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A Relationship between El Nino/Southern Oscillation and Winter Temperatures over British Columbia, Canada

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RELATIONSHIP BETWEEN EL NIÑO/SOUTHERN OSCILLATION AND WINTER TEMPERATURES OVER BRITISH COLUMBIA, CANADA

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ABSTRACT

Winter (DJFM) temperature data from 7 stations in British Columbia, Canada covering the period 1888-1992 were analyzed to determine any relationship between El Niño events and interannual temperature variations. It was found that winter temperatures are generally warmer in BC during a moderate to strong El Niño event although the probability of significant warming varies from station to station.

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1. Introduction

Average winter temperatures over British Columbia fluctuate dramatically. This paper explores links between these fluctuations and the El Niño/Southern Oscillation phenomena.

Walker (1923, 1924) and others have shown that a fluctuation in sea-level pressure between Tahiti and Darwin, Australia known as the Southern Oscillation (SO) affects weather patterns around the world. Bejerknes (1969) established an important link between the SO and fluctuations in eastern equatorial Pacific sea surface temperatures (SST). Warmer waters (positive SST) near the South America coast associated with what is known as El Niño (EN) events, occur in conjunction with abnormal surface pressure in the southeast Pacific region. The mechanics and causes of the El Niño/Southern Oscillation (ENSO) are not yet fully understood. For the purposes of this paper, the two terms, ENSO and El Niño will be used interchangeably.

2. Mechanics of ENSO

The Pacific equatorial trade winds usually blow from east to west pushing warm water to the west. The air then rises over the western Pacific while descending over the west coast of South America, thus accounting for the normally large precipitation amounts found in Indonesia and relatively little precipitation in western South America. Warm episodes or El Niño events normally occur every 2 to 7 years. During the onset of an El Niño episode a reversal in the eastern equatorial trade winds causes the warmer water of the western Pacific ocean to move eastward until it reaches the coast of South America. The reversal of winds is also characterised by below normal precipitation in Indonesia and above normal precipitation in the central and eastern

Pacific, as air ascends over eastern areas and descends in the west. SST rises of 6 to 8°C in the eastern equatorial Pacific ocean are common (Freeland, 1993). Due to the overriding of cooler water by the warm western equatorial waters, fish stocks, which rely on cold, nutrient-rich upwelling along the South American coast, decrease in the eastern equatorial Pacific ocean. An El Niño will typically begin late in the year and thus the term El Niño meaning "boy child", and will last on average 12 - 18 months. The strength of an El Niño will vary from episode to episode. The strongest episode this century occurred in 1982/83 causing a flurry of studies to be conducted, greatly increasing our knowledge of El Niño. For a more thorough explanation of the physical characteristics and effects of an El Niño episode, the reader is referred to Freeland, (1993).

Ropelewski and Halpert (1986) examined North American precipitation and temperature patterns for the period 1875 - 1980. They found there was no clearly defined relationship over Northwestern North America between the ENSO and precipitation. However, they did find an area of "well-defined seasons of potentially significant ENSO-related response in Northwest North America". This paper examines the effect on British Columbia winter temperatures in greater detail.

3. Data

This study examines winter (December, January, February, March) temperatures from seven stations in British Columbia and compares them with the occurance of an El Niño event. The station locations are shown in Figure 1.

The data consist of calculating the mean temperature of the four winter months, (DJFM) of each year, and taking the average of these values to obtain a base mean temperature for the period of record. The standard deviation was then calculated for each winter using this base mean. ie:

where: **BM = Base Mean**

$$BM=(\overline{X_{w_1}}+\overline{X_{w_2}}+\ldots+\overline{X_{w_n}})$$

$$\overline{X_{w_1}}=DJFMMeanYear1$$

$$\overline{X_{w_n}}=DJFMMeanForFinalYear$$

The determination of past El Niño episodes has been a matter of some issue. Only moderate to strong episodes have been chosen (Rasmusson and Carpenter 1982) using marine data.

