Influence of the Recession of the Pasterze Glacier, Austria, on Water Discharge Used for Hydro-power Production

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ABSTRACT

The Pasterze Glacier is rapidly receding, and the meltwater is collected downstream in the Margaritze reservoir. The water is used for electric power production. In this paper, we show the influence of climate and the glacier's recession on water discharge and on the production of hydro-power.

Keywords: Pasterze Glacier, Margaritze reservoir, recession, Ikonos.

INTRODUCTION

Using ground and satellite data, this study examines the recession of the Pasterze Glacier, Austria, and its impact on the production of hydroelectric power. Accelerated melting of the glacier could produce more water for hydropower production; however, if the glacier continues to melt dramatically, then future production of hydropower could be compromised. The precipitation and temperature data of two nearby weather stations, the Sonnblick and the Rudolfshütte (provided by Zentralanstalt für Meteorologie and Geodynamik), are compared to the loss of ice volume of the tongue of the glacier (University of Graz, Austria, 1965 to 2011). In addition, the data of the water discharge (provided by Verbundgesellschaft Hydro Power AG) are used to correlate with the climate and ice/water volume data.

The Pasterze Glacier, Austria, is the largest glacier in the Eastern Alps, with a length of 8 km. The drainage area of the Pasterze is approximately 44 km² (Niedermühlbichler, 2011). At the southern end, a dam was started in 1938 and completed in 1955 to collect the water from the Pasterze Glacier in the Magaritze reservoir (Economypoint, 2012; Figure 1). The water is pumped through the mountains in the nearby Kaprun Valley where it is used for hydroelectric power production. The Margaritze reservoir has a capacity of 3.2 million m³ of water storage (ALPRESERV, 2006; Figure 2). A total of 160 million m³ water is available with the Moserboden and Wasserfallboden reservoirs located in the Kaprun Valley where the power station is located (Schrott, 2012).

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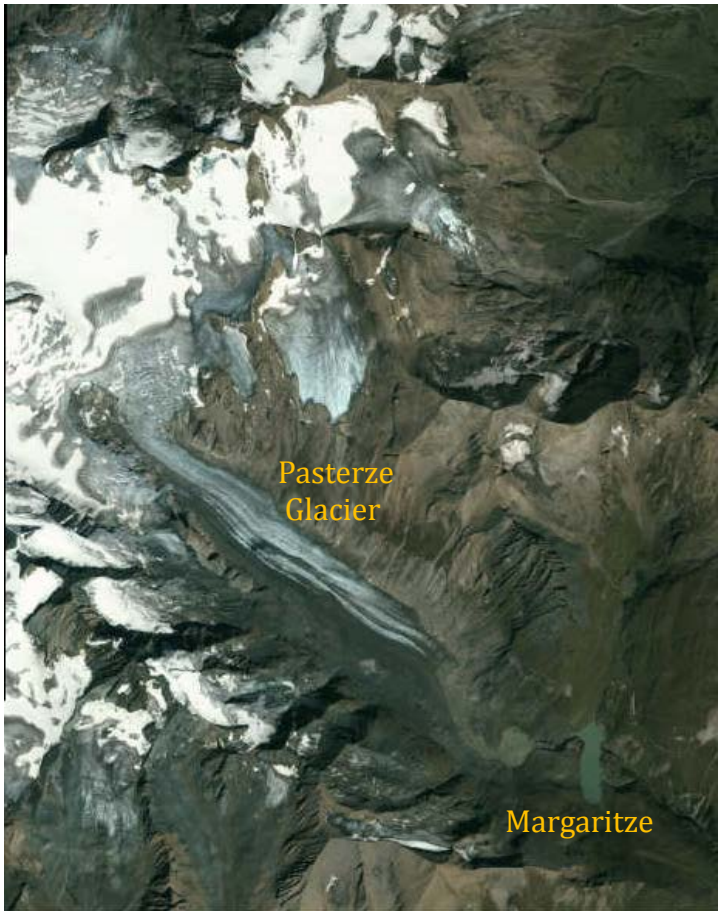

Figure 1. The tongue of the Pasterze glacier and the Margaritze reservoir. (Ikonos image acquired on August 22, 2011.)

Figure 2. The Margaritze Reservoir. At present, the Pasterze Glacier has a length of approximately 8 km. Since 1880 the tongue of the Pasterze has receded 1255.23 m (Figures 3 and 4; Bundesamt, 1972; Österreichischer Alpenverein, 2006; University of Graz, Austria, 1965 to 2011).

Figure 3. The Pasterze Glacier and adjacent glaciers in 1969.

