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CLIMATE CHANGE ALONG THE EXTRATROPICAL WEST COAST OF SOUTH AMERICA (CHILE): DAILY MAX/MIN TEMPERATURES

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1 . INTRODUCTION

Assessment of extreme climatic episodes is highly relevant due to their significant socioeconomic impacts. Recent studies have shown that extreme daily temperatures have significantly increased during the XX century (Folland *et al*, 2001, Alexander *et al*., 2005), contributing to an increase in the frequency of warm nights (Frich *et al*., 2002 and *Alexander et al*., 2005).

The objective of this study is to assess long-term changes in the regimes of daily extreme temperatures (maximum and minimum) along the extratropical West coast of South America, with particular emphasis in the interannual and interdecadal variability and associated factors.

2. DATA AND METHODOLOGY

Daily records of maximum and minimum temperatures were compiled for 16 meteorological stations belonging to the Chilean Weather Service, for the period 1961-2003 (Table 1). These stations, representing the region to the West of the Andes from 18°S to 53°S, were carefully selected according to the quality and completeness of the records. Missing data (less than 5% at any station) were interpolated from observations at surrounding stations. Data homogeneity was tested using methodology described by Alexanderson (1986).

Warm (cold) nights were defined as those when minimum daily temperature was above (below) the 90*th* (10*th*) percentile of the 1961-90 distribution corresponding to the specific date. A similar statistical consideration, but applied to maximum temperatures, was used in the definition of warm and cold days. Other indices are the number of days with maximum temperature above 25°C (summer days); the number of days with minimum temperature below 0°C (frost days); the number of consecutive frost days (CDF); the number of days with maximum temperature below 0°C (ice days) and the diurnal temperature range (DTR).

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Table 1. Selected stations: geographical location, elevation above sea level, and years when the stations were moved to a different location.

Station	Latitude (°S)	Longitude (°W)	Height (m)	year
Arica	-18.20	-70.20	52	1957
Iquique	-20.32	-70.11	52	1981
Antofagasta	-23.26	-70.26	135	1944
Copiapó	-27.18	-70.25	291	1964
La Serena	-29.54	-71.12	142	1972
Santiago	-33.26	-70.41	520	-
Curicó	-34.58	-71.14	228	-
Chillán	-36.34	-72.01	147	1941
Concepción	-36.46	-73.03	12	1958/1966-68
Temuco	-38.45	-72.38	114	1967
Valdivia	-39.38	-73.05	19	1953/1965
Osorno	-40.36	-73.04	65	1958/1963-67
Puerto Montt	-41.26	-73.07	90	1945/1960/1964
Coyhaique	-45.35	-72.07	310	1967
Balmaceda	-45.59	-71.43	520	1974
Punta Arenas	-53.00	-70.51	37	1965

3. RESULTS

Linear trends for the annual number of cold and warm nights during 1961-2003 are presented in Fig. 1. Patterns show mostly positive trends for warm nights and negative ones for cold nights, suggesting that the distribution of minimum temperature is shifting upward. At coastal stations of northern Chile the average decrease in the annual number of cold night was around -15.5 days/decade during this period. Positive trends of similar magnitude were detected for the annual number of warm nights. These results are consistent with those presented by Vincent *et al*. (2005) which also show a large increase in the frequency of warm nights along the West coast of South America. However linear trends do not capture the real evolution of these variables in recent decades due to the fact that interannual and interdecadal climate variability along West coast of South America is highly modulated by ENSO and the Pacific Decadal Oscillation (PDO).

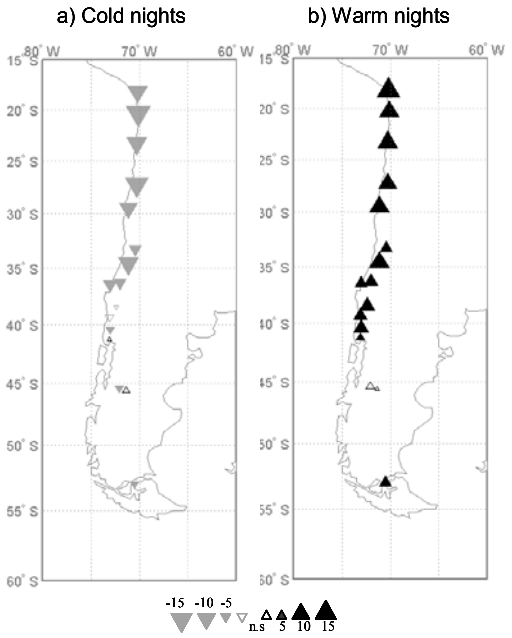

Figure 1. Trend maps of annual values of cold nights (a) and warm nights (b) indicated in [days/dec] over 1961-2003. Upward (black) and downward (gray) pointing triangles indicate positive and negative trends, respectively. Size of triangles is proportional to the magnitude of the trend.

Thus, the noticeable increase in the number of warm nights after the mid 1970's, shown in Fig. 2, seems related to a concurrent change of the PDO from the negative (cold) phase to the positive (warm) phase. The strong influence of El Niño episodes is well apparent in this figure, particularly during the most intense 1982-83 and 1997-98 events. Thus large positive and negative trends shown in Fig. 1 are not indicative of a steady and continuous climate change but are originated by a stepwise change in the temperature regime in the mid 1970's linked to the evolution of the PDO.

