Response to Anonymous Referee #1

We thank you very much for your insightful review. Your comments are highly appreciated. We added our response below each of your comment.

The authors Park et al. used a sedimentary record from Miryang in the Korean Peninsula to describe climate induced hydrological changes for the Holocene period ca. 8.3-2.3 ka BP and indicate shifts in the human population with changing intensity of the East Asian Summer Monsoon (EASM). They mainly used a pollen record in combination with high-resolution titanium XRF scanning data and grain size variations to decipher the influence of the Kuroshio Current in the Pacific Ocean and El Nino Southern Oscillation (ENSO) in connection with solar forcing that influenced the development of EASM-regulated hydrologic variations. A summed probability distribution indicates correspondence with changes in the local population in response to climate variations. This manuscript is well written, logically structured and provides reasonable explanations for the influences of different signals on hydrological variations and EASM impact. However, there are several aspects which need to be considered:

1. The chronological frame is not well explained. For example, there is no information how calendar ages related to OSL dating were connected with radiocarbon ages (uncalibrated) to develop a Bayesian age model (Blaauw and Christen, 2011).

Response: We modified the sentence in Lines 107–109 as follows: "Compiling the OSL and radiocarbon dating results, we constructed an age model using the *bacon* R package (Blaauw and Christen, 2011) ver. 2.3 (Fig. 2b). The package allows a combination of different types of dates in a single age-depth modelling. Here, the radiocarbon dates were calibrated based on the IntCal13 calibration dataset (Reimer et al., 2013), while the OSL dates were not because they were already set on the calendar scale. All resulting ages applied in our analysis were expressed as calendar ages".

Furthermore, any explanation about potential reservoir errors is lacking.

Response: Essentially, the OSL dating method does not require a reservoir correction. For radiocarbon dates, general coherency with other OSL dating results (Fig. 2b) indicates that reservoir effect is negligible in our STP18-03 core.

2. With respect to the table1, it remains open, how the authors calibrated the 14C ages. Did they use 1 or 2 sigma uncertainties, and did they report mean, median or weighted mean values? How do these values differ from the Bacon age model? A column should be added to show this. The uncertainty values (in table 1) for the calibrated values are somewhat strange. They should check and correct it, while mentioning this in the results part under 4.1 Chronology.

Response: We replaced the calibrated ages in Table 1 to weighted mean ages as calculated from the *bacon* package (Blaauw and Christen, 2011) based on the IntCal13 dataset (Reimer et al., 2013), which are the same as used in our analysis. We added this information to the caption. The previous dates in Table 1 were the ones preliminarily calculated at the dating institution with OxCal (Ramsey, 1995), and they were not directly related to our age-depth model. We appreciate your noticing.

By the way, the age-depth model in figure 2b needs a readable age axis. It is impossible to read it because the axis description is far too small.

Response: We modified Fig. 2b as your direction.

Furthermore the authors should explain that the reported ages later in the discussion part refer to calibrated (cal.) ages BP or not. How did they deal with OSL calendar ages in this respect?

Response: We modified the sentence in Line 107–109 as follows: "Compiling the OSL and radiocarbon dating results, we constructed an age model using the *bacon* R package (Blaauw and Christen, 2011) ver. 2.3 (Fig. 2b). The package allows a combination of different types of dates in a single age-depth modelling. Here, the radiocarbon dates were calibrated based on the IntCal13 calibration dataset (Reimer et al., 2013), while the OSL dates were not because they were already on the calendar scale. All resulting ages applied in our analysis were expressed as calendar ages".

2. The explanation in the methods part is not sufficiently provided. How did they drill and how long were the core sequences?

Response: The length of the core is 20 meters, as mentioned in Line 100. For drilling, we used a hydraulic piston corer mounted on a truck. We modified the sentence in Line 100 as follows: "In April 2018, the 20-m STP18-03 core was collected in 1-m sections from a former floodplain of the Miryang River, using a hydraulic piston corer (Fig. 1)".

Furthermore how did they deal with potential sediment loss/overlapping at the boundary between the core segments? Finally how did they splice the different core sequences towards a composite one?

Response: Our hydraulic piston corer was mounted on a truck and drilled under stable conditions. The truck was anchored on the solid ground while the drill was put into the hole with consistent mechanic settings. Therefore, we assumed that potential loss or overlapping between core the segments was minimal and spliced them without additional correction process.

Furthermore, how was the instrumental setting for detecting titanium signals by XRF scans?

