



Supplement of

Worldwide biogenic soil NO_x emissions inferred from OMI NO₂ observations

G. C. M. Vinken et al.

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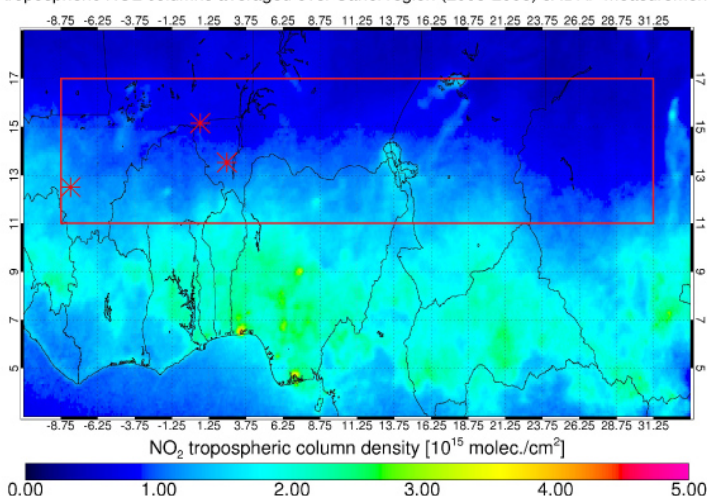
Supplementary Material to 'Worldwide biogenic soil NO_x emission estimates from OMI NO₂ observations and the GEOS-Chem model'

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1. Locations of IDAF, EMEP, and EPA surface monitoring stations

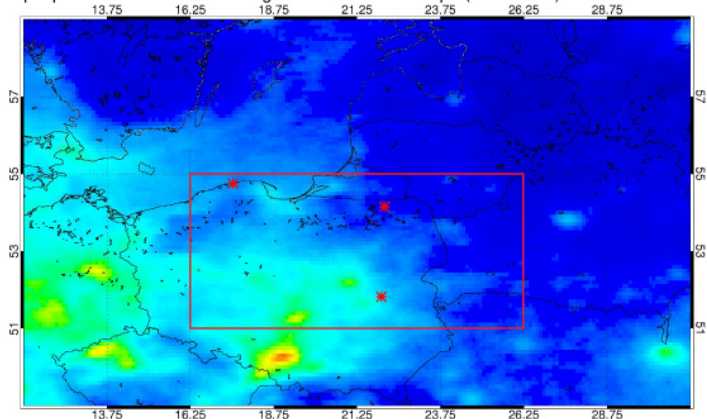
In this study we use NO₂ measurements from surface monitoring stations in Africa, Europe and the USA. Locations of the measurement stations are shown in Fig. S1a for IDAF in Africa, in Fig. S1b for EMEP in Poland, and in Fig. S1c for the mid-USA. OMI tropospheric NO₂ columns averaged over 2005-2008 show that measurement stations are located in rural areas, away from large anthropogenic sources.

(a) OMI tropospheric NO₂ columns averaged over Sahel region (2005-2008) & IDAF measurement stations



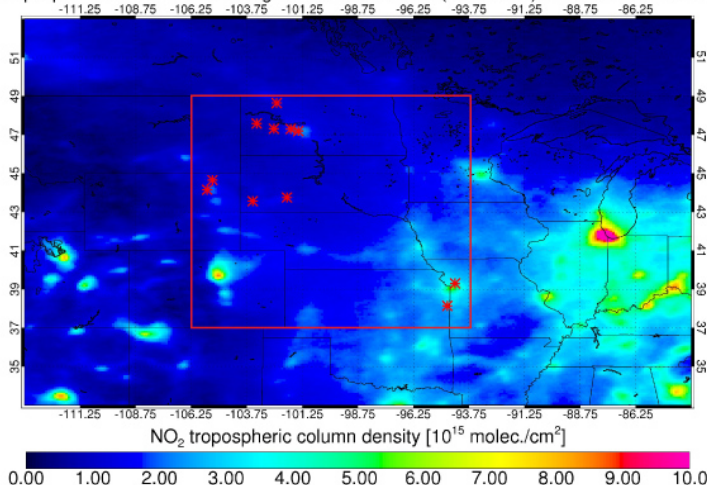
Station	Location
Banizoumbou, Niger	13°31'N, 2°28'E
Katibougou, Mali	12°30'N, 8°5'W
Agoufou, Mali	15°09'N, 0°40'E

