Responds to the reviewer's comments and suggestions

We thank the anonymous referee for her or his helpful comments. All the suggested modifications will be carefully revised in our manuscript. The detailed responses to the reviewer's comments are listed as followed.

Discussion:

1) The effect of uplift on climate is regionally differing (e.g. Liu and Yin (2002) and also many of the other studies go into more detail with that). Kutzbach, Prell et al. (1993) also mention the regional response to a uniform Tibetan uplift and monsoon intensification (wetter to the south and east of Tibetan plateau, dryer to the north and west).

Response: Different model setups and boundary conditions might affect the simulation results. Firstly, Kutzbach et al. (1993) conducted simulation experiments using scenarios of "full-mountain" and "no-mountains". However, the Tibetan Plateau (TP) uplift had been intermittent or episodic. To make the numerical simulations closer to the geological history, phased uplift of the TP in subsequent experiments were designed to examine its impact on the climates in Asia (e.g. Liu and Yin, 2002; An et al., 2001, Kitoh, 2004). Although the different sub-systems of Asian Monsoon has different sensitive to the phased uplift of TP, the regional climates responded to the uplift when the TP exceed a critical height are same as the climate effect simulating by plateau uplift as a whole in a single episode. The South and East Asia become wetter, while the North and West Asia become dryer. However, the phased uplift conforms closer to the geological records of the plateau uplift, but this type of experimental design is still not perfect, because the plateau uplift has obvious sub-regional differences, and which would then produce different effects on the climatic environment of various regions in the surroundings (e.g. Boos and Kuang, 2010, 2013; Wu et al., 2012; Tang et al., 2011, 2013).

2) Additionally there is the hypothesis (and modelling studies exist) that show the

importance of the drying of the Paratethys during the late Miocene for Asian monsoon development. This point should also be mentioned (Ramstein, Fluteau et al. 1997; Guo, Sun et al. 2008). Guo, Sun et al. (2008) mention also the effect of a spreading of the South China Sea.

Response: A large number of geological evidences suggest that the vast majority even all Paratethys regression in Tarim Basin (northwest China) occurred in Oligocene ago (e.g. Bershaw et al., 2012; Bosboom et al., 2014). This not only has a significant impact on the major climate reorganization in Asia during the late Oligocene/early Miocene (Zhang et al., 2007; Ramstein et al., 1997; Guo et al., 2008), but also have a profound climate impact on Europe and north Africa during late Miocene (Micheels et al., 2007, 2011; Zhang et al., 2014). Although the Paratethys retreat can strengthen the East Asian monsoon and greatly increase humidity and aridity respectively in the monsoon areas and northwest China, its impact on East Asian climate should be limited during late Miocene. However, we agree that the spreading of South China Sea may help to enhance the south-north contrast of humidity (Guo et al., 2008).

3) It would be advantageous to confront also the different modelling studies and proxy records as far as possible (e.g. general intensification of monsoon, but regional effects on precipitation vary largely among the studies). For example, the study of Tang, Micheels et al. (2011) indicates that with uplift only the EASM strengthens, whereas the EAWM weakens, which is at odds with proxy records of the publications you mention here)

Response: We totally agree that both the proxy record and modeling result are indispensable to fully understand the mechanism of TP and its environmental effects. Actually, although both of proxy records and numerical simulations can reconstruct the history of climate changes, each approach has its advantages and weaknesses (Liu and Yin, 2011), even sometimes resulting in inconsistent with each other. Boundary conditions should be based on the geological/proxy results and are the weak points of models (Micheels et al., 2011). For instance, the uplift of TP was not synchronized across the Plateau during the Late Miocene, and is still discussed controversially; hence, the paleoelevation history of TP is not fully clear (Molnar, 2005; Lu and Guo, 2014). The model resolves the regional scale, whereas proxy data are local conditions (Micheels et al., 2011). Model can represent the larger-scale rainfall trend and proxy data resolve local conditions (Micheels et al., 2011). In addition, the model is designed as an average state over the entire period (Micheels et al., 2007), while the climate was not constant during the time interval. Due to this integration, it is not trivial to compare model results with proxy data (Micheels et al., 2007). For example, with regard to European proxy data, Micheels et al. (2007) observed that the Tortonian run tends to correspond rather more to the Late Tortonian than to earlier parts of the time interval. For us, Zone-2 and Zone-3 in our palynology record reflect temperate open forest and open forest-steppe environment respectively in consist with Tang et al.'s (2011) TORT-model setup (open forest in the northern TP and the Loess Plateau). In addition, the study of Tang et al. (2011) indicates that their regional Tortonian model run shows a stronger East Asian winter monsoon and a weaker summer monsoon compared to today. The proxy records of our cited publications also indicate a weaker summer monsoon during the Late Miocene and a relatively strong winter monsoon during the late Late Miocene. It is in consistent with Tang's results. The northern and northeastern Tibetan Plateau significantly uplifted in the late Miocene and the Pliocene-Pleistocene, and the main uplift occurred as late as the Pleistocene (Li et al., 1979; Li, 1999). Although the Tibetan Plateau experienced rapid uplift during the Late Miocene, its paleoelevation might be just reach Tang's TORT-model setup (northern TP: 30% (of present-day height); central and southeastern TP: 80%; southern TP: 100%; Tian Shan, Gobi Altai and Zagros: 70%; other orography: 70-90%).

