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Spatial-temporal heterogeneity of air pollution and its relationship with meteorological factors in the Pearl River Delta, China

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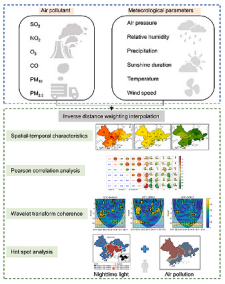
HIGHLIGHTS

- The mean SO_2 concentration decreased from 52.4 μg/m^3 in 2006 to 7.8 μg/m^3 in 2019.
- The O_3 concentration increased with a Sen's slope of 0.649 μg m^{-3}·year^{-1}.
- The time-frequency relationship between $PM_{2.5}$ and meteorological factors was explored by wavelet coherence.
- Higher air pollution was detected in regions with higher night-time brightness.

GRAPHICAL ABSTRACT



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ABSTRACT

Analyzing the distribution of air pollution and its influencing factors is critical for regional air pollution prevention and control. This study takes the Pearl River Delta (PRD) as a study area, analyzes the spatial-temporal changes in air pollution (including sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), carbon monoxide (CO), and particles with an aerodynamic diameter less than 10 μm (PM_{10}) and less than 2.5 μm ($PM_{2.5}$)) from 2006 to 2019, and explores the relationship between air pollution and meteorological factors. The results showed that (1) most air pollutant concentrations decreased from 2006 to 2019, with the most obvious change being the decrease in the SO_2 concentration from 52.4 μg/m^3 to 7.8 μg/m^3. The O_3 concentration increased, with a Sen's slope of 0.649 μg m^{-3}·year^{-1}. Air pollution was lower in coastal areas (Shenzhen and Huizhou) than in inland areas (Foshan and Zhaoqing), affected by ocean atmospheric transmission, and coastal areas had the cleanest air quality. (2) Air pollutants had high correlations with air pressure, relative humidity, precipitation, and temperature. The most serious air pollution was found in winter, which was partially due to the meteorological conditions in winter that were more unfavorable for pollutant dispersion and dilution than were the conditions in other seasons. (3) Through the wavelet coherence method, an interesting finding revealed that other air pollution and meteorological factors exhibited complex period-dependent characteristics that were significantly related to $PM_{2.5}$. Areas with less air pollution were more susceptible to meteorological factors. (4) The overlapping area of the $PM_{2.5}$ distribution hotspot and nighttime light hotspot was mainly in Foshan and Guangzhou, representing approximately 12.1% of the study area. Our work contributes to the literature by considering seasonal and timescale-dependent characteristics of meteorological factors affecting air pollutant emissions, and it provides new insights into recognizing regions that need to prioritize urban air pollution control based on hotspot analysis.

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