Supplementary material for "Improved satellite retrievals of NO_2 and SO_2 over the Canadian oil sands and comparisons with surface measurements" by McLinden et al.

1. Wood Buffalo Environmental Association

The Wood Buffalo Environmental Association (WBEA; www.wbea.org) operates 15 continuous air monitoring stations in and around the oil sands region (Percy et al., 2012). Some of these stations are equipped with in-situ NO_2 and PM2.5 (particulate matter with a diameter of 2.5 μm or smaller) detectors (Hsu et al., 2010; Kindzierski, 2010). A summary of the stations used in this study is given in Table S1.

The WBEA data protocols, standard operating procedures, and quality control/quality assurance procedures are all compliant with the regulations for routine monitoring. This includes daily zero/span calibration and monitoring of instrument performance, monthly multi-point calibrations, annual independent third-party audits, and independent system evaluations conducted every three years (Phillips, 2010).

2. Estimating the effect of smoothing

Figure S1 shows idealized distributions of surface concentration of NO_2 and SO_2, and an estimate of how the OMI satellite would see the distribution by accounting for its spatial resolution. These were constructed using two-dimension Gaussian functions. The parameters chosen via trial and error such that (i) their vmrs were comparable to the average measured values at the ground-based (GB) stations and (ii) after smoothing the distributions generally resembled those from Figure 8 (although not necessarily the absolute values). For NO_2, the sum of three Gaussians was used: one each for the north and south grouping of mines, and a smaller one for the Fort McMurray area. For SO_2 only one Gaussian was used, reflecting the lack of a significant source of SO_2 in the north or Fort McMurray. GB measurements from Fort Chipewyan (station 12) were used to define background values. The NO_2 and SO_2 idealized distributions are shown in Figure S1a and S1c, and after smoothing in Figure S1b and S1d.

References

Hsu, Y.-M., K. Percy, and M. Hansen, Comparison of Passive and Continuous Measurements of O_3, SO_2 and NO_2 in the Athabasca Oil Sands Region, Proc. 2010 A&WMA Conf., 2010-A-834-AWMA, pp. 5.

Kindzierski, W. B. (2010), Ten-years trends in regional air quality for criteria pollutants in the Athabasca oil sands region, Proc. 2010 A&WMA Conf., 2010-A-1079-AWMA, pp 14.

Percy, K. E., Hansen, M. C., and Dann, T.: Air Quality in the Athabasca Oil Sands Region, in Volume 11: Alberta Oil Sands, Energy, Industry and the Environment, edited by K. Percy, Elsevier, 2012

Phillips, D. (2010), The WBEA air quality monitoring network: history of operation and current status, Proc. 2010 A&WMA Conf., 2010-A-914-AWMA, pp. 8.

