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Fluctuations in the Surface Profile of a Part of Ice Shelf in Central Dronning Maud Land, East Antarctica

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Abstract

The data pertaining to the surface level variations of the shelf ice near Dakshin Gango$ri Station, Central Dronning Maud Land, East Antarctica for a period of four years from March 1990 to February 1994 has been evaluated to find out behavioral pattern of the shelf-ice and also to establish a relationship between the rate of growth (snow accumulation/ ablation) of the shelf-ice and the seasonal variations, so that the same could be applied for short and long term prediction of the seasonal changes in and around the area of study.

It has been found that the annual rate of accumulation of snow (mainly due to precipitation) is +18.71 gm/cm of water equivalent which has a strong seasonal bias; very high (+2.22 gm/cm^2/month) from January to June and low (+0,89 gm/cm^2/month) during rest of the year.

Introduction

The surface level measurements of the shelf ice near Dakshin Gangotri Station, Central Dronning Maud Land, East Antarctica were carried out in February 1994 during the thirteenth Antarctic expedition as part of the ongoing programme of GSI The studies were initiated in 1983 during the second expedition (Kaul *et al„* 1985) but, the regular monitoring for trie behaviour of the snow surface in terms of level variation due to accumulation/ ablation studies started only during the film expedition (Singh et al., 1988). A set of nine stakes were fixed in a rhombic grid pattern at intervals of 50 m in a 100 x 100 m area, free from obstructions (Fig. 1).

In the beginning, these stakes could be monitored on fortnightly and monthly basis because of their proximity to the Dakshin Gangotri Station. Later on, after the DG station was closed, these stakes have been monitored only during visits to DG station with convoys for logistic requirements. Due to various constraints such visits have not been made at regular intervals.

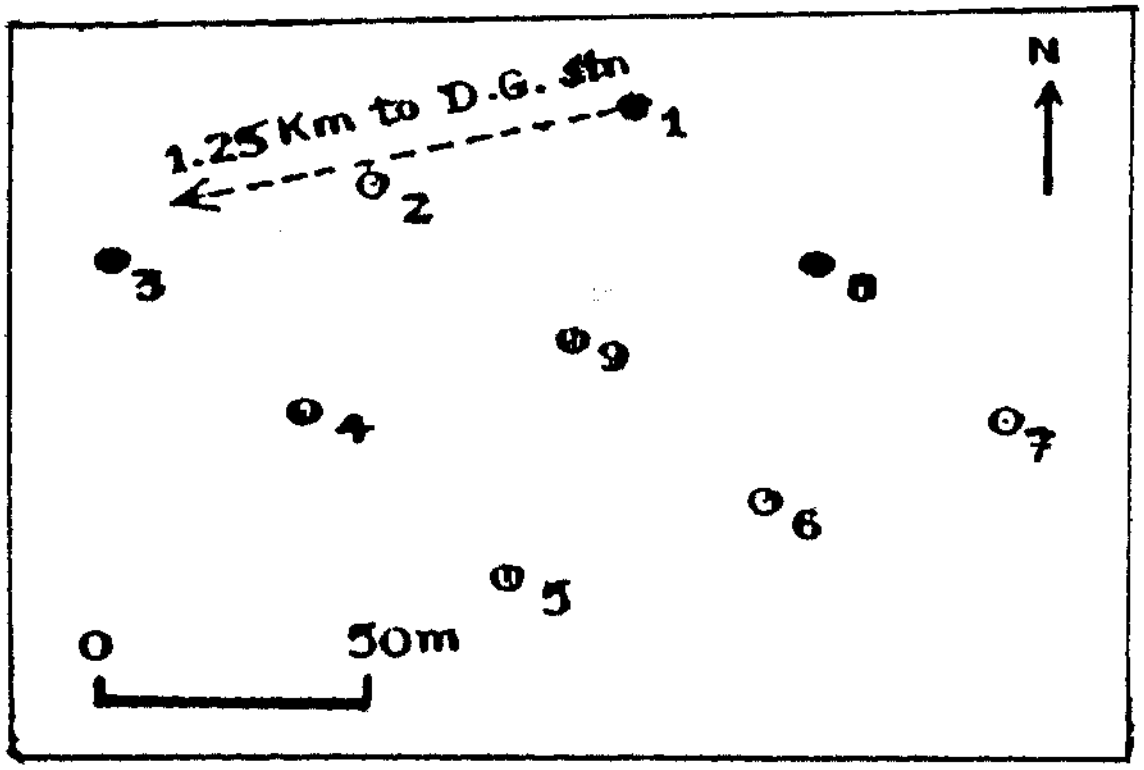

Fig. 1

Date Analysis

The data given in Table 1 show stakewise relative snow accumulation in water equivalent from March 1990 to February 1994. Accumulation is shown by +ve values and ablation by -ve values. Following Singh et al. (1988) the density of snow (0.37) at ice shelf is taken as the factor to convert vertical accumulation snow into water equivalent i.e., gm/cm^2. Stake No.7 shows null values from March 1992 onwards as it was broken and completely buried and no data could be obtained.

