PROJECT TITLE	Integrated Airborne-Mobile Ground Observations and Inventory for Enhanced VOC Source Attribution and Ozone Precursor Mapping in Texas	**PROJECT #**	26-029
PROJECT PARTICIPANTS	**PIs:** Pawel Misztal, Lea Hildebrandt Ruiz, Yue Zhang, Nathan Malarich, Munkhbayar Baasandorj **Students and Postdocs:** *TAMU:* Alana Dodero, Jiayun Zhao, Alexander Treadway, John Gonzales, Rajab Mammadov *UT Austin:* Keuntaek Kim, Hyeonjun Lee, Chun-Ying Chao, Shihao Zhai, Daniel Sung, Sam Lin, Kat Konon *CU Boulder/NOAA:* Nathan Malarich	**DATE SUBMITTED**	08/10/2026
REPORTING PERIOD	**From: 7/01/2026 To: 8/01/2026**	**REPORT #**	4

A Financial Status Report (FSR) and Invoice will be submitted separately from each of the Project Participants reflecting charges for this Reporting Period. I understand that the FSR and Invoice are due to the AQRP by the 15th of the month following the reporting period shown above.

Detailed Accomplishments by Task for reporting period

Preliminary Analysis

Mobile Measurements

Mobile Measurements (UT Austin)

Since the last MTR update, the calibrated VOC data have been quality checked and analyzed. One of the guiding research questions was how median concentrations of VOCs differ between the 3 metropolitan areas. Figure 1 shows the preliminary concentration comparison across the cities for 5 VOCs (benzene, toluene, xylenes+ethylbenzene, styrene, and decamethylcyclopentasiloxane (D5)) averaged across mobile and stationary periods. All these VOCs reveal higher median abundance in Houston, with $C_8H_{10}H^+$ (C8 aromatics) higher by one order of magnitude and C_8H_8H+ (Styrene) by two orders of magnitude. Median benzene concentration was the most consistent of the five within one order of magnitude across the 3 cities whereas D5 was significantly lower in Dallas than in other cities.

