The Satellite-Derived Northern Hemisphere Snowcover Record for the Winter of 1977–78

DONALD R. WIESNET AND MICHAEL MATSON

NOAA/National Environmental Satellite Service, Washington, DC 20233

(Manuscript received 5 July 1978, in final form 19 March 1979)

ABSTRACT

NOAA satellite-derived snowcover data for the winter of 1977–78 are presented. Comparison with the 12-year satellite snowcover record shows 1) a record-high North American winter snowcover, exceeding the expected variability; 2) a record-high Eurasian winter snowcover, within the expected variability; and 3) a record-high Northern Hemisphere winter snowcover, exceeding the expected variability. The satellite data provides timely monitoring of continental snowcover, which may in turn serve as an index of winter severity and climatic fluctuation.

1. Introduction

The satellite "climatology" of Northern Hemisphere snowcover consists of a fairly short period, i.e., from December 1966 to the present. Three years ago Wiesnet and Matson (1976) published a paper that demonstrated the value of satellite-derived monthly mean snowcover data. Subsequent papers (Kukla *et al.*; 1977; Matson, 1978) have extended the measurements until now a full set of data on snowcover for the Northern Hemisphere and its two continents, Eurasia and North America, has been completed for each month[1] since December 1966. It is this set of monthly mean snowcover data that we refer to as a "climatology." Monthly mean snowcover charts are constructed by transferring the snow boundary on each NOAA/NESS Weekly Snow and Ice Chart onto an overlying sheet of tracing paper, the process being repeated for subse-

[1] Data for December 1967 and January 1968 have been reconstructed from previously unobtainable satellite images and Weekly Snow and Ice Cover Charts.

TABLE 1. Monthly mean winter snow-cover extent ($\times 10^6$ km^2).

Month	1966	67	68	69	70	71	72	73	74	75	76	77	78	10-Year $\bar{X}$	10-Year S
								Eurasia							
Jan		24.3	27.2	25.1	24.6	26.2	29.5	29.8	27.3	26.2	27.4	30.2	28.9	27.0	2.1
Feb		25.1	31.0	24.1	22.5	28.8	31.3	30.0	27.5	25.5	28.0	29.3	29.7	27.4	3.0
Mar		23.0	20.3	24.6	19.1	26.2	25.2	23.8	22.6	24.0	25.8	23.0	25.2	23.5	2.3
Dec	22.6	25.5	23.1	20.0	23.4	25.1	26.2	25.1	22.4	25.2	26.1	27.8		24.0	2.1
								North America							
Jan		15.1	16.0	16.6	16.7	16.0	15.9	15.9	16.4	16.2	16.2	17.1	17.4	16.2	0.5
Feb		15.9	14.8	16.1	15.0	16.2	15.3	16.1	15.4	16.2	15.8	15.7	17.6	15.7	0.5
Mar		14.2	12.7	15.1	13.7	15.0	14.2	13.4	16.4	14.9	14.7	14.1	15.2	14.3	1.0
Dec	14.7	13.8	14.9	12.8	15.1	15.7	16.2	15.0	14.5	15.8	15.4	15.1		15.0	0.9
								Northern Hemisphere							
Jan		39.4	43.2	41.7	41.3	42.2	45.4	45.7	43.7	42.4	43.6	47.3	46.4	43.2	2.3
Feb		41.0	45.8	40.2	37.5	45.0	46.6	46.1	42.9	41.7	43.8	45.0	47.3	43.1	3.0
Mar		37.2	33.0	39.7	32.8	41.2	39.4	37.2	39.0	38.9	40.5	37.1	40.4	37.9	2.9
Dec	37.3	39.3	38.0	32.8	38.5	40.8	42.4	40.1	37.0	41.0	41.5	42.9		39.0	2.9

True surface-area correction constants used to update Matson (1977): Eurasia: $+3.7 \times 10^6$ km^2; North America: $+1.3 \times 10^6$ km^2; Northern Hemisphere: $+5.0 \times 10^6$ km^2.

