Sensitivity of Deep Convective Updrafts and Microphysics to Thermodynamic and Aerosol Environments Using TRACER Observations

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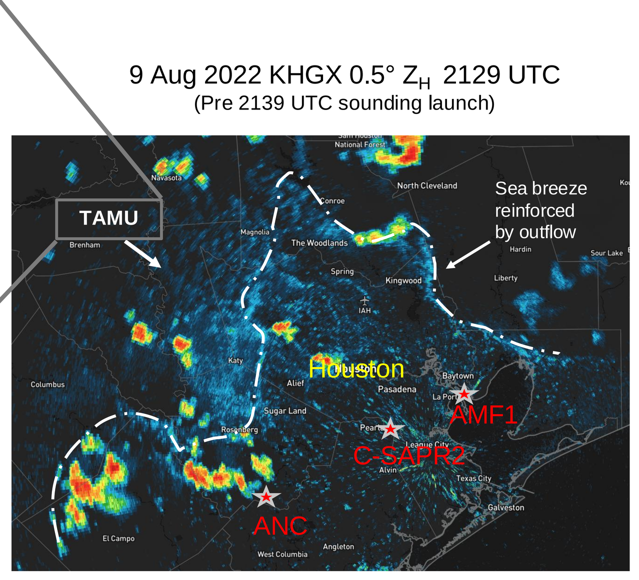
Motivation

Overarching goal of TAMU TRACER: Use field measurements and idealized modeling to understand how the vertical distributions of aerosols correspond to the inflow layer of deep convection in maritime and continental airmasses, and how these variations influence properties of deep convection initiated by sea breeze

TAMU TRACER DATA

TAMU TRACER BAMS PAPER



Research Question

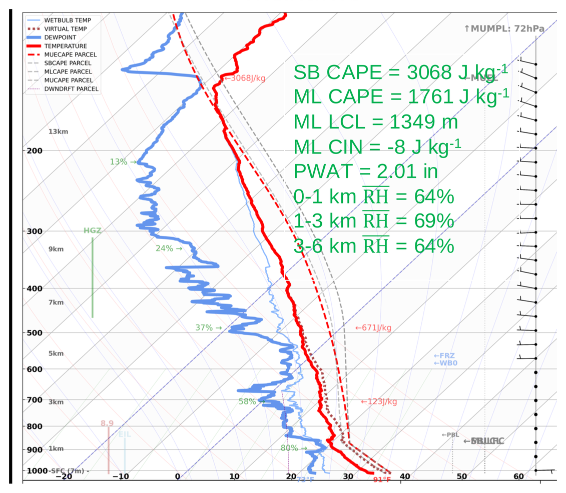
What are the effects of aerosols vs. meteorology on isolated convection using measured thermodynamic and aerosol inflow environments for cells initiated in sea breeze airmasses?

- Ensemble simulations pair measured thermodynamics with respective measured aerosol size distributions, hygroscopicity, and retrieved vertical profiles
- Additional simulations interchange aerosols with other measured profiles from same or different airmass
- Sensitivity to microphysics scheme is also tested by comparing simulations using bin vs. bulk microphysics