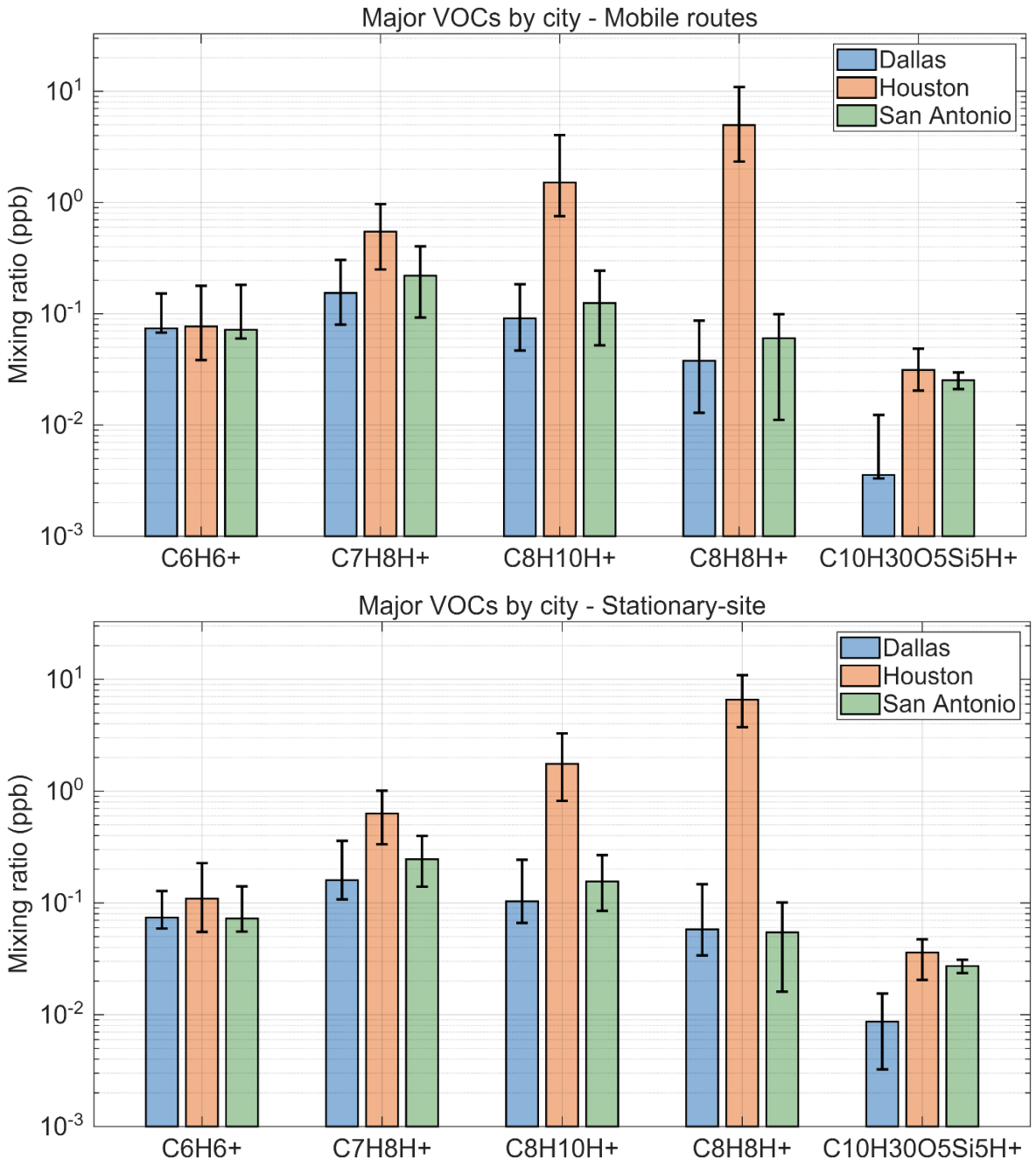
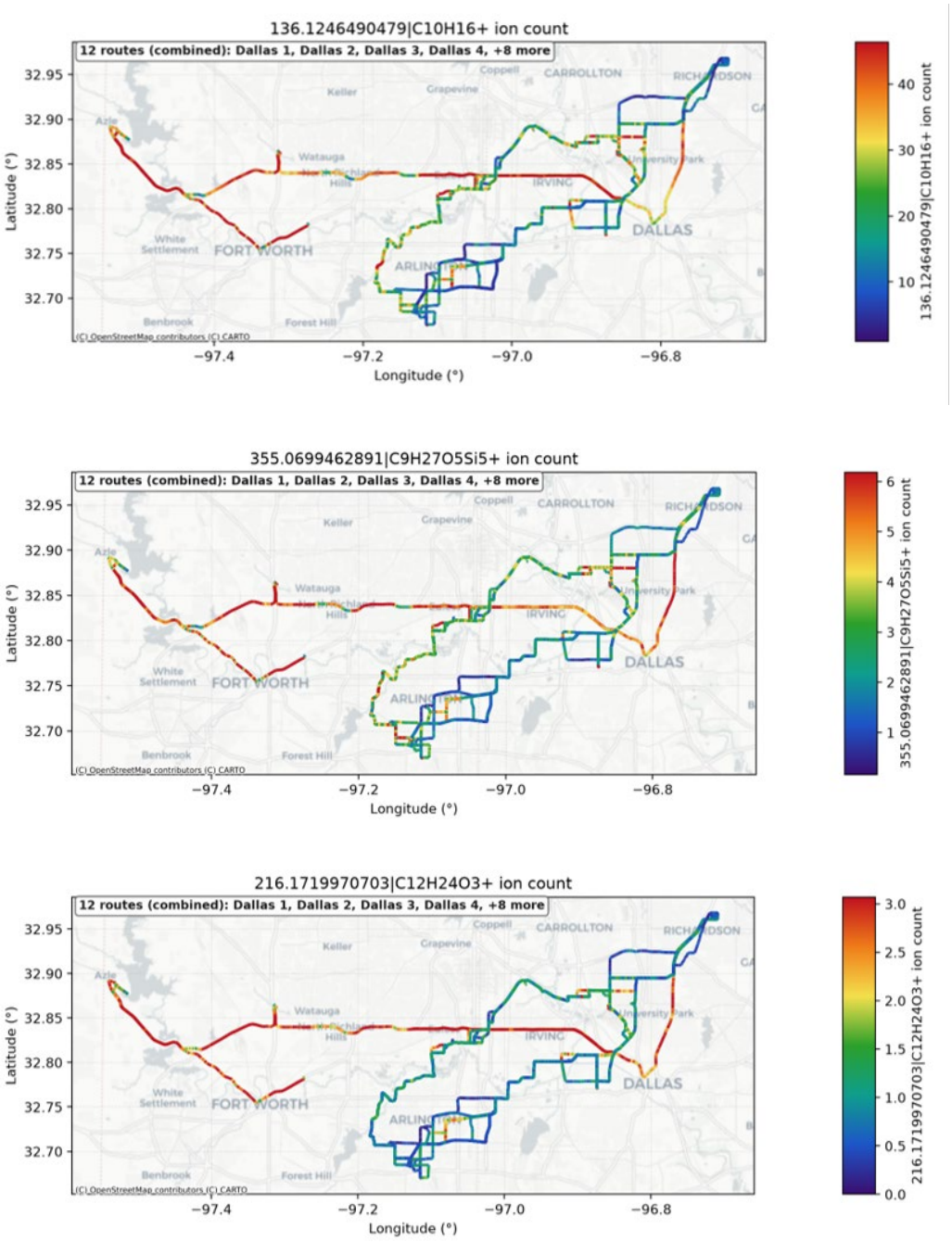


