The Effects of Transboundary Air Pollution from China on Ambient Air Quality in South Korea

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Air pollution problem in South Korea

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Three potential sources

1) Domestic emissions (power plants, factories, vehicles, etc)

2) Asian Dust Storms (ADS): Only in spring

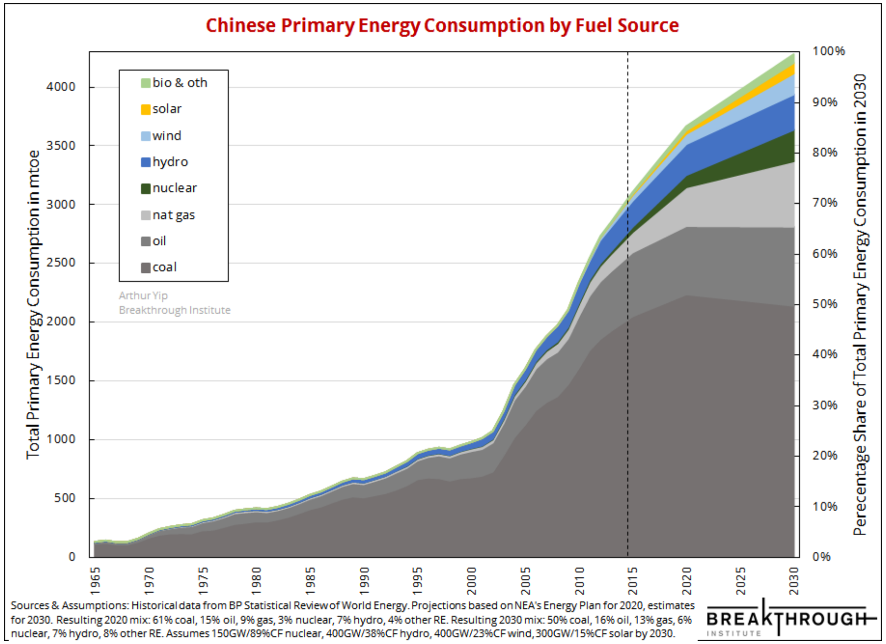
3) Emissions from China that migrate to South Korea via prevailing wind patterns

3) Emissions from China

Figure 1. Power plant locations in China

Source: TIME, D. Stout. “One Map Shows You Why Pollution in China is So Awful, Dec 13, 2013; http://world.time.com/2013/12/13/one-map-shows-you-why-pollution-in-china-is-so-awful/

Notes: The most power plants are located at eastern China.



