Supplement of Atmos. Chem. Phys. Discuss., 14, 20647–20676, 2014
http://www.atmos-chem-phys-discuss.net/14/20647/2014/
doi:10.5194/acpd-14-20647-2014-supplement

Atmospheric Chemistry and Physics Discussions
Open Access

Supplement of

Atmospheric wet and dry deposition of trace elements at ten sites in Northern China

Y. P. Pan and Y. S. Wang

Correspondence to: Y. P. Pan (panyuepeng@mail.iap.ac.cn) and Y. S. Wang (wys@mail.iap.ac.cn)

Supplementary material includes Tables S1, S2, S3 and S4, and Figures S1, S2, S3 and S4.

Figure S1. Locations of the study area (a) and sampling sites (b) in Northern China with lead deposition and SO_2 emission distributions. The total lead deposition data are means of 3-yr observations from December 2007 to November 2010. The emission data for SO_2 are from 2006 (Zhang et al., 2009) and have a resolution of 0.5 °×0.5 °. In Northern China, the annual SO_2 emission unit of kt grid^{-1} is approximately 400 mg m^{-2}.

Figure S2. The automated wet and dry deposition sampler used in this study. The agricultural station of Yucheng in Shandong Province (left) and a schematic diagram of the sampler with the main apparatus (right): rainfall sampler (a), dry deposition bucket (b), and PUF filter for sampling dry-deposited particles (c).

Figure S3. Temperature-controlled microwave digestion of a PUF filter with dry-deposited particles using 5 ml HNO_3, 2 ml H_2O_2 and 0.2 ml HF (Pan et al., 2010).

Figure S4. Annual wet deposition fluxes of trace elements vs. precipitation in Northern China.

Table S1 Atmospheric dry deposition fluxes of metals within and outside China (mg m^{-2} yr^{-1}, but kg ha^{-1} yr^{-1} for Na, Ca, Mg, Fe, Mn and Al)

Site	Period	Na	Ca	Mg	Al	Mn	Fe	Cu	Pb	Zn	Cd	Co	Ni	Cr	V	Reference
Xinghua Bay, China	2004-2005	6.69	/	/	7.83	/	6.83	2.71	3.83	14.39	0.08	0.28	7.82	11.63	/	(Wu et al., 2006)
Yellow sea, China	1995-1996	12.42	6.32	2.89	4.49	0.08	2.55	0.23	1.92	2.91	0.04	0.2	0.63	1.11	1	(Liu et al., 1998)
East Sea China	2005-2007	/	/	/	0.15	0.02	0.14	4.38	0.91	6.94	0.07	/	0.09	0.08	0.55	(Hsu et al., 2010)
Taiwan China	2009-2010	/	/	/	/	0.08	1.52	20.8	20.03	18.03	/	/	/	9.20	/	(Zhang et al., 2012)
Hong Kong ,China	1998-1999	6.67	/	1.15	0.83	0.07	0.78	5.25	28.98	27.95	/	/	/	/	0.19	(Zheng et al., 2005)
Matsuura, Japan	2004-2006	/	/	/	1.32	0.09	/	3.01	1.55	/	0.06	/	3.72	4.28	0.54	(Sakata and Asakura, 2011)
Seoul, S. Korea	Spring,1998	/	23.0	/	19.7	/	/	/	73.0	73.0	/	/	40.2	/	/	(Yi et al., 2001a)
Maagan Michale, Israel	1994-1997	/	/	/	4.97	0.11	4.32	0.23	1.54	1.98	0.07	/	/	1.27	/	(Herut et al., 2001)
Chicago, U.S.	1990s	/	25.51	9.12	/	0.4	/	69.4	46.4	266.5	4.4	/	/	19.3	/	(Fang, 1992)
Chicago, U.S.	1993-1995	/	/	8.29	3.80	0.21	/	23.0	13.87	43.80	/	/	/	2.08	1.21	(Yi et al., 2001b)
Sleeping Bear Dunes, U.S.	1993-1995	/	/	0.21	0.27	0.01	/	29.0	12.78	24.82	/	/	/	0.58	0.06	(Yi et al., 2001b)
South Heaven, U.S.	1993-1995	/	/	1.90	1.24	0.08	/	11.3	8.40	18.62	/	/	/	0.27	0.44	(Yi et al., 2001b)
Tor Paterno, Italy	1999	/	/	/	/	/	/	11.03	11.41	43.64	0.36	/	12.23	17.04	/	(Morselli et al., 2004)
Cap Ferat, France	1988-1989	/	/	/	1.20	0.02	0.88	1.19	1.85	3.20	/	0.02	0.33	0.38	/	(Chester et al., 1999)
Amman, Jordan	1995	/	/	/	/	/	/	5.55	4.20	29.69	0.15	/	/	/	/	(Momani et al., 2000)
Izmir, Turkey	2000-2001	/	157.32	11.32	/	0.49	44.13	45.3	80.3	697.2	8.8	/	47.1	5.8	/	(Odabasi et al., 2002)
Bursa, Turkey	2002-2003	/	88.44	12.88	/	0.62	29.23	71.17	55.84	366.46	1.10	2.92	46.36	22.26	/	(Tasdemir and Kural, 2005)

Table S2 Atmospheric wet deposition fluxes of metals within and outside China (mg m^{-2} yr^{-1}, but kg ha^{-1} yr^{-1} for Fe, Mn and Al)