Response: We separated the sentences in Line 127–133 as a new paragraph for better readability.

3. In chapter 4.2 the authors described the selected zones based on the provided data. This part is partly mixed with interpretation of data variations. The authors should perhaps change the title of chapter 4 (Results) to Results and interpretation.

Response: We modified the title of Chapter 4 as your advice: "Results and interpretation".

Furthermore, I wonder why the authors did not provide graphs for the clay and silt fractions in addition to the sand fractions. In line 149 they mention that the sediments mainly consist of clay. This would we worthy to demonstrate this by the clay and silt fraction graphs. They could be attached to figure 2a.

Response: We added the clay and silt fractions to Fig. 2 along with the sand fraction data. We also added a description of core lithology and changed the figure caption as follows: "Figure 2: (a) Lithology of the STP18-03 core and (b) ~~ (c–h) results of multi-proxy analyses of (c) clay fraction, gray; (d) silt fraction, light brown; (e) sand fraction, dark brown; (f) titanium (Ti) content, black; (g) tree pollen percentage, green; and (h) sum of Artemisia (mugwort) and Poaceae (wild grass) pollen and fern spores, magenta. Zones are separated by black horizontal lines.".

We also edited figure numbers throughout the text which are associated with Fig. 2.

We modified the Line 149 as follows: "This zone consists mainly of very dark brown silt and sand alternating in multiple layers with ~15 % of clay (Fig. 2a and c–e)".

We modified the Line 164 as follows: "From 790 to 400 cm, the clay and silt content gradually increase as depth decreases, from ~15 and ~30 % to ~20 to ~70 %, respectively (Fig. 2c and da).".

4. Lines 229-234: The authors refer to a cooling trend around 6.4-6.0 ka BP and mention that this is not seen in other records. They used an example (lines 232-234), but to my understanding this explanation supports their finding. So, what are the differences? This part of the discussion remains not very clear and shall be considered for revision.

Response: To clarify the discussion, we revised the paragraph (Lines 229–249) as follows: "Among these periods, a sign of drying and/or cooling around 6.4–6.0 ka BP (Fig. 4b–e) at Miryang is consistent with our previous finding at Lake Pomaeho in the central Korean Peninsula (Constantine et al., 2019) (Fig. 1b). Outside of the peninsula, Daihai Lake (Xiao et al., 2004) and Gonghai Lake (Chen et al., 2015a) in North China and Dongge Cave in South China (Wang et al., 2005) (Fig. 1a) also record abrupt shifts toward less precipitation at ca. 6.4–6.0 and 7.5–7.1 ka BP. These findings altogether suggest a possibility that the climate events were widespread phenomena in the East Asian region. Nevertheless, this possibility should be carefully addressed, as some study sites such as Lake Xiaolongwan (Chu et al., 2014; Xu et al., 2019) and Lake Sihailongwan (Stebich et al., 2015) (Fig. 1a) do not clearly exhibit a drying/cooling signal. Regarding this inconsistency, a couple of possibilities can be considered. One possible factor is an issue of temporal resolution. In the case of Dongge Cave, the high-resolution DA stalagmite (Wang et al., 2005) detects a drying signal while the D4 stalagmite (Dykoski et al., 2005), with a lower resolution, does not. It is not reasonable to assume difference in actual climate conditions because they were collected from the same cave. Similarly, in the Korean Peninsula, our previous study at Gwangyang (Fig. 1b, GY-1) does not exhibit a climate shift at ca. 6.4–6.0 ka BP (Park et al., 2019) in contrast to Miryang (this study). As Gwangyang is located only ~100 km west to Miryang, it is unlikely that climate conditions were considerably different between those two study sites. Rather, temporal resolution is a more convincing explanation as the sample intervals covering the period are large in GY-1 (~80 years) relative to our present study (~20–30 years).

