Anvil Clouds of Mesoscale Convective Systems and Their Effects on the Radiative Heating Structure

ASR Science Team Meeting
March 2010, Bethesda, MD

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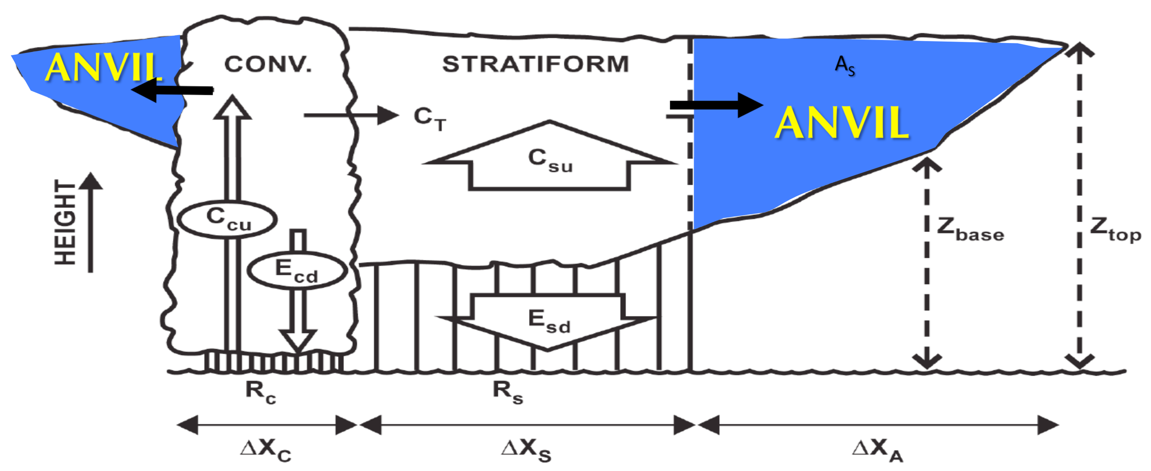
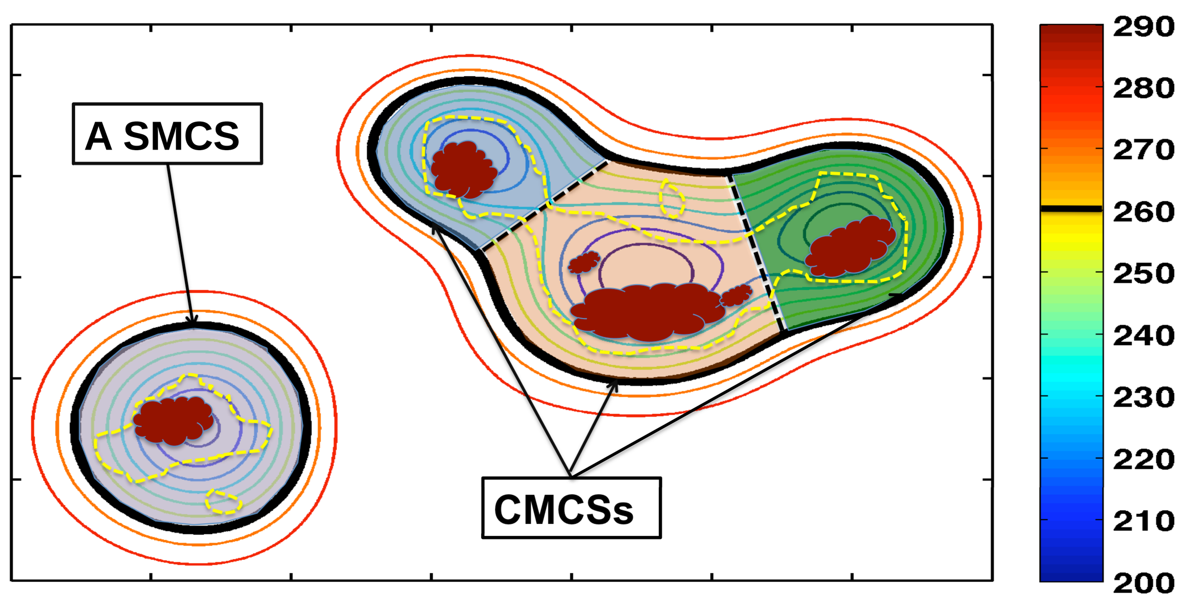
Introduction

Mesoscale convective systems (MCSs) are objectively identified (*Yuan and Houze 2010a*). Active MCSs are further divided into two types: separated MCS (SMCS) and connected MCS (CMCS). Combining three types of A-Train data (MODIS, AMSR-E and CloudSat) allows us not only to identify MCSs but also to separate their non-raining anvils from their raining regions. Hence, we are able to have quantitative global maps of anvil coverage and the global impact of MCS diabatic heating structure can be more comprehensively investigated.



