Do Atmospheric Particulates Make Storms Stronger? A Field Study in the Urban-Coastal Environment of Houston, TX

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Community Advisory Council Virtual Webinar

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Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY

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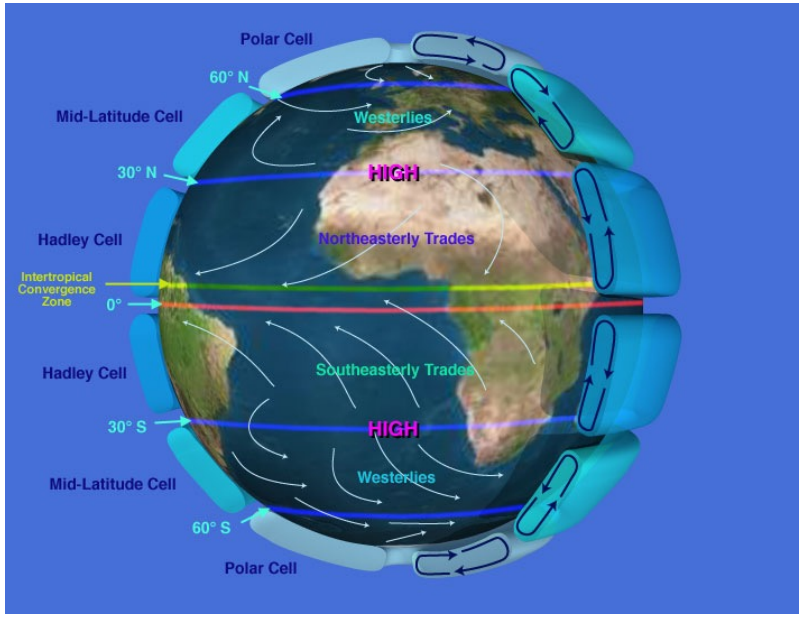
Why do we care about convective clouds?

- Act as atmospheric "elevators"
- Drive the global atmospheric circulation
- Regulate the global energy balance
- Building blocks of storms and severe weather
- Major producer of precipitation



Simulation is difficult:

- Lifecycle driven by multi-scale processes
- Complex interactions between surface, lower-, and upper-atmosphere
- Need to "untangle" effects of atmospheric processes
- Lack of detailed observations

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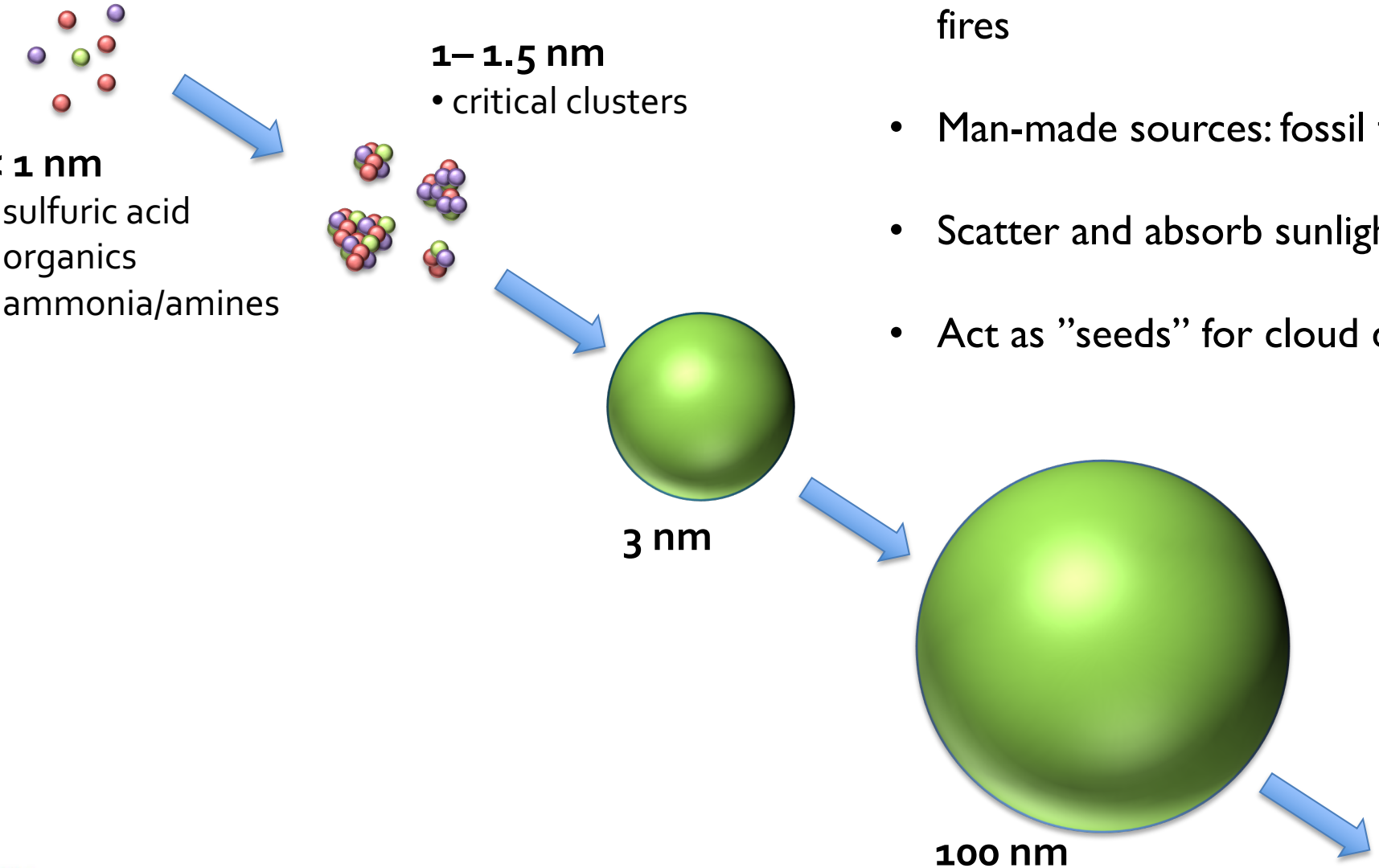
What are aerosols?

