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


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## Abstract


Changchun is affected by multi-scale interactions of dust storms, biomass burning, industrial activity, and traffic emissions. At the same time, indoor air is further influenced by factors such as ventilation efficiency and the infiltration of pollutants. This work advances understanding of aerosol behavior and supports evidence-based strategies for the aerosol pollution exposure reduction.


## Instruments

In autumn 2024, the AERONET station in Changchun, Jilin University, was installed. It is equipped with a sun-lunar-sky photometer, allowing for high-precision, long-term aerosol monitoring.

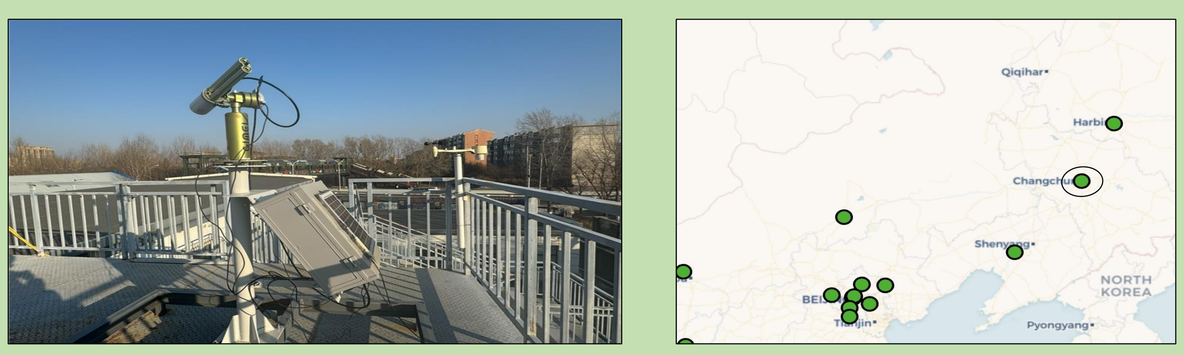
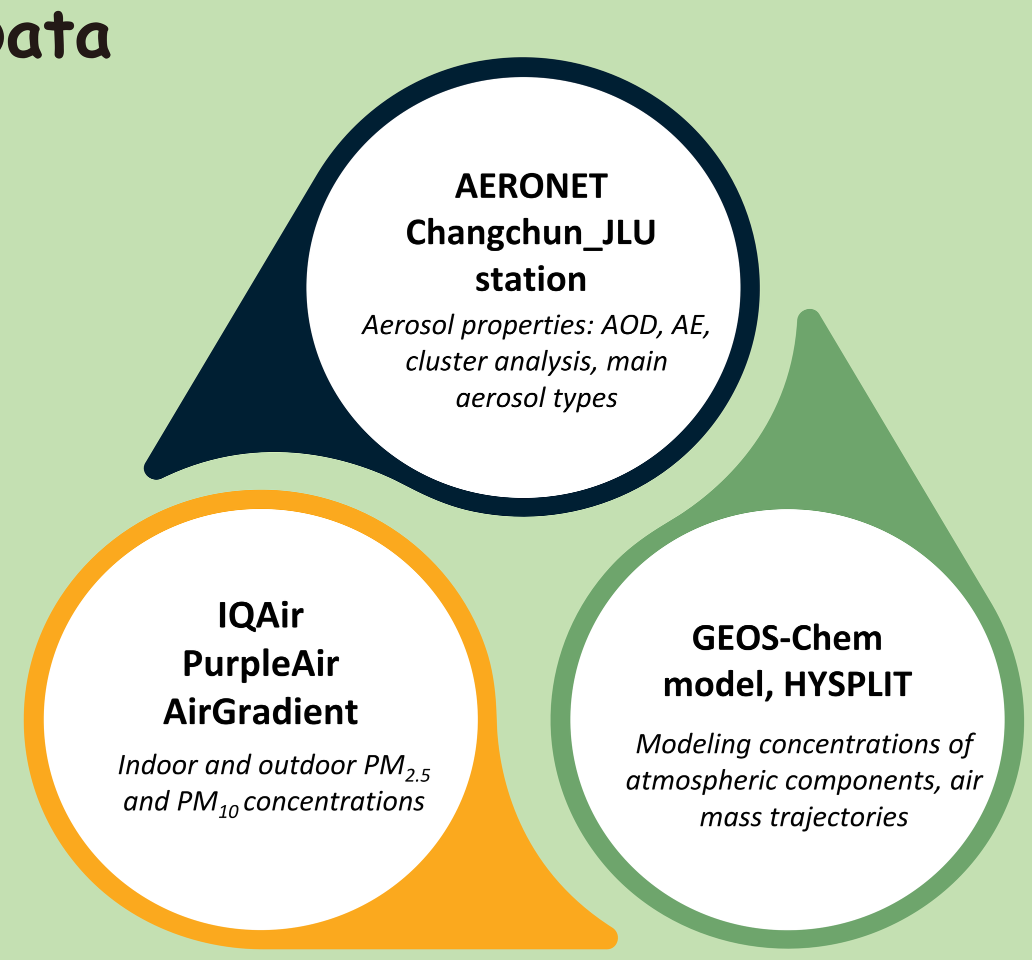


