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International Global Atmospheric Chemistry (IGAC) Programme Global Emissions Inventory Activity (GEIA)

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INTERNATIONAL GLOBAL ATMOSPHERIC CHEMISTRY (IGAC) PROGRAMME
GLOBAL EMISSIONS INVENTORY ACTIVITY (GEIA)

PROCEEDINGS

OF

THE IGAC/GEIA WORKSHOP ON GLOBAL EMISSION INVENTORY

LILLESTRØM, NORWAY

22-24 JUNE, 1992

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1 INTRODUCTION

In accordance with the work plan of the IGBP/IGAC Global Emissions Inventory Activity (GEIA), a Workshop on Global Emissions Inventories was organized by the GEIA Secretariat and the Norwegian Institute for Air Research (NILU) from 22 to 24 June, 1992 in Lillestrøm, Norway (see Annex 1).

The workshop was attended by 34 participants from 9 countries and 3 international organizations. The programme of the workshop and the list of participants are included in Annexes 2 and 3.

2 GOALS OF THE WORKSHOP

The overall goals of the workshop were to review the progress of work within individual GEIA projects and to plan further activity, as well as to discuss new projects. Major focus was placed on projects related to emissions of acidic components, such as SO_2 and NO_x, other nitrogen compounds, and CFCs. Other pojects will be discussed at the next meeting in the Netherlands in 1993 or are at the initial stage only. A very important task of the workshop was to establish new projects in close collaboration with various international organizations. There are two projects of special importance in this respect:

the CH_4 emission project (collaboration with the OECD/IPCC) and the lead/toxics project (co-operation with the UN ECE).

The first part of the workshop was devoted to reports on emission inventorying within various international programmes. The results from these programmes are very often directly used in the GEIA projects and it is of great importance for the GEIA community to learn about the status and plans of the programmes. The second part of the workshop included parallel discussions within the existing and new projects. The third part of the workshop included discussion leading to recommendations for future work of GEIA, as well as short reports by the Workshop participants on their emission inventory activities. The reports are presented in Annex 4.

3 RAPPORTEUR'S REPORT OF THE WORKSHOP

3.1 REPORT FROM THE FIRST PLENARY SESSION

Chairman : T.E. Graedel
Rapporteur : J. Dignon

3.1.1 History of GEIA

- T. Graedel

This is our third meeting. Our first meeting was held in Chamrousse, France, in September 1989 concurrently with the CACGP-meeting. The second meeting was held in Baltimore, MD, in December 1990.

GEIA is one of 24 activities of the International Global Atmospheric Chemistry (IGAC) program, under the Global Distributions and Trends subheading.

Within the last year GEIA has adopted a logo developed by C. Veldt.

At the Baltimore meeting 4 requirements for inventories were adopted:

- Spatial Resolution: 1 x 1 degree globally
- Point by point reliability
- Working groups are to be international and intercontinental
- Inventories should be published in the refered scientific literature.

The goal is to obtain/develop inventories that the modelers need to run models:

- acidification
- air toxics
- climate
- events
- source type
- processes

The following projects are currently in operation:

NH_3, NO_2 (N), N_2O	-	L. Bouwman (NL)
CO_2 (A)	-	G. Marland (USA)
CFCs (A)	-	D. Cunnold (USA)
SO_2, NO_x (A)	-	J. Pacyna (NOR)
VOC (A)	-	C. Veldt (NL)
VOC (N)	-	N. Hewitt (UK), A. Guenther (USA)
Radioisotopes (N)	-	M. Kritz (USA)
CH_4	-	N. Roulet (CAN), E. Matthews (USA)
Heavy Metals	-	E. Voldner (CAN)
Biomass Burning	-	J. Levine (USA), B.Stocks (CAN)
Data Management	-	P. Middleton (USA)
Secretariat	-	J. Pacyna (NOR)

where N = natural sources and A = anthropogenic sources

The topics under consideration:

CO (A)	-
Organochlorines	-
Aerosol Particles	-
Aircraft Emissions	-
Ship Emissions	-

To date GEIA has had little official funding, however, the US National Science Foundation has agreed to provide a small grant of $75K to develop our data management center and to support some future workshops. The Norwegian authorities support GEIA with $25K yearly.

Our next meeting will be in the Netherlands January 31-February 5, 1993, concurrently with the OECD Methane Workshop. The following meeting will be in the fall of 1993, location to be announced. Another meeting is tentatively scheduled to be held concurrently or immediately adjacent to the CACGP meeting in Tokyo, Japan, September 5-10, 1994.

3.1.2 Opening of the Workshop

H. DOVLAND, NILU, DIRECTOR

As host of the meeting H. Dovland expressed warm welcome to the convenors and expressed his strong support for the crossflow of information between the science and policy makers GEIA represents. He stressed harmonized emissions data bases, standardized definitions, correctness of emission factors and praised the cooperation that has been bred through GEIA particularly between UN ECE and CORINAIR. He announced the next meeting of the UN ECE Emission Task Force in the Netherlands on June 7-11, 1993.

J. PACYNA, GEIA SECRETARIAT

J. Pacyna expressed welcome to the convenors and established the goals of this meeting:

1. See progress within individual projects, and
2. Propose future activities.

J. Pacyna announced the 2 new working groups on CH_4 and heavy metals, and gave a brief overview of the meeting schedule.

3.1.3 Project groups report:

CFSs, D. Cunnold:

After performing mass balance testing in the past, the CFC emissions did not agree with the observed concentrations measured at the 5 GAGE sites which have been making continuous observations since 1978. With the input of Eastern Europe emissions, CFC 11 and 12 now seem to agree. F113 still does not balance. Either the emissions estimates are too high or less likely there is an unknown sink. These questions are being addressed.

Because of the way usage is given by country by the Chemical Manufacturers Association (CMA) a gridded breakdown is difficult. A proxy for the spatial distribution is needed. Pollution events are currently being studied in Tasmania and Ireland to determine if NO_x or some other pollutant which is more spatially resolved can be used as a surrogate.

Currently CH_3Cl_3 production figures exist by continent only. Suggestions for a proxy are needed here as well (NO_x or population).

Question D. Ahuja:
- How do you determine emissions from the production rates reported by CMA?
- Models have been developed specifically for this purpose and are dependent on the usage (e.g. DuPont).

Question J. Dignon:
- Do you also plan to inventory HCFCs?
- Yes, in the future.

NO_x, SO_2, J. Pacyna/C. Benkowitz:

Goals of Project Group:

1) compile existing data for geographical regions,
2) develop methodologies for emission estimation, and
3) develop methods for estimating future scenarios as well as historic emissions.

Further activities:

1) Seasonal resolution,
2) Separate sources, and
3) Natural sulfur emission.

The Inventory:

Base inventory is 1980 from J. Dignon (1992) with NAPAP (1985) for US and Canada, EMEP (1985) for Europe, and Kato and Akimoto (1992) for Asia excluding Siberia.

Future work: Dignon estimate for 1985, Australian EPA estimates for Australia.

Question Hayashi:

- Have you considered natural emission of sulfur species?
- Some gridding has been done of Bates et al (1992).

Question D. Cunnold:

- Have you been comparing emission estimates with observation of species concentration (e.g. a mass balance)?
- It is hard to do so because short lived species and multiple sources.

Lex Bouwman, Nitrogen Compounds

NH_3 - There is a reasonably complete inventory for Europe (UN ECE Task Force). Other parts of the world are unknown although contacts have been made in China and India.

Modelling can be done to address the number of animals and fertilizer application, however, there is no support to do this work.

N_2O - A paper written by Bouwman, Fung and Mathews has been submitted to Global Biogeochemical Cycles on emissions from natural soil sources. Oceanic emissions are currently being looked at by J. Elkins.

NO (Natural) - There has been an initial attempt by J. Dignon based on the work of E. Williams.

H.P. Baars VOC (anthropogenic) for C. Veldt:

Announcement was made that C. Veldt will be retiring next year and replaced by J. Berdowski. Since there is now a new group for CH_4 the question of whether this group will address CH_4 has been decided.

The group decided in Baltimore to define a source sector split and to propose emission factors.

Proposed inventory of activities:

Activity:	Availability for data:
Oil and gas production, transport	OECD
Petro-chemical industry	Emission factors in progress

Residential fuel Combustion	Biomass - proposal completed Other fuels - avaialble
Mobile sources	OECD available Other - scarce data Catalytic convertors in progress.
Solvent use	OECD - consumption "known" Other - economic sectors - check global mass balance
Other coal mines land fills	

T. Scholtz, Canadian Effort

The Canadian group is developing a global inventory of NO_x, SO_2 and VOC at 2 levels addressing point and area sources. They have been compiled and compared with the following inventories:

Data used:	J. Dignon (NO_x, SO_2) Watson (VOC (A)) EMEP LOTOS NAPAP Asian Point Source (Pacyna) China Emissions
Requested:	Japan + Thailand (J. Pacyna) Mexico CORINAIR

After attempting this comparison they stress the importance in maintaining version number and a unified data center for all levels of data. Estimates for such a center were roughly a 18 persons staff costing 1.2 million Canadian dollars.

3.1.4 Reports on emission inventorying within other international organizations

M. Heymann, GENEMIS Project

The GENEMIS program addresses European emissions only. Since its goal is to address pollution events, GENEMIS is very interested in high spatial and temporal resolutions (order of hours).

There will be a GENEMIS workshop Oct. 7-8, 1992 in Stuttgart.

Question T. Scholtz:
- Why is there no data on Northern Scandinavia?
- Uncertain, perhaps lack of data or the version of data.

Question G. McInnes
- When looking at temporal resolution, how do you determine what are the most important features to maintain?
- This depends on the source category e.g. traffic would need to be hourly whereas space heating needs only be seasonal.

Question E. Voldner
- How far east in Europe does your inventory go?
- Same coverage as LOTOS up to the Ural Mts.
- What is the spatial resolution?
- 80 km x 80 km.

L. Tarrason, EMEP

L. Tarrason has expressed a need for the use of the SO_2 inventory for the Northern Hemisphere in a model of concentration, transport and deposition of pollutants. Preliminary calculations illustrated the systematic underestimate along western coastlines due to the lack of shipping data and natural DMS emissions.

G. McInnes, UNECE Task Force on Emission Inventories

G. McInnes stressed the need for complete, consistant, transparent inventories, build on what has already been done. He presented source category sectors common for CORINAIR, and EMEP.

P. Schwengels, OECD emission activity on greenhouse gas inventorying

This is a 2 year project in accordance with IPCC to:
1) develop national inventories of greenhouse gas net emissions,
2) establish widespread use of uniform methodologies, and
3) create an on-going data management system.

The OECD program expects to produce a document on internationally agreed methods by 1992. The focus will primarily include CO_2, CH_4, N_2O and CFCs. They look forward to cooperation with GEIA on technical information, software advice and scientific review.

R. Bouscaren, CORINAIR

CORINAIR has developed an emission factor handbook released in January 1992. They are currently preparing a 1991 inventory, and implementing sattelite software.

E. Voldner, Proposal for a Heavy Metals Working Group

Proposal includes:

1) analysis of measurement strategies,
2) interpretation of environmental measurements,
3) understanding of pathways of pollutants,
4) relative significance of various sources,
5) trends of concentrations,
6) source-receptor relationship,
7) evaluation of control strategies, and
8) ecosystem response time.

The Pb project to determine Pb emissions for the Northern Hemisphere - participants include NILU, U.S. EPA, Environment Canada.

An emission inventory for Pb is expected by 1993.

T. Scholtz, Canadian Global Emissions Inventory Center

Environment Canada has done a feasability study on determine what would be required to provide inventories to all models and what would the ideal features include.

K. Murano, Asian Activities

Kato and Akimoto have developed an emission inventory by country for all Asian countries east of Pakistan except Siberia for the years 1975-1981. They plan to compare this with the data of Fujita and Tanooka. They propose to estimate future scenarios of NOx and SO_2 emissions. There is a workshop for East Asian emissions in Japan in January 1993.

Question L. Bouwman:
- Have you determined per capita emissions?
Murano: Not at this time.
Dignon: I have done these estimates if you are interested.

3.2 WORKING GROUP ON SO_2 AND NO_x

Chairman: C. Benkovitz
Rapporteurs: E. Voldner and T. Scholtz

The following items were addressed during the discussions:

1) Requirements/guidelines for data:

   a) Base year
   b) Source category breakdown/individual point sources
   c) Release height
   d) Seasonal breakdown

2) Validation/verification/uncertainty.

3) Documentation. Products. Communications.

4) Natural sulfur emissions.

Ad. 1) Requirements/guidelines for data

Initial base year agreed on is 1985.

Requirements for input data:

The most detailed level of data available should be requested as input. Full documentation should accompany the data. Data will be requested for base year and most recent available year (if subsequent to 1985). Steering committee should be cc'ed on all letters requesting data.

Action: Produce standardized letter for data request (Benkovitz/Scholtz/Voldner).

Internal Representation of the Data:

Distinguish anthropogenic SO_2 and SO_4, reported as S; NO and NO_2 reported as N.

We should distinguish major point sources and non-major sources; this last category includes other point sources and area sources. Data for major point sources should include geographic location, emissions, stack parameters (stack height, temperature, volume), type of source and seasonal variation. Non-major sources will be divided into fuel combustion sources and industrial processing of S containing material for sulfur emissions and into stationary sources and mobile sources for nitrogen emissions.

Standard output to GEIA Data Management:

Annual totals on a 1 deg x 1 deg grid, single level, expressed as S and N.

Standard output from SO_2/NO_x Group:

Annual totals on a 1 deg x 1 deg grid, two levels in the vertical (physical stack height of 100 m), expressed as S and N, for the specified source categories.

All products will be accompanied by version number clearly identifying its status. We recognize that some of the desired point source information may not be available for parts of the world; thus default/surrogate values will be used to produce the standard outputs defined above.

Data Requested (but not received):

1. CORINAIR (follow-up Voldner)
2. Mexico (follow-up Voldner)
3. Australia (follow-up Pacyna/Benkovitz)
4. Detailed East Asia (must be re-requested)

Data to be requested:

1. Alaska (Eva Voldner).
2. South America through Brazil (J. Pacyna).
3. Detailed Akimoto East Asia as in Akimoto
   a) Pacyna/Graedel,
   b) Voldner via international agreements.
4. Africa.
   a) Pacyna to contact OECD representatives.
   b) Ahmed through funding.
5. Middle East.
   a) Saudi Arabia - Pacyna through Ahmed.
   b) Israel - Benkovitz.

Additional Data Work:

1) Asian part of USSR. Pacyna to compare NILU work with Berlyand report.

2) Shipping. Approach UNECE task force on shipping-N. Kilde (RISØ).
Fallback: EMEP major shipping routes combined with information on shipping.
Action: Pacyna.

Ad. 2) Validation/Verification

Topic was discussed in length, with references to the report on the Regensburg meeting and results from the first meeting of the UNECE Task Force on Emissions. Group agreed that quantitative statements on the grid level data quality are desirable, but at present only minimum qualitative statements on the country level data may be possible.
Action: Benkovitz and Pacyna to develop initial protocol.

Ad. 3) Documentation. Products. Communications

All incoming products should be accompained by full documentation; copies will be submitted to the GEIA Data Management Center. Products will include reference listing when possible.

Communications for steering committee will be minimum of monthly informal reports E-mail or fax; report for group on quarterly basis. Outgoing data requests should be submitted to steering committee and working members. Progress reports at GEIA meetings.

Of all surrogate data used in SO_2/NO_x inventory development, uniformity in gridded population density is the most pressing.

<u>Action</u>: Graedel to request release of Logan-generated population file for use in this GEIA project.

Ad. 4) <u>Natural Emissions</u>

The group agreed to address only oceanic DMS for the present.

There are two current approaches: L. Tarrason has developed monthly gridded inventory for North Atlantic. She agreed to extend this work to other major water bodies.
<u>Action</u>: Tarrason will initiate this task in February 1993.

Benkovitz developed global gridded inventory for October by distributing Bates et al. global inventory longitudinally using Coastal Zone Color Scanner data as surrogate for ocean productivity.
<u>Action</u>: Benkovitz to explore possibility of obtaining student under BNL educational programs to expand work for other months and help in comparison with Tarrason results.

Anthropogenic SO_2 and NO_x group members:

1. C. Benkovitz - chairman
2. T. Scholtz - rapporteur
3. D. Cunnold
4. J. Dignon
5. C. Evers
6. M. Heymann
7. M. Memmesheimer
8. K. Murano
9. D. Oertel
10. J. Pacyna - co-ordinator of the project
11. L. Tarrason
12. Y. Tonooka
13. E. Voldner

3.3 GEIA-OECD/IPCC WORKING GROUP ON METHANE EMISSIONS

Chairman : P. Schwengals
Rapporteur: A. Wilkinson

The Working Group commenced with a brief discussion of the individual needs of the OECD/IPCC GHG Emissions and GEIA programmes.

The OECD/IPCC GHG Emissions work is aimed at constructing national emissions inventories for anthropogenic sources of greenhouse gases. The GEIA programme, however, is aimed at producing global emissions inventories for a wider range of pollutants on a 1^{o} x 1^{o} grid and considers both natural and anthropogenic sources.

It was noted that although the product from each programme was different, since each was intended to satisfy different goals, the GEIA and OECD/IPCC GHG Emissions programmes have a common need to develop robust methodologies for determining emissions estimates.

It was noted that other parts of the IPCC programme are interested in identifying potential control/reduction strategies which are closely related to emissions. The Netherlands/RIVM Workshop on CH_4 and N_2O, to be held in February 1993, is being designed to assist IPCC with both emission and control options.

The remainder of the meeting was focussed on how to facilitate the development of the necessary methodologies for methane emission sources, within the time frames of each programme.

The Working Group agreed that it should identify those areas where technical information was currently lacking for each programme. It was also agreed that several sub-groups of experts should be contacted and invited to discuss the current range of methodologies, or develop new methodologies for each methane emissions source.

The Working Group identified/classified the sources of methane as:

<u>Anthropogenic</u>

1. Coal mining
2. Oil and Gas Systems and E&P
3. Rice Paddies
4. Landfills
5. Animal - Enteric Digestion
6. Animal Wastes
7. Sewage and Municipal Liquid Wastes
8. Biomass burning
9. Industrial - Petrochemical, Processes and Refineries
10. Combustion/End Use, including Transport

<u>Natural</u>

11. Natural Leakage from Oil/Gas Reservoirs
12. Natural Wetlands
13. Termites
14. Clathrates

By grouping (2) and (11), (3) and (12), (5) and (13) and (4) and (7) a total of nine sub-groups would need to be established.

In order to facilitate organisation and to co-ordinate effort, the Working Group agreed that a Steering Group should be appointed. The Steering Group would be responsible for drafting the terms of reference for each expert sub-group and for co-ordinating output.

Proposed membership to the Steering Committee are:

N. Roulet	(Canada)
E. Mathews	(USA)
P. Schwengals	(OECD)
A. Van Amstel	(NL)
P. Crutzen	(Germany)

It was agreed that in order to meet the different end-user requirements of the OECD/IPCC GHG and GEIA Emissions programmes, the terms of reference would include cosideration of whether the determined methodology would need modification to transfer from national emission estimates to those on a 1^o x 1^o resolved grid.

