Using TWP-ICE and MC3E Observations to Expose Dynamical and Microphysical Causes of CRM and LAM Simulated Deep Convection Biases

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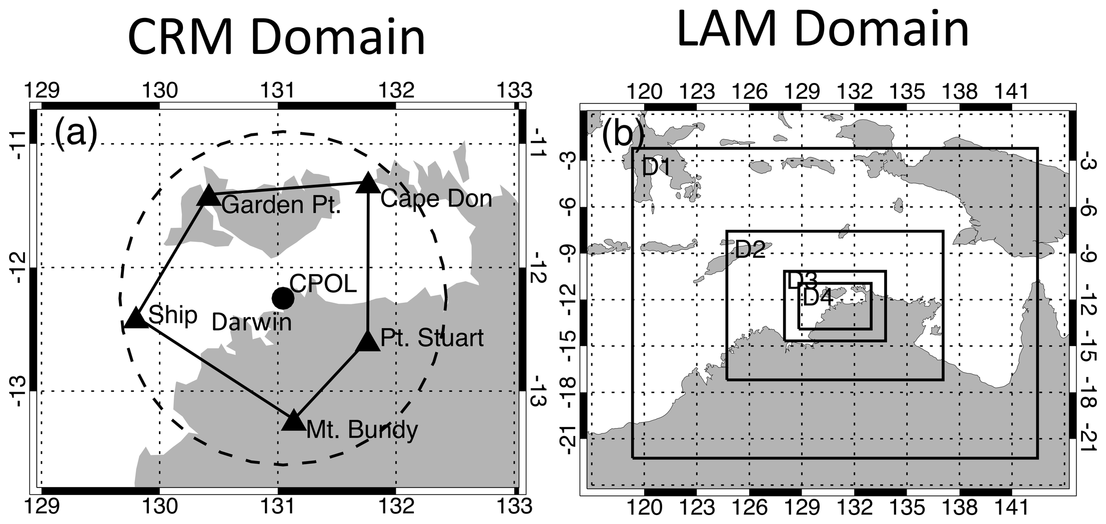
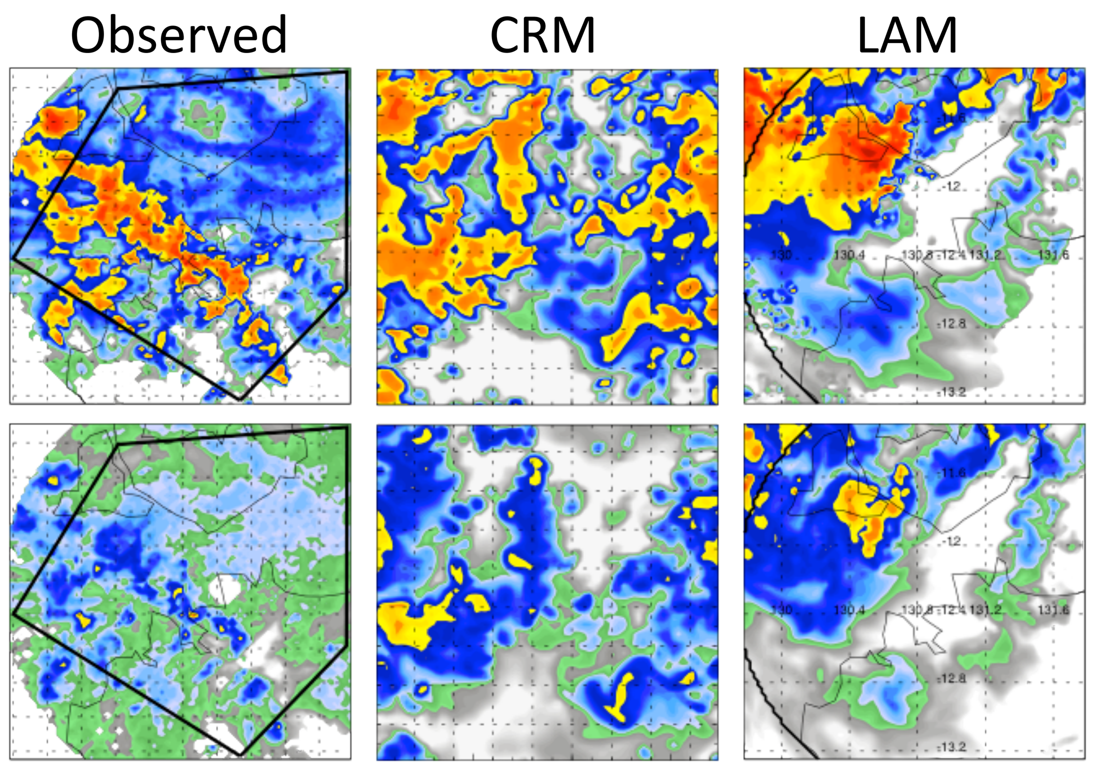
INTRODUCTION

