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Supplement of

Multi-model study of mercury dispersion in the atmosphere: atmospheric processes and model evaluation

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Table S1. Characteristics of ground-based sites measuring GEM.

Code	Site name	Network	Longitude	Latitude	Elevation
AMS	Amsterdam Island	GMOS	77.55	-37.8	70
BAR	Bariloche	GMOS	-71.42	-41.13	801
CAL	Calhau. Sao Vicente	GMOS	-24.87	16.86	10
CPT	Cape Point	GMOS	18.49	-34.35	230
DOC	Dome Concordia	GMOS	123.35	-75.10	3220
EVK	Ev-K2	GMOS	86.81	27.96	5050
KOD	Kodaikanal	GMOS	77.47	10.23	2333
LIS	Listvyanka	GMOS	104.89	51.85	670
LON	Longobucco	GMOS	16.61	39.39	1379
MAL	Mt. Ailao	GMOS	101.03	24.54	2503
MAN	Manaus	GMOS	-59.97	-2.89	110
MCH	Mt. Changbai	GMOS	128.11	42.40	741
MHE	Mace Head	GMOS	-9.9	53.33	15
MWA	Mt. Waliguan	GMOS	100.9	36.29	3816
NIK	Nieuw Nickerie	GMOS	-57.04	5.96	1
PAL	Pallas Matorova	GMOS	24.24	68.0	340
RAO	Rao	GMOS	11.91	57.39	5
SIS	Sisal. Yucatan	GMOS	-90.05	21.16	7
AND	Andoya	EMEP	16.01	69.28	380
BIR	Birkenes II	EMEP	8.25	58.39	219
BRE	Bredkalen	EMEP	15.33	63.85	404
DBL	Diabla Gora	EMEP	22.07	54.15	157
STN	Station Nord	EMEP	-16.61	81.58	30
TRO	Troll	EMEP	2.53	-72.01	1275
VAV	Vavihill	EMEP	13.15	56.02	175
WAL	Waldhof	EMEP	10.76	52.8	74
ZEP	Zeppelin (Ny Alesund)	EMEP	11.88	78.91	474
ZIN	Zingst	EMEP	12.73	54.43	1
BMH	Birmingham	AMNet	-86.82	33.55	200
BSV	Beltsville Second Instrument	AMNet	-76.82	39.03	46
GNB	Grand Bay NERR Second Instrument	AMNet	-88.43	30.43	2
HRM	Horicon Marsh	AMNet	-88.62	43.47	287
MLO	Mauna Loa	AMNet	-155.6	19.5	3399
PSC	Pensacola	AMNet	-87.38	30.55	45
SLC	Salt Lake City	AMNet	-111.96	40.71	1297
STB	South Bass Island	AMNet	-82.83	41.66	
STW	Stilwell	AMNet	-94.67	35.75	299
UDH	Underhill	AMNet	-72.87	44.53	399
YKV	Yorkville	AMNet	-85.05	33.93	395
ALE	Alert	NAtChem	-62.34	82.49	210
EGB	Egbert	NAtChem	-79.79	44.23	196
FTM	Fort McMurray	NAtChem	-111.48	56.75	370
KEJ	Kejimkujik	NAtChem	-65.21	44.43	155
LWC	Lower Camp	NAtChem	-111.5	57.03	240
MBL	West Coast Marine Boundary Layer	NAtChem	-125.54	48.92	15
STR	Saturna Island	NAtChem	-123.13	48.78	196
WBT	Mingan	NAtChem	-64.23	50.27	11
WBZ	St. Anicet	NAtChem	-74.0	45.2	49
WSL	Whistler	NAtChem	-122.93	50.07	2182

Table S2. Characteristics of ground-based sites measuring RM.

Code	Site name	Network	Longitude	Latitude	Elevation
AMS	Amsterdam Island	GMOS	77.55	-37.8	70
LON	Longobucco	GMOS	16.61	39.39	1379
MAN	Manaus	GMOS	-59.97	-2.89	110
WAL	Waldhof	EMEP	10.76	52.80	74
BSV	Beltsville Second Instrument	AMNet	-76.82	39.03	46
GNB	Grand Bay NERR Second Instrument	AMNet	-88.43	30.43	2
HRM	Horicon Marsh	AMNet	-88.62	43.47	287
PSC	Pensacola	AMNet	-87.38	30.55	45
SLC	Salt Lake City	AMNet	-111.96	40.71	1297
STW	Stilwell	AMNet	-94.67	35.75	299
UDH	Underhill	AMNet	-72.87	44.53	399
YKV	Yorkville	AMNet	-85.05	33.93	395
ALE	Alert	NAtChem	-62.34	82.49	210
KEJ	Kejimkujik	NAtChem	-65.21	44.43	155

Table S3. Characteristics of ground-based sites measuring wet deposition.

