# 2023 Canadian wildfires impacted air quality as far away as Europe and China, study finds

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Numerical air quality models have described the extent of severe negative impacts on air quality resulting from the record 2023 Canadian wildfires, demonstrating that almost the whole of the Northern Hemisphere, not just Canada and the northern United States, were affected.

A paper describing the findings was published in the journal Advances in Atmospheric Sciences.

Canadian record-setting wildfires in 2023 made headlines around the world not just for their extent—the largest area burnt in the country's history—but also for how severely they impacted air quality across this very large country, and even deep into the United States. Smoke from the fires produced repeated severe air quality alerts and even evacuations in many locations.

But it was not known how far beyond Canada and the northern US such dangerous air pollution had reached, and even within North America, the understanding of the dispersal of the most harmful pollutants was limited.

"There were photographs from New York City in July in news outlets around the world that showed the city trapped in an almost unbreathable orange haze like something out of a dystopian movie," said Zhe Wang, lead author of the study and a researcher with the State Key Laboratory of Atmospheric Boundary Layer Physics at Institute of Atmospheric Physics (IAP) of Chinese Academy of Sciences.

"But what we know about long-range transport of particulate matter means that the fires likely impacted Europe and Asia as well. We just didn't know to what extent."

So Dr. Wang and other researchers from IAP set out to calculate the full global reach of this threat to public health by using numerical air quality model models. Similar to climate models, air quality models use mathematical techniques to simulate how weather and chemical reactions impact the dispersal of air pollutants.

For this work, the IAP scientists used the Aerosol and Atmospheric

Chemistry Model of the Institute of Atmospheric Physics (IAP-AACM), a computer model developed in house as a module within the broader Chinese Academy of Sciences Earth System Model (CAS-ESM).

The researchers found that while Canada was most severely affected, almost the whole of the northern hemisphere was subject to marked significant declines in air quality due to long-range wind transport of pollutants.

There were six main widespread air pollution episodes over the course of Canada's wildfire 'season': May 15-22, June 5-9, June 24-July 1, July 12-19, August 17-15, and August 17-22. In addition to Canada itself, the first such episode affected air quality in the central northern parts of the US. The second episode impacted the northeastern US, and particularly badly.

The model results here match real-world observations. The concentration of fine particles with diameters of 2.5 microns or less (termed $PM_{2.5}$—the particulate matter that is most dangerous, as compared to larger but less harmful particles with a diameter of 10 microns, or $PM_{10}$) on June 7 was found by 11 monitoring sites in New York City to have reached the worst air quality level for more than 50 years.

During the third main episode of severe air pollution, the model suggested that PM2.5 pollutants were transported to Europe, while the fourth such episode concentrated its severest presence in western Canada and the central northern US once again. The fifth episode mainly affected northern Canada, while the sixth episode affected both western and eastern coast regions of the U.S.. Due to the northward movement of the wildfires, high concentrations of PM2.5 were transported to the Arctic region over the course of the mid and late summer.

PM2.5 concentrations higher than the World Health Organization air-quality guidelines of 15 micrograms per cubic meter mainly occurred over North America, with an excess of 40 pollution days exceeding this limit over western and eastern Canada, as well as more than 10 such days over the northeastern U.S..

But due to the wildfire plumes being transported by prevailing westerly winds across the Atlantic Ocean, vast swathes of Europe and western, central and east Asia suffered from increases in such concentrations. This meant that maximum PM2.5 concentrations exceeded 1 microgram per cubic meter over most areas of the Northern Hemisphere—lower than the WHO guideline but not without impact. PM2.5 concentration in the northwest region of China increased to roughly two micrograms per cubic meter.

Western and eastern Canada were most severely impacted, suffering PM2.5 concentration over 150 PM2.5, some ten times the WHO maximum.

While focusing on air quality, the researchers also used computer modeling to investigate the global distribution of greenhouse gases (GHGs) produced by the Canadian fires. They found that the conflagration had resulted in an increase in carbon dioxide levels mainly over North America in May, and also over Europe and northwestern Asia in June. The wildfire-related $CO_2$ concentrations exceeded 0.1 part per million (ppm) over most Northern Hemisphere areas except southeast Asia, India and southern China in July, and increased to more than 0.2 ppm in August.

This increase in GHGs due to the fires has two major consequences. First, its production of enhanced warming in these regions atop existing global warming increases the likelihood of the sort of conditions that exacerbated wildfires. In other words, more wildfires means even more wildfires.

Second, the level of wildfire-related greenhouse gas emissions in Canada in 2023 were more than twice the country's legislated plan for cumulative reductions in human-caused GHGs over the next ten years.

"Canada's 2030 Emissions Reduction Plan has been wiped out by a single year of wildfires," said Zifa Wang, corresponding author of the study.

**More information:** Zhe Wang et al, Severe Global Environmental Issues Caused by Canada's Record-Breaking Wildfires in 2023, *Advances in Atmospheric Sciences* (2023). DOI: 10.1007/s00376-023-3241-0

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