P2.11 UPWELLING AND COASTAL CLIMATE VARIABILITY IN SOUTHERN CALIFORNIA, 1998-2007: A RETURN TO THE COOL PHASE OF PDO?

Steve LaDochy [1*], Pedro Ramirez[2] and William C. Patzert[3]

Department of Geography & Urban Analysis[1]
Department of Geological Sciences[2]
California State University, Los Angeles
Jet Propulsion Laboratory, NASA, Pasadena, CA[3]

INTRODUCTION

Large-scale oceanographic/atmospheric interactions result in distinguishable patterns of climate variability in the Pacific that impact ecosystems, precipitation and stream run-off, and sea surface temperatures and sea level heights. The Pacific Decadal Oscillation (PDO), a commonly recognized term in the scientific literature, was described by Mantua et al. (1997) as shifts in Pacific sea surface temperature associated with shifts in climate commonly persisting for 20-30 years. PDO signal shifts are designated as negative or cool and positive or warm. According to Mantua et al., cool or negative PDO phases occurred from 1890-1924 and from 1947-1976. Warm or positive phases typified the periods from 1925-1946 and from 1977 through early 1998.

In southern California, warm PDO events are characterized by decreased upwelling and productivity, warmer sea surface temperatures and increased sea level heights, and increased precipitation and stream run-off. Additionally, the Pacific High centered over the mid North Pacific weakens and the Aleutian Low pressure area off of Alaska strengthens leading to weaker clockwise wind stress along the eastern portion of the North Pacific. Consequently, west coast sea surface temperatures (SSTs) and sea levels rise, while coastal upwelling is suppressed. Temperatures and precipitation are both higher than normal in southern California. Contrastingly, increased upwelling and productivity, cooler sea surface temperatures and lower sea level heights, and decreased precipitation and runoff characterize a cool PDO phase in the southern California area.

Superimposed on PDO cycles are temporally smaller-scaled El Niño/La Niña events persisting for months to over a year. Southern California climatic impacts associated with La Nina events are similar to cool PDO phases and those related to El Niño are similar to that of warm PDO phases. Together, North American and more specifically, southern California climate is significantly modified by these interannual and interdecadal climate shifts. Furthermore, climate change, independent of the aforementioned climate shifts, also may modify sea surface temperatures, upwelling patterns, wind stress, precipitation and stream runoff.

LaDochy et al. (2007), through an analysis of historical data, showed that both PDO and ENSO (El Niño_Southern Oscillation) events are reflected in southern California records of upwelling, meridional winds, sea surface temperatures and heights, and coastal climate. The authors also indicated that patterns of ocean warming and increasing precipitation found along the southern California coast in the last 60 years could be attributable to the switch from the cold to warm phase of the PDO occurring during much of the period. LaDochy et al. also speculated that climate change may also be impacting southern California upwelling and related local coastal oceanic patterns as well as local climatic patterns. However, insufficient data make these interpretations tentative at best.

In this study, we continue our analysis of the southern California climate record by examining the parameters listed in the previous paragraph during the last ten years (1998-2007). Through examination of these parameters, we hope to identify with greater certainty whether a transition from warm positive phase is occurring as indicated by several authors. A major emphasis of this report is the relationship of southern California upwelling patterns to PDO, NOI, and SOI. Figure 1 shows the area and sites studied.

---

*Corresponding author address: Steve LaDochy, Dept. of Geography, California State University, Los Angeles, CA 90032; email: sladoch@calstatela.edu

Figure 1. Index figure of study area. Figure shows the Monterey, Los Angeles, and Baja upwelling stations (white circles with location names in yellow letters). Pasadena and Santa Paula climate stations are shown as white open squares with location names in red letters. Also shown is Scripps Pier (triangle) where sea surface temperatures were obtained along with a buoy at 33N, 120W (not shown). Components of the California Current are shown as arrows.