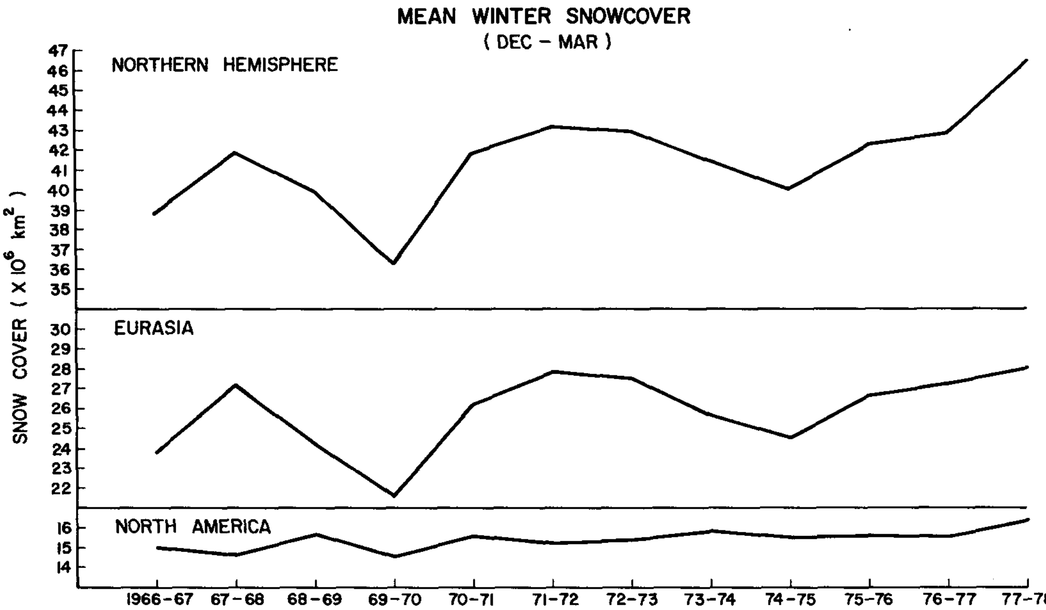

FIG. 1. Graph of mean winter snowcover for the Northern Hemisphere, Eurasia and North America from 1966–1978.

