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RAMBOLL

# **Emissions and Air Quality Implications of Upstream and Midstream Oil and Gas Operations in Mexico's Transforming Energy Sector**

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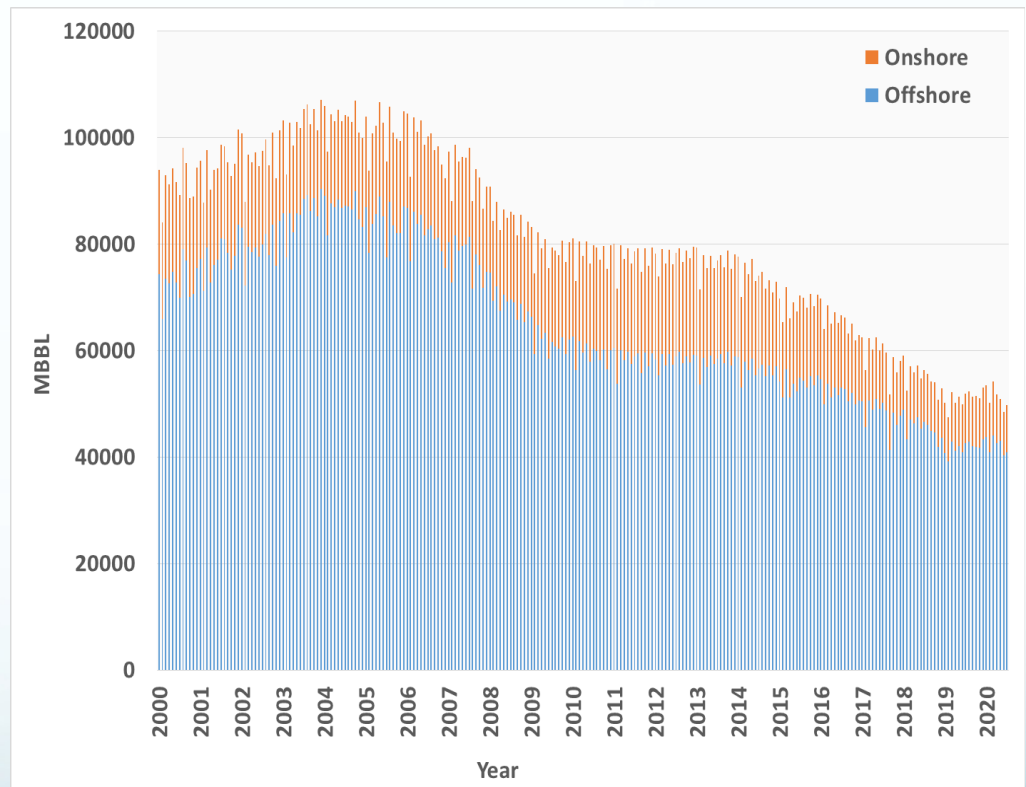
John Grant, Tejas Shah, Greg Yarwood  
Ramboll  
Novato, California

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# Background

- Long history of oil production central to Mexican economy
- State-owned Petróleos Mexicanos (Pemex) monopoly
- Oil production peaked in 2004 with supergiant Cantarell field
- Energy sector challenged by declining oil and natural gas production revenues and constraints in investment resources and technical expertise

Annual Onshore and Offshore Oil Production Volumes (MBBL): 2000-2020



Source: Comision Nacional de Hidrocarburos, 2021

# Transformational Changes

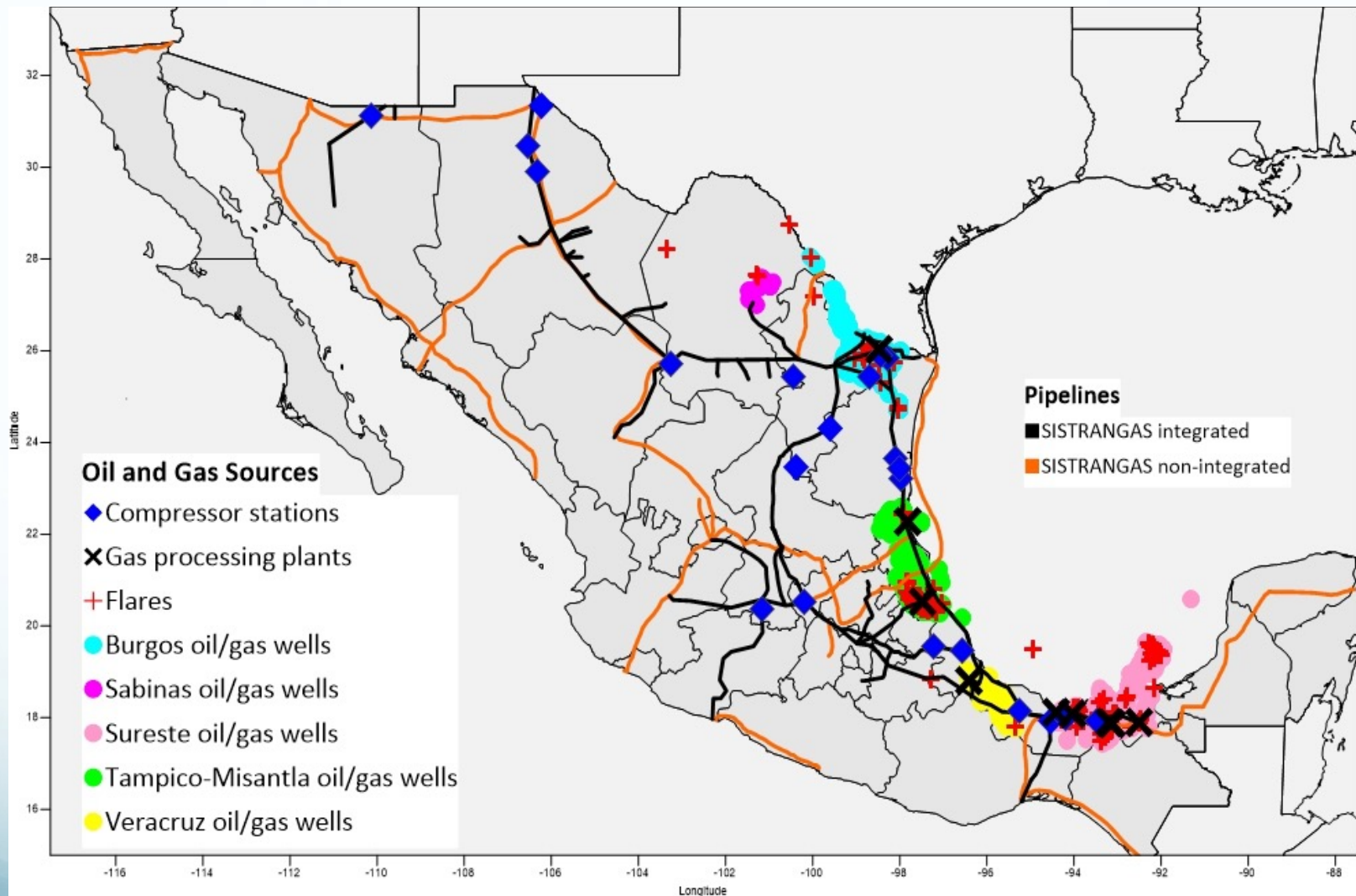
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- Energy reform was part of the *Pacto por México* implemented during Peña-Nieto administration
- Required ratification of amendments to the Mexican Constitution adopted in December 2013 with secondary implementing legislation in August 2014
- An objective was to expand investment and growth in oil and gas production and electric power sectors
- Significant outcome was allowance for private and foreign investment and participation for oil and gas exploration and extraction
- Between 2015-2018, Mexico conducted nine bidding cycles for onshore, shallow water, deepwater hydrocarbon resources

