Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Environmental Physics
Department of Environmental Sciences

On the risk of overshooting 2°C

Implications of the uncertainty in climate sensitivity for the derivation of 'safe' stabilization and peaking concentrations

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pre-final

Overview

Part 1:

Why 2°C?

Part 2:

What CO_2 concentration corresponds to 2°C?

Part 3:

What are necessary (global) emission reductions?

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EU's 2°C target

"[...] the Council believes that global average temperatures ***should not exceed 2 degrees above pre-industrial level*** *and that therefore concentration levels lower than 550 ppm CO2 should guide global limitation and reduction efforts.[...]"* (1939th Council meeting, Luxembourg, 25 June 1996)

EU's 2°C target

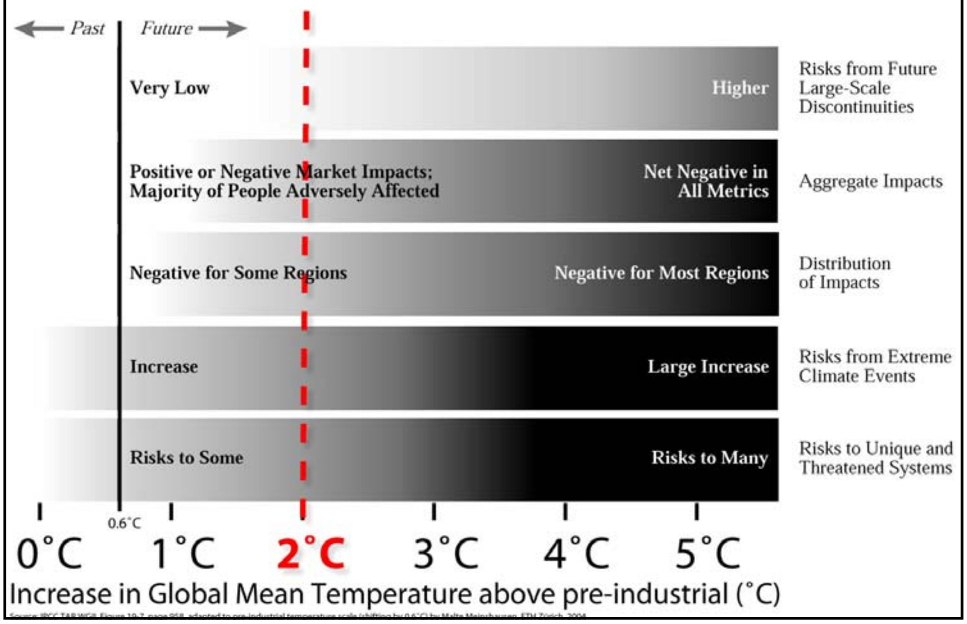
"[...] NOTES that ***scientific uncertainties*** *exist in translating a temperature increase of 2°C into greenhouse gas concentrations and emission paths; ...*

... however, RECOGNISES that recent scientific research and work under the IPCC indicates that it is ***unlikely*** *that stabilisation of greenhouse gas concentrations above 550 ppmv CO_2 equivalent would be consistent with meeting the 2°C long-term objective ...*

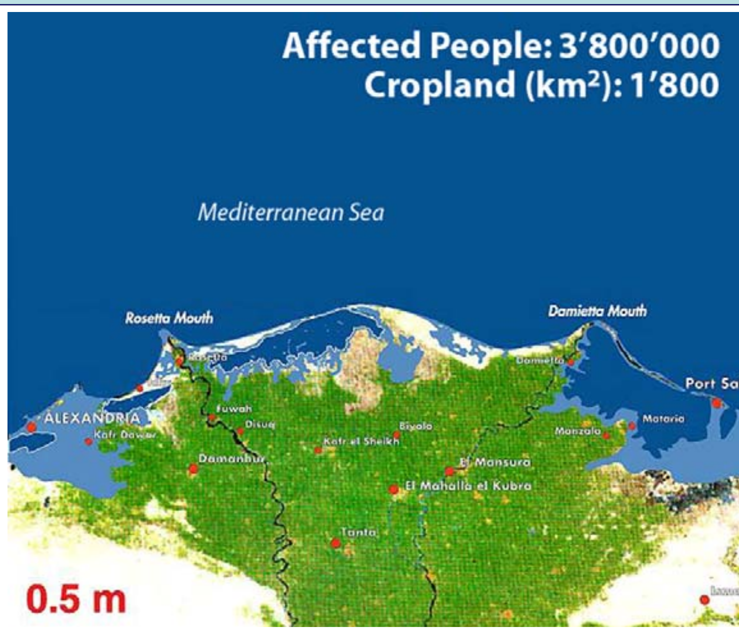
... and that in order to have a reasonable chance to limit global warming to no more than 2°C, stabilisation of concentrations ***well below 550 ppmv CO_2 equivalent*** *may be needed; ...*

... NOTES that keeping this long-term temperature objective within reach will require global greenhouse gas emissions to peak within two decades, followed by substantial reductions in the order of at least 15% and ***perhaps by as much as 50% by 2050 compared to 1990 levels****. [...]"* (2632nd Council Meeting, Brussels, 20th December 2004)

Reasons for Concern (IPCC TAR WGII)

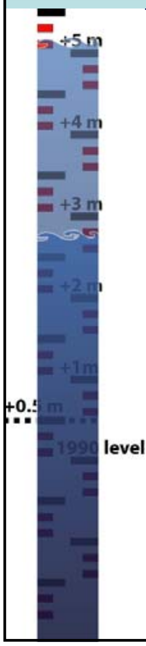


Potential Impact of Sea Level Rise: Nile Delta



Sources: Otto Simonett, UNEP/GRID Geneva; Prof. G.Sestini, Florence; Remote Sensing Center, Cairo; DIERCKE Weltwirtschaftsatlas

Sea level rises 3-5 meters by 2300 for 3°C



Source: Rahmstorf, S., C. Jaeger (2004)

- 3°C → dangerous interference
- “*Even a stabilisation target of 2ºC cannot necessarily be considered “safe” in terms of the sea level rise caused*”

+ Antarctica	1.0 - 2.0 m	Estimate based on WAIS decay over 900-1800 years
+ Greenland	0.9 - 1.8 m	Lower: IPCC TAR Upper: doubled
+ Glaciers	0.4 m	IPCC TAR, assumed 80% loss of total
Thermal expansion	0.4 - 0.9 m	IPCC TAR, not fully considering THC
Total	**2.7 - 5.1 m**	

...and increasing further from there

Conclusions Part 1

Scientific research into climate impacts indicates that...

