Second Memo from GCI
to the UK House of Commons
'Environmental Audit Committee'

and their 2009 ENQUIRY into

'Targets in the UK Climate Act: -
Where did they come from?
Were the models upon which they were based valid'?

Contents

Summary for Policy Makers

Introduction

1. The EAC Enquiry set up in April 2009 asked about *"'targets' in the UK Climate Act: - where did they come from and were the model[s] on which they were based valid?"*
2. Detail supporting this summary is given in this *"Second Memo from GCI to the UK House of Commons Environmental Audit Committee and their 2009 Enquiry into Targets in the UK Climate Act".*
3. The Committee on Climate Change [CCC] acknowledged that the targets originally came from the Royal Commission on Environmental Pollution [RCEP] Report [2000]. The RCEP report recognised the validity of the Contraction and Convergence [C&C] model and advocated its adoption as the global mitigation framework.

Global context

1. UK targets and budgets will be subject to an international treaty mandated by the UNFCCC. This treaty must comply with the existing Convention in achieving a safe and sustainable level of concentrations in the atmosphere to avoid dangerous climate change, in accordance with the UNFCCC principles of equity and precaution.
2. C&C has been proposed by many as the necessary global framework for the treaty. Evidence given by Lord Turner [CCC Chair] to both the EAC and the Energy and Climate Change Committee [ECCC] in February and March this year acknowledged the CCC report was, *"strong support for what GCI has been saying"* and confirmed two global C&C points of relevance to policy makers:
    - that converging to equal per capita entitlements globally is the only option that is in his words, *"doable and fair"* for organising and sharing the full-term emissions-contraction-event to bring us to UNFCCC-compliance.
    - that *"if, for reasons of urgency the rate of global contraction has to be accelerated, for reasons of equity the rate of international convergence has to be accelerated relative to that."*
3. We urge the Parliamentarians of the EAC to continue their advocacy of C&C, aware that many others are now making this judgement as well [see page 9 this memo].

UK targets and budgets are too little too late

1. The CCC report has a calculated policy prescription for the global emissions contraction event, with the leading scenario designated 2016:4% low [see pages 22 & 23 this memo] and Government repeatedly claim this gives us a 50:50 chance of avoiding a two degree Celsius temperature rise globally. It thus prescribes the contraction event, rather than proposing the C&C model as a basis of negotiation.
2. CCC say this is broadly in line with the 50% cut in emissions globally by 2050 agreed at the G-8 in 2007/8 (base year not specified). However, the global emissions reduction target calculated by CCC and shown in the Appendix is 34%-46% below 1990 levels by 2050. By comparison, the EU target is to reduce global emissions to at least 50% below 1990 levels by that date.
3. It embeds a convergence to equal per capita sharing globally by 2050, requiring therefore an 80% cut in emissions by 2050 for the UK and Annex One parties. It thus prescribes the convergence year, rather than proposing the C&C model as a basis of negotiation.
4. The CCC says it is fully up to date with the latest coupled-carbon-cycle feedback. While CCC correctly note that, *"feedbacks further alter GHG concentrations in response to climate change: in particular, carbon cycle feedbacks are likely to add to CO_2 concentrations and have been incorporated into the latest model projections".* The prescription was processed by the Hadley Centre with the use of an out-of-date version of the 'MAGICC' model [4.1] with assumptions made in 2004. The next version of MAGICC was 5.3, *"brought up to date after IPCC AR4 [2007]"* and the current version is 6.

5. IPCC AR4 says, *"The emission reduction to meet a particular stabilisation level reported in the mitigation studies assessed here might be underestimated due to carbon cycle feedbacks,"* and *"CO_2 emissions in most models do not include emissions from decay of above ground biomass that remains after logging and deforestation, and from tundra-melt, peat fires and drained peat soils."*
6. The impression is spun that the CCC's scenario is consistent with 50:50 odds for avoiding atmospheric concentrations of 500 ppmv CO_2e and a global 2◦ Celsius temperature rise though in the fine-print of the CCC Appendix, the odds of success in avoiding 2◦ C are shown as 44% and not 50%.
7. The CCC's UK emissions reduction targets and carbon budgets are thus founded on global targets that are insufficient to provide an acceptable level of security to remain within 2◦ C warming above pre-industrial levels. Further, the UK strategy is highly dependent on COP 15 arriving at an agreement that would secure the objective of keeping global temperature rise to within the 2◦ C limit. Failure at Copenhagen would result in delay to Peak and could require significantly faster rates of reduction to be adopted.

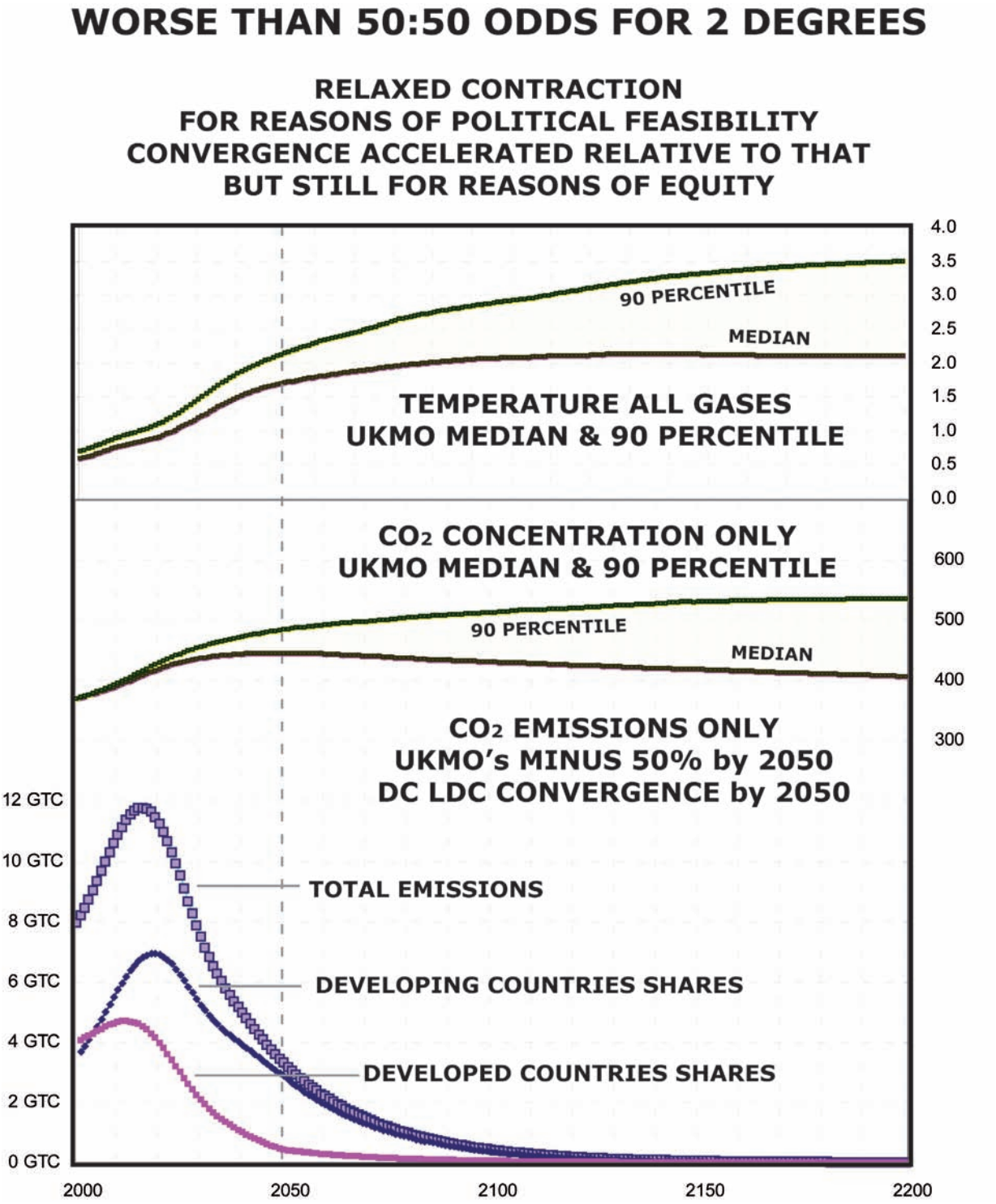
CCC Methods and modelling

1. GCI asked the CCC and the Hadley Centre about the coupled-carbon-cycle feedback effects that we observed were omitted from the scenarios and they spent much time asserting that these effects had all been dealt with. We questioned the unexpectedly rapid gains in 'sink-efficiency' shown in the CCC scenarios and the Hadley Centre offered to perform runs of the GCM to seek corroboration of what they had done with MAGICC. As things stand this has not yet been done and we recommend that the EAC press for this. As a holding position the Hadley Centre observed that these rates of efficiency gain seem to be, *"physically reasonable behaviour for some plausible values of the model parameters we use in MAGICC to represent the uncertainty in scientific understanding."*
2. This is a vague and an insufficient response, as it quantitatively:
3. Contradicts all IPCC published contraction:concentration scenarios for the last 15 years [pp 14/15]
4. Contradicts the coupled carbon-cycle feedback models from the C4MIP results published in IPCC AR4 [2007] and profoundly contradicts James Hansen [see memo pp 16/17 19/20].
5. Repeats the same parameters in all nine of the CCC scenarios, from 2014:3% low to 2028:1.5% and from 1.5 - 5.25 degrees Celsius temperature rise, monotonically.
6. The *"plausible values of the model parameters"* they used in MAGICC were not revealed in the CCC report. However, it appears they were uniformly applied throughout the range of scenarios with a wide range of temperature variance.
7. This procedure raises questions on the validity of the CCC/Hadley Centre approach: the monotonic application of assumptions and parameters across all emissions scenarios modelled with widely differing values. In this way the CCC scenarios mimic a conceptual shortcoming in models over the last 17 years: - tipping points and the fact that the most important feedback effects leading to these, are still not in the climate-models being used.

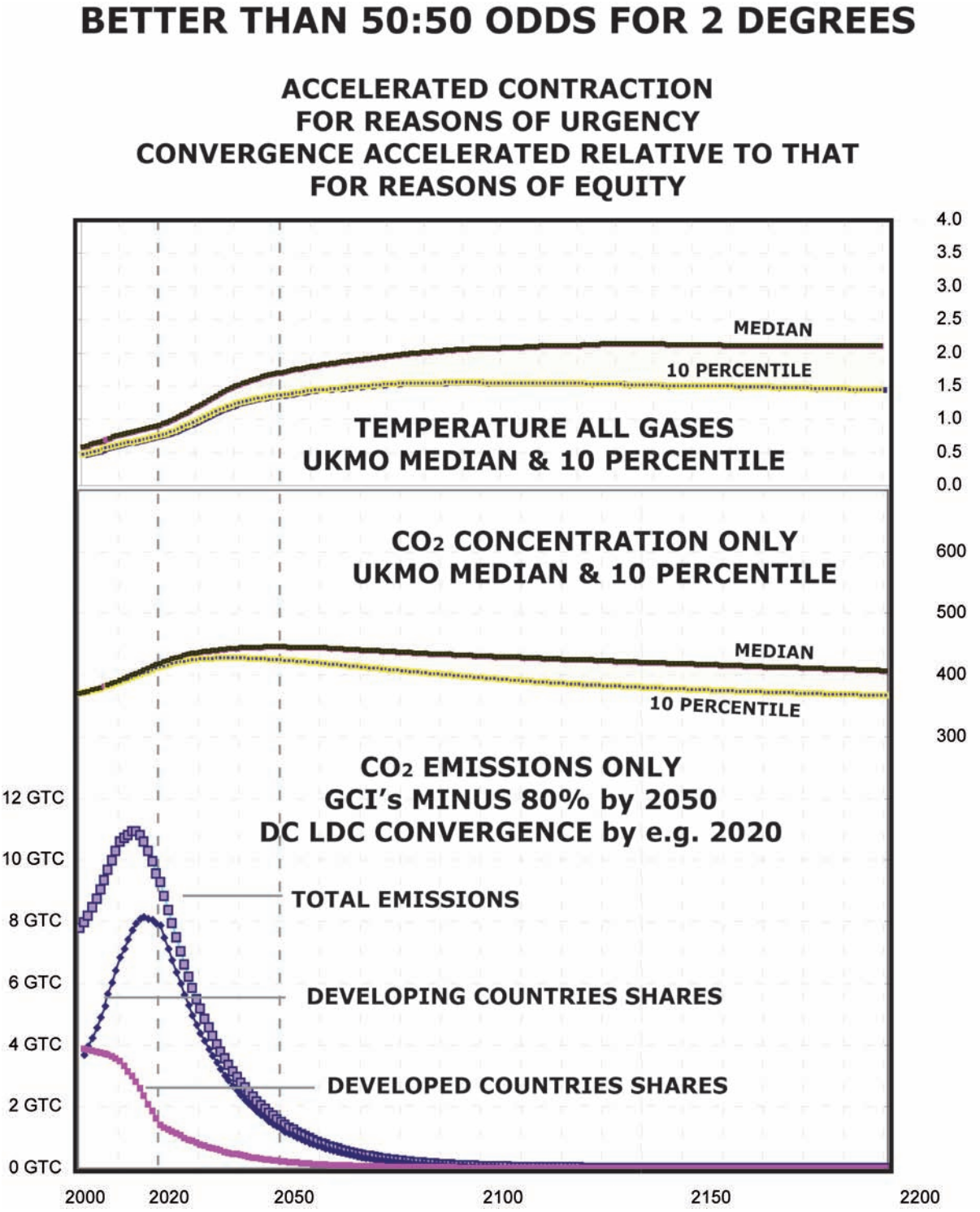
GCI target and budget recommendation for enough, soon enough

1. As shown on pages 6 and 7, GCI proposes that to keep within 2 degrees, a global contraction budget no more than 350 - 400 GTC, with a minimum 80% cut all emissions globally by 2050 and negotiating a convergence to equal per capita shares of this globally to have occurred within one third of the timeline for contraction i.e. no later than 2030. This is as indicated in GCI's first memorandum to the EAC enquiry.
2. We also recommend that the EAC recommend to the UK Government and its negotiators a more candid and coherent C&C basis for their negotiating strategy at the UNFCCC. Their handling of the C&C argument so far has been a 'half-truth'; lacking transparency it has been partial and prescriptive.
3. We are confident that arguing the 'whole truth' of C&C - the truth of contraction and the reconciliation of convergence - and openly encouraging this truly global 'framework-based market' to be the stated basis of negotiation and reconciliation at the UNFCCC, will foster the atmosphere of 'justice without vengeance' that the process now so urgently needs.

CCC Odds are Worse than 50:50 for a maximum 2 Degrees Scenario



GCI Odds are Better than 50:50 for a maximum 2 Degrees Scenario



1. Introduction

The Environmental Audit Committee [EAC] Enquiry into the Climate Act

1. The EAC Enquiry - *"Targets in the UK Climate Act - Where did they Come From and were the models upon which they were based valid?"* - was set up in April 2009. It was done in response to a challenge to the evidence given in February to the EAC by Adair Turner, the Chair of the UK Government's Climate Change Committee [CCC]. Speaking about the CCC *'Building a Low Carbon Economy'* Report and the Climate Act that was based on it, Adair Turner informed the EAC that in all the 'climate-modelling' upon which their targets were based, all the relevant feedback effects - or *coupled carbon cycle feedback effects* - were included. GCI challenged this point saying the situation was worse than had been portrayed by CCC.
2. Both to the EAC and to the new Climate Minister at DECC, Adair Turner explained the rationale behind the 'new' Government target of an 80% emissions cut in the UK by 2050: - it all came from the Royal Commission Report of 2000 that had advocated the principle of Contraction and Convergence [C&C]. Starting there he argued, if the world agreed as a whole to a 50% cut in emissions by 2050, an 80% cut within this for the UK and all the Developing Countries, would bring everyone to a per capita average globally of 2 tonnes CO_2e by 2050. He said there was no other way likely to the 'global climate deal' so urgently needed to keep at or below 2 degrees Celsius and so avoid dangerous rates of climate change.
3. After 2000 the EAC has steadily supported the principle of C&C but the Government had steadily resisted it. EAC members knew this 'convergence' to equal per capita globally was a turnaround for the Government.

Was the Government misled by the CCC?

1. As the authors of the C&C principle since 1990 and the formal calculus since 1995, GCI has tracked the growing support for C&C internationally. So we had an interest in this evolution in the UK Government's position which we welcomed. However, we wrote to the EAC Chairman saying that Adair Tuner had unintentionally misled the EAC on the matter of all the feedbacks being 'in' the models.
2. We referred EAC to the IPCC AR4 WG1 Chapter 10. In this the *coupled carbon cycle feedback models* were clearly distinguished from the *uncoupled carbon cycle feedback models* where the quantitative differences between these emissions scenarios for different 'contraction:concentration-events' was shown to be very considerable [see pages 16 and 17 of this memo].
3. GCI's evidence to the EAC Enquiry showed the reduced size of future 'contraction:concentration-events' in the coupled runs was a major revision of the 'contraction:concentration-events' reported by IPCC as necessary for 'stabilization' of ghg levels in the atmosphere.
4. The IPCC had published information on this starting in 1994 and again in 1995 [SAR], again 2000 [TAR] and again in the main report in 2007 [AR4] [see pages 16 and 17 of this memo]. However, in the Policy Maker's Summary of the AR4 attention was repeatedly drawn to increasing inefficiency of sinks and concern was expressed about the omission from the models of potentially major feedback effects.

Political Derivation of UK Government emissions scenario in the CCC report

1. A global-consensus-seeking position on 'Post-Kyoto Emissions' was started by Al Gore on Earth Day 2006: - a global cut in emissions of 50% by 2050 inside which the Developed Countries would cut by 80% to arrive at a global per capita emissions average of around two tonnes per person per annum by that date. This 'two-degrees' 'C&C-position' was then acknowledged, taken up, advocated and even supported widely: -
    - Nicholas Stern saw it as a position with 'ethical attractions' in his 2006 Report.
    - It was adopted by UNDP in their Annual Report for 2007.
    - It was argued for at the Government's Progressive Governance Conference in 2008.
    - Angela Merkel advocated it in 2008.
    - Nicholas Sarkozy advocated it in 2008.
    - Ross Garnaut [Stern's opposite number in Australia] advocated it in his Report
    - C&C was advocated at the G-8 in 2007 and 2008.
    - The 15th SAARC summit adopted C&C in 2008.

2. The UK Government adopted C&C in the CCC's BLCE Report and the Climate Act in December 2008. Adair Turner told the EAC in February, *"The core [of the UK Climate Act] is contract and converge. We cannot imagine a global deal which is both doable and fair which doesn't end up by mid-century with roughly equal rights per capita to emit and that is clearly said in the report. This is strong support for what GCI has been saying."*
3. A selection of institutional support for C&C shows it has been extensive and high-level
    - RIBA adopted C&C in 2006.
    - The International Union of Architects adopted C&C in 2008.
    - The British Medical Association adopted C&C in 2008.
    - The LANCET/UCL Commission adopted C&C in 2008.
    - The World Health Organization promoted the need for C&C in the 2008 report.
    - The Asia Development Bank advocated C&C in their 2009 'Development Challenge'.
    - The Global Humanitarian Forum in Geneva adopted it in 2009.
    - The World Bank acknowledged it in their report in 2009.
    - The UN World Economic and Social survey acknowledged it in their report in 2009.
    - The Optimum Population Trust adopted C&C with a 'population base--year' in 2009.
4. The extent of support over the years for C&C is now vastly greater than this. It is certainly true to say it is the most widely cited model in the debate and arguably the most widely supported.
5. The purpose of making these comments about the global C&C frame-of-reference is to encourage the UK Government to avoid the political cost of arguing the case for C&C locally through to the Climate Act yet irrationally failing to advocate this global rationale globally at the UNFCCC negotiations.
6. Negotiations are now breaking down yet again over the predictably iterative and worsening quarrel between Developed and Developing Countries over the principled sharing of the future rights to emit subject to the overall limit that achieves the objective of the UNFCCC.
7. After the G-8 2007, Angela Merkel stated that convergence to equal per capita globally, but not further than that as that would not be fair, is what she supported. However, arguing for accelerated convergence, Developing Countries are calling for deeper cuts and sooner by the Developed Countries. In the context of a necessary demand for a global contraction that caps everyone, Developed Countries' are fumbling this and in response, stating that 'science does not trump equity, India is now openly supporting China's yet more extreme demand for 'accumulated per capita convergence' and looney leftist proposals [such as GDRs] are being introduced in support of this demanding negative emissions rights for Developed Countries within two decades plus huge reparation payments to the injured parties.
8. As the UNFCCC Secretariat itself has said, *"Contraction and Convergence is inevitably required to achieve the objective of the UNFCCC* [2004]*."* For UNFCCC-compliance, validation of this rests on the issue of the correct rates of C&C, as rates which fail to achieve the objective of the UNFCCC will progressivley invalidate everything.

2. Sink performance

Sink- Efficiency' - is this what the EAC Enquiry really turns on?

1. Having repeatedly advocated C&C since 2005, EAC members were aware of these matters. The feeling was that while adopting the right principle was welcome, advocating it at the wrong rates was not and negotiating the right rates was the inevitable requirement.
2. Evidence taken by the DECC Committee from Adair Turner in March, agreed with proposition that if for reasons of urgency that rate of Contraction had to be accelerated, then for reasons of equity the rate of Convergence had to be accelerated relative to that. However, for the rest of the year, evidence from CCC and the UKMO and letters from Adair Turner Ministers at DECC resisted this, simply saying that all feedback warnings had been heeded and all feedback effects had been modelled.
3. This is incorrect. Analysis of the CCC position shows that contrary to these claims, 'sink-efficiency' will increase dramatically and this extraordinary claim is what the EAC enquiry now turns on.

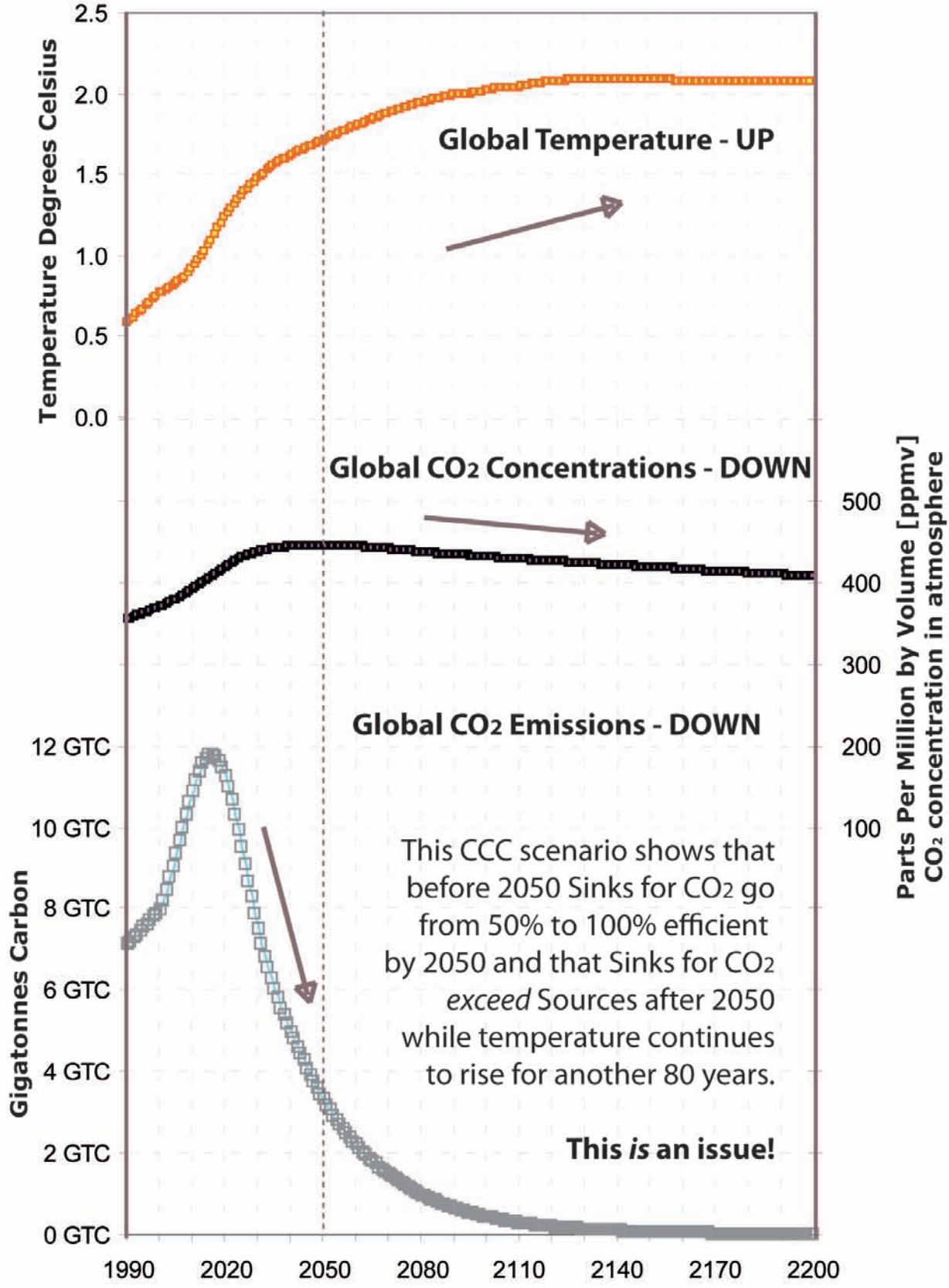
Comment on UK Government preferred emissions scenario in the CCC report

1. The UK climate change Act is based on the report of the Committee on Climate Change [CCC] from December 2008. The CCC report correctly says that: - *"Work on the carbon cycle in particular has highlighted the danger that global warming will reduce the rate of absorption of atmospheric CO_2 by terrestrial carbon sinks, such as forests, and the oceans. These currently absorb around half of all manmade CO_2 emissions."*
2. The report then goes on: - "*However, as temperatures increase, the effectiveness of sinks is predicted to decline. For any given level of manmade emissions, this would result in a higher long-term increase in CO_2 concentrations and hence temperatures."*
3. In conclusion, the CCC report actually says that with its 'preferred' scenario, humanity has a worse than 50:50 chance of avoiding more than 2 degree Celsius temperature rise with the CO_2 emissions contraction-event as quantified here, although in the fine print it gives only a 44% chance.
4. The CCC published spreadsheets setting out the quantitative detail for this their preferred scenario. These show that while temperature continues to rise until 2134 and to a value of 2.134 Degrees Celsius, concentrations *fall* very rapidly as emissions fall.
5. With slim argument and without any evidence to support this and much evidence to suggest the unlikeliness of these claims, the Government's preferred scenario shows that the ratio of source:sinks or the sink-efficiency for CO_2 suddenly *increases from 50% of emissions to **more** than 100% within 40 years while temperature continues to rise* [see pages 26 and 27 of this memo].
6. This rate of gain for sink-efficiency [negative feedback] is without precedent and is very suspect as are the alleged 50:50 odds for 'success' that are based upon it. It means somewhat improbably that the natural sinks will actually pull CO_2 out of the atmosphere faster than we are adding CO_2 to it with emissions.

