AeroCom emissions and a global emission inventory for aerosol simulations of the period 1980 - 2006

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AeroCom emissions

Issues to be discussed:

- What do we need?
- What *is* available?
- What can be expected in the near future (~ 1 year)?

Emission scenarios

- Past: ~ 1850 - 2006
- Near Present: 1980 – 2006
  - Higher temporal resolution, more detailed sectors
- Future Scenarios (IPCC): 2030, 2050, 2100, ...

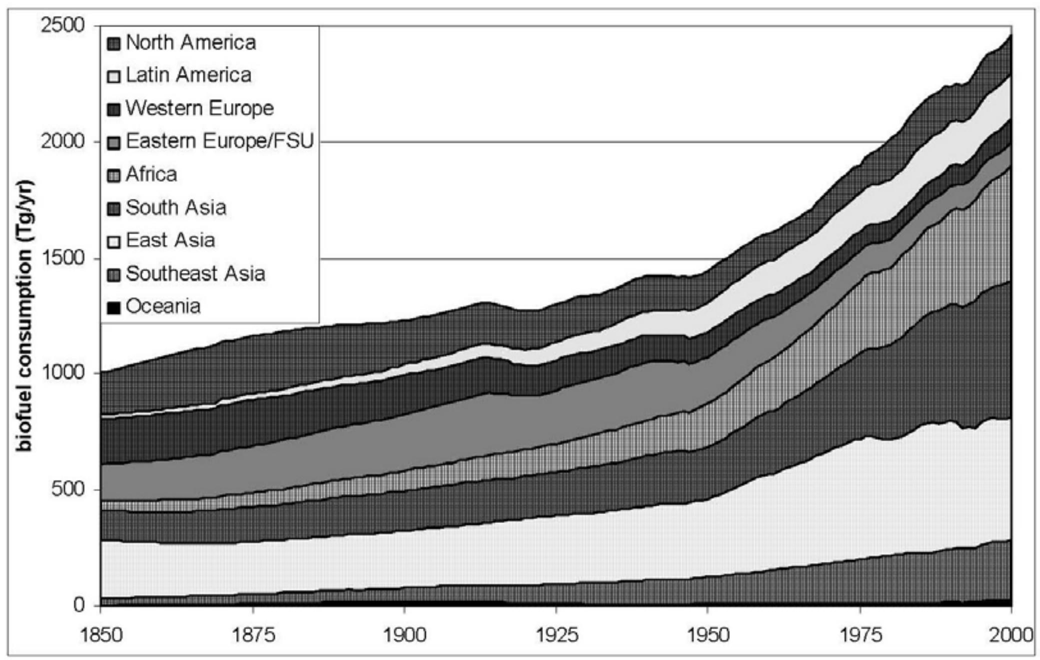
Emissions for the past

- Anthropogenic:
  - T. Bond: BC and OC, 1850-2000, 1x1, decadal
  - EDGAR HYDE: SO_2, 1890-1990, 1x1, decadal
  - EDGAR v4(?): 1970-2004, 0.1x0.1 (by country)
- Biomass burning:
  - GFEDv2: dry biomass burned, 1997-2006, 1x1, monthly and 8-daily
  - Duncan et al.: dry biomass burned, 1979-2000, 1x1, monthly
  - RETRO: BC, OC and SO_2, 1960-2000, 0.5x0.5, monthly

Biofuel reconstruction for past emissions

Goes beyond per-capita scaling, considering...

- *Urban/rural population*
- *Fuel scarcity*
- *Introduction of fossil fuels*

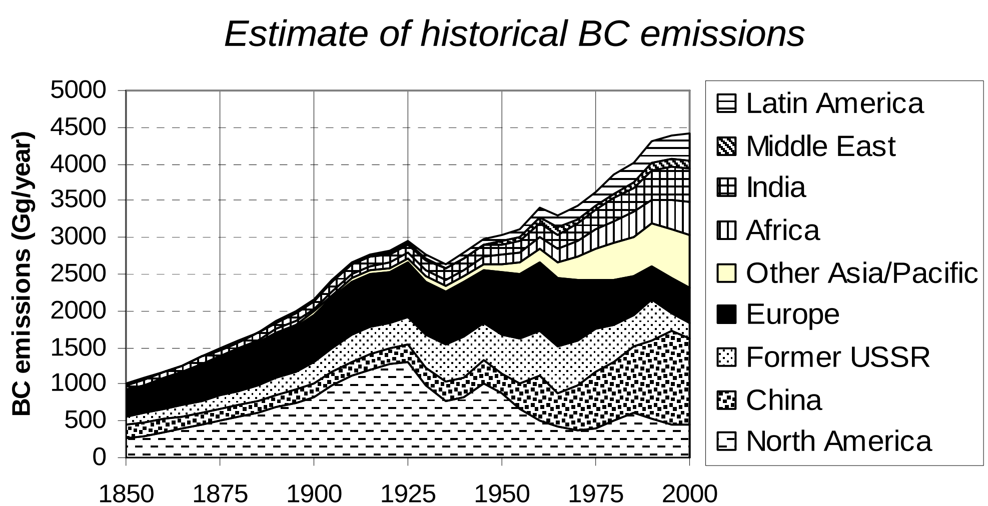


Fernandes et al (2007), Global biofuel use, 1850-2000, *Global Biogeochemical Cycles*, *21*, GB2019, doi:10.1029/2006GB002836.

