Pandemics and pollution: A conversation with an atmospheric scientist

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You may have seen the striking before-and-after photos: cities previously blanketed by a dense fog of air pollution now sporting clear skies, as COVID-19 stay-at-home orders bring auto traffic and industry to a halt.

But the issue of improved air quality is not as simple as the photos may suggest, says Caltech's Paul Wennberg, the R. Stanton Avery Professor of Atmospheric Chemistry and Environmental Science and Engineering. Wennberg, an atmospheric chemist and environmental geochemist, studies the influence of human activity on the global atmosphere.

We talked with Wennberg by Zoom to get his take on what we can learn by observing COVID-19's impact on air pollution, and why we are not seeing the same dramatic effects in the Los Angeles area that have been observed elsewhere in the world.

Can you describe the effects on the environment that have been attributed to the COVID-19 stay-at-home orders?

It really depends on where you are. We have seen substantial drops in air-pollution levels as indicated by nitrogen dioxide (NO2) levels, first in China and then in Europe and North America. But there's a lot of nuance in how you interpret those observations because they're very sensitive to things like weather.

For example, Los Angeles had a very rainy period following the start of the stay-at-home orders, and the rain helps clear the air by removing a lot of the soluble pollutants such as aerosols and particles. Linkages between the reduction in emissions and improvements in the air quality are much easier to make in places like India and China than in a place like Los Angeles.

Why is that?

People sometimes don't realize it, but in Los Angeles cars are thought to contribute only a small fraction of the air pollution. Compared to decades past, cars have gotten incredibly clean. We anticipate that the reduction in car traffic reduced the emissions of major pollutants by maybe 10 percent, which is substantial, but pretty small overall. These days, NOx [nitrogen oxide] emissions in Los Angeles come primarily from trucks and other diesel-fueled engines. If you just go out on the highway now, you'll see there are still plenty of trucks.

What about elsewhere in the world?

In other places, the connection between the reduction in traffic associated with COVID-19 and a reduction in air pollution is easier to establish. In Europe, there are far more diesel cars, which emit a lot of NOx. Taking them off of the road has made a much more noticeable impact.

In India, there's been a substantial reduction in electricity demand—a 26 percent drop in just 10 days—so they're turning off coal plants, which also leads to cleaner air. You can contrast that with California, where electricity consumption is down, but not that much. We're down maybe 5 to 10 percent. We're all at home here, but we're still online, using our computers. A lot of the activities that demand electricity just really haven't changed in the way that they would have in a place like India or China, where the manufacturing sector is so dominant.

Will global weather patterns eventually have a homogenizing effect, causing cleaner air everywhere?

To an extent. We anticipate seeing the background levels of ozone in the atmosphere decrease in a more global way, which is a good thing. But a lot of particulate matter doesn't travel far, so the environment's response to this is still going to be pretty localized.

What impact will the changes in air quality have on cloud formation?

Two aspects of this are being tracked. We are interested in quantifying the role of aircraft in producing high-altitude cirrus clouds, which can be found above 16,500 feet and warm the earth. Studies done following 9/11 tried to pin that down using the lack of aircraft in that week following the attack, and these studies suggested that cirrus-cloud creation accounts for perhaps half of the total climate impact of aviation, trapping heat and contributing to global warming.

With the number of flights worldwide decreasing by about two thirds from the end of February to the end of March, we're seeing the 9/11 effect on a global scale. This will be much easier to interpret because it's persisting for a long time, and because it varies by region. For the most part, air travel decreased in China first, and then in Europe, and then in the United States. Presumably the return to aviation will also be heterogeneous, allowing one to try to disentangle the local effects from the effects of the airplanes themselves.

We're also interested in low-altitude clouds, which occur below 6,500 feet. Every cloud droplet has, at its core, a particle that was pre-existing in the atmosphere, so it has been suggested that aerosol pollution has led to changes in cloudiness, and that this has been an important component of climate forcing. Clouds can trap heat, warming the earth. The reduction in aerosol pollution associated with the COVID-19 situation should provide a very, very useful test of those theories which are hard to evaluate in other ways, because effectively both the climate and the pollution story have been co-evolving over 50 years.

What other research opportunities does this represent?

Right before this happened, we had submitted a proposal to the National Science Foundation to study what Los Angeles and the United States would look like, from an air-quality perspective, if we didn't have emitting vehicles anymore. Now we have a better idea based on hard data. As a side project to that proposal, the Resnick Sustainability Institute and the Ronald and Maxine Linde Center for Global Environmental Science commissioned an air-quality station for campus, and it was assembled by one of my staff members, John Crounse [Ph.D. '11], in January and February, just in time to start observing this.

What other tools will be useful for analyzing this?

Right now, we aren't able to get access to a lot of the national science assets that you'd use to track air quality. Normally, you can say, "Let's go take that National Science Foundation airplane and go fly over and have a look and see what's going on." Now, those planes are grounded.

However, we do have a number of remote-sensing instruments, such as the Orbiting Carbon Observatories, OCO-2 and OCO-3. Most of the images that you'll see in the newspaper and on Twitter come from a Dutch instrument called Tropomi, which is a sensor that was launched just a couple of years ago and maps a number of criteria of pollutants, as we call them, from space at pretty high resolution. In addition, there are a couple of other JPL instruments [JPL is managed by Caltech for NASA] that are tracking changes in, for example, carbon monoxide pollution.

Is this going to have a long-term impact, or will air pollution just go back to where it was when the stay-at-

home orders lift?

That's actually more of a social than an environmental question. Once you restart the activities that cause air pollution, it'll come roaring back. But there are places that have historically had really bad air pollution and a lot of the population has never really experienced clean air. Suddenly they're experiencing it, and I just can't believe that won't have an effect. People will have seen something different, and I wouldn't be surprised if they will then demand it. We've shown in the U.S. that you can have both good air quality and substantial economic activity. I think people haven't experienced this in a lot of the rest of the world.

What is next?

Springtime weather in Los Angeles is highly variable, making it complicated to interpret the air-quality data we're gathering now. If the stay-at-home orders go on through the summer—and let's hope they don't—we'll have a much better answer to the scientific question of what happens when you reduce car traffic by a factor of two, or three, or four, or whatever we've done.

From a climate-change standpoint, it's as though we've been conducting a centuries-long global experiment by slowly adding more and more carbon dioxide and particulate pollution into the atmosphere. Our knowledge of the impacts of those emissions is challenged by the lack of historical records. But now we've done the reverse—especially for particulate pollution—in a very dramatic and direct way, and at a time when we have better tools to understand it. Seeing how this plays out should be quite a bit more straightforward.

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