

Press release for The Pollution-Climate Connection, a presentation in the AAAS session "Climate Change is in the Air."

## **Effects of future climate change on regional air pollution episodes in the United States**

Summertime pollution may intensify in the northeastern and midwestern U.S. due to global warming.

Harvard University climate scientists have found that summertime air pollution may intensify in the northeastern and midwestern parts of the United States because of climate change. Based upon a climate simulation model first developed at the NASA Goddard Institute of Space Studies (GISS), the researchers predict that by 2050, pollutant concentrations during peak episodes could increase by five to ten percent, and that the duration of these episodes could also increase—from an average of two days in the current climate to three or four days. The Harvard study, which appeared in *Geophysical Research Letters* (Vol. 31, L24103), suggests that a decline in the frequency of cold fronts from southern Canada, responsible for blowing the pollutants away, is to blame.

"It is well known that day-to-day weather affects air quality," says Dr. L.J. Mickley, a research associate in Harvard University's Division of Engineering and Applied Sciences. "For example, unusually hot and stagnant conditions in the summer of 1988 led to the highest ozone levels on record in the northeastern United States. As greenhouse gas concentrations increase and climate change takes place over the next century, the consequences for air quality are likely to be significant, but the magnitude and even the sign of the effects have so far been unknown."

Summertime pollution episodes in the northeastern and midwestern United States occur when a high-pressure system stalls, allowing ozone and microscopic particles called aerosols to build up. The "bad air" remains until a cold front moves across the region and sweeps it away. These fronts accompany low-pressure systems—called mid-latitude cyclones—that move across southern Canada.

The Harvard study predicts that the frequency of mid-latitude cyclones will decrease in the future as greenhouse gases increase and the climate changes. The longer the stalled air lingers, the greater the accumulation of pollutants within the air mass (See Figure 1). The result: over the next several decades, pollution in the Midwest and Northeast could stick around considerably longer and air quality could worsen during the dog days of summer.

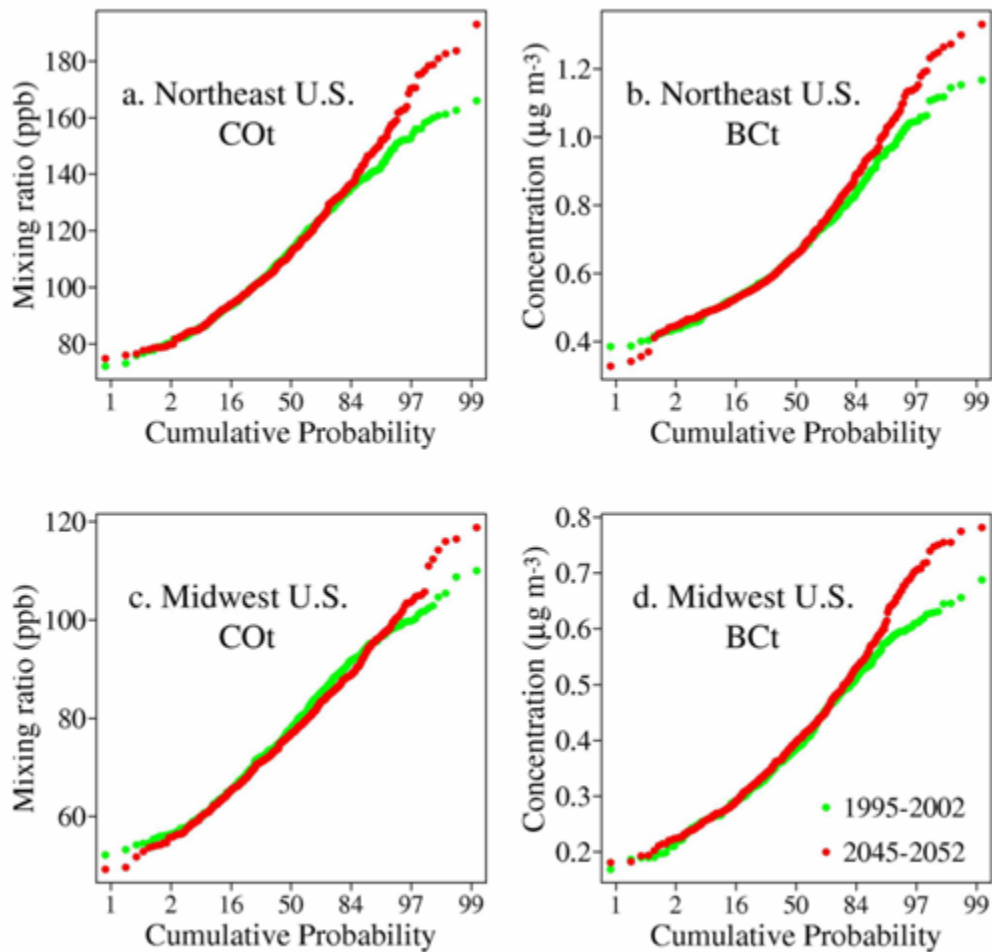
“Mid-latitude cyclones play a critical role in transferring heat and moisture from the tropics to polar regions,” explains Dr. Mickley. “Cyclones arise because of the unequal heating of the earth’s surface by the sun. Winds generated by the differences in surface temperature lead to centers of low and high pressure. In the future atmosphere, polar regions are expected to warm more rapidly than the tropics, weakening the temperature contrast across latitudes. That means fewer cyclones would be generated over the mid-latitudes, with fewer accompanying cold fronts. Such a decrease in cyclone frequency is already apparent in long-term observations dating from the 1960s.”

