Detailed response to reviewer's comments:

The responses are in blue. The revisions are marked in red in the revised manuscript.

The comments were separated into several parts and responded to point by point.

Reviewer #1:

Major comments:

1. The authors say the Jiayuguan is finally closed in 1539 AD and this is the end of the Ancient Silk Road on land (Line 213-215). However, Fig 2 b-c show the tribute trades through the Jiayuguan Pass still exist after 1539 AD. The authors should give more details and explanation on this contradiction.

Response: Thanks for the reviewer's constructive suggestion. Jiayuguan Pass was the primary routeway connecting the western region to the domestic territory during the study period. The closure of the Jiayuguan Pass in 1539 AD was essentially the official abandonment of territory outside the Jiayuguan Pass (including the Dunhuang area); it also intensified the tribute trade restriction. The twice closure of the Jiayuguan Pass contributed to a much stricter management system for tribute trades and also caused the obvious decline of trade frequency (*Yang et al., 1997; Yang et al., 2014*). On the other hand, a small number of trades still continued between the Ming government and several Western countries (*Research Institute of History and Language of the Central Academy,1962; Sheng, 1989; Tian, 1999*). So, small number of tribute trades through the Jiayuguan Pass still exist after 1539 AD but the Silk Road lost prosperity.

References:

Research Institute of History and Language of the Central Academy. Ming Shilu, Ming Xiaozong Shilu, Taiwan, 1962.

Sheng, S. X., Ming Hui Dian, China Publishing House, Beijing,1989.

Tian, S. Tributary trade between Gansu town and in western regions in Ming Dynasty. China's borderland history and geographic studies, 1999 (01):15-24.

Yang, F. X. The Overland Silk Road and its Trade in Ming Dynasty. China's borderland history and geographic studies, 1997(02):12-20.

Yang, L. K., West wind miles of river road: Study on emissaries and business Trips on the Silk Road in the Western Regions of Ming Dynasty, Lanzhou University Press, Lanzhou. 2014.

2. The Jiayuguan Pass was first closed in 1524 AD and finally closed in 1539 AD. In Fig 2 f-g, the tree-ring based precipitation and streamflow reconstructions show the

drought climate condition is during 1450- 1510 AD and the hydroclimate returns to average since 1520s. This indicates that the rainfall is normal during 1524 to 1539. Moreover, the driest decade is around 1460s (Fig 2f-g) and 1490s (Fig 2f) and there are several trade teams in these intervals. This means that it is possible for people to reach Jiayuguan under the worst climate condition. Therefore, there must be other critical factors for the closure in 1539. More evidences are needed to prove which factor is the most important one.

Response: Thanks for the reviewer's constructive suggestion. We agree that the influence of the ~1450 AD arid event on the streamflow of the Qilian Mountain gradually decreased after 1520s. However, oasis formation and development are long-term processes (*Stamp, 1961; Zhang and Hu, 2002; Li et al., 2016*). The oasis ecological response would not be to disappear immediately (*Fan, 1993*), and in addition it takes at least 15-20 years for an oasis to recover after degradation within ~1-3 years (*Zhang and Hu, 2002*). Therefore, the degraded oasis was not as easily reversible as the streamflow does. In addition, once land desertification occurred, the recovery is a long process. We accept the reviewer's advice and have modified the text accordingly. Please sees **Line 452-462.**

On the other hand, the Silk Road on land "interrupted or not" refers to the flourishing or decline of commercial trade between the Ming government and Western countries operating in central Asia. The East-West tribute exchange existed during entire duration of the Ming dynasty (*Research Institute of History and Language of the Central Academy,1962; Sheng, 1989; Tian, 1999*), and there were several trade teams operating around the1460s (Fig 2f-g) and 1490s (Fig 2f). In addition, after 1450 AD, the pronounced decline in tribute exchange indicates that the prosperity of the Silk Road declined abruptly in the Ming dynasty after 1450 AD. Although the immediate cause of the closure in 1539 AD was government policy, we argue that the policy was a result of other factors (Feng et al., 2019). We propose that climatic deterioration and subsequent desertification event during the late 15th century triggered serial social problems such as the abandonment of farmlands in Dunhuang that was the major policy to maintain governance in western frontier areas, extensive human migrations eastward, the increasing threaten of powers in adjacent areas, and then final closure of the Jiayuguan Pass.

References:

Fan, Z.L., A study on the formation and evolution of Oases in Tarim Basin, Acta Geographica Sinica, 1993, 48:421-427.

Feng, Q., Yang, L., Deo, R. C., AghaKouchak, A., Adamowski, J. F., Stone, R., Yin, Z. L., Liu, W., Si, J. H., Wen, X. H., Zhu, M., Cao, S. X.: Domino effect of climate change over two millennia in ancient China's Hexi Corridor, Nat. Sustain., 2, 957-961, 2019.

Li, X., Yang, K., Zhou, Y., Progress in the study of oasis-desert interactions. Agricultural and Forest Meteorology, 2016, 230-231:1-7.

Research Institute of History and Language of the Central Academy. Ming Shilu, Ming Xiaozong Shilu, Taiwan, 1962.