3) Emissions from China

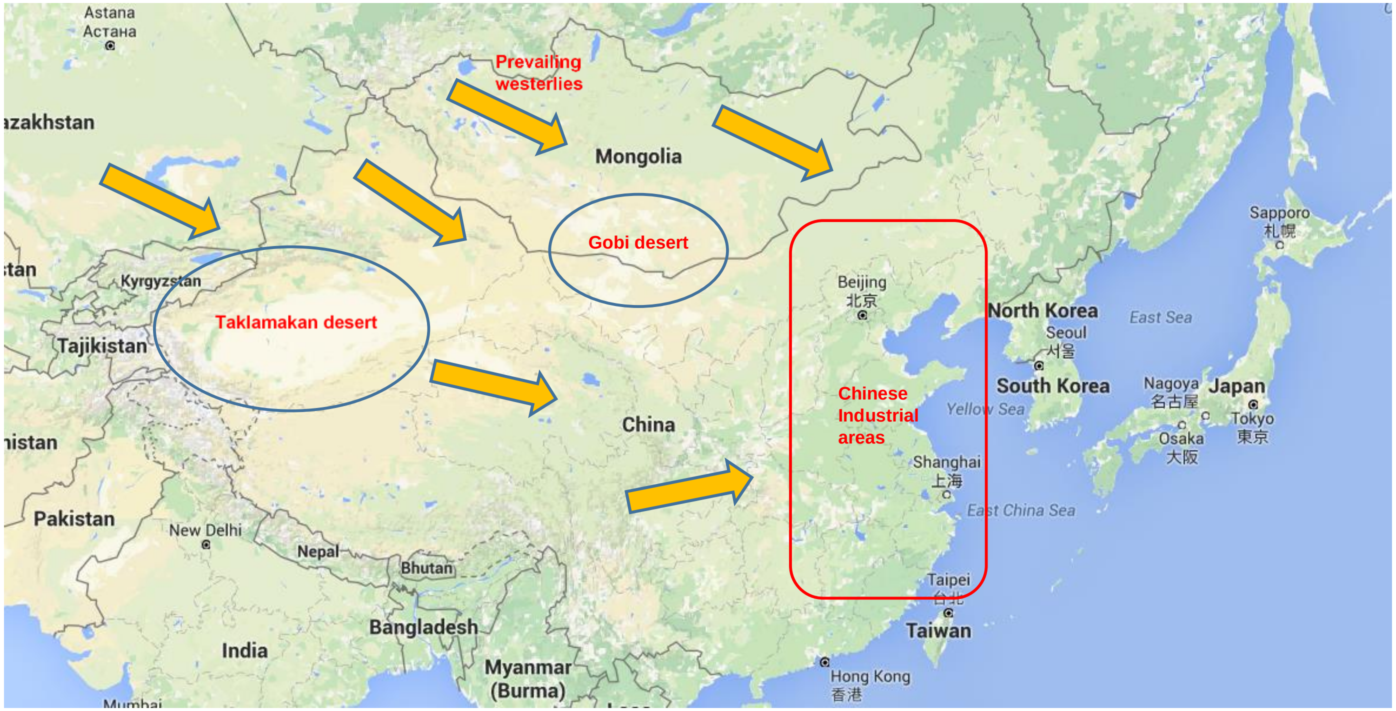
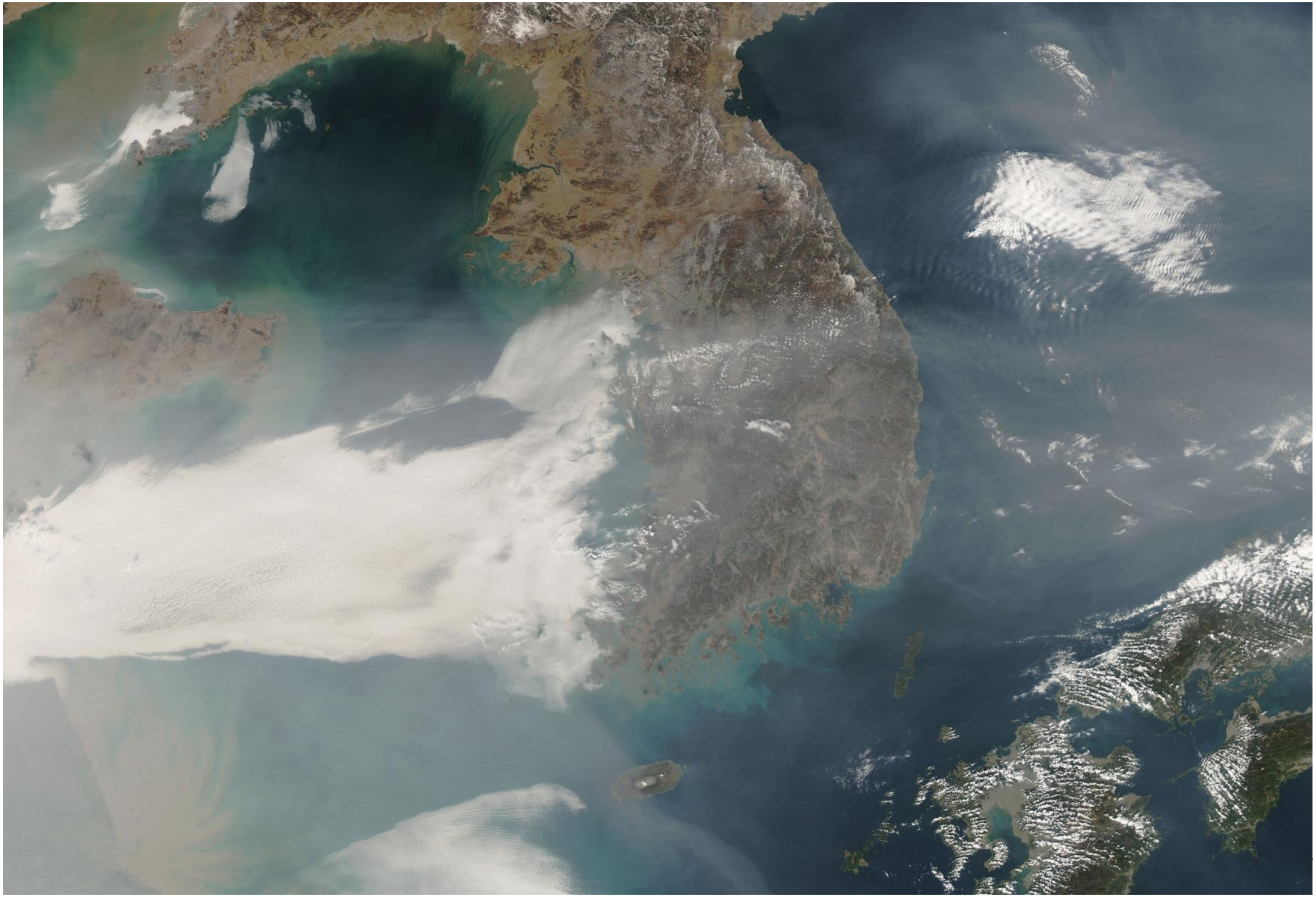


