Breakout summary: Aerosol Deep Convection-Cloud Interactions (ADCI)

Overarching question: ***What aerosol-related processes influence deep convection cloud properties relevant to climate (precipitation, cloud radiative forcing, latent heating profiles)?***

ASR Cloud Lifecycle WG Plenary
March 13, 2014

Objectives

- To investigate relationships between aerosols and anvil radiative forcing, convective characteristics, latent heating, precipitation, etc. through rigorous analysis of **observations** from both ARM data and other datasets.
- To improve our understanding of the mechanisms governing aerosol-deep convection interactions using **models** in conjunction with observational data.
- Identify differences in aerosol impacts on convection across **models**, and understand specific processes responsible for explaining these differences.

4:00-4:15 Marcus van-lier Walqui: Storm and cell-scale polarimetric radar signatures of deep convective updrafts observed during MC3E

4:15-4:30 Wojciech Grabowski: Aerosol indirect effects on deep convection over the Maritime Continent

4:30-4:45 Qing Yang: Model evaluation of aerosol wet scavenging in deep convective clouds based on observations collected during the DC3 campaign

5:15-5:30 Jiwen Fan: ASR CRM intercomparison study on aerosol-deep convective cloud interactions

5:30-6:00 Discussion of CRM intercomparison study and focus group activities

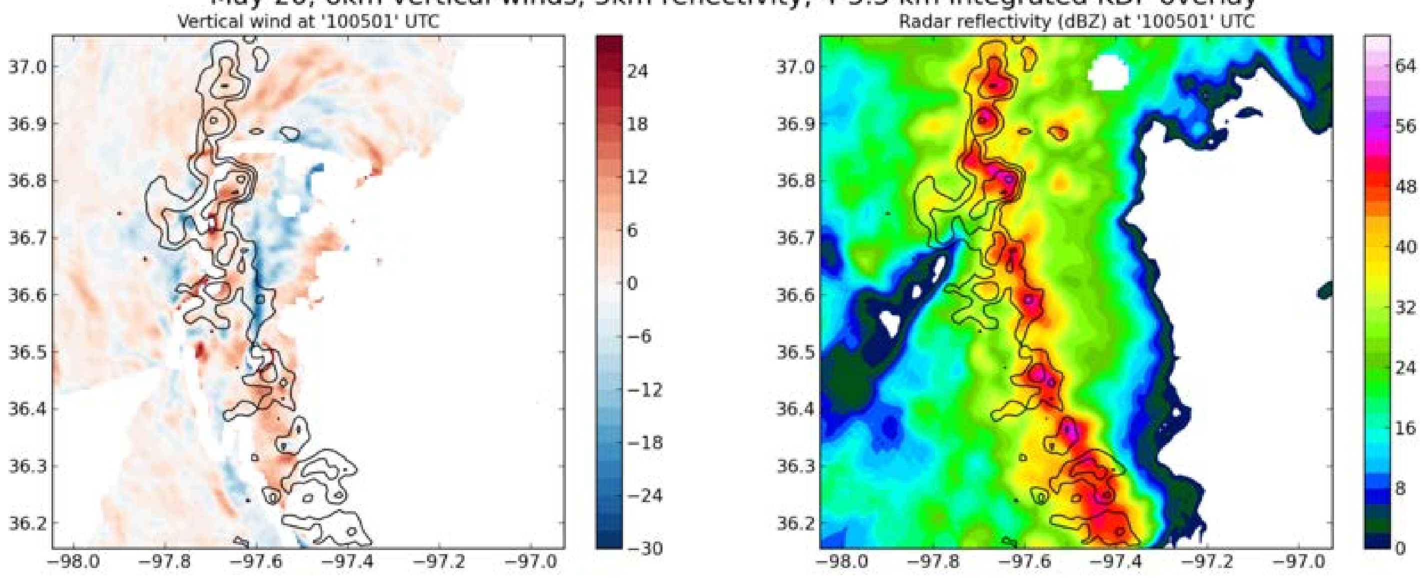
Analyze strong updraft cores

- Use Open Source Py-ART (Python ARM Radar Toolkit) to process/analyze radar data
- Identify deep convection by KDP column, ZDR column, 3-doppler updrafts
- Assess consistency/variability of observed polarimetric patterns/relationships
- Analyze storm-scale *and* convective cell-scale signatures
- Identify microphysically meaningful observational targets

