Small Publications in Historical Geophysics

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A Period of Anomalous Winter Climate and the Scandinavian Glacier Maximum in the 1700s

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1. Introduction

It is well known that the mountain glaciers in the northern hemisphere started melting towards the end of the 19th century. For those large glaciers where data exist also from earlier times, it can be infered that they were approximately stable during the centuries before. However, Scandinavia's largest glacier, Jostedalsbreen in southern Norway, seems to form an exception from that rule. This glacier, including its outlet glaciers, grew considerably during the first half of the 18th century. (Details will be given in Section 7.) The question now arises: Was there any anomaly in the Scandinavian climate at that time, especially in the winter climate, that could contribute to such an effect?

During the last decade some papers have been published containing very long time series of climate-related data from Scandinavia and the Baltic Sea. They include temperature data, sea ice data, lake ice data and river ice data, all going back to at least about 1720. The temperature series stems from Uppsala in southern Sweden. The main sea ice series is from the southernmost part of the Baltic Sea, close to the Baltic entrance. The main lake ice series is from Lake Mälaren in southern Sweden, but there is also a shorter series from Lake Storsjön in central/northern Sweden. The river ice series, finally, is from Tornio River close to the northenmost tip of the Gulf of Bothnia. All these time series will be studied and compared here. From the comparisons we will try to draw conclusions on the dominating atmospheric winter circulation pattern during the crucial part of the 1700s, hopefully also contributing to an understanding of the South-Scandinavian glacier maximum around 1750.

2. Winter temperature

Meteorological recordings in Uppsala date back to 1722. The earliest observations, including temperature measurements, were made by a young student at the University of Uppsala, Anders Celsius, later well-known as the inventor of the Celsius temperature scale (Celsius, 1742). The whole temperature series has been compiled, checked and homogenized by Bergström (1990) and Moberg & Bergström (1997), who also have calculated and published monthly and seasonal mean temperatures from 1722 onwards.

The oldest temperature measurements, up to 1750, suffer from two main problems. The first problem is that a number of different thermometer scales were used. However, observations were often made simultaneously with several different thermometers. This has made it possible to calibrate all scales against the present-day Celsius scale. The second problem is that there are no observations 1732 - 1738 (when Celsius visited other European universities

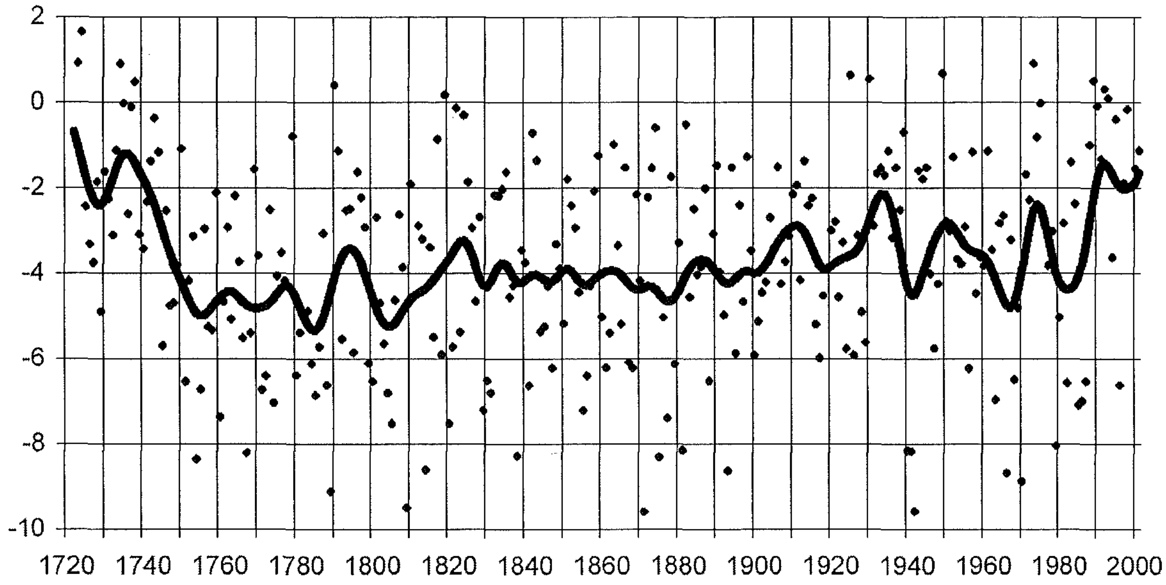

Figure 1. Winter temperature in Uppsala since 1722, °C (based on Moberg & Bergström, 1997).

and took part in the French arc measurement expedition to the Arctic circle). However, observations were made at a place south-west of Uppsala (Risinge) during this period and also, fortunately enough, during some overlapping years with Uppsala. This has made it possible to fill the gap in the Uppsala record. Thus both problems have been successfully solved by the above authors. Still, the early 18th century temperatures must be considered slightly more uncertain than later ones. This is especially true for temperature data taken before 1739, when the thermometers were located in such a way that they were poorly ventilated, resulting in too small diurnal temperature cycles.

