Daily variation of $PM_{2.5}$ and covarying meteorological conditions during wintertime using long-term observation in Seoul

Wooseok Jang and Jin-Ho Yoon ginseng15@gm.gist.ac.kr
School of Earth Sciences and Environmental Engineering, Gwangju Institute of Science and Technology, Gwangju, South Korea

EGU23-10407

Motivation

- Gaining insight into the co-variability between surface particulate matter (PM) concentrations and meteorological conditions could enhance our understanding of how PM levels fluctuate under specific weather conditions, ultimately leading to improved prediction capabilities.
- A challenge in this type of analysis is the **relatively short data length of $PM_{2.5}$**. However, in the Seoul metropolitan area, PM_{10}, which is likely correlated with $PM_{2.5}$, has more than 30 years of relatively reliable observations available for study.

Research questions

Q1. Do $PM_{2.5}$ and PM_{10} concentrations in Korea exhibit **similar daily variabilities** during the winter season?

Q2. What are the spatiotemporal patterns of meteorological conditions that demonstrate **co-variability with $PM_{2.5}$**?

Data & Methods

* National Institute of Environmental Research
** Seoul Research Institute of Public Health and Environment

Daily, DJF 2000-2020	
JRA-55	Zonal and meridional wind, geopotential height, temperature
NIER*	PM_{10}
SRIPHE**	$PM_{2.5}$

- **Extended $PM_{2.5}$ concentration** by averaging the two longest observations (Seongdong-gu and Gwangjin-gu) from 2000 to 2021 among the 25 monitoring stations in Seoul, provided by SRIPHE.
- The two-station averaged $PM_{2.5}$ data showed significant correlation with NIER $PM_{2.5}$ data (0.99) and SRIPHE all-station averaged $PM_{2.5}$ data (0.94) for their common data periods.
- Daily anomalies of meteorological data are used.

Inconsistencies in daily PM fluctuations in case of Asian dust events

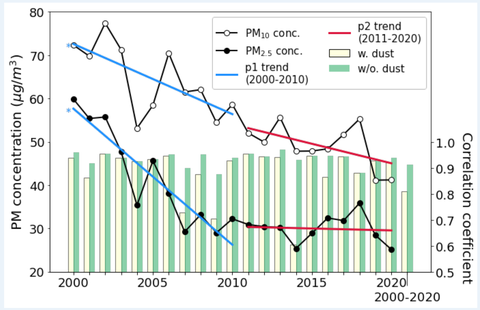

Figure 1. (lines) Winter (DJF) mean trends of PM_{10} and $PM_{2.5}$ (*: 95% significance level). (bars) Daily correlation coefficient between PM_{10} and $PM_{2.5}$ of each winter.

- The declining trends of PM_{10} and $PM_{2.5}$ seasonal averages have become less pronounced in the recent decade (2011-2020) compared to the previous decade (2000-2010), particularly for $PM_{2.5}$.
- $PM_{2.5}$ and PM_{10} exhibit notably similar daily fluctuations when excluding Asian dust days, in contrast to the results when they are included.
- During winter season, **Asian dust events lead to inconsistencies between the daily fluctuations** of $PM_{2.5}$ and PM_{10}.

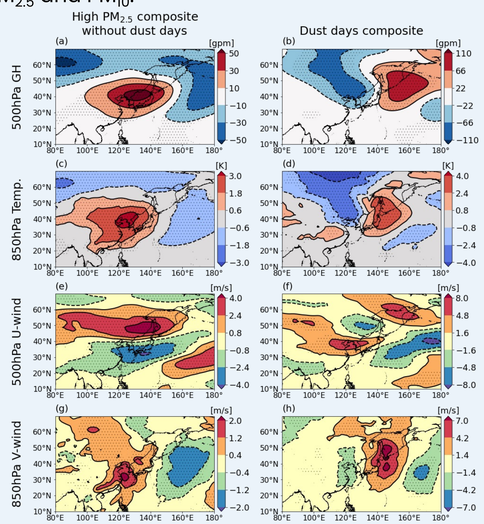

Figure 2. Composite maps of (left) high $PM_{2.5}$ cases without Asian dust days, (right) and only for Asian dust days.

