Supplementary material

Development of CarbonTracker Europe-CH_4 – Part 2: global methane emission estimates and their evaluation for 2000-2012.

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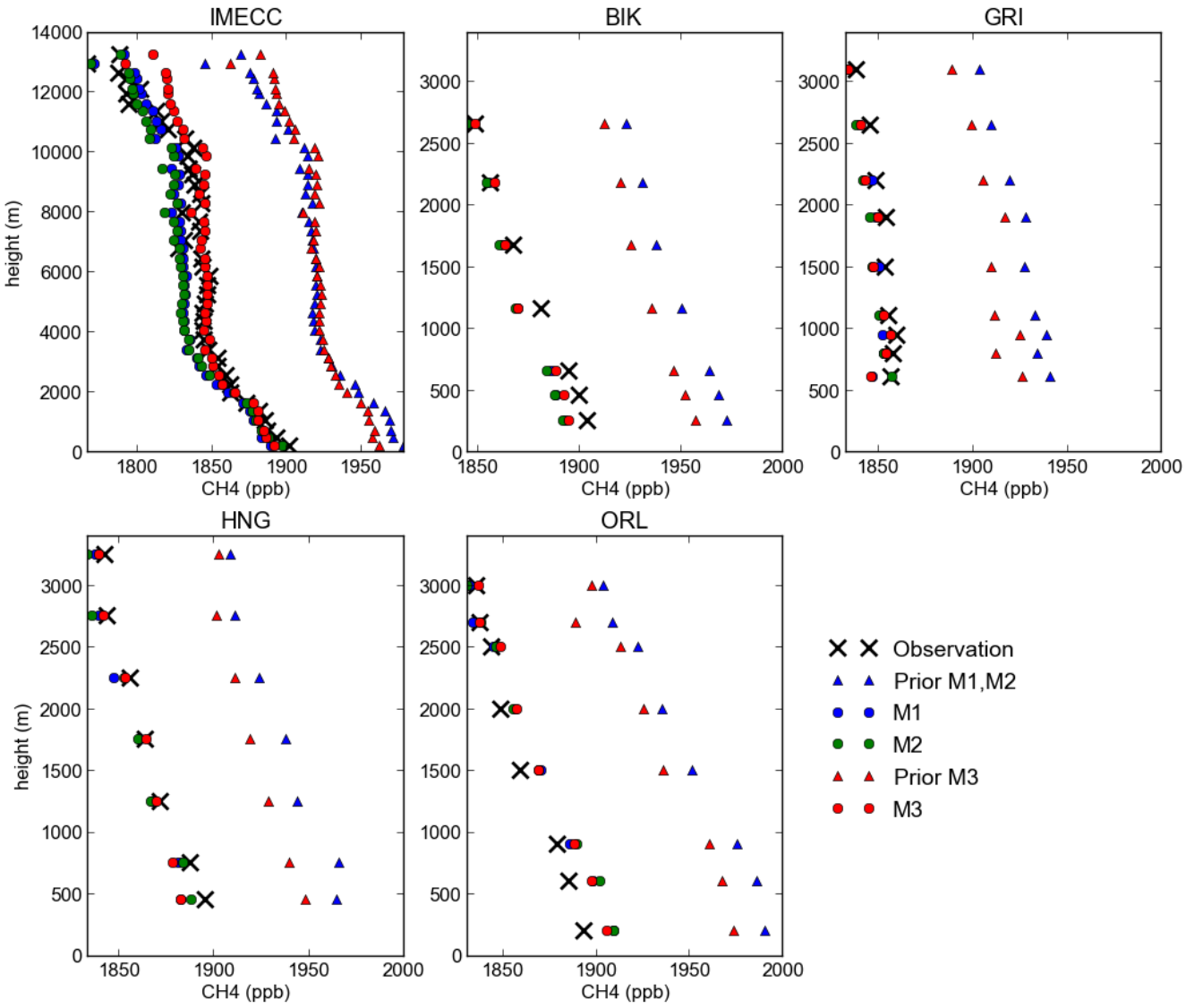

Figure S1. Average mole fractions from aircraft campaigns and the model estimates. The observations are not assimilated in the model.

