# COVID impacts on methane emissions from US oil and natural gas industry

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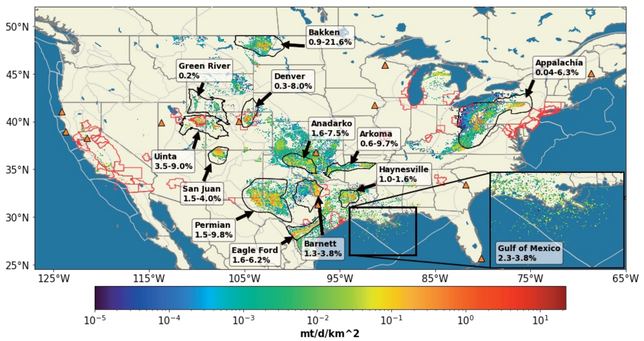
## Introduction

Methane ($CH_4$) is a powerful greenhouse gas with significantly greater global warming potential but much shorter atmospheric lifetime than carbon dioxide. Rapid reduction of methane emissions can therefore quickly slow the rate of global warming. Oil and natural gas (O&G) activities have been found to be the largest industrial sources of methane in the U.S. The outbreak of COVID have resulted in significant reductions in economic activities including oil and gas industry, providing an unprecedented opportunity to **assess changes in methane emissions from oil and gas activities and subsequent impacts on atmospheric methane concentrations**.

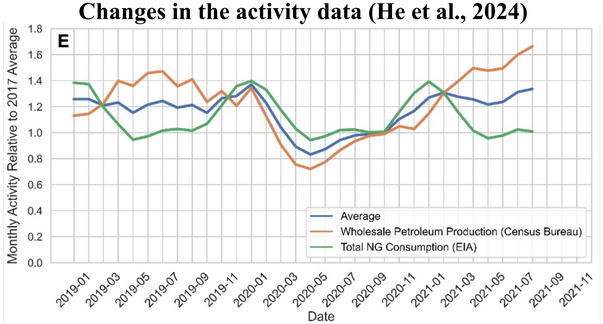
- The Fuel-based Oil and Gas (**FOG**) inventory has been developed previously to estimate oil and gas emissions in the US and has been updated to account for the COVID impacts on the oil and gas operations
- We evaluate COVID-induced US oil and gas emission changes for methane in the Weather Research and Forecasting model coupled with Chemistry (WRF-Chem) along with satellite observations

## FOG inventory

**O&G Methane emissions (McDonald et al., 2023)**

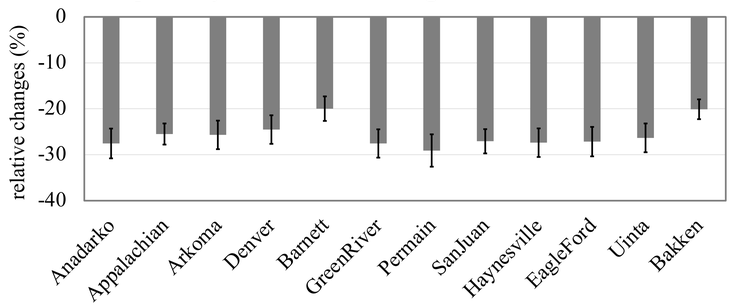



**Changes in the activity data (He et al., 2024)**




## COVID impacts on O&G methane emissions

**April-July 2020 emission changes relative to 2019**

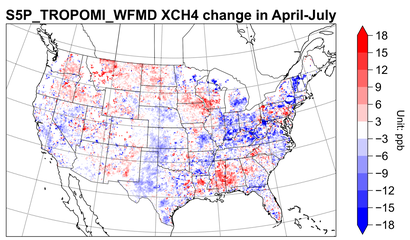


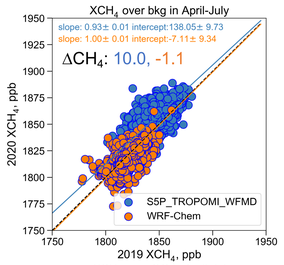

**Simulating methane emission changes in WRF-Chem model (He et al., 2024)**

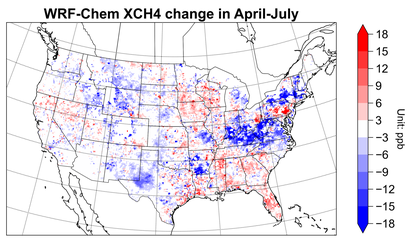
- 12-km Continental United States (CONUS)
- Interactive chemistry (RACM_ESRL_VCP)
- Business-as-usual emissions vs COVID adjusted emissions
- April-July 2019 and 2020

