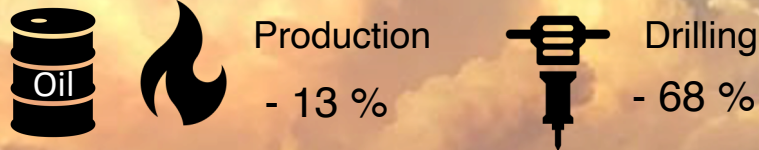


COVID-19 impact on Oil and Gas industry emissions: A case study of the Permian Basin (US)

Raquel Serrano ¹, Barbara Dix ³, Joost de Gouw ^{3,4}, Pieternel Levelt ^{1,2}, Pepijn Veeffkind ^{1,2}

The COVID-19 impact on the O&G respect to 2019 in the Permian basin

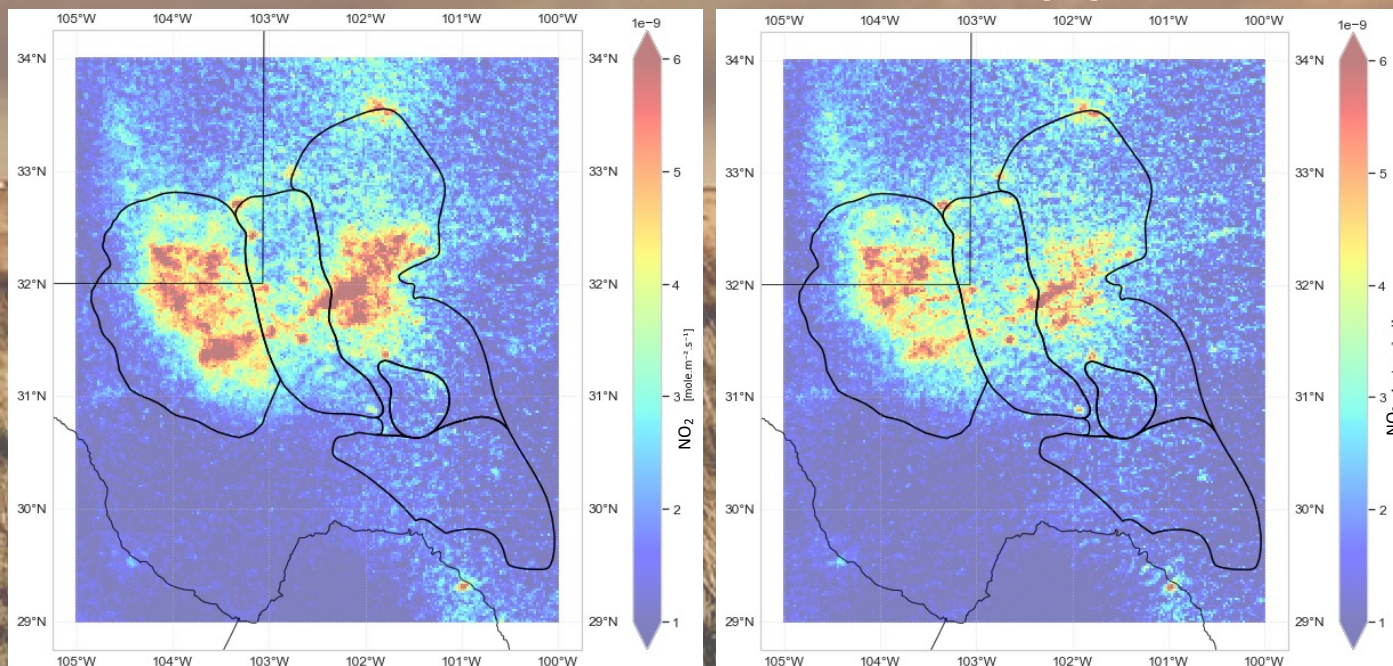


Unprecedented scenario to evaluate the contribution of the O&G industry to NO₂ and CH₄ emissions

