Aviation climate impacts : the global and regional points of view

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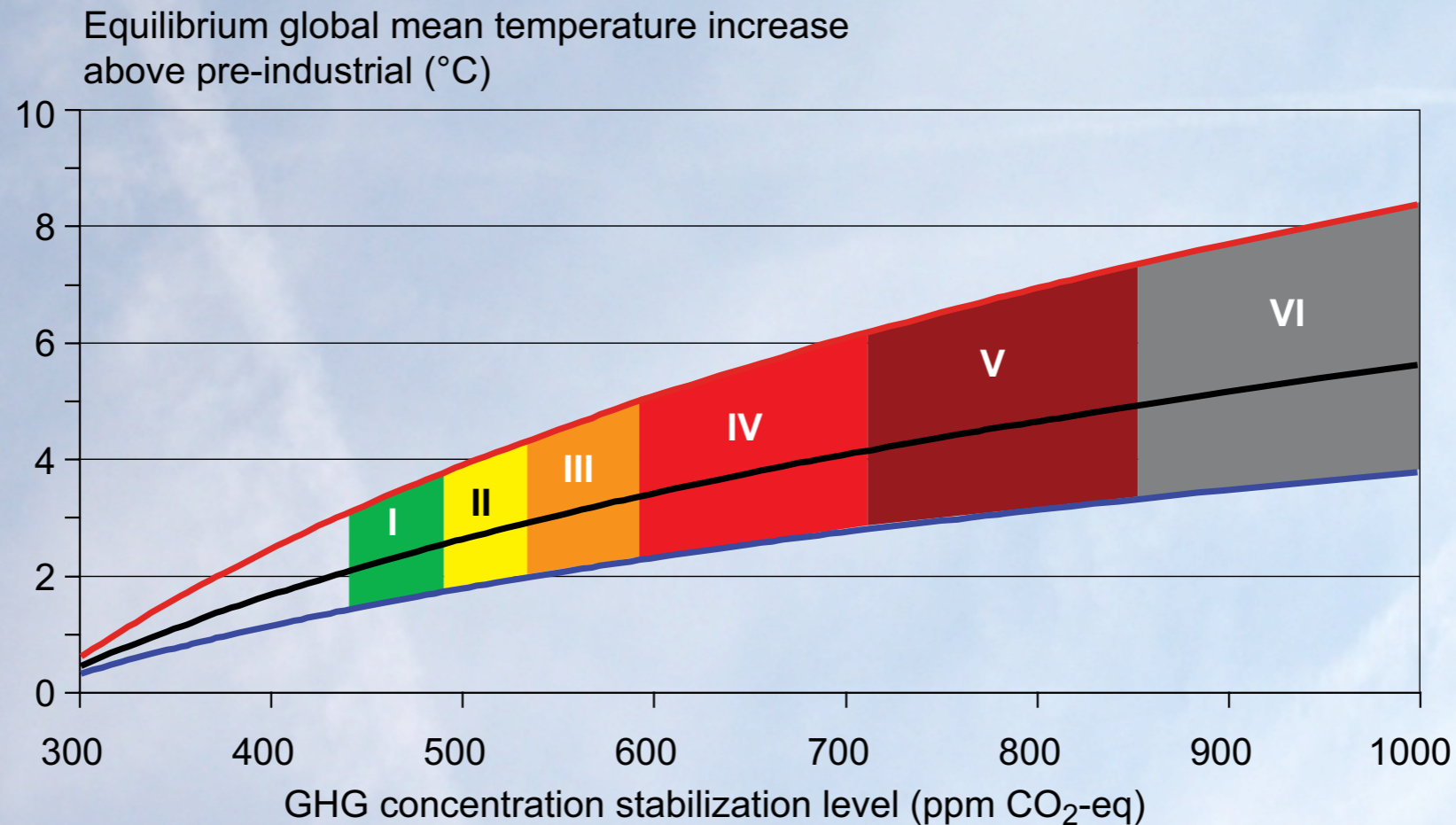
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Outline

- Emission reductions needed to stabilize climate

- The carbon cycle and carbon offset projects

- The non-CO_2 climate effects of aviation

- Regional aviation impacts

- The importance of time horizons
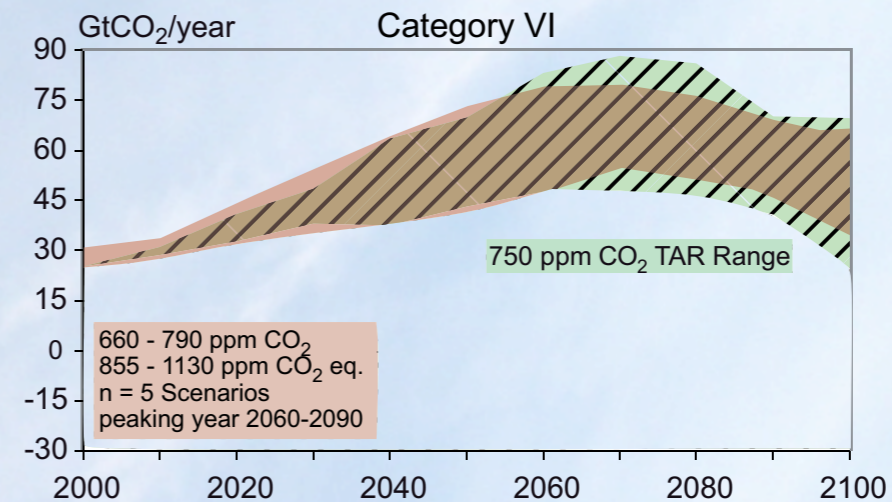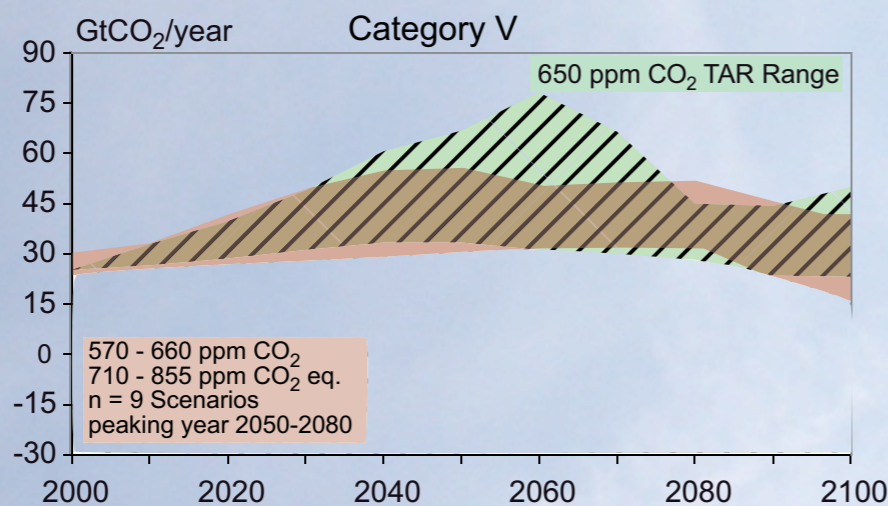
Stabilization of global temperatures

