New research reveals that wildfires can influence El Niño

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Wildfire is a phenomenon that has affected pretty much every vegetated environment on Earth for millions of years. However, during the past few decades, the planet has been experiencing extraordinary wildfire

activity, with widespread devastation in diverse places such as the Mediterranean, North and South America, Southeast Asia, Australia and even Siberia. The current year has already shown troubling signs of massive fires—for example, Europe's total burnt area for the 2022 fire season is four times greater than the 2006–2021 average, according to the European Forest Fire Information System (EFFIS).

In addition to causing direct damage to ecosystems and communities, wildfires also lead to enormous quantities of pollutants being emitted into the atmosphere. Globally, wildfire emissions upset the carbon cycle and the Earth's radiation equilibrium; a phenomenon known asclimate forcing. They also influence temperature, clouds and rainfall, prompting air quality degradation and the subsequent death of around 300,000 people every year.

Despite the fact that catastrophic wildfires are rapidly intensifying and that their effects on people and the environment can be drastic, it is one of the most poorly understood processes in the Earth system. Given that wildfires emit greenhouse gases and aerosols (tiny smoke particles) that affect radiation in the atmosphere, it is expected with high confidence that they also result in disturbances to global and regional climate.

The limits of current models

However, the extent of such effects is highly uncertain. Models currently used for predicting the evolution of future climate, such as those participating in simulation experiments in support of the Intergovernmental Panel for Climate Change (IPCC) reports, either do not include a representation of wildfire effects or do so in a way that is not satisfactory. Without models that can accurately represent influences of climate change on wildfires, and, in turn, influences of wildfire-generated pollution on climate (i.e., fire-climate feedbacks), the future climate change predictions that we have available as a society might be

suffering from significant biases.

Fire emissions do not only have the potential to influence long-term climate, but they can also alter short-term weather conditions in different parts of the globe. This is also a poorly understood scientific topic, despite the existence of some sporadic studies that have attempted to examine it.

A recent set of experiments by our team of climate scientists from the U.K. and Greece is shedding light on this question. The work involved a set of novel state-of-the-art climate model simulations of El Niño events, through which the impact of intense wildfire emissions over Equatorial Asia that have accompanied strong El Niño events in recent decades have been quantified.

Longer dry seasons in Asia

El Niño is a climate phenomenon with significant societal impact, altering weather patterns around the Pacific region, as well as in multiple regions across the globe. One consequence is a deeper and prolonged dry season in Equatorial Asia. During recent large El Niño events, such as in 1997 and 2015, this has combined with expanding agricultural land clearance to produce vast fires in peat-dominated areas. These are some of the largest fires on Earth, attracting both scientific and media attention due to the blanket of smoke they produce across the region lasting several weeks, impacting the health of millions of people.

Previous literature has focused on the magnitude of these El Niño-driven smoke emissions and their serious health impacts. However, there has been surprisingly little research on the climate feedback of this transient but very large aerosol radiative forcing. The hypothesis of the new study is that these smoke emissions can drastically influence atmospheric conditions in the western Pacific and therefore modify the development

of the El Niño phenomenon itself.

The study represents the first time that the impact of intense smoke emissions over Equatorial Asia have been investigated in full-complexity climate simulations. These allowed the researchers to compare the development of El Niño events with and without the presence of large wildfire emissions from Equatorial Asia, using the intense 1997 fire season as a test case.

Wildfires' impact on El Niño

The findings suggest that the intense smoke emissions result in a strong lower atmospheric heating over Equatorial Asia, which enhances local convection (ascending motion of air), cloud concentration and rainfall over the Maritime Continent. This in turn shifts cloud cover westward in the Pacific, and significantly strengthens the "Walker circulation," which is the typical pattern of air flow in the tropical lower atmosphere. This opposes the typical El Niño circulation in the Pacific (which is a weakening of the Walker circulation) and results in a negative feedback on the El Niño event itself. The researchers find that the El Niño event is weakened by around 22% on average due to the wildfire emissions that the El Niño event itself produces.

As well as being an indication of the climate impact that these exceptional El Niño-driven fire seasons in Indonesia can have, these findings also have clear implications for El Niño predictability. Including the impact of enhanced wildfire emissions during large El Niño events can significantly influence the progression and intensity of the El Niño itself. More generally, these findings pave the way for more such studies investigating the implications of fire-generated pollution for atmospheric circulation, rainfall, and temperatures, in a variety of world regions, both on short (weather) and on long (climate) timescales.

In addition to the scientific significance of this research, it also has the potential to significantly impact a variety of economic sectors and societal stakeholders. Better weather and climate forecasts resulting from an improved representation of wildfires in models is expected to lead to better-informed policy making, and to higher-quality weather/climate information available to businesses and to society as a whole.

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