



Greenland surface mass balance 1870-2013 based on an improved/optimised runoff model

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The positive degree day (PDD) method is commonly used to determine melt as a function of temperature and precipitation in the degree-day calculation. This includes the temperature parameterisation σ , the standard deviation of temperature, which accounts for short-term (i.e. hourly-daily-weekly within a month) temperature variations, thus enabling the calculation of melt where the average temperature is below 0°C. For Greenland Ice Sheet (GrIS) surface mass balance (SMB) modelling, σ is typically assumed to be constant and is often prescribed a value between 2.5°C and 5.5°C. It is unclear in much of the literature how these values were reached and there is little evidence of sensitivity analysis or validation. Here we present an alternative parameterisation for σ from 1870 to 2013 inclusive, based on the standard deviations of downscaled, corrected 2m air temperatures from Twentieth Century Reanalysis (20CR) meteorological reanalysis (1870 to 1978) and European Centre for Medium-Range Weather Forecasts (ECMWF) Interim (ERA-I) meteorological reanalysis (1979 to 2013) on a 5x5-km polar stereographic grid for the GrIS. Temperatures from the two reanalysis products are spliced together to give a continuous time series and breakpoint analysis carried out on 20CR data to remove artificial breaks in the 2m air temperatures. The resulting σ values reveal a distinct seasonal cycle, with summer values ranging from 1.7°C to 5.9°C and a mean summer value of 3.2 degC from 1870 to 2013: 1.0 degC lower than the value of 4.2°C commonly assumed in the literature. As summer months dominate the melt calculation, this new σ parameterisation will give a smaller melt area and therefore a more positive modelled SMB for the GrIS. Validation was carried out against automatic weather station (AWS) surface air temperature data from the Danish Meteorological Institute (DMI), Greenland Climate Network (GC-Net) and Program for monitoring of the Greenland Ice Sheet (PROMICE) 2m air temperatures. The standard deviations of these temperatures were calculated and compared to those obtained from reanalysis data. Overall there is good agreement between the calculated and observed values, with R values of 0.78, 0.48 and 0.33 for annual, summer and July respectively, all of which are statistically significant correlations at the 95% level. The new variable σ values are then fed into a PDD model to calculate a new GrIS SMB series from 1870 to 2013. We present an analysis of changes in SMB, focusing on the period of recent mass loss since the early 1990s.