4) Last but not least with the discussion of model experiments the large differences between the different studies should be mentioned (resolution, uplift scenarios, types of models –coupled or atmosphere only, RCM or GCM, differences in other boundary conditions that might influence the model response-e.g. Tortonian boundary

conditions and forcing data in Tang, Micheels et al. (2011) etc.).

Response: In our manuscript, we maily used palynology record to discuss the late Miocene vegetation evolution in the northeastern TP. Given the research focus and the limited length, we did not perform detailed comparison of models and only cited the results of model simulations, but we will supplement the comparison between different models with different model setups and boundary conditions mentioned by reviewer. For example, the low spatial resolutions in most models prevent accurate portray of the real topographic features, which may have exerted substantial impact on the development of the Asian monsoon in the Late Miocene (Tang et al., 2011). Different model setups and boundary conditions also influence the explanation of the climate response mechanism of the plateau uplift. The thermal forcing of the Tibetan plateau drives the Asian monsoon system (e.g. Chen et al., 2014; Kutzbach et al., 1993). The insulation effect of the narrow orography of the Himalayas and adjacent mountain alone may trigger the Indian monsoon circulation, while the TP may be very important for East Asian climate (Boos and Kuang, 2010, 2013). New modeling results that the heating of the TP is still necessary to maintain the Asia monsoon circulation (Wu et al., 2012). Some modeling research also considered the regional difference and asynchronous growth of the plateau, and reached the same conclusion that the regional tectonic could affect the monsoon circulation (Tang et al., 2011, 2013; Chen et al., 2014). Although the climate response mechanism of the plateau uplift still has not consensus, the climate effects are seemingly uniform (wetter to the south and east of TP, dryer to the north and west of TP).

5) You might find the following publications also useful: (Kitoh 2004; Wu, Liu et al. 2009; Boos and Kuang 2010; Kitoh, Motoi et al. 2010; Zhang and Liu 2010; Wu, Liu et al. 2012; Wu, Liu et al. 2012; Boos and Kuang 2013; Chen, Liu et al. 2014)

Response: Thanks for your advice and important references will be added in manuscript.

6) Please also add some more detail on your discussion of the impact of global

cooling on Asian climate evolution.

Response: Ok, more detailed discussion will be added in revised manuscript. Considering the decreased atmospheric moisture content with decreasing air temperature, it is to be expected that global cooling should somehow lead to net aridification on the whole planet, but cooling and aridification trends do not seem to run parallel (van Dam, 2006). The spatial complexity of the systems of atmospheric and oceanic circulation ensures that general cooling may result in precipitation decrease in some regions and increase in others (van Dam, 2006). However, integrated studies indicate 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 East Asia (Lu and Guo, 2014). This would result in 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 East 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).

Minor comments

Abstract:

P5244, L12: "…more humid climate developed." better: … rather humid climate existed." as it is not know from the data whether the climate was wetter or dryer before 11.4 Ma.

Response: Thanks for your suggestion. We will revise that.

P5244, L16: "… Asian aridification … " Maybe better write "Central Asian aridification" or aridification in the study area, as there is no proof for a general aridification trend all over Asia, this is to my knowledge e.g. the case for Central Asia, whereas in some regions even more humid conditions developed during that time period.

Response: Thanks for your suggestion. We will revise that.

Introduction:

P5245, L 1+2: is modern Asian Social development relevant for the study? If not, please eliminate that sentence.

Response: Thanks for your suggestion. We will eliminate that sentence.

P5245, L 28+29: "… of northern China through and the evolution of the Asian Monsoon." this sentence is weird.

Response: It will be modified to "Its particular geological and geographical characteristics make it sensitive to document the aridification history of northern China and the evolution of Asian Monsoon accurately."

P5246, 1st paragraph: please indicate a reason why you assume the Longzhong Basin to be the most promising for distinguishing TP uplift and any assoc. env. change.

Response: Geographically, the basin is located in the northeasternmost margin of the Tibetan Plateau, the transition zone of the main Tibetan Plateau and Chinese Loess Plateau. Basin infill will record the uplift history of the plateau. Climatically, the basin is located in the transition zone of the monsoon region and the non-monsoon region, sensitively response to climate change. This northeasternmost corner of the collision highlands also provides the best model of a small, still actively growing and rising, Tibetan Plateau (Tapponnier et al., 2001). In a search for the ideal field area, the northeast margin of the plateau might allow precise timing of both tectonic and local climatic events using the same material (Molnar, 2005).

Discussion:

P5255, L6: "..during toward..." -double wording?

Response: Thanks for your suggestion. We will modify that.

Figure captions:

Figure 4: the labelling is mixed up:

what is g) in the figure is not included in the caption, whereas g) in the caption should be h) and h) should be i).

Response: Thanks for your careful work. (g) Carbon isotope ratios of leaf wax C_{31} *n*-alkane extracted from ODP Site 722 (Huang et al., 2007).

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