Modelling the Risks of Climate Change

Prepared for the Cambridge Centre for Risk Studies

by

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Plan of talk

- The need for evidence.
- The PAGE09 model.
- Scientific and economic inputs.
- Impacts and $SCCO_2$.
- Next steps.

The need for evidence

A global deal to tackle climate change is all but impossible in 2010, leaving the scale and pace of action to slow global warming in coming decades uncertain, according to senior figures across the world involved in the negotiations.

The climate secretary, Ed Miliband, last night warned of the danger of a public backlash against the science of global warming in the face of continuing claims that experts have manipulated data.

The Guardian, Monday 1 February 2010

…a third of voters, 33%, say "the planet is getting warmer but this is mostly due to natural forces rather than the actions of humans".

guardian.co.uk, Tuesday 15 December 2009

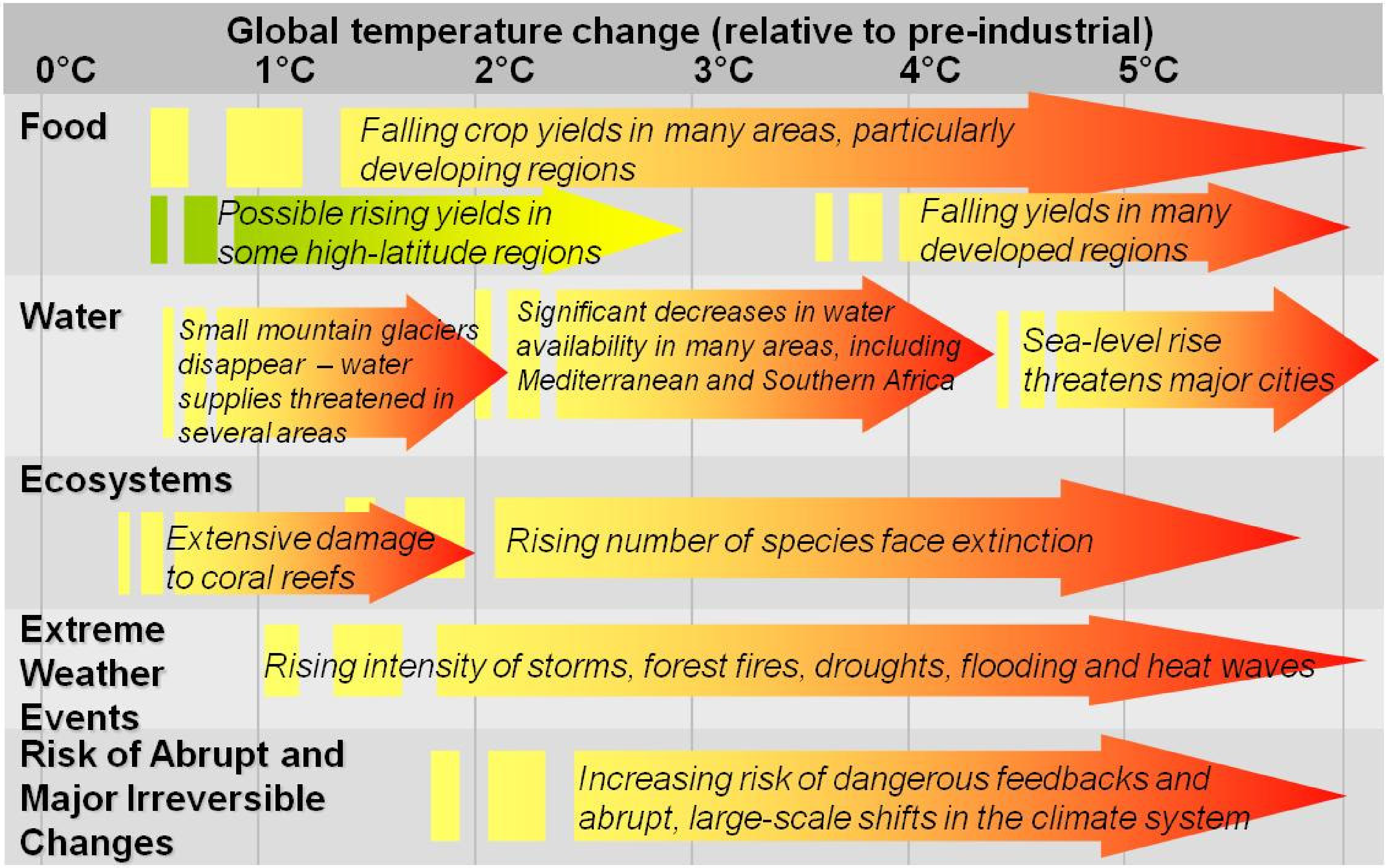
Most viewed on guardian.co.uk in last 24 hours

1. No apology from IPCC chief Rajendra Pachauri for glacier fallacy

2. Climate change emails between scientists reveal flaws in peer review

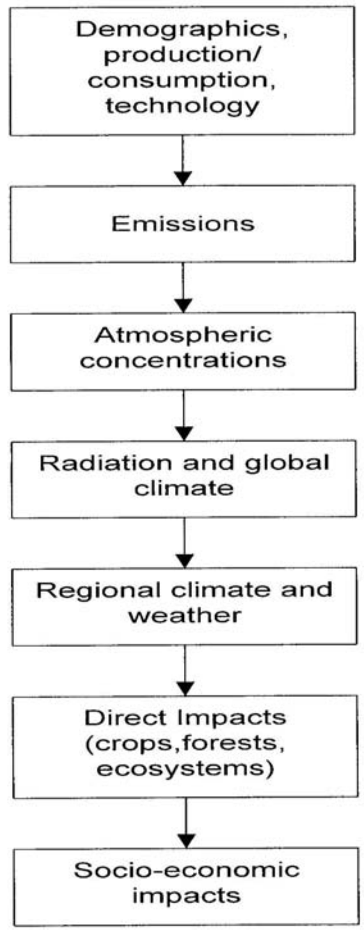
guardian.co.uk, Thursday 4 February 2010

Projected impacts of climate change



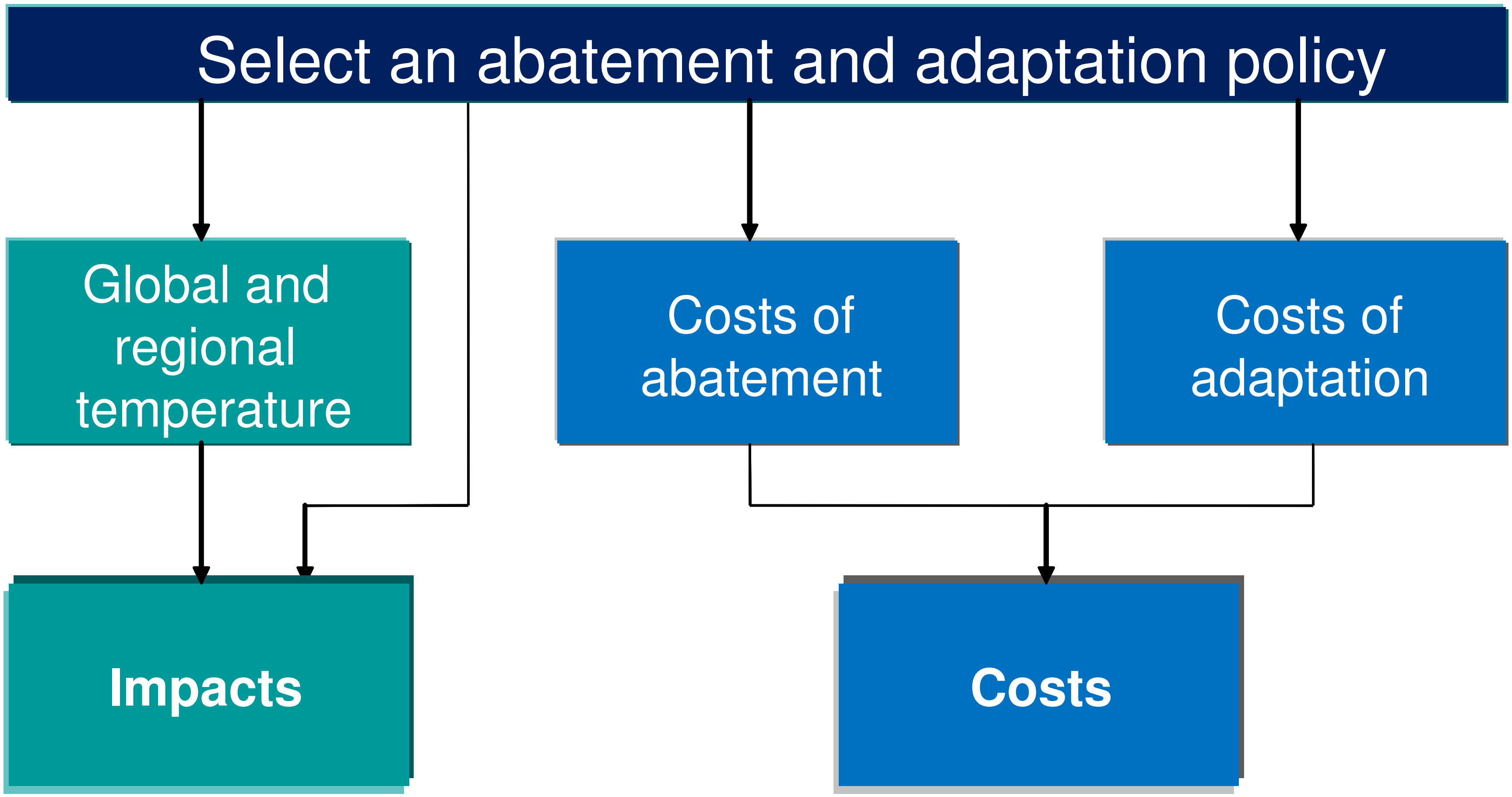
Source: Stern Review on the Economics of Climate Change, 2006

Integrated Assessment Models for Climate Change Policy



Source: Parson and Fisher-Vanden, 1997

Structure of the PAGE09 model



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Brief history of the PAGE model

PAGE = Policy Analysis of the Greenhouse Effect

- PAGE91 – Combining science and economics under uncertainty
- PAGE95 – Added cooling effect of sulphates
- PAGE2002 –Added discontinuities, varying discount rates
- PAGE09

The PAGE09 model

- Excel 2007 worksheet with @RISK 5.5 add-in
- 8 regions
- 10 analysis years
- 4 impact sectors
- 2 policies and their difference
- 112 uncertain inputs
- 10000 runs to calculate probability distributions of outputs

New features of PAGE09

- Better representation of carbon cycle feedbacks.
- Includes sea level rise explicitly.
- Possibility of benefits for small temperature rise.
- Saturation of impacts.
- Impacts as an explicit function of GDP/cap.
- Impacts measured as expected utility.