- Peer-reviewed literature shows high biases in simulated convective area and radar reflectivity aloft within non-continental regime tropical deep convective systems using model setups with 1 km horizontal grid spacing.
- This bias has generally been attributed to overproduction of graupel in simulations, although we have found that snow in 2-moment schemes can also be a major contributor.
- Some have labeled this as an ice microphysics problem because convective vertical velocities seem somewhat reasonable, but is this true?
- We are using TWP-ICE and MC3E observations with many simulation setups to investigate. This poster shows only TWP-ICE results.





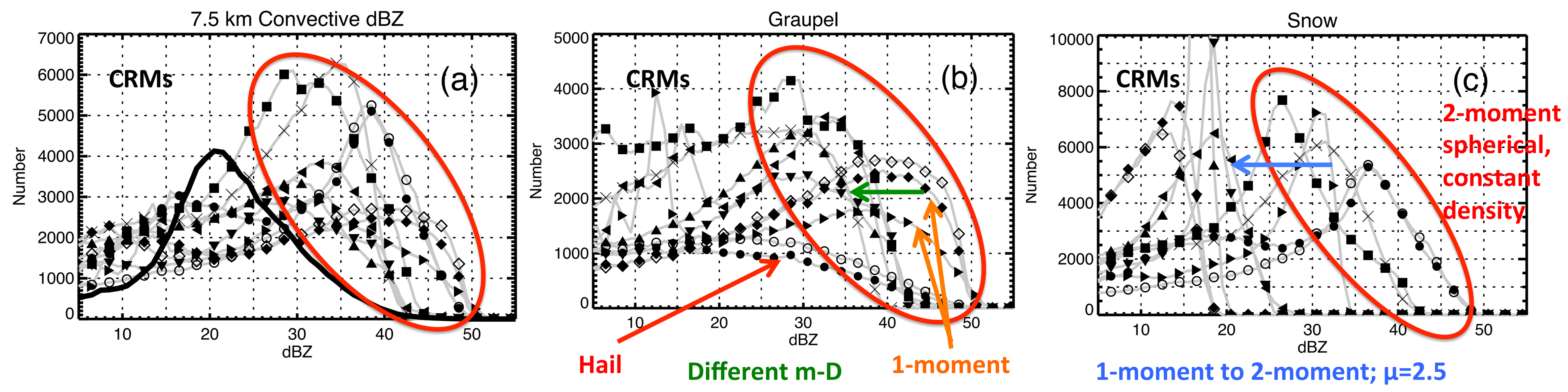
2.5 km and 7.5 km Radar Reflectivity at 18Z 23 January, 2006

METHODS

- Compare 10 CRM simulations and 4 LAM (WRF) simulations of an active monsoon MCS on January 23-24, 2006 with available observational retrievals. Simulations are taken from or based on setups from TWP-ICE CRM and LAM Intercomparison Studies [Fridlind et al., 2012; Zhu et al., 2012].
- All simulations have 0.9-1 km horizontal grid spacing with 76-102 vertical levels.
- CRM domain sizes range from 176 km x 176 km to 192 km x 192 km. These simulations use periodic lateral boundaries with an idealized oceanic surface and are forced with an observationally derived variational analysis.
- LAMs are forced by the ECMWF analysis and have 4 2-way nested domains with the innermost domain 450 km x 330 km. These simulations include land and employ analysis nudging in outer domains.
- All simulations use various 1- and 2-moment bulk microphysics schemes with similar setups for other schemes.

