THE ROLE OF OTHER GREENHOUSE GASES

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SUMMARY

This talk will consider …..

- Future changes in the main climate-influencing gases (CO_2, CH_4, N_2O and selected halocarbons) under a 'no-climate-policy' assumption.

- The indirect effects of the reactive gases (NO_x, CO and VOCs) through CH_4 and tropospheric ozone.

- Global Warming Potentials as a means of comparing emissions reductions in non-CO_2 gases to CO_2 emissions reductions.

THE SRES EMISSIONS SCENARIOS

The Intergovernmental Panel on Climate Change (IPCC), as part of its Third Assessment Report, sponsored the production of a new set of 'no-climate-policy' emissions scenarios for GHGs, sulfur dioxide, and other gases

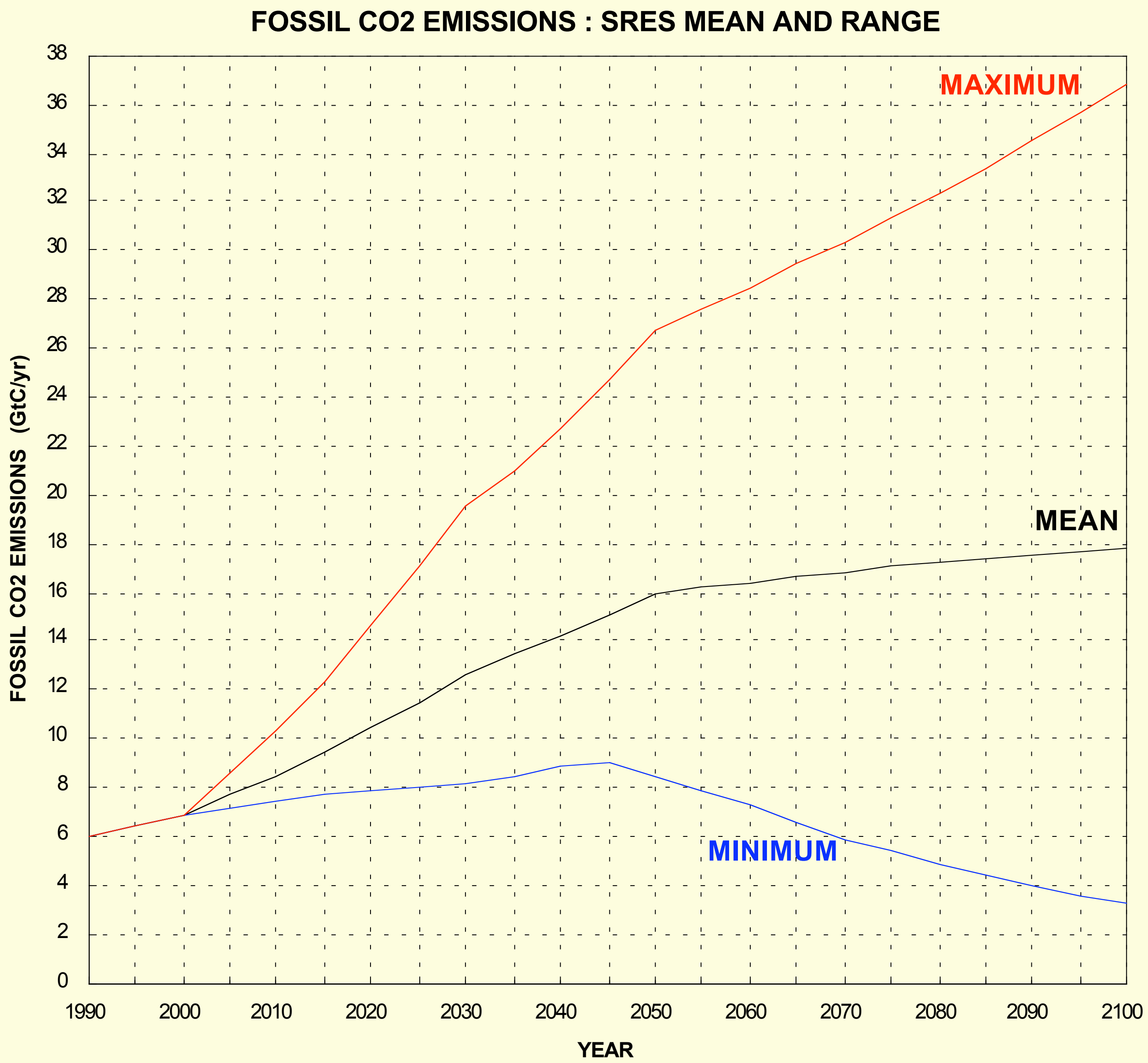
These scenarios are based on a range of assumptions regarding future population, economic growth, energy technology growth, etc.

The scenarios are published in a **S**pecial **R**eport on **E**missions **S**cenarios – hence the acronym **SRES**

