Health burden of air pollution from the oil and gas lifecycle in Texas

Karn Vohra[1], Ploy Achakulwisut[2], Eloise A. Marais[1], Jamie Kelly[1], Colby Francoeur[3,4], Colin Harkins[3,4], Brian McDonald[4]

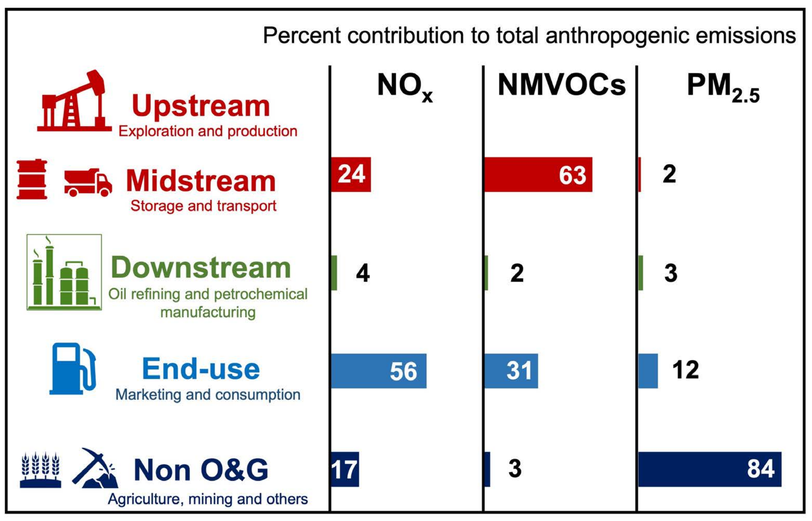
[1]University College London, [2]Stockholm Environment Institute, [3]University of Colorado Boulder, [4]NOAA Earth System Research Laboratory

1. INTRODUCTION

- Texas is the largest oil and gas (O&G) producing state in the US. Recent (mid-2010s) increases in production and lack of enforcement of regulations targeting activities such as flaring is leading to a rapid increase in air pollution (*Cushing et al., 2021, Dix et al., 2019*).
- Previous studies have focused on end use (*Vohra et al., 2021*) or the collective sector (*Fann et al., 2018*).
- Here we use updated emissions estimates for 2017 and GEOS-Chem at high spatial resolution (25-31 km) to quantify the impact of major segments in the O&G lifecycle on air quality and health in Texas.

2. UPDATED EMISSIONS INVENTORY

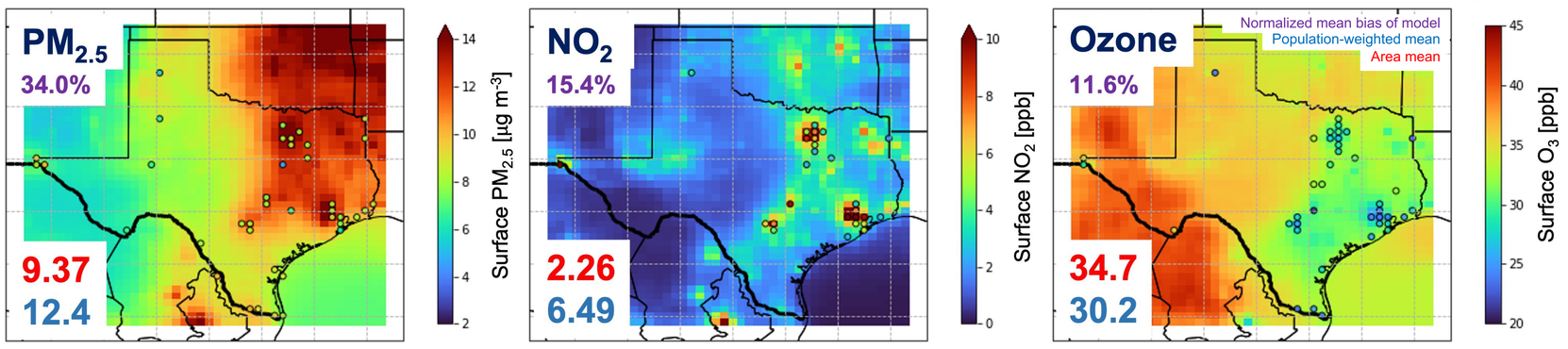
- US EPA National Emissions Inventory (NEI) reports emissions data for **oil and gas production**. Here, we use NEI 2017 for point and area sources from each O&G lifecycle segment and mobile sources for end-use emissions from the Fuel-based Inventory for Vehicular Emissions (*Harkins et al., 2021*).
- Texas O&G lifecycle contribution to anthropogenic emissions is 84% of nitrogen oxides (NO_x), 97% of non-methane volatile organic compounds (NMVOCs) and 16% of primary fine particles ($PM_{2.5}$) emissions.