Site	Period	Fe	Mn	Al	Cu	Pb	Zn	Cd	Cr	Co	Ni	V	Reference
Nam Co, central Tibetan Plateau, China	2007-2008	0.05	0.003	0.055	0.23	0.06	0.27	0.002	/	0.007	0.09	0.03	(Cong et al., 2010)
Hong Kong, China	1998-1999	0.78	0.04	0.62	4.67	86.94	33.15	/	/	/	/	2.65	(Zheng et al., 2005)
Yellow Sea, China	2000-2002	/	/	/	1.99	0.37	0.12	37.4	/	/	/	/	(Liu et al., 2003)
Kathmandu, Nepal	2011-2012	2.47	0.08	2.10	1.95	1.42	24.44	0.10	1.60	1.00	0.71	/	(Tripathee et al., 2014)
Dhunche, Nepal	2011-2012	1.00	0.04	0.98	0.02	0.02	0.18	0.00	0.00	0.01	0.02	/	(Tripathee et al., 2014)
Chuncheon, Korea	2006-2009	/	0.03	0.10	1.21	1.06	6.93	0.05	/	/	0.37	0.10	(Kim et al., 2012)
Nakanoto, Japan	2003-2005	/	0.07	/	1.8	10	27	0.31	0.40	/	1.40	0.78	(Sakata and Asakura, 2009)
Higashi-Hiroshima, Japan	1995–1997	/	0.02	<0.01	0.89	1.78	6.84	0.09	/	/	0.42	0.33	(Takeda et al., 2000)
Singapore	2000	0.62	0.07	0.48	14.56	8.84	18.72	0.78	4.16	1.56	10.14	9.10	(Hu and Balasubramanian, 2003)
Fiordland, New Zealand	1993–1995	3.70	0.001	/	0.02	0.04	0.07	0.00	/	/	/	/	(Halstead et al., 2000)
New Castle, U.S.	1996–1997	0.14	/	0.17	0.67	0.78	8.33	0.12	0.08	0.12	0.42	0.72	(Pike and Moran, 2001)
Chesapeake and Delaware Bay, U.S.	1995–1996	0.14	0.01	0.20	0.97	0.35	3.60	0.04	0.04	/	0.82	/	(Kim et al., 2000)
Massachusetts, U.S.	1992–1993	0.36	0.01	0.29	0.70	0.86	2.70	0.21	1.50	0.01	3.00	/	(Golomb et al., 1997)
Bermuda, U.S.	1982–1983	0.016	0.001	/	0.07	0.31	0.66	0.02	/	/	0.08	0.07	(Church et al., 1984)
Ankara, Turkey	1993–1994	0.007	/	0.003	0.45	0.87	2.84	1.32	0.16	/	0.20	0.21	(Kaya and Tuncel, 1997)
North Sea	1992–1994	/	/	/	10.50	11.00	31.00	/	1.40	/	/	/	(Injuk et al., 1998)
Dutch Delta, The Netherlands.	1990	/	/	/	0.23	4.23	12.67	0.07	/	/	0.88	/	(Nguyen et al., 1990)

Table S3 Atmospheric total deposition fluxes of metals within and outside China (mg m^{-2} yr^{-1})

Site	Period	Cd	Cu	Ni	Pb	Zn	As	Mn	V	Reference
Pearl River Delta, China	2001–2002	/	18.6	/	12.7	104	/	/	2.1	(Wong et al., 2003)
Hong Kong ,China	1998-1999	/	9.92	/	115.92	61.1	/	10.29	2.84	(Zheng et al., 2005)
Kushiro, Japan	2008	0.02	0.56	0.72	0.98	4.02	/	4.74	/	(Okubo et al., 2013)
Tokyo Bay, Japan	2004-2005	0.39	16	6.8	9.9		2.9	87	6.9	(Sakata et al., 2008)
Virolahti, Finland	2007	0.04	1.00	0.14	1.1	3.8	0.09	2.3	0.36	(Kyllönen et al., 2009)
Paris, France	2001–2002	0.24	6	0.62	4.2	30	/	/	/	(Motelay-Massei et al., 2005)
Massachusetts Bay, US	1992–1993	0.27	2.5	1.5	1.8	7.8	0.02	3.4		(Golomb et al., 1997)
Chesapeake Bay, US	1992–1993	0.05	0.26	0.26	0.56	1.34	/	/	/	(Motelay-Massei et al., 2005)
Lake Superior, US	1993–1994	0.46	3.1	0.8	1.5	8.8	0.17	4.2	0.34	(Sweet et al., 1998)
Lake Michigan, US	1993–1994	0.45	1.9	0.61	1.6	6	0.14	2.8	0.14	(Sweet et al., 1998)
Lake Erie, US	1993–1994	0.49	4.2	0.74	1.8	17	/	/	/	(Sweet et al., 1998)
Fiorland, New Zealand	1993–1995	0.004	0.023	0.035	0.025	/	/	/	/	(Halstead et al., 2000)
Varna, Bulgaria, Black Sea	2008-2009	0.02	17.8	0.41	0.73	15.18	/	2.01	1.1	(Theodosi et al., 2013)
North Sea	1993–1994	/	1.24	/	3.52	6.5	0. 25	2.6	1.1	(Injuk et al., 1998)
Irish Sea	1993–1994	/	2.6	/	1.62	/	/	5.07	/	(Williams et al., 1998)
Mediterranean Coast	1988–1993	0.31	2.6	0.57	3.8	/	/	/	/	(Guieu et al., 1997)
Ligurian Sea	1997–1998	0.06	1.28	1.1	1.2	41.2	/	/	/	(Sandroni and Migon, 2002)

Table S4 Average enrichment (increment) of elemental content in top soil (0−10 cm) relative to deep soil (60−100 cm) vs. atmospheric total deposition flux of metals at agricultural sites on an annual basis (mg m^{-2})

Site	Item	Mo	Mn	Zn	Cu	Fe	Se	Cd	Pb	Cr	Ni	As
	Increment	22.3	-4684.6	662.1	749.4	-231178.5	43.6	0.6	420.8	-838.8	-349.7	-217.7
LC	Deposition	0.5	49.7	135.0	8.4	2453.0	1.5	0.6	21.8	4.2	5.0	3.0
	Ratio	**0.02**	**-0.01**	**0.20**	**0.01**	**-0.01**	**0.03**	**1.03**	**0.05**	**0.00**	**-0.01**	**-0.01**
	Increment	-12.8	3536.9	1709.3	10.1	-86889.7	13.0	2.1	347.4	232.5	-190.4	35.5
YC	Deposition	0.6	43.0	57.0	7.9	2388.8	1.4	0.4	16.2	3.4	11.2	3.6
	Ratio	**-0.05**	**0.01**	**0.03**	**0.78**	**-0.03**	**0.11**	**0.18**	**0.05**	**0.01**	**-0.06**	**0.10**

Data shown in bold was the ratio of total deposition to increment of metals in soil.

