Texas Air Quality Research Program
Research Priorities, 2024-2025

A State of the Science assessment, available on the Texas Air Quality Research Program (AQRP) web site (http://aqrp.ceer.utexas.edu/publications.cfm), summarizes the scientific understanding of air quality issues that emerged from projects funded by the AQRP during the 2016-2021 project cycles. Findings have been summarized in the areas of emissions inventory development and assessment, tropospheric chemistry, and atmospheric physical processes and long-range transport of pollutants. While these AQRP project findings have advanced scientific understanding in these areas, additional research needs have emerged from this work. Addressing these additional research needs, which are summarized below, involve collection and analysis of field measurements, improvements to photochemical models and improvements to emission inventories. These research needs, the associated data collection, and model improvements, might be addressed through multiple funding mechanisms.

- **TRACER-AQ and over-water measurements:** In the 2020-2021 and 2022-2023 biennia, the AQRP and the TCEQ funded measurements of ozone and ozone precursors over Galveston Bay, in Houston and the Gulf of Mexico. In addition, the TRACER-AQ (Tracking Aerosol Convection ExpeRiment-Air Quality) Study, supported by the National Aeronautics and Space Administration (NASA) and the Department of Energy, continues to examine the role of coastal/maritime boundary layers and wind cycles on ozone and particulate matter formation and accumulation in Houston-Galveston-Brazoria (HGB) area. Additional analyses of the data already collected, and collection of additional measurements, could address questions such as:
    - Which meteorological models most accurately replicate the extensive meteorological data collected as part of TRACER-AQ?
    - How well do coupled mesoscale meteorological and photochemical grid modeling of coastal/maritime boundary layers replicate observations?
    - Do the light and energy absorbing properties of carbonaceous Particulate Matter (PM) influence boundary layer development?
    - How well do photochemical grid models such as CAMx predict over water concentrations and formation rates of ozone?
    - What are the spatial distributions of particulate matter, ozone, and ozone precursors during TRACER-AQ on days with on-land monitors recording exceedances of the National Ambient Air Quality Standard?
    - Which emission source categories affect ozone formation over Galveston Bay and the Gulf of Mexico?

- **Photochemical air quality models:** Photochemical air quality models take data on meteorology and emissions, couple the data with descriptions of the physical and chemical processes that occur in the atmosphere, and mathematically and numerically process the information to yield predictions of air pollutant concentrations. The models are used to quantitatively assess the potential effectiveness of air quality management strategies. AQRP projects directed at improving model performance have focused on improving the description of emissions and atmospheric chemistry, improvements in cloud characterizations, cloud processes, and models of wind fields. A variety of projects, outlined below, could continue to make improvements to the accuracy of photochemical models.

- Model development
  - Improvements to WRF planetary boundary layer schemes to represent coastal, marine, and residual boundary layers.
  - Framework and/or method development to incorporate TCEQ or EPA emission inventories into WRF-GC, WRF-Chem, GEOS-CF, and/or other research photochemical models.
- Chemical data assimilation in the CAMx and CMAQ regulatory photochemical models
- Incorporating field study results of marine environment chemistry into the CAMx and CMAQ regulatory photochemical models (e.g., aerosol nitrate photolysis).
- Improvement of global atmospheric chemistry models (e.g., GEOS-Chem) to directly read CAMx and CMAQ gridded emission inventories.

- **Improve emission inventories:** New geolocation and remote sensing data sources, and machine learning techniques involving analyses of imagery, are becoming increasingly available, and may be useful for improving emission inventories for on-road, non-road, commercial marine, and rail. For example, machine learning of traffic camera images, or other data on vehicle mixes, could be used to identify, categorize, and count vehicles by use type, and create new inputs for on-road sources using MOVES3. New sources of activity data may be identified and applied to existing inventories using new techniques or analytics. Projects on emission sources where recent analyses have suggested emission inventory improvements may be needed, such as vehicle brake wear and volatile consumer product emissions, are also of interest. Projects that lead to results that are rapidly actionable and could be incorporated into state and regional emission inventories are of interest. Emission inventory categories of interest include, but are not limited to:
  - On-road emission sources
  - Non-road construction equipment sources
  - Commercial marine sources
  - Satellite-based estimates and verification
  - Population/activity counts
  - Temporal profiles of point source categories. This topic could look at potential temporal profiles for specific industrial activities such as tank degassing and when they normally occur. This would let us better model the emissions from these activities at the right time.
  - Projections of emissions/activity data for future years. This topic will allow us to review the projections data we use for future years.