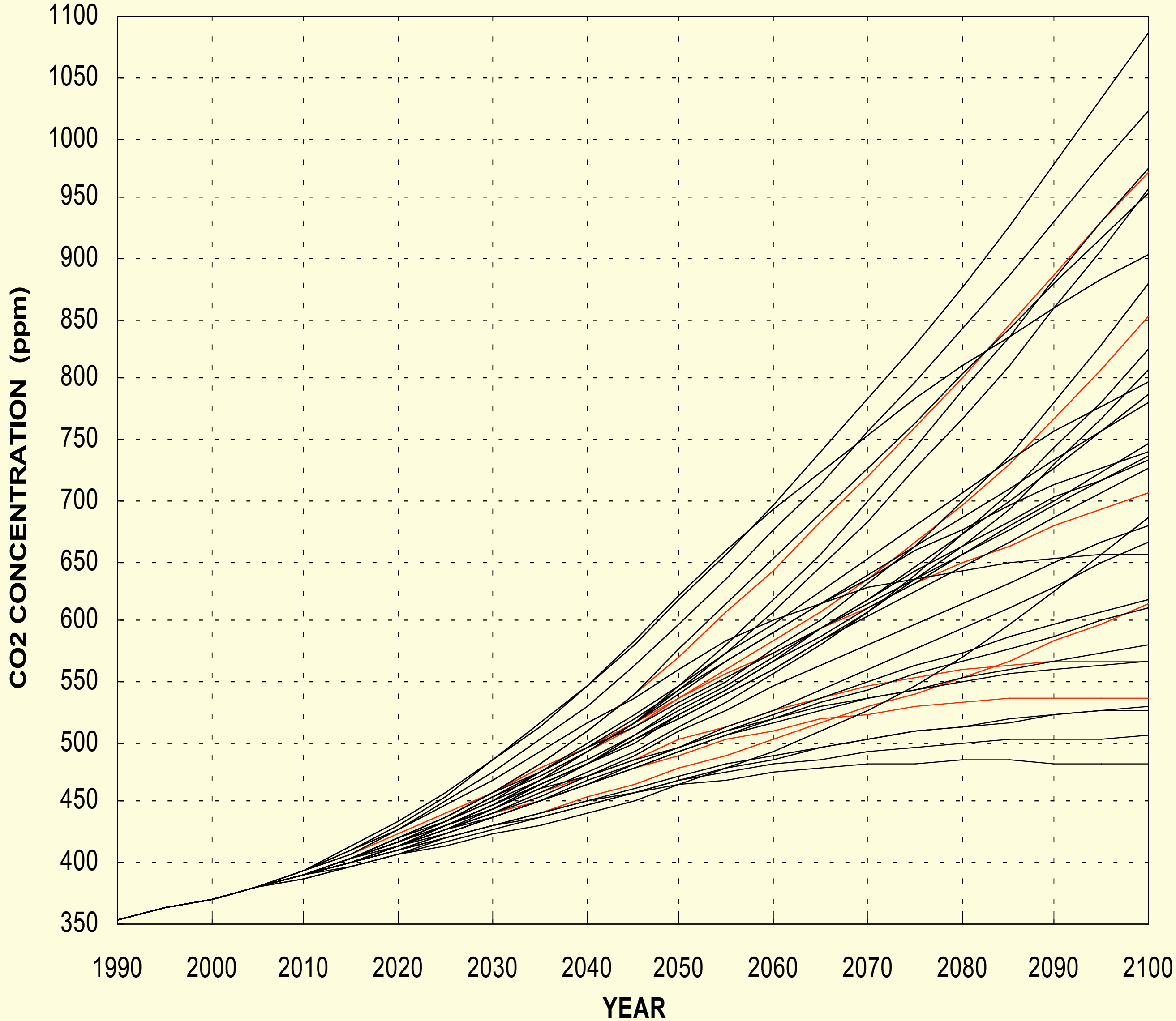
GASES CONSIDERED BY SRES:

CO_2
CH_4
N_2O
SO_2
Reactive gases (CO, NO_x, VOCs)
Halocarbons (CFCs, HCFCs, HFCs, PFCs, SF_6)

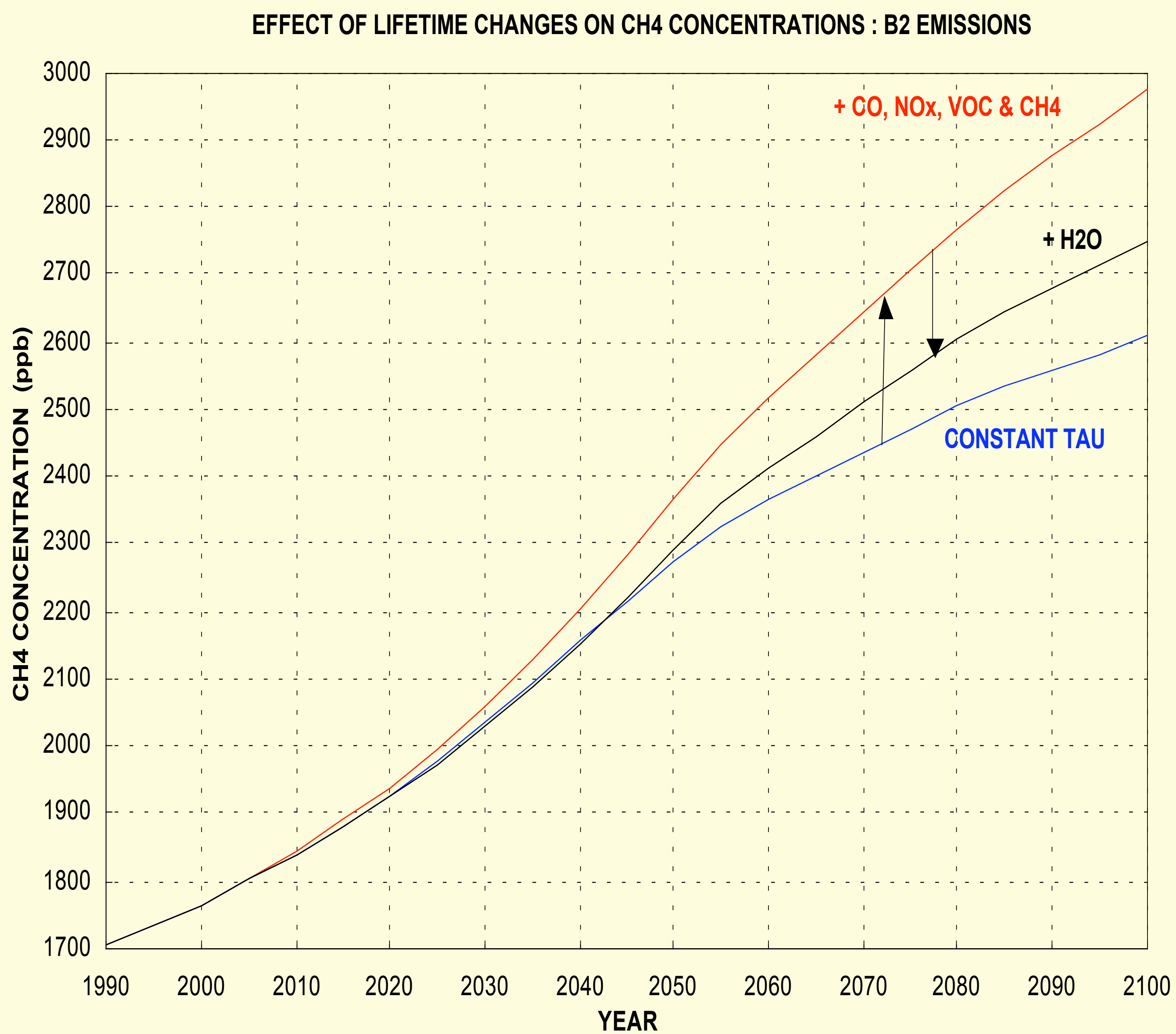
CARBON DIOXIDE : CO_2


FOSSIL CO2 EMISSIONS : SRES MEAN AND RANGE
FOSSIL CO2 EMISSIONS (GtC/yr)
YEAR
MAXIMUM
MEAN
MINIMUM
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100

