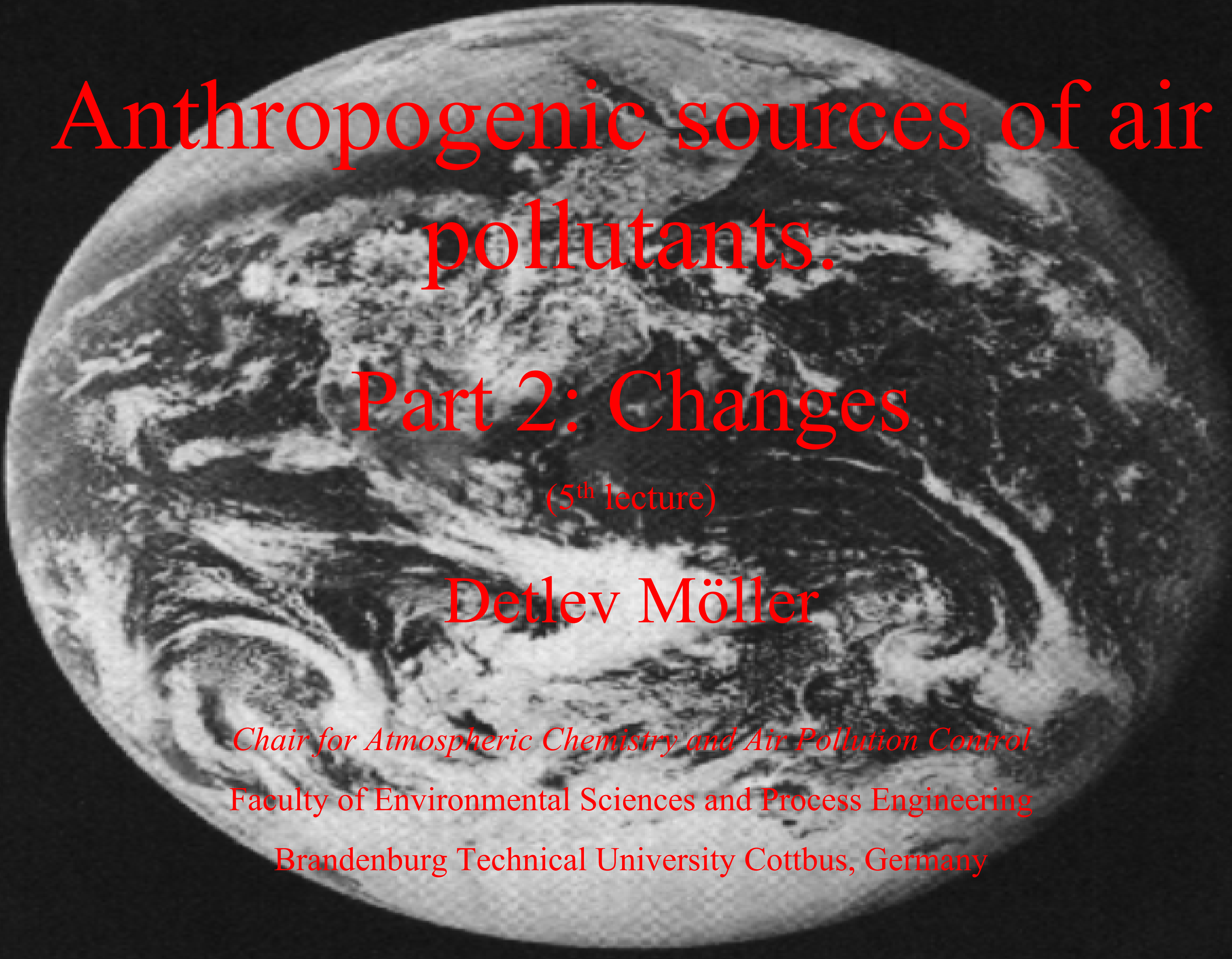

Anthropogenic sources of air pollutants.

Part 2: Changes

(5^{th} lecture)

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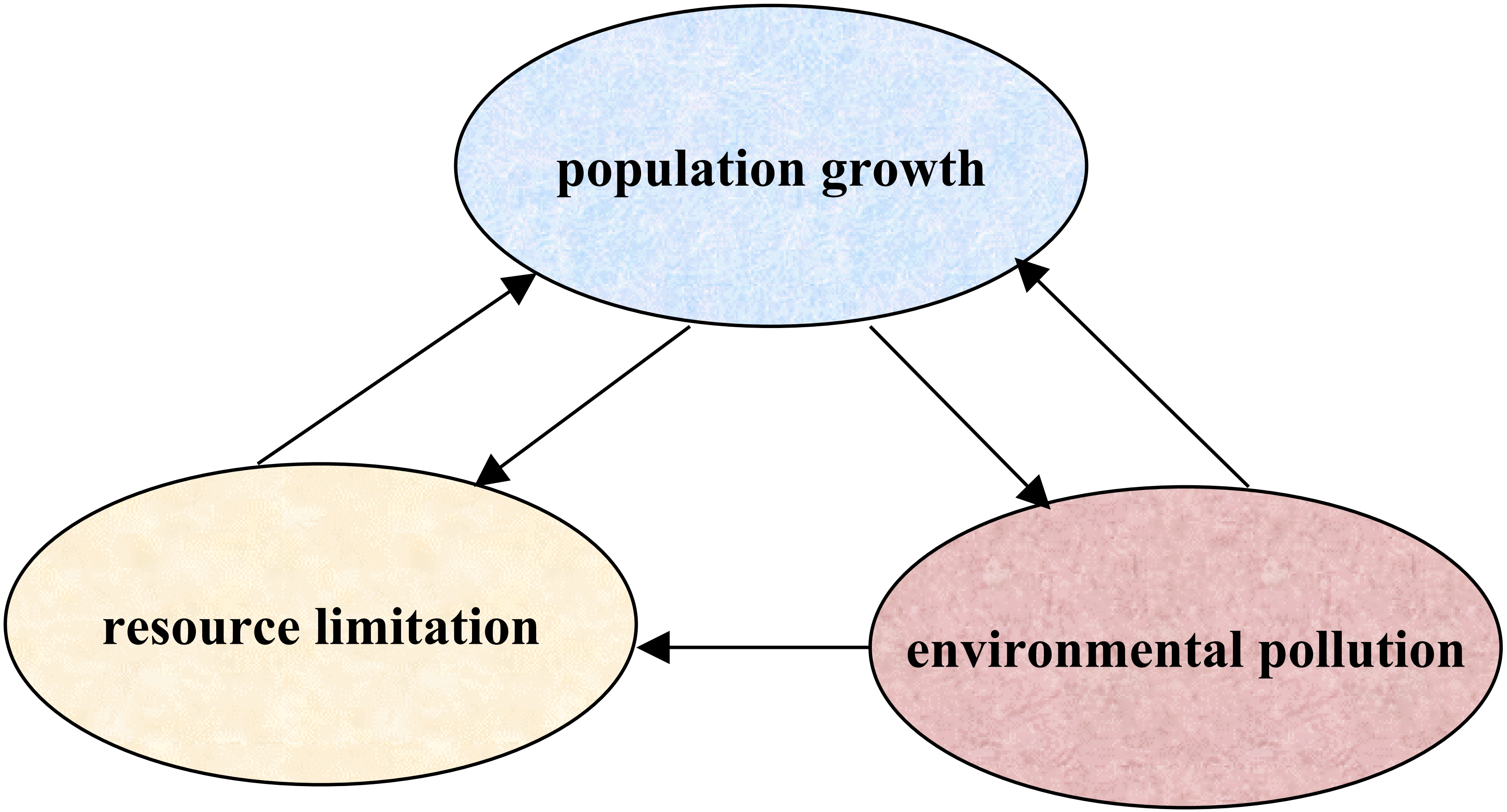
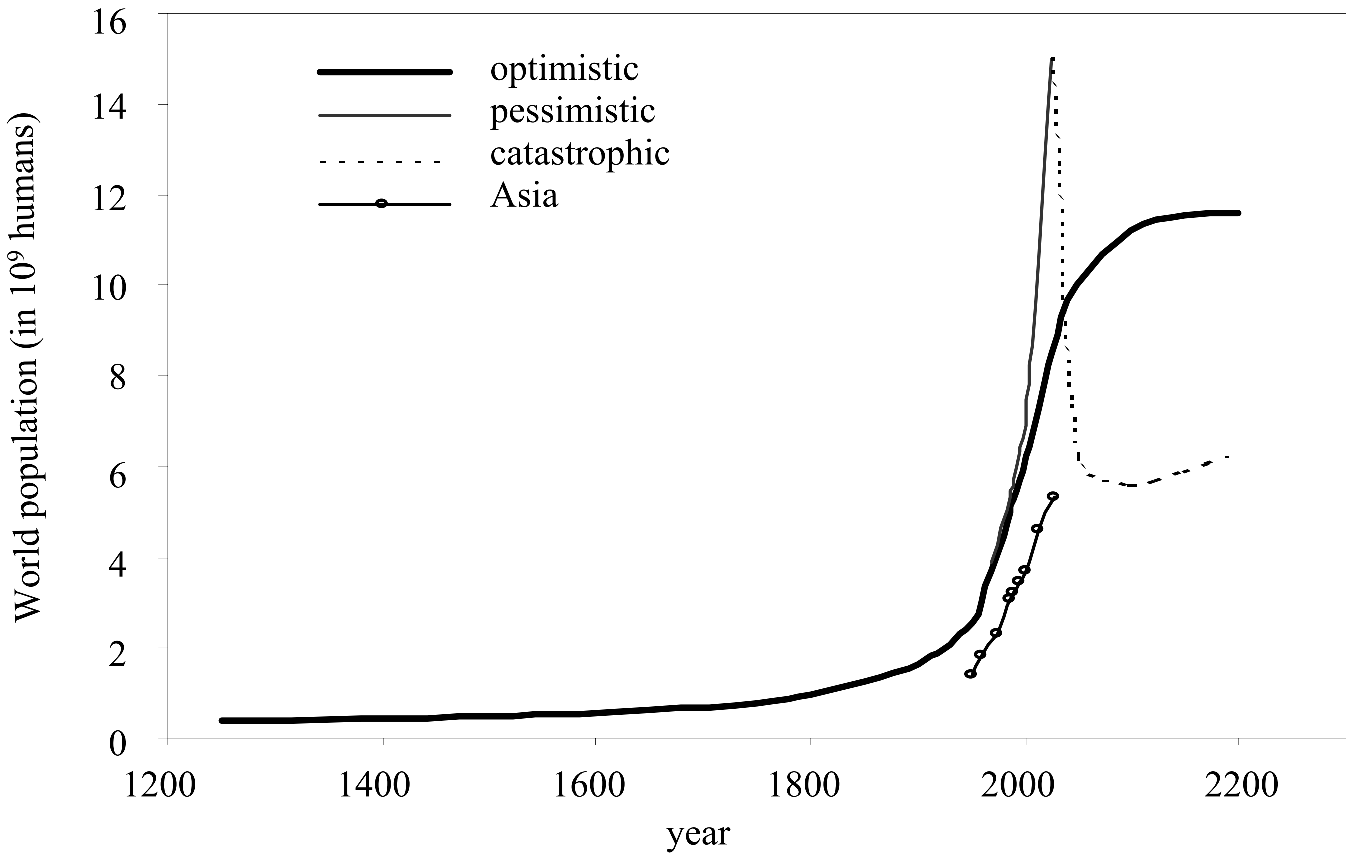
Objectives:

