Spatio-temporal distinct patterns in variations of PM_{10} and $PM_{2.5}$ relative to the recent drivings of emission sources in Mongolia

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Abstract

Storyline:

1. A new pattern is emerged
2. Air quality in urban sites is episodically dictated by dust events in spring or late autumn, yet seasonally governed by anthropogenic emissions in winter. [Air quality is governed by natural dust emission, and anthropogenic emissions]
3. With recent growing interest in urban life style, and combustion of coal/oyutolgoi for heating winter conditions results a highly increase in not only capital city but also towns
4. In a result, spring coarse dust, plus winter fine pollutants
5. spring coarse dust is immediately transported and deposited in the source area, whereas winter fine pollutants is permanently stayed in the source area due to stagnant atmosphere govern over entire country., perhaps floating in the near surface, deposits in the surface]
6. Alarms, the Mongolian dust in the spring, optical properties might be shifted; this gives ... Gobi dust and sand storms has become tuiren, from the shoroon shuurga. which clearly requires the attention.
7. r ratio shows ... emission source; dust might carry anthropogenic fine particulates as well.

Introduction

Mongolian dust is well-known by its term of coarse, * color of brown, * its influence on downwind regions, * and big role in global dust, * and its seasonality.

Because, it mainly consists of coarse fractions researchers neglect its role in global climate into elaborating global dust-aerosol effects. *However, recent change in the driving of the emissions of particulate matters might cause fluctuations* its spatio-temporal variations and * characteristics and * emerge a new pattern, eventually it may lead to the role in the regional and global dust, so on climate system through * altering solar incidence, cloud formation, and precipitation or warming * the climate with the fraction of finer particulates.

Mongolia might turn into the not only coarse-dust source region but also fine-mixed coarse-dust region.

- Use of coal is increased
- Urbanization
- The monthly mean concentrations of PM10 (PM2.5) reached annual maximum in December and January due to winter synoptic governing conditions in Ulaanbaatar, capital city of Mongolia (Jugder).
- Despite this, the spring dust storms creates another polluted season in UB. On spring, the dust storm from the Gobi Desert contribute significantly to increased aerosols in the atmosphere and ambient air pollution, leading to sporadic peaks in PM10 concentrations reaching as high as 64-234 $\mu g m^{-3}$ per day or exceeding 6000 $\mu g m^{-3}$ per hour (Jugder).
- Siberian anticyclonic activity governed over Mongolia, which create a significant vulnerability to winter air pollution in the populated areas.
- A such changes in PM10 and PM2.5 to stagnant weather conditions, and local or transported dust was also observed in other countries China (Wang), Korea (Kim) and Japan ().
- deposition

- concentrations of particulate matter is ephederemal, yet vary depending on whether the pollution cause is natural or industrial, local or transported, seasonal or non-seasonal, makes complex and challenging.

Therefore, we aimed to demonstrate the distinct temporal and spatial variations of PM2.5 and PM10 across urban and rural Mongolia using extensive data from 2008 to 2020.

- The present study will contribute significantly to the understanding of air particulate matter patterns in Mongolia and providing comprehensive data insights for policymakers and public health sectors.
- Our findings is useful not only for addressing national health impacts but also beneficial for understanding air particulate matter as ambient air pollution, and tackling atmospheric aerosol effects in the climate system, and revealing their transboundary effects to the downwind regions in South-east Asia.

Results and Discussion

Urban and rural distinct Spatio-temporal diverse variations of PM_{10} and $PM_{2.5}$

