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Interactive comment on "Anthropogenic and biophysical contributions to increasing atmospheric CO_2 growth rate and airborne fraction" *by* M. R. Raupach et al.

M. R. Raupach et al.

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Author Comment on signed review by Niki Gruber

We appreciate very much the detailed and insightful review by Niki Gruber. He makes two main points, concerning (A) "the large uncertainty in the magnitude and trends associated with the land use change (LUC) emissions", and (B) "the framing of the issue of changes in the global carbon cycle in terms of changes in the airborne fraction ... is confusing at best, and could even be misleading".

A. Uncertainty in LUC flux estimates

We absolutely agree with this point. As requested, we have substantially extended the discussion of LUC uncertainties, as follows:

(1) We now include a review of several recent LUC flux estimates in the literature, with discussion of sources of uncertainty.

(2) We have made new calculations based on two perturbations of our LUC flux estimates (FLUC). The first ("perturbation 1") uses an FLUC time series which is uniformly reduced to 0.6 of the primary values used here, giving values similar to the lowest estimate quoted above, 0.9 PgC/y for the 1990s (DeFries et al., 2002). The second ("perturbation 2") assumes that the growth rate in FLUC is 1%/y higher than the time series used in the primary calculation, giving a perturbed FLUC which is the same as the primary value in 2000 but 0.67 of the primary value in 1960. Perturbation 1 yields an estimated trend r(aE) in airborne fraction which is still positive but not significantly different from zero, while perturbation 2 yields nearly zero trend. However, both perturbations also have the effects of increasing the positive trend in the land fraction to values significantly above zero, and further decreasing the already negative trend in the ocean fraction. Both of perturbations 1 and 2 are near the edges of the present uncertainty bands around estimates of emissions from land use change. Opposite perturbations, which are also possible, would influence our primary trend estimates in the opposite sense to perturbations 1 and 2, increasing the estimated trend r(aE).

B. Framing of the issue of changes in the global carbon cycle in terms of changes in the airborne fraction

We agree with most of the points made by Niki Gruber. We take the fact that he felt it necessary to make these points as a sign that the submitted draft of the paper did not adequately convey our views on the status of airborne fraction as a carbon-cycle indicator. To make these views clear, and at the same time to acknowledge and respond to the points made in the review, we have made the following changes to the paper.

(3) We include the calculated partition of total (land plus ocean) sinks into separate

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land and ocean components, in a new Figure 5. This obviously requires additional information (modelled ocean sink estimates from Le Quere et al., 2007). Also, this inclusion allows estimation of the effect of LUC uncertainty on the separate land and ocean sinks, with results given in the paragraph summarised under point (2) above.

(4) In the revised Discussion and Conclusions, we now discuss the strengths and limitations of the airborne fraction as a carbon-cycle diagnostic tool. This discussion addresses points about the nonlinearity of ratios and the potential for misleading interpretation of the airborne fraction. It also makes an additional point which we believe is critical, concerning the "gateway" role of the airborne fraction between anthropogenic forcing and atmospheric response. Total CO2 emissions influence atmospheric CO2 growth, and thence the CO2 contribution to anthropogenic radiative forcing and climate change, via a set of carbon-cycle feedbacks with combined effects given by the airborne fraction. The relative roles of biophysical and anthropogenic influences are then quantified by the extended Kaya identity. This leads to one of our main conclusions: from 1959 to 2006, trends in anthropogenic factors (population, per-capita income and carbon intensity) have had a much greater effect on the growth rate of atmospheric CO2 than the integrated trends in biophysical factors expressed by changes in the airborne fraction.

References

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