Figure 1. *Median mixing ratios (bars) and 25th-75th percentile range (error bars) of benzene ($C_6H_6^+$), toluene ($C_7H_8H^+$), xylenes+ethylbenzene ($C_8H_{10}H^+$), styrene ($C_8H_8H^+$), and D5 siloxane ($C_{10}H_{30}O_5Si_5H^+$) measured during (a) mobile and (b) stationary measurement in Dallas, Houston, and San Antonio. (Fig. by Keuntaek Kim, Misztal Group)*

Mobile Measurements (TAMU)

Since the last MTR update, the mass calibration and background subtraction for Dallas, Houston, and San Antonio have been completed. Currently calibration factors are being applied to select VCPs. Figure 1 shows the average spatial distribution for representative VCPs in Dallas.



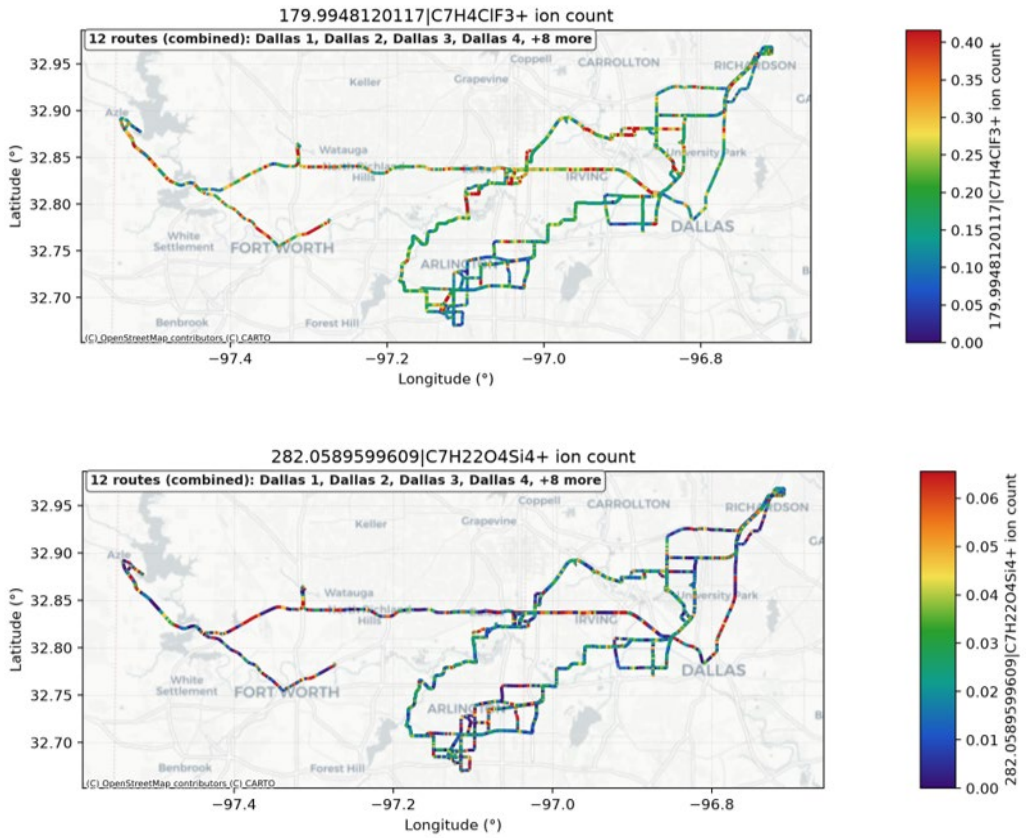


Figure 2. *Average spatial distribution in Dallas for monoterpene (detected as $C_{10}H_{16}^+$ at m/z 136.125), D5-siloxane (detected as $C_9H_{27}O_5Si_5^+$ at m/z 355.070), Texanol (detected as $C_{12}H_{24}O_3^+$ at m/z 216.172), PCBTF (detected as $C_7H_4ClF_3^+$ at m/z 179.995), and D4-siloxane (detected as $C_7H_{22}O_4Si_4^+$ as m/z 282.059). The signal is averaged over the full week of sampling at 100 m grid cells. (Figure credit: Alex Treadway, TAMU)*

