Current strategies using satellite data limit the accuracy of space-based estimates of how aerosols brighten clouds

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All cloud liquid drops and ice crystals originate on small particles called aerosols. Therefore, clouds can be sensitive – or susceptible – to particle variations in space and time that affect cloud characteristics such as their extent, lifetime, reflectivity, and precipitation. Computer model estimates of cloud susceptibility to aerosols frequently disagree with satellite susceptibility estimates and indicate that model clouds are more susceptible than real clouds.

To investigate the differences between model and satellite estimates of cloud susceptibility to aerosols, scientists at the U.S. Department of Energy's Pacific Northwest National Laboratory led a study using satellite simulators, which mimic in a model the procedure and information content that satellite instruments use to view clouds and aerosols from space.

Although models still have easily identified weaknesses in representing critical processes affecting susceptibility, the team found that a lot of the discrepancies between models and satellite estimates could be explained by limitations in the procedure and the information content used in the satellite retrieval, especially in clean (low aerosol) environments.

This study identified the components of common satellite aerosol retrieval procedures that can contribute to errors in satellite estimates of susceptibilities. The study showed that discrepancies are reduced when

similar procedures are used to examine models and real-world data in the presence of noise and the kind of information available from satellites compared to evaluations that ignored the compromises currently used to estimate susceptibility from space.

The study suggests that current satellite estimates do not serve as a strong constraint on model behavior, and that conventional model-satellite comparison approaches that ignore the compromises made in producing satellite estimates may lead to scientific misunderstanding and drive model development efforts in the wrong direction. The paper also suggests ways in which more accurate susceptibility and forcing estimates can be obtained from current lidar products that will make the comparison more fair and consistent.

Aerosol-cloud interactions remain a major uncertainty in Earth system research. Studies indicating that model estimates of cloud susceptibility to aerosols frequently exceed satellite estimates have motivated model reformulations to increase agreement. This study showed that conventional ways of using satellite information to estimate cloud susceptibility to aerosols can serve as only a weak constraint on models because the estimate is sensitive to errors in the retrieval procedures.

Using satellite simulators to investigate differences between model and satellite estimates of susceptibilities, researchers found that satellite procedures could not characterize susceptibility in low aerosol loading conditions, a situation in which theory and models suggest clouds are particularly susceptible. Scientists quantified the observational requirements needed to constrain models and found that nighttime lidar measurements of aerosols provided a better characterization of these tenuous conditions.

The research team concluded that observational uncertainties and limitations must be accounted for when comparing models and

observations to understand the role of aerosols in the climate system.

More information: Po-Lun Ma et al. Observational constraint on cloud susceptibility weakened by aerosol retrieval limitations, *Nature Communications* (2018). DOI: 10.1038/s41467-018-05028-4

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