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A Note on The Glaciological Studies Carried Out During Eleventh Indian Expedition to Antarctica

S.MUKERJI, V.RAVIKANT, B.R.BEJARNIYA, L.K.OBEROI and S.C.NAUTIYAL

Geological Survey of India
NH-5P, N.I.T., Faridabad - 121 001.

Abstract

Glaciological observations on shelf ice, polar ice tongue and icebergs were carried out on a routine basis as part of a long term study of these elements. Some variation in the accumulation/ablation pattern over shelf ice is noticed during 1992 austral summer. A near steady state of recession of the snout of Dakshin Gangotri Glacier is indicated.

Introduction

The ice shelf around Antarctic continent is in a constant state of change with a dynamic surface which reflects net accumulation and ablation of drift as well as precipitated snow. However, a large volume of Antarctic ice gets dislodged from its shelf edge and floats free in the form of icebergs, in the waters of Southern Ocean. Geological Survey of India has been monitoring the pattern of this change on the shelf ice and movement of cap ice for the last several years in a part of Central Dronning Maud Land. Also, following the guidelines of Norwegian Polar Institute, a regular observation is carried out on the icebergs that are encountered during the voyage by ship between India and Antarctica.

Snow accumulation/ablation over the ice shelf

A set of nine stakes (Fig 1) fixed in shelf ice near India's first research station 'Dakshin Gangotri' is being monitored every year to record the accumulation and ablation of snow in that area. Although the area covered by stakes is only 10,000 sq metres (Singh et al., 1988), the pattern of fluctuation of surface level is interpreted at present for a very large area which is flat and free from obstructions.

The exposed height of stakes numbered 1 to 9 were measured in January '92, March'92, November'92 and February'93 (Table I). Stake no.7 has completely disappeared needing a replacement. Taking data of March, 1991 as base, ablation and accumulation at these stake locations have been calculated. A cumulative account of accumulation is presented in Table II taking into account the density of shelf ice as 0.37 gm cm^{-3}. In Table III are calculated season wise accumulation/ablation between January'92 and February'93. Clearly, the net accumulation of 16.69 gm cm^{-2} W.Eq. during austral summer of 1992 is phenomenal. It is also seen that the net accumulation of 2.17 gm cm^{-2} is far less during the following summer of 1992-93. Even an accumulation of 9.27 gm cm^{-2} during austral winter of 1992 is significantly less compared to the summer accumulation of the same year.

Fig 3 shows a composite picture of trend surfaces, drawn by computer using SURFER Access System version 4.04, for the levels of snow measured between January'92 and February'93. These are drawn with the reference base of March, 1991. The high degree of accumulation between January'92 and March'92 is in sharp contrast to the ablation recorded between October, 1990 and March '91 (see Ravindra et al.,1994). This unusual accumulation of snow is attributed to very bad weather condition during the period which included a number of blizzard days (Table IV of Koppar,1995 - this volume) in early March'92.

Table I: Exposed Heights of Stakes Fixed on Ice Shelf Near Dakshin Gangotri Station, Antarctica

Date of observation	03.03.91	20.01.92	14.03.92	26.11.92	17.02.93
Sl.No.	Expsd.Ht. (cm)	Expsd.Ht. (cm)	Expsd.Ht. (cm)	Expsd.Ht. (cm)	Expsd.Ht. (cm)
1	278.00	273.00	206.50	180.00	182.00
2	288.00	283.00	216.50	182.00	175.00
3	296.00	276.50	215.50	199.00	186.00
4	306.00	245.50	208.00	197.00	190.00
5	279.00	192.50	232.50	187.00	172.00
6	292.00	257.50	211.50	188.00	184.00
7	36.00				
8	300.00	264.00	211.50	188.00	180.00
9	282.00	267.50	196.50	177.00	182.00

Table II: Cumulative Snow Accumulation in W.Eq. at Each Stake Calculated taking Data of March 1991 as Base, (Ref. Table I). Mean Density of Snow Taken as 0.37

Stake No.	Jan-92 (gm/cm^2)	March-92 (gm/cm^2)	Nov-92 (gm/cm^2)	Feb-93 (gm/cm^2)
1	1.85	26.45	36.26	35.52
2	1.85	26.45	39.22	41.81
3	7.22	29.78	35.89	40.70
4	22.39	36.26	40.33	42.92
5	32.01	17.20	34.04	39.59
6	12.77	29.78	38.48	39.96
7	13.32	13.32	13.32	13.32
8	13.32	32.74	41.44	44.40
9	5.37	31.63	38.85	37.02

Base as 3.3.91

Table III: Stakewise Seasonal Accumulation/Ablation of Snow in W.Eq. Over Ice Shelf

