Emission pathways reducing the risk of dangerous climate change

Kirsten Zickfeld

Climate Modelling Group
School of Earth and Ocean Sciences
University of Victoria

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Outline

- What is “dangerous climate change”?
- The UVic Earth System Climate Model
- Experimental design
- Results: CO_2 emissions compatible with specified temperature targets
- Conclusions

UNFCCC Article 2

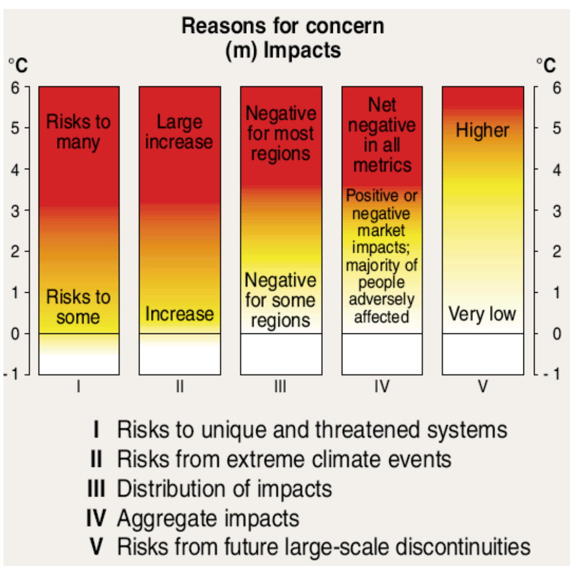
“The ultimate objective of this convention … is to achieve … stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.
Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.”

What is “dangerous”?

Interpretation of Article 2 involves

- Scientific assessment of what impacts might be associated with different levels of greenhouse gas concentrations or levels of climate change.
- Normative evaluation by policy-makers of which impacts and associated likelihoods constitute “dangerous anthropogenic interference”.

IPCC’s reasons for concern



IPCC, TAR, Synthesis Report, 2001

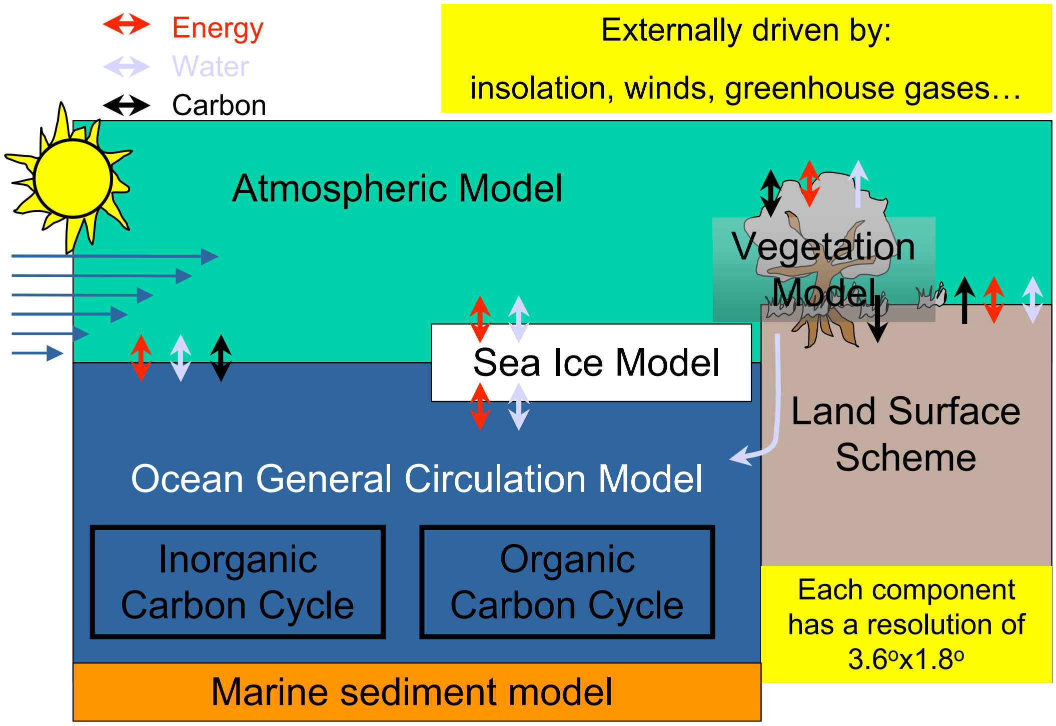
Motivation

- Recent international climate policy discussions framed around limiting global mean temperature increase to 2°C relative to pre-industrial times.
- Earlier studies have linked specific CO_2 concentration levels with the probability of meeting the 2°C target.
- Probability of meeting that target is ‘likely’ ($p<0.33$) at CO_2 equivalence concentration levels below 450 ppmv.
- Link to allowable CO_2 emissions usually provided by integrated assessment models including highly simplified representation of the carbon cycle.
- Scope of this study: Consistently derive cumulative emissions compatible different temperature targets using state-of-the-art climate-carbon cycle model.