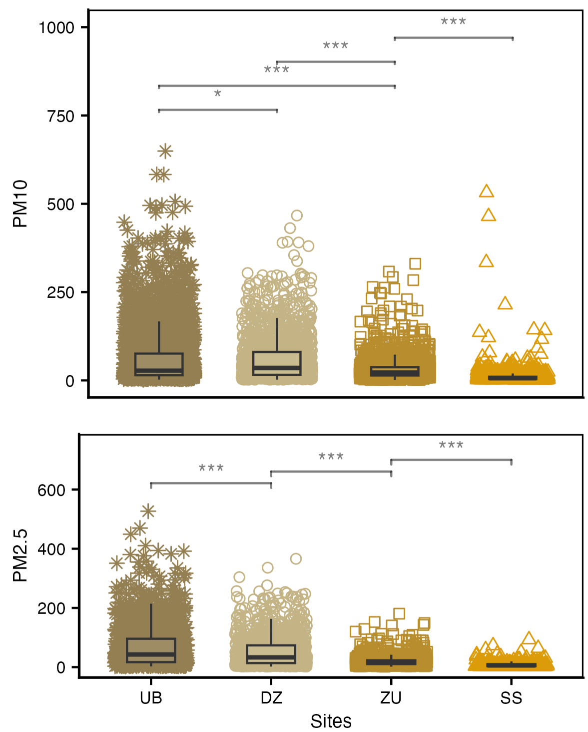

Figure 1: Distinct concentrations of coarse and fine particulates among sites

1. Compare the concentrations of PMs at UB is the 2. Significance level difference 3. Conclude

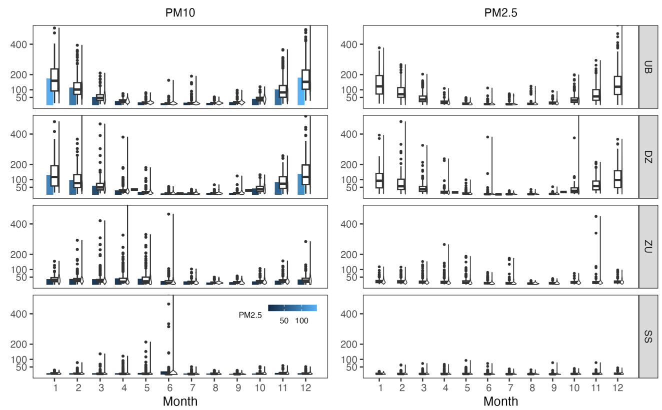

Figure 2: Annual variations of PM_{10} and $PM_{2.5}$

1. Clear annual variations at UB and DZ from pm2.5 pollutions 2. at ZU, and SS has a seasonally peaks episodic spring and late autumn from PM10

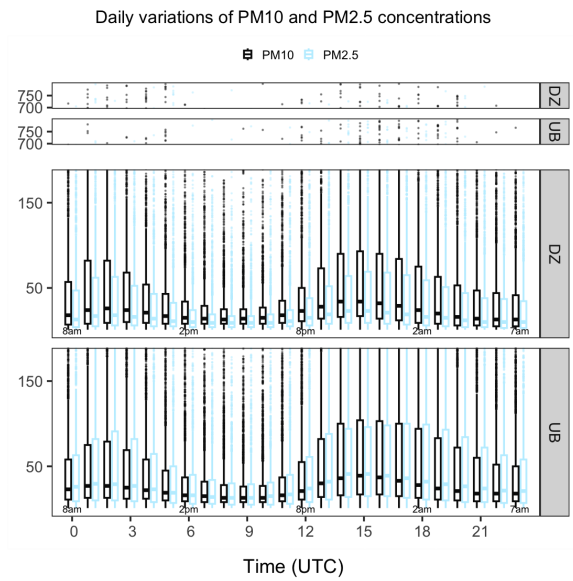

Figure 3: Daily variations of PM_{10} and $PM_{2.5}$ at UB and DZ sites

Meteorological influence on PM_{10} and $PM_{2.5}$ variations

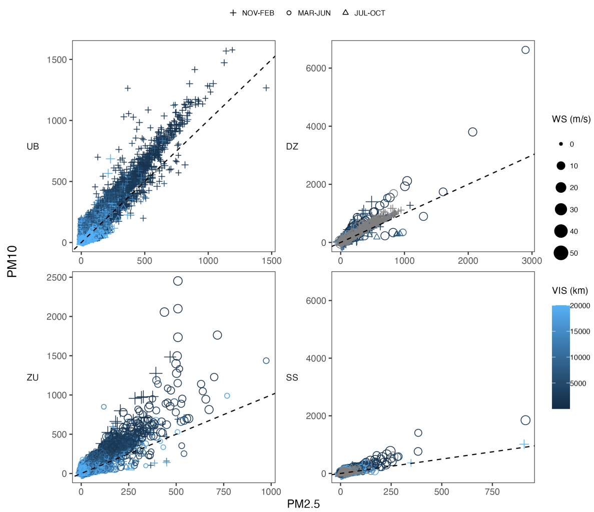

Figure 4: Relationships between meteorological major factors and variations of PM_{10} and $PM_{2.5}$