Code	Site name	Network	Longitude	Latitude	Elevation	Group[1]
ZEP	Zeppelin (Ny Alesund)	GMOS	11.88	78.91	474	Northern Europe
PAL	Pallas	GMOS	24.24	68.00	340	Northern Europe
RAO	Rao	GMOS	11.91	57.39	5	Northern Europe
MHE	Mace Head	GMOS	-9.90	53.33	15	Western Europe
MWA	Mt. Waliguan	GMOS	100.90	36.29	3816	Asia
MAL	Mt. Ailao	GMOS	101.03	24.54	2503	Asia
SIS	Sisal. Yucatan	GMOS	-90.05	21.16	7	North America 1
AMS	Amsterdam Island	GMOS	77.55	-37.80	70	Indian Ocean
CGR	Cape Grim	GMOS	144.69	-40.68	94	Australia
BRE	Bredkalen	EMEP	15.33	63.85	404	Northern Europe
BIR	Birkenes	EMEP	8.25	58.38	190	Northern Europe
VAV	Vavihill	EMEP	13.15	56.02	175	Northern Europe
WES	Westerland	EMEP	8.31	54.93	12	Northern Europe
ZIN	Zingst	EMEP	12.73	54.43	1	Northern Europe
ACM	Auchencorth Moss	EMEP	-3.24	55.79	260	Western Europe
ZIL	De Zilk	EMEP	4.50	52.30	4	Western Europe
HAR	Harwell	EMEP	-1.33	51.57	137	Western Europe
KOK	Koksijde	EMEP	2.66	51.12	4	Western Europe
ISK	Iskrba	EMEP	14.86	45.56	520	Southern Europe
NMB	Niembro	EMEP	-4.85	43.44	134	Southern Europe
EVG	Everglades National Park-Research Center	MDN	-80.68	25.39	2	North America 1
EWB	Everglades-Western Broward County	MDN	-80.82	26.17	4	North America 1
EGN	Everglades Nutrient Removal Project	MDN	-80.40	26.66	10	North America 1
CHW	Chassahowitzka National Wildlife Refuge	MDN	-82.56	28.75	3	North America 1
GRB	Grand Bay NERR	MDN	-88.43	30.43	2	North America 1
PSC	Pensacola	MDN	-87.38	30.55	45	North America 1
OFN	Okefenokee National Wildlife Refuge	MDN	-82.13	30.74	45	North America 1
OKG	Oak Grove	MDN	-88.93	30.99	100	North America 1
SPI	Sapelo Island	MDN	-81.28	31.40	3	North America 1
LNV	Longview	MDN	-94.71	32.38	103	North America 2
CTV	Centreville	MDN	-87.25	32.90	135	North America 2
CPR	Cape Romain National Wildlife Refuge	MDN	-79.66	32.94	1	North America 2
SVN	Savannah River	MDN	-81.65	33.25	90	North America 2
BMH	Birmingham	MDN	-86.82	33.55	200	North America 2
CGS	Congaree Swamp	MDN	-80.78	33.81	34	North America 2
YKV	Yorkville	MDN	-85.05	33.93	395	North America 2
LMR	Lake Murray	MDN	-97.07	34.10	245	North America 2
CNF	Converse Flats	MDN	-116.91	34.19	1724	North America 2
WMW	Waccamaw State Park	MDN	-78.48	34.26	10	North America 2
MGC	McGee Creek	MDN	-95.89	34.32	195	North America 2
WCT	Wichita Mountains NWR	MDN	-98.71	34.73	492	North America 2
GSM	Great Smoky Mountains National Park-Elkmont	MDN	-83.59	35.66	640	North America 2
PTG	Pettigrew State Park	MDN	-76.51	35.74	2	North America 2
STW	Stilwell	MDN	-94.67	35.75	299	North America 2
SEQ	Sequoia National Park-Giant Forest	MDN	-118.78	36.57	1921	North America 3
MIM	Miami	MDN	-94.76	36.90		North America 3
CPN	Copan	MDN	-95.88	36.91	255	North America 3
MNG	Mingo National Wildlife Refuge	MDN	-90.14	36.97	105	North America 3

Table S3. Continued.

