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Glaciological Observations In and Around Schirmacher Oasis, East Antarctica during 27th Indian Antarctic Expedition

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ABSTRACT

During the 2nd Indian Antarctic Expedition, Dakshin Gangotri glacier snout was identified in the Schirmacher Oasis, East Antarctica. Since then, the monitoring of the snout is a regular annual observation. Analysis of the recorded data shows that from 1996 onwards there is a recession of 65 to 70 cm per annum. During 2007 and 2008, there is a yearly average recession of 110 cm. Detailed analysis shows that there is variable amount of recession at different parts of the snout. In the year 2001, additional measurement points were set up along the Western Wall of the glacier. In 2008, accumulation/ ablation studies in India Bay region show an average accumulation of 5.9 cm on the Ice Shelf, but ablation is recorded at few stakes.

Keywords: Schirmacher Oasis, DG Glacier Snout, Recession, Ice Shelf, Ablation.

1.0 INTRODUCTION

In 1983, as a part of the programme on monitoring fluctuations in continental ice sheet margin in central Dronning Maud Land (cDML), East Antarctica, a prominent glacial tongue was identified in western Schirmacher Oasis **(Fig. 1)** and it was named Dakshin Gangotri (DG) Glacier snout **(Fig. 2)**. This snout was monitored annually from fixed survey points, which showed a consistent recession, but with fluctuations in the rate (Asthana et al., 1996; Chaturvedi et al., 1999a, b & c, Chaturvedi et al., 2003, 2005, 2008; Singh and Jayaram, 1989). The annual recession rates were averaging 0.57 m during 1983 to 1995. In 1996, nineteen points were fixed along this snout periphery **(Fig. 3)** to enhance observation details. Also, the advancing patterns along the periphery of the glacier were recorded every month, during the austral winter of 1996-98. Again, during the winter months of 1999-2000, advancement of the glacier was recorded. This established the overall yearly model of advance and retreat of the glacier. In 2001, the area of observation was increased by many km to cover the

entire western wall of polar continental ice margin in Schirmacher Oasis; this wall also shows annual recessions, but with fluctuations in yearly magnitude.

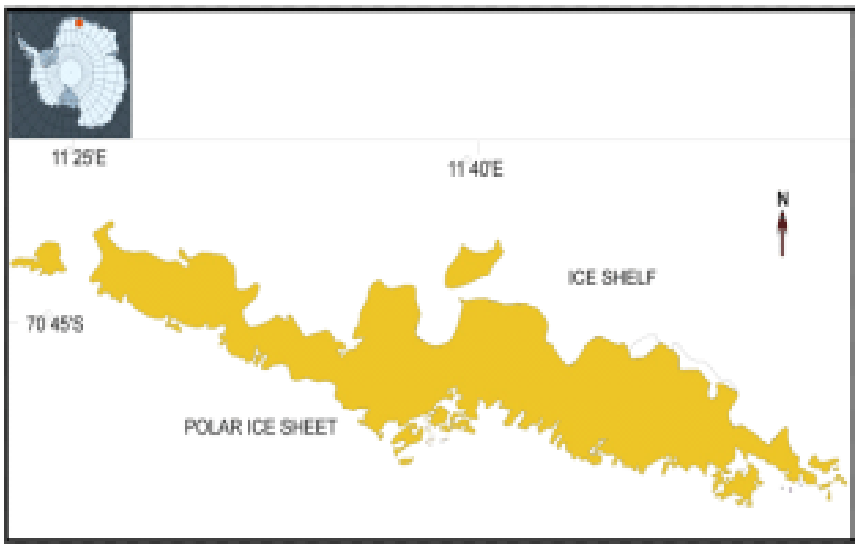

Fig. 1: Location map of Scirmacher Oasis, East Antarctica (Inset: Map of Antarctica showing the location of this oasis.)

