Nocturnal Temperature Estimation in a Cold Pool Area

Soo-Ock Kim[1] and Jin I. Yun[2*]
[1]National Center for Agro-Meteorology, Seoul National University, Seoul 151-742, Korea
[2]Department of Ecosystem Engineering, Kyung Hee University, Yongin 446-701, Korea

Cold air on sloping surfaces flows down to the valley bottom in mountainous terrain at calm and clear nights. Existing models assume the cold air flow might be the same for the water flow and estimate the temperature drop due to the cold air accumulation at a given location which can be determined by the water-like freely flowing manner. However, in case of a closed catchment whose outlet is blocked by man-made obstacles like banks and roads, the free flow assumption is not valid anymore, because the cold air fills up the bottom first. We developed an empirical model to quantitatively estimate the effect of cold pool on nocturnal temperature in closed catchments. We treated the closed catchment by “a vessel”, and then used a digital elevation model (DEM) to calculate the maximum capacity of the cold pool formed in a closed catchment. Cold air accumulation potential, originally in dimensionless unit, was converted to get volume unit. A topographical variable which can be calculated as a ratio of cold air accumulation potential over the whole catchment area to the maximum volume of the cold lake was introduced to describe the relative size of temperature drop across diverse shapes of catchment. This variable is then used to simulate the density profile of cold lake formed in a given catchment based on a hypsometric equation. The cold lake module was incorporated with the existing model to form a new method for predicting minimum temperature distribution in closed catchments. This method was applied to Akyang valley, a typical closed catchment in the southern skirt of Mt. Jiri National Park with the area of 53km^2 and 12 automated weather stations, and tested for the feasibility of delineating the temperature pattern accurately at cold lake forming nights. Improved results in simulating the spatial pattern of lower temperature at the valley bottom were obtained by this method as was confirmed from thermal images scanned across the valley at dawn of 17 May 2011. In addition, temperature estimation error (RMSE) was substantially decreased by this method from 1.30 to 0.71 °C at the 10 low-lying stations, showing the feasibility of this method for the site-specific freeze and frost warning.

Acknowledgement: This work was carried out with the support of "Cooperative Research Program for Agriculture Science & Technology Development (Project No. PJ907129)" Rural Development Administration, Republic of Korea.

* Corresponding Author: Jin I. Yun (jiyun@khu.ac.kr)