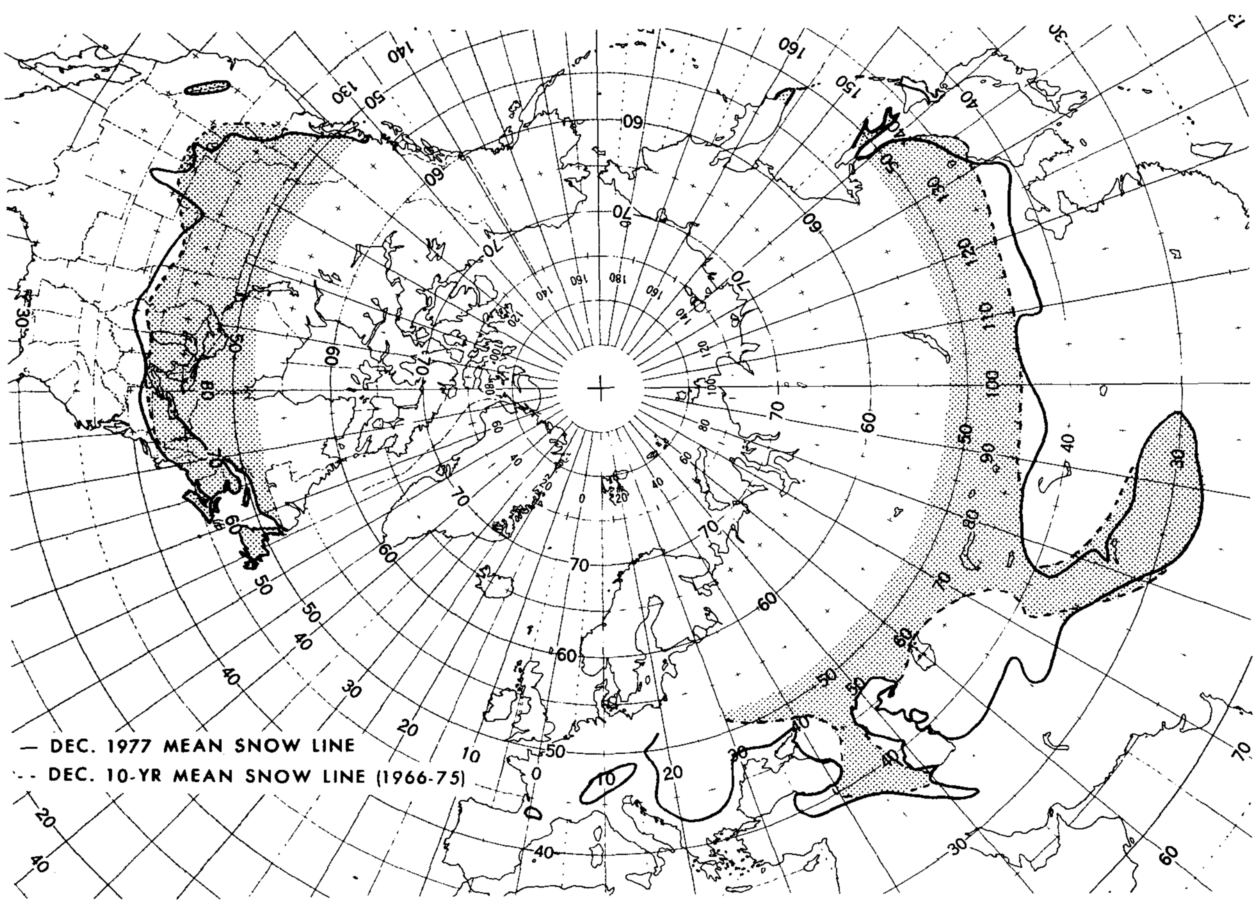

FIG. 2. Northern Hemisphere December 1977 mean snow line versus Northern Hemisphere December 10-year mean snow line. Due to lack of sufficient solar illumination for satellite visible data, the snow line is terminated at 52°N.

quent weeks of each month. The weekly overlay sheets were then superimposed and registered with another sheet of tracing paper on which was traced out an average monthly snowcover boundary. Climatologists, both in the United States and abroad, have indicated in personal communications that these data are useful to them in their studies. Various checks and validation experiments (Wiesnet and Matson, 1976) indicate that continental snowcover mapping is within the 5% error specified by various authorities as the desired accuracy.

This snowcover climatology now includes maps for each month since 1966, maps showing the winter (i.e., December, January, February and March) 10-year mean monthly snowline, and tables showing the area (km^2) covered by snow. The purpose of this paper is to examine the extensive snowcover of the winter of 1977–78 in the context of the snowcover climatology of the past 12 years in order to see what trends or changes may be in evidence. A secondary purpose is to provide a new table of winter snowcover areas that has been corrected to show true surface-area coverage. The areas in Table 1 differ from those in Matson (1977) by constants that are also listed.

2. Snowcover record for the winter of 1977–78[2]

a. Eurasia

The mean monthly snowcovered area in Eurasia in December 1977 was 27.8 × 10^6 km^2, 16% above the 10-year December mean (24.0 × 10^6 km^2). It was the largest areal coverage recorded for any December for the period (1966–77). In January 1978, the snow-covered area increased to 28.9 × 10^6 km^2, but this was only the fifth highest January of record. This amount was less than in January 1977, but the figure was still 7% above the 10-year mean. The February 1978 Eurasian snowcover was determined to be 29.7 × 10^6 km^2, 8% above average, but February 1968, 1972 and 1973 were greater. March 1978 snowcover, 9% above the 10-year mean, was the third highest of the satellite record. Of the four winter months, however, only December snowcover exceeded one standard deviation of the 10-year mean.

Summarizing, Eurasia experienced an above-average winter snowcover but one which, with the

[2] The measurement technique used to determine snowcovered area is described in Wiesnet and Matson (1976).

