NILU: F 06/2003

NILU: F 06/2003
REFERANSE: Q-303
DATO: FEBRUAR 2003

Kjemisk sammensetning av atmosfæren – hvor store er de globale endringene fra pre-industriell tid til i dag?

Koplinger mellom atmosfærens kjemi og klima

Frode Stordal

Presentert i Oslo Geofysikeres Forening
Det norske meteorologiske institutt, Oslo
12. februar 2003

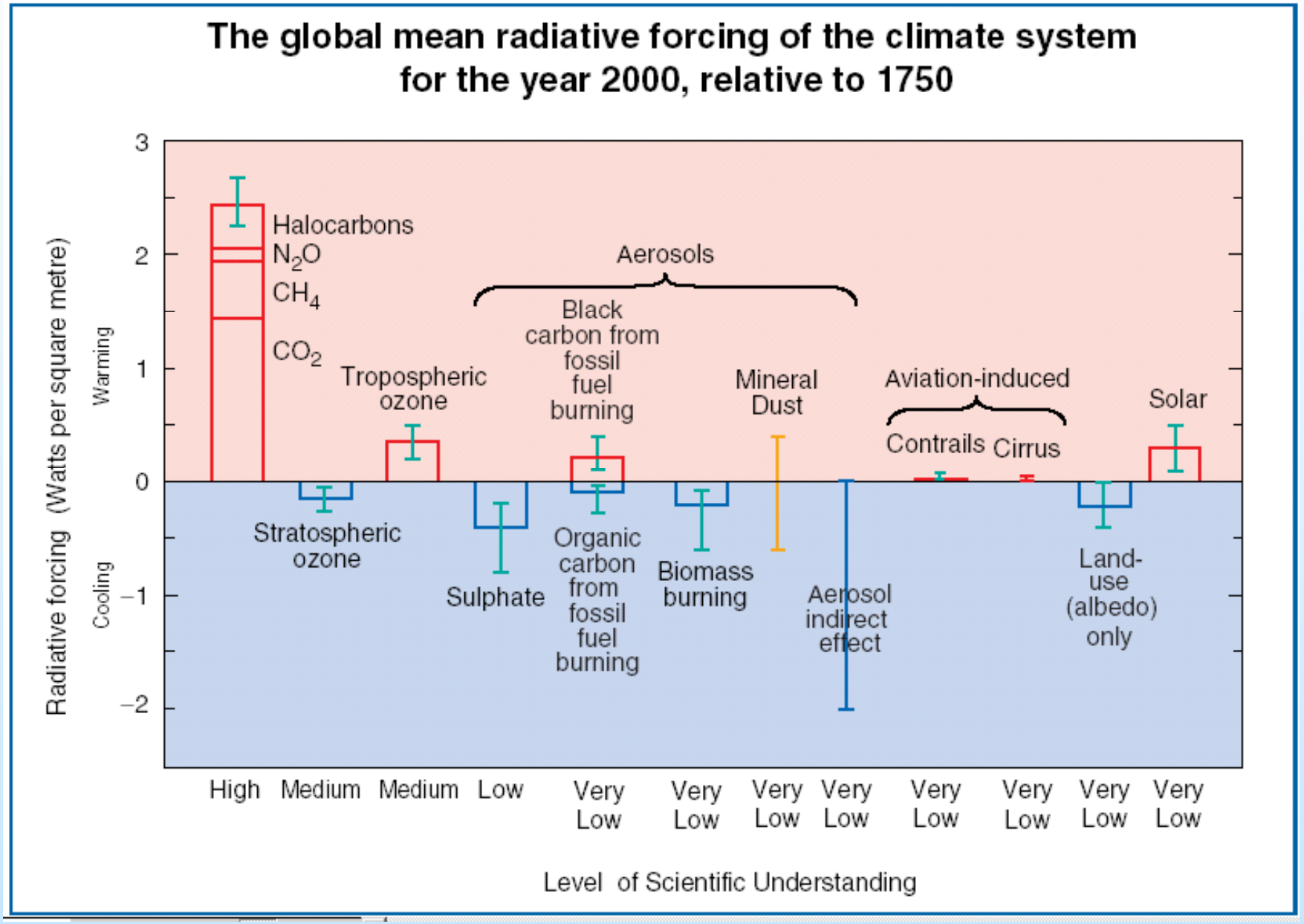
Kjemisk sammensetning av atmosfæren - hvor store er de globale endringene fra pre-industriell tid til i dag?

