

## ***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.***

**E. M. McFadden et al.**

ramage@lehigh.edu

Received and published: 30 November 2010

General Response: Images used in this study were compiled prior to 2008. Available Landsat imagery was limited at the time, restricting the time series presented in the article. Although more complete data are now available, the presented research is meant as a preliminary study in the Central Peruvian Andes where little SLA/ELA data are available. We therefore constructed SLA time series to determine the validity and applicability of the methods outlined in this paper and to examine if SLA/ELA variability in this region show any temporal differences that should be investigated further.

In response to the time-of-year of our selected Landsat imagery: Images were primarily

C1219

selected from the dry season to ensure minimal snow-cover conditions for SLA delineation. Although the December 1989 image has slightly lower SLAs in the Cordillera Huayhuash, and may not represent the absolute minima in annual snow cover for the given year, there are no signs of recent snow fall on the image, most-likely indicating recent (i.e. within the last few days) snowfall did not affect our SLA delineation.

Regarding the Klein and Isacks (1998) reference: We specifically reference this paper for our justification behind using dry season images to represent minimum annual snow cover. This justification is from their statement: “As most of the images were collected during the dry winter months, the snow cover shown in the TM mosaic should be near its annual minimum. The modern snowline, which is used as a rough proxy for the elevation of the ELA, was estimated by determining the lower elevational limit of the classified snow cover.” Thus, by employing a similar method, we are utilizing the same assumption that dry season SLAs can be used as a rough estimate of ELAs.

Regarding the use of dry season data to approximate ELAs: We note the commenter’s citations regarding little melt during the dry season within the intertropical convergence zone. There are no ground observations for these specific glaciers that quantify their melt volumes during either the wet or dry season, forcing us to examine SLAs during the dry season to maximize the probability of delineating the SLA in the absence of recent snowfall. Although this may not be the best method to employ in future studies, our interpretation must be either validated or rejected by ground studies, which currently do not exist in this region.

Climatic Interpretation: The discussion section has been reworded considerably to express the uncertainty in our interpretations. Although our time series have temporal limitations, namely that we do not have annual resolution in the records, we believe the observed changes for the Cordillera Raura are larger than observed inter-annual variability or random noise. We mention that climate is not the only influence on ELA position, including the topography of the individual glaciers, which is why our analysis focuses on the mean for each range. By examining the mean, we hope to minimize the

C1220

other controls of ELA variability, such as topography and microclimate, which should essentially act as random noise on ELA position when considering the mean for each range. Our statistical analysis of the mean SLA change for each range supports our assertion that the SLA rise in the Cordillera Raura is due to climate change, but the SLA change in the Cordillera Huayhuash is insignificant.

ENSO Comments: We have removed the discussion on ENSO because our data does not have enough temporal coverage to fully assess any effects of ENSO on SLA position.

Image availability: We note the commenter's list of available Landsat imagery and use of a more complete time series will occur in future work of a similar manner. When this investigation was carried out, the dataset was more limited, thus forcing use of the images considered in this paper. We believe our current preliminary results prove the effectiveness and usefulness of our methods despite the incomplete time series presented here. Additionally, data collected after 2003 was spatially limited due to the SLC failure in May of that year (causing striping over entire glaciers), as now mentioned in the revised text.

---

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