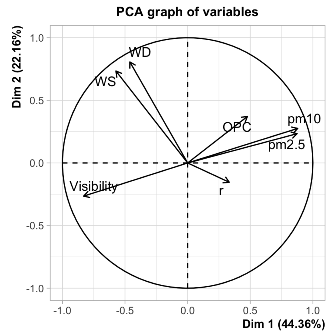

Figure 5: Spatio-temporal distinct feature of variations of PM_{10} and $PM_{2.5}$ with PCA analysis

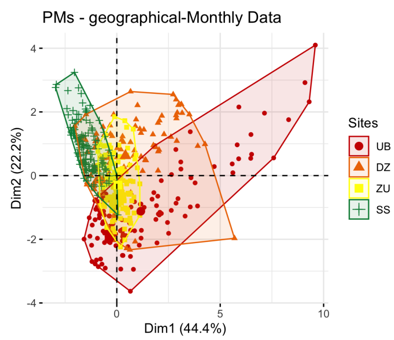

Figure 6: Patterns of meteorology and PMs at the 4 sites

Trends

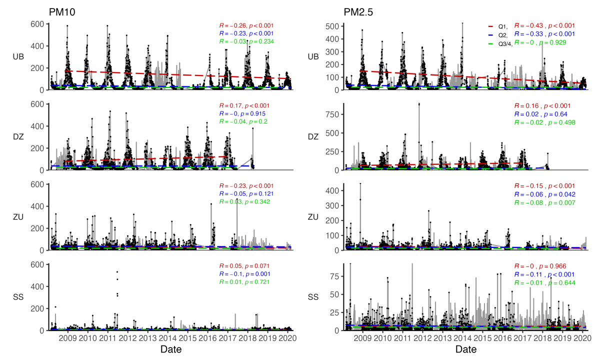

Figure 7: Interannual and seasonal trends of PM_{10} and $PM_{2.5}$ variations

Conclusions

In this study, we investigated the temporal variations of PM2.5 and PM10 concentrations at the 4 sites of rural and urban those located along the the wind corridor. Three distinct variations has been detected.

1. Air quality in urban sites is episodically dictated by dust events in spring or late autumn, yet seasonally governed by anthropogenic emissions in winter.
2. Air quality in rural sites of SS and ZU is episodically dictated by dust events in spring or late autumn.
3. Air quality in rural sites of SS and ZU is episodically dictated by dust events in spring or late autumn.

A clear seasonal variations in the sites of UB and DZ is [Air quality is governed by natural dust emission, and anthropogenic emissions] * Due to rapid increase in urban, and combustion of coal/oyutolgoi for heating winter conditions results a highly increase in not only capital city but also towns * In a result, spring coarse dust, plus winter fine pollutants [spring coarse dust is immediately transported and deposited in the source area, whereas winter fine pollutants is permanently stayed in the source area due to stagnant atmosphere govern over entire country., perhaps float- ing in the near surface, deposits in the surface] * Alarms, the Mongolian dust in the spring, optical properties will be shifted; this gives ... Gobi dust and sand storms has become tuiren, from the shoroon shuurga. which clearly requires the attention.

Following problems

- On downwind regions
- On national-level Demonstrating temporal and spatial variations of air particulate matter has become important for understanding characteristics of particulate matter in the climate system, providing valuable information for well-established air quality measures, and illustrating the good trace data for health studies. Because particulate pollutants have a

