Planned TRACER Modeling Activities

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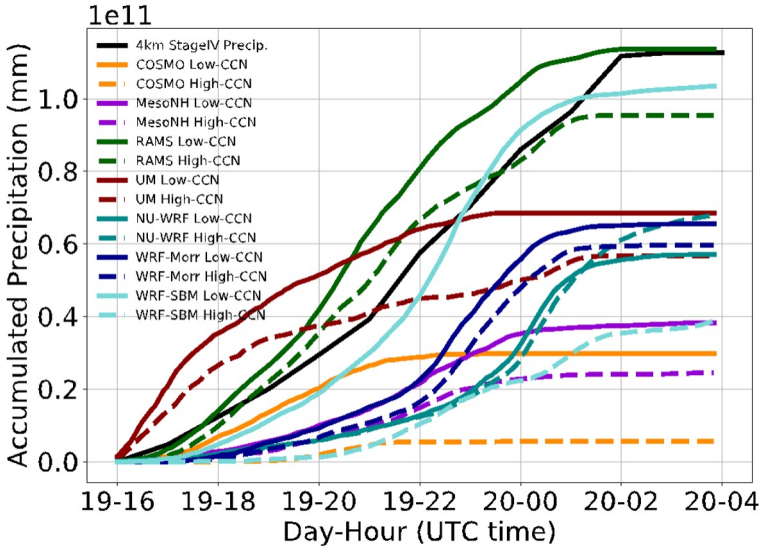
Modeling Activity organized by TRACER modeling group

TRACER Model Intercomparison Project (TRACER-MIP)

Background

- The previous ACPC MIP (pre-campaign activity) showed a large model spread in simulating precipitation and aerosol-cloud interactions (ACI). Because of lacking observational data, the model performances are not evaluated much. Also, the previous MIP employed single aerosol mode without considering ultrafine particles and did not consider Houston urbanization effects.

- Therefore, the ACPC community decided to have a new MIP for TRACER, which was documented by the ACPC Deep Cloud Roadmap 2021 http://acpcinitiative.org/Docs/ACPC_DCC_Roadmap_2021.pdf. The community had a dedicated session to discuss this new MIP at the workshop in May of this year. This can be a candidate case for the WMO International Cloud Modeling Workshop 2024.



Van den Heever et al., 2019

Objectives

- **With well-observed TRACER cases, we aim to**

(1) identify each **model's deficiencies** and **measure** model performances

(2) identify factors/processes leading to the model biases and large model spread, both of which were not achieved in the previous MIP. This effort will ultimately help reduce the ACI uncertainty.

Hypotheses:

(1) The different **representations of condensation and ice microphysics** are the major source of inter-model spread, thus, leading to the main model differences in the simulation of ACI;

(2) The models that **reproduce** the observed cases and employ **explicit calculation** of condensation give **qualitatively consistent ACI effects**, particularly for the effect of ultrafine particles.

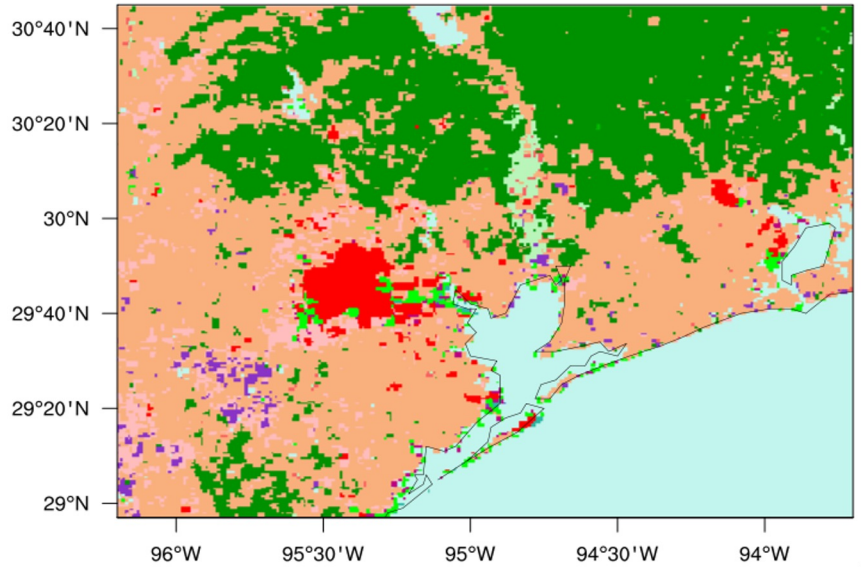
Approach

The TRACER-MIP follows the protocol of the previous ACPC MIP, with the following new features:

- Extensive **model evaluation** against observations.
- **A couple of** golden cases with **different** environmental and convective conditions.
- The effects of **urbanization** will be considered.
- **Ultrafine aerosol** will be considered.
- **Two tiers**: prescribed and prognostic aerosols.
- Focus on **factors/processes** leading to model biases and large model spread

Model domain setup

Different from the ACPC MIP, **a single domain** at 0.5 km (or 0.25 km) grid, with initial and boundary conditions from HRRR (3 km), RAP (13 km), or NAM and FNL (need to test with different forcing data; different cases might use different forcing datasets)



Example domain (Fan et al. ACP, 2020)

Aerosol setup

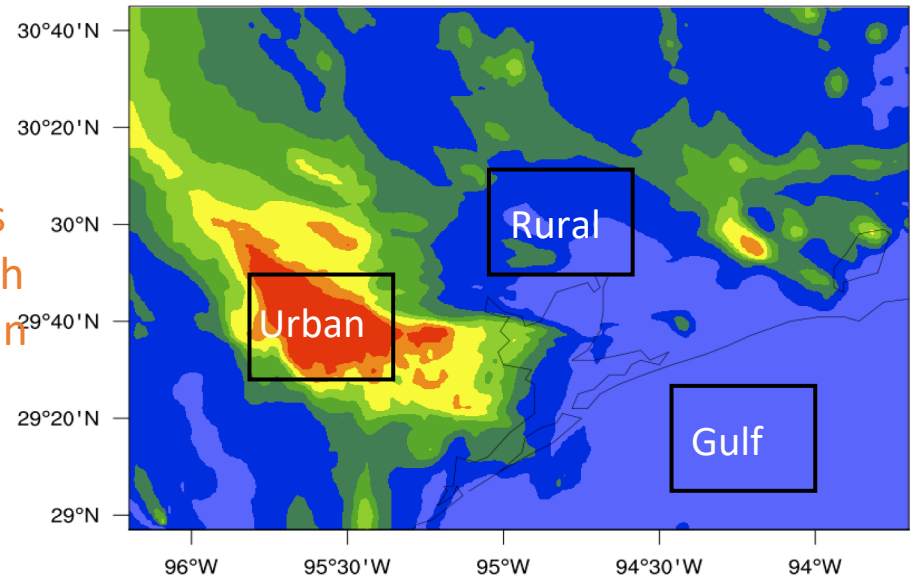
Tier 1:

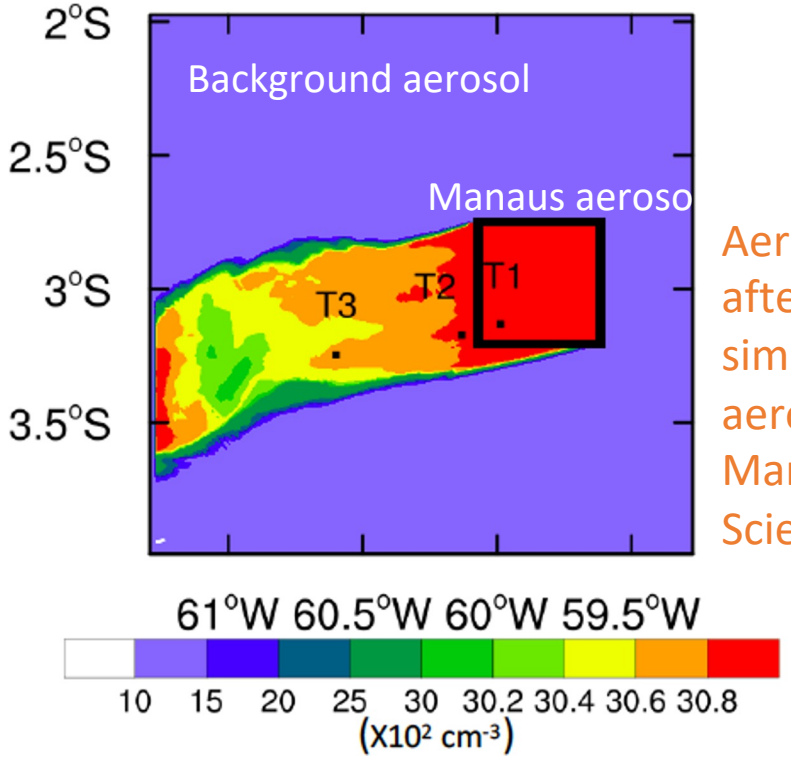
- Fixed aerosol number or droplet number over the entire domain

Tier 2:

- Prognostic aerosols with contrasting aerosols between background and Houston following what we did for the GoAmazon study where there is a city Manaus.