Argument unresolved.

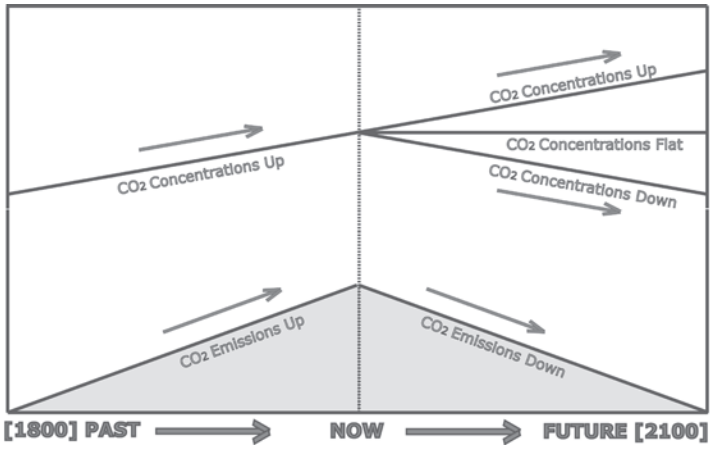
1. The sudden arrival of **this extent** of negative feedback is momentous. If 'true', why wasn't it even mentioned? Could it be that nobody even noticed it?
2. The contradiction between what CCC says and what its model shows is clear. Yet Ministers from DECC, the CCC executive and technical experts from the Hadley Centre have been defending the CCC position throughout this year, coordinating their message in letters and evidence to the record in the enquiry by the House of Commons Environmental Audit Committee [EAC] and beyond without any mention or apparently even awareness of this
3. The Hadley Centre have now [in September 2009] acknowledged there is an issue and have considered running the GCM again to see if it corroborates what the CCC scenario shows. This is not a small issue. GCI submits this memo to the EAC wondering whether it will happen. It remains to be seen how the Hadley Centre, the CCC and DECC deal with this.
4. We wrote to the Hadley Centre on 21 10 2009 to ask if they agree that in the two images [here on pages 6 and 7] the odds for remaining at or below 2 degrees Celsius are better in the case marked 'better' than they are in the case marked 'worse'?
5. As at 23 10 2009, we have not yet received a reply though the key meeting between EAC and the CCC is on the 27 10 2009.

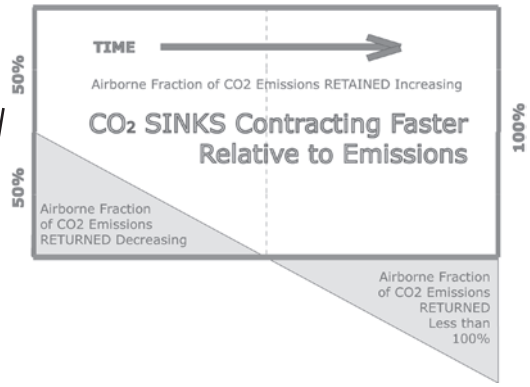
CCC Scenario for temperature, CO_2 concentrations & emissions for no more than two degrees Celsius.

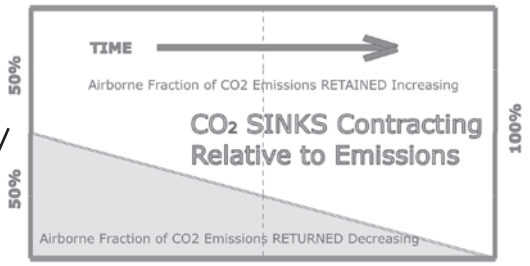


Sources and Sinks - Government imprudence with a 'Wicked Problem'?

1. The issue of climate change has been described as 'a wicked problem'.
2. In fact long-before we settle on the correct path for resolving this, the challenge of conceptualising, let-alone measuring the changing relationship between sources and sinks of greenhouse gas into the future is itself a truly 'wicked problem'.
3. In very simple terms of 'stock-and-flow' it helps to understand this relationship with the following bath-tap-plug analogy: -
   - emissions 'sources' are a 'flow' [like water from a tap] into
   - the atmosphere which is a 'stock' [like a bath where the water accumulates]
   - with 'sinks' [like a plug-hole] where flow drains away from the atmosphere [bath].
4. Since industrialisation sources of human emissions to the atmosphere have risen [like a tap flowing faster and faster] raising the level of greenhouse gas concentration in the atmosphere [like a bath level rising] while the sinks [the plug-hole] initially grew at an average of half the rate of the emissions.
5. The resulting 'airborne fraction of emissions' was on average constant at 50% of emissions over time and so CO_2 concentrations rose over the two hundred years since industrialisation from 280 to over 380 parts per million by volume, nudging global temperature upwards and changing global climate.
6. The really wicked problem of conceptualising relates to what happens next: - i.e. in the future.
7. If emissions contraction is recognized as a way of stopping the rise of concentrations, the key question is: - what is the rate of emissions contraction required to stabilize greenhouse gas concentration in the atmosphere at a level below dangerous i.e. to be UNFCCC-compliant? In other words, how fast do we need to turn the tap off?
8. The diagram opposite shows the past where concentrations rose at a roughly constant rate of 50% of emissions retained in the atmosphere with the other 50% of emissions returned to the natural sinks in the biosphere on land and in the ocean. A key here is that as sources expanded, sinks expanded to accommodate around half of what was emitted but as sink-efficiency decreases, they appear to be absorbing less than 50%.
9. What the diagram opposite suggests is that in the future the relationship between source and sinks is a dimension of understanding that is highly contested.
10. What happens to concentrations depends variously on: -
    - the rate of emissions contraction [the only factor we can directly control]
    - the rate of sink-failure or sink-recovery [a factor over which we have less if any control]
    - even that sinks can turn to sources [as a forest burns down for example]
    - even that sinks can expand more rapidly than sources contract and so take away more than 100% of emissions [as the UK Government is saying] which would increase ocean-acidification even as we were 'solving the problem'
    - all interactively affected by the rate of temperature change triggered by the above.
11. Trying to mathematically model this is the only way we can try to organize to meet the conceptual challenge. Having said that, the models are only models and we all know that many significant factors [like methane release from the clathrate deposits and CO_2 release from melted tundra] are left out. We can only guess at what the temperature-led 'tipping points' are, beyond which, those factors come irresistibly into play. We do know that while temperature rises, we are going closer to these tipping points, not further away from them. It is considerations of these acute risks that have led James Hansen to create 350.0rg and demand 100% cuts by even 2020, 'bull-dozing coal fired power plants' if necessary [see pages 20 and 21 of this document].
12. So for the UK Government to advocate the "2016:4% low" scenario to generate a global consensus for C&C with '50:50' odds while depending on this 'heroic' source:sink modelling is misleading.


CO2 Concentrations Up
CO2 Concentrations Up
CO2 Concentrations Flat
CO2 Concentrations Down
CO2 Emissions Up
CO2 Emissions Down
[1800] PAST
NOW
FUTURE [2100]


TIME
Airborne Fraction of CO2 Emissions RETAINED Increasing
CO2 SINKS Contracting Faster Relative to Emissions
50%
50%
100%
Airborne Fraction of CO2 Emissions RETURNED Decreasing
Airborne Fraction of CO2 Emissions RETURNED Less than 100%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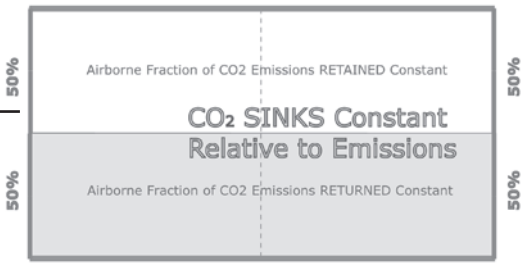
Airborne Fraction of CO2 Emissions RETAINED Constant
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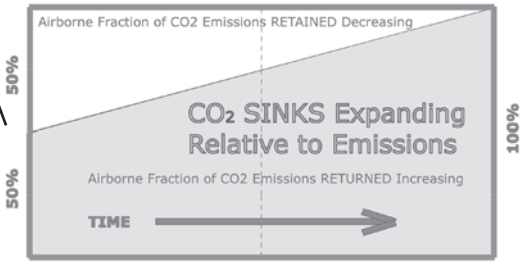
Airborne Fraction of CO2 Emissions RETURNED Constant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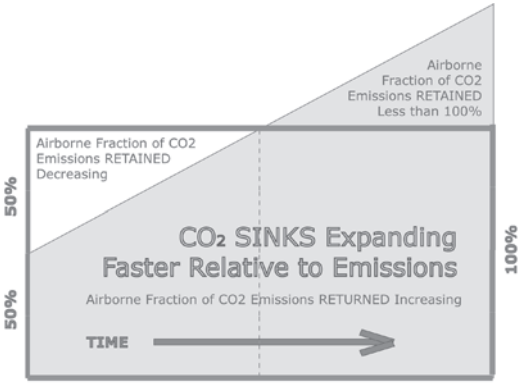
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CO2 SINKS Expanding Faster Relative to Emissions
50%
50%
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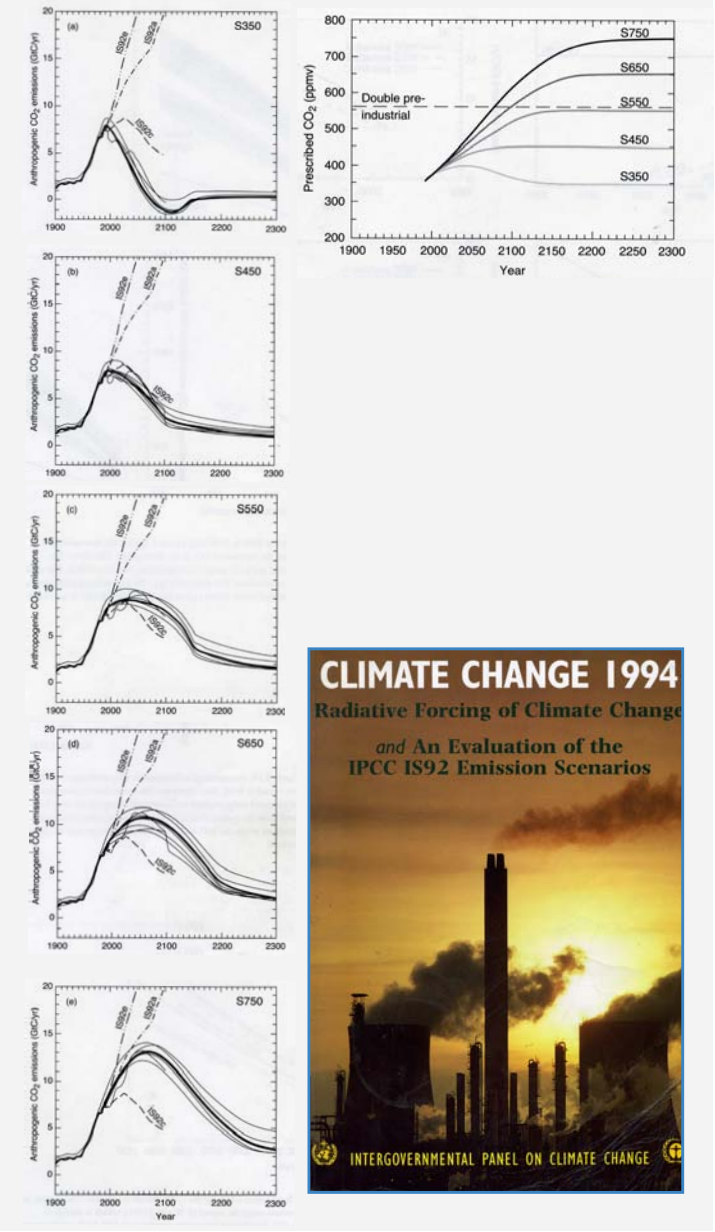
Airborne Fraction of CO2 Emissions RETURNED Increasing
TIME

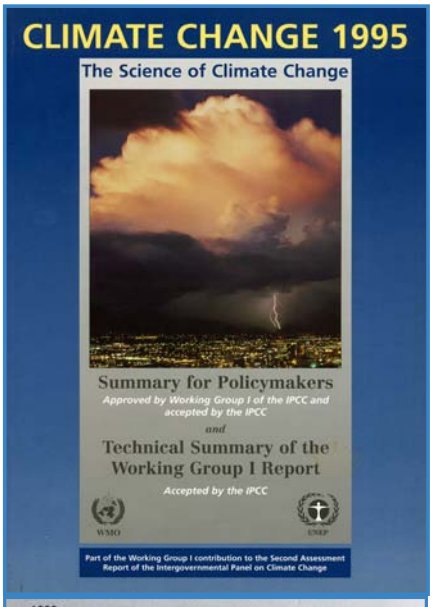
3. IPCC climate modelling

IPCC - 1994-2007 - with various contraction:concentrations scenarios.

1. 1. Since the 1980s ‘climate models’ have been developed to help predict the future atmospheric concentration of CO_2 and CH_4 under various forest and fossil-fuel burning ‘scenarios’. With that, the implications of this array of potential ‘futures’ on global temperature and climate change have been assessed.
2. A main focus of these has been on the ‘carbon-cycle’ through the oceans, atmosphere and biosphere, but as influenced by the impact of the emissions of these gases from human sources as a result of the start of burning forests and fossil fuels [coal, oil, gas] with the onset of industrialisation.
3. The principal carbon cycle model used to help answer this question was the ‘Berne Model’ and output from it was first published by the Intergovernmental Panel on Climate Change [IPCC] in 1994. Five ‘scenarios’ were published; these were future carbon-emissions ‘contraction-events’ or ‘budgets’ for outcomes of 350, 450, 550, 650 and 750 ppmv atmospheric CO_2 concentration in the global atmosphere.
4. These reflected a judgment given in the IPCC’s ‘First Assessment Report’ [FAR] from 1990. In 1990 the atmospheric CO_2 concentration was 353 parts per million by volume [ppmv] or 25% above the pre-industrial maximum value of 280 ppmv. IPCC’s judgment was that an immediate 60-80% cut in human emissions of CO_2 would be needed if the upward rise in the atmospheric concentration of CO_2 in that year were to be halted immediately. They didn’t say it had to be done and they didn’t say it didn’t; but two things were crucial.
5. First: - it was apparently not the 100% cessation of emissions that was required. Continuing with 40-20% of emissions was judged to be consistent with atmosphere CO_2 ‘stabilisation’. This view came from observing human emissions and global concentrations of CO_2 since 1800. Measurements covering those 200 years showed [a] roughly half of any year’s emissions from human sources returned to the apparently enlarging natural ‘sinks’ for CO_2 and [b] the other half remained in the atmosphere - where a pattern seemed to have emerged of what became misleadingly known as the ‘Constant Airborne Fraction’ [CAF].
6. Second: - the ‘airborne fraction’. Whether this fraction was in reality constant or not, it was cumulative because the human emissions that stayed in the atmosphere added up over time as a rising ‘stock’. That explained the rise in ppmv of atmospheric concentrations of CO_2. By June 1992 the UN had agreed a Climate Convention, the objective of which was to stabilise the rise of ghg in the global atmosphere below a value that was ‘dangerous’. The probability of ‘positive-feedback’ where natural ‘sinks’ ceased to enlarge, shrank and even turned to sources, so accelerating the rates of climate change was largely ignored, as they were ‘speculative’ and difficult to model.
7. Fossil fuel dependency had become fundamental to modern economic activity and the correlation of GDP to CO_2 from fossil fuel burning has been and remains at nearly 100%. The heat-trapping implications of rising CO_2 had serious implications for the future. The climate change questions ‘how much how soon’ became ‘will the benefits of global growth gradually be outweighed by the damages caused by global climate changes’.



8. All the questions about UK carbon budgets in the Climate Act asked by the EAC relate to that global question. In this 'battle-of-the-rates' the C&C propositions offered by GCI for the last 15 years relate to feedbacks and fighting that battle by answering that question rationally.
9. With the 350 ppmv budget removed and one for 1,000 ppmv added due to pressure from industry lobbyists in Working Group Three of IPCC, the IPCC re-published these Berne-Model-type results from 1995 onwards. As is shown below, for the IPCC 1995 Second Assessment Report [SAR] the 2001 Third Assessment Report [TAR] and the 2007 Fourth Assessment Report [AR4], these scenarios were repeated and have remained the standard reference set for the 'climate-policy' community for more than ten years until the present time.
10. It is of note that over 300 years of future time with CO_2 concentrations theoretically stabilising 'safely' at up to 1,000 ppmv, on the back of finding, extracting and combusting an inventory of up to 2 trillion tonnes of future fossil fuel resources, these scenarios all modelled contraction:concentration events that, ignoring the positive feedbacks not-too-mention the rapid depletion of reserves of oil and gas, *ludicrously* assumed the airborne fraction of emissions in these scenarios would all remain constant at around 50% right up to 1,000 ppmv.



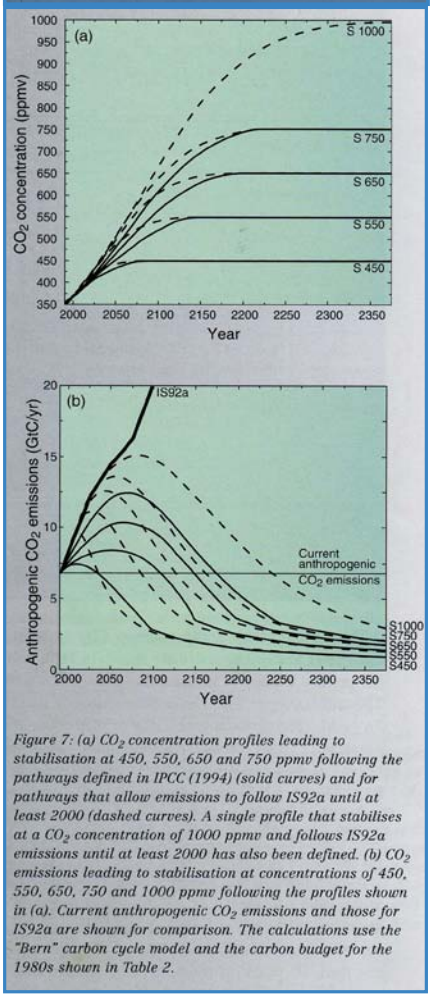
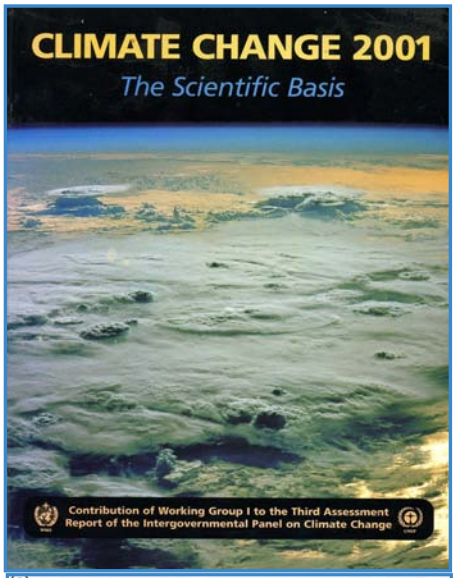


Figure 7: (a) CO_2 concentration profiles leading to stabilisation at 450, 550, 650 and 750 ppmv following the pathways defined in IPCC (1994) (solid curves) and for pathways that allow emissions to follow IS92a until at least 2000 (dashed curves). A single profile that stabilises at a CO_2 concentration of 1000 ppmv and follows IS92a emissions until at least 2000 has also been defined. (b) CO_2 emissions leading to stabilisation at concentrations of 450, 550, 650, 750 and 1000 ppmv following the profiles shown in (a). Current anthropogenic CO_2 emissions and those for IS92a are shown for comparison. The calculations use the "Bern" carbon cycle model and the carbon budget for the 1980s shown in Table 2.



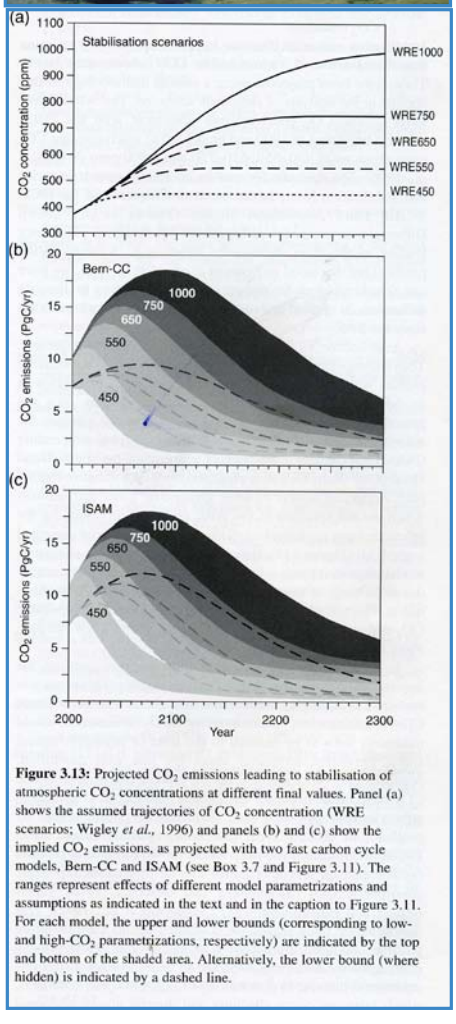
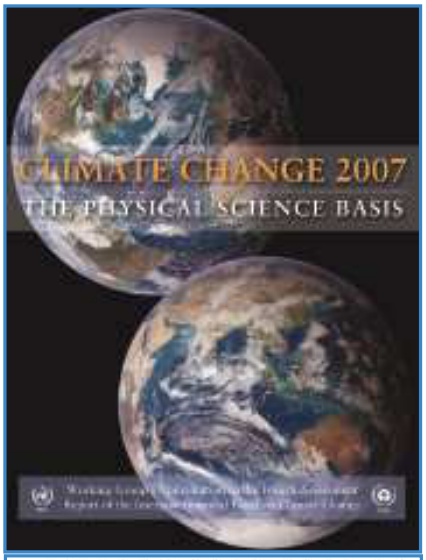
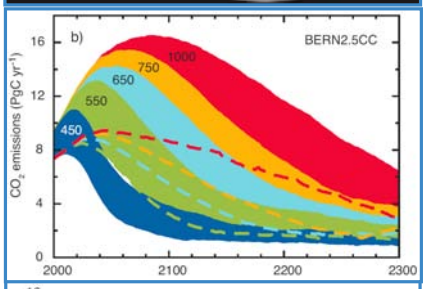
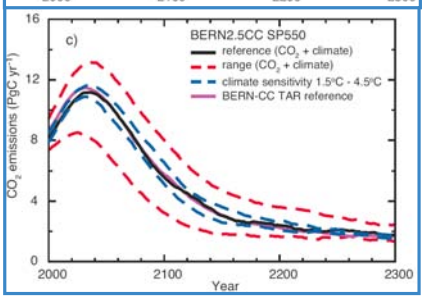


Figure 3.13: Projected CO_2 emissions leading to stabilisation of atmospheric CO_2 concentrations at different final values. Panel (a) shows the assumed trajectories of CO_2 concentration (WRE scenarios; Wigley *et al.*, 1996) and panels (b) and (c) show the implied CO_2 emissions, as projected with two fast carbon cycle models, Bern-CC and ISAM (see Box 3.7 and Figure 3.11). The ranges represent effects of different model parametrizations and assumptions as indicated in the text and in the caption to Figure 3.11. For each model, the upper and lower bounds (corresponding to low- and high-CO_2 parametrizations, respectively) are indicated by the top and bottom of the shaded area. Alternatively, the lower bound (where hidden) is indicated by a dashed line.

