‘Beyond the Summit’

Sensitivity, Target Temperature and the Carbon Budget

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The initial presentation was given in video-conference on 24th September 2014, just 20 hours after the end of the Climate Summit 2014, convened in New York by Ban Ki-moon, the Secretary General of the United Nations.

Re-mastered Video-recording can be found at:
https://onsync.digitalsamba.com/play/wasdell/18327-beyond-the-summit

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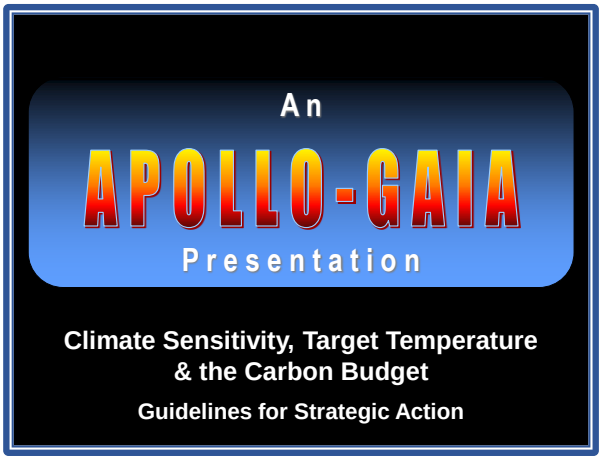
Introduction

It is just over a year since I gave the keynote presentation to the annual conference of the Club of Rome. My subject then was: **“Sensitivity, Non-Linearity and Self-Amplification in the Global Climate System”**. The robust value for the Earth System Sensitivity established on that occasion is taken as read for the rest of this presentation. (See: http://www.apollo-gaia.org/sensitivitycarbonbudget.html) I ended my address to the Club of Rome with the words:

I have a dream*: that humanity will break out of its state of denial and find the courage to face the harsh realities of now.*
I have a dream*: that we will rise up and overthrow the collusional power of political and economic vested interest.*
I have a dream*: that we will acknowledge the life-destroying gravity of our addiction to the dark energy of yesterday, to kick the habit of our fossil dependency, and detox the global system.*
I have a dream*: that we will repudiate the myth of eternal growth, and learn to live sustainably within the limits of our finite world. That we will find a way to stabilise the climate of planet earth before the temperature rises too far. That we will find a way to abort the extinction event of the Anthropocene before it grows to catastrophic proportions.*
I have a dream*: that as a species we will look back on the current crisis and celebrate the solutions we were able to put in place and say with pride "that was humanity's finest hour!"*

That was the dream. But if you don’t have a dream, how are you going to have a dream come true? Moreover, when navigating towards a dream, it is essential to keep one eye firmly fixed on reality.

This new presentation, **“Sensitivity, Target Temperature and the Carbon Budget”**



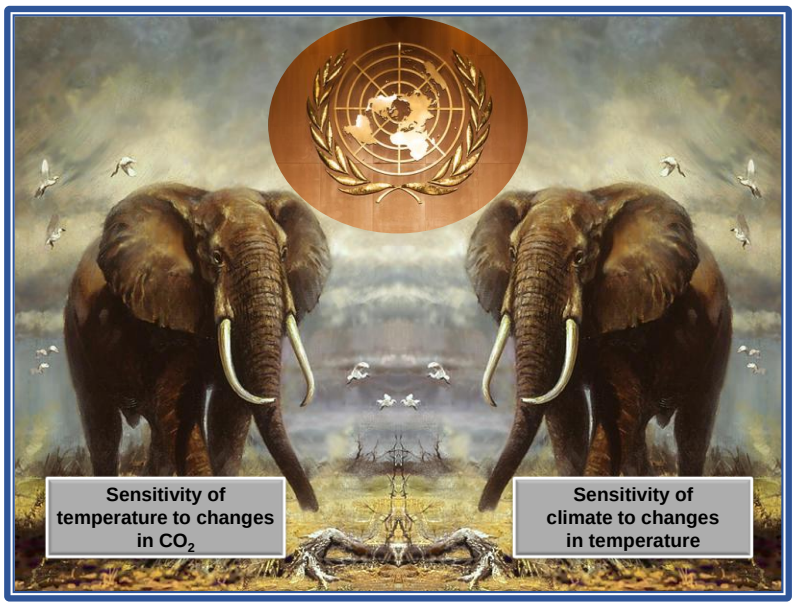
aims to ground our discourse in reality just 20 hours after the closing session of the Climate Summit 2014, convened in New York by Ban Ki-moon, the Secretary General of the United

Nations. That Summit was a Himalayan moment. As we toiled upwards and eventually reached the peak, we realised that, after all our efforts, we had still only scaled a foothill!

From its vantage point we gazed out over a vista of valleys and ridges to the great range of soaring peaks still before us on our journey.

In New York there was enormous (and completely understandable!) political pressure to make sure that everyone was singing from the same hymn sheet. Under those conditions it is all too common for critical scrutiny of the actual wording to be suppressed and rendered taboo – fertile breeding ground for the proverbial elephant in the room. This presentation breaks that taboo.

Looking back it is possible to identify two bull elephants rampaging unnoticed through the corridors of impotence in New York. I call them the "Sensitivity Twins".

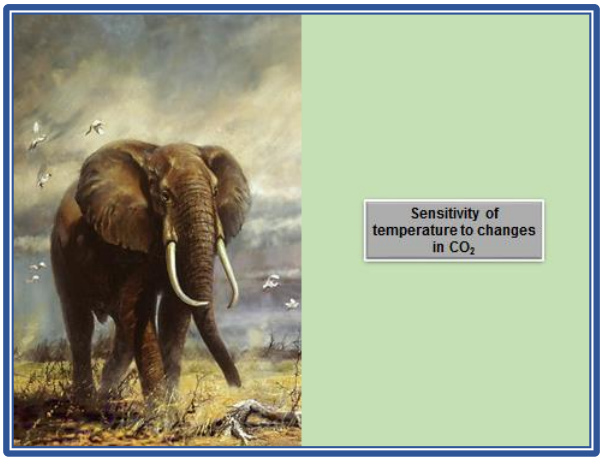


The first elephant concerns the **sensitivity of the global temperature** to change in atmospheric carbon-dioxide. That determines the size of the available carbon budget, or even whether any such budget exists.

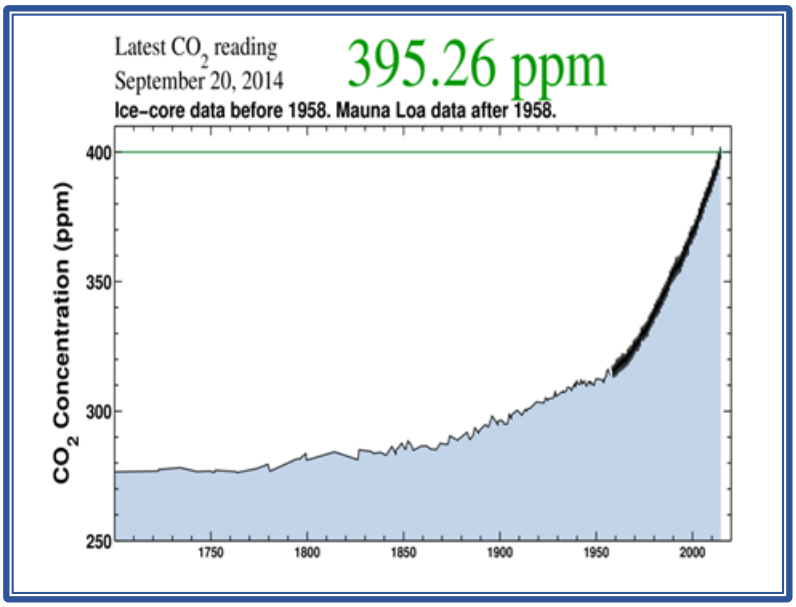
The second elephant concerns the **sensitivity of the global climate** to small changes in average global temperature. That introduces the question as to whether the target temperature change of not more than 2°C might be way too high to avoid dangerous climate change.

These two critical issues define the "problem space" in response to which the international community is seeking strategic solutions. If the problem space is wrongly defined, then the proffered strategic solutions are not fit for purpose.

Part 1: Temperature Sensitivity to Change in CO_2 Concentration



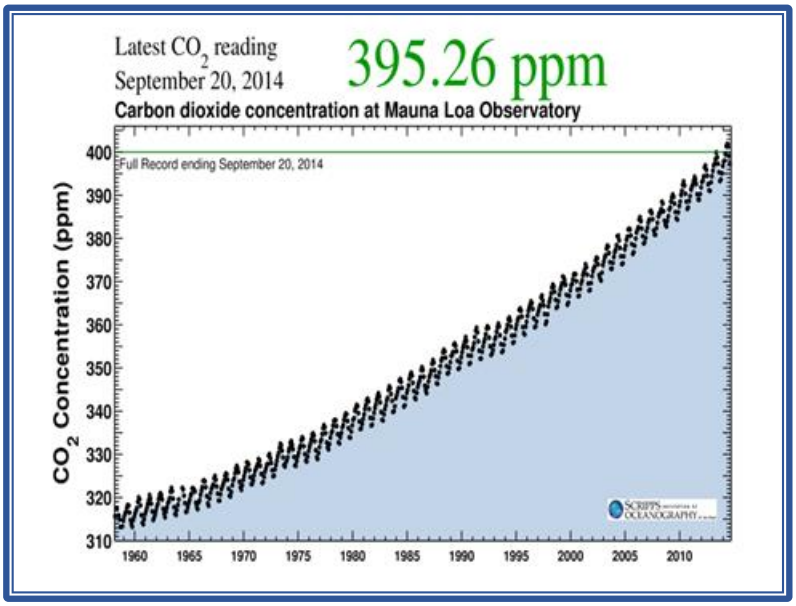
Now, let me introduce the first elephant in the room: the one representing the sensitivity of the global temperature to change in the concentration of atmospheric carbon-dioxide. As a first step I am putting up some of the basic information about the increase of carbon dioxide – the climate changing greenhouse gas in the atmosphere - since the year 1700,



just before the beginning of the industrial revolution. At that time its concentration stood at around 280 parts per million and was quite stable. It began to be disturbed around 1800 as we started to burn coal on a significant scale. Then on through to 1850 when it really began to take off, rising through the 1900s, the hiatus during the second world war, and then increasing rapidly during the second half of the 20th century.