BC/OC emission history

Energy use reconstructed by sector & end-use

- Sectors: Electricity production, industry, domestic & “other”, transportation
- End uses: road, ships, rail, changes in firing & control technology
- Could be used for any emission (not just BC/OC)
- 1x1 grids every 10 years (RIVM population)

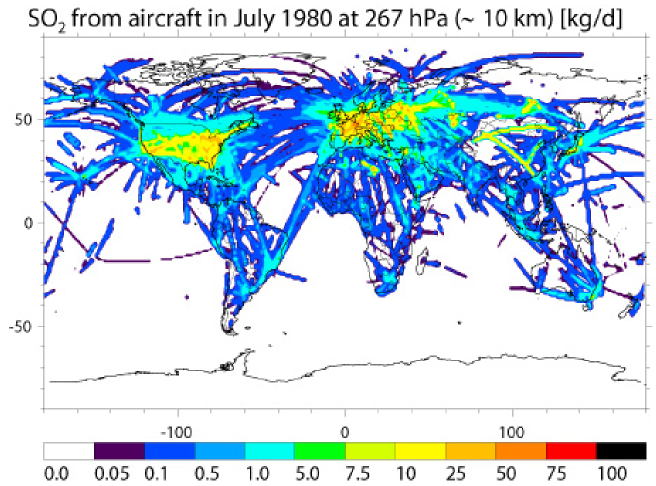


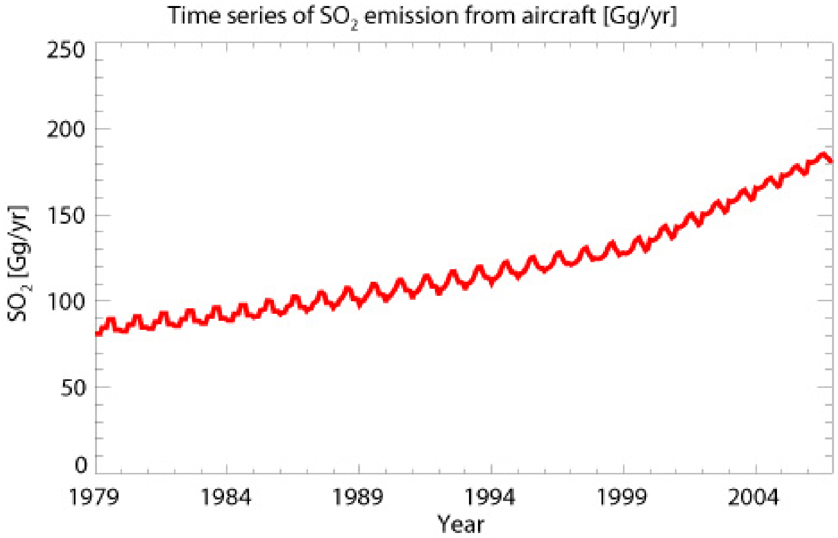
Bond et al (2007), Historical emissions of black and organic carbon aerosol from energy-related combustion, 1850-2000, *Global Biogeochemical Cycles*, *21*, GB2018, doi:10.1029/2006GB002840.

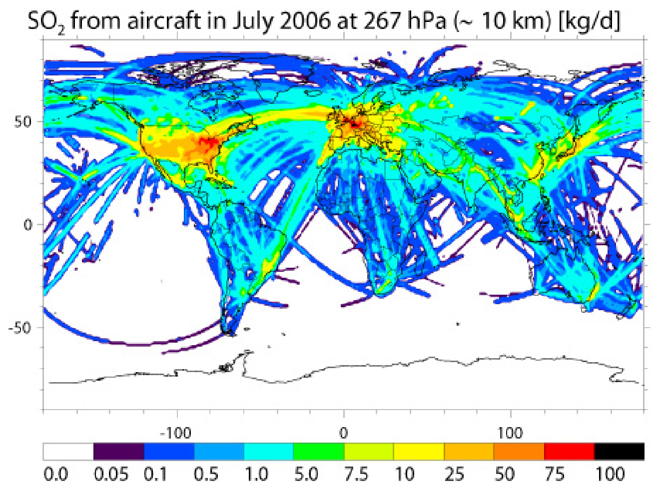
Emissions for 1980-2006

- Quantify the relation between changes of aerosol loading, emissions, and surface radiation (“global dimming”, “global brightening”)
- Determine impact of intercontinental transport on air quality of other regions
- Support the interpretation of satellite products, etc....
- Long-term global simulations together with observations are a prerequisite for these analyses
- 1980-2006 is of particular interest because:
  - The distribution of industrial emissions was substantially changed
  - Several large volcanic eruptions occurred
  - A plethora of observational data became available

