

PM₁₀, NO₂ AND AIR TEMPERATURE ARE RELATED TO THE OCCURRENCE OF RESPIRATORY DISEASES IN THE CITY OF SÃO PAULO, BRAZIL

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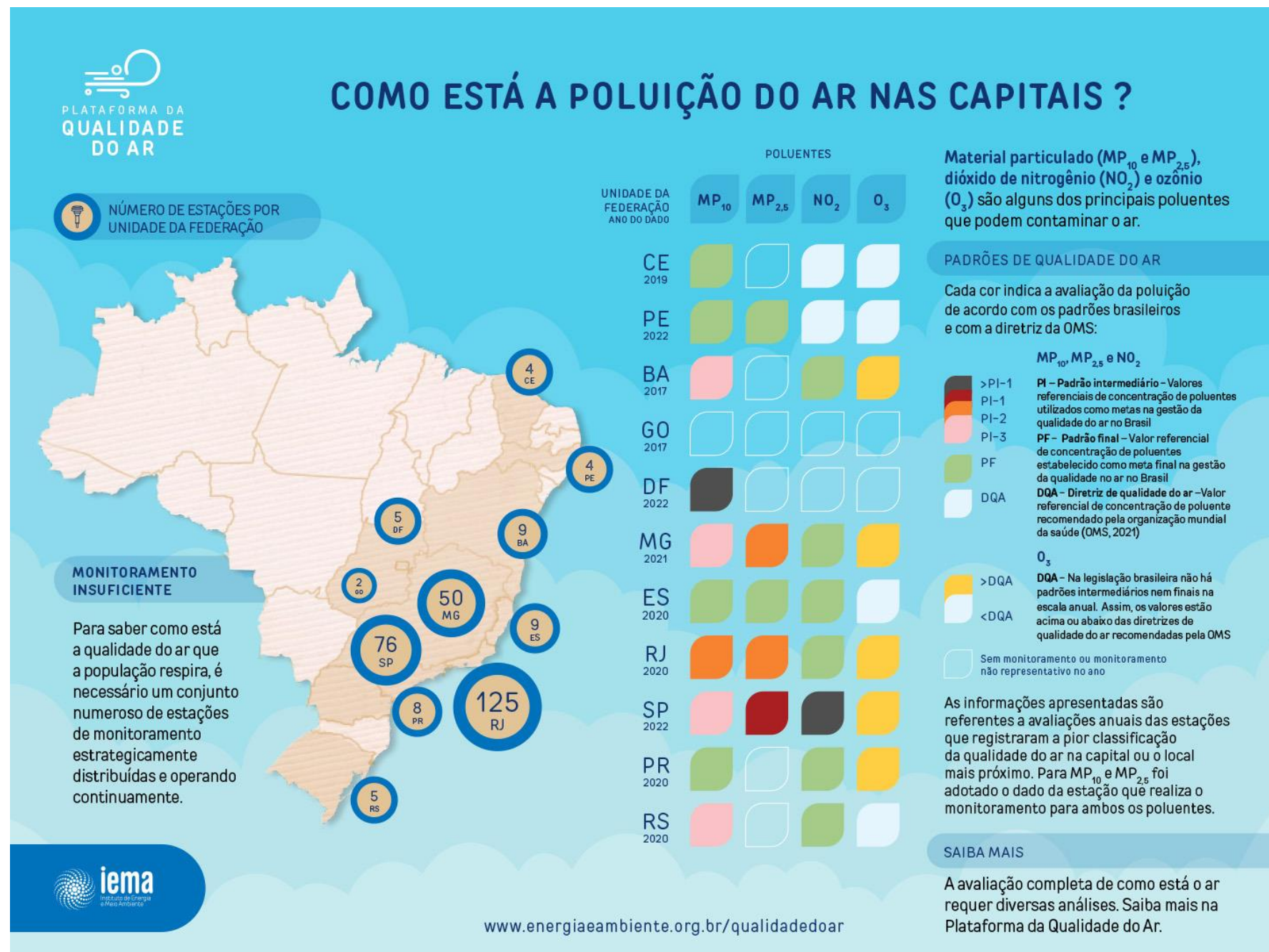
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INTRODUCTION

CAIPORA (*Aplicação de deep learning na epidemiologia Paisagística utilizando dados do DataSUS para previsão e análise espacial de doenças endêmicas e crônicas não transmissíveis no Brasil* - CAIPORA) is a project funded by the Brazilian National Council of Scientific and Technological Development (CNPq). The project was originally designed to be applied on the 26 capitals and 1 federal district to predict and evaluate the incidence of chronic and transmissible diseases. However, here only the city of São Paulo was investigated.