Equilibrium global mean temperature increase
above pre-industrial (°C)

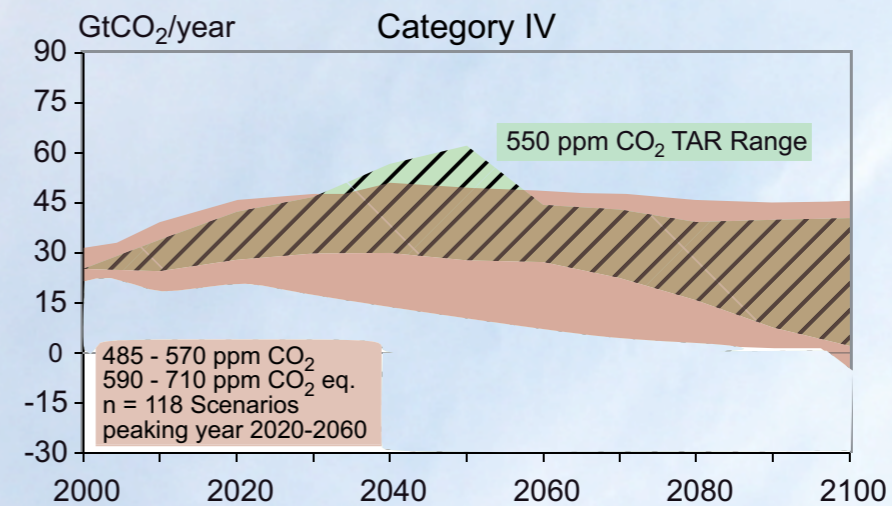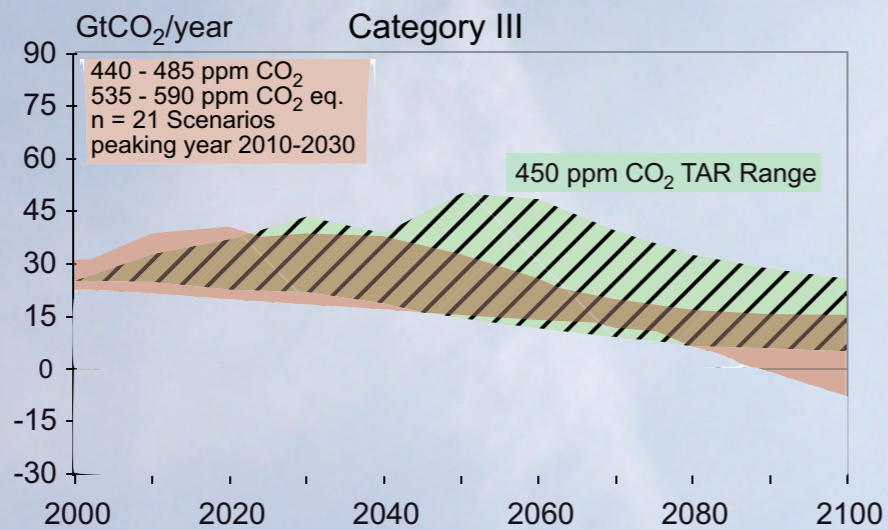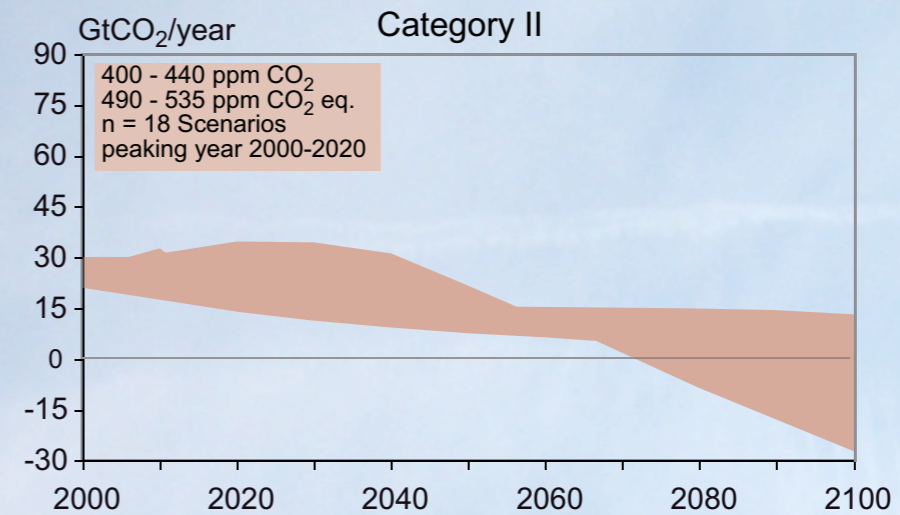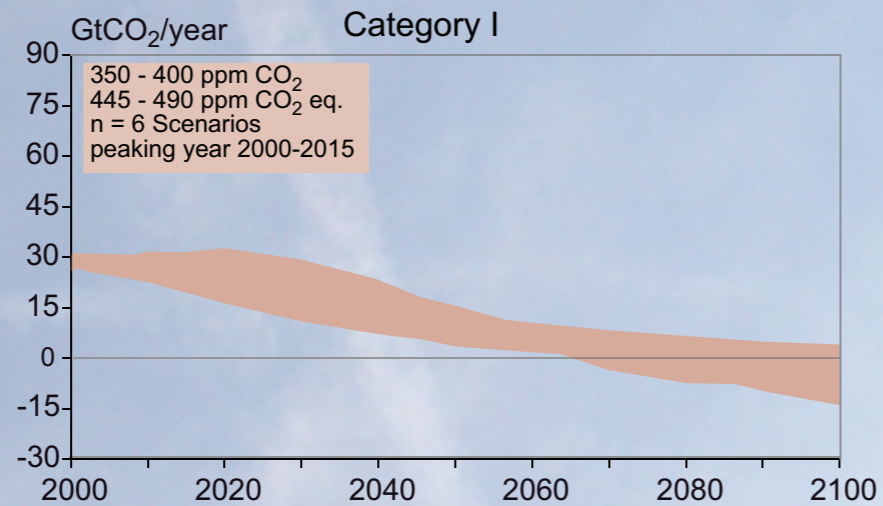GHG concentration stabilization level (ppm CO_2-eq)