Code	Site name	Network	Longitude	Latitude	Elevation	Group[1]
MMC	Mammoth Cave National Park-Houchin Meadow	MDN	-86.15	37.13	236	North America 3
CMR	Cimarron National Grassland	MDN	-101.82	37.13	1021	North America 3
MVR	Mesa Verde National Park-Chapin Mesa	MDN	-108.49	37.20	2162	North America 3
WMN	West Mineral	MDN	-94.94	37.27	274	North America 3
MLP	Molas Pass	MDN	-107.69	37.75	3248	North America 3
CFY	Coffey County Lake	MDN	-95.66	38.20		North America 3
SNH	Shenandoah National Park-Big Meadows	MDN	-78.43	38.52	1072	North America 3
SSL	Lake Scott State Park	MDN	-100.92	38.67	863	North America 3
ALW	Ashland Wildlife Area	MDN	-92.20	38.75	257	North America 3
SSN	Smithsonian Environmental Research Center	MDN	-76.56	38.89	20	North America 3
BTV	Beltsville	MDN	-76.82	39.03	46	North America 3
CVI	Canaan Valley Institute	MDN	-79.42	39.06	988	North America 3
GES	Glen Elder State Park	MDN	-98.34	39.51	456	North America 3
PNY	Piney Reservoir	MDN	-79.01	39.71	769	North America 3
WNB	Waynesburg	MDN	-80.29	39.82	452	North America 3
ARV	Arendtsville	MDN	-77.31	39.92	269	North America 3
RSR	Reserve	MDN	-95.57	39.98	265	North America 4
MLV	Millersville	MDN	-76.39	39.99	84	North America 4
BDV	Bondville	MDN	-88.37	40.05	212	North America 4
VLF	Valley Forge	MDN	-75.88	40.12	46	North America 4
APR	Allegheny Portage Railroad National Historic Site	MDN	-78.56	40.46	739	North America 4
NBW	New Brunswick	MDN	-74.42	40.47	21	North America 4
BFP	Buffalo Pass - Summit Lake	MDN	-106.68	40.54	3234	North America 4
FCL	Fort Collins	MDN	-105.14	40.59	1570	North America 4
LDR	Leading Ridge	MDN	-77.94	40.66	287	North America 4
SLC	Salt Lake City	MDN	-111.96	40.71	1297	North America 4
BRX	Bronx	MDN	-73.88	40.87	68	North America 4
MED	Mead	MDN	-96.49	41.15	352	North America 4
MLF	Milford	MDN	-74.82	41.33	212	North America 4
LTP	Little Pine State Park	MDN	-77.36	41.36	228	North America 4
GDR	Goddard State Park	MDN	-80.15	41.43	385	North America 4
LPR	Lesperance Ranch	MDN	-117.50	41.50	1388	North America 4
YTR	Yurok Tribe-Requa	MDN	-124.09	41.56	110	North America 4
GBR	Gibb's Ranch	MDN	-115.21	41.57	1849	North America 4
KEF	Kane Experimental Forest	MDN	-78.77	41.60	618	North America 4
HLC	Hills Creek State Park	MDN	-77.19	41.80	476	North America 4
BSB	Biscuit Brook	MDN	-74.50	41.99	634	North America 4
ERI	Erie	MDN	-80.11	42.16	177	North America 4
WNG	Winnebago	MDN	-96.47	42.25	360	North America 4
RNT	Roundtop Mountain	MDN	-108.72	42.53	2534	North America 4
GNL	Lake Geneva	MDN	-88.50	42.58	288	North America 4
MWK	Milwaukee	MDN	-87.88	43.08	206	North America 4
RCS	Rochester	MDN	-77.55	43.15	136	North America 4
DVL	Devil's Lake	MDN	-89.68	43.44	389	North America 4
CSB	Casco Bay Neck Farm	MDN	-70.06	43.83	15	North America 4
HTW	Huntington Wildlife	MDN	-74.22	43.97	500	North America 5
BRG	Bridgton	MDN	-70.73	44.11	222	North America 5
EGB	Egbert	MDN	-79.79	44.23	196	North America 5
LBT	Lamberton	MDN	-95.30	44.24	367	North America 5
MFH	Acadia National Park-McFarland Hill	MDN	-68.26	44.38	150	North America 5

Table S3. Continued

Code	Site name	Network	Longitude	Latitude	Elevation	Group[1]
KEJ	Kejimkujik	MDN	-65.21	44.43	155	North America 5
UDH	Underhill	MDN	-72.87	44.53	399	North America 5
EGL	Eagle Butte	MDN	-101.24	44.99	742	North America 5
CBT	Carrabassett Valley	MDN	-70.21	45.08	259	North America 5
BLN	Blaine	MDN	-93.22	45.14	275	North America 5
GNV	Greenville Station	MDN	-69.66	45.49	322	North America 5
PTW	Potawatomi	MDN	-88.81	45.56	570	North America 5
BDP	Badger Peak	MDN	-106.55	45.63	1312	North America 5
PPR	Popple River	MDN	-88.40	45.80	421	North America 5
TRL	Trout Lake	MDN	-89.65	46.05	509	North America 5
CRP	Camp Ripley	MDN	-94.50	46.25	410	North America 5
SNY	Seney National Wildlife Refuge-Headquarters	MDN	-85.95	46.29	220	North America 5
BLR	Brule River	MDN	-91.61	46.75	207	North America 5
CRB	Caribou	MDN	-68.01	46.87	191	North America 5
MEF	Marcell Experimental Forest	MDN	-93.47	47.53	431	North America 5
STL	Seattle/NOAA	MDN	-122.26	47.68	11	North America 5
FMG	Fernberg	MDN	-91.50	47.95	524	North America 5
MKH	Makah National Fish Hatchery	MDN	-124.65	48.29	6	North America 5
FWS	Glacier National Park-Fire Weather Station	MDN	-114.00	48.51	964	North America 5
SPV	Stephenville	MDN	-58.57	48.56	62	North America 5
STR	Saturna Island	MDN	-123.13	48.78	196	North America 5
CPS	Chapais	MDN	-74.98	49.82	379	North America 6
HRK	Henry Kroeger	MDN	-110.83	51.42	779	North America 6
GNS	Genesee	MDN	-114.20	53.30	761	North America 6
KDK	Kodiak	MDN	-152.56	57.72	7	North America 7
BTT	Gates of the Arctic National Park - Bettles	MDN	-151.68	66.91	630	North America 7

[1] Groups of sites in North America: (1) – 20°N-32°N; (2) – 32°N-36°N; (3) – 36°N-40°N; (4) – 40°N-44°N; (5) – 44°N-49°N; (6) – 49°N-54°N; (7) – 54°N-70°N.

