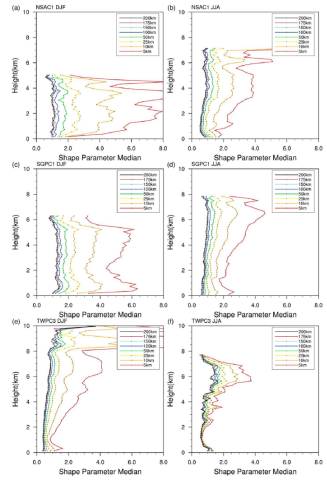
Scale#Aware Parameterization of Liquid Cloud Inhomogeneity and Its Impact on Simulated Climate

Research Highlight

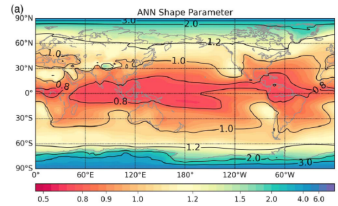
The subgrid distribution of cloud liquid water is known to impact radiation and microphysics processes in climate models. Its parameterization usually assumes a fixed parametric distribution such as what was used in the Community Earth System Model (CESM). The parameters often need to be tuned for different resolutions of the model. A more physically based approach is desired.

Using long-term radar-based ground measurements from the Atmospheric Radiation Measurement (ARM) program, we derived the inhomogeneity parameter of cloud liquid water as represented by the shape parameter of a Gamma distribution. We found a relationship between the inhomogeneity parameter and the model grid size as well as atmospheric conditions. A larger grid scale and more unstable atmosphere are associated with larger inhomogeneity. This relationship is implemented as a scale-aware parameterization of the liquid cloud inhomogeneity in the CESM. Relative to the default CESM with the finite-volume dynamic core at 2-degree resolution, the new parameterization reduces the cloud inhomogeneity in high latitudes and increases it in low latitudes. This is due to both the smaller (larger) grid size in high (low) latitudes in the longitude-latitude grid setting of CESM and the more stable (unstable) atmosphere. The new parameterization leads to increases in the cloud liquid water path in polar regions and decreases in low latitudes.

A scale-aware parameterization of the subgrid scale inhomogeneity of cloud liquid water was developed for climate models by using ARM data. It has been implemented in CESM.



The shape parameter of cloud water inhomogeneity from ARM CMBE data at NSA C1, SGP C1, and TWP C3 sites in DJF and JJA. Different colors represent different scales as shown in the legend.



Annual mean of the shape parameter of the subgrid-scale cloud water from the new parameterization in CESM at 2° resolution. The default model uses 1.0 as the shape parameter.

Reference(s)

Xie X and M Zhang. 2015. "Scale-aware parameterization of liquid cloud inhomogeneity and its impact on simulated climate in CESM." Journal of Geophysical Research – Atmospheres, 120(16), doi:10.1002/2015JD023621.

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Cloud Life Cycle