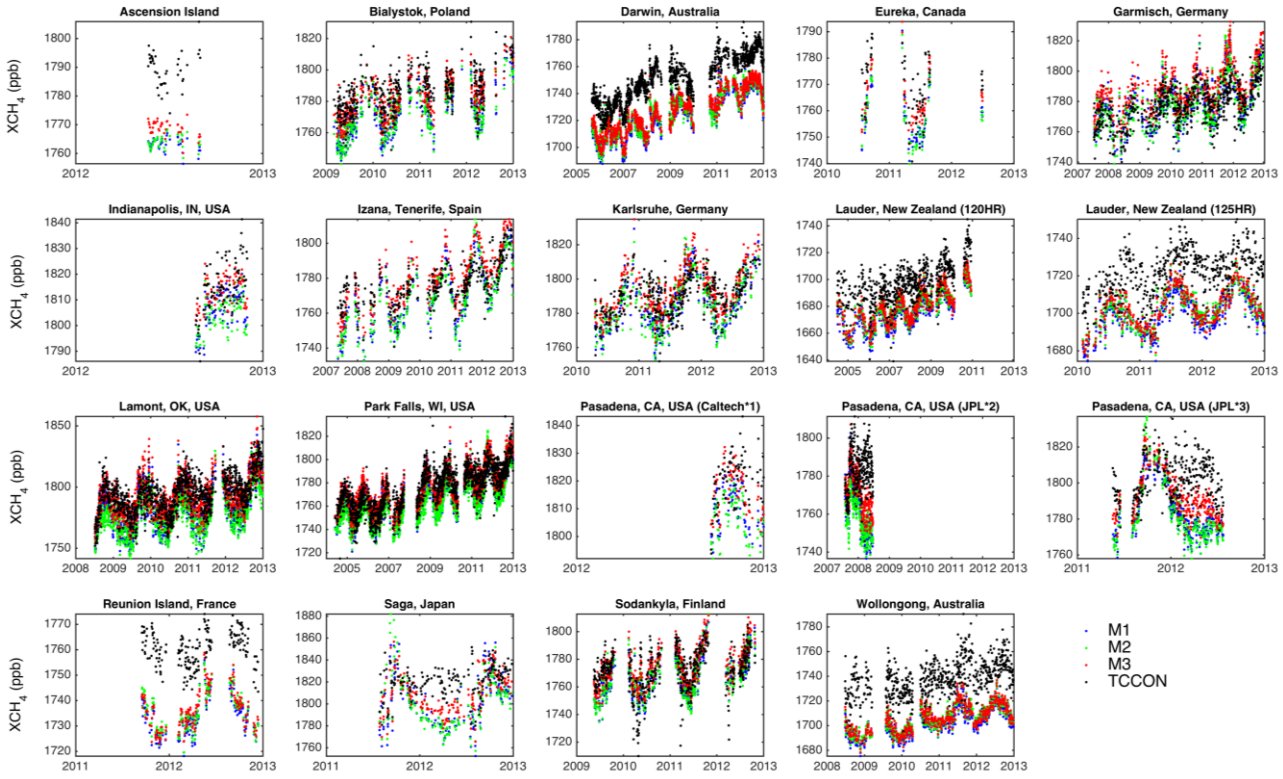

Figure S2. Observed and estimated daily mean XCH_4 at TCCON sites.

