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The Impact of Land Uses on PM10 Concentration in South Korea

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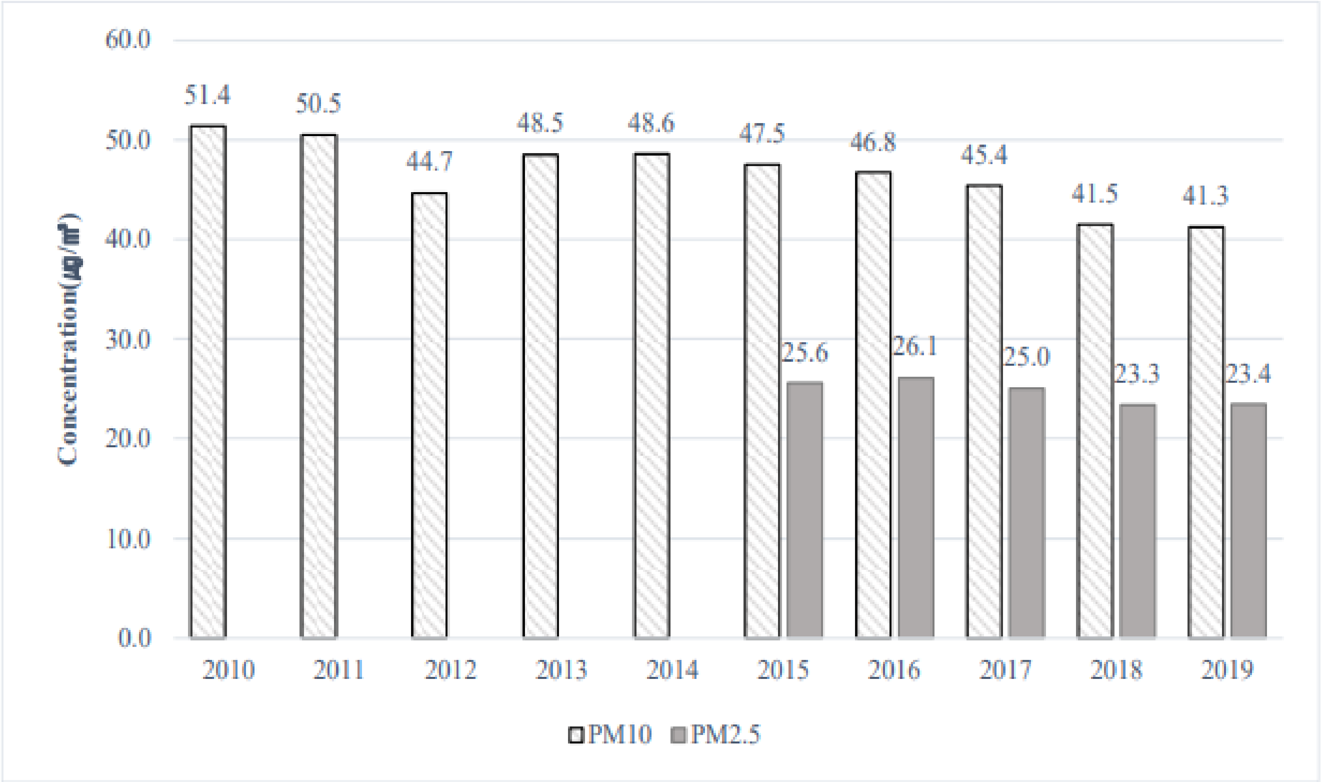
PM10 and Land Use

Particulate Matter (PM10) has become a critical environmental issue in South Korea.

In South Korea, although PM10 concentration levels tend to decrease the days of over WHO's standard are increasing rapidly for the last decade (Sung, 2020)

Land use is known as one of the most important factor that results in the increase of PM10, however few studies about the relationship have been conducted in South Korea.

