CLOUDS: THE WILD CARD OF CLIMATE CHANGE

Will Clouds Speed Or Slow Global Warming?

THE BIG QUESTION

It is a little-known but significant fact that about 70 percent of the Earth's surface is covered by clouds at any given time. But not all clouds are the same; different types of clouds affect the Earth's climate differently. While some types of clouds help to warm the Earth, others help to cool it.

Currently, all of the Earth's clouds together exert a net cooling effect on our planet. But the large and opposing influences of clouds on the Earth's climate begs the question: What will be the net effect of all of the Earth's clouds on climate as the Earth continues to warm in the future? Will clouds accelerate warming or help offset, or dull, warming? Right now, "The scientific community is uncertain about how the effects of clouds will change in the future," says Hugh Morrison, a scientist at the National Center for Atmospheric Research (NCAR) in Boulder, Colo.

That's why, in 1997, the Intergovernmental Panel on Climate Change (IPCC) described clouds as "the largest source of uncertainty" in predictions of climate change. To reduce this uncertainty and improve predictions of climate change/global warming, scientists are now working to better understand the relationships between clouds and climate.

THE ENGIMA OF CLOUDS

Clouds--those cotton puffs in the sky--are but collections of water droplets and tiny ice particles suspended in the sky. But even with their limited types of components, clouds are complex. This complexity is reflected in their nonstop, weather-portending parades across the sky--all the while, as they move, swiftly forming and dispersing; changing hues from alabaster whites to mercurial grays; and billowing into new heterogeneous shapes that are frequently so amorphous they lack so much as defined edges.

As clouds continually change and dance across the horizon, they invariably create a mesmerizing, ethereal mystique.

But many of the very same characteristics that give clouds their mesmerizing mystique also make them vexing, perplexing and difficult for scientists to study. These characteristics include their ephemeral, short life-spans, constant motion, ever-changing shapes, wispy, heterogeneous structures and high altitudes; clouds may reach 12 miles or more above the Earth.

Another factor that helps shroud clouds in mystery is their status as multi-scale phenomena. That is, the behavior of clouds is determined by complex phenomena operating at a wide range of scales, including:

- cloud particles that are fractions of a millimeter across;
- individual clouds that are a few kilometers in diameter;
- cloud systems that range over many kilometers; and
- weather systems that cover many thousands of kilometers.

What's more, cloud phenomena that occur on any particular scale may influence cloud phenomena occurring at other scales. For example, large-scale cloud movements, which are controlled by factors such as wind and turbulence, affect micro-processes, such as the formation of rain droplets, snow and hail, the speed at which these forms of precipitation fall, and their changing shapes.

And by the same token, the formation of rain droplets, snow and hail may influence large-scale phenomena, such as the sizes, shapes and life-spans of entire clouds. Therefore, in order to predict cloud behavior, scientists must not only understand cloud phenomena occurring within various scales, but also the interactions between differently scaled cloud phenomena.

Since clouds interact with their environment over a wide range of scales, according to Morrison, a key to understanding the role of clouds in climate is to better understand these multi-scaled phenomena. Scientists are currently feverishly working to better understand intra and inter cloud processes by continually collecting and analyzing data on clouds and by improving the power of computer models to predict cloud behavior.

CLOUD CLOUT AND DOUBT

The IPCC reported in 2007 that it projects the Earth's average temperature to be about 1.8 to 4 degrees Celsius higher by the end of the century than it was in 1900--a rapid rate of increase compared to observed rates of increase in the Earth's recent history. Scientists could probably narrow down the Earth's projected temperature range further if they better understood the relationships between clouds and climate as well as other factors, such as the amount of greenhouse gases that will be pumped into the atmosphere by 2100.

Most scientists doubt that the net cooling effect of clouds will ever be large enough to completely offset ongoing warming. But many scientists say that if warming were to increase the number or kind of cooling clouds or decrease the presence of warming clouds, the current net cooling effect of clouds on the Earth's climate would probably increase, and thereby moderate, or offset, ongoing warming.

If warming were to continue, the net cooling effect of clouds would increase and, in a negative feedback loop, perpetuate the moderating force on ongoing warming provided by clouds. The result: The Earth's end-of-the-century temperature may be pulled down toward the lower end of its predicted range.

But, if on the other hand, warming were to increase the number or kind of warming clouds or decrease the presence of cooling clouds, scientists say the current net cooling effect of clouds on the Earth's climate would probably decrease; and an important moderating force on ongoing warming would thereby diminish. The result: The Earth's end-of-the-century temperature may be pushed up towards the upper end of its predicted range.

This resulting rise in temperature would, in a positive feedback loop, tend to promote the formation of even more warming clouds or further reduce the presence of cooling clouds. Either way, temperatures would rise even higher. This temperature increase would tend to further increase the presence of warming clouds or decrease the presence of cooling clouds, and thereby perpetuate the warming cycle.

CLOUDS: A SHADY DEAL OR WARM PUFFS?

Why do different types of clouds impact climate differently? The climactic impacts of the three most important types of clouds--stratus, cirrus and cumulus--depend on their heights and thicknesses.

- **Stratus clouds:** These clouds hang low in the sky--usually within two kilometers of the Earth's surface--and resemble a gray blanket covering thousands of miles of sky. Because these clouds block sunlight from reaching the Earth, they act like a sunscreen or shady umbrella that helps cool the Earth. Therefore, they have a net cooling effect that helps offset warming.

- **Cirrus clouds:** These clouds are wispy and feathery, and positioned up to 20 kilometers above the Earth's surface. Cirrus clouds let much sunlight pass through them and may also trap the Earth's heat, just as greenhouse gases do. Therefore, they have a net warming effect that helps magnify warming.

- **Cumulus clouds:** These clouds look like balls of cotton that extend vertically high in the sky. Cumulus clouds, which have sharply defined edges, may form alone, in lines or in clusters. Cumulus clouds can block sunlight, but also trap the Earth's heat. Their net effect on warming depends on their heights and thicknesses.