Emission Inventory Issues for MICS-Asia Phase II

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The model inter-comparison study is using a variety of emission inputs, as assembled at http://www.adorc.gr.jp/adorc/obs_emis_dataset07055850427.html. These consist of four separate components: anthropogenic, biomass burning, biogenic, and volcanic. Model results are then compared with observations for the periods March 2001, July 2001, December 2001, and March 2002. For anthropogenic emissions, the TRACE-P inventory is used. This inventory is specifically developed for the year 2000, and monthly averaged emissions (one-twelfth of annual) were used in the modeling. One issue, therefore, is how representative are the monthly averaged TRACE-P emissions for the particular observational time periods. This involves issues of growth in the period 2000 to 2001 and to 2002, and intra-annual monthly variation of emissions. For the purposes of MICS-Asia Phase II, we have examined these issues carefully. Similar issues relate to biomass burning emissions. For volcanic emissions, we present a construction of the time trend of the Miyakejima volcano that was erupting during this period; these emissions were made available to the modeling team prior to the model runs, so no issues should remain. Biogenic emissions are not discussed here.

Anthropogenic Emissions

The TRACE-P inventory [*Streets et al*., 2003a] investigated the monthly variation of emissions of the major species in China. Primarily, this addressed additional emissions during the winter heating season in China and the greater intensity of evaporative emissions during warmer months. For this study we have applied these monthly variation profiles to emissions of four of the relevant species for MICS-Asia Phase II: SO_2, NO_x, NMVOC, and NH_3. In addition, we have projected growth in emissions of these four species from 2000 to 2001 and 2002, using appropriate sector- and fuel-specific factors from the China Statistical Yearbooks, 2000-2003. The results are shown in Figure 1 (a)-(d). These figures show the emissions relationships for the various periods, separately disaggregated for three major regions: Northern China, Central China, and Southern China. Table 1 summarizes the changes relative to the averaged year-2000 emissions.

Some significant growth trends are predicted for this period on the basis of fuel-use changes and changes in other activity parameters. The increase in SO_2 emissions shown in Table 1 is not, however, consistent with official Chinese estimates of SO_2 emissions in the period 2000-2002, which are essentially flat. (A large increase occurs later, in 2003.) Either the Chinese data are incorrect or they incorporate reductions in the average sulfur content of coal or sulfur removal efficiency. Certainly, coal use increased substantially in this period, according to the statistics. We do not know the answer to this question at the present time. For now, the SO_2 changes shown in Table 1 should be viewed cautiously, as they may err on the high side. The growth in emissions of NO_x and NMVOC are reasonable, as they reflect the increase in vehicle traffic and use of petroleum products. Monthly variability is high for NMVOC and NH_3 and may be expected to be reflected in the comparisons between model and observations. In all cases except for NH_3/December 2001, projected emissions are higher than used in the inter-comparison study, and therefore one might expect general model under-predictions. For December 2001, NH_3 emissions may be significantly smaller (25%) than in the TRACE-P average, and this is expected to be manifested mostly in Southern China. As a general observation from the emissions perspective, the results for March 2001 and July 2001 may be the most reliable, especially for SO_2 and NO_x and NMVOC (July only). A tendency toward under-prediction is likely for December 2001 and March 2002.