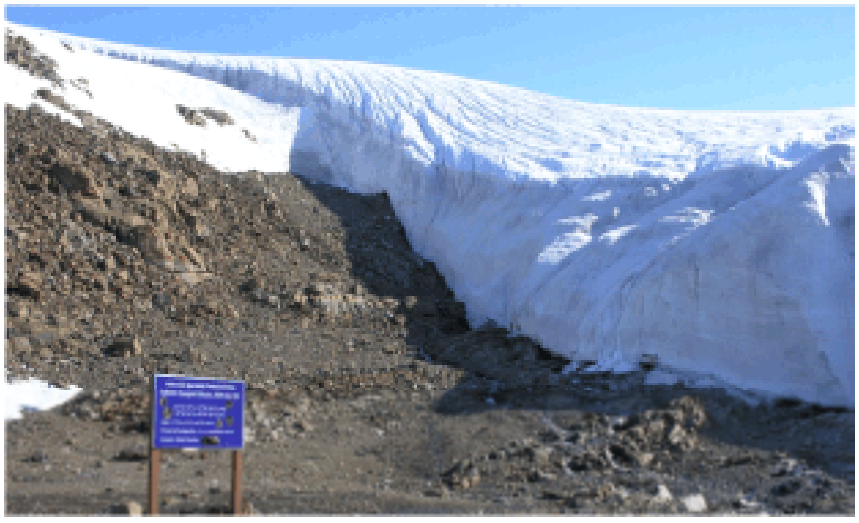

Fig. 2: View of DG Glacier Snout, Scirmacher Oasis, East Antarctica

Another long term project initiated in the second Indian Antarctic Expedition was to record the accumulation and ablation patterns on the ice

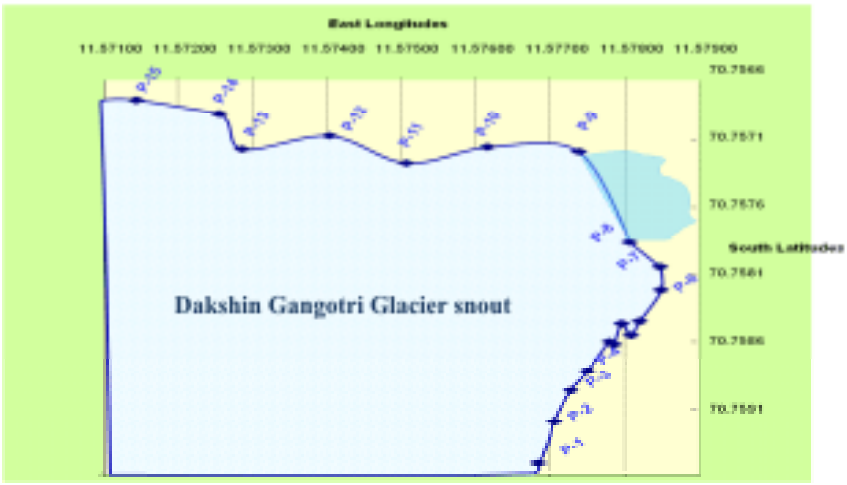

Fig. 3: Sketch of DG glacier Snout periphery with Observation Points

shelf near erstwhile Dakshin Gangotri Station, cDML, East Antarctica (Kaul et al., 1985); this was done using fixed network of stakes. Depending on the availability of logistics, network farms containing 8, 16 and 20 stakes were fixed in a square grid fashion and have been monitored over a period of last 22 years (Chaturvedi et al., 2008, Ravindra et al., 1992, Singh et al., 1988). These observations have continued on yearly basis and sometimes details of monthly patterns are also available from wintering teams.

Monitoring of icebergs in Antarctica as per the guidelines of the Norwegian Polar Research Institute for keeping a world-wide watch on icebergs had been a part of glaciological programme of the GSI since the beginning of Indian Antarctic Expeditions in the year 1981. The observations include recording the location, dimensions and morphological characteristics of the icebergs observed during the cruise. As the journey to Antarctica was performed by flight, this data could not be taken up during the current expedition.

2.0 METHODOLOGY

The study involves the measurement of DG Glacier Snout and its western flank with respect to fixed observation points. The permanent markers were fixed in 1996, from where the distance of the projected points along a marked direction are measured every year. The accumulation and ablation pattern on the ice shelf area near former Dakshin Gangotri station in India Bay region was obtained using a network of 16 stakes, fixed over the ice shelf in a grid of 4 stakes in each row, separated 50m X 50m, encompassing an area of 22500 square meters.

3.0 OBSERVATIONS

The monitoring activities at three sites— the Dakshin Gangotri Glacier Snout, the Western Wall of DG Glacier in Schirmacher Oasis, and the Ice Shelf region are described below. These observation points spread over a distance of about 80 km.

3.1 Glacier Snout

The monitoring of Dakshin Gangotri (DG) snout, overriding Schirmacher Oasis shows continued recession like previous years, but the intensity of recession differs at all the 19 points of observation, which cover the whole periphery of the snout. These observation points are numbered serially from the SE end to NW end, passing through the central part; a proglacial lake has formed in the central part after the glacier vacated the area (Fig. 2). Among these 19 recorded points **(Table 1)** (Fig. 3), 18 points show a marked recession in year 2007-08, compared to the previous years **(Fig. 4)**. The observation point 1, which is situated in the south eastern extreme of the snout, shows maximum recession of 357cm and observation point 5, situated at the eastern periphery shows an advancement of 40cm.

