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TRACER-ACE: Aerosol Characterization Experiment Field Campaign Report

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ARM

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Acronyms and Abbreviations

ACE	Aerosol Characterization Experiment
ACSM	aerosol chemical speciation monitor
AMF	ARM Mobile Facility
ANC	ancillary site
AOS	Aerosol Observing System
ARM	Atmospheric Radiation Measurement
ASR	Atmospheric System Research
CCN	cloud condensation nuclei
CPCF	condensation particle counter-fine
CPCUF	condensation particle counter-ultrafine
IOP	intensive operational period
M1	main site
MT	Moody Tower
PTR-MS	proton transfer reaction-mass spectrometer
TBS	tethered balloon system
TRACER	Tracking Aerosol Convection Interactions Experiment

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1.0 Summary

An objective for the U.S. Department of Energy's Atmospheric Radiation Measurement (ARM) Tracking Aerosol Convection Interactions Experiment (TRACER) is to provide high-temporal-and-spatial-resolution observations of convective clouds in the Houston region, over a broad range of environmental and aerosol regimes (Jensen et al. 2022). The TRACER siting strategy was to deploy the first ARM Mobile Facility (AMF1), with its full suite of cloud, aerosol, precipitation, and atmospheric state measurement capabilities, in a region that experiences the full diversity of aerosol properties from the Houston domain including rural, urban, and industrial atmospheric aerosol environments (see Figure 1).

01 Oct. '21 – 30 Sep. '22
IOP June – Sep. 2022

1. AMF1 – La Porte
2. C-SAPR Site - Pearland
3. ARM Ancillary Site – Guy
4. UH Coastal Center (UAV, CUBIC)
5. Lemon Reservoir (UAV)
6a. Seawolf Park (TAMU)
6b. Hempstead (TAMU)
6c. Waller (TAMU)
6d. Hocksley (TAMU)
7. Moody Tower, UH
8. Aldine (CUBIC)
9. Jones Forest (MAP)
10. Battleground (MAP)

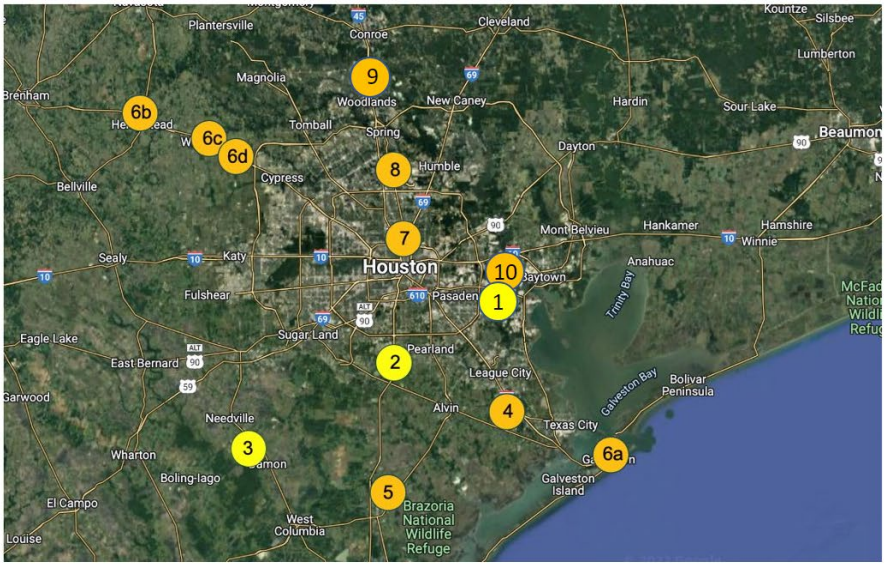

Figure 1. Locations of measurement sites during the TRACER campaign, for both ARM facilities and Atmospheric System Research (ASR)-funded projects.

An ancillary site (ANC) was deployed during TRACER-ACE in a region that is expected to experience more consistently "cleaner" aerosol conditions, more representative of the background atmospheric state for this region compared to the more urban/industrial atmospheric aerosol environment of the main site (M1) (see Figure 2).

Figure 2. The ancillary (ANC) site in Guy, Texas, located in a farmer's field. Panning from the left to the right: the ARM tethered balloon system (TBS) trailer, the aerosol measurement containers (in support of TRACER-ACE), the ARM meteorology field, the TBS "igloo", and a TBS supporting trailer.

