Responds to Dr. Dupont's comments and suggestions

We thank you for your helpful comments. All the suggested modifications will be carefully revised. The point to point responses to the comments are listed as followed.

1. The timing of the aridification is discussed in the context of the Miocene cooling as recorded in benthic foraminifera and in the context of the uplift of the Himalaya. The discussion about the foraminifer record is not very clear and I have some questions put on the annotated manuscript (page 5255). The discussion is illustrated with Figure 4 and, although I have some issues with its caption (see specific remarks), the message seems to be clear: the aridification of central Asia between 7 and 8 Ma falls during a period of major Tibetan Plateau uplift but not during the strong Miocene global cooling trends. This is at odds with the conclusion 'that global cooling may have been a potential driving force for aridification of the Asian interior, and that TP uplift probably enhanced this process'. Therefore, I suggest clarifying the discussion and altering the conclusion as to present the uplift as the main driver of aridification during the late Miocene to which global cooling might have helped.

Response: Your suggestion is reasonable. Although the global cooling should somehow lead to net aridification on the planet, cooling and aridification trends do not seem to run parallel (van Dam, 2006). However, integrated studies showed that the global cooling during the late Cenozoic had significant influences on driving the Asian monsoon climate and the interior Asian arid climate (e.g. Lu et al. 2010; Tang and Ding, 2013; Lu and Guo, 2014). In particular, the global cooling might have played a more important role since the late Miocene (Lu and Guo, 2014). It is clear that the global cooling has strengthened the Siberia High, which dominates winter monsoon circulation and aridity in eastern Asia (Lu and Guo, 2014). This would result in enhanced and more frequent cold surges in the mid-latitudes of Northern Hemisphere. Meanwhile, the global cooling caused the weakening of hydrological

cycle, lowering of sea level and increasing of continental surface. For eastern Asia, cooling weakens monsoon circulation, and consequently drying conditions expand following retreat of the monsoonal rain belt, while in the west, cooling reduces water vapor pressure and therefore reduces the moisture mass transported into the continental interior (Tang and Ding, 2013). In fact, the most significant late Cenozoic global cooling event occurred at ~14Ma (Zachos et al., 2001; Mudelsee et al., 2014), followed by a longer-term, but minor cooling 4-to-10-Ma trend (named by Mudelsee et al., 2014); hence, only minor cooling events occurred at ~10.1Ma and ~7.4Ma. However, seasonal sea ice was present in the Arctic basin during late Miocene (6-10Ma) when Greenland glacial ice began to grow (Moran et al., 2006). Therefore, we think that the global cooling might force the Asian climate change during late Miocene, no matter whether the Tibetan Plateau uplift. The general trend towards a dry climate in interior Asian might be correlated with long-term global cooling. Meanwhile, the uplift of the Tibetan Plateau played an essential role in forming the monsoon and arid climate by blocking moisture transported from the ocean to the interior Asia, enhancing the heating difference between the ocean and land, and affecting the atmospheric circulation that controlled precipitation in eastern Asia (Kutzbach et al., 1993; Li, 1999; An et al., 2001; Dettman et al., 2001, 2003; Boos and Kuang, 2010, 2013; Liu and Yin, 2011; Wu et al., 2012). Although numerous geological evidences suggest that the Tibetan Plateau experienced rapid uplift during 8-10Ma (Molnar et al., 2010; Molnar, 2005; Fang et al., 2003, 2005; Li et al., 2014; Enkelmann et al., 2006; Zheng et al., 2006, 2010; Wang et al., 2006; Lease et al., 2007), there is still much disagreement on the timing and amplitude of the Tibetan Plateau uplift and growth. The northern and northeastern Tibetan Plateau significantly uplifted in the late Miocene and the Pliocene-Pleistocene, but the main uplift occurred as late as the Pleistocene (Li et al., 1979; Li, 1999). Base on model researches, Liu and Yin (2011) indicate that, once the plateau reached certain elevation, arid climate may continue to irreversibly exist in north and northwest China. However, the integration research shows that the Pliocene era might be wetter than late Miocene in China (Guo et al, 2008). The age of the Taklimakan Desert is 5.3Ma (Sun and Liu,

2006), and other deserts' formation time might be the Quaternary (Dong et al., 2013). We recognize that interior Asian aridification may have been enhanced by the uplift of the Tibetan Plateau during late Miocene, but significantly impact on Asia climate should be the uplift during the Pliocene and Quaternary.