Simulated aerosol concentrations in Houston with WRF-Chem (Fan et al., ACP, 2020)





Aerosol concentration after 1-day WRF simulation with the aerosol source set in Manaus (Fan et al., Science, 2018)

Discussion

1. Case selection

- Need **a list of cases** since some of cases may not be simulated well.
- Case selection criteria:

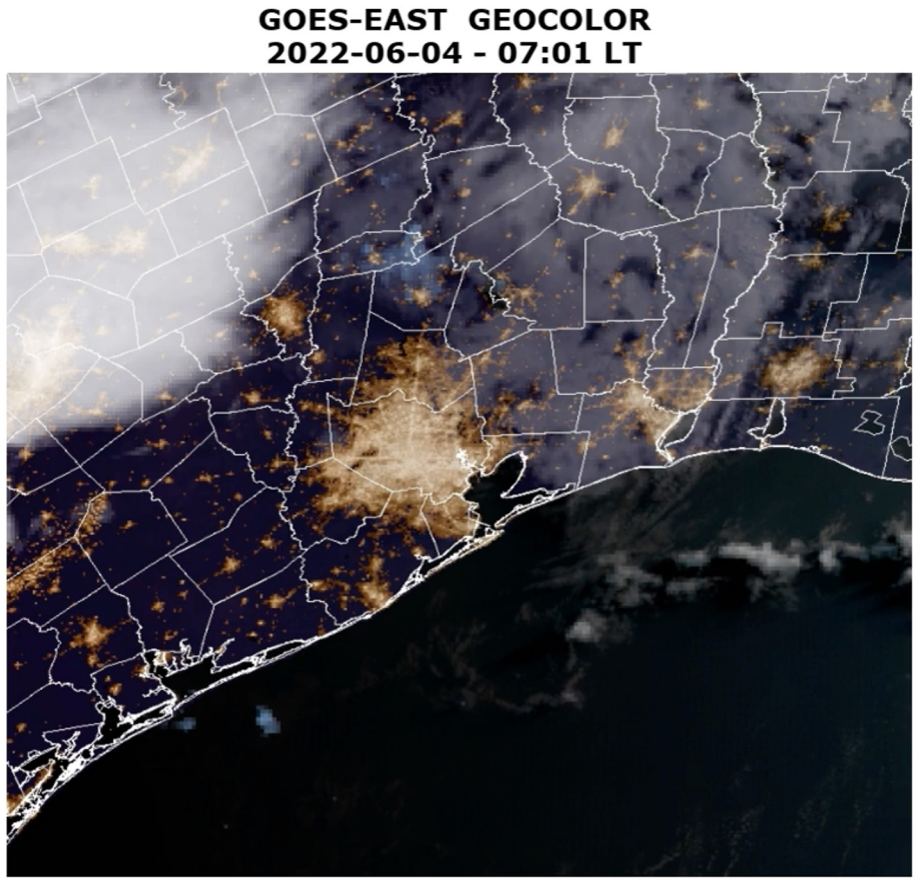
○ **Sea breeze cases** occurring in **different environmental** conditions (e.g., inflow air is polluted vs. clean)

○ **Initiated** near Houston or **pass over** Houston

○ **Comprehensive measurements** in aerosols, meteorology, cloud, and precipitation (aerosol and meteorology before thunderstorm initiation and the cell-tracking observations are important. It is even better if the case has the ESCAPE aircraft measurements).

○ **Contrasting forecasts**: such as one case where forecasts did a good job and another case where forecasts missed or did a poor job.