*Fig. 1. AERONET Changchun_JLU station in Changchun*

Complementary data on PM concentrations come from the AirVisual, PurpleAir and AirGradient networks. Aerosol sources, transport, and distribution over northeast China and Changchun are analyzed with GEOS-Chem, a global 3D chemical transport model simulating atmospheric processes and their spatiotemporal variability.

## Data




## Results

### 1. AERONET observations

The data shows clear seasonal variations in aerosol properties, with increased load in spring and early summer 2025 (see Fig. 2). Higher AOD and Ångström Exponent values suggest a rise in fine aerosol particles during this period.

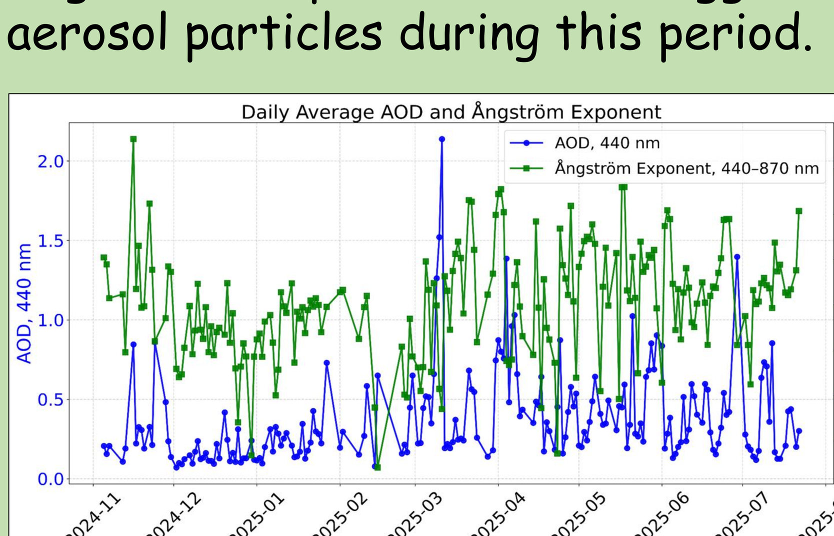



*Fig. 2. Daily values of Aerosol Optical Depth (AOD, 440 nm) and Ångström Exponent (AE, 440–870 nm) in 2024–2025*

The daily data show a noticeable increasing in AOD on March (see Fig 3). Peaks in April and May reflect episodes of elevated aerosol concentration. AE values peak between March and June, especially in April and May, pointing to enhanced presence of fine aerosols during spring (see Fig 4).

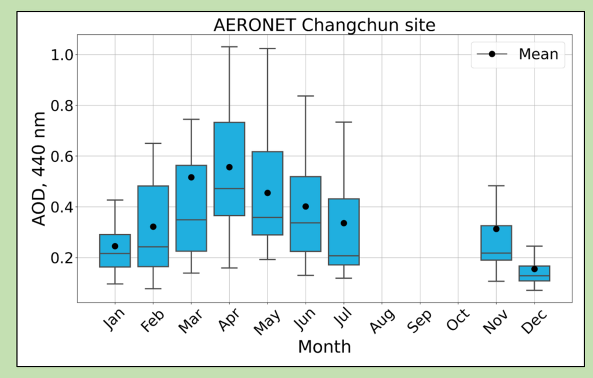



*Fig. 3. Monthly variations of AOD at 440 nm*

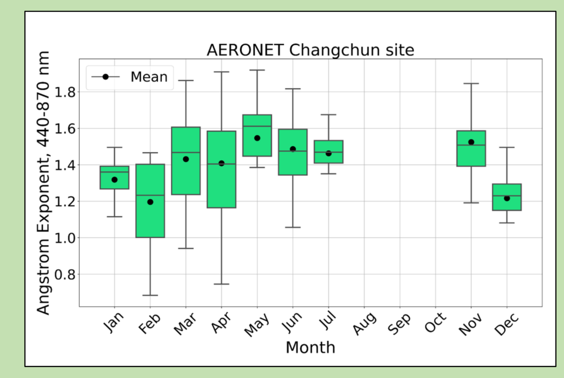



*Fig. 4. Monthly variations AE at 440-870 nm*

Figure 5 shows that urban pollution and biomass burning are associated with higher AE values, indicating dominance of fine particles. Mineral dust events are characterized by lower AE and higher AOD values, reflecting coarse particle contribution.