BACKGROUND

An examination of local, regional and large-scale Pacific oceanic and atmospheric conditions since 1998 illuminate the PDO-southern California climate connection (LaDochy et al. 2007). If the PDO is undergoing a transition, then climatic patterns related to this period of PDO phase transition, which occurs over the span of a few years, should be evident in local oceanic upwelling indices, sea surface temperatures, and southern California precipitation and air temperatures.

During the last decade weather in Southern California displayed a peculiar pattern. The southern California coast was subject to five consecutive unusually cool summers, 1998-2002. "June Gloom" conditions persisted for much of the summers (LaDochy et al. 2003). More typically, "June Gloom" conditions, which result from the intrusion of warm Pacific air moving over colder waters off southern California coastal areas, endure for only the early part of the summer. The period of cooler summers corresponds more closely with a negative PDO phase and may reflect the switch of the Pacific Decadal Oscillation (PDO) from a strongly positive to negative phase. Mostly hot summers succeeded cooler ones from 2003 through the present. Weak El Niños typify this period. The hotter summers and weak El Niños seem to contradict 1998-2002 patterns. This contradiction is noted in the literature as a possible new PDO signal different from previous ones (Bond et al. 2003; Peterson and Schwing, 2003).

Regionally, recent changes in both Pacific oceanic and atmospheric conditions have led to record-breaking weather (hot, cold, wet, dry) in coastal southern California during the past decade, while the regional western U.S. has suffered from one of the worst droughts in an approximately 500-year proxy record (Piechota et al. 2004). This record-breaking weather may reflect the changing PDO regimes.

Initial anaysis of the 1998-2002 period in southern California climate using PDO, SOI, and NOI indicators suggested a return to the cool phase of the PDO (Table 1). However, from 2003-present, climatic patterns are reversed from those of 1998-2002. Overall, for the entire 1998-present period examined, local sea surface temperatures follow ENSO shifts with warm SSTs and negative SOIs prevailing during El Niño years and cooler SSTs and positive SOIs dominating during La Niña years. Recent upwelling indices show somewhat variable patterns attributable to major atmospheric/oceanographic changes. Trends and shifts since 1998 in local upwelling indices, SSTs, precipitation, and air temperatures, when compared with earlier (1948-present) patterns, appear to be distinct. So far there are no tendencies that favor the appearance of a PDO cool phase. Similarities between this phase shift (from 1998) and phase shifts to previous negative PDO multi-decadal periods are not presently shown as global warming may have significantly impacted conditions since the last cool phase.

DATA AND METHODOLOGY

A brief description of data and methodology is presented below. A more detailed discussion of data and methodology is presented in LaDochy et al. (2007). Below is a listing of data sources used in this paper, which extends the data for the past 10 years through 2007.

Upwelling Indices

Monthly upwelling indices for northern Baja (30N, 119W), southern California Bight (33N, 119W) and Monterey Bay (36N, 122W) for 1946 to 2007 were obtained from the Pacific Fisheries Environmental Laboratory (PFEL), NOAA (http://www.pfel.noaa.gov/products/PFEL/modeled/ind ices/upwelling /upwelling.html). They are proximal to our study area (Fig 1).

Sea Surface Temperatures

Sea surface temperature data used in the analyses were derived from measurements made from buoys off the southern California coast as well as Scripps Pier, LaJolla, and Santa Monica Pier. The Scripps Pier is maintained by U.C. San Diego and the data extend from 1917-present, while Santa Monica Pier data runs 1948-present. Sea surface temperature data derived from buoys centered at 35N, 125W and 33N, 120W, operated by NOAA, were also used in this study (NOAA NCEP Reynolds-Smith Reanalysis). Monthly and annual temperatures and anomalies were calculated for each location. These locations were chosen as they overlapped the upwelling sites and provided continuous, long-term data.