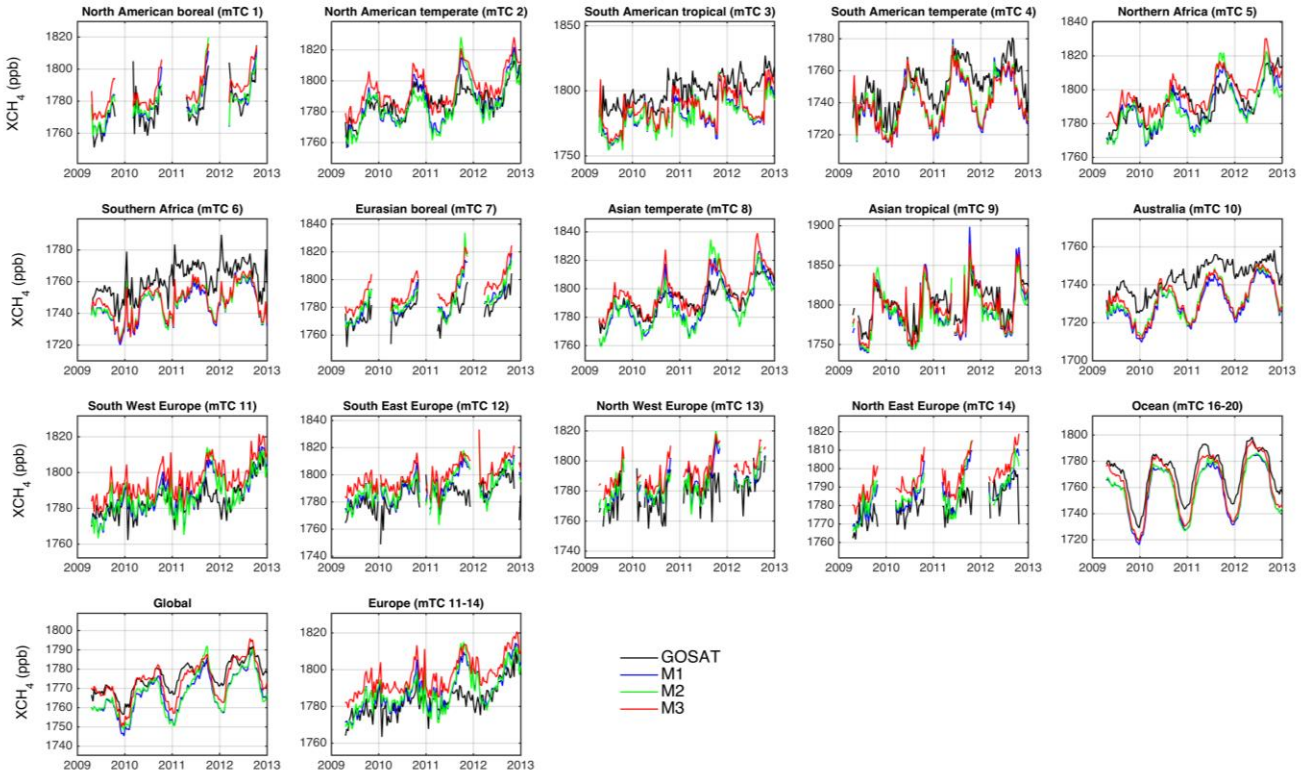

Figure S3. GOSAT retrieved and estimated regional 10-day mean XCH_4 at mTC regions.

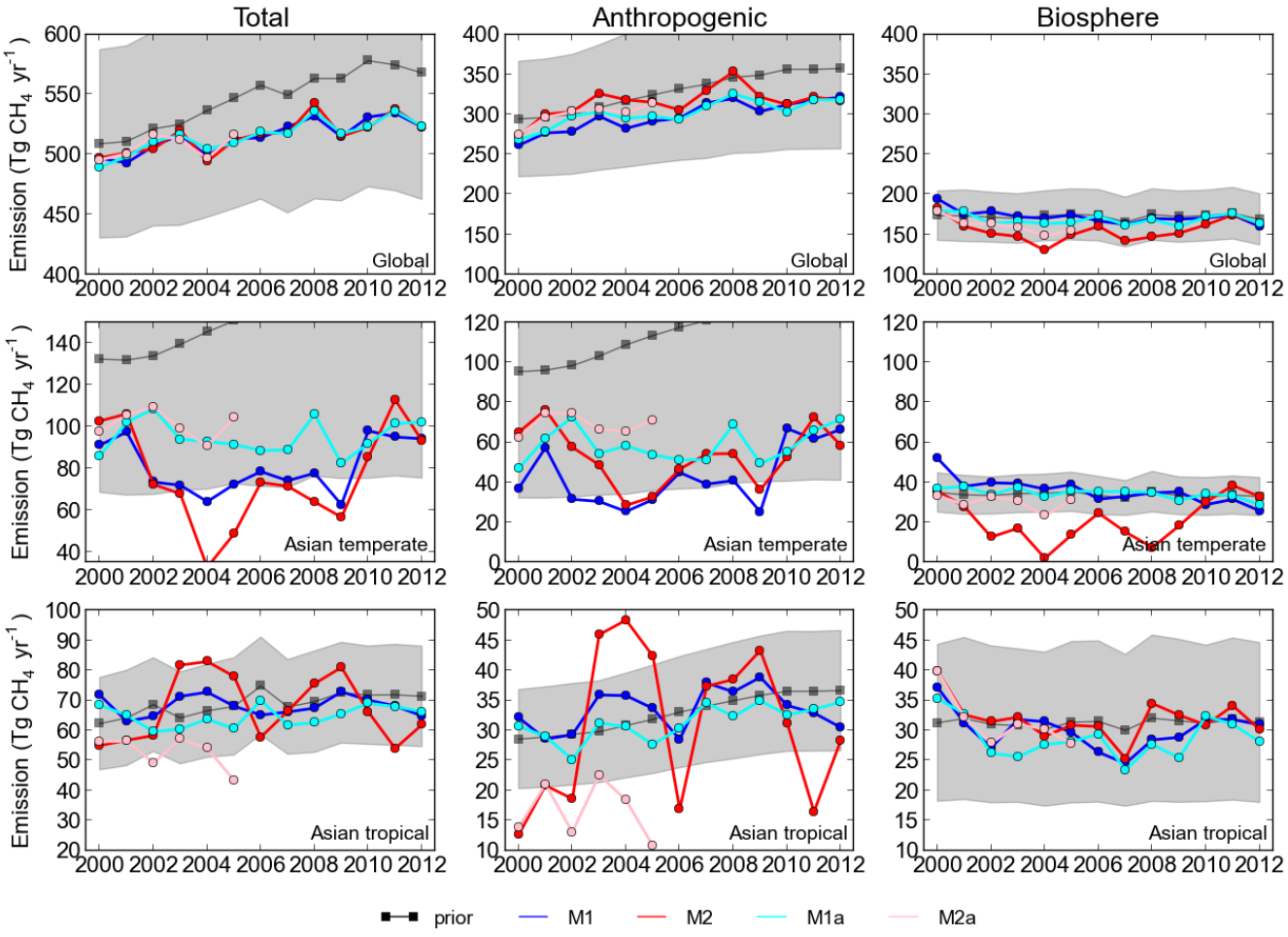

Figure S4. Annual mean total, anthropogenic and biosphere emission estimates for global, Asian temperate and Asian tropics. The grey shaded area is the uncertainty of the prior estimates. Note differences in y-axis scales.