Source : IPCC,2007.
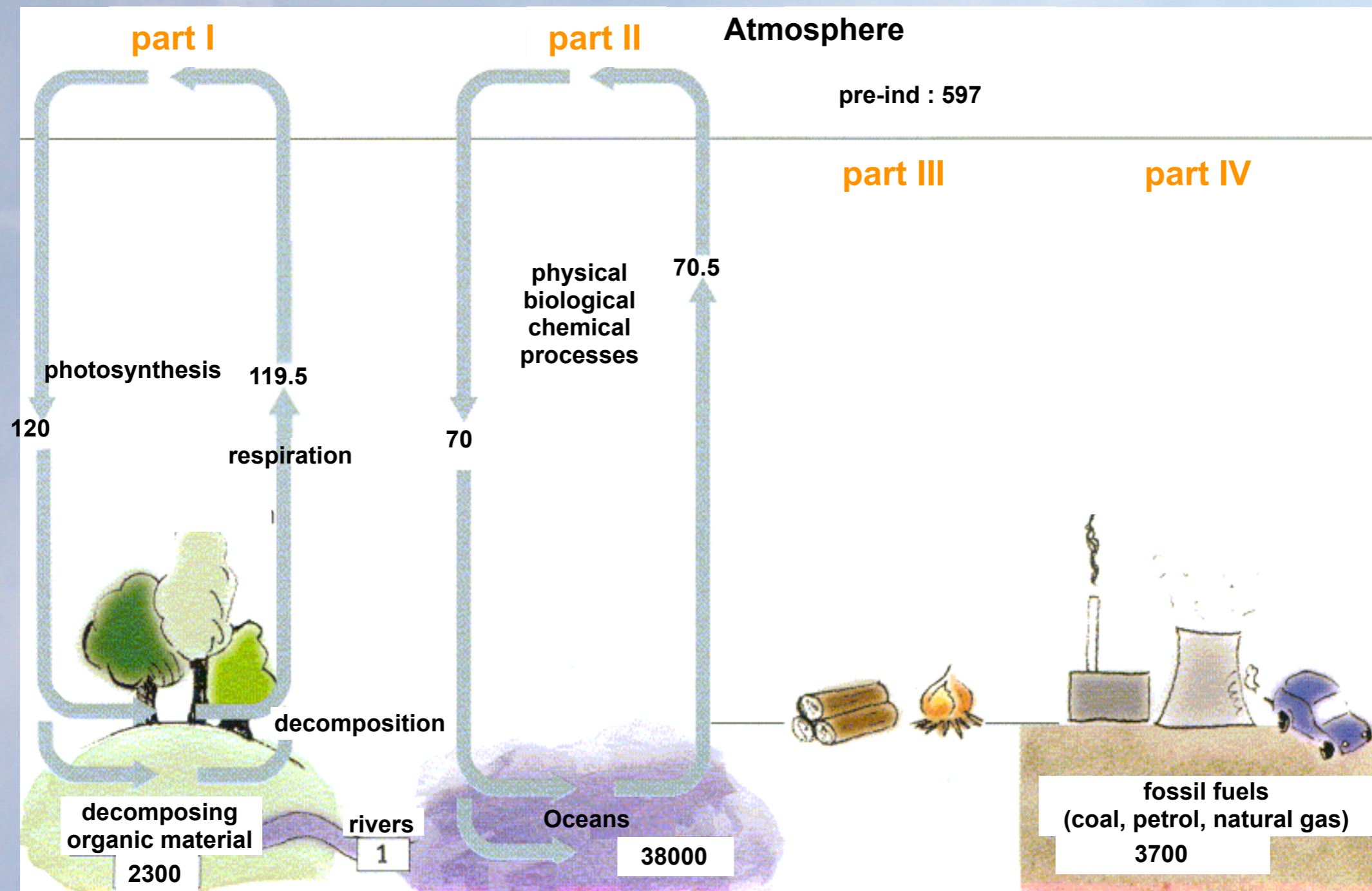
lower bound of likely-range of climate sensitivity (2°C)
best guest climate sensitivity (3°C)
upper bound of likely-range climate sensitivity (4.5°C)

Emission reductions needed

Category I — GtCO$_2$/year

350 - 400 ppm CO$_2$
445 - 490 ppm CO$_2$ eq.
n = 6 Scenarios
peaking year 2000-2015

Category II — GtCO$_2$/year

400 - 440 ppm CO$_2$
490 - 535 ppm CO$_2$ eq.
n = 18 Scenarios
peaking year 2000-2020

Category III — GtCO$_2$/year

440 - 485 ppm CO$_2$
535 - 590 ppm CO$_2$ eq.
n = 21 Scenarios
peaking year 2010-2030

450 ppm CO$_2$ TAR Range

Category IV — GtCO$_2$/year

485 - 570 ppm CO$_2$
590 - 710 ppm CO$_2$ eq.
n = 118 Scenarios
peaking year 2020-2060

550 ppm CO$_2$ TAR Range

Category V — GtCO$_2$/year

570 - 660 ppm CO$_2$
710 - 855 ppm CO$_2$ eq.
n = 9 Scenarios
peaking year 2050-2080

650 ppm CO$_2$ TAR Range

Category VI — GtCO$_2$/year

660 - 790 ppm CO$_2$
855 - 1130 ppm CO$_2$ eq.
n = 5 Scenarios
peaking year 2060-2090

750 ppm CO$_2$ TAR Range

Source : IPCC,2007.