Figure 2. Prevailing westerly winds transport dust from deserts in west China and Inner Mongolia (i.e., Taklamakan, Gobi) and pollution from industrial cities (Beijing, Shanghai) to South Korea.

3) Emissions from China



Tripartite Environmental Ministers' Meeting

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In the tripartite environmental ministers' meeting, they agreed to

a) improve the forecasting accuracy for ADS

b) reduce air pollutant emissions

c) share knowledge to monitor and control them.

However, the level of contribution is still a subject of considerable debate.

Previous research

- **Korean Government (2013)**:

30-50% of ambient $PM_{2.5}$ pollution levels in South Korea originated from Chinese deserts and cities.

- **Li et al. (2014)**:

The long-range transport (LRT) of air pollutants from China is estimated to account for about 26% and 13.6% of annual contribution of PM_{10} in Korea and Japan respectively

- **Park and Han (2014)**:

assert that the previous studies which estimate an annual contribution of LRT on average as around 30% might be underestimated.

Research goals

Empirically test whether:

1. Air pollution from China affects ambient air quality in South Korea.
   - Westerly winds

2. The effect of the cross-border pollution is strongest in winter and spring.
   - Coal-based heating (winter)
   - Asian dust storm (spring)

3. The wind directions that affect South Korean ambient air quality are different by seasons.

Data

Two sets of panel data used:

- daily mean data from 2006-2014 (9yrs)
- 7 metropolitan cities and 9 provinces

1. Air pollution data

- downloaded from the Korea Environment Corporation webpage
- PM_{10}, SO_2, NO_2, CO, O_3
- 257 monitors nationwide

2. Weather data

- downloaded from the National Climate Data Service webpage
- precipitation, temperature, wind speed, and wind direction
- 93 monitors nationwide

