

ASSESSMENT OF METHANE CONCENTRATIONS IN ESTUARINE REGIONS ON THE COAST OF THE STATE OF SÃO PAULO

Thaís Corrêa^{1*}, Izabel da Silva Andrade¹, Fernanda de M. Macedo², Elaine Cristina Araújo¹, Maria de F. Andrade³, Elisabete S. Braga⁴, Eduardo Landulfo¹

¹Instituto de Pesquisa Energética e Nuclear, Universidade de São Paulo, Brazil.
elaine.c.araujo@usp.br izabel.andrade@usp.br correa-thais@usp.br elandulf@ipen.br

²Faculdade de Tecnologia do Estado de São Paulo, Brazil.
fernanda.m.macedo@alumni.usp.br

³Instituto de Astronomia Geofísica e Ciências Atmosféricas, Universidade de São Paulo, Brazil.
edsbraga@usp.br

⁴Instituto de Oceanografia, Universidade de São Paulo Brazil.
maria.andrade@iag.usp.br

Contact: *correa-thais@usp.br

Abstract

We evaluated concentrations of atmospheric CH₄, which is considered one of the main gases causing global warming. We observed methane concentrations in the Cananéia-Iguape estuarine system on the southern coast of the state of São Paulo, Brazil and in the Santos estuary, Baixada Santista region, coast of the state of São Paulo, Brazil. The south coast region is widely studied as it presents very well-preserved fauna and flora and thus offers an important background on natural emissions. Data acquisition was carried out by a portable gas analyzer (LGR-ICOS™ GLA131), this equipment has a high sensitivity in detecting the gases under study and was placed on board the research vessels Albacora and Alpha Delphini owned by the Institute of Oceanography at the University of São Paulo in campaigns that were carried out between 2021 and 2023 in specific periods. The concentrations observed during the exploratory campaigns in the estuaries on the coast of the State of São Paulo (Iguape Cananéia Estuarine-Lagunar Complex and Santos Estuary) behaved as described in the literature, regions with greater anthropic impact present higher values of methane concentrations in the atmosphere, low-impact regions have lower methane concentrations.

Introduction

Methane (CH₄) is one of the most important greenhouse gas (GHG), being ranked in second when the question is the radiative forcing[1]. Methane has a several sources, being the naturals crucial to the maintenance of its concentrations in atmosphere. The production from soil occurs when organic matter is anaerobically degraded. Several bacteria degrade organic material through a complex food net where the final step in this process is carried out by methanogenic, methane-producing bacteria [2]. Many studies demonstrate the natural wetlands are the origin of main sources of atmospheric methane, several researchers have attempted to quantify global emissions from wetland environments [3].

Methods

Microportable Greenhouse Gas Analyzers (LGR-ICOS™ GLA Series), have high sensitivity and a very fast response time, approximately 1 second. Based on the integrated cavity spectroscopy technique (OAICOS), which is widely used for detecting trace gases, due to its numerous advantages such as fast response, high sensitivity, and stability. The portable gas analyzer has a diode laser and its wavelength is adjusted according to the "target" gas molecule. In this work, equipment was used that has two lasers at wavelengths 1,600 nm and 1,650 nm and measures the concentrations of the gases CO₂, CH₄, and H₂O. Its operation is similar to non-portable benchtop equipment for the analysis of trace gases,

where the gas sample enters the equipment through the INLET, where the gas is filtered and goes through pressure adjustment to guarantee a specific set point contributing to the efficiency of the equipment, immediately after this step the sample passes again through another high efficiency filtration system, which removes particles of up to 0.01 m and goes to the optical cell cavity, where the light is transmitted along the cavity, being The variability of light is detected and transformed into a digital signal and stored on a computer.



Figure 1: Microportable Greenhouse Gas Analyzers (LGR-ICOS™ GLA Series)

Results

For data acquisition, the equipment was placed at two fixed points, also in 5 navigation campaigns with the Albacora Research Boat in partnership with the Institute of Oceanography in different periods. Below we present the locations for data acquisition.