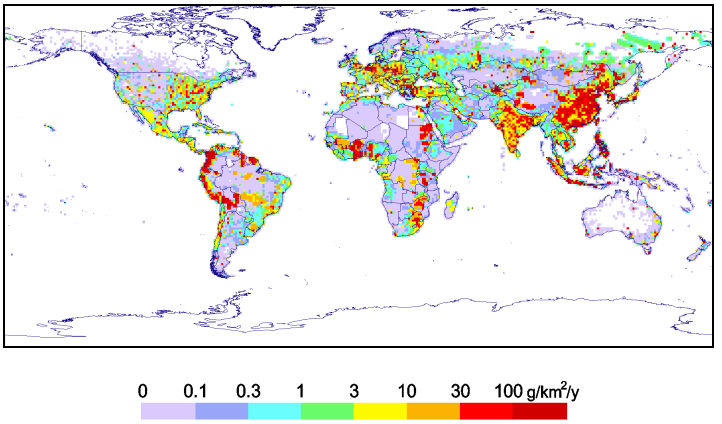

Figure S1. Spatial distribution of Hg anthropogenic emissions in 2010 according to (AMAP/UNEP, 2013).

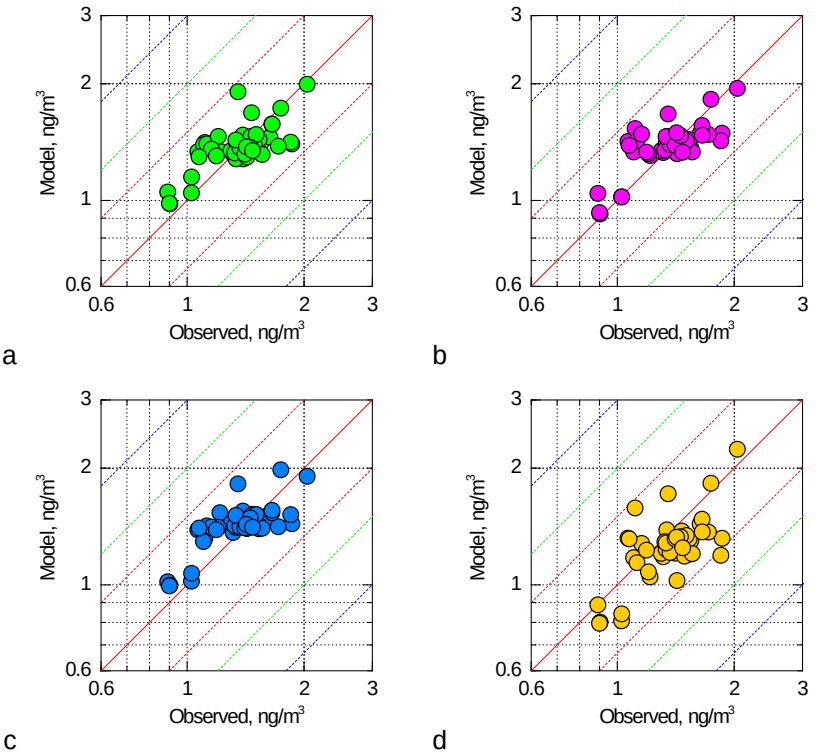

Figure S2. Scatter plots of annual mean GEM air concentration in 2013 measured at selected ground-based sites vs. simulated by different models: (a) – GLEMOS; (s) – GEOS-Chem; (c) – GEM-MACH-Hg; (d) – ECHMERIT. Red solid line depicts the 1:1 ratio; dashed lines show different deviation levels: red – by factor of 1.5. green – by factor of 2. blue – by factor of 3.

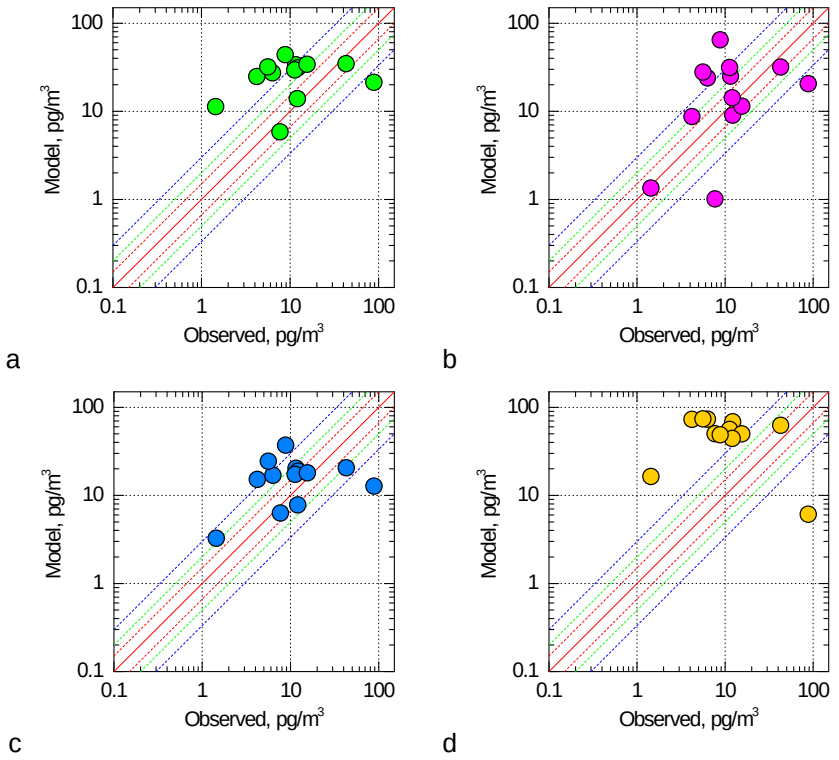

Figure S3. Scatter plots of annual mean RM air concentration in 2013 measured at selected ground-based sites vs. simulated by different models: (a) – GLEMOS; (s) – GEOS-Chem; (c) – GEM-MACH-Hg; (d) – ECHMERIT. Red solid line depicts the 1:1 ratio; dashed lines show different deviation levels: red – by factor of 1.5. green – by factor of 2. blue – by factor of 3.

