



WESTERN REGION TECHNICAL ATTACHMENT  
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## El Niño and California Precipitation

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John Monteverdi      Professor of Meteorology, Chairman  
                                 [Department of Geosciences](#), San Francisco State University  
                                 [Email](#)

Jan Null                Lead Forecaster  
                                 [National Weather Service Forecast Office](#), San Francisco Bay  
                                 Area  
                                 [Email](#)

Send comments or corrections to [the Site Manager, John Monteverdi](#)

**Last Updated December 11, 1997**

### **El Nino Event Still Strong, Still Expected To Persist Through Winter**

(Figures relating to [seasurface temperatures](#) are updated weekly; [NASA sealevel images](#) have been updated; [mean seasurface temperature index chart](#) has been updated; sea-surface temperature [anomaly forecasts](#) have been updated).

*A total of **22606** people have accessed this page since October 6, 1997.*

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Initial newspaper, television and radio reports (in summer 1997) on the issue of El Niño and its impact on California rainfall were, in many cases, misleading. For example, early predictions of a spectacularly wet winter for extreme Southern California (by meteorologists and oceanographers in the southern portion of the state) were widely reported as applying to the whole state.

In addition, much confusion was apparent in the press on the issue of what El Niño actually was and what the impacts of El Niño would be. All of this has led to a domino effect of poorly drawn conclusions and overreactions.

The purpose of this site is to dispel some of this confusion.

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**Read the box at right for our point of view. If you would like to see the reasoning and some excellent graphical illustrations, proceed to the information below.**

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## Summary

### What Past Type 1 El Niño Events Tell Us About San Francisco Rainfall In The Upcoming Winter

**(Read Below For Other Areas in California and for CPC Forecasts for West Coast Precipitation This Winter)**

a. ***IF THE PRESENT EL Niño PERSISTS THROUGH THE WINTER, IT IS REASONABLE TO EXPECT GREATER THAN NORMAL PRECIPITATION.*** 6 out of 8 past Type 1 El Niños (75% of an admittedly small sample) had greater than normal precipitation. Hence, the concerns that the upcoming winter will be wetter than normal appear reasonable.

b. ***ALSO, IF THE PRESENT EL Niño PERSISTS THROUGH THE WINTER, IT IS REASONABLE TO PREPARE FOR MUCH HEAVIER THAN NORMAL PRECIPITATION*** (defined as greater than roughly 170% of the normal rainfall). 3 out of the 8 past Type 1 El Niños (82-83, 72-73 and 57-58) had about 170% (or greater) of the normal precipitation. Again, this is a small sample upon which to make generalizations. However, the history of these recent events suggests that San Franciscans should be prepared for a winter potentially much wetter than normal, although there is nothing in the past record that indicates that this will be a likely occurrence.

# What is El Niño ?

## Brief Definition of "El Niño"

The term El Niño refers to a rapid, dramatic warming of the sea-surface temperatures in the eastern tropical Pacific, chiefly along the north-central coast of South America and westward.

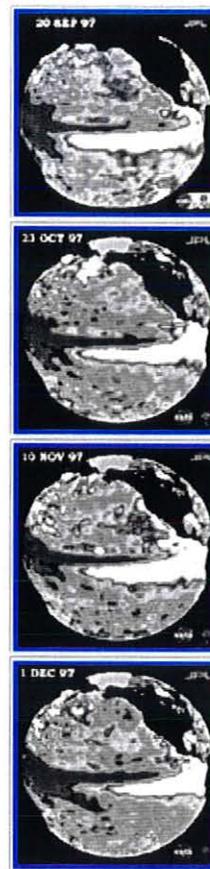
[Link to NOAA El Niño Explanation Page](#)

[Link to Environmental News Network El Niño Explanation Page](#)

**At right find a progression of NASA images** which actually show deviations of sealevel from average. Where sealevel is higher, the ocean is warmer than normal (yellows, reds, and whites). Blues and purples indicate depressed sealevels (colder than normal). The latest image shows that the region of warmer than normal ocean temperatures in the eastern Pacific has contracted.

Although this suggests that this El Niño event may have peaked, it is important to keep in mind that this is consistent with [the forecasts discussed below](#) (that indicate that El Niño conditions should be present but waning through the next several months). In addition, although the fraction of the Pacific experiencing warmer than normal ocean temperatures may have decreased, the fraction of the eastern Pacific experiencing very warm conditions has actually **INCREASED** ([see below](#)). *It is important to keep in mind the fact that El Niño conditions will be with us throughout the winter.*

[Link to NASA Discussion Of These Images](#)



**Click On Each Image  
To See Larger  
Versions**

[Quicktime Movie](#)  
showing the progression  
from a *La Nina* last  
November to the current  
El Niño conditions.

