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Another look at glacier reaction time scales

M.P. Lüthi
ETH Zurich, VAW Glaciology, Zurich, Switzerland (luethi@vaw.baug.ethz.ch)

Variations of glacier length and volume under changes in equilibrium line altitude are investigated on simple model glacier geometries. A minimalistic representation of the glacier with two volumes, joined by a flux element is used to represent glacier response with a two-parameter dynamical system. Explicit expressions for volume-length scaling relations, and the volume and area time scales are derived. Both time scales are inversely proportional to the mass balance gradient γ, and depend on the ratio ζ between vertical extent of the ablation area and ice thickness at the equilibrium line. The volume time scale can then be written as $\tau_v \sim \frac{1.23}{\gamma}\frac{1}{\zeta-1.23}$. Since ζ is approximately proportional to bedrock slope and glacier length, long and steep glaciers have shorter volume time scales than short and flat glaciers. Also high mass balance gradients lead to a short volume time scale. Negative volume time scales indicate unstable glacier response for very short glaciers, and are used to infer a minimum glacier size.