ETH
Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

UP
Environmental Physics
Department of Environmental Sciences

Working Group I: The Climate Challenge

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Final v3

Overview

Part 1:
2°C and climate impacts

Part 2:
What CO_2 level corresponds to 2°C?

Part 3:
What are necessary global emission reductions?

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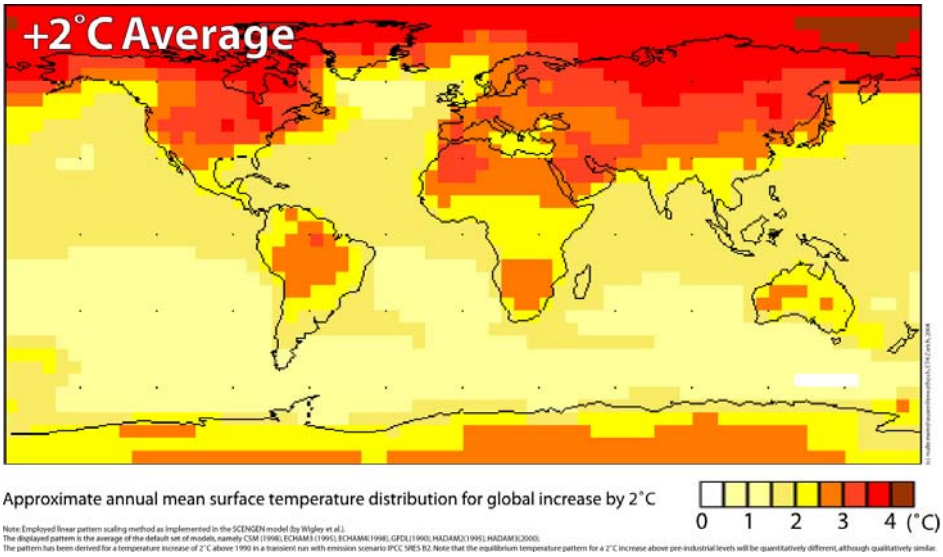
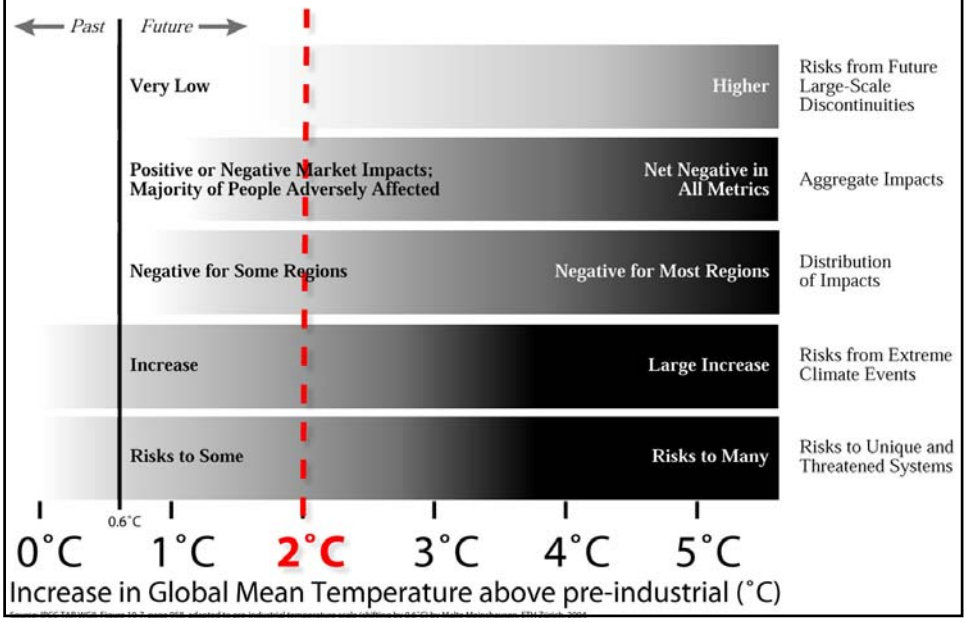
EU's 2°C target

- *"[...] the Council believes that global average temperatures **should not exceed 2 degrees above pre-industrial level** [...]"* (1939th Council meeting, Luxembourg, 25 June 1996)
- *"REAFFIRMS that, with a view to meeting the ultimate objective of the United Nations Framework Convention on Climate Change [...] to prevent dangerous anthropogenic interference with the climate system, overall global annual mean surface temperature increase **should not exceed 2°C above pre-industrial levels** in order to limit high risks, including irreversible impacts of climate change; RECOGNISES that 2°C would already imply significant impacts on ecosystems and water resources [...]"* (2610th Council Meeting, Luxembourg, 14 October 2004 Council 2004, 25-26 March 2004)

