Studying Mixed-phase Cloud Properties with in Situ and Remote Sensing Measurements

Zhien Wang (zwang@uwyo.edu), Damao Zhang, Jing Yang, Xiaohong, Liu, Tao Luo, Min Deng, and Yong Wang
University of Wyoming

Summary

Mixed-phase clouds are poorly simulated in models due to our limited understanding. Our efforts focus on characterizing and understanding stratiform and convective mixed-phase cloud properties and their connections with aerosols by combining ACRF multi-sensor remote sensing with other measurements. This poster summarizes our recent activities and progresses. 1) Development of an advanced multi-sensor retrieval algorithm for stratiform mixed-phase clouds: In addition to liquid and ice phase water contents and effective particle sizes, the algorithm is capable to provide ice number concentration. The combined lidar-radar IWC retrievals in these clouds are extensively evaluated with collocated airborne remote sensing and in situ measurements during STROMVEX/CAMPS. The improved algorithm is applied to long-term ACRF measurements at the NSA site. 2) Quantifying of dust impact on mixed-phase clouds: Strong dust impacts in stratiform mixed-phase clouds (**SMC**) are identified from observations and are used to evaluate the Community Atmospheric Model version 5 (CAM5) simulations. 3) Liquid/ice mass partition in convective mixed-phase clouds: Due to precipitation or dominated contribution of warm liquid to the total column liquid water, there are limited ground-based remote sensing capabilities to explore the liquid/ice partition in these clouds. Analyses of in situ data are performed to provide insights of the liquid/ice partition in fresh convective between -5 and -18°C. 4) Mixed-phase cloud parameterization improvement: With the observed aerosol dependency of ice number concentrations, we are testing ice microphysics parameterization in CAM5.

An advanced multi-sensor retrieval algorithm for stratiform mixed-phase clouds

Inputs: Cloud radar, MWR, lidar (MPL or HSRL), temperature profile

Outputs: Ice phase: IWC, general effective radius, and Ice concentration in the mixed-phase layer
liquid phase: LWC, LWP, effective radius and droplet concentration

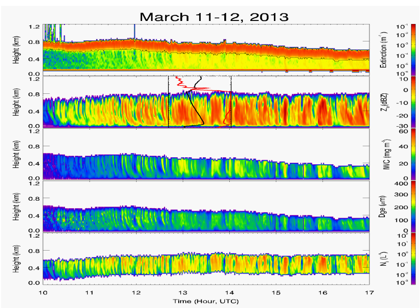


Figure 1. An retrieval example of ice phase cloud properties

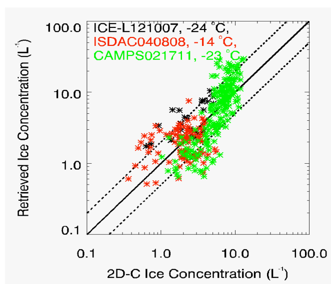


Figure 2. A comparison of radar retrieved ice concentrations with 2D-C measurements for three stratiform mixed-phase clouds systems during ICE-L (black), ISDAC (red) and CAMPS (green) field campaigns.

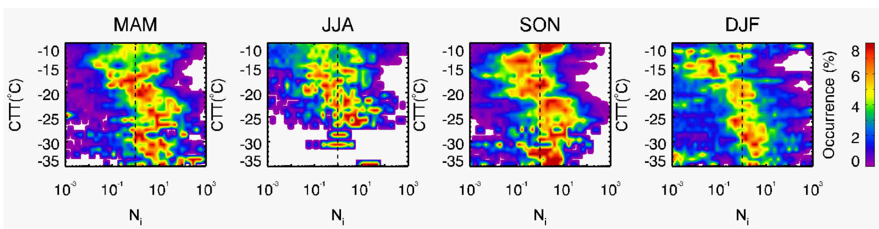


Figure 3 Seasonal variations of retrieved ice concentrations as a function of Cloud Top Temperature (CTT) in SMCs at the NSA site.

