Heating Rates of Observed and Simulated Anvil Clouds over Niamey

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1. Introduction

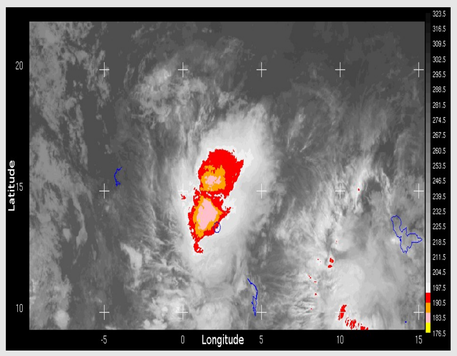
- Anvil clouds play an important role in radiative heating in upper troposphere and impact the general circulation in the tropics.
- A high-resolution cloud resolving model is used to simulate mesoscale convective systems (MCSs) that may be compared to observed MCSs.
- Anchoring model microphysics to observations allows us to study radiative heating effects of anvil clouds as well as the water budget and dynamics of MCSs.

2. Model

- Goddard Cumulus Ensemble (GCE)[1]
- Forced with sounding budget data from AMMA processed at Colorado State University.
- Domain: 1024km x 1024km centered over Niamey, Niger
- Spatial Resolution: 1km
- Vertical levels: 63 with 300m or better resolution
- One-moment microphysics scheme[2] introducing ice crystal concentration in mixed phase region[3].

3. MCS of August 10-11, 2006

- METEOSAT-8 infrared satellite imagery detects an MCS passing over Niamey (13N, 2E) on Aug. 10-11, 2006.
- Instruments at the ARM site sampled a small region of leading anvil, a convective and stratiform region, and a trailing anvil.

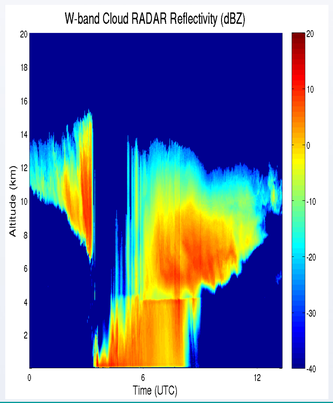


August 11, 2006, 06UTC

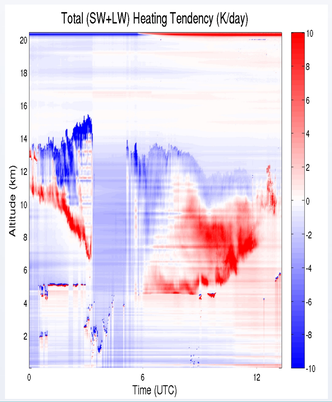
4. ARM Observations

- GCE is anchored to ARM vertically pointing W-band cloud radar observations from Niamey, Niger.
- Radar-lidar retrieval used; retrieved cloud properties entered into radiative transfer code[4].
- Contour interval for joint PDF is 0.001 from 0.001 (blue) to 0.018 (red).

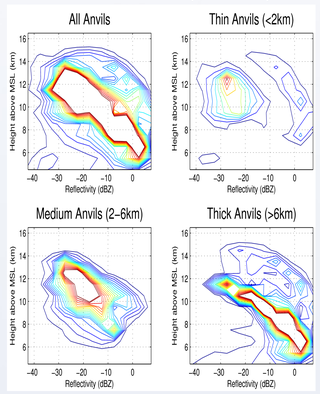
W-band (94GHz) reflectivity



Retrieved Heating Rates[4]



Joint PDF of Reflectivity and Altitude (CFAD[5])