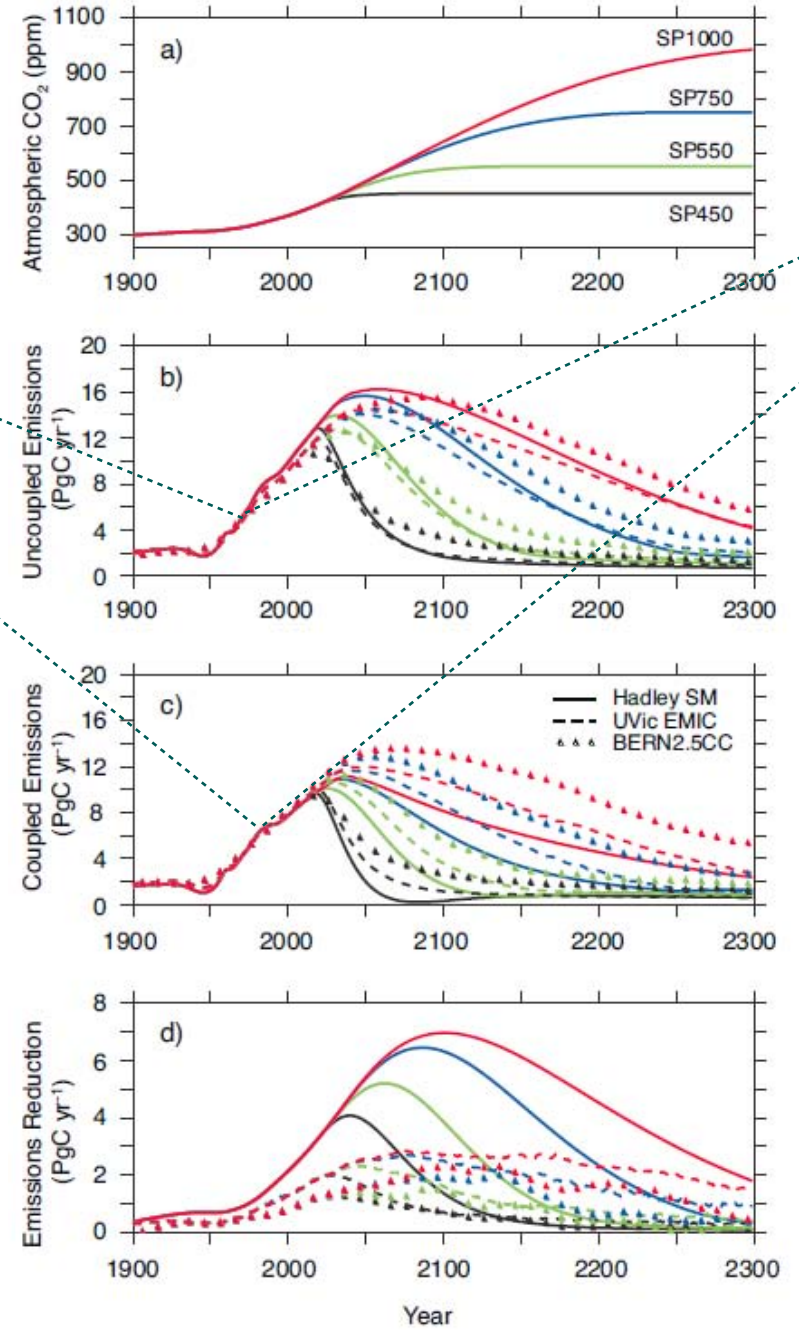






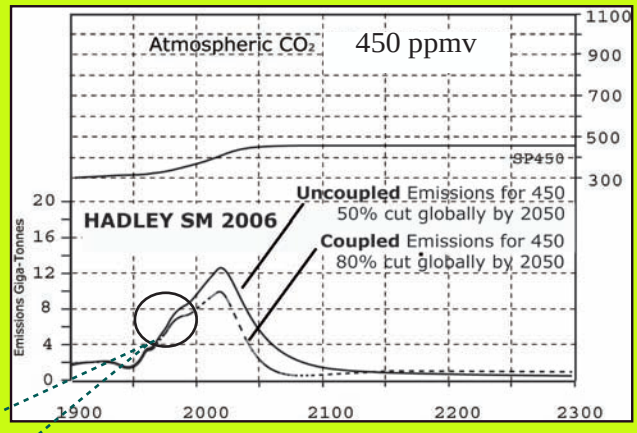
IPCC Coupled/Uncoupled for various contraction:concentrations Scenarios

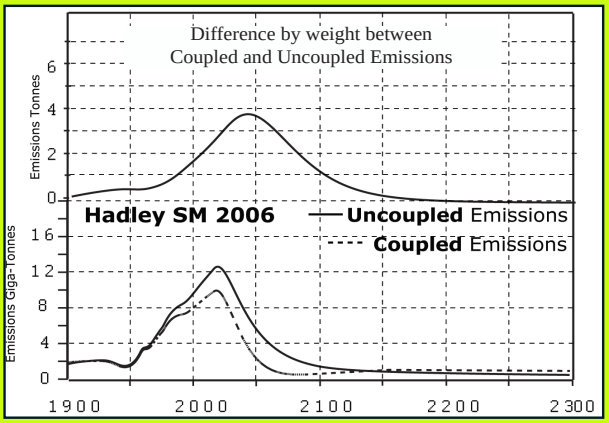
1. However, in Chapter 10 of IPCC AR4 [2007] Working Group One [WG1] an important contribution from the 'Models Inter-Comparison Group' was included which addressed this feedback issue openly for the first time. All the carbon-cycle emissions scenarios were revisited comparing the past 'Uncoupled' model runs with the new 'Coupled' model runs, with IPCC saying: -
2. *"There is unanimous agreement among the coupled climate carbon cycle models driven by emission scenarios run so far that future climate change would reduce the efficiency of the Earth system (land and ocean) to absorb anthropogenic CO_2."*
3. Published in a non-headline-grabbing manner with a complexity of graphic information that discouraged interpretation, the graphic [exactly as below] appeared on page 791 where: -
4. Three models: -
   - Berne 2002,
   - UVic 2004 and
   - Hadley 2006
5. in two versions each: -
   - Uncoupled and
   - Coupled
6. for four 'scenarios': -
   - 450 ppmv
   - 550 ppmv
   - 750 ppmv
   - 1000 ppmv
7. were largely superimposed on each other [as shown].
8. Because of the density of this overlay, but especially because of the significance of the acknowledgement of the positive-feedback issue being modeled and published by IPCC for the first time, GCI wrote to the Technical Support Unit [TSU] of IPCC Working Group One [WG1] to get confirmation that the information as shown in the graphics on page 13 had correctly disentangled the IPCC graphic on page 12. With thanks, TSU confirmed this saying, *"we wish out authors had been this clear."*
9. The principal reason for this enquiry was the quite extraordinary discovery that in all the coupled-uncoupled comparisons and unclearly shown in the images published in the AR4, two different paths for emissions globally were being shown prior to 2000, as is shown by following the dotted lines.

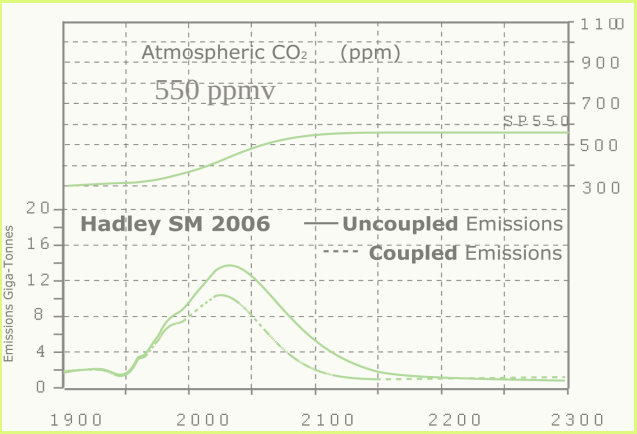


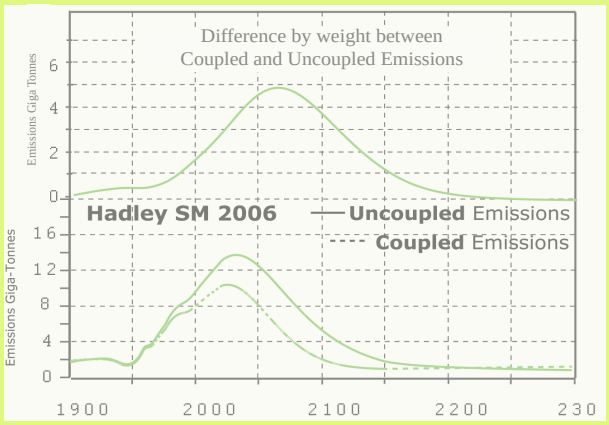
10. The reason for this was finally given by the Hadley Centre who said that when 'coupling' to reflect feedbacks was calculated, the revision of source:sink relations in the carbon-cycle showed that sink-function in the models had certainly been over-estimated prospectively and retrospectively as well.
11. In other words, with the 'weight-record' of concentrations and past fossil fuel emissions well documented, the modelers concluded that the recent historic emissions from deforestation had also been overestimated, throwing their estimates of the strength of sink-function into further doubt.

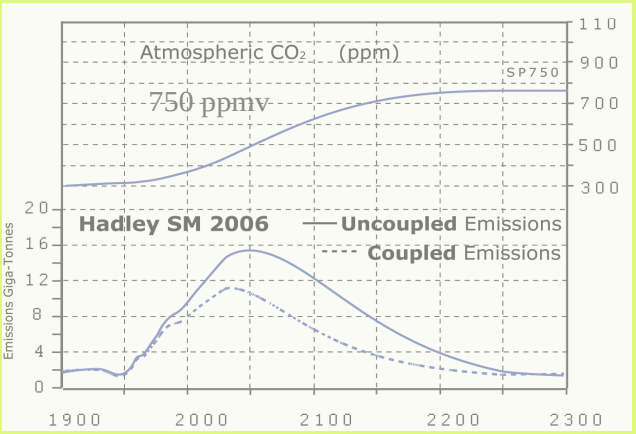
It is the uncoupled and the coupled contraction events for 450 ppmv that are relevant here as they show 50% and 80% cuts by 2050 respectively.

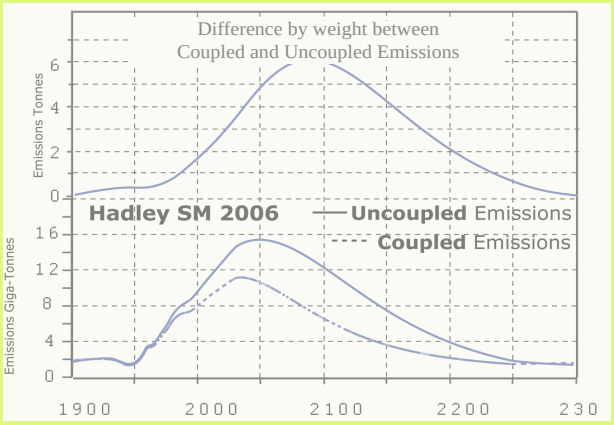


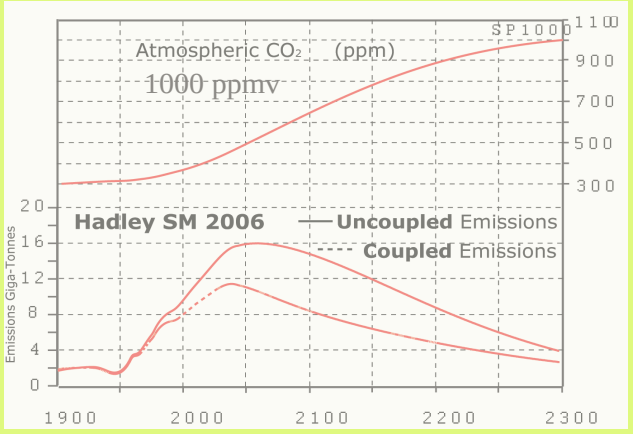


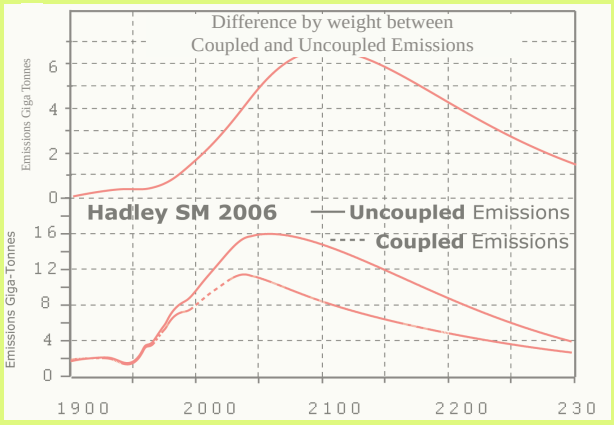












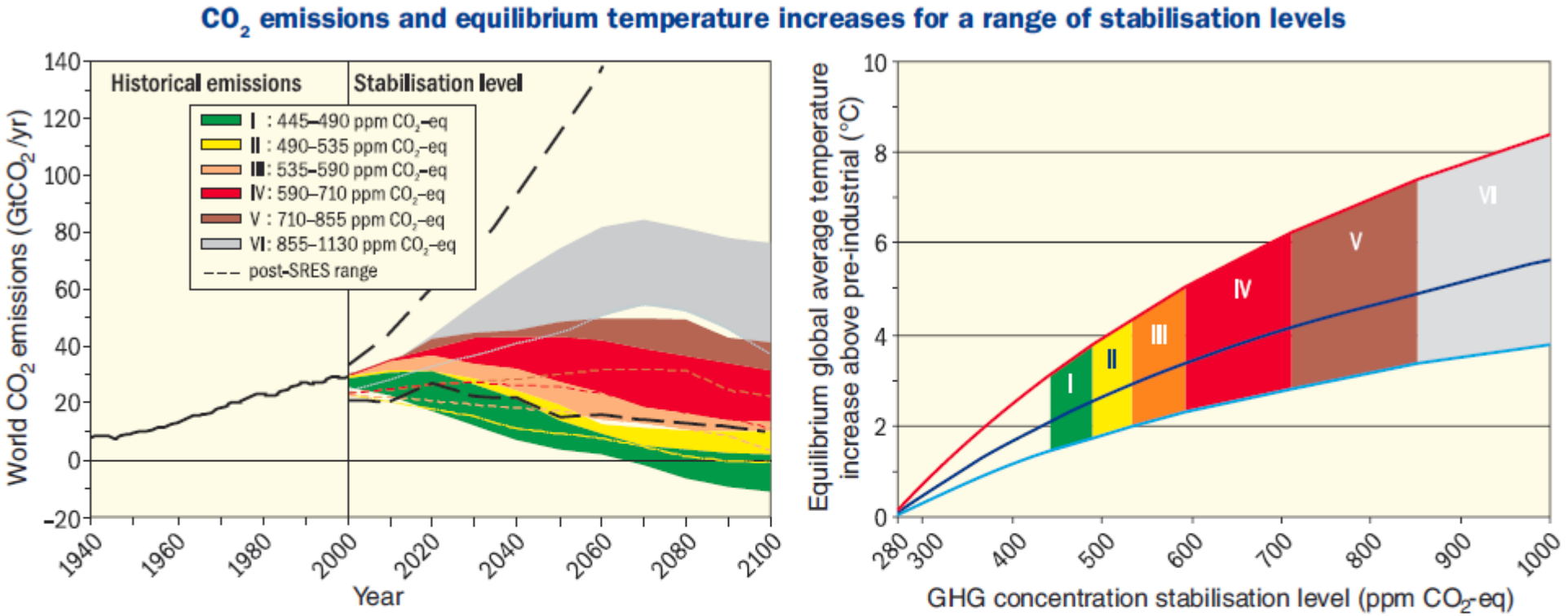


Figure SPM.11. *Global CO_2 emissions for 1940 to 2000 and emissions ranges for categories of stabilisation scenarios from 2000 to 2100 (left-hand panel); and the corresponding relationship between the stabilisation target and the* likely *equilibrium global average temperature increase above pre-industrial (right-hand panel). Approaching equilibrium can take several centuries, especially for scenarios with higher levels of stabilisation. Coloured shadings show stabilisation scenarios grouped according to different targets (stabilisation category I to VI). The right-hand panel shows ranges of global average temperature change above pre-industrial, using (i) 'best estimate' climate sensitivity of 3°C (black line in middle of shaded area), (ii) upper bound of* likely *range of climate sensitivity of 4.5°C (red line at top of shaded area) (iii) lower bound of* likely *range of climate sensitivity of 2°C (blue line at bottom of shaded area). Black dashed lines in the left panel give the emissions range of recent baseline scenarios published since the SRES (2000). Emissions ranges of the stabilisation scenarios comprise CO_2-only and multigas scenarios and correspond to the 10th to 90th percentile of the full scenario distribution. Note: CO_2 emissions in most models do not include emissions from decay of above ground biomass that remains after logging and deforestation, and from peat fires and drained peat soils. {Figure 5.1}*

Table 5.1. Characteristics of post-TAR stabilisation scenarios and resulting long-term equilibrium global average temperature and the sea level rise component from thermal expansion only.[a] (WGI 10.7; WGII Table TS.2, Table 3.10, Table SPM.5)

Category	CO_2 concentration at stabilisation (2005 = 379 ppm)[b]	CO_2-equivalent concentration at stabilisation including GHGs and aerosols (2005=375 ppm)[b]	Peaking year for CO_2 emissions[a,c]	Change in global CO_2 emissions in 2050 (percent of 2000 emissions)[a,c]	Global average temperature increase above pre-industrial at equilibrium, using 'best estimate' climate sensitivity[d,e]	Global average sea level rise above pre-industrial at equilibrium from thermal expansion only[f]	Number of assessed scenarios
	ppm	ppm	year	percent	°C	metres	
I	350 – 400	445 – 490	2000 – 2015	-85 to -50	2.0 – 2.4	0.4 – 1.4	6
II	400 – 440	490 – 535	2000 – 2020	-60 to -30	2.4 – 2.8	0.5 – 1.7	18
III	440 – 485	535 – 590	2010 – 2030	-30 to +5	2.8 – 3.2	0.6 – 1.9	21
IV	485 – 570	590 – 710	2020 – 2060	+10 to +60	3.2 – 4.0	0.6 – 2.4	118
V	570 – 660	710 – 855	2050 – 2080	+25 to +85	4.0 – 4.9	0.8 – 2.9	9
VI	660 – 790	855 – 1130	2060 – 2090	+90 to +140	4.9 – 6.1	1.0 – 3.7	5

Notes:
a) The emission reductions to meet a particular stabilisation level reported in the mitigation studies assessed here might be underestimated due to missing carbon cycle feedbacks (see also Topic 2.3).
b) Atmospheric CO_2 concentrations were 379ppm in 2005. The best estimate of total CO_2-eq concentration in 2005 for all long-lived GHGs is about 455ppm, while the corresponding value including the net effect of all anthropogenic forcing agents is 375ppm CO_2-eq.
c) Ranges correspond to the 15th to 85th percentile of the post-TAR scenario distribution. CO_2 emissions are shown so multi-gas scenarios can be compared with CO_2-only scenarios (see Figure 2.1).
d) The best estimate of climate sensitivity is 3°C.
e) Note that global average temperature at equilibrium is different from expected global average temperature at the time of stabilisation of GHG concentrations due to the inertia of the climate system. For the majority of scenarios assessed, stabilisation of GHG concentrations occurs between 2100 and 2150 (see also Footnote 30).
f) Equilibrium sea level rise is for the contribution from ocean thermal expansion only and does not reach equilibrium for at least many centuries. These values have been estimated using relatively simple climate models (one low-resolution AOGCM and several EMICs based on the best estimate of 3°C climate sensitivity) and do not include contributions from melting ice sheets, glaciers and ice caps. Long-term thermal expansion is projected to result in 0.2 to 0.6m per degree Celsius of global average warming above pre-industrial. (AOGCM refers to Atmosphere-Ocean General Circulation Model and EMICs to Earth System Models of Intermediate Complexity.)

1. While Please observe this is note [a] on the table 5.1: -
2. "The emission reduction to meet a particular stabilisation level reported in the mitigation studies assessed here might be underestimated due to missing carbon cycle feedbacks [see Topic 2.3]"
3. This is section 2.3 - Climate sensitivity and feedbacks
4. *"The equilibrium sensitivity is a measure of the climate system response to sustained radiative forcing. It is defined as the equilibrium global average surface warming following a doubling of CO_2 concentration. Progress since the TAR enables an assessment that climate sensitivity is likely to be in the range of 2 to 4.5 C with a best estimate of about 3 C, and it is very unlikely to be less than 1.5 C. Values higher than 4.5 C cannot be excluded but agreement of models with observations is not as good for those values. [WG1 8.6 9.6 Box 10.2 SPM]. Feedbacks can amplify or dampen the response to a given forcing. Direct emissions of water vapour [a greenhouse gas] by human activities make a negligible contribution to radiative forcing. However, as global temperature increases, tropospheric water vapour concentrations increase and this represents a key positive feedback but not a forcing of climate change. Water vapour changes represent the largest feedback affecting climate equilibrium sensitivity and are now better understood than in the TAR. Cloud feedbacks remain the largest source of uncertainty. Spatial patters of climate response are largely controlled by climate processes and feedbacks. For example, sea-ice albedo feedbacks tend to enhance the high latitude response. [WG1, 2.8 8.6 9.2 TS 2.1.3 TS 2.5 SPM].Warming reduces terrestrial and ocean uptake of atmospheric CO_2 increasing the fraction of anthropogenic emissions remaining in the atmosphere. This positive carbon cycle feedback leads to larger atmospheric CO_2 increases and greater climate change for a given emissions scenario, but the strength of this feedback varies markedly among models. [WG1 7.3 TW 5.4 SPM WG2 4.4.]."*
5. This is in AR4 Chapter 10 where carbon cycle feedbacks are discussed and calculated [as per GCI memo to EAC]
6. "There is unanimous agreement among the coupled climate carbon cycle models driven by emission scenarios run so far that future climate change would reduce the efficiency of the Earth system (land and ocean) to absorb anthropogenic CO_2. There is evidence that the CO_2 airborne fraction is increasing, so accelerating the rate of climate change."

1. As the CCC says, *"the [CCC's] spreadsheets, contain all the relevant inputs and outputs of the climate modelling work carried out for the 2008 report by the Committee on Climate. Change (CCC). Inputs were constructed by the CCC and outputs were produced by the Met Office Hadley Centre using a modified version of the MAGICC 4.1 climate model. See the Chapter 1 technical appendix: projecting global emissions, concentrations and temperatures for further details."*
2. The BLCE Report itself states that, *"The MAGICC climate model is used here (www.cgd.ucar.edu/cas/wigley/magicc/) with a distribution of climate sensitivity taken from Murphy, J.M., et al. (2004). Quantification of modelling uncertainties in a large ensemble of climate change simulations. Nature, 429, 768–772."*
3. We trust there is still a consensus-seeking agenda operating between the EAC, the CCC and GCI. So in case there is any perception that the criticisms levelled by GCI against the CCC's work are extreme', participants may care to consider the graphic output alongside which comes from Stanton et al [Oct 2009] using the much more recent MAGICC version 5.3 in conjunction with inputs as created by Jim Hansen.
4. Hansen is now progenitor of the global "350.org" campaign and we can note from these charts that in order to control temperature and concentrations at rates that this fairly eminent scientist deems necessary to avoid a catastrophe, in his most extreme case, global emissions are required to go deeply below zero by 2020!
5. Yet the 50% cut by 2050 advocated by the CCC is described by Mark Bainbridge of the CCC as 'drastic'. Hardly. Situated between Hansen and CCC, the GCI recommendation to the EAC in April for a global emissions contraction involving a minimum 80% cut with accelerated convergence to perhaps 2020 is reasonable, practical, doable [negotiable] and also supported.
6. GCI wrote to Mark Bainbridge of the CCC asking*, "Were you aware that the source:sink ratio output from the MAGICC model shown for the "2016:4% low" scenario was more than 100% sink-efficiency after 2050?"* [shown in the GCI analysis]
7. He wrote saying *"We are aware that atmospheric CO_2 concentrations start to fall in our low emission trajectories. Once strong climate action has been taken and emissions have been cut drastically, there will still be elevated concentrations. So natural sinks will still be taking up large amounts of carbon even though emissions are small, and hence the source/sink ratio in this future is unlikely to be the same as it is today."*
8. GCI responded with graphics examining CCC's scenario. We then pursued this matter of 'sink-efficiency' with the Hadley Centre. They have now agreed that this analysis of the 'model-runs' behind UK Government 'Climate-Targets' in new and the analysis charted is correct. They responded further saying*, 'it really got us thinking - in fact we were thinking of doing some runs with the GCM' to see if it could produce these results'* . They also agreed that there are many things that are relevant in the area of feedbacks that are not yet in the climate-models largely because of the great difficulty of modelling events like large methane release etc. However difficult to model this may be, this is no small omission. In the light of the odds given by CCC, we asked CCC to consider the negative-albedo effects of that on rising temperature locally [Arctic], aggravated by CO_2 and CH4 release from the thawed tundra locally and to sum something about that back into the carefully worded odds attending the CCC's global averages.
9. As the graphics suggest, the issue of where the goal posts are set up, frames any sensible and coherent adjudication of this. CCC's goal-posts of 10 Percentile and 90 Percentile around the 'median' path preferred by CCC on the "2016:4% low" path CCC has preferred, sound [as probably intended] like choosing the moderate middle. In fact this has statistically skewed these goal posts to the point of near absurdity. The '10 Percentile' path is not just improbable, it is obvious to any experienced analyst that it is completely impossible. However, the 90 Percentile path is not impossible, nor is it necessarily improbable either.

Results for climate sensitivity 6°C.
Error bars represent range of values from climate sensitivity 1.5 to 10°C. [Ackerman et al with MAGICC 5.3; Hansen et al. (2008)].

