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Climate of the Past Discussions

Interactive comment on "Late Glacial-Holocene climatic transition record at the Argentinian Andean piedmont between 33–34° S" *by* A. E. Mehl and M. A. Zárate

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We thank the reviewer for his helpful comments and suggestions about our contribution. All detailed technical comments and minor corrections raised by the referee have been addressed as well as his valuable specific comments that contribute to improving the quality and readability of the contribution. Misinterpretations were checked and corrected. The observation of the referee about spelling and syntax errors are greatly appreciated. Manuscript editing was made trying to improve the overall text language.

Specific Comments: In general, I agree with the overall structure of the paper but would suggest an improved structure for the discussion chapter. In order to support the au-

thor's line of argument and increase the overall clarity of the discussion, it could be divided into subchapters which build on each other ("zoom out") – and successively address the various scales of interpretation: (i) What do micromorphology and pedogenic processes mean for the resulting soil types and local environments (soil forming processes)? (ii) In how far would these processes relate to regional climate vs site specific geomorphic conditions (e.g. the activity of the fluvial system, which in itself could be controlled by climate)? (iii) How does this compare to a) other paleosol-sediment-sequences and b) other paleoclimate proxies (e.g. pollen, speleothems) in southern South America, and (iv) which could be the responsible hemispheric or global drivers: : :?!

Response: the discussion section was restructured in 3 sub-sections following the referee's recommendations. Modifications into paragraphs order was made according to the new structure of the section. Also, information about the regional pollen record and the inferences about vegetation Lateglacial-Postglacial changes derived from it were added. Figure 8 was removed from the Discussion as well as the text in which it was referred. The three following references were removed from the Discussion section, and the seven references below them were incorporated:

Barros, V., Doyle, M., González, M., Camilloni, I., Bejarán, R., and Caffera, R., Climate variability over subtropical South America and the South American monsoon: a review, Meteorologica, 27, 31–55, 2002. Garreaud, R. D., Vuille, M., Compagnucci, R., and Marengo, J.: Present-day South American climate, Palaeogeogr. Palaeocl., 281, 180–195, 2009. Vuille, M., Burns, S. J., Taylor, B. L., Cruz, F. W., Bird, B. W., Abbott, M. B., Kanner, L. C., Cheng, H., and Novello, V. F.: A review of the South American monsoon history as recorded in stable isotopic proxies over the past two millennia, Clim. Past, 8, 1309–1321, doi:10.5194/cp- 8-1309-2012, 2012.

Abarzúa, A. M., Villagrán, C., and Moreno, P. I.: Deglacial and postglacial climate history in east-central Isla Grande de Chiloé, southern Chile (43°S), Quaternary Res 62, 49–59, 2004. Markgraf, V.: Late and Postglacial Vegetational and Paleoclimatic

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changes in Subantarctic, Temperate and Arid environments in Argentina, Palynology 7, 43–70, 1983. Markgraf, V., Dodson, J. R., Kershaw, A. P., McGlone, M. S., and Nicholls, N.: Evolution of Late Pleistocene and Holocene climates in the Circum-South Pacific land areas, Clim. Dynam., 6, 193–211, 1992. Montade, V., Nebout, N. C., Kissel, C., Haberle, S. G., Siani, G., Michel, E.: Vegetation and climate changes during the last 22,000 yr from a marine core near Taitao Peninsula, southern Chile, Palaeogeogr. Palaeocl., 369, 335–348, 2013. Rojo, L. D., Páez, M. M., Chiesa, J. O., Strasser, E. N., and Schäbitz, F: Palinología y condiciones paleoambientales durante los últimos 12.600 cal. años AP en salinas del Bebedero (San Luis, Argentina), Ameghiniana 49, 427–441, 2012b. Zárate, M.A. and Páez, M.M.: Paleoambientes y paleoclimas de la transición Pleistoceno- Holoceno entre los 32-38°S de Argentina, in: Anáis do VIII Congresso da Associação Brasileira de Estudos do Quartenário (ABEQUA), Porto Alegre, 14-20 October 2001, abstracts, 350-351, 2001. Varma, V., Prange, M., Lamy, F., Merkel, U. and Schulz, M.: Solar-forced shifts of the Southern Hemisphere Westerlies during the Holocene, Clim. Past, 7, 339–347, doi:10.5194/cp-7-339-2011, 2011.

- p. 6139, line 1-2: “higher frequency of flooding events” – This interpretation needs to be backed up or discussed with more detail, and in my opinion shows that the paleoenvironmental significance of any sediment and paleosol also depends on its stratigraphic context of the sedimentary environment in which it forms (in this example, the relation to the channel). Why would laminated sediments indicate higher frequency? Could also mean that the channel at that time was getting closer to the study site (by lateral migration), or do you have any indications where it was during this time? Alternatively, it could mean that flood magnitudes (instead of frequencies) increased, with flooding now occurring in places which were previously unaffected by overbank. This would indicate a major change in fluvial dynamics providing the stability for pedogenic processes to form well-developed soil horizons, but requires the discussion of both (i) the fluvial system and vegetation/sediment yield relations, AND (ii) the paleosol.

