Spatio-temporal mass balances variability of four glaciers in different climate regimes

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Mass balance of glaciers are essential to study climate changes in different regions of the world. Previous studies showed that it is crucial to directly use the point mass balance observations to extract a consistent climatic signal rather than glacier-wide mass balances. However, for this purpose, accounting for the high spatio-temporal mass balance variability observed on glaciers is needed. First, the point mass balance observations show a strong spatial variability, even in the same range of altitude. Second, point mass balance observations reveal a temporal variability of the mass balance decreasing with altitude on most of glaciers. We propose a statistical nonlinear model to take into account the spatial and temporal changes of point mass balances. To test this model, we selected 4 glaciers in different climatic regimes, Argentière in France, Zongo in Bolivia, Chhota Shigri in India and Nigardsbreen in Norway for which (i) point annual mass balances and coordinates of each measurements are available, (ii) the altitude range is large enough to observe this non linearity, (iii) independent geodetic mass balances are available. Our model allows us to extract a robust common signal for each glacier. In addition, combined with geodetic data, this method enables to calculate a consistent glacier-wide annual mass balance series from a heterogeneous network.