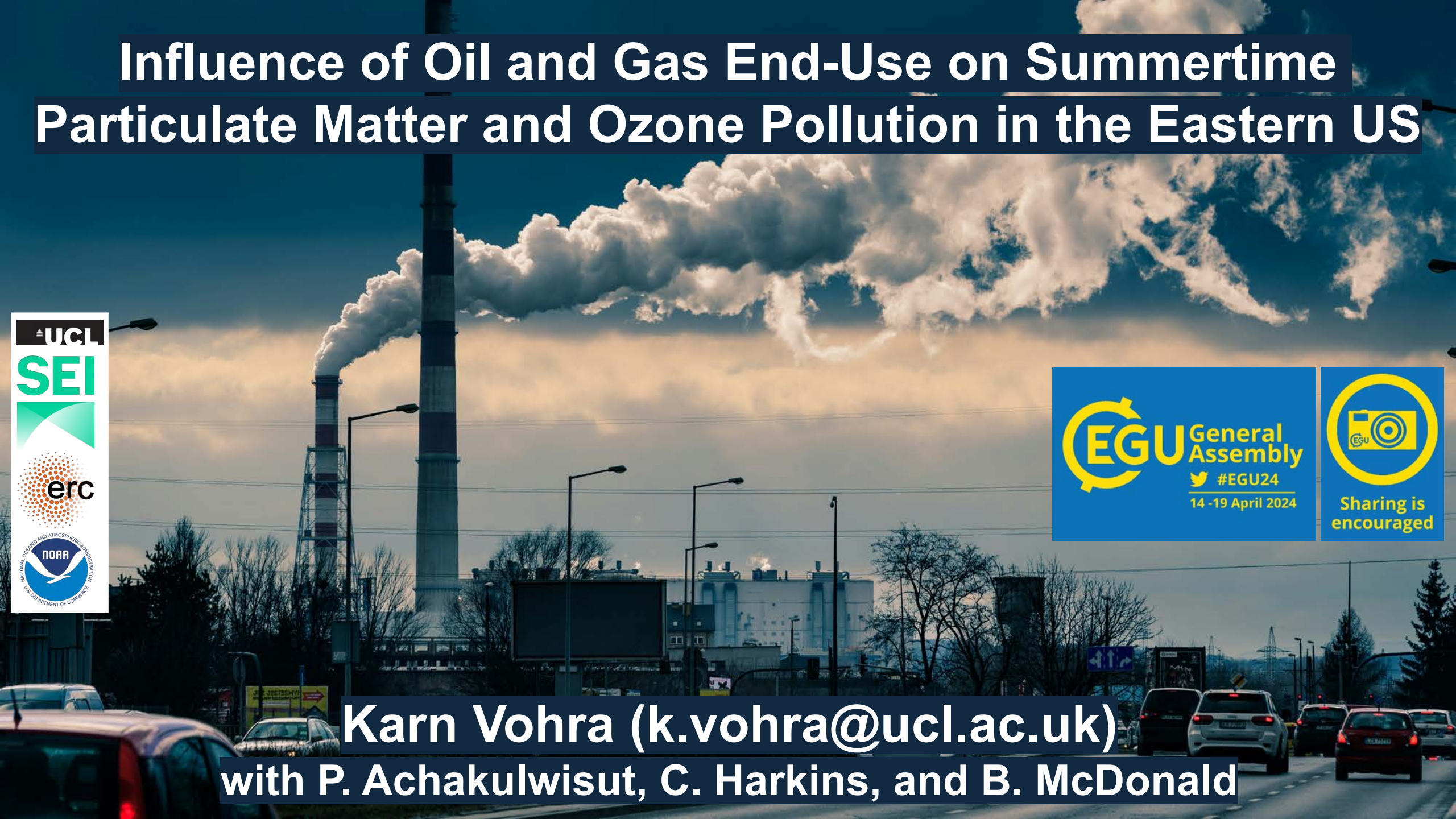
Influence of Oil and Gas End-Use on Summertime Particulate Matter and Ozone Pollution in the Eastern US



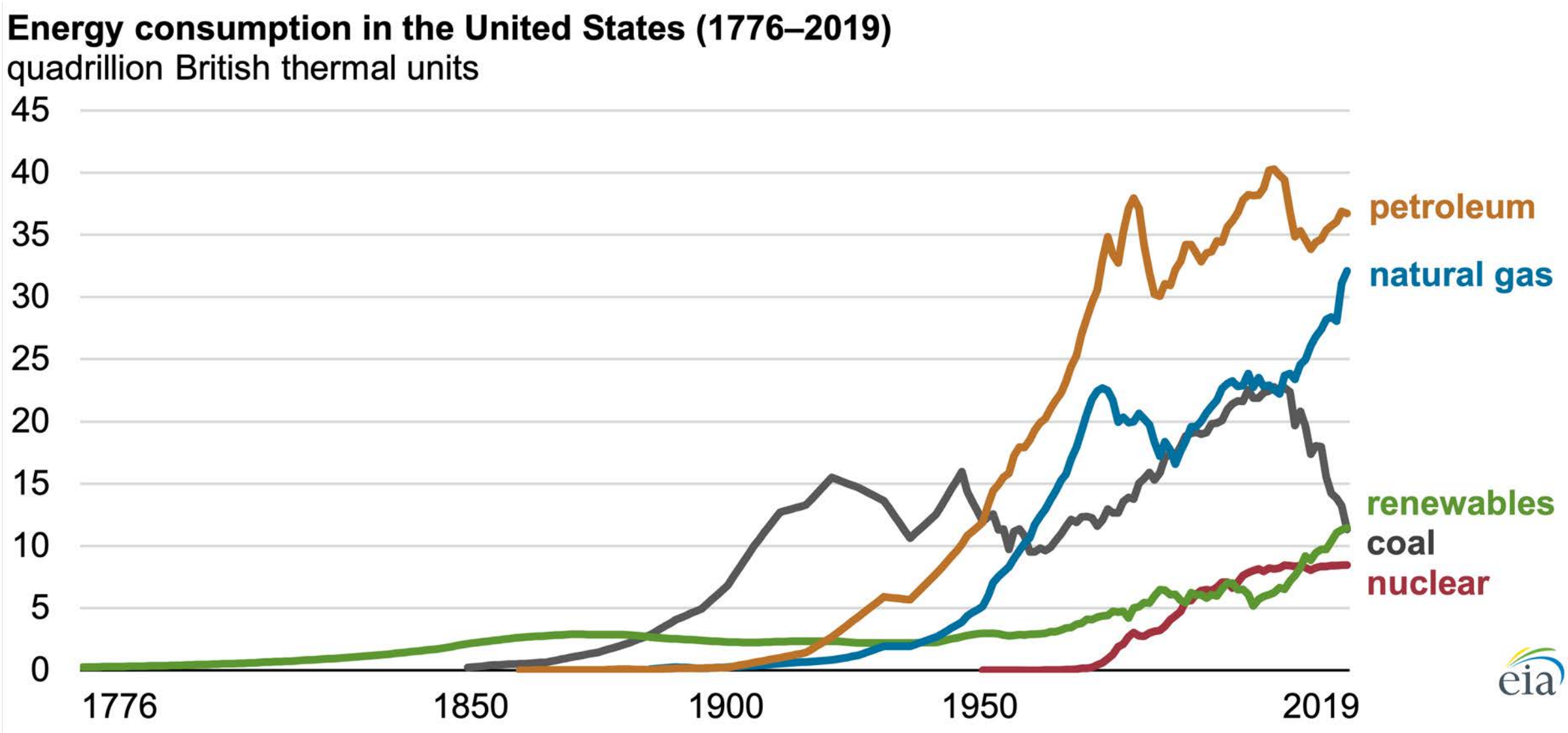
Karn Vohra (k.vohra@ucl.ac.uk)

