Atmospheric Chemistry and Physics

Supplemental materials for

Mineralogy and geochemistry of Asian dust: Dependence on migration path, fractionation, and reactions with polluted air

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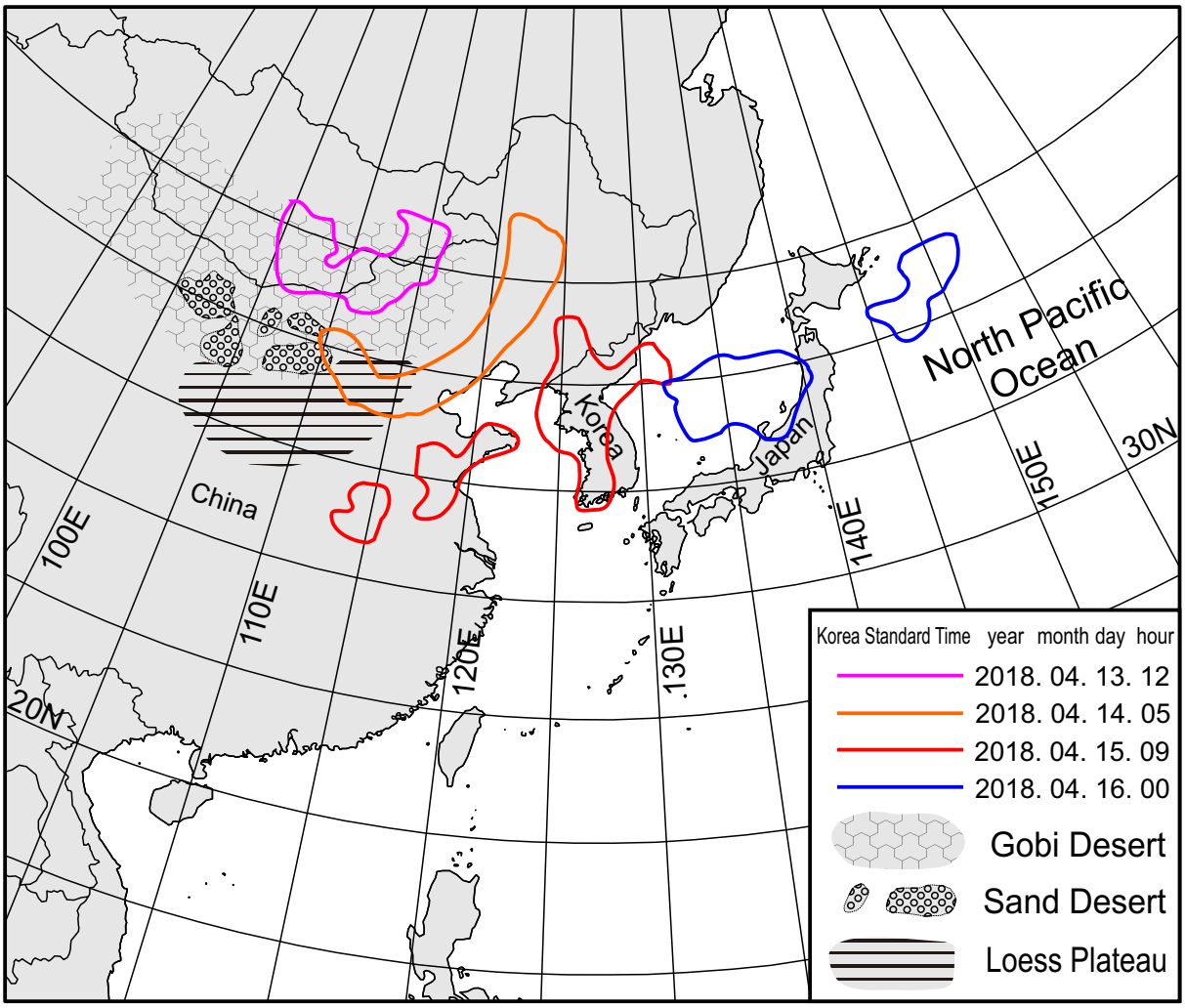
Supplementary Figure S1. Illustration of dust outbreak (magenta line), migration toward Korean Peninsula (orange), crossing Korean Peninsula (red), and migration toward North Pacific Ocean (blue) (upper panel) during the fourteen Asian dust events. The extents of Asian dust were drawn based on satellite dust index images (lower four panels). Maps were drawn based on the image of Communication, Ocean, and Meteorological Satellite (National Meteorological Satellite Center, 2019).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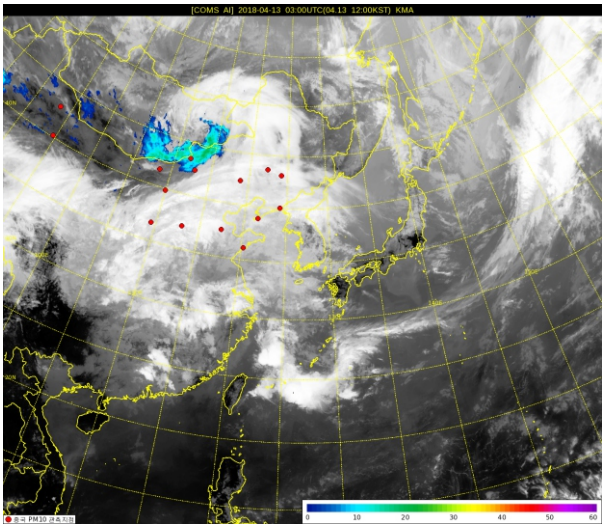

