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# Distributed glacier mass balance modelling as an important component of modern multi-level glacier monitoring

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Modern concepts of worldwide glacier monitoring include numerical models for (a) interconnecting the different levels of observations (local mass balance, representative length change, glacier inventories for global coverage) and (b) for extrapolations in space (coupling with climate models) and time (back and forth). In this context, one important new tool is distributed mass balance modelling in complex mountain topography. This approach builds on simplified energy balance models and can be applied for investigating the spatio-temporal representativity of the few mass balance measurements, for estimating balance values at the tongue of unmeasured glaciers in order to derive long-term average balance values from a great number of glaciers with known length change, and for assessing special effects such as the influence of Sahara dust falls on the albedo and mass balance or auto-correlation effects due to surface darkening of glaciers with strongly negative balances. Experience from first model runs in the Swiss Alps and from applications to the extreme conditions in summer 2003 provide evidence about the usefulness of this approach for glacier monitoring and analysis of glacier changes in high-mountain regions. The main difficulties concern the estimation of accumulation (strongly variable spatial pattern, snow redistribution by wind and avalanches). Field measurements remain essential to tie the models to real ground conditions.