- **Use of satellite and other remote sensing data:** Satellite and other remote sensing data sources are becoming increasingly available, and may be useful for improving understanding of a variety of issues in air quality. These include, but are not limited to emissions, cloud processes, transport of pollutants at multiple spatial scales, and land cover characteristics. Projects that lead to results that are rapidly actionable and could be incorporated into state and regional emission inventories and photochemical modeling are of interest. These types of projects may include better methods for converting existing air quality information into forms that can be reconciled with satellite measurements, such as better characterization of the contribution of stratospheric concentrations to total column concentrations detected by satellites, and better understanding of the dynamics of conversion of emitted NOx into NO_2, which is detectable by satellites. Specific topics of interest include, but are not limited to:

  - What are NO_2 and SO_2 concentrations above the planetary boundary layer (PBL) and how do the concentrations vary over the continental US? How much do these concentrations above the PBL to influence total column measurements?
  - How does the lifetime of NO_2 vary with exhaust characteristics and meteorology? Would additional information on the lifetime of NO_2 significantly influence reconciliations between model predictions and satellite observations?
  - Analysis of TEMPO data in Texas
    - Comparison of TEMPO retrievals to surface monitor data, ozonesonde profiles, Pandora profiles, and other available data.
    - Evaluation of the diurnal and seasonal patterns of ozone production sensitivities across Texas.
    - Emissions estimates from flux divergence and other advanced methods.

- **Domestic fire emissions:** Multiple AQRP projects have focused on international transport of particulate matter and ozone into Texas from agricultural burning and wildfire sources in Mexico, and this remains an area of continuing interest, however, there is limited information on the impact of domestic wildfires and fires at the wildland-urban interface on particulate matter, particulate matter precursor, ozone and ozone precursor concentrations in Texas. 2021 was a record wildfire year in many parts of the United States, and the large-scale air pollutant transport associated with these fires may lead to new insights. Questions of interest include, but are not limited to:
  - What are concentrations of PM and ozone, and their precursors, transported into Texas, from domestic wildfires and wildland-urban fires?
  - Is the atmospheric chemistry of fire plume interaction with urban air accurately captured in photochemical models?
  - What role do domestic and international smoke emissions have in exceptional events?

- **Trends in wind-blown dust ($PM_{2.5}$) in Texas:** Predictions and observations of the component of particulate matter concentrations attributable to wind-blown dust are often significantly different. Recent AQRP projects have made improvements to wind-blown dust emission models, however significant uncertainties remain. Issues of interest include, but are not limited to, better characterization of the multiple sources of windblown dust and their contribution to coarse particulate matter, PM_{10} and $PM_{2.5}$.

- **2021 San Antonio Field Study (SAFS) data analysis:** Measurements made during the SAFS conducted in 2021 have not been fully analyzed. The measurement data may be used to answer questions about the emission source categories that contribute to high ozone in San Antonio. Questions include, but are not limited to:
  - Which emission source categories affect ozone formation in San Antonio during May-June time periods and has this changed since the San Antonio Field Study of 2017?

- How much do the different source categories contribute to the peak concentrations observed?
- How much do upwind source categories contribute to ozone concentrations in San Antonio?
- Can contributing source categories be identified and quantified from measurement data?

- **Development of an ozone and $PM_{2.5}$ field study in El Paso** Multiple urban areas in Texas have had air quality field campaigns conducted to examine the chemical and physical processes that lead to ozone and fine particulate matter formation and accumulation. El paso, however, has seen relatively few measurements. Some areas of exploration may include:
  - Determining why El Paso experiences high toluene measurements. What could be the sources of the emissions (e.g., local industry, gasoline productions, motor vehicles, or Mexican emission sources)
  - Causes of ozone in El Paso including its unique geography and sources.
  - The new $PM_{2.5}$ standard leads to greater interest in the sources of fine particulate matter transported into El Paso. Specifically, dust transport from Mexico.