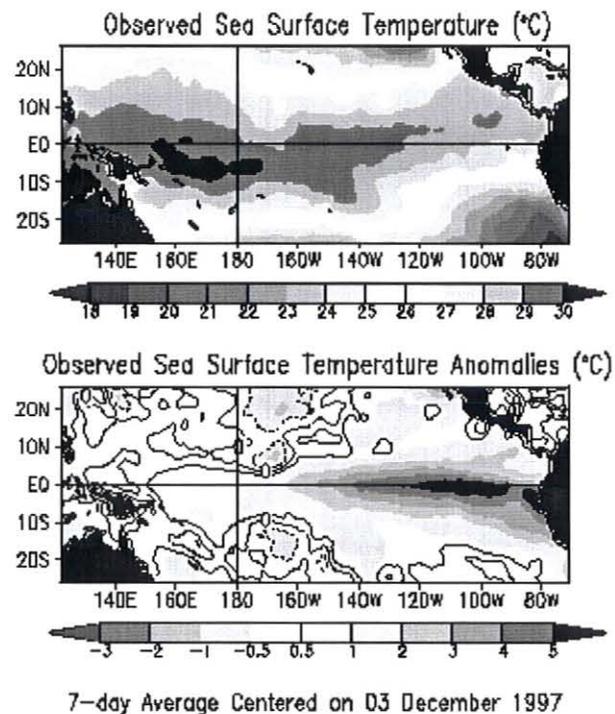
## The Present El Niño

El Niño events are characterized by sudden onset of large temperature deviations (on the order of 2°C, or about 4°F or greater) usually peaking in December (hence the name which refers to Christmas--"El Niño" = "the Christ Child").

Warmings occur rather frequently (on the order of once every four years or so) as part of the [Southern Oscillation](#), a cyclical change in the pressure and temperature distribution along the Equator.

In the current El Niño Southern Oscillation (ENSO) event, ocean temperatures have risen over 5°C (almost 11°F) in that area. The image at right shows that the portion of the eastern Pacific with a greater than 5°C anomaly has expanded (compared to the November pattern), although the positive anomalies have abated somewhat near the Dateline.

(Note: the term *ANOMALY* is a synonym for *DEVIATION FROM NORMAL*).



### Current Sea Surface Temperature Anomalies Showing Well Developed El Niño

[Link to More on Development of Present Pattern from NOAA/NCEP](#)

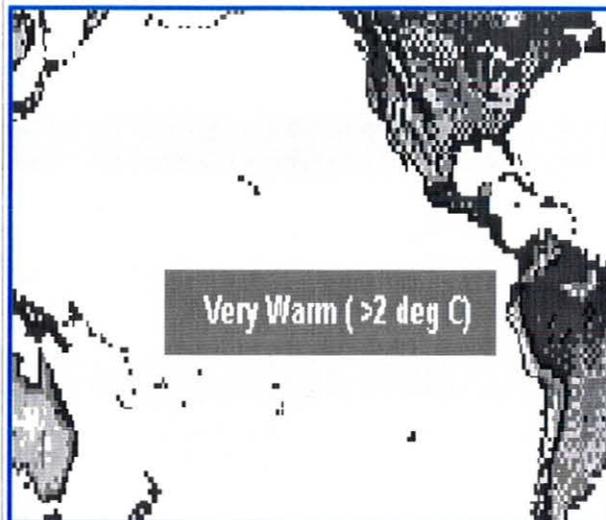
## Not All El Niño Events Are Alike

The present El Niño is a so-called "Type 1" El Niño (Fu et al. 1986). Type 1 events have the strongest SST anomaly ( $>2.0$  C) and extend from approximately 160E to 80W. During the period of 1949-1993, there were eight Type 1 ENSO events: 1951-1952, 1957-1958, 1965-1966, 1968-1969, 1972-1973, 1977-1978, 1982-1983, and 1991-1992 (Schonher and Nicholson 1989).

### [Link To Discussion of Three El Niño Types](#)

Fu, C., Diaz, H. F. & Fletcher, J. O., 1986: Characteristics of the Response of Sea Surface Temperature in the Central Pacific Associated with Warm Episodes of the Southern Oscillation. *Monthly Weather Review*, 114, 1716-1738.