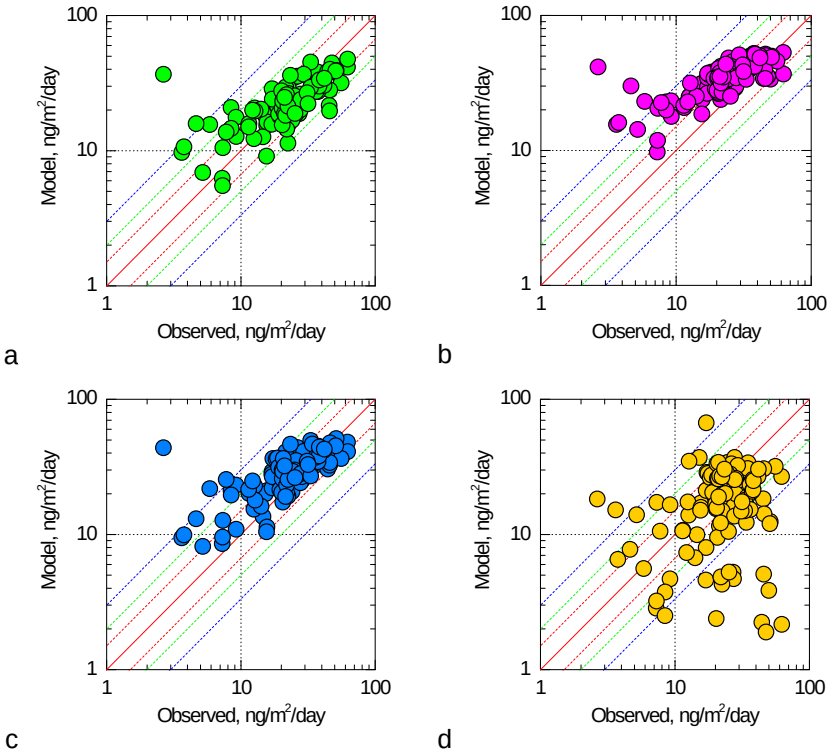

Figure S4. Scatter plots of annual mean Hg wet deposition in 2013 measured at selected ground-based sites vs. simulated by different models: (a) – GLEMOS; (s) – GEOS-Chem; (c) – GEM-MACH-Hg; (d) – ECHMERIT. Red solid line depicts the 1:1 ratio; dashed lines show different deviation levels: red – by factor of 1.5. green – by factor of 2. blue – by factor of 3.