Stake No.	austral summer Jan 92 - March 92 ($gm\ cm^{-2}$)	austral winter March 92-Nov 92 ($gm\ cm^{-2}$)	austral summer Nov 92-Feb 93 ($gm\ cm^{-2}$)
1	24.60	9.80	-0.74
2	24.60	12.76	2.59
3	22.57	6.10	4.81
4	13.87	4.07	2.59
5	-14.80	16.83	5.55
6	17.02	8.69	1.48
7	-	-	-
8	19.42	8.69	2.96
9	26.27	7.21	-1.85
Net Accumulation	16.69	9.27	2.17

In Fig 2 the contour diagrams showing snow accumulation at these stakes, are presented. Unlike the observation made by Singh et al.(1988) no relation-

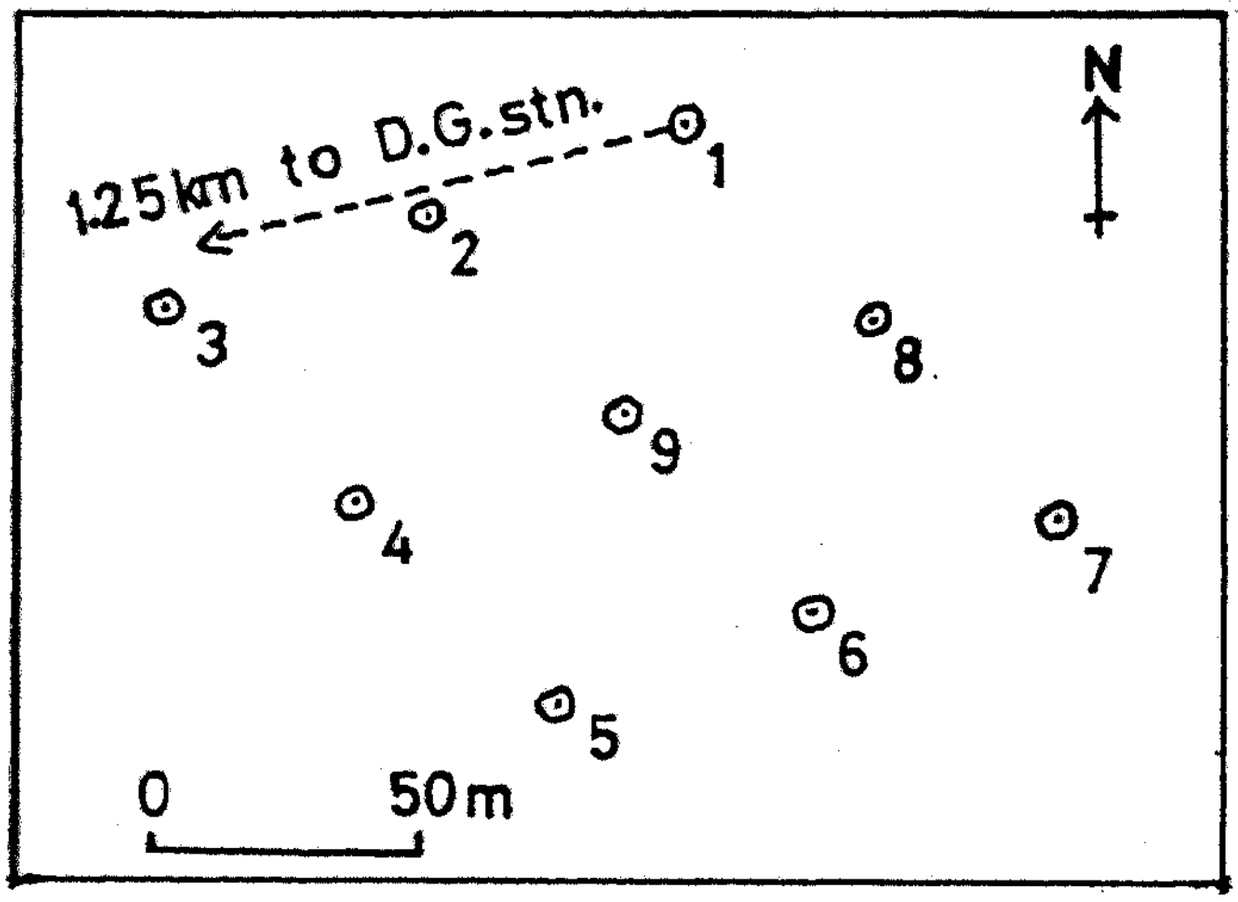
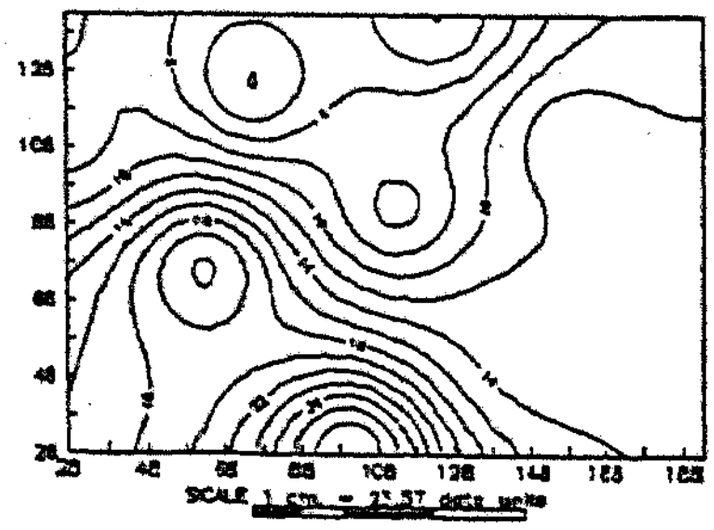