- ... 2°C is no guarantee to avoid significant adverse climate impacts
- ... overshooting 2°C is likely to multiply adverse impacts and potentially trigger large scale catastrophic events

Part 2

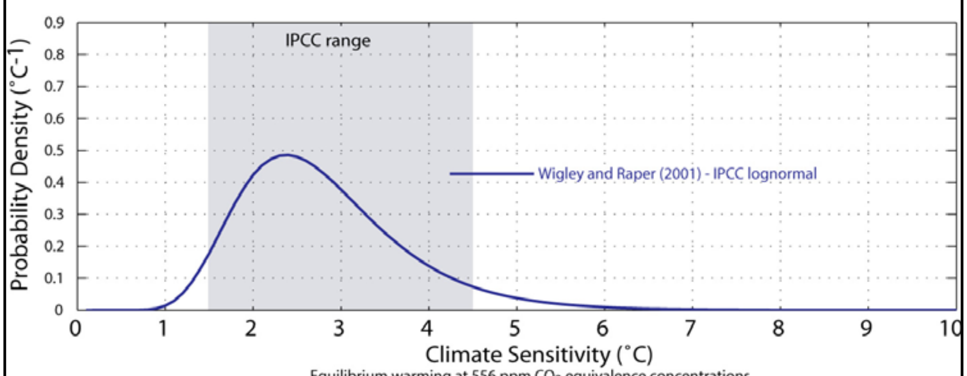
What CO_2 concentration corresponds to 2°C?

Expected warming for ~550ppm CO_2eq

Climate Sensitivity ...

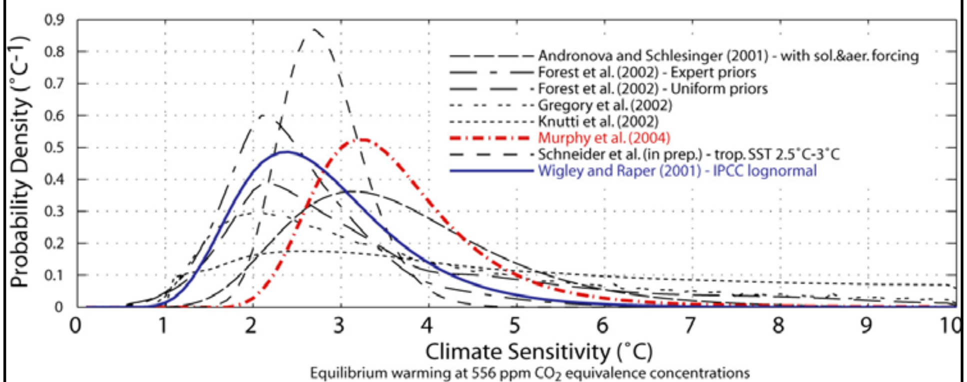
... summarizes key uncertainties in climate science for long-term projections

... is the expected average warming of the earth's surface for a doubling of CO_2 concentrations (556 ppm CO_2)



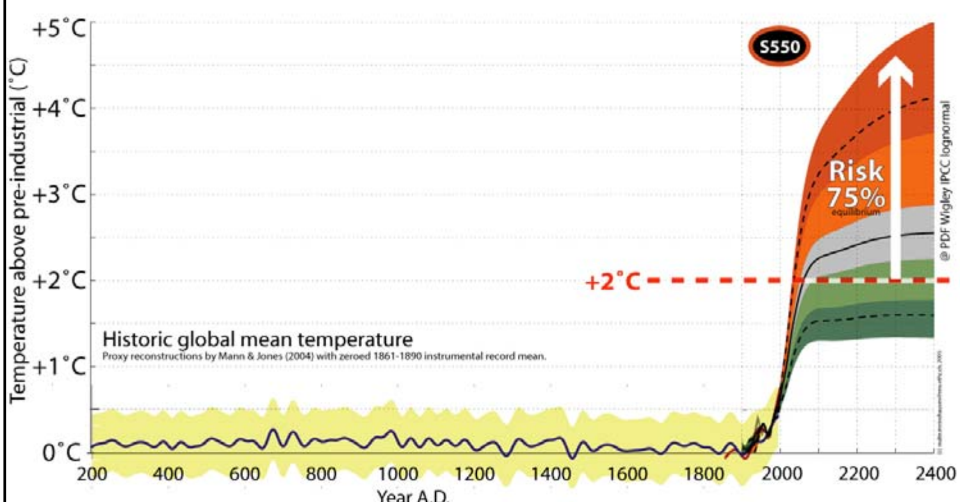
Expected warming for ~550ppm CO_2eq

- Current research cannot exclude very high warming levels (e.g. > 4.5°C) for stabilization of greenhouse gases at 550ppm CO_2 equivalence
- see e.g. Stainforth et al. (today)



