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Climate of the Past Discussions

Interactive comment on "Climate warming and vegetation response at the end of Heinrich event 1 (16 700–16 000 cal yr BP) in Europe south of the Alps" *by* S. Samartin et al.

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General remark: The manuscript submitted to The Climate of the Past by Samartin et al. presents new data of chironomid-derived july temperatures from Lago di Origlio (southern Alps) for the interval between 17,500 and 11,000 cal yr BP. This manuscript is clearly written and well organized. The take-home message of the authors is that a Pre-Bølling warming, between 16500-16000 cal yr BP, occurred south of the Alps just after the end of Heinrich event 1. While this result is interesting and deserves publication, it relies heavily on how accurate the age model is.

Remark 1: Terrestrial sequences such as that from Lago di Origlio do not preserve di-

rect tracers of Heinrich events, i.e. layers of ice-rafted debris. Therefore, it is difiňĄcult to correlate reliably vegetation and climate changes onland with episodes of freshwater input in the North Atlantic. It is also for this reason that there is a major inconsistency in the manuscript between the title and the conclusions. The authors refer in the title to a climate warming "at the end of Heinrich event 1" while in the conclusions section they suggest the occurrence of a warming "after the Heinrich event 1". A problem of terminology is added to this inconsistency. The term Heinrich event deïňĄnes the rapid (less than 200 years, Roche et al., 2004) iceberg discharges in the North Atlantic while the Heinrich stadial (HS) is the climate impact of these discharges that can last a few millennia (Sanchez Goñi and Harrison, 2010). It is more appropriate to use in this manuscript the term Heinrich stadial and give its chronological boundaries which, following different authors, encompasses the period between âĹij19,000-15,000 cal yrs BP (âĹij15,000-13,000 14C yr BP) (Naughton et al., 2007, 2009; Sanchez Goñi and Harrison, 2010; Standford et al., 2011).

Response 1: Many thanks to Maria Fernanda Sanchez-Goñi for her helpful review. She is right, there is considerable confusion about the definition of Heinrich events throughout the literature. We therefore fully rely on the new conceptual model proposed by Stanford et al. (2011), who from our point of view has made the clearest suggestion about how to deal with the anatomy of the last Heinrich event with a succession of 3 phases during H1:

(1) 19,000-17,500 cal yr BP, onset of the AMOC (Atlantic Meridional Overturning Circulation) collapse (2) 17,500-16,700 cal yr BP, main HE-ss1 (Heinrich event sensu stricto 1). (3) 16,700-14,600 cal yr BP, Heinrich event 1 clean-up and AMOC resumption.

The entire sequence of events associated with H1 extends over 4000 years, rather than several centuries as previously suggested (e.g. Roche et al., 2004). All three phases form the Heinrich event sensu lato 1. In our article we used the term Heinrich event 1 to refer to Heinrich event sensu stricto 1. We have now added a cautionary clause in the introduction to avoid misunderstandings. For these reasons we prefer to stay with

our original concept. We also adjusted the wrong statement “at the end of Heinrich event 1”, correctly it is “after the Heinrich event 1” (which corresponds to Heinrich event 1 sensu stricto according to Stanford et al. 2011). We do not have evidence of a Heinrich “stadial” in our study region (continuous continental paleorecords show quite stable conditions 19,000-16,500 cal yr BP, see e.g. Kaltenrieder et al. 2009), we thus prefer not to use the term “stadial” to avoid confusions or misunderstandings.

Kaltenrieder, P., Belis, C. A., Hofstetter, S., Ammann, B., Ravazzi, C., Tinner, W.: Environmental and climatic conditions at a potential Glacial refugial site of tree species near the Southern Alpine glaciers. New insights from multiproxy sedimentary studies at Lago della Costa (Euganean Hills, Northeastern Italy), Quaternary Science Reviews, 28, 2647-2662, 2009. Roche, D.; Paillard, D.; Cortijo, E.: Constraints on the duration and freshwater release of Heinrich events 4 through isotope modeling, Nature, 432, 379–382, 2004. Stanford, J. D., Rohling, E. J., Bacon, S., Roberts, A. P., Grousset, F. E., and Bolshaw, M.: A new concept for the paleoceanographic evolution of Heinrich event 1 in the North Atlantic, Quaternary Science Reviews, 30, 1047–1066, 2011.

Remark 2: Using a direct correlation approach between marine and terrestrial (pollen) climatic tracers Naughton et al. (2009) have clearly demonstrated that the second part of HS 1, just before the sharp expansion of deciduous tree forest at the onset of the Bølling/Allerød interstadial, was warmer (and drier) in southwestern Europe than its ïňĄrst part. During the second phase iceberg melted south of the Ruddiman belt that is the preferential zone for iceberg melting. Naughton et al. (2009) proposed that during the second part of HS 1, as the second part of HS 2 and HS 4, the intensiïňĄcation and more northerly direction of the westerlies was the atmospheric conïňĄguration explaining the observed warming. Surprisingly, this work is not cited in the Samartin et al. manuscript. The authors should therefore refer to the work by Naughton et al. discuss their results in the light of this contribution.

Response 2: The work of Naughton et al. (2009) has been included and briefly discussed in the discussion section. However, we work in an area more remote from the

direct climatic influence of the North Atlantic than western Iberia. To thoroughly discuss these findings, therefore, goes beyond the scope of this manuscript. As indicated in response to the comments of Reviewer 2, we acknowledge that temperature developments may have been different in southwest Europe (e.g. the Pyrenees, the Iberian Peninsula) than in the Po-River (Adriatic) catchment.

