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The Social Cost of CO2 from the PAGE09 model

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Abstract

A new version of the PAGE integrated assessment model, PAGE09, is introduced. The most important scientific, impact, emission and adaptation inputs in the latest default version of the model, PAGE09 v1.7 are described. The scientific and economic impact results are presented for a business as usual (BAU) emissions scenario, and for a low emissions scenario which aims to have a 50% chance of keeping the rise in global mean temperatures below 2 degC. Today's mean social cost of CO2 is about $100 per tonne of CO2 in the BAU scenario, and about $50 per tonne in the low emissions scenario. The major influences on the SCCO2 are found to be the transient climate response, the pure time preference rate, the elasticity of the marginal utility of consumption, the feedback response time of the earth and the weight on non-economic impacts. Less than 10% of the mean SCCO2 comes from impacts in annex 1 from annex 1 emissions, while over 45% comes from impacts in the rest of the world (RoW) from RoW emissions. About one third of the mean SCCO2 comes from impacts in the RoW caused by emissions in Annex 1, while just over 10% comes from impacts in annex 1 caused by emissions in the RoW.

Introduction

PAGE09 is a new integrated assessment model that values the impacts of climate change and the costs of policies to abate and adapt to it. It is designed to help policy makers understand the costs and benefits of action and inaction.

PAGE09 is an updated version of the PAGE2002 integrated assessment model. PAGE2002 was used to value the impacts and calculate the social cost of CO2 in the Stern review (Stern, 2007) and the Asian Development Bank's review of climate change in Southeast Asia (ADB, 2009), and value the impacts and costs in the Eliasch review of deforestation (Eliasch, 2008). The PAGE2002 model is described fully in Hope, 2006, Hope, 2008a and Hope, 2008b.

The update to PAGE09 been made to take account of the latest scientific and economic information, primarily in the 4th Assessment Report of the IPCC (IPCC, 2007). This paper describes the most important scientific, impact, emission and adaptation inputs in the latest default version of the model, PAGE09 v1.7. Nearly all the inputs are independent triangular probability distributions, defined by a minimum, mode (most likely) and maximum value. The full set of scientific, impact, emission and adaptation inputs to the model are shown in the appendix.

Users are allowed, indeed encouraged, to change the input distributions away from their default values if they have other input values whose implications they wish to explore. To help with this process, this paper identifies the most important influences on one of the main outputs of the model, the social cost of CO2.

PAGE09 uses simple equations to simulate the results from more complex specialised scientific and economic models. It does this while accounting for the profound uncertainty that exists around climate change. Calculations are made for eight world regions, ten time periods to the year 2200, for four impact sectors (sea level, economic, non-economic and discontinuities). The PAGE09 model equations are available in a companion technical paper (Hope, forthcoming).

Inputs to the PAGE09 model

Science

Climate sensitivity

The climate sensitivity is the equilibrium temperature rise that results from a doubling of CO2 concentrations. As will be shown later in the paper, it is a very large influence on global and regional temperature rise over the next two centuries.

The climate sensitivity in PAGE09 is derived from two inputs, the transient climate response (TCR), defined as the temperature rise after 70 years, corresponding to the doubling-time of CO2 concentration, with CO2 concentration rising at 1% per year, and the feedback response time of the Earth to a change in radiative forcing, otherwise known as the half-life of global warming, and abbreviated to FRT in the model equations.

"The TCR is *very likely* larger than 1°C and *very unlikely* greater than 3°C based on climate models, in agreement with constraints from the observed surface warming." (IPCC, 2007, ch10, p749)

The default triangular distributions for these two parameters , from Andrews and Allen, 2008 figure 3(d), are shown in table 1 below, with the resulting mean values also shown.

Table 1 Climate sensitivity input values in the default PAGE09 model

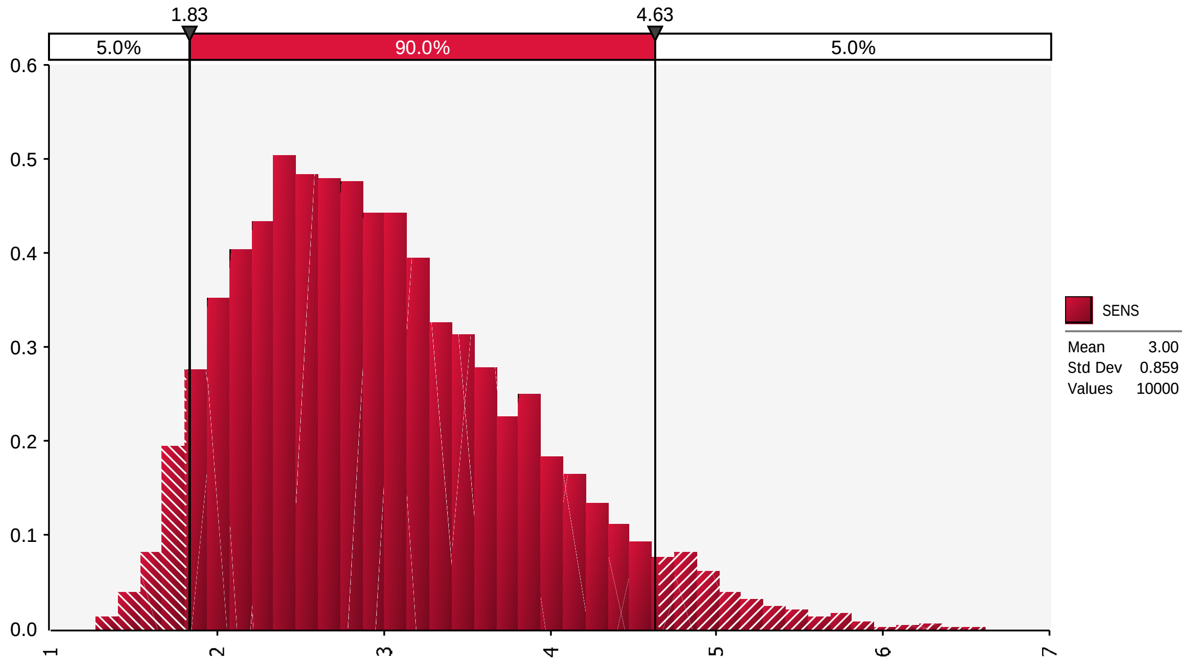
		mean	min	mode	max	
Transient climate response	*TCR*	*1.70*	1	1.3	2.8	degC
Half-life of global warming	*FRT*	*35.00*	10	30	65	years

These values give a climate sensitivity shown in Figure 1. The lowest values are about 1.5 degC, there is a 5% chance that it will be below about 1.85 degC, the most likely value is about 2.5 degC, the mean value is about 3 degC, there is a 5% chance that it will be above 4.6 degC, and a long tail reaching out to nearly 7 degC. This distribution is consistent with the latest estimates from IPCC, 2007, which states that

"equilibrium climate sensitivity is likely to be in the range 2°C to 4.5°C, with a best estimate value of about 3°C. It is very unlikely to be less than 1.5°C. Values substantially higher than 4.5°C cannot be excluded, but agreement with observations is not as good for those values. Probability density functions derived from different information and approaches generally tend to have a long tail towards high values exceeding 4.5°C. Analysis of climate and forcing evolution over previous centuries and model ensemble studies do not rule out climate sensitivity being as high as 6°C or more." (IPCC, 2007, TS4.5)

The mean value is unchanged from the default PAGE2002 mean value of 3°C, but the range at the upper end is greater. In PAGE2002, the climate sensitivity was input as a triangular probability distribution, with a minimum value of 1.5°C and a maximum of 5°C.

Figure 1 Climate sensitivity probability distribution in the default PAGE09 model.



Effect of sulphates

The emissions of sulphates from the combustion of fossil fuels have both a direct (D) and an indirect (IND) cooling effect (IPCC, 2007, SPM). The direct sulphate forcing input in PAGE2002 was not easily understandable. In PAGE09 we make the input, D, the level of mean base year direct sulphate forcing in W/m2. The forcing from sulphates is now allowed to vary by policy, so that if a policy makes large cuts in CO2 emissions, it is now possible to model the associated cuts in sulphates that are very likely to occur as well.

The default triangular distributions for these two parameters are shown in table 2; they give a direct sulphate cooling effect in 2008 of -0.2 to -0.8 W/m2 with a mean of -0.5 W/m2, and an indirect sulphate cooling effect in 2008 of -0.3 to -1.9 W/m2 with a mean of -1.1 W/m2, consistent with the ranges in IPCC, 2007, figure SPM.2, of -0.1 to -0.9 W/m2 for direct forcing, with a mean of -0.5 W/m2 and -0.3 to -1.8 W/m2, with a mean of -0.7 W/m2 for indirect cooling in 2005. The ranges are almost unchanged from PAGE2002, whose default values gave a mean total sulphate cooling effect of -1.3 W/m2 in 2000 and -1.5 W/m2 in 2010, with a 5 – 95% range from -0.9 to -2.2 W/m2.