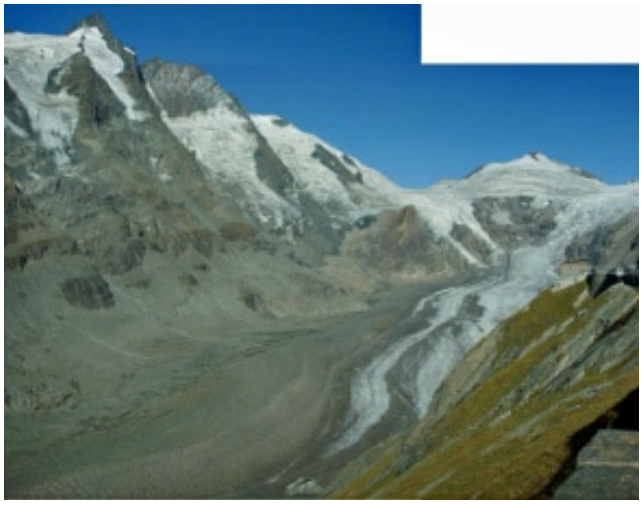

Figure 4. From almost the same vantage point as seen in Figure 3—the Pasterze Glacier and adjacent glaciers in 2011.

DISCUSSION

The average precipitation at the Sonnblick weather station (Figure 5) for the years from 2000 to 2010 clearly shows an increase of precipitation for almost all months versus the years from 1965 to 1975 and 1985 to 1995. The Rudolfshütte weather station has a slight increase in precipitation during the 2000 to 2010 period (the 1965 to 1975 data were not available). The average yearly precipitation at the Rudolfshütte weather station (Figure 6) for 1985–1995 decreased from 2450.94 mm to 2377.3 mm during the 2000–2010 period while at the Sonnblick weather station the amount increased from 1441.54 mm to 1724.72 mm during the 2000–2010 time period (for the 1965–1975 time period, the average amount of precipitation was 1469.55 mm).