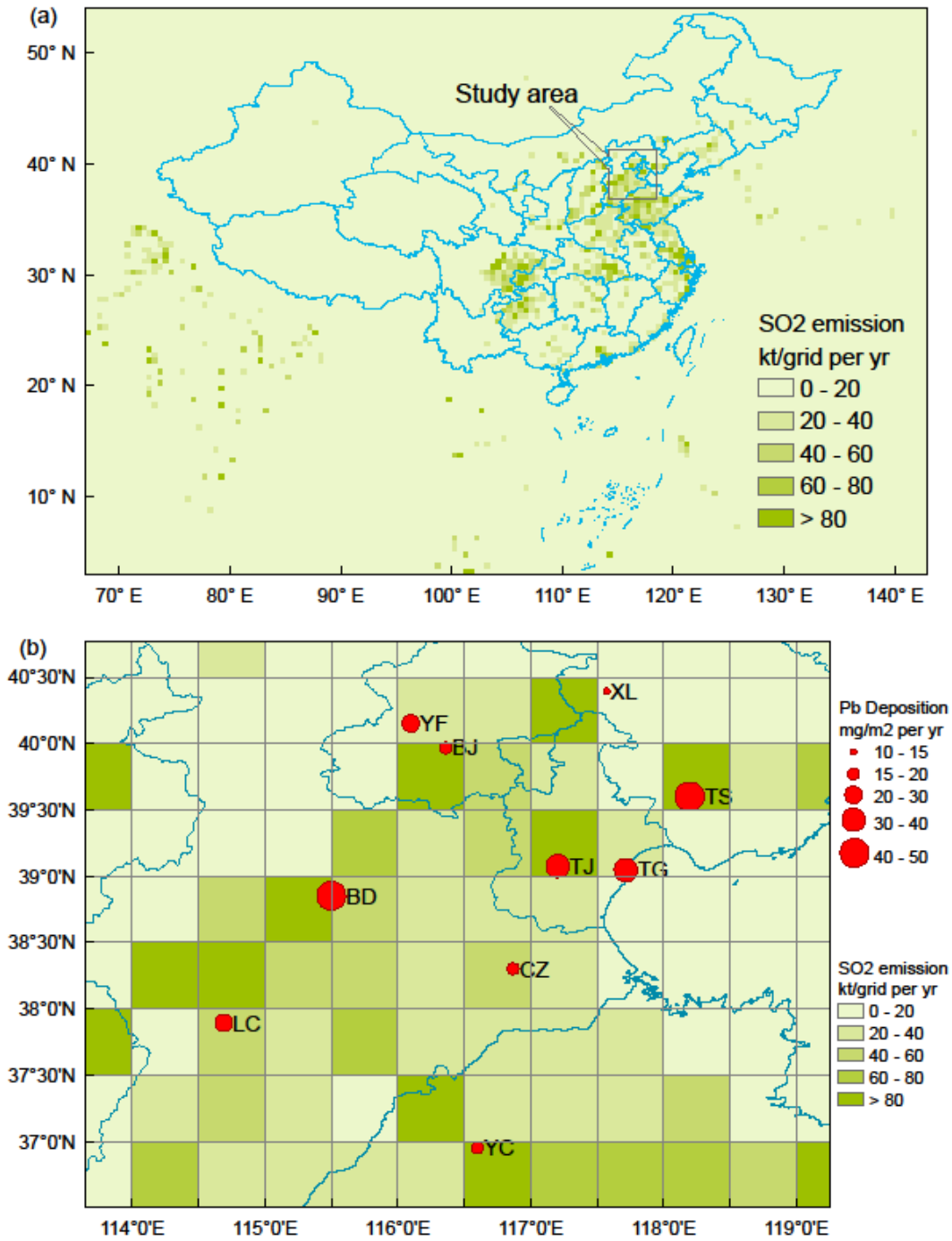


Figure S1. Locations of the study area (a) and sampling sites (b) in Northern China with lead deposition and SO_2 emission distributions. The total lead deposition data are means of 3-yr observations from December 2007 to November 2010. The emission data for SO_2 are from 2006 (Zhang et al., 2009) and have a resolution of 0.5 °×0.5 °. In Northern China, the annual SO_2 emission unit of kt grid^{-1} is approximately 400 mg m^{-2}.

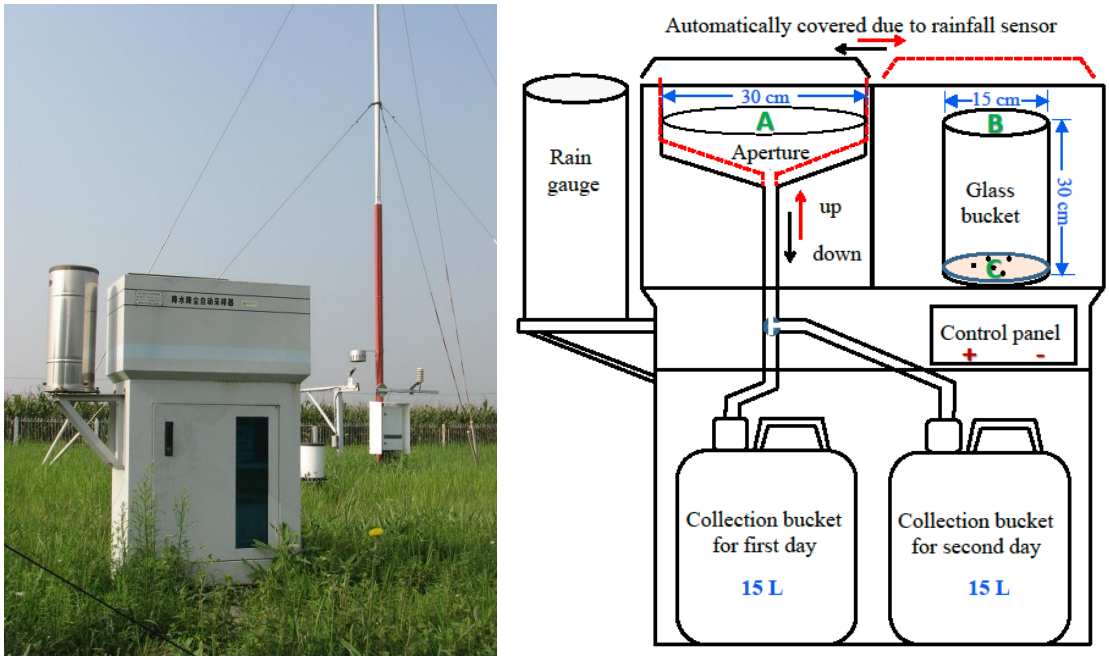


Figure S2. The automated wet and dry deposition sampler used in this study. The agricultural station of Yucheng in Shandong Province (left) and a schematic diagram of the sampler with the main apparatus (right): rainfall sampler (a), dry deposition bucket (b), and PUF filter for sampling dry deposited particles (c).

