Cloud condensation nuclei closure study using HI-SCALE field campaign data – preliminary results

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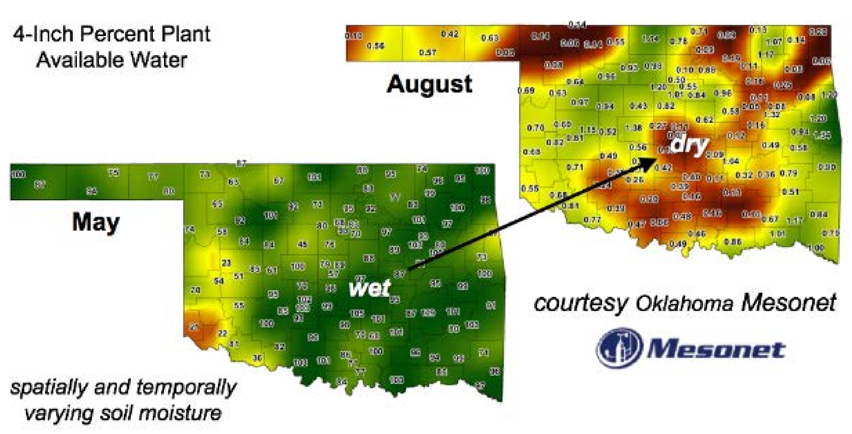
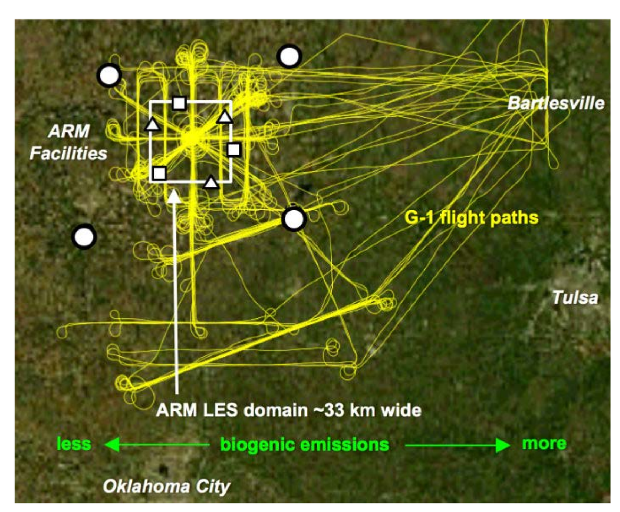
Cloud condensation nuclei (CCN) closure studies involve comparing measured CCN concentrations with theoretical predictions that are based on simultaneously measured aerosol physical and chemical composition data. Such closure experiments provide a theoretical basis to predict the CCN concentrations of the aerosol that is essential for understanding and modeling aerosol-cloud interactions.

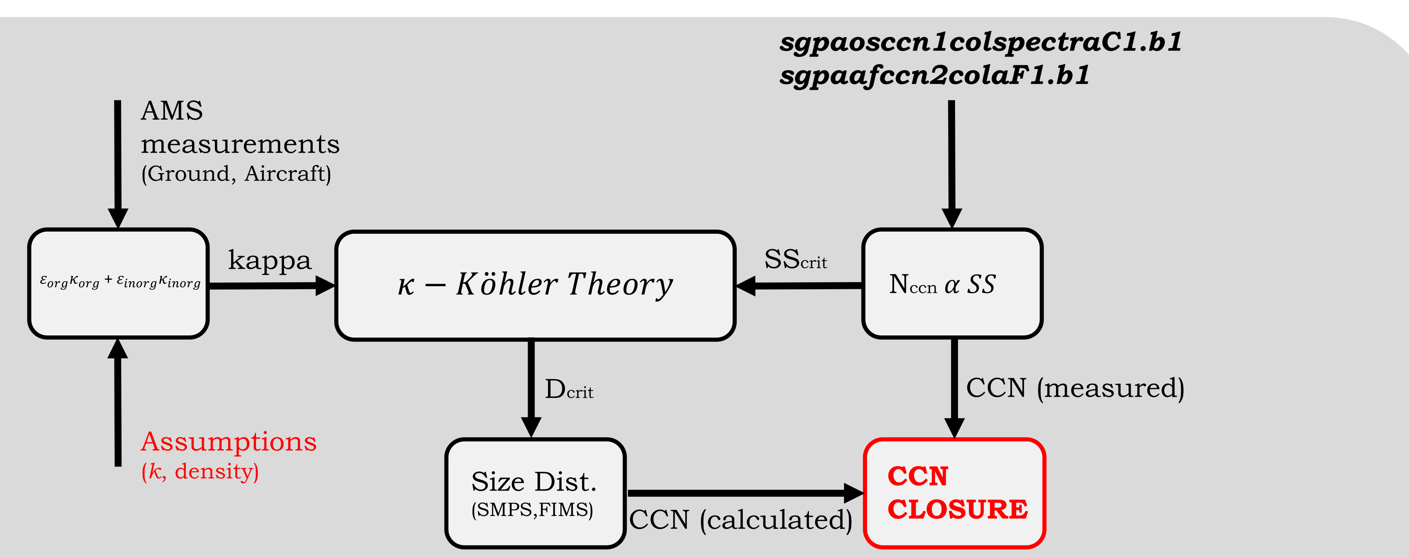
The Holistic Interactions of Shallow Clouds, Aerosols, and Land-Ecosystems (HI-SCALE) campaign was designed to provide a detailed set of measurements that are needed to obtain a more complete understanding of the lifecycle of shallow clouds by coupling cloud macrophysical and microphysical properties to land surface properties, ecosystems, and aerosols.[a]



