emission inventories and emission scenarios

Perspectief

A lot is happening.....

There are many activities on inventories and scenarios aiming at harmonization between past, present and future emissions:

- HTAP (Keating, Zuber)
- IPCC-AR5 Scenario group (Lamarque e.a.)
- CCM-Val (Eyring, Stevensen)
- GEIA (Granier e.a.)
- AC&C Hindcast (Rash e.a.)
- Trop-Chem
- .....

There is a risk of duplication of work or that one project makes the other obsolete.

Most projects are “free-ride” projects, that is take available emissions data and used it to the extend possible.

1. HTAP emission inventory activity:

2. Summary of IPCC expert on new scenarios

3. Emissions harmonization exercise to facilitate new scenarios for AR5

4. Some discussion points

Recommendations of Emission workshop (Beijing, 2006) and Interim Assessment report 2007.

Improve the quality of emission methodology and inventories for sources that are poorly known:

- biomass burning (agricultural waste, biomass for heating and cooking, and forest fires)
- small and medium scale industry and energy production,
- transport
- domestic use of coal

A. Improvements can only be achieved through improved data capture in cooperation with experts from different countries bringing in knowledge of the local conditions

B. There is thus a strong need to update any emission data base to hold as recent data as possible due to rapidly changing emissions in emerging economies.

II. Emission inventories: what's out there and what to select?

Year 2000-2005 country inventory data

North America: USA, Canada, (Mexico) emission inventories (info on grid/season)

W-Europe: CLRTAP EMEP inventories (info on grid/season)

EURAsia: partly CRLTAP EMEP inventories (large adjustments made by EMEP)

South-America: NatCom Annex I (CO, NOx, NMVOC, SO2)

Africa: GAPF inventories and individual studies, project inventories (AMMA)

Asia: GAPF inventories and individual studies (REAS, trace-p)

Oceania: NatCom Annex I (CO, NOx, NMVOC, SO2)

Global inventories (2000-200?): GAINS, Smith(SO_2), EDGAR
BC/OC default: Bond (SPEW), Liousse, IIASA + individual countries from above

Roadmap towards HTAP emission inventory (2000-2005)

Table 1: Overview of available historical emission datasets covering the period 2000 -2005 that should be considered for various world regions (See explanation below table) .

Region	SO2, NOx, NMVOC, CO	NH3	CH4	PM	OC, BC	POP	HM	grid	latest year
North America	NEI	NEI	NatCom	NEI	calc	?	?	USA/CAN	2002-2004
W-Europe	NEI	NEI	NatCom	NEI	Calc	NEI	NEI	EDGAR	2005
Eastern Europe and Russia	NEI/ANNEX I or EDGAR	NEI/ EDGAR	NEI/ EDGAR	NEI/ EDGAR	calc/EDGAR	?	?	EDGAR	2005
South America	Annex I or EDGAR	EDGAR	Annex I or EDGAR	EDGAR	EDGAR	?	?	EDGAR	2005
Africa	EDGAR	EDGAR	EDGAR	EDGAR	EDGAR	?	?	EDGAR	2005
Asia	Choice	Choice	Choice	Choice	Choice	?	?	EDGAR	2005
Oceania	Annex I or EDGAR	EDGAR	Annex I or EDGAR	EDGAR	EDGAR	?	?	EDGAR	2005

NEI: data will included by main emission sector from national inventories reported to EMEP or the national inventories of USA and ENV Canada

Annex I: Emissions of CH4, NOx, SO2, NMVOC and CO as reported by main emissions sector from National Communications of Annex I countries to UNFCCC. Annex II countries do not (always) report data in the period 2000-2005.

EDGAR: EDGAR v4 emissions calculations

Calc: Based on reported PM emissions, the % of PM that is BC and OC will be applied (sources: USEPA, Bond et al, IIASA).

Choice: a choice is needed based on analysis of inventory literature or on request to used government endorsed datasets

RAPIDC, Male declaration inventories: no complete datasets available yet
OC/BC: Bond as alternative
REAS/Streets and others: choice for Asia
Biomass burning: GFED
Natural emissions: not decided
Post processing: not decided

Status:

*** NEI:**	**ok and in database (QC, Monni/Pagliari)**
*** Natcom:**	**ok and in database (QC, Monni/Pagliari)**
*** Choice:**	**discuss China. India, maybe Russia (this workshop, van aardenne)**
*** Calc:**	**not done**
• Grid:	**ok, except mining, industrial processes not finished (Orlandini/van Aardenne)**

EDGARv4: (1970-2005)

Finished: agriculture, waste, industrial process (except iron/steel)

At 90%: road transport (Doering/QUANTIFY) India, China, L-AM (abatement), SO_2

At 70%: energy emissions (Van Aardenne), abatement measures

Just started: QC/report writing

Summary of IPCC expert on new scenarios

Towards New Scenarios for Analysis of Emissions, Climate Change, Impacts and Response Strategies

19-21 September 2007
Noorwijkerhout, NL

Summary of IPCC expert on new scenarios

Why this IPCC expert meeting?

- **identify requirements and plans for the development of new scenarios of emissions, climate change and adaptation and mitigation**

- **decision of proposed set of benchmark concentration pathways**

Participants:

- **ESM: researchers on Earth Systems Modeling including climate, carbon cycle, atmospheric chemistry**

- **IAV: researchers on modeling of Impacts, Adaptation, Vulnerability**

- **IAM: researchers on Integrated Assessment Modeling**

- **users: experts from the policy and user communities**

Note: Development of scenarios is done by research community (not IPCC scenarios !)

<u>GOAL</u>: To Develop new scenarios of emissions, climate change and adaptation and mitigation including processes like carbon cycle, aerosols, chemistry, dynamic vegetation.

