Model Intercomparison Project of Simulated Convective Cases Observed During the TRACER Campaign

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Introduction

- **The 1st deep convection model intercomparison project (MIP) of the Aerosol, Cloud, Precipitation and Climate (ACPC) initiative focused on aerosol convection interactions (ACI) associated with storm updrafts, microphysics, and precipitation via simulations of ordinary convection near Houston (19-20 June, 2013).** ***(Marinescu et al., 2021; Saleeby et al., 2023; van den Heever et al., 2023)***

- **Efforts of the ACPC working group provided the motivation for the TRacking Aerosol Convection interactions ExpeRiment (TRACER) that took place in the Houston Area with an intensive observation period (IOP) from June-Sept 2022.**

- **A 2nd follow-on "TRACER MIP" will simulate at least two of six "Golden" case study days from the IOP period selected by TRACER observational and modeling teams.**

TRACER-MIP Objectives

- ✧Invite original ACPC MIP contributors to participate and open the TRACER MIP to new participants. (The DOE has graciously approved HPC compute time and data storage for this effort.)

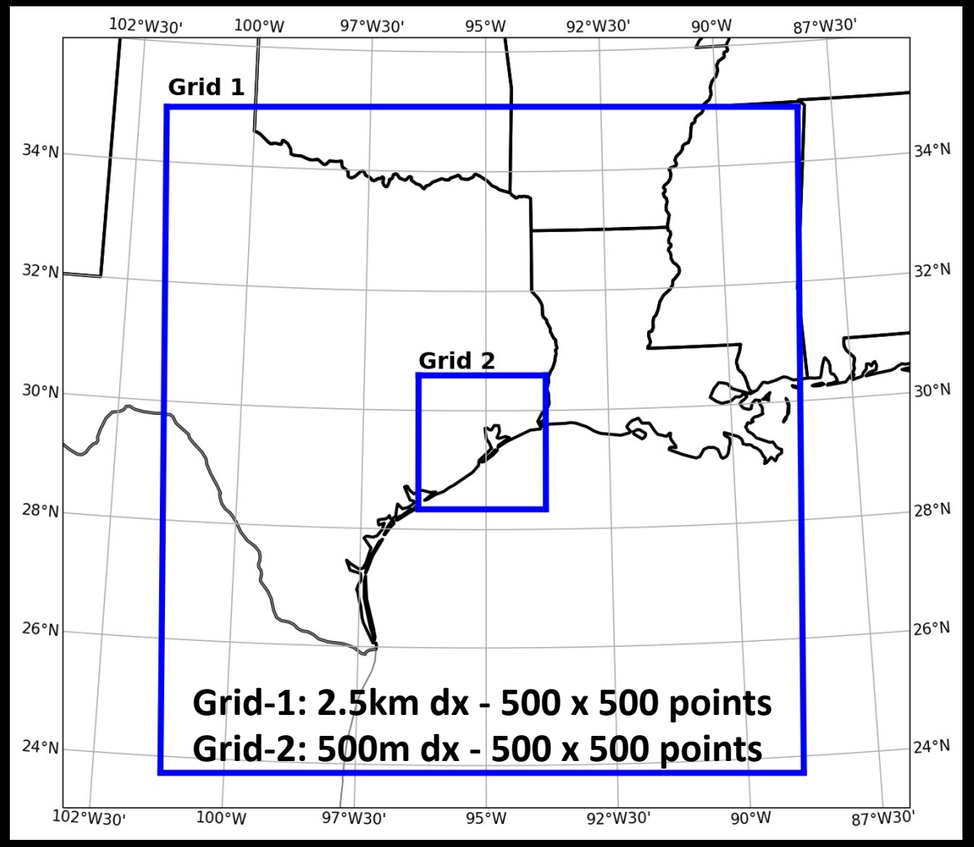
- ✧Identify each participating model's deficiencies and measure model performances. While the original MIP case study had limited observations for validation, TRACER IOP observations offer a vast array of data for simulated case study assessment.

- ✧Examine processes leading to model biases and large model spread in order to ultimately help reduce uncertainty in ACI.

TRACER-MIP Objectives

Original MIP Models	Institution	Collaborators
Consortium for Small-scale Modeling	Karlsruhe Inst. of Technology	Hoose, Barthlott, Barrett
Meso NH Model	Meteo-France	B. Vie
Regional Atmos. Modeling System	Colorado State Univ.	S. van den Heever, P. Marinescu
Icosahedral Non-Hydrostatic Model	Univ. of Leipzig	J. Quaas, R. Cherian
Unified Model	Univ. Leeds	A. Miltenberger
Weather Research & Forecasting Model (w/ Morrison Micro)	Univ. of Oxford	P. Stier, M. Heikenfeld, B. White
NASA Unified WRF	NASA Goddard	A. Fridlind, T. Matsui
WRF – Spectral Bin Microphysics	Pacific Northwest National Lab	J. Fan, Y. Zhang, J Shpund

TRACER MIP Model Domain



The TRACER MIP innermost grid is the same as the earlier MIP. Outer grids were modified to simplify setup and reduce compute demand.

Case Study Selection

Primary criteria for cases selection:

- **Convection observed**

Availability of the following data:

- **TRACER AMF1 (5 soundings)**
- **C-SAPR2 tracked cells**
- **Aerosol observations (ACSM & SMPS)**

Prefer to also have:

- **Observed Sea-breeze**
- **Isolated sea-breeze convection rather than organized large-scale convection**

