Annual Nitrous Oxide
Review of information currently on the GEIAv1 N_2O

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1. The strengths and weaknesses in the current GEIA emission databases for N2O

The current GEIA N_2O file contains data sets for nine N_2O sources for the year 1990, as published by Bouwman et al. (1995). The sources are: (1) Soils under natural vegetation and fertilized agricultural fields, (2) Animal excreta, (3) Post-forest clearing enhanced, (4) Ocean, (5) Industrial, (6) Fossil fuel burning, (7) Biofuel burning, (8) Agricultural waste burning, and (9) Biomass wasting. The GEIA files include global maps for each of these nine sources at 1^o x 1^o grid resolution, as described by Bouwman et al. (1995) and references therein. These inventories remain relevant, but some could be improved by incorporating information that has been published during the last decade into each analysis.

The main conclusions from the 3rd Non-CO_2 Greenhouse Gas Symposium , Maastricht, The Netherlands, 21-23, January 2002, (Kroeze and Mosier, 2002) were that in recent years, no new sources of N_2O have appeared, emission factors for mobile combustion need to be revisited; agricultural emissions need to be re-evaluated; process-based simulation models need to be considered as an alternative to emission factors in providing national, regional and global emissions estimates; and the need still exists for more experimental data in terrestrial and aquatic systems, particularly long term measurements. Finally, even though the uncertainty in estimates of N_2O emissions from terrestrial systems is typically estimated to be at least 50%, the uncertainty of emissions from aquatic systems (which include subsurface and surface aquatic systems) is even greater, due to the lack information.

Global nitrogen fixation, conversion of dinitrogen into reactive forms through combustion, fertilizer production and biological sources, continues to parallel or exceed the rate of growth of human population. During the past two decades the global distribution of fixed nitrogen production and consumption has continued to shift from economically developed regions to economies in transition and developing regions. As a result, regional distribution of N_2O emissions continues to shift (Mosier et al. 2001).

2. Alternative emission distributions

The Emission Database for Global Atmospheric Research (EDGAR Version 3.2) includes an update of 1990 emissions and new emissions for 1995, on a grid 1x1 degree for a number sources, including (a) fossil-fuel production, transmission, transformation (e.g. coke production, oil refineries) and combustion, (b) biofuel production, transformation (charcoal production) and combustion, (c) industrial production and consumption processes (including solvent use), (d) agricultural activities, (e) biomass

burning, (f) waste handling (Olivier et al., 2001a,b). For N_2O also emissions estimates for 1970 and 1980 will be made available. The information is available at http://arch.rivm.nl/env/int/coredata/edgar/

A recent analysis of global agricultural N_2O emissions was prepared by the Food and Agricultural Organization of the United Nations (FAO) (http://www.fao.org) and the International Fertilizer Industry Association (IFA) (http://www.fertilizer.org). More recent global analysis of other N_2O emissions sources have not been made as far as we are aware.

3. Emission trends

During the past 50 years atmospheric N_2O concentration has been increasing, relatively linearily at the rate of approximately 0.7 ppbv (ftp.cmdl.noaa.gov/hats/N2O/insitu GCs/global/). Mosier and Kroeze (2000) and Kroeze et al. (1999) discuss atmospheric trends in N_2O concentration and the underlying increasing emissions.

4. The seasonality of the emissions

General concepts on seasonality of emissions need to be re-evaluated. During the past several years considerable new information shows that globally important emissions of N_2O occur during freeze-thaw cycles in ecosystems where freeze-thaw occurs. The existing GEIA analysis does not consider this fact or the fact that N_2O emissions occur during winter in snow-covered environments, or only to a limited extent. Global seasonal trends may tend to be dampened because of the increased generation and consumption of fixed nitrogen in the tropics.

5. Natural emissions as a function of soil characteristics

Natural N_2O emissions can be related to environmental and other factors (see for instance Bouwman et al., 1995). However, natural variability of the processes involved makes it difficult to quantify relations between global emissions and environmental factors. We expect that process-based modeling derived inventories are likely to be the basis for future inventories.

6. New GEIA inventory projects

As mentioned above, future GEIA activities could focus on a number of issues. Of these two may deserve particular attention: (1) the use of process-based models in preparing gridded emission inventories, and the (2) the estimates of so-called *indirect* emissions of N_2O from agriculture, induced by enhanced denitrification in natural systems due to nitrogen losses from agricultural systems. At least two research projects may contribute to this. These are summarized below:

A) Carolien Kroeze (Wageningen University, The Netherlands) and collaborators are initiating a new project that may be used in GEIA synthesis work. The

project focus will be on denitrification and associated N_2O emissions in terrestrial and aquatic systems, and the transport of N from terrestrial (agricultural) to aquatic systems as a result of leaching and runoff. Attention will be paid to process-based modelling, interactions between terrestrial and aquatic systems, dynamical aspects, and different forms of nitrogen. The work builds on earlier modeling activities, that were used as the basis for the present GEIA inventories for aquatic systems (Seitzinger and Kroeze, 1998). Expertise gained during co-operation with national and international research groups will be used.

B) Arvin Mosier (USDA-ARS) and collaborators have initiated a project to utilize process-based models to conduct annual inventories of N_2O emissions from United States and Canadian soils. Depending upon the progress of this project, the concept of using such models for global inventories will be considered. Pertinent publications include Brown et al. (2002) and Del Grosso et al. (2002).

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