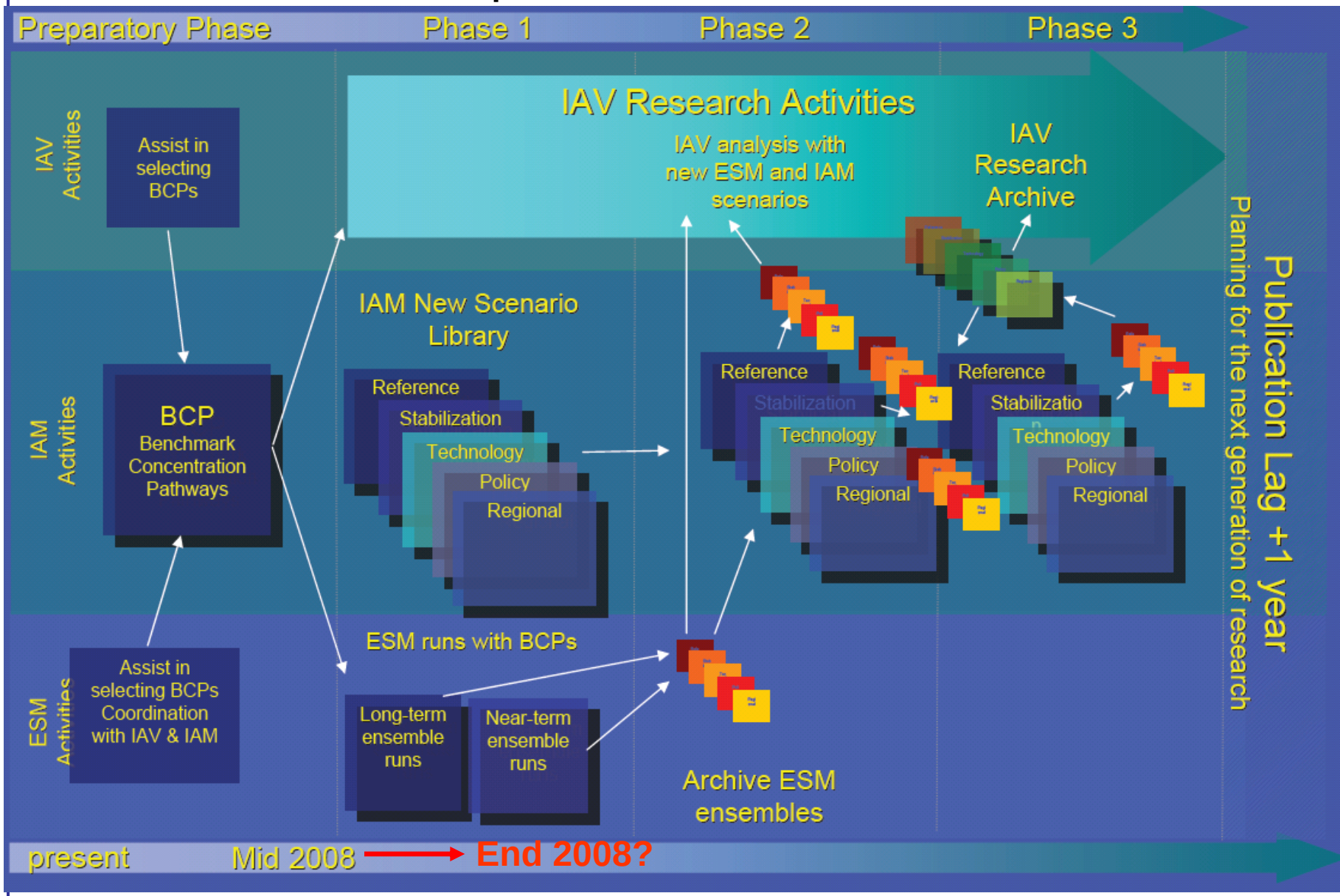
Near term scenarios (to ~2030)

- **develop better projections of *regional climate change* and its impacts**
- **include *co-benefits with air quality and synergies between adaption-mitigation***
- **high resolution models**
- **IAM and IAV study uncertainties by exploring larger variety of scenarios**

Longer term scenarios (to 2100 and beyond)

- **options for stabilization of anthropogenic influences on climate or consequences of failure to do so.**
- **feedbacks between climate and biogeochemistry and non-linearties in climate system.**
- **lower resolution models**
- **ESM determine uncertainty through large ensemble simulation for small number of scenarios.**

Timeline of the new scenario experiments:



Now: 2008

Preparatory phase: Benchmark Concentration Pathways (BCP) from IAM should be delivered to GCM, AOGCM and ESM modelers.

Next steps:

Phase 1:

a) GCM, AOGCM and ESM used BCP to produce climate scenarios
b) IAM prepare new socio-economic, land use etc scenarios into a scenario library (open process for regional and global model teams)

Phase 2:

a) Downscaling of ensemble scenarios from ESM to study regional manifestation of global climate
b) IAV impact assessments
c) IAM: incorporate feedback processes in emission scenarios (ecosystem, carbon-cycle

Phase 3:

a) development of internal consistent scenarios on emissions, atmosphere-climate-ocean change, effect of climate change impacts
b) publication of results to feed AR5

New concept of benchmark concentration pathways:

