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The impact of the 2015-2016 El Niño–Southern Oscillation (ENSO) event on greenhouse gas exchange and surface energy budget in an Indonesian oil palm plantation

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The 2015-2016 El Niño–Southern Oscillation (ENSO) event was one of the strongest observed in the last 20 years. Oil palm plantations cover a large fraction of tropical lowlands in Southeast Asia but despite their growing areal extent, measurements and observations of greenhouse gas exchange and surface energy balance are still scarce. In addition, the effects of extreme events such as ENSO on carbon sequestration and the partitioning of surface energy balance components are widely unknown.

In this study, we use micrometeorological measurements located in commercial oil palm plantations in the Jambi province (Sumatra, Indonesia) to assess the impact of the 2015-2016 ENSO event and severe forest fires on greenhouse gas exchange and surface energy budget. Continuous measurements are in operation since July 2013 and we assess turbulent fluxes of carbon dioxide (CO_2), water vapour and sensible heat using the eddy covariance technique before, during and after the 2015-2016 ENSO event.

In the beginning of the ENSO event, the area experienced a strong drought with decreasing soil moisture, increasing air and surface temperatures, and strong atmospheric vapour pressure deficit. During the peak of the drought from August to October 2015, hundreds of forest fires in the area resulted in strong smoke production, decreasing incoming solar radiation by 35% compared to pre-ENSO values and diffuse radiation became almost the sole shortwave radiation flux. During the beginning of the drought, carbon uptake of the oil palm plantation was around 2.1 gC m-2 d-1 and initially increased by 50% due to clear-sky conditions and high incoming photosynthetically active radiation (PAR) but increasing density of smoke turned the oil palm plantation into a source of carbon.

The turbulent heat fluxes experienced an increase in sensible heat fluxes due to drought conditions at the cost of latent heat fluxes resulting in an increase in the midday Bowen-ratio from 0.17 to 0.40. Strong smoke generally decreased the magnitude of the turbulent heat fluxes by 45% compared to pre-ENSO values. Overall, the ENSO event forest fires resulted in a major anomaly of exchange processes between the oil palm plantation and the atmosphere.