Geophysical Research Abstracts
Vol. 21, EGU2019-8082, 2019
EGU General Assembly 2019

Forecasting fire activity in Indonesia as a function of fire weather and land cover change

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Extreme peatland forest burning episodes in Indonesia, notably the 1997-98, 2002, 2006 and 2015 events, are a major source of global atmospheric greenhouse gases and have adverse effects on human health and ecosystems on local and regional scales. The re-occurrence of such episodes has refocused attention on the 2002 ASEAN Agreement on Transboundary Haze Pollution, signed and ratified by a total of 10 ASEAN states, including Indonesia since 2014. An operational fire early warning system based on seasonal forecasts has been identified by these states as a key requirement of the Agreement to help mitigate the impacts of widespread burning and haze. However, such a system currently does not exist. Moreover, to develop such a system, a sound understanding of how fire activity responds to climate and human-driven changes in the region is needed.

Past research demonstrates that extreme burning events in Indonesia are induced by drought conditions associated with El-Niño and/or positive Indian Ocean Dipole conditions that disrupt the normal monsoonal rainfall patterns across the maritime continent. Several studies have reported clear correlations between antecedent fire weather and fire activity at regional scales. However, most present-day fires in Indonesia result from human-driven land use and land cover (LULC) change and practices associated with agricultural and plantation activities at local scales, and as a result relationships between fire weather and fire activity can be expected to vary depending on past LULC change. Consequently, any effort to develop an operational fire danger early warning system for Indonesia must account for both fire weather and LULC. However, the impact of the interaction of the two factors on fire activity has received comparatively little quantitative attention.

This study addresses this research gap by statistically analysing relationships between fire occurrence, fire weather and LULC change across Indonesia from 2002 through 2018. The study uses individual MODIS active fire detections aggregated to 0.25o grid as a proxy for fire activity. Fire weather is characterised by the Canadian Forest Fire Danger Rating System (CFFDRS) indices; Fire Weather Index (FWI) and Drought Code (DC), which are calculated using ERA-5 climate reanalysis products at 0.25 degree resolution. LULC changes are obtained from South East Asia and Peatland land cover maps and forest cover loss datasets. Previous work conducted at (sub-)regional scales in Indonesia has used piecewise regression to establish threshold values for DC and FWI, above which a precipitous increase in fire activity occurs. We revisit these analyses at finer resolutions to determine how such thresholds shift for various LULC types.

Our results indicate that relationships between CFFDRS indices and fire activity vary in space and depend on land cover type. The piecewise regression analyses suggest different threshold values for FWI and DC for different land cover types examined, including pristine versus degraded peatland forests, large-scale plantations and small-holder agriculture areas. These results reinforce the importance of considering LULC as part of any future fire early warning system in Indonesia based on near-time climate forecasts.