2019 ARM/ASR PI Meeting

Updraft and Downdraft Core Kinematics of Mesoscale Convective Systems as Revealed by Radar Wind Profilers

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CMDV

Mesoscale Convective Systems

ARM

ASR Atmospheric System Research

BROOKHAVEN NATIONAL LABORATORY

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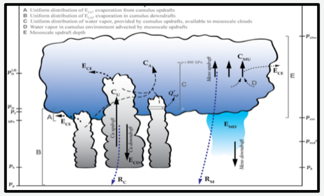
NCAR

What Motivates Mesoscale Convective System Studies?

Mesoscale Convective Systems (**MCSs**) regulate the global energy through their extensive cloud coverage and the exchange of latent heat.

A goal of the Climate Model Development and Validation (**CMDV**) project is to improve DOE's climate model:

- Climate models (GCMs/ESMs) are unable to resolve convection at its natural spatiotemporal scales.



GCM **cumulus parameterizations** (and cloud resolving models) typically evaluated against larger-scale metrics (e.g., precipitation maps).

Except for limited aircraft campaigns, **few observations** to guide modelers on whether storm dynamics-microphysics looks reasonable.

- MCS observations require creativity given their size, known sampling limitations.

Unique Ground-based Observations for Vertical Velocity

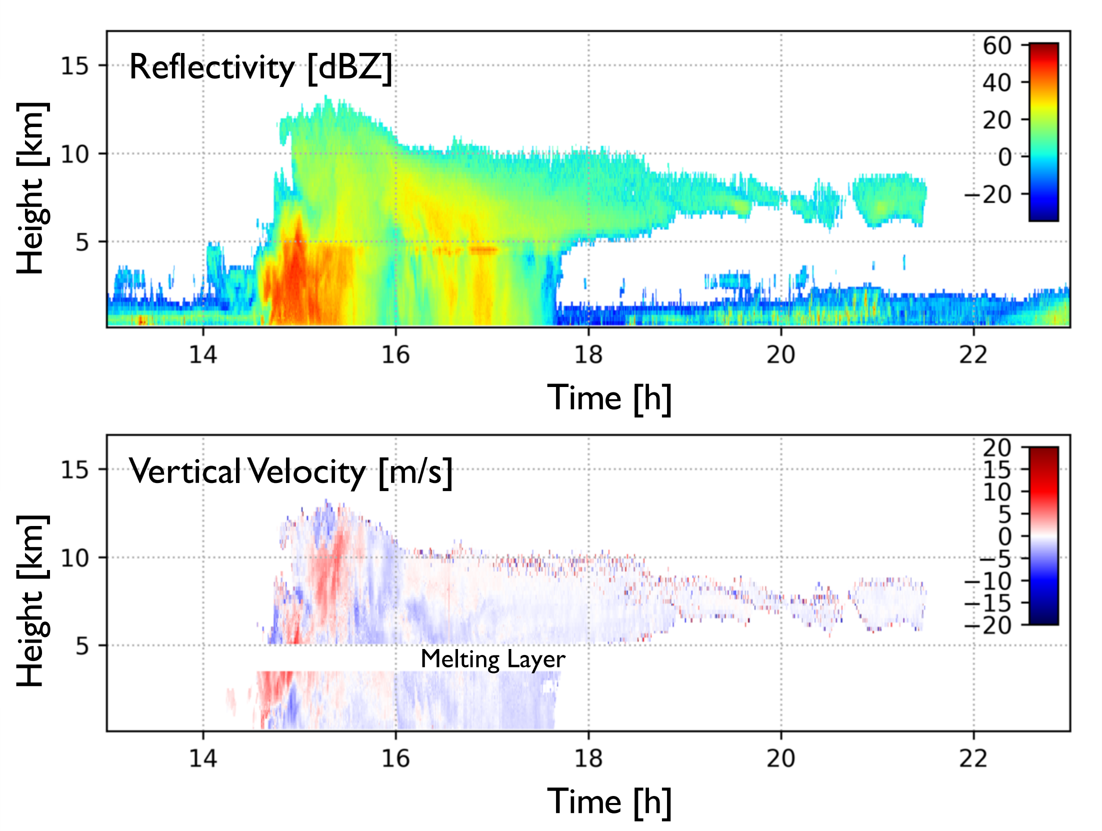
- **ARM datasets for MCS studies:**
  - The Southern Great Plains (SGP) facility, Lamont, Oklahoma
  - The Green Ocean Amazon (GoAmazon2014/5), Manaus, Brazil