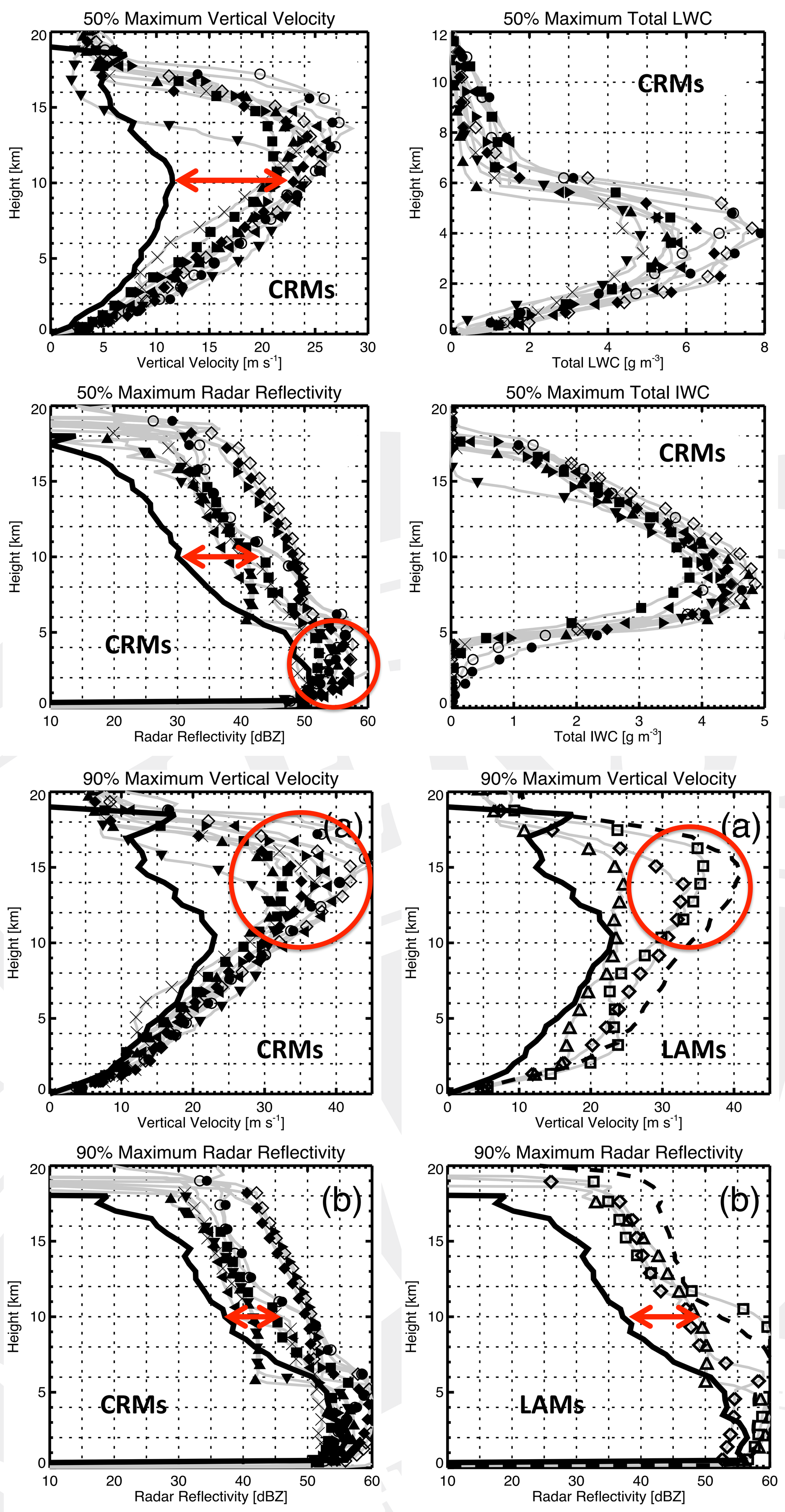
CONVECTIVE RADAR REFLECTIVITY

Simulated values are clearly modulated by hydrometeor size distribution assumptions, but all simulations produce high bias compared to observed in black. Is this due to large water contents?



DEEP CONVECTIVE UPDRAFT PROPERTIES

Comparison of simulated (symbols) and dual-Doppler derived deep updrafts in black (beginning below 1 km and ending above 15 km) shows significantly stronger vertical velocities in simulations despite large water contents. Previous profiler, airborne Doppler radar, and aircraft observations of near coastal intense tropical convection are similar to dual-Doppler values produced for this case.