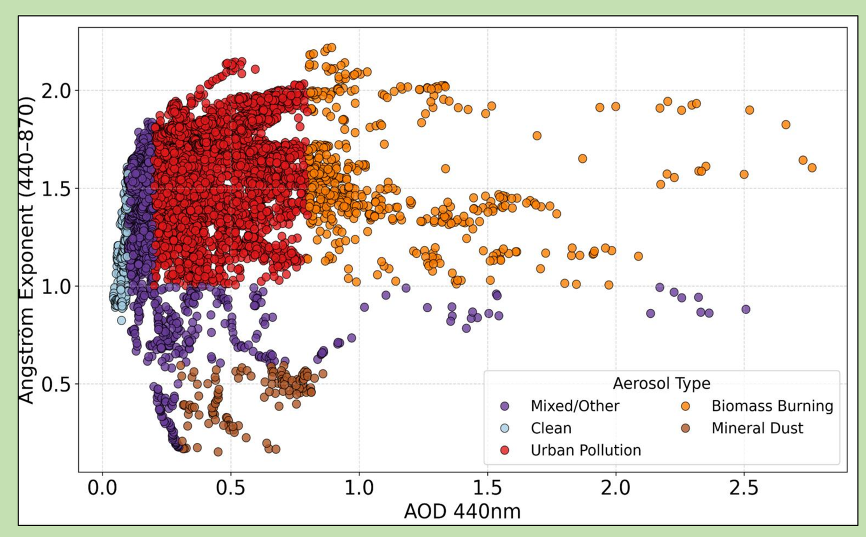



*Fig. 5. Aerosol classification based on AOD (440 nm) and AE (440–870 nm)*

Aerosol types vary seasonally: winter shows mixed, polluted, and dusty conditions; spring highlights urban pollution and biomass burning; summer and autumn are dominated by mixed aerosols, with cleaner air most frequent in autumn (see Fig. 6).

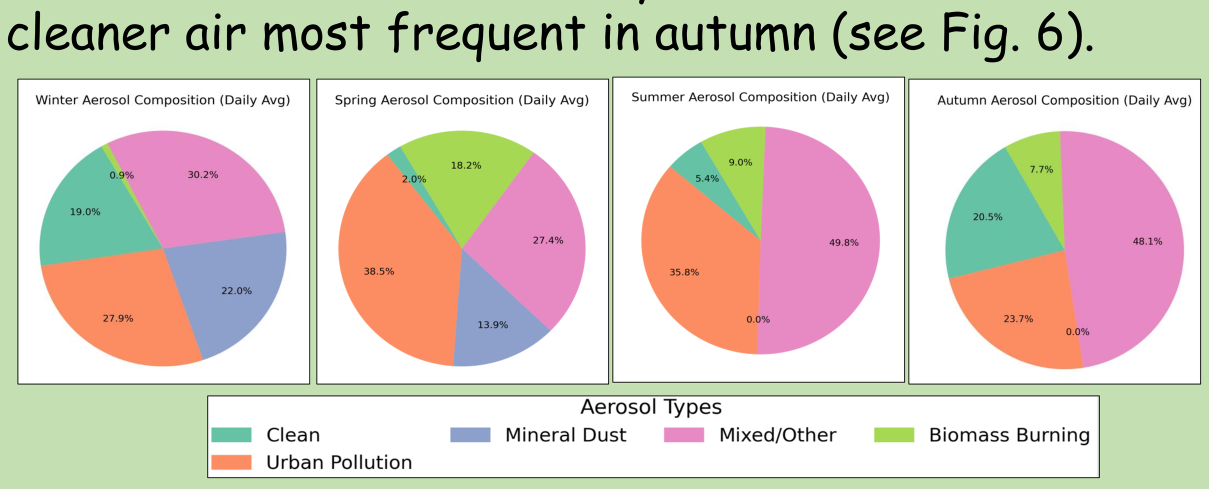



*Fig. 6. Seasonal variations in aerosol types (daily averaged data)*

### 2. HYSPLIT back trajectories

The backward trajectories in Figure 7 demonstrates that in winter and autumn northwesterly flows are dominated linked to continental sources bringing dust storm events, while spring shows mixed transport pathways with additional input from the southwest. In contrast, summer is characterized by stronger southeasterly influence, suggesting contributions from marine or regional sources.

