

# ***Interactive comment on “Early last glacial maximum in the Southern Central Andes reveals northward shift of the westerlies at ~39 ka” by R. Zech et al.***

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We thank Vera Markgraf for her comment and, in the following, will try to address her “only concern [...], the assumption that precipitation is the parameter in this region for glacier movements.” (this region is the southern Central Andes. “Northern Andes” in Markgraf’s comment is probably just a typo, maybe missing “Northern Patagonian Andes”, to which our research location at 39°S also belongs).

The cited authors Luckman and Villalba (2001) indeed report that “measurements of the terminal position of the Frias Glacier since 1976 indicate a strong relationship between summer climatic conditions (particularly temperature variations) and fluctuations

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of the position of the Frias Glacier front (Villalba et al., 1990).” That site, however, is located at  $\sim 41^{\circ}\text{S}$  and already receives much more precipitation than our site due to the strong latitudinal precipitation gradients. Reviewing Little Ice Age glacier fluctuations from further north ( $32\text{--}33^{\circ}\text{S}$ ), Luckman and Villalba (2001) report that “under the extreme dry conditions that prevail in the central Andes, glacier variations are strongly affected by precipitation variations (Leiva et al., 1986)”, which explains that observed glacier advances there correlate with maximum precipitation between 1820 and 1910. In their abstract, Luckman and Villalba (2001) summarize and generalize these findings: “Contrasting glacial histories can be observed for glaciers within relatively short distances, particularly in climatic transition zones. These differences reflect the varying dominance of precipitation and temperature controls on mass balance [ . . . ]”

At first glance, it seems difficult to robustly determine whether glaciers at our research location were more sensitive to past temperature or to precipitation changes, because we are right at the transition zone and we don't know a priori how this transition zone has changed in the past. Our modeling studies cited in the manuscript only corroborate that past glacier advances required substantial precipitation increases ( $\sim 100\%$ ) at  $29^{\circ}\text{S}$  (Kull et al., 2002) and  $35^{\circ}\text{S}$  (Waeger et al., submitted), but unfortunately we have no respective modeling results for the dated moraine in the Rucachoroi Valley.

However, comparison of the glacial chronologies between the region  $30\text{--}40^{\circ}\text{S}$  (more arid and thus more precipitation-sensitive; glaciers were more extensive at  $\sim 39$  ka than during the global LGM) with the chronologies from Patagonia (more humid and thus more temperature-sensitive; glaciers were most extensive between  $\sim 25$  and  $18$  ka) strongly supports our interpretation that increased precipitation caused the pre-LGM advances in the southern Central Andes.

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Interactive comment on Clim. Past Discuss., 6, 1991, 2010.

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