Schonher, T. & Nicholson, S. E., 1989: The Relationship between California Rainfall and ENSO Events. *Journal of Climate*, 2, 1258-1269.

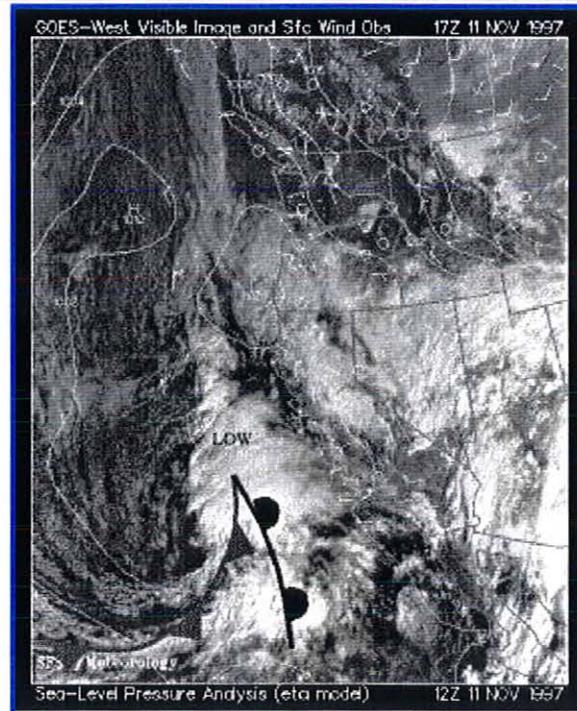


**Schematic Chart Showing Portion of the Pacific With Positive Temperature Anomalies in Type 1 El Niños**

**El Niño is NOT:**

- a series of catastrophic flood producing weather events in California or the West
- a hurricane
- a period of drought in California or the West
- a series of storms

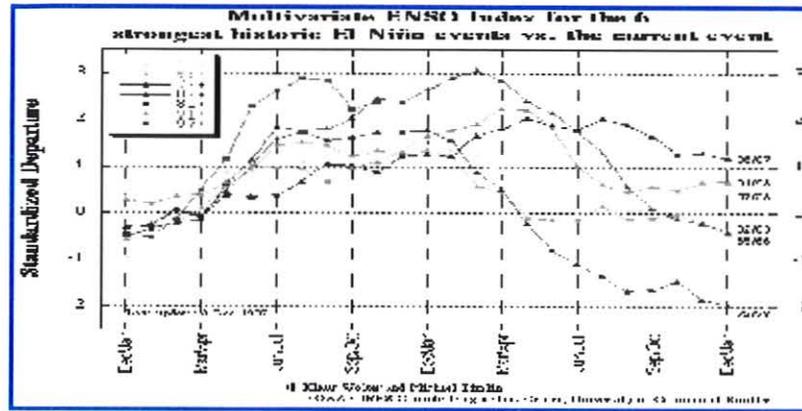
Any of these MAY occur as an impact of El Niño (or be associated with it coincidentally).



**A Storm or Series of Storms Is Not El Niño**

## Is This El Niño Event Similar To Other Type 1 Events?

The present event is dissimilar to other Type 1 Events in that it grew more rapidly after its initial onset than any other observed. Because of this there was a concern that it also might dissipate too soon to impact California's winter precipitation systems.



(Image Courtesy of Klaus Wolter and Michael Timlin, NOAA-CIRES, CDC)

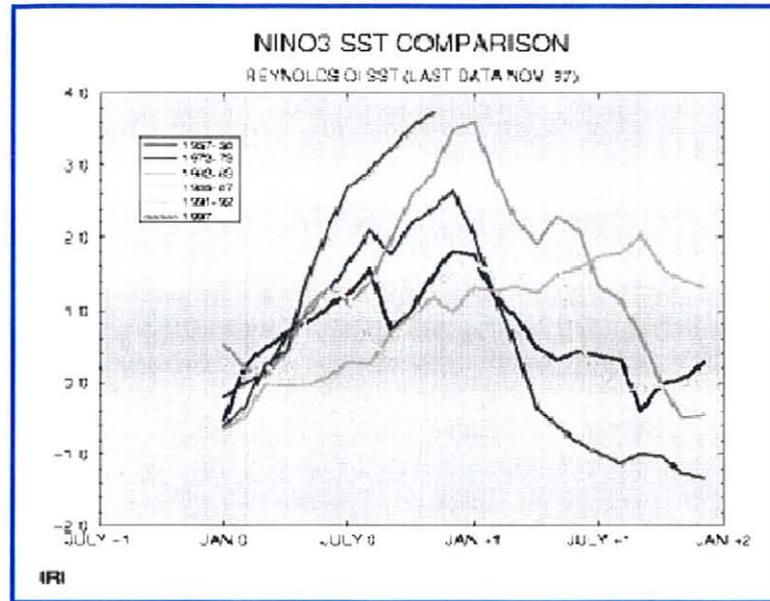
Click on the graph above to see a **READABLE** version of it.

