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Biogeosciences Discussions

Interactive comment on "The carbon budget of terrestrial ecosystems at country-scale – a European case study" *by* I. A. Janssens et al.

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GENERAL COMMENTS

The manuscript breaks down the land-based, continental-scale estimate of the European terrestrial C sink, which has been presented by the authors earlier (Janssens et al., 2003), into country-specific estimates of C balances. Country-specific data of C sequestration by terrestrial ecosystems are highly desirable, because nations and not continents are the main actors in international negotiations and efforts addressing global climate change (e.g. United Nations Framework Convention on Climate Change, http://unfccc.int/). As people involved in these political processes might have limited access to classic scientific journals, an open-access journal like "Biogeosciences" might be especially suited for publication of the country-specific data presented in the manuscript.

Compiling a data set of C budgets of all main terrestrial ecosystem types for 34 individual countries is a challenging task that requires assumptions and simplifications.

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From my point of view, the manuscript could be improved by explaining methods and assumptions in more detail. The authors stress that the overall C balance is very sensitive to small changes of the C balance of individual ecosystem types because it is the sum of large but opposing fluxes (e.g. P168 L13-17). Hence, a more detailed analysis of the uncertainty and the sensitivity of the C balance of ecosystem types with respect to the assumptions that have been made appears crucial to me. Especially the adjustment of the output of the CESAR model for all countries seems questionable to me and needs a better justification, in-depth analysis, and discussion. This would also require a more detailed presentation of the results than is currently achieved by the graphs. Finally, the discussion of mitigation options in chapters 3.6 and 3.7 appears somewhat disconnected from the rest of the manuscript because it is not directly based on the country-specific data presented. The integration of this section could probably be improved by illustrating the potential of measures for individual countries, not for Europe as a whole (e.g. Denmark for reductions of agricultural C losses, Sweden or Slovakia for maintaining the forest carbon sink, Ireland for protecting peat reservoirs...).

SPECIFIC COMMENTS

Abstract

The sentence in lines 6-8 (P168) addressing the drainage and extraction of peat could be formulated more precisely. I suggest the formulation: "Drainage and extraction of peat strongly reduced the net carbon uptake of terrestrial ecosystems in countries characterized by a large fraction of peat land."

Introduction

As stated above, the main reason to derive country-specific estimates of C sequestration is probably that these estimates are needed within the framework of international political processes. Therefore I would emphasize the importance of country-specific estimates e.g. for the Kyoto process in the rationale section of the introduction, rather than placing the political aspect in the objectives. This would also justify the discus-

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sion of mitigation options with respect to the Kyoto protocol on pages 180-183. I would not stress the dual constraint approach in the introduction, because comparisons between top-down and bottom-up estimates of C sequestration are not the focus of the subsequent analysis.

Materials and Methods

Generally, I would appreciate more detailed information on the methods applied. If this information exceeds the space that is available for Materials and Methods in the manuscript, the authors could make use of the possibility to prepare supplementary material for online publication.

Especially the decision to use the value half way between the average and the smallest result of the CESAR model for all countries instead of the mean outputs needs to be explained and justified in more detail (P171 L8-13). According to the authors, table 1 on page 186 indicates that the CESAR model generally tends to overestimate the release of C from agricultural soils (P171 L10). However, estimates derived with the model are in good agreement with reports of C stock changes for two of four countries. I would conclude from table 1 that the CESAR model describes the C processes in agricultural soils of Belgium and the UK quite well, whereas it has difficulties to describe C turnover in soils of Finland and Austria. The model uses a set of parameters that has been mainly derived from experiments in the Netherlands (Table 2 of Vleeshouwers and Verhagen, 2002). It seems reasonable to me that crop and soil parameters determined for the Netherlands fit better to the situation in Belgium and the UK than to the situation in Finland and Austria. In fact, Vleeshouwers and Verhagen (2002) stress that the Dutch crop parameters might be not "the best estimates for countries with lower levels of crop production". From my point of view this calls for a more detailed analysis of the performance of the CESAR model under different agro ecological conditions. I would suggest two options to achieve a better insight into the performance of the CESAR model. It might be useful to run CESAR with input data from agricultural long-term experiments that monitor changes in soil carbon stocks in different agro ecological zones

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to compare model outputs with experimental results. A second alternative might be to compare the results of CESAR with the results of more sophisticated soil C models that have been calibrated for the conditions in different countries. These approaches might provide an idea of the error of the CESAR results for different countries. In the best case, they might allow some kind of recalibration of the model for conditions very different from the ones in the Netherlands. It might also be illustrative to use the mean output and an adjusted output of the model to explore the sensitivity of the results to these adjustments.

