Relationships between an Integrated Pacific Oscillation Factor and New Mexico Precipitation

Charlie A. Liles

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Since 1990, a number of local studies have been written on relationships between the El-Niño-Southern Oscillation (ENSO), La Niña and New Mexico precipitation. Since 1999, several studies have been written to describe the relationships between the Pacific Decadal Oscillation (PDO) and New Mexico precipitation. This study attempts to combine the effects of the ENSO and PDO on New Mexico precipitation in an effort to work toward better seasonal and annual precipitation forecasts for the state, and each climate division within the state. Water management has always been an issue in New Mexico, and this issue will only become more and more important in the future. Successful management of water resources demands the scientific community rise to the challenge of providing accurate seasonal forecasts.

Previous papers have demonstrated some of the more apparent relationships between ENSO and New Mexico precipitation. In short, we know that El Niño events tend to produce enhanced precipitation in New Mexico, especially during the transitional seasons of spring and autumn. The integrated effect of El Niño on New Mexico=s precipitation usually produces more abundant precipitation during the cooler half of the year, leading to above-normal stream flows during the spring run-off from snow melt. In my local studies, I=ve found that even the summer monsoon tends to get a little boost in New Mexico during an El Niño event, with precipitation averaging slightly (up to 15 percent) above normal for the June through August period. Meanwhile, using the four months of June through September, the Sevilleta Long-Term Ecological Research Project found that summer precipitation was slightly enhanced over southern New Mexico but slightly reduced over the north.

It has also been documented that La Niña events tend to produce diminished precipitation in New Mexico, especially during the winter and spring seasons. For both ends of the ENSO spectrum (El Niño and La Niña), spring is the season with the strongest signal.

Relationships between the PDO and New Mexico=s precipitation have also been demonstrated. Positive PDO indices are generally related to enhanced precipitation in New Mexico, especially during the spring and autumn. Negative PDO indices are generally related to diminished precipitation, especially during the spring and autumn. Similar to ENSO, spring is the season with the strongest signal.

Most researchers who have investigated both ENSO and PDO have concluded that the two phenomena are closely related. The positive phase of the PDO is related to sea surface temperature in the Pacific Ocean quite similar to those observed during El Niño events. Similarly, the negative phase of the PDO Alooks@ a bit like a La Niña event (see figure 1). However, an ENSO cycle tends to be anywhere from 2 to about 7 years. A PDO cycle is roughly 50 to 70 years. Consequently, these two cycles will be in phase at times and out of phase at other times.

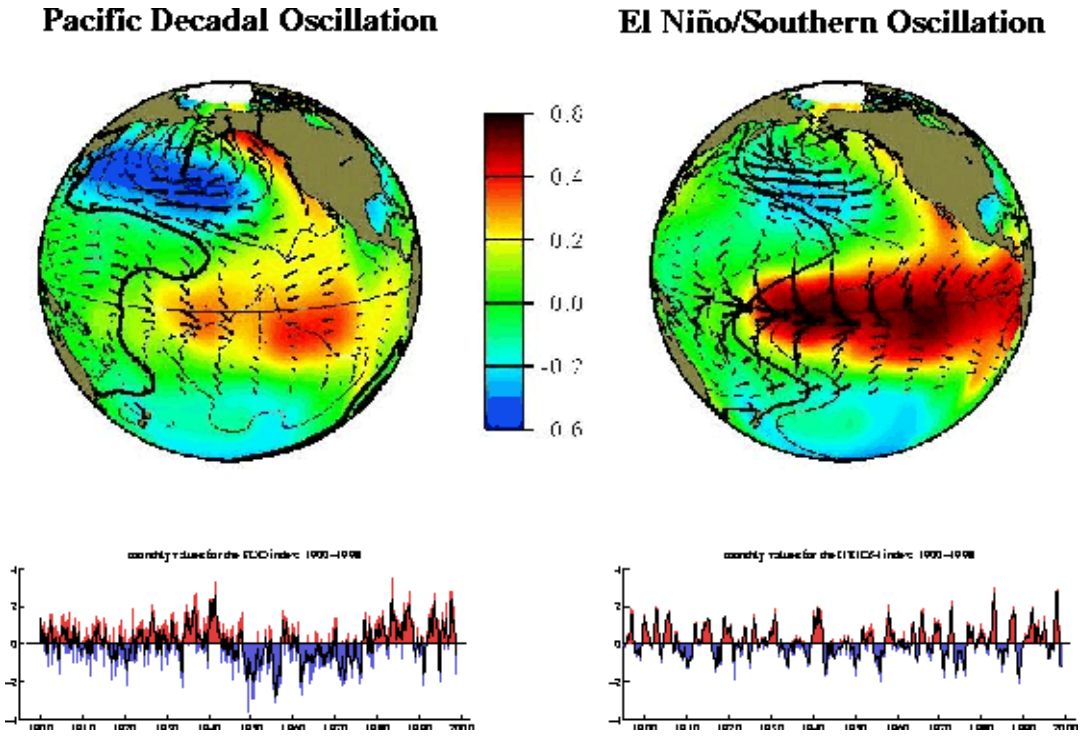

Pacific Decadal Oscillation
El Niño/Southern Oscillation
0.6
0.4
0.2
0.0
-0.2
-0.6

Figure 1

A reasonable question to ask is what do expect when the ENSO-PDO cycles are out of phase? For example, what happens when the PDO is positive and a La Niña occurs, or the PDO is negative and an El Niño occurs.

To determine the combined effects, I developed an AIntegrated Pacific Oscillation Factor,@ (IPOF). This index is a simple subtraction of the Southern Oscillation Index (SOI) from the PDO. This is *somewhat* similar to the Pacific (P) index developed by Castro, McKee and Pielke (2001) in their attempt to combine the signals by using the North Pacific Index (NPO) and ANiño 3" anomalies. In future studies the possible influence of yet another Pacific Index, the North Pacific Oscillation, should be investigated, although a cursory look at this index suggested the main influence of the NPO may be over the northern U.S.

Methodology

The SOI was subtracted from the PDO for each season from 1900 through 2000. Consequently, a positive PDO and negative SOI produces the largest positive index, and is indicative of an El Niño and positive PDO occurring at the same time (an in-phase relationship). A negative PDO and positive SOI leads to the largest negative IPOF, indicative of another in-phase relationship with a La Niña combining forces with the negative PDO. Out-of-phase relationships (PDO and SOI of the same sign) of either kind creates a small absolute value.

Next, standard deviations were calculated. This revealed a set of significantly positive and negative seasons. Precipitation for each of the significant seasons was calculated and averaged. Finally, the average precipitation for the significantly positive and negative seasons was compared to the long-term average seasonal precipitation. These calculations were carried out for each climate division in the state.

Table I shows the IPOF for each season as well as an annual average for the period 1900 through 2000.