Koplinger mellom atmosfærens kjemi og klima

Frode Stordal
NILU

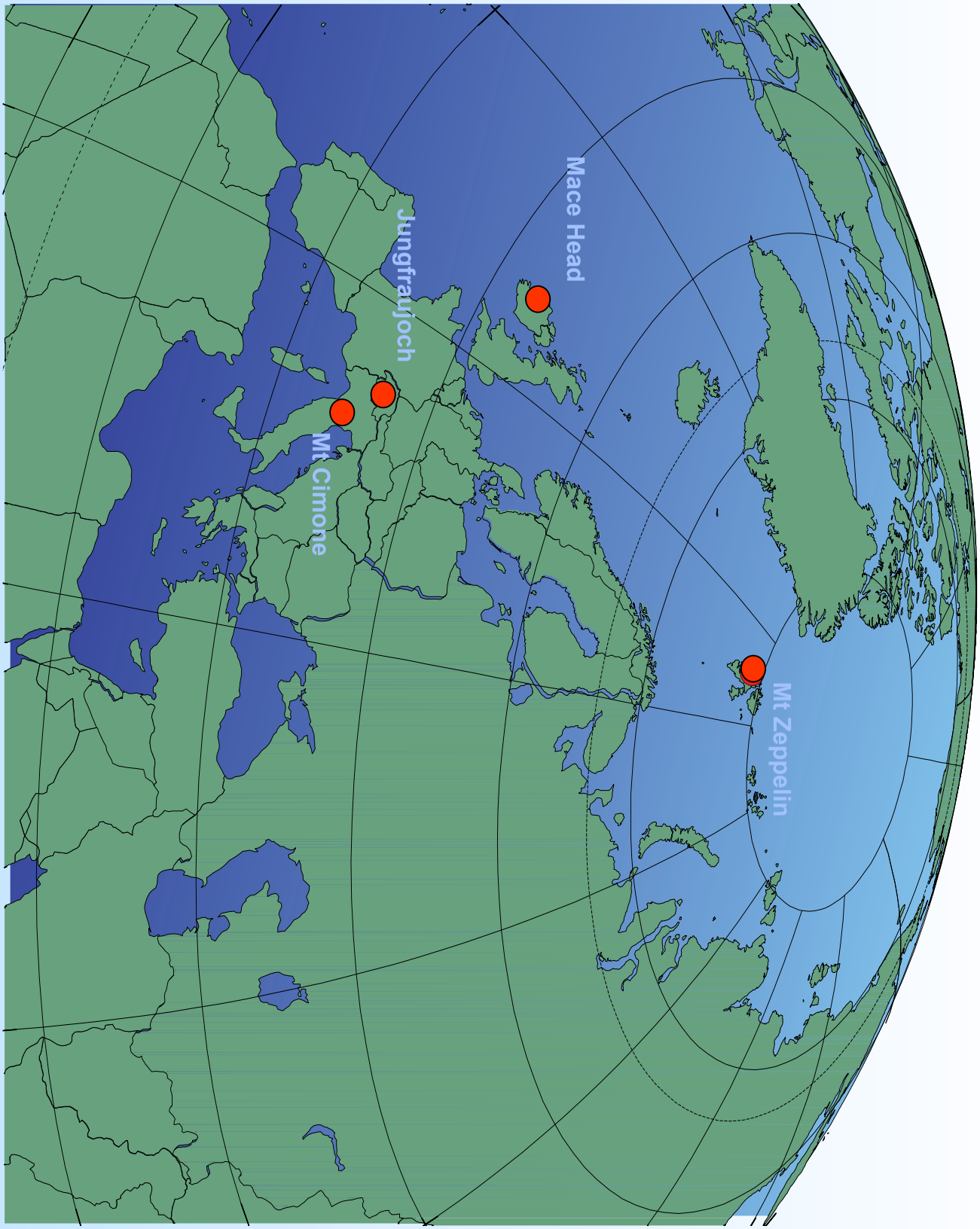
OGF 12.2.2003

IPCC TAR

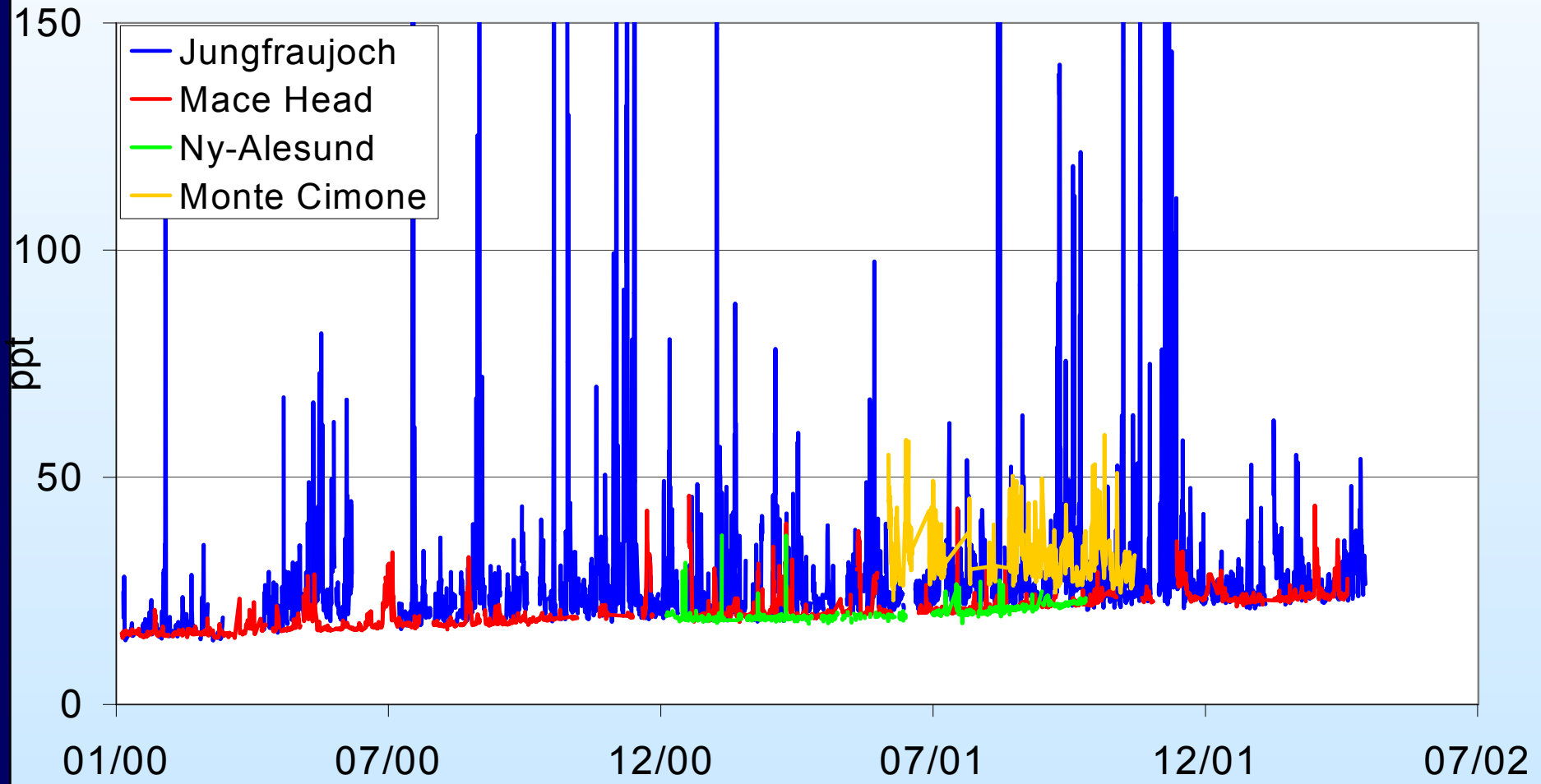


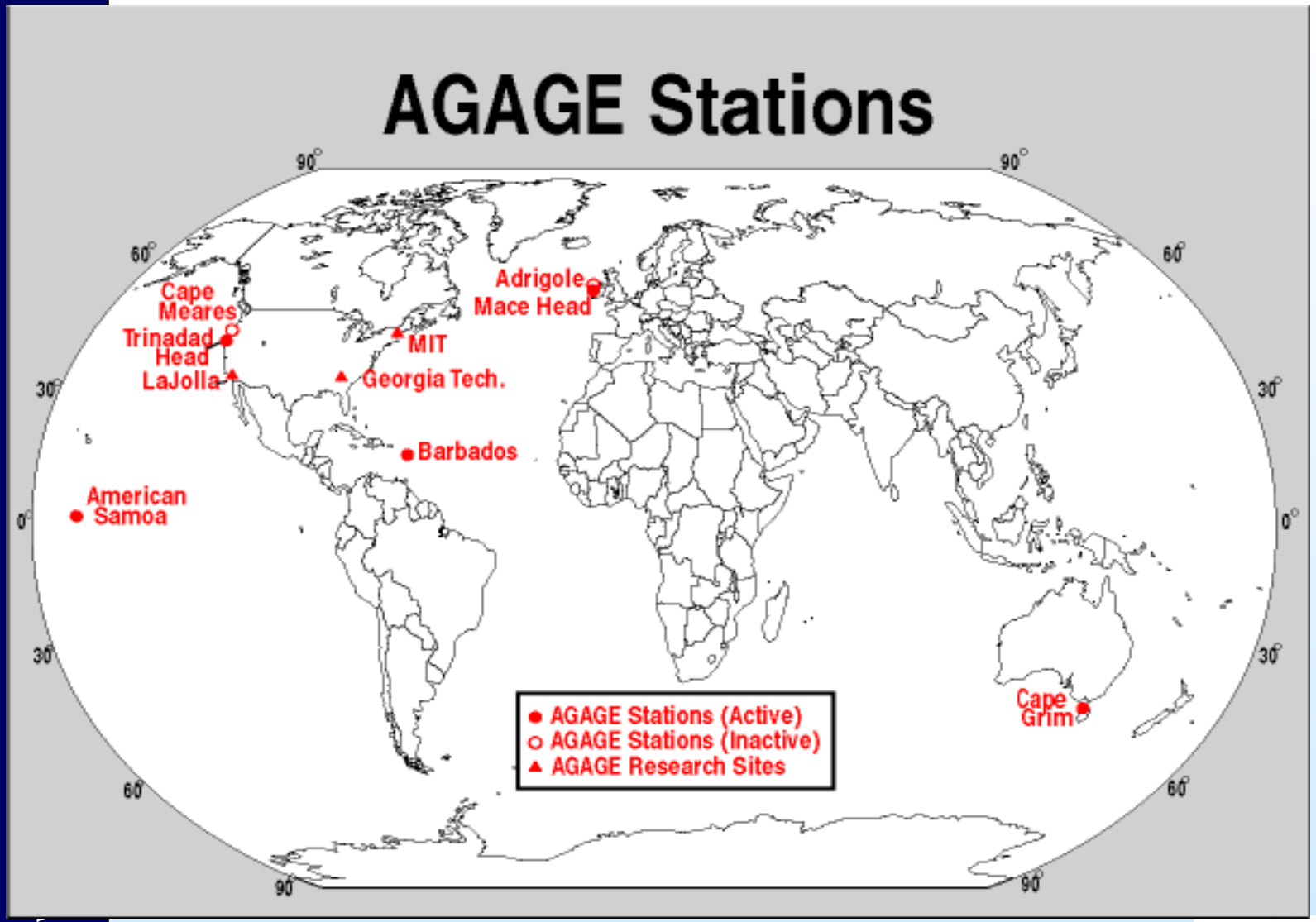
Mt Zeppelin

78º54´N
11º53´E
475 m asl


Mace Head
Jungfraujoch
Mt Cimone
Mt Zeppelin

The coolant agent F-134a at the SOGE sites




AGAGE Stations
90°
60°
30°
0°
Adrigole
Mace Head
Cape
Meares
Trinadad
Head
LaJolla
MIT
Georgia Tech.
Barbados
American
Samoa
Cape
Grim
AGAGE Stations (Active)
AGAGE Stations (Inactive)
AGAGE Research Sites

AGAGE

NILU

EU report on ozone-climate interactions

Ivar Isaksen, Univ Oslo
Neil Harris, Univ Cambridge
Bram Bregman, Hennie Kelder, KNMI
Martin Dameris, DLR
Frode Stordal, NILU
Claire Granier, MPI Hamburg

Ch. 2: The effect of stratospheric ozone changes on climate

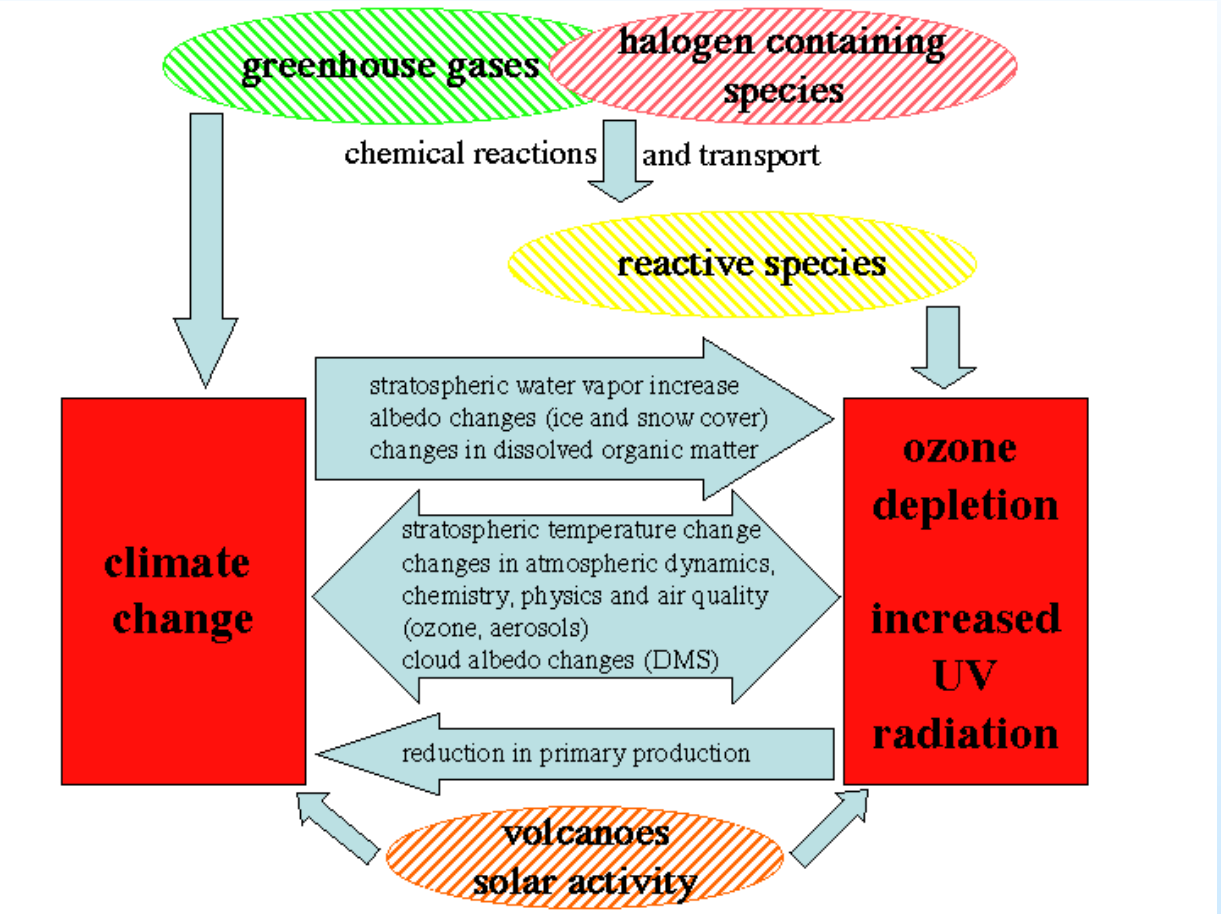


Diagram 1. Summary of the stratospheric ozone – climate interactions described in chapter two and three.

Polar Stratospheric Clouds – Blindern, Oslo – Jan 15, 2003

Ch. 2: The effect of stratospheric ozone changes on climate

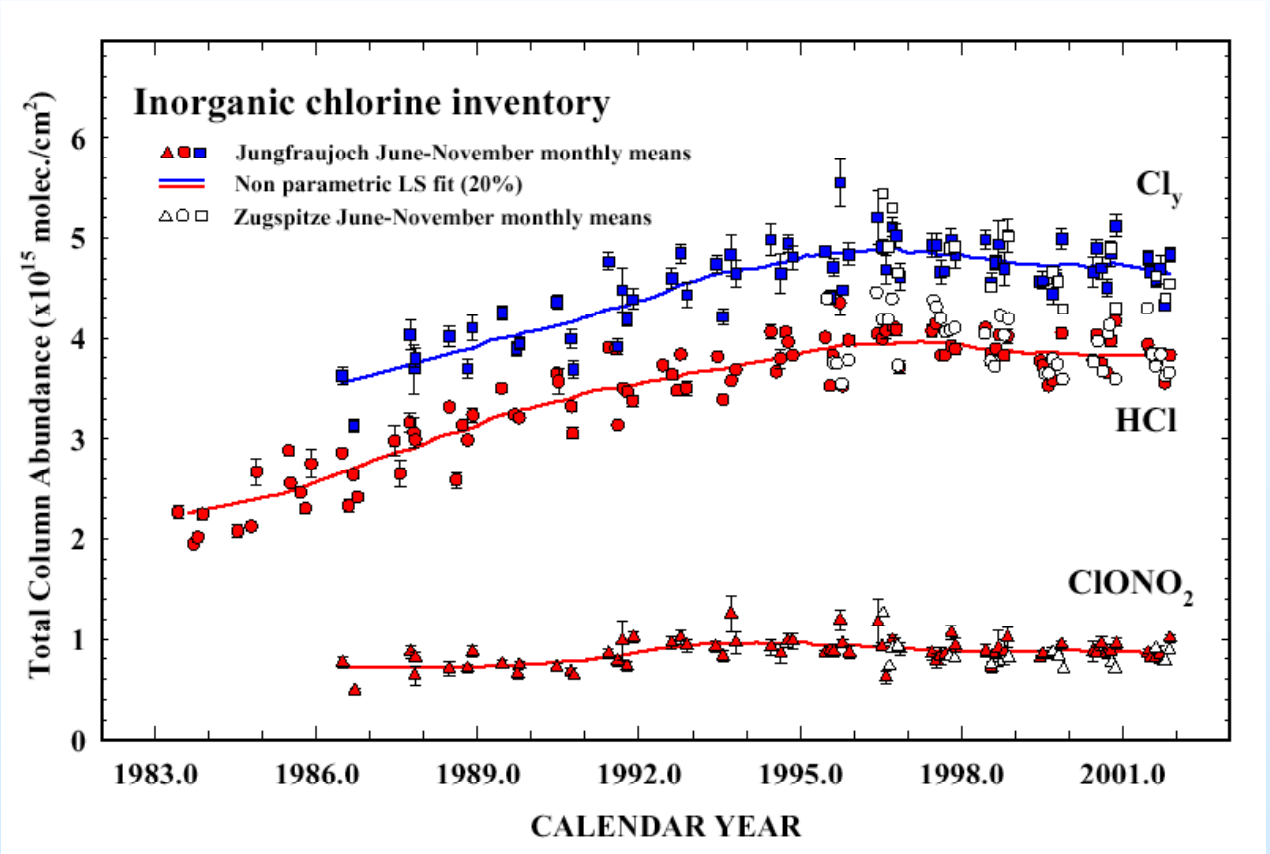


Figure 2.2. Vertical column amounts of HCl and $ClONO_2$ above the Jungfraujoch (located in the Swiss Alps as part of the NDSC primary station NDSC-ALPS). Only June to November monthly mean vertical column abundances are used in order to avoid large winter-spring variability. The reported Cl_y includes a ClO background load derived from model calculations (updated from Mahieu et al., 2000).