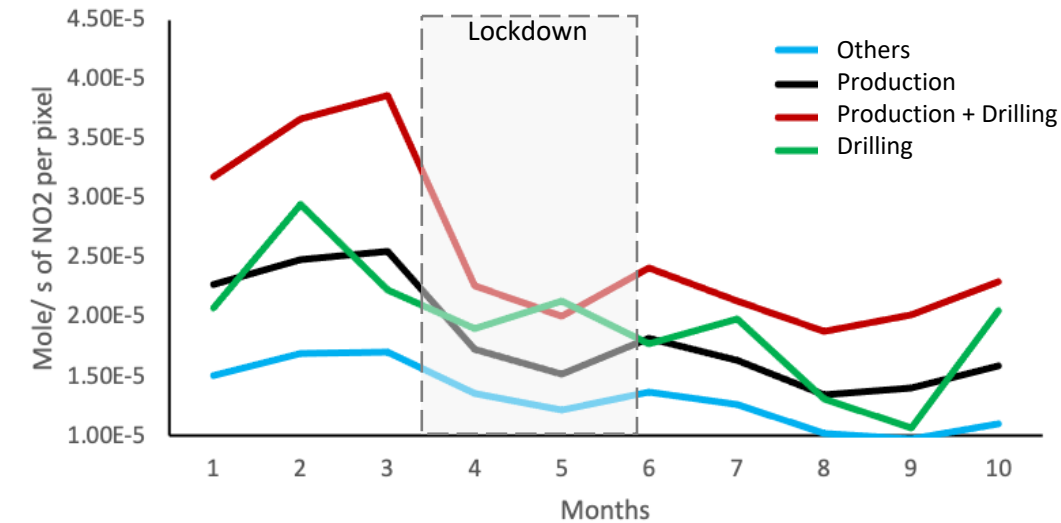
NO₂ (mole m⁻² s⁻¹) emissions annual average

2019

2020



2020 NO₂ emissions of O&G activities



CH₄

Decrease in most productive basins but not during COVID19 lockdown

0.3– 1.5 % of max [CH₄] values

0.5– 1.6 % of min [CH₄] values

NO₂

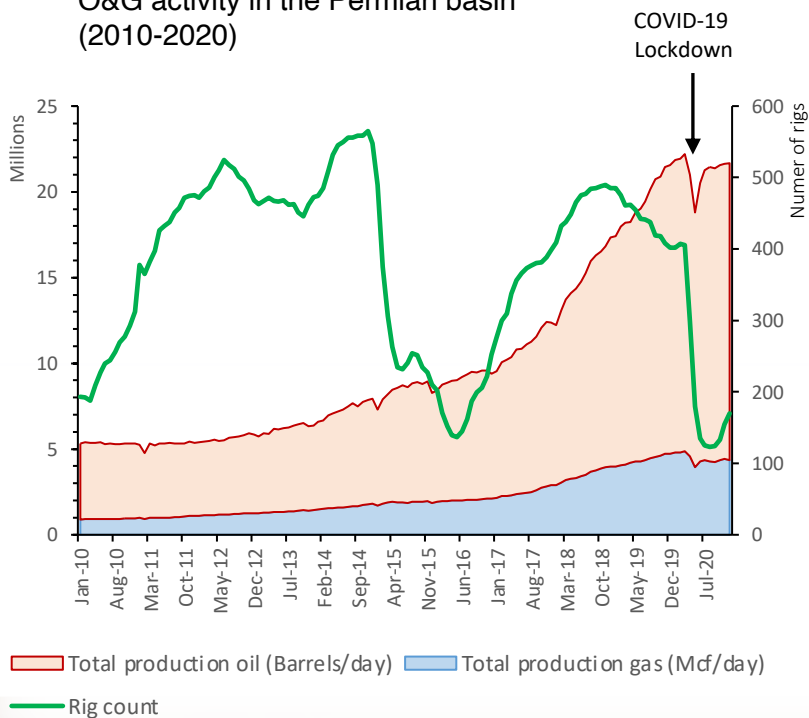
- 32% in NO₂ emissions in areas of Production + Drilling

- 67% in NO₂ emissions in areas of Production + Drilling during the lockdown

7% decrease of NO₂ emissions in 2020 respect 2019

Introduction

O&G activity in the Permian basin
(2010-2020)