Some Context

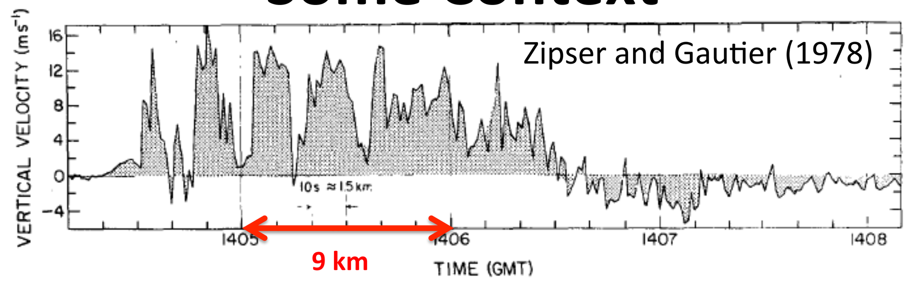
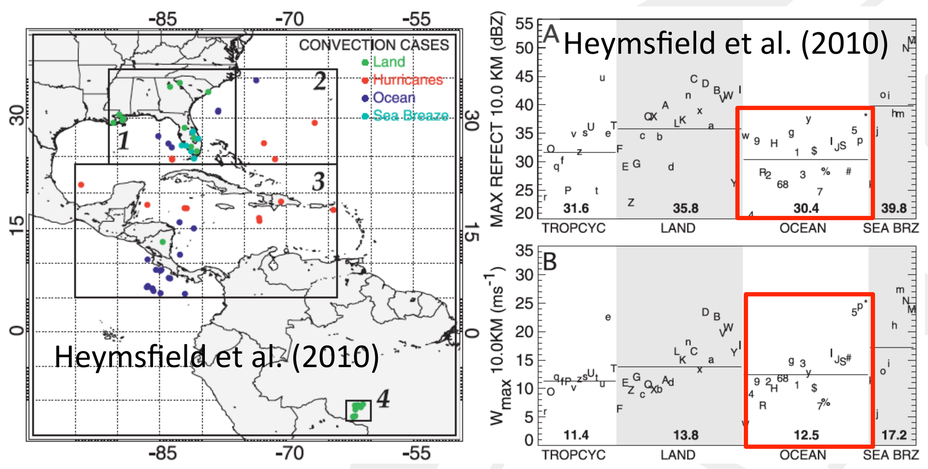


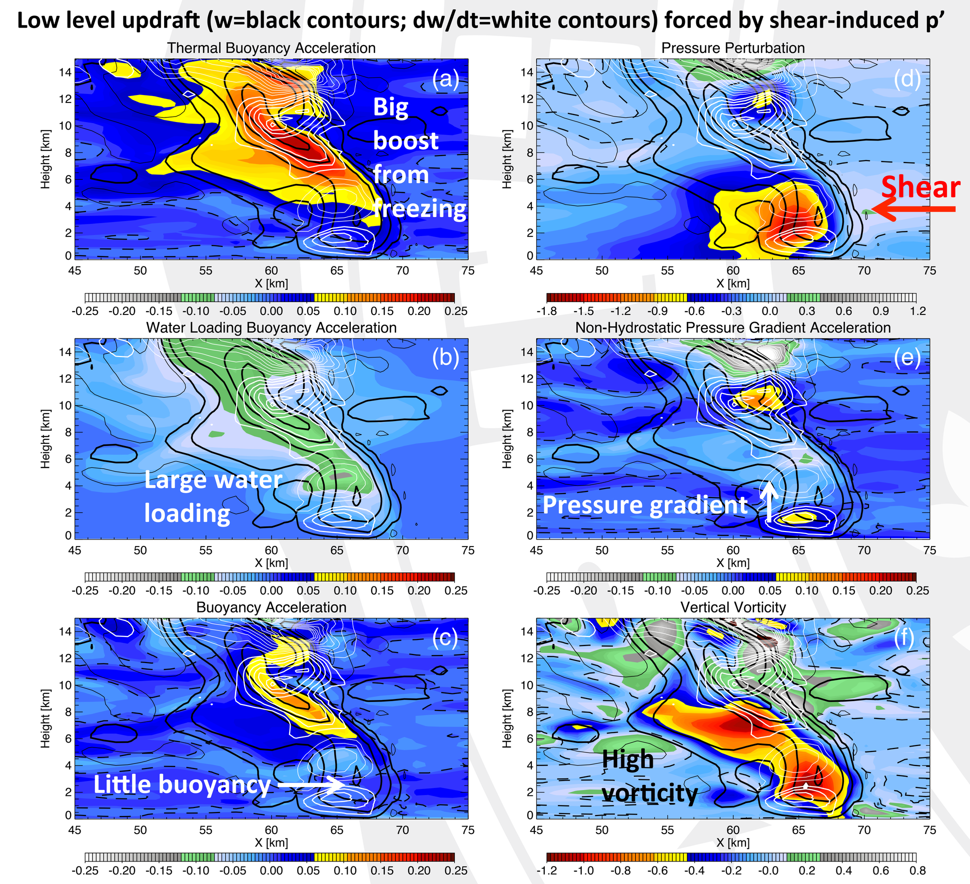
FIG. 14. Vertical velocity trace from C-130 showing cumulonimbus encounter while westbound along 14°N for 1404–1407 GMT 15 July 1974. Time resolution is 1 s.