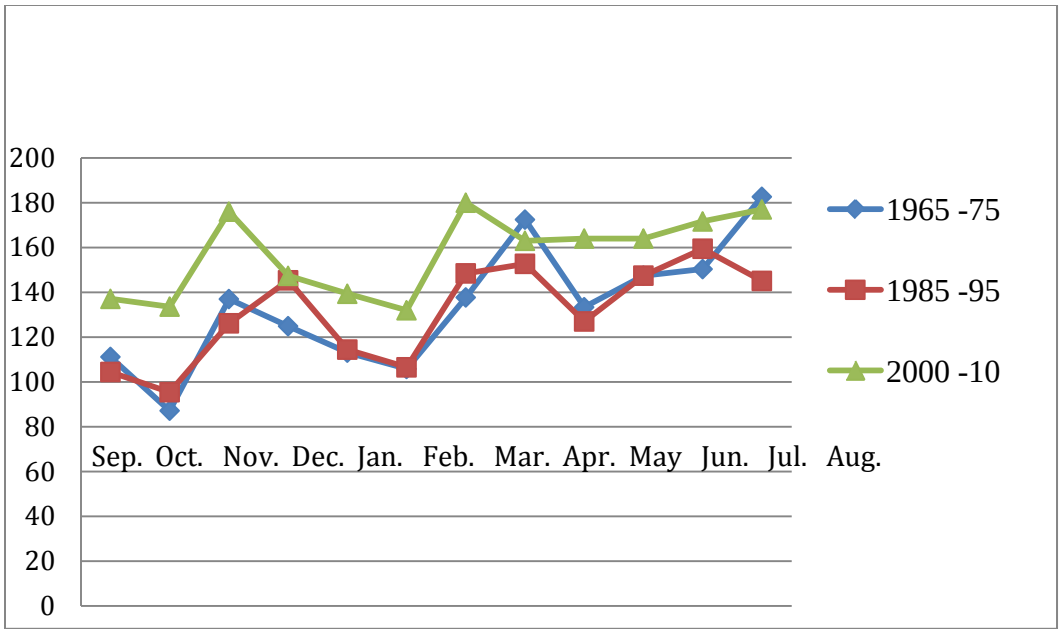

Figure 5. Average Precipitation: Sonnblick Weather Station (3109) in mm

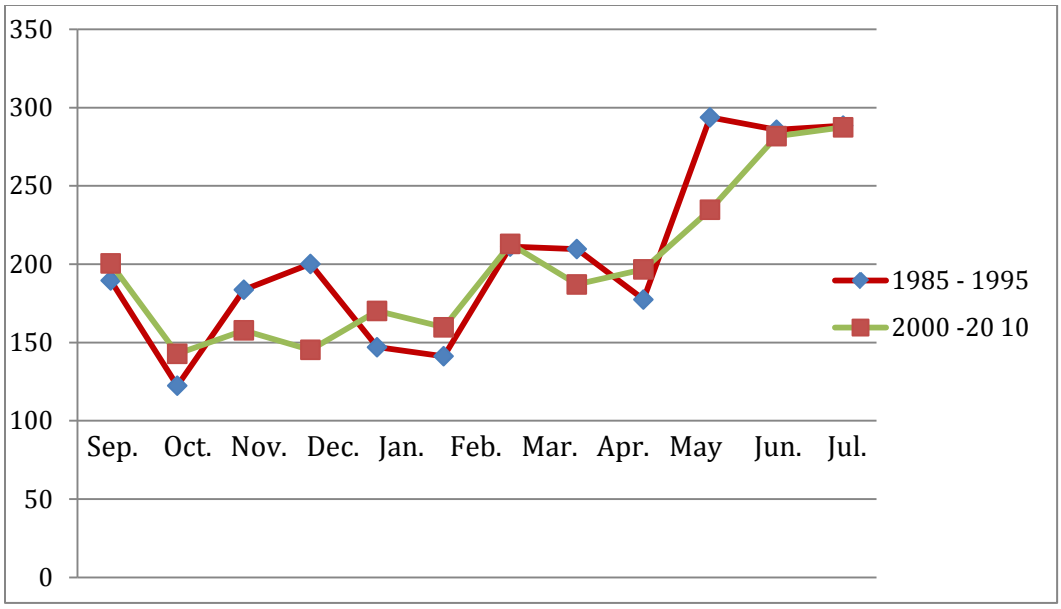

Figure 6. Average Precipitation: Rudolfshütte Weather Station (2304 m) in mm

Using a trend line for both the Rudolfsütte and Sonnblick weather station (Figures 7 and 8), one can see that the average temperature increased approximately 1°C in August from the 1985–1995 to the 2000–2010 periods. The temperature difference is less than 1°C for both stations in September and varies throughout the years. The temperature increase from the 1965 to the 2000 periods at the Sonnblick weather station was almost 2°C in August but almost the same for all years in September.

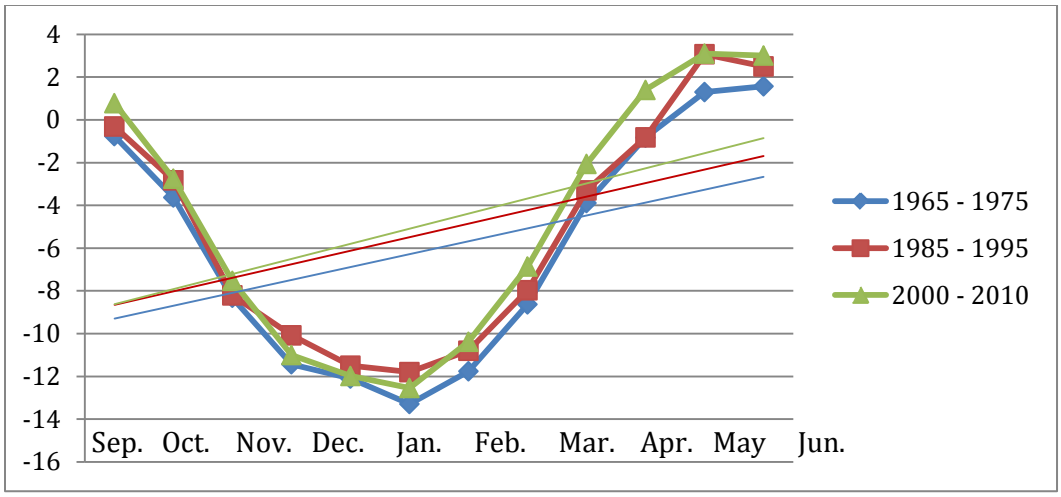

Figure 7. Average Temperature: Sonnblick Weather Station (3109 m) in °C.