It was noted that there are several complementary studies also underway, that are considering methane emissions estimates and/or inventory methodologies. Brief details were noted on four such activities; these were:

1. US EPA Study - outlined by Dilip Ahuja
2. The UK Watt Committee Working Group on Methane Emissions
3. The forthcoming Dutch International Conference
4. US EPA Symposium, Washington DC, August 1992

The Working Group agreed that it would be preferential to establish contact with each of the above activities so that future efforts could be efficiently co-ordinated to prevent any duplication of effort.

It was agreed that the future procedure would be for the appropriate chapter of the US EPA Report to Congress, that is due to be drafted by July 1992, to be forwarded to the members of each expert sub-group. The chapter would form the basis for discussion, comment and criticism.

The proposed membership of the expert sub-groups would be determined by the Steering Group and key co-ordinators/contacts. The latter were identified as follows:-

SUB-GROUP	CONTACT	ORGANISATION/LOCATION
Coal	Kirchgessner	USEPA, RTP/NC
	Kruger	USEPA, WASHINGTON
	Williams	Australia

plus representatives from Watt Committee and Karlsrühe University

SUBGROUP	CONTACT	ORGANISATION/LOCATION
Oil and Natural Gas		
	Rosland	Norway
	Hogan	USEPA, WASHINGTON

plus representatives from oil and gas industries eg E&P Forum, IGU and GRI

Rice Paddies		
	Minami	Japan
	Neue	IRRI, Phillippines
	Khalil	U.S.A

Animals/Ruminants

Johnson	U.S.A
Gibbs	U.S.A
Costigan	UK
Leng	Australia

Landfills and Municipal Liquid Wastes/Sewage

Thorneloe	USEPA, RTP/NC
Richards	UK, ETSU
Bogner	Argonne National Lab.

Animal Wastes

Hashimoto	U.S.A
Woodbury	U.S.A
Safley	U.S.A

Plus representatives from India/China

Biomass Furning

Ahuja	India, working out of U.S.A.
Delmas	France

Industrial - Petrochem., Processes and Refineries

Beck	USEPA, RTP/NC
Veldt	The Netherlands

Combustion/End Use, including Transport

Williams	UK,
Beck	USEPA, RTP/NC

Initially the groups will focus on developing transparent national emissions estimate methodologies although some consideration would be given, at a later date, to the relevance of spatial resolution.

Other relevant meetings, prior to the Dutch meeting in February 1993, were noted to be:

EPA Meeting, August 1992
Watt Committee, September 1992
Emissions Inventory User's Meeting, Berkley, USA, September 1992
Climate Change Country Study

and information will be brought on the forthcoming international meetings of the natural gas, oil and coal industries.

GEIA - OECD/IPCC CH_4 group memebers

1. P. Schwengels - chairman
2. A. Wilkinson - rapporteur
3. D. Ahuja
4. L. Beck
5. T. Graedel
6. G. McInnes
7. J. McKenna

3.4 REPORT OF THE VOC AND NATURAL N SPECIES GROUP

Chairman and rapporteur: A.F. Bouwman

- VOC from anthropogenic sources

Work is still in a planning phase. C. Veldt and M. Woodfield are working on a proposal for emission factors and VOC profiles. This proposal will be distributed by the end of this year to the VOC Steering Committee. Data on solvent use in the EC will be available next year. As a first approach the division proposed in Veldt's report to this meeting in 5 or 6 major source categories is considered appropriate for global studies. In later phases the more detailed classification as agreed upon in the UN-ECE task force on emission inventories may be adopted for North America and Europe.

- VOC from natural sources

A. Guenther and N. Hewitt are working on a 1st version of this inventory. The VOC's considered are:

- Isoprenes,
- monoterpenes,
- other VOC's.

This inventory is hoped to be completed as a draft version for discussion during the GEIA workshop in 1993 in the Netherlands.

Recommendations

A discussion document on VOC emission factors and VOC profiles for anthropogenic sources and further plans should be prepared for the GEIA workshop in the Netherlands in 1993, as well as a description of the methodology used in the compilation of the natural VOC emission inventory. The natural and anthropogenic VOC need full attention, and steering committee members and other experts should be stimulated to participate in the GEIA workshop in the Netherlands in 1993.

- NH_3

Work on NH_3 emissions from animal waste, fertilizer production and fertilizer use is progressing in Europe (Asman, Van Hoek) as contribution to the UN-ECE task force, and in China (Zhao Dianwu). For North America data from the NAPAP study in the mid eighties may be used. Contacts in other parts of the world are still needed. K. Murano offered to start the inventory of NH_3 for Japan.

Recommendations

Animal densities and regional estimates of animal weight, waste production presented by NASA-GISS coupled with estimates of N in excreta are proposed to be used for areas of the world for which specific information is not on hand. These first estimates may be substituted as soon as regional or country estimates become available.

- NO_x from soils and lightning

A first inventory of NO_x from soils has been prepared by Jane Dignon. This inventory is based on the work of Eric Williams (NOAA, Boulder). It uses empirical functions, and is based on soil types, soil temperature and soil water content. It also includes estimated enhanced NO emissions in burned areas. It is difficult to estimate NO_x emissions from lightning as a global total; estimates for the geographical distribution are even more difficult at this moment due to lack of meteorological databases of convective activity and lightning.

Recommendations

In autumn or winter 1992 Eric Williams, J. Dignon, L. Bouwman and possibly M. Keller will meet in the USA to discuss improvement of the approach followed by J. Dignon and methods for calibration of the model.

A first new version of the methodology for the inventory for NO_x from soils may be discussed in the next GEIA meeting in 1993.

Meanwhile, I. Galbally will be contacted for further input. The inventory of biomass burning (NASA) will be used as soon as it is available to compile the inventory of stimulated NO_x emissions in burned areas.

- N_2O

Nitrous oxide has many recognized sources (natural soils, agricultural soils, animal waste, biomass burning, tropical land disturbance, oceans, coastal marine waters, inland waters, water treatment plants, nylon and fertilizer production, fossil fuel combustion). A first inventory of N_2O from soils, biomass burning and animal waste is now being used in an atmospheric tracer model by J. Taylor. Major unknown source is still the oceanic source, coastal marine and inland waters. Publication of the N_2O from natural soils is expected by the end of 1992 in Global Biogeochemical Cycles. Improved biomass inventory is expected to be available in early 1993 (NASA, J. Levine).

Recommendations

C. Neveson should be contacted for input. She is doing work with atmospheric models and can give useful advice. The results of John Taylor's exercise should be discussed at the GEIA meeting in 1993 in the Netherlands. The two experts on aquatic N_2O sources in the N_2O Steering Committee (Elkins and Seitzinger) should be stimulated to participate in 1993 and develop a methodology to estimate the geographical distribution of aquatic sources.

GENERAL RECOMMENDATIONS

The Steering Committees for the anthropogenic VOC, natural VOC, NH_3, NO_x and N_2O should be encouraged to participate in the 1993 workshop in the Netherlands.

Suggested topics for discussion:

- source category breakdown,
- seasonal breakdown,
- base year,
- handling of uncertainties,
- documentation,
- aguatic N_2O emissions, and
- emissions of NO_x from lightning.

VOC and natural N species group members

1. L. Bouwman - chairman and rapporteur, co-ordinator of the project
2. H.P. Baars
3. R. Bouscaren
4. J. Dignon
5. J. Fudala
6. P. Middleton
7. F. Prechtl

3.5 GEIA DATA MANAGEMENT CENTER

Chairman : E. Voldner
Rapporteur: J. McKenna

The following notes have been taken during the discussion.

1. Transfer of data

L. Bouwman believes that each institute has its own way to document files. He will send an example. P. Middleton asks if we should use ASCII files.

C. Benkovitz says that commercial software can build a database with reference formats. We could send out guidelines of documentation to comment on/receive comments on.

D. Cunnold suggests that we use the Earth Observing System (EOS D.I.S.- Data and Information System) or Upper Atmosphere Research System (UARS) as a model.

P. Middleton proposes to use a smaller system to begin. We could start with a basic inventory to use that as text; use supporting data for those interested. We will also need to develop header records.

C. Benkowitz suggests that we start with the SO_2 database but it is not yet available. But, a timeline can be developed after the SO_2 meeting. We should also set criteria for version differences.

A. Semb believes that we should stress the need for a simple data format because there will be different grid formats and different models. Not everyone uses 1^0 x 1^0 grid format.

P. Middleton responds that we do not need to re-grid. Working groups can help here.

J. Dignon mentions that GEIA does not have software specialists available to juggle formats. It is a difficult and lengthy process.

D. Cunnold states that we should not restrict ourselves to a $1^\circ \times 1^\circ$ database.

T. Scholtz asks to restate last year's objectives, especially if it involves different grids.

P. Middleton says that we should collect information from major point sources. We should cover as many chemicals as possible now.

T. Graedel stresses that we serve the global community first. We should not be restrictive.

C. Benkowitz suggests that we lay down guidelines then see how data comes in. At that point, we can make decisions.

P. Middleton states that we should use the prototypes of SO_x and NO_x data in harmonizing data into a grid, then transfer to the data center.

E. Voldner says that if GEIA just stores $1^\circ \times 1^\circ$ grids, people will search anywhere to find information regarding the data.
E. Voldner discusses the approach to organization. We will need to access various governments. Thus, each project needs various contacts.

J. Dignon comments on documentation, in that context files should include their original reference.

2. <u>Uncertainty</u>

C. Benkowitz stresses the need to define UNCERTAINTY. The definition should be what we do not know about data rather than variability.

L. Beck adds that we should define qualitative data.

L. Bouwman states that the degree of uncertainty depends on what source one is speaking about. For example, soil and climatology contain many uncertainties.

3. Communication

P. Middleton indicates that we want more than a paper trail toward the Database Management System. We will keep the $1^0 \times 1^0$ grid. We should practice prototypes with "Guinea pig" SO_2 inventory.

It will be important to enhance the communication network and to get feedback as soon as possible. Send out news notes, for example, E-mail.

C. Benkowitz suggests to make E-mail available at the data center, as soon as possible. E-mail is very efficient.

E. Voldner suggests that we start with low level activity, get values, and begin tapping programs for funding.

4. Data management recommendations

1. GEIA Data Management should be conducted in phases. Phase 1 focuses on providing basic $1^o \times 1^o$ data on annual basis. Later phases should consider other resolutions and distribution of supplemental data such as in phase 1, the documentation will cover the various existing alternatives.
2. Data transfer should be accomplished through E-mail, FTP N or other simple methods at first. It was recommended that various software be examined for use at a later stage. At the least, each file must be carefully labelled.

3. Uncertainty must be defined carefully and documented for each data entry.

4. Communication through E-mail is highly recommended, at the minimum.

ANNEX 1

First Circular of the 2nd
IGAC/GEIA Workshop on
Global Emission Inventory

GEIA WORKSHOP ON GLOBAL EMISSION INVENTORY

LILLESTRØM, NORWAY, 22-24 JUNE, 1992

1 Circular

The Global Emissions Inventory Activity (GEIA) is a part of the International Global Atmospheric Chemistry (IGAC) Project, formally initiated in 1990. The goal of IGAC is to measure, understand, and predict changes in the chemistry of the global atmosphere over the next century, with particular emphasis on changes affecting the oxidizing capacity of the atmosphere, impacts on climate and atmospheric chemical interactions. IGAC operates as a volunteer network linking scientists and projects in various countries and coordinating and stimulating research in areas of particular importance to the goals of the program.

The major goal of GEIA is to establish and maintain reliable inventories of emissions to the atmosphere from natural and anthropogenic sources around the world. A secondary goal is to provide a selection of emission inventories for typical global development scenarios. Various subprojects are being prepared under GEIA, estimating emissions of:

- SO_2 and NO_x from anthropogenic sources,
- various compounds from biomass burning,
- CO_2 ,
- VOC from anthropogenic sources,
- NH_3 , NO_y , and N_2O,
- radionuclides, and
- CFCs.

It is planned to start emission estimation for trace metals, persistent organic compounds, CH_4 , CO, and VOCs from natural sources.

According to the GEIA work plan, a workshop on Global Emission Inventories will be held in Lillestrøm, Norway from 22 to 24 June, 1992.

The major objective of the workshop is to review the progress of emission inventorying within the above mentioned subprojects and to discuss further work in order to improve emission inventorying within GEIA. Other topics of the Workshop include: review of the data management planning framework of GEIA, development of data base at the GEIA Secretariat, and development of communication structure.

The program of the Workshop will be presented in the second circular to be distributed in April 1992.

The Workshop will be held in the Olavsgaard Hotell, some 15 km from the Oslo centrum. 60 single rooms have been reserved for the Workshop participants. We hope that you will be able to attend the Workshop and ask you to complete the enclosed registration form and return it by the end of March 1992 to:

Dr. Jozef M. Pacyna
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P.O.Box 64
N-2001 LILLESTRØM
NORWAY

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ANNEX 2

An Agenda for the 2nd
IGAC/GEIA Workshop on
Global Emission Inventory

THE SECOND GEIA WORKSHOP ON GLOBAL EMISSION INVENTORY

Lillestrøm, Norway, 22-24 June 1992

AGENDA

<u>Monday 22 June</u>	<u>Chairman</u>: T. Graedel, <u>Rapporteur</u>: J. Dignon
0900-1000	Welcome, introduction, goals - T. Graedel (GEIA Convenor) - H. Dovland (NILU, Director - host) - J.M. Pacyna (Domestic)
1000-1040	Review of work within various GEIA projects - D. Cunnold - J.M. Pacyna/C. Benkovitz/T. Scholtz
1040-1110	Break
1110-1150	Review cont. - A.F. Bouwman - C. Veldt
1150-1230	International activity on global emissions within other programmes and organizations - GENEMIS, M. Heymann - EMEP, L. Tarrason
1230-1400	Lunch
1400-1500	International activity on global emissions within other programmes and organizations - UN ECE, G. McInnes - OECD, P. Schwengels - CORINAIR emission inventorying system, R. Bouscaren
1500-1540	Heavy metals - new GEIA subproject/GEIA as an emission centre for AMAP - E. Voldner/T. Scholtz
1540-1610	Break
1610-1630	Emission inventorying in Asia, K. Murano
1630-1730	Meeting of the working groups Chairmen: Benkovitz, Schwengels, Bouwman Rapporteurs: Scholtz, Wilkinson, Bouwman
1900	Dinner

Tuesday 23 June	Chairman: E. Voldner, Rapporteur: J. McKenna
0900-1030	Data Management Center - review of activity, structure of the Center - P. Middleton
1030-1100	Break
1100-1230	Working groups (parallel sessions for individual projects) Chairmen: Benkovitz, Schwengels Rapporteurs: Scholtz, Wilkinson
1230-1400	Lunch
1400-1530	Parallel sessions - cont.
1530-1600	Break
1600-1730	Emission inventory software (plenary session) - Introduction: GLOED emission inventory software, L. Beck
Wednesday 24 June	Chairman: J. Pacyna, Rapporteur: G. McInnes
0900-1040	Presentations by national experts - CO emission inventory, P. Middleton for J. Logan - Presentation of the Canadian project on SO_2, NO_x, and VOC emission worldwide, E. Voldner and T. Scholtz - Emission inventory of Japan and East Asia, Y. Tonooka - Emission modelling for chemical transport models, M. Memmesheimer - Progress of the Dutch EDGAR emission project, H.-P. Baars
1040-1100	Break
1100-1230	Group rapporteurs reports & discussion - J. Dignon - E. Voldner - J. McKenna - L. Bouwman - A. Wilkinson
1230-1400	Lunch
1400-1530	Conclusions Plan for future work Other business
1530	Closing of the meeting

ANNEX 3

A list of participants

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ANNEX 4

Papers presented at
the Workshop

GLoED

presented by Lee Beck

A. GLoED is an Emission Inventories software package that can calculate emissions given the parameters: country, source, sector, pollutant.
The origin of data is integral to GLoED.

B. Outputs from GLoED
1) Thematic Maps
- colored countries according to quantity
2) Other graphics
- bar charts
- pie charts
- numeric test displays

C. Advantages
1) Automatically converts units
2) Imports/Exports files: LOTUS, dBase, ASCII
3) Creates Standardized, Quality Assured Emissions Inventories.

D. Uses
1) Stores data from varied database
2) Calculates Emissions totals
3) Shows "HOT" spots - high concentrations of requested inform.
4) A 3/D country/gas/source database will be available

E. Demonstration
1) One begins by generating a scenario by choosing a database, a country, and pollutants.
2) The scenario is calculated and graphics are displayed as a World Map, or charts, or text.

DISCUSSION

Rapporteur: J. McKenna

L. Beck mentions that the graphics take a bit of time on a 20 Megaherty computer. R. Bass adds that GLoED was designed with space restraints in mind.

P. Schwengels states that this product was donated by EPA to OECD/IPCC. We would like to develop an advisory group to receive/field comments regarding GLoED feedback and development. This product could carry out the Database Management Center functions within GEIA.

R. Bass explains that the source code, written in C, is available. There is another package within GLoED that handles the graphics.

L. Beck adds that he has added "gridded" software to use in GLoED. He has also put VOC in 10° grids into the system as another possibility. Both kinds of grid data are possible.

We have, after the discussion, received agreement for 5 experts to advise IPCC/OECD to EPA on computer software:

C. Benkovitz
G. McInnes
E. Voldner
J. Dignon
P. Middleton

92-142.01

The IGAC Activity for the Development of Global Emissions Inventories: Description and Initial Results

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INTRODUCTION

The International Global Atmospheric Chemistry Project (IGAC, Galbally [1]) is an international cooperative effort of atmospheric scientists designed to measure, understand, and attempt to predict changes in the chemistry of the global atmosphere over short and long time scales. Of particular interest are changes in the oxidizing capacity of the atmosphere, the impacts of these changes on climate, and the chemical interactions of the atmosphere and biota. These goals are broad and include several environmental issues of urgent concern, including greenhouse warming due to the accumulation of trace gases in the atmosphere, depletion of stratospheric ozone, increased acidity of rainfall, increased oxidant levels in the troposphere, and resulting biological damage. IGAC functions as a volunteer network linking scientists and projects in different countries and coordinating and stimulating research in areas of particular importance to the goals of the program.

One of the most important scientific tools used in the assessment of atmospheric chemistry, air quality, and climatic conditions of the past, present, and future is mathematical models of transport and transformations in the atmosphere. These models rely in part on inventories of emissions constructed on appropriate temporal and spatial scales and including the required chemical species. The production of such inventories, initially regarded as adjunct to modeling activities, is now a separate area of research whose importance to the accuracy of results of modeling and assessment activities has been fully recognized. The myriad of problems involved in the compilation of accurate inventories on a local or regional basis is multiplied manyfold when the geographic area of interest is extended to the multinational, hemispheric, and global domains. Recognizing that the most accurate information on emissions is usually developed by experts from individual countries, the IGAC Steering Committee has defined an activity whose main goal is the development of global emissions inventories by international teams of experts.

THE GLOBAL EMISSIONS INVENTORY ACTIVITY (GEIA).

