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The effect of debris cover on glacier dynamics: insights and implications using a dynamic flow model

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Debris cover is known to alter surface melt and can strongly reduce ablation and thereby affect a glacier's dynamical response to climatic forcing. This study is focussing on glaciers with relatively high debris content and a simple 1-dimensional flow model has been developed that includes the evolution of the debris thickness with time and its subsequent effect on surface ablation. Applying this model to glaciers with high debris content (approximate cases of glaciers in the Alps, Himalaya and New Zealand) the effect of debris cover on the dynamic behaviour in context of climate warming is explored. We find that the length record of such glaciers can be highly asynchronous and such glaciers keep an extended current positions that may refer back to cold periods of many decades or centuries ago (e.g. Little Ice Age). The relationship between delay-time in length response and climate warming does not only depend on the debris content but on the general internal response time-scale of the glacier and the previous history of debris accumulation on the glacier. Further, the effect of debris on the surface profile, flow speed and ice tongue stagnation is investigated. The modelling implies that debris covered glaciers are highly asynchronous to climate forcing and care must be taken in interpreting length changes in context of climate change . This asynchrony further means that glacier reconstruction from dated major moraines can not necessarily be used to reconstruct climate history.