Stationary Measurements

Houston Supersite – Formaldehyde and TOF-AMS (UT Austin and TAMU)

UT Austin AMS analysis

In the last MTR we provided an overview time series of the ToF-AMS measurements and meteorological parameters (Fig. 3). Since then we have further analyzed diurnal trends and the high concentration period at the end of the campaign as described in more detail below.

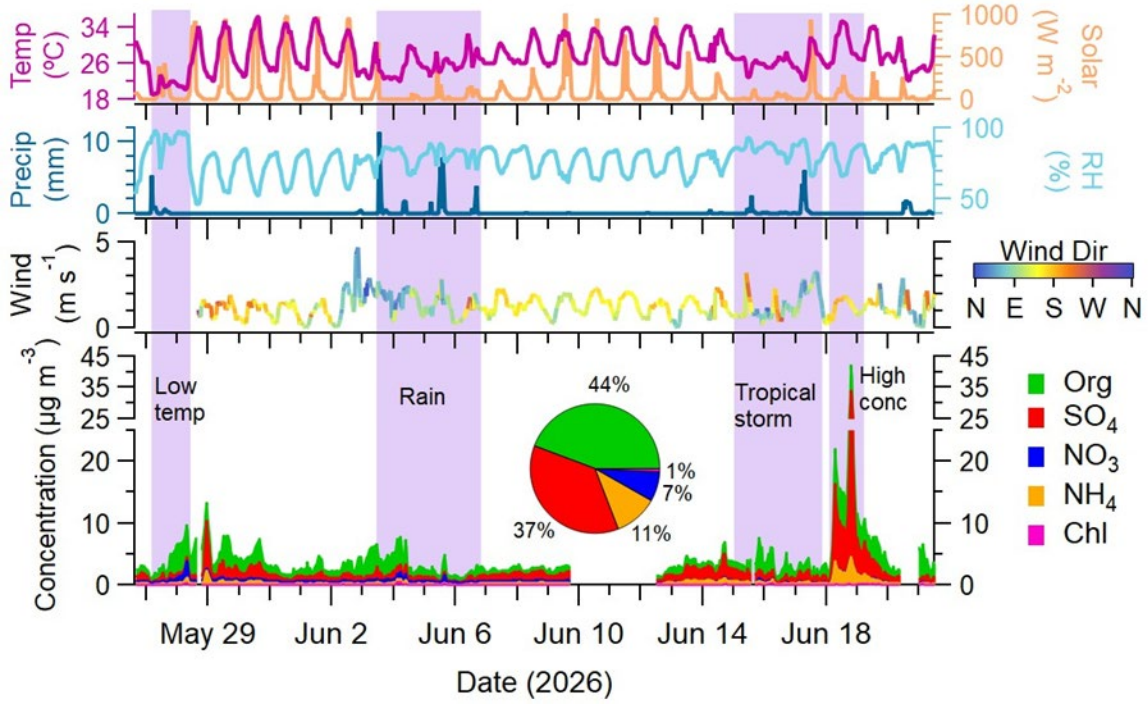


Figure 3. *Time series of NR-PM1 measurements (µg m^{-3}) and meteorological parameters temperature (ºC), solar irradiance (W m^{-2}), relative humidity (%), precipitation (mm), and wind speed (m s^{-1}) colored by wind direction. The pie chart shows the campaign average percent composition for each bulk species. (Figure credit: Kat Konon; Data collected and processed by Chung-Ying Chao and Shihao Zhai)*