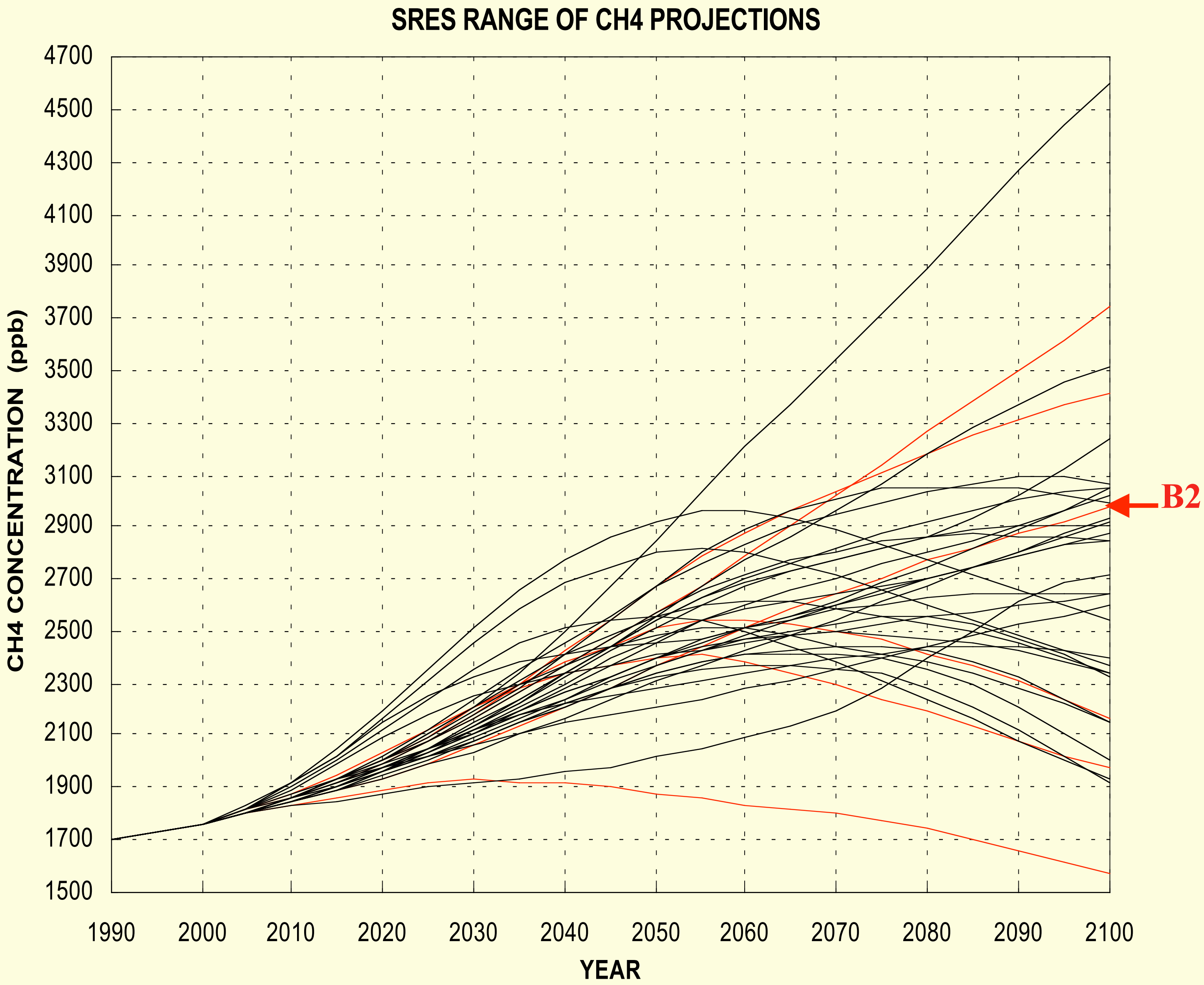
SRES RANGE OF CO2 PROJECTIONS



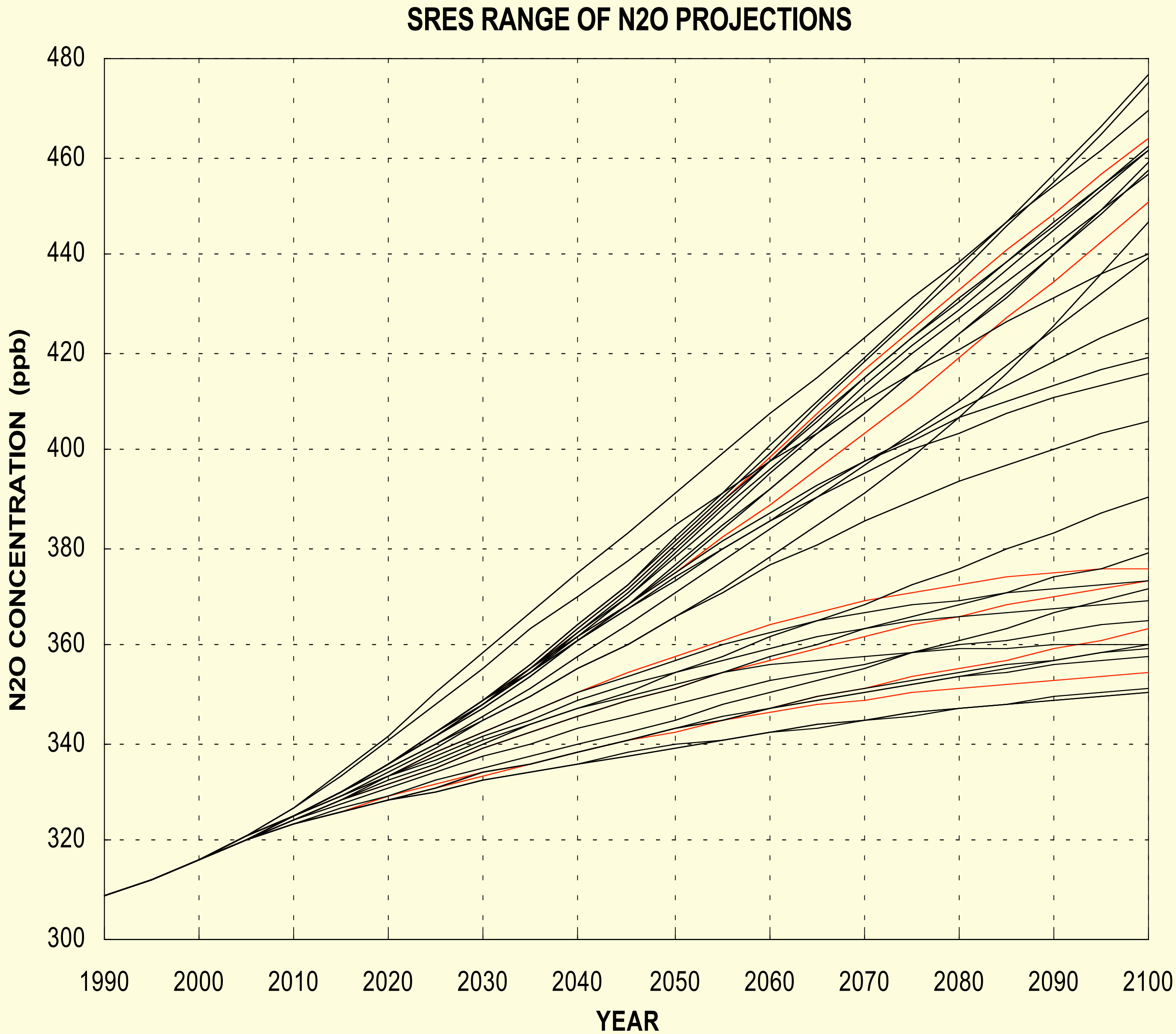
METHANE : CH_4



EFFECT OF LIFETIME CHANGES ON CH4 CONCENTRATIONS : B2 EMISSIONS
CH4 CONCENTRATION (ppb)
3000
2900
2800
2700
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
YEAR
+ CO, NOx, VOC & CH4
+ H2O
CONSTANT TAU


SRES RANGE OF CH4 PROJECTIONS
4700
4500
4300
4100
3900
3700
3500
3300
3100
2900
2700
2500
2300
2100
1900
1700
1500
CH4 CONCENTRATION (ppb)
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
YEAR
B2

NITROUS OXIDE : N_2O


SRES RANGE OF N2O PROJECTIONS
N2O CONCENTRATION (ppb)
480
460
440
420
400
380
360
340
320
300
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
YEAR