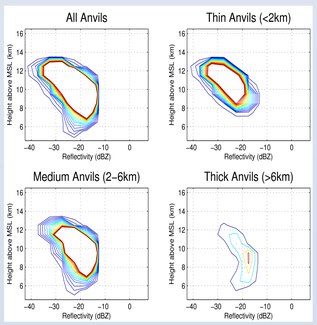
5. Model Evaluation

a. Microphysics

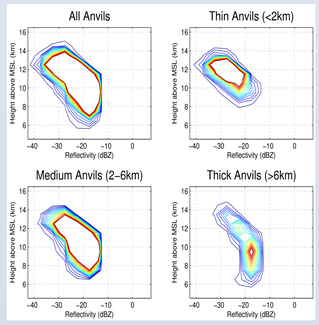
- We compare modeled anvils to the observed anvil using joint probability density functions of reflectivity and altitude.
- Reflectivity of modeled anvils is estimated using a radar simulator[6] with parameterizations for cloud ice[7,8].
- Simulation 1: Ice crystal concentration (ICC) in mixed phase region (MPR) of 1.2e-5cm^{-3}.
- Simulation 2: ICC in MPR of 1.2e-4cm^{-3}.

i. CFADS (include cloud ice only)

Simulation 1



Simulation 2



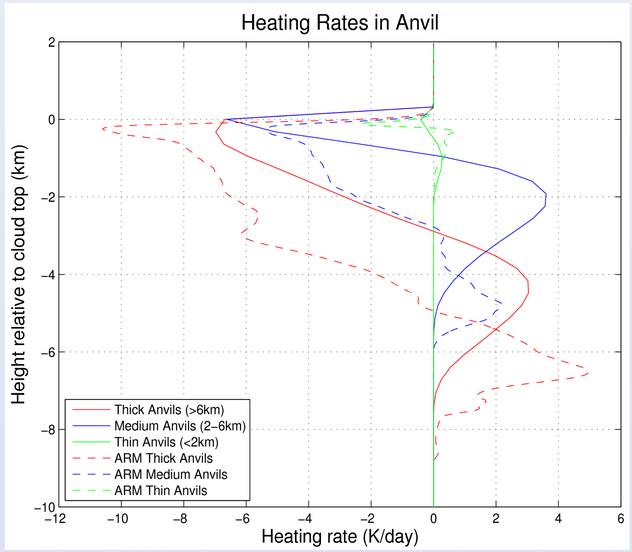
ii. Fraction of total anvil that is thin, medium, or thick

	Observations	Simulation 1	Simulation 2
Thin Anvil	55.8%	63.5%	52.8%
Medium Anvil	20.8%	35.6%	42.4%
Thick Anvil	23.3%	0.9%	4.8%

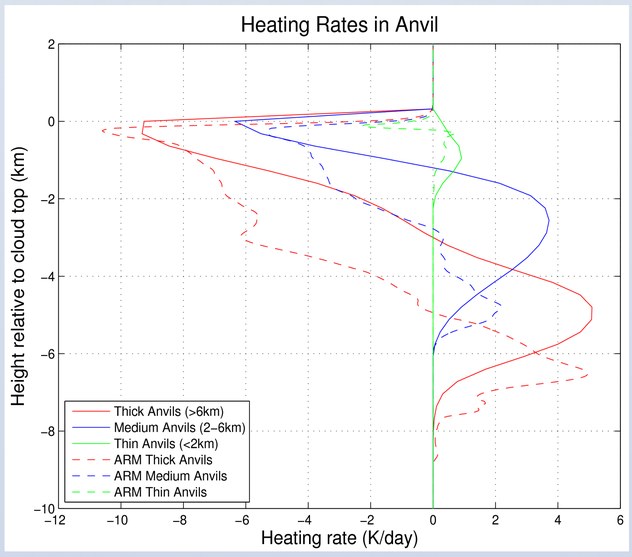
b. Radiative heating profiles

Since modeled MCSs occur at different times of day than observed systems, only longwave fluxes are considered for comparison.

Simulation 1



Simulation 2



6. Summary

- GCE generates thin anvil, medium anvil, and the tops of thick anvil with appropriate reflectivities at altitudes similar to that seen in observations.
- Higher ice nucleus concentrations in the mixed phase regions are required for sufficient anvil areal coverage.
- Magnitude of maximum modeled radiative heating is similar to observed heating rates.
- Although more cases should be studied, results suggest that MCSs can be modeled in a general circulation model to determine affects of anvil on tropical circulation.

7. References

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8. Acknowledgements

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