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RECENT TRENDS IN NORTHERN HEMISPHERE SNOW COVER

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1. INTRODUCTION

Empirical and modeling studies show snow cover to have an influential role within the global heat budget, chiefly through its effect of increasing surface albedo (Walsh et al., 1985; Robinson & Kukla, 1985; Barnett et al., 1989). Global models of anthropogenically-induced climate change suggest enhanced warming in regions where snow cover is currently ephemeral (Manabe & Wetherald, 1980; Dickinson et al., 1987). For this reason, snow cover has been suggested as a useful index for detecting and monitoring such change (Barry, 1985; Schlesinger, 1986).

Accurate information on snow cover is essential for understanding details of climate dynamics and climate change. It is also critical that snow observations be as lengthy and geographically extensive as possible. While only several decades in length, the premier data set for monitoring snow extent over all Northern Hemisphere lands is produced on a weekly basis by NOAA. Here, a brief discussion of the techniques employed in producing these charts is followed by an explanation of a new routine to calculate monthly snow cover areas. Finally, annual, seasonal, hemispheric and regional time series of extent over the past two decades are examined.

2. NOAA WEEKLY SNOW CHARTS

In 1966, NOAA began to map the snow and ice areas in the Northern Hemisphere on a weekly basis (Matson et al., 1986). That effort continues today, and remains the only such hemispheric product. NOAA charts are based on a visual interpretation of photographic copies of shortwave imagery by trained meteorologists. Snow is identified by recognizing characteristic textured surface features and brightnesses. Up to 1972, the subpoint resolution of the meteorological satellites commonly used was around 4 km. Beginning in October 1972, the Very High Resolution Radiometer (VHRR) provided imagery with a spatial resolution of 1.0 km, which in November 1978, with the launching of the Advanced VHRR (AVHRR), was reduced slightly to 1.1 km. Charts show boundaries on the last day that the surface in a given region is seen. Since May 1982, dates when a region was last observed have been placed on the charts. An examination of these dates shows the charts to be most representative of the fifth day of the week.

Shortcomings to monitoring snow with shortwave imagery include, 1) the inability to detect snow cover when solar illumination is low or when skies are cloudy, 2) the underestimation of cover where dense forests mask the underlying snow, 3) difficulties in discriminating snow from clouds in mountainous regions and in uniform lightly-vegetated areas that have a high surface brightness when snow covered, and 4) the lack of all but the most general information on snow depth (Dewey & Heim, 1982). In fact, it is recognized that in early years the snow extent was underestimated on the NOAA charts, especially during Fall. However, with the deployment of the VHRR sensor and increased observer experience, charting improved considerably in the early 1970s, and since then accuracy is such that this product is considered suitable for continental-scale climate studies (Kukla & Robinson, 1981).

The NOAA charts are digitized on a weekly basis using the National Meteorological Center Limited-Area Fine Mesh grid. This is an 89 x 89 cell Northern Hemisphere grid, with cell resolution ranging from 16,000 km^2 to 42,000 km^2. If a cell is interpreted to be at least fifty percent snow covered it is

