Clouds of (slightly less) unknowing

Researchers are beginning to understand aerosols and clouds better. The result is to lower estimates of how much they cool the climate

Clouds and aerosols have long been two of the more mysterious forces in the climate. They sometimes warm and sometimes cool the Earth. The net effect, it was thought, was that they offset part of the overall warming trend, which would have been greater had it not been for their influence. But the details were obscure.

They still are, but much less so. Scientists' improved understanding of clouds and aerosols is, says Piers Forster of the University of Leeds, "the most interesting development since AR4". That acronym refers to the fourth assessment report of the Intergovernmental Panel on Climate Change (IPCC), which was published in 2007. The first parts of its successor, the fifth assessment, were published on September 27th and 30th. And the upshot of its assessment of clouds and aerosols is that their cooling effect looks less strong than it did.

The mystery about aerosols starts with their size and variety. A cubic centimetre of air typically contains thousands of suspended liquid or solid particles. These are aerosols. They vary in size from being a few nanometres to several microns across—that is from billionths of a metre to millionths of one. Often, aerosols such as sulphates and soot are man-made. Others, such as sea spray, are natural. If suspended in the lower atmosphere they hang around for only a few days. In the stratosphere they can stay up for more than a year.

This variety makes it hard to calculate their effect on the climate. Some reflect sunlight back into space, cooling the Earth. Others warm it by absorbing that light. The cooling effect dominates. But the variety generates uncertainty.

Better measurements have begun to pierce this uncertainty. Laboratory techniques such as photoacoustic measurements (a biomedical-imaging method used to investigate cancers) make it possible to look at how individual aerosol particles behave. This matters, because it turns out that the ability of an aerosol to, for example, absorb water (which affects its influence on clouds) depends on its size and composition. An aerosol's property of scattering or absorbing heat also depends partly on its size. So, argues Ilona Riipinen of Stockholm University, scientists can now be more precise about which aerosols do what.

They have also gained a better understanding of how aerosols evolve. Such particles do not just float around unchanged. Sulphates, for example, grow from vapours into clusters of a few molecules and then into nanometre-sized particles. The rate at which these clusters emerge depends on the presence of compounds such as ammonia and amines.

Armed with greater detail about what aerosols look like and how they behave, researchers have been able to paint a more accurate picture of how they affect clouds, and hence the climate. Clouds grow on aerosols: that is, water droplets or ice crystals form on aerosol particles. The more particles there are, the more numerous the water droplets and the more reflective the cloud. That connection is well established and is the main reasons for the link between aerosols, clouds and global cooling.

But there was thought to be a secondary connection which added to the cooling. If more particles grow from a given amount of vapour, each has to be smaller. That means the droplets which form on them are smaller too, and that means a cloud is less likely to produce rain or snow and more likely to reflect even more radiation. It turns out, though, that this secondary influence is not as strong as was once thought—ie, there is not as much extra cooling. But one particular aerosol is more influential than had previously been calculated. This is soot, which absorbs heat, as black things do. There is more of it around than previously thought. It is also blacker than was realised.

Putting all these influences together, the new assessment reckons the net effect of aerosols is minus 0.82 watts per square metre of the Earth's surface (ie, a cooling of that amount). In the 2007 assessment, the IPCC reckoned the cooling was larger: minus 1.2 watts per square metre.

Tracking uncertainty

New research into the impact of clouds goes further. Like aerosols, clouds vary greatly, as any landscape painter knows. A rule of thumb for their impact on the climate is that low clouds reflect sunlight and also let through heat radiated back from the Earth's surface, thus cooling things down. High clouds let sunlight through and also trap outgoing heat, thus warming things up. So—as with aerosols—the climate science is all about which clouds matter and where they are.

Some of the more important turn out to be those in the temperate zones of both hemispheres (ie, in latitudes that embrace America and Europe in the northern hemisphere, and the southern cone of Latin America and southern Australia in the southern). These are referred to as "mid-latitude storm tracks".

Over the past 30 years, storm-track clouds have moved a couple of degrees north or south, towards the poles. This movement has had three effects, all tending towards greater warming. Because there is less sunlight near the poles, less is reflected away by low clouds (though there is slightly less outgoing heat to be trapped, too). And more sunlight is streaming through at those lower latitudes which are being vacated by the storm-track clouds (for example, at the southern edge of the northern track, meaning the Mediterranean and Texas). More sunlight, more heat. Lastly, it seems that at the higher latitudes where the storm tracks are treading, there are more high clouds and fewer low ones. Again, that implies more warming.

Intriguingly, argues Frida Bender of Stockholm University, there may be a connection between the poleward movement of clouds and climate sensitivity, which measures how much the global climate would warm up if it settled on a new equilibrium in response to a doubling of carbon-dioxide concentrations. Climate models which predicted the shift towards the poles also had higher estimates for climate sensitivity. This presumably reflects the importance of clouds and aerosols to the climate. However, in its new report the IPCC has lowered its estimate of climate sensitivity, partly because of a 15-year pause in the rising trend of surface temperatures. It remains to be seen how this lowering of sensitivity fits with an improved understanding of clouds. The picture may be slightly clearer than it was. But it remains—ahem—cloudy.

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