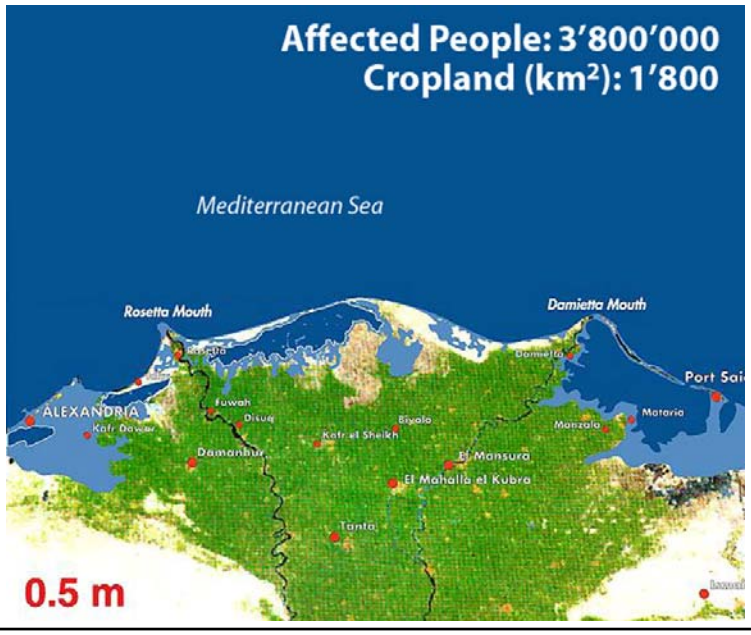
Temperature increase higher over land



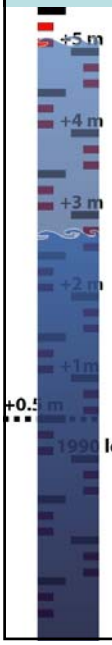
Reasons for Concern (IPCC TAR WGII)



Potential Impact of Sea Level Rise: Nile Delta



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 shows 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

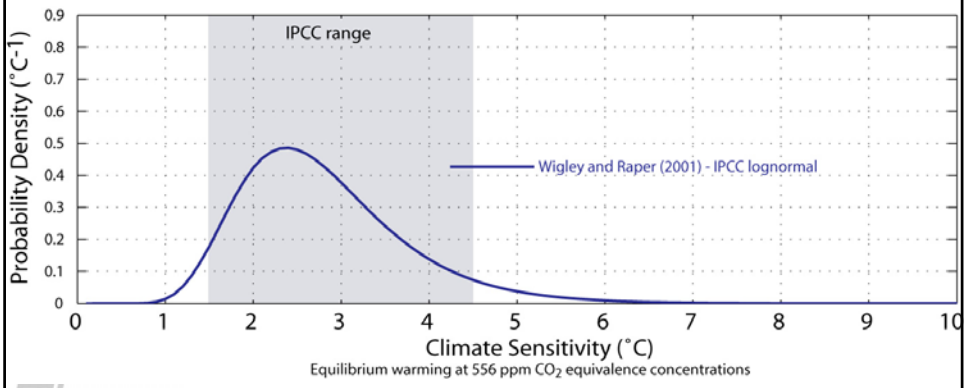
What CO_2 level corresponds to 2°C?

Expected warming for ~550ppm CO_2eq

Climate Sensitivity ...

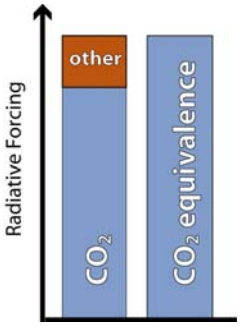
... summarizes key uncertainties in climate science

... is the expected average warming of the earth's surface for a doubling of CO_2 concentrations (about 550 ppm CO_2)