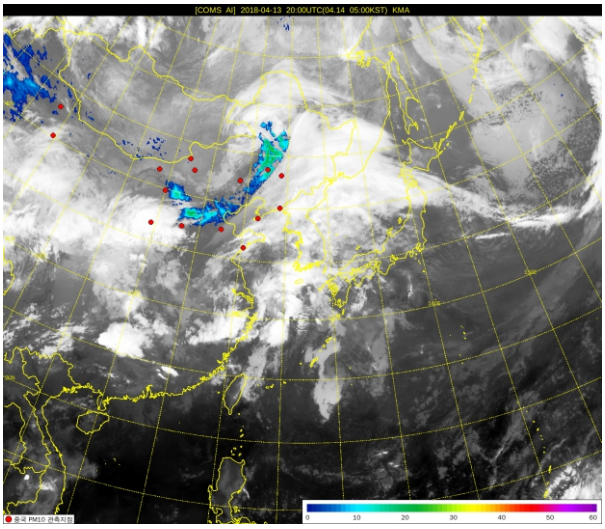

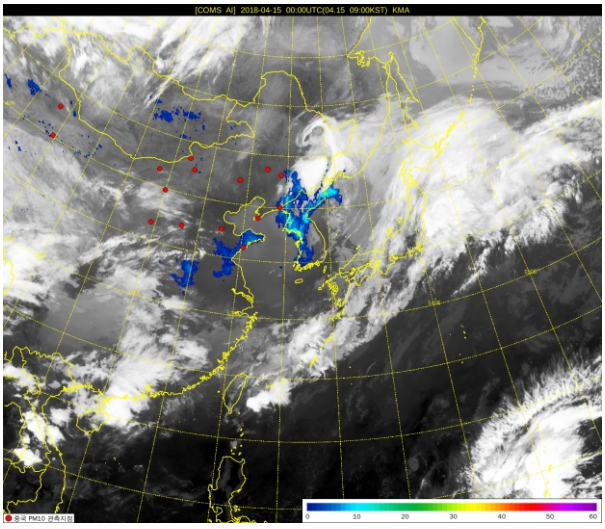

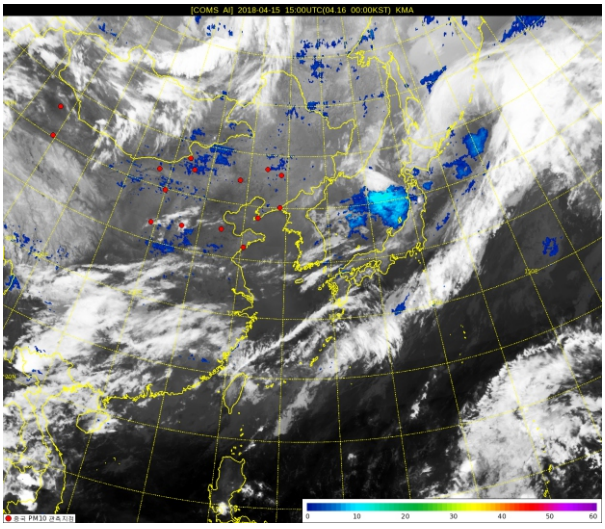

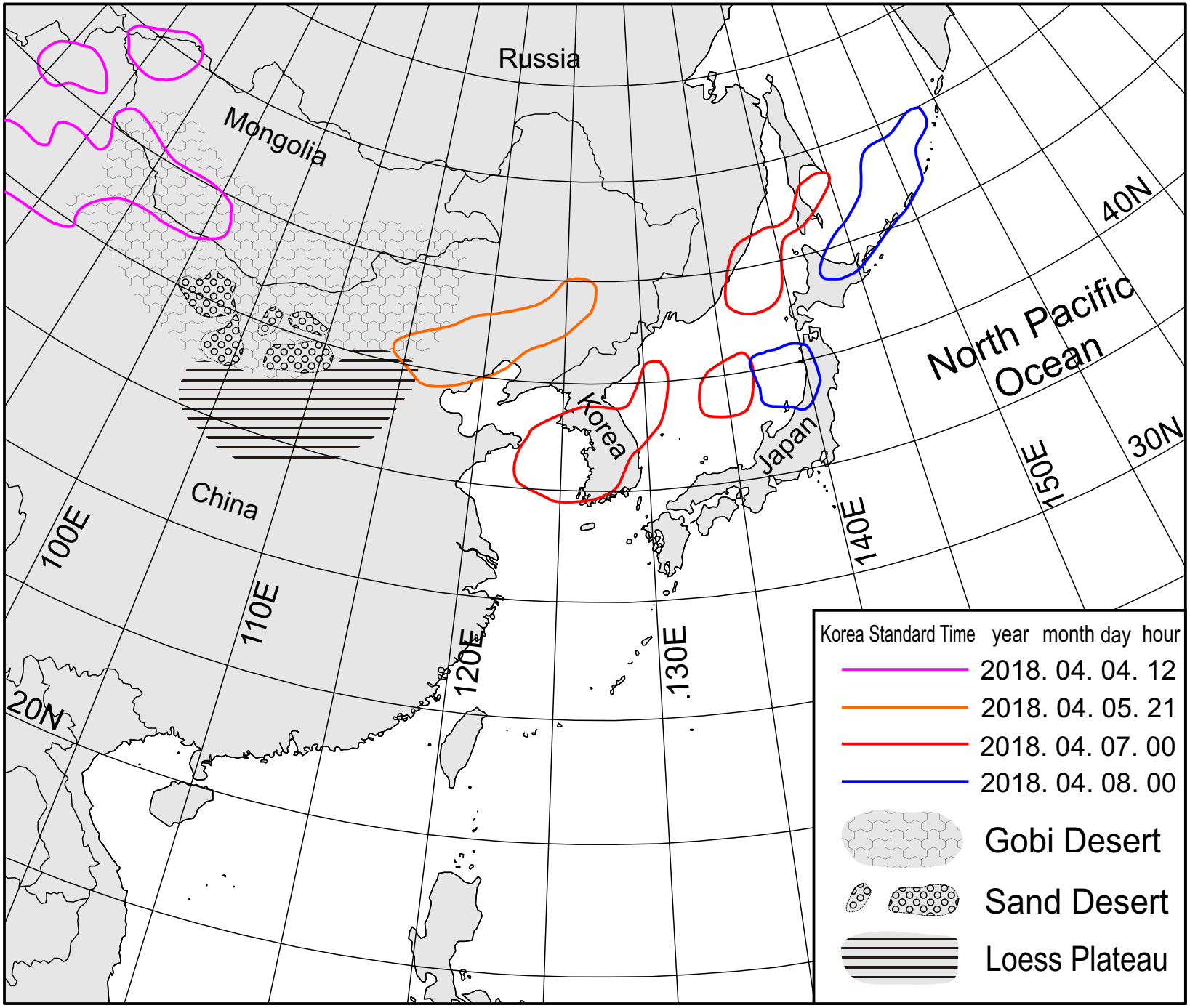
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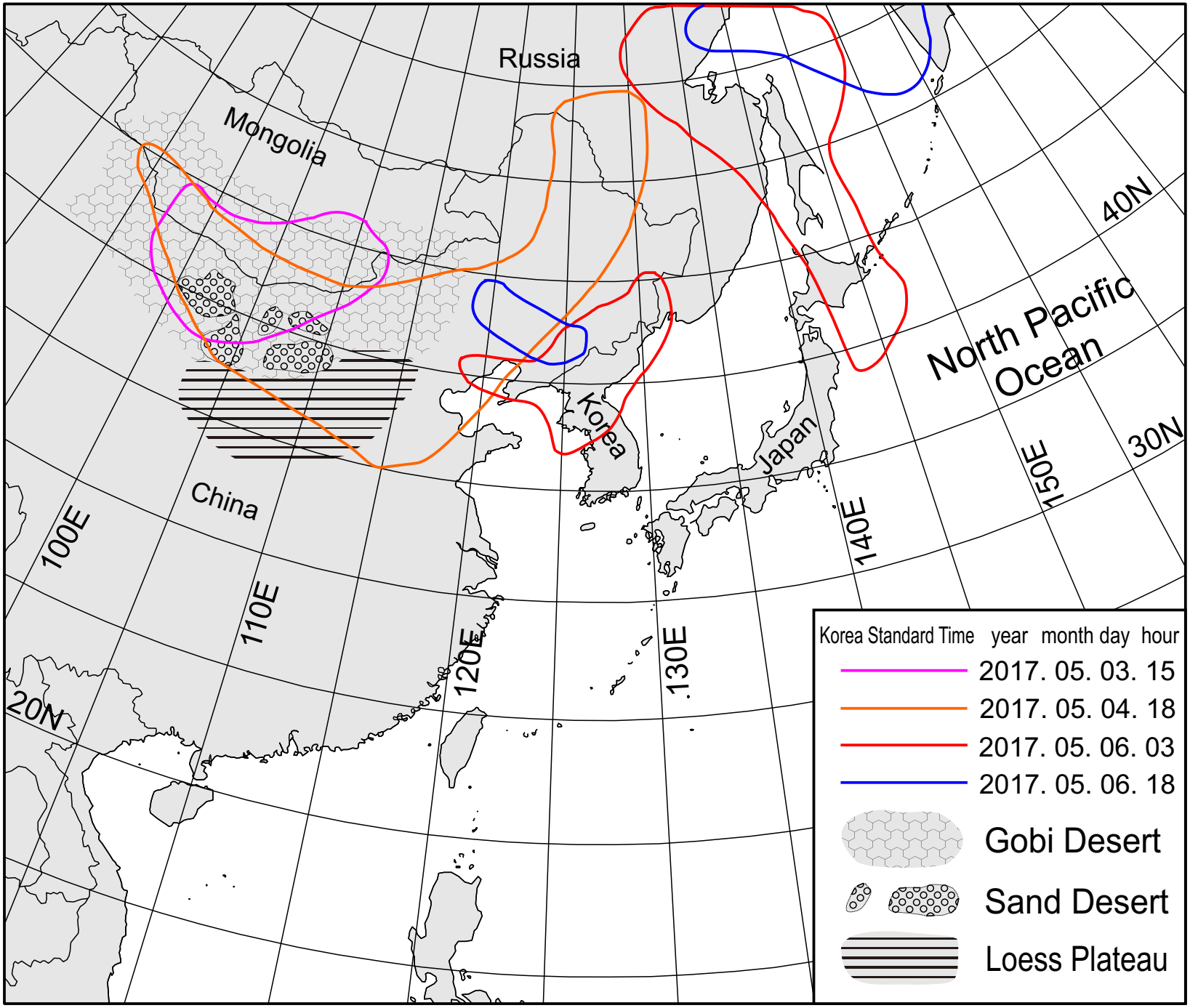
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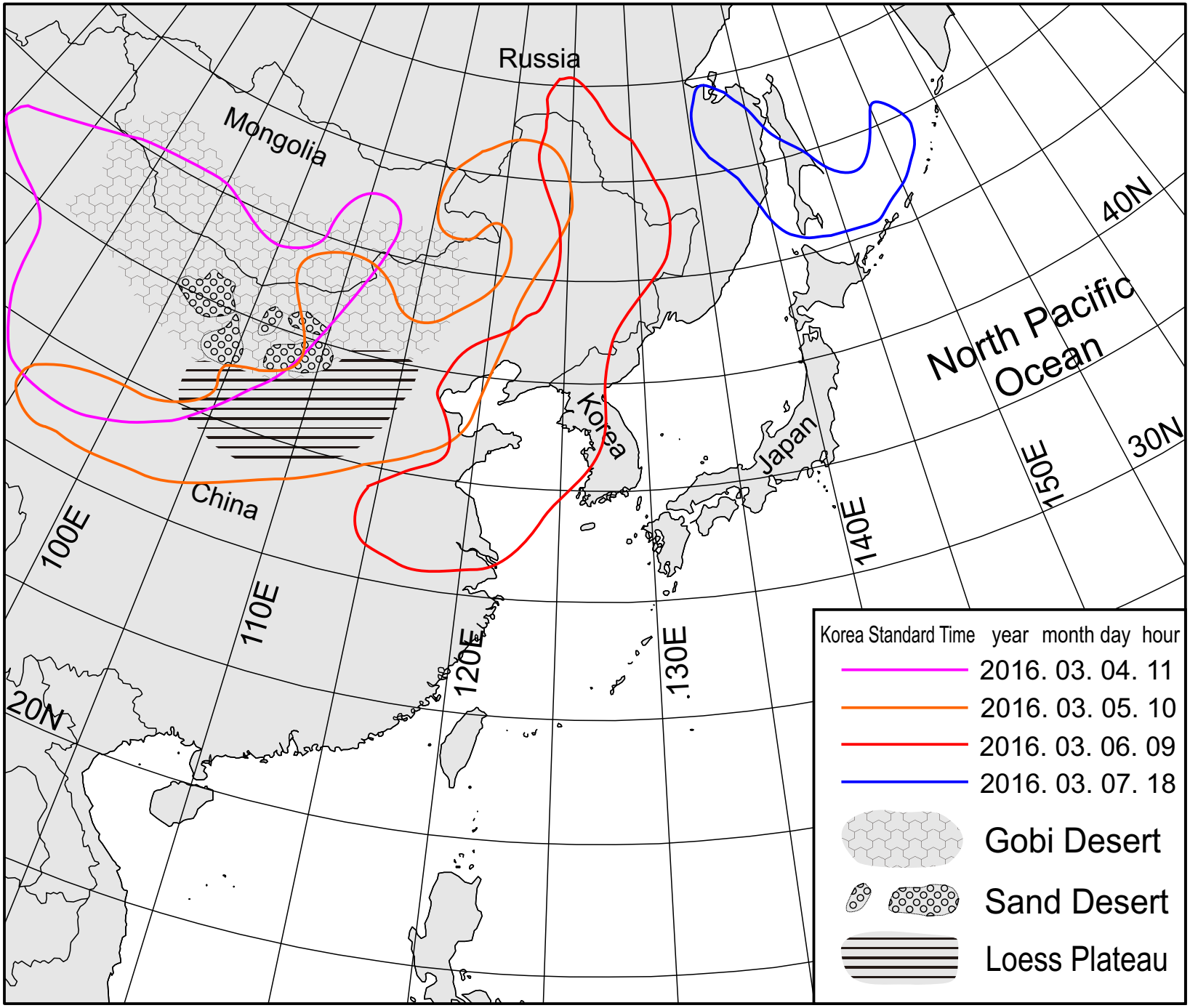