	Integrated Pacific Oscillation Factor							
YEAR	Spring	Summer	Autumn	Winter	YEAR	YEAR	SOI Yr	PDO Yr
1900	7.49	-3.27	4.22	2.49	10.93	1900	-6.17	4.76
1901	-1.1	-6.6	4.65	1.31	-1.74		1.96	0.22
1902	-0.94	4.14	3.94	2.15	9.29		-1.86	7.43
1903	-5.34	1.54	-0.98	-4.71	-9.49		10.55	1.06
1904	-6.59	-1.66	4.90	2.96	-0.39		-0.72	-1.11
1905	10.9	6.82	4.24	4.45	26.41		-18.25	8.16
1906	3.37	0.73	-2.96	-1.97	-0.83		4.94	4.11
1907	0.82	0.53	1.93	2.62	5.90		-1.48	4.42
1908	0.80	-0.56	-2.51	3.91	0.92		2.48	3.40
1909	2.41	-6.29	-2.22	-3.26	-9.36		5.77	-3.59
1910	-1.84	-5.70	-4.45	-2.15	-14.14	1910	13.07	-1.07
1911	-0.79	5.14	2.62	1.28	8.25		-10.97	-2.72
1912	4.05	3.28	3.54	3.32	14.19		-10.10	4.09
1913	1.17	5.32	5.31	2.47	14.27		-7.64	6.63
1914	2.00	4.66	2.29	3.49	12.44		-10.84	1.60
1915	3.84	-1.93	-0.54	-1.58	-0.21		1.78	1.57

1916	1.11	-6.71	-3.09	-6.33	-15.02		8.11	-6.91
1917	-7.16	-8.69	-8.76	-7.63	-32.24		26.98	-5.26
1918	-4.67	3.74	1.92	4.93	5.92		-5.52	0.40
1919	2.71	2.63	1.98	0.91	8.23		-10.80	-2.57
1920	-1.79	-5.56	-2.05	-3.45	-12.85	1920	1.82	-11.03
1921	-1.81	-2.96	-1.33	-0.64	-6.74		7.04	0.30
1922	1.40	-2.91	-2.37	-0.77	-4.65		2.80	-1.85
1923	-0.23	6.42	5.10	2.25	13.54		-6.44	7.10
1924	2.35	-2.95	-2.78	-2.22	-5.60		6.03	0.43
1925	-0.77	1.58	4.60	5.54	10.95		-7.19	3.76
1926	5.73	6.88	3.37	2.87	18.85		-3.41	15.44
1927	-2.90	-0.37	0.48	1.37	-1.42		2.06	0.64
1928	-0.85	0.19	-4.33	-1.99	-6.98		8.59	1.61
1929	2.28	-0.56	-0.18	-2.48	-0.94		4.17	3.23
1930	-1.31	1.32	-1.18	4.10	2.93	1930	-2.45	0.48
1931	0.78	-1.24	0.75	-0.11	0.18		6.20	6.38
1932	3.56	2.09	0.67	1.01	7.33		-6.48	0.85
1933	-1.29	-3.36	-3.67	-1.48	-9.80		2.18	-7.62
1934	4.46	3.61	4.01	3.83	15.91		-0.77	15.14
1935	0.81	3.24	-0.21	6.24	10.08		1.24	11.32
1936	1.23	7.66	6.25	0.59	15.73		1.01	16.74
1937	0.19	1.73	2.19	-0.68	3.43		1.47	4.90
1938	-0.66	-5.93	-1.41	-0.89	-8.89		11.66	2.77
1939	-1.16	-0.26	0.51	6.90	5.99		-2.87	3.12
1940	10.19	12.09	7.51	12.25	42.04	1940	-20.37	21.67
1941	9.84	14.68	7.99	5.7	38.21		-16.69	21.52
1942	3.04	0.85	0.36	-4.32	-0.70		3.70	3.63
1943	-0.40	-0.37	-1.74	2.69	0.18		1.70	1.88
YEAR	**Spring**	**Summer**	**Autumn**	**Winter**	**YEAR**	**YEAR**	**SOI Yr**	**PDO Yr**
1944	0.48	-0.54	1.14	-1.31	-0.23		-1.94	-2.17
1945	-1.53	-0.40	-2.70	-2.55	-7.18		3.97	-3.21
1946	1.92	0.96	1.21	-0.09	4.00		-10.79	-6.79
1947	2.93	-0.04	-0.09	1.22	4.02		2.15	6.17
1948	-1.53	-1.05	-3.78	-5.79	-12.15		-3.10	-15.25
1949	-2.76	-0.12	-2.90	-8.59	-14.37		0.20	-14.17
1950	-8.58	-11.64	-9.00	-8.13	-37.35	1950	18.07	-19.28
1951	-1.47	-0.66	1.43	-1.83	-2.53		-6.57	-9.10
1952	-2.02	-3.97	-1.05	1.49	-5.55		-3.01	-8.56
1953	3.06	3.50	-0.03	-2.41	4.12		-8.29	-4.17
1954	-2.13	0.67	-0.49	-3.77	-5.72		3.84	-1.88
1955	-4.99	-11.92	-11.87	-11.1	-39.88		12.6	-27.28
1956	-9.60	-7.17	-7.08	-4.85	-28.70		9.77	-18.93
1957	1.16	4.61	5.28	3.49	14.54		-8.44	6.10
1958	5.36	2.90	1.66	4.40	14.32		-7.21	7.11
1959	-1.91	1.52	-0.37	0.46	-0.30		0.54	0.24
1960	-0.66	-0.41	-2.14	1.10	-2.11	1960	3.59	1.48
1961	1.75	-2.40	-6.96	-8.28	-15.89		2.03	-13.86
1962	-4.39	-3.83	-5.21	-2.28	-15.71		3.76	-11.95
1963	-2.83	-0.97	0.87	0.75	-2.18		-5.76	-7.94
1964	-6.24	-4.27	-4.20	-2.87	-17.58		6.14	-11.44
1965	1.14	4.19	4.47	1.21	11.01		-13.23	-2.22
1966	1.61	-0.08	-1.86	-2.58	-2.91		-2.13	-5.04
1967	-3.54	-4.52	-0.96	-2.22	-11.24		1.46	-9.78

1968	-2.01	-1.48	0.39	-1.31	-4.41		-1.29	-5.70
1969	0.61	1.93	3.30	4.63	10.47		-8.40	2.07
1970	1.76	-2.96	-7.52	-7.92	-16.64	1970	7.19	-9.45
1971	-10.28	-5.70	-5.11	-6.73	-27.82		12.15	-15.67
1972	-2.79	2.45	3.83	1.89	5.38		-13.69	-8.31
1973	-1.64	-5.43	-7.93	-8.93	-23.93		12.48	-11.45
1974	-6.33	-2.02	-0.56	-1.45	-10.36		7.64	-2.72
1975	-5.87	-8.36	-9.66	-8.86	-32.75		18.09	-14.66
1976	-4.69	4.17	3.75	5.59	8.82		-2.97	5.85
1977	5.05	6.61	2.04	5.37	19.07		-17.27	1.80
1978	3.86	-2.27	0.60	-2.18	0.01		-0.88	-0.87
1979	3.01	0.30	3.44	1.42	8.17		-1.03	7.14
1980	6.92	1.57	3.25	2.38	14.12	1980	-6.05	8.07
1981	6.07	0.37	1.61	0.03	8.08		1.43	9.51
1982	0.52	7.27	8.53	11.10	27.42		-24.89	2.53
1983	10.42	9.02	1.71	4.02	25.17		-4.38	20.79
1984	5.01	0.99	2.06	3.26	11.32		-1.77	9.55
1985	-0.12	3.10	1.22	3.40	7.60		-1.69	5.91
1986	5.52	2.33	4.48	7.33	19.66		-5.64	14.02
1987	12.95	11.87	7.26	4.93	37.01		-16.62	20.39
1988	2.35	-0.96	-5.60	-5.50	-9.71		11.95	2.24
1989	-4.93	0.31	-1.61	1.99	-4.24		3.11	-1.13
1990	-0.17	1.13	-0.32	-5.41	-4.77	1990	-1.76	-6.53
1991	2.46	0.65	5.59	6.23	14.93		-16.39	-1.46
1992	7.87	7.21	5.61	3.35	24.04		-13.02	11.02
1993	8.10	12.23	6.74	3.16	30.23		-11.67	18.56
1994	8.42	5.12	-0.49	0.88	13.93		-17.58	-3.65
1995	4.64	3.19	1.35	1.40	10.58		-1.50	9.08
1996	3.25	-0.27	-0.80	-2.42	-0.24		7.10	6.86
1997	7.33	12.00	9.82	10.36	39.51		-20.10	19.41
YEAR	**Spring**	**Summer**	**Autumn**	**Winter**	**YEAR**	**YEAR**	**SOI Yr**	**PDO Yr**
1998	9.28	-2.86	-6.61	-5.52	-5.71		5.20	-0.51
1999	-3.82	-3.42	-7.71	-7.99	-22.94		8.60	-14.34
2000	-1.81	-1.69	-7.07	-1.89	-12.46	2000	9.10	-3.36

Table I

Seasonal results for years in which the IPOF was outside of one standard deviation from the mean values (for each season) are shown in the tables below, along with a discussion of results. The climate divisions of New Mexico are shown in figure 2, below table II.

