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EXTENDED ABSTRACT

Impact of multi-scale aerosol sources on air quality in Changchun, northeast China

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Abstract: The air quality in Changchun is influenced by diverse aerosol sources, including industrial emissions, traffic-related pollution, biomass burning smoke, and long-range transport of mineral dust. These pollutants interact across regional, urban, and apartment scales, necessitating a comprehensive study of their dynamics, modeling, and interconnections. However, the synergistic effects of pollution processes at these scales remain insufficiently understood. At the regional scale, Changchun's atmosphere is significantly affected by the transport of coarse aerosols from the Gobi and Taklamakan deserts, particularly in spring. Additionally, fine particulate matter from agricultural biomass burning contributes to pollution episodes in spring and autumn. At the urban scale, emissions from industrial activities and heavy vehicular traffic exacerbate pollution levels, often reaching intensities comparable to dust storms and smoke plumes, especially under stagnant atmospheric conditions during anticyclonic events. At the apartment scale, localized ventilation inefficiencies in residential buildings further degrade indoor air quality, directly impacting urban residents. To investigate these multi-scale interactions, including their mutual amplification, overlapping effects, and individual contributions, we deployed an enhanced monitoring network. This includes: (1) AirVisual (IQAir) and PurpleAir sensors for high spatial-temporal resolution PM_{2.5} and PM₁₀ measurements (both indoors and outdoors); (2) a newly operational by our team AERONET sun-lunar-sky photometer (Changchun_JLU station) for detailed aerosol characterization. Using this equipment data, as well as GEOS-Chem for aerosol atmospheric transport modeling and HYSPLIT for back-trajectory analysis, we aim to: (1) quantify the contributions of dust storms, biomass burning, and anthropogenic emissions; (2) model pollution dispersion pathways; (3) develop targeted mitigation strategies to reduce aerosol exposure for urban populations. This integrated approach is discussed. That could help with advance the understanding of multi-scale air pollution dynamics and support evidence-based policy interventions.

Key words: aerosol, AERONET, dust storm, GEOS-Chem, particulate matter (PM)

Introduction

Atmospheric aerosols are particles that impact both human life quality and the radiation balance. Although many studies have been carried out on the parameters of aerosol pollution in the atmosphere over China, these works are mainly concentrated in the central part of China and the southern regions. However, a few aerosol studies in detail have been

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conducted in the northeast China region, and particularly in Jilin Province and in Changchun city (Zhao et al., 2019; Duanmu et al., 2023).

Air quality in Changchun city, northeast China, shaped by complex interactions among diverse aerosol sources, including industrial emissions, traffic-related pollutants, biomass burning smoke, and long-range mineral dust transport (Zhang et al., 2020; Chen et al., 2022). These pollutants operate across regional, urban, and residential scales, creating synergistic effects that remain poorly quantified. To address this gap, we integrate multi-platform observations (AERONET and low-cost sensors) with high-resolution modeling (GEOS-Chem) to unravel the city's pollution dynamics and inform targeted mitigation strategies. The aerosol property data are now accessible through the newly installed by our team the sun-lunar-sky CE318-TS9 photometer at the AERONET Changchun_JLU site. We also are monitoring in situ the PM₁, PM_{2.5}, and PM₁₀ aerosols in two city regions using the IQAir, PurpleAir and Airgradient low-cost sensors.

This study aims to: (1) quantify contributions and frequency of dust storms, biomass burning, and anthropogenic emissions to Changchun's aerosol load; (2) model dispersion pathways using GEOS-Chem to identify pollution hotspots and transport mechanisms; (3) study mitigation strategies (e.g., emission controls, urban planning) to reduce exposure risks.

