Research Highlights

Coupling Clouds and Land to Mitigate Aerosol-Cloud Uncertainties

Aerosol-cloud interactions have a notable influence on the Earth's energy and water cycles. However, they remain a significant source of uncertainty in climate modeling. This uncertainty is partly due to the incompleteness of current measurement approaches for capturing aerosols at the cloud level, leading to inadequate representations that go into models.

A May 2024 paper presents a new approach to tackling aerosol-cloud interactions by better representing the aerosol particles that serve as cloud condensation nuclei. Rather than relying just on satellite and ground-based sensors, which assume uniform mixing in the vertical direction, scientists used field measurements, including aircraft data, from ARM's Southern Great Plains atmospheric observatory. The data helped them gain detailed insights that aid in the quantification of aerosol-cloud interactions.

"The discrepancies between observations and model estimates of aerosol-cloud interactions have been a persistent challenge in our community," said lead author Tianning Su of Lawrence Livermore National Laboratory in California. "Our study focused on how cloud-surface coupling can influence aerosol-cloud interactions."

They found that in a coupled system, interactions with aerosols from the lower atmosphere lead to an increased efficiency of particles activated into more, smaller cloud droplets and stronger aerosol-cloud interactions. In decoupled systems where cloud and surface interactions are weak, aerosols from the free atmosphere predominantly influence cloud properties. There is a disconnect between the cloud properties and boundary-layer aerosols, leading to weaker aerosol-cloud interactions and inconsistencies in aerosol measurements and cloud properties.

"Using either ground-based or spaceborne measurements of aerosol loading can lead to biases in estimates of aerosol-cloud interaction," said the University of Maryland's Zhanqing Li, who oversaw the research. "This is likely a major contributor to the discrepancies found between observational and model-based estimates."

This work underscores the critical importance of accounting for cloud-surface coupling in analyzing aerosol-cloud interactions. Incorporating information about land surface influences can lead to more accurate estimates of aerosol-cloud interactions and the overall climate.

Cloud-surface coupling, involving the exchange of aerosols, humidity, and turbulence between the land surface and cloud base, can influence aerosol-cloud interactions.

Reference

Su, T, Z Li, N Henao, Q Luan, and F Yu. 2024. "Constraining effects of aerosol-cloud interaction by accounting for coupling between cloud and land surface." *Science Advances* 10(21), https://doi.org/10.1126/sciadv.adl5044.

All Highlights for FY2024 Journal Articles