Estimating Methane Emissions in the Gulf of Mexico: Insights from SCOAPE-II

SY23D-2510

GMAO
Global Modeling & Assimilation Office

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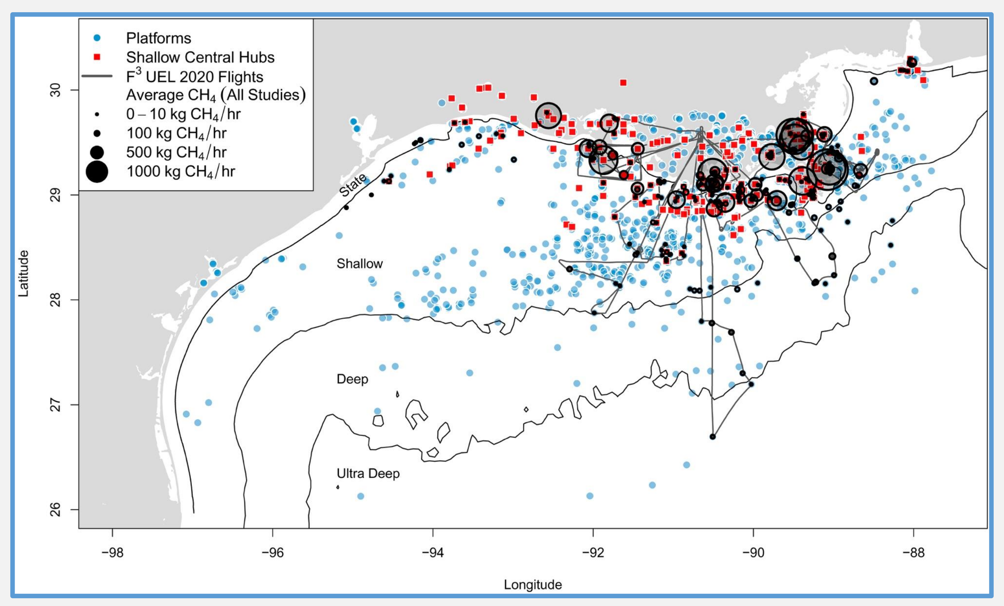
Background