- 20 MCSs between 2012 – 2016;
- Sisterson et al., 2016

- 60 MCSs during the 2-year deployment;
- Martin et al., 2016 BAMS;
  Giangrande et al., 2017

ARM RWP Vertical Velocity Measurements

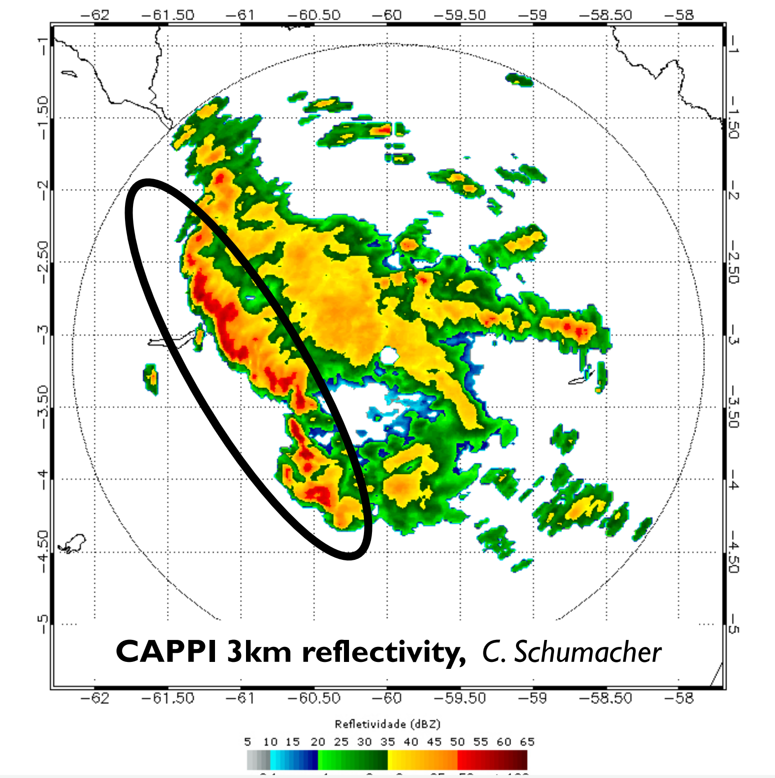
- ARM reconfigured **radar wind profiler (RWP)**: vertically pointing radar, precipitation mode.
- Unique RWP application, **vertical velocity** retrievals based on Giangrande et al., (2013; 2016).



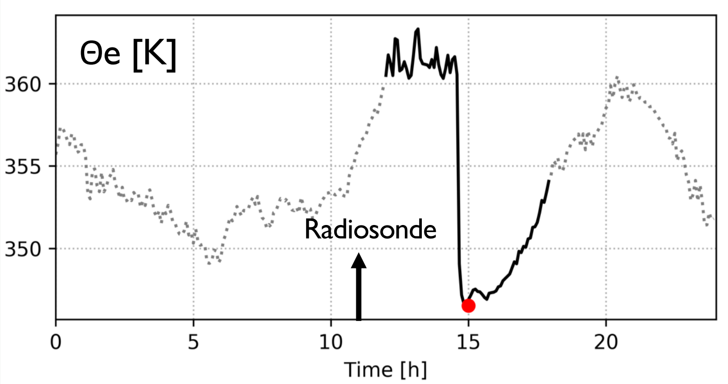
ARM/CMDV PI products available at ARM.gov

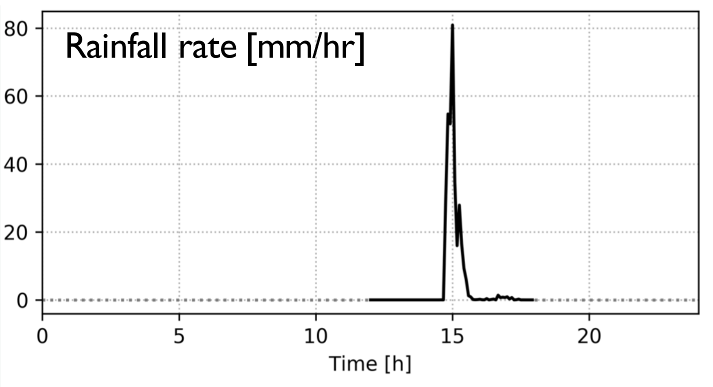
Contrasts of RWP Profiles Between MCS Datasets

- **Contrast Oklahoma (midlatitude), Amazon (tropical) datasets to highlight MCS variability between the different climate regions.**
  - MCS identified using several definitions:
    - Scanning radar (visual inspection);
    - Surface θe drop > 5 K (e.g., Schiro & Neelin, 2018);
    - Maximum rainfall rate > 10 mm/hr.