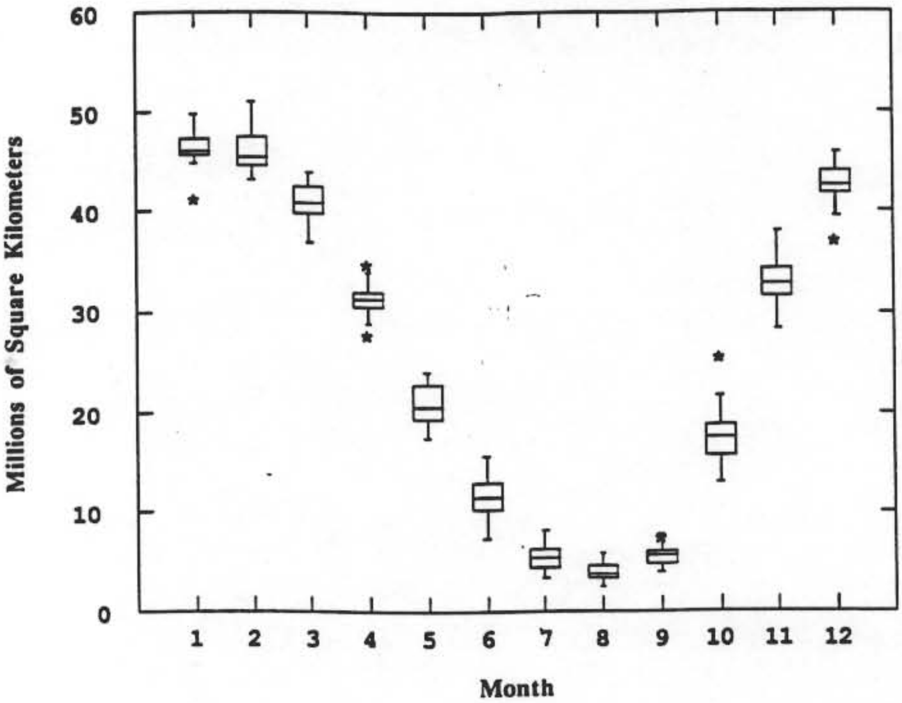
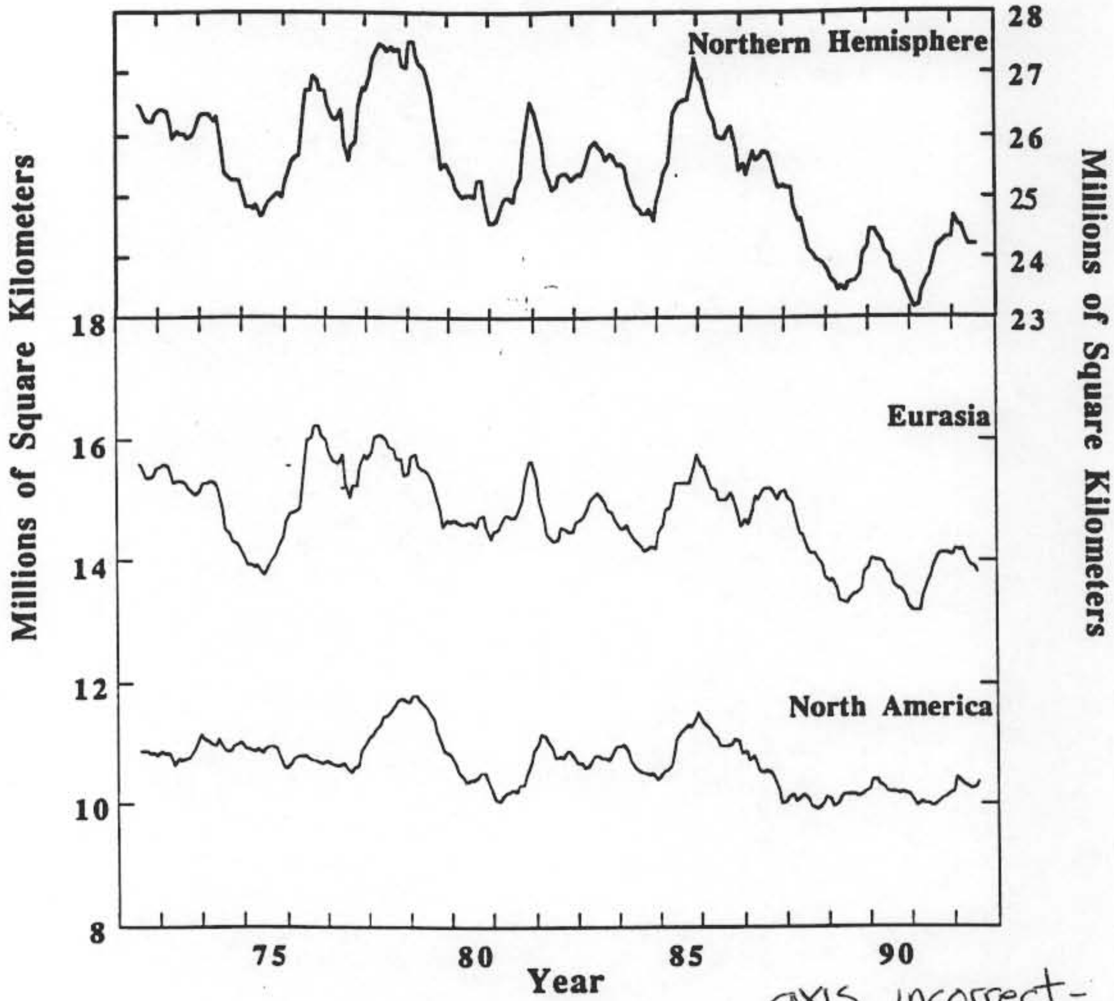


Figure 1. Monthly snow cover over Northern Hemisphere lands (including Greenland) between January 1972 and May 1992. The median area of cover is the horizontal line within the twelve monthly boxes, and the interquartile range (ICR) is between the top and bottom of the box. Whiskers show the extreme values between ±1 and ±1.5 * ICR, and asterisks show values outside this range. Values are calculated from NOAA weekly snow charts using the Rutgers Routine.

Twelve-month running means of continental snow extent best illustrate the periods of above normal cover that occurred in the late 1970s and mid 1980s (fig. 2). Intervals with lower snow extents include the mid 1970s and early 1980s, however neither approach the deficit of snow cover observed in recent years. Of the 58 months between August 1987 and May 1992, only five had above normal snow cover (Jan 88, Sep 89, Dec 89, Dec 90, Nov 91). In 1990, monthly minima occurred in eight months (table 1). Spring cover has shown pronounced deficits over the past five years in Eurasia and six years in North America; areas in these Springs have been at or below lows established before this period (fig. 3). During the same interval, both continents have had low seasonal cover in the Fall and Summer, although frequently neither continent has been at or approached record low levels. Winter cover has been close to average over the past six years.



axis incorrect - should be stretched 7 mos. (eg. lines should end in Dec 91)

Figure 2. Twelve-month running means of snow cover over Northern Hemisphere lands (including Greenland) for the period January 1972 through May 1992. Running means are also shown for Eurasia and North America (including Greenland). Values are plotted on the 7th month of the 12 month interval, and are calculated from NOAA weekly snow charts using the Rutgers Routine.