# Objectives

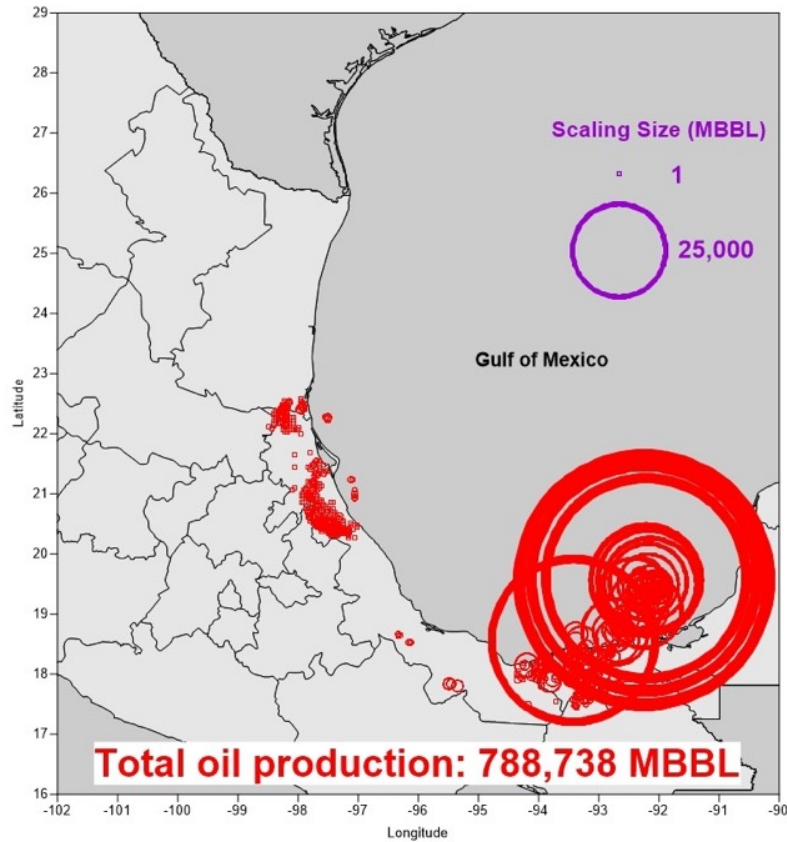
- Develop a bottom-up emissions inventory for criteria pollutants and precursors ( $\text{NO}_x$ , VOC, CO,  $\text{SO}_2$ ,  $\text{PM}_{2.5}$ ) from upstream and midstream sources for the 2016 base year
  - Developed from data that was fully documented and would allow future modifications and improvements
  - Provide a foundation for assessing the impacts of future national policies and oil and gas production activity in Mexico
  - Support North American and international air quality modeling efforts
- Apply CAMx to examine contributions of onshore and offshore oil and gas producing regions in Mexico to ozone and  $\text{PM}_{2.5}$  concentrations in Mexican and U.S. border states
- Examine progress and status of blocks awarded through the bid rounds

