Interactive comment on "The European forest sector: past and future carbon budget and fluxes under different management scenarios" *by* Roberto Pilli et al.

Roberto Pilli et al.

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Many thanks for this critical and constructive review. Regarding your general comments, our study is based on the application of the Carbon Budget Model (CBM) to National Forest Inventory (NFI) or Forest Management Plans (FMP) input data, combined with additional information provided by FAOSTAT (on the historical harvest removals), by other research institutes (i.e., the European Forest Institute database on the forest storms), by literature or directly provided by countries. The CBM is a well-known and documented forest inventory model (Kull et al., 2016) largely applied in many scientific studies and different countries (see for example, between the most recent scientific publications, Kim et al., 2016; Smyth et al., 2014; Pilli et al., 2013). The

NFI and FMP input data applied by model are generally public available, see Tab. 1 on the manuscript, with few exceptions (where we received some personal communications by country's experts), highlighted on the same table. The main input data used to define the harvest demand and the main disturbances are also public available (see FAOSTAT and EFI web sites). The principle of transparency, requires clear explanations of methods to allow full understanding of the methodologies and data behind the estimates (IPCC, 2010). In this sense, we respectfully disagree with the reviewer, our results are not based on a "black box", and the fact that CBM is not an "open source" model, doesn't mean that this is not transparent. On the contrary, our estimates were based on a transparent model framework (all model details are described in the model's user guide, Kull et al., 2016), using public available data. A synthesis of the general framework followed to apply the CBM model to each country is reported in Figure 1, based on the suggestions reported by the IPCC check list for documenting the application of a Tier 3 model-based approach at the local level (IPCC, 2010). If useful, additional details on our methodological assumptions and input data can be certainly added (also as supplementary materials). However, in our opinion, the current version of the manuscript already provides general information and many references about the model framework and our methodological assumptions. As noticed by the reviewer, the paper is already quite long, and we will try to further synthetize our results and discussion, without adding further information already provided by previous studies.

As highlighted by the reviewer, the manuscript provides important information for countries' planning and international agreements. In this paper, however, we focus on the forest C fluxes and stocks related to the interactions between biological, physical and human processes and between a terrestrial life system (i.e., the forest system) and the atmosphere. In this sense, in our opinion, the manuscript corresponds to the objectives of this journal, achieving an interdisciplinary view of these interactions. Apart from some important update on our input data (see again Tab. 1), in comparison to other previous studies (Pilli et al., 2016a and b), in the present work, (i) we quantified in detail the C fluxes and stocks between the forest pools and the atmosphere, includ-

ing Net Primary Productivity (NPP), Net System Exchange (NSE) and Heterotrophic respiration (Rh); (ii) these and many other quantities were quantified not only for the historical period 2000 – 2012 but even to 2030, under different model scenarios. None of these elements was considered by our previous studies.

Specific comments:

1. L. 16, we would edit the text, as suggested.

2. L. 23, we will carefully check the abstract.

3. L. 31 – 32: our study distinguished the forests existing in 1990, defined as Forest Management area (FM) by the land use change (due to afforestation and deforestation) occurred on this area (see also point 7). In many European countries, due to an ageing process, part of the FM area is getting older and despite the increasing NPP, the greater increase of heterotrophic respiration leads to a decrease of the forest C sink. This confirms an age-related decline in the productivity of the European forests (Zaehle et al., 2006), and it is consistent with the results from other studies in the literature, suggesting some signs of C sink saturation in existing European forest biomass (Nabuurs et al., 2013).

4. L. 40, as explained on paragraph 2.3, our study confirms that the build-up of biomass stocks results from woody NPP, exceeding losses by harvest and natural disturbances. This relationship can be also analyzed by comparing the evolution of the biomass as a function of the NPP, i.e., the turnover time (τ). Through a statistical analysis, we compared the τ of each country, highlighting some statistical difference (we can identify at least three groups of countries and turnover times). This means that, contrary to the assumptions proposed by other authors, this relationship cannot be assumed as a constant for all the European countries.

5. L. 58, we would edit the text, as suggested.

6. L. 132, we would edit the text, as suggested.

7. L. 138-139, in order to model the land use change (i.e., afforestation and deforestation) occurred on the European forest area, we need to define a benchmark (i.e., a baseline) for the forest area existing in a certain year. To be consistent with other study and to provide more useful information (also at country level), we prefer to use the Kyoto Protocol base year, assuming the 1990 as base year. In this context, forest area existing in 1990 is generally defined as "Forest management" area.