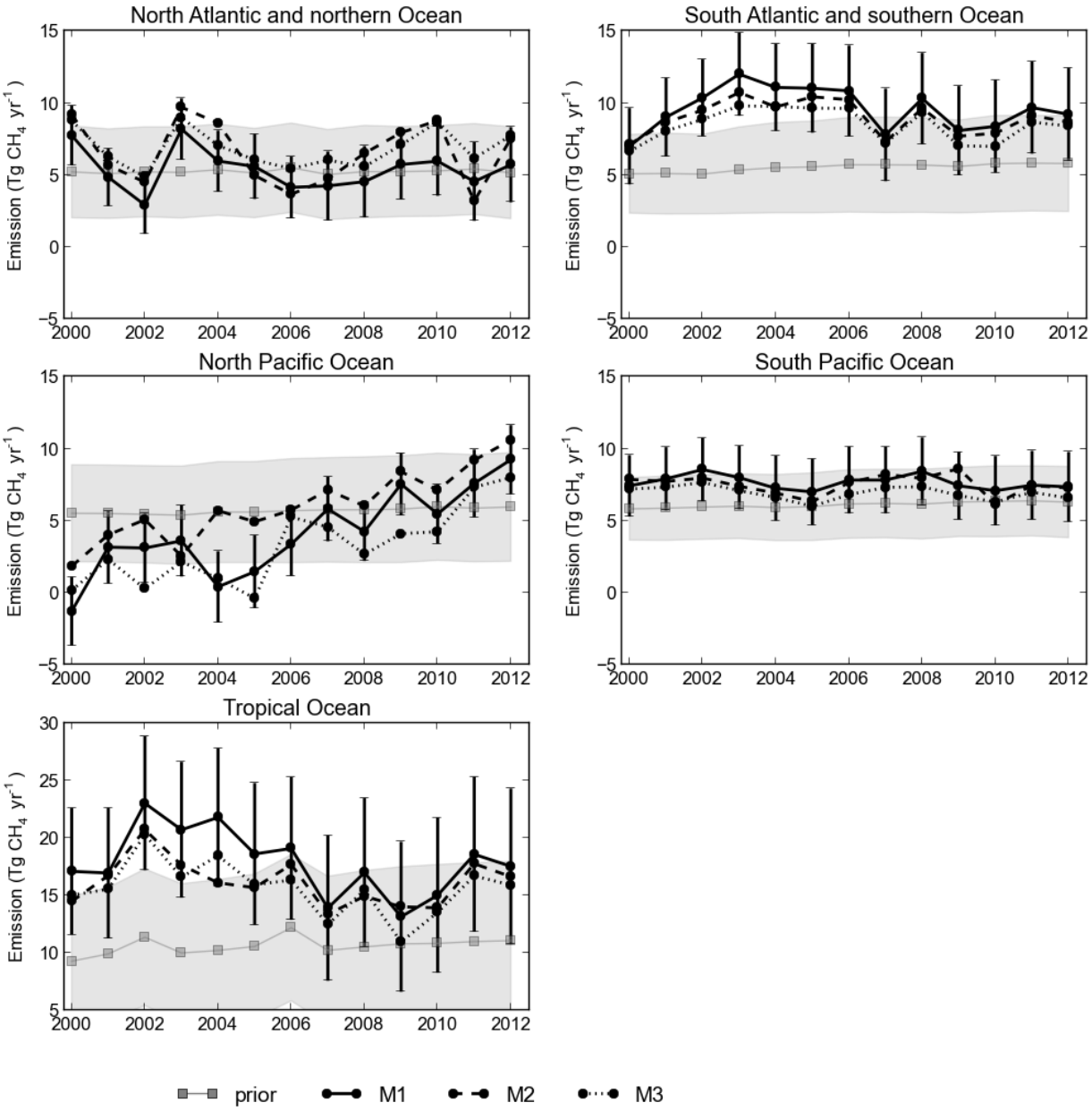

Figure S5. The regional total emission estimates for open ocean.