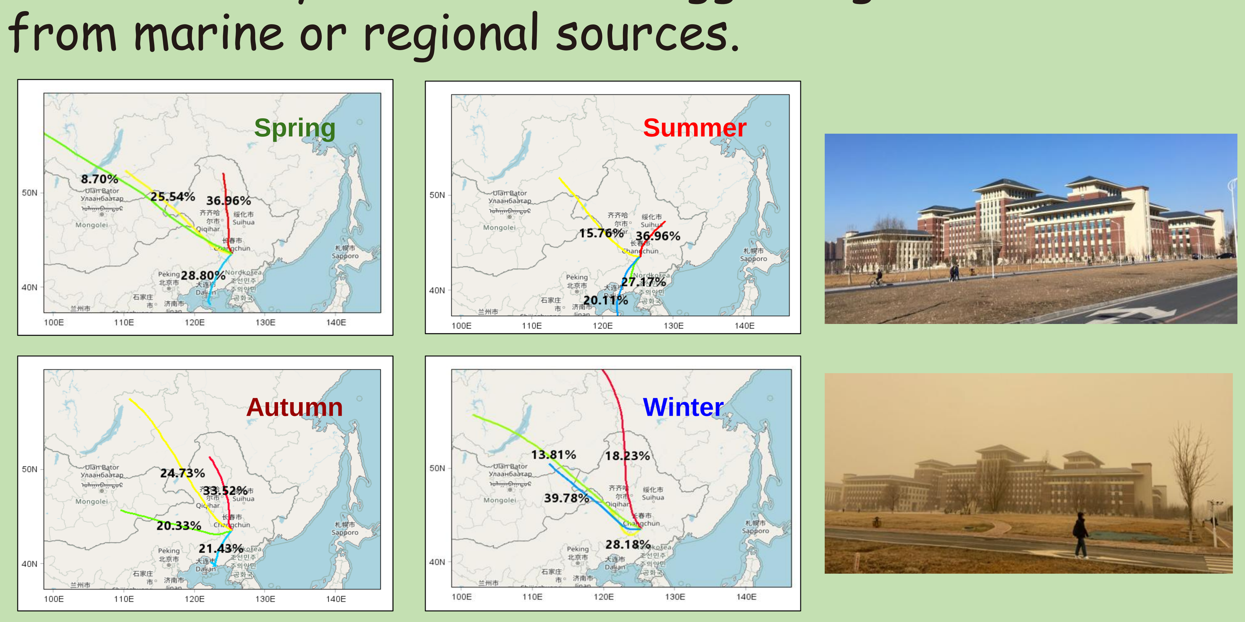



*Fig. 7. 48h backward trajectories in Changchun 2023 – 2024 (500 m) and dust storm event view*

