

Interactive comment on “Landsat TM and ETM+ derived snowline altitudes in the Cordillera Huayhuash and Cordillera Raura, Peru, 1986–2005” by E. M. McFadden et al.

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General comments:

McFadden et al (2010) present a multi-annual investigation of Snow Line Altitudes (SLAs) in two remote mountainous regions in Peru based on Landsat imagery and the Global ASTER DEM, and attempt to set the resulting SLAs into relation to climate data. The topic is very interesting, addresses currently relevant scientific questions, and fits well within the scope of TC. Despite the detailed study, the discussion and interpretation of the results should be partly seriously reconsidered. Especially the argumentation on rising SLAs due to climate changes in the section “Discussion and

C1619

conclusion” is confusing, partly unfounded, and should be revised. I would appreciate the resubmission of the paper after some corrections and an improved discussion of the results.

Specific comments:

1. The word “climate” is often used in a confusing way throughout the paper. Do not mix up annual meteorological variability and climate variability, as these expressions refer to different time scales!
2. Your results are a great basis for further investigations in the selected areas. Additionally to the investigation of the changes of the mean SLAs on glaciers in both research areas, a discussion about the multi-annual variation of the SLAs considering the exposition of the individual glaciers would be very interesting.
3. At the end of a melting season, the remaining snow areas on glaciers are often patchy. How did you define the snow line in such a case?
4. How did you take care for multi-annual snow areas (firn), which are often very difficult to discriminate from snow areas of the last winter, but belong to the ablation area on a glacier?
5. Please revise the section on image calibration, as well as the complete discussion of your results. Detailed comments related to the text and associated Tables and Figures are listed below.

Technical corrections:

1. Page 1933, lines 9 – 14: These three sentences describe similar issues, but are rather confusing than informative in the current version. Rewrite and point to the gist.
2. Page 1933, lines 20 – 21: To talk about “annual climate variability” is contradictory, as the climate does not change annually. But snow lines are sensitive on local meteorological influences, which can have an annual variability. Rewrite.

C1620

3. Page 1934, line 4: The standard pixel size of Landsat imagery is 30 m. Why do you refer to 28.5 m?
4. Page 1935, line 1: Landsat imagery derived from USGS and GLCF are available in raw formats (digital numbers). The radiometric calibration of both sensors (TM and ETM+) follows the same rules, but other calibration values are required due to different ranges of the spectral bands. Why do you only describe the radiometric calibration for Landsat 5 TM imagery? What about the radiometric calibration of Landsat 7 ETM+ imagery?
5. Page 1935, lines 7 – 8: “representing planetary surface reflectance as a ratio.” This part is confusing, as not the surface reflectance is represented by the radiometrically calibrated values, but the reflectance at the top of the atmosphere. The retrieval of surface reflectance requires an atmospheric correction. Rewrite.
6. Page 1935, line 14: Calibration constants are listed in Tables 1, 2, and 3. Further comments to these Tables are listed below.
7. Page 1935, line 21: DN = the quantized calibrated pixel value in a Digital Number. This notation is not only used for Landsat 5 TM, but also for Landsat 7 ETM+ imagery. The conversion of DN to at-satellite radiance is also not limited on the bands 1, 2, 3, 4, 5, and 7, but can be applied on the thermal (TM and ETM+) and panchromatic (ETM+) bands, too. Rewrite.
8. Page 1935, lines 22 and 24: The maximum DN for all bands is 255. Only the spectral radiances scaled on the minimum and maximum DN depend on the spectral range of a band and are thus variable. Rewrite.
9. Page 1936, line 15: “and Eq. 2”. You’ve already mentioned that Equation 2 is used for the conversion of at-satellite radiance to top of atmosphere reflectance. Remove.
10. Page 1938, lines 1 – 2: Obscure sentence. Rewrite.
11. Page 1938, lines 26 – 27: “Snowlines are used to approximate the glacier ELAs.”

C1621

You never rely on the glacier ELAs in the following text, but only on the SLAs. Remove this sentence, as it has no significance for the further discussion, and you’ve already mentioned that the SLAs can be used as proxy for the ELAs in these regions.