<u>Golden TRACER Cases:</u>

June 2, June 17, June 21
Aug 7, Sep 17, Sep 18

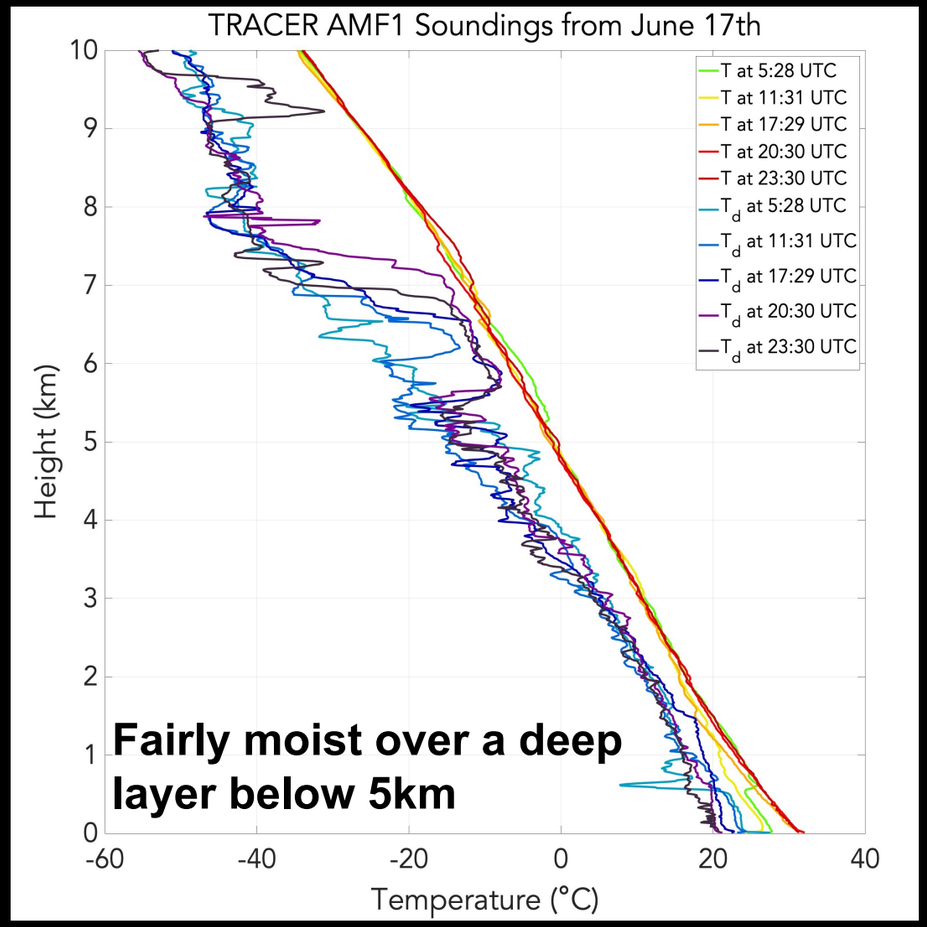
<u>Top Cases for MIP:</u>

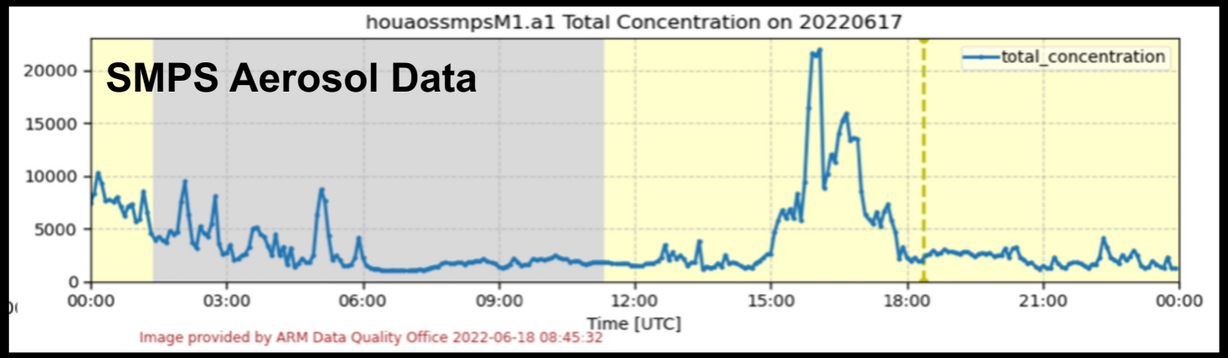
Jun 17 and Aug 7 chosen based on:

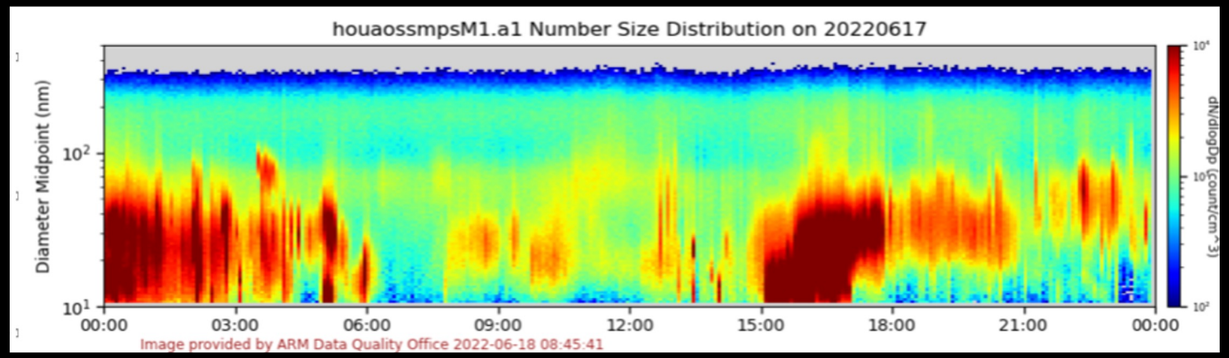
1. **data availability**
2. **high forecast skill score (70+)**
   (from Toshi Matsui's group)
3. **contrasts in column moisture & aerosol concentration.**

June 17, 2022 Event

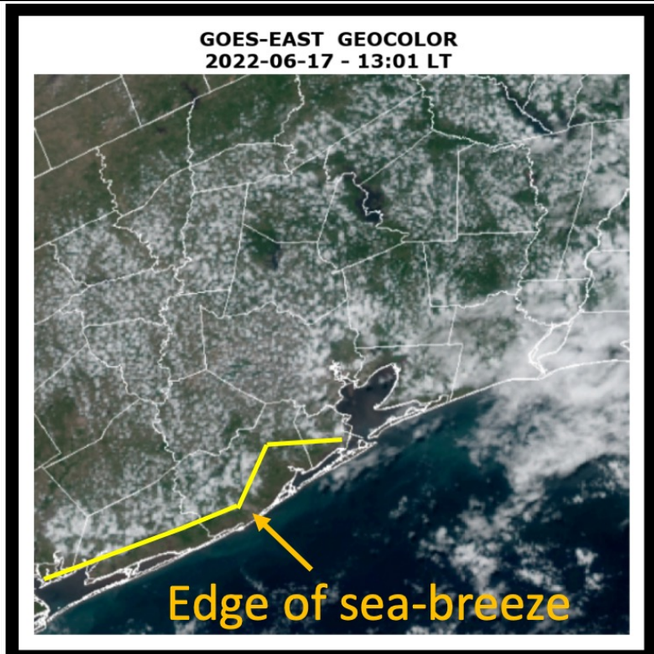
- Distinct sea-breeze edge
- Sea-breeze convection + large-scale convection
- Overlaps with NSF-ESCAPE
- Aerosols (no ACSM, yes SMPS)
  88% - clean marine
  8% - regional continental