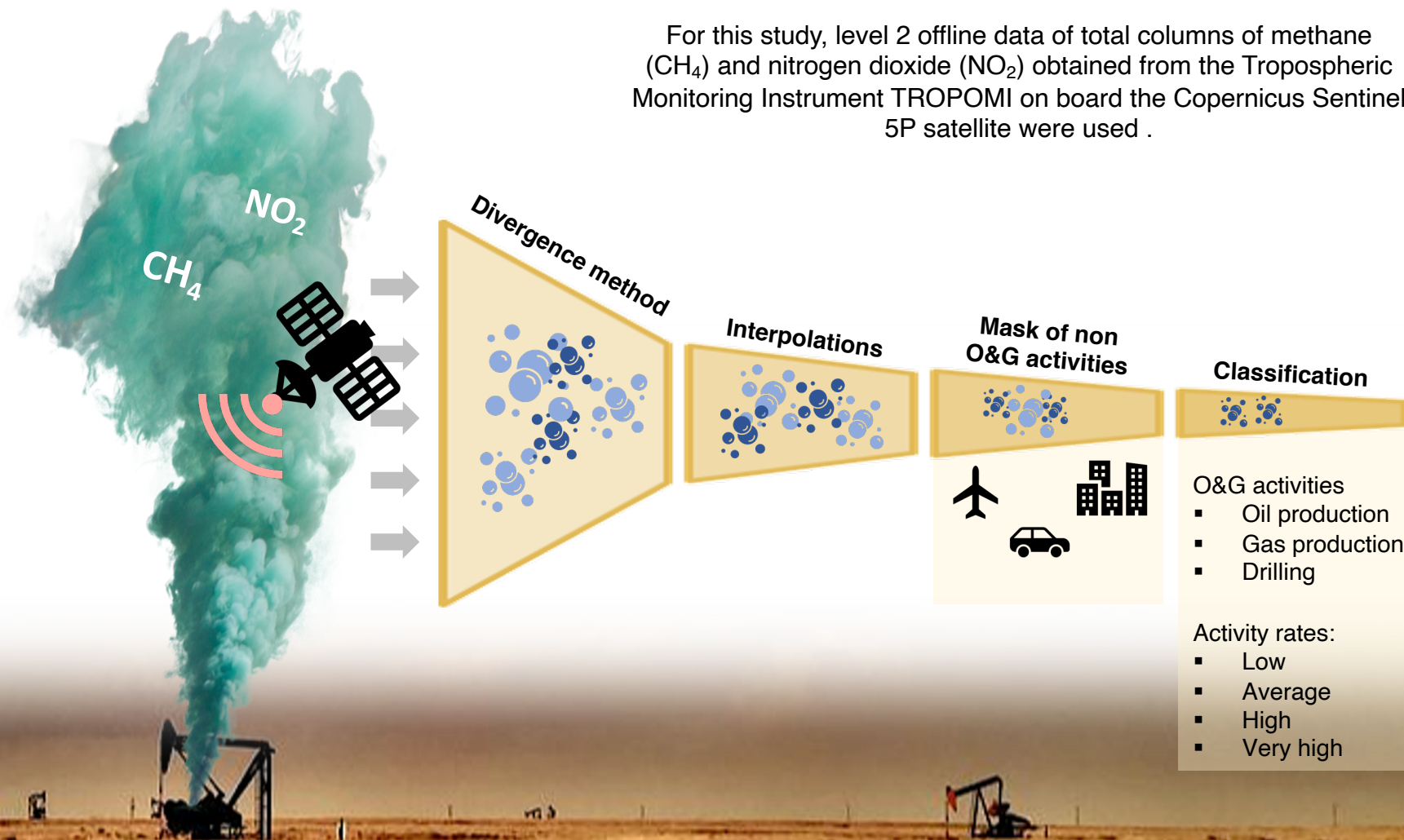
* Data source: Energy Information Administration

The United States is the largest O&G producing country, with the Permian basin being the second largest hydrocarbon-bearing area.

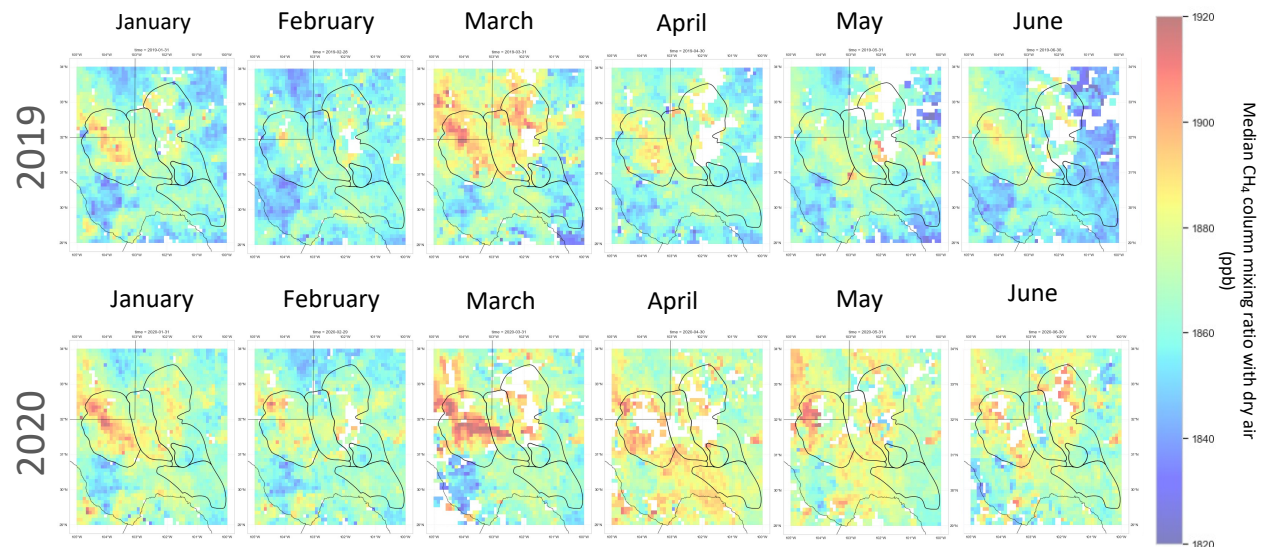
In March 2020, the COVID-19 pandemic caused an historic collapse in fossil fuel demand and unprecedented scenario for fossil fuel emission analysis.

