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Comment

***Interactive comment on “The European  
CO<sub>2</sub>, CO, CH<sub>4</sub> and  
N<sub>2</sub>O balance between 2001 and 2005”  
by S. Luyssaert et al.***

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Referee 2

Section 1: “GHG balance must be estimated by at least two independent approaches”  
Is this an over-statement? Could an alternative estimated be derived by using all the  
bottom-up information as constraints in the top-down inversion method?

The following statement was added: ‘Alternatively, all bottom-up information could be  
used as constraints in the top-down inversion method; an approach that is currently  
being developed (Rayner et al., 2005).’

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Table 1: Check references. Should these all be listed in the supplementary material? eg Grassi is missing from the reference list. Should Bryne be Byrne (component 2l?)

We checked whether all names (product description) appeared in the supplementary material. The spelling of Byrne was corrected.

From Table 1 it appears 2a and b are independent estimates of NEE, but Eq(2) and Figure(2) suggest they are gross components of NEE, perhaps GPP and ecosystem respiration? This needs to be clearer.

Added the following text to Eq 2 'Where  $f_{2a}$  denotes gross primary production (GPP or photosynthesis) and  $f_{2b}$  denotes ecosystem respiration (Re or the sum of autotrophic and heterotrophic respiration). When the eddy-covariance method is used the net flux  $f_{2a} + f_{2b}$  is directly measured (further labelled as  $f_{2ab}$  in Table 1) and the component fluxes can only be estimated (Reichstein et al., 2005).'

Table 1: 2fgh: Is this supposed to be net land use change emissions? (Component title is a little unclear).

Done

In general, Equations 1-10 are difficult to read. "The use of terms "1a etc: : ":" is not appropriate for inclusion in equations. The numbers and letters could appear as subscripts on variables" eg  $f_{1a}$  (f for flux).

Done

A little more explanation of each equation in the preceding text might be helpful. Otherwise each equation requires a taxing term-by-term cross-referencing of Table 1 and Figure 2, which themselves could be a little clearer (see eg the two comments above).

All equations are now introduced so the reader gets a broad idea of what is being calculated. For the details, however, the reader needs to switch back and forth between

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the equations and Table 1.

â€”c Omit “-“ on the left hand side of each equation, unless it is meant as a minus sign.

Done

â€”c Equation 9: A sign “+” is missing between 6d and 2ab. â€”c

Added

What is the significance of grouping terms in parentheses in Equation 9?

The meaning of the terms between brackets has been explained in the text i.e. ‘. For the flux-based approach, the contributions from inland waters, land ecosystems and the biological products (these three components are delimited by brackets) should be summed:…’

â€”c Many terms are common to both the inventory- and flux-based approaches. Attention should be brought to these and the consequences for independence of the estimates evaluated.

The following sentence was added: ‘Finally, the inventory-based approach cannot make use of stock changes in the geological pool and therefore uses the same data as the flux-based estimate. Inventory and flux-based approaches also share the data for emissions from bio-fuels.’

Sections 1 and 2.3 : replace “confronted with” by “compared to”

Done

Section 2.6: qualify “interannual variability”. Is this 1 s.d.?

Done (added ‘one standard deviation’ to the text)

Section 2.6: “balance sheets” does not have a precise meaning here.

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Replace 'balance sheets' by 'aggregated fluxes'

Section 3.1: "interannual variability hints at the sensitivity of the land surface to climate variability": Reword to be more specific.

We added 'For example, the 2003 heatwave over Europe was instrumental in understanding how the land surface may respond to future climate (Ciais et al., 2005) for which similar events are predicted to become more frequent (Stott et al., 2004).'

Section 3.1 "Contrary to our observations : : :": Your observations of what? This sentence does not make sense.

This sentence was rephrased 'Contrary to the observed low variability in northern Europe, this set-up of the inversions is expected assigning the residual fluxes and thus the highest variability to northern and southern Europe.'

Section 3.2.2. The uncertainty estimate of about 50% on the flux-based estimates of NEE seems quite generous. From Jung et al. 2011, "With a modeling efficiency of 0.32 and an RMSE of 197 g C m<sup>-2</sup> yr<sup>-1</sup> the among-site variability of NEE is poorly reproduced by MTE, particularly for sites that are strong carbon sinks. Clearly, we are lacking determinants of mean NEE in the predictors for MTE such as soil and biomass pools, disturbances, ecosystem age, management activities and land use history." Also, the flux-based NEE inherently has no information on temperature or CO<sub>2</sub> trends which are key determinants of mean NEE.

It is not entirely clear whether the reviewer feels that we are too generous for the method (and thus underestimate the uncertainty) or that we are too generous with our uncertainty (and thus overestimate it). Based on the subsequent sentences in this comment we interpreted the comment as we underestimated the uncertainty. We tend to agree that we may underestimate the uncertainty of this approach, however, rather than trying to guess the most realistic uncertainty for every individual component, we decided to simply assume the same uncertainty for all data products for which a formal

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analysis was missing. For the MTE approach a formal analysis was missing so we applied the 50% (s.d.) uncertainty.

Following this comment we checked whether such a rigid approach could have influenced our final conclusions. An even more uncertain flux-based approach would have had little effect on our 'best available estimates' as their uncertainty is largely determined by the inventory-based approach. Further NEE is already the single largest contributor to the uncertainty of the flux-based estimate. Further increasing its uncertainty would not change this observation.

Given the above we preferred the current simple approach rather

Section 3.4. "Applying the Bayesian theorem.." Please explain how Bayes' theorem was applied here.

A new section 2.7 was added to the materials explaining how how Bayes' theorem was used. '2.7 Best available estimate. The inversion-based, inventory-based and flux-based estimates were used to obtain a single 'best available estimate'. The Bayesian theorem was used to calculate the posterior density of the flux estimates by informing a vague normal distributed prior with extremely large variance with the flux estimates from the three aforementioned sources. The posterior density was approximated through Markov Chain Gibbs sampling making use of WinBUGS software (Spiegelhalter et al., 2002)'

Section 3.5, p2027 Replace "Afforestation doubled the sink strength by: : :'" to "Afforestation doubled the sink strength to: : :'"

Done

Section 3.5, Table 5: It would be helpful to have the absolute sink strength for each land-use type listed in Table 5.

Done, see second column of Table 5)

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Section 4: In the priority list of C-balance components which should be addressed to reduce uncertainty in the overall budget, could you be more prescriptive (rather than ending the list with etc.)?

Replaced 'etc' by listing the relevant fluxes. 'Given that both the net land to atmosphere CO<sub>2</sub> balance and the land C-uptake are determined by a few large fluxes i.e. emissions from fossil burning, change in C content of forests and product decay the uncertainty of these key components needs to be formally estimated before efforts could be made to reduce the uncertainty.'

Section 4: Can you return to the hypothesis of an increasing European C-sink, which was introduced in Section 1?

We added 'For the same reason we could not estimate the European sink for two time periods and can therefore not determine whether the sink increased decreased or remained unchanged. Given the high uncertainty, important changes in the sink strength would be required to result in a statistical significant change.'

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Interactive comment on Biogeosciences Discuss., 9, 2005, 2012.

**BGD**

9, C2213–C2218, 2012

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