The **multivariate index** (above) is a combination of other indices (pressure differences across the tropical Pacific etc.). The more positive the index, the greater the likelihood of El Niño conditions in the eastern tropical Pacific. **The steep decrease in the index in October has reversed.** The **sea surface temperature anomalies** (below) for the NINO3 region (5S-5N; 150W-90W) in the eastern tropical Pacific show that, despite the early peak in the multivariate index, this El Niño episode was continuing to intensify through November. Note that the anomalies have now exceeded those observed for 1982-83, making the present El Niño event the strongest of the 20th century.

[Link To NOAA El Niño Evolution Page](#)

[Link to El Niño Index Page from Climate Diagnostics Center](#)

[Link to International Research Institute for Climatic Prediction](#)



(Image Courtesy of International Research Institute for Climatic Prediction)

Click on the graph above to see a **READABLE** version of it.

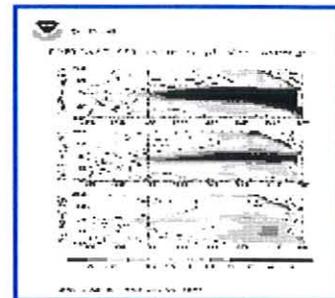
## Predictions for the Coming Winter

### Will This El Niño Event Persist Through The Winter?

Here is the *latest series of forecasts* from the National Centers for Environmental Prediction (NCEP). The figure [at right](#) shows sea surface temperature (SST) anomaly forecasts by 3-month period through next spring.

Although the temperature anomalies associated with El Niño are forecast to decrease slightly by March 1998, apparently they will persist through the spring. Thus, **it appears that winter precipitation systems in California will be affected by the present El Niño.**

[Link to NCEP ENSO Forecast Page](#)



**NCEP Prediction Issued  
12/4/97**

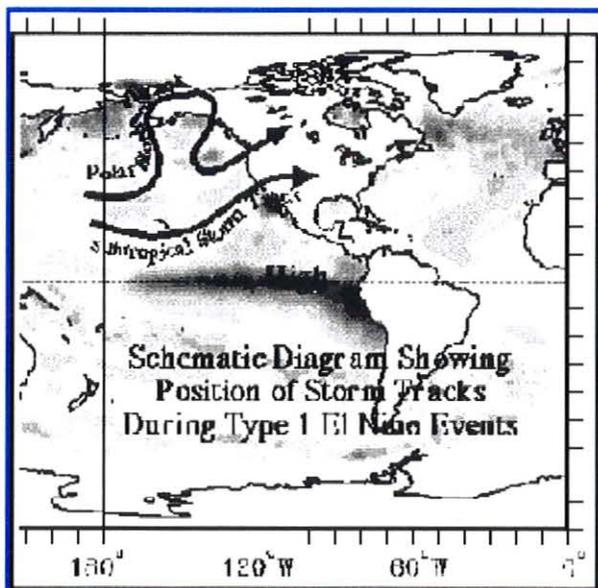
### How Will This El Niño Event

## Affect The Pacific Storm Track?

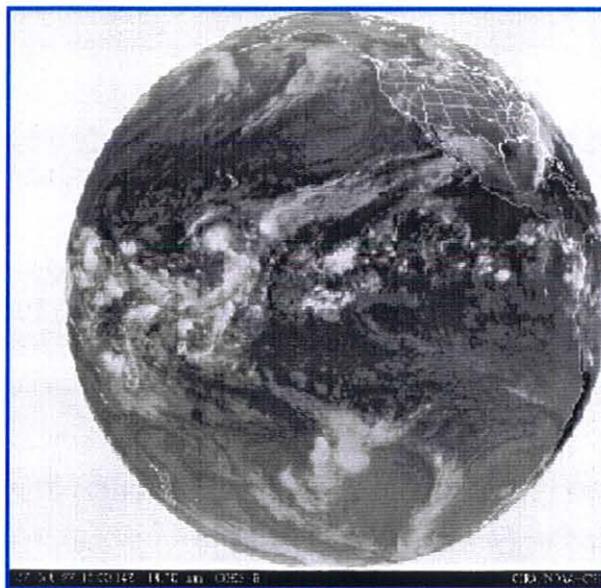
The unusually warm sea surface temperature pattern in the eastern tropical and subtropical Pacific is expected to create a southern branch of the storm track. This southern branch (green arrow) should extend from the latitude of Hawaii (approximately 20°N) to the southern (or central) coast of California.