- Minute particles suspended in the atmosphere
- Natural sources: sea salt, desert dust, volcanic ash, forest fires
- Man-made sources: fossil fuels, biomass burning
- Scatter and absorb sunlight and infrared radiation
- Act as ”seeds” for cloud droplets



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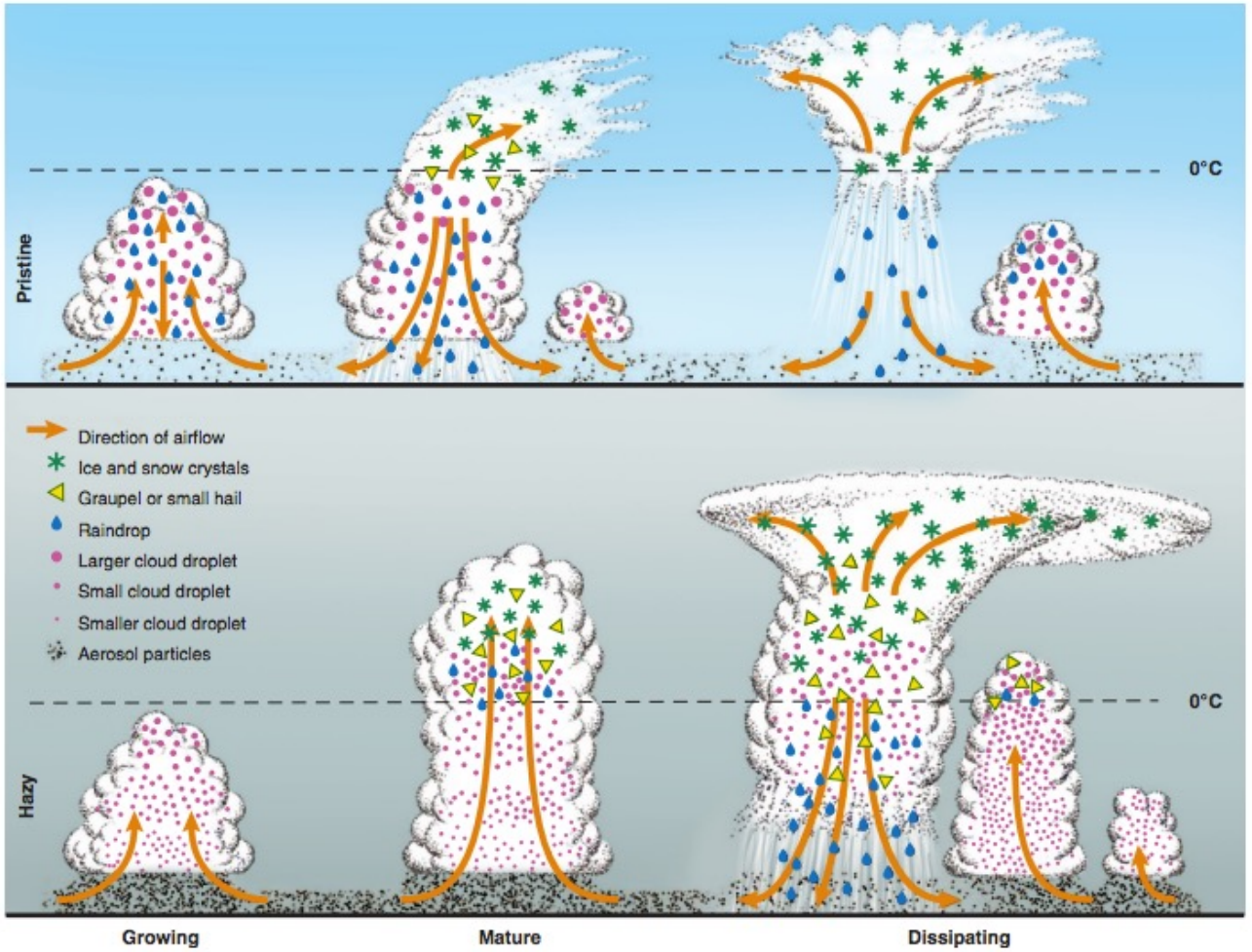
How do aerosols interact with clouds and storms?