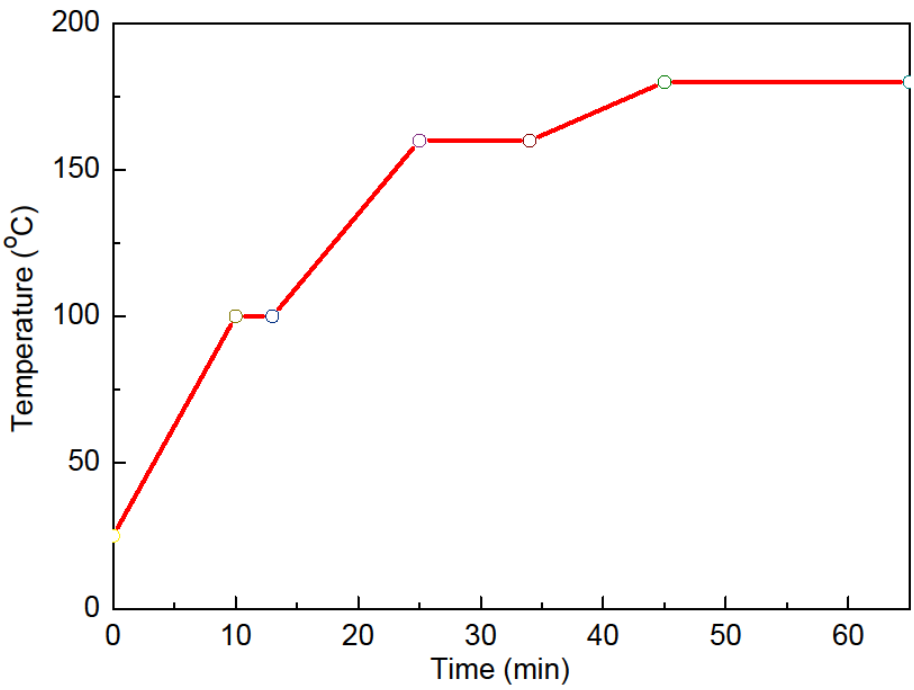
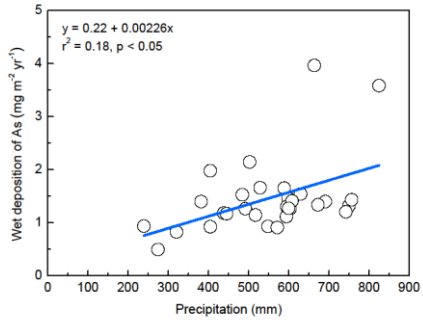
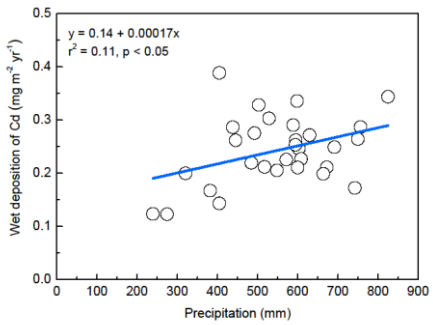


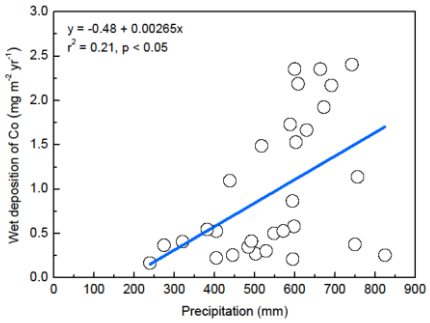
Figure S3. Temperature-controlled microwave digestion of a PUF filter with dry-deposited particles using 5 ml HNO_3, 2 ml H_2O_2 and 0.2 ml HF (Pan et al., 2010).

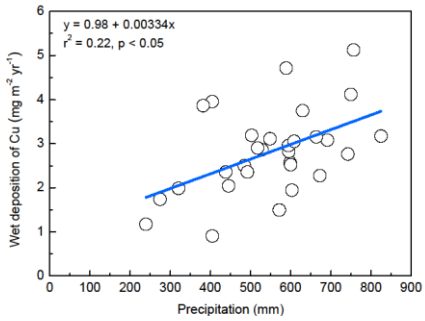
56


y = 0.22 + 0.00226x
r2 = 0.18, p < 0.05
Wet deposition of As (mg m-2 yr-1)
Precipitation (mm)

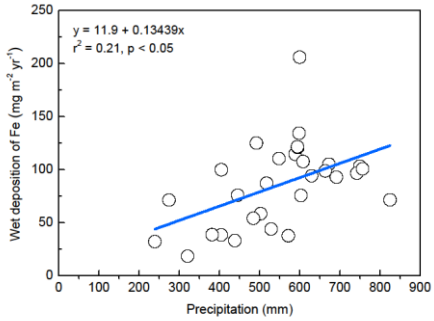

y = 0.14 + 0.00017x
r2 = 0.11, p < 0.05
Wet deposition of Cd (mg m-2 yr-1)
Precipitation (mm)

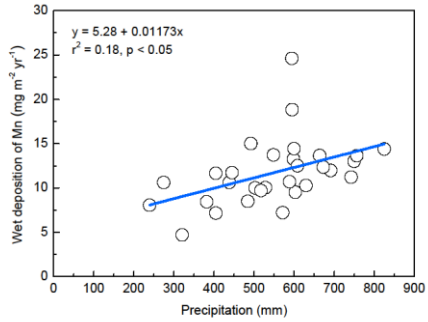
57


y = -0.48 + 0.00265x
r2 = 0.21, p < 0.05
Wet deposition of Co (mg m-2 yr-1)
Precipitation (mm)