Comparison with PAGE2002

	PAGE2002	PAGE09
Number of uncertain inputs	93	112
Calculations per run per policy	6017	14399
Emissions and climate	1238	1593
Impacts	2267	5130
Abatement costs	1643	6067
Adaptive costs	869	1609
Calculation method	Relative cell addressing	Range names & array formulas
Runs per second	**50**	**5**

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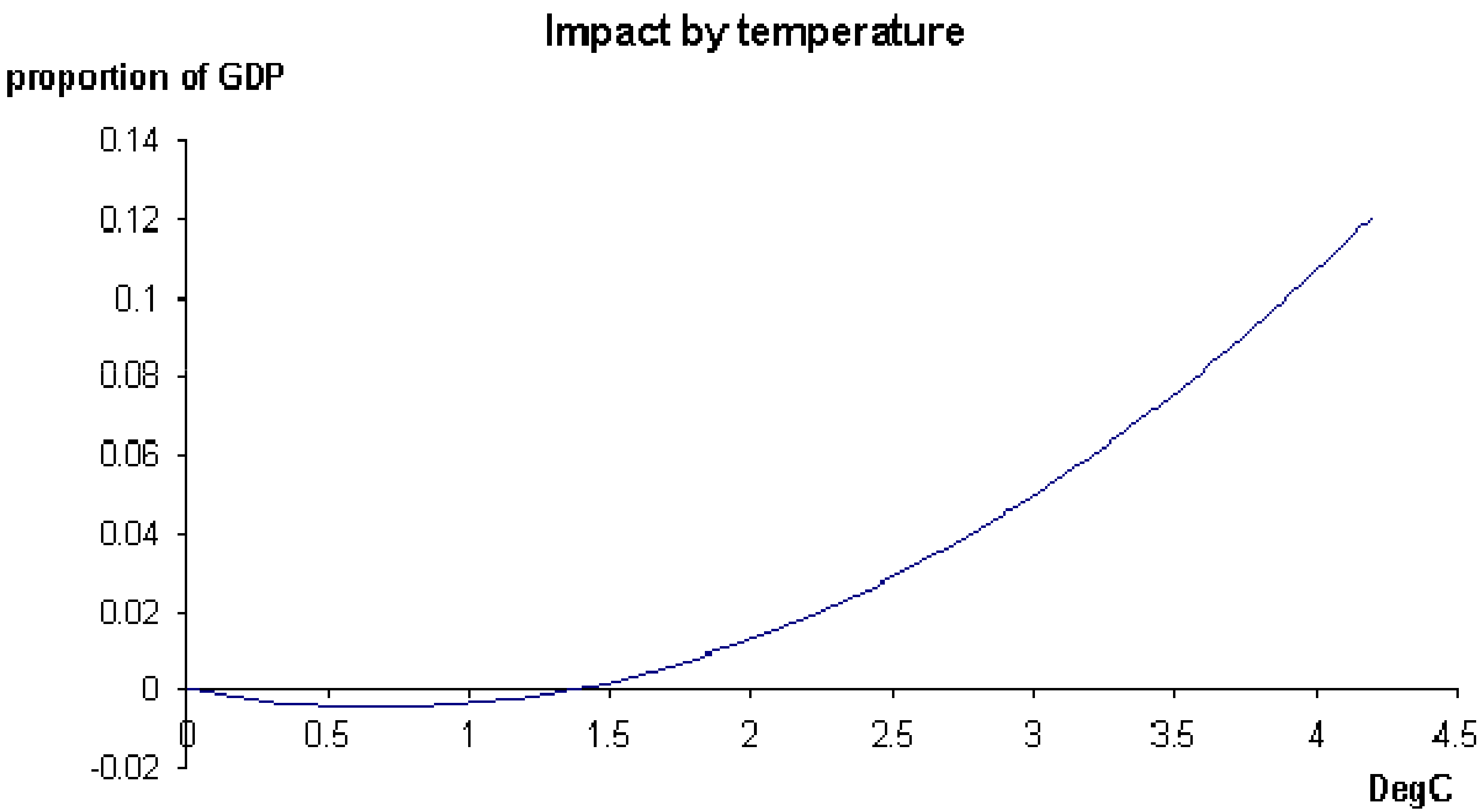
Possibility of benefits



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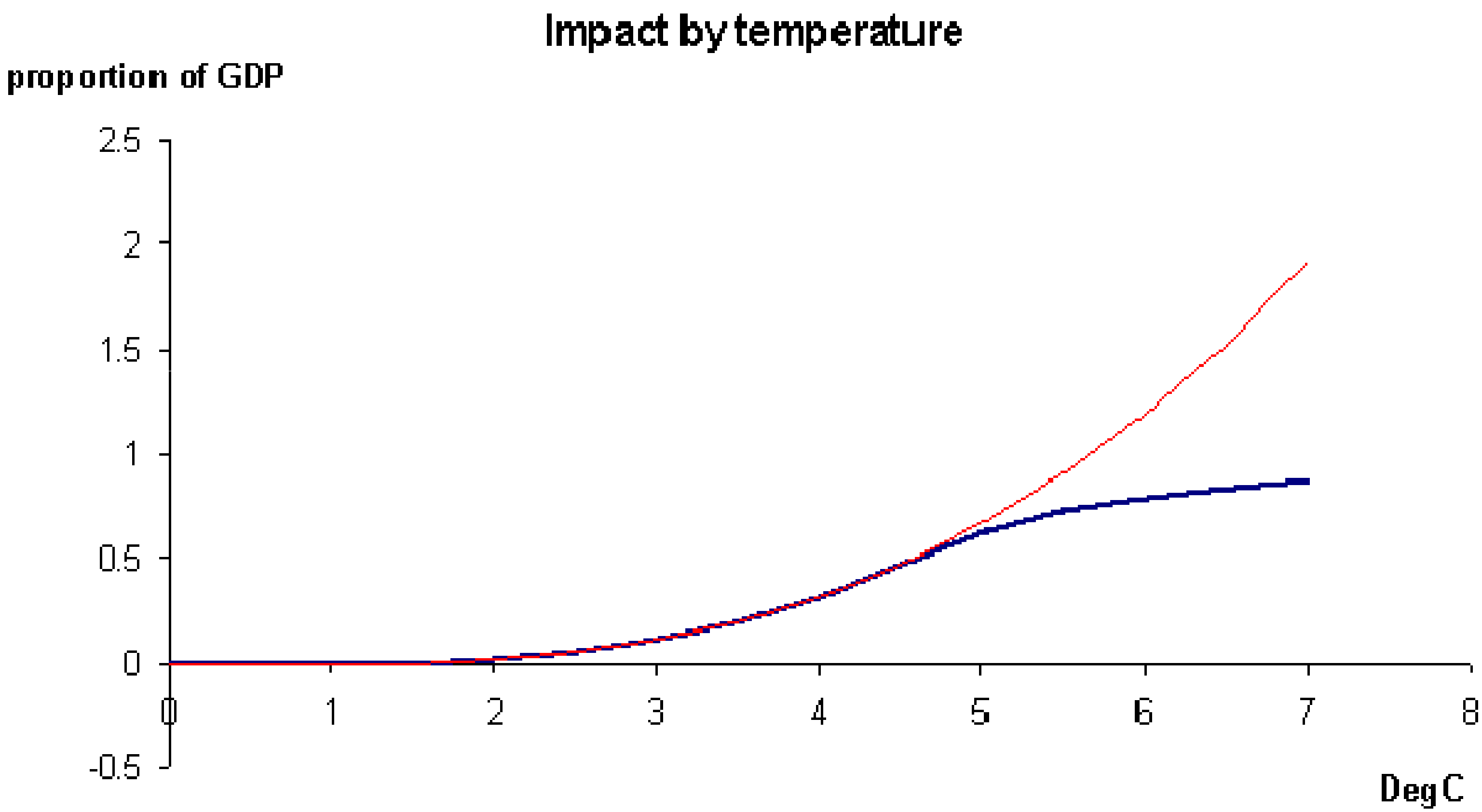
Saturation of impacts



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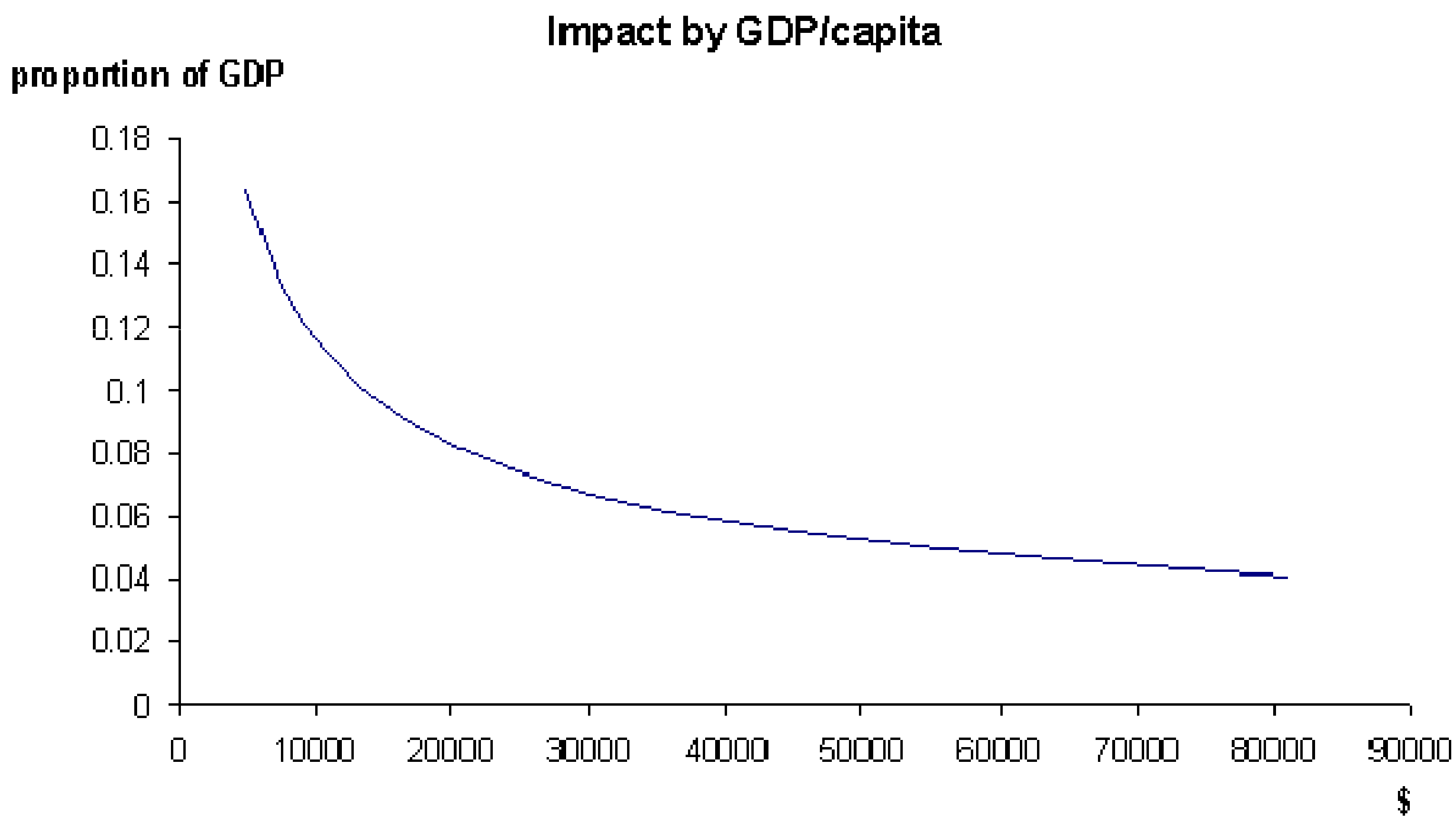
Impacts as a function of GDP/capita