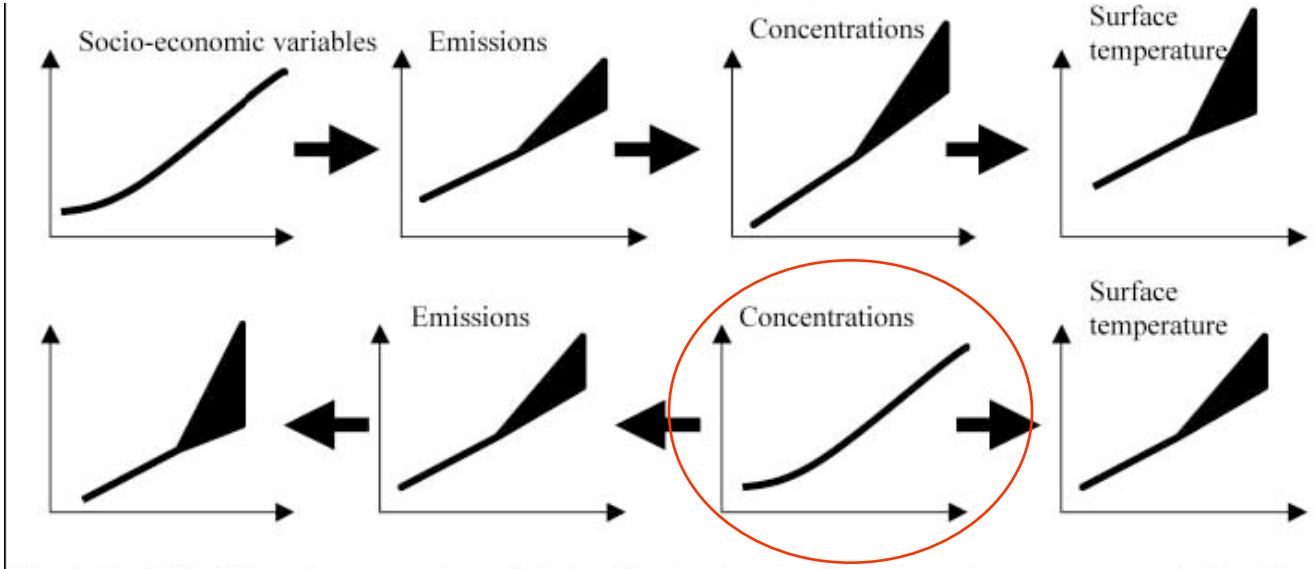


Fig. 3. (top) Traditional progression of derived emissions to climate sysiem response starting from socioeconomic variables, emissions, concentrations, and climate change. (bottom) New strategy starts with benchmark concentration scenarios from IPCC WGIII scientists to modeling groups, from which emissions are calculated, and supplied to WGIII scientists to derive socioeconomic variables consistent with emissions stabilization pathways. The climate system response is still generated from concentrations (arrow from concentrations to temperature).

Serial activity, groups wait on each other

Parallel process of different groups

EOS transactions, 2007

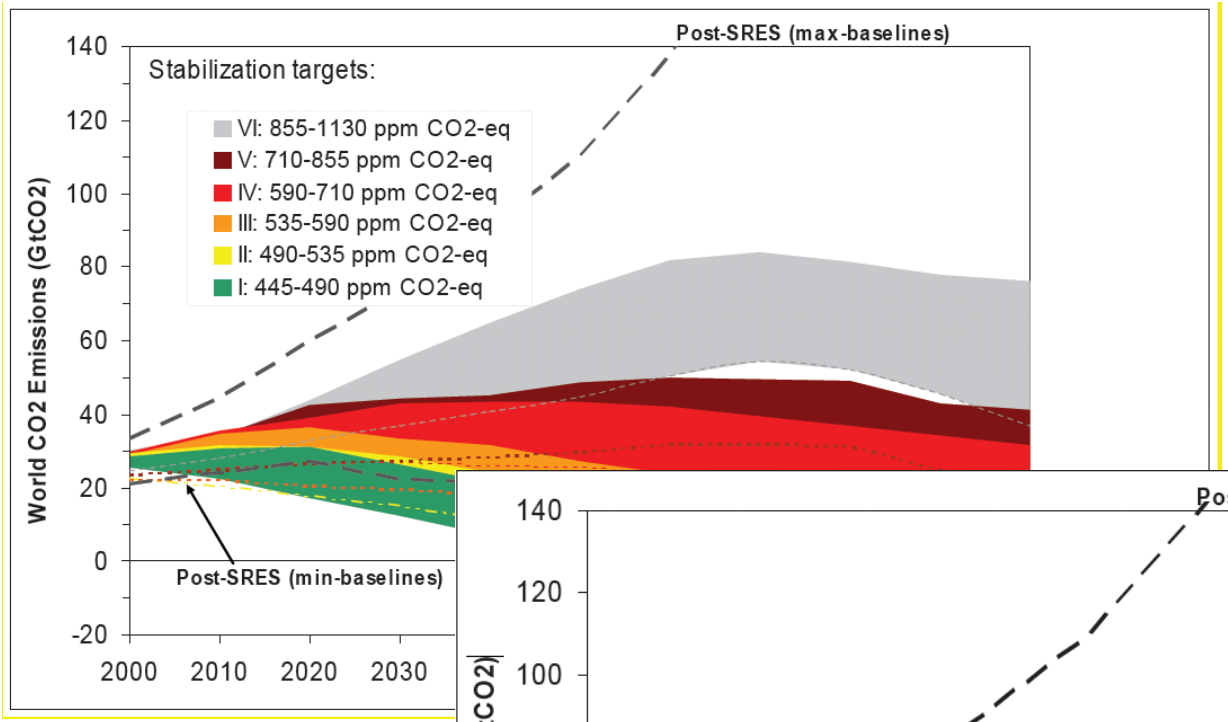
Benchmark scenarios to be selected *from existing literature* (as used in AR4)