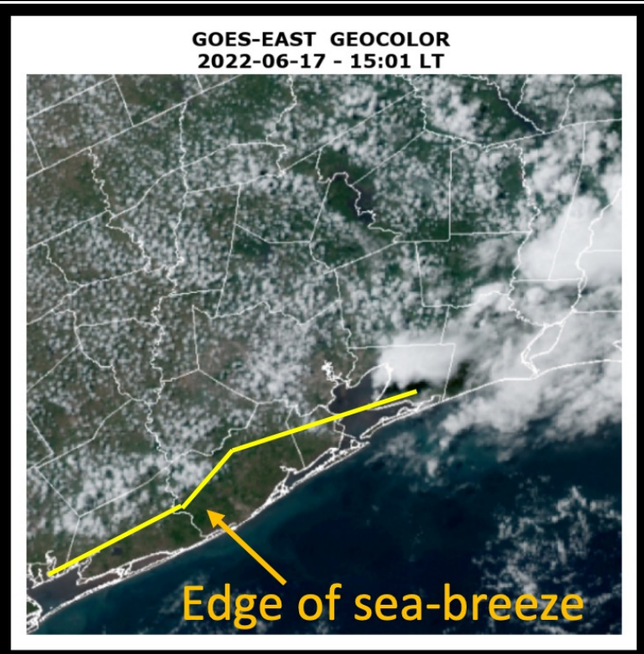


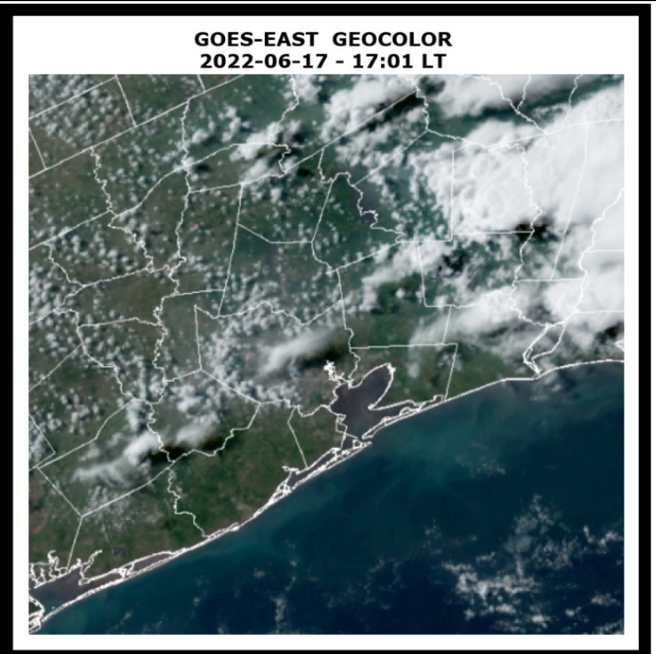


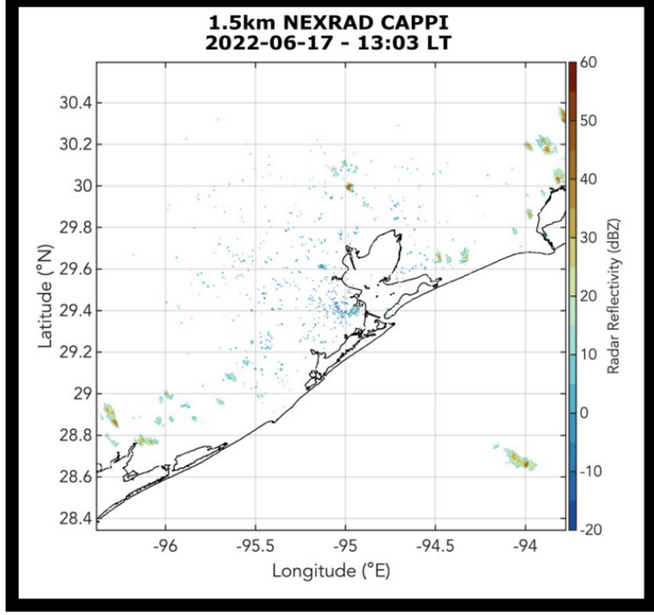


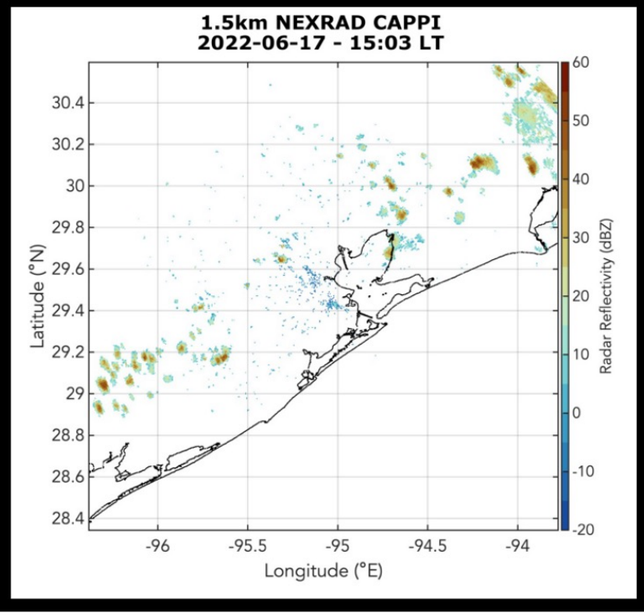
June 17, 2022 Event

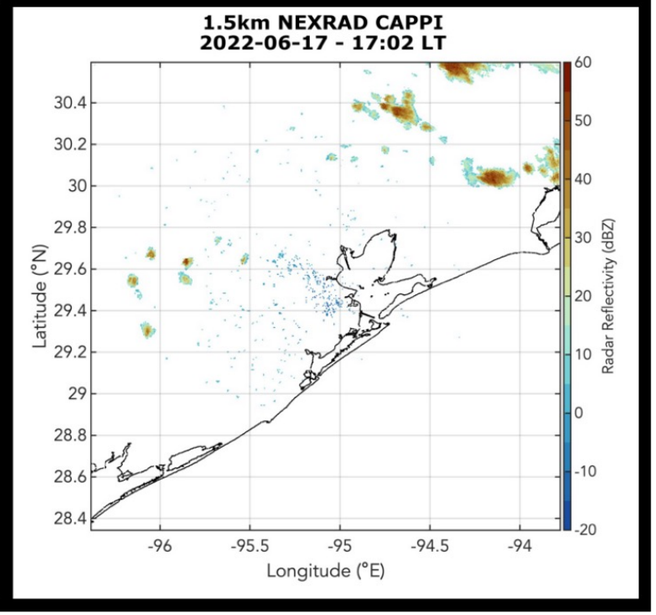






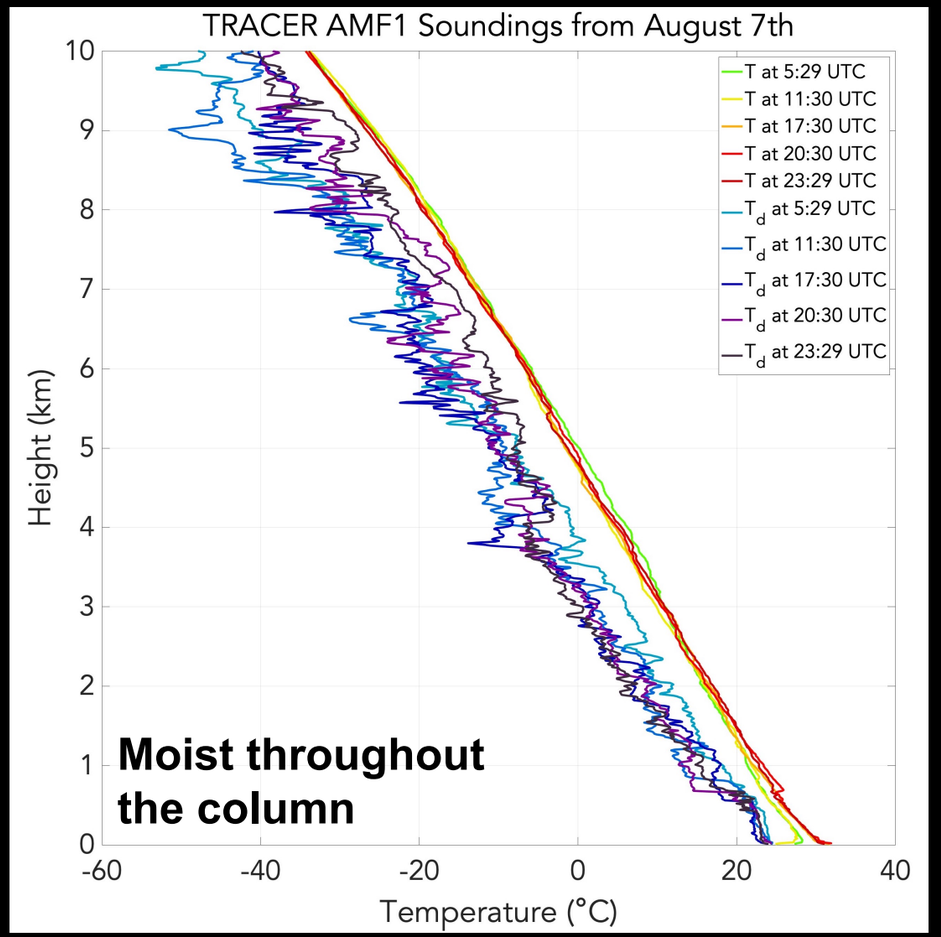


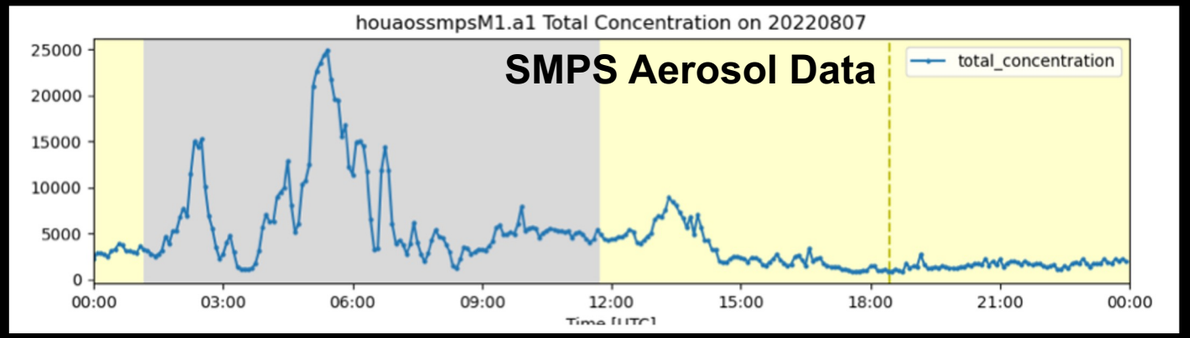