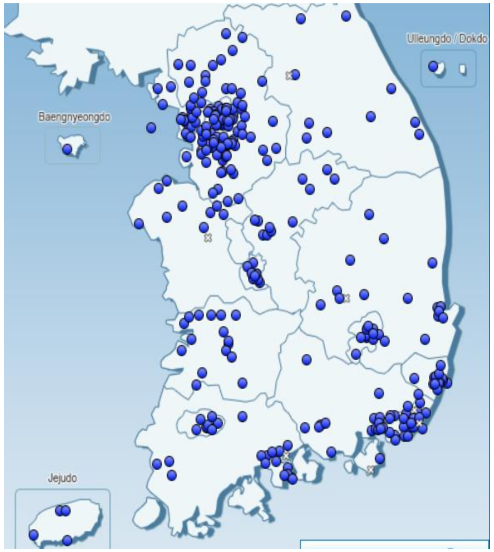


Figure 1. Air Quality Monitoring Stations across South Korea

Source: Air Korea website (www.airkorea.or.kr) by Korea Environment Corporation

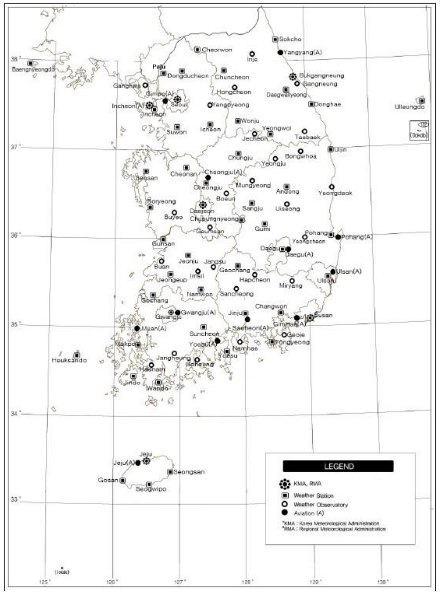
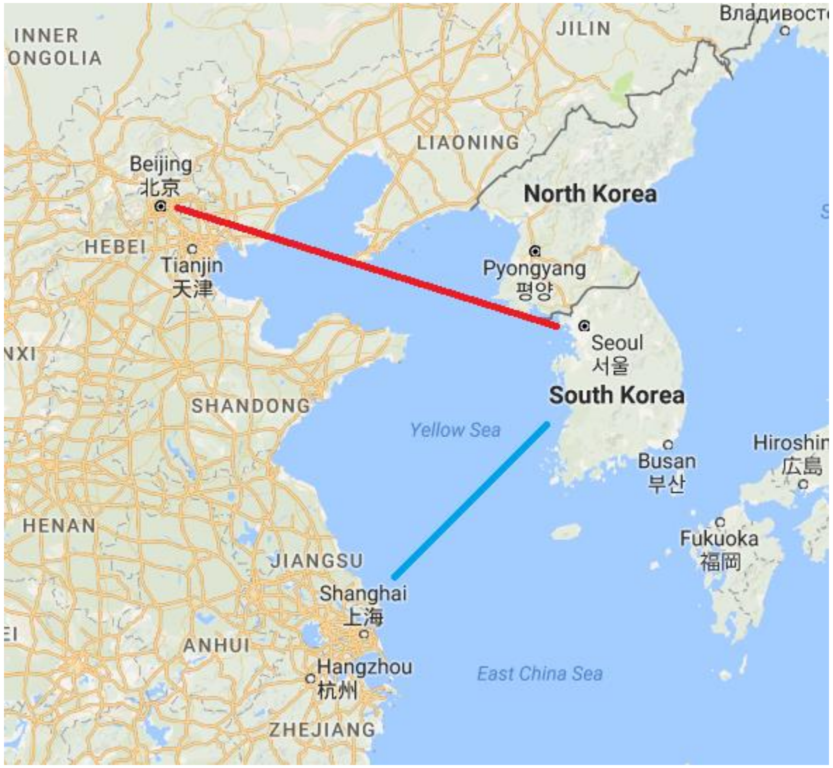