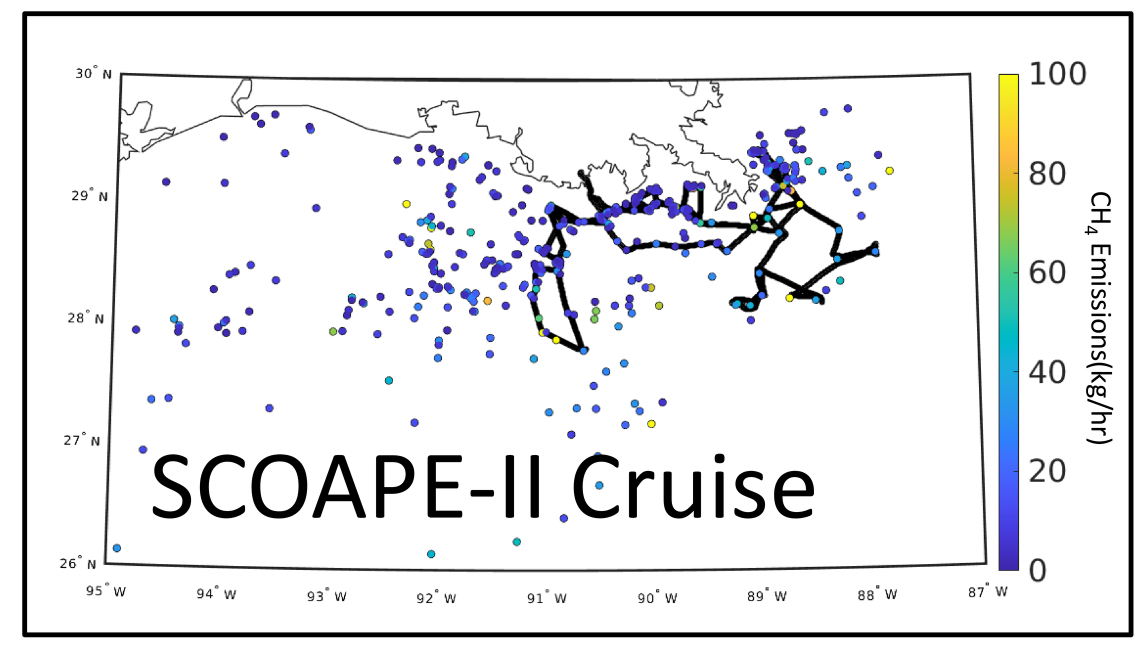
- The endeavor to better understand the nature of methane (CH_4) emissions from oil and gas activities in the Gulf of Mexico (GOM) on the Outer Continental Shelf (OCS) is a relatively new one.
- Relevant studies covering CH_4 emissions in GOM:
  - Shipboard campaign 2018 (Yacovitch et al., 2020)
  - Airborne pilot study 2018 (Negron et al., 2020)
  - Airborne F3UEL campaign 2020 (Negron et al., 2023)
  - Airborne Carbon Mapper campaign 2021 (Ayasse et al., 2022)
  - Airborne F3UEL campaign 2022 (Biener et al., 2024)
  - **Shipboard SCOAPE-II campaign 2024 (this work)**
- Oil and gas production platforms along with the corresponding distribution pipelines are responsible for most of the GOM CH_4 emissions on the OCS.
- Shallow water OCS platforms gather production from smaller satellite facilities for processing. In shallow to mid-depth waters, medium platform installations produce and process at the same time. In deep waters, large facilities produce and process high volumes of oil and gas.
- Natural gas is expelled by cold venting (shallow waters) or by flaring (deep waters).

SCOAPE-II Campaign

- The US Dept of Interior's Bureau of Ocean Energy Management (BOEM) has air quality (AQ) jurisdiction in the Western and Central GOM on the OCS.
- In addition to AQ BOEM is also interested in Oil and Gas (ONG) greenhouse gas emissions, particularly CH_4, but it relies on ONG operator reporting for its GOM emissions inventories.
- In June of 2024, the second Satellite Coastal and Oceanic Atmospheric Pollution Experiment (SCOAPE-II) cruise sponsored by BOEM set out to further investigate GHGs as well as air quality in the GOM with support from airborne measurements (AVIRIS-3) and satellite CH_4 products from the privately owned company GHGSat.



In the Figure to the left from Negron et al. (2023) black lines show 2020 FU3EL flights and black circles indicate estimated CH_4 emissions. The divisions between shallow (<200 m), deep (200 m to 1520 m), and ultradeep (>1520 m) waters and between federal and state waters (three or nine nautical miles depending on the state) are shown. Shallow waters estimations show highest CH_4 facility emission, especially at central hub facilities.