with P. Achakulwisut, C. Harkins, and B. McDonald

EGU General Assembly #EGU24 14 -19 April 2024

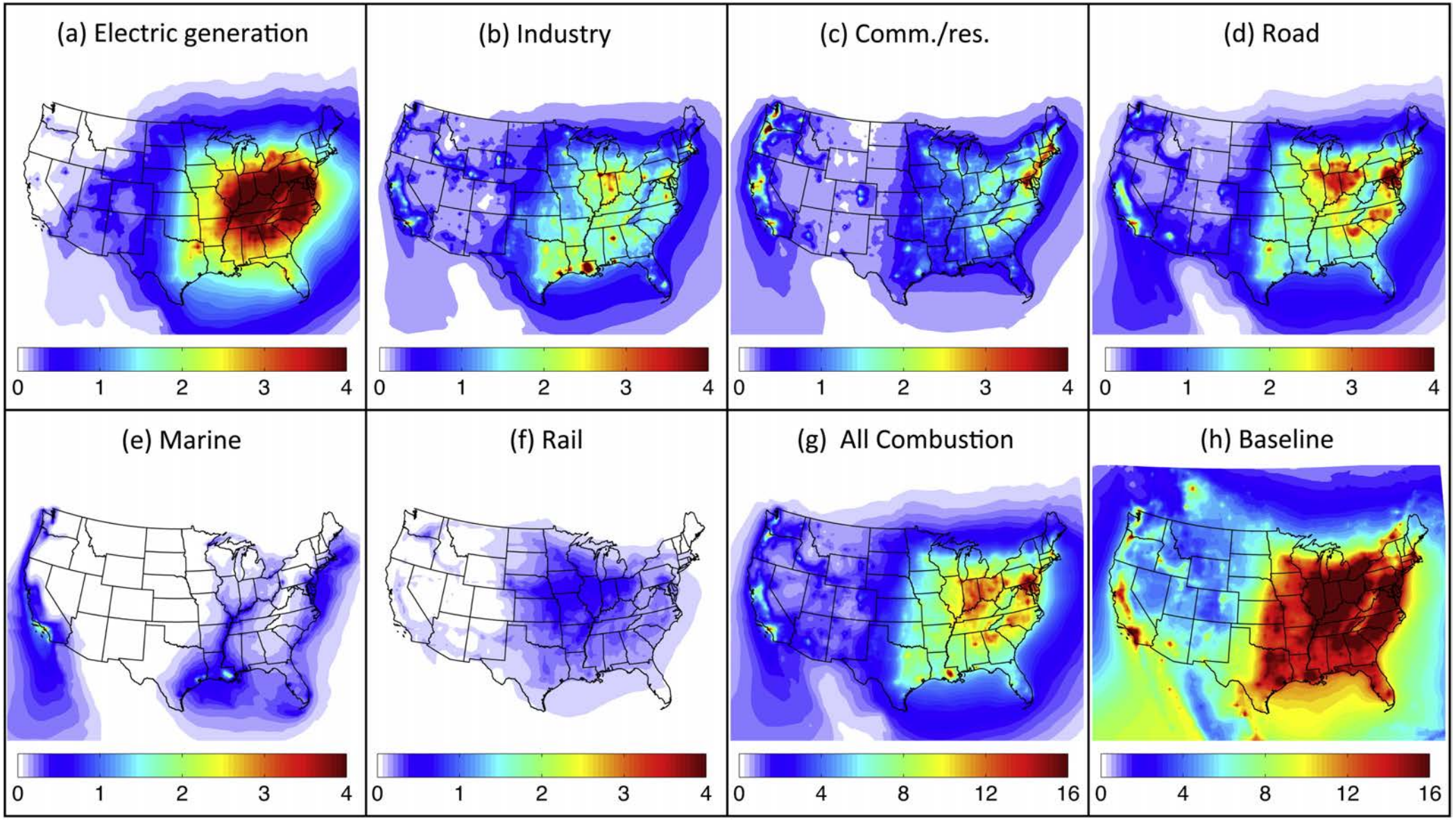
Sharing is encouraged

Reliance on oil and gas in the United States



[US EIA, 2020]

$PM_{2.5}$ concentration ($\mu g\ m^{-3}$) from combustion sources in the US

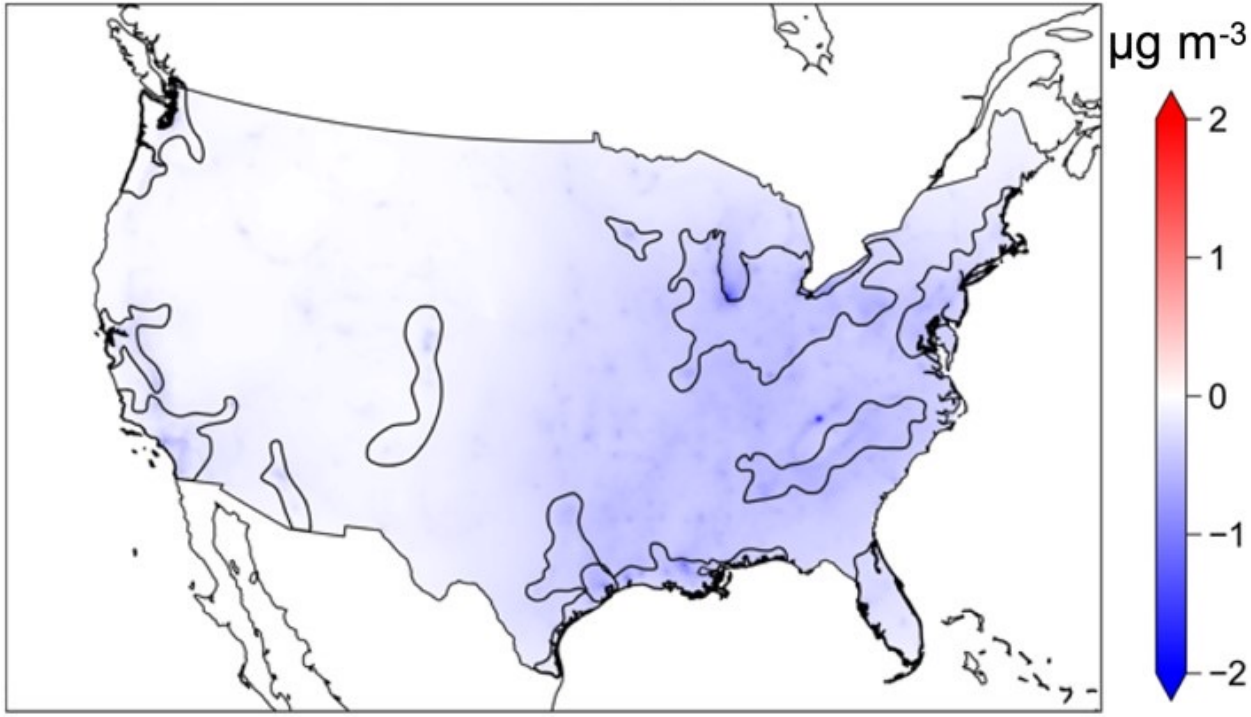


[Caiazzo et al, 2013]

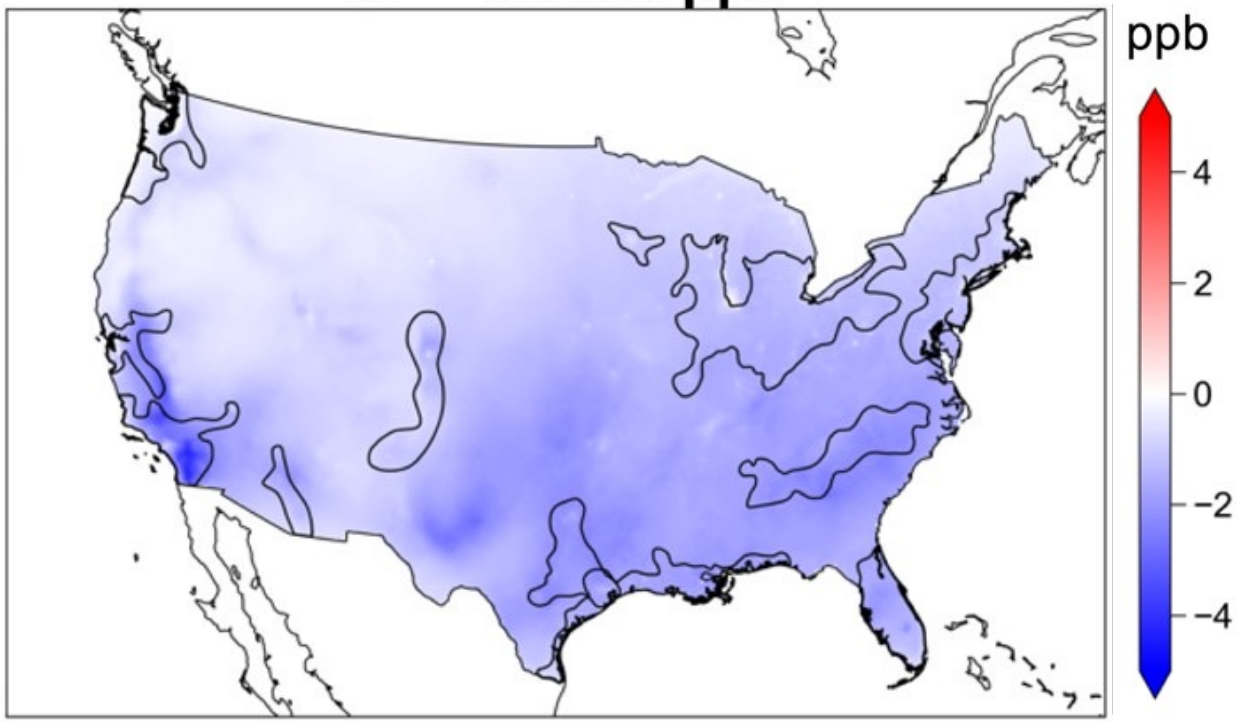
COVID-19 lockdowns provide an assessment of contribution of road traffic to air pollution