NR-PM_1 Diurnal Trends

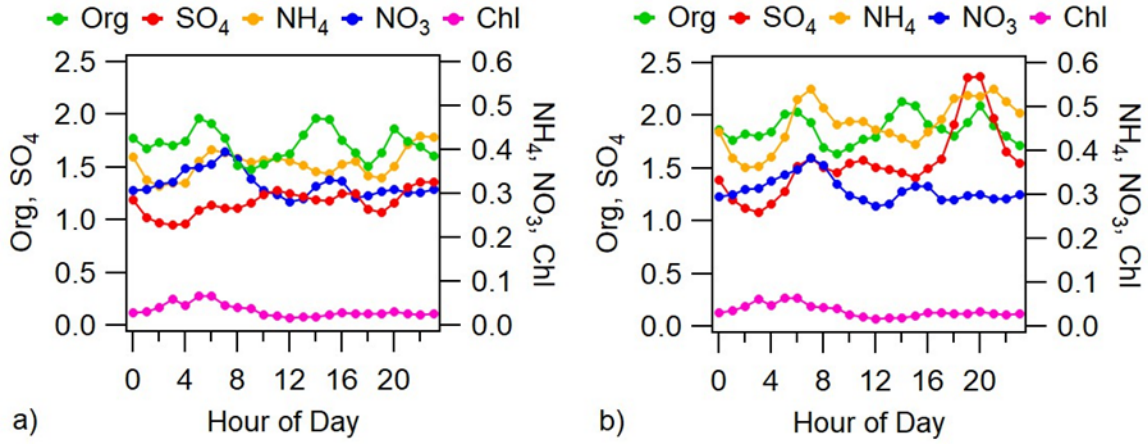


Figure 4. *Diurnal cycles of organics, sulfate, ammonium, nitrate, and chloride for a) the whole campaign excluding the high concentration period after the tropical storm and b) the whole campaign. The high concentration period after the tropical storm (4:00 June 18 – 4:00 June 19) heavily influenced the sulfate and ammonium diurnal cycles.* (Figure credit: Kat Konon; Data collected and processed by Chung-Ying Chao and Shihao Zhai)

Figure 4 shows diurnal cycles of the HR-ToF-AMS bulk species. Figure 4a represents the whole campaign from May 26-June 21, excluding the high concentration day (4:00 June 18 - 4:00 June 19) and Figure 4b shows the whole campaign including the high concentration day. The high concentration day heavily influenced the sulfate and ammonium diurnal cycles, as shown by the peaks in these species at 7:00 and 19:00 in Figure 4b that are not present in Figure 4a.

The shapes of the organics, nitrate, and chloride diurnal cycles are similar for both periods, with likely boundary layer enhancement and influence from aqueous SOA formation in the morning (4:00-6:00) (Nault et al., 2021; Seinfeld & Pandis, 2016). The morning rise in both organics and nitrate may suggest overnight organonitrate formation, which has been well documented in Houston (Bean et al., 2016; Dai et al., 2019; Stutz et al., 2010). Organics peaked again in the afternoon when photochemical activity is highest (14:00-16:00), pointing to SOA formation from atmospheric processing of emissions (Ng et al., 2010; Turpin & Huntzicker, 1995). The slight evening organics enhancement (20:00) could again be due to boundary layer effects. Analysis of the organic aerosol (OA) by positive matrix factorization (PMF) is ongoing, and the results will help elucidate the age and sources of OA, which made up 44% of the measured NR-PM_1.

High Concentration Period

After the tropical storm, sulfate, ammonium, and organics concentrations were elevated, especially from 4:00 on June 18 to 4:00 on June 19. During this time, average sulfate concentration (9.4 μg m^{-3}) was six times the campaign average (1.5 μg m^{-3}), ammonium (2.4 μg m^{-3}) was five times the campaign average (0.46 μg m^{-3}), and organics (5.1 μg m^{-3}) was over double the campaign average (1.9 μg m^{-3}). We used HYSPLIT back trajectories to investigate the paths of air masses that arrived at the measurement site at various times (Rolph et al., 2017; Stein et al., 2015). Figure 5a shows a 48-hour back trajectory initiated at 23:00 CST on June 17, corresponding to the passing of the tropical storm at the measurement site. This image shows counterclockwise transport of continental air masses west of Houston, transport over the Gulf of America southeast of the site, and transport over the highly industrialized Houston Ship Channel east of the site. However, NR-PM_1 concentration was 3.1 μg m^{-3} at that time, which was below the campaign average (4.2 μg m^{-3}), likely due to precipitation (causing wet scavenging that clears PM from the air) and/or higher wind speeds (and therefore dilution) during the tropical storm.