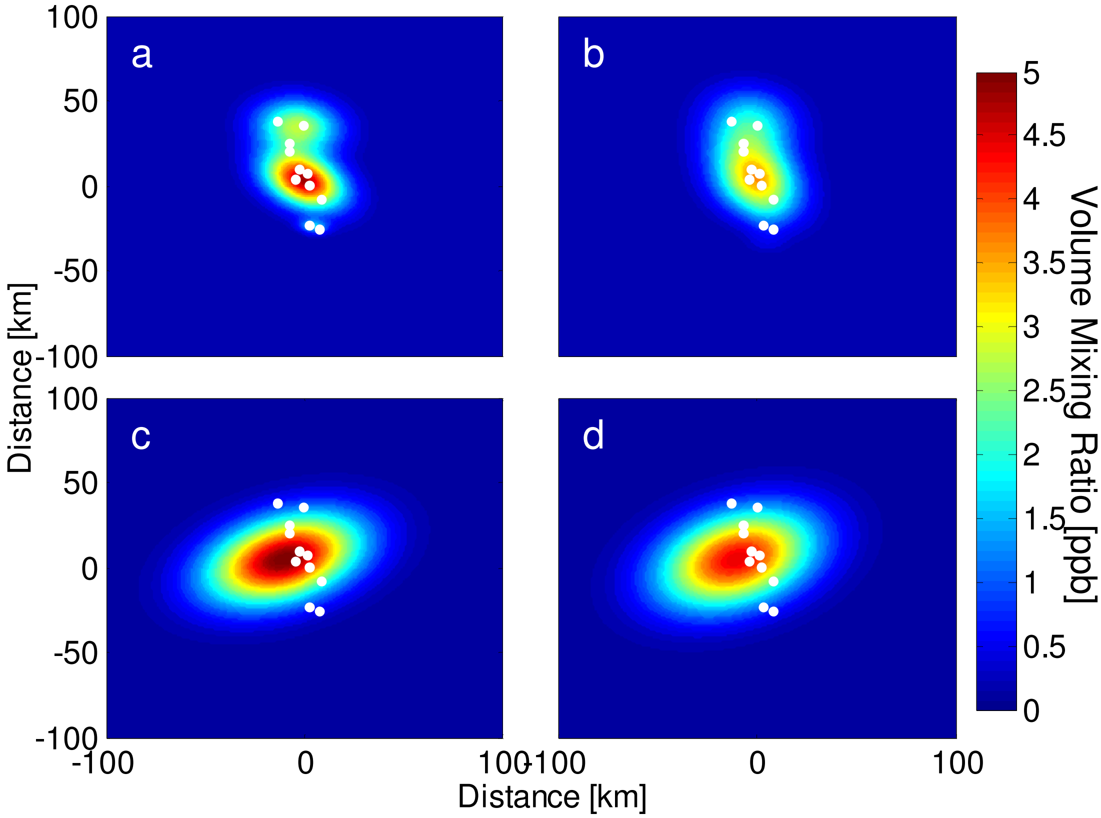

Figure S1. Idealized volume mixing ratio distributions over the oil sands surface mining area: (a) NO_2, (b) NO_2 after smoothing with a 2D boxcar comparable to the OMI horizontal resolution, (c) SO_2, (d) SO_2 after smoothing with a 2D boxcar comparable to the OMI horizontal resolution. The white dots denote the location of the WBEA surface stations.

Table S1: List of WBEA monitoring stations used in this study and associated information.

No.	Station	Lat	Long	Instrument (X = not measured)		Interference correction[a]	OMI smoothing effect correction[b]		Clear-sky bias correction[c]	
				NO_2	SO_2	NO_2	NO_2	SO_2	NO_2	SO_2
1	Fort McMurray-Athabasca Valley	56.73	-111.39	Thermo 42CTL	Thermo 43	0.41±0.06	1.59	0.69	1.56	0.94
2	Fort McMurray-Patricia McInnes	56.75	-111.48	Thermo 17C	Thermo 43	0.50±0.04	1.55	0.76	1.56	0.94
3	Millennium	56.89	-111.38	Teledyne API, 200A	Thermo 43	0.64±0.07	1.16	1.02	1.08	0.89
4	Mannix	56.97	-111.48	X	Thermo 43	N/A	1.38	1.18	1.08	0.89
5	Buffalo Viewpoint	57.00	-111.59	X	Thermo 43	N/A	1.36	1.21	1.08	0.89
6	Lower Camp	57.03	-111.50	X	Thermo 43	N/A	1.28	1.21	1.08	0.89
7	Mildred Lake	57.05	-111.56	X	Thermo 43	N/A	1.21	1.21	1.13	0.85
8	Syncrude UE1	57.15	-111.64	Thermo	Thermo	0.69±0.11	0.89	1.08	1.27	0.90

				42C	43					
9	Fort McKay	57.19	-111.64	Thermo 17C	Thermo 43	0.56±0.01	0.94	1.01	1.34	0.93
10	Albian Mine	57.28	-111.53	Teledyne API, 200A	Thermo 43	0.45±0.06	1.28	0.84	1.07	0.76
11	CNRL Horizon	57.30	-111.74	Teledyne API, 200A	Thermo 43	0.35±0.16	1.23	0.72	1.34	0.93
12	Fort Chipewyan	58.71	-111.18	Thermo 42C-TL	Thermo 43	0.40±0.09	1.0	1.0	1.17	1.14

[a] Calculated using equation (10). Value is based on mean value of GEM-MACH and GEOS-CHEM models, plus/minus half their difference.

[b] Sampled from Figure S1.

[c] Calculated using GEM-MACH averaged over May-September and based on ratio between all-sky and cloud-fraction < 0.2.