Biogeosciences Discussions

Biogeosciences Discuss., referee comment RC1
https://doi.org/10.5194/bg-2022-228-RC1, 2022


# Comment on bg-2022-228

Anonymous Referee #1

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Referee comment on "Assessing global-scale organic matter reactivity patterns in marine sediments using a lognormal reactive continuum model" by Sinan Xu et al., Biogeosciences Discuss., https://doi.org/10.5194/bg-2022-228-RC1, 2022

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This study proposes an alternative equation to describe and predict the degradation of organic matter in marine sediments. A log-normal function is fitted to 123 depth profiles of TOC, demonstrating that this function better characterizes organic matter decay over time and depth. Moreover, the function is extrapolated to a global map of surface reactivities, based on 5600 TOC concentration measurements.

This initiative to improve the characterization and understanding of long-term organic matter behaviour is very welcome, as previous models have not fully resolved the complexity of the problem. This study clearly is an important contribution to the field. I only propose to consider a few aspects which could make this work even more universal and help to address a broader audience.

The mathematics is rather complex to understand, including terms as “gamma”-function and “lognormal”-function. According to Wikipedia: “In probability theory, a log-normal (or lognormal) distribution is a continuous probability distribution of a random variable whose logarithm is normally distributed. Thus, if the random variable X is log-normally distributed, then Y = ln(X) has a normal distribution”. It should be thought through what physical meaning this has, i.e., what in the nature of a mix of organic matter gives rise to this function?

One general finding from ocean drilling is the observation of general power law decrease in activity with depth. This was already recognized during some of the early studies in deep biosphere research (Jørgensen, 1978), and a power law trend has been repeatedly confirmed, not only for organic matter decay but also for prokaryotic cell numbers (D’Hondt et al., 2004; Kallmeyer et al., 2012) and metabolic rates measured using the radiotracer method (Parkes et al., 2005).

It is understandable that microbial activity and abundance is ultimately controlled by the rate of decay of larger molecules via hydrolysis, then giving rise to a cascade of fermentation processes. While a single compound reacts with an exponential decay function (Berner, 1964), it has been the common tenet that a complex mixture of compounds results in an approximate power law decay function (see Tarutis, 1993). We can therefore ask the heretical question why it matters, whether a gamma function or a lognormal function is used, if the physical meaning is anyway the one of a power-law function.

**Minor comments:**

Line 31: The results show that …

Lines 45-49: I suggest to modify the sentence as follows, thereby specify the references with respect to the listed phenomena:

"In particular, the reactivity of benthic OM imposes a substantial control on the magnitude of benthic carbon **export and burial (… sequestration happens in the photic zone!)** over geological timescales **due to** the recycling of inorganic carbon **by dissimilatory microbial activity in the deep biosphere** (Boudreau, 1992), the dissolution and precipitation of carbonates (Meister et al., 2022), and the production of methane (Dickens et al., 2004).

Line 60: Here it would be good to refer to the power law function (see comments above).

Line 92: "Boudreau and Ruddick" is duplicated

Line 98: "Middelburg" is duplicated

Line 127: Consider re-organizing the methods description to start with explaining what was simulated.

Line 142: Title 2.3 should be rephrased: not the sedimentation rate is upscaled, the model is.

Line 154: Eq. 5 defines the sedimentation rate as a function of waterdepth z. However,

sedimentation rate has also been observed to vary with depth due to compaction. This has an effect also on the organic matter decay with depth.

Line 170: Why is a multi-G method used if the log-normal method would be better?

Line 185: on the shelf

Line 194: Also, Meister et al. (2013) evaluated the effects of a and nü in the reactive continuum model on the sulphate and methane concentration profile. Presumably, the log-normal model has similar effects?

Line 198: WHAT is divergent?

Line 237: This matches the observations by Kallmeyer et al. (2012) that also microbial cell numbers are shifted by magnitudes between the regions.

Line 242: In the reactive continuum model, the parameter a has actual meaning, as the "initial age". Which parameter would represent this property in the lognormal model?

Line 262: Perhaps also refer to the South Pacific Gyre, as the region that is most depleted in organic carbon (see also Kallmeyer et al., 2012).

Line 287: But often the OMZ is in shallower depth, on the shelf or shelf slope, and also affects anoxic shelf basins.

**References:**

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