To understand the relationship between economy, atmospheric chemical composition and air pollution control for establishing a sustainable development. Changes and trends:

- population growth and energy demand
- greenhouse gases
- German situation: final states of air pollution control
- perspective (conclusions)


population growth
resource limitation
environmental pollution



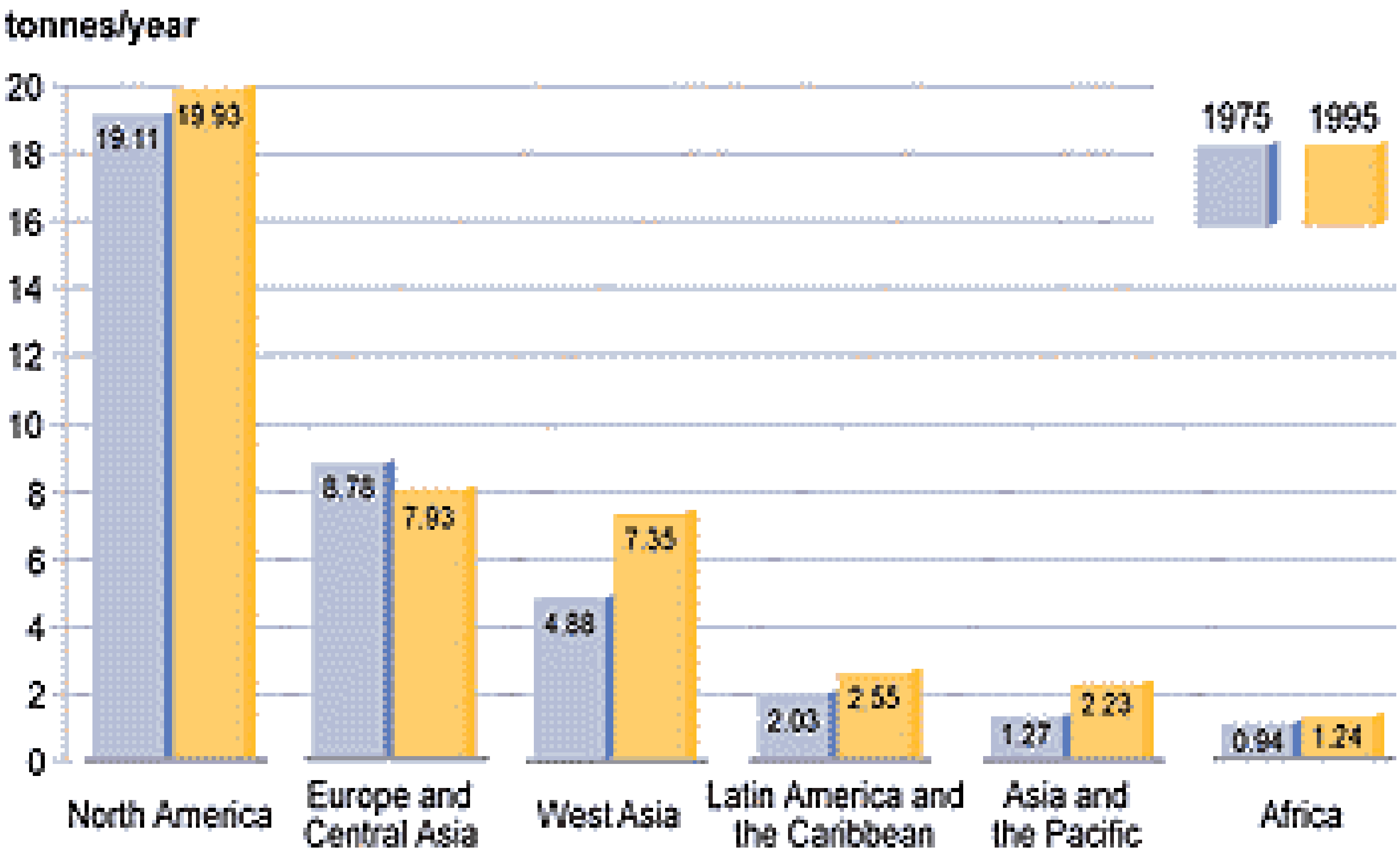
Population growth with different scenarios

Regional distribution of resources and emissionen 1990, after UN Statistical Yearbook

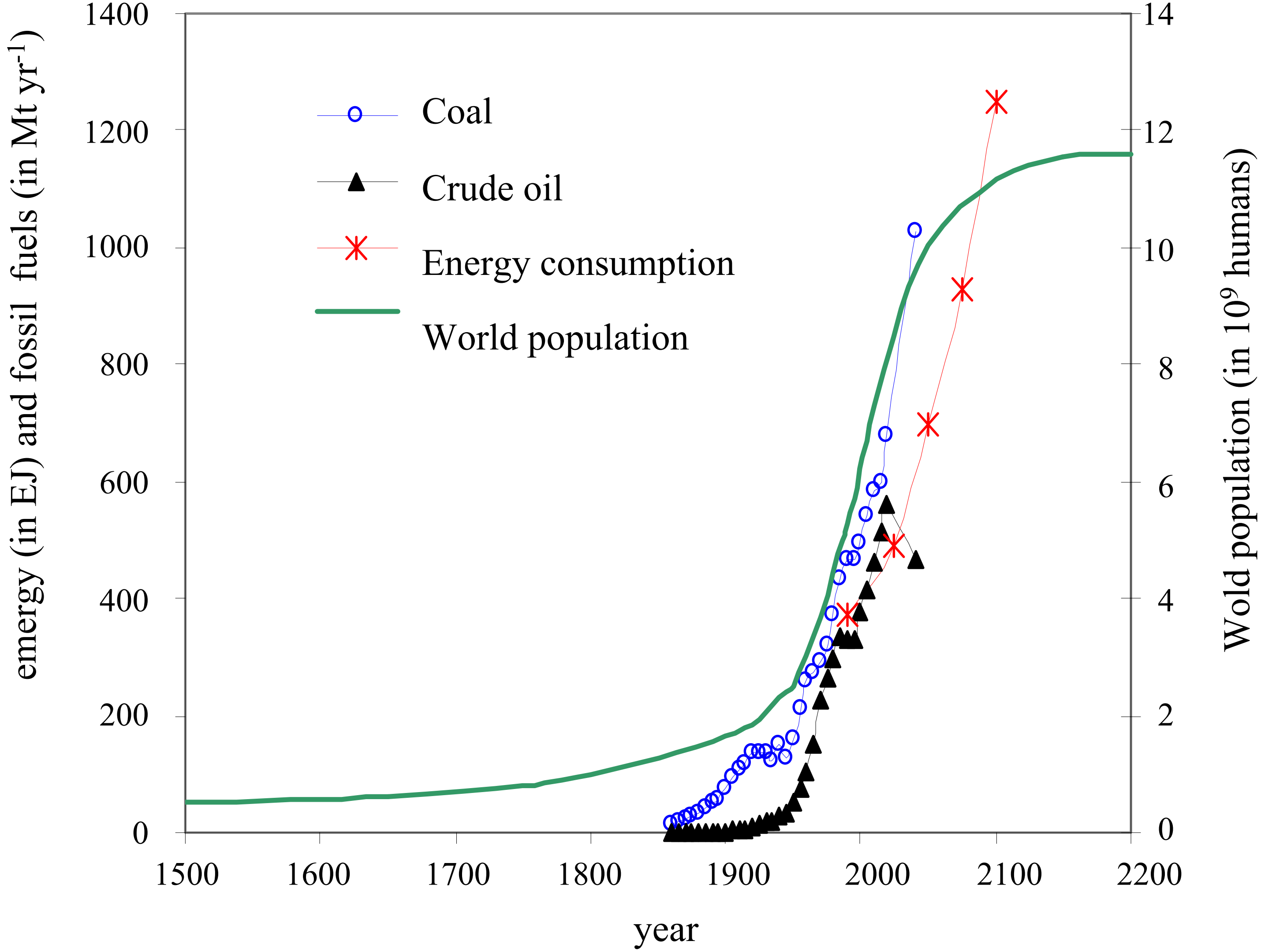
	ratio of percentage of world consumption to percentage of world population			percentage of world population (in %)	agricultural square (ha/capita)	percentage of SO_2 + NO emission (in %)	percentage of emission of SO_2 + NO to percentage of world population
	fossil fuels	fertilizers	food				
Northern America	7,75	6,00	4,0	4	0,8	25	6,25
Europea	4,00	5,40	3,5	8	0,2	30	3,75
East Asia	0,30	0,25	0,4	40	<0,1	25	0,62

„developed" world: high per-capita consumption and air pollution, but potential to control emission

„developing" world: low per-capita consumption and air pollution and now potential to control emission, but high growth rates



CO_2 emission per capita



Energy growth and world population

Global percentages (in %) of different energy carriers

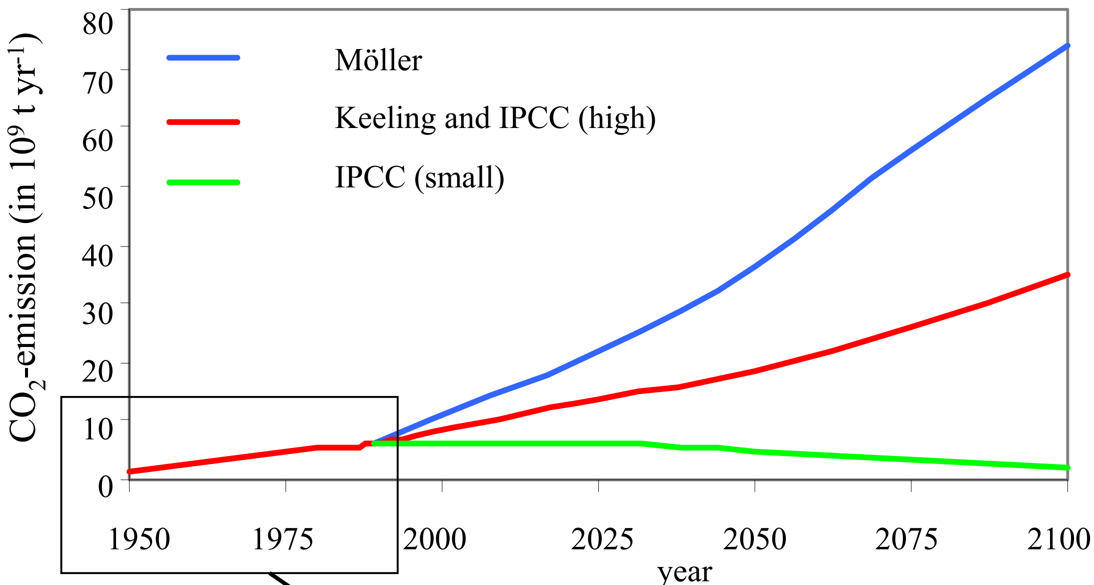
Resource	1995 (IEA, 1999)[c]	1997 (US Dept. 2000)	present (Wellmer 2000)	2020 (US Dept. 2000)	2025 (Elistratov 2000)
nuclear	6.6	7	6	6	20
renewable	13.8[d]	8	8[a]	9	10[b]
gas	20.1	22	30	25	50
coal	23.7	25	20	23	5
oil	35.8	38	36	37	15