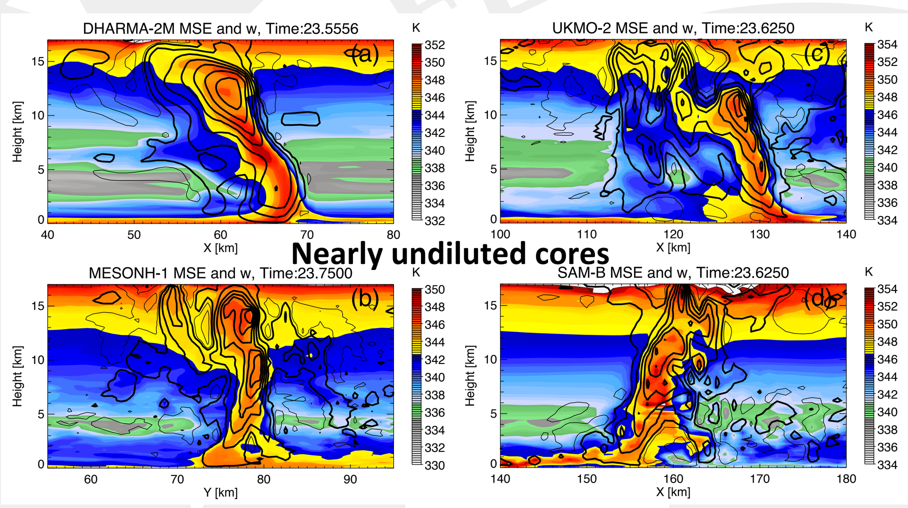


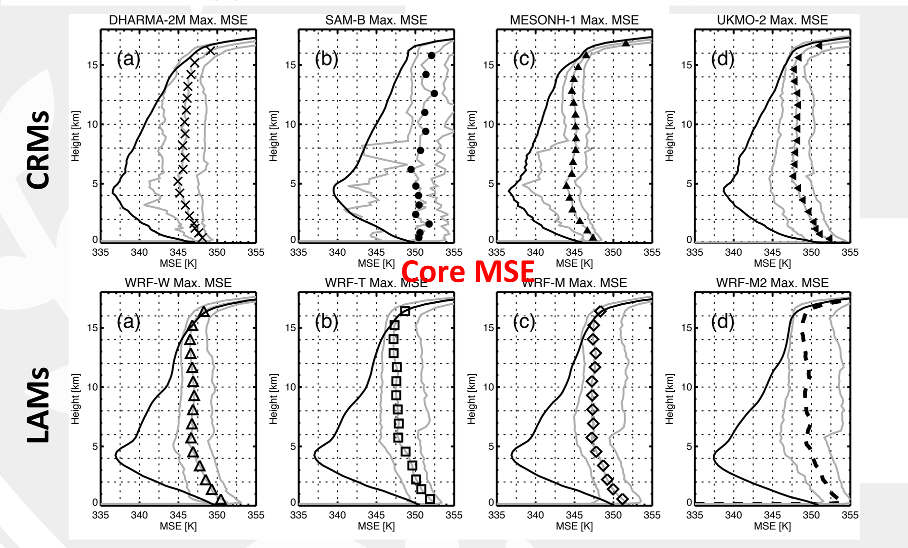
WHY SUCH STRONG UPDRAFTS?

The strongest simulated updrafts entrain very little low MSE environmental air by using substantial environmental vertical shear to their advantage. Large upper tropospheric peaks in *w* are a result of latent heating from large amounts of freezing condensate.

