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Title of Thesis:

Reconstructing the Mass and Energy Balance of the Silvretta Glacier using Tree Rings

Summary

Information about past climate is important for the development of climate models and future climate scenarios. Since glacier fluctuations (e.g., volume and length changes) are strongly dependent on climatic conditions, the reconstruction of glacier history provides valuable data about paleoclimate. However, historic glacier records are discontinuous and the uncertainties are considerable. Efforts have been made to use trees as high-resolution climate proxies for filling in gaps in glacier history. Although this approach is promising, the potential for obtaining information about glacier volume from tree rings is poorly known.

The aim of this study was to analyze the relationship between the energy balance and tree growth and the mass balance and tree growth, respectively, by fitting different statistical models to these relationships and extending existing glacier series back in time. The Silvretta Glacier is used in this study because both energy and mass balance series are available. Three correlation analyses were performed to understand the influence of climate on the energy balance, on the mass balance (net, winter and summer balances) and on tree growth. From existing and sampled tree-ring data, two ring-width chronologies – one temperature-sensitive, the other precipitation-sensitive – were built. These variables were the input for linear regression and scaling models that were fitted to the energy balance and to the net and summer mass balances of the Silvretta Glacier. The summer mass balance was finally reconstructed to the year 1053. The reconstruction was then evaluated using data about historic glacier fluctuations.

This study has shown that, in the case of the Silvretta Glacier, a suitable model only results for the summer mass balance, which is mainly influenced by summer temperature, for which tree rings are a good proxy. In contrast, the net mass balance depends also on winter precipitation, a parameter that cannot be modeled well enough with trees. No model could be fitted to the energy balance because the energy balance is strongly influenced by the glacier albedo, which is unrelated to temperature. On an annual basis, model errors are high, but decrease considerably when data are averaged over several years. The reconstructed summer mass balance shows partial agreement with glacier fluctuations. A problem of tree-ring based estimates of the mass balance is the influence of glacier dynamics on mean specific mass balances.

This study could be further improved by making a more detailed selection of ring-width data. Beside, since the overall energy balance is strongly affected by the glacier albedo, it might prove more useful to reconstruct the temperature-dependent components of the energy balance rather than the entire balance.

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