

Interactive comment on “Modelled glacier equilibrium line altitudes during the mid-Holocene in the southern mid-latitudes” by C. Bravo et al.

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The authors present a set of simulations of glaciers in New Zealand and Patagonia during the Pre-Industrial (AD1750; PI) and Mid-Holocene (6 ka; MH) periods. Climate model simulations from the PMIP2 group are used as inputs for a simple glacier model to calculate regional equilibrium line altitudes (ELA) for each timeslice, and comparison with the glacial geomorphological record is attempted. A difference in ELA between the MH and PI of about –30 m is found for both regions. Overall the results appear inconclusive in part because it is not clear to the reader if the significance of the results is quantitative, which would be expected with a model-based study, rather than qualitative. The experimental design for the application of the glacier model does not seem entirely suitable to achieve the aims of the paper. Moreover, the manuscript is some-

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what disorganised, and would benefit from more thorough editing for structure and clarity, particularly to be more quantitative than qualitative throughout (e.g. the abstract does not state the amount of change in temperature and precipitation inferred to drive the resulting change in ELA, the source of the topographic data is not given). Below are some specific comments describing suggested areas for improvement.

1. Resolution of the glacier model. The glacier model was applied at the same grid spacing as the climate model results (0.5 degrees, about 50 km), and therefore does not capture the impact of the mountainous topography of the two study regions on mass balance. Topography exerts a major control on the extent and therefore ELA of small mountain glaciers such as those that are the subject of this paper, and these ELA reconstructions are likely to contain large uncertainties, potentially exceeding those given in the results, which already exceed by several times the inferred change in ELA between the PI and MH periods.

2. Validation of climate and glacier modelling results. The authors compare their climate model results with present-day measurements from automatic weather stations (AWS). However, as stated in the text, the climate model represents a period that predates the climate data by 250 years so this validation is poor. The authors would give more confidence in their results if they compared a present-day climate simulation with the AWS data, or if this is not possible, applied their glacier model to calculate present-day ELAs using the AWS data for comparison to present day observations. Moreover, the similarity in sign between results from NZ and Patagonia does not seem sufficient to justify the conclusions.

3. Treatment of precipitation data. Precipitation is poorly represented in the modelling as the authors assume a linear relationship between precipitation amount and elevation. The Southern Alps and Patagonian Andes are classic examples of orographic precipitation regimes, where the interaction of westerly circulation with high topography results in precipitation distributions that strongly deviate from the linear model used here. The use of a linear relationship to describe precipitation as an input to a glacier

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model has been quantified for the Southern Alps, and will introduce a further uncertainty to the results equivalent to a difference in ELA of about 80 m (Rowan et al., 2014, JGR-ES). Certainly for New Zealand if not Patagonia, that availability of precipitation data are much better than implied in this manuscript; both range profile and gridded precipitation data based on interpolation of AWS measurements are available (e.g. Tait et al., 2006, International Journal of Climatology; Henderson and Thompson, 2000, Journal of Hydrology) and it is not clear why the authors did not compare their results to or use these data in their modelling.

4. Link between glacier change and orbital forcing. The results presented here do not convincingly achieve the aim of the paper to explore the influence of orbital forcing on glacier advance during the MH, as the model results cannot be linked to a particularly period. A very recent paper (Doughty et al., 2015, Geology) has demonstrated from moraine geochronologies that orbital forcing may not play a role in controlling Late Quaternary glacier behavior in New Zealand and the authors may wish to consider their results in light of this evidence.

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