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Improving NEXRAD Rainfall Estimates with Artificial Neural Networks

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Nearly everyone has become familiar with NEXRAD Doppler radar these days. Just turn on the news on a stormy day and you will get a detailed, moving image of how thunderstorms and potential tornadoes are tracking across the state. NEXRAD has become an everyday tool for monitoring severe weather before it strikes. Currently, a joint project between the Agricultural Engineering Department and Dr. Jeffrey Andresen from the Geography Department is working on developing artificial neural networks (ANN) for making NEXRAD a more accurate tool for estimating the water balance across the state. The goal of this study is to develop an accurate, real-time, spatial estimate of rainfall amounts by adjusting the basic NEXRAD rainfall estimate with ground-based rain gauges and an ANN. More accurate estimates of rainfall amount at a high-spatial resolution provides a powerful tool for making management decisions with respect to agriculture, especially irrigation timing and understanding of the water balance in the state, such as groundwater recharge rates, surface runoff, and water levels in the Great Lakes.

The NEXRAD system does not directly measure rainfall amounts, but estimates rainfall rate (R), via an empirical relationship with radar reflectivity (Z). Rainfall rates are proportional to the volume of the raindrops, but reflectivity is proportional to raindrop surface area. Therefore, a raindrop size distribution must be converted from reflectivity to rainfall rate by the Z-R relationship where $Z = aRb$. Unfortunately, a number of errors, such as systematic and random errors in the radar and Z-R conversion error, introduce up to 100% discrepancies between NEXRAD rainfall estimates and actual rainfall at the Earth's surface. In our study, we are improving the NEXRAD rainfall estimate by comparing the NEXRAD to rainfall values collected from ground rain gauges across the state. The ANN examines the amount of error between the NEXRAD estimate and the actual rainfall values from the ground gauges, and based on the error, the ANN develops an adjusted NEXRAD rainfall surface.

This methodology was developed and tested using the South Eastern Michigan Council of Governments (SEMCOG) rain gauge network. The SEMCOG network consists of about 110 recording rain gauges that cover Oakland, Wayne, Livingston, Macomb, and Washtenaw Counties. In our initial study, daily rainfall values from 68 gauges were used to test the ability of the ANN to adjust the NEXRAD rainfall. Half of the rain gauges were randomly chosen for training the ANN model to adjust the NEXRAD rainfall. The other half was used to test the validity of the ANN model. Using rainfall values from 1999 and 2000, the ANN model was able to improve the estimate of the NEXRAD rainfall by 70% on average across the SEMCOG area. This summer, based on the excellent results from the initial study, we are expanding the ANN model to adjust the hourly and daily NEXRAD rainfall across the state.