



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:

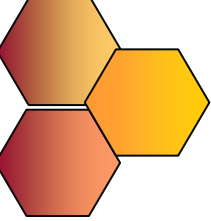
- What do we need?
- What *is* available?
- What can be expected in the near future (~ 1 year)?

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

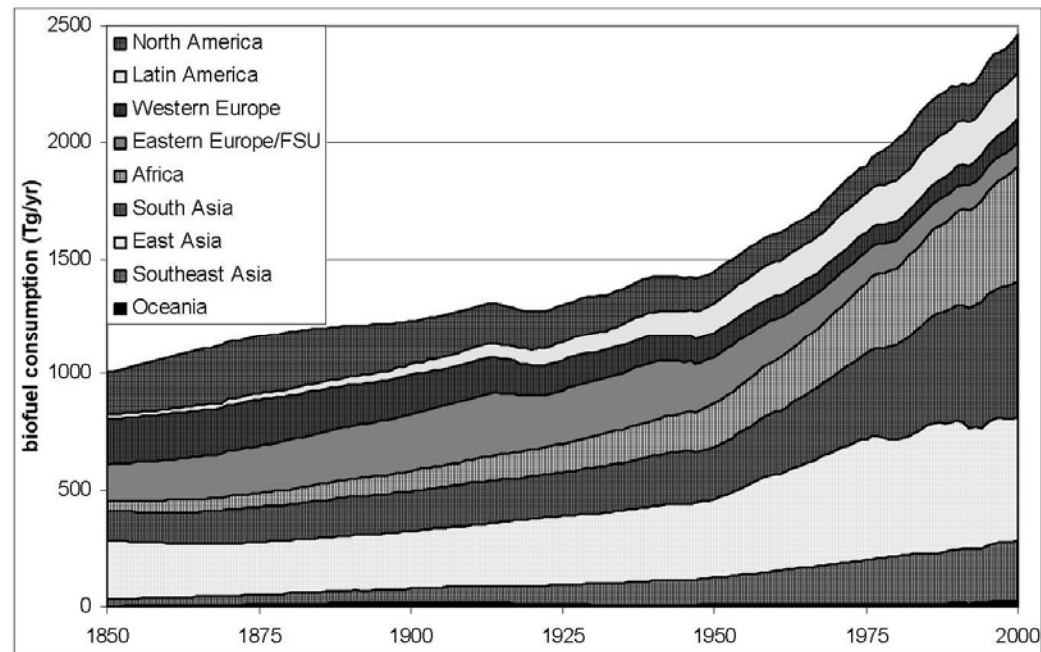
- Anthropogenic:
 - T. Bond: BC and OC, 1850-2000, 1x1, decadal
 - EDGAR HYDE: SO₂, 1890-1990, 1x1, decadal
 - EDGAR v4(?): 1970-2004, 0.1x0.1 (by country)
- Biomass burning:
 - GFEDv2: dry biomass burned, 1997-2006, 1x1, monthly and 8-daily
 - Duncan et al.: dry biomass burned, 1979-2000, 1x1, monthly
 - RETRO: BC, OC and SO₂, 1960-2000, 0.5x0.5, monthly



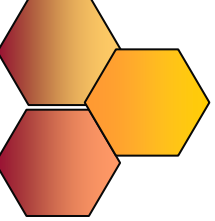
Biofuel reconstruction for past emissions

Goes beyond per-capita scaling, considering...

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



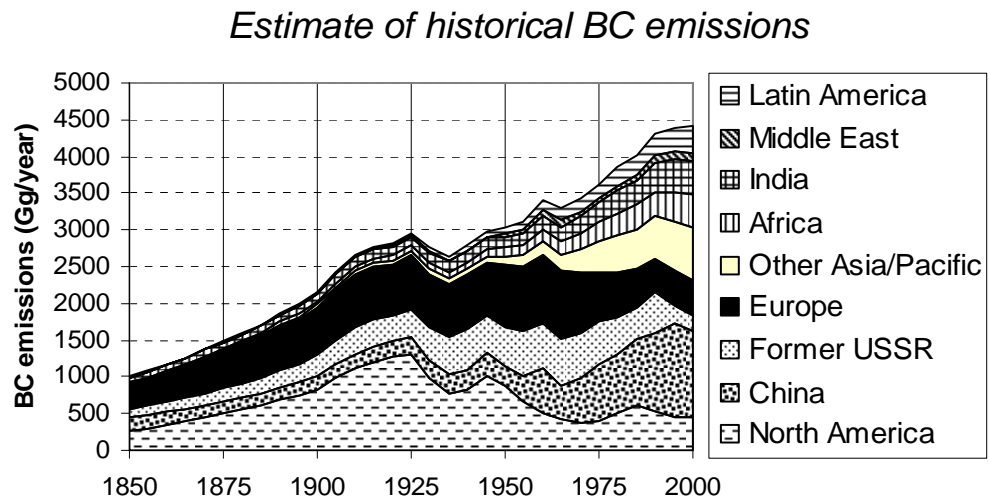
Fernandes et al (2007), Global biofuel use, 1850-2000, *Global Biogeochemical Cycles*, 21, GB2019, doi:10.1029/2006GB002836.



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.

