

Interactive comment on “Variability of glacier albedo and links to annual mass balance for the Gardens of Eden and Allah, Southern Alps, New Zealand” by Angus J. Dowson et al.

Anonymous Referee #2

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Title: Variability of glacier albedo and links to annual mass balance for the Gardens of Eden and Allah, Southern Alps, New Zealand

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The paper proposes to use minimum MODIS albedo to approximate snow line altitudes (SLA). The paper requires a substantial effort to improve the clarity and organisation. The authors need to clearly define the objectives of the paper then use the results to support the objectives.

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General comments: A clearly stated set of objectives is required. The authors need to put some significant thought into this as no surface mass balance (smb) records are presented. The authors need to find a way to make a better connection to smb, otherwise the analysis compares a proxy for smb to another proxy for smb. The manuscript requires substantial editing for clarity and organisation. The error analysis of MODIS albedo and the potential for sensor degradation (post 2016 on the Terra bus) need to be addressed. Please use continuous line numbers and do not restart the line numbers at every page. A series of paper citations are listed at the end of this review for you to consider. Please remove the words “important”, “meaningful”, “arguably”, etc. from the manuscript. Let the readers decide for themselves. Julian Day should probably be referred to as Day of Year. A substantial amount of effort is required to understand the errors in SLA, and minimum albedo related to their temporal mismatch. The figures are not used to full effect in the text. A clearer description and analysis of the figures in the text is required. The word significant should be reserved to describe statistical significance, otherwise words like substantial should be used to describe a large change. If the authors are going to invoke the 50 EOSS glaciers, then a much stronger analysis of how the 12 glaciers in this study compare to the 50 is required.

Specific comments: Line 10: Using the whole glacier minimum albedo the dynamics of the glacier are somewhat smoothed over. Perhaps define what is meant by dynamics in this instance. Is it annual minimum albedo that was used, or melt season? Line 13: briefly define new approach Line 14: provide the evidence in brief Line 12: Was surface mass balance measured, or was EOSS SLA measured – the two are not the same thing? Line 16: Define “high snow line” p-value should be $p < 0.001$, etc. depending on level of significance. The results section of the Abstract need to be rewritten to present all of the results. Furthermore, a statement of why you have done this analysis is required. Lines 26-27: Define climate units. Introduction: P2, Line 17: The minimum albedo method does not infer mass balance. It scales to ELA and AAR, which in turn scale to mass balance. Without measurements of mass balance to quantify the relationship to minimum albedo, ELA, or AAR, mass balance should not really enter into

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the discussion. P2,Line 20: Define “relationships”. P2,Line 20-23: There are more citations for this method – see below. P2,Line 25: why is the glacier contribution “globally significant” and define (i.e., X m sea level increase). P2,Line 29: Air temperature is important in controlling glacier mass balance – but on line 19 you said shortwave radiation played a governing role on smb. Which is it? Both I gather, so this section should be expanded to detail the nuanced nature of the controls on glacier smb. P2,Line 31: define cloud properties and how they influence smb. What is the role of longwave forcing? P2,Line 32: “global warming in the Southern Alps” is nonsensical. P3,Line 1: define “fast-responding glaciers” what does this mean and why is it important? P3,Line 3: Why was minimum albedo method not used on these two glaciers? If that analysis has already been conducted, then provide an analysis of ELA, AAR and minimum albedo for these two glaciers in reference to smb. Once completed then the analysis presented on the other glaciers without smb will be on a better footing. P3,Line 4: Define what was measured then tell me why it is important. P3,Line 10: There is going to be a large problem using MODIS grids on very small glaciers because of the grid size to glacier area mismatch - discuss. P3,Line 11: have meant – means P3,Line 13-21: this sounds like the missing research question that should have been addressed in the end of the Abstract. P3,Line 22-27: Provide better links to the tables and figures detailing the study site. The last paragraph of the Introduction is redundant and should be removed.

