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Glacial changes, water cycle observations and mass balance development on the Stubacher Sonnblickkees in recent years

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Abstract

Since 1981 the Stubacher Sonnblickkees, a small north-west exposed slope glacier in the Granatspitz group, has lost approx. 26 % of its total mass.

It has been monitored since 1959, which makes it the glacier with the longest observed mass balance series in the Hohe Tauern National Park. The yearly mass balances have been calculated by using semi-direct and direct glaciological methods.

As there are only few glaciers worldwide, which have been observed for more than four decades, these long-term observations are a valuable contribution to the understanding of the glacier climate relationship.

Observing the genesis and the development of "new" lakes around the glacier is also an important part of the monitoring programme, which is sponsored by the Hydrological Service.

In 1990, "Lake Eisrandsee", a small tarn situated at a sea level of 2,500 m between the glacier snout and a rock barrier to the east of the glacier, appeared for the first time and due to constant melting of the Stubacher Sonnblickkees, has continuously grown to an actual length of 203 m and a width of 112 m.

The hydrological system of the recent lake is very complex and in order to understand the ongoing processes, Lake Eisrandsee as well as its two outlets (Keesbach and Eislbach) situated at different altitudes, are being monitored by means of automatic gauging stations.

Daily fluctuations of the lake's water level combined with slightly delayed and different discharge reactions in the two above mentioned streams were also observed as well as the regular water temperature fluctuations which depend on global radiation.

Keywords

Alps, Hohe Tauern, Stubacher Sonnblickkees, glacier, mass balance, long-term observations, discharge, runoff from glacier, glacial hydrology, water balance, year 2003

Introduction and objectives

Snow, a solid form of precipitation, and ice, which is mainly to be found on glaciers, are important components of the water balance. Both are of significant importance for water storage as the water, which has been accumulated in snow and ice, is not immediately effective in runoff.

In 2003 the distinctive influence of glaciated catchments on the summerly runoff was noticeable in almost every stream on the north face of the Hohe Tauern and was even to be registered further downstream in the City of Salzburg, where it had a compensating influence on the low water situation of the River Salzach.

Glaciers need certain climatic conditions, are very sensitive to changes in the environment and react with a certain delay, with smaller glaciers responding more sensitively than the larger ones.

As there are only few glaciers, which have been observed for more than four decades, the long-term observations at the Sonnblickkees are a valuable contribution to the understanding of the glacier - climate relationship and will therefore be carried on into the future.

Observing the genesis and the development of new lakes around the glacier is also an important part of the monitoring programme, which is sponsored by the Hydrological Service of Austria.

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Study area

The Stubacher Sonnblickkees, situated in Salzburgian Granatspitz group, which is a part of the Hohe Tauern mountain range of the Austrian Alps, is a small north-west exposed slope glacier with a surface area of 1.4 km² (2003) at an altitude ranging between 3050 m and 2500 m above sea level (Fig. 1).

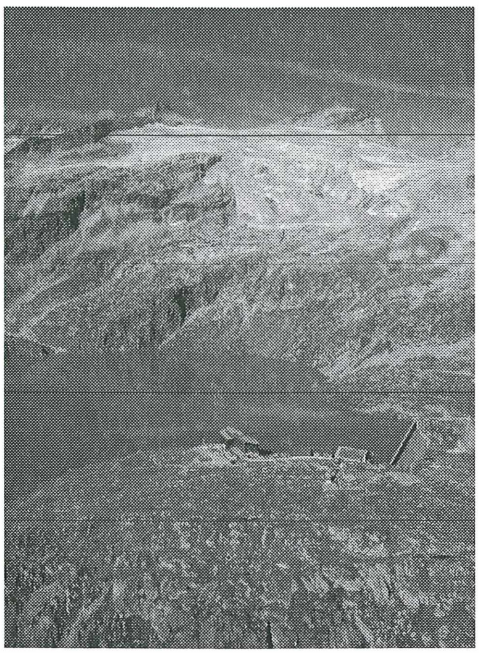

Fig. 1

Due to rough terrain, the Kees (glacier) has a complex shape resulting in an irregular interlocking of accumulation and ablation patterns. Between 1850 and 1860 the glacier terminated in Lake "Weißsee", now a dammed lake used for hydro-electric power production, whose natural catchment area comprises of 5.3 km² At present only a third of the catchment is covered by glaciers whilst in 1850 approx. 70 % was glaciated.