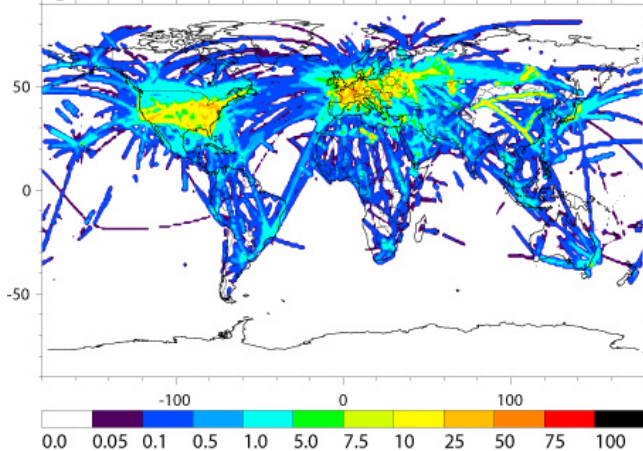
Emissions for 1980-2006

- 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

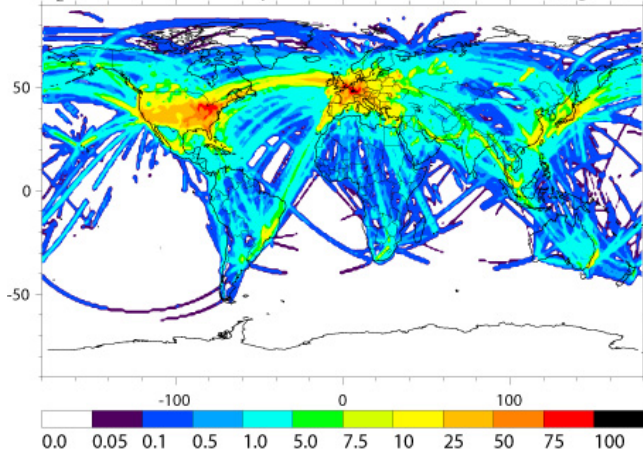
Aircraft emissions



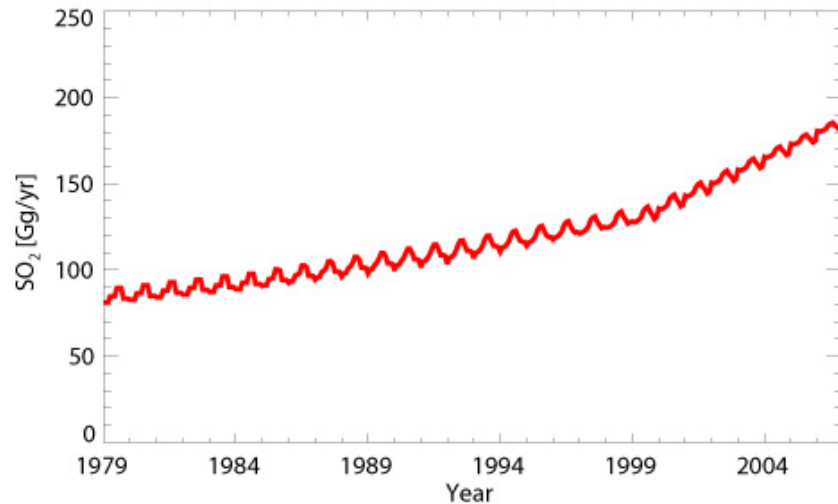
SO₂ from aircraft in July 1980 at 267 hPa (~ 10 km) [kg/d]



SO₂ from aircraft in July 2006 at 267 hPa (~ 10 km) [kg/d]



Time series of SO₂ emission from aircraft [Gg/yr]

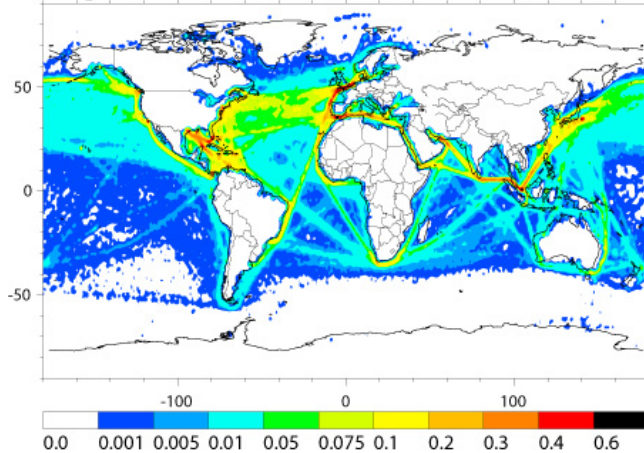


- Based on gridded burnt fuel files from AEAP project for 1976, 1984, 1992, 1999, and a projection for 2015
- Flight pattern is preserved between base years for interpolation
- EI of 0.8 assumed for SO₂ (0.8 g SO₂/kg fuel); height dependent EI for BC; OC=1/3 BC; all hydrophilic

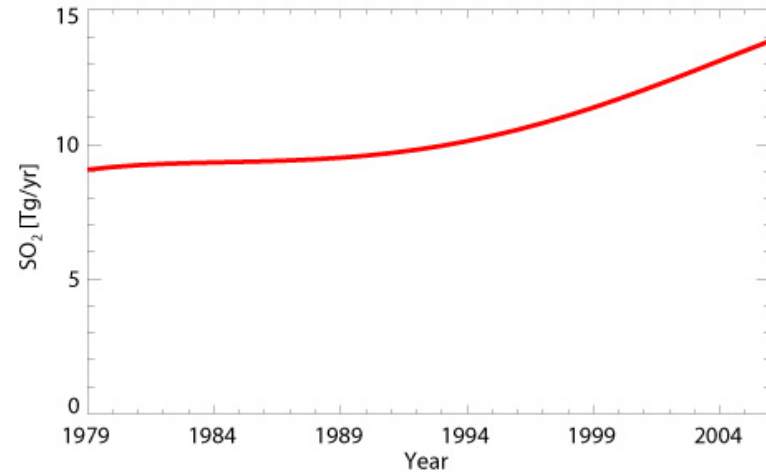
Emissions from international ship traffic