Background: Difference between CO_2 and CO_2equivalence

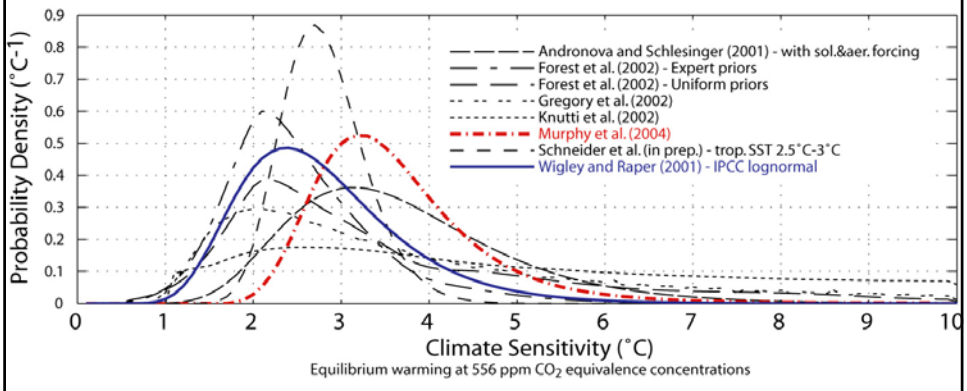
- "CO_2equivalence" summarizes the climate effect ('radiative forcing') of all human-induced greenhouse-gases and aerosols, as if we only changed the atmospheric concentrations of CO_2.
- Like "bread exchange" units for food or "tonnes oil equivalent (toe)" for energy sources.



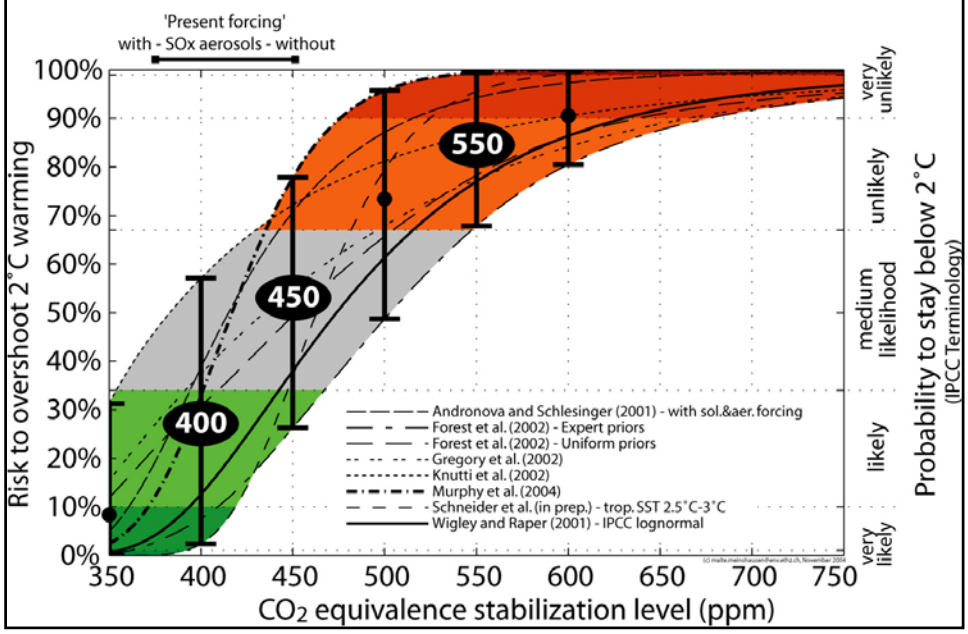
Conversion Table for > 2100		
CO_2 (ppmv) + other GHG + aerosols		CO_2eq (ppmv)
350 + other	≈	400
390 + other	≈	450
470 + other	≈	550
550 + other	≈	650