Table 1 Sulphate input values in the default PAGE09 model

		mean	min	mode	max	
Sulphate direct effect in 2008	*D*	*-0.47*	-0.8	-0.4	-0.2	W/m2
Sulphate indirect effect for doubled conc	*IND*	*-0.40*	-0.8	-0.4	0	W/m2

Carbon cycle feedback from temperature to CO2 concentration

The carbon cycle feedback (CCF) is introduced as a linear feedback from global mean temperature to a percentage gain in the excess concentration of CO2, to simulate the decrease in CO2 absorption on land and in the ocean as temperature rises (Friedlingstein et al, 2006). This is applied each analysis year, and is not carried forward from one analysis year to the next. The additional feedback gain is capped (at CCFFmax) so that the concentration does not run away in higher emission scenarios.

The default triangular distributions for these two parameters are shown in table 3; they give carbon cycle feedbacks with mean values in 2100 of about 95 ppm, with a 5 -95% range of 45 -160 ppm, for business as usual emissions, and about 30 ppm, with a 5 -95% range of 12 -45 ppm, for an aggressive abatement scenario designed to keep CO2 concentrations below about 450 ppm. In 2200 the mean carbon cycle feedbacks rise to about 190 ppm, with a 5 -95% range of 95 -280 ppm, for business as usual emissions, but fall to about 20 ppm, with a 5 -95% range of 10 -40 ppm, for the aggressive abatement scenario.

These results are consistent with the ranges in Friedlingstein et al, 2006, and Van Vuuren et al, 2009, figure 8, which have mean values in 2100 of about 100 ppm, with a range of 40 -200 ppm, for a slightly different business as usual scenario, and about 35 ppm, with a range of 10 -60 ppm, for a slightly different aggressive abatement scenario; the range for this scenario in 2200 is about 10 -50. PAGE09 is much better able to simulate these carbon cycle feedback results than PAGE2002.

Table 3 Carbon cycle feedback input values in the default PAGE09 model

		mean	min	mode	max	
Stimulation of CO2 concentration	*CCF*	*9.67*	4	10	15	%/degC
CO2 stimulation limit	*CCFFMAX*	*53.33*	30	50	80	%

Impacts

Sea-level, economic and non-economic impacts as a proportion of GDP

The PAGE09 model values the impact of climate change in four sectors: sea level, economic, non-economic and discontinuities.

In PAGE09, sea level impacts before adaptation are a polynomial function of sea level rise, and economic and non-economic impacts before adaptation are a polynomial function of the regional temperature. Economic impacts are those that are included directly in GDP, such as agricultural losses and air-conditioning costs; non-economic impacts are those that are not included directly in GDP, such as human health and ecosystem impacts. The default triangular distributions for these parameters in the focus region of the EU are shown in table 4.

Table 4 Impact input values in the default PAGE09 model

		mean	min	mode	max	
Calibration sea level rise	*SCAL*	*0.50*	0.45	0.5	0.55	m
Sea level impact at SCAL	*W_S*	*1.00*	0.5	1	1.5	%GDP
Sea level exponent	*POW_S*	*0.73*	0.5	0.7	1	
Calibration temperature	*TCAL*	*3.00*	2.5	3	3.5	degC
Economic impact at TCAL	*W_1*	*0.50*	0.2	0.5	0.8	%GDP
Economic exponent	*POW_1*	*2.17*	1.5	2	3	
Non-economic impact at TCAL	*W_2*	*0.53*	0.1	0.5	1	%GDP
Non-economic exponent	*POW_2*	*2.17*	1.5	2	3	

They produce a mean impact before adaptation of just under 2% of GDP for a temperature rise of 3 degC (Warren et al, 2006), including the associated sea level rise of just under half a metre (Anthoff et al, 2006). Sea level impacts rise less than linearly with sea level rise, as land and people (and hence GDP) are concentrated in the most low-lying areas (Anthoff et al, 2006, figure 1). Economic and non-economic impacts rise on average as just over a quadratic function of temperature; the same range as in Ackerman et al, 2009.

Other regions are on average less vulnerable than the EU for the same sea level and temperature rise, and at the same GDP per capita, largely because of the long coastline of the EU. The multiplicative weight factors applied to impacts in other regions are shown in table 5 (see appendix for definitions of the regions) (Anthoff et al, 2006). The range of impacts is consistent with the range of 0 – 3% of GDP for a 2 – 3 degC warming, with higher costs in poor countries, quoted in Stern 2007, p143.

Table 5 Regional weight input values in the default PAGE09 model

	mean	min	mode	max
US weights factor	0.80	0.6	0.8	1
OT weights factor	0.80	0.4	0.8	1.2
EE weights factor	0.40	0.2	0.4	0.6
CA weights factor	0.80	0.4	0.8	1.2
IA weights factor	0.80	0.4	0.8	1.2
AF weights factor	0.60	0.4	0.6	0.8
LA weights factor	0.60	0.4	0.6	0.8

Extra flexibility is introduced by allowing the possibility of initial benefits from small increases in regional temperature (Tol, 2002), by linking impacts explicitly to GDP per capita and by letting the impacts drop below their polynomial on a logistic path once they exceed a certain proportion of remaining GDP to reflect a saturation in the vulnerability of economic and non-economic activities to climate change, and ensure they do not exceed 100% of GDP (Weitzman, 2009).

Discontinuity impacts

There is a risk of a large-scale discontinuity, such as the Greenland ice sheet melting, if climate change continues (Lenton et al, 2008).

The default triangular distributions for the parameters for the risk of a possible future large-scale discontinuity are shown in table 6. The modal parameter values imply that a large-scale discontinuity only starts to become possible when the temperature has risen by 3°C above pre-industrial levels (Lenton et al, 2008, table 1), with a range of 2 -4°C (Stern, 2007, box 1.4) and that for every 1°C rise in temperature beyond this, the chance of a large-scale discontinuity occurring rises by 20%, so that with modal values it is 20% if the temperature is 4°C above pre-industrial levels, 40% at 5°C, and so on (Ackerman et al, 2009). The ranges here are wide, as our knowledge is so limited. The upper ends of the ranges imply that a discontinuity will certainly occur if the temperature rises by about 6 °C, the lower ends that there is only about a 20% chance of a discontinuity for the same temperature rise (Lenton et al, 2008, table 1, Stern, 2007, box 1.4).

If the discontinuity occurs, the EU loses between 5% and 25% of its GDP, and other regions lose more or less depending upon their GDP per capita and weights factors; the lower figure is the value for a 10m sea level rise in Anthoff et al, 2006, the upper figure is that assumed by Nordhaus, 1994. The losses build up gradually with a mean characteristic lifetime of 90 years, and a range of 20 -200 years, after the discontinuity is triggered. The shorter values for this lifetime are appropriate for discontinuities like monsoon disruption and thermohaline circulation, with the longer values more appropriate to the loss of ice sheets (Lenton et al, 2008). PAGE09 assumes that only one discontinuity occurs, and if it occurs it is permanent.

Table 6 Discontinuity input values in the default PAGE09 model

		mean	min	mode	max	
Tolerable before discontinuity	*TDIS*	*3.00*	2	3	4	degC
Chance of discontinuity	*PDIS*	*20.00*	10	20	30	% per degC
Loss if discontinuity occurs	*WDIS*	*15.00*	5	15	25	%GDP
Half-life of discontinuity	*DISTAU*	*90.00*	20	50	200	years

Discounting and equity weighting of impacts

PAGE09 uses the equity weighting scheme proposed by Anthoff et al (2009) which converts changes in consumption to utility, and amounts to multiplying the changes in consumption by

E(r,t) = (G(fr,0)/G(r,t))^ EMUC

where G(fr,0) is today's GDP per capita in the focus region, where the results of the model are to be applied (which in PAGE09 is normally the EU)and EMUC is the negative of the elasticity of the marginal utility of consumption. As EMUC is always greater than zero, the effect is to increase the valuation of impacts in regions that are poorer than the focus region in the base year, and decrease the valuation of impacts in regions that are richer.

This equity weighted damage is then discounted at the utility rate of interest, which is the pure time preference (PTP) rate.

The default triangular distributions for these two parameters are shown in table 7. The PTP values cover the range from the Stern review assumptions at the low end to the empirical estimates in Nordhaus (2007) at the high end. The equity weight values are based on HM Treasury, 2003, which uses a value of 1.0, reduced from 1.5, and table 1 of Evans, 2005.

