Supporting Information

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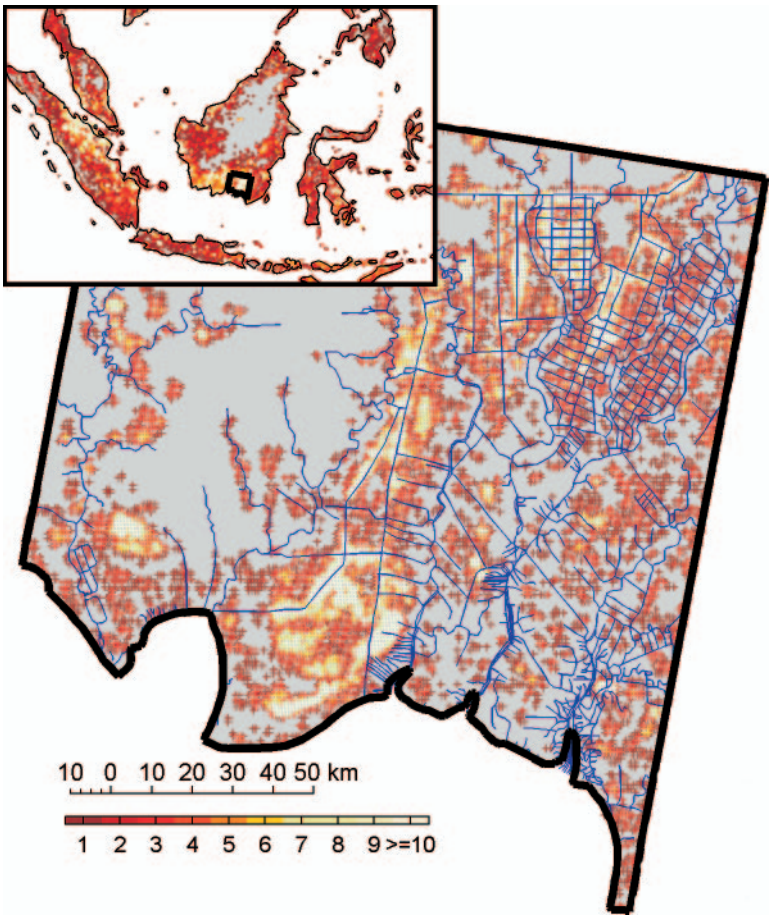

Fig. S1. Fire locations (number of detected fires during 2000–2006) superimposed on a drainage map (blue). Note how most fires occur along drainage canal banks or are concentrated in new deforestation zones (for example, the southern peninsula). The inset shows the location of the study region within Borneo, corresponding to Landsat scene path 118 row 062. Canals and rivers were digitized by hand to derive mean distance to these waterways for each year on the basis of Terra-MODIS active fires (Table 1).

