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Research Article

A comparative assessment of air quality spatial distribution in Alagoas and Asia

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Abstract:

The state of Alagoas in the Brazilian Northeast (NEB) has not yet been assessed for pollutant spatial distribution through satellite remote sensing and reanalysis data. This research aimed to analyse the state's spatial distribution throughout 2022 by collecting and processing data from Atmospheric Infrared Sounder (AIRS) and Modern-Era Retrospective Analysis for Research and Applications, Version 2 (MERRA2). The data were then interpolated and provided as a state map distribution by city or municipality for all the 102 towns in Alagoas. Additionally, the state is divided into three mesoregions (Coastal – "litoral", Hinterland – "agreste", and Arid – "sertão"), each with its specific climatology and characteristics. The pollutants chosen were Ozone (O3) (ozone), Carbon Monoxide (CO), Methane (CH4), and Particulate Matter 2.5 nm (PM2.5) and were displayed in a gradient state map from coastal to arid. The results were also compared to other case studies in Asia. The findings show that pollutants O3 and CH4 form a gradient from the coast to the state's interior, which is associated with local effects and mesoscale circulation. In contrast, CO and PM2.5 directly relate to high concentrations of vehicles, industries, and agricultural production.

Keywords: Air quality, Spatial distribution, Pollutant spatial distribution, Python, Satellite data, Satellite remote sensing, Mesoscale circulation, Environmental policy.

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1. Introduction

The deterioration of air quality poses a significant threat to environmental sustainability and public health, especially in heavily populated urban regions. The employment of satellite and reanalysis data for environmental surveillance offers intricate insights into air pollutants' dispersion and concentration levels (García-Burgos et al., 2022; Abecasis et al., 2022). In the past, a few studies on the air pollution were carried out in the State of Alagoas, in the Eastern Northeast of Brazil (ENEB), for instance Mollmann Junior *et al.* (2013) and Nunes *et al.* (2020). However, these studies were limited in their spatial approach and confined to a single pollutant. This study evaluates the air quality in Alagoas, Brazil in comparison with Asia, by charting the distribution of pollutants such as O_3, CO, CH_4, and PM2.5.

In harmonising the discoveries of this research with those put forth by Mollmann Junior *et al.* (2013) and Nunes *et al.* (2020), this research study broadens the horizon of the air quality scrutiny in Alagoas by integrating a more extensive array of pollutants and implementing a spatial examination throughout the entire state.

While Mollmann Junior *et al.* (2013) concentrated on the dispersion of carbon monoxide emanating from sugarcane burning, and Nunes *et al.* (2013) probed into the spatial-temporal variability of ozone and its correlation with ultraviolet radiation, this research explores and enriches these viewpoints by presenting an all-encompassing perspective on multiple pollutants and their dispersion over a spatial distribution map for the state.

2. Methodology

The methods and material used in this study are elaborated as follows:

2.1. Retrieving and processing

These datasets are instrumental in analysing the spatial distribution of critical air pollutants (O_3, CO, CH_4 and PM2.5) across Alagoas (NEB). The methodology involves several steps, from data acquisition to spatial analysis, employing Python (v. 3.12.1) for data processing and interpolation. The primary source of the data downloaded for this study was NASA's Giovanni Project (Giovanni is a NASA Goddard Earth Science Data and Information Services Centre (GES DISC) Distributed Active Archive Centre (DISC) web application that provides a simple, intuitive way to visualise, analyse, and access Earth science remote sensing data, particularly from satellites.

2.2. Net CDF data and spatial analysis shapefile

The data for the concentrations of O_3, CO, and CH_4 is from AIRS. And the data for the concentration of PM2.5 is from MERRA2. Each of the Net CDF files was processed and interpolated with each other, and then the programming script put the necessary data analysis in place (Python v.3.12.1).

The shapefile for Alagoas was collected from the Brazilian Geographics and Statistics Institute (IBGE) regarding the cities within the state region. Also, the mesoregions are defined in the same shapefile, and the proper analysis was again put in place.

2.3. Study area

The study region was Alagoas (NEB), and the information includes the population density and vehicle count. There are two main metropolitan regions: the Metropolitan Region of Maceió (MRM), which is the state's capital, and the Metropolitan Region of Agreste (MRA). They were highlighted due to their significant populations and potential impact on air quality.

As per the data from the Brazilian Institute of Geography and Statistics (IBGE), in 2022, Alagoas had a population of 3,127,683, with a population density of 112.38 inhabitants/km². The state, with a total of 1,034,187 vehicles, held the 22nd rank among the 27 states. The MRM Region, with a population of 1,330,291, had a GDP of BRL 37,110,902,374. The MRA Region, encompassing 15 municipalities, had a population of 508,073. This data provides a comprehensive demographic and economic snapshot of Alagoas and its regions.