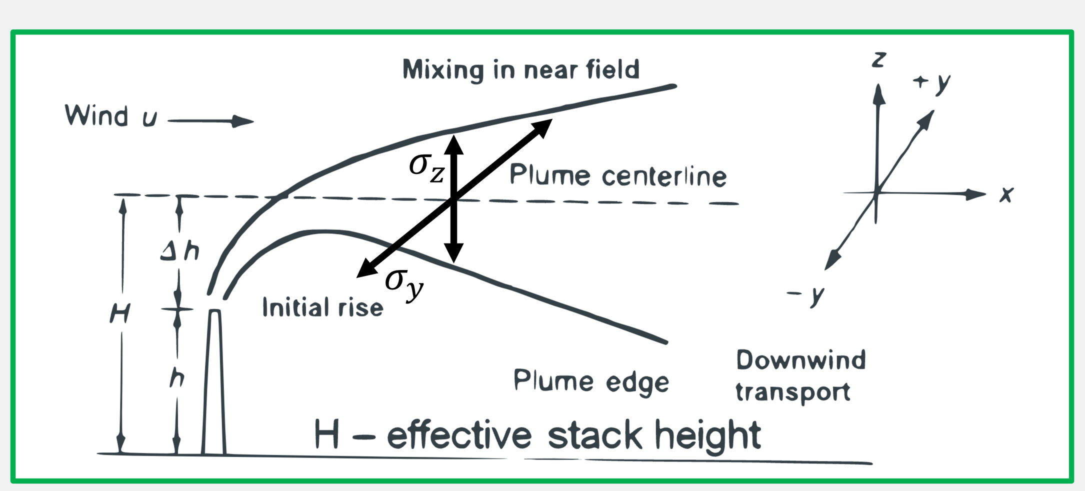


Conclusions

- Emissions of CH_4 at GOM are extremely intermittent as evident from the several examined studies and current campaign.
- We need to figure out strategies that would allow for long-term and consistent monitoring of the CH_4 at GOM (towers and regional model).
- GHGSat was not able to detect any plumes during SCOAPE-II (detection limit is somewhere around 100-200 kg/hr).

Gaussian Plume Modeling

- Allows for a simple simulation of horizontal plume cross-section based on a Gaussian plume modeling.
- Main variables that determine how much a plume is expanding horizontally and vertically are σ_y and σ_z and depend on atmospheric stability conditions.
- Stability conditions can be determined by looking up Pasquil stability classes, which depend on wind speed and solar insolation.

