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Interactive comment on "Can mud (silt and clay) concentration be used to predict soil organic carbon content within seagrass ecosystems?" *by* O. Serrano et al.

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Response to Reviewers for "Can mud (silt and clay) concentration be used to predict soil organic carbon content within seagrass ecosystems?" by Serrano et al. We would like to thank the Reviewers for their efforts and comments, which have the potential to improve the manuscript. Please find below a detailed response to each of the issues raised.

Anonymous Referee #1 Serrano et al. review General Comments: This manuscript reports the organic matter content of seagrass sediments as a function of mud content and type of seagrass, focusing on whether percent mud offers predictive value for organic matter content. They find that sediments hosting longer-lived species, with greater below-ground biomass, accumulate organic matter to levels beyond that predicted by, and not well correlated to, mud content. The paper will thus be a useful report for "blue carbon" strategists in relating carbon accumulation to types of seagrass meadows, and fits the mission of BGD. To be useful, however, some clarifications are needed. Specific Comments: 1. The relationship between organic matter and minerals is usually best seen with clay-sized fractions, rather than at the 63μm cutoff used here. Phrased another way, a correlation coefficient between organic matter and weight fraction of fine-grained sediment would be expected to improve as the latter parameter uses finer sized cutoffs. The main point of this paper derives from the significance of correlations, and use of finer-grained cutoffs might have led to higher significance levels than those which led to the manuscript's conclusions.

Response comment 1: In this manuscript we explored the relationships between mud (clay and silt, 'lutite'; <0.063 mm) and organic carbon (Corg) contents in bulk seagrass soils. There are three main issues or disadvantages linked to the use of clay (<0.004 mm) instead of clay and silt (mud, <0.063 mm) to explore the relationships between sediment grain-size composition and Corg content in bulk soils: A. Seagrass soils generally don't have much clay (concentrations ranging from 0 to 0.5%; in particular in meadows found in coastal areas). B. Data on clay concentration is not available for half of our analyses because our laser-diffraction particle analyser measured silt and clay (mud) together. C. The silt fraction (0.004-0.063 mm) provides binding sites for Corg on the surface of minerals, increasing the available space within the mineral matrix for Corg aggregates, and thereby potentially underestimating Corg content. Therefore, correlations between bulk soil Corg and mud sediment fraction (i.e. silt and clay) are expected to be higher than correlations between bulk soil Corg and clay (<0.004 mm) because: 1) the lower number of 'zeros' in the correlations; and 2) the mud fraction is more representative of the bulk soil (i.e. silt also binds Corg) and a higher correlation is expected when comparing bulk soil Corg with a larger and more representative fraction of the sediment (clay and silt rather than clay alone). Indeed, the lack of clay data for a substantial portion of the dataset precludes a comprehensive exploration of the relationships.

2. Cores were collected to depths ranging from 10-475 cm. Because below-ground biomass likely does not extend as deeply as carbon storage, it would be useful to report any depth relationships found. Because the authors allude frequently to the "blue carbon" justifications for their study, they should alert readers to these depth implications for two issues. First, upper soil horizons of terrestrial soils – where discrete organic detritus persists - commonly show organic matter concentrations above those levels explained by finer- grained mineral association (e.g., Gami et al. 2009, Geoderma, 153:304, and Mayer and Xing 2001, SSSA 65:250). Thus, does enhanced carbon storage of certain sea- grasses species extend to depths below the zone of living or recently dead biomass? Second, if tests of the predictive value of mud content were made at 0-10 cm only or 100-110 cm only, would the conclusion in lines 181, 189-190 and elsewhere still apply? While the authors may not have sufficient data for as thorough an analysis as was done for entire cores, the manuscript would benefit greatly from any insights based on subsets of the data.

Response comment 2. We explored the relationships between soil Corg and mud contents within different core depths (from 1 to 10 cm-thick deposits, and from 11 to up to 475 cm thick deposits) for bare sediments and each group of seagrass species (Figure 1 below), as suggested by the referee. The results obtained show that soil depth is not an important factor when attempting to predict soil Corg content based on mud content in bare sediments (i.e. $R2 > 0.74$ for all core depths explored; 1 to 110 cm-thick, 1 to 10 cm-thick, and 11 to 110 cm-thick). However, a clearer pattern appeared when exploring the correlation between soil Corg and mud contents in top 10 cm and within 11-110 cm soil depths of combined Halodule, Halophila and Zostera species (R2 = 0.17 and