In 1990 "Lake Eisrandsee", a small tarn situated at a sea level of 2500 m between the glacier snout and a rock barrier to the east appeared for the first time. In 1994 it was surveyed using conventional geodetic instruments and a length of 80 m, a width of 30 m and a surface area of 6762 m² as well a maximum depth of 8 m were recorded. Over the years and especially during the extreme summer of 2003 it has increased to a present length of 203 m, a width of 112 m and it is still growing especially at its north-westerly end (Fig.2).

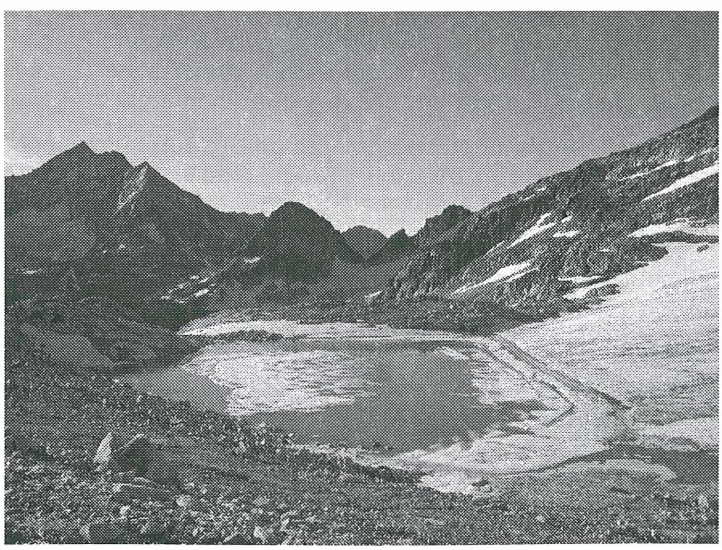

Fig. 2

Methods

The Stubacher Sonnblickkees has been monitored since 1959 and mass balances have been calculated by using semi direct (AAR) and direct glaciological methods.

From 1964 to 1980 the yearly mass balance has been measured directly. Based on this series of 17 years, a correlation between the net balance and the accumulation area ratio (AAR) was calculated thus enabling an estimation of the net balance 1959 to 1963 and 1981 until now. For this purpose it is necessary to map the accumulation patterns ("firn area") at the end of the balance year (coinciding with the maximum elevation of the equilibrium line). This mapping is done by using either terrestrial or aerial photogrammetry, monoplotting surveys, classical and GPS surveys or by means of amateur photos. Nevertheless, in all cases long time experience is necessary.

Along with these surveys, the development of the new born lakes "Kees See" and "Eisrandsee" has been mapped several times. Preliminary sounding gave an idea of the depth and volume of the temporary stages of the lakes.

The hydrologic system of Eisrandsee is very complex and in order to understand the ongoing processes, the recent lake as well as its two outlets (Keesbach and Eislbach) situated at different altitudes, have been monitored since 2002 by means of automatic gauging stations. Water level and water temperature are registered every 15 min and discharge measurements, using current meters and tracer methods, are carried out in order to achieve accurate discharge rating curves at the outlet gauges.

In order to calculate the main components of the hydrological water balance, climatic data (e.g. temperature, windspeed, precipitation, humidity etc.) are registered at the "Rudolfshütte" meteorological station, operated by the ZAMG (Central Institute for Meteorology and Geodynamics). Several totalizers in the surrounding catchments are used in order to achieve a better areal distribution of precipitation.

Results

Whilst 1965 was a very positive year with a mass gain of 3.5 Mill. m³, the Stubacher Sonnblickkees lost approx 4.02 Mill. m³ of its mass (representing 2.9 m on average in height) in 2003, when a record mass loss was registered on many alpine glaciers. On the Stubacher Sonnblickkees this record loss was mainly caused by rapid snow melting in May and June, high temperatures and lack of snow fall during summer, as well as by the negative influence of a Sahara sand layer (as a result of a storm in November 2002) on the glacier's albedo.

2003 was certainly an outstanding year but due to global warming the process of mass loss, which started in 1850, will carry on with a high probability in the future. This will result in a distinct shrinking, a decrease in area as well as in glacier retreat.

