Conference Volume | 5th Symposium for Research in Protected Areas 10 to 12 June 2013, Mittersill | pages 747 - 750

Six years of glacier mass balance on Mullwitzkees (Hohe Tauern) and Hallstätter Gletscher (Dachstein)

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Abstract

Since 2006 the Mullwitzkees, situated within the core zone of the Hohe Tauern National Park and the Hallstätter Gletscher, situated in the Dachstein region within the northern limestone alps, are subject to mass balance monitoring programs. The mass balance of these glaciers is measured using the direct glaciological method with fixed dates by ascertaining the ice ablation at stakes and the accumulation at snow pits. The Mullwitzkees is located south of the main Alpine crest and is exposed to the south. The highest point of the glacier is the Hoher Zaun (3450 m a.s.l.) and the lowest part of the snout called Zettalunitzkees reaches down to an elevation of 2690 m. In comparison the Hallstätter Gletscher is the northernmost glacier of the Austrian Alps and is exposed to the north within an elevation range between 2150 m a.s.l. and 2900 m a.s.l., but both of the glaciers cover an area of about 3 km^2.

During the past six years both of the glaciers have experienced negative mass balances but at different magnitudes. Within the hydrological year 2006/2007 the specific mass balance of the Hallstätter Gletscher was about -0.3 m w.e. (water equivalent) whereas the specific balance of the Mullwitzkees was approximately five times larger (-1.4 m w.e.). Despite of this huge difference the mean specific mass balance (2006/2007 – 2011/2012) is nearly the same for both glaciers.The ELA (equilibrium line altitude) on the Mullwitzkees is about 500 m higher as it is on the Hallstätter Gletscher. These differences are mainly caused by topographic effects and different climate conditions.

Keywords

glacier, massbalance, Mullwitzkees, Venediger, Hallstätter Gletscher, Dachstein

Aims and funding of the project

The projects on Mullwitzkees and Hallstätter Gletscher aim at the measurement and interpretation of mass balance and climate data and the interpretation of the relationship of these measured parameters with respect to the current glacial recession and hydrology as well as for the development of future glacier scenarios for the both. The project on Mullwitzkeesis funded by the Hohe Tauern National Park and the Hydrological Service at the Government of Tyrol. The project on Hallstätter Gletscher is funded by the Government of Upper Austria and the Energie AG. Both projects were started in 2006.

Area of study

The Mullwitzkees is situated in the Venediger Massive within the core zone of the Hohe Tauern National Park and is divided into the "innere" and "äußere" Mullwitzkees. Glacier fluctuations since the end of the LIA (Little Ice Age) are summarised by Patzelt 1973. This study focuses on the "äußere" Mullwitzkees which is therefore regarded as Mullwitzkees. The upper part of the glacier is exposed to the south and is confined by a ridge with the highest point Hoher Zaun at an elevation of 3450 m a.s.l.. The snout called Zettalunitzkees is exposed to the south-west and reaches down to an elevation of 2690 m a.s.l.. In 1998, Mullwitzkees (and Zettalunitzkees) covered an area of 3.24 km^2. The glacier area diminished to 3.08 km^2 in 2007 (Stocker-Waldhuber 2010).

The Hallstätter Gletscher covers an area of 3 km^2 and is the biggest glacier in the northern limestone Alps (Lambrecht & Kuhn 2007). The glacier is exposed to the north and surrounded by a mountain ridge with the highest point Hoher Dachstein. From a great plateau above 2550 m a.s.l., arise three short glacier tongues.The highest point of the glacier is located at the north face of the Hoher Dachstein at an elevation of 2900 m a.s.l.. The middle tongue of the glacier reaches down to an altitude of 2150 m a.s.l.. Since the LIA maximum in 1856 the glacier area diminished by 43% (Helfricht 2009).

