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The Southern Oscillation and rainfall in SW Tarija

Technical report

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Resumen

La variabilidad de pluviosidad en el sudoeste de Tarija se considera con mayor frecuencia de estar relacionado con el efecto de la Oscilación del Sur (OS). La ausencia de buenos datos meteorológicos para estaciones en los valles y el altiplano de Tarija impide la estimación de la importancia de la OS en la explicación de variaciones de pluviosidad. Hemos examinado los datos meteorológicos disponibles para la ciudad de Tarija y una serie de estaciones cercanas y en el altiplano para establecer cual es la relación entre la OS y la pluviosidad.

Concluimos que, durante los episodios cálidos - El Niño - es muy probable que la pluviosidad durante la época lluviosa sea menor que normal. Se nota mucha variabilidad en la pluviosidad de un mes a otro. 58 por ciento de los meses durante un período de Niño tenía por debajo de 80% del promedio de pluviosidad pero 14% de los meses tuvieron más de 120% del promedio.

La relación entre los episodios fríos - La Niña - y la pluviosidad es débil. Aunque hay meses cuando la pluviosidad es mayor que el promedio, también hay muchos meses cuando es menor.

Since they were first identified in the early 20th century, analyses of relationships between the Southern Oscillation (SO) and rainfall have focused on those areas where they seemed most pronounced. In particular, strong SO signals appear to influence rainfall in south-eastern South America, north-east Brazil, coastal Peru and central Chile (Ropelewski and Halpert 1987, Caviedes and Waylen, 1998 and Tapley and Waylen 1995).

A series of papers have been published in recent years that provide evidence for a relationship between the SO signal and rainfall in the Bolivian altiplano and, to a lesser extent, lowland eastern Bolivia. The recent establishment of a meteorological station on the summit of Sajama, in the western mountain margin of the Andes in Bolivia, has provided further data in depth on Bolivian weather. Although no study has so far included data from Tarija department, there is little reason to believe that relationships between the SO and rainfall in altiplano and valley areas will differ substantially from that further north. A paper by Ronchail reviews rainfall variations in Bolivia, using data from a larger number of stations but includes only Cochabamba among the eastern valleys (Ronchail 1998) and mainly contrasts rainfall in the altiplano with that in the eastern lowlands. It is useful, therefore, to examine the strength (or otherwise) of any relationship between the SO and rainfall in SW Tarija in order to establish its possible use as a forecasting tool for the benefit of the region's farmers. SW Tarija includes both an area that shares may of the characteristics of the Bolivian altiplano - both high altitude (around 3700 m) and aridity - and the more densely-populated valleys (around 2000 m) near to the city of Tarija where a substantial proportion of the department's population lives.

Although a striking feature of rainfall in highland and valley Bolivia is its variability, it is commonly thought that the SO phenomenon has a strong influence on the amount of rainfall during the wet season. Various reviews of national rainfall patterns have concluded that the warm phase SO - El Niño (ENSO) - is associated with lower than average rainfall in the Altiplano (Ronchail 1998, Vuille et al 1998) but other periods of drought occur that are unrelated to ENSO. Vuille has concluded that 'precipitation tends to be deficient over the western Bolivian altiplano during [ENSO summers] …but the relation is weak and statistically insignificant' (Vuille 1999, 1979). The cold phase LNSO - La Niña - conversely is thought to have less marked effects on rainfall although it may sometimes be associated with higher rainfall than average in the highlands. Ronchail and Vuille have recently noted a tendency for more than average rainfall in the wet season following an ENSO event (Ronchail, 1998, Vuille 1999). Both Ronchail and Aceituno & Montecinos (1993) mention changes in the relationship between SO events and rainfall during the past century and SO events became more frequent during the last three decades of the 20th century.