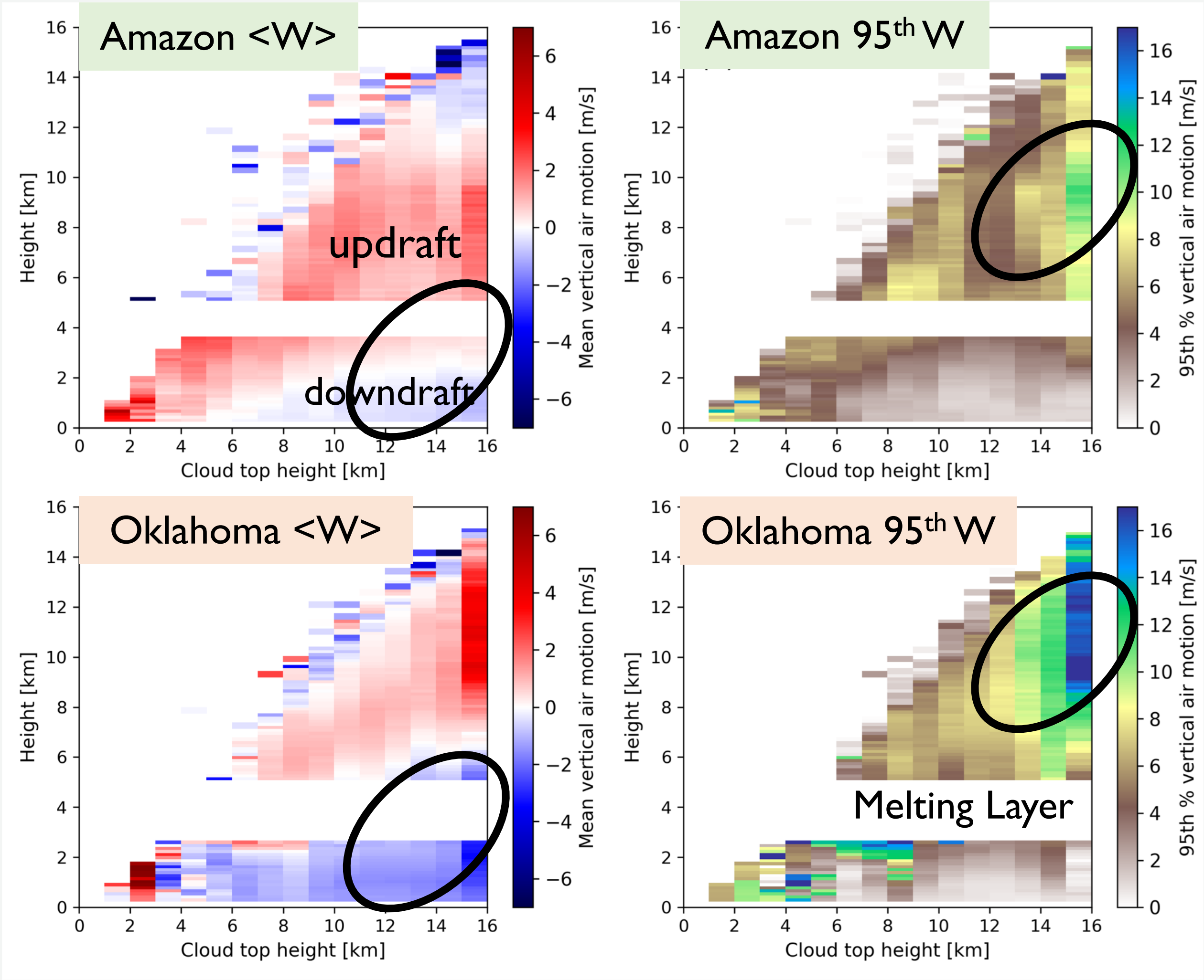
CAPPI 3km reflectivity, *C. Schumacher*





Up-/Downdraft Intensity Comparison (Convective area)