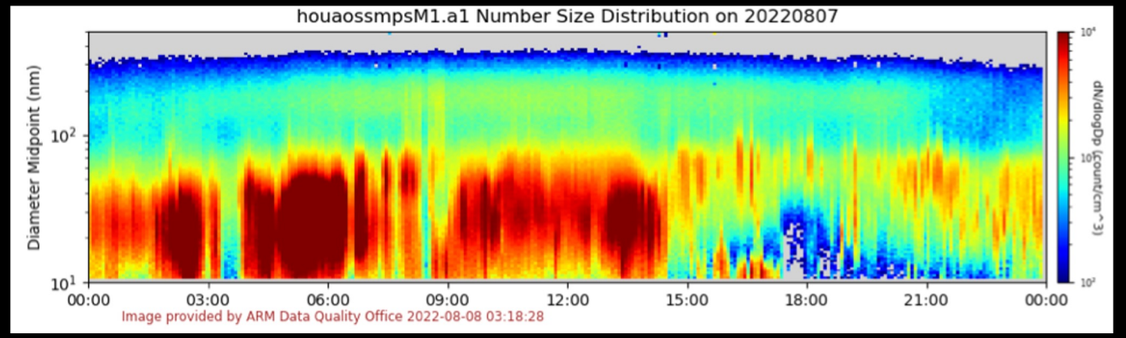


August 7, 2022 Event

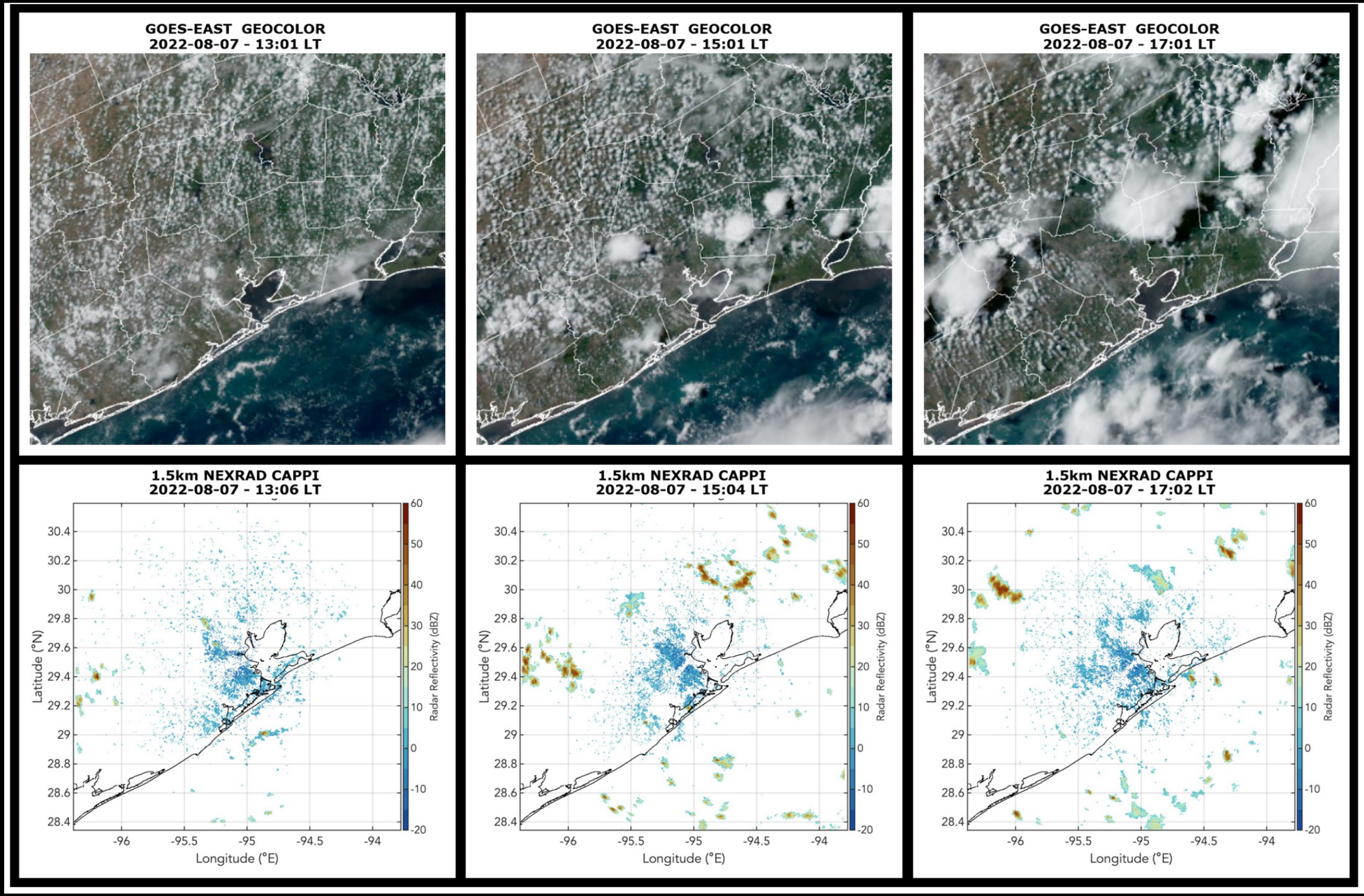
- Consistent onshore flow, early sea-breeze front
- Isolated convection with a few longer-lived cells late in the day
- CSAPR tracked cell for 1.5 hours
- Aerosols (yes ACSM & SMPS):
  High concentration early
  92% - clean post-sea-breeze







