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Interactive comment on "Plants or bacteria? 130 years of mixed imprints in Lake Baldegg sediments (Switzerland), as revealed by compound-specific isotope analysis (CSIA) and biomarker analysis" *by* M. Lavrieux et al.

Anonymous Referee #2

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Comments and over view: The manuscript is well written and describes a study of the sedimentation changes in a hypertrophic freshwater lake over a period of 130 y before present. Most of the techniques used in this study were appropriate and it is good to see a study trying to use an alternative biomarker to the CSIA of fatty acids as a cross check to validate those results. However, there are some issues in this manuscript that I feel need addressing. My comments are therefore on the overall concept presented in the manuscript and are intended to be helpful. I focus on 1) the need to apply known corrections to data and 2) the three hypotheses raised by the authors to interpret their

results.

1) It has been documented (Verburg 2007) that samples from lake sediment cores going back in time to when the isotopic value of δ13C in the atmospheric CO2 was less depleted than at present, need to be corrected for this Suess effect. This is because plants assimilate atmospheric CO2 during photosynthesis to produce the fatty acids. Those isotopic values on that day are transferred to the fatty acids which bind to the soil and which are measured in the CSIA tracer study. Consequently, to use present day land use samples as the reference sources for the sediment in the core samples over time, the core data must be corrected for the Suess effect. The authors argue that, compared with isotopic depletion of the tracers in the deeper sections of the core, the Suess effect is "considered as negligible" and was not done. My understanding is that the main objective of science is find the truth from the limited resources and knowledge available. The Suess effect is a known truth and needs to be applied to the core data. It doesn't matter that effect is small relative to other unknowns, I believe that the authors should apply the correction to the data. This will save the authors a page of text arguing that it is not needed.

My contention is that, if everyone picks and chooses which corrections to apply to specific types of data, the supplementary data provided with each manuscript will be worthless.

2) The most important finding in this study is that there is increasing isotopic depletion in the FAs with depth and the authors have correctly associated this effect with methanogenesis by bacteria in the anaerobic sediments. This isotopic depletion, however, causes a problem where the sediment sample isotopic values do not plot within the source polygons, as in this study. The authors raise three hypotheses suggesting that "either (1) that values have to be corrected for the atmospheric 13C-depletion of the industrial era (Suess effect; Suess, 1955; Keeling, 1979) (2) that the major contributors to most of the lake FA isotopic signal are not the main source soils of the catchment, or (3) that the signal, originating from catchment soils, was altered after its

introduction into the lake."

Simply applying the Suess correction removes hypothesis 1.

Hypothesis 3) violates the primary assumption of the CSSI sediment tracing technique (Gibbs 2008) that the isotopic signatures of FAs bound to the soil particles do not change over time. The discussion around this point is speculative and then assumed to be correct without supporting evidence. The authors need to provide irrefutable evidence for the alteration in the isotopic signature of a soil-bound FA after it has been deposited in the sediment or acknowledge the basis for using FAs as tracers as correct, which removes this hypothesis.

This leaves hypothesis 2) "that the major contributors to most of the lake FA isotopic signal are not the main source soils of the catchment". This is a realistic hypothesis, which the authors need to investigate further. Internal cycling is common in most lakes. Expanding on this concept, the 'other' sources need to be able to consume a food that is isotopically depleted and the consumer must be able to produce long-chain, even-carbon number FAs that can bind to the sediment particles rendering them stable against decomposition and fractionation to short-chain molecules. Methanotrophic bacteria assimilate the methane and produce odd-carbon chain lengths mostly in the C15, C17 and C19 chain lengths. Consequently, the bacteria are not the source of the even-carbon FAs, but they are the food source for chironomid larvae living in the anoxic sediment. Work by Jones and Grey (2004: Boreal Environment Research 9: 17–23), Deines et al (2007: Aquatic Microbial Ecology 46: 273–282), and others, indicate that chironomid larvae can take up the depleted isotopic signature from the bacteria and acquire highly depleted isotopic signatures. They may leave their skins and head capsules in the sediment when they hatch or the unseived sediment samples may have contained whole organisms. In severely hypertrophic lakes, chironomid populations can reach very large numbers. And yes, chironomids produce FAs (e.g., Makhutova et al 2017: Contemporary Problems of Ecology, 10: 230–239).

A further issue around the selection of the fatty acid tracers, the authors have chosen to use only C24:0, C26:0 and C28:0 and wonder why they cannot discriminate grasses. Grasses produce very low levels of these long-chain FAs but high levels of C18:0 and C18:1 fatty acids. There is also no bulk δ13C data. Including these tracers may help sort out some of the source identification problems in this manuscript. If all the tracers are not included in the isotopic inputs to the mixing model, they cannot be seen in the model output.

In the conclusions, the authors have reiterated a statement "strongly overprinted by carbon exchanges". As stated above, this is an unsupported hypothesis which cannot be correct. It is more likely that the FA signatures from the terrestrial sources have been overprinted by an in-lake source that has not been sampled and more work is required to identify that source.

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