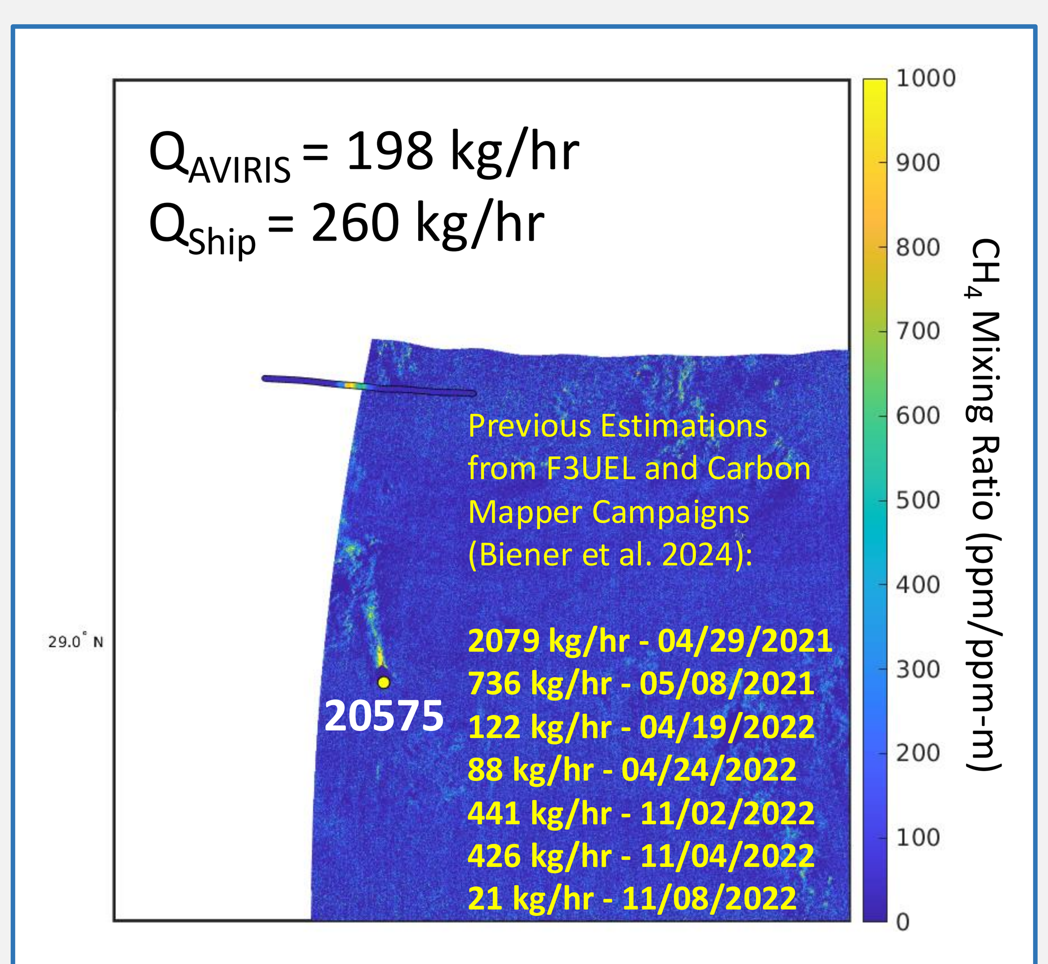


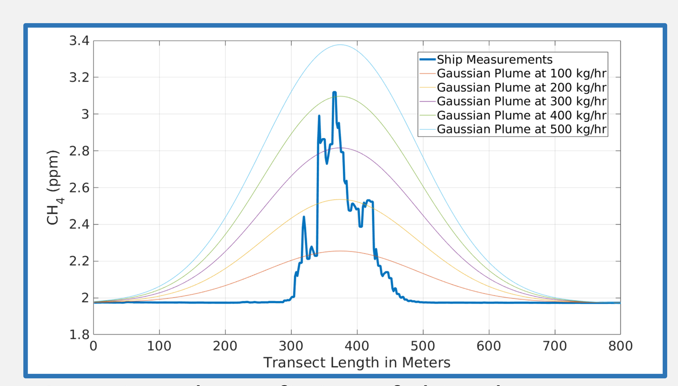
$$C_{CH4} = \frac{Q_{CH4}}{2\pi u \sigma_y \sigma_z} exp\left(-\frac{y^2}{2{\sigma_y}^2}\right)\left[exp\left(-\frac{(z-H)^2}{2{\sigma_z}^2}\right) + exp\left(-\frac{(z+H)^2}{2{\sigma_z}^2}\right)\right]$$

June 3, 2024 AVIRIS-3 (1750 UTC) and Ship Measurements (0030 UTC)

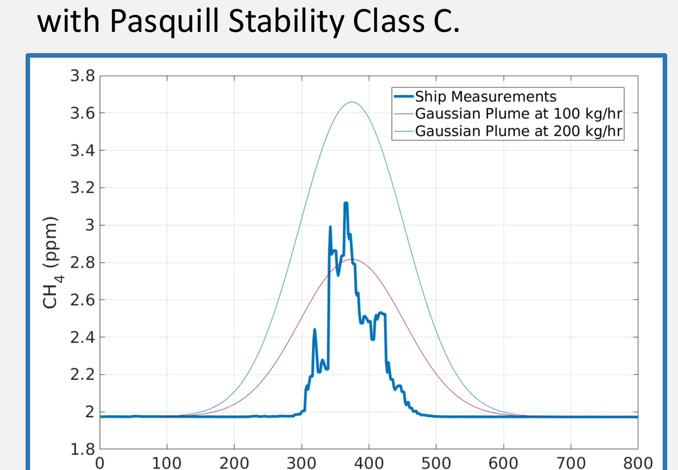
- Emissions from AVIRIS-3 flight scenes can be calculated by using the equation to the right.
- U_{eff} is derived from 10-meter wind using relationship based on WRF-LES simulations.
- $\Delta\Omega$ is XCH_4 plume enhancement at a pixel with area A.