Data and Methods

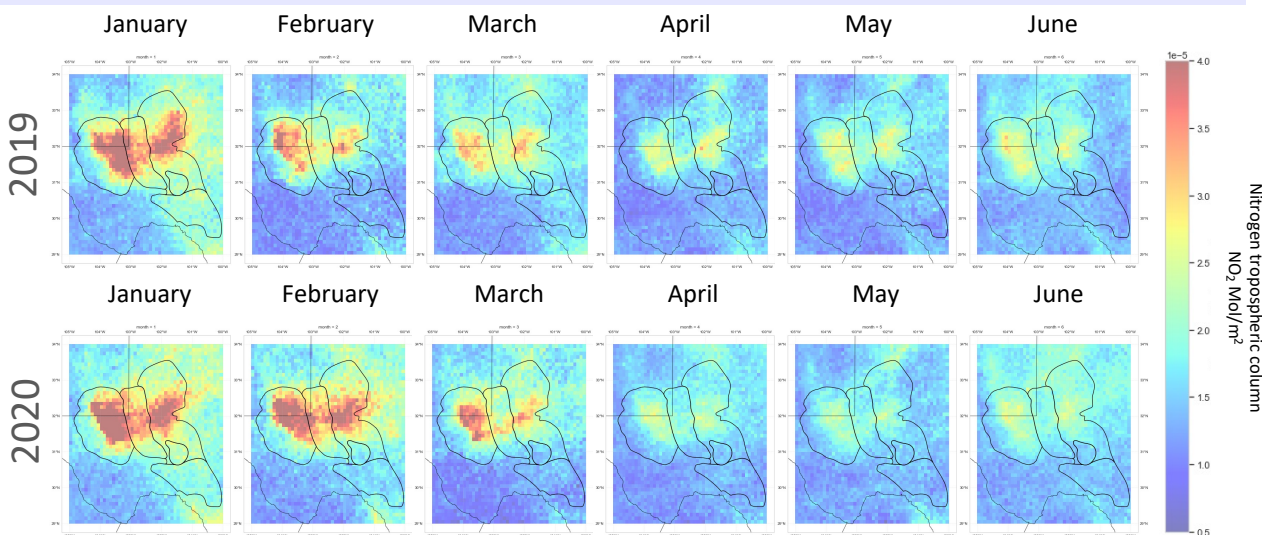
For this study, level 2 offline data of total columns of methane (CH_4) and nitrogen dioxide (NO_2) obtained from the Tropospheric Monitoring Instrument TROPOMI on board the Copernicus Sentinel 5P satellite were used .