Only in the 1990s, especially during and following the ENSO event of 1997-98, did public and government perception of ENSO in Bolivia and its influence of rainfall - both droughts and prolonged heavy rains - grow. The inevitable simplification of reality by communications media has resulted in El Niño being consistently linked with droughts on the Altiplano and excessive rains in the eastern lowlands. This is irrespective of actual rainfall amounts. Even in the midst of a supposed crisis period - whether drought or flood - seldom is reference made to actual monthly rainfall or even any quantitative measure of abnormality. This encourages the public to ignore the considerable (and normal) variation in both time and space in rainfall in

much of Bolivia. There is only a vague public perception of the nature of the relationship between the SO and rainfall and no discussion of the quantitative evidence to reinforce popular perception of extreme rainfall deficits or abundance. No seasonal forecasts are made and there is little comment on the likelihood of drought [or flooding] once a strong SO event has been identified.

This report reviews the relationship between past SO events and rainfall during the wet season (October-March) during the period for which rainfall has been recorded. We use meteorological data from seven localities in SW Tarija, Bolivia[1]. Little rain falls during the other half of the year, which can therefore be ignored in this simple analysis. An attempt is made to assess the extent of differences in rainfall variations in years with strong SO signals in different parts of SW Tarija, particularly in the area where we are currently working. Our intention is to judge the reliability and possible value of climate forecasts, based on the strength of present and forecast future SO conditions, to help farmers plan for the forthcoming wet season. In our future work with farm households, we shall collaborate with three village schools to record temperature and rainfall, collect local knowledge of past extreme climatic events and document local practices with regard to forecasting weather and climate.

This research and collaboration with people in three sample communities is taking place at a time when increasing attention is being given to ways in which improved climate forecasting methods can be used to improve the information available to farmers to assist forward planning. Previous work has been carried out in southern Africa (reported in general in Blench 1999) and work in various world regions has been reviewed in a recent synthesis by Stern and Easterling (1999). Comparable work is in progress in Peru and northern Bolivia (Valdivia et al. 1999).

Precipitation data are available for nine SO episodes in SW Tarija, five of which were warm El Niño episodes and four were cold La Niña episodes. The present cold phase (1999-2000) was included although only data for Tarija airport were available.

Table 1 SO episodes for which data analysed

Warm El Niño episodes	1972-73, 1982-83, 1986-87, 1991-92 and 1997-98
Cold La Niña episodes	1973-74, 1975-76, 1988-89 and 1999-2000

Rainfall data for the period 1970-1999 are presented for the locations in the table below (Table 2). They include two stations in the Tarija valleys (Tarija Airport and Concepción), two on the edge of the mountain front (Alisos and Rejará), two with short periods of records on the altiplano (Izcayachi and Pasajes) and one in the valley of the Río San Juan del Oro (Tojo).

Table 2 Meteorological station records used

Station	Mean rainfall (mm.)	Period of records used
Tarija Airport	597	1951-2000
Rejará	1134	1980-94
Alisos	851	1982-94
Tojo	319	1975-94
Concepción	595	1970-94
Pasajes	298	1986-94
Izcayachi	325	1989-97

Rainfall data for wet seasons were analysed and the monthly totals were expressed as a percentage of the monthly mean. The mean is naturally a more reliable statistic for those stations with the longest records.

The deviation of rainfall from the monthly mean was compared each month with a measure of the intensity of the SO episode reported by the CPC for the corresponding three-month period

[1] These data were provided by SENAMHI, Tarija whose assistance is acknowledged

(CPC 2000). This was calculated using tropical Pacific sea-surface temperatures in three-month periods for each of which the episodes were ranked as weak, moderate or strong. The data set for Tarija airport is the longest for the Tarija valleys and offers the most secure statistical means for comparing rainfall with the strength of the SO event (Table 3).