Aircraft emissions

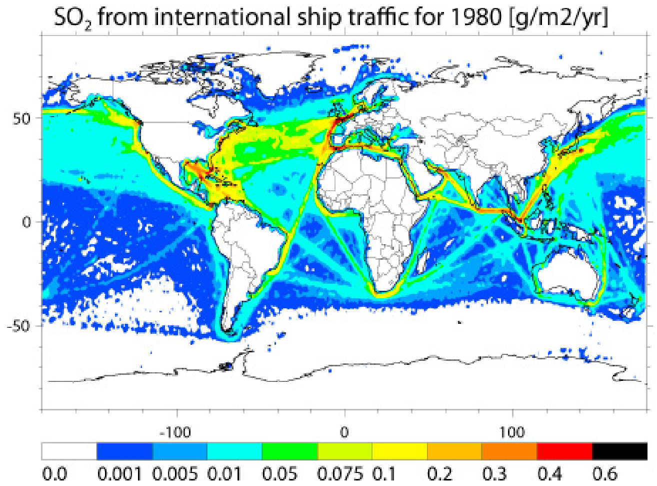


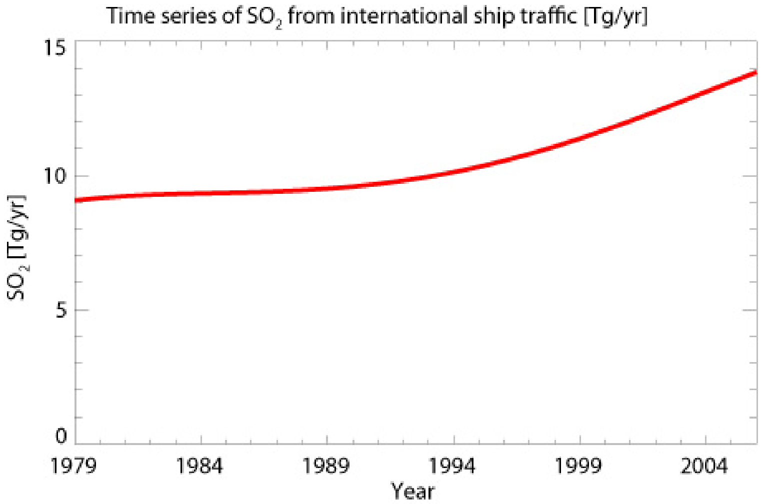


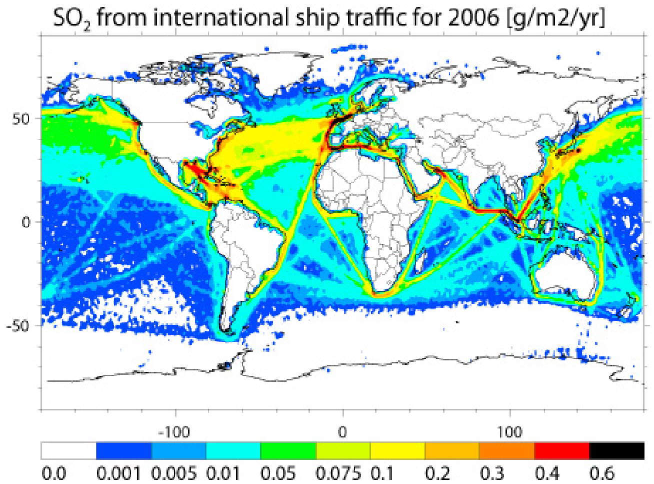


- Based on gridded burnt fuel files from AEAP project for 1976, 1984, 1992, 1999, and a projection for 2015
- Flight pattern is preserved between base years for interpolation
- EI of 0.8 assumed for SO_2 (0.8 g SO_2/kg fuel); height dependent EI for BC; OC=1/3 BC; all hydrophilic

Emissions from international ship traffic

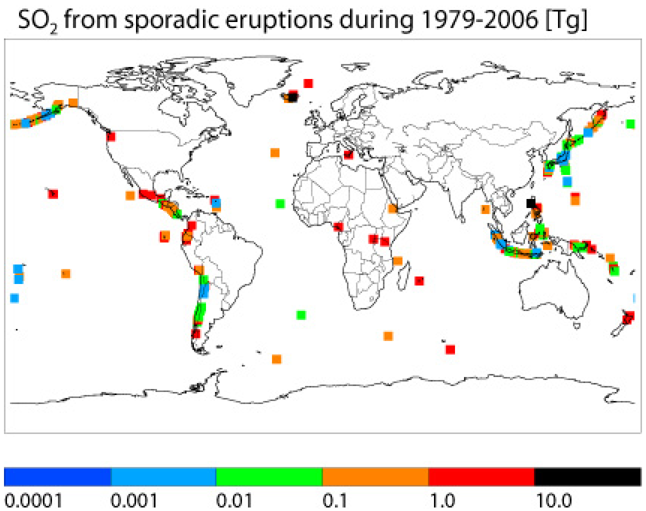


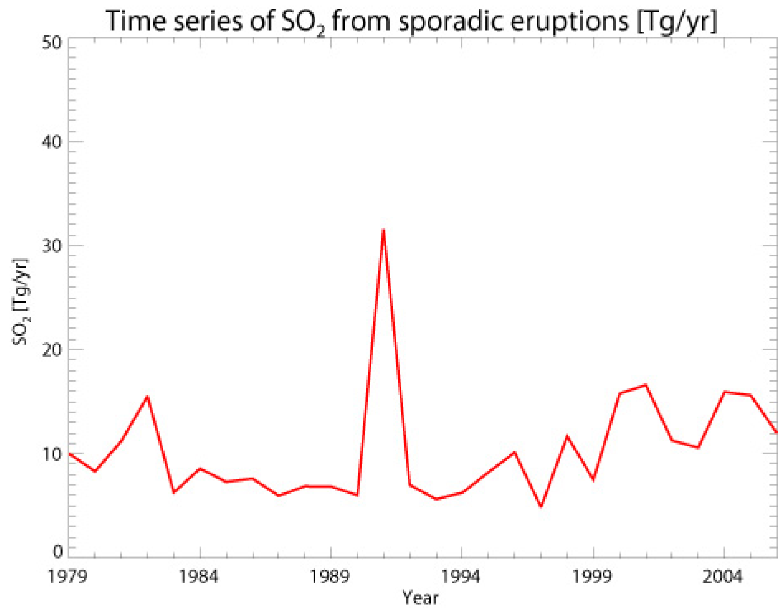


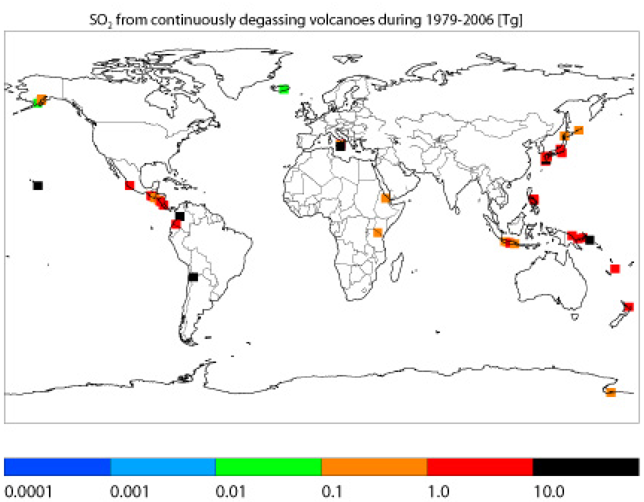


- Based on estimates of total SO_2 and PM emissions of Eyring et al. for 1980, 1995, and 2001, and a projection for 2020.
- These numbers were used to scale gridded SO2 emissions from the EDGAR 32FT2000 database for 2000 (http://www.mnp.nl/edgar)