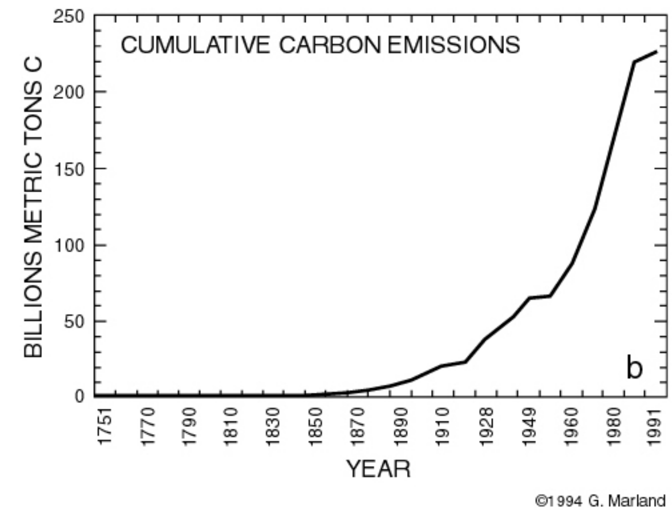
[a] mainly water power

[b] too optimistic

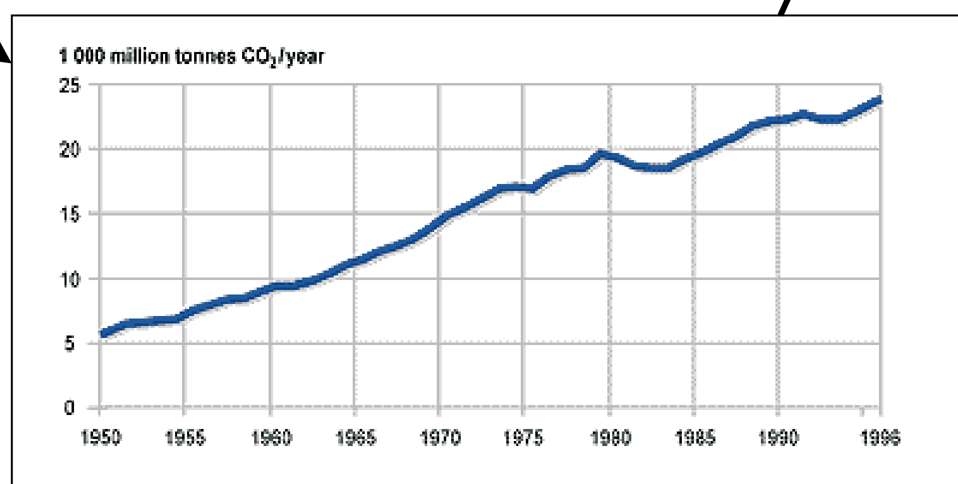
[c] total energy consumption: $4{,}0 \cdot 10^{20}$ J

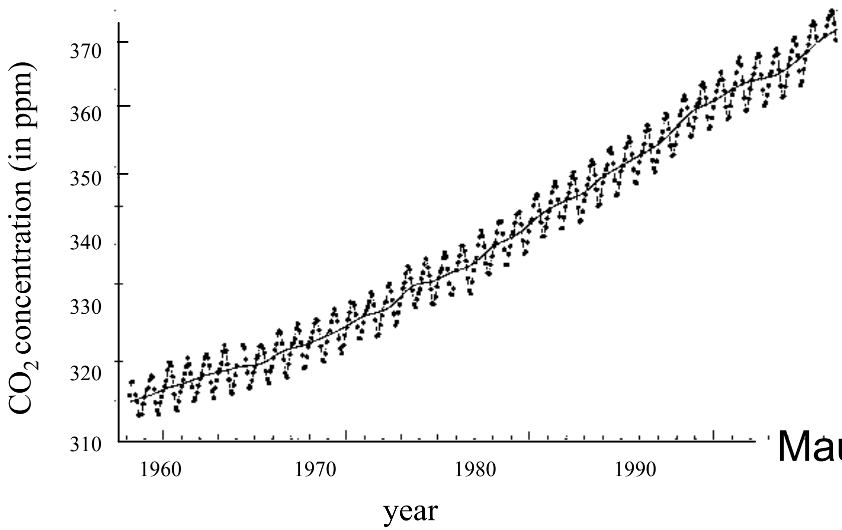
[d] incl. burning of biological waste and biomass (11%), i.e., the sum of solar, water, wind and thermal energy amounts 3% (where water contributes to 2/3)



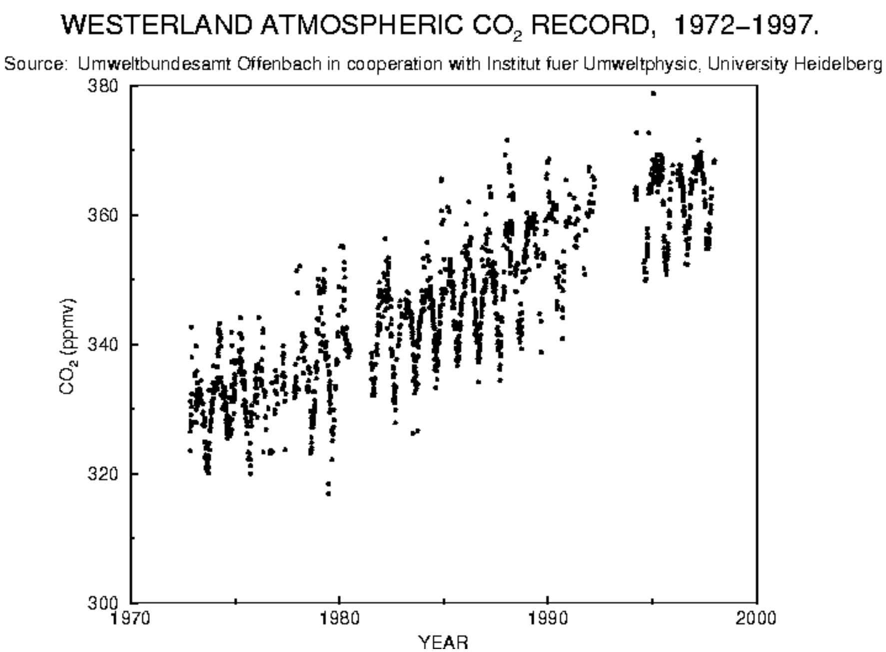


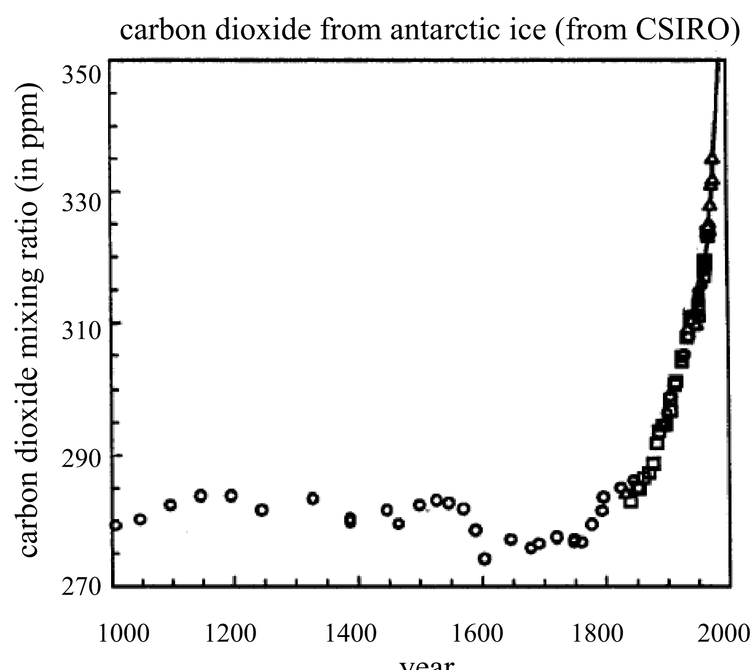
Global CO_2 emission



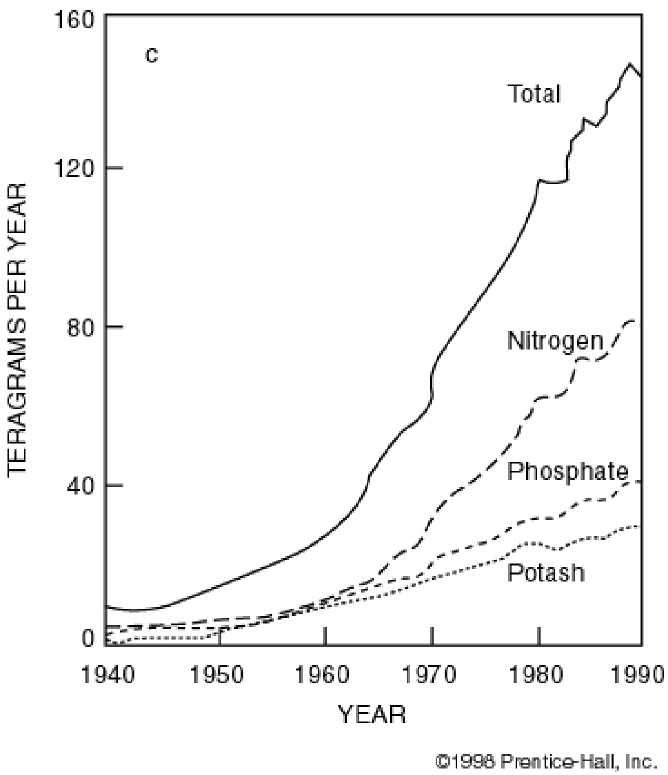


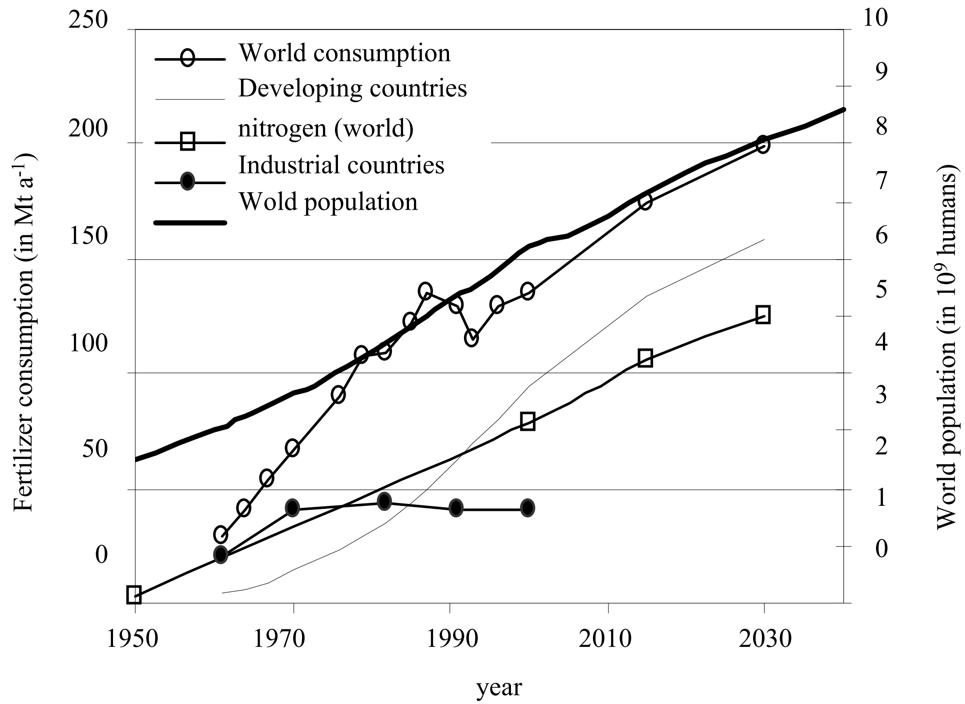
Mauna Loa observatory (Keeling building)