$$Q_{IME} = \frac{U_{eff}}{L}\sum_{i=1}^{N} \Delta\Omega_i A_i$$

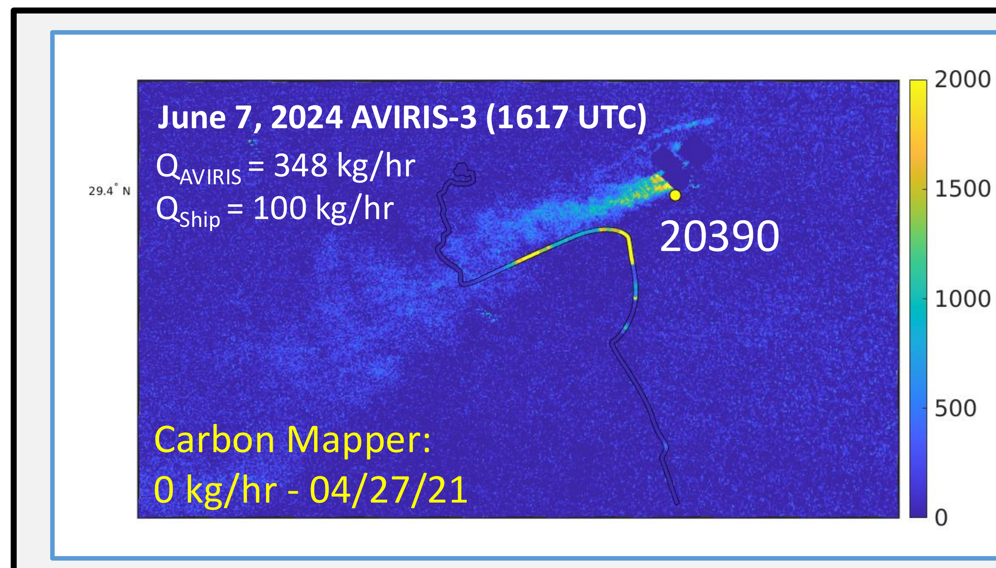


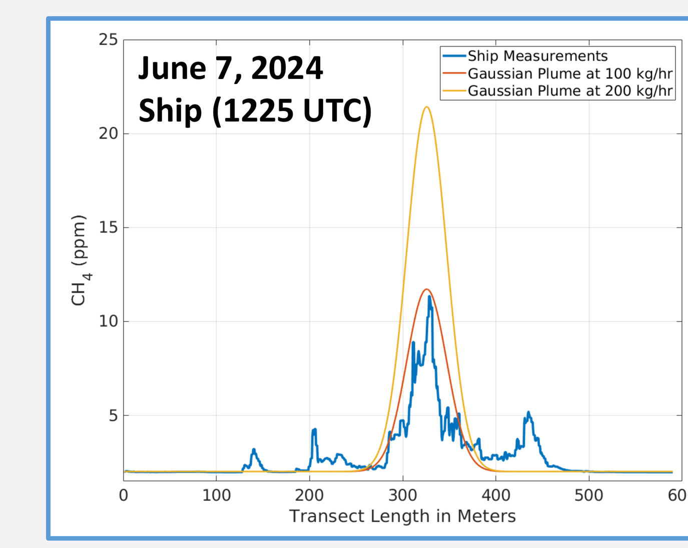


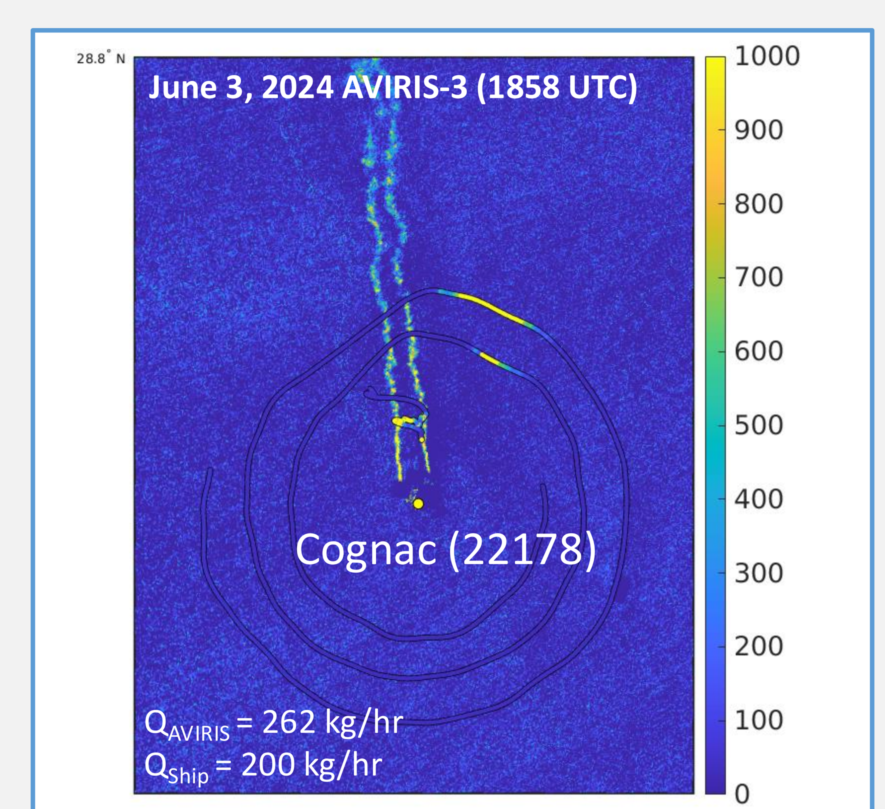
