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# Atlantic Arctic Cyclones and the Mild Siberian Winters of the 1980s

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**Abstract.**The winters of the 1980s were among the warmest on record over northern Siberia. Daily and monthly sea level pressures, 500 mb heights, and an index of Atlantic storm track extent (toward the northeast) and intensity, are used to examine atmospheric circulation variability during extremely warm and cold winter months in Siberia. In recent years, the comparatively warm months are associated with an increased frequency in the passage of intense Atlantic cyclones that enter the extreme northeastern Atlantic and traverse the Barents and Kara Seas. These arctic cyclones bring strong westerly flow into Siberia along with passages of extensive cyclone warm sectors. Conversely, the surface mean Siberian anticyclone and large-scale features such as the North Atlantic Oscillation appear to have little effect on warm Siberian winters.

## Introduction

The decade of the 1980s was one of the warmest on record for the Northern Hemisphere (*Jones and Wigley, 1991*). The middle and higher northern latitudes were the warmest, especially over northwestern North America and north-central Asia (*Chapman and Walsh, 1993;* their Figures 1 and 2). Both areas exhibited a warming trend in annual mean temperature exceeding +0.75°C per decade from 1967 to 1986 (*Jones, 1988; Chapman and Walsh, 1993*), but relatively mild conditions were especially pronounced in winter and spring (*Climate Analysis Center, 1991;* their Figs. 9-13). Climatic conditions and atmospheric circulation anomalies associated with the recent warming over northwestern North America have been described (*Trenberth, 1990; Rogers and Raphael, 1992*), but the Eurasian warm events have been described only briefly. *Quiroz* (1983, 1984) reported anomalously warm conditions persisting over Eurasia from mid-autumn through March of 1982-83 and 1983-84. Winter air temperatures in 1982-83 were two standard deviations above the mean (*Quiroz, 1983*) and were characterized by the penetration of strong westerlies into the Eurasian continent. This paper discusses the linkage between recent Siberian climate variability and the atmospheric circulation, on synoptic time scales and in the monthly time-averaged data.

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Diagrams in some aforementioned papers indicate that the Eurasian warming was centered on roughly the 90th meridian between 55-75°N, an area east of the Ural Mountains that includes portions of western Siberia and the central Siberian Plateau, northward to the Taymyr Peninsula and the Kara Sea. Figure 1 illustrates the winter mean surface air temperature anomalies from *Jones et al.* (1991) averaged for several grid points within this "Siberian" region from 55-70°N and 70-100°E including 75°N, 80°E which is the only grid point at that latitude with data extending for several decades. The ten-year running mean (Fig. 1) illustrates the dominance of cooler winters prior to 1910 and comparatively warmer winters from 1910 to 1945 followed by a cooling trend reaching a minimum in 1968-1969. A strong winter warming trend ensued around 1970 with large positive anomalies occurring in winters of the early and late 1980s. The long-term upward trend noted by *Jones* (1988) is apparent.

To investigate the relationship between warm and cold Siberian winters and the atmospheric circulation, the 30 warmest winter months (10 each for December, January, and February) and the 30 coldest winter months since 1950 were selected. For these months both mean sea level pressure and mean 500 mb heights were averaged to produce Siberian 'warm' and 'cold' composites. The post-1950 period is chosen due to the higher quality of sea level pressure analyses compared to earlier in the century (*Jones, 1987*). Fig. 2(a) illustrates that during anomalously warm months the Icelandic low has two centers with mean pressures just under 1000 mb, one of which lies over the Norwegian and

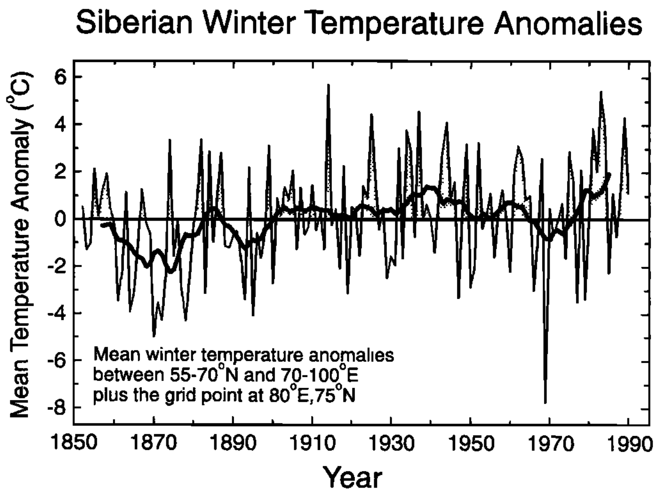


**Figure 1.** Winter mean air temperature anomalies (°C) from the long-term mean are shown for an area of Siberia spanning 55-70°N, 70-100°E plus 75°N, 80°E, (from *Jones et al.*, 1991). The 10-year running mean (thick line) reveals the lower frequency temperature variability.