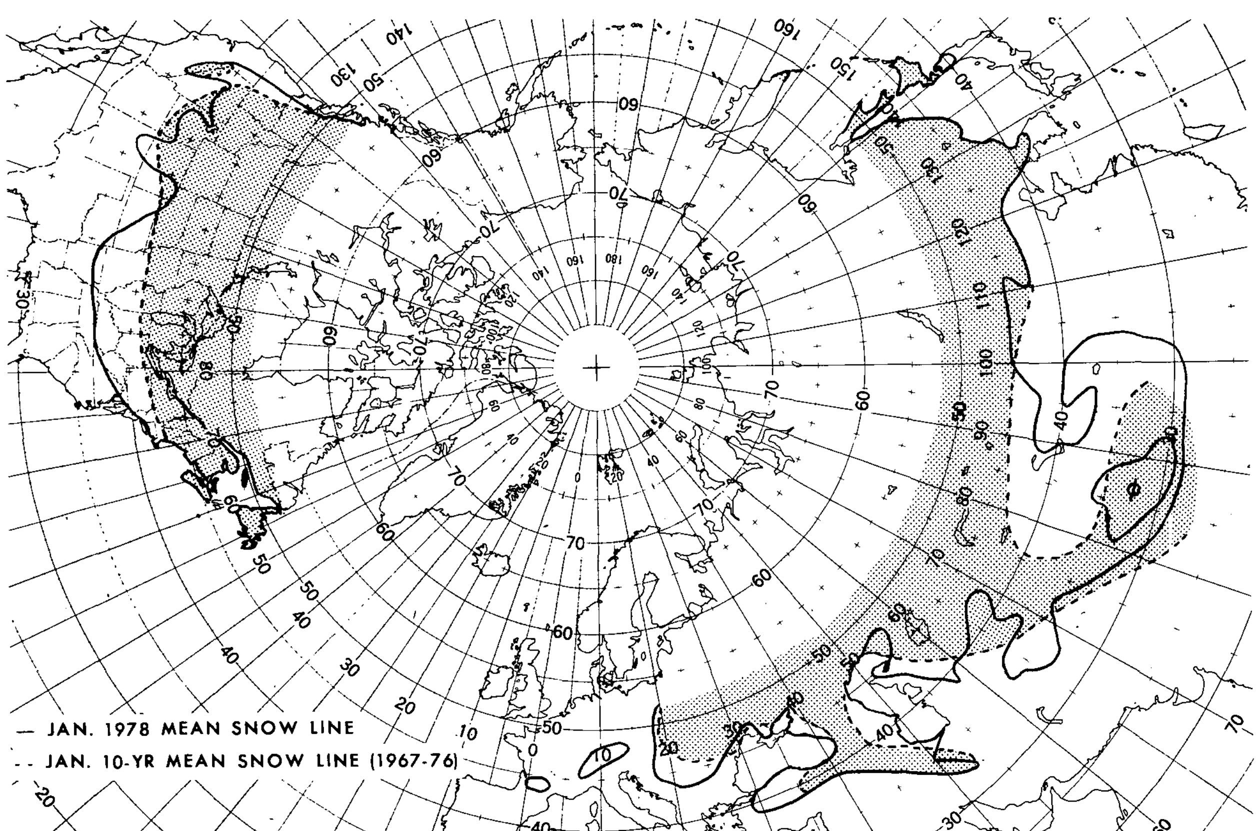

FIG. 3. As in Fig. 2 except for January 1978.

exception of December, was within the expected variability for winter snowcover.

b. North America

The December 10-year monthly mean snowcover for North America is 15.0×10^6 km², and the December 1977 North American snowcover was 15.1×10^6 km²—very close to the mean (within less than 1%). But January snowcover was rather unusual. Bearing in mind that the memorable January weather of 1977 established a new North American snowcover record (17.1×10^6 km²), January 1978 broke that record with 17.4×10^6 km² of snowcover—17% above the mean. February followed with an even greater amount, establishing a new high of 17.6×10^6 km², almost *four* standard deviations (12%) above the 10-year mean (Table 1). Another way of illustrating the magnitude of the February snowcover is to calculate the percent of area exceeding the 10-year mean from Table 1. Thus, for February 1978 the mean monthly snowcover in North America was 12% above the mean, and in Eurasia, it was 8% above the mean.

March 1978 snowcover, unlike 1977, was well above (9%) the 10-year mean. In fact, the 15.6 $\times 10^6$ km² of snowcover exceeded one standard deviation and was the second highest of record. The winter of 1977–78 as a whole produced the greatest snowcover in North America since satellite data collection began in 1966–67.

In summary, an average December snowcover was followed by a satellite-derived 12-year record snowcover in January. This record lasted only one month, as February established a new record. March set no new record but was well above average. All months except December exceeded the expected variability for North American snowcover.

c. Northern Hemisphere

By adding North American and Eurasian snowcover totals we may derive the hemisphere snowcover (Table 1). Time variations of areal snowcover for the Northern Hemisphere (Fig. 1) are heavily influenced by the large variations that occur in Eurasia.