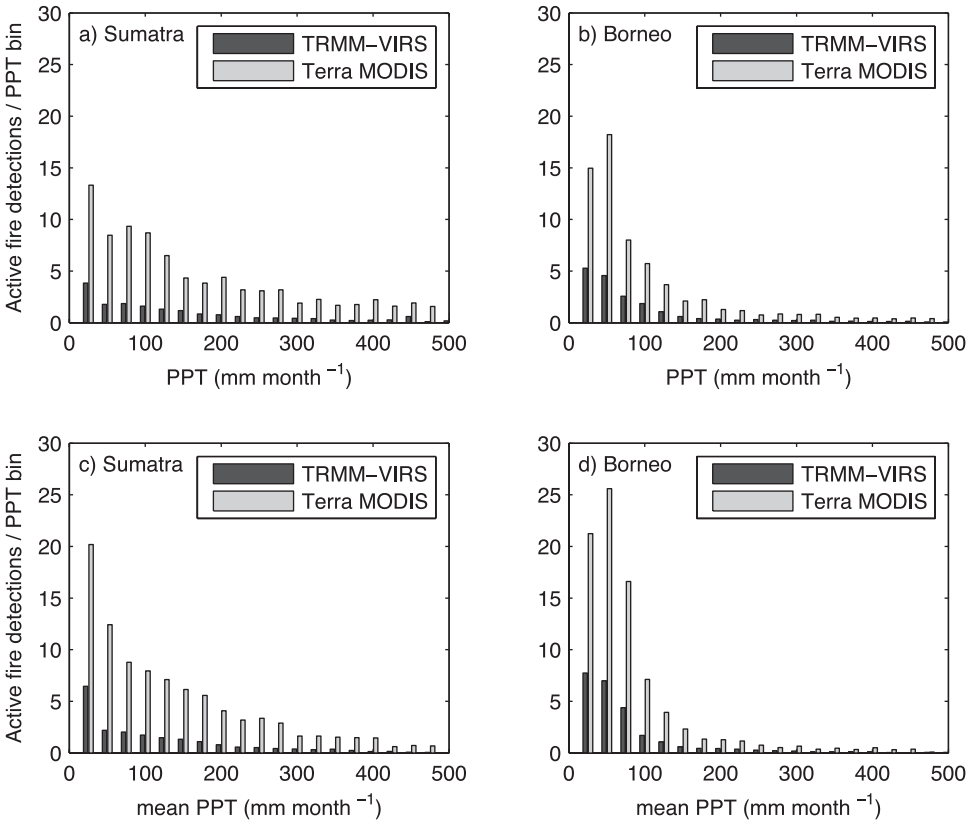

Fig. S2. Average number of TRMM-VIRS (37) (1998–2006) and Terra-MODIS (20) (2000–2006) active fire detections per 25-mm precipitation (PPT) bins for corresponding months (*a* and *b*) or average precipitation over the month when active fires were detected and the previous month (*c* and *d*) for Borneo (*a* and *c*) and Sumatra (*b* and *d*). Precipitation rates were derived from TRMM (14).