Table 3
Rainfall divergences from mean, Tarija airport[2]
(Percentages)

Wet season year	*SO Index*	*Oct*	*Nov*	*Dec*	*SO Index*	*Jan*	*Feb*	*March*
1955-56	C+	28	102	29	C	138	163	21
1957-58	W	204	51	93	W+	139	71	116
1965-66	W+	36	16	92	W	131	34	109
1972-73	W+	57	87	86	W	112	75	199
1973-74	C+	53	25	64	C+	77	145	105
1974-75	C+	73	26	152	C	152	110	28
1975-76	C+	41	123	126	C	114	54	134
1982-83	W+	90	32	157	W+	43	55	7
1988-89	C+	44	18	140	C+	81	62	116
1992-93	W	228	83	43	W+	194	110	67
1997-98	W+	15	99	44	W+	69	38	79
1999-2000	C	37	101	25	C+	76	92	263

W+ Strong warm El Niño, W Moderate warm El Niño C+ Strong cold La Niña

Every wet season for which a strong SO signal is recorded (W+ or C+) in at least one three-month period is included. It can readily be observed that variability of rainfall is large both within wet seasons as well as between years. Even during the two wet seasons with the strongest ENSO signal (1982-83 and 1997-98) one month occurred in each in which rainfall was normal or greater than normal. However, while the warm current El Niño years are frequently associated with less rain than average, the cold current La Niña years are as often drier than average than wetter.

A comparison is made of the number of months with strong SO signals and rainfall anomalies based on rainfall records at Tarija airport (Table 4).

Table 4
Rainfall variation and strong SO signals
Percentages

Strong signal	Dry months (<80% mean)	Wet months (>120% mean)
La Niña	54	25
El Niño	58	13

This shows that well over half the months with a strong ENSO (El Niño) signal recorded less than 80% of the mean rainfall. It is also noteworthy that 14 per cent of those months (actually 3 out of 24 months) had more rain than normal and one month (January 1993) almost twice the mean rainfall. There is little support for the belief that La Niña years are wetter than average, in fact drier than average months are more likely than wetter months.

Data from other localities in SW Tarija are scanty and do not offer such a reliable evidence for relating rainfall to SO signals. Data for four localities presented in Table 5 show the proportion of months in which SO signals are strong and rainfall is strongly divergent from the mean[3].

[2] Mean rainfall 597 mm
[3] That is less than 80% of mean (dry) or more than 120% mean (wet)

Table 5
Rainfall in periods of strong SO signals

Locality	Site	Mean rainfall	El Niño	La Niña	# months with strong signal
		mm.	Dry months (%)	Dry/wet months (%)	
Rejará	Mountain margin	1134	89	100 dry	12
Alisos	Mountain margin	851	67	67 dry	12
Tojo	Western Río San Juan del Oro valley	319	56	50 dry	17
Concepción	Dry Tarija area valley	595	33	22 wet	21

It can be observed that the incidence of drier than normal months in El Niño periods is similar or stronger than for Tarija airport but Concepción appears highly anomalous. La Niña periods, as in the case of Tarija airport, do not show a consistent relationship with either wet or dry months. Differences between the physiographic regions of SW Tarija cannot be detected on the basis of the scanty data available and data is particularly scanty for the altiplano area. It seems that the ENSO signal is more related to drier than usual wet seasons. Further analysis using data from nearby altiplano areas - Tupiza in Potosí - and other locations to the east of the mountains is necessary before any even tentative conclusions can be drawn.

Conclusions

For El Niño (warm) episodes, there is a considerable likelihood of drier than usual months during the wet season but considerable variation both from month to month and year to year occurs. It seems unlikely that the strength of the SO signal can be used as a very reliable element in medium-term climate forecasts although it does have a role as part of a multi-component forecast. Farmers need more detailed information than can be provided by seasonal climate forecasts - particularly forecasting the likelihood of rain during the planting period - but even low probability forecasts may be worth communicating.

During La Niña (cold) episodes, the variation of rainfall from the mean follows no clear pattern and drier as well as wetter than average months may be expected. Such episodes seem unlikely to help create reliable forecasts for farmers.

This brief analysis of rainfall data for a part of Tarija department shows broad agreement with Ronchail and Vuille's work. It is necessary to extend the analysis to other highland and valley areas with good rainfall data sets to test further any relationships that may exist between SO signals and rainfall. It seems likely that, in the future, SO indices may be able to be used as part of a varied set of predictions in order to help farmers. Such forecasts should be readily comprehensible, their limitations clearly stated and set in the context of the range of local information already used by rural people to forecast possible climate scenarios.

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