Pollution trials for the Beijing Olympics

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Michael McElroy
Harvard School of Engineering and Applied Science

by Stephanie Renfrow

In the summer of 2008, humanity's fastest, strongest, and most skilled athletes will compete in the Olympic Games in Beijing, China. How will a city that many people associate with traffic-stopping road congestion and health-endangering levels of pollution handle the additional influx of Olympians and their many followers?

In November of 2006, Chinese officials used a smaller-scale gathering, the Summit of the Forum on China-Africa Cooperation, as a sort of dress rehearsal for the Olympics. During six days surrounding the summit, officials increased bus capacity, limited access to certain roads, and banned or restricted the use of government, commercial, and private vehicles. The idea was to make it easier for summit participants to get around Beijing, while also providing a logistical trial run that would benefit athletes and spectators in 2008.

Harvard environmental studies professor Michael McElroy, a participant in a lesser-known conference, the China International Counsel for Cooperation on Environment

Beijing's traffic volume leads to high levels of pollution, as well as difficulty navigating clogged streets. (Courtesy Tym Altman) and Development, also happened to be in Beijing in November 2006. McElroy leads Harvard's China Project, an interdisciplinary program that studies the impact of air pollution on the environment, economy, public health, and law. One morning during his visit, he picked up the *China Daily* newspaper and noticed an article about the traffic restrictions. He said, "I read the article and thought, 'Aha! Wouldn't it be neat if we could take advantage of this natural experiment to improve our ability to detect pollution and see if the restrictions had an impact?'"

Policy inspires research

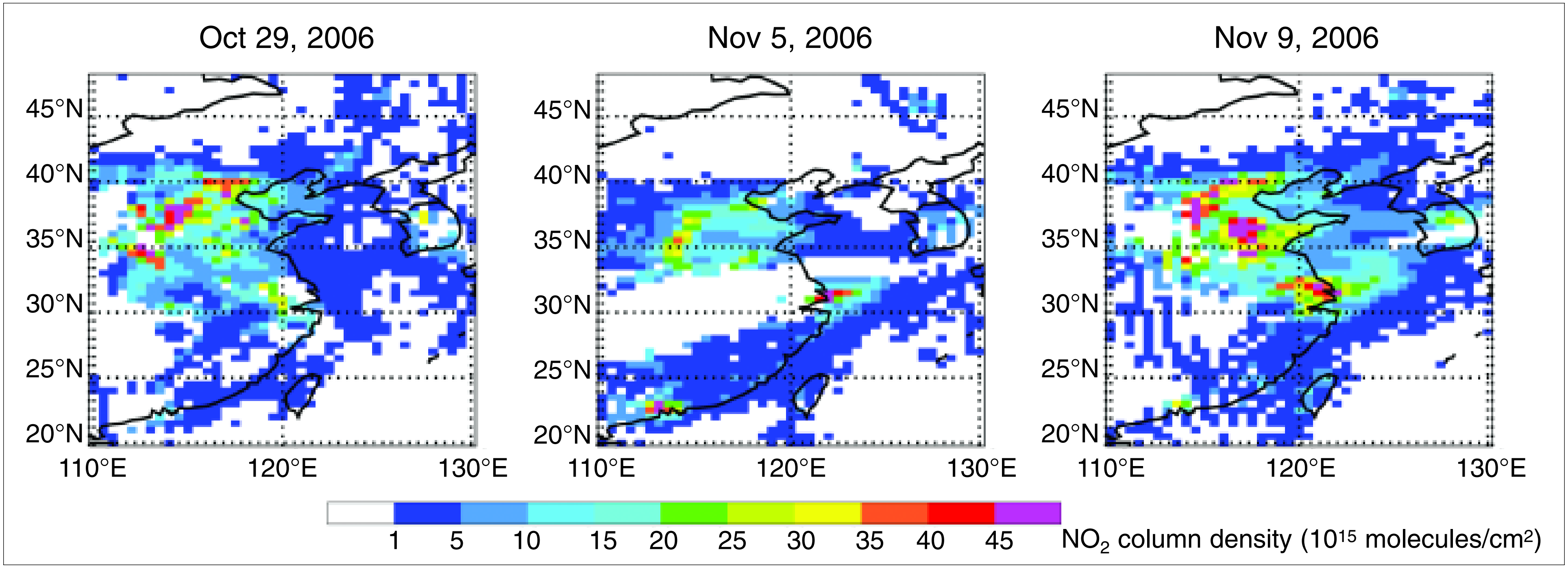
McElroy called upon postdoctoral student Yuxuan Wang, an atmospheric scientist and long-time participant in the China Project, to lead the research study. Wang knew that she would need access to accurate, daily data that offered high-resolution coverage. Based on her experience in using satellite data to understand atmospheric composition, she and her colleagues immediately turned to atmospheric data from the Ozone Monitoring Instrument (OMI). OMI flies on NASA's Aura satellite and is archived at the NASA Goddard Earth Sciences Data and Information Services Center (GES DISC).

Wang said, "OMI is perfect for this type of work. Unlike previous instruments, it sees all parts of the globe daily, which we really needed for a project covering such a short event." Another advantage of OMI is its small footprint, around twenty-four by thirteen kilometers (fifteen by eighteen miles). "The urban center of Beijing, where the traffic restrictions were in place, is about fifty by fifty kilometers [thirty-one miles by thirty-one miles]," Wang said, "so OMI's footprint was perfect."