Table 7 Discounting and equity weighting input values in the default PAGE09 model

		mean	min	mode	max	
Pure time preference rate	*PTP*	*1.03*	0.1	1	2	%/year
Equity weight	*EMUC*	*1.17*	0.5	1	2	

These assumptions are often of similar importance to the climate sensitivity in determining the valuation of total impacts and the social cost of CO2 in the model, as will be shown later. As with all inputs to the model, they can be changed by the user to explore the effect of different assumptions.

Emissions and adaptation

Emissions

The business as usual emissions scenario in the default PAGE09 model is the IPCC's A1B scenario to 2100(Nakicenovic and Swart, 2000), with constant emissions thereafter. Aggressive abatement is represented by a scenario with emissions that peak in 2016 and then reduce at 5% per year to a very low value by 2100 and after (Gohar and Lowe, 2009). This scenario keeps mean peak CO2 concentrations to about 450 ppm. The exact GDP, population and emissions assumptions are shown in the appendix.

Adaptation

As the climate changes, there will be opportunities to adapt to the changes, either reactively, as the climate changes, or pro-actively, anticipating what future changes might occur. Table 8 shows the default assumptions about adaptation in the EU region (other OECD regions are similar, developing countries are less able to adapt; see the appendix for details).

In the economic sector, adaptation means that we will eventually be able to tolerate a 1 degC rise in temperature with no impacts. It is assumed that this adaptation was started in 2000 and will take 20 years to take full effect. If the temperature rises more than 1 degC, adaptation will not be fully effective, but will be able to reduce impacts by 30%; this type of adaptation starts in 2010 and takes 20 years to reach its full effect. It only works for the first 2 degC of temperature rise above the tolerable level (3 degC above pre-industrial); beyond that temperature rise adaptation is assumed to be ineffective.

In much of the non-economic sector, such as ecosystems, adaptation is harder, so there is no tolerable temperature rise, and the reduction in impacts is only 15%, starting in 2010 and taking 40 years to reach its full effect, which only applies for the first 2 degC of temperature rise above pre-industrial levels.

The evidence base for assumptions about adaptation is very thin, but the assumptions made here are consistent with the findings of deBruin et al (2009) that

"the optimal level of adaptation varies from 0.13 to 0.34, with an average of 0.27, that is 27 percent of gross damages are reduced due to adaptation." (p15),

and their table 2 showing residual damages of about 85% of damages without adaptation in 2030, and 72% in 2100.

Parry et al, 2009, finds that "much damage will not be adapted to over the longer term… the amount may be significant and is likely to increase over time", but the only quantitative estimate is for agriculture where residual impacts are estimated at about a fifth of all impacts in 2030, so that adaptation is 80% effective for this sector (p13).

Table 8 Adaptation input values in the default PAGE09 model

	Plateau	Pstart	Pyears	Impred	Istart	Iyears	Impmax
EU Economic	1.0	2000	20	30	2010	20	2
EU Non-econ	0	2000	100	15	2010	40	2

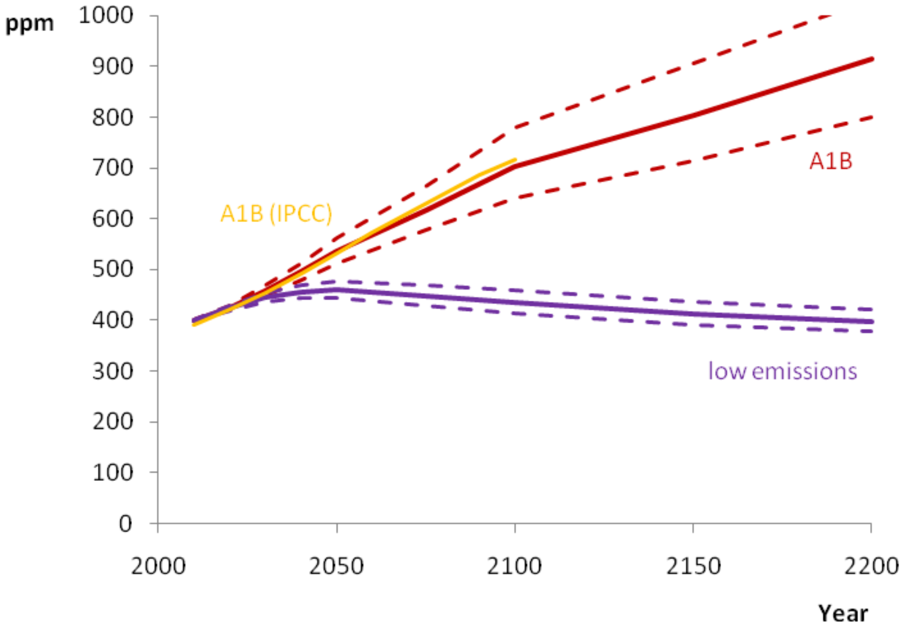
The adaptation inputs are policy variables in PAGE09. They result from policy decisions and so are represented as single choice values rather than probability distributions. These default assumptions in PAGE09 assume less adaptation than in PAGE2002, particularly in the economic sector, which was criticised for possibly being over-optimistic (Ackerman et al, 2009).

Results from the PAGE09 model

CO2 Concentration

The CO2 concentrations over time in the two scenarios are shown in figure 2 below. In these and subsequent figures, the mean results are shown by the thick line, with 5% probability lines dashed below, and 95% probability lines dashed above. All results are from 10000 runs of the default PAGE09 v1.7 model.

Figure 2 CO2 concentrations, by scenario and date.



The mean CO2 concentration rises to about 705 ppm by 2100 and over 900 ppm by 2200 in the A1B scenario - remember that the A1B scenario is only defined to 2100 by the IPCC and this paper assumes emissions remain constant thereafter. The mean concentration given in the IPCC TAR to 2100 is shown for comparison (IPCC, 2001). The mean concentration results from PAGE2002 were 800 ppm in 2100 and over 1300 ppm in 2200 (Warren et al, 2010), so the effect of the improved carbon cycle feedback in PAGE09 is clear.

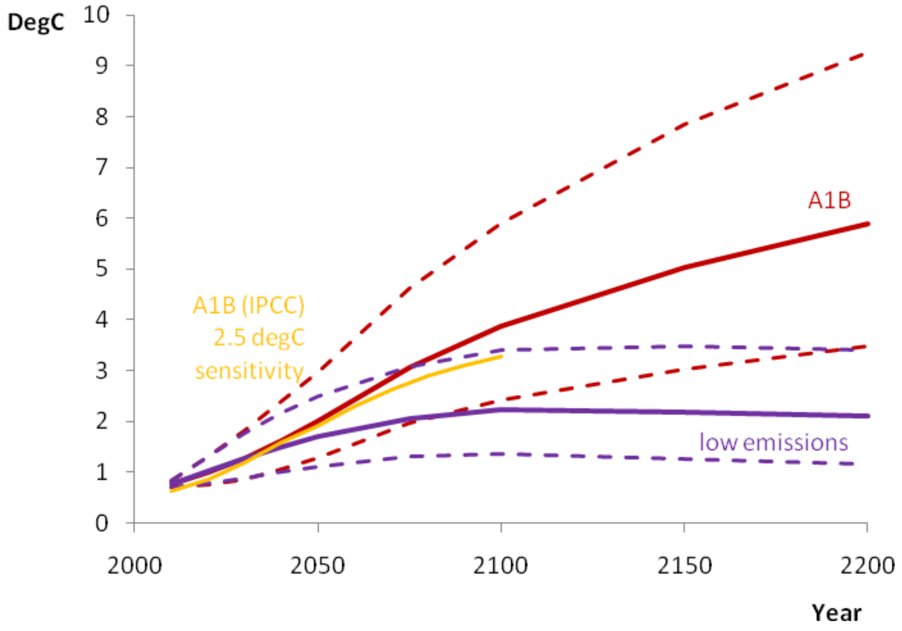
The concentration becomes quite uncertain in the A1B scenario, because the rate of removal of CO2 from the atmosphere is uncertain, and because the exact scale of the carbon cycle feedback is not well known. Both of these uncertainties have a large effect in scenarios like A1B, where emissions are unconstrained.

In the low emissions scenario, the mean CO2 concentration reaches a peak of about 460 ppm in 2050, declining to about 435 ppm in 2100 and 400 ppm in 2200. Uncertainties in the concentration are much smaller than in the A1B scenario.

Global mean temperature

Figure 3 shows the rise in global mean temperature in the two scenarios over time.