Ch. 3: The effect of changes in climate on stratospheric ozone

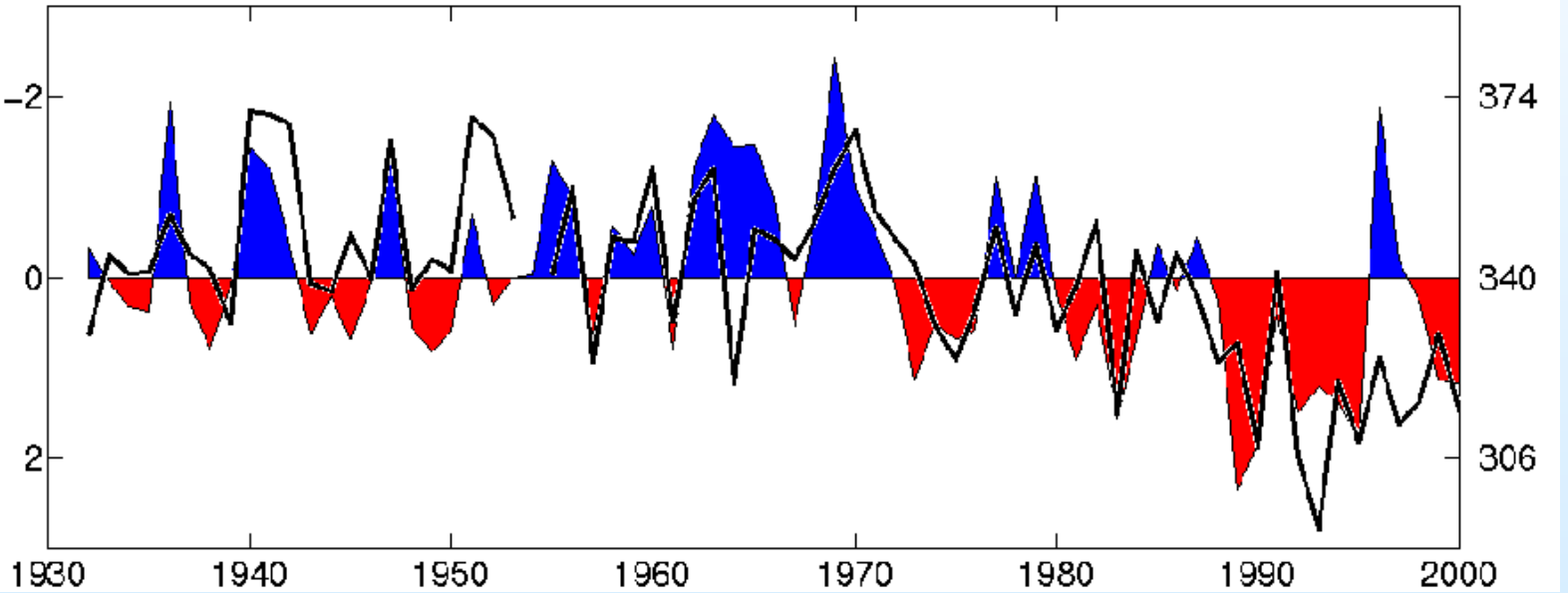
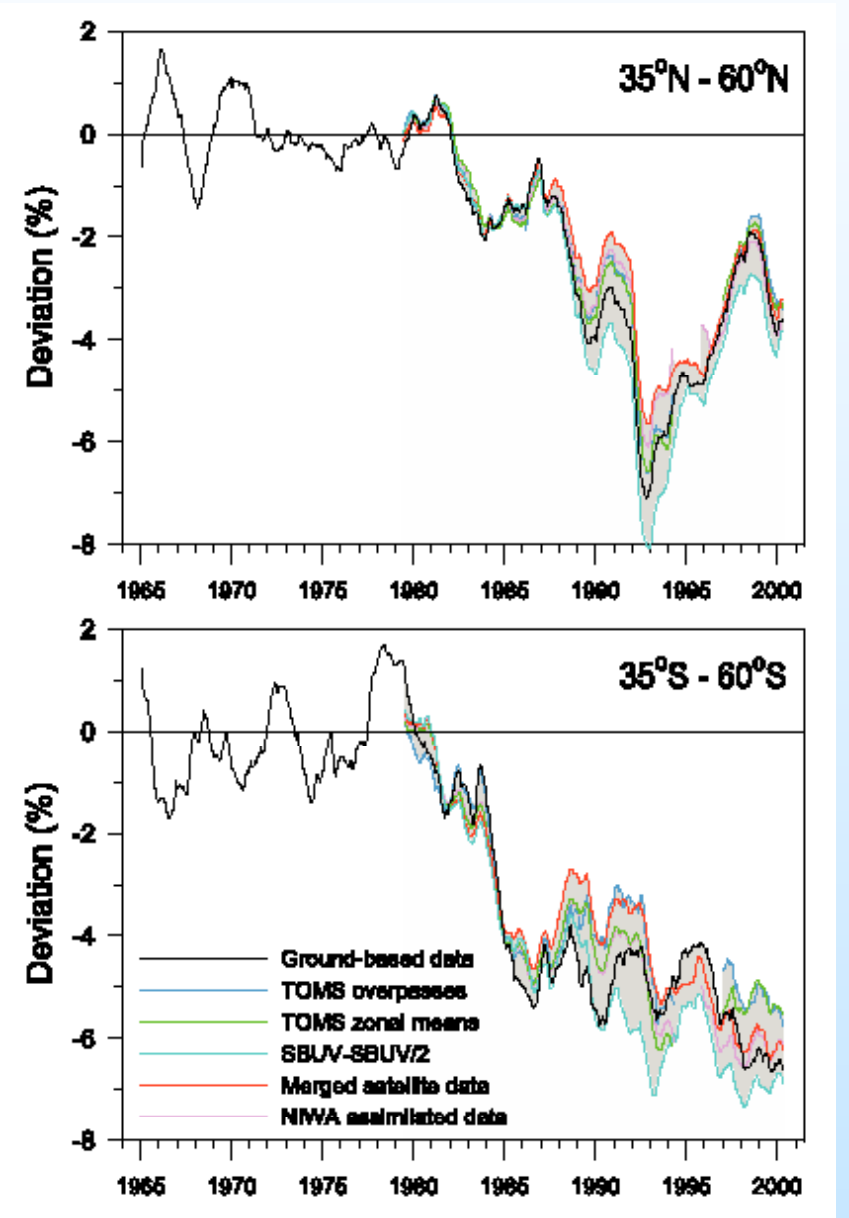


Figure 3.10: Total ozone in winter over Arosa, Switzerland (black line; in DU, right scale) and the normalised NAO index (colour coded; left scale). Adapted from Appenzeller et al. (2000).

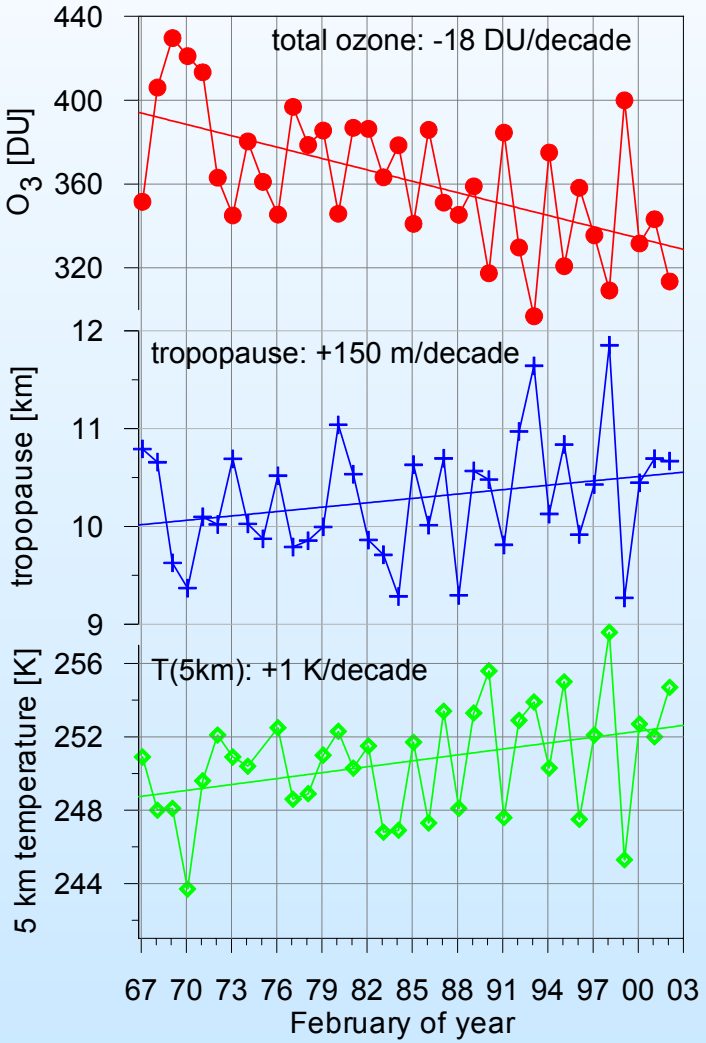
Ch. 2: The effect of stratospheric ozone changes on climate

Figure 2.1.
Total ozone deviations from the pre-1980 level in percent for the 35-60S and 35-60N zones estimated from six data sets (Ground-Based data, TOMS overpass data, TOMS zonal means, SBUV-SBUV/2 zonal averages, merged TOMS and SBUV-SBUV/2 data, and the National Institute of Water and Atmospheric Research (NIWA) assimilated data, based on TOMS, version 7 and GOME data (Bodeker et al., 2001), with seasonal, QBO, and solar cycle removed. The data are smoothed by 25 months running means. The shaded area indicates the spread of the different data sets (from: Fioletov et al., 2002).

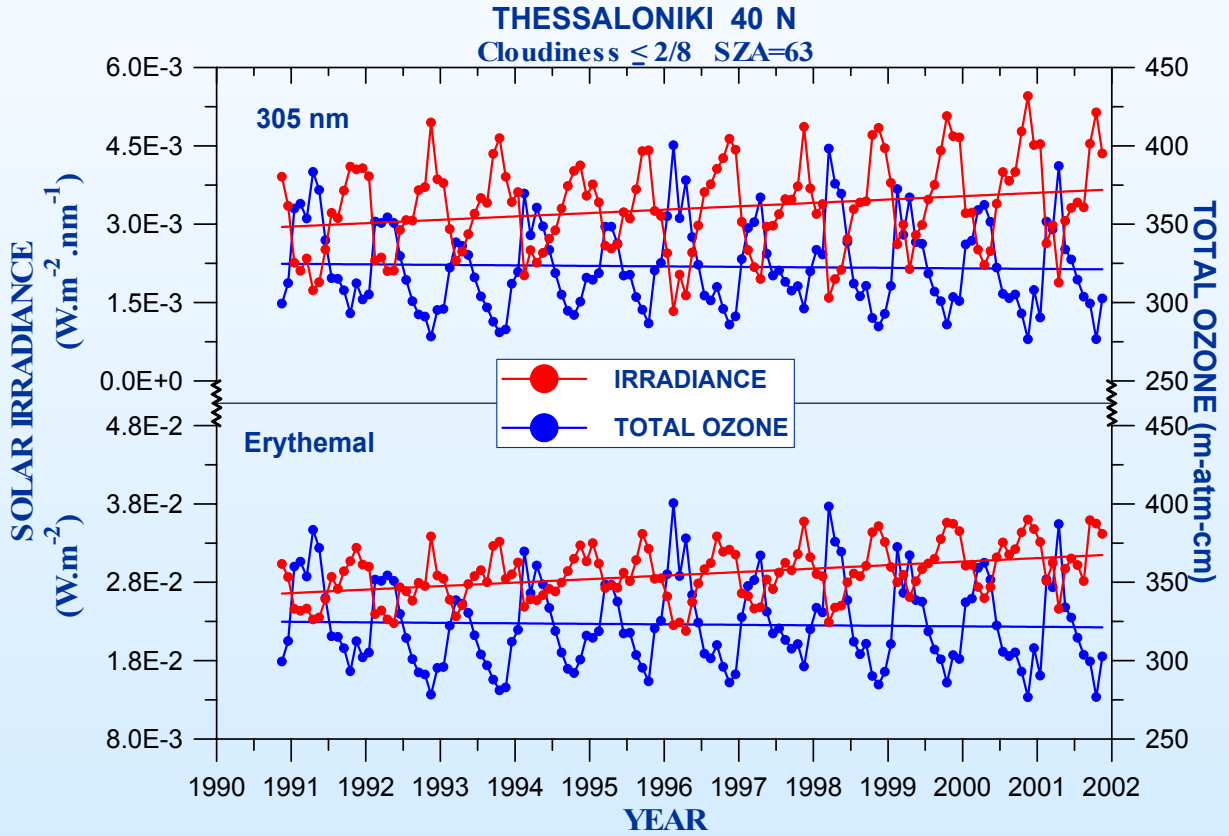


Ch. 3: The effect of changes in climate on stratospheric ozone

Figure 3.6: Inter-annual variability and long-term trends of February monthly means of total ozone (top), tropopause height (middle) and temperature at 5 km altitude over Hohenpeissenberg. The high correlation between 5 km temperature and tropopause height on inter-annual and decadal time scales points to a very strong link between these parameters. At the same time a strong anti-correlation is evident between total ozone and tropopause height, again on inter-annual and longer time scales. It is estimated that about two thirds of the long-term total ozone decrease over Hohenpeissenberg is caused by anthropogenic chlorine, one third is attributed to the observed increase of tropopause height (updated from Steinbrecht et al., 1998).



Ch. 2: The effect of stratospheric ozone changes on climate



PERIOD: 1990-2002			
IRRADIANCE	**MEAN**	**SLOPE**	**%/decade**
305 nm	3.3	0.065	19.7
Erythemal	29.0	0.450	15.5

Figure 2.7 Updated version of the inverse long-term relationship between increases in 305 nm irradiance, the erythemal dose and the decrease in total ozone under clear skies over Thessaloniki (from Zerefos and Meleti, private communication).

