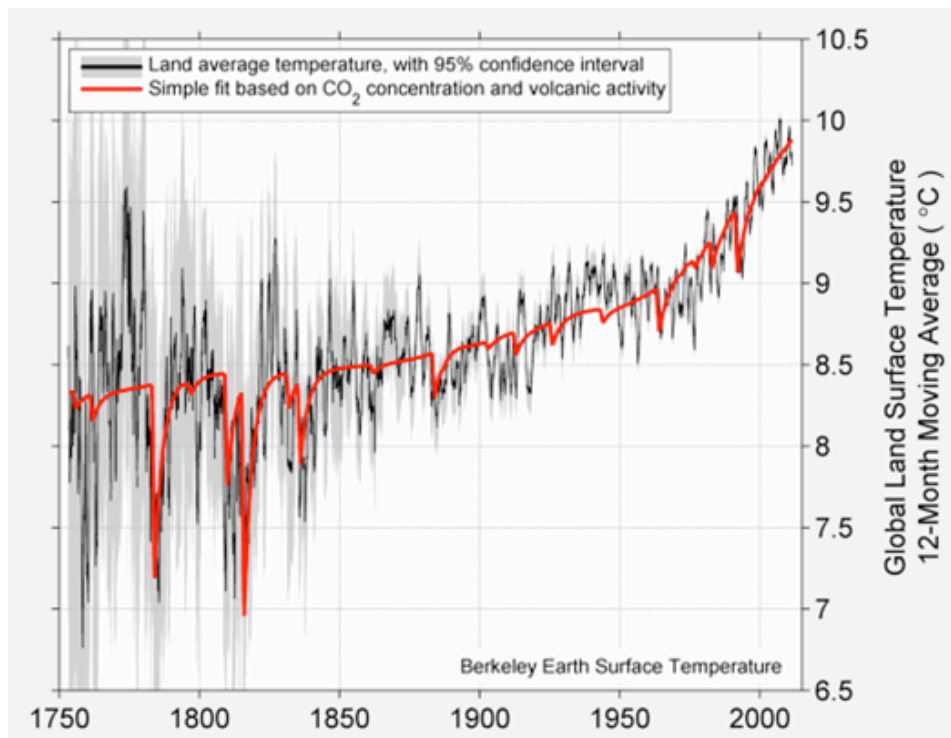


## Changing Climate Changing Culture

Glaciers are melting worldwide and taking more with their flowing waters than just ice and paleoclimate history. Quelccaya is the world's largest and most studied tropical icecap. It is located 13.5 degrees south of the equator in Peru at an elevation of 18,000 feet within the world's longest continental mountain range, the Andes (Pappas, 2013). Quelccaya spans seventeen square miles and receives most of its snowfall from November to April, accumulating an average of 1.15 meters of water annually (American Geosciences Institute, 2014). However, the well-studied Quelccaya ice cap is melting rapidly and is a case example for surrounding tropical glaciers in the Andes, such as the Ausangate, which sustains life in the traditional pastoral community of Pucarumi (The World Bank, 2007). Natural annual melt-water from Ausangate provides drinking water as well as irrigation water for grazing lands and crops (most notably native potatoes) in Pucarumi. But why are glaciated regions melting? Climate change has become a frightening reality for subsistence communities in Peru where retreating glaciers are placing livelihood and culture at stake.

Since the start of the Industrial Revolution, which marked the beginning of modern technological development and implementation, there has been a drastic increase in carbon dioxide concentrations in the atmosphere (Houghton, 2009, pg. 37). The pre-industrial value of atmospheric carbon dioxide was 280 ppm, while the current concentration is 400 ppm. This increase is due to anthropogenic reliance on and use of fossil fuels for development, production and energy consumption. Plants absorb and use carbon from the atmosphere to photosynthesize and release oxygen (Houghton, 2009, pg. 41). Fossil fuels are fossilized plants, which are made of carbon. Carbon dioxide is a greenhouse gas, which absorbs thermal long wave radiation emitted from the Earth's surface and reradiates this thermal energy toward the Earth's surface and into outer space (Houghton, 2009, pg. 26). As carbon dioxide concentrations in the atmosphere increase, the optical depth of the atmosphere thickens and traps more radiative energy in the atmosphere. This is known as the blanket effect, which causes Earth surface temperatures to increase. Surface temperatures rise due to increased energy input in the Earth system as additional radiation is transmitted from greenhouse gases in the atmosphere and back toward the surface of the planet (Houghton, 2009, pg. 27). Figure 1 shows the increasing and direct relationship between atmospheric carbon dioxide concentration levels and Earth surface temperatures since the Industrial Revolution. This warming trend is melting tropical Peruvian glaciers, threatening traditional culture and life in the Andes. Annual precipitation rates in the Quelccaya icecap region have not changed, but it has been found that temperatures have risen around  $.1^{\circ}\text{C}$  per decade in the last 70 years (Pappas, 2013). It has been reported by many online news sources and scientists that Quelccaya's ice, which required 1,600 years to compact from accumulating snow, has melted in just 25 years (Gillis, 2013). Even more concerning, Buffen et al reported in 2009 that the retreating Quelccaya is uncovering 6,000 year old plant specimens, which indicates that the icecap has not receded this far since many millennia ago.

