THE CONSEQUENCES OF DELAYED ACTION ON CLIMATE CHANGE

Postponing international action to reduce greenhouse gas emissions would likely lead to substantially more damage. Delaying the peak emissions date by ten years (from 2015 to 2025) increases the temperature outcome by approximately 0.5°C by 2100.

Martin Parry, Jason Lowe and Clair Hanson

Negotiators meeting this month in Poznan and next December in Copenhagen have set their sights on achieving international agreement on targets to reduce emissions that will avoid dangerous climate change. Two key questions face the negotiators: How much to reduce emissions and how soon to begin making these reductions. In a previous commentary for *Nature*[1] we analysed the effect of different amounts of reduction, but we assumed that action would be agreed at Copenhagen in 2009 and lead to global emissions decreasing from a peak in 2015. We concluded that 80% cuts in emissions by 2050 are necessary to avoid the most serious global impacts. This assumes, however, not only that very substantial actions are agreed in 2009 but also that the actions are able to halt completely the increase in global emissions within five years: an extremely tight schedule. Now we are able to consider the effects of delayed actions with peak emissions in 2025 and 2035.

The median temperature outcomes for each rate and date of action have been estimated using a simple Earth System Model[2], which has been tuned to represent closely the global average behaviour of the 11 Earth Systems Models used in the 2007 IPCC assessment[3]. Table 1 summarises the results relative to 1990 (the base year often used in studies of climate impacts). The results show that, for example, to achieve the EU's target of not exceeding 2°C above pre-industrial temperatures would require at least 4% annual cuts in emissions with a peak date in 2015 (equivalent to a 60% cut by 2050). But this scenario gives little more than a 50% chance of staying below the EU target. To have a significantly greater chance than 50% of staying below this temperature target requires a 6% annual cut (equivalent to about 80% by 2050). This gives a 0.3°C margin of safety in the median temperature rise by 2100.

	Annual Reduction Rate after peak emissions					
Peak Year	**1%**	**2%**	**3%**	**4%**	**5%**	**6%**
2015	2.6°C	2.1°C	1.8°C	**1.6°C**	**1.5°C**	**1.4°C**
2025	3.0°C	2.6°C	2.3°C	2.1°C	1.9°C	1.8°C
2035	3.4°C	3.0°C	2.8°C	2.6°C	2.5°C	2.4°C

Table 1: Median increases in global mean temperature (°C) by 2100 relative to 1990 levels for annual reduction rates in emissions of 1% to 6%, and three peak emissions years. Only the scenarios that give more than a 50% chance of staying below the EU temperature target are coloured green.

The table also shows that delaying the peak emissions date by just one decade (from 2015 to 2025) increases the median temperature outcome by about 0.5°C by 2100, and delaying the peak date another decade (to 2035) increases it a further 0.5°C. This is why the Copenhagen meeting in 2009 is so crucial, because a postponed decision would mean that the option of avoiding dangerous climate could quickly slip from our grasp.

The implications of delayed action can be seen by plotting the climate outcomes on a table of impacts (see Figure 1). The