August 7, 2022 Event

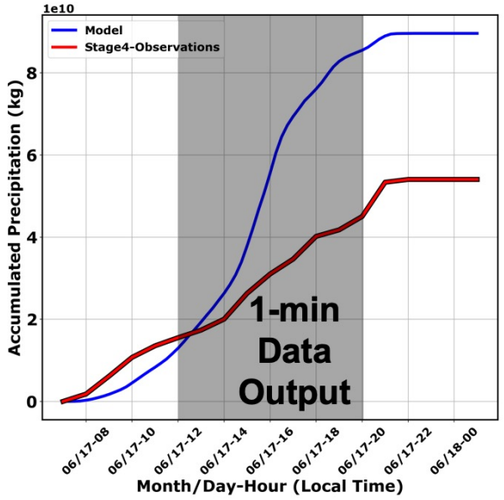


TRACER MIP Simulation Setup & Output

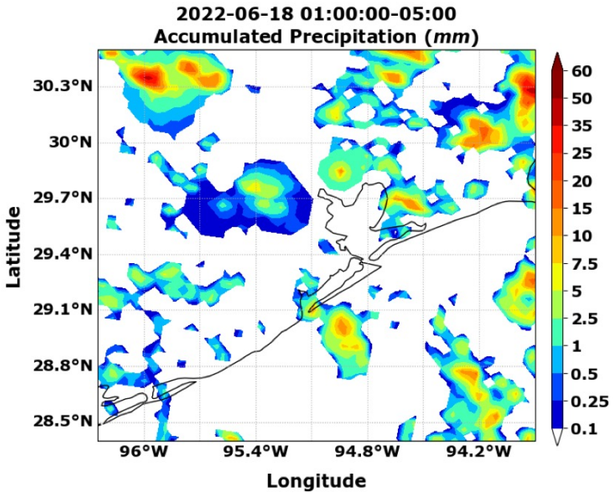
- **ERA5 reanalysis for initialization of atmosphere and soil moisture.**
- **Reynold's 1-deg weekly-averaged SSTs.**
- **95 vertical grid levels from previous MIP.**
- **Case day 0600 UTC model start time, run for 24 hours.**
- **Retain all relevant model fields in one output file per output time.**
- **Microphysical process rates computed as sums between output write times. List of requested variables provided in roadmap doc.**
- **1-min output from 1200-2000 LT for cell tracking, otherwise 5-min. Longer duration of 1-min data compared to previous MIP will permit capturing more convective cells for cell tracking statistical analysis.**

June 17, 2022 Event

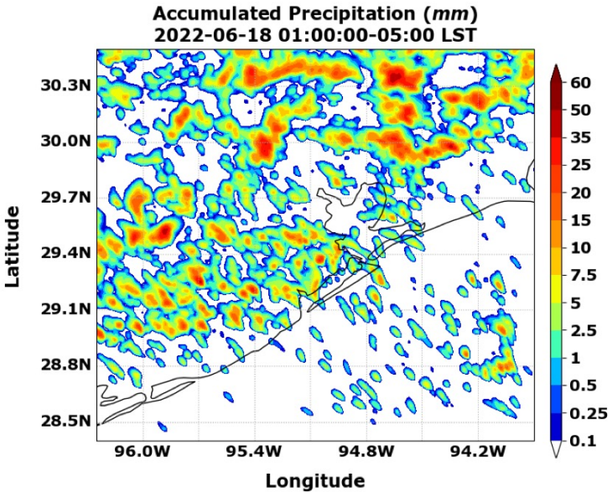
Precipitation Time Series



Stage-IV Observations

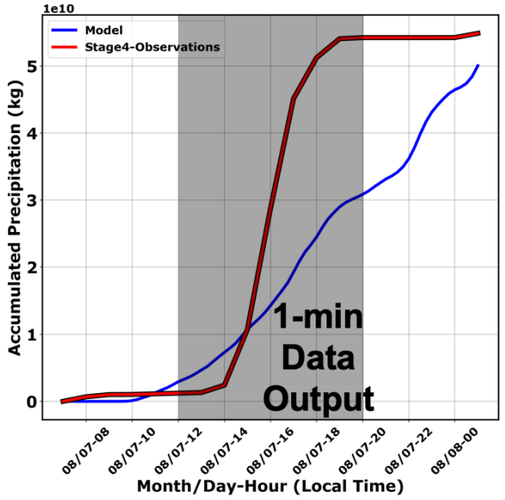


RAMS Low-CCN Test Run

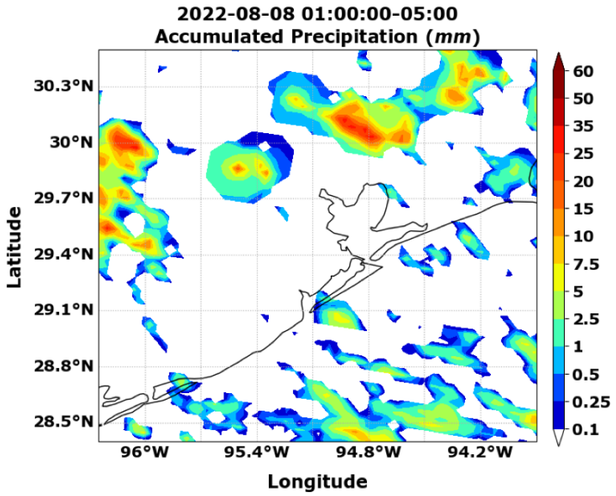


August 7, 2022 Event

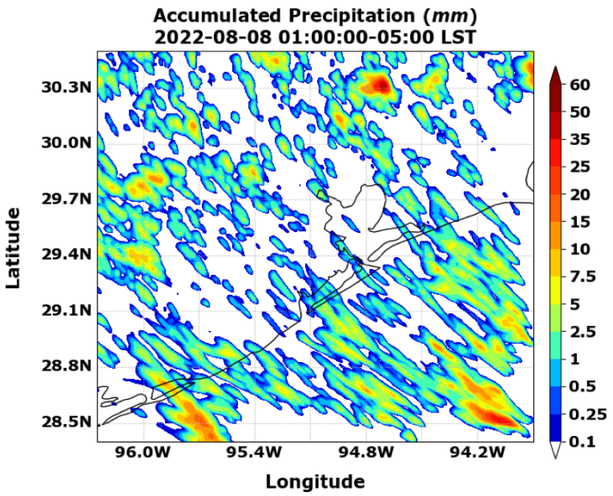
Precipitation Time Series



Stage-IV Observations



RAMS Low-CCN Test Run



Observational Data Needs

Needs for model setup:

Aerosol (accumulation mode and ultrafine) number, size distribution, kappa or fractional solubility, as well as vertical profiles for aerosols in the urban air and marine air.

