A Comparison of Heating Rates and Related Cloud Properties from CloudSat and ARM Observations at Manus Island

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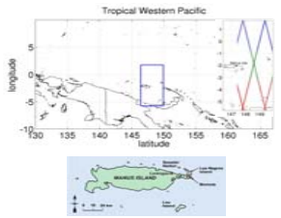
Introduction

Radiative heating is an important processes linking cloud, water vapor and tropical dynamics in both local and large-scale circulation. Here we analyze retrieved cloud properties and radiative heating rates from both ARM and CloudSat. These retrievals differ due to both the different measurement perspectives and retrieval schemes used.



Data description

- CloudSat: 2B-GEOPROF, 2B-CWC-RO and 2B-FLXHR products, Jun 2006 to Sep 2007.
- ARM: ARSCL product, combined cloud properties retrieval and heating rate calculation, Jan 2007 to Mar 2007

Direct comparison

- All-sky heating maximum are at different levels.
- Clear-sky heating rates agrees well.
- All-sky low level difference comparable to clear-sky contribution.

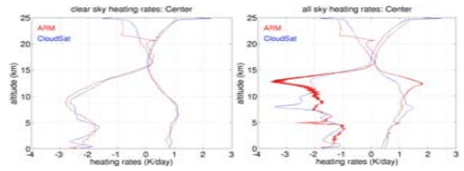
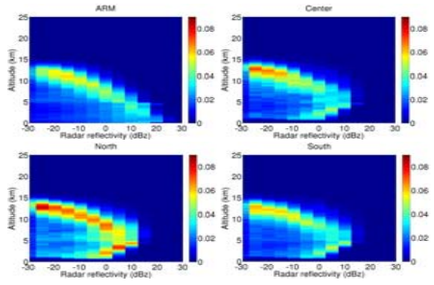


Figure 2: Shortwave and longwave heating/cooling rates are in red for CloudSat and in blue for ARM.

Radar reflectivity



- Here we compare ARM obsservations with CloudSat observations for three “cells” near the ARM site.
- “Moving-block bootstrap” resampling method is applied to CloudSat statistics to produce 95% confidence levels.
- Northern cell has higher cloud occurrence at all levels than the other two cells and the ARM site.
- CloudSat central and southern cell statistics agree well with ARM measurements between 5~10 km.

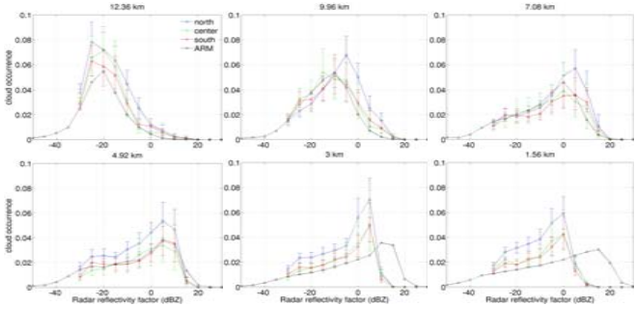


Figure 4: Error bar indicate the 95% confidence level of CloudSat Z_e statistics. Each CloudSat overpass are divided into four parts. The block length is 2.

- Low cloud occurrence for ARM at 12km is probably due to attenuation from below.
- Differences at 1.5km and 3km are probably due to different behavior 35GHz radar and 94GHz radar in precipitation.

Categorized heating rates and cloud water content

- Choose outgoing longwave radiation (OLR) as the classification criterion.
- Aggregate the heating rate and cloud water content profiles by OLR regimes and calculate the statistics in each regime.

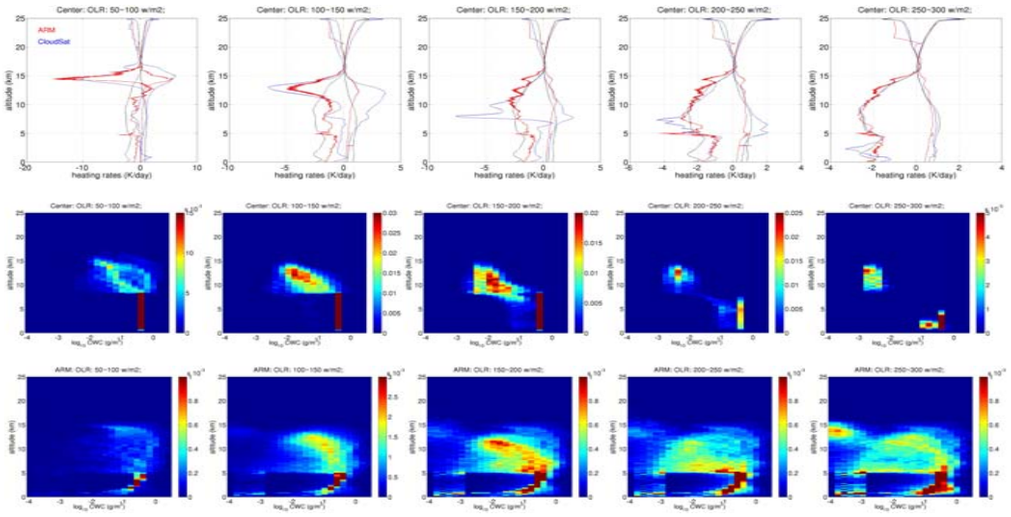


Figure 3: Heating rates calculated from ARM data are in red lines, CloudSat in blue and CloudSat clear-sky in black. Only CloudSat data in central cell are demonstrated here.

- The ARM retrievals in 100~150 w/m^2 OLR regime is dominant and bring its 13km heating feature into the all-sky profile. CloudSat produce strong heating at 7km in 100~200 w/m2 OLR regime, which could be artificial effect of misplacement of ice-water interface.
- ARM CWC combines several retrievals algorithms, using radar, lidar, and microwave radiometer observations. The main scheme for ice cloud uses radar reflectivity & Doppler velocity. The ARM scheme produces a broader distribution of ice CWC than is obtained by the CloudSat reflectivity only algorithm.

Conclusion

- Radar reflectivity from CloudSat and ARM cloud radar exhibit good agreement.
- CloudSat and ARM retrievals produce similar heating rates but different level of heating maximum.
- A better understanding of mixed-phase cloud is required to remove artificial heating.
- ARM CWC profiles in 100~150 w/m^2 regime and CloudSat profiles in 100~200 w/m^2 regime dominates their contribution to the total heating.