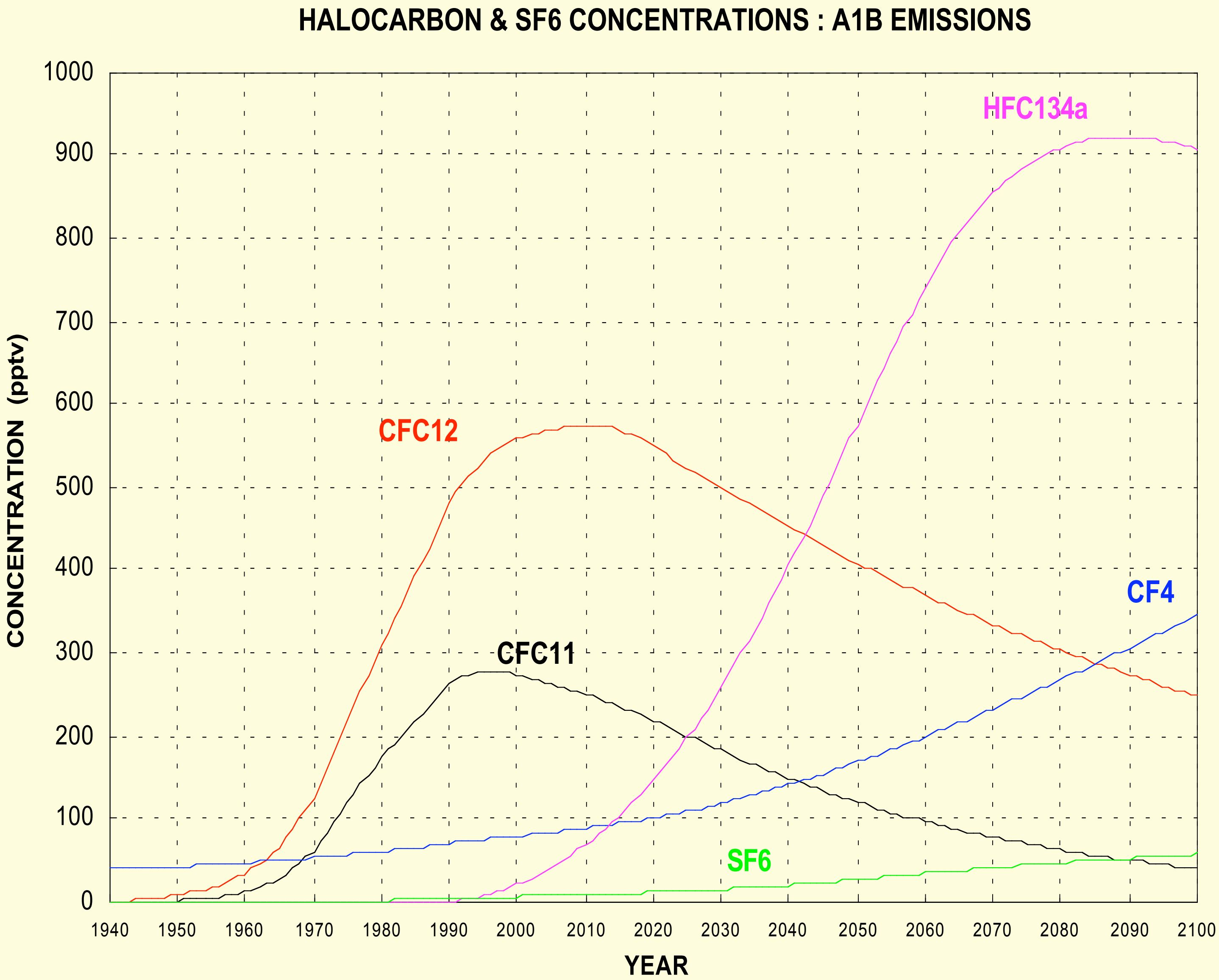
SELECTED HALOCARBONS

CFC11*, CFC12*, HFC134a, CF_4, SF_6

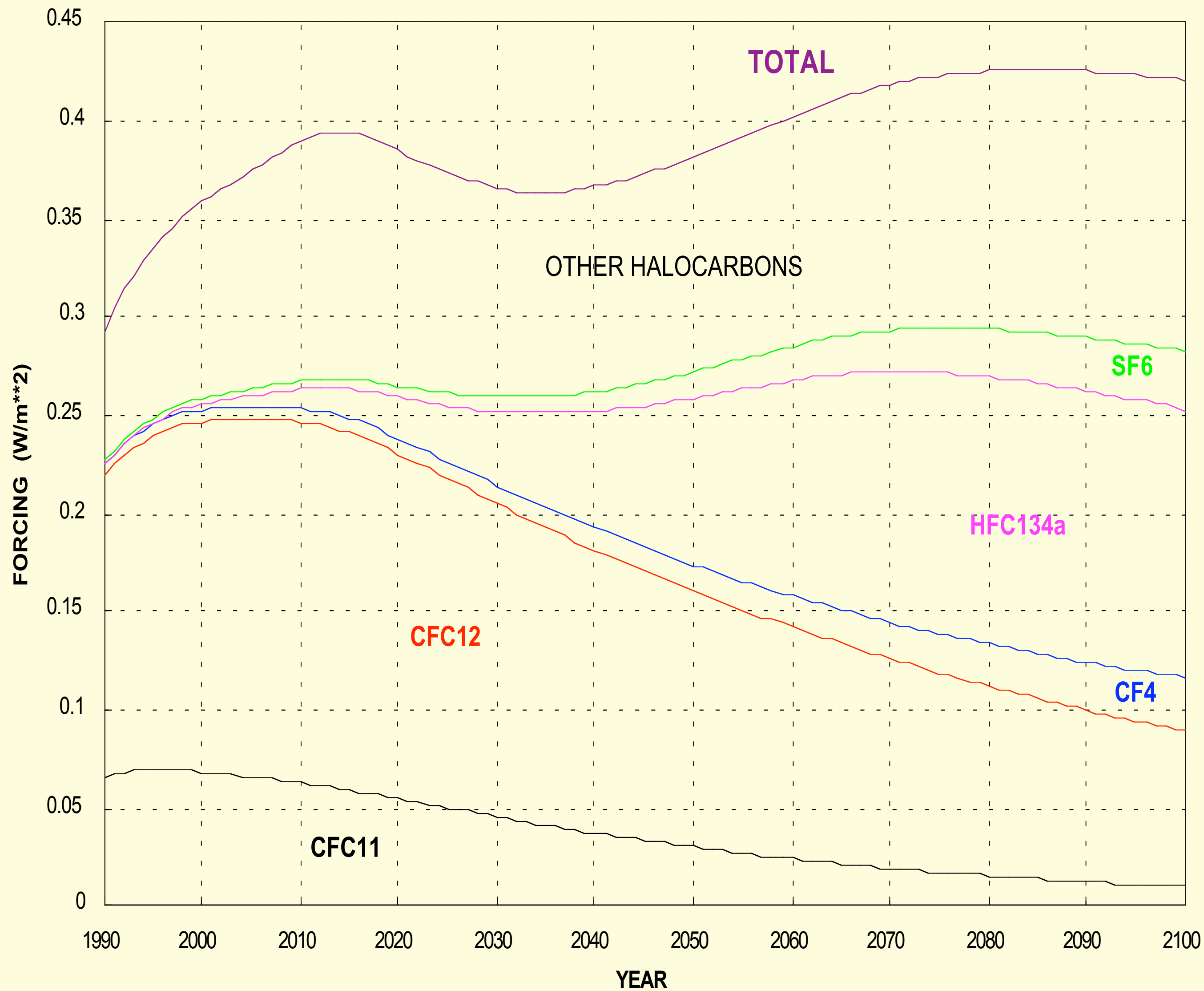
* Already controlled under the Montreal Protocol.

GAS	Lifetime (years)	dQ/dC ($W/m^2/ppb$)
CFC11	45	0.25
CFC12	100	0.32
HFC134a	14	0.08
CF4	50000	0.15
SF6	3200	0.52

For comparison, current dQ/dC for CO_2 is 0.00014 $W/m^2/ppb$


HALOCARBON & SF6 CONCENTRATIONS : A1B EMISSIONS
CONCENTRATION (pptv)
YEAR
HFC134a
CFC12
CFC11
CF4
SF6
0
100
200
300
400
500
600
700
800
900
1000
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100