- Composite maps of (left) high $PM_{2.5}$ cases without Asian dust events are the conducive conditions for the high $PM_{2.5}$ event, and (right) maps of only the Asian dust events resemble the cold surge patterns.
- **The contrasting atmospheric conditions by Asian dust events** may cause the aforementioned inconsistencies in daily fluctuations of $PM_{2.5}$ and PM_{10}.

Covarying patterns leading to $PM_{2.5}$ daily variation

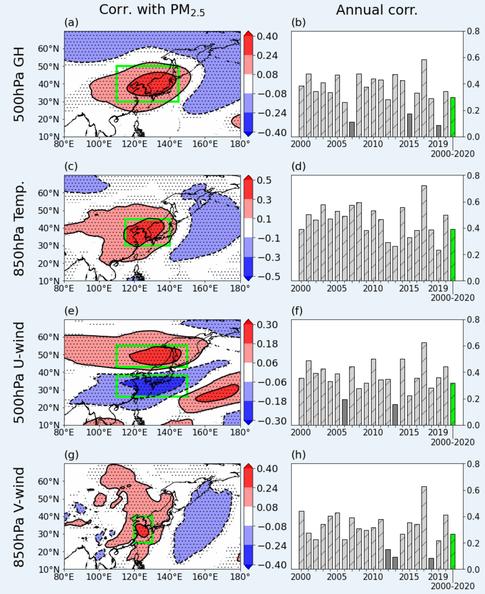

Figure 3. (left) Correlation maps of $PM_{2.5}$ and meteorological factors. (right) Correlation coefficients of $PM_{2.5}$ and area-averaged meteorological factors. Dots on the map and hatches on the bar show the significant composites at a 95% confidence level.

- (left) The correlation patterns are consistent with the conducive conditions for the high $PM_{2.5}$. These synoptic scale patterns are the **dominant patterns** leading to $PM_{2.5}$ daily variation in the winter.
- (right) The relationships have **interannual variabilities**, which are significant for the entire period while few years showed low correlation.

Temporal evolution of the synoptic circulation

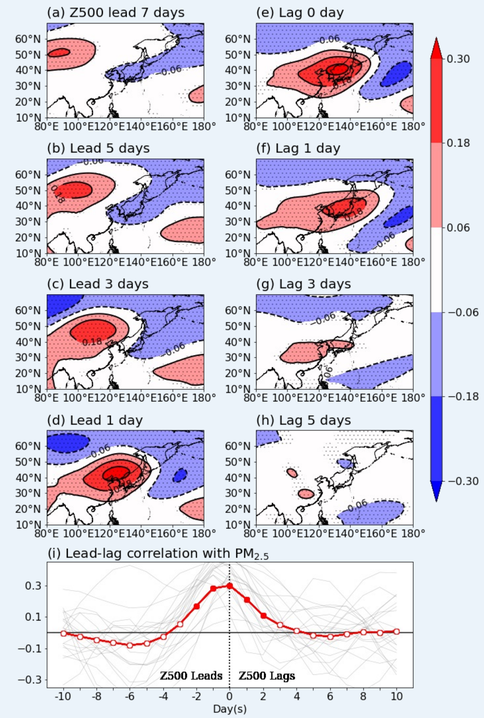

Figure 4. Lead-lag correlation analysis between $PM_{2.5}$ and Z500.

- Lead-lag correlation analysis between $PM_{2.5}$ and Z500 show the **migratory anticyclone** from northwestern China is blocked by the cyclone over the Northern Pacific and stagnates over Korea.
- The duration of the influence on $PM_{2.5}$ was within 5 days.

Key points

- ✓ **Asian dust events cause inconsistencies between daily fluctuations of $PM_{2.5}$ and PM_{10}.**
- ✓ **Migratory synoptic scale circulation system leads to $PM_{2.5}$ daily variations and conduces high concentrations.**