The records in the first part of the graph are taken from ice-core data, those in the second half of the graph, from 1958 onwards, present the direct observations made at Mauna Loa on Hawaii, from 1958 right up to 3 days ago. At this point the concentration stood at 395 and a bit parts per million. It has gone over the 400 mark once or twice this year and the average will be 400 by the time we arrive in Paris for the international conference on Climate Change in 2015.

This next slide takes us into the last half century.



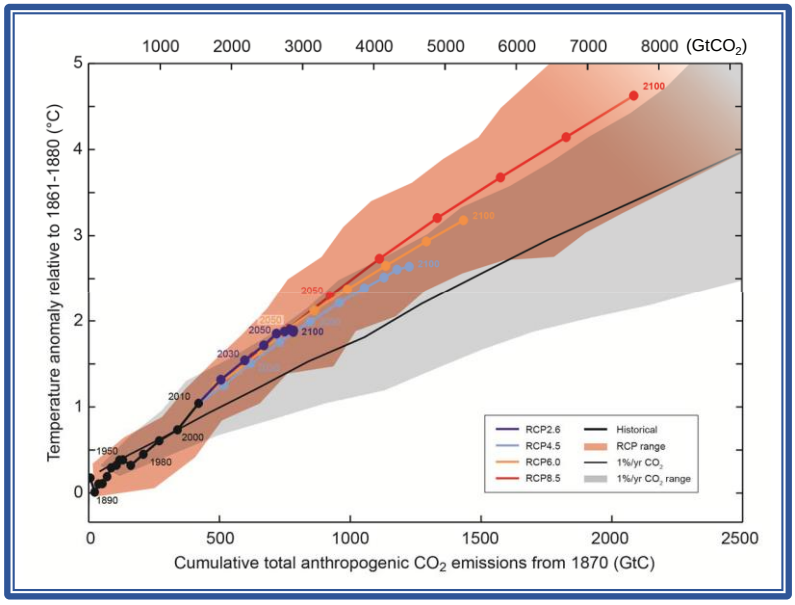
You will see that the dates range from 1958 right the way through to 2014. The saw-tooth pattern represents the breathing of the hemispheres. As the seasons follow each other, leaves come out, leaves die back. As they come out carbon is absorbed from the atmosphere. As they die back and rot it is released again. So as winter follows summer we observe this oscillation. But the average has been going up and up and up and up. That is the problem, because those greenhouse gases trap energy at the surface of the earth and put temperatures up. They prevent energy getting out and allow energy to come in, just as in a greenhouse, which is why they are called greenhouse gases. In 2013 we emitted a total of 44.4 gigatonnes of carbon-dioxide ($GtCO_2$,) that is almost exactly 6.0 tonnes of CO_2 per annum, for every man, woman and child alive on the planet.

One of the key questions that we have to ask is: 'What are the temperature implications of carbon dioxide increasing in this way?'

In other words: 'How far will the temperature increase above its pre-industrial base-value as a result of the change in the greenhouse effect?'

Temperature Response to CO_2 Emissions: the IPCC approach

The Inter-Governmental Panel on Climate Change produces its Assessment Reports every 4 or 5 years. The fifth one, published in 2013/14, had a critically important visual in the Summary for Policymakers of Workgroup 1 (the scientific section). It relates the cumulative effect of greenhouse gas emissions and the implications for temperature rise. It is a complicated graphic, but here it is, and I will try and explain it as we go.



You will see along the bottom is the total cumulative amount of carbon that has been emitted since the beginning of the industrial revolution, through where we are today and then on and projected into the future. On the vertical axis is the temperature anomaly, in other words the amount by which the temperature is expected to increase as a result of emissions of this level being put out into the atmosphere. Across the top there is a translation of gigatonnes of carbon into gigatonnes of carbon dioxide. Carbon dioxide molecules weigh a lot more than carbon atoms, so the weight of carbon dioxide is quite a lot more than the weight of the carbon emitted, but they are actually equivalent scales. One of CO_2, the other of carbon.

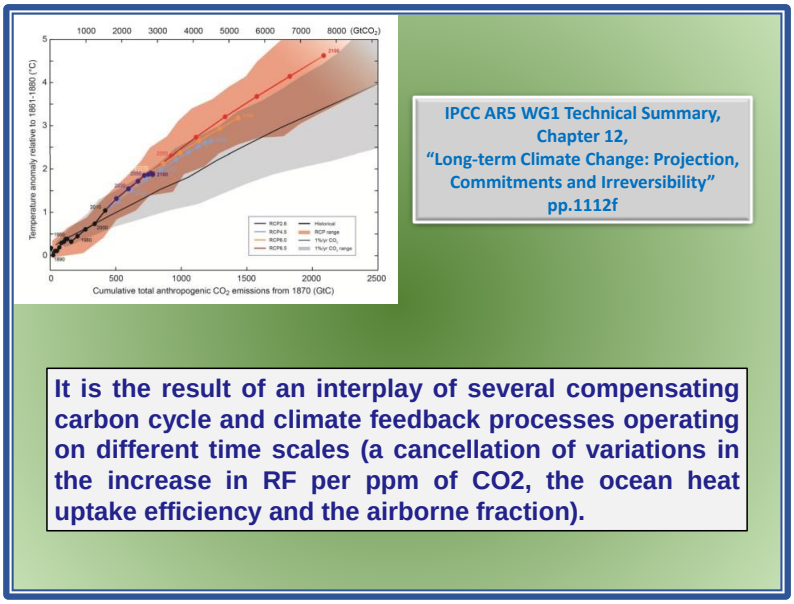
Now let's look at the image itself. What are called the Representative Carbon Pathways (RCPs) are plotted on the graph. They show different rates of emissions to the end of the century. If we have a low rate of emissions then the total by the end of the century will come at the end of the dark blue trace. If we increase the rate of emissions it will go up to the end of the light blue line, the end of the orange line, or even end of the red trace. What is interesting about the whole presentation is that the relationship between the total amount emitted and the expected temperature increase is almost a straight line. That is very helpful in determining what temperature rise is equivalent to any given total output of CO_2.

Now this visual, produced for the Summary for Policymakers, is the basis on which the available carbon budget is determined – namely the amount of carbon dioxide from all human sources that we can afford to emit before risking going above the agreed upper limit of 2°C. It is probably the most significant and most influential strategic piece of visual information ever produced by the IPCC. It is also the most profoundly misleading and, as I have charged in other situations and on other occasions, actually renders the Summary for Policymakers unfit for the purpose of policy making.

There are several critical problems embedded in this image that must be addressed if the problem space is to be realistically defined. For instance, the temperature scale on the vertical axis is actually a transient temperature increase – not the final increase when everything has settled down at equilibrium. It represents a short term temperature response. On this scale, we should therefore be looking at something a little below 2.0°C in the short term if we are going to keep below the 2.0°C in the long term. Unfortunately, this graph is being treated as if the short term figure is itself the target. That makes us over-estimate the budget of available emissions before we overshoot the agreed limit of not more than 2°C above the pre-industrial benchmark.

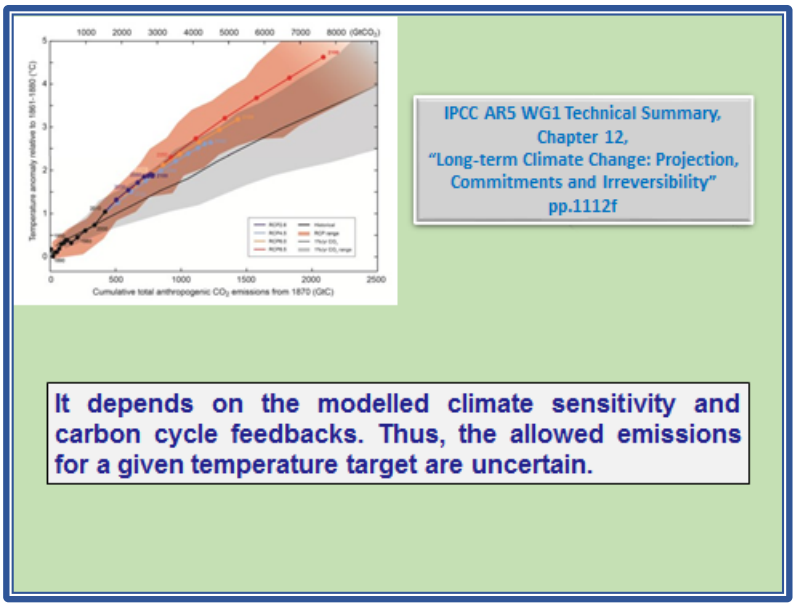
There are other difficulties with this figure, and I will introduce them to you as a set of boxed comments quoted from Chapter 12 of the Technical Summary of IPCC AR5 WG1 ("Long-term Climate Change: Projection, Commitments and Irreversibility" pp1112f).

Several aspects related to the concept of a cumulative carbon emission budget should be kept in mind. The ratio of global temperature and cumulative carbon is only approximately constant.



- The graph is the result of an interplay of carbon cycle and other climate feedback processes on different time scales which are erroneously asserted to be mutually compensating.
- There has been a cancellation of the change in the efficiency of carbon dioxide as a greenhouse gas – at low concentrations it is much more powerful than it is at higher concentrations and that makes the graph curve downwards as it moves to the right. It also leads to an underestimate of the temperature response to current cumulative emissions and so to a further over-estimate of the available carbon budget.
- The efficiency of ocean heat uptake has also been ignored. At the moment the ocean is taking up far more heat than had been expected, so the short-term surface temperature increase is much lower than predicted.
- Another thing that is not dealt with is the airborne fraction which is treated as constant. However, as the natural carbon sinks begin to degrade, the airborne fraction increases and so the graph tends to get less accurate as those phenomena come into force.

This next point is the most critical issue:



The relationship between cumulative carbon emissions and temperature depends on modelled climate sensitivity and on carbon cycle feedbacks. Nowhere in the Summary for Policy Makers is that dependence on climate sensitivity noted. It is in fact taken out of the equation. So the conclusion in the basic scientific text is 'allowed emissions for a given temperature target are uncertain'.