Further, need minimum and maximum aerosol number to bound the simulation experiments.

Needs for model evaluation and analysis:

Precipitation, radar reflectivity, cloud top height, vertical velocity, etc.

Meteorological conditions, sea breeze analysis, and PBL properties

Discussion Items

1. Need to establish clean and polluted aerosol vertical profiles, based on TRACER obs, for model initialization. Also aerosol size distribution and kappa or solubility fraction.

2. May consider initializing aerosols with polluted obs over land and clean obs over ocean and let sea-breeze transport marine aerosols inland.

3. Single or dual mode of initial aerosols (some teams may not have this option).

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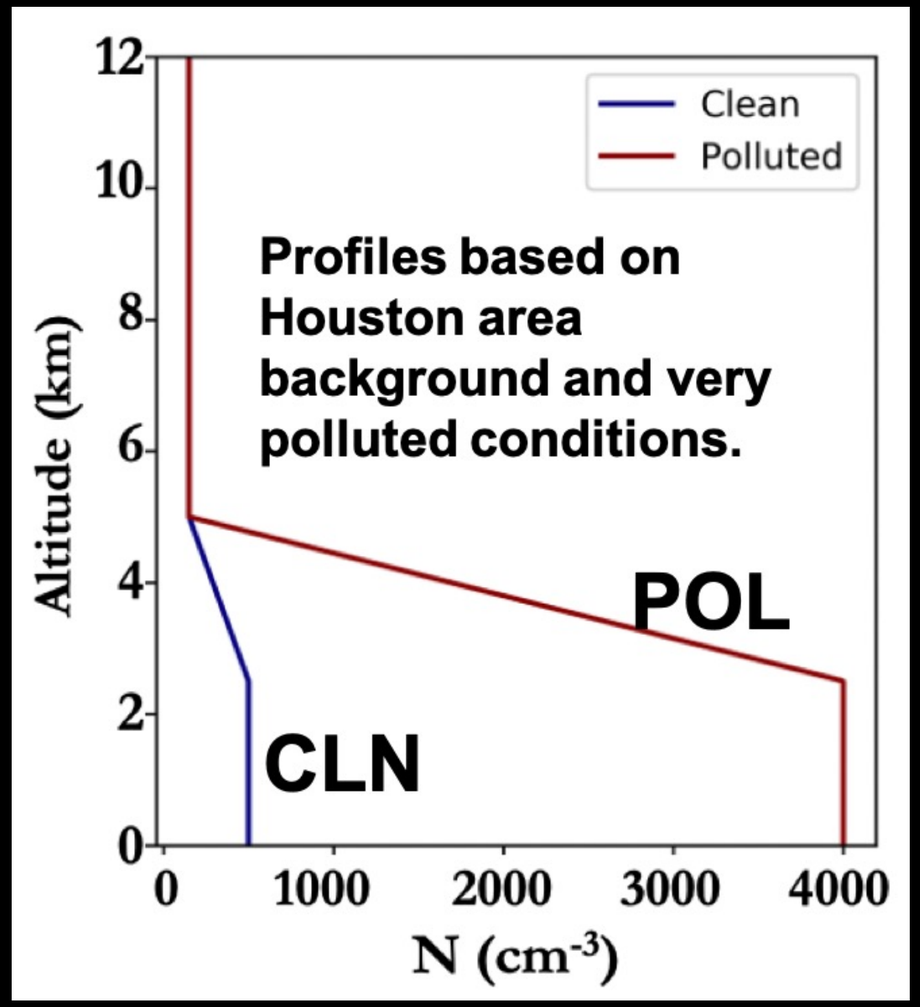
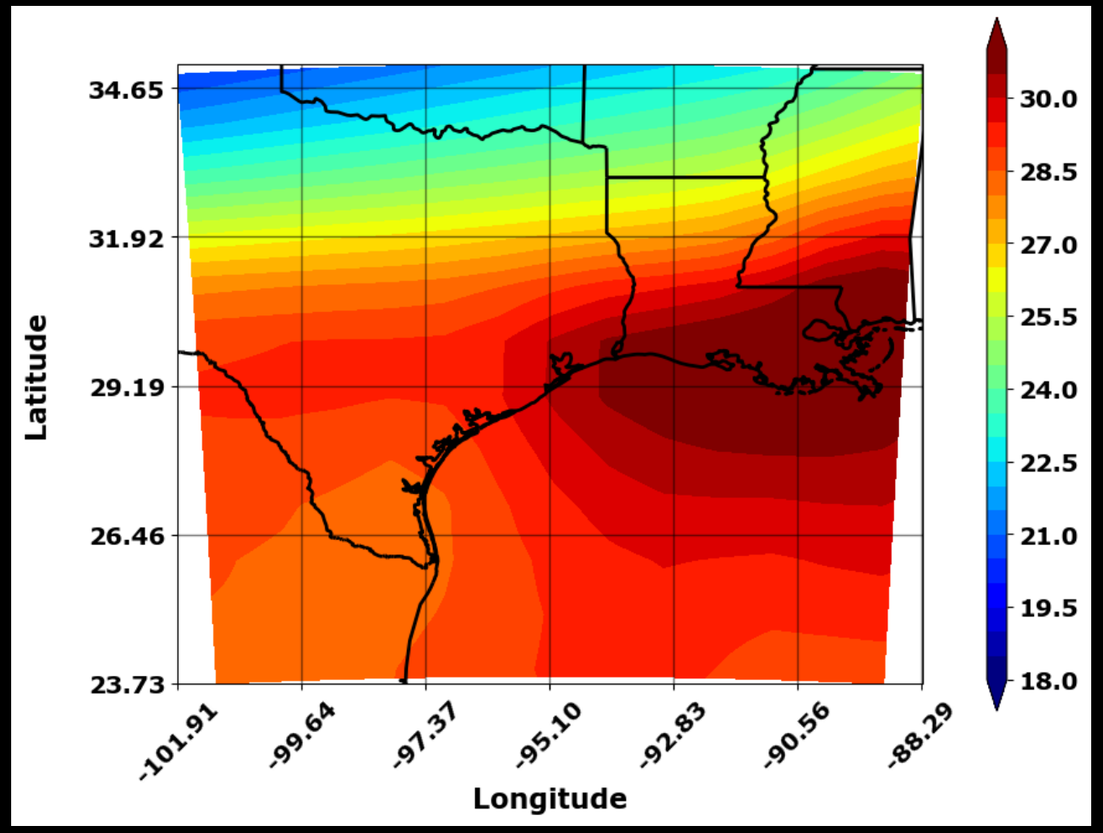
Extra Slides

