Satellite LCLUC Capabilities to Advance Wildfire Management in View of Increased Fire Danger Potential from Climate and Urban Changes

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Wildfires are among the most serious problems in California (CA) and in European countries with a similar Mediterranean climate, which is characterized by the semi-arid to arid biomes and vegetation types. Although they are a part of the natural cycles related to the regional climate, effective strategic fire management is necessary due to highly variable weather conditions, pervasive drought durations, and significant urban sprawl/growth creating an array of wildland-urban interfaces (WUI) across the extensive built environment. These complexities demand new scientific advances to assess impacts of both natural and anthropogenic factors in a changing climate on wildfire danger to enhance the efficacy of proactive fire management with the utilization of new capabilities from satellite observations of land cover and land use change (LCLUC), including urbanization and ecosystem change.

In the present study, we show effects of large-scale atmospheric circulations on an early start and then extended length of fire seasons. More specifically, we find that multiple climate indices such as North Atlantic Oscillation (NAO) and El Niño-Southern Oscillation (ENSO) are closely related with weather conditions in the southwestern United States region, and they affect local wildfire potential in spring and early summer. This is determined by obtaining a 34-year record of Keetch-Byram Drought Index (KBDI) variability using multi-decadal reanalysis datasets to investigate impacts of multiple climate indices on precipitation, temperature, and the regional wildfire potential characterized by KDBI. Then for an effective fire danger assessment, we successfully test the capability of satellite vegetation indices (VIs) in replicating in-situ live fuel moisture (LFM), which is a critical parameter used by fire agencies to determine fire danger levels in Southern California. VIs can be derived from data collected with multispectral sensors aboard satellites such as MODIS on Aqua and Terra, VIIRS on Suomi NPP, MERIS on Envisat, and MSI on Sentinel-2. To estimate LFM from satellite data, we identify the relationship between satellite VIs and seasonal/interannual characteristics of in-situ LFM to develop an empirical model function of LFM. Advancing beyond previous studies based on point-wise comparisons, we examine the LFM relationship with VIs averaged over different areal coverage, radially extended by 0.5 km to 25 km from each LFM sampling site in chamise-dominant areas of the chaparral ecosystems.

Moreover, an innovative method, called the Dense Sampling Method based on the patented invention of the Rosette Transform, has enabled the use of data acquired by satellite scatterometers (e.g., QuikSCAT, SeaWinds) to delineate and monitor decadal urban change including lateral sprawl and vertical growth from increasing urbanization across the world in various areas of the built environment including WUI. Together with the satellite-VIs capability for a break-through improvement of the spatial and temporal coverage by more than an order of magnitude compared to current manual methods for LFM sampling, we discuss practical applications of our results to significantly enhance fire danger assessment and prediction. Beyond California, these results will be directly relevant to European countries in the Mediterranean climate.