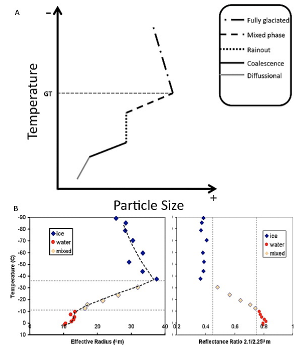
Estimating Glaciation Temperature of Deep Convective Clouds with Remote Sensing Data

Research Highlight

Homogeneous freezing is inefficient at temperatures much warmer than approximately -38°C, the temperature at which most water droplets transform into ice particles instantaneously, except for extremely large drops. Knowledge about the vertical structure of cloud phase and associated latent heat release is needed to better understand our global atmosphere circulation and better predict future climate. Currently, there is no good observational constraint on glaciation temperature (GT), the temperature above which water content inside clouds is all in ice phase, in our climate models. In most models and some retrieval techniques a threshold of GT is assumed.

We propose a technique to estimate the deep convective cloud (DCC) glaciation temperature using passive remote sensing data. It is based on a conceptual model of vertical hydrometeor size profiles inside DCCs. Estimates from the technique agree well with our general understanding of the problem. Furthermore, the link between vertical profiles of cloud particle size and hydrometeor thermodynamic phase is confirmed by a 3D cloud retrieval technique. The technique is applied to aircraft measurements of cloud side reflectance, and the result was compared favorably with an independent retrieval of thermodynamic phase based on different refractive indices at 2.13 µm and 2.25 µm.

The technique presented here offers a powerful tool to fill in the sparse observational record of the level of cloud phase transition. The technique can be applied at the regional and global scales to give better constraints on the glaciation level currently assumed in passive and active retrieval method of ice water path and in global regional models. We also see this information offering an opportunity to supplement latent heat and precipitation retrievals from the TRMM satellite and from GPM in the future. Furthermore, we found that the glaciation level in a cloud is sensitive to environmental conditions such as continental versus maritime. Part of those differences can be traced to the different thermodynamic conditions and atmospheric circulations, while part may be also due to the availability of aerosols: cloud condensation nuclei and ice nuclei that affect the cloud microphysical structure. With our method, we can investigate the correlations between environmental conditions, aerosol concentrations, and cloud glaciation properties on regional to global scales. Separating out any thermodynamic and dynamic influences will help us unravel the complex aerosol effects on deep convective clouds, which will have major implications for aerosol-induced changes to latent heat release, precipitation patterns, and radiative properties of DCCs.



(a) A conceptual diagram of cloud particle size vertical evolution inside a deep convective cloud. (b) Cloud side scanner retrievals of (left) particle size and (right) cloud phase.

Reference(s)

Contributors

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Working Group(s)

Cloud Life Cycle