Figure 5b shows a 72-hour back trajectory initiated from the beginning of the high sulfate period (4:00 CST on June 18), and Figure 5c shows a 72-hour back trajectory initiated at the end of the high sulfate period (4:00 CST on June 19). Based on Figures 5b and 5c, the high sulfate air mass likely spent some time traveling over the Gulf of America before reaching the measurement site. This area experiences heavy marine traffic, and ships are the main source of sulfur dioxide (SO_2) over the Gulf (Bates et al., 2008; Zhou et al., 2023). Sulfate-containing aerosol forms from atmospheric oxidation of SO_2, so it is likely that an aerosol plume with high sulfate content that traveled over the Gulf was influenced by shipping activity. However, there are many sources of SO_2 in the Greater Houston area, including petrochemical plants, power plants, and vehicles. With the Houston Ship Channel 5.5 km to the east of the measurement site, industrial SO_2 emissions also could have contributed to the high NR-PM_1 formation. PMF analysis of the OA during this time will help clarify the source of this NR-PM_1 plume. For example, if the OA is mainly more-oxidized oxygenated organic aerosol, this would indicate an aged air mass originating far from the site (e.g. over the Gulf). In contrast, if the OA is mainly less-oxidized oxygenated organic aerosol, this would point to fresher emissions closer to the site (e.g. the Houston Ship Channel) (Ng et al., 2011).

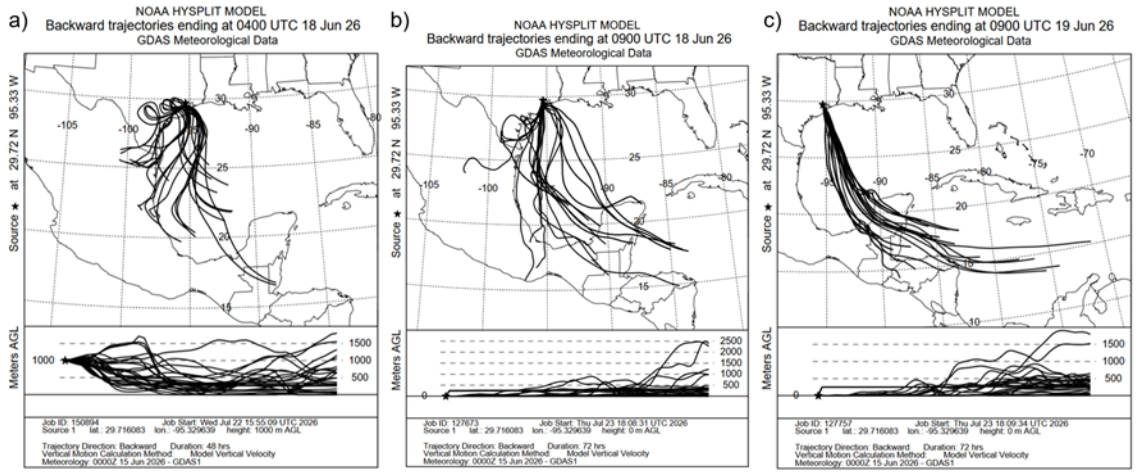


Figure 5. *HYSPLIT back trajectories initiated from a) 23:00 CDT on June 17 (end of tropical storm), b) 4:00 CDT on June 18 (beginning of high concentration period), and c) 4:00 CDT on June 19 (end of high concentration period).*

NOAA Aircraft and Other Preliminary Analyses

The calibration gases are still at Ellington Field, the NOAA team is coordinating a return of these gases with another NOAA field campaign at the same air base. The team has no updates with preliminary field data. The preliminary ozone analysis and conducted airborne tracks were presented in the previous MTR.

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Identify Any Problems or Issues Encountered and Proposed Solutions or Adjustments

None.

Goals and Anticipated Issues for the Succeeding Reporting Period

UT Austin HR-AMS plans are to focus on factor analysis of collected data using positive matrix factorization. Further quality assurance and quality control of the mobile records, mass calibration and background subtraction of the PTR-TOF-MS data, source apportionment (including PMF where appropriate), and intercomparison of the UT, TAMU, University of Houston, NOAA, and Houston supersite datasets are ongoing. The team will consolidate route-density products and collocation logs for all four metropolitan areas and prepare data for delivery to TCEQ. BTEX compounds will be compared for the Dallas highest ozone day during the aircraft spiral (see UT Austin data in the Appendix A). Doug Boyer (TCEQ) provided trace gas and VOC data from TCEQ monitoring stations which will continue to be utilized in the analyses.

Publications and Presentations

Do you have any publications related to this project currently under development? If so, please provide a working title, and the journals you plan to submit to.

☐ **Yes** ☒ **No**

Do you have any publications related to this project currently under review by a journal? If so, what is the working title and the journal name? Have you sent a copy of the article to your AQRP Project Manager and your TCEQ Liaison?