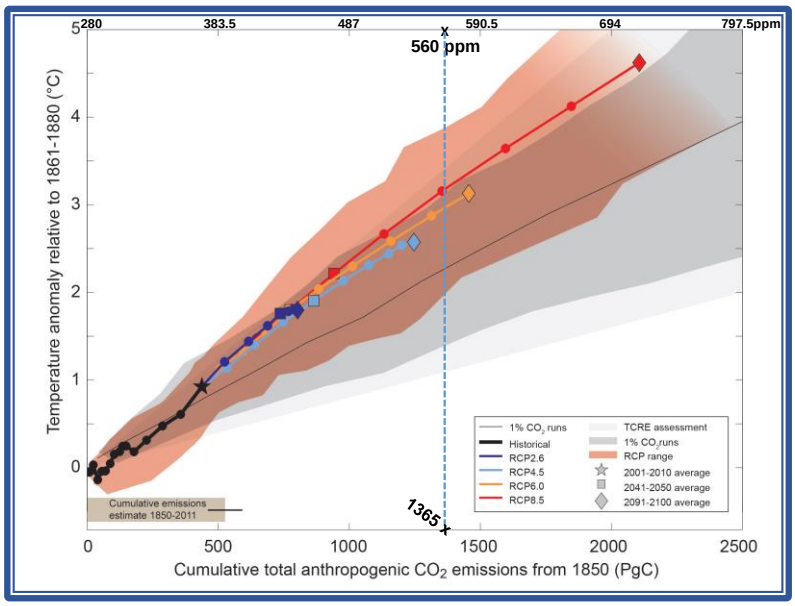
> **Thus, the allowed emissions for a given temperature target are uncertain. Nevertheless, the relationship is nearly linear in all models. Most models do not consider the possibility that long term feedbacks may be different.**

Most models show the relationship as a fairly straight line. Almost no models consider the possibility that long term feedbacks will change the picture.

So as the basis on which to establish the available carbon budget for the strategic purposes of ensuring that temperature does not increase by more than 2°C above the pre-industrial base-line, the Summary for Policymakers uses a transient temperature, a fixed understanding of sensitivity, and an elision of significant feedback dynamics including those relating to the carbon cycle and others operating on a longer term.

The Sensitivity value embedded in the Summary for Policymakers

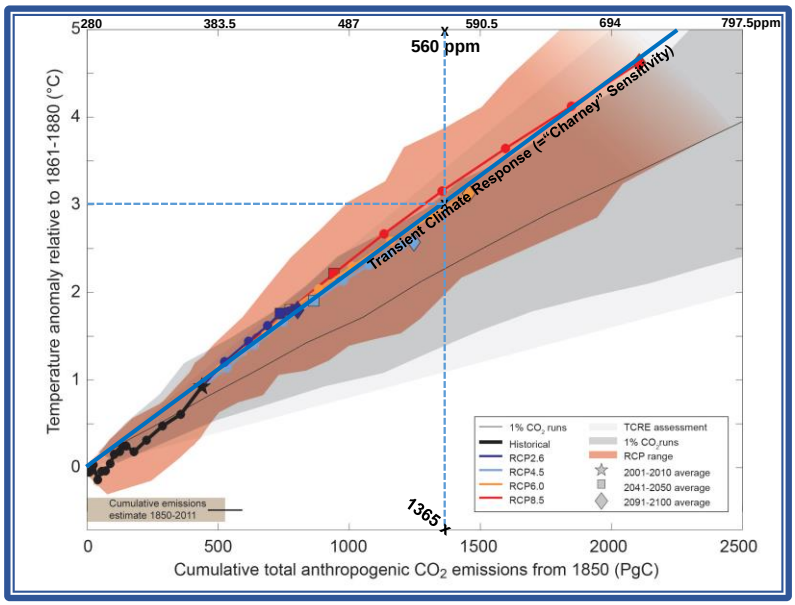
As a first step in the exploration of the strategic significance of the inadequate presentation in the IPCC Summary for Policymakers, I return to the original draft of the analysis – not the one from the Summary for Policymakers that was altered by government agents in the final days before publication – but the one that was actually submitted by the scientific community. Then I have added some further elements to help with the explanation



For instance, how much have we actually emitted to date? Well that is there in the original scientific text but was taken out, apparently by those most threatened by the implications of what we have already done. For convenience, across the top, I have translated gigatonnes of carbon into parts per million of the atmospheric concentration of CO_2. It is a much more familiar concept. It is not necessarily 100% accurate, but for decision-making purposes it is perfectly adequate as a translation of gigatonnes of carbon into parts per million.

You will notice the atmospheric concentration started, as before, at 280 parts per million just at the beginning of the industrial revolution, and it has risen since then. Now we know that a doubling of carbon dioxide in the atmosphere from 280 to 560 parts per million is equivalent to a cumulative total of about 1365 gigatonnes of emitted carbon. Of that amount, approximately 52% represents the airborne fraction – the amount that has stayed in the atmosphere as a greenhouse gas.

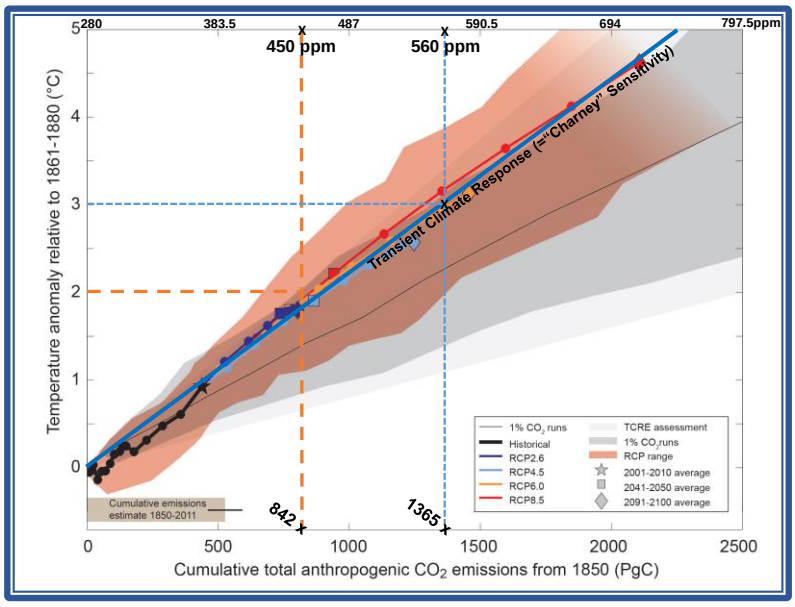
The ensemble of climate models on which the IPCC AR5 depends, uses a very basic



understanding of feedbacks – what we call the "fast-feedbacks" sensitivity. This predicts that the temperature increase expected at equilibrium after a doubling of carbon dioxide (the technical definition of "Climate Sensitivity") should be about 3°C. I have therefore drawn a blue horizontal line from the 3°C point across to where it intersects the vertical line denoting a doubling of CO_2 concentration beyond the pre-industrial baseline. Next I have drawn a straight blue line from the pre-industrial origin through that point. What is very interesting about this is that the fast feedback sensitivity – we call it the 'Charney' sensitivity – runs right up the centre of the graphic being used in the Summary for Policymakers.

There are enormous implications of that. It means that the Policymakers, i.e. those who are making the decisions about the future strategy to tackle climate change, are implicitly being told that sensitivity is a fixed quantity. Apparently, Climate Sensitivity has no bearing on the available carbon budget. Other (potentially more robust) values of Sensitivity are completely ignored. This is the first elephant in the room. Sensitivity matters. Remember that the text in the scientific technical summary said this gradient, the slope of this line, depends on climate sensitivity, and in the light of that "'allowed emissions for a given temperature target are uncertain'.

Before dealing with that in detail I want to look at the 2°C marker in this transient anomaly scale.

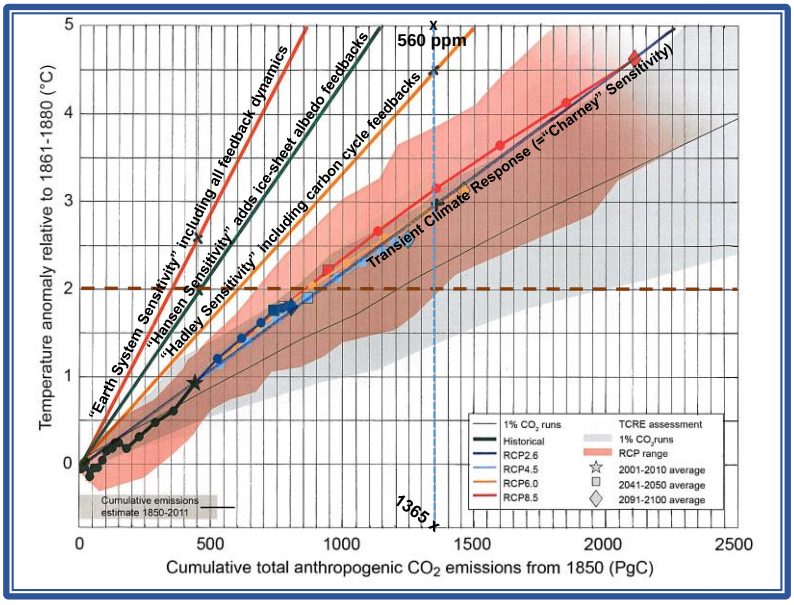


In fact I have drawn the orange horizontal line at 2°C and then dropped the vertical line just before it hits the blue "Charney Sensitivity". This partially compensates for the fact that the SPM temperature scale represents "transient" values rather than full equilibrium implications. The vertical line represents total carbon emissions of some 842 GtC or a CO_2 concentration of about 450 parts per million. 450ppm and 2°C are taken in the SPM as the ceiling values of concentration and temperature that defend us against dangerous climate change.

By 2015 we will have emitted some 570 GtC, so on this analysis the gap between 570 and 842 GtC represents the "available carbon budget" that the global community can use before it risks going above the 2°C target ceiling. Or so it would seem if the value of sensitivity is as set out in this visual of the Summary for Policymakers.