The whole series of winter mean temperatures (December - February) is shown in Figure 1. This figure reveals a period with extremely mild winters between 1722 and 1745. The average winter temperature then was 2°C above the average for the whole period till today, or - 2°C instead of - 4°C. Only during the last decade do we find such a warm winter period again.

Now, this result may be somewhat questioned with regard to the mentioned uncertainty of the early 18th century temperatures. However, Bergström (1990) and Bergström & Moberg (2002) have been able to check the oldest temperatures by comparing them with other data. In front of all, they found a possibility to compare the temperatures during winter with the character of the precipitation, i.e. snow or rain. Such a comparison revealed that the temperature at which 50 % of the precipitation is snow and 50 % is rain is + 1-2°C, both for the oldest data and for modern data. Thus there should be no large systematic errors in the average winter temperature. At least this holds for "typical" winter temperatures, although periods with more extreme cold weather may have been underestimated.

3. Sea ice extent

Collecting historical ice information from places close to the Baltic entrance, Koslowski & Glaser (1995) produced a time series of ice extent or winter severity in the southwestern Baltic Sea, mainly the Belt Sea, dating back to 1701. Recently the same authors have managed to extend this series as far back as 1501; see Koslowski & Glaser (1999).

Their main sources are documents from a number of German ports, together with an earlier compilation by Speerschneider (1915) from Danish ports and light-houses. Also such a thing as the frequency of ship passages through Öresund during winters contributes to the picture. Because of the considerable number of "overdeterminations", i.e. information on the same ice winter from several independent sources, the reconstruction of this ice extent or winter severity series is considered very reliable for most of the years.

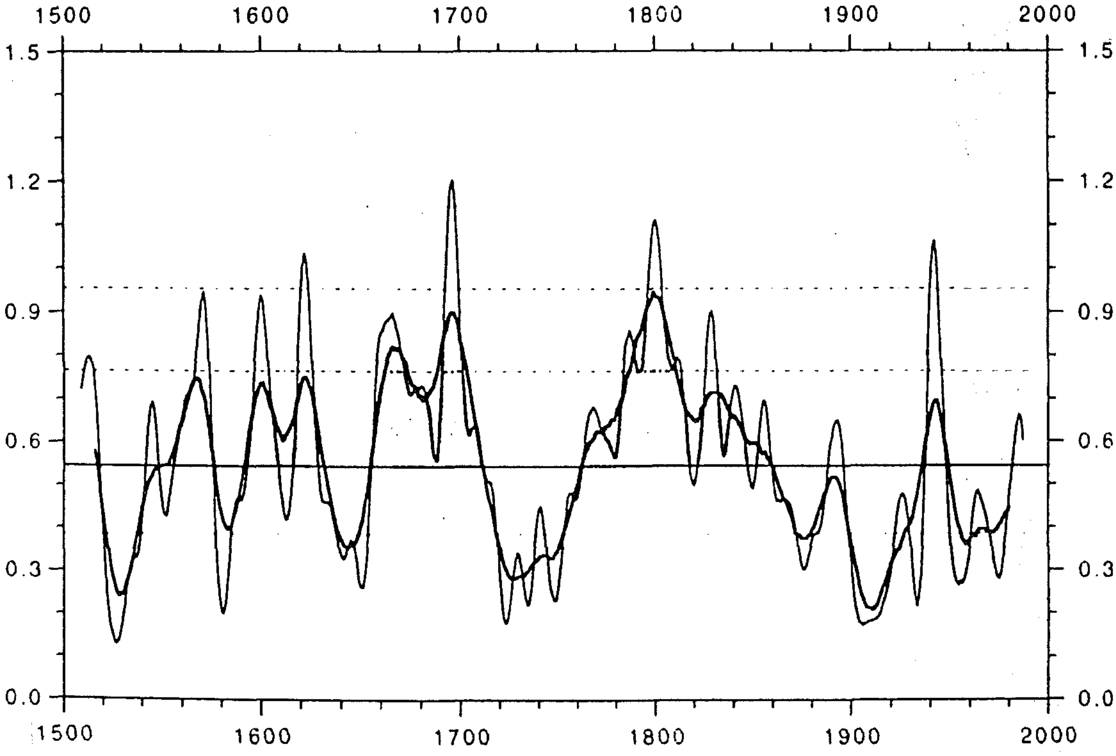

Figure 2. Ice winter index for the southwestern Baltic Sea since 1501 (Koslowski & Glaser, 1999).