HALOCARBON AND SF6 RADIATIVE FORCING : A1B EMISSIONS



TROPOSPHERIC OZONE

- Tropospheric ozone is a powerful greenhouse gas

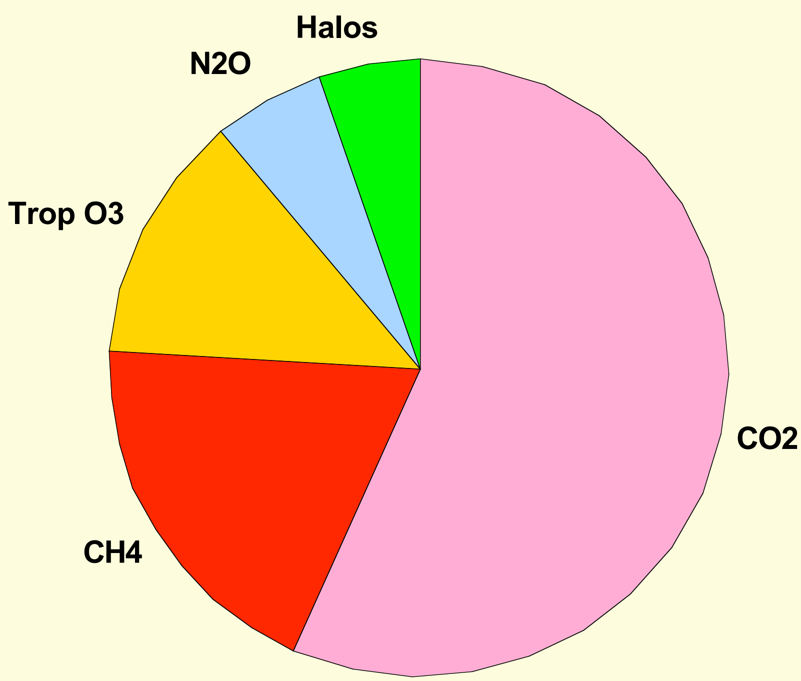
- Future tropospheric ozone levels are determined by: (1) the emissions of reactive gases; and (2) future CH_4 concentrations

- It is important to distinguish between these two sources. Reactive gases will probably be controlled mainly by pollution policies, while CH_4 will probably be controlled mainly by climate policies

- The effect of CH_4 on tropospheric ozone is normally included in its Global Warming Potential (GWP).