The average relative snow accumulation has been calculated using data of all the stakes exposed during the period. The data so obtained are cumulated for the entire period," taking March 1990 as the base to determine the absolute accumulation or the actual rise in the surface level of the ice shelf. The cumalative rise in the surface level of the ice-shelf has been plotted against time (months) on an X-Y scatter plot in Fig. 2. In this figure-

(i) Every data point has been characterised by a Y-error bar indicating maximum and mimmum accumulation (+ve or -ve).

(ii) The second order polynomial best fit curve with R2=0.965 (measure of reliability) for the period indicates that the level of the ice-shelf is progressively rising.

Table 1: Snow Distribution on Individual Stakes(gm/cm^2)

Stake No.	Mar-90	May-90	Aug-90	Sep-90	Oct-90	Mar-91	Jan-92	Mar-92	Nov-92	Feb-93	Jul-93	Sep-93	Oct-93	Nov-93	Feb-94
1	9.25	3.33	4.07	0.74	5.18	-5.92	1.85	24.61	9..81	-0.74	20.35	0.37	0..00	4.44	2..96
2	4.81	9.62	2.59	1.11	1.85	-11.10	1.85	24.61	12.77	2.59	19.61	-1.48	-0..37	3..70	2..59
3	4.44	5.92	2.59	0.74	6.29	-12..21	7..22	22.57	6..11	4.81	12.58	7.77	-0..37	3.70	2,59
4	2.96	10.73	4.44	1.11	1.85	-10.36	22..39	13.88	4.07	2.59	16.28	-2.22	1..48	1.48	1..11
5	2.22	14.06	4.07	0.74	0.37	-5.18	32..01	-14.80	16..84	5.55	12.95	5.18	-0.7 4	0..37	2,22
6	5.18	4,81	2.58	0.74	1.11	-8.88	12.77	17.02	8.,70	1.48	23.31	-0.37	-1.4 8	3..70	2.96
7	1.85	15.17	0.00	0.74	0.00	-11.84	13 .32								
8	7.03	4.07	9..25	0.00	-0.37	-10.,73	13.32	19.43	8..70	2.96	15.17	-1.11	-0.7 4	10..36	2 96
9	2.22	8.14	10.73	0.37	1.11	-5.18	5..37	26.27	7.	-U 5	18.50	1.48	-1.85	3..70	2 59
Avg.	4.44	8.43	5.59	0..70	1.27	-9.04	12 . 3	W.70	9.27	2.17	17.34	1.20	-0.51	3,,93	1.76
Max.	9.25	15.17	12.58	1.11	6.29	-5.18	32.01	26.27	16.84	5.55	23.31	7.77	1,,48	10.,36	2 96
Min.	1.85	3.33	0.00	0.00	1.85	-12.21	1.8 5	-14.80	4.07	-1.85	1258	-2.22	-1.85	0.,37	2.96
Average Cumulative Accumulation (gm/cm^2) with Max & Min															
Cum~Avg	4.44	128I7	18.46	19.16	20.43	11..39	23.,62	40.31	49.59	51.76	69.11	70.31	69.80	73.,73	75.49
CumAvg+Max	13.69	28.04	31.04	20.27	26.72	6.,21	55,,62	66.58	66.42	57.31	9242	78.08	71.28	84.09	78.45
CunLAvg-Min	2.59	9..54	18..46	19.16	18.58	-0.,82	21,,77	25.51	45..52	49.91	56.53	68J09	67,95	73.36	72 53

(Data from March 1990 to March 1991 after RJtavindra *etal.,* 1994 and from January 1992 to February 1993 after SMukerji *et* a/. 1995)