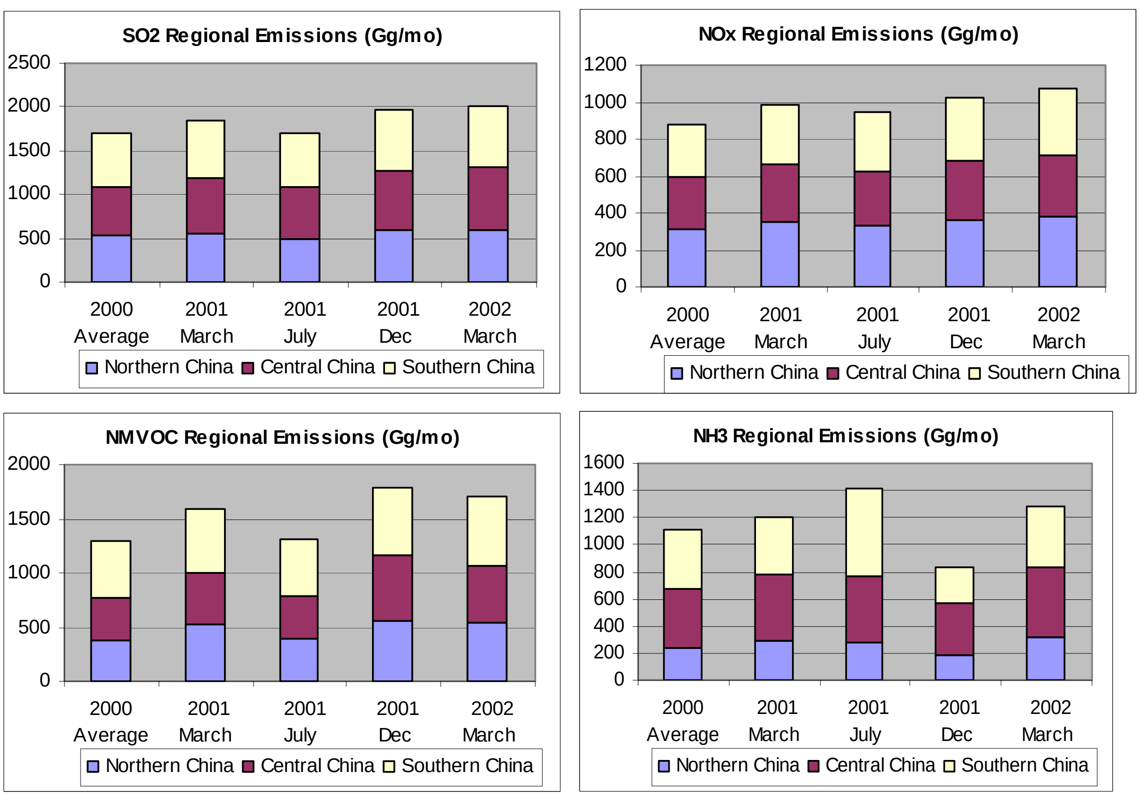

Figure 1 Estimated changes in anthropogenic emission between TRACE-P and four observation months for SO_2, NO_x, NMVOC, and NH_3

Table 1 Differences in Anthropogenic Emissions Relative to the Year-2000 TRACE-P Average (%)

	Mar-01	Jul-01	Dec-01	Mar-02
NO_x	12.3	7.8	16.5	22.5
SO_2	8.9	0.9	15.8	19.2
NMVOC	22.8	1.2	38.9	31.4
NH_3	8.3	26.7	-25.4	15.9

SO_2 Emissions from the Miyakejima Volcano

Mt. Oyama on Miyakejima Island (Miyakejima volcano: 139.53E, 34.08N, 813m MSL), located in the northwest Pacific Ocean, 180 km south of Tokyo metropolitan area, began to erupt on July 8, 2000, and has emitted huge amounts of SO_2 since then [*Kajino et al.*, 2004]. The Seismological and Volcanological Department of the Japan Meteorological Agency (SVD-JMA) has performed continuous measurements of the SO_2 emissions and smoke height above the crater since September 2000, two months after the beginning of the eruption [*Kazahaya*, 2001].

Figure 2 illustrates the time variation of the SO_2 emissions and the smoke height of the eruption measured by SVD-JMA for two years from July 2000 to June 2002, including the entire MICS-Asia analysis period. The maximum SO_2 emission was 82,200 tons/day on November 16, 2000; and emissions were maintained at 10,000 to 20,000 tons/day throughout the period. The maximum measured smoke height is 14,000 m (out of range) on August 18, 2000, and on average near the tropopause at around 500m throughout the period.

Table 2 shows the SO_2 emissions and smoke height during the four MICS periods. In March 2001 the eruption was still quite intense. SO_2 emissions were 27,350 tons/day on average, with a maximum of 45,900 tons/day and with a larger standard deviation than during the other periods. The SO_2 emissions decreased with time but increased again in March 2002. Smoke height varies from 100m to 2,000m and the average, maximum, and standard deviation decreased over time. A comparison of model results in March 2001 and March 2002 should reveal interesting effects of the eruption on regional air quality.