Sheng, S. X., Ming Hui Dian, China Publishing House, Beijing,1989.

Stamp, L.D., 1961. A history of land use in arid regions. Literary Licensing, LLC.

Tian, S. Tributary trade between Gansu town and in western regions in Ming Dynasty. China's borderland history and geographic studies, 1999 (01):15-24.

Zhang, Q., Hu, Y.Q., The geographical features and climatic effects of oasis. Advance in Earth Sciences, 2002,17(4).

3. The author should provide some quantitative evidences of the oasis fragile. For example, how many years continuous drought could destroy it and could the oasis recover when climate return to better condition. There are also many extreme drought years occurred before 1450s but the Silk Road is not interrupted.

Response: This is a very good question. It's quite difficult to quantitatively estimate how many years continuous drought can destroy oasis, and how soon it can recover when climate return to better condition, due to the difference in both local natural and social environments. When ancient human abandoned vast farmlands as was occurred in Dunhuang after ~1450 AD, it provided plenty of material sources to aggravate desertification. Zhang and Hu (2002) suggested that it takes at least 15-20 years for an oasis to recover that has been degraded within ~1-3 years. This means that once destroyed, it takes about ten times longer for an oasis to recover under manual intervention. Therefore, the ancient oasis is very difficult to recover even climate return to better condition. The two desertification events in Dunhuang during ~800-600 BC and post ~1450 AD were primarily triggered by severe climate deterioration that persisted for many decades with large amplitude (Fig. 3), according to the tree records in eastern Qilian mountains (Yang et al., 2014), the duration and drought degree during the Little Ice Age was unparalleled during the past 2000 years, which can explain why the Silk Road was not interrupted by other droughts since Han Dynasty.

References:

Yang, B., Qin, C., Wang, J.L., He, M.H., Melvin, T.M., Osborn, T.J., Briffa, K.R. A 3500-year tree-ring record of annual precipitation on thenortheastern Tibetan Plateau. Proc Natl Acad Sci USA, 2014, 111, 2903-2908.

Zhang, Q., Hu, Y.Q., The geographical features and climatic effects of oasis. Advance in Earth Sciences, 2002,17(4).

4. Which season do most the trade teams passed through the Hexi Corridor? Or do they move in all seasons? The authors say LOI and Rb/Sr profiles represent the spring and autumn period (Line 346). How about other proxies in Fig 2 and 3?

Response: The team mentioned in this study passed through the Taklamakan desert in the autumn (September-November) of 1993 (*Blackmore, 2000*). In addition, the explorer Sven Anders Hedin (1865-1952) preferred to cross the desert in winter (*Hedin, 1996*). The "Spring and Autumn period" that we mentioned is the period during the Zhou dynasty from approximately 771 to 476 BCE (from Wikipedia) but we do not emphasize the seasons. Please see **Line 353-354.** The dating result of 800-600 BC period corresponds to this historical period. All of paleoclimatic proxies in the XSW section show the same trend of variation.

References:

Blackmore, C.: Crossing the Desert of Death: Through the Fearsome Taklamakan. John Murray press, London, 2000.

Hedin, S.A., My Life as an Explorer, Kodansha International, 1996.

https://en.wikipedia.org/wiki/Spring_and_Autumn_period

5. Line 140-146. The topic of the paper is the end of the Ancient Silk Road in Mid-Ming Dynasty while the main data is a sediment core that only has one dating sample since Ming Dynasty. More high resolution data should be included. Authors may be interested in recently published paper. Hao et al. (2019) Climatic changes during the past two millennia along the Ancient Silk Road. Progress in Physical Geography.

Response: Thanks for the reviewer's constructive suggestion. The decline of the Ancient Silk Road is shown by closure of Jiayuguan. We found that the main cause of this closure was desertification inducted by climate change, based on the evidence of the sedimentary profile at XSW, records of stream flow, tree-rings and temperature changes. This is also supported by historical records of the consequent effects in terms of the steep fall in trade, more wars, and eastward migration events in the area. Your suggestion is very important as the more the evidence, the sounder our conclusion. However, we did search many sites for more sections and evidence during the field trip, as the reviewer suggests. Unfortunately, no other profiles were found in the surrounding

areas other than the XSW site, as most of the area is covered by sandy desert. The wood sample, which can be precisely dated by advanced ^{14}C dating techniques, was the only wood sample that we found in the top sand layer. The dating result corresponds well with the ~1450 AD event. The coarse-grained quartz OSL signal was too dim to date in younger upper section of the XSW site. In the basal sand layer at 185-250 cm, no reliable radiocarbon dating material was found. However, the quartz OSL dating approach can be applied for this age range.

The reference of Hao et al. (2019) "Climatic changes during the past two millennia along the Ancient Silk Road. Progress in Physical Geography" was very supportive and enlightening for our research. Thank you for the reviewer's kind reminder. We have cited this paper in the text. Please see **Line 41-42.**

6. Minor comments: 1. Line 146, 270 m should be 270 cm. 2. Line 340, Fig2 should be Fig3.

Response: Thanks for the reviewer's kind reminder. We have modified the content correspondingly. Please see **Line 153 and Line 347.**