Storms moving along this path carry warm and very moist subtropical air to the West Coast and are associated with heavy precipitation and high snowlines in California. Warm temperatures to high elevations often exacerbate the situation by creating substantial snowmelt, adding to runoff and contributing substantially to local flooding along stream margins. The position of the subtropical branch determines which portion of California and/or the West receives the heaviest precipitation.<sup>1</sup>

In the satellite image at bottom right, note the area of enhanced convection south of the Hawaiian Islands and the plume of middle and high cloudiness



Schematic Diagram Showing Midwinter Upper Tropospheric Features Common During Type 1 El Niño Events (Compare With Satellite Image Below)



Infrared Satellite Image, 1500 UTC 10/27/97

[Click on Images To See Full Size Graphics](#)

of middle and high cloudiness extending from that region northeastward to the Baja California coastline. This cloud plume delineates a subtropical branch of the jet stream.

Such a feature, more strongly developed and located further north, can be associated with "*Low Latitude Type*"<sup>2</sup> surface cyclones that advance northeastward to the California coast. Such a pattern characterized the winter of 1982-83.

<sup>1</sup>Another impact on precipitation can occur when advancing middle latitude type cyclones intercept the moister air (due to higher sea-surface temperatures) along the California coast during the mature phase of El Niño. Heavier rainfall and a higher incidence of thunderstorms occurs in association with such storms.

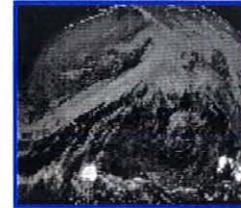
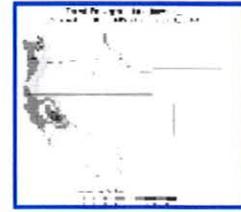
<sup>2</sup>It should be pointed out that "*low latitude type*" cyclones are a normal feature of the California climate even in non-El Niño years. (For example, the storms of December 1996 and January 1997 were "low latitude" type.) Such storms tend to be more frequent and more vigorous, however, in association with warm episode ENSO events.

## A Word About Flooding in California

Not all flooding events in California occur during El Niño years, and not all El Niño years produce widespread flooding. For example, last season (a non El Niño year) saw seasonal rainfall totals near normal throughout most of California. However because most of last season's precipitation fell during December and January (instead of being spread throughout the season) (see [graphic at upper right](#), which shows the rainfall totals from December 20, 1996 through January 3, 1997) there were record floods in many parts of the state. Some other historic floods in California that have occurred during non-El Niño Years include Christmas 1955, December 1964, January 1982 and February 1986.

The [graphic at bottom right](#) shows the low latitude storm type associated with the flooding rains in late December 1996 and early January 1997, a non El Niño winter season.

The type of situation that most often leads to flooding in California is when a succession of low latitude storms impact an already saturated region in a short period of time. The probability of this occurring is greater during El Niño events because of the shift in the storm track, but even a day or two break between weather systems can make a large difference in the flood potential.



**Click on Image To See Full Size Graphics**

The bottom line for individuals and public agencies is that parts of California do flood during both El Niño years and non El Niño years.

### **Snow or Not!!**

It is not true that heavier than normal precipitation necessarily relates to greater snowfall at the elevation of major ski resorts. In fact, the warm, subtropical air masses associated with "low latitude" type storms often have snowlines above the 7000 to 8000 foot level in the central Sierra, with heavy rain below that elevation.