3. GEOS-CHEM MODEL: SIMULATIONS AND PERFORMANCE

- We use the 3D chemical transport model GEOS-Chem (v13.0.0) nested over Texas at 0.25° × 0.3125° to simulate surface concentrations of pollutants hazardous to human health.
- The model overestimates air pollutant concentrations by 12-15% for NO_2 and ozone and more (34%) for $PM_{2.5}$ due to a known bias in nitrate aerosol in winter (*Shah et al., 2018*).

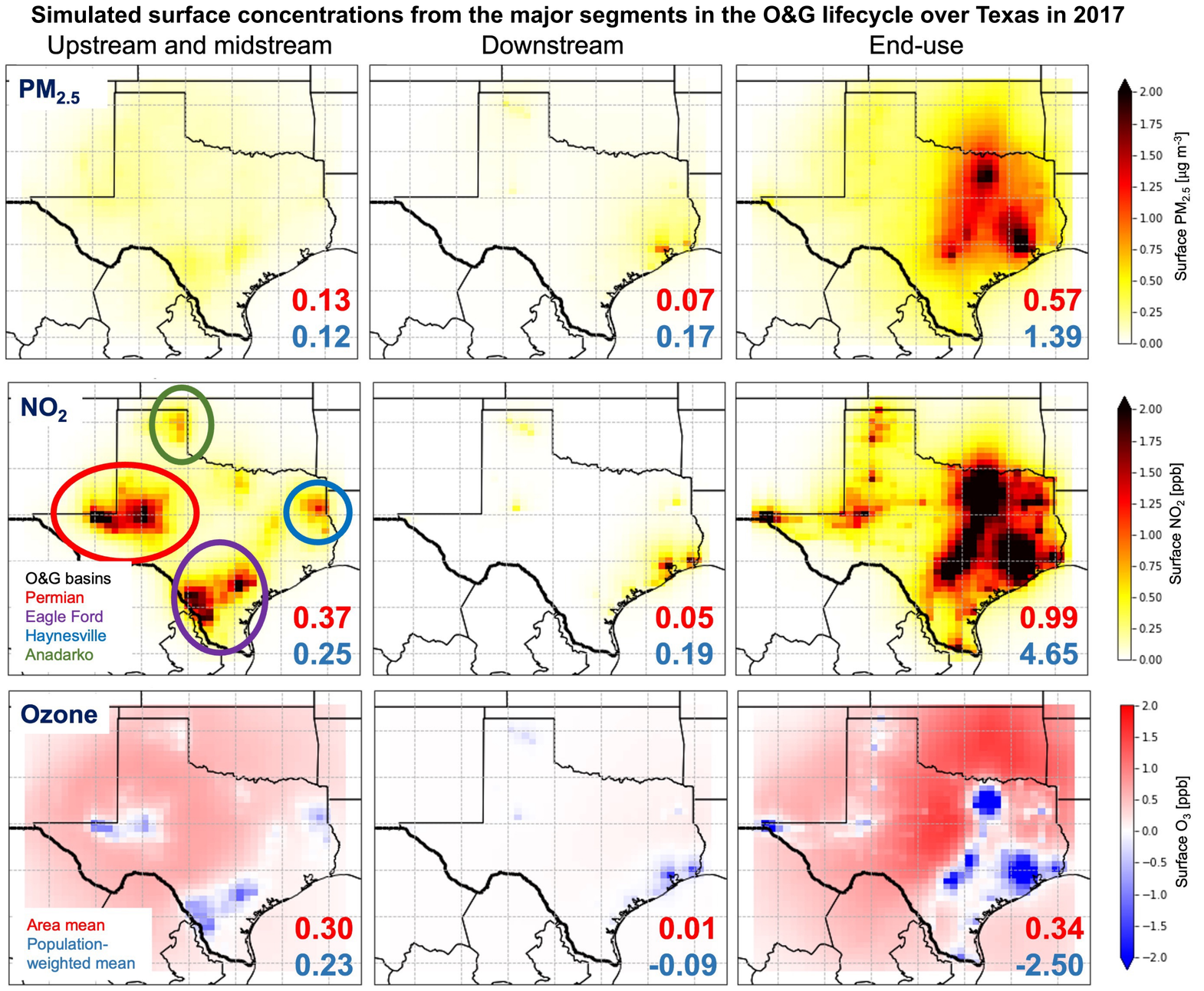
Simulated surface concentrations for the base simulation over Texas in 2017. Circles are US EPA monitoring sites.