2020 minus 2019 (April-June)

$PM_{2.5}$ Δ = -0.4±0.2 µg m^{-3}



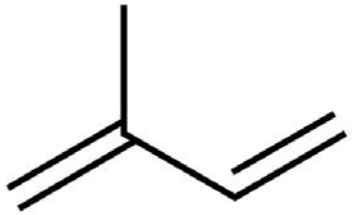
$MDA8O_3$ Δ = -1.4±0.6 ppb



… But occurrence of these lockdowns was limited to early spring. Summertime is onset of peak ozone pollution in eastern US and biogenic isoprene emissions in southeastern US

[He et al, 2024]

NO_x modulates the oxidative fate of isoprene



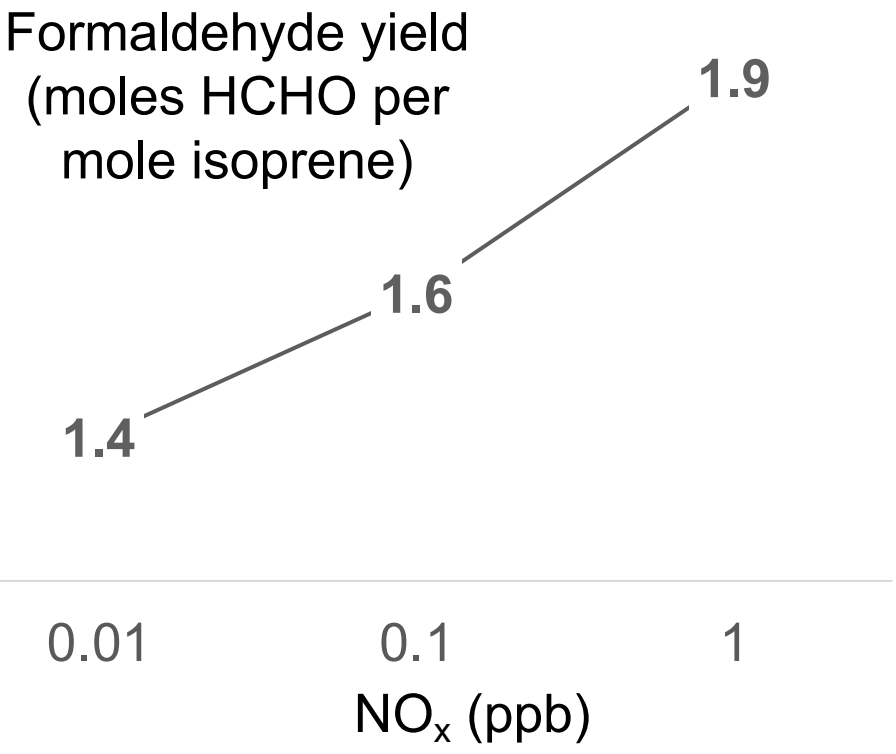
Isoprene

OH → Isoprene peroxy radical

NO 49%

HO_2 27%

Isoprene SOA precursors

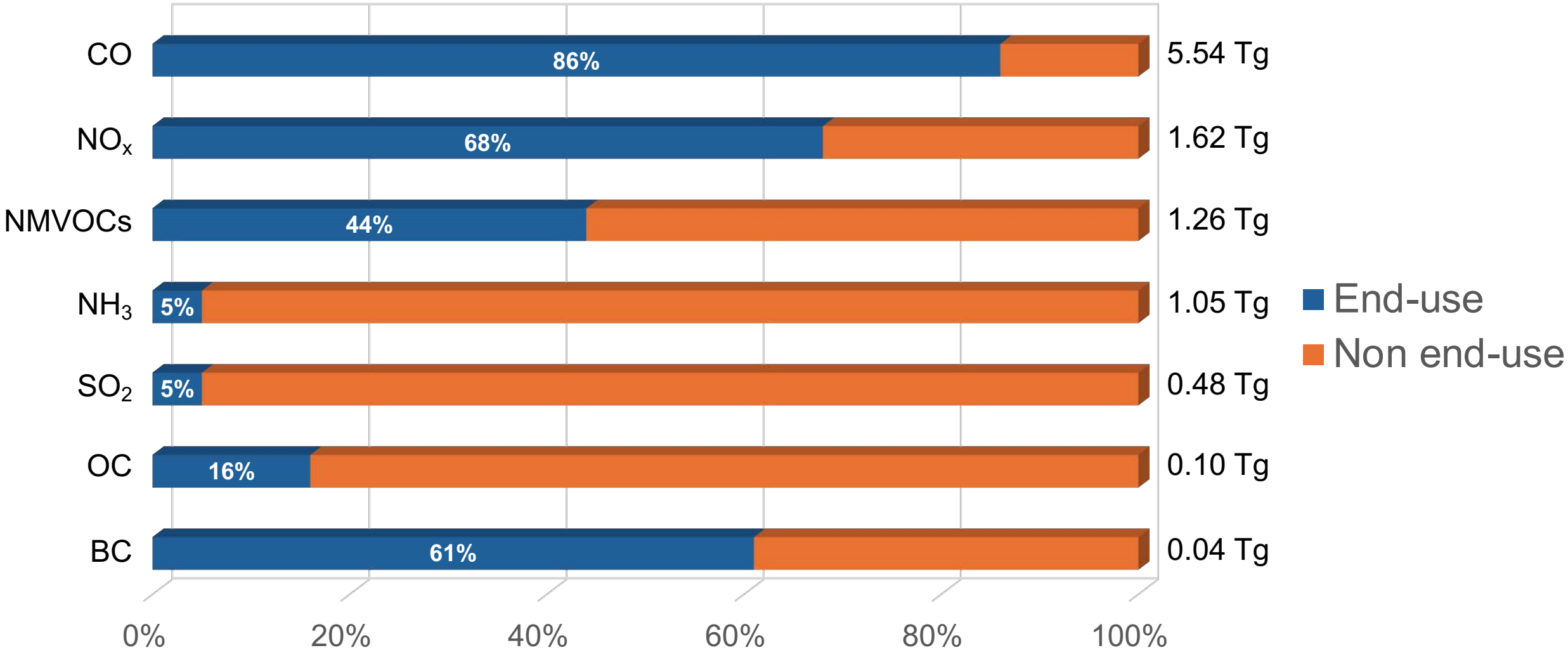


[Marais et al, 2012]

Here, we examine the influence of emissions from end-use activities on summertime ozone and $PM_{2.5}$ pollution

Contribution of end-use emissions to total anthropogenic emissions

We use FIVE for on-road and off-road mobile sources and NEI 2017 for all other anthropogenic sources



Dominant end-use activities: Mobile sources for CO and NO_x, diesel vehicles for BC and volatile chemical products for NMVOCs

