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In the line of fire: Modelling the impact of drought and fire-induced haze during the 2015-2016 El Niño–Southern Oscillation (ENSO) event on surface energy balance and greenhouse gas fluxes in an oil palm plantation using CLM-Palm model

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The 2015-2016 El Niño–Southern Oscillation (ENSO) event was one of the strongest observed in the last 20 years. ENSO resulted in a strong drought in Southeast Asia and particularly in Indonesia, which experienced severe outburst of forest-, peat- and grassland fires. These fires spread over vast areas and the emitted smoke covered parts of Borneo, Sumatra and West Malaysia for several weeks under a dense blanket of haze. One region which was heavily affected by fire and haze is tropical lowland of Sumatra, Indonesia. During the past decades, large areas of tropical forest in this region have been converted into commercial oil palm (Elaeis guineensis Jacq.) plantations.

In this study we investigate the impact of drought and fire-induced haze during the 2015-2016 ENSO event on surface energy balance and greenhouse gas fluxes in a commercial oil palm plantation in Jambi province (Sumatra, Indonesia). We apply the perennial crop module CLM-Palm within the framework of the Community Land Model (CLM4.5) and develop different scenarios of drought and haze intensities. Model results are validated with on-site eddy covariance and meteorological measurements.

Meteorological measurements show that during the haze solar radiation decreased by 35% compared to pre-ENSO conditions. Increasing density of haze resulted in a strong reduction in carbon uptake and the oil palm plantation turned into a small source of carbon for 1.5 months. During the drought sensible heat fluxes experienced an increase at the cost of latent heat fluxes and midday Bowen ratio increased from 0.17 to 0.40. During the haze the magnitude of the turbulent heat fluxes gradually decreased, with average decrease of 45% compared to pre-ENSO values. The CLM-Palm model generally overestimates fluxes of sensible heat and CO_2 fluxes, especially during the period of intense drought and increasing haze. Coefficient of determination (R2) is 0.56 for sensible heat flux and 0.77 for CO_2 flux. Modelled latent heat fluxes are in good agreement with the observed fluxes from eddy covariance measurements, with R2 of 0.83.