1 *Supplemental Materials for*

2 **Effectiveness evaluation of temporary emission control action in 2016**

3 **winter in Shijiazhuang, China**

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The measurement of the height of mixed layer

The height of mixed layer was measured at an atmospheric gradient monitoring station of Shijiazhuang with a lidar scanner (AGHJ-I-LIDAR (HPL)). The lidar scanner use 532-nm linearly polarized laser to accomplish the remote sensing detection of atmospheric particulate matters. Based on the vertical and horizontal polarization signal detection, the lidar can analyze some parameters about atmospheric layer, including atmospheric extinction coefficient, polarization ratio profile, height and optical thickness of mixed layer and so on. And then, information about temporal and spatial distribution-characteristics of atmospheric particulates, the spatial and temporal variations of atmospheric pollution layer, the transmission and deposition of particulate pollution can be obtained.

Control measures during the TECA period

(1) **Reduce the usage of coal.** The generating capacity of thermal power enterprises is reduced to the utmost. Coal-fired facilities without using clean fuels are shut down, whose steaming tons are less than 20 tons and don't undertake the task of centralized heating. The non-civilian coal-fired facilities in gas-related enterprises have to be shut down.

(2) **Decrease industrial production.** Except for the enterprises that provide residential heating and ensure people's livelihood, all the industrial enterprises in the whole city which include steel, cement, coke, casting, glass, ceramics, etc. are obliged to stop production. In principle, all the production processes that can generate volatile organic compounds (VOCs) are shut down. All the gas-related enterprises that cannot meet the standard emissions must stop production.

(3) **Inhibition of dust emission.** The main urban areas of Shijiazhuang and built-up areas of county are prohibited from the building demolition, road excavation, concrete mixing and earthwork, etc. without the approval of the municipal government. All building sites are used in totally-enclosed dustproof measures. All the open-air mines, sand mining, stone processing, and sand and stone processing industry must stop production in the whole city.

(4) **Driving restriction**. Motor vehicles are restricted on the basis of odd-and-even license plate rule in urban area of Shijiazhuang, and the bus-travel is free during the sword action period. Strictly prohibited the sale of gasoline, diesel and ordinary diesel oils that don't meet the fifth stage vehicle emission standard in China

52 (http://www.zhb.gov.cn/gkml/hbb/bgg/201601/t20160118_326596.htm). The system of staggered

53 working hours is implemented in all the administrative departments and institutions in the whole

54 city.

55   (5) **Prohibit open burning**. Crack down on these behaviors that burning straw, garbage, leaves,

56 weeds, and burning mountain, etc. in the whole city during the control action period.

