Report of the GEIA Open Conference
November 29-30; December 1st

This report includes reports from the 4 sessions of the conference:

Session 1: Anthropogenic emissions: past, present future
Chairpersons: H. Akimoto (Japan) and J. VanAardenne (Italy)
Rapporteurs: J.F. Lamarque (USA) and S. Reimann (Switzerland)

Session 2: Integration spatial/temporal scales; emissions for air quality
Chairpersons: J. Olivier (The Netherlands) and V. Vestreng (Norway)
Rapporteurs: W. Winiwarter (Austria) and B. DeJong (Mexico)

Session 3: Terrestrial ecosystems and biomass burning
Chairpersons: J.F. Müller (Belgium) and C. Reeves (United Kingdom)
Rapporteurs: D. Serça (France), M. Sanderson (United Kingdom) and L. Viegas de Barros (United Kingdom)

Session 4: Aerosols
Chairpersons: I. Isaksen (Norway) and C. Liousse (France)
Rapporteurs: K. Tsigaridis (France) and S. Reddy (United Kingdom)

SESSION SUMMARIES

Session 1: Anthropogenic emissions: past, present and future

7 plenary lectures and 9 posters

1.1 General Comments

Anthropogenic emission, as well as natural emission, inventories can be characterized by the following properties: the inventories

- Are developed for a variety of purposes (policy or science)
- Cover a wide range of geographical and temporal scales
- Are produced using both bottom-up or top-down approaches

In all bottom-up approaches, the emission inventory starts from a set of activity data, usually available per sector and technology, with some knowledge of abatement measures. Activity data are limited in availability. For example, fossil fuel combustion can be provided by statistics from the International Energy Agency (IEA). Use of single data sources can lead to substantial biases, if the activity data do not reflect reality because of misrepresentation or mischaracterization of the actual energy use.

The second step in bottom-up emission inventory development is the selection of emission factors. This is a major source of uncertainty since factors and their evolution in time are not well characterized. In addition, there is much variability across sectors regarding the levels of detailed information on available technology and/or geographical and temporal variations. This makes the aggregation of emissions from different processes a significant source of uncertainty. Improved estimates of emission factors based on measurements are the only way the large uncertainties in emission scenarios can be alleviated. This is particularly true for non-methane hydrocarbons emissions from two-stroke engines, black carbon emissions associated with diesel exhaust and cooking stoves in developing regions, and ship emissions.

From the presentations it seems clear that much more work on validation of emission inventories is needed. This can be done through comparison with in-situ data (such as the exhausts of power plants in the United States) or through the comparison of chemistry-transport model simulations with observations (ground-based, aircraft-based or satellite-based) and inverse calculations.

In addition, there are significant trends towards developing inventories with higher amounts of specialization and higher temporal and horizontal resolution and assessing uncertainties more rigorously. Finally, policy-making is becoming an important driver for generating emission estimates.

1.2 Specific Topics

Emissions from the transportation sector are expected to increase in the near future, even in the industrialized regions of North America and Europe. This increase is associated with an increase in the fleet size and the opening of new shipping routes (especially if the Arctic Ocean becomes free of ice during a significant fraction of the year).

The major uncertainties in transportation emissions are related to

- Knowledge of the fleet age and vehicle maintenance
- Regional characterization of tail pipe emissions
- Identification and characterization of "super-emitters"

These will become even more critical in an environment with strong abatement policies.

More generally, emission scenarios appear to be produced by a variety of unrelated socio-economic models. This wide variety is critical to insuring that the future is well bracketed by those scenarios. There is, however, the risk that the methodologies followed in the scenarios are not in agreement with estimates of present and past emissions, making the connection between those estimates and the scenarios difficult. The key to solving this problem is to construct tools for building emission inventories that are flexible enough to accommodate various degrees of complexity and knowledge.

