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New constraints on flow and sliding laws derived from a flow-modeling of Unteraargletscher

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The sensitivity of various aspects of the flow regime of Unteraargletscher to different types of flow laws and sliding conditions is investigated in a fully three-dimensional non-linear flow model. It is found that the spatial pattern of vertical velocities is strongly dependent on basal sliding conditions. Combined data sets on surface velocities at 35 m grid spacing, GPS data on vertical velocities across the medial moraine, and tilt measurements in boreholes, allow us to put stronger constrains on the flow law and the form of the sliding law than has previously been possible. In particular, we find that measurements of borehole deformation can not be reproduced using Glen's flow law and typical values for the rate factor and the flow-law exponent. Furthermore, it is shown that the incorrect description of basal sliding conditions is responsible for previous unsuccessful attempts to reproduce the variations of vertical velocities. This new numerical model reproduces both short-scale (100 m) variations in vertical velocities and the general forward motion of the glacier to a high accuracy.