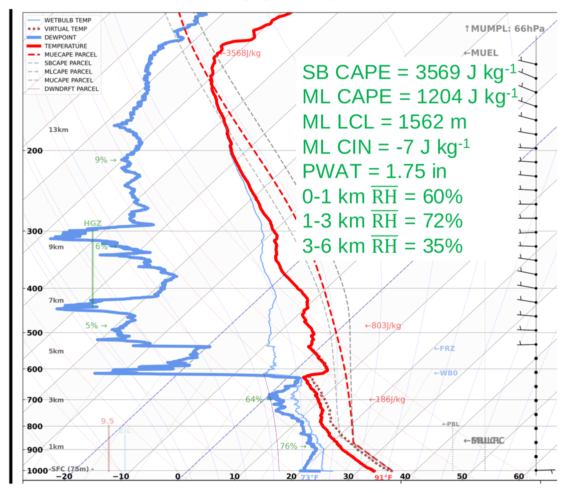
Simulation Design

Thermodynamic & Kinematic Environments

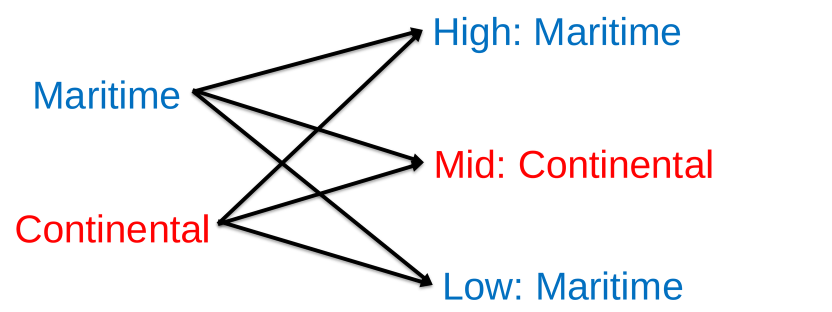
Maritime



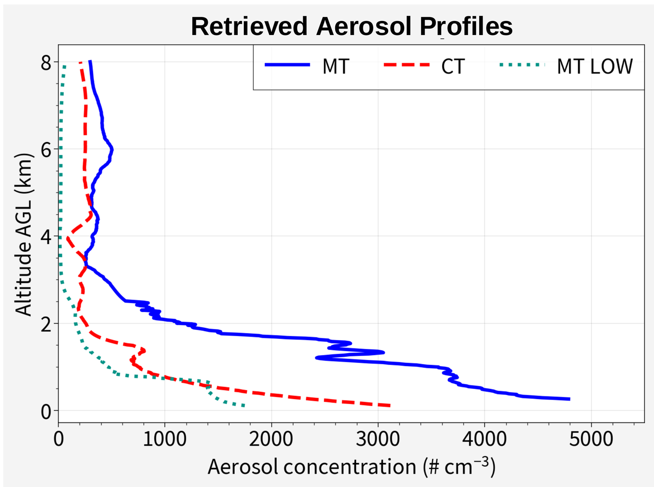
Continental

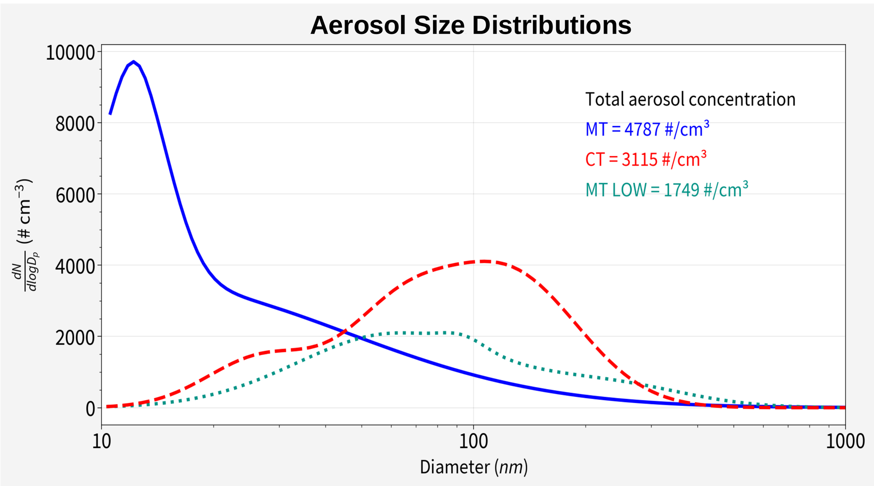


6 Simulation suite



Aerosol Environments

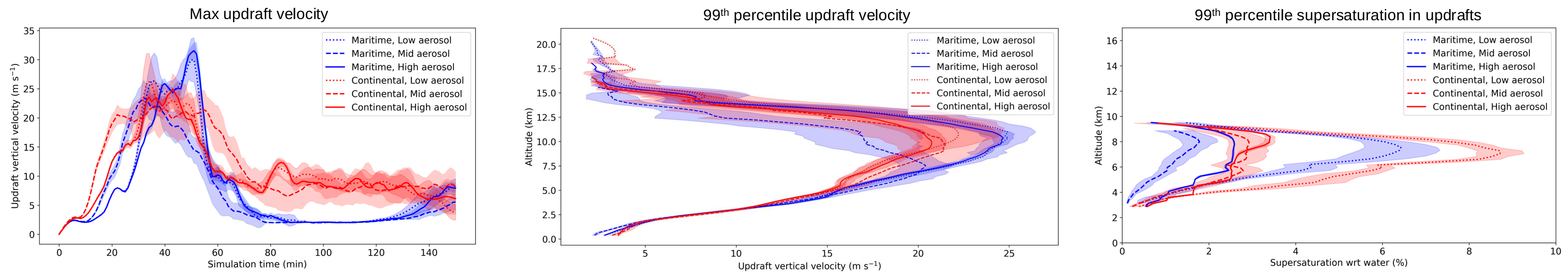




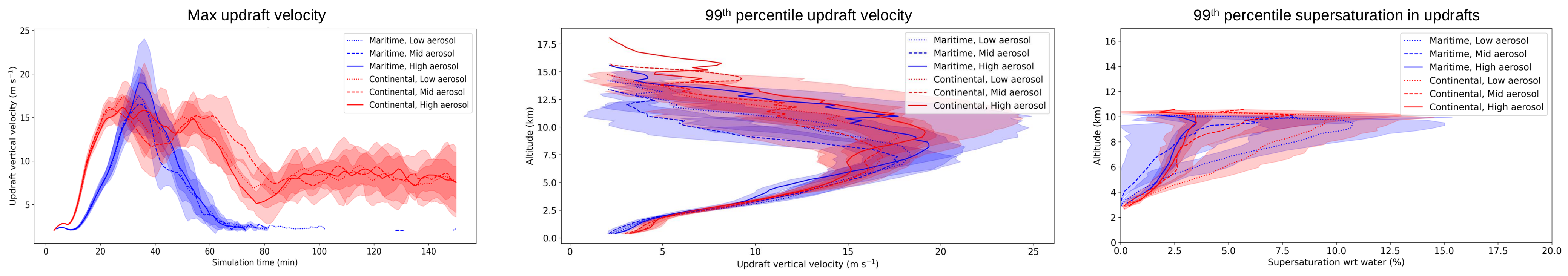
Model setup	Parameter value
Domain size	60 km x 60 km x 22 km
Grid spacing (horizontal)	500 m
Grid spacing (vertical)	200 m
Microphysics scheme	Fast Spectral Bin Microphysics – 3 Aerosol Modes, NSSL 3-Moment – 3 Aerosol Modes
Aerosol species used	Generic, with observed mean κ = 0.14
Integration time step	2 s
Simulation duration	150 minutes
Initialization method	Warm bubble θ perturbation = 3 K
Output frequency	1 min
Boundary conditions	Open (both x and y)
Sub-grid turbulence	1.5 order TKE closure
10-member ensemble	Random warm bubble θ perturbation = ±0.1 K