In summary, with reference to your suggestions, the conclusion will be "The general long-term drying trend was a response to global cooling, while the stepwise aridification was mainly caused by regional tectonic uplift.".

2. In the discussion, the magnetic susceptibility record of the section is mentioned (and shown in Figure 4). However, there is no reference indicating that the susceptibility data have not been properly published, yet. If that is the case, please describe the measurement and the results in the appropriate sections.

Response: We cite the magnetic susceptibility from Zhang (2013). This reference will be added in the revise manuscript.

Zhang Jun, 2013. Late Miocene climatic changes recorded by colors in the Yaodian section of the Tianshui Basin and its influencing factors. Science Paper Online, 201301-272: 1-10.

SPECIFIC REMARKS

RESULTS. Please add the depth (in meters) to the description of the zones in the results section. Do not give percentages with a precision that is not warranted. Round all percentage values to the nearest integer. The sentence "This diagram principally demonstrates that tree pollen decline stepwise as herbaceous pollen increases" is bad for several reasons. Not the POLLEN decline but the PERCENTAGES decline. The more important objection concerns the meaninglessness of the remark. Because the values are expressed in percentages of the total, the values of the one always will decline if those of the other increase. The Euphorbiaceae is a large plant family with

many representatives, some of them ubiquitous. I cannot believe that no Euphorbiaceae are growing in the area.

Response: Thanks for your advice. We will modify these in the revised manuscript.

DISCUSSION. I do not understand the argument about global cooling leading to a gradual aridity increase (page 5255, line 15-16) in contrast to a stepwise one. Please clarify.

Response: Global cooling is an ongoing process during our studied interval, and affects the environment through a series of feedback process. Presumably, under the assumption of linear forcing, when the global cooling occurs gradually and consistently, the corresponding climate change will be gradual and consistent; if the cooling is episodic, such as Eocene-Oligocene Transition, Oligocene-Miocene Boundary and Middle Miocene Climate Transition, then the corresponding climate change will be intermittent and abrupt. The reality, however, is not such simple because of the non-linear character of the climate system. Here we consider the global cooling as the tectonic scale. We simply think that global cooling would reduce evaporation and evapotranspiration from the ocean and land surfaces, and subsequently decrease the moisture holding capacity of atmosphere and cause long-term decreasing trends in precipitation during our studied interval.

FIGURE CAPTIONS. Please add an explanation of 'GPTS' in the caption of Figure 2. The reference Li et al. (2007) is not listed in the reference list. Please delete the names of the mammals in the caption of Figure 4 as these details are beyond the scope of the paper. Add an explanation for panel (g).

Response: Thank you for your careful reading of our manuscript. We will correct these in the revised manuscript.

LANGUAGE. Sporopollen is a casual term that might better be substituted by ‘pollen and spores’ or ‘palynomorphs’ in writing. In the title I suggest to use ‘palynological’. As the paper does not disclose any spore data, you also could just write ‘pollen’. The use of the word ‘spectrum’ might induce associations with spectral analysis and for that reason, I advise not to use it. Please refrain from the use of vis-à-vis. Often ‘low abundance’ is preferable to ‘low content’. The use of the word ‘content’ in the meaning of ‘percentages’ might be confusing. I learned that in English (I am not a native speaker) ‘this’ is used sparingly and in many cases can be replaced by ‘the’. The Chinese Loess Plateau is only mentioned three times and, therefore, it does not have to be abbreviated.

Response: Thanks for your advice. We will carefully correct these mistakes.

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