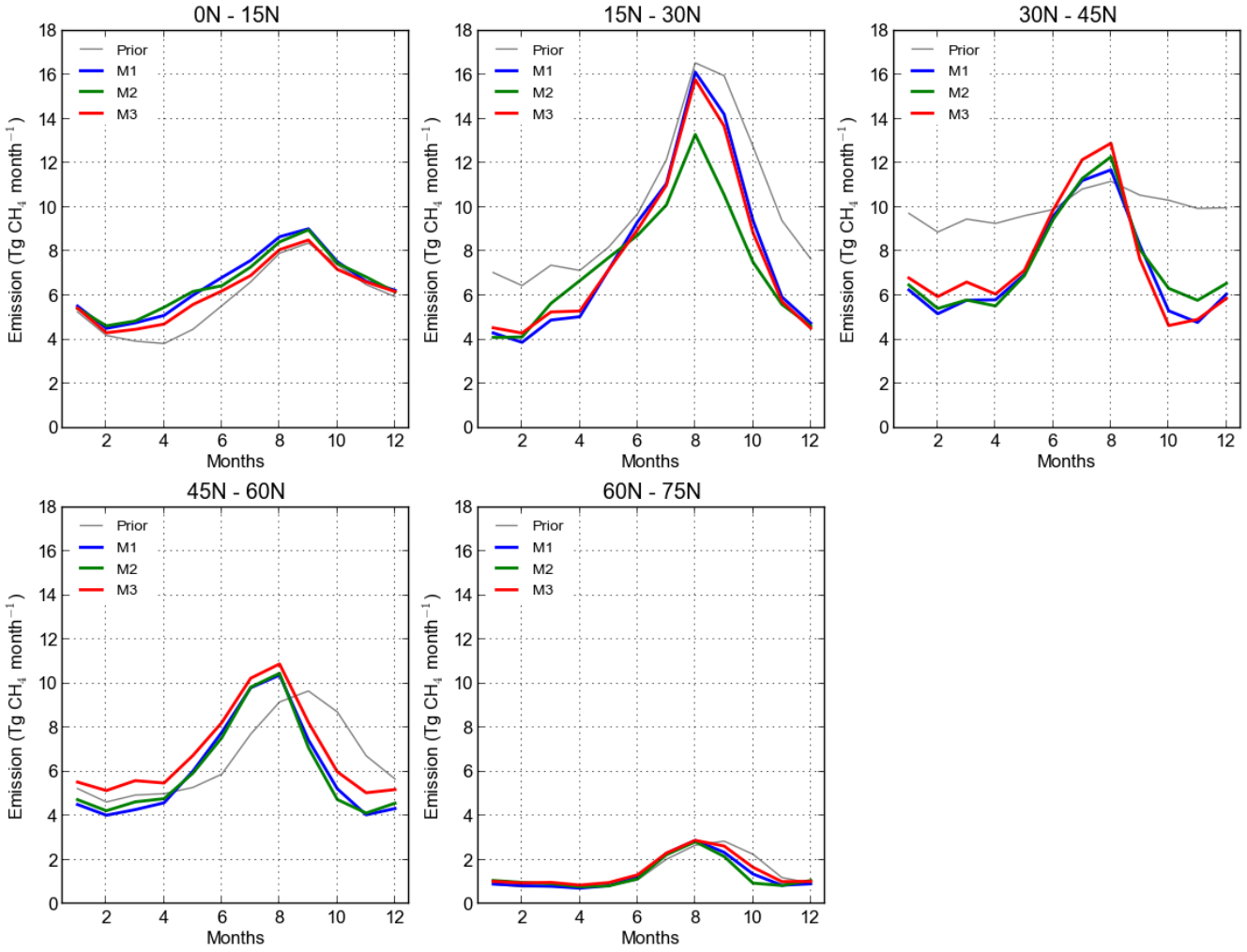

Figure S6. Monthly mean of total emission estimates at latitudinal bands, averaged over 2000-2012.

Table S1. Mean emission estimates and their uncertainties before and after 2007 (Tg CH_4 yr-1). The prior uncertainties are of M1 and M3. M2 has higher prior uncertainties in all regions due to a model feature. Region names and modified TransCom (mTC) region numbers are indicated.