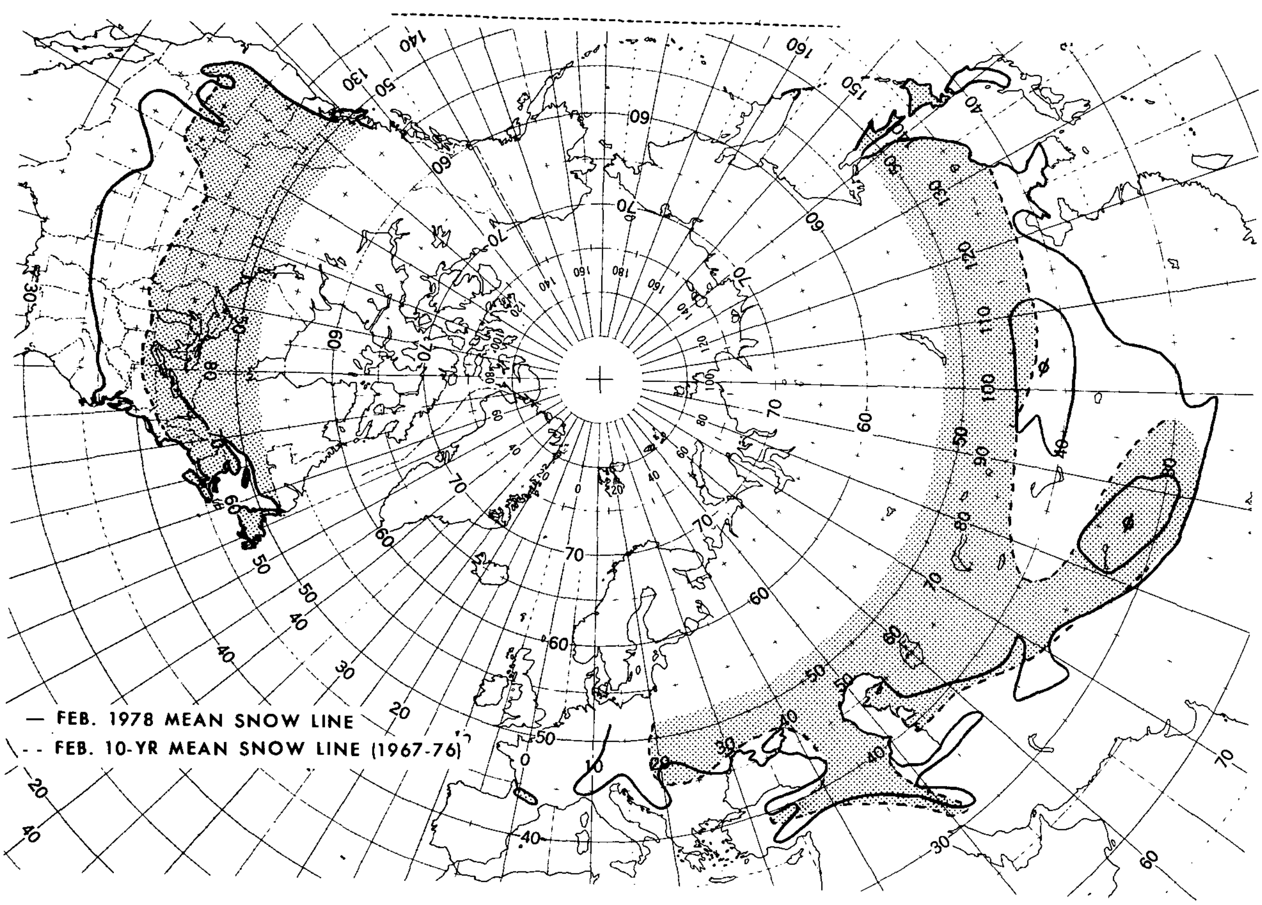

FIG. 4. As in Fig. 2 except for February 1978.

December 1977, as stated previously, experienced a new snowcover high for Eurasia and, as expected, produced a new high for the Northern Hemisphere. January 1978 was above average, but was below the snowcover measured in 1977 and 1968 despite the North American record cover. February's above-average Eurasian snow coupled with North America's 12-year record snowcover was enough to establish February 1978 as the month having the most extensive snowcover in the Northern Hemisphere since the satellite climatology began.