- We plot the mean (and 95th %) vertical velocity profiles, sorted by **Echo-top Height** (10 dBZ).
- Deeper cores (higher ETH) show increasing vertical velocity.
- **Oklahoma MCSs show intense updrafts** (stronger background forcing; greater instability).
- **Oklahoma MCSs show strong downdrafts** that occur more frequently at higher altitudes (~ 6 km)

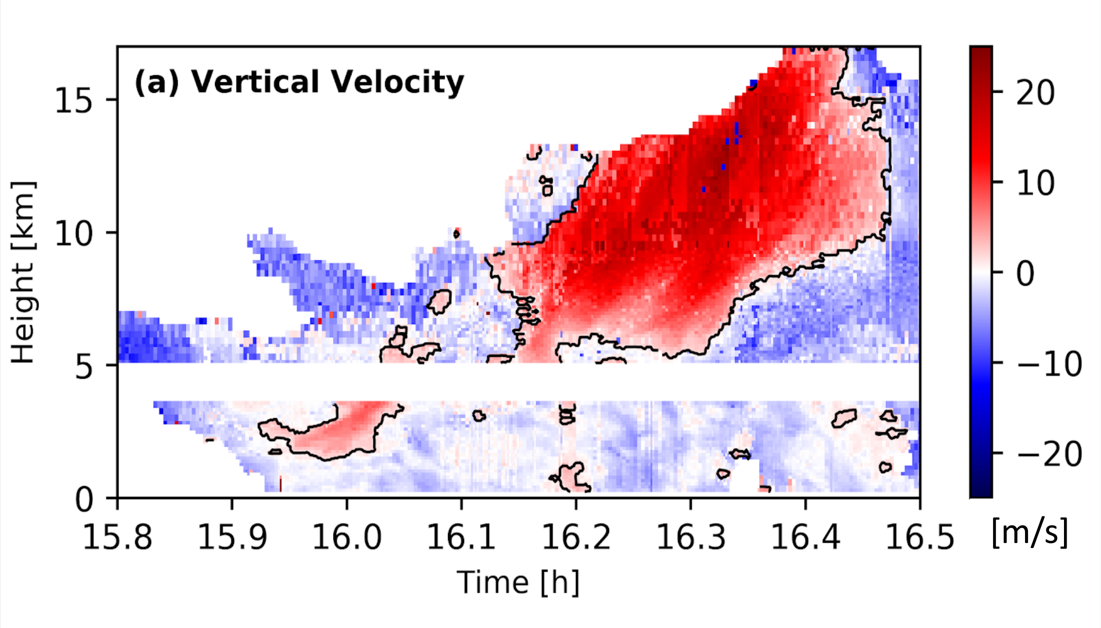


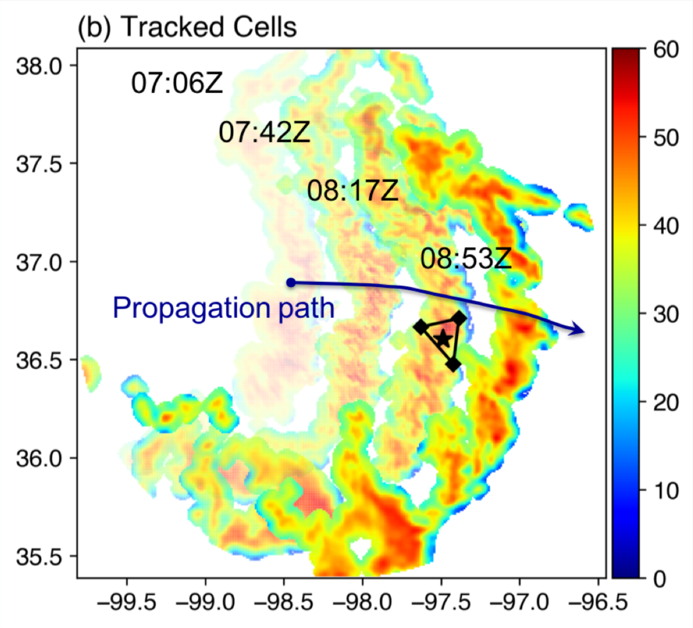
Echo Top Height [km]

***Wang** et al. 2019, JGR*

Up- and Downdraft Core Designation

- **Higher resolution RWP observations provide detailed information about up- and downdrafts**
  - Convective core definitions:
    - Coherent regions with |*W*| > 1.5 m/s; <*Z*> > 20 dBZ; *R* > 10 mm/hr
  - Estimation of core size:
    - Convective line propagating speed from surveillance radar (Feng et al., 2012, TARANIS ➡ next talk, Joe Hardin)