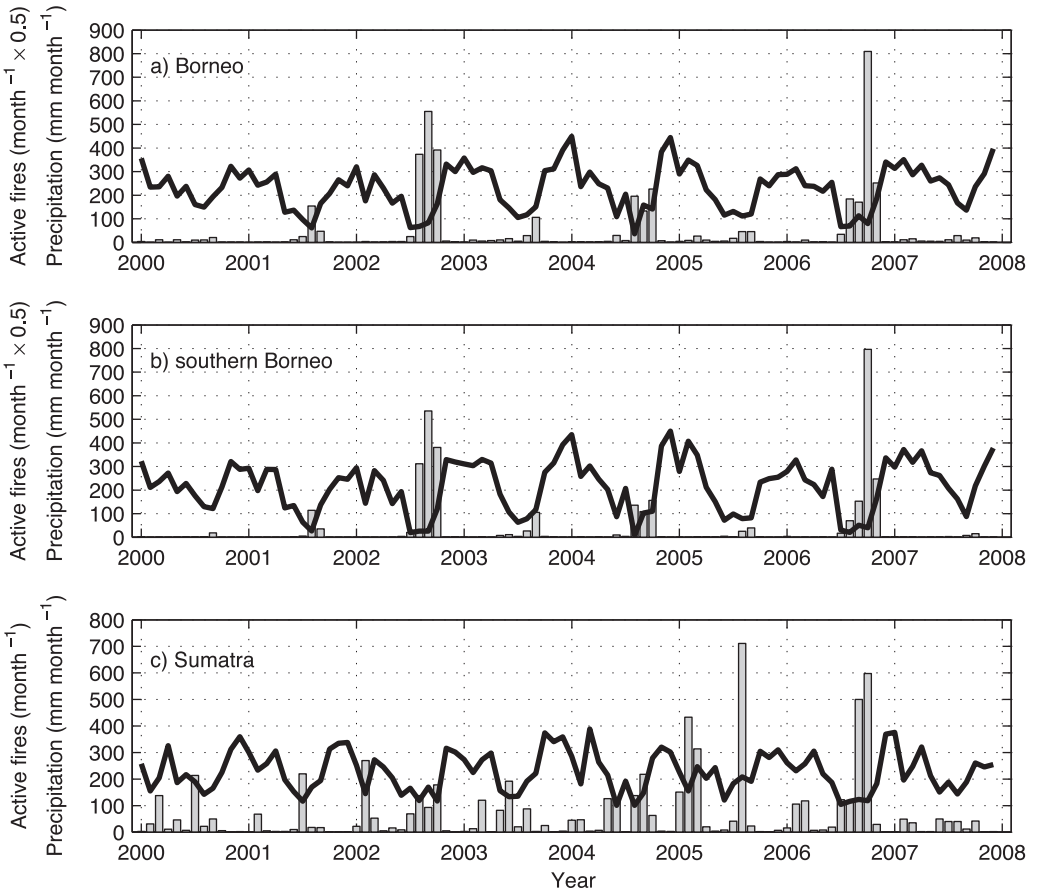

Fig. S3. TRMM precipitation (solid line) and (A)ATSR active fire detections (bars) for (*a*) all of Borneo, (*b*) Borneo south of 1°S, and (*c*) all of Sumatra. Due to La Niña conditions in 2007, average precipitation rates during the fire season did not drop below 100 mm month^{-1} and the number of active fire detections was limited compared to other years.

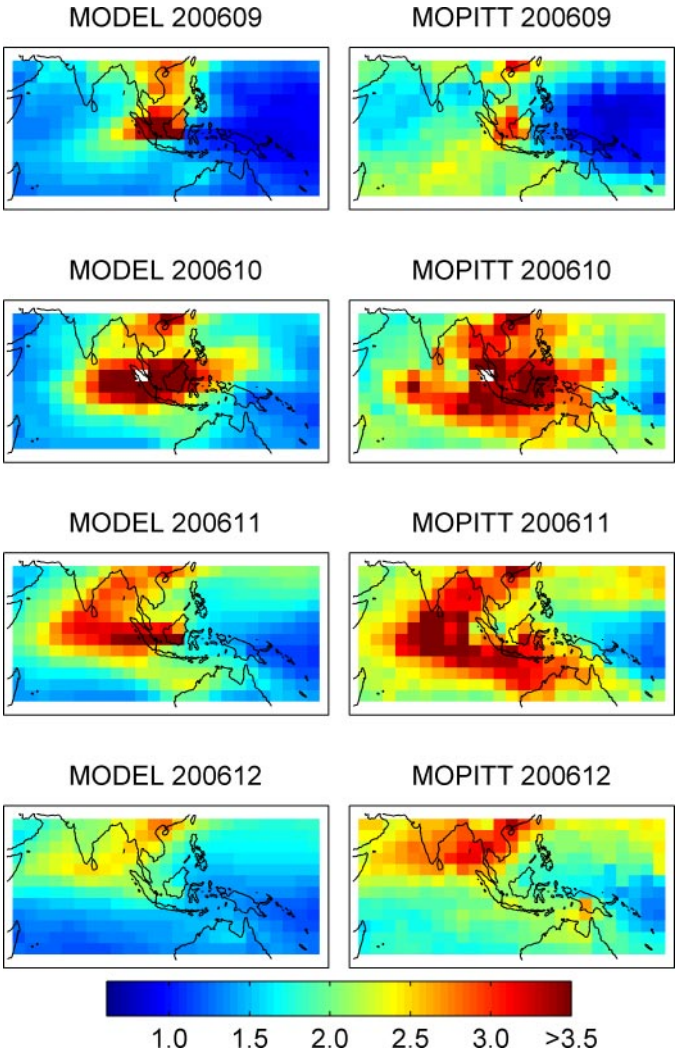

Fig. S4. Evolution of modeled and MOPITT measured CO mixing ratios ($\times 10^{18}$ molecules cm^{-2}) emissions during September–December 2006, the time period of extensive burning in Borneo. Modeled CO mixing ratios were based on all bottom-up modeled sources, including fossil fuel emissions, oxidation of CH_4 and VOCs, contributions from fires outside the study region, and the local fires that elevated CO mixing ratios during the time period shown.

