

## ***Interactive comment on “Modelling soil organic carbon stocks in global change scenarios: a CarboSOIL application” by M. Muñoz-Rojas et al.***

**M. Muñoz-Rojas et al.**

miriammunozrojas@gmail.com

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We thank Anonymous Referee #3 for the insightful comments and constructive suggestions. We gratefully accept all suggestions which have improved considerably the manuscript. Please, see below the responses to each specific comment.

[Comment] In the Introduction section, a brief description about the Mediterranean systems and their role in a climate change scenario could be interesting. This would help readers not familiarised with these systems to understand the importance of the paper and the consequences of climate change in Mediterranean systems. [Response] A brief description of the interrelations of climate change and Mediterranean systems has been incorporated in the introduction section. Please, see the paragraph below: “Soil carbon contents in Mediterranean areas are usually lower than in temperate re-

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gions because of the particular climate features of these regions such as seasonal dryness (Jones et al., 2005). Mediterranean ecosystems are particularly sensitive to climate change because of the predicted reduced water availability and the increase of desertification risk (IPCC, 2007). These factors might lead to a decrease of plant productivity and a lower C input to soils. As a consequence, most Mediterranean soils would be depleted of SOC which would translate in low soil fertility (Aguilera et al., 2013). Therefore, it is crucial to study the effects of climate change on SOC contents of different land use and soil types of Mediterranean areas in order to prevent SOC decreases by adequate land planning and adoption of management practices”.

[Comment] The first objective of the paper states: “to test and validate the CarboSoil model in climate change scenarios”. This is confusing. The validation of the model should be made according to current climate data. Once validated, the model can be used for future predicting purposes. [Response] The objectives have been modified according to the suggestion. Please, see the following paragraph that has been incorporated: “ In this study, CarboSOIL model together with climate outputs from different GCMs (BCCR-BCM2, CNRMCM3, and ECHAM5) driven by SRES scenarios (A2, A1B and B2) were used to study the effects of climate change on SOC dynamics in a Mediterranean region (Andalusia, S Spain). The main objectives are: a) to predict SOC contents in future climate projections for different soil and land use types, (b) to obtain the spatial distribution and SOC stocks for different climate projections and (c) to determine CarboSOIL model sensitivity to climate variables.”

[Comment] In the Material and Methods section, it should be clear stated if CarboSoil is either a simulation model or a tool. Also, it should be stated which type of model is. Since it seems that the model has not been published yet, more information about the model would be interesting to show. In my opinion Fig. 2 is not adding some much information to the paper. Thus, I would replace it with a new figure. Probably a conceptual diagram showing how the model works would help to understand better the model. [Response] Since it may be confusing, we have specified in the materials and

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method that CarboSOIL is a simulation model (set of submodels). Additional information has been incorporated in this section regarding the model. Also, Figure 2 has been replaced by a new figure (please, see Figure R2 attached), which is a general diagram of CarboSOIL representing the input factors, process and output factors of the model.

[Comment] It is not clear for me what authors consider as “study area”. Why is not Valencia described in the study area section as it is made for Andalusia? I think it should be included since it was used for validation purposes. [Response] The dataset of Valencia region was used as the test data to build the model. However the application of CarboSOIL in climate change scenarios has been undertaken in Andalusia. Therefore we have removed the Valencia region from the study area map (please, see new Figure 1R attached) and the materials and methods section.

[Comment] Please include the range of ETo values in the study area. [Response] The range of ETo values in Andalusia has been included in the materials and methods section.

[Comment] Regarding the SOC observed values, when was the sampling performed? Were all the profiles sampled at the same time? If not, please indicate the time period. [Response] The sampling performed for the data collection of the soil profiles used in this study were taken during the years 1994-2004 within different studies and projects compiled in the SEIS net database (De la Rosa et al., 2002) and the Technical Report from Jordan and Zavala (2009).

[Comment] It would be interesting to see the proportion of soil profiles sampled for each land use class. [Response] A new table has been included (please, see Table R5 attached) which shows the initial stocks of the different land use and soil types including the number of soil profiles sampled for each land use class and soil type.