The ultimate and very ambitious target of the Global Emissions Inventory Activity (GEIA, Graedel et al [2]) of IGAC is to establish emissions inventories for a number of trace species, incorporating fluxes from both anthropogenic and natural sources, with recognized accuracy and enough spatial, temporal and species resolution to serve as standard inventories for the international community of atmospheric scientists. To accomplish this, GEIA has the following goals:

- To establish a framework for the development and evaluation of global emissions inventories.
- To conduct a critical survey of existing emissions inventories of compounds of major importance in global atmospheric chemistry.
- To publish inventories in the open literature and provide appropriate data files for use by scientists worldwide.

As with all other IGAC activities, GEIA tries to include all interested parties on a volunteer basis. Emissions inventory experts from individual countries, supported by local organizations, conduct their own research while maintaining contact through a network which includes FAX communication, electronic mail and participation in periodic face-to-face meetings, usually held in conjunction with other functions of mutual interest. The GEIA forum allows participants to discuss their work, draw on the combined expertise of their fellow members, and, most important, to coordinate their efforts so that results of their work are compatible and can be combined with a minimum of effort. GEIA activities include a project to provide basic data management support for the maintenance and distribution of the resulting inventories.

EMISSIONS INVENTORIES

Existing emissions inventories have been compiled for a variety of uses. Their spatial, temporal and species resolution are dependent not only on their final use but also on the resources available for and the methodologies used in their development. Historically, emissions inventory development started with what may be termed "effects inventories"; these inventories were directed toward specific impacts, such as environmental acidification or atmospheric visibility, or towards species that contribute to those effects. These inventories were generally regional or national in scope and included only anthropogenic sources. With the advent of environmental regulations, inventories were also needed to develop and administer these regulations; additional details on emission sources were included in the inventories to help in these endeavors.

Since individual measurement of every emissions source in large geographic areas is beyond the scope of any inventory project, emissions inventory methodologies must rely on combining "ancillary" data with extrapolation of detailed studies of representative samples of emission sources. In the compilation and use of the ancillary data, two main methodologies have been used; we choose to distinguish them as top-down and bottom-up; methodology selection depended on the level of detail needed in the inventory and the resources available. Top-down methods collect ancillary data at a high level of aggregation (e.g., fuel use in a geographic region), estimate emissions, and apportion these to lower levels via the use of surrogate information. Bottom-up methods collect ancillary data on a disaggregated level (e.g, fuel use by individual installation), estimate emissions, and aggregate values to obtain results at higher levels of aggregation. In general, inventories which must also support regulatory activities require details on individual sources and so use the later method to estimate emissions.

As scientific studies of environmental problems advanced, it became recognized that the interaction between natural and anthropogenic emissions could not be separated. Thus emissions from natural sources must be known with the same attributes as for anthropogenic sources. Because of this belated recognition, however, work on detailed emissions inventories from natural sources has lagged behind that for anthropogenic sources. In addition, the atmosphere is ignorant of regional and national boundaries and provides a mixing and reaction chamber for all emissions. It was also recognized that chemical interactions between disparate species must be considered, especially if the effects of changes in emissions patterns are to be evaluated. Thus the need developed for inventories of both anthropogenic and natural sources, incorporating multiple species and covering large geographic areas. Resources and expertise needed to compile detailed inventories covering these large areas (multinational, hemispheric, and global) were generally not available to individual scientific projects. To date, the development of large inventories has been accomplished using top-down methods, and has encountered large difficulties obtaining appropriate data.

The GEIA activity will encompass all the phases of the compilation of the desired emissions inventories. To help direct the work, inventories have been initially classified into five types: supporting inventories, effects inventories, process inventories, specific events inventories, and past/future inventories.

- Supporting inventories do not themselves include atmospheric data nor emissions values; these are the inventories (or data files) needed for the derivation or apportionment of the actual emissions values, i.e., the ancillary data. These data may reflect natural conditions or human activities; examples include populations (human, animal, etc), vegetation cover, topography, land use, soil type, etc.

- Effects inventories have been described above; these inventories are directed to the study of a specific impact such as acidification, or towards a species that contributes to that effect. As previously mentioned, these were the first types of inventories to be developed and are the most common to date.

- Process inventories are those connected with a specific process or activity; biomass burning is a good example. Biomass burning is a significant contributor to many global atmospheric budgets and is a periodic event in many parts of the world.

- Specific events inventories comprise those emissions arising from specific events. These inventories are usually produced as the need arises rather than on a regular basis; examples include emissions from large volcanic events, emissions related to war, etc. Development of inventories for some events, previously considered of short duration, are being extended to a more regular basis; an example is inventories of emissions from degassing volcanoes.

- Past/future inventories refer to specific periods in the past, used in studies related to historical atmospheric chemistry, or present scenarios of emissions for some future period of time, used in connection with predictive studies of atmospheric chemistry and air quality. In connection with field data from sediments and ice cores, they provide the potential to link emissions with effects over very long time periods.

Key atributes of emissions inventories include geographic area covered, spatial scale, temporal resolution, species included, etc. These attributes mainly depend on the purpose for which the inventory is assembled and on compromises between data availability and the resources available for inventory compilation. Two of the most important attributes of any inventory are the geographic area covered and the spatial scale. For some urban areas and regional locales emissions inventories are available on quite detailed spatial and temporal scales; however, in general, current availability of detailed emissions information for large areas is limited and is expected to be no easier to assemble in the future. This presents problems for atmospheric modelers. Regional and urban area models in use today have the potential to use inventories with spatial scales of only a few kilometers. While today's best climate models typically have spatial resolutions of about 4° latitude by 5° longitude, as computing power increases over the next decade or so these models are expected to improve their spatial resolution to 1° by 1° and to add increasingly sophisticated chemistry. These detailed and refined models will be of limited benefit unless reliable emissions inventories on the same spatial scale are available.

Another important attribute of emissions inventories is the temporal scale. The majority of existing inventories are constructed on an annual basis, a time scale appropriate for very long-lived species such as chlorofluorocarbons, or for models interested in assessing long-term variability of atmospheric chemistry. In many cases, models are designed to assess atmospheric chemical variability on shorter time scales: seasonal, monthly, diurnal, etc. As with spatial scale, the temporal scale of emissions inventories must be suited to the problem that will use the information, or results will be of limited usefulness. Today's best global climate models have temporal scales of annual or at most seasonal; this resolution is expected to be maintained for some time.

Yet another important attribute of emissions inventories is the chemical species that are included, since atmospheric chemistry models may involve complex reactions. The study of photochemical smog is an example of a problem requiring complex chemistry. The necessary emissions inventories include information on oxides of nitrogen, hydrocarbons and perhaps other species. Hydrocarbon emissions require further chemical speciation; categories to be included depend on the chemical mechanisms being used and vary between different models. The compilation of inventories for this problem needs to draw on inventories designed for compatibility, and in which the same techniques are used to derive emissions estimates for all chemical species of interest.

Emissions inventories produced under GEIA auspices are not expected to begin to be available before 1993, and many will require a much longer time period. In advance of providing GEIA's internationally recognized emissions inventories, a GEIA subcommittee has compiled a summary and description of existing inventories, together with their spatial and temporal attributes and a few interpretive comments (Graedel et al [2]). The only global ensemble emissions inventory that is regarded as good at the present is that for CFCs. Those for CO_2, CH_4, NO_x, SO_2, reduced sulfur, and radon are regarded as fair. "Good" impleas an estimated accuracy of 20% or better, "fair" of 50% or better. In selected regions, the spatial resolution of emissions is well-determined for CO_2, CO, NO_x and SO_2. The temporal resolution of existing inventories is almost uniformly poor. This compilation provides the detailed justification for the GEIA inventory activities, while, in addition, serving to some degree the needs of the modeling community on the immediate time scale.

CURRENT GEIA ACTIVITIES

Work under the GEIA umbrella is directed by a Steering Committee and carried out by study groups. The Steering Committee is drawn from members of the individual study groups; it sets the overall direction for and coordinates all GEIA activities. The Steering Committee has adopted several principles of operation to govern emissions inventory tasks:

- The ultimate goal of GEIA is to produce emissions inventories for all species of interest on a 1° by 1° global grid.
- All inventories shall be accompanied by point by point assessments of their degree of uncertainty.
- The study groups formed for each GEIA activity shall be international and intercontinental in makeup.

Given the many possibilities for inventory development, the Steering Committee has decided to begin the GEIA tasks by concentrating on evaluating and producing effects inventories targeted to individual species or groups of closely related species. Individual study groups will be established as the interest of participants develops. Table 1 presents a summary of the GEIA study groups active as of January 1992, the director or directors for each group, and the target temporal resolution for each inventory. Supporting inventories, especially those used for the development of the effects inventories to be evaluated and used, will be recognized and encouraged but will not be a formal part of GEIA. Part of the mandate of the Data Management group is to develop and implement the GEIA policy towards this type of inventory. Event inventories, historical inventories and future scenario inventories are also within the GEIA purview; these will be accomplished as time, personnel and resources allow. In fact, one of the current GEIA study groups is addressing what was previously defined as a "regular specific event", biomass burning.

ANTHROPOGENIC SO_2/NO_x INVENTORY: INITIAL WORK

Currently the most advanced work of the GEIA study groups is the compilation of an anthropogenic emissions inventory of SO_2 and NO_x. The study group, headed by Jozef Pacyna of the Norwegian Institute for Air Research (NILU), has set a deadline of June 1992 for an initial version of annual inventories and December 1992 for an initial version of seasonal inventories. Inventories are being assembled in an incremental mode; a basic global inventory is selected and emissions for a particular geographic area are substituted as more accurate, complete data become available. Work on inventories covering two timeframes, annual and seasonal, is proceeding in parallel.

Compilation of global emissions inventories for SO_2 and NO_x started in the early 1980s. The following articles describe information that can be utilized.

Cullis and Hirschler [3] developed a global inventory of sulfur emissions from all sources; the methodolo-

Table 1. GEIA Study Groups, January 1992

Species	Source Type	Temporal Res.	Director
SO_2	Anthropogenic	S	J.M. Pacyna, NOR
NO_x	Anthropogenic	S	J.M. Pacyna, NOR
CO_2	Anthropogenic	A	G. Marland, USA
NH_3, N_2O	Natural	S	A.F. Bouwman, NL
VOC	Anthropogenic	S	C. Veldt, NL
Radioisotopes	Natural	A	M. Kritz, USA
Biomass Burning		S	B.J. Stocks, CAN J.S. Levine, USA
VOC	Natural	S	N. Hewitt, UK A. Guenther, USA
Data Management	NA	NA	P. Middleton, USA

A=Annual S=Seasonal NA=Not applicable

gy used is based on estimates of activity rates, fuel sulfur content, and appropriate emission factors. Their global estimate for 1976 is 103.6 Tg S, of which 91.1 Tg S are from fuel use.

Möller [4] developed a global inventory of anthropogenic sulfur emissions from all sources. His methodology is based on estimates of activity rates, fuel sulfur content, and appropriate emission factors. The total global estimate for 1985 is 90 Tg S; for fuel combustion sources only, the figure is 82.5 Tg S. Linear interpolation to 1980 results in 80.0 Tg S total emissions and 74.0 Tg S for emissions from fuel combustion. Langner and Rodhe [5] have allocated the Möller 1980 figures to geographic grids based on the emission pattern for CO_2 presented by Marland et al [6] and Rotty [7].

Várhelyi [8] developed a global inventory of anthropogenic sulfur emissions from all sources for 1970 and 1979. The methodology used is based on a data survey of the consumption of fossil fuels containing sulfur, their sulfur contents, production statistics of SO_2 emitting industrial processes and the appropriate emission factors. Total emissions for 1979 is 79.2 Tg S yr^{-1}, and from fuel combustion 64.1 Tg S yr^{1}. This inventory is not available in gridded form.

Hameed and Dignon [9] developed global inventories of anthropogenic sulfur and nitrogen emissions of SO_2 and NO_x which includes fuel combustion only and extend to 1980. The methodology used was detailed in Dignon and Hameed [10] 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 data were allocated to a 5° x 5° latitude/ longitude grid based on population. Global estimates are 57 Tg S yr^{-1} and 20 Tg N yr^{1}. Dignon [10] upgraded this inventory to a 1^0 by $1°$ grid, with global emissions of 62 Tg S yr^{-1} and 22 Tg N yr^{-1}.

Levy and Moxim [12] developed an inventory of NO_x emissions on a 2.4° x 2.4° grid with three levels in the vertical. Data for this inventory were derived from values in the National Acid Precipitation Assessment Program's 1980 inventory for North America, from values in Eliassen et al [13] for Europe and from Hameed and Dignon [9] for the rest of the world.

Spiro et al [14] developed a global inventory of anthropogenic and biogenic sulfur emissions for 1980. Methodology used was also based on activity rates, sulfur contents of fuels and appropriate emission factors. Revised estimate of anthropogenic emissions is 88.4 Tg S yr^{-1}; emissions from fuel combustion are given as 81.7 Tg S yr^{-1}.

Two gridded inventories of anthropogenic SO_2 emissions are based on a 1° x 1° grid: Dignon [11] and Spiro et al. [14]. The Dignon inventory includes only emissions from fossil fuel combustion, while the Spiro et al. inventory includes emissions from industrial activities. Only one inventory of anthropogenic NO_x emissions is based on a 1° x 1° grid: Dignon [11]. However, at the start of our project to compile the annual inventory for GEIA the only data files available were from the Dignon work, so these were selected as the basic GEIA inventories for SO_2 and NO_x. 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).

To date, 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, [15]). 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. Table 2 presents an overall summary of results.

Table 2. Summary of North American Emissions in GEIA Inventory

	SO_2	NO_x
Units: 10^6 metric tons as	S	N
Basic GEIA fuel combustion emissions	62.8	21.9
NAPAP 1985 total emissions for NA	12.3	6.2
Current GEIA global emissions	62.1	21.4
Basic GEIA emissions for NA	13.0	6.7
Basic GEIA emissions for non-NA cells	49.8	15.2
NAPAP 1985 combustion emissions	9.8	5.9
NAPAP 1980 combustion emissions	11.3	6.3

The NAPAP 1985/1980 combustion emissions were obtained from the corresponding NAPAP reports (Saeger et al, [15]; Wagner et al, [16]) by adding the categories: electric utilities, industrial combustion, commercial/residential/ other combustion and transportation.

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, Iversen et al, [17]). Values from this inventory have been 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; these values will be transferred to the 1° x 1° GEIA grid and will replace the corresponding values in the basic GEIA inventories.

Contact has been established with researchers in Japan, who are working to compile inventories of SO_2 and NO_x emissions for Asia. This work is expected to be based on geopolitical entities (provinces, etc.) for the larger countries, and on the country basis for smaller countries. Emissions will be apportioned to the GEIA grid based on population, using the methodologies and data files developed for the Dignon [11] work. Contact has also been established with researchers in Australia; an inventory for this area is expected in June 1991. Additional contacts have been established with researchers in Brazil; it is hoped that these and future contacts will be able to provide more accurate emissions data for their geographic areas.

DISCUSSION

One of the most important scientific tools used in the assessment of atmospheric chemistry, air quality and climatic conditions of the past, present and future is the mathematical model of transport and transformations in the atmosphere. Such models rely in part on inventories of emissions constructed on appropriate temporal and spatial scales and including the required chemical species. The production of such inventories is an area of research whose importance to the accuracy of results of modeling and assessment activities has come to be fully recognized.

The ultimate goal of the Global Emissions Inventory Activity (GEIA) of IGAC is to establish emissions inventories for all trace species of interest to the modeling community, incorporating fluxes from both anthropogenic and natural sources, with enough spatial, temporal and species resolution and of recognized accuracy to serve as standard inventories for the international community of atmospheric scientists. The current GEIA study groups (Table 1) represent a vigorous start toward that goal, but many other topics also require attention. In Table 3 we list a number of inventories that have been proposed by atmospheric modelers. We invite anyone who would like to take the lead or participate in developing any of these inventories to contact either of the authors.

Table 3. Proposed GEIA Study Groups, January 1992.

Species	Source Type	Temporal Resolution
Effects Inventories		
Ammonia	Anthropogenic	S
Carbon Monoxide	Anthropogenic	S
Methane	Anthro + Natural	S
Organochlorines	Anthropogenic	A
Reactive Chlorine	Anthro + Natural	S
Reduced Sulfur	Anthro + Natural	S

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Species	Source Type	Temporal Resolution
Soot	Anthro + Natural	S
Particulate Matter	Anthro + Natural	S
Trace Metals	Anthropogenic	A
Process Inventories		
Aircraft	Anthropogenic	S
Specific Event Inventories		
Volcanoes	Natural	A
Past/Future Inventories		
Historic Carbon	Anthro + Natural	D
Historic Nitrogen	Anthropogenic	D
Historic Sulfur	Anthropogenic	D
Future Scenarios	Anthropogenic	A

S = seasonal A=annual D=decadal.

Finally, we emphasize that no amount of development of atmospheric modeling capability can produce improved assessments of atmospheric chemistry and its associated impacts unless suitable, rigorous emissions inventories are available. The development of these inventories, in close cooperation with the scientific community, is the goal of the GEIA project. We invite contributions of all interested parties throughout the world.

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Chlorofluorocarbon Emissions

Since the last IGAC emissions committee meeting, there has been significant convergence in the release estimates for $CFCl_3$ and CF_2Cl_2 between figures derived from industrial production and those inferred from atmospheric measurements. The worldwide consumption figures for 1986 given in the recently released United Nations Environmental Programme Report (UNEP, 1990) have provided new information on production in Eastern Europe and the former USSR. Simultaneously, the ALE/GAGE measurements have now been referenced to the Weiss absolute calibration side and the data has been carefully analyzed recognizing the potential impact of non-linearities in the measurement system (Cunnold et al, 1992).

Fig. 1 shows a comparison of the two sets of emission estimates for $CFCl_3$ and CF_2Cl_2 There is some disagreement in 1978-1980, but it is suggested that this disagreement would be substantially reduced if $CFCl_3$ emissions in Eastern Europe and the USSR were to bear the same ratio to CF_2Cl_2 emissions before 1983 as was reported for 1986 in UNEP (1990). The ALE/GAGE emission estimates are slightly dependent on atmospheric modeling assumptions and are based on atmospheric lifetimes, at equilibrium, of 42 years for $CFCl_3$ and 122 years for CF_2Cl_2. These lifetimes have been inferred from the data and are in excellent agreement with those calculated in a three-dimensional model (Golombek and Prinn, 1992) based on the measured photodissociation cross-sections of these molecules. Overall, there is excellent agreement between the two sets of emission estimates; in particular, both estimates show a reduction in emissions since 1988 in response to the production limitations contained in the Montreal Protocol (UNEP, 1987).

Based on this agreement, the chlorofluorocarbon emissions sub-committee should now focus on the spatial distribution of releases. Unfortunately, for competitive reasons, at best, production figures may be broken down into continental size regions. Therefore, modelers have been forced to employ proxies such as population and electric power consumption figures in attempts to obtain regional emission estimates. A preliminary comparison of CH_3CCl_3 emission figures by continental-size region shows little relationship with the above-named proxies. We expect to obtain some production figures for Australia and we have begun discussions with the United States EPA to see what figures might be available for the USA. An in-depth discussion of these issues is being planned and may take place at the time of the next emissions committee meeting.