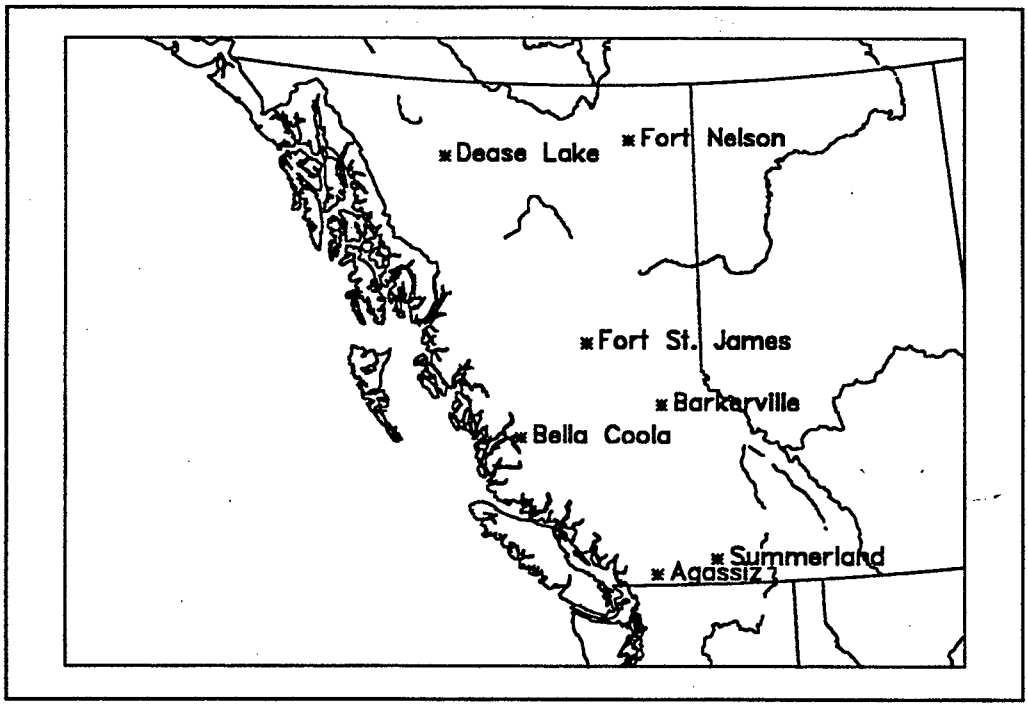

Figure 1 - 7 stations used in the study.

As an El Niño episode will typically begin in the latter half of one year and last through the next year, the convention used in this paper is to name the El Niño year as the year in which the El Niño began. Thus, the El Niño of 1982 began in late 1982 and lasted through the winter months of January, February and March of 1983. A listing of the ENSO years used is given in Table 1.

For the stations used in the current study, El Niño episodes occurring during the period of record range from 9 at Dease Lake, the station with the shortest record, to 23 at Agassiz and Barkerville. This equates to an average El Niño episode every 4.4 years at Agassiz and Fort St. James, 4.3 years at Barkerville, 4.6 years at Fort Nelson and Summerland, 4.7 at Bella Coola, 4.8 at Dease Lake.

Table 1. El Niño Episode Years

1891	1939
1896	1941
1899	1951
1902	1953
1905	1957
1911	1965
1914	1969
1918	1971
1923	1976
1925	1982
1930	1986
1932	1991

Updated from Rasmussen & Carpenter, 1983.

4. Analysis of Data

Appendix 1 shows the time series of winter temperatures at all seven stations and highlights the ENSO years.

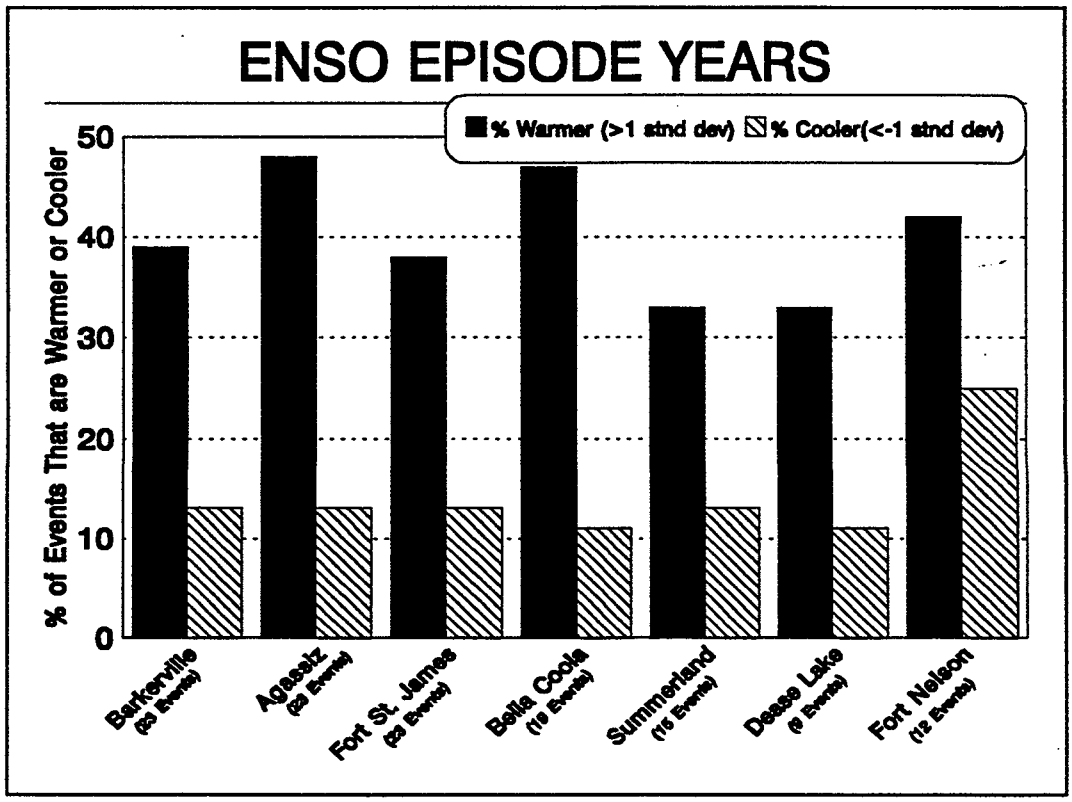

Figure 2 - % ENSO years significantly warmer or cooler than average.