Monthly median methane concentration column January – June 2019 and 2020



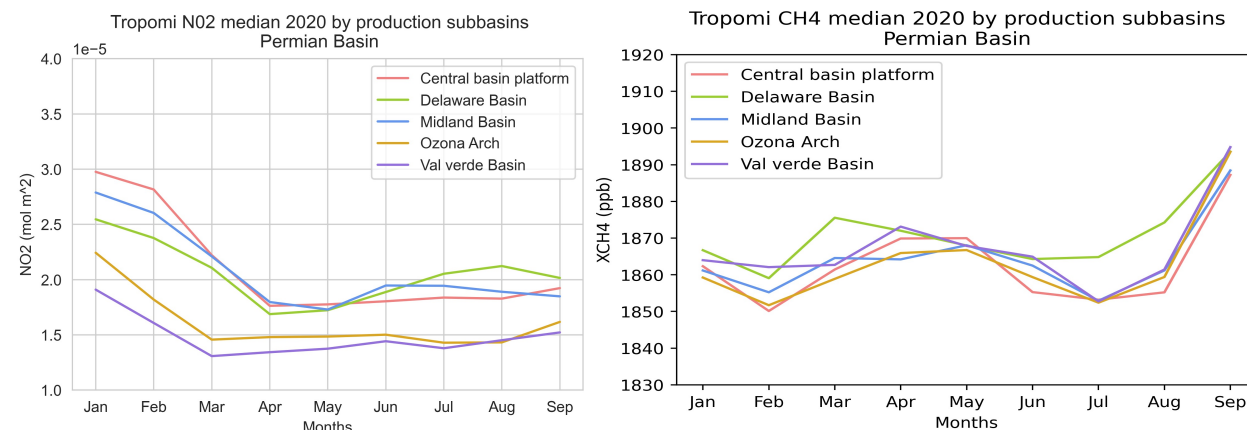
Monthly median nitrogen dioxide column January – June 2019 and 2020



NO₂ and CH₄ % difference from January - September between 2019 and 2020

Sub-basin	CH ₄ mean	CH ₄ min	CH ₄ max	NO ₂ mean	NO ₂ min	NO ₂ max
Delaware	0.26%	1.54%	0.25%	-4.35%	-5 %	0%
Midland	0.17%	0.57%	-0.32%	-4.55%	21%	-28 %
Central	0.1%	0.57%	-1.02%	-4.55%	-76%	12 %
Ozona Arc	0.12%	0.49%	-0.54%	-6.25%	30%	0 %
Valverde	0.15%	0.55%	-1.55%	0%	0%	55%

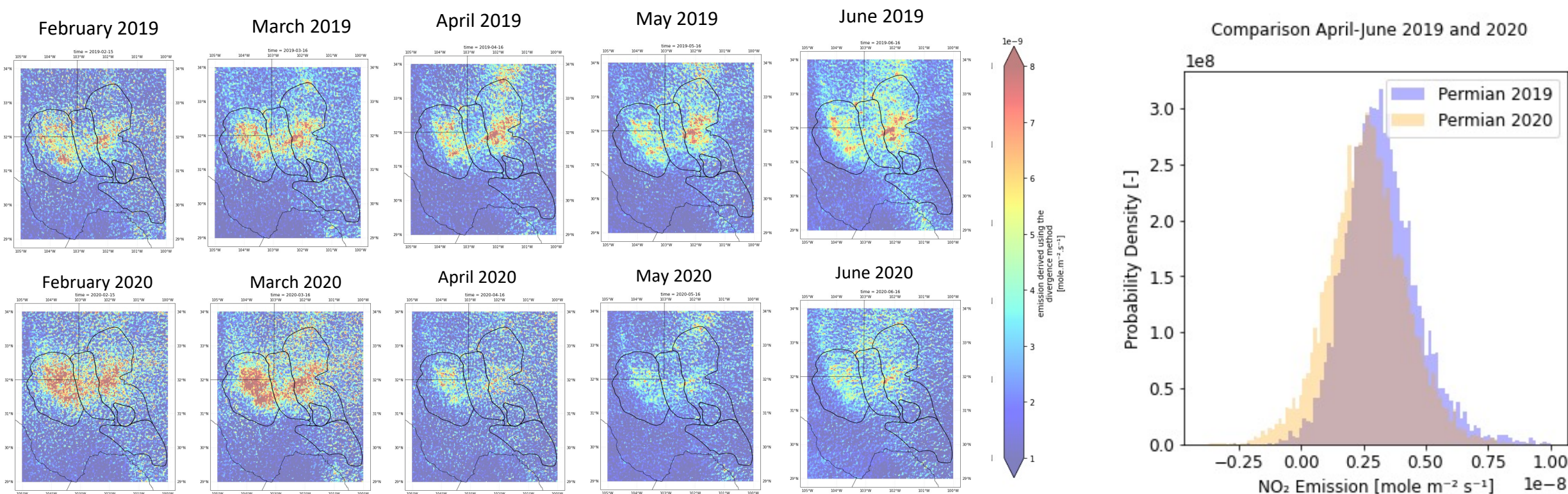
Monthly median methane and nitrogen dioxide column during 2020



Nitrogen dioxide was more impacted by the COVID-19 not only during the lockdown period, but also in 2020 mean concentrations respect to the 2019.

