A Meridian Dialogue

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A Critical Response to a paper by Dr. Malte Meinshausen of Potsdam Institute for Climate Impact Research (PIK), Germany Entitled:

<2°C Trajectories – a Brief Background Note

Meinshausen's paper was prepared to inform the conference "KyotoPlus – Escaping the Climate Trap" on 28th/29th September 2006, Berlin.

Introduction

The author opens by restating the fundamental global commitment of the Rio Earth Summit from 1992: **"The ultimate goal agreed to by basically all nations is to 'prevent dangerous anthropogenic interference with the climate system'"**. He goes on to affirm that: **"near term action will have to be guided by long-term goals."** That is the international framework for engagement with anthropogenic climate change. It is grounded in real behaviour of the actual earth system, and dictates the terms of reference of any action required for the mitigation of such dangerous anthropogenic interference and against which any intervention strategies must be judged according to their coherence with the long-term goal and their effectiveness in achieving it.

Meinshausen then speaks of a different kind of goal under the terms: **"Policy goals for the long-term have been set by various actors; e.g. the EU's established its 2°C objective first in 1996."** Policy goals have to do with political realities not environmental realities. They are derived from what is seen to be acceptable in terms of political stability, continued economic growth and the protection of vested interests. They follow in the tradition of the USA modification of the Rio Summit Declaration in terms of the necessity 'not to harm economic well-being'.

The ultimate goal from Rio set the environmental reality as the determining contextual constraint within which the economy had to take its place. In contrast, the policy goal set the economy as the determining context within which mitigation of climate change had to take its place as an affordable intervention. The two systems are incompatible.

Meinshausen affirmed strongly: **"Clearly, such a policy goal is not a "safe level" as a global mean temperature rise up to 2°C already implies serious adverse climate impacts in various regions".** Having noted at the outset the discrepancy between the ultimate goal and the policy goal, Meinshausen then dedicates the rest of his paper to attempts to derive emission trajectories to meet the policy goal of keeping global warming below the 2°C level. In addition he addresses the level of certainty required in the achievement of the policy goal. Let us therefore be very clear from the outset that this is not a paper about achieving the prevention of dangerous anthropogenic interference with the climate system, but is dedicated to describing potential action scenarios which have a reasonable level of certainty – in his opinion – of achieving the policy goal. The paper does not address the conference objective of "Escaping the Climate Trap" but is dedicated rather to achieving the policy targets of political leaders, even though those policy targets are known to be profoundly at odds and incoherent with the ultimate objective.

Uncertainty and Complexity

Moving on to speak about the uncertainties in climate science he notes: **"Substantial uncertainties remain in the exact sensitivity of the climate system to human-induced perturbations, i.e. the greenhouse gas emissions."** He also notes that **"we do have certainty about the fact that the climate is changing due to human-induced greenhouse gas emissions and that potentially catastrophic impacts might be triggered."** At this initial point Meinshausen speaks of 'human induced perturbations" in the system behaviour and there is an inherent understanding that the disturbances of the complex system may be setting off behaviours triggered by the human intervention but not linearly and causally dependent upon it. Unfortunately, this is an insight into systems behaviour that is not consistently followed through in the rest of the paper. It is also worth noting that Professor John Holdren, the current President of the American Association for the Advancement of Science, has noted that: **"We have already precipitated dangerous climate change. The task now facing us is the avoidance of catastrophic climate change."**

Uncertainty in climate sensitivity means that estimation of the equilibrium temperature in response to doubling CO_2 concentrations from pre-industrial levels ranges from about 1.5°C to 4.5°C. Obviously the necessary level of emission reductions depends upon the level of certainty required (the uncertainty tolerable) in achieving the policy goal of a maximum of 2°C increase from pre-industrial average global temperature.

Climate Sensitivity

As a basis for his next section, Meinshausen expounds the standard definition of climate sensitivity, namely: **"the equilibrium global mean surface temperature increase for a doubling of atmospheric CO_2 concentrations".** There is a non-validated assumption built in of the logarithmic relationship, so that if doubling pre-industrial concentration from, say, 278 to 556 ppm leads to a climate sensitivity of 3°C, then a doubling again up to 1112 ppm leads to a further 3°C warming. The assumption is a mathematical convenience and is not tested or validated against observed sensitivities of the whole earth in its historical behaviour.

He goes on to affirm: **"Unfortunately, it is not clear, what the real climate sensitivity is …. higher values cannot be excluded."** In spite of that he makes a profound generalisation in the words: **"Taking … recent studies into account, our current knowledge about the climate systems suggests that only stabilization around or below 400ppm CO_2 equivalence will likely allow us to keep global mean temperature levels below 2°C in the long-term."** It is a statement with unqualified uncertainty built in, but then is taken to be and becomes the foundation for the rest of the paper's exposition. It must be noted that these studies of climate sensitivity are based on the outcomes of computer modelling reflecting the mathematical assumptions built into them.