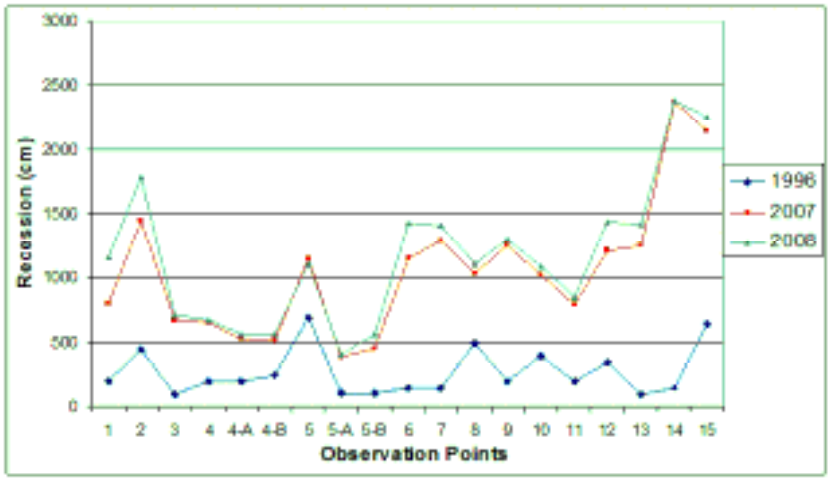

Fig. 4: Recession in Dakshin Gangotri Glacier Snout

But overall comparison with the baseline data of 1996 indicates that observation point 14, situated in the westernmost part, shows maximum recession of 2232 cm; and observation point 5A shows minimum recession of 294 cm. The average annual recession was calculated as 110.05 cm. Compared to the baseline data of 1996, the cumulative average recession

Table 1— Recession of Dakshin Gangotri Glacier Snout

Point No.	Latitude	Longitude	96-Feb Original positions (cm)	Jan-07 (cm)	Jan-08 (cm)	Recession 1996-2008 (cm)	Recession 2007-2008 (cm)
1	70°45.566'	11°34.614'	200	805	1162	962	357
2	70°45.548'	11°34.626'	450	1450	1785	1335	335
3	70°45.534'	11°34.64'	100	672	711	611	39
4	70°45.526'	11°34.653'	200	652	680	480	28
4-A	70°45.513'	11°34.67'	200	524	563	363	39
4-B	70°45.514'	11°34.674'	250	520	563	313	43
5	70°45.505'	11°34.681'	700	1148	1108	408	-40
5-A	70°45.51'	11°34.628'	110	390	404	294	14
5-B	70°45.504'	11°34.695'	110	455	563	453	108
6	70°45.49'	11°34.113'	150	1155	1435	1285	280
7	70°45.48'	11°34.712'	150	1290	1410	1260	120
8	70°45.469'	11°34.687'	500	1035	1109	609	74
9	70°45.429'	11°34.646'	200	1250	1297	1097	47
10	70°45.427'	11°34.573'	400	1020	1094	694	74
11	70°45.434'	11°34.507'	200	790	852	652	62
12	70°45.422'	11°34.445'	350	1215	1436	1086	221
13	70°45.428'	11°34.374'	100	1251	1422	1322	171
14	70°45.412'	11°34.356'	150	2374	2382	2232	8
15	70°45.406'	11°34.289'	650	2142	2253	1603	111
Avg.						897.84	110.05

is 897.84 cm. The statistical analysis of the recession pattern between 1996 and 2008 shows that the eastern part of the glacier snout has a better correlation (R-squared value = 0.639) **(Fig. 5)** than the northern and western parts. The calving of the glacier snout in the northern part due to a higher solar insolation may be responsible for this poor correlation. The regional NE trending movement of the entire Polar ice sheet, south of Schirmacher Oasis, (Sunil et al., 2007) is also a controlling factor for the patterns of advance and retreat of the DG Glacier Snout.