Figure 2. Weather Monitoring Stations across South Korea

Source: Annual Climatological Report 2014, Korea Meteorological Administration

Bivariate relationship between PM_{10} and wind direction



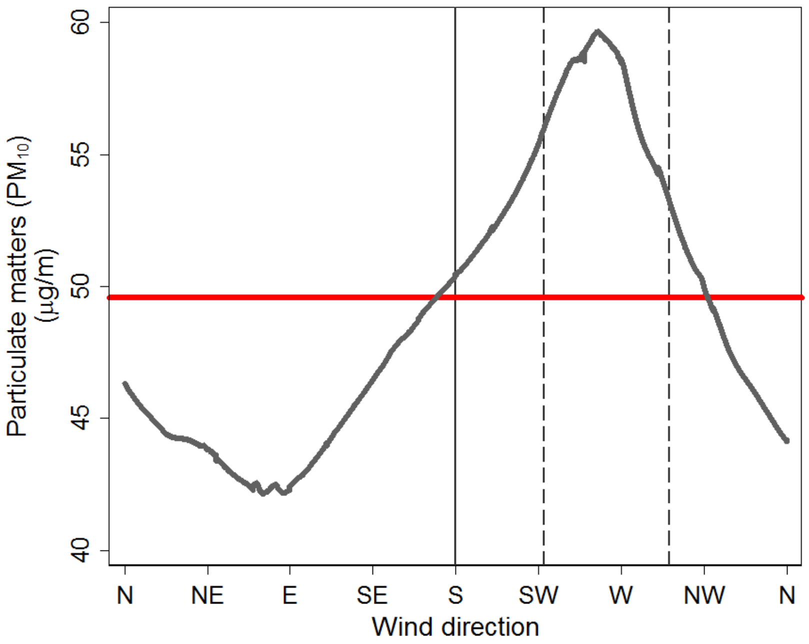


Figure 3. PM_{10} concentrations by wind directions (2006-2014)

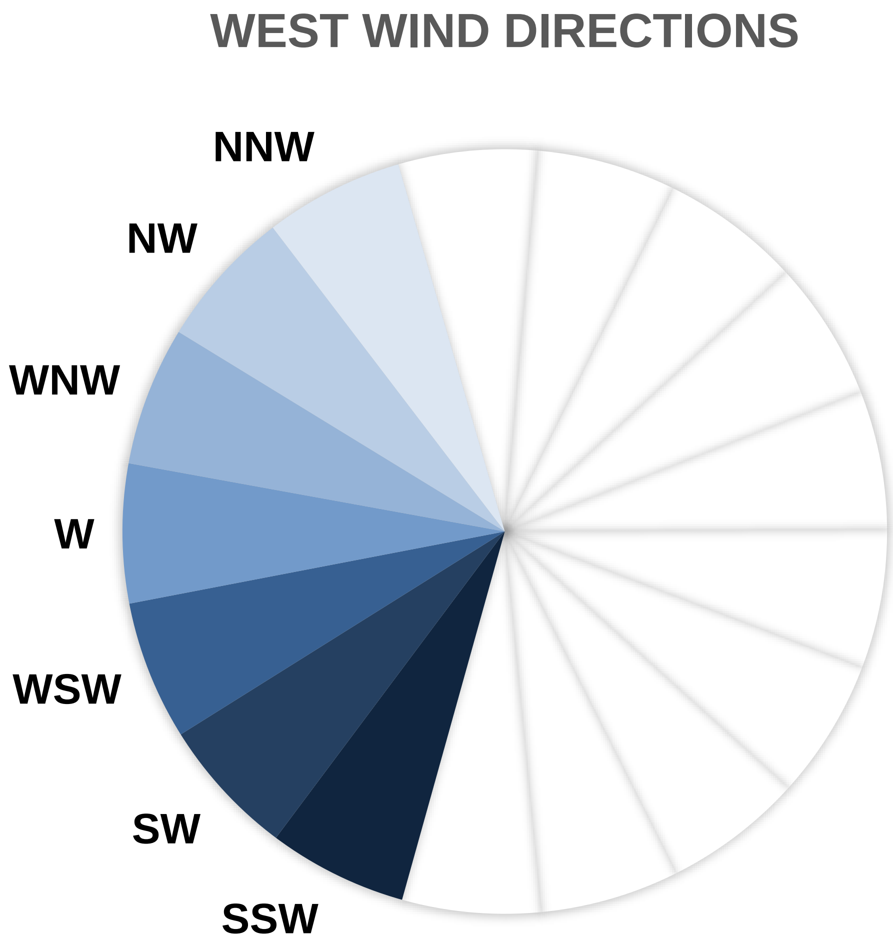
Note: Locally Weighted Scatterplot Smoothing (LOWESS) with bandwidth of 0.2. Left dashed line indicates the mean direction from Shanghai toward South Korea. Right dashed line indicates the mean direction from Beijing toward South Korea.