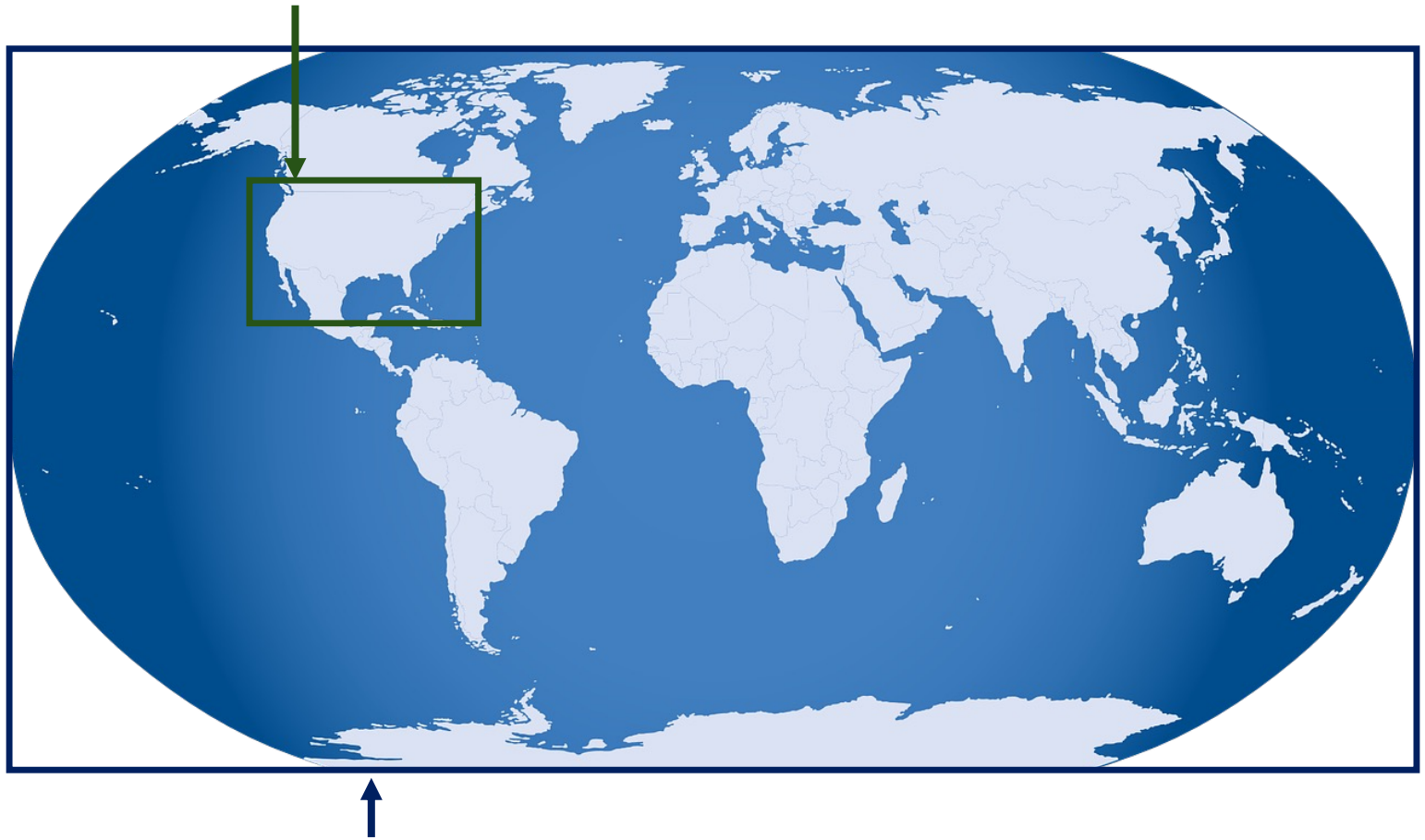
We use state-of-the-art 3D chemical transport model to simulate surface concentrations of atmospheric components

Emissions

GEOS Chem

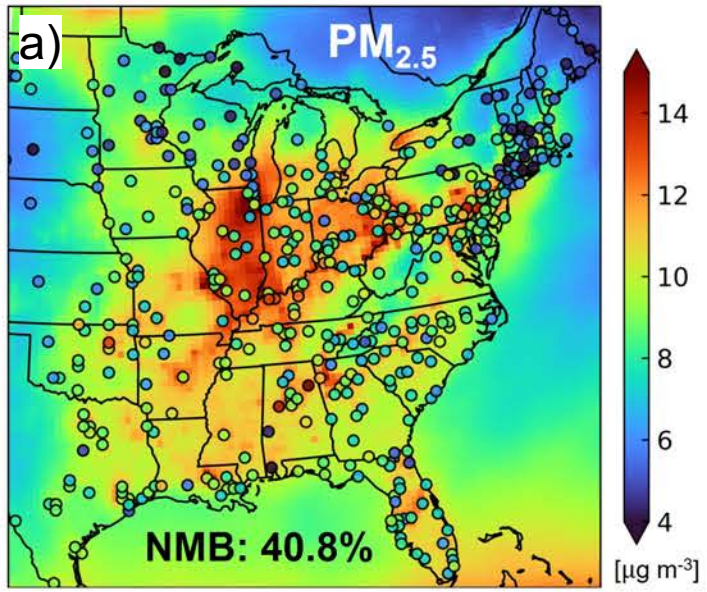
v13.0.0

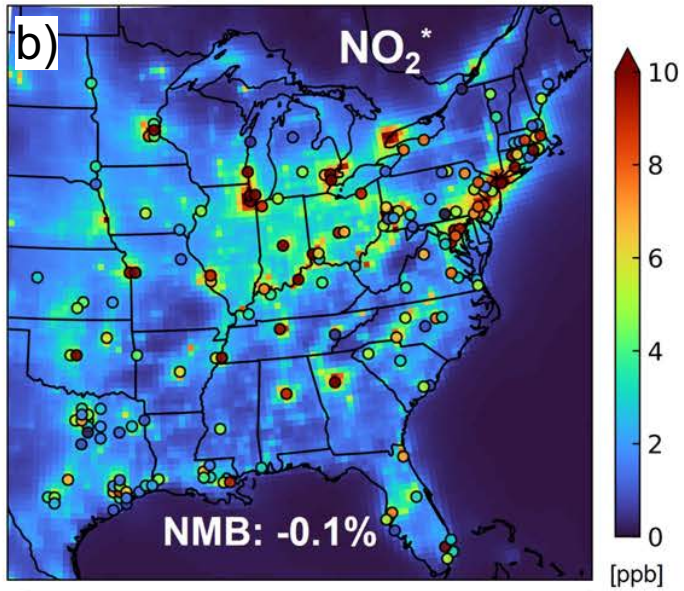
Meteorology

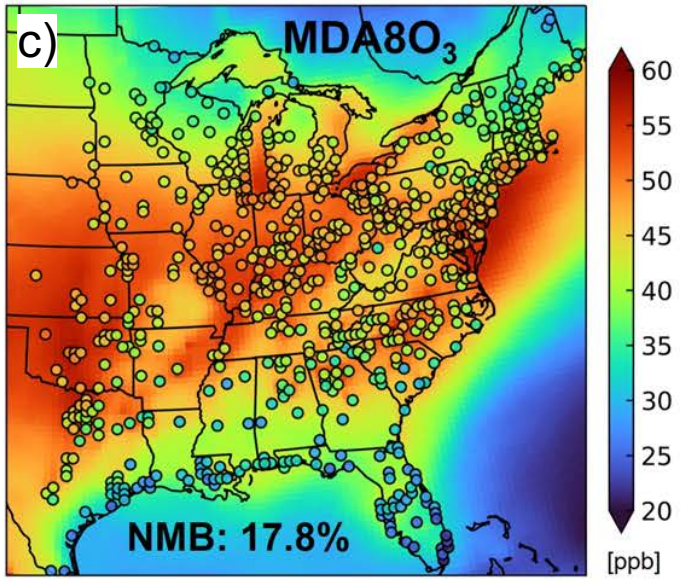


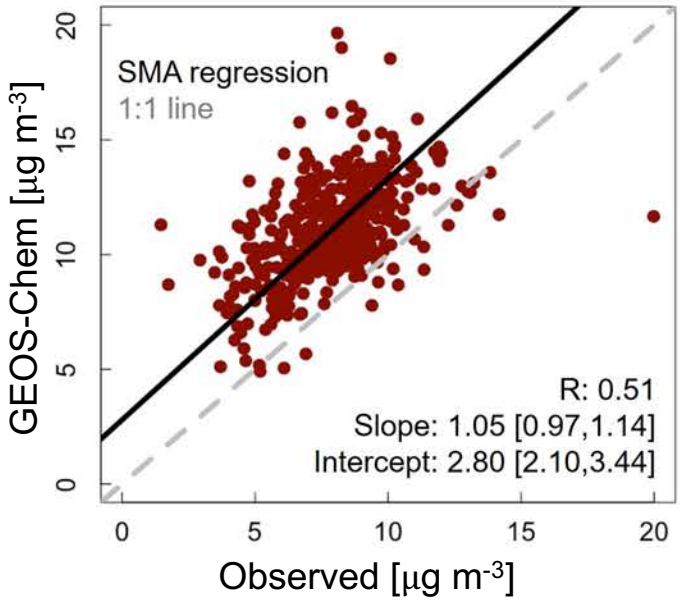
We run nested model with and without end-use emissions

