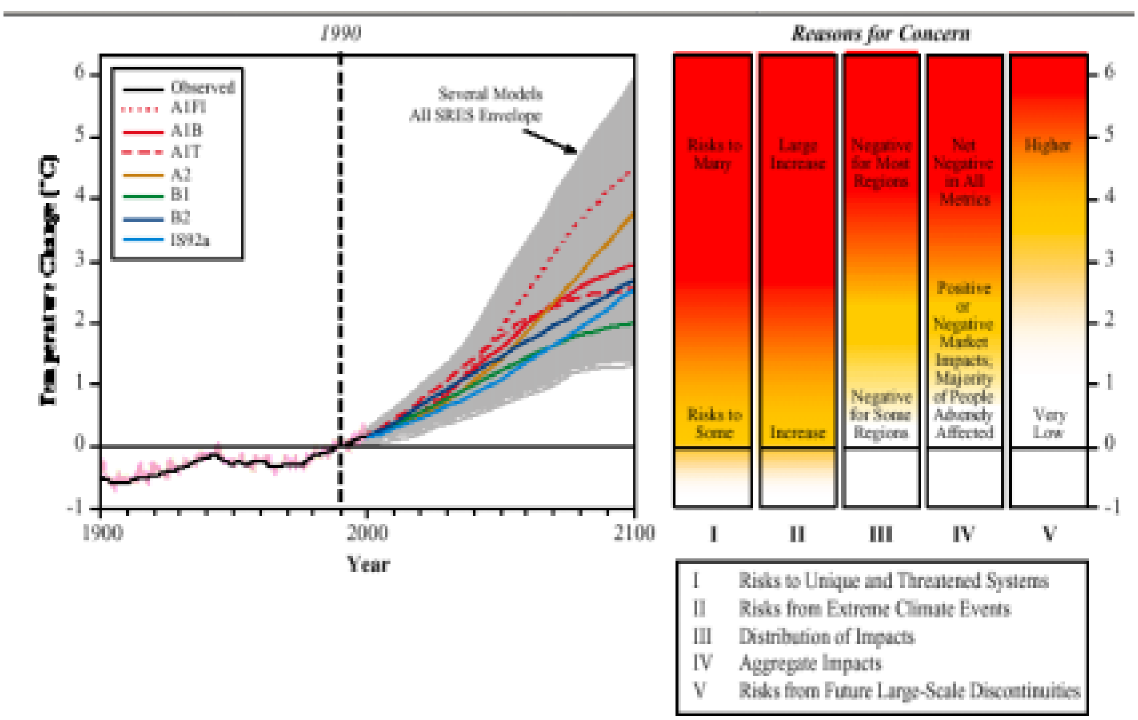
Keeping below 2 degrees

Avoiding dangerous climate change

It is widely recognised that if the worst impacts of climate change are to be avoided then the average rise in the surface temperature of the Earth needs to be kept at less than 2^{o}Celsius above the levels prevailing the pre-industrial period, i.e. before the late eighteenth century. This is the view not only of many scientists but also of some countries and blocs of countries. It is the official position of the EU, agreed not only in the Environment Council but also by heads of government (Council Decision of December 2004).