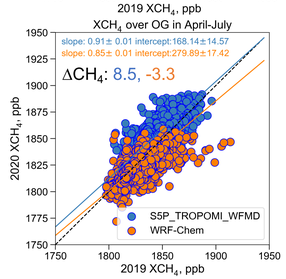
## Satellite evaluations

**Uniform background correction** (MLO $\Delta CH_4$: +9.8 ppb)



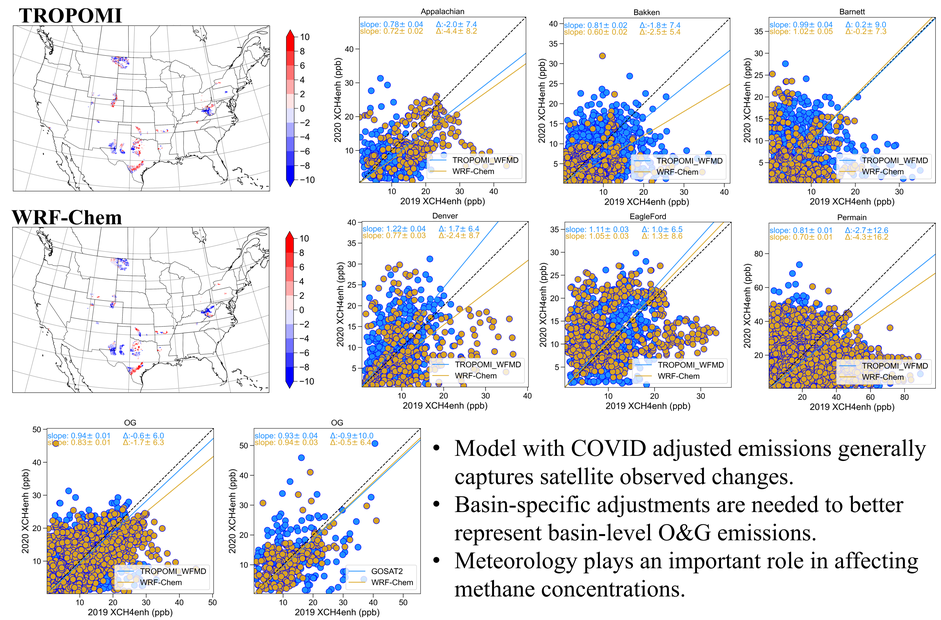




- Same initial and boundary conditions applied for 2019 and 2020, so minor changes over background are expected in WRF-Chem.
- Observed $XCH_4$ increased by 8.5 ppb over O&G basins, lower than that over background region (10 ppb), suggesting decreased contributions from O&G in April-July 2020.

## Basin-level comparisons of methane enhancement

**Changes in the enhanced $XCH_4$ (ppb) over oil and gas basins**




- Model with COVID adjusted emissions generally captures satellite observed changes.
- Basin-specific adjustments are needed to better represent basin-level O&G emissions.
- Meteorology plays an important role in affecting methane concentrations.

## High resolution methane modeling over the US

**Model Setup:**

- WRF-Chem, 4-km CONUS
- Include source tagged tracers for methane, ethane ($C_2H_6$), and methane carbon isotope ($^{13}CH_4$)
- Include chemical loss due to OH

**Emission Inventories:**

- Oil & gas: NOAA CSL FOG & EPA GHGI (Maasakkers et al., 2023)
- Other $CH_4$ emissions: NOAA GFDL-AM4 (He et al., 2020), EPA GHGI

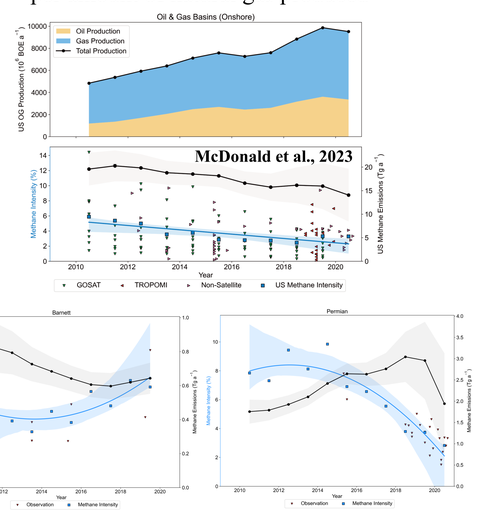
**Meteorology:**

- Assimilated hourly meteorological fields from NOAA/NCEP Rapid Refresh (RAP) operational weather prediction system

**Initial and boundary conditions:**

- $CH_4$: NOAA GML CarbonTracker-$CH_4$ (Oh et al., 2023)
- $C_2H_6$ and $^{13}CH_4$: NOAA GFDL-AM4

**Methane intensity**: the amount of methane emitted per amount of natural gas produced




**References:** **McDonald et al. (2023)**, A review of oil and gas methane and air pollutant emissions and identifying gaps in monitoring, EM Magazine, Oil and Gas Sector Emissions; **He et al. (2024)**, COVID-19 perturbation on US air quality and human health impact assessment, PNAS Nexus; **Maasakkers et al. (2023)**, A Gridded Inventory of Annual 2012-2018 U.S. Anthropogenic Methane Emissions, Environ. Sci. Technol.; **He et al. (2020)**, Investigation of the global methane budget over 1980-2017 using GFDL-AM4.1, Atmos. Chem. Phys.; **Oh et al. (2023)**, CarbonTracker CT-$CH_4$-2023, NOAA Global Monitoring Laboratory.