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The Cryosphere Discussions

Interactive comment on "Regional estimates of glacier mass change from MODIS-derived equilibrium line altitudes" *by* J. M. Shea et al.

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Shea et al (2012) have developed a valuable method for automated derivation of the equilibrium line altitude (ELA) and transient snow line (TSL) from MODIS imagery for alpine glaciers that could yield important results. I encourage the authors to focus more on a more detailed description of the methods and validation of the method. The paper has three issues that need to be addressed before this value can be realized. 1) At present the research is not well informed by a careful enough reading of the existing applications of similar methods. 2) The reporting on the following are insufficient: the specific amount and dates of MODIS imagery utilized, sources of balance gradient information, snowline identification error analysis, and identification of what simple regional ELA's represent. 3) Validation of the balance gradients and ELA data derived

needs to be expanded. There are several fairly simple techniques that have been previously applied that could be applied here. There is limited discussion of the relative increase in error due to low resolution for the smaller alpine glaciers in the study.

Specific Points:

3758-24: It is inaccurate to identify only a handful of annual mass balance records for western North America. There are 20 such glaciers that have submitted data to the WGMS for the last 20 years and 24 glaciers for shorter periods (WGMS, 2011).

3759-20: Cogley et al (2011), is not the appropriate reference. Either Ostrem (1975) or Williams et al (1991) would be more appropriate.

3760-11: The use of MODIS for ELA-TSL observation is not a new technique in this region and reference to this fact needs to be made. Pelto (2011) utilized both Landsat and MODIS to identify the TSL and ELA on Taku Glacier.

3761-5: Why use data from Bridge and Andrei Glacier as part of the validation when the records are both short and do not overlap with the study period? Given the changes in area of glaciers in the region noted in several studies the balance gradient from the previous time period may not be particularly accurate for the last decade. There are certainly other glaciers that could be used.

3761-26: What data was used in the time series of snowline variation?

3762-11: What imagery is used in this process just MODIS, if so from when how many dates at the various locations?

3762-23: The method of transfer of data from specific to regional glaciers is not carefully described or defended. Some reference to Kuhn et al (2009) or Huss et al (in press) should be made, even if their method is not utilized. Jiskoot et al (2009) also test several methods of ELA assessment and transference to glaciers with various levels of ground truth in the same study area.

3763-23: What is the source of the balance gradient information for each glacier, how long is the record? What is the robustness from year to year?

3764-3: There are difficulties given the 250 resolution in using MODIS for small glaciers to derive snowlines. How reliable can the results be on South Cascade Glacier and Place Glacier where the glacier width in many areas is only two pixels? Pelto and Brown (2012) were unable to utilize MODIS to aid in snowline mapping on Mount Baker, North Cascades, due to poor resolution.

3764-9: Juneau is noted in Table 3. I assume this is the Juneau Icefield, what is utilized for the icefield ELA, is it the Taku and Lemon Cree, all glaciers or just the Alaskan side?

3764-8: Some comparison with the observations of Jiskoot et al (2009) who also comment on changes in the ELA on Peyto Glacier is essential.

3764-23: What dates are utilized for MODIS imagery? There is no listing of the number of dates for which MODIS was analysed and TSL derived for any of the glaciers. How did the TSL change during a melt season as observed on a glacier? Is the changing snow cover area fraction utilized (Huss et al, in press)?

3765-11: Where is this constructed time series? Table 3 has overall data as does Figure 6 but I do not see a time series presented.

3765-20: Three issues are noted by the authors that could be addressed with a bit of further examination of the data in hand, and have been contemplated by previous research. (1) improperly specified mass balance gradients. In this case the rise of the TSL with time on glaciers where the mass balance is measured also allows validation of the balance gradient derived from TSL observations compared to actual surface mass balance. Given the automated methods this would be a particularly valuable outcome. Hock et al (2007), Pelto (2011) and Huss et al (in press) applied this methodology. Pelto (2011) examined the balance gradient for one of the same glaciers, Taku Glacier, comparing the MODIS-Landsat observed ELA and the field observed balance gradient.

I suggest the authors utilize both the Taku Glacier work and extend this analysis to at least one other glacier, such as Peyto Glacier, since it is smaller and in a different climate setting. The combination would provide an essential validation of the balance gradient. (2) errors in MODIS-derived ELAs. This can be examined by comparison of same date imagery with Landsat or field assessment. Pelto (2011) did this for a single date, which is clearly insufficient. This is particularly important on smaller glaciers. (3) differences in the dates of geodetic image acquisition and our calculation. If the mean rate of TSL change observed at the end of the melt season is identified, this can be either applied directly to adjust for the number of days between TLS observation and the end of the melt season (Hock et al, 2007; Pelto, 2011) or the rate of TSL rise late in the melt season identified in the MODIS imagery could be used in conjunction with temperature data to use a simple positive degree day model to make this adjustment.

3766-28: An ELA is only useful for determining mass balance if it used to derive either the AAR or the snow covered area fraction, the elevation alone is not (Huss et al., 2012; WGMS, 2011). How in this method is the ELA transitioned to represent the mass balance, just using the hypsometry?

Figure 6: For these glaciers the actual ELA is also reported to the WGMS, how does MODIS compare to that?

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