### 3. IQAir, AirGradient and PurpleAir sensors PM monitoring in Changchun

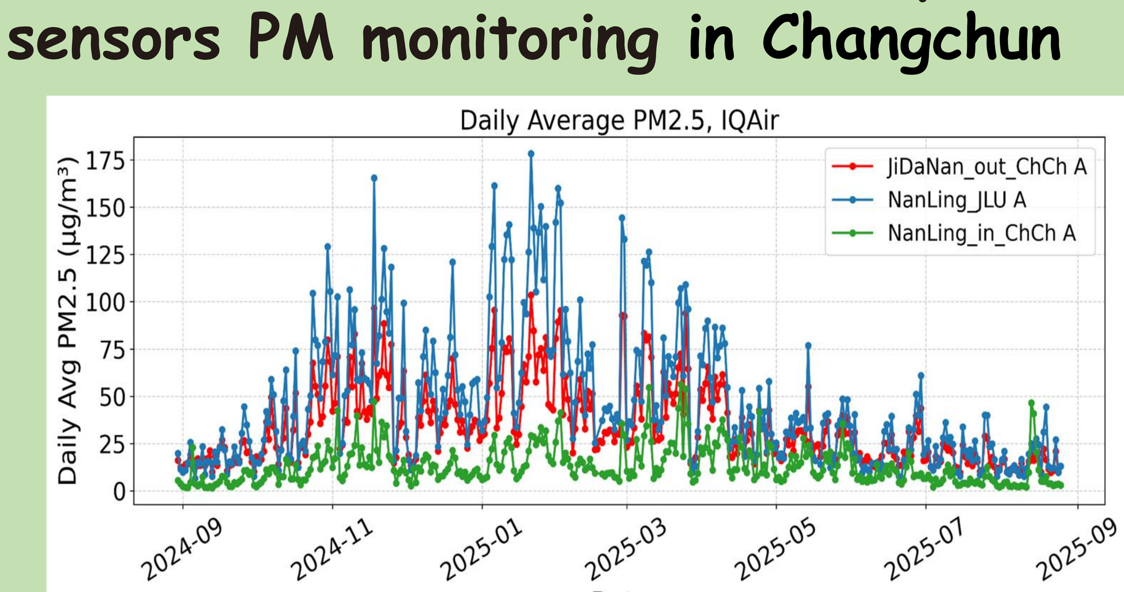



*Figure 8. Daily mean PM2.5 concentrations, IQAir sensors*

Daily averages of PM2.5 across three IQAir monitoring sites (NanLing Outdoor, JiDaNan Outdoor, NanLing Indoor) in one year period. Clear seasonal cycle is evident: wintertime PM2.5 reaches 100–180 µg/m³ outdoor, while summer values are typically < 40 µg/m³ outdoors and < 20 µg/m³ indoor. Indoor measurements consistently demonstrate lower exposure levels compared with outdoor environments with high PM2.5 spikes.

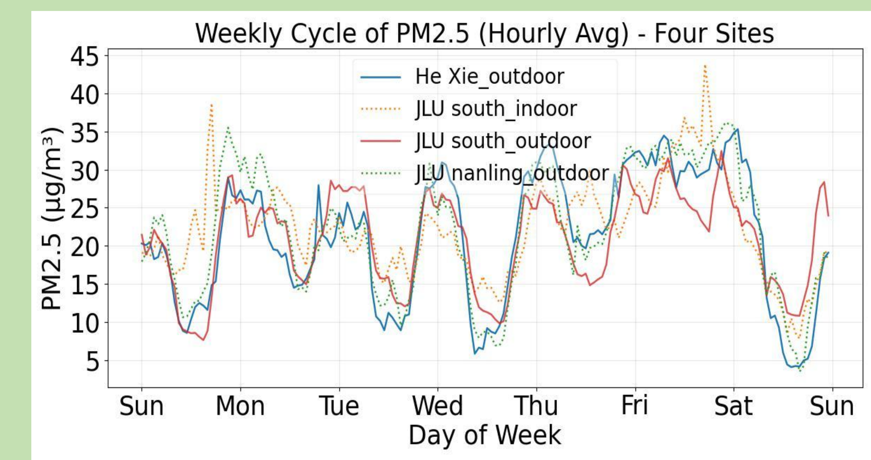



*Fig. 7. Weekly cycle of PM2.5 (hourly mean), AirGradient*

Mean diurnal–weekly cycle of PM2.5, aggregated across the entire observation period. Outdoor stations show enhancing values on weekend. Indoor averaged concentrations remain low (~10–20 µg/m³) with increasing in weekend mainly.

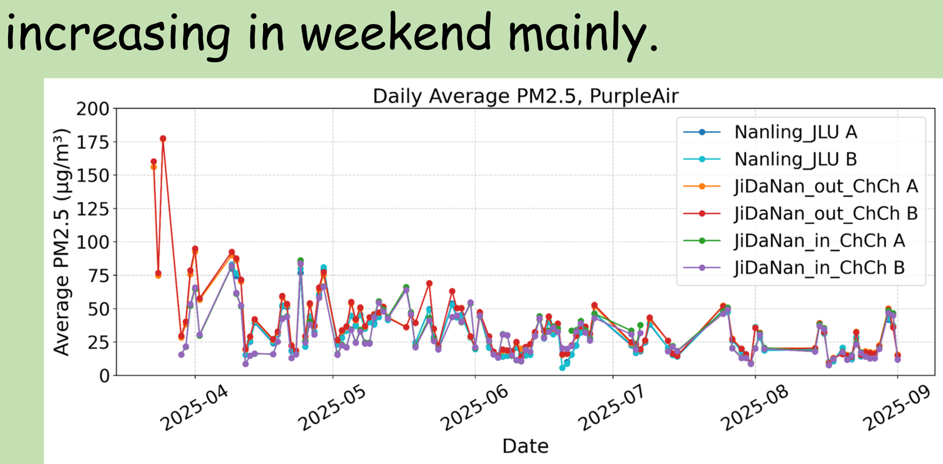



*Fig. 8. Daily average PM2.5 in Changchun from PurpleAir sensors*

Daily averages smooth short-term fluctuations and indicate an overall decline in concentrations after April 2025 corresponded to seasonal behavior.

