

Dear editor, dear referee, dear EGU sphere,

First, we would like to thank the referee for the time invested reviewing the paper, and the constructive comments and suggestions that were made. We take this opportunity to answer the most important questioning and suggestions in detail. We took notes of other minor comments to correct and improve the manuscript in its revised form.

Question 1: When all is said and done, the main take home point of this work seems to be Fig. 3 and its subsequent discussion. Perhaps I'm being unduly harsh, but I'm not really sure I see a lot here that is really that new, as is indicated by the discussion toward the latter part of section 3.2. In some senses though, this consistency between the model results here and wide range of diverse observations regarding organic matter reactivity and composition is re-assuring, and in some ways this work does act to help "unify" these observations. On the other hand, in other places (lines 339 and 359), the authors note that "the *l*-RCM can be further used to calculate the budget of OM degradation at regional or global scales and assess the significance of the sedimentary carbon cycle on the hydrosphere and atmosphere." To me at least, adding such a calculation to this manuscript would be as (if not more) important and interesting as is Fig. 3. It could then be compared to other regional and global estimates of such quantities cited on lines 328-330, or reported more recently in Jørgensen et al. (2021, *Earth-Sci. Rev.* 228:103987). These estimates might also be a way of somewhat independently verifying how "good" this lognormal approach is, as compared to other models of sediment OM reactivity.

Response: Thank you for your valuable comments and suggestions. It is really true as the Reviewer suggested that we should add the further application of the *l*-RCM to the revised manuscript. We have read the references you provided. Next, we will simulate the degradation process of organic matter using the *l*-RCM on basis of the distribution characteristics of organic matter reactivity in different regions of the global ocean, estimate the amount of organic matter degradation in global sediments and then compare to regional and global estimates of such quantities using other models, thereby further reflecting the advantages of the *l*-RCM. In the revised version, we will fully

consider the Reviewer's comments and add this part to the section of Discussion.

Question 2: The overall manuscript is chopped up in such a way that makes it very hard for the reader (or at least me) to follow. Specifically, things discussed in the Supplementary Material section are not well-referenced in the text, and I was very confused when I first started reading the main text, until I realized I had better go through the Supplementary Material section first.

Response: Thank you for pointing out this question. In the revised the manuscript, we will reorganize the structure of the manuscript and put the relevant contents in the Supplementary Material section into the text to improve the readability of the manuscript.

Question 3: The math in the supplementary section is very dense and confusing in places (also see point 5 below).

Response: We will check and correct this section according to the Reviewer's comment in the revised version.

Question 4: Maybe I'm missing something, but there seem to be two definitions of (eqn. 4 and eqn. 7, which is the same as eqn. S3) and in plots like Figs. 2 and 3 it's not clear which is being used. This confusion needs to be cleared up in the revisions.

Response: Thank you for this suggestion. We will carefully check and clear up this confusion accordingly.

Question 5: The referencing in the early part of the manuscript needs to be cleaned up. You don't write "... Washington and Jefferson (Washington and Jefferson, 1776) said ..." but rather "... Washington and Jefferson (1776) said ...". Also references with 2 authors do not use et al. (e.g., see lines 138 and 179), and again remove the author names from inside the parenthetical statement.

Response: Thank you for pointing put this mistake. In the revised version, we will

check and revise these references accordingly.

Question 6: The quantity $\rho(\ln(k))$ or $\rho(k)$ is plotted in several places (Figs.1C, S4, S5, S12, S13). This parameter is not clearly defined in the text (maybe I missed it), and it is also not clear how it relates to other parameters being looked at here (this comment may actually be a specific example of the general concern noted in point 3 above).

Response: Thank you for your suggestion. We will revise the definition of $\rho(\ln k)$ in the figure caption. The lognormal distribution is symmetric in the logarithmic coordinate system, as shown in Figure 1.

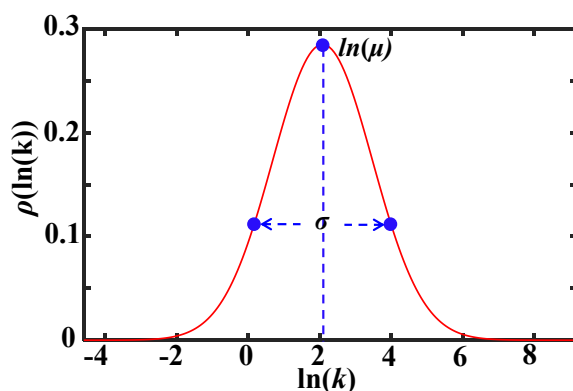


Figure 1. Schematic diagram of lognormal distribution

In this manuscript, the x -axis represents the distribution of organic matter reactivity (k , yr^{-1}). Considering that the coordinate system is a logarithmic coordinate system, the value of the horizontal coordinate is $(\ln k)$. The y -axis represents the fraction corresponding to the organic matter reactivity, which is usually referred as probability density function (PDF) in statistics. In this study, $\rho(\ln k)$ is used to represent the organic matter reactivity. We will give the clear definition of this parameter and address this issue in the revision.

In addition, we will also make further revisions to other minor issues that the Reviewer proposed to improve the readability of this manuscript.

Thank you very much for your valuable comments and suggestions again.