Fig 1: Location of stakes (numbered 1 to 9) on ice shelf new Dakshin Gangotri station, Antarctica, (after Singh et al., 1988)



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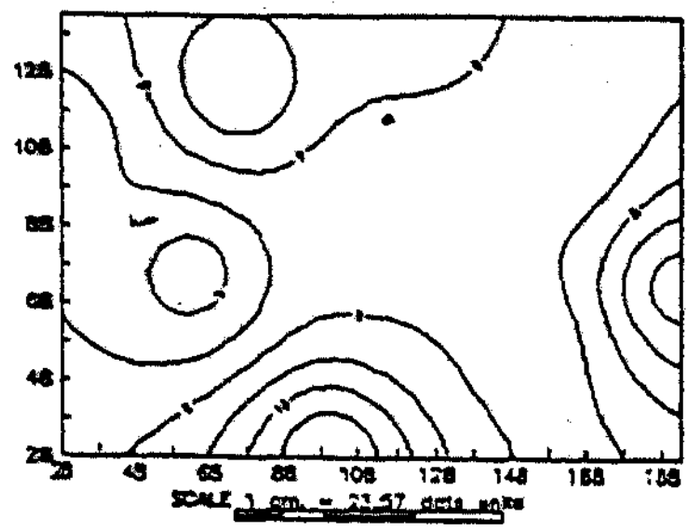

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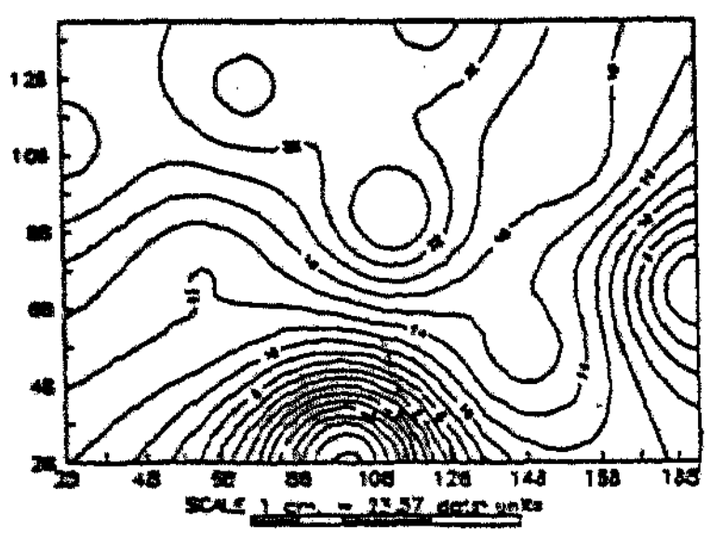

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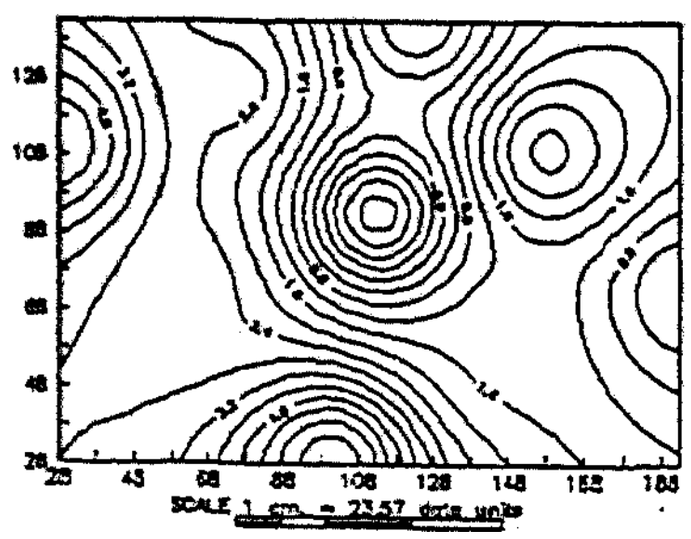

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Fig 2 : Contour diagrams to show snow accumulation/ablation patterns over shelf ice - based on data from Table II