The whole ice series is illustrated in Figure 2 in terms of an "ice winter index", the mean value of which is 0.55. The Little Ice Age is clearly seen between, say, 1550 and 1850, with an average ice winter index approaching 0.70. There is, however, a remarkable break in the Little Ice Age between 1720 and 1750, with an ice winter index below 0.30, indicating extremely mild winters during this period. This is in full agreement with the findings in the Uppsala temperature record treated above.

It should be mentioned here that Seinä & Palosuo (1996) have published a time series of the maximum ice extent of the Baltic Sea in general, commencing in 1720. The older part of this ice series was originally constructed by Jurva (1953), by collecting information from a variety of old sources. It appears that for the first 50 years one of his main sources was Speerschneider (1915), also used by Koslowski & Glaser for the southernmost Baltic. Hence, Jurva's result is considerably influenced by the winter conditions in the south and cannot be used as an independent data set in our context.

There are also time series of estimated winter severity for two ports in the eastern Baltic, Tallinn and Riga, from the 1500s onwards (Tarand & Nordli, 2001; Jevrejeva, 2001). These series are based on dates of the beginning of ship traffic after the winter season, a measure that might be too crude for our purpose. For very mild winters the ice distribution at the end of the season, and thereby the shipping dates, are sensitive to temporary wind conditions. Anyway, it should be mentioned that the Tallinn series shows a warm period between approximately 1720 and 1740, contemporary with the findings above, whereas the Riga series is more inconclusive.

4. Lake ice break-up

There are two large lakes in Sweden where dates of ice break-up have been observed during the 1700s. The main lake is Mälaren in southern Sweden, where ice break-up has been recorded at Västerås since 1712. The other lake is Storsjön in central/northern Sweden, the ice break-up of which was recorded, although with some gaps, between 1697 and 1766.

For Lake Mälaren in the south, a table of break-up dates was first published by Hülphers (1765); a complete table was given by Hildebrandsson (1872). For the period after that, when systematic observations are lacking, Eklund (1999) has calculated the missing dates from observations at ten other lakes in the same part of the country.

The whole ice break-up series is illustrated in Figure 3. It shows a period during the 1720s and 1730s with unusually early break-up dates, indicating

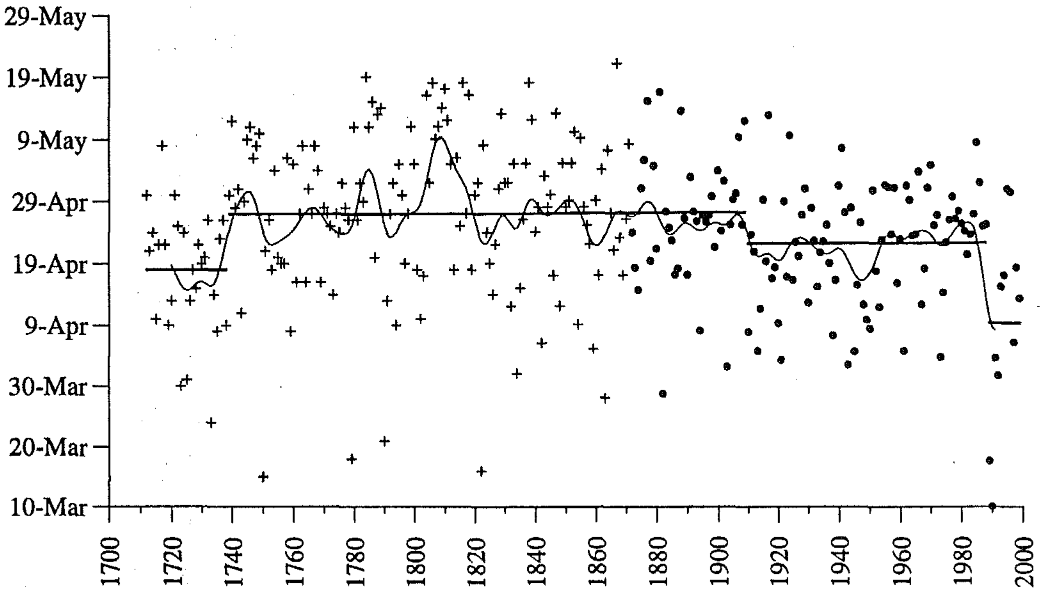

Figure 3. Ice break-up dates for Lake Mälaren at Västerås since 1712 (Eklund, 1999).

extremely mild winters at that time. Eklund (1999) has found a good correlation between break-up dates and the winter/spring temperature at Uppsala. The average break-up during the 20-year-period 1719 - 1738 occurred 14 April, nearly two weeks earlier than for the rest of the direct observation period up to 1872, when it occurred 26 April. This fits very well together with the corresponding findings of warm winters in the Uppsala temperature record as well as in the southern Baltic sea ice record.