Evolution of world fertilizer use between 1940 and 2030





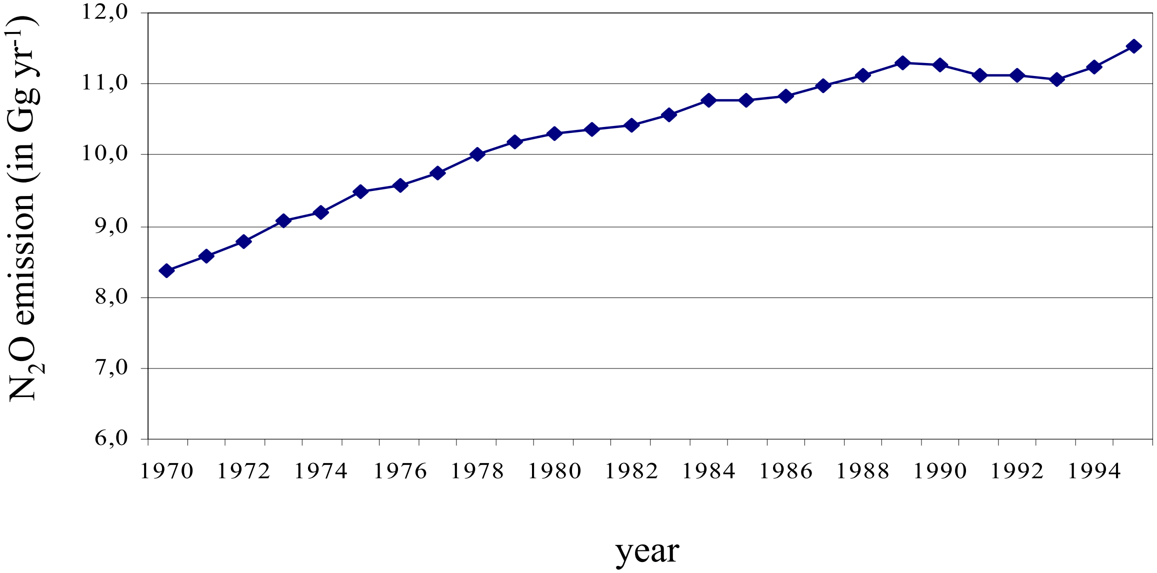
Möller (2003)

Brasseur, G. P., J. J. Orlando and G. S. Tyndall, eds. (1999) Atmospheric chemistry and global change. Oxford Univ. Press, New York

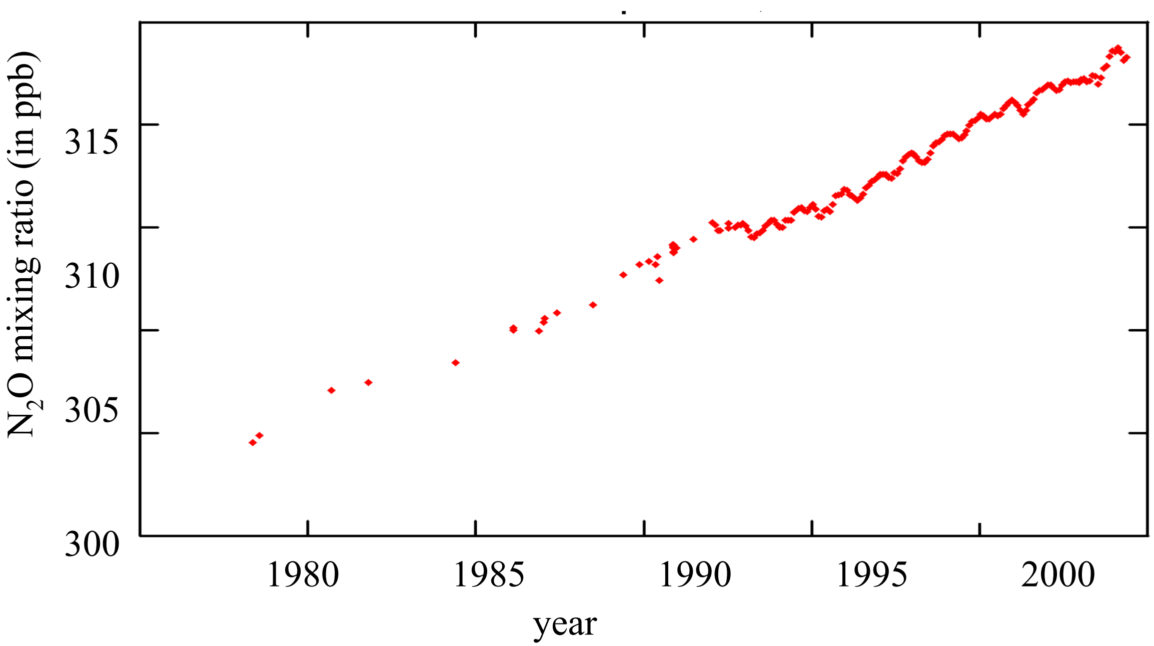
Trend of greenhouse gas emissions in the EU (in Mt CO_2 equivalent yr^{-1}), after EEA (2000)

Substance	1990	1992	1994	1996	1998
CO_2	3320	3269	3217	3359	3328
CH_4	440	414	387	374	367
N_2O	399	377	375	392	360
CFC	-[a]	-	-	58	-

[a] unknown

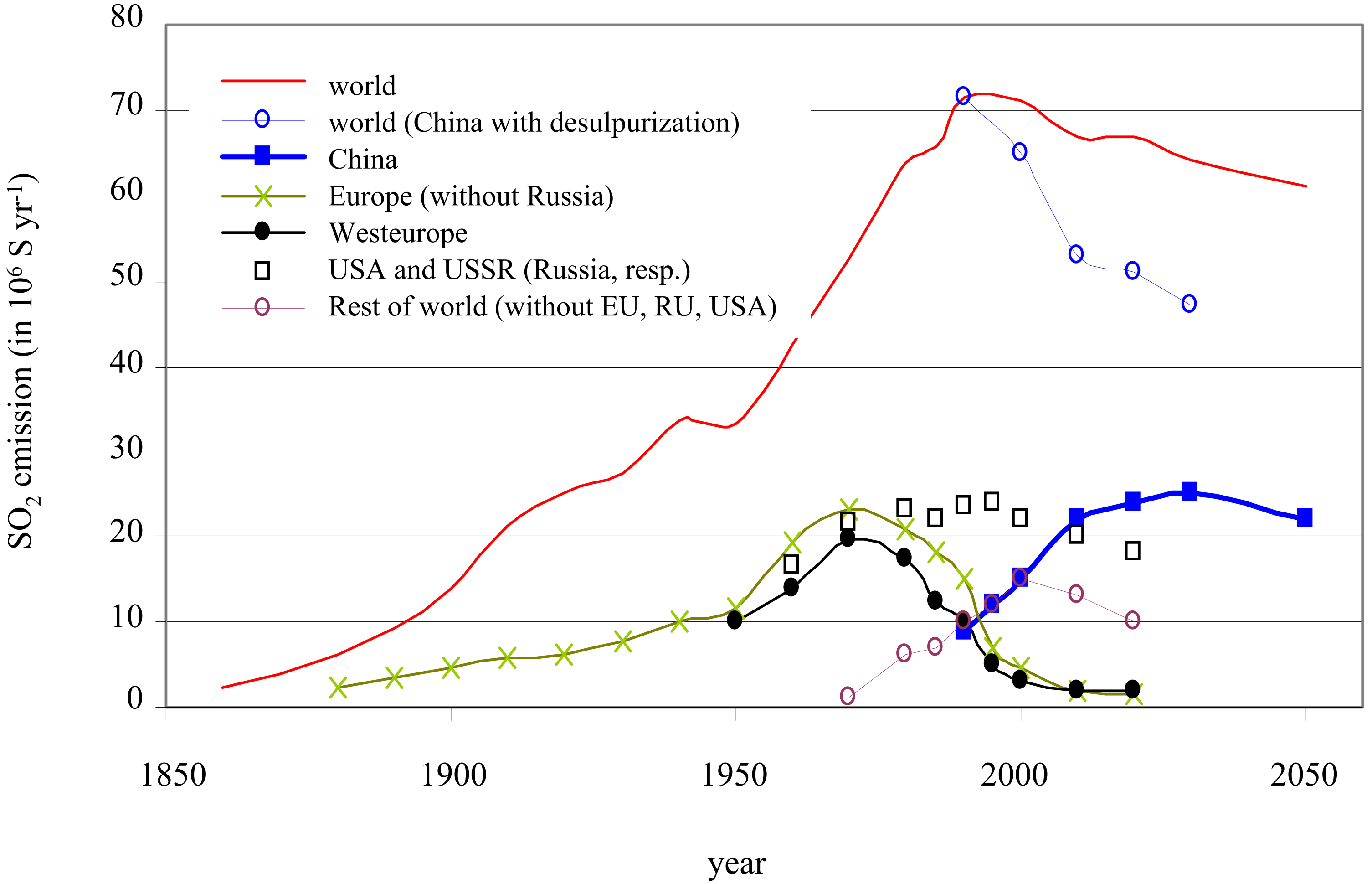


global N_2O emission,
(after GEIA)

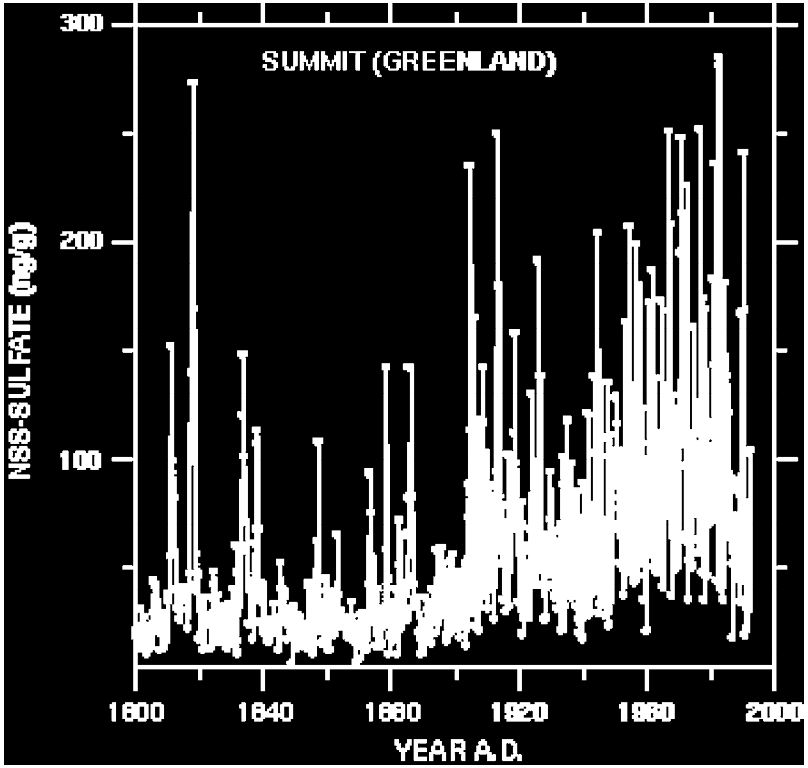


N_2O trend at Cape Grim (Tasmania),
(after CSIRO)