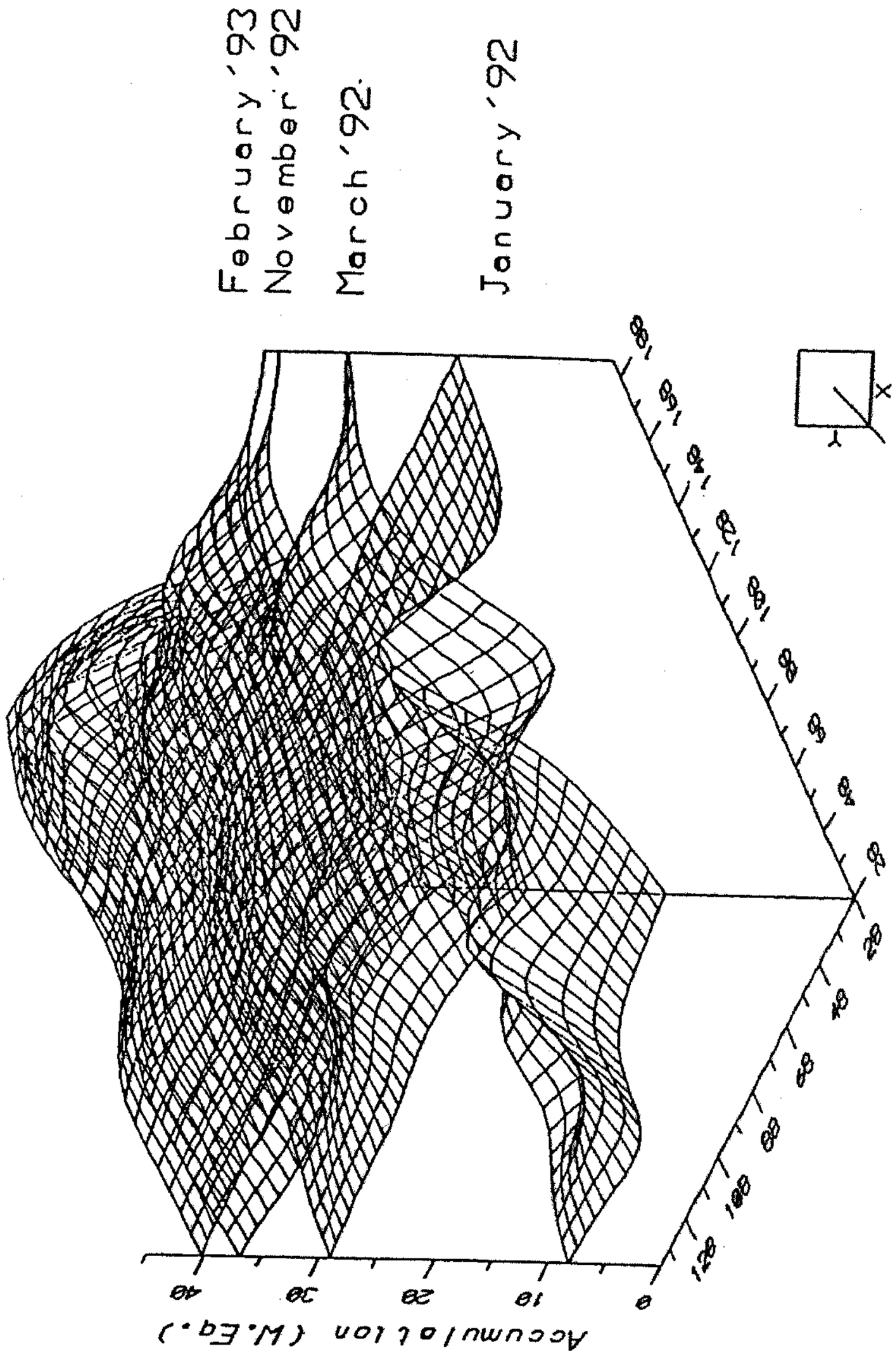

Fig 3 : Composite picture of trend surfaces showing accumulation over shelf ice.

ship could be drawn between prevailing wind direction and the pattern shown by these contours due to non-availability of wind data from the area of study which lies ~ 100 kms away from Maitri station. However, if ablation troughs are any indication of prevailing wind direction (Singh et al.,1988), the present contour diagrams show an erratic wind pattern which is a common phenomenon in coastal areas during bad weather days.

Secular movement of polar ice front

Southern margin of Schirmacher.Oasis is overridden by the polar ice front, fluctuation of which along the ice-rock interface makes an interesting study. To keep a watch on the secular and temporal movement of ice in this interface area, a projection or tongue of the cap ice named "Dakshin Gangotri Glacier" (Kaul et al.,1985) is being regularly monitored since 1983 austral summer. During the austral summer of 1992 the snout boundary of the glacier and the outline of its proglacial lake were mapped by using Electronic Distance Measurement (EDM) unit in collaboration with Survey of India.