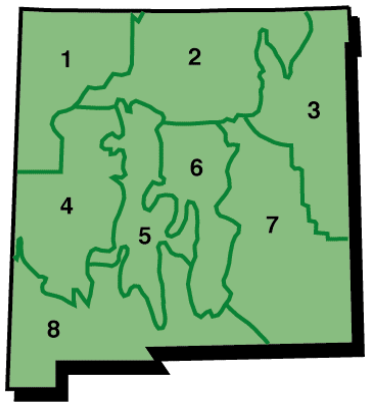
Spring

POSITIVE SPRING	**Northwest**	**Northcntrl**	**Northeast**	**Westcntrl**	**Cntral Vly**	**Cntrl mtns**	**Southeast**	**Southwest**
YEAR	Div1	Div2	Div3	Div4	Div5	Div6	Div7	Div8
1900	2.18	5.57	4.78	1.40	1.09	3.18	2.56	1.06
1905	4.83	7.59	7.18	3.79	2.68	5.77	4.28	2.89
1926	4.47	6.40	7.73	3.98	3.02	5.71	5.93	2.89
1940	1.93	4.00	3.57	2.16	1.84	3.77	3.68	1.40
1941	6.04	8.48	14.04	5.26	4.48	8.36	13.61	3.55
1958	2.57	5.35	6.50	3.52	3.06	5.83	3.80	3.31
1980	1.86	4.92	5.11	1.42	0.94	2.37	2.30	1.18
1981	3.71	4.00	3.52	2.10	1.87	2.48	3.49	1.75
1983	3.15	3.60	3.01	1.99	1.12	2.99	1.95	1.79
1986	2.69	4.05	3.89	1.85	1.51	3.33	2.60	1.29
1987	2.28	3.36	3.81	1.82	1.58	3.91	3.94	1.03
1992	4.06	4.33	4.00	5.65	3.58	5.29	6.33	4.71
1993	1.80	3.61	3.28	1.57	0.83	2.16	1.62	0.51
1994	3.19	6.71	6.03	2.58	2.33	5.44	4.40	1.22
1997	2.75	3.77	5.51	2.51	2.40	4.03	4.44	2.01
1998	2.14	2.37	2.68	2.07	2.26	2.60	1.28	0.90
Normal	2.12	3.59	3.61	1.62	1.38	2.68	2.52	1.03
Average	3.10	4.88	5.29	4.01	2.16	4.20	4.14	1.97
% norm.	**146**	**136**	**147**	**248**	**157**	**157**	**164**	**191**
Std.Dev	1.18	1.63	2.70	1.29	0.99	1.66	2.81	1.13
NEGATIVE SPRING								
YEAR	Div1	Div2	Div3	Div4	Div5	Div6	Div7	Div8
1903	1.30	1.83	1.57	0.69	0.60	1.19	1.24	0.42
1904	1.56	2.41	1.34	0.80	0.16	0.74	0.15	0.24
1917	2.52	3.15	2.63	1.63	0.61	1.28	0.61	0.72
1918	1.78	2.52	2.23	0.95	0.65	1.83	1.44	0.48
1950	0.54	1.01	1.07	0.55	0.34	0.50	0.92	0.11
1955	1.07	5.09	4.69	0.78	0.46	1.71	1.37	0.74
1956	0.71	1.22	1.93	0.37	0.08	0.51	1.12	0.08
1962	0.82	1.24	1.68	0.78	0.48	1.03	0.93	0.59
1964	2.09	2.57	1.83	1.43	1.14	2.69	1.23	1.23
1971	0.88	2.08	2.25	0.51	0.60	1.13	0.74	0.30
1974	0.67	1.47	0.83	0.61	0.65	0.95	0.97	0.42
1975	2.51	2.93	2.31	1.34	0.84	2.57	1.67	1.01
1976	1.34	2.60	2.37	1.52	1.71	3.06	2.42	1.01
1989	0.35	1.91	1.73	0.61	0.61	1.52	0.85	0.76
1999	2.76	5.95	8.40	1.24	2.19	3.35	5.49	0.81
Normal	2.12	3.59	3.61	1.62	1.38	2.68	2.52	1.03

Average	1.39	2.53	2.46	0.92	0.74	1.60	1.41	0.59
% norm.	**66**	**70**	**68**	**57**	**54**	**60**	**56**	**58**
Std.Dev	0.76	1.33	1.80	1.52	0.54	0.89	1.20	0.33

Table II

Figure 2



Discussion of Spring results: When the PDO is in the positive phase and El Niño is also occurring, the Pacific signals are in harmony in providing the set-up for a wet spring in New Mexico. During these 16 spring seasons, precipitation averaged 160 percent of normal for the state. This ranged from 136 percent of normal in division 2 (northern mountains) to 248 percent in division 4 (west-central mountains). As with most of the Pacific signals such as individual components of the IPOF as well as the southwest monsoon, the signals generally weaken toward the Colorado border. The largest standard deviations were in the Plains (division 3 and 7). While the variability in the Plains was greater than in other areas, some of the large standard deviation was certainly due to the incredibly wet spring of 1941. The magnitude of the 1940-41 IPOF was unsurpassed throughout the remainder of the century.

New Mexico=s Afeast or famine@ related to the IPOF is obvious when looking at the negative IPOF years. During those 15 years, precipitation averaged only 63 percent for the state. This ranged from 54 percent in the central valley to as high as 70 percent in the northcentral mountains. Once again, it shows the weaker signal of the IPOF influence near the Colorado border. As with the positive years, the greatest standard deviation is in the Plains (northeast), although the northcentral mountains was 2nd in that category. The southeast Plains (division 7) had the third highest standard deviation.

Summer

POSITIVE Summer	**Northwest**	**Northcntrl**	**Northeast**	**Westcntrl**	**Cntral Vly**	**Cntrl mtns**	**Southeast**	**Southwest**
YEAR	Div1	Div2	Div3	Div4	Div5	Div6	Div7	Div8
1905	2.42	6.17	8.09	4.97	3.42	6.86	6.38	4.53
1923	5.90	9.33	7.88	7.47	4.84	8.88	5.03	5.11
1926	3.00	5.90	7.06	4.89	3.31	6.17	5.46	3.69
1936	4.89	6.77	4.99	4.83	3.05	6.16	3.77	2.73