Figure 1. The diagram presents the air quality situation in the only Brazilian capitals where the air pollutants are monitored.



Source: Instituto de Energia e Meio Ambiente (IEMA).

The effects of air quality degradation on people's health have been the subject of research in São Paulo, Brazil, for decades. São Paulo has 11,4 million inhabitants (IBGE, 2024) and 9,7 million vehicles (Ministry of Transport, 2024) located in South America with constant air quality exceedances, despite the implemented policies and legislation to improve the air quality at the national and regional levels. Atmospheric pollutants, such as O₃, PM₁₀, and NO₂, have been highlighted to be related to the occurrence of respiratory diseases among children and adults, also provoking the aggravation of allergic diseases (Saldiva et al., 1994; Santana et al., 2024). This study investigates the relationship between atmospheric air pollutants, atmospheric meteorological variables, and respiratory diseases in 3 age groups (children, adults, and older adults) from 2004 to 2024 in São Paulo.

Figure 2. Caipora webpage with the available data and prediction model.



Source: <https://www.portalcaipora.org/>

METHODOLOGY

All disease data used in this study were collected from the DataSUS website (<https://datasus.saude.gov.br/>), a Brazilian Ministry of Health repository to São Paulo Municipality. The data were divided into three age groups: Children (0 - 14 years), Adults (15 - 59 years), and Older Adults (60 years or older), Figure 3.

The incidence rate ratio (IRR) was estimated using a univariate negative binomial regression. The IRR was chosen to investigate the relationship between the number of weekly hospitalizations to each age group (children, adults, and older adults) and the Mean, Median, and Maximum values of Air Temperature (T in °C), Relative Humidity (RH in %), the hourly mass concentration of PM₁₀, PM_{2.5}, NO₂, SO₂, and O₃ in µg m⁻³. The pollutants and meteorological variables were used as independent variables. The negative binomial regression model initially included all variables. Variables with a p-value greater than 0,01 were removed using manual backward stepwise elimination. Finally, the model was created based on the most relevant variables. The period from January 2004 to September 2024 was used for the analyses.

Figure 3. Data and results workflow diagram.