All else being equal, more aerosols > more smaller cloud droplets

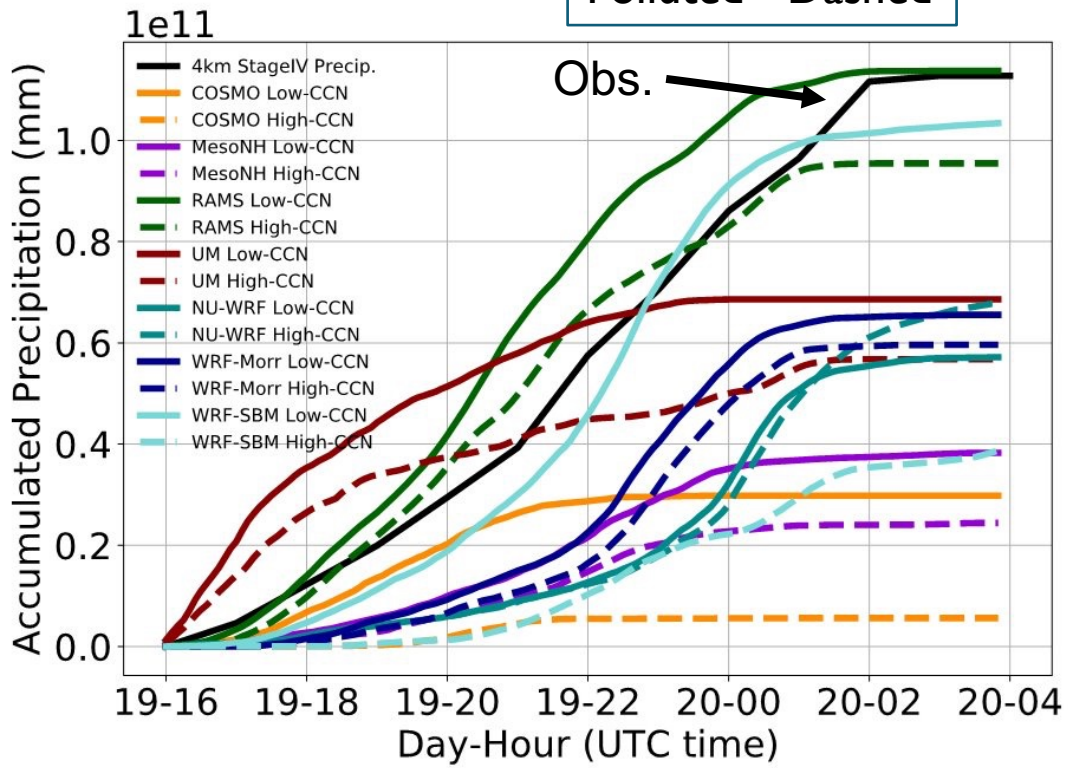
(abridged) Storm Impacts:

- "Cold-phase" invigoration
  - rain formation suppressed
  - more water lifted above freezing level
  - latent heat of freezing released
  - warms air making it more buoyant
  - stronger storm
- "Warm-phase" invigoration
  - increased droplet surface area
  - more condensation
  - Latent heat of condensation released
  - Warms air making it more buoyant
  - Stronger storm



Aerosol, Clouds, Precipitation & Climate - Pilot Study

Clean – Solid
Polluted - Dashed



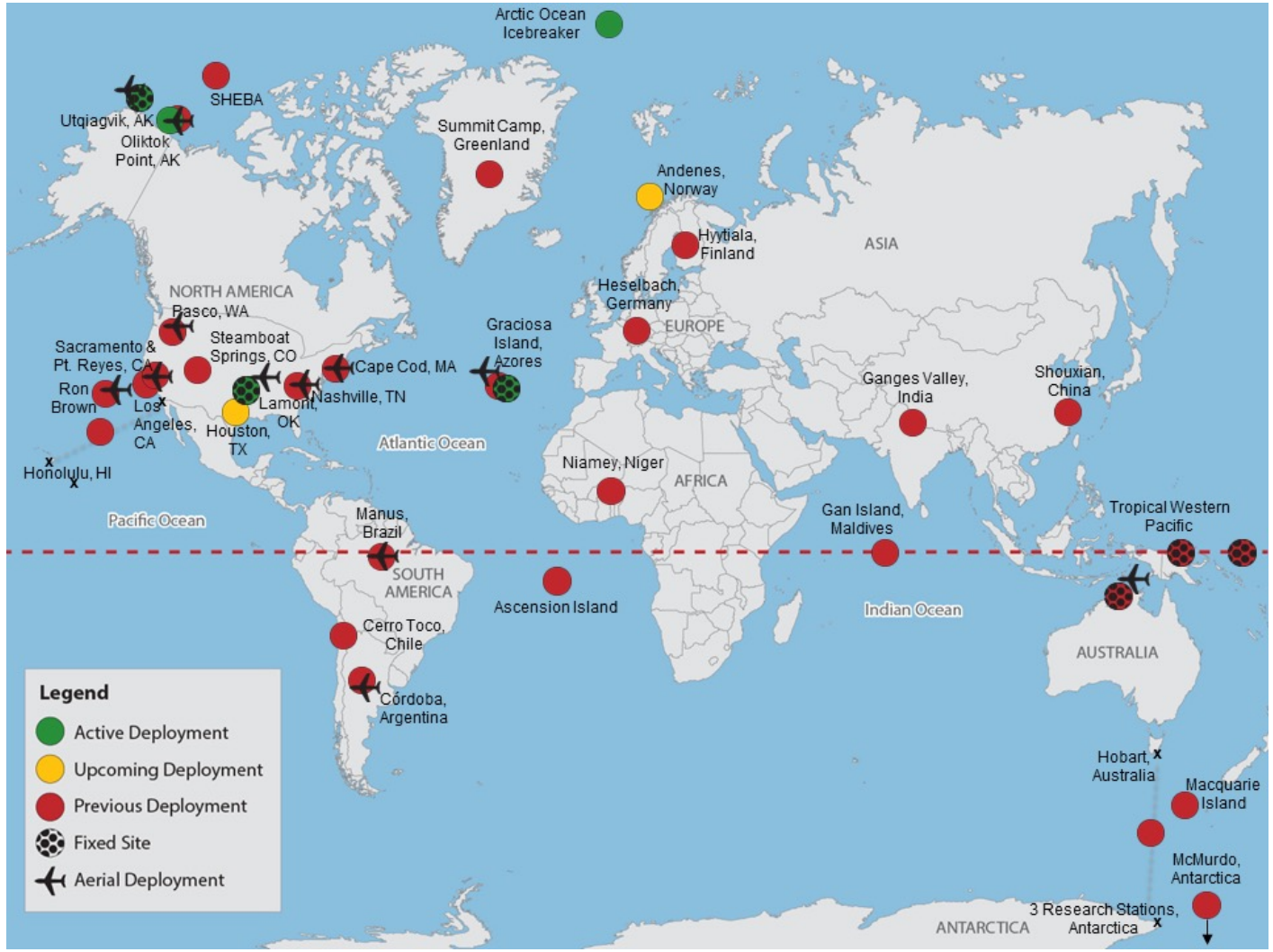
- Intercomparison of 7 state-of-the-art computer models of clouds
- Precipitation differences vary greatly among models
- Most models underestimate the total precipitation by more than 40%
- Aerosol impacts vary significantly