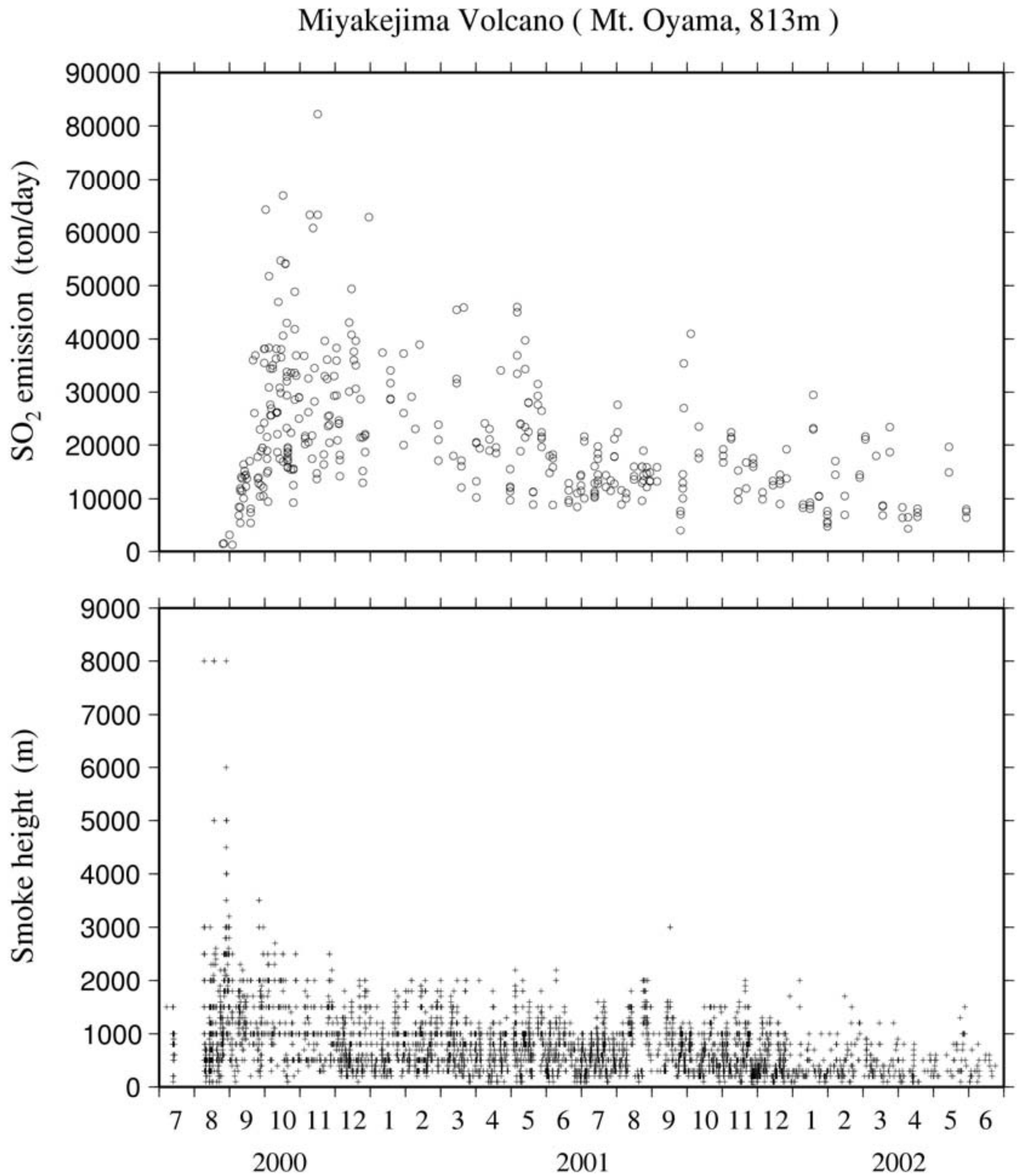

Figure 2 Time variations of SO_2 emissions and smoke height of the Miyakejima volcanic eruption from July 2000 to June 2002 measured by SVD-JMA.

Table 2 SO_2 emissions and smoke height of the Miyakejima volcanic eruption during the MICS periods, with values of average, standard deviation, minimum, maximum and median.

