Asian dust transport proteinaceous matter from the Gobi Desert to Northern China

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Introduction

The supporting information contains the supplementary Text 1, Table S1~S4 and Figure S1~S2.

Text 1

The atmospheric deposition fluxes of CAAs (mg N m^{-2} d^{-1}) at four sampling sites are estimated from equation (1):

$$\mathrm{Fdry}=\mathrm{C}\cdot\mathrm{Vd} \qquad (1)$$

The uncertainty range of protein-N deposition fluxes can be calculated by using the formula (2) for error propagation for multiplication:

$$\left(\frac{\Delta Fdry}{Fdry}\right)^2 = \left(\frac{\Delta C}{C}\right)^2 + \left(\frac{\Delta Vd}{Vd}\right)^2 \qquad (2)$$

The uncertainty for the deposition velocity of aerosol protein-N in this study was set to a factor of 3. The concentration C is measured with negligible uncertainty (0.1) compared to Vd, the term △C/C can be considered zero. Therefore, the equation simplifies to:

$$\frac{\Delta Fdry}{Fdry} = \frac{\Delta Vd}{Vd} \qquad (3)$$

Given △Vd/Vd = 3:

$$\frac{\Delta Fdry}{Fdry} = 3$$

Consequently, Fdry will also have the same factor of uncertainty:

$$F_{dry,min} = C \cdot \frac{Vd}{3}$$

$$F_{dry,max} = C \cdot 3 \cdot Vd$$

Each deposition fluxes of protein-N with the uncertainty range at the four sampling cities was provided in Figure 8.

Table S1. Information on the sampling sites and numbers, average and standard deviation of Ala%/Pro%, Gly%/Pro%, Glu%/Pro%, δ15N values of combined glycine and combined leucine determined in these samples.

Location	Latitude (°N) and longitude (°E)	Samples	number	Ala%/Pro%	Gly%/Pro%	Glu%/Pro%	$\delta^{15}N$ values of combined glycine	$\delta^{15}N$ values of combined leucine
Soil								
Gobi Desert	43.46~43.60, 112.00~112.05	Surface soil	n=5	2.0±0.4	1.8±0.5	0.1±0.1	2.7±0.4	1.9±1.8
Beijing	39.98, 116.31	Surface soil	n=6	1.6±0.3	1.8±0.6	1.1±0.4	1.7±0.4	3.0±1.4
Tianjin	39.11, 117.17	Surface soil	n=4	1.3±0.3	1.1±0.2	0.8±0.5	0.6±0.6	-0.6±1.1
Shijiazhuang	38.03, 114.51	Surface soil	n=3	0.8±0.2	0.6±0.2	0.8±0.3	1.6±0.2	2.9±0.5
Taiyuan	37.86, 112.51	Surface soil	n=5	1.1±0.2	1.0±0.2	0.8±0.2	4.2±2.1	3.3±0.8
Plant								
Gobi Desert	43.46~43.60, 112.00~112.05	*Chenopodium ambrosioides*	n=3	0.5±0.4	0.2±0.4	2.7±0.8	8.3±0.4	16.1±1.4
Gobi Desert	43.59, 112.04	*Tripogon chinensis*	n=4	2.0±0.8	0.3±0.4	6.1±0.5	10.8±0.2	11.0±0.8
Gobi Desert	43.59, 112.04	*Tamarix chinensis*	n=5	2.7±0.9	0.7±0.6	65.6±3.5	6.8±0.7	8.9±1.7
Beijing	39.98, 116.31	*Platanus orientalis*	n=5	1.0±0.1	1.0±0.2	0.9±0.04	-8.7±0.6	-1.7±0.5
Tianjin	39.11, 117.17	*Platanus orientalis*	n=16	0.9±0.2	1.0±0.2	1.5±0.7	1.6±1.2	-0.8±1.0
Shijiazhuang	38.03, 114.51	*Platanus orientalis*	n=6	0.8±0.1	0.9±0.1	1.0±0.1	-6.9±0.4	-0.2±1.2
Taiyuan	37.86, 112.51	*Platanus orientalis*	n=5	0.6±0.04	0.7±0.05	0.9±0.2	-8.4±1.5	-2.2±1.6

Table S2. The recoveries and precision of CAA analysis.

Amino acids	Recovery (%)	Precision (%)
Glycine (Gly)	106.5	1.1
Alanine (Ala)	92.6	3.6
Aspartic acid (Asp)	95.0	8.6
Glutamic acid (Glu)	105.6	8.8
γ-amino butyric acid (Gaba)	95.7	7.7
Serine (Ser)	92.7	5.7
Proline (Pro)	93.2	6.7
Threonine (Thr)	90.0	6.1
Valine (Val)	95.5	1.3
Lysine (Lys)	82.5	6
Leucine (Leu)	92.0	0.8
Isoleucine (Ile)	93.1	2
Arginine (Arg)	85.4	9.4
Phenylalanine (Phe)	93.7	5.4
Ornithine (Orn)	91.5	9.9
Tyrosine (Tyr)	80.7	0.3
Histidine (His)	95.1	1.7
Methionine (Met)	86.6	2.7

Table S3. Particle Mass Concentrations and mean ratio of $PM_{2.5}$ to PM_{10} at four sampling sites. Please note BJ represent Beijing, TJ represent Tianjin, SJZ represent Shijiazhuang, TY represent Taiyuan.