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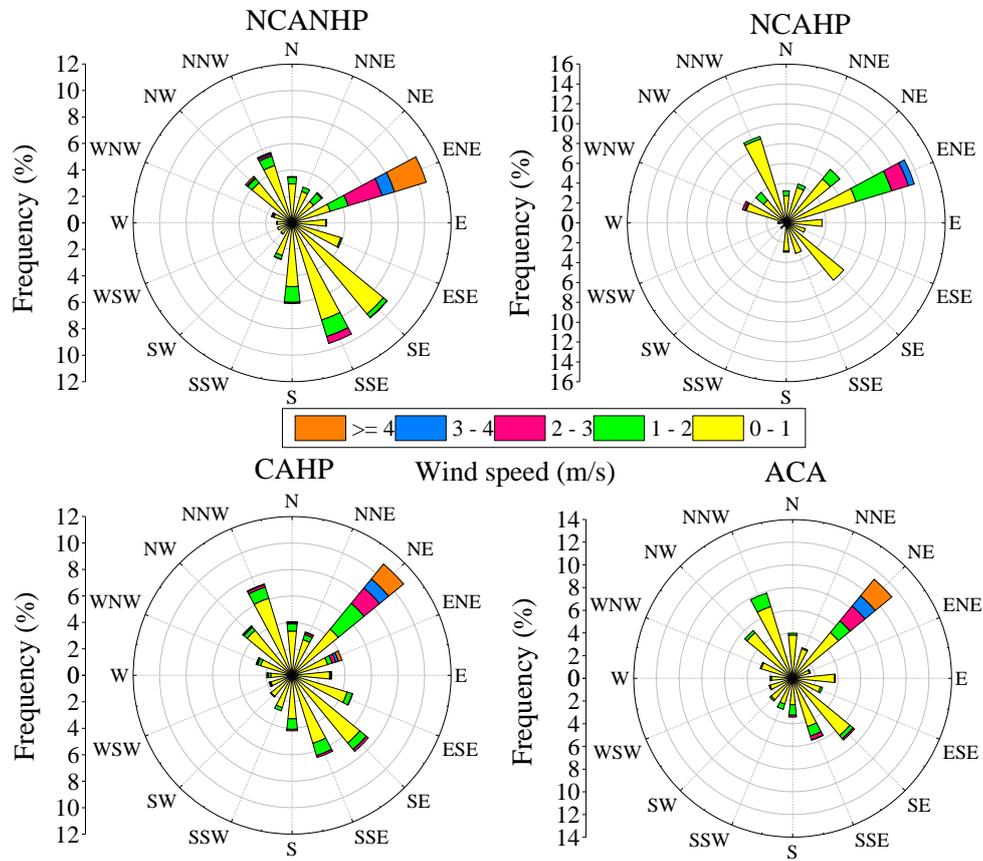
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Fig. S1. Rose map of wind directions and wind speeds in Shijiazhuang during the four stages of TECA period.

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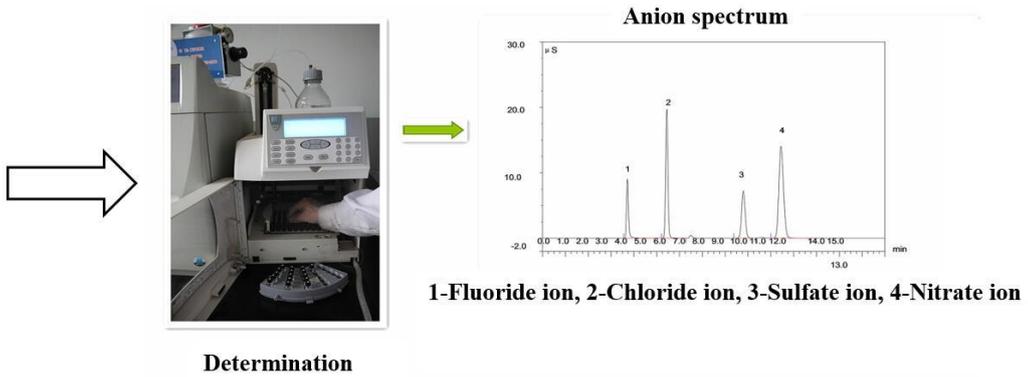
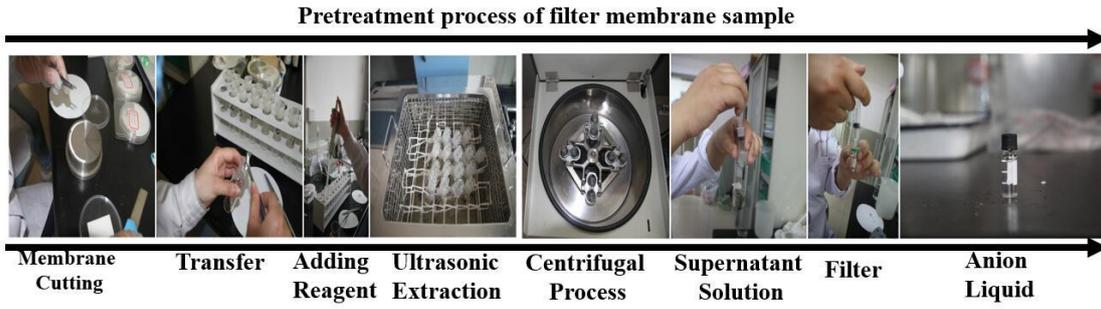
Pretreatment process of filter membrane sample

| Membrane Cutting | Transfer | Adding Reagent | Ultrasonic Extraction | Centrifugal Process | Supernatant Solution | Filter | Anion Liquid |