Response: both alternatives have been now indicated in the text in a way that makes

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reference to geomorphological condition of the fluvial systems or a major change in fluvial dynamics -flood magnitude increase-. At the moment, no evidence of the early Holocene channel position is available along the analyzed outcrops.

- p. 6138, line 1-3: Are there any indications for an elevated position in the floodplain? Of all sedimentary environments, I would expect floodplains to be comparatively flat, so the pedogenic development of the paleosols in the same floodplain should be very similar? Could the topographic variations be the result of more patchy aeolian forms and deposits which underlay the paleosol (i.e. meaning that the soils are not "floodplain soils")?

Response: it is expected floodplains to be relative flat environments, so the sentence was slightly modified to correct the misinterpretation there. It was inferred that the LP-EH paleosol was developed over aeolian sediments -parent material- (Zárate and Mehl, 2012, see reference in Discussion paper). Nonetheless, these aeolian deposits are inferred to be deposited blanketing a floodplain environment and indicating the dominance of the aeolian aggradation over the fluvial aggradation by the end of the Lateglacial; the morphology of the aeolian deposit seems not to be patchy along the outcrops but tabular and laterally continuous. In such a context the LP-EH paleosol was not strictly formed over floodplain sediments but it was formed in an environment that most of the time since the LGM has been under fluvial influence.

Also, I am unsure of the author's conclusion of climatic "amelioration" in southern Mendoza during the early Holocene, and hope the authors could add more detail to their arguments, clarifying their paleoenvironmental and/or paleoclimatic interpretation of the LG-EH paleosol.

Response: The term 'amelioration' has been removed from the abstract were it was used in connection to the climatic condition after the Lateglacial in the eastern Andean piedmont. The term was misapplied; the sentence intended to refer to a new climatic condition in the eastern Andean piedmont under which a paleosol was developed.

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Before it no paleosol development has been identified at the present-day outcrops of the arroyo La Estacada basin.

Here some thoughts and comments to consider: - p. 6137, line 14-16: “slight increase in the relative atmospheric humidity” is responsible for the LG-EH paleosol? Today it is dry, so which soils would form in the region? Where would you find soils similar to the paleosols today? Could a lower seasonality with possibly increased winter rains explain the transition from aeolian processes to somewhat calcic paleosols (which would require more moisture than before and today)? And could decreasing (westerly?) wind strengths at the end of the Pleistocene play a role? Is there any information about vegetation response at this interval (which could be strongly affected by temperature instead of precipitation and would influence sediment yields and therefore the fluvial system)?

Response: the role of the Westerlies at the end of the Pleistocene-early Holocene is now included the Discussion section. Information is mainly derived from terrestrial and marine pollen records from Chile between 32° and 41° S (e.g. Jenny et al., 2002; Abarzúa et al., 2010; Montade et al., 2012; Montade et al., 2013). Also, inferences from pollen analysis in the Argentine Andean piedmont (study area and at 37°S) were incorporated to provide information about the regional modifications in vegetation during the considered interval. We agree with the referee that temperature could be a major influence in the paleosol development, and we have modified this in the MS text. However, water availability at the beginning of postglacial times is also indicated by the pollen assemblages -halophytic communities were abundant at the Lateglacial- in the arroyo La Estacada record (Zárate and Páez, 2002).

- p. 6138, line 14: “pedological processes ended: : :” – please rephrase this sentence, as the pedological processes themselves have probably not ended (they never end) but either (i) changed in type under changing environmental conditions, or (ii) were outpaced by renewed sedimentation and active fluvial deposition following change in fluvial depositional environment!!!

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Response: the sentence was rephrased.

- p. 6139, line 21-24: The authors infer heavy summer rainfalls during the early Holocene, but how does this combine with the low summer insolation in the Southern Hemisphere during the early Holocene? If the climatic conditions are comparable to today, do we also see comparable pedogenic processes and soils (see above)? This is not mentioned anywhere (and does not seem to be the case), so either (i) climate is not comparable (=different from today, and mean annual precipitation is not a representative measure for overall moisture), or (ii) today the land surface is drier than during the EH (but is this due to climate or fluvial incision and lowered groundwater?).

Response: although the authors inferred heavy summer rainfalls in the eastern Andean piedmont during the early Holocene, they would have had a sporadic character as it is expected to happen in arid area as the study one. Pollen regional information at the eastern Andean piedmont at the studied latitude points out to a Holocene climatic condition similar to the present one in the area, with regional vegetation represented by desert shrub –Monte- pollen while the local arroyo environment is indicated by hydrophytic polen taxas. The present-day regional land surface (regional aggradational plain -RAP) is representative of an arid landscape with Monte vegetation development in areas not affected by anthropogenic disturbance. However, at the fluvial basin of the arroyo La Estacada, the current floodplain environment is placed nearly 20 m below the RAP and in a narrow fluvial valley; it records anomalous water availability in the region. The arroyo, of meandering pattern and perennial discharge, is fed by springs located along a fault line and also by Arroyo Anchayuyo, a stream collecting water in a catchment area dominated by Tertiary deposits. Sporadic higher flow events at the arroyo are recorded in summer during rainstorms affecting the piedmont mainly derived from an Atlantic source of humidity. In the fluvial valleys of the study area, floodplain current soils develop under this regime.

Interactive comment on Clim. Past Discuss., 9, 6125, 2013.