Fair-weather clouds hold dirty secret

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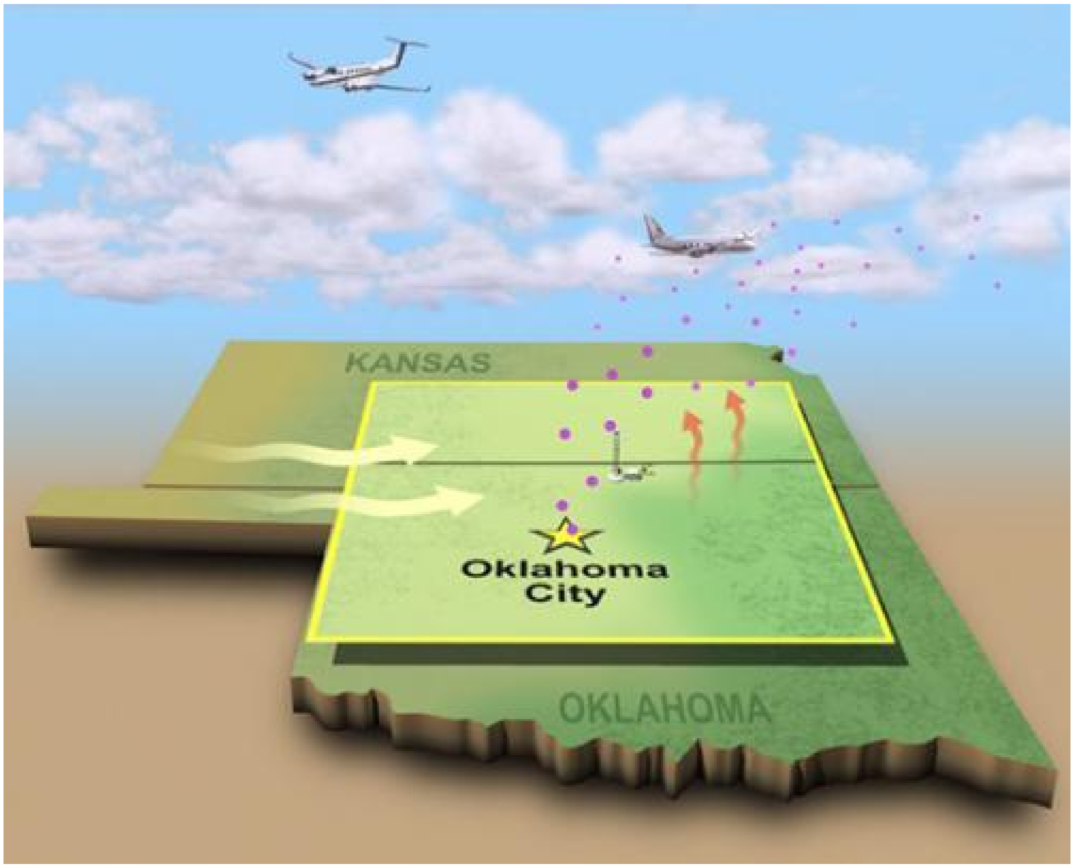
Scientists are looking into the true nature of fair-weather cumulus clouds. They may appear innocuous, but researchers show that they contain an increasing number of particles released from human-caused pollution. Credit: ARM Climate Research Facility

(Phys.org) —Their fluffy appearance is deceiving. Fair-weather clouds have a darker side, according to scientists at Pacific Northwest National Laboratory. Fair-weather cumulus clouds contain an increasing amount of droplets formed around pollution particles. The new simulations, using data collected over Oklahoma, show how pollution from Oklahoma City increased the number of cloud droplets and reduced their size, affecting their sunlight absorbing, light scattering and cloud-seeding performance.

"The results of this study show a regional model's ability to represent several aspects of cloud and aerosol interactions within short-lived, shallow cumulus clouds," said atmospheric scientist and lead author Dr. Manish Shrivastava. "Our research indicates that pollution may be changing clouds in many more locations than we previously thought."

When aerosols-tiny particles of dust and chemicals in the air-interact with clouds, they affect the climate in several ways. They do this by heating or cooling the atmosphere through changes in the amount of sunlight absorbed or reflected by the clouds, and also by changing the cloud's lifetime. How clouds affect aerosols and aerosols affect clouds are the toughest interactions for climate models to simulate.



Air currents sweep over Oklahoma City to pick up both naturally occurring and man-made particles affecting fair-weather clouds in the vicinity. Scientists collected size and chemical composition information on cloud droplets and the atmospheric particles between clouds with aircraft-based measurements during a field campaign to study cumulus clouds in 2007. Their results are revealing new information about the climate impact of these small-scale fair-weather clouds.

Previous studies have focused on sheet-like clouds called stratiform or tall, deep storm clouds termed deep convection. But seemingly innocuous fair-weather clouds occur more frequently in many areas and thus have more opportunity to affect the climate. Like tiny minnows in a large ocean, small and wispy cumulus clouds escape the coarse fish-net of global models. In this study, researchers used a popular regional meteorological-chemical model to capture these shallow cumulus clouds, showing their true impact.

The research team conducted coupled cloud-aerosol-meteorology simulations using the Weather Research and Forecasting with Chemistry (WRF-Chem) model to examine cloud-aerosol interactions observed during the 2007 field study over Oklahoma City called Cumulus Humilis Aerosol Processing Study (CHAPS). During the CHAPS campaign, data was collected using instruments aboard the U.S. Department of Energy's Gulfstream-1 (G-1) research aircraft. They collected measurements below, within and above clouds using a Counterflow Virtual Impactor and an isokinetic inlet to sample large cloud droplets and non-activated interstitial aerosols, respectively.

The researchers modified the WRF-Chem model to increase computational efficiency and predictive ability for secondary organic aerosols using the 2-species volatility basis-set and coupled it with the Model for Simulating Aerosol Interactions and Chemistry (MOSAIC) to represent inorganic aerosols. In this way, the model delivered better predictions of aerosol chemical composition and size. The team then compared model predictions and field observations to understand how cloud chemistry changes the chemical composition of particles embedded within clouds and how the particles related to human activities change the effective size distribution of cloud droplets within fair-weather shallow cumuli.

Results from this study are being used as a baseline to evaluate a new computationally efficient parameterization for cumulus clouds developed at PNNL. The study covers the treatment of small-scale shallow cloud processes within coarser grid chemical transport models. The new revised cumulus parameterization will significantly improve representations of aerosol-cloud interactions within coarse-grid regional models.

More information: Shrivastava, M. et al. 2013. Modeling aerosols and their interactions with shallow cumuli during the 2007 CHAPS field study. *Journal of Geophysical Research: Atmospheres*, 118(3):1343-1360. DOI:10.1029/2012JD018218.

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