		2001.03	2001.07	2001.12	2002.03
SO_2 emission (ton/day)	ave	27350	14611	12960	15875
	stdev	12585	3476.5	2659.0	6266.5
	min	12100	10100	9000	6900
	max	45900	21600	19200	23400
	med	24850	13400	13050	18350
Smoke height (m)	ave	758.7	563.8	481.0	446.1
	stdev	427.7	297.0	309.7	246.3
	min	100	100	100	100
	max	2000	1600	1700	1200
	med	700	500	400	400

Biomass Burning Emissions

Monthly data sets of biomass burning emissions were provided for the model inter-comparison runs. These reflected typical monthly profiles developed from analysis of AVHRR fire-counts in the period 1999-2000, applied to the TRACE-P estimate of typical annual biomass burning amounts by region [*Woo et al.*, 2003; *Streets et al.*, 2003b]. However, it is necessary to perform some check to see if actual burning in the months analyzed was larger or smaller than expected. These months are in 2001 and 2002, for which no fire count analysis has been performed within the MICS-Asia community. As a qualitative check, monthly global fire maps were downloaded from the ATSR World Fire Atlas [*European Space Agency*, 2004] and are shown in Figure 3.

Results are typical, and show no unexpected features. In March 2001, Asian burning is restricted to Southeast Asia (severe) and isolated areas of eastern China (perhaps land clearing). By July 2001, fires in northern Siberia have become widespread, but may only affect the most northerly part of the MICS domain. There is now very little burning in Southeast Asia and only a few isolated areas in eastern China. By December 2001, there is essentially no biomass burning occurring in this part of Asia. In March 2002, there is again extensive burning in Southeast Asia and only very isolated burning spots in eastern China. I think that it is reasonable to conclude that biomass burning in these four months is quite typical and will be reasonably represented by the emissions profiles provided.

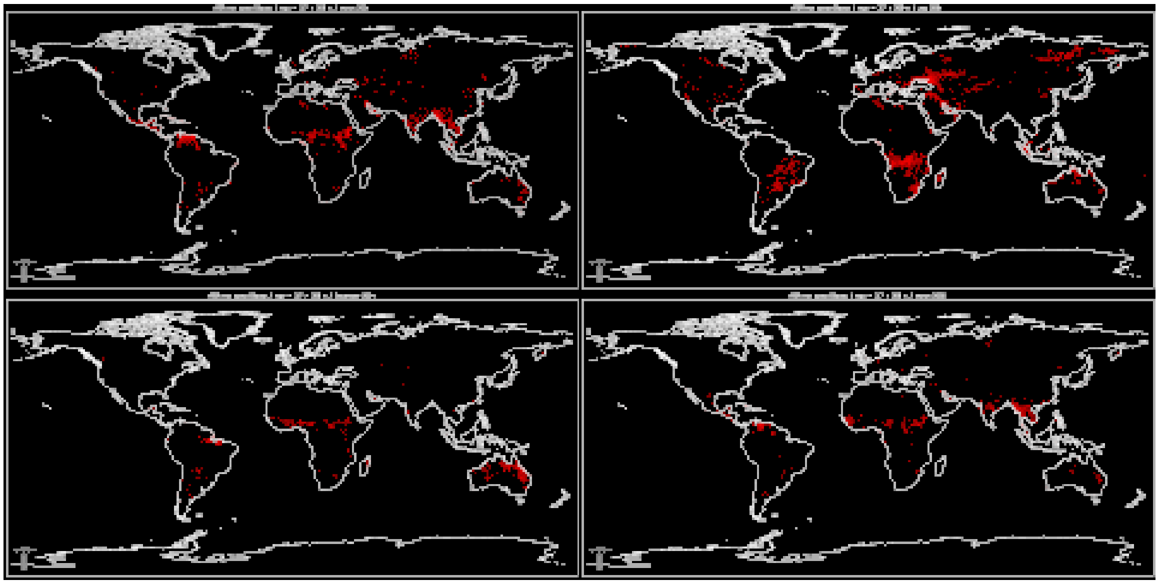

Figure 3 Global ATSR fire maps for March 2001 (upper left), July 2001 (upper right), December 2001 (lower left), and March 2002 (lower right).

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