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The Cryosphere Discussions

Interactive comment on "Investigating spatiotemporal patterns of snowline altitude at the end of melting season in High Mountain Asia, using cloud-free MODIS snow cover product, 2001–2016" *by* Zhiguang Tang et al.

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The use of MODIS imagery to identify end of melt season snowline line altitude (SLA) as a proxy for ELA is not a new process. The MODIS derived SLA can be a proxy for mass balance, but is difficult to actually expect the approach here at the grid cell level using 500 m pixels to yield accurate mass balance values. As a consistently observable and reportable metric of glacier-climate across the HMA there is value in that this is a repeatable measurement, how accurately it predicts mass balance is not the value here. There are several significant issues the authors need to address to

make this a useful contribution. 1) There are three key references just published in The Cryosphere in the last seven years that are essential to review. All use approaches that overlap with part of the process used here. 2) The footprint of MODIS in steep terrain leads to significant errors in establishing a SLA. This has to be explored, particularly given a grid scale measurement is used, and is not validated against more specific glacier by glacier observation for a few sample grids. 3) The interpretation of the SLA variation being dependent on latitude and regional mean elevation does not capture key drivers of this including differences in moisture sources, and seasonal distribution of precipitation.

10: Why use a new acronym instead of the excepted terminology of transient snow line (TSL) for observations of the snow line not at the end of the melt season or snow line altitude (SLA) if it is the end of the melt season and is equivalent to the ELA, than just use ELA.

45: Check, Flint (1971) not a good interpretation of snowline.

56: There are useful references here including from the HMA that illustrate more frequent SLA observation (Das and Chakraborty, 2015)

79: This is not true, note work of Barundun et al (2018): "The integration of TSL observations into conventional modelling is shown to be highly beneficial for filling the gaps in long-term SMB series for periods for which direct glaciological measurements were discontinued or are missing completely."

84: Shea et al (2013) used MODIS for regional snowline altitude assessment just as you propose. There basic approach is "We describe a method to calculate regional snow line elevations and annual equilibrium line altitudes (ELAs) from daily MODIS imagery (MOD02QKM) on large glaciers and icefields in western North America. An automated cluster analysis of the cloud-masked visible and near-infrared bands at 250m resolution is used to delineate glacier facies (snow and ice) for ten glacierized regions between 2000–2011. For each region and season, the maximum observed value of

the 20th percentile of snowcovered pixels is used to define a regional ELA proxy."

87: Pelto et al (2011) compared MODIS and Landsat for snow line identification: "The MODIS imagery is from band 1 which has a resolution of 250 m. With the average surface slope of 1.6âŰę this yields an error of less than $\pm$10 m in elevation for TSL. A comparison of a Landsat image and MODIS image from 29 July 2009 is provided (Fig. 2). It is evident that though some detail is lost the TSL position identified overall is not significantly different."

129: Given the 500 m pixel size and the average slopes how much accuracy is there for SLA? This is a key issue given you are reporting a grid cell average. This should be validated for a few particular grid cells with Landsat, SPOT or Sentinel observation of SLA in that same grid cell on glaciers. This is done for SCA using Landsat that is a different measure.

142: How many report ELA observations?

189: "However, the snow area with MODIS SCD$\geq$365d fails to really indentify the perennial snow area, due to the affect of the annual cumulated errors in MODIS snow mapping algorithm and cloud removal method."

201: Why is the 25km2 glacier area of the 30km2 grid chosen?

214: The correlation from 332d to 347d is relatively consistent indicating this is a good window, and 347d alone does not have to be relied upon if imagery is poor. If the this time of 347 days shifts that is a measure too.

218: Given that many of these glaciers report ELA to WGMS, which provides a more direct measure of the adequacy of your method, it would be appropriate to provide this measure. The mass balance provides a correlation that is similar, however, the standard deviation between the methods is meaningless with the different units. This could be done collectively versus glacier by glacier.

241: In figure 6 it is provide legend for the various regions. The continued declining

ratio of Landsat/MODIS beyond 347d suggests that the melt season is continuing and the SLA would still be rising.

258: This method appears to be quite useful for providing a comparable SLA elevation across the region annually, even if it is not overly accurate to a glacier in particular grid cells or for mass balance assessment.

287: How does fit with the results of Barundun et al (2018) from the Tien Shan and Pamir-Altay?

288: How much of this is latitude versus level of maritime climate influence, or degree to which the glacier is a summer accumulation type? Many references have examined this issue.

291: Both altitude and elevation are used in this sentence, are you referring to the average elevation of the grid cell?

306-307: Your percentages refer to discrete linear responses and should be grouped in a way that the 100% is reached in a clear way. Lump together the significance groupings. Lump together the slope groupings.

311-313: Quantify what % of decreasing trends are from the indicated regions.

347: The comment about the rising SLA and water resources is a generic statement that needs support or removal. Thayyen and Gergan (2010) have described how the runoff from summer accumulation type glaciers is less of a resource than for other areas. If the melt season expands into the fall months as has been noted, this is a lower flow period and water resources could be increased with more glacier melt.

369: I do not see how this study is a precedent for using MODIS for snow cover mapping regardless of region or end product.

390: That SLA is a good indicator of mass balance is well established. In this case an indicator is not a substitute for any of the other methods that provide an actual quantity

that can be validated with one of the other methods.

397: The stipulation that elevation and latitude are the key variables is not supported by much of the literature that indicates how impacted by the summer monsoon and the winter westerlies is a key variable depending on location. That they are two well correlated parameters is accurate.

420: They do indicate declining mass balance.

467: The rising snowlines have already led to a decline in mass balance and mass flux down glacier. This is a continuation of regional mass loss that has driven thinning and a slowdown in glacier movement in 9 of 11 regions in HMA from 2000-2017 (Dehecq et al 2019).

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