

TRacking Aerosol Convection interactions ExpeRiment (TRACER) – An upcoming ARM field campaign

Michael P. Jensen, PI
Brookhaven National Laboratory

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TRACER Breakout Session
Joint ASR PI, ARM Facility User Meeting
Bethesda, Maryland
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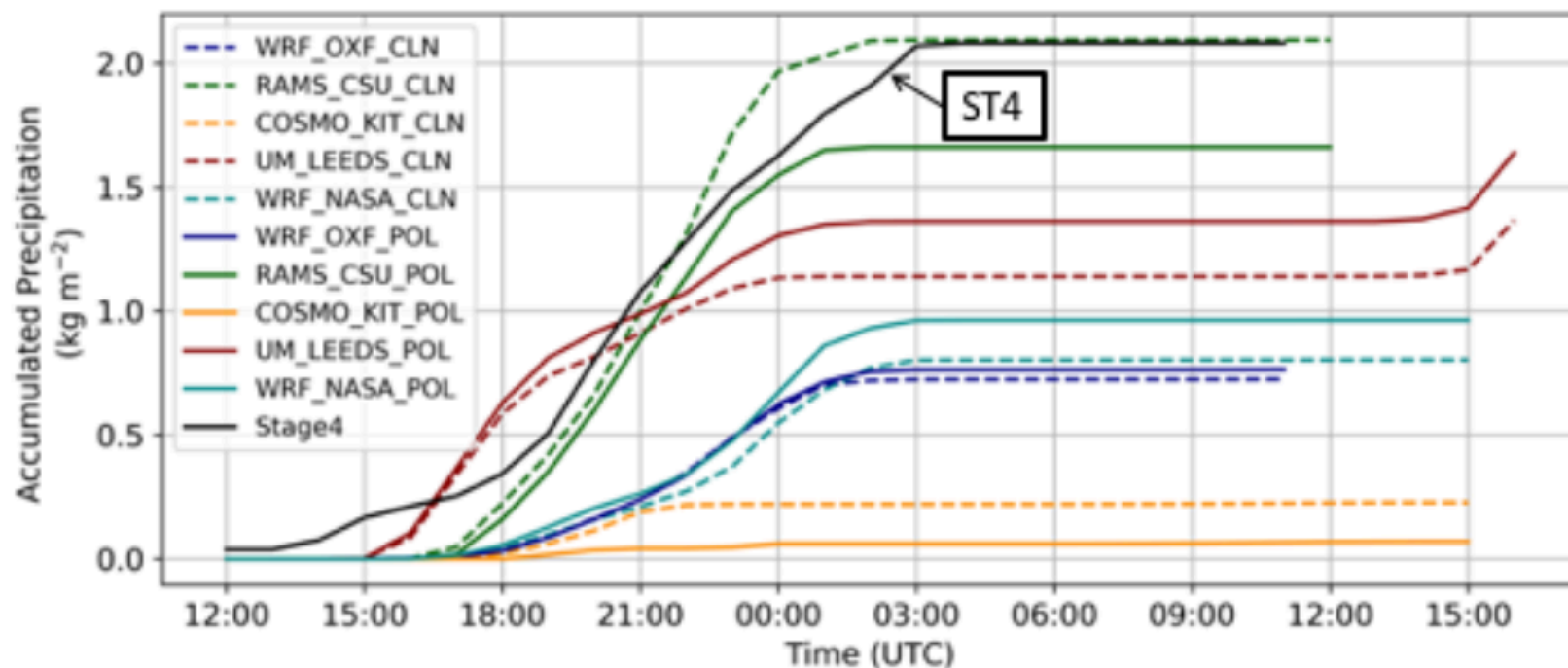
Aerosol, Clouds, Precipitation and Climate WG

(<http://acpcinitiative.org/index.html>)
(IGBP, WCRP, iLEAPS, IGAC, GEWEX)



