Evaluating the spatiotemporal variability of coastal atmospheric properties using Uncrewed Aircraft Systems (UAS) during TRACER

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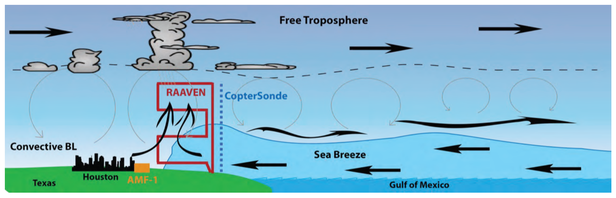
ASR Atmospheric System Research

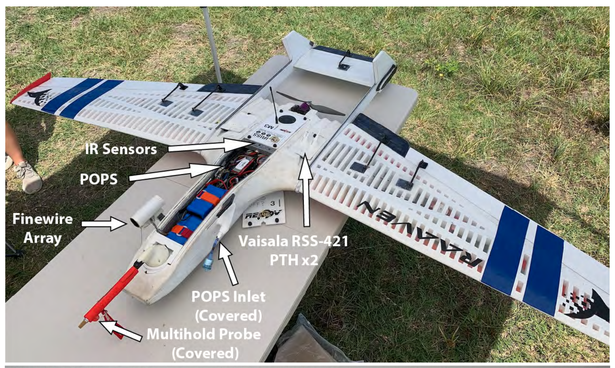
Introduction

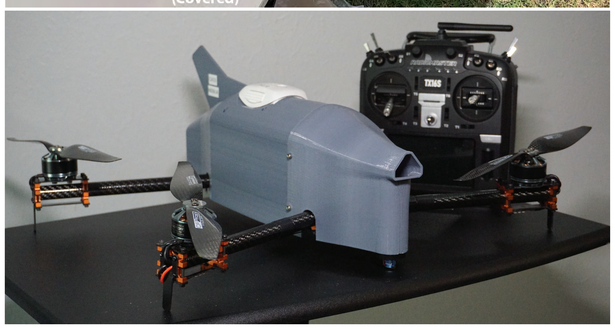


To better understand the drivers of convective storms in the greater Houston (Texas, USA) area, the US Department of Energy and research partners conducted the Tracking Aerosol Convection Interactions Experiment (TRACER) project during 2021-2022. TRACER included the deployment of atmospheric sensors around the greater Houston urban environment, setting out to measure the complex interactions between local circulations including the sea breeze from the Gulf of Mexico, the bay breeze off of Galveston Bay, and circulations associated with the urban heat island, aerosol gradients associated with the heterogeneous surface types in the area and local anthropogenic sources of pollution, and boundary layer development. The US Department of Energy Atmospheric Radiation Measurement (ARM) program deployed one of its mobile facilities to Houston, along with additional instrumentation including intensive aerosol measurement systems, cloud and precipitation radars, and more.

In support of TRACER, the University of Colorado Boulder and the University of Oklahoma deployed uncrewed aircraft systems (UAS) to the greater Houston area. The CU RAAVEN was equipped to make measurements of atmospheric thermodynamic state, winds and turbulence, and aerosol size distribution. At the same time, the OU Coptersonde system operated on a regular basis to evaluate in high resolution the vertical structure of thermodynamic state and winds. Together, these systems operated for approximately 12 weeks between June 1 and September 30, 2022, conducting flight operations at two coastal locations between the Gulf of Mexico and Houston.