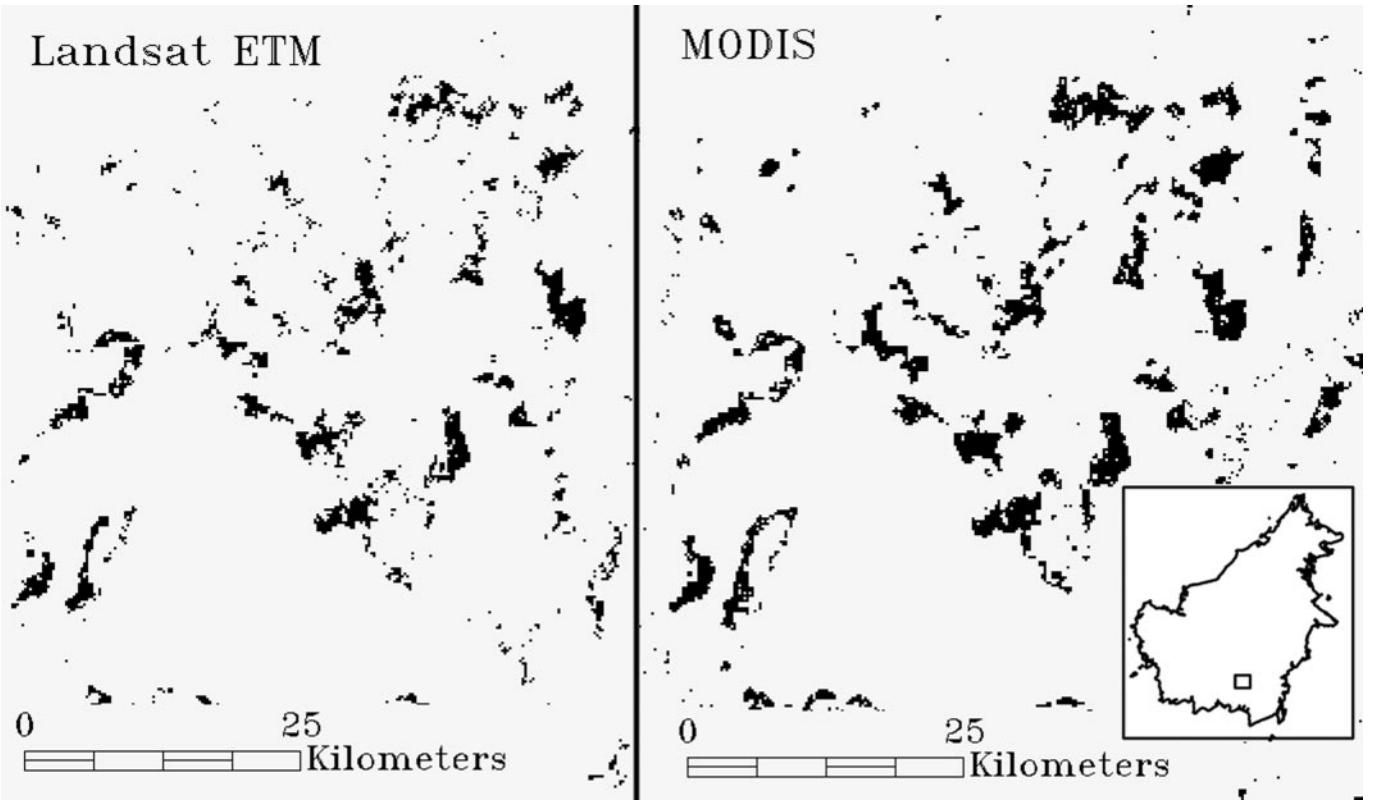

Fig. S5. Spatial patterns of deforested areas detected using Landsat ETM data (left) and MODIS data (right) for corresponding time periods in 2002. The omission error was 21.0% and the commission error was 23.1%.

Table S1. Borneo bottom-up CO emissions, number of active fires detections, emission factors, bottom-up C emissions, and optimized C emissions

