M.S. Defense Announcement
Murakami Yasutaka
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M.S. Defense

January 30, 2020
1:00 p.m.

Defense
ATS West Seminar Room (121 ATS West)

Post Defense Meeting
Riehl Conference Room (211 ACRC)

Committee:
Christian Kummerow (Adviser)
Susan van den Heever (Co-adviser)
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On the Relation between Satellite Observed Liquid Water Path, Cloud Droplet Number Concentration and Cloud Base Rain Rate and Its Implication for the Auto-Conversion Rate in Stratocumulus Clouds

Stratocumulus clouds are low-level convective clouds that developed within atmospheric boundary layer. Their persistence and broad coverage of the earth's surface produces important impacts on the global radiation energy budget and hydrological cycle. Precipitation processes of these stratocumulus clouds play a large role in its longevity and spatial distribution through its interaction with the vertical profiles of humidity and temperature within the atmospheric boundary layer. This has led to a number of field campaigns to understand the precipitation processes of stratocumulus clouds. Because of the limited domain and small amount of these observations, however, it is difficult to draw a statically significant conclusion on the precipitation processes of global stratocumulus clouds from these data. In this study, space-borne observations from A-Train satellites are utilized to obtain robust relation among liquid water path, cloud droplet number concentration and cloud base rain rate for three regions with similar large-scale environments, namely the north east Pacific off the coast of California, the south east Pacific off the coast of Peru and the south east Atlantic off the coast of Namibia, where strong subsidence flow from the subtropical-high is observed.

Radar reflectivity from Cloudsat's Cloud Profiling Radar is employed to estimate cloud base rain rate. Liquid water path (LWP) and Cloud droplet number concentration (Nd) are estimated from MODIS cloud optical thickness and effective radius. The relation between cloud base rain rate and the ratio of liquid water path to cloud droplet number concentrations (LWP/Nd) are obtained from a large number of A-train observations that show similar probability density distribution for all three target areas in this study. Cloud base rain rate has a positive correlation with LWP/Nd and its rate of increase becomes larger as LWP/Nd increases, which is consistent with the result from previous ground-based observations. The results also show that cloud base rain rate to LWP/Nd increases more slowly at larger Nd regions, which suggests that the relation between cloud base rain rate and LWP/Nd changes with different cloud droplet number concentrations. These findings are consistent with our cloud physical understandings that 1) auto-conversion and accretion growth of rain embryos becomes more effective as cloud droplet number concentrations near cloud top becomes smaller, and 2) auto-conversion is suppressed when cloud droplet radius is small enough.

The sensitivity of the auto-conversion rate on cloud droplet number concentration is investigated by examining pixels with small LWP whose cloud base rain rate is considered to have little influence from the accretion process. The upper limit of the dependency of auto-conversion on the cloud droplet number concentration is discussed from the relation between cloud base rain rate and cloud top droplet number concentration since the sensitivity is exaggerated by the accretion process. The upper limit of the sensitivity of auto-conversion found in this study was cloud droplet number concentration to the power of -1.44 ± 0.12. This study demonstrates that satellite observations are capable of detecting the average behavior of how precipitation processes are modulated by the liquid water path and drop number concentrations.