# 2016 Upstream and Midstream Sector Emission Sources

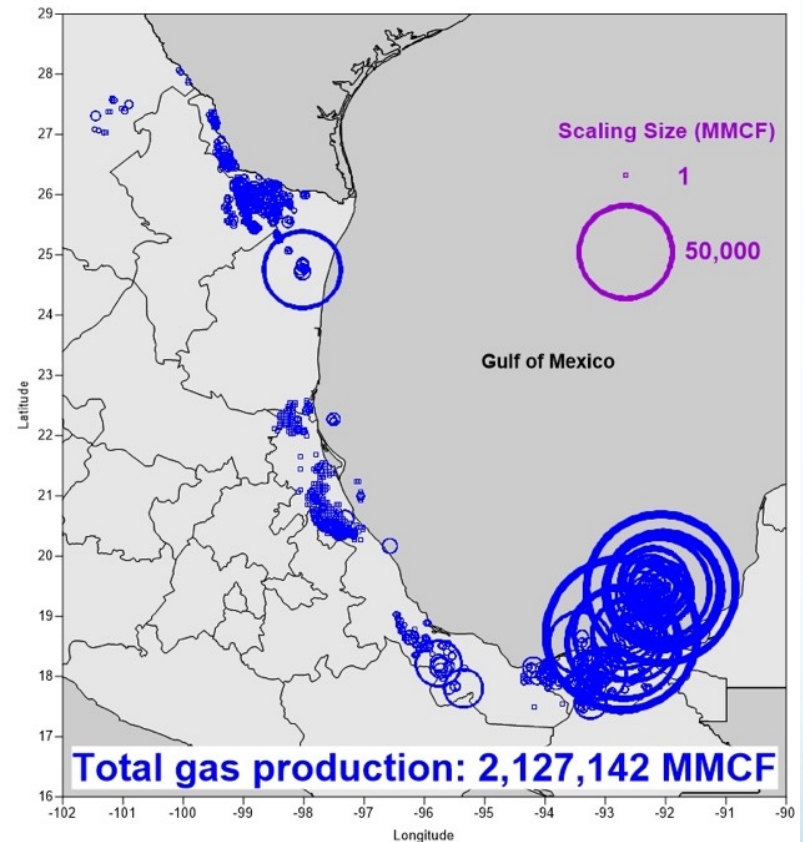




# Annual Oil and Natural Gas Production in 2016



Onshore: 163,598 MBBL (21%)  
Offshore: 625,141 MBBL (79%)



Onshore: 971,696 MMCF (46%)  
Offshore: 1,155,446 MMCF (54%)

# Upstream Emissions Inventory Development

## Onshore Well Sites and Offshore Platforms

- Location and activity data (well counts, spud counts, production volumes): Mexico's National Hydrocarbons Commission (CNH) and North American Cooperation on Energy Information (NACEI)
- Emission Factor Development
  - Onshore well sites: EPA 2014 NEIv2 and EPA Oil and Gas Emissions Estimation Tool for Texas basins with similar operations and hydrocarbon resources with emission control assumptions removed
  - Offshore platforms: production and emissions data for shallow water leases under BOEM jurisdiction in 2014

## Flaring

- Shah et al (2018) estimated 2012 emissions using VIIRS flaring locations and flared gas volumes and emission factors from AP-42 and EPA Oil and Gas Emissions Estimation Tool
- 2016 projections based on 2016/2012 gas production volumes by basin

# Midstream Emissions

## Natural Gas Processing Plants

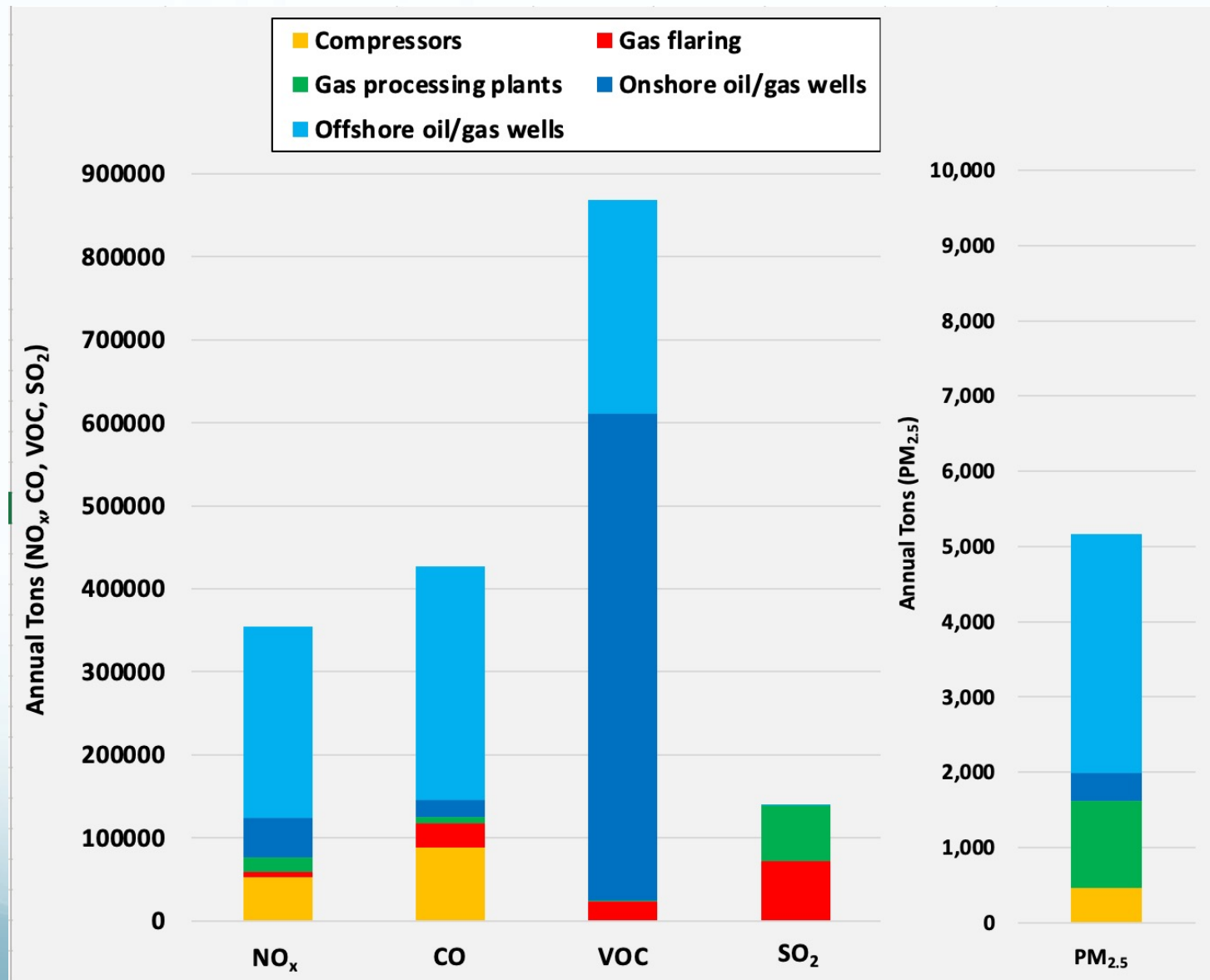
- Pemex (2016) identified 11 plants
- Eight plants: 2008 Mexico National Emissions Inventory (INEM) projected to 2016 using natural gas intake volumes from Pemex
- Three plants: linear regressions of 2016 emissions and petrochemical production for eight INEM facilities

