CLIMATE SCIENCE FORUM

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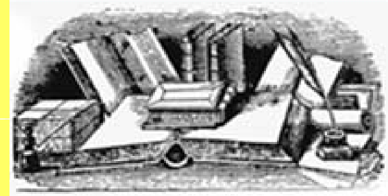

Airborne Particles & Climate

Do *Smoke & Smog* still offset CO_2 greenhouse effect ?

"Dust Bowl" storm gallops through Stafford, Texas in the 1930s. CREDIT: NOAA Photo Library

Climate News: *this Issue*

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Chief Editor: Michael A. Fortune, Ph.D.

Email: editor *(at)* climate-science *(dot)* org

Published quarterly at Silver Spring, Maryland, USA

Tel: (301) 754-1766

A fresh breeze of new research in 2009 has swept away the murky uncertainty about how airborne particles affect global climate.

It's agreed that particles generally cool the land and climate, and offset much of the heating caused by greenhouse gases like carbon dioxide (CO_2). But sooty, dark particles heat the atmosphere, and this so-called "black carbon" portion is becoming larger. The hundred-year "grace period" when airborne particles have counteracted up to one-half of global warming appears to be nearing an end. This is one more reason why the trend of rising global temperatures is expected to accelerate.

Phenomena from smoke, haze, and smog to the "brown clouds" of pollution that plague many cities and continents are made up of tiny solid particles that remain airborne for days or a week or so. Two different types of particles have distinct effects on sunlight shining through murky air. Lighter, reflective particles (lighter in color, not in weight) cool the planet by scattering sunlight back to space. It is well known that volcanoes can cool the entire Earth for one to two years after a large eruption. The cataclysm expels an enormous cloud of ash and sulfate particles high into the stratosphere, where particles remain for months, scattering some light back to space – light that normally illuminates and heats up the land.

Most pollution particles likewise scatter light, except that polluted air is washed out by rainfall within a few days. Yet so much pollution is emitted that it has kept the climate cooler than expected over the last hundred years. Many scientists maintain that "scattering" particles were largely responsible for the cooling that the Northern Hemisphere experienced from 1940 to 1975, even when greenhouse gases were increasing. The amount by which they offset the greenhouse effect has been highly uncertain.

Light-colored particles not only scatter light di-

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rectly, some also aid the formation of clouds, which indirectly affects climate. These particles attract water vapor that condenses on them so that tiny droplets of water form—so-called "cloud droplets." Once formed, a cloud can reflect most of the sunlight that strikes it. Clouds are much brighter and more reflective than either smoke, haze, or the underlying land. Unfortunately, it is quite uncertain how important this indirect effect of particles may be for climate cooling.

Dark smoke and soot particles from incomplete burning have the opposite effect. Collectively called "black carbon," darker particles absorb sunlight and heat up the atmospheric layer where they are found. When black carbon falls on snow, it darkens snow and makes it melt faster. These sooty particles originate mainly in fires: forest fires, fires set to burn agricultural waste and debris after land is cleared, coal or wood incompletely burned, and cook stoves widely used in Asia, tropical Africa and the Americas. Black carbon contributes to the greenhouse warming effect, unlike scattering particles in pollution, haze and dust.

In the end does the mix of pollution particles cool or warm the planet? Scientists now are putting forth evidence that black carbon is gaining ground over the scattering particles and is increasing twice as rapidly. The concentration of reflective, scattering particles has declined in developed countries where air pollution campaigns were successful – in most of Europe and North America. And new research (reported in the Climate Briefs) has reduced the uncertain climatic impact of all particles.

Clean air campaigns in Europe and North America have resulted in a cleaner atmosphere which is speeding the pace of global warming. Scattering particles are less abundant now than from 1900 to 1970 and no longer offset as much warming from greenhouse gases. Worse, brown clouds containing black carbon are becoming pervasive. As a result the Polar and middle-latitudes of the Northern Hemisphere are warming faster than the rest of the Earth, and faster than they did before.

Read about research news on airborne particles and climate in the "**Climate News Briefs**."

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Black Carbon or Soot:

Second most important agent of climate warming

The insidious role of "*black carbon*" (here termed *soot* or soot particles) has been debated since at least 2000. In an excellent update[1] of the climatic effects of black carbon, Ramanathan and Carmichael write that the warming effects are more powerful than had been thought.

Unlike all other airborne particles, soot particles absorb solar energy and heat the air where they are found. In clean air that sunlight would warm the surface of the Earth; but in dirty air the surface cools while the atmosphere is warmed.

Soot causes considerable warming of the planet: Carmichael and Ramanathan say its warming is at least half as large as that due to carbon dioxide alone, and more than any of the other greenhouse gases. They estimate its warming effect is more than twice as much as what the Intergovernmental Panel on Climate Change (IPCC) estimated in 2007. This warming is heavily concentrated in China, equatorial Africa, and other nations in the tropical belt where people burn traditional biofuels for cooking or burn agricultural wastes and forests to clear the land.

Sooty particles and scattering particles have opposite effects on global climate change: these authors calculate that black carbon adds energy at the rate of +0.9 Watts per square meter into the climate system, while all other particles remove energy at minus 2.3 Watts per square meter. The net effect of all airborne particles is an overall cooling, but less and less cooling as the proportion of black carbon increases.

Since soot particles heat the air but cool the surface, they *stabilize* air layers and make it less likely that the atmosphere will mix. That hurts the dispersal of smog, haze, or pollution. And there's more: less water evaporates from the cooler land or ocean surface. When the two effects are combined, the conditions necessary for clouds to form and rain to fall occur less often. Then pollution is less likely to be washed out of the air.

These are some of the reasons that the brown cloud over Asia and the Indian Ocean is believed to be weakening the Asian monsoon, diminishing the life-giving rainfall that sustains one billion people in the region.

CITATION:

1. V. Ramanathan and G. Carmichael (2008): "Global and regional climate changes due to black carbon": *Nature Geoscience*, v. 1, 221-227, April, 2008.

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