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Climate of the Past Discussions
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Interactive comment on "Environmental dynamics since the last glacial in arid Central Asia: evidence from grain size distribution and magnetic properties of loess from the Ili Valley, western China" *by* Yue Li et al.

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For General Comments

CS: Many studies deal with the correspondence between loess deposits and climate circulation but the causal relations are indeed poorly understood. Previously, the attention has been drawn to competing circulation systems of westerlies and monsoons. Thus, relations are indeed best studied in a region where different systems could have been present at times. Consequently, the studied region is favorably situated for this timely research. A most interesting result is the importance of precipitation on the loess

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depositional signal. Until now most attention has been paid to temperature variability that of course also impacts the wind circulation. It seems by this study that resulting oscillations in loess deposition show a complex pattern. And this may be the reason for the fact that the oscillating loess signals in C. Asia and the NE Tibetan Plateau are not that simply correlated with D-O-events or H-events. The paper is well written, designed and archived.

AR: Thanks for your positive comments. This paper made aims to investigate the causal relations between loess deposits and climate circulation. Recently, many researchers have paid much attention to paleoclimate reconstruction in transitional regions where different atmospheric systems predominate at different times, e.g. the Central Balkans (Ramisch et al., 2016), the Qinghai Lake region (An et al., 2012), southwest Asia (Hamzeh et al., 2015). Our study area is likewise situated in the zone influenced by different climatic systems. It therefore becomes important prerequisite to clarify the paleoenvironmental significance of various proxies, in particular which proxies reflect temperature, which represent precipitation, and which indicate wind strength. Our manuscript explores the potential impacts of precipitation on the loess depositional signal, and identifies areas where more work needs to be done in the future. We agree that some scientists have focused on the influence of temperature variability on wind circulation, and in particular the role of local insolation minima in driving an early onset of the LGM in the Southern Hemisphere (Vandergoes et al., 2005). The temperature variability caused by local insolation may reflect larger scale climate change, although we suspect that oscillating loess signals in Central Asia may not so simply reflect D/O events or H events. The aeolian loess sediments in Central Asia are more likely to respond to a complex mixture of global signals with local insolation, glacial activity and local weathering. This overlap will weaken the global signals as preserved within the loess.

For Minor Comments

CS: L 343-359: Two different explanations are claimed for the origin of the fine-grained

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endmember 3 (c. 18.9 μm). The main difference seems to be, if I understand well, that one hypothesis invokes high-suspension transport while in the other one surface winds are involved. However, both hypotheses interpret that this component is the result of background loess supply (as confirmed in lines 389-395) as previously demonstrated by Prins et al (2007), Vriend et al (2011) and Zhang et al (1999). It is not realistic to separate the grain-size fractions of 2-8 μm (transported by westerlies) and 8-15 μm (=EM3, transported at low altitude) as the authors seem to do. Both components react jointly constituting background loess supplied by westerlies as described by e.g. Prins et al. (2007).

AR: We agree with the reviewer on this point. The origins of the EM3 size fraction is indeed complex. For example, based on modern dust monitoring from the high-altitude subtropical Puna-Altiplano Plateau in South America, Gaiero et al. (2013) found that "Finer mode dust is deposited during event periods, which point to a dominant long-range transport, contrasting with a dominance of coarser mode observed for non-dust sampling periods, pointing to dominant local sources." Prins and Vriend (2007) and Prins et al. (2007) suggested that the clayed loess component represented the fine dust component supplied over the entire Loess Plateau by long-term suspension processes, and the high-level subtropical jet stream (westerly winds) might, at least partly, be responsible for the input of this fine-grained loess component. End-member unmixing results of Xiaoerbulake (XEBLK) loess (Li et al., 2016) grain-size distributions show the similar EM3 component to NLK loess (Fig. 1), which suggests that the fine-grained EM3 (c. 18.9 μm) is also the result of background loess supply in the Ili Basin regardless of its origin (Vriend et al., 2011;Zhang et al., 1999;Prins et al., 2007). It is difficult to determine the origins of the fine silt/clay. The appearance of the fine component in dust deposition may be caused by aggregation, due to fine particles adhering to the coarse particles, as well as chemical weathering. Perhaps the method of Machalett et al. (2008) is the better alternative. They neither removed organic matter and carbonates from the stratigraphic samples and nor applied an intensive ultrasonic treatment to disaggregate particles.

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CS: L 441-447: If the Ili valley is sheltered from northeastern wind, as the authors claim, what is then the source area for the EM1 and EM2 fractions? There is no apparent difference between these coarse-grained fractions on the CLP, N Tibet Plateau and in the Ili valley where a distinct supply is clear from the northeast under the influence of the Siberian High.