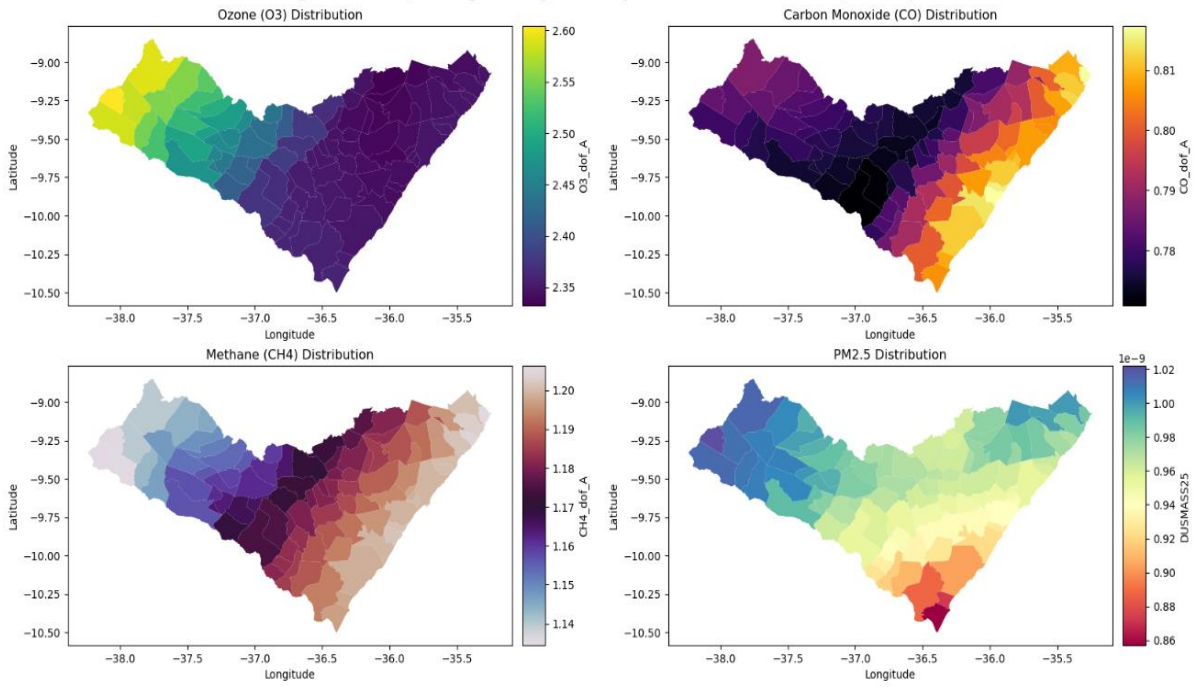
3. Results and discussion

3.1. Geographical dispersion

The geographical examination for the year 2022 (as depicted in Figure 1) shows unique patterns in the dispersion of air contaminants across Alagoas. It also emphasises the influence of urban and industrial discharges on the levels of CO and PM2.5.

This examination brings attention to areas of deep concern due to increased pollutant concentration, which could indicate the necessity for strategies designed for the air quality management of those specific regions (cities). Moreover, a side-by-side comparison with land observations validates the dependability of AIRS and MERRA2 data, notwithstanding minor inconsistencies, endorsing a combined surveillance approach (Gupta & Christopher, 2009).

Figure 1: Spatial distribution of pollutants (O_3, CO, CH_4 and PM2.5) in Alagoas, 2022



3.2. Comparison to Asian case studies

In a study conducted by Zhang *et al.* (2019), the spatial distribution and seasonal variation of air pollutants, including PM2.5, O_3, and NO_2, were analysed across various cities in China. This research utilised satellite data, ground station measurements, and air quality modelling to provide a comprehensive overview. The findings show a significant urban-rural gradient, with higher concentrations of pollutants in densely populated areas and industrial zones. This study highlights the critical role of anthropogenic emissions in air quality deterioration, as well as Alagoas, Brazil, albeit with a different pollutant profile due to varying industrial activities and vehicle densities.

Kim *et al.* (2020) focused on South Korea, examining the impact of transboundary pollution from mainland China on local air quality. Through satellite observations and atmospheric transport models, the study quantified the contributions of external sources to domestic pollution levels, particularly for PM2.5 and ozone. The research underscores the complexity of air pollution as a regional issue. This aspect of air quality management brings an additional layer of complexity not directly addressed in the Alagoas study, pointing towards the interconnectedness of air quality issues across borders.