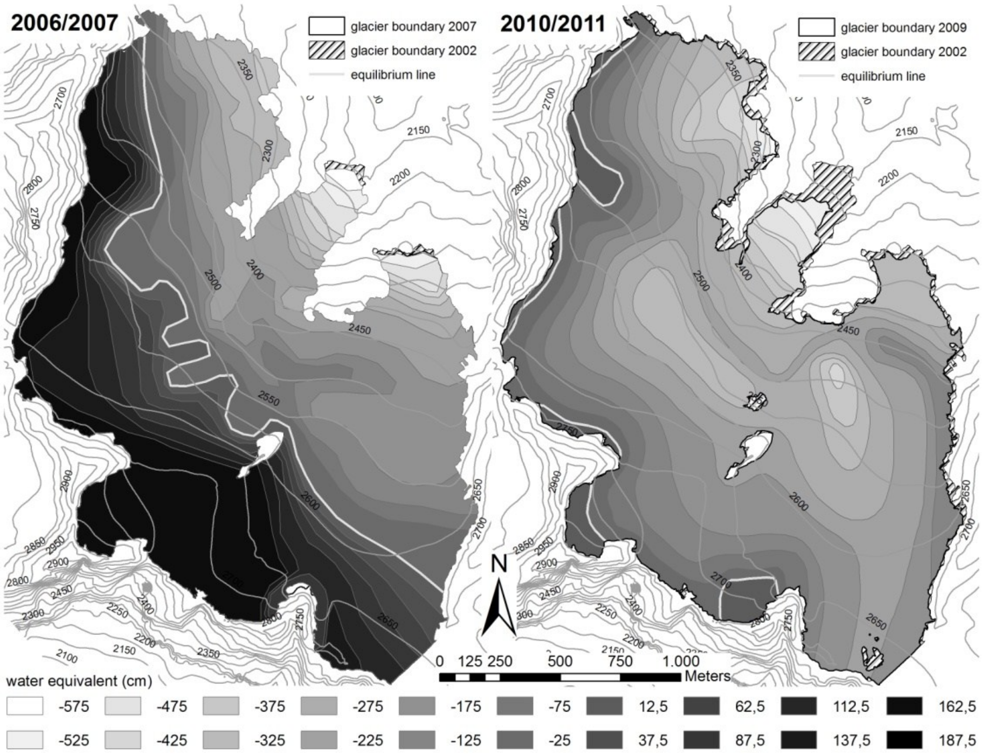

Figure 1: Distribution of the most positive (left fig.) and the most negative (right fig.) mean specific mass balance on Hallstätter Gletscher since the beginning of the measurements in 2006. The mass balance is colored gradually into 50 cm intervals within the ablation area and into 25 cm intervals within the accumulation area; the equilibrium line is plotted as a thick grey line.

The glacier boundaries in Figure 1 and Figure 2 originate from the second Austrian glacier inventory of 1998 (LAMBRECHT & KUHN 2007, KUHN et. al. 2008). For the years2007 and 2009 the glacier´s boundaries were reduced on the basis of Orthophotos and digital elevation models according to the third Austrian glacier inventory (ABERMANN et. al. 2010, STOCKER-WALDHUBER et. al. 2010). Zettalunitzkee sand Hallstätter Gletscher are also subject to measurements of glacier length by the glacier survey of the Austrian Alpine Club (e.g. PATZELT 2005, PATZELT 2006).