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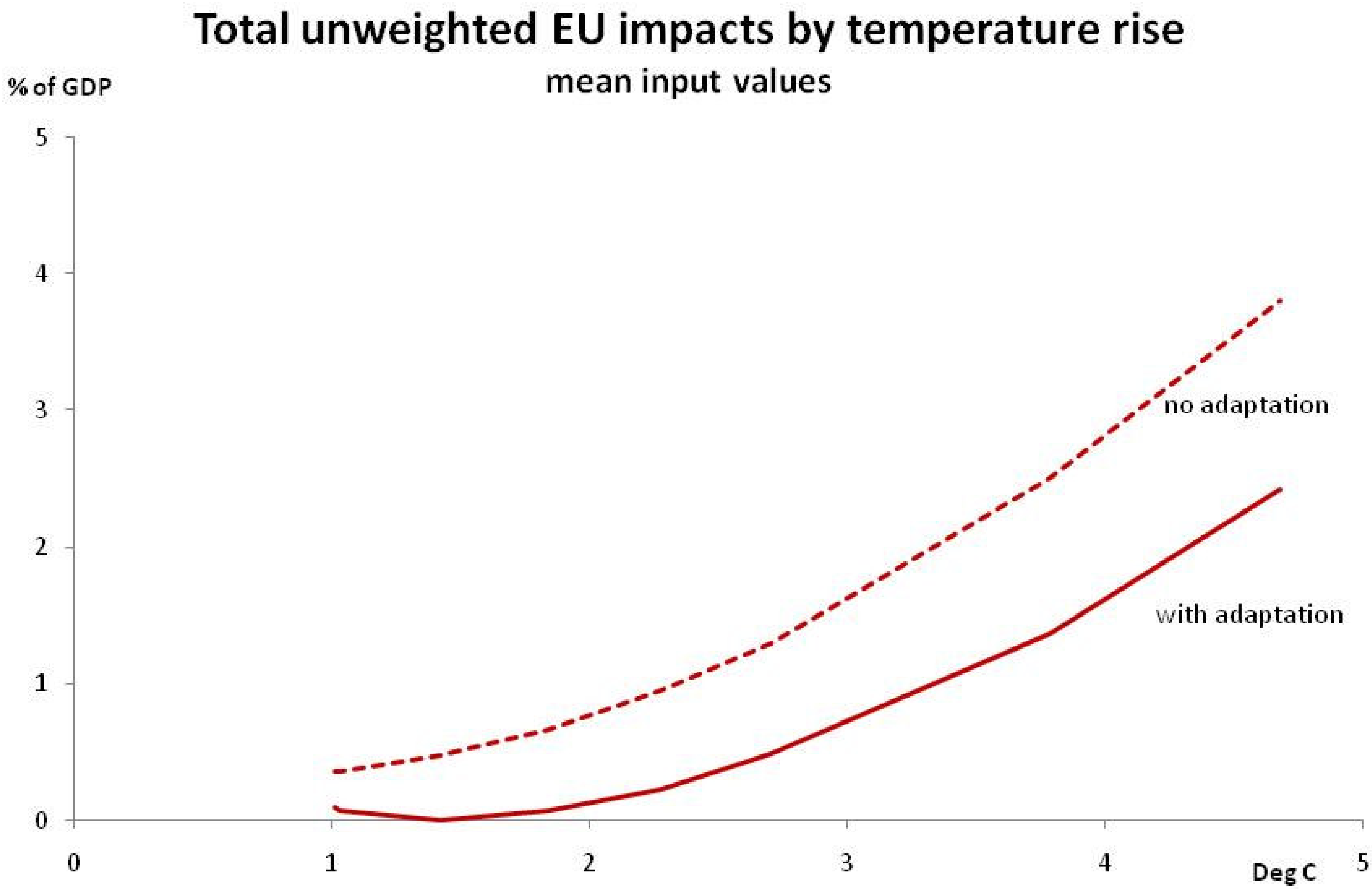
Adaptation



Source: PAGE09; A1B scenario

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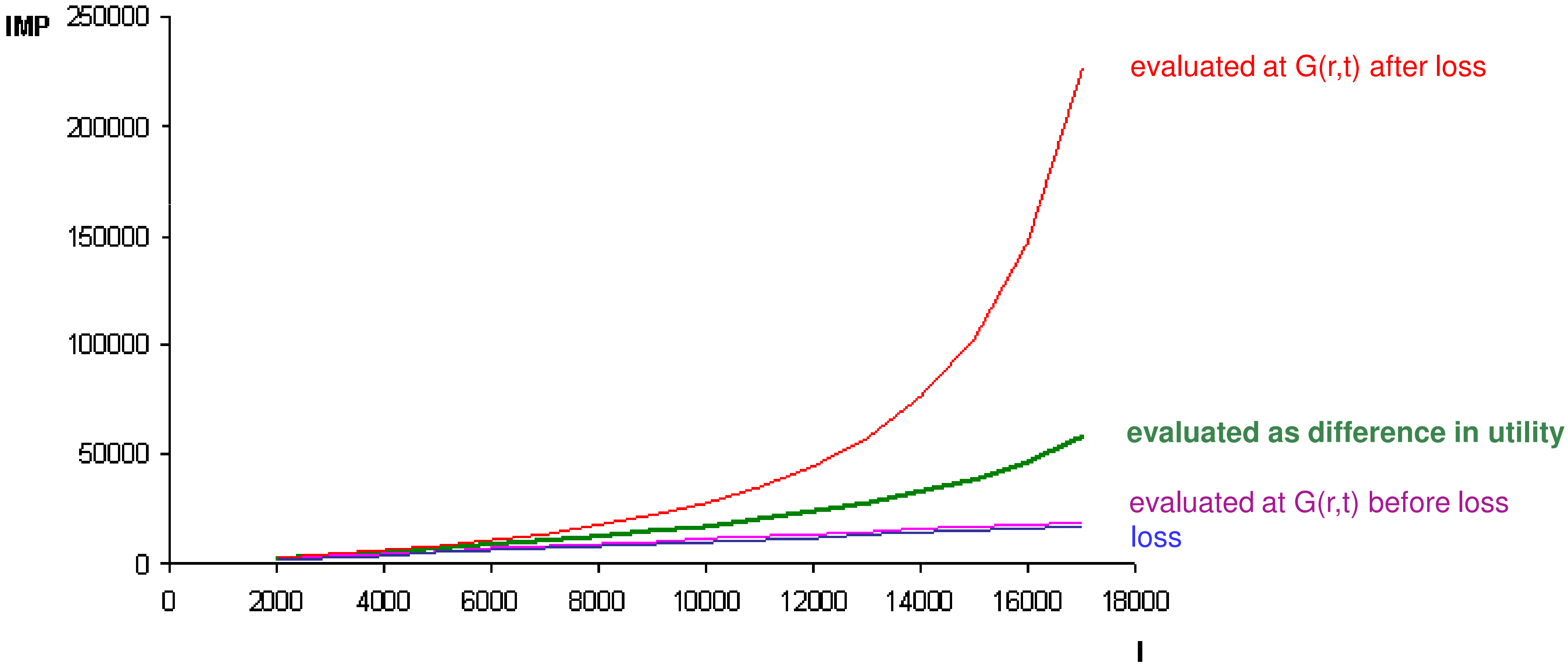
Impacts as expected utility

Multiply loss by (G(r,t)/G(fr,0))^ (-EMUC)

Eg G(fr,0) = $22000, G(r,t) before loss = $20000, EMUC = 1.3 :



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Scientific and economic inputs

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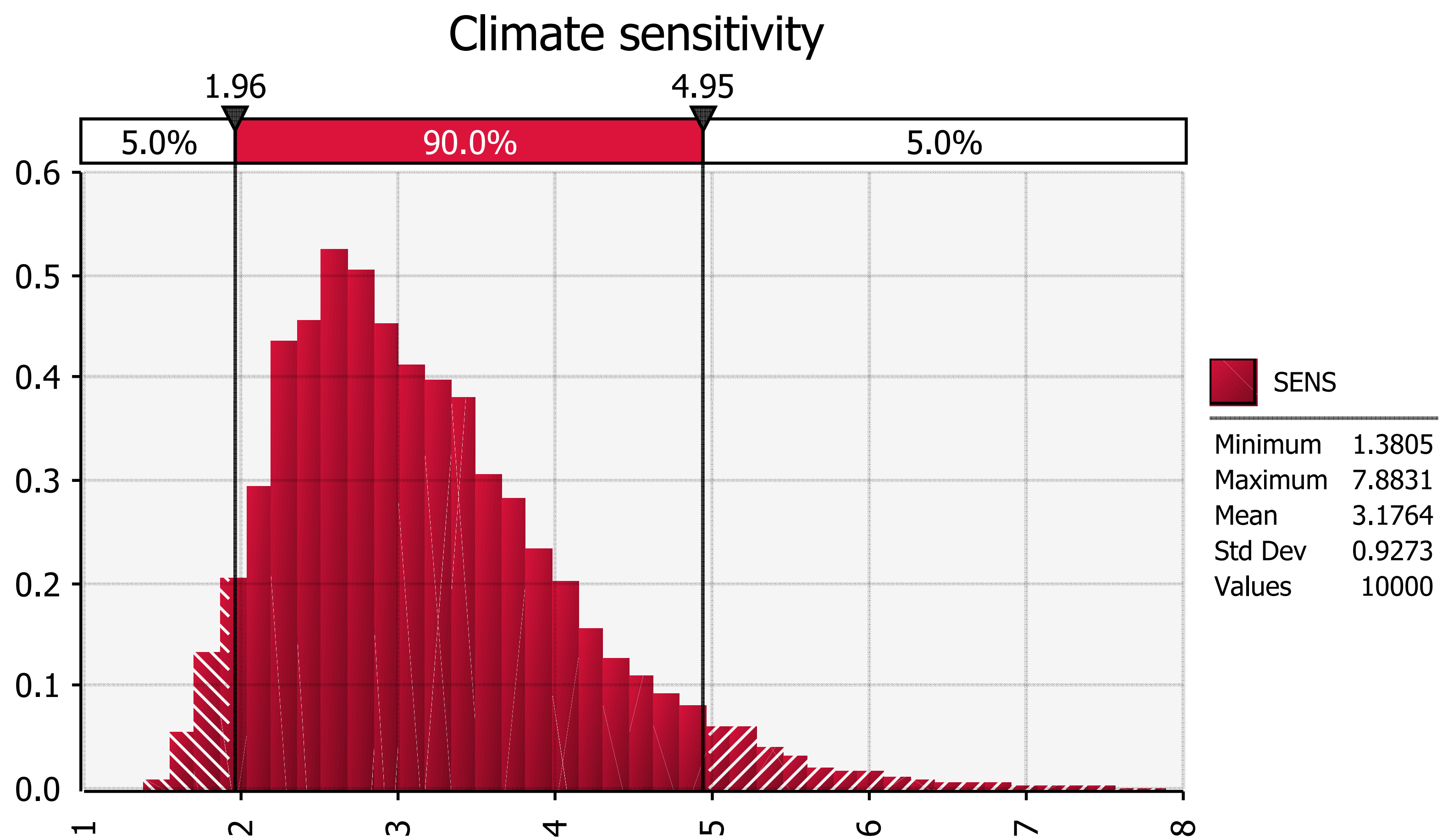
Climate sensitivity