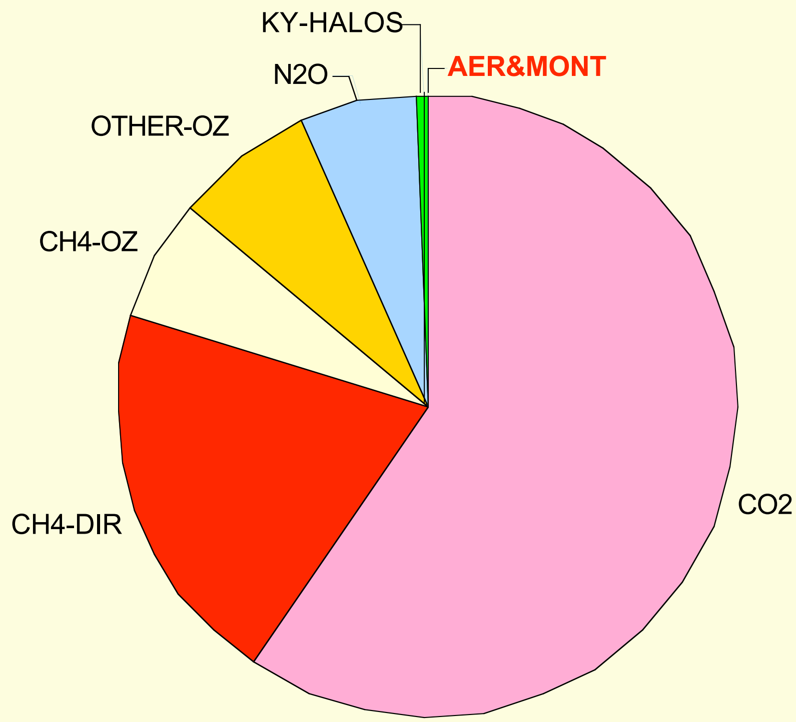
RELATIVE IMPORTANCE OF DIFFERENT SPECIES TO RADIATIVE FORCING

OBSERVED YEAR 2000 GHG FORCING

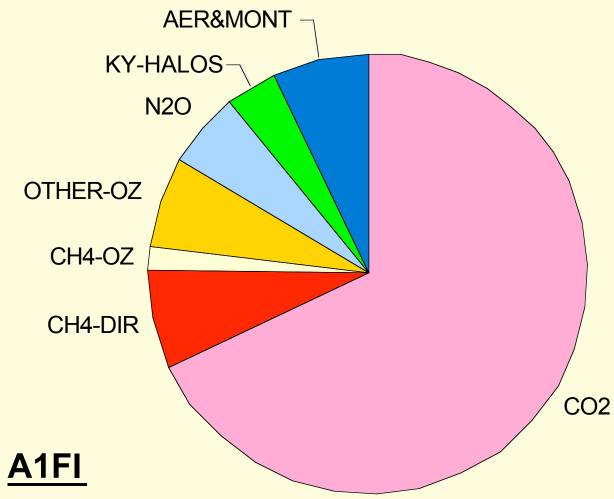


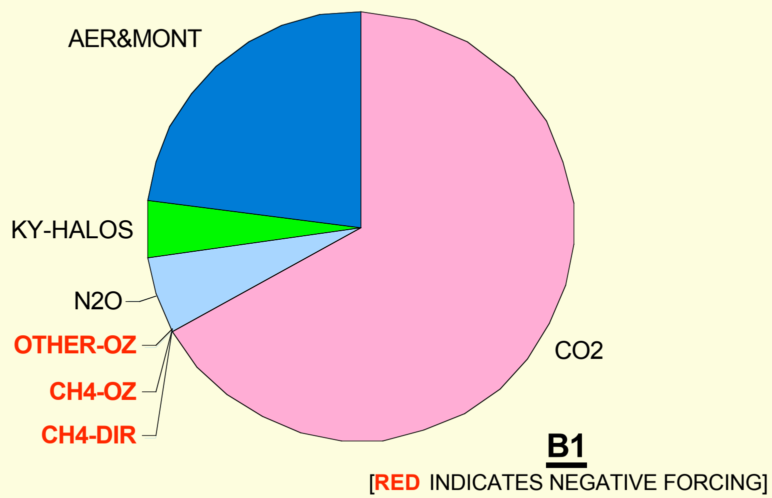
OBSERVED 2000 FORCING BREAKDOWN

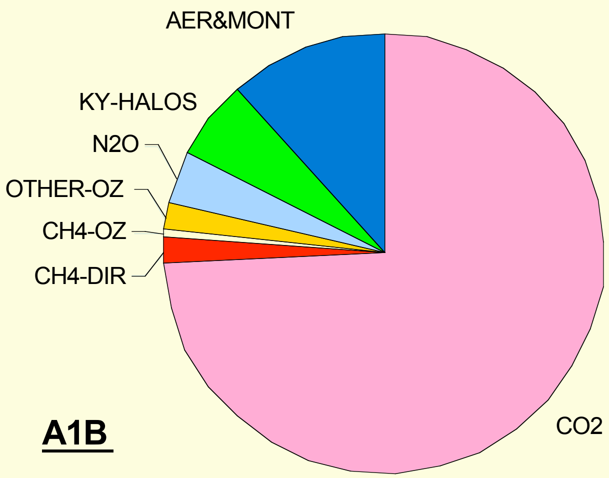
[**RED** INDICATES NEGATIVE FORCING]