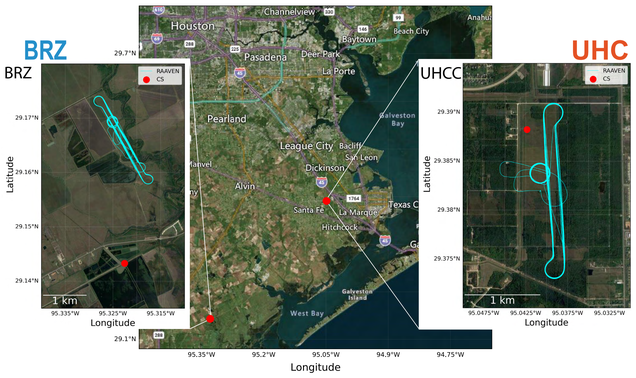
UAS Platforms





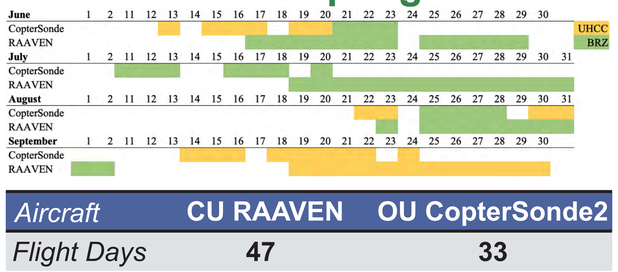
The CU RAAVEN (top), and OU Coptersonde (bottom).

Flight Locations and Statistics



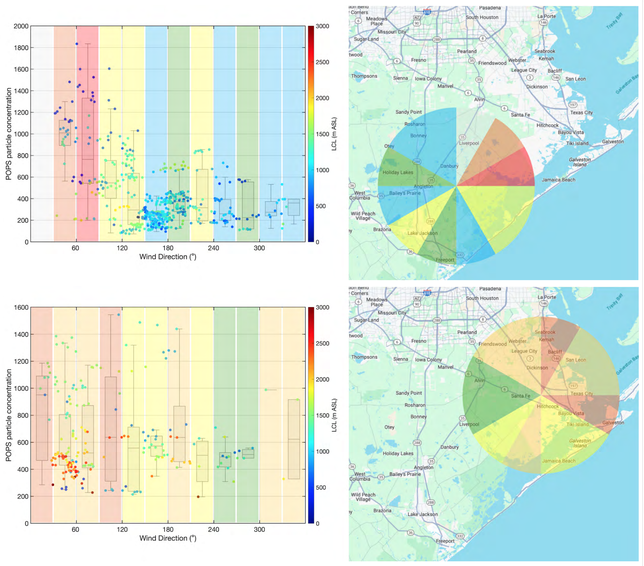
A map illustrating the location of TRACER-UAS operations, including two sites near the **Brazoria National Wildlife Refuge (BRZ)**, and the **University of Houston Coastal Center (UHC)**.

Overview of Sampling



Aircraft	CU RAAVEN	OU CopterSonde2
Flight Days	47	33
Flights	131	546
Profiles	251	544
Flight Hours	187	56

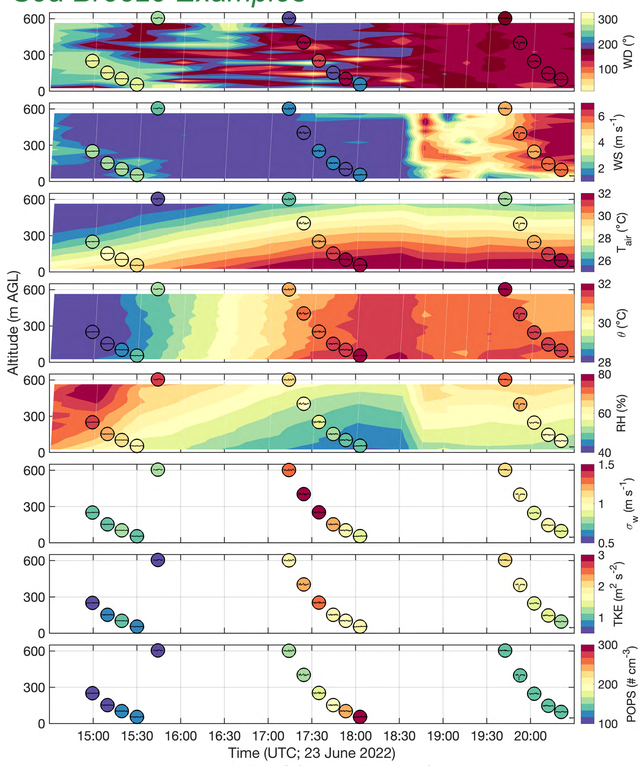
Tables summarizing TRACER flight activities conducted by the RAAVEN and CopterSonde2. Deployments were staggered to increase coverage, but still maintain some overlap.