Marcus van Lier-Walqui

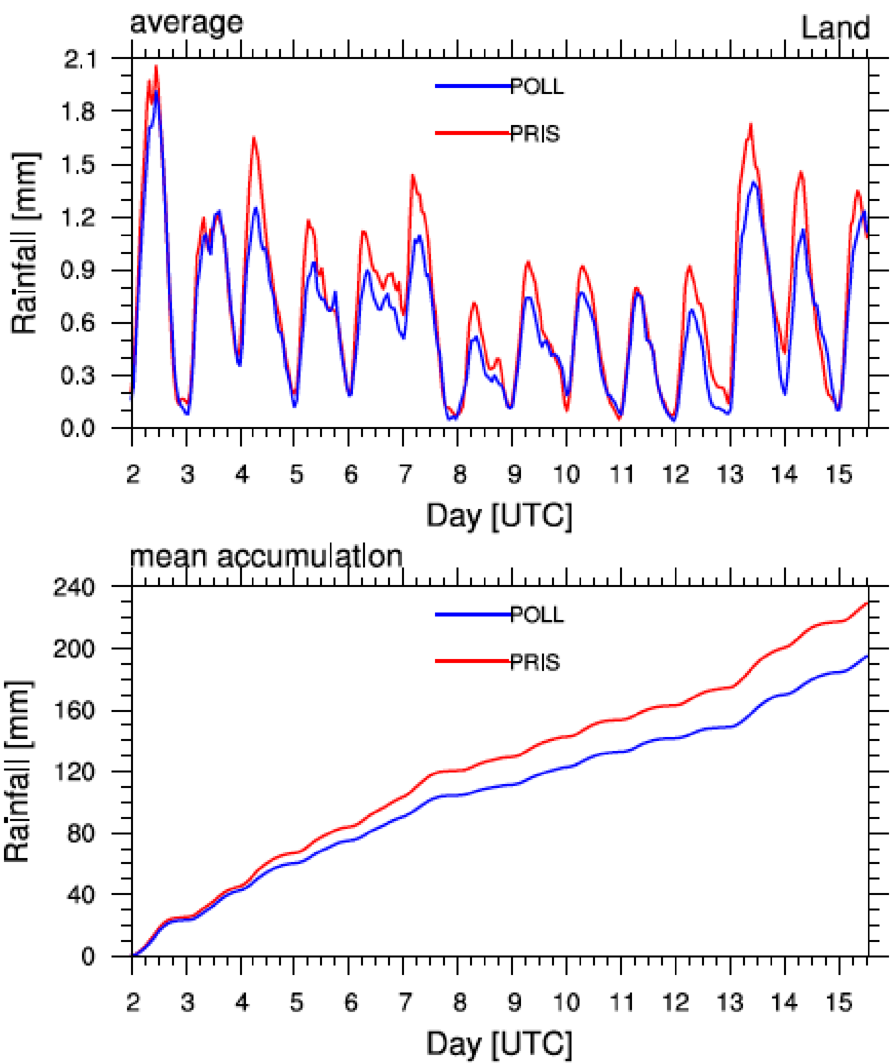
Use observational targets to constrain microphysics in simulations which use realistic (measured) aerosol distributions