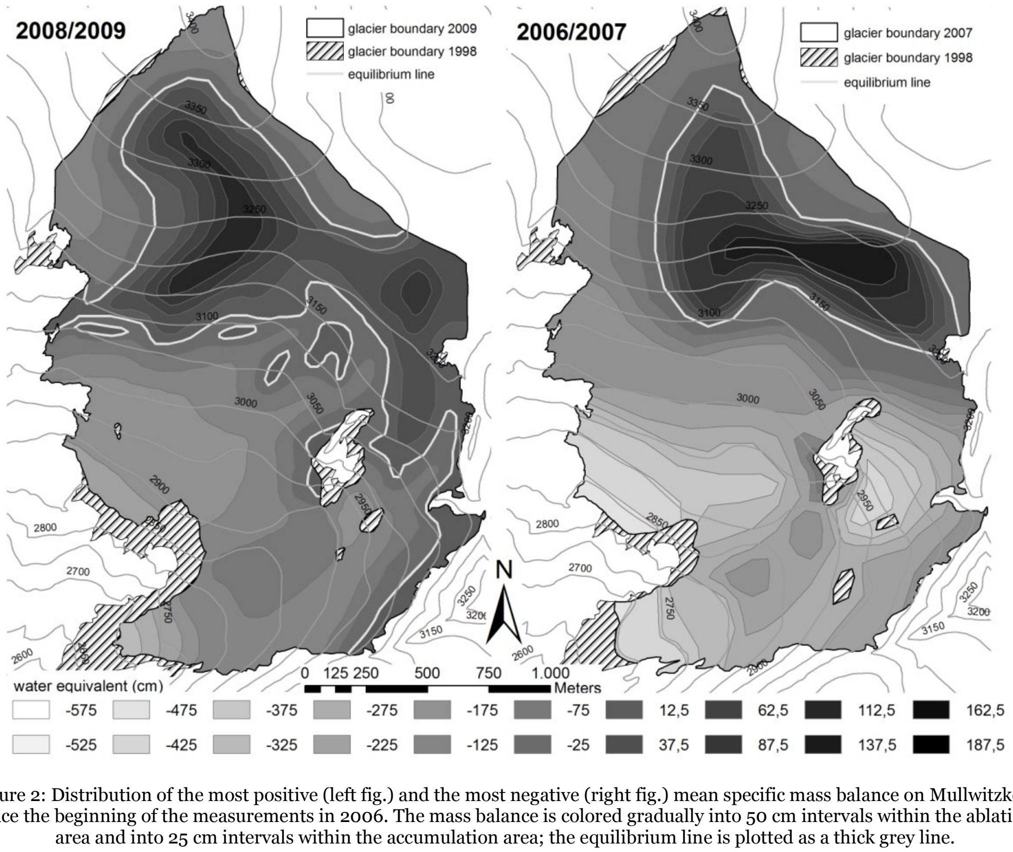

Figure 2: Distribution of the most positive (left fig.) and the most negative (right fig.) mean specific mass balance on Mullwitzkees since the beginning of the measurements in 2006. The mass balance is colored gradually into 50 cm intervals within the ablation area and into 25 cm intervals within the accumulation area; the equilibrium line is plotted as a thick grey line.

Method

To determine the mass balance of this glacier the direct glaciological method with fixed dates is used (HOINKES 1970). The method detects the mass gain and loss of the glacier within one year. The year is divided into the accumulation period from the 1st of October to 30th of April when a mass gain of the glacier is expected and the ablation period from the 1st of May to 30th of September when the glacier experiences a mass loss.

Ablation is measured with ablation stakes in the ablation area. During summer the free ends of the stakes are measured several times. At the 30th of April multiple snow pits are dug to measure the height and density of the accumulated snow cover and on the 30th of September this work is repeated to determine the mass gain of the glacier within the hydrological year. The direct glaciological method is described in PATERSON 1994.

Results

The Mullwitzkees (MWK) has experienced a mass loss of $4.46*10^6$ m^3 w.e. (water equivalent) and a specific mass balance of -1447 mm during the first year 2006/07 which is the most negative balance whereas on Hallstätter Gletscher (HSG) the mass loss devoted $0.88*10^6$ m^3 w.e. and a specific balance of -289 mm which was the minimum annual mass lossduring the six years between 2006 and 2012. During the second year 2007/08 both glaciers got about the same negative specific balance with -642 mm (MWK) and -700 mm (HSG). In 2008/09 Hallstätter Gletscher lost nearly twice as much of its mass (-924 mm) as Mullwitzkees (-487 mm) and in 2009/10 the specific balance of Hallstätter Gletscher was -700 mm and -490 mm on Mullwitzkees. The most negative mass balance of Hallstätter Gletscher with a specific balance of -2011 mm was measured in 2010/11 which corresponds to a mass loss of about $-6*10^6$ m^3 w.e., whereas on Mullwitzkees the specific balance with -1303 mm was nearly the same as is it was in 2006/07. In 2011/12 the specific mass balance of both of the glaciers were nearly the same with -1228 mm on Hallstätter glacier and -1276 mm on Mullwitzkees but there where huge differences between both glaciers with regard to the winter and summer balance. The specific summer mass balance of Hallstätter Gletscher in 2012 was the most negative one since the beginning of the measurements but was balanced in a large part by the most positive specific winter mass balance since 2006.