Results and Discussions

Figures 1, 3, and 4 are difficult to understand. As far as I understood, the authors normalized the total C flux from or into the ecosystem types to the total area of the respective country on the y-axis and plotted this value against the fraction of forest land, arable land or grassland. In case that my interpretation is correct, the significant correlations presented in the graphs are not surprising to me. I agree with the authors, that the variability of the C balance of ecosystem types of different countries is much more interesting (e.g. P172 L26). However, the exact values for different countries are difficult to obtain from the figures. I suggest to replace figures 1, 2, 3, and 4 by one big table that includes the areas of ecosystem types for the different countries and for the total study area, the C balance of ecosystem types per square meter and as integral, the uncertainty or the range of C fluxes for the ecosystem types of different countries and for Europe as a whole, and the total carbon balance. I think that such a table would improve the transparency of the results and would facilitate the detailed analysis of the factors that determine C sequestration, the discussion of uncertainties, and the comparison of the results with data from the literature.

The authors state correctly that the C sink estimated from forest inventories relies heavily on biomass expansion factors (BEFs, P173 L11-17), which are supplied by the individual countries. I would appreciate an analysis of the sensitivity of the forest C balance with respect to the BEFs that are used. Would it be possible to provide a correlation

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between the specific C balance of e.g. spruce or pine forests of different countries and the BEFs used by these countries? Such correlation might give an impression how sensitive the forest C sink (and subsequently the total C balance) is to "manipulations" of the BEFs by individual countries. Another way to explore the sensitivity of the forest C sink might be to use default BEFs from the "good practice guidelines" or average BEFs in comparison to country-specific BEFs.

On page 179, L16-23, it is stated that the positive C balances of European forests are the result of an age structure with a significant share of young forests, which implies the risk of decreasing C uptake with progressing tree age structure in the future. It is not obvious for me in which ways continuous-cover forestry and setting aside productive forests counteract the abovementioned process to maintain the current sink strength of forests.

The explanation of Articles 3.3. and 3.4 on page 180 (L6-29) appears somewhat lengthy and excursive to me.

The discussion of C losses from arable soils on page 175 (L8-28) is almost identical to the discussion published by the authors on page 1539 (last paragraph of the left column and first paragraph of the middle column) of Janssens et al. (2003). The analysis and discussion of the results of the CESAR model for different agro ecological conditions suggested above probably provide a good opportunity to add important aspects to the discussion published earlier in "Science".

TECHNICAL CORRECTIONS

P168 L15: Consider "small" instead of "relatively minor".

P168 L18: Replace "balance" by "uptake".

P168 L26: Consider "from the burning of fossil fuels and from deforestation (IPCC, 2001)."

P168 L26-P169 L1: Consider: "One reason for this..."

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P173 L9: delete "annually"

P181 L1: change "3.7 Reduce the leak" into "3.6.2 Reduce the leak"

P181 L11-13: I would prefer SI units (e.g. "Tg") instead of "Mt".

P181 L11-12: "Freibauer et al., 2003" is missing in the list of references.

P184 L5: title of the reference Janssens et al. (2003) is missing.

P184 L30: Please check if "Olivier J.G.J." is cited in the text.

References:

Janssens, I.A., Freibauer, A., Ciais, P., Smith, P., Nabuurs, G.-J., Folbert, G., et al.: Europe`s terrestrial biosphere absorbs 7 to 12% of European anthropogenic CO2 emissions, Science 300, 1538-1542, 2003.

Vleeshouwers, L.M. and Verhagen A.: Carbon emissions and sequestration by agricultural land use: a model study for Europe, Glob. Change Biol., 8, 519-530, 2002.

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