Figure 2 shows the winter temperature variability during ENSO years at each climate station. The graph illustrates that warm winters occurred much more frequently than cool winters during El Niño years. The percent of warm ENSO years averages 40%, while the percent of cool ENSO years averages only 14%.

It is interesting to note that the strength of an ENSO event does not necessarily correlate to the degree of warming in BC. For example, the 1982/83 episode, called "the record event of the century" (Freeland, 1993) did not produce record warm winter temperatures although most sites were warmer than average. Fort Nelson actually recorded temperatures just slightly below the long-term average in the 1982/83 winter.

5. Conclusion -

ENSO events over the last century have generally been associated with warmer than normal winters (DJFM) in BC. Using seven widely spaced stations as representative of the province of British Columbia, we find that during ENSO episodes, 40% of the winters were warmer than one standard deviation, while only 14% were cooler than one standard deviation. These percentages could be used as one tool for predicting the average temperature variation of upcoming winters.

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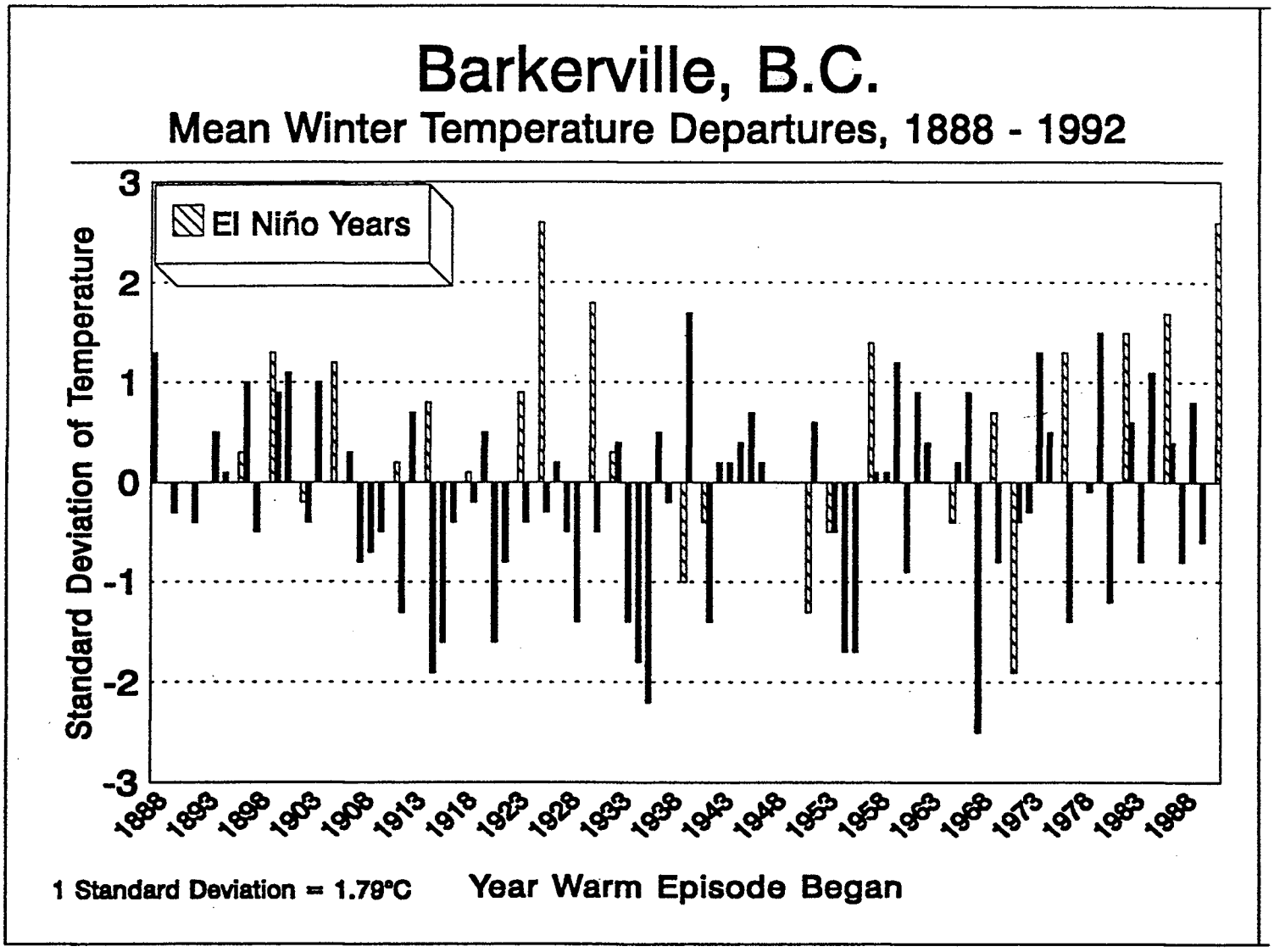
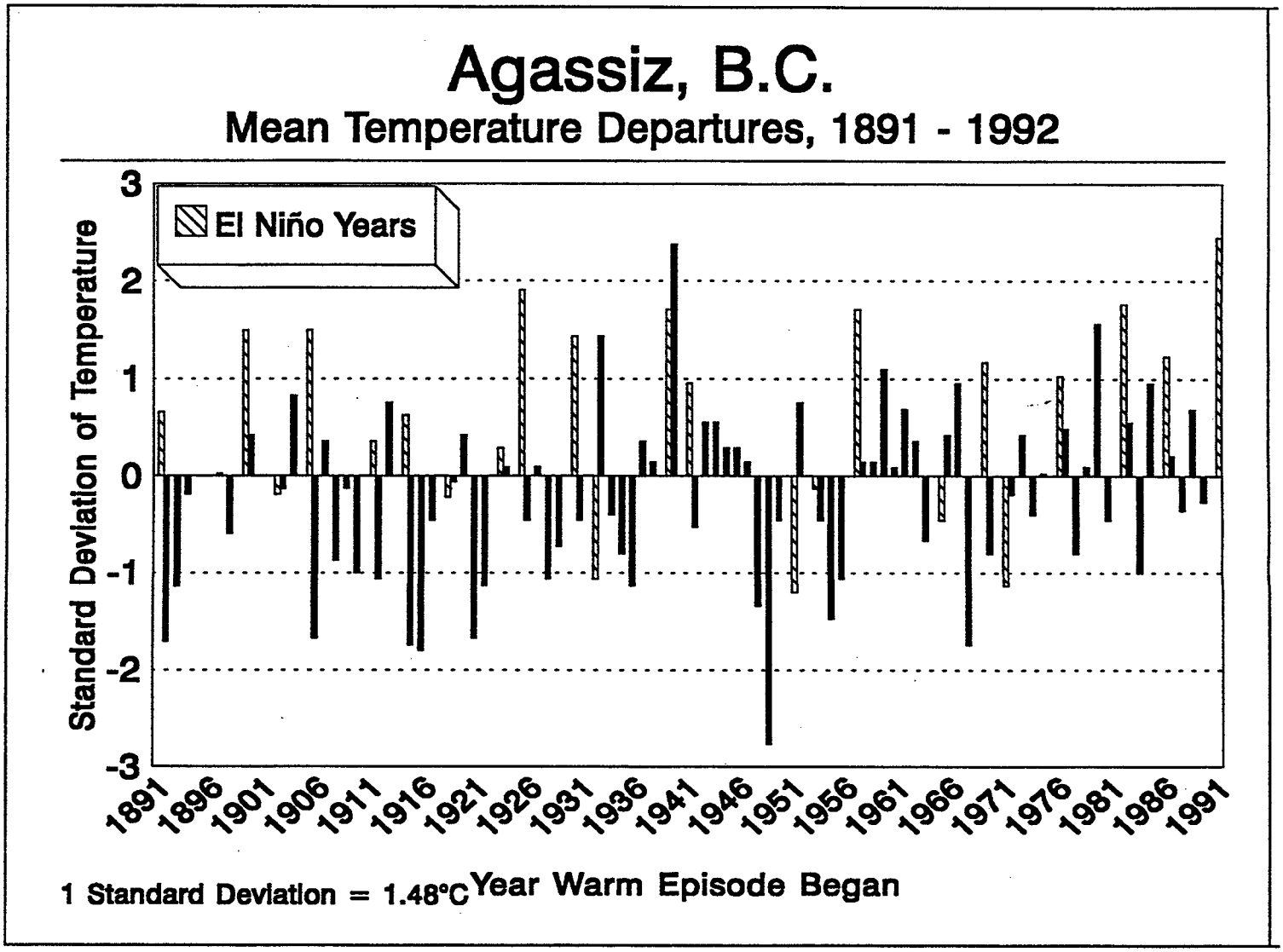