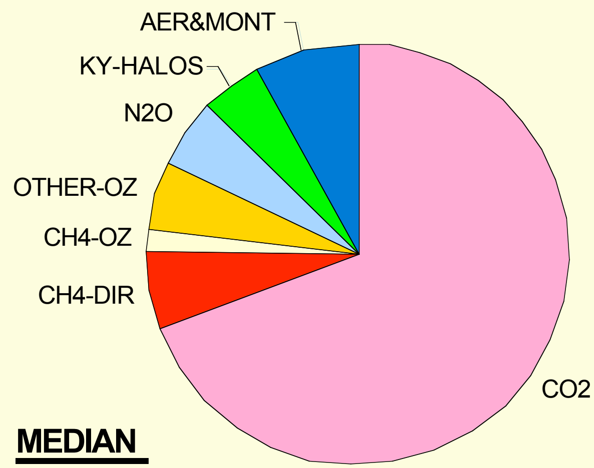


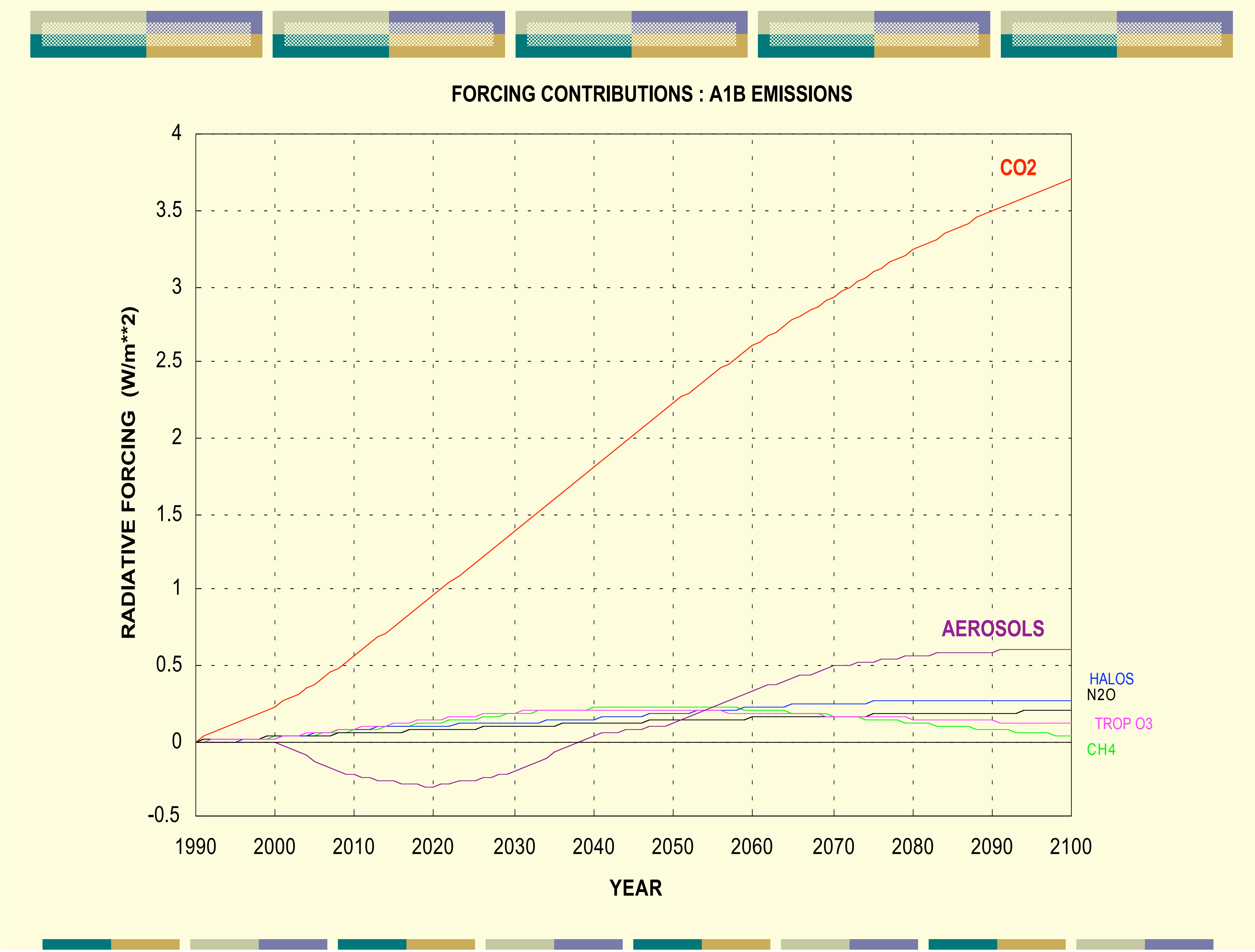
1990-2100 FORCING BREAKDOWN











FORCING CONTRIBUTIONS : A1B EMISSIONS
RADIATIVE FORCING (W/m**2)
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
YEAR
CO2
AEROSOLS
HALOS
N2O
TROP O3
CH4

GLOBAL WARMING POTENTIALS (GWPs)

- GWPs are a method for determining the equivalency of emissions reductions for different gases.

- The use of 100-year GWPs is part of the Kyoto Protocol

- As an example, the 100-year GWP for $CH_4 \approx 28$.

- Hence, a reduction in CH_4 emissions of 1 $TgCH_4$ is equivalent to a CO_2 emissions reduction of 28 $TgCO_2$ = 0.007642 GtC.

- There are many problems with GWPs, but even with their simplest interpretation they do not work well.

GWP TEST

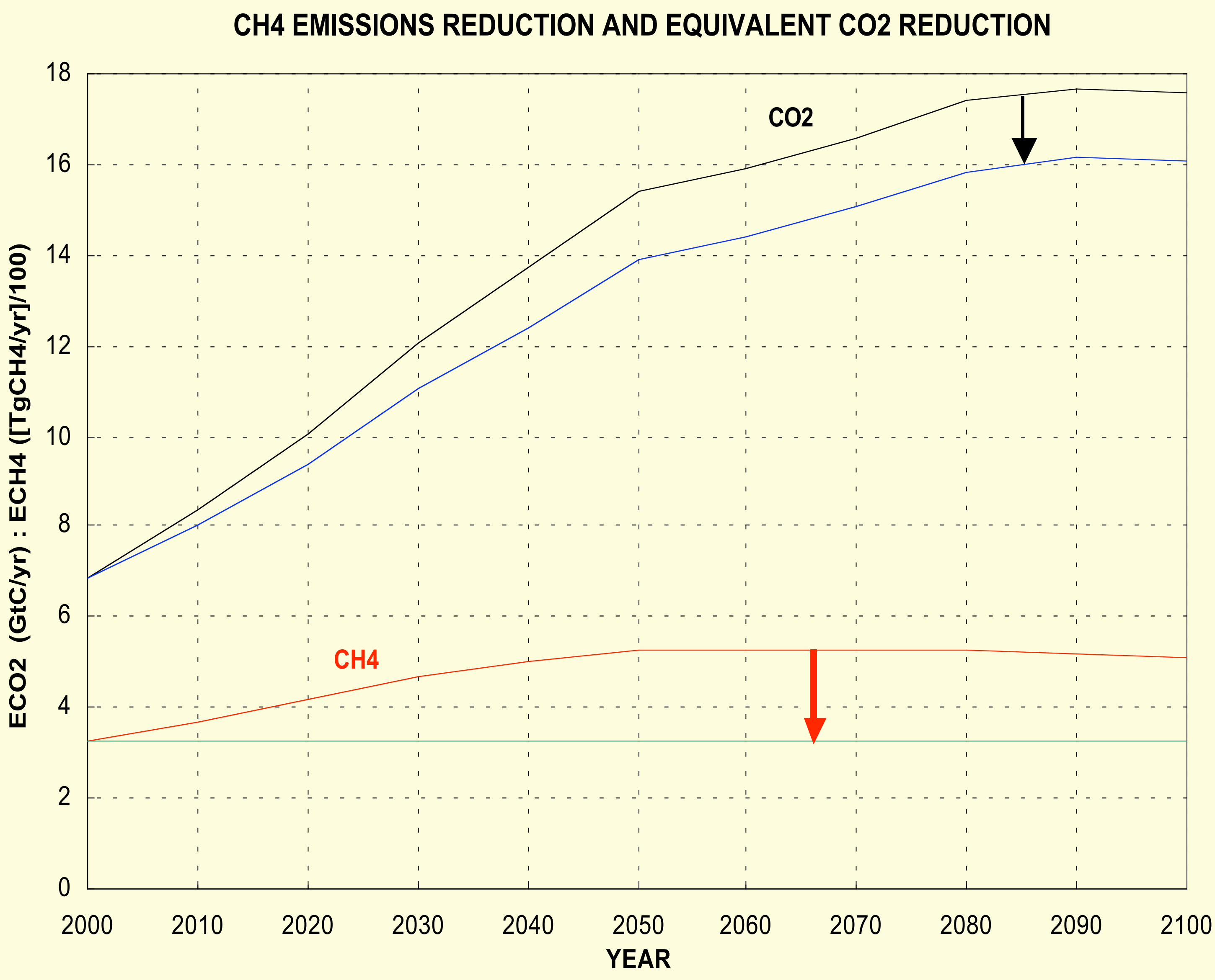
- As a baseline scenario I consider the median of the SRES scenarios (‘P50’).