Volcanic emissions





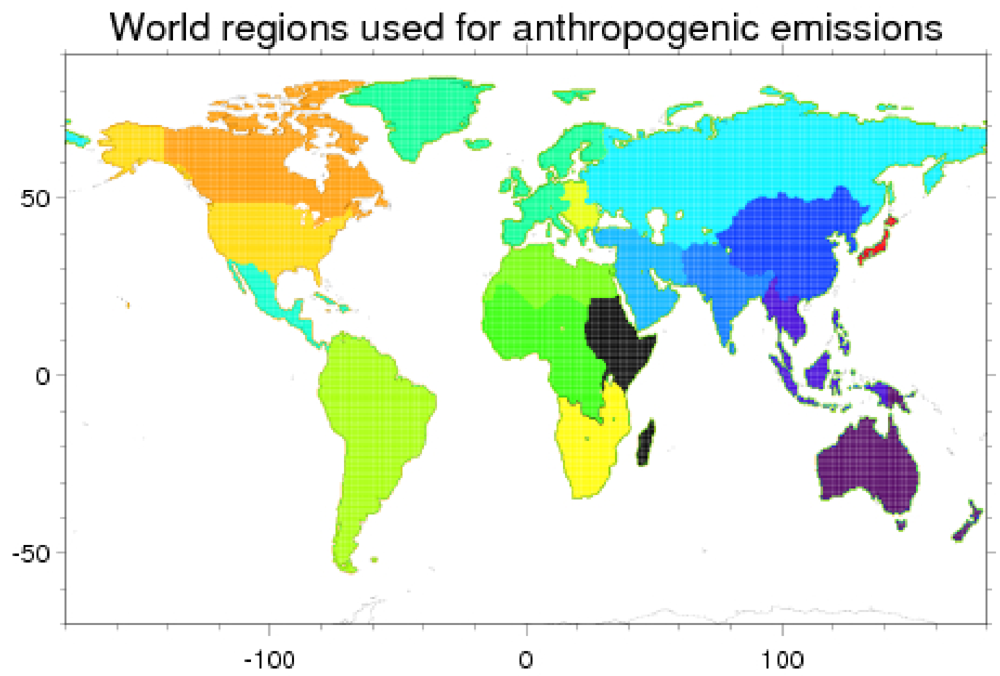


- Sporadic eruptions are based on the Smithsonian Institution's Global Volcanism Program
- Cloud column height is derived from the VEI and SO_2 data is derived from the modified SO_2 index proposed by Halmer et al.
- TOMS SO_2 data is used when available
- Continuously degassing volcanoes are from the climatological GEIA database

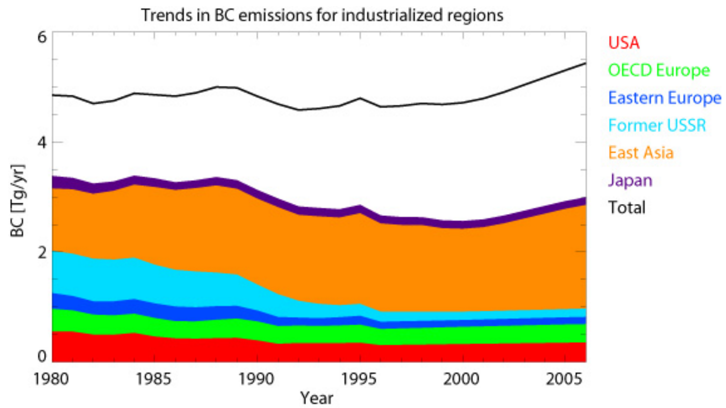
Anthropogenic emissions

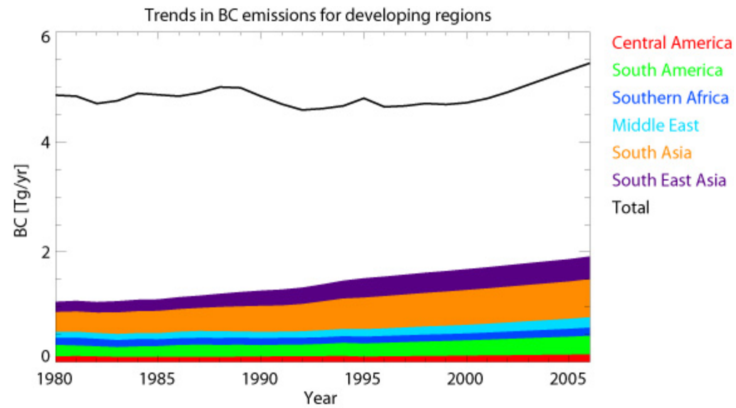
(excluding BB, aircraft and intl. ship traffic)

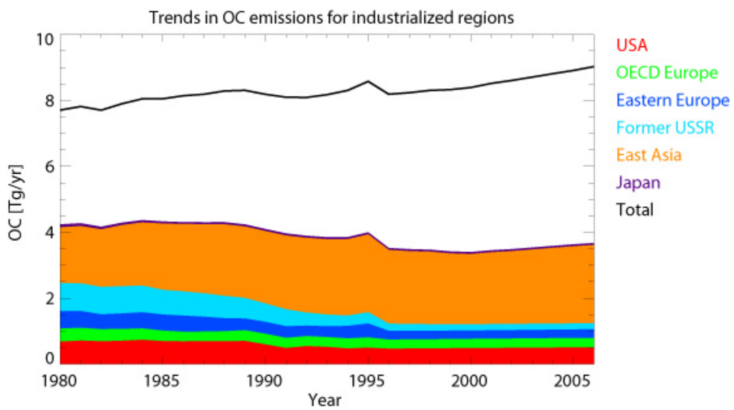
- Gridded BC and OC emissions for 1996 are based on the Speciated Particulate Emissions Wizard (SPEW) inventory (Bond et al. 2004)
- Gridded SO2 emissions for 2000 are from the EDGAR 32FT2000 database.
- The gridded files were extended to an annual trend by scaling with regional BC, OC, and SO_2 emission numbers for 17 regions for each year from 1980 – 2006 (D. Streets, personal communication)