	Total		Anthropogenic		Biosphere	
Region (mTC)	Before 2007	After 2007	Before 2007	After 2007	Before 2007	After 2007
Global						
Prior	532.9+/-86.7	566.0+/-102.6	313.0+/-80.7	350.5+/-97.5	172.8+/-31.6	171.8+/-31.8
M1	507.0+/-45.1	526.3+/-43.7	287.0+/-36.4	314.9+/-34.5	172.8+/-28.7	167.7+/-28.7
M2	508.2+/-62.0	526.3+/-60.9	311.4+/-50.2	326.0+/-49.7	149.7+/-45.1	156.6+/-44.1
M3	509.1+/-45.9	527.6+/-44.0	287.9+/-37.4	312.2+/-34.8	174.1+/-28.8	171.7+/-28.9
Europe (11-14)						
Prior	56.2+/-14.2	55.0+/-14.5	45.4+/-13.6	45.0+/-14.1	9.8+/-3.9	9.0+/-3.5
M1	54.2+/-10.4	51.5+/-10.5	46.8+/-10.3	43.8+/-10.5	6.4+/-2.7	6.8+/-2.5
M2	53.3+/-13.3	53.3+/-13.3	45.1+/-13.4	45.1+/-13.5	7.2+/-3.6	7.1+/-3.4
M3	59.7+/-10.6	58.5+/-10.7	50.9+/-10.6	49.1+/-10.7	7.7+/-2.7	8.4+/-2.5
North American boreal (1)						
Prior	16.4+/-8.3	16.1+/-8.4	0.5+/-0.2	0.5+/-0.2	15.1+/-8.3	14.9+/-8.4
M1	13.7+/-2.0	12.8+/-1.5	0.5+/-0.2	0.5+/-0.2	12.4+/-2.0	11.6+/-1.5
M2	14.3+/-3.5	13.9+/-2.7	0.6+/-0.5	0.8+/-0.4	12.9+/-3.5	12.5+/-2.7
M3	15.7+/-2.1	14.9+/-1.6	0.5+/-0.2	0.5+/-0.2	14.4+/-2.1	13.7+/-1.6
North American temperate (2)						
Prior	42.0+/-20.5	41.9+/-20.5	33.2+/-20.3	32.9+/-20.3	7.7+/-3.0	7.8+/-3.0
M1	49.2+/-7.7	51.9+/-6.8	41.8+/-7.7	45.1+/-7.0	6.3+/-2.7	5.7+/-2.6
M2	48.4+/-9.2	48.1+/-6.8	42.2+/-9.4	43.1+/-7.3	5.1+/-3.7	3.8+/-3.5
M3	55.6+/-8.4	59.1+/-7.5	47.4+/-8.4	51.3+/-7.7	7.2+/-2.7	6.6+/-2.7
South American tropical (3)						
Prior	52.2+/-24.2	53.6+/-24.4	10.5+/-4.3	11.4+/-4.6	35.8+/-23.8	35.9+/-23.9
M1	53.6+/-23.9	55.1+/-24.1	11.0+/-4.3	11.7+/-4.5	36.7+/-23.5	37.1+/-23.6
M2	53.1+/-28.9	54.7+/-29.2	11.1+/-10.3	12.7+/-11.2	36.0+/-26.9	35.7+/-27.0
M3	53.3+/-23.9	54.3+/-24.1	10.7+/-4.3	11.4+/-4.5	36.7+/-23.5	36.6+/-23.7
South American temperate (4)						

Prior	40.0+/-14.9	42.8+/-16.0	23.2+/-13.1	25.5+/-14.4	14.2+/-7.0	14.5+/-6.9
M1	49.4+/-14.6	63.3+/-14.9	28.0+/-12.9	39.9+/-13.5	18.8+/-6.9	20.6+/-6.7
M2	51.9+/-24.6	66.0+/-24.7	33.6+/-22.5	46.4+/-23.0	15.7+/-9.8	16.9+/-9.9
M3	46.0+/-14.6	58.8+/-15.0	26.3+/-12.9	37.9+/-13.5	17.0+/-6.9	18.2+/-6.8
Northern Africa (5)						
Prior	32.2+/-14.9	33.4+/-16.4	18.6+/-14.7	20.4+/-16.2	7.2+/-2.4	7.1+/-2.4
M1	38.5+/-13.8	39.5+/-14.0	24.9+/-13.6	26.6+/-13.8	7.2+/-2.4	7.0+/-2.4
M2	40.6+/-19.5	39.2+/-19.0	27.2+/-16.9	26.8+/-16.6	7.0+/-9.8	6.4+/-9.4
M3	37.2+/-14.0	37.3+/-14.2	23.6+/-13.7	24.4+/-14.0	7.2+/-2.4	7.0+/-2.4
Southern Africa (6)						
Prior	24.8+/-7.2	26.6+/-8.0	9.4+/-6.8	10.4+/-7.5	7.8+/-2.3	8.6+/-2.5
M1	27.9+/-6.9	28.6+/-7.6	12.4+/-6.5	12.3+/-7.2	7.9+/-2.3	8.6+/-2.5
M2	28.1+/-12.2	27.4+/-13.4	12.2+/-8.8	11.3+/-9.8	8.3+/-8.5	8.5+/-9.0
M3	27.1+/-7.0	27.7+/-7.7	11.6+/-6.6	11.6+/-7.3	7.9+/-2.3	8.5+/-2.5
Eurasian boreal (7)						
Prior	18.8+/-7.4	20.0+/-8.7	9.5+/-6.8	11.5+/-8.2	7.1+/-3.0	6.7+/-2.9
M1	19.6+/-5.4	18.9+/-6.2	10.1+/-4.6	10.6+/-5.6	7.3+/-3.0	6.5+/-2.8
M2	20.6+/-9.2	18.4+/-9.5	12.1+/-7.7	10.2+/-8.6	6.4+/-5.9	6.4+/-5.4
M3	22.0+/-5.5	21.6+/-6.2	12.5+/-4.7	13.2+/-5.6	7.3+/-3.0	6.6+/-2.8
Asian temperate (8)						
Prior	142.4+/-72.7	164.7+/-89.8	106.2+/-72.1	129.3+/-89.3	34.2+/-9.6	33.4+/-9.5
M1	76.3+/-24.2	83.7+/-20.1	36.9+/-25.0	50.1+/-20.7	37.4+/-6.5	31.5+/-6.1
M2	66.8+/-28.7	80.6+/-24.2	48.4+/-26.6	54.8+/-23.2	16.4+/-24.7	23.8+/-22.5
M3	78.2+/-25.2	81.0+/-19.9	37.8+/-26.1	44.2+/-20.6	38.5+/-6.9	34.8+/-6.4
Asian tropical (9)						
Prior	67.7+/-15.8	70.8+/-16.6	30.6+/-8.7	35.7+/-9.8	31.1+/-13.2	31.3+/-13.3
M1	67.5+/-14.3	68.3+/-14.7	32.0+/-8.4	35.1+/-9.3	29.6+/-12.1	29.4+/-12.1
M2	69.2+/-27.8	67.5+/-28.8	32.2+/-23.0	32.5+/-24.7	31.1+/-19.6	31.3+/-19.7
M3	63.2+/-14.3	65.1+/-14.8	29.8+/-8.4	32.8+/-9.4	27.4+/-12.2	28.5+/-12.2
Australia (10)						
Prior	7.1+/-4.3	7.2+/-4.6	5.7+/-4.3	6.1+/-4.6	-0.9+/-0.2	-0.9+/-0.2