Carbon cycle

part I   part II   **Atmosphere**

pre-ind : 597

part III   part IV

physical
biological
chemical
processes   70.5

photosynthesis   119.5

120

respiration   70

decomposition

decomposing
organic material   rivers   Oceans

2300   1   38000

fossil fuels
(coal, petrol, natural gas)

3700

Source : adapted from IPCC 2007

Units: GtC (billion tons of carbon) or GtC/an

Carbon cycle

part I   **part II**   **Atmosphere**

pre-ind : 597   **+ 3.2/an**

part III   **part IV**

physical
biological
chemical
processes   70.5

photosynthesis   119.5

120

sinks   respiration

70

1.6   6.4

deforestation
(land-use changes)   fossil fuels

2.2

decomposition

decomposing
organic material   rivers   Oceans

2300   **-40**   1   38000   **+120**

fossil fuels
(coal, petrol, natural gas)

3700   **-244**

Source : adapted from IPCC 2007

Units: GtC (billion tons of carbon) or GtC/an

Carbon cycle

part I   part II   Atmosphere

pre-ind : 597   + 3.2/an

part III   part IV

photosynthesis   119.5

physical biological chemical processes   70.5

120

sinks

respiration

70

1.6 deforestation (land-use changes)

6.4 fossil fuels

2.2

decomposition

decomposing organic material   2300   -40

rivers   1

Oceans   38000   +120

fossil fuels (coal, petrol, natural gas)   3700   -244

Source : adapted from IPCC 2007

Units: GtC (billion tons of carbon) or GtC/an

Carbon offset projects

Climate impact of aviation

Factor of : climate warming   climate cooling

$$NO_x + C_xH_y + CO_2 + H_2O + CO + C_{BC} + SO_x$$ (Direct emissions)
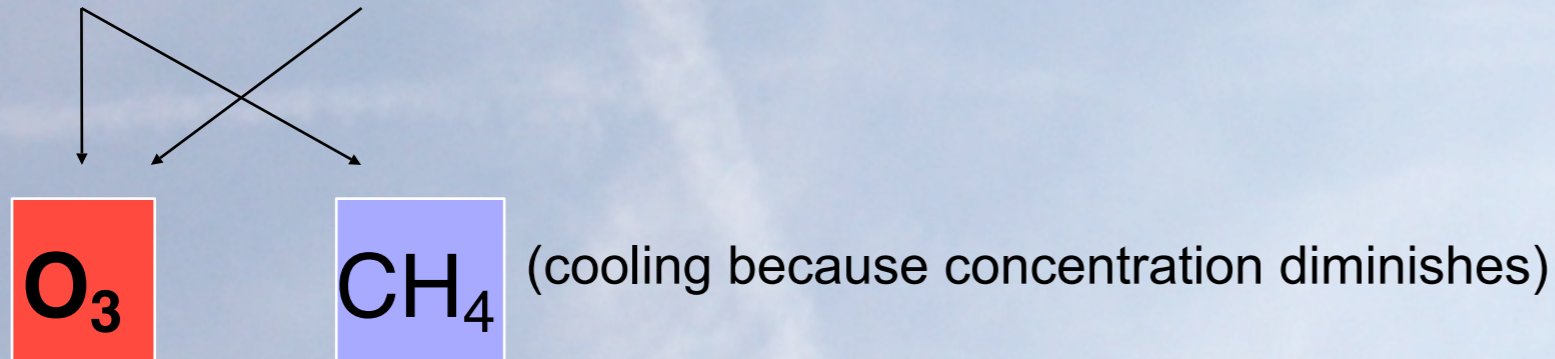
(Transformation in the Wake of planes)

O_3 CH_4 (cooling because concentration diminishes)

Condensation trails (Contrails)

if air is supersaturated

cirrus !