Relationship between Climate Sensitivity and Available Carbon Budget

On this next slide we show the effects on the value of Climate Sensitivity, first by inclusion of the carbon-cycle feedbacks, then adding the longer term ice-sheet albedo dynamics, and finally introducing the full Earth System Sensitivity. It clearly demonstrates that as our understanding of Climate Sensitivity becomes ever more accurate, the gradient of the temperature response becomes steeper and steeper.



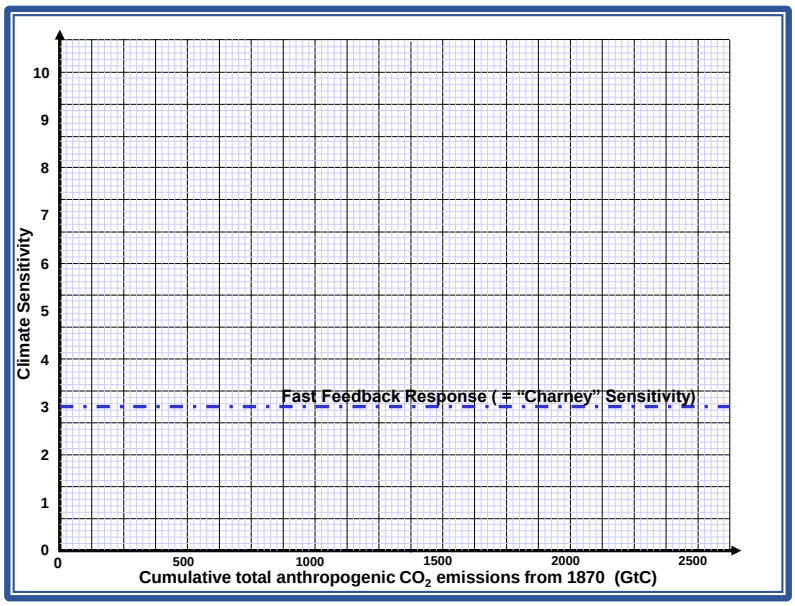
As it does so, the point at which the sensitivity line crosses the 2°C marker moves steadily to the left. The value of the carbon budget decreases, then vanishes altogether before collapsing into an escalating overdraft. It is absolutely clear that the amount of the available carbon budget is completely dependent on the value of Climate Sensitivity, a fact that is masked from view by the assumptions embedded in the Summary for Policymakers of the IPCC AR5 WG1.

In this section we therefore explore the detailed relationship between sensitivity and total carbon budget for a particular target temperature.

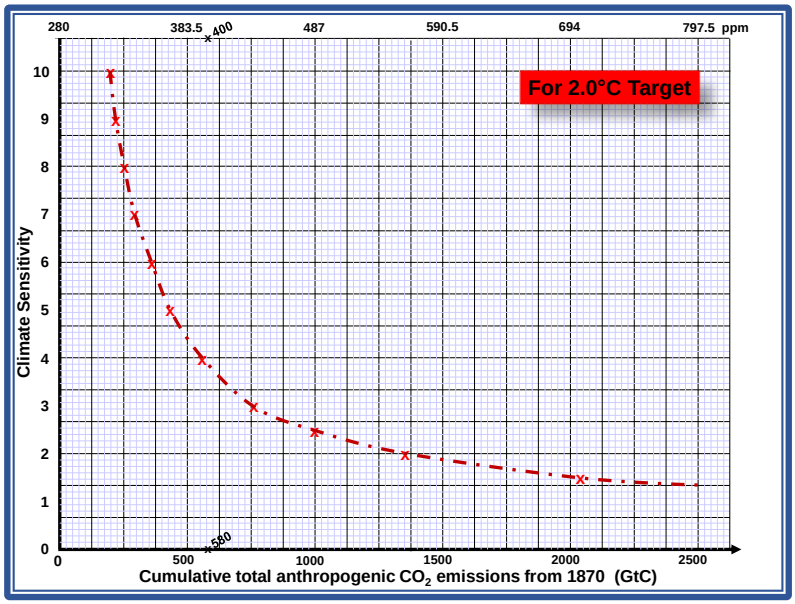
I start by taking a new grid. **Along the bottom** (as before) we plot the cumulative total anthropogenic carbon emissions going from zero at the beginning of the industrial revolution and on up to 2500 gigatonnes. **On the vertical axis** we are no longer plotting change in temperature, but values of Climate Sensitivity itself, (defined as the projected change in average surface temperature of the planet at equilibrium following a doubling of the atmospheric concentration of carbon dioxide). It is measured in degrees centigrade per doubling of atmospheric CO_2. **Along the top**, as before, I have put the parts per million equivalent to the total cumulative emissions.

The fast-feedback or "**Charney" sensitivity** (used in the Summary for Policymakers of the IPCC AR5 WG1) assumes a sensitivity value of around 3°C for a doubling of atmospheric CO_2. It is portrayed by the horizontal dotted blue line.

First of all we are going to look at the **ceiling of 2°C** as the target temperature. It is currently the unanimous commitment of the international community that we must not allow the temperature increase to exceed 2°C above the pre-industrial baseline.



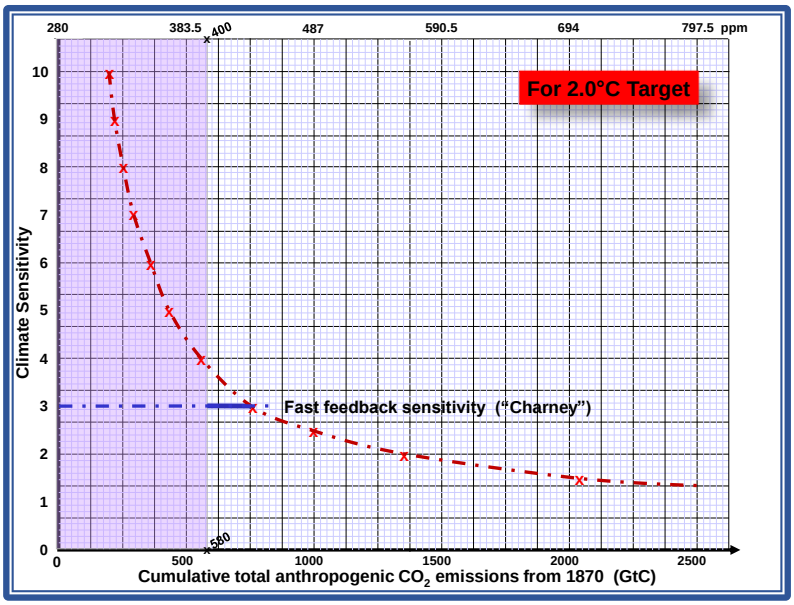
Now think with me. If the sensitivity is very, very high indeed, then even tiny amounts emitted would send the temperature above the 2°C limit. Conversely if the sensitivity is very, very low indeed then it doesn't matter how much we emit, the temperature increase would never reach 2°C. So the 2°C marker points race off to infinity as tangents to the axes like this:



As I said, with a very low sensitivity there are virtually no temperature-related limits to our cumulative carbon emissions. However, for a very high sensitivity there are enormously stringent conditions on what we can put into the atmosphere. Permitted carbon emissions are totally dependent on the value of Climate Sensitivity.

Joining the points we establish the 2.0°C boundary line. If we stay beneath and to the left of this line and work in this area, then we stay in the so-called "safe zone" where the temperature increase does not exceed 2°C. If we stray above and to the right of the 2°C boundary line, then our cumulative CO_2 emissions will drive the temperature increase over the 2°C limit. The line marks the boundary between below and above the 2°C target.

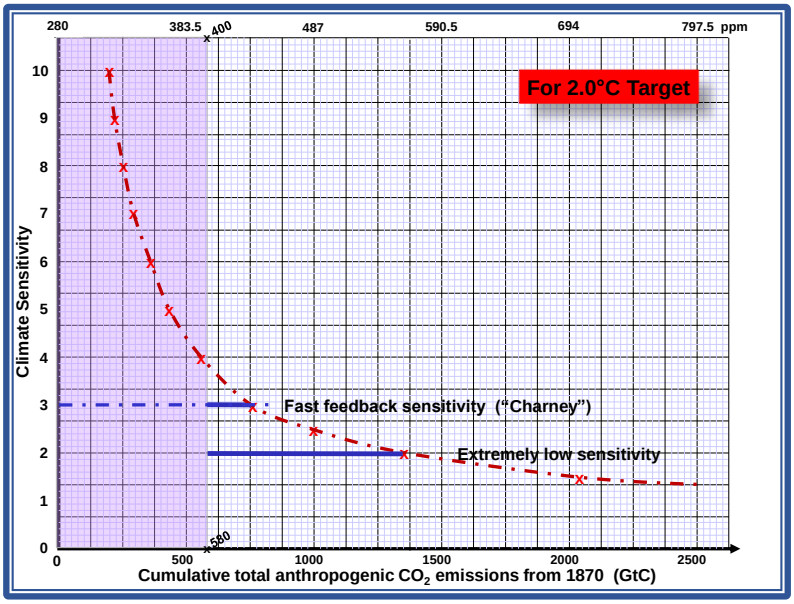
Now let's add some more information.



The light purple shading represents the amount we have emitted to date. In 2014 we hit 400 ppm which is equivalent to about 580 gigatonnes of total cumulative carbon emissions, just over half of which stays in the atmosphere.