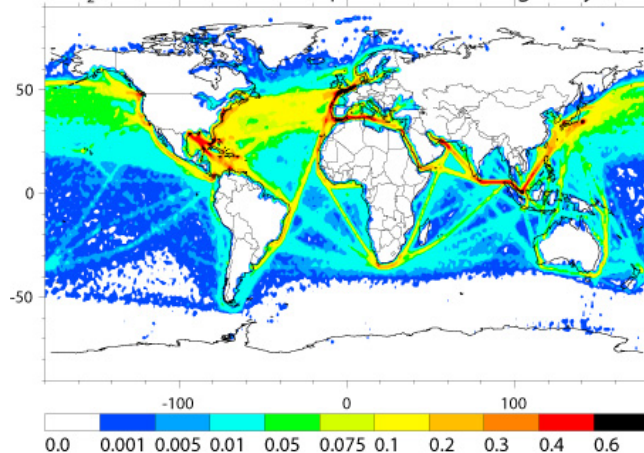
SO₂ from international ship traffic for 1980 [g/m²/yr]



Time series of SO₂ from international ship traffic [Tg/yr]



SO₂ from international ship traffic for 2006 [g/m²/yr]

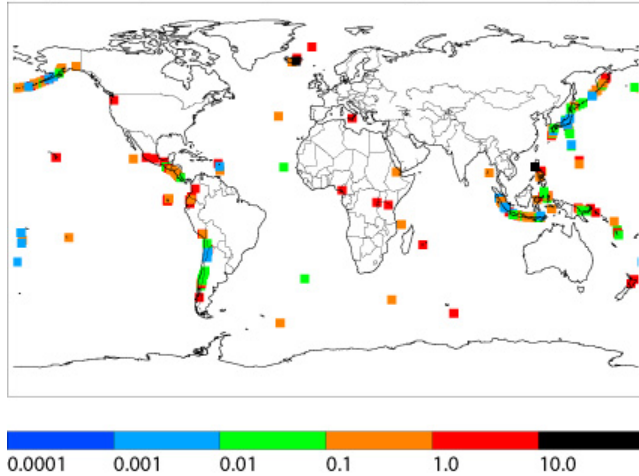


- Based on estimates of total SO₂ and PM emissions of Eyring et al. for 1980, 1995, and 2001, and a projection for 2020.
- These numbers were used to scale gridded SO₂ emissions from the EDGAR 32FT2000 database for 2000 (<http://www.mnp.nl/edgar>)

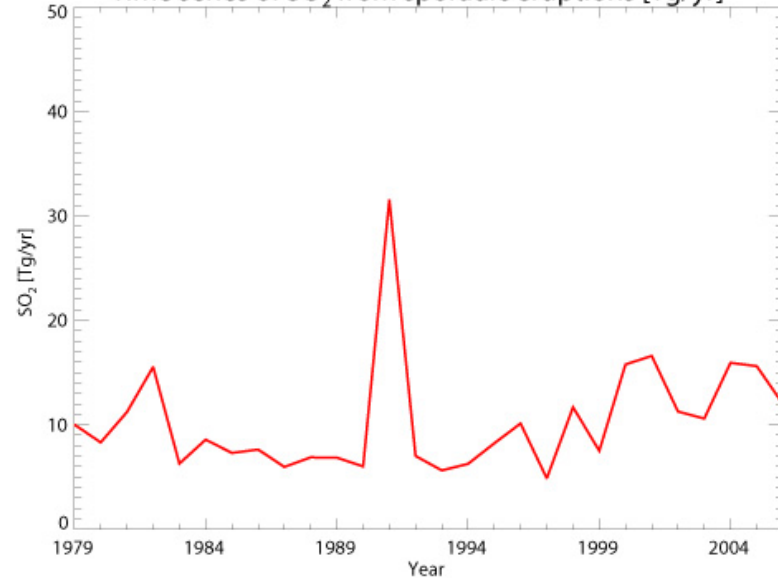
Volcanic emissions



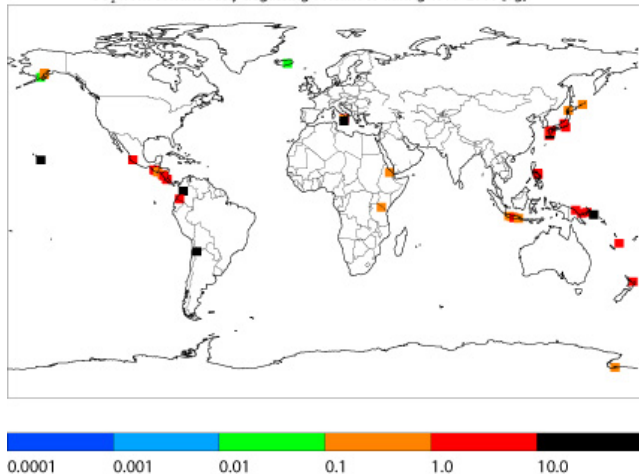
SO₂ from sporadic eruptions during 1979-2006 [Tg]



Time series of SO₂ from sporadic eruptions [Tg/yr]



SO₂ from continuously degassing volcanoes during 1979-2006 [Tg]