Since 1981 the Stubacher Sonnblickkees has lost 26.2 Mill. m³ i.e. approx.26 % of its total mass (Fig.3) and a hypothetical extrapolation of the last 20 years shows that the Kees could disappear within the next 50 to 80 years (Fig. 4).

This trend of constant mass loss is also to be found on many Austrian glaciers.

In the Austrian glacier inventory of 1969 (PATZELT, 1981) altogether 925 glaciers with an area of approx. 543 km² (i.e. 0.6 % of Austria's total area) were registered. In the new inventory which was carried out between 1996 and 1999, but has not yet been completely finished, Austria's glaciated area has been reduced to less than 500 km². In the same time-span the glaciers of the Granatspitz group (including the Stubacher Sonnblickkees) lost 23 % of their area (KUHN, 2005).

First results of the observations at Lake Eisrandsee show rhythmical daily water level and water temperature oscillations during the melting period as well as slightly delayed and different discharge reactions in the two above mentioned streams. The water level of the lake rises approx. 4 m until it reaches the outlet level of Eislbach, which then functions as an overflow. In late autumn or early winter as the glacier melting rate is reduced due to lower temperatures, all the water is drained towards Keesbach by a sub-glacial flow system and no discharge is to be observed at Eislbach.
A special phenomenon was observed in spring 2004, when heavy rainfall on the frozen and snow covered lake as well as surface discharge from the glacier created a slush-water mixture, which caused a sudden rise of the ("water") level in Lake Eisrandsee and a small glacier flood in Eislbach.

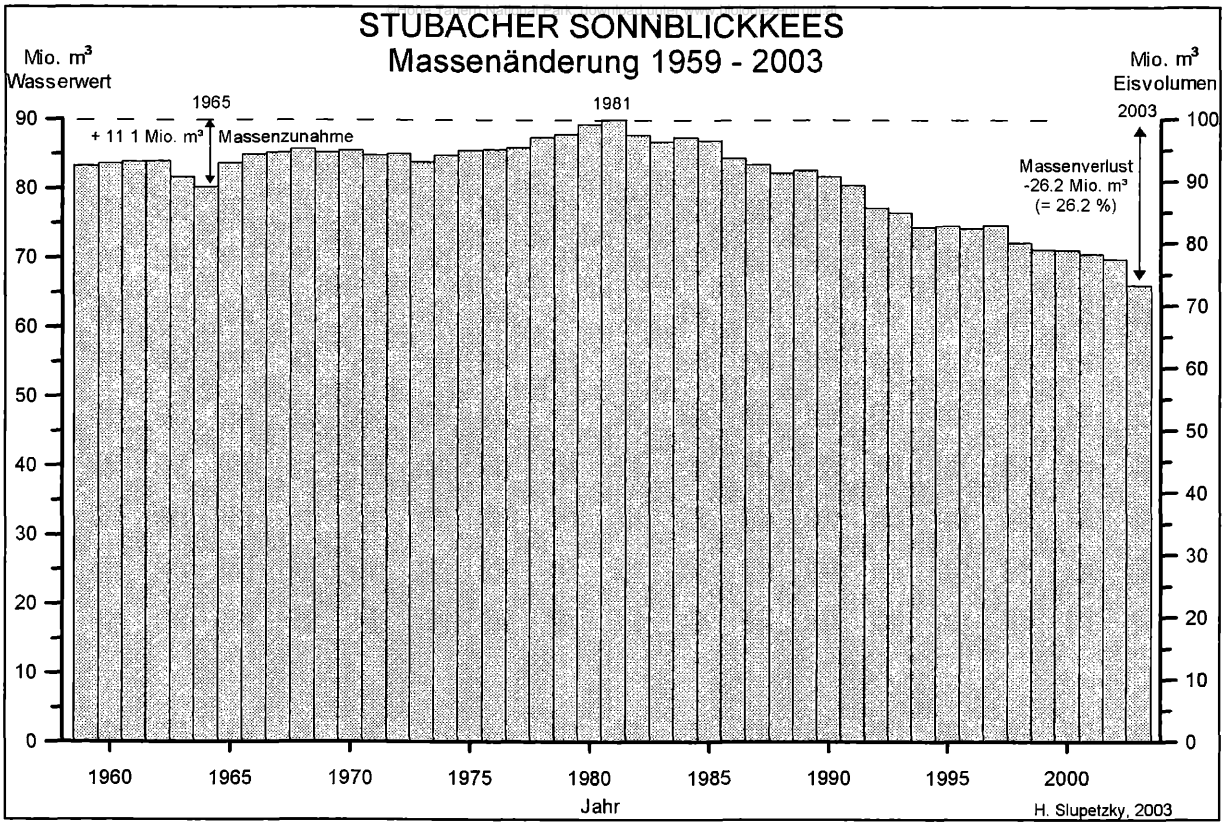
STUBACHER SONNBLICKKEES
Massenänderung 1959 - 2003
Mio. m³ Wasserwert
Mio. m³ Eisvolumen
1965
1981
2003
+ 11 1 Mio. m³ Massenzunahme
Massenverlust
-26.2 Mio. m³
(= 26.2 %)
90
80
70
60
50
40
30
20
10
0
100
1960
1965
1970
1975
1980
1985
1990
1995
2000
Jahr
H. Slupetzky, 2003