Anion spectrum

1-Fluoride ion, 2-Chloride ion, 3-Sulfate ion, 4-Nitrate ion

Determination

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75   **Fig. S2.** The determination process of anions in the $PM_{2.5}$ filter membrane samples.
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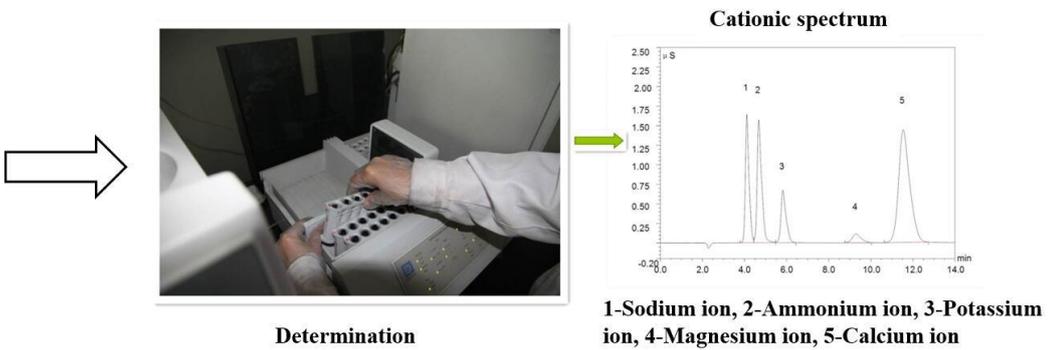
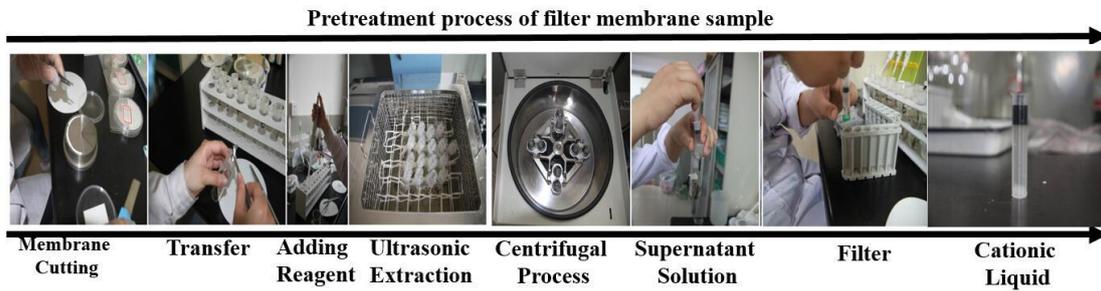
Pretreatment process of filter membrane sample

| Membrane Cutting | Transfer | Adding Reagent | Ultrasonic Extraction | Centrifugal Process | Supernatant Solution | Filter | Cationic Liquid |

Cationic spectrum

1-Sodium ion, 2-Ammonium ion, 3-Potassium ion, 4-Magnesium ion, 5-Calcium ion

Determination

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79   **Fig. S3.** The determination process of cations in the $PM_{2.5}$ filter membrane samples.

