Surface velocity measurements on Storglaciären, Sweden

Report for the GlacioEuroLab Course 2, April 2001.

Greet De Keukelaere, Arctic Studies Programme, Rovaniemi.

Introduction

The glaciology field course took place at the Tarfala Research Station. This Station is located in the Tarfala Valley, 68°55' N 18°36' E, at 1130 m above sea level in the Kebnekaise mountains, Swedish Lapland. There is a long history of glaciological work on Störglaciären and surrounding glaciers. Storglaciären has been studied since1945, its mass balance records provides continuous winter, summer and net balance data from 1945 till present. Other research was done on measurements of surface velocity fields, radar profiling of the geometry, hydrological measurements and local climate.

Glacier Velocity

Glacier dynamics studies, among other things, the flow of glaciers. How the velocity varies along a flow-line, across a valley glacier, and with depth. For obvious reasons of access, measurements of velocities are concentrated on velocity measurements of the surface. During the last decades, several theories and models are developed for the flow of ice. Starting from surface velocity measurements, these models calculate velocities accross a transsect, along a vertical profile, or in all the grid points distributed over the glacier. Thus surface velocity measurements yield important information as they are used in more and extensive models.

Field measurements

The field measurements were done with a Differential Global Positioning System (DGPS). This method gives a higher accuracy than the common GPS. For DGPS, two receivers are used within a reasonable distance and the position of one must be known accuratly from other sources. The travel time of radio signals is

measured and converted into physical distance using the speed of the radio signal. The speed of the radio signal is known with a relatively high accuracy. Errors due to the sattelite clock, the satellite orbit, and the ionosphere then affect both receivers the same way and with the same magnitude. The exact position of the first receiver can be used to calculate errors in the measurements. These are reported to the second receiver. In theory the accuraty of DGPS measurements are of the order of milimeters, in practise slight leaning or vibrating stakes make the accuracy around 1-2 cm.

The stake net contains of 42 stakes, each ca. 5 m long. They were placed in bore holes in a grid of 7 by 6. to the bad weather conditions, only one day of measuring was possible. On April 4, 24 of the stakes, the upper 4 rows were measured. Previous surveys were perfomed in July and September 2000.

The measurements were preformed using two Javad GPS-systems, each consisting of a receiver and an external antenna. The systems were powered by external batteries. One was fixed near the station on a rstake with wellknown coordinates, the other was the mobile and was carried on the glacier. The mobile antenna was fixed on the top of the stakes. The stake position was recorded for 3 minutes, taking measurements every 10 seconds.

The data from the measurement campaign were downloaded at the research station to make a first quality check. The data were transferred, analysed and converted to the AMG Grid format zone 34.

Surface velocity calculations

The displacement of the stakes and the surface velocity can be obtained from the positions of the stakes between two measurement campaigns. In this report the results of the measurements of September 6th, 2000 and April 5th, 2001 are used. The displacement of one stake is calculated as follows:

dx=lat2 - lat1=displacement in m in latitude

dy=lon2 - lon1=displacement in m in longitude,

with 1 and 2 corresponding to the first and the second measurement.

The real displacement is then calculated by the root of the squares of the

displacements in latitude and longitude.

The velocity is calculated by simply dividing the displacement by the number of days (211 in this case).

The results of these calculations can be found in table 1.

table1.xls

Surface velocity profiles

The results of the calculations are presented by row of stakes in graph1.

graph1.xls

The graph shows four velocity profiles. The velocities are high in the center of the glacier surface (around 4.2 cm/day), and low at the glacier margins,the lateral boundaries, (between 3 and 3,8 cm/day), due to the large lateral shearing. Although the velocities are higher in the center than at the margins, the difference is not more than 25%.

The upper 3 rows show a very similar velocity profile, with values that are of the same magnitude. The velocities of the 4th row, the row that is more downstream, shows clearly higher velocities except for the margins. This difference can be explained by the bedrock topography. The 4th row is situated close to a ridge in the bed topography. At the same time the surface of the glacier has a steeper slope. The last two rows of stakes (row 5 and 6) probably would have shown more pronounced velocity profiles due to the topography; unfortunatly these rows could not be measured due to bad weather conditions.