Figure 3 Global mean temperature rise, by scenario and date



The mean rise in global mean temperature since pre-industrial times in the A1B scenario is just under 4 degC by 2100 and just under 6 degC by 2200. The uncertainty in concentration carries through to uncertainty in temperature, and is amplified by the uncertainty in climate sensitivity. The 95% probability line shows that there is a 5% chance that the temperature rise will exceed about 6 degC by 2100, and 9 degC by 2200 in this scenario. The mean temperature rise given in the IPCC TAR to 2100 is shown for comparison (IPCC, 2001); it is lower than the PAGE09 mean result because of the lower, 2.5 degC, climate sensitivity assumed in the IPCC TAR.

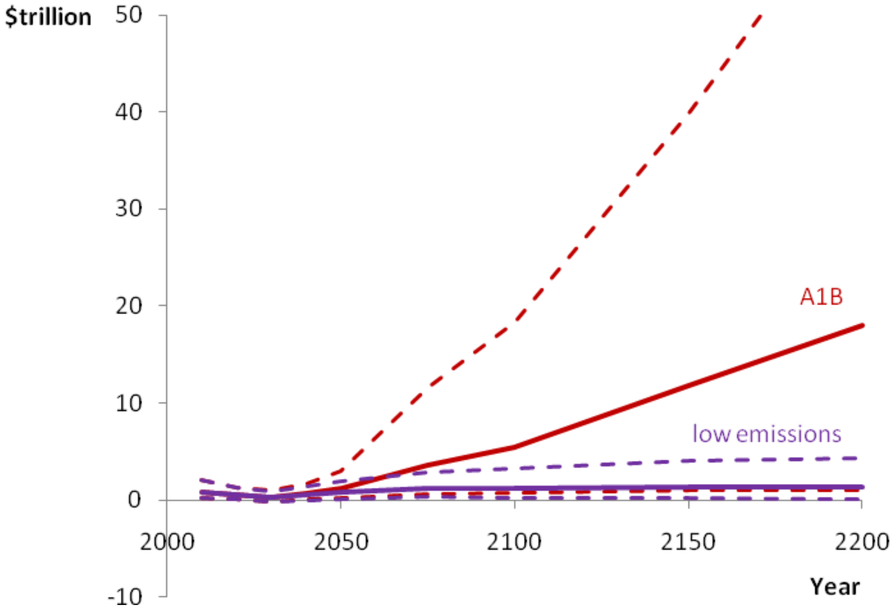
In the low emissions scenario, the mean rise in global mean temperature since pre-industrial times reaches a peak of about 2.2 degC in 2100, declining to about 2.1 degC in 2200. The peak in temperature rise is some 50 years after the peak in concentrations, because of the many lags in the thermal response of the Earth.

The relative certainty in the concentration in this scenario does not carry through to global mean temperature because of the uncertainty in the climate sensitivity. The 95% probability line shows that there is a 5% chance that the temperature rise will exceed about 3.4 degC in 2100 and 2200 in this scenario.

Impacts

Figure 4 shows the annual global impacts from climate change over time in the two scenarios. The equity weighting implies that these are the impacts as valued by a representative person with the average per capita income in 2008 in the focus region of the model, the EU. All impacts are measured in $US of the year 2005.

Figure 4 Global impacts, by scenario and date



In the A1B scenario, the mean global impact is kept below $1 trillion (million million $US(2005)) until 2050 by a combination of fairly low temperature rise, and the gradual introduction of adaptation. The mean annual impact rises to $5 trillion in 2100 and $18 trillion in 2200. The uncertainty in temperature carries through to impacts and is augmented by uncertainties in economic valuation, and in the likelihood of discontinuities. The 95% probability line shows that there is a 5% chance that the annual global impacts will exceed about $20 trillion by 2100, and $60 trillion by 2200 in this scenario. The rapid rise in the 95% probability line between 2050 and 2075 is because discontinuities start to become a serious possibility by 2075. Without adaptation the mean impacts reach $7 trillion in 2100 and $21 trillion in 2200.

In the low emissions scenario, the mean global impact stays below $1.5 trillion throughout, as the global mean temperatures stay on the whole below the level likely to trigger a discontinuity. Even without adaptation, the mean impacts in the low emissions scenario never exceed $2.5 trillion.

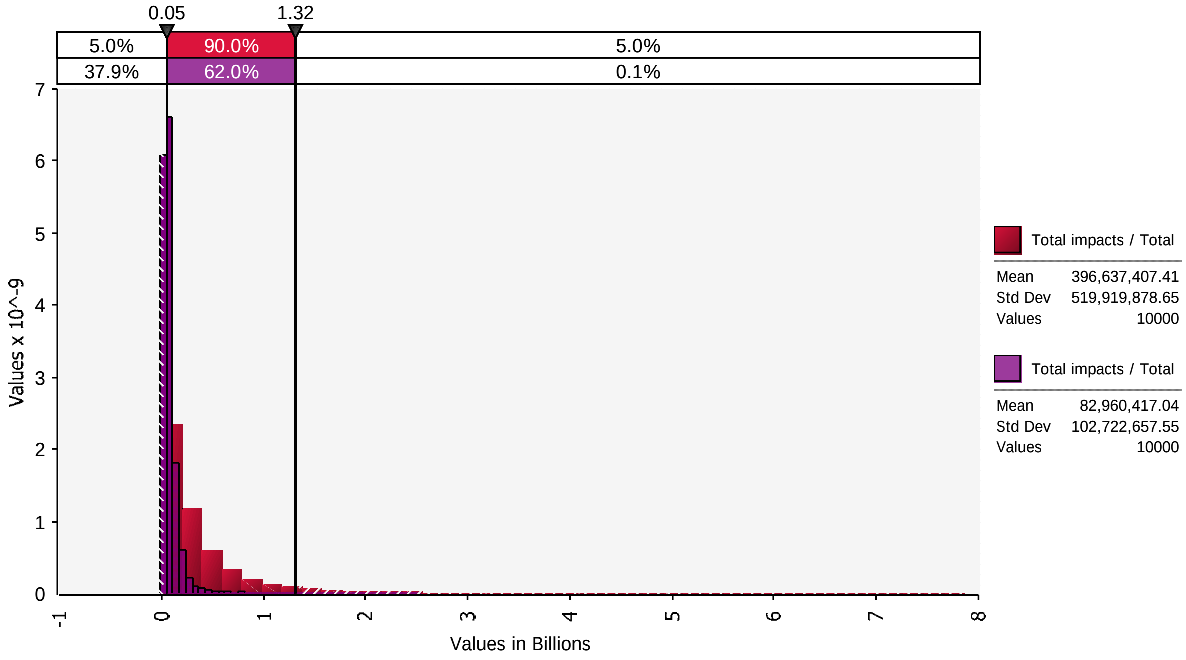
NPV of Impacts

The Net Present Values of the impacts aggregated over the whole time period to 2200 are shown in figure 5, as probability density functions. The units on the horizontal axis of the figures are billions of $millions, equivalent to thousands of $trillion. The equity weighting and discounting is done using the range of inputs described earlier.

In the A1B scenario, the mean NPV of impacts is about $400 trillion, with a 5% to 95% range of about $50 trillion to $1300 trillion. For comparison, global world product in the base year of 2008 is about $60 trillion. So the mean cumulative impact of climate change until 2200 is equivalent to about the total loss of 7 years worth of today’s global production (The standard deviation of the result is larger than the mean, at about $500 trillion, implying that with 10000 runs the standard error of the mean NPV is about $5 trillion. 90% of the time another 10000 runs would give a mean NPV within about $10 trillion of the $400 trillion found here). Without adaptation the mean impact would increase to about $550 trillion.

The 95% point is equivalent to over 20 years of lost production. The shape of the distribution shows a long right tail. A few runs have an unfortunate combination of high climate sensitivity and a low tolerable temperature before a discontinuity occurs, and these runs contribute substantially to the mean NPV. The highest impact is over $7 000 trillion, or over 100 years worth of initial global world product. With mean values for all the inputs to the model, the NPV of impacts comes to only about $200 trillion, showing how important the proper treatment of risk is to understanding the magnitude of the problem.

Figure 5 The NPV of global impacts by scenario



In the low emissions scenario, the mean NPV of impacts is about $80 trillion, with a 5% to 95% range of about $15 trillion to $200 trillion. Without adaptation the mean impact would more than double to about $180 trillion. The long right tail is still evident, but does not extend anything like as far, as the chances of a discontinuity are much smaller, and it will occur much later if it does occur. There is only a 0.1% chance that the NPV of impacts in the low emissions scenario will exceed $1300 trillion, the 95% point on the NPV of impacts in the A1B scenario. At the other end of the distribution, there is a very small chance of negative impacts when emissions are kept as low as this, as the NPV of benefits from small temperature rises can exceed the NPV of later negative impacts.

