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Modeling surface response of the Greenland Ice Sheet to interglacial climate

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We present a new parameterization of surface mass balance (SMB) of the Greenland Ice Sheet (GIS) under interglacial climate conditions validated against recent satellite observations on a regional scale. Based on detailed analysis of the modeled surface melting and refreezing rates, we conclude that the existing SMB parameterizations fail to capture either spatial pattern or amplitude of the observed surface response of the GIS. This is due to multiple simplifying assumptions adopted by the majority of modeling studies within the frame of the positive degree day method. Modeled spatial distribution of surface melting is found to be highly sensitive to a choice of daily temperature standard deviation (SD) and degree-day factors, which are generally assumed to have uniform distribution across the entire Greenland region. However, the use of uniform SD distribution and the range of commonly used SD values are absolutely unsupported by the ERA-40 and ERA-Interim climate data. In this region, SD distribution is highly inhomogeneous and characterized by low amplitudes during the summer months in the areas where most surface ice melting occurs. In addition, the use of identical degree day factors on both the eastern and western slopes of the GIS results in overestimation of surface runoff along the western coast of Greenland and significant underestimation along its eastern coast. Our approach is to make use of (i) spatially and seasonally variable SDs derived from ERA-40 and ERA-Interim time series, and (ii) spatially variable degree-day factors, measured across Greenland, Arctic Canada, Norway, Spitsbergen and Iceland. We demonstrate that the new approach is extremely efficient for modeling the evolution of the GIS during the observational period and the entire Holocene interglacial.