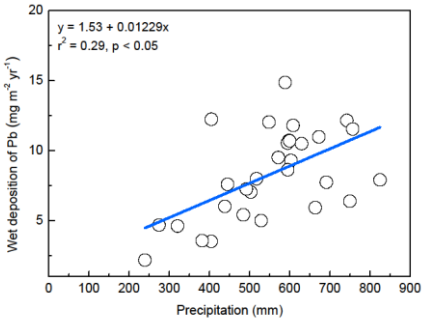

y = 0.98 + 0.00334x
r2 = 0.22, p < 0.05
Wet deposition of Cu (mg m-2 yr-1)
Precipitation (mm)

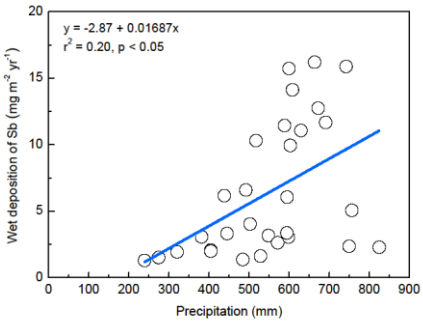
58


y = 11.9 + 0.13439x
r2 = 0.21, p < 0.05
Wet deposition of Fe (mg m-2 yr-1)
Precipitation (mm)

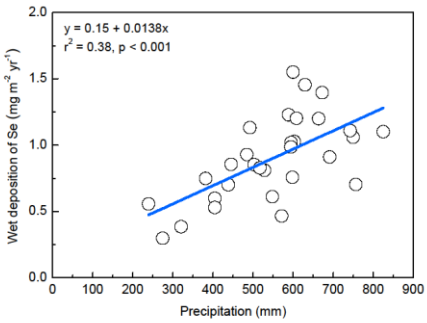

y = 5.28 + 0.01173x
r2 = 0.18, p < 0.05
Wet deposition of Mn (mg m-2 yr-1)
Precipitation (mm)

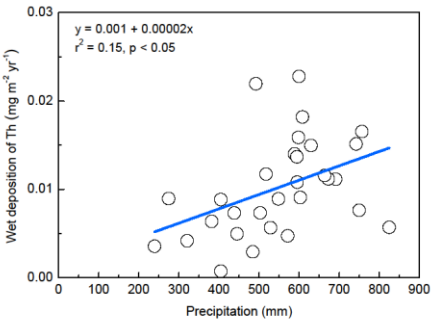
59


y = 1.53 + 0.01229x
r2 = 0.29, p < 0.05
Wet deposition of Pb (mg m-2 yr-1)
Precipitation (mm)

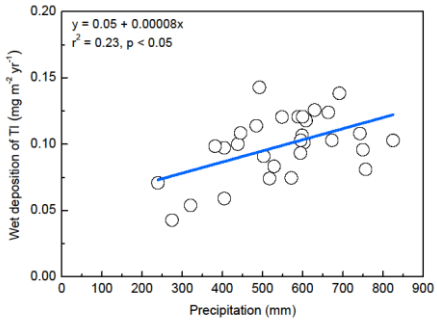

y = -2.87 + 0.01687x
r2 = 0.20, p < 0.05
Wet deposition of Sb (mg m-2 yr-1)
Precipitation (mm)

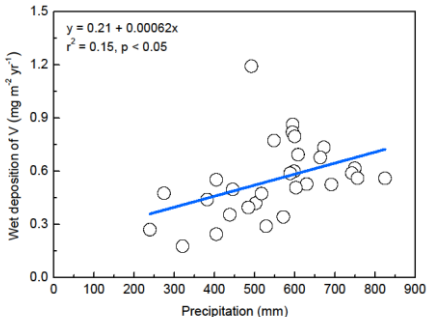
60


y = 0.15 + 0.0138x
r2 = 0.38, p < 0.001
Wet deposition of Se (mg m-2 yr-1)
Precipitation (mm)

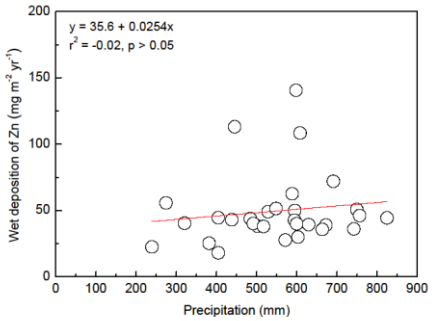

y = 0.001 + 0.00002x
r2 = 0.15, p < 0.05
Wet deposition of Th (mg m-2 yr-1)
Precipitation (mm)

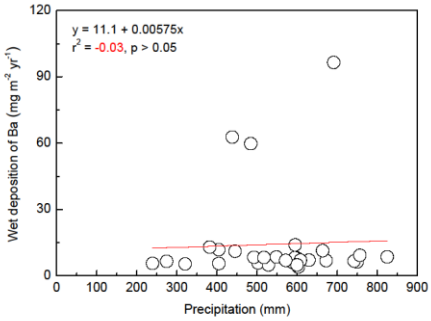
61


y = 0.05 + 0.00008x
r2 = 0.23, p < 0.05
Wet deposition of Tl (mg m-2 yr-1)
Precipitation (mm)

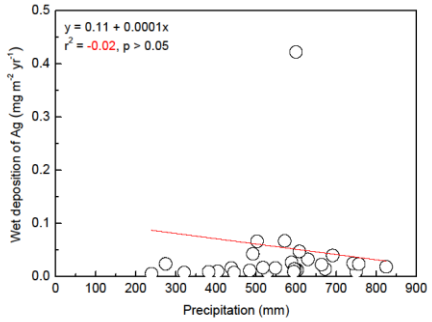

y = 0.21 + 0.00062x
r2 = 0.15, p < 0.05
Wet deposition of V (mg m-2 yr-1)
Precipitation (mm)

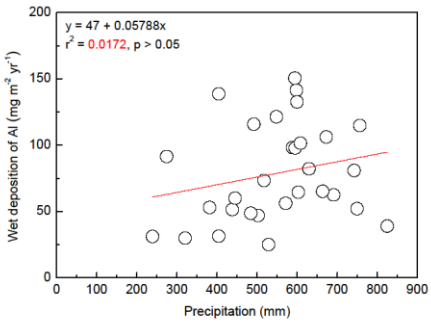
62


y = 35.6 + 0.0254x
r2 = -0.02, p > 0.05
Wet deposition of Zn (mg m-2 yr-1)
Precipitation (mm)