4. Conclusion

This assessment and evaluation of the air quality in Alagoas, Brazil in comparison to Asia highlights the importance of utilising the satellite and reanalysis of the data for base analysis. It pinpoints the regions with heightened levels of pollutants, where O_3 and CH_4 exhibit a gradient from the coastline to the state's interior. This pattern is influenced by local phenomena and mesoscale circulation, contrasting with CO and PM2.5, which are directly linked to the dense presence of vehicles, industries, and agricultural activities.

Declaration of conflict of interest

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References

Abecasis, L., Gamelas, C. A., Justino, A. R., Dionísio, I., Canha, N., Kertesz, Z., & Almeida, S. M. (2022). Spatial distribution of air pollution, hotspots and sources in an urban-industrial area in the Lisbon metropolitan area, Portugal—a biomonitoring approach. *International Journal of Environmental Research and Public Health*, *19*(3), 1364. https://doi.org/10.3390/ijerph19031364

Duncan, B. N., Prados, A. I., Lamsal, L. N., Liu, Y., Streets, D. G., Gupta, P., ... & Ziemba, L. D. (2014). Satellite data of atmospheric pollution for US air quality applications: Examples of applications, summary of data end-user resources, answers to FAQs, and common mistakes to avoid. *Atmospheric environment*, *94*, 647-662. http://dx.doi.org/10.1016/j.atmosenv.2014.05.061

García-Burgos, J., Miquelajauregui, Y., Vega, E., Namdeo, A., Ruíz-Olivares, A., Mejía-Arangure, J. M., ... & McNally, R. (2022). Exploring the Spatial Distribution of Air Pollution and Its Association with Socioeconomic Status Indicators in Mexico City. *Sustainability*, *14*(22), 15320. https://doi.org/10.3390/su142215320

Gurney, K. R., Mendoza, D. L., Zhou, Y., Fischer, M. L., Miller, C. C., Geethakumar, S., du Can, S. D. L. (2015). High-resolution fossil fuel combustion CO2 emission fluxes for the United States. *Environmental Science & Technology, 43*(14), 5535-5541. https://doi.org/10.1021/es900806c

Gupta, P., & Christopher, S. A. (2009). Particulate matter air quality assessment using integrated surface, satellite, and meteorological products: A case study. Journal of Geophysical Research. Gupta, P., & Christopher, S. A. (2009). Particulate matter air quality assessment using integrated surface, satellite, and meteorological products: Multiple regression approach. *Journal of Geophysical Research: Atmospheres*, *114*(D14). https://doi.org/10.1029/2008JD011496

Kim, H., Kim, Y., Lee, S., Lee, H., Lee, J., Kim, S., Kim, S., Kang, J., & Cho, C. (2020). Transboundary Air Pollution in South Korea: An Analysis of Dust Transport Patterns and the Impact of Chinese Emissions. *Atmospheric Environment, 224*, 117357. https://doi.org/10.1016/j.atmosenv.2020.117357

Mollmann Jr., R. A., Silva Junior, R. S., Barros, H., Gomes, M. A. L. M. (2013). Estudo da dispersão de monóxido de carbono (CO) emitido através da queima de cana-de-açúcar, no estado de Alagoas. Revista Brasileira de Geografia Física, 6(03), 488-499. https://doi.org/10.5902/2179460X16230

Nunes, M. D., Mariano, G. L., Alonso, M. F. (2020). Variabilidade espaço-temporal da coluna total de ozônio e sua relação com a radiação ultravioleta na América do Sul. *Revista Brasileira de Geografia Física, 13*(05), 2053-2073. https://doi.org/10.26848/rbgf.v13.5.p2053-2073

Pope III, C. A., Ezzati, M., Dockery, D. W. (2009). Fine-particulate air pollution and life expectancy in the United States. *The New England Journal of Medicine, 360*, 376-386. https://doi.org/10.1056/NEJMsa0805646

Streets, D. G., Canty, T., Carmichael, G. R., de Foy, B., Dickerson, R. R., Duncan, B. N., Edwards, D. P., …, Wecht, K. J. (2013). Emissions estimation from satellite retrievals: A review of current capability. *Atmospheric Environment, 77*, 1011-1042. https://doi.org/10.1016/j.atmosenv.2013.05.051

Valappil, N. K. M., Hamza, V., Oliveira Júnior, J. F. (2022). Evaluation of daily average temperature trends in Kerala, India, using MERRA-2 reanalysis data: a climate change perspective. *Environmental Science and Pollution Research, 30*(10), 26663-26686. https://doi.org/10.1007/s11356-022-23895-9

Zhang, Q., Zheng, Y., Tong, D., Shao, M., Wang, S., Zhang, Y., … & Hao, J. (2019). Drivers of improved PM2.5 air quality in China from 2013 to 2017. *Proceedings of the National Academy of Sciences of the United States of America, 116*(49), 24463-24469. https://doi.org/10.1073/pnas.1907956116