

Author Response:

We would like to thank the reviewer for his/her technical comments to improve our manuscript. All the points below have been considered thoroughly and corrected.

Please find our response in red below.

*Sapart et al.,*

Some remaining small issues:

line 62, “The four suggested key mechanisms” — too much certainty! Suggest “Four suggested mechanisms” instead.

**This has been corrected.**

line 65: Wintereld -> Winterfeld

**This has been corrected.**

line 71-73: flip the sentence around for clarity: “The remobilized carbon can be used to produce CH<sub>4</sub>, a strong greenhouse gas (IPCC, 2013) under anaerobic conditions and depending on its type and quality (Schuur et al., 2013).”

(“a strong greenhouse gas (IPCC, 2013)” can probably be deleted. I think readers know that...)

**This has been corrected.**

line 96-97: “However, this fractionation is considered to be relatively small” —> it is relatively small!, so just say “However, this fractionation is relatively small”

**This has been corrected.**

line 108-109: “The destabilization of gas hydrates is the most discussed CH<sub>4</sub> source from this region”

I would disagree with that—there have been many many papers discussing the other sources. Perhaps “The destabilization of gas hydrates is frequently discussed as a CH<sub>4</sub> source in this region” is better?

**This has been corrected.**

line 110: suggest adding reference to Ruppel and Kessler, 2016, The interaction of climate change and methane hydrates, Reviews of Geophysics, 10.1002/2016RG000534.

**This has been corrected.**

line 115: “radiocarbon content on sediment” —> “radiocarbon content in sediment”

**This has been corrected.**

line 120: “thus helps determining” —> “thus helps in determining”

**This has been corrected.**

line 183: “for more detailed on the sample locations” —> “for more detail on the sample locations”

**This has been corrected.**

line 217: “untypical” —> “atypical”

**This has been corrected.**

line 243: “with a much more depleted” —> “with much more depleted”

**This has been corrected.**

line 253 “too depleted” → “more depleted”

**This has been corrected.**

line 261: “For these cores and because” → “For these cores, because”

**This has been corrected.**

line 262: “on the field” → “in the field”

**This has been corrected.**

line 272: “ levels below 200pmC thus” → “ levels below 200pmC, thus”

**This has been corrected.**

line 279: “the sediment showing that it is not originating from the surface” → Or it could have been pushed down to 30 m from the surface—I don’t see how this is disproven in the data. You could write instead “the sediment suggesting that it may not originate from the surface”

**This has been corrected.**

line 279-280: “Our first assumption is” → This is not an assumption, this is an informed guess, or a suggested possibility. Suggest: “Our first suggestion is” ..

**This has been corrected.**

line 296: “for a part” → “partly”

**This has been corrected.**

line 334-335: “Our dataset does not support this interpretation,” → WRONG. Your dataset says nothing about the “interpretation” of Overduin et al—they were looking at a different core in a different location. Perhaps you mean something like: “Our cores suggest that the Overduin et al core is not typical for the entire area, as we did not observe similar D and 13C enrichments associated with decreases in CH4 concentrations”

**This has been corrected.**

line 352: “become indiscernible” → “becomes indiscernible”

**This has been corrected.**

line 359: “deep Earth’s crust” → “Earth’s deep crust”

**This has been corrected.**

line 373: “for most of it” → “for the most part”

**This has been corrected.**

line 418: “at location” → “at locations”

**This has been corrected.**

line 424-427: “Our results show that thawing subsea permafrost of the ESAS emits CH4 with an isotopic signature that cannot be easily distinguished from Arctic wetland emissions when looking only at stable isotope data.”

This is an important point, but it comes out of nowhere as presented in the conclusions here. No examples of wetland emission dD or d13C are given in the manuscript. Can the authors motivate this earlier in the manuscript? This is the first time the word “wetland” even appears! This isotopic overlap problem is discussed with examples in Thornton et al 2016 “Double-counting challenges the accuracy of high-latitude methane inventories” (GRL) 10.1002/2016GL071772.

**A sentence has been added at the end of the introduction to introduce this subject and the Thornton et al., 2016 reference has been added.**

line 643: what is the .... in the author list?

**This has been corrected.**

## Supplement

The supplementary material is now much better presented than in the earlier version of this manuscript.

Line 52: "produced at the surface of ice sheets (Baudin et al., 1973)"

There is nothing in the Baudin et al paper about ice sheets (it is about Oklo). Also the year of the Baudin paper is 1972, not 1973. I also did some quick searching for references on  $^{14}\text{C}$  production on ice sheets but found nothing.

My apologize, it seems that the references have been mixed up in the revised version of the SI. The production of  $^{14}\text{C}$  at the surface of ice sheet is quite well known in the ice core community and several old and recent studies exist about it. I have added here the reference of the study of Firemann and Norris, 1982 who were one of the first to highlight this issue.

Line 54-56: " Nuclear production of  $^{14}\text{C}$  involves formation by neutron activation as consequence of a nuclear chain reaction, which may either take place naturally or artificially."

This statement is confusing: neutron activation processes do not require a nuclear chain reaction or a reactor, they only require a source of neutrons. E.g. in the atmosphere cosmic rays produce neutrons which can react with  $^{14}\text{N}$  to produce  $^{14}\text{C}$ . That said, it is true that radiocarbon can be produced via neutron activation in a reactor, but this is not the only way.

A sentence has been added here: Nuclear production of  $^{14}\text{C}$  involves formation by neutron activation as consequence of a nuclear chain reaction, which may either take place naturally or artificially. In the atmosphere, cosmic rays can also produce neutrons which can react with  $^{14}\text{N}$  to produce  $^{14}\text{C}$

Line 57: " The only place on Earth, where nuclear fission has occurred naturally"

Incorrect. Oklo is the only place where evidence of a natural nuclear reactor has been found. Nuclear fission occurs naturally at very low rates in U anywhere on the planet, without a reactor.

This has been corrected.

The Baudin et al 1972 reference is very early in studies of Oklo. Some later general overviews, when the Oklo system operations were better understood, include:

Cowan, George A. "A natural fission reactor." Scientific American 235.1 (1976): 36-47.

Kuroda, Paul K. "The Oklo phenomenon." The Origin of the Chemical Elements and the Oklo Phenomenon. Springer Berlin Heidelberg, 1982. 31-55.

These references have been added.