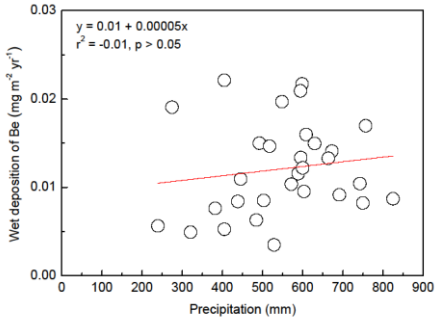

y = 11.1 + 0.00575x
r2 = -0.03, p > 0.05
Wet deposition of Ba (mg m-2 yr-1)
Precipitation (mm)

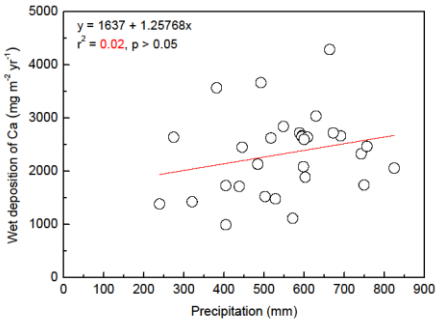
63


y = 0.11 + 0.0001x
r2 = -0.02, p > 0.05
Wet deposition of Ag (mg m-2 yr-1)
Precipitation (mm)

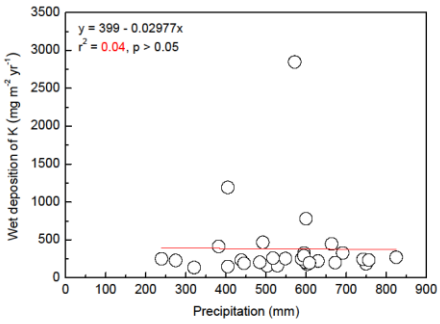

y = 47 + 0.05788x
r2 = 0.0172, p > 0.05
Wet deposition of Al (mg m-2 yr-1)
Precipitation (mm)

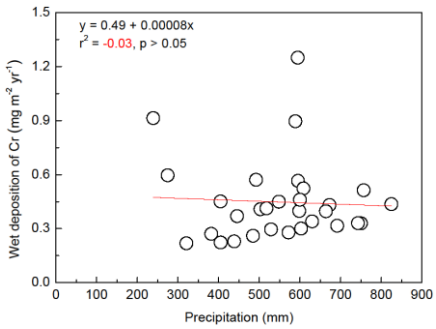
64


y = 0.01 + 0.00005x
r2 = -0.01, p > 0.05
Wet deposition of Be (mg m-2 yr-1)
Precipitation (mm)


y = 1637 + 1.25768x
r2 = 0.02, p > 0.05
Wet deposition of Ca (mg m-2 yr-1)
Precipitation (mm)

65


y = 399 - 0.02977x
r2 = 0.04, p > 0.05
Wet deposition of K (mg m-2 yr-1)
Precipitation (mm)


y = 0.49 + 0.00008x
r2 = -0.03, p > 0.05
Wet deposition of Cr (mg m-2 yr-1)
Precipitation (mm)

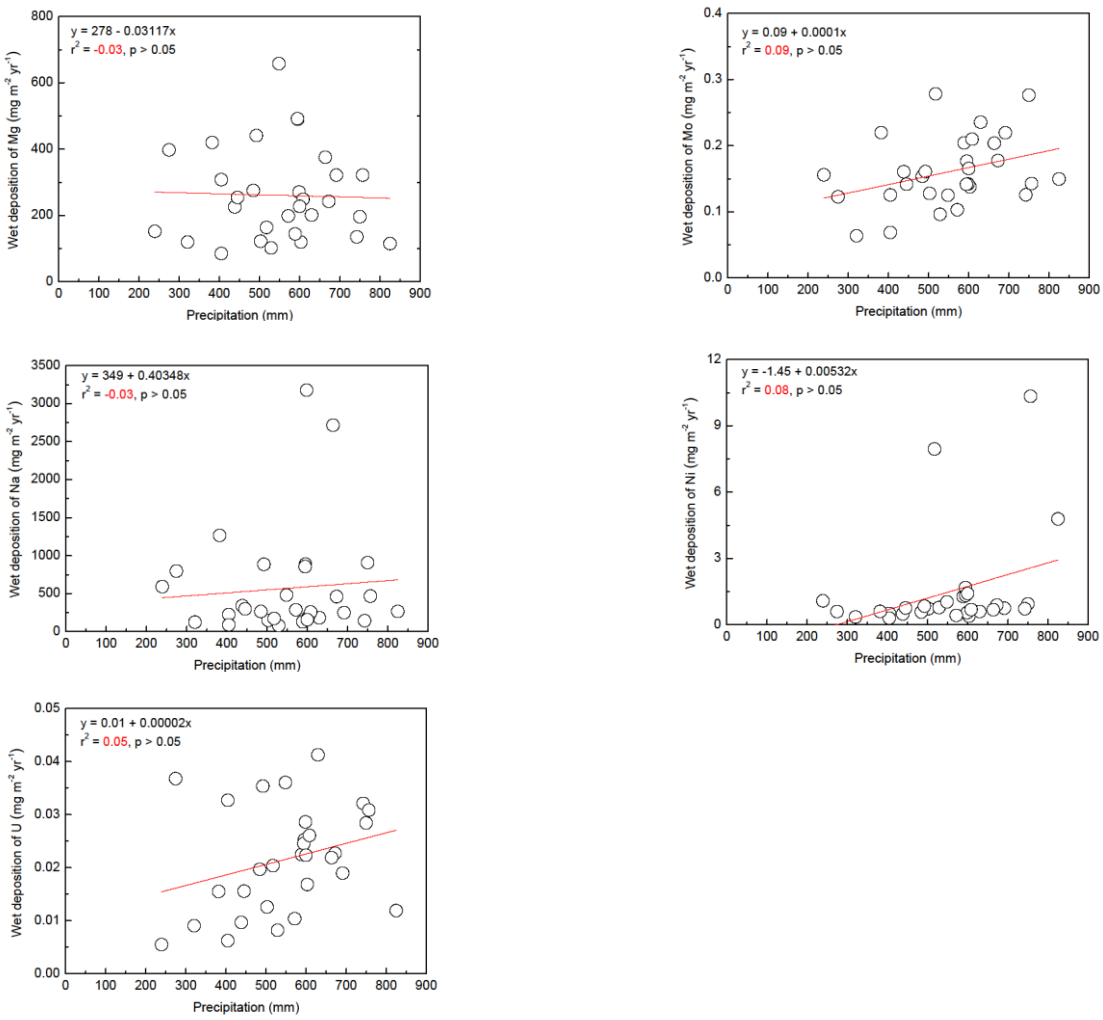


Fig. S4 Annual wet deposition fluxes of trace elements vs. precipitation in Northern China.