M1	10.6+/-4.2	8.4+/-4.4	9.1+/-4.2	7.3+/-4.4	-0.8+/-0.2	-0.9+/-0.2
M2	16.2+/-5.4	11.5+/-5.6	14.8+/-5.1	10.4+/-5.4	-0.9+/-1.6	-0.9+/-1.5
M3	9.4+/-4.2	8.1+/-4.5	7.9+/-4.2	6.9+/-4.5	-0.8+/-0.2	-0.9+/-0.2
South West Europe (11)						
Prior	13.0+/-4.9	12.6+/-4.7	11.4+/-4.9	11.0+/-4.7	1.4+/-0.8	1.3+/-0.7
M1	14.4+/-2.3	12.8+/-2.2	13.0+/-2.4	11.4+/-2.3	1.2+/-0.6	1.1+/-0.5
M2	14.6+/-2.0	13.6+/-2.0	12.8+/-2.2	12.0+/-2.2	1.5+/-1.0	1.3+/-0.9
M3	16.5+/-2.5	13.9+/-2.4	14.7+/-2.6	12.4+/-2.5	1.6+/-0.6	1.2+/-0.6
South East Europe (12)						
Prior	8.8+/-6.1	8.7+/-6.0	8.1+/-6.1	8.1+/-6.0	0.4+/-0.1	0.3+/-0.1
M1	11.6+/-5.1	10.1+/-4.9	10.9+/-5.1	9.5+/-4.9	0.4+/-0.1	0.3+/-0.1
M2	12.6+/-6.5	10.2+/-6.0	11.9+/-6.5	9.6+/-6.0	0.4+/-0.5	0.3+/-0.4
M3	12.3+/-5.2	10.8+/-5.0	11.6+/-5.2	10.2+/-5.0	0.4+/-0.1	0.3+/-0.1
North West Europe (13)						
Prior	13.5+/-2.2	12.2+/-2.1	10.7+/-1.6	9.6+/-1.5	2.7+/-1.6	2.5+/-1.5
M1	11.7+/-1.0	11.3+/-1.1	10.7+/-0.8	9.8+/-0.9	0.9+/-0.9	1.5+/-0.8
M2	11.0+/-1.3	11.4+/-1.6	9.7+/-1.6	9.7+/-1.9	1.2+/-1.4	1.7+/-1.3
M3	13.1+/-1.0	12.7+/-1.1	11.4+/-0.8	10.4+/-1.0	1.6+/-0.9	2.2+/-0.9
North East Europe (14)						
Prior	20.8+/-10.4	21.5+/-11.0	15.2+/-9.8	16.3+/-10.6	5.3+/-3.2	4.9+/-2.9
M1	16.5+/-8.6	17.4+/-8.9	12.3+/-8.4	13.1+/-8.8	3.9+/-2.4	3.9+/-2.2
M2	15.1+/-12.0	18.0+/-12.3	10.7+/-12.0	13.8+/-12.3	4.0+/-3.2	3.8+/-2.9
M3	17.8+/-8.7	21.2+/-9.0	13.3+/-8.6	16.1+/-8.9	4.2+/-2.5	4.7+/-2.2
Ocean (16-20)						
Prior	32.9+/-8.6	33.9+/-9.2	20.1+/-8.6	21.6+/-9.2	3.7+/-0.0	3.7+/-0.0
M1	46.3+/-7.7	44.2+/-8.4	33.5+/-7.7	31.9+/-8.4	3.7+/-0.0	3.7+/-0.0
M2	45.5+/-9.2	45.7+/-9.8	32.1+/-8.6	31.9+/-9.3	4.4+/-3.5	5.3+/-3.4
M3	41.6+/-7.7	41.1+/-8.4	28.9+/-7.7	28.8+/-8.4	3.7+/-0.0	3.7+/-0.0
Ice (15)						
Prior	0.1+/-0.0	0.1+/-0.0	0.1+/-0.0	0.1+/-0.0	-0.0+/-0.0	-0.0+/-0.0
M1	0.1+/-0.0	0.1+/-0.0	0.1+/-0.0	0.1+/-0.0	-0.0+/-0.0	-0.0+/-0.0