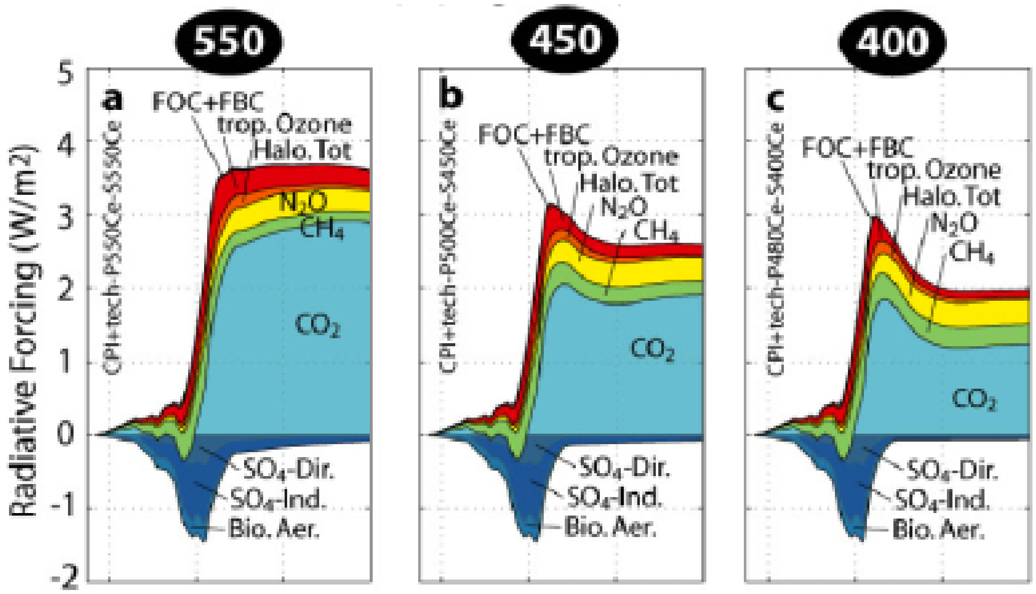
The reason for a 2^{o}C limit is perhaps best illustrated succinctly by a figure known as the ‘burning ember’ in the Third Assessment Report (2001) of the Intergovernmental Panel on Climate Change (IPCC) which is tasked by the UN with reviewing the science of climate change. The figure is reproduced below. The right hand side gives reasons for concern about climate change and the first two columns indicate that environment and development groups should be very concerned. Column I covers risks to unique and threatened systems (mainly ecosystems) and column II covers risks from extreme climate events, such as increased risks from storms, floods and droughts. The figure on the left shows the IPCC’s six, main ‘illustrative ‘ scenarios, with grey borders to indicate uncertainty.

It can be seem that all of the IPCC’s main illustrative scenarios take the World well into the red zones on the columns, showing risks to many unique and threatened systems and a large increase in extreme climate events. Indeed, in the case of both columns, we are already, on the basis of current warming, already in the region of increased risk. As we are likely to experience a further 1^{o}C, whatever we do to limit emissions, a 2^{o}C limit appears sensible.



Concentration targets

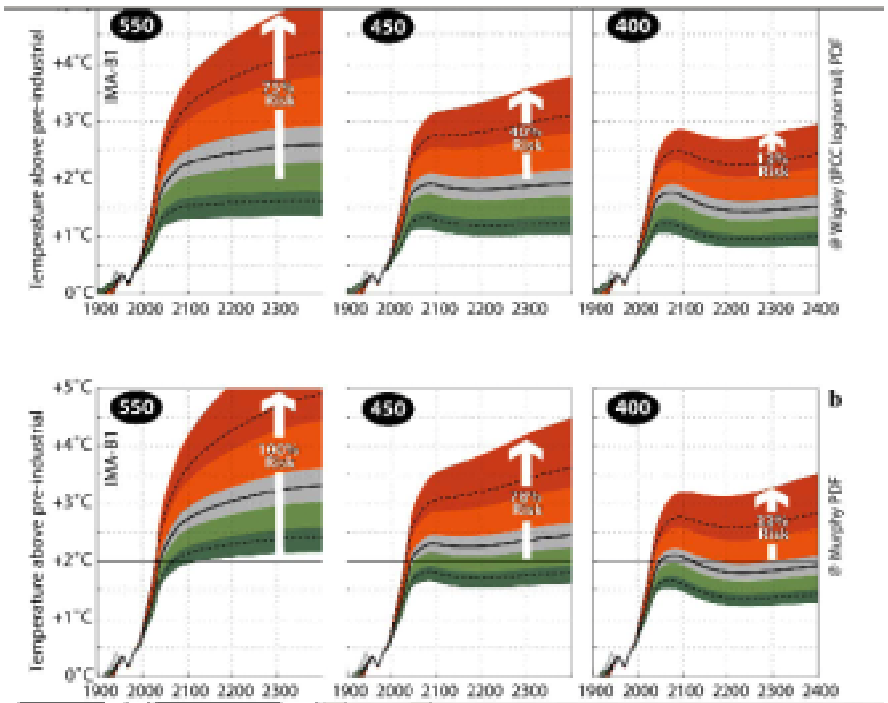
If the 2°C is to be attained atmospheric concentrations of greenhouse gases need to be maintained below a particular level. Precisely what level depends what the concentrations of greenhouse gases there are the atmosphere at a particular time and how much each gas contributes to the heating effect – giving rise to a degree of uncertainty. There is also uncertainty about the assumed levels of gases that will cool the atmosphere, such as the oxides of sulphur from burning 'dirty' coal. However, it is possible to work out what the net effect of all of these factors will be in terms of so-called radiative forcing for different concentration stabilisations, see below for an example.