This photograph of the Hall of Supreme Harmony in Beijing's Forbidden City was taken on a relatively clear day, but air pollution often obscures much of Beijing's famous architecture. (Courtesy Photos.com)

Wang began by downloading near-real-time nitrous oxide OMI data, which the Royal Netherlands Meteorological Institute in the Netherlands retrieves from the satellite data. Wang chose nitrous oxide to measure pollution levels both because of the availability and quality of the data and because it is a chemical precursor to smog and ozone. After downloading the OMI data, she plotted a time series of nitrous oxide measurements taken before, during, and after the summit.

However, before Wang could interpret what she saw, she had to take one more step. "When pollution is emitted from the surface, it moves around in the atmosphere," she said. "For example, you might look at the data and think that emissions were reduced—but maybe conditions that day were windy, blowing the pollution away." So, to get an accurate measure of levels of nitrous oxide, Wang first needed to subtract differences caused by natural variation and weather, such as clouds. To do this, she used a chemical transport model called GEOS-CHEM that simulated changes in meteorology, helping her determine their influence on the OMI nitrous oxide data.



This series of graphics shows the success of traffic restrictions over Beijing; pinks and reds indicate high levels of nitrous oxide before (October 29), during (November 5), and after (November 9) the restrictions were in place. (Courtesy Yuxuan Wang)

In addition to using the GEOS-CHEM model, Wang was also glad to see clear weather in Beijing surrounding the summit. "The days we studied were clear, not very cloudy," she said, "so we had an easier time getting a nice series of day-to-day changes. We got lucky!"

Successful restrictions

With the effects of weather and natural variation removed, Wang could begin to interpret the data. Her findings were clear. "We saw a dramatic change in atmospheric concentrations of nitrous oxide during the time of the traffic restrictions," she said. "The traffic restrictions were very effective in cutting down nitrous oxide in Beijing's urban area—a 40 percent reduction in emissions."

However, Wang acknowledges that verifying the data has been difficult. "We didn't have access to in situ observations or to official estimates of how much the flow of traffic was actually reduced," she said. McElroy had originally hoped to access data on gasoline sales before, during, and after the summit. These figures would have provided Wang with a way to corroborate the atmospheric data from OMI. McElroy said, "Unfortunately, we couldn't get that data. There was some nervousness about making adverse comments about the environment in the lead-up to the Olympics."

However, although the Chinese were not willing to make gasoline consumption data public, McElroy did get an unofficial confirmation that their measurements were accurate. "A Chinese official did let me know that our estimate was not far from what they had calculated," he said. Wang added, "Plus, Beijing newspapers did report a 30 percent reduction in traffic, which is also similar to what we found."

The future: Olympics and the planet

Despite the lack of in situ data to confirm their findings surrounding the summit traffic restrictions, Wang and McElroy hope to push the research forward during next summer's Olympic Games. Wang said, "We are offering to collaborate with Chinese scientists around the Olympics, and we are hopeful that they will share their data with us." A combination of in situ measurements of pollution, a realistic estimate of traffic flow reductions, and the OMI nitrous oxide data could provide a more complete picture concerning how traffic restrictions can address pollution concerns. But why is that complete picture important? McElroy said, "With China's economic growth has come an explosion in coal-burning factories and cars on the road—and a steady deterioration of the atmospheric environment. A lot of people are getting sick, and that costs money in medical care and in missed work."

The idea of pollution hurting people's health is becoming more commonly accepted in China. However, the idea that pollution generated by a healthy economy can actually begin to damage the economy itself is an important concept for McElroy. "If the cost of air pollution is 8 percent of China's Gross Domestic Product, or GDP, and GDP is growing at 10 percent . . . you can do the calculation. The economic growth actually isn't very much, in the end."

Beyond being concerned about Olympic athletes breathing in hazardous levels of pollution, why should people outside of China care about pollution problems on the other side of the world? "Pollution doesn't stay where it is generated; it can drift halfway around the world," McElroy said. "So the Chinese care what we do, and we should care what they do. The globalization of economies is becoming the globalization of environments."

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For more information

NASA Goddard Earth Sciences Data and Information Services Center (GES DISC)
http://daac.gsfc.nasa.gov/

Harvard Researcher Listings: Michael McElroy
http://harvardscience.harvard.edu/node/2005/

Yuxuan Wang Web site
http://www.people.fas.harvard.edu/~wang3/index.html

About the remote sensing data used

Satellite	Aura
Sensor	Ozone Monitoring Instrument (OMI)
Data set used	Tropospheric nitrous oxide
Resolution	24 by 13 square meters
Parameter	Nitrous oxide
Data center	NASA Goddard Earth Sciences Data and Information Services Center (GES DISC)

About the scientists

Michael McElroy is a professor of Environmental Studies at the Harvard School of Engineering and Applied Science in Boston, Massachusetts. He studies changes in atmospheric composition, focusing on the effects of human activity. McElroy leads the interdisciplinary Harvard China Project, which seeks to identify environmentally sensitive paths for China's future development. His funding for the Beijing pollution study came from the National Science Foundation.

Yuxuan Wang is an atmospheric scientist at the Harvard School of Engineering and Applied Science; she works with Michael McElroy on the Harvard China Project. She specializes in using satellite data to study Asian atmospheric pollution. Funding for the Beijing pollution study came from the National Science Foundation.