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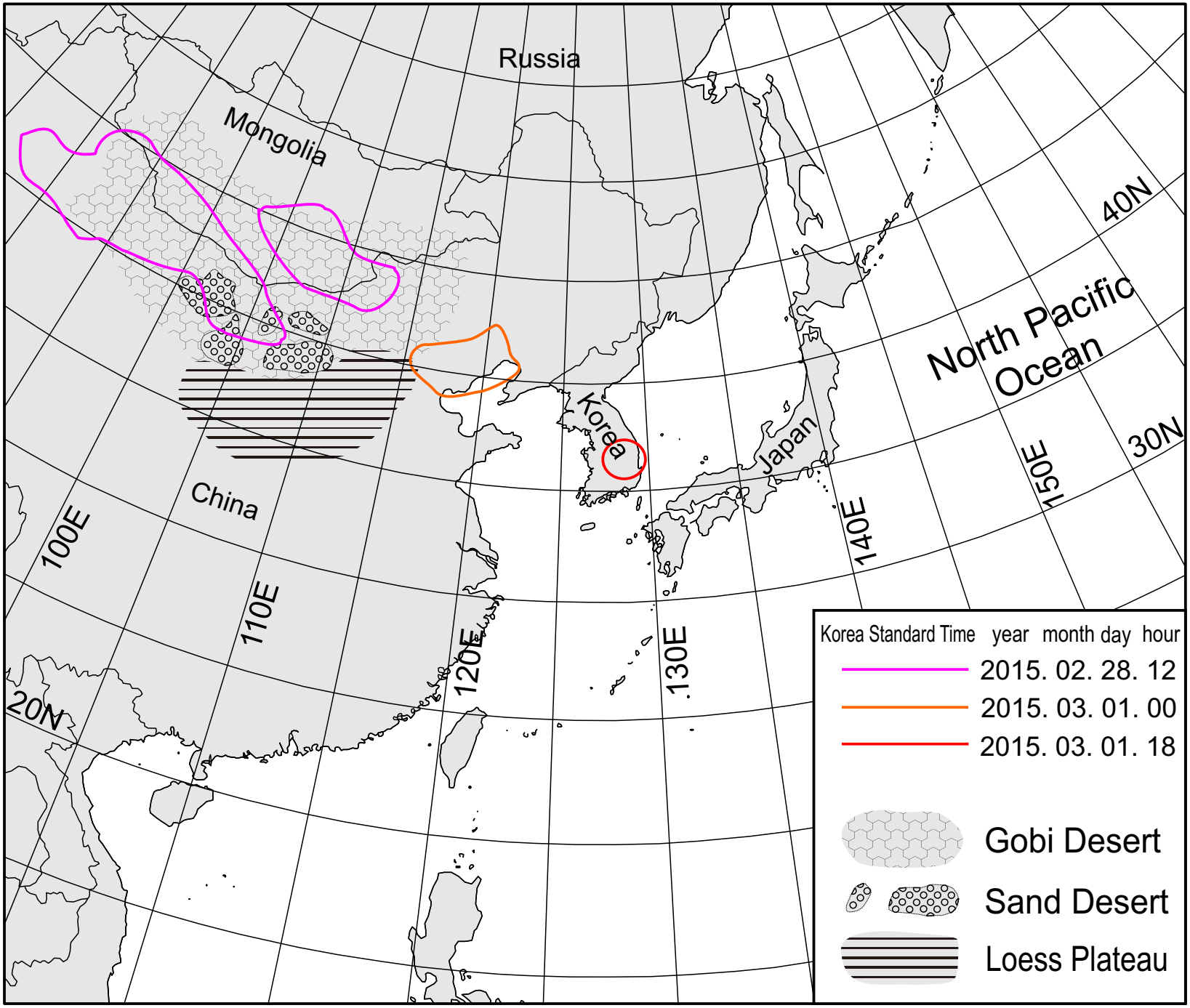
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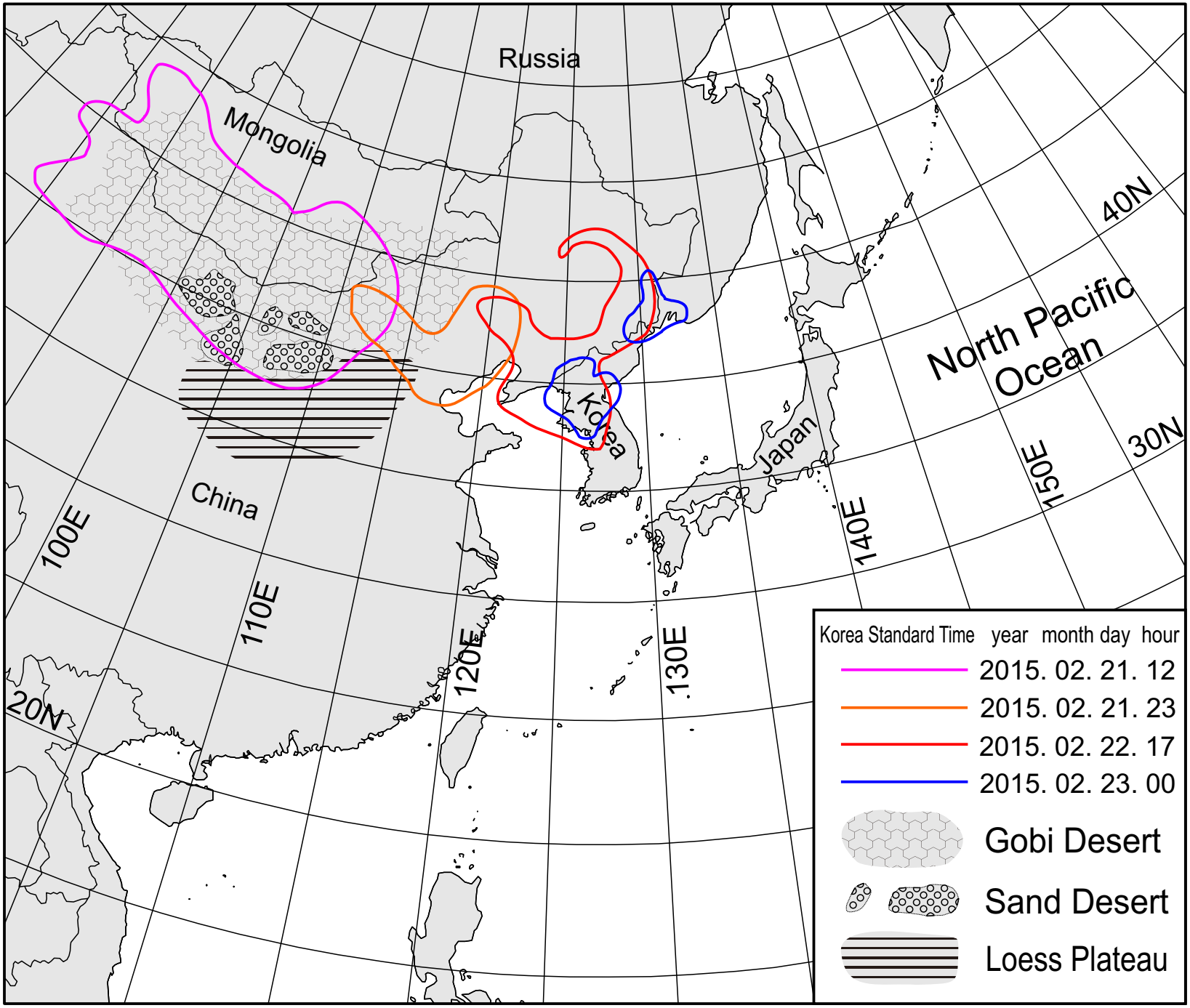
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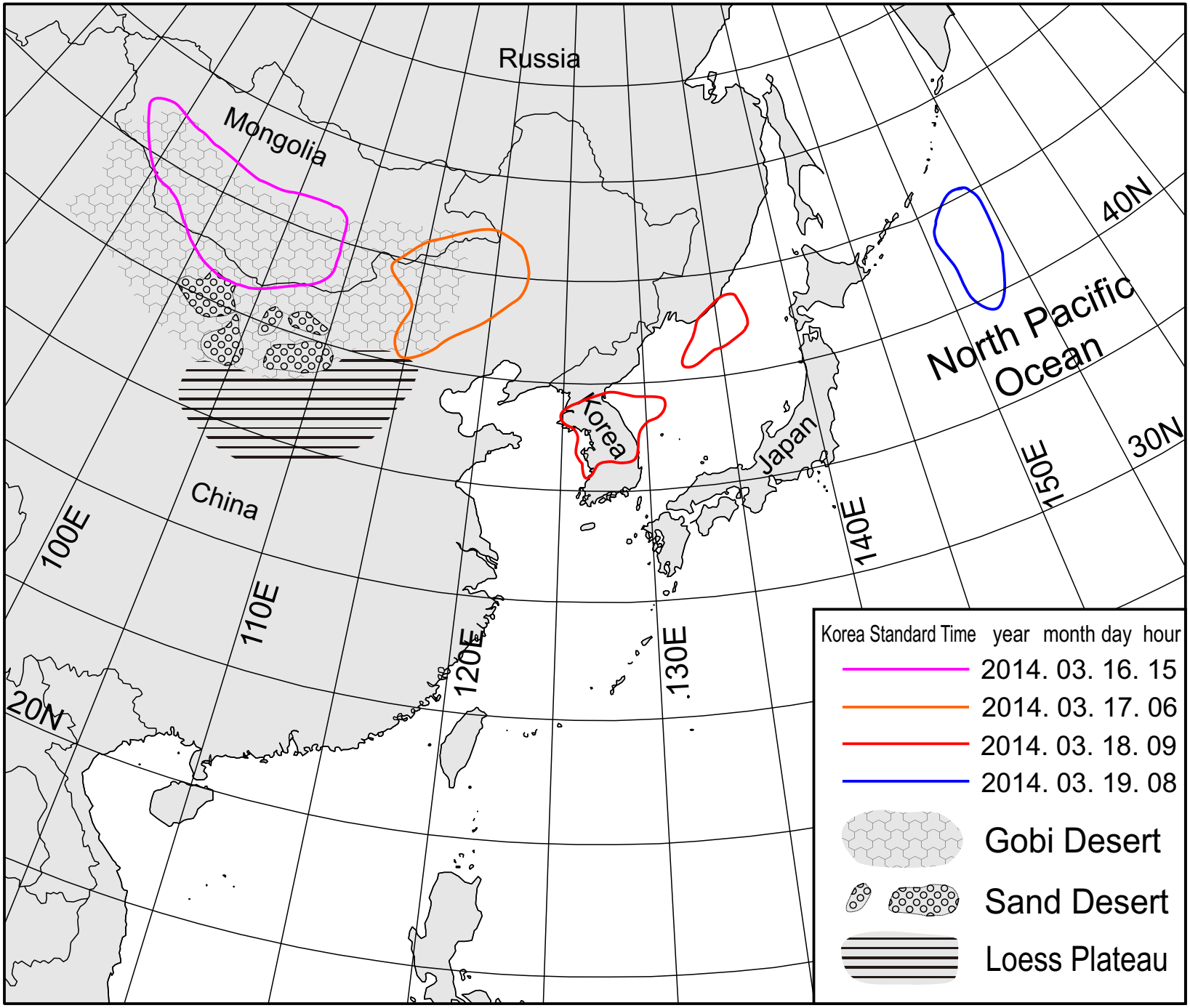
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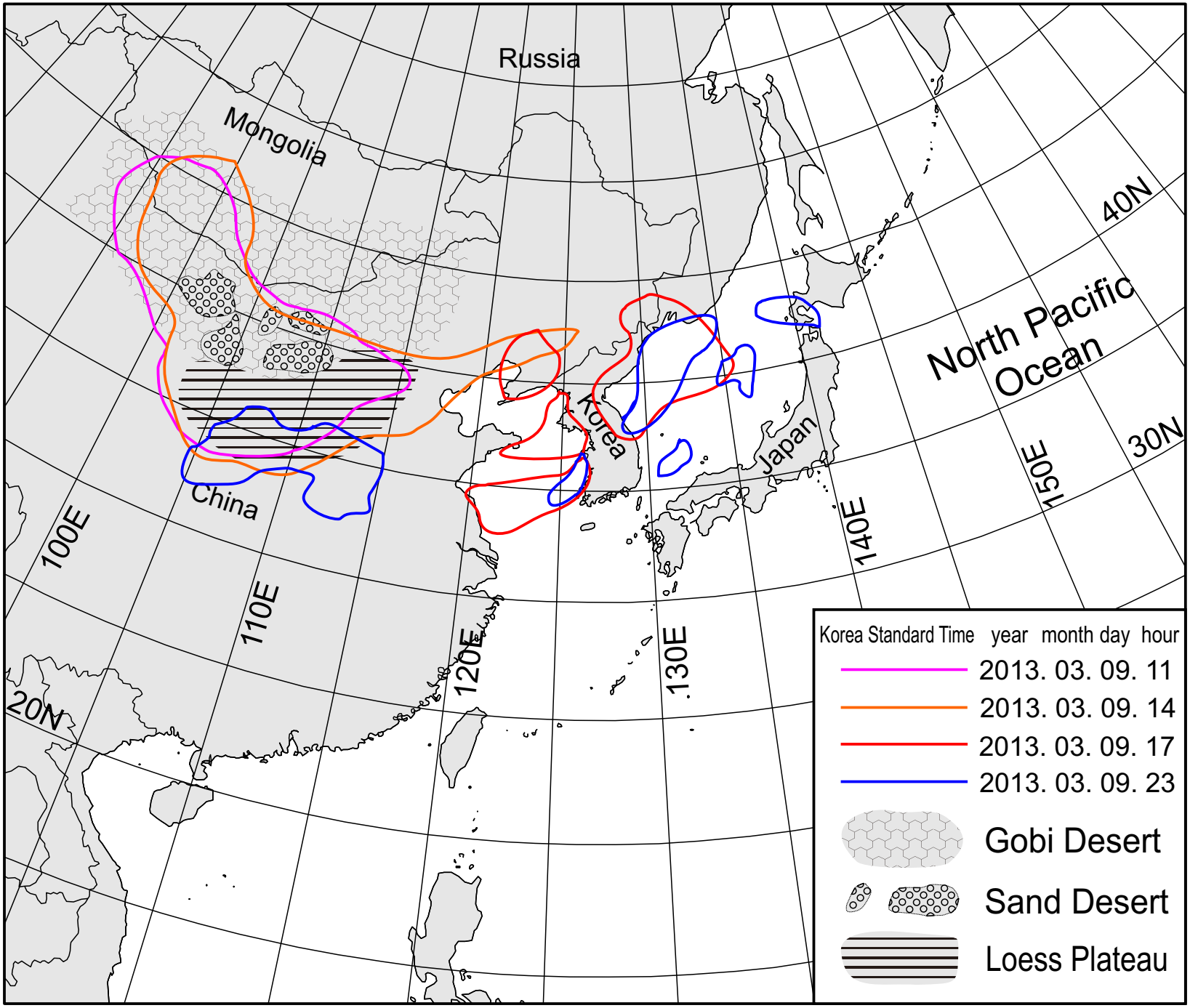