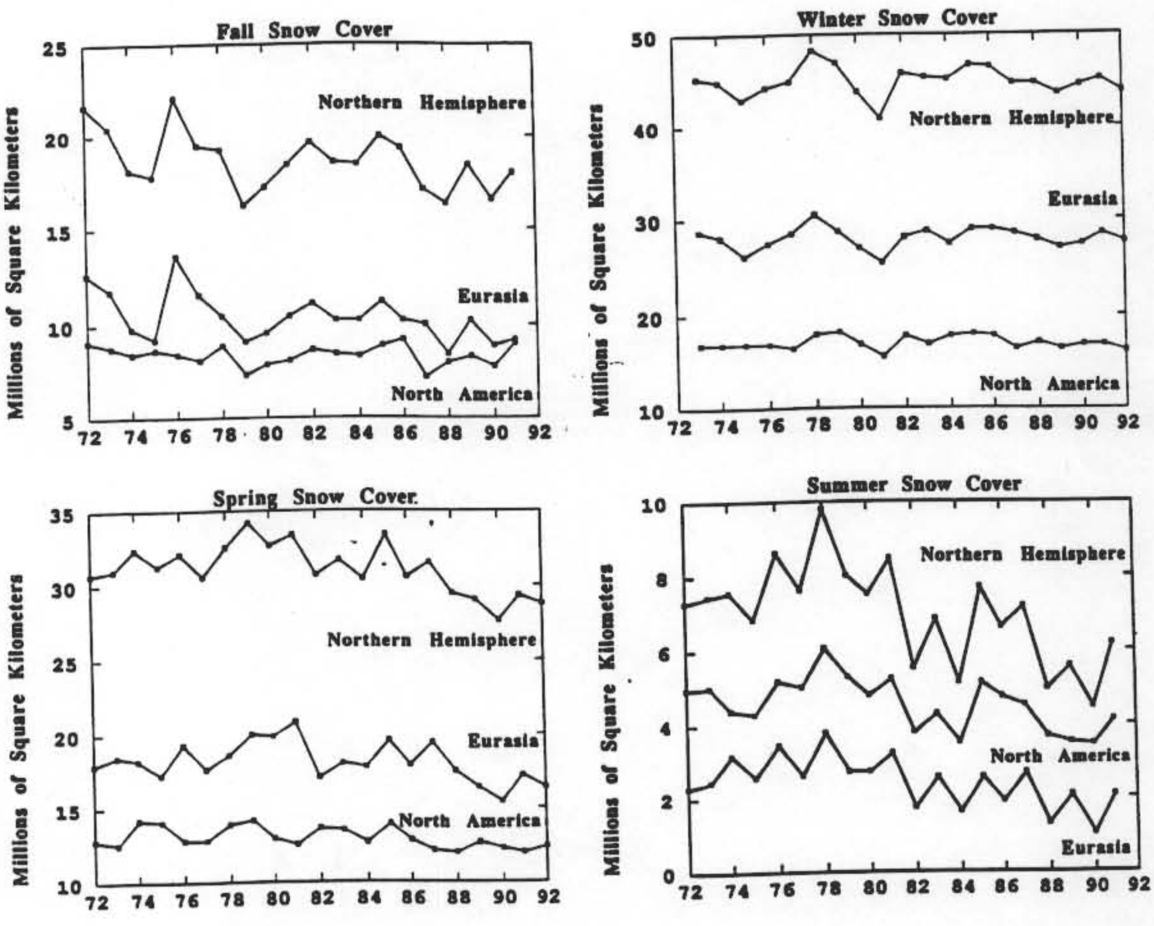


Figure 3. Seasonal time series of snow cover over Eurasia and North America (Greenland is excluded). Values are calculated from NOAA weekly snow charts using the Rutgers Routine.

4. CONCLUSIONS

Northern Hemisphere snow cover has shown some notable variations over the past two decades. In particular, recent years have seen a striking deficit of Spring snow. These findings, are accompanied by an increasing recognition of the association between snow cover and surface air temperature anomalies (Robinson and Dewey, 1990; Leathers and Robinson, submitted). For instance, it will certainly be interesting to see if any cooling which may result from the eruption of Mt. Pinatubo will be associated with an increase in snow cover from the low values of recent warm years. All the above, along with the expected role of snow feedbacks in anthropogenically-induced climate change, support the continued diligent monitoring of snow cover.

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