Reflexion of incoming solar light
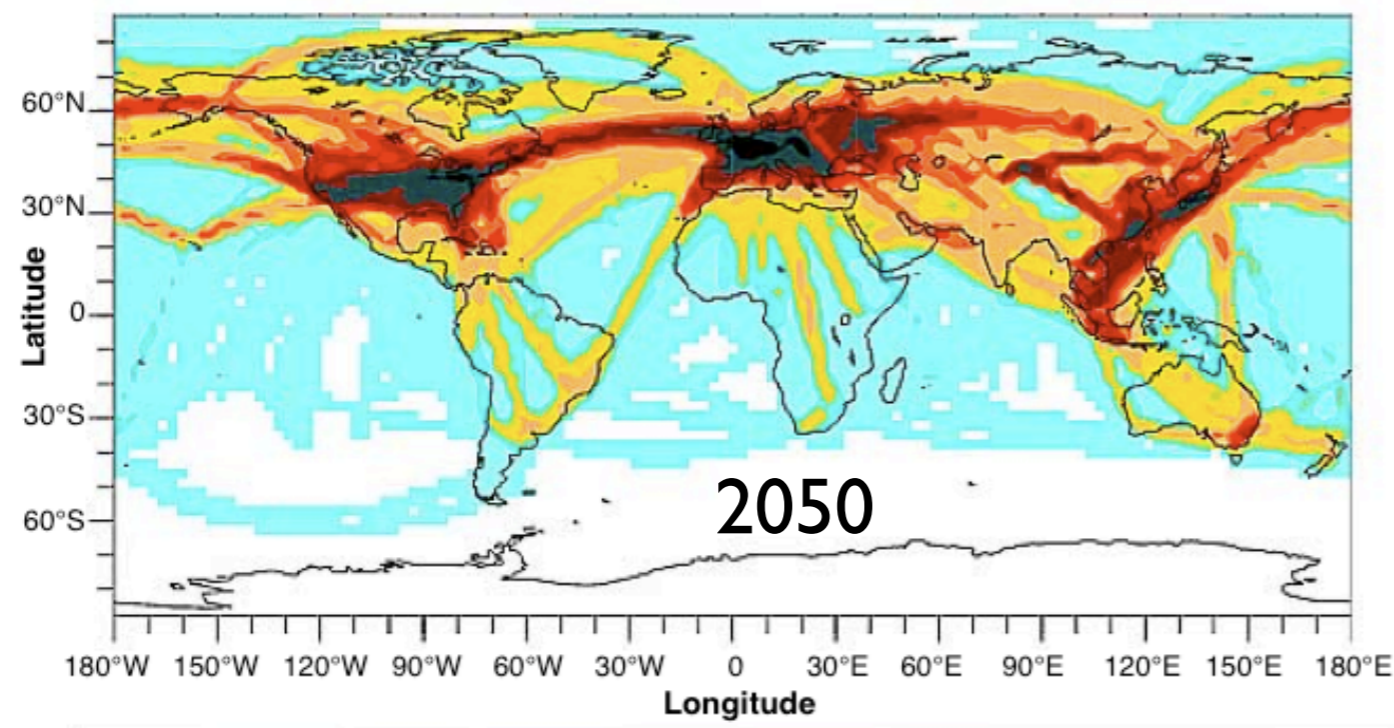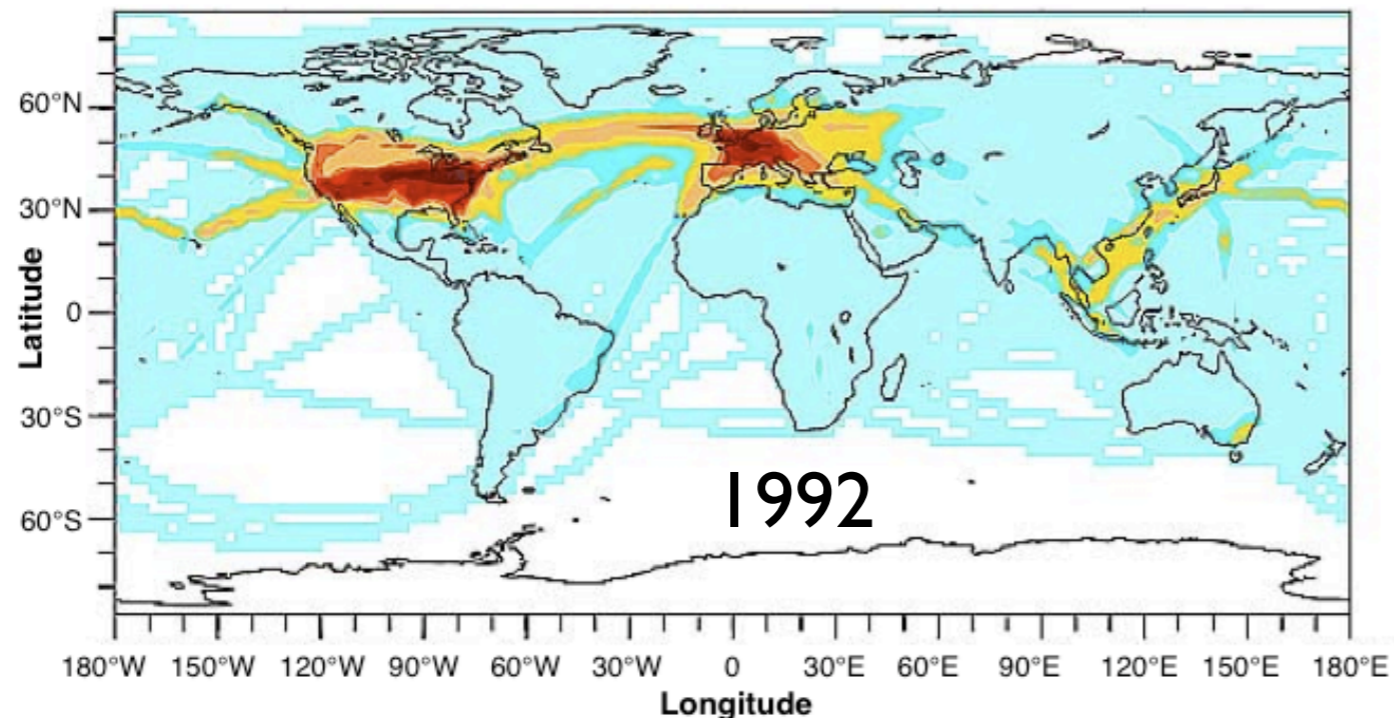
Absorbtion of outgoing long wave terrestrial radiation