BARKERVILLE -

Barkerville has the longest period of record of the 7 stations studied, dating to 1888 although several years are missing: 1889/90, 1891/92, 1893/94, 1906/07,1948/49, 1949/50, 1950/51, 1964/65, and 1978/79.

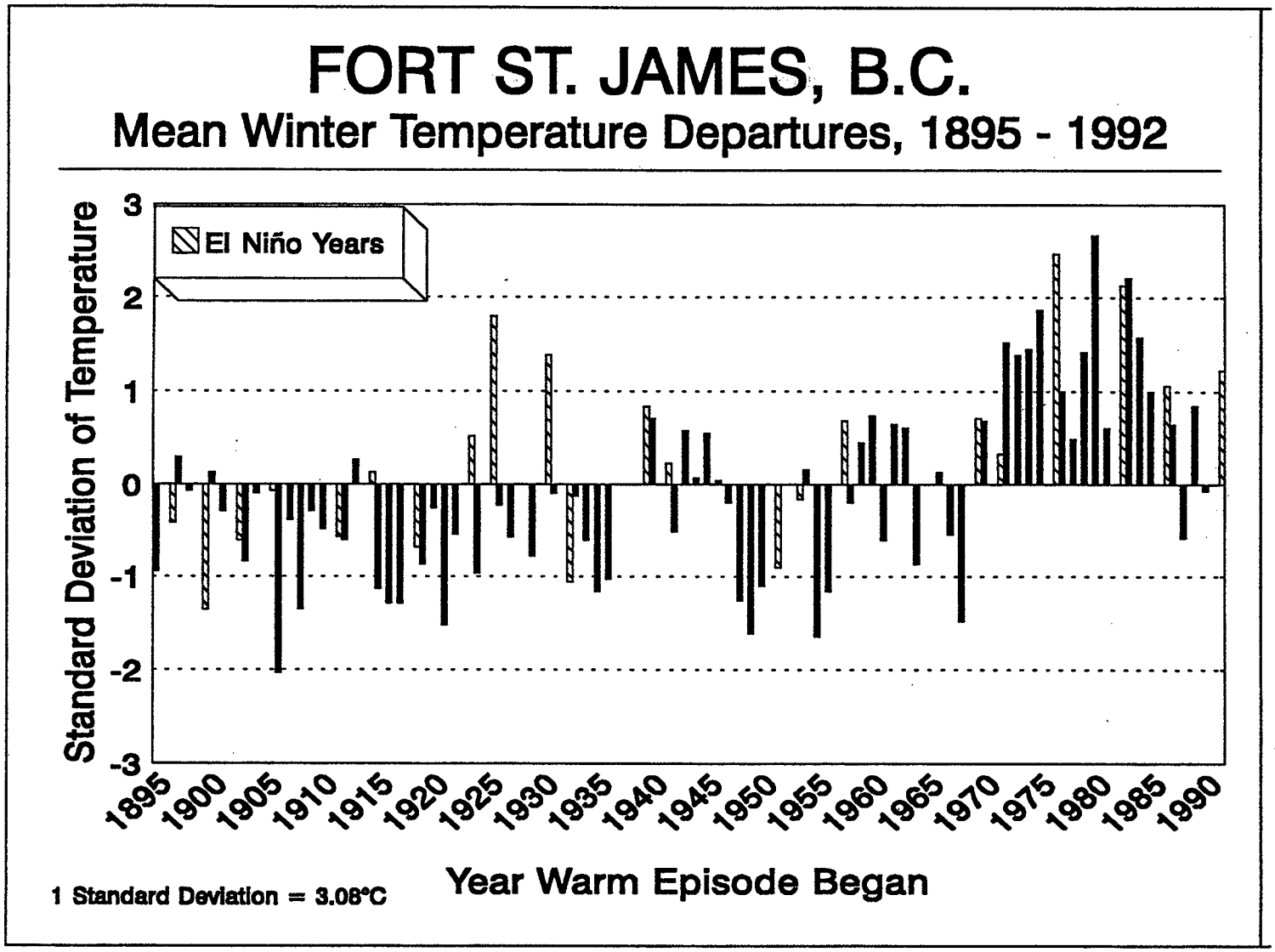
39% of El Niño episodes are significantly warmer than +1 standard deviation. However, only 13% of El Niño episodes are significantly cooler than -1 standard deviation. Therefore, based on this limited sample, it is three times more likely that December, January, February and March temperatures during an El Niño episode will be significantly warmer than significantly cooler at Barkerville.



AGASSIZ -

The period of record for Agassiz is the second longest of the 7 stations studied. It is also the most complete record with only the years 1896/1897, 1901/02 and 1985/86 missing.

The data show that 48% of the El Niño episodes are significantly warmer than +1 standard deviation (1 standard deviation = 1.48°C). However, only 13% of El Niño episodes are significantly cooler than -1 standard deviation. Therefore, it is 4 times more likely that DJFM temperatures will be significantly warmer than significantly cooler for Agassiz during an ENSO episode. It is interesting to note that in the top 16 warmest years, 12 were El Niño years.