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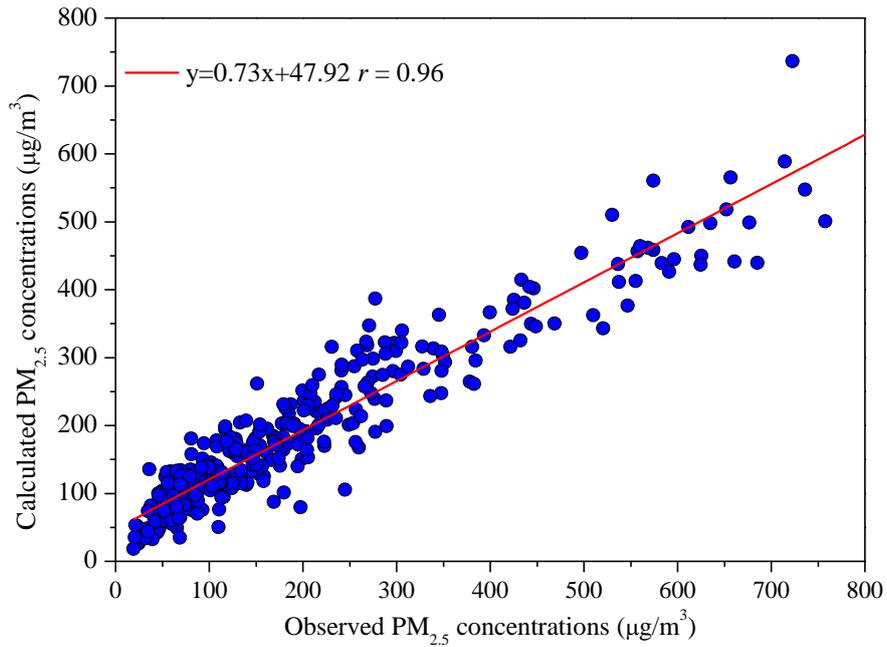
81 **Fig. S4.** Correlations between observed and calculated PM2.5 concentrations during the whole sampling period:

82 November 24, 2015 to January 9, 2017. Also shown are the linear regression lines with regression equations.

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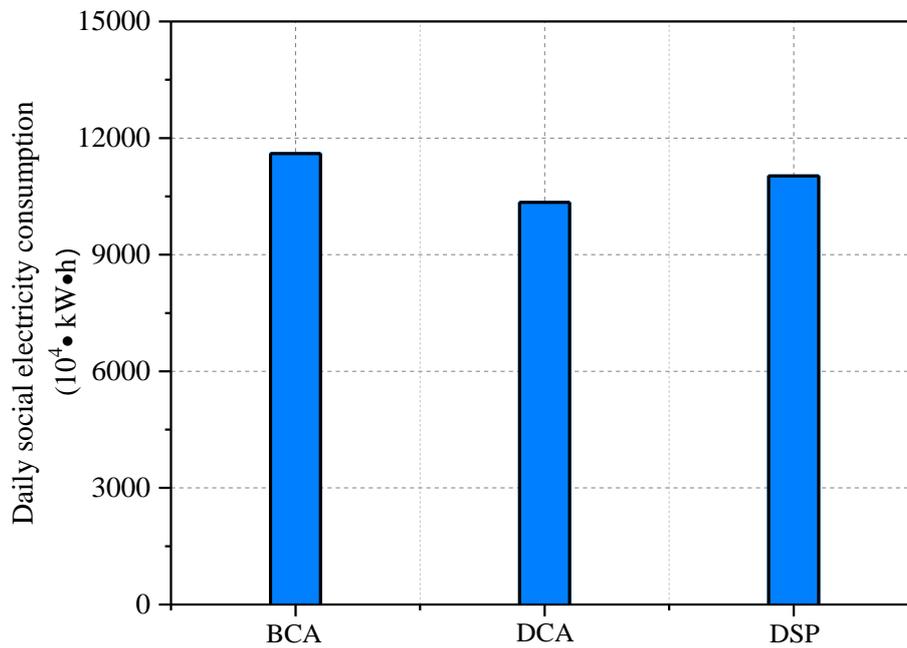
87 **Fig. S5.** Daily social electricity consumption during the TECA in Shijiazhuang. BCA represents before the control

88 action i.e. from November 1 to 17, 2016; DCA represents during the control action i.e. November 18 to December

89 31, 2016; DSP represents during the same period of the TECA in 2015 i.e. November 18 to December 31, 2015.