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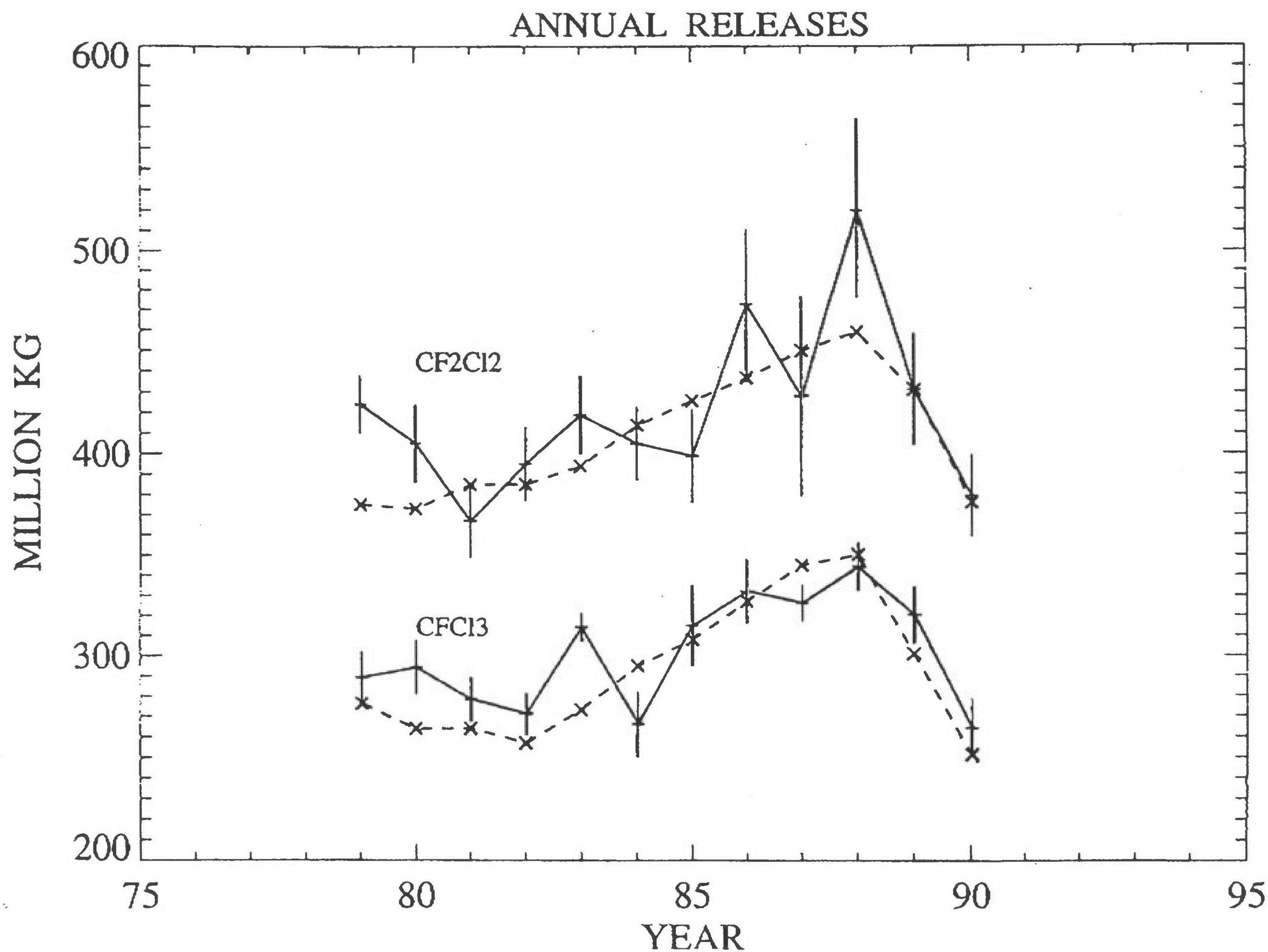

Figure 1. Annual releases of $CFCl_3$ and CF_2Cl_2 and 1σ uncertainties estimated from 13 years of ALE/GAGE data (points are joined by a full line). These are compared against the most recent estimates of world releases (Miller, 1992) (crosses joined

Second GEIA Workshop on Global Emissions Inventories

Anthropogenic SO_2/NO_x Committee

Summary of Current Status - Annual Inventory

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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 basis for the GEIA SO_2 and NO_x annual inventories. The Dignon data include emissions from fuel combustion only and currently extend 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).

To upgrade the basic GEIA inventories, data for the differe[illegible]phic regions are being solicited from researchers located within these areas. T[illegible]wing upgrades have been accomplished.

The most comprehensive inventories of SC[illegible]ted States and Canada has been compiled by the National Ac[illegible]am (NAPAP, Saeger et al., 1989; Wagner et al., 1986). [illegible]ase year 1985 emissions inventories were selected to replace va[illegible]A inventories for the U.S. and Canada. Annual values for point sources [illegible]ocated to the GEIA 1° x 1° grid; the NAPAP spatial allocation file, which all[illegible]ea sources to the NAPAP 20 km grid was used as the basis for the allocation of area [illegible]urces to the GEIA grid. Table 1 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 basic 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, Iversen et al., 1991). 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

Base Inventory: Dignon (1992).	
1980 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})	62.8
Global NO_x emissions (10^6 metric tons N yr^{-1})	21.9
U.S./Canadian Inventory: 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 base inventory (10^6 metric tons S yr^{-1})	13.0
NO_x emissions in base inventory (10^6 metric tons N yr^{-1})	6.7
European Inventory: EMEP (1991).	
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})	23.0
European NO_x emissions (10^6 metric tons N yr^{-1})	7.6
SO_2 emissions in base inventory (10^6 metric tons S yr^{-1})	23.2
NO_x emissions in base inventory (10^6 metric tons N yr^{-1})	7.1
Asian Inventory: Kato and Akimoto (1992).	
1985 emissions from transformation, industrial, transportation and misc.	
Regional based emissions for China and India, country based 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 base inventory (10^6 metric tons S yr^{-1})	13.6
NO_x emissions in base inventory (10^6 metric tons N yr^{-1})	3.6

Table 1
Summary of Current Work on Annual SO_2 and NO_x Inventories

km x 150 km polar stereographic grid; these values were transferred to the 1° x 1° GEIA grid and replaced the corresponding values in the basic GEIA inventories. Table 1 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 basic GEIA inventory.

Kato and Akimoto (1992) developed inventories of SO_2 and NO_x emissions for 25 [1] 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. Table 1 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 2 summarizes the current status of the GEIA work on annual emissions of SO_2 and NO_x from anthropogenic sources. Table 3 summarizes the next steps to be taken by this project.

Base Inventory:	Dignon 1980 fuel combustion emissions. (Dignon, 1992).
North America:	48 Lower U.S States/Canada from NAPAP 1985 vers. 2.
	Alaska and Hawaii from base inventory.
	Mexico from base inventory.
Central America:	All countries from base inventory.
South America:	All countries from base inventory.
Europe:	EMEP 1985.
Asia:	USSR from base inventory.
	All others, 1985 emissions from Kato and Akimoto.
Africa:	All countries from base inventory.
Australia:	From base inventory.
Current Contributors:	
Hajime Akimoto (Japan)	Carmen M. Benkovitz (US)
Jane Dignon (US)	Nobuo Kato (Japan)
Jozef Pacyna (Norway)	David Simpson (Norway)

Table 2
Summary of Current Status of Annual SO_2 and NO_x Inventories

[1] 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 to be upgraded to 1985 emissions.
Australia emissions expected from Dr. F. Carnovale, EPAV, Australia.
Asian emissions from several sources to be studied and selection made: Major point sources in Asian part of Russia compiled by NILU. Work on Asian emissions by Arne Semb, NILU. Work on Chinese emissions by Xu Quiang. Work on Chinese emissions by Weng Wenxing. Work on Japanese emissions by Tonooka.
Berlyanda report on emissions in old USSR to be studied.
Initiate/pursue contacts with researchers in Brazil, OECD representatives from African countries, Saudi Arabia, Israel.
Study the development of an inventory of DMS emissions from oceans.
Sudy the development of an inventory of sulfur emissions from volcanoes.

Table 3
Future Work on Annual SO_2 and NO_x Inventories

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PROGRESS REPORT NATURAL AND AGRICULTURAL N_XO_Y AND NH_3 INVENTORIES

I NH_3 emissions inventory

Steering committee: K. Van Der Hoek, RIVM, Netherlands; W. Asman, Nat. Env. Inst., Roskilde, Denmark; C.T. Ripberger, EPA, USA; Prof. Zhao Dianwu (China)

- European inventory: this work is carried in the framework of the UNECE Task Force on Emission Inventories. Leader of the NH_3 expert panel is K. vd Hoek (RIVM, Netherlands). A first inventory has been carried out by W. Asman (Denmark), K. vd Hoek. The plan is to prepare a final digitized database for Europe in 1995.
- China: the inventory of NH_3 emissions in China has started by the Research Center for Eco-Environmental Sciences, Academia Sinica, Beijing (Prof. Zhao Dianwu). Prof. Dianwu work is progressing well.
- Other developing countries: Prof. Mitra has been asked to investigate how and by whom the Indian inventory can be carried out.
- Compilation and data collection for white spots: to be able to start this work in 1992, funding for the required 1-2 person years of work has been requested from the Dutch Ministry of Public Health, Physical Planning and Environment (VROM) earlier this year. This was not possible, and now possibilities to get the work done with funding from RIVM are investigated in June/July.

II N_2O emissions inventory

Steering committee: S.P. Seitzinger (Philadelphia Acad. Sci), J. Elkins (NOAA, Boulder, Colorado), A.F. Bouwman (Netherlands); M. Keller (NCAR) and possibly Australian (John Taylor ?) and German experts.

- The paper on N_2O emissions from natural soils has been submitted to Global Biogeochemical Cycles. If accepted, the 1x1° database can form one of the pieces in the N_2O puzzle.
- A paper on agricultural emissions and emissions related to biomass burning and animal excreta has been presented in Tsukuba, Japan at the CH_4 and N_2O workshop, March 1992. Work on this inventory is still ongoing, and the plan is to discuss the results in the following GEIA workshop in February 1993 in The Netherlands.
- Oceanic emissions and emissions from surface waters: experts in this field (Elkins, Seitzinger) will be encouraged to participate in the following GEIA workshop.
- John Taylor (CSIRO, Australia) has offered to use his atmospheric tracer model to check the emission inventory prepared. If this kind of calibration of models and inventories is possible, the work will be carried out in the course of this year. Taylor will try to attend the GEIA meeting in The Netherlands.

III NO_x EMISSIONS

Steering committee: E.J. Williams and F. Fehsenfeld (NOAA, Boulder, USA), J. Dignon (LLNL, USA), A.F. Bouwman (RIVM, Netherlands); M. Keller (NCAR, Boulder); R. Delmas, Universite P. Sabatier, Toulouse, France; contact is being sought with I. Galbally (CSIRO, Australia).

- The database developed by Jane Dignon (paper on soil NO_x emissions presented at the Chemdrawn meeting in December 1991) may form a good basis. The simple model used would need to be checked with measurements from other regions with different climatic conditions. For example, measurements are made from September 1990, and this long term record may be very helpful.

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ANTHROPOGENIC VOLATILE ORGANIC COMPOUNDS INVENTORY STATUS REPORT

June 1992

INTRODUCTION

Since the first IGAC-GEIA workshop (Baltimore, December 1991) no substantial progress has been made due to a delay in funding. In the second half of 1992, however, work is expected to develop within the framework of the Netherlands' National Research Programme on Global Air Pollution and Climate Change. For the third workshop in December 1992, therefore, hopefully real progress can be reported. This interim report summarizes developments in the first half of 1992.

STEERING COMMITTEE

Dr.Michael Woodfield (Warren Spring Laboratory, Stevenage, UK) joined the Committee. He and his group are active in VOC factor and -profile development.

Dr.Shinji Wakamatsu resumed work on VOC after a time-consuming reorganisation of his institute.

Committee members are

Lee Beck (EPA, USA)
Carmen M.Benkovitz (BNL, USA)
Remy Bouscaren (CITEPA, France)
Chris Veldt (TNO, Netherlands)
Shinji Wakamatsu (NIES, Japan)
Mike Woodfield (WSL, UK)

ACTIVITIES, GENERAL

At the end of 1991 proposals for the development of parts of a methodology for estimating global VOC were distributed among experts with the request for further distribution. Remaining forthcoming responses and personal contacts give the impression that inventorying VOC still widely is approached timorously c.q. will only reluctantly be used for global purposes.

For global inventorying, however, it is necessary that a distinction is made between sources that can be treated with existing knowledge and those about which only speculation is possible.

A proposal for a complete methodology is planned. It is hoped that this will stimulate discussion and cooperation.

ACTIVITIES, MAIN SOURCES

Oil industry

A reevaluation of emission factors is in progress by WSL.
The suspiciously high emissions in Russia need to be discussed with experts. First, these have to be found. A start has been made, but prospects are not well.
Operation and maintenance in regions outside the OECD, as far as different from this organizations' members practice are a serious constraint on the inventory. Extrapolation will be inevitable. Expert groups will be consulted.

Combustion of biomass

A classification can be made as follows:
Large scale : vegetation
Medium scale: agricultural waste
Small scale : residential use
There is no well defined boundary between the first and second category. Only the third category is part of the VOC-A programme. It can contribute to the second.
From abundant studies on fuel use reasonable estimates can be made of mass rates in LDC's. Mass rates in OECD countries and eastern Europe have been estimated with an accaracy that should be considered as satisfactorily. Amounts of agricultural waste burned in situ will be more difficult to assess (not in all regions).
Emission factors and profiles for all three categories have been developed from relatively scarce data. A comparative study is being done by TNO.

Mobile sources

In OECD countries emission factors have a firm basis in measured data (although uncertainties are still present). In LDC's, vehicle fleet characteristics and driving habits generally are different from those in OECD countries and are only partly quantified. Because measured data are scarce, extrapolation will be necessary for factor development. Prospects for this are slightly optimistic. COPERT can make suggestions which should be applied in cooperation with EPA.
Comparatively, there is sufficient information on profiles, but differentiation is possible only with respect to fuels and catalytic control.
WSL have committed themselves to reevaluate profiles of controlled and uncontrolled exhaust.

Solvent losses

Both factors and -profiles are determined by consumption. Therefore, market data are the basis for an inventory. In the USA and western Europe these are reasonably well known. Extrapolation to other regions is not possible. Contacts with suppliers are necessary but no action has started as yet. First approximations might be made from volumes of specific economic sectors, such as graphic arts, metal products- and pharmaceutical industry, tyre manufacturing and paint consumption.

Small-scale combustion of solid fossil fuels

Emission factors are available. Recent measurements by WSL will add to the almost absent information for profile development.

Large methane sources
Apart from natural gas use, coal mines and landfills are the main anthropogenic sources of methane. For both categories factors have been developed.

PROFILES, GENERAL

The suggested extension of the SAROAD code listing should be discussed when consensus is reached about profiles.

C.Veldt, IMET-TNO
June 1, 1992

Modelling temporal resolution of emissions in GENEMIS

by Matthias Heymann

Institute of Energy Economics and the Rational Use of Energy
Stuttgart University

In this paper the main features of GENEMIS will shortly be presented and modelling approaches for temporal resolution in the LOTOS inventory from TNO and the Baden-Württemberg inventory from the IER be discussed.

1. Main features of GENEMIS

GENEMIS is part of the EURECA environmental project EUROTRAC, which is dedicated to the investigation of transport and transformation of environmentally relevant trace constituents in the troposphere over Europe. Within EUROTRAC many subprojects are dealing with emissions, chemical processes and transport phenomena in the atmosphere, measurements and instrument development. The final objective is to increase our knowledge about photo-oxidants and the formation of acidity, and to provide models, which describe atmospheric processes and improve the scientific basis for political decisions.

For certain episodes measurement campaigns of ambient air concentration are carried through and models for the same episodes are applied to test and verify the model performance. It is quite obvious that emission data of very high quality are needed as input to facilitate atmospheric modelling of episodical air pollution. These emission data have to cover the whole area of Europe, all relevant pollutants, and they have to have good spatial and temporal resolution.

Quite some knowledge about annual emissions in Europe is available, which does not help very much to understand episodical pollution phenomena caused by species with short atmospheric lifetimes. Extremely little and not very reliable information exists about monthly, daily and hourly emissions. I only know three studies dealing with the temporal resolution of emissions: one study of US EPA for the United States, the PHOXA study from a collaboration between German and Dutch groups for parts of Northern and Western Europe and studies of my institute for the land of Baden-Wuerttemberg in Germany.

Because emission data for EUROTRAC needs are not available in sufficient quality, the GENEMIS project was founded in 1991 and started its work this year. The acronym GENEMIS stands for 'Generation of European Emission Data for Episodes'. As all EUROTRAC-projects, GENEMIS is an international project consisting of several working groups in different countries, my instute being the coordinating institute. The main tasks of GENEMIS are:

* the development and improvement of methodologies for the calculation of emission data for episodes
* the preparation of hourly emission data for episodes from 1985 to 1994 for EUROTRAC activities.

Features of the data to be provided are the following:

pollutants covered:	SO2, NOx, VOC (including VOC-splits), CO, NH3 and Cl-.
investigation area:	the whole area of Europe
investigation period:	episodes between 1985 and 1994; future periods up to 2005
spatial resolution:	territorial units; different grids
temporal resolution:	1 to 3 hour periods

The work of GENEMIS will be based on available annual emission data from different inventories, which have to be temporally disaggregated.

2. Modelling approaches for temporal resolution

Concerning the temporal resolution of emission data, not many experiences have been made so far. I will shortly discuss the efforts of the LOTOS inventory, of my institute, and the modelling approaches planned for GENEMIS, as well as the shortcomings of these efforts.

a. LOTOS: Emission inventory for Europe

LOTOS was prepared by Chris Veldt from TNO as a first emission data base for EUROTRAC. It is based on CORINAIR 1985 data and on information from different sources in Eastern Europe and Scandinavia. Additionally it provides simple time factors for the temporal resolution, which had been taken from the Dutch-German PHOXA inventory.

The features of LOTOS data are the following:

area:	Europe
species:	SO2, NOx, VOC, CO
investigation area:	Europe
year:	1985, update 1986, update 1990 in progress
source categories:	12 (including natural emissions)
grid size:	1° latitude, 2° longitude
temp.res.:	day/night emissions; time factors

As one example total NOx emissions for the whole area of Europe can be seen on the first graph. The highest emissions occur in Western Europe mainly due to traffic intensity. For the GDR emissions given by LOTOS are equally high, which seems rather unprobable.

LOTOS time factors distinguish winter/summer, workday/weekendday and day/night emissions. For different source categories different factors have been prepared, but the temporal variation is assumed to be the same in all European countries, which, of course, is a very rough estimation. Statistical information for the estimation of time factors has been used for two source categories only: utility combustion, for which statistical material had been easily available, and road traffic, for which traffic counts in Germany and in the Netherlands had been taken into account. This information had been assumed representative of all European countries. All other time factors are simply and only based on assumptions.