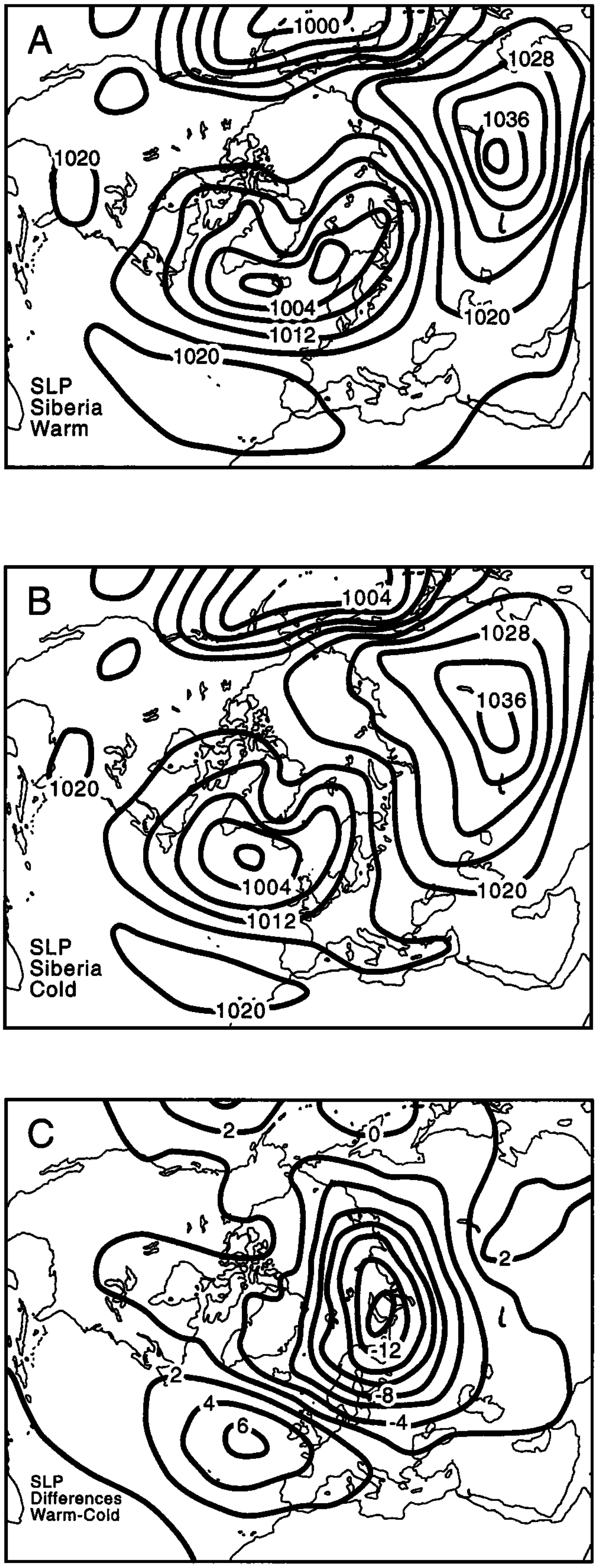


**Figure 2.** Mean sea level pressure (mb) during (A) the 30 warmest months and (B) the 30 coldest months in Siberia since 1950 are shown along with (C) the mean sea level pressure differences between the warm and cold composites.

Barents Seas, and with the 1004 mb isobar extending eastward to Novaya Zemlya. In anomalously cold months (Fig. 2b) the mean pressure southwest of Iceland is again just under 1000 mb, but pressure is about 8 - 12 mb higher over the Norwegian and Barents Sea, reaching 1016 mb over Novaya Zemlya. The net mean pressure differences (Fig. 2c) between the two composites are large over northern Siberia and the Barents and Kara Seas, with a maximum of nearly 16 mb over Novaya Zemlya. The mean pressure differences are statistically significant with 95% confidence in areas where they exceed ± 4 mb, which includes the Norwegian and Arctic Seas, northern Europe and Siberia. Note that the differences are small and insignificant in the area of the climatological mean Siberian anticyclone.

The Novaya Zemlya center in Fig. 2c is comprised of anomalously low pressure in the warm cases, but anomlously high pressure in the cold cases. Thus enhanced westerly flow occurs across much of Europe and especially into Siberia during warm winters (Fig. 2a) while a more easterly flow around an implied Kara Sea anticyclonic anomaly occurs during cooler winters. An analysis identical to that for Fig. 2 was conducted on a set of warm and cold winter months from 1899 to 1950, with virtually identical results.