PM10 concentration in South Korea (2010-2019)



(Sung, 2020)

Land Use and Dynamic PM10 Variations at Multiple Spatial/Temporal Scales

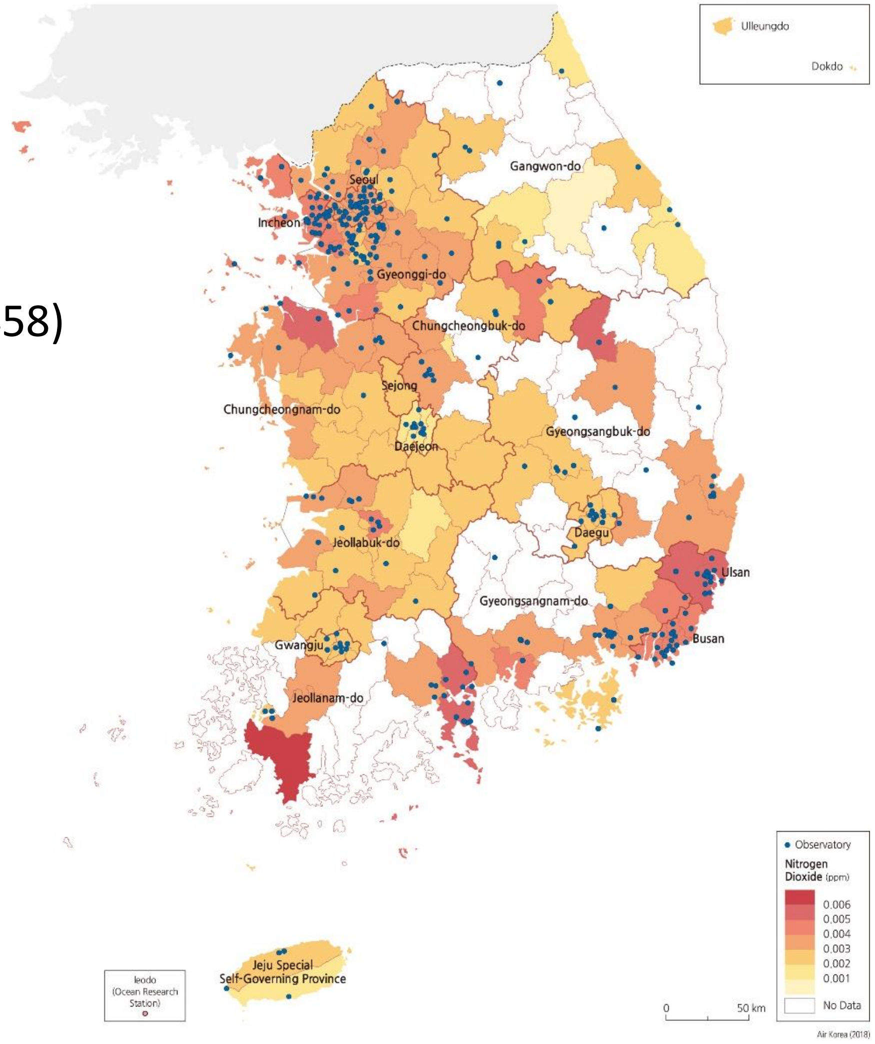
Studies focusing on limited spatial and temporal scales do not capture the variations and dynamics of PM10 concentrations over times and across different regions

Multi-year studies considering fluctuations across different regions are crucial for understanding complicated and dynamic relationships between land use patterns and PM10 concentration

Research Purposes

This study aims to understand the relationships between PM10 concentration and surrounding land use patterns at multiple spatial and temporal scales in South Korea

Air Pollution Monitoring Stations (458)



Research Methods

We used multiple regression and panel data analysis using PM10 concentration data from 458 Air Quality Monitoring Stations(AQMS) across South Korea in 2004, 2007, 2013, and 2019

458 out of 584 because of unavailability of land cover data adjacent to Demilitarized Zone (DMZ)

T-test: understand how various types of PM10 concentration data are associated with different types of land uses and other related variables

Panel data analysis: model the impact of land use on PM10 while accounting for both temporal and spatial autocorrelation

Variables

Dependent Variables:

1. PM10 concentration: mean and standard deviation of PM10 per year
2. Mean and standard deviation of high PM10 season(1-3 & 12) per year
3. Days over WHO's 24hrs mean of PM10

Independent Variables:

1. Land cover data within 1km, 3km, and 5km buffers (2004, 2009, 2018)
   residential/commercial/leisure/public area, industrial, agricultural area, forest/grassland, wetland/waterbody, barren area, transportation
3. Meteorological data:
   mean value and standard deviation per year, mean value and standard deviation of high PM10 seasons(1-3 & 12) per year)

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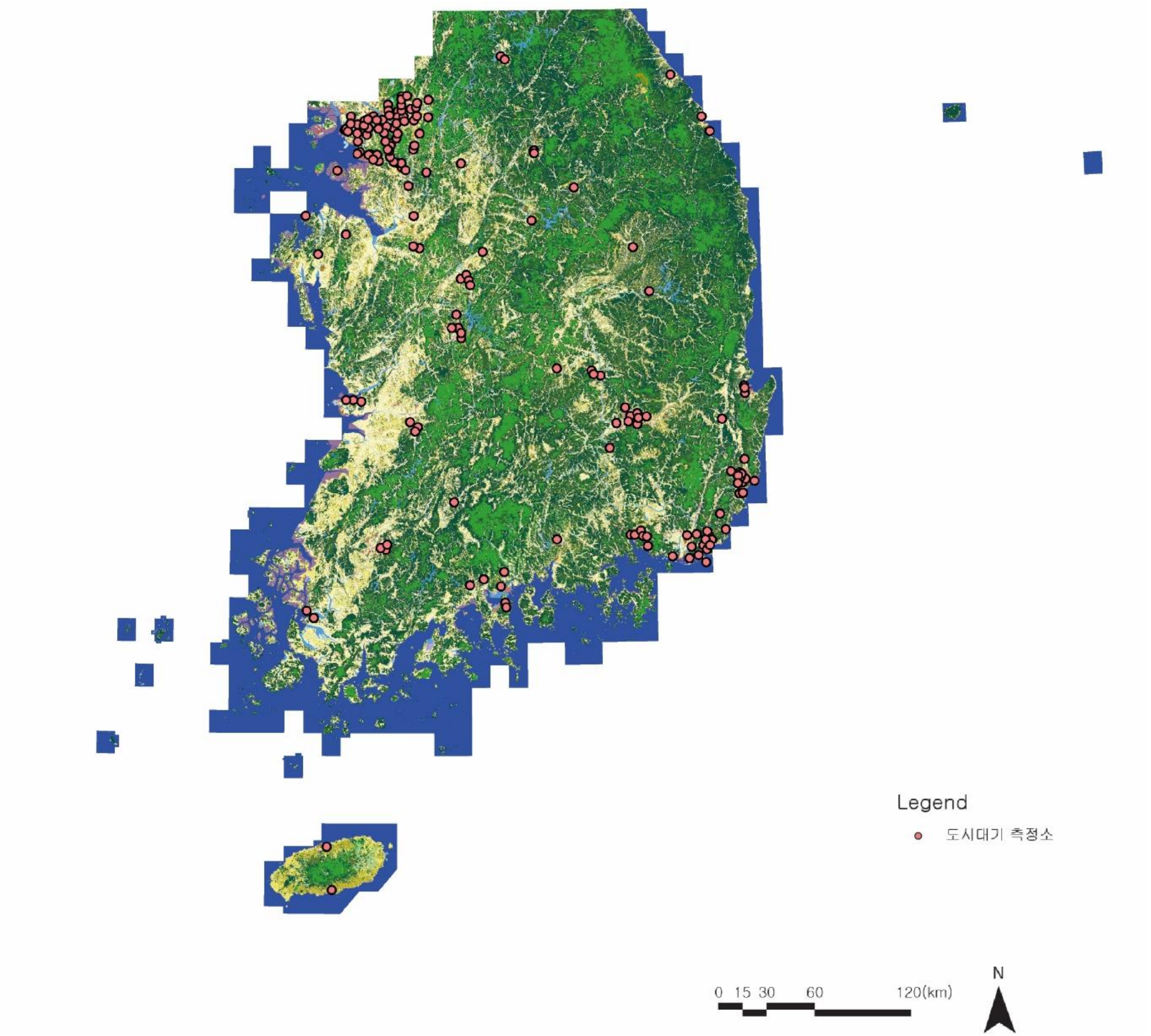
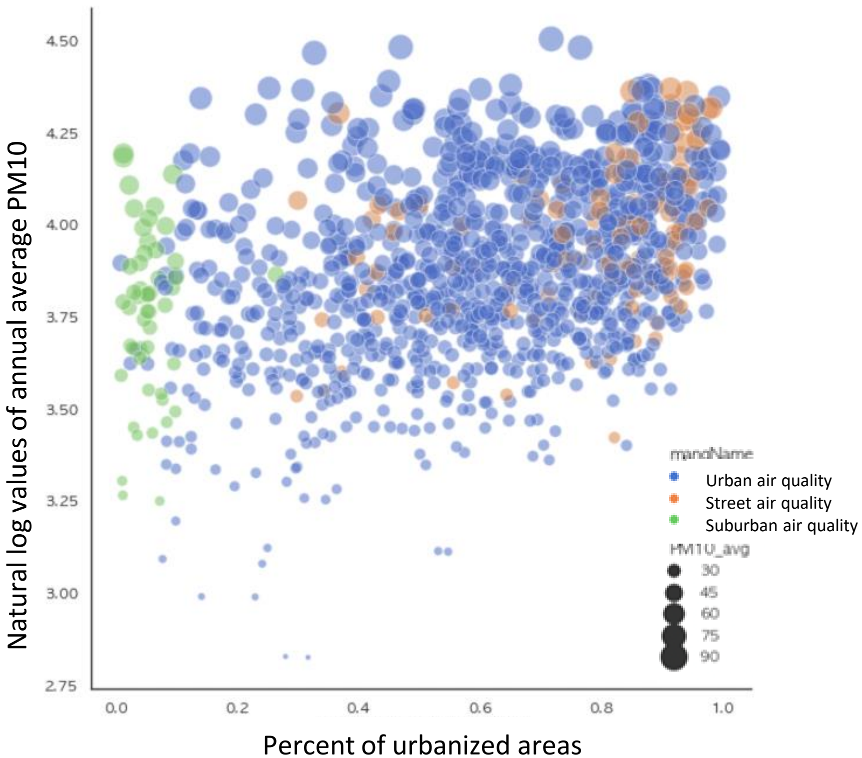
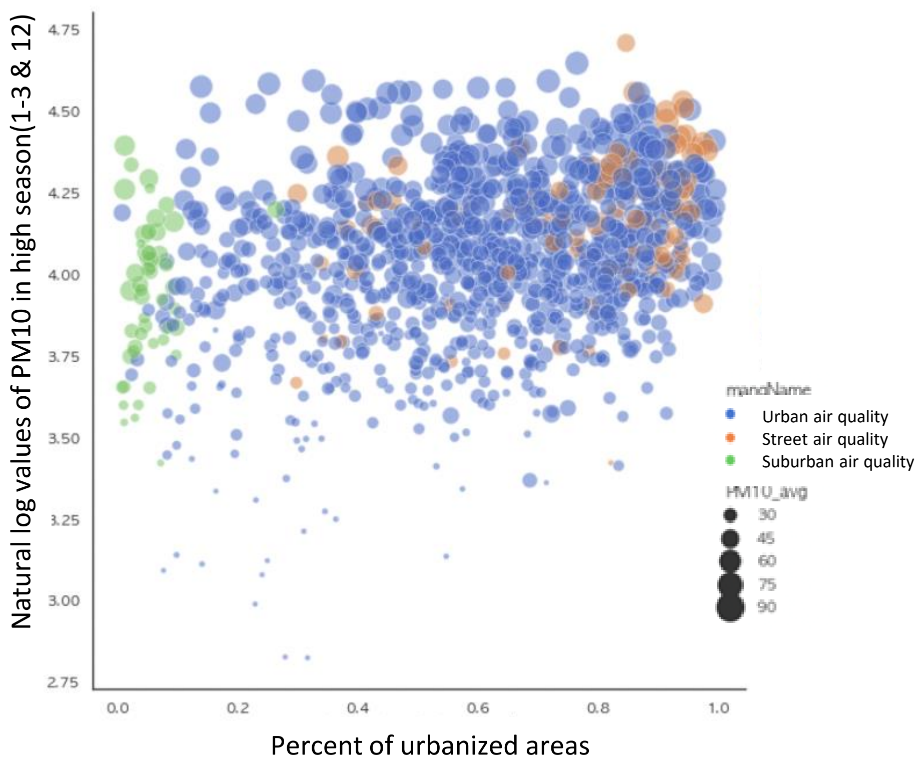
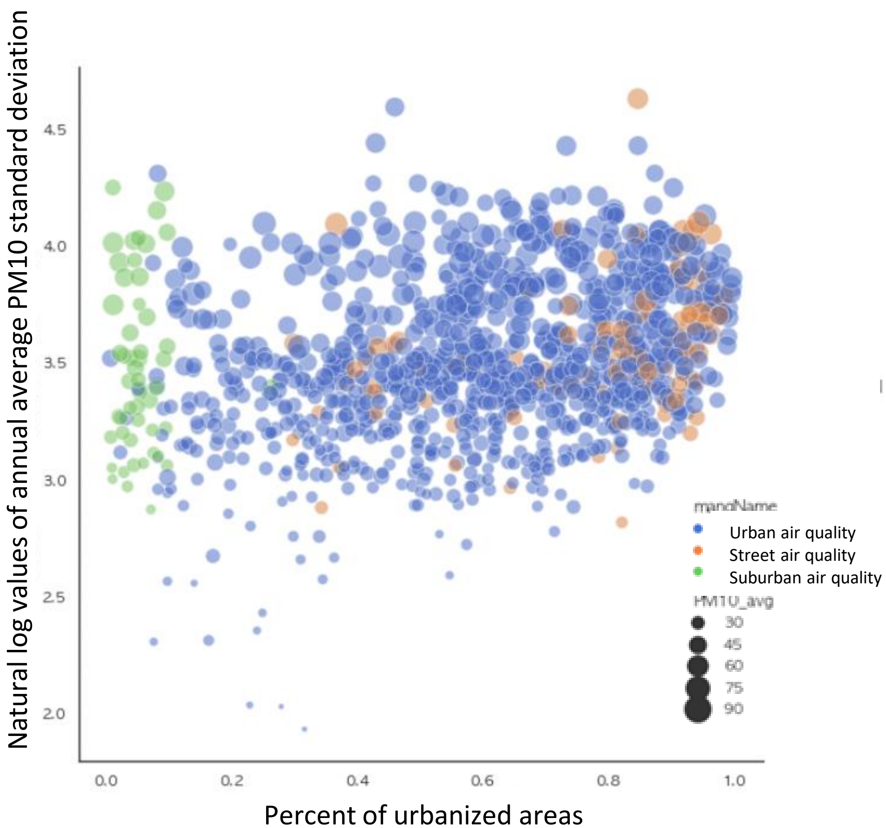