May 20, 6km vertical winds, 5km reflectivity, 4-5.5 km integrated KDP overlay

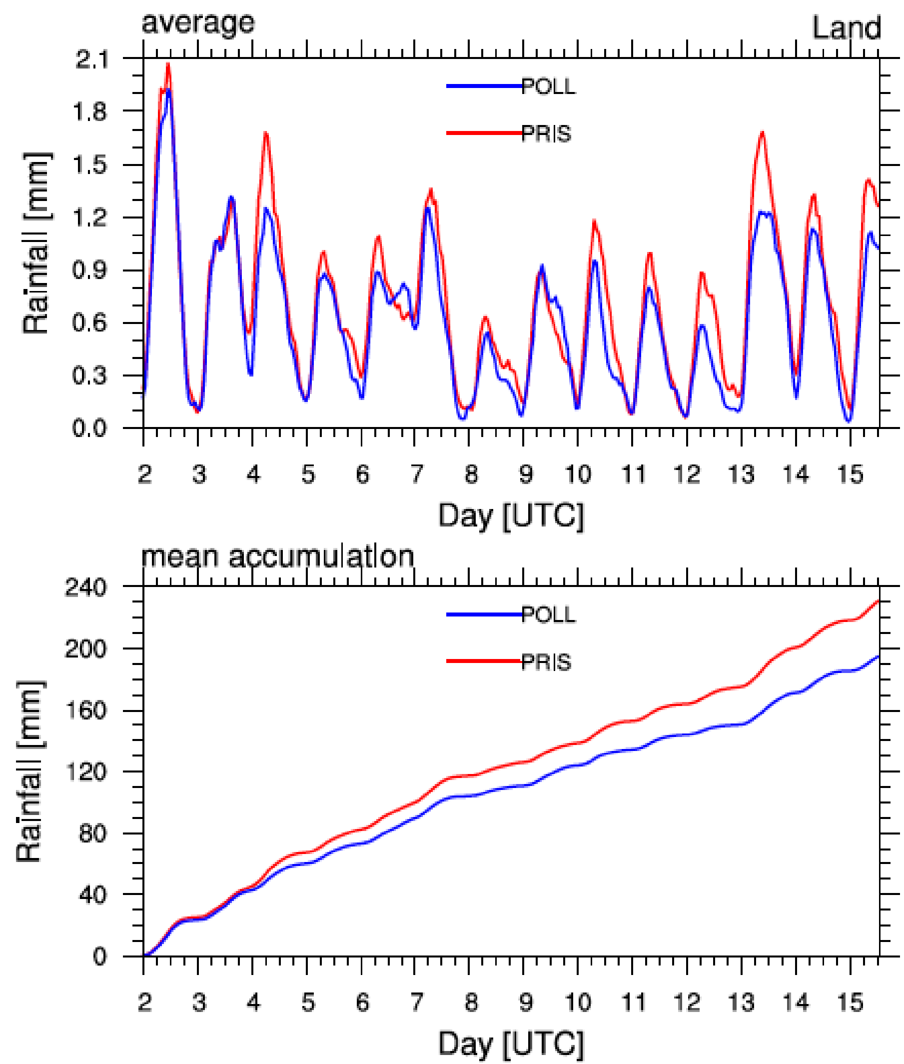


Wojciech Grabowski

Results: total accumulated rainfall – land



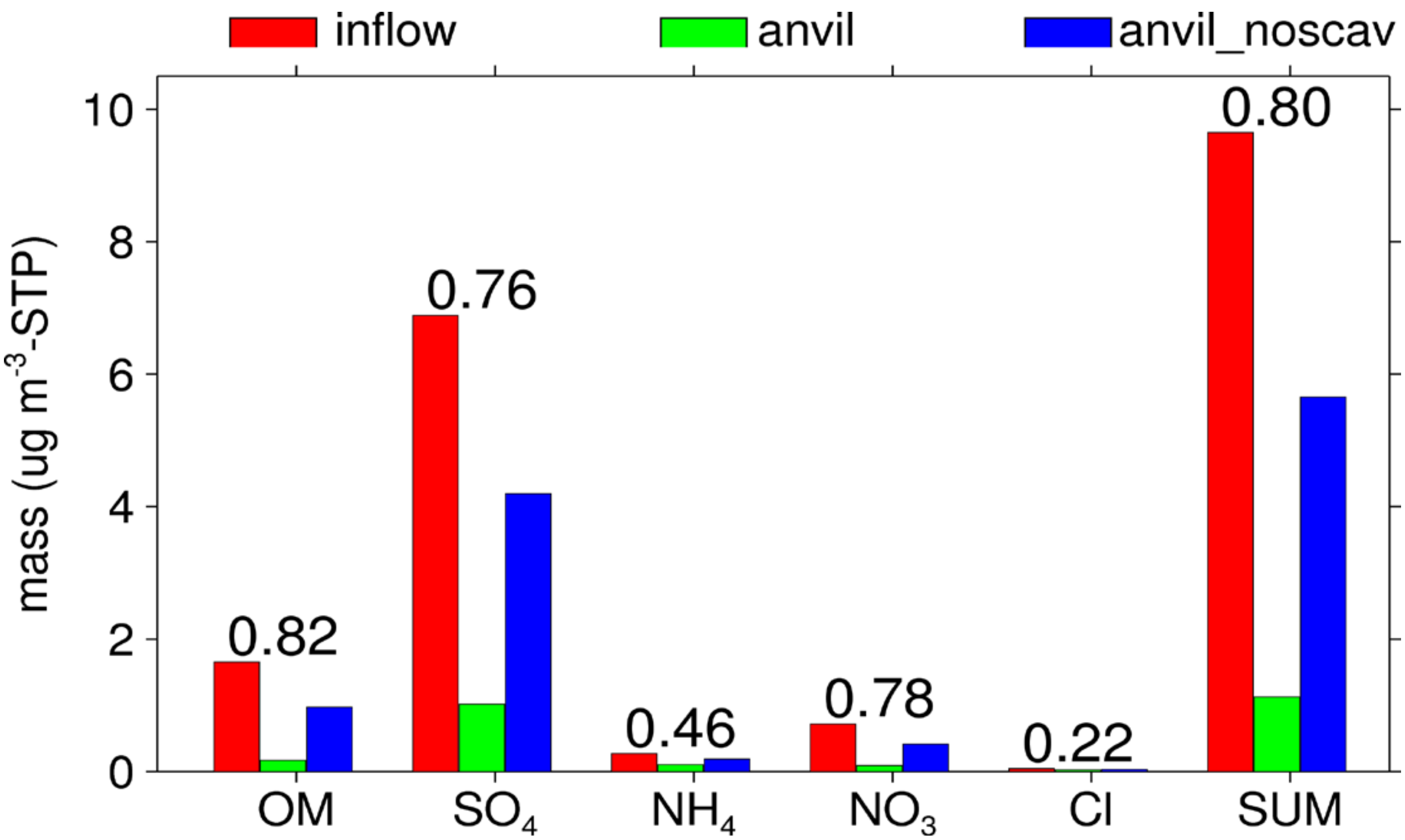
(a) v3.3



(b) v3.5.1

Qing Yang

Observed aerosol concentrations at the inflow and anvil and the estimated wet scavenging efficiencies



What are we doing collectively?

1. Obtain observational estimation and constraints of both ERDari and ERFaci using ARM and Satellite data (Li)
2. Estimation of CCN at cloudbase (Rosenfeld)
3. 3-D wind and hydrometeor retrievals (Kumjian, Ghate, Cmostock, North, Collis, Giangrande, van Lier-Walqui)
4. Multi-platform datasets tailored for DCS (Dong)
5. CRM simulations (Fan, van den Heever, Fridlind, van Lier-Walqui, Tao, Morrison)
6. Convection/sub-grid parameterization and global and/or SCM simulations (Zhang, Gentine, Donner, Wang, Ovchinnikov)

Key issues and uncertainties

- Co-variability of aerosol and meteorology make it difficult to separate correlation from causation

- Large spread of aerosol effects (and deep convection simulations generally) among CRMs; evidence that convective characteristics from CRMs can be much different from observations (e.g., bias in updraft velocity for TWP-ICE shown by Adam Varble et al.)

- Aerosol impacts on deep convection have generally been neglected in GCMs; this is starting to be addressed but challenges remain in how to best represent the relevant physics in convection parameterizations

A focused problem: Understanding large *inter-model differences and biases* in CRM deep convection simulations

•***A general microphysics/dynamics problem*** – not just aerosol effects → strong links to Cloud Lifecycle Working Group (e.g., Mesoscale Convective Organization, Vertical Velocity Focus Group)

•Spread of models means we don't have anything close to a "benchmark" for developing deep convective parameterizations in GCMs

Objectives and Plans

Jiwen Fan et al.

- To identify processes/factors contributing to the large spread of CRM deep convection simulations and provide insights to improve bulk parameterizations.
- To identify processes and feedbacks important to represent in GCM parameterizations in aerosol-DCC interactions.

➢ **Using the same model (WRF3.4.1) with the same aerosol setup, we want to conduct two-step investigations:**

Step 1

Identify major contributors from microphysical processes.