Low level updraft (w=black contours; dw/dt=white contours) forced by shear-induced p'

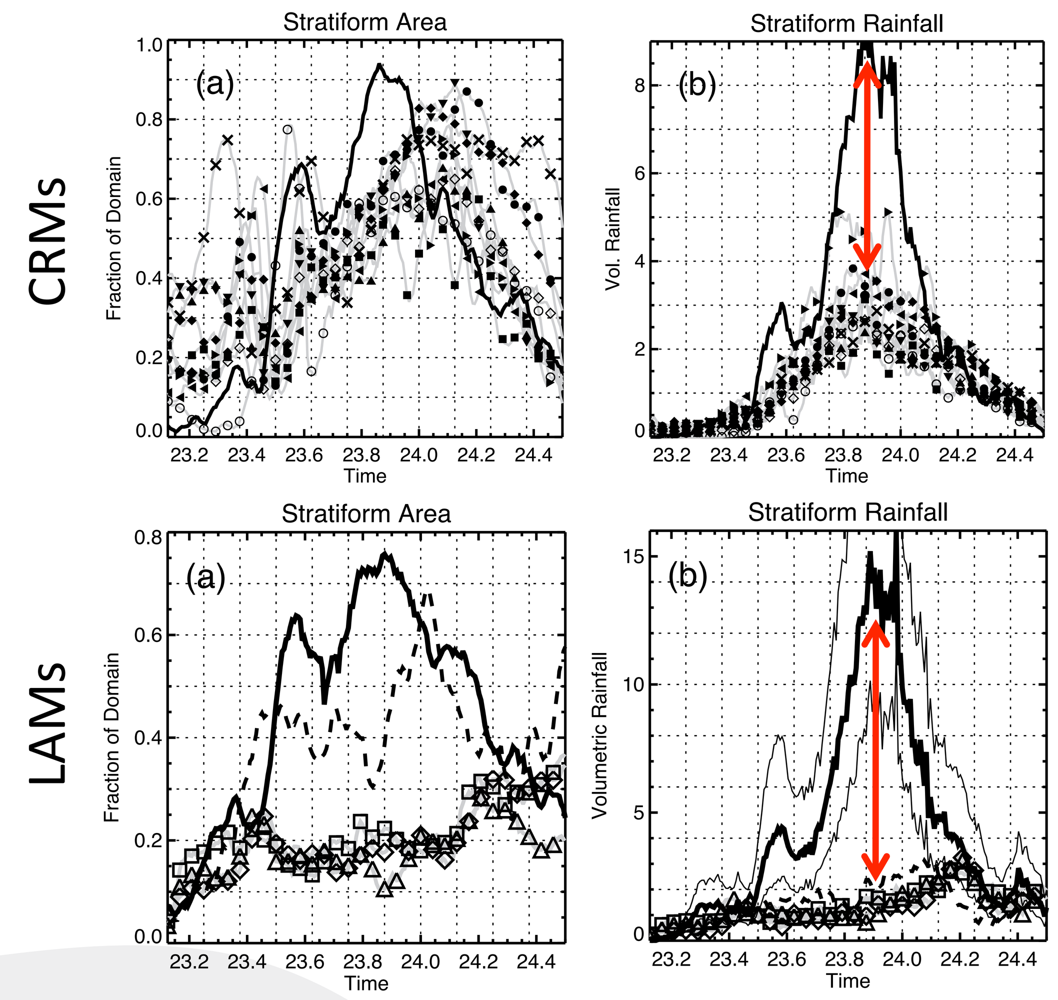






EFFECTS ON STRATIFORM REGIONS

Simulated stratiform rainfall is lower than observed (in black) because IWC is too low at the melting level (rain rates below are too low), which is likely related to convection that detrains too high in the troposphere and model setup biases.



WHY ARE REAL UPDRAFTS DIFFERENT?

- Difference in: Large-scale environment? Turbulence? Ice multiplication? Hydrometeor fallout? Dynamic feedbacks? Perhaps a bit of everything.
- Preliminary results from a CRM run with 100 m grid spacing show greater entrainment, but high reflectivity and water contents aloft are still produced.

CONCLUSIONS AND FUTURE WORK

- Although not provable, indirect evidence supports the hypothesis that simulated deep convective updrafts are too intense (i.e., vertical velocities and water contents are too high), which couples with hydrometeor N(D) assumptions to yield high biases in radar reflectivity aloft and convective area.
- Updrafts are able to lift large amounts of rain by utilizing significant vertical shear to protect the updrafts from entrainment.
- Intense convection and model setup likely negatively impact stratiform region development in both CRMs and LAMs, possibly related to convection detraining too high in the troposphere, compensating subsidence from the intense convection, and model forcing biases.
- Superior MC3E observations are being used to test these these hypotheses for mid-latitude continental convection.
- As a community, we should focus on modeling weak to moderate convective situations and get back to penetrating convective updrafts with better instrumentation and within range of remote sensing.

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