Ch. 2: The effect of stratospheric ozone changes on climate

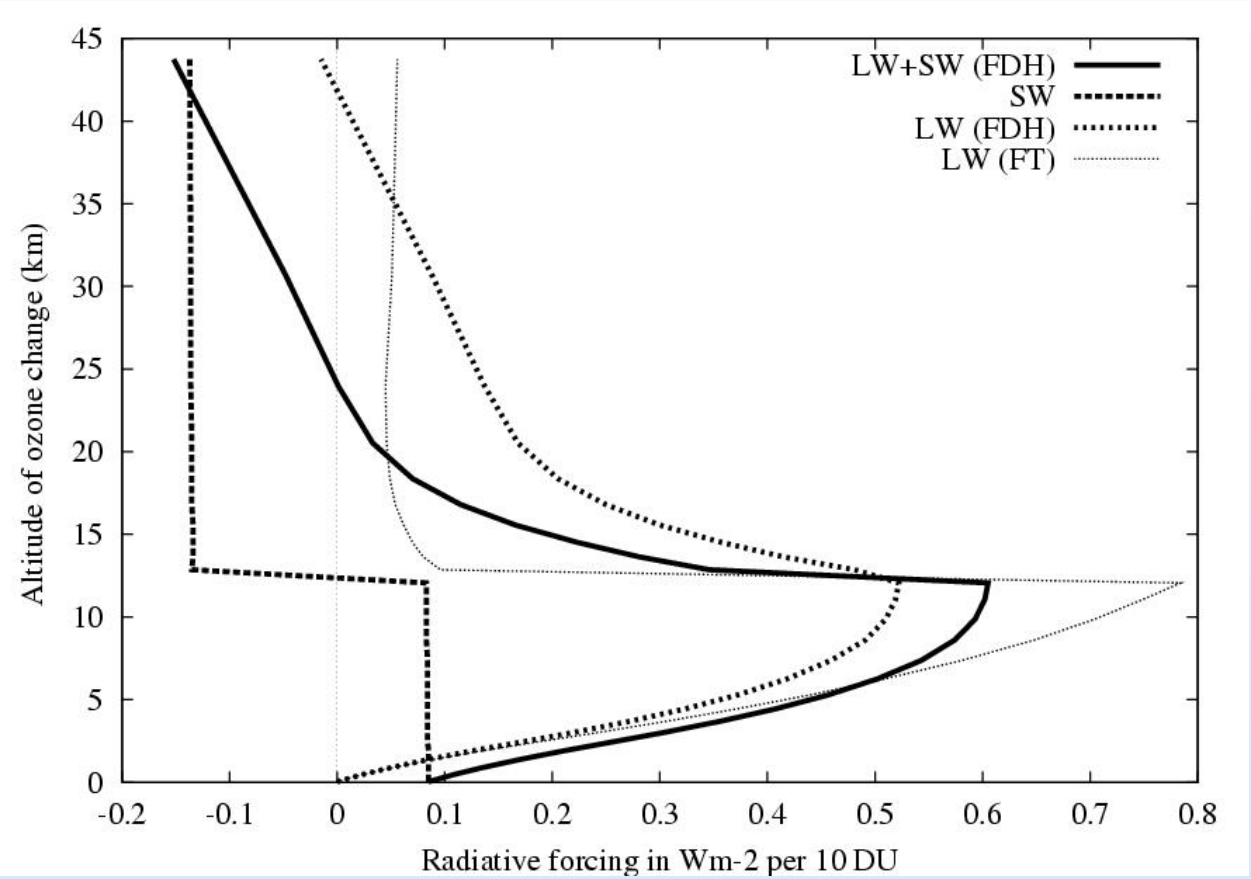


Figure 2.3: Ozone sensitivity curve in a clear sky Mid-Latitude Summer atmosphere in terms of radiative forcing per 10 DU ozone change at given altitude. Shown are the total (solid line), the long-wave (dotted line), and the short-wave (dashed line) radiative forcing using the fixed dynamical heating (FDH) concept. The thin line represents the long-wave forcing using the fixed temperature (FT) concept (updated from Van Dorland and Fortuin, (1994). The difference between FDH and FT represents the effect of taking into account stratospheric temperature changes.

Ch. 3: The effect of changes in climate on stratospheric ozone

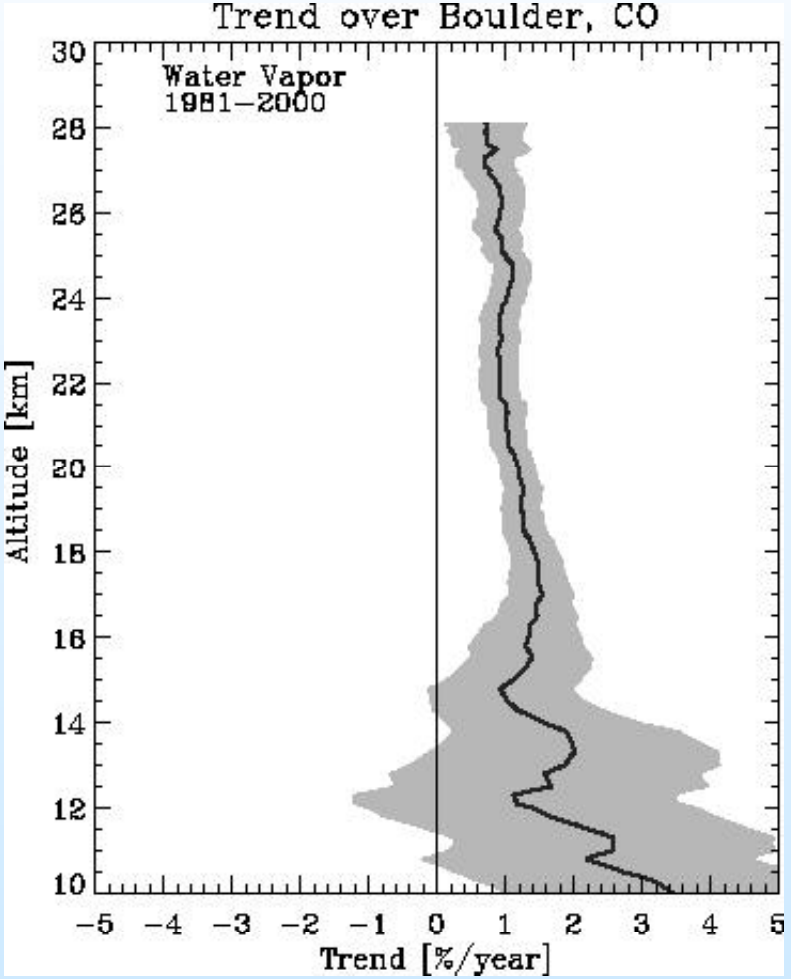


Figure 3.2: Water vapour trend determined from measurements at Boulder (in %/year).

Ch. 2: The effect of stratospheric ozone changes on climate

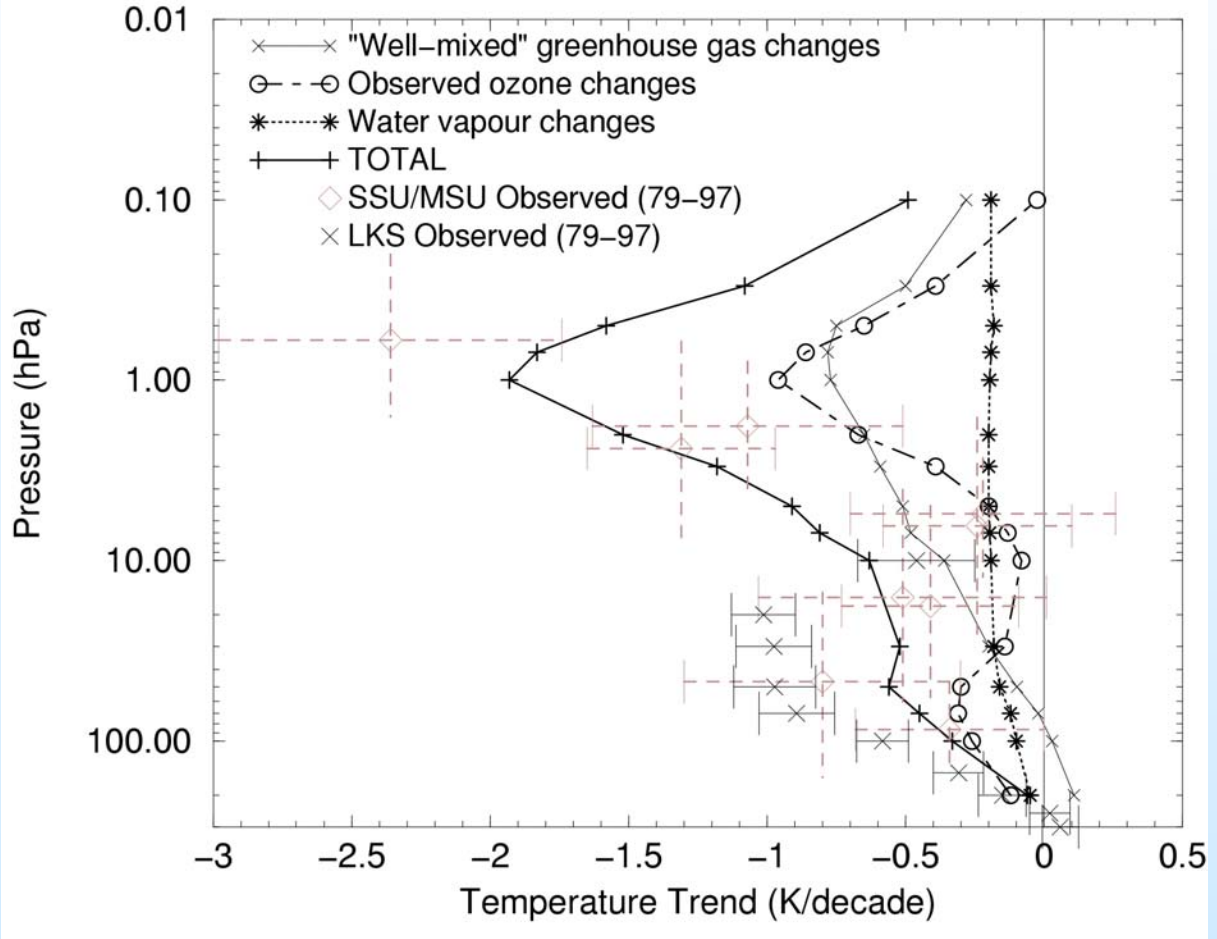


Figure 2.5. Global and annual mean temperature trends from an average of models results for imposed height-resolved ozone trends and greenhouse gases. The water vapour results are the Imperial College IGCM HALOE trends. The satellite trends from MSU and SSU, and the radiosonde trends from Lanzante et al. (2002) are also shown (LKS). The 2-sigma error bars in the observations are included; the vertical bars are intended to give the approximate altitude range sensed by the particular satellite channel (from Shine et al., 2003).

Ch. 3: The effect of changes in climate on stratospheric ozone

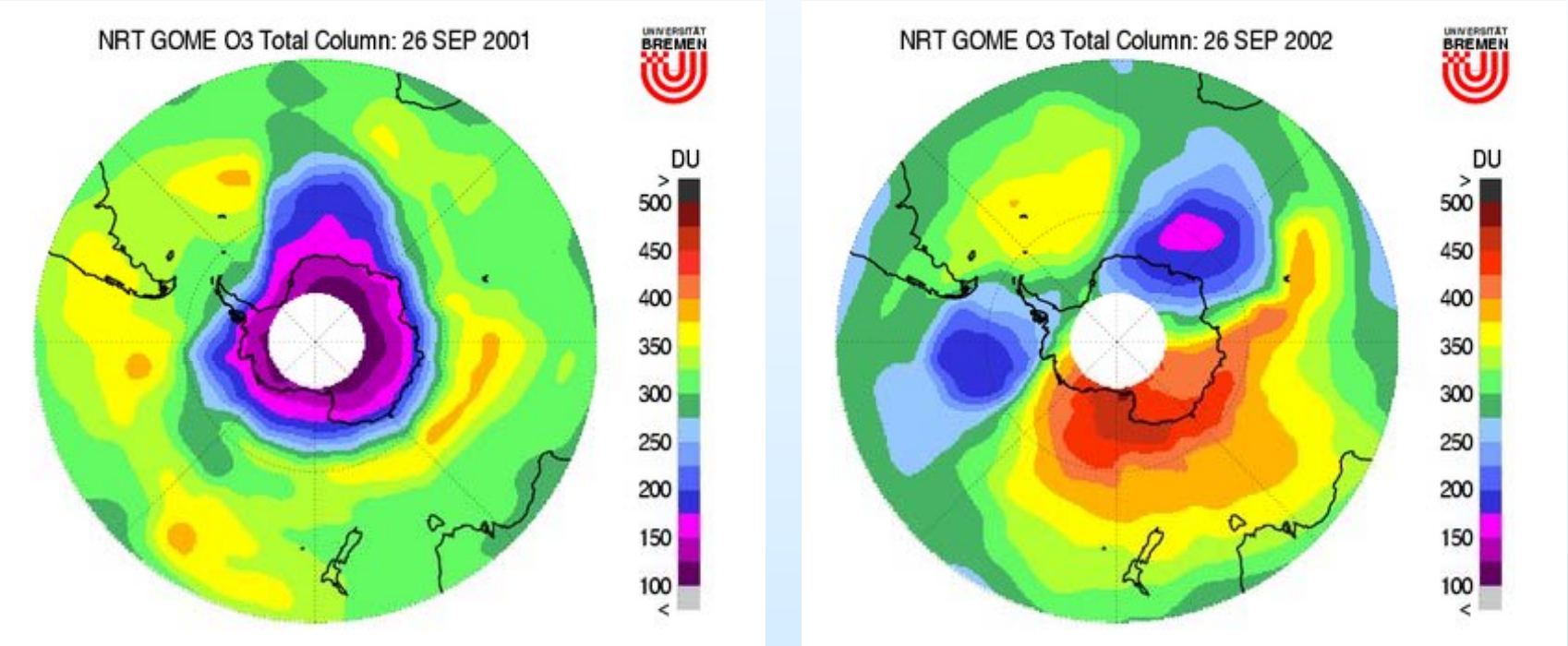


Figure 3.7: Total ozone columns (in DU) over Antarctica in September 2001 (left) and 2002 (right) as measured from the GOME instrument on satellite ERS-2 (pictures provided from the IUP, University Bremen). White coloured areas indicate data gaps.