1. Standard full package run, compare with obs. and examine model differences
2. No ice run to identify contribution from warm cloud processes
3. Sensitivity tests for each ice microphysical process

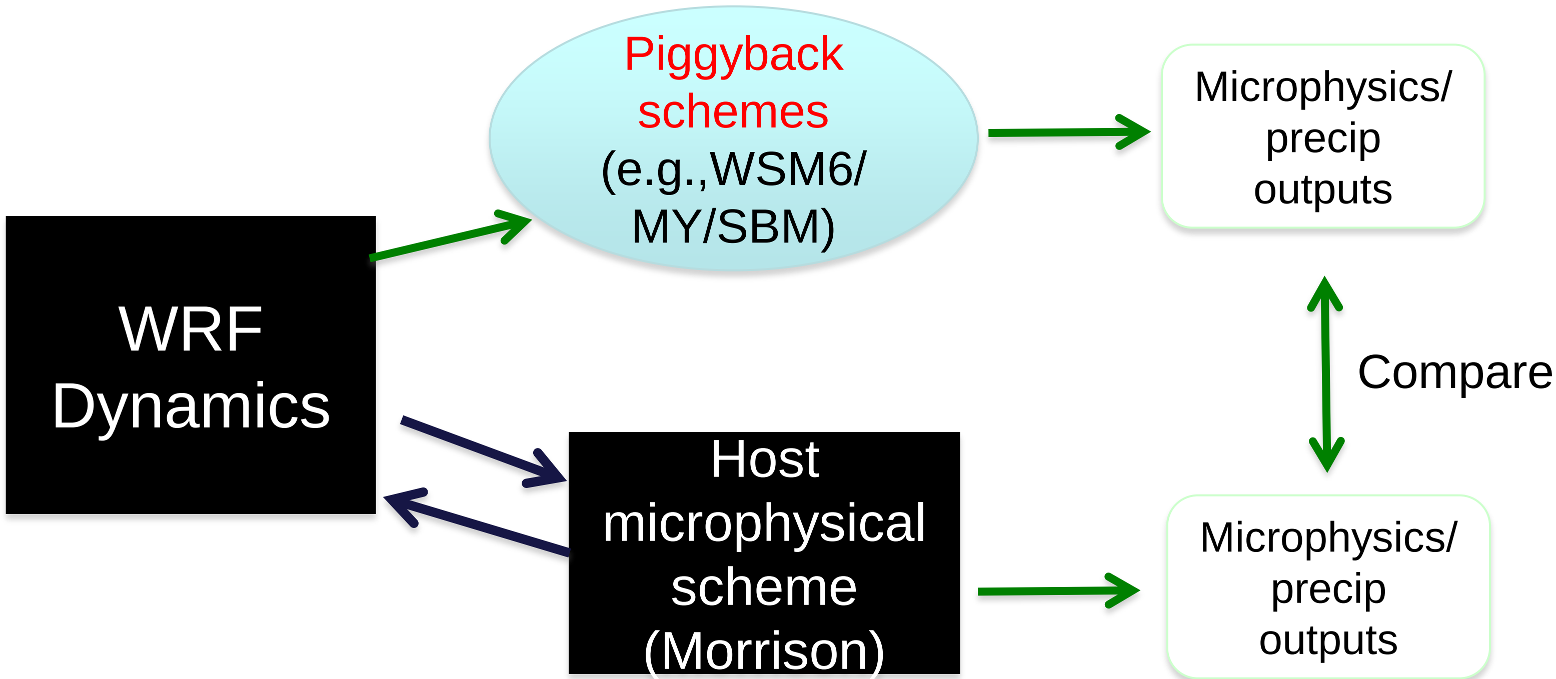
→

Step 2

Identify major feedback processes between dynamics-microphysics interactions.

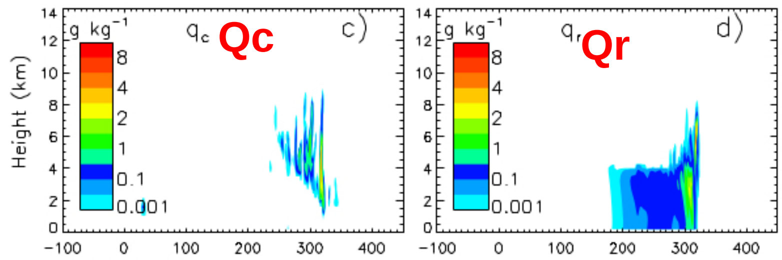
(1) Feedback of latent heat from each process to convection
(2) Feedback of hydrometeor loading to updraft/downdraft
(3) Cold pool feedback.