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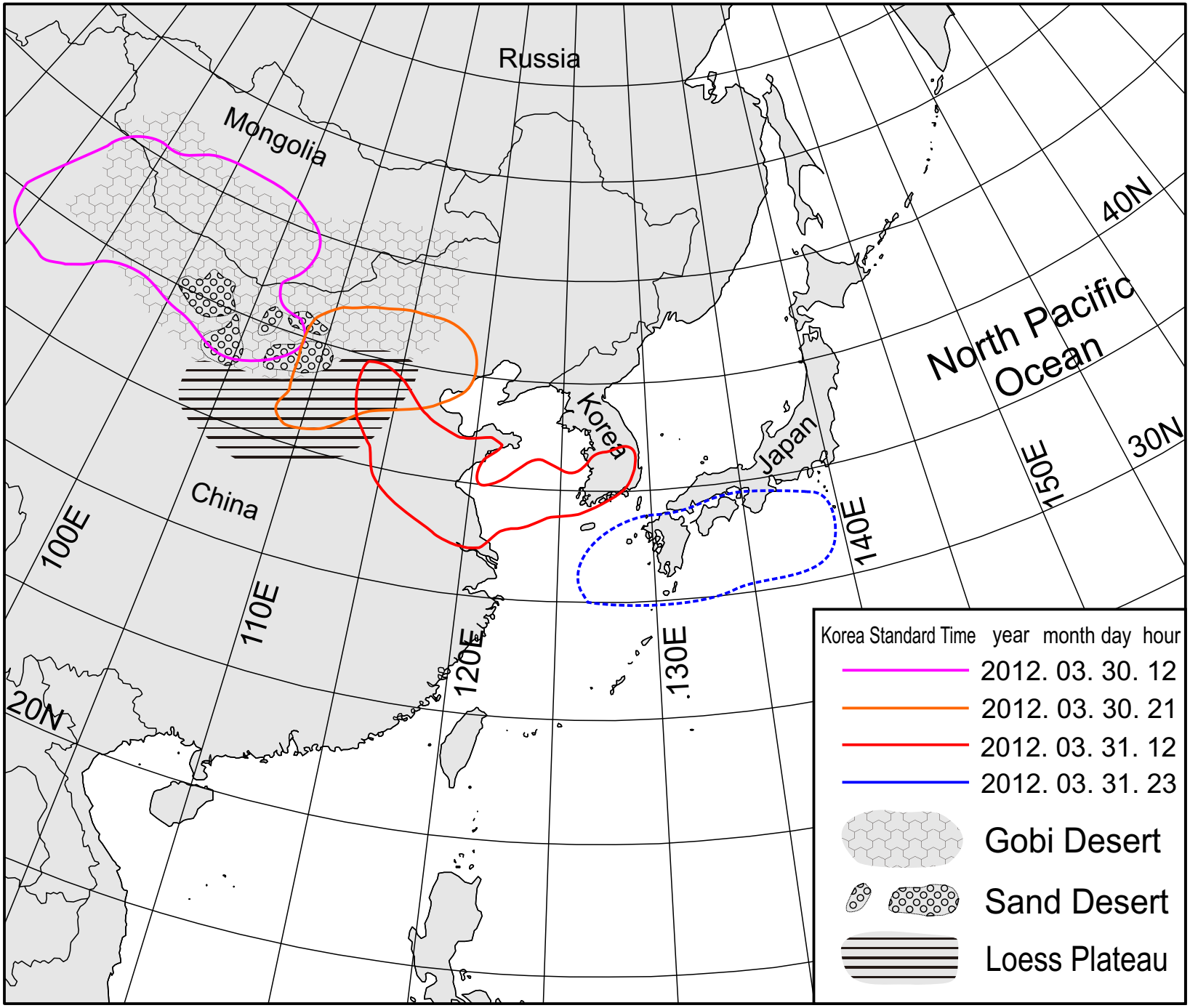
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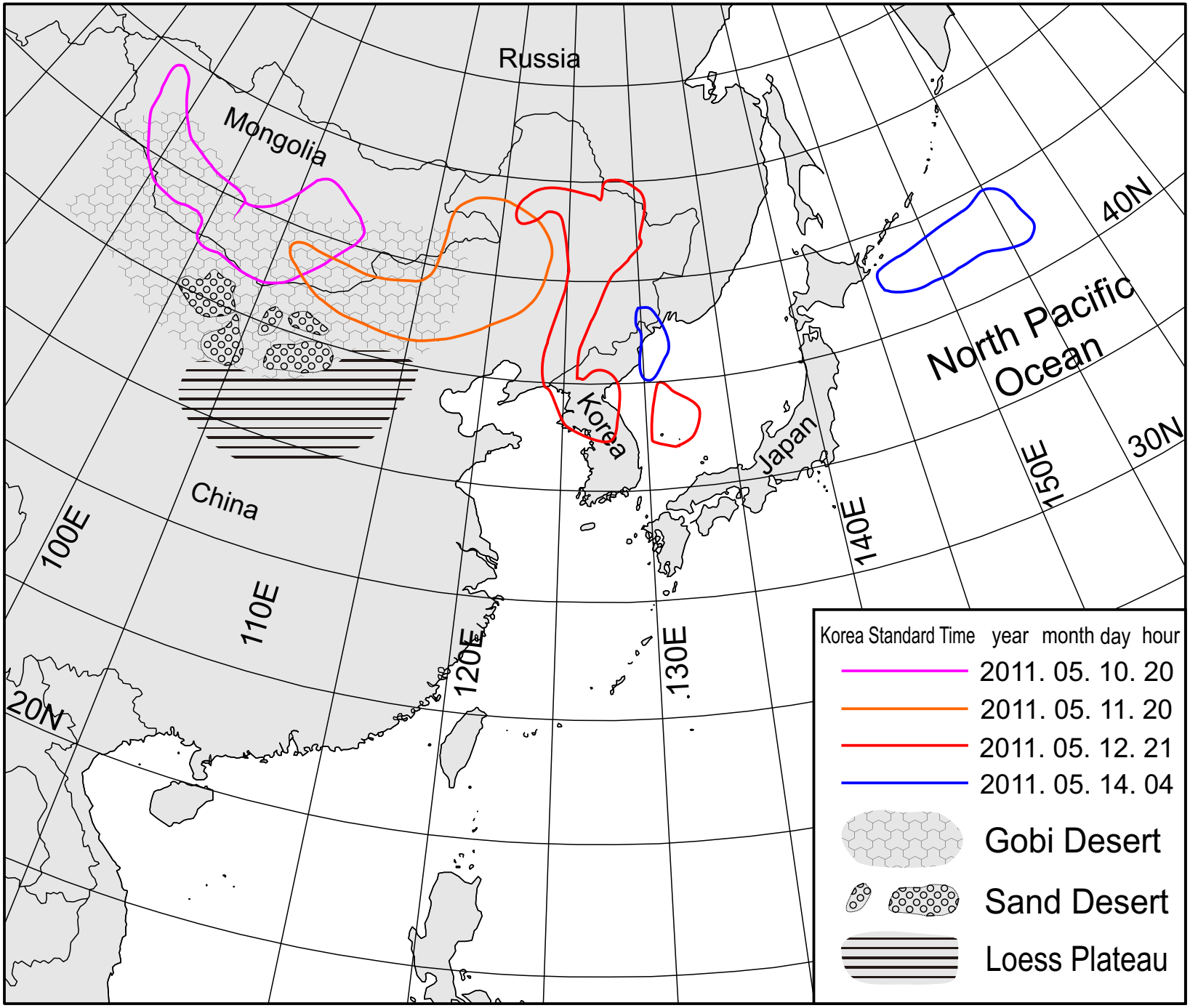
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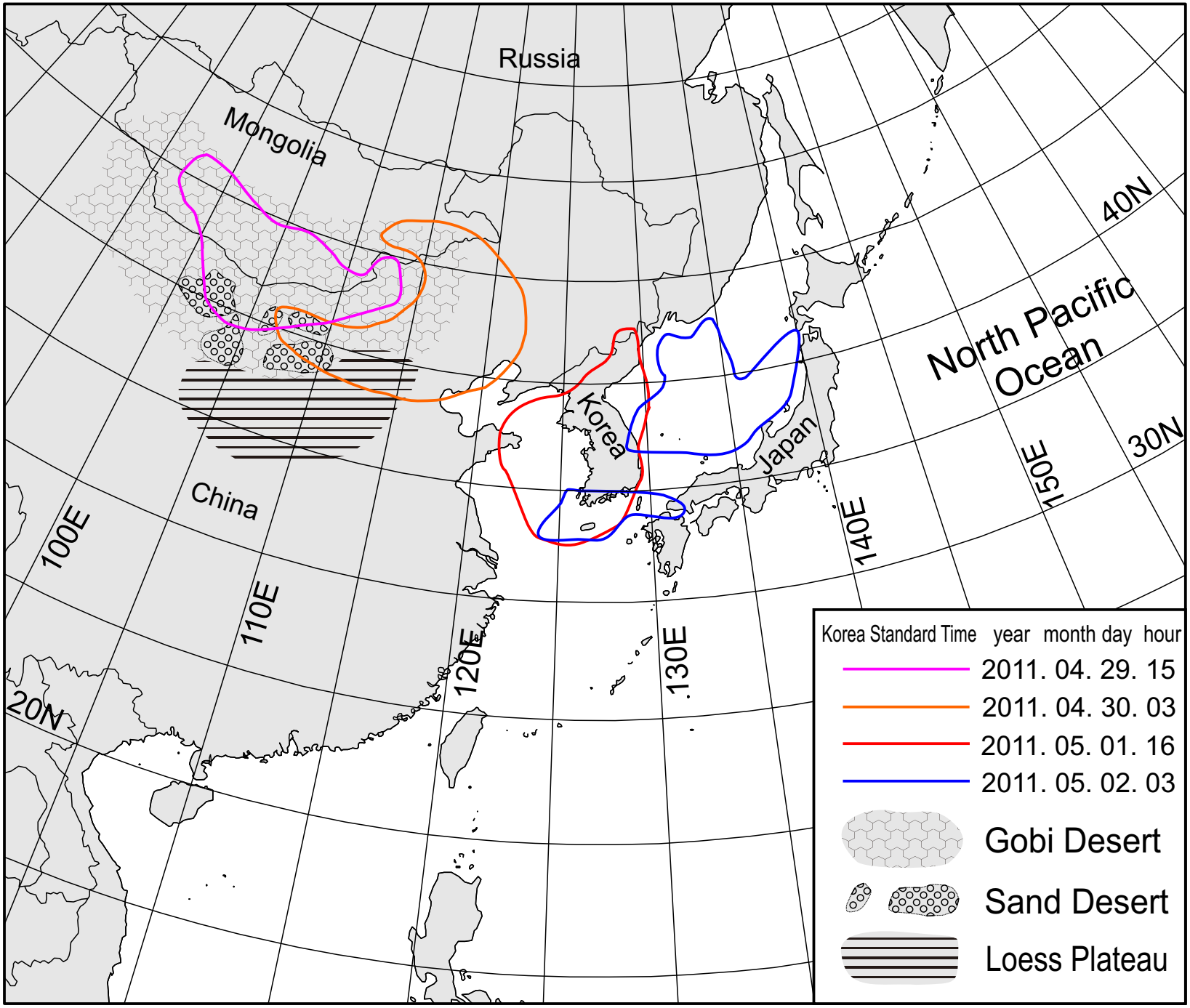
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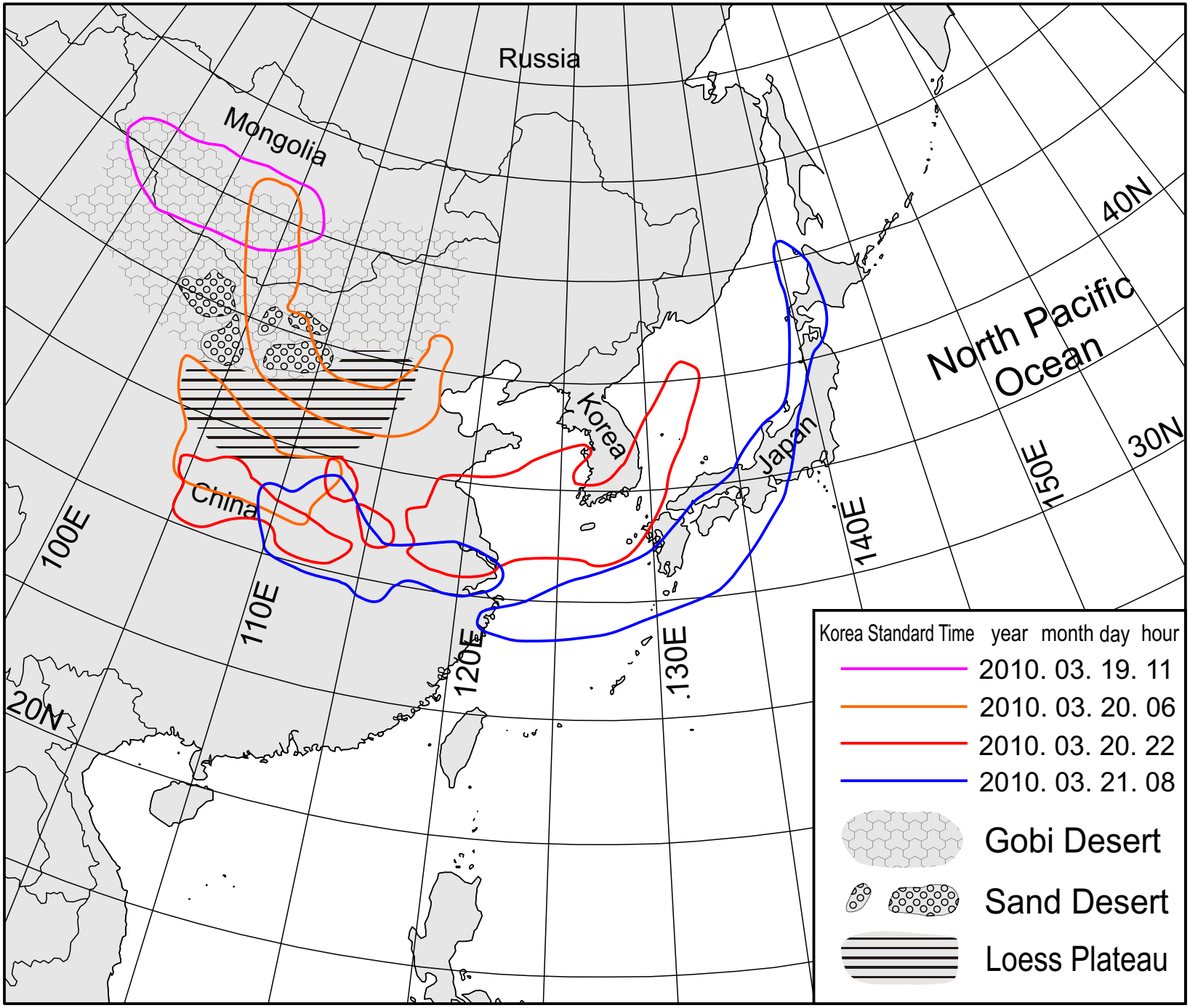
