Quantifying the Benefits of Temporary Carbon Sequestration

I.G. Enting

MASCOS

The University of Melbourne

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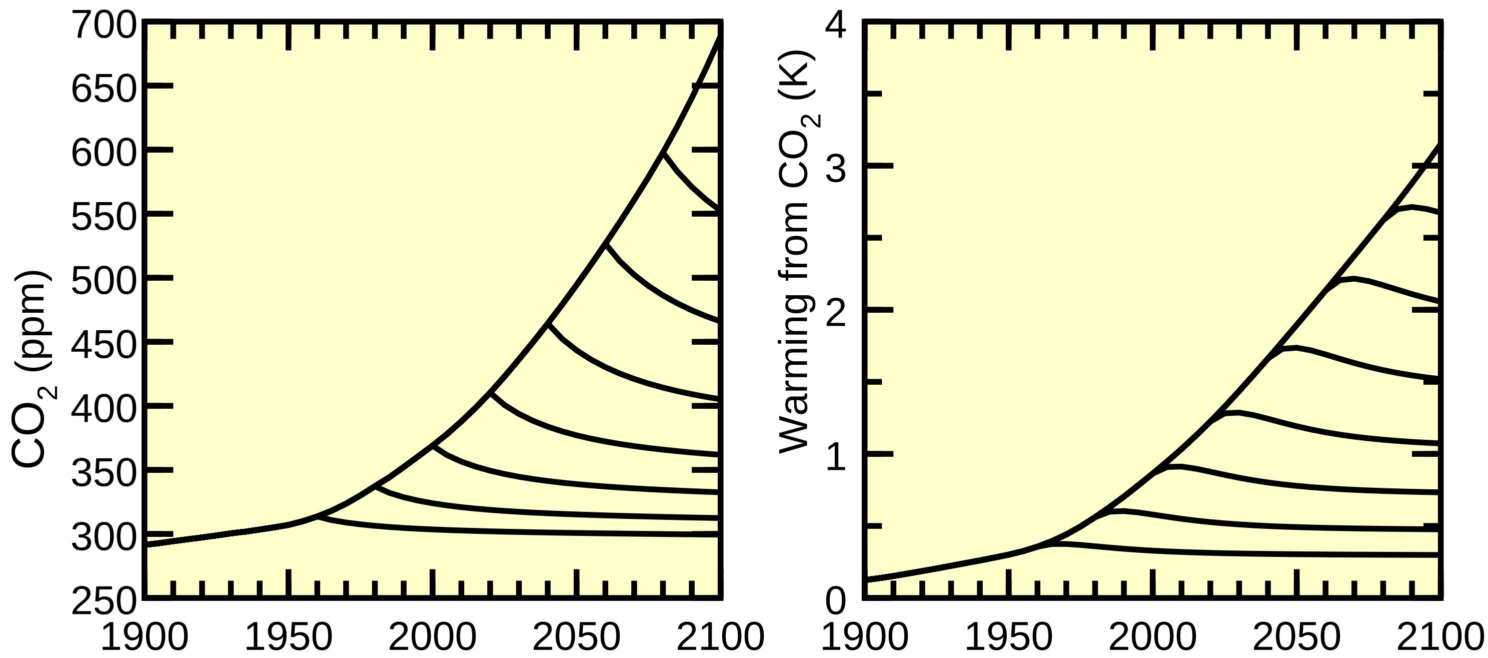
Summary

- Climate Change and Mitigation
  - Time-scale issues
  - Indicators of global change
- Sequestration
  - terrestrial — oceanic — geological
- The IPCC CCS Special Report
- Time-scale issues
  - Plantation
  - Geosequestration

Timescales

CO_2 concentrations and consequent warming, partitioned according to time of emission.



Lowest bands are from pre-1960 emissions, next from 1960 to 1980 emissions, etc.
Increase in contribution to warming after time of emissions from ‘committed warming’ effect.

Mitigation Frameworks

Targets : Fixed vs flexible.

- equal reductions (Kyoto – annex 1 only);
- sector-based, as 'used' within EU;
- reflect responsibility (Brazilian proposal);
- contraction and convergence.

Mechanisms :

- Taxes, permits, subsidies.

Technologies :

- Efficiency, substitution, sequestration.

The IPCC CCS Report*

Carbon Capture and Storage

Report covers: sources, capture, transport, storage for:
ocean sequestration, geosequestration, mineralisation.

Geosequestration capacities: $GtCO_2$			
Oil and gas fields	650	–	900
Unminable coal seams	3	–	200
Deep saline formations	1000	–	10000

Divide by 3.7 to get GtC.

* Based on internet version of 10 October 2005.