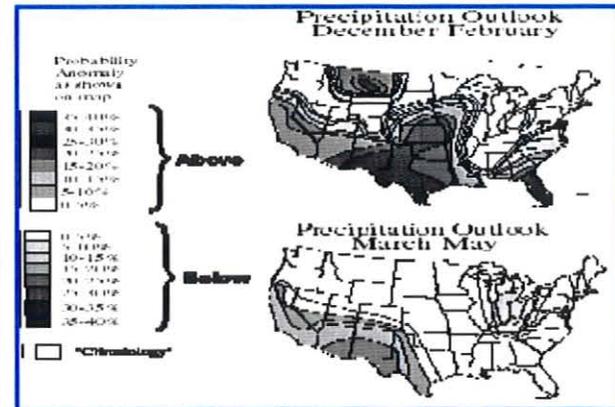
Snowfall above this elevation can be very heavy, but with the characteristic high water content typical of "Sierra cement."

## Current Climate Prediction Center Forecast for the Winter

Here are the current temperature and rainfall forecasts for the upcoming six months or so from NOAA's Climatic Prediction Center (CPC).

Green to dark green colors on precipitation forecast charts generally indicate high probability of *Above Normal Precipitation* (meaning rainfall greater than about 70% of the observed annual rainfalls in the past).

[Link to CPC ENSO WebSite](#)



Click on Image To See Full Size Graphic

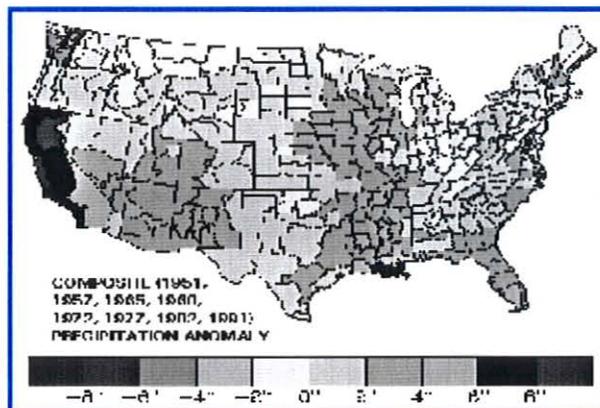
# California Rainfall for Recent Type 1 El Niños

Based Upon Statistical Analyses of **Historical** Rainfall Data

## How Have Type 1 El Niño Events **Historically** Affected The General Precipitation Patterns Over the West?

Type 1 Events have a very strong signal in the precipitation record of the West. The graph at **right** shows the composite precipitation anomalies (inches) by climatic division across the coterminous United States for Type 1 Events.

Wetter than normal conditions are suggested for California. The Pacific Northwest has experienced generally normal to slightly subnormal precipitation during Type 1 El Niños, with Washington state experiencing dry conditions.



**Click on Image To See Full Size Graphic**

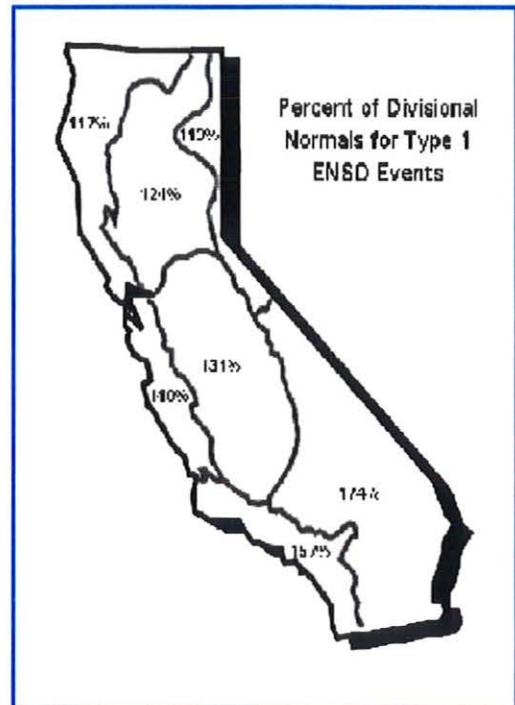
Chart showing the [anomalies above as a fraction of the standard deviation](#) for each climatic division in the US.

## How do the anomalies shown in the last section relate to the normal annual rainfall?

The map at right shows the **precipitation history** in California for Type 1 El Niño events. It was computed by dividing the anomalies shown in the last section by the mean rainfall for each climatic division. In coastal California, the the greatest departures from normal have occurred from San Francisco south.