- Deep Convective Cloud Group Roadmap
 - Builds on Multi-model Case Study Simulations (Houston, 19-20 June 2013)
 - Builds on ACPC observational analyses (NEXRAD, LMA, satellite)
 - Prevalence of isolated deep convection, localized aerosol sources
 - Need for targeted, high-resolution, detailed observations

Aerosol-Convection Interactions: ACPC Pilot Study (I)

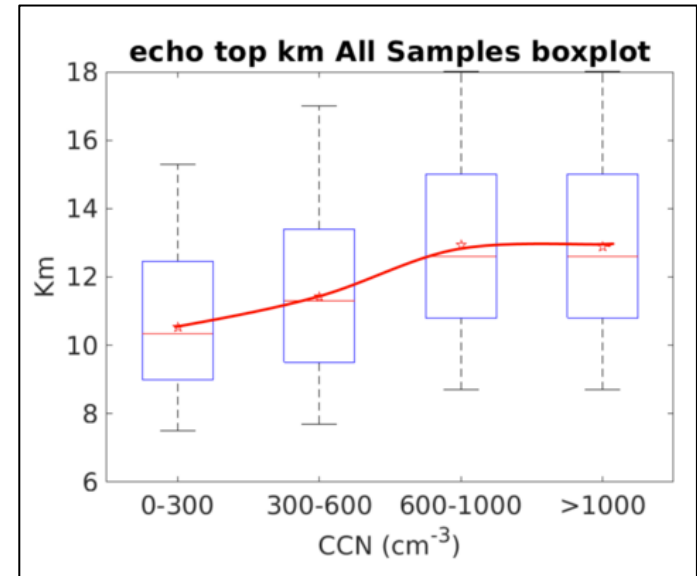
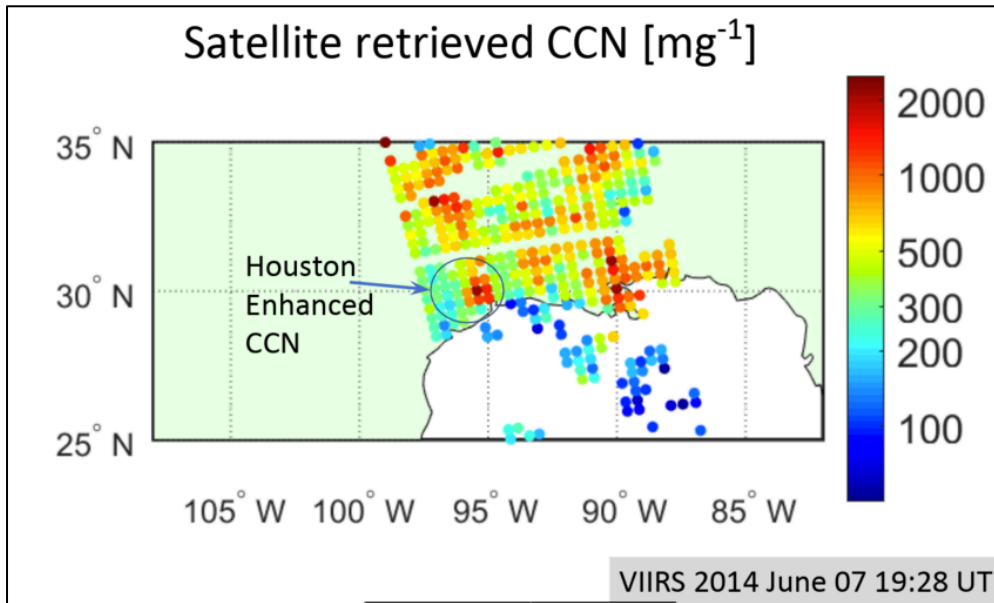


Courtesy van den Heever

- Comparison of accumulated precipitation
- For clean (dashed) and polluted (solid)
- Simulations for 19 June 2013 Houston, TX
- ST4 (black) is from NEXRAD observations
- Variability in microphysical representation among models
- Aerosol impact has different signs in different models