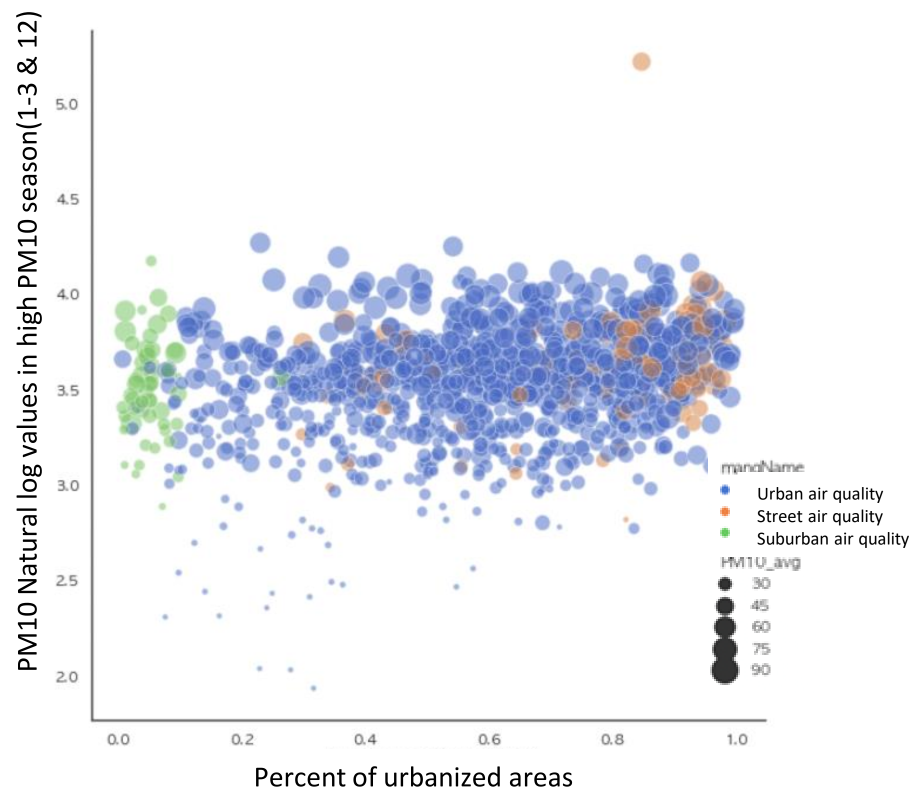
Correlation between urbanized area and PM10 concentration in annual average PM10 and high season