Updrafts & Supersaturation

Spectral Bin Microphysics

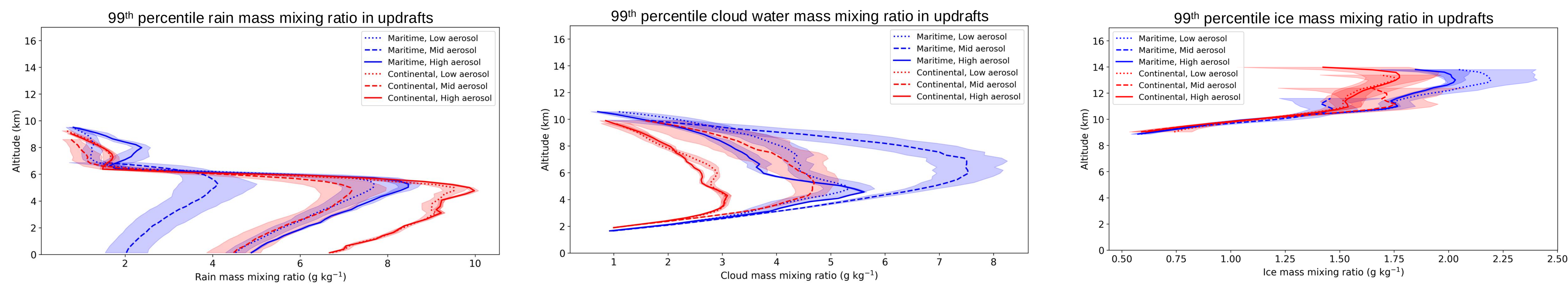


NSSL Three-Moment

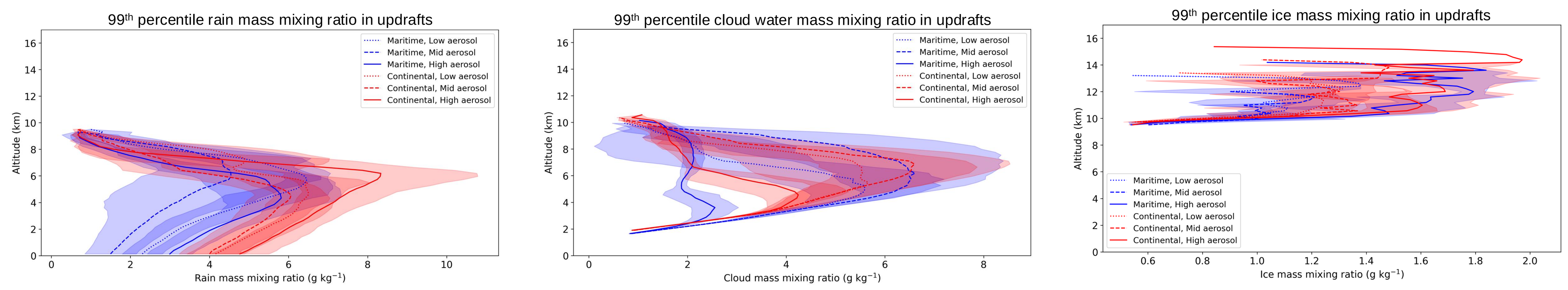


Microphysics

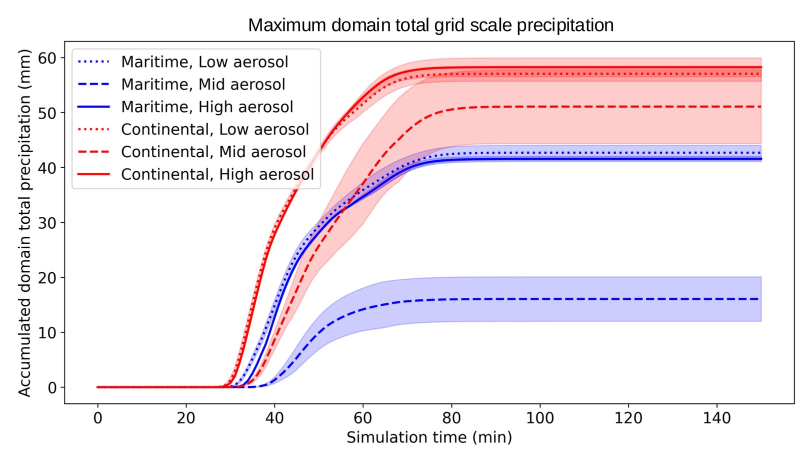
Spectral Bin Microphysics



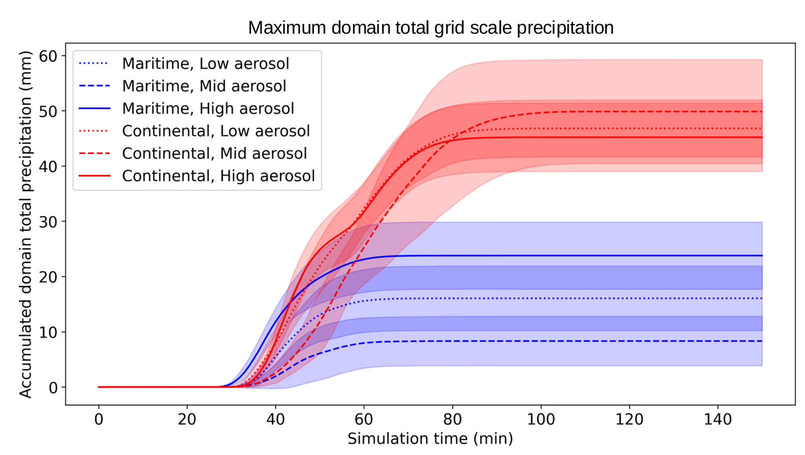
NSSL Three-Moment



Spectral Bin Microphysics



NSSL Three-Moment



Key Takeaways & Future Work

- *The ensemble spread can be as large as base state aerosol or meteorological sensitivity*
- *Larger differences in updrafts, convective evolution, microphysics & precipitation between thermodynamic environments than low vs. high aerosol environments*
  - *Caveat: there appears to be a "tipping point" in thermodynamics - aerosols interactions for the mid-range aerosol concentration/size distributions*
- *Bulk scheme sign of aerosol-cloud interaction reverses from bin scheme and has larger ensemble spread*
  - *Future studies will also investigate the sensitivity to kappa, aerosol vertical profiles, initiation mechanisms, and resolution*

This research is funded by DOE ASR grant DE-SC0021047 and supported by ARM Field Campaigns AFC07023, AFC07055.

Acknowledgments: Special thanks to: Drs. Erik Nielsen, Montana Etten-Bohm, and Don Conlee and TAMU students C. Hood, P. Langford, S. Lewis, C. Perez, B. Tomerlin, J. Treviño, B. Musall, M. Mancilla, K. Nunez, T. Borgstedte, K. Griese, T. Peña, S. Alegrias, L. Mata-Rodriguez, R. Lane, B. Kropp, S. Gardner, J. Ribail, J. Hale, S. Butler, K. Lange, J. Lewis, A. Sebok, D. Leathe, S. Jorgensen, B. Smith, J. Spotts, and D. Topping for assisting with TAMU TRACER and TRACER+ forecasting, nowcasting, deployments, and instrumentation.