Assessing the Impact of Spatially and Temporally Allocated NOx Emissions from Unconventional Oil and Gas Development on Regional Ozone Formation

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Background. Unconventional oil and gas development (UOGD) in the US is a rapidly growing source of ozone (O_3) precursors, such as nitrogen oxides (NOx) and volatile organic compounds (VOCs). Ground level ozone is one of six criteria pollutants regulated under the National Ambient Air Quality Standards (NAAQS). As a secondary pollutant, its sources are complex to identify and can depend on the spatial and temporal patterns of VOCs and NOx emissions. Most regional and national emission inventories report NOx and VOCs emissions annually, with varying spatial resolution. In oil and gas production regions where biogenic VOCs are abundant, such as the Eagle Ford Shale (EFS), understanding the spatiotemporal patterns of NOx emissions is important as they may impact local and regional ozone formation. Here, we allocate NOx emissions from UOGD sources, particularly from hydraulic fracturing, at various spatial and temporal scales to assess their impact on regional ozone formation.

Methods. We developed four synthetic emission scenarios by varying the duration and spatial allocation of the annual county-level NOx emissions from oil and gas sources in the EFS. For Case 1, we evenly distributed the total county-level NOx emissions to all active well-sites and assumed they emit continuously all year. For Cases 2, 3, and 4, we focused on Karnes County, one of the most active production regions in the EFS. For Case 2, we assigned NOx emissions from hydraulic fracturing only to the wells that were fractured in that year. We assumed that these emissions lasted for two weeks before a well goes into production. For Case 3 and 4, we kept the spatial allocation in Case 2 but reduced the duration of NOx emissions from hydraulic fracturing to one week and two days, respectively. These emissions were added to the 2019 Base Case emissions, V1 developed by the Texas Commission for Environmental Quality (TCEQ) for use in photochemical modeling. We utilized the Comprehensive Air Quality Model with Extensions (CAMx) to simulate ozone impacts from Cases 1-4 for April to October 2019.

Results. We compared the magnitude, spatial extent, and period of ozone exceedances across all four scenarios. As the simulated emission duration decreased, we observed significant changes in the **D**aily **M**aximum of 8-hour **A**verage $\mathbf{O_3}$ concentrations (**MDA8** $\mathbf{O_3}$) across the EFS. MDA8 O_3 concentrations were consistently 5, 8, and 10 ppb higher than the base case for the two-week, one-week, and two-day emission period, respectively across August and September.

Conclusions. UOGD activities like hydraulic fracturing occur at selected well-sites and last only for 1-2 weeks prior to production. Accurate spatial and temporal allocation of their NOx emissions leads to significant localized ozone formation. These results are significant for attaining the NAAQS for ozone in San Antonio, the seventh largest city in the US.