Synoptic forcing + Sea breeze, evolving into organized convection



Movie from Steve Saleeby

Two sea breeze cases with isolated cells at Houston

Cell-tracked with the modified FLEXTRKR (Feng et al., 2022), by Ye Liu at PNNL

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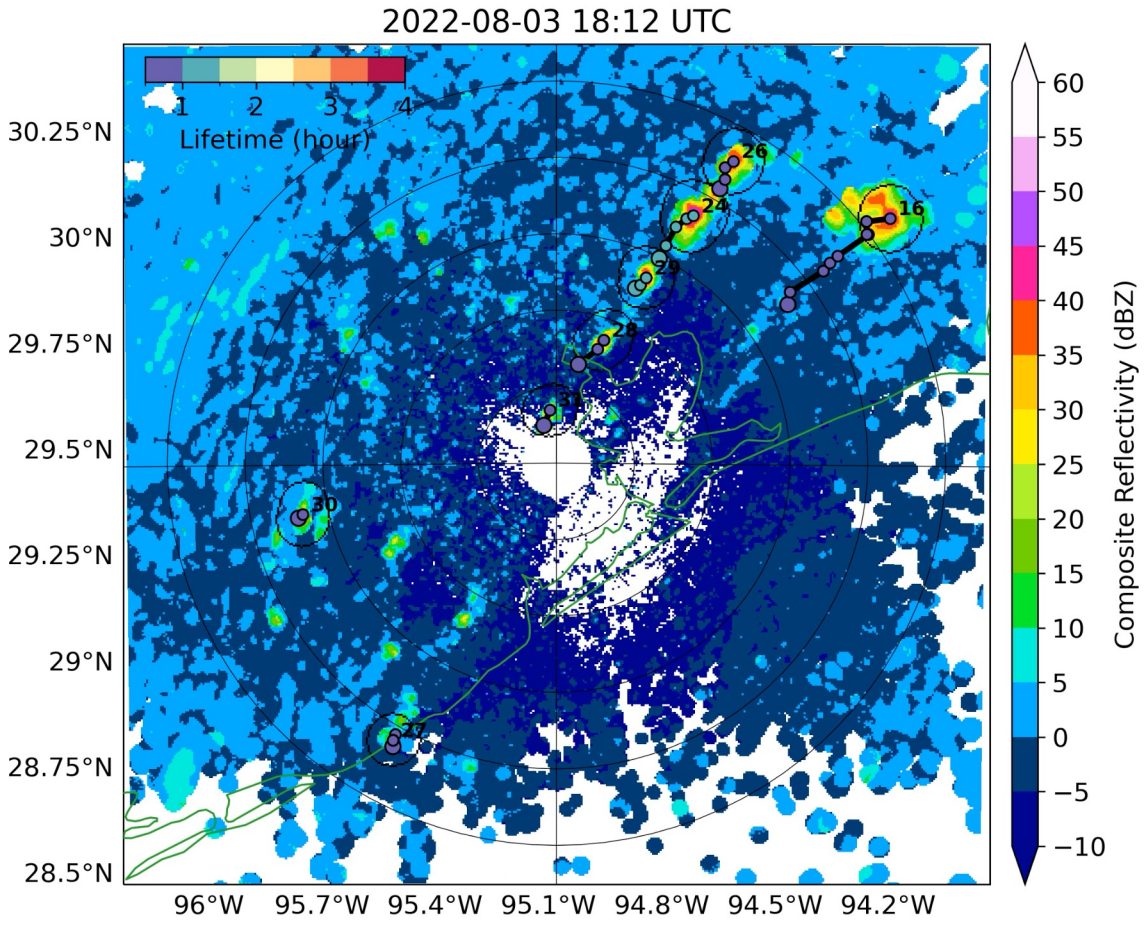