	Year										Average	
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2000–2006	1997–2006
GFED CO emissions (Tg CO year^{-1})	128	65	5	3	9	38	9	20	10	71	23	36
Terra-MODIS fire detections				3,301	9,337	30,080	8,389	19,205	8,564	34,608	16,212	
Fraction peat emissions* (−)				0.39	0.53	0.40	0.46	0.39	0.44	0.35	0.42	
Fraction forest emissions* (−)				0.17	0.18	0.34	0.22	0.25	0.20	0.46	0.26	
Fraction other emissions* (−)				0.44	0.29	0.26	0.32	0.37	0.36	0.19	0.32	
CO emission factor (g CO kg^{-1} DM^{-1})*†				128 ± 28	149 ± 31	137 ± 28	140 ± 29	131 ± 28	137 ± 29	133 ± 27	136 ± 28	
Fraction peat emissions‡ (−)				0.68	0.78	0.65	0.72	0.66	0.71	0.58	0.68	
Fraction forest emissions‡ (−)				0.13	0.12	0.24	0.15	0.19	0.14	0.34	0.19	
Fraction other emissions‡ (−)				0.19	0.11	0.11	0.13	0.16	0.14	0.08	0.13	
CO emission factor (g CO kg^{-1} DM^{-1})†‡				168 ± 34	182 ± 36	169 ± 33	176 ± 34	168 ± 33	174 ± 34	163 ± 32	171 ± 34	
Combined EF (g CO kg^{-1} DM^{-1})§				148 ± 44	166 ± 47	153 ± 43	158 ± 45	149 ± 43	155 ± 45	148 ± 42	154 ± 44	
Carbon emissions (Tg C year^{-1})¶‖	408 ± 117	206 ± 59	15 ± 4	8 ± 2	27 ± 8	123 ± 35	28 ± 8	66 ± 19	32 ± 9	234 ± 66	74 ± 21	115 ± 33
Anomaly optimized + mean (Tg C year^{-1})¶	413 ± 187	208 ± 95	15 ± 7	7 ± 3	27 ± 12	123 ± 56	27 ± 12	66 ± 30	31 ± 14	236 ± 106	74 ± 33	115 ± 52
Absolute optimization (Tg C year^{-1})¶	448 ± 180	226 ± 91	17 ± 7	9 ± 4	30 ± 12	135 ± 54	30 ± 12	72 ± 29	35 ± 14	257 ± 102	81 ± 32	126 ± 51

*Assuming each active fire detected represented an equal amount of carbon emissions.
†Based on emission factors of 210 ± 40, 104 ± 20, and 65 ± 20 for peat fires, deforestation fires, and other fires, respectively (19, 31).
‡Assuming each active fire detected burned the same area.
§Based on the mean of the two scenarios, with the standard deviations in quadrature.
¶Scalars for 1997–1999 taken from the average of 2000–2006.
‖Based on a carbon content of dry matter of 49% (31).

Table S2. Sumatra bottom-up CO emissions, number of active fire detections, emission factors, bottom-up C emissions, and optimized C emissions

	Year										Average	
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2000–2006	1997–2006
GFED CO emissions (Tg CO year^{-1})	58	5	9	8	1	15	10	16	44	25	17	19
Terra-MODIS fire detections				11,863	6,189	16,174	10,443	14,962	25,543	27,318	16,070	
Fraction peat emissions* (−)				0.42	0.45	0.59	0.56	0.61	0.7	0.54	0.55	
Fraction forest emissions* (−)				0.11	0.14	0.13	0.12	0.13	0.08	0.27	0.14	
Fraction other emissions* (−)				0.47	0.41	0.28	0.32	0.26	0.21	0.19	0.31	
CO Emission factor (g CO kg^{-1} DM^{-1})†*				130 ± 28	136 ± 29	156 ± 32	150 ± 31	158 ± 32	170 ± 34	154 ± 31	151 ± 31	
Fraction peat emissions‡ (−)				0.71	0.73	0.82	0.81	0.83	0.89	0.76	0.79	
Fraction forest emissions‡ (−)				0.08	0.1	0.08	0.08	0.08	0.04	0.17	0.09	
Fraction other emissions‡ (−)				0.20	0.17	0.10	0.12	0.09	0.07	0.07	0.12	
CO Emission factor (g CO kg^{-1} DM^{-1})†‡				172 ± 34	175 ± 35	188 ± 36	185 ± 36	189 ± 37	195 ± 38	182 ± 35	184 ± 36	
Combined EF (g CO kg^{-1} DM^{-1})§				151 ± 45	155 ± 45	172 ± 48	168 ± 48	173 ± 49	183 ± 51	168 ± 47	167 ± 47	
Carbon emissions (Tg C year^{-1})¶‖	170 ± 48	16 ± 4	27 ± 8	26 ± 8	4 ± 1	44 ± 12	29 ± 8	47 ± 13	118 ± 33	74 ± 21	49 ± 14	55 ± 16
Anomaly optimized + mean (Tg C year^{-1})¶	118 ± 95	30 ± 24	36 ± 29	35 ± 29	23 ± 19	46 ± 37	38 ± 30	47 ± 38	88 ± 71	63 ± 50	49 ± 39	53 ± 42
Absolute optimization (Tg C year^{-1})¶	40 ± 58	4 ± 5	6 ± 9	6 ± 9	1 ± 1	10 ± 15	7 ± 10	11 ± 16	28 ± 40	17 ± 25	12 ± 17	13 ± 19