(b) OMI tropospheric NO₂ columns averaged over Eastern Europe (2005-2008) & EMEP measurement stations



Station	Location
Leba, Poland	54°45'N, 17°32'E
Diabla Gora, Poland	54°9'N, 22°4'E
Jarczew, Poland	51°49'N, 21°59'E

(c) OMI tropospheric NO₂ columns averaged over the mid-USA (2005-2008) & EPA measurement stations



Site ID	Location
20-107-0002	38°8'N, 94°44'W
29-047-0005	39°18'N, 94°23'W
38-013-0004	48°39'N, 102°24'W
38-025-0002	47°35'N, 103°18'W
38-025-0003	47°19'N, 102°32'W
38-057-0004	47°18'N, 101°46'W
38-065-0002	47°11'N, 101°26'W
46-033-0132	43°33'N, 103°29'W
46-071-0001	43°45'N, 101°56'W
56-005-0123	44°39'N, 105°17'W
56-005-0456	44°9'N, 105°32'W

Figure S1: OMI NO₂ observations averaged over 2005-2008 on a 0.1°x0.1° resolution (selection criteria as in Sec. 3.1). Note that (a) has a different color bar than (b) and (c). Overplotted are the IDAF (a), EMEP (b), and EPA (c) monitoring stations used in this study, with specific locations indicated next to the Figures.

2. Regression statistics of GEOS-Chem NO₂ columns versus soil NO_x emissions

Statistics of the Reduced Major Axis (RMA) fit of GEOS-Chem NO₂ columns and soil NO_x emissions are given in Table S1. All simulated NO₂ columns were filtered following the filtering scheme of section 3.1. We highlighted months that are included in our constraints in green ($R^2 > 0.2$).

Table S1: Statistics of RMA fit of GEOS-Chem NO₂ columns versus soil NO_x emissions.

