The Unusual 2010-11 La Niña Winter in California

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Introduction

The winter of 2010-11 will be remembered as an unusually wet year for California, with record rains in southern California and extremely heavy snowfall amounts in the Sierras. It will be considered unusual since it occurred during a moderate to strong La Niña, when forecasts were predicting a relatively cool and dry winter for the state. Normally La Niñas divert the polar jet stream into the Northwest, leaving the southern tier states drier than normal (figure 1). However, during a 6-day period in December (17th-22nd), an atmospheric river of moisture from just west of Hawaii produced record rainfall in southern California and the wettest snowfall amounts in the Sierras.

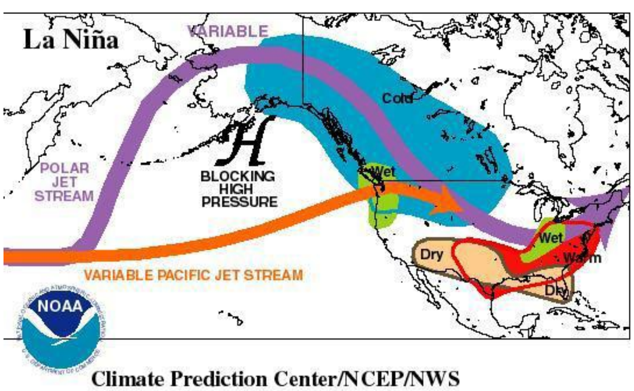

Figure 1. Jet stream circulation pattern and resulting climate during La Niña.

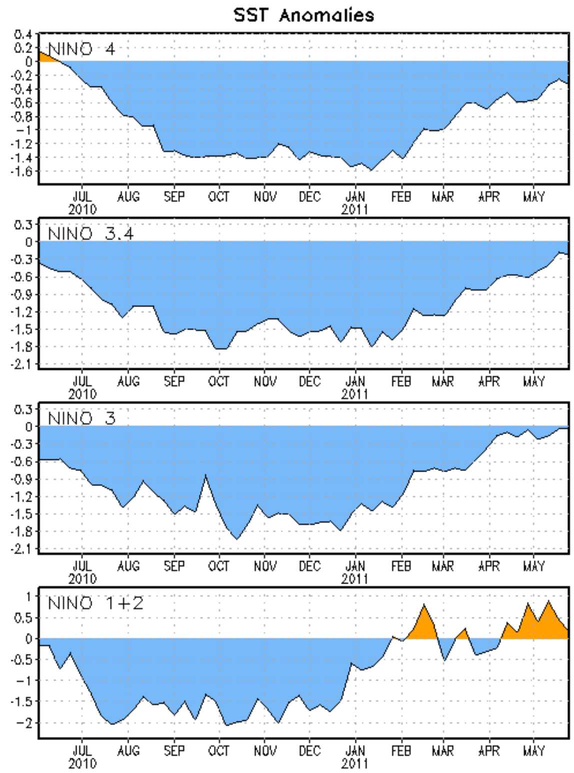

Figure 2. ENSO regions SST departures from June 2010 to June 2011. Source: CPC NCEP NOAA.

In 2010, the equatorial Pacific changed from an modest El Niño to a moderate to strong La Niña, with SSTs in the eastern equatorial ENSO sites running 1.5 to 2°C below average (figure 2). Climate forecasters expected the typical La Niña climate for winter 2010-11. Forecasts were not too bad overall (figure 3), but missed terribly in California, which broke December rainfall records in southern California. Unusually high snowfall totals also occurred in the Sierra Nevada Mountains. Why did this La Niña event turn into such a powerful rain and snow machine? Not all La Niñas produce drier conditions in California. For southern California, only 9 out of 12 La Niña years resulted in below normal rainfall. For strong La Niñas, Los Angeles was drier in 2 out of 4 cases (Monteverdi and Null 1997). Contrary to opinion, heavy rainstorms in southern California are not preferentially linked to El Niños, but occur under La Niña and neutral ENSO conditions as well.

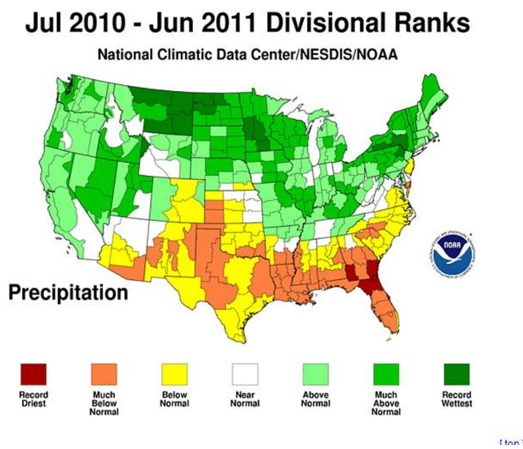

Figure 3. U.S. precipitation for the June 2010 to June 2011 period.