Correlation between urbanized area and PM10 concentration in standard deviation and high season





Panel Model 1000m

		Pm10 yearly average		Pm10 average in high season		Pm10 yearly standard deviation		Pm10 standard deviation in high season		Days over WHO's Pm10 standard	
		(1)		(2)		(3)		(4)		(5)	
		ln_PM10_avg		ln_PM10_Hi~g		ln_PM10_std		ln_PM10_Hi~d		ln_PM10_ov~G	
Residential, commercial, public	Area_pro~199	0.052*	(1.86)	0.033	(1.11)	-0.038	(-1.33)	-0.037	(-1.35)	0.102**	(2.22)
Industrial	Area_pro~120	0.337***	(7.86)	0.288***	(6.21)	0.179***	(3.46)	0.137***	(2.60)	0.670***	(9.53)
Transportation	Area_pro~150	0.105**	(2.02)	0.135**	(2.36)	0.131*	(1.82)	0.152***	(2.60)	0.293***	(2.97)
Forest, grassland	Area_pro~349	-0.114***	(-3.06)	-0.088**	(-2.11)	-0.046	(-1.05)	-0.036	(-0.96)	-0.258***	(-3.41)
Wetland, waterbody	Area_pro~579	-0.037	(-0.42)	0.008	(0.09)	-0.171*	(-1.77)	0.062	(0.76)	-0.191	(-0.95)
Temperature	ln_Tempera~e	0.007	(0.08)	-0.321***	(-3.16)	0.444***	(4.69)	0.021	(0.22)	-0.310**	(-2.30)
Wind speed	ln_WindSpeed	-0.019	(-0.78)	-0.014	(-0.47)	-0.201***	(-6.18)	-0.164***	(-5.88)	-0.049	(-1.19)
Precipitation	ln_Precip	-0.040***	(-3.29)	-0.076***	(-5.49)	-0.067***	(-3.54)	-0.064***	(-3.57)	-0.141***	(-6.37)
	2004.Year	0.000	(.)	0.000	(.)	0.000	(.)	0.000	(.)	0.000	(.)
	2007.Year	-0.012	(-1.44)	0.016*	(1.78)	0.282***	(23.29)	-0.001	(-0.07)	-0.046***	(-2.89)
	2013.Year	-0.219***	(-19.39)	-0.167***	(-12.71)	-0.245***	(-17.21)	-0.240***	(-18.17)	-0.281***	(-13.90)
	2019.Year	-0.333***	(-20.11)	-0.150***	(-8.15)	-0.382***	(-15.84)	-0.286***	(-16.74)	-0.557***	(-16.12)
Longitude	longitude	-0.025***	(-3.57)	-0.035***	(-4.57)	-0.050***	(-5.80)	-0.110***	(-17.61)	-0.023**	(-2.03)
Latitude	latitude	0.061***	(10.08)	0.093***	(13.40)	0.054***	(6.85)	0.049***	(6.35)	0.117***	(9.98)
	_cons	5.219***	(5.18)	6.508***	(5.88)	7.459***	(5.56)	16.436***	(15.12)	5.774***	(3.19)
	N	809		809		809		809		809	

