Brightening clouds: Atmospheric scientists evaluate a technique for reflecting more sunlight back to space

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When aerosol particles from ship exhaust enter the lower atmosphere, marine stratocumulus clouds are brightened, leaving “ship tracks” visible in satellite images. Credit: Jeff Schmaltz, MODIS Rapid Response Team, NASA/GSFC.

(PhysOrg.com) -- What happens when tiny seawater particles are intentionally injected into low clouds over the ocean? To answer this question, scientists at Pacific Northwest National Laboratory and the National Oceanic and Atmospheric Administration developed a high-resolution model to better understand the effects of particle injection and evaluate whether this technique could be used to offset some effects of global climate change. The study was published in the journal *Atmospheric Chemistry and Physics*.

Droughts. Floods. Extreme weather events. To alleviate some of the consequences of global climate change, some climate experts propose geo-engineering, the deliberate manipulation of the planet's climate. One such proposal calls for offsetting climate warming by brightening marine stratocumulus clouds. Brighter clouds reflect more sunlight back into space, reducing the amount of heat absorbed by the earth. While not an endorsement of this proposal, the PNNL-NOAA research provides fundamental information for evaluating the practicality of cloud brightening and similar geo-engineering concepts.

"The geo-engineering concept of cooling the Earth by making clouds brighter was proposed more than two decades ago, but we are still at a very preliminary exploration stage. The purpose of our research is to not only better understand the physics of cloud brightening, but also understand potential unintended consequences, such as shifting weather patterns or effects on Arctic sea ice" said Dr. Hailong Wang, a PNNL atmospheric scientist who led the research team.

Located in the boundary layer, the lowest level of the earth's atmosphere, marine stratocumulus clouds cover vast areas of the ocean surface. When aerosol particles from ship exhaust enter these clouds, tell-tale "ship tracks" are visible in satellite images. One proposal to offset some effects of climate change envisions a global fleet of wind-driven, unmanned ships designed to spray tiny seawater particles into low ocean clouds. Like ship exhaust, injected aerosols composed of seawater particles brighten clouds by causing water droplets become smaller and more numerous.

The PNNL-NOAA research team ran model simulations of aerosol injection using a high-resolution version of the Weather Research and Forecasting (WRF) model to investigate how the injected particles are transported through the marine boundary layer and how they affect the microphysical processes inside clouds. Interactions of aerosols, clouds

and rain were studied across several sets of experiments. Each set combined different meteorological and aerosol background conditions observed off the coast of California. The injection of seawater particles was simulated in the model using moving point sources, closely mimicking the behavior of the conceptual seawater spraying vessels.

The simulations confirm that aerosol injection does brighten clouds, but the amount of solar radiation reflected may not be enough to balance the global warming caused by burning fossil fuels. The amount of sunlight reflected also depends on several factors, including the distribution of injected aerosols, ambient levels of water vapor and pollution, and the timing of aerosol injections (because cloud brightening is only meaningful in the daytime). Also, the PNNL-NOAA study team found that adding aerosols changes the amount of rain falling from clouds, which is an important result because changes in rainfall and other climate variables may have even larger impacts than changes in temperature alone.

The research team will compare the model results with satellite and in situ observations of ship tracks and other disturbances and will extend the computer model experiments to other geographical regions, meteorological conditions, and cloud types.

More information: Wang H, et al: "Manipulating marine stratocumulus cloud amount and albedo: a process-modelling study of aerosol-cloud-precipitation interactions in response to injection of cloud condensation nuclei," *Atmospheric Chemistry and Physics*, 11, 4237-4249, DOI:10.5194/acp-11-4237-2011 , 2011.

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