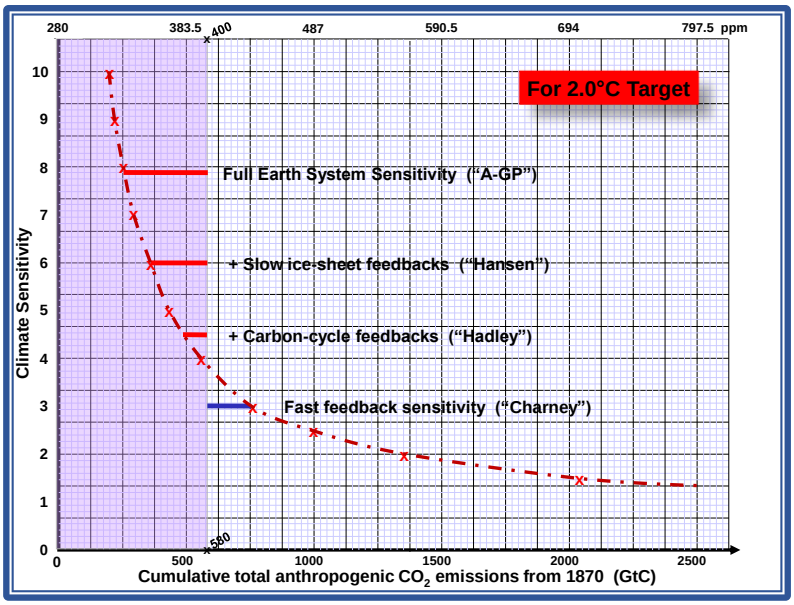
Next we explore the 3°C sensitivity, the fast feedback or "Charney" sensitivity embedded in the Summary for Policymakers. It is pretty clear that with this value for sensitivity, we still have some space in the air-fill site in which we can put more emissions before hitting the 2°C marker line. The thick blue line represents the "available carbon budget".

Some people are suggesting that the sensitivity is much lower than is being suggested by the Inter-Governmental Panel, say around 2°C for a doubling of atmospheric CO_2.



Obviously extremely low sensitivity would give us much more space to go on emitting without the danger of passing the 2°C limit. In other words, the available carbon budget would be much larger. That is not scientific. It is running completely counter to our understanding of the whole global process. I think it is an action of wish fulfilment that I wish to ignore. What has given rise to the suggestion is the fact that the average surface temperature of the planet has not risen much in the last 2 decades. That is because during this period almost all the excess heat energy has been taken up in the oceans and in melting of ice. Some of the incoming solar energy has also been reflected back into space by sulphur-based emissions from coal-fired power stations without particulate filters. These issues have no bearing whatsoever on the long-term sensitivity of the planetary system, so I am going to ignore the extremely low values for sensitivity because they have no bearing on the decision making process.

You remember the technical summary said we should take account of the carbon cycle feedbacks? Well here they are. If we include the effects of the carbon cycle feedbacks in our understanding of sensitivity, then it goes up to about 4.5°C for a doubling of atmospheric CO_2. With this value for sensitivity we are already in overshoot because we are on the wrong side of the 2°C line. We have overshot by the amount of the thick red bar.

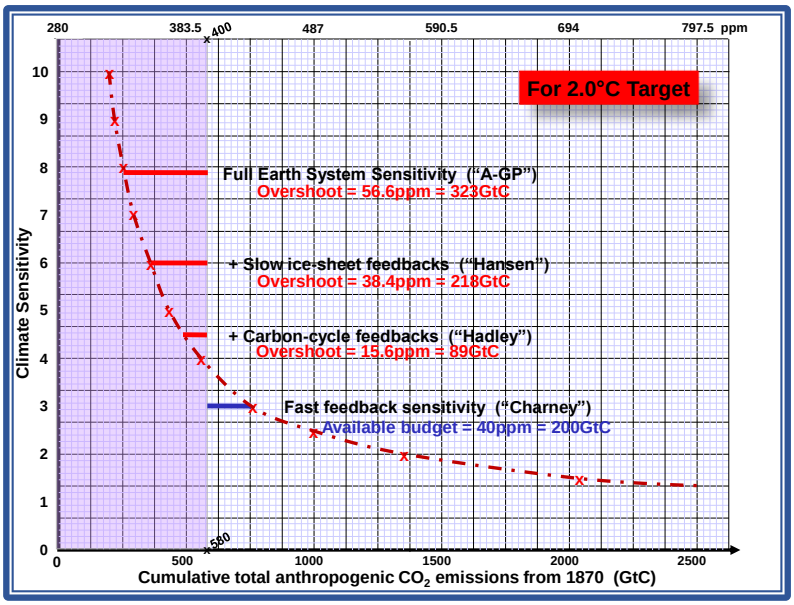


The technical summary also said we should be looking at some of the longer term feedbacks. Jim Hansen has taken account of the slow ice-sheet dynamic feedbacks. When those are added in it puts the value of sensitivity up to about 6°C for a doubling of CO_2. That is double the 3°C value being taken for granted in the Summary for Policymakers. With this sensitivity value current emissions have overshot the 2°C marker-line by an even greater margin.

If we include all the feedbacks, known and unknown, all the complex relationships between them, and all the temperature-driven changes in feedbacks that affect the actual concentration of greenhouse gases in the atmosphere, then we move well outside the capacity of the ensemble of climate models. We have to look instead at the actual historical data of the way the earth has responded to changes in temperature in step with changes in carbon dioxide concentrations over many millions of years. The historic correlation of average surface temperature and the concentration of atmospheric CO_2 gives us a robust value for what is called the Whole Earth System Sensitivity. (The technical derivation is available as a peer-reviewed and open access academic paper on the web-site of the Apollo-Gaia Project. See: http://www.apollo-

gaia.org/sensitivitycarbonbudget.html) We arrive at a minimum value for the Earth System Sensitivity of about 7.8°C for a doubling of atmospheric CO_2, a value that should now be taken as the basis for strategic decision-making. At this value of Climate Sensitivity, the full extent of current overshoot becomes very clear indeed.

Let's put some figures onto that.



The Summary for Policymakers – limiting itself to fast feedback sensitivity - indicates an available budget of about 200 to 250 gigatonnes of carbon before serious risk of passing the 2°C threshold. Since we are currently emitting about 10 gigatonnes a year we have space in the sky-fill site for another 20/25 years' worth. That would allow us to reach zero emissions over the next 50 years or so. The implication is that we have some time to play with, moving towards a peak of our emissions followed by a slow decline to zero and the move to a low carbon economy towards the middle or end of the century. That is the position taken in the Summary for Policymakers. It was endorsed at the Climate Summit 2014 in New York. It is fundamental to the position taken in the Synthesis Report of the IPCC AR5 to be published on 1st November 2014. It is being treated as the unquestionable basis of decision making as we move towards Paris for the COP 21 in December 2015.

However, as soon as we add in the carbon cycle feedbacks we have no available budget – it has already been spent. Overspent in fact by about 15 and a bit parts per million, or 89 gigatonnes of carbon.

If we add in the slow ice sheet feedbacks the current overshoot goes to 218 gigatonnes of carbon.

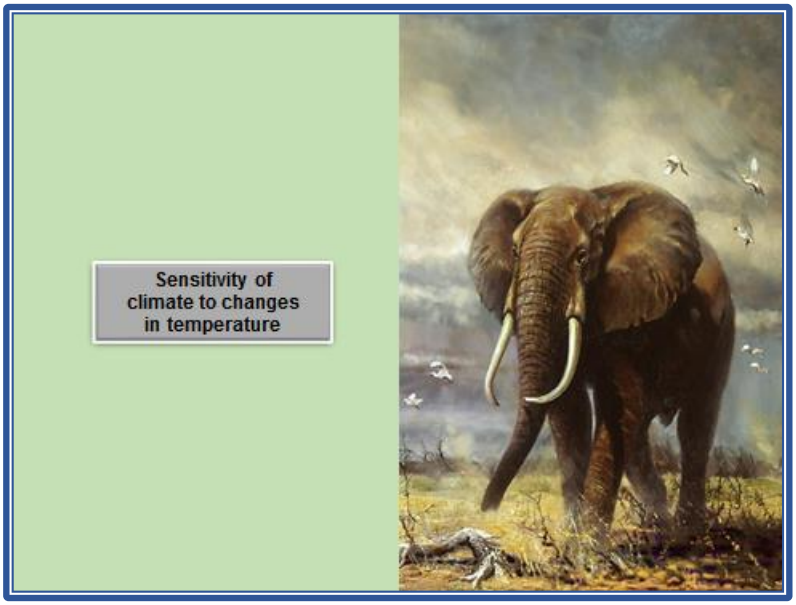
But if we go to the level of the Full Earth Systems Sensitivity, which must now be taken as the basis for effective decision making, then we have already overshot the 2°C target by about 56 ppm. At 400 ppm we are way past the concentration that will give us an eventual increase of 2°C. And in terms of having emitted about 580 gigatonnes we have already overloaded the skyfill site by about 320 GtC. To comply with the 2°C limit, we would have to draw-down that amount from the atmosphere.

Obviously we will not cease all emissions overnight, so the purple zone will inevitably expand to the right. Everything to the right of the 2°C line, including the result of all future emissions, will have to be removed from the atmosphere.

So strategically we have to go to zero carbon emissions in the shortest possible time and then draw down from the atmosphere much of the current stock. That is a totally different strategic task than that postulated on the basis of the Summary for Policymakers of the IPCC AR5. There is no available carbon budget. We are already deeply in debt. There are no more capital assets in the bank account.

Part 2: Sensitivity of Climate to Small Changes in Temperature

Now I must introduce the second of the elephants whose presence could not be acknowledged at the Climate Summit 2014 in New York. The first elephant had to do with the sensitivity of temperature to changes in carbon dioxide. The second elephant is a different animal altogether. This second elephant represents the issue of the sensitivity of global climate dynamics to small changes in average surface temperature.

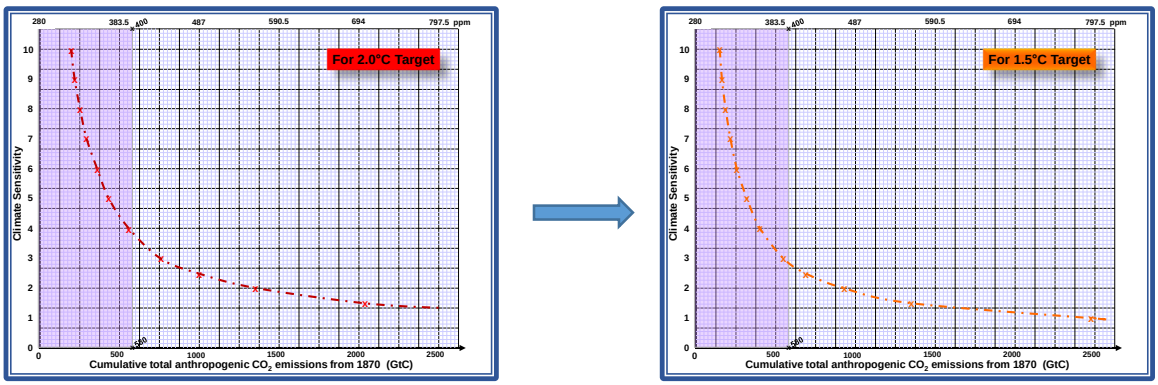


The figure of 2°C was put forward in the 1990s as a potentially achievable limit to the increase in average surface temperature, one that would hopefully protect us from dangerous climate change. It wasn't really based in scientific analysis and was not supported by very much evidence. Today we have a lot of evidence that says a 2°C increase is way above danger level.

