Weather Patterns and American River Floods

by
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Abstract

Eleven (11) of the 12 largest floods on the American River from 1905 through 1997 were caused by the same weather pattern, or storm type. Sorting of the 12 floods is based upon the 3-day mean river flow measured and/or computed at the Fair Oaks gaging station. The use of weather pattern/storm type knowledge appears to provide an opportunity to increase the reliability of Sacramento’s flood management system.

TEREC Weather Pattern

This paper continues the work begun in a paper written by Donald Baker and Gary Estes entitled "Using the TEREC Weather Pattern to Predict Heavy Rainfall in California." It was presented at the first California Weather Symposium in June 1994.

Donald Baker is a meteorologist who has lived in California for much of his life. He became interested in heavy rainfall events in California. When researching the 500 millibar weather charts for floods in 1955, 1964, 1969, and 1986, he observed a similar pattern in the location of the high and low pressure systems for these four flood events. Figure 1 shows the inclusive dates of the four floods.

<table>
<thead>
<tr>
<th>Figure 1: Dates of Flood Events</th>
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<tbody>
<tr>
<td>December 18-24, 1955</td>
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<tr>
<td>December 19-24, 1964</td>
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<tr>
<td>January 18-26, 1969</td>
</tr>
<tr>
<td>February 12-20, 1986</td>
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</table>

While thinking about a name to describe the weather pattern he was studying, Donald Baker came across the following description written by Bill Mork, Senior Meteorologist, California Department of Water Resources, about the weather events producing the February 1986 flood:

"On Friday, February 14, the computer model predictions for Sunday afternoon through Monday (February 16-17) became very alarming. . . . The precipitation regime was similar to that of December 1964 except that it was displaced a couple of hundred miles south. . . . The computer model on Saturday confirmed fears of a truly extraordinary rainfall event."

(Italics added, California Dept. of Water Resources, 1988, p. 7)
FIG. 2. WEATHER PATTERN AT BEGINNING OF HEAVIEST RAINFALL OF DECEMBER 1955 TERC

FIG. 3. WEATHER PATTERN AT BEGINNING OF HEAVIEST RAINFALL OF DECEMBER 1964 TERC
FIG 4. WEATHER PATTERN AT BEGINNING OF HEAVIEST RAINFALL OF JANUARY 1969 TEREQ

FIG 5. WEATHER PATTERN AT BEGINNING OF HEAVIEST RAINFALL OF FEBRUARY 1986 TEREQ
Bill Mork’s description gave him an idea, Truly Extraordinary Rainfall Event in California or TEREC. He coined the term “TEREC” (pronounced ter’ek like Deric) to refer to this weather pattern.

Figures 2 through 5 are based on the National Weather Service's 500 millibar (mb)\(^1\) weather maps corresponding with the beginning of the heaviest rainfall of each TEREC. The key similarities of these four storm events are (1) the blocking high pressure near the Aleutian Islands of Alaska, (2) the jet stream\(^2\) flowing south below the high pressure bringing tropical moisture into California from around Hawaii, and (3) a cold low pressure over Canada moving toward the southwest pushing up against the southerly jet stream (Baker and Estes, 1994).

The jet stream bringing in moisture from near Hawaii is the reason this flow has been called the “Pineapple connection.” Just another name describing the TEREC weather pattern.

**Low-Latitude Storm Type**

At the 1995 California Weather Symposium, Dr. John P. Monteverdi from San Francisco State University presented a paper titled, “Overview of the Meteorology of Rain Events in California.” His paper described the research done by Robert L. Weaver, U.S. Weather Bureau (now the National Weather Service). Weaver wrote Hydrometeorological Report No. 37 (HMR-37) entitled “Meteorology of Hydrologically Critical Storms in California.” Published in December 1962, Weaver categorized the major flood-producing disturbances in California on the basis of synoptic patterns and defined three basic “storm types.”

The three storm types are the high-latitude storm type, mid-latitude storm type, and low-latitude storm type. From HMR-37 we learn that the low-latitude storm type is the same thing as the TEREC weather pattern identified by Donald Baker.

The names for the storm types are based upon the latitude location of the low pressure systems. Figure 6 is taken from Dr. Monteverdi’s paper. It shows the approximate location of the low pressure systems used by Weaver in HMR-37 to categorize storms.

The low-latitude storm type has a blocking high pressure around 160 to 180 degrees west longitude near the state of Alaska. The low pressure systems originate from below 35 degrees north latitude. Usually the low-latitude storm type impacts the upper two-thirds of California.

The high-latitude storm type has low pressure systems originating from above 45 degrees north latitude. The blocking high pressure is usually east of longitude 160 degrees west. Southern California is impacted by this storm type.

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\(^1\) The 500 mb weather maps show where the jet stream is located. Each line represents the height above sea level in tens of meters where the atmosphere has a pressure of 500 mb. Average sea level pressure is 1013.25 mb (29.92 inches of mercury). The 564 mb line represents an altitude of 5640 meters (18,500 feet) above sea level for the 500 mb pressure surface.