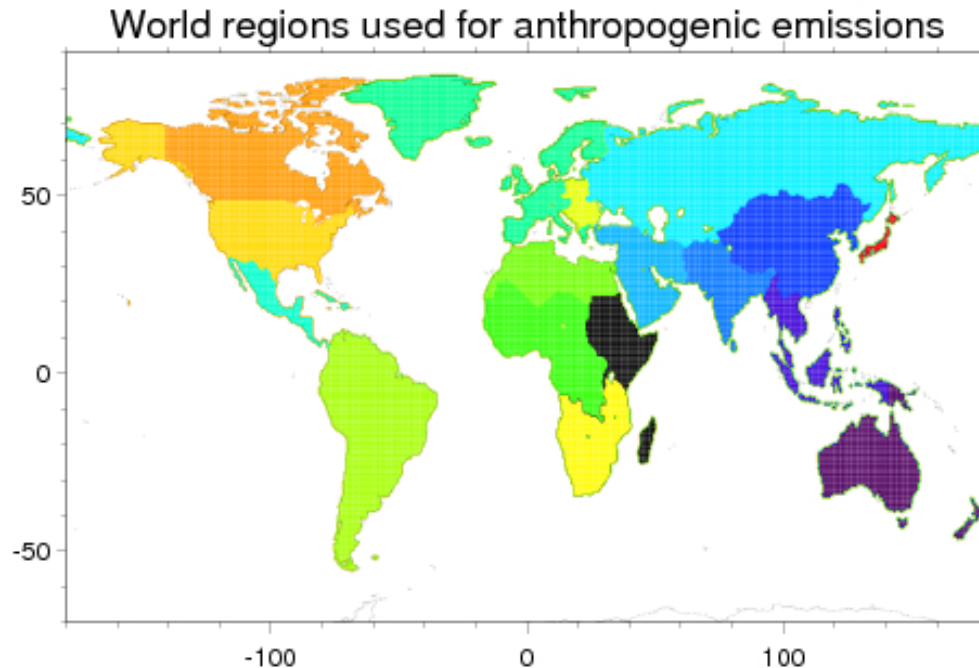


- Sporadic eruptions are based on the Smithsonian Institution's Global Volcanism Program
- Cloud column height is derived from the VEI and SO₂ data is derived from the modified SO₂ index proposed by Halmer et al.
- TOMS SO₂ data is used when available
- Continuously degassing volcanoes are from the climatological GEIA database

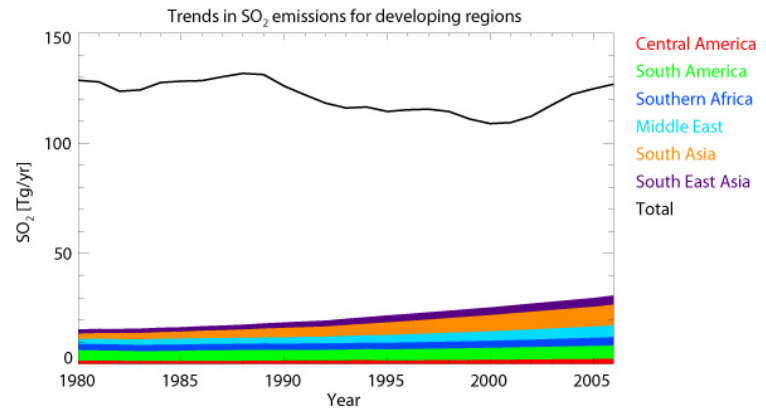
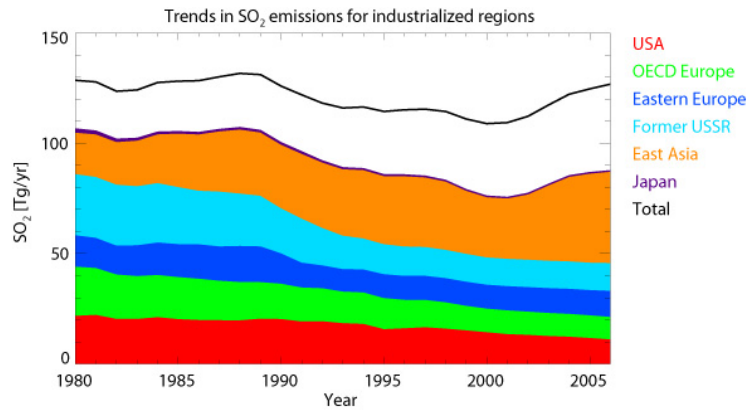
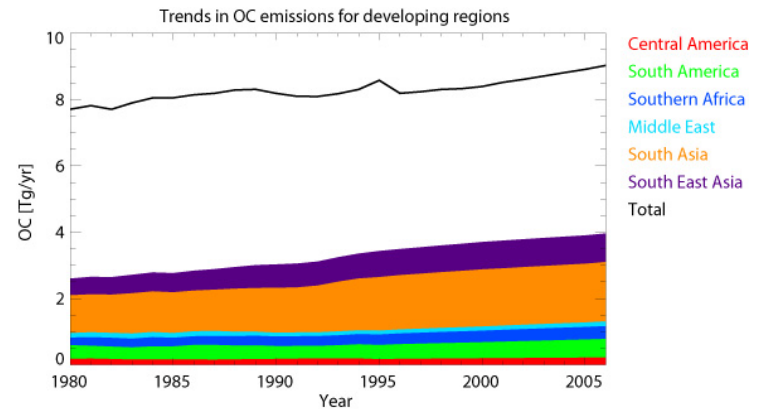
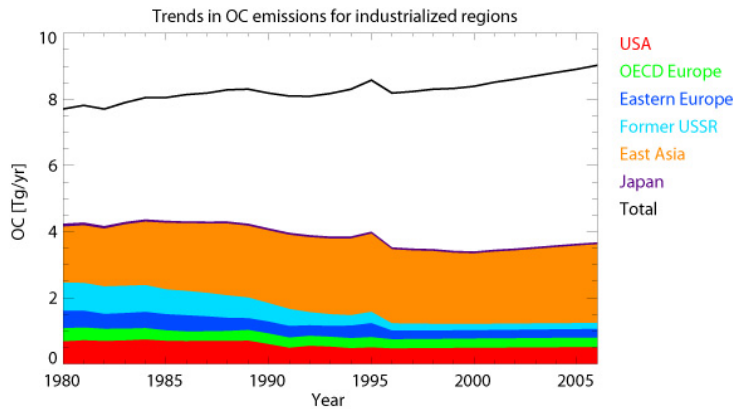
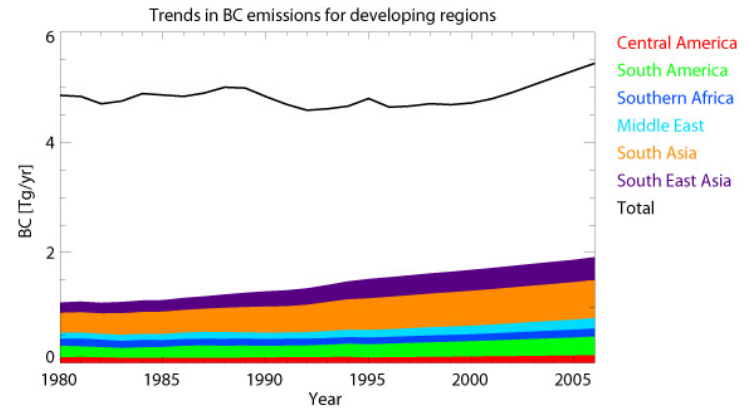
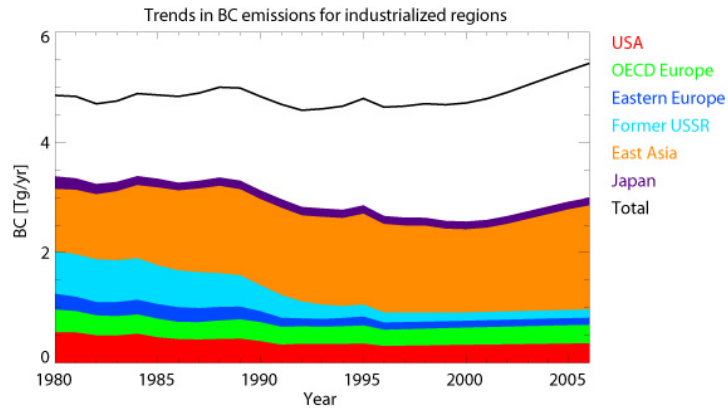
Anthropogenic emissions

