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ANTHROPOGENIC SO_2/NO_x COMMITTEE - CURRENT STATUS

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International Global Atmospheric Chemistry Programme

Global Emissions Inventory Activity

Anthropogenic SO_2/NO_x Committee

Current Status[1]

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Current activities of the Anthropogenic SO_2/ NO_x Committee center around the compilation of Version 1 of the GEIA inventories. These inventories will be based on the GEIA-specified 1° by 1° grid (lower left corner at 180°W/ 90°S, west to east and south to north), reflect 1985 emissions and consist of two data sets: Version 1A inventories with annual emissions at one level and Version 1B inventories with seasonal emissions, two vertical levels (defined at 100 m) and sectoral split information. The basic information used for both versions of the GEIA inventories will be identical; i.e., emissions totals across both inventories will be the same. Work is being carried out in two complementary working groups; Carmen Benkovitz, Brookhaven National Laboratory, Upton, NY, USA heads the work on the annual inventory, Eva Voldner, Atmospheric Environment Services, Canada and Trevor Scholtz, ORTECH International, Canada, head the work on the seasonal inventory.

Inventories of Anthropogenic Emissions of SO_2 and NO_x, Version 1A.

At the First GEIA Workshop on Global Emissions Inventories, held in Baltimore, MD on December 1-2, 1991, data on anthropogenic emissions of sulfur and nitrogen developed by Dignon (1992) were selected to form the default emissions data for the GEIA SO_2 and NO_x annual inventories. The Dignon data include emissions from fuel combustion only and extended to 1980. The methodology used was detailed in Dignon and Hameed (1985) and consists of statistical regression models based on available emissions data from the U.S. and some other member countries of the Organization of Economic Co-operation and Development (OECD), which includes Australia, Canada, Japan and western European countries. Control regulations are incorporated via the use of different statistical parameters. The grid definition from these inventories was also adopted for the GEIA grid: origin at 180°W, 90°S, 1° x 1° resolution (i.e., 360 cells in the longitude direction, 180 cells in the latitude direction). At the Second GEIA Workshop on Global Emissions Inventories, held in

[1] Presented at the Third GEIA Workshop on Global Emissions Inventories, Amersfoort, The Netherlands, January 31 - February 2, 1993.

Lillestrøm, Norway, June 22-24, 1992, 1985 was selected as the year for the initial GEIA inventory of anthropogenic SO_2 and NO_x emissions. The Dignon fuel combustion inventories were again selected as the default emissions data.

Most current emissions data for the different geographic regions are being solicited from researchers located within these areas. To date, the following upgrades have been accomplished.

The most comprehensive inventories of SO_2 and NO_x emissions for the United States and Canada has been compiled by the National Acid Precipitation Assessment Program, NAPAP, (Saeger et al., 1989; Wagner et al., 1986). Version 2 of the NAPAP base year 1985 emissions inventories were selected to replace values in the basic GEIA inventories for the U.S. and Canada. Annual values for point sources were directly allocated to the GEIA 1° x 1° grid; the NAPAP spatial allocation file, which allocated area sources to the NAPAP 20 km grid was used as the basis for the allocation of area sources to the GEIA grid. Appendix A summarizes the main inventory characteristics and includes emission totals for the U.S. and Canada as compiled from the NAPAP inventory and the emissions that were replaced in the default GEIA inventory.

The most comprehensive inventories of European SO_2 and NO_x emissions compiled under a unified methodology have been assembled by the Co-Operative Program for Monitoring and Evaluation of the Long Range Transmission of Air Pollutants in Europe, EMEP, (Sandnes and Styve, 1992). Values from this inventory were selected to replace values in the basic GEIA inventories for Europe. The EMEP inventory values are available in a 150 km x 150 km polar stereographic grid and included emissions for certain portions of North Africa and the Middle East. The non-European emissions were deleted from the inventory, European emissions were transferred to the 1° x 1° GEIA grid and replaced the corresponding values in the default GEIA inventories. Appendix A summarizes the main inventory characteristics and includes emission totals for Europe as compiled from the EMEP inventory and the emissions that were replaced in the default GEIA inventory.