Mean Sea Level

Mean monthly sea level data for Los Angeles, Santa Monica and Scripps Pier, LaJolla, are available from Proudman Oceanographic Laboratory, Permanent Service for Mean Sea Level (PSMSL) (http://www.pol.ac.uk) and for recent data from NOAA Center for Operational Oceanographic Products and Services, Tides & Currents website: http://tidesandcurrents.noaa.gov/index.shtml. Los Angeles records are continuous since 1924, Santa Monica from 1933, and Scripps from 1925.

Meridional and Resultant Winds. Meridional winds and anomalies, monthly and annual, are available from NOAA NCEP-NCAR CDAS-Monthly Intrinsic Pressure Level Meridional Wind data: http://iridl.ldeo.columbia.edu/SOURCES/.NOAA/.NCEP-NCAR/.CDAS-1/.MONTHLY/.Intrinsic/.PressureLevel/.v/X/-125./VALUE/Y/35./VALUE/P/1000/VALUE/T+exch/ Meridional wind data (m/sec) show the strength of the northerly (negative) or southerly (positive) wind component at 35N, 125W, 30N, 120W, and 30N, 115W from 1949-2007. Resultant wind speeds (m/sec) and anomalies were available from the same source for 35N, 125W from 1949-2007.

Climatic Indices

Climatic indices, both monthly and annual, were downloaded from NOAA NCEP Climate Diagnostic Center: http://www.cdc.noaa.gov/ClimateIndices/Analysis/ Indices included in the analyses are: SOI, PDO, NOI, NP, PNA, WP, MEI and others (NOAA-CIRES CDC http://www.cdc.noaa.gov/ClimateIndices/Analysis/,) mostly from 1950 to present, although some have values back to 1900.

Climatic Data and Weather Charts

Atmospheric weather charts were found at: NOAA NCEP Climate Diagnostics Center, Monthly, Seasonal Composites page, http://www.cdc.noaa.gov/cgi-bin/Composites/printpage.pl Temperature and precipitation monthly and annual data were acquired for CA6 climate division, which is the southern CA coastal climate division, from NOAA NCEP CDC, http://www.cdc.noaa.gov/cgi-bin/Timeseries/timeseries1.pl for 1950-present, to look at impacts of oceanic conditions on southern California climate variability. Precipitation data for Pasadena and Santa Paula from 1948-2007 are from Western Regional Climate Center, Desert Research Institute, Reno, NV at: http://www.wrcc.dri.edu .

Streamflow (Discharge) Data

In the southern California area, numerous rivers and streams drain the San Gabriel and Santa Monica Mountains. Urbanization and the need for water storage and flood control has resulted in the modification of many of these rivers. Only two rivers we examined, Arroyo Seco near Pasadena and Sespe Creek near Santa Paula, meet the USGS definition of remaining unadulterated and are used in this study relating to climate variability. Stream flow discharge anomalies were calculated and plotted, in water years. Monthly streamflow for Arroyo Seco and Sespe Creek are available from USGS National Water Information System, NWIS, for the years 1948 to 2007 at: http://waterdata.usgs.gov/nwis.

RESULTS

PDO

From 1998 to early 2002, the PDO Index is mostly negative (Fig 2). The index switches to mostly positive in the mid-2002 to 2007 interval. Short periods of negative months in late 2004, late 2005 and late 2006 occur interspersed with the mostly positive ones. In 2005, PDO values are positive from January through August and are especially positive for the April to September upwelling season. The 2005 values peaked in May. For 2006, PDO values are positive from January through July and peak during the June upwelling month. The PDO index is mostly negative since August 2006, although it is weakly positive in early 2007.

SOI

From mid-1998 until mid 2002, the SOI Index is mainly positive (La Niña). Since 2002, SOI values remained largely negative until late 2005. The SOI index is negative throughout most of 2004, peaking to -6.7 in February 2005 (Fig 2). The negative values persist through the upwelling season of 2005. Positive SOI months characterize the beginning of 2006 followed by a shift again into negative values in May. SOI values remain weakly negative into 2007.