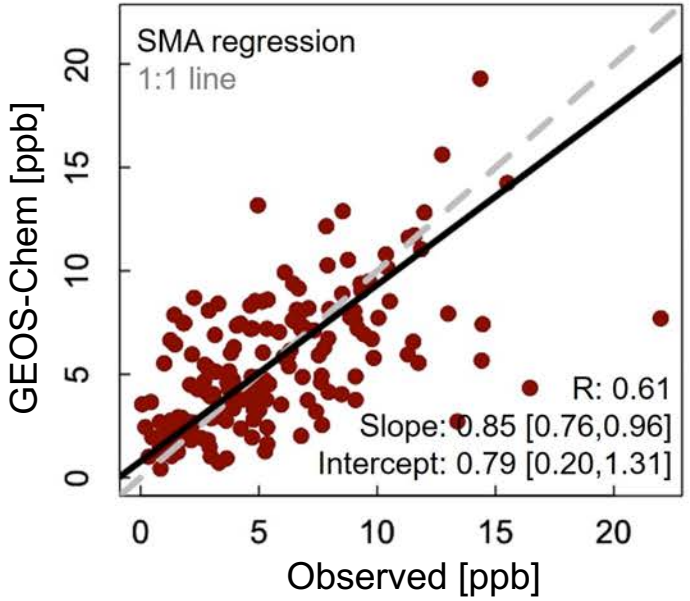
We evaluate model output against US EPA observations

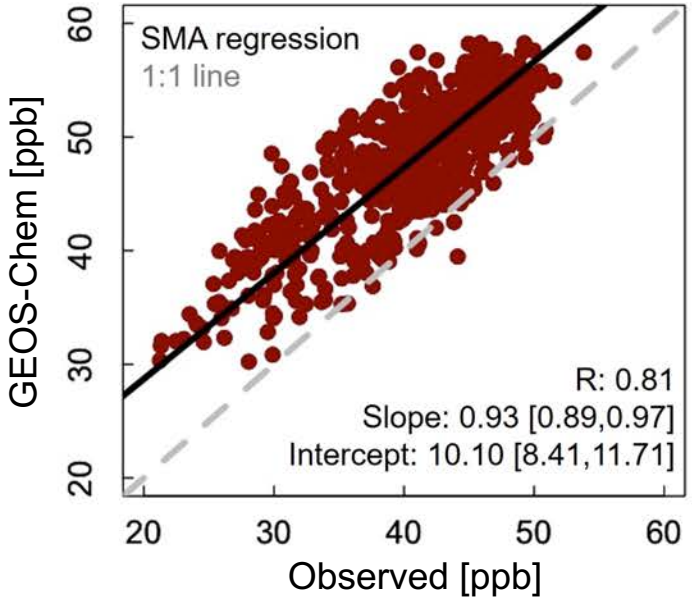






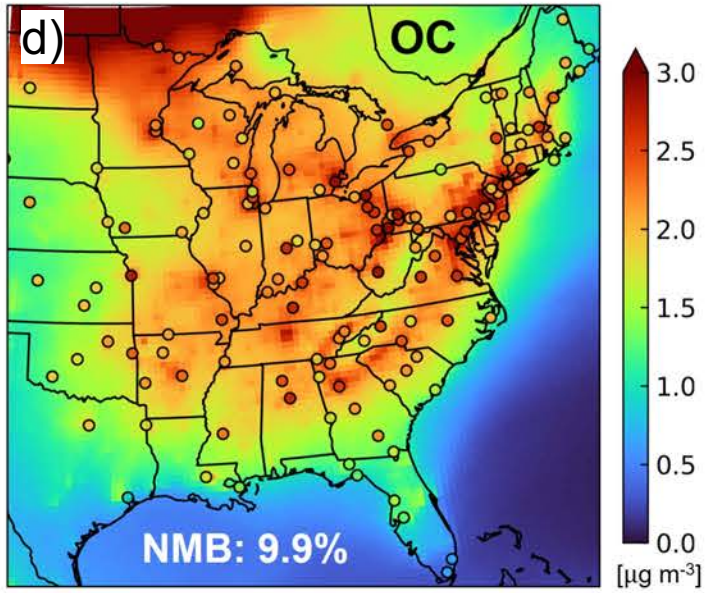


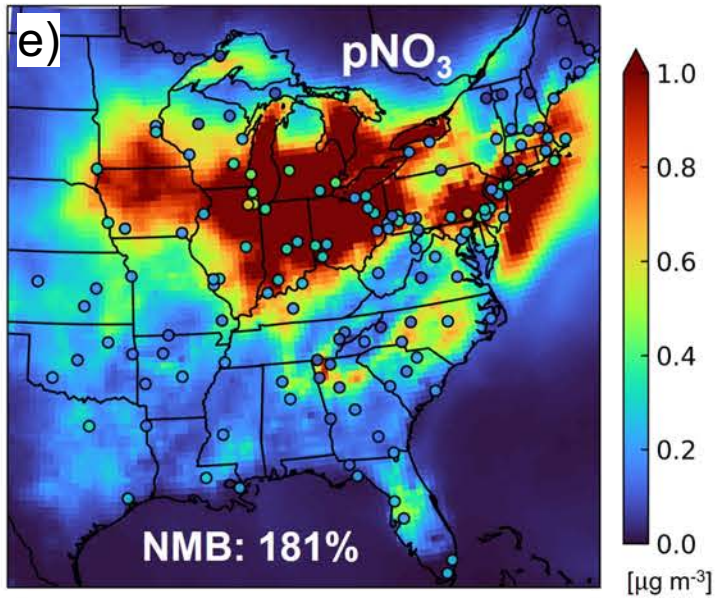


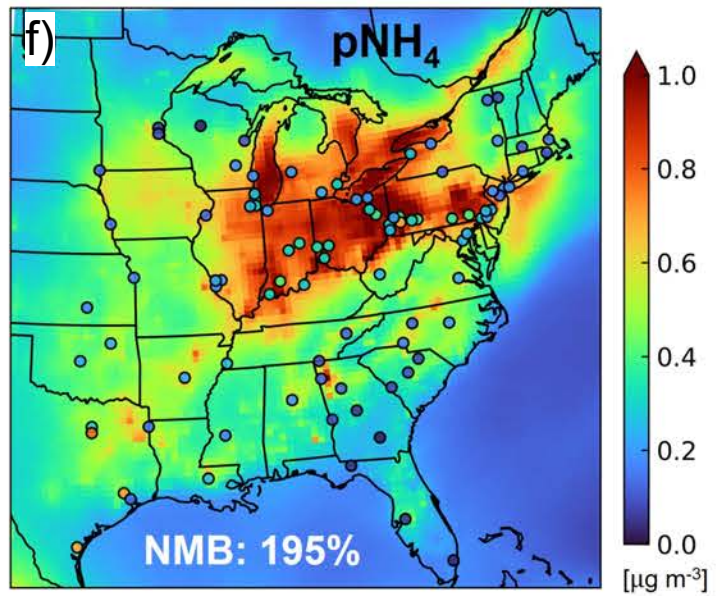


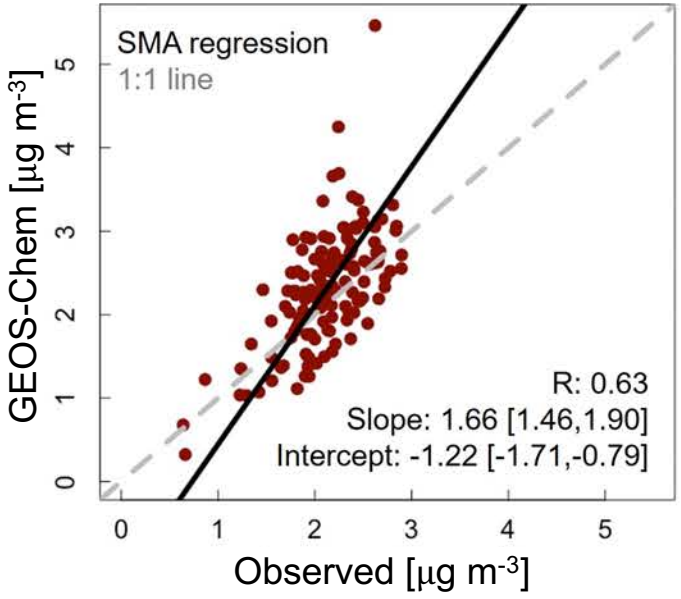
Regression slopes close to unity support use of GEOS-Chem for perturbation simulations