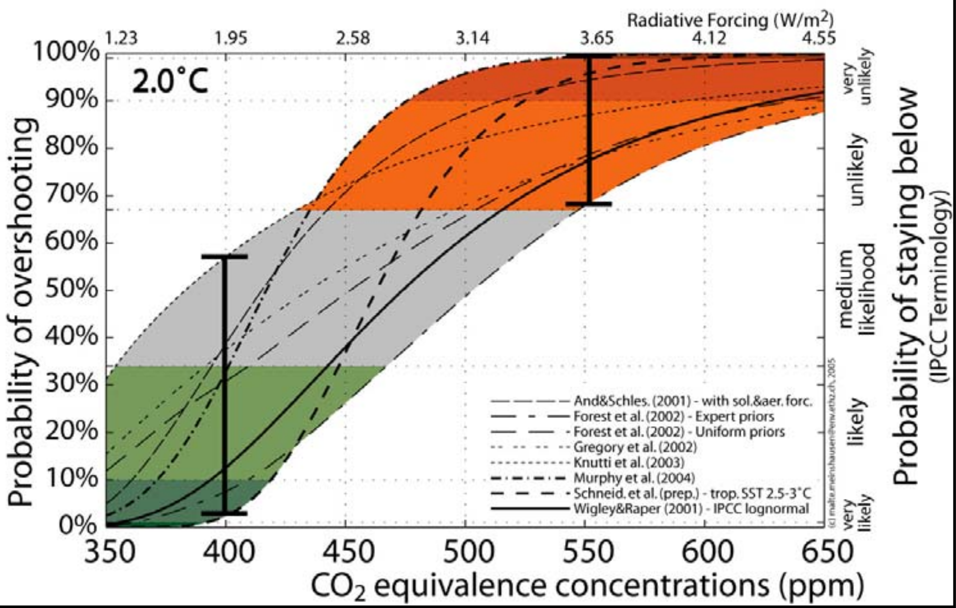
ETH

550 ppm overshooting 2°C: 75% risk

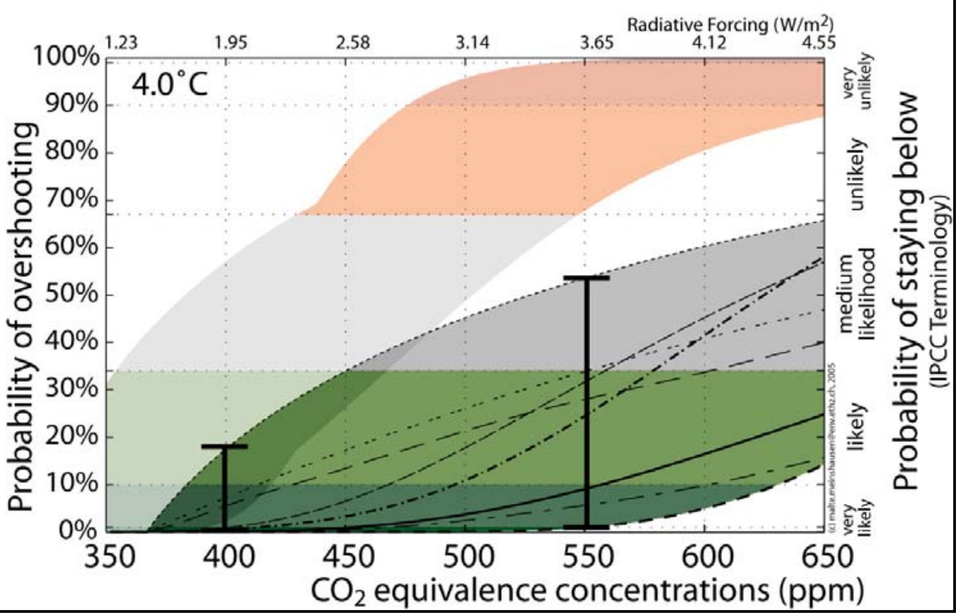


ETH

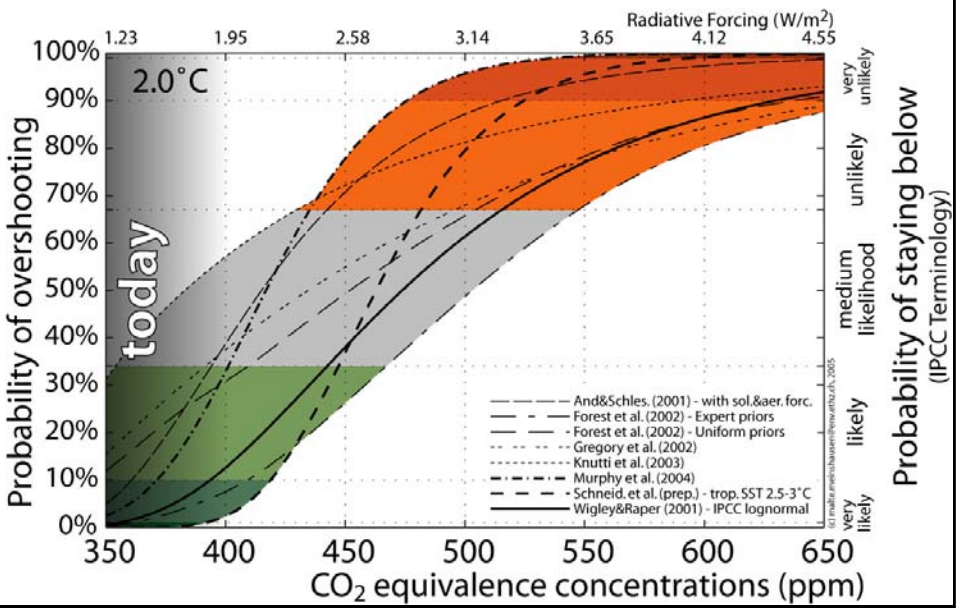
Probability of overshooting 2°C (stabilisation)



Probability of overshooting X°C (stabilisation)



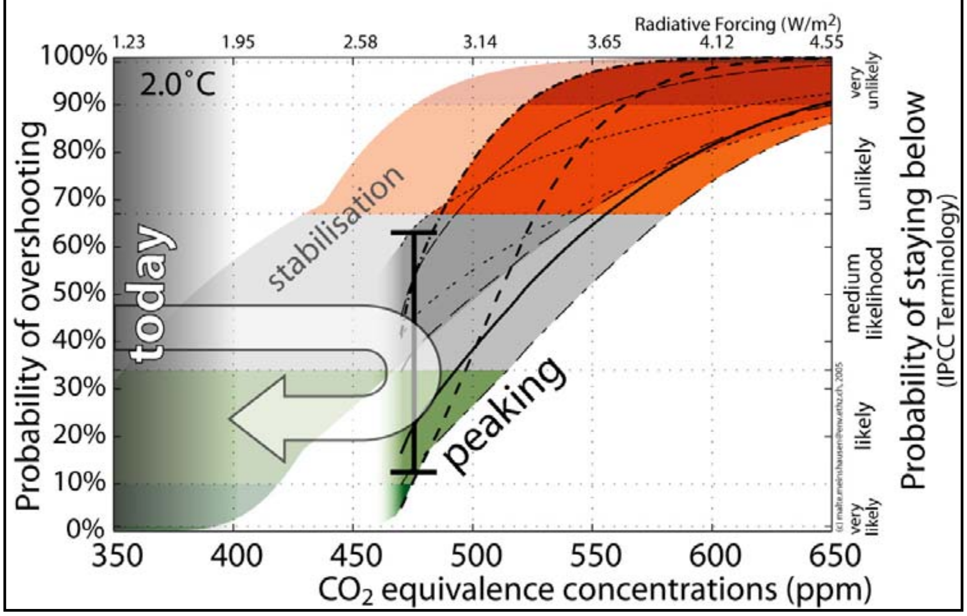
Where we are today?