NOI

From mid-1998 through mid 2002, NOI values are positive (Fig 2). These positive values result from a strong North Pacific High and a weaker Aleutian Low. Following mid-2002, the NOI is mostly negative with the exception of the positive values in spring 2004. From January to May 2005, negative NOI numbers dominate with February showing the greatest values. NOI values are fairly neutral in summer, becoming positive in fall 2005 and winter 2005-06. In spring and summer (Mar-Aug) 2006, NOI values are again negative with peaks in April and July. The NOI is strongly positive since Nov 2006, with an overall positive mean from 2003-2007.

SST (120.5W, 32.5N)

Local SST patterns follow the ENSO tropical SSTs. SSTs are warmer during El Niño years and cooler during La Niña periods. Since the dramatic switch from a strong El Niño to strong La Niña event in 1998, local SSTs have remained mostly negative until the end of 2002. Subsequently, weakly positive SSTs occur through most of 2003 and are near normal for 2004. From mid-winter to summer (February through August) 2005, positive SSTs predominate. SSTs during this period peak in May. During the upwelling season of 2006, SST anomalies are positive since April and peak in August. SSTs have been negative since Jan 2007 (Fig 2). Negative SSTs correlate with mostly positive SOI values. Although the period reviewed is too short to firmly establish global warming trends, it does continue the warming trend evident in the 50+ year record until 1998 due to the switch from cool to warm PDO (Di Lorenzo et al. 2005). Other southern California buoy and pier data show similar results.

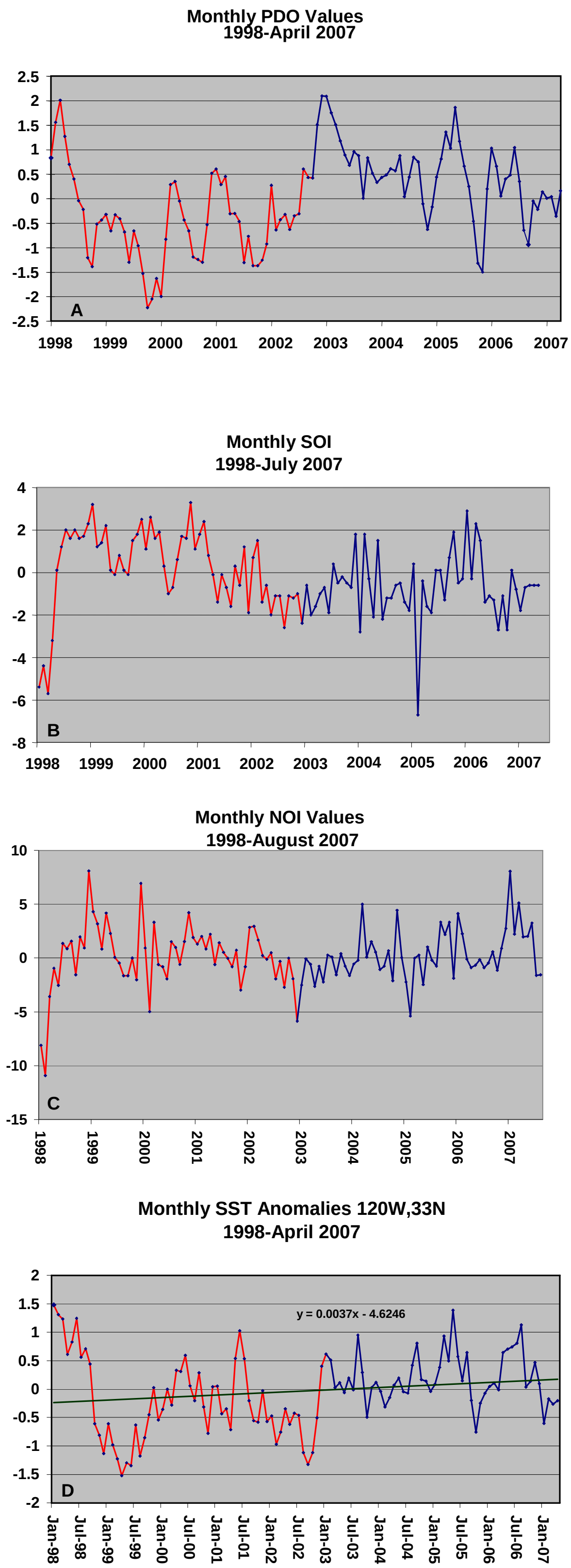
Upwelling Indices (30, 33, 36N)