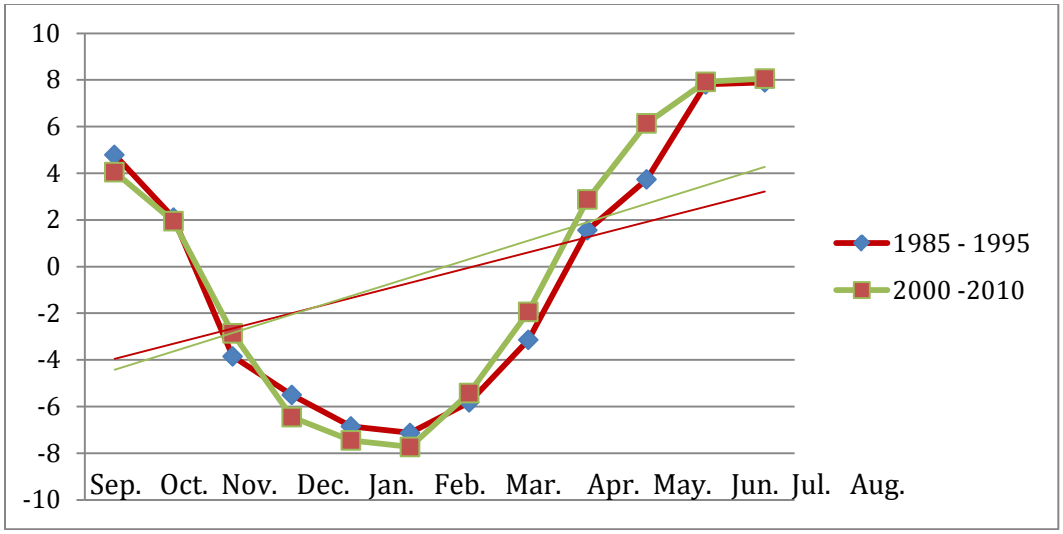

Figure 8. Average Temperature: Rudolfshütte (2304 m) in °C.

The thinning of the Pasterze was recorded by the University of Graz survey team over the years (University of Graz, Austria, 1965 to 2011). While some years of height loss are missing, the Pasterze shows a loss of 88.61 m at the ablation area from the 1965/66 snow year on. An accelerated ablation has taken place in the years 2000–2010 with a loss of 39.17 m. In addition to the survey team's findings, three profile lines were drawn across the tongue of the 1928 map and the 2006 map. The loss of height was measured as 192m, 112 m, and 140 m. It is estimated that a one meter loss in height converts to a loss of 5.6 million m^3 in water volume based on a glacier tongue size of four km^2 (Figure 9).

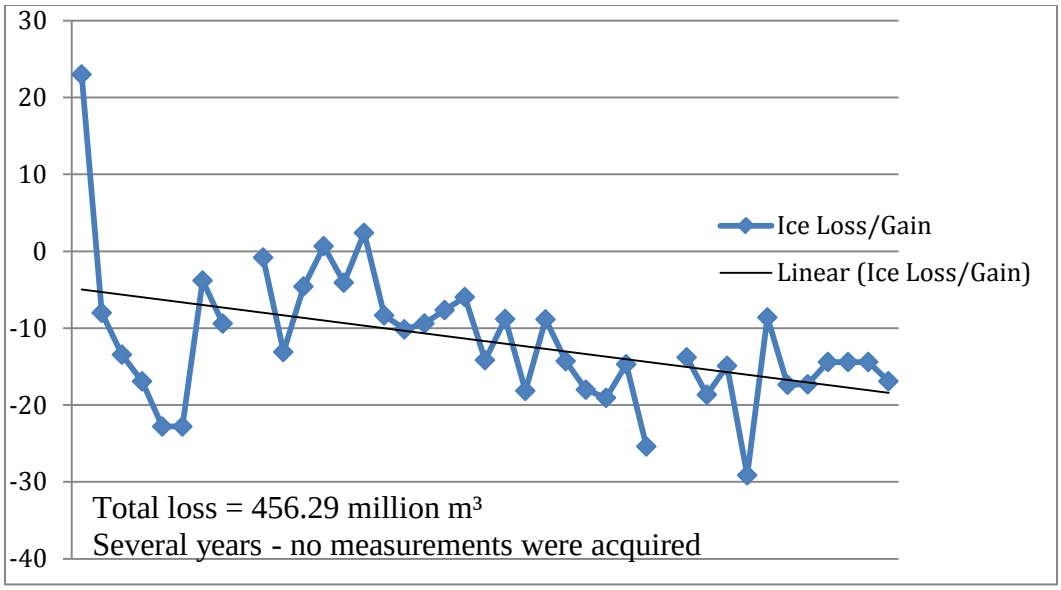

Figure 9. Loss/Gain of Water Volume of the Pasterze Glacier from 1965 to 2010 in million m³ (University of Graz, Austria, 1965 to 2011); several losses were calculated.

RESULTS AND CONCLUSION

The Pasterze Glacier has receded 1255 m since 1880 and approximately 786 m since 1965 (University of Graz, Austria, 1965 to 2011; Bayr et al., 2009). In addition to the loss of length, the height of the glacier tongue decreased by 88 m, which resulted in 456 million m³ of water discharge. The Margaritze reservoir collects the meltwater of the glacier. From there it flows through tunnels in the nearby Kaprun Valley where it is stored in two reservoirs for the production of electricity mostly during the wintertime. It is an "on demand power station." While only the Sonnblick weather station shows an increase in precipitation, both stations recorded an increase in the average temperature, which resulted in a more rapid recession of the length but also in the height of the glacier. The trend line indicates a gain of 23 million m³ in 1965 to a loss of 29.12 million m³ in 2003 of volume of water from the Pasterze (Figure 9). The greater loss of water in recent years collected in the Margaritze reservoir ensures more water for the production of hydro-power. The result is that at present, there is no shortage of water for the production of hydro-power. Should the glacier totally ablate in the future and only water collected in the watershed will be available, the power station might be in jeopardy.

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