Dear editor,

Many thanks for your comments. We have asked the Editage Editing Service Company to edit the English thoroughly once again (please see the following letter from the editor of this company). Meantime, we have inserted figures into manuscript. Thus, we sincerely hope to publish it in BG journal. Please contact me freely if you have any questions.

Best Regards,

Guoan Wang

Letter from the editor

Message from your editor, Thomas

Dear Author,

It was a pleasure working on your document. Do go through my changes and comments in the edited file, as well as the notes in this document.

Please send me your feedback or any questions through your Editage Online account (online.editage.cn).

A point-by-point response Referee #1

Dear Dr. Martin J. Hodson,

Many thanks for your comments. We have modified the manuscript following the comments.

Response to the comments:

1) The reviewer felt it needs some shortening of the discussion. We think the suggestion is great, thus, some unnecessary contents have been deleted in the new discussion.

2) The reviewer felt that the English needs attention. Thank you. We have asked Professor Eric Posmentier in department of Earth Sciences, Dartmouth College to do the English editing again, and he had edited the English thoroughly. Thus, I believe the English must be greatly improved. Actually, Professor Eric Posmentier has done English-editing of the manuscript last year, however, we added some new contents in the manuscript after his editing, this may introduce some English mistakes.

3) The title was changed following the comment.

A point-by-point response to Referee #2

Dear Dr. SL Yang,

Many thanks for your comments. We have modified the manuscript following the comments.

Response to the comments:

1) Your suggestion that the discussion needs some shortening is great, thus, some unnecessary contents about C_4 plant distribution in China (in the first paragraph in the old version) have been deleted in the new discussion. In addition, we have deleted the discussion about the influence of precipitation on soil isotope.

2) The reviewer felt that the English needs some corrections. We had asked Professor Eric Posmentier in department of Earth Sciences, Dartmouth College to do the English editing again. We believe English was greatly improved in the new version. Thank you.

A point-by-point response to Referee #3

Dear Referee #3.

Many thanks for your comments. We have modified the manuscript following the comments.

Comment-1: That being said, said that the discussion wanders quite a bit and discusses several topics that are irrelevant to the paper or are obvious, such as the humidity cline and the plant variation. The discussion should focus mainly on the temperature and soil main effect and that would tighten it up and strengthen it.

Response: We think the suggestion is great, thus, the influence of precipitation was deleted in new discussion; the content with respect to plant variation was greatly shortened.

Comment-2: Overall, there are several grammatical errors including missed commas, etc. The writing is okay, but could be improved and it needs to be retitled.

Response: Thank you. In order to improve the English, we asked an English service company, Editage Company, to edit the manuscript thoroughly. Referee #3 suggested that it needs to be retitled. Referee #1 also suggested us to change the title. Thus, we modified the title following their suggestions.

Best wishes

Sincerely yours,

Guoan Wang

Temperature exerts~~ed~~ no influence on ~~the~~ organic matter $\delta^{13}C$ of surface soil along the 400-mm isopleth of mean annual precipitation in China

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Abstract

Soil organic carbon is the largest pool of carbon in the terrestrial ecosystem, and its carbon isotopice composition is affected by many a number of factors. However, the influence of environmental factors, especially temperature, on soil organic carbon isotope values ($\delta^{13}C_{SOM}$) is poorly constrained. This impedes interpretations andthe application of the variability of organic carbon isotopes in to reconstructions of paleoclimate, and paleoecology, and global carbon cycling. Given then considerable temperature gradient along the 400-–mm isohyet (isopleth of mean annual precipitation – MAP) in China, this isohyet provides ideal experimental sites for studying the influence of temperature on soil organic carbon isotopes. In this study, the effect of temperature on surface soil $\delta^{13}C$ was assessed by a comprehensive investigation at of 27 sites across a temperature gradient along the isohyet. This work Results demonstrates that temperature did does not play a role in soil $\delta^{13}C$. This suggests that organic carbon isotopes in sediments cannot be used for paleotemperature reconstruction and that the effect of temperature on organic carbon isotopes can be neglected in the reconstruction of paleoclimate and paleovegetation. Multiple regressions with MAT (mean annual temperature), MAP, altitude, latitude, and longitude as independent variables and $\delta^{13}C_{SOM}$ as the dependent variable show that these five environmental factors in totaltogether account for only 9% of soil $\delta^{13}C$ variance. However, one-way ANOVA analyses suggest that soil type and vegetation type are significant influential factors influencing on soil $\delta^{13}C$. Multiple regressions, in which the five aforementioned environmental factors were taken as quantitative variables and vegetation type, soil type based on the Chinese Soil Taxonomynomenclature soil type, and World Reference Base (WRB) soil type were separately introduced used as dummy variables, separately show that 36.2%, 37.4%, and 29.7%, respectively, of the variability in soil $\delta^{13}C$ are explained, respectively. Compared to the multiple regressions in which only quantitative environmental variables were introduced, the multiple regressions in which soil and vegetation were also introduced explain more of the isotopic variance, suggesting that soil type and