(excluding BB, aircraft and intl. ship traffic)

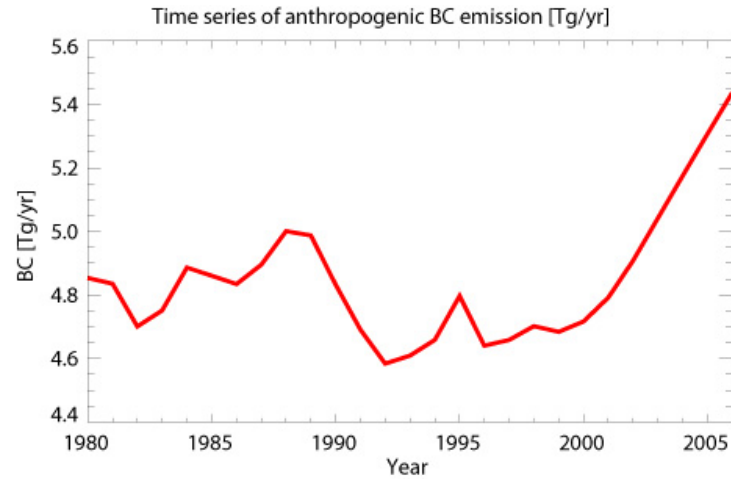
- Gridded BC and OC emissions for 1996 are based on the Speciated Particulate Emissions Wizard (SPEW) inventory (Bond et al. 2004)
- Gridded SO₂ emissions for 2000 are from the EDGAR 32FT2000 database.
- The gridded files were extended to an annual trend by scaling with regional BC, OC, and SO₂ emission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



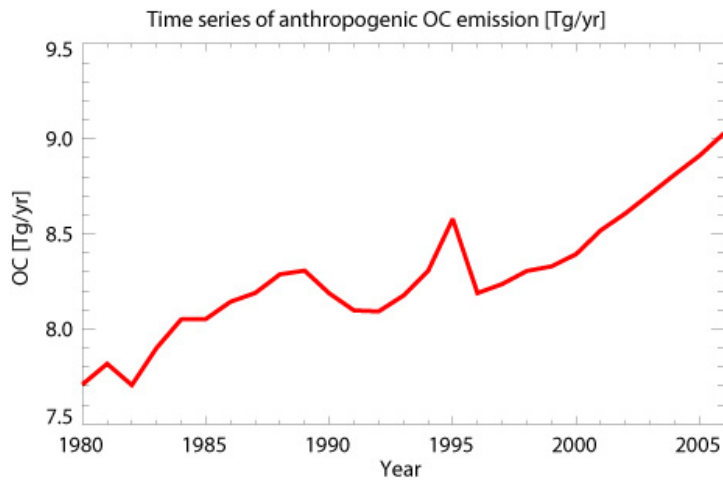
Trends in anthropogenic emissions



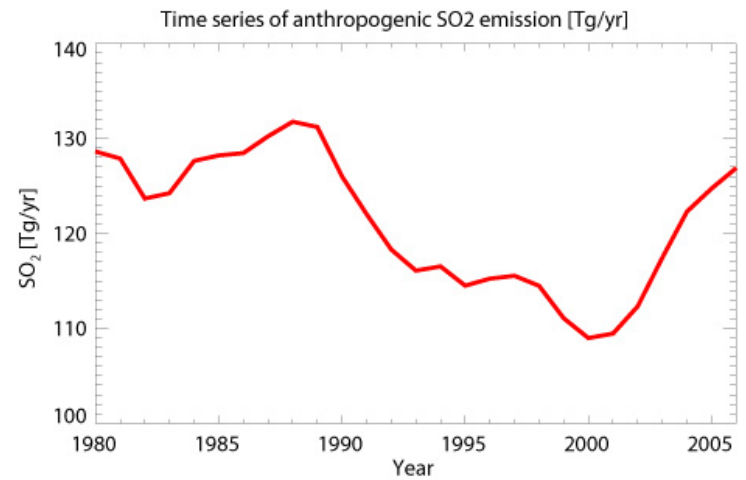
Time series of anthropogenic emissions



BC [Tg/yr]