Mean diurnal effect = **Climate warming**

Global radiative forcing

Source : adapted from Schumann 2005.
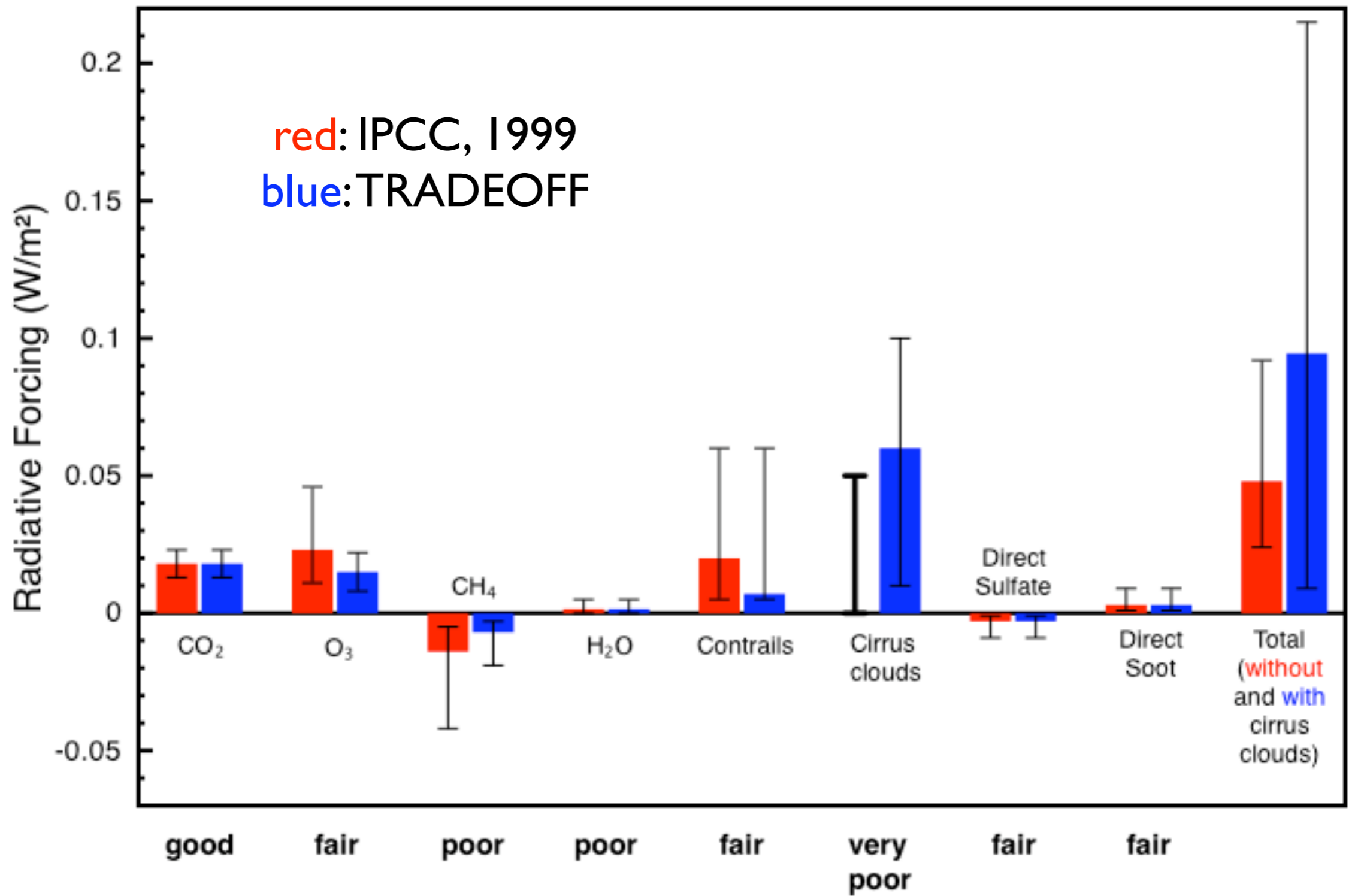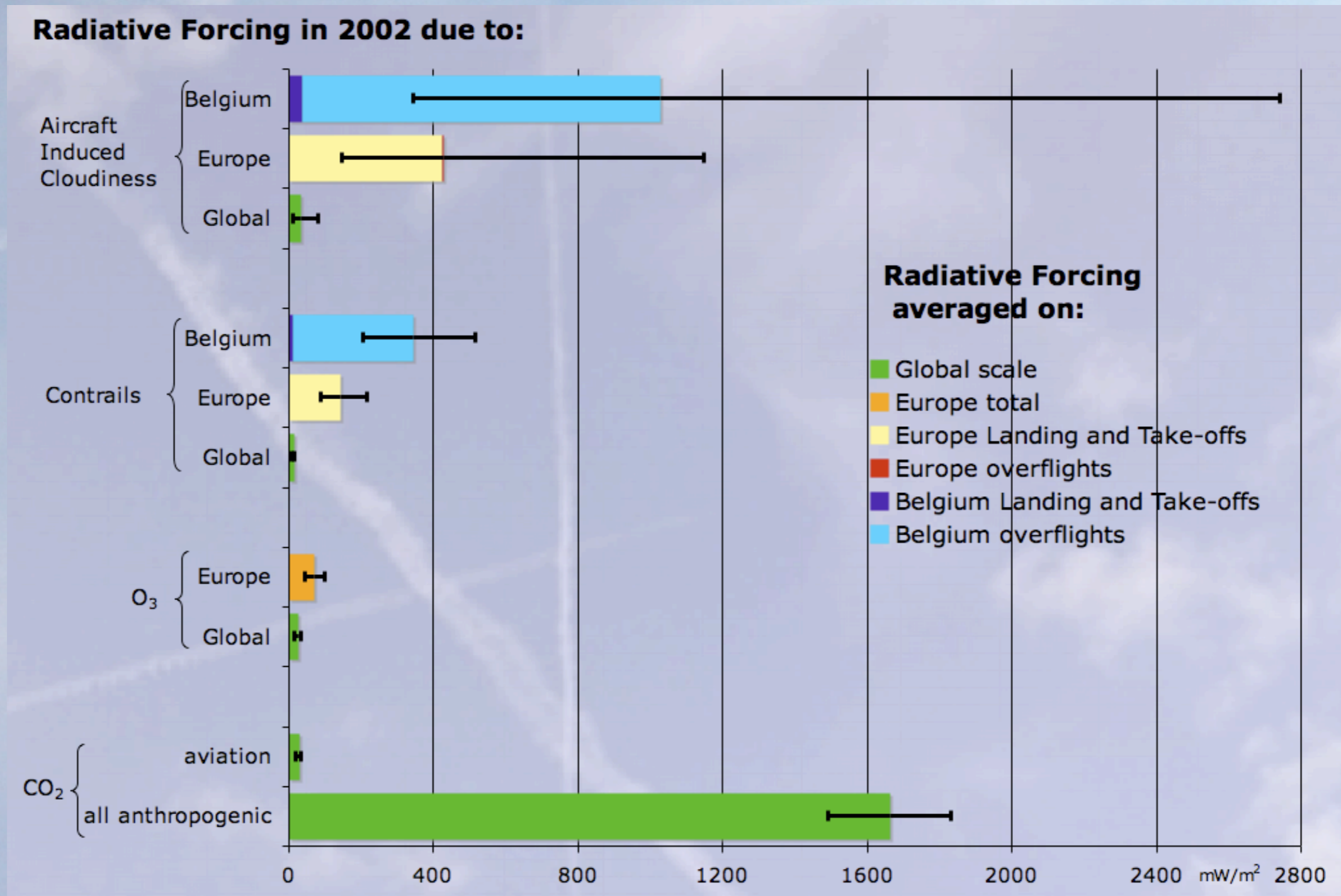
Regional distribution of contrail coverage

Strong regional coverage in Europe, especially over Belgium, situated between:

London
Frankfort
Paris
Amsterdam

Source : IPCC 1999.
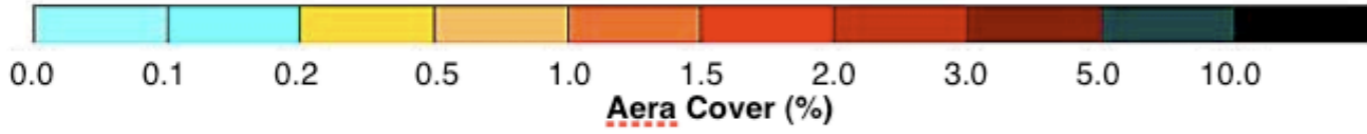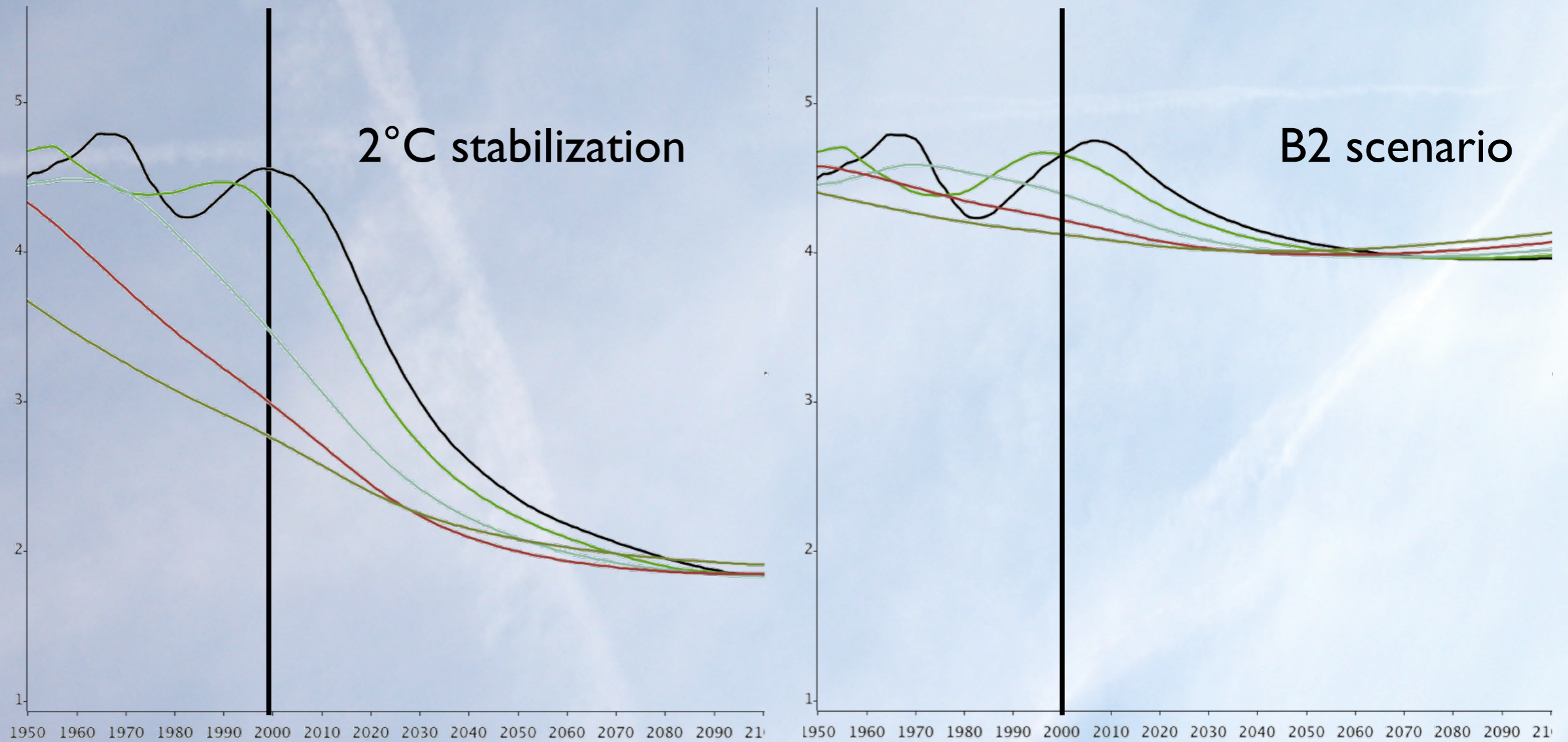
Regional radiative forcing

In Belgium, there is a strong forcing from overflying aircrafts

→ propose a strong mechanism to include the non-CO_2 gases, either within the ETS or some parallel process.

Importance of time horizon

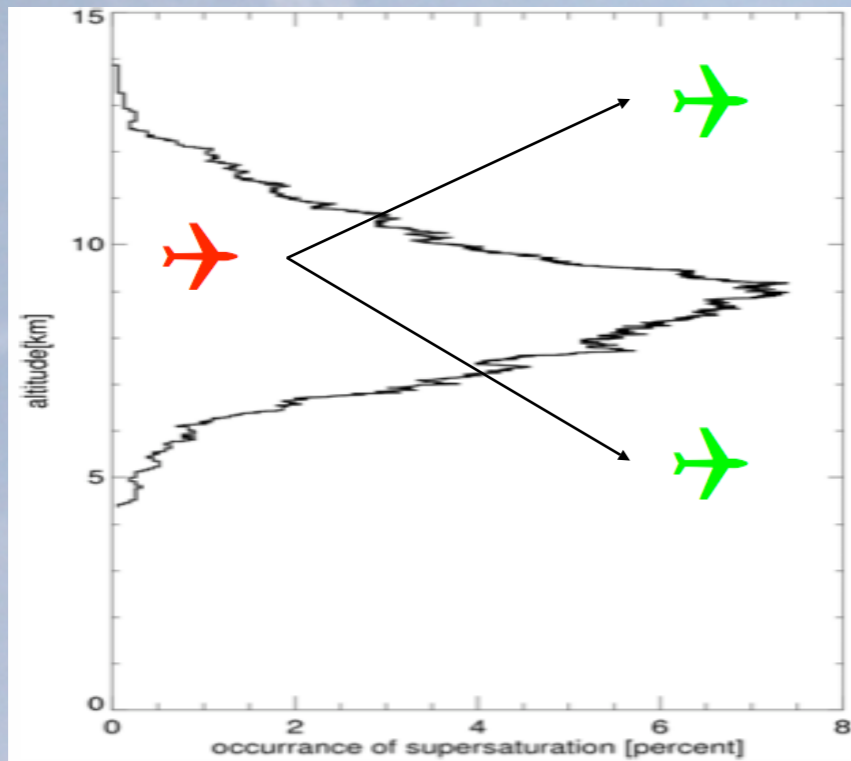Calculations of time variation of radiative forcing index (RFI) with JCM