Marinescu et a. 2021

DOE Atmospheric Radiation Measurement (ARM) Facility

- Multi(9)-Laboratory DOE User Facility
- 3 fixed measurement sites
  - Central Oklahoma
  - North Slope Alaska
  - Azores
- 3 "Mobile" Facilities
- ARM Aerial Facility
- ARM Data Center

ARM
CLIMATE RESEARCH FACILITY



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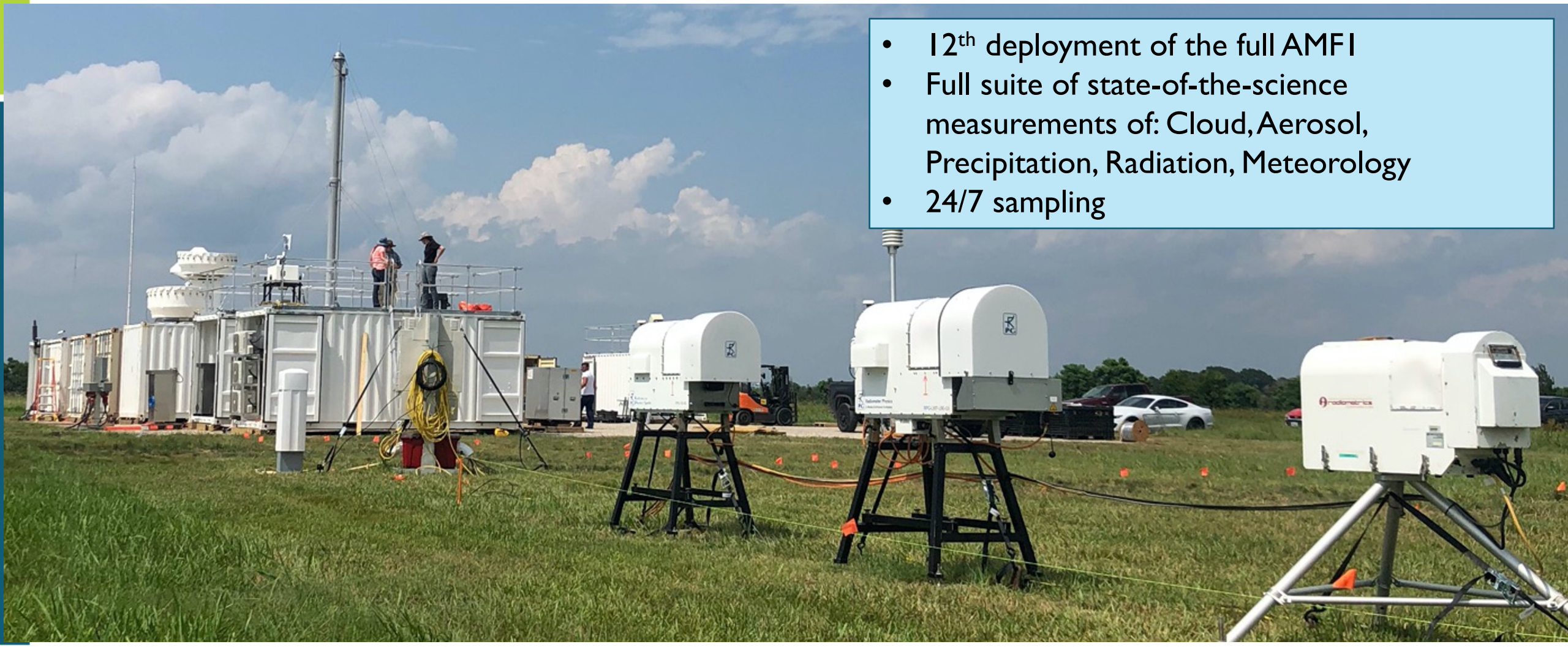
TRacking Aerosol Convection interactions ExpeRiment (TRACER)