Gaussian plume fitting of ship observations with Pasquill Stability Class C.

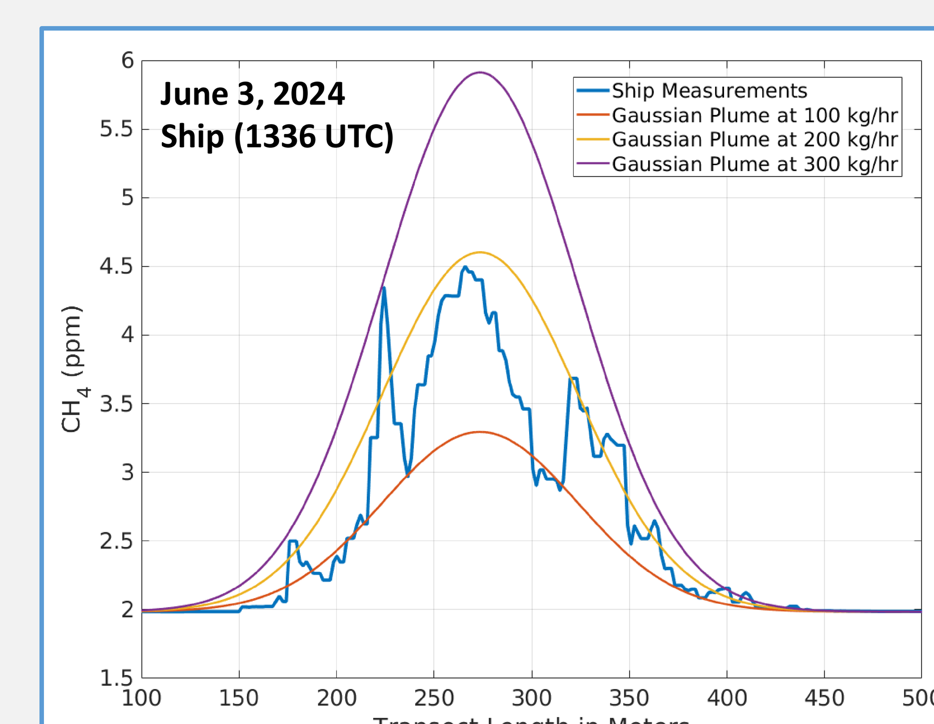


Gaussian plume fitting of ship observations with Pasquill Stability Class D.









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