The ELA (equilibrium line altitude) was located at a mean elevation of about 2590 m a.s.l. on Hallstätter Gletscher and at 3140 m a.s.l. on Mulwitzkees during the first four years. In 2010/11 the ELA shifted up to 2822 m a.s.l.on Hallstätter Gletscher and on Mullwitzkees even above the summits and likewise during the summer 2012. Accordingly the AAR (accumulation area ratio) was very low during the year 2011/12 with 0.11 on Mullwitzkees. Due to the great amounts of winter and summer balances on Hallstätter Gletscher in 2011/12 the AAR was higher than on Mullwitzkees with 0.32.Table 1 gives an overview of the mass balance parameters of both glaciers of the yearsfrom 2006/07 to 2011/12 (FISCHER et al. 2013, STOCKER-WALDHUBER et al. 2013). Figure 1 and Figure 2 show the distribution of the most positive and most negative mean specific mass balances.

Table 1: Characteristic numbers of the mass balance onHallstätter Gletscher and Mullwitzkees for the hydrological years from 2006/07 to 2011/12. (S: glacier area, B: total mass balance, b: mean specific mass balance, bs: mean specific summer mass balance, bw: mean specific winter mass balance, ELA: equilibrium line altitude, AAR: accumulation area ratio, w.e.: water equivalent)

Hallstätter Gletscher

	mass balance						ratio
	S	B	b	b_s	b_w	ELA	AAR
	km^2	$10^6 m^3$	mm w.e.	mm w.e.	mm w.e.	m	
2006/2007	3,04	-0,88	-289	-2222	1933	2581	0,490
2007/2008	3,04	-2,13	-700	-3270	2570	2592	0,490
2008/2009	3,01	-2,79	-924	-3069	2145	2616	0,341
2009/2010	3,016	-2,11	-700	-2334	1634	2588	0,483
2010/2011	3,016	-6,07	-2011	-3497	1486	2822	0,046
2011/2012	3,016	-3,70	-1228	-3953	2725	2664	0,318

Mullwitzkees

	mass balance						ratio
	S	B	b	b_s	b_w	ELA	AAR
	km^2	$10^6 m^3$	mm w.e.	mm w.e.	mm w.e.	m	
2006/2007	3,08	-4,46	-1447	-2121	674	3163	0,207
2007/2008	3,08	-1,98	-642	-2052	1410	3115	0,396
2008/2009	3,03	-1,47	-487	-2006	1519	3116	0,367
2009/2010	3,03	-1,48	-490	-1797	1307	3150	0,332
2010/2011	2,93	-3,82	-1303	-2127	824	****	0,147
2011/2012	2,93	-3,74	-1276	-2772	1496	****	0,111

Discussion

Comparing the first six years of mass balance measurements on Mullwitzkees one of the most noticeable results is the position of the accumulation area, which is displaced from the ridge to lower elevations due to wind drift during winter. The ice thickness is decreasing at the highest elevations of this glacier (SPAN et. al. 2005, FISCHER et. al. 2007). In contrast to the Mullwitzkees the mass balance of the Hallstätter Gletscher mainly depend on the snowfall amounts during winter which can be increased by orographic lifting of the Dachstein massive. Both glaciers react in a different way on the weather conditions during a specific year and benefit alternately depending on a northwesterly or southwesterly incoming flow direction.

These investigations do not relate to the status of protection, but both glaciers are located within protected areas. Nevertheless mass balance measurements are the coherency between glacier and climate and therefore it is of great importance to observe the actual conditions.These measurements help to answer questionssuch as how long the glaciers of the Hohe Tauern Nationalpark or within the areas of Natura 2000 tend to exist.

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Zeitschrift/Journal: Nationalpark Hohe Tauern - Conference Volume

Jahr/Year: 2013

Band/Volume: 5

Autor(en)/Author(s): Stocker-Waldhuber Martin, Fischer Andrea, Jurgeit Florian, Reingruber Klaus

Artikel/Article: Six years of glacier mass balance on Mullwitzkees (Hohe Tauern) and Hallstätter Gletscher (Dachstein) 747-750