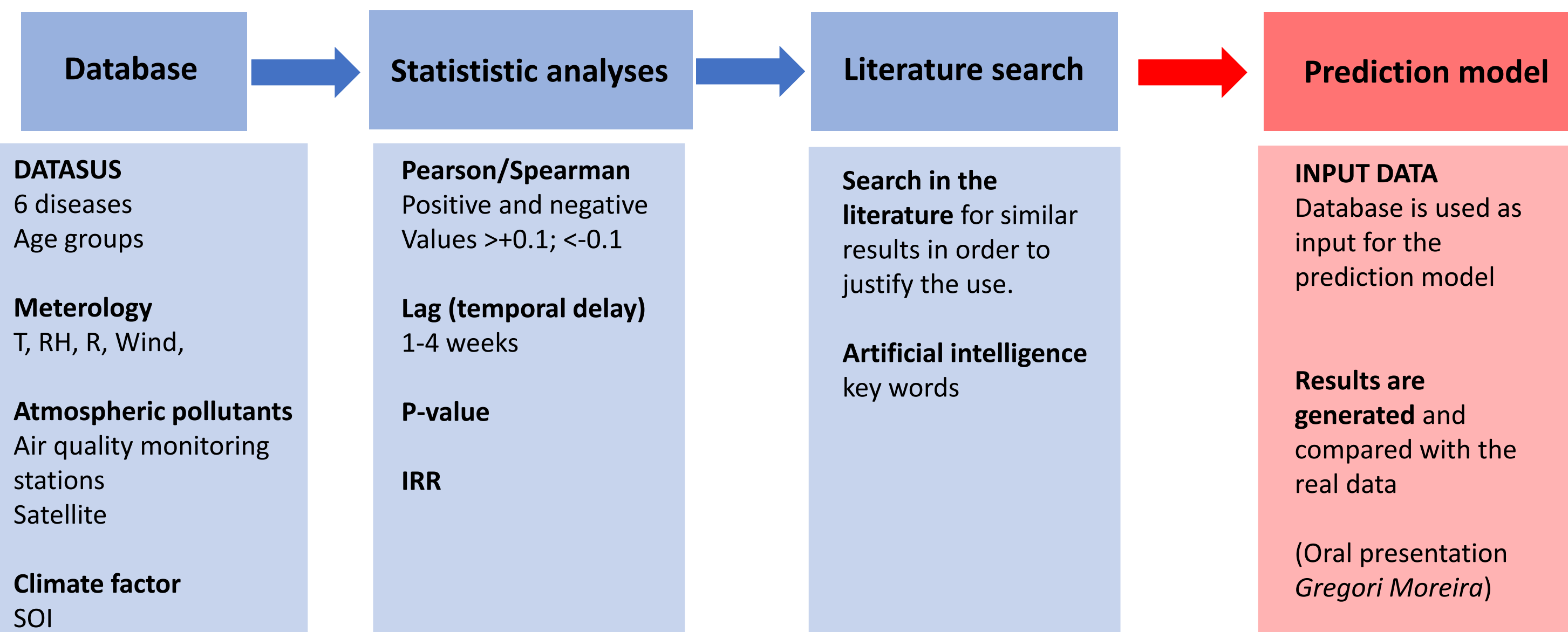
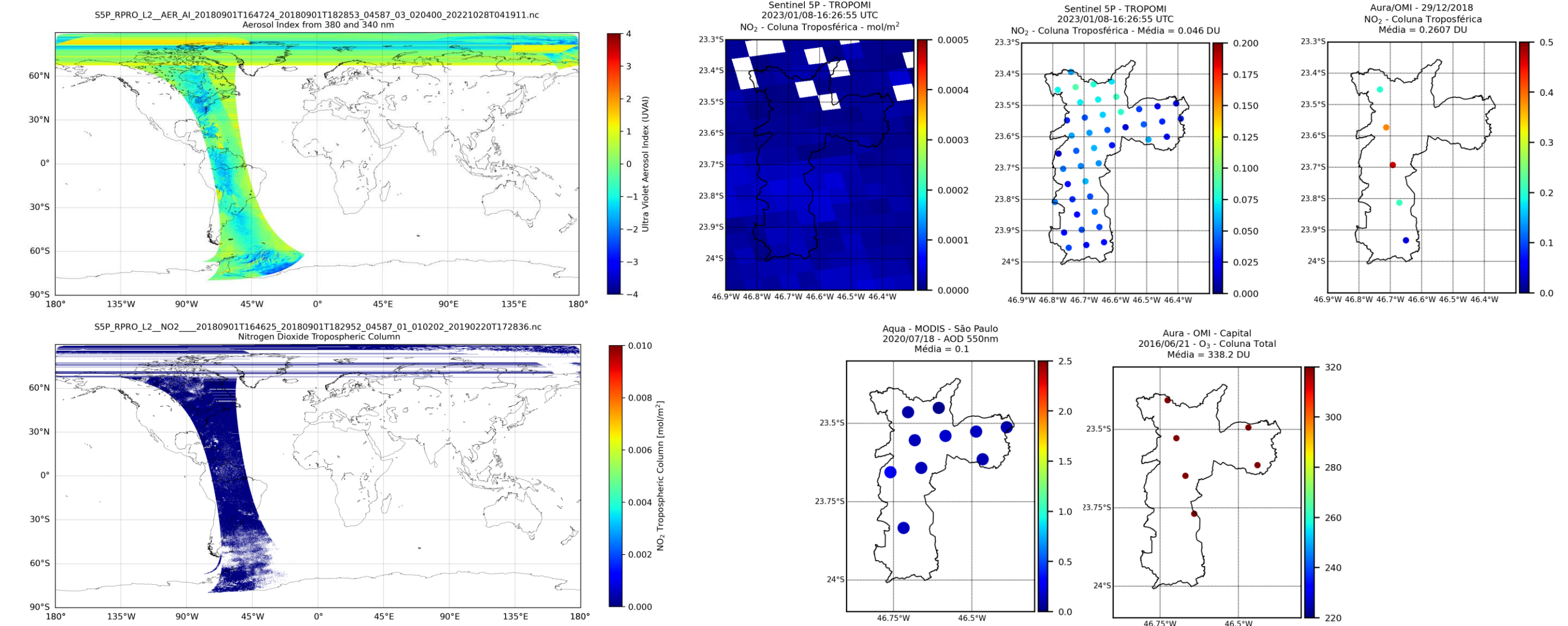