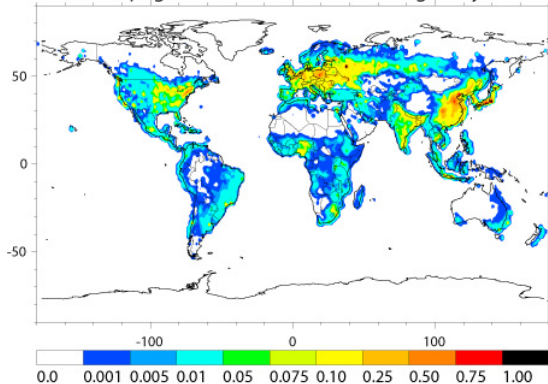
OC [Tg/yr]



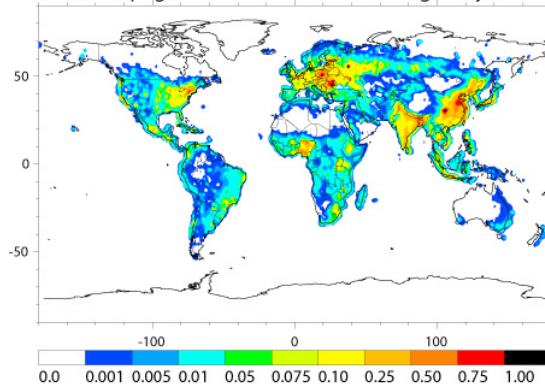
SO₂ [Tg/yr]

Gridded anthropogenic emissions

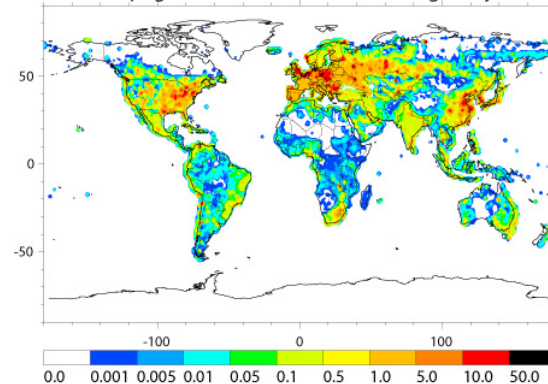
Anthropogenic BC emissions for 1980 [g/m²/yr]



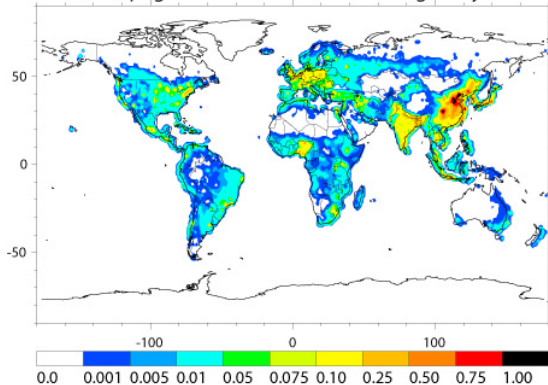
Anthropogenic OC emissions for 1980 [g/m²/yr]



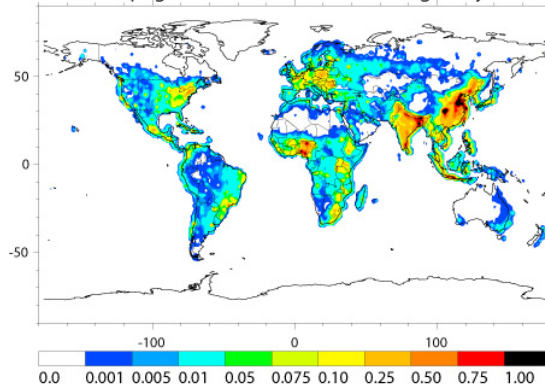
Anthropogenic SO₂ emissions for 1980 [g/m²/yr]



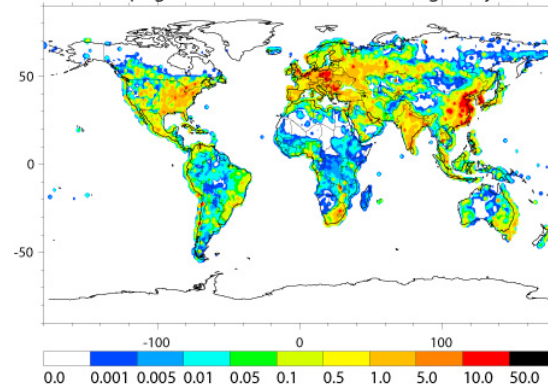
Anthropogenic BC emissions for 2006 [g/m²/yr]



Anthropogenic OC emissions for 2006 [g/m²/yr]