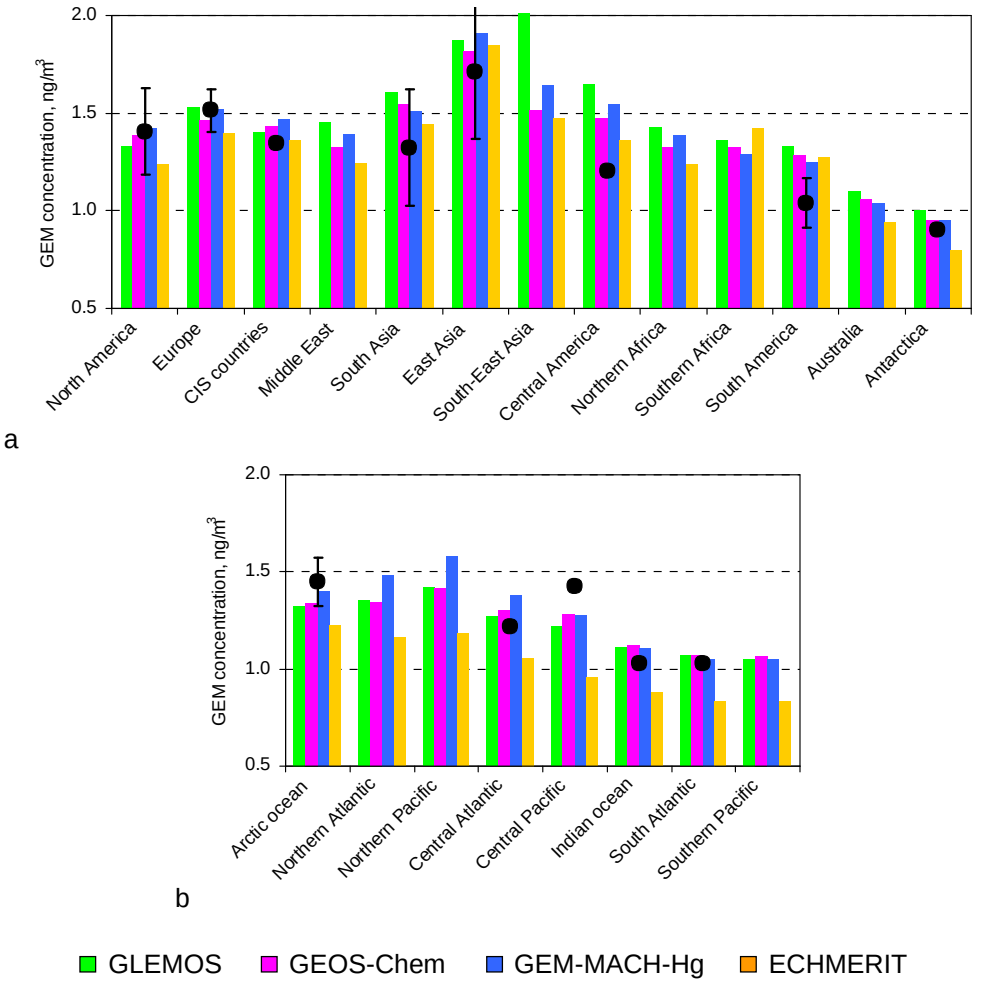

Figure S5. Annual mean GEM air concentration in 2013 averaged over various terrestrial (a) and aquatic regions (b) as simulated by four global models according to the BASE case. Black dots present observations averaged over all sites of particular region, whiskers show standard deviation among the individual sites.

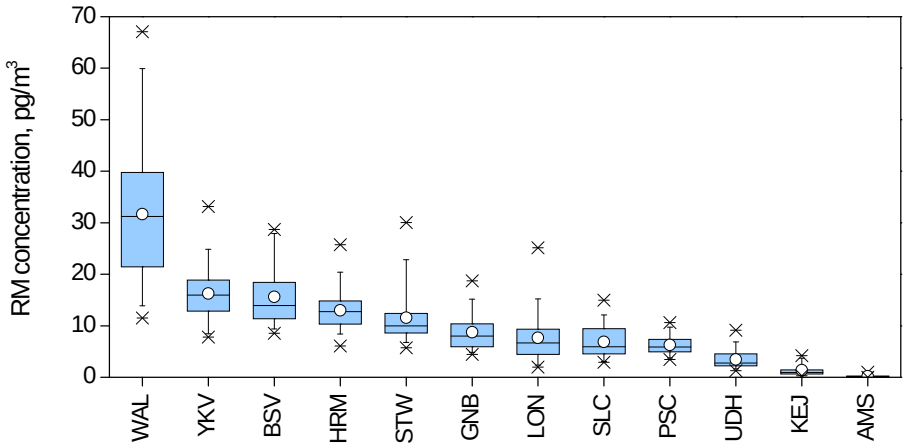

Figure S6. Model ensemble average annual air concentration of RM at selected measurement sites in 2013 simulated with no atmospheric chemistry applied by the models. Site codes are defined in Table S2.

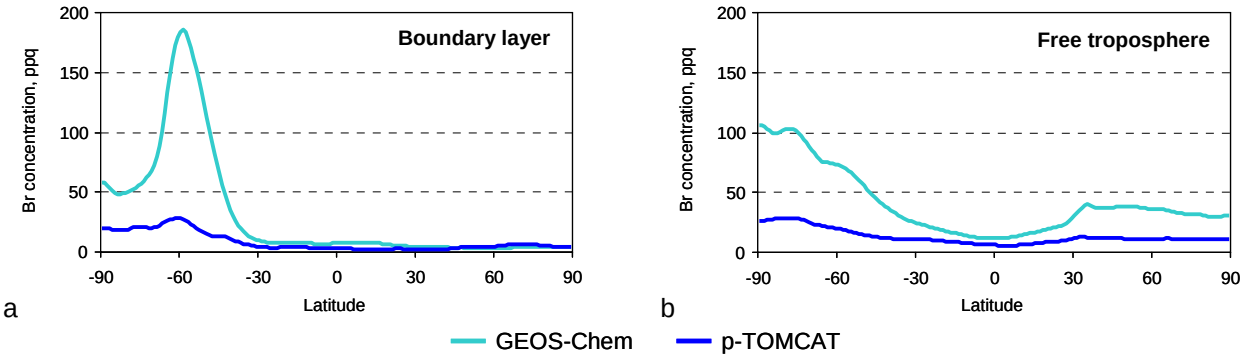

Figure S7. Global zonal-mean distribution of Br air concentration in 2013 simulated by GEOS-Chem (Parrella et al., 2012) and p-TOMCAT (Yang et al., 2005; 2010): (a) – in the boundary layer (< 1 km); (b) – in the free troposphere (1-10 km).

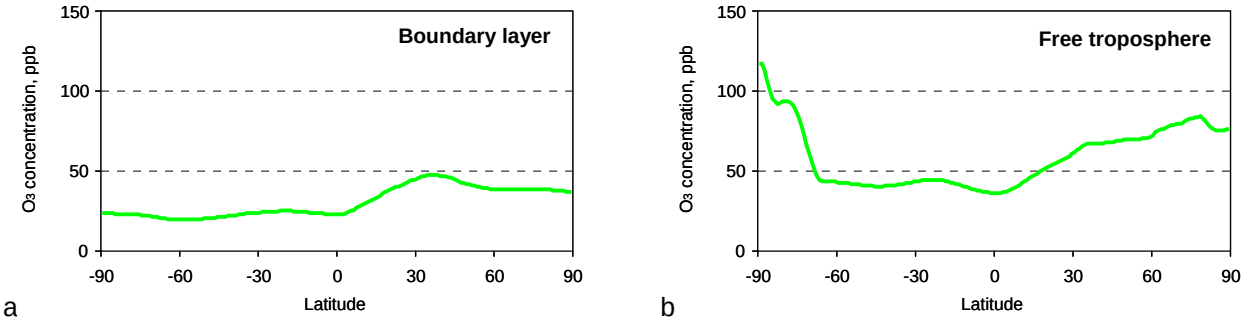

Figure S8. Global zonal-mean distribution of O_3 air concentration in 2013 simulated by MOZART (Emmons et al., 2010): (a) – in the boundary layer (< 1 km); (b) – in the free troposphere (1-10 km).