## Compressor Stations

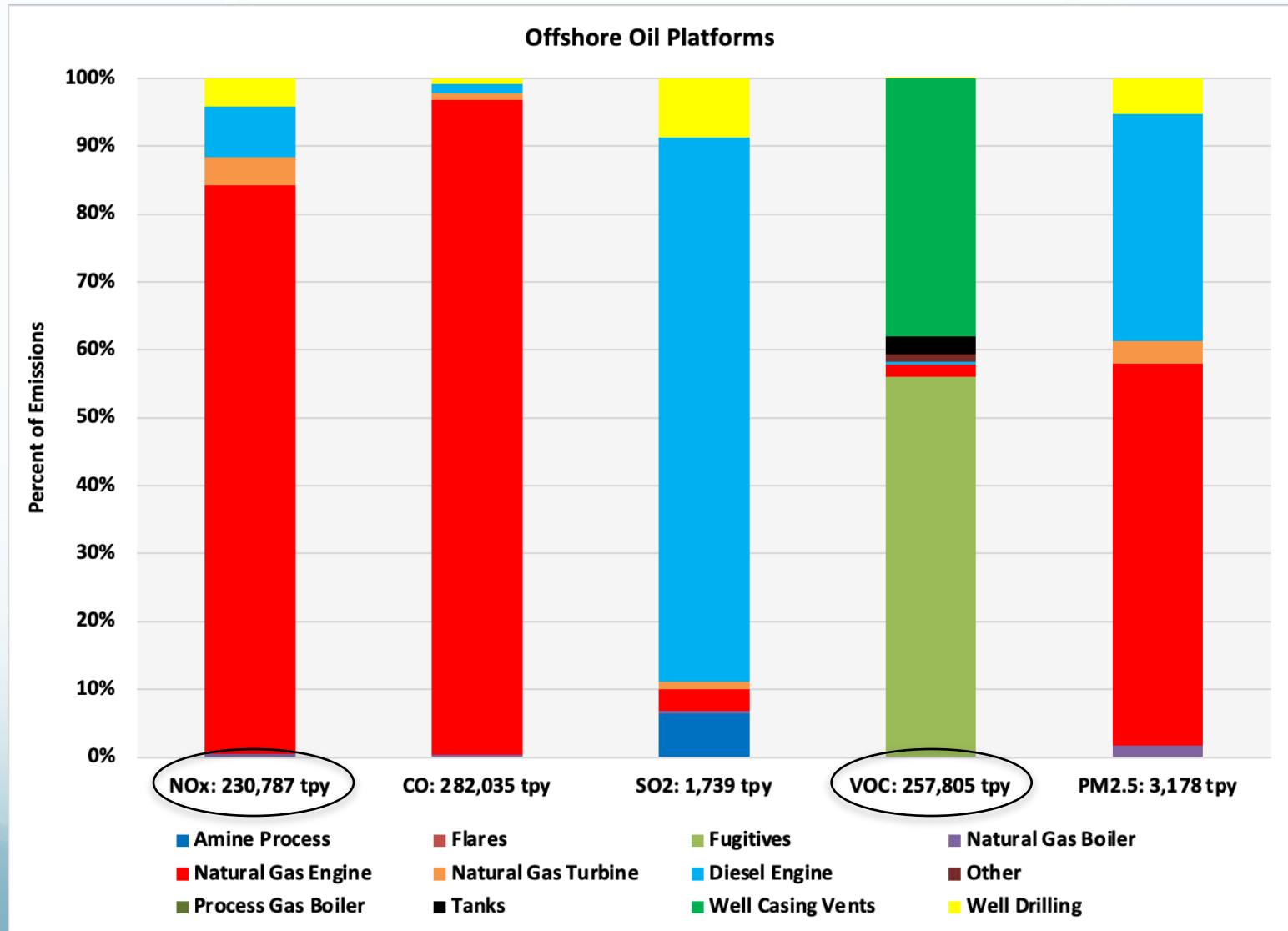
- CNH identified 22 stations along Mexico's Integrated National Natural Gas Transportation and Storage System (SISTRANGAS) pipeline grid
- Eighteen stations: installed horsepower from Mexico's Ministry of Energy (SENER, 2013) and Eduardo (2018) and AP-42 emission factors for uncontrolled 4-stroke rich burn engines
- Four stations: average installed horsepower of eighteen stations with AP-42 factors