During the warm Siberian months, once daily pressure values over Novaya Zemlya (70°N, 50°E) are less than 1000 mb on 411 days (Fig. 3a), while they are below 1000 mb on 129 occasions in the cold cases (Fig. 3b). The daily pres-

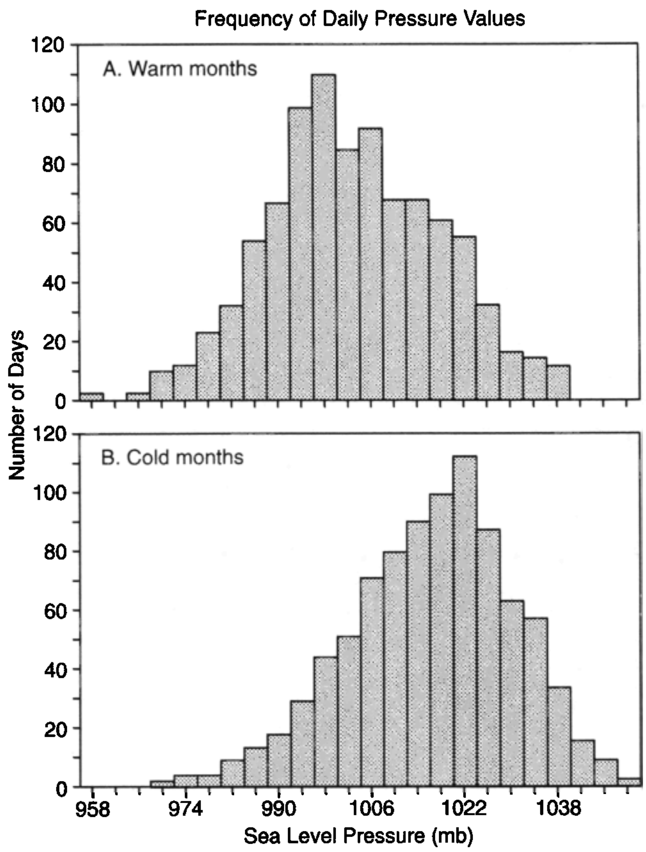


**Figure 3.** The frequency distributions of once-daily pressures over Novaya Zemlya (70°N, 50°E) are given for the 30 (A) warmest and (B) coldest months in Siberia.

sures lie most commonly between 996 and 1000 mb during warm months and between 1020 and 1024 mb during cold months, suggesting that deeper cyclones occur during warmer months (Fig. 3a). While the range of daily pressures is just over 80 mb for both the warm and cold months, the distribution shifts noticeably toward higher values in the cold winter months (Fig. 3b).

Strong 500 mb zonal flow prevails over much of western and central Siberia during the 30 warm winter months (Fig. 4a) with closed lows over Baffin Island and the Kara Sea. In the cold Siberian months, the Eurasian center of low mean geopotential height shifts from the Kara Sea toward eastern Siberia (Fig. 4b). The net 500 mb height differences (Fig. 4c) exhibit a wavetrain pattern with centers over the eastern Atlantic, the Barents and Kara Seas, and central Siberia. The mean height differences exceed 120 m in the latter two areas and the pattern implies strong westerlies during warmer winters, but much weaker westerlies, or even easterly flow, in northeastern Siberia during colder winters. The Siberian center, located between Lakes Baikal and Balkhash, lies over the surface location of highest pressure in the mean Siberian anticyclone (see Figs. 2a or 2b), which exhibited little variation between sea level pressure composite extremes (Fig. 2c). Despite the small sea level pressure variations occurring between Lakes Baikal and Balkhash, a net 1000-500 mb thickness difference of about 120 meters occurs over this region.

*Rogers* (1994) devised a principal-component based index of winter monthly (DJF) Atlantic storm tracks for the period 1899-1992. This storm track index is negative when cyclones are comparatively weak and confined to areas near Labrador and southern Greenland with concurrent anomalously high pressure dominating the northeastern Atlantic and Atlantic Arctic. Positive index values are associated with a raw mean sea level pressure distribution similar to that in Fig. 2a, with deep Atlantic cyclones extending far to the northeast into the Barents Sea and toward Novaya Zemlya. The storm track index is represented by the normalized scores for rotated principal components of monthly root-mean squares of sea level pressure, obtained from once-daily high-pass filtered (2-8 day periods) pressures on a $5^0 \times 5^0$ grid around the Atlantic and surrounding areas. Four key points based on storm track index analysis are summarized below and collectively suggest that an increase in cyclone activity in the high Arctic is linked to the recent mild Siberian winters.

(1) Winter (DJF) mean values of the storm track index are highly correlated to grid-point winter temperatures over Siberia, reaching a correlation coefficient (r) of +0.60 (1899-1990) at grid point 60°N, 90°E.

