ON THE SEASONALITY OF COLD AIR POOLING ACROSS SCALES

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INTRODUCTION

The dynamics of cold air pooling refers to the cycle of formation and dissipation of stable cold air which forms in valley depressions due to radiative cooling of the ground. The physical mechanisms responsible for describing the phenomenon across scales are hypothesized to be radiative cooling, along-valley and cross-valley flows, and stability of the boundary layer. Since the mechanisms are affected by topography and seasonality (Daley, 2010), the dynamics of cold air pooling should be different at different topographic settings throughout a year. According to Daley et al. (2010), the effect of topography becomes less important than the effect of synoptic forcing (cyclonic conditions) in the formation of cold air pooling during winter while the effect reverses during the summer when the Anticyclonic condition exists. Radiative cooling is a mechanism by which a surface loses heat by emitting long wave radiation to the sky. The underlying physical law is described by Stephan-Boltzmann equation. Along-valley winds are categorized as topographically induced winds which blow parallel to the valley axis from higher to lower elevations as mountain winds (drainage flow) during calm nights and from lower to higher elevations as valley winds during daytime (AMS). Cross-valley winds blow perpendicularly to the valley axis from the less heated sidewall towards the more heated sidewall. This wind is categorized as a thermally driven flow (anabatic or katabatic) (AMS). Stability refers to the characteristics of a system if a small disturbance occurs, the system reacts either by decreasing the intensity of the disturbance or by oscillating periodically (AMS). The objective of this study was to study the dynamics of cold air pooling at local (Primet and Vannet) versus regional scales (the HIA Forest) during different seasons.

Study site: Established in 1948, the Andrews Forest is an experimental site in Oregon’s western Cascades Mountains. It is part of a long-term ecological research (LTER) network supported by NSF. It is a 6475-ha site with complex topography including V-shaped and U-shaped valleys, alluvial fans, fluvial terraces, hilltops, and vegetated floodplains. The Primet and Vannet are two meteorological stations which are located at 450 m and 1250 meters above sea level respectively. The first is located on a fluvial terrace whereas the latter is close to a ridge. Data: The hourly mean temperature, wind speed, wind direction, incoming shortwave radiation, vapor pressure deficit, and relative humidity for Primet and Vannet were acquired for three days (15, 20, 25) in July and December 2014.

METHODS

Experiments: Primet and Vannet (local scale). A value of 300 Wm$^{-2}$ for the incoming shortwave radiation in July 2014 was used as a threshold for determining the stability of the boundary layer. Any value less than 300 Wm$^{-2}$ contributes to the stability of the boundary layer whereas values equal or greater than 300 Wm$^{-2}$ contributes to the instability of the boundary layer. A value of 0.37 m/s was determined as a threshold for the mean wind speed too. These values were determined based on trial and errors and also comparing them with other values including hourly mean temperatures and saturation vapor pressure from 8:00 am to 4:00 pm on July 15, 20, and 25, 2014. For December 2014, the threshold values of 1Wm$^{-2}$ and 1 m/s were determined for the hourly mean incoming shortwave radiation wind speed from 8:00 am to 4:00 pm respectively.

DISCUSSION

As Dobrowski et al. (2009) has mentioned the physiographic factors are the most important ones in the formation of cold air pools in stable condition while in unstable condition, lapse rate is more important. This finding is consistent with Pepin et al. (2011) findings regarding the influence of synoptic condition on decoupling and the resultant cold air pool formation. They claim that the synoptic weather pattern during winter has more influence on decoupling than physiography. The findings of this research is consistent with the findings from the aforementioned studies as well.

CONCLUSION

In summary, this study was motivated by an urge to understand how cold air pooling events form and dissipate across scales during different times of a year. One of the most important limitations of this study was lack of data availability. The use of suggested method is recommended on multiple years of data in future studies. In addition, studying the contribution of the cross-valley flows to the along-valley flow between Vannet and Primet is highly recommended for the future studies.

REFERENCES


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