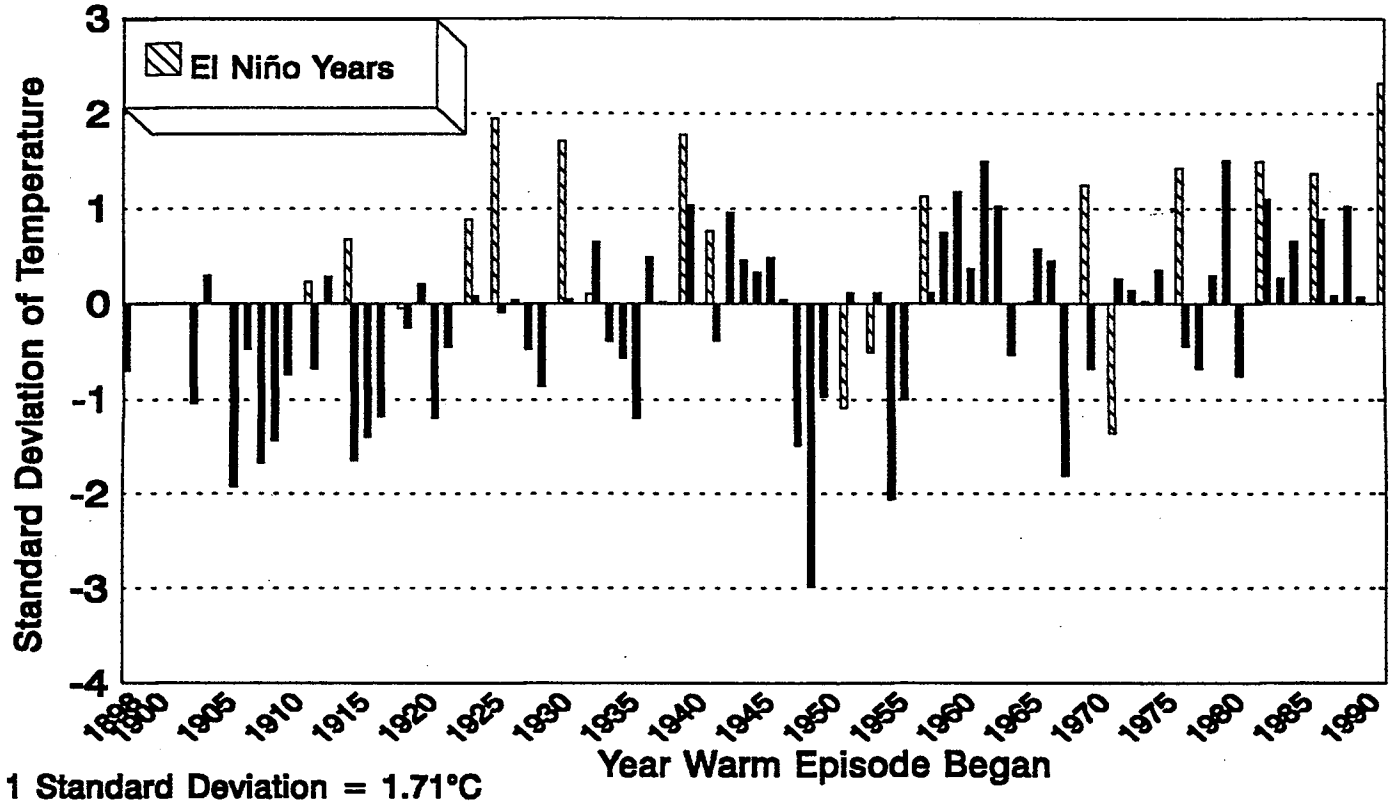
FORT ST. JAMES -

The period of record for Fort St. James is 96 years with only the years 1938/39 and 1952/53 missing.

The statistics show a similar pattern to that of Barkerville in that 38% of the El Niño episodes are significantly warmer (greater than +1 standard deviation) while only 13% of the El Niño episodes are significantly cooler (less than -1 standard deviation). One standard deviation for Fort St. James is 3.08°C. Therefore, it is 3 times more likely in Fort St. James that DJFM temperatures will be significantly warmer than significantly cooler during an El Niño episode.