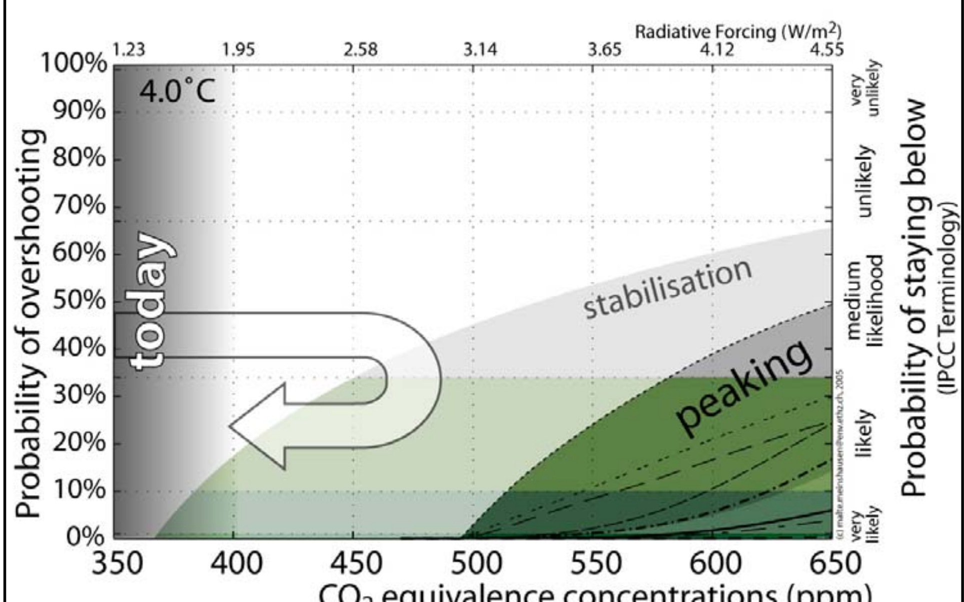
Probability of overshooting (stabilisation)

- Chance of staying below 2°C is “likely” only for stabilisation around 400 ppm or below.
- Risk of very high warming levels cannot be completely excluded for stabilisation scenarios other than pre-industrial or maybe 350 ppm CO_2eq.
- To keep option open of low stabilisation levels: concentrations will have to peak.
- What are the risks associated with peaking?

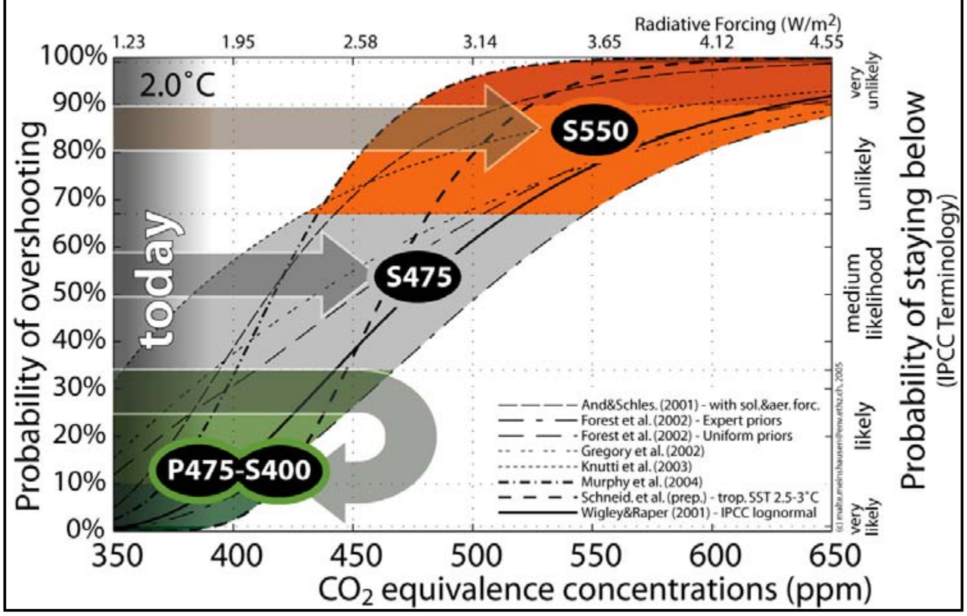
The way to get to low stab. levels: peaking