The current rise in global temperature is running at some 0.85°C and we are already seeing huge changes in climate that are threatening the livelihoods of many: disturbing the monsoon; destabilising weather patterns across the northern hemisphere; disrupting food production; Arctic sea-ice is collapsing; the Greenland ice sheet is melting; methane is being released from thawing submarine permafrost; we have problems of rising sea level; flooding; droughts; wild fires; extreme weather events; the tracks of hurricanes; typhoons and storms are changing and their intensity is increasing. We are already experiencing dangerous climate change with an increase of just 0.85°C. The 2°C target is set way, way too high. Many countries are now pressing that we should have a lower target.

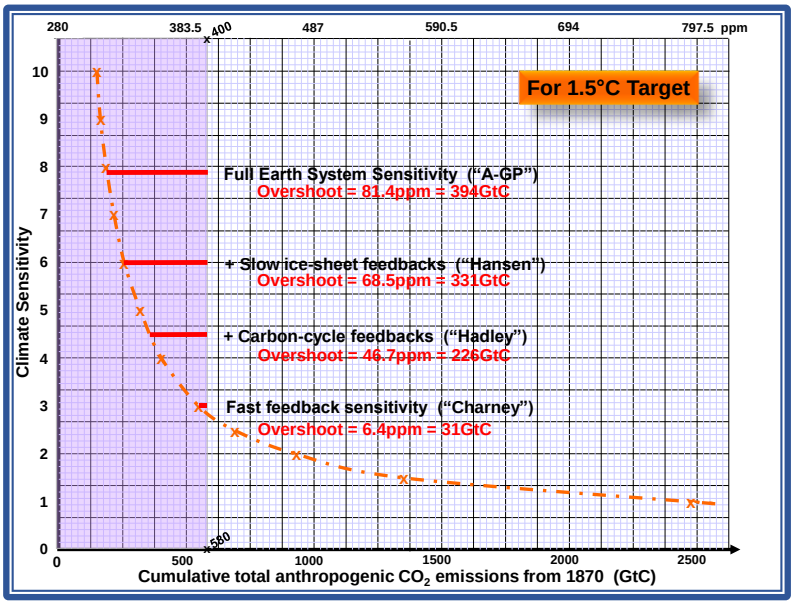
Proposed Reduction of Target Temperature Ceiling from 2°C to 1.5°C

Some say the target should be lowered from 2°C to 1.5°C. Did you see what happened?



Watch the red line as we go from the red 2°C target to the orange 1.5°C. The boundary marker-line moves closer to the axes. Safety conditions become more stringent.

As before, we add detailed information.

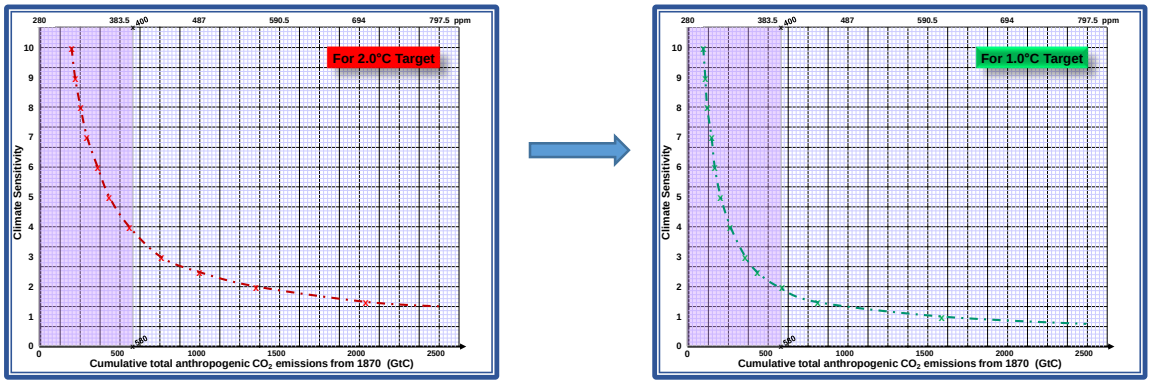


If the computer generated fast-feedback sensitivity used in the Summary for Policymakers is applied to a temperature target of 1.5°C, then we note that the limit has already been passed. There is no further budget, just a small overshoot. As we add in the carbon cycle feedbacks, then the slow ice-cap dynamics and go on to the full Earth System Sensitivity, the overshoot grows to nearly 400 gigatonnes of carbon. That means that not only do we have no available carbon budget, but in order to stay under one and a half degrees we have to draw down nearly 70% of the anthropogenic addition to the pre-industrial stock of atmospheric CO_2.

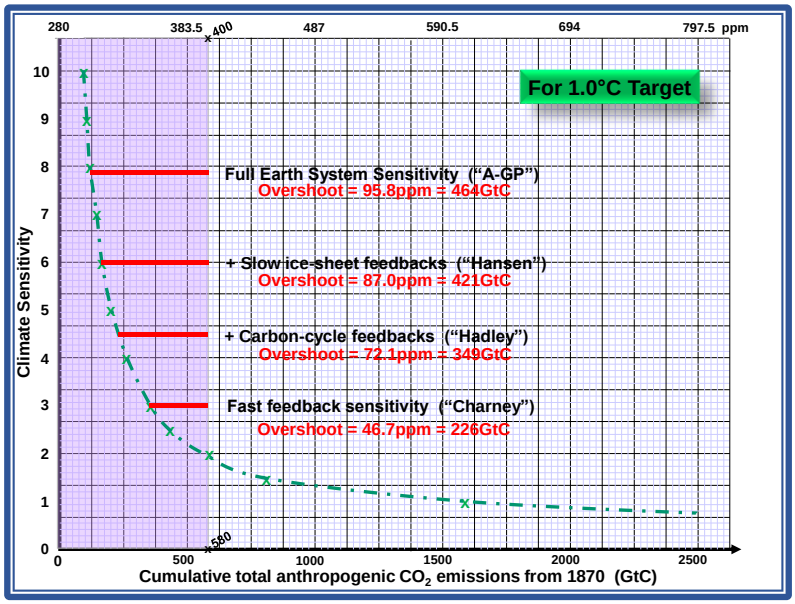
Proposed Reduction of Target Temperature Ceiling from 2°C to 1.0°C

But even 1.5°C is almost twice the temperature change that we have already experienced. There is a strong and growing body of opinion that notes that dangerous climate change is already with us, so that an increase of 1.0°C degree is about as far as we ought to go.

Again watch the change between the red line for 2.0°C and the green line for a 1.0°C target – the boundary line sits very much tighter to the axes.



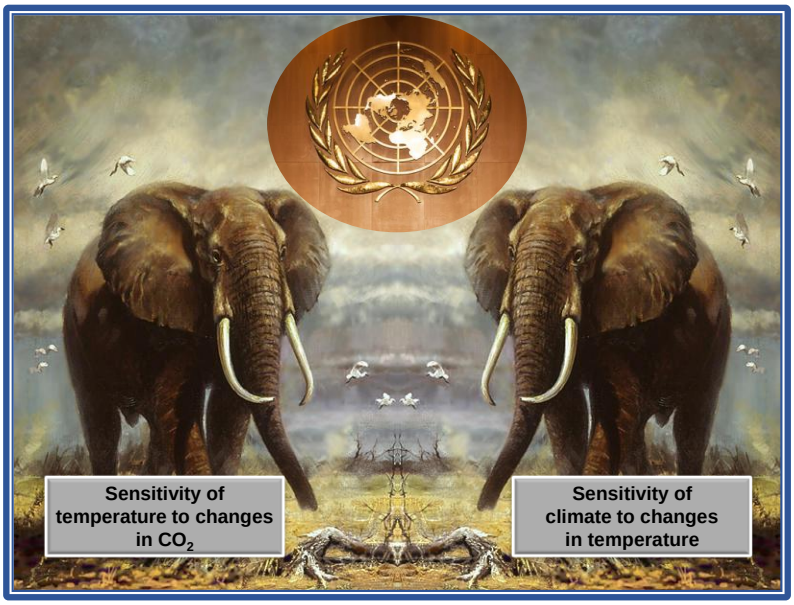
And again, mapping the same information.



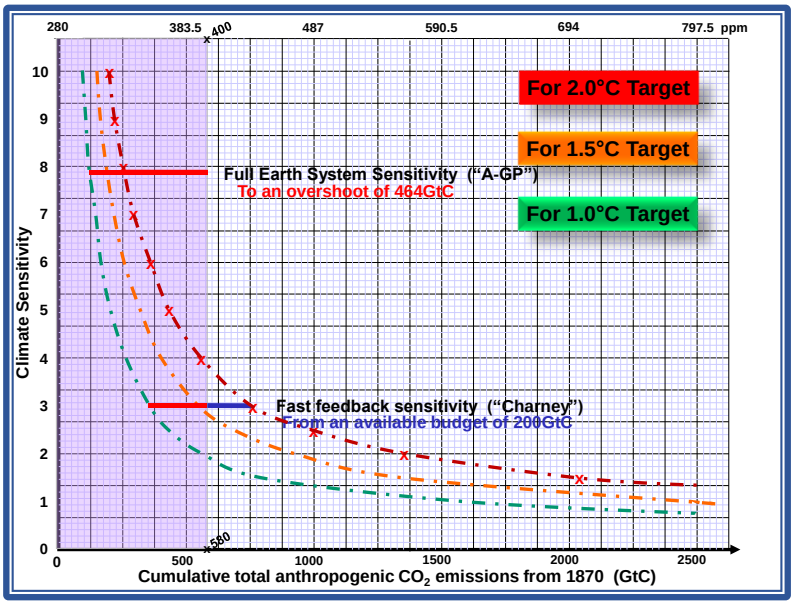
Even using the conservative estimate from the Summary for Policymakers, we are now way overdrawn by about 226 GtC. Applying the full Earth System Sensitivity shows us that, for this target, in reality, the overdraft is more like 464 GtC. So if we really want to stay on course to avoid dangerous climate change and set a target rise in temperature of not more than 1.0°C, the strategic implications are profound.