SO_2 and NO_x emissions for Australia were obtained from F. Carnovale (1992), Australian Environment Protection Authority, AEPA. Data were gridded to 1° resolution, with additional information for point sources. NO_x data for some point sources were missing, and were also not available in the gridded format. Appendix A summarizes the main inventory characteristics and includes emission totals as presented in the AEPA inventory and the emissions that were replaced in the default GEIA inventory.

SO_2 and NO_x emissions for South Africa were obtained from S.M Lloyd, South African Department of National Health and Population Development, and R.K. Dutkiewicz, Energy Research Institute, University of Capetown (1993). Sectors represented included electric generation, synfuels, industry, metallurgy, mining, agriculture, transport and domestic. Data were gridded to 1° resolution. Appendix A summarizes inventory characteristics and includes emission totals as presented in the South African inventory and the emissions that were replaced in the default GEIA inventory.

Kato and Akimoto (1992) developed inventories of SO_2 and NO_x emissions for 25 [2] Asian countries east of Afghanistan and Pakistan for years 1975, 1980, 1985, 1986 and 1987. Transformation (electric utilities, petroleum refineries, etc.), industrial, transportation and other sectors are included in these inventories. Estimates are available on a province and regional basis for China and India; on a country basis for all other countries. Emissions for 1985 were apportioned by J. Dignon to the GEIA grid based on population, using the methodologies and data files developed for her 1992 work. Appendix A summarizes the main inventory characteristics and includes emission totals for Asia as compiled from the Kato and Akimoto inventory and the emissions that were replaced in the basic GEIA inventory.

Table 1 summarizes the current status of the GEIA work on annual emissions of SO_2 and NO_x from anthropogenic sources.

Future Activities

As of this date, there are several additional sources of information on anthropogenic emissions of SO_2 and NO_x which are being studied for possible inclusion in the GEIA inventories. For Western Europe, the CORINAIR (Bouscaren and Fontelle, 1992) system offers additional information on point sources and sectoral splits; these data are being acquired and a study will be conducted to determine how best to incorporate the additional detail offered.

Other sources of emissions information for Japan, China, Taiwan, South Korea and North Korea that are being studied include: inventory compiled for the Central Research Institute of Electric Power Industry (CRIEPI) (CRIEPI Research Group of Acidic Deposition, 1992) and received from G. Carmichael, University of Iowa, Iowa City, IO, USA; inventory compiled by Y. Tonooka, Institute of Behavioral Sciences, Tokyo, Japan; and information available from the NILU Circumpolar SO_2 Emission Survey (Semb, 1985).

Information for SO_2 and NO_x emissions from point sources in the Asian part of the former USSR has been compiled by J. Pacyna, NILU (Pacyna, 1992). These data are being compared with the information used in the default inventory, to insure that no source is double counted; emissions not accounted for in the default inventory will be added.

At a meeting of the working groups held at Brookhaven National Laboratory, Upton, NY, USA, on October 23, 1992, it was decided that DMS emissions from the ocean and

[2] Countries included: Afghanistan, Bangladesh, Brunei, Cambodia, China, Hong Kong, India, Indonesia, Japan, N. Korea, S. Korea, Laos, Macao, Malaysia, Maldivies, Mongolia, Myanmar, Nepal, Pakistan, Phillipines, Singapore, Sri Lanka, Taiwan, Thailand, Viet Nam.

Base Inventory:	Dignon 1985 fuel combustion emissions. (Dignon, 1992).
North America:	48 Lower U.S States/Canada from NAPAP 1985 V2.
	Alaska and Hawaii from default inventory.
	Mexico from base inventory.
Central America:	All countries from default inventory.
South America:	All countries from default inventory.
Europe:	EMEP 1985 (September 1985 version).
Asia:	USSR from default inventory.
	All others, 1985 emissions from Kato and Akimoto.
Africa:	S. Africa: S. Africa Dept. Nat. Health and Pop Develop.
	All other countries from default inventory.
Australia:	Australian Environmental Protection Authority.