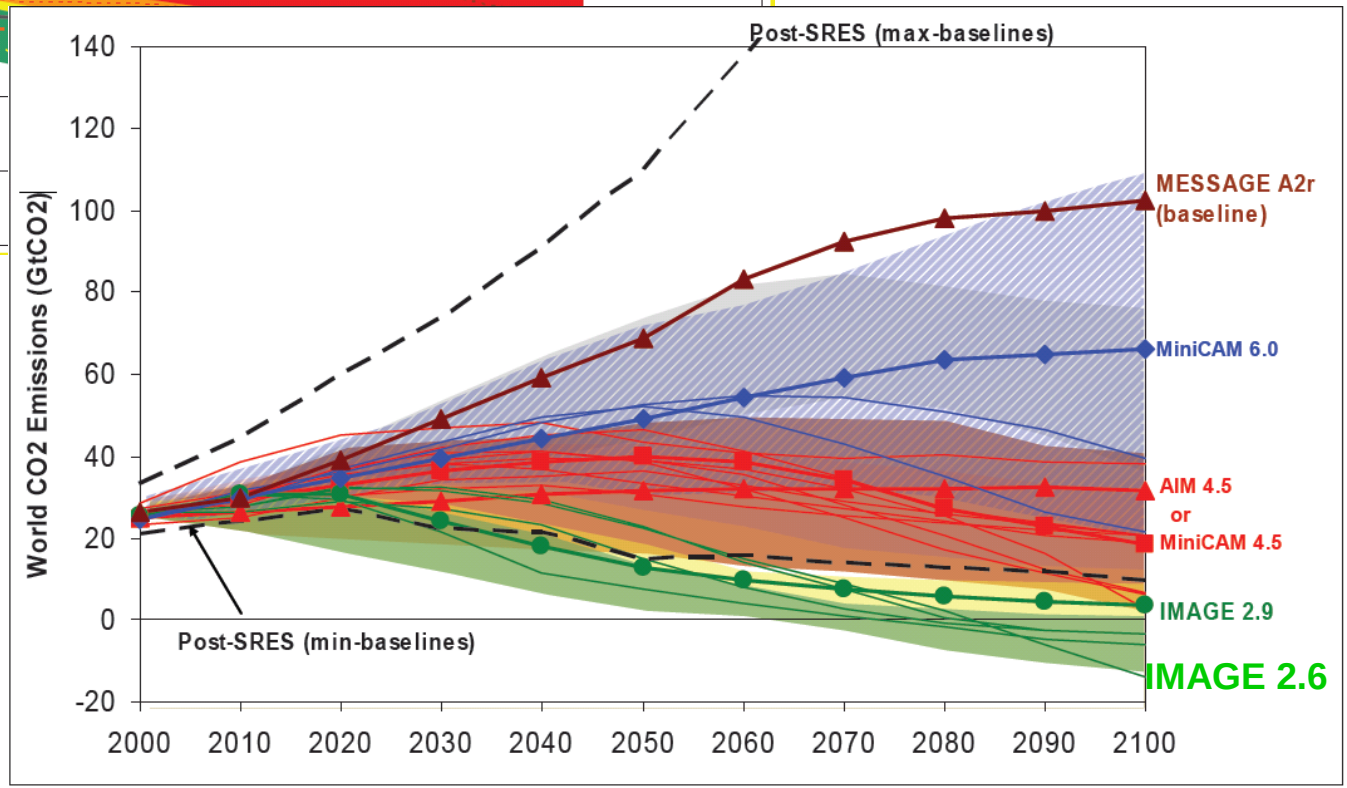
What is in the benchmark scenarios?
-GHG emissions and concentrations resulting from IAM
- GHG: CO_2, CH_4, N_2O, CFCs, HFCs, PFCs, SF_6
- Reactive gases: CO, NO_x, NH_4, VOCs
- Derived GHGs: tropospheric O_3
- Emissions of aerosol (precursors): SO_2, BC, OC
- Land use and land cover

Extension to existing scenarios:
-downscaling of short lived species and land use/land cover to 0.5x0.5 (near-term simulations) and 1x1 degree (long-term)
-extension to 2300 by simple scaling (e.g. population).

Deadlines for Benchmark scenarios: ~September 2008.

Range of radiative forcing and selection of BCP





BCP 8.5 (850 ppmv): MESSAGE model (IIASA)

BCP 6: most likely MINICAM (PNNL)

BCP 4.5: most likely AIM (NIES)

Lowest case: IMAGE model (MNP)

Sensitive issue: proposed BCP3 seen too far from policy targets.

BCP2.6 IMAGE scenario as tentative realization, scientific community attempts to derive a similar pathway to show that this is not an outlyer scenario.

BCP2.9 IMAGE scenario as fallback option

Decision to be made by IAM consortium together with 2 external experts (summer 2008)

Information request by ESM models (what might be available by mid-2008?)

Appendix 4, Table 3: Indication of the information needed by ESM modeling groups

Variable	Units	Spatial scale	
Greenhouse gases		Concentrations	Emissions
CO_2 (fossil fuel, industrial, land-use change)	ppm and Pg/yr	Global average	Sum
CH_4	ppb and Tg/yr	Global average	$\leq 1^\circ$ x 1°
N_2O	ppb and Tg/yr	Global average	$\leq 1^\circ$ x 1°
HFCs	ppb and Tg/yr	Global average	Sum
PFCs	ppb and Tg/yr	Global average	Sum
CFCs	ppb and Tg/yr	Global average	Sum
SF_6	ppb and Tg/yr	Global average	Sum
Aerosols*			
Sulfur (SO_2)	Tg/yr	Generated by ESM	$\leq 1^\circ$ x 1°
Black Carbon (BC)	Tg/yr	Generated by ESM	$\leq 1^\circ$ x 1°
Organic Carbon (OC)	Tg/yr	Generated by ESM	$\leq 1^\circ$ x 1°
Chemically active gases*			
CO	Tg/yr	Generated by ESM	$\leq 1^\circ$ x 1°
NO_x	Tg/yr	Generated by ESM	$\leq 1^\circ$ x 1°
VOCs	Tg/yr	Generated by ESM	$\leq 1^\circ$ x 1°
NH_4	Tg/yr	Generated by ESM	$\leq 1^\circ$ x 1°
Land-use & land cover			
CO_2 flux (land use change)	Tg/yr	n/a	$\leq 1^\circ$ x 1°
Land use & land cover	Fraction of types	$\leq 1^\circ$ x 1°	

- Additional resolution by species and/or sector is requested through 2030 for one of the BCPs.
- Note that O_3 concentrations are not included in the list as IAMs calculate these concentrations at a scale too coarse to be meaningful for ESMs. Emissions of O_3 precursors are provided instead.