Figure 2: Cananéia-Iguape estuarine system on the southern coast of the state of São Paulo

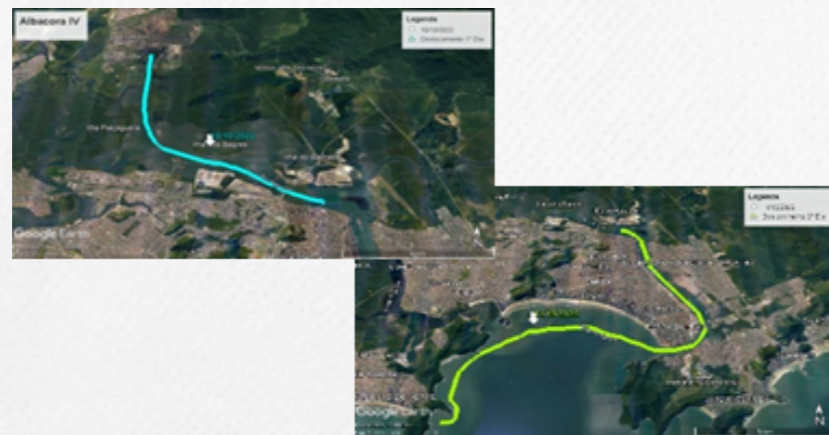


Figure 3: Santos estuary, Baixada Santista region, coast of the state of São Paulo

In figure 4 we did not observe high variability in methane concentrations during the campaign or between day and night periods. Averages of 1.81 ppm, minimum of 1.79 ppm, 1.96 ppm at night and 2.055 ppm during the day.

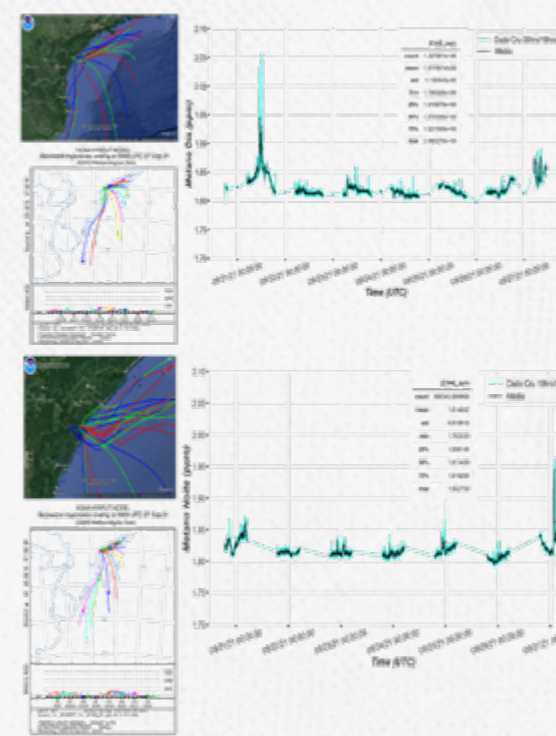


Figure 4: Methane values (ppm) observed in the City of Cananeia in September 2021

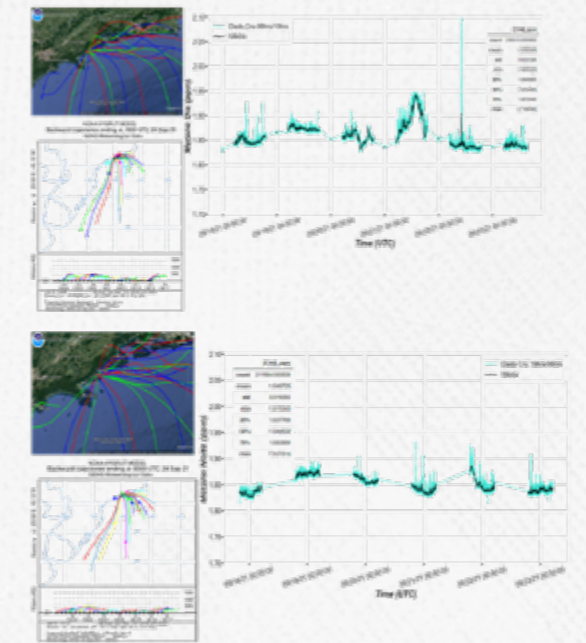


Figure 5: Methane values (ppm) observed in the City of Ubatuba in September 2021

In figure 5, the concentrations observed in the Ubatuba region were 1.81 ppm and 1.93 ppm, maximum and minimum respectively, and an average concentration of 1.85 ppm, not showing significant variability during the exploratory campaign.