vegetation type exert~~ed~~ significant influence on $\delta^{13}C_{SOM}$.

1. Introduction

While g~~G~~lobal climate change has ~~recently~~ received a great deal of attention in recent years, ~~and~~ effective predictions of future climate change depend on ~~the~~ relevant information ~~from~~ about climate in the geological past. Over recent decades, stable carbon isotopes in sediments such as loess, paleosol, as well as in lacustrine~~,~~ and marine sediments have been widely used to reconstruct paleo-vegetation and paleo-environments~~,~~ and have provided important insights into patterns of past climate and environmental changes. For examples, ~~many~~numerous researchers have used organic carbon isotopes of loess to reconstruct paleo-vegetation and paleo-precipitation. Vidic and Montañez (2004) conducted a reconstruction of paleovegetation ~~at~~ of the central Chinese Loess Plateau during the Last Glaciation (LG) and Holocene using ~~the~~ organic carbon isotopes in loess from Jiaodao, Shanxi Province. Hatté and Guiot (2005) carried out a pal~~a~~eo-precipitation reconstruction by inverse modeling using the organic carbon isotopic signal of the Nuβloch loess sequence (Rhine Valley, Germany). Rao et al. (2013) reconstructed high-resolution summer precipitation variations ~~in~~ on the western Chinese Loess Plateau during the LG using a well-dated organic carbon isotopic dataset. Yang et al. (2015) ~~derived~~ reconstructed a minimum 300~~-~~km northwestward migration of the monsoon rain belt from the Last Glacial Maximum to the Mid-Holocene using ~~the~~ organic carbon isotope datas from 21 loess sections across the Loess Plateau. However, to our knowledge, there are no researchers have conducted paleo-temperature reconstructions using organic carbon isotope records of loess and paleosol because it has been argued that temperature exerts only a slight, or even no influence on soil organic carbon isotope values ($\delta^{13}C_{SOM}$). While this may be likely, it needs to be demonstrated investigated because only few studies have addressed the influence of temperature on organic carbon isotopes of modern surface soil. Lee et al. (2005) and Feng et al. (2008) both reported no relationship between temperature and surface soil $\delta^{13}C$ in central-east Asia. However, Lu et al. (2004) discovered a nonlinear relationship between mean annual temperature (MAT) and $\delta^{13}C_{SOM}$ from for the Qinghai–-Tibetan Plateau.; Sage et al. (1999) compiled the data from Bird and Pousai (1997) and also found a nonlinear trend for the variation in $\delta^{13}C_{SOM}$ along a temperature gradient in Australian grasslands and savannas.