Comparisons

Reservoir:	Land	Ocean	Geological
Technique:	Plantation	CO_2-injection * liquid or dissolved	Injection oil/gas fields saline formations
Time-scale:	Decades	Centuries +	Millennia + ?
Risks:	Harvest Fire	Ocean acidity	Leakage Sudden escape

* Note: Fe-fertilisation seems to be ineffective.

Note also BECS: Biofuel energy capture and storage.

Indicators of Global Change

Measures of global change for comparing strategies:

- Integrated radiative forcing
  - (as in GWPs)
- Temperature change
  - projected to specific time
- Rate of temperature increase
  - rate of change vs adaptive capability of human and natural systems

Different indications capture different timescales of global change.

Much of this work is based on approaches used in analysing the Brazilian proposal.

Harvest Analysis

For temporary sequestration in plantations:

- GWPs imply no net benefit
- Integrated radiative forcing **evaluated at any single time** shows net benefit (Dobes, Enting and Mitchell 1998).
- Carbon release after harvest can lead to exacerbating rate of change of temperature.
  - With limited land available, terrestrial sequestration should be timed to have uptake phase coincide with time of maximum rate of temperature increase (Kirschbaum).

Geosequestration Calculations

Capture efficiency: Assume 90%.

Energy penalty: Assume 30%,
(c.f. IPCC 24% to 40% to achieve 90% capture).

Leakage rates: 10, 1, 0.1, 0.01, 0.001 % pa.

CO_2 model: Non-linear CO_2-fertilisation and air-sea exchange coupled to linear responses (Joos et 1996).*

Climate response: Two timescale response function. *

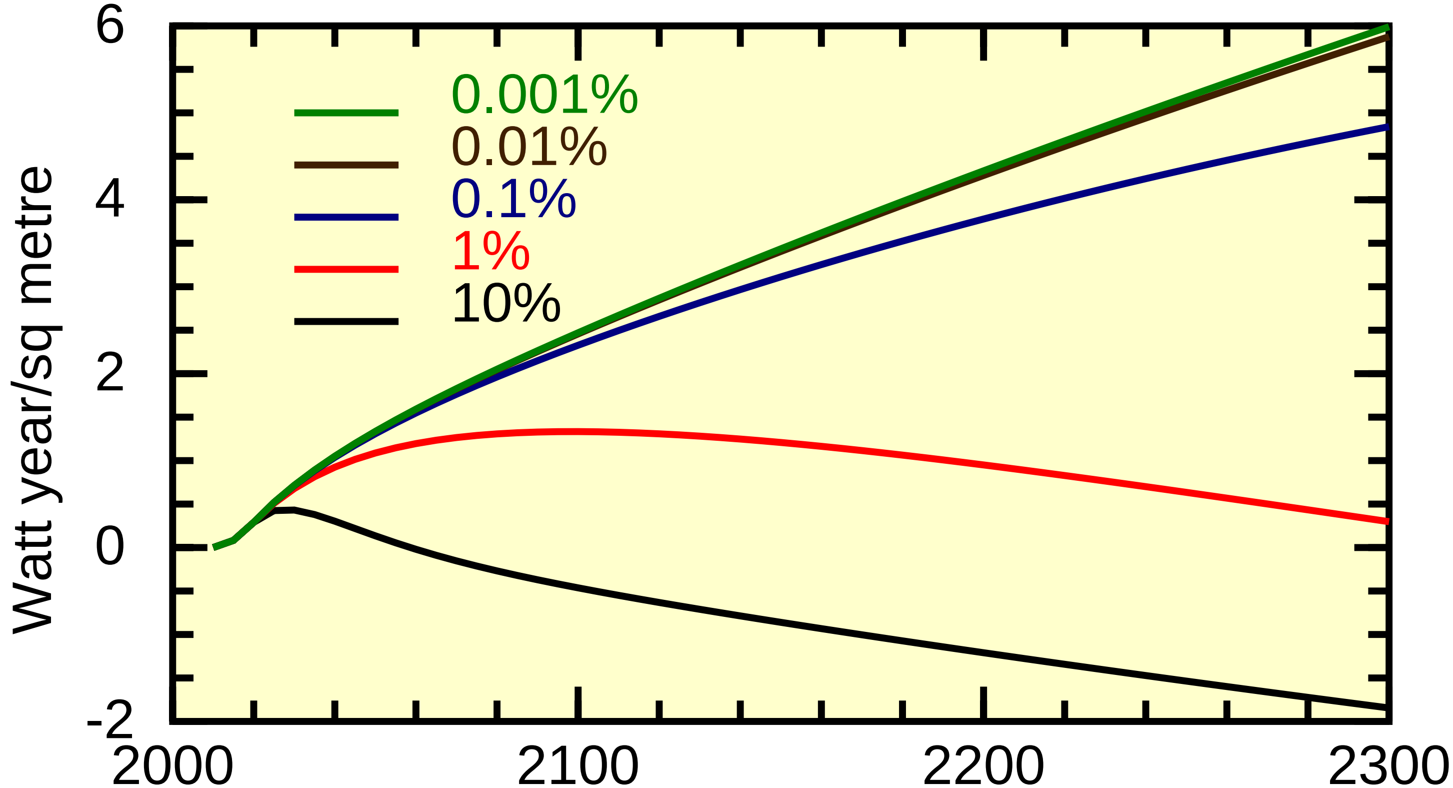
Comparisons: 1 GtC/yr over 2010-2020, c.f. 1.3GtC/yr 90% captured, but subject (post-2020) to specified annual leakage rate).