SO_2 emission



Sulphate in Greenland ice cores



Upper part of the Eurocore- GRIP nss- sulfate profile (402 values) obtained at Summit (central Greenland) covering the two last centuries. The gray continuous curve is a running average on 3 values. In the 19th century, variability was natural: spikes were caused by large volcanic eruptions (e.g., Tambora, 1815 and Krakatoa, 1883). Note the sudden increase in the concentrations observed in 1903, linked partly to a volcanic event (most likely Santa Maria, 1902). The continuous line is a polynomial average of degree 10 including 200 values. The first "bump" on this curve is most probably linked to increasing pollution, but also to sporadic volcanism. A marked decrease of pollution is observed in the last two decades

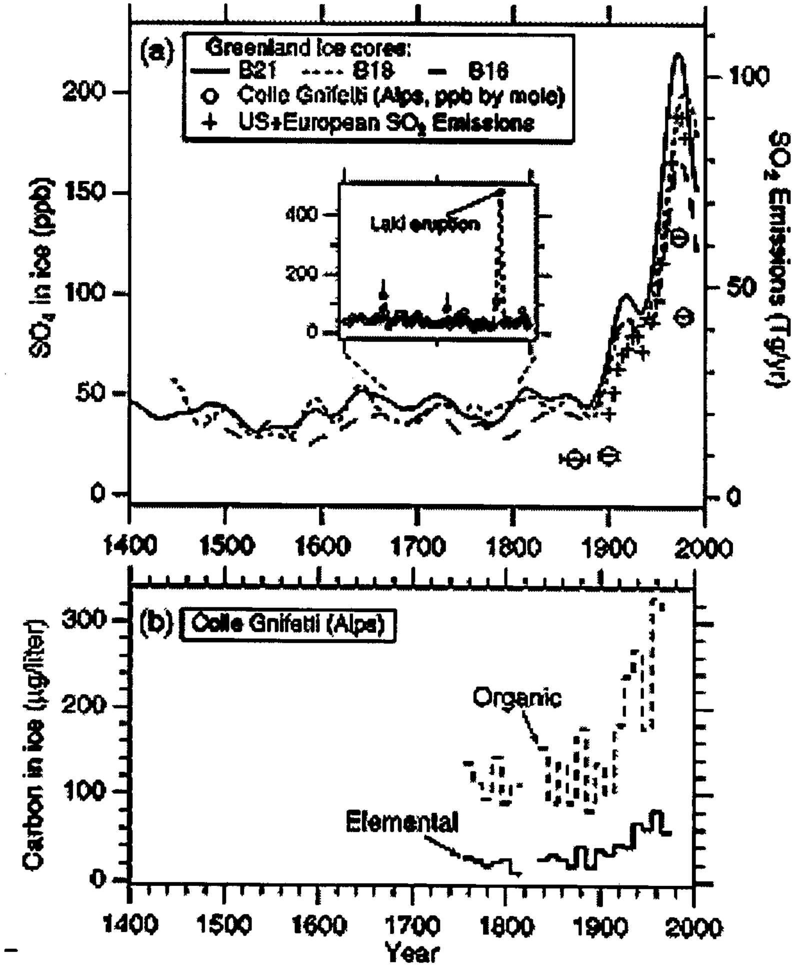
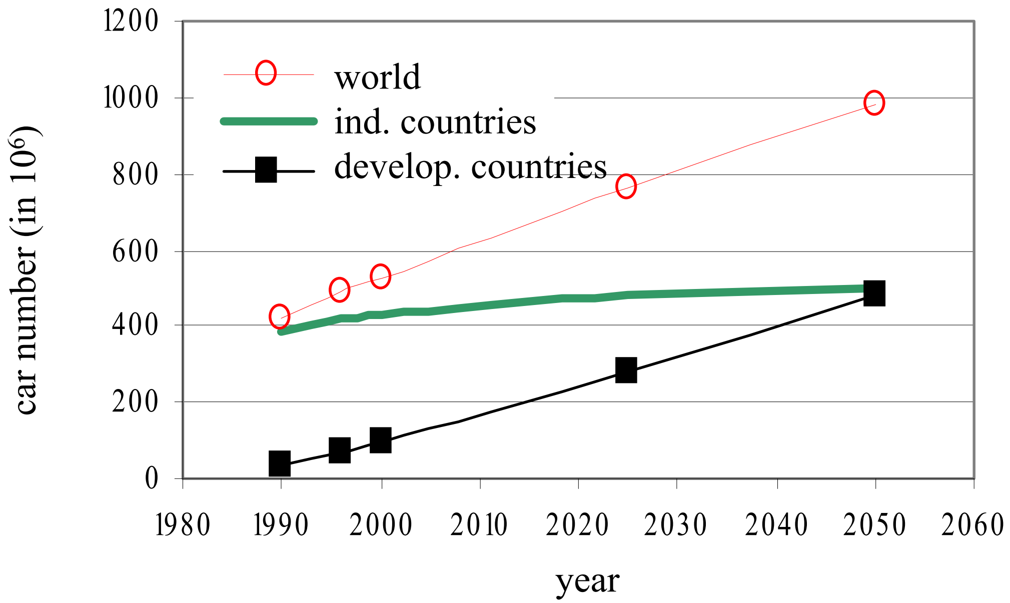
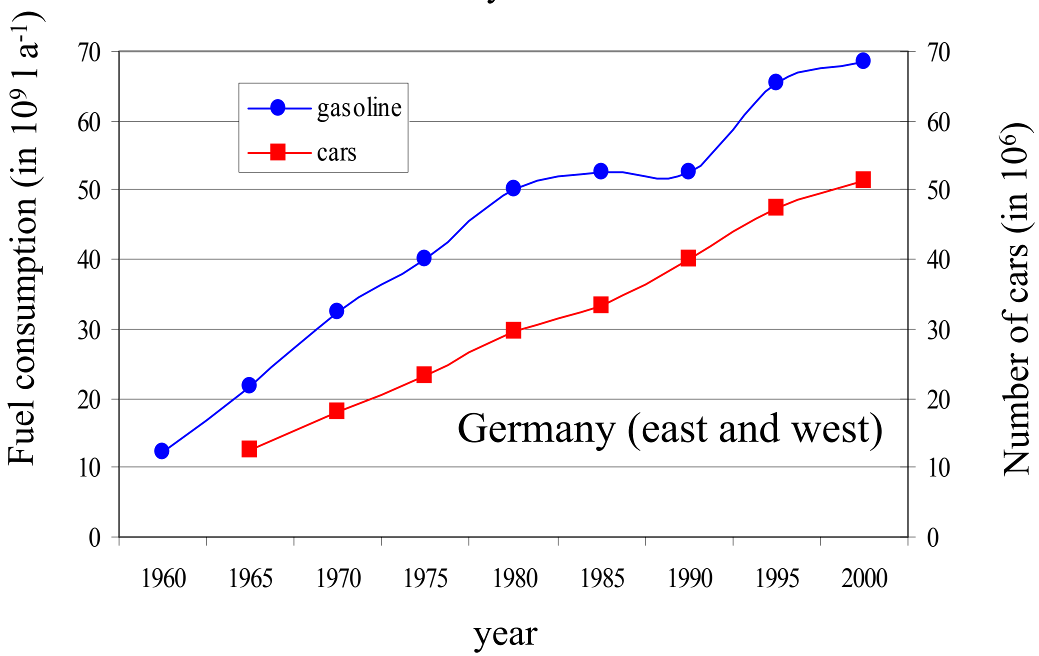


***Figure 5.4:** (a) Sulphate concentrations in several Greenland ice cores and an Alpine ice core (Fischer et al., 1998; Döscher et al., 1995). Also shown are the total SO2 emissions from sources from the US and Europe (Gschwandtner et al., 1986; Mylona, 1996). The inset shows how peaks due to major volcanic eruptions have been removed by a robust running median method followed by singular spectrum analysis.*
(b) Black carbon and organic carbon concentrations in alpine ice cores (Lavanchy et al., 1999).



How many cars needs the world?

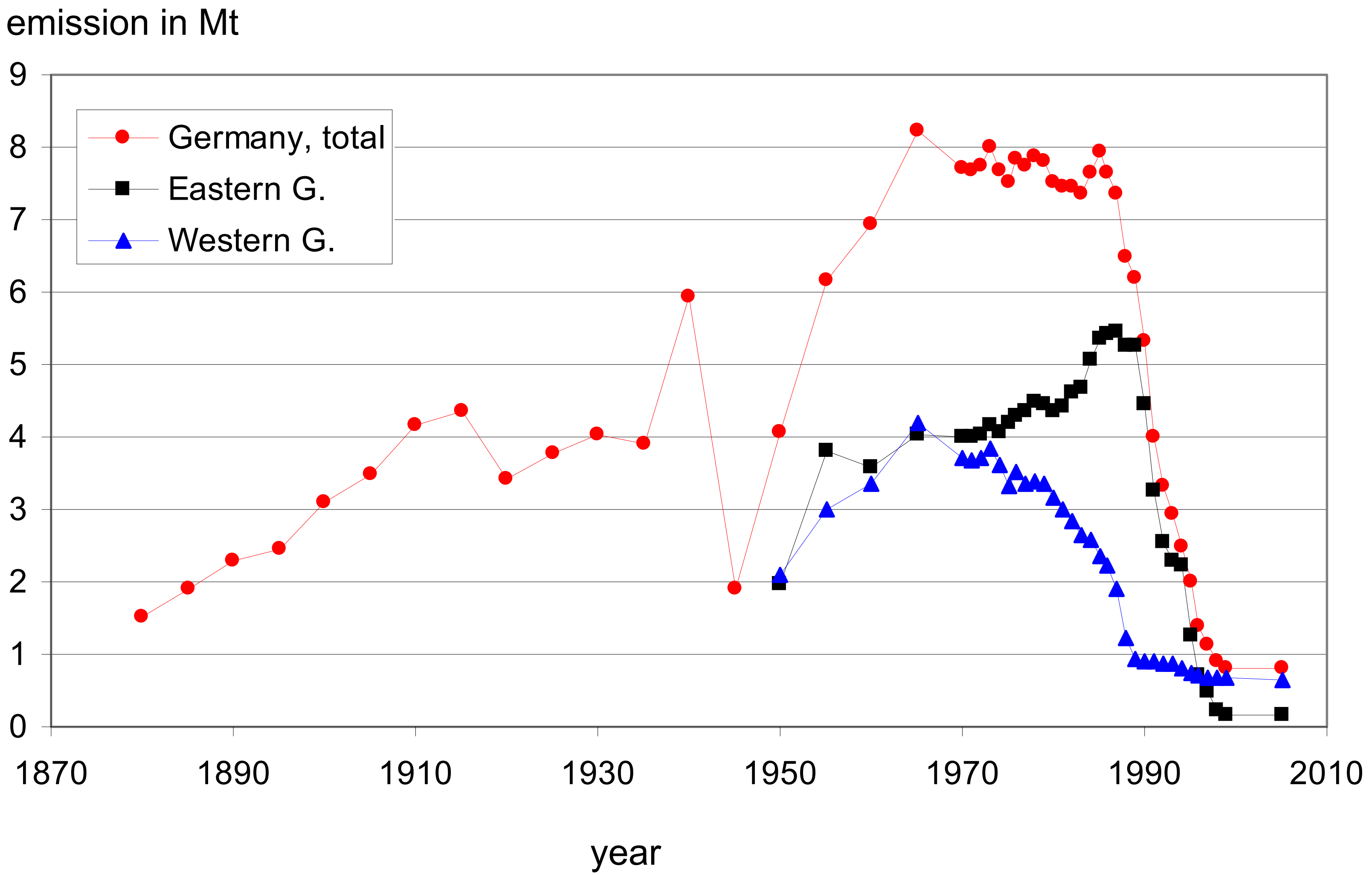


Self-limitation by traffic jam and prices.