Expected warming for ~550ppm CO_2eq

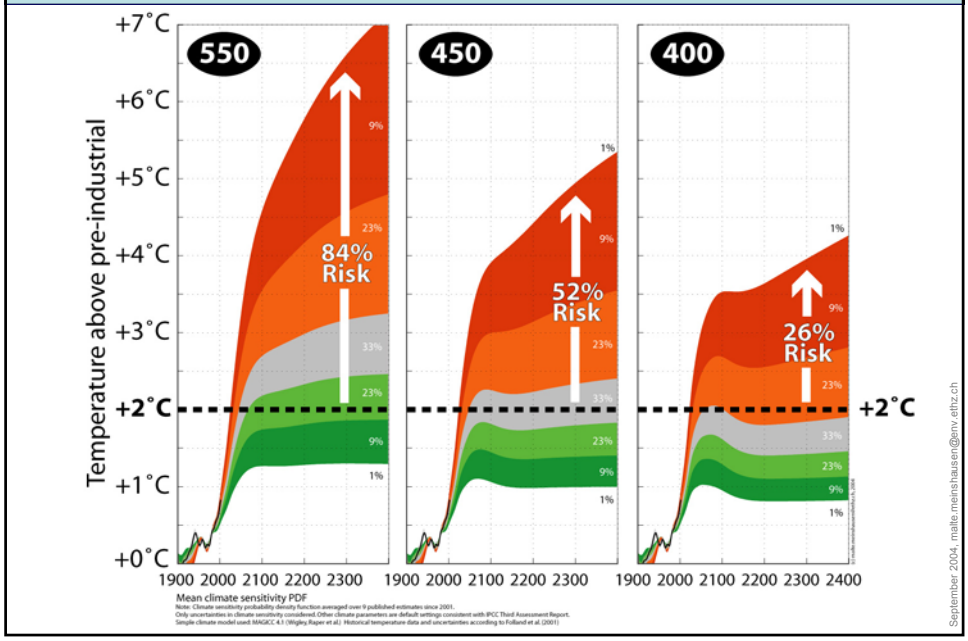
- New research cannot exclude very high warming levels (e.g. > 4.5°C) for stabilization of greenhouse gases at 550ppm CO_2 equivalence
- "*The fact that we are uncertain may actually be a reason to act sooner rather than later*" (Eileen Claussen)



The risk to overshoot 2°C



The Risk to overshoot 2°C



Conclusions Part 2

What CO2 level corresponds to 2°C?

- 550 ppm CO_2 equivalence is “unlikely” to meet the 2°C target
- 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%)
- The risk to overshoot 2°C can be substantially reduced for lower stabilization levels.
- There is a “likely” achievement of the 2°C target for stabilization at 400ppm CO_2eq (the mean risk to overshoot 2°C is about 25%).

Part 3

What are the necessary global emission reductions?

Background

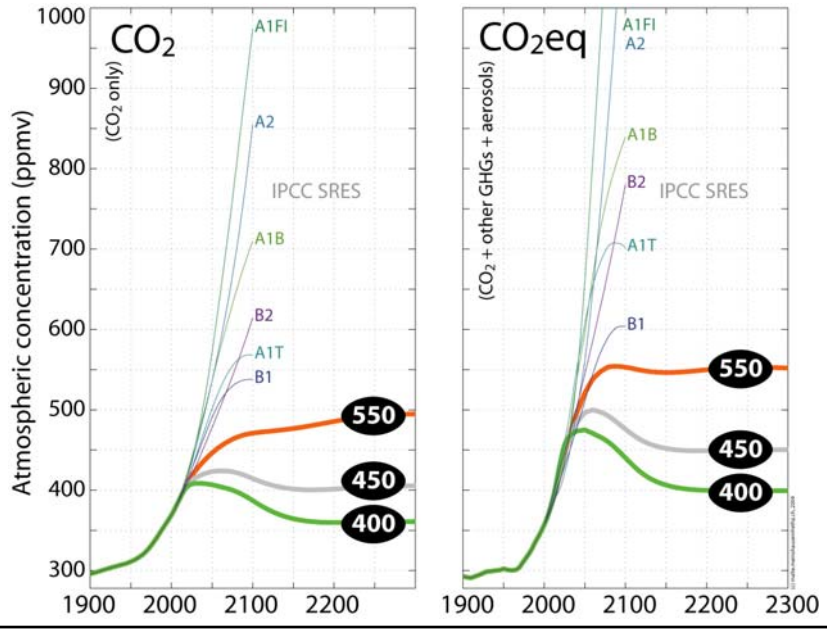
The presented stabilization pathways ("EQW")...

- 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")...

