

Interactive comment on “Regional Greenland Accumulation Variability from Operation IceBridge Airborne Accumulation Radar” by Gabriel Lewis et al.

Anonymous Referee #1

Received and published: 20 November 2016

This is a generally very good study of Greenland Ice Sheet accumulation based on Ice-Bridge data, that compares the results with several different regional climate models and a kriged map of ice-core data. Finally, an attempt is made to interpret recent accumulation variations (spatial and temporal) with reference to the Atlantic Multidecadal Oscillation and North Atlantic Oscillation changes, although Greenland Blocking should also be mentioned here. This latter section is less strong and can be supplemented with some extra material from recent studies (see below). I'm not convinced, from the results presented, that the AMO is necessarily the main driver of the Greenland accumulation increase seen since 1976, and would welcome a bit more analysis of this aspect. Overall the paper is important because it presents a major new dataset of

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Greenland accumulation and highlights some major regional differences between the RCMs and IceBridge data, that need to be reconciled in future work. It helps to identify key regions where Greenland accumulation data are relatively lacking and need to be collected.

Specific comments Please use "GrIS" rather than "GIS" (Geographic Information Systems!) abbreviation for Greenland Ice Sheet. page 1, line 30: reference "Shepherd 2012" should be "Shepherd et al. 2012". I would add several further recent references here: Enderlin, E. M., I. M. Howat, S. Jeong, M.-J. Noh, J. H. van Angelen, and M. R. van den Broeke (2014) An improved mass budget for the Greenland ice sheet, *Geophys. Res. Lett.*, 41, 866–872, doi:10.1002/2013GL059010. Hanna, E., F. J. Navarro, F. Pattyn, C. Domingues, X. Fettweis, E. Ivins, R. J. Nicholls, C. Ritz, B. Smith, S. Tulaczyk, P. Whitehouse & J. Zwally (2013) Ice-sheet mass balance and climate change. *Nature* 498, 51–59, doi: 10.1038/nature12238. van den Broeke, M. R., Enderlin, E. M., Howat, I. M., Kuipers Munneke, P., Noël, B. P. Y., van de Berg, W. J., van Meijgaard, E., and Wouters, B.: On the recent contribution of the Greenland ice sheet to sea level change, *The Cryosphere*, 10, 1933–1946, doi:10.5194/tc-10-1933-2016, 2016. p.2, l.3: supplement van den Broeke et al. (2009) reference with van den Broeke et al. (2016) (full details above). p.2, l.5 "due to complex relationships between accumulation variability and surface melt runoff" - add reference: Hanna, E., P. Huybrechts, I. Janssens, J. Cappelen, K. Steffen, and A. Stephens (2005), Runoff and mass balance of the Greenland ice sheet: 1958–2003, *J. Geophys. Res.*, 110, D13108, doi:10.1029/2004JD005641. p.2, l.8: "preferred modes of climate variability like the NAO and AMO: add Greenland Blocking Index (GBI, Hanna et al. 2016) to these: Hanna, E., T. Cropper, R. Hall, J. Cappelen (2016) Greenland Blocking Index 1851–2015: a regional climate change signal. *International Journal of Climatology*, MS no. JOC-15-0742.R1, accepted/in press. p.2, l.13 Suggest add text in CAPS to the following: "but are too sparse to capture the full spatial variability of GIS accumulation, especially in the southeast," **ALTHOUGH ATTEMPTS HAVE BEEN MADE TO INTERPOLATE ICE-CORE-BASED ACCUMULATION DATA - SUPPLEMENTED WITH COASTAL PRECIPITATION DATA - TO THE**

WHOLE-ICE-SHEET SCALE (BALES ET AL. 2009). HOWEVER, THIS APPROACH MAY POSSIBLY UNDERESTIMATE ACCUMULATION IN PARTS OF THE INTERIOR COASTAL MOUNTAINS OF SOUTH-EAST GREENLAND. p.2, l.15 -> "more spatially distributed AND REPRESENTATIVE GIS accumulation dataset..." p.3, l.6 (and throughout MS) - correct "principle component analysis" to "principal component analysis". p.3, l.18: How are the IRHs related to spatial and/or temporal changes in accumulation? p.5, l.17, Equation 3: Is $\rho(z)$ the *mean* density of the respective layer? p.6, l.14: missing full stop . at end of sentence. p.8, l.21: "data set" -> "dataset". p.9, l.29: -> "where ice cores were collected several decades ago". p.9, l.31: "data poor regions" -> "data-poor regions". p.10, l.10: you can't really have a percentage of SMB as there is no absolute zero point, so I'm not sure this makes sense. p.10, l.26 slightly reword to "These correlations indicate AN ASSOCIATION BETWEEN the AMO AND Greenland precipitation ALTHOUGH, DUE TO COLLINEARITY, ANY PHYSICAL RELATION COULD PARTLY BE ACTING THROUGH NAO CHANGES." pp.10/11 overlap: Point out that the positive GrIS precipitation-AMO correlation, with warmer North Atlantic & Greenland temperatures, might also be due to associated storm-track or blocking changes (e.g. Hanna et al. 2013 IJOC, Hanna et al. 2016). Hanna, E., J.M. Jones, J. Cappelen, S.H. Mernild, L. Wood, K. Steffen & P. Huybrechts (2013) The influence of North Atlantic atmospheric and oceanic forcing effects on 1900–2010 Greenland summer climate and ice melt/runoff. Int. J. Climatol. 33, 862–880, doi: 10.1002/joc.3475. p.11, l.7 "Negative correlations in the northern and western regions...are indicative of greater precipitation during NAO negative conditions..." - but there should be positive correlations for Greenland overall (Greenland precip more generally reduces under negative NAO) because negative NAO is usually linked with positive GBI (anticyclonic conditions over Greenland, which should overall suppress precipitation) - please clarify. Obviously there are well-documented regional variations of this relation. p.11, l.25 -> "used to validate THE study". p.11, l.30 "we hypothesize that rising accumulation over most of the GIS interior since 1976 is related to an increasing AMO index" - rising accum. could equally well reflect changes in atmospheric circulation, e.g. a more

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meridional airflow on average - with more moisture laden south-westerly winds, affecting Greenland. p.12, l.6: The Hanna et al. (2013) reference cited here should be for the IJOC paper referenced above, not the Nature paper - please amend. p.13, l.6 : change "strongest" to "most strongly". References Box & Rinke 2003 paper has the authors' names repeated twice. Please add other author names (or et al.) of the Shepherd 2012 Science paper. Table 1: add in the caption what the plus/minus figures represent.

Interactive comment on The Cryosphere Discuss., doi:10.5194/tc-2016-248, 2016.

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