Author responses to the review of Referee #2 of the Biogeosciences manuscript bg-2019-251: 'Leaf wax *n*-alkane patterns and compound-specific $\delta^{13}C$ of plants and topsoils from semi-arid Mongolia'

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We are thankful to referee #2 for the detailed and constructive comments on our manuscript, and we will revise it accordingly.

Please find below our point-to-point response to the review of referee #2. Referee comments are given in *black italic font,* our response to each point is given in blue regular font. Resulting changes are given in *blue italic*.

Anonymous Referee #2:

The authors of this manuscript investigated the link between several environmental parameters (mean annual temperature, mean annual precipitation, and aridity index) and molecular and stable carbon isotope compositions of leaf wax n-alkanes extracted from modern higher plants and topsoils along 2 broad transects in Mongolia. The manuscript provides much needed molecular and stable isotope data for that area and will be of interest to biogeochemists, paleoecologists, and paleoclimatologists studying past climate change in the arid zones of central Eurasia. The manuscript fits within the scope of Biogeosciences Discussions and should be published in this journal provided the authors address the following issues:

→ We are very happy about this positive comment on our manuscript.

Major point to address

First, lumping topsoil n-alkane data when looking at Transects I and II

Transect II The data shown in Fig. 4 and Fig. 5 for Transect II has a lot of scatter. The transect includes 3 different areas A, B, and C, with area B corresponding to an altitudinal transect. Could this scatter be the result of additional factors controlling the molecular and d13C data along the altitudinal transect in addition to those that play role along the W-E transect (i.e. A, through B (only sites 22, 23, 24, 25) through C)? Could the altitudinal transect sites be plotting separately?

Transect II + Transect I A similar issue could be the reason for a large scatter in the d13C data in Fig. 6 (top 2 sections). There is a lot of scatter at ~ - 6C MAT, ~210 mm MAP, and ~0.28 AI. Could this be caused by multiple factors (in addition to those plotted along the X-axis) controlling the d13C values of n-alkanes along and within these transects? Can the data be plotted separately to provide a more nuanced assessment?

→ Thank you for this comment. The scatter you mentioned is not caused by the samples from the altitude transect (TSII-B), but by the samples from the Telmen catchment (TSII-C) (Fig.1). Fig. 1 shows exemplarily the correlation of $\delta^{13}C$ *n*-C_{29} with altitude, MAT and MAP, with colours indicating the different sites.

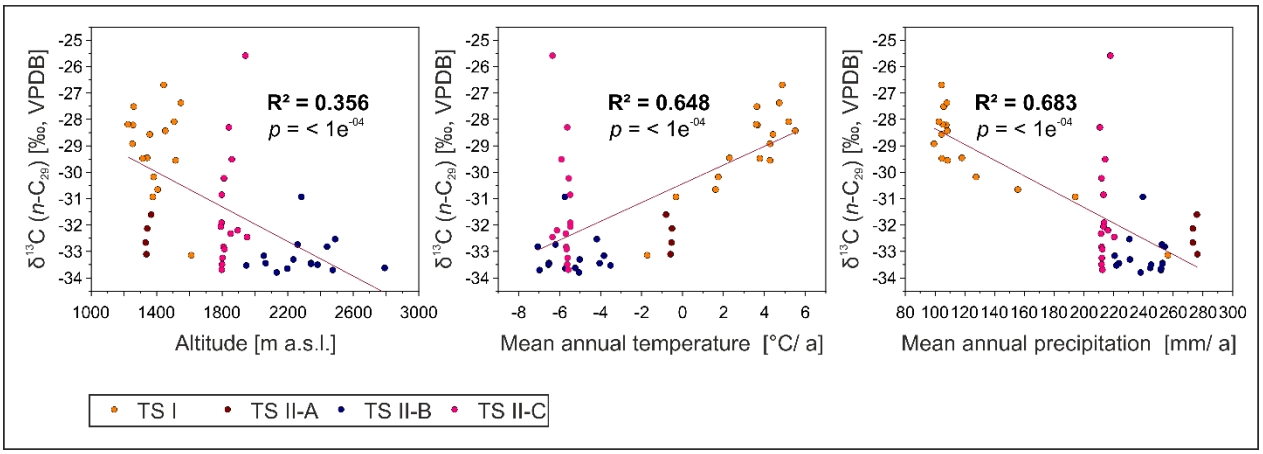

Figure 1: Compound-specific $\delta^{13}C$ (n-C_{29}) from Mongolian topsoils correlated against altitude and climatic parameters (MAT, MAP). Red trend lines illustrate linear regressions. Bold values indicate the level of significance (α = 0.05)

For all leaf wax proxies, we checked for altitude as a controlling factor. There are significant correlations between altitude and Σ *n*-alkane (both, *n*-C_{23} – *n*-C_{35} and *n*-C_{25} – *n*-C_{35}), OEP and $\delta^{13}C$ (both, *n*-C_{29} and *n*-C_{31}). Correlation with ACL is weak and non-significant, and the *n*-alkane ratio shows no correlation at all. We will include a detailed description about altitude as a controlling factor within the figures and the discussion part.