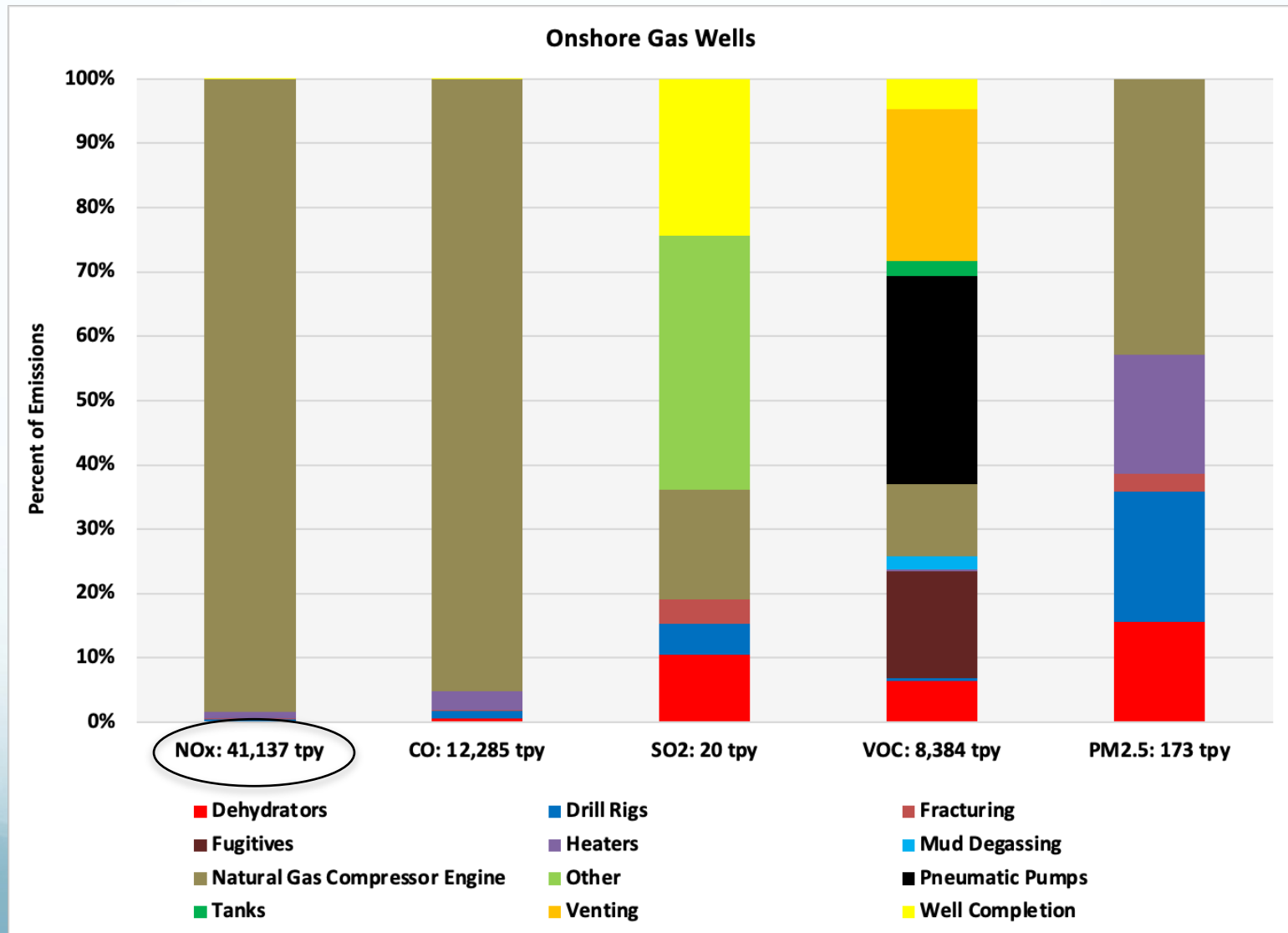
# 2016 Annual Emissions Estimates



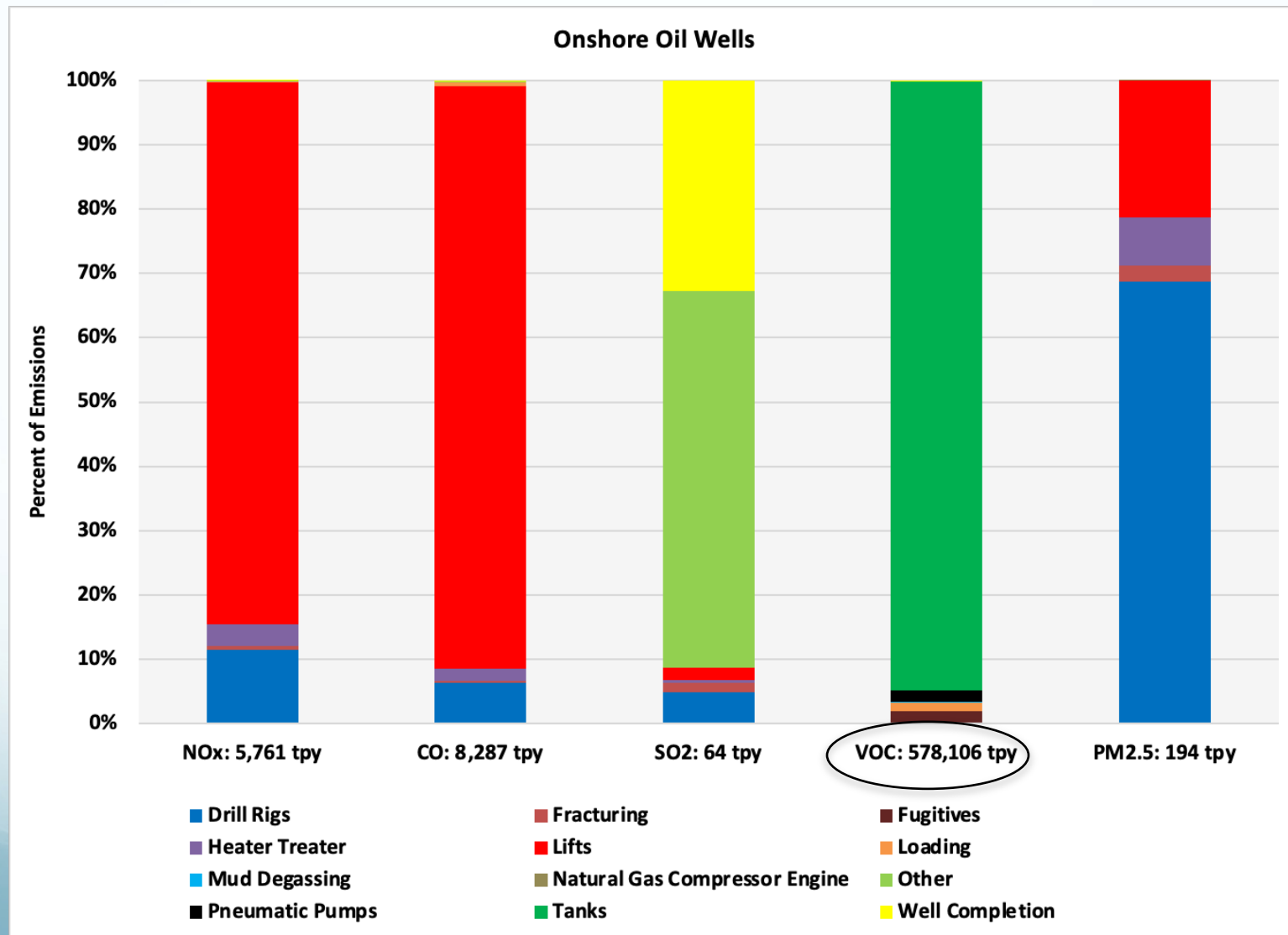
# Contributions to Emissions from Offshore Oil Production Platforms by SCC-Based Categories