The GISS model, like other models, also predicts increased evaporation of tropical oceans in a warmer world, leading to greater quantities of heat carried to high latitudes in the latent form of water vapor. When the transported vapor finally condenses into droplets, heat is released. With increased water vapor doing more of the work of heat transport, fewer cyclones are spawned.

To conduct the study, Dr. Mickley and her colleagues included two simple “tracers” of manmade pollution—carbon monoxide (CO) and black carbon aerosol (BC)—in the GISS model. Ultimately, scientists hope to provide a more comprehensive picture for how air quality is related to coming climate change. “Summertime pollution episodes are a major cause of asthma outbreaks and high aerosol levels have been implicated in cardiovascular mortality,” says Dr. Mickley. “Evidence of a link between climate change and human health could give policymakers greater confidence in decisions to cut back emissions of greenhouse gases.”

Dr. Mickley’s co-authors included D. J. Jacob and B. D. Field, both in the Division of Engineering and Applied Sciences at Harvard University. The work was funded by a Science to Achieve Results (STAR) grant from the Environmental Protection Agency.

**Figure 1**



Cumulative frequency distributions of simulated daytime concentrations of manmade carbon monoxide (CO) and black carbon (BC) averaged over the northeastern and midwestern United States in July and August. Each point represents the spatial average for a particular day. The x-axis is a probability scale such that a normal distribution (or "bell curve") would plot as a straight line. Results are shown for the present-day climate (1995-2002, in green), and the future climate (2045-2052, in red). To isolate the effect of climate change, sources of CO and BC and the sink of CO are the same for the present-day and future simulations. Concentrations at the high end of the distributions are significantly greater in the future relative to the present-day.

## **Researcher Biography**

Dr. Loretta J. Mickley is a research associate in the Division of Engineering and Applied Sciences at Harvard University. She primarily investigates the complex relationship between climate change and tropospheric ozone and aerosols. Dr. Mickley's work addresses an array of chemistry-climate questions such as: How has human activity changed the composition of the atmosphere? What effect does tropospheric ozone, a greenhouse gas, have on climate change? What causes pollution episodes and will future climate change influence air quality? Dr. Mickley received her master's degree in chemistry from the University of Illinois at Chicago and her Ph.D. in geophysical sciences from the University of Chicago.