During the intensive operational period (IOP; June-September 2022), continuous aerosol observations were obtained in the relatively "cleaner" region to the southwest of Houston in Guy, Texas. These measurements, in combination with those from the AMF1, provide an understanding of the variability of aerosols and meteorology across the rural-to-urban gradient in the larger Houston domain. These aerosol measurements include: the CCN number concentration as a function of water vapor supersaturation, the total aerosol number concentration at various cut-sizes (e.g., >3 nm, >10 nm) to target the formation of newly formed aerosol, and the total aerosol size distribution from 10-500 nm to characterize the Aitken/fine/accumulation-mode aerosol, and from 0.25-35 microns to characterize the coarse-mode aerosol. Additional ARM aerosol measurements were also made during TRACER-ACE including the aerosol chemical speciation monitor (ACSM), the proton transfer reaction-mass spectrometer (PTR-MS), and aerosol water-uptake (principal investigator: Jian Wang). These continuous measurements helped to address the following scientific objectives: characterization of the aerosol water-uptake and size distribution properties at a "clean" site, assessment of the frequency, strength, and "regionality" of new particle formation, and (in conjunction with co-located radiosonde and meteorological observations) identification of the atmospheric conditions and processes that potentially control new particle formation at a site less impacted by urban emissions and pollution.

Measurement challenges: The IOP at the ANC site was characterized by extended periods of high ambient temperature (e.g., >90 degrees Fahrenheit), which presented some coupled, environmental challenges. TRACER-ACE instruments were deployed inside a measurement container with aerosol inlet flow characteristics, pumping equipment, and environmental control systems comparable to those of a standard ARM Aerosol Observing System (AOS; Uin et al. 2019). The ANC AOS air conditioning units were operated to meet the nominal thermal requirements for the TRACER-ACE instruments. However, this also resulted in water condensation forming inside the sampling lines (due to the high ambient dew point), which could "scrub" the aerosol prior to instrument sampling in ways that are difficult to quantify.

As a partial remedy to this situation, sample lines were further insulated with foam, and, for some instruments, “cooler” air was more directly applied (Figure 3).

Figure 3. The condensation particle counter-fine (CPCF) and condensation particle counter-ultrafine (CPCUF) inside the ANC AOS of TRACER-ACE, with a small fan directing cooling air to the instruments.

2.0 Results

ANC is a remote site on agricultural land in Guy, Texas, around 75 km from M1 (main site), and is representative of a rural background aerosol environment. However, ANC does periodically experience emissions from surrounding agricultural activity and vehicular emissions from a road ~ 1 km away. Generally, the ANC measurements indicate a “cleaner” aerosol environment when compared to the M1 (main) site, and an additional urban sampling location on the roof of the University of Houston Moody Tower (MT). Figures 4 and 5 summarize the differences in the aerosol number size distribution across the two urban sites (M1 and MT) and the rural background site (ANC), where the ANC site generally presents lower aerosol concentrations compared to the urban sites.