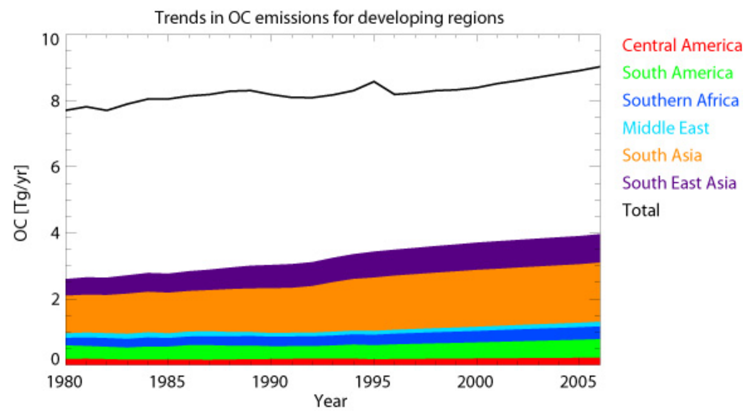


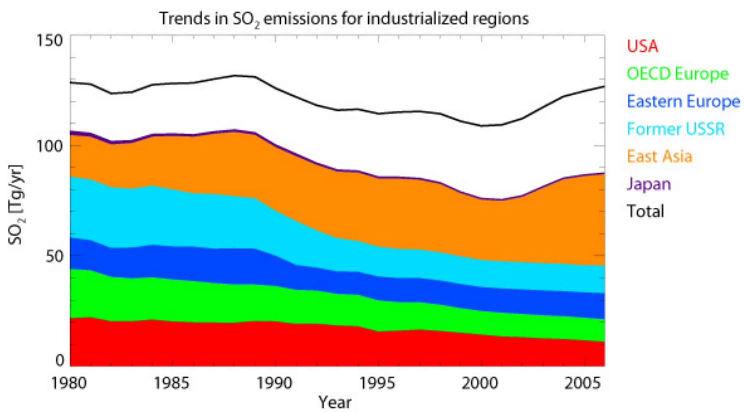
Trends in anthropogenic emissions

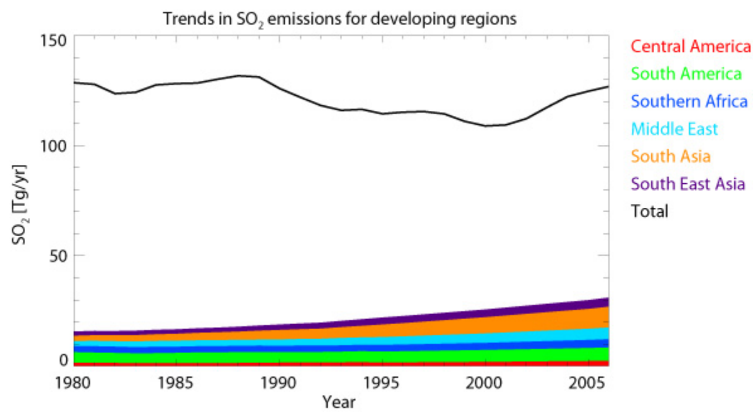




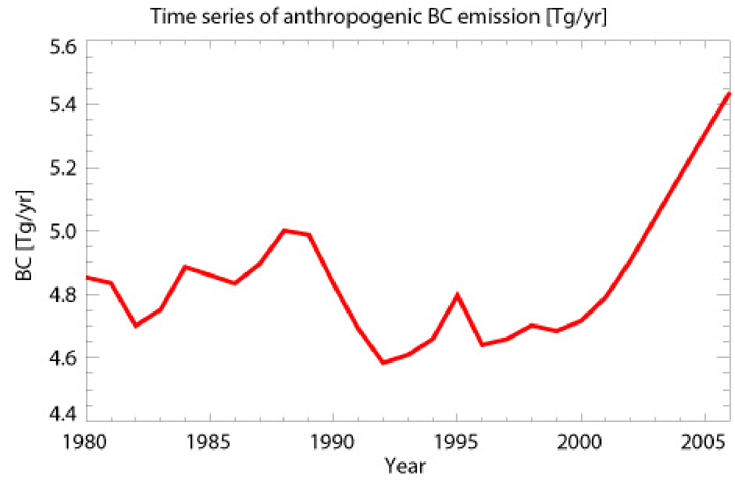




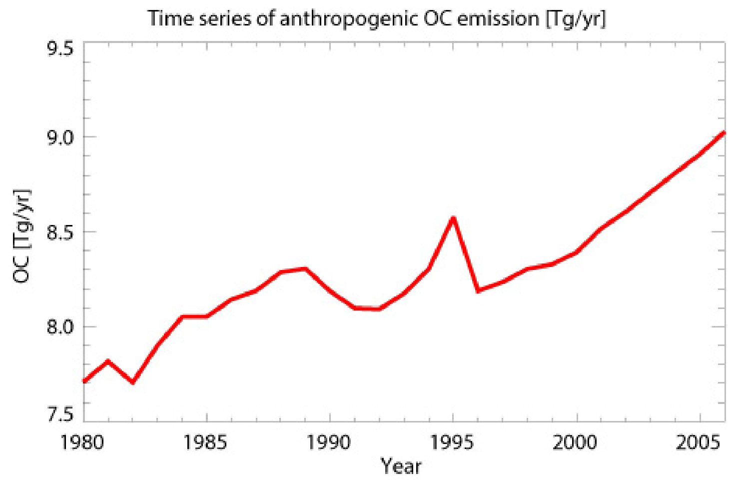


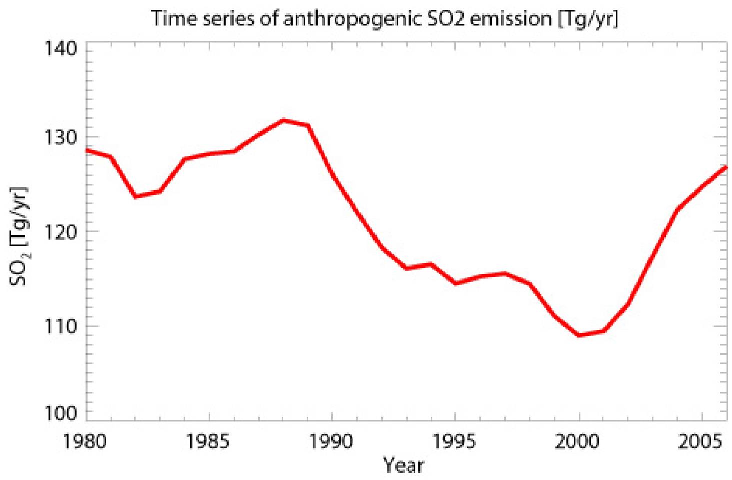


Time series of anthropogenic emissions



BC [Tg/yr]

