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Interactive comment on "Extraordinary runoff from the Greenland Ice Sheet in 2012 amplified by hypsometry and depleted firn-retention" *by* A. B. Mikkelsen et al.

Anonymous Referee #2

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A review of:

Mikkelsen, A. B., Hubbard, A., MacFerrin, M., Box, J., Doyle, S., Fitzpatrick, A., Hasholt, B. and Bailey, H.: Extraordinary runoff from the Greenland Ice Sheet in 2012 amplified by hypsometry and depleted firn-retention, The Cryosphere Discussions, 9(5), 4625–4660, doi:10.5194/tcd-9-4625-2015, 2015.

General Comments:

Mikkelsen et al 2015 use in situ measurements including proglacial river discharge from

the Watson River in western Greenland and ice density profiles in concert with climate model based estimates of meltwater production and runoff to infer the importance of firn retention. They compare the extreme summertime melt events of 2010 and 2012. They find that the cumulative proglacial discharge from Watson River ice catchment was nearly one-third larger during the extreme melt season of 2012 compared to the extreme melt season of 2010, despite only a 3% difference in net radiation. They conclude that the discovery of an extensive layer of dense ice approximately one meter from the ice surface found in 2012 in situ measurements acted as a barrier to infiltration and thus enhanced runoff and mitigated infiltration/refreezing.

The results of this study are novel and help emphasize both the importance and complexity of the Greenland Ice Sheet cryo-hydrologic drainage network, drainage efficiency, meltwater retention/refreezing processes and ice hypsometry in sea level rise estimates. Overall, the manuscript is compelling, well supported, thorough and makes an important contribution to the cryosphere science community. I recommend that this manuscript be published in The Cryosphere given that the authors adequately respond to the detailed comments and corrections below.

Specific Comments:

Mikkelsen et al 2015 acknowledge that ice catchment delineation is a potential source of uncertainty in estimating runoff. They use a previously published ice catchment delineated using ice surface topography. They argue that the spatial resolution of current bedrock topography data is insufficient for accurate subglacial watershed extraction. At close inspection, these arguments fall short in withstanding critique. The reasons for this are threefold:

(1) Potential for subglacial piracy - Lindbäck et al 2015 find evidence of potential 'subglacial piracy' wherein en-/sub-glacial meltwater channels seasonal evolution results in meltwater exiting the ice sheet into different proglacial rivers at different times during the melt season. Is it possible that such a parallel scenario could help explain proglacial

discharge volume differences between the extreme melt events?

(2) Multi watershed approach - Smith et al 2015 suggest adopting a multi-watershed approach whereby a range of watershed delineation techniques and topographic datasets are used. Would the results here be upheld if such a multi-watershed approach were used? Lindbäck et al 2015 also argue that ice catchments likely evolve and that that this "should be considered in studies that attempt to relate estimates of surface runoff from energy balance models with. . .proglacial discharge and ice dynamics"

(3) Basal topography resolution - it is important to note that new basal topography datasets with improved spatial resolution are available (e.g.: Bamber et al 2013; Morlighem et al 2014). Furthermore, MODIS data is being used to map lakes and lake drainages and is also being resampled to a 5km grid for snow/ice albedo mapping - all at coarser resolutions than available topography datasets.

Technical Corrections:

Abstract is long; could be consolidated and some points could be moved to other sections of text Pg. 4638, Line 1-2: spelling error 'Kanherlussuaq'

Citations:

Bamber, J. L., Siegert, M. J., Griggs, J. A., Marshall, S. J. and Spada, G.: Paleofluvial Mega-Canyon Beneath the Central Greenland Ice Sheet, Science, 341(6149), 997–999, doi:10.1126/science.1239794, 2013.

Lindbäck, K., Pettersson, R., Hubbard, A. L., Doyle, S. H., van As, D., Mikkelsen, A. B. and Fitzpatrick, A. A.: Subglacial water drainage, storage, and piracy beneath the Greenland ice sheet, Geophys. Res. Lett., 42(18), 2015GL065393, doi:10.1002/2015GL065393, 2015.

Morlighem, M., Rignot, E., Mouginot, J., Seroussi, H. and Larour, E.: Deeply incised submarine glacial valleys beneath the Greenland ice sheet, Nature Geoscience, 7(6),

418–422, doi:10.1038/ngeo2167, 2014.

Smith, L. C., Chu, V. W., Yang, K., Gleason, C. J., Pitcher, L. H., Rennermalm, A. K., Legleiter, C. J., Behar, A. E., Overstreet, B. T., Moustafa, S. E., Tedesco, M., Forster, R. R., LeWinter, A. L., Finnegan, D. C., Sheng, Y. and Balog, J.: Efficient meltwater drainage through supraglacial streams and rivers on the southwest Greenland ice sheet, Proceedings of the National Academy of Sciences, 112(4), 1001–1006, doi:10.1073/pnas.1413024112, 2015.

Interactive comment on The Cryosphere Discuss., 9, 4625, 2015.