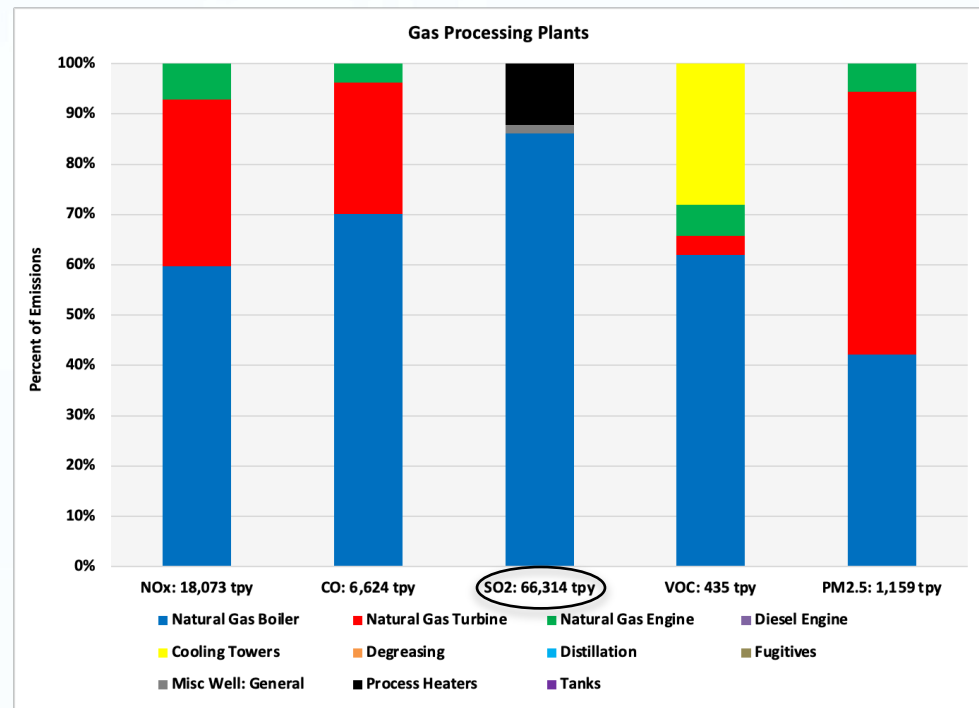
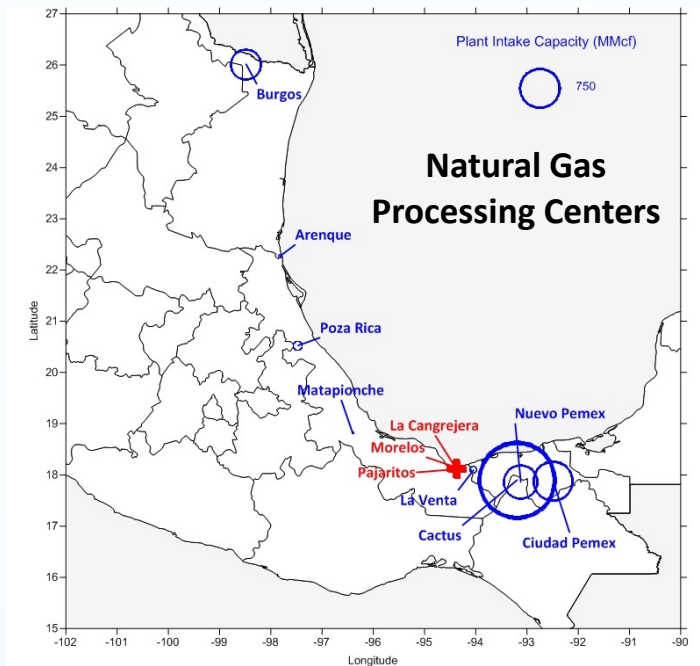
# Contributions to Emissions from Onshore Gas Well Sites by SCC-Based Categories



# Contributions to Emissions from Onshore Oil Well Sites by SCC-Based Categories



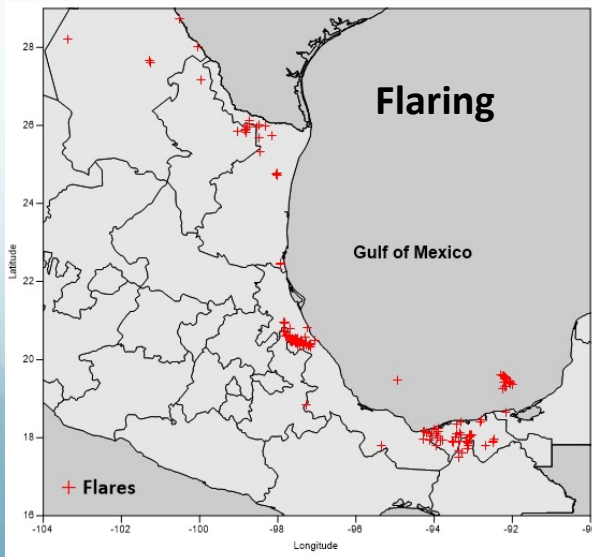
# SO<sub>2</sub> Emissions from Flaring and Natural Gas Processing