great impact on human health (Dockery and Pope,1994; Harrison and Yin, 2000; Hong et al., 2002), high atmospheric concentrations of these pollutants was a major concern particularly in urban areas, in the last 2-3 decades. Recent studies highlight that even low concentrations of these pollutants can lead to various health issues, and may associate with morbidity and mortality across the life span (Zigler et al., 2017). Children exposed to high levels of air pollution show increased rates of asthma, decreased lung function growth, and increased risk of early markers of cardiovascular disease (Bourdrel et al., 2017; Gauderman et al., 2015; Hehua et al., 2017). Short-term exposure with high level of PM10 resulted the chronic cardiovascular disease in Mongolia (Enkhjargal 2020). In addition to these health issues, (prenatal) neurodevelopmental impacts such as effects on intelligence, attention, autism, and mood, while aging populations experience accelerated cognitive decline when exposed to high levels of pollution is detected (Power et al., 2016). Long-term exposure to low levels of particulate matter, such as concentrations as low as 10 $\mu g m^{-3}$ (equilibrium to WHO Air Quality Guidelines), has been linked to increased lung cancer in the EU (Hvidtfeldt et al. 2021), with similar evidences reported in Canada (Bai et al., 2019), and significantly higher rates captured in China with concentrations up to 30 $\mu g m^{-3}$. Apparently, pollutants of particulate matters has effects to various health issues with the different thresholds and exposure durations. However, more in-depth and diversified research on air pollution and its health effects is essential, with the detailed information is necessary (Tan et al

2021) to have accuracy of assessing exposure to air pollution during developmentally relevant time periods, such as trimesters or months (Becerra et al., 2013; Gong et al., 2014; Kalkbrenner et al., 2014) or weeks (Chiu et al., 2016). Many research findings/Numerous research findings have advanced the field, and air quality indices is widely used for providing guidance, and public perception of air quality has been improved (Mirabelli et al., 2020).

Materials and Methods

A description of study sites

According to the spatial magnitude of wind stress in Mongolia (Figure 1), the largest magnitude of wind speed is on the Gobi sites, particularly those located in the southeast edge of the country.

- The impact of high winds on plant diversity varies across environmental gradients of precipitation and soil fertility (Milchunas et al., 1988).
- In the desert steppe zone, species richness was lower in the drier years but did not vary with grazing pressure.
- In the steppe zone, species richness varied significantly with grazing pressure but did not vary between years. Species richness is not impacted by grazing gradient in desert steppe, but it is in the steppe (Cheng et al., 2011).

In the last 2 decades, due to poverty and natural disasters there is population immigration has taken place from the rural to urban, especially to capital city of Mongolia. Due to tiny infrastructure to provide the mega city with the dense population, it introduces the urban pollution. Therefore, Ulaanbaatar air particulate matter mainly reflects the coal burning, and partly, natural dust.

Consequently, the atmospheric environment and climate for Mongolian Gobi has been impacted the most by frequent dust and and sand storm in the spring.

Our study was carried out in Dalanzadgad (town center) (Tbl. 1; 43.57°N, 104.42°E), Sainshand (Tbl. 1; 44.87°N, 110.12°E) and Zamyn-Uud (Tbl. 1; 43.72°N, 111.90°E) in the Gobi Desert, and at Ulaanbaatar (Tbl.??.??°N, 104.42°E) (city center) located in the temperate Mongolian steppe of Mongolia (Figure 2). Nomads and settlements of this sum have raised a large number of livestock, and they rank at number 30 out of 329 sums for the largest number of livestock raised per sum (Saizen et al., 2010). In the last decade, the number of dust events associated with wind erodibility increased by 30 % in Bayan-Önjüül (Kurosaki et al., 2011). This is an area where dust emissions activity has been monitored on a long-term basis (Shinoda et al., 2010a) at a dust observation site

(DOS) adjacent to the study site (Fig. 1a). According to long-term meteorological observations made at the monitoring station of the Institute of Meteorology and Hydrology of Mongolia located near the site, the prevailing wind direction is northwest. Mean annual precipitation is 163 mm, and mean temperature is 0.1$\circ$C for the period 1995 to 2005 (Shinoda et al., 2010b). Soil texture is dominated by sand (98.1 %, with only 1.3 % clay and 0.6 % silt; Table 1; Shinoda et al., 2010a). Insert figure legends with the first sentence in bold, for example:

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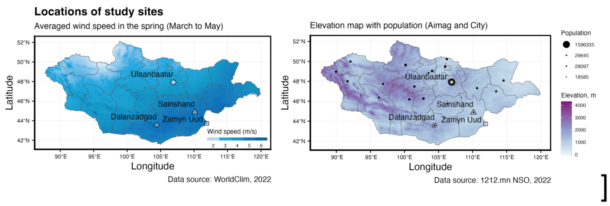

