Wildfires and other burns play bigger role in climate change, professor finds

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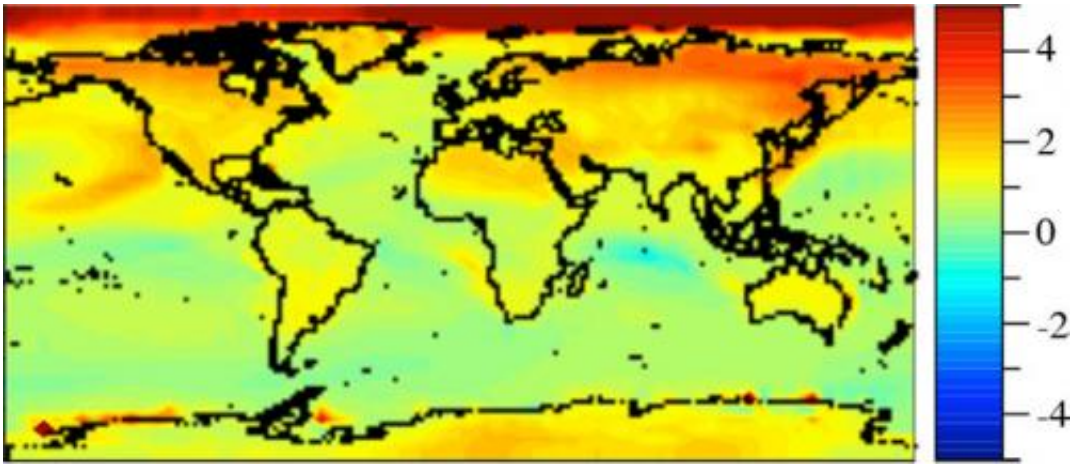

The map shows the predicted global warming impact of all anthropogenic emissions, including biomass burning, on global near-surface air temperature since 1850. Credit: Mark Jacobson

It has long been known that biomass burning – burning forests to create agricultural lands, burning savannah as a ritual , slash-and-burn agriculture and wildfires – figures into both climate change and public health.

But until the release of a new study by Stanford University Civil and Environmental Engineering Professor Mark Z. Jacobson, the degree of that contribution had never been comprehensively quantified.

Jacobson's research, detailed in a paper published July 30 in the *Journal of Geophysical Research: Atmospheres*, is based on a three-dimensional computer model simulation of the impacts of biomass burning. His findings indicate that burning biomass is playing a much bigger role in climate change and human health issues than previously thought.

"We calculate that 5 to 10 percent of worldwide air pollution mortalities are due to biomass burning," Jacobson said. "That means that it causes the premature deaths of about 250,000 people each year."

Carbon, of course, is associated with global warming. Most carbon emissions linked to human activity are in the form of carbon dioxide gas (CO_2), but other forms of carbon include the methane gas (CH_4) and the particles generated by such fires – the tiny bits of soot, called black carbon, and motes of associated substances known as brown carbon.

Jacobson explains that total anthropogenic, or human-created, carbon dioxide emissions, excluding biomass burning, now stand at more than 39 billion tons annually. That incorporates everything associated with non-biomass-burning human activity, from coal-fired power plants to automobile emissions, from concrete factories to cattle feedlots.

Jacobson, the director of Stanford's Atmosphere/Energy Program and a senior fellow at the Woods Institute for the Environment and the Precourt Institute for Energy, said almost 8.5 billion tons of atmospheric carbon dioxide – or about 18 percent of all anthropogenic carbon dioxide emissions –comes from biomass burning.

But Jacobson's research also demonstrates that it isn't just the CO_2 from biomass burning that's the problem. Black carbon and brown carbon maximize the thermal impacts of such fires. They essentially allow biomass burning to cause much more global warming per unit weight than other human-associated carbon sources.

Black and brown carbon particles increase atmospheric warming in three ways. First, they enter the minuscule water droplets that form clouds. At night, that's not an issue. But during the day, sunlight scatters around within clouds, bathing them in luminescence.

When sunlight penetrates a water droplet containing black or brown carbon particles, Jacobson said, the carbon absorbs the light energy, creating heat and accelerating evaporation of the droplet. Carbon particles floating around in the spaces between the droplets also absorb scattered sunlight, converting it to heat.

"Heating the cloud reduces the relative humidity in the cloud," Jacobson said.

This causes the cloud to dissipate. And because clouds reflect sunlight, cloud dissipation causes more sunlight to transfer to the ground and seas, ultimately resulting in warmer ground and air temperatures.

Finally, Jacobson said, carbon particles released from burning biomass settle on snow and ice, contributing to further warming.

"Ice and snow are white, and reflect sunlight very effectively," Jacobson said. "But because carbon is dark it absorbs sunlight, causing snow and ice to melt at accelerated rates. That exposes dark soil and dark seas. And again, because those surfaces are dark, they absorb even more thermal energy from the sunlight, establishing an ongoing amplification process."

Jacobson noted that some carbon particles – specifically white and gray carbon, the variants associated with some types of ash – can exert a cooling effect because they reflect sunlight. That must be weighed against the warming qualities of the black and brown carbon particles and CO2 emissions generated by biomass combustion to derive a net

effect.

Jacobson said the sum of warming caused by all anthropogenic greenhouse gases – CO2, methane, nitrous oxide, chlorofluorocarbons and some others – plus the warming caused by black and brown carbon will yield a planetary warming effect of 2 degrees Celsius over the 20-year period simulated by the computer. But light-colored particles – white and gray particles primarily – reflect sunlight and enhance cloudiness, causing more light to reflect.

"The cooling effect of these light-colored particles amounts to slightly more than 1 C," Jacobson said, "so you end up with a total net warming gain of 0.9 C or so. Of that net gain, we've calculated that biomass burning accounts for about 0.4 C."

Jacobson's model also tracks the impact of the direct heat produced by combusting biomass.

"The direct heat generated by burning biomass is significant and contributes to cloud evaporation by decreasing relative humidity," Jacobson said. "We've determined that 7 percent of the total net warming caused by biomass burning – that is, 7 percent of the 0.4 C net warming gain – can be attributed to the direct heat caused by the fires."

Biomass burning also includes the combustion of agricultural and lumber waste for energy production. Such power generation often is promoted as a "sustainable" alternative to burning fossil fuels. And that's partly true as far as it goes. It is sustainable, in the sense that the fuel can be grown, processed and converted to energy on a cyclic basis. But the thermal and pollution effects of its combustion – in any form – can't be discounted, Jacobson said.

"The bottom line is that biomass burning is neither clean nor climate-

neutral," he said. "If you're serious about addressing global warming, you have to deal with biomass burning as well."

Exposure to biomass burning particles is strongly associated with cardiovascular disease, respiratory illness, lung cancer, asthma and low birth weights. As the rate of biomass burning increases, so do the impacts to human health.

More information: web.stanford.edu/group/efmh/ja … oburn/14BburnJGR.pdf

Provided by Stanford University