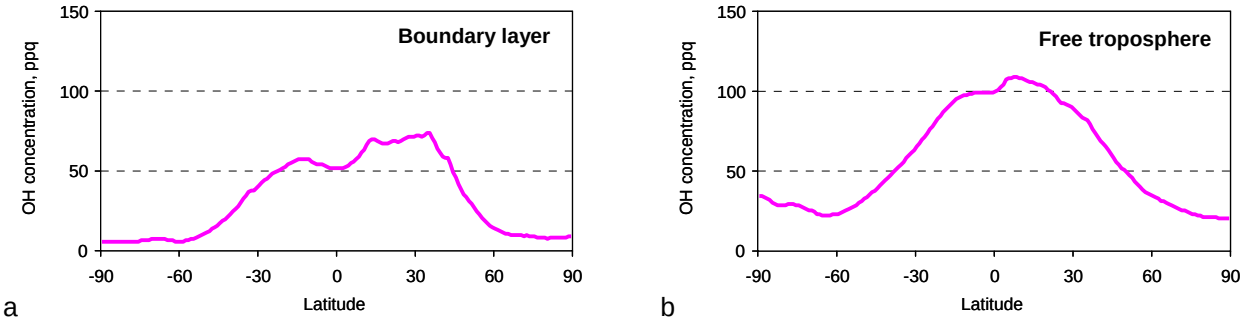

Figure S9. Global zonal-mean distribution of OH air concentration in 2013 simulated by MOZART (Emmons et al., 2010): (a) – in the boundary layer (< 1 km); (b) – in the free troposphere (1-10 km).

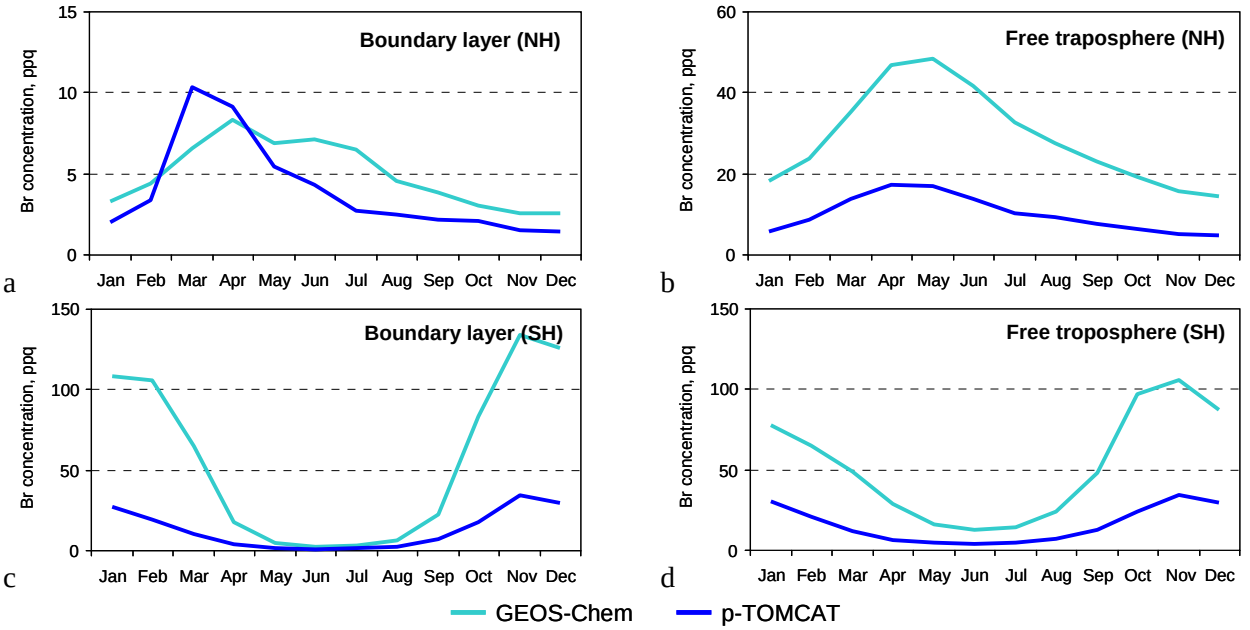

Figure S10. Seasonal variation of Br air concentration in 2013 simulated by GEOS-Chem (Parrella et al., 2012) and p-TOMCAT (Yang et al., 2005; 2010): (a) – in the boundary layer (< 1 km) of the Northern Hemisphere; (b) – in the free troposphere (1-10 km) of the Northern Hemisphere; . (c) – in the boundary layer (< 1 km) of the Southern Hemisphere; (d) – in the free troposphere (1-10 km) of the Southern Hemisphere.