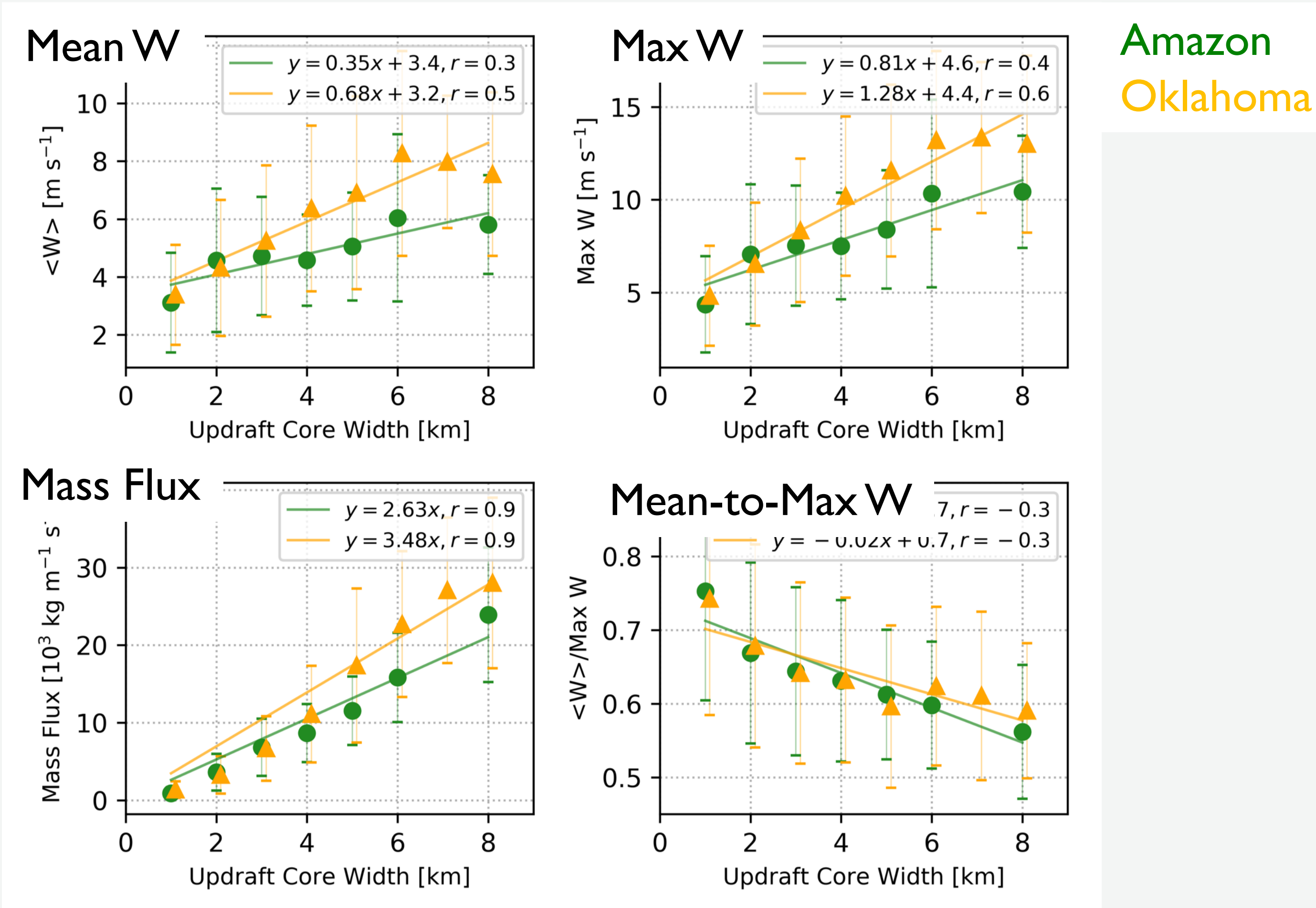




***Wang** et al. JGR, under review*

Convective Core Properties

- Updraft core intensity increases with core size; Oklahoma cores are more intense;
- Similar mean-to-max ratios (core shape);
- Updraft mass flux is larger for wider cores (mass flux = air density * <W> * core width).