The Ausangate glacier is located just 25.5 miles northwest of the Quelccaya ice cap and is also vanishing. The foothills below Ausangate are arid, but the glacier sustains life in an otherwise uninhabitable environment by providing drinking and irrigation waters (The World Bank, 2007). Melting of the Ausangate glacier occurs each year as temperatures increase in the spring and summer, which allows for moderate dispatch of glacial melt-water into streams. The people of Pucarumi are traditionally pastoral and use glacier melt-waters for irrigation to create grazing grounds for their alpaca and sheep herds. However, due to increasing water scarcity in the region from Ausangate's retreat, there isn't enough melt-water to sufficiently irrigate the grazing pastures and maintain the health of the alpaca and sheep (The World Bank, 2007). Consequentially, the animals' wool coats are thinning and rather than producing their own yarn as they traditionally have, the people in Pucarumi have begun to buy synthetic wool yarns from markets to make their clothing. The melting of Ausangate is changing an ecosystem-reliant culture and causing a disconnection between the people, animals and land. In a documentary composed by the World Bank, one Pucarumi villager reports that the rising temperatures may cause the boggy pastures to dry out, increasing competition between alpaca herders and farmers with cattle and horses for grazing lands and water resources.



**Figure 1.** The relationship between average global land surface temperature and atmospheric carbon dioxide concentrations since the Industrial Revolution. There is a direct relationship between increasing atmospheric carbon dioxide concentrations and global surface warming. Retrieved from: <http://berkeleyearth.org/summary-of-findings>

Food security within the Pucarumi community is also dependent upon the health of the Ausangate glacier (The World Bank, 2007). Journalist Barbara Fraser explained in 2009 that Chuño (the traditional freeze-dried potatoes) are reliant upon cold climate conditions and are a staple in Pucarumi. After the potatoes are harvested, they are exposed to frost, smashed to remove water and then stored for long-lasting food (Fraser, 2009). The World Bank reported in 2007 that warming in the region is reducing crop yields of the native potato and causing water scarcity in the lowlands where farmers once planted. The potatoes must now be sowed at higher elevations, and space is becoming a limiting factor as crops are planted further up mountain slopes each year in hopes for a productive harvest (The World Bank, 2007; Fraser, 2009). However, the native potato species may be lost altogether once the ecosystem and climate can no longer provide necessary growing conditions. Due to changes in soil moisture, the land no longer supports the native potato as it used to and non-native potatoes are being introduced to the region (The World Bank, 2007). The villagers now plant various potato species at a range of altitudes to ensure that some will survive if growing conditions are suboptimal for one of the varieties (Fraser, 2009). Pucarumi villagers once relied only on manure from the alpaca and sheep corrals to ensure a productive harvest of the native potato. However as a result of climate change, farmers must now buy chemical fertilizer to harvest non-native potatoes and provide food for their families (The World Bank, 2007). A warming climate and loss of Ausangate glacial melt-water are synonymous with a loss of livelihood in Pucarumi.



**Figure 2.** Pucarumi farmers harvesting potatoes. The arid vegetation characteristic to the Andes region can be seen in the background. As temperatures rise and change ecosystem dynamics, farmers must plant their potato crops at higher elevations each season. Farmers are concerned about the limited remaining space on

mountainsides for potato planting. Retrieved from:

<http://www.dailyclimate.org/tdc-newsroom/2009/10/altered-climate-forces-cultural-change-high-in>

Ausangate's retreat is also altering the Cusco region religious festival Quyllur Rit'i (Star Snow festival) in Pucarumi (Fraser, 2009). After days of dancing and feasting and before the extensive melting of Ausangate, the men of the village would visit the glacier to cut and carry large ice blocks back to the village. However, removing ice from the glacier is now prohibited. The Ausangate Mountain has become increasingly darker as the glacier has melted away, which frightens many of the villagers who believe it is a sign of the spiritual world's unhappiness with their community (The World Bank, 2007). The people in Pucarumi may be forced to leave their native region for surrounding cities if Ausangate continues to worsen (Fraser, 2009). If the Ausangate glacier disappears, Pucarumi will cease to exist.

Fossil fuel burning is causing the Earth's surface to warm and leading to rapid melting of tropical glaciers, threatening the quality of life and culture of many in the Andes region. The arid region of the Pucarumi village will become warmer and dryer once the Ausangate glacier has melted completely. Reduced water supplies will lead to food shortage and the eventual loss of Pucarumi culture once the fragile alpine ecosystem can no longer support the community. The villagers will ultimately be forced to leave the region and abandon their way of life. This is especially disheartening, because it is the Ausangate glacier, which has allowed Pucarumi culture and lifestyle to persist. Through close connections to their ecosystem and climate, Pucarumi villagers have learned how to sustain their community with glacier melt-water. Subsistence communities like Pucarumi are a grim foreshadowing for the surrounding region. Cities located downstream from and also reliant upon Andes glacial melt-water, such as Huaraz, Peru will be harmed by flooding and drought as flows increase and then disappear (United Nations Environmental Program, 2013). The fact that ecosystems, lives, cultures and traditions are in danger due to carbon emissions from other regions is unacceptable. Carbon emissions lead to a thickening of the atmosphere, which traps additional heat near the Earth's surface. This additional heat disperses evenly through the entire atmosphere and does not stay within nation-specific regions. Because the atmosphere interconnects us all, the burning of fossil fuels in one country will ultimately affect the ecosystems and landscapes of others. Ausangate's retreat is a sign of the impending alteration of the global environment and loss of culture and life as currently known.

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