Fig B3: Hansen's Global Average Annual Temperature Change (0C 1990)

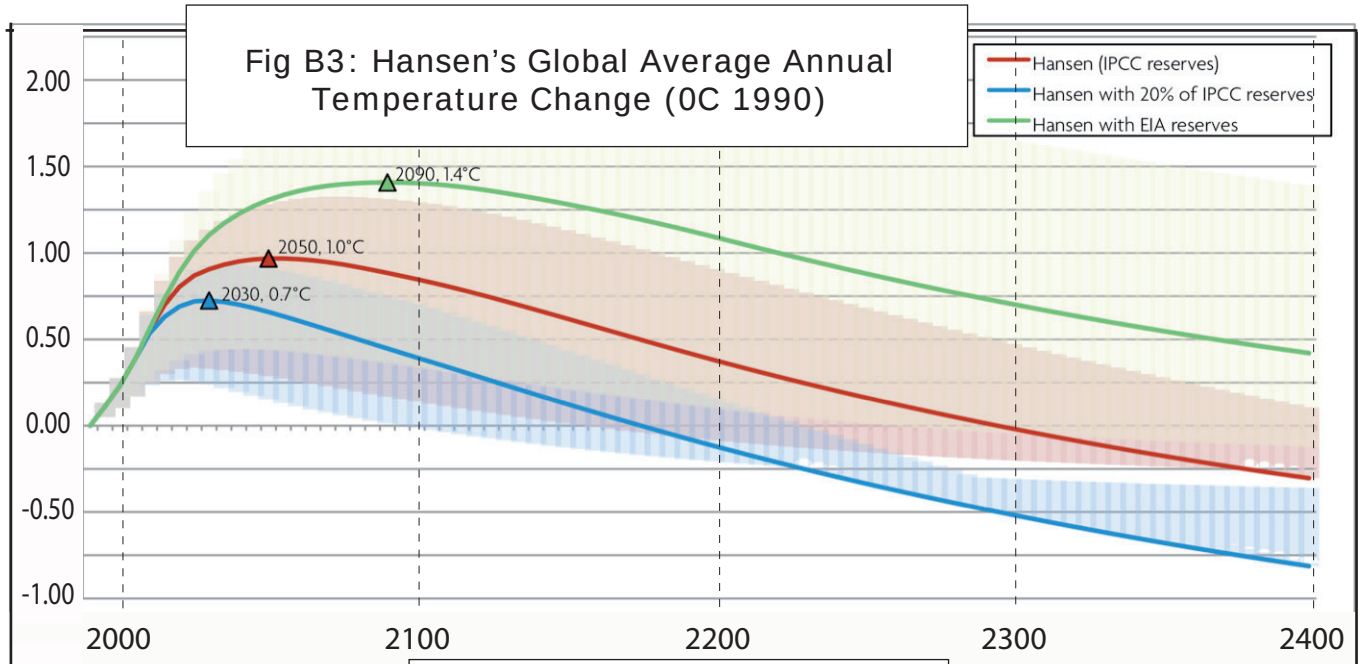


Fig B2: Hansen CO_2 Emissions in ppmv

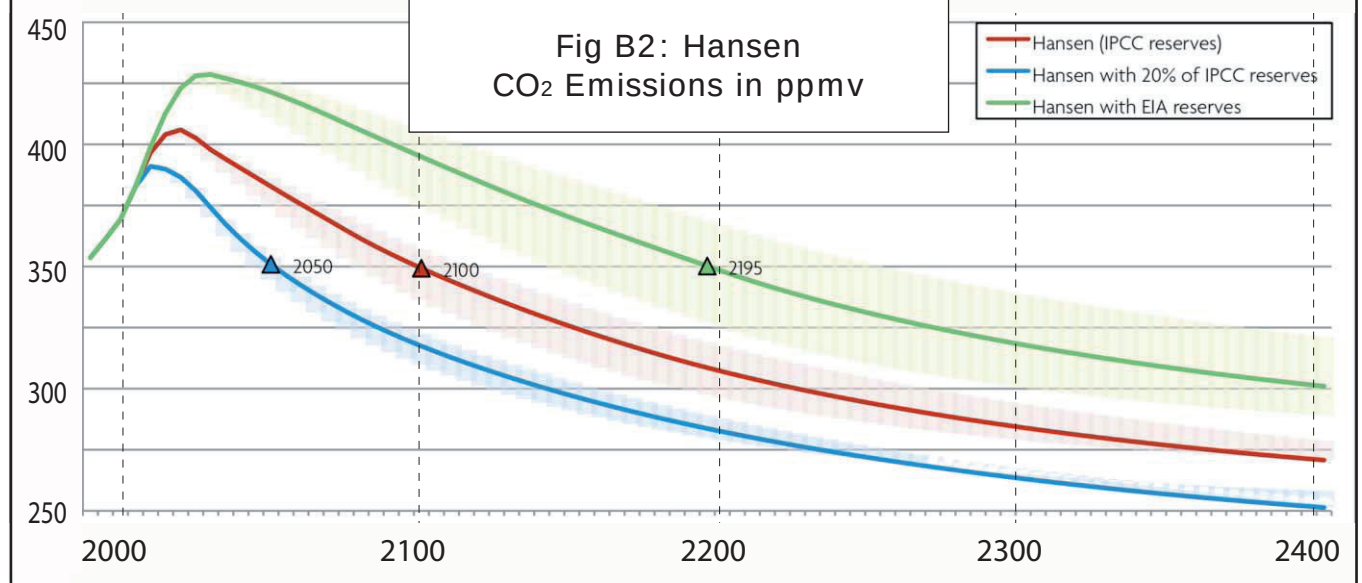
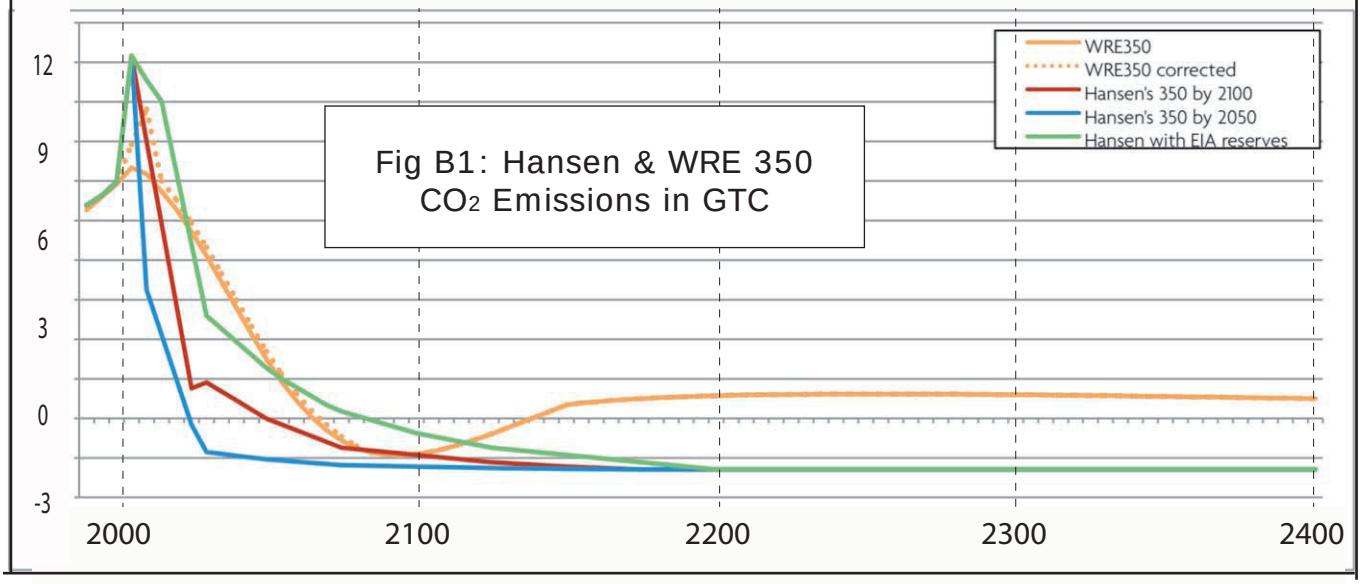


Fig B1: Hansen & WRE 350 CO_2 Emissions in GTC



4. CCC lead scenario

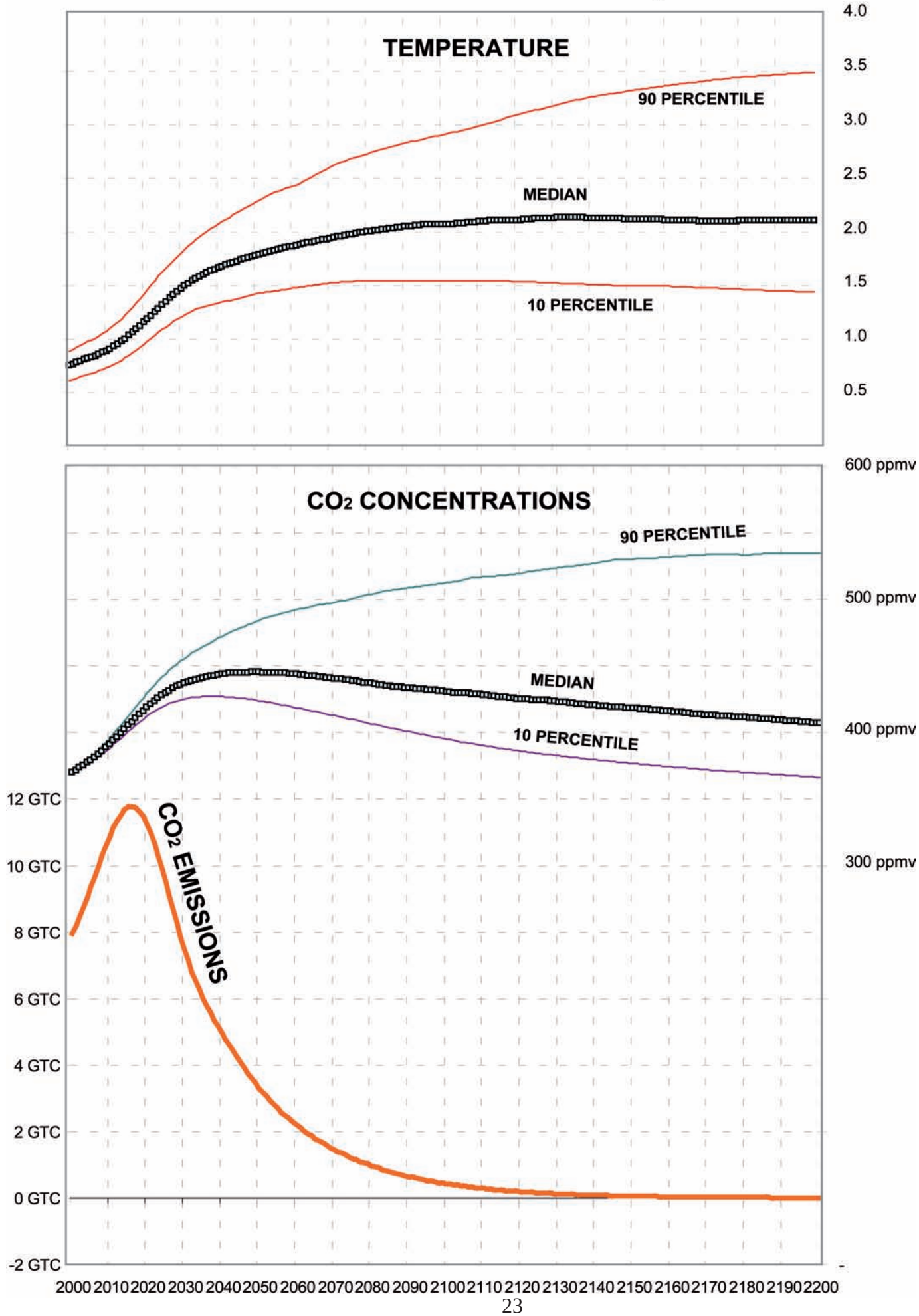
Setting the Goal-Posts around "2016:4% low".

1. When dealing with sink performance in this memorandum, GCI analyses CO_2 separately [that is CO_2 as shown in the CCC scenario spreadsheets] precisely in order to clarify the emissions:source:sink arithmetic in the CCC's modelling. This is done to reveal that, contrary to all the verbal warnings in IPCC AR4 and elsewhere about declining sink-efficiency as temperature rises, this CCC scenario in fact shows the very opposite: - the CCC claims that a dramatic *gain* in sink efficiency occurs in their preferred scenario. This despite even the 'median' case temperature rise they calculated, continuing for more than a century [till ~2120], during which time land-sinks are under assault due to fires, logging and die-back, oceans that are warmer and increasingly 'acidic' with carbonic acid due to increased carbon absorption, are occurring, all of which constitute the *decreasing* and not the *increasing* efficiency of sinks.
2. 'Sink-Efficiency' is measured here like this: -
   - **50% 'sink-efficiency'** - For the last 200 years, we have observed a trend average of around 50% sink-efficiency: - i.e. for any year's human source CO_2 emissions as they rose from a few million tonnes carbon in 1800 to 8 GTC in 2000, 50% was returned to an enlarging natural sink [that no-one can adequately explain]. The other 50% was retained in the atmosphere where it has been accumulating and it is this accumulation that explains the accelerating rise from 280 parts per million by volume [ppmv] in 1800 to nearly 390 ppmv at the present time.
   - **100% 'sink-efficiency'** is when human and other sources of emissions equal sinks, [not experienced in the trend average of the last 200 years - i.e. since industrialisation].
   - **More than 100% 'sink-efficiency'** - When human and other sources of emissions are less than what the sinks are removing and this is what Government is forecasting. Other than when going into an ice-age, over Centuries, no precedent exist for this phenomenon in the human record.
3. The Climate Act was passed into law by the UK Parliament in 2008. It is based on targets for global temperature and global greenhouse gas concentration rise which in turn come from a greenhouse gas [ghg] 'emissions-scenario' created by the Government's 'Climate Change Committee' [CCC].
4. This 'scenario' - alongside - was selected from the several created and it is called the '2016:4% low' scenario. It is from this that the so-called 'median' case has been preferred as the reference case.
5. What the CCC calls the 'drastic' ghg emission budget for CO_2 only was created by the CCC; it is shown in red in the graphic below. It rises from 8 Gigatonne Carbon [GTC] in 2000, to 12 GTC in 2016, whereafter it declines to 50% of 1990 values by 2050 and on asymptotically towards zero, nearly reached by 2100 and beyond.
6. The other greenhouse gases [not shown here] are projected for the same period were projected by the CCC, adding an annual 3 GTC 'equivalent' to the emissions curve with concentrations raised ~50 ppmv pro-rata [above what is shown here for CO_2 only] throughout as a result. The temperature curves shown are for all gases [i.e. not just CO_2].
7. Between these goalposts of percentiles at 10% and 90%, the 'median' scenario is what the Government's claim to have a '50:50' chance of avoiding more than a 2 degree Celsius temperature rise globally is based.

Is this claim unreliably 'optimistic'?

1. It certainly appears to be because, reversing the source:sink arithmetic published by the IPCC for the last thirteen years, the assumptions driving these model runs of MAGICC by UKMO quite remarkably calculate a very rapid increase in the 'efficiency' of the sinks for CO2 over the next thirty to forty years [see pages 24 - 29 of this memo for details]. The 'Median' case is shown to achieve more than 100% efficiency by 2050 and the 10 Percentile case more than 100% efficiency by 2040.
2. Remarkably, this 'good-news' was not mentioned anywhere: [so we ask, was it even noticed?].
3. Even though the 90 Percentile case is shown to achieve 100% efficiency by 2070 it is with concentrations already at 500 ppmv and global temperature already at 3 degrees.

CCC's 2016:4% Low - Median Case for CO_2 Emissions:Concentrations Temperature



5. Analysis of CCC scenario range

CCC's 2016:4% Low - *10th Percentile*

1. In the CCC's '10th Percentile' trace:
   - Temperature rises to no higher than 1.5 degrees Fahrenheit above pre-industrial by 2120 and declines slightly thereafter
   - CO_2 concentrations, deviating quickly from an Airborne Fraction of 50%, rise to ~430 ppmv by around 2030 and decline thereafter to ~370 ppmv by 2200.
   - CO_2 emissions from all human sources, rise from 8 GTC in 2000 to 12 GTC in 2016 after which they contract as shown until 2200. Budget integrals as shown here: -

1800 - 2000	475 GTC
2000 - 2100	480 GTC
2100 - 2200	10 GTC
2000 - 2200	490 GTC

2. CO_2 concentrations are shown with a frame of reference [the shaded area] where emissions are added up constantly at both 50%/year and 100%/year. The 10th Percentile line quickly deviates from the Airborne Fraction Constant at 50% of emissions and is equal to 100% of emissions by ~2040.

How is this changing 'airborne fraction' calculated?

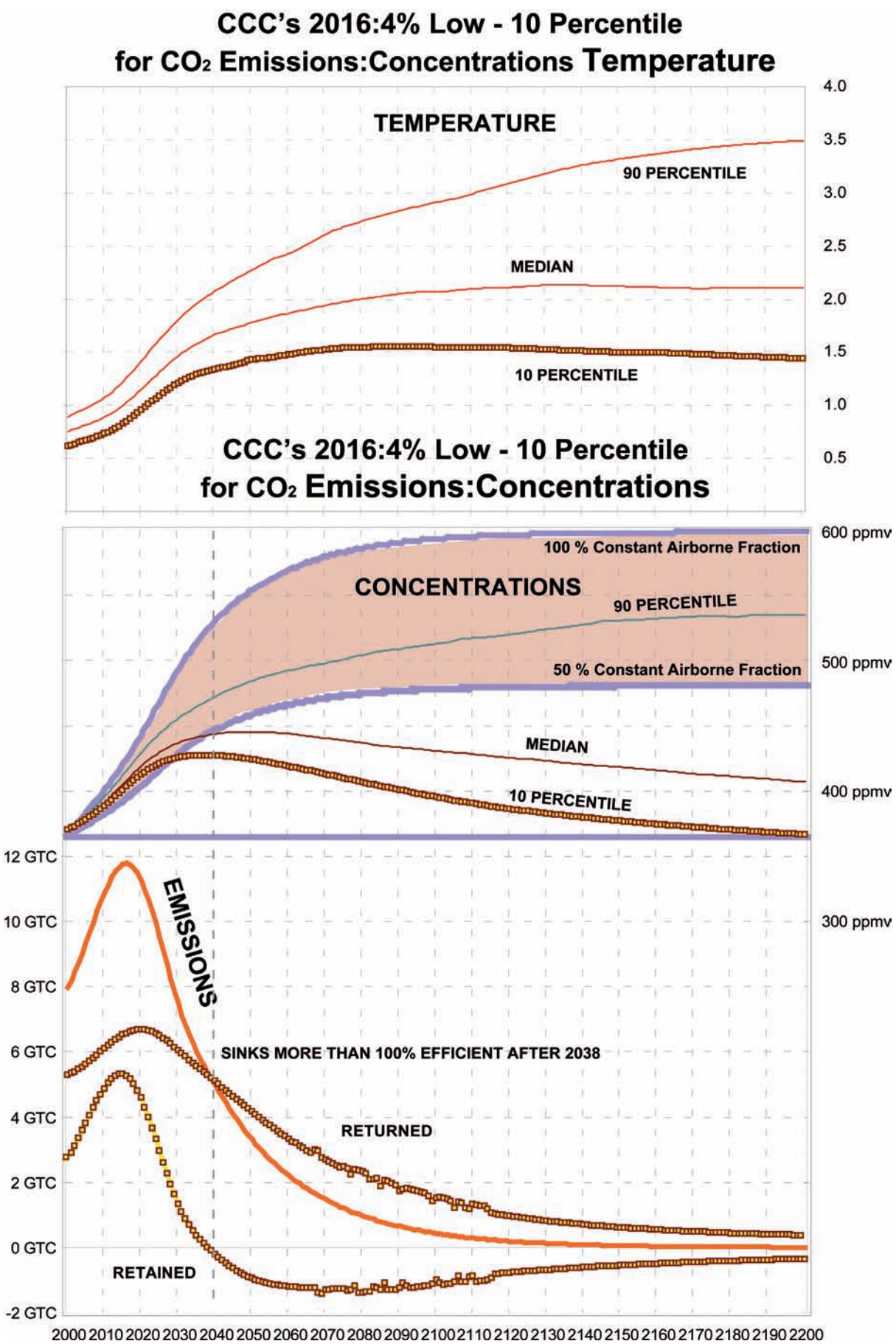
- For the purposes of calculating changing source:sink ratios, atmospheric concentrations in ppmv are converted to a 'weight' of carbon in GTC [1 ppmv CO_2 = 2.13 GTC] year on year [2000-2200] for all three lines i.e. 10 percentile, median & 90 percentile.
- These weights are then subtracted one year from the next [2000-2200], to get 'weight-change' in 'concentrations' year on year [2000-2200].
- Then CCC given-emissions for each year [2000-2200] are made minus the 'weight change for each year [2000-2200] for the 'RETURNED' fraction' &
- Then CCC given-emissions for each year [2000-2200] are made minus the 'RETURNED' fraction to get the 'RETAINED fraction as shown in the graphic alongside.

Sink-Efficiency?

- In this context "Sink-efficiency" [all in terms of gain/loss in GTC] means when: -
- sinks=sources - sinks are 100% efficient
- sinks<sources - sinks are less than 100% efficient
- sinks>sources - sinks are more than 100% efficient

Rate of Change in Sink-Efficiency - 10th Percentile

3. The rate of gain in 'sink-efficiency' between 2000 and 2040 is very rapid indeed. It goes from below 60% efficient to 100% efficient by 2040 and significantly more efficient after 2040. This means that after 2040 sinks are removing the equivalent of all sources, plus a rising amount that equals more than twice all sources after 2070.
4. All the evidence so far - as reported by IPCC for the last 15 years is that the airborne fraction has been constant at around 50% and that it is now very gradually increasing as sink efficiency decreases with rising temperature.
5. When all the evidence reported is that sinks are becoming less-efficient as temperatures rise, to suggest that this rate of gain in this scenario is remotely credible is deeply irresponsible as it is plainly inconceivable that this should occur.


CCC's 2016:4% Low - 10 Percentile
for CO2 Emissions:Concentrations Temperature
TEMPERATURE
90 PERCENTILE
MEDIAN
10 PERCENTILE
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
CCC's 2016:4% Low - 10 Percentile
for CO2 Emissions:Concentrations
100 % Constant Airborne Fraction
CONCENTRATIONS
90 PERCENTILE
50 % Constant Airborne Fraction
MEDIAN
10 PERCENTILE
600 ppmv
500 ppmv
400 ppmv
300 ppmv
12 GTC
10 GTC
8 GTC
6 GTC
4 GTC
2 GTC
0 GTC
-2 GTC
EMISSIONS
SINKS MORE THAN 100% EFFICIENT AFTER 2038
RETURNED
RETAINED
2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100 2110 2120 2130 2140 2150 2160 2170 2180 2190 2200

CCC's 2016:4% Low – *Median*

1. In the CCC's 'Median' trace: -
   - Temperature rises to slightly more than two degrees Fahrenheit above pre-industrial by 2130 and declines very slightly thereafter
   - Deviating less quickly from an Airborne Fraction of 50%, CO2 concentrations rise to ~450 ppmv by around 2050 and declines thereafter to ~400 ppmv by 2200.
   - CO_2 emissions from all human sources, rise from 8 GTC in 2000 to 12 GTC in 2016 after which they contract as shown until 2200. Budget integrals as shown here: -

1800 - 2000	475 GTC
2000 - 2100	480 GTC
2100 - 2200	10 GTC
2000 - 2200	490 GTC

2. CO_2 concentrations are shown with a frame of reference [the shaded area] where emissions are added up constantly at both 50%/year and 100%/year. The Median line deviates less quickly from the Airborne Fraction Constant at 50% of emissions and is equal to 100% of emissions by ~2050.

How is this changing 'airborne fraction' calculated?

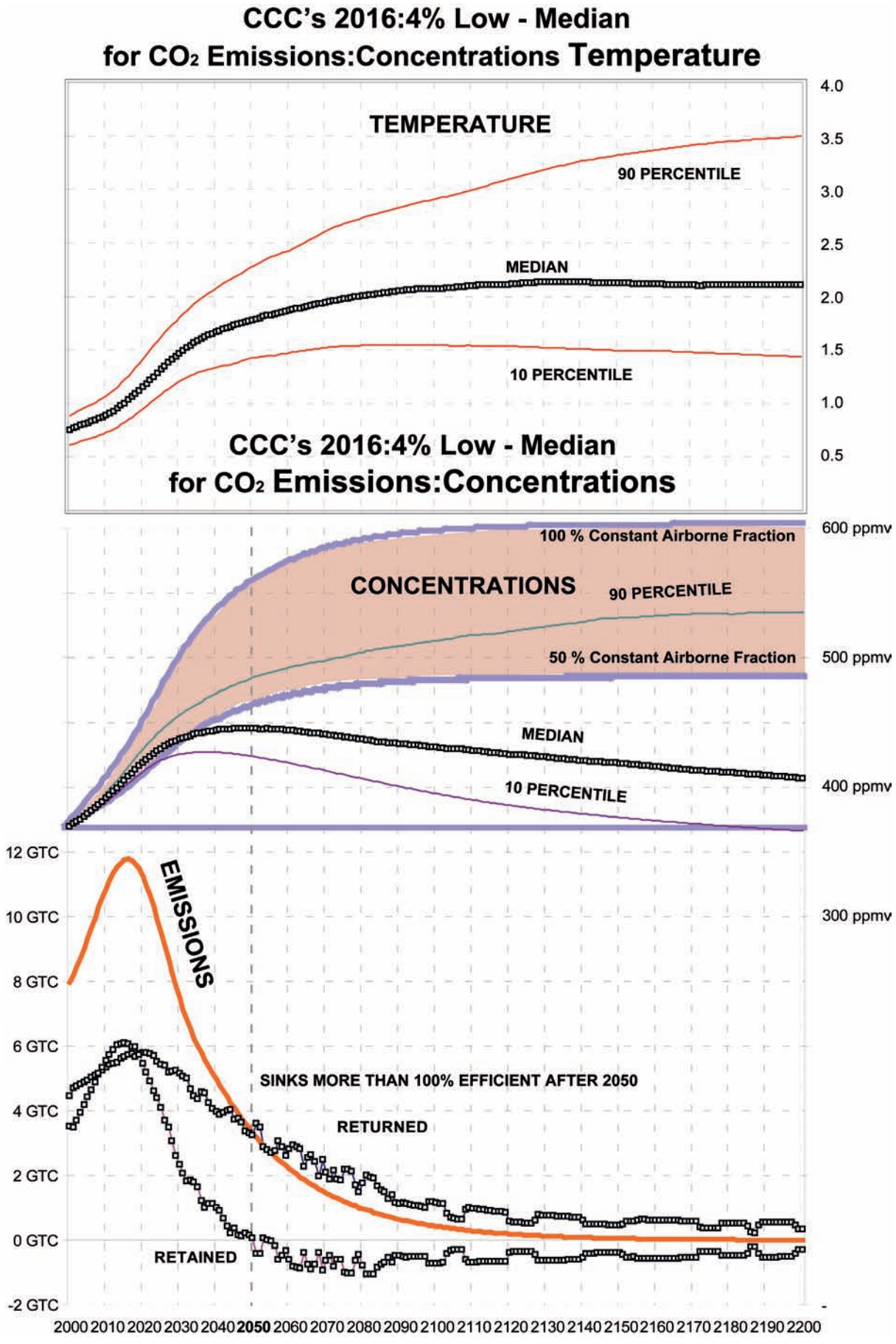
- For the purposes of calculating changing source:sink ratios, atmospheric concentrations in ppmv are converted to a 'weight' of carbon in GTC [1 ppmv CO2 = 2.13 GTC] year on year [2000-2200] for all three lines i.e. 10%-ile, median & 90%-ile.
- These weights are then subtracted one year from the next [2000-2200], to get 'weight-change' in 'concentrations' year on year [2000-2200].
- Then CCC given-emissions for each year [2000-2200] are made minus the 'weight change for each year [2000-2200] for the 'RETURNED' fraction' &
- Then CCC given-emissions for each year [2000-2200] are made minus the 'RETURNED' fraction 'to get the 'RETAINED fraction' as shown in the graphic alongside.