Plant residues are the most important source of soil organic matter. Values for $\delta^{13}C_{SOM}$ is are generally close to plant $\delta^{13}C$ values, despite isotopic fractionation during the decomposition of organic matter (Nadelhoffer and Fry, 1988; Balesdent et al., 1993; Ågren et al., 1996; Fernandezet al., 2003; Wynn, 2007). Thus, the influential factors for influencing plant $\delta^{13}C$ might also influence $\delta^{13}C_{SOM}$. Plant $\delta^{13}C$ valuesin plants, especially those of C_3 plants, is are tightly associated with precipitation, so suggesting that precipitation may also affect soil $\delta^{13}C$ (Diefendorf et al., 2010; Kohn, 2010). In addition to the effect of precipitation, manynumerous other factors, such as temperature, air pressure, atmospheric CO_2 concentration, altitude, latitude, and longitude may also influence $\delta^{13}C$ in plants (Körner et al., 1991; Hultine and Marshall, 2000; Zhu et al., 2010; Xu et al., 2015). Although variation patterns of ~~variation in~~ plant $\delta^{13}C$ with respect to temperature are so far unresolved ~~so far~~ (e.g., Schleser et al., 1999; McCarroll and Loader, 2004; Treydte et al., 2007; Wang et al., 2013), it ~~has been~~is widely accepted that temperature has a slight effect on plant $\delta^{13}C$. ~~As such~~Therefore, if the ^{13}C enrichment during soil organic matter decomposition is a constant value, we expect only a slight or no influence of temperature on soil $\delta^{13}C$. However, ~~this~~ ^{13}C-enrichment is affected by environmental and biotic factors (Wang et al., 2015). Thus, it is difficult to determine whether or how temperature affects soil $\delta^{13}C$, and there should be specific investigations focusing on this issue. Although the relationship between temperature and $\delta^{13}C_{SOM}$ has been investigated in the studies mentioned above, these studies were unable to effectively separate the influence of temperature from the effect of precipitation. In addition, there are no meteorological stations near most of the sampling sites in the aforementioned ~~previous~~ studies, suggesting that ~~mentioned above; thus, they had to interpolate~~ meteorological data had to be interpolated, which can ~~be~~lead to unrealistic precipitation data in regions with strong topographical variability. This interpolation could have ~~produced~~introduced errors in the relationships between temperature and $\delta^{13}C_{SOM}$ that were established in these studies.

~~Thus, new investigations are necessary.~~ The present study includes ~~an intensive~~a detailed investigation of the variation in $\delta^{13}C_{SOM}$ with respect to temperature across a temperature gradient along the 400 mm isohyet (isopleth of mean annual precipitation; MAP) in China. We sampled surface soil along ~~the~~ a specific isohyet to minimize the effect of precipitation changes on $\delta^{13}C_{SOM}$.

~~In addition, there are no meteorological stations near most of the sampling sites in the previous studies mentioned above; thus, they had to interpolate meteorological data, which can be unrealistic in regions with strong topographical variability. This interpolation could have produced errors in the relationships between temperature and~~ ~~$\delta^{13}C_{SOM}$ that were established in these studies.~~ In ~~the present investigation~~addition, we collected samples only at ~~those~~ sites with meteorological stations.~~;~~ ~~thus~~Thus, the climatic data ~~that~~ we obtained from these stations are ~~probably~~ likely more reliable ~~compared to~~than ~~the~~ interpolated values~~pseudo-data~~.

2. Materials and methods

2.1. Study site

In this study, we set up a transect along the 400 mm isohyet from Langk~~K~~az~~Z~~i (site 1, 29°3.309′N, 90°23.469′E) on the Qinghai–~~-~~Tibetan Plateau in southwest China to Beij~~J~~ic~~C~~un (Site27, 53°17.458′N, 122°8.752′E) in Heilongjiang Province, ~~in~~ northeast China (Fig. 1, Table 1). The straight-line distance between the ~~above~~ two sites is about 6000 km. Twenty-seven (27) sampling sites were set along the transect. Among these sampling sites, 10 sites ~~were~~ are located on the Qinghai–~~-~~Tibetan Plateau and the ~~others~~ remaining sites ~~were~~ are in north China. Beijicun ~~BeiJiCun~~ and Kud~~D~~ue~~E~~r ~~had~~ have the lowest MAT of -5.5 ~~℃~~ ℃, while Shenm~~M~~u ~~had~~ has the highest MAT of +8.9 ~~℃~~ ℃. The average MAP of these sites ~~was~~ is 402 mm. In north China, rainfall from June to September accounts for approximately 80% of the total annual precipitation, and the dominant control over the amount of precipitation is the strength of the East-~~-~~Asian monsoon system. ~~In~~ On the Qinghai–~~-~~Tibetan Plateau, however, precipitation is associated with both the Southwest monsoon and the Qinghai–~~-~~Tibetan Plateau monsoon; approximately 80–~~-~~90% of rainfall occurs in the summer season (from May to October).