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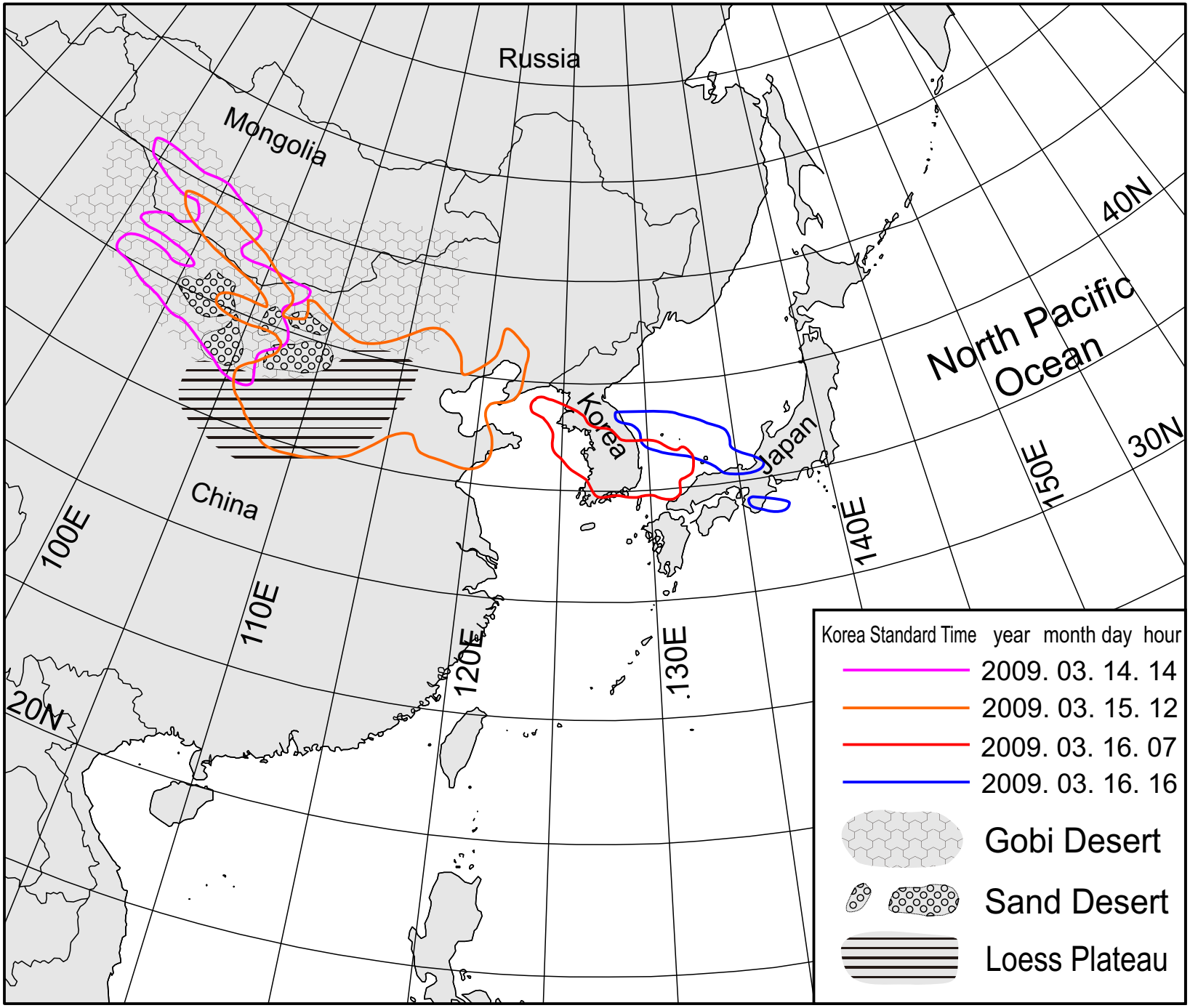
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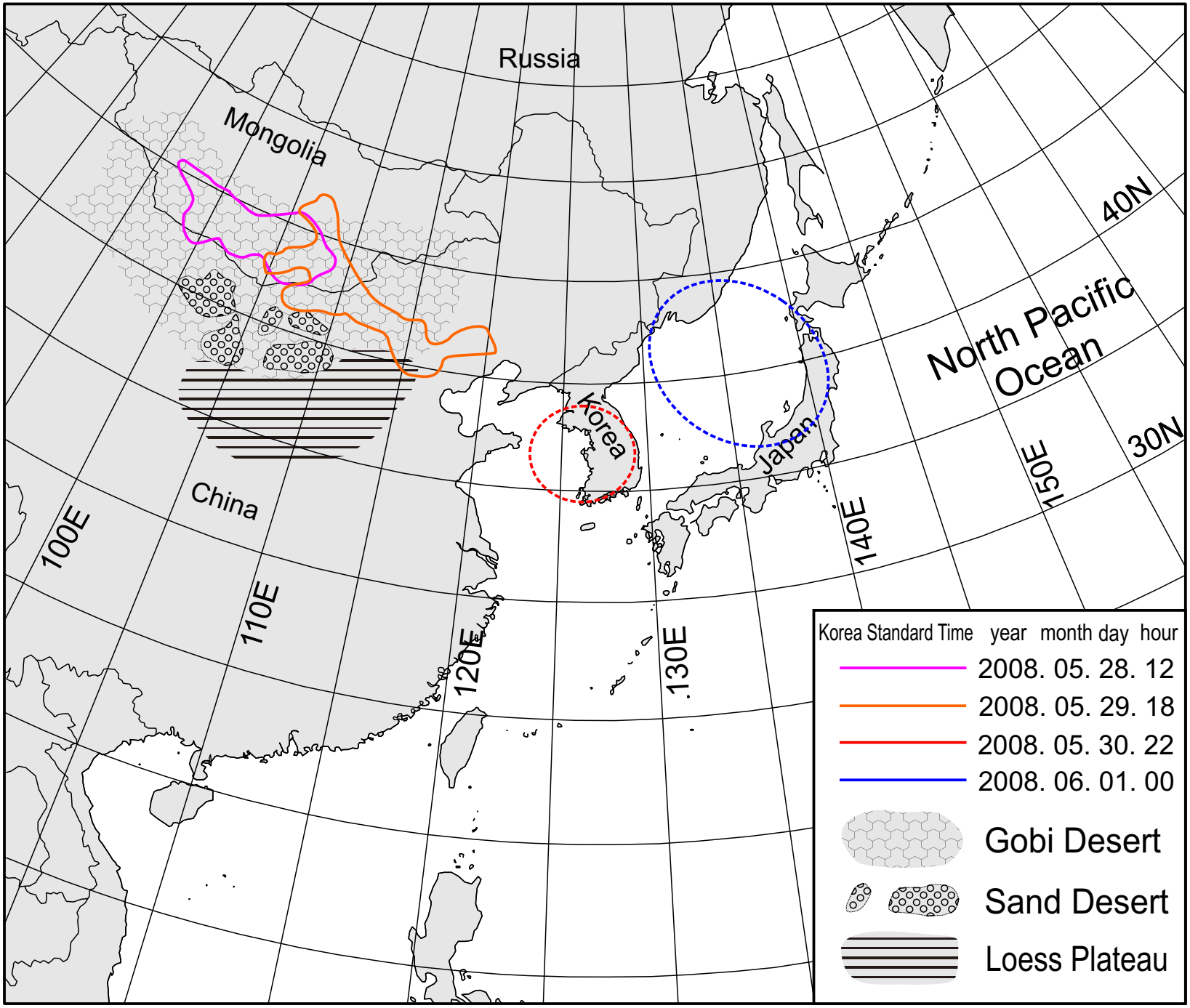
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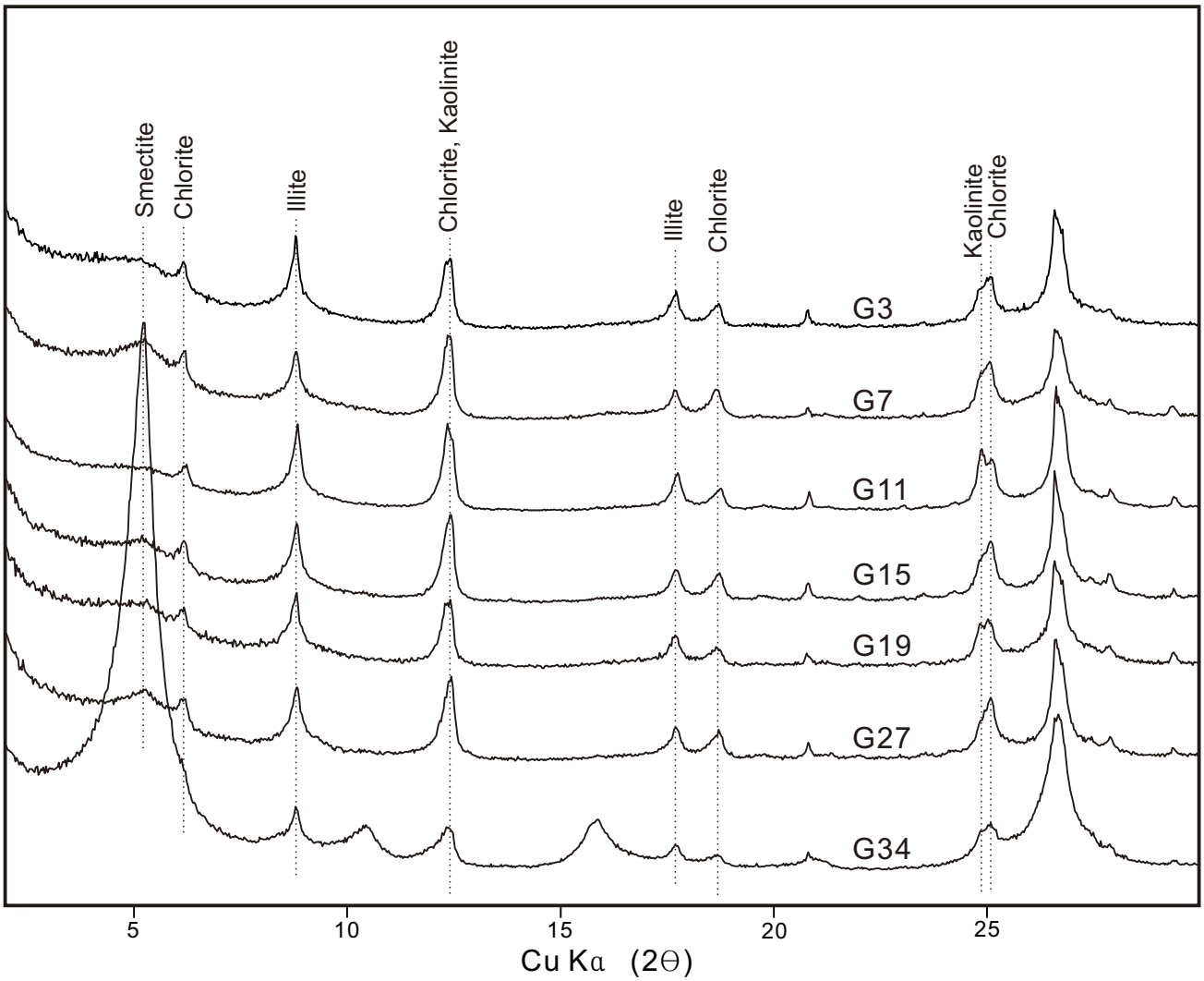
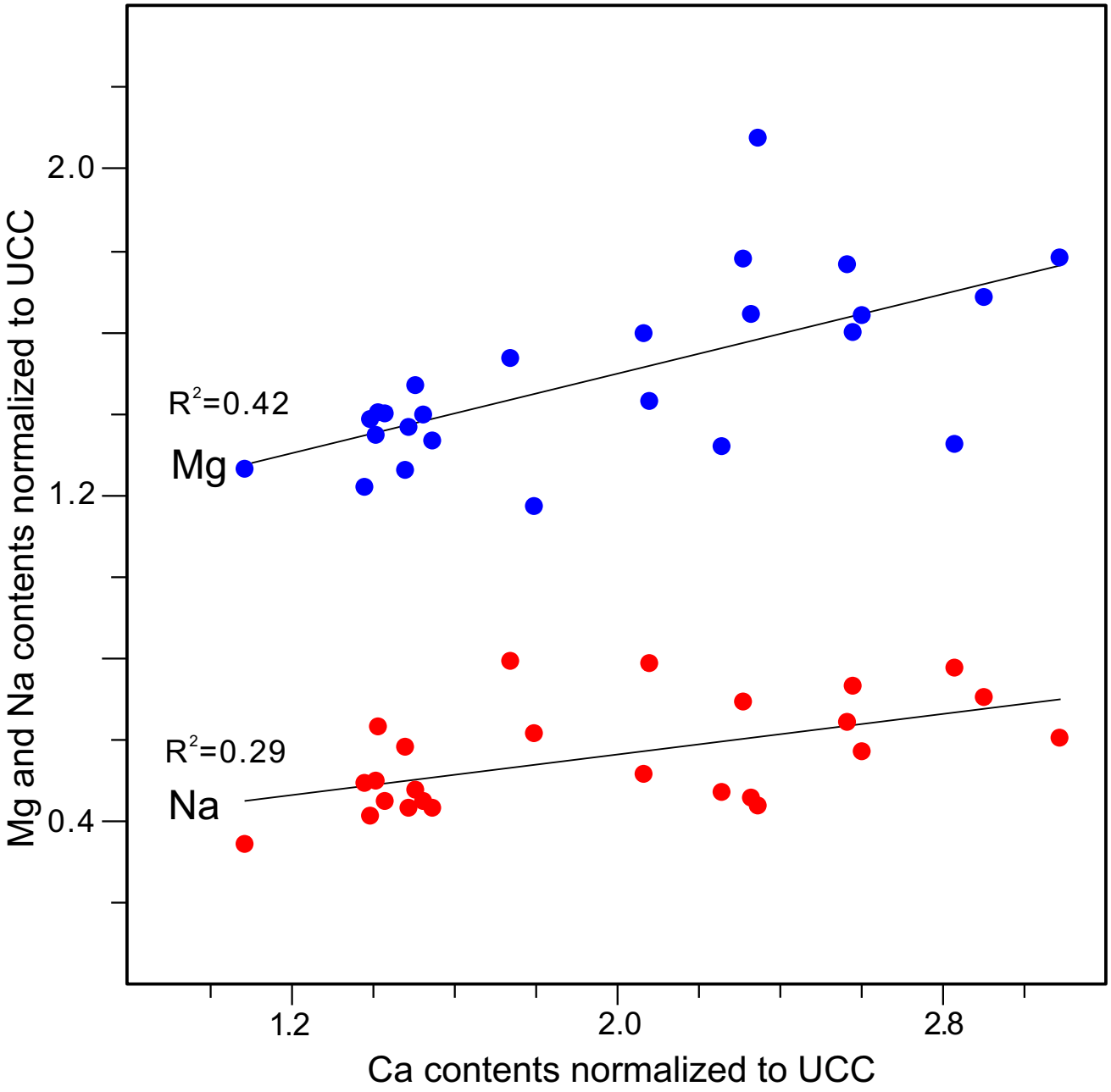