Nevertheless, altitude generally controls MAT (R^2 = 0.624) and MAP (R^2 = 0.395), and we think that all factors are important and influence the leaf wax signal. However, the scatter in our transect is rather the result of site-specific/micro-climatic characteristics and variations in plant physiology. We will strengthen the discussion and possible reasons for the scatter within the manuscript. In case of $\delta^{13}C$ (*n*-C_{29}), the scatter of TS II – C is caused by the occurrence of succulent plants using the CAM metabolism and are thought to be more enriched in ^{13}C.

Concerning Fig. 4 and Fig. 5, we see no real added value in separating the altitudinal transect. At this point, we simply separate the dataset in predominantly arid (transect I) and predominantly semi-arid (transect II) to show differences between both environments. However, we understand your argumentation and we will divide the dataset for the scatterplots (Fig. 6) as exemplarily shown here in figure 1.

Other minor issues

Line 34 (here and similar issues throughout the manuscript) "an enrichment of leaf wax d13C" d13C values are numbers. Values can't be enriched or depleted. Please re-phrase. 13C-enriched leaf wax perhaps?

➔ We will rephrase those sentences or change it to "^{13}C enriched".

Lines 82-83 "the topsoils were sampled together with the dominant plant species, which comprise the woody shrub Caragana spp. …" How the dominance of these species was assessed? Is there any previous study concerning species distribution in the area covered by this project? Or is it a subjective assessment?

➔ This is a subjective assessment! Different plants were sampled around the soil sampling sites (~5 m²). Those plants were sampled individually and determined by a botanist at the Institute of Plant and Agricultural Sciences, Mongolian University of Life Sciences, Darchan, Mongolia.

Line 90 "Total lipids … of plants" What part(s) of plant was(were) extracted? Just leaves or was it together with the stem and roots?

➔ For lipid extraction, just the leaves/needles were used, except for the grasses where we used the entire grass without roots.

Line 107 "were 0.1 per mil the standard deviation" Is there an "and" missing? Also, does it make sense to report d13C values in Suppl. Mat to the second digit after the decimal point, if the reported std. dev. is 0.1 per mil, i.e. no better than the first digit after the decimal point?

➔ This was truly a mistake! The std. dev. for the topsoils and plants was better than 0.66 per mil (0.7) for both compounds. We will change the sentence as follows:

➔ *The ~~average~~ standard deviation for the triplicate measurements were < 0.7‰ and the standard deviation for the alkane standards was better than 0.2‰ (n = 102).*

Lines 110-111 "n-alkane concentrations … were calculated as the sum of n-C25 and n-C35" Why was n-C23 excluded? It is a major n-alkane in Larix sp.

➔ The sum of *n*-C_{25} to *n*-C_{35} typically comprises the *n*-alkanes within the leaf waxes of higher terrestrial plants. It is true that *Larix* has their dominance in *n*-C_{25} and *n*-C_{23}. However, differences between the concentration calculated from *n*-C_{25} - *n*-C_{35} and *n*-C_{23} - *n*-C_{25} are minor and *n*-C_{23} and *n*-C_{25} are not dominant in the respective topsoils, but we will implement this data within the supplements.

Lines 118-119 "A normalised n-alkane ratio … n-C29 and n-C31"; lines 177-178 Please explain the significance of this ratio. If this refers to trees/shrubs vs. grasses, why not to include n-C27 and n-C33, respectively?

➔ We have chosen this normalized n-alkane ratio, because *n*-C_{29} and *n*-C_{31} are the most dominant *n*-alkanes for the grasses as well as for the shrubs *Caragana spp*. and *Artemisia spp*. For those plants, *n*-C_{27} and *n*-C_{33} are not the dominant chain-lengths and allow no separation in terms of grasses vs. shrubs, which you can see in the ACL that include *n*-C_{27} and *n*-C_{33}.

Line 165 "in line with previous regional studies" Specify what regions were covered by these studies previously? Is it similar to the region covered in this project?

