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Atmospheric Chemistry and Physics Discussions



# *Interactive comment on* "An emission inventory of sulfur from anthropogenic sources in Antarctica" *by* S. V. Shirsat and H. F. Graf

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**Author corrections as suggested by Referee (A. Stohl). Referee Comment received on 27th January 2009.**

**1. Correction 1. Page 1909, Replace Lines 5-7 by the following text.**

In the Arctic, critical concentrations of $SO_2$ (5 $\mu g/m^3$) have been exceeded over a large area and pose damage to ecosystems due to anthropogenic activities (nickel smelters) occurring in the nearby Norilsk region and Kola Peninsula (Kashulina et al., 2003; AMAP report, 1998).

**2. Correction 2. Page 1911, Replace Lines 10 – 13 by the following.**

Investigations by Minikin et al. (1998) reveal an annual mean concentration of methanesulfonate and sulphate from 3 different coastal Antarctic stations to be 38



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and 151 ngm$^{-3}$ at Neumayer (1983–1995) and 20 and 147 ngm$^{-3}$ at Dumont d'Urville (1991–1995) and 15 and 50 ngm$^{-3}$ at Halley (1991–1992).

**3. Correction 3. Page 1911, Replace Lines 22-25 by the following.**

These emission data will in the future be included in a regional climate chemistry model, REMOTE (Regional Model with Tracer Extension) (Langmann, 2000), used widely in Europe and beyond to investigate atmospheric composition, transport and surface deposition.

**4. Correction 4. Page 1912, Replace Lines 5-7 by the following.**

Firstly, estimates of fuel consumption for each anthropogenic activity are made using available fuel consumption information and extrapolation is applied for sources (vehicles, ship) whose information is not obtainable.

**5. Correction 5. Page 1921, Replace Lines 18-20 by the following.**

Hence, the total $SO_2$ emissions from aircraft operations in Antarctica for November 2004–March 2005 is 0.05% of the 1991/1992 global annual $SO_2$ emissions from aircraft fleet.

**6. Correction 6. Page 1921, After Line 22. Please include the following text and Tables 4 and 5 (at the end on separate pages). New Section 2.5 is also to be included in continuity with this text.**

Besides $SO_2$, chemicals like $CO_2$, CO, Hg, Pb etc. are also emitted from anthropogenic activities in Antarctica. Using the fuel consumption values and emission factors for each anthropogenic activity the total emission flux for $CO_2$, CO, Hg and Pb is calculated and shown in Table.4.

It should be emphasised here that the flux of $CO_2$, CO, Hg, Pb (refer Table 4) and $SO_2$ (refer section 2.1, 2.2, 2.3 and 2.4) estimated from each anthropogenic activity in Antarctica are the best estimates based on the known fuel consumption values



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and emission factors available from the literatures and NAEI. It is seen that $CO_2$ released from anthropogenic sources mentioned above is the highest of all emissions. Although these and many other chemicals are released during anthropogenic operations in Antarctica, an emission inventory of $SO_2$only has been prepared by assigning the chemical specie at the grid cell position of the regional model (REMOTE) in order to examine the transport, distribution and deposition rates in future.

**Section 2.5 Comparison of $SO_2$ emissions from different parts of the world**

Comparison of $SO_2$ fluxes from anthropogenic activities in Antarctica and other regions of the world has been done and is shown in Table 5.

As seen from Table 5, the $SO_2$flux from power generation and transportation (vehicle, ship and aircraft) in Antarctica during 2004-05 is between 3-4 orders of magnitude less than the emissions from similar operations in US, Europe and China, and between 2-3 orders of magnitude lower than emissions in Norilsk and Kola Peninsula for the 1990 period. High emission of sulphur in Norilsk and Kola Peninsula is because of non-ferrous smelters operating in these areas (AMAP report, 1998). The $SO_2$ emission from transportation and power/heat generation in Antarctica is much lower because research stations and transportation majorly occurs during summer. During winter, because of harsh climatic conditions human population at the stations is comparatively less, with some stations temporarily shut down and no transportation occurring to or within the continent. However, these emissions are an indication of human presence within Antarctica and stand important when pristinity of the continent is concerned.

**7. Corrections in Table 1. Page 1929.**

Remove entries 6–10.



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## TABLES

**Table 4.** Estimates of $CO_2$, CO, Hg and Pb from each anthropogenic emission source from this study.

| Activity | $CO_2$ (all units in Mg/year) | CO | Hg | Pb |
|---|---|---|---|---|
| Power/heat generation and vehicles. | $11x10^3$ | 24 | 0.00015 | 0.0008 |
| Shipping | $13x10^4$ | 1119 | 0.0034 | 0.073 |
| Aircrafts | 66900 | 855 | 7.7e-7 | 0.0043 |
| Total | 207900 | 1998 | 0.00355 | 0.0781 |



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**Table 5.** Comparison of $SO_2$ emissions from different parts of the world.

| Source | Region | Category: Emission | Base year | Reference |
|---|---|---|---|---|
| Only Power generation and Transportation. | USA | 15.477 Tg/year of $SO_2$ | 1990 | EDGAR emission inventory |
| Only Power generation and Transportation. | W.Europe & E.Europe | 9.634 and 6.911 Tg/year of $SO_2$ | 1990 | EDGAR emission inventory |
| Only Power generation and Transportation. | China | 7.871 Tg/year of $SO_2$ | 1990 | EDGAR emission inventory |
| Natural and Anthropogenic. | Norilsk | 1.2 Tg/year of S or 2.4 Tg/year of $SO_2$ | 1990 | Heidam et al., 1999 |
| Natural and Anthropogenic. | Kola Peninsula | 0.4 Tg/year of S or 0.8 Tg/year of $SO_2$ | 1990 | Heidam et al., 1999 |
| Power generation & Transportation | Antarctica | 0.004 Tg/year of $SO_2$. | 2004–05 | This study |

Interactive comment on Atmos. Chem. Phys. Discuss., 9, 1907, 2009.