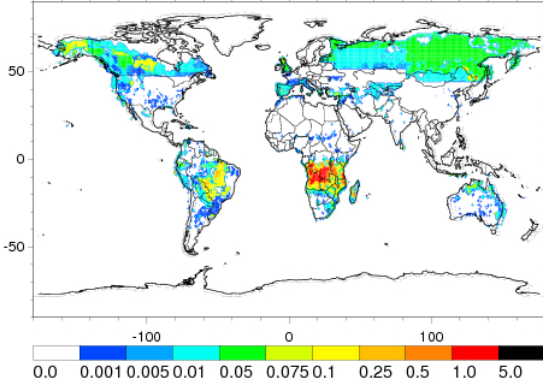
Anthropogenic SO₂ emissions for 2006 [g/m²/yr]



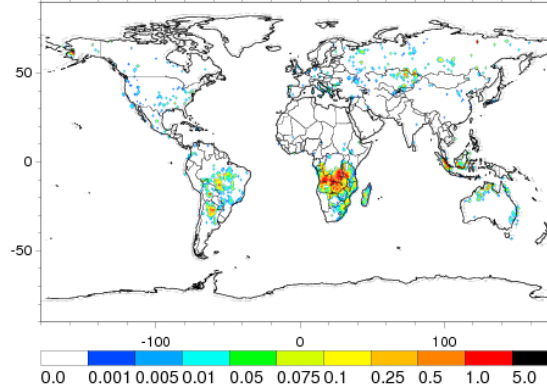
Biomass burning emissions



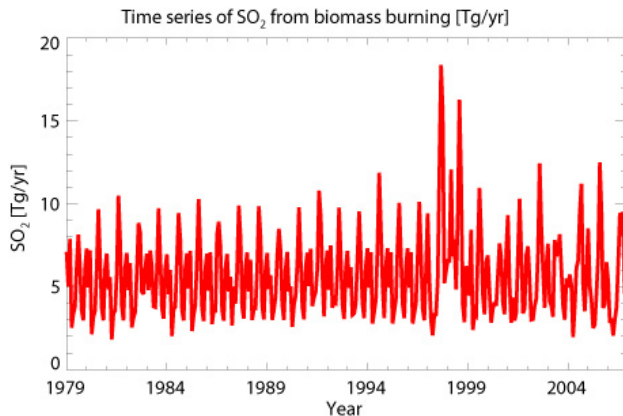
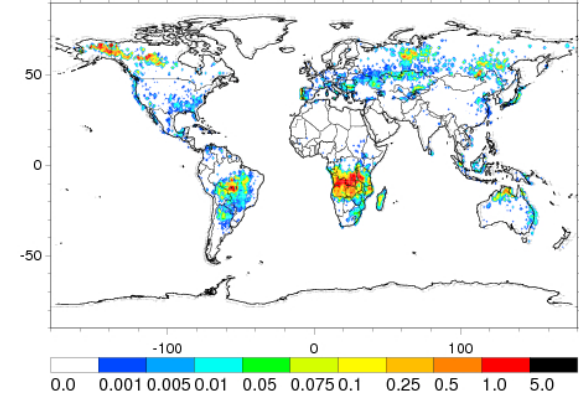
SO₂ from biomass burning for July 1980 [g/m²/yr]



SO₂ from biomass burning for July 1997 [g/m²/yr]



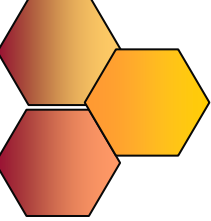
SO₂ from biomass burning for July 2004 [g/m²/yr]



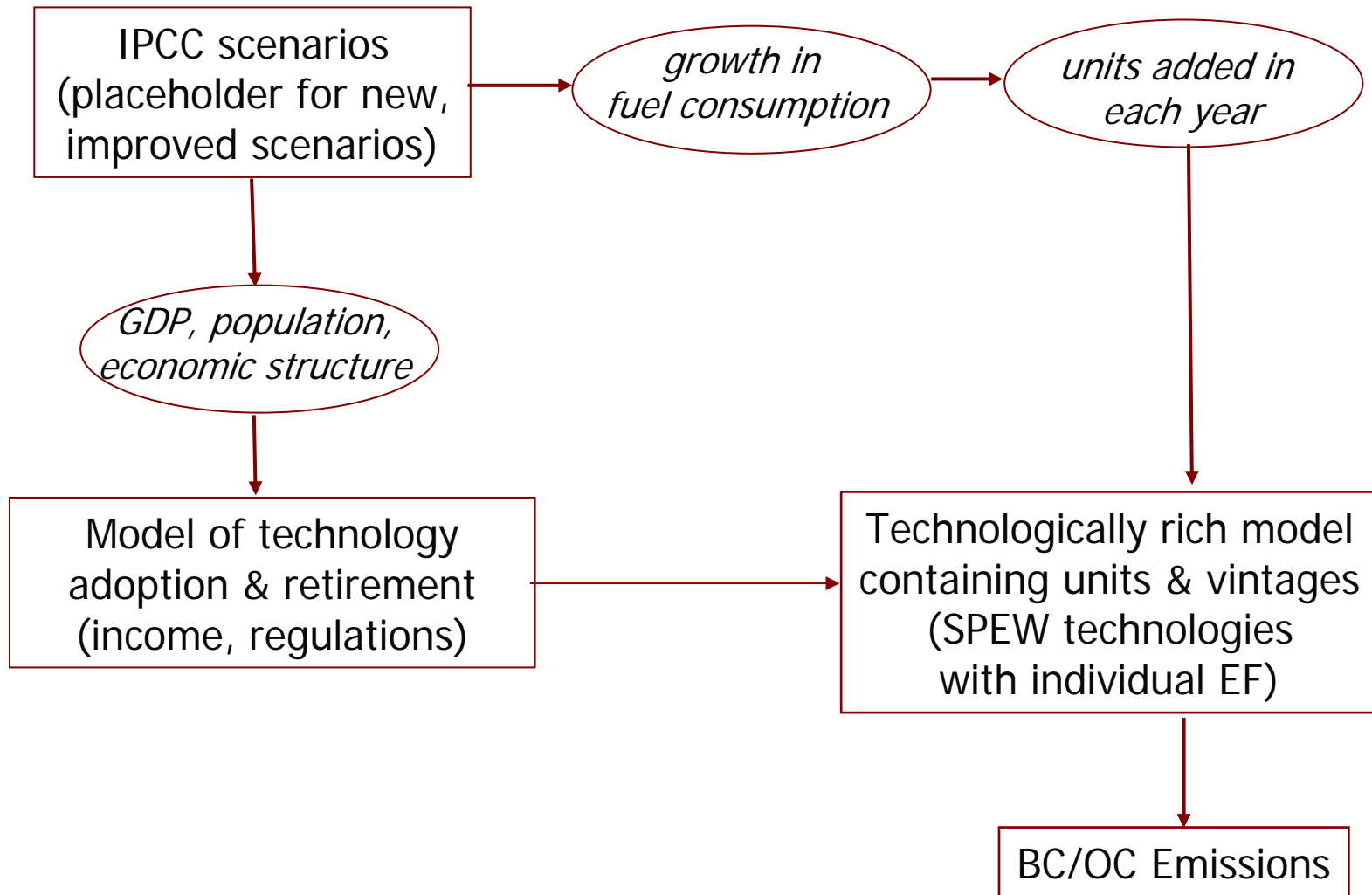
- For 1997-2006, we use the Global Fire Emission Dataset (GFED) version 2
- SO₂, BC, and OC for 1980 – 1996 derived from a scaled version of a total dry mass burned inventory from Duncan et al.
- Scaling factors determined from overlapping period 1997-2000 by adjusting the Duncan dataset to GFEDv2

