Recession of the Ampatuni and Ausangate Glaciers in Peru

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Introduction

Glacier recession is occurring in regions around the world due to rising global temperatures and changing weather patterns associated with climate change. The Center for Advancement of Undergraduate Studies and Experience (CAUSE) 2016 course provided twelve students the opportunity to travel to two of these regions, one being the high-altitude Andes Mountains of Peru. More than 99% of all tropical glaciers are located in the Andes, and 71% are in Peru (Kaser, 1999). These glaciers are particularly important during the dry season (typically May to September), when they serve as a critical source of water for people, agriculture, and hydropower. Tropical glaciers are especially sensitive to changes in climate due to higher exposure to solar radiation and the wet season coinciding with the summer period, when temperatures are highest (Chevallier et al., 2004).

The recession of these glaciers, and the effects it will have on nearby ecosystems and communities that rely on glacial meltwater supported streams, was a main focus of the CAUSE course. This study aims to quantify the recession of two glaciers witnessed by the CAUSE students this past summer in Peru. Historical satellite imagery from the Landsat program was used to estimate the surface area of the Ampatuni and Ausangate glaciers in southern Peru in four different years between 1988 and 2016. The imagery was analyzed using ArcGIS geospatial software to estimate how much the glaciers have receded over this time period. These estimates were compared with previous results from Salzmann et al. (2012), who analyzed the same area from 1962 - 2006, as well as estimates from other regions in the tropical Andes.

Data and Methods

Data:

- Archived satellite imagery was acquired online via LandsatLook Viewer from the United States Geological Survey (USGS). Landsat satellites have been collecting images of Earth since 1972.

Methods:

- LandsatLook “Natural Color” Images from 1988, 1997, 2010, and 2016 were downloaded in GeoTIFF format.
- Uploaded satellite images to ArcMap, created by the Environmental Systems Research Institute (ESRI).
- Created new shapefiles in ArcCatalog using same spatial reference as satellite images (WGS 1984 Web Mercator Auxiliary Sphere).
- Created polygons tracing the extent of the glaciers for each year.
- Calculated area of the polygons in square kilometers.
- Selected Ampatuni and Ausangate polygons to measure recession individually.

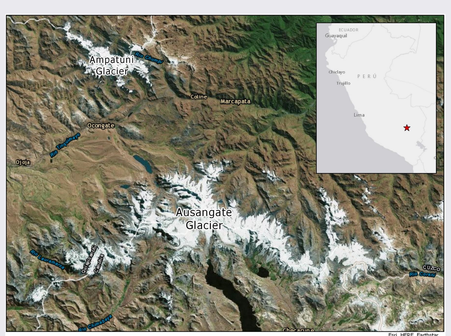


Figure 1. Reference map of glacier locations and study area in southern Peru. CAUSE field work was done in wetland areas (known as bofedales) just to the southeast of the Ampatuni glacier, and just to the north of the center of the Ausangate glacier.

Visualizing Glacier Recession

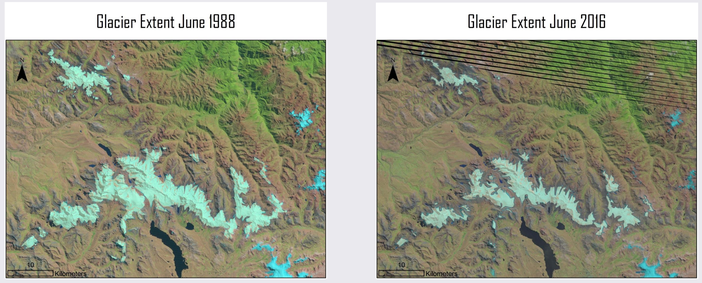
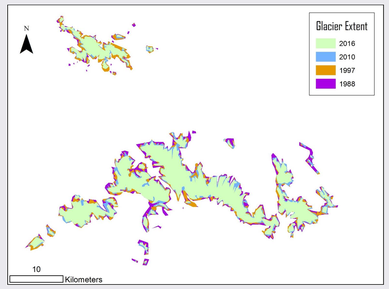
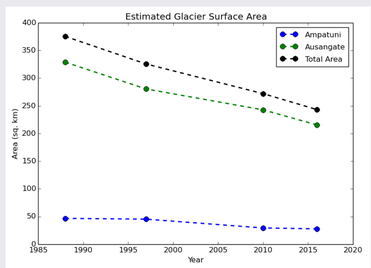