It is recognized that the interpretation of the climate scenarios is sensitive to:
1: level and geographical distribution of aerosols and chemically active gases
2: land use patterns.

For the short term experiment depending on the ESM and on the scientific purpose calculation of space and time distribution of gases and aerosols will be performed online (in ESM if capable) or offline (global 3D chemistry models).

As side-event a group of IAM, ESM met to discuss a harmonization exercise (initiative by Jean Francois Lamarque).

Aim: a) consistent past, present, future emissions trend
b) consistent gridding of emissions (0.5 or 1 degree)
c) post-processing of emissions (VOC speciation, seasonality etc).
d) consistent land use datasets

Emissions harmonization exercise to facilitate new scenarios for AR5 Paris , May 14-16, 2008

Attendance: Jean-François Lamarque (NCAR), Claire Granier (UPMC), Cathy Liousse (CNRS), Aude Mieville (UPMC), Steve Smith (UMC), Keywan Riahi (IIASA), Toshihiko Masui (NIES, Japan), Sawako Ishiwatari (NIES, Japan), Martin Schultz (FZJ), Glynis Lough (USA), Detlev van Vuuren (MNP), Veronika Eyring (DLR), David Stevenson (U Ed.), Elke Stehfest (Netherlands Environmental Assessment Agency), John van Aardenne (Ispra), Tami Bond (USA, by phone), Michael Schulz (CEA)

Summary of "IPCC" emissions meeting

Aim:

Define anthropogenic and biomass burning emissions for non-CO2 gases, aerosol precursors and aerosols for 1850-2000, with the 2000 dataset used for harmonization by the Integrated Assessment Models (IAMs).

Emission inventories needed for:

Greenhouse gases: (CH4 on grid; N2O, HFCs, PFCs, CFCs, SF6 as global sum)
Aerosols: SO2, BC, OC (on grid)
Active gases: CO, NOx, NMVOC, NH3 (on grid)

Required format:

0.5x0.5 grid: this to allow different models to allocate grids to specific world regions (which vary between different IAM's)

Timeframe

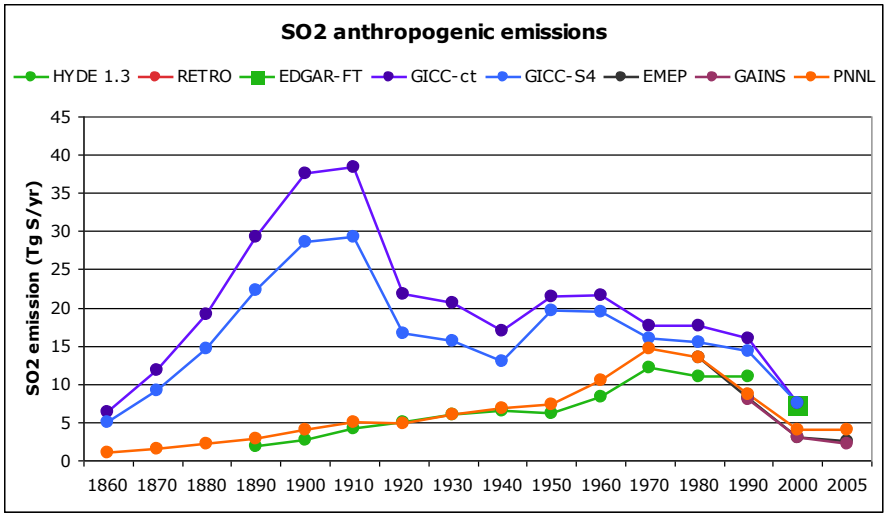
Year 2000 dataset available (asap)
Historical trends back to 1890 (pre-industrial) in steps of 10 year (September)