Fig. 1

Table 1

2.2 Soil sampling

Soil samples were collected in the summer of 2013 between 12 July ~~12~~ and 30 August ~~30~~. To avoid disturbance ~~of~~ by human activities, sample sites were chosen 5–~~-~~7 km from the towns where the meteorological stations are located. We set three ~~quadrates~~ squares (0.5 × 0.5 m) within a 200 m^2 area to collect surface mineral soil (0–~~-~~5 cm) using a ring knife. The O-horizon, including litters, moders, and mors, was removed before collecting mineral soils. About 10 g of air-dried soil was sieved ~~at~~ using a 2-mm mesh. Plant fragments and the soil fraction coarser than 2 mm were removed. The remainder of the sieved sample was immersed ~~using excessive~~in HCl (1 mol ~~/~~L^{-1}) for 24 ~~h~~hours. To ensure that all carbonate was ~~cleared~~removed, ~~we conducted artificial~~the samples were stirred~~ing~~ four times during the immersion. Then, the samples ~~was~~ were washed to neutrality using distilled water, ~~. Finally it was~~ oven-dried at 50 °C, and ground. Carbon isotope ratios were determined ~~on~~ using a

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Delta^{Plus} XP mass spectrometer (Thermo Scientific, Bremen, Germany) coupled with an elemental analyzer (FlashEA 1112; CE Instruments, Wigan, UK) in continuous flow mode. The elemental analyzer combustion temperature was 1020 ~~℃~~ ℃.

~~The carbon~~Carbon isotopic ratios are reported in delta notation relative to the V-PDB standard using the following equation:

$$\delta^{13}C = (R_{sample}/R_{standard} - 1) \times 1000 \quad (1)$$

where $\delta^{13}C$ is the carbon isotope ratio of the sample (‰) and R_{sample} and $R_{standard}$ are the $^{13}C/^{12}C$ ratios of the sample and the standard, respectively. ~~For this measurement, we~~We obtained a standard deviation of less than 0.15‰ among replicate measurements of the same soil sample.

3. Results

Except for one $\delta^{13}C_{SOM}$ value (-18.8‰), all other data ~~ranged~~ vary ~~from~~ between -20.4‰ ~~to~~ and -27.1‰ with a mean value of -23.3‰ (n = 80, s.d. = 1.45). Multiple regressions with MAT, MAP, altitude, latitude, and longitude as independent variables and $\delta^{13}C_{SOM}$ as the dependent variable shows that only 9% of the variability in soil $\delta^{13}C$ can be explained ~~as~~ by a linear combination of all five environmental factors ($p = 0.205$; Table 2). Considering the possibility of correlations among the five explanatory variables, stepwise regression was used to eliminate the potential influence of collinearity among them. Variables ~~were incorporated into the model~~ with *P*-values < 0.05 were incorporated into the model and ~~excluded~~ variables with *P*-values > 0.1 were excluded. Statistical analysis show~~sed~~ that only latitude ~~was~~ is included in the stepwise regression model (R^2 = 0.077, p = 0.012). In order to better constrain the relationship between soil $\delta^{13}C$ and each environmental factor, bivariate correlation analyses of soil $\delta^{13}C$ against some of the environmental factors were conducted. The bivariate correlation analyses show that $\delta^{13}C_{SOM}$ is not related to MAT (p = 0.114) or SMT (p = 0.697) along the isohyet (Fig. 2a, b). In addition, in order to further determine the response of $\delta^{13}C_{SOM}$ to temperature, we considered three subsets of our soil samples defined according to the climate, topography, or vegetation type of the Qinghai ~~-~~Tibetan Plateau (mainly alpine meadow, ~~including~~ 10 sites), steppe or grassland (11 sites), and coniferous forest (six sites; Table 1). Bivariate correlation analyses within these subsets also show no relationship between $\delta^{13}C_{SOM}$ and MAT for all categories. The correlation analysis of $\delta^{13}C_{SOM}$ with respect to altitude is shown in Fig. 3, which displays no relationship (p = 0.132). Although longitude ~~was~~ is not found to influence $\delta^{13}C_{SOM}$ in the above stepwise regression, bivariate correlation analyses show~~ed~~ that both latitude and longitude ~~were~~ are ~~both~~ negatively correlated ~~to~~ with $\delta^{13}C_{SOM}$ (p = 0.012 and 0.034, respectively; Fig. 4a, b).