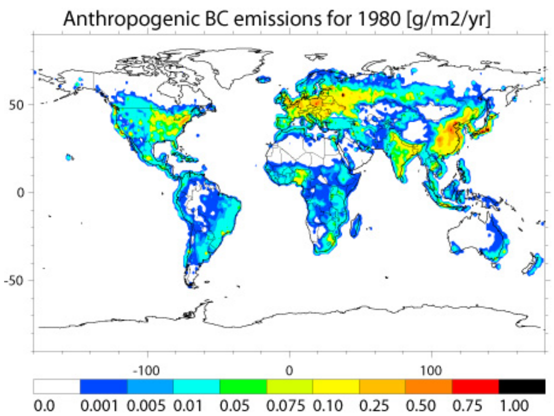


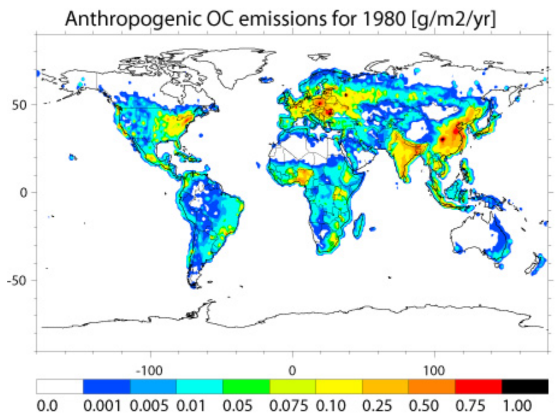


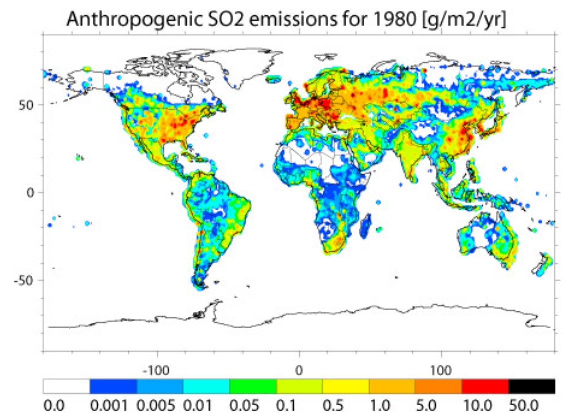
OC [Tg/yr]

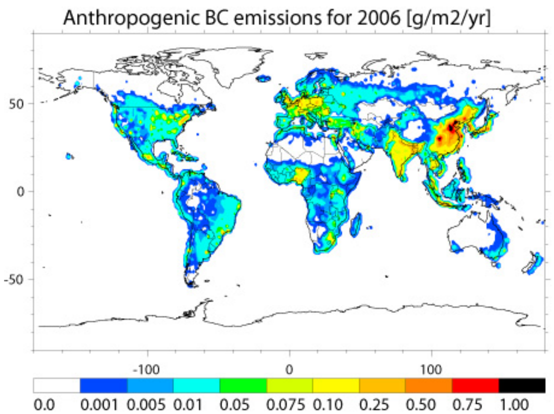
SO_2 [Tg/yr]