1.3 Proposed Actions

In the short-term, it seems that the combination/harmonization (for example blending regional estimates within global estimates) and the intercomparison of existing inventories, along with trying to better understand the nature of the inventory differences, are the most important steps.

In the long-term, we propose three main avenues of research

- Validation of emission inventories
- Regionalization and specialization of emission factors
- Harmonization of past/present/future emissions to follow socio-economic scenarios of relevance to other scientific research groups (such as the carbon cycle or IPCC)

Session 2: Integration spatial/temporal scales: emissions for air quality

7 plenary lectures and 6 posters

2.1 General Comments

This session discussed methodological aspects of emission inventories that lead to improved integration. A wealth of information is available, albeit it is sometimes difficult to access. Efforts undertaken to establish inventories for a specific purpose may be useful for other purposes as well. Consolidating and comparing databases from different scales and origins (including related air quality information) may be a tedious task on its own, but may be very beneficial in terms of inventory quality assessment.

Different aspects of intercomparing were highlighted, and the applicability of the methods introduced was often demonstrated with real data. An extended overview of available global and regional emission inventory provided the introduction to the session. This overview also allowed for a critical assessment of emission information, and supported the use of quality indicators for inventories.

2.2 Specific Topics

The following specific topics were considered in one or more of the papers presented:

- Recombination of emission information from a "bottom-up" procedure, regulatory database and the problems associated with it. There was a recommendation to separately pursue establishing a research emission database to overcome the flaws of the regulatory database (i.e., lack of timeliness, lack of consistency between contributors, lack of focus towards improvement). Topics that specifically require improvements include non-point sources, specifically fugitive sources, and industrial sources and their connection to stack measurements.

- Resolving emission information temporally and spatially, using point source information plus surrogate statistics for downscaling. Sensitivity studies also can be used to assess the influence of differently resolved inventories on photochemical models
- Satellite measurements as independent datasets to validate emission inventories. Several examples were presented, underscoring the useful applications of this technique. Agreement in the variation of emissions was identified between stack measurements and satellite observation. Differences between an a-priori emission estimate and a-posteriori results from inverse modeling indicated systematic aberrations of the original emission estimates. Trends over several years seen from satellite data, but not from inventory data, suggests inventory inability to depict the changes. Differences between countries seen in the inventory, but not in the inverse modeling results, also points towards incompatibilities between inventories.
- Ground based measurements and inverse modeling, or ground based measurements and regional modeling have been used successfully to draw conclusions on emissions, and compare these with official emission reporting.
- Not only activities, but also emission factors, may show a temporal variation and cycles - e.g., when cost considerations call for a shutdown of abatement devices in less critical situations.
- Studies of the influence of adequate coverage of megacities in global models indicates that coverage is important for compounds as PAN, but not so much for ozone or OH concentrations. The same study also shows that global model results depend on the choice of the inventory to be used, calling for emission inventory improvement and validation of inventories on the global level.
- Methods were presented to systematically collect uncertainty information from emission inputs, and to trace such uncertainty through the emission calculations.

2.3 Proposed Actions

A number of major conclusions of the session can be drawn and actions are recommended. A surprising wealth of emission information is available both globally and locally. Some, but not all of this information can readily be used for other purposes than those originally established for. This calls for improvement and validation of emission data. Fugitive emissions, especially those that lack a well-established emission point, have been identified as top priority for improvement. Spatial and temporal scales of the given inventories may not always provide acceptable reliability and this needs to be improved. Often it is difficult to perform adequate downscaling of emission data to the appropriate temporal and spatial resolution – specifically, when variations in emission factors have to be considered in addition to those of activities. Very promising results in terms of emission validation have been demonstrated from inverse modeling of measurements, both taken by satellites and ground based sites. The regional source strength as well as the spatial and temporal trends of emissions may be identified, if applying the correct data retrieval models and scale of the data. Further refinement of these methods will help provide validated global emission inventories as a reliable foundation for global and regional modeling.