Supplementary Figure S2. X-ray diffraction patterns of clay fractions (< 2 μm) separated from surface soils in Mongolian Gobi Desert. The clays were smeared on glass slide, dried, and treated with ethylene glycol vapor at 60^{O}C (2 day).



Supplementary Figure S3. Positive correlation of Ca vs. Mg and Na contents in Asian dust.

Supplementary Table S1. Mineral compositions of surface soils (<20 micron) from Mongolian Gobi desert determined by X-ray diffraction.

Sample	Q[1)]	P	Kf	ISCMs	Ch	Ka	A	Ca	D	G	H	Total clay	P/kf
G1	19.9	14.5	6.7	50.5	2.4	1.5	1.4	2.6	0.2	0.3	0.0	54.4	2.2
G2	15.7	8.9	1.9	37.8	4.3	2.5	1.2	26.1	0.1	1.5	0.0	44.6	4.6
G3	28.9	20.3	7.3	36.0	3.0	1.8	1.8	0.5	0.2	0.1	0.0	40.9	2.8
G4	22.9	16.6	6.8	39.5	4.1	2.9	1.4	5.1	0.7	0.0	0.0	46.5	2.5
G5	18.6	13.8	5.3	46.7	4.6	3.0	1.7	5.7	0.5	0.0	0.0	54.3	2.6
G6	21.4	15.0	5.7	46.0	3.9	2.9	1.1	3.5	0.4	0.1	0.0	52.7	2.6
G7	16.3	12.6	5.4	49.0	5.0	3.5	1.8	5.3	0.5	0.5	0.0	57.5	2.3
G8	22.1	14.6	6.3	42.5	4.0	1.2	1.1	7.5	0.7	0.0	0.0	47.7	2.3
G9	22.2	17.3	7.4	32.7	4.1	3.4	1.0	11.2	0.3	0.4	0.0	40.2	2.3
G10	19.0	14.9	6.5	42.0	3.3	2.4	0.8	10.2	0.8	0.0	0.0	47.8	2.3
G11	16.6	9.6	4.0	51.3	4.4	3.9	0.7	8.8	0.7	0.1	0.0	59.5	2.4
G12	17.2	11.2	4.3	48.4	6.5	3.0	0.4	8.5	0.6	0.0	0.0	57.9	2.6
G13	19.8	13.2	4.8	42.8	5.0	3.5	1.7	8.8	0.4	0.0	0.0	51.3	2.7
G14	20.7	13.8	4.7	42.0	4.3	3.5	0.5	9.2	1.2	0.0	0.0	49.8	2.9
G15	23.6	17.5	6.0	35.5	5.2	4.1	1.3	5.9	0.9	0.0	0.0	44.8	2.9
G16	15.4	11.8	5.1	48.7	4.3	3.0	1.3	9.7	0.6	0.0	0.0	56.0	2.3
G17	17.0	11.5	5.0	50.4	5.2	3.1	1.1	5.9	0.4	0.3	0.0	58.8	2.3
G18	32.1	25.4	5.8	25.3	3.4	1.5	0.0	5.7	0.7	0.0	0.0	30.2	4.3
G19	13.8	9.6	3.8	40.7	2.7	1.6	1.6	25.9	0.3	0.0	0.0	44.9	2.5
G20	21.0	11.8	5.2	45.5	4.8	3.7	1.0	6.2	0.7	0.0	0.0	54.0	2.3
G21	19.3	13.0	5.5	39.6	4.6	3.6	0.3	13.0	0.8	0.2	0.0	47.9	2.4
G22	13.5	11.1	5.1	46.5	3.5	2.2	2.0	9.3	0.5	5.6	0.6	52.2	2.2
G23	25.5	18.8	6.5	27.1	3.5	2.1	2.0	13.5	0.9	0.0	0.0	32.8	2.9
G24	25.1	18.2	8.5	28.5	5.6	3.2	1.0	9.0	0.5	0.4	0.0	37.3	2.1
G25	22.4	15.6	6.1	30.5	5.1	3.3	1.9	10.3	0.5	4.4	0.0	38.9	2.6
G26	25.6	17.6	5.3	27.5	6.2	4.5	1.9	10.2	1.3	0.0	0.0	38.1	3.3
G27	25.9	19.2	6.5	30.7	6.0	4.4	1.6	4.7	0.8	0.3	0.0	41.0	3.0
G28	15.2	9.6	3.3	39.5	3.5	2.4	2.2	23.1	0.5	0.7	0.0	45.4	2.9
G29	16.3	14.6	5.6	48.0	2.5	0.9	1.4	9.5	0.2	0.9	0.0	51.5	2.6
G30	19.0	19.2	5.1	29.6	6.0	4.5	3.3	12.7	0.5	0.0	0.0	40.2	3.7
G31	11.2	8.2	3.7	56.0	3.7	2.3	1.8	6.7	1.1	3.2	2.0	62.0	2.2
G32	20.2	14.6	6.4	30.7	7.1	6.4	1.7	12.3	0.5	0.0	0.0	44.3	2.3
G33	19.1	13.2	6.1	40.1	3.6	5.6	1.5	9.6	0.8	0.4	0.0	49.3	2.2
G34	8.8	9.5	6.2	67.4	0.0	0.8	1.2	5.5	0.4	0.3	0.0	68.2	1.5
Average	19.7	14.3	5.5	41.0	4.3	3.0	1.4	9.5	0.6	0.6	0.1	48.3	2.6
St.dev.	4.9	3.8	1.3	9.4	1.4	1.2	0.6	5.8	0.3	1.3	0.4	8.5	0.6

[1)]Q=quartz, P=plagioclase, Kf=K-feldspar, ISCMs=illite-smectite series clay minerals, Ch=chlorite, Ka=kaolinite, A=amphibole, Ca=calcite, D=dolomite, G=gypsum, H=halite.

Supplementary Table S2. Major element composition of fine fractions (<20 μm) of surface soils from Gobi Desert on volatile-free basis (unit in wt.%).

Sample	Si	Al	Fe	Mn	Mg	Ca	Na	K	Ti	P	Total
G1	28.87	9.51	5.24	0.11	1.50	2.20	1.32	3.10	0.73	0.14	52.72
G2	23.98	7.23	3.20	0.11	1.65	16.66	1.12	1.69	0.32	0.10	56.05
G3	30.99	8.51	4.63	0.09	1.50	1.54	1.59	2.34	0.66	0.10	51.92
G4	29.10	8.78	4.78	0.09	1.92	3.59	1.31	2.47	0.59	0.11	52.76
G5	28.19	8.82	5.00	0.15	2.17	4.19	1.36	2.67	0.50	0.16	53.21
G6	28.83	9.19	5.01	0.10	2.06	3.01	1.30	2.46	0.58	0.15	52.70
G7	27.24	9.25	5.65	0.12	2.44	3.68	1.72	2.62	0.62	0.12	53.47
G8	29.00	8.35	4.40	0.10	1.79	5.20	1.22	2.22	0.57	0.11	52.95
G9	27.90	8.28	4.32	0.08	1.75	7.07	1.34	2.13	0.59	0.09	53.57
G10	27.61	8.38	4.36	0.10	1.86	7.23	1.37	2.13	0.55	0.11	53.68
G11	26.61	9.57	4.93	0.11	2.55	5.55	0.98	2.77	0.49	0.13	53.70
G12	26.92	9.41	5.11	0.12	2.32	5.39	1.07	2.63	0.50	0.13	53.62
G13	27.51	8.93	4.81	0.11	2.17	5.54	1.18	2.63	0.54	0.11	53.52
G14	27.44	8.70	4.86	0.10	2.12	5.89	1.35	2.40	0.57	0.15	53.59
G15	28.66	8.66	4.76	0.11	1.94	4.41	1.45	2.31	0.60	0.12	53.01
G16	26.71	9.31	4.98	0.11	2.28	6.24	1.07	2.41	0.51	0.13	53.75
G17	27.70	9.38	5.28	0.09	2.16	4.15	1.09	2.75	0.54	0.13	53.27
G18	29.58	8.19	4.37	0.09	1.53	4.50	1.71	1.97	0.64	0.11	52.71
G19	23.43	7.98	4.37	0.09	1.99	14.30	0.95	2.32	0.47	0.10	56.01
G20	28.43	9.15	4.80	0.08	1.97	4.27	1.01	2.63	0.50	0.14	52.98
G21	26.61	8.45	4.69	0.11	2.31	7.54	1.21	2.49	0.53	0.17	54.11
G22	25.57	8.57	4.91	0.12	2.71	7.56	2.03	2.54	0.47	0.13	54.60
G23	27.71	7.71	4.08	0.09	1.79	8.28	1.69	1.92	0.52	0.09	53.88
G24	27.99	7.79	4.35	0.11	1.98	6.59	1.76	2.43	0.57	0.14	53.71
G25	26.85	7.90	4.08	0.10	1.97	8.96	1.62	2.19	0.48	0.10	54.26
G26	27.92	8.18	4.51	0.10	2.04	6.32	1.52	2.27	0.56	0.12	53.55
G27	29.32	8.29	4.51	0.10	1.84	4.34	1.58	2.10	0.58	0.12	52.78
G28	24.20	8.16	4.40	0.07	1.92	12.96	1.07	2.20	0.49	0.09	55.55
G29	26.81	8.21	4.50	0.10	2.22	8.03	1.61	2.01	0.50	0.10	54.09
G30	26.93	8.17	4.48	0.10	2.12	8.09	1.61	1.94	0.50	0.09	54.04
G31	25.14	9.88	5.31	0.13	2.85	5.26	2.56	2.64	0.49	0.11	54.36
G32	26.76	8.61	4.60	0.10	2.28	7.46	1.14	2.43	0.52	0.11	54.01
G33	26.69	9.31	5.36	0.12	1.68	6.02	1.20	2.63	0.66	0.18	53.83
G34	28.52	10.16	3.92	0.08	1.84	3.98	1.71	1.94	0.42	0.05	52.63
Average	27.40	8.67	4.66	0.10	2.04	6.35	1.41	2.36	0.54	0.12	53.66
St.dev.	1.62	0.67	0.47	0.02	0.32	3.20	0.34	0.30	0.08	0.03	0.91