Gas flaring and natural gas processing contributed 52% and 47% of total SO<sub>2</sub> emissions

98% of SO<sub>2</sub> emissions from natural gas processing are from facilities in the Sureste Basin (Tabasco, Chiapas)

SO<sub>2</sub> emissions from flaring occur offshore (59%) and onshore (24%) in the Sureste Basin and onshore in the Tampico-Misantla Basin (15%)



# Emissions Inventory Availability

- 2016 inventory for Mexico's upstream and midstream oil and gas sectors and electricity sector\* in an AIRS Facility System (AFS) format
- Available upon reasonable request from the authors

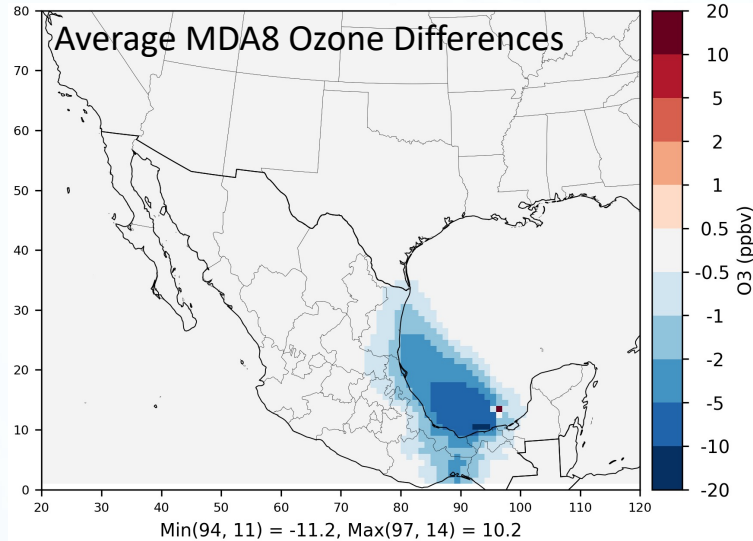
\*Refer to McDonald-Buller et al. (2021) Mexico's electricity grid and fuel mix: implications of a fifteen-year planning horizon on emissions and air quality, *Environ. Res. Lett.* **16** 074050, doi: <https://doi.org/10.1088/1748-9326/ac0fa5>



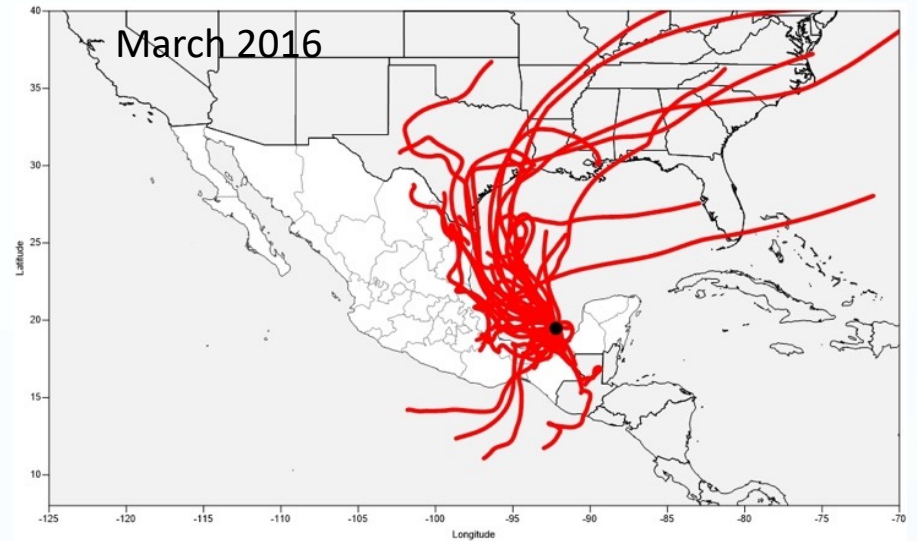
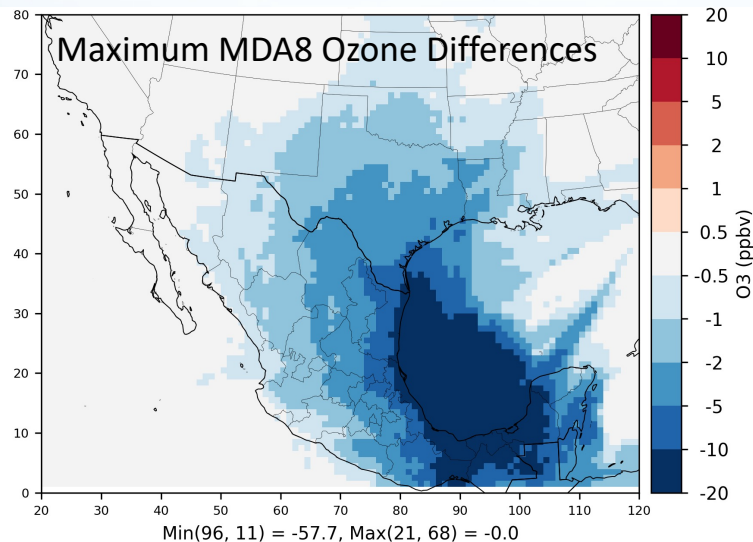
# Air Quality Modeling

- Adapted CAMx air quality modeling platform from Texas Commission on Environmental Quality (TCEQ) based the 2016v1 Emissions Modeling Platform from the National Emissions Inventory Collaborative
- Point source inventory modified with our emissions estimates for Mexico's upstream and midstream oil and gas sectors and electricity sector
- December 15, 2015 – January 1, 2017
- Examined contributions of midstream sources and different geographic regions with upstream oil and gas operations (Sureste, Tampico-Misantla, Veracruz, Burgos/Sabinas) to maximum daily 8-hour average (MDA8) ozone and 24-hour average PM<sub>2.5</sub> concentrations across Mexican and U.S. border state areas
- Zero-out approach