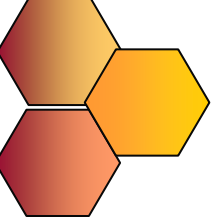
Emission heights

- 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



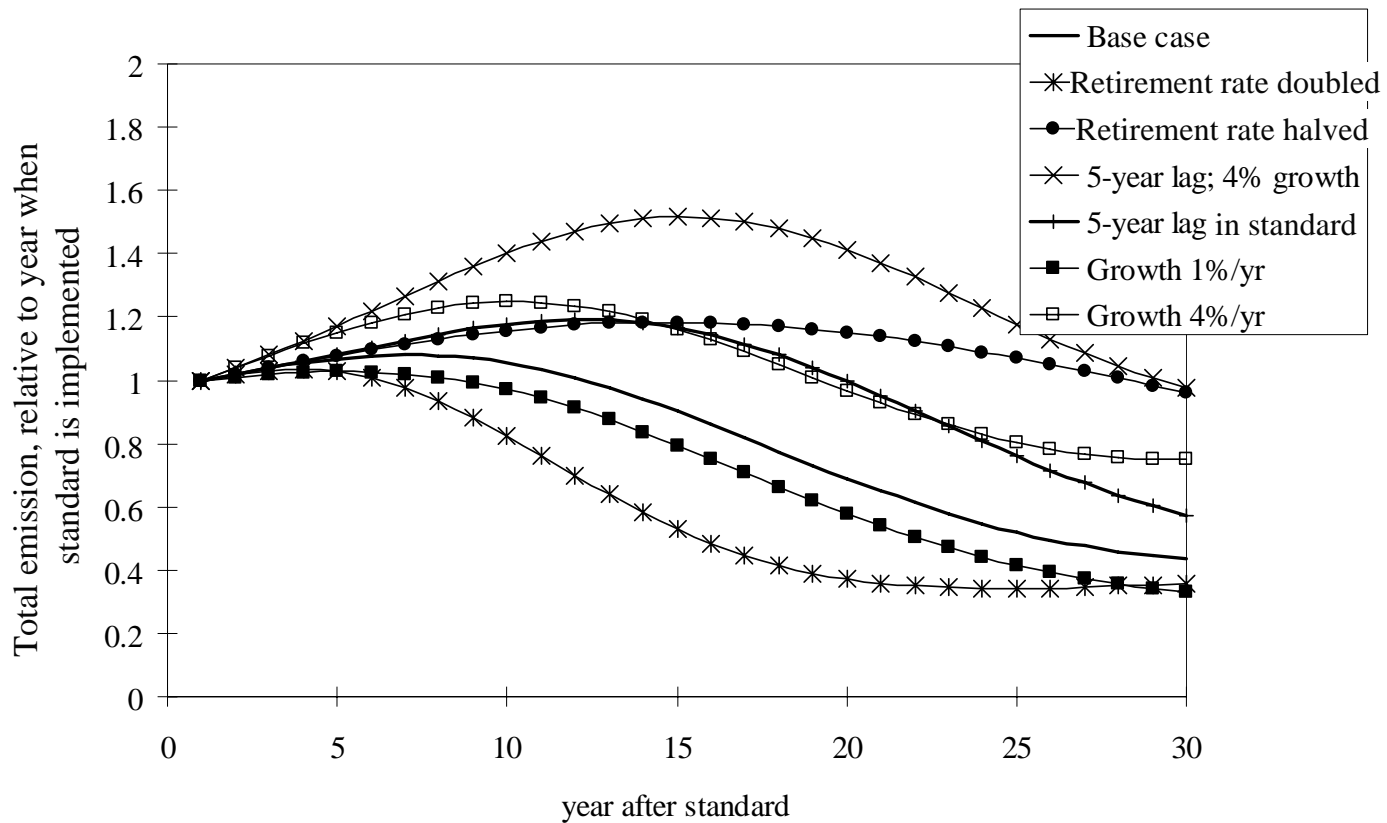
Projection modeling underway





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?