Glaciological and climatological investigations at Qamanârssûp sermia, West Greenland

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As part of the GGU programme of investigations in connection with hydropower in West Greenland, glaciological and climatological measurements were continued at Qamanârssûp sermia (inventory no. 1CH21002) in 1983. The station was first established in late summer 1979 so that records for four complete summers 1980–1983 are now available. Brief reports on the work have been given by Olesen (1981), Olesen & Braithwaite (1982) and Braithwaite (1983a), while more detailed analyses and presentations of data can be found in Braithwaite & Olesen (1982) and Braithwaite (1983b). A similar detailed report on the 1983 field work is now in preparation. As a supplement to the routine programme of measurements by GGU, mapping and survey work have been carried out by N. T. Knudsen & J. T. Møller of Aarhus University. A detailed map on the 1:10 000 scale of the lower parts of Qamanârssûp sermia has been prepared by Knudsen & Møller (1982), while ice velocity variations were analysed by Andreasen (1982).

Field work in 1983

The field programme for 1983 was essentially the same as in previous years although problems were encountered due to the extremely bad weather conditions throughout the field season (mid-May to early September). A sketch map of Qamanârssûp sermia, showing locations of stakes and survey points, is given by Braithwaite (1983a).

Measurements of transient balances were made at varying intervals during the season within the network of stakes which extends up to an elevation of 1500 m above sea level. Ablation readings were made at the '751' stakes near to base camp on an almost daily basis. All stake positions were determined by triangulation from fixed points on bedrock in late June, and again in mid-August. Full climatological observations were made at the base camp between 18th May and 2nd September, supplemented by a thermohygrograph station at Stake 075 in the middle of the glacier at roughly the same elevation as the base camp. A further thermohygrograph station was established on a nunatak close to the climatic firn line at about 1500 m, but the record is incomplete because of difficulty in visiting the station often enough.

An automatic climate station has also been operated by the Greenland Technical Organization (GTO) at the base camp in cooperation with GGU since the beginning of the project. The records for the station for the period September 1982 to August 1983 have not been analysed yet, but it appears that the station did function throughout the whole period (Thorkild Thomsen, GTO, personal communication).

When the field party arrived in the area in mid-May it was obvious that there had been much more snowfall in the winter of 1982–1983 than usual, as in other parts of Greenland. However, when a snow scooter traverse was made up to 1500 m in late May, melting had already started. There was also evidence within the snowpack of earlier periods of strong melting, i.e. thick ice layers and signs of strong metamorphism right down to the 1982

Table 5. Climatological and glaciological data summary for base camp, Qamanârssûp sermia 1980–1983

	JUNE	JULY	AUGUST	SUMMER
Monthly mean temperature (deg C)				
1980	4.7[a]	6.6	5.5	5.6
1981	5.2[b]	7.5	3.9	5.5
1982	4.9	6.0	4.3	5.1
1983	3.3	5.2	1.8	3.4
Mean	4.5	6.3	3.9	4.9
Monthly precipitation (mm)				
1980	20[a]	61	64	145
1981	27[b]	148	81	256
1982	8	111	55	174
1983	101	102	190	393
Mean	39	106	98	242
Sunshine duration (hrs)				
1980	(226)	258	327	811
1981	(252)	214	124	590
1982	314	130	222	666
1983	204	164	121	489
Mean	249	192	199	639
Mean ablation of the three '751' stakes (mm)				
1980	(910)	1330	1010	3250
1981	(1110)	1860	800	3770
1982	1070	1580	1160	3810
1983	890	1460	570	2920
Mean	1000	1560	890	3440

[a] = based on 26 days of record
[b] = based on 29 days of record
() = adjusted to full month

autumn ice surface. Some problems were encountered on the snow scooter traverse because the early melting had weakened snow-bridges over crevasses.

Despite the early onset of the melt season, the subsequent summer months, June to August, were exceptionally cold and wet. A summary of climate data at the base camp, and of ablation at the nearby '751' stakes, is given in Table 5 from which it can be seen that the 1983 summer was the coldest, wettest and most cloudy summer of the four for which measurements are available. The result of this was that the June–August ablation at the '751' stakes was also the lowest for the four years. The effect of low temperatures, giving low ablation, was further reinforced by the fact that proportionally more precipitation fell in the form of snow during the summer, so that the equilibrium line was about 300 m lower than previously observed on Qamanârssûp sermia, i.e. around 1200 m above sea level. The condition of a low-lying equilibrium line for 1983 may be generally true for the Godthåbsfjord area as no exposed ice was seen on any of the local glaciers between Qamanârssûp sermia and Godthåb when the field party was evacuated by helicopter in early September.

