

Clim. Past Discuss., referee comment RC1
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Comment on cp-2021-67

Maria Fernanda Sanchez Goñi (Referee)

Referee comment on "The role of ice-sheet topography in the Alpine hydro-climate at glacial times" by Patricio Velasquez et al., *Clim. Past Discuss.*,
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The manuscript submitted by Velasquez et al. to the *Climate of the Past* presents a combination of global and regional model simulations to test the sensitivity of the glacial Alpine hydro-climate to northern hemisphere, Laurentide and Fennoscandian, and local ice-sheet changes during the Last Glacial Maximum (LGM) and Marine Isotope Stage (MIS) 4. For the LGM, they find that thickening of the northern hemisphere ice-sheets, mainly the Laurentide ice caps, and local ice-sheet topography generally lead to increase in winter precipitation and decrease in summer rainfall, both enhancing glacial conditions. In winter, dynamics processes related to the intensity and position of the Alpine winds explain the moistening in the southern part of the Alps while the simulated summer drying all over the Alps is related to thermodynamic processes, i.e. colder temperatures. In contrast, Fennoscandian ice-sheet changes have a negligible impact on the Alpine hydro-climate. For MIS 4, marked by lower global ice volume than the LGM, Velasquez et al. find wetter climate in the Alps attributed to thermodynamic processes, i.e. warmer temperatures. This manuscript is clearly written and convincing for the LGM. In contrast, I have several caveats related to the MIS 4 model results and comparison with the regional (western European) climate at that time when compared to that of the LGM (see below). Overall, this work deserves publication in CP after the authors address the comments that I have listed below. I am not a modeling expert, and I will only comment on the data discussed in this work.

Lines 40-50: It would be relevant to cite the paper by Harrison and Digerfeldt (1993, *Quaternary Science Reviews*), one of the first paper showing that southern Europe was wet during the LGM (centered at 21 ka) based on the high water levels recorded in several lakes around the Mediterranean region. Iberian margin pollen records also provide evidence that the LGM in southern Europe was wetter than the Heinrich Stadial (HS) 2 and HS 1 bracketing it (Naughton et al., 2007, *Marine Micropaleontology* ; Turon et al., 2003, *Quaternary Research*).

Lines 50-54 and lines 407-415: To support the idea that MIS 4 was warmer and wetter

than the LGM, Velasquez et al. only refer to global studies (Eggleston et al., 2016), Australasian records (De Deckker et al., 2019 ; Newham et al., 2017) and model simulations for the North Atlantic and Greenland climate (Hofer et al., 2012; Merz et al. papers) that cannot be used to account for the climate in Europe at that time and, particularly, at 65 ka, the date chosen for their simulations. This date is concomitant with the maximum of global ice volume during MIS 4 (Waelbroeck et al., 2002, Quaternary Science Reviews), coincides, within the chronological uncertainties, with Greenland Interstadial 18 and precedes the massive iceberg discharges in the North Atlantic leading to the HS 6, 64-60 ka (Sanchez Goñi et al., 2013, Nature Geoscience, Figure S3 of the supplementary information).

To realistically compared the recorded and simulated climate in Europe at 65 ka, the authors should discussed their wind field and climate reconstructions in the context of the climate prevailing in the western European margin and the adjacent landmasses during this period, climate that is mainly controled by the westerlies during winter. The work by Sanchez Goñi et al. (2013, Nature Geoscience, Figure 2 and Figure S3 of the supplementary information) zooms in on MIS 4, and shows relatively wet and warm atmospheric conditions at 65 ka, based on the increase of heathlands and pine forest, contemporaneous with foraminifera-based warm summer sea surface temperatures in the western European margin, reaching 15°C in the Bay of Biscay and the SW Iberian margin and 10°C in the NW Iberian margin. However and in contrast with the authors' idea that the LGM was colder than MIS 4 in the European margin, higher sea surface temperatures in the Bay of Biscay (Sanchez Goñi, 2020, Evolutionary Human Sciences, Figure 2) and in NW and SW Iberia (Sanchez Goñi et al., 2008, Quaternary Science Reviews, Figures 3 and 4) are recorded during the LGM compared to MIS 4. Both periods are characterised by low and similar temperate forest abundance and similar heathlands development suggesting that MIS 4 was not warmer and wetter compared to the LGM.

Line 395-406: The authors should add in the revised version of the manuscript the new evidence from a cryogenic carbonate record in the Alps (Spötl et al., 2021, Nature Comm.) showing heavy snowfall during autumn and early winter during the LGM. These results combined with thermal modelling, provide compelling evidence that the LGM glacier advance in the Alps was fueled by intensive snowfall late in the year, likely sourced from the Mediterranean Sea.

Lines 436-440: The authors should delete the references of Finlayson et al., 2004, 2006 and 2008 and that of Burke et al., 2014 and Baena Preysler et al., 2019. These works do not refer to the Alpine regions and, therefore, they are not relevant for this study.

Minor comments

Liner 72: Please add Regional Climate Models to explain RCM.

Line 158: Please replace « eighth experiment » with « eighth experiments ».

Line 255: Please replace « associated to » with « associated with ».