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Using upper-air meteorological data to model mass balance and total iceberg production: Columbia Glacier, Alaska, 1948-2007

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Daily temperatures at four standard levels in the atmosphere and wind and relative humidity at one level are used in a simple accumulation-ablation model tuned to mass balance observations during 1977-1978, 1983-1995, and 1992-1997 at 67 locations on Columbia Glacier at altitudes ranging from 135 to 2645 meters. Precipitation is taken to be proportional to the product of the 850-hPa humidity and wind component from 140 °. Precipitation, when temperature T interpolated in the upper-air data at the altitude of the site is $\leq +2$ °C, is taken to be snow. When $T > +2$ °C, it is assumed to be rain that immediately runs off without refreezing in the glacier. Root mean square model error is 1.1 m ice equivalent, with $r^2 = 0.88$.

The model uses a single ablation coefficient in a positive degree-day (PDD) model, even though the seasonal duration of snow cover on the glacier surface increases with altitude. By contrast, most published PDD models use a larger coefficient for ice than for a snow-covered surface. The model also assumes that precipitation does not increase with altitude. Although these simplifications would both seem to contribute to negative model bias at higher altitude — overestimating ablation and underestimating precipitation there — they are justified by the fact that model error is uncorrelated with altitude.

The evolving glacier topography is represented as a temporally nonlinear combination of the 1957 and 2007 area-altitude distributions. When integrated over that topography, the model yields a 1948-2007 total mass balance of 45 km^3 of ice. This represents about a quarter of the iceberg production over the period, the remainder resulting from loss of glacier volume due to downwasting and to disintegration of the part of the lower reach between the pre-retreat terminus and the present terminus.