Health burden of air pollution linked to each major oil and gas lifecycle stage in the US

Karn Vohra[1], Ploy Achakulwisut[2], Eloise A. Marais[1], Susan Anenberg[3], Gongda Lu[1], Jamie Kelly[1], Colby Francoeur[4,5], Colin Harkins[4,5], Brian McDonald[5], Tia Scarpelli[6]
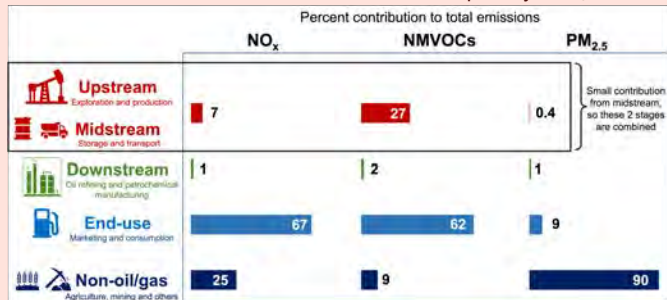[1]University College London, [2]Stockholm Environment Institute, [3]George Washington University, [4]University of Colorado Boulder, [5]NOAA Earth System Research Laboratory, [6]Carbon Mapper

1. INTRODUCTION

- US is the world's largest producer of oil and gas. 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.
- Previous studies have focused either only on end use or the collective sector of oil and gas production.
- Here we use air pollutant emissions for 2017 and GEOS-Chem at high spatial resolution (25-31 km) to quantify the impact of individual stages in the lifecycle on air quality and health. Stages include upstream, midstream, downstream, and end-use activities.

2. OIL AND GAS EMISSIONS

- Air pollutant emissions from the US EPA National Emissions Inventory (**NEI 2017**) are aggregated for each major oil and gas lifecycle stage, Fuel-based Inventory for Vehicular Emissions (**FIVE**) for mobile sources.
- Oil and gas activities in the US contribute to **75%** of anthropogenic emissions for NO_x, **91%** for *NMVOCs* and **10%** of primary $PM_{2.5}$.

Percent contribution to total emissions

	NO_x	NMVOCs	$PM_{2.5}$
Upstream (Exploration and production)	7	27	0.4
Midstream (Storage and transport)			
Downstream (Oil refining and petrochemical manufacturing)	1	2	1
End-use (Marketing and consumption)	67	62	9
Non-oil/gas (Agriculture, mining and others)	25	9	90

Small contribution from midstream, so these 2 stages are combined

3. GEOS-CHEM MODEL: SIMULATIONS AND PERFORMANCE

- We use the 3D chemical transport model **GEOS-Chem** (v13.0.0) nested over contiguous US at 0.25°×0.3125° to simulate surface concentrations of pollutants. GEOS-Chem is run with and without emissions for each major oil and gas lifecycle stage to determine its contribution to air pollutants.
- Model evaluated against observations from the US EPA Air Quality System database and the IMPROVE program. GEOS-Chem overestimates air pollutant concentrations by **19.2%** for annual mean $PM_{2.5}$ and **3.5%** for annual mean NO_2*.


PM₂.₅   NO₂*
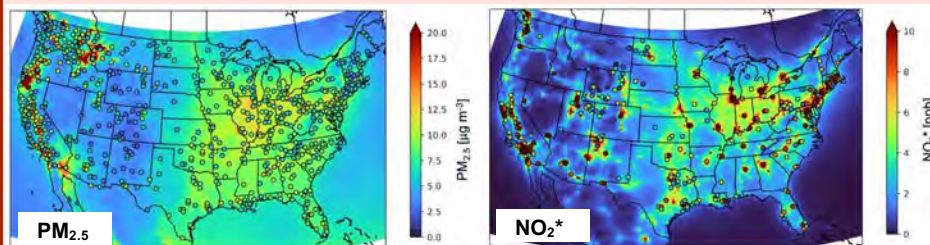
We calculate NO₂* (from thermal decomposition of NOx-reservoir compounds) to compare to measurements from chemiluminescence instruments.
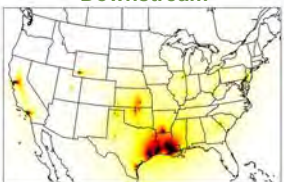
4. AIR POLLUTION FROM MAJOR OIL AND GAS LIFECYCLE STAGES IN THE US

