Coupling between cloud and land surface changes aerosol-cloud interactions

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Main drivers of climate change



IPCC, 2013

Aerosol radiative forcing







ARM observations

Southern Great Plains (SGP):





https://www.arm.gov/capabilities/instruments

Linkage between surface, PBL, and cloud



Cloud-PBL coupling is equivalent to cloud-land coupling over land

Su et al., 2022, ACP

Retrievals of cloud-land coupling

Dynamic evidence from Doppler lidar



Highlight in DOE ARM Annual Report

Cloud-Land Coupling Examined at Southern Great Plains Observatory

ARM

2022

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ATMOSPHERIC RADIATION MEASUREMENT

OENERGY

Cloud-Land Coupling Examined at Southern Great Plains Observatory

Connections between the surface and clouds are important for understanding how clouds develop. Most previous work on these connections has centered on oceans rather than land. Data from ARM's Southern Great Plains atmospheric observatory allowed researchers to study the coupling between clouds and land.

In research published by Atmospheric Chemistry and Physics in January 2022, scientists simultaneously measured the planetary boundary-layer height and coupled states under cloudy conditions. A lidar-based method developed by the researchers relies on the planetary boundary-layer height, lifted condensation level (the altitude at which a moist but unsaturated air parcel becomes saturated), and cloud base height to identify cloud coupling.

As coupled and decoupled clouds have distinct features, the new method offers an advanced tool to separately investigate them. Researchers generated a 20-year climatology by using the method.

Reference

Su T, Y Zheng, and Z Li. 2022. "Methodology to determine the coupling of continental clouds with surface and boundary layer height under cloudy conditions from lidar and meteorological data." *Atmospheric Chemistry* and Physics 22(2):1453-1466, https://doi.org/10.5194/acp-22-1453-2022.



Analyzing data from the MOSAIC expedition, scientists noted a difference in ice-nucleating particle concentration scales between different temperatures. Error bars represent standard deviation. (Copyrighted image from the journal.)

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One of nine studies highlighted in the Annual Report

How does the coupling process affect aerosol-cloud interactions?



Estimation of aerosol-cloud interaction



Can aerosol proxy represent aerosols near clouds?

Cloud-land coupling can answer this question

DISCOVER-AQ Campaigns











Cloud-land coupling affects aerosol distributions



Cloud coupling changes responses of clouds to aerosol



Constraining aerosol indirect radiative effects by accounting for cloud-land coupling

Aerosol first indirect effect (PD-PI)



The neglect of cloud coupling results in an underestimation of aerosol-cloud interaction



Su et al. under review.

Summary



References

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