Ch. 2: The effect of stratospheric ozone changes on climate

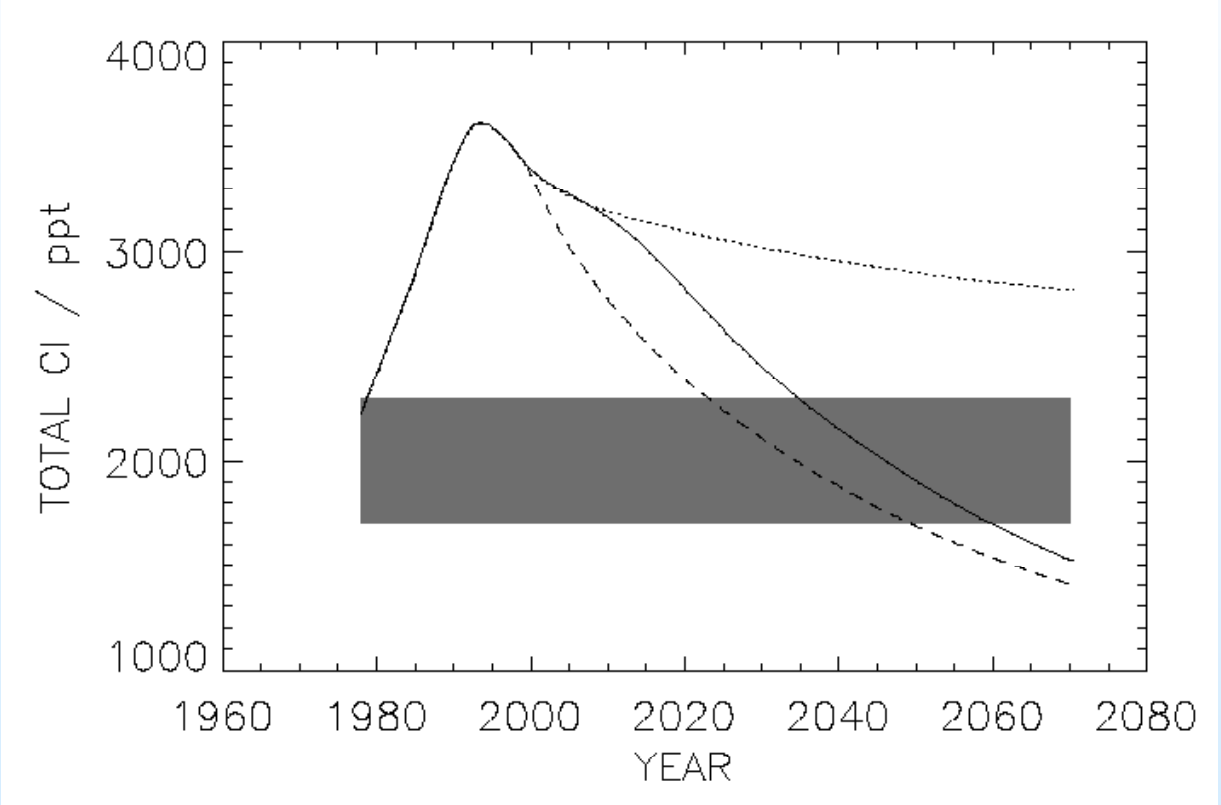
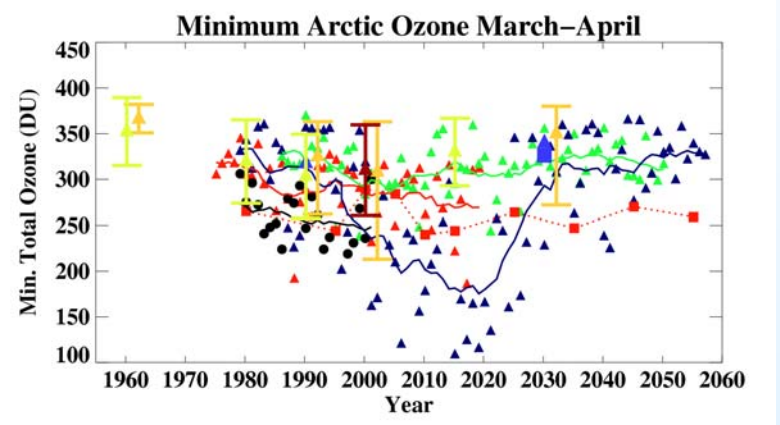


Figure 2.8. Calculated evolution of tropospheric chlorine based on tropospheric trends of CFCs-11, -12, -113, HCFC-22, CCl_4, and CH_3CCl_3 measured by NOAA-CMDL (updated from e.g. Elkins et al. 1993, and Montzka et al., 1996) and three different future emission scenarios: a) emissions stop in the year 2000 (dashed line), b) the base scenario given in WMO (1998) (solid line) and c) the emissions remain at the level assumed for the year 2000 in the base scenario (dotted line). The decay of chlorine species is calculated based on the best estimate of atmospheric lifetimes given in WMO (1998). The grey shaded area depicts the range of total chlorine present in 1980 in the troposphere (upper limit) and the stratosphere (lower limit). The stratospheric chlorine levels for 1980 are based on mean age derived from stratospheric observations of SF_6 and CO_2 (see Engel et al., 2002 for details).

Ch. 3: The effect of changes in climate on stratospheric ozone



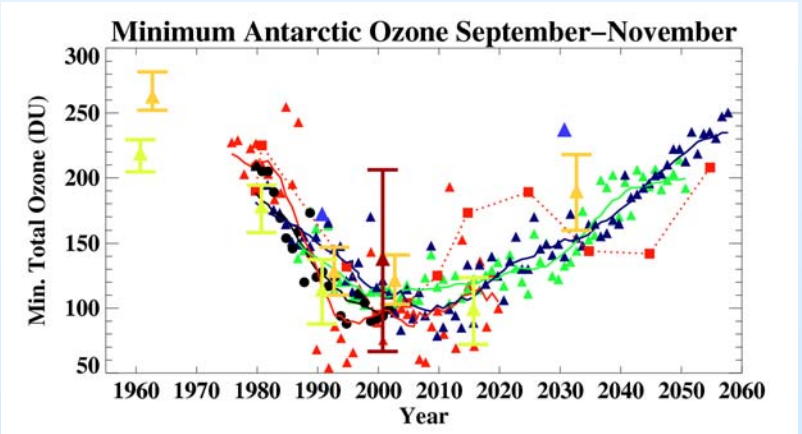


Figure 3.1: Minimum Arctic (March/April) and Antarctic (September/October/November) total ozone calculated from different coupled chemistry-climate models. The solid lines show running decadal averages for transient model simulations, the symbols with bars indicate the mean and 2 standard deviations for multi-year timeslice runs. For comparison, the TOMS observations (black dots) are included (from WMO, 2003).

Ch. 4: Climate impact of tropospheric ozone changes

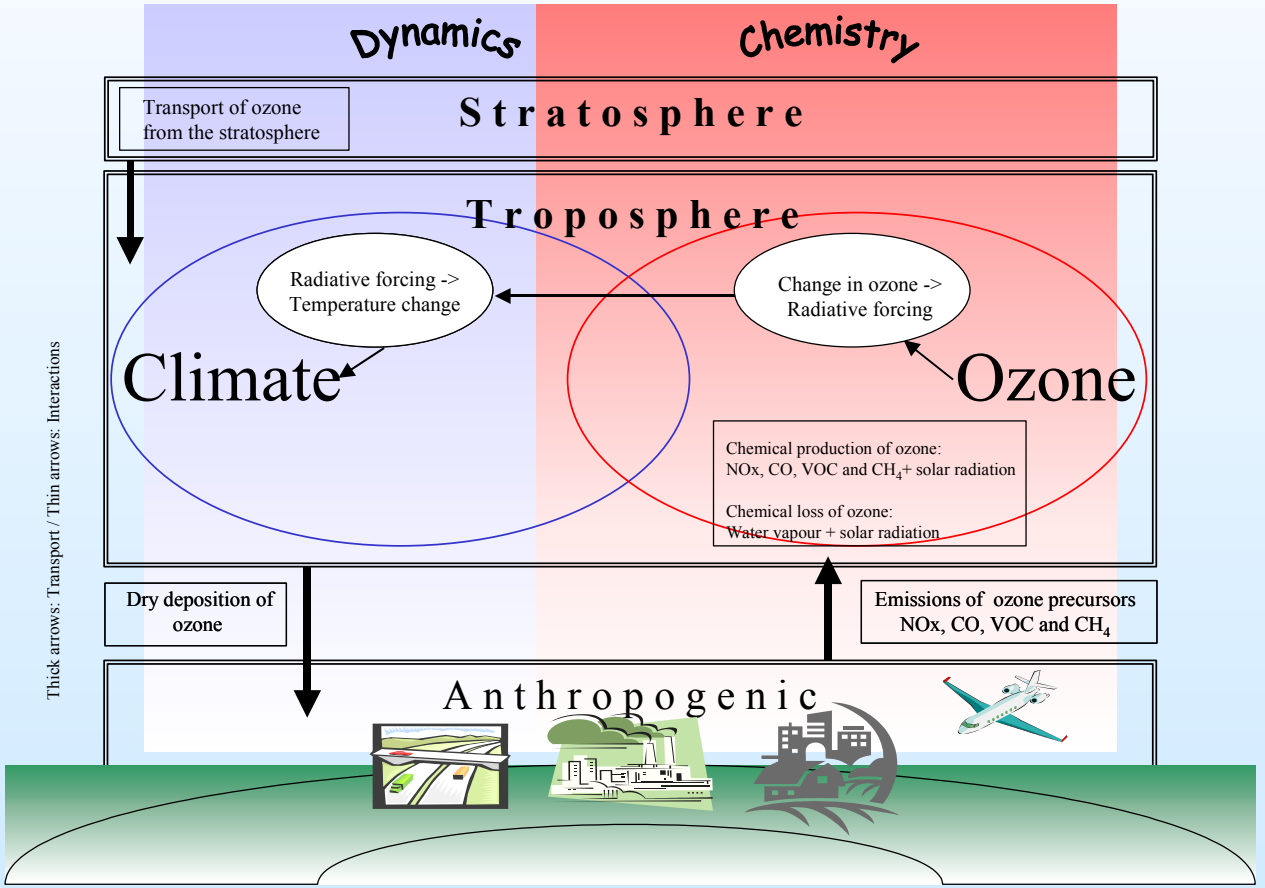


Figure 4.1: Processes governing the budget of tropospheric ozone and processes through which changes in tropospheric ozone impacts the climate.

Ch. 5: Impact of climate change on tropospheric ozone

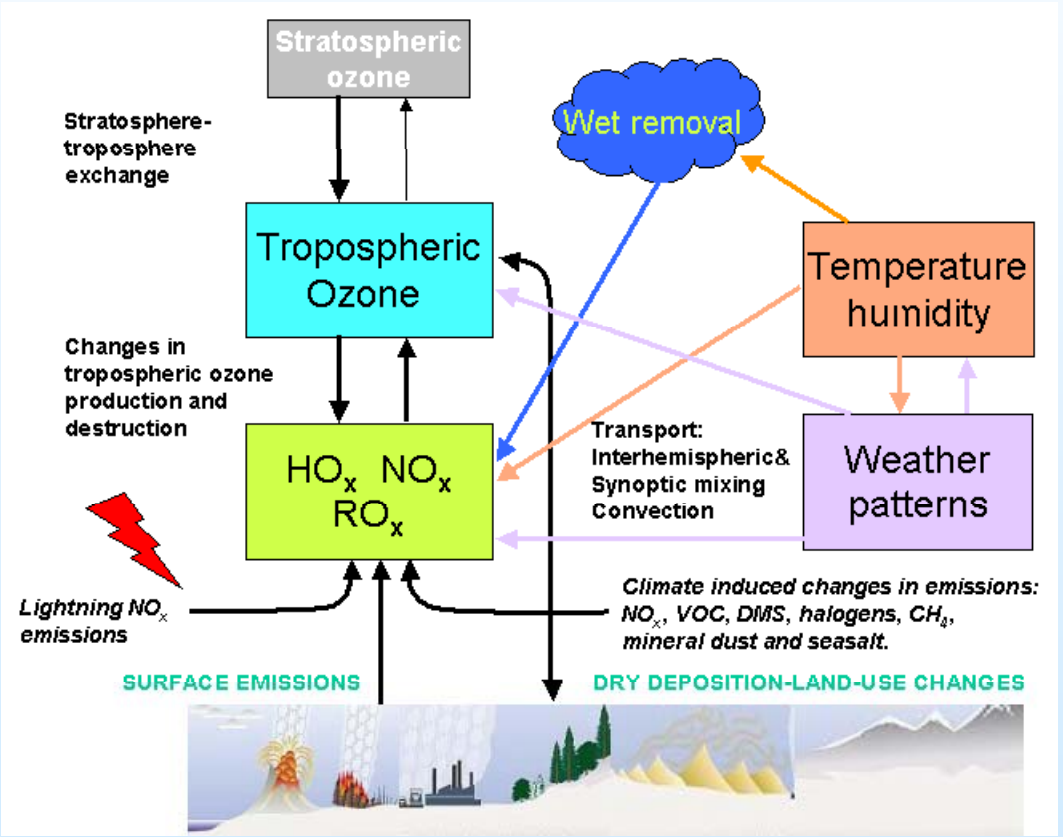


Figure 5.1: Schematic description of the chemical and physical processes discussed in the chapter.