For Lake Storsjön more to the north, a similar table was published by Tryggdahl & Granbom (1767). This table, although suffering from some gaps, does not show any sign of a period with early break-up dates. For the years 1719 - 1732 (after that there is a gap in the series) the average break-up date is 22 May, which is identical to that of the rest of the years.

The lack of an early break-up period for the northern lake might indicate a more normal winter climate in the north. However, ice break-up dates of a northern lake are not always easily interpreted in terms of winter temperature only, because of more permanent isolating snow cover.

5. River ice break-up

Dates of ice break-up in the Tornio River have been recorded since 1693. The river, at that time in Sweden, now forms the boundary between Sweden and Finland north of the Gulf of Bothnia. The observations have been performed at Tornio (Torneå) close to the river mouth. This very long time series has been compiled, checked and homogenized by Kajander (1993).

The ice break-up at Tornio is a spectacular and quite well-defined event. This has caused a lot of interest in the phenomenon, and a number of scientifically minded persons have, since 1693, produced lists of break-up dates. During the crucial period for our investigation the observations were compiled, and partly peformed, by Hellant (1748), a scientist devoted to collecting geo-data in northernmost Scandinavia, especially Lapland. (He also served as an assistant to Celsius during the French arc measurement expedition in this area.)

The whole ice break-up series has a clear trend towards earlier dates, the break-up now occurring nearly two weeks earlier than 300 years ago. What is noteworthy from our point of view, however, is the complete lack of a warm period at the older part of the time series. On the contrary, the period 1710 - 1740 seems to be a particularly cold one. During these years the average break-up date is 21 May, nearly one week later than for the following 100 years, when it is 15 May. This seems to support the indications in the northern lake ice series, but to be contradictory to the southern lake ice series and the southern Baltic Sea ice series as well as to the Uppsala temperature series.

Now, it should be noted that the ice break-up dates at Tornio are not only dependent on winter temperature, but even more on spring temperature (Kajander, 1993). However, such warm winters as indicated by the Uppsala temperature during this period would in any case reduce the probability for late ice break-ups, thus still indicating some contradiction, although uncertain, between Uppsala and Tornio winter temperatures.

6. Conclusions on the atmospheric circulation pattern

Comparing the available climatic data for the last 300 winters, we obtain an anomalous and quite interesting picture for the period 1710/1720 - 1740/1750, characterized by extremely mild winters over a large part of Scandinavia; see Table 1.

Table 1. Estimated winter climate during the period 1710/1720 - 1740/1750 for different latitudes in Scandinavia.

Location	Data	Lat.	Winter climate
Baltic entrance	Sea ice	55°	Very mild
Lake Mälaren	Ice break-up	59°	Very mild
Uppsala	Temperature	60°	Very mild
Lake Storsjön	Ice break-up	63°	Normal ?
Tornio River	Ice break-up	66°	Normal/cold ?

Our results in Table 1 require an atmospheric winter circulation pattern with very dominating winds from south-west and west over Scandinavia, at least over its southern half. Thus, during the above time period, the low air pressures must have moved along tracks systematically more to the north than normally. The uncertain northern results in Table 1 do not allow any statement on how much to the north, but vaguely indicate an increased north-south temperature contrast over central Scandinavia. The general picture is supported by the early wind observations at Uppsala: They show considerably more frequent winds from south-west and west during the time period in question, and correspondingly less frequent winds from north-east and east (Bergström, 1990).

7. The glacier maximum in the Scandinavian mountains

The largest glacier in the Scandinavian mountain range is Jostedalsbreen in southern Norway (between 61° and 62° latitude), with an approximate length of 70 km and an average width about 1/10 of that. From Jostedalsbreen there are several outlet glaciers. They have attracted a lot of interest since about 1710, when their growth started to threaten the farming activity in the valleys; see Rekstad (1902) and Østrem et al (1976), and also Figure 4.