Limitations: Full account of non-linearities would require perturbation with respect to specific scenario.

***** as used in CSIRO Brazilian proposal studies.

For Greenhouse 2005

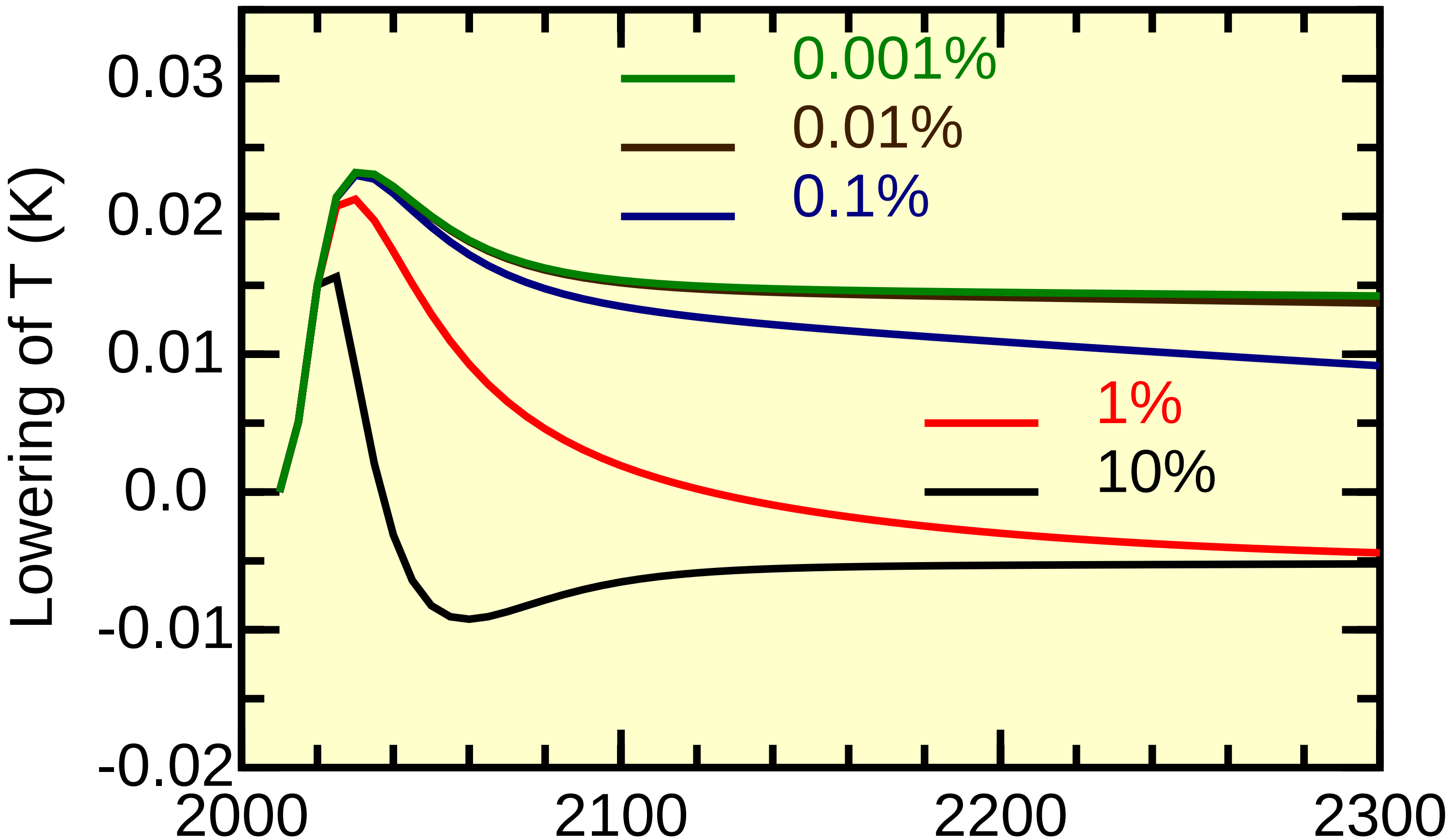
Integrated Radiative Forcing



Time-integrated radiative forcing from replacing 1 GtC/yr over 2010–2020 by geosequestration with 90% capture efficiency, 30% energy penalty for sequestration and various leakage rates.