AR: This is a constructive question. The northern Tien Shan Range reaches altitudes of > 4000 m a.s.l. For the particles with grain size of > 20 μm, it is unlikely that grains of this coarser silt fraction were transported by north-easterly winds above the 4000 m altitude over the northern Tien Shan and into the Ili Basin. We therefore interpret the coarser grained loess particles in the Ili Basin to have been predominantly transported by near-surface winds. The topographic context (see Fig. 1 in the manuscript) most likely ensured the westerly winds coming to be the transporting agent. In our speculation as to the provenance of the NLK loess, we initially compared the REE parameters of NLK loess with those of desert sands and modern soils from the Ili Basin and further west into Kazakhstan (Fig. 2). Our results indicated that the deserts and topsoils in Kazakhstan are unlikely to be the main potential source areas. In contrast, topsoils from the Ili Basin probably provide the most important source materials in the NLK loess. The Quaternary sediments of the Ili Basin mainly consist of alluvial fans and floodplains, and the top soils developed on those. We therefore speculate a proximal source for the NLK loess. Furthermore, recent work from our group indicates that size-differentiated rare earth elements (REE) may help to distinguish potential proximal or distal sources (Chen et al., 2017). In future, we expect to find more substantial evidence for tracing loess provenance in the region.

CS: L 454-456: Explain better how the ‘cyclonic storms’ originated by protrusion of the Arctic polar front, rather than by other circulation patterns.

AR: Thank you for this suggestion. After excluding the influences of the Asian monsoon and the Siberian high-pressure system based on modern observations, we consider that both the polar front and mid-latitude westerlies had important impacts on our study area. Cyclonic circulation associated with the polar front is one of the major driving forces for aeolian dust transport in central Asia today (Lydolph, 1977;Liu et al., 2004). The importance of the polar front is also embodied in other studies (Kirby et al., 2002;Diefendorf et al., 2006;Schöne et al., 2004). According to Harman (1991) and Shriner and Street (1998), the polar front is a discontinuous border zone that generally separates the moister tropical air to the south from the drier polar air to the north. These two air masses from the south and north can generate temperature and pressure differences, which will be settled by the development of the near-surface midlatitude cyclones and the development of troughs in the polar front jet stream. We therefore speculate near-surface northerly transport of the NLK loess deposits with a mean grain size of > 20 μm, whereas westerlies occur in the upper atmosphere throughout the year and are responsible for finer grained transport (Fig. 3). Therefore, we link the polar front with loess deposition at NLK. When the polar front moved southwards in the cold periods, the frequency and strength of cyclonic storms were most likely increased, leading to dust transport and the accumulation of loess deposits (Fig. 8 in Machalett et al. (2008)).

CS: L 476: The interesting absence of correlation between the observed grain-size signals and N Atlantic abrupt events is not only found in the Ili valley but also previously in Tadjikistan and the NE Tibet Plateau (Vandenberghe et al. 2006)

AR: That point has been attracting the attention of our group recently. In our view, the lack of good correlation between observed grain-size and millennial-scale Atlantic events suggests that the loess records in Central Asia represent a response not only to global signals but also local signals such insolation, glacial activity and local weathering. This overlap will weaken the global signals. In contrast, on the orbital timescale, the mid-westerlies may impact on the accumulation of loess deposits by controlling precipitation patterns owing to northward or southward migration of the system.

CS: L 483-484: This sentence is not clear: is 'which' referring to the conclusions by the authors or by Vandenberghe et al.? It is not clear therefore what really is contradicting

AR: I am so sorry for the poor expression. The 'which' referred to the conclusions by the authors. We have revised the sentence, like this "Darai Kalon is located in a region where the mid-latitude westerlies clearly have a much stronger influence, especially during full glacial conditions (Vandenberghe et al., 2006). In contrast, our results from the Ili Basin suggest that the mid-latitude westerlies did not always predominate north of the Kyrgyz Tian Shan due to northward or southward movement of the climate sub-system. In this case, the high mountains in Central Asia most likely obstructed the migration of the Asiatic polar front further south towards Tajikistan where those data were derived (Machalett et al., 2008), thereby resulting in a stronger westerlies signal at Darai Kalon than at NLK." The movement northward or southward of mid-latitude westerlies makes the Ili Basin more sensitive to paleoclimate change in Central Asia, which establishes the strategic position of the Ili Basin in paleoclimatic reconstruction.

For Technical comments

CS: L 123: 'more reliable' than what?

AR: Thank you for your careful reading. We have rewritten this sentence. Actually, we mean that the optically stimulated luminescence (OSL) dating is more reliable for constructing a loess chronology than AMS 14C ages for older than MIS2 aeolian sediments according to Song et al. (2015).

CS: L 317: 'shorter' than what?

