An Analysis of the Temporal Variability of the Vertical Temperature Gradient on Red Mountain, Washington

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Understanding the micro scale spatial variability in the diurnal cycle of temperatures at different elevations is crucial for accurate local temperature prediction and effective frost protection. This study was motivated in part by the need for growers to understand whether wind machines would provide a mixing induced increase in surface temperature that was sufficient to protect vulnerable crops on frost nights. The goal of this study was to understand how temperatures at different elevations vary over time. The objectives of this investigation were to examine average and absolute maximum vertical temperature gradients, along with the average monthly temperatures and diurnal temperature ranges at different elevations. Hourly temperature data collected between May of 2009 and January of 2010 at nine different sites on Red Mountain, near Benton City, WA were examined. The elevation of the sites varied from approximately 500 feet (mean sea level) at the lowest site at the base of the mountain to around 1200 feet at the highest site near the summit. Surprisingly we found that the long-term averaged temperature difference between the top and the base during the period of study was approximately zero, while the instantaneous temperature difference was almost always nonzero. The vertical temperature profile strongly followed a diurnal cycle whose long term variability followed a seasonal cycle and whose short term variability was strongly influenced by the synoptic weather pattern. Typical daily maximum night-time inversion strength (ΔT) between the top (highest site) and the base (lowest site) of Red Mountain (700 foot elevation difference) ranged from 4˚F to 12˚F. The daily maximum inversion strength varied considerably depending upon the weather pattern. ΔT ranged from approximately -2˚F (warmer at the base) during well-mixed or strong advection nights, to 20˚F (colder at the base) during clear and stable nights that featured strong radiative cooling. Monthly average diurnal temperature ranges varied from 8.5˚F at the top site in December 2009 to 37.6˚F at the base site in July 2009. The top site had a diurnal range that is 5˚F to 12˚F smaller than the base site. This study illustrates the need for further research into understanding what effect the antecedent weather pattern has on nighttime residual layers and the near-surface vertical temperature gradient for mountain terrain in eastern Washington.