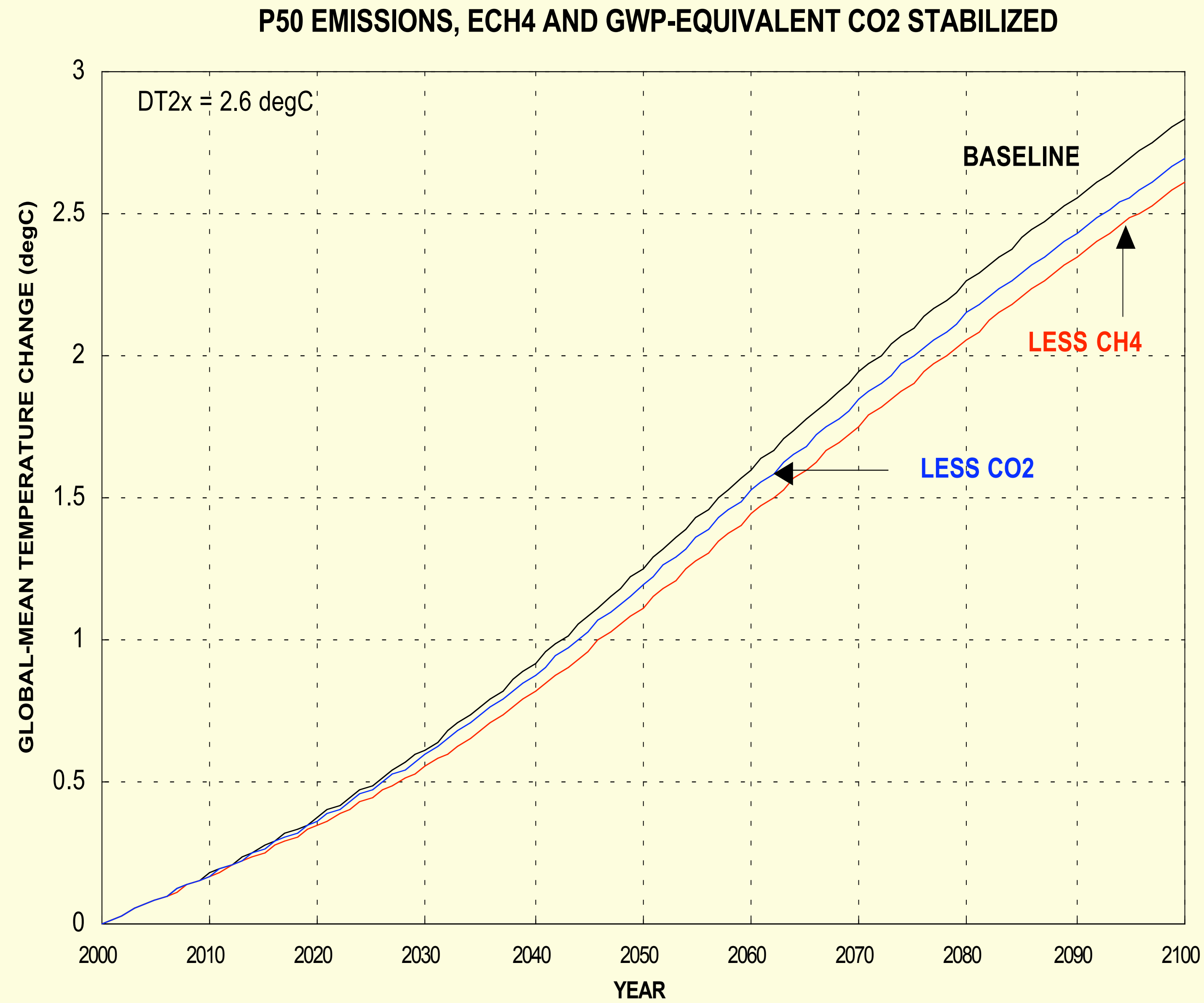
- I first assume that CH_4 emissions in this scenario are stabilized at their year-2000 value (‘P50-CH4’).

- I then calculate the equivalent reductions in CO_2 emissions using the 100-year GWP for CH_4.

- I then reduce the P50 CO_2 emissions by this amount, keeping the CH_4 emissions at their original levels, to give an equivalent CO_2 reduction scenario (‘P50-CO2’).

- Finally, I run these emissions scenarios in a climate model to compare their temperature reductions.


CH4 EMISSIONS REDUCTION AND EQUIVALENT CO2 REDUCTION
ECO2 (GtC/yr) : ECH4 ([TgCH4/yr]/100)
0
2
4
6
8
10
12
14
16
18
CO2
CH4
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
YEAR


P50 EMISSIONS, ECH4 AND GWP-EQUIVALENT CO2 STABILIZED
DT2x = 2.6 degC
BASELINE
LESS CH4
LESS CO2
GLOBAL-MEAN TEMPERATURE CHANGE (degC)
YEAR
0
0.5
1
1.5
2
2.5
3
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100

IMPLICATIONS OF GWP TEST

- To match the two cases, the GWP for CH_4 would have to be approximately doubled.

- A CH_4 GWP of 56 corresponds to a time horizon of about 30 years.

- For CH_4, the Kyoto-recommended GWP seriously underestimates the value of CH_4 emissions reductions.

CONCLUSIONS

- In the absence of climate policies, there are large uncertainties in the future composition of the atmosphere.
- CO_2 will be the dominant cause of future climate change.
- The potential for reducing climate change by reducing the emissions of non-CO_2 gases depends on the baseline scenario.
- Reducing CH_4 emissions has additional climate and non-climate benefits through tropospheric ozone effects. The climate effects are included in the GWP for CH_4, but the non-climate effects are not accounted for.
- Control of climate by reducing tropospheric ozone is complicated by the effects of non-climate (pollution-control) policies.
- Reducing the emissions of reactive gases, like CH_4, has multiple (climate and pollution) benefits.
- GWPs are not a good metric for comparing different gases.