Figure 4. Satellite data of gases (O₃, NO₂), AOD (550 nm) and other parameters for the city of São Paulo. TROPOMI: 2008–2024. Aqua, Terra (MODIS), Sentinel 5-P (TROPOMI) and Aura (OMI).



RESULTS AND DISCUSSIONS

The results from the univariate negative binomial regression indicate that among the children age group, the variable with the largest IRR was the mean air temperature (IRR=1,07; 95% CI, Table 1). These results suggest that an increase of 1 °C in the mean air temperature resulted in a 7% increase in respiratory diseases among the children in the city of São Paulo in the period analyzed. In addition, the variables mean PM₁₀ and NO₂ were identified among the most relevant atmospheric pollutants for the occurrence of respiratory diseases in children at São Paulo with IRR values of 1,02 and 1,01, respectively. Among the adult age group, the median PM_{2.5} and the mean NO₂ were identified with p-values smaller than 0,01 and IRR=1,01 for both pollutants. Finally, among the older adults, the IRR value for respiratory diseases was 1,01 for the median PM_{2.5} pollutant variable.

Table 1. Incidence Rate Ratio [95%CI] of respiratory diseases in São Paulo Municipality for children, adults, and older adults age groups.

Age group	Variable	IRR	95% CI
Children	T _{median}	1,07	1,05-1,09
	PM ₁₀ , mean	1,02	1,00-1,04
	NO ₂ , mean	1,01	1,00-1,01
Adults	PM _{2.5} , median	1,01	1,00-1,01
	NO ₂ , mean	1,01	1,00-1,01
	PM _{2.5} , median	1,01	1,00-1,01

Table 2. Parallel studies with other diseases and variables in São Paulo.

R or S (Variable vs disease)	Global radiation	O ₃ (satellite)	BC _{anthr}	OC _{anthr}	T
Acute bronchitis	0.48	0.47	0.12	0.15	-0.18
Bronchitis+ bronquitis	0.10	0.13	0.51	0.51	-
Chikungunha	0.27	-0.33	-0.10	0.38	0.37
Bronchiectasis	-	0.13	0.20	0.20	-

FINAL CONSIDERATIONS

- ✓ The results indicate that air quality degradation remains an issue in São Paulo even after decades of implemented public policies.
- ✓ Pearson correlation and Spearman analyses between single variables suggested low and moderate relationship.
- ✓ The median air temperature increase might be a concern in the current and future warning climate, especially among children, who are particularly vulnerable to respiratory problems due to their developing lungs. Therefore, the policymakers must focus on specific legislation and practices for this age group.
- ✓ Air quality continuous monitoring is crucial for tracking pollutant levels and implementing effective regulations. Nevertheless, policies to drastically reduce the vehicle fleet and to improve the public transportation are urgent and will provide co-benefits for climate initiatives, addressing two major problems simultaneously.
- ✓ Lack of data coverage (air pollution and DATASUS) represent a major obstacle to obtain results in other capitals.

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