Bed topography and mass-balance distribution of Columbia Glacier, Alaska, U.S.A., determined from sequential aerial photography

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ABSTRACT. An internally consistent data set of geometry and flow variables for the lower part of Columbia Glacier, south-central Alaska, is derived entirely from vertical aerial photography. The principle of mass conservation is imposed in the form of a centered finite-difference approximation of the continuity equation. It is applied on a 120-node section of a square grid covering the 15 km long, high-velocity stretch ending at the grounded, heavily calving terminus of this large glacier.

Photography was obtained 22 times between June 1977 and September 1981. Surface altitudes on the dates of the flights and the displacement vectors between pairs of flights were determined photogrammetrically. Natural features on the glacier surface were sufficiently prominent and enduring to be followed from the date of one flight to the next.

Because both the altitude points and displacement vectors were irregularly positioned spatially, interpolation was necessary to get values on the grid nodes. The points had already been subjected to the method of optimum interpolation to get surface altitudes on the grid nodes. The displacement vectors are subjected here to a constrained-interpolation method to get velocity vectors at the grid nodes that are consistent, through the continuity equation, with the other variables.

The other variables needed to achieve closure of the variable set are bed topography and mass-balance distribution. The latter was taken to be a separate linear function of altitude for each time interval. Values for bed altitudes at 120 nodes and two coefficients of each of 21 balance functions were inferred as the 162 model parameters in a nonlinear minimization problem having 4305 observed velocity components as its data.