Sink-Efficiency?

- In this context "Sink-efficiency" [all in terms of gain/loss in GTC] means when: -
- sinks=sources - sinks are 100% efficient
- sinks<sources - sinks are less than 100% efficient
- sinks>sources - sinks are more than 100% efficient

Rate of Change in Sink-Efficiency – Median

3. The rate of gain in 'sink-efficiency' between 2000 and 2050 is rapid. It goes from ~50% efficient to 100% efficient by 2050 and significantly more efficient after 2050. This means that after 2050 sinks are removing the equivalent of all sources, plus a rising amount that equals more than twice all sources after 2100.
4. The fact this 'good news' was not mentioned, suggests it wasn't even 'noticed'.
5. All the evidence so far [as reported by IPCC for the last 15 years] is that the airborne fraction has been constant at around 50% and that it is now very gradually increasing as temperature rises and sink efficiency decreases. When all the evidence reported is that sinks are becoming less-efficient as temperatures rise, suggesting that this rate of gain is credible is optimistic to say the least. Interestingly as land-sinks are under attack from fires, die-back, clearfelling and tundra-melt, this suggests that the oceans will be taking up the excess and thereby acidifying that much faster which also reduces sink-function.


CCC's 2016:4% Low - Median
for CO2 Emissions:Concentrations Temperature
TEMPERATURE
90 PERCENTILE
MEDIAN
10 PERCENTILE
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
CCC's 2016:4% Low - Median
for CO2 Emissions:Concentrations
100 % Constant Airborne Fraction
CONCENTRATIONS
90 PERCENTILE
50 % Constant Airborne Fraction
MEDIAN
10 PERCENTILE
600 ppmv
500 ppmv
400 ppmv
300 ppmv
12 GTC
10 GTC
8 GTC
6 GTC
4 GTC
2 GTC
0 GTC
-2 GTC
EMISSIONS
SINKS MORE THAN 100% EFFICIENT AFTER 2050
RETURNED
RETAINED
2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100 2110 2120 2130 2140 2150 2160 2170 2180 2190 2200

CCC's 2016:4% Low - *90th Percentile*

1. In the CCC's '90th Percentile' trace: -
   - Temperature is still rising above 3.5 degrees Fahrenheit above pre-industrial after 2200.
   - Increasingly the Airborne Fraction beyond 50%, CO_2 concentrations rise to ~550 ppmv by 2200 and, harbouring 'runaway', appears even to increase after that.
   - CO_2 emissions from all human sources, rise from 8 GTC in 2000 to 12 GTC in 2016 after which they contract as shown until 2200. Budget integrals as shown here: -

1800 - 2000	475 GTC
2000 - 2100	480 GTC
2100 - 2200	10 GTC
2000 - 2200	490 GTC

2. CO_2 concentrations are shown with a frame of reference [the shaded area] where emissions are added up constantly at both 50%/year and 100%/year. The 90th Percentile line deviates goes above the Airborne Fraction Constant at 50% of emissions in 2000 and rises to an average of 70% of emissions by ~2050.

How is this changing 'airborne fraction' calculated?

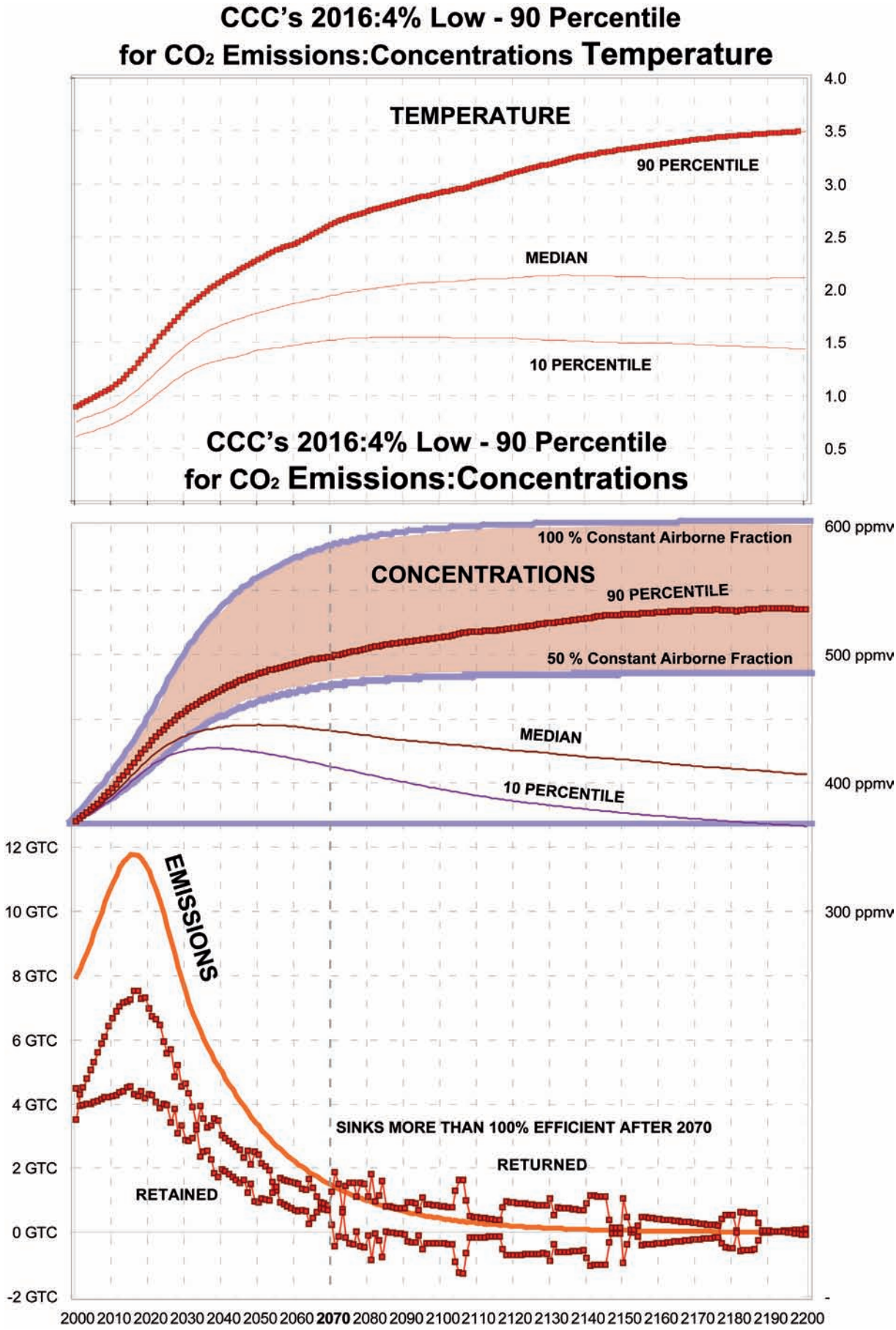
- For the purposes of calculating changing source:sink ratios, atmospheric concentrations in ppmv are converted to a 'weight' of carbon in GTC [1 ppmv CO_2 = 2.13 GTC] year on year [2000-2200] for all three lines i.e. 10%-ile, median & 90%-ile.
- These weights are then subtracted one year from the next [2000-2200], to get 'weight-change' in 'concentrations' year on year [2000-2200].
- Then CCC given-emissions for each year [2000-2200] are made minus the 'weight change for each year [2000-2200] for the 'RETURNED' fraction' &
- Then CCC given-emissions for each year [2000-2200] are made minus the 'RETURNED' fraction 'RETAINED fraction as shown as shown in the graphic alongside.

Sink-Efficiency?

- In this context "Sink-efficiency" [all in terms of gain/loss in GTC] means when: -
- sinks=sources - sinks are 100% efficient
- sinks<sources - sinks are less than 100% efficient
- sinks>sources - sinks are more than 100% efficient

Rate of Change in Sink-Efficiency - 90th Percentile

3. The rate of change in 'sink-efficiency' between 2000 and 2070 is progressive. In this definition, it goes from ~50% efficient to ~100% efficient by 2070. This means that after 2070 sinks are removing the equivalent of the sources, less whatever amounts where natural sinks themselves turn to sources.
4. The fact this 'bad news' was not mentioned, suggests it wasn't even 'noticed' either
5. All the evidence so far [as reported by IPCC for the last 15 years] is that the airborne fraction has been constant at around 50% and that it is now very gradually increasing as temperature rises and 'total' sink efficiency decreases. When all the evidence reported is that total sinks are becoming less-efficient as temperatures rise, suggesting that this rate of loss is credible is not irresponsible. If these rates of change are experienced and sinks become sources, it is overwhelmingly likely that the period during which human actions trying to mitigate climate ius being superseded by 'runaway' conditions.


CCC's 2016:4% Low - 90 Percentile
for CO2 Emissions:Concentrations Temperature
TEMPERATURE
90 PERCENTILE
MEDIAN
10 PERCENTILE
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
CCC's 2016:4% Low - 90 Percentile
for CO2 Emissions:Concentrations
100 % Constant Airborne Fraction
CONCENTRATIONS
90 PERCENTILE
50 % Constant Airborne Fraction
MEDIAN
10 PERCENTILE
600 ppmv
500 ppmv
400 ppmv
300 ppmv
12 GTC
10 GTC
8 GTC
6 GTC
4 GTC
2 GTC
0 GTC
-2 GTC
EMISSIONS
SINKS MORE THAN 100% EFFICIENT AFTER 2070
RETURNED
RETAINED
2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100 2110 2120 2130 2140 2150 2160 2170 2180 2190 2200

CCC's 2028:3% - *10th Median and 90th Percentile*

1. In these 10th, Median and 90th Percentile traces for the CCC's 2028 scenario: -
   - Temperature is still rising above 4.5 degrees Fahrenheit above pre-industrial after 2200.
   - Increasingly the Airborne Fraction beyond 50% for 60 years and CO_2 concentrations rise beyond 500 ppmv and harbours 'runaway'.
   - CO_2 and all other greenhouse gas emissions from all human sources, rise from 11 GTC in 2000 to 18 GTC in 2028 after which they contract as shown until 2200. CO_2 budget integrals as shown here: -

1800 - 2000	475 GTC
2000 - 2100	747 GTC
2100 - 2200	148 GTC
2000 - 2200	895 GTC

2. All gas concentrations and temperature are shown for the 10th, the median 90th Percentiles.
3. The monotonicity of overall approach is clearly evidenced at these higher values.
4. Deviations here [shown opposite] are less alarming [i.e. more 'optimistic'] than those projected in IPCC AR4 [as shown below] which are for CO_2 only measured as the gas molecule and not the carbon atom [conversion 1 tonne carbon equals 3.666 tonnes CO_2]: -

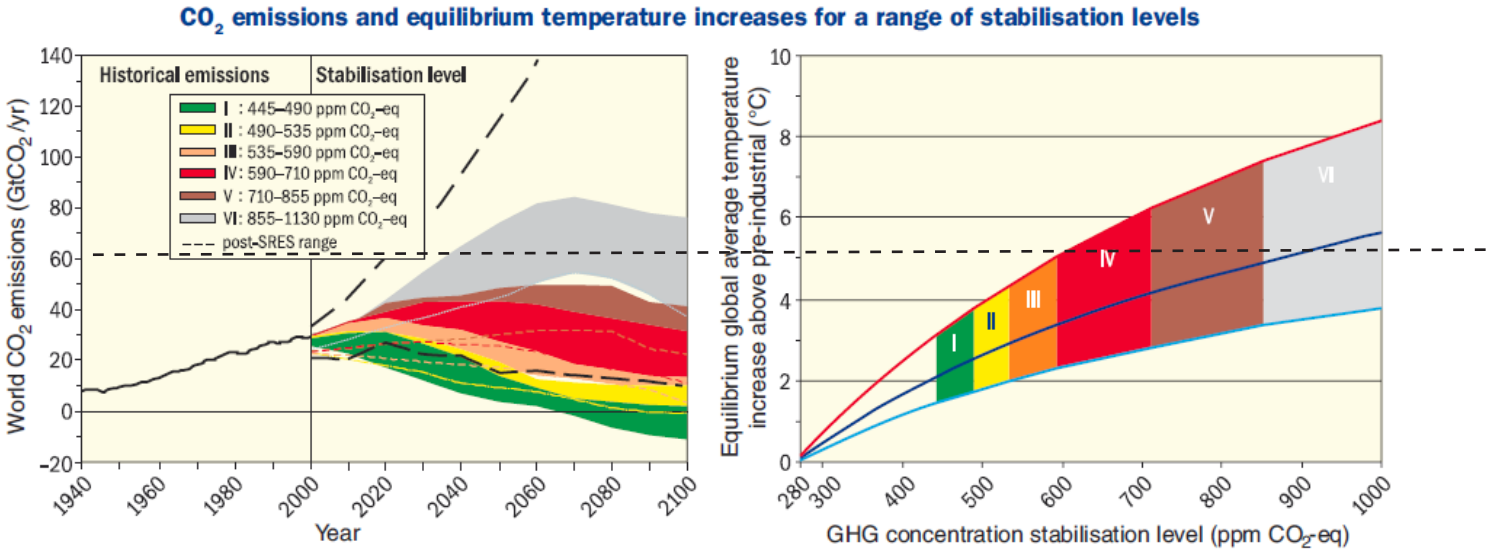
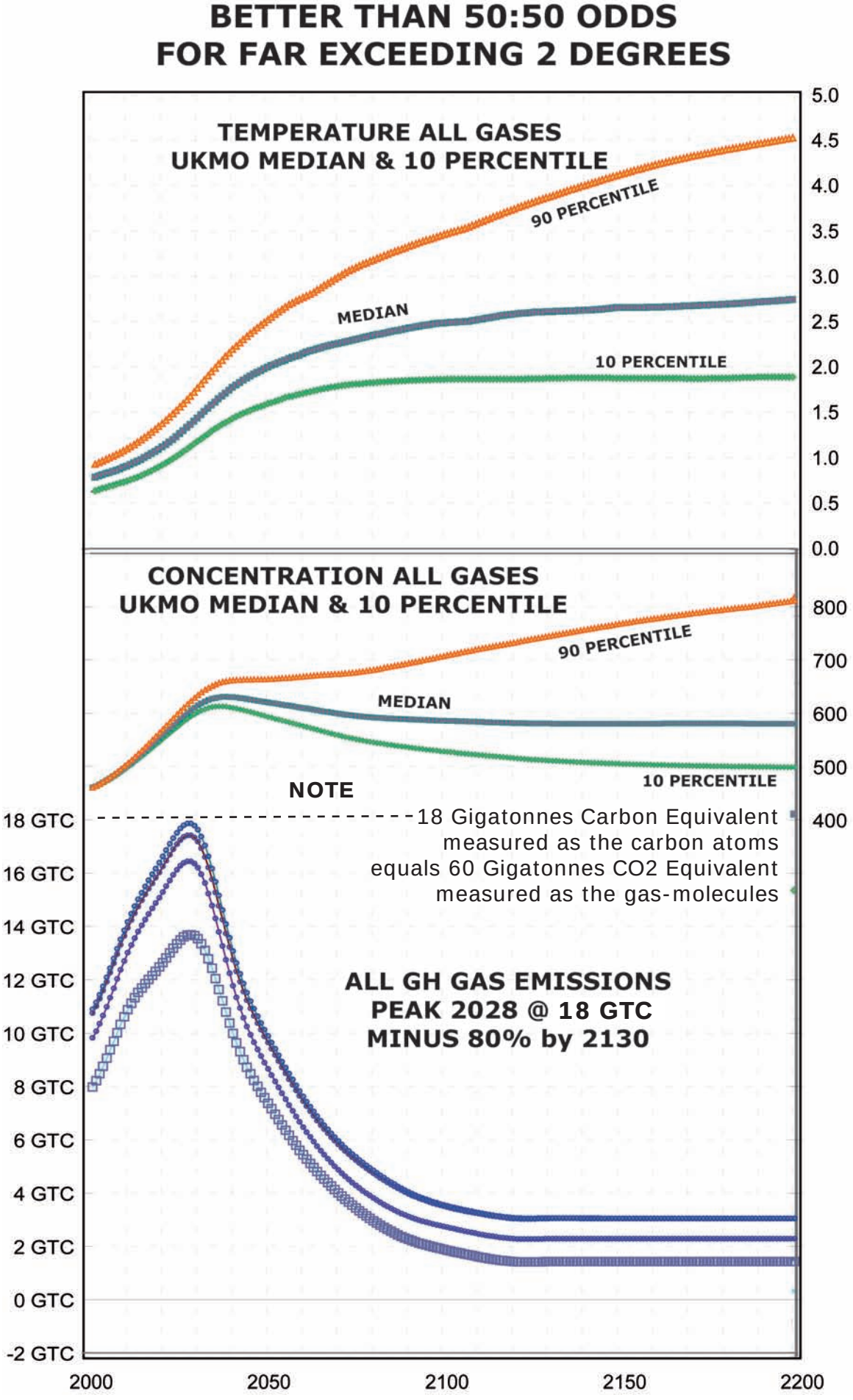


Figure SPM.11. *Global CO_2 emissions for 1940 to 2000 and emissions ranges for categories of stabilisation scenarios from 2000 to 2100 (left-hand panel); and the corresponding relationship between the stabilisation target and the* likely *equilibrium global average temperature increase above pre-industrial (right-hand panel). Approaching equilibrium can take several centuries, especially for scenarios with higher levels of stabilisation. Coloured shadings show stabilisation scenarios grouped according to different targets (stabilisation category I to VI). The right-hand panel shows ranges of global average temperature change above pre-industrial, using (i) 'best estimate' climate sensitivity of 3°C (black line in middle of shaded area), (ii) upper bound of* likely *range of climate sensitivity of 4.5°C (red line at top of shaded area) (iii) lower bound of* likely *range of climate sensitivity of 2°C (blue line at bottom of shaded area). Black dashed lines in the left panel give the emissions range of recent baseline scenarios published since the SRES (2000). Emissions ranges of the stabilisation scenarios comprise CO_2-only and multigas scenarios and correspond to the 10th to 90th percentile of the full scenario distribution. Note: CO_2 emissions in most models do not include emissions from decay of above ground biomass that remains after logging and deforestation, and from peat fires and drained peat soils. {Figure 5.1}*


BETTER THAN 50:50 ODDS
FOR FAR EXCEEDING 2 DEGREES
TEMPERATURE ALL GASES
UKMO MEDIAN & 10 PERCENTILE
90 PERCENTILE
MEDIAN
10 PERCENTILE
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
CONCENTRATION ALL GASES
UKMO MEDIAN & 10 PERCENTILE
90 PERCENTILE
MEDIAN
10 PERCENTILE
800
700
600
500
400
NOTE
18 GTC
18 Gigatonnes Carbon Equivalent
measured as the carbon atoms
equals 60 Gigatonnes CO2 Equivalent
measured as the gas-molecules
16 GTC
14 GTC
12 GTC
10 GTC
8 GTC
6 GTC
4 GTC
2 GTC
0 GTC
-2 GTC
ALL GH GAS EMISSIONS
PEAK 2028 @ 18 GTC
MINUS 80% by 2130
2000
2050
2100
2150
2200

Appendix A

Notes on the method and modelling used for defining UK emissions reduction targets

Summary

1. The Committee on Climate Change's UK emissions reduction targets and carbon budgets are founded on global targets that are insufficient to provide an acceptable level of security to remain within 2oC warming above pre-industrial levels. The UK strategy is highly dependent on COP15 arriving at an agreement that would secure the objective of keeping global temperature rise to within the 2oC limit. Failure at Copenhagen would result in delay to Peak and could require significantly faster rates of reduction to be adopted.
2. Annual percentage rates of global emissions reduction were determined at the outset on the basis of supposed economic feasibility. These reduction rates were then used to drive trajectories with a high probability of failure to keep within 2oC temperature rise by 2100. This has led to a "best we can do" outcome rather than "what is required". It falls far short of the UNFCCC principle of precaution.
3. The CCC Report does not explain how full account was taken of the findings of the C4MIP and IPCC AR4 WGI coupled modelling exercises in preparation for the CCC/Hadley modelling exercise. Since the report was produced, a new version of MAGICC/SCENGEN (version 5.3.v2) has been released with significant changes to treatment of carbon cycle feedbacks and climate sensitivity.
4. The method used for developing global and UK targets did not fully demonstrate rational and transparent risk assessment and evaluation of options. The balance between science-based and political decisions is not clear enough. The model used lacked transparency and is presented as a black box.
5. Presentation of findings and conclusions in the CCC reporting documentation is confusing and could possibly mislead. Targets are given a 50% probability of staying within 2oC where this is not consistent with the modelling results presented. Incorrect claims for consistency of results with the work of others and difficulties of reconciling the results of different coupled modelling exercises result in increased uncertainty about the reliability of targets and budgets.

1. Introduction

1. The UK Government asked the Committee on Climate Change to recommend the level of UK carbon budgets, subject to a legally binding constraint that the emissions reduction by 2020 must be at least 26% relative to 1990. The Committee recommended UK carbon budgets for the first three budget periods, 2008-12, 2013-17 and 2018-22. The CCC in conjunction with the Hadley Centre determined global and UK emissions reduction targets as the foundation for the UK carbon budgeting exercise.
2. These targets and budgets were published by the Committee in its report "Building a low carbon economy" in December 2008.
3. In March 2009, the parliamentary Environment Audit Committee initiated an enquiry into UK carbon budgets. GCI submitted written evidence to the Committee, stating:
4. *"To keep within the 2 degrees Celsius temperature limit, the budgets need to be based on a global emissions contraction of 80% by 2050 and where the airborne fraction may still stay constant at ~50% giving a 450 ppmv outcome. But with sinks failing at ~0.5%/yr, the outcome may still be >450ppmv".* (GCI Memorandum to the EAC, 27 April 2009)
5. These notes were produced by GCI for the enquiry following additional evidence presented during the hearings. The main sources used by GCI were the Committee's report and its Technical Appendix. Reference is also made to written evidence submitted to the EAC enquiry. References to these and other sources are given at the end of the notes.

2. Role of the Committee on Climate Change

1. The role of the Committee on Climate Change is outlined in the Chairman's Foreword to the Committee's report, "Building a low carbon economy":

2. *"Our role is to recommend a path of emissions which is appropriate as a UK contribution to global climate change mitigation, and to identify whether that path is feasible at manageable economic cost, given the range of different technologies and policy levers which could be deployed. This Report therefore sets out alternative ways in which emission reductions could be achieved, and assesses whether there are reasonable scenarios in which different combinations of actions would deliver the required emission reductions path".* (CCC Report, Page v)

3. These "terms of reference" appear to place the development of emissions paths ahead of the feasibility test. This would give the opportunity to develop science–based paths, allowing a proper assessment of risk and cost in the latter part of the global trajectory feasibility study.

3. Method used by the Committee on Climate Change

1. The method used to develop emissions reduction targets is described in the CCC Report and its Chapter 1 Technical Appendix and Spreadsheet. In outline, the method used consists of the following steps:

Set a global climate objective

2. The broad global climate objective set by the Committee was:

3. *to limit our central expectation of temperature rise to 2°C, or as close as possible. In addition we propose an additional rule which is to reduce the risk of extremely dangerous climate change to very low levels (e.g. less than 1%). We have made the judgment that 4ºC this century would be this 'extreme danger' threshold"* (CCC Report page 16).

4. Consideration of climate risk at this stage is addressed in terms of a target temperature threshold of 2^{o}C following an assessment of scientific evidence, with a further limit in percentage probability terms for the extreme case of 4^{o}C. No thresholds are set at this stage for levels of concentration of ghg's in the atmosphere. Risk of exceeding 4^{o}C is restricted to a 1% probability; risk of exceeding 2^{o}C is not restricted to any other measure.

Prepare global emissions reduction scenarios

1. The Committee took the following approach:

2. *"The number of different emissions scenarios which could be modelled is infinite. We therefore need to choose a manageable number of trajectories which together cover the range of likely desirable policies. We do this by varying three parameters: the year at which we assume that global emissions peak, the pace of emissions reduction achievable thereafter, and the ultimate emissions floor. In each case the path of emissions before peaking is assumed to follow a baseline scenario. CO_2 emissions include those relating to land-use as well as those from fossil fuels and industrial processes, and emissions of other relevant gases are also accounted for".* (CCC Report, Page 21)

3. Having noted that the potential number of scenarios is infinite, the CCC chose a manageable number to cover a range of desirable policies. The desirability of low risk was not overtly recognised amongst these and the ensuing parameters.