Identify Active MCSs



Solid-thick black contour lines: Tb11=260 °K
Semi-Transparent masks: Indexed High Cloud Systems (HCS)
Dark red patches: High Rain rate Area (HRA, r >6 mmhr^{-1})
Gold dashed thick lines: Precipitation Features (PF, r>1 mmhr^{-1})

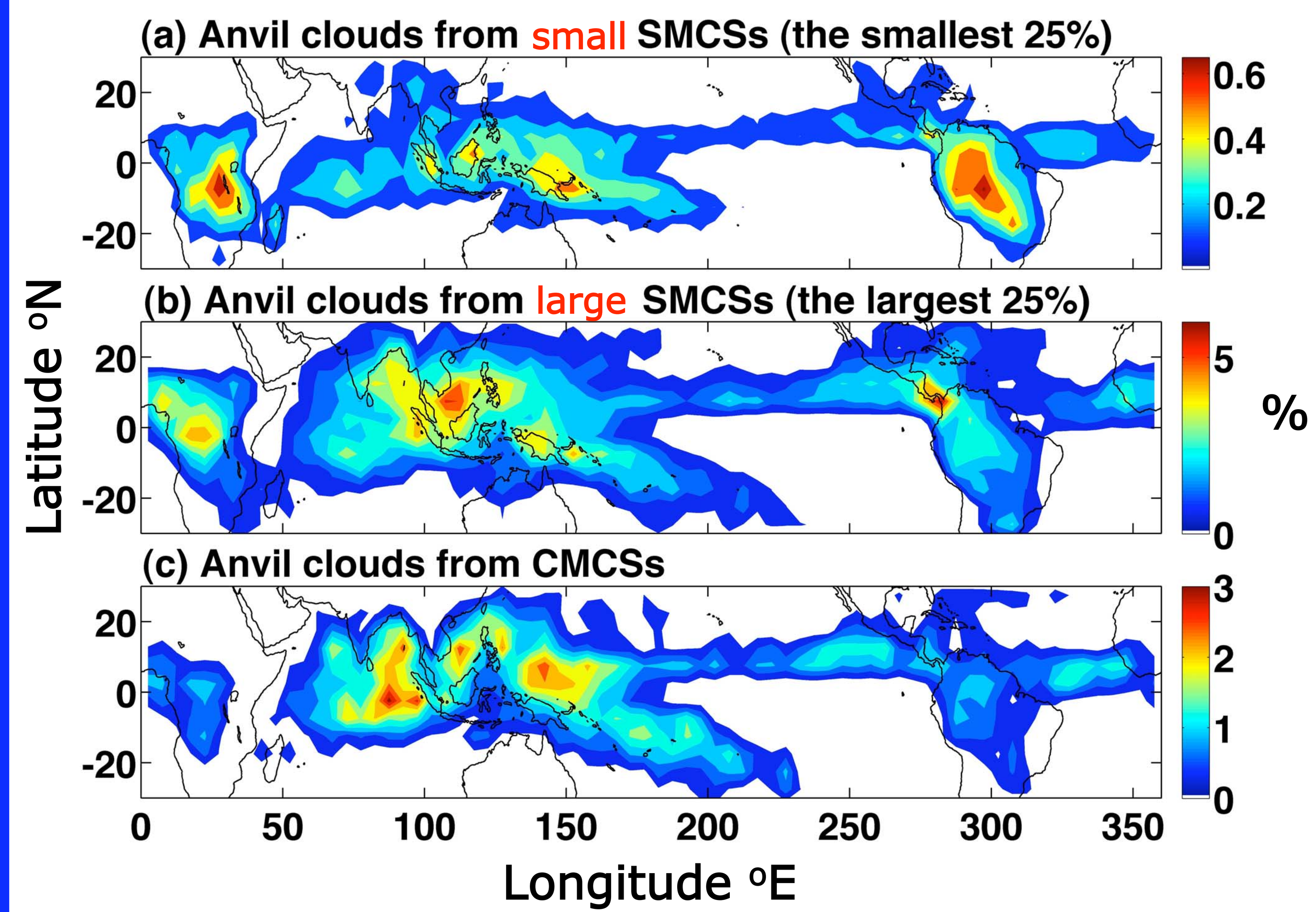
Any HCSs whose *largest* Rain Core (RC1) satisfies the following criteria:

1. Exceeds 2000 km^2 in total area
2. Accounts for >70% of the total area with rain >1 mm h^{-1} inside the HCS
3. Minimum cloud-top temperature above the RC1 is <220 K
4. More than 10% of the RC1 is occupied by HRA

SMCS/CMCS
The RC1 of the MCS is part of a PF that contains less than 3/at least 3 dominant RCs of any MCS.