In the beginning of the 1700s one of the expanding outlet glaciers, Nigardsbreen, gradually destroyed grasslands and other cultivated land. In the 1730s the situation became so critical that a Royal commission was sent to the area. It reported from the largest farm in the valley that the ice had advanced so far that it was "only a stone-throw from the farm house". According to a later statement, the ice had by then advanced 1/4 of an old Norwegian mile, 2 - 3 km, since 1710. In the 1740s the glacier completely destroyed the farm: "The ice, which in 1742 was located 100 Norwegian ells [60 m] from the houses, moved forward within the next year so that the houses were demolished, and a smaller farm lost all its arable land during the following years". The glacier reached its maximum extent in 1748 (Østrem et al, 1976). After that it has, with minor interruptions, retreated again.

A similar development is reported from another of the outlet glaciers, Åbrekkebreen. Also here the ice advanced a couple of km from the first decade of the 1700s until the 1740s (Rekstad, 1902), destroying farmlands and buildings. After that it has, most of the time, retreated again.

Glaciers tend to grow during periods with very snowy winters (and cool summers). The winters during the period 1710/1720 - 1740/1750 were, according to what we concluded in the preceding section, extremely mild with very dominating south-westerly and westerly winds over much of Scandinavia, at least over its southern half. In addition there might have been an enhanced temperature contrast over central Scandinavia, although this is uncertain. These conditions should have promoted repeated heavy snowfall over the coastal Scandinavian mountain range, particularly over its southern part in south-western Norway. Hence, the observed glacier advance there, and the resultant historical glacier maximum, might be understood in the light of our winter climate findings in this publication.

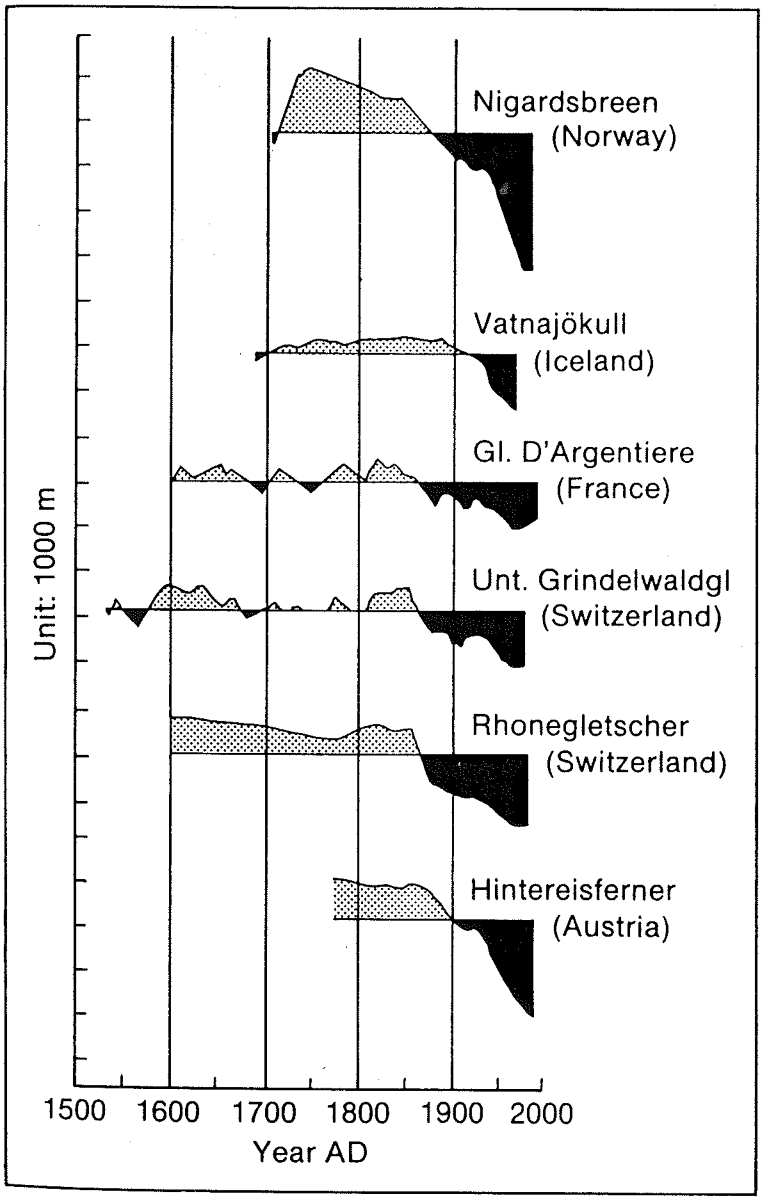

Figure 4. Changes of European glaciers measured by their length (Warrick & Oerlemans, 1990; the Norwegian glacier originally from Østrem et al, 1976).

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