Source: 10000 PAGE09 runs

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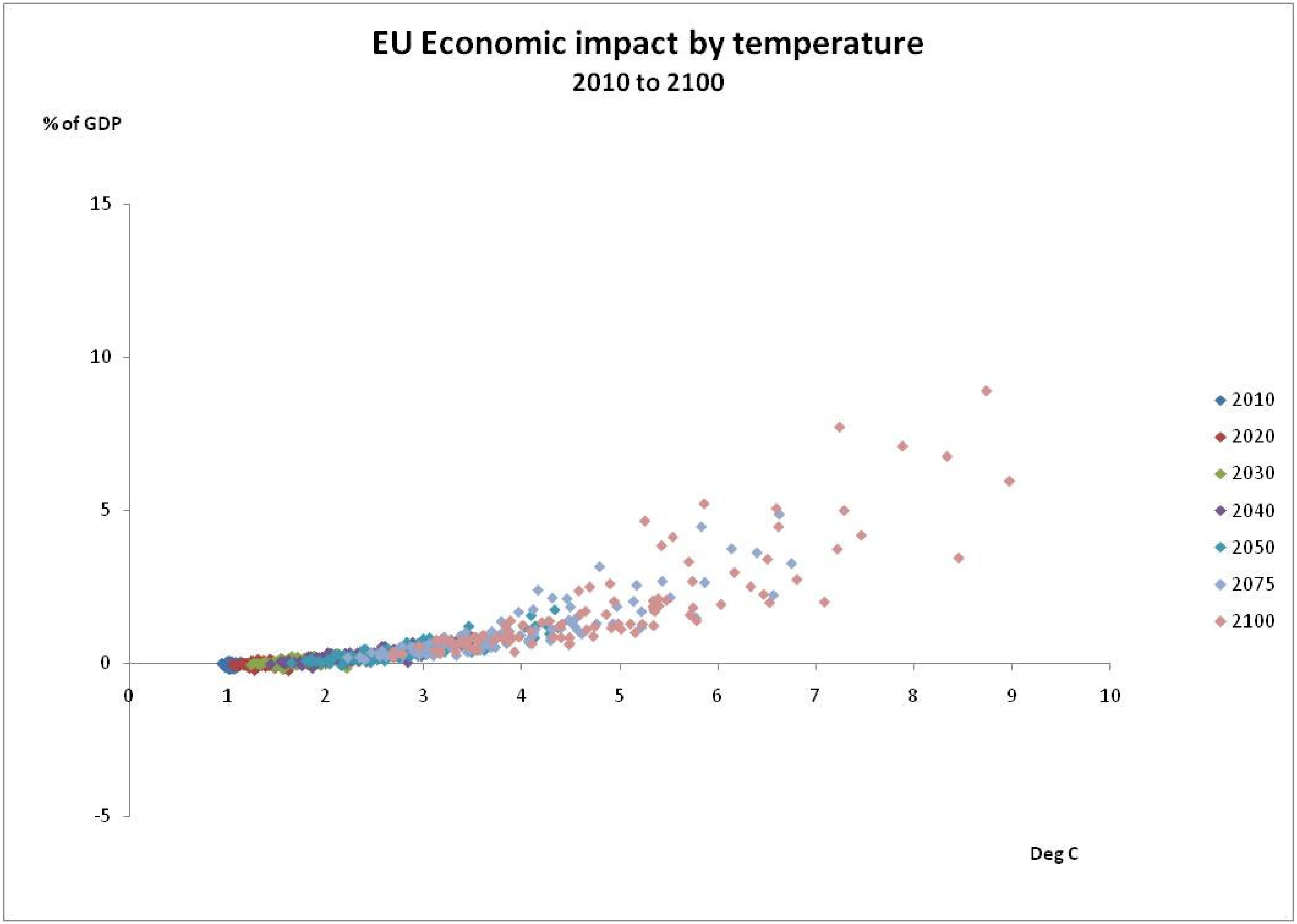

Source: 100 PAGE09 runs; A1B scenario

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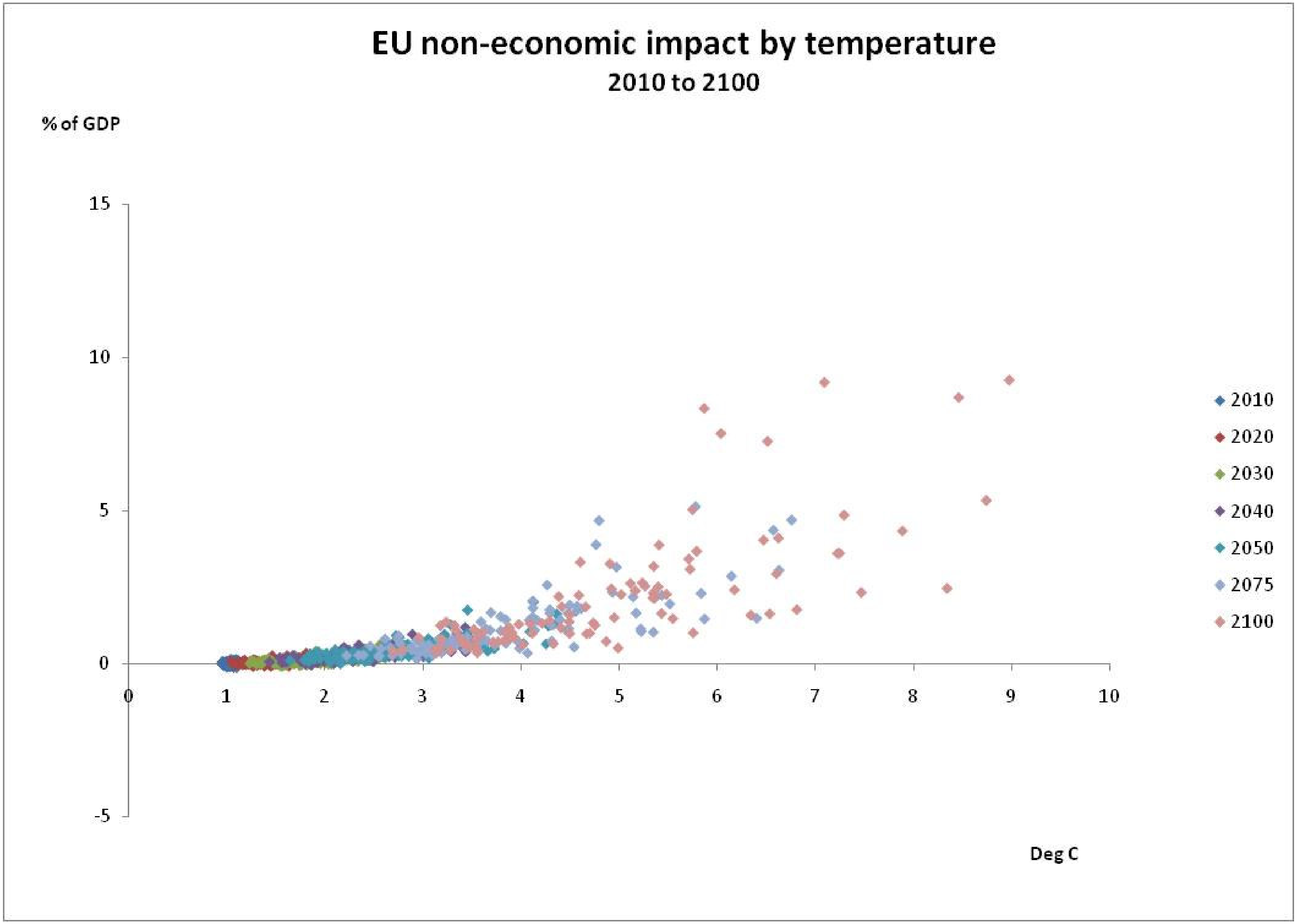

Source: 100 PAGE09 runs; A1B scenario

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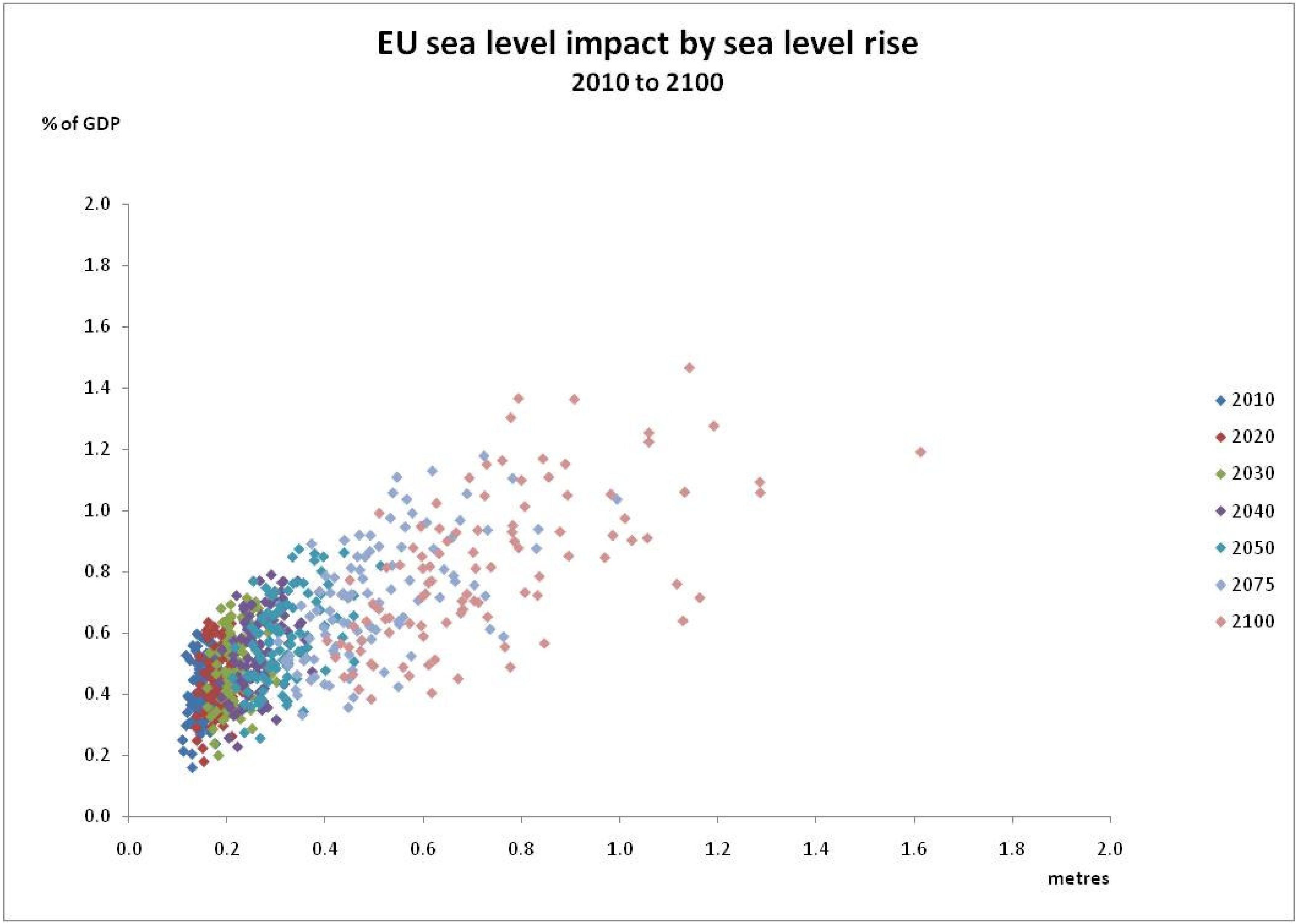