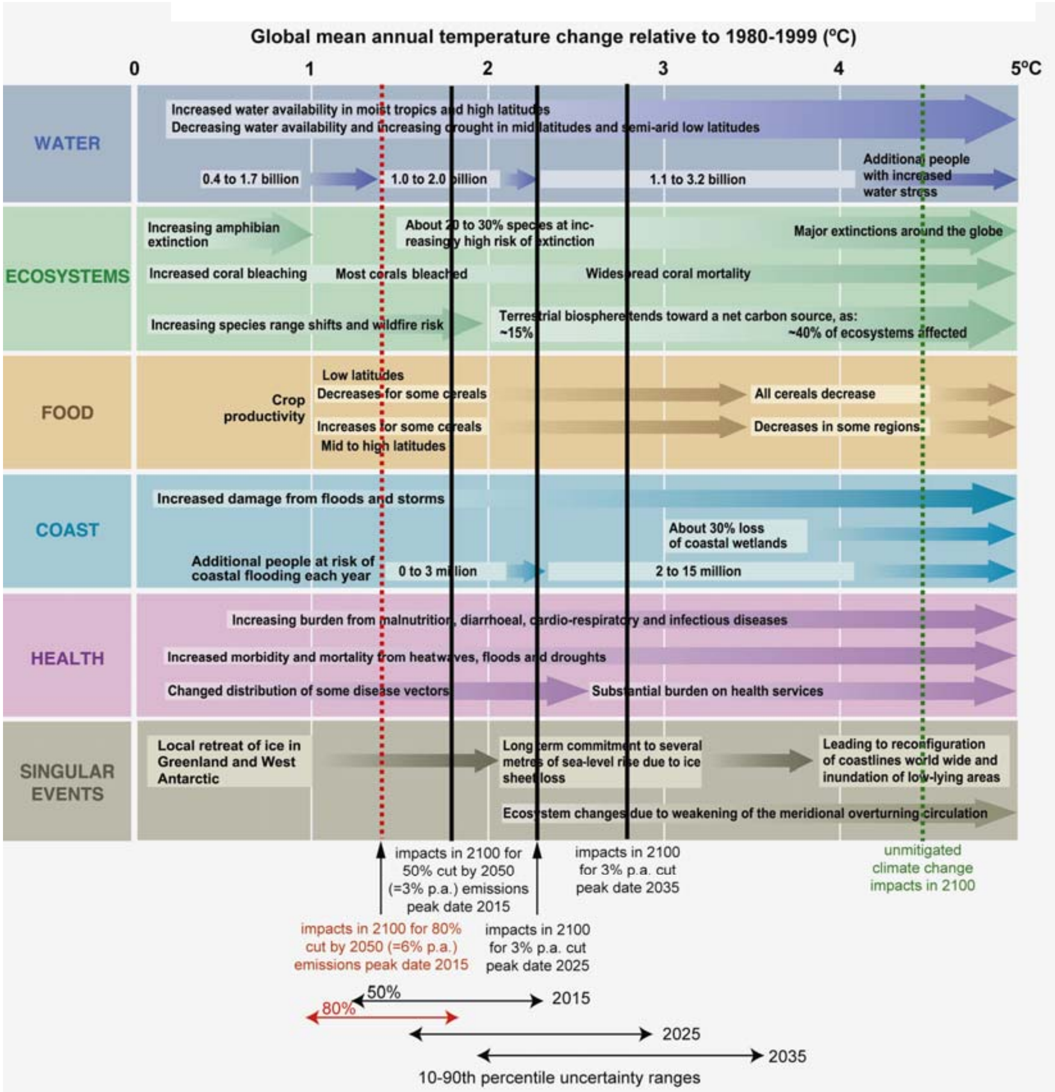

Figure 1: Selected global impacts in 2100 from warming associated with varying amounts of emissions cuts (% reduction of 1990 levels by 2050) and varying peak dates of global greenhouse gas emissions. Vertical lines indicate likely impacts of the median warming expected to result from indicated emissions scenarios. Adapted from Table TS3 in Technical Summary of ref 3.

background table is one we constructed, together with all IPCC Working Group II authors, for the IPCC's 2007 Assessment[4]. Damages to the right of the vertical lines represent those probably avoided by various mitigation actions. Damages to the left of the lines would need to be borne or be adapted to. However, the vertical lines are median temperature outcomes, and there is a wide range of uncertainty around them (see the 10th to 90th percentile ranges in Figure 1).

From Figure 1, we can judge that delaying the peak emissions date by twenty years approximately doubles the potential impact in 2100 when measured in terms of millions of people at risk from water stress or coastal flooding. The figure also indicates, not only that a large swathe of other damages would come into play, such as widespread coral mortality and extinction of terrestrial species, but that we would be committing ourselves to long-term change that could be difficult to reverse, such as the terrestrial biosphere turning from a sink to a source of carbon and long-term sea level rise in the order of metres rather than centimetres.

To conclude, the window of opportunity for action is very narrow. Delaying action would likely lead not only to very much more damage and adaptation cost, but to levels of impact that could well exceed our capacity to adapt, and to conditions that would be difficult to reverse.