Having said that there is there is uncertainty in such calculations, much of it arises from assumptions that inevitably have to be made about emissions of different gases in the future. Whilst there is uncertainty about the heating effects of gases it is increasingly clear that the effect itself is bigger than previously thought. A decade or so ago it was thought that carbon dioxide concentration doubling (to about 550ppm) would lead to an average temperature rise of about 2.5 degrees but it now seems that the real value is greater than this. Moreover, the uncertainty range has shifted upwards. The possibility that temperature rise would be quite low, say 1.5 degrees, now seems very unlikely whereas a temperature rise of 4 degrees is much more likely.

In the last few years, a number of modellers have started examining the probability of attaining different average surface temperature levels for difference concentration stabilisation scenarios. These obviously vary, depending on the starting assumptions, but they do give remarkably good guidance to policy makers.

The figure overleaf shows the results of two such exercises with different base assumptions, in each case for greenhouse gas concentration stabilisations of 550ppm, 450ppm and 400ppm. Although the results are dissimilar in detail, it can be seen that only the 400ppm case gives a good chance of attaining a 2°C target, with a 13% chance of missing it in one case and a 33% chance in the other. (The grey areas are the medians and the dashed lines represent 90% confidence.) The lower estimates (den Elzen and Meinshausen) are more recent than the upper ones (Wigley and Raper) and, amongst other things, employ a slightly higher median estimate of climate sensitivity (temperature rise for a doubling of concentration over 100 years): 2.6°C as opposed to 2.5°C which is probably reasonable in light of recent work on the subject.



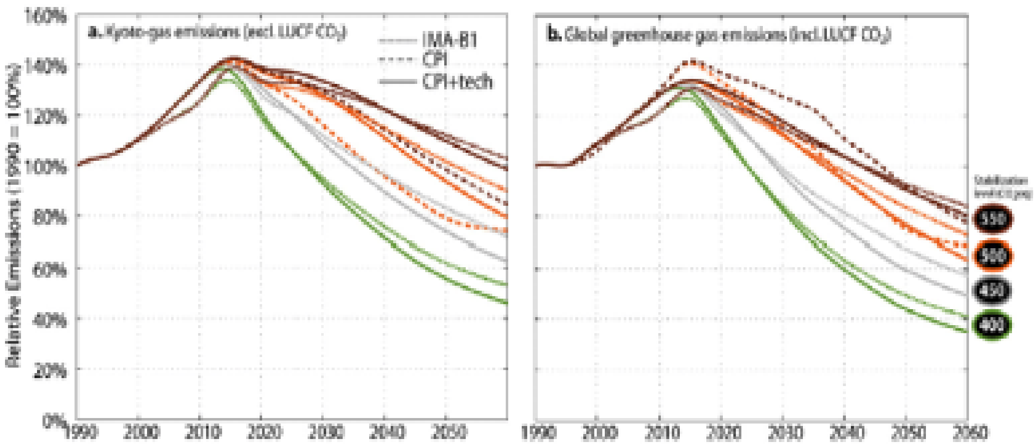
However, to achieve a 400pmm concentration stabilisation target by gradually moving upwards towards it would be impossible. Direct measurement of carbon dioxide concentrations in the atmosphere shows that they are already at level of about 380 ppm which is rather more than 400ppm in terms of all greenhouse gases, depending on the assumptions one uses about other greenhouse gases. It is thus likely that it may be necessary to peak at a higher level than 400ppm and then bring the concentration down rapidly. Den Enzel and Meinshausen employ an overshoot value of 475ppm with a later stabilisation at 400ppm.

It should be stressed that the figures given above are not the only ones that could be derived but they are reasonable estimates published in peer-reviewed literature. Wigley, who derived the upper set of figures is particularly well-known and respected and has worked in the field for decades. Indeed, for some time, a Wigley, Richels, Edmunds paper published in Nature was probably the definitive work on stabilisation scenarios.

