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Biogeosciences Discussions

Interactive comment on "A model-based constraint of CO_2 fertilisation" *by* P. B. Holden et al.

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We are grateful for the helpful comments of both referees. All of the replies below will be incorporated into our revised manuscript. A supplementary document is attached. This details the LUC validation and implications for revisions to our analysis (most notably a change of the KC prior assumption).

Anonymous referee #1

1) The introduction and discussion will be expanded to describe all of the mechanisms that have been subsumed into "CO2 fertilisation" and possible implications for extrapolations into future.

2) The emulator is needed because we need to consider marginal distributions for

VPC and KC as DeltaCO2 is strongly dependent on both. The 670 simulations are not sufficient to sample the 28D input parameter space to properly quantify either the expectation or the parametric uncertainty throughout the 2D subspace. Note that the contribution of parametric uncertainty to DeltaCO2 (i.e. the uncertainty arising from the 26 other parameters) is not constant across the VPC/KC sub-space, ranging from 14ppm (low KC, high VPC) to 24ppm (high KC, low VPC). The emulator is applied here essentially as a sophisticated smoothing tool. It allows us to fully and evenly span the 28D input parameter space, producing well-quantified estimates of both expectation and uncertainty at all points in the 2D subspace.

2a) The principal benefit is that the method is independent from bottom-up estimates. In a Bayesian context, the independence of the two approaches has particular benefits as two independent pdfs can be combined, thus reducing uncertainty. In addition to discussing this aspect more fully, we will revise the manuscript to detail the weaknesses and strengths of the two approaches.

2b) Fossil fuel emission uncertainty is subsumed within the structural error. Our 1 sigma structural error assumption of +/-17ppm is approximately equivalent to a 1-sigma uncertainty in accumulated emissions of +/-59 GTC. The 2-sigma uncertainty (+/-118 GTC) compares to estimated total fossil fuel emissions (to 1750-2000) of 278 GTC.

3) We will address the comparison with the results of single deconvolution in the revised manuscript. The methods are closely related as both use an ocean model to constrain carbon uptake and solve for the terrestrial source from the carbon budget. The principal difference is that we are using the budget constraint to calibrate model parameters, thus constraining the dynamics of the vegetation rather than just the output fluxes.

4 a,b) The supplementary document describes the validation of the LUC model (with respect to both temporal and spatial emissions). This will be detailed in the revised manuscript, together with a discussion of the qualities of the LUC model.

4c) Although ENTS is based around a single PFT, the climatic dependencies of this

PFT are sufficient to provide a reasonable spatial description of vegetative carbon density (see Williamson et al 2006 or plots in supplementary attachment). As a result, simulated spatial patterns of LUC emissions vary greatly (and reasonably, see supplement) depending upon whether the local potential vegetation is "forest" (high veg carbon density) or "grassland" (low veg carbon density). We will discuss this within the LUC validation.

d) The dynamics of Equation 3 do not distinguish between crops and pasture because at the level of detail of Equation 3, and with a single PFT, we believe the principal difference between crop and pasture is the value of KC (the reduction of leaf litter input to soils). This varies between crop and pasture but equally has substantial spatial variation between different cropland areas (and also pastures). In our parametric approach to the quantification and reduction of uncertainty, the most appropriate was to represent this variation is by considering a range of values for KC.

At the global scale, the effect of LUC on soil accumulation/depletion is captured through KC. As discussed in the supplementary material, KC can be constrained by independent data and used to refine the validation of the model, an approach that will be followed in the revised manuscript. Vegetation carbon is reasonably represented by ENTS, and a wide range of uncertainty is encompassed. However, the response of soil carbon to LUC is governed not only by ENTS uncertainty, but also KC uncertainty. We now consider that the prior for KC should be chosen to ensure that a reasonable range of historical LUC emissions is encompassed. The consequence is that the global soil response to LUC should be reasonably encompassed. However, we are aware that there are limitations to this approach (and to GENIE in general) at the regional level.

5) See response to 4 and supplementary material.

6) It is, to our knowledge, the first attempt at a top-down probabilistic calibration, though not the first attempt at a top-down quantification per se (as the manuscript presently reads). The revised manuscript will clarify this.

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/9/C4955/2012/bgd-9-C4955-2012-supplement.pdf

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