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Using upper-air temperatures to model high-altitdude summer balance on 23 glaciers

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A positive degree-day model uses daily upper-air temperatures in the NCEP-NCAR Reanalysis database and mass balance measurements, mainly in the WGMS archive. It estimates summer balance at several altitudes extending to above 3000 meters on each of 23 glaciers in the northern hemisphere. For each glacier the model uses a single degree-day coefficient at all altitudes, in all years. At each altitude where balance is reported, the model interpolates free air temperature at that altitude from the nearest NCEP-NCAR gridpoint. Because dates of summer balance measurements are generally not recorded, the degree-day accumulation extends over the entire calendar year except for two in North America for which the dates are known. The numerical values of the 23 coefficients are similar to values reported in the literature for models using temperatures measured at nearby weather stations.

The rms error of the model, calculated over all altitudes and all years, ranges between 0.28 and 0.53 m/a w.e. for the 19 glaciers in continental climates in Europe and Asia, between 0.68 and 0.78 for the four in western North America. The 23 correlations between upper-air temperature and summer balance range between -0.96 and -0.84. Several factors affecting the efficiency of the glacier surface in assimilating received energy can be expected to vary with altitude, such as albedo and air humidity. Nevertheless, for the 23 glaciers analyzed here with a single degree-day coefficient used at all altitudes, model error is nearly uncorrelated with altitude; r ranges between -0.19 and $+0.14$.

For the 12 glaciers with records longer than 10 years, the published profiles have considerable regularity.