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Interactive comment on "A new spatially and temporally variable sigma parameter in degree-day melt modelling of the Greenland Ice Sheet 1870–2013" *by* A. E. Jowett et al.

A. E. Jowett et al.

a.jowett@sheffield.ac.uk

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Firstly we would like to thank the reviewer for their comments. In response to the first point, the scientific relevance of using a spatially and temporally varying σ is highlighted in the introduction to this paper: please see lines 9-12 and 19-21 on page 4. Using a spatially and temporally varying σ not only enables regional differences in temperature fluctuations to be captured, but also allows for a determination of whether these fluctuations in temperature have changed over time in both magnitude and location. As temperature varies, sometimes rising above 0oC over large parts of the Greenland Ice Sheet (GrIS) in summer, a correct representation of sigma has the clear potential to

significantly affect the GrIS SMB. If more excursions above 0oC are captured by the variable σ parameter, this results in more modelled melt and therefore a lower SMB than using the constant parameter. The implications for SMB of the new σ presented here are discussed in a second paper as stated in lines 5-7 (page 7) and are not intended to be the focus of this study, and so the implications for SMB are not discussed at length here. The σ value cannot be included as a small part of this study since it is important to first highlight the approach taken here in calculating the parameter and second show how the parameter has changed over time and therefore why it is important to vary σ rather than use the constant σ approach. Similarly, the authors are currently working in collaboration with others to carry out a comprehensive SMB model inter-comparison which will be much more in depth than that of Vernon et al. (2013) and, as such, this will be the focus of a further paper and so is not discussed here. Our σ is unique compared to other variable series in that we use the 20CR series, which hasn't been done before, and in combining this long-term analysis with the ERA-I series from 1979 we produce a unique 144-year σ series. The 20CR series is also corrected with reference to the ERA-I series, which is deemed more accurate (e.g. Hanna et al. 2011) and, in so doing, we believe we have presented the longest running and most up-to-date σ series currently available. RCM-based GrIS SMB studies are generally restricted to the period since the 1950s, as they are relatively data-hungry and so suffer from unreliable data input issues before around that time. So it is not obvious that RCM-based studies are inherently better for GrIS SMB/climate studies going back into the Nineteenth Century (which are crucial for placing recent global warming-related changes in a longer-term climatic context); the relatively simple PDD model has an innate advantage here. The new sigma value could be used in large-scale Greenland Ice Sheet (dynamical) models but that is not the main purpose of the present study. There are several advantages in presenting a new/extended σ series for the last 144 years. The primary purpose of going this far back is to allow as comprehensive a validation as possible and determine any long-term trends in not just temperature but temperature variability over the ice sheet, as well as the relationship between σ and other climatic

indices: aspects which to the best of our knowledge have not been investigated on this timescale before. We use the new σ parameterisation in SMB modelling and the results will be published in separate papers (e.g. Wilton et al. 2015, in preparation). This matter will be clarified in the revised version of this paper.

References Hanna, E., Huybrechts, P., Cappelen, J., Steffen, K., Bales, R.C., Burgess, E.W., McConnell, J.R., Steffensen, J. P., van den Broeke, M., Wake, L., Bigg, G.R., Griffiths, M. and Savas, D. (2011). Greenland Ice Sheet surface mass balance 1870 to 2010 based on Twentieth Century Reanalysis, and links with global climate forcing. Journal of Geophysical Research - Atmospheres, 116, D24121. doi:10.1029/2011JD016387 Vernon, C. L., J.L. Bamber, J.E. Box, M.R. van den Broeke, X. Fettweis, E. Hanna & P. Huybrechts (2013) Surface mass balance model intercomparison for the Greenland ice sheet. The Cryosphere 7, 599-614, doi:10.5194/tc-7-599-2013 Wilton, D.J., Jowett, A., Hanna, E., Bigg, G.R., van den Broeke, M.R., Fettweis, X., & Huybrechts, P., 2015. High resolution (1-km) positive degree day modelling of Greenland Ice Sheet surface mass balance, 1870-2012 using reanalysis data. The Cryosphere, in preparation.

Interactive comment on The Cryosphere Discuss., 9, 5327, 2015.