8. L. 399, the forest ecosystem balance reported by Figure 4 is given by difference between the main input (i.e., the NPP) and outputs (Rh, harvest and natural disturbances) quantified at country level.

9. L. 469, we would edit the text, as suggested.

10. L. 490, we would edit the text, as suggested.

11. Thank you, we appreciate this

12. L. 588, we would edit the text, as suggested.

13. L. 590, thank you for this suggestion, we would consider this for our ongoing work. Since the current model framework is not considering the effect of climate change, at this stage, we would prefer to compare our results with similar studies, such as the models reported by Tupek et al. 2010. However, we are currently working to include the effect of climate change, on a longer time frame, linking CBM with process-based models, such as the models considered by the CMIP5 archive. However, this is part of our ongoing working program, not considered in the present study.

14. L. 613 – 638, generally, the purpose of the Conclusions is highlight the main findings (i.e., conclusions) and provide an explanation of the importance and relevance of the study. In this sense, we think that conclusions should recall some of the main results reported above. In any case, we understand your point and we will review and further summarize this section, as suggested.

15. We will add the acronyms, as suggested.

16. We understand your point, but due to the complexity of the figure we think that it has to be clearly explained in the caption. Anyway, if necessary, we can move part of the text to the methods.

Additional references:

IPCC, Intergovernmental Panel on Climate Change. Use of Models and Facility – Level data in Greenhouse Gas Inventories. (Report of the IPCC Expert Meeting on Use of Models and Measurements in GHG Inventories. 9 – 11 August 2010, Sydney, Australia). Eds.: Eggleston, H.S., Srivastava, N., Tanab,e K., Baasansuren, J., Fukuda, M., GHG Pub. IGES, Japan 2010.

Kim, M., Lee, W.K., Kurz, W.A., Kwak, D.A., Morken, S., Smyth, C.E. and Ryu D. Estimating carbon dynamics in forest carbon pools under IPCC standards in South Korea using CBM-CFS3. iForest - Biogeosciences and Forestry, 1071-1080, DOI, 10.3832/ifor2040-009, 2016.

Kull S.,J. Rampley G.J., Morken S, Metsaranta J., Neilson E.T. and Kurz W.A. Operational-Scale Carbon Budget Model of the Canadian Forest Sector (CBM-CFS3) Version 1.2: User's Guide. Canadian Forest Service, Northern Forestry Centre, 2016.
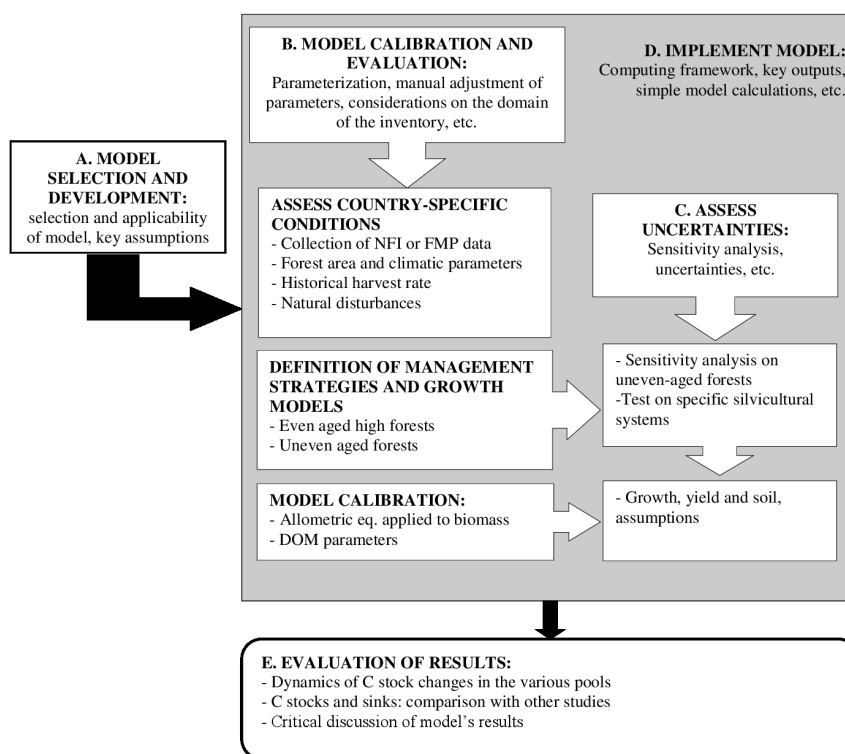
Fig. 1. General framework followed to apply the CBM to country-specific case studies. The capital letters (A to E), refer to the IPCC check list for the application of Tier 3 model-based approach (IPCC, 2010)