Source : Matthews JCM

$$RFI = \frac{\text{Total aviation RF}}{\text{RF due to } CO_2 \text{ emitted by aircrafts}}$$

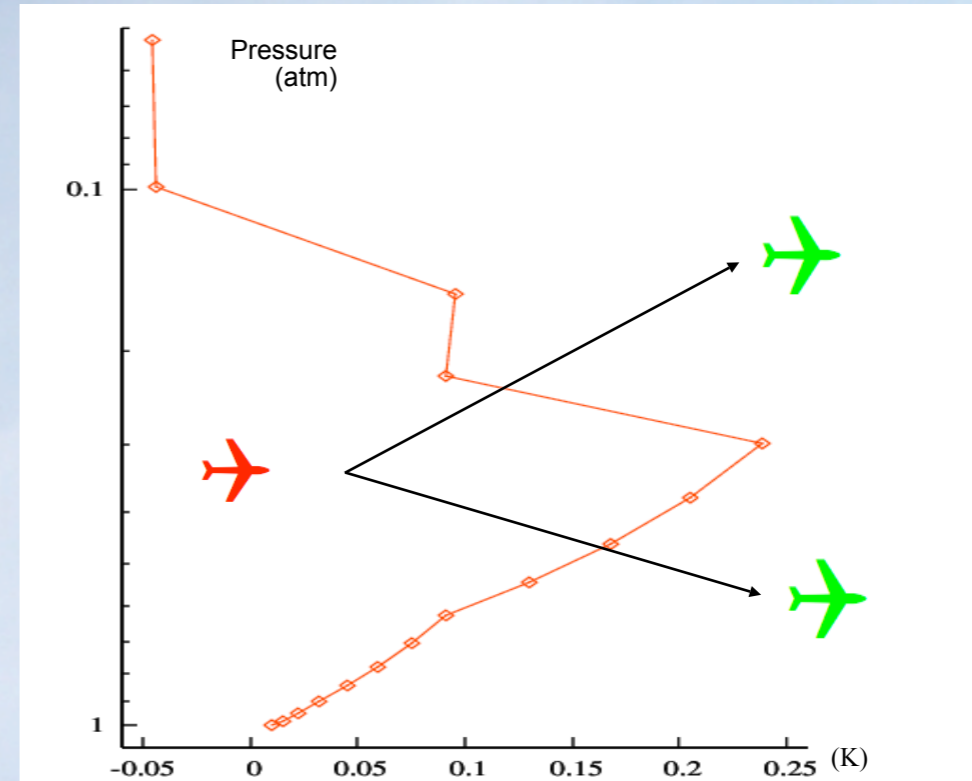# Changes of flight altitude
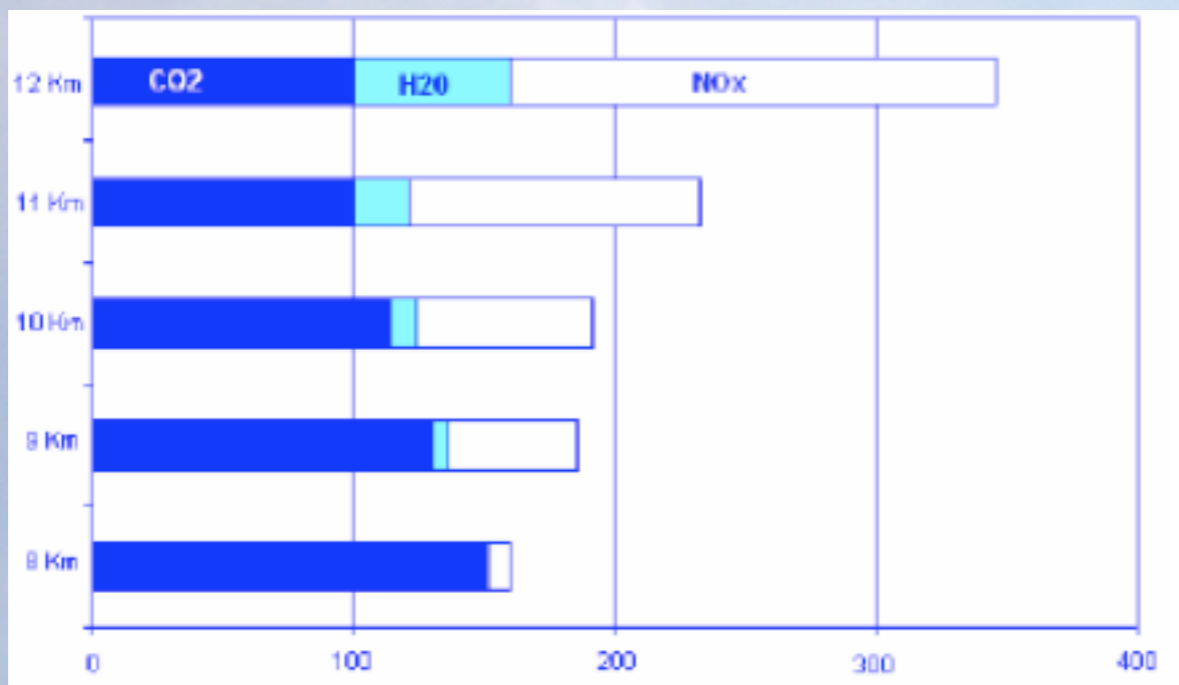
Occurence of supersaturation (%)

Surface temperature increase due to an increase of ozone at different altitudes

Relative climate impact of CO_2, NO_x and H_2O according to the altitude (100 = reference of CO_2 impact at 12 km)

Conclusions

- Non-CO$_2$ forcings from aviation are difficult to address with carbon offset projects

- The total forcing from aviation depends on the location and time horizon considered

- Due to its geographical situation Belgium receives a strong forcing from overflights

Outlook

- In WP7 of the ABCI project we will investigate the impact of contrails in Europe with a regional climate model (CCLM, COSMO model in CLimate Mode)

- This will help us to investigate some possible strategies to minimize the impact of non-CO_2 forcing (e.g. changes in flight altitudes)

- First preliminary results of this research can be found in the intermediate report

CCLM