Since the strong La Niña event of 1998-99, upwelling anomalies have been positive (stronger than normal) at 36N until late 2002. These anomalies are associated with a more vigorous California Current System, and as indicated above, cooler SSTs suggesting a switch in the PDO phase (Bond et al. 2003). At 30 and 33N, upwelling anomalies only remain positive through 1999, becoming slightly negative in 2000 through June 2001. At 33N, positive anomalies extend from July 2001 through most of 2003. This positive trend is interrupted by negative anomalies present from late 2002 until March 2003. In contrast, anomalies at station 30N remain negative through most of 2002 and 2003. Upwelling anomalies are also positive at the 36N station for most of 2003. Negative anomalies dominate throughout 2004 at all three locations. For the upwelling season of 2005, both stations at 33 and 36N show negative anomalies, followed by positive ones by fall. This unusual upwelling pattern has been described as being similar to those associated with past El Niño events, yet the large-scale forcing was not considered predominately tropical (Schwing et al. 2006). At 30N, negative anomalies occur in summer 2005 and revert to positive, concurrent with those at higher latitudes. For the upwelling season of 2006, all three locations show negative anomalies, peaking from April through July. From fall 2006 through April 2007 all 3 locations show strengthening positive anomalies.

CA Climate Division 6 (coastal southern California) Temperatures, Precipitation

From mid 1998 through 1999, temperatures were below normal in CA6. In spring and summer 2000, temperature anomalies are positive, becoming negative in early 2001. The months of May and June 2001 show positive temperature anomalies while temperatures for the remainder of 2001 are near normal. Temperatures in 2002 are cooler than normal, while in 2003 they are warmer, especially during January (+7.6^{o}F). Early 2004 temperature anomalies are negative. The anomalies trend towards positive in spring 2004 and remain near normal for the rest of 2004. CA6 temperature anomalies related to the upwelling season of 2005 are positive. Temperatures for the winter of 2005-06 were warmer than normal. These warmer temperatures were succeeded by a cool spring. Warmer temperatures again prevailed during the upwelling months of May-July 2006. June 2006 temperatures are 4.8^{o}F above average, while those in July of the same year hit 5.6^{o}F above average. July 2006 also is associated with a devastating heat wave throughout the West. Numerous high temperature records were set during the heat wave, including the hottest temperature (119^{o}F, July 22nd) ever recorded in Los Angeles County. Temperatures for fall and winter 2006-7 are normal, while those for spring 2007 are above average.

CA6 precipitation anomalies are negative in 1998-99, then positive in1999-2000. For 2000-01 precipitation anomalies are near normal. In 2001 the winter is drier and the spring wetter than normal. From 2001-02 precipitation anomalies are slightly above normal. During this period the winter is wetter and the spring drier than average. 2002-03 is a wet period, with Jan. +7.5” above the norm. For 2003-04, precipitation is above average, especially in the spring, when March precipitation reached +6.85” above normal. A wet period characterizes 2004-05. The months of January and February during the period are especially wet. An interval of drier than average conditions occurs during 2005-06. During that time winter precipitation is below average and in the spring it is above the norm. CA6 becomes drier than normal from June 2006 through spring 2007, with a record dry year in southern California occurring during the 2006-2007 rain year.