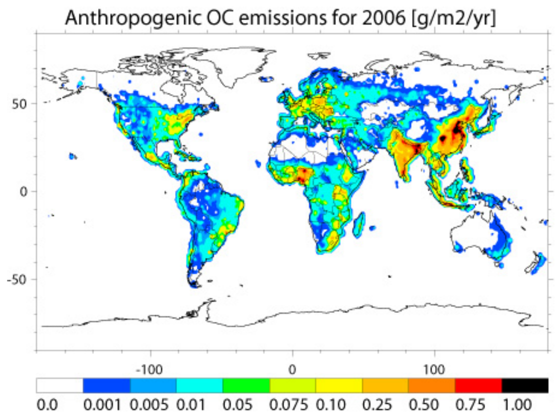
Gridded anthropogenic emissions

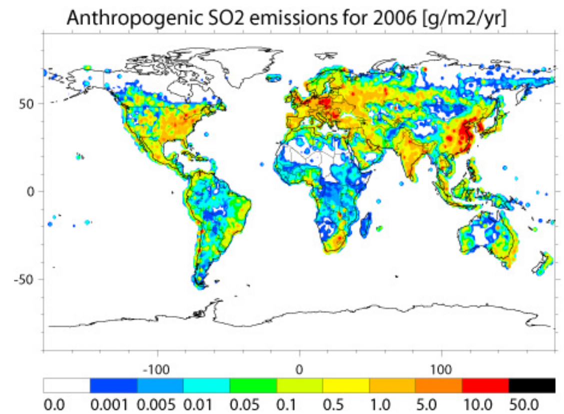




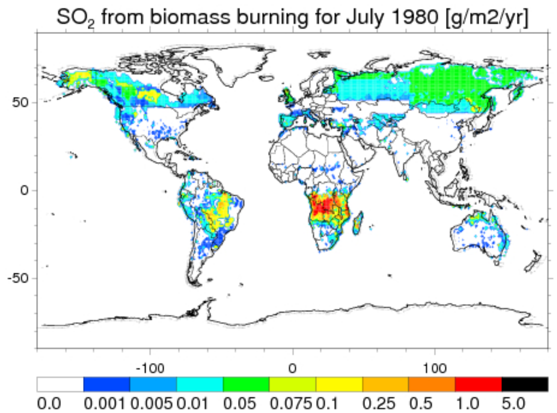


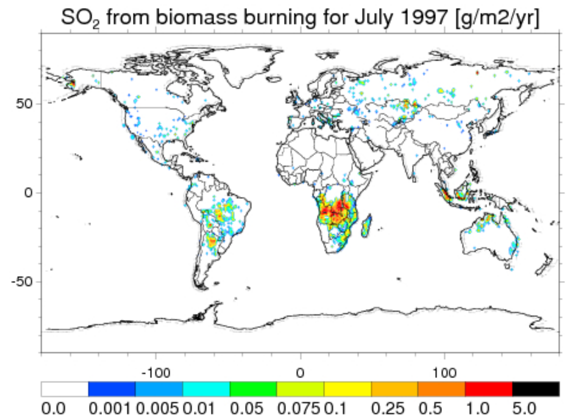


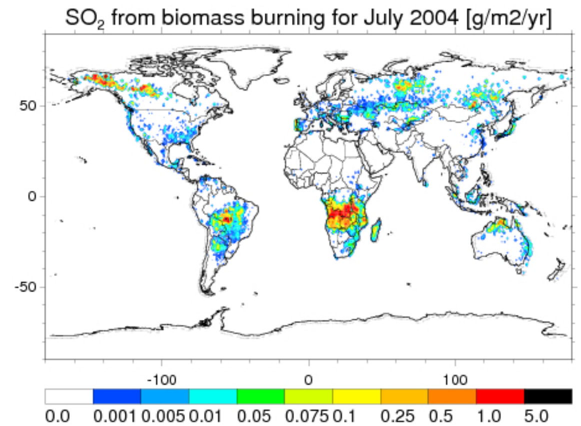


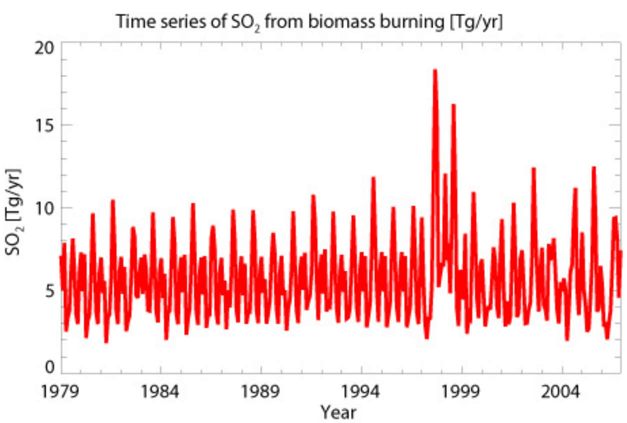


Biomass burning emissions







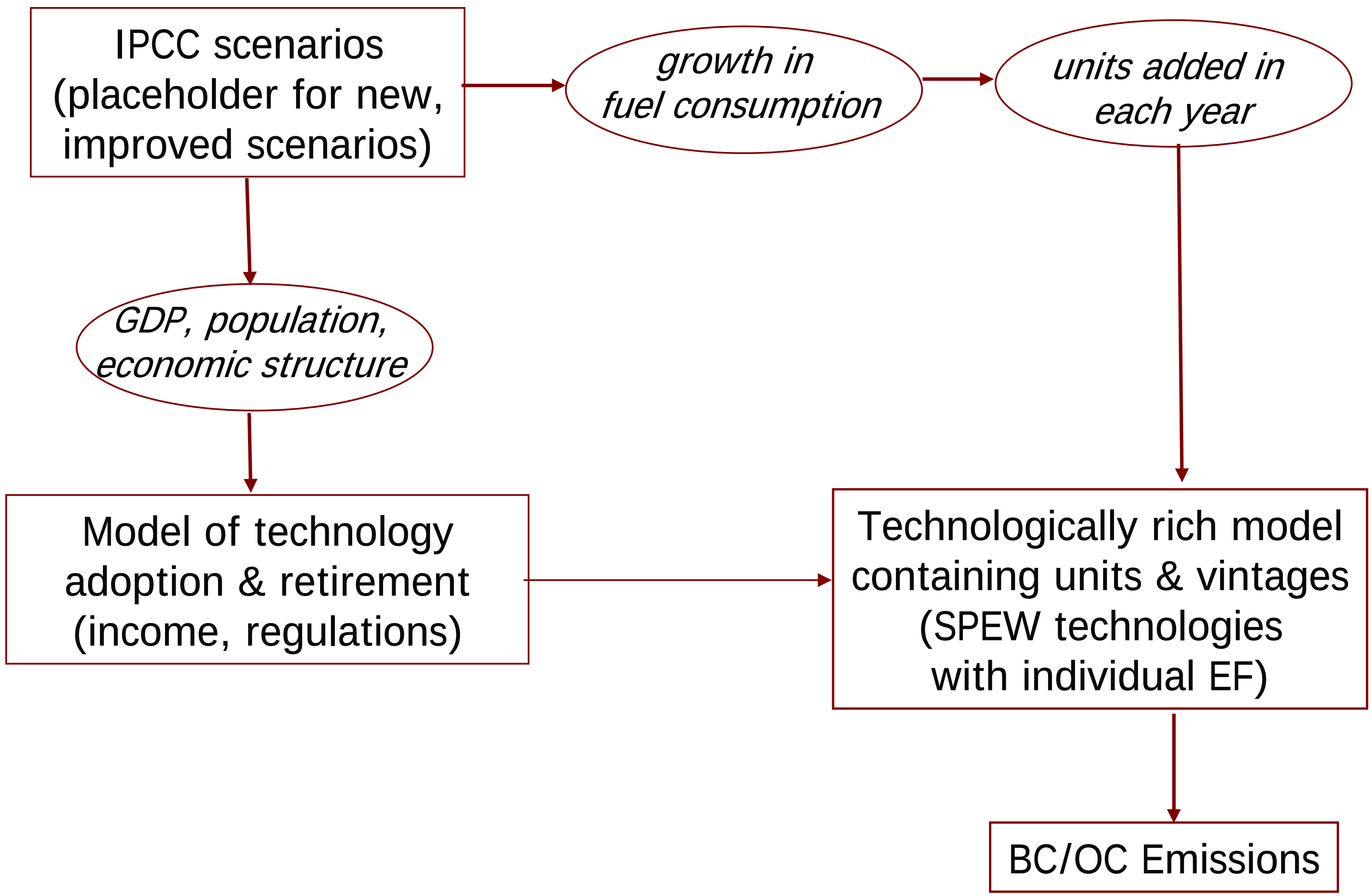


- For 1997-2006, we use the Global Fire Emission Dataset (GFED) version 2
- SO_2, BC, and OC for 1980 – 1996 derived from a scaled version of a total dry mass burned inventory from Duncan et al.
- Scaling factors determined from overlapping period 1997-2000 by adjusting the Duncan dataset to GFEDv2