		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Argentina (56.3°-66.3°W; 23°-39°S)	slope; intercept	0.11;0.49	0.14;0.36	0.15;0.32	0.25;0.21	-0.48;1.6	0.32;0.27	0.55;0.26	0.51;0.07	0.23;0.28	0.16;0.37	0.11;0.45	0.09;0.41
	R ² ; N	0.62; 31	0.22; 23	0.37; 24	0.02; 16	0.0; 10	0.12; 14	0.62; 22	0.05; 13	0.05; 22	0.20;30	0.30; 32	0.38; 30
Mid-USA (93.8°-106.3°W; 37°-49°N)	slope; intercept					0.21;0.47	0.20;1.02	0.16;1.01	0.12;1.02	0.18;0.85			
	R ² ; N					0.81; 18	0.77; 15	0.80; 26	0.69; 25	0.71; 25			
West-USA (113.8°- 123.8°W; 37°-49°N)	slope; intercept					0.33;0.03	0.16;0.33	0.19;0.31	0.13;0.55	0.16;0.51	0.25;0.41		
	R ² ; N					0.76; 6	0.70; 8	0.08; 20	0.25; 19	0.35;15	0.51; 7		
Spain- France ^a (1.3°-6.8°W; 39°-43°N & 1.3°W-3.8°E; 43°-47°N)	slope; intercept				0.30;0.65	0.18;0.83	0.10;1.13	-0.06;2.1	-0.12;2.5	0.25;1.09			
	R ² ; N				0.13; 4	0.34; 7	0.46; 8	0.07; 8	0.05; 8	0.02; 8			
Eastern Europe ^a (16.3°-26.3°E; 51°-55°N)	slope; intercept					0.41;0.57	0.23;0.95	0.16;0.94	0.26;0.85	0.50;0.77			
	R ² ; N					0.88; 4	0.85; 8	0.82; 8	0.75; 8	0.72; 7			
Sahel (8.8°W-31.3°E; 5°S-1°N)	slope; intercept	0.18; 0.5	0.21;0.45	0.11;0.63	0.13;0.52	0.13;0.57	0.14;0.70	0.15;0.59	0.13;0.58	0.09;0.67	0.15;0.50	0.23;0.36	0.26;0.36
	R ² ; N	0.74; 17	0.62; 38	0.71; 37	0.69; 41	0.50; 44	0.43; 40	0.47; 40	0.38; 26	0.70; 25	0.56; 29	0.78; 28	0.84; 29
Namibia- Botswana (16.3°-26.3°E; 19°-25°S)	slope; intercept	0.14;0.44	0.10;0.50	0.05;0.59	0.05;0.62	0.12;0.54	0.17;0.62	0.09;0.71		0.18;0.65	0.10;0.91	0.07;0.72	0.17;0.56
	R ² ; N	0.04; 7	0.49; 12	0.65; 12	0.55; 12	0.12; 12	0.22; 12	0.73; 11		0.62; 5	0.03; 11	0.50; 12	0.73; 9
India (71.3°-88.8°E; 18°-23°N)	slope; intercept	0.49;0.39	0.15;1.07	0.25;0.56	0.13;1.23	0.16;0.81	0.11;0.72	0.07;0.75				0.23;1.10	0.38;0.71
	R ² ; N	0.36; 16	0.56; 16	0.42; 20	0.82; 20	0.67; 21	0.62; 21	0.98; 3				0.44; 5	0.95; 5
Australia (143.8°-148.8°E; 29°-37°S)	slope; intercept	0.07;0.69	0.06;0.62	0.14;0.48	0.15;0.59	0.48;0.25	0.53;0.12			0.11;0.32	0.06;0.35	0.06;0.51	0.07;0.50
	R ² ; N	0.77; 8	0.66; 7	0.64; 8	0.54; 8	0.59; 6	0.81; 5			0.66; 5	0.22; 6	0.64; 7	0.66; 8
Brazil (41.3°-56.3°W; 15°-23°S)	slope; intercept		0.12;0.35	0.09;0.56	0.13;0.48	0.21;0.14	0.16;0.47	0.20;0.54	0.39;0.00	0.23;0.53	0.15;0.67	0.05;0.81	0.14;0.27
	R ² ; N		0.07; 13	0.19; 12	0.29; 13	0.19; 20	0.16; 14	0.14; 18	0.48; 11	0.34; 10	0.12; 18	0.22; 12	0.00; 8
South Kazakhstan (46.3°-83.8°E; 35°-49°N)	slope; intercept				0.06;0.42	0.07;0.62	0.06;0.87	0.06;0.95	0.06;0.95	0.12;0.64	0.19;0.50		
	R ² ; N				0.27; 18	0.25; 30	0.18; 30	0.48; 28	0.05; 30	0.37; 30	0.56; 28		

^a regression done on data filtered for soil fraction larger than 0.2

3. Regression statistics of GEOS-Chem NO₂ columns versus OMI NO₂ columns

Statistics of the Reduced Major Axis (RMA) fit of GEOS-Chem and OMI tropospheric NO₂ columns are given in Table S2. All simulated and observed NO₂ columns were filtered following the filtering scheme of section 3.1. We highlighted months that are satisfy our correlation criteria ($R^2 > 0.35$ in this regression, and $R^2 > 0.2$ between GEOS-Chem NO₂ columns versus soil NO_x emissions).