March's near-record snowcover in Eurasia coupled with the North American near-record snowcover came close to the 1971 all-time March high of 41.2×10^6 km^2.

In summary, a record December snowcover plus an all-time record high in February, plus an above-average January added to a near-record March, made the winter of 1977–78 as a whole a record-setting year for snowcover in the Northern Hemisphere. Comparisons of the 1977–78 monthly mean continental winter snowlines south of 52°N with the satellite-derived 10-year mean snowlines are shown in Figs. 2–5.

3. Significance

The citizens of Buffalo, New York, Providence, Rhode Island, or Boston, Massachusetts, would be quick to agree that the past two winters have been harsh. Indeed, not only the public but also climatologists are genuinely—and properly—concerned with possible climatic variations or trends. It is unsettling to everyone to contemplate that the earth's climate might possibly be deteriorating. Respected climatologists, such as Murray Mitchell of NOAA's Environmental Data Service and Stephen Schneider of the National Center for Atmospheric Research, have often pointed out that we have experienced an unusually stable (though generally cooling) period of climate from the 40's to the early 70's, and that it is "normal" for climate to be more variable (Schneider, 1976, pp. 4–5; Mitchell, personal communication).

We do not, at this time, have any desire to enter the climatological arena in which the question of long-term global heating or cooling is being debated. However, we think that our development of this new set of hemispheric and continental snowcover data based on satellite measurements has