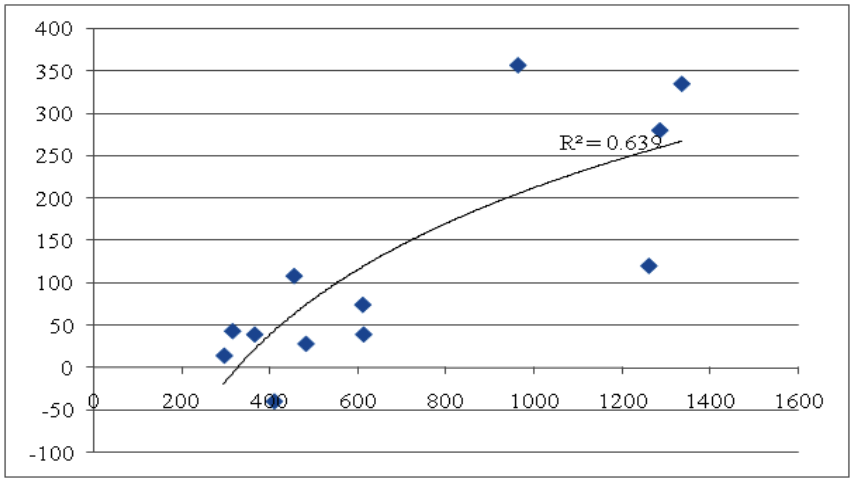

Fig. 5: Correlation of recession values from the eastern part of the DG Glacier Snout

3.2 Glacier Wall

The western extension of the ice wall was also measured to see the impact of recession. In this year of observation, some of the fixed points on the western wall were covered by sediment debris and snow depositions. Thus, only seven points could be precisely measured **(Table 2)**. The data have been compared with the previous year, (2006-07) and the baseline year of 2001. In the year 2007-08, the observation point XX8 shows maximum advancement of 11.45m; and observation point XX13 shows a maximum recession of 6.40m. The maximum cumulative recession of 17m from the baseline data of 2001was observed at observation point XX9; this point show yearly recession of only 2.80m, which is lowest among the seven recorded points.

3.3 Snow Accumulation Studies

The accumulation and ablation pattern on the ice shelf area near former Dakshin Gangotri station shows mainly accumulation, with some ablation.

Table 2— Recession of the Glacier Wall in the western side of Schirmacher Oasis

Points	Latitude	Longitude	2001 (m)	2007 (m)	2008 (m)	Recession 2007-08 (m)	Recession 2001-08 (m)
XX2	70 44.603	11 26.390	1.06	30.50	--	–	--
XX3	70 44.621	11 26.529	0.95	28.60	--	–	--
XX4	70 44.729	11 27.660	0.78	20.25	--	–	--
XX5	70 44.797	11 28.147	1.53	14.15	--	–	--
XX6	70 44.879	11 28.562	2.67	21.20	--	–	--
XX7	70 44.932	11 28.905	2.53	11.13	15.47	4.34	12.94
XX8	70 45.225	11 31.120	2.50	16.75	5.30	-11.45	2.80
XX9	70 45.268	11 31.401	1.72	22.70	18.72	-3.98	17.00
XX10	70 45.300	11 31.614	3.30	20.05	10.75	-9.30	7.45
XX11	70 45.417	11 33.135	1.84	9.70	9.76	0.06	7.92
XX12	70 45.428	11 33.289	1.08	5.90	7.96	2.06	6.88
XX13	70 45.407	11 33.478	1.58	6.10	12.50	6.40	10.92
XX14	70 45.403	11 33.619	1.02	8.20	--	–	--
XX15	70 45.424	11 33.733	4.06	4.90	--	–	--
XX16	70 45.436	11 34.022	0.53	4.40	--	–	--
XX17	70 45.631	11 34.739	0.94	In lake	--	–	--

The data displays that out of 16 points, three stakes show an ablation, whereas 13 points show a marked accumulation **(Table 3) (Fig. 6)**. Stake no. 2 shows maximum ablation of 3cm and the stake no. 8 shows a maximum accumulation of 25cm. The average accumulation for this area was calculated as 5.87 cm. The variation of the snow accumulation/ ablation pattern is due to the role of drift snow, altering the surface profile of the shelf ice (Mukerji et al., 1995) and temporal variation (Beg et al., 1997). The overall accumulation pattern shows that there is a zone extending along E-W in which accumulation is more compared to its surroundings **(Fig. 7)**.