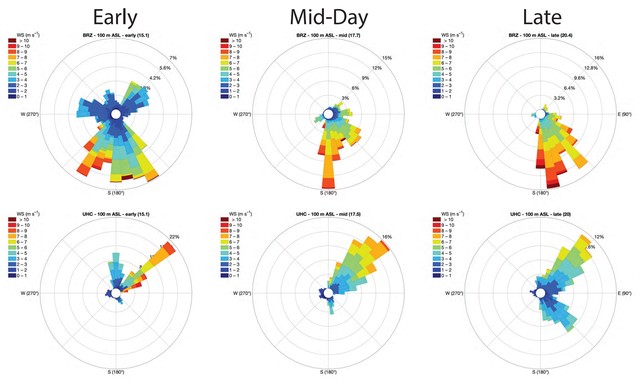
Figures illustrating distributions of particle concentrations (150-2500 nm), as a function of wind direction. The colored dots represent estimated LCL height, as a proxy for ABL depth. The maps show clean and polluted sectors, based on the data at left.

Observed Phenomena of Interest

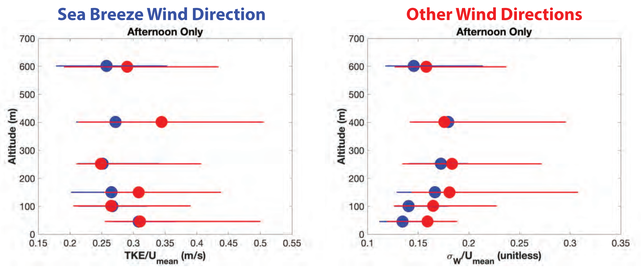
Sea Breeze Examples



Time-height cross sections of (top to bottom) wind direction, wind speed, temperature, potential temperature, relative humidity, vertical velocity variance, TKE, and coarse mode aerosol concentration, measured during a sea breeze case measured by both the CopterSonde2 (shading) and RAAVEN (circles).

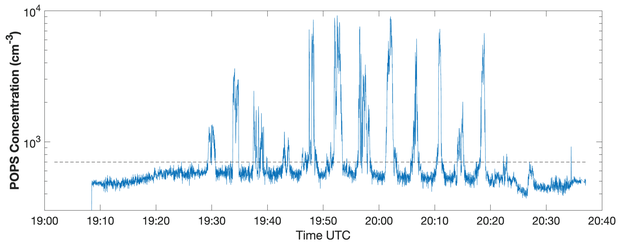


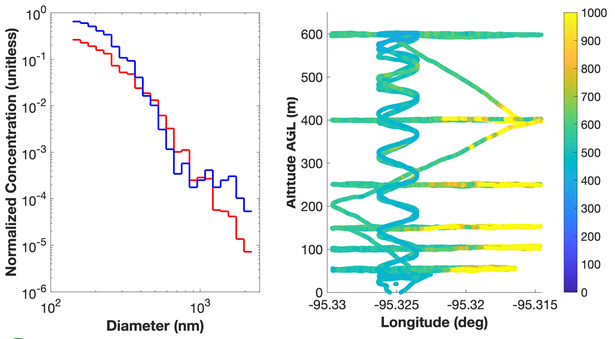
Wind roses illustrating the diurnal variability in wind speed and direction at 100 m AGL, as measured by RAAVEN.



Profiles of windspeed-normalized TKE (left) and vertical velocity variance (right) for sea breeze and non-sea breeze wind directions.

31 August Wildfire Smoke Plume





Summary

The TRACER-UAS campaign succesfully collected over 200 flight hours of data in coastal Texas during summer 2022.

Data have been processed and uploaded to the ARM data archive, and are available to the community for download (see references).

Initial analysis has focused on understanding sea breeze properties and gaining insight into aerosol properties in the region.

A data paper is being developed and is the final stages of review at *Earth System Science Data*.

References

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