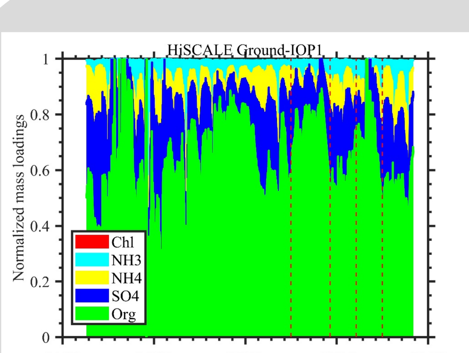
Soil moisture distribution during May and August of 2016. [a]



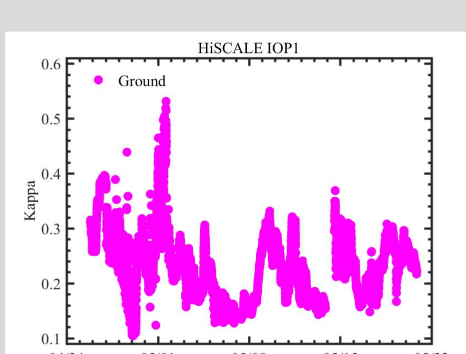
Flight paths during first HI-SCALE IOP1 (April/May 2016). [a]



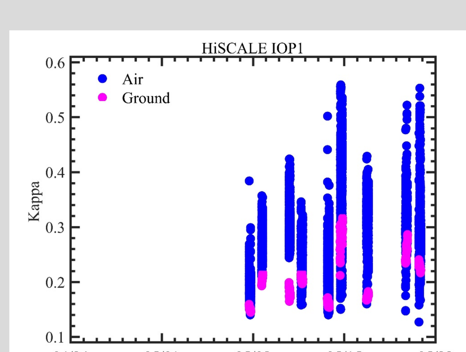
CCN Closure methodology using CCN, composition and particle size measurements. For airborne closure SS = 0.24% and only out-cloud measurements are used.



Bulk composition from ground AMS measurement showing normalized mass fractions of reported five chemical species. Closure for days corresponding to vertical dashed lines are shown.



Time series of kappa distribution during IOP1. kappa for organics and inorganics was assumed 0.1 and 0.7 for the calculation. The composition was assumed uniform across the size distribution.