Supplementary Table S3. Trace element compositions of fine fractions (<20 μm) of surface soils from Gobi desert (unit in ppm).

Sample	S	Sc	V	Cr	Co	Ni	Cu	Zn	Ga	Rb	Sr	Y	Zr	Nb	Sn	Sb	Cs	Ba	Hf	Ta
G1	39	14	99	70	18	35	28	118	24	151	228	35.0	207	18.6	2	1.9	17.7	639	5.5	1.37
G2	280	9	57	50	7	23	27	55	12	62	385	24.3	145	7.8	2	0.5	4.3	377	4.0	0.57
G3	19	14	106	90	14	36	33	85	18	100	222	37.2	384	13.8	3	1.0	7.2	556	9.8	1.07
G4	27	15	100	90	15	38	39	85	19	103	243	34.2	245	11.8	3	1.4	7.8	554	6.1	0.99
G5	37	16	110	80	19	41	50	90	20	104	256	27.6	131	9.9	1	1.4	8.1	496	3.6	0.78
G6	21	16	106	90	17	42	49	93	20	104	245	29.7	202	11.2	2	1.3	7.8	519	5.2	0.98
G7	51	18	133	110	21	52	54	104	22	112	234	32.3	177	13.0	1	3.2	9.1	472	5.0	1.00
G8	24	13	93	80	14	34	33	78	18	95	249	32.5	314	11.8	3	0.9	7.2	510	8.1	1.02
G9	27	13	100	80	12	32	36	77	17	85	283	35.8	338	10.8	3	0.9	6.6	513	8.3	0.95
G10	23	13	95	70	13	31	35	86	17	84	264	41.7	319	14.5	3	1.1	6.4	481	8.3	1.07
G11	33	16	112	90	17	56	37	93	20	120	291	28.2	150	12.4	3	2.3	15.1	520	4.5	0.94
G12	36	16	113	80	17	40	55	103	20	107	283	31.6	147	12.3	3	1.3	9.6	503	4.0	0.86
G13	22	16	107	80	17	41	42	92	19	105	272	31.0	196	11.9	3	1.8	8.6	521	5.1	0.92
G14	46	15	111	80	15	39	38	89	19	98	264	33.1	242	13.0	3	1.6	7.9	439	6.4	1.03
G15	29	15	111	90	16	41	43	88	18	94	264	35.1	295	13.8	3	1.4	7.0	510	8.0	0.99
G16	29	16	112	80	16	41	45	87	20	94	336	28.6	143	10.0	2	1.1	7.2	472	4.2	0.70
G17	50	16	111	90	16	46	55	97	21	112	205	32.7	179	12.5	3	1.3	8.7	544	5.0	0.95
G18	27	13	103	90	12	32	33	73	16	73	310	35.8	382	13.0	2	1.2	4.6	493	9.9	0.91
G19	36	13	90	70	14	31	34	59	16	82	385	32.2	177	8.0	< 1	2.0	8.4	391	4.6	0.67
G20	12	16	99	70	13	38	39	88	20	106	266	30.8	166	10.6	3	1.1	10.6	482	4.6	0.88
G21	51	15	107	80	15	40	43	87	18	94	262	29.9	211	11.5	3	1.2	7.2	477	5.5	0.90
G22	1080	15	109	70	15	40	44	81	17	89	608	24.4	136	10.1	2	1.3	7.5	461	3.8	0.80
G23	26	13	105	80	13	32	40	66	15	66	419	32.4	304	9.4	2	0.7	4.4	502	7.9	0.76
G24	61	14	102	80	13	35	36	76	17	81	382	36.0	352	11.6	3	1.1	5.4	545	8.8	0.95
G25	848	13	87	70	12	35	33	70	16	86	429	30.6	198	10.6	2	0.6	6.4	454	5.0	0.83
G26	66	15	104	80	14	38	36	88	17	88	301	33.4	272	11.7	2	1.0	6.4	502	7.0	0.94
G27	29	15	105	80	15	37	35	82	17	83	261	32.7	257	12.3	2	0.9	6.4	478	6.8	1.01
G28	137	13	95	60	11	37	43	69	15	77	389	33.1	185	9.3	2	0.9	5.8	474	4.9	0.68
G29	31	15	106	90	16	41	40	73	17	75	305	27.7	131	8.3	< 1	1.0	5.1	484	3.6	0.69
G30	30	15	109	90	15	42	39	75	17	72	318	26.5	132	10.0	2	1.0	5.1	490	3.5	0.76
G31	915	17	110	80	17	43	38	90	20	107	477	27.9	136	11.1	2	1.5	7.7	482	3.5	0.90
G32	37	14	99	70	14	37	33	84	18	99	284	30.8	199	12.8	3	1.3	6.9	506	5.3	0.99
G33	27	15	103	80	17	37	33	99	20	116	302	37.9	243	17.2	3	1.4	9.5	613	6.0	1.22
G34	38	11	73	70	11	27	28	62	22	93	293	20.0	118	9.3	3	0.6	7.1	454	3.3	0.91
Average	125	15	102	80	15	38	39	84	18	95	309	31.6	218	11.6	2	1.3	7.7	497	5.7	0.91
St.dev.	266	2	13	11	3	6	7	13	2	18	84	4.3	78	2.3	1	0.5	2.7	51	1.9	0.16

Supplementary Table S3. *Continued*.

Sample	Tl	Pb	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	Th	U	(La/Yb)N[1)]	Eu/Eu*[1)]
G1	0.75	25	58.2	118.0	13.20	48.9	9.05	1.84	7.39	1.12	6.26	1.21	3.56	0.513	3.40	0.519	17.2	3.66	11.5	0.69
G2	< 0.05	12	28.8	53.3	6.73	26.7	5.81	1.13	4.74	0.73	4.34	0.82	2.42	0.360	2.47	0.390	8.9	1.88	7.9	0.66
G3	0.53	19	44.6	90.0	10.30	38.4	7.59	1.48	5.78	0.99	6.05	1.22	3.73	0.567	3.86	0.613	13.2	3.33	7.8	0.68
G4	0.63	19	44.4	86.6	10.30	39.4	8.00	1.63	6.14	1.05	5.99	1.16	3.47	0.496	3.25	0.519	12.9	3.03	9.2	0.71
G5	0.37	17	34.2	73.1	8.24	30.6	6.26	1.34	5.37	0.87	4.85	0.97	2.79	0.405	2.67	0.416	10.4	2.55	8.6	0.71
G6	0.61	19	40.0	84.2	9.42	35.0	6.89	1.52	5.16	0.86	5.42	1.10	3.00	0.428	3.13	0.473	12.1	2.78	8.6	0.78
G7	0.38	19	46.6	97.1	10.80	39.8	7.80	1.50	6.51	1.02	5.81	1.11	3.21	0.477	3.14	0.472	14.5	3.81	10.0	0.64
G8	0.59	18	43.9	89.4	10.10	38.1	7.44	1.48	5.66	0.94	5.86	1.12	3.34	0.477	3.31	0.536	13.3	3.09	8.9	0.70
G9	0.54	17	45.4	80.9	10.70	40.9	8.32	1.57	6.54	1.06	6.23	1.24	3.53	0.541	3.41	0.556	12.3	3.15	9.0	0.65
G10	0.52	20	44.3	87.4	10.60	41.7	8.35	1.36	6.83	1.18	7.75	1.47	4.30	0.658	4.01	0.640	11.8	3.12	7.4	0.55
G11	0.76	19	38.4	79.1	8.83	32.8	6.30	1.37	5.31	0.88	5.16	1.03	3.04	0.454	2.81	0.441	12.6	4.07	9.2	0.72
G12	0.58	19	38.6	79.9	9.01	34.8	7.24	1.31	5.76	0.94	5.81	1.12	3.00	0.476	2.84	0.488	11.5	3.04	9.2	0.62
G13	0.53	19	39.7	81.3	9.11	35.3	6.98	1.43	5.73	0.90	5.60	1.12	3.14	0.477	3.24	0.497	12.1	3.00	8.3	0.69
G14	0.49	16	43.7	88.6	9.96	38.0	7.54	1.47	5.81	0.99	6.10	1.15	3.41	0.512	3.33	0.544	13.1	3.43	8.8	0.68
G15	0.44	19	42.5	86.8	9.78	38.2	7.49	1.50	6.06	1.02	6.24	1.21	3.65	0.540	3.50	0.563	11.8	3.20	8.2	0.68
G16	0.43	17	35.0	71.6	8.08	32.5	6.56	1.41	5.23	0.88	5.29	1.03	2.89	0.437	2.77	0.457	10.1	2.72	8.5	0.74
G17	0.55	19	39.6	73.9	9.22	35.6	7.57	1.55	5.95	0.96	5.85	1.14	3.26	0.515	3.22	0.527	12.0	2.92	8.3	0.71
G18	0.38	15	41.0	81.1	9.62	36.9	7.76	1.57	6.03	1.01	6.26	1.27	3.73	0.559	3.61	0.594	10.6	3.30	7.7	0.70
G19	0.23	14	35.6	68.1	8.91	34.1	7.42	1.60	6.34	1.03	5.90	1.14	3.21	0.429	2.94	0.485	9.8	3.18	8.2	0.71
G20	0.76	12	34.5	71.2	8.37	32.6	6.83	1.54	5.70	0.89	5.30	1.07	3.15	0.460	3.12	0.496	10.3	2.69	7.5	0.75
G21	0.46	18	37.1	76.6	8.48	33.1	7.03	1.40	5.27	0.88	5.58	1.02	2.96	0.436	2.95	0.487	11.2	3.22	8.5	0.70
G22	< 0.05	13	27.5	57.2	6.34	24.5	5.53	1.21	4.45	0.70	4.58	0.86	2.39	0.363	2.37	0.377	9.3	4.47	7.8	0.75
G23	0.31	13	34.2	68.9	7.96	30.7	6.51	1.32	5.21	0.91	5.58	1.09	3.13	0.494	3.15	0.522	9.5	3.06	7.3	0.69
G24	0.41	15	42.9	87.7	10.00	38.0	7.69	1.60	6.19	0.99	6.50	1.23	3.59	0.544	3.64	0.565	12.0	3.05	7.9	0.71
G25	0.35	16	36.7	72.6	8.46	32.7	6.70	1.37	5.65	0.94	5.42	1.02	3.07	0.436	2.87	0.449	10.1	3.09	8.6	0.68
G26	0.40	22	39.3	80.8	9.26	35.3	7.37	1.45	5.78	0.96	5.95	1.11	3.34	0.505	3.29	0.539	11.4	3.20	8.1	0.68
G27	0.34	17	40.0	82.2	9.23	35.9	7.16	1.60	5.75	0.97	6.09	1.16	3.42	0.511	3.47	0.534	10.9	3.08	7.8	0.76
G28	0.30	13	39.2	64.7	9.47	36.4	7.45	1.58	6.35	1.06	6.00	1.10	3.19	0.494	3.34	0.499	10.0	3.05	7.9	0.70
G29	0.16	15	32.6	63.8	7.98	29.9	6.36	1.32	5.31	0.88	5.02	0.98	2.84	0.408	2.53	0.417	8.3	2.58	8.7	0.69
G30	0.51	14	32.7	64.2	7.80	31.1	6.00	1.32	5.11	0.81	4.75	0.91	2.63	0.384	2.65	0.421	8.4	2.71	8.3	0.73
G31	0.12	16	34.5	73.1	8.10	30.9	6.23	1.38	5.20	0.84	4.95	0.90	2.63	0.387	2.63	0.441	12.6	4.19	8.8	0.74
G32	0.50	18	42.0	83.3	9.56	36.3	7.23	1.44	5.37	0.93	5.61	1.08	3.10	0.469	2.95	0.493	12.9	3.86	9.6	0.71
G33	0.60	21	61.3	123.0	13.80	52.1	9.75	1.83	7.64	1.16	6.69	1.31	3.74	0.543	3.54	0.550	16.4	4.15	11.7	0.65
G34	0.63	18	38.9	79.6	8.24	30.8	5.46	1.15	4.28	0.66	3.86	0.70	2.03	0.301	2.04	0.328	16.8	4.69	12.9	0.73
Average	0.47	17	39.9	80.0	9.29	35.5	7.17	1.46	5.75	0.94	5.67	1.09	3.17	0.472	3.10	0.496	11.8	3.25	8.73	0.70
St.dev.	0.16	3	6.9	14.2	1.50	5.4	0.93	0.16	0.72	0.12	0.73	0.15	0.45	0.071	0.44	0.068	2.2	0.58	1.23	0.04