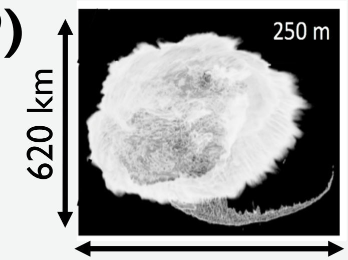


Updraft core size [km]

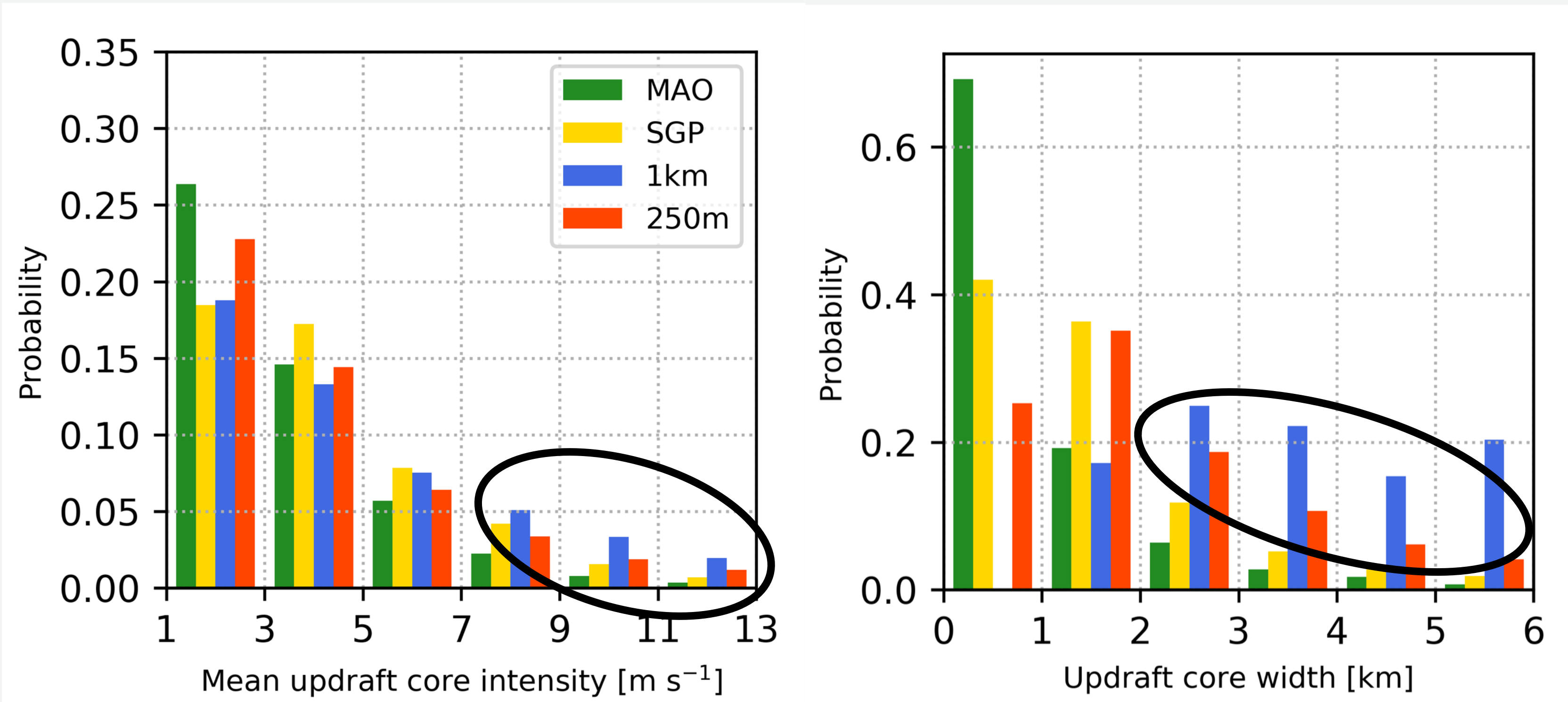
***Wang** et al. JGR, under review*

Idealized MCS Simulations

- **5 Idealized WRF MCS simulations (Prein et al., 2019)**
  - At 4 km to 250 m grid spacings;
  - Midlatitude MCS environments;
  - Convective cores from mature stages



- Models overestimate the updraft core intensity and size at all resolutions.