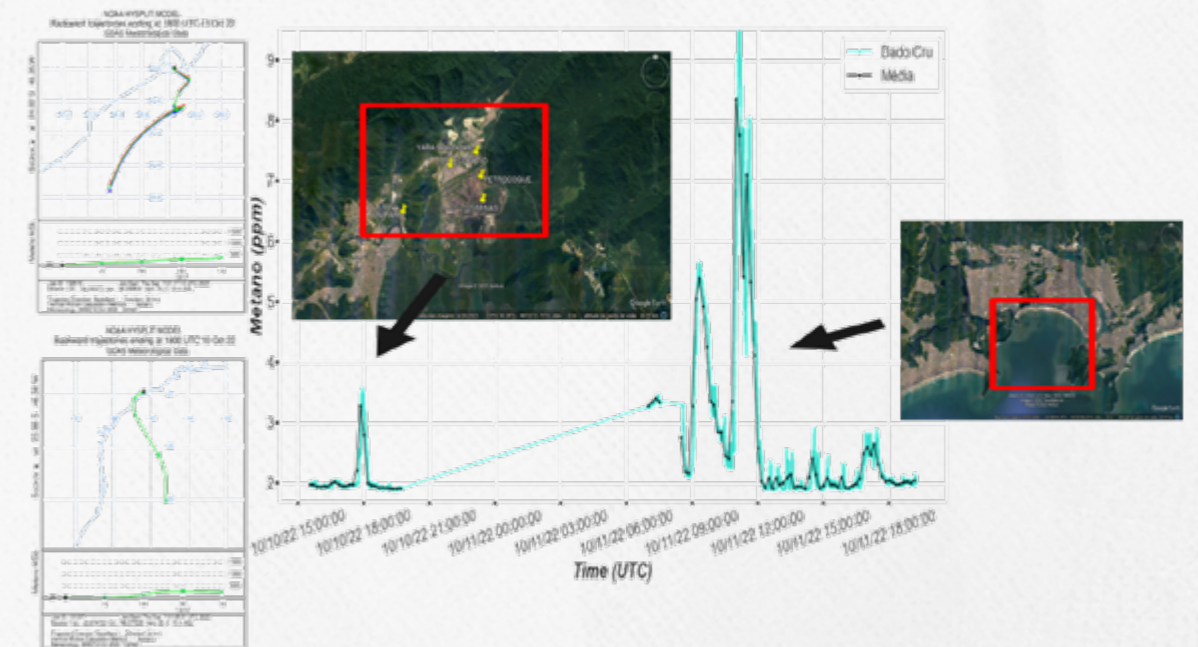


Figure 6: Methane values (ppm) observed in the City of Santos in October 2022

The average concentrations were 2.07 ppm and maximum value 3.56 ppm observed on the first day of data collection in the Santos region, this area includes many industries in the chemical sector. Concentrations during the second day of data acquisition were a minimum of 1.89 ppm and a maximum of 10.59 ppm, with an average of 2.82 ppm. The observed region is impacted by the emission of domestic waste ($5.3\text{m}^3\text{s}^{-1}$). We observed values above 4 ppm for 4 consecutive hours.

Conclusion

The concentrations observed during the exploratory campaigns in the estuaries on the coast of the State of São Paulo (Iguape Cananéia Estuarine-Lagunar Complex and Santos Estuary) behaved as described in the literature, regions with greater anthropic impact present higher values of methane concentrations in the atmosphere, low-impact regions have lower methane concentrations.

The data observed during the displacement campaigns in the Iguape Cananéia Estuarine-Lagunar Complex had average values of 1.8 ppm and 1.9 ppm, at times the methane concentrations were slightly below the methane concentration values expected in the atmosphere by literature (1,903 ppm)

In the Santos Estuary region, we observed concentration values above those expected in the literature, with average concentration values around 2 ppm, but with significant peaks along the displacement, mainly close to the Santos submarine outfall.

The literature proposes that estuaries are a possible source of greenhouse gas emissions, but we observed few moments in which concentrations were above expected values. When we observe the Iguape Cananéia Estuarine-Lagunar Complex, we can evaluate the system's emissions without human interference and thus evaluate the natural contributions. To confirm this trend we need constant monitoring of the regions.

References

- [1] Montzka, S. A., Dlugokencky, E. J., And Butler, J. H.: Non-Co2 Greenhouse Gases And Climate change, *Nature*,476,43–50,2011.
- [2] Oremland, R. S., Biogeochemistry Of Methanogenic Bacteria.In: Zehnder Ajb (Ed)Anaerobic Microbiol (Pp 641–705). Wiley, New York(1988)
- [3] Matthews, E., And I. Fung, Methane Emission From Natural Wetlands: Global Distribution, Area, And Environmental Characteristics Of Sources, *Global Biogeochem. Cycles*, 1, 61-86, 1987.
- [4] Grebenkov, D.S.; Serror, J. Following a trend with an exponential moving average: Analytical results for a Gaussian model. *Phys. A Stat. Mech. Appl.* 2014, 394, 288–303.