t statistics in parentheses

* p<0.1, ** p<0.05, *** p<0.01

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Panel Model 3000m

		Pm10 yearly average		Pm10 average in high season		Pm10 yearly standard deviation		Pm10 standard deviation in high season		Days over WHO's Pm10 standard	
		(1)		(2)		(3)		(4)		(5)	
		ln_PM10_avg		ln_PM10_Hi~g		ln_PM10_std		ln_PM10_Hi~d		ln_PM10_ov~G	
Residential, commercial, public	Area_pro~199	-0.006	(-1.64)	-0.008*	(-1.86)	-0.017***	(-4.51)	-0.010***	(-2.67)	-0.009	(-1.35)
Industrial	Area_pro~120	0.044***	(5.39)	0.034***	(4.14)	0.014	(1.44)	0.007	(0.74)	0.086***	(5.88)
Transportation	Area_pro~150	0.005	(0.70)	0.013	(1.57)	0.002	(0.20)	0.018**	(2.02)	0.006	(0.40)
Forest, grassland	Area_pro~349	-0.030***	(-6.30)	-0.027***	(-5.25)	-0.024***	(-4.75)	-0.014***	(-2.94)	-0.067***	(-7.25)
Wetland, waterbody	Area_pro~579	-0.034***	(-4.70)	-0.030***	(-4.29)	-0.027***	(-3.56)	-0.009	(-1.24)	-0.103***	(-6.98)
Temperature	ln_Tempera~e	0.093	(1.01)	-0.228**	(-2.22)	0.491***	(4.78)	0.033	(0.34)	-0.167	(-0.99)
Wind speed	ln_WindSpeed	-0.035	(-1.31)	-0.035	(-1.20)	-0.195***	(-5.83)	-0.169***	(-6.19)	-0.070	(-1.37)
Precipitation	ln_Precip	-0.041***	(-3.42)	-0.082***	(-6.06)	-0.063***	(-3.60)	-0.062***	(-3.52)	-0.150***	(-6.15)
	2004.Year	0.000	(.)	0.000	(.)	0.000	(.)	0.000	(.)	0.000	(.)
	2007.Year	-0.008	(-1.01)	0.011	(1.23)	0.290***	(25.55)	0.006	(0.56)	-0.033**	(-2.09)
	2013.Year	-0.205***	(-17.15)	-0.160***	(-12.24)	-0.232***	(-15.82)	-0.236***	(-18.04)	-0.247***	(-10.89)
	2019.Year	-0.320***	(-18.53)	-0.152***	(-7.92)	-0.352***	(-15.04)	-0.279***	(-14.31)	-0.497***	(-13.73)
Longitude	longitude	-0.010	(-1.35)	-0.029***	(-3.71)	-0.043***	(-4.70)	-0.105***	(-15.35)	-0.000	(-0.03)
Latitude	latitude	0.058***	(8.60)	0.084***	(11.67)	0.057***	(6.75)	0.044***	(5.65)	0.103***	(8.33)
	_cons	3.415***	(3.10)	6.056***	(5.29)	6.515***	(4.55)	15.965***	(14.08)	3.319	(1.61)
	N	809		809		809		809		809	

