

Interactive comment on “Fatty acid carbon isotopes: a new indicator of marine Antarctic paleoproductivity?” by Kate Ashley et al.

Anonymous Referee #2

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The high latitude region of the Southern Hemisphere which include Antarctic ice sheet and Southern Ocean is thought to play an important role in climate system, especially in long-climate change. Hence, it is important to investigate paleoclimate change the region to better understand Earth's climate. However, due to limited application of environmental proxies in the region, significant portions of Earth history, environmental records in the high latitude region are less developed than that of low and mid latitudes. Lower and higher molecular fatty acids that are produced by varieties of organisms in the ocean environment are ubiquitous in ocean sediments. Thus, fatty acids may have a potential as paleoenvironmental proxy. This study explores paleoclimatic utility of fatty acids in Southern Ocean sediments and suggests that stable carbon isotope ratio of the low (C18) and mid (C24) chain fatty acids could be used as productivity proxy in the

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sea ice area. Although further studies are needed to confirm robustness of the proxy, this study contributes development of biogeochemical proxy which has a potential to apply to high latitude ocean sediment. Hence, this study fits scope of Biogeosciences and suitable for publication in the journal. I have some comments on the article as below.

1. I would suggest to include some explanations that application of biomarker proxy is limited in polar regions into the introduction section (e.g. a powerful proxy such alkenone is not applicable in this region. HBI compounds, that are useful proxy of sea ice, are labile and cannot be applied to geological deep past. On the other hand, fatty acids are ubiquitous and abundantly detected even in old sediment and has a potential but its utility has not been investigated well). Such explanations highlight importance of this work. 2. Although a number of fatty acids including C16 to C26 were abundantly detected in the studied samples (Figure S2), the authors show and discuss $\delta^{13}\text{C}$ results of C18 and C24 fatty acids only. I wonder why the authors focus the two compounds only. I suppose that aim of this paper is to investigate paleoclimatic utility of fatty acids in marine sediments. Hence, it is worth to also include results of the other compounds into the manuscript. I think many people are interested in results of other compounds and know how $\delta^{13}\text{C}$ profiles of other compounds look like. Including this significantly contributes to develop application of fatty acids in marine sediments to paleoclimate study. 3. As for pCO_2 effect on plankton $\delta^{13}\text{C}$, important literature is missing in the manuscript (Pop et al., 1999, vol 13, 827-843, GBC). They measured $\delta^{13}\text{C}$ of POC along the north-south transect of the Southern Ocean and show significant negative correlation between dissolved CO_2 and $\delta^{13}\text{C}$ of POC, suggesting strong control of pCO_2 on $\delta^{13}\text{C}$ of phytoplankton. There needs to take into consideration the result for discussion. 4. 4.2.3. Productivity section: The authors argue that changes in productivity is the most plausible driver for variability of fatty acid $\delta^{13}\text{C}$ recorded in the sediment core based on the results of previous studies conducted in the Southern Ocean (Villinski et al., 2008; Arrigo et al., 2015; Zhang et al., 2014). I basically agree that significant increase in productivity results in remarkable higher values of

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phytoplankton $\delta^{13}\text{C}$ in the polynya environment. However, those papers (Villinski et al., 2008; Arrigo et al., 2015; Zhang et al., 2014) all argue that observed increases in productivity in the regions are caused by meltwater input which promote surface stratification in summer time with reducing vertical mixing and supplying Fe, providing ideal condition for algal growth. Shadwick et al., GRL (2013) and Jack Pan et al., PlosOne (2019) also clearly show a significant correlation between meltwater fraction, chlorophyll concentration and surface water pCO_2 drawdown. Especially, Shadwick et al., GRL (2013) investigates glacial meltwater impact on biological carbon drawdown in the studied region. Indeed, those paper shows lowering surface pCO_2 happened in the regions where meltwater plume intruded. Regardless of sea ice fluctuations, plankton production takes place in summer when ice sheet melts. This suggests variability of meltwater input rather significantly affects productivity. Therefore, I would suggest to consider possible link between meltwater and productivity in the manuscript. Indeed, the observed recent increase in $\delta^{13}\text{C}$ of C16 fatty acid in sediment core is consistent with the fact of significant melting of Antarctic ice sheet for the past decades. 5. *F. cylindrus*% and *F. rhombica*% records are shown in Figures 6 and 7, but the authors do not mention anything about those records in the manuscript. I wonder why those data are shown in the figures.

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