Clean Air, Cool Climate: Solving these problems together

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Given the health risks posed by air pollution, it is easy to understand why the Chinese government wants to address this problem. However, the dilemma is that some steps to clean up air pollution can actually contribute to global warming.

A study published in 2015 **attributed 1.6 million deaths per year** in China (an average of over 4,000 per day) to PM2.5, which are tiny particles in the atmosphere that are less than 2.5 micrometers in diameter. For reference, the diameter of a human hair is between 17 and 171 micrometers. Because PM2.5 are so small, they can penetrate deep into a person's lungs, where they can be especially deadly. In recent years the Chinese government has made some dramatic moves to work to clean up the air, including the announcement in 2013 of **budgeting $277 billion to clean up air pollution** and **prohibiting the development of new coal plants** in certain large metropolitan areas.

There are two main types of policies that can address air pollution, both of which the Chinese government is attempting to implement. The first is by using technologies to remove individual pollutants, such as sulfur dioxide, from fossil fuel emissions. These technologies, colloquially referred to as 'scrubbers,' can be effective at reducing emissions of individual pollutants into the atmosphere. However, scrubbers have certain drawbacks. They require a small amount of energy to run, which usually comes from additional fossil fuel burning and therefore slightly increases carbon emissions. Adding scrubber technology could also reduce a potent **driver** of Chinese action on climate and clean energy. This is because immediate environmental impacts (PM2.5) would be less, but the accompanying carbon emissions would continue because they are not reduced by scrubbers. The effective lifetime of fossil fuel equipment could be extended because there would no longer be as much of an immediate public health reward for reducing carbon emissions. The second way to address air pollution is to substitute out fossil fuels altogether for cleaner energy sources, a policy often referred to as 'fuel-switching.' Fuel-switching has the obvious benefit of reducing greenhouse gas emissions while also addressing local air pollution. What is less obvious is that following a scrubber approach would actually exacerbate warming due to the effect of scrubbers on reducing pollution of PM2.5, with impacts most prominent over China itself. Here's why.

PM2.5 are aerosols, and aerosols affect climate

Cleaning up air pollution is like removing China's sun umbrella. In the climate science community, PM2.5 are referred to as aerosols. Atmospheric aerosol as a category encompasses all the tiny solid and liquid particles that are suspended in the air, a large portion of which are PM2.5. Aerosols are important for climate because of how they interact with radiation. Some aerosols scatter and reflect incoming sunlight, analogous to mirrors in the sky. Other aerosols absorb light and can heat the surrounding air, like what happens to a paved road on a sunny day. Whether or not light reaches the surface or is intercepted by aerosols affects ground-level temperatures, which in turn can affect winds and local weather.

Figure 1: Effects of Aerosols on Climate

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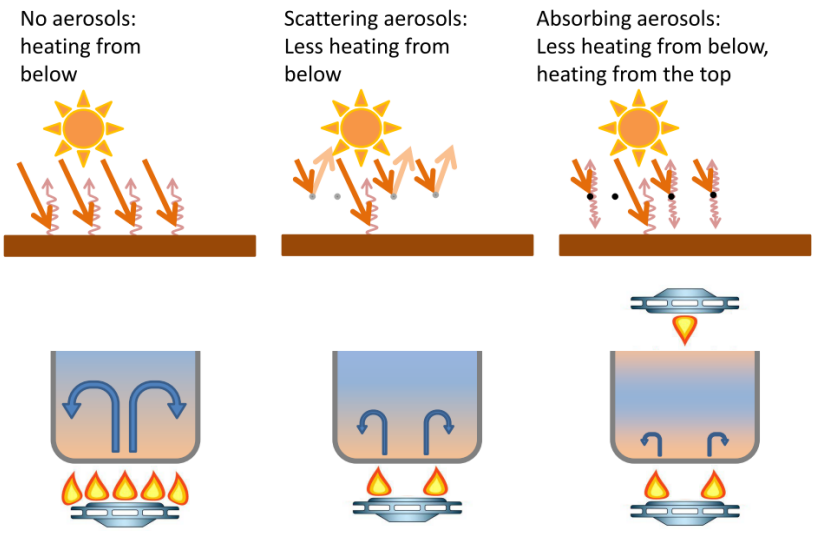

Illustration by Jonathan Moch

Figure 1: an illustration of how aerosols interact with sunlight and affect the mixing of local air masses. More sunlight reaching the surface can lead to more mixing, like turning up the heat on a boiling pot of water. Scattering (reflective) aerosols alone can lead to less mixing. Adding in absorbing aerosols which heat the atmosphere from above can lead to even less mixing. Over China, scattering aerosols are dominant.

With scattering aerosols dominant over China, reducing air pollution will actually increase the amount of radiation reaching the surface, which means temperatures over China could increase even faster than the global average.

A **new study** in which I participated with Chinese colleagues illustrates how dramatic the climate effects of Chinese air pollution reductions may be. In the Intergovernmental Panel on Climate Change's 5th **assessment report**, different warming scenarios for the global climate system were laid out, each requiring estimates of the emissions of greenhouse gases and air pollutants for different countries. For the scenario designed to limit global average surface warming to 2 degrees Celsius, called RCP4.5, there is assumed to be significant climate action across the globe and large reductions in emissions of air pollutants.

In the RCP4.5 vision of the future, reductions in the emissions of air pollutants lead to a 54% reduction in PM2.5 concentrations over east China in 2050 compared to 2000. This reduction in air pollution would have huge health benefits, but it also comes at a cost for the climate. In our study, we found that the reduction in air pollution leads to an increase in radiative forcing, a measure of how much radiation reaches the surface of the Earth, by an average of 1.88 W/m2 across eastern China. To put that number in perspective, RCP4.5 assumes that the global average radiative forcing levels out at 4.5 W/m2. This means that over east China, the radiative forcing from decreasing aerosols in 2050 is equal to about 40% of the average global radiative forcing for the near 2 degrees warming scenario.

Holistic approaches to addressing air pollution and the role of US-China collaboration

So, is there a way to both clean up the air and turn down the thermostat? China's 13th five year plan included targets and policies that would promote both fuel switching and scrubber deployment. Given the severity of China's air pollution problems, it is understandable that China would try whatever is possible to improve local air quality. However, it is important for China, and all countries, to keep in mind long term climate trends and the unintended warming consequences of air pollution reductions.

Fortunately, there are some indications that a holistic Chinese air pollution policy is evolving, taking into account both the short term urgency of air pollution and the longer term problem of climate change. China's progress on renewable energy bodes well for both the climate and for air pollution. Policies addressing energy efficiency, such as China's **target of a 15% reduction in energy intensity** of its economy by 2020, will also be beneficial for both goals.

Progress in the energy sector now needs to be matched with progress in the residential and commercial sectors. Along with Chinese domestic policies, the U.S. and China collaborative efforts have also begun to contribute to efficiency improvements and fuel switching in such instances as industrial boilers and buildings. Industrial boilers and coal boilers used for heating are major sources

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of both local air pollutants and greenhouse gases. So far, this project has focused on two pilot cities, Ningbo and Xian, and has brought together Chinese and U.S. companies, scientists, government officials, and local stakeholders. The U.S. and China are also working together on researching technologies to improve the energy efficiency of buildings, which account for about **40% of global greenhouse gas emissions**.

These projects are a good example of how the U.S. and China can work together towards solving the pressing problem of air quality in a way that benefits, rather than harms, efforts to combat global climate change. How we combat air pollution today will affect our climate tomorrow, so it is good for future U.S.-China collaborative efforts to continue to take that relationship into account.

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