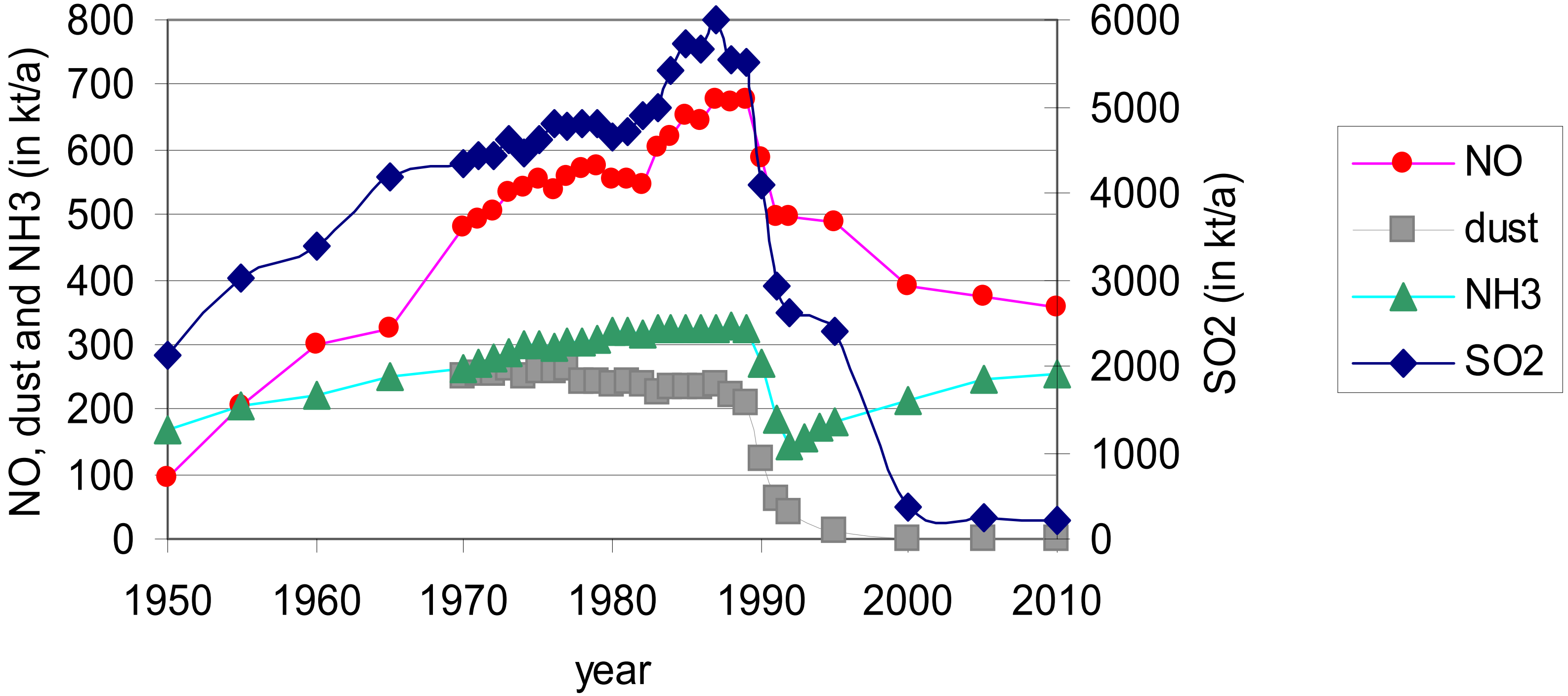
Alternatives due to ending of oil era ~2050.

German emissions

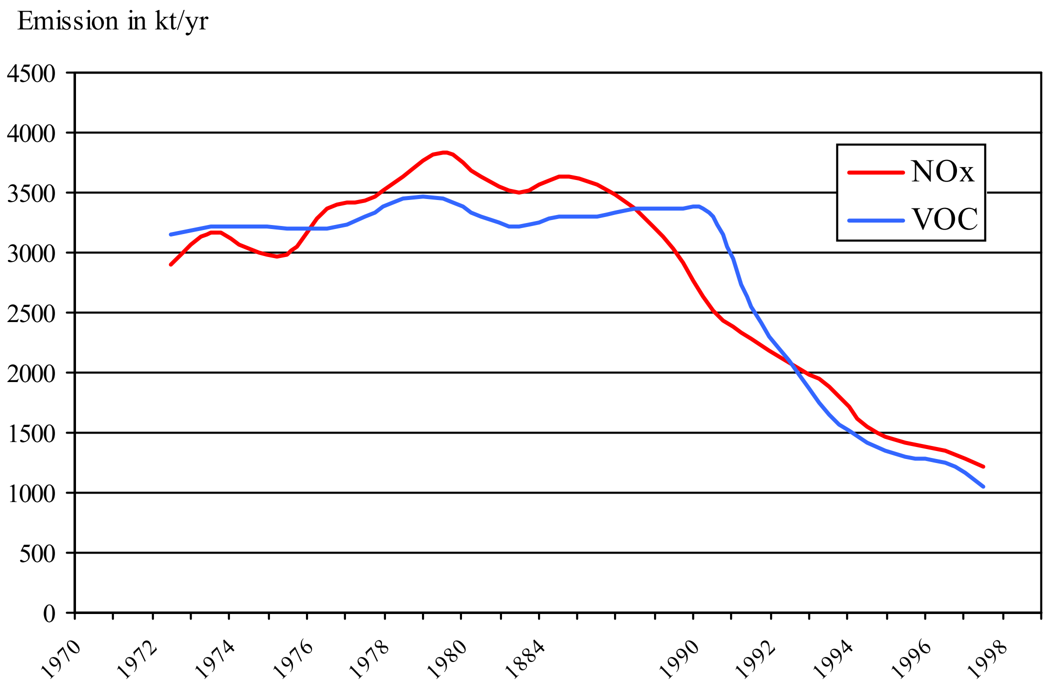
German SO_2 emission trend



Emission Trend in Eastern Germany



Trend of emission in Germany (after data from UBA)



Prognosis of emission (in kt) from traffic Germany (in kt nach EURO III Norm), after Tappe et al. (1996), Data for 1986 and 1991 after Friedrich (1999)

	1960	1970	1980	1983	1985[a]	1986[b]	1991	1995	2000	2005	2010
NMVOC					417	1420	1170	619	345	202	151
Benzene					61			6,9	5,1	8,5	5,9
CO					330	720	560	358	236	141	96,4
NO					515	1020	930	660	543	409	338
NO[c]	68	136	228	210			200[d]		215		
dust								42	30	21	17

[a] western Germany (after UBA)

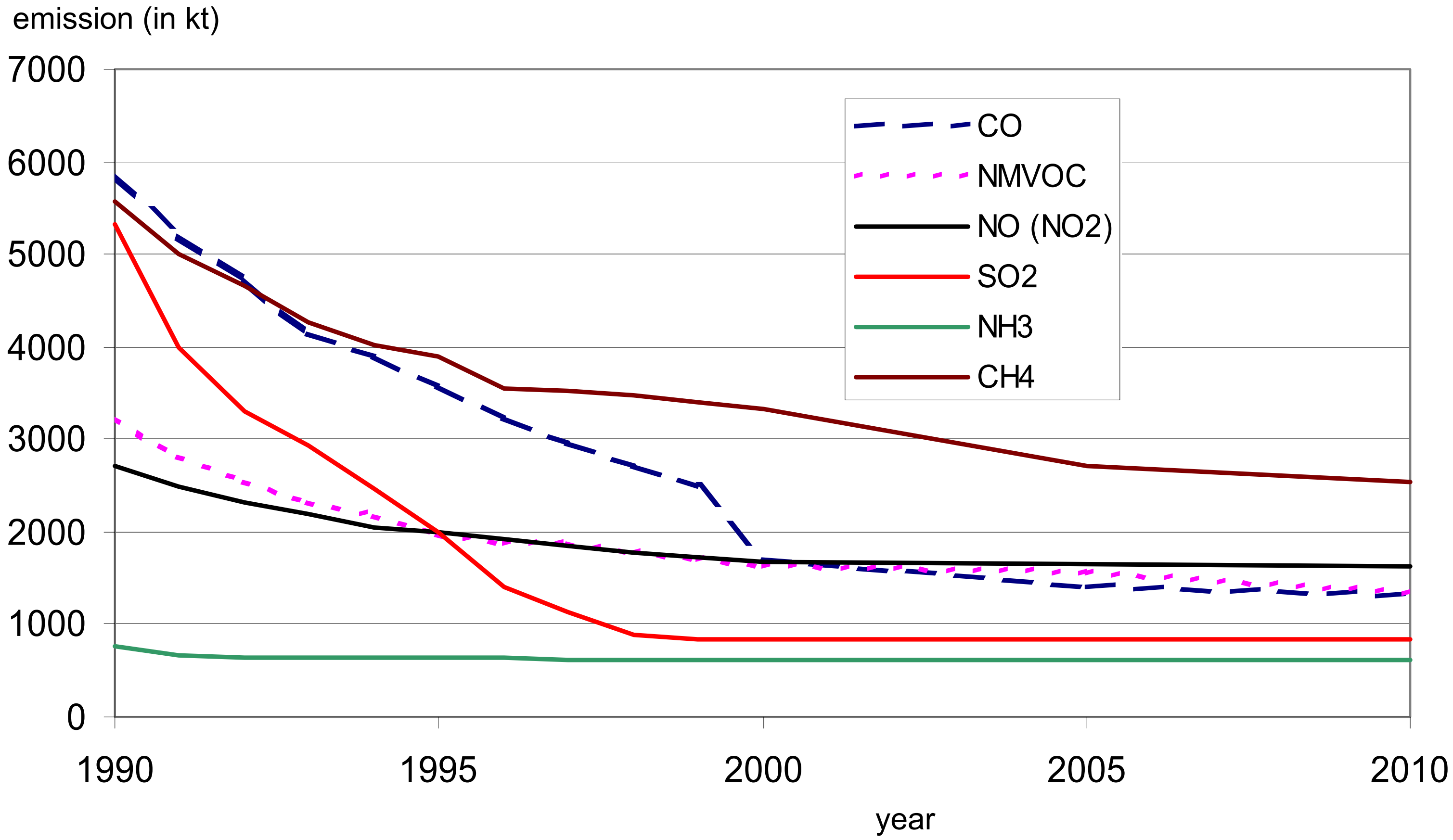
[b] eastern and western Germany; 1986/87 arised a maximum of traffic emissions