Another recent approach has explored the historical sensitivity of the actual global climate system during the last four cycles of ice-age and inter-glacial warm periods. These studies indicate a CO_2 concentration correlation with temperature change showing convergence around the ratio of 20 ppm rise equivalent to 1°C. These studies would indicate that a stabilised CO_2 concentration of 400 ppm would lead to a temperature increase of 6°C on the global average at equilibrium. These studies indicate a climate sensitivity for the doubling of pre-industrial levels of CO_2 concentrations of between 14°C and 16°C.

The position underlying the discrepancy seems to be that computer models are based on the thermodynamics of absorption of infra-red radiation within certain wavebands by the CO_2 and other greenhouse gasses, whereas the historical observations deal with the earth system as a whole, including the cumulative and interactive response of various complex feedback loops, not as yet adequately modelled within the computer systems. The behaviour of the whole differs from the behaviour of the sum of all its parts. But the computer models omit even some of those parts!

Concentration Levels

In the next section Meinshausen introduces the strategy of peak and decline in CO_2 equivalent concentrations as a more realistic strategy than that which attempts simply to approach the required CO_2 equivalent stabilisation level. He notes: **"Given the need for a 400ppm CO_2 eq stabilization, a slightly disturbing fact is that we are currently already close to that level and will most likely cross the 400ppm CO_2 eq level in the near future."** Interesting that the paper was delivered in September 2006, whilst in February of that year figures being quoted as confirmed at the Scientific Committee of the European Environment Agency's meeting noted that we had just past the 420 ppm of CO_2 eq concentration and by mid-autumn of 2006 the figure of 430 ppm was being consistently used in contemporary literature. He also goes on to say that **"The CO_2 concentrations alone are currently around 380ppm, rising by nearly 2ppm per year."** Worth noting in passing that current concentrations are above that now at just over 382 ppm and that the tangent to the Mauna Loa CO_2 concentration graph indicates a 2.14 ppm per year increase, a rate which is itself increasing slightly year by year.

Meinshausen notes that other anthropogenic greenhouse gasses increase the global warming, whilst certain human-induced aerosols and so forth have a cooling effect. He estimates that these might cancel each other out, whilst noting the huge uncertainly in regard to the cooling effect of aerosols, which may be masking quite significantly the radiative forcing inherent from the rise in CO_2 eq of greenhouse gasses. Not only is that uncertainty ignored in the rest of the paper, but the likelihood that the aerosol emissions rate will decay quite dramatically over the coming decades is also not taken into account. Increased radiative forcing as aerosols are removed from the atmosphere will approximate more and more closely to that inherent in the CO_2 eq concentration.

Feedback and Complexity

What I find most extraordinary at this point is the total omission of water vapour from his understanding of greenhouse gasses. Whilst temperature is stable or the changes are minimal, change in water vapour density can be ignored. However since water vapour forms the basis of some 50% of the overall greenhouse gas effect in the atmosphere, as soon as temperature start to rise, there is an incremental increase in water vapour density and a substantial positive feedback loop between temperature and greenhouse gas effect that is independent of the carbon cycle and independent of anthropogenic emissions.

Meinshausen goes on to introduce the concept of peak and decline in CO_2 eq concentration as a means to attain the policy goal of staying below 2°C. He affirms with some certainty that **"If global concentration levels peak this century and are brought back to lower levels again, like 400ppm, the climate system's inertia would help us to stay below 2°C."** It is fascinating to note that he speaks of **"our goal to stay below 2°C"** indicating his complete adoption of the policy goal and his relinquishing of the tension between that and the ultimate goal of **'avoiding dangerous anthropogenic interference with the climate system'**.

As radiative forcing increases the heating effect, so the extra energy inserted into the near-earth-surface system, begins to raise temperature. The inertia to which he refers represents the fact that it takes a lot of energy to raise the temperature of earth, and even more of water but less so of the atmosphere, so that there is a significant time-lag between increased radiative forcing and an outcome consequential increase in temperature. The so-called 'inertia' is also enhanced by the endothermic phase-changes from ice to water and from water to water vapour. These energy inputs to the system have to be added to the thermal inertia to give an idea of the overall impact of the radiative forcing. However, he seems to assume that the system is a simple system with inertia delaying the outcome of a simple linear cause and effect response.

Meinshausen gives as an example: **"It's a bit like cranking up the control button of a kitchen's oven to 220°C (the greenhouse gas concentrations here being the control button). Provided that we are lowering the control button fast enough again, the actual temperature in the oven will never reach 220°C."** This illustration belies a total lack of understanding of the complex dynamics of the earth's climate system. This simplistic cause and effect relationship underlies his schematic representations of the relationship between emissions, concentration and temperature, on which his policy recommendation scenarios are based. The myth here is that a single control, namely modification of greenhouse gas concentration, is all that is required to stabilise temperature. The myth simply does not bear examination. To render his oven more consistent with reality, there would need to be sensors detecting rise in temperature and turning on other sources of heat not controlled by the button on the front of the cooker.