Dust Impact on Stratiform Mixed-phase Clouds

Observed Dust impact at the NSA site

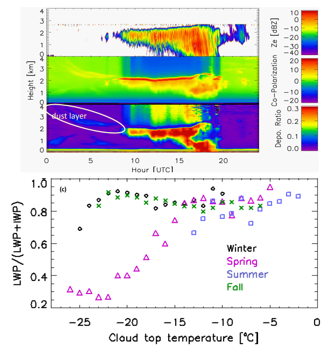


Figure 4. Top: an example of dust influenced SMC (29 March 2008); Bottom: the high occurrence of dust at the NSA site during Spring season results in lower liquid mass partitions at temperature colder than -15 degree than the other seasons.

Observed Dust impact on middle-level SMCs over the dust belt

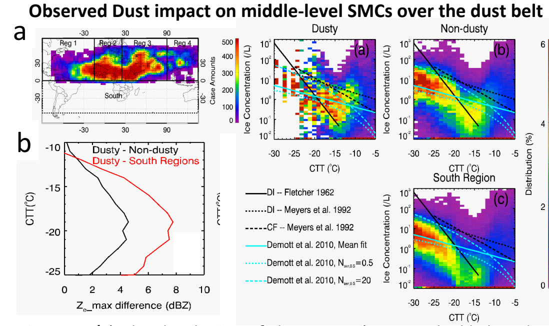


Figure 5: (**a**) The distribution of dusty SMC (SMCs embedded in dust layers) based on 4-year CloudSat and CALIPSO measurements. (b) Z_e_max differences between dusty, non-dusty and 'South Regions' SMCs as a function of CTT for similar SMCs; a 8-dB peak Ze difference indicating a factor 6 difference in concentration. (c) Retrieved ice concentrations for different dusty conditions in the context of several ice concentration parameterizations.

Liquid/ice mass partition in convective mixed-phase clouds

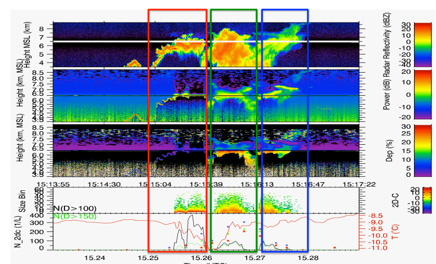
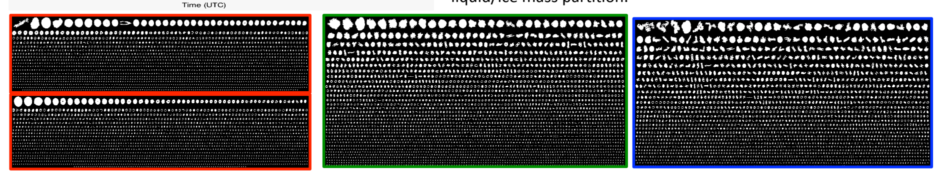


Figure 6. C-130 penetration of three convective turrets during their different life stages (red box- developing stage, green box- dissipating stage, blue box—remnants).

Left: from top are up and down cloud radar reflectivity, lidar power, lidar linear depolarization,2D-C size distributions and large particle concentration and flight level temperature.

Bottom: images of 2D-C images showing liquid-ice transition among the different developing stages. In the developing stage, large drops and small droplets are dominated. In the dissipating stage, larger ice particles are dominated. In the remnants, almost all are ice. Over aircraft 50 penetrations of convective clouds between -5 and -18°C are being analyzed now to characterize liquid/ice mass partition.



Mixed-phase cloud parameterization improvement

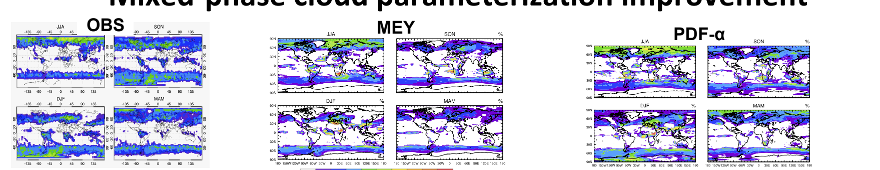


Figure 7. Comparison of observed supercooled liquid fraction (%) with two CAM5 runs: one with Meyers et al. ice nucleation parameterization (MEY), and one with a physically-based parameterization linking to dust and soot (PDF-alfra).