In addition to the effects of quantifiable environmental factors, qualitative factors such as soil type and vegetation type may influence $\delta^{13}C_{SOM}$. Various concepts have been introduced in soil taxonomy, leaving varied soil nomenclatures in use. In this study, we adopted the Chinese Soil Taxonomy ~~soil nomenclature~~ and the World Reference Base (WRB) to describe the observed soils. The soil ~~was~~ samples can be divided into eight or six types based on the Chinese Soil Taxonomy or WRB, respectively (Table 1). One-way ANOVA analyses suggest that both soil and vegetation type play~~ed~~ a significant role ~~in~~ for $\delta^{13}C_{SOM}$ ($p = 0.002$ for soil type based on the Chinese Soil Taxonomy, $p = 0.003$ for soil type based on WRB, and $p = 0.001$ for vegetation type; Fig. 5).

To further constrain the effects of soil and vegetation type on $\delta^{13}C_{SOM}$, multiple regressions with soil and vegetation type as dummy variables were conducted. Considering the tight relationship between soil type and vegetation type, especially in the Chinese Soil Taxonomy~~soil taxonomy~~, ~~the~~ soil variables and ~~the~~ vegetation variables were separately introduced into the statistical analyses. Multiple regression, in which the five aforementioned explanatory environmental factors were taken as quantitative variables and the eight soil types of the Chinese nomenclature as values of a dummy variable, shows that environmental factors and soil types ~~in total~~ account for 37.4% of the soil $\delta^{13}C$ variance ($p < 0.001$; Table 2). Using the six soil types based on WRB rather than the Chinese nomenclature, 29.7% ($p = 0.003$) of the variability is explained (Table 2). Similarly, multiple regression with vegetation types as dummy variables shows that the five environmental factors and vegetation types ~~in total~~together can explain 36.2% of the variability in soil $\delta^{13}C$ ($p = 0.001$; Table 2). Compared to the multiple regressions in which only quantitative environmental variables were introduced, the multiple regressions in which soil and vegetation were also introduced explain more of the variance, suggesting that soil type and vegetation type play~~ed~~ a significant role in $\delta^{13}C_{SOM}$ variability.

Table 2

Fig. 2a, b

Fig. 3

Fig. 4a, b

Fig. 5

4. Discussion

Soil $\delta^{13}C$ depends on the $\delta^{13}C$ of plants and on carbon isotopic fractionation during organic matter decomposition. $\delta^{13}C$ values of C_3 plants vary between -22‰ and -34‰ with a mean of -27‰, and C_4 plants range from -9‰ to -19‰ with a mean of -13‰ (Dienes, 1980). Carbon isotope fractionation occurs during the process of plant litter decomposition ~~into~~ to soil organic matter in most environments, especially in non-arid environments, causing ^{13}C-enrichment in soil organic matter compared to the plant sources (Nadelhoffer, 1988; Balesdent et al., 1993; Ågren et al., 1996; Fernandezet al., 2003; Wynn et al., 2005; Wynn, 2007). ~~An intensive~~A detailed investigation of isotope fractionation during organic matter decomposition, which was conducted ~~in~~ on Mount Gongga, an area of the Qinghai–~~-~~Tibetan Plateau dominated by C_3 vegetation with herbs, shrubs, and trees, showed that the mean ^{13}C-enrichment in surface soil (0–~~-~~5 cm depth) relative to the vegetation was 2.87‰ (Chen et al., 2009). Another investigation of 13 soil profiles from the Tibetan Plateau and north China showed that the $\delta^{13}C$ difference between surface soil ~~(0-5 cm depth)~~ and the original biomass varied from 0.6 to 3.5‰ with a mean of 1.8‰ (Wang et al., 2008). Thus, the $\delta^{13}C_{SOM}$ dataset from this study ($\delta^{13}C_{SOM}$ ranges from -20.4‰ to -27.1‰) indicates that the modern terrestrial ecosystem along the isohyet is ~~greatly~~ dominated by C_3

