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Fire in the Vegetation and Peatlands of Borneo, 1997-2007: Patterns, Drivers and Emissions from Biomass Burning

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The peatland forests of equatorial SE Asia cover over 20 Mha with most located in Indonesia. Indonesian peatlands are globally one of the largest near-surface reserves of terrestrial organic carbon, with peat deposits of up to 20m thick and an estimated carbon storage of 55-61 Gt.

The destructive fires in Indonesia during the exceptionally strong drought of late 1997 and early 1998 mark some of the largest peak emissions events in recorded history of global fires. Past studies estimate that about 1Gt of carbon was released to the atmosphere from the Indonesian fires in 1997– equivalent to 14% of the average global annual fossil fuel emissions released during the 1990s.

Previous studies have established a non-linear negative correlation between fires and antecedent rainfall in Borneo, with ENSO-driven droughts being identified as the main cause of below-average rainfall events over the past decade or so. However, while these studies suggest that this non-linear relationship is mediated by ignitions associated with land use and land cover change (LULCC), they have not demonstrated it. A clear link between fires and logging in Borneo has been reported, but this work was restricted to eastern Kalimantan and the period 1997-98. The relationship between fires, emissions, rainfall and LULCC across the island of Borneo therefore remains to be examined using available fine resolution data over a multi-year period.

Using rainfall data, up-to-date peat maps and state-of-the art satellite sensor data to determine burnt area and deforestation patterns over the decade 1997-2007, we show at a pixel working resolution of 0.25 degrees the following: Burning across Borneo predominated in southern Kalimantan. Fire activity is negatively and non-linearly correlated to rainfall mainly in pixels that have undergone a significant reduction in forest cover, and that the bigger the reduction, the stronger the correlation. Such pixels occur overwhelmingly in southern Kalimantan. These correlations are noticeably much weaker or absent in Sarawak and Sabah, and central Borneo, where little or no deforestation was observed. Emissions from biomass burning reflect fire activity, and that fires in the carbon-rich peats of southern Kalimantan dominate the emissions profile during the El Nino years of 1997-98, 2002, 2004 and 2006.

Previous work in southern Amazon forests demonstrates that recurrent fires promote a change from tree-dominated to grass-dominated ecosystems which, in turn, promotes even more fires. We show that recurrent fire and deforestation are also linked as part of a similar positive feedback process in Kalimantan. Our results support the detailed field work undertaken in 1997-98 in East Kalimantan, and reinforce these findings across time and space.

Emissions from fires in Kalimantan peatlands represent a serious perturbation in terms of forcing from trace gases and aerosols on regional and global climate. Several global and regional climate modelling studies have reported that equatorial SE Asia, including Borneo, will experience reduced rainfall in future decades. At the same time, demands for establishing pulp paper and palm oil plantations to replace native rainforests, especially on peatlands where tenure conflicts among land owners tend to be minimal, is forecast to increase. These joint scenarios imply even more fires and emissions in future. It is critical therefore that present efforts to

mitigate emissions through reduced deforestation programs in the region works, otherwise the consequences will be disastrous.