Session 3: Terrestrial ecosystems and biomass burning

6 plenary lectures and 18 posters

3.1 General Comments

In this session, the emissions of a wide range of trace gases from ecosystems and biomass burning were discussed. The uncertainties in these emissions were highlighted. The use of concentration data from surface measurements and satellites to infer emissions was also included. Databases of the driving variables, and access to these and other key data using innovative data portals were described.

3.2 Specific Topics

Biomass burning. Fires and the resulting emission of CO_2, and pollutants such as carbon monoxide (CO) and smoke particles have important effects on climate and air quality. The number and extent of fires, at least in the tropics, are controlled by the rainfall during the preceding wet season. This rain is necessary for growth of the trees, which are the fuel for the fires. The number of fires is also controlled by periods of drought, although fire activity may increase or decrease with droughts. For example, the Indonesian region was unusually dry during the El Nino of 1997-1998, and the fires were particularly large. The CO from these fires may have caused the anomalously high methane growth rate observed during this period. The use of satellite data to obtain burned areas of land and forecast emissions of smoke and trace gases was also discussed.

NO_x emissions from soils. Nitrous oxide (N_2O) is an important greenhouse gas. It has significant natural source, and understanding this is necessary for current and future assessments of N_2O emissions and climate forcing. Tropical rainforest soils are the largest natural source of N_2O, with the forests in South America producing about half of all the N_2O emissions from tropical forests globally. There is still considerable uncertainty in the magnitude of these emissions. Currently, there are insufficient data to estimate NO_x emissions from soils by the same method. Other estimates of NO_x emissions by soils, and there influence on surface ozone levels, were also presented.

Hydrocarbon emissions. Isoprene emissions from plants have been found to be reduced by increasing levels of CO_2. Simulations incorporating this effect have shown that the CO_2 inhibition effect will offset the increase in isoprene emissions caused by higher temperatures, so that isoprene emissions at the end of the 21st century were projected to be similar to those of the present day. However, it is not clear whether emissions of other hydrocarbons (e.g., terpenes) are affected by CO_2 levels. Emissions of these latter species may continue to rise with increasing temperature. The variability of natural hydrocarbon emissions caused by changes in the different controlling factors were also studied. Satellite measurements of glyoxal, a species produced from the degradation of isoprene and terpenes, are very useful in determining the emissions.

Access to key databases. Development of emission inventories depends on a clear understanding of driving variables and access to reliable data. Intercomparisons of emission data are also important in the development and testing of inventories. To address these needs, ECCAD, a GEIA-ACCENT database of driving variables, has developed an ancillary database for calculating surface emissions of gases and particles that are important in determining the distribution of tropospheric chemicals. In addition, the NEISGEI web portal has been set up to make it much easier for researchers to gain access to distributed emission datasets and combine them. The exact methods used will be clear.

3.3 Proposed Actions

Fire-driven global deforestation will depend on how ENSO behaves in the future with climate change, and the subsequent impacts in tropical Asia, economies of countries in Africa, and the speed of deforestation in South America. All of these factors will need to be properly taken into account in developing biomass burning scenarios. Better understanding of the contributions of peat burning also will reduce uncertainties in estimates of the overall impacts of biomass burning on trace gas concentrations and climate change.

The relationship between CO_2 levels, climate, productivity and other factors that determine NMVOC emissions from vegetation (particularly terpene emissions) need to be characterized more precisely. Similarly, the intimate connections between climate change, nitrogen deposition and nitrogen emissions need to be better understood and quantified. Expanded use of satellite imagery to help track land use changes and other key factors influencing terrestrial emissions, as well as trace gases that can be used as a proxy for the emissions, will be essential for obtaining better estimates of emissions worldwide. These problems clearly overlap with some of the findings of session 2. The combination of different datasets to create emissions databases will be made easier and more transparent by web portals like NEISGEI. Their use should be encouraged.