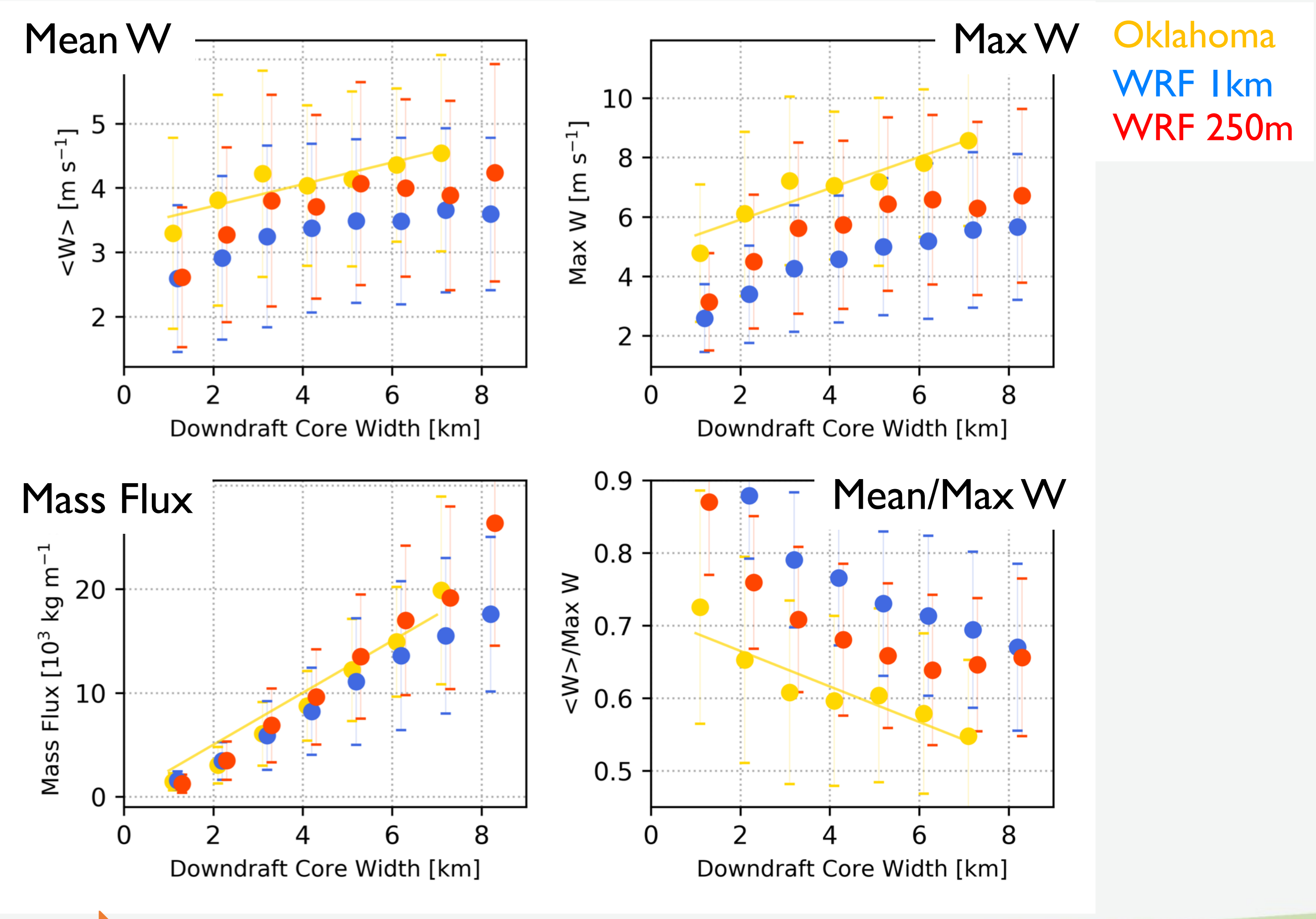


***Wang** et al. JGR, under review*

Simulated Convective Core Properties

- The simulations at Δx = 250 m exhibit draft intensity, mass flux, sizing, and shape parameter performances best matching with observed properties.

Downdraft Cores



Core size [km]

Wang et al. JGR, under review

Summary

- ARM radar wind profiler observations for deep convective cloud coupled kinematic-microphysics property study and model evaluation.
- Models overestimate the updraft core size and intensity; underestimate the downdraft intensity.
- Models best match observed convective core properties at finer resolution.

❖ See my poster **A1-103** for more information on vertical distribution of core properties at various scales.

Many Thanks to:

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