Source: 100 PAGE09 runs; A1B scenario

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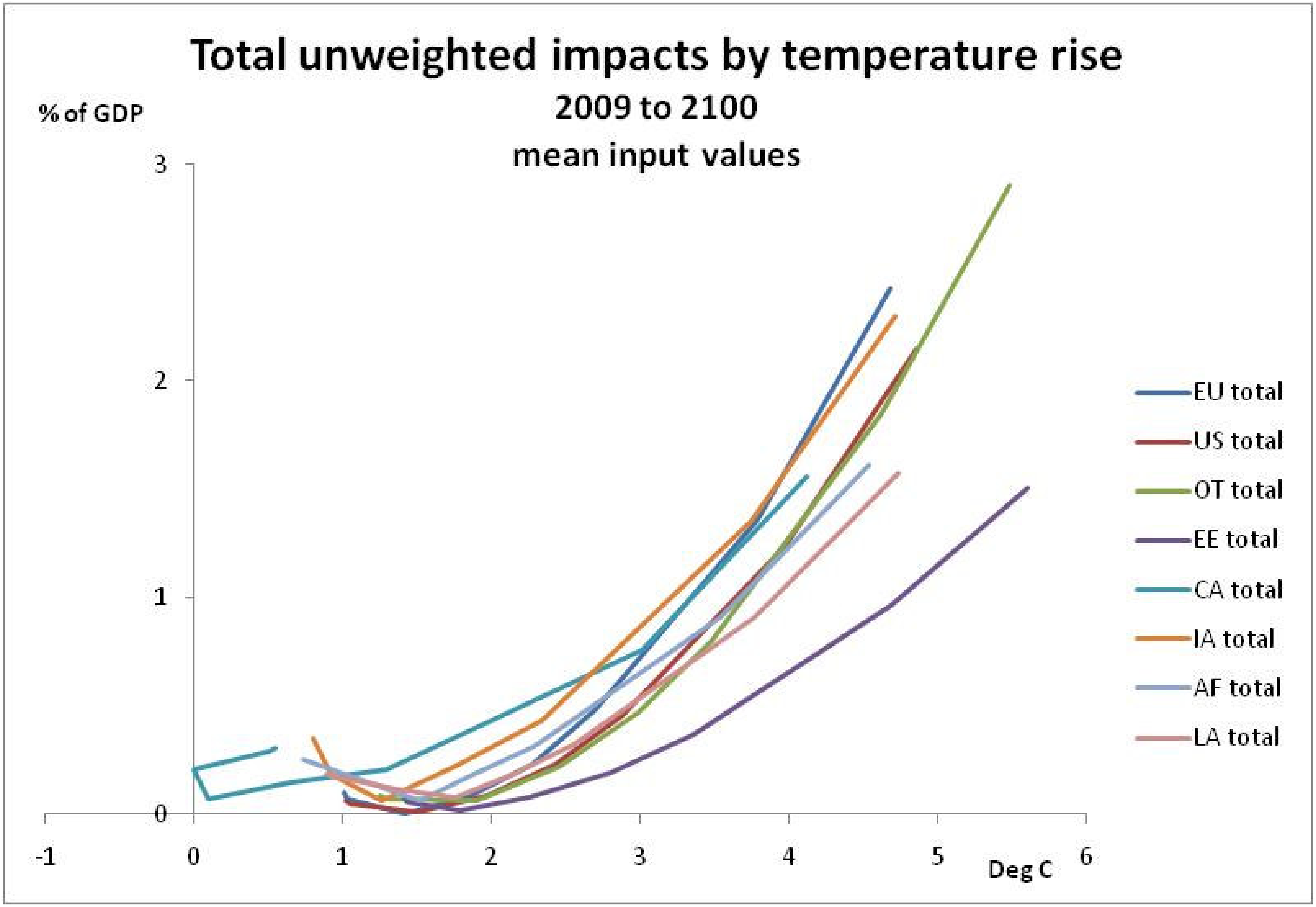
Discontinuity inputs

	mean	min	mode	max	units
Tolerable before discontinuity	*3.00*	2	3	4	degC
Chance of discontinuity	*20.00*	10	20	30	% per degC
Loss if discontinuity occurs	*15.00*	5	15	25	%GDP
Discontinuity exponent with income	*-0.13*	-0.3	-0.1	0	
Half-life of discontinuity	*90.00*	20	50	200	years

Impacts and $SCCO_2$

- Business as usual scenario: A1B.
- Moderate adaptation.
- Currency unit: $2005, PPP exchange rates, EU base year GDP/cap.



Source: PAGE09; A1B scenario

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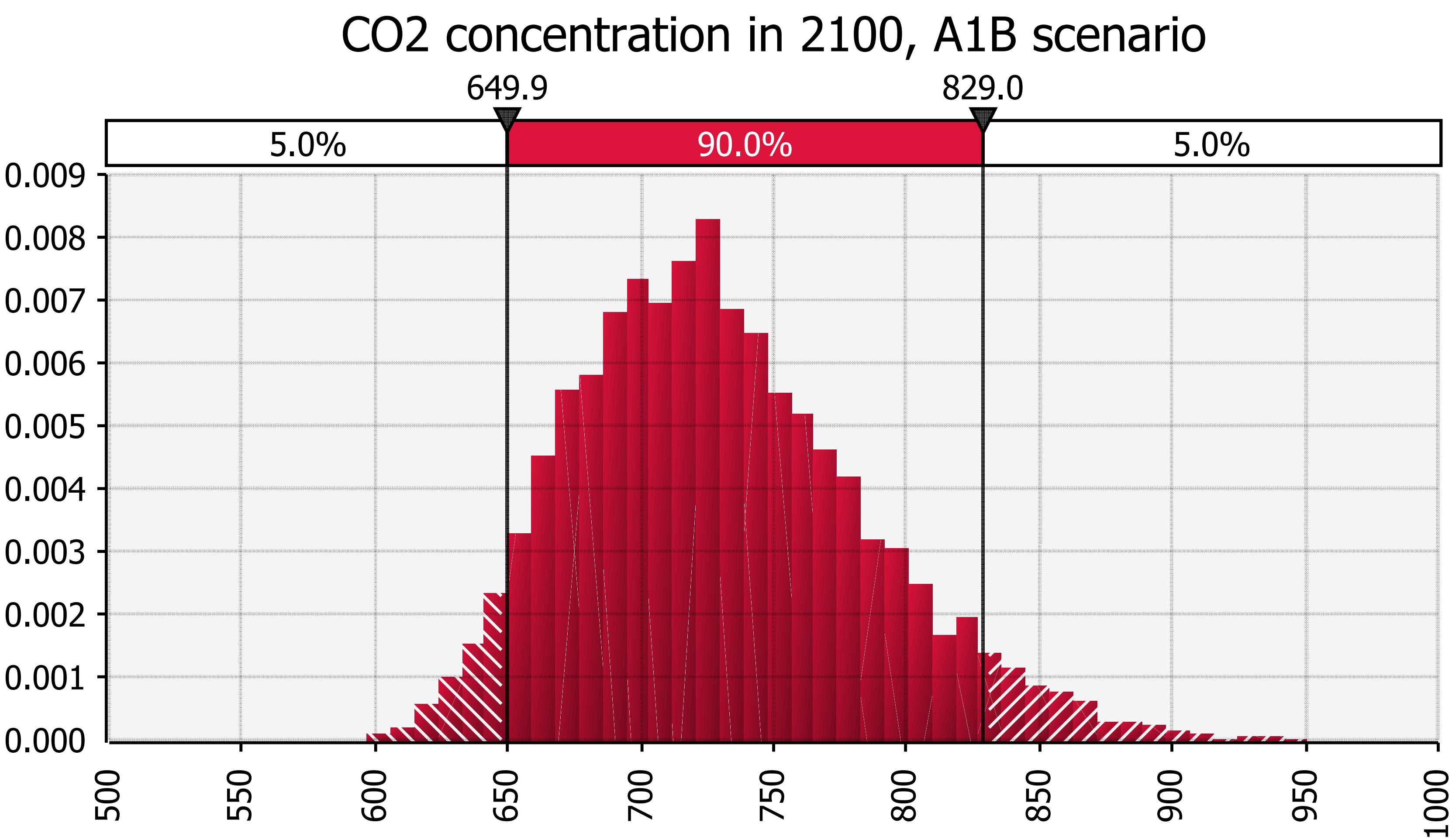
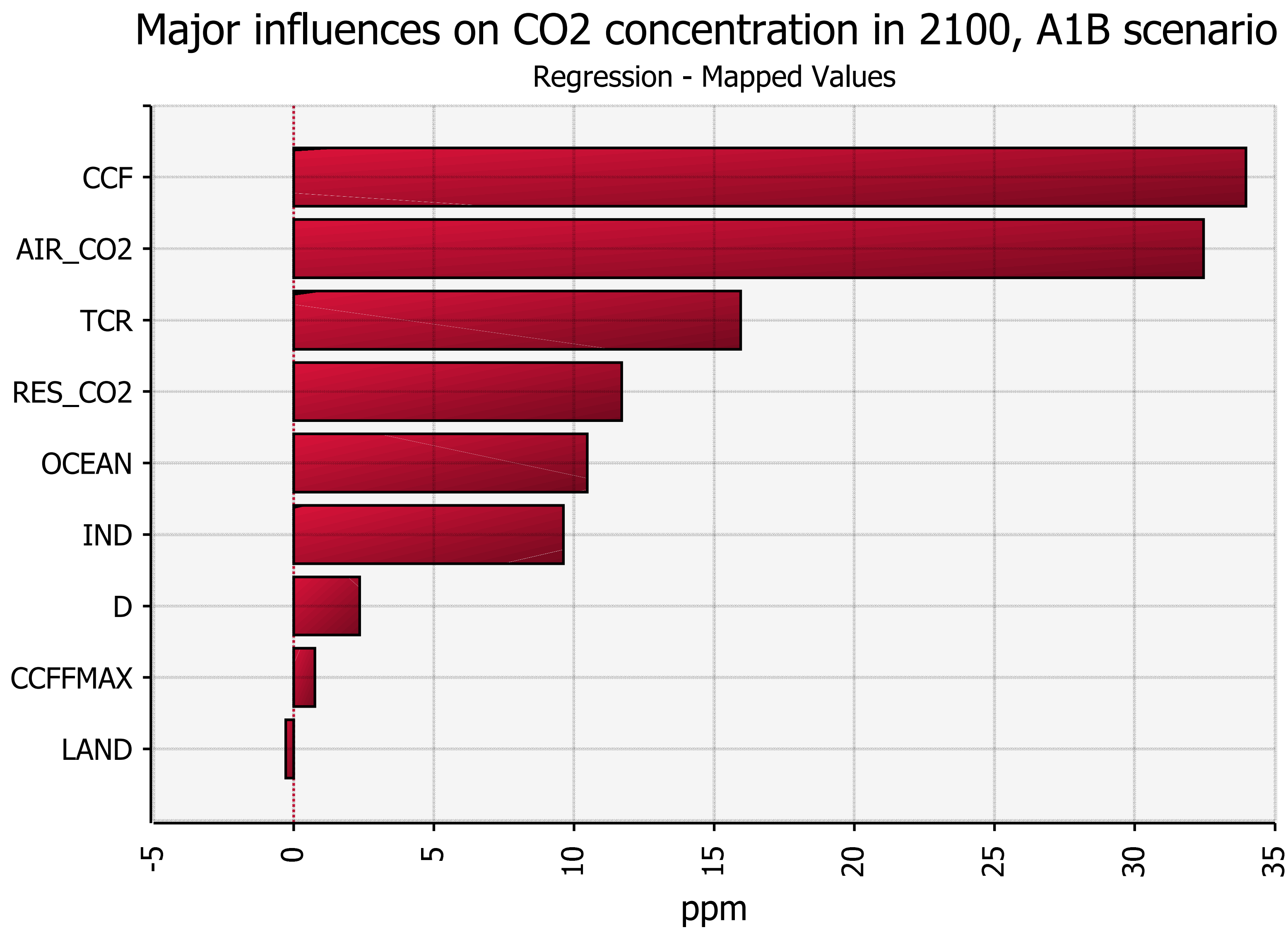