References

Chester, R., Nimmo, M., and Preston, M. R.: The trace metal chemistry of atmospheric dry deposition samples collected at Cap Ferrat: a coastal site in the Western Mediterranean, Mar. Chem., 68, 15-30, doi:10.1016/S0304-4203(99)00062-6, 1999.

Church, T. M., Veron, A., Patterson, C. C., Settle, D., Erel, Y., Maring, H. R., and Flegal, A. R.: Trace elements in the North Atlantic troposphere: shipboard results of precipitation and aerosols, Global. Biogeochem. Cy, 4, 431-443, doi:10.1029/GB004i004p00431, 1984.

Cong, Z., Kang, S., Zhang, Y., and Li, X.: Atmospheric wet deposition of trace elements to central Tibetan Plateau, Appl. Geochem., 25, 1415-1421, doi:10.1016/j.apgeochem.2010.06.011, 2010.

Fang, G. C.: A study of mass size distributions and particle deposition velocities in ambient air, Ph.D.Thesis of Illinois Institute of Technology, Illinois Institute of Technology, Chicago, 220 pp., 1992.

Golomb, D., Ryan, D., Eby, N., Underhill, J., and Zemba, S.: Atmospheric deposition of toxics onto Massachusetts Bay-I. Metals, Atmos. Environ., 31, 1349-1359, doi:10.1016/S1352-2310(96)00276-2, 1997.

Guieu, C., Chester, R., Nimmo, M., Martin, J., Guerzoni, S., Nicolas, E., Mateu, J., and Keyse, S.: Atmospheric input of dissolved and particulate metals to the northwestern Mediterranean, Deep Sea Research Part II: Topical Studies in Oceanography, 44, 655-674, doi:10.1016/S0967-0645(97)88508-6, 1997.

Halstead, M. J. R., Cunninghame, R. G., and Hunter, K. A.: Wet deposition of trace metals to a remote site in Fiordland, New Zealand, Atmos. Environ., 34, 665-676, doi:10.1016/S1352-2310(99)00185-5, 2000.

Herut, B., Nimmo, M., Medway, A., Chester, R., and Krom, M. D.: Dry atmospheric inputs of trace metals at the Mediterranean coast of Israel (SE Mediterranean): sources and fluxes, Atmos. Environ., 35, 803-813, doi:10.1016/S1352-2310(00)00216-8, 2001.

Hsu, S. C., Wong, G. T. F., Gong, G.-C., Shiah, F. K., Huang, Y. T., Kao, S. J., Tsai, F., Candice Lung, S. C., Lin, F. J., Lin, I. I., Hung, C. C., and Tseng, C. M.: Sources, solubility, and dry deposition of aerosol trace elements over the East China Sea, Mar. Chem., 120, 116-127, doi:10.1016/j.marchem.2008.10.003, 2010.

Hu, G. P., and Balasubramanian, R.: Wet deposition of trace metals in Singapore, Water Air. Soil Poll., 144, 285-300, doi:10.1023/A:1022921418383, 2003.

Injuk, J., Grieken, R. V., and Leeuw, G. D.: Deposition of atmospheric trace elements into the north sea: Coastal, ship, platform measurements and model predictions, Atmos. Environ., 32, 3011-3025, doi:10.1016/S1352-2310(97)00497-4, 1998.

Kaya, G., and Tuncel, G.: Trace element and major ion composition of wet and dry depositon in Ankara, Turkey, Atmos. Environ., 31, 3985-3998, doi:10.1016/s1352-2310(97)00221-5, 1997.

Kim, G., Scudlark, J. R., and Church, T. M.: Atmospheric wet deposition of trace elements to Chesapeake and Delaware Bays, Atmos. Environ., 34, 3437-3444, doi:10.1016/S1352-2310(99)00371-4, 2000.

Kim, J.-E., Han, Y.-J., Kim, P.-R., and Holsen, T. M.: Factors influencing atmospheric wet deposition of trace elements in rural Korea, Atmos. Res., 116, 185-194, doi:10.1016/j.atmosres.2012.04.013, 2012.

Kyllönen, K., Karlsson, V., and Ruoho-Airola, T.: Trace element deposition and trends during a ten year period in Finland, Sci. Total. Environ., 407, 2260-2269, doi:10.1016/j.scitotenv.2008.11.045, 2009.

Liu, C. L., Zhang, J., and Yu, Z. G.: Study on the characteristics of the aerosol and atmospheric flux of the heavy metals over the Yellow Sea, Mar. Environ. Sci., 17, 1-6 (in Chinese), 1998.

Liu, C. L., Ren, H. B., Chen, H. T., and Xia, N.: Heavy metals in precipitation from the Yellow Sea and the East China Sea Regions, Mar. Sci., 27, 64-68 (in Chinese), 2003.

Momani, K. A., Jiries, A. G., and Jaradat, Q. M.: Atmospheric deposition of Pb, Zn, Cu, and Cd in Amman, Jordan, Turk. J. Chem., 24, 231-238, 2000.

Morselli, L., Brusori, B., Passarini, F., Bernardi, E., Francaviglia, R., Gataleta, L., Marchionni, M., Aromolo, R., Benedetti, A., and Olivieri, P.: Heavy metals monitoring at a Mediterranean natural ecosystem of Central Italy. Trends in different environmental matrixes, Environ. Int., 30, 173-181, doi:10.1016/S0160-4120(03)00170-3, 2004.

Motelay-Massei, A., Ollivon, D., Tiphagne, K., and Garban, B.: Atmospheric bulk deposition of trace metals to the Seine river Basin, France: concentrations, sources and evolution from 1988 to 2001 in Paris, Water Air. Soil Poll., 164, 119-135, doi:10.1007/s11270-005-1659-x, 2005.

