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Characterizing atmospheric stability and roughness lengths for wind resource assessment in complex terrain

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Atmospheric stability influences vertical profiles of turbulence and wind speeds, yet surface-layer theories incorporating stability to predict profiles are not always suitable in complex terrain or at modern turbine hub heights. In this study, twelve months of three-dimensional sonic anemometer data mounted on a 60 m wind resource assessment tower in western Canada are used to characterize atmospheric stability and test wind profile models at a prospective wind energy production site. Three clear stability regimes are identified at this site that follow distinct diurnal and seasonal cycles. These stability classes are distinguished by unique wind speed distributions, vertical wind velocity shear, and turbulence characteristics. A comparison between six wind profile methods is performed to test whether including stability parameters from the sonic anemometer improves modelled predictions of vertical wind speed profiles. Three separate methods to estimate roughness length based on sonic anemometer data, wind profile during neutral conditions, and surface morphology are also used in wind profile calculations and tested against observations. Preliminary results show additional stability parameters do not improve wind profile predictions, likely because i) sonic measurements are de-coupled from the surface layer during stable conditions and ii) wind profiles diverge from theoretical predictions due to terrain influences. For roughness lengths, profile-based estimates in neutral conditions likely are more representative of local-scale conditions than sonic anemometer measurements at a single height.