https://www.arm.gov/research/campaigns/amf2021tracer

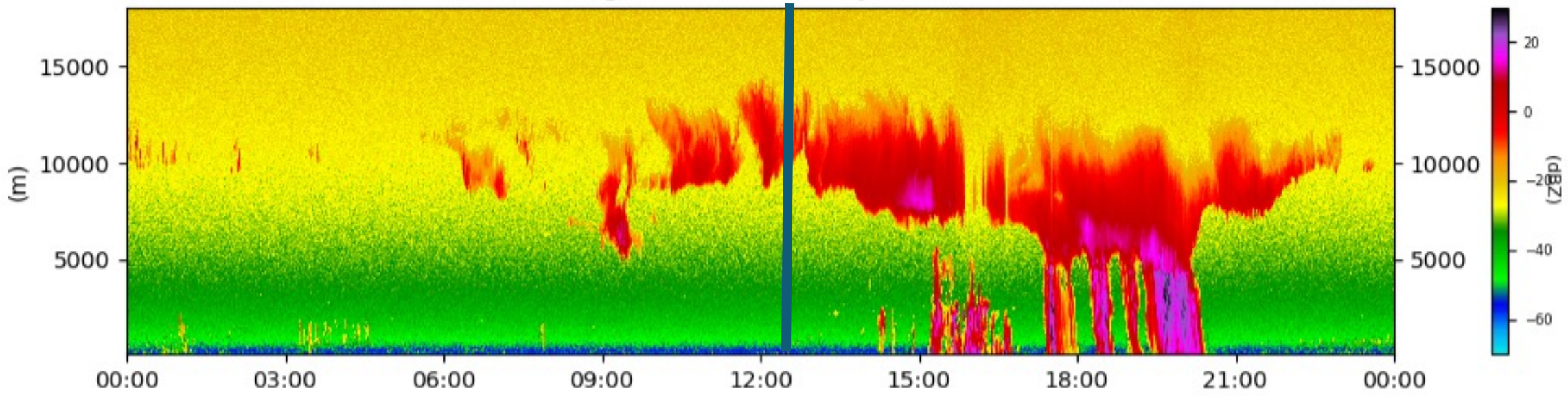
Who?	DOE ARM, DOE Atmospheric System Research
What?	First ARM "Mobile" Facility C-band Scanning ARM Precipitation Radar Many Guest Instruments
Where?	Houston Metropolitan Region
When?	01 October 2021 – 30 September 2022 01 June – 30 September 2022 (Intensive Observational Period)

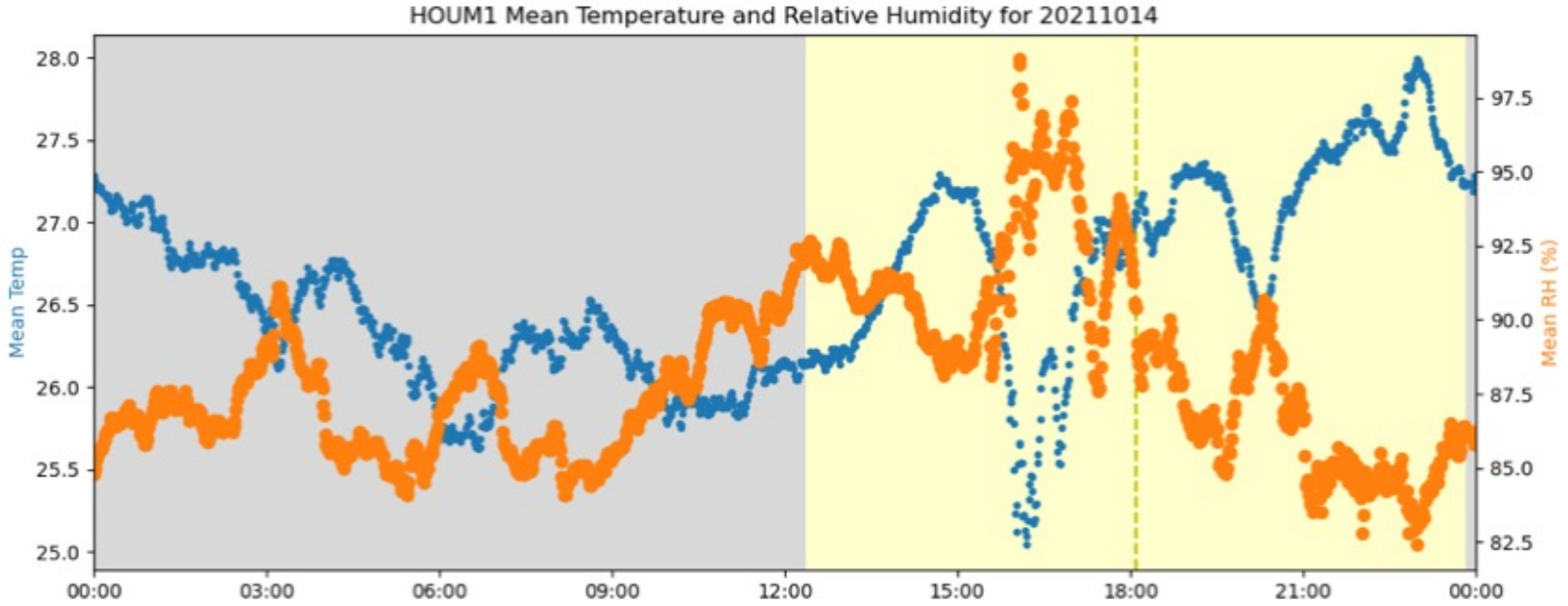
The First ARM Mobile Facility (AMF1)