Bella Coola, BC

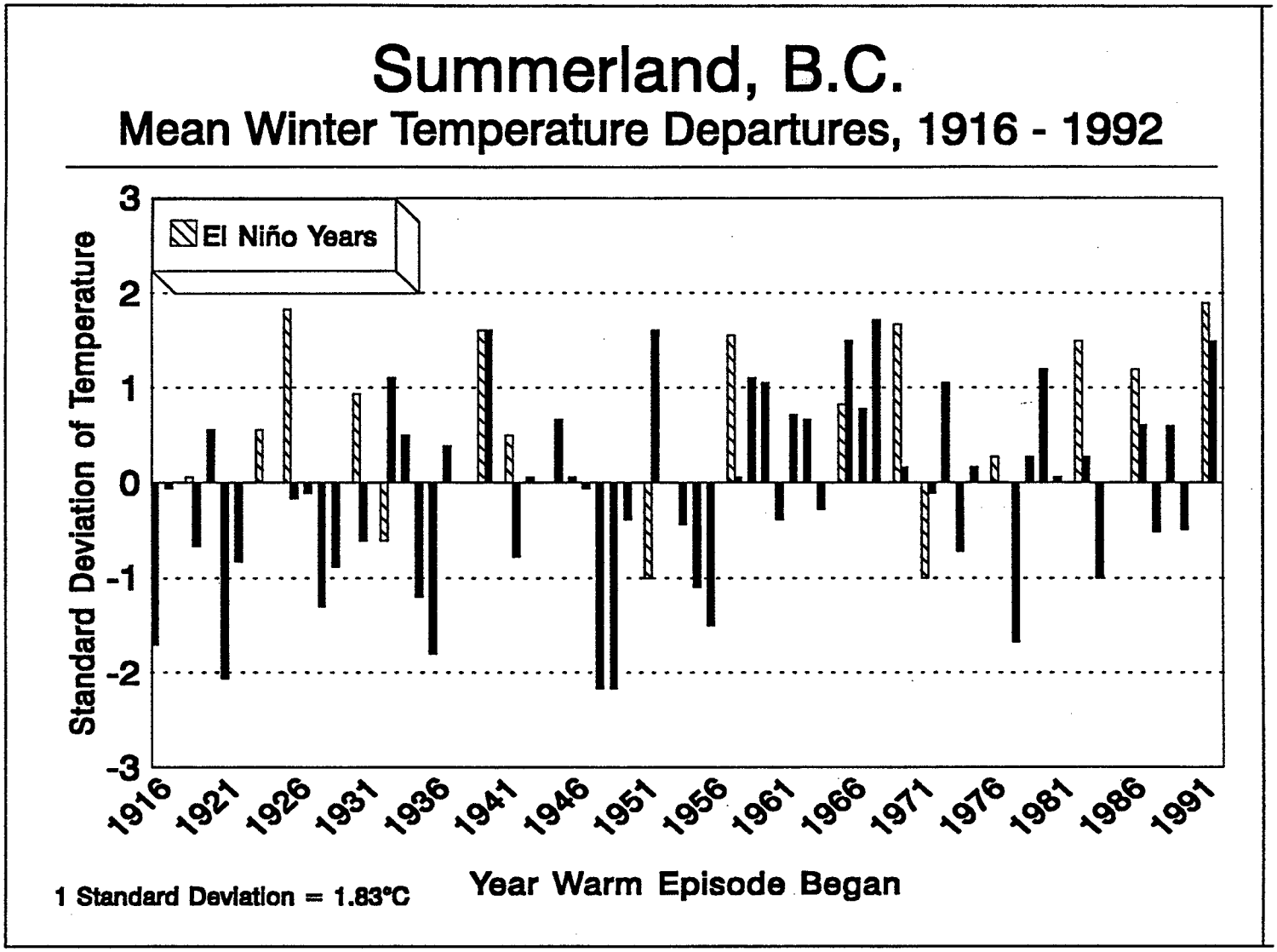
Mean Temperature Departures 1898 - 1992



1 Standard Deviation = 1.71°C

BELLA COOLA -

Bella Coola also has a lengthly record dating to 1898/99 with the years 1899/00 through 1902/03 and 1905/06 missing. With 47% of the El Niño episode years significantly warmer than + 1 standard deviation (1 standard deviation = 1.71°C) and only 11% of these years significantly cooler than -1 standard deviation, DJFM temperatures in Bella Coola would, in general, be more than 4 times more likely to be significantly warmer than cooler.

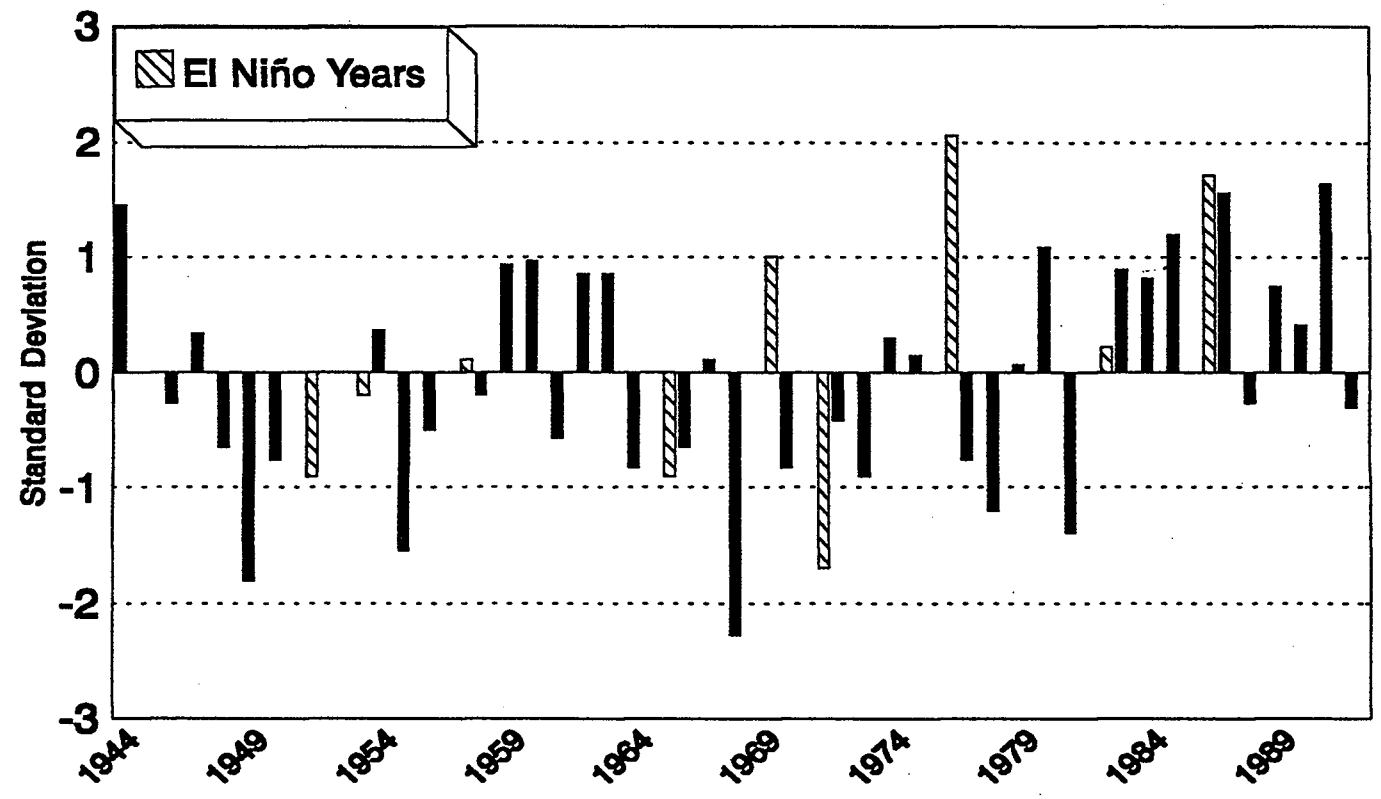


SUMMERLAND -

Summerland has one of the most complete records with data dating from 1916/17 with no records missing. Of the 15 ENSO episodes during this time, 33% show a significant warming (greater than +1 standard deviation = 1.83°C). This is almost 3 times greater than the 13% of El Niño episodes that are significantly cooler than -1 standard deviation. Therefore, this data shows there is almost a 3 fold probability that DJFM will be significantly warmer than cooler during an El Niño episode.

