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Development and evaluation of leaf wetness duration model based on machine learning for orchards in South Korea

Jun Sang Park, Ju-Young Shin, Kyu Rang Kim, and Yun Am Seo

Applied Meteorology Research Division, National Institute of Meteorological Science, Seogwipo-si ,Jeju-do, Republic Of Korea, (happy3424@korea.kr)

Background: Diseases of plants are depending on many factors including temperature and leaf wetness duration (LWD). While temperature is usually measured at weather stations, LWD sensors frequently are unavailable in weather stations. Even if they are available, observed data are less reliable. Therefore, these properties of LWD observations may act as constraints on the use of disease warning system because LWD is critical in modeling disease. It even lacks of standard protocol (for example, angle, height, and orientation) in measurement (Gleason et al., 2008). The LWD measurement has been often replaced by its estimation used other meteorological variables (Wang et al., 2019).
Aim: In this study, we developed a LWD prediction model based on machine learning method. The model was evaluated by observation datasets and compared with other LWD prediction models.
Method: Deep Neural Network (DNN) modeling was employed for a development of the LWD prediction model as a machine learning method. The Number of Hours of Relative Humidity, Classification And Regression Tree/Stepwise Linear Discriminant (CART/SLD), Penman-Monteith, and DNN models were developed using meteorological observations of temperature, relative humidity, wind speed, short wave radiation, and rainfall at 11 orchards in Jeju, South Korea in 2016. The sensitivity and prediction accuracy of these LWD prediction models were investigated using the observational data in 2017.
Results: The performances of LWD models without rainy days were superior to those of LWD models with rainy days. The seasonal errors of the DNN model ranged similar magnitude (RMSE of ca. 3 hours) among all seasons excluding winter. The other models except DNN had greater magnitude of errors showing the largest (RMSE of ca. 9.6 hours) in summer and the smallest (RMSE of ca 3.3 hours) in winter. Based on the evaluation criteria, the prediction accuracy was best with the DNN model whereas worst with the CART/SLD model.
Conclusion: The DNN-based LWD prediction has a capability to extend spatial coverage with higher accuracy of disease warning systems. It would help better decision making in many agricultural practices.

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