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Machine Learning Approaches to Drought Monitoring and Assessment through Blending of Multi-sensor Indices for Different Climate Regions

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Drought causes a water shortage problem which threats human life as well as affects agricultural resources. Unlike other natural disasters such as floods, earthquakes, and landslides, drought is a slow-moving disaster, which is hard to accurately quantify spatio-temporal starting and ending points of the process. It is also difficult to estimate the damage from drought, because such damage combines social, economic, and environmental components in multi-temporal scales. There are many definitions of drought considering its type, temporal scales and regions. Drought has been actively monitored all over the world using in situ meteorological and climate measurements and satellite remote sensing measurements. There are many drought indices that use in situ measurements collected at weather stations, including z-score, Standard Precipitation Index (SPI), and Palmer Drought Severity Index (PDSI). However, these indices are point-based and limited in covering vast areas to show spatial distribution of drought. Since spatial interpolation is required to estimate spatial distribution of drought from in-situ measurements, uncertainty of drought estimation typically increases where in situ data are limited. Drought monitoring and assessment using satellite products provide an effective way as satellite data cover vast areas at high temporal resolution (e.g., daily). Most of remote sensing-based drought studies have focused on arid regions because satellite products usually well respond to the surface condition of short-term drought in arid regions. While drought often occurs in humid regions, satellite-based drought monitoring of such regions needs further investigation.

In this study, remote sensing-based drought monitoring and assessment were evaluated for both arid and humid regions in the United States between 2000 and 2012 focusing on metrological and agricultural drought. Since there is no single indicator that represents complexity and diversity of drought, a total 11 products from Moderate Resolution Imaging Spectroradiometer (MODIS) and precipitation data from Tropical Rainfall Measuring Mission (TRMM) were used as input data. The products were collected between April and September (i.e. growing seasons) during the thirteen year period and daily products were aggregated into monthly data. We extracted points-based data from weather stations for satellite products and reference data. The randomly selected 80% of the data were used for model calibration and the remaining 20% were used for validation. Three machine learning approaches such as random forest, Cubist, and support vector regression were used to assess drought in both arid and humid regions. SPI and crop yield data were used as reference data for meteorological and agricultural drought, respectively. Model performance was evaluated and relative variable importance was examined by model and drought type. Random forest generally produced better results than Cubist and support vector regression for both arid and humid regions.