# Predicting warming effect of human-induced greenhouse gases

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The warming effect of human-induced greenhouse gases is a given, but to what extent can we predict its future influence? That is an issue on which science is making progress, but the answers are still far from exact, say researchers from the Hebrew University of Jerusalem, the US and Australia who have studied the issue and whose work which has just appeared in the journal *Science*.

Indeed, one could say that the picture is a "cloudy" one, since the determination of the greenhouse gas effect involves multifaceted interactions with cloud cover.

To some extent, aerosols –- particles that float in the air caused by dust or pollution, including greenhouse gases – counteract part of the harming effects of climate warming by increasing the amount of sunlight reflected from clouds back into space. However, the ways in which these aerosols affect climate through their interaction with clouds are complex and incompletely captured by climate models, say the researchers. As a result, the radiative forcing (that is, the disturbance to the earth's "energy budget" from the sun) caused by human activities is highly uncertain, making it difficult to predict the extent of global warming.

And while advances have led to a more detailed understanding of aerosol-cloud interactions and their effects on climate, further progress is hampered by limited observational capabilities and coarse climate models, says Prof. Daniel Rosenfeld of the Fredy and Nadine Herrmann Institute of Earth Sciences at the Hebrew University of Jerusalem,

author of the article in Science. Rosenfeld wrote this article in cooperation with Dr. Steven Sherwood of the University of New South Wales, Sydney, Dr. Robert Wood of the University of Washington, Seattle, and Dr. Leo Donner of the US National Oceanic and Atmospheric Administration. .

Their recent studies have revealed a much more complicated picture of aerosol-cloud interactions than considered previously. Depending on the meteorological circumstances, aerosols can have dramatic effects of either increasing or decreasing the cloud sun-deflecting effect, the researchers say. Furthermore, little is known about the unperturbed aerosol level that existed in the preindustrial era. This reference level is very important for estimating the radiative forcing from aerosols.

Also needing further clarification is the response of the cloud cover and organization to the loss of water by rainfall. Understanding of the formation of ice and its interactions with liquid droplets is even more limited, mainly due to poor ability to measure the ice-nucleating activity of aerosols and the subsequent ice-forming processes in clouds.

Explicit computer simulations of these processes even at the scale of a whole cloud or multi-cloud system, let alone that of the planet, require hundreds of hours on the most powerful computers available. Therefore, a sufficiently accurate simulation of these processes at a global scale is still impractical.

Recently, however, researchers have been able to create groundbreaking simulations in which models were formulated presenting simplified schemes of cloud-aerosol interactions, This approach offers the potential for model runs that resolve clouds on a global scale for time scales up to several years, but climate simulations on a scale of a century are still not feasible. The model is also too coarse to resolve many of the fundamental aerosol-cloud processes at the scales on which they actually

occur. Improved observational tests are essential for validating the results of simulations and ensuring that modeling developments are on the right track, say the researchers.

While it is unfortunate that further progress on understanding aerosol-cloud interactions and their effects on climate is limited by inadequate observational tools and models, achieving the required improvement in observations and simulations is within technological reach, the researchers emphasize, provided that the financial resources are invested. The level of effort, they say, should match the socioeconomic importance of what the results could provide: lower uncertainty in measuring man-made climate forcing and better understanding and predictions of future impacts of aerosols on our weather and climate.

**More information:** "Climate Effects of Aerosols-Cloud Interactions." Daniel Rosenfeld, Steven Sherwood, Robert Wood, Leo Donner. *Science* VOL 343 24 JANUARY 2014

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