Fig 4 shows the present limit of the glacier snout and the lake alongwith their positions during austral summers of 1983, 1986, 1987 and 1989. An

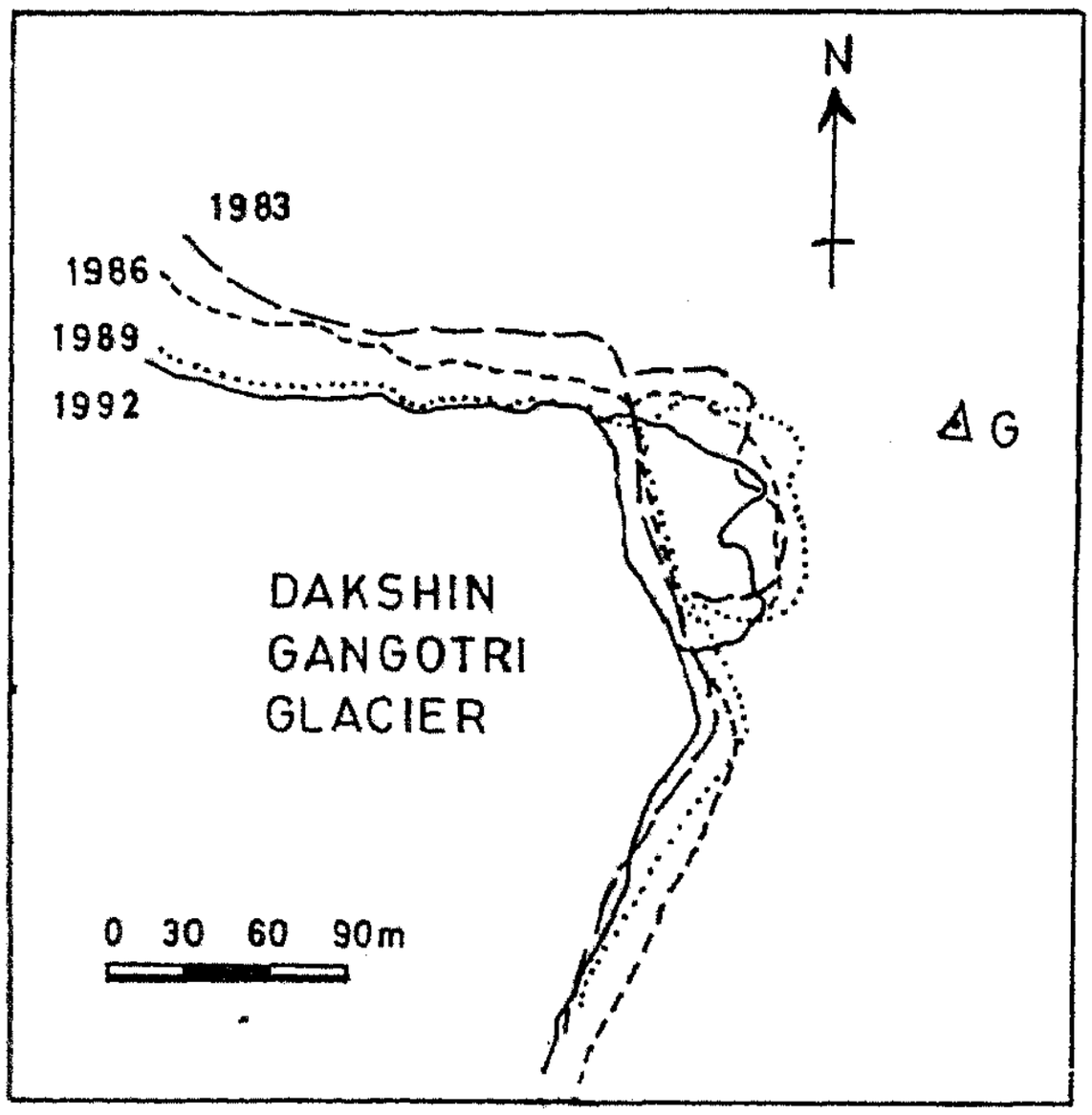

Fig 4 : Year wise position of the Dakshin Gangotri Glacier snout. 'G' is fixed reference point for all measurements

oscillatory trend of the glacier margin has been noticed by earlier workers (Kaul et al.,1988 and Ravindra el al.,1994). However, 1992 position of the outline shows a marked recession of the ice body in both its northern and southern flanks and also at its frontal portion except for a very small advancement in part of its southern flank if compared to 1983 position. If three yearly movement of glacier body is taken into account it is very interesting to find that between 1986 and 1989 the glacier body vacated an overall area of approximately 2600 m^2 which is remarkably close to the figure of approximately 2520 m^2 that was further exposed between 1989 and 1992. In both these three year periods there has been recession on either flank of the glacier tongue. Between 1983 and 1986 however, the glacier retreated only at its northern flank leaving exposed an identical area of 2529 m^2 although the net change during that period was only of the order of - 343 m^2 (Kaul et al., 1988).