Session 4: Aerosols

6 plenary lectures and 6 posters

4.1 General Comments

The aerosols session addressed anthropogenic, biomass burning, and natural aerosol emissions, as well as modelling atmospheric transport from regional to global scales. Most of the complexity of the aerosols (i.e., source origins, primary emissions, and secondary formation of organic aerosols), along with recent developments at characterizing the complexity was discussed.

4.2 Specific Topics

Organic matter aerosols. Natural aerosol emissions are one of the least understood processes, especially for the organics. Organic matter that is emitted directly as aerosols in the atmosphere (e.g., pollen, fungal spores and plant debris) contributes mainly to the coarse aerosol size range. Bacteria contribution to the accumulation range is possibly negligible. There are limited data available for estimating these emissions. Emission factors derived from the atmospheric concentration lead to an estimate of 0.2 Gg of primary organic matter from natural sources over Europe.

Dust. Mineral dust aerosol sources are predominantly natural, but anthropogenic influences on climate have altered its source strength. Long term atmospheric dust concentrations at Barbados (13.17° N. 59.43°W), largely transported from Western Africa, show a factor of 4 increase in concentrations from late 1960's. The dust emission strength is strongly influenced by surface properties and characteristics and local meteorology. Hence, emission intensities are not the same for all deserts. The Gobi desert and Sahara show more extreme events, maximizing their global contribution to dust emissions. Both the interannual and seasonal variability of dust storm intensity are needed to properly calculate the source strength. Reconstruction of dust emissions (past, present and future), using Sahel precipitation index (SPI) of the previous year to parameterize dust emissions for the following year using an interactive dynamic land surface model, is a promising approach. A test for the Western Sahara in the GFDL general circulation model shows that the model is able to reproduce the atmospheric dust concentrations at Barbados from 1960s to present day on monthly mean basis.

Sea Salt. The role of sea-salt on radiative impact has been explored with the RegCM3 model. Important regional differences are indicated.

Carbonaceous aerosols. Carbonaceous aerosols include black carbon and organic carbon particles. Organic aerosols are difficult to model, since they have both primary (mainly combustion) and secondary (oxidation of volatile organic compounds) sources. Further, the contribution of secondary organic aerosols (SOA) to the total carbonaceous aerosol mass is still an open question. It was shown that recent ^{14}C measurements indicate that biogenic SOA contribution to total carbonaceous aerosol mass is of the order of 25% in European cities, even during the winter time, while anthropogenic SOA contribution is about 1-3%. An improvement of emission inventories with new sets of emission factors for black carbon and primary organic carbon for different sources is needed. European emission inventories at different scales (global/European/regional) were evaluated, by modelling of black carbon (BC) and organic carbon (OC). The comparison between modelled and measured data showed that in central Europe, particularly in Poland, large differences appear in BC and OCp between the existing inventories. SOA inclusion, highly influenced by gas/aerosol partition coefficient parameterization, improves the comparison with measurements for OC. Large uncertainties of VOC emissions have been also shown in present and future SOA modelling, partly due to model sensitivity of SOA production to the vapour pressure assumptions. As for Europe and Asia, Africa regional inventory development is needed to decrease uncertainties in emissions. A new anthropogenic emission inventory for the African continent was presented. Biomass burning is the most important source, while South Africa accounts for the majority of fossil fuel emissions.

4.3 Proposed Actions

The aerosols session provided great insights into the state of the aerosol emissions inventories from regional to global scales. The modelling studies underscored the usefulness and importance of regional emissions inventories. Use of region specific soil, surface characteristics and meteorology in emissions parameterization leads to more realistic dust emissions. Use of region specific fuel consumption and emission factors results in more realistic anthropogenic emissions. Development of these more detailed regional factors is a high priority. Another research priority is the improved characterization of biogenic sources of organic aerosols and the emissions of gaseous precursors to organic aerosols.