☐ **Yes** ☒ **No**

Do you have any bibliographic publications (ie: publications that cite the project) related to this project that have been published? If so, please list the reference information. List all items for the lifetime of the project.

☐ **Yes** ☒ **No**

Do you have any presentations related to this project currently under development? If so, please provide working title, and the conference you plan to present it (this does not include presentations for the AQRP Workshop).

☐ **Yes** ☒ **No**

Do you have any presentations related to this project that have been published? If so, please list reference information. List all items for the lifetime of the project.

☐ **Yes** ☒ **No**

Have any personnel changes occurred that were not listed in the original proposal? If so, please include a detailed description of the personnel change(s) below.

☐ **Yes** ☒ **No**

Are any delays expected in the progress of the research? If so, please include a detailed description of the potential delay below.

☐ **Yes** ☒ **No**

Describe any possible concerns/issues (technical or non-technical) that AQRP should be made aware of.

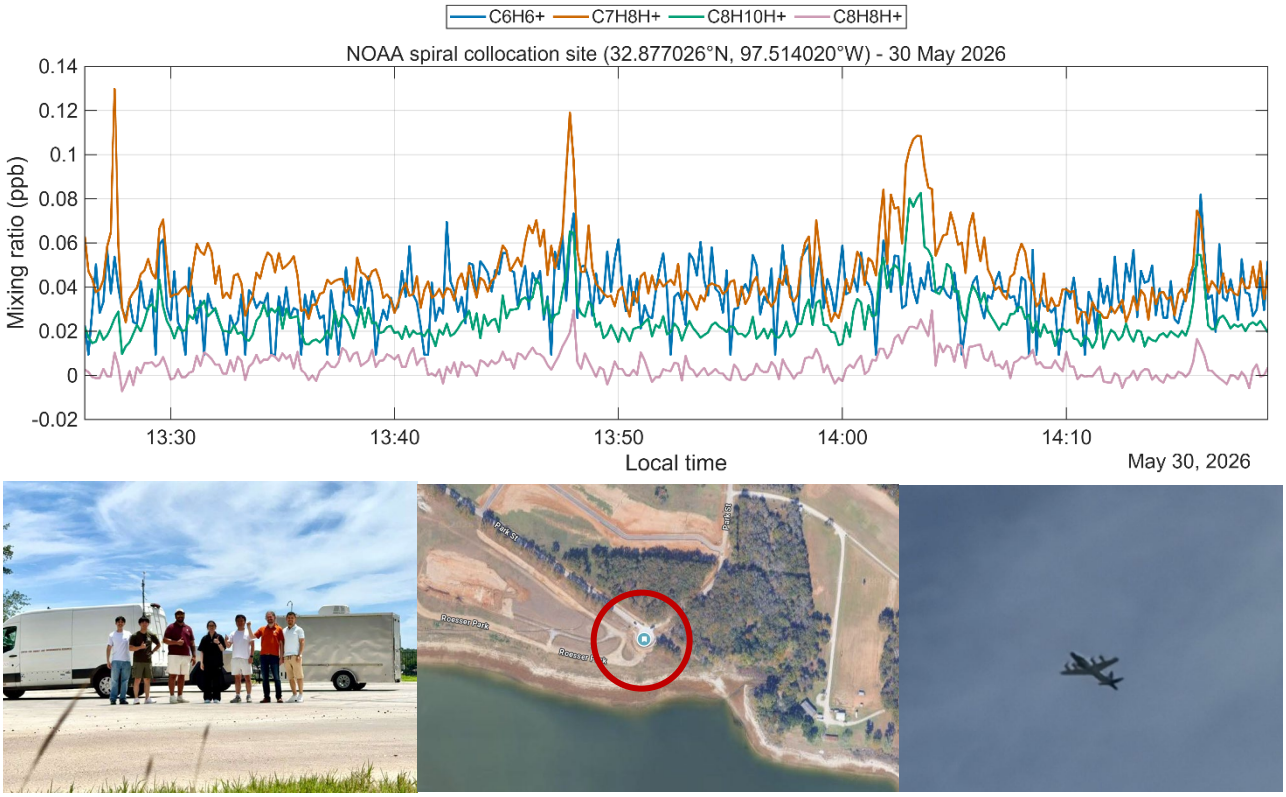
None

Are you anticipating using all the available funds allocated to this project by the end date? If not, why and approximately what is the amount to be returned?

