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Satellites reveal peatland fire susceptibility

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Peatland fires in Southeast Asia come at a huge cost to human health and sustainability. Smoke from the fire in Kalimantan Tengah, Indonesia, October 2015. Credit: Aulia Erlangga / CIFOR

When large areas of carbon-rich soil catch fire, the blaze emits massive amounts of carbon into the atmosphere and creates a thick haze some residents of Southeast Asia know all too well. In 2015, the haze from peatland fires was fatal, responsible for more than 100,000 premature deaths in Indonesia, Malaysia and Singapore.

Because of how they accumulate organic material for long periods of time, undisturbed peatlands are considered one of the most effective natural ecosystems for carbon storage. So large fires come at a huge cost to human health and sustainability.

"Although they only cover 3 percent of the world's land area, peatlands are estimated to contain 21 percent of the world's soil carbon," said Stanford University doctoral candidate Nathan Dadap, lead author on a new study correlating soil moisture with fire vulnerability in peatlands.

In order to understand fire susceptibility in Asian peatlands, where blazes have increased in scale and severity over the past 30 years due to land-use changes, scientists developed a novel approach to measuring soil moisture using a previously underestimated tool: satellite data.

Since tropical peatlands are found in swamps where the ground can be obscured by dense vegetation, it was thought impossible to use satellite data for monitoring soil moisture. By developing an alternative algorithm, Stanford scientists have shown for the first time that analyzing remote sensing data can reveal soil moisture in this region, which can in turn be used to predict fire risk. The research appeared in *Environmental Research Letters* Sept. 9.

"This clearly shows the potential to lead to improved fire predictions," said co-author Alexandra Konings, an assistant professor of Earth system science in Stanford's School of Earth, Energy & Environmental Sciences (Stanford Earth). "More research is needed, but it opens the door to a new way of figuring out long-term policies for managing peatland fire risk."

Thick gray smoke hovers over the Southeast Asian island of Borneo on Oct. 19, 2015, triggering air quality alerts and health warnings in Indonesia and neighboring countries. Red outlines indicate hot spots where the sensor detected unusually warm surface temperatures associated with fires. Credit: Jeff Schmaltz / NASA

Researchers analyzed data from the NASA Soil Moisture Active Passive (SMAP) mission during the 2015 El Niño and found that the replacement of tropical forests with palm oil and acacia plantations allowed for measurement of the soil moisture in this region. The analyses show that drier soil up to 30 days before a fire correlated with a larger burned area. While rainfall is currently used as an indicator for fire risk in the region, soil moisture is the most direct way of assessing that risk.

"The problem with using precipitation as an indicator is that it doesn't take into account the local conditions," Dadap said. "If one area has drainage canals and another does not, but you still have the same amount of precipitation, the one with canals still is going to have a much higher risk of fires. That's why we think that inclusion of soil moisture can be an important metric for capturing conditions on the ground."

Carbon sink or fossil fuel?

When fires start in peatlands and the soils are dry enough, blazes there can quickly become out of control, causing haze downwind in the densely populated cities of Jakarta and Singapore and ushering in long-term climate impacts that affect the whole planet.

"In the 2015 peat fires, nearly the same amount of carbon dioxide was released as India's total annual carbon emissions from fossil fuels," Dadap said.

Nearly 95 percent of the peatlands in this region of Sumatra, peninsular Malaysia and Borneo have been degraded—a factor that increases susceptibility to widespread fires—yet those land-use changes also enabled the researchers to use satellite data to measure its soil moisture. Their new approaches for interpreting the satellite data might also work in other peatlands where the land cover allows for accurate soil moisture measurement, Dadap said.

Workers install soil moisture and water table depth sensors in a burned peatland in Badas, Brunei Darussalam. Credit: Nathan Dadap

While policymakers have expressed some interest in implementing water table-based management policies in the area, measurements for creating such guidelines would need to happen on the ground—a process that would be extremely labor-intensive for such a large region and infeasible in some areas, according to Konings. The approach used in this study shows the value of using satellite data for a more detailed understanding of peatland hydrology.

"This shows that the consideration of hydrologic factors beyond just the commonly cited water table in this region—factors like soil moisture or canals that might be easier to map than a water table—could be relevant for avoiding fire outcomes," Konings said.

Laboratory links

While exploring the relationship between fire susceptibility and soil moisture in peatlands, Dadap turned to lab-based research for supporting evidence. The satellite data analysis showed that burned areas were much larger when soils were below a certain soil moisture value. A laboratory study from the 1990s similarly showed that ignition of peat samples was much more likely below the same value.

"That was probably the most shocking finding, since we were measuring soil moisture from the satellite—it was a totally different method than this laboratory ignition study," Dadap said. "It was a pleasant surprise to have an independent comparison that seems to match up really well."

Provided by Stanford University

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