*Assuming each active fire detected represented an equal amount of carbon emissions.
†Based on emission factors of 210 ± 40, 104 ± 20, and 65 ± 20 for peat fires, deforestation fires, and other fires, respectively(19, 31).
‡Assuming each active fire detected burned the same area.
§Based on the mean of the two scenarios, with the standard deviations in quadrature.
¶Scalars for 1997–1999 taken from the average of 2000–2006.
‖Based on a carbon content of dry matter of 49% (31).

Table S3. Regression statistics and scalars for the two optimizations for different spatial domains

Region*			Spatial correlation†			Temporal correlation‡			Multiple linear regression scalars				
									Anomaly optimization§		Absolute values optimization¶		
Index	Latitude	Longitude	R^2	Slope	Intercept	R^2	Slope	Intercept	Sumatra	Borneo	ROTW¶	Sumatra	Borneo
1	4N–4S	82.5E–122.5E	0.62	0.91	0.10	0.88	0.98	0.04	0.45 ± 0.18	0.65 ± 0.11	1.10 ± 0.02	0.25 ± 0.16	0.74 ± 0.09
2	4N–4S	77.5E–127.5E	0.65	0.90	0.14	0.89	0.98	0.05	0.47 ± 0.20	0.72 ± 0.12	1.10 ± 0.02	0.25 ± 0.17	0.81 ± 0.10
3	8N–8S	77.5E–127.5E	0.72	0.93	0.08	0.90	1.00	0.00	0.52 ± 0.24	0.87 ± 0.15	1.10 ± 0.02	0.24 ± 0.21	0.95 ± 0.12
4	8N–8S	72.5E–132.5E	0.72	0.93	0.09	0.90	1.00	0.00	0.52 ± 0.26	0.92 ± 0.16	1.10 ± 0.02	0.24 ± 0.23	1.00 ± 0.13
5	12N–12S	67.5E–137.5E	0.72	0.92	0.12	0.89	1.01	−0.02	0.59 ± 0.33	1.06 ± 0.20	1.10 ± 0.02	0.24 ± 0.29	1.13 ± 0.16
6	12N–12S	62.5E–142.5E	0.73	0.92	0.12	0.89	1.01	−0.01	0.61 ± 0.35	1.09 ± 0.21	1.10 ± 0.02	0.24 ± 0.31	1.18 ± 0.17
7	12N–12S	57.5E–147.5E	0.73	0.93	0.11	0.88	1.00	0.00	0.62 ± 0.38	1.12 ± 0.23	1.10 ± 0.02	0.23 ± 0.33	1.22 ± 0.18
8	16N–16S	57.5E–147.5E	0.73	0.91	0.15	0.87	0.99	0.01	0.68 ± 0.43	1.17 ± 0.26	1.10 ± 0.02	0.22 ± 0.38	1.28 ± 0.20
9	16N–16S	52.5E–152.5E	0.71	0.90	0.16	0.86	0.99	0.02	0.69 ± 0.46	1.19 ± 0.28	1.10 ± 0.02	0.21 ± 0.39	1.32 ± 0.21
10	16N–16S	47.5E–157.5E	0.71	0.91	0.15	0.85	0.98	0.03	0.70 ± 0.49	1.19 ± 0.29	1.11 ± 0.02	0.19 ± 0.43	1.35 ± 0.23
11	20N–20S	47.5E–157.5E	0.71	0.86	0.24	0.83	0.97	0.06	0.77 ± 0.56	1.22 ± 0.32	1.11 ± 0.02	0.20 ± 0.48	1.40 ± 0.25
12	20N–20S	42.5E–162.5E	0.70	0.86	0.24	0.82	0.96	0.07	0.78 ± 0.58	1.22 ± 0.34	1.12 ± 0.02	0.19 ± 0.49	1.44 ± 0.26
13	24N–24S	37.5E–167.5E	0.71	0.86	0.24	0.79	0.94	0.11	0.85 ± 0.68	1.22 ± 0.39	1.12 ± 0.02	0.22 ± 0.59	1.51 ± 0.30
3–7‖									0.57 ± 0.43	1.01 ± 0.36	1.10 ± 0.02	0.24 ± 0.34	1.10 ± 0.31

*Different box sizes used.