Aerosol-Convection Interactions: ACPC Pilot Study (2)

Observations of possible impacts of CN vs. CCN on cloud invigoration and electrification in the Houston area (Hu, Rosenfeld)



Observations include:

- satellite retrieved CCN concentration (Rosenfeld et al. 2014 JGR)
- radar tracked cell characteristics
- Lightning mapping array

Conclusions

- Echo-top height increases with CCN (between 600-1000 cm^{-3})
- Lightning flash count increases with CCN (once convection is initiated)

TRacking Aerosol Convection Interactions Experiment (TRACER)

- Houston, TX region
- April 15th, 2021 – April 15th, 2022
- June 1st – September 30th, 2021 [IOP]

ARM assets (so far)

- 1st ARM Mobile Facility
- 2nd generation C-band Scanning ARM Precip. Radar
- Additional site with aerosol, cloud and atmospheric state measurements

TRACER science questions (I)

I. Convective Cloud Lifecycle Kinematic and Microphysical Properties

- Characteristics of convective updrafts
(size, depth, precipitation properties)
- How are these characteristics influenced by updraft strength?
- Where are cloud/rain/snow/graupel/hail particles generated?
- How do these particles impact up/downdraft properties?
- How well are these processes and properties represented in models?

TRACER science questions (2)

2. Meteorological Controls on Convective Lifecycle

- How do pre-convective conditions control initiation, location and intensity of convective cells?
- How do environmental conditions influence storm properties?
- Impact of urban heat island and local circulations on convective properties.
- How does precipitation and local circulations modulate aerosol variability and aerosol-convection interactions?

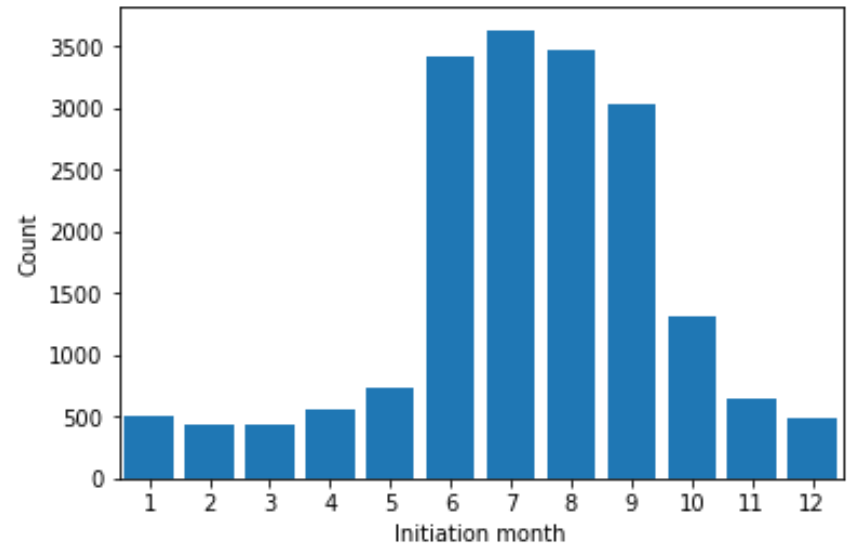
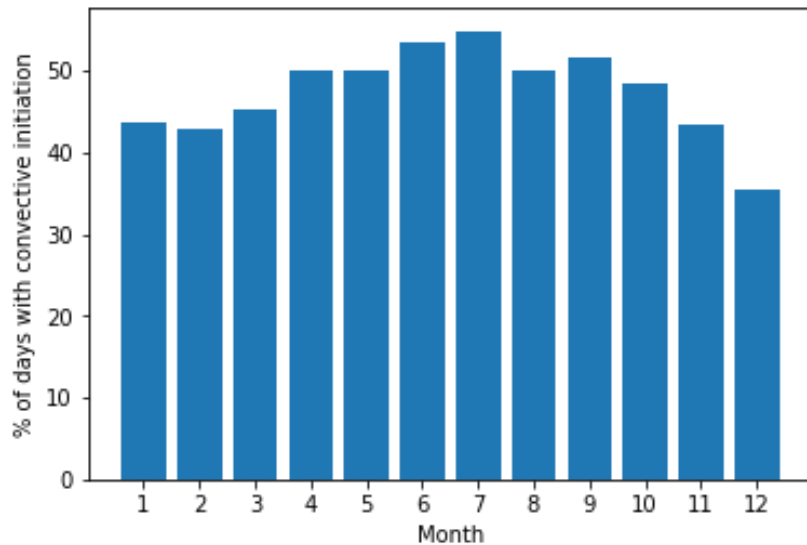
TRACER science questions (3)