1940	3.19	5.94	4.17	6.51	4.35	7.25	6.20	3.64
1941	3.55	7.11	10.09	6.53	4.48	8.56	7.58	5.20
1977	4.26	7.76	7.11	7.19	4.23	7.53	5.65	5.66
1982	4.53	7.29	10.09	5.54	2.99	6.22	5.09	3.28
1983	3.89	5.67	4.17	5.22	2.30	5.04	2.29	3.54
1987	3.52	6.02	8.23	6.35	4.68	7.54	6.78	6.41
1992	4.57	7.17	9.11	5.91	4.56	6.16	6.01	4.22
1993	3.71	7.73	9.60	7.85	5.78	8.45	6.02	5.44
1997	5.33	7.48	9.07	6.59	5.67	8.39	6.81	4.45
Normal	3.87	6.95	7.64	6.10	4.18	7.68	6.03	4.93
Average	4.06	6.95	7.67	6.14	4.13	7.17	5.62	4.45
%norm.	**105**	**100**	**100**	**101**	**99**	**93**	**93**	**90**
Std. Dev.	0.94	0.99	2.01	0.97	1.01	1.14	1.33	1.03
NEGATIVE SUMMER								
YEAR	Div1	Div2	Div3	Div4	Div5	Div6	Div7	Div8
1901	3.50	6.73	6.43	5.61	3.92	8.00	5.19	5.00
1909	5.72	7.78	5.93	6.86	4.18	7.67	4.26	4.54
1910	3.53	6.29	5.76	5.75	3.65	6.80	3.78	4.63
1916	4.72	7.38	7.36	6.84	4.83	8.67	6.06	5.17
1917	3.11	5.34	4.83	4.92	2.83	5.78	2.68	3.91
1920	3.78	6.96	8.85	5.89	4.43	7.80	8.06	4.12
1938	3.26	6.47	6.39	5.69	4.01	6.74	6.17	4.31
1950	1.78	7.44	11.33	4.48	3.57	9.15	7.66	5.00
1955	4.41	7.05	5.21	6.60	4.36	8.45	4.74	5.73
1956	2.18	4.38	5.43	4.08	2.31	5.66	3.42	2.77
1967	5.76	10.76	10.44	7.57	6.42	10.54	6.50	6.01
1971	3.67	7.08	8.03	5.53	3.38	7.25	7.42	3.69
1973	2.92	5.04	6.30	4.50	4.48	6.82	4.89	4.44
1975	2.79	5.37	6.32	5.20	3.53	5.41	5.97	3.83
Normal	3.87	6.95	7.64	6.10	4.18	7.68	6.03	4.93
Average	3.65	6.72	7.04	5.68	3.99	7.48	5.49	4.51
%norm.	**94**	**97**	**92**	**93**	**95**	**97**	**91**	**91**
Std. Dev.	1.13	1.49	1.89	.98	0.94	1.39	1.57	0.82

Table III

Discussion of Summer Results: As with individual components of the IPOF, the influence of the Pacific signals during summer are not nearly as clear cut. During the positive IPOF summers, precipitation for the state averaged 97 percent of normal. There did appear to be a consistent north-south trend, with precipitation normal to slightly above normal in the north, and a little below normal in the south. Division 8 (Southwest) averaged only 90 percent of normal. Standard deviations were relatively consistent except for division 3 (northeast), where it was roughly double the average for the other divisions. This appeared to be mainly due to the very wet summers of 1941 and 1982 in the northeast.

For negative IPOF summers, precipitation averaged slightly below normal for all climate divisions. The statewide average was 94 percent of normal. There wasn't much variation from

division to division, with averages ranging from 91 percent of normal in divisions 7 (southeast) and 8 (southwest) to 97 percent in divisions 2 (northern mountains) and 6 (central mountain chain). Standard deviations were smallest in the divisions most affected by the southwest monsoon.

Autumn

POSITIVE SPRING	**Northwest**	**Northcntrl**	**Northeast**	**Westcntrl**	**Cntral Vly**	**Cntrl mtns**	**Southeast**	**Southwest**
YEAR	Div1	Div2	Div3	Div4	Div5	Div6	Div7	Div8
1901	2.23	3.25	3.83	3.42	3.03	4.10	5.11	3.35
1904	2.54	4.86	6.55	4.43	3.95	6.34	8.21	5.01
1913	2.50	3.36	3.72	2.50	2.08	3.75	5.06	2.64
1923	5.12	5.98	6.49	4.86	4.21	5.75	6.57	3.84
1925	3.24	3.82	2.96	3.26	2.39	3.74	3.35	2.70
1936	2.72	4.38	2.58	3.70	2.75	5.11	4.28	3.89
1940	4.35	5.11	3.37	4.94	2.90	3.53	3.13	2.47
1941	7.25	8.33	12.99	6.27	6.30	10.72	12.49	7.56
1957	2.69	6.53	4.38	3.00	3.22	5.77	4.25	3.07
1965	3.10	4.05	2.87	2.98	2.93	4.29	2.24	2.55
1982	2.83	4.24	3.73	3.24	2.27	5.19	4.62	3.00
1986	1.76	7.05	8.08	6.25	6.05	8.01	7.14	5.31
1987	3.77	2.50	2.26	2.30	1.43	2.75	2.30	2.11
1991	2.86	5.09	5.36	3.46	3.78	5.44	6.18	3.18
1992	2.53	2.40	1.60	2.55	2.81	3.01	1.54	1.79
1993	5.55	2.93	2.25	2.42	1.84	3.28	2.15	1.77
1997	2.92	5.06	4.00	5.27	3.87	5.69	5.25	3.59
Normal	2.94	3.64	3.40	3.32	2.57	3.90	3.70	2.86
Average	3.41	4.64	4.53	3.81	3.28	5.09	4.93	3.40
%norm.	**116**	**127**	**133**	**115**	**128**	**131**	**133**	**119**
Std. Dev.	1.37	1.59	2.70	1.25	1.29	1.94	2.63	1.41

NEGATIVE AUTUMN								
YEAR	Div1	Div2	Div3	Div4	Div5	Div6	Div7	Div8
1910	2.03	2.30	1.51	1.13	0.96	1.75	1.76	0.86
1917	1.07	1.75	1.36	1.66	1.16	1.77	1.50	1.46
1928	3.49	4.25	3.98	2.89	2.83	4.02	4.22	2.16
1955	0.59	1.49	2.47	0.99	1.08	2.18	4.13	1.13
1956	0.68	0.65	0.75	0.56	0.44	0.98	1.01	0.43
1961	3.33	4.14	4.82	4.56	2.84	4.10	2.95	4.03
1962	5.85	4.20	2.67	5.06	3.86	5.31	4.34	4.27
1970	3.20	3.27	3.76	2.28	1.44	1.71	3.12	1.81
1971	4.35	5.55	4.77	5.28	3.66	5.61	4.31	3.82
1973	1.79	2.59	2.07	0.82	0.94	1.54	2.09	0.42
1975	2.87	4.01	2.83	5.87	3.65	4.34	2.84	5.02
1998	5.26	5.77	5.70	4.24	2.87	5.76	4.35	3.71
1999	1.28	2.10	2.29	2.71	1.38	2.26	1.66	1.82
2000	3.50	4.74	5.78	6.01	4.44	5.26	4.92	4.15

Normal	2.94	3.64	3.40	3.32	2.57	3.90	3.70	2.86
Average	2.81	3.34	3.20	3.15	2.25	3.33	3.09	2.51
%norm.	**96**	**92**	**94**	**95**	**88**	**85**	**84**	**88**
Std. Dev.	1.59	1.51	1.56	1.91	1.28	1.68	1.26	1.54

Table IV

Discussion of Autumn results: Similar to the PDO itself, the IPOF has a distinct association with autumn precipitation in New Mexico. Also similar to the PDO, the IPOF autumn results are not as dramatic as spring. During positive IPOF autumns, precipitation averaged 126 percent of normal for the state. This ranged from 115 percent in division 4 (west-central) to 133 percent in divisions 3 and 7. Although the average for the state (126 percent) was nearly identical to the positive PDO average of 124 (not shown in this paper), the areas most affected are were a bit different. For the IPOF, the most favored areas were in the east, especially divisions 3 and 7 (the northeast and southeast plains). Since a positive IPOF favors more upper-level troughs over the Rocky Mountains, it is likely that positive IPOF autumns would favor more autumn frontal passages southward through the eastern plains of New Mexico. However, standard deviations were also greatest in these two divisions.

Negative IPOF autumns were related to diminished precipitation in New Mexico, with the statewide average 90 percent of normal. This ranged from 84 percent in division 7 (southeast) to 96 percent in division 1 (northwest).