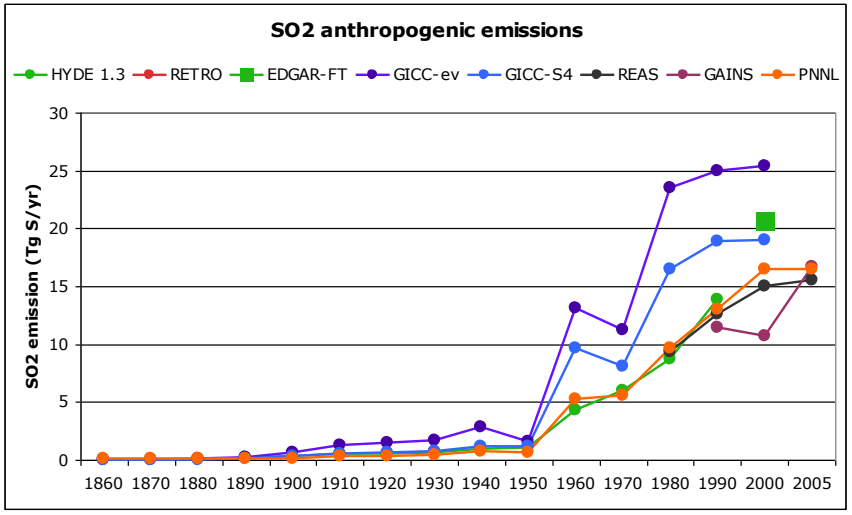
Sector requirement

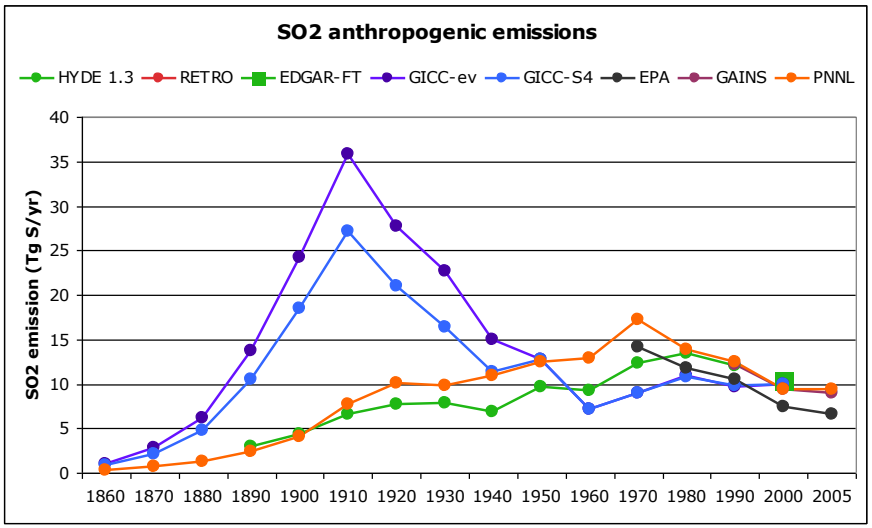
In order to perform comparison and harmonization across different emission datasets and different periods (including future emissions), it was agreed that emissions would be made available for the following sectors

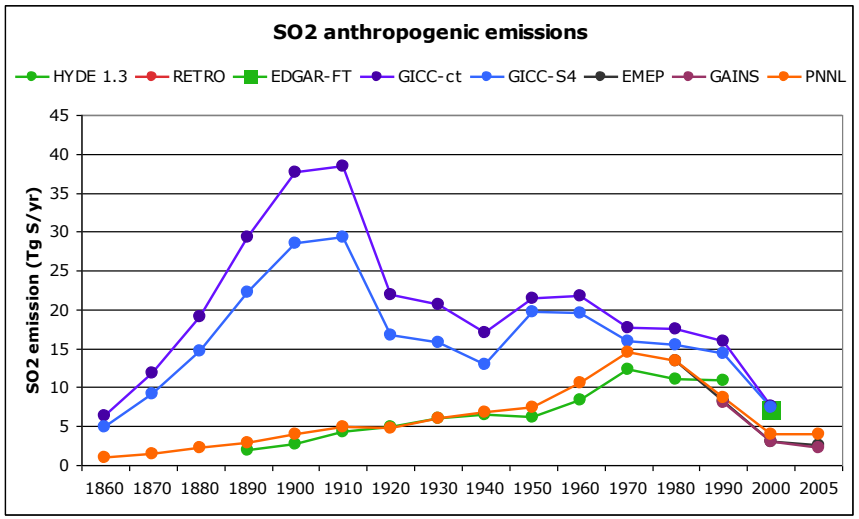
Categories for harmonization exercise	IPCC source classification	EDGARv32 codes
Energy industry (production, power plants, distribution and conversion)	1A1+1B	B20+B30+F20+F30+F70+F80+F90
Industrial processes and combustion	1A2+ 2A+2B+2C+2D+2E	B10+F10+I10+I20+I30+I40+I50+I60+I90+F60
Land transport	1A3b+1A3c+1A3e	B51+F51+F54
International shipping	1A3d	F58
Aviation	1A3a	F57
Residential, commercial	1A4	B40+F40
Solvents	2F+3	I70+H10+H20+H30+H40+H50+H60
Agriculture: animals, soils	4A+4B+4C+4D+4G	L20+L30+L15+L10+L71+L75+L60+L50
Agricultural waste burning	4F	L43
Waste	6A+6B+6C+6D	W10+W20+W30+W40+W50
Savannah burning	4E	L42
Land use change/deforestation/slash and burn	5A+5B+5C+5D+5E	L41+L44+L45+L47
Natural emissions	-	-

Examples of comparisons made for SO_2









Graphs made by Steve Smith

Example of comparison:

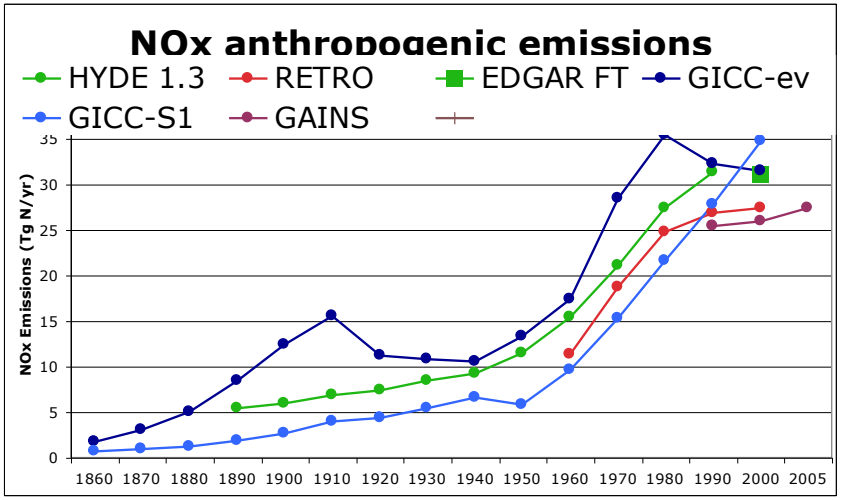


Figure 1: Global anthropogenic NOx emissions (prepared by Granier/Mauville))