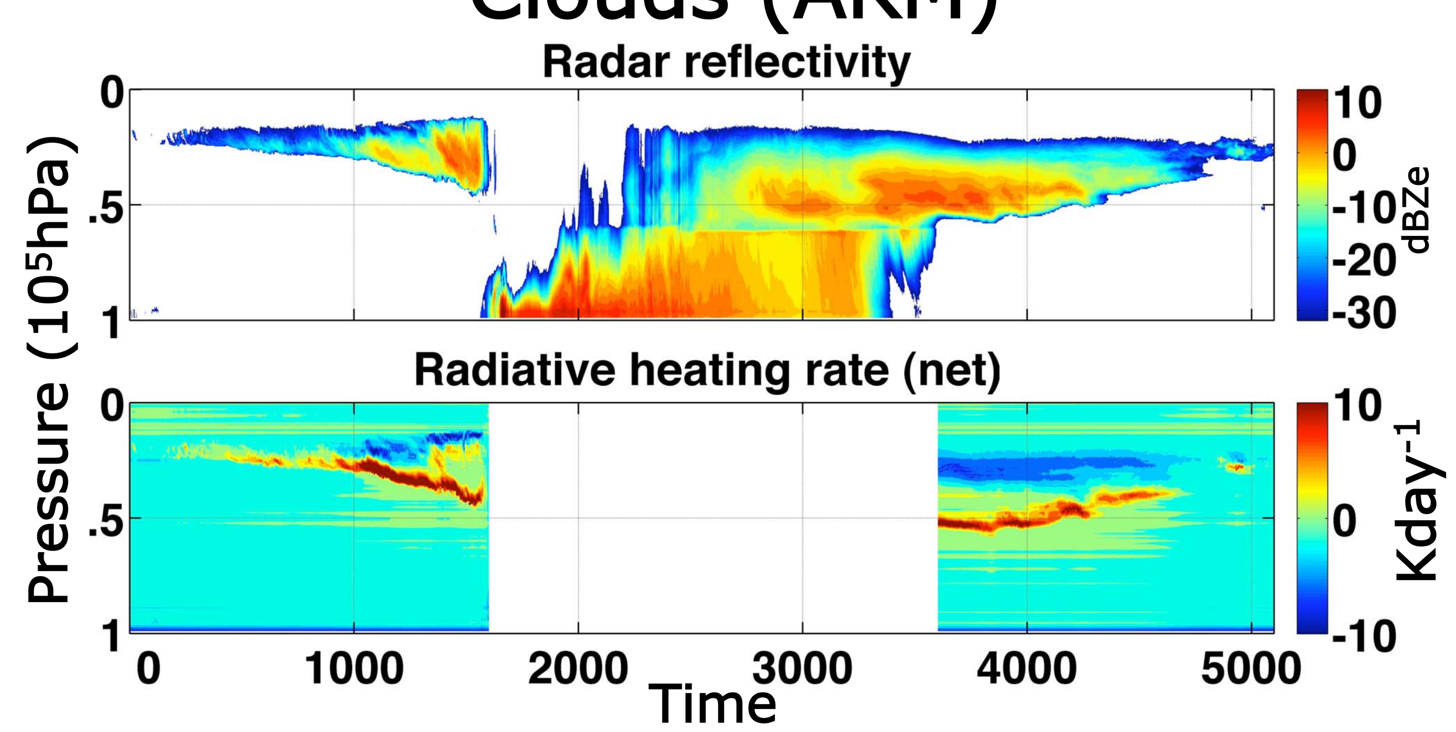
*(please see **Yuan and Houze 2010a** for detailed information about MCS identification)*

Annual Mean Coverage of Anvil Clouds of Active MCSs



- Anvil clouds from small SMCSs happen more frequently over two continental convective regions and large islands.
- Anvil clouds from large SMCSs tend to occur more over warm ocean areas. They cover several times more area overall than do small SMCSs.
- Anvil clouds from CMCSs are common over open ocean areas, with most of them occurring over the Indian Ocean-West Pacific warm pool.

Radiative Heating of MCS Anvil Clouds (ARM)



- Radiative heating calculations are based on ARM ground radar measurements and sounding data at Niamey.
- Ice cloud properties follow *Liu and Ilingworth* (2000), *Heymesfield and McFarquhar* (1996) and Fu (1996). Fu-Liou model (*Fu and Liou* 1992) is used.
- Long-wave radiation dominates daily averaged heating profile.