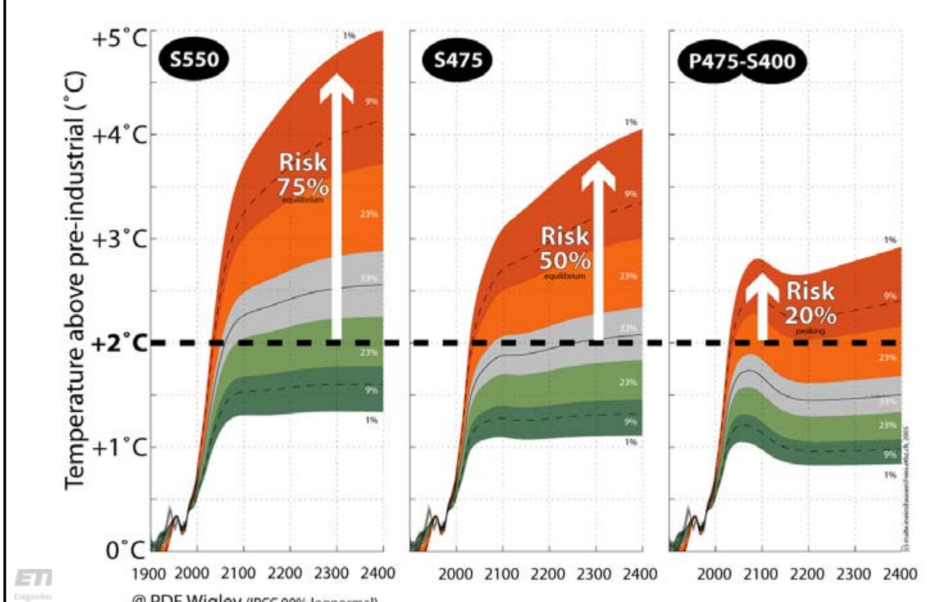
Peaking can avoid high temperature risk



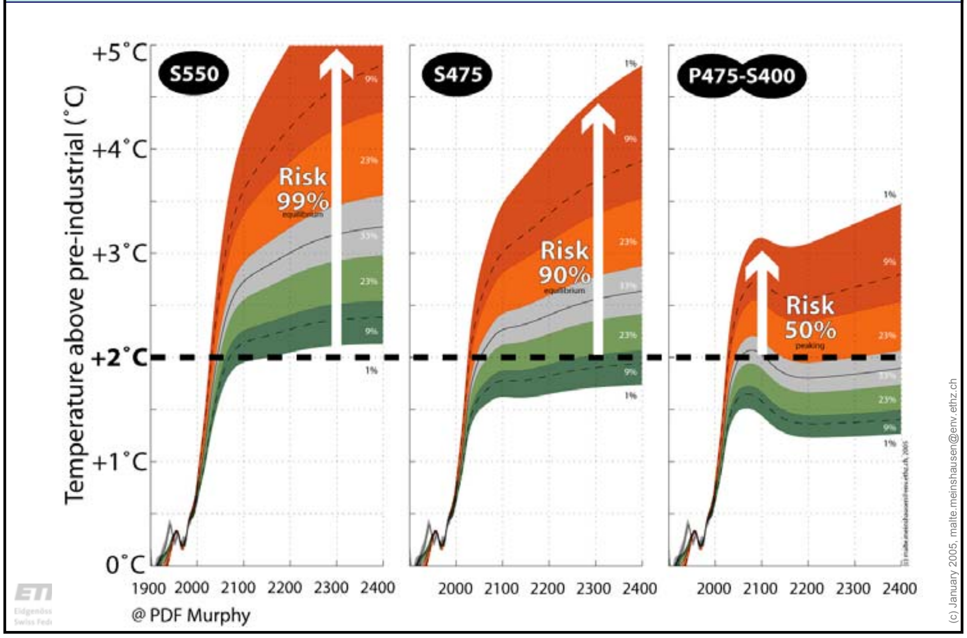
Three pathways



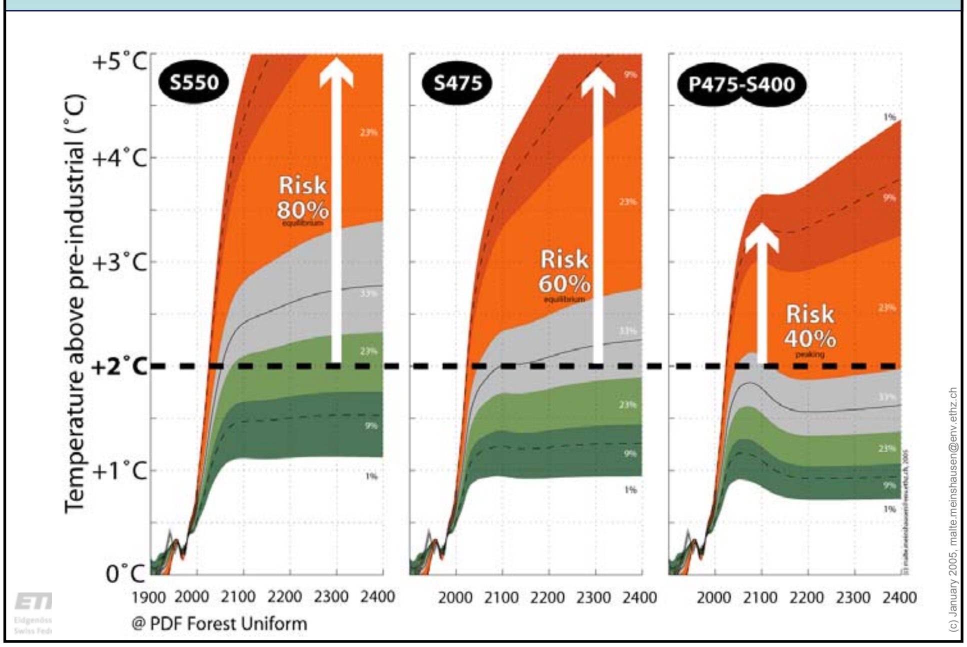
Risk decreases for lower peaking / stabilisation levels



Risk decreases for lower peaking / stabilisation levels



Risk decreases for lower peaking / stabilisation levels



Conclusions Part 2

- 550 ppm CO_2 equivalence is "unlikely" to meet the 2°C target (risk of overshooting = 70% to 99%)
- For stabilization at 550 ppm CO_2eq, the chance to stay below 2°C is about equal to the risk of overshooting 4.5°C ("mean" ~16%)
- Need to keep the option open for very low stabilisation levels. → Concentrations will have to peak.
- There is a "likely" achievement of the 2°C target for peaking below 475ppm and stabilization below 400ppm CO_2eq (the "mean" risk to overshoot 2°C is about 25%).

Section 3

What are the necessary global emission reductions?

Background

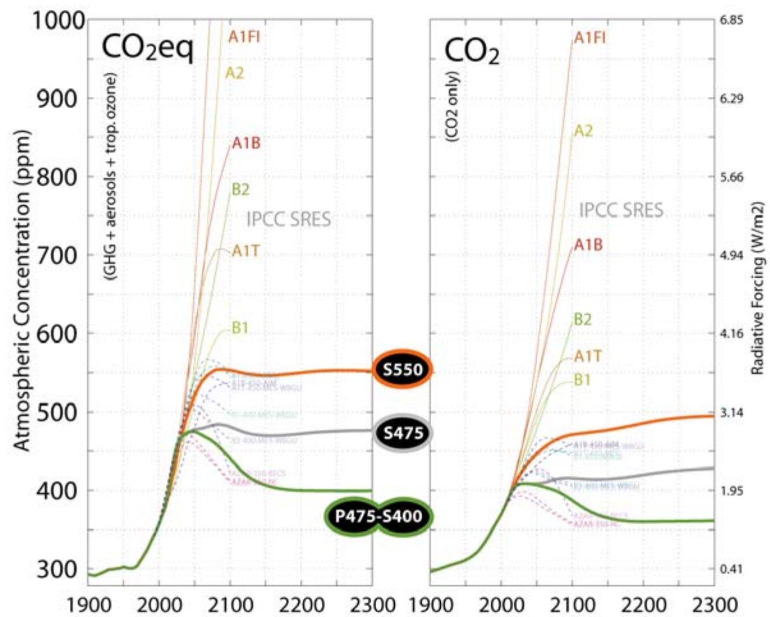
The presented stabilization pathways (“EQW”)...

- are built on 54 published IPCC baseline and mitigation scenarios
- reflect emissions of 14 greenhouse gases and aerosols
- method is described in “Multi-gas emission pathways to meet climate targets” by Meinshausen, M., W. Hare, T. Wigley, D. van Vuuren, M. den Elzen and R. Swart, submitted June 2004

The used climate model (“MAGICC 4.1”)...

