Pollutant Haze Heats the Arctic

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Arctic climate already is known to be particularly prone to global warming caused by industrial and automotive emissions of carbon dioxide and other greenhouse gases. Now, a University of Utah study finds a surprising new way society's pollutants warm the far north: the Arctic's well-known haze – made of particulate pollution from mid-latitude cities – mixes with thin clouds, making them better able to trap heat.

The effect makes the Arctic 2 degrees to 3 degrees Fahrenheit warmer during polluted, cloudy episodes than it would be if the air was clean, concludes the study by Tim Garrett, an assistant professor of meteorology, and Chuanfeng Zhao, a doctoral student in meteorology.

"The Arctic is warming very quickly, especially compared with the rest of the world, due to the greenhouse effect caused by carbon dioxide from factories and cars," Garrett says.

"Now we are finding there is another way pollution can warm up the Arctic. Particulate pollution from factories and cars can be transported long distances to the Arctic, where it changes clouds so that they become more effective blankets, trapping more heat and further aggravating climate warming."

Arctic haze has been seen in the Arctic since the Industrial Revolution began about 1750. "Whalers and explorers noticed what looked like pollution and couldn't figure out where it was coming from," Garrett says. The Inuit (Eskimos) called it "poo-jok."

Scientists already knew particulate pollutants make clouds more effective at reflecting sunlight, which reduces surface temperatures. So the newly discovered effect is a surprise.

“What we found is an opposing effect where particulate pollution changes clouds so they warm the surface,” Garrett says. “This effect is most pronounced in Arctic winter when it is dark and there is no sunlight. The Arctic winter is when it is most polluted because there is almost no precipitation to wash out the pollutants, and there also is a strong inversion.”

He notes that the thickness of Arctic sea ice “is affected by such things as how much the atmosphere blankets the surface. Sea ice is changing very rapidly in the Arctic because of surface warming. This may be one contributing factor.”

“The Arctic represents the front line of climate change and is projected to warm at a rate at least double that of the Earth as a whole,” says University of Utah meteorology Chair Jim Steenburgh, who wasn’t involved in the study. “Although the importance of greenhouse gas emissions is well-documented, particulate pollution also may play an important role in the Arctic climate system. Tim’s work suggests that where pollution and thin clouds are coincident, they act to warm the surface by about 2 degrees to 3 degrees Fahrenheit.”

“This represents another important effect of humans on the weather and climate of the Arctic, although additional research is needed to fully understand its contributions to the Arctic climate system,” Steenburgh says.

Measuring Heat and Pollution in Alaskan Skies

The new study was published in the April 6 issue of the journal Nature.

Garrett and Zhao conducted the study using data collected at two research sites near Barrow, Alaska, the northernmost town in the United States:

-- U.S. Department of Energy instruments that look upward and measure "multispectral infrared radiation" – essentially different wavelengths or "colors" of heat – emitted by clouds. "We used this data, and some other data, to infer how effective low-lying clouds were at absorbing heat emitted by the Earth's surface – how good a blanket they were," Garrett says. (The more heat clouds absorb from the ground, the more heat they emit.)

"Using sophisticated theory, we also used these data to estimate how much water the clouds had, and also the sizes of droplets in the clouds."

-- A National Ocean and Atmospheric Administration research station measured concentrations of particulates, mostly sulfates from coal-burning power plants and smelters and from fossil fuels burned by automobiles and other sources in cities.

The Arctic haze, noted by explorers more than 200 years ago, resembles that seen during winter inversions in the Salt Lake City area. Both areas are desert-like, and pollution is trapped when warmer air aloft holds down cold air at the ground surface.

"The pollution is similar to the haze we get in the Salt Lake Valley," says Garrett. "These [Arctic pollution] concentrations can get very high in winter and spring for exactly the same reasons Salt Lake has high pollution. The Arctic gets the 'inversion' for months at a stretch during the long, dark winter. The difference is that here [in Salt Lake] the pollution source is local, whereas in the Arctic, the pollution source is from industry far away – mostly from northern Europe and Eurasia."

Garrett and Zhao used four years of measurements from the two sites to measure cloud "emissivity" – how much clouds act like a blanket – and water droplet size in the clouds when the clouds were polluted and not polluted.

"We found that when clouds were present and the air was polluted, the clouds were more effective at stopping the surface from releasing its heat to outer space," Garrett says. "The reason this was true is that the pollution particles made the cloud droplets more numerous, but consequently smaller. Even if the amount of water is the same in the cloud, a larger number of small droplets corresponds to a more effective blanket."

People living in Salt Lake City or other mid-latitude desert climates experience the same effect during winter. "When clouds are present, it doesn't get as cold at night as when they are absent," says Garrett.

Smaller cloud droplets making the cloud a better blanket is the same physical behavior that explains why a potato cooks faster in a microwave oven if it is cut into smaller pieces. "Same amount of potato, but more efficient cooking, because more of the interior of the potato is exposed to the penetrating microwave radiation," Garrett says.

Source: University of Utah