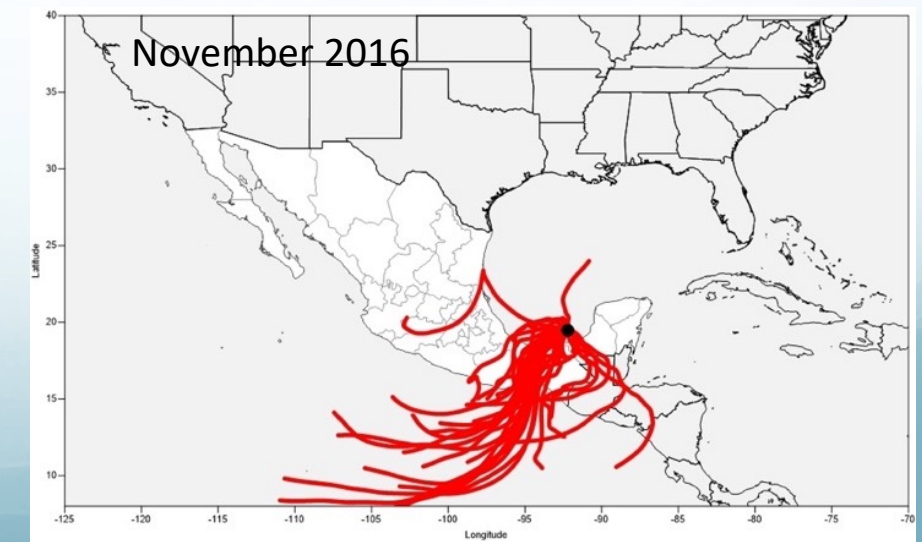
# MDA8 Ozone Impacts & Seasonal Transport Patterns (2016): Sureste Basin Offshore Oil and Gas Production Platforms



Annual average and maximum differences in MDA8 ozone by grid cell between zeroing of offshore platform emissions in Sureste Basin and base case

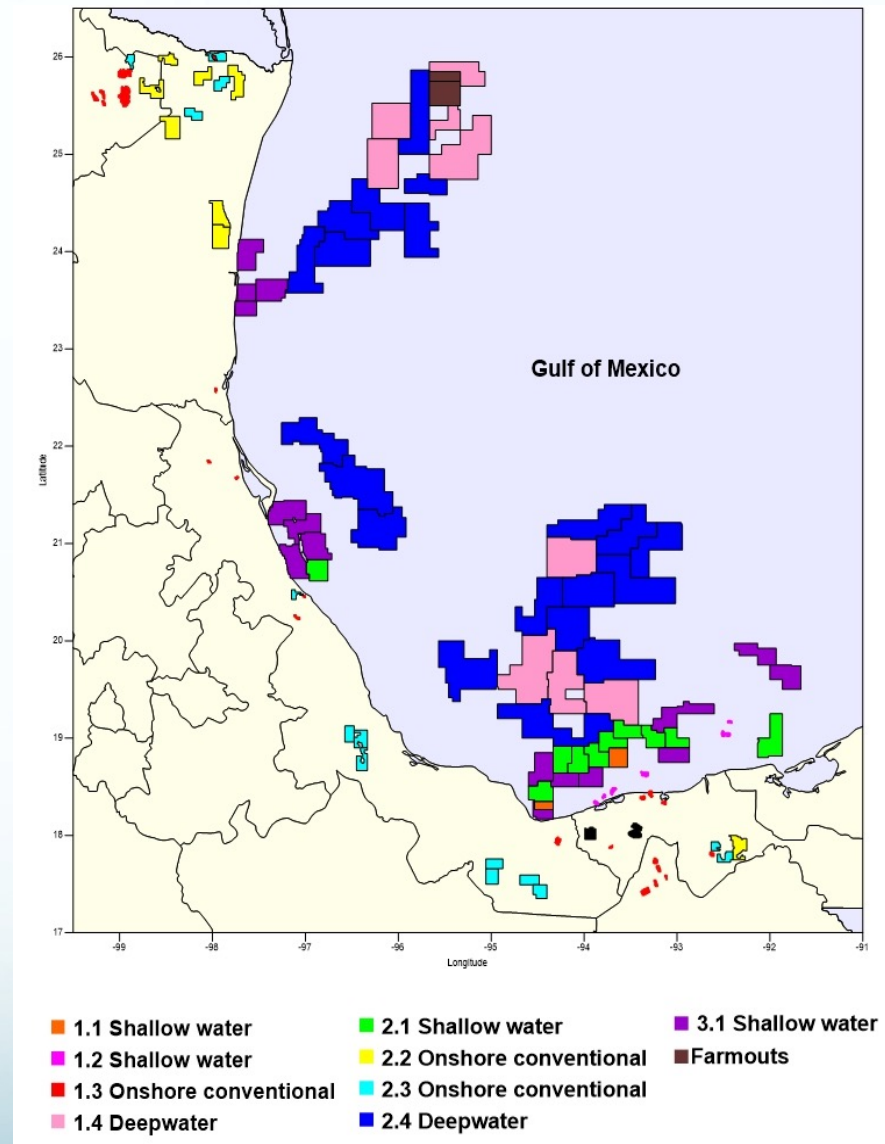


Daily HYSPLIT forward trajectories initiated at 500m AGL at 1pm local time offshore within the Sureste Basin



# A Complex Future

- Changes in production activity in new or existing areas could alter Mexico's oil and gas sector emissions profiles
- Between 2015-2018, 107 contracts awarded to companies from Mexico and 19 other countries through bid rounds
- Moratorium on new awards following transition to López Obrador administration in December 2018
- Existing awards have continued, but shifting national objectives have created an uncertain and challenging future for private investment and participation in Mexico's energy sector



Source: <https://rondasmexico.gob.mx/eng/rounds/>

# Acknowledgments

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*The findings, opinions and conclusions are the work of the authors and do not necessarily represent findings, opinions, or conclusions of the AQRP or the TCEQ*