Winter

POSITIVE SPRING	**Northwest**	**Northcntrl**	**Northeast**	**Westcntrl**	**Cntral Vly**	**Cntrl mtns**	**Southeast**	**Southwest**
YEAR	Div1	Div2	Div3	Div4	Div5	Div6	Div7	Div8
1918	2.50	2.52	0.89	1.84	1.01	2.15	0.64	1.36
1925	1.53	1.73	0.83	1.22	0.67	1.92	0.75	1.17
1935	3.48	2.65	0.58	3.17	2.33	2.73	0.76	1.89
1939	3.24	3.02	2.37	2.86	1.61	3.85	1.90	2.42
1940	2.65	2.92	2.22	2.83	1.42	2.92	1.42	1.96
1941	5.46	3.97	1.03	4.33	2.40	3.91	1.38	3.34
1969	2.77	2.06	0.92	1.46	0.79	2.92	0.76	1.26
1976	1.24	1.30	0.52	1.64	0.78	1.55	0.68	1.76
1977	1.34	1.25	0.59	0.98	0.99	2.62	0.71	1.19
1982	2.83	2.44	0.49	2.34	0.83	2.38	0.68	1.51
1986	1.76	1.36	1.12	1.55	0.94	2.05	1.11	1.07
1987	3.77	3.56	3.37	3.40	2.36	5.54	4.01	3.31
1991	2.86	2.35	0.85	2.59	1.44	3.35	1.31	3.09
1997	2.92	3.25	1.38	2.02	1.34	2.69	1.90	1.84
Normal	2.28	2.23	1.19	2.07	1.30	2.65	1.29	1.95
Average	2.74	2.46	1.23	2.30	1.35	2.90	1.29	1.94
%norm.	**120**	**110**	**103**	**111**	**104**	**109**	**100**	**99**
Std. Dev.	1.07	0.82	0.82	0.91	0.59	0.99	0.87	0.77

NEGATIVE WINTER YEAR	Div1	Div2	Div3	Div4	Div5	Div6	Div7	Div8
1903	1.89	2.37	1.67	1.77	1.49	3.26	2.09	1.87
1916	4.34	3.77	1.14	3.78	1.76	3.71	0.92	3.16
1917	2.48	2.26	0.60	1.88	0.94	2.02	0.36	1.62
1948	2.24	3.80	3.05	3.37	2.67	3.88	2.22	2.44
1949	2.80	2.71	1.86	3.79	1.53	3.39	2.41	4.69
1950	1.67	1.66	0.44	1.21	0.55	1.82	0.53	1.27
1955	2.05	1.84	0.46	1.14	0.60	1.63	0.55	1.26
1956	2.50	2.15	0.86	1.79	0.97	2.32	0.87	0.92
1961	1.70	2.41	1.97	1.69	1.47	2.79	2.83	2.29
1970	0.91	1.17	1.01	1.38	1.22	2.17	1.26	1.74
1971	1.50	1.14	0.41	0.84	0.56	1.50	0.44	0.63
1973	2.65	1.84	1.23	2.77	1.76	3.65	2.38	3.54
1975	2.00	2.86	1.55	2.19	1.60	3.72	2.21	1.92
1990	1.31	2.42	2.60	1.25	0.90	2.73	1.26	1.42
1998	2.81	2.11	2.61	2.79	1.95	4.43	2.78	2.84
1999	0.64	0.79	1.16	0.89	0.53	1.30	1.20	0.65
Normal	2.28	2.23	1.19	2.07	1.30	2.65	1.29	1.95
Average	2.09	2.21	1.41	2.03	1.28	2.77	1.52	2.02
%norm.	**92**	**99**	**118**	**98**	**98**	**105**	**118**	**104**
Std. Dev.	0.85	0.81	0.80	0.95	0.59	0.94	0.85	1.07

Table V

Discussion of Winter Results: The results for IPOF winters was quite different from PDO winters (not shown in this paper). While the state averaged 127 percent of normal precipitation during positive PDO winters, the average for positive IPOF winters was only 108 percent. Values ranged from 99 percent of normal in division 7 (southeast) to 120 percent of normal in division 1 (northwest). .

The negative IPOF winters were even more interesting. Although all of New Mexico suffers during negative PDO winters, some areas of New Mexico actually received more precipitation during winters when the IPOF was significantly negative. Precipitation actually averaged 102 percent of normal for the state, but the range was from 92 percent of normal in division 1 (northwest) to 118 percent of normal in divisions 3 and 7 (the northeast and southeast plains). When looking at the table, it's clear that northwest New Mexico benefits from positive IPOF winters and receives diminished precipitation during negative IPOF years (120 percent versus 92 percent). However, this trend gradually reverses as one heads east. For division 7 (southeast), the positive IPOF years produced normal (100 percent) precipitation while negative IPOF years produced 118 percent of normal precipitation. Close to the middle, division 6 exhibited a range from 109 percent of normal during positive IPOF winters to 105 percent during the negative winters.

Out of Phase Relationships

To determine out-of-phase relationships between ENSO and the PDO, seasons outside of one standard deviation of the seasonal means were determined for the SOI and PDO. Whenever a season exhibited both SOI and PDO values that were of the same sign, and both at least one standard deviation from the mean, those seasons were determined to be seasons in which the SOI and PDO were out of phase.

Tables VI and VII show the SOI and PDO categories, respectively. The AN@ designates one standard deviation in the negative direction from the mean. A AP@ designates one standard deviation in the positive direction from the mean. Two letters (N or P) signify 1.5 standard deviations. Three letters represents 2 standard deviations, and four letters indicates 2.5 standard deviations. As you can see, I=ve also listed a column for the year, which reflects an average condition for the year. These were used (discussion is later in this paper) to determine Avery significant IPOF years.@

SOI

YEAR	Spring	Summer	Autumn	Winter	YEAR
1900	NNN	PP	NN		3N
1901		PP	NN		0
1902	P				1P
1903	PP			PP	4P
1904	PPP				3P
1905	NNNN	N	N	N	7N
1906			PP		2P
1907					0
1908			P		1P
1909		PP			2P
1910		PP	PP		4P
1911		N		N	2N
1912	NN				2N
1913			N		1N
1914		N		N	2N
1915	N	P			0
1916		PP		P	3P
1917	PPPP	PPPP	PPP	PP	13P
1918	P			N	0
1919		N	N		2N
1920					0
1921					0
1922					0
1923		N	N		2N
1924					0
1925	P	N	N	N	2N
1926					0
1927	P				1P
1928	P			PP	3P
1929					0
1930					0

1931	P	P			2P
1932					0
1933					0
1934					0
1935					0
1936	P				1P
1937					0
1938		PP		P	3P
1939			N		1N
1940	N	NN	NN	NNN	8N
1941	N	NN	NN	N	6N
1942					0
1943					0
1944					0
1945					0
1946			N		1N
1947					0
1948					0
1949				P	1P
1950	PP	PPP	P	PP	8P
1951					0
1952					0
1953	N				1N
1954					0
1955		PP	PP	P	5P
1956	P	P			2P
1957				N	1N
1958				N	1N
1959					0
1960					0
1961				P	1P
1962					0
1963					0
1964			P		1P
1965		NN	NN		4N
1966	N				1N
1967					0
1968					0
1969					0
1970			PP	P	3P
1971	PPP		PP		5P
1972		NN		N	3N
1973			PP	PPP	5P
1974	PP				2P
1975	P	PP	PPP	PP	8P
1976					0
1977	N	NN	N	NN	6N
1978					0
1979					0
1980	N				1N
1981					0
1982		NNN	NNNN	NNNNN	12N
1983	NN				2N

1984					0
1985					0
1986				N	1N
1987	NNN	NNN			6N
1988			PPP	P	4P
1989	PP			N	1P
1990					0
1991	NN		N	NNN	6N
1992	NN				2N
1993	N	NN			3N
1994	NN	NN	N		5N
1995					0
1996				P	1P
1997	N	N	NN	NNNN	8N
1998	NN	P	P	PP	2P
1999				P	1P
2000			PP	P	3P