Emission pathways

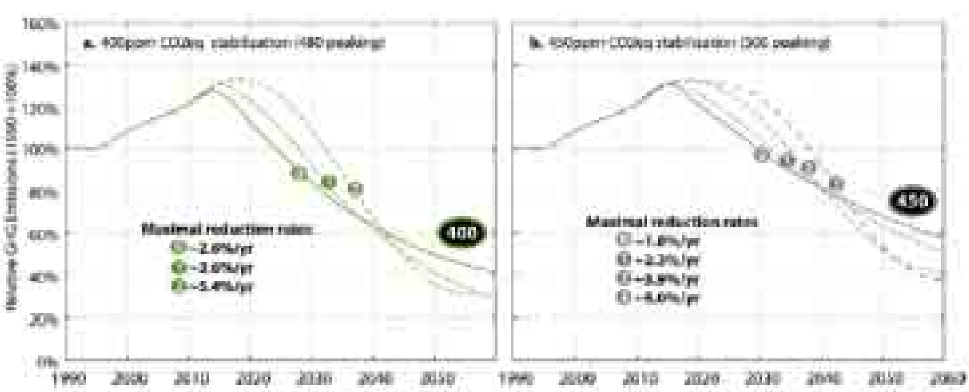
Global pathways

There are many possible emission pathways for attaining stabilisation at a particular atmospheric concentration of greenhouse gases. The ones given below were derived so as to minimise the rate of emissions decrease, it being felt that a rate of greater than about 2.5% for a global emission abatement rate was probably unrealistic given the inertia in the energy production system. It is also assumed that it would be unrealistic to peak and decline before 2015. The pathways illustrated are for attaining stabilisation at four levels (400, 450, 500 and 550ppm) and using three base scenarios with different underlying assumptions. The figure on the left is for greenhouse gases covered by the Kyoto protocol and does not include emissions from land use change and forestry (LUCF) – mainly tropical deforestation. The figure on the right includes all emissions.



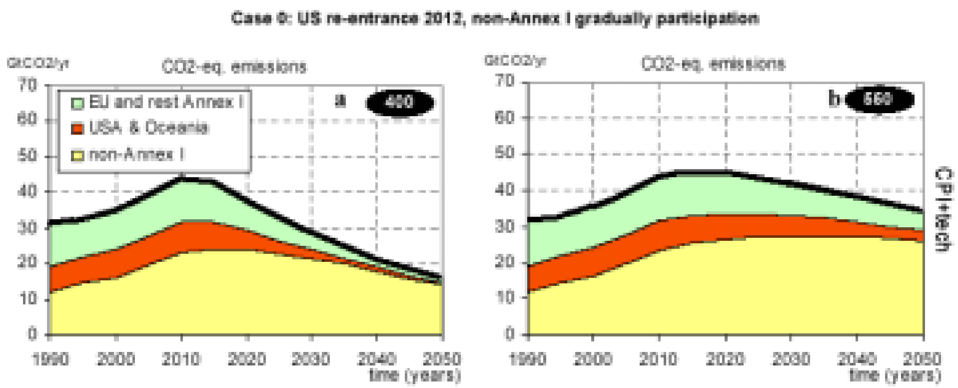
In the pathways illustrated, the only ones that exceeds a rate of decline of 2.5%/year are those associated with stabilisation at 400ppm, but only for twenty years and not by very much, between 2.5 and 3%. A global rate of decline of up to 3% per year is, however, a very steep rate, especially given that emissions from developing countries are likely to increase as they develop. It is, however, a realistic rate in terms of attaining a 2°C target.

The effects of a delayed in peak emissions results in the maximum rates of decline increasing very rapidly, doubling for a delay of five to ten years, see below.