[c] East German emission after Kind (1985)

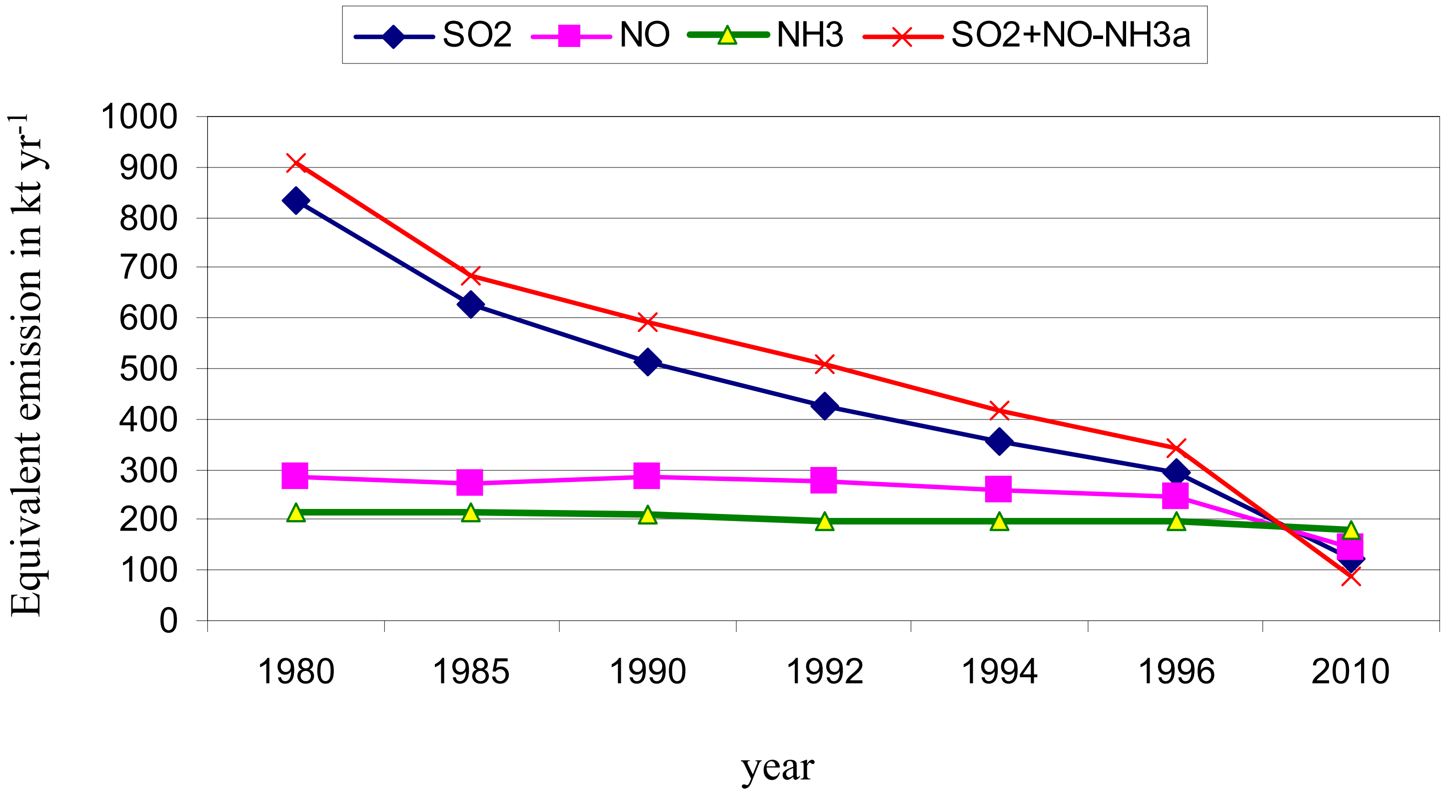
[d] 1990

Trend of German emissions since 1990 (prognosis from 2000)

(after Umweltbundesamt UBA)

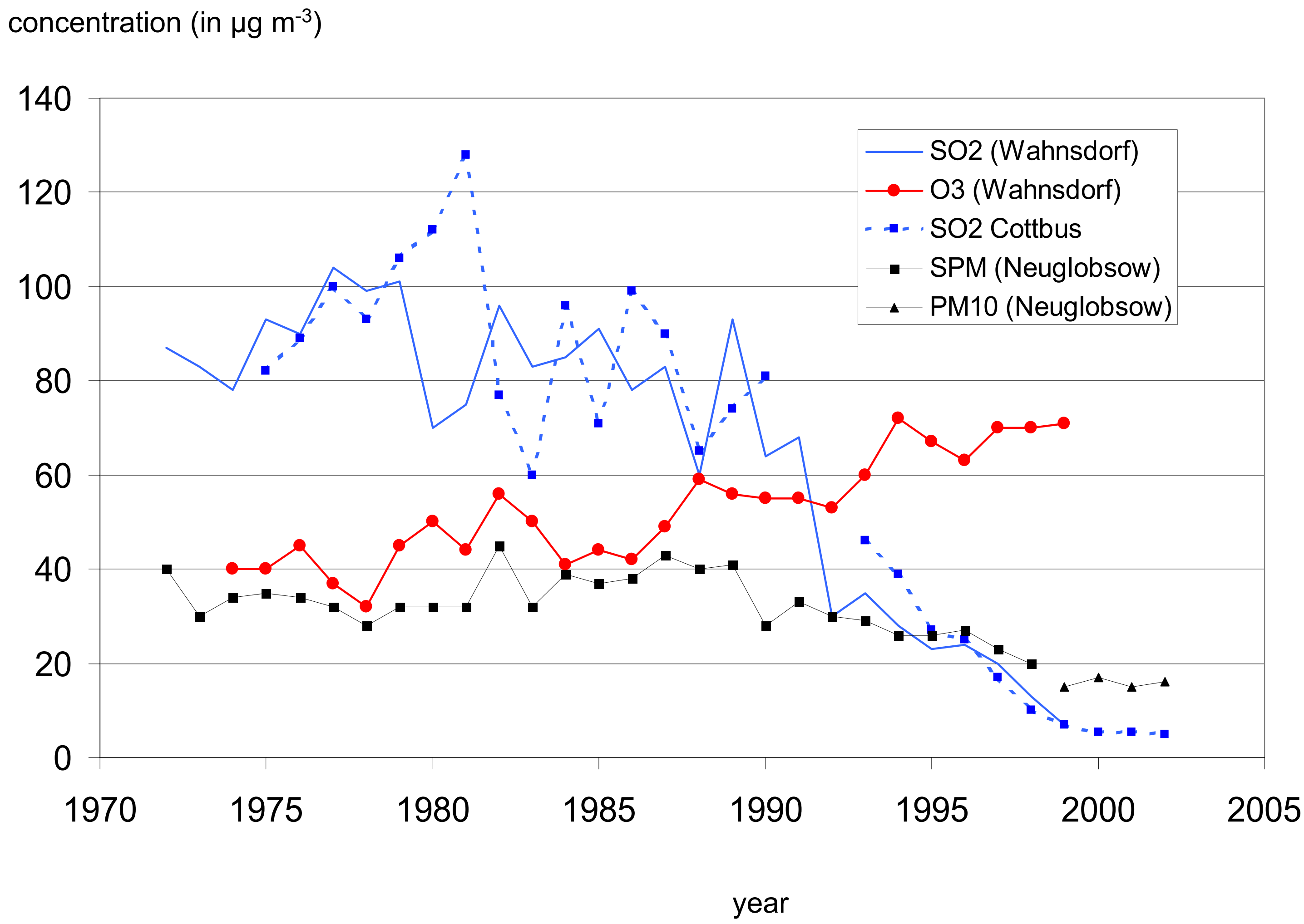


The end of the acid rain era (SO_2 was responsible)



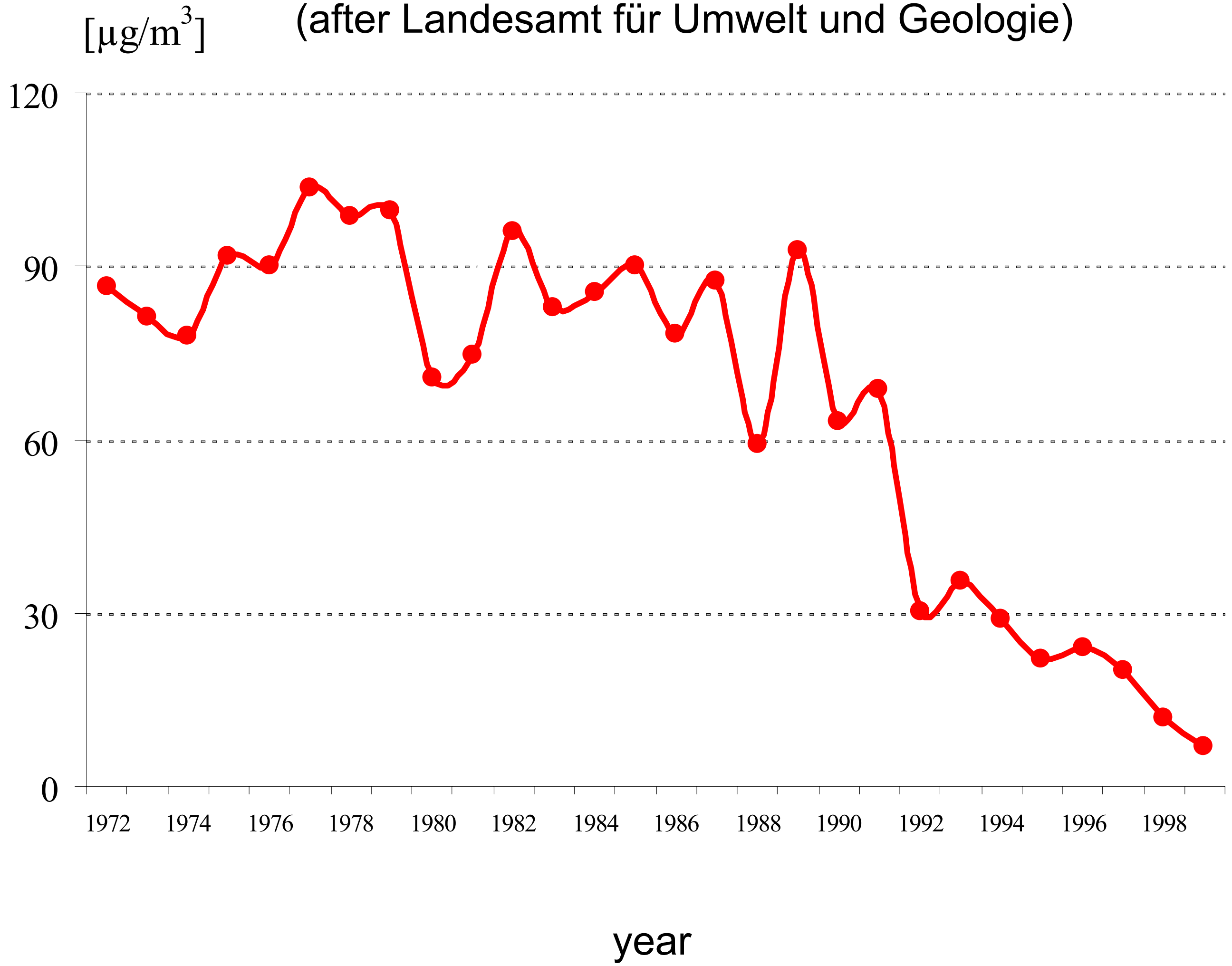
Trend of acidifiying emisisons in EU (in kt equivalent yr^{-1}), after EEA (2000)