Table VI

PDO

YEAR	Spring	Summer	Autumn	Winter	YEAR
1900					
1901					
1902		P			1P
1903					
1904		N			1N
1905					
1906					
1907				P	1P
1908					
1909					
1910					
1911					
1912					
1913		P			1P
1914					
1915					
1916				N	1N
1917					
1918					
1919					
1920	N	NN			3N
1921					
1922		N			1N
1923					
1924					
1925					
1926		PP	PP	P	5P
1927					
1928					
1929					
1930				P	1P

1931	P				1P
1932					
1933		N	N		2N
1934	P		PPP	P	5P
1935				PP	2P
1936	P	PPP	PP		6P
1937					
1938				P	1P
1939			N	PP	1P
1940	PPP	PP	P	PPP	9P
1941	PPP	PPPP	PP		9P
1942					
1943					
1944					
1945					
1946					
1947					
1948			N	NNNN	5N
1949			N	NNN	4N
1950	NN	NN	NNN	N	8N
1951	N			N	2N
1952	N	N			2N
1953				N	1N
1954					
1955	NN	NNNN	NNNN	NNNN	14N
1956	NNNN	N	NN	N	8N
1957			P		1P
1958		P			1P
1959					
1960					
1961		N	NNN	NN	6N
1962	N	N	N		3N
1963		N			1N
1964	NN			N	3N
1965					
1966					
1967	N	N			2N
1968				N	1N
1969					
1970			N	NN	3N
1971	NNN	N		NNN	7N
1972	NNN				3N
1973		N	N	N	3N
1974					
1975	N		NN	NN	5N
1976	N		P	P	1P
1977					
1978	P				1P
1979			P		1P
1980	P				1P
1981	P				1P
1982					
1983	PPP	PPPP	P	PP	10P

1984	PP			P	3P
1985				P	1P
1986	PP		P	P	4P
1987	PPP	PP	PPP	P	9P
1988	P				1P
1989					
1990				NN	2N
1991	N				1N
1992	N	P	P		1P
1993	P	PPP	PP	P	7P
1994			NN		2N
1995		P			1P
1996	PP				2P
1997	P	PPPP	PPP	P	9P
1998	P		N		
1999		N	NNN	N	5N
2000			N		1N

Table VII

Table VIII shows the seasons that were found to be out of phase.

Year	Spring	Summer	Autumn	Winter
1931	P+P			
1938				P+P
1939			N+N	
1991	NN+N			
1994			N+NN	

Table VIII

Considering the sample of years listed in Table VIII, it appears that out-of-phase relationships between the SOI and PDO do not occur very often. If the longer-term cycle of the PDO is the dominant cycle, it simply appears difficult to develop an El Niño during a significantly negative PDO year, or to develop a La Niña during a significantly positive PDO year. I believe we have seen a good example of this relationship in 2001-2002. What appeared to many to be an El Niño developing as early as mid-2001 was still in the formative stages in early 2002. As this El Niño finally developed during 2002, the PDO became less negative and was on the verge of becoming positive (likely for a temporary period) late in the year.

The following table shows precipitation by climate division for the out-of-phase relationships listed above. The first two cases (1931 and 1938) are situations with a significantly-positive PDO along with some stage of La Niña. The other three cases are situations with a significantly negative PDO along with an El Niño. The 1991 case shows that the SOI was negative by more than 1.5 standard deviations (two ANs@). In the 1994 case, the PDO was negative by over 1.5

standard deviations.

Year	Seas.	Div1	Div2	Div3	Div4	Div5	Div6	Div7	Div8	
1931	Spr	3.41	4.50	5.57	3.62	3.80	4.94	5.28	2.15	Ave
		2.12	3.59	3.61	1.62	1.38	2.68	2.52	1.03	Norm
		161	125	154	223	275	184	210	209	%
1938	Win	2.20	2.23	1.64	1.79	1.36	2.85	2.09	2.00	Ave
		2.28	2.23	1.19	2.07	1.30	2.65	1.29	1.95	Norm
		96	100	138	86	105	108	162	103	%
1939	Aut	2.79	3.64	2.05	4.29	3.51	4.60	2.26	3.76	Ave
		2.94	3.64	3.40	3.32	2.57	3.90	3.70	2.86	Norm
		95	100	60	129	137	118	61	131	%
1991	Spr	1.53	3.60	3.27	1.20	0.65	2.48	0.94	1.04	Ave
		2.12	3.59	3.61	1.62	1.38	2.68	2.52	1.03	Norm
		61	100	91	74	47	93	37	101	%
1994	Aut	4.66	5.81	2.54	6.25	4.45	5.90	2.96	4.05	Ave
		2.94	3.64	3.40	3.32	2.57	3.90	3.70	2.86	Norm
		159	160	75	188	173	151	80	142	%

Table IX

Discussion of Results: The first two cases (1931 and 1938) are seasons with significantly positive PDO values and La Niña occurring. For 1931, the enhanced precipitation was very substantial, averaging 179 percent of normal. While precipitation is enhanced during significantly positive PDO years without consideration of ENSO signals, the enhancement during 1931 was even greater. La Niña tends to be associated with reduced spring precipitation in New Mexico. Consequently, in 1931 it appears the positive PDO was the dominant factor.

The only other case with significantly positive PDO values occurring along with La Niña was the winter of 1938. The Plains (divisions 3 and 7) were wet, similar to what would be expected from the positive PDO alone. However, the remainder of the state experienced precipitation that was close to normal. These other divisions are generally wet during positive PDO winters, suggesting that La Niña had a dampening effect on precipitation production for all but the plains divisions. This seems reasonable since the ENSO effects (considered alone) tend to have the least amount of influence over the eastern plains.

For the three years in which El Niño occurred during significantly negative PDO values, two (1939 and 1994) were autumns and one (1991) was spring. These are the two seasons of the year in which ENSO signals historically have the greatest influence on New Mexico precipitation. In both autumn cases, wet weather prevailed everywhere except the plains (divisions 3 and 7). This suggests that El Niño was the dominant factor for areas of the state where ENSO signals tend to have the greatest influence. Once again, divisions 3 and 7 (the plains) were dry both years, as the negative PDO was the dominant factor in those areas.

The spring of 1991 was generally dry for New Mexico, showing the influence of the negative PDO. The El Niño seemed to exert little influence on enhancing precipitation, even in areas where ENSO signals usually do show up.

Overall, it appears that when El Niño events are coincident with significantly negative PDO years, that is, when El Niño occurs during times of conflicting PDO signals, the El Niño influence is likely to dominate in areas of the state where ENSO signals are historically most significant. In the Eastern Plains where ENSO signals are generally weaker, the PDO signals will dominate the weather during these times when El Niño and the negative PDO are in conflict (the Plains).

For La Niña events during significantly positive PDO years, it was interesting to see that the positive PDO seemed to totally dominate the picture in the spring of 1931, regardless of the La Niña. However, precipitation was reduced during the winter of 1938 (compared to what would be expected considering the PDO alone) except in divisions 3 and 7 (the plains). Once again, divisions 3 and 7 seem to be least effected by the ENSO, and the positive PDO was related to greatly-enhanced precipitation. Elsewhere, it appears La Niña put a damper on winter precipitation that year. However, it=s impossible to draw definitive conclusions from this small sample of out-of-phase relationships.

Significant Years

For each year, seasonal deviations of SOI and PDO from the mean were summed to arrive at an IPOF year value. For example, if a season had an SOI that was three standard deviations from the mean, the SOI was given the value of plus or minus 3. The total SOI deviations for the year were summed and combined with the PDO deviations to arrive at the IPOF value for the year. Table
X, XI and XII (below) show the SOI, PDO, and combined categories for the period 1900 through 2000.