Source: 10000 PAGE09 runs; A1B scenario



Source: 10000 PAGE09 runs; A1B scenario

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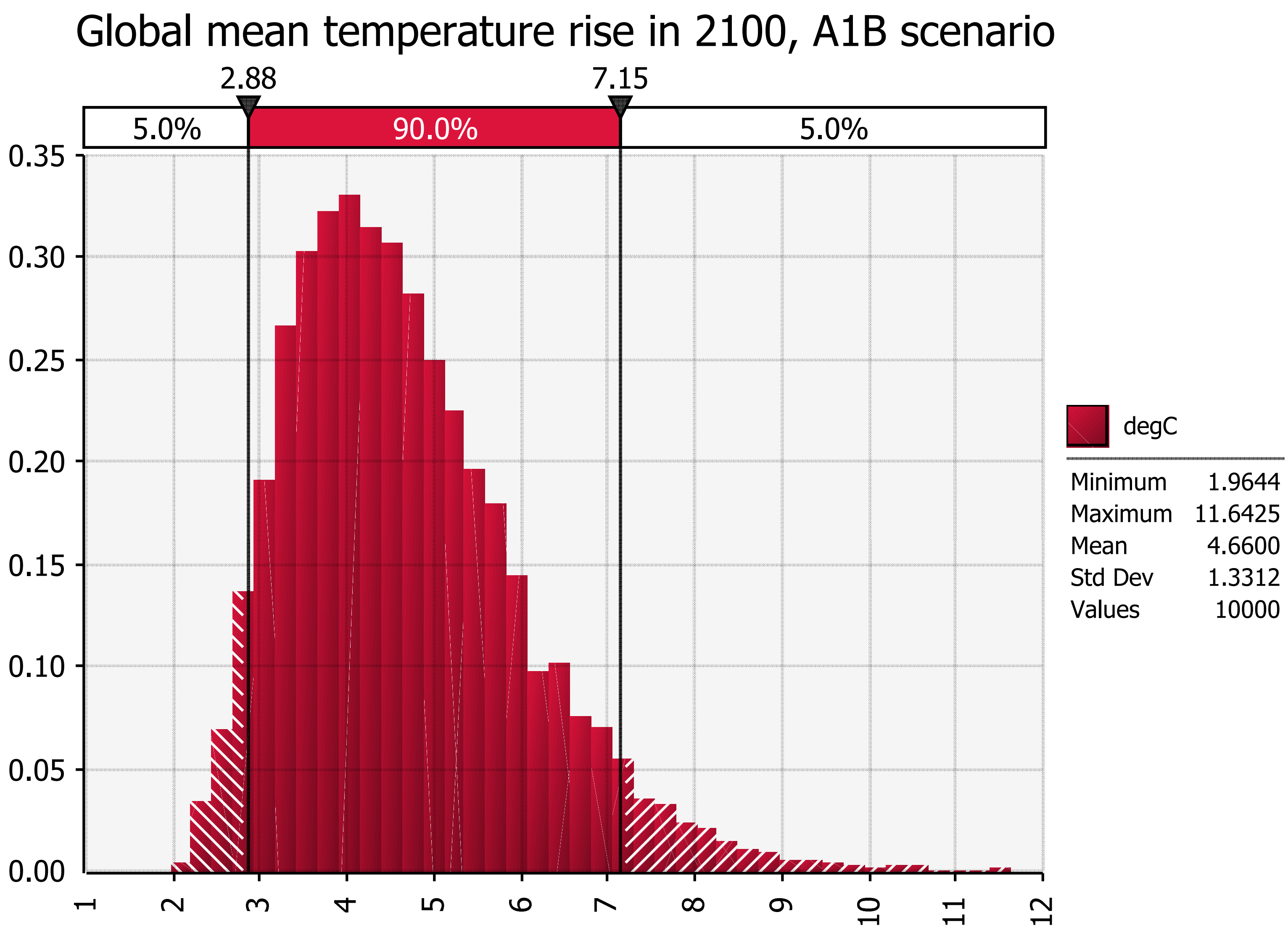

Source: 10000 PAGE09 runs; A1B scenario

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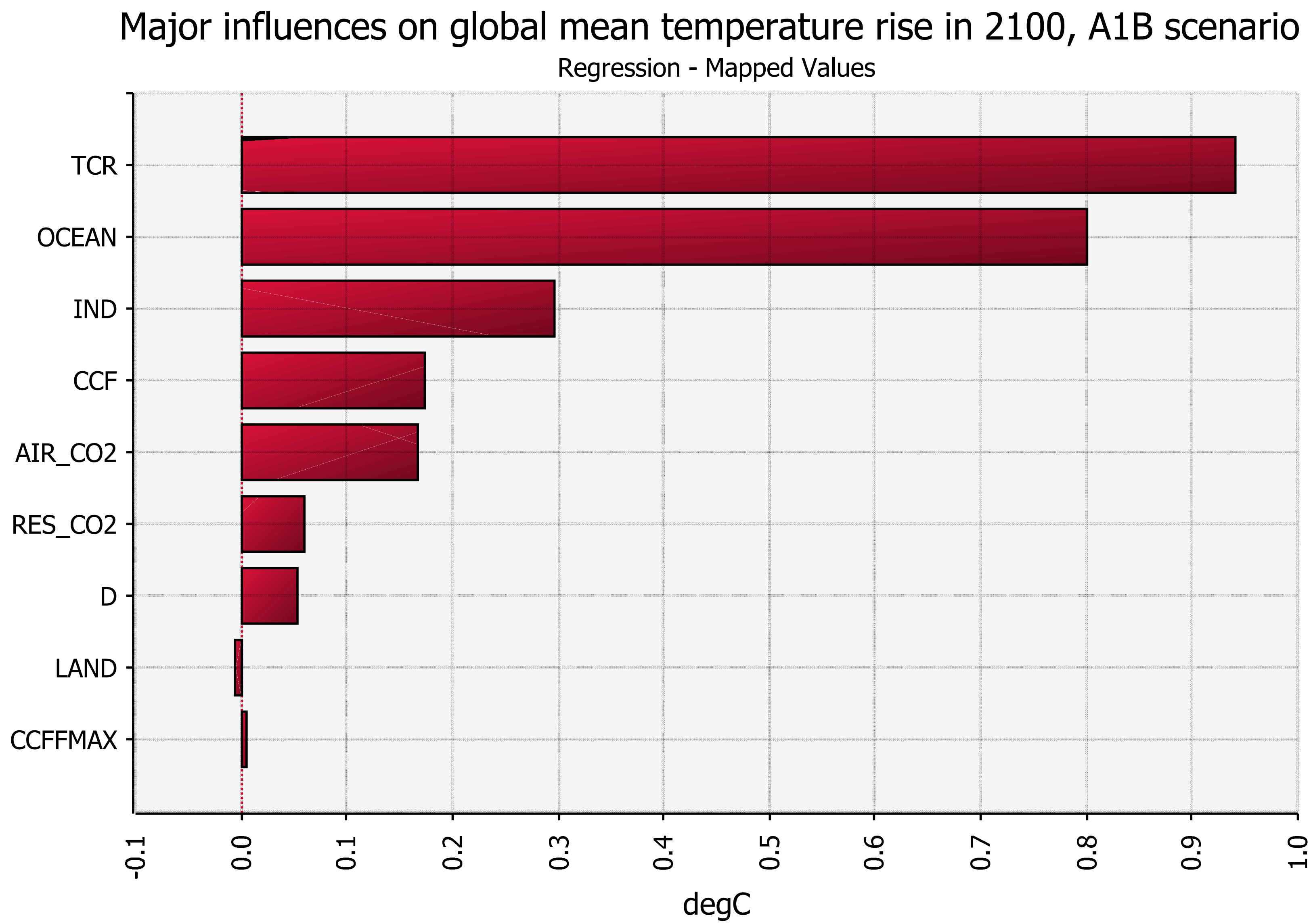

Source: 10000 PAGE09 runs; 2016 r5 low scenario

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Major influences on global mean temperature in 2100; input ranges

	mean	*sd*	min	mode	max	units
Transient climate response	*1.67*	*0.31*	1	1.5	2.5	degC
Half-life of global warming	*28.33*	*6.24*	15	25	45	years
Sulfate indirect (log) effect for a doubling of sulphates	*-0.40*	*0.16*	-0.8	-0.4	0	W/m2
Stimulation of CO2 concentration	*3.00*	*1.02*	0.5	3	5.5	%/degC
Percent of CO2 emitted to air	*56.33*	*4.52*	46	55	68	%

