in mountainous terrain in the Canadian Rocky Mountains

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Temperature estimates for hydrological and ecological studies in mountainous regions are often based on lapse rate adjustments using sparse low elevation measurements. These measurements may not be representative of the area where estimates are required. This study examines the effects varying topographic settings under different weather types have on the temperature/elevation relationship.

The Foothills Climate Array study recorded hourly temperature between 2004 and 2010 at ∼230 weather stations over an area of approximately 24 000 km^2 in the Canadian Rocky mountains, extending to the Canadian prairies. 132 sites are considered mountain sites, comprising a range of elevation values, surface types and varied terrain morphology. Correlations are calculated between all station pairs for daily minimum and maximum temperatures, grouped by weather type for the 2006 data. Topographic and surface type characteristics - horizontal and vertical separation, height above valley bottom, slope aspect and angle and land surface type - for the 10 highest correlated neighbours for each site are examined as a means of determining which of these measures drives a similar behavior in temperature. Results indicate a weak temperature/elevation relationship for daily minimum temperatures. The average temperature/elevation correlation coefficient is -0.31 for daily minimum temperatures, varying from weaker than -0.2 for weather types where cold air pooling is a common occurrence to stronger than -0.6 for cool wet weather days. Daily maximum temperatures have an average correlation coefficient of -0.78, but the correlation weakens to -0.4 for cold weather events. There is a nonlinear maximum temperature/elevation relationship, with weak correlations below 2000 m and stronger correlations at higher elevations. Choosing sites with similar topographic settings does strengthen the correlation coefficient, but the temperature/elevation relationship remains weak due to large day to day variability and additional unmeasured/intrinsic site factors influencing temperature.

Variable and weak correlation coefficients translate into high variability in lapse rates to be used to estimate temperatures at unmeasured locations. We recommend hydrological or ecological model applications requiring daily temperature estimates should sample from a range of lapse rates and, where possible, use reference sites with similar topographic characteristics to the areas being modelled.