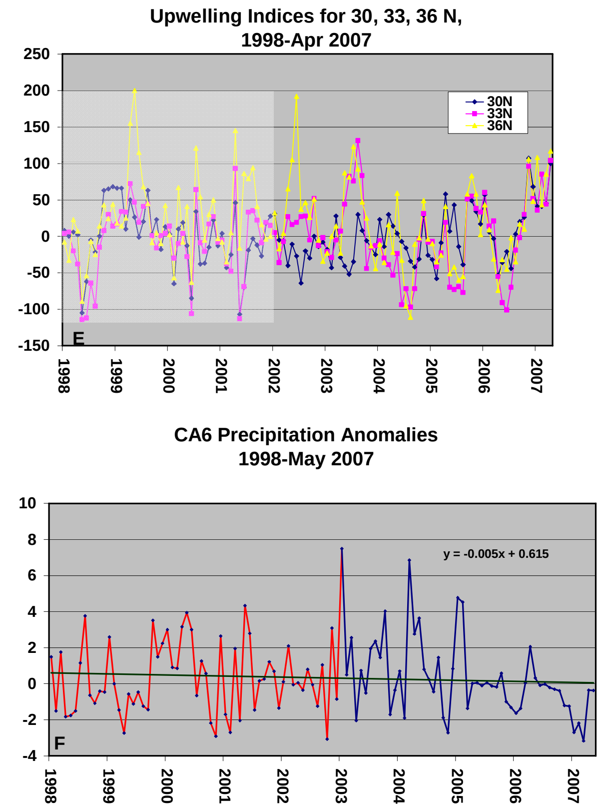


Figure 2. Monthly values of climatic indices from 1998 through 2007 for (A) PDO, (B) SOI, and (C) NOI; SST anomalies at 120W, 33N (D); upwelling indices for 30, 33, 36N (E); and monthly anomalies for climatic division CA 6 for temperature (F) and precipitation (G). Red line on graph represents data extending from 1998-2002 and the blue on is for data from 2003-2007. The lighter gray rectangular block in E

Regionally, 1999-2007 was remarkably dry in the southwestern U.S. A persistent drought extending from1999-2004 resulted in historic low water levels in several Colorado River reservoirs. For example, Lake Powell attained only approximately 40% of capacity (Piechota et al. 2004). During the winter of 2004-5, a weak El Niño event occurred with record rainfall in Los Angeles and an above average precipitation season for the Southwest. However, since then, precipitation has again been below average, with the 2006-7 winter season setting records for the driest year ever in southern CA and parts of the Southwest. Ironically, NOAA (2006) declared a weak El Niño occurred during 2006-7.

Synoptic Meteorology

Generally, since late 1998 through 2006, pressure heights have been above normal over the mid-North Pacific at all levels. At the surface, pressure along the California coast has been generally below normal or near normal for each season and for the annual average. At 700 mb heights pressures are above normal along the California coast for the annual average and for each of the seasons, except for fall when pressures are near normal. At 500 mb, the overall 1999-2006 pattern is like that of the 700 mb one.

However, in 1999 a La Niña-like pattern occurred with large negative anomalies in the Gulf of Alaska and large positive anomalies over the mid North Pacific (centered at 40N). This configuration tended to send the jet stream and storms farther north, away from California. The winter of 1999-2000 also shows positive 500 mb heights over the US, with a negative center over Alaska. Southern California averaged over 40 mm above normal for the rainy November 1999-February 2000 season. Spring and summer remained above normal at 500 mb for the western US and near normal during fall and winter of 2000-01. Spring and summer 2001 again showed positive anomalies at 500 mb over the western US. These positive anomalies were quite large over the rainy season of southern California in 2001-02 leading to a record dry year in Los Angeles, while the spring was the driest year for the Southwest. Positive height anomalies remained over the western US until late 2003. A trough off California in 2004-05 led to record rains in southern California, but large anomalies at 500 mb over the West in summer 2006 led to deadly heat waves.

