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Glacier melt, air temperature and energy balance in different climates: the Bolivian Tropics, the French Alps and northern Sweden

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This study investigates the physical basis of temperature-index models for three glaciers in contrasting climates: Zongo (16°S, 5050 m, Bolivian tropics), St Sorlin (45°N, 2760 m, French Alps), and Storglaciären (67°N, 1370 m, northern Sweden). The daily energy fluxes were computed during melt seasons and correlated with each other and with air temperature on and outside the glacier. The relative contribution of each flux to the correlations between temperature and melt energy was assessed. At Zongo, net short-wave radiation controls the variability of the energy balance and is poorly correlated to temperature. On tropical glaciers, temperature remains low and varies little, melt energy is poorly correlated to temperature, and degree-day models are not appropriate to simulate daily melting. At the yearly scale, the temperature is better correlated to the mass balance because it integrates the ablation and the accumulation processes over a long time period. At Sorlin, the turbulent sensible heat flux is greater because of higher temperatures, but melt variability is still controlled by short-wave radiation. Temperature correlates well with melt energy mainly through short-wave radiation, probably due to diurnal advection of warm air from the valley. At Storglaciären, high correlations between temperature and melt energy result from substantial variability and good correlations with temperature of the turbulent fluxes of sensible and latent heat, which both supply energy to the glacier. In the three climates, long-wave irradiance is the main source of energy, but its variatibility is small and poorly correlated to the temperature mainly because of cloud emissions.