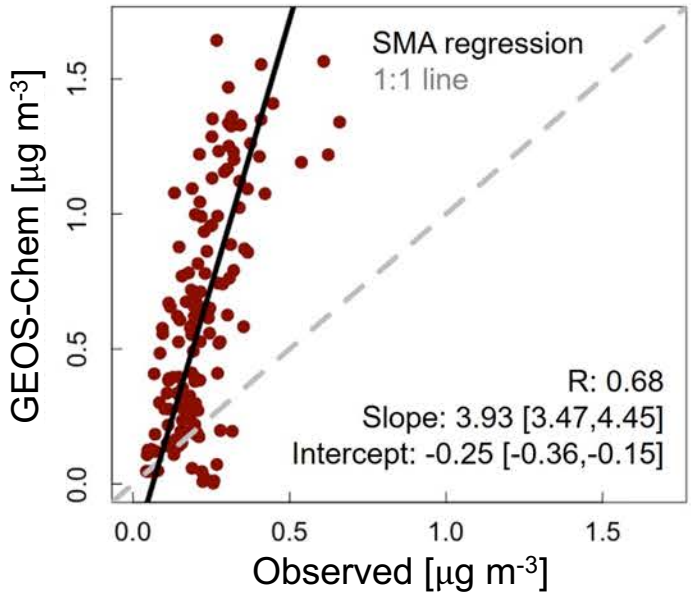
We evaluate model output against US EPA observations

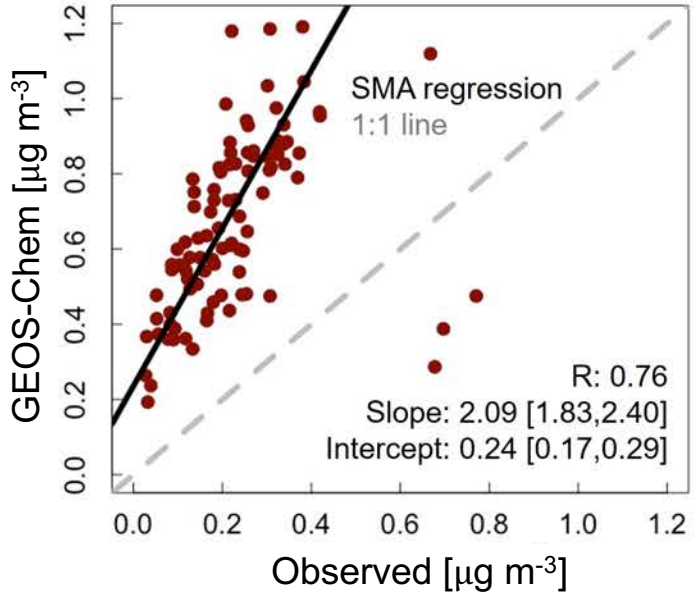










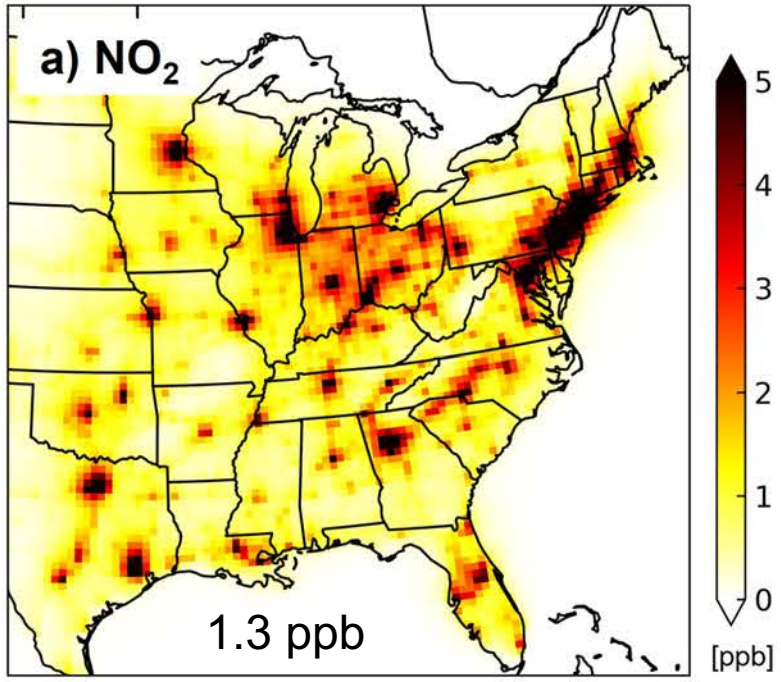


We correct for the 3-fold model overestimate in pNO_3 and pNH_4

Contribution of end-use activities to ozone and its precursors

Large contributions to summertime mean NO_x of up to 20 ppb;

$NO\text{-to-}NO_2$ is small (9%) but end-use NO increases the proportion of isoprene oxidized by NO rather than by HO_2 from 42:30 to 49:27



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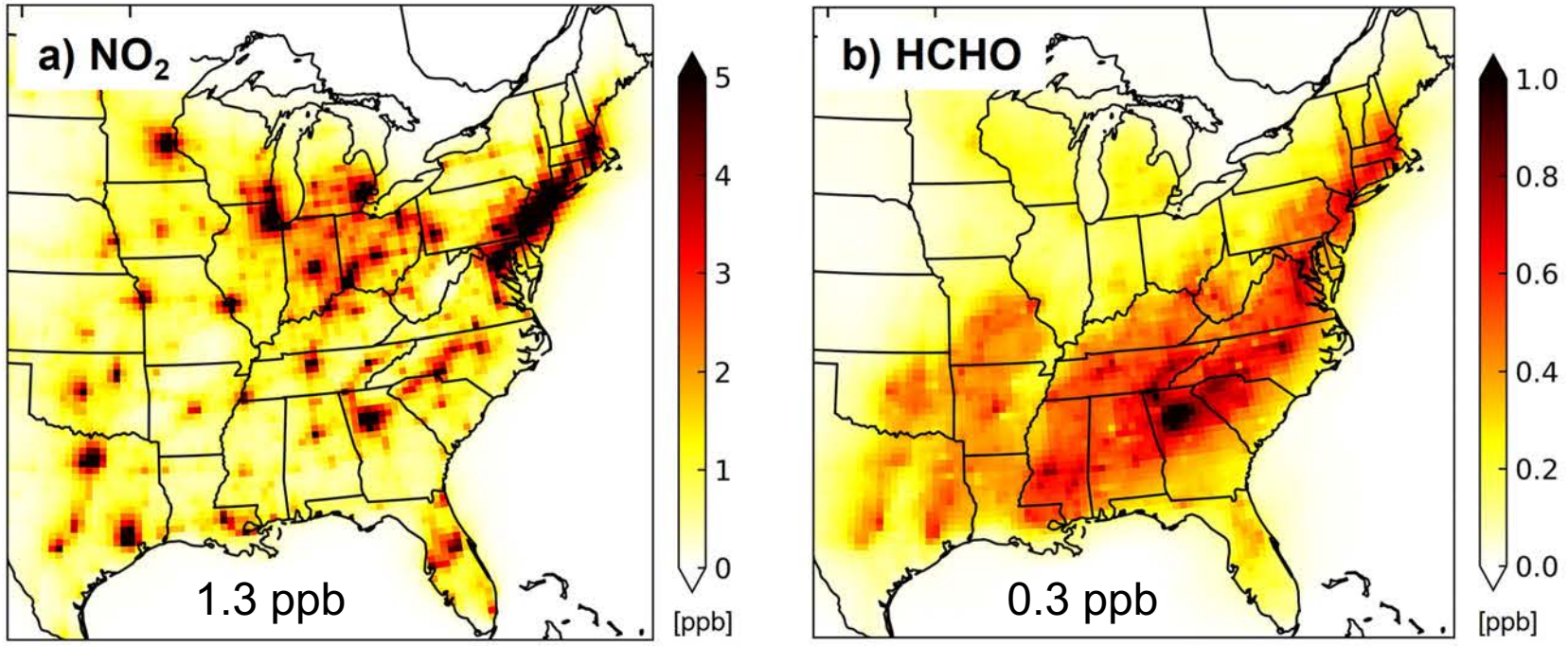