plants. This result is consistent with the observations of vegetation along the isohyet completed in our previous study (Wang et al., 2013). We are surprised by suchThe high relatively heavy soil $\delta^{13}C$ values (mean: -20.4‰) occurring at RikKazZe (Site 2; Fig. 3 and Table 1) are surprising because only four species of C_3 plants grew grow there, and there were no C_4 species are absent. This abnormal observation suggests that very high large carbon isotope fractionation with during SOM degradation has occurred in the local ecosystem. Previous studies have also observed a similar phenomenon, although the mechanism responsible for the unusually high large isotopic fractionation remains unclear. For example, Wynn (2007) reported that isotopic the fractionation enriched soil organic carbon by ^{13}C up to ~-6‰ with respect to the original biomass.

The MAT, MAP, altitude, latitude, and longitude combined are responsible for only 9% of the variability in soil $\delta^{13}C$ in the multiple regression model, suggesting that the contribution of these five environmental factors to the soil $\delta^{13}C$ variance is very small. Our previous study conducted along the same isohyet resulted inindicated a strong positive relationship between the $\delta^{13}C$ of plants and MAT, with a coefficient of 0.104‰ ‰/°C^{-1} (Wang et al., 2013). The difference between the maximum and minimum temperature along the isohyet is 15 °C, so the greatest possible effect of temperature on plant $\delta^{13}C$ along the temperature gradient is 1.56‰, which is not very substantial. Because the main source of soil organic matter along the isohyet is C_3 plants, the induced variance in soil $\delta^{13}C$ by plant $\delta^{13}C$ can also cannot be very high. On the other hand, although the ^{13}C-enrichment with during SOM degradation

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follows a Rayleigh distillation process (Wynn, 2007), our recent study shows that temperature does not influence carbon isotopic fractionation during decomposition of organic matter (Wang et al., 2015), which also explains the lack of a relationship between soil $\delta^{13}C$ and temperature. Feng et al. (2008) and Lee et al. (2005) ~~respectively~~ reported no relationship~~s~~ between soil $\delta^{13}C$ and MAT and SMT, respectively, which is consistent with our results. Their field campaigns were conducted in central Asia, which is also dominated by C_3 plants, similar to the area along the 400-mm isohyet. This is the reason why the same pattern exists in both central Asia and in the area along the 400-mm isohyet.

~~The observations~~Observations ~~in~~ by Bird and Pousai (1997) and Sage et al. (1999) appear to be inconsistent with our findings; ~~they~~ the authors found a nonlinear relationship between soil $\delta^{13}C$ and MAT in Australian grasslands. However, if they considered only soil with pure C_3 plants (MAT is below 16 °C), soil $\delta^{13}C$ and temperature were not related in Australian grasslands, which agrees with our results. Below 15 °C, the C_4 contribution to productivity in Australian grasslands is negligible, whereas above 23 °C, C_3 contribution is negligible. Between 14 °C and 23 °C, soil $\delta^{13}C$ is positively correlated with MAT, indicating an increase in C_4 representation ~~increasing~~ with increasing MAT (Sage et al., 1999). Lu et al. (2004) also reported a nonlinear relationship between soil $\delta^{13}C$ and MAT. Similarly, if ~~the~~ their soil data with C_4 plants are excluded from the nonlinear correlation, soil $\delta^{13}C$ is also not related to MAT ~~in Lu et al. (2004)~~ (see Fig. 5 b in Lu et al., 2004). Thus, the present study and the previous observations are consistent in showing that in a terrestrial ecosystem in which the vegetation is dominated by C_3 plants, temperature does not influence soil $\delta^{13}C$ variance.