See the charts we have constructed for

- [Arizona](#)
- [Colorado](#)
- [Idaho](#)
- [Montana](#)
- [Nevada](#)
- [New Mexico](#)
- [Oregon](#)
- [Utah](#)
- [Washington](#)

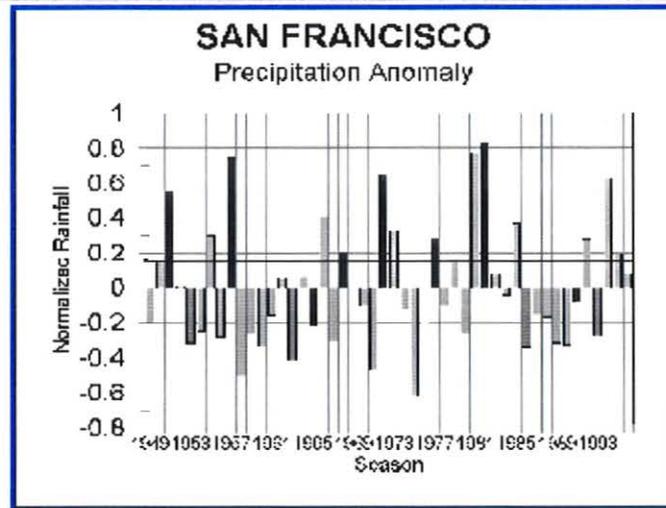


Click on Image To See Full Size Graphic

## What Sort of Rainfall in the San Francisco Bay Region Has Characterized Type 1 El Niño Events?

For the eight well-documented Type 1 winter El Niño events since 1950 (rainfall seasons of 1951-52, 1957-58, 1965-66, 1968-69, 1972-73, 1977-78, 1982-83 and 1991-92), **rainfall at San Francisco averaged about 37% greater than normal**, with a mean anomaly of about 7.5 inches at San Francisco<sup>1</sup> (thus, implying an average rainfall for Type 1 El Niño events of around 28.5" compared to the 30 year average of 21" or so).

<sup>1</sup> The official NWS rainfall measuring site is in downtown San Francisco. Everyone should realize that there is tremendous areal variability of rainfall amounts in the SF area, from as little as 14" per year in the Santa Clara Valley to nearly 60" per year in parts of the Santa Cruz Mts., the north Bay and Marin County. The increases at these locations will be proportional.



The chart above shows the deviation from the normal seasonal rainfall at downtown San Francisco from the 1949-50 rainfall season to present time. The red bars represent the rainfall for Type 1 El Niños.

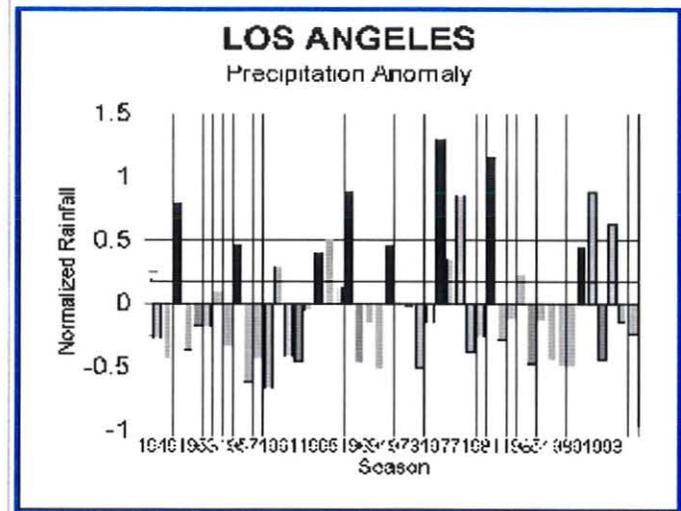
The zero line here represents the long term or 30 year average rainfall (inches) (also called the "Normal" rainfall). The blue line represents the 70th Percentile rainfall amount. (This means that rainfalls exceeding this value are greater than 70% of the values observed). Red bars indicate seasonal rainfall for El Niño Type 1 years, green bars indicate rainfall for El Niño [Type 2](#) events and yellow bars indicate rainfall for El Niño [Type 3](#) events.

Can we expect [more days with rain and will the rain on those days be very heavy?](#)

(Based on work of Jan Null of the National Weather Service. See his [El Niño page](#) which has a compilation of most if not all links to El Niño sites around). Also, see [Prof. Jerry Steffen's careful statistical analyses](#) of the rainfall during Type 1 El Niño winters at a number of California sites for an overview of the statistical backing for our opinions.