[1)] Values calculated from chondrite-normalized concentration. Chondrite values by Boynton (1984).

Supplementary Table S4. Rare earth element contents of loess samples from the Chinese Loess Plateau (Jeong et al., 2008) (unpublished data). $(La/Yb)_N$ and Eu/Eu* were calculated from the REE values normalized by average values of Chondrite (Boynton, 1984)

Sample (Depth in m)	La	Sm	Eu	Gd	Yb	$(La/Yb)_N$	Eu/Eu*
Ziuzhoutai section							
2.0	36.1	6.42	1.21	5.37	2.81	8.7	0.63
5.0	34.3	5.91	1.25	5.1	2.59	8.9	0.70
8.0	33.2	5.7	1.14	4.98	2.77	8.1	0.65
12.0	32.4	5.59	1.11	4.81	2.48	8.8	0.65
18.0	33.5	5.6	1.13	4.86	2.48	9.1	0.66
20.0	32.5	5.54	1.08	4.9	2.39	9.2	0.63
23.0	35.1	5.97	1.16	5.14	2.72	8.7	0.64
25.0	39.8	6.4	1.3	5.64	2.8	9.6	0.66
26.6	36.7	6.21	1.25	5.37	2.72	9.1	0.66
28.0	33.4	5.61	1.13	5.27	2.63	8.6	0.64
30.0	36.4	6.24	1.25	5.37	2.6	9.4	0.66
30.8	34.5	5.85	1.15	5.06	2.67	8.7	0.65
32.2	32.8	5.45	1.11	5.17	2.63	8.4	0.64
33.0	35.4	6.09	1.22	5.04	2.79	8.6	0.67
33.4	37.1	6.34	1.24	5.56	2.84	8.8	0.64
33.6	34.8	5.71	1.19	5.33	2.89	8.1	0.66
36.0	34.4	5.71	1.18	5.03	2.63	8.8	0.67
39.0	31.7	5.28	1.11	4.85	2.53	8.4	0.67
Dadongling section							
17.75	35.9	6.18	1.16	5.14	2.85	8.5	0.63
18.75	35.2	5.88	1.12	4.88	2.62	9.1	0.64
19.75	35.5	5.98	1.12	5.07	2.52	9.5	0.62
20.25	31.3	5.27	1.06	4.49	2.29	9.2	0.67
22.5	33.8	5.69	1.14	4.99	2.5	9.1	0.65
23.75	37.2	5.94	1.3	5.22	2.81	8.9	0.71
25	31.9	5.27	1.05	4.6	2.28	9.4	0.65
28.8	33.6	5.86	1.12	4.81	2.59	8.7	0.65
Banshan section							
6.3	33	5.81	1.17	4.94	2.75	8.1	0.67
7.3	32.9	5.67	1.14	5.03	2.71	8.2	0.65
8.3	33.7	5.9	1.16	5.22	2.77	8.2	0.64
9.3	36.6	6.28	1.28	5.46	2.85	8.7	0.67
11	34	5.78	1.22	5.05	2.75	8.3	0.69
12.2	36.3	6.33	1.26	5.62	2.87	8.5	0.65
12.8	30.5	5.16	1	4.64	2.33	8.8	0.62
13.6	31	5.53	1.06	4.87	2.55	8.2	0.62
Liujiapo section							
3.4	38.4	6.7	1.35	5.92	3.02	8.6	0.66
4.2	37	6.19	1.25	5.47	2.83	8.8	0.66
4.5	36.8	6.43	1.27	5.62	2.75	9.0	0.65
5.2	38.3	6.56	1.31	5.56	3.02	8.6	0.66
5.5	41.8	7.05	1.41	6.49	3.29	8.6	0.64
6.3	40.3	6.98	1.4	6.21	3.16	8.6	0.65
6.5	41.1	6.97	1.38	6.09	3.23	8.6	0.65
7	39.3	6.77	1.4	5.97	3.19	8.3	0.67
8	36.7	6.62	1.32	5.68	3.11	8.0	0.66
11.4	36.3	6.18	1.25	5.37	2.88	8.5	0.66
Average						8.7	0.65

Supplementary Table S5. Rare earth element contents of loess samples from Chinese Loess Plateau (Jahn et al., 2001).

Sample	La	Sm	Eu	Gd	Yb	$(La/Yb)_N$	Eu/Eu*
XN-1	29	4.85	0.99	4.7	1.98	9.9	0.63
XN-2	28.7	4.85	1.00	4.71	1.98	9.8	0.64
XN-3	21.2	3.25	0.64	3.17	1.34	10.7	0.61
XN-4	23.0	4.04	0.87	4.13	1.95	8.0	0.65
XN-5	30.2	5.15	1.00	4.90	2.06	9.9	0.61
XN-6	22.9	4.04	0.88	4.16	1.96	7.9	0.66
XN-7	21.4	3.99	0.85	4.03	1.97	7.3	0.65
XN-8	18.7	3.18	0.67	3.32	1.56	8.1	0.63
XN-9	33.2	5.54	1.12	5.15	2.22	10.1	0.64
XN-10	24.8	4.30	0.90	4.24	1.88	8.9	0.64
XF-1	32.5	5.58	1.13	5.26	2.53	8.7	0.64
XF-2	33.0	5.75	1.15	5.35	2.62	8.5	0.63
XF-3	30.7	5.29	1.08	5.00	2.40	8.6	0.64
XF-4	31.8	5.39	1.09	5.14	2.53	8.5	0.63
XF-5	31.8	5.34	1.10	5.06	2.59	8.3	0.65
XF-6	29.4	5.21	1.09	5.08	2.33	8.5	0.65
XF-7	32.2	5.42	1.13	5.18	2.64	8.2	0.65
XF-8	31.2	5.26	1.08	5.05	2.49	8.4	0.64
XF-9	33.3	5.53	1.16	5.14	2.39	9.4	0.67
XF-10	30.9	5.16	1.10	5.10	2.27	9.2	0.66
JX-1	34.1	5.74	1.20	5.34	2.62	8.8	0.66
JX-2	29.1	4.90	1.01	4.62	2.26	8.7	0.65
JX-3	32.6	5.36	1.08	4.95	2.07	10.6	0.64
JX-4	31.0	5.17	1.05	4.68	2.03	10.3	0.65
JX-5	31.5	5.33	1.11	5.06	2.44	8.7	0.65
JX-6	30.8	5.19	1.05	4.92	2.4	8.7	0.64
JX-7	34.9	5.8	1.16	5.19	2.27	10.4	0.65
JX-8	27.4	5.03	1.02	4.71	2.38	7.8	0.64
JX-9	34.2	5.78	1.21	5.28	2.45	9.4	0.67
JX-10	26.5	4.46	0.91	4.13	1.84	9.7	0.65
Average						9.0	0.64

Supplementary Table S6. Rare earth element contents of Asian dustfall on the Korean Peninsula and Arctic Canada.

Sample	La	Sm	Eu	Gd	Yb	$(La/Yb)_N$	Eu/Eu*
Korean Peninsula (Lee et al., 2010)							
BC	583.66	90.99	18.57	107.75	33.73	11.7	0.57
UC	275.28	45.41	8.52	52.71	16.15	11.5	0.53
JC	2715.1	448.5	86.1	530.1	162.7	11.3	0.54
Average						11.5	0.55
Yukon Territory, Canada (Zdanowicz et al., 2006)							
QSC	34.54	6.03	1.19	5.19	2.18	10.7	0.65
QSA	34.34	6.37	1.26	5.59	2.38	9.7	0.65
KTL (1)	38.81	6.31	1.27	5.21	2.24	11.7	0.68
KTL (2)	28.59	5.71	1.08	4.99	1.78	10.8	0.62
KTU (1)	34.43	6.05	1.19	5.18	2.14	10.8	0.65
KTU (2)	40.06	6.44	1.23	5.53	2.15	12.6	0.63
Average						11.1	0.65

Supplementary Table S7. Rare earth element contents of eolian sediments from the North Pacific Ocean.

Sample	La	Sm	Eu	Gd	Yb	$(La/Yb)_N$	Eu/Eu*
Central North Pacific Ocean (Nakai et al., 1993)							
V32-128	31.2	4.43	0.9	3.81	2.38	8.8	0.67
DSDP 463	45.1	6.24	1.22	5.35	3.07	9.9	0.65
LL44-GPC-3	28.9	3.74	0.76	3.14	2.3	8.5	0.68
Average						9.1	0.66
Subarctic North Pacific Ocean (Serno et al., 2014)							
32	26.329	5.979	1.415	5.552	2.707	6.6	0.75
33	27.920	5.102	1.120	4.560	2.556	7.4	0.71
34	27.110	4.843	1.036	4.041	2.314	7.9	0.72
36	29.746	6.132	1.369	5.744	2.760	7.3	0.71
37	20.968	3.034	0.606	1.956	1.402	10.1	0.76
38	26.908	5.123	1.157	4.800	2.589	7.0	0.71
39	24.492	4.942	1.153	4.731	2.541	6.5	0.73
40	19.164	3.088	0.651	2.088	1.480	8.7	0.78
41	24.688	4.589	1.041	4.391	2.450	6.8	0.71
42	23.380	4.253	0.975	4.063	2.339	6.7	0.72
45	18.686	3.851	0.897	3.710	2.335	5.4	0.73
Average						7.3	0.73
Northeast equatorial Pacific Ocean (Type 1) (Hyeong et al., 2005)							
2-3	27.4	3.81	0.79	3.18	2.11	8.8	0.69
24-25	26.7	3.49	0.72	2.58	1.95	9.2	0.73
74-75	13.1	2.2	0.47	1.95	1.75	5.0	0.69
99-100	17.1	2.36	0.53	1.89	1.84	6.3	0.77
174-175	24.5	3.11	0.67	2.44	1.92	8.6	0.74
200-201	23.1	2.81	0.65	2.27	2.02	7.7	0.79
224-225	20.9	2.68	0.6	2.26	1.73	8.1	0.75
249-250	21.2	2.68	0.63	2.36	1.77	8.1	0.77
Average						7.7	0.74