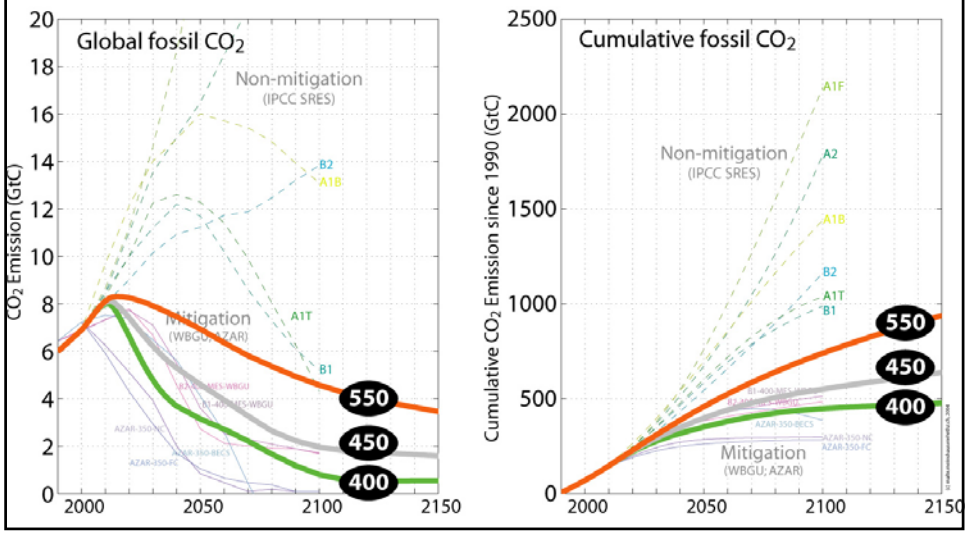
- is the primary simple climate model used in IPCC's Third Assessment Report for global mean temperature and sea level rise projections
- is built by Wigley, Raper et al. and available online at http://www.cgd.ucar.edu/cas/wigley/magicc/

Greenhouse-gas Concentrations

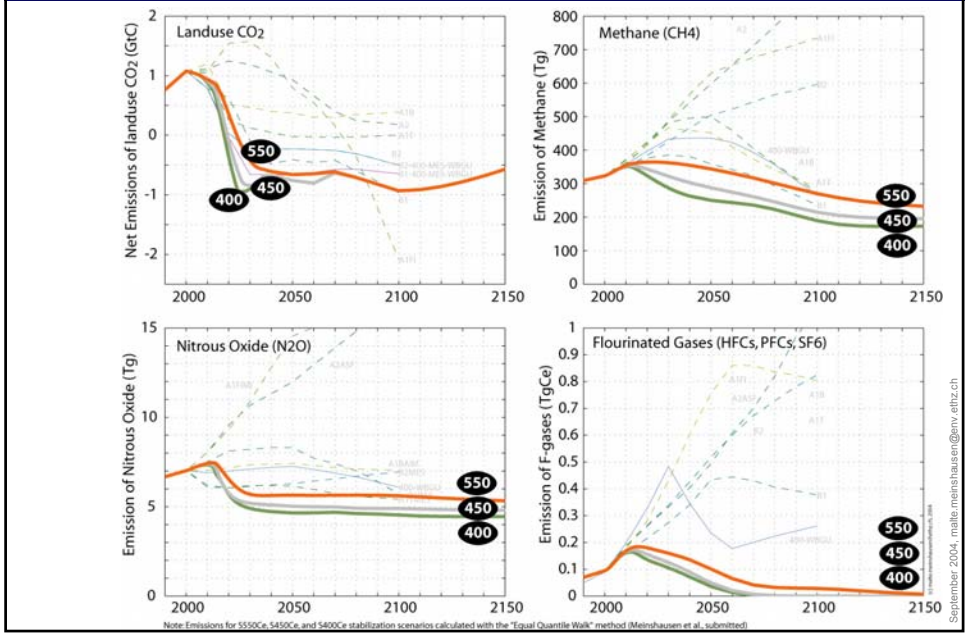


Fossil Fuel CO_2 emissions

- Fossil carbon budget about 500 GtC for stabilization at 400 ppm CO_2eq. Can be lower (<400 GtC), depending on net landuse emissions.