Emission heights

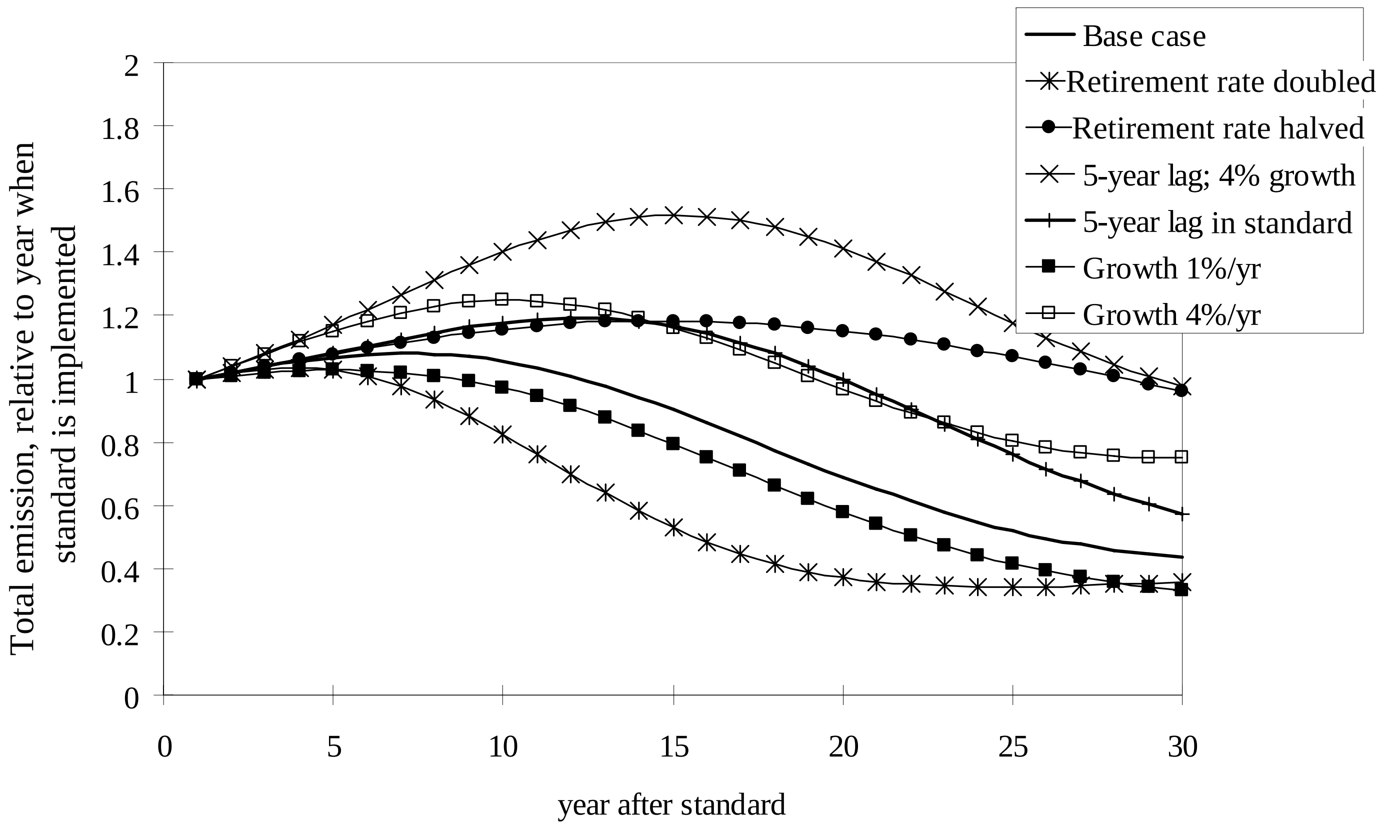
- Sporadic volcanic eruptions: evenly distributed within top third of the plume height
- Continuous degassing: injected only into the level of the crater (no flank degassing is considered)
- Biomass burning emissions: distributed within boundary layer
- Ship emissions and anthropogenic emissions are currently only injected into the lowest model level

Projection modeling underway



Example of sensitivities

Why is technology stock modeling important?



Emissions for future scenarios

Potential topics to be discussed:

- IIASA?
- T. Bond?
- J. van Aardenne (EDGAR)?
- Interaction with other initiatives, e.g. the Atmospheric Chemistry and Climate Initiative (AC&C) or GEIA?

Consistency issues

- Combination of emissions from different sources
- Example 1: EDGAR HYDE and EDGAR 32FT2000
  - different sectors
- Example 2: Streets and Bond datasets
  - same tool (SPEW)
  - same sectors

Summary

We compiled an emission inventory in 1°x1° for BC, OC, and SO_2, taking into account the following sources:

- International ship traffic, 1980 – 2006
- Aircraft, 1980 – 2006
- Other anthropogenic sources, 1980 – 2006
- Biomass burning, 1980 – 2006
- Volcanic emissions, 1980 – 2006

Emissions required by GOCART

Dust: based on topographic source [Ginoux et al. 2001] and modifications from M. Chin for Asia

Sea salt: based on parameterization using the wind speed at 10 m [Gong 1997] and swelling by RH

DMS (oxid. to SO2): based on observed sea surface concentrations [Kettle at al. 1999]

SOA formation (OC) due to biogenic emissions (Terpene): based on [Guenther et al. 1995]

Black Carbon (BC)

Organic Carbon (OC)

SO_2 (and SO_4)

New time-dependent inventory (yearly, monthly, daily) in 1.0°x1.0°