US-wide oil and gas activities contribute to a population exposure of **2.56** µg m⁻³ (**26%**) of $PM_{2.5}$, **5.36** ppbv (**68%**) of NO_2, and **5.45** ppbv (**11%**) of maximum daily 8-hour ozone (**MDA8O₃**).
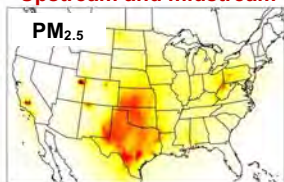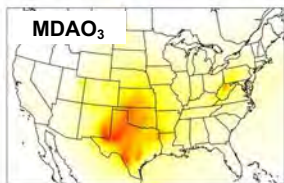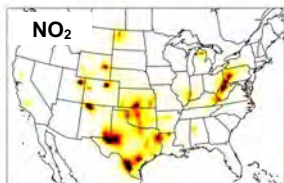
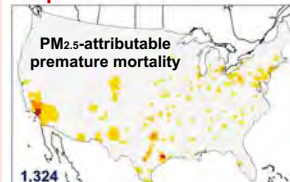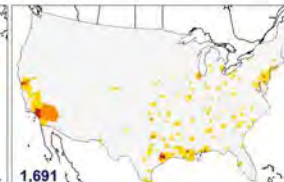**Upstream and midstream**   **Downstream**   **End-use**
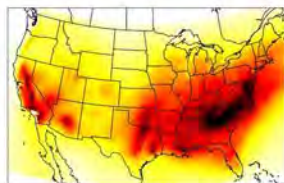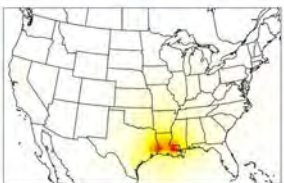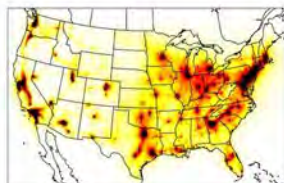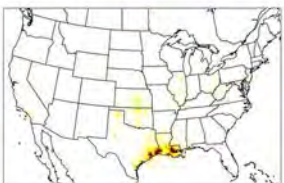
5. HEALTH BURDEN ASSESSMENT

Oil and gas activities in the US are linked to **49,500** $PM_{2.5}$-attributable adult premature deaths, **220,400** NO_2-attributable paediatric asthma incidences and **1,820** VOCs-attributable cancer incidences.
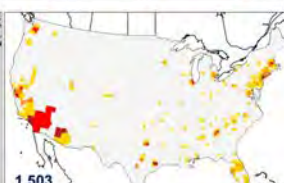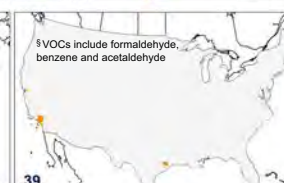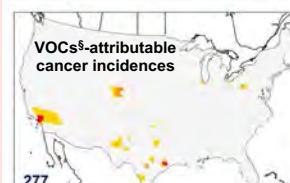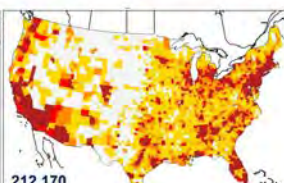
Upstream and midstream   **Downstream**   **End-use**

$PM_{2.5}$-attributable premature mortality: 1,324 | 1,691 | 46,549

NO_2-attributable asthma incidences: 5,224 | 2,165 | 212,170

VOCs§-attributable cancer incidences: 277 | 39 | 1,503

§VOCs include formaldehyde, benzene and acetaldehyde
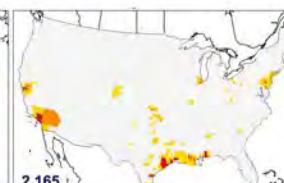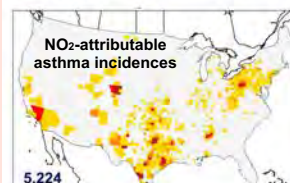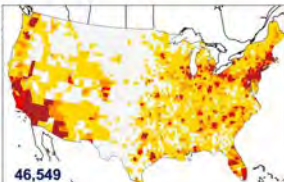
FINAL REMARKS End-use activities in the US make the largest contribution to $PM_{2.5}$, NO_2 and MDA8O₃, but there are large VOCs emissions (~30%) from oil and gas production. All of these are linked to adverse health outcomes underscoring the need to mitigate air pollutant emissions from the whole oil and gas lifecycle. For more information, contact Karn Vohra: **k.vohra@ucl.ac.uk**; X (Formerly Twitter): **@kohra_thefog**