Step 1 concept

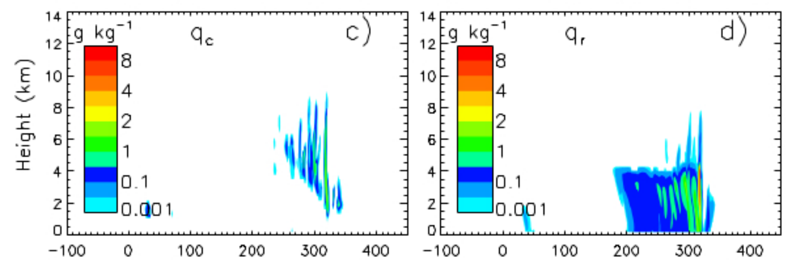


Preliminary results

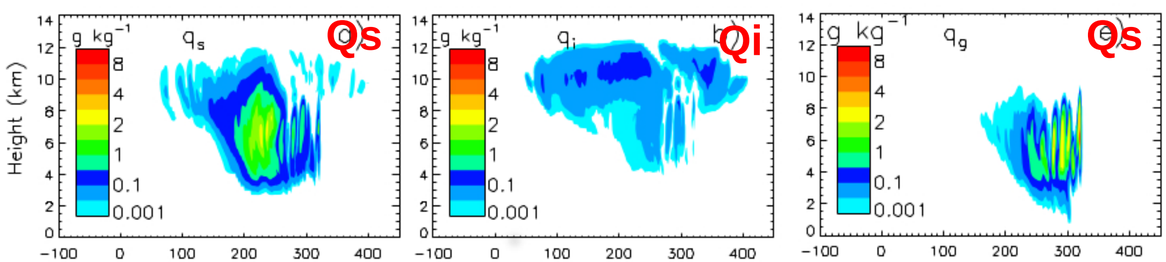
Morrison



WSM6



Morrison



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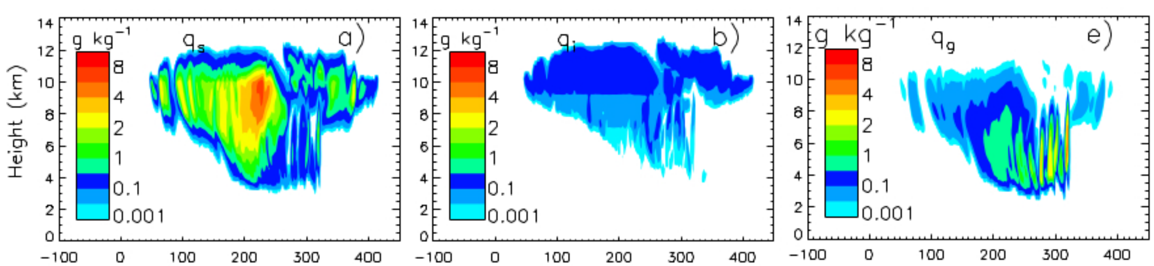
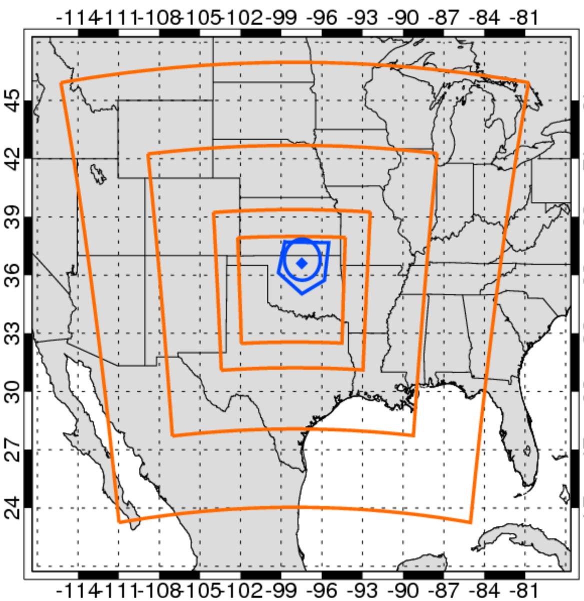
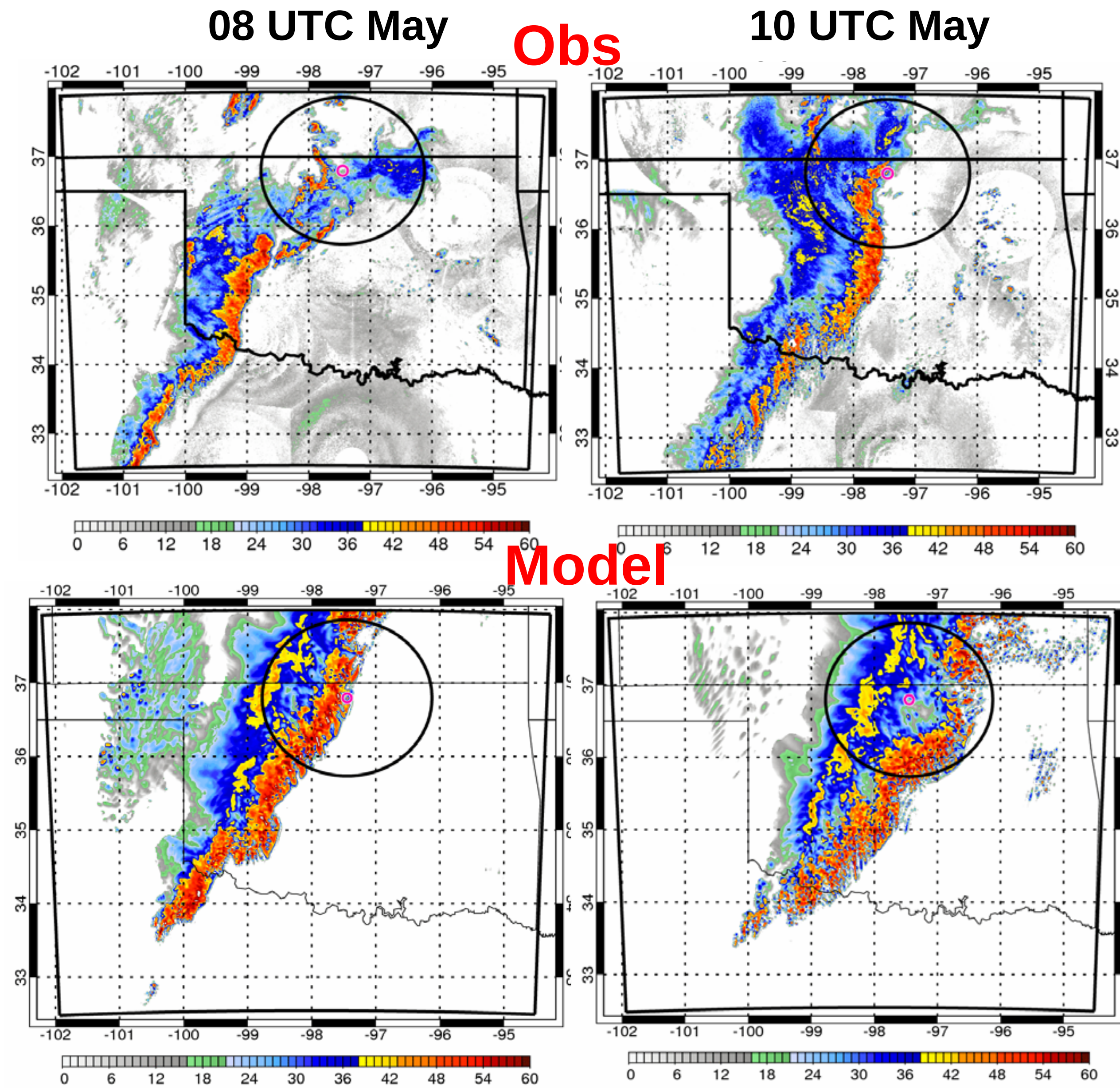


Candidate case: Adam Varble’s May 20 MC3E setup





- **Timing and location of the simulated squall-line are close to observations**

Key observations for constraining the model

- 3D vertical velocity (convective drafts)
- 3D condensate and microphysical profiles (especially in updrafts to quantify condensate loading)
- 3D latent heating
- Cold pool properties (integrated through depth)
- Size, number, and morphology of convective drafts
- CCN (and IN) profiles