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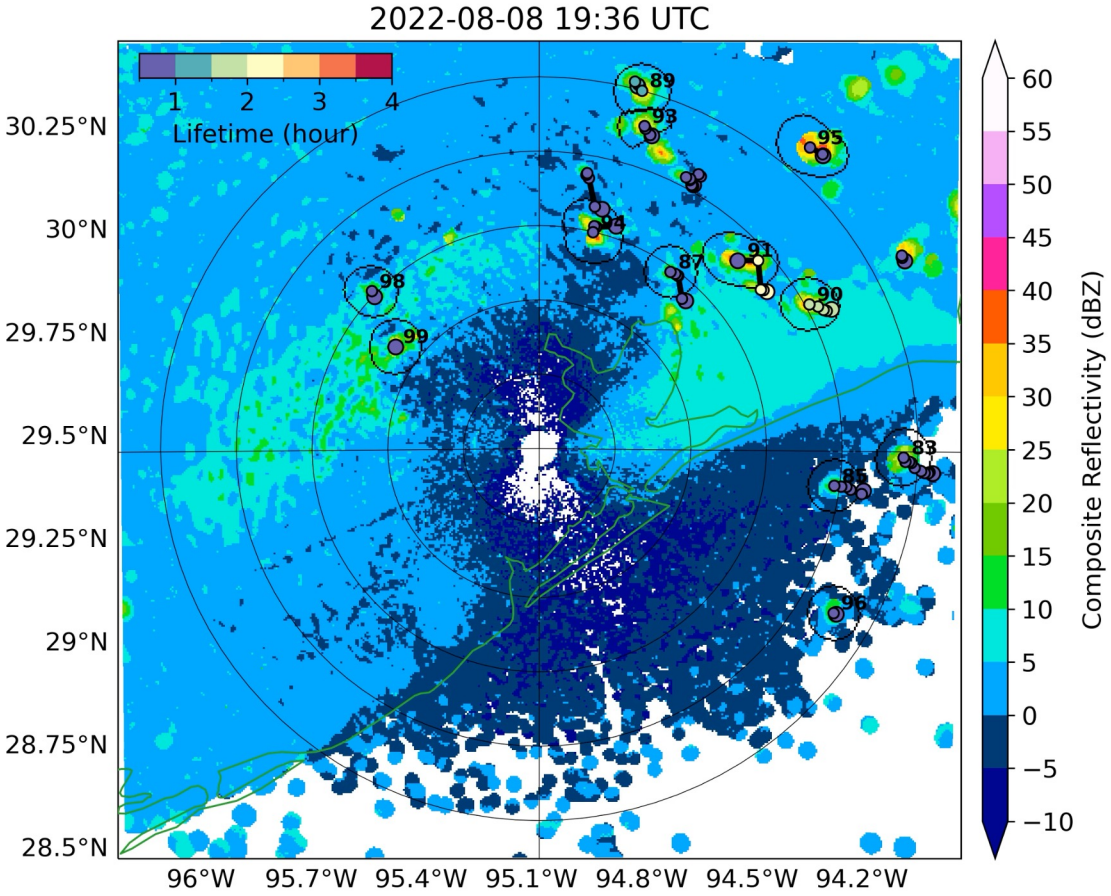
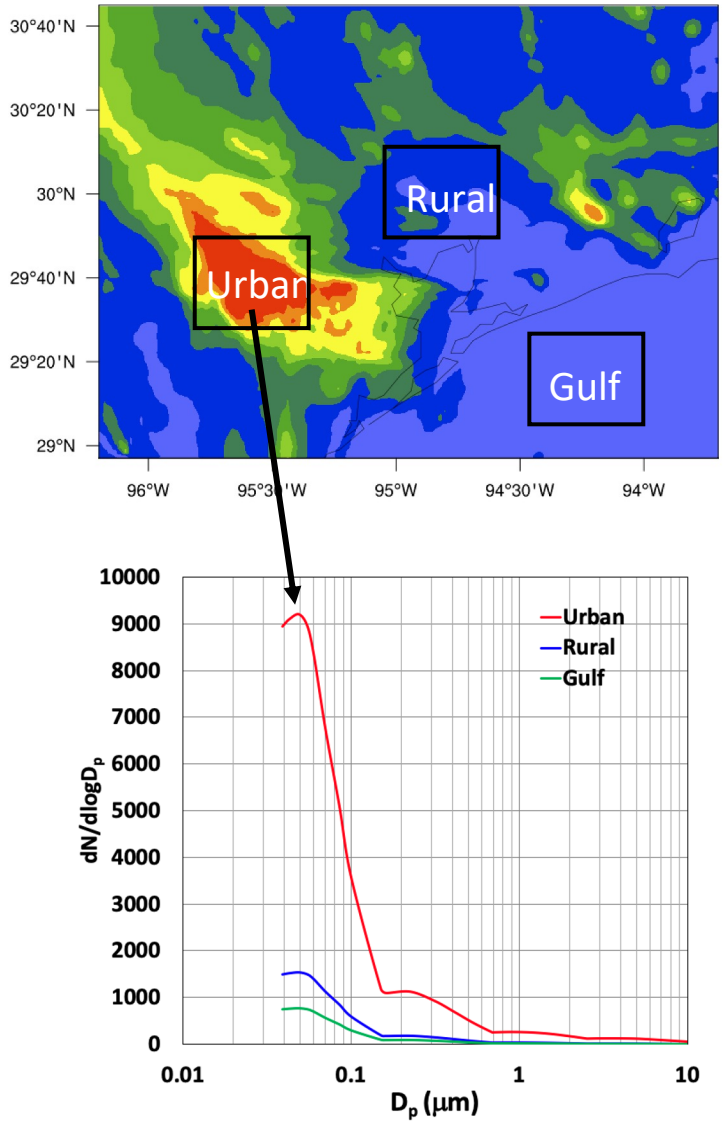