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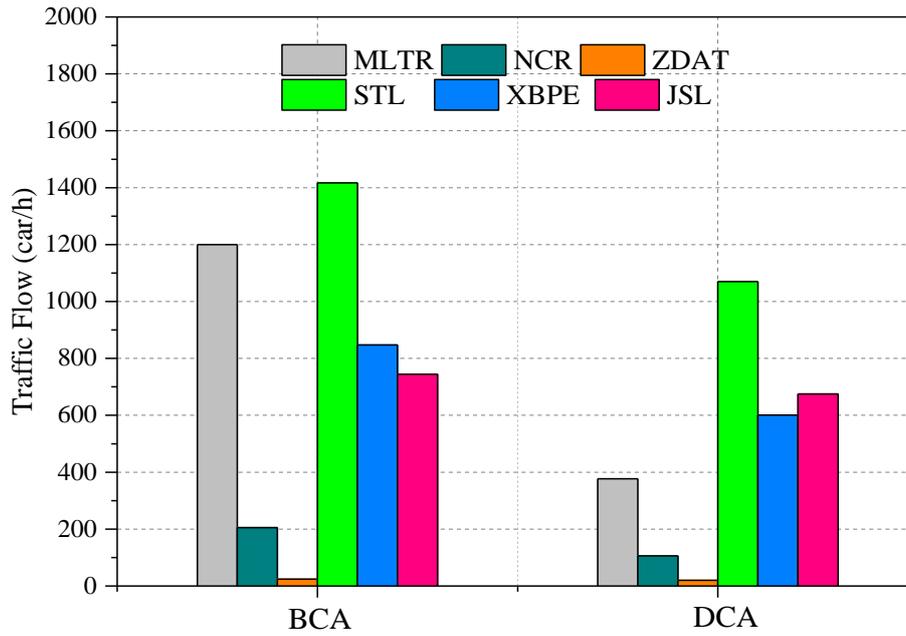
Fig. S6. The average traffic flow on arterial roads during different stages of TECA. BCA represents before the control

action i.e. from November 1 to 17, 2016; DCA represents during the control action i.e. November 18 to December

31, 2016. The arterial roads include the main line of the third ring road (MLTR), new city road (NCR), the road that

from Zhengding high-speed railway station to airport (ZDAT), the Shitai line of Beijing-Kunming expressway (STL),

Xibaipo expressway (XBPE) and Jingshi line of the Beijing-Kunming expressway (JSL).