Social cost of CO2

Finally we get to the result that is of most interest for setting prices on CO2 emissions, the amount by which the NPV of impacts increases if one more tonne of CO2 is emitted, or decreases if one less tonne is emitted – the social cost of CO2 (SCCO2). In the PAGE09 model, this is calculated by changing the emissions of CO2 in 2009 by 100 Gt, and dividing the difference in the NPV of impacts by 100 billion. This may seem like a non-marginal change, but tests with changes in emissions of 1 Gt, 10 Gt and 100 Gt give results within 1% of each other for mean values of the inputs, and so 100Gt can actually be considered a marginal change in emissions.

Figure 6 The SCCO2 in 2009, A1B scenario

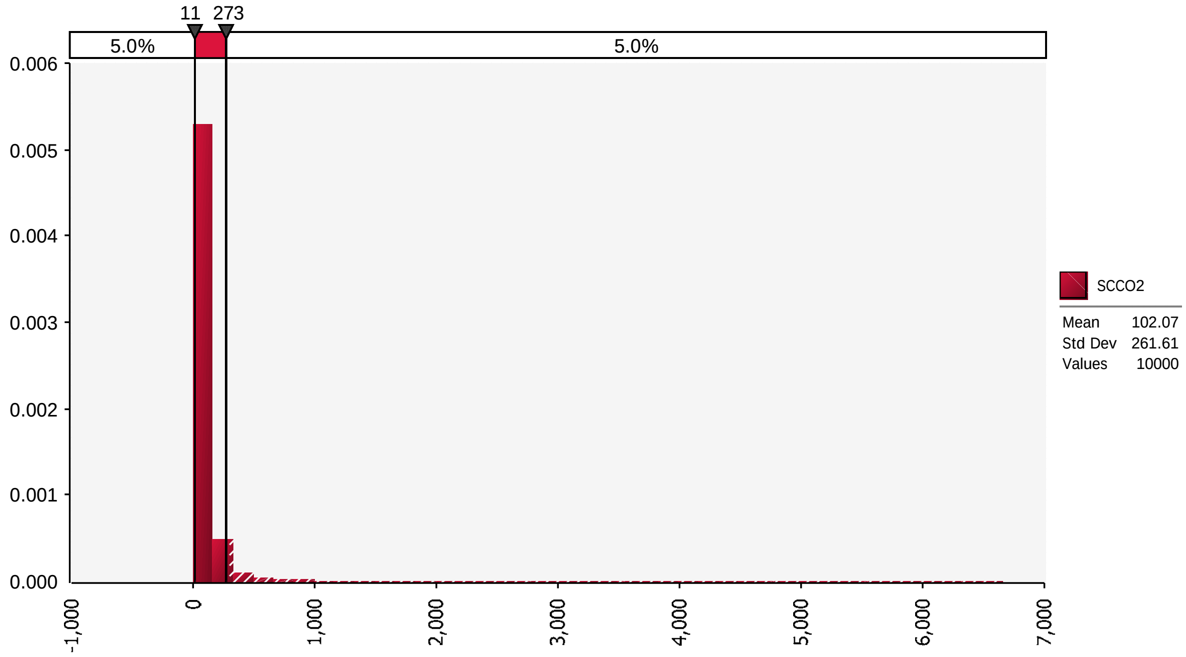
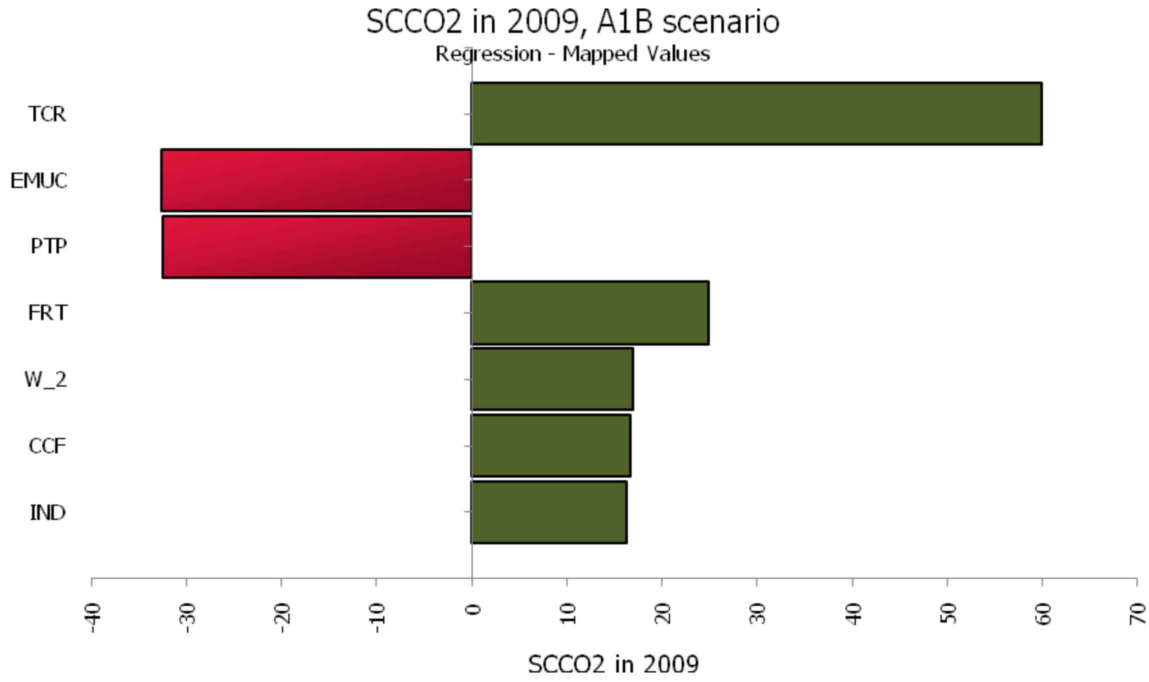


Figure 6 shows that in the A1B scenario, the mean SCCO2 for emissions in 2009 is about $100 per tonne of CO2, with a 5% to 95% range of about $10 to $270, all in $US(2005) (The standard deviation of the result is larger than the mean, about $260, implying that with 10000 runs the standard error of the mean NPV is about $2.6; 90% of the time another 10000 runs would give a mean NPV within about $5 of the $100 found here).

The SCCO2 is so hard to pin down accurately because of the possibility that even a small amount of extra emissions, such as 100Gt of CO2 might lead to an earlier discontinuity, in, say,2075 rather than 2100. On average this happens in about 300 of the 10000 runs, and this is what produces the very long right tail in the distribution, giving a few SCCO2 values of up to $5000 or so. With mean values for all the inputs to the model, the SCCO2 comes to only about $50, showing how important the proper treatment of risk is to understanding the SCCO2.

Another useful aid to understanding the variation in the SCCO2 is shown in figure 7. This shows the amount by which the SCCO2 increases if the seven most important influences on the SCCO2 increase by one standard deviation.

Figure 7 Major influences on the SCCO2 in 2009, A1B scenario



The most important influence is one of the components of the climate sensitivity. An increase in the transient climate response (TCR) by one standard deviation increases the SCCO2 by about $60. As the TCR has a triangular distribution with minimum value 1, mode 1.3 and maximum value 2.8 degC, its standard deviation is 0.4 degC.