Ch. 4: Climate impact of tropospheric ozone changes

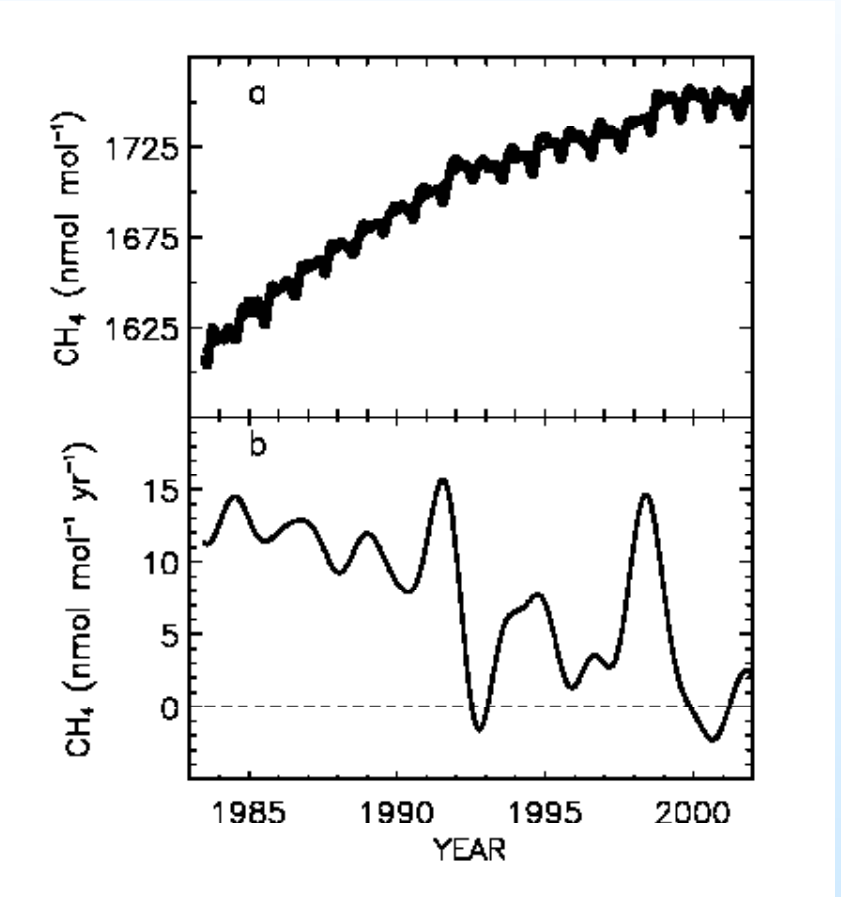


Figure 4.3: CH_4 mixing ratio (upper panel) and growth rate (lower panel).

Ch. 4: Climate impact of tropospheric ozone changes

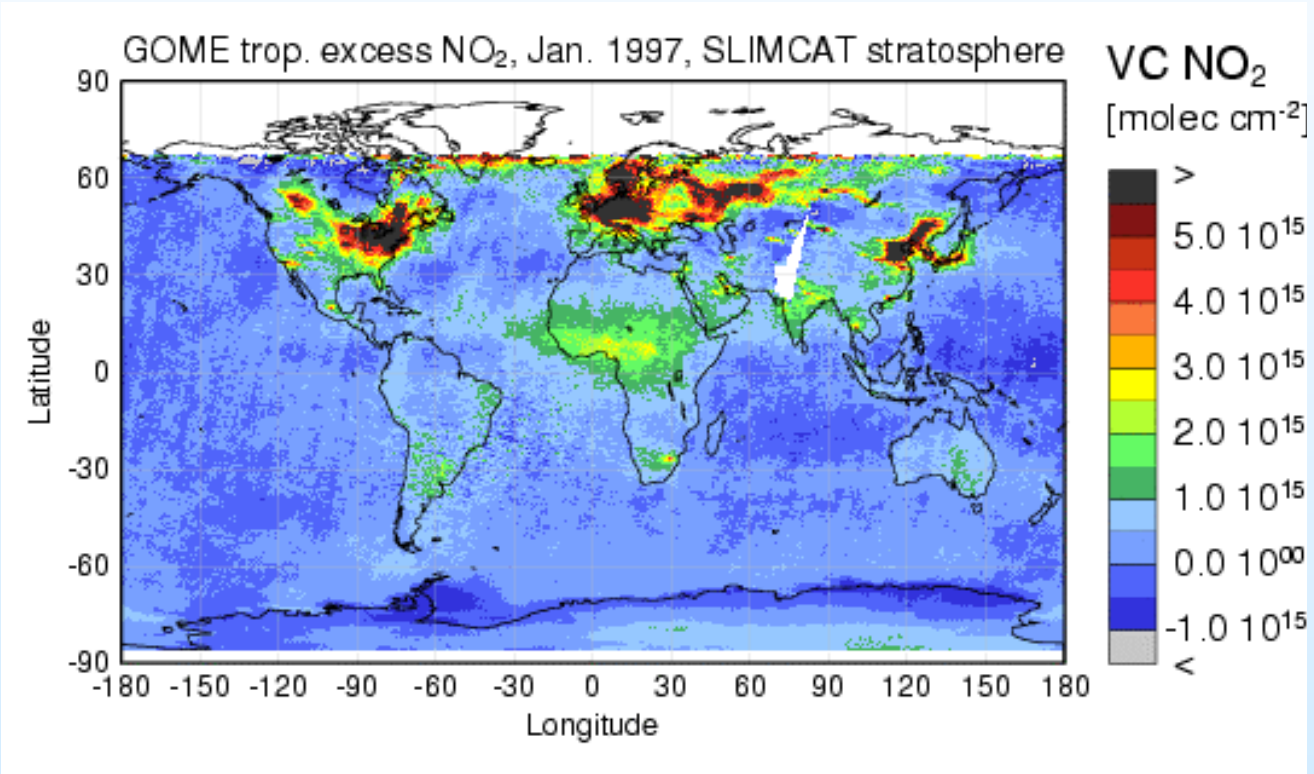


Figure 4.6: Global distribution of the tropospheric NO_2 column derived from the GOME instrument (TROPOSAT Annual Report 2001). The stratospheric SLIMCAT model has been used to remove the stratospheric part of the column.

Ch. 4: Climate impact of tropospheric ozone changes

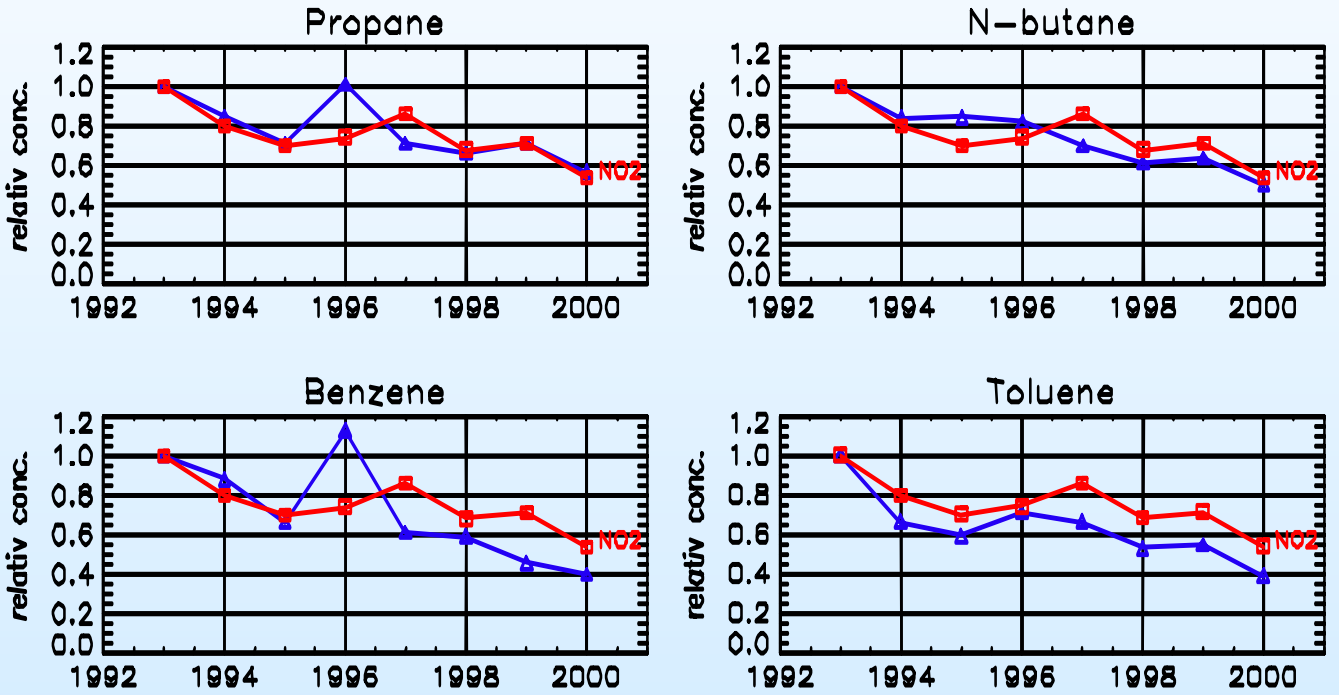


Figure 4.5: Winter medians (Jan-March) of selected hydrocarbons (blue) and NO_2 (red) at Waldhof from 1993-2000. The NO_2 data are 24h samples and only from those days when hydrocarbon samples were collected. All data are relative to the medians in 1993 (Solberg et al., 2002).

Ch. 4: Climate impact of tropospheric ozone changes

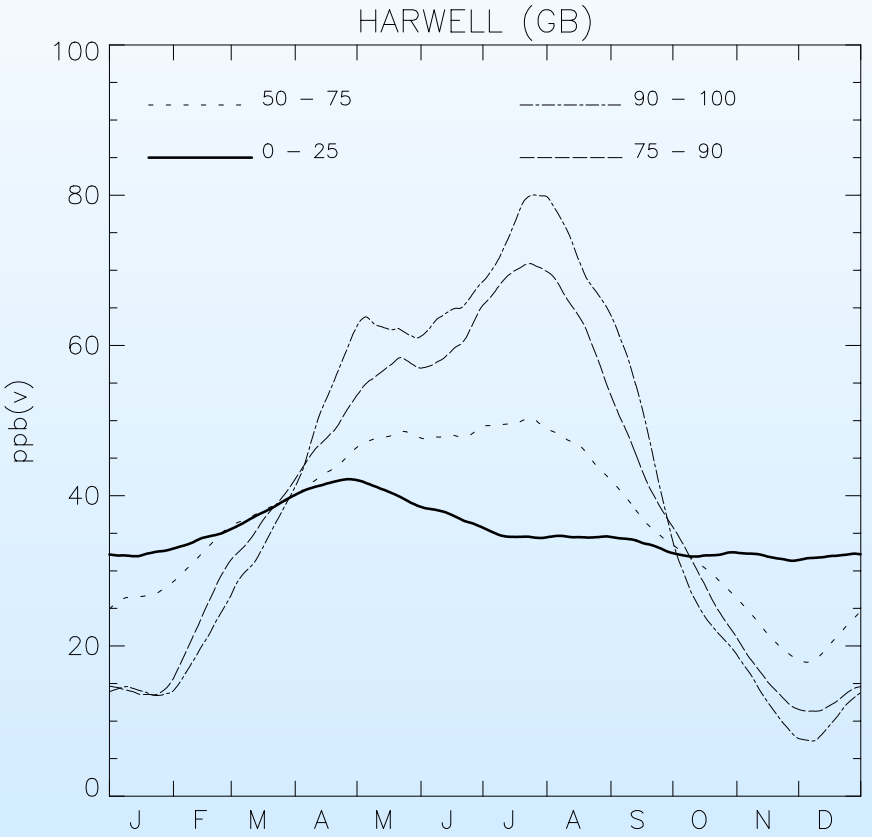


Figure 4.8: Seasonal cycles of ozone at Harwell, UK, as a function of the NO_x emissions integrated along back trajectories from the time of measurement. The different curves represent seasonal cycles for the different quartiles of the trajectory integrated NO_x (from Solberg et al., 2002).