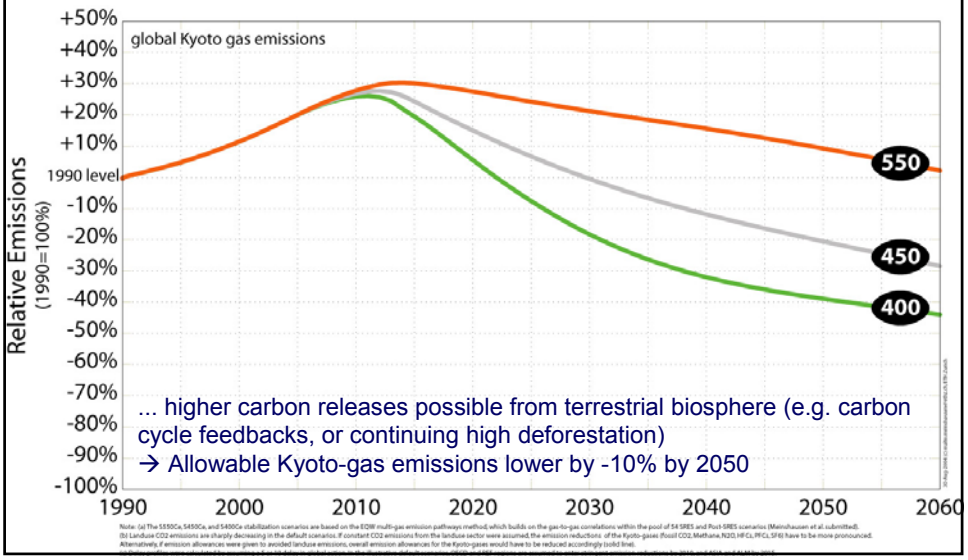


Other Greenhouse Gas Emissions



Kyoto-gas emissions relative to 1990

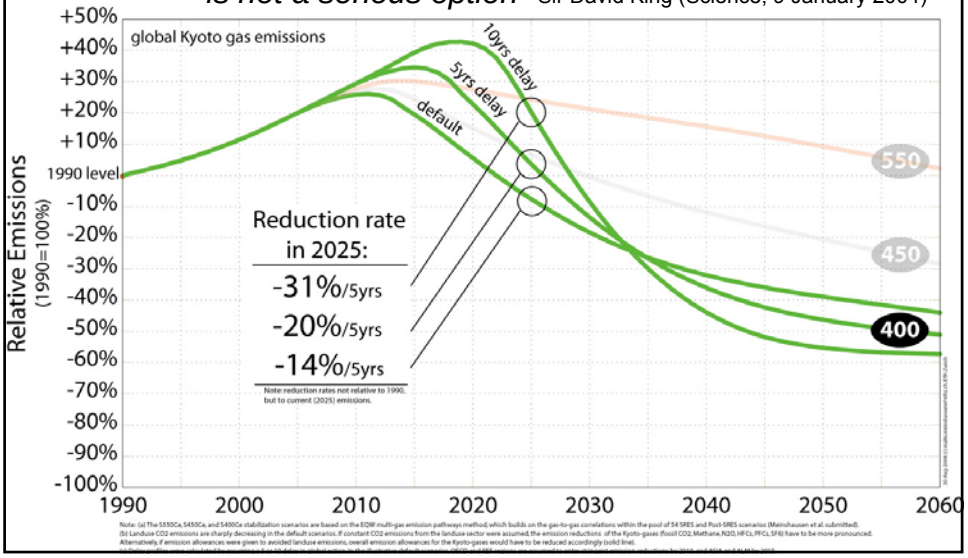
- For stabilization at 400ppm CO2eq, global emissions have to be reduced by about 40% below 1990 levels at around 2050, but ....



... higher carbon releases possible from terrestrial biosphere (e.g. carbon cycle feedbacks, or continuing high deforestation)
→ Allowable Kyoto-gas emissions lower by -10% by 2050

Issue: Delay

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



Conclusions Part 3

Part 3: What emission reductions are necessary?

- For stabilization at 550 ppm, Kyoto-gas emissions have to return to about 1990 levels by 2050.
- For stabilization at 450 ppm, Kyoto-gas emissions have to be reduced by -20% to -30% below 1990 levels by 2050.
- For stabilization at 400 ppm, Kyoto-gas emissions have to be reduced by -40% to -50% below 1990 levels by 2050.
- A delay of global action by 10 years doubles the required reduction rates in 2025. Specifically, from 14% per 5 year commitment period to -31% per commitment period.
- Open question about how fast the "ocean tanker" can brake.

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)

Appendix: Methods & Credits

- **STABILIZATION EMISSION PATHSWAYS:**
  The three presented stabilization emission paths EQW-S550Ce, EQW-S450Ce, 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.

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References

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- Meinshausen, M., W. Hare, T. Wigley, D. van Vuuren, M. den Elzen, R. Swart (submitted) "Multi-gas emission pathways to meet climate targets", submitted to Climatic Change, June 2004, available from the author.
- Hare, B. and M. Meinshausen (2004) "How much warming are we committed to and how much can be avoided?", PIK-Report No. 93, available online at http://www.pik-potsdam.de/publications/pik_reports

Climate sensitivity studies summarized in this presentation:

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- Forest, C.E., Stone, P.H., Sokolov, A., Allen, M.R. and Webster, M.D.: 2002, 'Quantifying Uncertainties in Climate System Properties with the Use of Recent Climate Observations', Science 295, 113-117.
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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.

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Appendix: Additional slides

Millions at Risk (Parry et al., 2001)