As an example of hourly emissions according to LOTOS time factors, the next graph presents hourly NOx emissions in a winter week. We recognize a very strong day/night variation and somewhat lower values for the weekend, which seems reasonable.

b. IER: Baden-Wuerttemberg inventory

In the last years my institute, the Institute for Energy Economics and Rational Energy Use (IER), at Stuttgart University carried through inventories for Baden-Wuerttemberg, which included the development of detailed models for the temporal resolution. This inventory has the following features:

species:	SO2, NOx, VOC, CO
area:	Land of Baden-Wuerttemberg, FRG
year:	1985
source cat.:	detailed source groups (no natural emissions)
grid size:	1 x 1 km2
time factors:	hourly emissions; detailed models

As an example you see on the next graph NOx emissions of one hour of a friday-afternoon summer 1985. Cities, highways and big roads can clearly be identified. The next graph presents hourly NOx emissions in a winter week. On this graph the hourly variation of power plant, industry, small industrial, residential and traffic emissions can be identified. The biggest share and the main temporal variation is caused by traffic. We see main peaks from monday until friday and somewhat smaller peaks for saturday and sunday. Every workday additionally has a morning and an evening peak, due to rush hours and evening leasure traffic.

Unlike LOTOS time factors, these emission data have been calculated with the help of detailed models. How such models may look like will be illustrated by two examples. As one example let us take a closer look at combustion in industrial burners. The hourly energy consumption of industrial burners depends in principle on parameters like

- specific energy consumption of particular branches
- working hours
- structure and amount of the production of goods; production rates
- outside temperature

Taking into account these parameters as variables, a modelling equation has been set up with several regression coefficients. The value of the coefficients has for every branch been determined by using measured data of energy consumption for a number of representative plants and performing a multidimensional regression analysis. The next figure demonstrates such regression analysis for the case of the chemical industry. The red curve shows measured values of the monthly energy demand. The other curves different regression analyses, of which the curve named FIT gives the best correlation.

Another example is the case of private combustion. For private combustion the energy consumption for

- space heating
- cooking
- and hot water supply

has to be investigated and used for setting up a simulation model. The energy demand of space heating, which takes a share of about 85% of total residential energy demand in Germany, depends on

- weather conditions (represented by outside temperature, solar radiation and wind velocity)

- type and age of buildings
- heat conduction and heat storage of the building
- type of firing installations
- and consumer habits (room temperature, ventilation)

Taking such parameters into account, a dynamic simulation model for heat transfer has been developed for characteristic house types in Baden-Wuerttemberg. The results for a multiple dwellings house are represented on the next figure. The heating of this house type is in operation only between 5 and 8 o'clock in the morning and between 4 and 9 o'clock in the afternoon. With a non dynamic calculation a totally different and more uniform course would have resulted.

Similar models have been prepared and simulations been carried through for all important source categories.

Interesting is a comparison of IER and LOTOS results, which shows that LOTOS assumptions render quite a similar curve structure. IER emission data, however, include much more information and are more transparent.

c. Modelling approach for GENEMIS

GENEMIS will be based on annual emission data from LOTOS, CORINAIR and others. The main job of GENEMIS is to further temporally disaggregate these emissions and calculate hourly emission data.

For the temporal resolution we decided on a twofold approach, which incorporates features of both of the presented approaches (LOTOS for Europe and of the IER for Baden-Wuerttemberg). Due to the ambitious task, little time (we have to be able to calculate hourly emissions in the beginning of next year) and to limited resources we will in a first step adopt a simplistic and pragmatic approach, which is similar to the PHOXA time factor approach and could be called top-down. In a second step, more detailed approaches for certain countries and certain source categories will be adopted, as far as sufficient information is available and groups within GENEMIS have time, funds and ideas to carry them through. This second approach could be called bottom up.

The pragmatic 'top-down' approach includes the:

adoption of a harmonized CORINAIR 1985 / LOTOS 1985 structure
calculation of time factors or functions for source categories
use of simple and limited information
ad hoc solutions in case of missing information
development of simple procedures to calculate time factors/functions
development of procedures applicable to all countries

The temporal resolution of emissions, of course, depends on information available to temporally disaggregate emission activities. For the top-down approach we will mainly focus on the following kind of data:

1. Energy statistics as disaggregated as possible
- energy consumption
- electricity production/consumption
2. Industry statistics as disaggregated as possible
- production figures
- working times/shifts
3. Traffic data
- vehicle fleets (classes, size, age)
- traffic counts (urban, rural, highway as far as available)
4. Other socio-economic data
- population density
- holidays
5. Meteorological data
- outside temperature
- wind velocity

The top-down approach will have to be finished at the beginning of next year. Results should be more reliable and complex than LOTOS time factors. The improvements should especially be:

- hourly emissions
- consideration of important dependencies like outside temperature, etc.
- consideration of much more statistical material
- different time factors/function for different countries/regions

A severe problem in emission inventorying and especially in calculating temporal resolution is the verification problem. Results will not be very precise and we don't even know, how great deviations and errors may be. Measurement campaigns would be the best way to validate the performance of models and procedures. Some measurements projects within GENEMIS exist, but as yet only cover few countries and source categories. For the sake of transparency and data assessment sources of information and qualitative labels will be given and sensitivity studies be conducted.

Having developed simple top-down procedures, a subsequent bottom-up approach may be an additional means for the validation and verification of results. At this time the availability of information and important features of different countries may have become clearer. For particular source categories the development of more detailed models including more and more detailed information may be possible and useful. The bottom-up approach may have the following features:

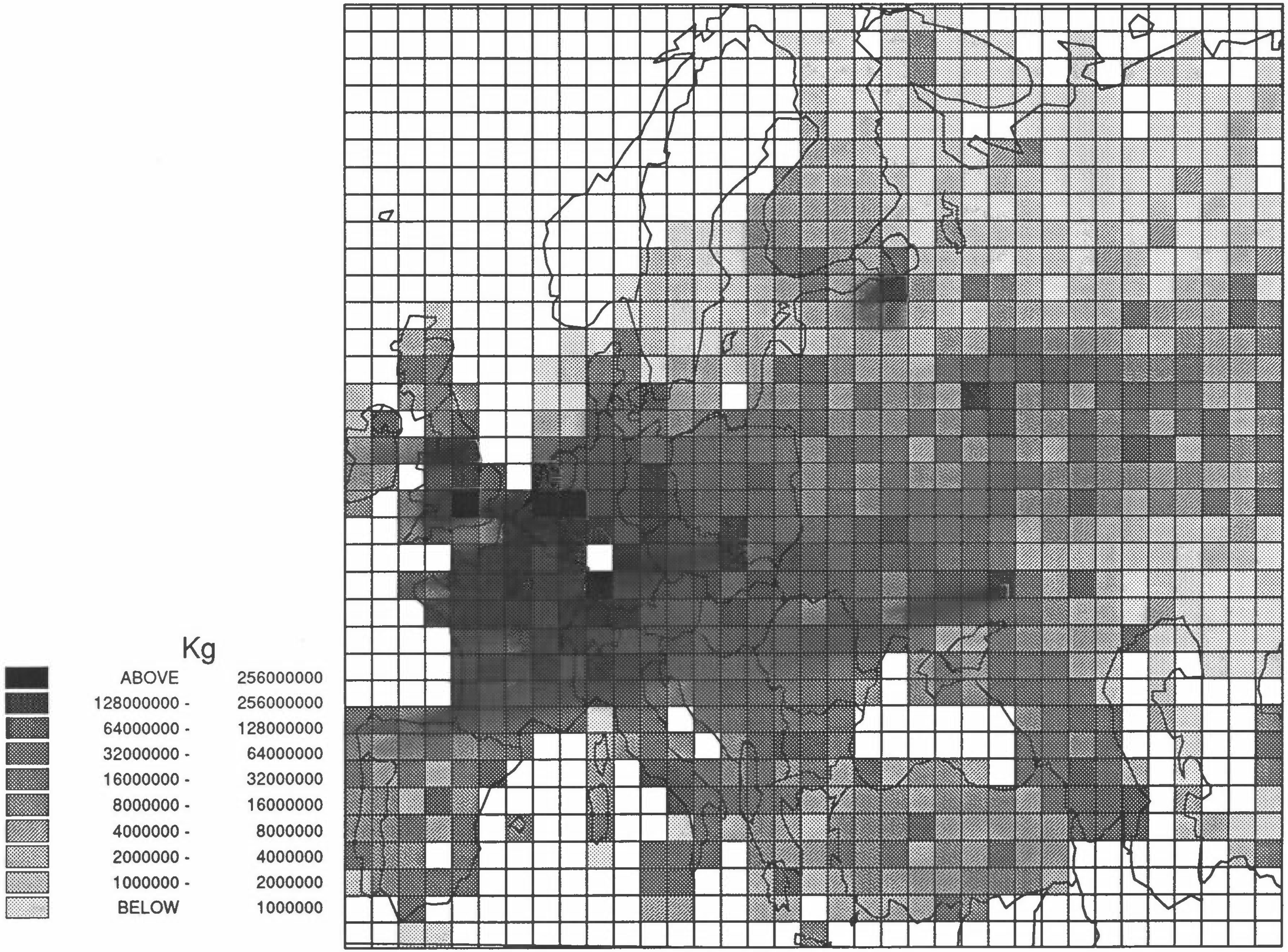
- use of more and more detailed information
- use of different statistical material for different countries
- development of different procedures for different countries
- consideration of better spatial resolution for certain countries/regions
- consideration of higher disaggregation of some source categories for certain countries

This second approach may render better results with higher disaggregation for all or certain regions or countries. Comparability and compatibility of results for different countries may, however, be reduced. Such models and procedures will be a more powerful tool to more detailed calculate hourly emissions, which could be used for the assessment of emission reduction strategies.

GENEMIS Workshop

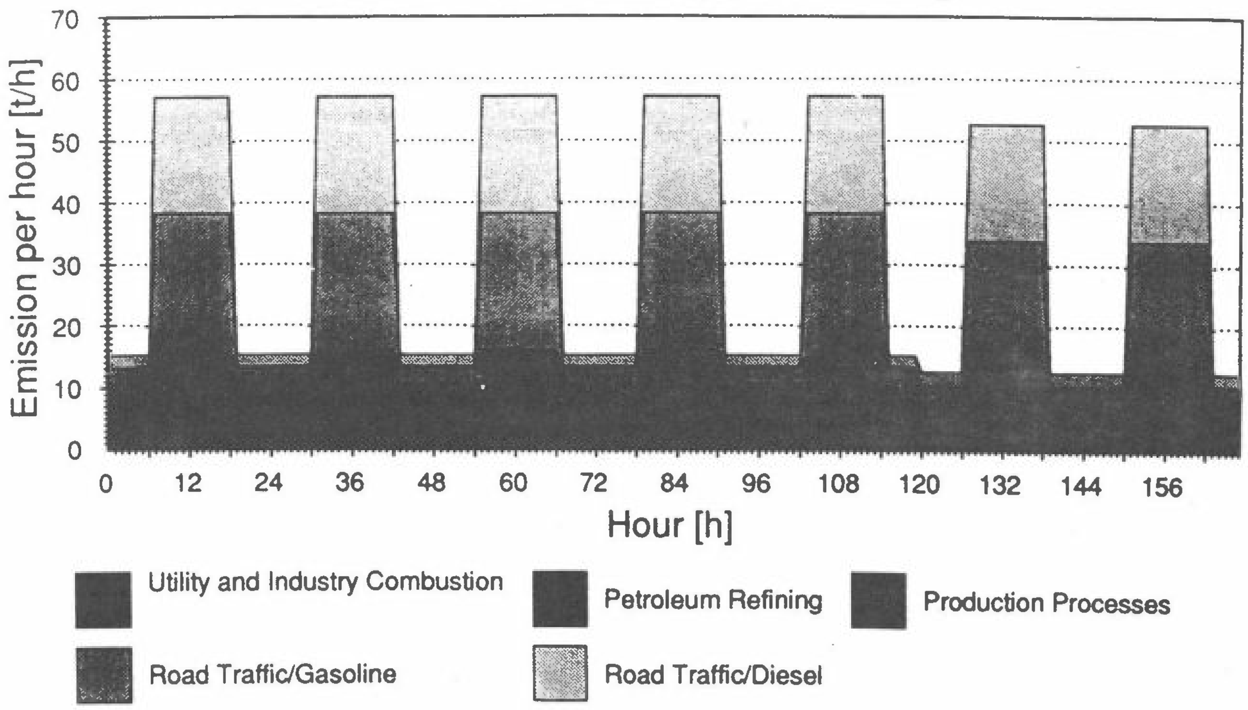
At the end I would like to mention the GENEMIS Workshop 1992, which will take place October 7-8th in Stuttgart. It is dedicated to the discussion of approaches to model the temporal resolution and updates of emission data. Certainly all of you are kindly invited. Papers to be presented would be very much appreciated.

Total NOx


Kg
ABOVE 256000000
128000000 - 256000000
64000000 - 128000000
32000000 - 64000000
16000000 - 32000000
8000000 - 16000000
4000000 - 8000000
2000000 - 4000000
1000000 - 2000000
BELOW 1000000