\(^2\) Knowing the location of the jet stream is essential for predicting weather. The jet stream is a "river" of air flowing between 15,000 and 30,000 feet. The jet stream is the area where the highest winds blow, and is responsible for the creation, growth, and death of tropical storms impacting California.
Figure 6: Schematic diagram showing genesis locations for various storm types affecting California (after Weaver, 1962)
In the mid-latitude storm type, the low pressure systems originate from between 35 to 45 degrees north latitude. Blocking high pressure over the western United States results in the low pressures moving into either northern or southern California about equally.

**American River Floods**

Weaver in HMR-37 classified the major flood events in California from 1900 through 1960 according to the three storm types. Combining Weaver's list with the work done by Donald Baker on the TEREC weather pattern and information provided by Bill Mork, California State Climatologist, we can classify the major Northern California storms from 1905 through 1997 according to the storm type which caused the flood. This is done on Figure 7.

Figure 7 shows the largest 12 floods from 1905 through 1997 on the American River based upon 3-day mean flow at Fair Oaks gaging station. By including the storm type/weather pattern classification for each flood, we see that 11 of the 12 largest floods were caused by the low-latitude storm type/TEREC weather pattern. The 12th flood was caused by the mid-latitude storm type. It produced a smaller flood which was about half the 3-day mean flow as the largest floods.

Three-day mean flow is used because Folsom Dam and Lake are impacted more by the volume of water coming into it from a flood than just peak flow in a day.

The Fair Oaks gaging station on the American River was operational in water year 1905. Actual river flows were measured at the station until Folsom Dam was built. Construction began in November 1948 and was officially completed in May 1956 (USACE, 1987, p. III-2). The Sacramento District, U.S. Army Corps of Engineers (USACE) has computed the unregulated river flow at the Fair Oaks gage since Folsom Dam impacted flows.

Looking back to Figures 2 through 5, look for the 564 millibar line. It is significant. Many West Coast meteorologists recognize this line as where the heaviest precipitation occurs during winter storms. The 564 millibar line in the January 1969 TEREC went through Southern California, whereas in other TEREC's the line went through different parts of Northern California. American River floods were in 1955, 1964, and 1986 when the 564 millibar line when through Northern California.

**Increasing Reliability of Sacramento's Flood Protection System**

Flood protection for Sacramento might be improved by looking for the low-latitude storm type/TEREC weather pattern as a way to predict when major floods will occur on the American River. Proposals to enlarge the river outlets of Folsom Dam would increase the ability to release more water sooner in a flood event. Knowing in advance there is a high probability that flood-producing rain will likely fall provides an opportunity to release water in anticipation of heavy rainfall. With the advances in satellite technology and computer-based weather models, the National Weather Service is able to make more accurate forecasts over longer time periods. Combining this prediction ability with the knowledge about the low-latitude storm type/TEREC weather pattern appears to provide an opportunity to increase the reliability of Sacramento's flood protection system.
<table>
<thead>
<tr>
<th>Water Year</th>
<th>3-Day Flow (in cfs)</th>
<th>Date (Note 2)</th>
<th>Storm Type (Note 2)</th>
<th>Major Event</th>
<th>Partial TEREC Event</th>
<th>Location (Note 3)</th>
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</thead>
<tbody>
<tr>
<td>1 1986</td>
<td>166,000</td>
<td>Feb 14-18, 1986</td>
<td>TEREC</td>
<td>X</td>
<td></td>
<td>N</td>
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<tr>
<td>2 1997</td>
<td>164,252</td>
<td>Dec 31, 1996-Jan 4, 1997</td>
<td>Low-latitude</td>
<td>X</td>
<td></td>
<td>N</td>
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<tr>
<td>3 1965</td>
<td>140,339</td>
<td>Dec 20-23, 1964</td>
<td>TEREC</td>
<td>X</td>
<td></td>
<td>N</td>
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<td>4 1956</td>
<td>127,449</td>
<td>Dec 18-24, 1955</td>
<td>Low/TEREC</td>
<td>X</td>
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<td>5 1951</td>
<td>107,500</td>
<td>Nov 15-20, 1950</td>
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<td>6 1928</td>
<td>98,167</td>
<td>Mar 22-27, 1928</td>
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<td>97,777</td>
<td>Jan 10-14, 1980</td>
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<td>93,881</td>
<td>Jan 30-Feb 1, 1963</td>
<td>TEREC</td>
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<tr>
<td>9 1907</td>
<td>87,833</td>
<td>Mar 16-20, 1907</td>
<td>Low-latitude</td>
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<tr>
<td>10 1909</td>
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<td>Jan 12-19, 1909</td>
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<td>78,853</td>
<td>Feb 14-16, 1982</td>
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<td>12 1969</td>
<td>71,861</td>
<td>Jan 19-21, 1969</td>
<td>TEREC</td>
<td>X</td>
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<td>S</td>
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</table>

Notes:


TEREC means "Truly Extraordinary Rainfall Event in California" and is the same storm type as the Low-Latitude type, described in HMR-37.

(3) N = Northern California, C = Central California, S = Southern California
References