Aerosol Profiles from ACPC MIP

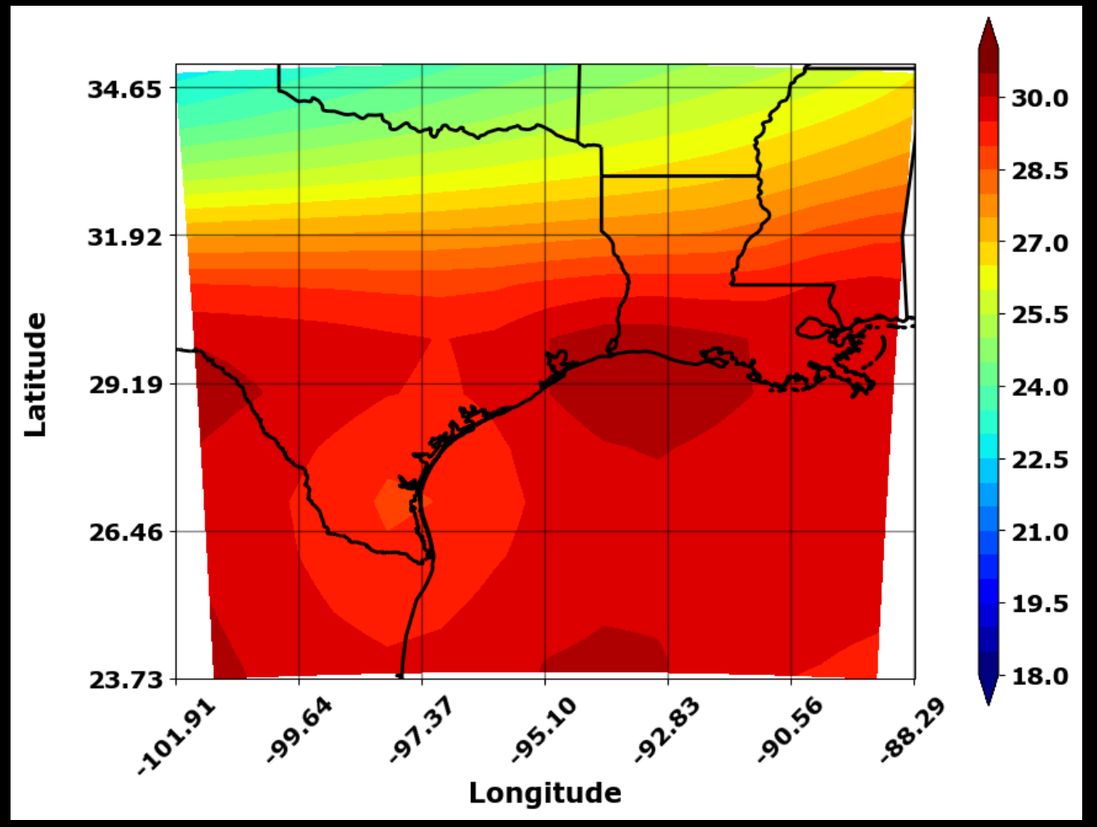


Reynold's 1°x1° Weekly OISST

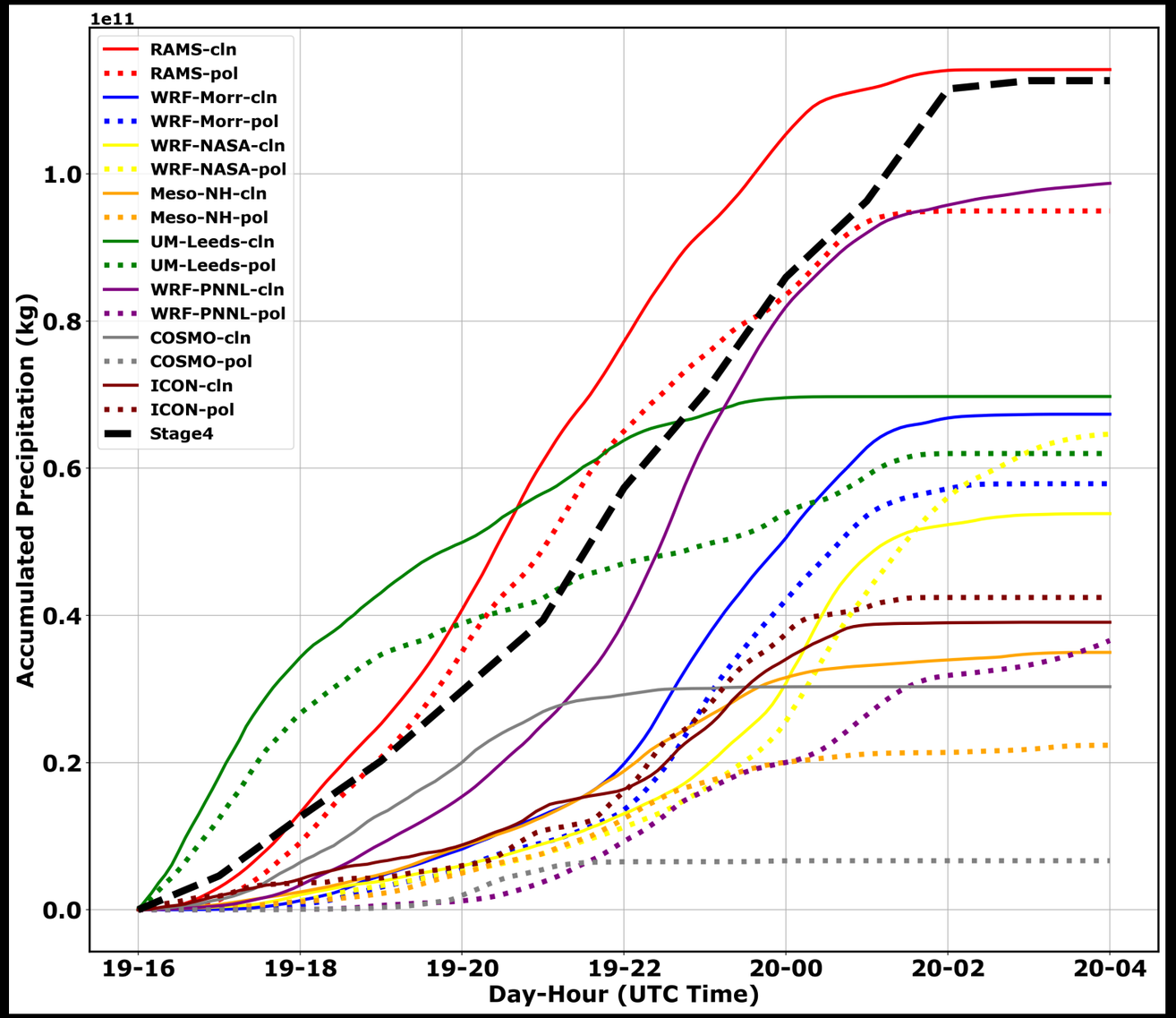
SST (C)
June 17 Case



SST (C)
Aug 7 Case



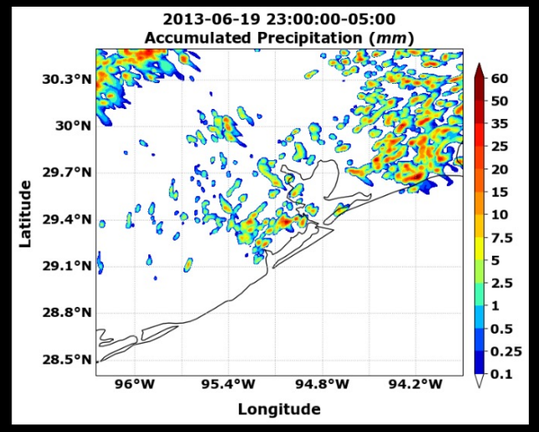
ACPC MIP Domain Accumulated Precipitation Time series