Working Group Members	Current Contributors:
Carmen M. Benkovitz (USA)	Hajime Akimoto (Japan)
Jane Dignon (USA)	Frank Carnovale (Australia)
Trevor Scholtz (Canada)	R.K. Dutkiewicz (S. Africa)
Leonor Tarrasón (Norway)	Nobuo Kato (Japan)
Eva Voldner (Canada)	S.M. Lloyd (S. Africa)
	Jozef Pacyna (Norway)
	Yutaka Tonooka (Japan)

Table 1. Summary of Current Status of Annual SO_2 and NO_x Inventories

sulfur emissions from volcanoes are significant and need to be addressed in order to properly study atmospheric sulfur chemistry. Since no other current GEIA committee is addressing these emissions, and several of the working group members are currently conducting studies that require information on these sources, the GEIA Committee on Anthropogenic Emissions of SO_2/ NO_x will address the compilation of inventories of these emissions as an extension to our work. Initial inventories of biogenic emissions will adopt the GEIA 1° geographic resolution and have seasonal time resolution. C. Benkovitz, USA and L. Tarrasón, Norway, plan to start a cooperative effort to study oceanic emissions of DMS in the timeframe of Summer 1993. C. Benkovitz and J. Dignon, USA and E. Voldner, Canada, have formed a subcommittee to plan the compilation of a global inventory of sulfur emissions from volcanoes. C. Benkovitz has established initial contact with Dr. Stanley Williams, Arizona State University, an expert volcanologist, who has indicated interest in becoming a collaborator in this project. Drafting of a workplan is under way.

Table 2 summarizes the next steps to be taken by this project. Figure 1 shows the currently estimated timelines for the work of this committee.

Additional information on European emissions from CORINAIR system.

Asian emissions from several sources to be studied and selection made:
- Major point sources in Asian part of Russia compiled by NILU.
- Asian emissions compiled by Arne Semb, NILU.
- Japan, China, Taiwan, So. Korea and No. Korea data from CRIEPI report.
- Japan, China, Taiwan, So. Korea and No. Korea data from Y. Tonooka.

Cooperative project to develop inventory of DMS emissions from oceans (Benkovitz, USA/Tarrasón, Norway).

Cooperative effort with university volcanologists to develop an inventory of sulfur emissions from volcanoes (Benkovitz, Dignon (USA)/Voldner (Canada).

Table 2. Future Work on Annual SO_2 and NO_x Inventories.

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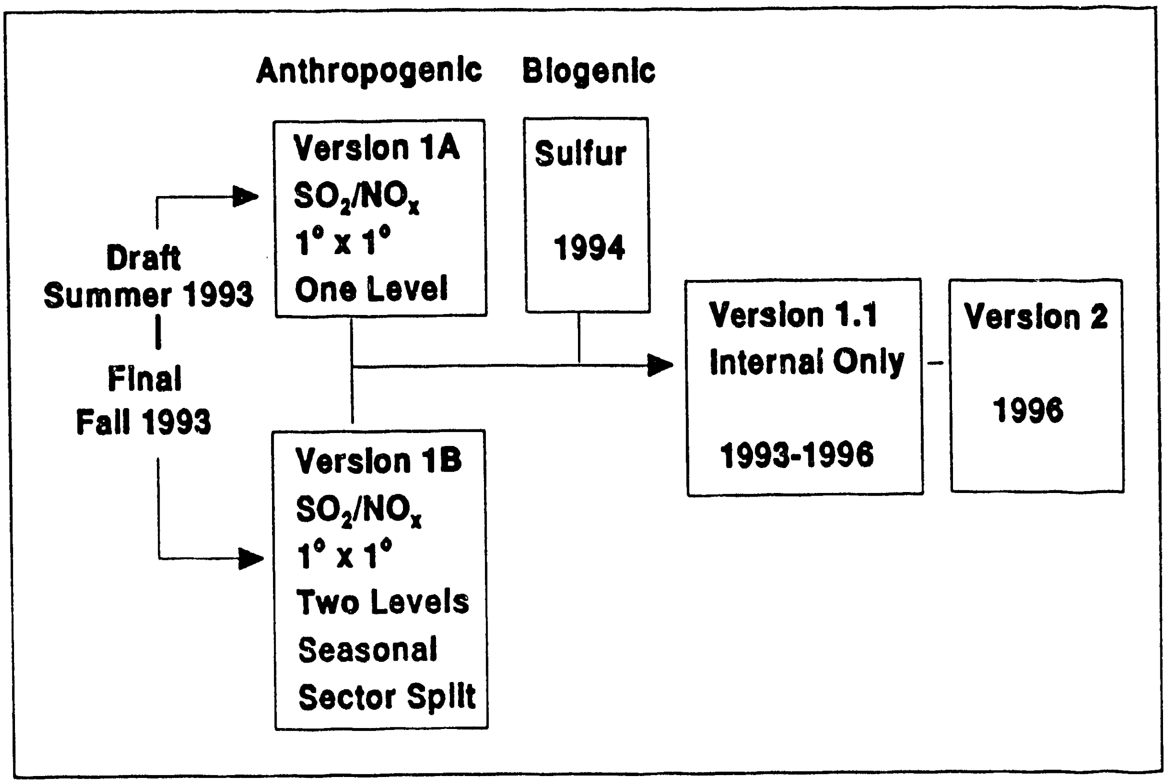