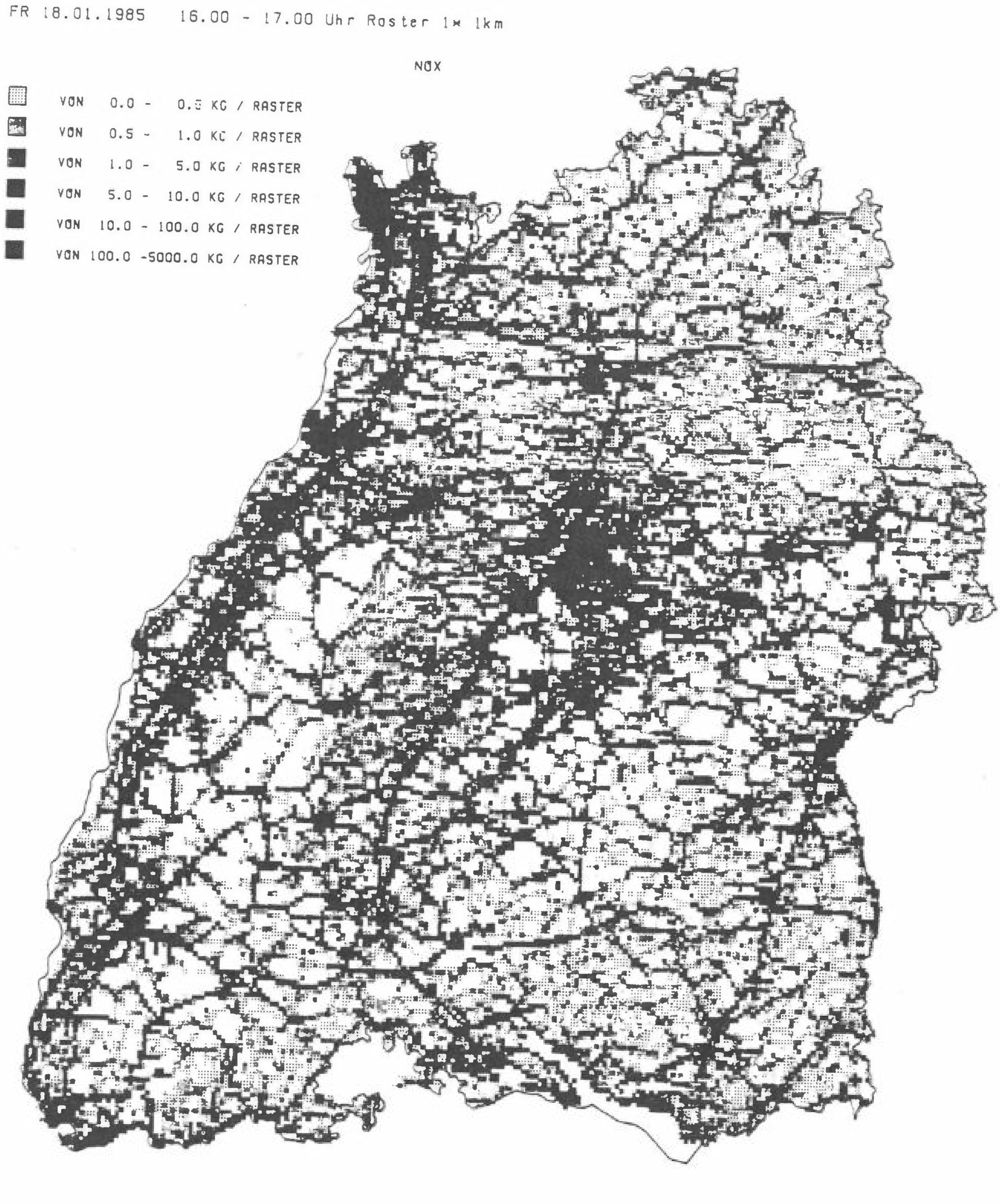
LOTOS: NOx-Emission in a Winter Week

Southern Part of Baden-Wuerttemberg

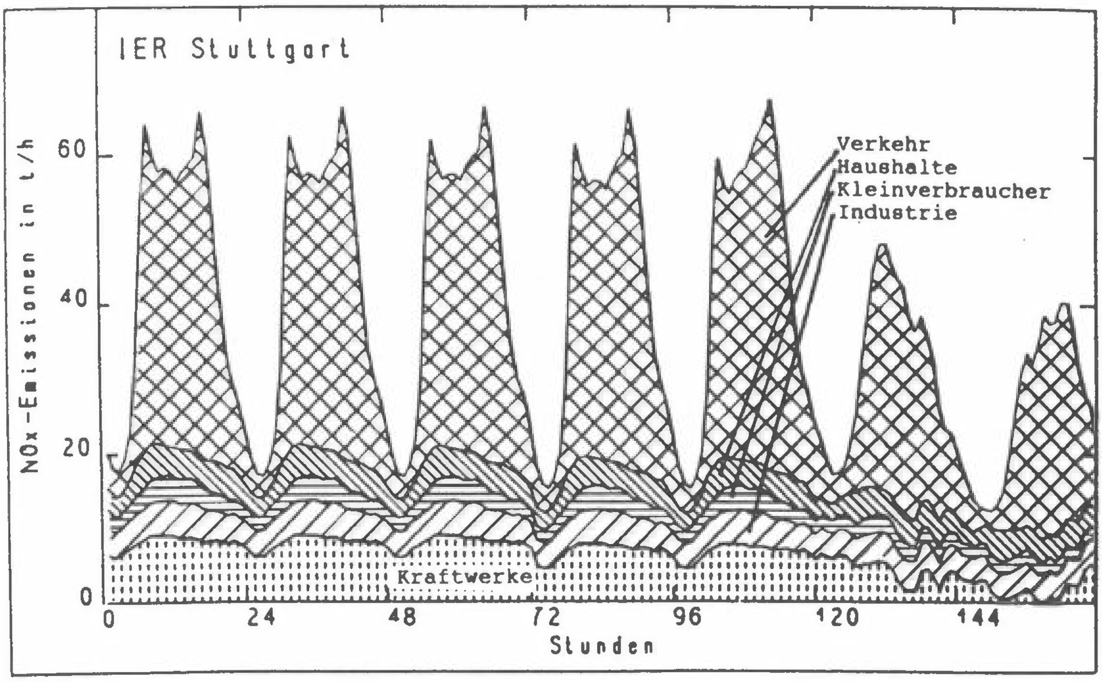


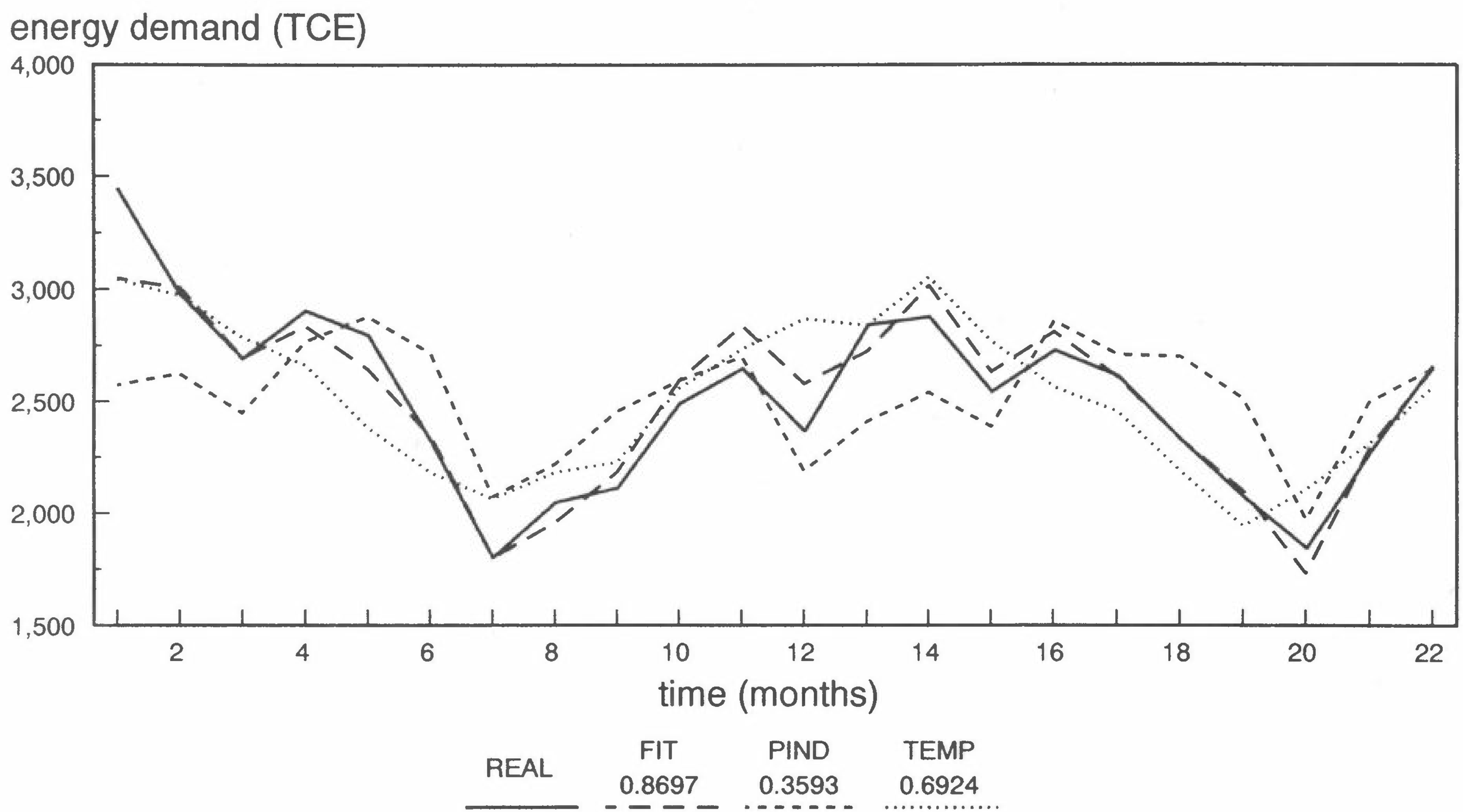
Institute of Energy Economics and Rational Energy Use (IER)

NOx-Emissions in Baden-Württemberg on a Friday Afternoon, Winter 1985



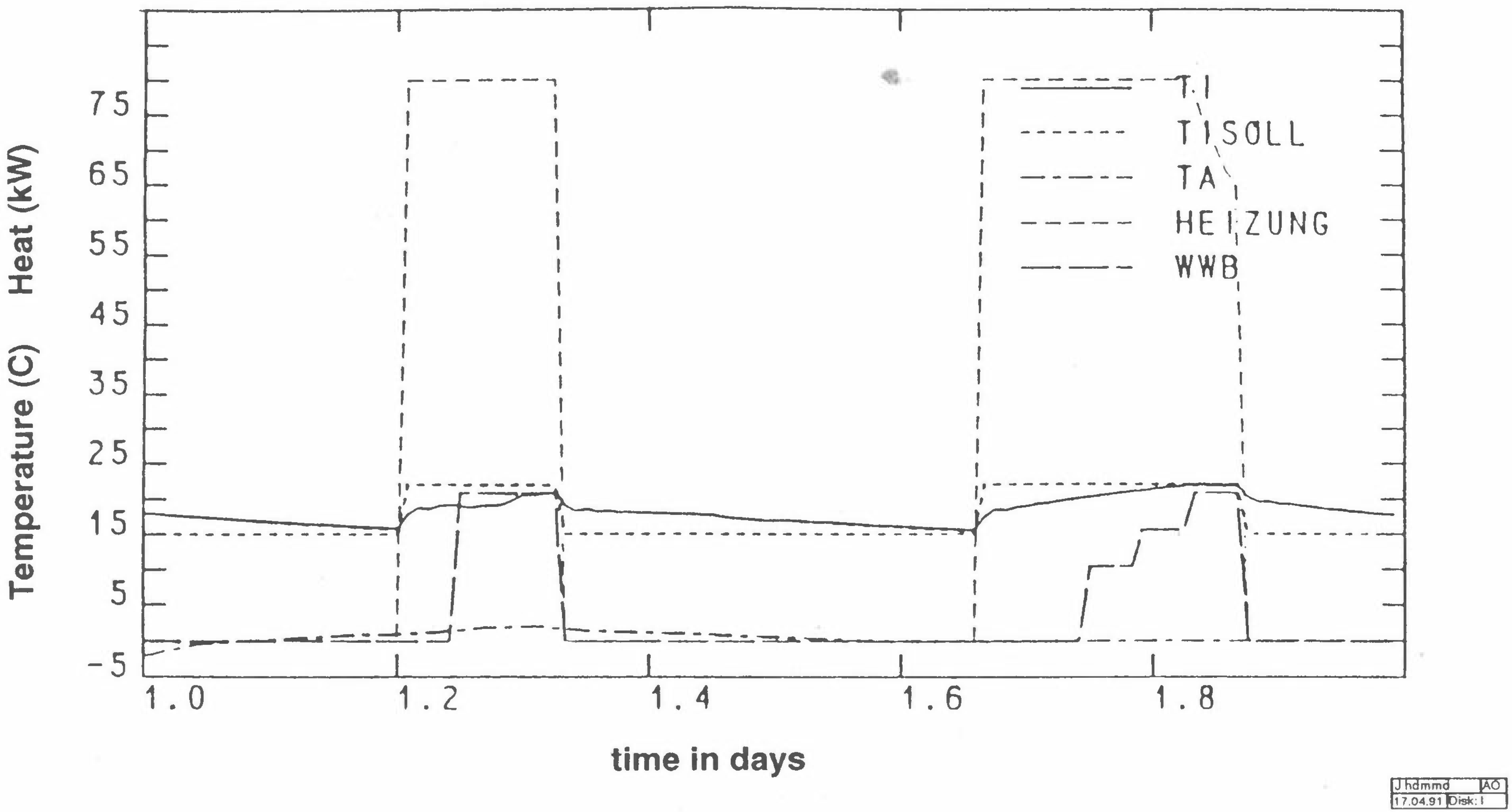
IER: NOx-Emissions, 14-20 January 1985
in Baden-Württemberg



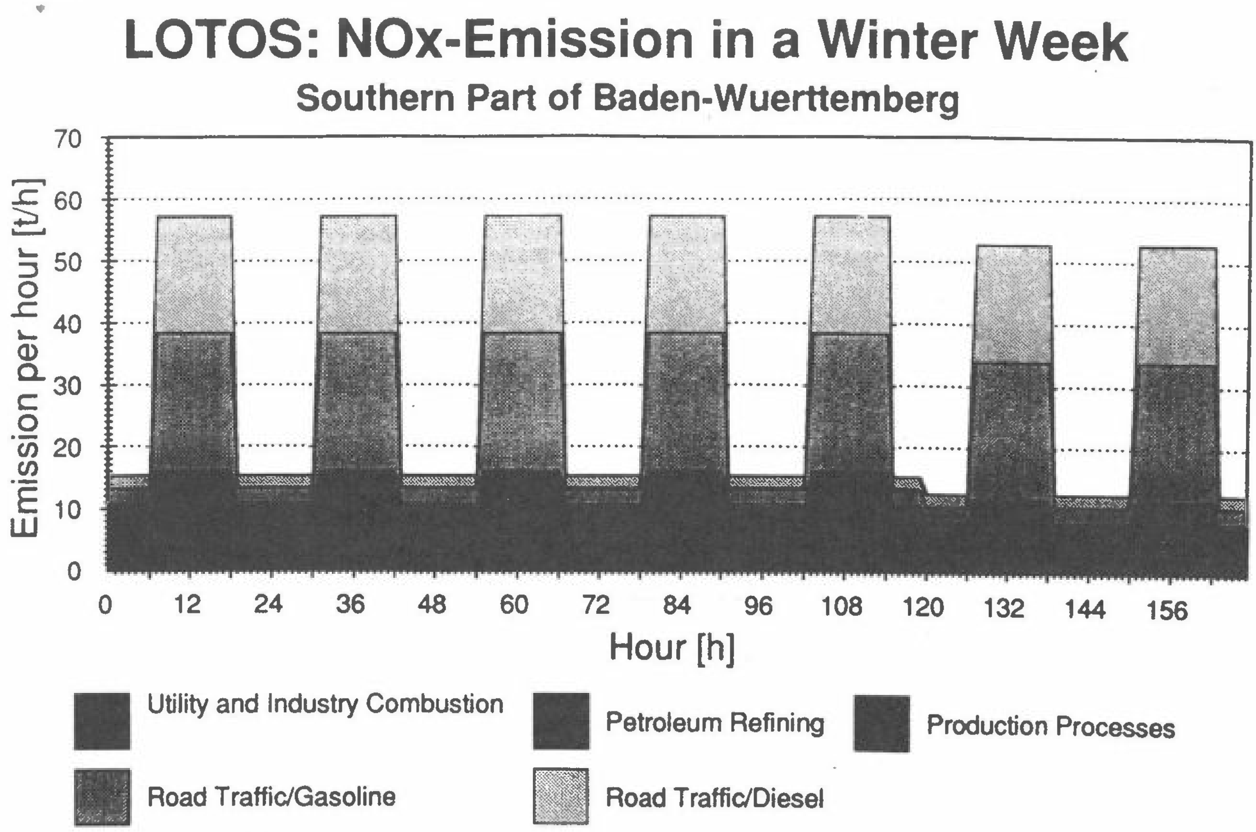


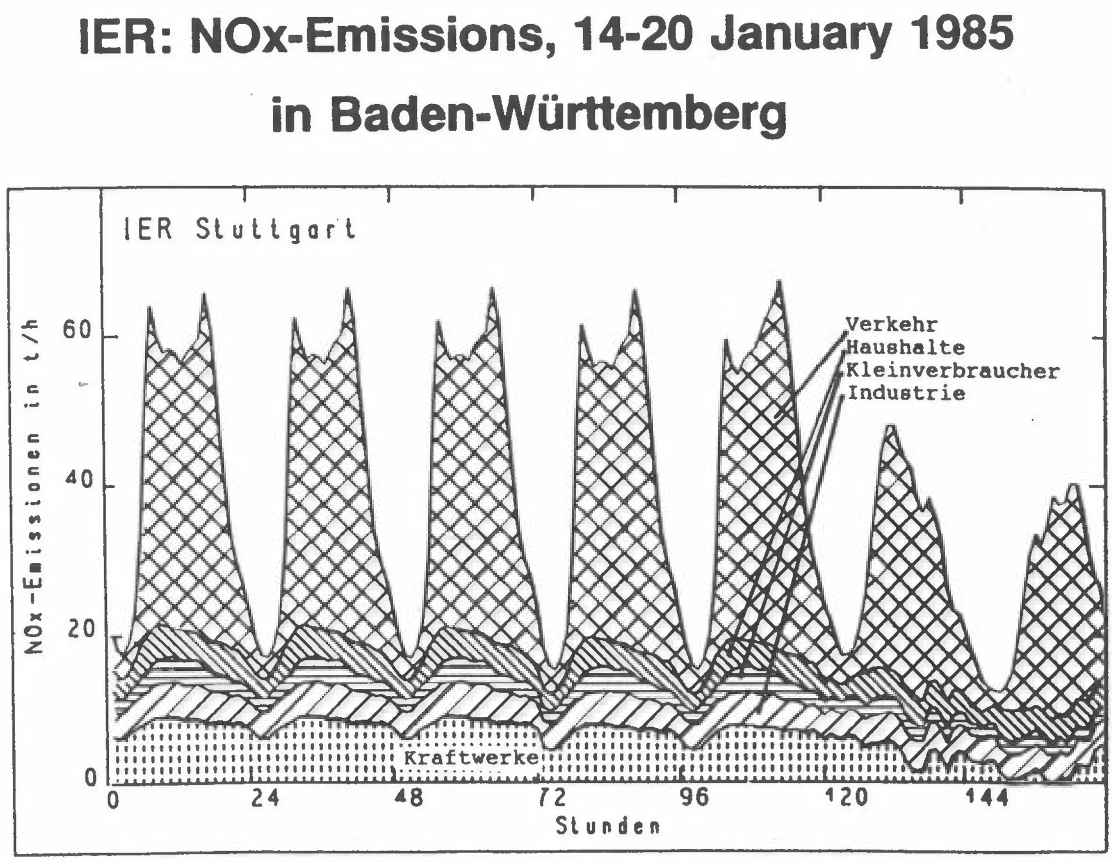
Monthly non-electrical energy demand of the chemical industry
Measured values and model calculations

IER



Heat demand in a multiple dwelling on a reference day


LOTOS: NOx-Emission in a Winter Week
Southern Part of Baden-Wuerttemberg
Emission per hour [t/h]
70
60
50
40
30
20
10
0
0
12
24
36
48
60
72
84
96
108
120
132
144
156
Hour [h]
Utility and Industry Combustion
Petroleum Refining
Production Processes
Road Traffic/Gasoline
Road Traffic/Diesel


IER: NOx-Emissions, 14-20 January 1985
in Baden-Württemberg
IER Stuttgart
NOx-Emissionen in t/h
60
40
20
0
0
24
48
72
96
120
144
Stunden
Verkehr
Haushalte
Kleinverbraucher
Industrie
Kraftwerke

Temporal Resolution of Annual Emission Data

Combined LOTOS- and CORINAIR source categories and proposed indicator data for monthly, daily and hourly distribution of emissions.

No.	LOTOS/ CORINAIR activities	indicator data for monthly emission	indicator data for daily emission	indicator data for hourly emission
1.	Combustion point sources	electricity production	electricity production	typical load distribution
2.	Combustion area sources (utility, industry)	electricity production, fuel consumption	ambient temperature	working times, heat demand
3.	Commercial/ residential Combustion	fuel consumption	ambient temperature	user behaviour, heat demand
4.	Refineries	production statistics	working days, holidays	shifts, working times
5.	Production Processes	production statistics	working days, holidays	shifts, working times
6.	Solvent Use	consumption statistics	working days, holidays	shifts, working times
7.	Road Traffic (Gasoline, Diesel, LPG)	fuel consumption, traffic counts	traffic counts, user behaviour	traffic counts, user behaviour
8.	Road Traffic Evaporation	fuel consumption, traffic counts	traffic counts, user behaviour	traffic counts, user behaviour
9.	Air Traffic	air traffic statistics	air traffic statistics	air traffic statistics
10.	Marine Traffic	marine traffic statistics	marine traffic statistics	marine traffic statistics
11.	Biogenic Emissions	meteorological parameters	meteorological parameters	meteorological parameters
12.	Others (waste disposal, gas distribution, etc.); CH4 only	production figures, etc.	different	different

HEMISPHERIC SCALE MODELLING OF SULPHUR DISPERSION

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1. INTRODUCTION

Hemispheric scale sulphur dispersion has been studied during the last years as a subprogram inside the European Monitoring and Evaluation Program for Long-Range Transport of Air Pollutants, hereafter denoted as EMEP. The main reason for the inclusion of global modelling inside EMEP was the need to get a better insight on the origin of background air pollution.

As it is known, the EMEP program is an important policy oriented tool, assisting in the negotiations for new protocols on emission reductions. This program, operative since the late 70's, has provided European countries under the UN-ECE convention with calculations on the deposition and air concentrations of pollutants. It has also supplied information on the quantity and significance of pollution fluxes across national boundaries. The program includes deposition allocated budgets that indicate the contribution from different European countries to the deposition levels over a certain area. These budgets include also an indeterminate contribution, that is, the contribution allocated to the assumed background air concentrations.

The present identification of background sulphur sources was derived from the EMEP distribution of background concentrations and depositions over Europe. It was observed that countries along the west coast of Europe had the largest relative contribution of indeterminate origin. That was particularly important in areas receiving large precipitation amounts when air arrived from the North Atlantic Ocean (Iversen et al., 1990). This suggested that background pollution could possibly originate from sources influencing Europe from the North Atlantic. A distinction was then made between: "anthropogenic intercontinental background" and "natural sources background".

The anthropogenic intercontinental background needed to be connected to the atmospheric general circulation and the global distribution of anthropogenic source areas in order to be coherently explained. The potential for intercontinental sulphur transport has already been discussed in previous works (Iversen and Tarrasón, 1990; Tarrasón and Iversen, 1992). And results from that discussion have helped to identify the dynamical and chemical processes involved in hemispheric scale sulphur dispersion. They have also shown how sulphur from remote sources reaches Europe as background pollution.

On the other hand, oceans, volcanoes and areas with dense vegetation are natural sources of sulphur. A full description of background concentrations would pass through the evaluation of these natural sources. At present, only biogenic emissions of dimethylsulphide (DMS) from the North Atlantic Ocean are included in the calculations. It can be argued, however, that these oceanic sources are the major biogenic contributors to the European pollution levels.

The present study is centered over the west coast of Europe, specially over areas with small domestic emissions. These areas are considered to be sensitive to long-range transport of pollutants and therefore are suitable to the study of the large scale variability processes associated with background.