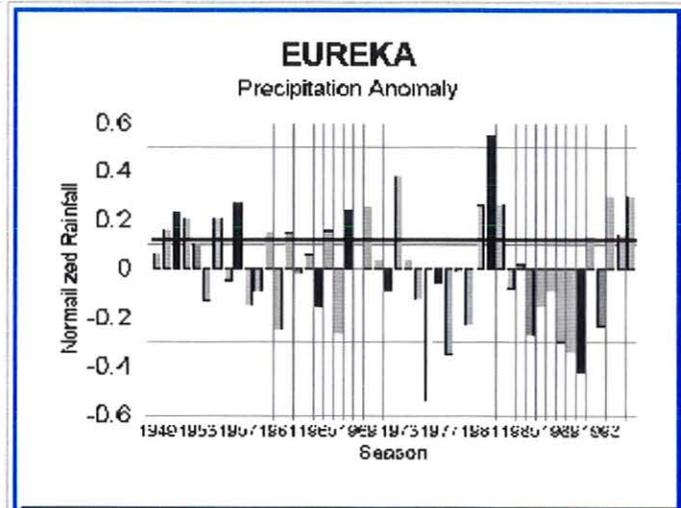
### The Los Angeles Area Has Experienced PROPORTIONALLY More Precipitation Than North-Central California In Type 1 El Niño Events

Note that for [Los Angeles Civic Center](#), EVERY Type 1 El Niño was associated with heavier than average precipitation. In fact, statistical analyses suggest that it is likely that Southern California will experience a wetter than normal winter this season. The average deviation for the 8 recent Type 1 Events was about 75% above the normal mean annual rainfall, giving an average rainfall for Type 1 El Niños at LA Civic Center of around 26 inches.



### Rainfall In The Eureka Area Is As Often Less Than Normal as it is Greater Than Normal During Type 1 El Niños

Note that for [Eureka](#), four Type 1 El Niño years had greater than normal rainfall, and four had lesser than normal rainfall. The average deviation was about 10% above the average, allowing us to anticipate that far northern California will be affected the least during the upcoming winter.





### Things To Keep In Mind

- both *predictions* (based upon computerized models of the linked physics of the oceans and the atmosphere) and *statistical analyses of the past rainfall record* (summarized above) suggest wetter than normal conditions for north-central California. However, two of the eight recent Type 1 El Niños were associated with subaverage precipitation in north-central California. The greatest positive anomaly occurred for the Type 1 El Niños of 1982-83 (182%) and 1957-58 (175%). (Interesting to note, that a Type 3 event in 1975-77 was associated with two of the driest seasons of the 20th century at SF).
- the present El Niño is one of the strongest (if not the strongest) of the 20th century. Despite the unprecedented rapid growth to maturity of the warm temperatures by late Spring, there is no evidence that this warm episode will peak early and disappear BEFORE the winter atmospheric patterns are in position to "take advantage" of the warm ocean temperatures. **Both current indications and predictions, however, suggest that this event WILL persist through the Spring**
- there is absolutely *NO evidence in the record* to support contentions that El Niño events can be (or ever were) associated with "**300% to 400% of normal rainfall**" in north-central California. The greatest rainfall total ever recorded at San Francisco (season of 1861-62) was on the order of 49" or so, about 230% of the long term average
- flooding events in California relate to timing and intensity of the rainfall systems that affect the state. It is true that low latitude type storms are more frequent in El Niño years. However, the phasing of such storms and other factors such as the saturation of the soils and tides determine whether or not flooding and mudsliding will occur even in an El Niño year in which the yearly precipitation is substantially greater than normal

The upshot here is that there is evidence (both CPC forecasts and statistical analyses of the California rainfall record for Type 1 El Niños) to support **a reasonable concern** for a wetter-than-normal winter for most of California and even a much wetter-than-normal cool season in Southern California. There is no reason, however, for panic or hysteria nor is there any evidence to support the overreactions stimulated by early news reports this past summer.

Graphics and Images on these pages are courtesy of:

[Department of Geosciences, San Francisco State University](#)

[International Research Institute for Climatic Prediction](#)

[National Centers for Environmental Prediction, El Niño Page](#)

[National Aeronautics and Space Administration, Jet Propulsion Laboratory](#)

[National Weather Service, San Francisco Bay Area, Forecast Office](#)

[NOAA/CIRES Climate Diagnostics Center](#)

[NOAA Climate Prediction Center ENSO WebSite](#)

**This is a Work In Progress.**

**It will be updated often for the duration of this event.**

**Check back frequently!!**

**Department of Geosciences**