Sampling sites	PM_{10}*		$PM_{2.5}$*		$PM_{2.5}/PM_{10}$	
	dust	Non-dust	dust	Non-dust	dust	Non-dust
BJ	1224**	141	147**	93	0.1	0.7
TJ	849**	135	75	77	0.1	0.6
SJZ	761**	161	130**	63	0.2	0.4
TY	611**	189	122**	64	0.2	0.4

* Units are μg m^{-3} for particle mass.

**$p < 0.01$

Table S4. Pearson correlations of the total concentration of the combined amino acids (TCAA) with the concentration of PM_{10}, NO_2, SO_2, O_3, as well as local meteorological conditions (including wind speed (WD), temperature (T) and relative humidity (RH)) in local cities.

		TCAA	PM_{10}	WD	T	RH	NO_2	SO_2	O_3
TCAA	r	1.00	0.82*	0.12	-0.15	-0.34	-0.29	-0.32	-0.30
	p value	--	0.00	0.56	0.45	0.08	0.15	0.11	0.13

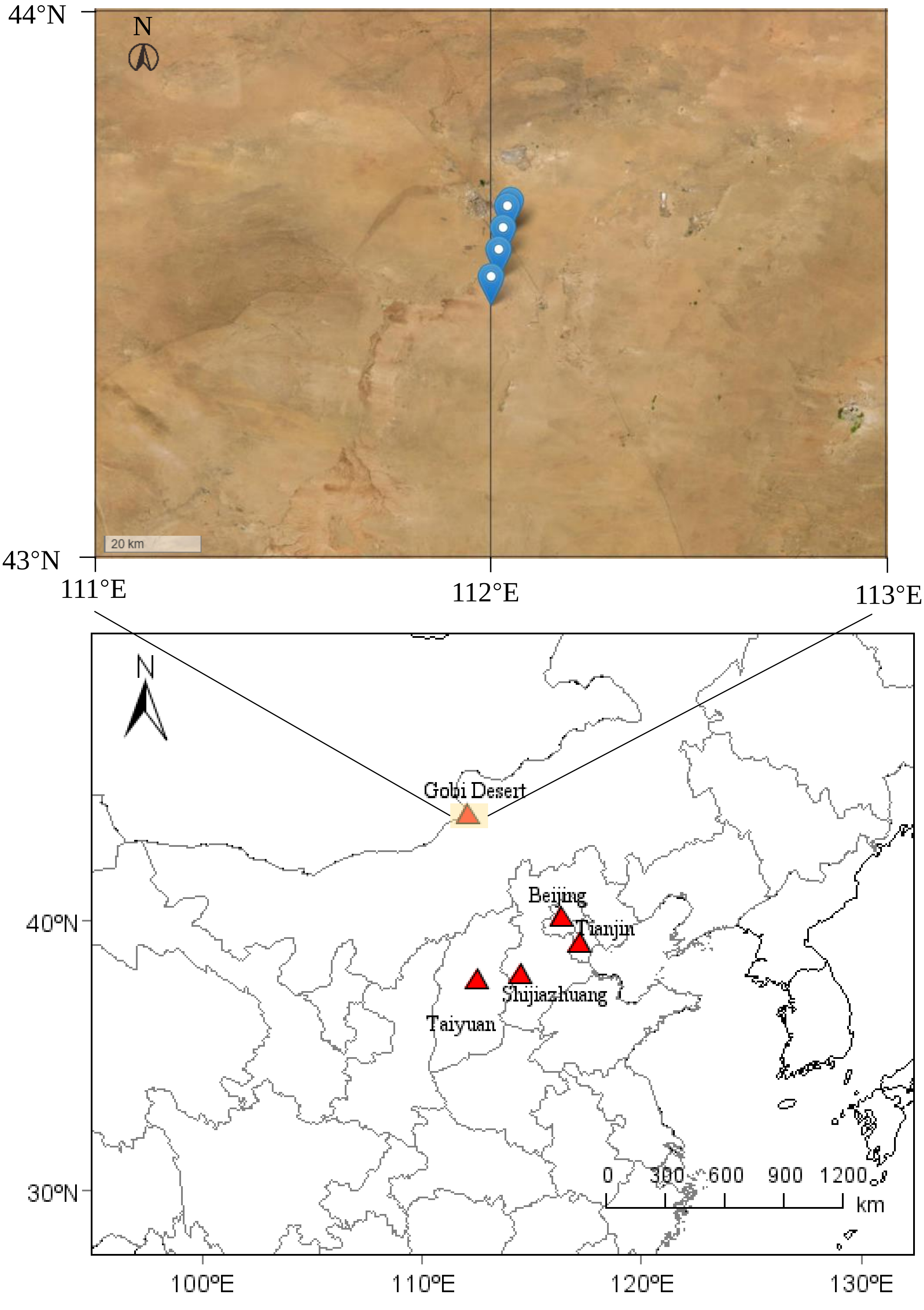

Figure S1. Sampling sites of the source region (Gobi Desert) and four urban areas in the downwind North China Plain, including Beijing, Tianjin, Shijiazhuang and Taiyuan.

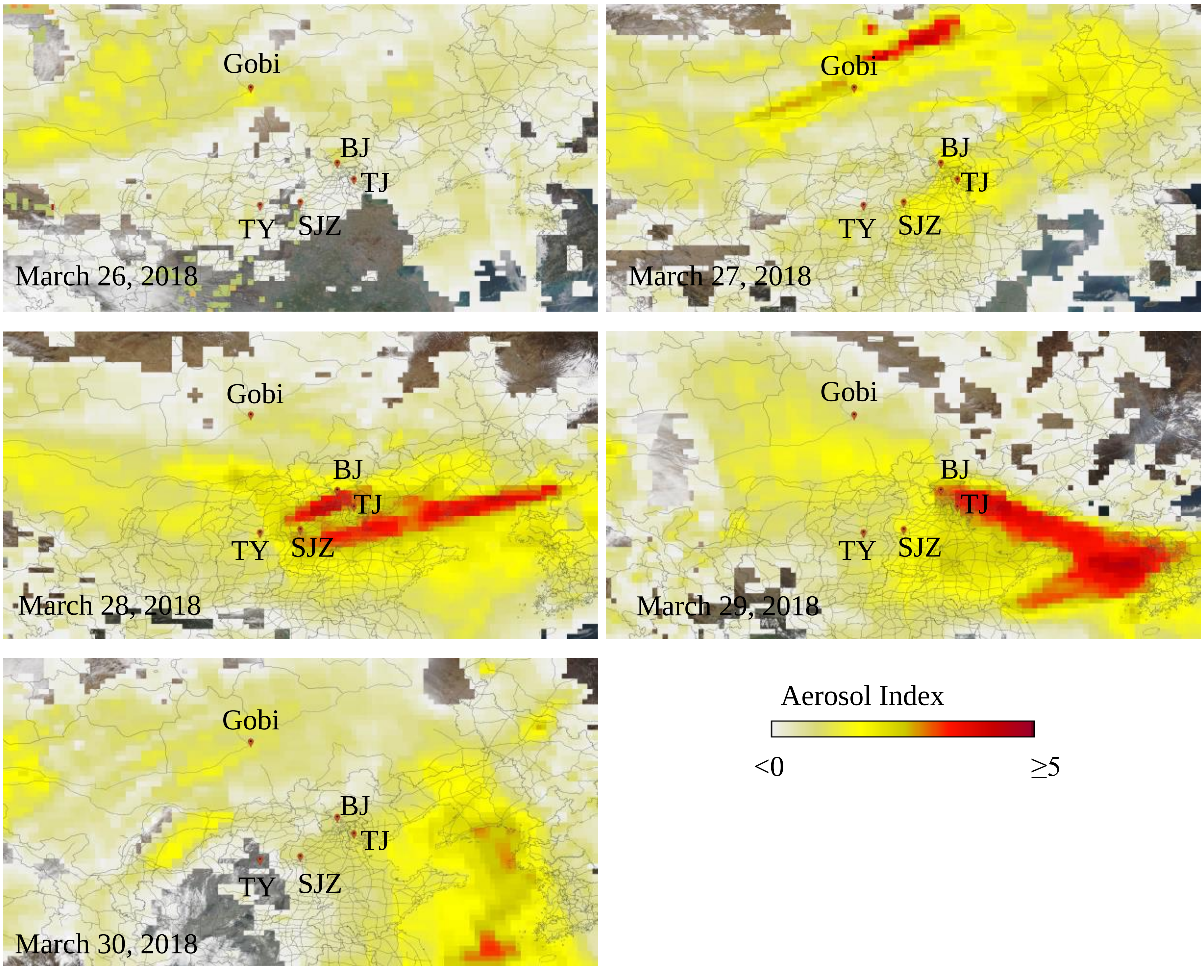

Figure S2. MODIS satellite image over North China Plain during the sampling period obtained from NASA (https://worldview.earthdata.nasa.gov/, last access on 7 Fed 2025). Red dots represent four sampling sites in the North China Plain.