Instruments, data and model

To investigate the multi-scale air pollution dynamics, including their mutual amplification, overlapping effects, and individual contributions, we deployed an enhanced monitoring network. This includes: (1) a newly operational by our team AERONET sun-lunar-sky photometer (Changchun_JLU site) for detailed aerosol characterization; (2) AirVisual (IQAir), PurpleAir sensors and the Airgradient monitors for high spatial-temporal resolution PM_{2.5} and PM₁₀ measurements (both indoor and outdoor). We use this equipment to study the atmospheric aerosol properties, distribution, transport and local sources. The AERONET Changchun_JLU station has been established in October 2024, which is providing detailed data on atmospheric aerosols parameters in this region, enabling high-precision, long-term aerosol monitoring including both day and night observations. Complementary data on PM concentrations in three sites in Changchun located in three different regions of the city come from the IQAir, PurpleAir and Airgradient sensors.

To provide an analysis of the sources, transport and aerosol types distribution over northeast China, and over Changchun city, we use the GEOS-Chem model (<http://www.geos-chem.org>). GEOS-Chem is a global three-dimensional atmospheric chemical transport model jointly developed by Harvard University and multiple research institutions, aimed in simulating the physical and chemical processes of atmospheric components and their spatiotemporal distribution. GEOS-Chem provides modeled

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concentrations of atmospheric components, offering the context for interpreting aerosol observations in Changchun.

Results

For this study we use the sun-lunar-sky photometer measurements taken from November 2024 till July 2025. The daily averaged aerosol optical depth (AOD) and Ångström Exponent (AE) measurements are shown in Figure 1a.

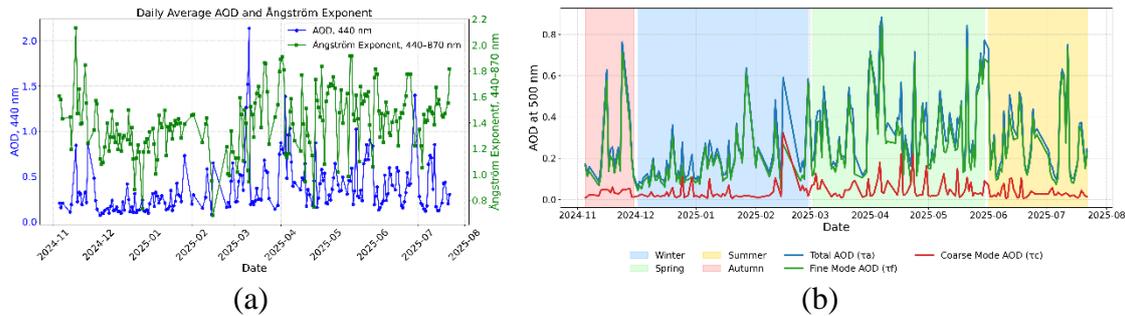


Figure 1. (a) Daily averaged AOD 440 nm and Ångström Exponent, (b) AOD 500 nm with highlights of seasons.

The data shows apparent seasonal variations in aerosol properties, with increased changes in spring and early summer 2025 (see Figure 2). Higher AOD and Ångström Exponent values suggest an increase in fine aerosol particles during this period. The AOD 500 nm values vary both during the day and at night, with higher daytime levels observed in March and April 2025 (see Figure 1b). Fine mode aerosols dominate throughout the period, especially in spring, indicating a higher presence of small particles (e.g., from urban pollution or biomass burning).

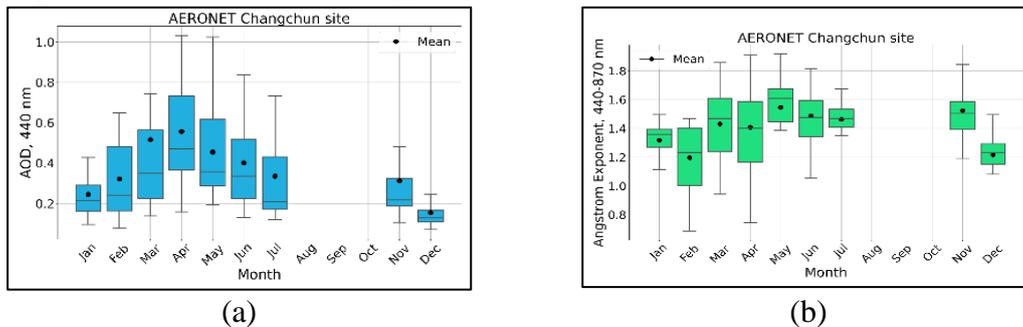


Figure 2. (a) AOD 440 nm and (b) Ångström Exponent seasonal patterns.