3. Aerosol – Deep Convection Interactions

- How do aerosols and cloud properties vary across Houston region? How do aerosols co-vary with meteorology.
- Which deep convective processes are most influenced by aerosols (e.g. cold or warm phase)?
- How do aerosols affect the height of and type (liquid or ice) of precipitation initiation?
- How are aerosol-deep convection interactions best represented in global and regional models?

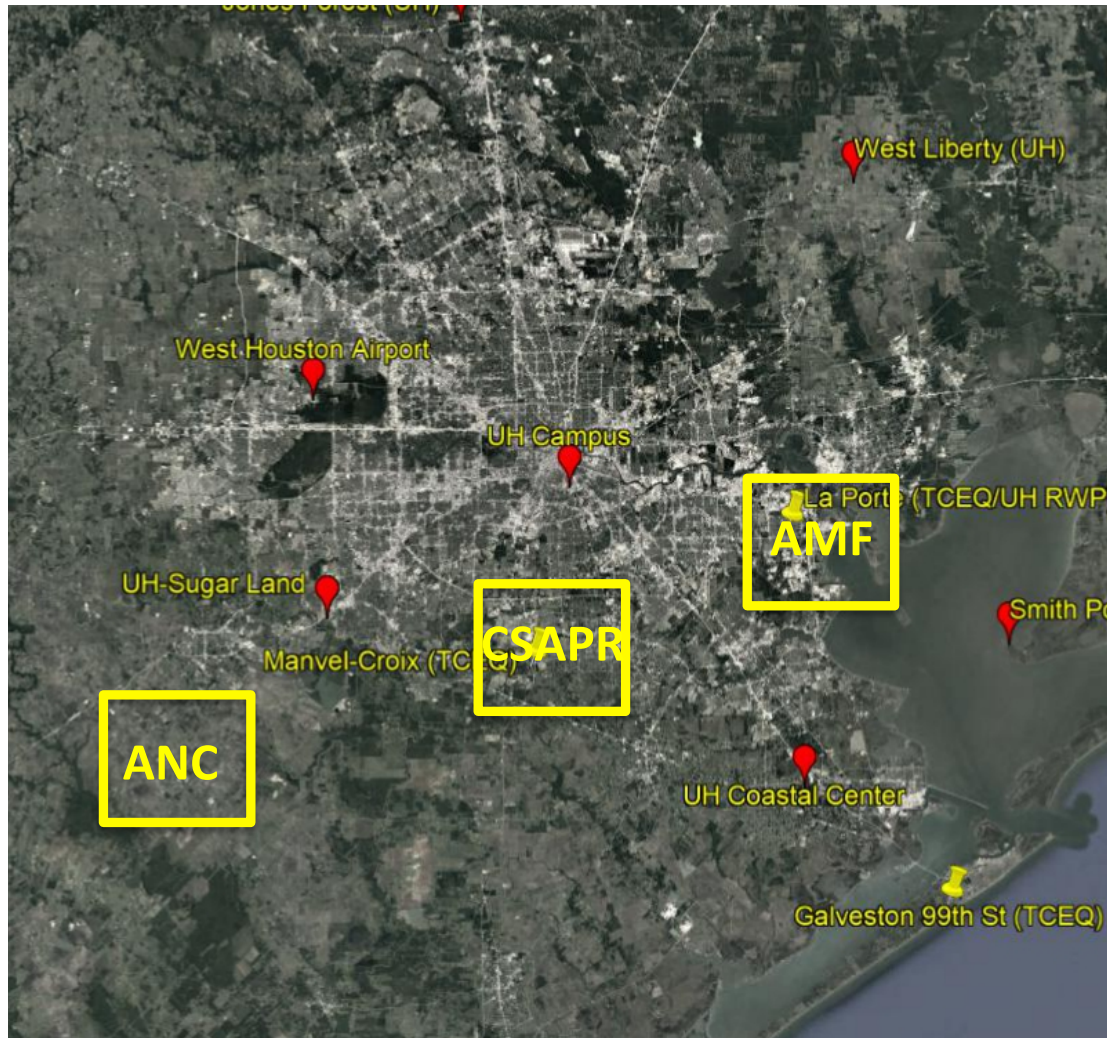
Why Houston? Convective Cloud Climatology