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Table 1. Measured data

	Location		Measured and collected data						Missing data	
SITE	COORDINATE	ELEVATION	TOTAL[1]	WS&WD[2]	VIS[3]	OPC[4]	PM2.5[5]	PM10[5]	PM2.5	PM10
Ulaanbaatar	47.92°N, 106.92°E	1350 m	76656	72603	72886	33241	67940	68777	11.4%	10.3%
Dalanzadgad	43.57°N, 104.42°E	1470 m	60336	46332	33812	-	46066	49172	23.6%	18.5%
Sainshand	44.87°N, 110.12°E	947 m	59040	50513	49720	-	47111	47313	20.2%	19.9%
Zamyn Uud	43.72°N, 111.90°E	967 m	67392	62432	63948	-	57317	58512	14.9%	13.2%

[1] Equipment height: 15 meter at urban site (Ulaanbaatar), 2 meter at Gobi sites (Dalanzadgad, Sainshand and Zamyn Uud); [2] Measurement range: 0–60 m/s; 0-365 degrees. Instrument model: Wind speed and direction PGWS-100, Gill, England; [3] Range: 10–20 000 m. Visibility meter PWD10, Vaisala, Finland; [4] Optical Particle Counter; [5] Range: 0.003–100 mg/m3, Flow rate: 20 L/m, Suction rate: 2 L/ m. Measured by Kosa monitor ES-640, TDK Co. LTD, Japan;

Figure 8: **Table 1.** A description of datasets obtained at the sites

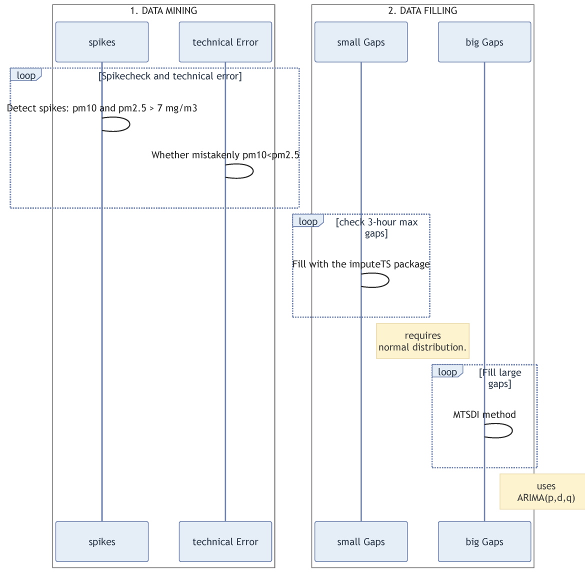

Figure 9: Scheme 1. Data handling procedure

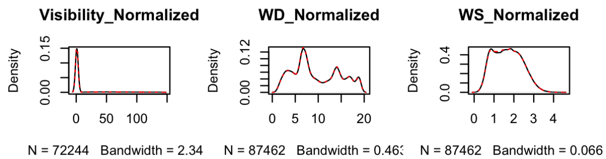

Figure 10: Figure 2. Data gap filling

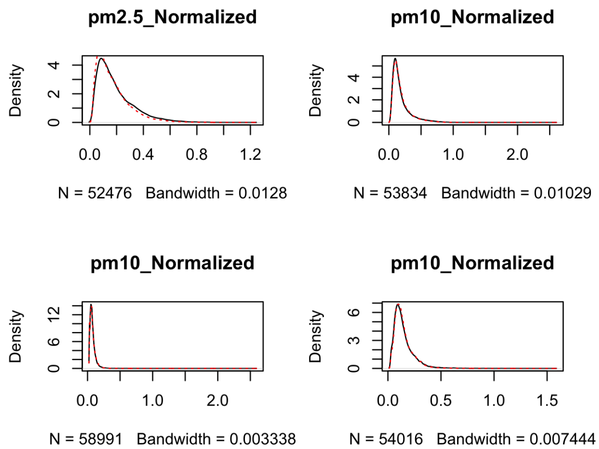

Figure 11: Figure 2b. Data gap filling

References