Besides the resolution issue, potential bias inherent in proxy-based climate reconstructions should be also noted. In pollen records, source area and/or overestimation effects inherent in palynological methodology (Seppä and Bennett, 2003) might affect pure climate signals. For example, in this study, we suspect that thermal optimum during the early to mid-Holocene (Wanner et al., 2008) might have rendered the smaller amplitude of the vegetation response during ca. 7.5–7.1 ka BP, whereas the other sedimentary proxies, XRF and sand percentage data exhibit clearer phase shifts with the Pacific Ocean (Fig. 4b–g). Similarly, in pollen records from Daihai Lake (Xiao et al., 2004) and Gonghai Lake (Chen et al., 2015a), drying signals during ca. 7.5–7.1 ka BP are less evident than ca. 6.4–6.0 ka BP. In this context, it cannot be ruled out that such climate shifts are not manifest in some records simply due to methodological problems. Furthermore, limiting to the cases of Lake Xiaolongwan (Chu et al., 2014; Xu et al., 2019) and Lake Sihailongwan (Stebich et al., 2015) in Northeast China (Fig. 1a), regionally varying climate imprints caused by high-latitude forcing such as sea ice in the Sea of Okhotsk (Stebich et al., 2015) should also be considered although this is beyond our research scope. Overall, in order to elaborate understanding on potential climate deterioration events at ca. 6.4–6.0 and 7.5–7.1 ka BP, further high-resolution data are required from multiple locations in East Asia. At least in this study, our finding at Miryang adds to evidence that such climate shifts were likely present in the Korean Peninsula during these two periods".

5. All parts of the discussion strongly rely on their provided chronology. Hence it is important to explain in more detail whether this chronology is reliable (see comment no.1).

Response: We added a sentence in Sect. 4.1 as follows: "Throughout the age-depth model, our dating results exhibited high coherency despite two different methodologies used, OSL and radiocarbon dating (Fig. 2b)".

For details regarding construction of the age-depth model, please refer to our responses above.

References

Blaauw, M. & Christen, J. A. 2011. Flexible paleoclimate age-depth models using an autoregressive gamma process. *Bayesian analysis,* 6**,** 457-474.

Ramsey, C. B. 1995. Radiocarbon calibration and analysis of stratigraphy: the OxCal program. *Radiocarbon,* 37**,** 425-430.

Reimer, P. J., Bard, E., Bayliss, A., Beck, J. W., Blackwell, P. G., Ramsey, C. B., Buck, C. E., Cheng, H., Edwards, R. L. & Friedrich, M. 2013. IntCal13 and Marine13 radiocarbon age calibration curves 0–50,000 years cal BP. *Radiocarbon,* 55**,** 1869-1887.

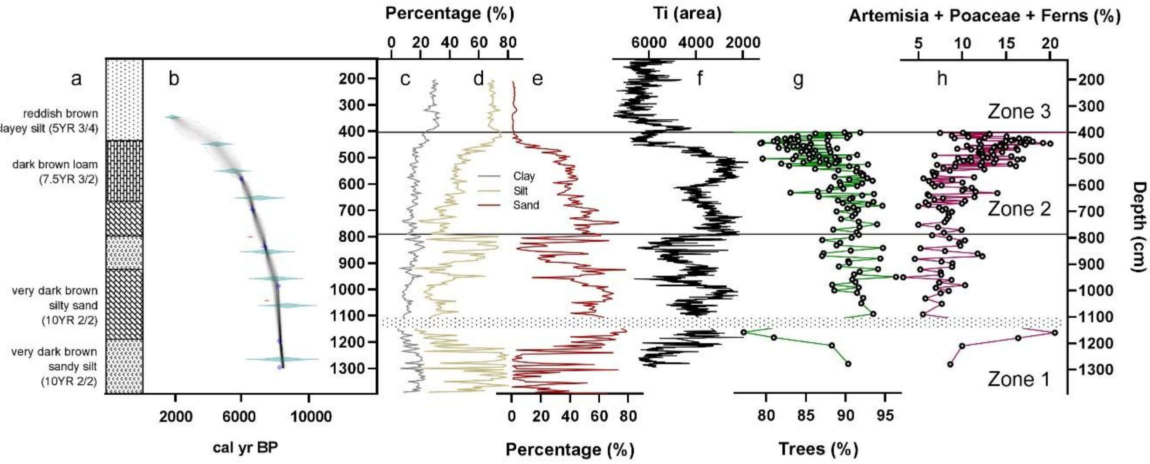

Figure 2: (a) Lithology of the STP18-03 core and (b) age–depth model constructed using the R *bacon* package ver. 2.3 (Blaauw and Christen, 2011) with the IntCal13 calibration dataset (Reimer et al., 2013). Samples omitted from the chronology model are indicated in red. (c–h) results of multi-proxy analyses of (c) clay fraction, gray; (d) silt fraction, light brown; (e) sand fraction, dark brown; (f) titanium (Ti) content, black; (g) tree pollen percentage, green; and (h) sum of *Artemisia* (mugwort) and *Poaceae* (wild grass) pollen and fern spores, magenta. Zones are separated by black horizontal lines.