Table 1 shows that in the long-term, the PDO affects southern California climate. With the warm phase, rainfall is greater and temperatures higher than with the cold phase. Although the number of phase changes is small, the number of years is substantial. Tree ring data extends the record even farther back. For example, Cook et al. (2004) showed that the wet and dry periods in the southwest follow a PDO signal for the last 400 years. LaDochy et al. (2004) and Alfaro et al. (2004) showed that west coast climates, especially California, show a strong positive correlation between PDO and temperatures. During the last 10 years, the first half showed more negative PDO characteristics, along with cooler SSTs, stronger upwelling, drier and cooler southern California climate. However the latter half of this decade showed more positive PDO characteristics, with higher SSTs, weaker upwelling, wetter and warmer climate. This decade also showed high inter-annual variability, especially since 2002. The only consistent index of change is the NOI (the North Pacific Oscillation Index), which shifted from a weaker than normal North Pacific High (negative) to stronger than normal (positive) after the 1997-98 El Niño.

CONCLUSIONS

1. Overall, southern California climate tends to follow large-scale patterns in the Pacific Ocean. In general, temperatures are warmer (cooler) and climate wetter (drier) with the positive (negative) phase of PDO and negative (positive) SOI.
2. At the same time, there has been an overall warming trend for southern California land and coastal waters, and a slight drying trend in rainfall since 1950.
3. Since the last big El Niño, the PDO has not shown a consistent shift to the cool (negative) phase with the years 1999-2002 being strongly negative, but 2003-2007 being overall positive. 2007 has been mainly negative.
4. Southern California weather has been highly variable since 1998, being very dry and cool through 2002, then somewhat wetter and warmer since 2003. Record dry years occurred first in 2001-02, then again in 2006-07. A record wet year occurred in 2004-05. Deadly heat waves also occurred in summers of 2006 and 2007, while a record cold January occurred in 2006.
5. Coastal upwelling patterns for southern California also follow PDO patterns, with higher upwelling values when PDO is negative and lower values with a positive PDO. Upwelling values in southern California were considerably higher in 1998-2002 than in 2003-2007.
6. The overall patterns for the last 10 years do not support the contention that the PDO has shifted to the cold phase. Only the NOI shows a consistent shift to a stronger North Pacific High, which could account for the overall positive upwelling anomalies and lower SST anomalies in the southern California coastal region. If this NOI feature continues positive, it may teleconnect with PDO (there is a strong negative correlation exists between NOI and PDO) to favor more negative phase tendencies in the coming decade.

ACKNOWLEDGEMENTS

The authors are indebted to JPL, NASA, especially Ichiro Fukimori, for providing assistance and support for this project.

REFERENCES:

Alfaro E., A Gershunov, D. Cayan, A. Steinemann, D. Pierce, T Barnett, 2004: A method for prediction of California summer air surface temperature. *EOS* Trans. 85:553, 557-558

Bond, N.A., J.E. Overland, M. Spillane and P. Stabeno, 2003: Recent shifts in the state of the North Pacific. *Geophys. Res. Lett*. 30(15):8020.

Cook, E.R., C. Woodhouse, C.M. Eakin, D.M. Meko, and D.W. Stahle, 2004. Long-term aridity changes in the western United States. *Science* 306:1015-1018.

Di Lorenzo, E., Miller, A. J., Schneider, N. and McWilliams, J.C., 2005: The warming of the California current system: Dynamics and ecosystem implications. *J. of Physical Oceanography*, **35**, 336-362.

Goericke, R., E.Venrick, A. Mantyla, S.J. Bograd, F.B. Schwing, A. Huyer, R.L. Smith, P.A. Wheeler, R. Hoof, W.T. Peterson, G. Gaxiola-Castro, J. Gomez-Valdes, B.E. Lavaniegos, K.D. Hyrenbach, W.J. Sydeman, 2004: *The state of the California Current, 2003-2004: A rare "normal" year*. Calif. Coop. Ocean. Fish. Invest. Rep. 45.