- 4 years of Houston/Galveston NEXRAD (KGHX) observations
- Convective cell identification and tracking (Collis, Jackson ANL)



- (left) Percent of days/month where convection was observed
- Convection observed ~40-50% of days through entire year
- (right) total number of convective cells in NEXRAD domain
- Peak occurrence of convection occurs June-Sept (IOP)

TRACER – ARM Facility Siting Considerations



- AMFI in polluted region
- ANC site to SW of Houston in “clean” air
- C-SAPR
 - Sample over both sites
 - Consider beam blockage and frequency allocation
 - 20-40 km distance from both AMFI and ANC
- Leverage existing, historical measurement sites

TRACER – ARM Facilities (I)

- First ARM Mobile Facility (AMFI)
 - Deployed for entire campaign [04/21-04/22]
 - Cloud – (Scanning [Ka/X] and VP) cloud radar, lidar, wind profiler, TSI
 - Aerosol – CCN, CPC, UHSAS, SMPS, etc...
 - Atmospheric State – MWR, AERI, D. lidar, Sfc. Met, Sondes
 - Precipitation – (Parsivel, video) disdrometer, rain gauge

TRACER – ARM Facilities (2)

2nd generation C-band Scanning ARM Precipitation Radar (CSAPR2)

- Provides polarimetric observations of convective clouds
- Implement focused-scanning cell tracking during IOP period
- Focus on evolution of core microphysical properties
- Baseline operational mode outside of IOP



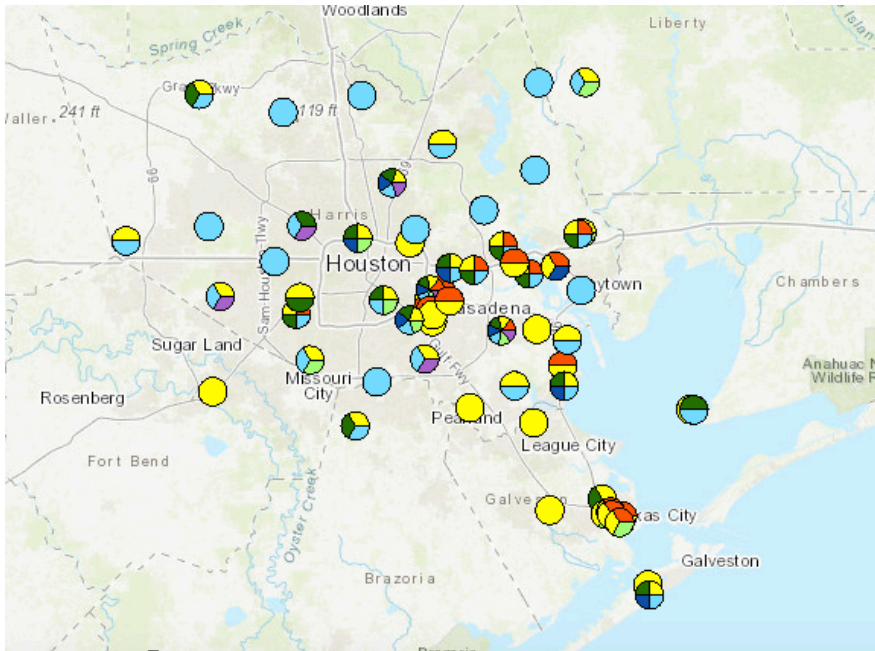
TRACER – ARM Facilities (3)