Ch. 4: Climate impact of tropospheric ozone changes

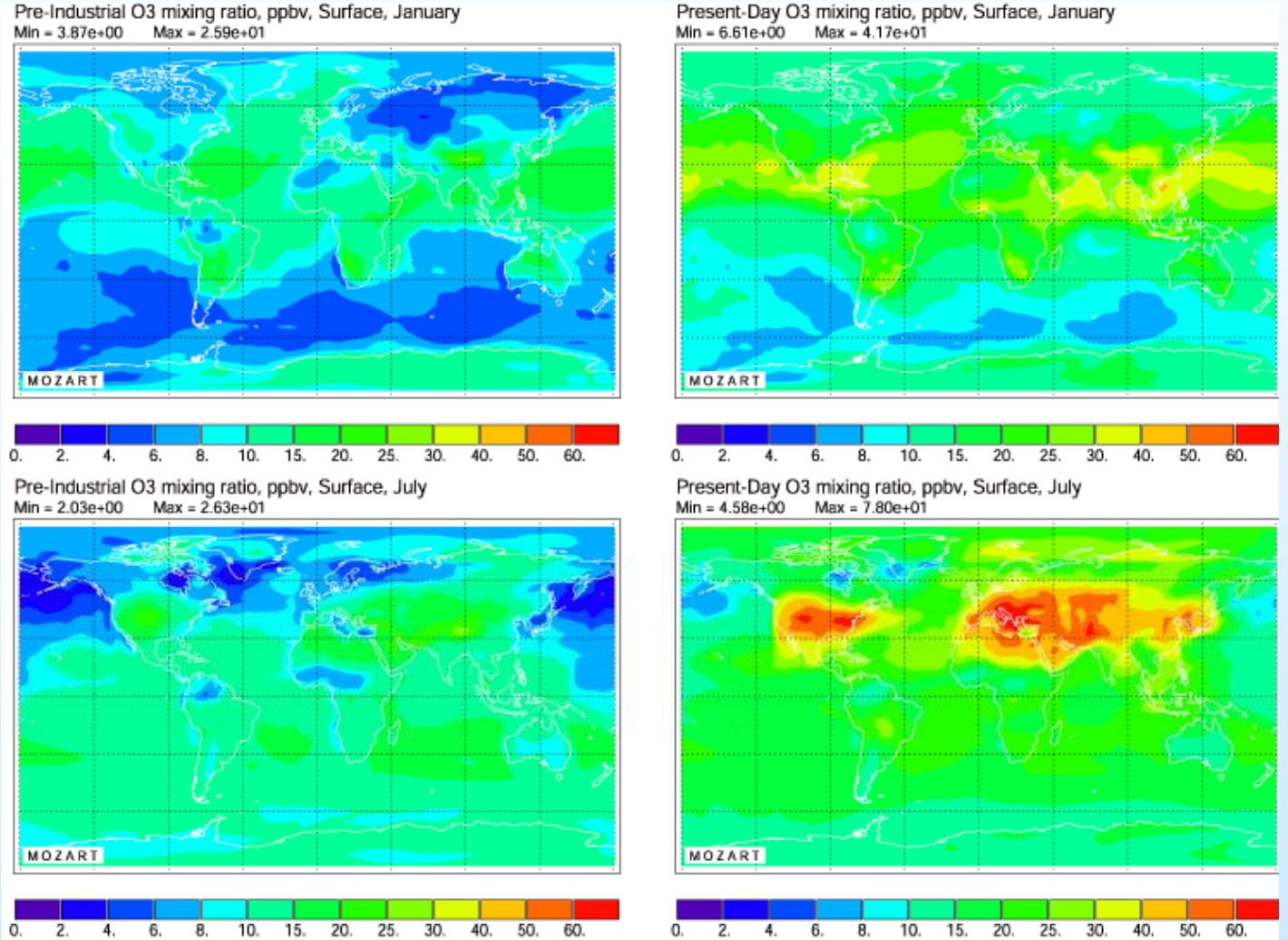


Figure 4.10: Surface distribution of ozone in January and July for preindustrial and present-day conditions (in ppbv, Hauglustaine and Brasseur, 2001).

Ch. 4: Climate impact of tropospheric ozone changes

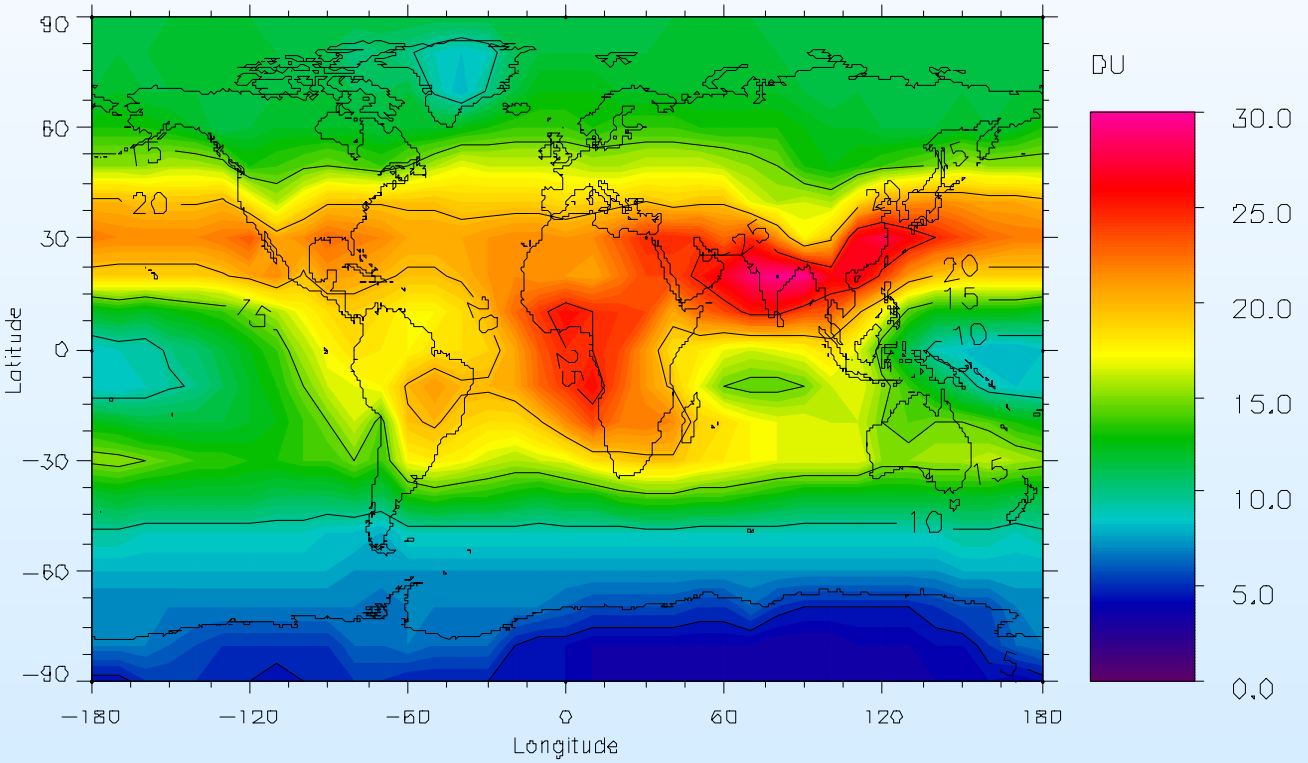


Figure 4.11: Changes in tropospheric ozone columns (DU) from year 2000 to 2100, as calculated by the 11 models in OxComp. The results shown are averages for all the models (based on results in Gauss et al., 2003).

Ch. 4: Climate impact of tropospheric ozone changes

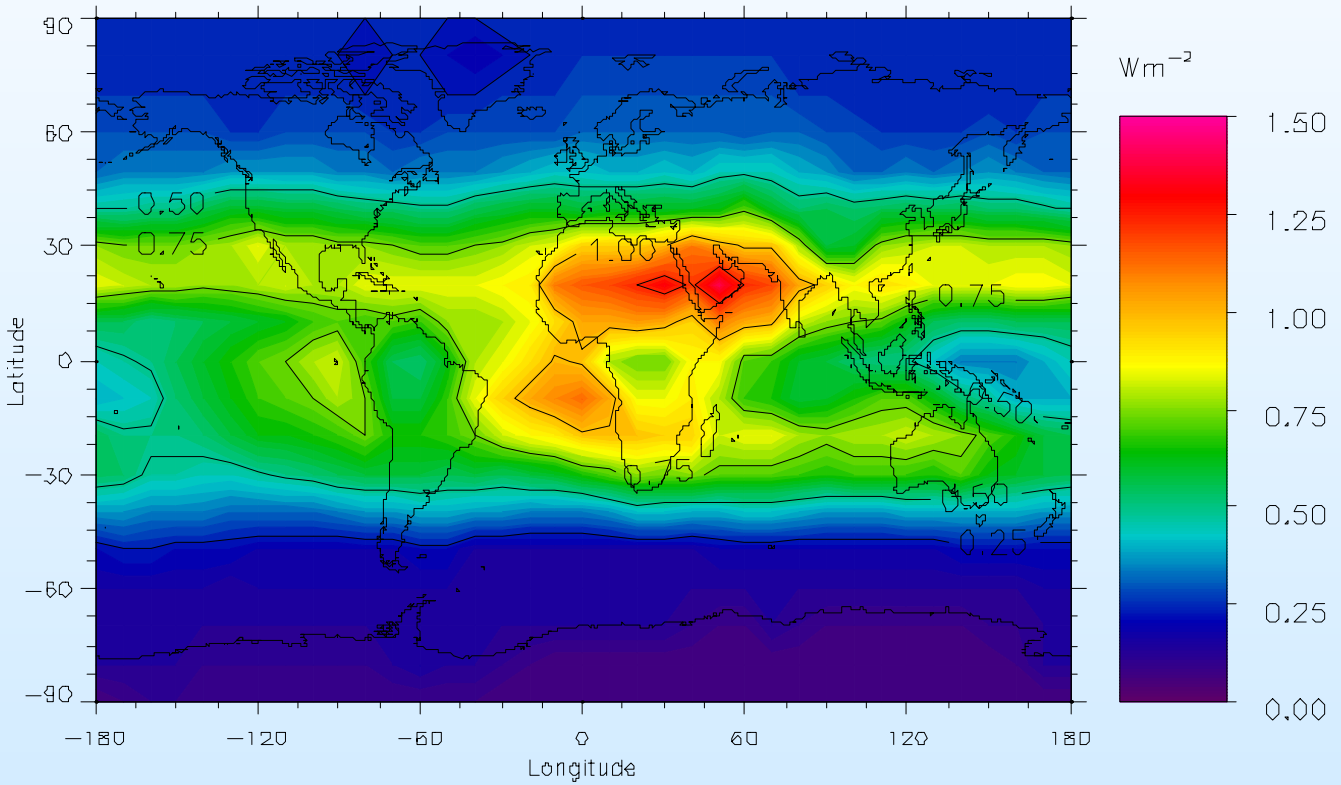


Figure 4.13: Radiative forcing due to changes in tropospheric ozone from 2000 to 2100 (average of 11 models in Gauss et al., 2003).

Ch. 4: Climate impact of tropospheric ozone changes

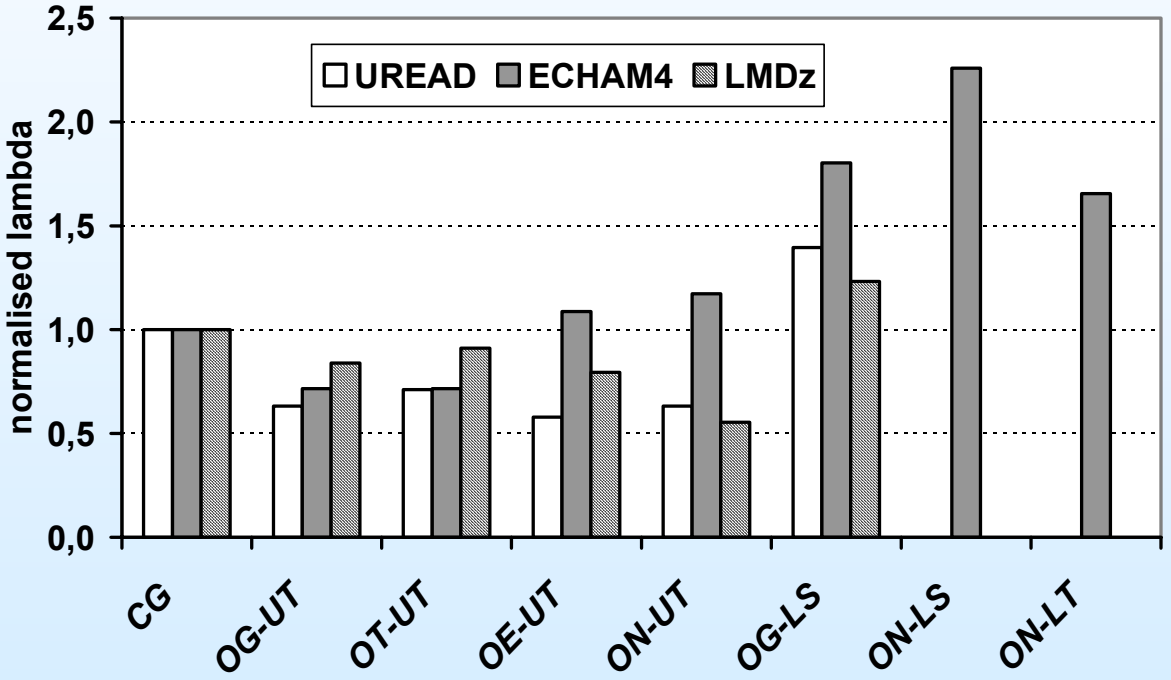
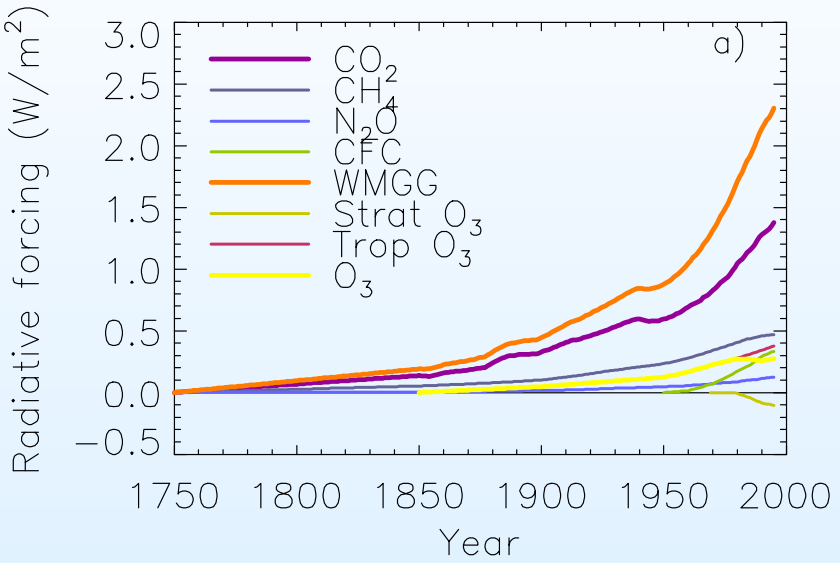
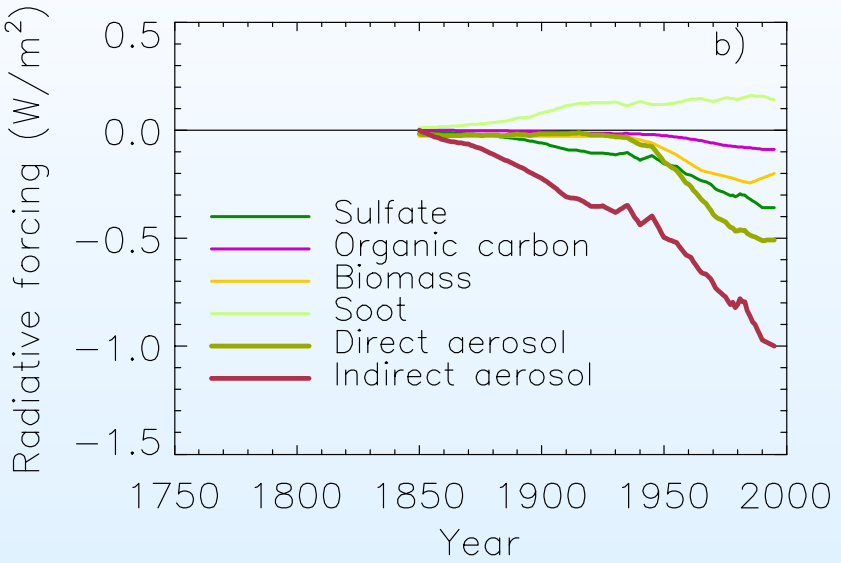
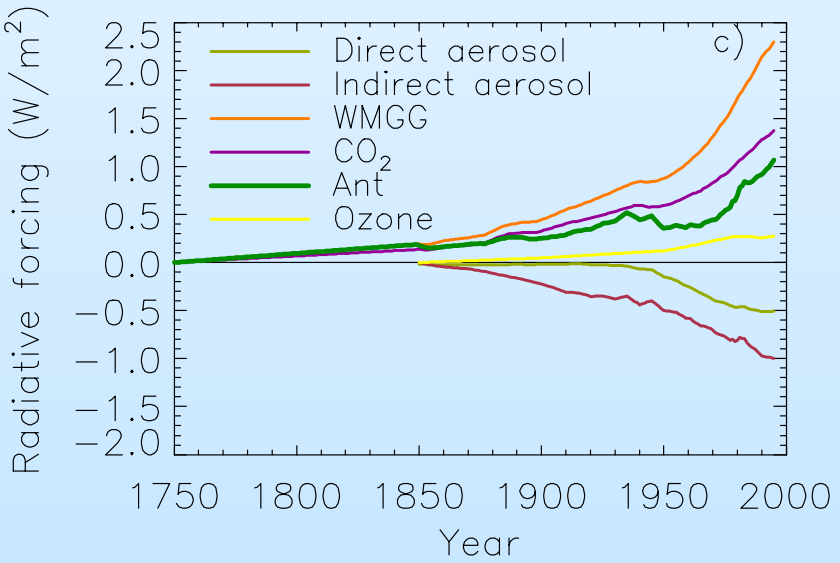


