Met Office

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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,

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