In the case of methane concentrations, due to the life time and the previous high emissions during winter months in 2020, the COVID-19 effect was not appreciated, specially in Delaware basin (the most productive basin in the Permian).

Median NO₂ emissions in pre and post COVID-19 lockdown



Most productive basins (April-June) 2020

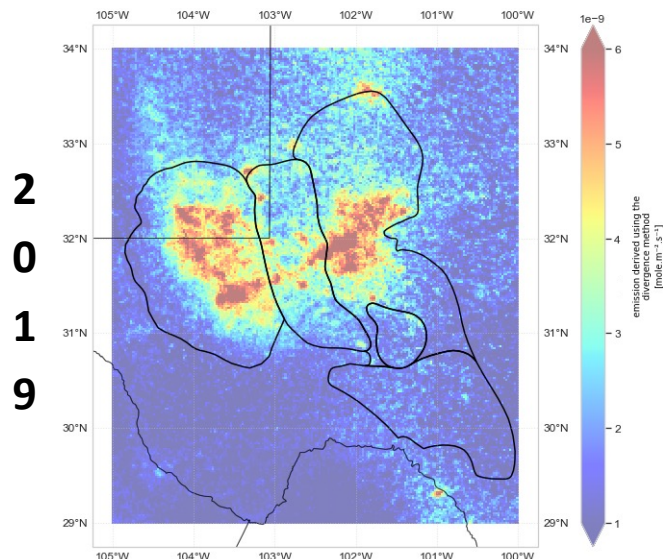
Basin	Mean + SD 2019	Mean +SD 2020	COVID19 impact
Delaware	3.5 e-09 ± 2.5e-09	2.5e-09 ± 1.8e-09	- 28%
Midland	3.9 e-09 ± 2.2e-09	2.6e-09 ± 2.2e-09	- 33%
Central	3.2e-09 ± 1.7e09	2.6e-09 ± 1.9e-09	- 18%

Less productive basins (April-June) 2020

Basin	Mean + SD 2019	Mean +SD 2020	COVID19 impact
Ozona arc	2.3e-09 ± 1.7e-09	1.6e-09 ± 2e-09	- 30%
Valverde	1.8e-09 ± 1.4e-09	1.3e-09 ± 1.9e-09	- 27%

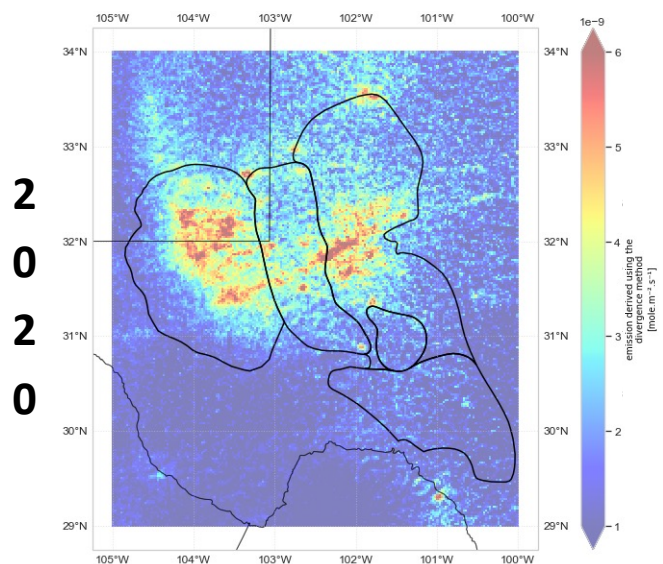
- 30% average in NO₂ emissions in all the sub-basins of the Permian

Median NO₂ emissions



Annually reduction can be observed in the NO₂ median emissions between 2019 and 2020.

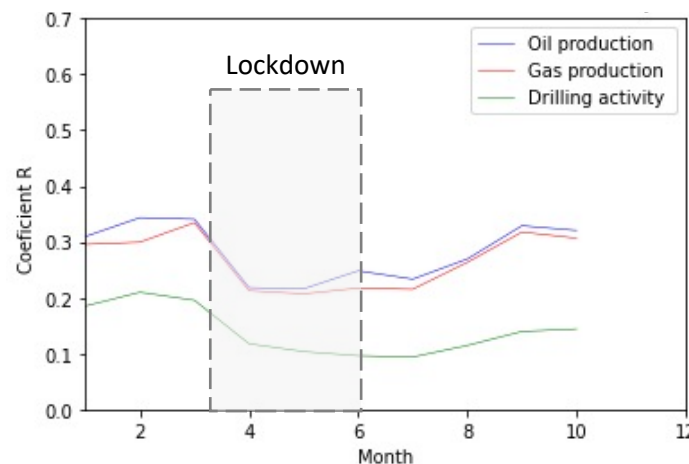
Features not related to the O&G such as roads or cities can be identified using the divergence method.