Summary of Parts 1 and 2, with Strategic Implications

So now we have uncloaked both of the elephants, whose presence, for all kinds of political, economic and psychological reasons, could not be acknowledged at the Climate Summit 2014 in New York. If the first elephant requires us to take full account of the implications of climate sensitivity, the second elephant points to the necessity to reduce the maximum rise in global temperature way below the 2°C that has been put forward as the unquestionable basis for negotiations in Paris.



Now let's summarise the argument so far: Here is the 2.0°C target slide that I used before with some of the noise taken out. I note the shift from the "fast-feedback sensitivity" (used in the IPCC AR5 WG1 Summary for policymakers) to the effect of the full Earth System Sensitivity which should take its place. I then show the difference between the 2°C target and the 1.5°C target and finally add in the 1.0°C target.



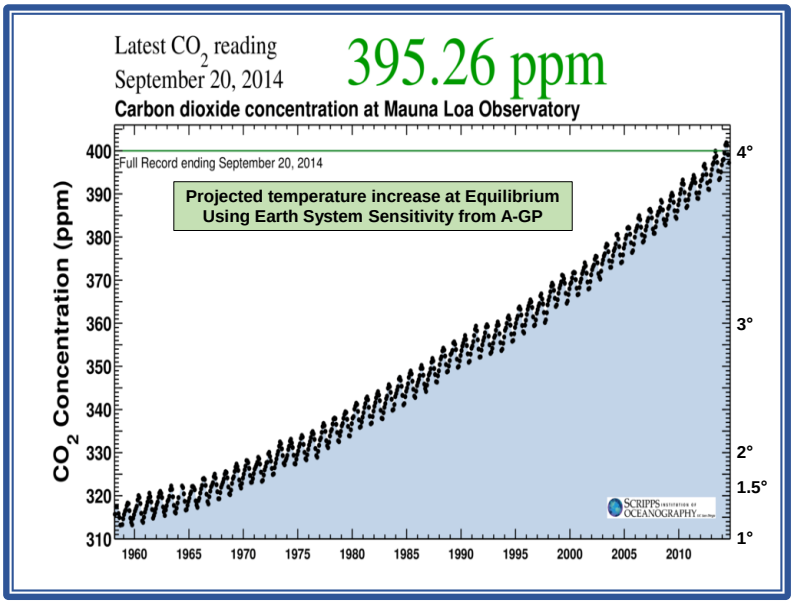
Strategically we move from the illusion of having an available carbon budget of over 200 GtC for the 2°C target using an inadequate understanding of climate sensitivity, to the harsh reality of a new imperative of a 1.0°C target using the full Earth Systems Sensitivity and a stock reduction of some 464 GtC. We recognise that emissions reduction on its own, essential though that is, is not sufficient to keep us below the 2.0°C target, let alone the 1.5°C and even more so for the 1.0°C target.

Emissions reduction on its own cannot deliver the goods. We must have a two pronged strategy of stopping all further emissions and reducing the atmospheric stock, drawing down from the atmosphere much that is already in place. Only that kind of dual strategy, within a time span that is appropriate for the earth systems behaviour, will enable us to achieve the agreed objective of avoiding dangerous climate change.

Part 3: Time, Task and the Implicit Temperature Response

In this next section we review issues of time and task. Firstly we explore the dates at which specific changes in eventual equilibrium temperature became historically implicit in the rising concentration levels of atmospheric CO_2.

As a basis I reintroduce the Keeling Curve from Mauna Loa.

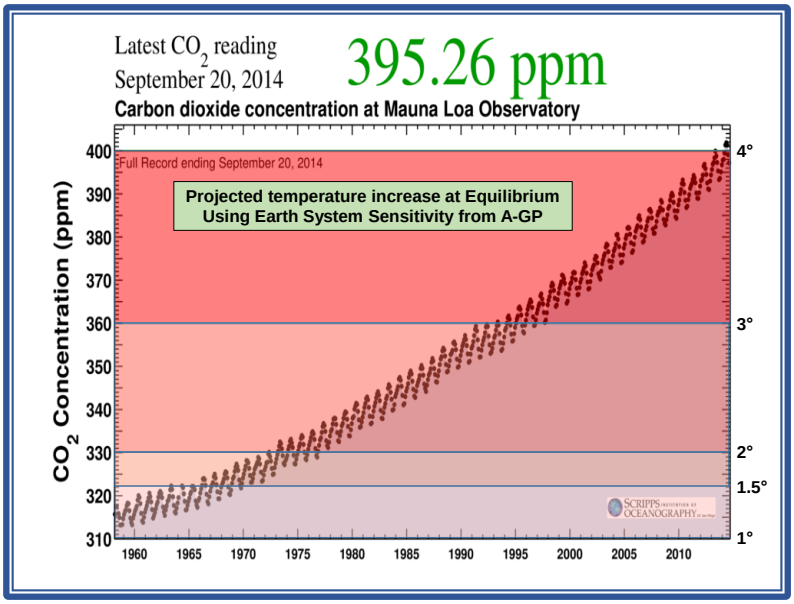


Up the right hand side I am going to put the projected temperature increase at equilibrium when everything has settled down, using – as we should – the full Earth Systems Sensitivity of 7.8°C for a doubling of atmospheric concentration of CO_2.

By the way, that figure is probably an underestimate because it is based on very slow change in the historical records under conditions of near equilibrium. Today change is happening some 300 times faster than at any time in the past records, and the rate of change, coupled with the massive inertia of the earth system means we are moving further and further away from equilibrium conditions. That is likely to increase the sensitivity of the system for all sorts of reasons. So the 7.8°C of the Earth System Sensitivity should probably be seen as a conservative minimum.

An equilibrium **increase of 1.0°C** above the pre-industrial bench-mark was implicit when the atmospheric concentration of CO_2 reached about 310 ppm – that threshold was passed around 1955 when CO_2 concentration had increased by about 30 ppm as a result of cumulative anthropogenic emissions.

A **rise of 1.5°C** was already implicit at an atmospheric CO_2 concentration of around 322 ppm, in about 1968. This part of the presentation exposes the massive thermal inertia of the climate system. There is a very long time-delay between cause and effect, which is why current observations give little indication of the long-term consequences of current cumulative emissions. It takes a long, long time to play catch up with the new concentration of carbon dioxide. The delay increases with rise in the rate of emissions.



When did we pass the 2°C marker? The **2°C degree** marker was implicit when concentration levels passed 330ppm in about 1974.

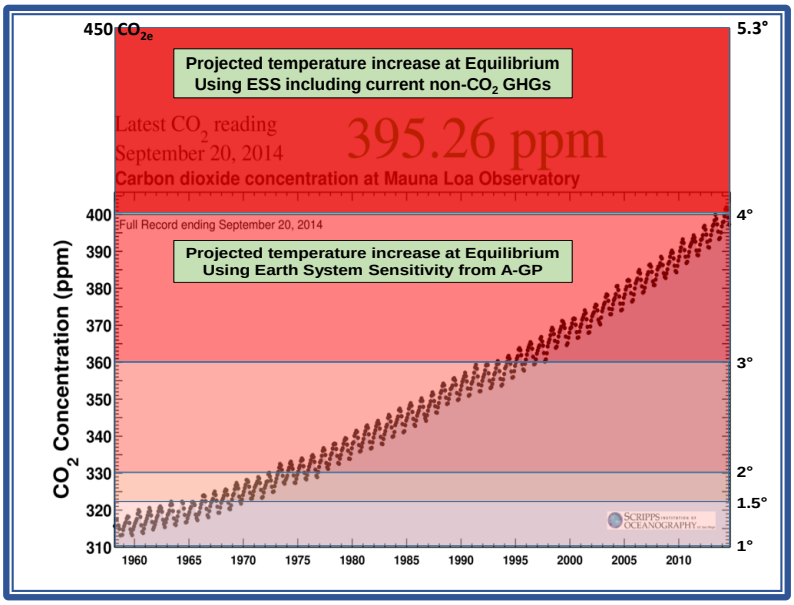
An equilibrium **increase of 3.0°C** was implicit in the system behaviour (at a concentration of c. 360ppm) by about 1994 – 2 years after the great Rio Earth Summit which was described as the last chance to intervene to prevent dangerous climate change. Since then concentration of atmospheric CO_2 has continued to climb without constraint.

As of today we are just on the 400 ppm. If we stopped all further emissions as of now and held the atmospheric concentration at that 395/400 mark, then the equilibrium temperature increase would not just be 1.5°C as projected in the IPCC AR5 Summary for Policymakers – but **a full 4.0°C change** by the time everything had worked its way through. We are way past the 2°C target as a result of cumulative carbon already emitted.

Inclusion of Forcing from non-CO2 Greenhouse Gasses

In all of this we have only considered the effect of accumulated CO_2.

To add in the effects of other anthropogenic GHGs I have to shrink the vertical scale, then extend the axes to display the current 450ppm level of CO_2 equivalent greenhouse gasses.