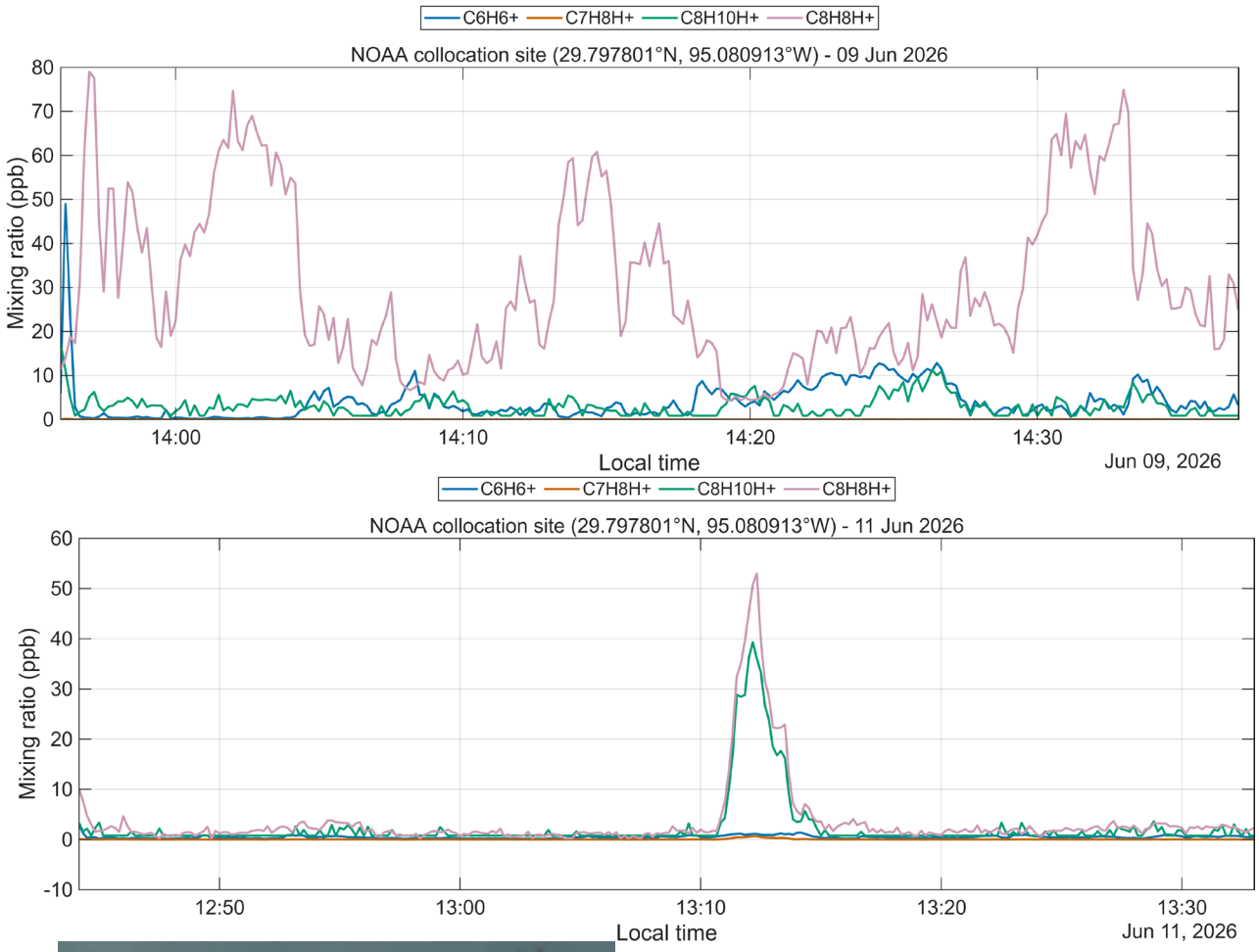
☒ Yes ☐ No

Submitted to AQRP by
Pawel Misztal

Appendix A: Other supplemental graphs or prelim analyses



Appendix Figure A1. Time series of benzene, toluene, xylenes+ethylbenzene, and styrene mixing ratios at the Dallas NOAA spiral collocation site (32.877026°N, 97.514020°W) on 30 May (Figure credit: Keuntaek Kim, UT Austin)



Appendix Figure A2. *Time series of benzene, toluene, xylenes+ethylbenzene, and styrene mixing ratios at the Houston NOAA spiral collocation site (29.797919°N, 95.080985°W) on 09 June and 11 June 2026 (UT Austin data). (Figure credit: Keuntaek Kim, UT Austin)*