†Regression values based on the mean monthly values.

‡Regression values based on all grid cell values for months where the combined fire CO emissions from Sumatra and Borneo exceeded 0.1×10^{18} molecules cm^{-2}.

§Optimization where fire emissions anomalies from Sumatra and Borneo were optimized to match MOPITT anomalies.

¶Optimization on absolute values, where Sumatra, Borneo, and the rest of the world (ROTW, which includes biomass burning emissions from outside equatorial Asia, fossil fuel and biofuel emissions, and methane and biogenic VOC oxidation) were adjusted to reach an optimum fit with MOPITT data.

‖Regions 3–7 yielded the highest correlation when taking both the spatial and the temporal correlation into account. The average scalar of these boxes was used to estimate emissions, and a subjective estimate of the standard deviations was taken as the maximum standard deviation for regions 3–7 added onto half the range of the scalars for regions 3–7 so that regions with scalars that departed from the mean fell within the standard deviation.

Table S4. Summary of annual emission estimates (Tg C year^{-1}) for Sumatra, Borneo, other regions, and all regions combined for three different approaches

		Year										Average	
Approach	Region	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2000–2006	1997–2006
Bottom-up model	Borneo	408 ± 117	206 ± 59	15 ± 4	8 ± 2	27 ± 8	123 ± 35	28 ± 8	66 ± 19	32 ± 9	234 ± 66	74 ± 21	115 ± 33
	Sumatra	170 ± 48	16 ± 4	27 ± 8	26 ± 8	4 ± 1	44 ± 12	29 ± 8	47 ± 13	118 ± 33	74 ± 21	49 ± 14	55 ± 16
	Other	193 ± 55	6 ± 2	3 ± 1	4 ± 1	3 ± 1	15 ± 4	2 ± 1	7 ± 2	3 ± 1	3 ± 1	5 ± 2	24 ± 7
	Whole region*	771 ± 138	228 ± 59	46 ± 9	37 ± 8	34 ± 8	182 ± 37	59 ± 12	120 ± 23	153 ± 34	311 ± 69	128 ± 25	194 ± 37
Anomaly optimization + mean†	Borneo	413 ± 187	208 ± 95	15 ± 7	7 ± 3	27 ± 12	123 ± 56	27 ± 12	66 ± 30	31 ± 14	236 ± 106	74 ± 33	115 ± 52
	Sumatra	118 ± 95	30 ± 24	36 ± 29	35 ± 29	23 ± 19	46 ± 37	38 ± 30	47 ± 38	88 ± 71	63 ± 50	49 ± 39	53 ± 42
	Other	195 ± 89	6 ± 3	3 ± 1	4 ± 2	3 ± 1	15 ± 7	2 ± 1	7 ± 3	3 ± 2	3 ± 1	5 ± 2	24 ± 11
	Whole region*	726 ± 228	244 ± 98	54 ± 30	47 ± 29	53 ± 22	185 ± 67	67 ± 33	120 ± 49	123 ± 72	303 ± 118	128 ± 51	192 ± 68
Absolute optimization	Borneo	448 ± 180	226 ± 91	17 ± 7	9 ± 4	30 ± 12	135 ± 54	30 ± 12	72 ± 29	35 ± 14	257 ± 102	81 ± 32	126 ± 51
	Sumatra	40 ± 58	4 ± 5	6 ± 9	6 ± 9	1 ± 1	10 ± 15	7 ± 10	11 ± 16	28 ± 40	17 ± 25	12 ± 17	13 ± 19
	Other	211 ± 85	6 ± 3	3 ± 1	4 ± 2	3 ± 1	16 ± 7	2 ± 1	8 ± 3	4 ± 2	4 ± 1	6 ± 2	26 ± 11
	Whole region*	699 ± 207	236 ± 91	27 ± 12	19 ± 10	34 ± 12	162 ± 56	40 ± 16	91 ± 33	66 ± 43	278 ± 105	99 ± 37	165 ± 55

*Standard deviations calculated in quadrature.
†Mean from bottom-up model.