2. MODEL FORMULATION

The model employed simulates sulphur dispersion in connection with large scale atmospheric flows and the distribution of sulphur sources over the Northern Hemisphere. It is a 3-dimensional Eulerian model that resolves the troposphere in 10 different vertical layers (using θ as vertical coordinate) and covers major parts of the Northern Hemisphere with a spatial resolution of 150x150 km^2.

Sulphur transport is modelled on the basis of actual atmospheric conditions which are introduced through 6-hourly objective analysis of the meteorological fields. The use of time-resolved meteorological fields is an important characteristic of this hemispheric scale model. In this way the model is able to account for the effect of transient eddy features in the general circulation description. The averaged deposition and air concentration fields that result from this analysis will be different from the results of climatologically averaged models because climatological models fail to describe the dymamics of transient features.

With this formulation, the model is able to follow transport of pollutants throught out the atmosphere, include vertical motions and reproduce scavenging by precipitation at different tropospheric levels.

2.1 Emission data

An accurate emission inventory is an important requirement for the reliability of the model results. The emission data used in this study was initially based in Semb's (1985) SO_2 circumpolar inventory and has now been updated for different areas. The emission data includes anthropogenic sulphur emissions from Europe (EMEP area), North America and Northern Asia, and biogenic emissions from the North Atlantic Ocean. The simulation year is 1988 and that years emission totals are given in Table 1.

Emissions over Europe are the official EMEP values for 1988. The emissions from international ship traffic that were supplied by MARINTEK, are also considered. The European total in Table 1 does not include natural sulphur from ocean areas. All natural oceanic sources are considered under the North Atlantic Ocean total, even those corresponding to the Mediterranean and the Black Sea. The seasonal variation of the European emissions is described with the same sinus function employed in the EMEP Lagrangian model (Sandnes and Styve, 1992).

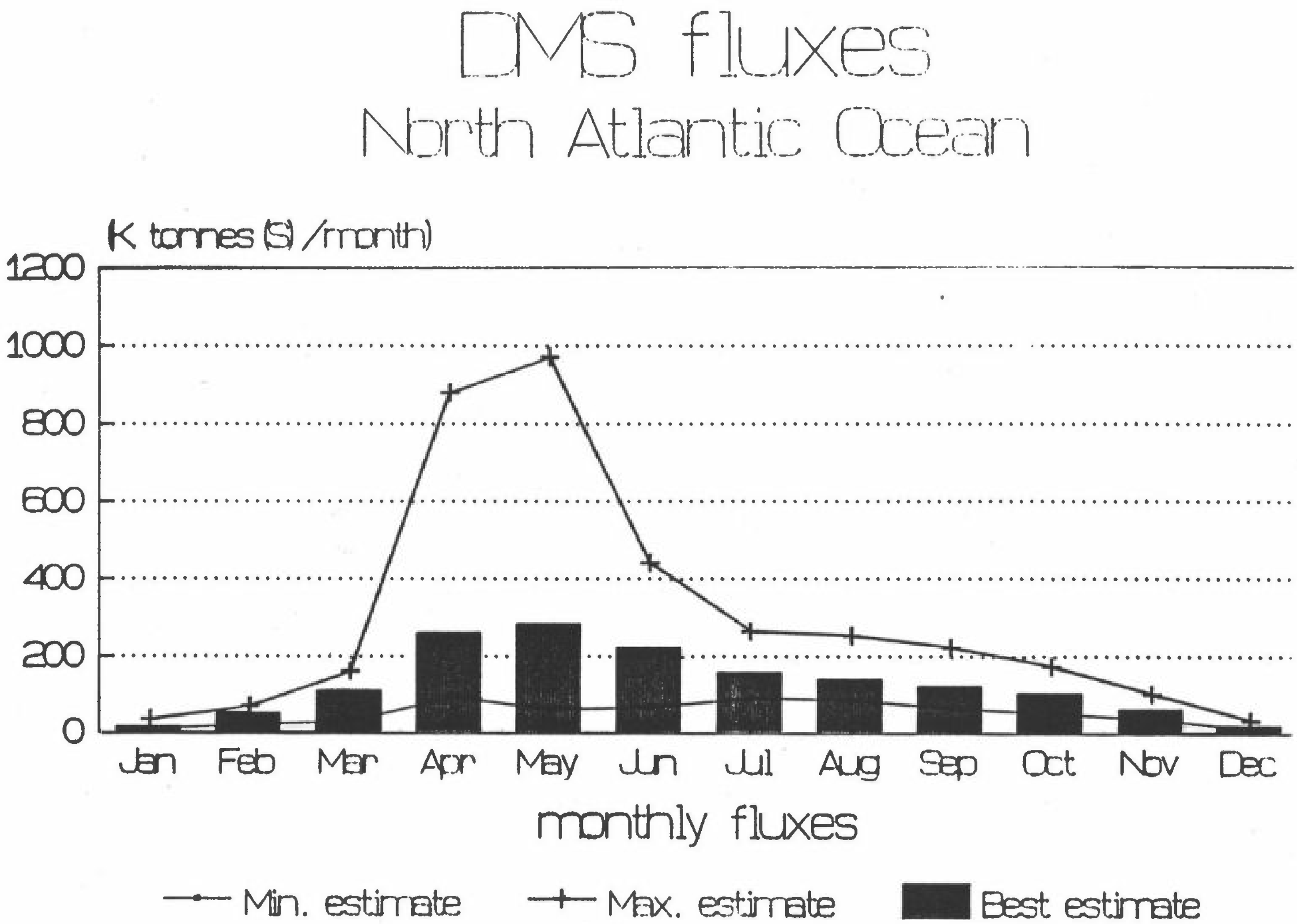
The NAPAP 1985 inventory is used for North American sources. This inventory does not include Alaska, therefore the estimations from Semb's circumpolar survey have been adopted over that area (Semb, 1985). The seasonal variation of North American emissions is much less pronounced than for European sources. It has been modelled following Seager et al. (1989) recommendations.

The Asian anthropogenic emissions are based on Kato and Akimoto's inventory from 1992 (in press). Point sources over the Asian part of former URSS are taken from Pacyna's estimates (Pacyna, pers. comm.). As no information was available on the seasonal variation of these sources, they have been distributed homogeneously over the year.

Table 1. Sulphur emission totals for 1988. Units: 1000 tonnes (S) a^{-1}.

European sources (EMEP area)	21 502
North American sources	12 482
North Asian sources	15 888
North Atlantic Ocean (Biogenic)	1 100
Total sources	50 972

The only natural sources included are related with the biogenic fluxes of dimethylsulphide (DMS) from the oceans (Tarrasón, 1991). An important characteristic of the DMS inventory is that it considers explicitely the seasonal variation of biogenic oceanic emisssions (see Figure 1.). There again, these are not complete since the North Pacific Ocean is not covered by the inventory. Volcanic emissions, which can be significant over Eastern asia, Iceland and Italy, are not considered either. However, it can be argued that the North Atlantic Ocean will be the major biogenic contributor to European pollution. In this sense, the present emission inventory is expected to give a reasonable description of the major sources affecting the sulphur pollution levels over Europe.



'early fluxes : North Atlantic Ocean
est estimate : 1569.3 K tonnes (S)
anges: 3610.0 – 648.9 K tonnes (S)

Figure 1. Estimated seasonal variation of dimethylsulphide fluxes from the North Atlantic Ocean.

3. PRELIMINARY RESULTS FOR THE FIRST SEMESTER OF 1988

The whole 1988 is presently being modelled with an integration timestep of 1/2 hour and with new meteorological data introduced every 6 hours. The results presented in the following are monthly averages for the first half year of 1988.

The model has been run separately for each of the four considered emission areas and once for all sources together. In this way, deposition of sulphur over the European west coast has been allocated to these four emission groups. The percentage contribution to dry and wet deposition from each of these groups is given in Table 2.

Table 2.

Percentage contributions to dry and wet deposition along the west coast of Europe

	dry deposition				wet deposition			
	Europe	N.America	N.Atlantic	Asian	Europe	N.America	N.Atlantic	Asian
January	99.3	0.5	0.1	0.1	85.5	14.0	0.1	0.5
February	98.9	0.5	0.3	0.3	87.5	11.0	1.0	0.5
March	98.0	0.7	0.5	0.4	80.0	16.7	2.3	1.0
April	97.6	0.2	1.8	0.4	88.5	5.2	3.1	3.2
May	96.0	0.5	3.1	0.4	91.8	5.4	2.5	0.3
June	96.2	0.3	3.5	0.0	56.5	34.8	8.0	0.7
Average	97.6	0.5	1.6	0.3	81.6	14.5	2.9	1.0

The on-going results for the first six months of 1988 indicate that the contribution of intercontinental transport occurs mainly as wet deposition. Naturally, sulphur deposition over Europe is dominated by European sources. North American sources appear to be the largest remote source contributor to the pollution levels over western Europe. The influence of natural sources from the North Atlantic Ocean varies in accordance with their assumed seasonality and reaches a maximum influence of 8% of the accumulated wet deposition in June. The contribution of Asian sources is estimated to be largest during spring and it affects primarily areas in northern Scandinavia.

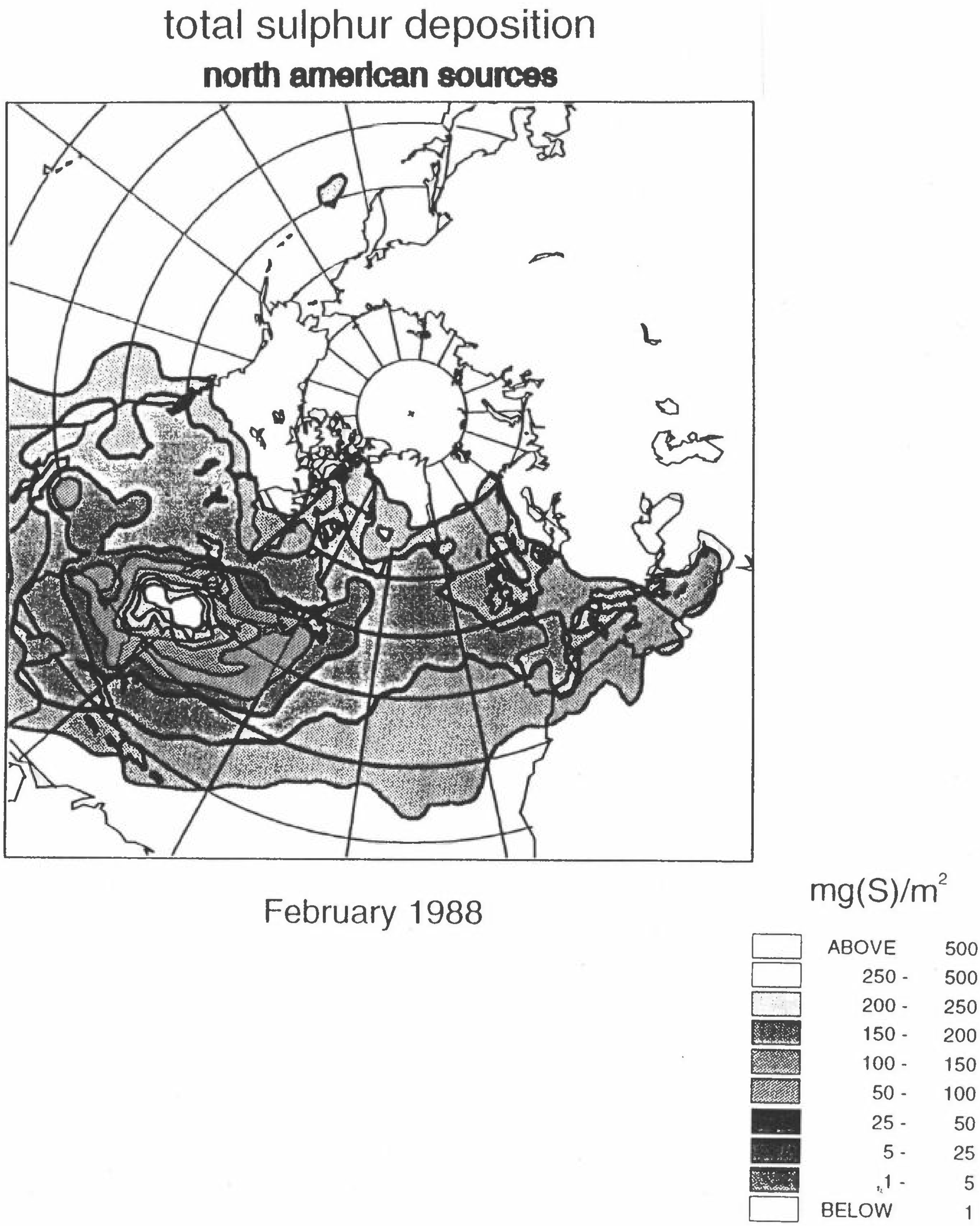


Figure 2. Monthly accumulated total (dry + wet) deposition of sulphur allocated to North American anthropogenic sources. Values for February 1988.

In absolute value, the influence of North American sources over Europe is maximum during the winter months (see Figure 2 as an example for the spatial extent of North American pollution during a winter month). The relatively high contribution of North American sources to wet deposition during the month of June is not due to larger absolute transport from North America. It is a consequence of a reduced volume of wet deposition from European sources and scarce precipitation amounts along the European coast during the summer.

In general, the results for the first six months of 1988 confirm the importance of vertical motions in the description of intercontinental transport. Vertical motions, either due to convective activities or in connection with frontal formations play an important role in the identification of the physical processes responsible of large-scale pollutant dispersion.

The results support the view of sulphur background air pollution as a global (hemispheric) problem and illustrate the potential of emission based 3D models as important tools in the design of emission reduction and pollution control strategies.

Acknowledgements

Special thanks are due to Professor A. Eliassen and Dr. T. Iversen for valuable discussions and suggestions. The author is grateful to Dr. R. Dennis that supplied data from NAPAP emission inventory for North America, and to Drs. C. Benkovitz, J.Dignon and J. Pacyna that helped in providing with gridded emission data from Asian sources. The calculations presented in this paper use meteorological data from ECMWF, U.K.

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RECENT ACTIVITY ON CORINAIR 90

R. BOUSCAREN

An emission inventory using the CORINAIR System has been achieved for the year 1985. The publication of the final report will be soon made available. Data have already been disseminated to Administrative organisations and Scientists. The CORINAIR 85 emission inventory only concerned the 12 EC Member-States.

For the year 1990, after a decision of close cooperation with the UNECE, a new emission inventory is underway in about 24 European countries. The organization of the Project is presented in Table 1.

Differences between CORINAIR 85 and CORINAIR 90 emission inventories are summarized in table 2.

A new nomenclature of activities SNAP 90 has been developed in order to fit with the needs for reporting required by the UNECE.

A new software, more complete, more friendly, nevertheless keeping the basic principle of the CORINAIR System, has been developed by the CITEPA under contract of the CEC DG XI. This software has been distributed.

The second edition of the "CORINAIR Emission Factor Handbook" (CEFH) has been updated (issue of January 1992) ; practically all pollutants are presently involved. Some emission factors are only proposals and need confirmation.

	Stationary sources	Mobile sources
SO_2	+	+
NOx	+	+
NMVOC	+	+
CH_4	+	+
CO	proposal	+
CO_2		+
N_2O	proposal	+
NH_3	+	+

In spite of the amount of information, this CEFH is far from being complete, some information are not present due to lack of knowledge. It is hoped that the solidarity of the CORINAIR Technical Group would contribute to assist, those experts without information, in choosing the "best available data".

An important effort of assistance has been put in place by the Commission to all experts, including the Eastern European countries (PHARE Programme). This assistance is mainly achieved by the CITEPA under contract of the CEC and should be as flexible as possible. The validation procedure has also been improved by comparing with the procedure developed in the CORINAIR 85 emission inventory.

In order to ensure that the CORINAIR data can be actually more and more used by Scientists and Administrations, many follow-up activities are presently under preparation or under progress :

- linkage with the emission inventory of **Large combustion Plants** (EC Directive 88/609). This directive requests each Member-state to provide the Commission with emissions of SO_2 and NOx from LCP under a coherent methodology (see J-P FONTELLE).

- preparation of a **VOC profile data base**. Such a data base is strongly needed by Scientists in some atmospheric chemistry models (such as photochemical pollution) (see G. Mc INNES).

- **International maritime traffic** emission inventory (see N.A. KILDE).

- **International air traffic** emission inventory (see G. Mc INNES).

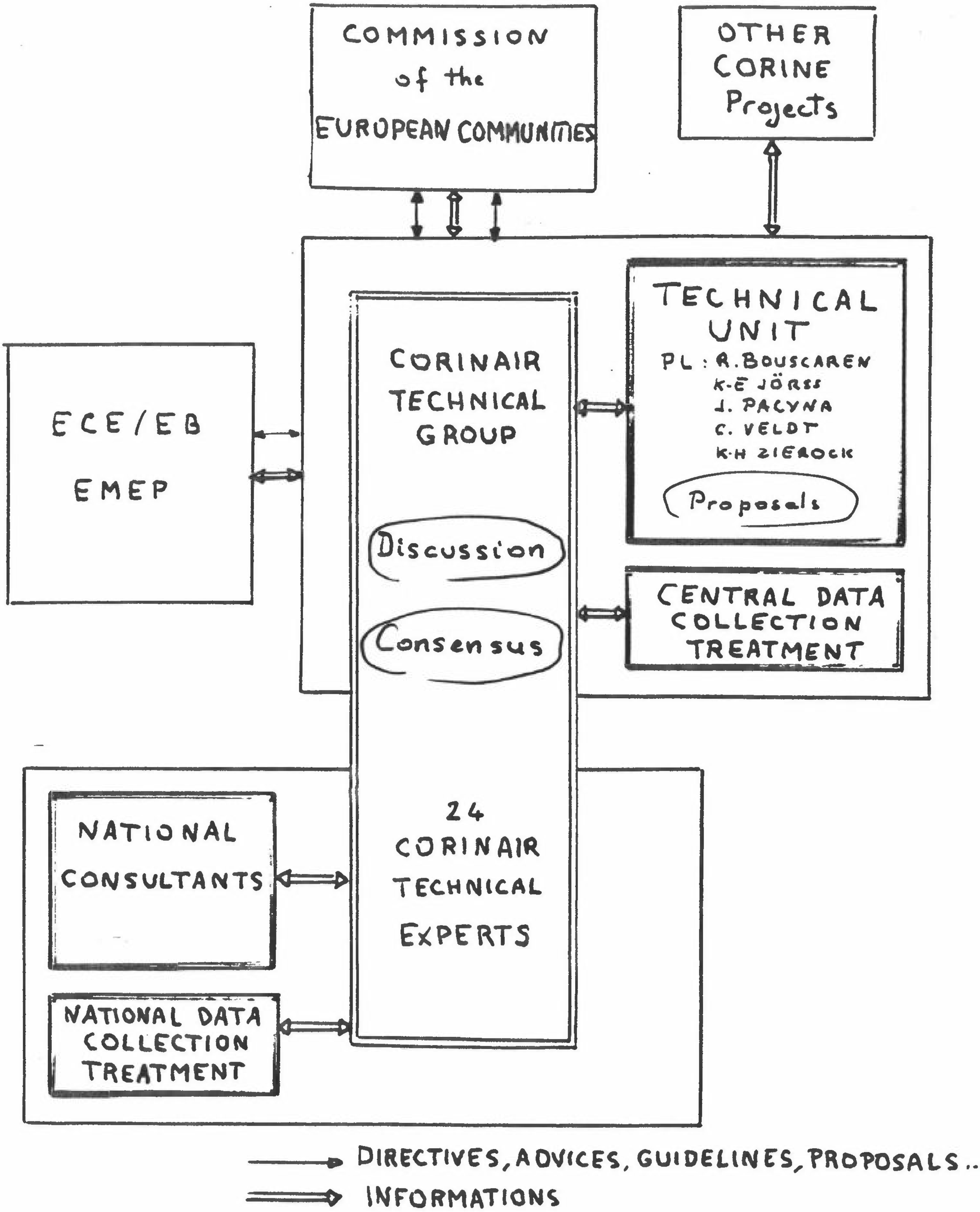
- **hourly allocation of CORINAIR annual data**. The development of a model for splitting the CORINAIR data in hourly emission, in every Territorial Unit, is requested by the scientific community. The objective is not to build every year enormous data base but only to develop a model which could be able to provide any scientist with hourly emissions in any region and in any period (see R. BOUSCAREN and R. FRIEDRICH).