Peak year

1. The Committee chose two options: 2016 and 2028.
2. *"For simplicity we have assumed two peaking years - 2016 and 2028. The former represents a case where the world community successfully commits to a global deal in Copenhagen in 2009, as set out in the "Bali Action Plan" of the United Nations Framework Convention on Climate Change, and the latter peaking year represents a much less optimistic world: Annex I and non-Annex I emissions both continue to follow the baseline until the world commits to action at a later date. In reality it is difficult to know for certain when global emissions will peak. A seven year period between achieving a global deal in Copenhagen and the peak in emissions does not seem unreasonable however, given that agreements will need to be ratified and policies will need to be developed and implemented".* (CCC Technical Appendix, Page 10)
3. In the event that COP 15 does not deliver an effective and workable agreement, a later peak may become necessary, with faster rates of emissions reduction relative to 2016. Meinshausen, at Exeter in 2006, said that the peak should occur in or by 2015 and that any delay of global action by 10 years would nearly double the required reduction rates around 2025. He went on to say that each 5 year delay would require a +1% increase in the rate of reduction. More recently in interview (2009), Pachauri has said that the peak year must be no later than 2015. A peak year of 2028 would probably require substantially greater rates to avoid exceeding 2^{o}C, as discovered somewhat later in the exercise by the CCC.

Baseline scenario

1. The Committee chose to use IPCC SRES A1B:
2. *"In order to select which single SRES marker scenario is most appropriate for use as a baseline we compared them to observed emissions trends since 2000, along with estimates of emissions, population and economic growth. Data on recent CO_2 emissions from fossil fuel use and industrial activity are available on an annual basis and are the most reliable. Comparison of the SRES scenarios against these data suggests the A1B scenario accounts most closely for both the magnitude and annual growth of these emissions, especially since around 2004. Furthermore, recent IEA forecasts of CO_2 emissions from fossil fuel use and industrial activity out to 2050 show closest matches to SRES scenarios A1B and A2".* (CCC Technical Appendix, Page 7)
3. *"In terms of population the A1B scenario forecasts a world population in 2050 of 8.7 billion, comparing favourably to the UN's most recent medium projection of 9.2 billion (7.8 to 10.8 billion). The A1B estimate of current and projected economic growth is at the upper end of the SRES scenarios, although at an average 3% per annum between 1990 and 2100, it is similar to the annual average growth rate experienced between 1970 and 2007 of 3.1%".* (CCC Technical Appendix, Page 9)

Pace of emissions reduction

1. In defining a range of annual reductions, the Committee adopted a separate approach for each gas. The approach for CO_2 was as follows
2. *"All CO_2 emissions are reduced at rates from 1.5% to 4% per annum. Our most rapid annual reduction rate leads to CO_2 emissions of around 12 Gt/yr in 2050, a reduction of 48 Gt/yr relative to baseline emissions. This is consistent with the International Energy Agency's (IEA) strongest mitigation scenario, which shows that a reduction of around 48 Gt/yr is possible by 2050 relative to their baseline for a cost of $200-500 per tonne of CO_2."* (Technical Appendix, Page 10)
3. The IEA scenario referred to in the Technical Appendix is the Blue scenario which gives a 48Gt/yr CO_2-only reduction relative to baseline. The original IEA baseline was taken to 2030; for the *Energy Technology Perspectives* exercise this was extended to 2050. The claim of consistency relates only to the 48Gt/yr reduction for the most rapid CCC rate of 4% with a 2016 peak . No explanation or reference is given for the other rates used by CCC.
4. The full set of rates used were as follow:
5. *"Trajectories with global emissions peaking in 2028, and with subsequent reductions in total CO_2 emissions of 1.5% per annum, 2% per annum, and 3% per annum (these are labeled trajectory 2028:1.5%, 2028:2%, and 2028:3%). Other GHG's are reduced at consistent rates.*

6. *Trajectories with global emissions peaking in 2016 and with subsequent reductions in total CO_2 emissions of 1.5%, 2%, 3%, and 4% (labeled 2016:1.5%, 2016:2%, 2016:3%, 2016:3%low, and 2016:4%low). Other GHG's are reduced at consistent rates".* (CCC Report, Page 21)
7. The floor for emissions reduction was set at 11GtCO_2e for the first six trajectories above, and reduced to 6GtCO_2e for the last two, designated "low".
8. Another scenario, 2014:3%low, was modelled and described in the Technical Appendix, but is not mentioned in the CCC Report.
9. The Committee provided the input rates of emissions reduction for each ghg as described above. They are broadly based on considerations of economic feasibility. The trajectories are driven by these input rates in the range 1.5-4%. No further consideration is given to risk at this stage, for example by setting target limits of probability for exceeding the temperature threshold. From these trajectories, the Hadley Centre produced carbon equivalents for each input ghg and then calculated the aggregate CO_2e for input to the modelling process.

Model concentrations, temperatures and probabilities

1. The base scenario, SRES A1B, and the eight reduction scenarios were processed with the MAGICC 4.1 model and summarised in the CCC Report. Detailed results were published in the Technical Appendix and Spreadsheet. A ninth scenario, 2014:3%low, was processed but not presented in the CCC Report.
2. Modelling results are summarised below:
3. 2100 probability of temperature rise staying within 2°C per scenario.

Scenario	°C increase	Probability
2014:3%low+	2.00	0.49
2016:4%low	2.00	0.44
2016:3%	2.00	0.37
2016:3%low	2.00	0.35
2016:2%	2.00	0.27
2016:1.5%	2.00	0.20
2028:3%	2.00	0.17
2028:2%	2.00	0.09
2028:1.5%	2.00	0.05
SRES A1B	2.00	0.00

2050 probability of temperature staying within 2°C per scenario.

2014:3%low+	2.00	0.80
2016:4%low	2.00	0.75
2016:3%low	2.00	0.72
2016:3%	2.00	0.75
2016:2%	2.00	0.72
2016:1.5%	2.00	0.70
2028:3%	2.00	0.56
2028:2%	2.00	0.56
2028:1.5%	2.00	0.57
SRES A1B	2.00	0.22

Source: Technical Appendix, Spreadsheet, Trajectory cdf's.

Trajectory Descriptions

Trajectory name	Peaking year	Kyoto emissions peak ($GtCO_2e$)	CO_2 emission decrease after peak	Kyoto emissions floor ($GtCO_2e$)	2050 Kyoto emissions cut, from			Cumulative emissions ($GtCO_2e$)			Chance of staying under 2°C by 2100
					1990	2000	2007	1990-2050	2000-2050	2007-2050	
2016:4%low	2016	56.80	4%/yr	6	46%	51%	59%	2423	2045	1743	44%
2016:3%low	2016	56.70	3%/yr	6	33%	40%	50%	2536	2158	1856	37%
2014:3%low+	2014	55.93	3%/yr	6	46%	51%	59%	2252	1879	1579	49%
2016:3%	2016	56.70	3%/yr	11	34%	40%	50%	2535	2157	1855	37%
2016:2%	2016	56.59	2%/yr	11	14%	22%	35%	2676	2298	1996	27%
2016:1.5%	2016	56.53	1.5%/yr	11	2%	11%	26%	2757	2379	2077	20%
2028:3%	2028	65.48	3%/yr	11	0%	9%	25%	3067	2688	2386	17%
2028:2%	2028	65.09	2%/yr	11		-9%	9%	3152	2774	2471	9%
2028:1.5%	2028	64.88	1.5%/yr	11			1%	3200	2821	2519	5%

Source: Technical Appendix, Spreadsheet, Plots

1. Detailed modelling results are shown in the Technical Appendix for all nine scenarios specified by the Committee, in addition to the baseline SRES A1B. Six of the nine scenarios specified have a less than 40% chance of staying under 2°C by 2100 and all nine have less than 50% probability. The only scenario above 40% probability referenced in the Report is 2016:4%low with a probability of just 44%. The scenario with the highest probability of remaining below 2°C by 2100 was 2014:3%low, with a probability of 49%; no reason is given for its exclusion from the Report.
2. A range of options where all have less than 50% probability of success presents a very difficult choice for policymakers.

Select preferred scenarios

1. The following scenarios were selected for the calculation of UK targets, with some important provisos:
2. Global 2050 emissions target, in terms of Kyoto GHG emissions, arising from trajectories 2016:3%low and 2016:4%low.

Emissions trajectory	Kyoto emissions ($GtCO_2e/yr$)			2050 emissions cut, relative to baseline year	
	1990	2007	2050	1990	2007
2016:3% / 2016:3%low	36.1	48.1	23.9	34%	50%
2016:4%low	36.1	48.1	19.6	46%	59%

Source: CCC Report, Table 1.2.

3. The Committee pointed out the importance of cumulative emissions and longer term emissions reduction beyond 2050:
4. *"It is important to note, however, that while discussion of a global deal tends to focus on emissions in 2050, two other considerations are also important:*
   - *The climate impact of our preferred trajectories depends primarily upon the cumulative emissions profile. Cumulative emissions between 1990 and 2050 for the trajectories recommended here are 2,420 GtCO2e to 2,540 GtCO2e, of which we estimate around 780 GtCO2e has been used already.*
   - *In addition, the climate impact of our preferred trajectories depends upon further emission reduction beyond 2050: emissions should fall to between 8 GtCO2e and 10 GtCO2e by 2100,with a cumulative budget between 2051 and 2100 of 590 GtCO2e to 760 GtCO2e. Should missions not fall further beyond 2050 then the climate outcomes set out in this section will not be achieved".* (CCC Report, Page 26)

The modelling process calculated concentrations for each scenario:

1. *"Trajectories with emissions peaking in 2016: all the trajectories except a 1.5% annual reduction after 2016 would keep concentrations below 550ppm of CO_2 equivalent, according to central model estimates (Figure 1.10). Only reductions at 3% or 4% per year would limit the chance of reaching 4ºC to very low levels, with central model estimates indicating a 2.2°C temperature rise this century from the 2016:3% trajectories, and a 2.1°C rise from 2016:4% low. Even in these cases it should be noted that the chances of exceeding 2°C by 2100 would be 63% and 56% respectively, according to our model distributions (Figure 1.11)".* (CCC Report, Page 21)
2. The relationships between emissions, concentrations and temperature are not fully described in the Report and Appendix, although a degree of uncertainty is expressed.
3. The results for 2014:3%low were comparable with those for 2016:4%low in terms of emissions reduction: both showed a 46% reduction on 1990 levels by 2050. However, the absolute emissions reduction was greater by 171$GtCO_2e$ and the probability of staying under 2ºC by 2100 was significantly higher at 49% compared with 44%. The probability of staying under 2ºC by 2200 was about the same at 47%.
4. As the CCC Report noted, the chances of the preferred cases exceeding 2°C by 2100 would be 63% and 56% respectively. In the case of the discarded 2014:3%low this was 51%.
5. The Hadley Centre, in its written evidence to the EAC, said that *"The Committee on Climate Change's 2016:4%low scenario corresponds to a CO_2 emission reduction of around 50% on 1990 levels by 2050. Using the Met Office Hadley Centre model, it corresponds to a median warming of a little over 2ºC, with a probability of around 50% of exceeding 2ºC"*.
6. In a letter to GCI, the Hadley Centre said*: " For each emissions scenario an output from the simulations was a probability distribution showing how likely different amounts of 21st century warming will be. The Committee on Climate Change then selected the emissions scenario that showed a 50% chance of limiting warming to approximately 2ºC above pre-industrial levels at 2100, as well as reducing the risk of a 4ºC rise to very low levels."* (Hadley letter to GCI
7. The Spreadsheet Plot for the 2016:4%low scenario gives 46% CO_2e reduction on 1990 levels by 2050 and a probability of 56% of exceeding 2ºC by 2100. (Technical Appendix, Spreadsheet, Plots, Trajectory Descriptions)

Set global emissions reduction target

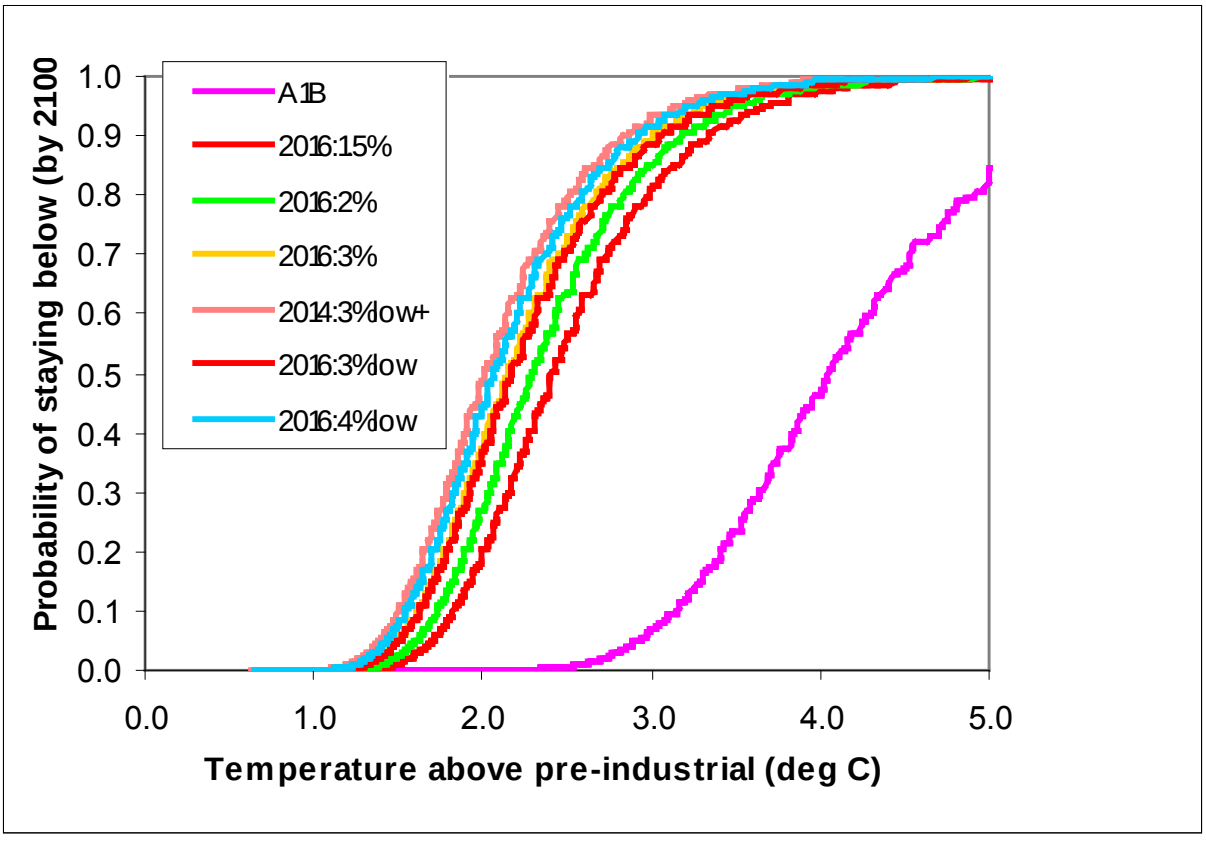
1. The following statement can be reconciled with the model output results summarised in 3c) Trajectory Descriptions above.
2. *"The Committee believes that it is a reasonable judgement that the objective should be to achieve a global commitment to a peak of emissions within the next ten years, with a subsequent reduction of all CO2 emissions at 3% per annum or more, accompanied by similar effort for other GHG's (the feasibility and cost of this reduction is considered in the Chapter 2). This would imply a global level of Kyoto GHG emissions of between 20 and 24 gigatonnes25 on a CO2-equivalent basis (GtCO2e) in 2050 compared with a 1990 level of about 36 GtCO2e and an estimated current level of about 48 GtCO2e. A global reduction of about 34% to 46% below 1990 levels and of 50% to 59% below current levels are therefore likely to be required to meet the global climate objectives we proposed in Section 3 above (Table 1.2). This is broadly in line with the commitments made at the G8 meetings at Heiligendamm and Hokkaido, which committed the G8 nations to a broad (global) 50% reduction without specifying the precise base year". (CCC Report, Page 26).*
3. *The global CO_2e emissions reduction target proposed here by the CCC is 34%-46% below 1990 levels by 2050. The EU target is to reduce emissions to at least 50% below 1990 levels by 2050:*
4. *"The EU firmly believes that global warming must not exceed 2°C above pre-industrial levels since there is strong scientific evidence that the risk of irreversible and possibly catastrophic environmental changes will become far greater beyond this threshold. Keeping within 2°C will require global emissions to peak by 2020 and then be at least halved from 1990 levels by 2050". (The European Commission stated objective at Poznan 2008).*
5. The global level of Kyoto GHG emissions of between 20 and 24 gigatonnes on a CO2-equivalent basis (GtCO2e) in 2050 referred to above is used as the basis for UK targets.

Set UK emissions reduction targets

1. UK targets were directly derived from the calculated global emissions reduction targets, using the principle of equal *per capita* emissions.
2. *"The simplest approach is to assume that in the long-term every person on the planet is entitled to an equal share of GHG emissions. If the world in total is to reduce emissions to a range of 20 $GtCO_2e$ to 24 $GtCO_2e$ by 2050, this would imply a per capita allowance of between 2.1 to 2.6 tonnes CO_2-equivalent (assuming a global population in 2050 of about 9.2 billion). A global deal on this basis would require that the UK reduces emissions to something like 146 $MtCO_2e$ to 180 $MtCO_2e$ compared to a 1990 baseline of 797 $MtCO_2e$ – this includes bunker fuels used for international aviation and shipping and emissions relating to land-use. This implies cuts of between 78% and 82% versus the 1990 baseline". (CCC Report, page 27)*
3. This estimate was based on population projections of global (9.2 billion) and UK (69 million) to suggest a UK emissions reduction of between 78% and 82%. The CCC selected 80% as the target.
4. When working on the *per capita* principle, *per capita* emissions calculations can be based on the population for any given year. Population figures may therefore be past or current actual or hypothetical future, in this case 40 years forward. Other less speculative values are available.

4. The MAGICC Model

1. The Committee with the Hadley Centre modelled concentrations, temperature and probability distributions of temperature increases for each trajectory. The MAGICC 4.1 climate model was used with a distribution of climate sensitivity taken from Murphy, J.M., et al. (2004).



Source: Technical Appendix, Spreadsheet Plots

2. There is some confusion in the presentation of method and results in the CCC Report and in the submissions to the EAC enquiry.

Climate-carbon cycle coupled modelling

1. The Hadley Centre has said that full account had been taken of the findings on feedbacks from the C4MIP and AR4 WGI coupled modelling experience in preparation for the CCC modelling exercise:

2. *"The models used by the Committee on Climate Change (CCC) did include a coupling between climate and the carbon cycle and took full account of the 'coupled' model research presented in the AR4 WG1 report, the C4MIP study and related researc*h". (Hadley letter to GCI, 2009).

C4MIP

3. The Friedlingstein report on the C4MIP coupled modelling exercise (2005) contained the following summary:

4. *"There was unanimous agreement among the models that future climate change will reduce the efficiency of the earth system to absorb the anthropogenic carbon perturbation. A larger fraction of anthropogenic CO_2 will stay airborne if climate change is accounted for. By the end of the twenty-first century, this additional CO_2 varied between 20 and 200 ppm for the two extreme models, the majority of the models lying between 50 and 100 ppm. The higher CO_2 levels led to an additional climate warming ranging between 0.1° and 1.5°C".* (Friedlingstein et al., AMS Vol.19, 2006)

5. Hadley summarised C4MIP as follows:

6. *"All of the models run in C4MIP demonstrated that coupling the climate to the carbon cycle is important and that by 2100 climate change leads to the biosphere being less able to absorb CO_2. A key result from the study was the significant variation across the models in the size of this effect, demonstrating sizeable uncertainty in representing the climate-carbon cycle feedback. Although C4MIP found that the Hadley Centre model showed the strongest feedback effect, the other ten models are also credible and their results cannot therefore be ruled out.* (Hadley letter to GCI 2009)

IPCC AR4 WG1 (2007)

7. The IPCC AR4 WG1 report gave a summary of the C4MIP project (WG1Chapter 7). It also gave the results of a later three model joint exercise using Hadley SM, Uvic EMIC and BERN 2.5CC EMIC. The Hadley SM curve in this exercise showed emissions reducing to zero by about 2060. In response to a question put by GCI, Hadley said:

8. "*The Hadley Centre curve shows a simple model set up to replicate the more complex Hadley Centre model used in C4MIP. The simple model was then used to study the emissions that lead to a stabilisation level for CO_2 of 450ppm for a single pathway. For this particular pathway, and only considering CO_2, the curve does show when coupling of climate to the carbon cycle is included, as it was by the CCC, emission levels would have to reduce further to achieve a given stabilisation level of CO_2 concentrations. However, given that all the models in C4MIP and fig 10.21 are considered credible we believe the appropriate scientific approach is to include information from the full range of available models not just the results of a single (worst case) model. To that extent the Hadley SM curve on the graph is not, by itself, a good indication of the need to reduce emissions targets further than was indicated in the CCC simulations".* (Hadley letter to GCI 2009)

CCC Report

9. The CCC Report does not fully explain what account was taken of these earlier coupled modelling exercises in MAGICC 4, although the process is mentioned in the Technical Appendix::

10. *"Our analysis draws on a normal distribution of carbon cycle strength parameters fitted to the behaviour of a range of fully coupled climate-carbon cycle models29, and a lognormal distribution of ocean mixing rates fitted to the general circulation models employed by the IPCC's Third Assessment Report. We use the default MAGICC value for aerosol radiative forcing from a given unit of aerosol. A key uncertainty is the choice of climate sensitivity probability distribution. We have investigated this sensitivity using a range of different distributions available in the literature. Our investigation of this sensitivity led us to choose a distribution presented in Murphy et al. (2004)".* (Chapter 1 Technical Appendix, Page 16)

11. The Hadley Centre subsequently expanded on this in response to a question from GCI:

12. *"This parity between the eleven models* (C4MIP) *meant it was important, in the work carried out for the Committee on Climate Change, that the results from all C4MIP models were used to select the strength of interaction between the climate and carbon cycle. Several different future emissions scenarios were then run through a climate model (which has a treatment of the carbon cycle), in each case estimating uncertainty in temperature and greenhouse gas concentrations. The full uncertainty range was due in part to the range of climate-carbon cycle feedbacks characterised in C4MIP. For each emissions scenario an output from the simulations was a probability distribution showing how likely different amounts of 21st century warming will be. The Committee on Climate Change then selected the emissions scenario that showed a 50% chance of limiting warming to approximately 2C above pre-industrial levels at 2100, as well as reducing the risk of a 4C rise to very low levels".* (Hadley letter to GCI 2009)

13. Having ascribed credibility and parity to all eleven C4MIP models, CCC/Hadley used the results to select the strength of interaction between the climate and carbon cycle. The values selected and how they were selected are not mentioned in the letter or the CCC Report.

14. The CCC Report makes no attributed reference to the Hadley SM, Uvic EMIC and BERN 2.5CC EMIC joint exercise.

15. In written evidence to the EAC, DECC said:

16. *"We agree with the Committee that more work is needed to determine whether MAGICC (as well as other simple climate models) is able to reliably emulate the response of general circulation models to significant emissions reductions".*

17. *"Work being carried out under the DECC/Defra-funded 'AVOID' Programme will provide further insight into the sensitivity of climate outcomes to variations in both emissions pathways and climate model parameters".*

18. Since the CCC Report was produced, a new version of MAGICC/SCENGEN (version 5.3.v2) has been released replacing version 4.1. There have been many changes, mainly to SCENGEN. These changes have been made primarily for consistency with the Working Group 1 report of the IPCC Fourth Assessment (AR4).

Consistency with other modelling exercises:

The CCC Report claimed consistency of findings with other model analyses:

1. *"Other investigations into the emissions reduction required to limit the risk of exceeding 2°C have come to a range of broadly consistent conclusions. One recent study showed that peaking in 2010 to 2015 followed by a 3% reduction in fossil fuel CO_2 emissions would give a 25% to 75% probability range of exceeding 2°C (Meinshausen, 2006). Our results are in broad agreement but are at the less optimistic end of this range (63%), reflecting the fact that we have accounted for the observed higher growth of emissions up to peaking. In the supporting material for this report we show how, for the same level of emissions in 2050, more rapid emissions reduction prior to 2020 can reduce the probability of exceeding 2°C. Both our trajectories and those in the above study suggest that GHG concentrations will have to overshoot an acceptable long-term level and then fall before temperatures have reached equilibrium. Stronger action would be required if it is assumed that overshooting is not acceptable. For instance, another study shows that long-term stabilisation at 450ppm of CO_2 equivalent without overshooting (leaving a roughly 50% probability of exceeding 2°C) will require a 6.5% annual reduction in fossil fuel CO_2 emissions given current emissions growth (Anderson and Bows, 2008). Others have recommended an 80% global reduction by 2050 relative to 1990, in order to further reduce the risks of exceeding 2°C (Parry et al., 2008)".* (CCC Report, Page 25).

2. The Hadley Centre held a different view:

3. *"The Anderson and Bows simulations suggest that more rapid post peak reductions in emissions than that estimated by the Committee on Climate Change will be required to achieve similar temperature outcomes. We believe this is an artefact of their method, and that this method is not as suitable as that used by the Committee on Climate Change and Met Office Hadley Centre".* (Hadley written evidence to EAC)

4. *"The Parry et al. scenarios use a similar approach to the Committee on Climate Change work and give a consistent result".* (Hadley written evidence to EAC)

5. The range of broadly consistent conclusions claimed by the Committee appears to be unsubstantiated. Of the three cases mentioned, Anderson and Bows clearly recommend stronger action and the case of Martin Parry, Jean Palutikof, Clair Hanson and Jason Lowe, (June 2008), would seem to be in favour of an 80% global reduction by 2050. Source references are given in Section 6 below.