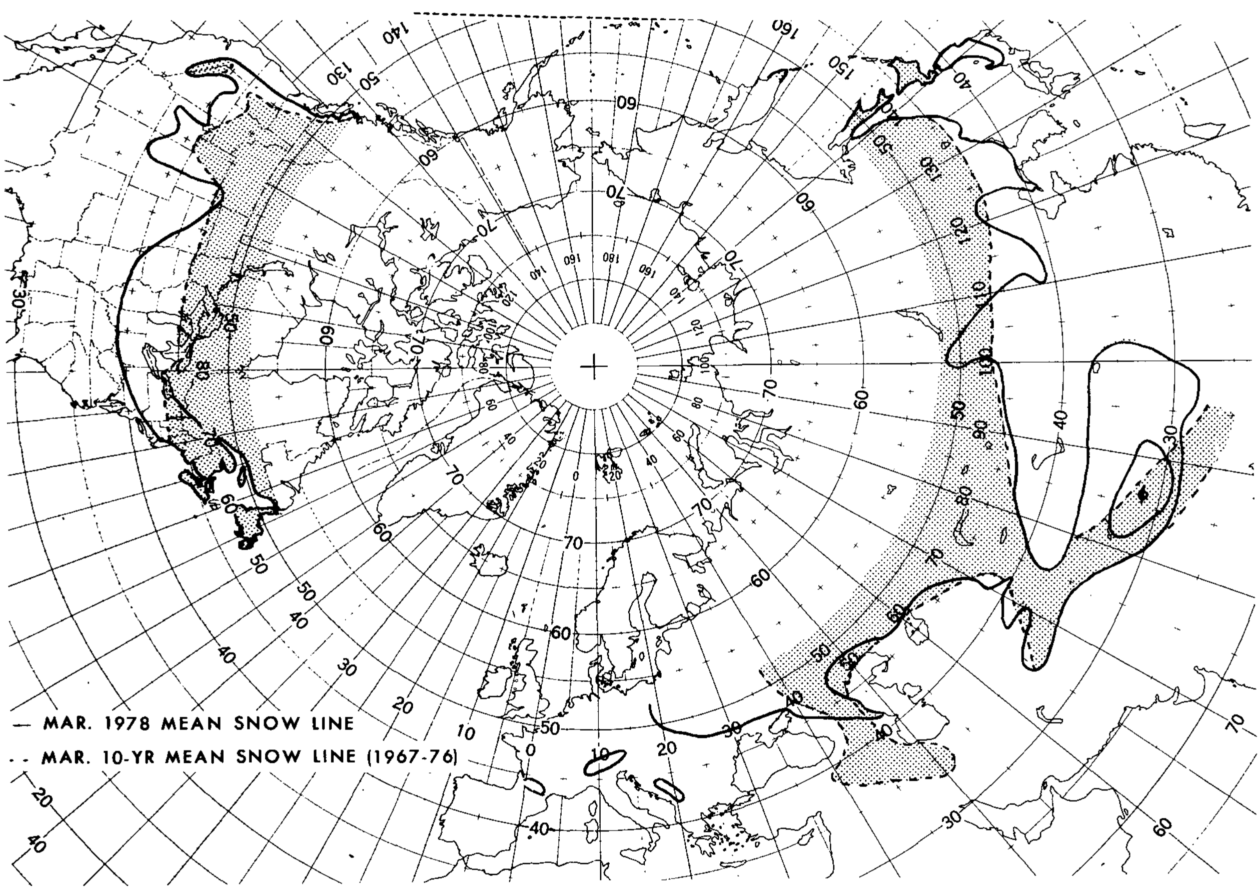

FIG. 5. As in Fig. 2 except for March 1978.

come at a most opportune time. We believe that snow-covered area is a good index to the earth's winter severity for it is a measure of spatially and temporally integrated precipitation and temperature, but it must be used in conjunction with many other variables and indices to be most effective.

In 1974 an increasing trend in winter snowcover was noted (Kukla and Kukla, 1974) from satellite-derived snowcover values for the winters of 1970–71 through 1972–73. Examination of Fig. 1, however, shows that the Northern Hemisphere winter snowcover of 1971–72 was the peak of a sinusoidal-like curve. The three winters that followed 1971–72 had successively less snowcover until the trend reversed in 1975–76.

While the temptation is strong to predict from Fig. 1 that next winter (1978–79) for the Northern Hemisphere will be milder than this year's—in terms of snowcover—prudence dictates that we instead recognize the well-known danger of using a short-period data set to establish long-term trends.

Localized or regional subcontinental relations based on the snowcover variable have already been pointed out. The retardation of the development of the Indian monsoon is one example (Hahn and Shukla, 1976). If the relationship these authors found is correct, the Indian monsoon should be a relatively weak one in 1978 with a concomitant decrease in grain production from that area.

The satellite evidence of climate variation that we present here is a rapid means of synthesizing global information to assess current conditions. It will and should be carefully considered by those whose research deals with forecasting, warming or cooling trends in months, seasons, years, decades or centuries. We encourage research scientists to follow the example of Dewey (1977), who used the satellite-derived data to improve local and regional forecasting, and Hahn and Shukla (1976), who used satellite-derived snowcover data to develop empirical relationships that can have impacts on long-range forecasting of both weather and crop yields.

Acknowledgments. The writers wish to thank Dr. George J. Kukla of Lamont-Doherty Laboratory for suggesting that we publish our snowcover data and our views on the past winter. We also gratefully acknowledge the careful work of Mrs. Olivia Smith in typing and Dr. E. Paul McClain for revising the manuscript.

REFERENCES

Dewey, K. F., 1977: Daily maximum and minimum temperature forecasts and the influence of snowcover. *Mon. Wea. Rev.*, **105**, 1594–1597.

Hahn, D. G., and J. Shukla, 1976: An apparent relationship between Eurasian snowcover and Indian monsoon rainfall. *J. Atmos. Sci.*, **33**, 2461–2462.

Kukla, G. J., and H. J. Kukla, 1974: Increased surface albedo in the Northern Hemisphere. *Science*, **183**, 709–714.

——, J. K. Angell, J. Korshover, H. Dronia, M. Hoshiai, J. Namias, M. Rodewald, R. Yamamoto and T. Iwashima, 1977: New data on climate trends. *Nature*, **270**, 573–580.

Matson, M., 1977: Winter snow-cover maps of North America and Eurasia from satellite records, 1966–1976. NOAA Tech. Memo. NESS 84, 28 pp. [NTIS PB 267–393].

——, 1978: The satellite snow-cover record: status, trends, and relationships. *Proceedings of the Second Annual NOAA Climate Diagnostics Workshop*, LaJolla, Calif., 18–20 October 1977, 10-1 to 10-16 [NTIS PB 282–151].

Schneider, S. H. (with L. E. Mesirow), 1976: *The Genesis Strategy, Climate and Global Survival.* Plenum Press, 419 pp.

Wiesnet, D. R., and M. Matson, 1976: A possible forecasting technique for winter snowcover in the Northern Hemisphere and Eurasia. *Mon. Wea. Rev.*, **104**, 828–835.