Results

Qamanârssûp sermia is not located in an area where a hydropower project has been proposed. However, some results have emerged from the present investigations which are of

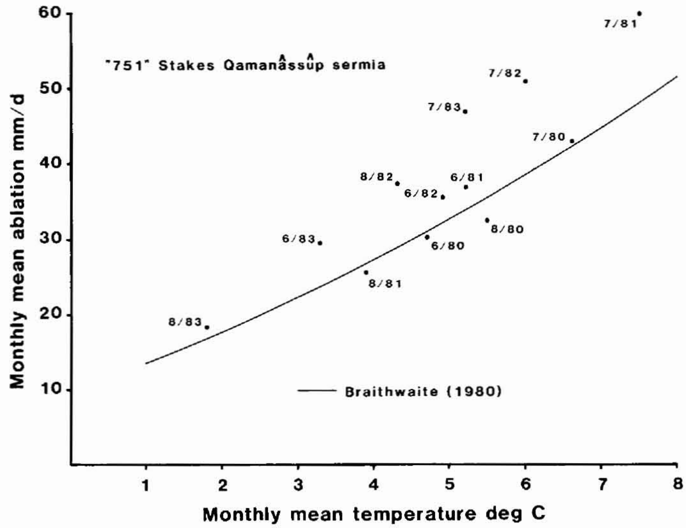

Fig. 48. Plot of monthly means of ablation rate at the '751' stakes versus monthly mean temperature at base camp. The curve represents the relationship proposed by Braithwaite (1980).

significance for Greenland hydropower, especially for the calculation of hydropower potentials by the use of runoff-climate models. Some results are quoted as follows:

Ablation-temperature relationship. Glacier runoff models often assume a relationship between ablation and air temperature. Correlations of the almost daily ablation readings at the '751' stakes with temperature at base camp have confirmed the existence of a relation between ablation and temperature. However, the magnitude of the degree-day factor (the parameter linking ablation to positive degree-day totals) is larger than previously assumed, i.e. an average of around 7.2 mm $d^{-1}deg^{-1}$ for the four summers 1980–1983, compared to the value 6.3 mm $d^{-1}deg^{-1}$ used by Braithwaite (1980). As an illustration, monthly values of the ablation rate at the '751' stakes are plotted against temperature in fig. 48 where the curve represents the relation suggested by Braithwaite (1980).

Ablation-radiation relationship. The relation between ablation and temperature is often explained by suggesting that temperature acts as a surrogate variable for net radiation, or even global radiation. At the '751' stakes on Qamanârssûp sermia there is no significant correlation between ablation and measured global radiation. Furthermore, the degree-day factor does not appear to follow any clear annual cycle in accordance with radiation variations. The double-mass curve of cumulated balance versus temperature over the course of a whole year given by Braithwaite (1983b, p. 25) illustrates this. There does not appear to be any point, therefore, in attempting to include radiation terms in the present generation of runoff-climate models for Greenland even if this were practical.

Automatic climate station. Data from the automatic climate station at Qamanârssûp sermia have been compared with hand-collected data from base camp for three summers 1980–1982 (Braithwaite, 1983c). For elements like air temperature and wind speed the agreement is excellent, while even large errors in measuring precipitation by the automatic station can be reduced by a simple mechanical adjustment of the sensor. The GTO have deployed similar automatic stations in basins under investigation for hydropower, but Qamanârssûp sermia is the only place where a detailed test of data quality can be made. The results from Qamanârssûp sermia do suggest that high quality data can be expected from automatic climate stations of this type.

Inland heating effect. From the general rise of glacier elevations from the coast around Godthåb to the Inland Ice in the interior of Godthåbsfjord it seems likely that there is an inland heating effect in the summer time, i.e. greater continentality of climate as one proceeds inland. Comparisons between year-round data from the automatic climate station at Qamanârssûp sermia and from Godthåb confirm the existence of such an effect. The temperature differences between the two stations roughly follow the annual cycle of shortwave radiation with strong heating in the summer and slight cooling in the winter (Braithwaite, 1983c). A similar effect might be expected in other locations and should be taken into account when extrapolating temperatures from coastal stations to inland basins.

Evaporation. Evaporation can represent a significant loss of water in glacier-free areas. Measurements of potential evaporation at Qamanârssûp sermia by a simple weighing-dish recorder and a Class-A pan confirm that the Penman method of estimating potential evaporation can be applied in Greenland if a suitable modification is made to the formula for calculating shortwave radiation (Braithwaite, 1983b, p. 29). Although there is still too little information about actual evaporation in Greenland, it is probably only about a half of the potential evaporation at Qamanârssûp sermia. This suggests that actual evaporation may be more controlled by availability of water, i.e. evaporation opportunity, than by the climatological conditions expressed by the potential evaporation.

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