Iceberg monitoring

Iceberg monitoring in the southern ocean waters was carried out as per the guidelines of Norwegian Polar Institute. The observations are made as a routine, mainly to provide base level information on iceberg concentration in southern seas for the ships navigating in that part of our planet. The icebergs are located both visually and on radar screen of the expedition ship. During austral summer of 1991-92 a total of 88 icebergs were observed between 51°12'S and 62°19'S latitudes. As observed by Ravindra et al.(1994) two zones of concentration of icebergs were noticed. While one was between the latitudes mentioned above, other one was south of 68°S latitude near Antarctic coast (Fig 5). Ravindra et al.(1994) noticed an iceberg free zone between 61° and 68°S latitudes. We found it slightly narrowed down between 63° and 68°S latitudes. This is reflected in Fig 6 which also shows maximum concentration of 59 icebergs between 59° and 61°S latitudes. In 1989-90 similar concentration was noticed between 57° and 58°S latitudes (Ravindra et al.,1994). Ravindra et al.(1994) have shown how the first sighting of iceberg in this sector has moved further north with every passing year. The trend continues as during the eleventh expedition first iceberg was seen at 51°12'S latitude compared to 51°23'S during the ninth expedition. The longitudes in these two cases were 34°I4'E and 32°50'E, respectively. No data is available for the iceberg sighting during the tenth expedition. In March 1993 when the winter team of eleventh expedition was returning home an eroded and tilted iceberg was noticed along the coast of Marion Island at 47°S (Fig 7). South African scientists camping at the island informed us over the radio that there were many more icebergs on the other side of the island, not visible to us.

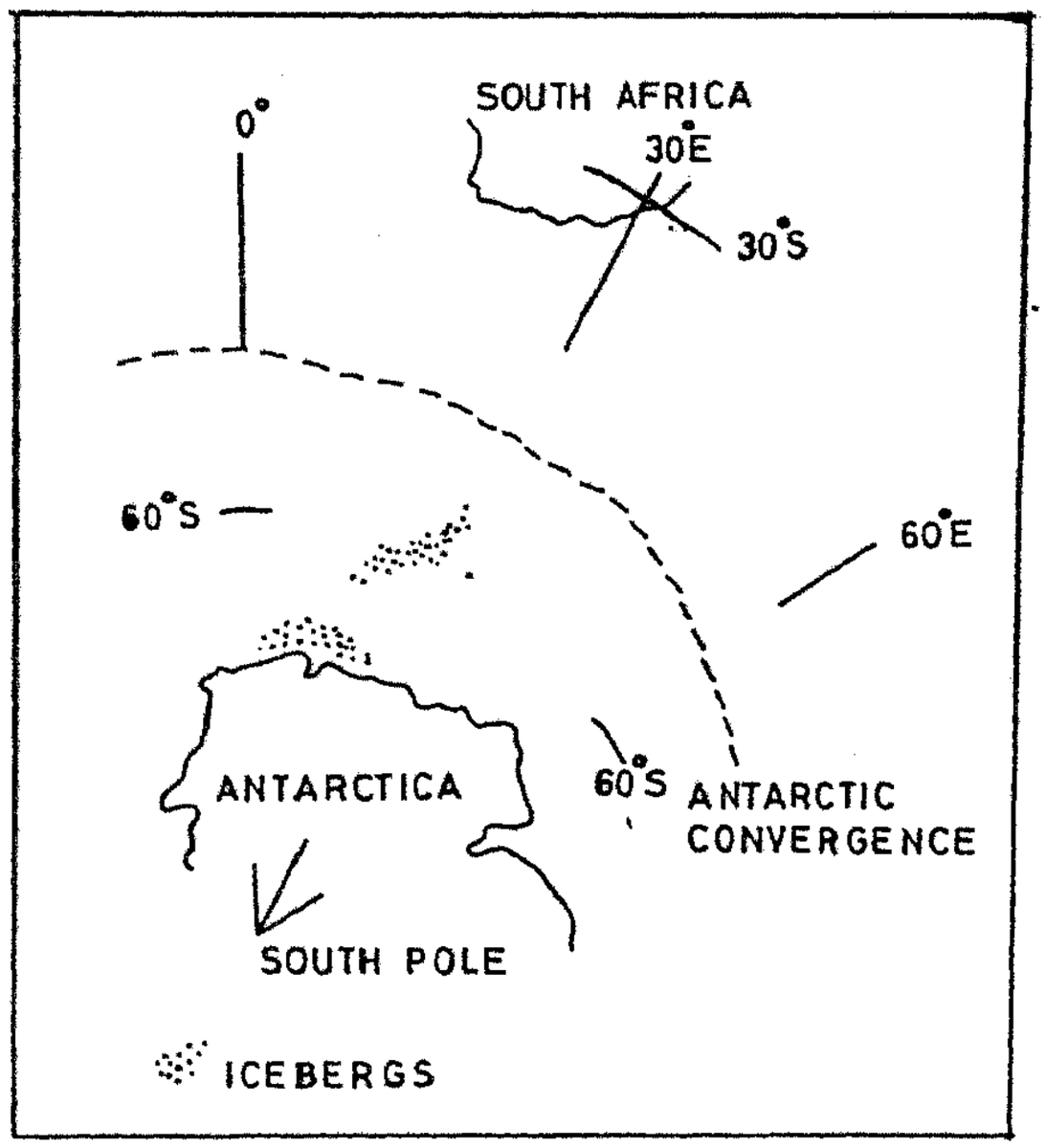

Fig 5 : iceberg concentrations as noticed during onward journey to Antarctica (1991-92)