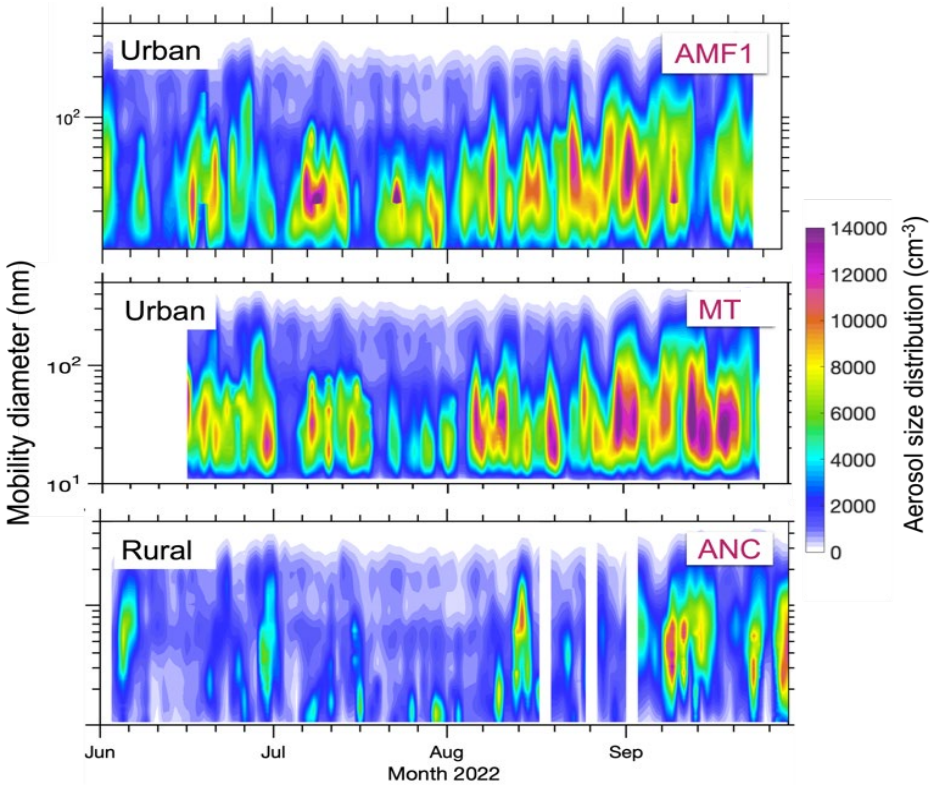

Figure 4. Daily averages of the aerosol number size distribution from the two urban sites (AMF1 main site-M1, Moody Tower-MT) and the rural site (ANC), over the IOP.

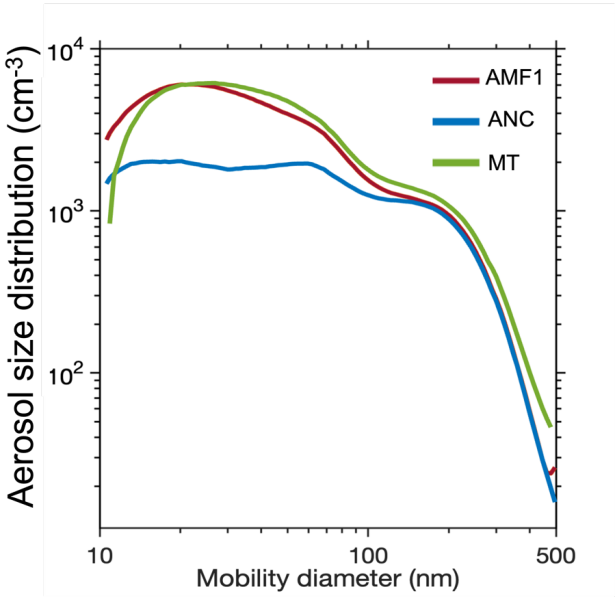

Figure 5. Comparison of IOP averages of the aerosol number size distribution across two urban sites (AMF1 and MT) and the rural site (ANC).

3.0 Publications and References

3.1 Presentations

Subba, T, M Zawadowicz, A Singh, M Jensen, R Trojanowski, and C Kuang. 2022. "Characterization of new particle formation events over the coastal region of Houston." Presented at the ARM-ASR Principal Investigators Meeting (poster)/American Geophysical Union Meeting (talk).

Subba, T, M Jensen, A Singh, R Trojanowski, D Wang, M Zawadowicz, and C Kuang. 2023. "Characterization of New Particle Formation Events during the TRACER campaign." Presented at the TRACER Meeting.

Subba, T, M Jensen, A Singh, R Trojanowski, D Wang, M Zawadowicz, and C Kuang. 2023. "Characterizing aerosol-climate interactions in the urban-coastal region of Houston." Presented at the Gordon Research Conferences Atmospheric Chemistry Conference (poster).

Subba, T, A Singh, R Trojanowski, D Wang, M Zawadowicz, M Jensen, and C Kuang. 2023. "Investigating the spatio-temporal controls of the summertime sea breeze circulation on the atmospheric aerosol environment in the coastal region of Houston." Presented at the ARM-ASR Principal Investigators Meeting (poster and breakout session talk).

3.2 References

Jensen, MP., JH Flynn, LM Judd, P Kollias, C Kuang, G Mcfarquhar, R Nadkarni, H Powers, and J Sullivan. 2022. "A Succession of Cloud, Precipitation, Aerosol, and Air Quality Field Experiments in the Coastal Urban Environment." *Bulletin of the American Meteorological Society* 103(2): 103–105, https://doi.org/10.1175/BAMS-D-21-0104.1

Uin, J, AC Aiken, MK Dubey, C Kuang, M Pekour, C Salwen, AJ Sedlacek, G Senum, S Smith, J Wang, TB Watson, and SR Springston. 2019. "Atmospheric Radiation Measurement (ARM) Aerosol Observing Systems (AOS) for Surface-Based In Situ Atmospheric Aerosol and Trace Gas Measurements." *Journal of Atmospheric and Oceanic Technology* 36(12): 2429–2447, https://doi.org/10.1175/JTECH-D-19-0077.1

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