Page 4: Site description: P4,Line 20: Provide climate normals. P5,Line 3: How is this a sensitive climate situation? Sensitivity means that there is a glacier response (dynamic, or mass loss etc.) for temperature or precipitation change. A case for neither of these scenarios has been presented. P5,Line 10: How do you know that the 14 March corresponds to the minimum ELA? P5,Line 12: What is “field knowledge”? Actually the whole section should be rewritten. What are the NDSI wavelengths used? There is almost two months difference between image capture dates. How is this reconciled? P5,Line 27: What is the superscript T on MODIS? The standard usage is MOD for Terra and MYD for Aqua. P5, Section 2.2: You should read:

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https://nsidc.org/data/modis/terra_aqua_differences There is some speculation that the Terra MODIS sensor is degrading. This degradation is largely correct for in the collection 6 data. There are several citations that should be considered in relation to this issue. These citations have been listed at the end of the review. P5, Line 29: orbits are usually described as ascending and descending. P6, Line 2: What does “exceptionally cloudy” mean? Provide a description with statistics. Why were only four days used for comparison between Terra and Aqua? Provide justification. The MODIS methods section does not indicate which albedo product was used, or how albedo was produced at 250 m. A much more clear description of data processing is required. O.k., I see the following section on albedo processing. Perhaps a sentence here to indicate that MODImLab will be detailed (and why) later in the paper. Section 2.3 requires a much better description of what exactly was done. P6, Line 21: Sentinel was used to “approximate” the timing and elevation of SLA. A great deal of effort should be spent on what approximate means in this instance. P8, Line 30: why was 50% used? How was this value determined? Should 100% be used if you want to remove debris-covered glaciers? Page 9, Section 3.3: The requirement of using only cloud free glaciers is very restrictive and substantially reduces the amount of data used in the analysis. Provide statistics on the amount and duration of cloud cover. When there is cloud cover will likely be as important as where there is cloud cover. Pixel is a picture element found on a display screen. Grid cell is a better usage. Page 10, L1: Artefact should be replaced by error. Section 4.3 should be presented in the Introduction section. Typical values for the different glacier states should be provided. This is an example of the systematic problem with this paper, in that there really aren’t that much in terms of reportable results. Page 11, L5: The classification of glaciers into four groups is accomplished by geographical variables. Without providing climate data, it is a mystery to me how the authors determine the glaciers are not behaving as a single climate unit. Page 11, L28: Either the declines are monotonic or they are not. Page 13, L15 (and elsewhere) R^2 values should be presented with significance values. Page 13, L29-30. What is a maximum summer snow line? When exactly was this observed within the summer

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period? P14,L10: Citation required. P14,L23: Using only 12 glaciers, which are argued to occupy different climactic regions, can size and elevation be reasonably discounted as predictors of the min albedo and SLA? P15,L7: define effective, precisely. P15,L23: I wouldn't have characterised the R^2 values found in the Results section as strong to moderate. Section 5.2 is results and should not be presented in the discussion section. P18,L7: "likely having as significant influence" means you don't know if it is significant or not. Section 5.3. This section should be expanded. Is the correlations between minimum albedo to SLA related to the amount of cloud cover? Figure 12 (left panel) There are obvious difference between MODIS Terra and Aqua related to Class. Why is this? Might this be related to the systematic increase in cloud cover in Aqua vs. Terra (Figure 14)?

Citations to consider:

Casey, K. A., Polashenski, C. M., Chen, J., & Tedesco, M., 2017. Impact of MODIS sensor calibration updates on Greenland ice sheet surface reflectance and albedo trends. *The Cryosphere*, 11, 1781–1795.

Polashenski, C.M., Dibb, J. E., Flanner, M. G., Chen, J. Y., Courville, Z. R., Lai, A. M., et al., 2015) Neither dust nor black carbon causing apparent albedo decline in Greenland's dry snow zone Implications for MODIS C5 surface reflectance. *Geophys. Res. Lett.*, 42, 9319–9327.

Van Tricht, K. et al., 2016. Clouds enhance Greenland ice sheet meltwater runoff. *Nat. Commun.* 7:10266 doi: 10.1038/ncomms10266.

Williamson, S.N., Copland, L., Hik, D.S., 2016. The accuracy of satellite-derived albedo for northern alpine and glaciated land covers. *Polar Sci.* 10, 262-269. Bahr, D.B., Radic, V., 2012. Significant contribution to total mass from very small glaciers. *The Cryosphere*, 6, 763-770.

Bennartz, R., Shupe, M., Turner, D. et al., 2013. July 2012 Greenland melt extent

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enhanced by low-level liquid clouds. *Nature*, 496, 83–86. doi:10.1038/nature12002

Zhang, Z., Jiang, L., Liu, L., Sun, Y., Wang, H., 2018. Annual Glacier-Wide Mass Balance (2000-2016) of the Interior Tibetan Plateau Reconstructed from MODIS Albedo Products. *Remote Sens.*, 10, 1031, <https://doi.org/10.3390/rs10071031>.

Interactive comment on The Cryosphere Discuss., <https://doi.org/10.5194/tc-2020-5>, 2020.

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