Long-term trend air pollutant concentration in Eastern Germany

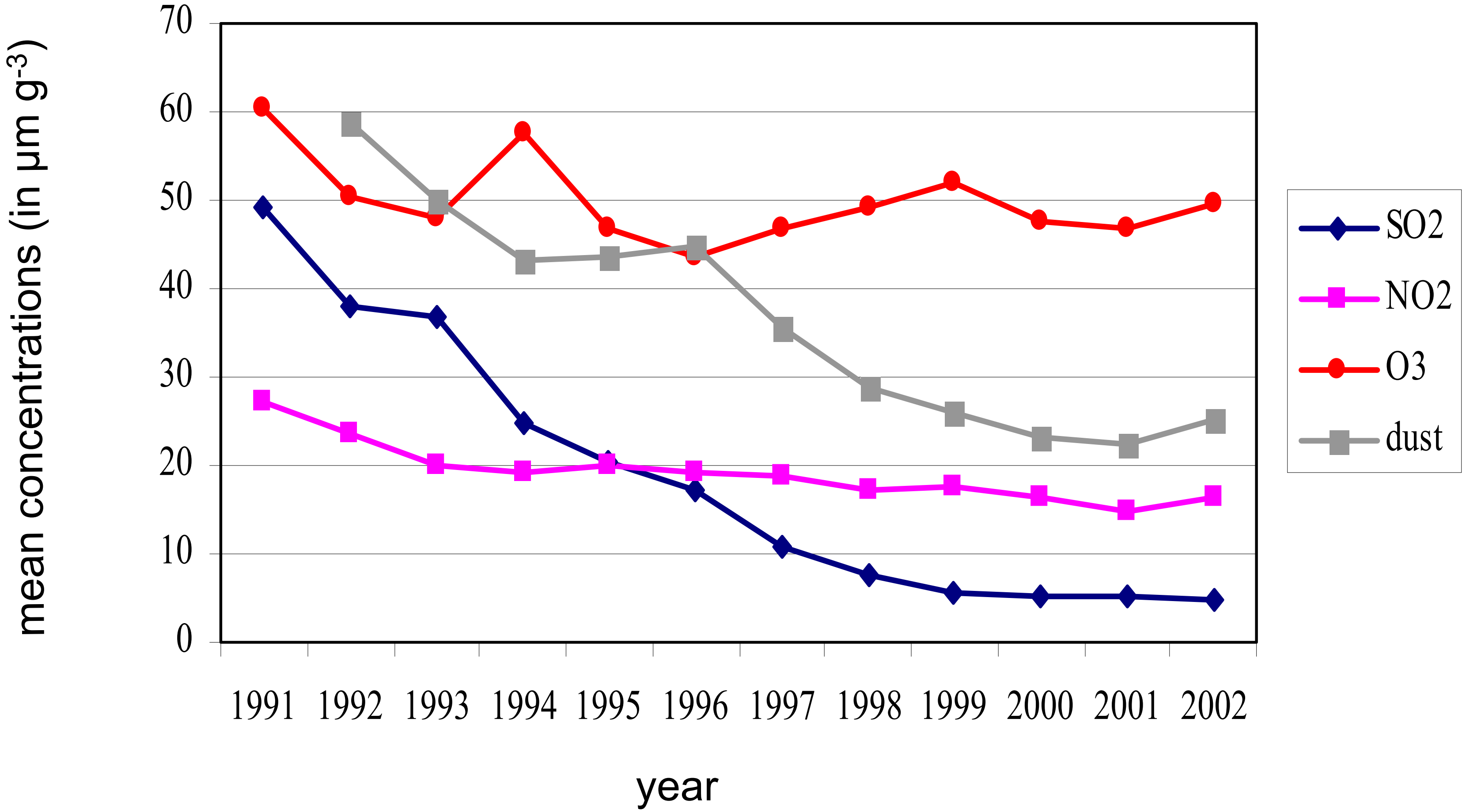


SO_2 trend (annual mean) at station Radebeul-Wahnsdorf (near Dresden)

(after Landesamt für Umwelt und Geologie)

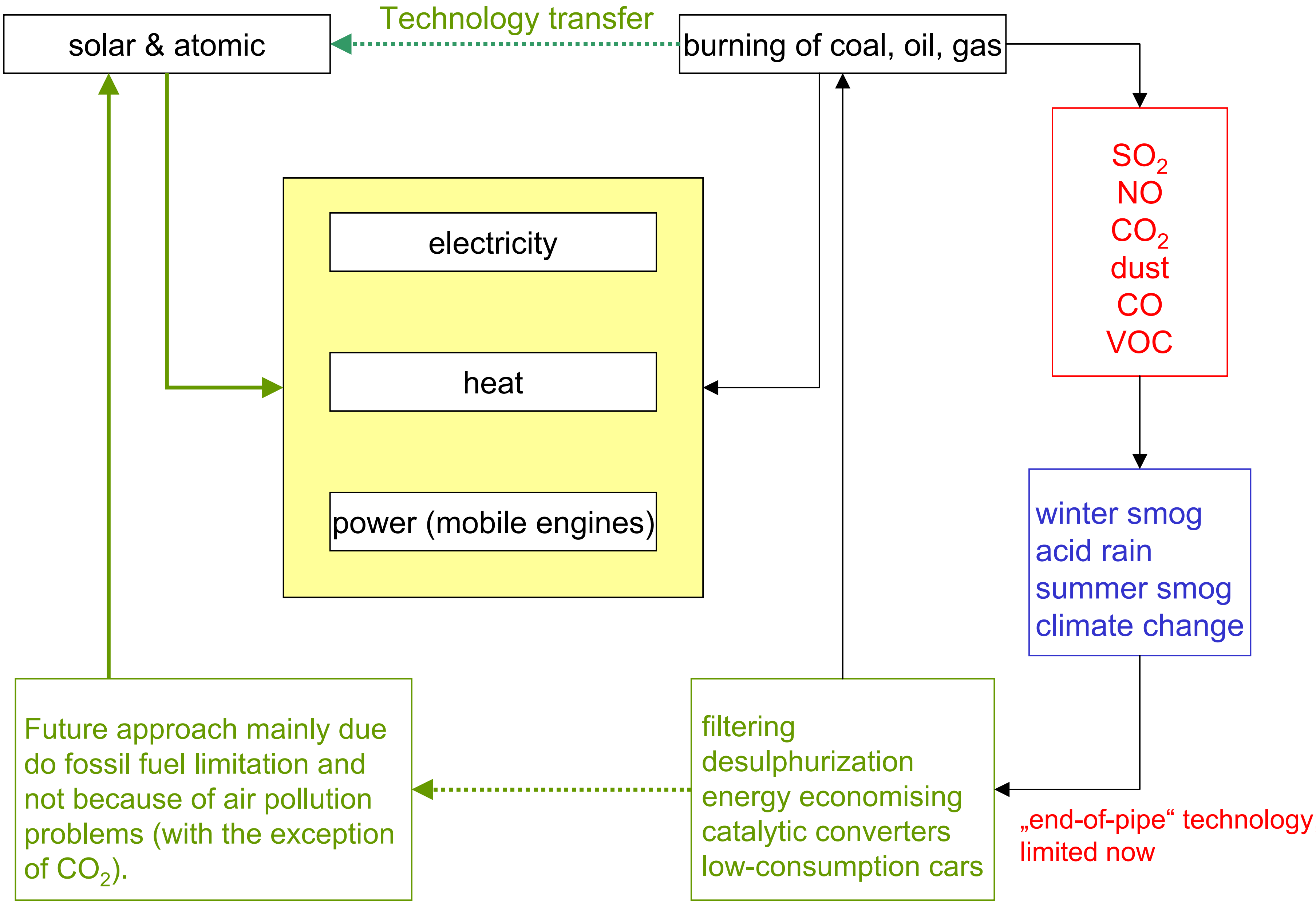


Air quality in Brandenburg State



Change of emission ratios in East Germany
(based on element and mass)

year	NO-N/NH_3-N	SO_2-S/NH_3-N	SO_2-S/NO-N	SO_2-S/dust
1970	2,2	10,0	9,7	8,7
1980	2,1	8,9	9,0	7,3
1988	2,5	10,2	8,8	12,6
1992	4,1	10,9	5,7	31,2
2000	2,7	1,4	1,1	384,0
2010	2,0	0,6	0,7	409,0


Technology transfer
solar & atomic
burning of coal, oil, gas
electricity
heat
power (mobile engines)
SO_2
NO
CO_2
dust
CO
VOC
winter smog
acid rain
summer smog
climate change
Future approach mainly due do fossil fuel limitation and not because of air pollution problems (with the exception of CO_2).
filtering
desulphurization
energy economising
catalytic converters
low-consumption cars
„end-of-pipe“ technology;
limited now

Conclusion 1

1. The „acid rain“ age has been finished in Europe. Main cause was SO_2. However, the pH did not drastically „recovered“, it has been increased by 0.2-0.4 units only. Most of acidity has been neutralized by (alkaline) flue ashes.

2. Due to drastic SO_2 emission reduction in Europe, however, the long-range transportation decreased significant. Consequently, „remote“ sites became again „remote“.

3. Forest decline („Waldschaden“) remains seriously, but out of political focus. Reasons are likely not „acid rain“ but permanent oxidative stress.

Conclusion 2

- 10-20% of sulphur emission remains until end of coal age
- Ammonia/ammonium becomes dominant but likely neutralised by acidic precursors (SO_2 and NO)
- PM abatement seems to be very limited; large-scale ammonium-sulfat-nitrate, (natural) OC and OC(SOA) and EC from traffic as well soil dust determine some 20 $\mu g\ m^{-3}$
- PM exceedance is likely due to dry periodes (and other meteorological conditions)
- CO and VOC from cars remain up to 30% due to cold start periode until new catalyst generations are available
- Traditional gasoline engines will be replaced in 20-30 years; thus finishing the „hot“ ozone problem
- After replacing of high-temperature processes (fuel burning) by alternative technologies, NO may drastic be reduced and larges geographical areas convert (back) into ozone destruction (?)

Outlook (1)

1. More air pollution abatement in high industrialized countries seems not longer being possible in a cost-effective approach by traditional technologies and end-of-pipe solutions.

2. Strengthening of new technologies for energy supply based on solar energy conversion (and transitional nuclear power) will solve the remaining air pollution problems (PM, ozone, greenhouse effect) all together.

3. Urban (life) quality is more than only air quality and it seems that other topics becomes much more important (noise, travel time, recreation, aesthetics, social relationships etc.).

Outlook (2)

We should replace the term „air pollution“ by „chemical climate“. Understanding the climate as the whole physical and chemical status of the atmosphere, we need more and much better equipped climate monitoring stations at some locations for long-term scientific monitoring our climate. Only on long-term base we can understand its change and variation and possibly to adopt control and adopting strategies. There is no human society existence without pernament stress on the „natural“ climate. Thus, the question is, what kind of „man-made“ climate (noosphere) we can and will accept.