Figure 1. Current Timeline for the GEIA Inventories of SO_2 and NO_x.

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Appendix A

Summary of Current Work on Annual SO_2 and NO_x Inventories

Default Inventory: 1985, Dignon (1992).	
1985 emissions from fossil fuel combustion only.	
1° x 1° resolution, (1,1) at 180°W, 90°S.	
Global SO_2 emissions (10^6 metric tons S yr^{-1})	64.1
Global NO_x emissions (10^6 metric tons N yr^{-1})	23.4
U.S./Canada: NAPAP 1985, Version 2.	
1985 emissions from all land sources. Partial emissions from shipping.	
Point sources gridded individually.	
Area sources gridded to 20 x 20 km NAPAP grid, aggregated to 1° x 1°.	
U.S./Canada SO_2 emissions (10^6 metric tons S yr^{-1})	12.3
U.S./Canada NO_x emissions (10^6 metric tons N yr^{-1})	6.2
SO_2 emissions in default inventory (10^6 metric tons yr^{-1}S)	9.6
NO_x emissions in default inventory (10^6 metric tons N yr^{-1})	6.3
Europe: EMEP 1985 (September 1992 Version).	
1985 emissions from all land sources. Ship traffic within Europe included.	
150 x 150 km grid reapportioned to 1° x 1° grid.	
European SO_2 emissions (10^6 metric tons S yr^{-1})	22.6
European NO_x emissions (10^6 metric tons N yr^{-1})	6.4
SO_2 emissions in default inventory (10^6 metric tons S yr^{-1})	21.9
NO_x emissions in default inventory (10^6 metric tons N yr^{-1})	7.7
Australia: 1985, Environment Protection Authority.	
Gridded to 1° resolution, plus point source information.	
Some NO_x emissions for point sources missing.	
Australian SO_2 emissions (10^6 metric tons S yr^{-1})	0.81
Australian NO_x emissions (10^6 metric tons N yr^{-1})	0.21
SO_2 emissions in default inventory (10^6 metric tons S yr^{-1})	0.61
NO_x emissions in default inventory (10^6 metric tons N yr^{-1})	0.16
South Africa: 1985, S. African Depart of Nat Health and Pop Develop.	
Gridded to 1° resolution, all sources included.	
South African SO_2 emissions (10^6 metric tons S yr^{-1})	0.89
South African NO_x emissions (10^6 metric tons N yr^{-1})	0.22
SO_2 emissions in default inventory (10^6 metric tons S yr^{-1})	0.51
NO_x emissions in default inventory (10^6 metric tons N yr^{-1})	0.05
Asia: 1985, Kato and Akimoto (1992).	
1985 emissions from transformation, industrial, transportation and misc.	

Regional emissions for China and India, country level for all others.
Gridded to 1° x 1° grid using population file (Dignon).

Asian SO_2 emissions (10^6 metric tons S yr^{-1})	13.1
Asian NO_x emissions (10^6 metric tons N yr^{-1})	4.2
SO_2 emissions in default inventory (10^6 metric tons S yr^{-1})	17.5
NO_x emissions in default inventory (10^6 metric tons N yr^{-1})	4.3

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