- Ancillary ARM site
 - Deployment during IOP (June- September) period
 - Located in ‘unpolluted’ region
 - CCN Counter
 - Condensation Particle Counters
 - Scanning Mobility Particle Sizer (SMPS)
 - Radiosonde profiling (4-7 x per day)
 - Surface Meteorology
 - Microwave Radiometer
 - Disdrometer, Rain gauge

TRACER – Leveraging Existing Observations (I)

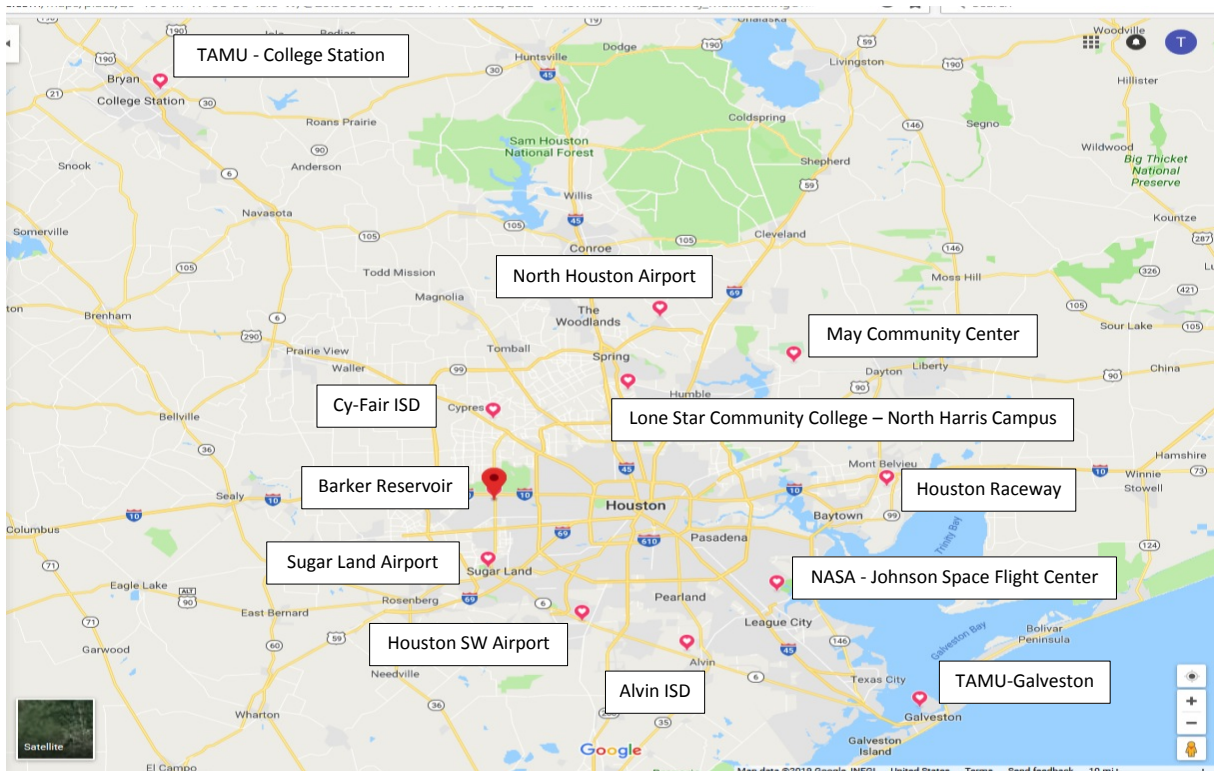
- Texas Commission on Environmental Quality (TCEQ)
 - Surface Meteorology Network
 - Trace Gas, PM2.5 measurements
 - 75 sites within Houston Metro-area