➔ Cheung et al. (2015) and Wang et al. (2018c) are located on the Tibetan Plateau, Liu et al. (2018) on the Chinese Loess Plateau and Bliedtner et al. (2018) in the Caucasus region. Concerning the environmental conditions, we think that the studies of Wang et al. (2018c) and Liu et al. (2018) are comparable to our study. Cheung et al. (2015) and Bliedtner et al. (2018) receives with 480 mm/a and up to 1800 mm/a higher amounts of precipitation compared to Mongolia. We will specify the regions of the previous studies in the manuscript.

Line 169 "the findings of Wang et al. (2018b) from China" What part of China? It is a big country with multiple climatic and ecological zones.

➔ The investigated transect of Wang et al. (2018b) covers the 400 mm isohyet in China. More specifically, it follows Inner Mongolia towards the Tibetian Plateau. We will change "from China" to "along a transect from north-western to central China".

Line 202-233 Section "The leaf wax signal from plants to topsoils along transect II" This section could be broken down into several paragraphs to make it easier to follow. Also, why not to give a number for this and the next (starting on line 234) subsections? 4.3.1 and 4.3.2 perhaps?

➔ We agree with this point and will implement this suggestion.

Lines 223-224 "Compared to the plants, … d13C isotopes of the topsoils are slightly more enriched" What does "d13C isotopes" mean? Please rephrase.

➔ The isotopic $\delta^{13}C$ signature of the topsoils from transect II. Will be specified.

Also, I don't see this from the graphs in Fig. 5. The d13C values of n-C29 alkane in soils aren't really that different from those in Caragana and Larix spp. The absence of this "enrichment" is particularly evident when looking at the d13C values of n-C31.

➔ Concerning the topsoils of transect II, differences between the topsoils (transect II) and plants reveal no statistical significance. However, the median of both compounds (*n*-C_{29} and *n*-C_{31}) is slightly enriched compared to the plants: For *n*-C_{29} it's up to 1.7‰ for *n*-C_{31} it's up to 1.5‰.

Line 237 "chapter 4.4" I'd call it a section rather than a "chapter".

➔ We agree!

Lines 248-249 "are in agreement with climatic control and the fact that higher temperatures reduce the decarboxylation pathway and the formation of n-alkanes (Shepherd and Griffiths 2006)" I don't think this explanation works here. The cited paper evaluates the effect of stress on various factors that control leaf wax biosynthesis within plants. The subject matter of this section is n-alkane content of soils. There are multiple other reasons, in addition to the biochemical ones within the plant, that could play a role in the distribution of n-alkanes along the transects studied.

➔ You are right, there are many other reasons playing a role, like *n*-alkane degradation, biomass productivity or livestock grazing, which we have discussed in this paragraph. Thus, we will delete this hypothesis to reduce confusion.

Lines 257-258 "In contrast, compound-specific d13C correlated significantly with climatic parameters." There is a lot of noise in the d13C data. Please discuss possible reasons for the scatter. See the MAJOR POINT above.

➔ Is discussed above.

Line 272 "Mongolian plants show" It is a peculiar way of referring to these plants. Using their species names and mentioning that they were sampled in Mongolia would be a better way of describing them.

➔ We agree and we will adapt this!

Lines 276-277 "for reconstructing vegetation changes in Larix sp." Sounds awkward. Please re-phrase.

➔ We will rephrase it as follows:
➔ *'However, Larix sp. produces only few amounts on n-alkanes and their dominance of mid-chain n-alkanes are not distinct in the respective topsoils. Thus, n-alkanes are not useful for reconstructing changes in the abundance of Larix sp.'.*

FIGURES

Figure 1 Please remind the reader what SRTM DEM stands for so that there is no need to look for this information in the text. Also, make the font and the arrows showing the location of Transect I and Transect II thicker to make them standout more.

➔ We agree with this point and add an explanation within the figure caption.
➔ Fonts and arrow thickness will be adapted

Figure 2 Make the bar representing the scale (0-500) less prominent. That's one of the first things that draws reader's attention when you look at the map. Instead, highlight A, B, C better, so that the title of each map is not hidden among all the other text on the maps.

➔ We agree with this point and will change it accordingly.

Figure 3 Please specify whether the n-alkane data shown in the bar graphs represents all the plants collected along the Transects I and II or only a subset. Figure 4 Remind the reader what kind of "n-alkane ratio" is plotted here.

➔ All the plants were sampled along transect II. We will highlight this information within the figures caption.
➔ We will add the equation of the n-alkane ratio within the figure.

Figure 5 Specify that "compound-specific" refers to n-C29 and n-C31 alkanes.

➔ We will adapt this.

Figure 6 Which homologues were included in the calculation of n-alkanes concentrations? What ratio of n-alkanes are the authors referring to?

➔ Both information will be added to the figure or at least within the caption.