Nguyen, V. D., Merks, A. G. A., and Valenta, P.: Atmospheric deposition of acid, heavy metals, dissolved organic carbon and nutrients in the Dutch delta area in 1980-1986, Sci. Total. Environ., 99, 77-91, doi:10.1016/0048-9697(90)90213-E, 1990.

Odabasi, M., Muezzinoglu, A., and Bozlaker, A.: Ambient concentrations and dry deposition fluxes of trace elements in Izmir, Turkey, Atmos. Environ., 36, 5841-5851, doi:10.1016/S1352-2310(02)00644-1, 2002.

Okubo, A., Takeda, S., and Obata, H.: Atmospheric deposition of trace metals to the western North Pacific Ocean observed at coastal station in Japan, Atmos. Res., 129–130, 20-32, doi:10.1016/j.atmosres.2013.03.014, 2013.

Pan, Y. P., Wang, Y. S., Yang, Y. J., Wu, D., Xin, J. Y., and Fan, W. Y.: Determination of trace metals in atmospheric dry deposition with a heavy matrix of PUF by inductively coupled plasma mass spectroscopy after microwave digestion, Environ. Sci., 31, 553-559 (in Chinese), 2010.

Pike, S. M., and Moran, S. B.: Trace elements in aerosol and precipitation at New Castle, NH, USA, Atmos. Environ., 35, 3361-3366, doi:10.1016/S1352-2310(00)00525-2, 2001.

Sakata, M., Tani, Y., and Takagi, T.: Wet and dry deposition fluxes of trace elements in Tokyo Bay, Atmos. Environ., 42, 5913-5922, doi:10.1016/j.atmosenv.2008.03.027, 2008.

Sakata, M., and Asakura, K.: Factors contributing to seasonal variations in wet deposition fluxes of trace elements at sites along Japan Sea coast, Atmos. Environ., 43, 3867-3875, doi:10.1016/j.atmosenv.2009.05.001, 2009.

Sakata, M., and Asakura, K.: Atmospheric dry deposition of trace elements at a site on Asian-continent side of Japan, Atmos. Environ., 45, 1075-1083, doi:10.1016/j.atmosenv.2010.11.043, 2011.

Sandroni, V., and Migon, C.: Atmospheric deposition of metallic pollutants over the Ligurian Sea: labile and residual inputs, Chemosphere, 47, 753-764, doi:10.1016/S0045-6535(01)00337-X, 2002.

Sweet, C. W., Weiss, A., and Vermette, S. J.: Atmospheric deposition of tace metals at three sites near the Great Lakes, Water Air. Soil Poll., 103, 423-439, doi:10.1023/A:1004905832617, 1998.

Takeda, K., Marumoto, K., Minamikawa, T., Sakugawa, H., and Fujiwara, K.: Three-year determination of trace metals and the lead isotope ratio in rain and snow depositions collected in Higashi-Hiroshima, Japan, Atmos. Environ., 34, 4525-4535,

doi:10.1016/S1352-2310(00)00103-5, 2000.

Tasdemir, Y., and Kural, C.: Atmospheric dry deposition fluxes of trace elements measured in Bursa, Turkey, Environ. Pollut., 138, 462-472, doi:10.1016/j.envpol.2005.04.012, 2005.

Theodosi, C., Stavrakakis, S., Koulaki, F., Stavrakaki, I., Moncheva, S., Papathanasiou, E., Sanchez-Vidal, A., Koçak, M., and Mihalopoulos, N.: The significance of atmospheric inputs of major and trace metals to the Black Sea, J. Marine. Syst., 109–110, 94-102, doi:10.1016/j.jmarsys.2012.02.016, 2013.

Tripathee, L., Kang, S., Huang, J., Sharma, C. M., Sillanpää, M., Guo, J., and Paudyal, R.: Concentrations of trace elements in wet deposition over the Central Himalayas, Nepal, Atmos. Environ., in press, doi:10.1016/j.atmosenv.2014.06.043, 2014.

Williams, M. R., Millward, G. E., Nimmo, M., and Fones, G.: Fluxes of Cu, Pb and Mn to the north-eastern Irish Sea: The importance of sedimental and atmospheric inputs, Mar. Pollut. Bull., 36, 366-375, doi:10.1016/S0025-326X(98)00199-4, 1998.

Wong, C. S. C., Li, X. D., Zhang, G., Qi, S. H., and Peng, X. Z.: Atmospheric deposition of heavy metals in the Pearl River Delta, China, Atmos. Environ., 37, 767-776, doi:10.1016/S1352-2310(02)00929-9, 2003.

Wu, C. X., Qi, S. H., Su, Q. K., Fang, M., and Wang, W.: Atmospheric deposition of heavy metals to Xinghua Bay, Fujian province, Environ. Chem., 25, 781-784 (in Chinese), 2006.

Yi, S. M., Lee, E. Y., and Holsen, T. M.: Dry deposition fluxes and size distributions of heavy metals in Seoul, Korea during Yellow-Sand events, Aerosol. Sci. Tech., 35, 569-576, doi:10.1080/02786820120775, 2001a.

Yi, S. M., Shahin, U., Sivadechathep, J., Sofuoglu, S. C., and Holsen, T. M.: Overall elemental dry deposition velocities measured around Lake Michigan, Atmos. Environ., 35, 1133-1140, doi:10.1016/S1352-2310(00)00242-9, 2001b.

Zhang, L., Fang, G. C., Liu, C. K., Huang, Y. L., Huang, J. H., and Huang, C. S.: Dry deposition fluxes and deposition velocities of seven trace metal species at five sites in central Taiwan – a summary of surrogate surface measurements and a comparison with model estimations, Atmos. Chem. Phys., 12, 3405-3417, doi:10.5194/acp-12-3405-2012, 2012.

Zhang, Q., Streets, D. G., Carmichael, G. R., He, K. B., Huo, H., Kannari, A., Klimont, Z., Park, I. S., Reddy, S., and Fu, J. S.: Asian emissions in 2006 for the NASA INTEX-B mission, Atmos. Chem. Phys., 9, 5131-5153, doi:10.5194/acp-9-5131-2009, 2009.

Zheng, M., Guo, Z., Fang, M., Rahn, K. A., and Kester, D. R.: Dry and wet deposition of elements in Hong Kong, Mar. Chem., 97, 124-139, doi:10.1016/j.marchem.2005.05.007, 2005.