Coarse mode AOD remains low across all seasons, with minor increases in late winter and spring. The daily averaged data show a noticeable increase in AOD values starting in March (Figures 1, 2). Peaks in February and May reflect episodes of elevated aerosol concentration. AE values peak between March and June, especially in March and May, pointing to the enhanced presence of fine aerosols during spring. For aerosol types classification by AOD and Ångström Exponent values we used the criteria proposed in the paper by Yu et al. (2022). According to this classification in Changchun most aerosol amount is urban pollution with episodes of biomass burning and mineral dust events. Seasonal variation in aerosol types using all AERONET Changchun_JLU data allows to

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separate aerosol load by types/seasons. In winter mixed/other aerosols and urban pollution dominate (60%) while biomass burning aerosol is minimal (Figure 3).

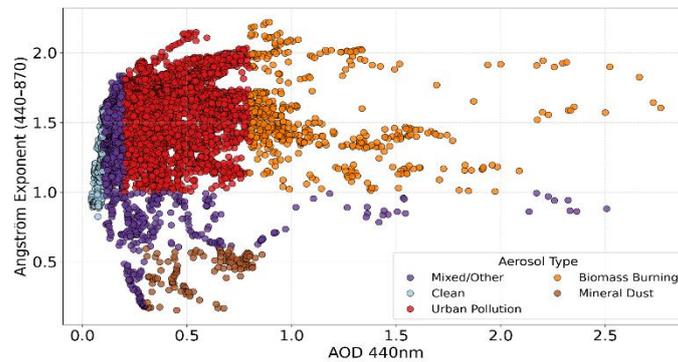


Figure 3. Aerosol types classification by AOD and Ångström Exponent.

In spring urban pollution is significant, biomass burning is notable and dust is present as well indicating frequent dust storm conditions. In summer mixed/other and urban pollution are the main aerosol types (85%) with a small part of biomass burning. In autumn aerosols of mixed/other types, along with urban pollution, dominate (70%), and no dust is detected.

Discussion and conclusions

Based on our measurements of aerosols in the atmosphere above Changchun, the pollution situation in the city is a mixture of various factors. The predominant aerosol pollution is urban pollution caused by intensive car traffic, which has virtually no seasonal fluctuations, as well as the industrial activity, the emissions of which can be assumed based on daily changes in PM, are periodic and dependent on the days of the week (there is a difference between working days and weekends).

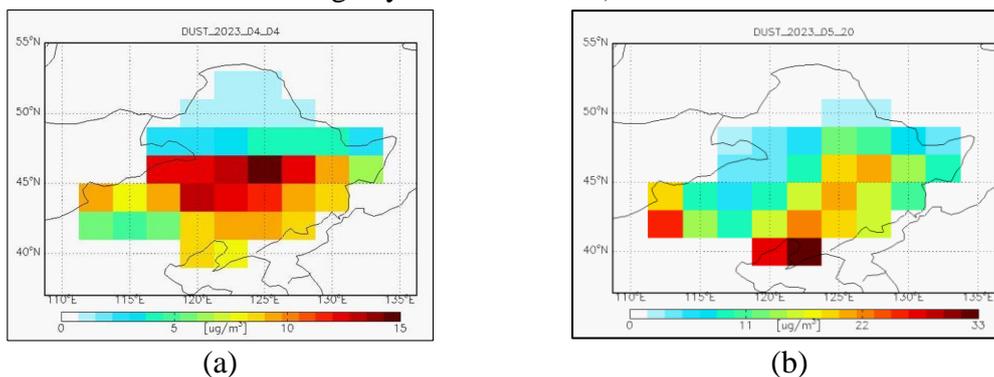


Figure 4. CEOS-Chem modelling dust aerosol distribution in northeast China in two dust storm events on (a) April 4 and (b) May 20, 2023.