Big problem with indoor contamination due to a luck of the ventilation efficiency (Fig. 9).

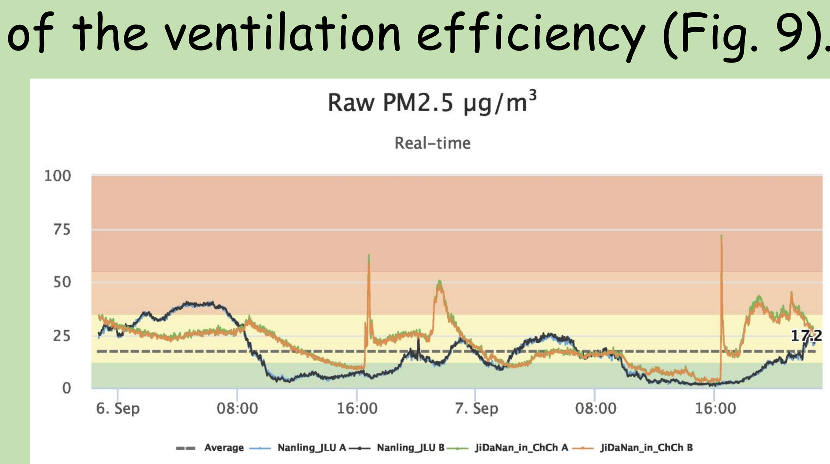



*Fig. 9. Indoor extreme spikes, PurpleAir*

### 4. GEOS-Chem dust storm modeling

GEOS-Chem modelling successfully captured the spatial distribution and intensity of major dust events in Changchun that is seen in spring mainly.

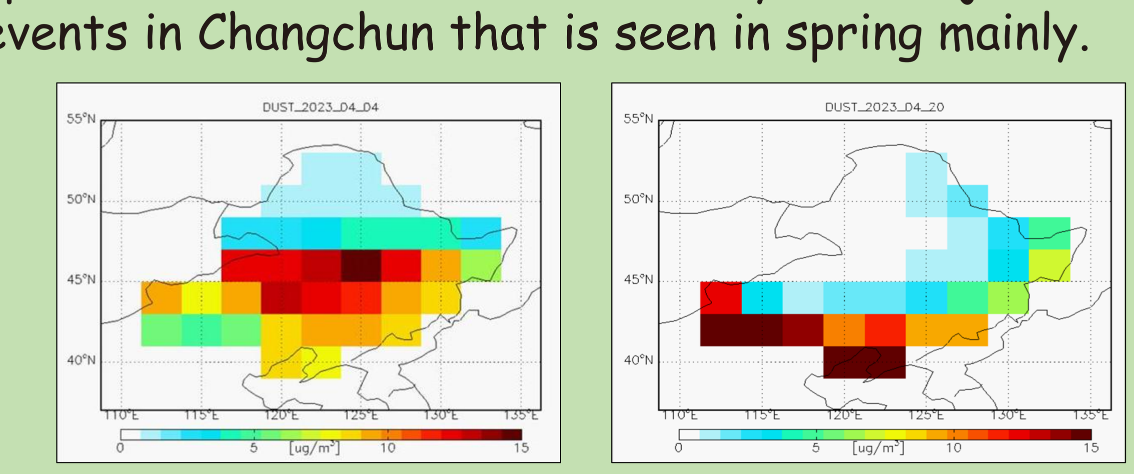


*Fig. 10. Dust storm events by GEOS-Chem modeling (northeast China)*

## Conclusions

**The study shows that aerosols in Changchun have clear seasonal variability, with the highest load in spring and early summer. Urban pollution and biomass burning fine particle combined with strong dust storm events, which contributes coarse particles and reduce air quality significantly. The results assist to (1) quantify the contributions of dust storms, biomass burning, and anthropogenic emissions; (2) reveal pollution pathways; (3) develop targeted mitigation strategies to reduce aerosol exposure for peoples.**