M2	0.1+/-0.1	0.1+/-0.1	0.1+/-0.1	0.1+/-0.1	-0.0+/-0.0	-0.0+/-0.0
M3	0.1+/-0.0	0.1+/-0.0	0.1+/-0.0	0.1+/-0.0	-0.0+/-0.0	-0.0+/-0.0

Table S2. Root mean squared error (RMSE) between TCCON and posterior XCH_4 without averaging kernel applied (ppb).

*1 = California Institute of Technology, 2012

*2 = Jet Propulsion Laboratory, 2007-2008

*3 = Jet Propulsion Laboratory, 2011-2012

Inversion			M1	M2	M3
Site	Latitude (°N)	Longitude (°E)	RMSE	RMSE	RMSE
Ascension Island	-7.92	-14.33	23.03	22.44	18.21
Bialystok, Poland	53.23	23.03	10.12	10.94	14.77
Darwin, Australia	-12.42	130.89	23.49	21.89	20.95
Eureka, Canada	80.05	-86.42	8.48	8.21	10.26
Garmisch, Germany	47.48	11.06	9.62	10.61	14.13
Indianapolis, IN, USA	39.86	-86	8.00	8.67	11.89
Izana, Tenerife, Spain	28.3	-16.5	10.84	10.87	16.62
Karlsruhe, Germany	49.1	8.44	11.17	12.32	10.89
Lauder, New Zealand (120HR)	-45.04	169.68	15.11	13.04	12.21
Lauder, New Zealand (125HR)	-45.04	169.68	15.48	13.30	13.03
Lamont, OK, USA	36.6	-97.49	14.37	16.69	11.11
Park Falls, WI, USA	45.95	-90.27	11.07	11.52	14.96
Pasadena, CA, USA (Caltech*1)	34.14	-118.13	16.78	20.14	12.33
Pasadena, CA, USA (JPL*2)	34.12	-118.18	26.65	28.16	18.04
Pasadena, CA, USA (JPL*3)	34.12	-118.18	23.77	24.86	16.17
Reunion Island, France	-20.9	55.49	21.05	19.34	18.73
Saga, Japan	33.24	130.29	18.25	18.94	13.33
Sodankylä, Finland	67.37	26.63	13.59	14.20	17.92
Wollongong, Australia	-34.41	150.88	26.84	24.36	24.46

Table S3. Root mean squared error (RMSE) between GOSAT and model XCH_4 without averaging kernel applied (ppb).

Region (mTC) \Inversion	M1	M2	M3
Global (1-20)	12.5	12.5	7.2
EU (11-14)	11.5	12.0	15.9
North American boreal (1)	11.2	11.7	15.1
North American temperate (2)	10.4	11.7	11.0
South American tropical (3)	26.9	26.6	23.5
South American temperate (4)	19.5	17.9	18.2
Northern Africa (5)	9.4	11.2	7.8
Southern Africa (6)	21.7	20.8	19.6
Eurasian boreal (7)	11.8	12.6	16.8
Asian temperate (8)	12.3	13.7	9.4
Asian tropical (9)	24.8	25.6	19.0
Australia (10)	18.8	17.0	16.6
South West Europe (11)	12.7	13.1	15.3
South East Europe (12)	13.7	14.5	18.0
North West Europe (13)	15.4	16.4	19.6
North East Europe (14)	12.7	13.5	17.5
Ocean (16-20)	17.0	16.2	12.3