2. Model Simulations and outputs

- Baseline simulations with **urban** and **aerosols** considered (are there models that can not consider urban?)
- Sensitivity simulations
  - Decrease aerosol concentration (for Tier 2, only decreasing aerosol in Houston to be the same value as rural)
  - Turn off urban parameterizations/replace urban land with cropland (optional?)
- Output variables and frequency
  - 5 min frequency: basic meteorology and cloud microphysics, precipitation (warm and cold rain), surface fluxes, 2-m T and moisture
  - 30-min frequency: all others?



Aerosol size distribution based on

3. Model evaluation

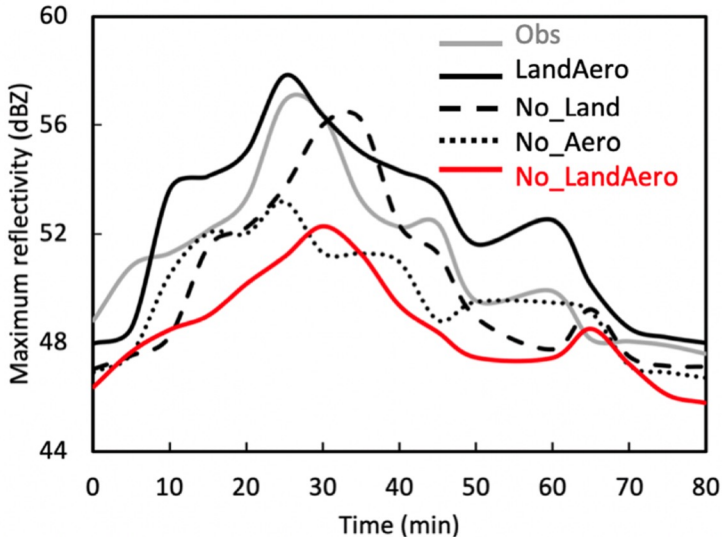
- Need **close collaboration** between observational data developers and modelers (observationalists need to know what modelers need, and modelers need to understand data caveats and uncertainty)

- **Development of integrated datasets for selected cases**: in both Eulerian and Lagrangian (with respect to tracked convective cells) frameworks, for aerosol properties, meteorological conditions, radar observations, and lightning

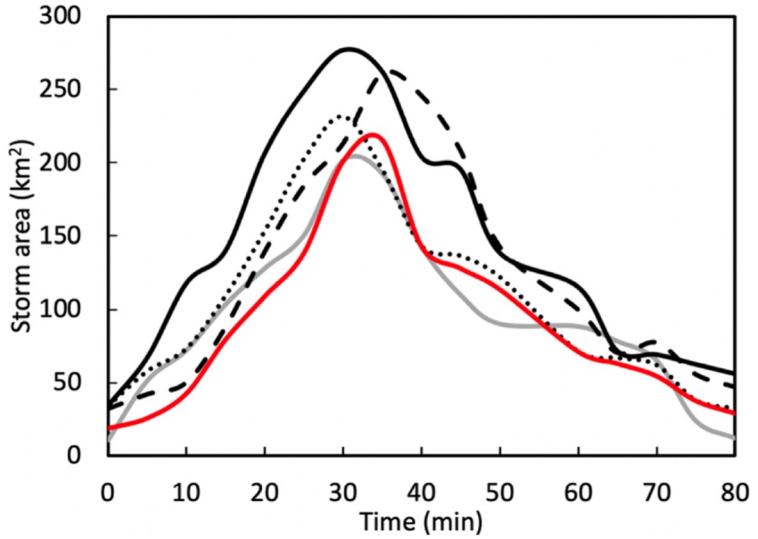
- **Offline running CR-SIM** for direct comparisons with radar measurements?