AR: EM1 is likely derived from shorter distance transport of suspended load owing to its larger modal grain size. Thus, its transport distance is shorter than the finer grains, like the EM2 and EM3 fractions in this manuscript.

CS: L 139: insert 'were' between 'S1)' and 'then'; Figure 1 is too small. L 182: remove 'are'; L 513: remove 'can' or 'may'.

AR: Yes, these are grammar errors. We have corrected these mistakes accordingly. We also adjusted the layout of Fig. 1 and increased front size. Thank you.

CS: I suggest to shorten the title a bit

AR: Yes, we have rewritten the title, “Environmental dynamics since the last glacial period in arid Central Asia inferred from loess deposits in the Ili Basin”. We look forward to your further comments about that. Thank you.

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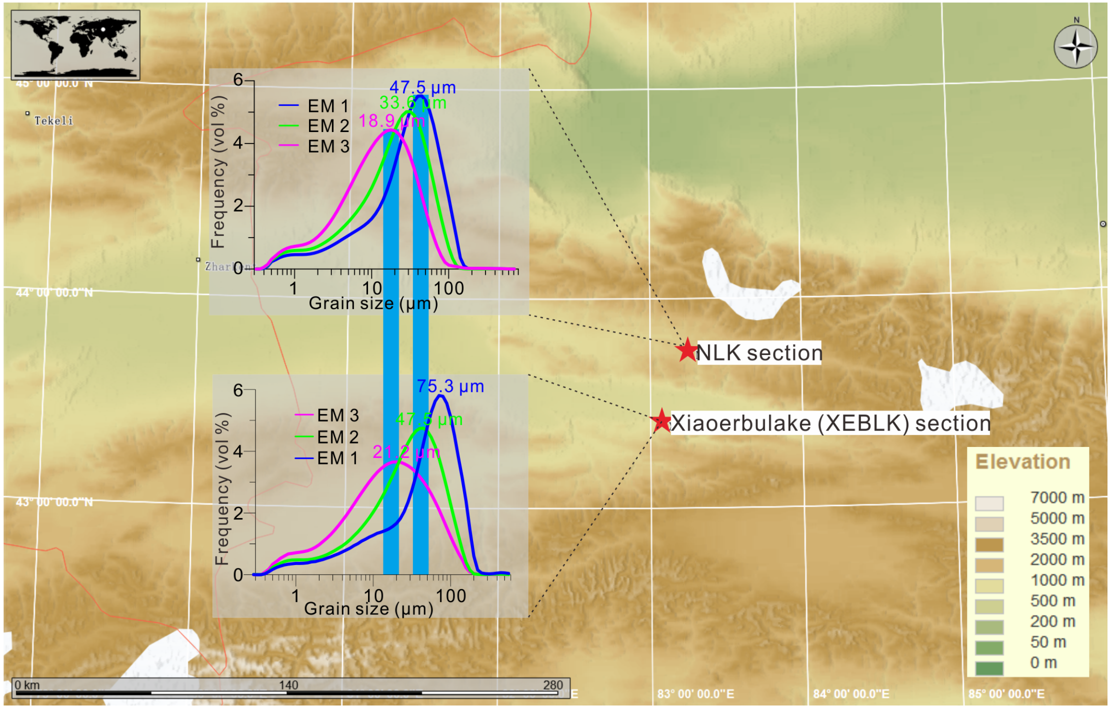

Fig. 1. Comparison of end-member unmixing results of NLK loess and Xiaoerbulake (XEBLK) loess grain-size distributions.