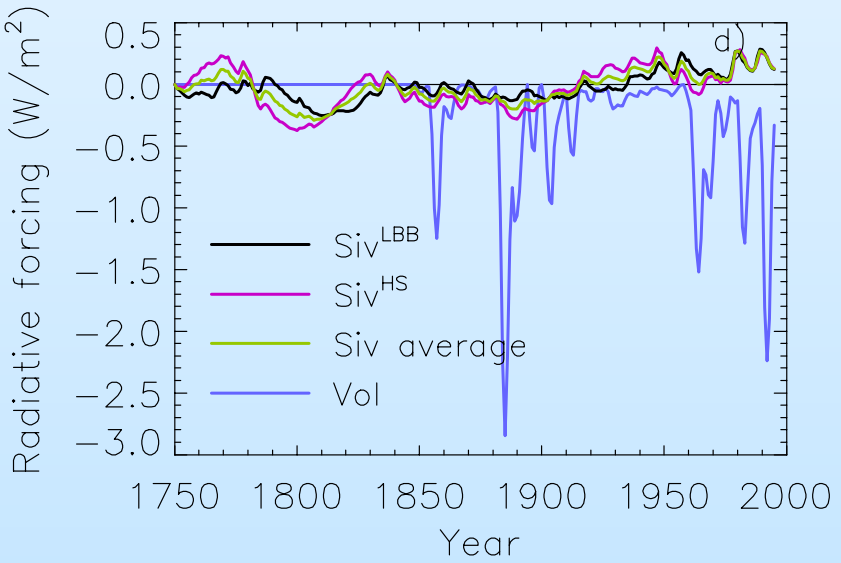
Figure 4.14: Normalised climate sensitivity parameters l/l_{CO2} as simulated by 3 different models (UREAD, ECHAM4, LMDz) for various experiments (*CG*: CO_2 added globally, vertically homogeneous; *OG-UT*: ozone added globally in the upper troposphere, i.e. in the levels just below the thermal tropopause; *OT-UT*: ozone added equatorward of 30° in the upper troposphere; *OE-UT*: ozone added poleward of 30° in the upper troposphere; *ON-UT*: ozone added northwards of 30°N in the upper troposphere; *OG-LS*: ozone added globally in the lower stratosphere (in levels that are everywhere higher than the tropical tropopause); *ON-LS*: ozone added northwards of 30°N in the lower stratosphere; *ON-LT*: ozone added northward of 30°N in the planetary boundary layer). The figure is adopted from Sausen et al. (2002) and from Joshi et al., 2003.

Time evolution radiative forcing

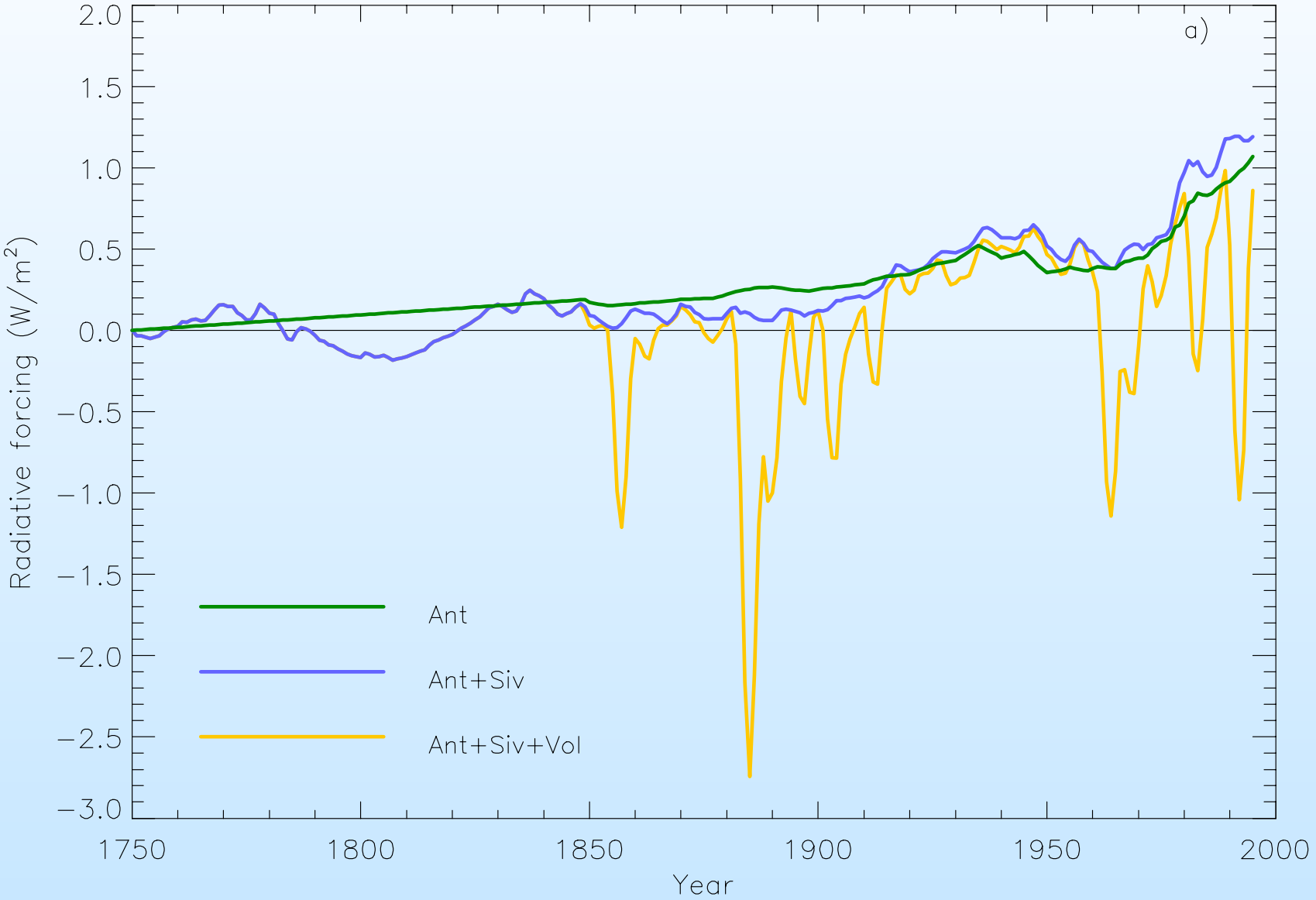




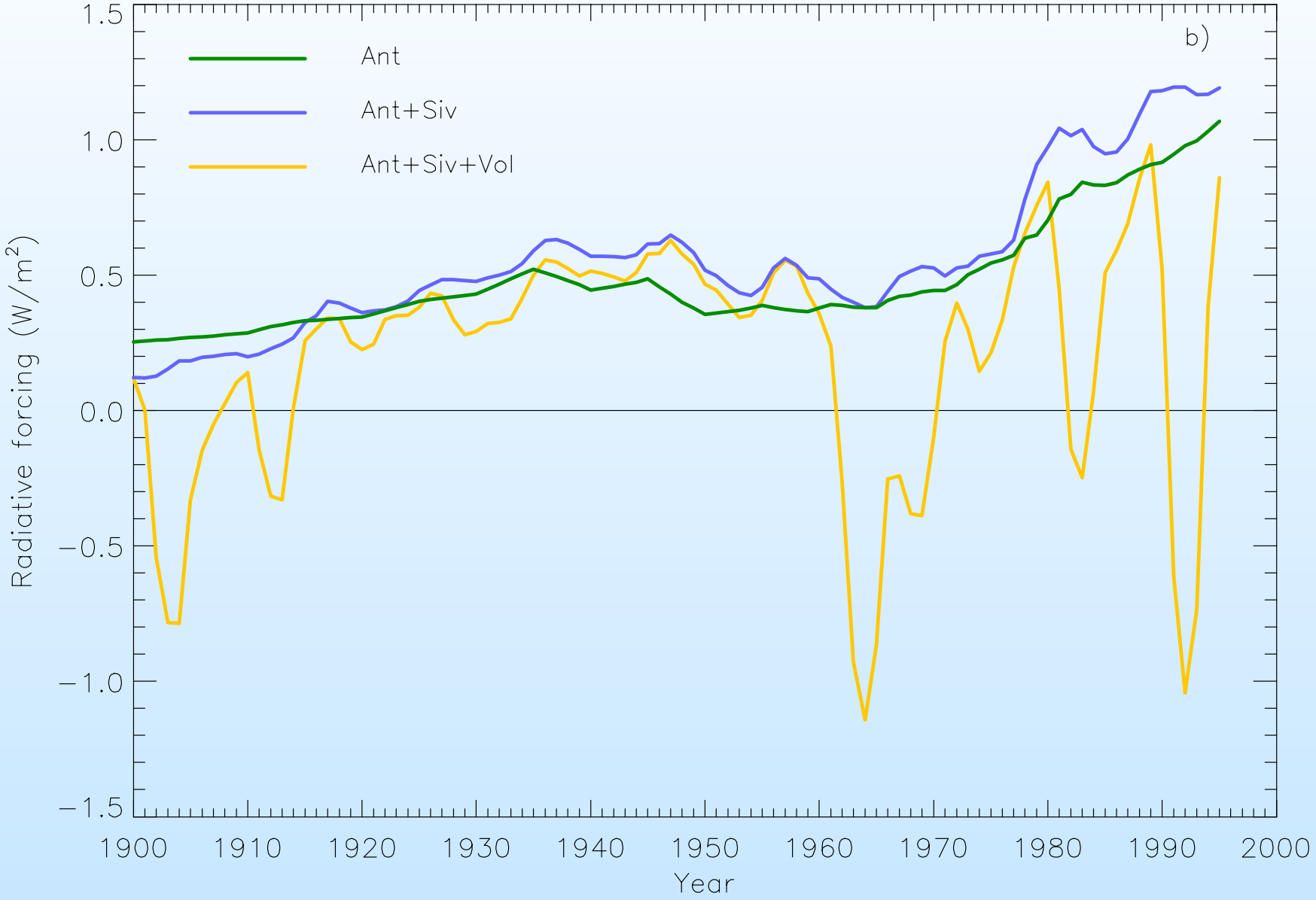




Time evolution radiative forcing



Time evolution radiative forcing



Time evolution radiative forcing