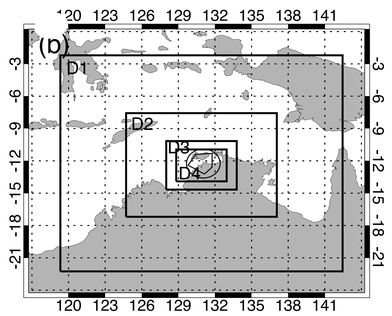
Analyzing and improving simulated convective and stratiform properties in high-resolution mesoscale simulations using MC3E and TWP-ICE observations

Adam Varble, Nick Bassill, and Ed Zipser
Department of Atmospheric Sciences, University of Utah

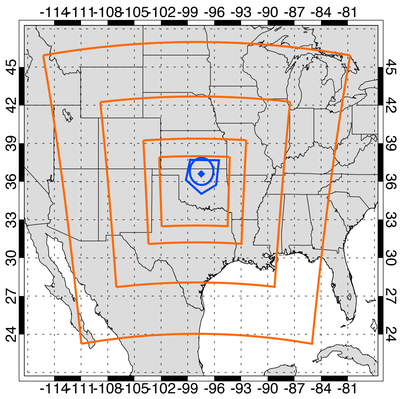
INTRODUCTION

- **Varble et al. (2011) show high-biased simulated convective area and radar reflectivity aloft in coastal, tropical monsoonal deep convective systems observed in TWP-ICE with bias magnitude modulated by microphysics assumptions.**
- **Varble et al. (submitted) show that these high biases may also result from overly intense simulated convective updrafts.**
- **These biases negatively affect stratiform precipitation development (Varble et al., submitted) and alter the distribution of atmospheric heating.**
- **Do these same biases exist for mid-latitude continental MCSs during MC3E?**



TWP-ICE Domain

Four two-way nested domains
Inner domain is 450 km x 300 km and encompasses the C-POL domain and sounding locations



MC3E Domain (May 20 Case)

Four two-way nested domains
Inner domain is 690 km x 600 km and encompasses the C-SAPR domain and sounding locations

METHODS AND MODELS

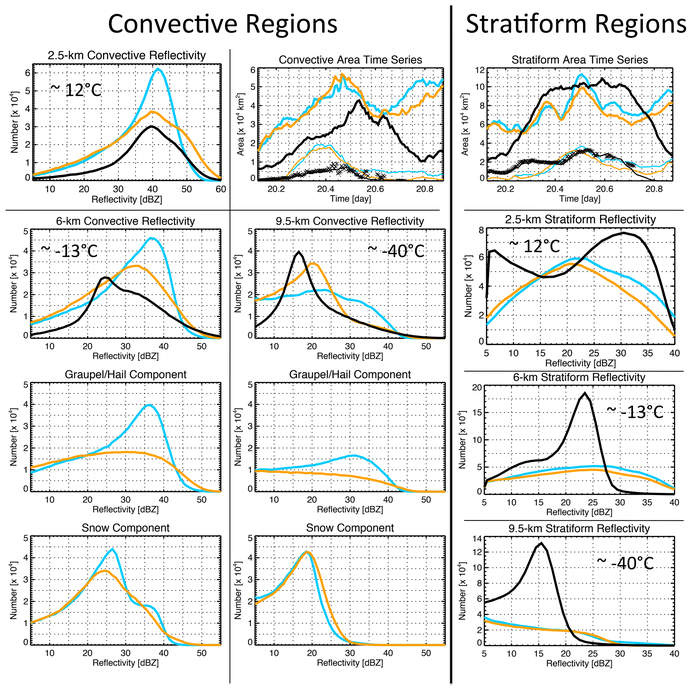
- **Compare WRF V3.3.1 simulations of a TWP-ICE active monsoon MCS on January 23-24, 2006 and MC3E MCSs on April 25th (not shown) and May 20th with available observational retrievals.**
- **All simulations have 1-km horizontal grid spacing with 92 vertical levels.**
- **TWP-ICE simulations are forced by the ECMWF analysis and MC3E simulations by the GFS analysis.**
- **Analysis nudging is used in the outer two domains.**
- **All simulations use the Morrison two-moment bulk microphysics schemes.**
  - **Others have been tested for TWP-ICE and will be tested for MC3E.**
- **All other physics schemes are kept constant.**
- **A modified Steiner et al. (1995) convective-stratiform (C-S) separation method is performed using observed and simulated low level reflectivity.**