For Greenhouse 2005

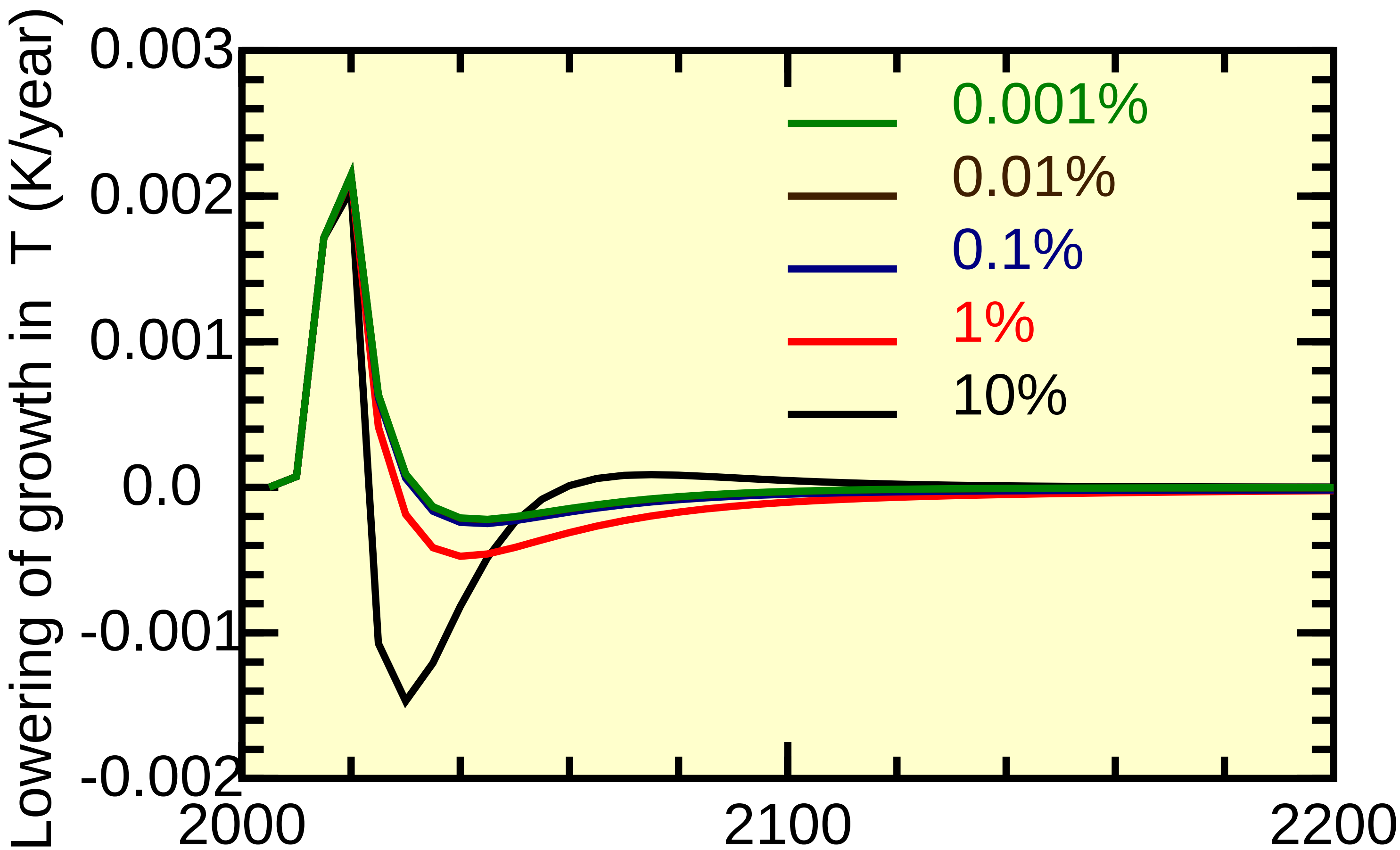
Temperature



Temperature reduction from replacing 1 GtC/yr over 2010–2020 by geosequestration with 90% capture efficiency, 30% energy penalty for sequestration and various leakage rates.

For Greenhouse 2005

Temperature Growth Rate



Reduction in temperature growth rate from replacing 1 GtC/yr over 2010–2020 by geosequestration with 90% capture efficiency, 30% energy penalty for sequestration and various leakage rates.

For Greenhouse 2005

Conclusions

- Geosequestration provides benefits when characterised in terms of a variety of climate ‘indicators’.
- Benefits accrue for leakage rates of order 1%pa or lower.
- Reduction in temperature growth rate is not followed by rebound
  - Geosequestration does not require sensitive timing needed for effective mitigation by temporary biosequestration.