(2) Of the 30 highest monthly numerical values of the storm track index in this century, ten occurred since 1980, corresponding to the recent increased frequency in mild Siberian winters.

(3) The Siberian monthly temperature anomaly is never below normal in any of the 30 winter months with the highest storm index values. Siberian mean air temperature anomalies average +3.5°C for the set of positive storm track index values and they average -1.3°C for a set of 30 extreme negative index cases.

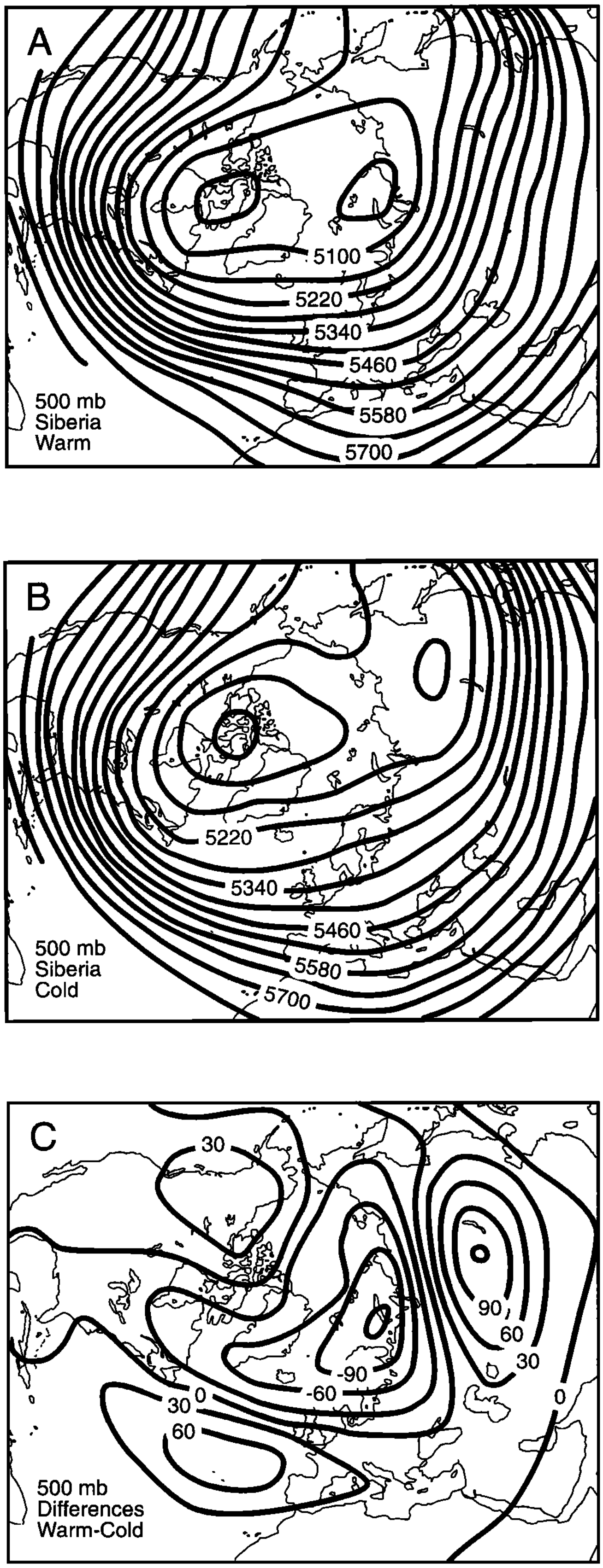


**Figure 4.** Mean 500 mb geopotential heights (m) are shown for (A) the warmest 30 months and (B) the coldest months in Siberia since 1950 along with (C) the mean height differences between the warm and cold composites.

(4) Conversely, the storm track index is positive in 20 of the 30 warm months used in the composites in this study, and is negative in 22 of the cold months. Mean storm track index values, are significantly different (99% confidence) between the warm and cold sets of months.

Large variations in the pressure around Iceland, or associated with the North Atlantic Oscillation, do not appear in conjunction with the Siberian air temperature extremes (Fig. 2). There is also little difference between the warm and cold months in the surface pressure variability associated with the thermodynamically induced Siberian anticyclone. Rather, it is the northeastward movement of comparatively deep cyclones into the Norwegian, Barents and Kara Seas, associated with a northeastward extention of the mean low (Fig. 2a), that bring milder air masses to central Siberia. Examination of synoptic analyses in some of the warm months shows that the cyclones traversing the Arctic seas are accompanied by extensive warm sectors to their south over Siberia. In the cold months, cyclones tend to move across the region farther south of 55°N, often first traversing the Mediterranean Basin.

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