R2 = 0.74, respectively). These results suggest that the relatively small belowground biomass of these species (i.e. organic detritus) only has an impact on the expected positive correlation between soil Corg and mud content within the top 10 cm, while the correlation for deeper soil depths (11-110 cm) improved (R2 = 0.74) compared to the whole dataset (R2 = 0.56). For combined Amphibolis and Posidonia species, the results obtained show that soil depth is not an important factor when attempting to predict soil Corg content based on mud content (i.e. $R2 < 0.3$ in all cases; whole dataset, 1 to 10 cm-thick, and 11 to 110 cm thick). These results suggest that the relatively large belowground biomass of these species (i.e. organic detritus) has an impact on the expected positive correlation between soil Corg and mud content within all depths (from 1 to 475 cm). All above could be included in the discussion of the final paper, after Editor's considerations.

3. The blue carbon rationale of this manuscript also calls for some perspective on how much of the carbon sequestered is due to seagrass. Likely the organic matter associated with minerals would be buried wherever the minerals accumulate in the absence of seagrass meadows. It is the organic matter that is not associated with the fine-grained minerals – roughly the residual carbon levels in meadows above the regression line of the bare sediment – that represents the amount that is additionally sequestered due to seagrass. Estimates of organic carbon partitioned into these two pools is made possible by the mud content parameter.

Response comment 3. Although it would be possible to run mixing models (i.e. based on the stable carbon isotopes rates of the organic matter explored in this study) to determine the percentage contribution of autochthonous (plant detritus) and allochthonous (seston, algae and terrestrial matter) Corg sources into the soil Corg pool for each ecosystem, we dismissed this option mainly because of the assumptions involved with this approach and its complexity (i.e. lack of robust δ13C data of potential Corg sources for each site, thereby including δ13C variability within latitude gradients, water depth, seasonality, diagenetic effects, etc.). The phenomena of Corg accumulation occurs over centennial time scales and we consider that using the same δ13C values of potential sources for all sites to run the models could lead to misleading results. Instead, we preferred to show the range of δ13C for seagrass detritus in Figure 1 of the manuscript, to allow identifying trends without running potentially misleading mixing models.

4. The authors give some attention to the roles of below-ground biomass and the lability of detritus of different size, but these points could use expansion. For example, papers such as Harrison and Mann (1975, L&O 20:924) showed loss rates dependence on detritus size. Also, Ember et al (1987, MEPS 36:33, especially their Figure 2) found that short form Spartina sediments showed elevated OC and del-13C values relative to tall form Spartina sediments; that finding does not seem consistent with the authors' argument that larger seagrasses lead to more seagrass carbon accumulation.

Response comment 4. In our paper we discussed differences in Corg storage and lability between seagrass groups. We argued that the contribution of seagrass detritus to the long-term carbon pool is a function of both sediment conditions for preservation and the intrinsic recalcitrance of the plant material itself, and plant productivity. Minor adjustments to the discussion will be made to include comparisons with other ecosystems (i.e. salt marshes), after Editor's considerations.

5. The figures would benefit from letters to indicate individual plots (A, B, etc.). In the figure captions the authors use the term "intermittent" circles. On the manuscript I received there is no visual difference between the two types of red circles on individual plots, so other than by deduction it's not clear what is meant by "intermittent". Further, many of these "circles" are actually ellipses. The terms "mud Corg saturation" and "low/high seagrass input" are confusing. Saturation of mud most likely explains the linear trend as seen in the Bare Sediment organic carbon vs. mud content regression line; the points above this line represent samples that are above this saturation level, but the authors have labeled them as "mud-Corg saturation". The "circled" "mud-Corg saturation" points for the Halodule plots do not seem to include exactly the same subset

of samples for the left and right plots. The "circled" "High seagrass input" data points in the two Amphibolis plots also are clearly not all the same samples, so why do they have the same label? 6. Line 160. Insert "variance in" between "the" and "trends". 7. Line 169. What is a "poor but slightly significant correlation"? 8. Line 195. A better way of phrasing this idea would be something like "providing more surface area and hence binding sites for Corg per weight of mineral". Also, I don't understand intent of the phrase "increasing the available. . .for Corg aggregates" in line 196. 9. The sentence in lines 201-204 is confusing – the points above this regression are not well-explained by the regression. 10. Line 202. Are the authors claiming that the three data points with del-13C of -25 (Figure 1, upper right plot) are the same as the data points with highest OC in the Figure 1, upper left plot? That could be true for only the sample with 6.6% OC, but the other two points must be close to the regression line. Thus these latter two terrestrially influenced samples are close to saturation – i.e. predicted by grain size. 11. Line 210. "obviating" would be a better word than "ending".