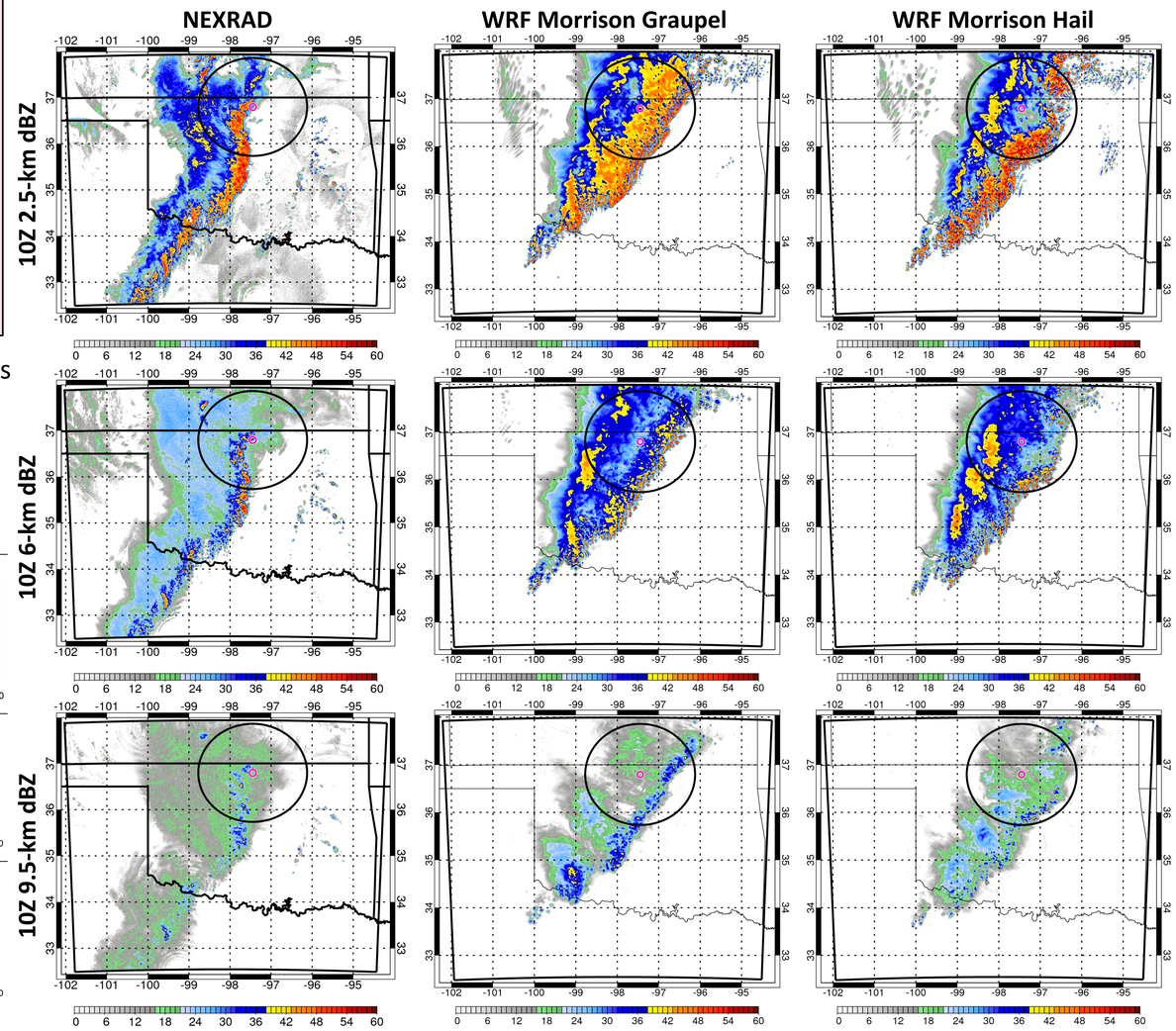
REFERENCES

Varble et al. (2011), Evaluation of cloud-resolving model intercomparison simulations using TWP-ICE observations: Precipitation and cloud structure. *J. Geophys. Res., 116*, D12206, doi:10.1029/2010JD015180.
Varble et al. (submitted to JGR), Evaluation of cloud-resolving and limited area model intercomparison simulations using TWP-ICE observations. Part 1: Deep convective updraft properties.
Varble et al. (submitted to JGR), Evaluation of cloud-resolving and limited area model intercomparison simulations using TWP-ICE observations. Part 2: Rain microphysics.

