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Biogeosciences Discussions

Interactive comment on "Estimation of land-use change using a Bayesian data assimilation approach" *by* Peter Levy et al.

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We thank the referee for their thorough reading of the manuscript. We address their points (*shown in italics*) below.

1. Notation - *use of upper-case bold letters for vectors*
The referee makes a valid point, but there is not a perfect solution. The confusion is that some of the vectors we refer to are subsections of a 3D array or matrix (e.g. $\mathbf{U}_{xy}$). We therefore retain the uppercase bold letters for these, and the subscripts define the dimensions referred to. Where the vectors are not part of an array or matrix, we will use lowercase bold as suggested (the vectors $\mathbf{t}$ for time, $\mathbf{g}$ and $\mathbf{l}$ for gains and losses).

There are also some inconsistencies which we will correct: the scalar $A_{gridcell}$ in Eqn 1 should appear as lowercase, so we replace it with l^2 where l is the length of the side of the grid cell.

2. Notation - *use of upper case U to indicate a scalar value* rather than *a random variable*.
This convention exists in the stats literature, but we can't try to be consistent with two different conventions. Apart from the points made in (1) above, we think it clearer to use the wider maths convention of uppercase bold denoting matrices (and arrays), with italics denoting the individual elements.

3. Countryside Survey *There is a reference to a bootstrapping procedure, but this is in an inaccessible internal report which, as far as we can tell, has not been peer-reviewed. What is the bootstrapping seeking to achieve, and how is the stratification which underlies the CS survey accounted for?*

Unfortunately, the details of the Countryside Survey data analysis are not available in a peer-reviewed published paper. The 1990 ITE Land Classification (https://catalogue.ceh.ac.uk/documents/235c42f5-6281-40f6-a74c-1b4eb29c78b1) was used to stratify the survey squares, and land-use change was estimated separately for each of the 32 classes. The bootstrapping is attempting to provide confidence intervals on the national-scale estimates of the areas of land-use transition (i.e. the $\mathbf{B}$ matrix). It does this by resampling the data within each class, allowing the within-class variability and classification errors to be propagated. We can add further details to the text, but we are proposing a better method, so CS is not the focus of the paper.

4. *Assumption of independence of errors in the likelihood functions*
In principle, the referee is correct, and the non-independence of the different land uses should be accounted for, rather than summing independent Gaussian terms. However, we do not think this is a serious issue here, for the following reasons.

- Several data sources were used, so different independent estimates of the area of the different land uses are brought in, which mitigates the problem.
- In all the likelihood functions, σ is generally large, making non-independence less of an issue, at least in relative terms.
- The consequence of assuming non-independence of errors would be to produce unreasonably small uncertainties in the posterior parameters. We don't see that.
- Unless the referee can see one, there is no obvious way to account for the non-independence mathematically. The Dirichlet distribution has been applied to related problems, where fractions must sum to 1, so the components are intrinsically correlated. However, it is not obvious how this could be applied here, and the method usually fails for numerical computation reasons when dealing with very small numbers. We can add some discussion to this effect, but we don't see an immediate solution.

5. *It would help the author's case if they could use their modelling framework to explore, independently of their data, the scope for variation in CO_2 fluxes associated with some fixed net land use change when gross land use changes are varying.*
We did consider this, but the problem seemed to us that if we devised an arbitrary land use change scenario (small fixed net change, larger gross change), the results (the CO_2 flux) would be also be arbitrary. A non-arbitrary scenario isn't obvious to us (but open to suggestions). We have submitted a paper elsewhere on the IACS data itself, where we contrast the CO_2 fluxes calculated using the detailed gross change versus the CO_2 fluxes calculated using only the net change. There is not an analagous comparison here.

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