- 12th deployment of the full AMF1
- Full suite of state-of-the-science measurements of: Cloud, Aerosol, Precipitation, Radiation, Meteorology
- 24/7 sampling

A sampling of AMF1 TRACER data (14 Oct.)





C-band Scanning Precipitation Radar (CSAPR2)

- 2nd deployment of CSAPR2
- Details about cloud and precipitation particles
- Special scanning to follow storms
- High-resolution temporal sampling
- Software development at BNL/SBU

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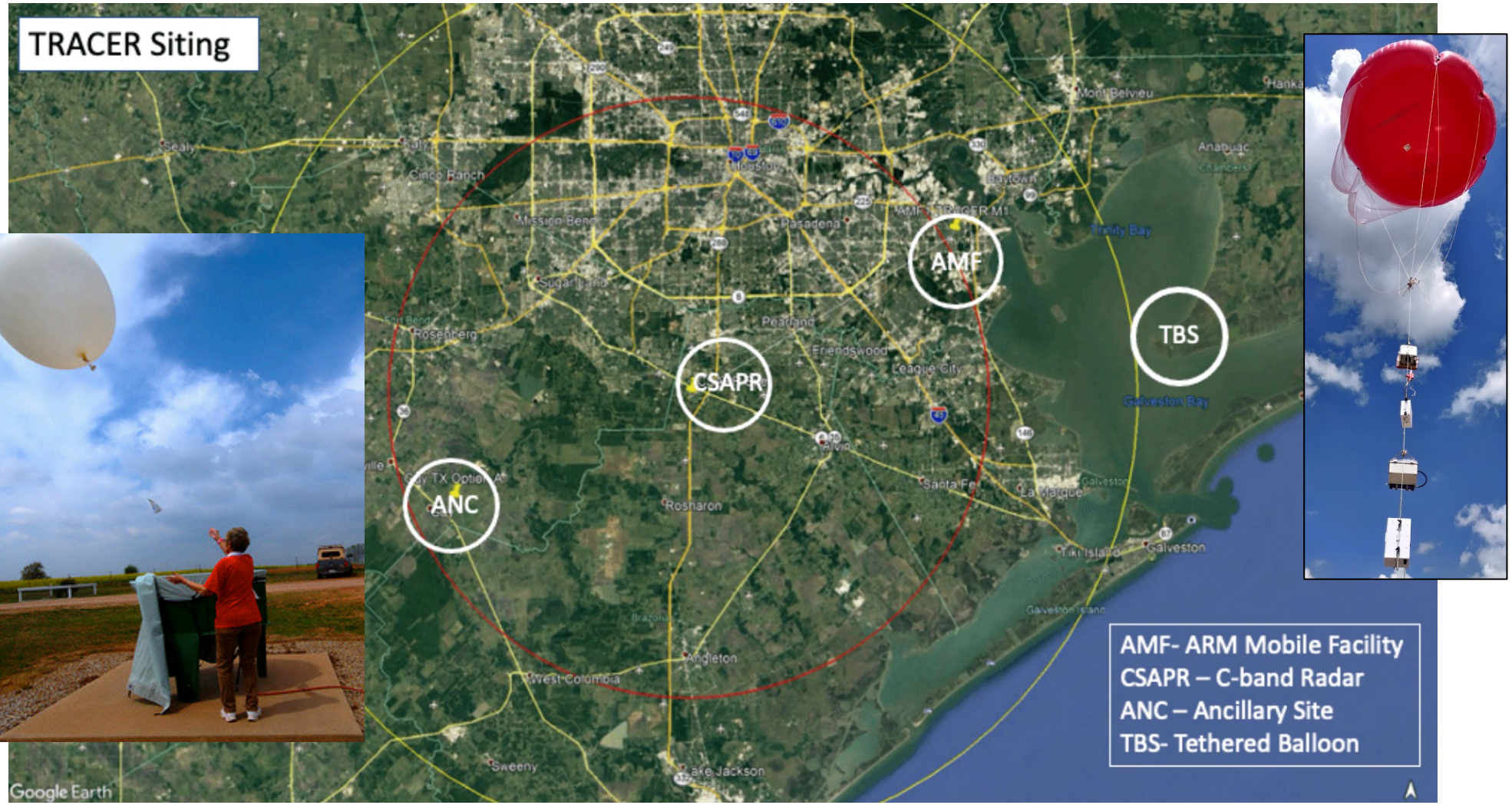
DOE ARM Measurement Sites during TRACER