MC3E May 20th MCS

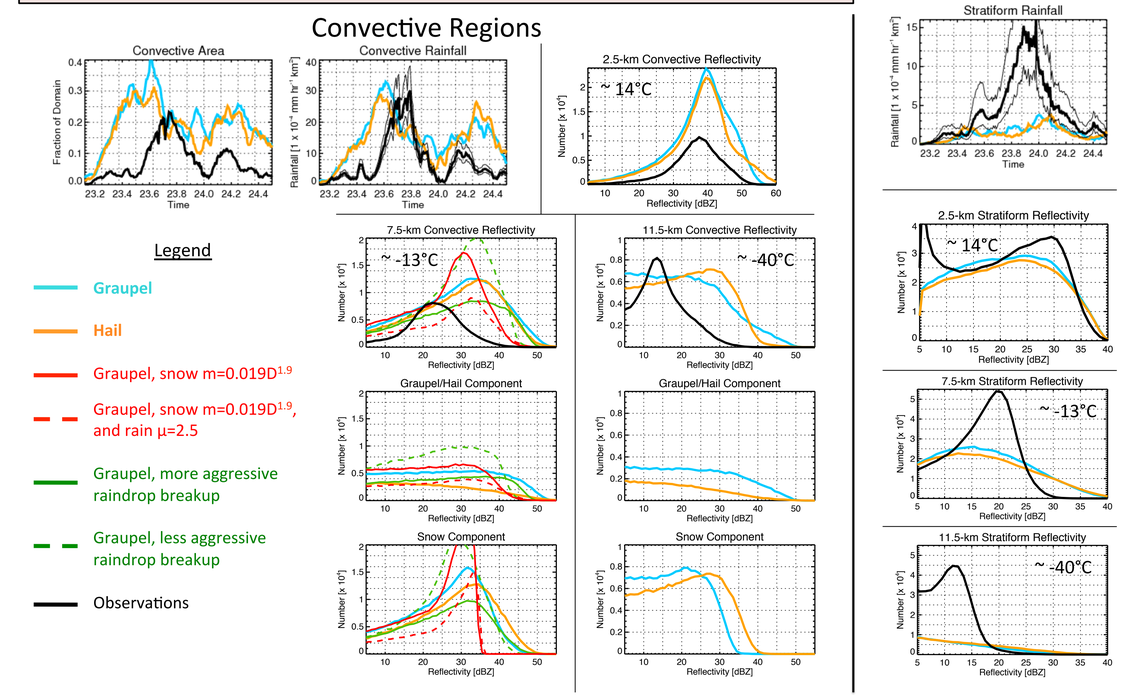
Simulations position the squall line too far north, but generally reproduce the observed life cycle. They produce more convective area than observed, which is partially a result of the C-S algorithm acting on high-biased reflectivities. Using hail (orange) rather than graupel (blue) produces the best agreement with observed convective reflectivity, but stratiform biases are the same in both simulations. Neither simulation reproduces the sharply peaked stratiform reflectivity distributions observed above the melting level.





TWP-ICE January 23-24 MCS

In both the MC3E and TWP-ICE cases, using hail or graupel does not affect convective and stratiform area. Convective area is overestimated, and stratiform area is slightly underestimated. MC3E and TWP-ICE simulated reflectivity biases are similar, but using hail rather than graupel for the TWP-ICE MCS does not improve comparisons with observed reflectivity as it did for the MC3E MCS. Altering the snow m-D, raindrop breakup, and rain gamma shape parameter reduces high-biased simulated convective area and reflectivity, but the biases are not eliminated.



CONCLUSIONS AND FUTURE WORK

- **Although the MC3E May 20th simulated squall positioning is displaced northward, its evolution is similar to observed.**
- **Convective area is biased high in all simulations.**
- **The C-S partitioning may need further adjustment to account for large simulated stratiform reflectivities.**
- **Reflectivity biases aloft are similar for both MC3E and TWP-ICE simulations.**
- **Using hail rather than graupel improves MC3E but not TWP-ICE convective reflectivity structure.**
- **Sharply peaked stratiform reflectivity distributions observed above the melting level are not simulated.**
- **Finish analysis of TWP-ICE simulations and run more MC3E simulations with different microphysics setups for April 25th and May 20th cases.**
- **Analyze thick and thin anvil regions.**
- **Perform comparisons of simulations with and test representativeness of C-SAPR reflectivity, rain rate retrievals, DSD retrievals, vertical velocity retrievals, and Citation in situ ice observations.**
- **Compare different cases to find commonalities and differences to guide parameterization improvement.**

ACKNOWLEDGEMENTS

We would like to thank the DOE ASR program for funding this research, the Center for High Performance Computing at the University of Utah for providing computing resources, NOAA NCDC for NEXRAD data, and Hugh Morrison, Ann Fridlind, Ping Zhu, Peter May, and Scott Collis for providing data or code.