Response comments 5-11. We agree with the comments made by the referee and we are willing to address these corrections in the final version of the manuscript, after Editor's considerations.

In summary, the manuscript is concerned primarily with the predictability of organic matter content by mud content, and seeks further insight into controls on organic matter by separating out some variables. Its main point of better predictive value in bare sediment and short-lived seagrass meadow sediment, but not in longer-lived seagrass meadows, is reasonably well made. The manuscript becomes confusing, however, in the explanations of different organic matter sources and amounts making up the total organic loading.

Response: We are willing to address all your concerns in the final version of the manuscript, after Editor's considerations.

M. Plus (Referee #1) Review report on the manuscript submitted to BiogeoSciences

Can mud (silt and clay) concentration be used to predict soil organic carbon content within seagrass ecosystems? By Serrano et al. General comments The manuscript reports on the correlations between organic carbon (Corg), mud content (silt and clay fraction < 63 μm) and delta-13C in sediment cores sampled in a variety of temperate and tropical seagrass habitats. More broadly, the authors investigate if mud content can be used as a good proxy for Corg sediment contents of seagrass ecosystems. The manuscript is totally consistent with the scope of this journal. The topic seems to me important, in the context of a growing interest in carbon sequestration assessment for marine ecosystems. The techniques used are not new, but this paper is well documented and refers, to my opinion, to relevant bibliography. The manuscript's main point (the mud content is not a universal proxy for blue carbon content but can be used for bare sediments and opportunistic seagrass ecosystems) is well supported by the observations as well as by the statistical treatment. I nevertheless have pointed out a few questions and comments that seem to me worthy to be answered before publication: Specific comments / technical corrections 1. line 73 & 76: I would prefer the words "significant relationship" instead "positive relationship". Even if it is true that we logically expect a positive relationship between mud content and Corg, rigorously a strong significant negative relationship could be as useful as a positive one. 2. Line 132-134: This sentence is not true for P. oceanica. Table 3 shows that for that species, the Corg content decreases when the mud content increases. 3. In Table 2: Amphibolis grifficiae or Amphibolis griffithii? 4. Line 148: the "exponential tendency" for combined Amphibolis spp. is speculative, please rephrase or test non linear relationships. 5. Lines 176 to 182: This is confusing to me. You say before that fine-grained sediment can bind larger amount of Corg. But the capacity for silt and clay to bind Corg is limited, high mud content in sediments provide reducing conditions that can preserve Corg (lower mineralization rates). Then why this could explain relative high Corg contents for some bare sediments with low mud contents ? This mud-Corg saturation needs to be clarified (specially for non-specialists as me). 6. Table 3: please add in caption what na stands for (not available ?). Would ns – non significant – not be better? 7. Figure 1

and 2: I don't see any difference between the red and the red-intermittent circles in the manuscript version I received. Please, verify. 8. Figure 2, lower-left graph (Mud content vs Corg for estuarine ecosystems). There are 4 points showing high Corg contents (around 6%) for very low mud contents. To which type of ecosystem are they related? P. autralis?

Response comments. We agree with the specific comments and technical corrections made by the referee and we are willing to address these corrections and clarifications in the final version of the manuscript, after Editor's considerations.

Figure 1. Relationships among soil Corg and mud contents in the habitats studied: bare sediments, combined Halodule, Halophila and Zostera species, and combined Amphibolis and Posidonia species.

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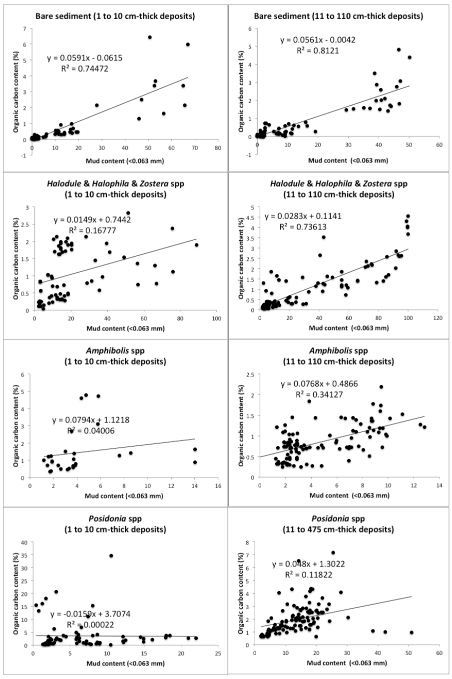

Fig. 1.