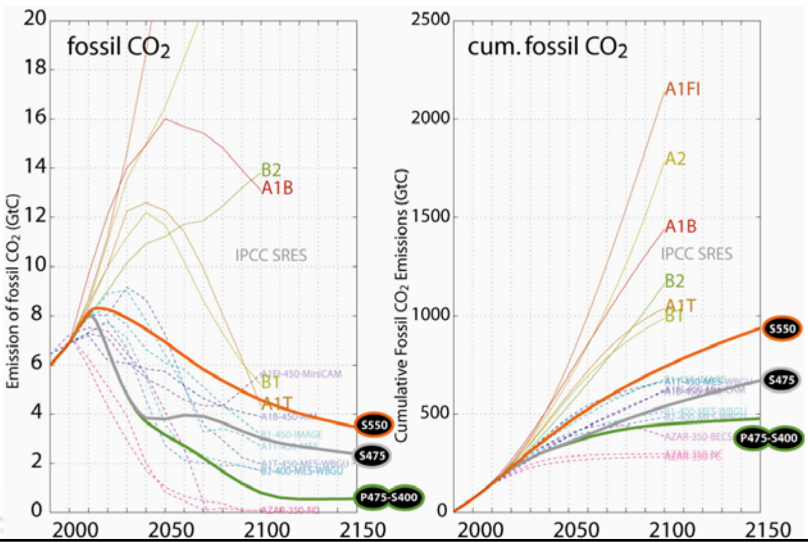
- is the primary simple climate model used in IPCC’s Third Assessment Report for global mean temperature and sea level rise projections
- is built by Wigley, Raper et al. and available online at http://www.cgd.ucar.edu/cas/wigley/magicc/

CO_2 equivalence and CO_2 concentrations

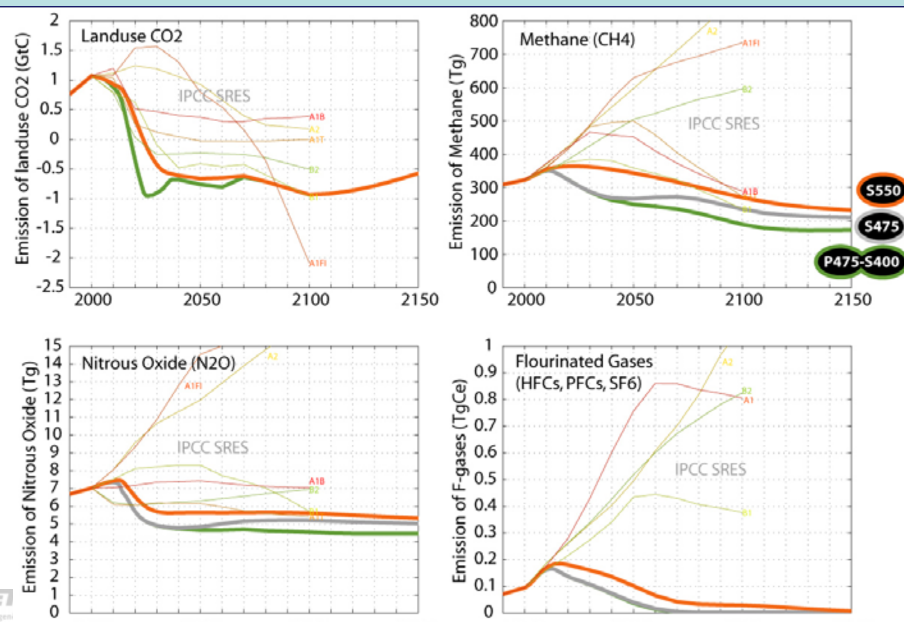


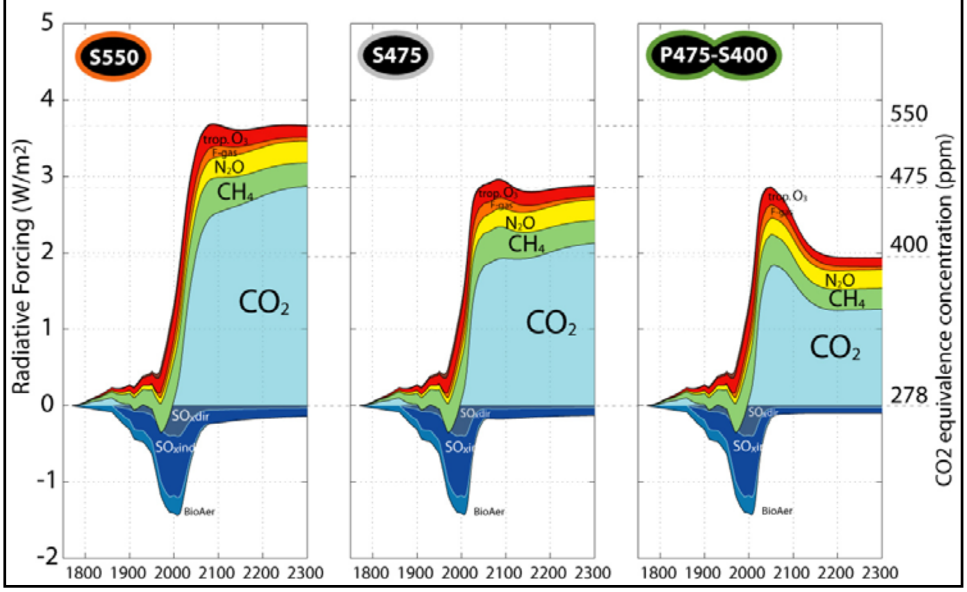
Fossil CO_2 emissions

- 475 peaking within range, but at lower end of existing mitigation scenarios
- Fossil carbon budget 400 GtC for stabilization at 400 ppm CO_2eq.