Large enhancements in formaldehyde (HCHO) from higher and more prompt HCHO yields via the NO isoprene oxidation pathway

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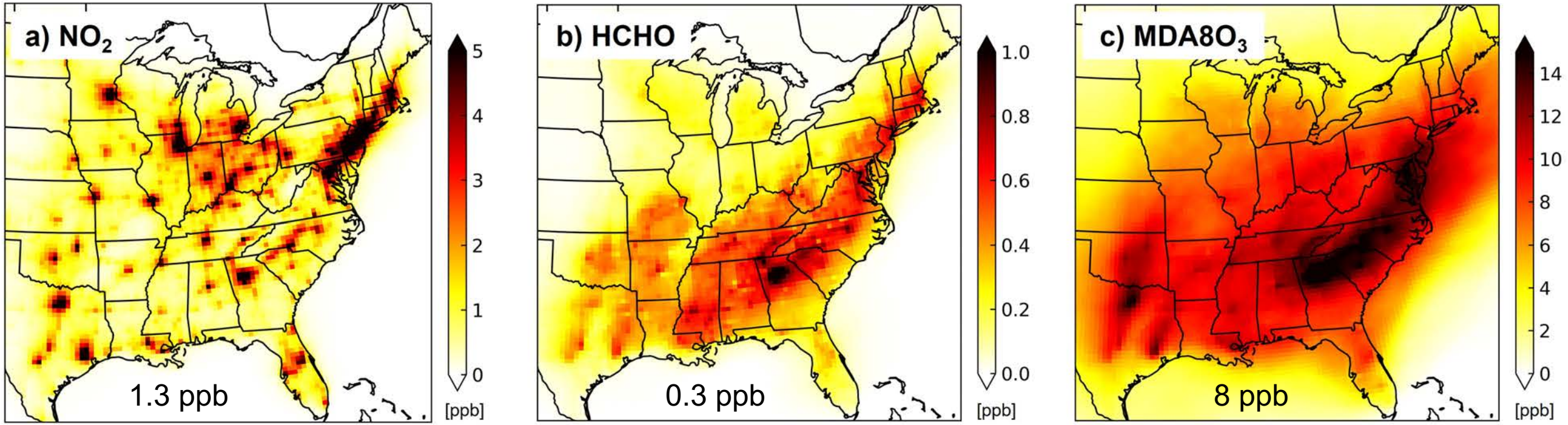

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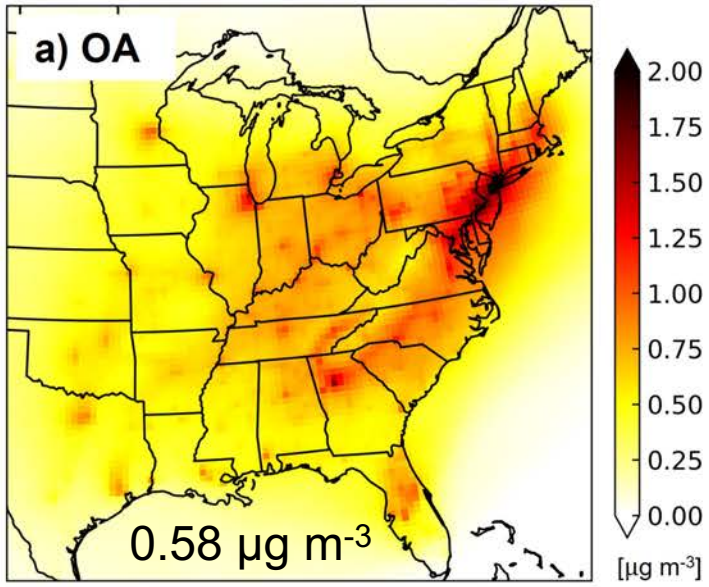
Ozone production in this region is limited by availability of VOCs and the enhanced HCHO yields contribute to $MDA8O_3$

Contribution of end-use activities to $PM_{2.5}$ and its components

Most end-use $PM_{2.5}$ is anthropogenic OA



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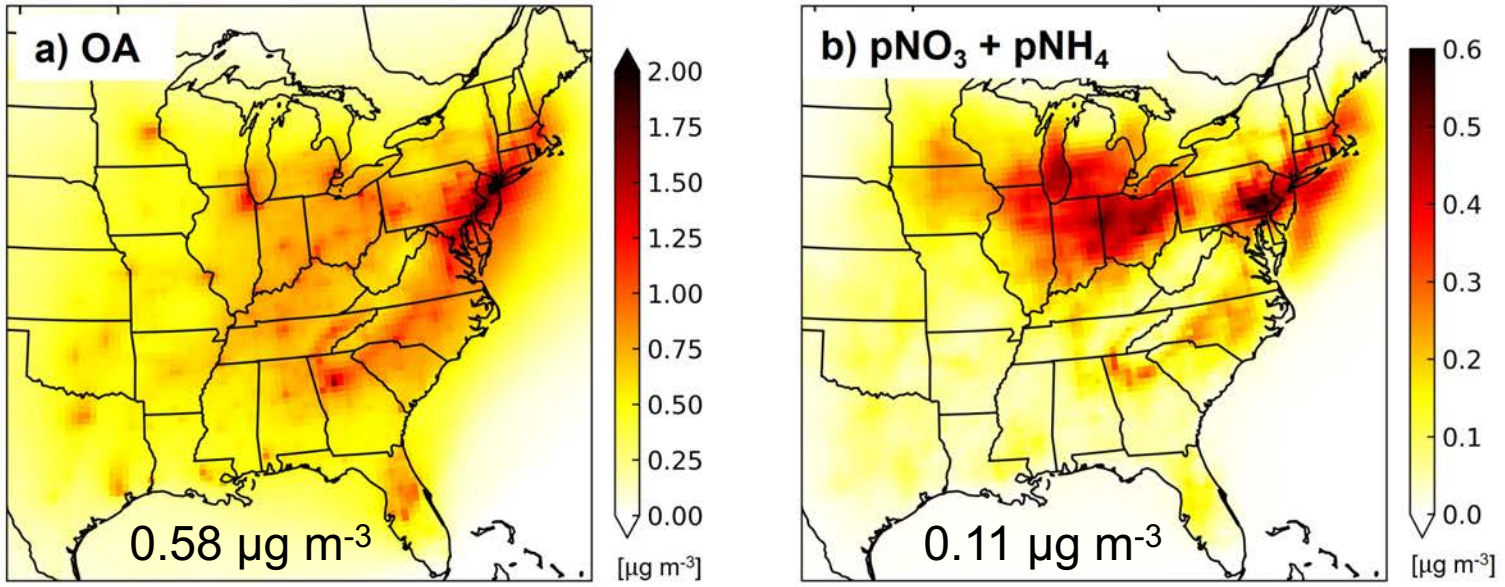

Acidic pNO_3 promotes uptake of ammonia

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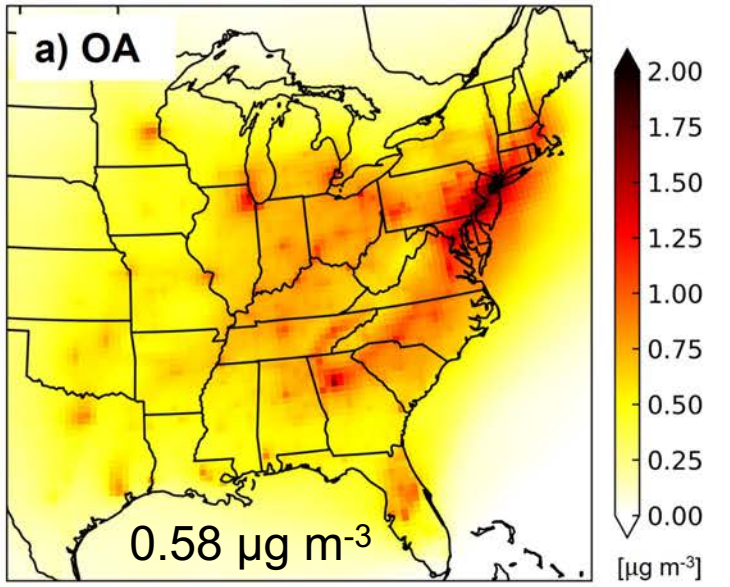

