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Derivation of Burn Scar Depths with Airborne Light Detection and Ranging (LIDAR) in Indonesian Peatlands

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Tropical deforestation and forest degradation contribute to about 20% of the global greenhouse gas emissions and Indonesia is a leading emitter. Forests are certainly critical; but the peat soils beneath can store 30 times more carbon than the trees above. Indonesia has the fourth-largest area of peatland in the world, ranging from 30 to 45 million ha, which is approximately 10 - 12% of the global peatland resource. Fire has a long tradition in Indonesian land clearing, where almost all fires are related to human activities. The 1997 - 1998 fires throughout Indonesia caused significant haze and smoke-related health problems across Southeast Asia. Strong and weak El Niño events in 1998 and 2002 accelerated burning as soil was parched. Green house gas emissions from the fires were the source of 60% of all anomalies globally for 1997 - 2000, particularly from drained peatlands.
In 2007/08 we participated in a study conducted by the World Wildlife Fund which focused on Sumatra's 8.3 million ha province of Riau, along the island's northeastern coastline. In this study CO2 emissions from deforestation and forest degradation, peat decomposition and burning over 17 years from 1990 – 2007 were estimated. Fire hotspot data for the years 1997 - 2000 from the NOAA AVHRR and MODIS sensors was used to identify burned peatland. Based on soil water availability the depths of peat burns were estimated. El Nino years with a water table of lower than 1.5 m propel intense burning so that a peat burn depth of 0.50 m was assumed, while normally only a peat burn depth of 0.15 m. Total emissions for the 1990 - 2007 period were estimated at 3.66 Gt CO2, composed of 1.17 Gt CO2 from deforestation, 0.32 Gt CO2 from forest degradation, 0.78 Gt CO2 from peat decomposition, and 1.39 Gt CO2 from peat burning. Average annual CO2 emissions were 0.22 Gt, equal to 58% of Australia's total CO2 annual emissions (including emissions/removals from LULUCF, in 2005); between 1990 and 2007, Riau produced more CO2 per year than the fourth-largest industrial nation, Germany, saved to achieve its Kyoto target. Since 1990, emissions from peat burning and peat decomposition have exceeded that of above ground biomass deforestation.
These numbers show how important it is to have more accurate estimations for peat burn depth in the future. Until now few field measurements were made, which would require to know the fire affected area in advance or ignite peatland on purpose. Furthermore fire scars are quickly covered by regenerating vegetation. Another problem is the lack of a method without actually having to go into the field (e.g. through remote sensing techniques), due to the fact that many of the fire locations are remote and very difficult to access. We investigated if airborne light detection and ranging (LIDAR), an active laser pulse technology by which the height of objects can be precisely measured, can be used to determine the amount of peat burned during a fire event. From a LIDAR data set acquired in Central Kalimantan, Borneo, in 2007, one year after severe fires resulting from the 2006 El Niño drought, we calculated that the average depth of a burn scar was 0.30 ± 0.15 m .This was achieved through the construction of digital terrain models (DTMs) by interpolating the LIDAR ground return signals in burnt and adjacent unburned peatland. These calculated depths were compared to in situ measurements, which came to similar results.
We believe that the method presented here to estimate burnt peat depth has the potential to considerably improve the accuracy of regional and global carbon emission models but would also be helpful for monitoring projects under the Kyoto Protocol like the Clean Development Mechanism (CDM) or the proposed Reducing Emissions from Deforestation and Degradation (REDD) mechanism.