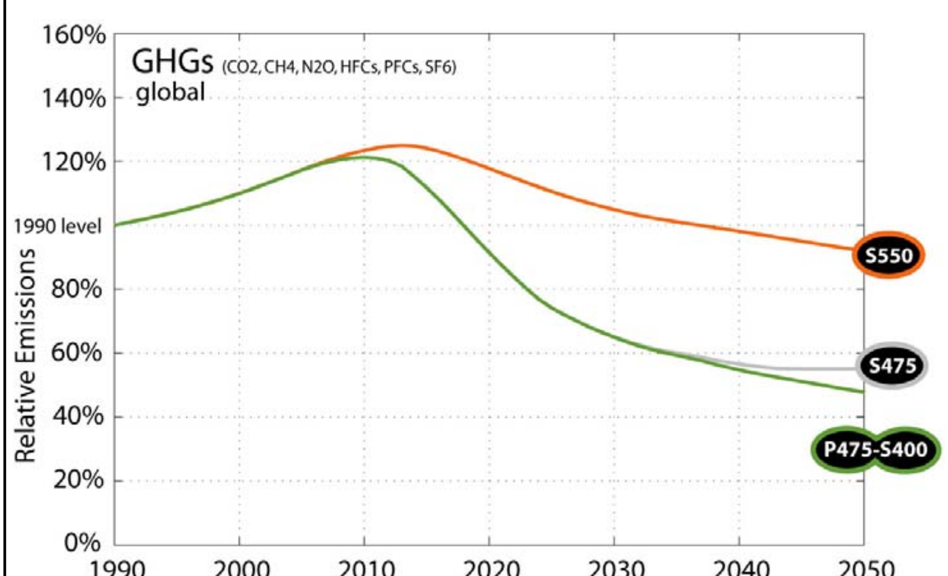


Other GHG Emissions

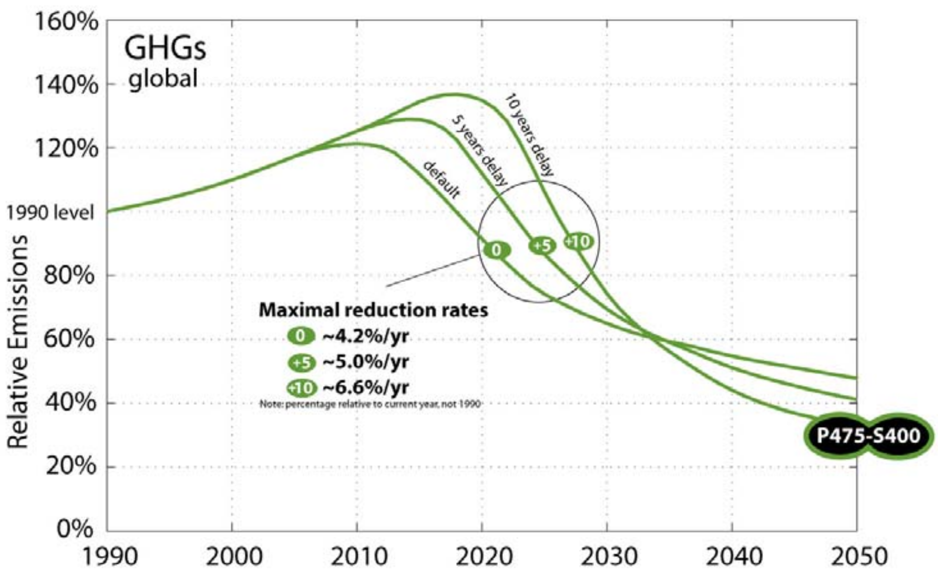




Emissions relative to 1990

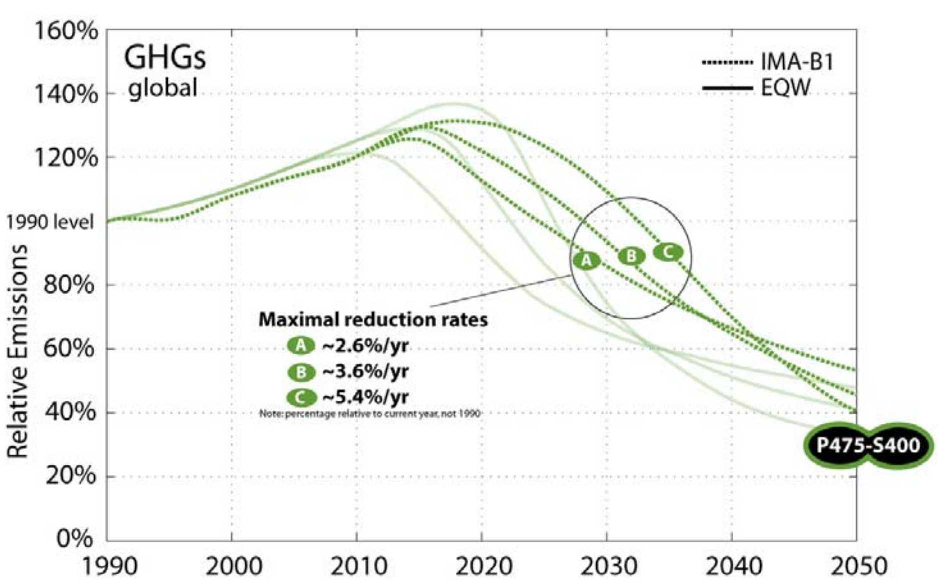


The Effect of Delay (same risk of overshooting)



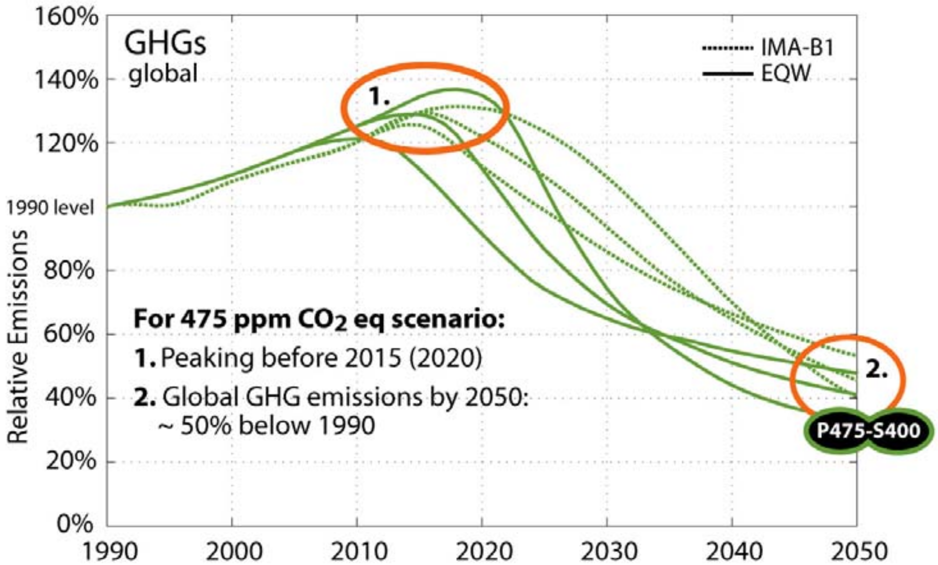
The Effect of Delay

Source for IMA-B1 P480-S400: den Elzen & Meinshausen



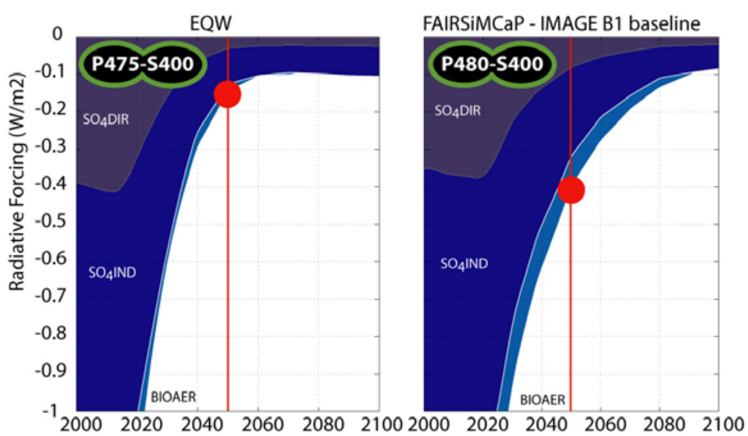
The Effect of Delay

Using different emission scenarios does not change the overall picture.



The reason is: aerosol forcing..