The speed on the centerline of the surface of the glacier, between 4 and 4.4 cm/day is much lower than the speeds measured during summertime. During the peak flow months of July, August and September speeds between 4.5 and 5.5 cm/day are calculated.

Conclusion

The surveys of the stakes give information on the displacement of the glacier and allows us to calculate glacier velocity profiles. The profiles that result from measurements in September 2000 and April 2001, show the typical profile for

surface velocities of a glacier. Speeds measured during this period are much lower than speeds obtained for the peak flow months of July to September.

Acknowledgements

The data used in this report were collected by different participants during the GlacioEuroLab courses in September 2000 and April 2001. Thanks to EU funding, participants were able to get in touch with instruments and the fieldwork. I would like to thank John Moore for the perfect organisation, his support to all students initiatives and patience with students mistakes. Thanks to all the participants for the good team work and the nice atmosphere.

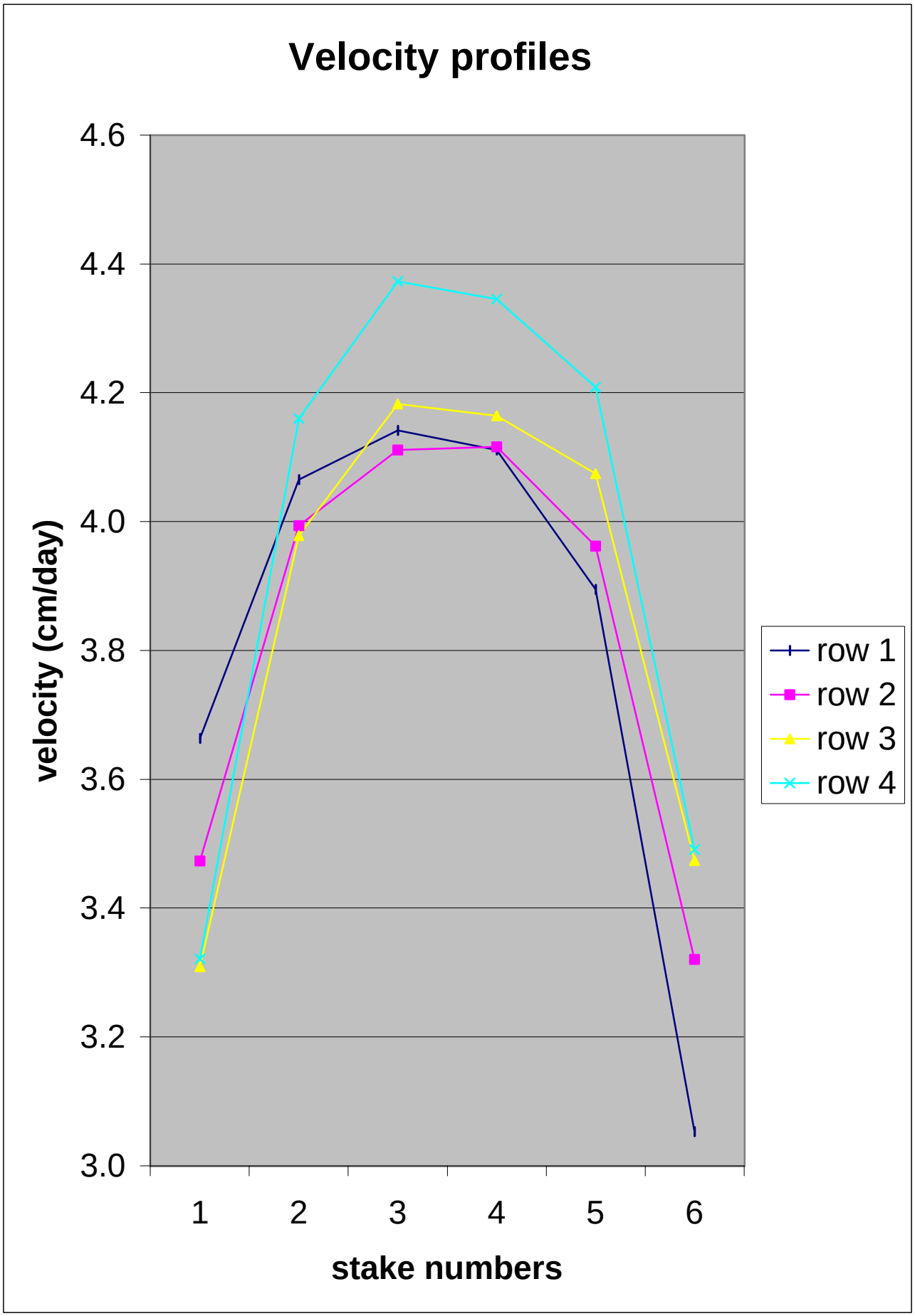
Literature

Hedfors Jim, 2000, Ice Flux Modelling on Storglaciaren, Sweden.