[Comment] In the Results section, Table 4 reports observed values and mean predicted values for each climate scenario. According to the explanation given in section 3.1, this table should be reporting observed SOC values and the predicted values for the current

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climate conditions instead. This dataset (predicted values from the current climate scenario) could be used for validation purposes. I do not think that predicted values from climate change conditions may be validated with current observed data. [Response] The climate datasets used in this study include projected scenarios in future climate projections but also baseline scenarios (current scenarios based on 1960-2000) that represent actual precipitations. Table 4 correlate the observed values of soil organic carbon contents and the modelled values in current climate conditions. However, since it may be confusing we have addressed this matter by clarifying the Table description (please, see Table R4 attached).

[Comment] The section 4.1 does not report any discussion to the data obtained. This section is a summary of similar studies performed in Europe. I recommend that authors eliminate this section from the Discussion. [Response] This section has been removed from the discussion.

[Comment] The section 4.2 needs more discussion. It would be interesting to see discussion about the different SOC change predictions obtained between land uses and between soil types. The model reports SOC changes in different soil layers. As reported in the results section, soil depth had a significant impact on SOC changes under climate change conditions. This finding should be more detailed in the Discussion section since it is an interesting finding. [Response] We have addressed this issue by elaborating on section 4.2. Please, see below some paragraphs that has been incorporated in section 4.2. “Increasing summer temperatures will affect the SOC pools up to 50 cm, with a consequent depletion of this pool, mainly in sensitive land areas such as salt marshes and fruit trees and berries plantations. On the other hand, the sensitivity analysis suggests that winter temperatures are desirable for increasing SOC contents. It has been reported that increasing temperatures will accelerate C decomposition (above photosynthesis rates) due to the rise of temperatures (Zhang et al., 2005). This effect will be stresses in managed soils and consequently, direct climate impacts on croplands and grasslands soils will tend to decrease SOC stocks

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all over Europe (Smith et al., 2005). Our results suggest that the effects of temperature are different along the soil profile decreasing with depth, which is in accordance with previous studies in Mediterranean areas (Albaladejo et al., 2013). These differences might be explained by changes of properties in soil organic carbon compounds or even enzymatic processes in different horizons. Although temperature clearly affects decomposition of a labile SOC fraction, a significant portion of SOC is influenced by other environmental factors (Davidson and Janssens, 2006). Another important factor to consider in the SOC distribution along the vertical section of the soil profile is the root allocation, which varies for different vegetation types. (Jobaggy and Jackson, 2000). In the deeper layers of “scrubs” the model projected considerable increments in SOC stocks, which might be explained by the growth in depth of the vegetation roots of new species adapted to arid conditions of a future climate. Also, areas as “open spaces” will undertake important declines of SOC stocks in the 0-25 and the 25-50 sections of the soil profile. These areas are particularly vulnerable since are usually burnt areas or areas under erosive processes (Muñoz-Rojas et al., 2011). In contrast, CarboOSIL model predicted minor losses of SOC stocks in “forests”, which can be explained by a higher relative aboveground allocation. Among the agricultural areas, the upper layers of “permanent crops” will be largely affected, in agreement with previous studies that reported decreases of SOC stocks of vineyards in Italy in the next decades (Francaviglia et al., 2012). The land use type “permanent crops” include olive groves, vineyards and sensitive crops such as fruit trees and berry plantations, which occupy more than 15% of the total area of Andalusia (Muñoz-Rojas et al, 2011). Therefore management practices should be considered to avoid SOC losses in these areas”

[Comment] Regarding section 4.3, a key source of uncertainty is that the model is not able to simulate the effect of CO<sub>2</sub> increase on C inputs and thus on SOC turnover. This issue should be discussed in the manuscript and how this limitation affects the final results found. [Response] We have addressed this issue by elaborating on section 4.3. Please, see below the new paragraph that has been incorporated in section 4.3. “Global warming and the increase of CO<sub>2</sub> concentrations of the atmosphere in a future

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climate scenario are predicted to increase the net ecosystem productivity (NEP). The increase in NEP, which is the organic carbon in an ecosystem available for storage, could lead to a larger input of organic matter in the soil (Lovett et al., 2006). CarboSOIL does not consider these factors which could have considerable impacts on predicted SOC contents in future scenarios. However, it is difficult to predict the CO<sub>2</sub> fertilization effect, in particular in a long-term period, because it might reach saturation, and other factors such as water deficit could play an important role (Fatichi and Leuzinger, 2013).”

Please also note the supplement to this comment:

<http://www.biogeosciences-discuss.net/10/C5553/2013/bgd-10-C5553-2013-supplement.pdf>

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Interactive comment on Biogeosciences Discuss., 10, 10997, 2013.

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