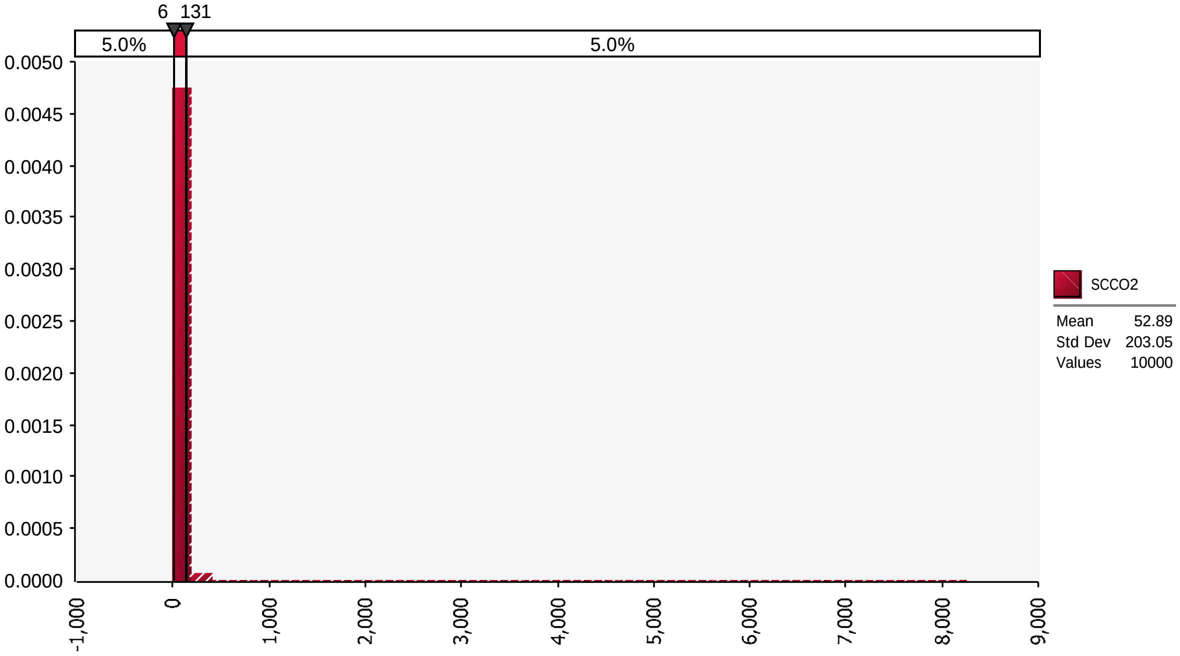
Next are the equity weights (EMUC) and the pure time preference (PTP) rate, and this time the signs of the influences are negative, with an increase in EMUC or PTP of one standard deviation, about 0.3 and 0.4% per year respectively, reducing the SCCO2 by about $30. A higher EMUC means that impacts that occur in the future, when consumption per capita is on average higher than today's consumption per capita in the EU, are weighted less. A higher PTP rate means that impacts that occur in the future have a lower NPV. The implication of these results is that a PTP rate of 0.1% per year, as used in Stern, 2007, would increase the mean SCCO2 by about $70, to about $170 per tonne of CO2. Using a PTP rate of 2% per year, as in Nordhaus, 2007, would decrease the mean SCCO2 by about $70 to about $30 per tonne of CO2.

An increase in the feedback response time (FRT) by one standard deviation, or about 11 years, increases the SCCO2 by about $25. It might be thought that the sign of this influence should be negative, as a longer half life means the Earth takes longer on average to respond to higher radiative forcing, but in fact, if the TCR is fixed, a higher value for FRT means a higher value for the climate sensitivity, and so a larger response to higher concentrations of CO2 overall.

Increasing the weight on non-economic impacts (W_2) by one standard deviation, about 0.2% of GDP, increases the SCCO2 by about $20, as does increasing the carbon cycle feedback (CCF) by 2.25% per degree C, and increasing (ie making less negative) the indirect sulphate effect by 0.16 W/m2 for a doubling of sulphate concentration.

The corresponding result for the low emissions scenario is shown in figure 8.

Figure 8 The SCCO2 in 2009, low emissions scenario



The mean SCCO2 in the low emissions scenario is about $50 per tonne of CO2, with a 5% to 95% range of about $5 to $130. The standard deviation of the result is about $200, implying that with 10000 runs the standard error of the mean NPV is about $2; 90% of the time another 10000 runs would give a mean NPV within about $4 of the $53 found here.

The mean value is about half that in the A1B scenario. The reduced chance of a discontinuity in this scenario, and all that that implies, means that the extra impact from one more tonne of emissions is lower than if emissions are allowed to grow unchecked.

Regional split

If a tonne of CO2 emitted in 2009 causes mean extra impacts of $100 (in the A1B scenario) or $50 (in the low emissions scenario), it is possible to use PAGE09 to answer the question:

What is the regional split of the mean extra impacts caused by the marginal tonne of CO2?

Combining this regional output with the regional split of emissions in 2009 allows a matrix to be drawn up showing the mean extra impacts in region i that are caused by emissions from region j, and vice versa.

Table 9 shows the results for the A1B scenario. The first row shows that 1.0% of the mean SCCO2 is contributed by extra impacts in the EU from emissions in the EU, 0.8% of the mean SCCO2 is contributed by extra impacts in the US from emissions in the EU, and so on. Globally, 11.3% of the mean SCCO2 is contributed by emissions from the EU.

The first column shows that 1.0% of the mean SCCO2 is contributed by extra impacts in the EU from emissions in the EU, 1.3% of the mean SCCO2 is contributed by extra impacts in the EU from emissions in the US, and so on. Globally, 8.5% of the mean SCCO2 is contributed by extra impacts in the EU.

Table 9 Regional distributions of the mean SCCO2, A1B scenario

	Mean extra impacts in								
% of SCCO2	EU	US	OT	EE	CA	IA	AF	LA	Global
From emissions in									
EU	1.0	0.8	0.5	0.3	1.2	4.0	2.9	0.8	**11.3**
US	1.3	1.1	0.7	0.4	1.7	5.6	4.0	1.1	**15.9**
OT	0.5	0.4	0.3	0.1	0.7	2.2	1.6	0.4	**6.3**
EE	0.7	0.6	0.4	0.2	0.9	3.0	2.1	0.6	**8.4**
CA	1.1	0.9	0.6	0.3	1.4	4.7	3.4	0.9	**13.4**
IA	1.9	1.5	1.0	0.5	2.3	7.7	5.6	1.5	**22.0**
AF	1.0	0.8	0.6	0.3	1.3	4.3	3.1	0.9	**12.3**
LA	0.9	0.7	0.5	0.2	1.1	3.7	2.7	0.7	**10.5**
Global	**8.5**	**6.8**	**4.5**	**2.2**	**10.5**	**35.1**	**25.5**	**7.0**	**100.0**

Table 10 summarises by combining the first four regions which make up the annex 1 regions, and the last four regions which make up the rest of the world, largely developing countries.

Table 10 Summary regional distributions of the mean SCCO2, A1B scenario

	Mean extra impacts in		
% of SCCO2	Annex 1	RoW	Global
From emissions in			
Annex 1	9.2	32.6	**41.8**
RoW	12.8	45.4	**58.2**
Global	**22.0**	**78.0**	**100.0**

Less than 10% of the mean SCCO2 comes from extra impacts in annex 1 from annex 1 emissions, while over 45% comes from extra impacts in RoW from RoW emissions. About one third of the mean

SCCO2 comes from extra impacts in the RoW caused by emissions in Annex 1, while just over 10% comes from extra impacts in annex 1 caused by emissions in the RoW. In total, annex 1 country emissions are on average responsible for about 40% of the mean SCCO2, while suffering about 20% of the extra impacts.

The regional breakdown for the low emissions scenario is very similar, as shown in table 11.

Table 11 Summary regional distributions of the mean SCCO2, low emissions scenario

	Mean extra impacts in		
% of SCCO2	Annex 1	RoW	Global
From emissions in			
Annex 1	9.4	32.4	**41.8**
RoW	13.1	45.0	**58.2**
Global	**22.6**	**77.4**	**100.0**

The responsibilities of the different regions are the same, as emissions are essentially the same in 2009 as in the A1B scenario. A slightly higher percentage of the extra impacts are felt in the annex 1 countries than under the A1B scenario, as the possibility of triggering a discontinuity which might lead to very low consumption in the RoW is much lower under the low emissions scenario (about 1% by 2100 and 1.5% by 2200) than under the A1B scenario (about 20% by 2100, 50% by 2200).

Future work

The results presented in this paper are only a small subset of the outputs that the PAGE09 model produces. The updates to the representation of abatement and adaptation costs are even more significant. Their derivation, form and effects will be the subject of a future paper. Combining abatement costs with impacts allows the net benefits of different scenarios, such as the low emissions scenario, to be found. Comparing marginal abatement costs with the social cost of CO2 helps to guide the search for economically efficient emission cutback paths. The effects of different types of discontinuity on the SCCO2; the contribution to the impacts from the long right tails of the input distributions; the impacts, costs and net benefits of cutbacks to the emissions of non-CO2 greenhouse gases – all these and more can easily be investigated with the PAGE09 model. Anyone interested in working with PAGE09 is invited to contact the author to obtain a copy of the model.