Fig. 3

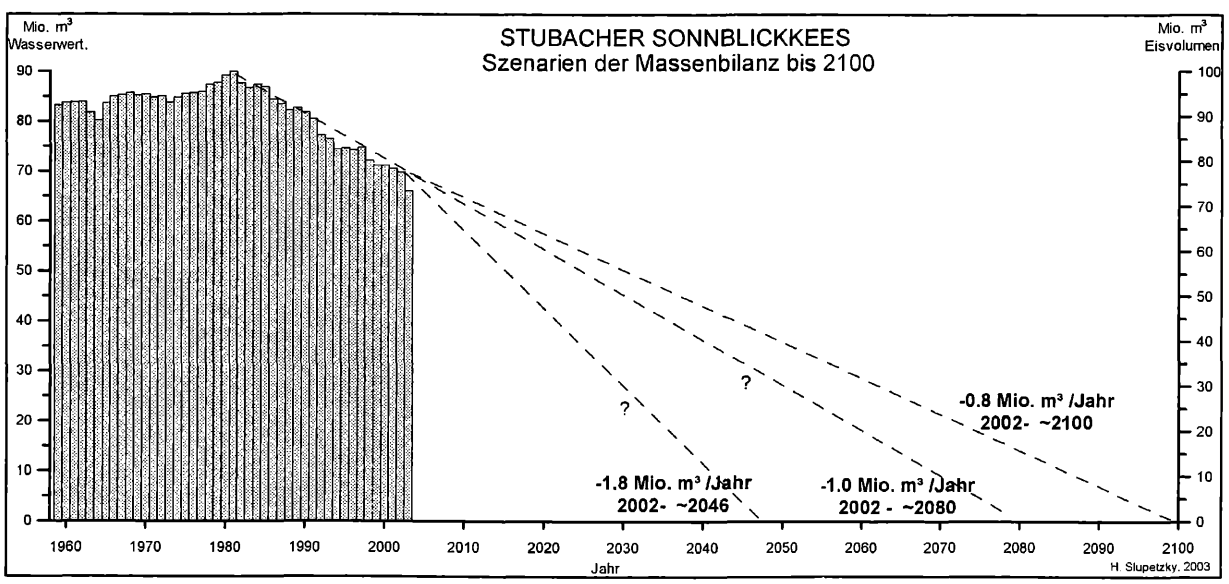
Mio. m³ Wasserwert.
STUBACHER SONNBLICKKEES
Szenarien der Massenbilanz bis 2100
Mio. m³ Eisvolumen
?
?
-0.8 Mio. m³ /Jahr
2002- ~2100
-1.8 Mio. m³ /Jahr
2002- ~2046
-1.0 Mio. m³ /Jahr
2002 - ~2080
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
2060
2070
2080
2090
2100
Jahr
H. Slupetzky, 2003

Fig. 4

Closing remarks

The public and the media are at present very sensitive about glaciers and their future development. Therefore, the exceptional (by today's terms) year of 2003 was a good chance to present the results of the long-term observations causing a sustainable effect on the awareness of the general public.

Surveying the glacier and the water cycle changes within the Hohe Tauern National Park also offers contributions to applied aspects (e.g. drinking water storage, flood hazards). Besides the main goal, gaining knowledge of the high alpine environment and ongoing natural processes due to the changing climate, it also provides useful information for park authorities concerned with public relations.

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