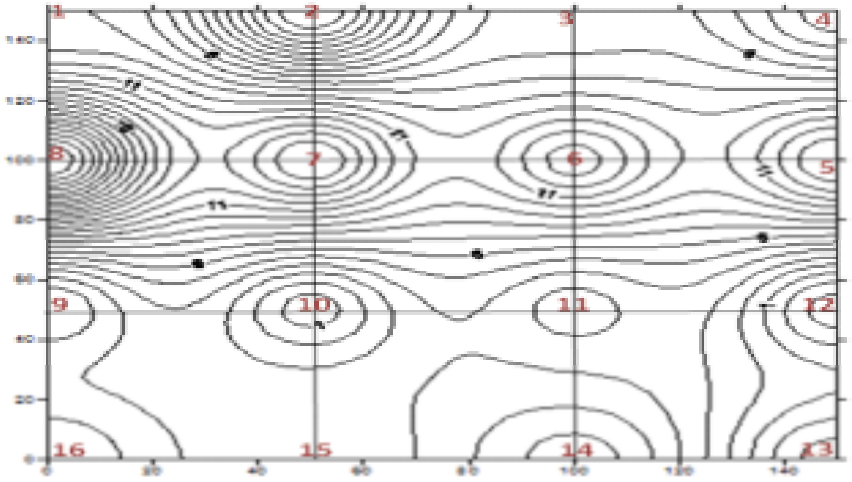

Fig. 6: Contour lines of snow accumulation/ ablation recorded in 2008 on ice shelf in India Bay region. (Red numbers are the location of stakes.)

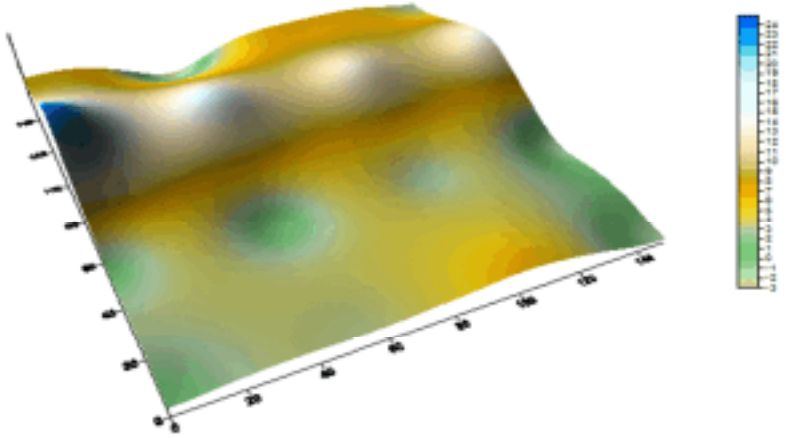

Fig. 7: Surface snow accumulation/ ablation map of the stake network on ice shelf in India Bay region

Table 3— Snow accumulation/ablation on ice shelf near erstwhile Dakshin Gangotri station

S. No.	Latitude (S)		Longitude (E)		2007	2008	Net Accumulation
	Deg	Min	Deg	Min	Exposed Height in cm	Exposed Height in cm	
1	70	4.383	12	1.659	106.0	98.0	8.0
2	70	4.39	12	2.037	121.0	124.0	-3.0
3	70	4.391	12	2.35	105.5	99.0	6.5
4	70	4.397	12	2.739	98.5	96.0	2.5
5	70	4.316	12	2.734	124.0	110.0	14.0
6	70	4.3	12	2.375	143.5	130.0	13.5
7	70	4.302	12	2.03	92.0	76.0	16.0
8	70	4.286	12	1.693	122.0	97.0	25.0
9	70	4.2	12	1.792	123.0	122.0	1.0
10	70	4.211	12	2.065	113.5	113.0	0.5
11	70	4.224	12	2.414	114.5	112.0	2.5
12	70	4.235	12	2.701	118.5	120.0	-1.5
13	70	4.081	12	2.714	99.5	101.0	-1.5
14	70	4.093	12	2.446	126.5	120.0	6.5
15	70	4.112	12	2.051	135.0	132.0	3.0
16	70	4.128	12	1.782	105.0	104.0	1.0
					Average accumulation		5.875

4.0 CONCLUSIONS

In the year 2008, the average recession of the DG Snout is 110 cm, compared to the previous year. Since 1996, the snout has receded by a cumulative 898 cm. Also, the recession is markedly variable at different points. Along the western wall of Schirmacher Ice Margin, the data could not be recorded from all observation points because most of the points were buried by debris and ice falls. Out of 17 observation points, data were recorded at 7 points. But on an average, the western wall has receded much more than the glacier snout. On the ice shelf, average annual accumulation recorded was 5.87 cm in year 2008; with three stakes showing some ablation. An E-W trending zone with higher accumulation has been observed.

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