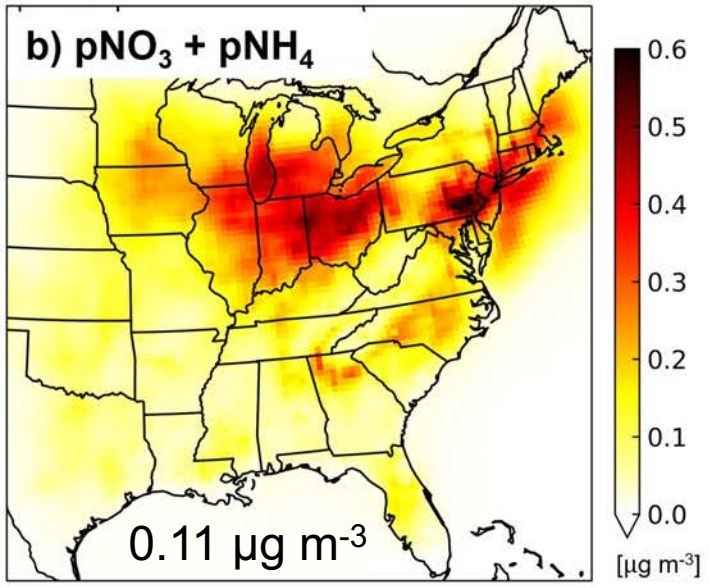

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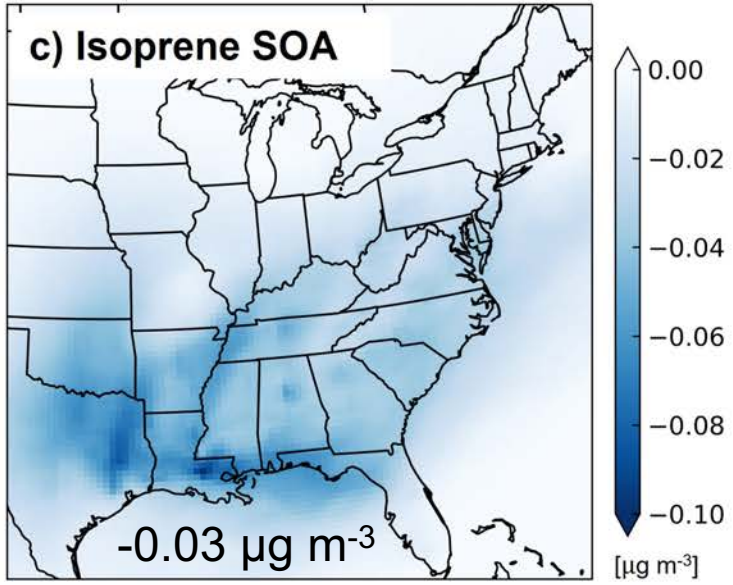
Reduction in HO_2 isoprene oxidation pathway



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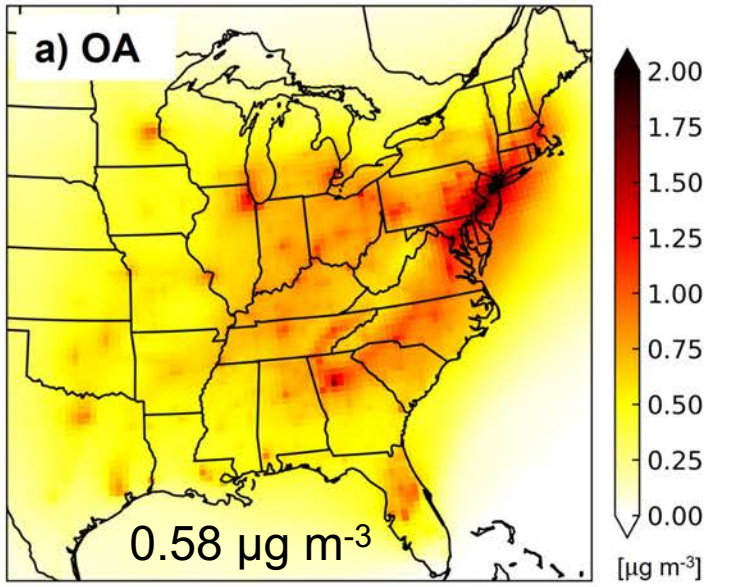

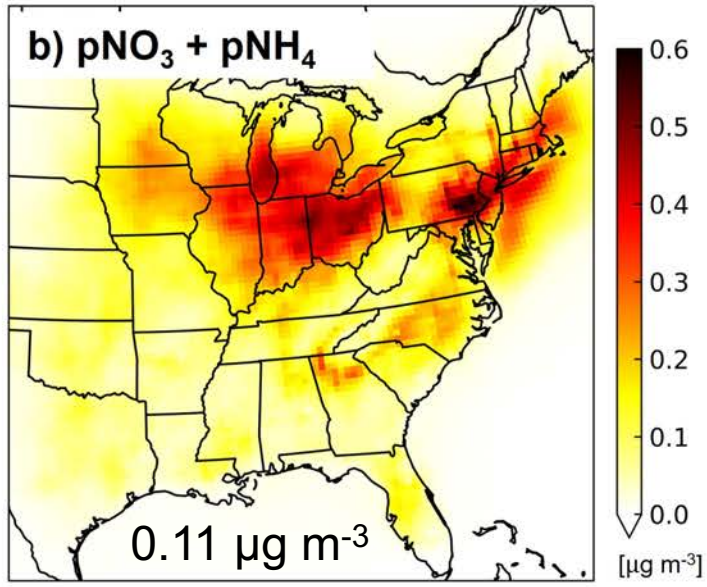

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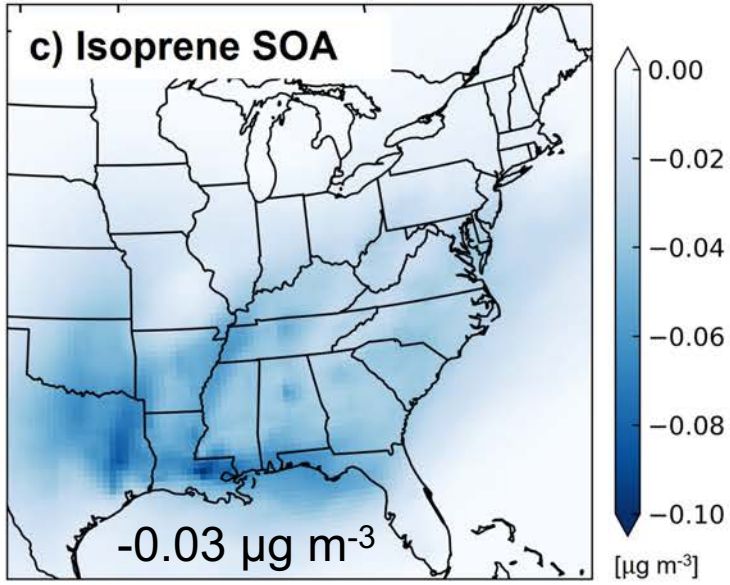

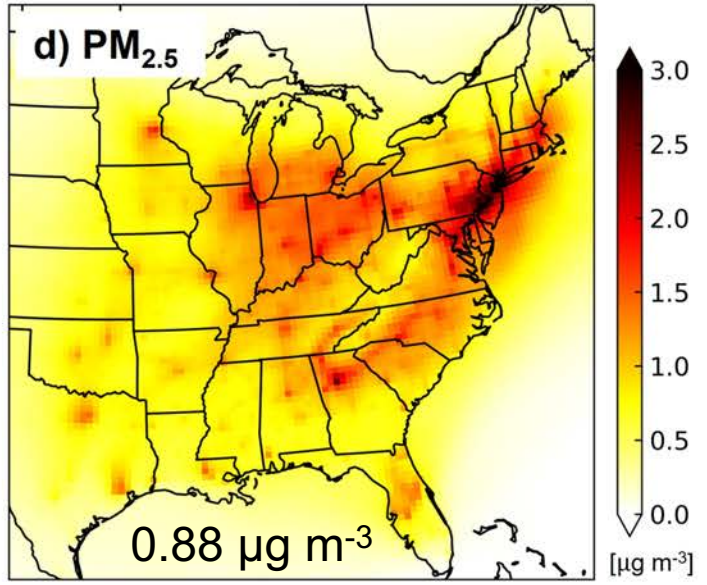

Net effect exceeds 3 µg m^{-3} mainly in cities and northeast coast

Influence of oil and gas end-use on eastern US summertime atmospheric composition