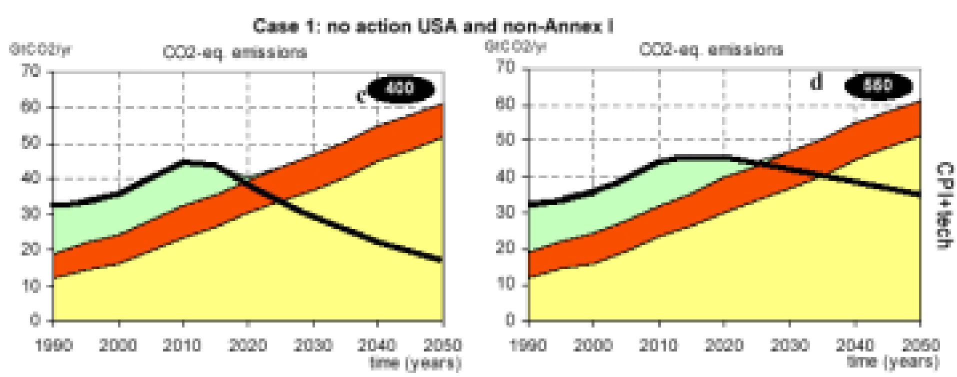
Regional and national pathways

There are clearly many ways of dividing up the task of emission reductions between nations and between differing types of nations. However, they all probably have to follow similar forms if the 2 degree target is to be achieved, i.e. with the developed countries (so-called Kyoto Annex I) taking the lead, with the USA doing nothing prior to 2012 but then participating and the large developing countries (non-Annex I)) also taking action post-2012 and peaking their emissions in about 2020. This type of outcome is shown below for a 400ppm and a 550pmm stabilisation.

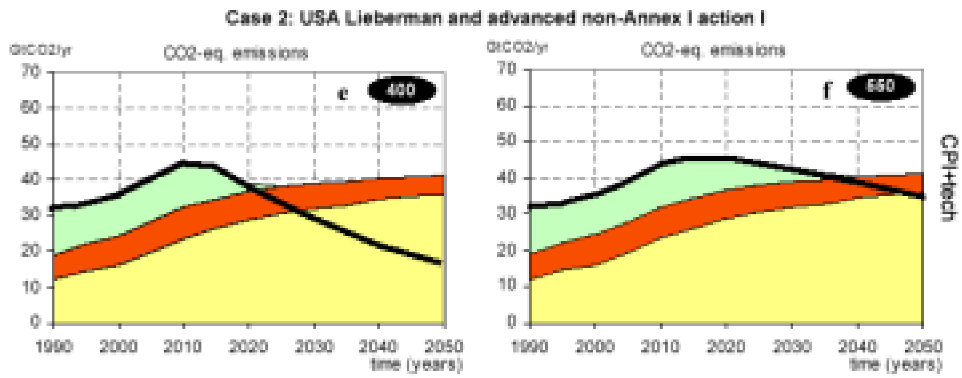


Under this scenario all of the developed countries would need to reduce emissions to almost zero by 2050 to stabilise at 400ppm, with developing countries restricting their emissions to more or less what they were in 1990. Developed countries would require targets of 20% from 1990 levels by 2020, and 59% by 2030, i.e. about 4% per annum between 2020 and 2030.

In an extreme case, if the USA and the developing countries (especially China) were to take no action before 2050, then even if the other developed countries reduced their emissions to almost zero by 2020, we would depart from the 400ppm path before 2025 and from the 550ppm pathway not long after 2030, see below. This is clearly not a realistic option.



A more politically realistic option might be that the US adopts domestic legislation along the lines of the McCain-Liebermann Bill (to regulate US emissions) and that the larger developing countries, such China, take on emission limitation commitments before 2025, see overleaf. In fact, however, this makes only a small difference to when the 400ppm pathway is missed and the EU, Japan and other developed countries would need to meet an 80% by 2020 emission reduction target in order to make up for the others. Whilst this might be fair and equitable, in theory, it is not practical.



Conclusions

There are uncertainties in estimating emission pathways that avoid exceeding a 2°C but not as many as it might at first seem. To be reasonably confident of missing 2°C, stabilisation at 400ppm (all greenhouse gases) is advisable. It may be possible to stabilise at higher levels but probably not much higher, especially given recent scientific evidence that we are likely to get more warming for a particular concentration that was previously thought.

To achieve stabilisation at 400ppm will be hard to achieve and effort will be needed from all countries with significant emissions. Although developed countries should, both for reasons of fairness and practicality, take the lead in cutting emissions, the rapidly industrialising developing countries will need to take action within the next decade.

Indeed, global emissions need to peak at or before 2015 and then decline steeply. Any delay in declining increases the rate of decrease to unrealistic levels. To be reasonably sure of staying below the 2°C target, emission reduction rates of 3% per annum look likely to be required. This is unrealistic for many countries in the near future, say to 2020.

Countries that can, with effort, achieve high emission reduction rates should do so, notably the UK and EU. The EU target, consistent with its 2°C target, should be 3% per annum.