12. Page 1938, line 27: Insert “following” before the word “text”.
13. Page 1939, line 16: Remove “in an effort”.
14. Page 1941, line 8: “The plots displayed in Fig. 4 display...”. Rewrite.
15. Section 3.1: Be careful with the word “trend”. Although the mean SLA of all glaciers slightly increases during the 20 year period there is no trend of increasing SLAs for the glaciers in the Cordillera Huayhuash, but the observed changes are rather annual variations (considering your results provided in Table 4 and Figure 4). The crux of a mean value is that it can be driven by an individual value, which is significantly anomalous, even if the rest of the data shows no large changes.
16. Page 1943, lines 22 – 24: “Although there is a great deal of variability in Delta SLA values throughout the range, the mean Delta SLA was +123 m.” Obscure sentence. Rewrite or remove.
17. Page 1943, lines 25 – 28: Repeated contents. Merge or rewrite sentences.
18. Page 1944, line 5: “...were located at at a...” Remove one “at”.
19. Page 1944, line 24: “...SLAs on the eastern side of the ridge are lower than...” Is this valid for glaciers in both regions, or only in Cordillera Raura?
20. Page 1945, lines 13 – 14: As mentioned before, there is NO significant rise of the SLAs in the Cordillera Huayhuash. Please rewrite this sentence.
21. Page 1945, lines 26 – 27: The values in this sentence are not in line with your hypothesis of rising SLAs. A more careful handling of notation and argumentation in the sections 3 and 4 would be advisable to avoid confusion related to the interpretation of your results.

C1622

22. Pages 1946 – 1947: The whole discussion about precipitation, humidity, and temperature changes as key factors for variations of SLAs is confusing and needs revision for clarification.
23. Page 1947, lines 28 – 29: Here, you finally declare, that there is no trend in the SLAs of the Cordillera Huayhuash. Why do you not use this finding in the previous discussion?
24. Page 1948, line 8: Replace “lies” by “is located”.
25. Page 1948, lines 8 – 9: Replace “...neighboring Cordillera Blanca and similar rate of...” by “neighbouring Cordillera Blanca. A similar rate of...”
26. Page 1948, line 23: Replace “prominent” by “dominant”.
27. Page 1950, lines 7 – 8: “...rising SLAs in both the Cordillera Huayhuash and ...” Contradictory to Page 1947, lines 28 – 29, cf. Comment 23.
28. Page 1950, lines 9 – 11: Obscure sentence. Rewrite or remove.

Table 1:

- T1.1. “USGS” stands for United States Geological Survey.
- T1.2. The date format provided in the header does not fit the date format in the table. Change (mm/dd/yyyy) to (dd/mm/yyyy), or change the date formats, respectively.
- T1.3. The units of “Resolution” and “d” in the header are shifted. Reformat.
- T1.4. The standard pixel size of Landsat imagery is 30 m. Why do you use 28.5 m instead?
- T1.5. Why don’t you provide the earth-sun distances used for the calibration of the Landsat 7 ETM+ imagery?
- T1.6. Additional information about individual Path/Row and remarks on the failure of the Scan Line Corrector of Landsat 7 ETM+ for the scenes taken in 2004 and 2005

C1623

would be helpful to get a full overview on the used data base.

Tables 2 and 3:

- T2_3.1. Why do you provide the constants for the radiometric calibration of Landsat 5 TM data, but not for Landsat 7 ETM+ data?
- T2_3.2. Tables 2 and 3 could be merged.

Table 6:

- T6.1. Replace “ELA change” in the table description by “SLA change”, as it is also referred to this nomenclature in the table and in the Note below.
- T6.2. Use a consistent nomenclature for the footnotes instead of mixing characters (a) and special signs (*).

Figure 1:

- F1.1. Revise or reformat the legends.
- F1.2. Reduce the description of this figure. You provide detailed information on the use of the ASTER GDEM in the text (section 2). There is no need to repeat this.

Figure 2:

- F2.1. Unfortunately, the snow lines are barely visible, although these are basically your main results. Please improve the illustration.

Figure 3:

- F3.1. Why do you show exactly this glacier as example for a detailed analysis? Are you convinced that this glacier represents the general pattern of the SLAs in this region? Or is it just the best example funding the hypothesis of rising SLAs? Considering the individual SLA information in Table 4, this glacier is the only one in this region with a really continuous rise of the SLA. The SLAs of the other glaciers you presented in Table 4 show rather variations in both directions, ascending and descending, but all within an

C1624

acceptable annual variation range.

F3.2. The visibility of the SL needs revision (cf. Comment to Figure 2).

F3.3. Figure 3B: The ASTER GDEM overlaid with the SL requires more contrast to make the figure meaningful. The current illustration does not give any significant information on the SLAs. Please improve, or enlarge instead Figure 3A and use for example overlaid contour lines for the topographic information.

F3.4. Legends of Figure 3B: The elevation legend is useless in the current version. But both legends require revision.

Figure 7:

F7.1. Description, line 2: Replace “In contrast with the Cordillera...” by “In contrast to the Cordillera...”

Interactive comment on The Cryosphere Discuss., 4, 1931, 2010.