- **Other datasets** (e.g., surface fluxes, soil moisture, sounding, PBL height)

Max. reflectivity for the tracked convective cell with MCIT



Cell area for the tracked convective cell



3. Computational resources and data storage

- ARM
- NERSC

Planned modeling efforts from individual groups

Name/group	Model	Resolution	Microphysics	Description (any additional information you want to let people know)
Zach Lebo	WRF	1 km	Thompson	1-day forecast type of simulations with urban canopy and aerosol considered
Jiwen Fan, Ye Liu, Jingyi Chen	WRF and WRF-Chem	Nesting; from 1 km to 0.5 km or 0.2 km	P3, SBM	Detailed urban model with buildings will be considered; focus on impact of urbanization, aerosols and soil moisture on sea breezes and convective storms
Taka Iguchi and Toshi Matsui (NASA GSFC)	NASA-Unified WRF	Nesting; 3 and 1 km	NSSL 2-moment with CCN prediction (revised)	48-hours forecast from 00UTC; plots will be uploaded in https://portal.nccs.nasa.gov/datashare/ (planned)
Philip Stier & Maor Sela	ICON and ICON-HAM (interactive aerosol)	Nesting;	Seifert & Beheng	
Chris Nowotarski, Anita Rapp, Milind Sharma (TAMU)	WRF, Idealized (maybe some CM1)	100-m	Thompson Aerosol Aware	Idealized, horizontally homogeneous, small domain, limited physics simulations mixing and matching observed meteoroogical (radiosonde) and vertical CCN and INP profiles (lidar and ground-level measurements) from opposite sides of sea-breeze or outflow boundaries.
Christian Barthlott and Corinna Hoose	ICON and/or ICON-ART	Nesting up to 300/150 m	Seifert & Beheng	
Steve Saleeby and Sue van den Heever	RAMS	Nesting up to 100m	Saleeby and van den Heever (2013)	RAMS simulations of TRACER – ESCAPE case studies including sensitivities to land surface types and processes, as well as aerosols ; tobac cell tracking

Provide your input to the google form: https://docs.google.com/spreadsheets/d/1TeVUrQZCfbPtTn9NIJiYBqy3c0pccf4g/edit#gid=571160921

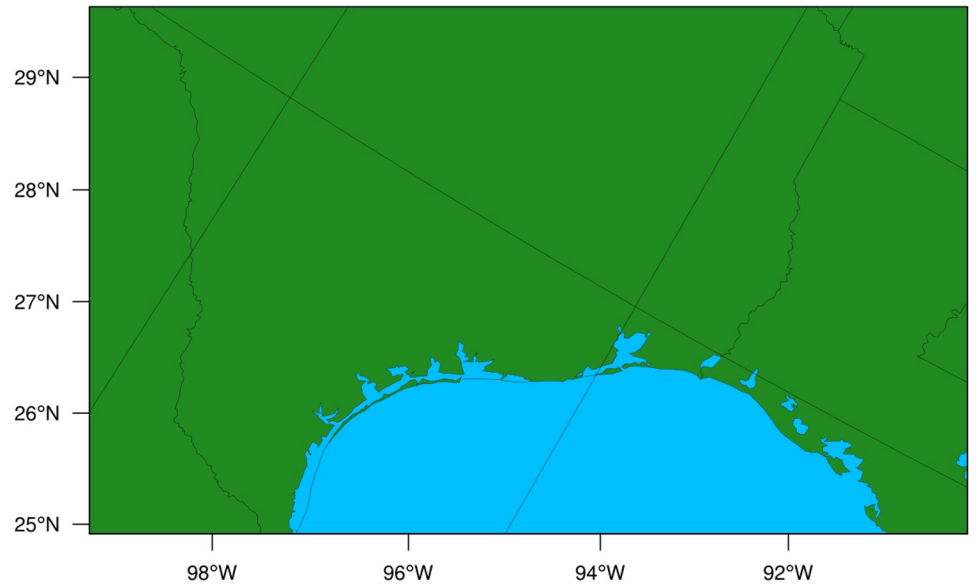
Zach's simulation data is available

- Forecast runs during ESCAPE for June 2022

Goal is to provide an ensemble of model simulations for analysis of aerosol, cloud, and precipitation interactions in convective clouds

- Microphysics: Morrison, P3, Milbrandt, Thompson
- PBL: MYNN, YSU
- IC/BC: HRRR (some used NAM and GFS 32-km)

Single domain at 1-km with grid points of 1000 X 600



View quick plots at
http://atmos.uwyo.edu/~zlebo/escape/

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