Conclusion

From the informations recorded above, interesting facts have emerged, like changes in the accumulation pattern over shelf ice, albeit in a small area of observation; startling resemblance in the data obtained showing recession of Dakshin Gangotri Glacier when three yearly calculations are taken into account and a progressive northward shift in the boundary of Antarctic icebergs. It will he worthwhile to extend these studies over wider areas with a modern approach for obtaining a regional picture of the processes going on at the ice-atmosphere interface.

Acknowledgement

We would like to thank the members of Survey of India component who carried out the EDM measurements for snout monitoring during austral summer of 1991-92. To our colleague Shri M.J.Beg we owe the computerised drawings and calculations made from the field data, a tedious-job turned into a simple affair for us.

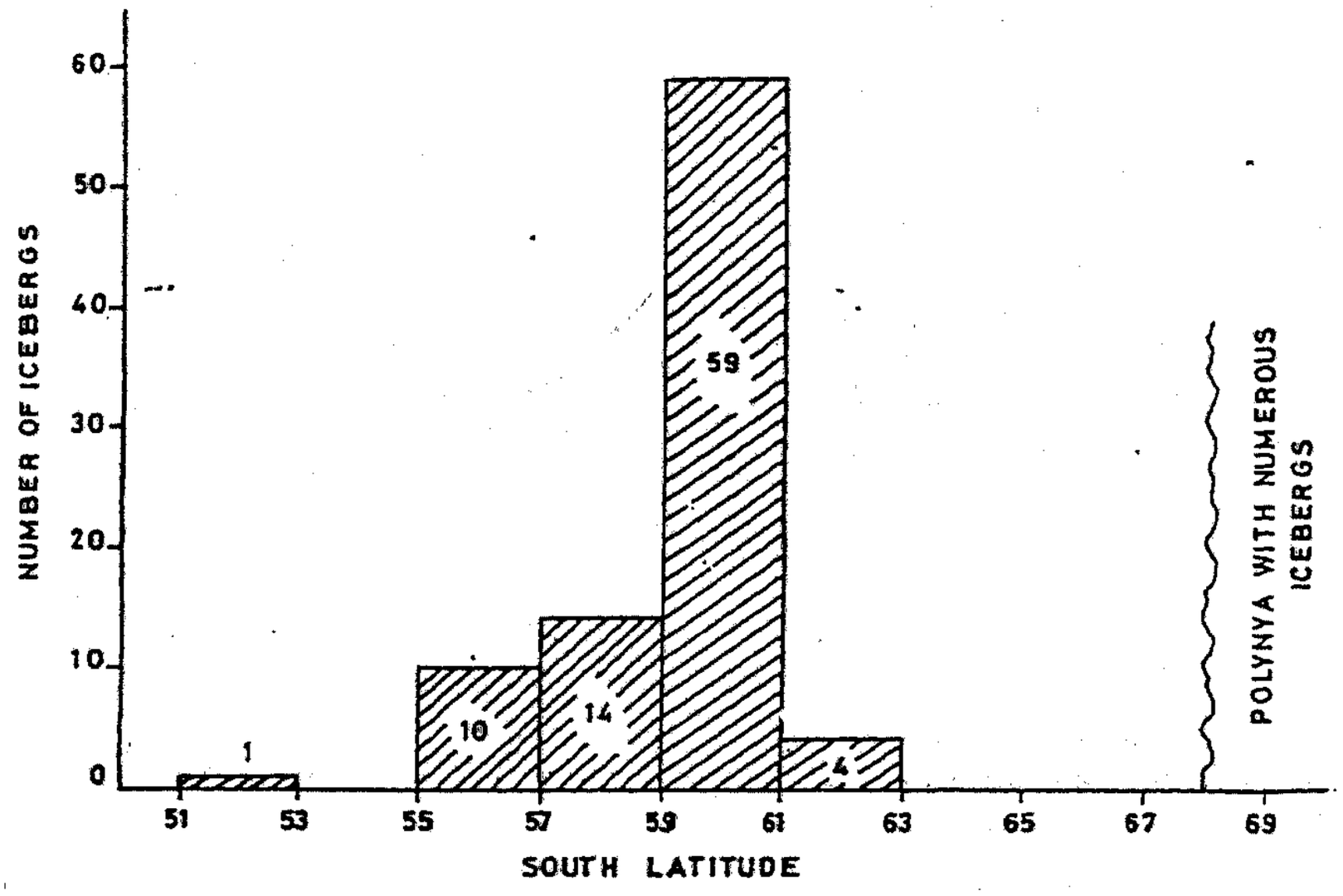

Fig 6 : Distribution of icebergs in Antarctic waters recorded during onward journey Eleventh Expedition (1991-92)