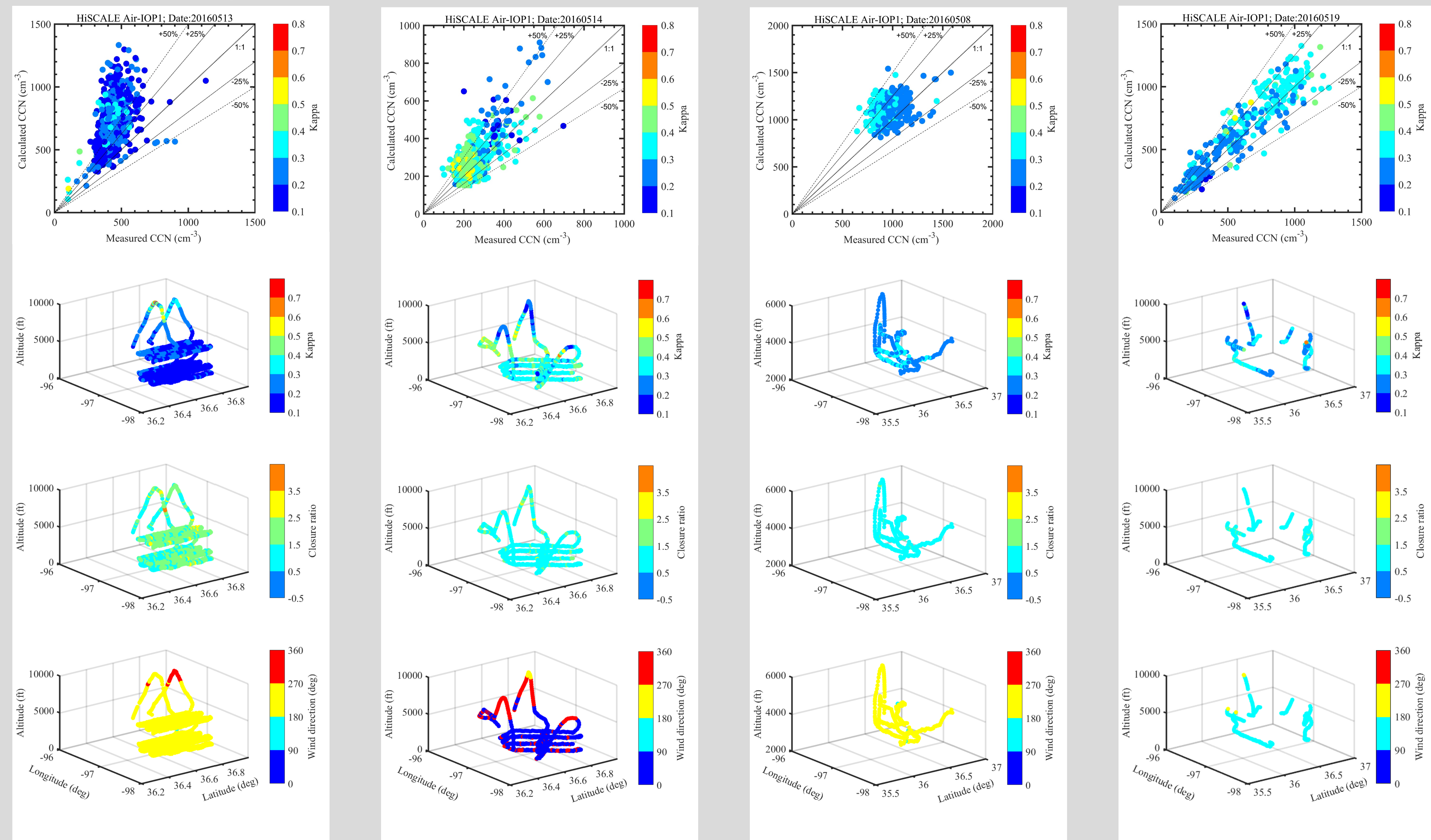


Comparison of kappa using measurements from G1-aircraft and SGP ground site. Kappa from ground shows little variation compared to airborne.

Goodness of Closure

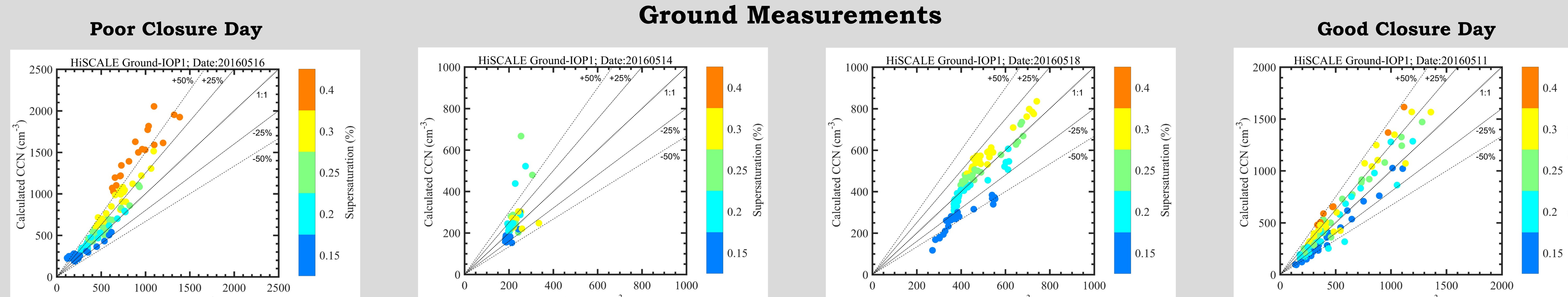
Aircraft Measurements

Poor Closure Day — **Good Closure Day**



Ground Measurements

Poor Closure Day — **Good Closure Day**



Summary

The bulk hygroscopicity parameter kappa (*k*) was calculated using individual *k* and density values of organics and sulfate chemical components. Airborne *k* shows wide variability compared to ground measurements. Closure studies based on *k*-Köhler theory showed that ratio of predicted to measured CCN concentration varied between 0.5 to 2.5. Poor closure is defined when calculated CCN is overpredicted by more than 50%. Different variations of individual *k* components were tested but did not yield significant improvement in closure. Results shows that goodness of closure depend upon the direction of transported air mass to the site indicating importance of composition and mixing state. More in-depth analysis are ongoing to understand these correlations.

Future Work

Sensitivity of the closure results will be investigated using: size-resolved particle chemical composition, number of different assumption of mixing state and composition measurements, and in/out-cloud sampling conditions. These studies would help us to understand the applicability of *k*-Köhler theory in cloud models and to quantify the prediction uncertainties associated with the simple assumptions of composition.

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[a] Fast J, L Berg, C Burleyson, J Fan, Z Feng, S Hagos, M Huang, A Guenther, A Laskin, M Ovchinnikov, J Shilling, M Shrivastava, H Xiao, R Zaveri, A Zelenyuk, C Kuang, J Wang, J Smith, D Turner, and P Gentine. 2017. Holistic Interactions of Shallow Clouds, Aerosols, and Land-Ecosystems (HI-SCALE) Field Campaign Report. Ed. by Robert Stafford, ARM Climate Research Facility. DOE/SC-ARM-17-014.

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