4. AIR POLLUTION IN TEXAS FROM MAJOR OIL AND GAS SEGMENTS

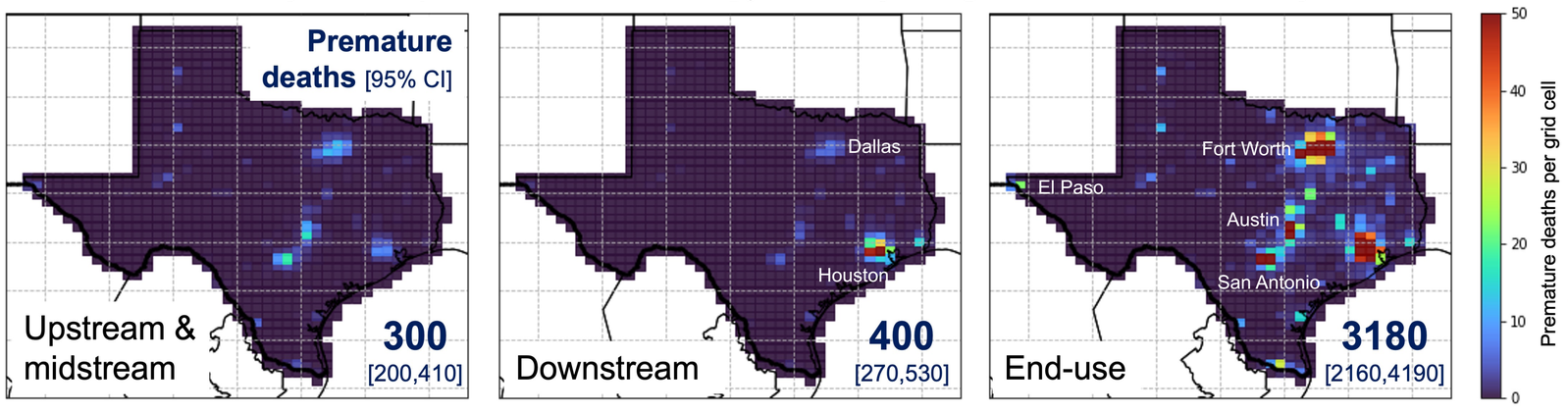
- We run sensitivity simulations by turning off emissions from major segments in the O&G lifecycle in Texas. The difference between the base simulation and sensitivity simulations is used to determine the contribution of the O&G lifecycle segment to pollutant concentration.
- O&G activities in Texas contribute to 0.77 μg m^{-3} (8.2%) of $PM_{2.5}$. Most of it is from end-use (0.57 μg m^{-3}) dominated by on-road mobile sources.
- 62% of NO_2 (1.41 ppb) in Texas from O&G activities. 0.99 ppb from end-use and 0.37 ppb from upstream and midstream activities such as flaring and use of compressor engines in Permian, Eagle Ford, Haynesville and Anadarko basins.
- Texas O&G lifecycle also contributes to $PM_{2.5}$ in neighbouring regions in the nested domain (**0.59 μg m^{-3} in Oklahoma, 0.48 μg m^{-3} in Louisiana, 0.18 μg m^{-3} in New Mexico, and 0.19 μg m^{-3} in Mexico**)
- Most $PM_{2.5}$ and NO_2 from end-use activities is in regions surrounding major cities in Texas and so the population-weighted mean is higher than the area mean.
- Decline in ozone occurs at NO_2 hotspots in Texas. Urban population exposure to ozone decreases due to NO_x titration.

Simulated surface concentrations from the major segments in the O&G lifecycle over Texas in 2017



5. HEALTH IMPACT ASSESSMENT

Premature mortality from exposure to ambient $PM_{2.5}$ from major segments in the O&G lifecycle in Texas



- We estimate adult (>14 years old) premature deaths from long-term $PM_{2.5}$ exposure using population data at 100 m resolution, county-level baseline mortality rates and an updated health risk assessment model (*Vodonos et al., 2018*) which includes more cohort studies at low $PM_{2.5}$ concentrations (<10 μg m^{-3}) and estimates higher relative risk at such low concentrations than previous health risk assessment models (*Burnett et al., 2014; 2018*).
- **3,880** premature deaths in 2017 from $PM_{2.5}$ exposure linked to Texas O&G activities (**82%** from end-use, **10%** from downstream and **8%** from upstream activities).

6. CONCLUSIONS

- End-use activities make the largest contribution (70-75%) to $PM_{2.5}$ and NO_2 from Texas O&G lifecycle, followed by combined upstream and midstream (17-26%) and downstream (4-9%) activities. End-use and downstream activities are in populated areas and so $PM_{2.5}$-attributable premature deaths from these is higher (82% and 10% respectively) than from upstream activities (8%).
- O&G production has grown by over 30% since 2017, so the current impact on health may be more severe than we estimate.

For more information, contact Karn Vohra: **k.vohra@ucl.ac.uk** **@kohra_thefog**

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