Martin Parry was Co-Chair of IPCC's 2007 Working Group II assessment and is now Visiting Professor at the Grantham Institute and Centre for Environmental Policy, Imperial College London. Jason Lowe is a senior research scientist in the Met Office Hadley Centre. Clair Hanson was Deputy Head (Science) of the 2007 IPCC Working Group II Technical Support Unit.
For correspondence: martin@mlparry.com

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Note on research method

The most complex earth system models simulate changes in climate over the globe in the atmosphere, ocean, cryosphere and elements of the earth's carbon cycle. The Met Office Hadley Centre simple earth system model can replicate the global average surface temperature response of these complex models and provides a first look at the warming expected for a range of new scenarios of future emissions.

The simple model has been tuned to represent the spread of models in the C4MIP inter-comparison project (ref 2) and has a mean climate sensitivity of around 3°C, with a range of 2-4.4°C. This is consistent with the likely range of climate sensitivity presented in the 2007 IPCC assessment but does not include any sensitivities above 4.5°C, which can not be ruled out. Non-CO_2 greenhouse gas and aerosol forcing is also included in the analysis.

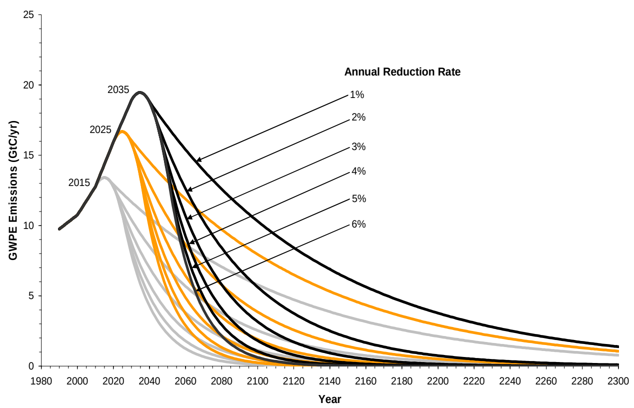

Figure A: Emissions of greenhouse gases for scenarios with peak emissions in 2015, 2025 and 2035 and eventual annual reduction rates of 1-6%.

We also made an estimate of model uncertainty by looking at the spread of simple model results for each scenario. The 10th and 90th percentile ranges estimated for four of our scenarios are shown in Figure 1.

Here we supply a range of idealised scenarios as input to the simple earth system model (Figure A and Table B). In each case the greenhouse gas emissions initially follow historical trends, then transition to our business as usual SRES A2 scenario until an aggressive mitigation policy is implemented. We envision this policy starting at various times in the future (2010, 2020 and 2030), peaking 5 years later (2015, 2025, 2035) and transitioning into a long-term reduction rate of between 1% and 6% per year, which is maintained throughout the scenario.

The results of this model are broadly consistent with other studies. As an example, ref 5 presents a scenario with emissions cuts by 2050 (relative to 1990) of around 50%, and using an SRES A1B baseline. This has a warming in 2100 relative to pre industrial levels of a little over 2°C for a climate sensitivity of 3°C. In comparison, our scenario with peak emissions in 2015 and later reduction of 3% per year has a reduction in emissions of 47% by 2050 and a median warming of 2.1°C. However, we do acknowledge the significant uncertainty that remains in estimating the risk of staying under a particular temperature. A further uncertainty in our results comes from the choice of aerosol reduction scenario: We reduce the sulphate aerosol emissions over a period of 50 years.

	Annual Reduction Rate					
Peak Year	**1%**	**2%**	**3%**	**4%**	**5%**	**6%**
2015	-2%	-29%	-47%	-60%	-69%	-76%
2025	+35%	+8%	-11%	-25%	-36%	-45%
2035	+75%	+58%	+48%	+42%	+40%	+41%

Table B: Absolute global emissions change (%) by 2050 relative to 1990 levels for six annual reduction rates and three peak emissions years. Negative/positive values represent a reduction/increase in emissions relative to 1990.