Dease Lake, B.C.

Mean Winter Temperature Departures, 1944 - 1992

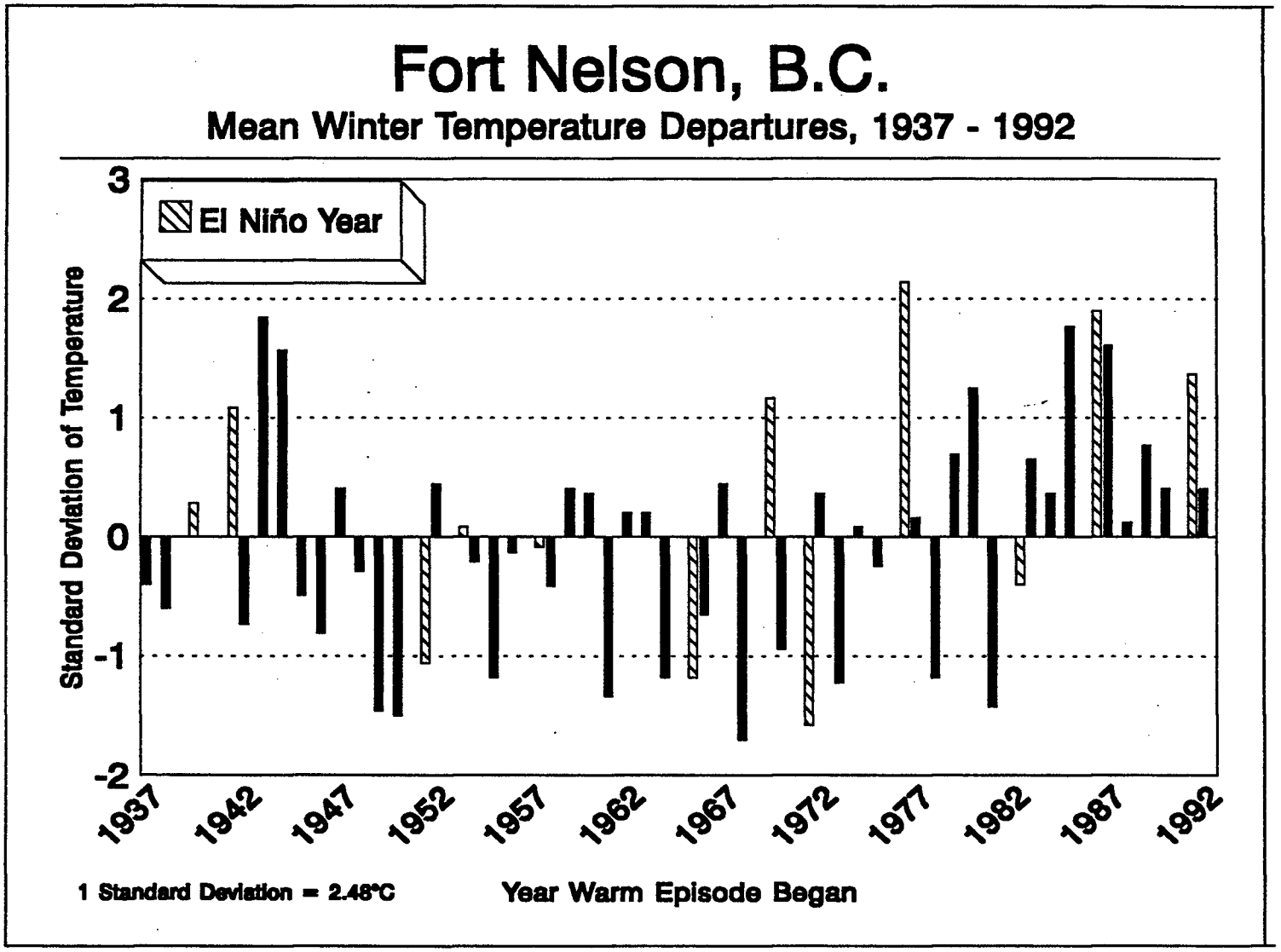


1 Standard Deviation = 2.67°C Year Warm Episode Began

DEASE LAKE -

As with the previous sites, the probability that an El Niño episode will produce a DJFM temperature that is significantly warmer (greater than +1 standard deviation) than significantly cooler is 3 times as great.

The probability that a winter temperature at Dease Lake greater than +1 standard deviation will be an El Niño year is 38%.



FORT NELSON -

Of the 12 ENSO episodes that have occurred during the period of record at Fort Nelson, 42% of the episodes have been greater than 1 standard deviation or significantly warmer than the climatological average. This compares to 25% that have been significantly cooler (less than -1 standard deviation). For Fort Nelson, one standard deviation equals 2.48°C.

Of the total number of years when the winter temperature was equal to or greater than +1 standard deviation, 50% were ENSO episode years.