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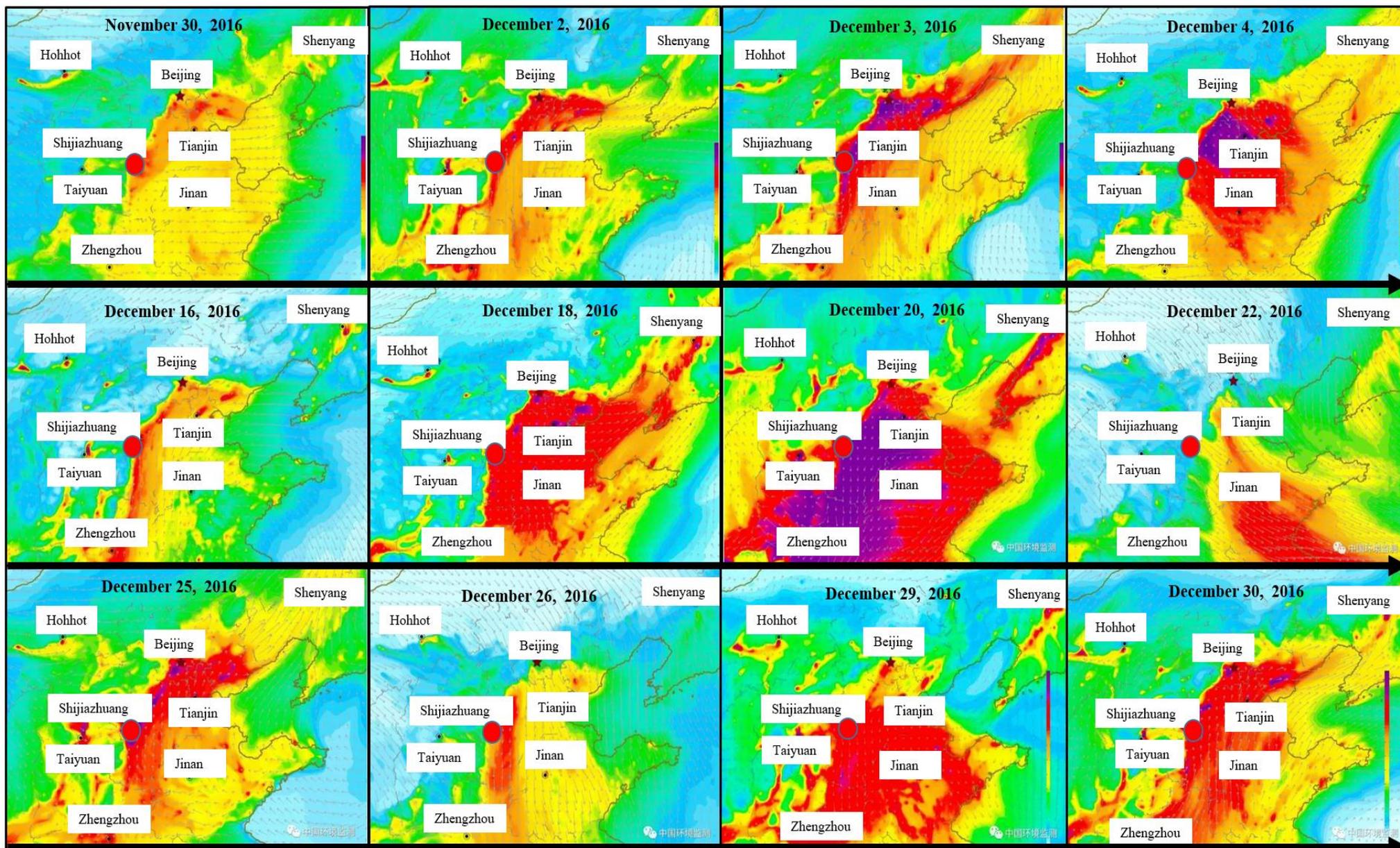
Fig. S7. The meteorological flow field maps and the spatial distributions of PM$_{2.5}$ in Shijiazhuang during the CAHP. Red and violet represent high PM$_{2.5}$ concentration areas. The arrows represent the movement

direction of the air masses. Pictures are cited from the website of the China Environmental Monitoring Station (http://www.cnemc.cn/).

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103 **Table S1.** Details of the twenty-four monitoring sites in Shijiazhuang during the TECA period.