Table S2: Statistics of RMA fit of GEOS-Chem and OMI tropospheric NO₂ columns. Regions as defined in Fig. 3 and Table S1.

		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Argentina	slope; intercept	0.75;0.23	0.88;0.06	0.97;0.04	1.14;-0.2	0.91;-0.1	1.07;-0.2	0.91;0.17	1.12;-0.2	2.01;-0.7	1.68;-0.3	1.33;-0.1	1.26;-0.1
	R ² ; N	0.59; 31	0.35; 23	0.34; 24	0.52; 16	0.45; 10	0.14; 14	0.50; 22	0.79; 13	0.38; 22	0.74; 30	0.28; 32	0.27; 30
Mid-USA	slope; intercept					0.90;0.31	0.77;-0.3	0.57;0.16	0.84;0.0	1.04;-0.5			
	R ² ; N					0.38; 18	0.77; 15	0.67; 26	0.66; 25	0.71; 25			
West-USA	slope; intercept					1.38;-0.1	0.91;0.18	1.41;-0.4	1.61;-0.9	1.57;-0.6	1.04;0.02		
	R ² ; N					0.89; 6	0.31; 8	0.87; 20	0.47; 19	0.72; 15	0.82; 7		
Spain-France ^a	slope; intercept				1.01;0.11	1.01;0.19	1.64;-0.8	2.26;-2.1	1.43; -1.0	2.14;-1.9			
	R ² ; N				0.76; 4	0.54; 7	0.51; 8	0.39; 8	0.72; 8	0.12; 8			
Eastern Europe ^a	slope; intercept					1.56;-0.5	1.42;-0.5	0.78;0.36	1.52;-0.6	1.28;-0.3			
	R ² ; N					0.92; 4	0.86; 8	0.33; 8	0.95; 8	0.89; 7			
Sahel	slope; intercept	0.50;0.28	0.94;0.06	1.17;-0.2	1.41;-0.4	1.48;-0.4	1.32;-0.4	1.07;0.05	1.28;-0.1	0.98;0.09	0.81;0.16	0.66;0.27	0.69;0.17
	R ² ; N	0.77; 17	0.75; 38	0.60; 37	0.70; 41	0.71; 44	0.62; 40	0.60; 40	0.51; 26	0.52; 25	0.74; 29	0.70; 28	0.90; 29
Namibia-Botswana	slope; intercept	2.56;1.12	0.87;0.12	1.06;-0.1	1.50;-0.5	0.75;-0.2	0.77;0.08	2.49;-1.3		1.13;-0.2	0.87;0.37	1.62;-0.5	1.23;0.0
	R ² ; N	0.02; 7	0.35; 12	0.22; 12	0.47; 12	0.20; 12	0.15; 12	0.02; 11		0.36; 5	0.72; 11	0.82; 12	0.72; 9
India	slope; intercept	1.45;-0.8	1.45;-0.8	1.25;-0.4	1.06;-0.5	1.23;-0.8	1.15;0.20					1.13;-0.2	-0.33;2.6
	R ² ; N	0.16; 16	0.05; 16	0.39; 20	0.27; 20	0.71; 21	0.64; 21					0.80; 5	0.00; 5
Australia	slope; intercept	1.41;-0.3	2.25;-0.8	1.18;-0.1	1.49;-0.1	0.99;0.15	0.68;0.38			1.15;0.40	2.93;-0.5	3.28;-1.2	1.14;0.25
	R ² ; N	0.60; 8	0.66; 7	0.76; 8	0.88; 8	0.47; 6	0.92; 5			0.01; 5	0.23; 6	0.09; 7	0.70; 8
Brazil	slope; intercept		1.08;-0.2	-1.3;-0.38	0.74;-0.2	1.02;-0.1	1.29;-0.7	1.51;-0.9	0.71;0.06	1.30;-0.4	1.06;0.03	-0.78;1.8	1.44;-0.3
	R ² ; N		0.45; 13	0.38; 12	0.75; 13	0.59; 20	0.43; 14	0.43; 18	0.28; 11	0.77; 10	0.46; 18	0.12; 12	0.16; 8
South Kazakhstan	slope; intercept				-4.4;2.9	2.66;-1.2	1.84;-0.8	1.46;-0.4	1.65;-0.8	1.28;-0.5	1.02;-0.2		
	R ² ; N				0.03; 18	0.39; 30	0.26; 30	0.59; 28	0.26; 30	0.02; 30	0.00; 28		