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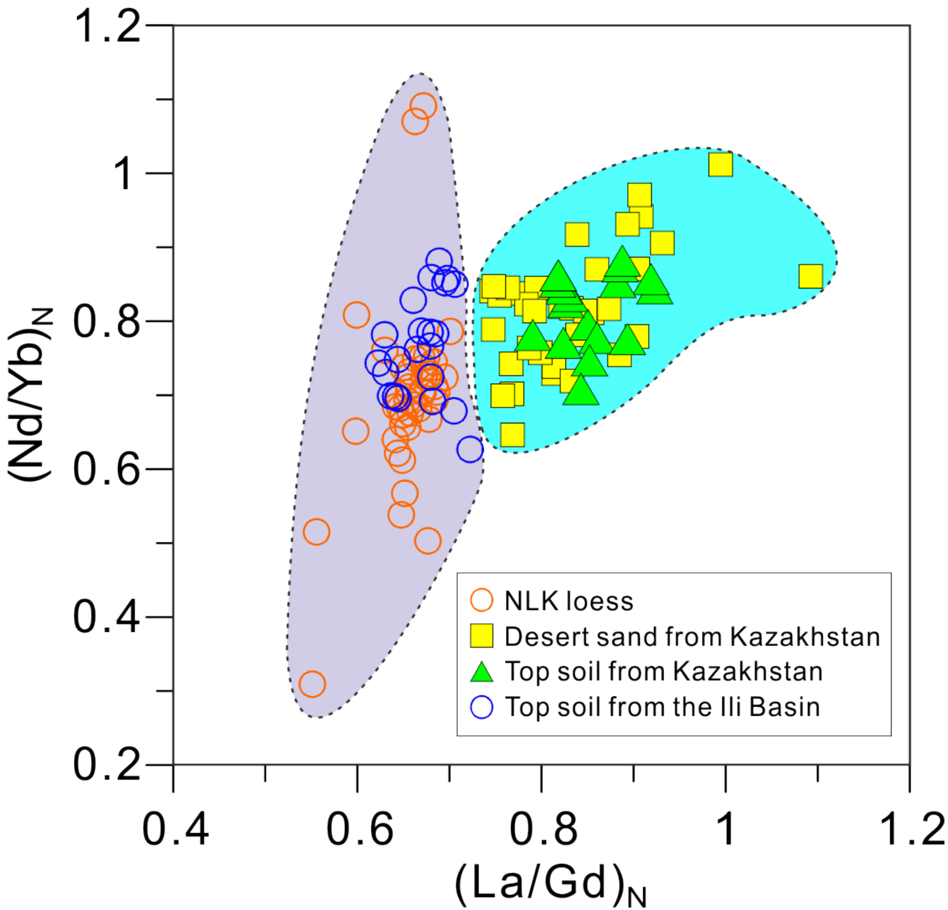

Fig. 2. (Nd/Yb)N vs. (La/Gd)N of loess, top soil and desert sands from the Ili Basin and Kazakhstan.

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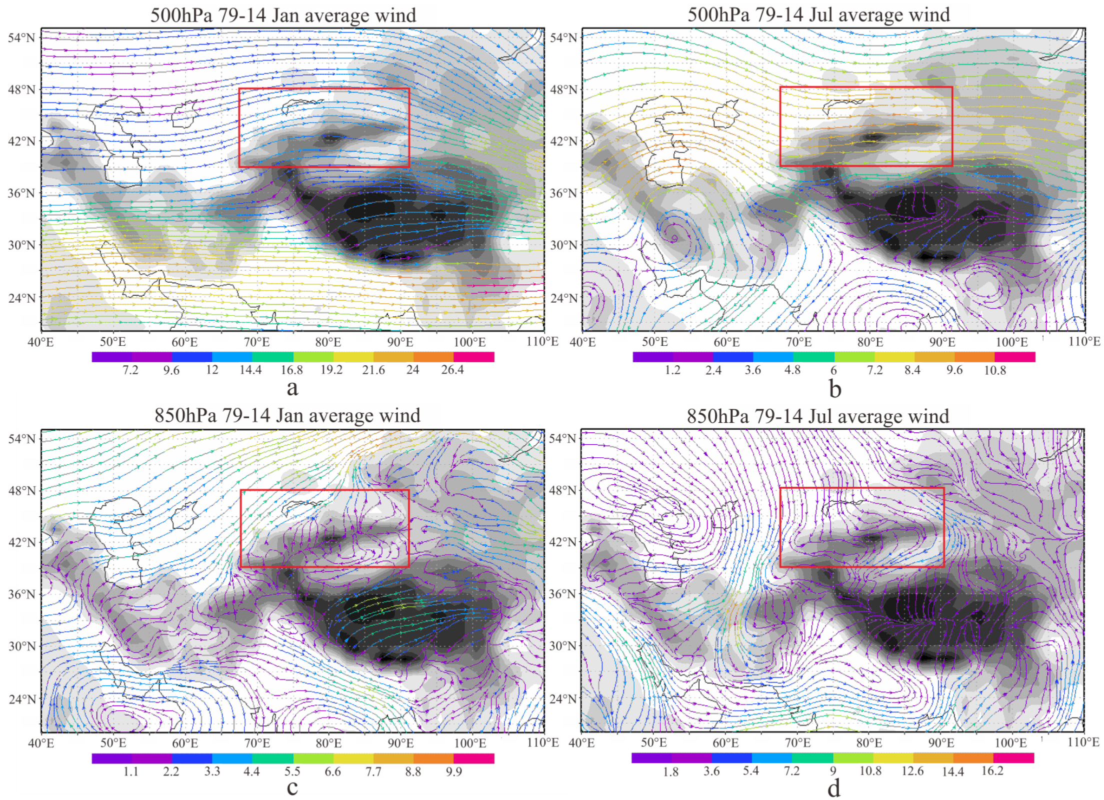

Fig. 3. Mean streamline (m/s) for the years 1979–2014 in Central Asia (data from the European Centre for Medium-Range Weather Forecasts)

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