Figure 2. Landsat satellite imagery of Ampatuni and Ausangate glaciers in June 1988 (left) and June 2016 (right). Semi-transparent polygons used for calculating surface area extent of each glacier are included.

Figure 3. Glacier loss visualized by overlaying glacier extent polygons for the years 1988, 1997, 2010 and 2016. Note the difference in extent between 1997 and 2010 for Ampatuni, and between 1988 and 1997 for Ausangate.



Quantifying Glacier Recession



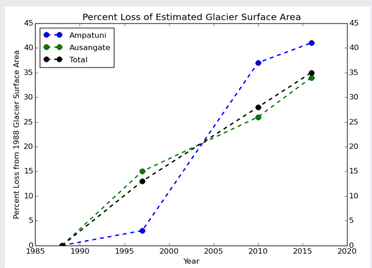


Figure 4. Plots of Estimated Glacier Surface Area (left) and Percent Loss of Estimated Glacier Surface Area from 1988 (right) over time. The area of the two glaciers has been trending significantly downward since 1988. Note the steep percent loss for Ampatuni from 1997 – 2010, and for Ausangate from 1988 – 1997, which was visible in Figure 3.

	Ampatuni		Ausangate		Total	
Year	**Area (km^2)**	**Percent Loss**	**Area (km^2)**	**Percent Loss**	**Area (km^2)**	**Percent Loss**
1988	46.57	0%	328.63	0%	375.2	0%
1997	45.17	3%	280.25	15%	325.42	13%
2010	29.28	37%	242.62	26%	271.9	28%
2016	27.68	41%	215.33	34%	243.01	35%

Table 1. Calculated values of surface area and percent loss for Ampatuni, Ausangate, and both glaciers combined. Ampatuni lost about one third of its area in just a 13-year period. Ausangate lost 15% in a 9-year period. Combined, the glaciers lost 132.19 km^2 of area over the full 28-year period, a rate of about 4.72 km^2 yr^{-1}.

Conclusions and Discussion

The Ampatuni glacier lost approximately 41% of surface area from 1988 - 2016. The Ausangate glacier lost approximately 34% over the same period. This amounts to about a 35% loss between these two glaciers in this time frame. These values agree with previous research on Peruvian tropical glacier recession.

- Salzmann et al. (2012) studied the Cordillera Vilcanota in southern Peru, the second largest glaciated mountain range in Peru, which encompasses the Ampatuni and Ausangate glaciers. They reported a 32% loss in area between 1962 and 2006, with about 30% of the loss in area occurring after 1985.
- Various glacier retreat studies of other glaciated regions in Peru were summarized by Rabatel et al. (2013). Each estimated a loss between 20% to 35% for the respective glaciers from the early 1960s to the late 1990s – early 2000s.
- The higher estimates from this study can be explained by the inclusion of the recession from 2006 – 2016. Vuille et al. (2008) showed that near-surface temperature in the Andes increased by 0.10 °C per decade from 1939 – 2008. A continuation of this trend over the past decade, among other factors, likely facilitated further recession of the Ampatuni and Ausangate glaciers in recent years.

Tropical glaciers in Peru (a majority of all tropical glaciers in the world) have receded significantly over recent decades. Retreat is expected to continue as the planet warms. This will cause many issues related to water resources, especially during the dry season.

Benito, a farmer who lives in the bofedale near the base of the Ampatuni glacier. Despite his minimal contributions to greenhouse gas emissions, he may be one of the first people severely impacted by climate change-induced glacier recession in this region.

Acknowledgements

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