

## ***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 #2 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.

[Specific comment] Abstract: Please clarify the status of the Valencia data set in the paper and specify that CarboSOIL is an empirical model. [Response] Specifications on CarboSOIL as empirical model have been included in the Abstract. The status of the Valencia dataset has been removed since it may be confusing. The Valencia dataset was used for the construction of the model as the test dataset but the purpose of this study is to describe the final model and apply it in Andalusia in global change scenarios.

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[Specific comment] p. 11001 l.8: What do you mean by “speciñAc for certain agricultural management”. RothC has been used and evaluated in a range of contexts. [Response] The paragraph has been removed since it was unclear. Indeed, RothC has been used in a range of contexts so we have eliminated this statement.

[Specific comment] p. 11002 l. 11-28: What does the CarboSOIL model stand for exactly? Does it refer to the set of regression models? This is not clear to me whether the equations and parameters of the submodels are speciñAc to each context. What is the genericity of the model? [Response] Yes, CarboSOIL is the set of models (or submodels), which includes CarboSOIL25, CarboSOIL50, CarboSOIL75 and CarboSOIL-TOTAL. It consists of the regression models and the software application in which each model can run separately.

[Specific comment] p.11002 l.14-15: What about the consistency of the prediction of SOC stocks in the different soil layers of a soil proïnAle? Is there any procedure used in the modeling approach to ensure it? between the different soil layers? between CarboSOILTOTAL and the sum of the predictions of the other models? Is CarboSOIL-TOTAL useful? [Response] CarboSOILTOTAL consider the total soil organic carbon in the soil profile without specification of the different layers. This submodel would be useful when the input dataset of the model user does not specify soil depth, or the user is interested in obtaining the total soil organic carbon of the entire profile. Although each submodel is independent they were built with the same database containing 1504 soil profiles for Andalusia region and 45 soil profiles for Valencia region. However the model does not include a procedure to ensure the consistency between the different layers, since different equations were used.

[Specific comment] p. 11002 l.20-27: I do not understand if calibration and validation are part of this work. If not, the different statistical techniques tested during model development should not be mentioned here; only the ñAnal model used should be appropriately described. Similarly, Valencia dataset should not be mentioned in the materials and methods section nor on the location map (Figure 1). If yes, the model

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chosen should be described in the Results section rather than in the Material and Methods section. [Response] Following this suggestion we have removed the statistical techniques tested during model development and have elaborated on the model description including a new figure which represents a diagram of CarboSOIL(please see Figure 2R attached). Accordingly Valencia region has been removed from the study area map (new Figure 1R attached) and the materials and methods section.

[Specific comment] p. 11003 l. 27-28: Please give more information about the spatializing process: how did you manage input data with different spatial resolutions? What is the resolution of the output SOC stock map? [Response] To spatialize the results we have used a topological intersection of the Soil Map of Andalusia (S 1:400.00) and the Land use Map of Andalusia (S 1:10.000), both vectorial, which cover the total area of Andalusia (87,000 km<sup>2</sup> ). With this intersection we obtained a new spatial dataset with 85,492 polygons which contain land use class/ soil type (landscape unit) information. Mean values of soil organic carbon of each landscape unit in the soil profiles database could be assigned to each polygon in the new dataset.

[Specific comment] p. 11005 l. 9: What does “type of iñCuvial network” refer to? Please explain. [Response] Since it may be confusing, the term “type of fluvial network” has been substituted by “type of drainage” (which can be adequate, poor or excessive).

[Specific comment] p. 11008 l.1: I suggest changing the title of section 2.7 for “CarboSOIL model evaluation” since no validation methods nor sensitivity analysis strictly speaking, are developed in this work. [Response] According to this suggestion the title and part of the content of section 2.7 has been modified.