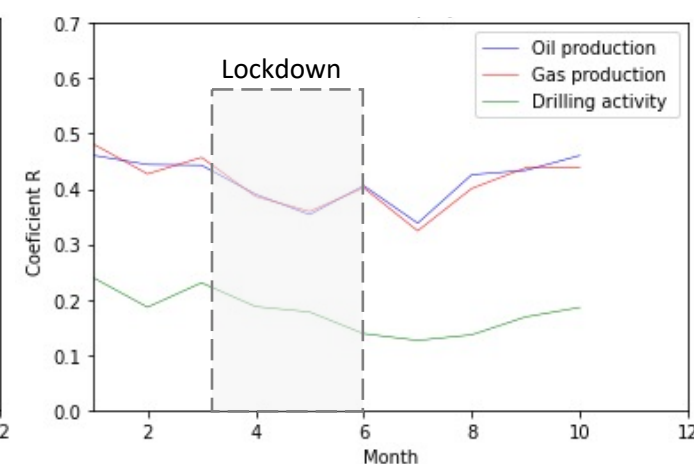
NO₂ emissions linked to O&G activities decreased on average of 7% on 2020 respect 2019 in the entire Permian basin.

Concentrations, emissions and O&G activity spatial relationships

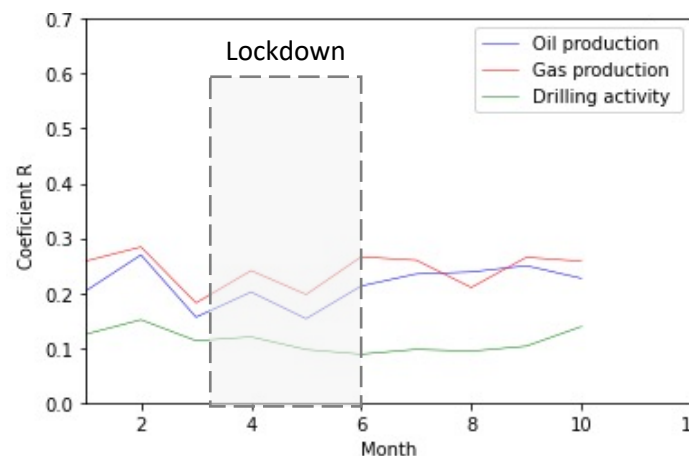
2020 NO₂ emissions vs O&G activities



2020 NO₂ concentrations vs O&G activities



2020 CH₄ vs O&G activities



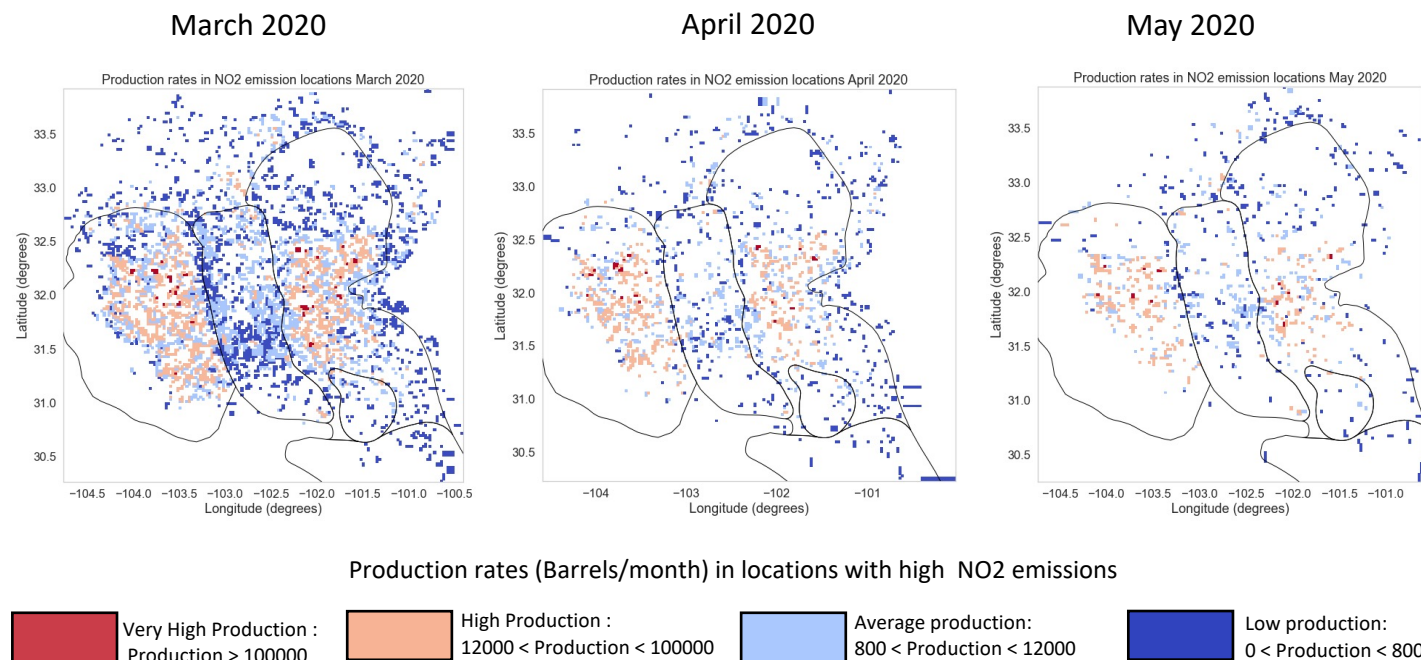
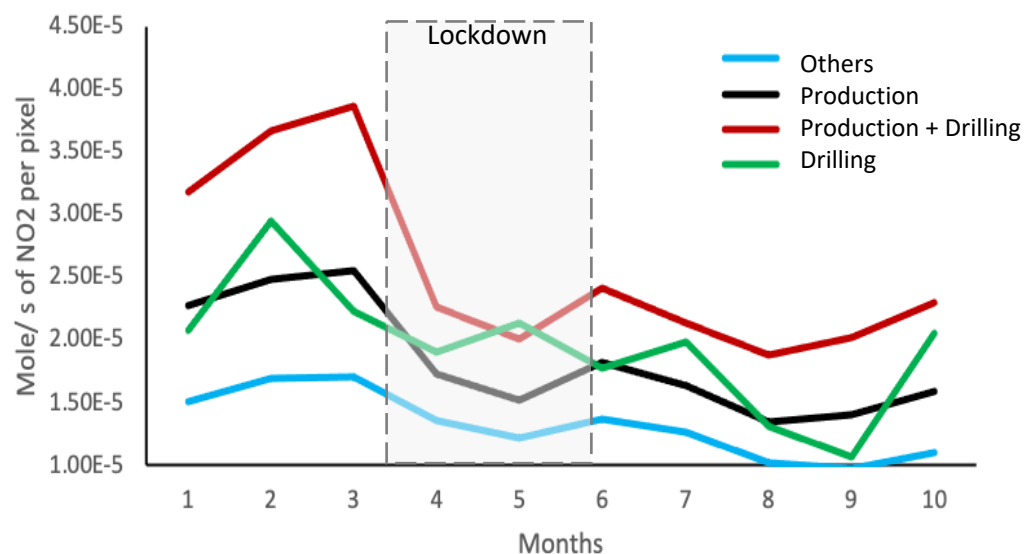
NO₂ emissions vs O&G activity has the higher spatial relationship.

NO₂ emissions and concentrations are more related to oil production (higher R coef) and methane concentrations with gas production.

Decrease of all spatial relationships in 2020

NO₂ emissions quantification and source attribution

2020 NO₂ emissions of O&G activities



Conclusions

- Tropomi can track downturn production and drilling activity in the Permian basin tracking the NO₂ emissions.
- NO₂ tropospheric concentrations have the highest values in the most productive regions (Delaware, Midland and Central basin)
- Concentrations of methane seems to increase during the COVID-19 lockdown for a posterior decrease during the summer months in 2020.
- NO₂ emissions calculated with the divergence method show a significant reduction during COVID-19 in the Permian basin.
- The divergence method seems to help to locate the emission source and identify the oil and gas related activity.
- Places where production and drilling activities occurred at the same time had the highest NO₂ emission rates and experienced the largest decrease during the COVID-19 lockdown.

Acknowledgements

This work is supported by Shell Global Solutions International B.V. The authors gratefully acknowledge the helpful discussions with the Shell team