6. There was a presumption that overshooting would be acceptable in the recommended trajectory. As the CCC Report notes, stronger action would be required if it is assumed that overshooting is not acceptable. This was not considered when selecting reduction rates. A rate in excess of 4% would be required to avoid overshooting. The Hadley remark on Anderson and Bows also implies that overshooting is acceptable without question.
7. In September or October 2007, Hadley presented to Defra the results of a modelling exercise showing emissions for the three major greenhouse gasses (CO_2, CH_4 and N_2O) expressed as carbon equivalent emissions and the predicted temperature rise for these scenarios. Peak years selected were 2013 and 2036, with SRES A2 as the baseline. The equivalent carbon emissions were projected to reach zero by about 2060 for the first of these cases (see 6. References).

5. Conclusions

1. The CCC's UK emissions reduction targets and carbon budgets are founded on global targets that are insufficient to provide an acceptable level of security to remain within 2°C warming above pre-industrial levels.
2. This shortfall stems from inception of the CCC/Hadley project when cost of mitigation was allowed to prevail over risk of climate damages. No detailed terms of reference are published in the reports. However the role description for the CCC recognises first the requirement for an appropriate emissions path and secondly a test of political and economic feasibility. In practice, these were not carried out in sequence; nor did the "terms of reference" make this requirement clear. A rational approach would be to place the recommendation of a suitable range of emissions reduction paths ahead of the feasibility test. This would give the opportunity to develop a range of science–based paths, followed by an informed assessment of risk and cost. Failure to do this has resulted in a global target with significantly less than 50% probability of success whilst opening the door to short-term overshooting from the outset.
3. The Peak year choice of 2016 is dependent upon success at COP15 in Copenhagen; there is no fallback position in UK plans. It is unlikely that a necessary and sufficient agreement will be negotiated in December of this year, such that global emissions can start being reduced at the end of 2015.
4. Peak 2014 was discarded for 2016 with the latter having lower probability of success and higher absolute emissions. In a recent interview Chairman of the IPPC, Rajendra Pachauri, said that global emissions reduction must peak by 2015 latest. Modelling should guide the decision on latest Peak year. 2028 was modelled without justification and found to be too high risk. At the rates used, this should have been apparent from the outset.
5. Annual rates of emissions reduction were chosen by the CCC on broad economic and political grounds, driving trajectories to low levels of probability of success. Probabilities of all 9 trajectories give <50% success for the year 2100. The 2016 trajectories gave a success range of 20-44%. The 2014 trajectory, with a 49% success level, was excluded without reason being given. Presentation of the CCC preferred trajectory for targets and budgets as having a 50% probability of staying within 2°C is not consistent with the modelling results and is misleading. The range of trajectories selected was unsuitable; experience would suggest that it was unnecessary to model the lower end and that more demanding cases should have been included at the top end.
6. There is a danger that as perceived climate risk increases, targets are set with reduced rates of probability of success rather than applying faster emissions reduction rates. Overshooting also becomes an increasingly attractive short-term palliative.
7. It is highly improbable that any major venture, political, military or economic, would willingly be undertaken on the basis of a less than 50% probability of success. New options with greater investment and lower risk would be required. Meinshausen et al. (2005 and 2006) have suggested a probability level of 60% or greater. A reduction rate of 5-6% or more might be appropriate for that level of security.
8. Assessment of level of risk of not staying within 2°C increase should be part of the declared objectives of the exercise rather than a product of the chosen rates of annual emissions reduction. Trajectories should be targeted on possible levels of risk, for example 50%, 60% and 70% probability of success. Economic and political decisions can then be taken within a proper assessment of climate risk.

9. Incorrect claims for consistency of results with the work of others and difficulties of reconciling the results of different coupled modelling exercises results in increased uncertainty in the reliability of targets and budgets. In principle, a safety margin or contingency provision should be made to reduce risk. There is no safety margin with a 50% success forecast. Less than 50% is high risk and not in accord with the UNFCCC principle of precaution.
10. Claims that the MAGICC 4.1 exercise did include coupling between climate and the carbon cycle and took full account of the 'coupled' model research presented in the C4MIP study, the AR4 WG1 report and related research have not been demonstrated in the CCC Report. Since the report was published, MAGICC 4.1 has been superceded by version 5.2, with significant increase in feedback impact and changes to climate sensitivity values.
11. The IPCC AR4 WGI three climate-carbon cycle models (Hadley SM, Uvic EMIC and BERN 2.5CC) included the Hadley model showing global emissions falling to zero soon after 2050. Hadley explained that this result could not on its own be regarded as relevant to the CCC exercise since the other two models produced less stringent results. Such a multi model approach could possibly have led to different conclusions from those of the CCC/Hadley exercise.

6. References

1. Committee on Climate Change: "Building a low carbon economy" http://www.theccc.org.uk/pdf/TSO-ClimateChange.pdf
2. Technical Appendix Chapter 1

   http://www.theccc.org.uk/other_docs/Ch1%20technical%20appendix%20- %20projecting%20global%20emissions,%20concentrations%20and%20temperatures.pdf
3. Technical Appendix Spreadsheet http://www.theccc.org.uk/pdfs/Ch1%20spreadsheet%20-%20model%20emissions%20and%20climate%20data%20-%20final.xls
4. Technical Appendix to Chapter 2 http://www.theccc.org.uk/pdfs/Tech%20Appendix%20Final.pdf
5. MAGICC/SCENGEN http://www.cgd.ucar.edu/cas/wigley/magicc/index.html
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7. Meinshausen M., et al. (2006) Multi-gas emissions pathways to meet climate targets. Climatic Change, 75 (1-2), 151-194. http://www.springerlink.com/content/2185481704614445/fulltext.pdf
8. Anderson, K. & Bows, A. (2008) Reframing the climate change challenge in light of post-2000 emission trends. Phil. Trans. R. Soc. A, 366 (1882), 3863-3882. http://www.tyndall.ac.uk/publications/journal_papers/fulltext.pdf
9. Martin Parry, Jean Palutikof, Clair Hanson and Jason Lowe (2008): Squaring up to reality nature reports climate change Vol. 2 June 2008. http://www.nature.com/climate/2008/0806/pdf/climate.2008.50.pdf
10. DECC (CCC) written evidence to the EAC: http://www.publications.parliament.uk/pa/cm200809/cmselect/cmenvaud/memo/carbonbudgets/uccb0202.htm
11. GCI written evidence to the EAC: http://www.publications.parliament.uk/pa/cm200809/cmselect/cmenvaud/memo/carbonbudgets/uccb07.pdf
12. Hadley written evidence to the EAC: http://www.publications.parliament.uk/pa/cm200809/cmselect/cmenvaud/memo/carbonbudgets/uccb0802.htm

Appendix B - Correspondence with GCI during 2009

Dr Jason Lowe

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Direct tel: +44(0)118 378 5612

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Dear Mr Meyer,

Received 4th August 2009

Thank you for your enquiry of 13th July about the evidence the Met Office provided to the Environmental Audit Committee's inquiry into carbon budgets. Before addressing your questions directly, I thought it would be helpful to give some background on the work that has been carried out to understand the impact of feedback between the climate system and the carbon cycle – which as you understand is an extremely important and evolving area of current research.

The C4MIP project, summarised in Chapter 7 of the IPCC AR4 WG1 report, set out to understand the importance of coupling the carbon cycle to climate change and its impact on the evolution of atmospheric concentrations of CO2. Eleven models that explicitly represented the interaction between climate and the carbon cycle were used in the project.

Each model was driven by a single emissions scenario - SRES A2 – and was run twice, once with climate coupled to the carbon cycle and once without. Each model simulation produced an evolving estimate of the total atmospheric concentration of CO2. By comparing the coupled to the uncoupled simulations, it was possible to gain an indication of the importance of feedback between climate and the carbon cycle.

All of the models run in C4MIP demonstrated that coupling the climate to the carbon cycle is important and that by 2100 climate change leads to the biosphere being less able to absorb CO2. A key result from the study was the significant variation across the models in the size of this effect, demonstrating sizeable uncertainty in representing the climate-carbon cycle feedback. Although C4MIP found that the Hadley Centre model showed the strongest feedback effect, the other ten models are also credible and their results cannot therefore be ruled out.

This parity between the eleven models meant it was important, in the work carried out for the Committee on Climate Change, that the results from all C4MIP models were used to select the strength of interaction between the climate and carbon cycle. Several different future emissions scenarios were then run through a climate model (which has a treatment of the carbon cycle), in each case estimating uncertainty in temperature and greenhouse gas concentrations. The full uncertainty range was due in part to the range of climate-carbon cycle feedbacks characterised in C4MIP. For each emissions scenario an output from the simulations was a probability

distribution showing how likely different amounts of 21st century warming will be. The Committee on Climate Change then selected the emissions scenario that showed a 50% chance of limiting warming to approximately 2C above pre-industrial levels at 2100, as well as reducing the risk of a 4C rise to very low levels.

Before the simulations for the Committee on Climate Change, the Hadley Centre and two other modelling centres had already carried out studies specifically to evaluate the impact of climate change on carbon cycle feedbacks, and therefore the emissions required to reach atmospheric stabilisation at a number of concentration levels. These are shown in fig 10.21 in the IPCC AR4 WG1 report. Emissions pathways were based on CO2 only, unlike the more realistic Committee on Climate Change simulations which included aerosols and other Kyoto gases. Also relevant is that the Hadley SM simulations in fig 10.21 were constrained so that atmospheric CO2 followed a particular pathway to 450ppm. In the Committee on Climate Change simulations the atmospheric concentrations were not constrained in the same way. Instead the emphasis was placed on the pathway of global temperature rise.

It is important to recognise the limitation of the experiments reported in fig 10.21 – which were largely to gain an understanding of the nature of the coupling between climate and carbon cycle rather than to provide definitive guidance on emissions reduction targets.

The models used by the Committee on Climate Change (CCC) did include a coupling between climate and the carbon cycle and took full account of the 'coupled' model research presented in the AR4 WG1 report, the C4MIP study and related research.

To answer your specific questions directly:

Question One

As I pointed out in the written evidence from GCI that you said that you looked at, my reading of the figure from IPCC AR4 Chapter 10 [I have attached it to this message again as well] is that with 'coupling' introduced, the image in fact shows the extent of the need to reduce the full-term emissions contraction-event associated with a given reference curve for concentrations.

Can you confirm that that is your understanding please?

Response: The graph taken from fig 10.21 of the IPCC AR4 WG1 report shows the results of three models. The Hadley Centre curve shows a simple model set up to replicate the more complex Hadley Centre model used in C4MIP. The simple model was then used to study the emissions that lead to a stabilisation level for CO2 of 450ppm for a single pathway. For this particular pathway, and only considering CO2, the curve does show when coupling of climate to the carbon cycle is included, as it was by the CCC, emission levels would have to reduce further to achieve a given stabilisation level of CO2 concentrations. However, given that all the models in C4MIP and fig 10.21 are considered credible we believe the appropriate scientific approach is to include information from the full range of available models not just the results of a single (worst case) model. To that extent the Hadley SM curve on the graph is not, by itself, a good indication of the need reduce emissions targets further than was indicated in the CCC simulations.

Question Two

In the example graphic taken from the IPCC AR4 in what is tagged as the C4MIP 'Hadley SM' model with runs for 450 ppmv it shows very clearly that what in the IPCC image is called: -

[a] 'uncoupled' for 450 ppm requires a 50% cut in carbon emissions globally by 2050 and
[b] 'coupled' for 450 ppmv requires an 80% cut in carbon emissions globally by 2050.

Can you confirm that that is your understanding of this image please?

Response: As explained above, fig 10.21 does not show results from C4MIP. The Hadley SM result shows the output of a simple climate model set up to emulate the more complex Hadley Centre model used in C4MIP. Furthermore, using the results of a single mode for a pathway of a particular shape and only considering CO2 to make general conclusions about global emissions reduction targets for a single year, 2050, is not appropriate. It is also important when discussing percentage emission reductions by 2050 to state the year to which they are relative. The CCC expressed their recommendations for UK emissions relative to 1990.

Question Three

You went on to say, *"The precise values we use to work out the magnitude of the coupling comes from elsewhere in IPCC and from a study referred to as a C4MIP study, which to date is the most comprehensive analysis of that particular type of feedback onto the carbon cycle."*

The runs in question and highlighted in the attached graphic from the IPCC AR4 bear the tag 'Hadley SM',.

Can you as a member of the UKMO Hadley Centre please explain to me what 'elsewhere in the IPCC' refers to?

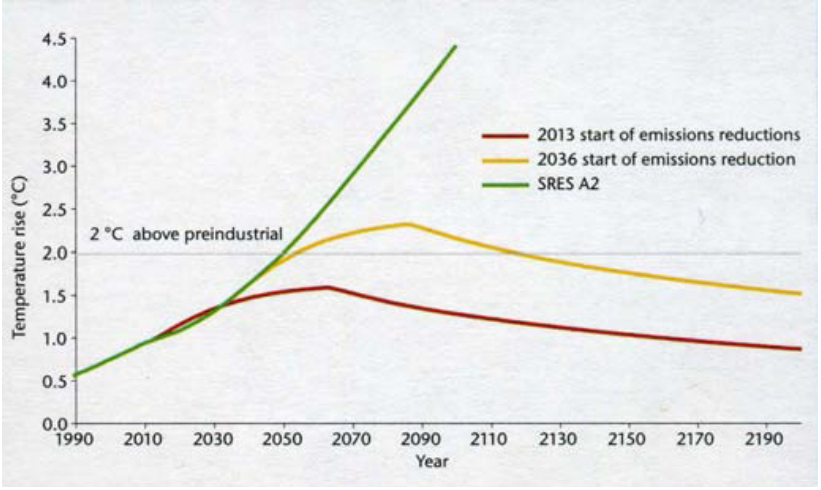
Response: Chapter 7 of the AR4 WG1 report summarises the results of the C4MIP project while table 7.4 presents the range of coupling factors for all 11 of the models used. C4MIP is mentioned extensively in section 10.4.1 of the IPCC AR4 WG1 report (the section from which you have taken fig 10.21).

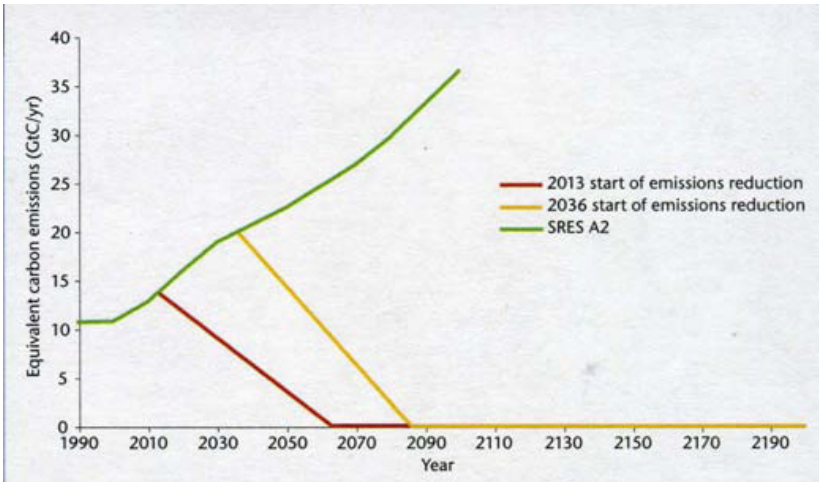
I hope this information is useful.

Yours sincerely

Dr. Jason Lowe
Head of Mitigation Advice

14 **Hadley presentation to Defra** (Sept –Oct 2007)





The emissions for the three major greenhouse gases (CO_2, CH_4 and N_2O) expressed as carbon equivalent emissions (upper panel) and the predicted temperature rise for these scenarios.

GLOBAL COMMONS INSTITUTE

21st May 2009

Joan Ruddock MP
Parliamentary Undersecretary of State,
Department of Energy and Climate Change
3 Whitehall Place
London SW1A 2HD

Dear Ms Ruddock

Contraction and Convergence

As you and your colleagues have acknowledged, with COP-15 now only months away, this is a critical year for climate change politics globally. We are really running out of time: -

1. to avoid exceeding the Government's stated aim of an overall two degree Celsius temperature rise globally and therefore
2. the truly horrifying prospect of runaway rates of climate change.

So I continue to be perplexed by your now routine dismissal of Contraction and Convergence with remarks hinging on whether it is fair or not.

In the European Committee A 12 May 09] you said to Colin Challen MP: -

> *"As always when I hear him speak, my hon. Friend referred to his favourite subject of contraction and convergence. He knows that many people are sympathetic to the idea that fairness should come out of a contraction and convergence process."*

The primary issue with C&C is Contraction and Concentrations.

With runaway rates of climate change the real danger that threatens is going beyond another degree Celsius temperature rise where this may well become unstoppable. So the question is this: - is the global 'contraction' rate sufficient to keep within two degrees and achieve the objective of the UNFCCC? [See enclosure].

Convergence is only relevant if the right rate of Contraction is engaged.

Rationality dictates that only when 'convergence' is understood as a function of the right rate of contraction, is 'fairness' - whatever that is? - relevant.

In its absence, remarks about 'fairness' are irrelevant and misleading and make me question the reliability of your sources of information.

You went on to say: -

> *"In the Council conclusions of 2008, the EU suggested that it should be possible to move to 2 tonnes per capita by 2050. However, I am sorry to tell him that that model is not acceptable to other countries. I am sure that he knows that. I say to him again that when we are trying to get a global agreement, we must work with the grain and go where we think the compromise can be struck. Although his suggestion might be the ideal method and the world might come round to it, it cannot be built in at this point in negotiations on getting to 2020, and certainly not by the EU."*

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This formulation appears to be based on what Lord Nicholas Stern incautiously propagated two years ago as his 'simple arithmetic' of climate change, a position which he himself has now conspicuously disowned [see enclosure].

So, for all this, I do enclose a copy of a GCI document. It is evidence to a current enquiry by the UK House of Commons Environmental Audit Committee [EAC] into the subject of *'carbon-budgets'* in the UK Climate Act asking, *'where did they come from ánd were the models on which they were based up to date?'*

This evidence shows the real arithmetic of Contraction and Convergence and why Lord Stern needed to disown the simple arithmetic of his that you quote and it leads to these simple questions from me to you: -

1. who advises you and which 'Council' are you referring to
2. why do you refute all the support in Europe for C&C e.g. Merkel [see enclosure]
3. when you and the other nameless parties you quote as finding 'the model' un-acceptable, did you mean Stern's model of simple arithmetic, or C&C per se?

Please, before you answer, do take account of the evidence enclosed. It gives factual information about C&C and rational rates of its application in the light of feedbacks as published in IPCC AR4. While you do, please note that Lord Adair Turner has: -

1. already confirmed to EAC that the carbon-budgets in the UK Climate Act came from Contraction and Convergence and that;
2. now, taking account of the revised position on urgency of Lord Stern's and others, further agreed with the Committee on Energy and Climate Change, that if the rate of contraction must be accelerated for reasons of urgency, the rate of convergence must be accelerated *relative to that* for reasons of equity.

C&C is a *methodology* that shows how that is done rationally. This supports and works with the grain of the climate negotiations within the scientifically defined limits that constrain us all. That is why C&C is now very widely cited and supported around the world, but it seems that you and your colleagues at DECC are unaware of this.

It seems that with nearly twenty years of a random and failed approach and time now running out, you continue with an opaque party line from DEFRA that ignores the C&C methodology and that we cannot continue to cause this problem faster than we act to avoid it with impunity.

More bureaucratic answers avoiding this, based on a 'faux' consensus of the lowest common denominator, inspire no confidence. Globally rational C&C-based arguments to the climate negotiations that consciously demonstrate we are acting in concert to stop this problem faster than we cause it, will inspire confidence. These will answer growing public axieties about the death-trap into which we move without them.

With kind regards

Aubrey Meyer

GCI

cc Greg Clark MP, Colin Challen MP, Tim Yeo MP, Martin Caton MP, Joan Walley MP, Robin Stott MD, Prof Ross Garnaut ANU, Sunand Prasad RIBA, Nicholas Stern, Adair Turner, Bill McGuire UCL, Andrew Dlugolecki CII, Tony McMichael WHO, Mike Hutchinson Tangent Films Julian Rush ITN; Nik Gowing BBC TV - full list on request.

GLOBAL COMMONS INSTITUTE

30th May, 2009

Joan Ruddock MP
Parliamentary Undersecretary of State,
Department of Energy and Climate Change
3 Whitehall Place
London SW1A 2HD

Dear Ms Ruddock

Contraction and Convergence

No acknowledgement of receipt of the letter I sent to you on the 21st of May has been received, let alone a reply.

Furthermore, my attempts yesterday to establish with DEC/DEFRA and your Parliamentary Office whether the letter had been received by you or not, proved - over some hours - completely unsuccessful. [Your parliamentary office assistant Jessica turned out to be the only person during this process, who was at least polite and helpful].

So I am sending the orginal letter and its enclosure to you again recorded delivery and I am asking you **please to acknowledge receipt of this**.

You can probably detect that I am more than a little irritated by this state of affairs and I certainly am. Since writing to you, it has further come to my attention that your colleague Mr Jos Delbeke, Deputy Director General of the Environment Directorate in the European Commission has also been publicly making ridiculous, untruthful and misleading assertions about contraction and convergence: -

> *"It's an extreme interpretation of fairness. It means tremendous transfer of resources - billions and billions a year from the West - and I'm not sure that's on the cards in the current economic climate."*

and I have written to him about this [enclosed copy].

After the inaccurate report around C&C related issues commissioned by DEFRA from EcoFys [2006 and quoted in the CCC report to Parliament] this seems to me to be a yet further indication of the kind of now routinely iterative nonsense about C&C that has been created over the years by you and your EC/DEFRA/DECC colleagues. That this represents a squandering of the small political capital we all have left in this matter, is extraordinary and unforgivable and a cause for shame amongst yourselves.

Once again I am copying this letter around and I now give you an assurance that - after twenty years of making a rational, sustained and not unsuccessful effort to articulate and advocate C&C - I will continue to press this matter upon you until I am satisfied that an honest and measured response to my questions has been provided.

With kind regards
Yours sincerely

Aubrey Meyer

GCI

cc Greg Clark MP, Colin Challen MP, Tim Yeo MP, Martin Caton MP, Joan Walley MP, Robin Stott MD, Prof Ross Garnaut ANU, Sunand Prasad RIBA, Nicholas Stern, Adair Turner, Bill McGuire UCL, Andrew Dlugolecki CII, Tony McMichael WHO, Mike Hutchinson Tangent Films Julian Rush ITN; Nik Gowing BBC TV - full list on request.

Table 5.1. Characteristics of post-TAR stabilisation scenarios and resulting long-term equilibrium global average temperature and the sea level rise component from thermal expansion only.[a] (WGI 10.7; WGII Table TS.2, Table 3.10, Table SPM.5)

Category	CO_2 concentration at stabilisation (2005 = 379 ppm)[b]	CO_2-equivalent concentration at stabilisation including GHGs and aerosols (2005=375 ppm)[b]	Peaking year for CO_2 emissions[a,c]	Change in global CO_2 emissions in 2050 (percent of 2000 emissions)[a,c]	Global average temperature increase above pre-industrial at equilibrium, using 'best estimate' climate sensitivity[d,e]	Global average sea level rise above pre-industrial at equilibrium from thermal expansion only[f]	Number of assessed scenarios
	ppm	ppm	year	percent	°C	metres	
I	350 – 400	445 – 490	2000 – 2015	-85 to -50	2.0 – 2.4	0.4 – 1.4	6
II	400 – 440	490 – 535	2000 – 2020	-60 to -30	2.4 – 2.8	0.5 – 1.7	18
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IV	485 – 570	590 – 710	2020 – 2060	+10 to +60	3.2 – 4.0	0.6 – 2.4	118
V	570 – 660	710 – 855	2050 – 2080	+25 to +85	4.0 – 4.9	0.8 – 2.9	9
VI	660 – 790	855 – 1130	2060 – 2090	+90 to +140	4.9 – 6.1	1.0 – 3.7	5

Notes:
a) The emission reductions to meet a particular stabilisation level reported in the mitigation studies assessed here might be underestimated due to missing carbon cycle feedbacks (see also Topic 2.3).
b) Atmospheric CO_2 concentrations were 379ppm in 2005. The best estimate of total CO_2-eq concentration in 2005 for all long-lived GHGs is about 455ppm, while the corresponding value including the net effect of all anthropogenic forcing agents is 375ppm CO_2-eq.
c) Ranges correspond to the 15th to 85th percentile of the post-TAR scenario distribution. CO_2 emissions are shown so multi-gas scenarios can be compared with CO_2-only scenarios (see Figure 2.1).
d) The best estimate of climate sensitivity is 3°C.
e) Note that global average temperature at equilibrium is different from expected global average temperature at the time of stabilisation of GHG concentrations due to the inertia of the climate system. For the majority of scenarios assessed, stabilisation of GHG concentrations occurs between 2100 and 2150 (see also Footnote 30).
f) Equilibrium sea level rise is for the contribution from ocean thermal expansion only and does not reach equilibrium for at least many centuries. These values have been estimated using relatively simple climate models (one low-resolution AOGCM and several EMICs based on the best estimate of 3°C climate sensitivity) and do not include contributions from melting ice sheets, glaciers and ice caps. Long-term thermal expansion is projected to result in 0.2 to 0.6m per degree Celsius of global average warming above pre-industrial. (AOGCM refers to Atmosphere-Ocean General Circulation Model and EMICs to Earth System Models of Intermediate Complexity.)