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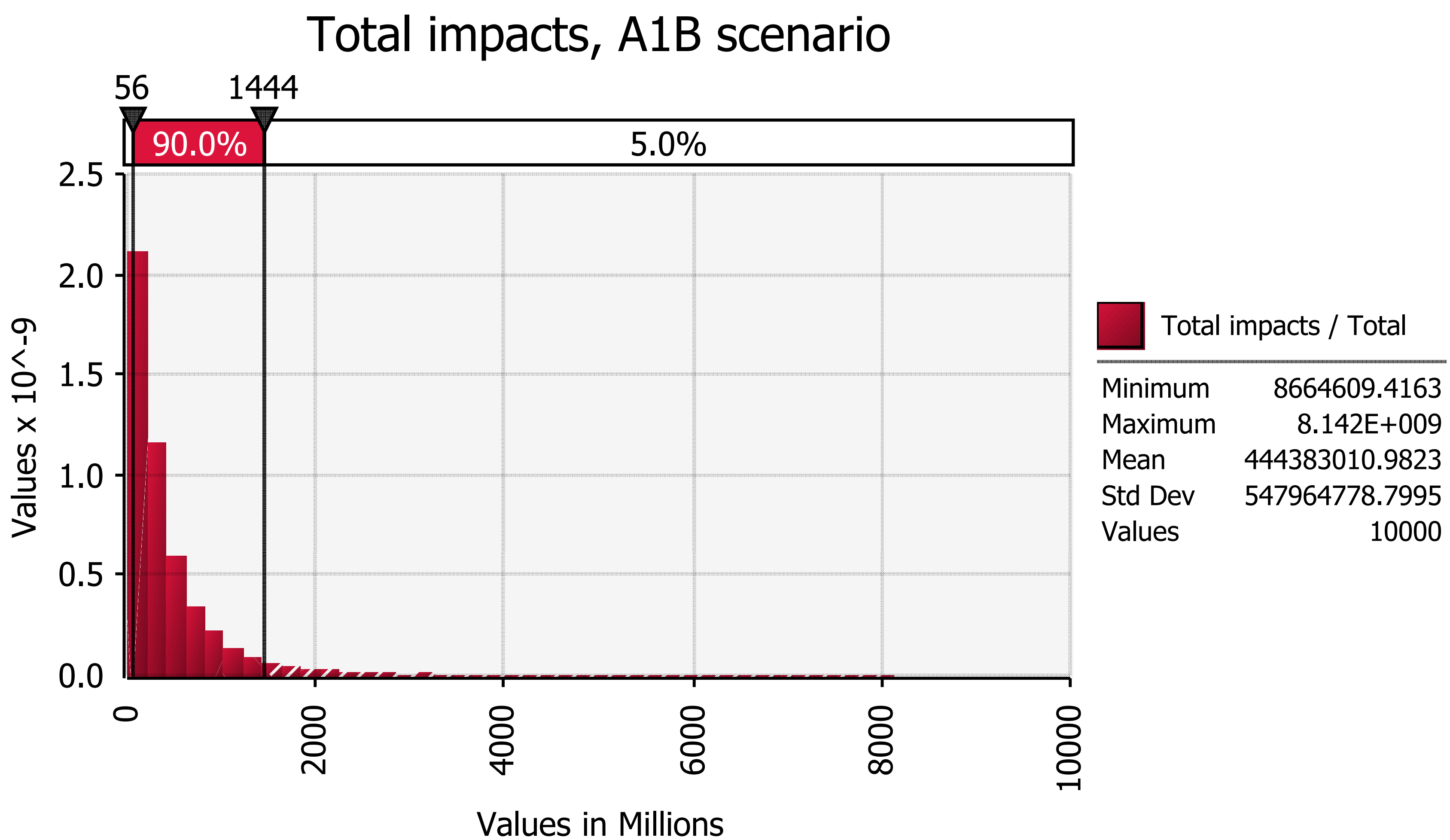

Source: 10000 PAGE09 runs; A1B scenario

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Major influences on total impacts, A1B scenario

Source: 10000 PAGE09 runs; A1B scenario

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Major influences on total impacts of A1B scenario; input ranges

	mean	*sd*	min	mode	max	units
Pure time preference rate	*1.03*	*0.39*	0.1	1.0	2.0	%/year
EMUC	*1.17*	*0.31*	0.5	1.0	2.0	
Non-econ impact at calibration temperature	*0.53*	*0.18*	0.1	0.5	1	%GDP
Non-econ impact function exponent	*2.17*	*0.31*	1.5	2	3	
Loss if discontinuity occurs	*15.00*	*4.08*	5	15	25	%GDP

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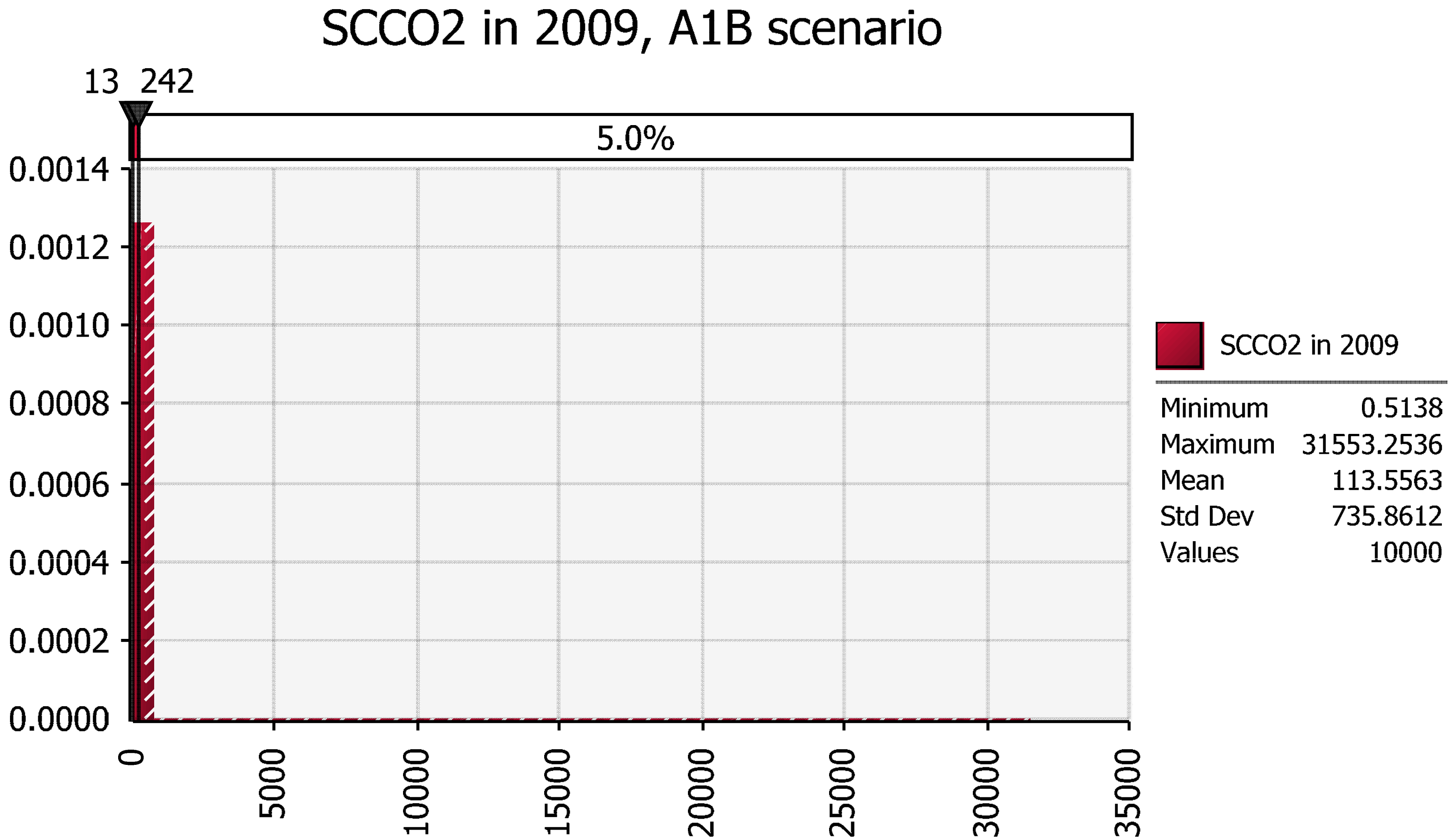

Source: 10000 PAGE09 runs; A1B scenario

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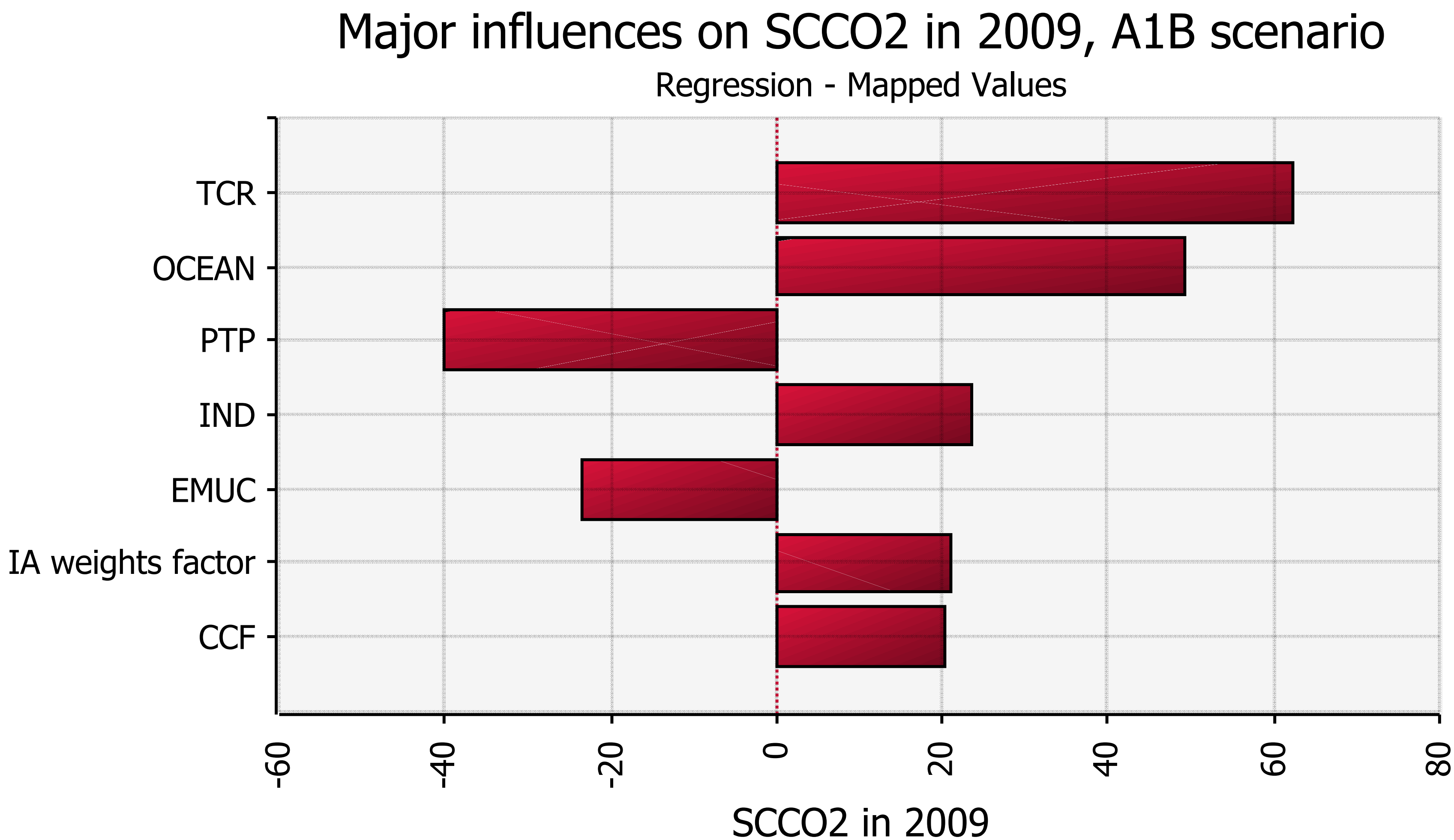