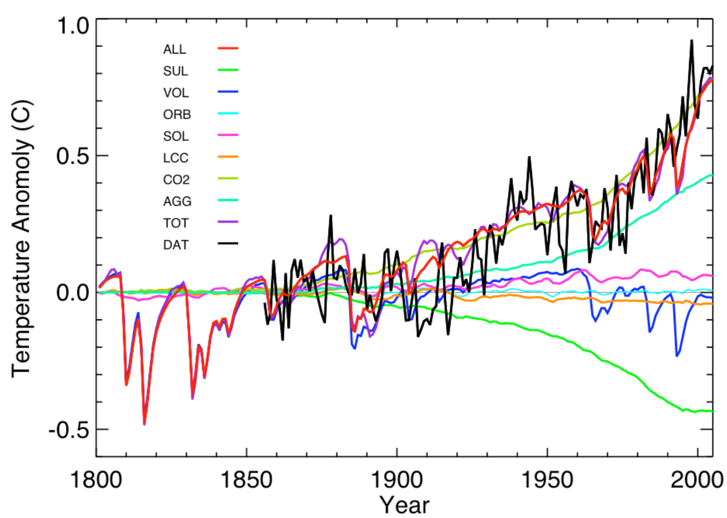
The UVic Earth System Climate Model

- “Intermediate complexity” model.
- Suited for climate studies on decadal to millennial time-scales.
- Computationally efficient (~160 model years in 1 day).

The UVic Earth System Climate Model

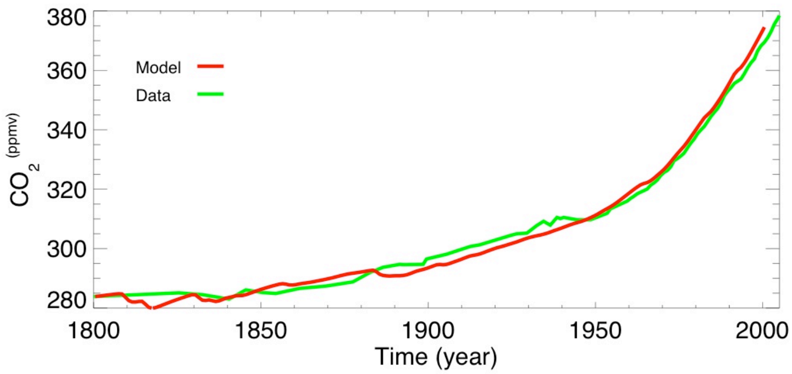


Model evaluation: Historical temperature change



Data: Jones et al. (2006)

Model evaluation: Historical CO_2 change



Data: Keeling et al., 2005

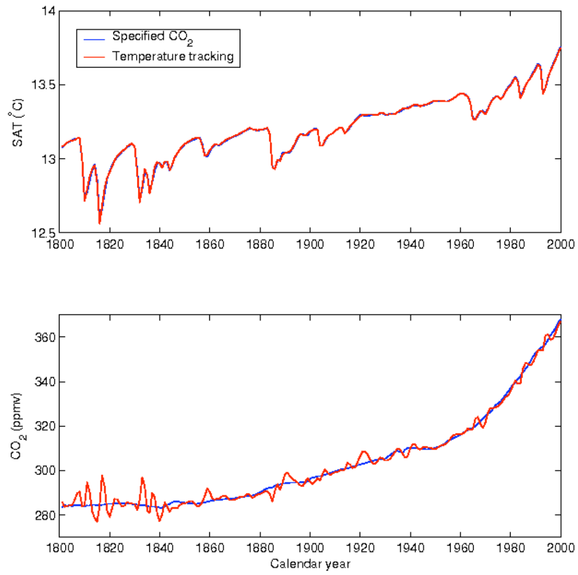
Experiment design

- Over the historical period (1800-2000) the model is driven by known forcings (greenhouse gases, sulphates, solar irradiance, volcanoes, land cover change).
- From 2000 on the model computes the CO_2 emissions consistent with a specified temperature profile ("temperature tracking"). Most non-CO_2 forcing agents are hold constant at year-2000 levels.
- Proportional control:

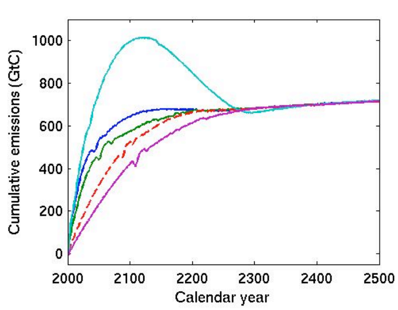
$$E(t) = k(\Delta T^{DATA}(t) - \Delta T(t))$$

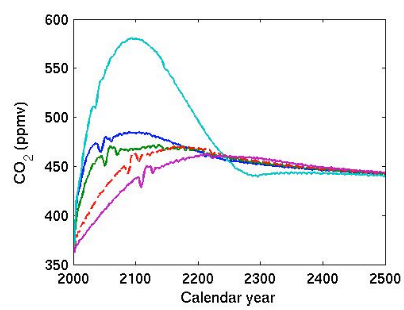
E - CO_2 emissions
k - constant
ΔT^{DATA} - prescribed temperature anomaly
ΔT - modelled temperature anomaly

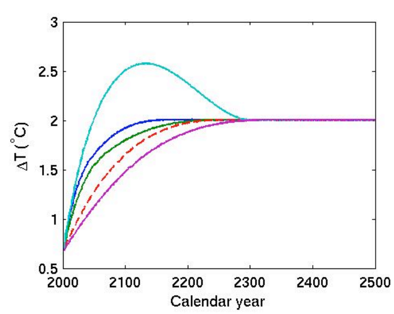
Temperature tracking



Cumulative emissions meeting 2°C target

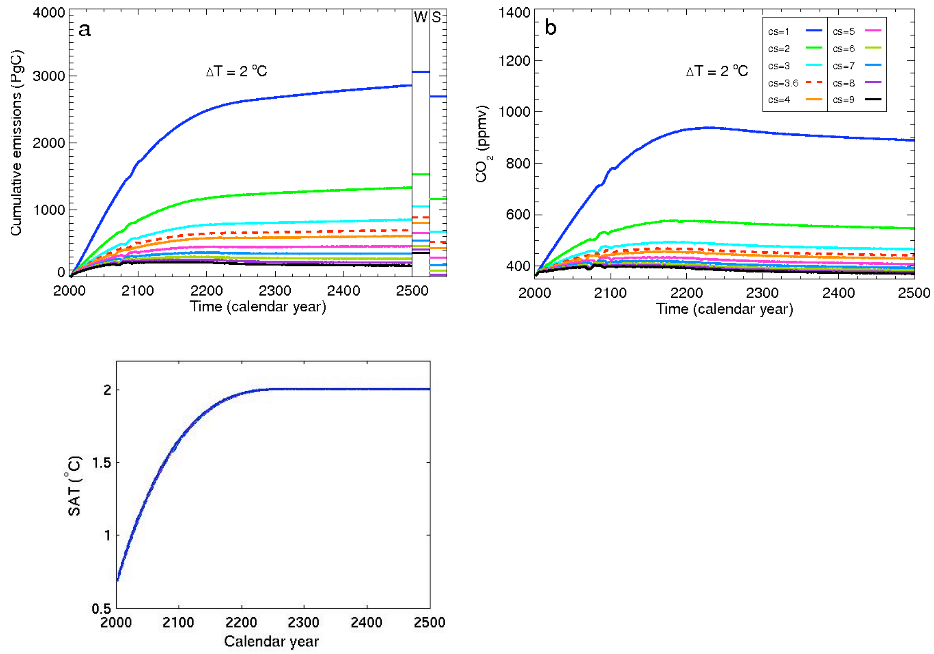




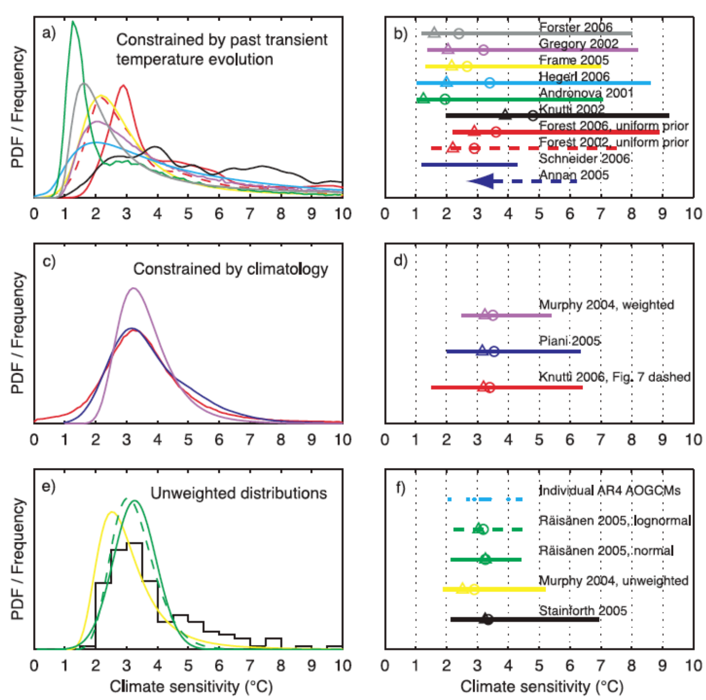


> Cumulative emissions in 2500 independent of specified temperature trajectory

Variation of climate sensitivity



PDFs for climate sensitivity



IPCC 2007, WG I, Ch 10

Probability of exceeding temperature target

Given $E(cs^0, \Delta T^{GOAL})$

$$P(\Delta T(E) \geq \Delta T^{GOAL}) = \int_{cs^o}^{\infty} P(cs = x)\, dx$$

$$= P(cs \geq cs^0)$$

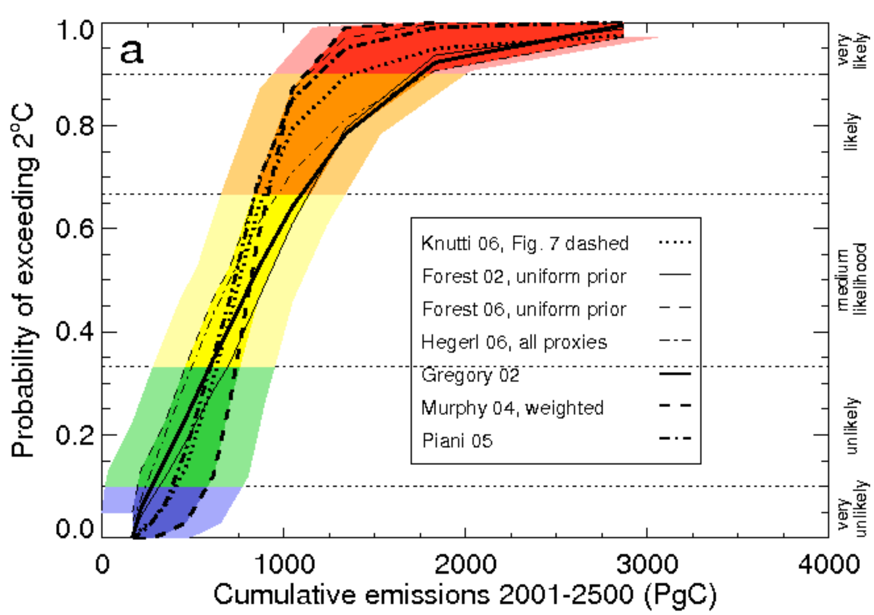
ΔT^{GOAL} - Temperature target

cs - Equilibrium climate sensitivity

$P(cs = \Delta T)$ - Climate sensitivity PDF

$P(cs \geq \Delta T)$ - Climate sensitivity CDF

Probability of exceeding 2°C target



Conclusions

- Cumulative CO_2 emissions compatible with 2°C target independent of path taken to stabilization.
- To limit global mean temperature rise to 2°C above pre-industrial with a probability of 0.33 cumulative emissions after 2000 must not exceed 640 PgC (range: 280-930 PgC).
- We suggest shift in focus from allowable greenhouse gas concentrations to total allowable emissions.
- Path independency may facilitate international climate policy negotiations: Countries are allocated total emissions shares. No need to agree on common time-line.

Thank you for your attention!

Contact:

Dr. Kirsten Zickfeld

Climate Modelling Group
School of Earth and Ocean Sciences
University of Victoria
Ian Stewart Complex
PO Box 3055 Stn CSC
Victoria, BC, V8W 3P6

Tel.: +1-250-4724008
Email: zickfeld@ocean.seos.uvic.ca
WWW: http://climate.uvic.ca/people/zickfeld

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