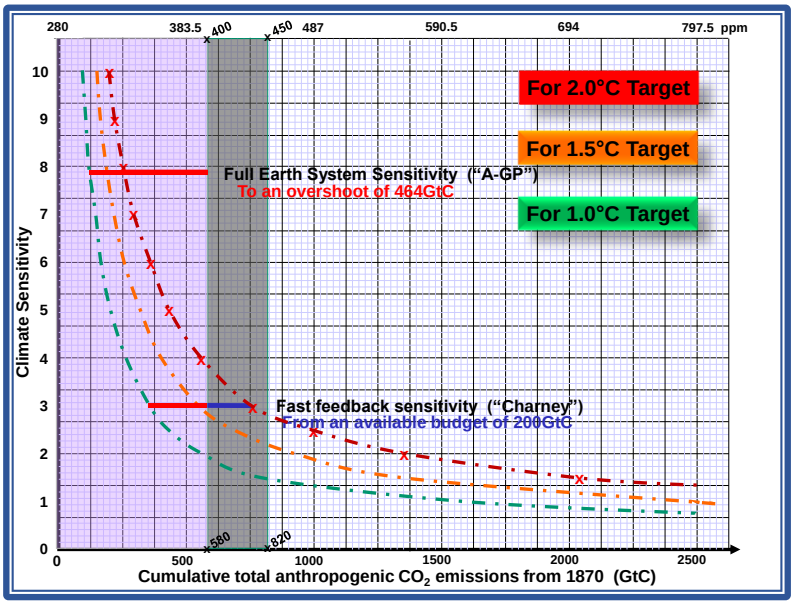


The projected equilibrium temperature as a result of this forcing, based on the full Earth System Sensitivity, would be **around 5.3°C**. At the moment the effects of the non-CO_2 GHGs are almost completely masked by the "global dimming" effects of atmospheric particulates. However, termination of the use of fossil energy would withdraw most of the particulates, leaving us exposed to the full effects of the non CO_2 GHGs.

Onwards and Upwards: Facing an Uncertain Future

Now let us move beyond the present situation and begin looking at the future with its implication for strategic interventions.

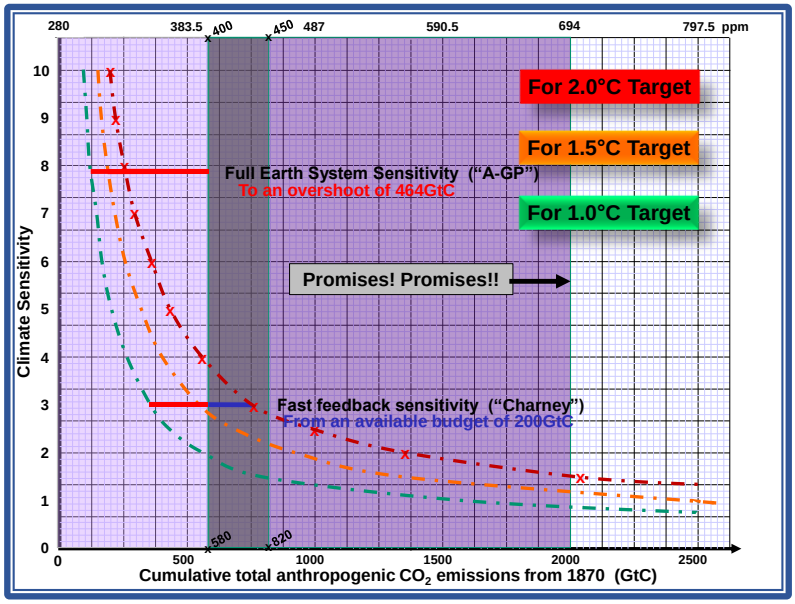
This is an equivalent graph to the last one. We are currently at 400 ppm (CO_2) and an accumulative total of carbon emissions at around 580GtC.



However, we have now included the current effects of non CO_2 GHGs as the band of grey shading added on to the purple area. That represents 450 ppm of CO_{2e} and the effect of cumulative carbon emissions of some 820 GtC. Even using the terms of reference of the Summary for Policymakers the available carbon budget disappears into an overshoot of about 40GtC once the non CO_2 GHGs are taken into consideration. Their omission from the SPM is indefensible.

At the end of the Climate Summit 2014 in New York there was very little change in the commitments, contributions, or the promises of reductions in emissions by the international community.

This next slide illustrates the effect of the best offers currently on the table as we move towards Lima and on to COP 21 in Paris

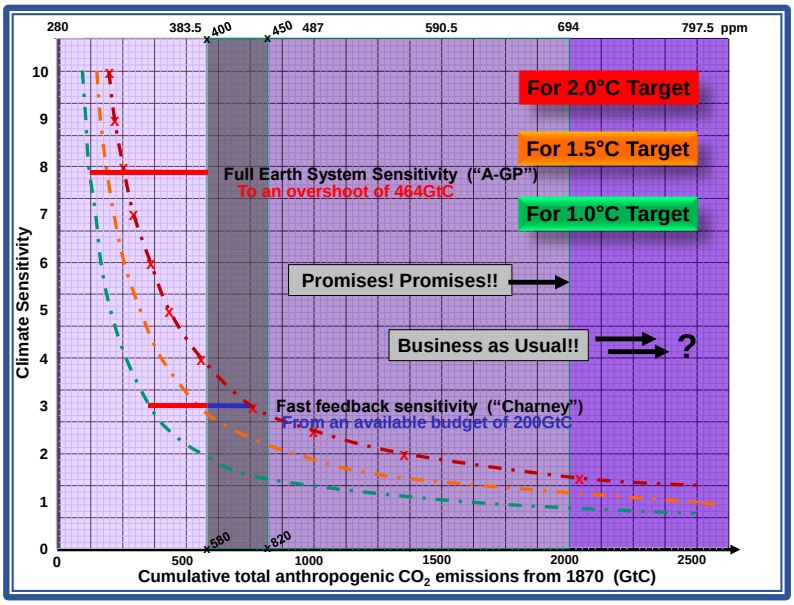


These are the commitments of the international community, which would take us by the end of the century to something like 2000 gigatonnes of carbon – way over the available budget even on the IPCC's inadequate Summary for Policymakers. The tragedy is that, for a combination of political and economic reasons, it may not be possible to deliver on many of these promises. Please note that we must add on the effects of the non CO_2 GHGs, currently masked by particulates but likely to become more and more effective as particulate emissions are reduced.

Today we are still engaged on the Business as Usual trajectory. That is pushing us way beyond the promises on the table. This is the course we are actually on.

If we continue on this pathway, we would be hitting an accumulation of something like two-and-a-half thousand GtC by the end of the century. If the promises take us to around 700 parts per million, then Business as Usual could push us way over 800 parts per million with enormous implications for the equilibrium temperature.

If concentrations of atmospheric greenhouse gasses were to be maintained at their peak value, then the IPCC "Budget" approach would leave us facing an implicit temperature increase at equilibrium of around 5.3°C. The promises (if delivered) would push that figure above 10°C, while 'business as usual' would drive it well above 12°C.



Five Steps towards a Sustainable Solution

We face a set of massive gaps between where we are going at the moment and where we need to be:

Step 1 is bringing business as usual back into line with the commitments and promises already on the table.

Step 2 is increasing the commitments to reduce emissions from the current set of promises back to match the budget embedded in the Summary for Policymakers. That is the basis of strategy currently being put forward for the international conference in Paris.

Step 3 is the removal or compensation for the effects of non CO_2 GHGs.

Step 4 recognises that we can't go on using this conservative, inadequate, under-estimate of sensitivity, but must replace it with the full Earth Systems Sensitivity. In which case there is a gap between the budget of the Summary for Policy Makers and the over-shoot indicated by the Earth System Sensitivity.

Step 5 is to recognise that the 2°C target is way too high. We need to bring it down through 1.5°C to the 1.0°C target. That requires an even greater reduction in the current stock of atmospheric CO_2.

So those are the strategic imperatives, the valleys and the ridges that we have to overcome in order to reach Everest on our long and difficult journey towards the over-arching goal of avoiding dangerous climate change.

In his concluding remarks at the end of the climate summit 2014 Ban Ki-moon reiterated the international commitment to achieve a meaningful and universal agreement in Paris 2015, with a draft to be presented in Lima next December. He noted the commitment to limit increase in global temperature to no more than 2°C by cutting emissions. He reported that several countries had indicted the need for emissions to peak before 2020 and decline thereafter, reaching carbon neutrality in the second half of the century.

Any agreement reached in Paris on those terms would be a strategic disaster, committing humanity to a course of action that would guarantee catastrophic climate change with all the unmanageable consequences that would involve.

It is now abundantly clear that limiting temperature change to 2°C cannot be achieved by emissions reductions on their own. There is no available carbon budget. Emissions must be reduced to zero in the shortest possible time and the existing stock of atmospheric greenhouse gasses must be drastically reduced. Moreover, the 2°C target has been set far too high and must be lowered from 2°C through 1.5°C to a mere 1°C in order to avoid dangerous climate change, and comply with the global commitment to the United Nations Framework Convention on Climate Change.

That is our Everest

It can be climbed!

Ending the Addiction: an Inspirational Challenge

We face massive obstacles on our journey, not least our addictive enslavement to fossil fuel as the energy-source of our global civilization. It is not just changing our energy mix. It is not just making political decisions. There are massive profits being made from the extraction, refining, marketing and use of fossil energy – whether it be coal, oil, gas, fracking or tar sands. And remember there are several very large national economies that are totally dependent on the income from fossil energy for their economic survival, social stability and political power base. The resistance to the implementation of any strategy required to avoid dangerous climate change is absolutely massive. **Never in the course of human history have so many been trapped in economic bondage to so few.**

We must break the power of fossil slavery. Fossil slavery is destroying our lives. Fossil slavery is destroying our world. Fossil slavery is costing the earth. We must end fossil slavery now. Fossil slavery has two strands of meaning. There is our enslavement to the Barons of the Fossil Empire and our insidious addiction to fossil energy as the source of their profit. But there is also the strand that recognises that fossil fuel itself replaced human slavery as a source of energy. The dynamics of slavery were perpetuated (fossilised) at the very heart of civilisation, incorporated in the economics of energy use and its associated political and financial instruments.

This is therefore a call for global transformation. It is a call to break free from our addiction to fossil energy. It is a call to break free from the fossilised slavery at the very heart of human civilisation. We must end fossil slavery now. That is the imperative of the strategic agenda.

It is time to say NO to the dark and toxic energy of the underworld. It is time to say YES to the pure and sustainable energy of the light. It is time to break free from our bondage to the past. It is time to embrace the freedom of the Sun. It is time to usher in the dawn of the Solar Society.

That transformation will call for a shift from the current conflicted dynamics of confrontation to the creative dynamics of collaboration. So, as humankind sets out on its long journey of recovery, I leave you with that iconic model of collaborative leadership in the role of Gene Kranz, the Mission Controller in the battle for survival of Apollo 13.