Also, significant factors affecting aerosol pollution in the city are periodic events associated with the transfer of aerosols from biomass burning and dust storms (see Figure 4), which significantly (3–5 times) worsen air quality, and these deteriorations last from one to three days. At the regional scale, in Changchun's atmosphere the springtime coarse aerosols events from the Gobi and Taklamakan deserts are dominant. GEOS-Chem

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modelling successfully captured the spatial distribution and intensity of major dust events in Changchun city and northeast China (Figure 4). AERONET data shows that biomass burning in spring/autumn contributes fine particulate matter (PM_{2.5}), exacerbating regional haze (Figure 1b). The findings using low-cost PM sensors reveal temporal variations in aerosol composition that reflect changes in atmospheric conditions, differences between outdoor and indoor concentrations, and shifts in their sources. Concentrations of PM_{2.5}, and PM₁₀ generally increased from summer to winter, with peak values observed between November and February with the strongest day–night contrast in PM₁₀ due to coarse particle resuspension. At the residential scale, poor ventilation in apartments traps pollutants, leading to indoor PM_{2.5} levels that often 5–10 times exceed outdoor concentrations, directly impacting public health. By coupling ground-based monitoring (AERONET for columnar aerosols, low-cost sensors for hyperlocal data) with atmospheric chemistry modeling, we cover the gap between observations and models. This framework advances understanding of multi-scale pollution interactions and supports evidence-based policy for cleaner air in Changchun city and other cities in northeast China. This policy should regulate and reduce emissions from industrial enterprises, promoting the total use of electric cars in transport. At the residential level, it is necessary to reconstruct the ventilation systems of old houses and take this problem into account when building new ones.

References

- Chen, W., Duanmu, L., Qin, Y., Yang, H., Fu, J., Lu, C., Feng, W., Guo, L. (2022). Lockdown-induced Urban Aerosol Change over Changchun, China During COVID-19 Outbreak with Polarization LiDAR. *Chin. Geogr. Sci.* 32, 824–833. <https://doi.org/10.1007/s11769-022-1303-3>.
- Duanmu, L., Chen, W., Guo, L., Yuan, Y., Yang, H., Fu, J., Song, G., Xia, Z. (2023). Vertical Profiles of Aerosols Induced by Dust, Smoke, and Fireworks in the Cold Region of Northeast China. *Remote Sensing*, 16(6), 1098. <https://doi.org/10.3390/rs16061098>.
- Zhang, M., Zhang, S., Bao, Q., Yang, C., Qin, Y., Fu, J., Chen, W. (2020). Temporal Variation and Source Analysis of Carbonaceous Aerosol in Industrial Cities of Northeast China during the Spring Festival: The Case of Changchun. *Atmosphere*, 11, 991. <https://doi.org/10.3390/atmos11090991>.
- Zhao, H., Ma, Y., Wang, Y., Wang, H., Sheng, Z., Gui, K., Zheng, Y., Zhang, X., Che, H. (2019). Aerosol and gaseous pollutant characteristics during the heating season (winter–spring transition) in the Harbin-Changchun megalopolis, northeastern China. *Journal of Atmospheric and Solar-Terrestrial Physics*, 188, 26–43. <https://doi.org/10.1016/j.jastp.2019.03.001>.
- Yu, F., Luo, G., Nair, A. A., Tsigaridis, K., Bauer, S. E. (2022). Use of machine learning to reduce uncertainties in particle number concentration and aerosol indirect radiative forcing predicted by climate models. *Geophysical Research Letters*, 49, e2022GL098551. <https://doi.org/10.1029/2022GL098551>.