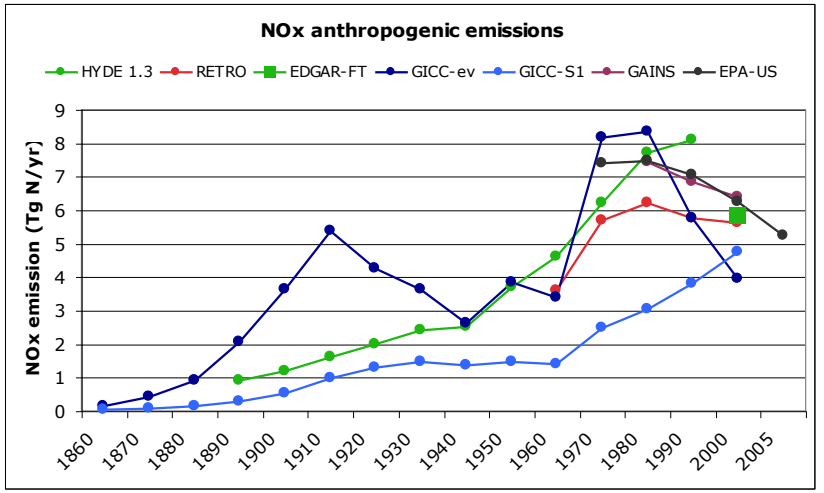


Figure 2: North America NO_x emissions (prepared by Granier/Mauville for IPCC meeting)

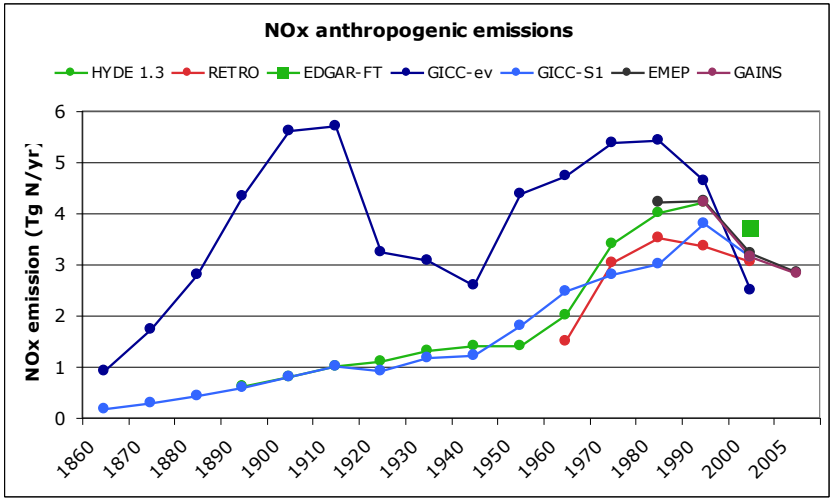


Figure 3: Western Europe NO_x emissions (prepared by Granier/Mauville for IPCC meeting)

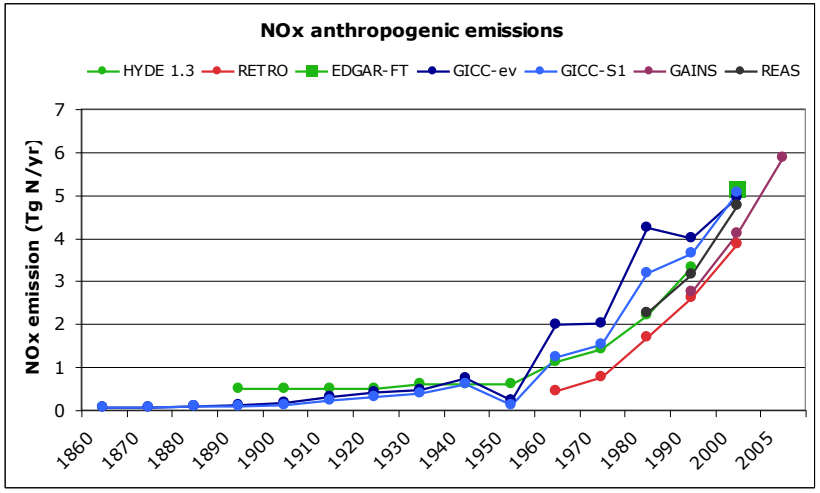
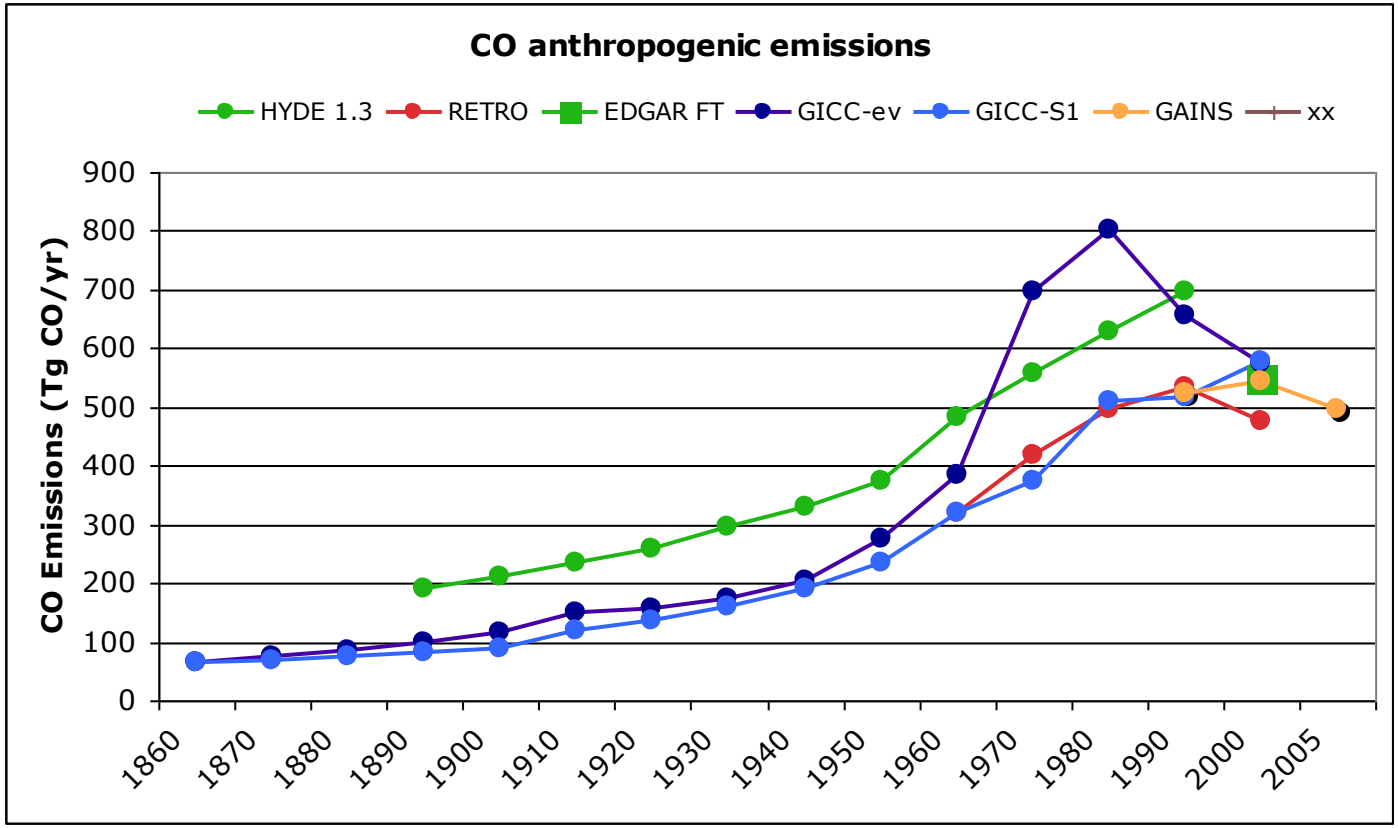