Full Names of Monitoring Sites	Abbreviations	Areas	Cities/Counties	Longitude (°)	Latitude (°)
Twenty-second Middle School	TSMS	Urban	Shijiazhuang City	114.56158	38.04198
High-tech Zone	HTZ	Urban	Shijiazhuang City	114.6046	38.03977
Great Hall of the People	GHP	Urban	Shijiazhuang City	114.52144	38.05237
Century Park	CP	Urban	Shijiazhuang City	114.54207	38.03062
Water Source Area in the Northwest	WSAN	Urban	Shijiazhuang City	114.50188	38.13979
University Area in the Southwest	UAS	Urban	Shijiazhuang City	114.46706	38.01180
Staff Hospital	SH	Urban	Shijiazhuang City	114.45479	38.05132
Fenglong Mountain	FLM	Suburb	Suburb of Shijiazhuang	114.35409	37.90970
Gaoyi	GY	Suburb	Gaoyi Country	114.6074	37.62268
Gaocheng	GC	Suburb	Suburb of Shijiazhuang	114.86178	38.03854
Xingtang	XT	Suburb	Xingtang Country	114.55955	38.44420
Jinzhou	JZ	Suburb	Jinzhou City	115.07879	38.03968
Jingxing Mining District	JXMD	Suburb	Jingxing Country	114.06893	38.07064
Lingshou	LS	Suburb	Lingshou Country	114.36702	38.31454
Luquan	LQ	Suburb	Suburb of Shijiazhuang	114.34733	38.08473
Luancheng	LC	Suburb	Suburb of Shijiazhuang	114.63308	37.90622
Pingshan	PS	Suburb	Pingshan Country	114.20421	38.26650
Shenze	SZ	Suburb	Shenze Country	115.21301	38.19672
Wuji	WJ	Suburb	Wuji Country	114.9909	38.17842
Xinle	XL	Suburb	Xinle City	114.69038	38.34926
Yuanshi	YS	Suburb	Yuanshi Country	114.51701	37.76645
Zanhuang	ZH	Suburb	Zanhuang Country	114.39238	37.67170
Zhaoxian	ZX	Suburb	Zhaoxian Country	114.76986	37.77079
Zhengding	ZD	Suburb	Zhengding Country	114.59258	38.15883

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107 **Table S2** Detailed information about online sampling.

Items	Production company	Model number
SO_2	Automated Precision Inc. (API)	T100
NO_2	Automated Precision Inc. (API)	T200
CO	Automated Precision Inc. (API)	T300
O_3	Automated Precision Inc. (API)	T400
$PM_{2.5}$ and PM_{10}	XianHe, Hebei	XHPM2000E
Meteorological conditions	Davis, America	Vantage Pro2

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Table S3 Details of the filter membrane sampling in Shijiazhuang.

Sampling Sites	Sampling period	Sample number	Sampling Instrument	Flow Rate	Sampling Period	Filter Diameter	Filter Pore Size
LC	20151124-20170109	260	Thermo Scientific Partisol 2025i	16.7L/Min	23h	47mm	1μm
LQ	20151124-20170109	260	Thermo Scientific Partisol 2026i	16.7L/Min	23h	47mm	1μm
TSMS	20151124-20170109	260	Thermo Scientific Partisol 2027i	16.7L/Min	23h	47mm	1μm

113   LC represents Luquan site, LQ represents Luancheng site, TSMS represents Twenty-second Middle School site.

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Table S4 The detection limits of all the elements by ICP.

Elements	Detection limits ($\mu g/m^3$)	Recovery rate (%)
Al	2.1×10^{-2}	82
Si	1.7×10^{-2}	83
Ti	1.4×10^{-3}	86
Cr	6.8×10^{-4}	100
Mn	6.4×10^{-4}	88
Fe	2.2×10^{-2}	86
Cu	1.4×10^{-2}	94
Zn	3.7×10^{-2}	120
As	6.5×10^{-5}	87
Pb	1.0×10^{-2}	90

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119   **Table S5.** The numbers of closed specific-enterprises in different districts and counties of
120   Shijiazhuang during the TECA period.

Districts and Counties	Number	Districts and Counties	Number
High-tech District	15	Pingshan County	59
Gaoyi County	26	Qiaoxi District	3
Gaocheng district	50	Shenze County	4
Xingtang County	23	Wuji County	13
Chemical Industry Park	5	Xinhua District	14
Jinzhou City	115	Xinle City	61
Jingxing Mining District	11	Yuhua District	1
Jingxing County	121	Yuanshi County	12
Lingshou County	559	Zanhuang County	16
Luquan District	121	Changan District	201
Luancheng District	69	Zhengding County	44

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