Results presented in Fig. 3 further reinforce the conclusion that changes in the frequency of cold and warm nights are significantly modulated by the PDO. The increase in the number of warm nights at Santiago (33°S) during recent decades broadly coincides with the evolution of the PDO from the negative to the positive phase during the mid 1970's. In fact, when linear trends in annual warm nights are calculated for periods before and after 1976 the trend patterns are characterized by mostly non significant values (Fig. 4).

The lack of consistency in the sign and intensity of the trends for the periods before and after 1976 is shown in Table 2, where the number of stations with significant positive or negative trends is indicated for the periods 1961-1976, 1977-2003 and 1961-2003. Regarding cold nights, 11 stations show a significant negative trend during the whole period, but just 2 of them exhibit a similar behavior in the most recent period. A similar situation occurs with the warm nights. In fact, while almost all stations show a significant positive trend during 1961-2003, this behavior is observed in only one station in 1976-2003. The remaining variables, with the exception of the diurnal temperature range (DTR), do not show a significant regional trend pattern during the most recent period (1977-2003)

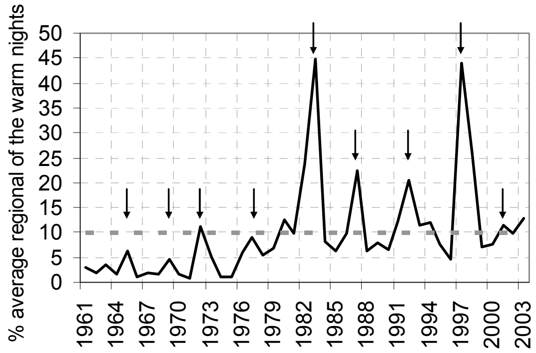

Figure 2 Mean value of the percentage of warm nights at 5 stations in northern Chile in the region 18°S - 30°S (Arica, Iquique, Antofagasta, Copiapó and La Serena) during 1961-2003. Arrows indicate the occurrence of El Niño events.

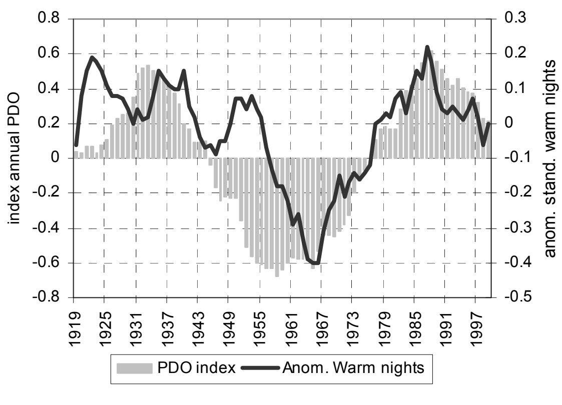

Figure 3: 11-year moving average of the standardized values of annual warm nights at Santiago (33°S, 70°W) during 1919 - 1999 (continuous line) and the Pacific Decadal Oscillation (PDO) index. Values are indicated at the central year of each period.

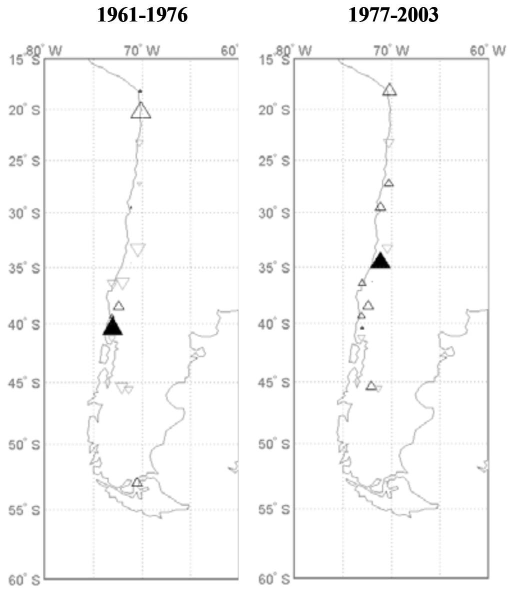

Figure 4: Linear trends in the annual numbers of warm nights for the period 1961-1976 (a) and 1977-2003 (b). Trends are indicated in [days/dec]. Upward (black) and downward (gray) pointing triangles indicate positive and negative trends, respectively. Size of triangles is proportional to the magnitude of the trend.

4. CONCLUSIONS

The significant positive (negative) trend in the frequency of warm (cold) nights documented here for the period 1961 - 2003 along the extratropical West coast of South America are mostly explained by a relatively abrupt change in the temperature regime during the mid-1970's associated with a change of the Pacific Decadal Oscillation from the negative to the positive phase. In fact, most of the indices related to temperature extremes in this region do not exhibit significant trends in their frequency during recent decades (after mid 1970's). These results suggest that a linear trend calculated over a long period of time do not necessarily provides an accurate description of slow climate changes.

Table 2 : Number of stations (N) with significant (95% level) positive or negative linear trend for the extreme temperature indices during the periods 1961-76, 1976-2003, and 1961-2003. Numbers in bold indicate cases when significant trends are detected in more than 25% of the stations.

		Negative			Positive		
Indices	**N**	61-76	77-03	61-03	61-76	77-03	61-03
Cold nights	16	1	2	**11**	**5**	2	0
Cold days	16	0	0	3	**6**	3	1
Warm nights	16	0	0	0	1	1	**15**
Warm days	16	3	1	0	0	0	3
Summer days	16	2	1	1	0	1	**4**
Frost days	12	0	0	2	0	1	0
CDF	12	0	1	1	0	2	0
Ice days	3	0	0	0	0	0	0
DTR	16	**6**	**5**	**10**	0	0	0

5. ACKNOWLEDGMENTS

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