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A comprehensive energy and mass balance firn model for simulations over multiple glacial cycles

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We present a fast yet physically comprehensive glacier surface mass balance model capable of simulations that cover the entire Northern Hemisphere over several glacial cycles. Fluxes of energy and mass are calculated between the atmosphere and a multilayer snow cover, including internal processes like densification and water percolation as well as snow and ice melt. The model is especially designed to provide upper boundary conditions to force ice sheet models on time scales of up to 10̂6 years. To achieve a high numerical efficiency, the model employs a variable time stepping scheme on the grid point level and a Lagrangian grid attached to the snow mass. The input variables are short wave radiation, air temperature and precipitation with half-weekly or daily time steps.
This new surface mass balance model has been tested in extensive ensemble simulations and yields realistic representations of present-day ice sheets. The extent of the intra-annual snow cover on the Northern Hemisphere correlates temporally and spatially well with satellite measurements. Perennial firn aquifers are simulated realistically in Greenland and the simulated densification and snow temperature at two bore hole sites in central Greenland yield promising results.