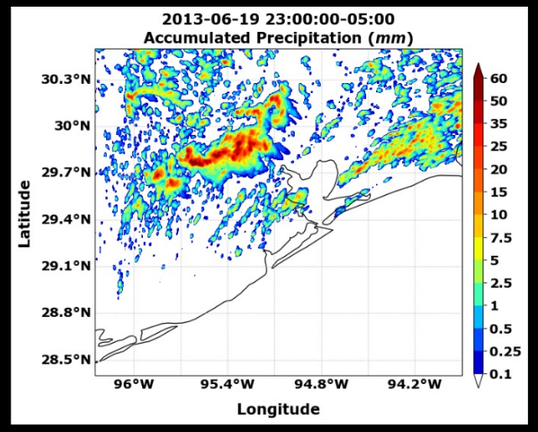
Total Accumulated Precipitation

19th, 1100 – 2300 LT

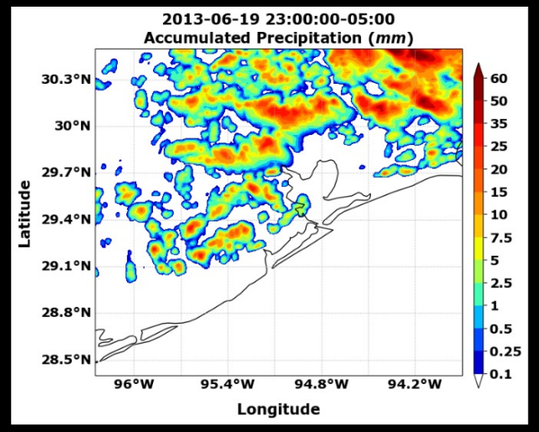
COSMO



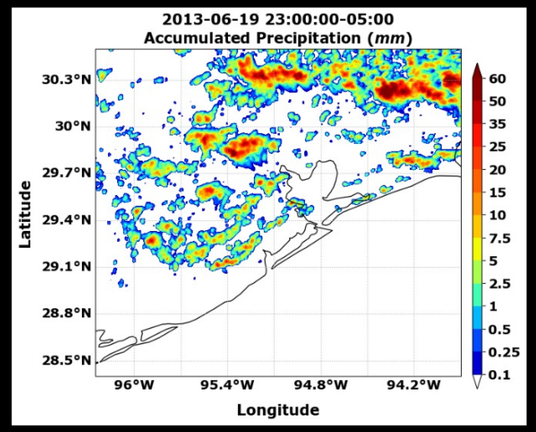
MesoNH



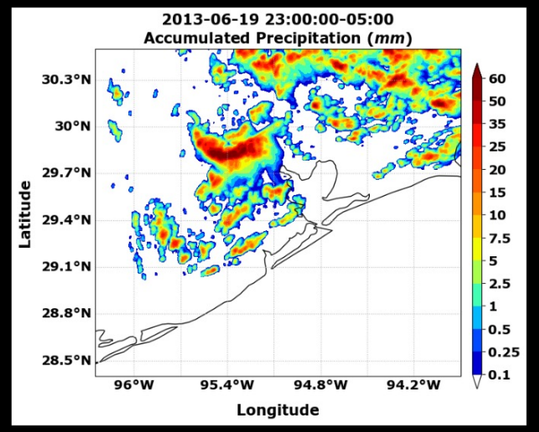
RAMS



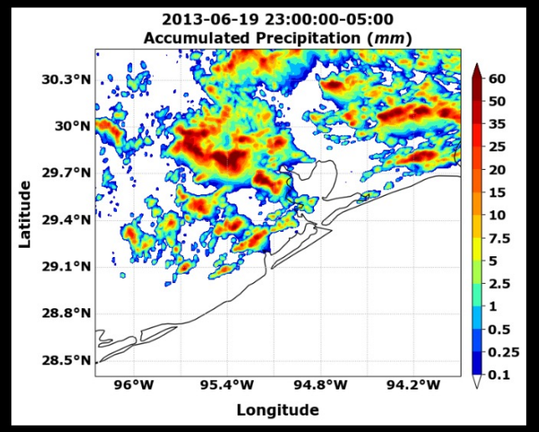
NU-WRF



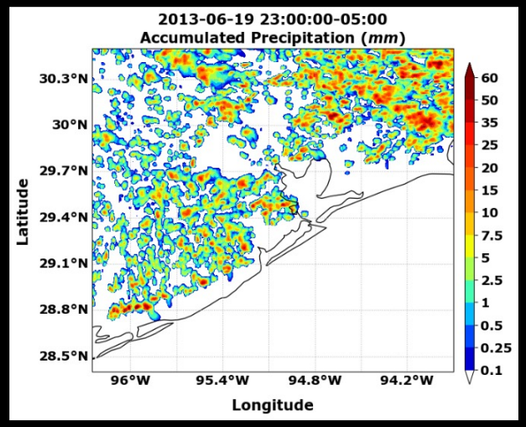
WRF-Morr



WRF-SBM



UM



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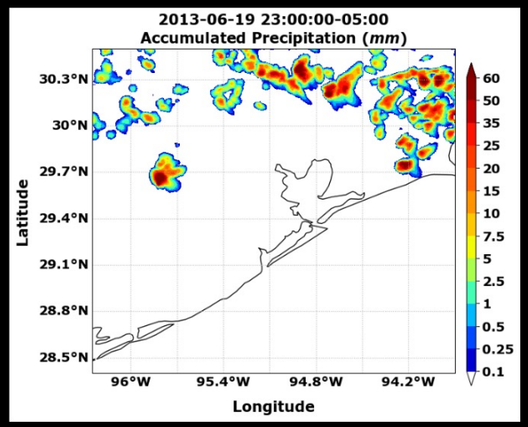
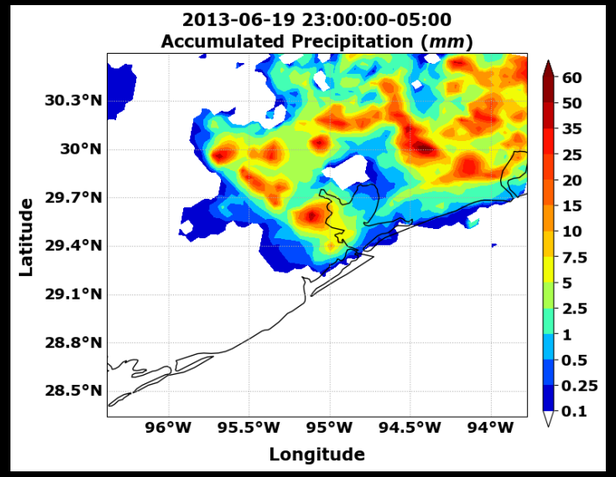


Stage IV Precipitation



While all models produce precipitating convective cells, the organization of precipitation and total accumulation is quite variable.

* From full simulation 5-min data. CLN simulations.