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Appendix: Full set of inputs for the calculations

PAGE09	version	1.7		Run	1		Date	14/05/10			
Base Year:	2008										
Analysis Years:		2009	2010	2020	2030	2040	2050	2075	2100	2150	2200

Impacts:					
EN	Economic				
CU	Non-econ				
ptp rate	1.033333	<0.1,1, 2>			%/ year
Equity weighted costs	1				
Elasticity of utility	1.166667	<0.5,1,2>			

	CO2	CH4	N2O	Lin		
Pre-industrial conc	278000	700	270	0	ppb	
Density	7.8	2.78	7.8	100000	Mt/ppb	
Forcing slope	5.5	0.036	0.12	0.2		
Stimulation		0	0	0	Mt/ppb	
Stay in air	30				%	<25,30,35>
Emit to air		100	100	100	%	
Half life		10.5	114	1000	years	
Base year conc	395000	1860	322	0.11	ppb	
Cumulative emissions	2050000				Mtonnes	
Base year forcing	1.735	0.550	0.180	0.022	W/m2	

Regions & baseyear:		Area:	GDP	Pop	CO2 emit	CH4 emit	N2O emit	Lin emit	S emit	Natural S	RT	Latitude	
EU	EU	4.50E+06	1.39E+07	496	4400	24	1.400109	73.61871	4.1	7.0E-08	1	45	(Focus region)
USA	US	9.36E+06	1.30E+07	315	6183	29	1.234923	191.6451	5.5	7.0E-08	1	40	
Other OECD	OT	1.42E+07	7.32E+06	273	2438	22	0.66379	69.02367	1.7	7.0E-08	1.2	40	
FSU & ROE	EE	2.29E+07	3.10E+06	304	3216	38	0.448255	24.67513	11.9	7.0E-08	1.4	55	

China & CP Asia	CA	1.17E+07	7.83E+06	1536	5040	56	2.436778	79.08005	32.2	7.0E-08	0.6	30
India & SE Asia	IA	8.90E+06	7.82E+06	2123	8286	71	1.02158	55.24011	6.6	7.0E-08	0.8	15
Africa & ME	AF	3.63E+07	4.69E+06	1219	4656	66	1.951801	33.74054	11.2	7.0E-08	0.7	20
Latin America	LA	3.47E+07	5.62E+06	581	3971	58	1.889284	30.18799	7.4	7.0E-08	0.85	20
		Km2	$million	million	Mtonne	Mtonne	Mtonne	Mtonne	TgS	Tg/Km2	degC	

GDP growth rates:	start	2008	2009	2010	2020	2030	2040	2050	2075	2100	2150	
	end	2009	2010	2020	2030	2040	2050	2075	2100	2150	2200	
	EU	1.9	1.9	1.9	1.9	1.9	1.7	1.7	1.7	1.7	1.7	%/year
	US	1.9	1.9	1.9	1.9	1.9	1.7	1.7	1.7	1.7	1.7	%/year
	OT	1.9	1.9	1.9	1.9	1.9	1.7	1.7	1.7	1.7	1.7	%/year
	EE	3.4	3.4	3.4	3.4	3.4	3.0	3.0	3.0	1.7	1.7	%/year
	CA	4.3	4.3	4.3	4.3	4.3	2.6	2.6	2.6	1.7	1.7	%/year
	IA	4.4	4.4	4.4	4.4	4.4	2.6	2.6	2.6	1.7	1.7	%/year
	AF	5.0	5.0	5.0	5.0	5.0	3.0	3.0	3.0	1.7	1.7	%/year
	LA	5.0	5.0	5.0	5.0	5.0	3.0	3.0	3.0	1.7	1.7	%/year

Pop growth rates	start	2008	2009	2010	2020	2030	2040	2050	2075	2100	2150	
	end	2009	2010	2020	2030	2040	2050	2075	2100	2150	2200	
	EU	0.3	0.3	0.3	0.3	0.2	-0.1	-0.2	-0.2	0.0	0.0	%/year
	US	0.8	0.8	0.8	0.8	0.6	0.4	0.4	0.3	0.0	0.0	%/year
	OT	0.4	0.4	0.4	0.1	0.0	-0.2	-0.3	-0.3	0.0	0.0	%/year
	EE	0.2	0.2	0.2	0.1	0.0	-0.3	-0.4	-0.5	0.0	0.0	%/year
	CA	0.5	0.5	0.5	0.4	-0.1	-0.7	-1.0	-1.5	0.0	0.0	%/year
	IA	1.6	1.6	1.6	1.2	0.7	0.1	-0.5	-1.1	0.0	0.0	%/year
	AF	2.5	2.5	2.5	2.1	1.3	0.7	0.0	-0.5	0.0	0.0	%/year
	LA	1.3	1.3	1.3	1.1	0.6	0.1	-0.3	-0.7	0.0	0.0	%/year
Excess forcing	0.65										W/m2	

PAGE09	version	1.7				
Science			**min**	**mode**	**max**	
	Percent of CO2 emitted to air	62.00	57	62	67	%
	Half-life of CO2 atmospheric residence	73.33	50	70	100	years
	Transient climate response	1.70	1	1.3	2.8	degC
	Stimulation of CO2 concentration	9.67	4	10	15	%/degC
	CO2 stimulation limit	53.33	30	50	80	%
	Land excess temperature ratio to ocean	1.40	1.2	1.4	1.6	
	Poles excess temperature change over equator	1.50	1	1.5	2	degC
	Sulfate direct (linear) effect in 2008	-0.47	-0.8	-0.4	-0.2	W/m2
	Sulfate indirect (log) effect for a doubling	-0.40	-0.8	-0.4	0	W/m2
	Sea level rise in 2008	0.15	0.1	0.15	0.2	m
	Sea level rise with temperature	1.73	0.7	1.5	3	m/degC
	Sea level asymptote	1.00	0.5	1	1.5	m
	Half-life of sea level rise	1000.00	500	1000	1500	years
	Half-life of global warming	35.00	10	30	65	years
	Equilibrium warming for a doubling of CO2	2.99				degC
Tolerable						
	Tolerable before discontinuity	3.00	2	3	4	degC
	Chance of discontinuity	20.00	10	20	30	% per degC
Weights						
	Savings rate	15.00	10	15	20	%
	Calibration sea level rise	0.50	0.45	0.5	0.55	m
	Calibration temperature	3.00	2.5	3	3.5	degC
	Sea level initial benefit	0.00	0	0	0	%GDP per m
	Sea level impact at calibration sea level rise	1.00	0.5	1	1.5	%GDP
	Sea level impact function exponent	0.73	0.5	0.7	1	
	Sea level exponent with income	-0.30	-0.4	-0.3	-0.2	
	Economic initial benefit	0.13	0	0.1	0.3	%GDP per degC

Economic impact at calibration temperature	0.50	0.2	0.5	0.8	%GDP
Economic impact function exponent	2.17	1.5	2	3	
Economic exponent with income	-0.13	-0.3	-0.1	0	
Non-econ initial benefit	0.08	0	0.05	0.2	%GDP per degC
Non-econ impact at calibration temperature	0.53	0.1	0.5	1	%GDP
Non-econ impact function exponent	2.17	1.5	2	3	
Non-econ exponent with income	0.00	-0.2	0	0.2	
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 saturate beyond	33.33	20	30	50	%consumption
Statistical value of civilisation	5.3E+10	1.00E+10	5.00E+10	1.00E+11	$million
US weights factor	0.80	0.6	0.8	1	
OT weights factor	0.80	0.4	0.8	1.2	
EE weights factor	0.40	0.2	0.4	0.6	
CA weights factor	0.80	0.4	0.8	1.2	
IA weights factor	0.80	0.4	0.8	1.2	
AF weights factor	0.60	0.4	0.6	0.8	
LA weights factor	0.60	0.4	0.6	0.8	

PAGE09 version 1.7

Prevention	**A1B emissions**										
	2009	**2010**	**2020**	**2030**	**2040**	**2050**	**2075**	**2100**	**2150**	**2200**	
EU CO2 emissions	100	100	102	104	98	97	80	66	66	66	%
US CO2 emissions	100	100	102	104	98	97	80	66	66	66	%
OT CO2 emissions	100	100	102	104	98	97	80	66	66	66	%
EE CO2 emissions	102	104	95	96	91	90	72	62	62	62	%
CA CO2 emissions	103	107	136	165	183	198	195	176	176	176	%
IA CO2 emissions	103	107	136	165	183	198	195	176	176	176	%
AF CO2 emissions	103	107	138	168	187	210	208	178	178	178	%
LA CO2 emissions	103	107	138	168	187	210	208	178	178	178	%
EU CH4 emissions	100	100	96	93	80	77	63	58	58	58	%
US CH4 emissions	100	100	96	93	80	77	63	58	58	58	%
OT CH4 emissions	100	100	96	93	80	77	63	58	58	58	%
EE CH4 emissions	104	107	113	109	92	86	69	62	62	62	%
CA CH4 emissions	101	103	121	142	147	143	103	81	81	81	%
IA CH4 emissions	101	103	121	142	147	143	103	81	81	81	%
AF CH4 emissions	102	103	124	141	142	146	125	97	97	97	%
LA CH4 emissions	102	103	124	141	142	146	125	97	97	97	%
EU N2O emissions	100	100	103	102	98	96	89	84	84	84	%
US N2O emissions	100	100	103	102	98	96	89	84	84	84	%
OT N2O emissions	100	100	103	102	98	96	89	84	84	84	%
EE N2O emissions	100	101	103	104	102	100	91	87	87	87	%
CA N2O emissions	100	101	102	107	110	111	108	108	108	108	%
IA N2O emissions	100	101	102	107	110	111	108	108	108	108	%
AF N2O emissions	100	100	101	105	107	109	109	109	109	109	%
LA N2O emissions	100	100	101	105	107	109	109	109	109	109	%
EU Lin emissions	103	107	97	101	105	109	117	126	126	126	%