- **prospective emission inventories** with linkage with national or European models and scenarios (see R. BOUSCAREN).

- development of **satellite softwares** for NH_3 emissions from agriculture or VOC emissions from nature (see C. VELDT and W. ASMAN).

- Development of **integrated emission inventories** (Air, Water, Soil,...)(see M.H. CORNAERT).

For most of these activities, a cooperation with CORINAIR experts is needed.



ORGANISATION of the PROJECT

- Table 1 -

	EC-1985 prototype inventory	EC-1990 proposal
Year of reference	1985	1990
Pollutants	SO_2, NOx, Total VOC (1)	SO_2, NOx, NMVOC (2), CH_4, CO, NH_3, N_2O, CO_2
Nomenclature of sources (SNAP)	Major sources (SNAP P)	All relevant sources (SNAP 90)
Sector split	One level structure 58 activities	Three level structure 11 groups 54 sub-groups 313 activities
Fuels	Four groups of fuels (defined country specific)	All relevant fuels separately
Spatial resolution	NUTS (5) levels 0 to III	NUTS (5) levels 0 to III (3)
Transformation from NUTS data set to grid system data set (GS)	NUTS → any GS by allocation factors for area sources	NUTS → any GS by allocation factors for area sources
Large point sources (4)	Power plants > 300 MWth Oil refineries H_2SO_4 units HNO_3 units Iron/steel > 3 Mt/y Paper pulp > 100 000 t/y Vehicle paint > 100 000 veh/y	-id.- + Airports + SO_2 NO_x VOC > 1000 t/y + CO_2 > 300000 t/y
Input data - point sources	Emission rates or activity rate x emission factor (6)	Emission rate and Activity rate x emission factor (6)
Input data - area sources	Activity rate x emission factor (6)	
Assistance for selection of emission factors	Working Groups and 1st edition of Emiss. Factor Handbook	Working Groups and 2nd edition of Emiss. Factor Handbook

- Table 2 -

Input levels of activities and emission factors data :		
- sector resolution	Level of SNAP	Level of SNAP
- spatial resolution	Whatever the level	Whatever the level
Organization	Technical Unit Regular meetings of CORINAIR experts	Technical Unit Regular meetings of CORINAIR experts (EC and non-EC)
Validation of data	CITEPA	CITEPA
Integration of LCP emissions (Dir. EEC 88/609)	Not relevant	Yes
Periodicity of national and territorial emission inventories	Prototype exercice	Yearly : Bud 5years : Flower
Temporal resolution	Calendar year	Calendar year

Global Emissions Database (GloED) Software

presentation to:

GEIA Workshop on Global Emission Inventory

Lillestrom, Norway

June 23, 1992

presented by:

Lee Beck

Office of Research and Development

U.S. Environmental Protection Agency

What is GloED?

- Stored Compilation of Published and New Emissions Inventory Data with References
- Calculator for Global Greenhouse Gas Emissions Data by Country/Source/Sector
  - Emission Factors (Amount of emissions per source - e.g., Tg/yr of methane per coal mine)
  - Activity Data (How many sources - e.g., number of coal mines)
- Constructor of Emission Scenarios
  - Using Data Stored in GloED
  - Using Data Inserted by User

What Generated Need for GloED?

- Increasing Number of Greenhouse Gas and Related Databases
  - Country or Source-specific (e.g., NAPAP, DOE, USDA, Specific Studies)
  - International Databases (e.g., OECD/IPCC, IEA, NATO, NASA, IGBP, CORINAIR, UN-ECE, EPA)
- Rapidly Changing Databases Based on Continuing Studies
- Need for Rapid, Internationally Accepted, Best Available Estimates and Comparisons
- Need for Clear Data Pedigree as New and Combined Estimates Are Generated
- Need for Uniform, Standardized, Databases to "Keep Track" of Emissions
  - To Show Effects of Individual/Joint Country Approaches To Achieving Potential Convention Goals (e.g., Emissions Trading, Global/Regional Bubbles, etc.)
  - To Show Progression of Emission Changes

What Are Current GloED Outputs?

- Thematic Maps
  - Countries Colored According to Quantity of Emissions
  - Data Ranges Chosen for Maximum Contrast
- Other Graphics Displays
  - Bar Charts
  - Pie Charts
  - Numeric/Text displays
- Printed Records
- Export Files To Lotus 123, dBase, ASCII
- Export Graphics or Text to Printer

What Are Some Advantages of GloED?

- PC Based - User Friendly
- Storage and Retrieval of Data is Quick and Easy
  - Updates Can Be Stored as Better Data Become Available
  - Current "Best Estimate" Always Available
- Units Specified by User are Automatically Generated by GloED
- References Linked to Data
  - Can Store History of Data Changes
  - Insures Clear Pedigree of Constructed Scenarios
- Mechanism to Create Standardized, Quality-Assured, Country-Specific Emission Inventories
- Imports From Lotus 123, dBase, ASCII
- Consistent with Adopted OECD/IPCC Standards for Emissions Measurement and Reporting

What Are Some Current Uses For GloED?

- Store Large Amounts of Data From Varying Databases
- Calculate Emission Totals
  - By Country/Region/Other
  - By Sector/Source
  - By Greenhouse Gases or Precursors
- Show "Hot Spots" of Emissions
- Convert Units

What Are Related Activities and Immediate Plans?

- Development of Greenhouse Gas Emissions Inventories (Ongoing)
  - Assembling "3-D Matrix" (Gas/Country/Source or Sector) to Focus Data Generation/Acquisition Needs
  - Beginning with Methane
  - Using OECD Reporting Conventions
- Complete GloED Peer Review (By August, 1992)
- QA Current Databases in GloED (By August, 1992)
- Development of Country Module (By October, 1992)
  - Will Be Separate Menu Item to Make Data Import More User-Friendly
  - Can Be Stand-Alone Program on Separate Diskette
- Development of Gridded Input Capabilities to Enable GIS Interface (Mid-1993)
- Development of PC Globe Version of GloED to Incorporate Additional Data and Zoom In on Individual Countries (By September, 1992)

What Are Related Activities and Immediate Plans? (Cont.)

- Development of Global Technology (GloTech) Database Management System (By End of 1993)
  - Will Be "Electronic File Cabinet" to House Greenhouse Gas Mitigation Technology
    - Performance
    - Cost
    - Availability
  - Will Allow Scenario Development and File Interaction Similar to GloED
    - Perform "Cost-Effectiveness" Calculations
    - Use Filed or User Input Data
    - Insure Data Pedigree
- Following Development of DOE/IPCC Technology Characterization Inventory (TCI) (ongoing)

What Are Some Potential Future Uses For GloED?

- Use with Country Modules to Facilitate Global Inventory Construction/Maintenance
- Assist in Global Climate Convention Agreements
  - Establish Country Baselines
  - Track Progress
- Join With Technical Database Such As GloTech
  - Show Effects of Potential Emission Reduction Scenarios
  - Assist Policymakers in Planning

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TNO Environmental and Energy Research

TNO-report

IMW-P 92/049

Emission Database for Global Atmospheric Research (EDGAR): Phase 2: data collection; and implementation

Authors : Ir H.P. Baars
Dr J.J.M. Berdowski
Drs J.G.J. Olivier *

Date : July 28, 1992

Order no. :

Proceeding GEIA Workshop,
Oslo, June 1992

* RIVM

Netherlands organization for applied scientific research

Based on the necessity for a sustainable development of society, TNO Environmental and Energy Research aims at contributing, through research and advice, to adequate environmental management, rational energy consumption and the proper management and use of subsurface natural resources.

Project title: Emission Database for Global Atmospheric Research (EDGAR): Phase 2: data collection; and implementation.

Projectleader: drs. J.G.J. Olivier

Research institute: National Institute for Public Health and Environmental Protection (RIVM-LAE), and
Netherlands Organization for Applied Scientific Research (TNO-IMW)

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Summary:

The project aims at developing a global database to establish at due levels of spatial, temporal and source aggregation the emissions of gases causing the enhancement of the greenhouse effect and of ozone depletion from anthropogenic and biogenic sources: CO_2, CH_4, N_2O, CO, NO_x (NO & NO_2), NH_3, non-methane VOC, SO_x (SO_2 & SO_4), halocarbons and dimethyl sulphide (DMS). In this way EDGAR will meet the urgent requirements of future developments in this field, such as IMAGE and other atmospheric chemistry and climate models. To comply with the requirements of climate modellers to make regionalized projections of past, present and future emissions EDGAR will include the complete set of data required to estimate the source strength of the various gases on a 1 x 1° resolution (altitude resolution about 1 km). These data comprise demographic data, social and economic factors, as well as internationally accepted projections of these data, land use distribution and emission factors (with due emphasis on the uncertainty).
Thus, EDGAR cannot only be used to produce inventories of current emissions, but it also allows for making projections of emissions using scenarios for developments of population, energy consumption, agriculture, etc. Due attention will be paid to flexibility regarding the

disaggregation of sources, spatial and temporal resolution and species. In the framework of GEIA (see below), TNO (anthropogenic VOC) and RIVM (biogenic N emissions) have committed themselves to coordinate a number of inventories. Besides these inventories/contributions from EDGAR to GEIA, early finished inventories by GEIA and other institutes will be included in EDGAR. In order not to duplicate activities close contact and co-operation with the GEIA group will be established. The same holds for other institutes collaborating with UNEP in developing energy related emission inventories, such as the Stockholm Environment Institute (SEI-Boston) (USA) and the Collaborating Centre on Energy and Environment (CCEE) at Risø (DK).
Although all sources will be dealt with, due to limited financial resources the research will be focused on the major source categories. This means that e.g. when spatial activity level data or regional emission factors are lacking or incomplete, no additional effort will be taken to enhance the quality of the GIS data; aggregate country data will then be spatially distributed using a simple surrogate allocation factor and using default or regionally calibrated emission factors.

The project is part of of the following programmes:

1. International Global Atmospheric Chemistry Programme (IGAC)
2. Global Emissions Inventory Activity (GEIA)
3. Global Biosphere project activities (MAP-LAE-MBS) at RIVM
4. National Research Programme on Global Air Pollution and Climate Change (NOP-MLK)

Duration:
July 1, 1991 - July 1, 1994

Emissions Database for Global Atmospheric Research (EDGAR)

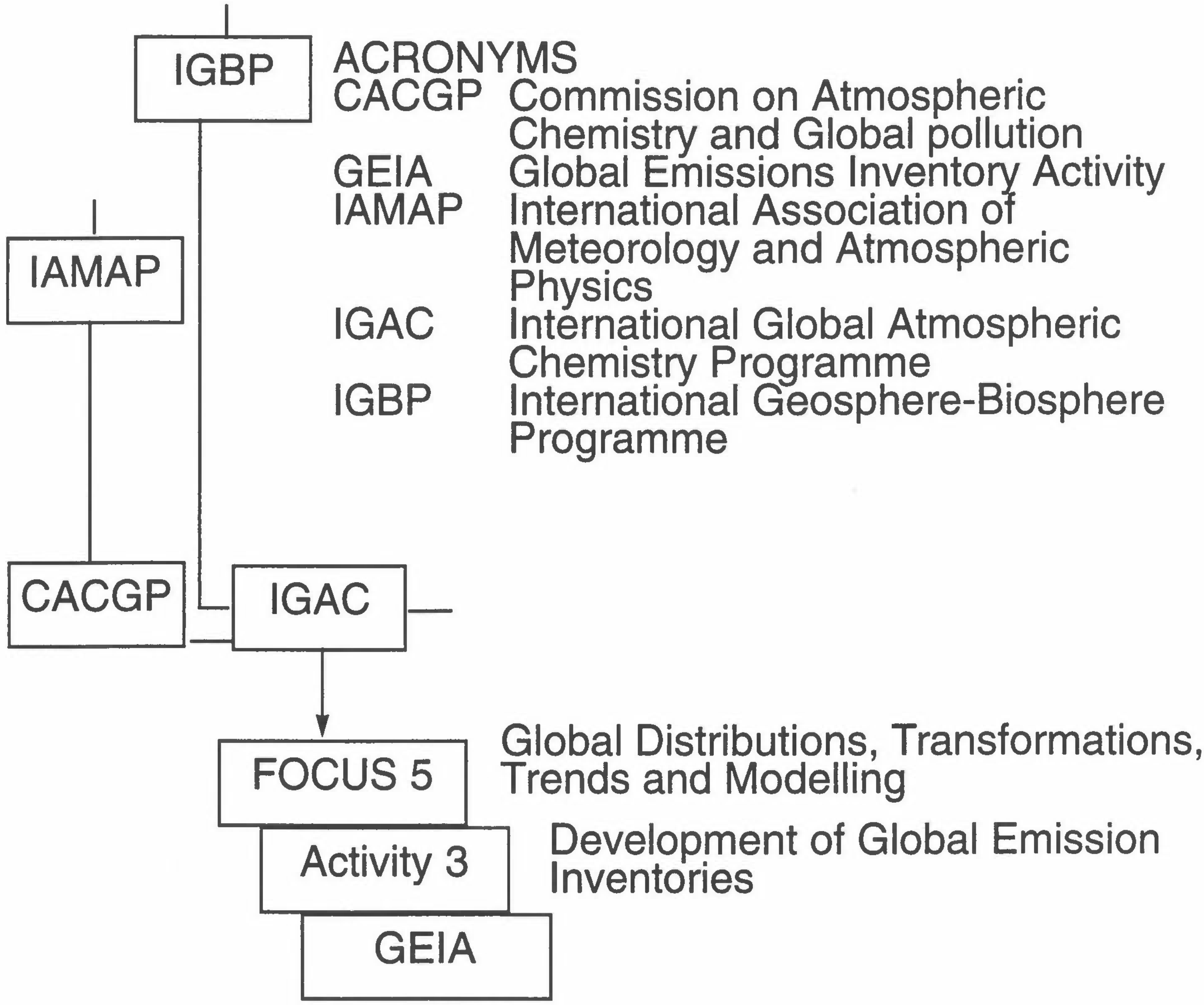
Project no.: 851060

TNO Berdowski
Baars
Veldt

RIVM Olivier
Bouwman
Smeets
Van der Maas

TNO

International action on global emissions inventory



Convenor : Graedel (AT&T Bell Labs)
Operations Centre : Pacyna (NILU)
Data management : Middleton (NCAR)

Aim of the project

1. Emissions estimates on a global scale for a base year (1990)
2. Scenario structure
3. Contributions to GEIA (anthropogenic NMVOC, Biogenic N-compounds)

Implementation

At RIVM, Ingres database, ARCINFO GIS

TNO

Characteristics EDGAR

Resolution output
Spatial : 1° x 1°
Temporal : year, representative day per season

Emission species
NO_x, N_2O, NH_3
SO_x, $(CH_3)_2S$
CO, CO_2
CH_4, total NMVOC+ profile per activity (CFC's included)

- Emission calculated
  with information in the database (emission factors, activity levels)
- Flexibility
  with respect to:
  - spatial and temporal resolution
  - expansion
  - import data
  - update documentation
  - output
- Scenarios
  coupling activities and scenario factors
- Accuracy
  the system should indicate the accuracy of all data

Access

1. Modellers in the field of atmospheric chemistry and climate change
2. Scenario studies and policy making

Application	Resolution	
	spatial	temporal
O_3 modelling	1°x1°	year, season
2-D models	5°x5°	month
GLOMAC	1°x1°	representative day + night
IMAGE	country	year
MPA smog episode model	5x5 km	1-6 hours
Acidifcation	5-15 km 0.5-1°	season + representative day

Form of access

Under discussion (tables, restricted on-line connection)

Source categorization

	Emission species						
	CH_4	CO_2	N_2O	NO_x	S-comp.	CO	NMVOC
gas distribution	x						
fuel recovery	x						
waste disposal	x						
wetlands	x						
livestock	x						
agriculture	x		x				
biomass burning	x	x	x	x		x	x
terrestrial ecosystems		x	x				x
road traffic		x	x	x		x	x
electrical power generation		x		x	x		
domestic combustion		x				x	
oceans		x					
consumptive use solvents							x

Information needed per source category

Activity level	- fuel consumption - production
Emission factor	- per point source - per area source type - emission/GJ-Energy related emission - emission/tons product - process emission
Localization	- point sources - area sources - distribution functions
Additional	- proper choice of emission factor explanatory variable - growth parameters (production, population)

System development

Inquiry
Report of preliminary study

Information analysis

Data analysis	-	object model
		entities model
		specialized data model
Function analysis	-	Data Flow diagrams
Process analysis	-	Actor-Process matrix
		User overview

Prototyping
Subprogrammes
Documentation

Data collection and processing system testing, consistency checks

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NORWEGIAN INSTITUTE FOR AIR RESEARCH
POSTBOKS 64, N-2001 LILLESTRØM

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OPPDRAGSGIVER Norges Allemennvitenskapelige Forskningråd (NAVF) og Norsk institutt for luftforskning (NILU)			
STIKKORD global emissions	inventory	proceedings	
REFERAT			

TITLE Proceedins of the IGAC/GEIA workshop on global emission inventory, Lillestrøm, 22-24 June, 1992.

ABSTRACT In accordance with the work plan of the IGBP/IGAC Global Emissions Inventory Activity (GEIA), a Workshop on Global Emission Inventory was organized by the GEIA Secretariat and the Norwegian Institute for Air Research (NILU). The workshop was attended by 34 participants from 9 countries and 3 international organizations. The overall goals of the workshop were to review the progress of work within individual GEIA projects and to plan further activity, as well as to discuss new projects. Major focus was placed on projects related to emissions of acidic components, such as SO_2 and NO_x, and other nitrogen compounds, and VOCs.

* Kategorier: Åpen - kan bestilles fra NILU A
Må bestilles gjennom oppdragsgiver B
Kan ikke utleveres C