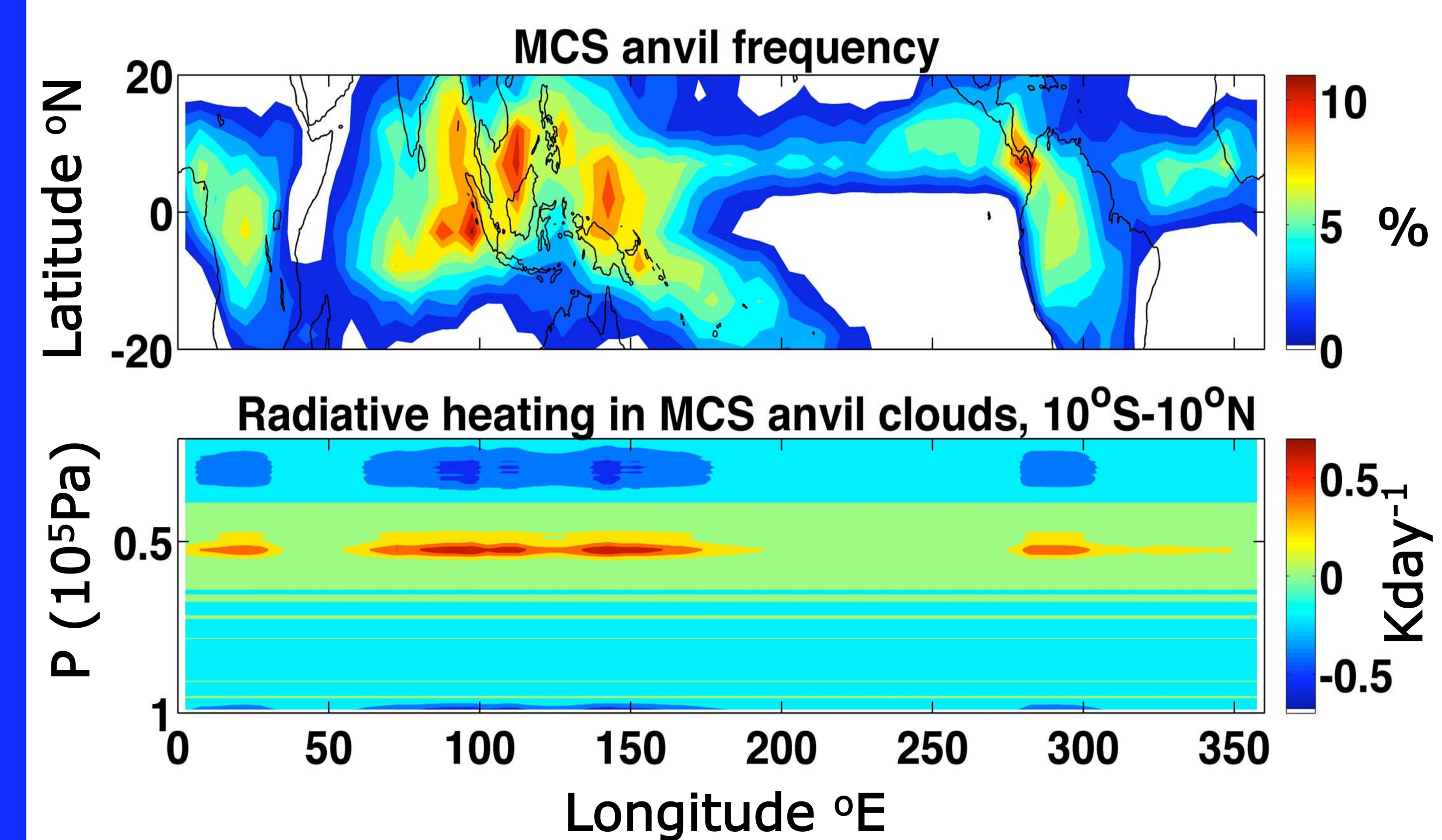
Conclusions and Summary

- Anvil distributions suggest MCSs objectively identified are consistent with prior knowledge & previous work.
- By separating anvil portions of active MCSs from their raining regions. The quantitative global map of MCS anvil coverage can then be obtained.
- Larger systems dominate anvil cloud distributions.
- Anvil clouds likely result in net radiative heating/ cooling in the middle/upper troposphere which modulates the total diabatic heating structure associated with MCSs.

Future work

Understanding the effects of more comprehensive diabatic heating of MCSs on the structure of mean large-scale circulation.

Annual Mean Coverage of MCS Anvil Clouds and Their Radiative Effects



- Anvil clouds from active MCSs concentrate in tropical deep convective regions.
- Anvil clouds associated with active MCSs result in strong net radiative heating/cooling concentrating in the middle/upper troposphere over regions where anvil clouds occur frequently.
- Anvil cloud radiative heating adds more variability in the vertical structure of the MCS diabatic heating profile.

Acknowledgements

We thank Stacy Brozik for her excellent work on the software support and data arranging. This work is funded by NASA grant NNX07AQ89G and ARM grant DE-SC0001164.