Figure 3: East Asian NO_x emissions (prepared by Granier/Mauville for IPCC meeting)

Example of comparison:



International shipping
-Result ATTICA project will be provided (Eyring)

Aviation
- Results from ATTICA project (Lee)

Biomass burning
- year 2000: GFED data average for 1997-2006 (as is)
- 1960-2000: RETRO dataset (Schultz)
- 1890-1960: (Liousse and Granier)

Natural emissions:
(no action defined)
-it is expected that many modeling groups will override that category with their own estimates.
-It is expected that the values of those emissions will be kept constant over the whole period (including future), except possibly for historical volcano emissions.

Action plan: compounds

SO2:
Smith et al. 1850-2000 (as is)

CH4:
EDGAR: 1890-2000 (as is)

Aerosols
Y_1890-2000 Compilation based on existing inventories work (Bond/Liousse)

Precursors
Y_2000: Follow the HTAP emission inventory (van Aardenne)
Y_1960-2000: discuss RETRO/EDGAR trends and apply to year 2000 (Schultz/van Aardenne
Y_1890-1960: compilation from IGCC inventory with EDGAR-HYDE (Liousse/van Aardenne)

VOC speciation:
Y_2000 following RETRO (= edgarv2 speciation?)
Y_1960-2000 evaluation RETRO

Action plan: other issues

SO2:
Smith et al. 1850-2000 (as is)

CH4:
EDGAR: 1890-2000 (as is)

Aerosols
Y_1890-2000 Compilation based on existing inventories work (Bond/Liousse)

Precursors
Y_2000: Follow the HTAP emission inventory (van Aardenne)
Y_1960-2000: discuss RETRO/EDGAR trends and apply to year 2000 (Schultz/van Aardenne
Y_1890-1960: compilation from IGCC inventory with EDGAR-HYDE (Liousse/van Aardenne)

Post-processing:
VOC speciation: Y_2000 following RETRO (= edgarv2 speciation?), Y_1960-2000 evaluation RETRO

Seasonal variations: will be parameterized by seasonal scaling to be extracted from RETRO (Schultz)

Stack height: should be provided whenever available; from the IAMs (mainly energy)

Vertical distribution: biomass burning in terms of fraction emitted at a certain altitude

Grid: Y_2000: detailed grid inventory for year 2000 (EDGAR), pre_2000: population maps (probably HYDE dataset), future maps not discussed.

Emissions between 2000 and 2010

Post-2000 emission datasets are available for a variety of regions and compounds. It is hoped that a compilation effort (such as th ework led by David Stevenson) will lead to a compilation of regional and sectoral totals that can be used for verification of IAMs projections. In particular, it is hoped that the future emissions between 2000 and 2010 will not deviate too much from those additinal inventories.

Distribution of data

- Where possible CF compliant netCDF

-NCAR Community Data Portal could be used as the central repository, available for internal (to this group) access until the release of the emissions to the general community. At that point, the GEIA portal will take over this distribution.

Discussion points

HTAP:

- Science for policy under HTAP: “best science” inventory or an “endorsed” inventory?

IPCC:

- Preparatory phase: “invited party”, in 2009 new scenario experiments (emissions/impacts)

General:

1. Harmonized datasets a requirement or should we learn through variety

2. Does community really needs new emissions?
   (Results based on 1990 EDGAR/SRES scenarios presented but and not “attacked”)

3. Challenge for community is outreach/capacity building in international community
   a) option_1: international project with funded deliverables.
   b) option_2: exchange of information
      - allow access to emission information, tools
      - HTAP results (e.g. excel toolkit with ozone and aerosol concentrations as a function of local reduction versus changing background values)