Intensive Observational Period – Summer 2022



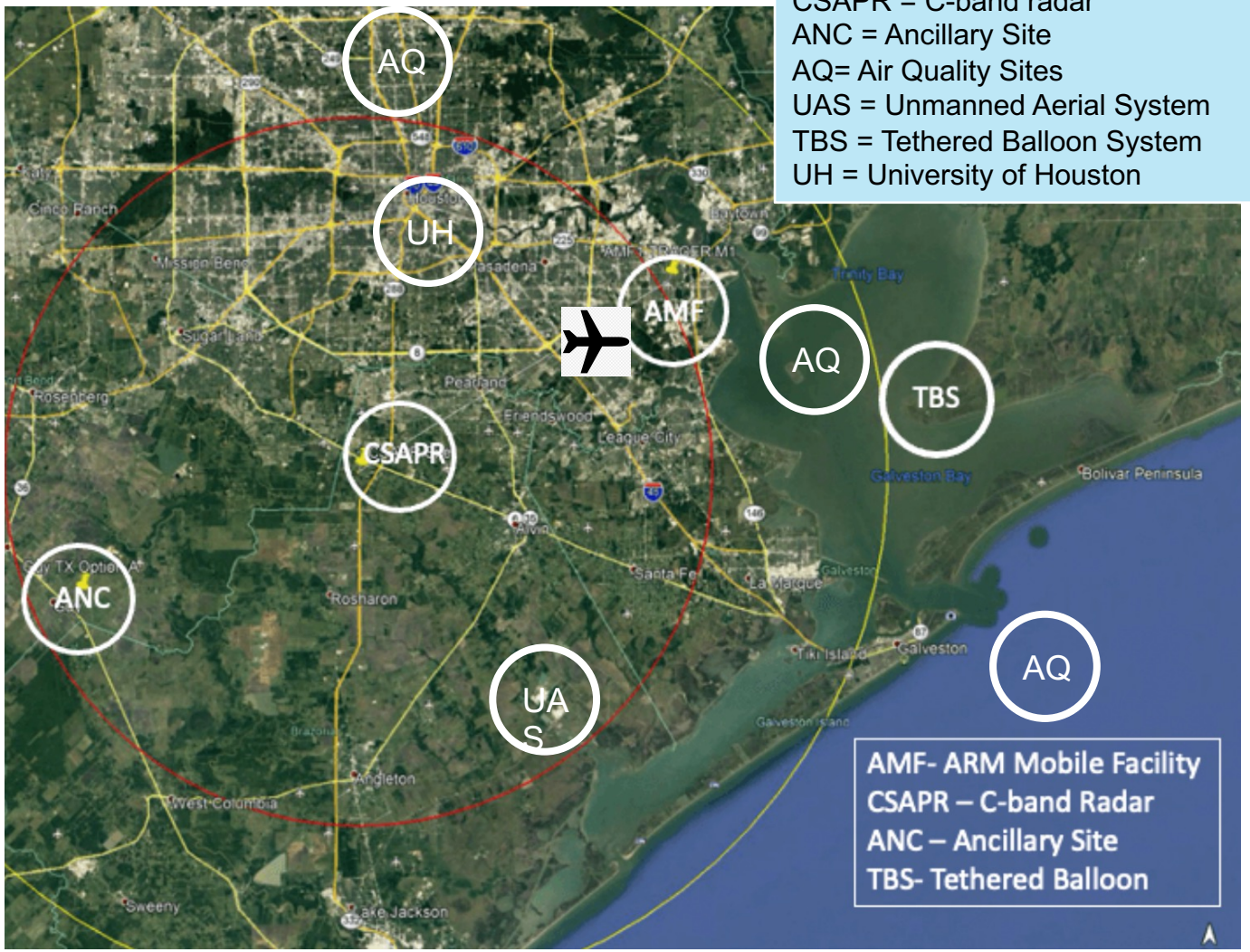
“Build it and they will come”

TRACER-AQ (NASA, TCEQ) – Sep ’21
Aircraft: Gulfstream V
Remote Sensing: Lidars, Radiometers
Mobile: Boats, Air Quality Lab
Ozone Balloons

ESCAPE (NSF) – Summer ‘22
Aircraft: C-130, SPEC Learjet
Radar: CSU C-band, 3 Mobile
Mobile: SBU Truck, BNL Research Truck

TRACER IOP (DOE) – Jun ‘22 -Sep ’22
Ancillary Site (SW of Houston)
Tethered Balloon (Aerosol, Meteorology)
N-Pol S-band Radar (NASA)
Mobile: Baylor, Oklahoma, Texas A&M
Unmanned Aerial Systems (CU)

AMF=ARM Mobile Facility
CSAPR = C-band radar
ANC = Ancillary Site
AQ= Air Quality Sites
UAS = Unmanned Aerial System
TBS = Tethered Balloon System
UH = University of Houston