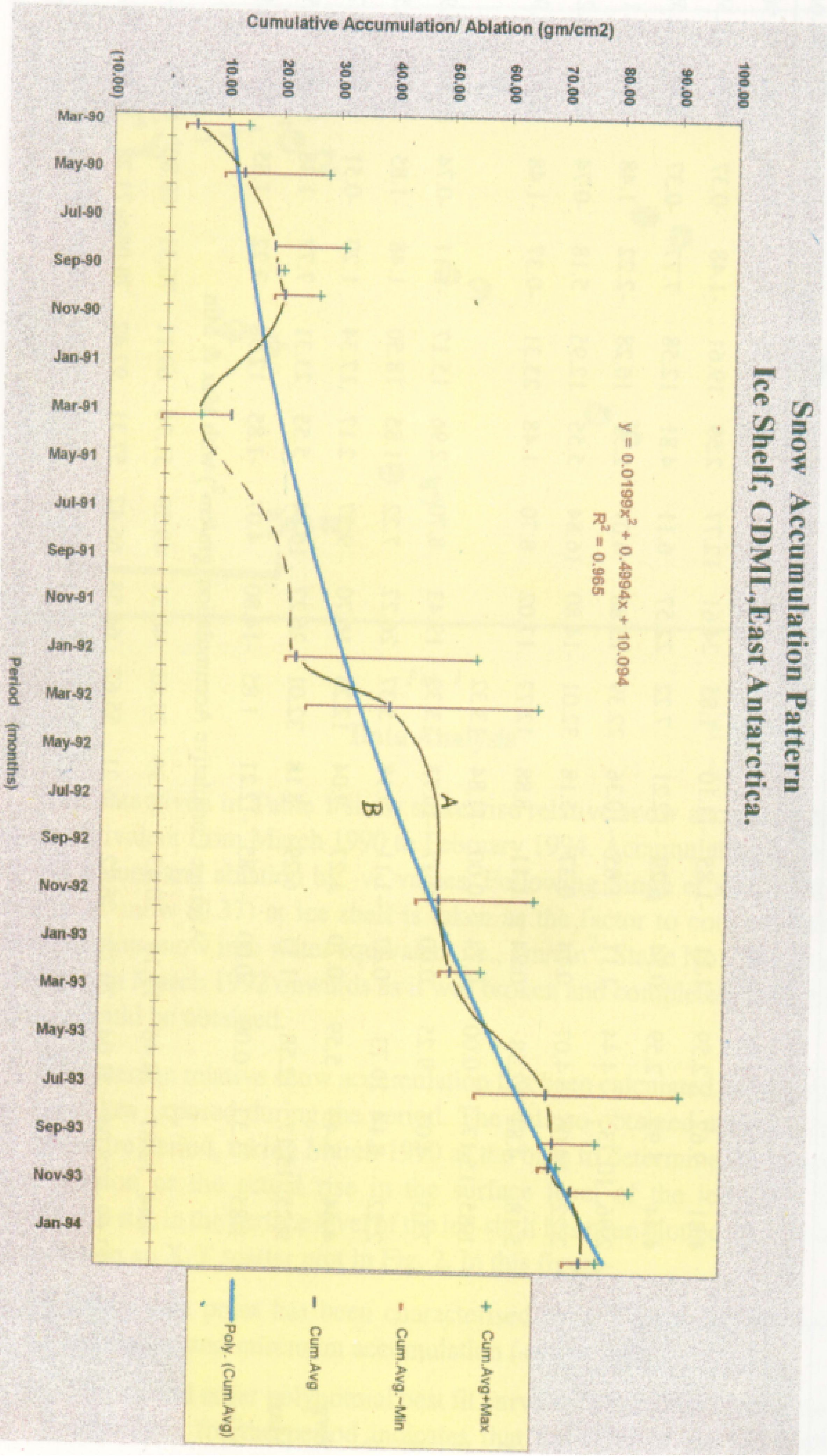
Snow Accumulation Pattern
Ice Shelf, CDML,East Antarctica.
Cumulative Accumulation/ Ablation (gm/cm2)
100.00
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
(10.00)
y = 0.0199x2 + 0.4994x + 10.094
R2 = 0.965
A
B
Mar-90
May-90
Jul-90
Sep-90
Nov-90
Jan-91
Mar-91
May-91
Jul-91
Sep-91
Nov-91
Jan-92
Mar-92
May-92
Jul-92
Sep-92
Nov-92
Jan-93
Mar-93
May-93
Jul-93
Sep-93
Nov-93
Jan-94
Period (months)
Cum.Avg+Max
Cum.Avg.-Min
Cum.Avg
Poly. (Cum.Avg)

Fig. 2

(iii) A free hand curve 'A' highlights a cyclic pattern suggesting that the rate of growth is not uniform and has a seasonal bias.

(iv) The rate of growth is indicated to be more from January to June and less during the rest of the year.

(v) The average rate of growth calculated for the peak months is +2.22 gm/cm^2/month whereas, during the lean period it is +0.89 gm/cm^2 /month. The calculated average annual rate of growth is +18.71 gm/cm^2.

Discussion

The curve 'A' (Fig. 1) clearly indicates that the growth pattern has a strong temporal bias, encompassing different segments of the year. During the polar summer, i.e., from 1st November to 31st March (Ravindra *et al.,* 1994) due to long hours of day light the temperature rises and reaches its peak during January (Singh and Kulandaivelu, 1994 and Koppar, 1995). This causes a rise in the humidity initiating some amount of precipitation (snow fall) in coastal areas. The precipitation continues till June (under the influence of increased humidity) though the temperature starts dropping from January onwards. From July to December the precipitation is negligible and marks the lean period making the rate of growth very sluggish.

In addition to the drift snow playing a role in altering the surface profile of the shelf ice as reported earlier (Mukerji *et al.,* 1995), it is evident from curve 'A' that the rate of growth is controlled strongly by the temporal changes during the calender year.

The gradient of the best fit polynomial curve 'B' between March'91 to Feb'94 indicating that the rate of growth has increased after March'91. This suggests that the Summer of 1990- 91 (1st November 1990 to 31st March 1991) was severe compared to the following summers (upto February 1994). Apparently the gradient of the curve indicates that the growth rate has reached its peak during February'94. It is expected to show a decline in future again corresponding to severe summers. A long term continuous monitoring of stake network at regular intervals on the basis suggested might help in delineating warmer and cooler cycles.

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