tceq.texas.gov



TRACER – Leveraging Existing Observations (2)

- Houston Lightning Mapping Array
 - Operated by Texas A & M (PI: Tim Logan)
 - 4D quantification of lightning discharge
 - Charge distribution, flash location, flash rate



TRACER – What happens during the IOP?

Ancillary site

Remote forecasting of convective (40) days
(Follow example of RACORO, SPARTICUS, ACE-ENA)

Cell-tracking, focused scanning of C-SAPR2
(Follow CASA model)

Sounding schedule – More frequent soundings, every 1.5 hours
between 1200 and 1800 LT

TRACER – Build it and they will come!

Evolving Interagency and International Partnerships (I)

- UH Wind Profiler and RASS (Flynn)
- NSF Facility Request (Kollias, Kumjian)
 - Mobile C-band, DOW-6, DOW-7, 2 mobile sounding units
 - 10 July – 30 August
- NSF Science Proposal (Encouraged by NSF PMs, Kollias et al.)
 - SBU dual-pol PA X-band, profiling radar/lidar (Kollias, Kumjian)
 - Lightning Mapping Array (Logan, Bruning)
 - Modelling (van den Heever, Lebo)
 - Small UAV (van den Heever, Kollias)
- ARM IOP TRACER-Carbonaceous Aerosol Thrust (Cappa, Dubey)
 - 2 CAPS-SSA
 - Photo-acoustic spectrometer (CRD-PAS)
 - Single Particle Soot Photometer (SP2)
 - 2 SP-AMS
 - Scanning Electrical Mobility Sizer

TRACER – Build it and they will come!

Evolving Interagency and International Partnerships (2)

- NSF Urban – uTRACER (Gonzalez, Bornstein)
 - 2 flux towers, scintillometer
 - Deployable Raman lidar
 - Extended surface meteorology network
- NASA GPM GV (Petersen)
 - Disdrometer network, N-POL radar
- Germany remote sensing (Quaas)
- NSF MSRI -SAGE Edge computing, software defined device (Beckman, Collis, Bruning, Chandrasekar)
 - Pan-tilt zoom camera, PM sensors, scanning MPL

TRACER – Measurement Gaps

Field deployments always involve a tradeoff between:

- Science
- Logistics
- Funding

Exploring options to improve....

- Thermodynamic Profiling
- Aerosol profiling (lidars)
- Surface aerosol network
- Urban impacts on convection and precipitation
- Coastal impacts on convection and precipitation

TRACER – Timeline

- May 2018 TRACER proposal submitted to ARM
- Oct. 2018 Notice of Selection by ARM
- Jan. 2019 Introductory Meeting with ARM
- Apr. 2019 ACPC Workshop
- June 2019 ARM/ASR Meeting
- Aug. 2019 Presentation for inter-agency U. S. program managers
- Jan. 2020 Site visits in Houston-area
- April 2020 TRACER meeting/ACPC workshop
- Jun. 2020 Forecasting Exercise
- Apr. 2021 Campaign Start
- Jun. 2021 IOP Start
- Jan. 2022 AMS Annual meeting in Houston, TX
- Sep. 2021 IOP End
- Apr. 2022 Campaign End