Source: 10000 PAGE09 runs; A1B scenario

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Revenue in the UK from a climate change tax of $100 per tonne of CO_2

•Revenue from CO_2 in first year:	£ 35 billion
(560 x 100 / 1.6) million	
•International Air Travel:	£ 4 billion
(20 x 3 x 100 /1.6) million	
•Other greenhouse gases:	£ 6 billion
(27/153 x 35) billion	
•Revenue in 2020:	£ 43 billion
(Tax rate increases by 35%, emissions reduce by 30%)	
•Total UK tax revenues	£500 billion

Source: Author's calculations

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Comparison with results from PAGE2002

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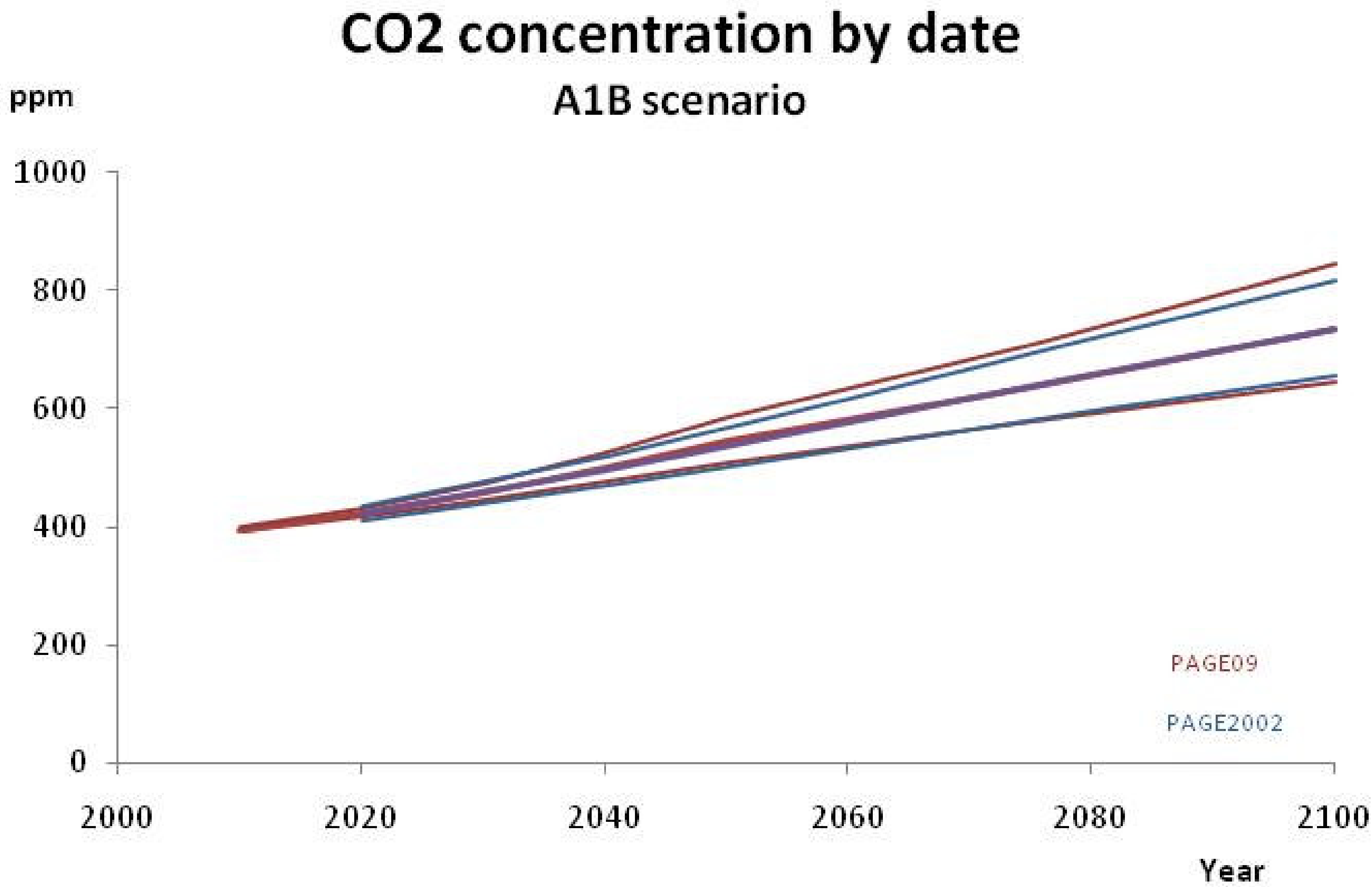

Source: 1000 PAGE09 runs; A1B scenario

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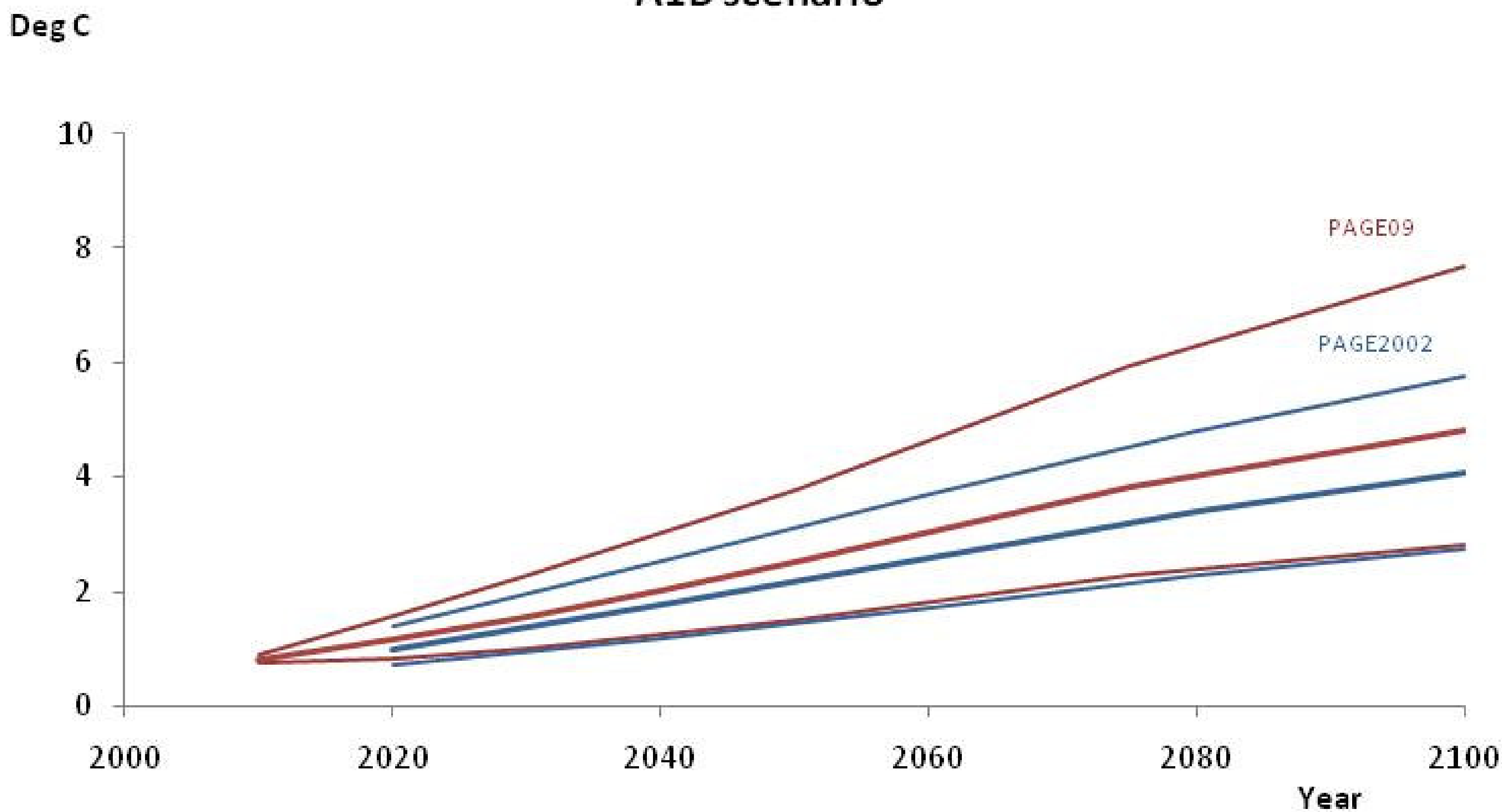
Global mean temperature by date

A1B scenario



Source: 1000 PAGE09 runs; A1B scenario

Total impacts in PAGE09 and PAGE2002

2008 - 2200			*$US trillion*
	5%	**mean**	**95%**
PAGE09	60	440	1440
PAGE2002	10	100	340

Source: 10000 PAGE09 and PAGE2002 model runs; A1B scenario

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$SCCO_2$ in PAGE09 and PAGE2002

2008 - 2200		*$US per tonne CO_2*	
	5%	**mean**	**95%**
PAGE09	10	110	240
PAGE2002	3	28	85

Source: 10000 PAGE09 and PAGE2002 model runs; A1B scenario

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Why are the impacts so much greater in PAGE09?

- The likelihood of higher temperature change.
- Less effective adaptation.
- Higher chance of a discontinuity.
- Proper accounting for very large impacts.
- $2005 not $2000.

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Next steps

- Refine and write up initial runs.
- Impacts and $SCCO_2$ from other scenarios.
- Costs and benefits of aggressive abatement.
- Hand PAGE09 to DECC, ClimateCost and other users.

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