SOI

YEAR	Spring	Summer	Autumn	Winter	YEAR
1900	NNN	PP	NN		3N
1901		PP	NN		0
1902	P				1P
1903	PP			PP	4P
1904	PPP				3P

1905	NNNN	N	N	N	7N
1906			PP		2P
1907					0
1908			P		1P
1909		PP			2P
1910		PP	PP		4P
1911		N		N	2N
1912	NN				2N
1913			N		1N
1914		N		N	2N
1915	N	P			0
1916		PP		P	3P
1917	PPPP	PPPP	PPP	PP	13P
1918	P			N	0
1919		N	N		2N
1920					0
1921					0
1922					0
1923		N	N		2N
1924					0
1925	P	N	N	N	2N
1926					0
1927	P				1P
1928	P			PP	3P
1929					0
1930					0
1931	P	P			2P
1932					0
1933					0
1934					0
1935					0
1936	P				1P
1937					0
1938		PP		P	3P
1939			N		1N
1940	N	NN	NN	NNN	8N
1941	N	NN	NN	N	6N
1942					0
1943					0
1944					0
1945					0
1946			N		1N
1947					0
1948					0
1949				P	1P
1950	PP	PPP	P	PP	8P
1951					0
1952					0
1953	N				1N
1954					0
1955		PP	PP	P	5P
1956	P	P			2P
1957				N	1N

1958				N	1N
1959					0
1960					0
1961				P	1P
1962					0
1963					0
1964			P		1P
1965		NN	NN		4N
1966	N				1N
1967					0
1968					0
1969					0
1970			PP	P	3P
1971	PPP		PP		5P
1972		NN		N	3N
1973			PP	PPP	5P
1974	PP				2P
1975	P	PP	PPP	PP	8P
1976					0
1977	N	NN	N	NN	6N
1978					0
1979					0
1980	N				1N
1981					0
1982		NNN	NNNN	NNNNN	12N
1983	NN				2N
1984					0
1985					0
1986				N	1N
1987	NNN	NNN			6N
1988			PPP	P	4P
1989	PP			N	1P
1990					0
1991	NN		N	NNN	6N
1992	NN				2N
1993	N	NN			3N
1994	NN	NN	N		5N
1995					0
1996				P	1P
1997	N	N	NN	NNNN	8N
1998	NN	P	P	PP	2P
1999				P	1P
2000			PP	P	3P

Table X

PDO

YEAR	Spring	Summer	Autumn	Winter	YEAR
1900					
1901					
1902		P			1P
1903					
1904		N			1N
1905					

1906					
1907				P	1P
1908					
1909					
1910					
1911					
1912					
1913		P			1P
1914					
1915					
1916				N	1N
1917					
1918					
1919					
1920	N	NN			3N
1921					
1922		N			1N
1923					
1924					
1925					
1926		PP	PP	P	5P
1927					
1928					
1929					
1930				P	1P
1931	P				1P
1932					
1933		N	N		2N
1934	P		PPP	P	5P
1935				PP	2P
1936	P	PPP	PP		6P
1937					
1938				P	1P
1939			N	PP	1P
1940	PPP	PP	P	PPP	9P
1941	PPP	PPPP	PP		9P
1942					
1943					
1944					
1945					
1946					
1947					
1948			N	NNNN	5N
1949			N	NNN	4N
1950	NN	NN	NNN	N	8N
1951	N			N	2N
1952	N	N			2N
1953				N	1N
1954					
1955	NN	NNNN	NNNN	NNNN	14N
1956	NNNN	N	NN	N	8N
1957			P		1P
1958		P			1P

1959					
1960					
1961		N	NNN	NN	6N
1962	N	N	N		3N
1963		N			1N
1964	NN			N	3N
1965					
1966					
1967	N	N			2N
1968				N	1N
1969					
1970			N	NN	3N
1971	NNN	N		NNN	7N
1972	NNN				3N
1973		N	N	N	3N
1974					
1975	N		NN	NN	5N
1976	N		P	P	1P
1977					
1978	P				1P
1979			P		1P
1980	P				1P
1981	P				1P
1982					
1983	PPP	PPPP	P	PP	10P
1984	PP			P	3P
1985				P	1P
1986	PP		P	P	4P
1987	PPP	PP	PPP	P	9P
1988	P				1P
1989					
1990				NN	2N
1991	N				1N
1992		P	P		1P
1993	P	PPP	PP	P	7P
1994			NN		2N
1995		P			1P
1996	PP				2P
1997	P	PPPP	PPP	P	9P
1998	P		N		
1999		N	NNN	N	5N
2000			N		1N

Table XI

Combined	SOI and PDO Categories			IPOF Standard Dev.
YEAR	SOI cat.	PDO cat.	IPOF cat.	
1900	3N		3	
1901	0		0	
1902	1P	1P	0	
1903	4P		-4	
1904	3P	1N	-4	
1905	7N		7	1 positive
1906	2P		-2	

1907	0	1P	1	
1908	1P		-1	
1909	2P		-2	
1910	4P		-4	
1911	2N		2	
1912	2N		2	
1913	1N	1P	2	
1914	2N		2	
1915	0		0	
1916	3P	1N	-4	
1917	13P		-13	2 negative
1918	0		0	
1919	2N		2	
1920	0	3N	-3	
1921	0		0	
1922	0	1N	-1	
1923	2N		2	
1924	0		0	
1925	2N		2	
1926	0	5P	5	
1927	1P		-1	
1928	3P		-3	
1929	0		0	
1930	0	1P	1	
1931	2P	1P	-1	
1932	0		0	
1933	0	2N	-2	
1934	0	5P	5	
1935	0	2P	2	
1936	1P	6P	5	
1937	0		0	
1938	3P	1P	-2	
1939	1N	1P	2	
1940	8N	9P	17	2 positive
1941	6N	9P	15	2 positive
1942	0		0	
1943	0		0	
1944	0		0	
1945	0		0	
1946	1N		1	
1947	0		0	
1948	0	5N	-5	
1949	1P	4N	-5	
1950	8P	8N	-16	2 negative
1951	0	2N	-2	
1952	0	2N	-2	
1953	1N	1N	0	
1954	0		0	
1955	5P	14N	-19	3 negative
1956	2P	8N	-10	2 negative
1957	1N	1P	2	
1958	1N	1P	2	
1959	0		0	

1960	0		0	
1961	1P	6N	-7	1 negative
1962	0	3N	-3	
1963	0	1N	-1	
1964	1P	3N	-4	
1965	4N		4	
1966	1N		1	
1967	0	2N	-2	
1968	0	1N	-1	
1969	0		0	
1970	3P	3N	-6	1 negative
1971	5P	7N	-12	2 negative
1972	3N	3N	0	
1973	5P	3N	-8	1 negative
1974	2P		-2	
1975	8P	5N	-13	2 negative
1976	0	1P	1	
1977	6N		6	
1978	0	1P	1	
1979	0	1P	1	
1980	1N	1P	2	
1981	0	1P	1	
1982	12N		12	2 positive
1983	2N	10P	12	2 positive
1984	0	3P	3	
1985	0	1P	1	
1986	1N	4P	5	
1987	6N	9P	15	2 positive
1988	4P	1P	-3	
1989	1P		-1	
1990	0	2N	-2	
1991	6N	1N	5	
1992	2N	1P	3	
1993	3N	7P	10	
1994	5N	2N	3	
1995	0	1P	1	
1996	1P	2P	1	
1997	8N	9P	17	2 positive
1998	2P		-2	
1999	1P	5N	-6	1 negative
2000	3P	1N	-4	

Table XII

Discussion of results: Significant IPOF years are those in which strong ENSO events occur in conjunction with significant PDO years with in-phase relationships. The combination of a strong El Niño occurring at a time when the PDO is significantly positive will produce a large positive IPOF value. Similarly, the combination of a strong La Niña and significantly negative PDO will create a large negative IPOF value. The fourth column in table XII shows the years for which the IPOF value was more than one standard deviation from the mean. Some years were over two standard deviations from the mean, and one year was over three.