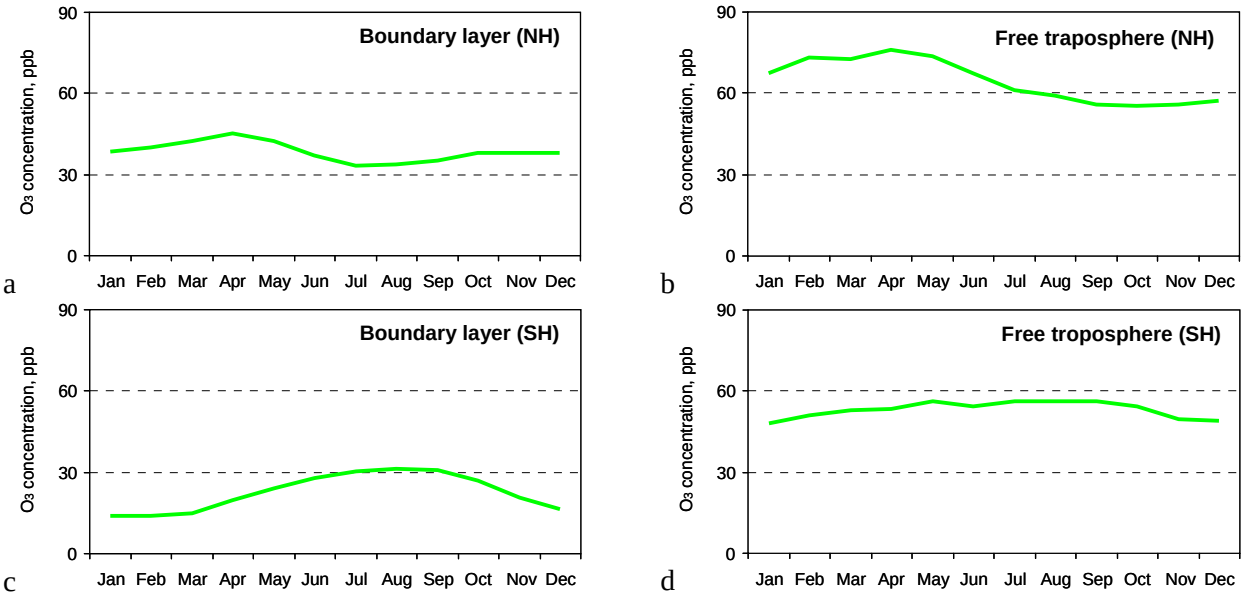

Figure S11. Seasonal variation of O_3 air concentration in 2013 simulated by MOZART (Emmons et al., 2010): (a) – in the boundary layer (< 1 km) of the Northern Hemisphere; (b) – in the free troposphere (1-10 km) of the Northern Hemisphere; . (c) – in the boundary layer (< 1 km) of the Southern Hemisphere; (d) – in the free troposphere (1-10 km) of the Southern Hemisphere.

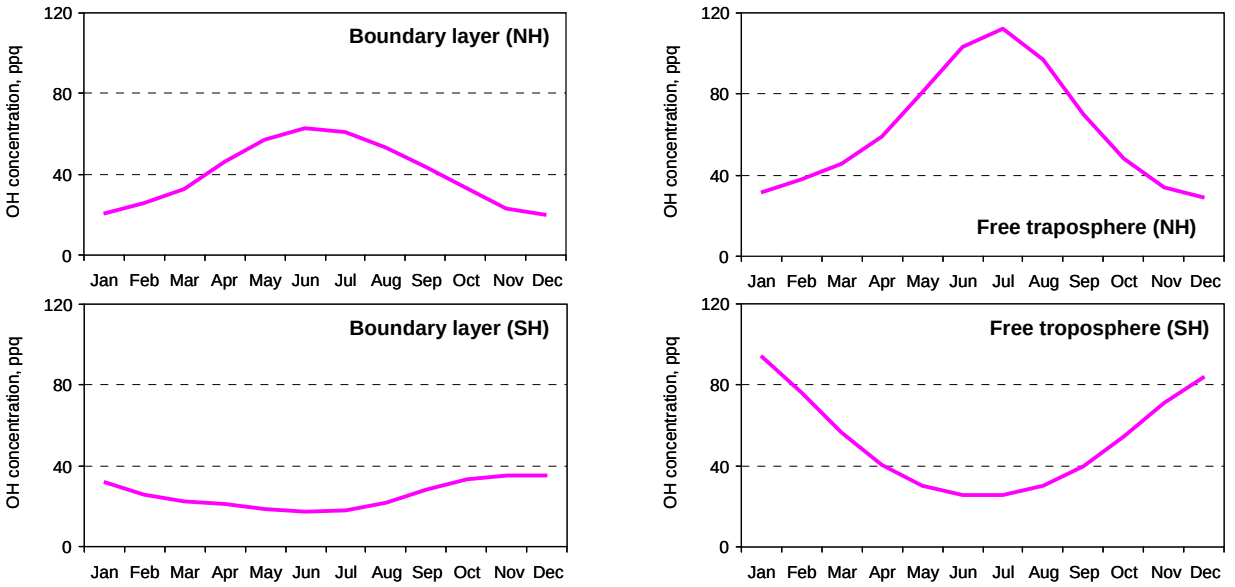

Figure S12. Seasonal variation of OH air concentration in 2013 simulated by MOZART (Emmons et al., 2010): (a) – in the boundary layer (< 1 km) of the Northern Hemisphere; (b) – in the free troposphere (1-10 km) of the Northern Hemisphere; . (c) – in the boundary layer (< 1 km) of the Southern Hemisphere; (d) – in the free troposphere (1-10 km) of the Southern Hemisphere.

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