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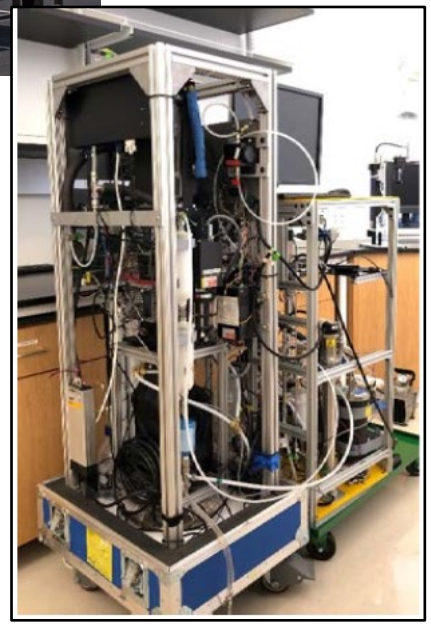
“Build it and they will come”



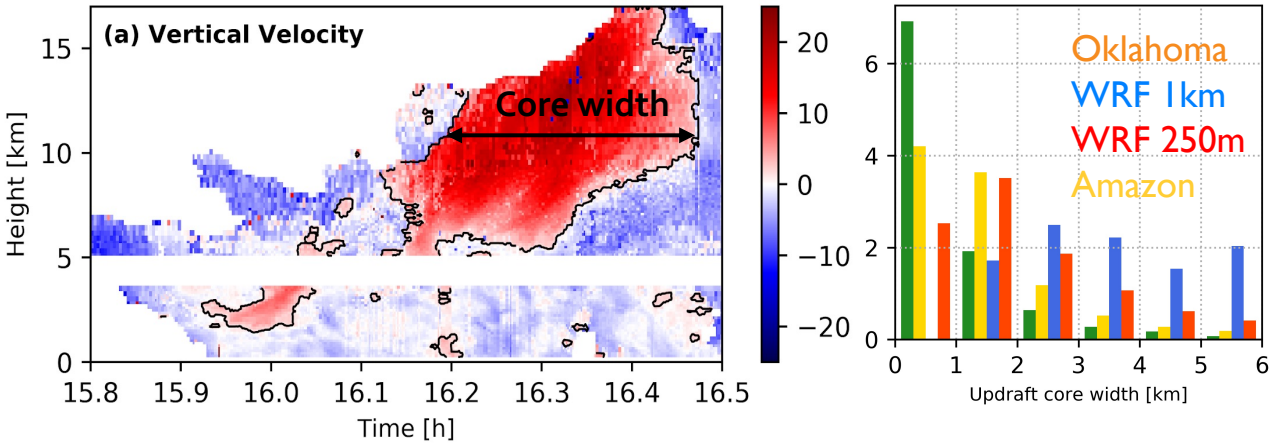
What will we do with all the data we collect?

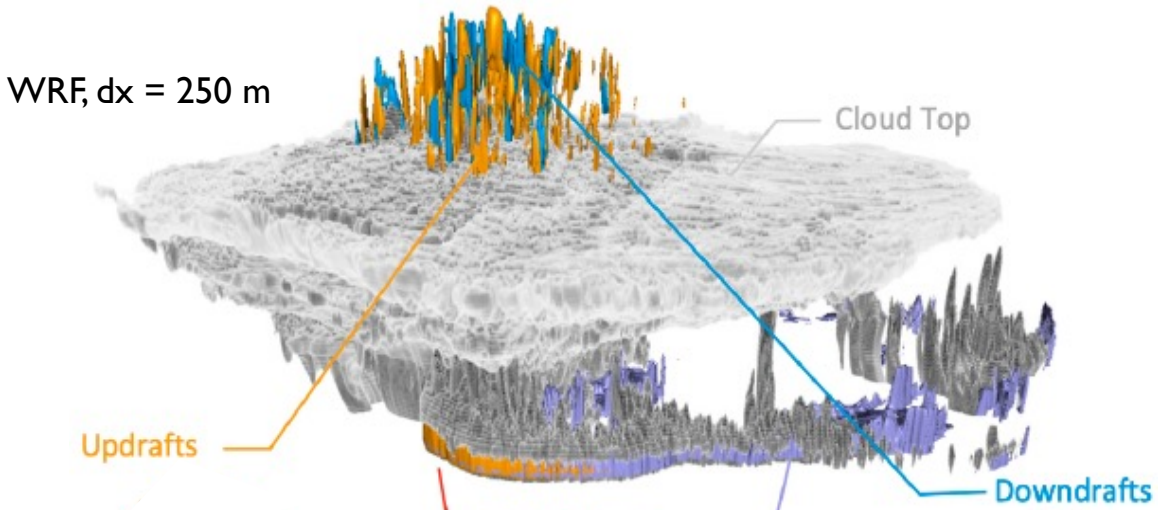
Blended modeling – observational approach

Observations:
- Regime Classification
- Correlation and Causality Analysis
- Boundary Conditions and Constraints

Models:
- Sensitivity Analysis
- Model Intercomparison
- Case Studies
- Long-Term Simulations

More Science than Meets the Eye:
- Aerosol Lifecycle
- Urban impacts on Clouds/Storms
- Sea- and Bay-Breeze Interactions
- Air Quality Studies
- Environmental Equity





Prein et al. 2020

Questions?

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