

## Response to RC1 on “*tc-2021-352*”

First, we would like to thank Prof. Atle Nesje for your careful reading and constructive comments. Major changes are summarized here followed by point-to-point responses to each comment. Reviewer’s comments are in black color and our responses are in blue color.

### General Comments:

Surface exposure dating with cosmogenic nuclides is inherited with relatively large age uncertainties (large standard deviations). Dating results using this technique must therefore be interpreted with care, especially when dating young LIA moraines that are relatively close in age. In ideal cases, this dating method should be supplemented with other techniques, such as lichenometry and AMS radiocarbon dating of organic material associated with the marginal moraines. The authors have, however, provided the necessary information about the surface exposure dates in the table of the dated samples.

### Reply:

Thank you for your suggestions. We agree that cross validation between various dating methods is necessary in constraining the ages of the LIA moraines. Therefore, we have added some discussions with the studies using different dating methods, including radiocarbon dating and lichenometry as follows:

- 1) L191: “Such divergent dating results were also confirmed by other dating methods, such as dendrochronology, ice core chronology, and radiocarbon ( $^{14}\text{C}$ ). By applying dendrochronology approach, Hochreuther et al. (2015) and Bräuning (2006) only detected one LIA substage in Gongpu glacier, Zepu glacier, Baitong glacier and Gyalaperi glacier, while more substages were found in Lhamcoka glacier (Bräuning, 2006), Xinpu glacier (Hochreuther et al., 2015), Gangapurna glacier, and Annapurna III glacier (Sigdel et al., 2020). Yi et al. (2008) identified three substages during AD 950-1820 based on 53  $^{14}\text{C}$  dating ages. The  $\delta^{18}\text{O}$  in the Dunde Ice Cap also indicated three obvious cold periods during AD 1400-1900 (Yao et al., 1991). In addition, Yang et al. (2003) found four cold phases during AD 1100-1150, 1500-1550, 1650-1700, and 1800-1850 over TP and eastern China according to the proxy data of paleoclimate.”
- 2) L220: “A regional moraine chronologies framework composed of  $^{14}\text{C}$ , lichenometry, and cosmogenic radionuclide ages also supports IPSL experiment (late-14<sup>th</sup>, 16<sup>th</sup> to early-18<sup>th</sup>, and late-18<sup>th</sup> to early-19<sup>th</sup>; Xu & Yi, 2014).”
- 3) L234: “In summary, four glacial substages at 1270s-1400s, 1470s-1520s, 1700s-1710s, and 1820s-1900s were found in BH. The maximum glacier extent appeared during early LIA (LIA-4) stage based on GISS, IPSL, and MPI experiments, comparable with the results obtained by Xu and Yi (2014).”

However, we should notice that the lack of organic carbon in high mountain environments over TP make radiocarbon dating difficult (Owen et al., 2005; Owen, 2009; Owen & Dortch, 2014; He et al., 2019). In addition, most of the tree-ring chronologies are hard to cover the entire LIA (He et al., 2019). Therefore, most researchers have selected cosmogenic nuclides to date the moraines over

TP since the 1990s and early 2000s (Owen, 2009; Owen & Dortch, 2014). To our knowledge, there are more than 2000 moraine boulders being dated based on  $^{10}\text{Be}$  method so that the measurement errors, at least in a statistical sense, can be alleviated (Zhang et al., 2018).

### **Minor points:**

1) Additional comments/suggestions are provided as sticky notes in the attached file.

Reply: We have corrected and revised our manuscript based on your comments/suggestions mentioned in the manuscript.

2) The English must be checked by an English native person who knows this field of science.

Reply: We have preliminarily checked the English and improved the writing of the manuscript. Further polishing of the article will be implemented after receiving comments/suggestions from all reviewers.

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