[Specific comment] p. 11010 l.8-13: The percentage change must also be weighed against the initial stock: Arenosols, Solonchaks and Planosols must also have low levels of initial C. Similarly, the initial content must be taken into account when you compare relative SOC stocks evolution in the different soil layers and in the different land use classes. [Response] Following your suggestion we have included a new table

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(please, see Table 5R attached) which incorporates information on the initial stocks of the different land use and soil types and we elaborate on this aspect in the results and discussion sections.

[Specific comment] p. 11011 and 11012: In this section, you list the models used to simulate climate change implications on SOC stocks. A stronger analysis of the advantages and drawbacks of empirical models compared to process-based models should be provided here. In particular, their ability to predict changes in SOC stocks in deep soil layers whereas processes are different from those involved in the surface layers (priming effect) and SOC transfers are not simulated, should be discussed. [Response] We have elaborated on these issues in the discussion section. Please, see some added paragraphs below: “CarboSOIL is an empirical model based on regression/correlation techniques. These techniques offer a high predictive ability and comprise multiple advantages such as ease in application and simplicity of interpretation (Hastie et al., 2001; Oliveira et al., 2012). Although these statistical procedures are not able to explain complex mechanisms within the soil system, such as process-based or mechanistic models, these types of models are useful tools to identify different drivers of SOC dynamics and perform projections of SOC stocks (Viaud et al., 2010). CarboSOIL, as an empirical model, does not require high quantity of detailed data, and the data needed is mostly available at national, regional and even plot-scale.” “Global warming and the increase of CO<sub>2</sub> concentrations of the atmosphere in a future 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).”

[Specific comment] p. 11013 l. 17-20: According to Table 2, the parameter related

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to precipitation is null for all models except CarboSOILTOTAL. Change in precipitation should not have any impact on SOC stocks in the 0-to-25-cm soil layer in Figure 3. Decrease in SOC stocks in the surface layer and increase in SOC stock in the deep layer cannot be explained by the decrease in annual precipitation. Please elaborate. [Response] Although the influence in precipitation in the 0-25 soil layer is not as relevant as in the total soil profile (0-25), the variable PRPT (total precipitation) is multiplied by the coefficient -0.003 in the equation. This is an error due to considering only two decimal places in the coefficients of the multiple regression equations. However, it has been corrected, and the new Table R2 (attached to these comments) includes three decimals to improve the accuracy of the model.

[Specific comment] p. 11013 l. 20-24: Are the input variables "type of iñCuvial network" and "active soil erosion processes" modified in the climate change scenarios? [Response] Only the climate variables have been modified according to the climate scenarios. The interrelated processes have not been considered in this application of CarboSOIL.

[Specific comment] p. 11014 l. 19-20: Erosion processes and growth in depth of the vegetation roots are not modeled with CarboSOIL. Overall the components of climate change, which could explain the contrasting evolution of SOC in surface and deep soil layers, are not clearly analyzed in the discussion. Please clarify. [Response] We have elaborated on these issues in the discussion section. Please, see added paragraphs below: "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 all over Europe (Smith et al., 2005).

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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"

[Specific comment] Figure 1: The scale is missing. [Response] It has been included (please, see Figure R1 attached)

[Specific comment] Figure 2: This figure is useless; it should be removed. [Response] This figure has been removed. A new figure (Figure R2 attached) has been placed instead with a diagram of CarboSOIL.

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[Specific comment] Figure 4: Is it possible to standardize the scale on the Y axis, to help the reader analyse changes in SOC stocks. [Response] I suggest leaving the figure as it is since having the graphs at the same scale would diminish the purpose of the figure, and the differences among scenarios for each soil section would not be visible.

[Specific comment] Figure 5: Please change <8 for <-8 [Response] It has been modified (please, see Figure 5R attached).

[Specific comment] Table 5: This table is redundant with Figure 6 [Response] Table 5 has been removed. A new table (Table 5R) has been included instead showing the initial stocks of the different land use and soil types as it was previously suggested.

Please also note the supplement to this comment:

<http://www.biogeosciences-discuss.net/10/C5546/2013/bgd-10-C5546-2013-supplement.pdf>

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

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