Scientists use satellites to measure how pollution particles affect clouds

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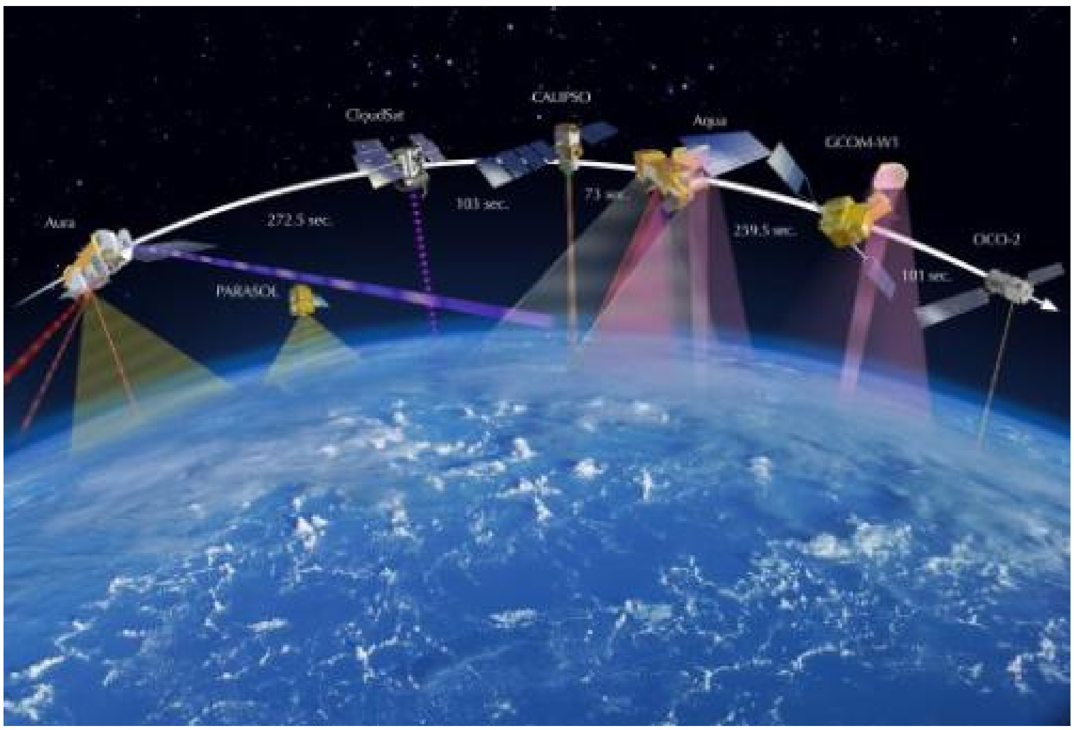

Described as a satellite constellation, the A-Train is shown in this artist's conception. The close timing and engineering of these satellites along a track means that they function as if they were all on the same platform. Data collected by the A-Train gave scientists in this study more complete information on atmospheric particles around the globe. Photo: NASA.

(Phys.org)—Grabbing a virtual tiger by the tail, scientists led by researchers at Pacific Northwest National Laboratory directly linked a cloud's inclination to rain to its effects on the climate. Using global satellite data and complex calculations, they were able—for the first time—to develop a proxy measurement for one of the most vexing questions in atmospheric science: how tiny particles in the atmosphere affect the amount of cloud. Using this new metric, they showed that aerosols' effects on clouds are overestimated by as much as 30 percent in a global climate model.

"Our study helps narrow the large aerosol-cloud interaction uncertainties in projections of future global warming," said Dr. Minghuai Wang, atmospheric scientist at PNNL and lead author of the study. "Wide ranges of estimates in aerosol effects on clouds have made it challenging to understand how clouds really affect the climate."

Understanding clouds and their effects on climate is a formidable challenge in trying to predict how the climate will change by the end of the century. On the line are questions of future melting of the polar ice, drought and water shortages, and increases in extreme weather events. One particularly tough question is how tiny pollution-caused particles in the atmosphere will affect clouds. This study shows how satellite observations can be used to hone in on aerosol effects on clouds and make it possible to better understand how clouds will affect climate.

"The use of satellite observations in studying climate processes like these is absolutely critical because it is the only way to obtain cloud and aerosol measurements over the whole globe," said Dr. Mikhail Ovchinnikov, PNNL atmospheric scientist and co-author of the study.

The study, led by PNNL scientists, constructed a new metric for rain frequency susceptibility, then closely correlated that metric to the aerosol effect on cloud amount, which is the total amount of water in the cloud and the cloud's size. This metric, along with satellite measurements, was then used in three global climate models to find new ranges of cloud amount change due to pollution-caused aerosol particles, compared to current estimates.

The team, for the first time, used "A-Train" satellite observations which collect coincident global measurements of aerosols, clouds, and precipitation to develop a new metric, termed rain frequency susceptibility or "S-POP." This metric provides a quantitative measure of the sensitivity of rain frequency to the amount of aerosols in clouds. They showed how S-POP is closely correlated to aerosols' effects on cloud amount, using three global climate models, including a multi-scale aerosol climate model developed at PNNL (PNNL-MMF) that embeds a cloud-resolving model at each grid column of a host global climate model.

Finally, the relationship between S-POP and the aerosol effects on cloud amount from the global climate models together with the observed rain frequency susceptibility from A-Train observations were used to estimate aerosol effects on cloud amount in global climate models. They showed that in one global model, the National Center for Atmospheric Research'sCommunity Atmosphere Model version 5 (CAM5), aerosol effects on clouds were overestimated by 30 percent.

This research also provides a guide for the development and evaluation of new parameterizations, techniques to computationally represent complex small-scale systems, of aerosol effects on clouds in global climate models.

The researchers plan to apply S-POP to evaluate cloud amount based on rain frequency susceptibility in other global climate models, and guide further improvement of the aerosol indirect effects estimations in CAM5 and the PNNL-MMF multi-scale aerosol-climate model.

More information: Wang M, SJ Ghan, X Liu, T L'Ecuyer, K Zhang, H Morrison, M Ovchinnikov, RC Easter, RT Marchand, D Chand, Y

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