1. While Please observe this is note [a] on the table 5.1: -
2. "The emission reduction to meet a particular stabilisation level reported in the mitigation studies assessed here might be underestimated due to missing carbon cycle feedbacks [see Topic 2.3]"
3. This is section 2.3 - Climate sensitivity and feedbacks
4. *"The equilibrium sensitivity is a measure of the climate system response to sustained radiative forcing. It is defined as the equilibrium global average surface warming following a doubling of CO_2 concentration. Progress since the TAR enables an assessment that climate sensitivity is likely to be in the range of 2 to 4.5 C with a best estimate of about 3 C, and it is very unlikely to be less than 1.5 C. Values higher than 4.5 C cannot be excluded but agreement of models with observations is not as good for those values. [WG1 8.6 9.6 Box 10.2 SPM]. Feedbacks can amplify or dampen the response to a given forcing. Direct emissions of water vapour [a greenhouse gas] by human activities make a negligible contribution to radiative forcing. However, as global temperature increases, tropospheric water vapour concentrations increase and this represents a key positive feedback but not a forcing of climate change. Water vapour changes represent the largest feedback affecting climate equilibrium sensitivity and are now better understood than in the TAR. Cloud feedbacks remain the largest source of uncertainty. Spatial patters of climate response are largely controlled by climate processes and feedbacks. For example, sea-ice albedo feedbacks tend to enhance the high latitude response. [WG1, 2.8 8.6 9.2 TS 2.1.3 TS 2.5 SPM].Warming reduces terrestrial and ocean uptake of atmospheric CO_2 increasing the fraction of anthropogenic emissions remaining in the atmosphere. This positive carbon cycle feedback leads to larger atmospheric CO_2 increases and greater climate change for a given emissions scenario, but the strength of this feedback varies markedly among models. [WG1 7.3 TW 5.4 SPM WG2 4.4.]."*
5. This is in AR4 Chapter 10 where carbon cycle feedbacks are discussed and calculated [as per GCI memo to EAC]
6. "There is unanimous agreement among the coupled climate carbon cycle models driven by emission scenarios run so far that future climate change would reduce the efficiency of the Earth system (land and ocean) to absorb anthropogenic CO_2. There is evidence that the CO_2 airborne fraction is increasing, so accelerating the rate of climate change."

DEPARTMENT OF ENERGY & CLIMATE CHANGE

Joan Ruddock MP
Minister of State
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Our ref: 136256/JW

Aubrey Meyer
Global Commons Institute
37 Ravenswood Road
London
E17 9LY

15 June 2009

Dear Mr Meyer,

Thank you for your letter dated 21 May enclosing a copy of a document submitted to the Environmental Audit Committee Enquiry about the Contraction and Convergence proposal that you and the Global Commons Institute have developed.

I agree entirely about the critical importance of this year for climate change politics globally. The Government is working closely with EU partners and other countries to secure a comprehensive, fair and robust global climate deal at the UNFCCC meeting in Copenhagen in December. We are seeking an ambitious agreement that includes a clear long term vision for global emissions reductions; comparable mid-term targets for developed countries; adequate contributions by developing countries according to their responsibilities and respective capabilities; and international architecture and mechanisms adequate to the task of meeting our mitigation objectives in the most cost effective manner.

The Contraction and Convergence proposal is to some extent compatible with this approach and, as you are aware, there are many people who regard your methodology as both effective and fair, given its focus on equal per capita emissions rights. However, there are also others who may not consider this to be such an equitable approach, as it does not take into account many factors relating to specific national circumstances.

Countries are strongly protective of their right to act in accordance with their own self-determined national circumstances and respective capabilities. For that reason methodologies with a focus on one particular indicator – such as per capita emissions – are encountering strong resistance. Furthermore, at this stage of the international negotiations, many countries are resisting any approach that would bind them to a rigid emissions reduction pathway determined in accordance with the rules of a particular methodology such as yours.

Given that we are trying to achieve a truly comprehensive agreement in Copenhagen, it remains the case that it would not be appropriate for the UK or EU

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to seek to promote Contraction and Convergence at this stage – or indeed any other framework proposal of this type. Nevertheless, Contraction and Convergence will continue to represent a stimulating contribution to the wider global debate about how we can reach an effective long term stabilisation goal, and of course I would not in any way wish to dissuade you and the Global Commons Institute from continuing to promote and develop your methodology.

With regard to your query about the Council conclusions I referred to at the European Committee on 12 May, the findings of the European Union Environment Council can we viewed on the following website:

http://register.consilium.europa.eu/pdf/en/09/st07/st07128.en09.pdf

You may also be interested in a presentation that was given by a representative of the South Centre, an intergovernmental policy think tank of developing countries, at the UNFCCC intersessional meeting in Bonn on 5 June. The presentation includes a discussion of the per capita emissions approach, and can be viewed on the following website:

http://www.southcentre.org

With best wishes,

JOAN RUDDOCK

18th June, 2009

Joan Ruddock MP
Parliamentary Undersecretary of State,
Department of Energy and Climate Change
3 Whitehall Place
London SW1A 2HD

Dear Ms Ruddock

Contraction and Convergence

Thank you for your letter of the 15th of June replying to mine of the 21st of May. You acknowledged receipt of the enclosure, GCI's evidence to the Environmental Audit Committee [EAC].

I do not understand why therefore, you entirely ignored its contents to do with the issue of positive feedback effects as presented in IPCC AR4. This was the core of GCI's evidence given to EAC. In avoiding this you fail to take the point of letter which said: -

The primary issue with C&C is Contraction:Concentrations.

> *"With runaway rates of climate change the real danger that threatens is going beyond another degree Celsius temperature rise where this may well become unstoppable. So the question is this: -* ***what global 'contraction' rate sufficient to keep within two degrees and achieve the objective of the UNFCCC?"***

The adjusted quantification of contraction:concentration profiles in the light of these, was published in the AR4 [Chapter 10 WG1] in 2007. The coupled-model runs from the Hadley Centre show each 'coupled' [i.e. with 'feedbacks'] contraction-event has to be shrunk by ~40% to achieve the atmosphere concentration in ppmv against those that have routinely been published as 'uncoupled' [i.e. without 'feedbacks'] by IPCC four times in a row in the four reports since 1994. Remarks in the IPCC AR-4 Summary for Policy Makers [overleaf] that these omitted feedback effects are positive are unambiguous.

This is a major change in the IPCC's assessment of the extent of the global emissions contraction that is needed to meet the most significant policy challenge in history - namely how to avoid runaway rates of climate change - yet you are ignoring it; why?

Please will you explain how you DECC, DEFRA and the EU do intend to take account of this, in the UK Climate Act and at the UNFCCC? Also, what global temperature average does the Government's announcement that we in the UK must be prepared to adapt to temperature rises of 4 degrees in the UK, imply? I fear that it implies that we soon will have failed to avoid runaway climate change and this fills me with dread as we cannot conceivably 'adapt' to this.

Avoiding these issues and making the wrong arguments about 'Contraction & Convergence' leads to the 'resistance' to it that you mention. The right argument represents its rationale - that we must collectively organize to live within the limit that saves us from runaway climate change. The international emissions shares must add up to a global whole no greater than the limit whereby we must solve this problem faster than we are creating it. The opposite continues to be true.

What I am asking you for is reassurance that you and the Government understand this in relation to the C&C rationale and the consequent need to reframe and restructure the 'political' debate at the UNFCCC in the light of it. Please will you provide this? Your answers so far do not.

In the recent words of Jim Hansen, *"The greatest danger is continued ignorance and denial which could make tragic consequences unavoidable."*

Yours sincerely

Aubrey Meyer

cc Greg Clark MP, Colin Challen MP, Tim Yeo MP, Martin Caton MP, Joan Walley MP, Robin Stott MD, Prof Ross Garnaut ANU, Sunand Prasad RIBA, Nicholas Stern, Adair Turner, Bill McGuire UCL, Andrew Dlugolecki CII, Tony McMichael WHO, Mike Hutchinson Tangent Films Julian Rush ITN; Nik Gowing BBC TV - full list on request.

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DEPARTMENT OF ENERGY & CLIMATE CHANGE

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Aubrey Meyer
Global Commons Institute
37 Ravenswood Road
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17. September 2009

Dear Mr Meyer,

Thank you for your follow-up letter dated 18th June 2009 and also for your letter to Ed Miliband MP of 13th July 2009 on your concerns about the Committee on Climate Change's analysis, which I am also responding to on his behalf. I apologise for the time it has taken to reply.

The main concern you raise is the possibility that the Committee on Climate Change (CCC) might not have included coupled carbon-climate feedbacks in their analysis, thereby invalidating the scientific basis for the UK target of 50% cuts in global emissions of CO_2 by 2050.

As detailed both in the oral evidence of Dr Jason Lowe to the Environmental Audit Committee (23rd June 2009) and the CCC's report (Building a Low-Carbon Economy – The UK's Contribution to Tackling Climate Change, Chapter 1 Technical Appendix, Section 3.1 Modelling Methods), the CCC did indeed take account of carbon cycle feedbacks in its analysis. As such the effects of carbon cycle feedbacks on the climate are already included in the scientific evidence on which we have based our policies. Therefore, they already inform our engagement with the UNFCCC and EU on emissions targets.

I hope I can clarify this further in my explanation below.

The importance of the inclusion of carbon-cycle feedbacks is highlighted in the Working Group I contribution to the IPCC Fourth Assessment Report, Figure 10.21, p791, and we therefore appreciate your concerns that this is an important feedback process to include.

This IPCC figure does not tell the full story however, and cannot be used to deduce the actual global emissions cuts required. This is because the models depicted have not included the effects of aerosols or the non-CO_2 greenhouse gases, and none of the uncertainties in the carbon-cycle feedback have been accounted for. (This is explained in the accompanying text on p790.)

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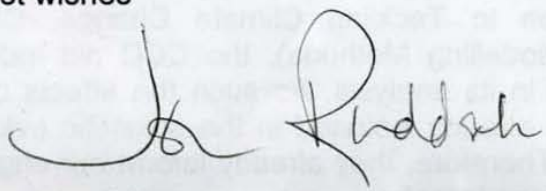
In order to account for the full range of factors known to affect the climate system, the CCC have based their analysis on results from a series of simulations using the MAGICC[1] model, which provides estimates of the global mean temperature at the surface and its uncertainty for a given emissions scenario. This model takes account of all known climate feedback processes (as determined from the more sophisticated general circulation models), including the carbon cycle. The modelling has also taken account of uncertainties relating to the climate system, including uncertainty in the strength of the carbon cycle feedback. The latter has been based on the results of the C4MIP[2] project, which to date is the most comprehensive study of the carbon-cycle feedback process.

It should also be noted in relation to this that the quote from Dr Jason Lowe in evidence to the Environmental Audit Committee that you include in your letter has unfortunately been taken out of context. If you will refer back to the transcript of the hearing[3] you will see that he was not in fact referring to Figure 10.21 on page 791 of working group 1 of AR4, as you indicate, but to the source of the estimates of the carbon cycle feedback used in the CCC analysis.

Finally, I fully agree with Lord Turner that it is hard to imagine a future long term emissions path which is not in some sense related to contraction and convergence of emissions. The UK will continue to push for a 50% reduction in global emissions by 2050. The best available science evidence suggests this will give us an approximately even chance of keeping global mean temperature increase to below 2°C.

With best wishes



JOAN RUDDOCK

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[1] 'Model for the Assessment of Greenhouse-gas Induced Climate Change' (http://www.cgd.ucar.edu/cas/wigley/magicc/)

[2] Friedlingstein, P., et al (2006) Climate-carbon cycle feedback analysis: results from the C4MIP model intercomparison. Journal of Climate, 19, 3337-33353

[3] http://www.publications.parliament.uk/pa/cm200809/cmselect/cmenvaud/uc616-ii/uc61602.htm Question 131

29th September, 2009

Joan Ruddock MP
Parliamentary Undersecretary of State,
Department of Energy and Climate Change
3 Whitehall Place
London SW1A 2HD

Dear Ms Ruddock

Thank you for your letter of the 17th of September.

I reassure you that I am very happy to acknowledge that DECC and its members including yourself, under Ed Milliband's leadership, have been making a serious effort to take Climate Change to the front-line and argue the case for an effective global deal.

This is much appreciated by people in and beyond the GCI community.

However, the letter you sent me reflecting the views of the UK modelling community which you kindly passed on to me does not contain good evidence to support the views you represent.

The arguments so-far about 'coupled models' have been completely overtaken by the trend data for CO2 emissions:concentrations in the CCC technical annexes. These clearly show that, contrary to the repeated claims by people who've been involved in this to the effect that all the feedback concerns over the carbon-cycle and the failing strength of the sink function have been dealt with in the CCC work, the opposite is true: - CCC published trend data for CO2 emissions:concentrations in the CCC's technical annexes show the complete opposite, namely that the sink function is increasing dramatically - see image overleaf. It is faithfully produced from the CCC preferred case for 50:50 odds on avoiding more that a 2 degrees Celsius rise in global temperature.

I re-iterate that it is in AR4 Chapter 10 where carbon cycle feedbacks are discussed and calculated [as per GCI memo to EAC]: - *"There is unanimous agreement among the coupled climate carbon cycle models driven by emission scenarios run so far that* ***future climate change would reduce the efficiency of the Earth system (land and ocean) to absorb anthropogenic CO2. There is evidence that the CO2 airborne fraction is increasing, so accelerating the rate of climate change.*****"**

I do not want DECC's efforts to be frustrated, to go unrewarded or indeed to be ridiculed because of the extent to which on this substantive matter, you are being misled.

However, as things stand, I am certain that you being misled and that the consequences of this matter being systematically avoided for nearly a year will be deeply counterproductive unless this matter is sorted out immediately.

The ending of the EAC enquiry provides an opportunity to do this.

I hope you agree and that you confirm this please.

With kind regards

Aubrey Meyer
Please note address change
GCI
57 Howard Road
LONDON E17 4SH
Ph 0208 520 4742

From: “ccu.correspondence@defra.gsi.gov.uk”
To: aubrey.meyer@btinternet.com
Sent: Tuesday, 20 October, 2009 4:52:33 PM
Subject: Response to your Query : - Ref:DWOE000153070 - Climate change science

Dear Aubrey,

Thank you for your letter of 29 September in response to Joan Ruddock?s letter of 17 September. I have been asked to reply on her behalf.

This Department fully appreciates your concern about ensuring that projected changes in the behaviour of carbon sinks are taken into account when establishing an appropriate emissions target for the UK. As you correctly realise, potential feedbacks arising from possible changes in the properties of these sinks are of crucial importance in assessing the severity of future climate change. Therefore, as you may recall, in her recent letter the Minister assured you that the carbon-cycle feedback was included in the Committee on Climate Change?s (CCC?s) analysis.

We undertake independent research to ensure the validity of the CCC?s work, and have found close agreement with their findings, in which carbon feedbacks were included. As you are undoubtedly aware, the Earth?s climate is a very complex system, and it is therefore difficult to unravel the precise details of each feedback from the overall outcome. From your enclosed plot it is not evident that this has been taken into account when arriving at your conclusion regarding the carbon cycle simulation in the models used by the CCC. This is perhaps why your conclusion is at odds with the CCC.

You will of course appreciate that we need to base our decisions on advice from scientific experts in the field of climate change. We maintain regular contact with a number of these scientists from a range of internationally respected organisations.

In closing, on behalf of DECC , I welcome your interest and motivation to ensure transparency in the process leading to important decisions concerning our planet and also for the valuable contributions you have made in the past to the climate change debate.

Yours sincerely,

Hilary Cartwright-Taylor
Customer Contact Unit
Department for Environment, Food and Rural Affairs (Defra)

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Dear Hilary

Thank you for your note.

You appear to have misunderstood the material sent to Ms Ruddock by GCI: - our conclusion is not at odds - as-you-put-it - with the CCC. You may not be aware that, on the contrary, the Hadley Centre have now confirmed that the GCI source-sink plot sent correctly lays out exactly what they/CCC presented. The success odds are the issue.

Apart from that that thank you for your appreciative remarks.

Yours sincerely

Aubrey Meyer
GCI
57 Howard Road
LONDON E17 4SH
Ph 0208 520 4742
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GLOBAL COMMONS INSTITUTE

1st May 2009

Lord Adair Turner
Chairman
The Independent Climate Change Committee
c/o The Financial Services Authority
25 The North Colonnade
Canary Wharf
London E14 5HS

Dear Lord Turner,

It is as the Chairman of the Independent UK Climate Change Committee that I write to you. Not being able to find an address for that committee I have written care of the address above.

Sparked by your evidence to the UK House of Commons Environmental Audit Committee [EAC] on the 4th of February, EAC have initiated an enquiry into the subject of *'carbon-budgets'* in the UK Climate Act and asks *'where did they come from?'* *

I read how you became involved in an exchange with EAC members on the subject of Contraction and Convergence saying that the Act was pretty strong support for what I have been saying.

As that may or may not be the case, I have taken the liberty of enclosing a copy of a GCI document that contains evidence to that enquiry as it is some indication of what I actually have been saying for most of the last twenty years.

This may be helpful to the committee, so I thought in the circumstances it might be helpful to you too. I hope so.

With kind regards

Aubrey Meyer
GCI

GLOBAL COMMONS INSTITUTE

29th May 2009

Lord Adair Turner
Chairman
The Independent Climate Change Committee
4th Floor, Manning House,
22 Carlisle Place,
London,
SW1P 1JA

Dear Lord Turner,

A month ago I wrote to you in your role as the Chairman of the Independent UK Climate Change Committee. Initially unable to find an address for that committee, I did send it care of the FSA address. Not having had a reply and now having found the address above, I am sending you this letter again and I would grateful to you it you would kindly acknowledge receipt of this and respond to the points raised.

Sparked by your evidence to the UK House of Commons Environmental Audit Committee [EAC] on the 4th of February, EAC have initiated an enquiry into the subject of *'carbon-budgets'* in the UK Climate Act and asks *'where did they come from?'*

I read how you were involved in an exchange with EAC members on the subject of Contraction and Convergence saying that the Act was pretty strong support for what I have been saying. As that may or may not be the case, I have taken the liberty of enclosing a copy of a GCI document that contains evidence to that EAC enquiry as it is some indication of what I actually have been saying for most of the last twenty years, as distinct from the often somewhat random constructions that have been put upon what I have actually been saying.

This may be helpful to the EAC and I thought in the circumstances it might be helpful to you and yours too. I hope so. Please let me know.

Since I am rewriting this letter now I wish also to ask you about this. Your evidence about the Act to the EAC included the remark, *"We did not call it Contract and Converge. Apart from anything else, for some reason which I do not quite understand, this has ended up in a slightly emotive sense and it also gets interpreted in particular ways."*

I am unable to explain these remarks. So it would helpful to me to know if you can explain what [especially the underlined] words mean. Many confused and misleading statements and even straight disinformation about C&C come from the mouths of various [including eminent] parties still at this time. This is true for example in the UK Parliament and the European Commission, as the enclosed letters to Ms Ruddock and Mr Delbeke indicate. Perhaps you can help sort this out? I hope so.

With kind regards

Yours sincerely

Aubrey Meyer
GCI

Committee on Climate Change

From the Chairman
Lord Turner

4th Floor
Manning House
Carlisle Place
London SW1P 1JA

Mr Aubrey Meyer
Global Commons Institute
37 Ravenswood Road
London E17 9LY

16th June 2009

Dear Mr Meyer,

Thank you for your letter of May 29th and the earlier letter for which I apologise that you did not receive a reply.

My own feeling, and that of the Committee, which is described in Chapter 1 of the Committee's first report, is that:

- The world should aim for a reduction of emissions to something like 20-24 gigatonnes by 2050, and further reductions beyond. Obviously, there can be different points of view on whether this is enough. But it is certainly a "contraction" of the total level of emissions.
- In terms of the appropriate distribution of effort between different countries, we then said that:
  - There are a wide variety of different methodologies proposed for dividing reduction responsibility between different countries, and indeed for dealing with developing countries which are likely to first increase emissions and then subsequently reduce them, and it is not for the Committee (which is not directly involved with international negotiations) to propose a particular one.

- However, we note that if there are 9 to 9.5 billion people in the world in 2050, 20-24 gigatonnes implies something like 2.2 to 2.4 tonnes per capita.

- And that unless we can specify which countries are going to be happy to stay permanently below 2.2 – 2.4 tonnes per capita, there cannot be countries significantly above.

- Therefore, it is difficult to imagine a global deal which, whatever its precise details, doesn't entail something like a roughly equal per capita right to emit at some time in the future. And it is difficult to imagine that anything radically different from this should be seen as fair.

- Therefore it is reasonable for the UK to set its national strategies round a target of about 2.2 – 2.4 tonnes per capita. And since (turning to issues which are within the direct remit of the Committee) we are confident that the UK can achieve this level at a relatively small cost to GDP (1% to 3%), therefore we recommend unilaterally setting this target, accepting that at a later date in the face of new scientific evidence and the results of international negotiations, we might shift to a more stretching target.

This was our logic. We did not explicitly describe it as "contract and converge", but I think within the normal use of the words, it could be described as that, since it involves "contraction" (a fall in the total global emissions) and "convergence", a long-term tendency towards a roughly equal per capita level as both a practical and an ethical principle.

Therefore, when people ask us "do you agree with "contract and converge"", I say that while we didn't explicitly use that term, that is actually a fair description of the approach we have actually recommended. And as it happens, I think "contract and converge" is a very good phrase, and one I am entirely comfortable in endorsing.

But, whether or not this is justified, I am often told by people who are more involved in the international negotiations, that the term "contract and converge"

Committee on Climate Change

is a bit of a red rag to a bull in many American circles. That is what I was referring to when I said rather ungrammatically, "this has ended up in a highly emotive sense" (i.e., the emotion to which I refer is the emotion of opponents, not proponents) I am clear that the long-run approach has to be something like "contract and converge" (in the sense of the Committee's recommendations); but if there is a sensitivity about using the term, and negotiators think that they are more likely to make progress by using a different one, I am happy for them to downplay the words, while pursuing the substance.

I hope that explains our position and that our approach appears sensible to you. May I say, in conclusion, that I have always had great admiration for the role you have played in proposing the broad principle that "convergence" of per capita emissions will in the long-term be reached.

Yours sincerely,

Adair Turner

Met Office

Dr Jason Lowe
Head of Mitigation Advice
Direct tel: +44(0)118 378 5612
Direct fax: +44(0)118 3785615
Email: jason.lowe@metoffice.gov.uk

16/10/09

Dear Mr Meyer,

Thank you for your letter dated 2nd October 2009 and your subsequent phone call of the 14th October about the "sink" of atmospheric carbon dioxide and how our understanding of it relates to the 2016_4%_low scenario featured in the Committee on Climate Change's reports.

Following my e-mail request for clarification on how you had calculated the returned and retained emission fractions, you stated:

" What I have done for all years, is: -
convert given CO2 concentration data [in ppmv] to weight in GTC [1ppmv CO2 = ~2.13 GTC] [10%-ile, median & 90%-ile]
1. with these then subtract one year from the next to get weight-change in 'concentrations' year on year
2. made CCC given-emissions minus weight change for 'returned fraction' &
3. made CCC given-emissions 'returned fraction' for 'fraction retained' [the ones shown in the graphic sent to you] "

You also clarified your definition of the term sink efficiency, such that:
"sinks=sources - 100% efficient
sinks<sources - less than 100% efficient
sinks>sources - more than 100% efficient"

I have discussed the points raised in your letter with my colleague, Chris Jones, and the following comments express our collective view.

Your calculation method for the strength of the sink seems reasonable, although I have not yet double checked the exact numbers on the plot you supplied.

The central point of your letter appears to be that in the 2016_4%_low scenario the atmospheric CO2 concentration is seen to decrease in the 10th percentile and median curves (although not in the 90th percentile) despite still having anthropogenic emissions greater than zero (i.e. the instantaneous sink efficiency by your definition exceeds 100%). Our work using simple climate models suggests this is a physically reasonable behaviour for some plausible values of the model parameters we use in MAGICC to represent the uncertainty in scientific understanding. When emissions reduce we expect the sink strength to persist for some time and so the instantaneous

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sink efficiency can exceed 100%. You correctly note that many studies (including our own research) conclude that the climate feedback on the carbon cycle will increase the airborne fraction (and so decrease sink efficiency) – so we would expect the efficiency to be higher still in the absence of a climate feedback.

We also note your definition of sink efficiency but suggest it might be more appropriate to define this in terms of the cumulative emissions and the cumulative fraction taken up by the sink. This is because the size of the sink is a function of several quantities including the atmospheric concentration, land and ocean carbon stores and the state of the climate both at present and in the past. It is not simply a function of the present emissions.

We also believe that it is important to ask if this behaviour is seen in more complex earth system models. To this end we can report on a recent project using the complex HadCM3LC model in which CO2 emissions followed a business as usual simulation until year 2050. At this point emissions were set to zero and we monitored the atmospheric CO2 concentration and the global carbon sinks for a further century. We found in this experiment that following the emissions being set to zero the atmospheric CO2 concentration declined at a rate of approximately 40 ppm/century. During the period 2050 to 2150 the simulated terrestrial carbon cycle returned around 50 GtC to the atmosphere but the ocean took up around 130 GtC, which is consistent with the decline in atmospheric CO2. The cumulative airborne fraction was also clearly declining during this period. This result is consistent with the conclusions of previous work on climate-carbon cycle feedback, as without including this feedback we would have expected the net carbon sink to be larger and the rate of atmospheric CO2 reduction to be greater. Thus, the complex model behaviour qualitatively reinforces what we see in the MAGICC simulations, although the MAGICC model is able to extend the result to cover a greater range of uncertainty, with some cases having a faster atmospheric CO2 decline than HadCM3LC (e.g. the 10th percentile) and some cases having a slower or no decline (e.g. the 90th percentile).

Finally, I'd like to reassure you that the Met Office does not advocate any preferred emissions scenario. Instead we provide advice on a wide range of future emissions.

Yours sincerely,

Dr. Jason Lowe
Head of Mitigation Advice

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