Because All all the soil samples were taken along the 400--mm isohyet; thus, this study shows that the contribution of precipitation to the variability in soil $\delta^{13}C$ is negligible. Although stepwise regression and correlation analysis both show a significant influence of latitude on soil $\delta^{13}C$ ($p = 0.012$; Fig. 4a), which was also described by Bird and Pausai (1997) and Tieszen et al. (1979), the five environmental variables, including latitude, were are responsible for only 9% of the variability in soil $\delta^{13}C$ in a multiple regression model (Table 2), suggesting that the contribution of latitude to soil $\delta^{13}C$ was is also limited. This study shows a negative correlation between latitude and $\delta^{13}C_{SOM}$ (p=0.012). Bird and Pausai (1997) and Tieszen et al. (1979) reported a similar pattern. Latitude is a comprehensive environmental factor, and change in latitude can bring about changes in other environmental factors, such as temperature, irradiation, cloud amount, and moisture. Among those, tTemperature and irradiation, however, should be most strongly related to latitude and obviously change with latitude. The observed significant relationship between latitude and soil $\delta^{13}C$ (Fig. 4a) suggests that environmental factors other than temperature might also contribute more or less to the variance in soil $\delta^{13}C$.

Control of soil $\delta^{13}C$ by vegetation type mainly reflects the effect of life forms on plant $\delta^{13}C$, which in turn influences and the effect of substrate quality on isotope fractionation during organic matter decomposition. Communities in which life forms of dominant plants are similar are generally treated as the same vegetation type. Plant

$\delta^{13}C$ is ~~tightly~~closely related to life form (Diefendorf et al., 2010; Ehleringerand Cooper, 1988), ~~and~~ which ~~this~~ causes $\delta^{13}C$ differences among varying vegetation types, ~~consequently~~ resulting in the observed effect of vegetation type on soil $\delta^{13}C$.

Substrate quality partly quantifies how easily organic carbon is used by soil microbes (Poageand Feng, 2004). It can be related to plant type and is often defined using ~~a~~ the C/N ratio, lignin content, cellulose content, and/or lignin content/N ratio (Melilloet al., 1989; Gartern et al., 2000). Our study ~~in~~ of Mount Gongga, China, showed that litter quality play~~ed~~s a significant role in isotope fractionation during organic matter decomposition, and that the carbon isotope fractionation factor α increase~~d~~s with litter quality (Wang et al., 2015). Thus, the isotope fractionation factor should differ among sites because litter quality is dependent on vegetation, ~~and this makes soil~~which causes changes ~~its~~ in soil $\delta^{13}C$ with vegetation type.

The effect of soil type on soil $\delta^{13}C$ may be associated with the effect of soil type on isotope fractionation during organic matter decomposition, which involves at least two mechanisms (see Wang et al. [2008] ~~has~~ for a detailed discussion~~ed the mechanisms in detail~~). First, properties and compositions of microbial decomposer communities are dependent on soil type (Gelsominoet al., 1999). Different microbes can have different metabolic pathways, even when they decompose the same organic compound (Macko and Estep, 1984), and the extent of isotope fractionation during decomposition may be ~~tightly~~closely related to the metabolic pathways of microbes (Macko and Estep, 1984). Second, physical and chemical properties such as pH, particle size fraction, and water-holding capacity ~~display~~ are considerabl~~e~~y differen~~tces~~ among soil types, ~~and this~~which causes organic compounds to decay at different rates in different soil environments. The magnitude of isotope fractionation during decomposition is linked to the degree of organic matter decomposition (Feng, 2002). Thus, soil type plays a significant role in soil carbon isotopic fractionation.

5. Conclusions

The present study ~~measured~~ analyzed organic carbon isotopes in surface soil along a 400-~~-~~mm isohyet of mean annual precipitation in China. Our results indicate ~~and observed~~ that both soil type and vegetation type ~~both~~ significantly influence~~d~~ soil organic carbon isotopes. However, temperature ~~was~~ is found to have no observable impact on $\delta^{13}C_{SOM}$, suggesting that $\delta^{13}C$ signals in sediments cannot be used for ~~the~~ temperature reconstructions ~~of temperature~~ and that the effect of temperature on $\delta^{13}C_{SOM}$ should be neglected in reconstructions of paleo-climate and paleo-vegetation that use carbon isotopes of soil organic matter.

Acknowledgments

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