Tables XIII and XIV show the precipitation by climate division and for the state for significant IPOF years.

Significantly Positive IPOF Years

YEAR	Div1	Div2	Div3	Div4	Div5	Div6	Div7	Div8	State
1905	**15.92**	**22.07**	**20.50**	**17.84**	**12.34**	**22.21**	**17.55**	**15.89**	**18.04**
1940	**13.92**	**19.27**	12.50	**17.66**	**10.81**	**17.88**	**14.01**	9.66	**14.46**
1941	**20.97**	**27.06**	**38.11**	**21.77**	**17.63**	**31.28**	**35.38**	**19.75**	**26.49**
1982	**14.65**	**17.87**	**17.43**	**15.06**	8.23	**17.32**	**14.00**	**11.28**	**14.48**
1983	**14.60**	15.41	12.40	**16.94**	**9.71**	**17.84**	11.77	**14.02**	**14.09**
1987	**12.51**	15.78	**17.86**	**14.51**	**10.06**	**19.36**	**15.97**	**12.02**	**14.76**
1997	**15.75**	**20.43**	**21.81**	**17.96**	**14.45**	**23.73**	**20.88**	13.73	**18.59**
Ave.	15.47	19.70	20.09	17.39	11.89	21.37	18.51	13.76	**17.27**
Norm.	11.17	16.42	15.85	13.10	9.43	16.90	13.54	10.77	13.40
%Norm	138	120	127	133	126	126	137	128	129

Table XIII

Above normal precipitation is shown in **bold** print.

Significantly Negative IPOF Years

YEAR	Div1	Div2	Div3	Div4	Div5	Div6	Div7	Div8	State
1917	**8.65**	**11.91**	**9.26**	**9.83**	**5.44**	**10.43**	**5.03**	**7.53**	**8.51**
1950	**5.19**	**11.98**	15.97	**7.52**	**5.71**	**13.78**	**12.83**	**7.59**	**10.07**
1955	**8.26**	**15.66**	**12.76**	**9.68**	**6.56**	**14.18**	**10.69**	**8.93**	**10.84**
1956	**5.58**	**7.94**	**8.90**	**6.60**	**3.63**	**9.03**	**6.50**	**4.27**	**6.56**
1961	11.38	17.45	17.46	**12.64**	**8.99**	17.87	**10.91**	11.04	13.47
1970	**9.77**	**13.84**	**12.53**	**10.10**	**6.02**	**11.75**	**9.85**	**7.62**	**10.19**
1971	**10.65**	16.89	16.18	13.11	**9.13**	**16.87**	13.67	**9.32**	**13.23**
1973	**10.37**	**14.34**	**14.24**	**10.27**	**9.03**	**15.28**	**11.54**	**9.42**	**11.81**

1975	**10.30**	**14.65**	**12.73**	14.68	**9.30**	**15.33**	**12.22**	11.85	**12.63**
1999	11.30	18.50	19.36	13.49	10.77	**15.83**	14.88	11.71	14.48
Ave.	9.15	14.32	13.94	10.80	7.46	14.04	10.81	8.93	11.18
Norm.	11.17	16.42	15.85	13.10	9.43	16.90	13.54	10.77	13.40
%Norm	82	87	88	82	79	83	80	83	83

Table XIV

Below normal precipitation is shown in **bold** print.

Very Significant Years

Tables XV and XVI show the results for years in which the IPOF value was outside the range of two standard deviations.

Very Significantly Positive IPOF Years

YEAR	**Div1**	**Div2**	**Div3**	**Div4**	**Div5**	**Div6**	**Div7**	**Div8**	**State**
1940	**13.92**	**19.27**	12.50	**17.66**	**10.81**	**17.88**	**14.01**	9.66	**14.46**
1941	**20.97**	**27.06**	**38.11**	**21.77**	**17.63**	**31.28**	**35.38**	**19.75**	**26.49**
1982	**14.65**	**17.87**	**17.43**	**15.06**	8.23	**17.32**	**14.00**	**11.28**	**14.48**
1983	**14.60**	15.41	12.40	**16.94**	**9.71**	**17.84**	11.77	**14.02**	**14.09**
1987	**12.51**	15.78	**17.86**	**14.51**	**10.06**	**19.36**	**15.97**	**12.02**	**14.76**
1997	**15.75**	**20.43**	**21.81**	**17.96**	**14.45**	**23.73**	**20.88**	13.73	**18.59**
Ave.	15.40	19.30	20.02	17.32	11.82	21.24	18.67	13.41	17.15
Norm.	11.17	16.42	15.85	13.10	9.43	16.90	13.54	10.77	13.40
%Norm.	138	118	126	132	125	126	138	125	128

Table XV

Above normal precipitation is shown in **bold** print.

Very Significant Negative IPOF Years

YEAR	Div1	Div2	Div3	Div4	Div5	Div6	Div7	Div8	State
1917	**8.65**	**11.91**	**9.26**	**9.83**	**5.44**	**10.43**	**5.03**	**7.53**	**8.51**
1950	**5.19**	**11.98**	15.97	**7.52**	**5.71**	**13.78**	**12.83**	**7.59**	**10.07**
1955	**8.26**	**15.66**	**12.76**	**9.68**	**6.56**	**14.18**	**10.69**	**8.93**	**10.84**
1956	**5.58**	**7.94**	**8.90**	**6.60**	**3.63**	**9.03**	**6.50**	**4.27**	**6.56**
1971	**10.65**	16.89	16.18	13.11	**9.13**	**16.87**	13.67	**9.32**	**13.23**
1975	**10.30**	**14.65**	**12.73**	14.68	**9.30**	**15.33**	**12.22**	11.85	**12.63**
Ave.	8.11	13.17	12.63	10.24	6.63	13.27	10.16	8.24	10.31
Norm.	11.17	16.42	15.85	13.10	9.43	16.90	13.54	10.77	13.40
%Norm.	73	80	80	78	70	79	75	77	77

Table XVI

Below normal precipitation is shown in **bold** print.

Table XVII (below) shows the ratio of precipitation during very significant IPOF negative years to very significant positive IPOF years.

	Div1	Div2	Div3	Div4	Div5	Div6	Div7	Div8	State
Negative	8.11	13.17	12.63	10.24	6.63	13.27	10.16	8.24	10.31
Positive	15.40	19.30	20.02	17.32	11.82	21.24	18.67	13.41	17.15
Ratio(%)	53	68	63	59	56	62	54	61	60

Table XVII

Discussion of Results: There was only one year in the significantly positive list (1905) that didn=t make it to the Avery@ significantly positive list. Since 1905 was basically a wet year anyway, there wasn=t much difference between the average precipitation calculations for the two. All climate divisions receive (on average) more precipitation during the significantly positive IPOF years, with a statewide average of 128 to 129 percent of normal. Greatest benefit was over the northwest and southeast corners (divisions 1 and 7), while least benefit was over the northern mountains (division 2).

Table XIV shows that all divisions suffer diminished precipitation during significantly negative IPOF years, with a statewide average of 83 percent of normal. From table XVI, it appears Avery@ significant years suffer even more, with a statewide average of 77 percent. In both cases, divisions 2 and 3 (northern mountains and northeast plains) suffer the least.

Table XVII shows the ratio of precipitation averages during the very significant positive and negative years. Climate division 2 (northern mountains) experienced the least difference, although receiving 68 percent of positive IPOF years during the negative years is certainly very significant. **Overall, the state receives just a little over half the precipitation during the very significantly negative years in comparison to the very significantly positive years**.

Relationships between Pacific oscillations and New Mexico precipitation appear to be profound. However, at this time, the relationships between the Pacific signals are not clearly understood, and no one has been able to accurately forecast ENSO or PDO trends. For this information to be useful, research is needed to accurately model and forecast the Pacific oscillations. Demands for longer-term management of water resources will require far more accurate, long-range forecasts for seasons, years, and multiple years.

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