- Higher aerosol emissions in FAIR-SiMCaP scenarios than in EQW scenarios (Δ~=0.25W/m²)



The Effect of Delay

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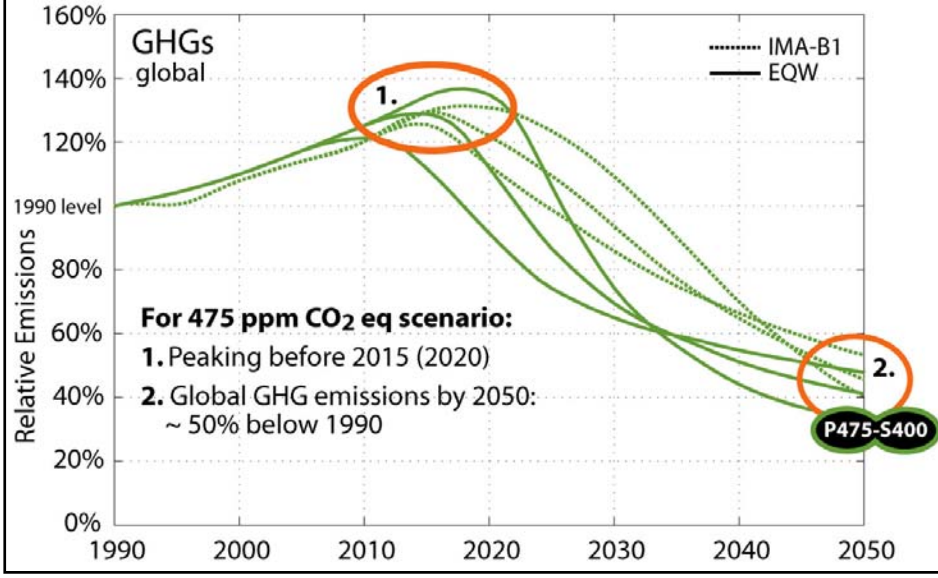
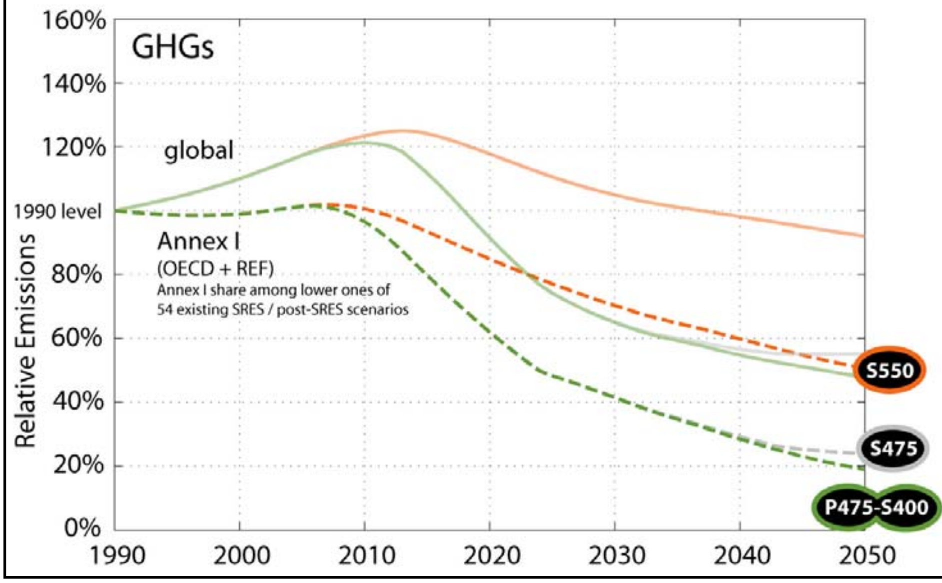


Sir David King

"Delaying action for a decade,
or even just years,
is not a serious option"
(Science, 9 January 2004)

Share of Annex I emissions

Note: The presented Annex I share is not based on an explicit emission allocation scheme



Conclusions Section 3

- For stabilization at 550 ppm:
  - global GHG emissions have to return to 1990 levels by 2040.
- For stabilization 400 ppm / peaking at 475ppm:
  - global GHG emissions have to be reduced **by ~50%** below 1990 levels by 2050.
  - Industrialised countries (Annex I) will have to reduce GHG emissions to **below 20%** by 2050 below 1990.
  - Application of emission allocation schemes (including indicators like capability, responsibility etc.) suggest even lower levels, i.e. 5%-15%.
- A delay of just 5 years matters. A delay of global action by 10 years nearly doubles the required reduction rates in 2025.

Lord Browne, CEO BP

"But if we are to avoid having to make dramatic and economically destructive decisions in the future, we must act soon."
(*Foreign Affairs*, July/August 2004)

Contact & download

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- Data and Presentation will be available at
  www.simcap.org

Appendix: Methods & Credits

- **STABILIZATION EMISSION PATHWAYS:**
  The presented stabilization emission paths EQW-S550Ce, EQW-S450Ce, EQW-S475Ce, EQW-S400Ce and its variants were developed with the "Equal Quantile Walk" (EQW) method. The EQW multi-gas method handles all 14 major greenhouse gases and aerosol emissions and is implemented in the SiMCaP pathfinder module. The method builds on the multi-gas and multi-region characteristics of 54 existing SRES and Post-SRES scenarios. For details, see "Multi-gas emission pathways to meet climate targets" by Meinshausen, M., W. Hare, T. Wigley, D. van Vuuren, M. den Elzen, R. Swart, submitted to Climatic Change. Available on request from the author.
- **CLIMATE MODEL:**
  The employed simple climate model is MAGICC 4.1 (by Wigley, Raper et al.). MAGICC 4.1 has been used in the IPCC Third Assessment Report for global mean temperature and sea level projections. MAGICC is an energy balance, upwelling-diffusion (simple) climate model.
- **DATA & GRAPHICS:**
  If not otherwise stated, all presented graphics and calculations were produced by Malte Meinshausen. Data is available on request. Slides might be used for non-commercial purposes, if source is acknowledged. Contact the author for any questions. (malte.meinshausen@env.ethz.ch).
- **ACKNOWLEDGEMENTS:**
  Thanks to Tom Wigley for providing the MAGICC climate model.

References

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- Wigley, T.M.L. and Raper, S.C.B.: 2001, 'Interpretation of high projections for global-mean warming', Science 293, 451-454.

Background II

➤ The Equal Quantile Walk method

See more details on the method (not on the specific emission pathways) in "Multi-gas emission pathways to meet climate targets" by M. Meinshausen, M., W. Hare, T. Wigley, D. van Vuuren, M. den Elzen and R. Swart, submitted June 2004

Constructing peaking pathways