Tiny Airborne Particles are a Major Cause of Climate Change

July 18 2006

A scientist at the Weizmann Institute of Science and his colleagues caused a storm in the atmospheric community when they suggested a few years back that tiny airborne particles, known as aerosols, may be one of the main culprits causing climate change – having, on a local scale, an even greater impact than the greenhouse gases effect. Attempts to understand how these particles influence clouds have generated many uncertainties.

A new paper by Dr. Ilan Koren of the Weizmann Institute Environmental Studies and Energy Research Department and Dr. Yoram Kauffman of the NASA/Goddard Space Flight Center, USA,* published in *Science Express* online, weaves together two opposing effects of atmospheric aerosols to provide a comprehensive picture of how they may be affecting our climate.

Cloud formation is dependent upon the presence of small amounts of aerosols such as sea salt and desert dust. These tiny particles serve as the seeds around which water vapor in the air condenses, forming tiny water droplets that rise as they release heat. As the small droplets rise, they collide and merge with larger droplets. When the droplets reach a critical size, gravity takes over, causing them to fall from the cloud in the form of rain.

One of the controversies surrounding the extent of aerosol impact on climate change is the duality of their influence. On the one hand, Koren and his colleagues previously found evidence to suggest that the extra seeds planted in the atmosphere by the emission of man-made aerosols (pollution, forest fires, and fuel combustion) lead to more, but smaller-sized, water droplets. The formation of larger water droplets by the collision process is less efficient and, therefore, rainfall is suppressed. The smaller droplets are lifted higher up into the atmosphere, creating larger and taller clouds that will persist longer. Not only does this alter the whole water cycle, but the increased cloud cover reflects more of the sun's radiation back into space, creating a local cooling effect on Earth.

But to complicate matters, Koren, in another study, showed that certain types of aerosols – those containing black carbon – can also decrease cloud cover, ultimately leading to a warming effect. This occurs as black carbon absorbs part of the sun's radiation, warming the surrounding atmosphere and reducing the difference in temperature between the Earth’s surface and the upper atmosphere. This combination prevents atmospheric instability – the condition needed to form clouds and rain. A stable atmosphere means fewer clouds; fewer clouds mean less reflection of sunlight; less reflection of sunlight and absorption of radiation lead to warming.

Policy makers have argued that, in the bottom line, the warming effect of the greenhouse gases and the (mainly cooling) aerosol effect may balance each other out so that the net global climate change will be small. Koren argues that it is the local climate change that is problematic: Clouds may persist without releasing their rain over regions where they would normally precipitate, such as rainforests, and move to precipitate over regions where rain is not needed, such as oceans. Or the effect could lead to the warming up of cold and the cooling down of hot regions. These additional effects to the already problematic warming by greenhouse gases could have disastrous repercussions in the long run.

Also controversial is the question of how such tiny localized particles affect weather systems thousands of kilometers away from their sources.

There is no doubt that aerosols do play a role, but the skeptics believe it is negligible compared to meteorological key players such as temperature, pressure, the amount of water vapor in the air, and wind strength.

What Koren needed was a way to separate meteorological from aerosol influences – something which was lacking in his previous studies. Together with Kauffman, he used a network of ground sensors (AERONET) to measure the effect of aerosol concentration on cloud cover. Radiation absorption is less affected by meteorology, so if the skeptics are right and meteorology is the main influence, then the correlation between aerosol absorption and cloud cover should have been seen in only a few circumstances. But this was not the case. They observed the duality effect on clouds: As total aerosols increase, cloud cover increases; and as radiation absorption by aerosols increases, cloud cover decreases – for all locations, for all seasons. Backed up with a mathematical analysis, it becomes harder to deny that it is, in fact, aerosols that have the major influence.

"We hope that this study has finally provided closure," says Koren. "Hopefully policy makers will start to tackle the issue of climate change from a different perspective, taking into account not only the global impact of aerosols and greenhouse gases, but local effects too."

* Dr. Yoram Kauffman, one of the leading researchers in atmospheric aerosols, was recently killed while riding his bike near the Goddard Space Center.

Dr. Ilan Koren’s research is supported by the Samuel M. Soref and Helene K. Soref Foundation; and the Sussman Family Center for the Study of Environmental Sciences.

Source: Weizmann Institute of Science