Complex dynamics, feedback loops, second order feedback processes, thermally-sensitive albedo response, non-anthropogenic greenhouse gas emissions – CO_2, methane and, particularly, water vapour – together with temperature-sensitive degrade of carbon sinks, all combine to make the system inherently an unstable equilibrium in which small perturbations can set off massively amplified diversion from the equilibrium state. Meinshausen appears to have no understanding of complex meta-stable systems capable of altering attractor basins under the impact of small perturbations. His paper is therefore profoundly misleading and ultimately dangerously misinformative as a foundation for any policy formulation, even for the achievement of 'policy-goals' let alone the prevention of dangerous, or even catastrophic, climate change.

Absorption

Another question must be examined at this point. Currently the global commons absorbs some 50% of anthropogenic greenhouse gas emissions. There seems to be some consequent assumption that reduction of anthropogenic emissions to 50% globally would therefore lead to a stabilisation in concentration. That is not so, on two counts. Firstly, there is a non-linear proportional relationship between emission levels and absorption levels. Reduction of emissions to 50% would probably mean that the absorption of even those emissions was between 50% and 60%, so that concentrations would still go on rising. There is no known level of reduction of emissions that does not slowly lead to the incremental increase of concentration. The implications of this new analysis are profound.

The second issue that must be taken into account is that over time, and in relation to rising concentrations, rising temperatures, global pollution and other anthropogenic changes of land use, the carbon sinks degrade. As a result, not only will anthropogenic emissions have to be kept well below global absorption rate and capacity, but that absorption rate as it degrades must also have to handle non-anthropogenic greenhouse gas emissions, such as the thermally induced increase in CO_2 emissions from enzyme activity, bacterial activity, burning of peat bogs, firing of forest as desertification goes forward, methane release, breakdown of atmospheric methane to CO_2 etc. The stabilisation scenarios put forward by Meinshausen are utterly simplistic and dangerously misleading.

Overshoot and Recovery

In his next section Meinshausen acknowledges the inevitability that we will overshoot the CO_2 eq concentration levels required for climate stabilisation (in his analysis) at or below 2°C rise on pre-industrial levels with a reasonable certainty of achievement. He goes on to explore what might be the lowest achievable peak level, and the gradient and shape of the recovery graph from peak to stabilisation level at around 400 ppm. He concludes that a peaking level around 475ppm CO_2 eq might be attainable, followed by a concentration reduction to around the 400 ppm over succeeding decades.

Apart from previous critique, this strategy depends on the timing in which the peak is achieved, i.e. how much we can slow emissions on the run-up to that peak concentration. It also depends on the descent profile, i.e. how fast we can bring down concentration levels. It still naively ignores the impact of feedback dynamics, particularly those which are thermally dependent and will respond to the increase in temperature during the time before stabilisation is achieved. Those feedbacks, of course, threaten the capacity to achieve any stabilisation at all. His figures also depend on an understanding of sensitivity which is model-derived and based on mathematical assumptions rather than whole-earth system observation.

Even with the revised target of achieving ‘policy-goals’ the analysis is profoundly flawed. There is, of course, no pretence that it has anything to do with the ultimate goal of preventing dangerous climate change.

However Meinshausen allocates his proposed reduction in global CO_2 eq emissions, whether on a regional, developmental or per capita basis, his illustrations of strategic interventions are incapable of achieving the policy goals. His notes to Figure 2 show his assumption of a 3°C climate sensitivity and standard carbon cycle feedbacks. The sensitivity coding itself is now under massive critique. Our understanding of the feedback system is much more sophisticated than simply reducing it to standard carbon feedbacks and his understanding of perturbation of a system of complexity in unstable equilibrium is totally inadequate. Once again, I reiterate that he does not take into account:

- the feedback dynamics of water vapour,
- non-anthropogenic greenhouse gas emissions and in particular of the methane cycle,
- the powerful albedo responses to temperature,
- the cumulative effect of sink degrade,
- the reduction of the damping effects of aerosols.

Although in the next section he goes some way to noting the uncertainties, he still comes nowhere near to current understanding of climate dynamics. These would indicate that the period during which temperature continues to rise while anthropogenic emissions of greenhouse gases peak and decline, would be one in which continued high risk of uncontainable perturbation of the system would be experienced.

In Conclusion

The task faced by the global community is now the avoidance of catastrophic climate change, let alone dangerous climate change. Meinshausen severs the relationship between the goal of relating to the fundamental realities of the global climate and what he describes as “policy-goals” - determined by political, economic and other vested interests - without recourse to the fundamental science. Even within the terms of reference of the attempt to achieve "policy-goals" Meinshausen's approach is fatally flawed. The realistic problems we face in the mitigation of dangerous and catastrophic climate change are far too important to allow this kind of work to be used as a basis for policy formulation and strategic action, whether at national, European, G8 or global levels.

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