US Lin emissions	103	107	97	101	105	109	117	126	126	126	%
OT Lin emissions	103	107	97	101	105	109	117	126	126	126	%
EE Lin emissions	104	107	184	266	349	361	368	334	334	334	%
CA Lin emissions	106	113	234	452	669	910	1108	1029	1029	1029	%
IA Lin emissions	106	113	234	452	669	910	1108	1029	1029	1029	%
AF Lin emissions	108	115	236	479	722	878	1007	952	952	952	%
LA Lin emissions	108	115	236	479	722	878	1007	952	952	952	%

EU sulphates	93	87	61	60	56	61	47	41	41	41	%
US sulphates	93	87	61	60	56	61	47	41	41	41	%
OT sulphates	93	87	61	60	56	61	47	41	41	41	%
EE sulphates	101	102	90	66	36	29	13	13	13	13	%
CA sulphates	104	109	140	99	51	39	17	16	16	16	%
IA sulphates	104	109	140	99	51	39	17	16	16	16	%
AF sulphates	104	108	136	201	191	192	89	65	65	65	%
LA sulphates	104	108	136	170	191	192	89	65	65	65	%

Excess forcing	0.70	0.71	0.80	0.83	0.81	0.80	0.69	0.55	0.55	0.55	W/m2

New adaptation

	Plateau	Pstart	Pyears	Impred	Istart	Iyears	Impmax
EU sea level	0.25	2000	20	50	2020	40	1
US sea level	0.25	2000	20	50	2020	40	1
OT sea level	0.25	2000	20	50	2020	40	1
EE sea level	0.25	2000	20	50	2020	40	1
CA sea level	0.20	2000	30	25	2020	40	1
IA sea level	0.20	2000	30	25	2020	40	1
AF sea level	0.20	2000	30	25	2020	40	1
LA sea level	0.20	2000	30	25	2020	40	1

	Plateau	Pstart	Pyears	Impred	Istart	Iyears	Impmax
EU Economic	1.0	2000	20	30	2010	20	2
US Economic	1.0	2000	20	30	2010	20	2
OT Economic	1.0	2000	20	30	2010	20	2

EE Economic	1.0	2000	20	30	2010	20	2
CA Economic	1.0	2010	30	15	2010	30	2
IA Economic	1.0	2010	30	15	2010	30	2
AF Economic	1.0	2010	30	15	2010	30	2
LA Economic	1.0	2010	30	15	2010	30	2

	Plateau	Pstart	Pyears	Impred	Istart	Iyears	Impmax
EU Non-econ	0	2000	100	15	2010	40	2
US Non-econ	0	2000	100	15	2010	40	2
OT Non-econ	0	2000	100	15	2010	40	2
EE Non-econ	0	2000	100	15	2010	40	2
CA Non-econ	0	2000	100	15	2010	40	2
IA Non-econ	0	2000	100	15	2010	40	2
AF Non-econ	0	2000	100	15	2010	40	2
LA Non-econ	0	2000	100	15	2010	40	2

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Prevention	**2016 r5 low emissions**										
	2009	**2010**	**2020**	**2030**	**2040**	**2050**	**2075**	**2100**	**2150**	**2200**	
EU CO2 emissions	100	100	84	55	26	15	4	1	1	1	%
US CO2 emissions	100	100	76	47	18	10	3	1	1	1	%
OT CO2 emissions	100	100	80	51	21	12	3	1	1	1	%
EE CO2 emissions	102	104	86	58	32	19	5	1	1	1	%
CA CO2 emissions	103	107	130	93	58	33	8	2	2	2	%
IA CO2 emissions	103	107	135	103	71	44	13	3	3	3	%
AF CO2 emissions	103	107	130	99	70	44	14	4	4	4	%
LA CO2 emissions	103	107	114	78	43	25	6	2	2	2	%
EU CH4 emissions	100	100	90	59	32	30	30	34	34	34	%
US CH4 emissions	100	100	86	56	29	29	33	42	42	42	%
OT CH4 emissions	100	100	79	47	19	16	14	16	16	16	%
EE CH4 emissions	104	107	94	57	23	20	18	18	18	18	%
CA CH4 emissions	101	103	111	73	40	33	26	22	22	22	%
IA CH4 emissions	101	103	133	99	71	70	71	65	65	65	%
AF CH4 emissions	102	103	121	87	59	60	68	71	71	71	%
LA CH4 emissions	102	103	104	66	32	28	25	25	25	25	%
EU N2O emissions	100	100	111	114	111	108	89	68	68	68	%
US N2O emissions	100	100	111	114	111	108	89	68	68	68	%
OT N2O emissions	100	100	111	114	111	108	89	68	68	68	%
EE N2O emissions	100	101	111	116	115	112	92	71	71	71	%
CA N2O emissions	100	101	110	120	124	125	109	87	87	87	%
IA N2O emissions	100	101	110	120	124	125	109	87	87	87	%
AF N2O emissions	100	100	108	117	120	122	110	88	88	88	%
LA N2O emissions	100	100	108	117	120	122	110	88	88	88	%
EU Lin emissions	94	88	32	28	23	16	5	1	1	1	%

US Lin emissions	94	88	30	25	21	15	5	2	2	2	%
OT Lin emissions	94	88	25	19	12	8	2	1	1	1	%
EE Lin emissions	103	105	97	63	29	18	4	1	1	1	%
CA Lin emissions	104	108	160	121	82	54	12	2	2	2	%
IA Lin emissions	104	108	198	176	154	109	33	7	7	7	%
AF Lin emissions	106	111	138	108	77	54	16	4	4	4	%
LA Lin emissions	106	111	123	84	45	28	6	2	2	2	%

EU sulphates	94	87	50	36	25	15	6	2	2	2	%
US sulphates	94	87	50	36	25	15	6	2	2	2	%
OT sulphates	94	87	50	36	25	15	6	2	2	2	%
EE sulphates	101	102	74	43	16	8	2	1	1	1	%
CA sulphates	104	109	115	66	23	12	2	1	1	1	%
IA sulphates	104	109	115	66	23	12	2	1	1	1	%
AF sulphates	104	108	112	94	85	50	13	3	3	3	%
LA sulphates	104	108	112	94	85	50	13	3	3	3	%

Excess forcing	0.70	0.71	0.74	0.58	0.40	0.27	0.16	0.12	0.12	0.12	W/m2

New adaptation

	Plateau	Pstart	Pyears	Impred	Istart	Iyears	Impmax
EU sea level	0.25	2000	20	50	2020	40	1
US sea level	0.25	2000	20	50	2020	40	1
OT sea level	0.25	2000	20	50	2020	40	1
EE sea level	0.25	2000	20	50	2020	40	1
CA sea level	0.20	2000	30	25	2020	40	1
IA sea level	0.20	2000	30	25	2020	40	1
AF sea level	0.20	2000	30	25	2020	40	1
LA sea level	0.20	2000	30	25	2020	40	1

	Plateau	Pstart	Pyears	Impred	Istart	Iyears	Impmax
EU Economic	1.0	2000	20	30	2010	20	2
US Economic	1.0	2000	20	30	2010	20	2
OT Economic	1.0	2000	20	30	2010	20	2

EE Economic	1.0	2000	20	30	2010	20	2
CA Economic	1.0	2010	30	15	2010	30	2
IA Economic	1.0	2010	30	15	2010	30	2
AF Economic	1.0	2010	30	15	2010	30	2
LA Economic	1.0	2010	30	15	2010	30	2

	Plateau	Pstart	Pyears	Impred	Istart	Iyears	Impmax
EU Non-econ	0	2000	100	15	2010	40	2
US Non-econ	0	2000	100	15	2010	40	2
OT Non-econ	0	2000	100	15	2010	40	2
EE Non-econ	0	2000	100	15	2010	40	2
CA Non-econ	0	2000	100	15	2010	40	2
IA Non-econ	0	2000	100	15	2010	40	2
AF Non-econ	0	2000	100	15	2010	40	2
LA Non-econ	0	2000	100	15	2010	40	2