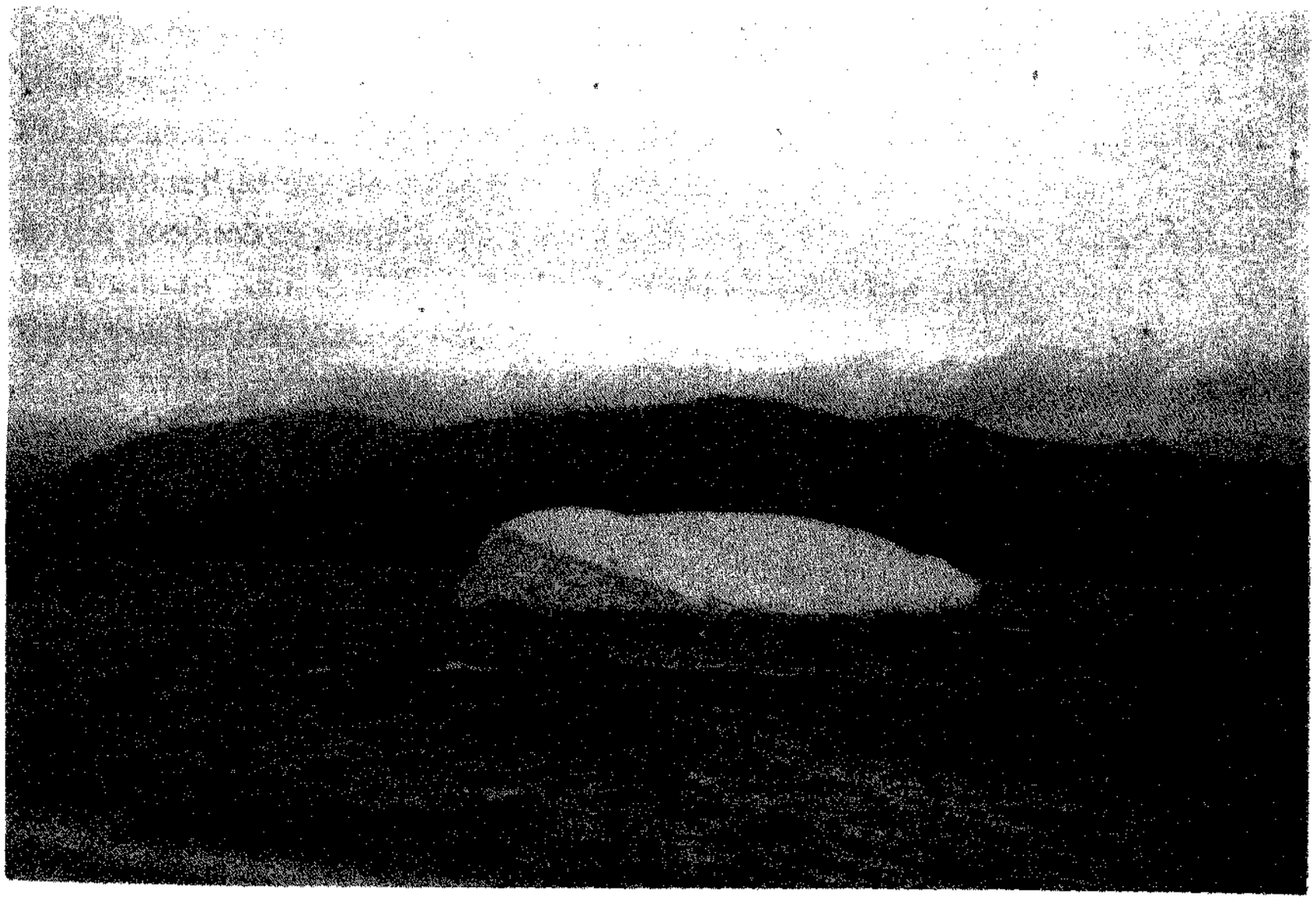

Fig 7 : Photograph showing tilted iceberg at the coast of Marion Island at 47°S latitude.

Thanks are due to Captain and crew of MV Thuleland for allowing us to use ship's bridge and radar at our will to make observations on icebergs.

Our colleague Shri M.P.Gaur has helped with the plottings and drawings. We are grateful to Shri M.K.Kaul, Director, Antarctica Division, GSI for his enthusiasm and encouragement which helped in bringing out this note in black and white.

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