Naughton, F., Sánchez Goñi, M. F., Kageyama, M., Bard, E., Duprat, J., Cortijo, E., Desprat, S., Malaizé, B., Joly, C., Rostek, F., and Turon, J.-L.: Wet to dry climatic trend in north western Iberia within Heinrich events, Earth and Planetary Science Letters, 284, 329–342, 2009.

Remark 3: Section 3.2: I wonder whether this section can be replaced by a table.

Response 3: The chironomid record is characterized by many gradual changes, which are better explained with a text than a table.

Remark 4: Section 4.1: The authors introduce for the ïňĄrst time in the manuscript the term Pre-Bølling. This term should be deïňĄned in section 2.3 “Radiometric dating and vegetation history”.

Response 4: The term pre-Bølling was used to refer to the period in the Origlio record preceding the Bølling. It was not intended as a new stratigraphical unit. However, we concede that the use of “Pre-Bølling” may cause confusion. For the warming period preceding the Bølling we now use the expressions “early Late Glacial warming at ca. 16,000 cal yr BP” or “warming before the onset of the Bølling/Allerød”.

Remark 5: In this section, the authors say “The onset of the Bølling-Allerød interstadial (GI-1) has an age of 14,650 cal yr BP. . .”. The authors should rephrase this sentence and say that “the onset of GI 1, considered the equivalent of the onset of the Bølling-Allerød interstadial, has an age of 14,650 cal yr BP. . .”.

Response 5: Sentence in section 4.2 on p. 1632 line 14/15 has been rephrased accordingly.

Remark 6: Also in this section, the authors state that the Ammersee δ18O record parallels the trend of the NGRIP δ18O. I am surprised about this statement. Von Grafenstein et al. (1999) and later Jouzel et al. (2007) state that the cooling in Greenland is contemporaneous with stable temperatures in central Switzerland, paralleling the d-excess record from Greenland ice core. Genty et al. (2006) and Combourieu-Nebout et al. (2009) also point out from speleothem and pollen data the contrasting trend between Greenland and midlatitude European palaeoclimatic records. The authors should change this part of the text accordingly.

Response 6: The sentence in section 4.2 on page 1632 line 20 has been corrected. Indeed, the Ammersee δ18O record suggests, in contrast to the NGRIP δ18O record, stable temperatures during the Bølling/Allerød.

Remark 7: The authors use indistinctly "onset of the Bølling" and "onset of the Bølling/Allerød". They should be consistent in the manuscript and chose one of the terms.

Response 7: In terms of consistency the term Bølling has been replaced with Bølling/Allerød throughout the article.

Remark 8: In the conclusions section, the authors say that forest expanded at âĹij13,000-11,000 cal yr BP in central and southern Italy. The original papers that the authors cite do not show that. Samartin et al have taken the 14C ages presented in Magri et al. (1999), Magri and Sadori (1999) and Allen et al. (2002) as ages in calendar years. The related paragraph on the relevant role of moisture for forest growth in Italy should therefore be modi- ïňĄed.

Response 8: This is not correct, we calibrated the original radiocarbon ages. For instance at Lago di Vico in central Italy (Magri and Sadori, 1999) afforestation startet at around 11,295 $\pm$ 165 uncal yr BP (p. 248, pollenzone V1-18) which is equivalent to 13,167 cal yr BP. Before 13,167 cal yr BP no forest was present and Artemisia showed pollen abundances > 50%. However when checking other records we noticed the out-

come of the review by Drescher-Schneider et al. (2007) who emphasize that despite the prevalence of very open forests till 11,000 cal BP in central Italy, afforestation processes probably started as early as 14,500 cal BP. We now adopt this interpretation for our manuscript.

Allen, J. R. M., Watts, W. A., McGee, E., and Huntley, B.: Holocene environmental variabilityâĂŤthe record from Lago Grande di Monticchio, Italy: The Value of Annually Laminated Sediments in Palaeoenvironment Reconstructions: Dedicated to Bjorn E. Berglund, Quaternary International, 88, 69–80, 2002. Drescher-Schneider, R., De Beaulieu, J.-L., Magny, M., Walter-Simonnet, A.-V., Bossuet, G., Millet, L., Brugiapalia, E., Drescher, A.: Vegetation history, climate and human impact over the last 15,000 years at Lago dell'Accesa (Tuscany, Central Italy), Vegetation history and archaeobotany, 16, 279-299, 2007. Magri, D. and Sadori, L.: Late Pleistocene and Holocene pollen stratigraphy at Lago di Vico, central Italy, Vegetation History and Archaeobotany, 8, 247–260, 1999.

Remark 9: Finally, at the end of the conclusions the authors cite twice Standford et al. 2011 referring to changes in the meridional overturning circulation during the period encompassing HS 1 and the Bølling/Allerød interstadial. The appropriate reference is that of McManus et al., 2004 who have provided the ïňĄrst Pa/Th record, indicating changes in this circulation. The authors should replace Standford et al., 2011 by McManus et al., 2004.

Response 9: The reference has been changed to McManus et al. (2004).

McManus, J. F., Francois, R., Gherardi, J.-M., Keigwin, L. D., and Brown-Leger, S.: Collapse and rapid resumption of Atlantic meridional circulation linked to deglacial climate changes, Nature, 428, 834–837, 2004.

Interactive comment on Clim. Past Discuss., 8, 1615, 2012.