Results

Table 1. Marginal effects of the westerly wind on PM_{10} concentrations

	Year round	Spring	Summer	Fall	Winter
Precipitation	-0.098***	-0.601***	-0.089***	-0.078*	-0.031
	(0.018)	(0.101)	(0.019)	(0.042)	(0.030)
Temperature	0.066**	0.169**	0.296***	0.135**	-0.128
	(0.028)	(0.075)	(0.076)	(0.068)	(0.084)
Wind speed	-1.820***	-2.098***	-0.987**	-0.930*	-2.819***
	(0.281)	(0.733)	(0.390)	(0.537)	(0.611)
$1(W_D)\times W_S$	**0.883*** **	**1.737*** **	**1.588*** **	**0.854** **	**2.209*** **
	(0.210)	**(0.553)**	**(0.306)**	**(0.416)**	**(0.407)**
city-fixed effect	Yes	Yes	Yes	Yes	Yes
time-fixed effect	Yes	Yes	Yes	Yes	Yes
R^2	0.855	0.848	0.804	0.839	0.818
Observation	7487	1872	1872	1872	1871

Results



Results

Table 2. Average effect of wind on South Korean PM_{10} by wind direction

	Wind direction	Marginal effect	Wind speed (m/s)	PM_{10} ($\mu g/m^3$)	Contribution
Year-round	NNW	-2.205***	2.23	46.60	-10.55
	NW	-0.802***	2.09	49.20	-3.40
	WNW	**0.869***	**2.11**	**53.76**	**3.41**
	W	2.259***	2.00	58.47	7.74
	WSW	3.155***	1.87	59.99	9.83
	SW	**3.294***	**2.02**	**55.71**	**11.93**
	SSW	3.155***	1.98	51.41	12.16
Spring	NNW	-0.693	2.17	58.54	-2.57
	NW	1.098	2.13	58.79	3.98
	WNW	**2.164***	**2.13**	**59.27**	**7.77**
	W	2.375***	2.10	60.08	8.29
	WSW	2.422***	2.09	60.60	8.34
	SW	**2.033***	**2.12**	**60.09**	**7.19**
	SSW	1.409**	2.13	59.70	5.03
Winter	NNW	1.931***	1.99	53.42	7.21
	NW	3.019***	1.98	53.61	11.15
	WNW	**2.841***	**2.00**	**54.27**	**10.48**
	W	2.419***	2.00	55.20	8.77
	WSW	1.929***	1.98	55.34	6.91
	SW	**1.053***	**2.02**	**54.55**	**3.89**
	SSW	0.204	2.00	53.90	0.76

Notes: West-northwest wind (WNW), marked in red, and southwest wind (SW), marked in blue, correspond to the direction from Beijing and Shanghai to South Korea respectively.

Conclusions

- Marginal effects of westerly winds
  - greatest in winter, followed by spring, summer, and fall.

- The average effect of transboundary air pollutants on Korean PM_{10} are estimated to account for **3% - 12%** of the mean PM_{10} depending on seasons and wind directions.

- This gives a clue that the previous estimates between 20-50% might be overestimated.

Next steps

- Apply more detailed data (e.g. hourly maximum).
- Estimate the effect of air pollution from China on health outcomes and hospital spending in South Korea.