^a regression done on data filtered for soil fraction larger than 0.2

4. Regression statistics of GEOS-Chem NO₂ columns (using top-down soil NO_x emissions) versus OMI NO₂ columns

Statistics of the Reduced Major Axis (RMA) fit of GEOS-Chem and OMI tropospheric NO₂ columns are given in Table S3. All simulated and observed NO₂ columns were filtered following the filtering scheme of section 3.1.

Table S3: Statistics of RMA fit of GEOS-Chem (using top-down soil NO_x inventory) and OMI tropospheric NO₂ columns. Regions as defined in Fig. 3 and Table S1.

		Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Argentina	slope; intercept	0.92;0.18	0.94;0.06					0.93;0.18			1.31;-0.3		
	R ² ; N	0.57; 31	0.34; 23					0.49; 22			0.48; 30		
Mid-USA	slope; intercept					0.95;0.30	0.84;-0.3	0.77;0.08	0.94; -0.1	1.05;-0.5			
	R ² ; N					0.36; 18	0.78; 15	0.76; 26	0.68; 25	0.67; 25			
West-USA	slope; intercept					1.14;-0.1			1.17;-0.8	1.18;-0.6	1.02;0.02		
	R ² ; N					0.89; 6			0.23; 19	0.56; 15	0.82; 7		
Spain-France ^a	slope; intercept					1.00;0.19	0.84;0.09						
	R ² ; N					0.54; 7	0.46; 8						
Eastern Europe ^a	slope; intercept					1.30;-0.4	1.16;-0.3		1.19;-0.5	1.16;-0.3			
	R ² ; N					0.92; 4	0.85; 8		0.91; 8	0.87; 7			
Sahel	slope; intercept	0.88;0.18	0.99;0.05	0.99;-0.1	1.10;-0.3	1.10;-0.3	1.15;-0.4	1.02;0.05	1.04;0.0	1.00;0.08	0.94;0.13	0.88;0.22	0.88;0.15
	R ² ; N	0.69; 17	0.74; 38	0.56; 37	0.55; 41	0.69; 44	0.59; 40	0.59; 40	0.45; 26	0.52; 25	0.76; 29	0.74; 28	0.90; 29
Namibia-Botswana	slope; intercept		0.96;0.11		0.57;0.05					1.07;-0.2		0.91;-0.1	1.08;0.00
	R ² ; N		0.45; 12		0.37; 12					0.31; 5		0.78; 11	0.68; 9
India	slope; intercept			1.11;-0.3		1.12;-0.8	0.97;0.37					1.08;-0.1	
	R ² ; N			0.29; 20		0.72; 21	0.64; 21					0.79; 5	
Australia	slope; intercept	0.98;-0.1	0.82;-0.1	1.04;-0.1	1.00;0.1	0.99;0.15	0.93;0.33						1.00;0.29
	R ² ; N	0.60; 8	0.39; 7	0.69; 8	0.85; 8	0.47; 6	0.93; 5						0.69; 8
Brazil	slope; intercept				0.81;-0.2					0.96;-0.2			
	R ² ; N				0.79; 13					0.76; 10			
South Kazakhstan	slope; intercept					0.88; -0.3		0.96;0.0					
	R ² ; N					0.00; 30		0.35; 28					

^a regression done on data filtered for soil fraction larger than 0.2