A statistical approach for detection of natural disturbances in forest ecosystems using remotely sensed phenology

Jitendra Kumar[1*], Forrest M. Hoffman[1], William W. Hargrove[2], Richard T. Mills[1], William M. Christie[2], Joseph P. Spruce[3], Steve P. Norman[2]

[1]Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA
[2]Eastern Forest Environmental Threat Assessment Center, USDA Forest Service, Southern Research Station, Asheville, NC 28804, USA
[3]Computer Sciences Corp, NASA Stennis Space Center, Stennis, MS 39529, USA

*jkumar@climatemodeling.org

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Forest ecosystems are vulnerable to natural and anthropogenic disturbances like extreme weather events, attacks of insects and diseases, wildfires, harvesting and other land use changes. Changes in vegetation phenology can be an indicator of ecological changes and/or natural or anthropogenic disturbance affecting the forest ecosystem. Vegetation phenology can be detected and monitored by remote sensing satellites since it has distinct seasonal cycles and known spectral reflectance characteristics. The Normalized Difference Vegetation Index (NDVI) is one of the most widely used indices for land surface phenology. In this study we have used the Moderate Resolution Imaging Spectroradiometer (MODIS) derived NDVI data available every 8 days at 231 m resolution for the conterminous United States (CONUS) for a period of 11 years (2000–2010) to statistically derive phenology based ecological regimes called phenoregions. A mutivariate cluster analysis technique was applied to develop maps of dynamic time series of phenological states for various phenoregions. The time series of these states were statistically analyzed to quantify the changes over time to produce annual disturbance maps for CONUS. Such an unsupervised analysis based on land surface phenology helps detect and quantify the areas of significant changes indicating disturbance. Using only NDVI it is not possible to distinguish types of disturbance, but the magnitude of change may provide a way to broadly classify them. The developed methodology was successfully applied for the detection of a range of natural disturbances like insect and disease attacks, wildfires, storm and hurricane damage across CONUS. The results from this analysis were compared and validated using available aerial and ground survey and remote sensing datasets.