Jansson Peter, 1994, Tarfala Research Station Annual Report, 1992 - 93.

Paterson W.S.B., 1994, The Physics of Glaciers.

van der Veen C.J., 1999, Fundamentals of Glacier Dynamics.


Velocity profiles
4.6
4.4
4.2
4.0
3.8
3.6
3.4
3.2
3.0
velocity (cm/day)
1
2
3
4
5
6
stake numbers
row 1
row 2
row 3
row 4

	stake	Lat 2000/09/06 (	Lon 2000/09/06 (	Lat 2001/04/05 (	Lon 2001/04/05 (
row 1	**1**	17533633.29730	398272.99280	17533633.1000	398280.7204
	2	17533728.40100	398289.73274	17533728.2300	398298.3093
	3	17533827.11740	398306.50727	17533826.9200	398315.2441
	4	17533927.12030	398323.12304	17533926.9200	398331.7961
	5	17534018.61490	398340.64013	17534018.4700	398348.8563
	6	17534124.27670	398349.40321	17534124.3300	398355.8454
row 2	**1**	17533616.04390	398373.91223	17533615.9300	398381.2401
	2	17533707.96050	398387.86876	17533707.7300	398396.2920
	3	17533808.93640	398404.31209	17533808.6800	398412.9832
	4	17533901.02060	398416.99829	17533900.6800	398425.6767
	5	17534004.18190	398433.80522	17534003.7000	398442.1511
	6	17534105.48850	398448.64672	17534105.2900	398455.6502
row 3	**1**	17533600.85100	398471.34224	17533600.5300	398478.3164
	2	17533692.16130	398487.88167	17533691.6900	398496.2628
	3	17533791.71000	398503.11862	17533791.7100	398511.9438
	4	17533892.00030	398517.27504	17533891.5900	398526.0517
	5	17533990.88360	398534.01741	17533990.5100	398542.6062
	6	17534086.40820	398551.79942	17534086.4700	398559.1295
row 4	**1**	17533583.69080	398569.85272	17533583.0200	398576.8285
	2	17533680.79640	398583.97097	17533680.0300	398592.7149
	3	17533776.17710	398598.01393	17533775.3400	398607.2025
	4	17533872.92530	398613.57624	17533872.0500	398622.7026
	5	17533972.19030	398630.34283	17533971.5300	398639.1989
	6	17534070.85690	398646.10427	17534070.8200	398653.4707

dx (m)	dy (m)	displacement (m)	velocity (cm/day)
-0.19730	7.72760	7.73012	3.66356
-0.17100	8.57656	8.57826	4.06553
-0.19740	8.73683	8.73906	4.14173
-0.20030	8.67306	8.67537	4.11155
-0.14490	8.21617	8.21745	3.89452
0.05330	6.44219	6.44241	3.05328
-0.11390	7.32787	7.32876	3.47334
-0.23050	8.42324	8.42639	3.99355
-0.25640	8.67111	8.67490	4.11133
-0.34060	8.67841	8.68509	4.11616
-0.48190	8.34588	8.35978	3.96198
-0.19850	7.00348	7.00629	3.32052
-0.32100	6.97416	6.98154	3.30879
-0.47130	8.38113	8.39437	3.97837
0.00000	8.82518	8.82518	4.18255
-0.41030	8.77666	8.78625	4.16410
-0.37360	8.58879	8.59691	4.07437
0.06180	7.33008	7.33034	3.47410
-0.67080	6.97578	7.00796	3.32131
-0.76640	8.74393	8.77745	4.15993
-0.83710	9.18857	9.22662	4.37281
-0.87530	9.12636	9.16824	4.34514
-0.66030	8.85607	8.88065	4.20884
-0.03690	7.36643	7.36652	3.49124