Goericke, R., E. Venrick, A. Mantyla, S.J. Bograd, F.B. Schwing, A. Huyer, R.L. Smith, P.A. Wheeler, R. Hoof, W.T. Peterson, F. Chavez, C. Collins, B. Marinovic, N. Lo, W.T. Gaxiola-Castro, R. Durazo, B.E. Hyrenbach, K.D. Sydeman, 2005: *The state of the California Current, 2004-2005: Still cool*? Calif. Coop. Ocean. Invest. Rep. 46.

LaDochy S, Brown J, Selke M, Patzert W (2004) Can U. S. West Coast climate be forecast? Proc. AMS, Symp. On Forecasting the Weather and Climate of the Atmosphere and Ocean, Seattle, WA Jan 11-14. Available at: http://ams.confex.com/ams/pdfpapers/71130.pdf

---------------, Brown, J and Patzert, W (2003): June gloom and heavy fogs: oceanic influences on bummer California summers, 12th Conf. On the Interaction of the Sea and Atmosphere, American Meteorological Society, Feb. 9-13, Long Beach, CA. (available via internet at url: http://ams.confex.com/ams/annual2003/techprogram/paper_56141.htm).

----------------, Ramirez, P and Patzert, W (2007): Southern California upwelling: Is recent weakening a result of global warming? 19th Conf. on Climate Variability and Change, Jan. 14-18, San Antonio, TX. Available at: http://ams.confex.com/ams/87ANNUAL/techprogram/program_391.htm

Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis, 1997: A Pacific interdecadal climate oscillation with impacts on salmon production. *Bull. of the Amer*. *Meteorol. Soc*., **78**, 1069-1079.

NOAA 2006: El Niño/Southern Oscillation (ENSO) Diagnostic Discussion, CDC/NCEP, September 13, 2006. Available at: http://www.cpc.noaa.gov/products/expert_assessment/ENSO_DD_archive.shtml

Piechota, T., J. Timilsena, G. Tootle and H. Hidalgo. 2004: The western U.S. drought: How bad is it? *EOS*, Trans., AGU, 85, 301, 304.

Peterson, W. T. and Schwing, F.B., 2003: A new climate regime in northeast Pacific ecosystems. *Geophys. Res. Lett*., **30**, No. 17, 1896, doi:10.1029/2003GL017528.

Schwing, F.B., N.A. Bond, S.J. Bograd, T. Mitchell, M.A. Alexander and N. Mantua. 2006: Delayed coastal upwelling along the U.S. West Coast in 2005: A historical perspective. *Geophys. Res. Lett*. 33, L22S01, doi:10.1029/2006GL026911.

Period	PDO Phase	Upwelling Anamolies *Stations*			PDO	SOI	NOI	SST Anom (°C)	CA6 Precip Anom (mm)	Temp Anom (°C)
		30N	*33N*	*36N*						
1947-77	–	4.91	4.12	4.25	-.59	0.11	0.577	-0.2	18	-0.66
1978-98	+	3.95	-.43	-0.2	0.62	-.86	-.884	0.4	43.4	0.21
1999-2007	**?**	16.25	-4.8	20.53	-.01	-.02	0.377	-0.03	-75.7	0.11
1998-2002	–	-7.65	9.22	36.13	-0.5	0.77	0.429	-0.25	-127.5	-0.05
2003-07	+	3.96	2.56	9.52	0.42	-.71	0.332	0.24	-34	0.24

Table 1. Comparison of parameters examined for this study. The table shows PDO indices calculated from data since 1947, established positive and negative PDO phases, and corresponding NOI and SOI values as well as upwelling, SST, precipitation and temperature anomalies. Also shown are the same parameters tabulated from data gathered over the last decade. The table shows that positive SOI and NOI values, negative SST and temperature anomalies, and decreased precipitation anomalies are associated with the negative PDO phase. The opposite is true for the positive PDO phase. Over the last decade, the aforementioned parameters do not exhibit distinct trends.