t statistics in parentheses
* p<0.1, ** p<0.05, *** p<0.01

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Panel Model 5000m

		Pm10 yearly average		Pm10 average in high season		Pm10 yearly standard deviation		Pm10 standard deviation in high season		Days over WHO's Pm10 standard	
		(1)		(2)		(3)		(4)		(5)	
		ln_PM10_avg		ln_PM10_Hi~g		ln_PM10_std		ln_PM10_Hi~d		ln_PM10_ov~G	
Residential, commercial, public	Area_pro~199	-0.003**	(-2.01)	-0.004**	(-2.17)	-0.006***	(-3.89)	-0.004***	(-2.68)	-0.005*	(-1.81)
Industrial	Area_pro~120	0.024***	(5.53)	0.013**	(2.44)	0.012**	(2.36)	0.005	(0.87)	0.046***	(5.49)
Transportation	Area_pro~150	-0.001	(-0.44)	0.003	(0.85)	-0.005	(-1.20)	0.004	(1.33)	-0.004	(-0.66)
Forest, grassland	Area_pro~349	-0.013***	(-7.96)	-0.012***	(-6.63)	-0.009***	(-4.98)	-0.007***	(-4.13)	-0.024***	(-7.78)
Wetland, waterbody	Area_pro~579	-0.013***	(-5.53)	-0.011***	(-4.68)	-0.006**	(-2.38)	-0.002	(-1.03)	-0.031***	(-5.92)
Temperature	ln_Tempera~e	0.033	(0.35)	-0.292***	(-2.71)	0.515***	(4.88)	-0.045	(-0.46)	-0.190	(-1.05)
Wind speed	ln_WindSpeed	-0.034	(-1.25)	-0.034	(-1.09)	-0.213***	(-6.31)	-0.177***	(-6.18)	-0.065	(-1.19)
Precipitation	ln_Precip	-0.040***	(-3.32)	-0.081***	(-5.85)	-0.061***	(-3.33)	-0.066***	(-3.74)	-0.137***	(-5.40)
	2004.Year	0.000	(.)	0.000	(.)	0.000	(.)	0.000	(.)	0.000	(.)
	2007.Year	-0.002	(-0.30)	0.014	(1.60)	0.296***	(26.44)	0.012	(1.22)	-0.028*	(-1.78)
	2013.Year	-0.200***	(-16.90)	-0.161***	(-12.32)	-0.218***	(-15.11)	-0.230***	(-18.33)	-0.239***	(-10.71)
	2019.Year	-0.302***	(-18.30)	-0.140***	(-7.27)	-0.321***	(-14.27)	-0.257***	(-14.72)	-0.473***	(-13.53)
Longitude	longitude	-0.006	(-0.79)	-0.022**	(-2.51)	-0.042***	(-4.32)	-0.103***	(-14.80)	-0.002	(-0.11)
Latitude	latitude	0.057***	(8.15)	0.084***	(10.38)	0.061***	(6.86)	0.042***	(5.34)	0.106***	(7.14)
	_cons	3.096***	(2.72)	5.370***	(4.17)	6.136***	(4.03)	16.035***	(14.01)	3.390	(1.39)
	N	815		815		815		815		815	

t statistics in parentheses
* p<0.1, ** p<0.05, *** p<0.01

Analysis and Discussion

Within 1km buffer, industrial areas show the highest positive correlation with PM10 concentration, followed by transportation, residential and commercial areas

Within 3km buffer, industrial and transportation areas have the highest effect on increasing PM10 concentration, while residential and commercial areas contribute to reducing PM10

Within 5km buffer, only industrial areas are correlated with high PM10 concentration, while residential and commercial areas are correlated with low PM10

Regardless buffer size, forests and wetlands are found to have a clearing effect on PM10 concentration.

Temperature is positively correlated with the high PM10 seasons of spring and winter, while the precipitation has a clearing effect on PM10 concentration.

Transportation areas are highly associated with high PM10 concentration in 1 km radius, but are not in 3 and 5 km radius. This means transportation areas tend to increase PM10 in smaller spatial scale, and need to managed accordingly.

Conclusions

Across the three spatial scales, Industrial land use is highly associated with yearly PM10 average and with high PM10 seasons.

Both industrial land uses and high temperature are closely associated with high PM10 concentration, and urban planning strategies should focus on avoiding overlapping effects of the two factors.

Residential and commercial land uses are negatively associated with high PM10 concentration in 1 km radius, but have positive effect in 3 and 5 km radius.

Future Research

Further research should be focused on understanding relationship between types and scales of industrial land uses with PM10 concentration.

Types of Industry are getting rapidly changed with the advances of high-tech and clean energy systems. Thus, the impact of industrial land uses on PM10 need to be specified according to their characteristics and contribution to PM10 concentration.

It may be also necessary to investigate how high PM10 areas with highly associated other pollutant sources such as CO and O3 are co-related with particular land uses.