Record December Precipitation

In December a river of atmospheric moisture poured copious amounts of rainfall over the state during a 6-day period (December 17-22). The south coast climate division and the Los Angeles area experienced their wettest December in the 116 year precipitation record with 11.80" (493% of normal) and 10.23" (536%), respectively. An average southern California December would have been drier than normal for the year. Heavy rains, coupled with exposed soil from the massive Station Fire of 2009, led to flooding and mud and debris flows in the Los Angeles region. The state as a whole received 223% of normal, the third wettest December on record, after 1955 and 1996. The 1955-56 winter was a strong La Niña year and wetter than normal statewide. The 6-days of record rainfall in southern California resulted from a steady stream of tropical moisture interacting with polar front cyclones. Although there are often the so-called "Pineapple Connection" streams of atmospheric moisture that reach the West coast during El Niños, this one occurred during a La Niña. The stream in mid-December originated from a tropical storm just west of Hawaii (figure 4) and flowed into the southern California region. The atmospheric circulation favored a southwesterly upper air wind pattern, as a Pacific High at 500 mb set up near the dateline, with a large trough of low pressure just west of Oregon. The polar jet stream also shifted south from November to December from a more anticyclonic flow at 250 mb off the west coast to a cyclonic west-southwest flow in early December. There was also influence from the western tropical Pacific. The MJO Index peaked in November, along with enhanced convection in western equatorial Pacific and west of Hawaii in late November-early December. A strong southwesterly anomaly at 850 mb from Hawaii to California occurred December 8-10, beginning the moist flow from the tropics into California.

Figure 4. Atmospheric river of moisture originates at Tropical Storm Omeka just west of Hawaii and reaches southern California during December 2010 record rainfall. Photo credit: NASA Goddard.

Heavy snowfall in the Sierras

Snowfall amounts in the Sierras benefited greatly from extreme moisture in the December storms, which put snowfall levels briefly above the record 1982-83 winter. These mountains also received large snow quantities from March storms that swept through northern California. A cool fall 2010 also had a decent start to the snow year with 264% of normal precipitation in the Sierra climate division in October. November continued cool and wet with another 134% of normal precipitation in the division. December storms added 367 mm (14.44 In) to the Sierras, the 4th wettest December in the 116 year record. Although the wettest snowfall year in the Sierras occurred in 1982-83, an unusually strong El Niño year, snowfall amounts exceeded

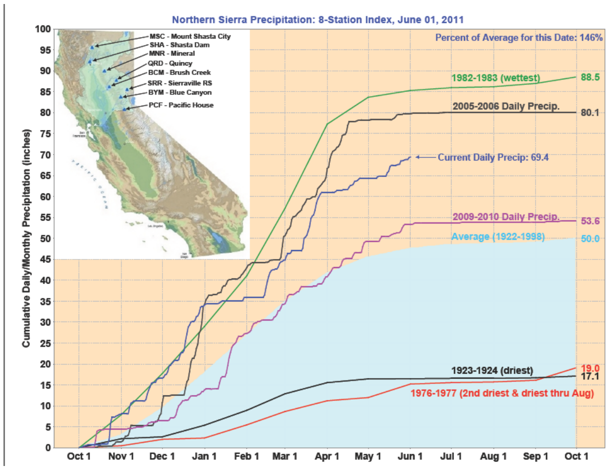

Figure 5. Northern Sierras precipitation 2010-11 compared to average and extreme years. Note that in December 2010, precipitation was the highest recorded.

that record year briefly in December. After relatively dry January and February, northern California storms added another 305 mm (12.43 in) in March, 219% of normal. May and June storms delayed the usual rapid melting in the spring adding 77 mm (3.02 in) and 97 mm (3.82 in), respectively. June's total was the wettest on record for the Sierras at 702% of normal. The northern Sierras cumulative precipitation curve shows that 2010-11 was comparable to the wettest year of 1982-83 (figure 5). At Mammoth ski resort, the abundance of heavy snow guaranteed skiing into July (figure 6). The late melt period also led to heavy runoff and some flooding on both sides of the Sierras. Water rationing in the Central Valley, due to a multi-year drought, was cancelled as most reservoirs in the state replenished their low levels.

Reflections on the 2010-11 winter

The winter of 2010-11 produced unusual rainfall and snowfall throughout California during a La Niña year. When a combination of favorable factors coincides over a short period, such as happened in late December, the results can be heavy precipitation and flooding (figure 7). Such a combination of contributing factors took place over a 6-day period. However, northern California storms and heavy snowfall in spring also contributed to a remarkably wet year for northern and central California. These late season storms were not associated with tropical moisture. But moisture levels were still high enough to set several March rainfall totals. March 13-19th totals were especially high in northern regions, while on March 20th rainfall records fell in several southern California locations (Weatherwise 2011). California's highly variable precipitation will continue to confound climate forecasters that rely on average ENSO conditions. While most ENSO events result in typical rainfall patterns, especially on the west coast, mother nature does not always follow statistics.

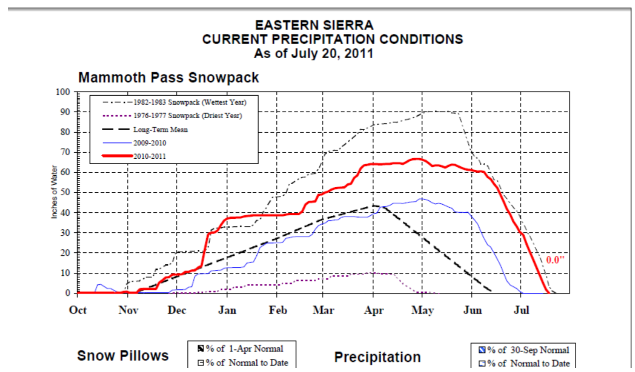

Figure 6. Mammoth ski area's 2010-11 snowpack (in.) compared to average and extreme years.

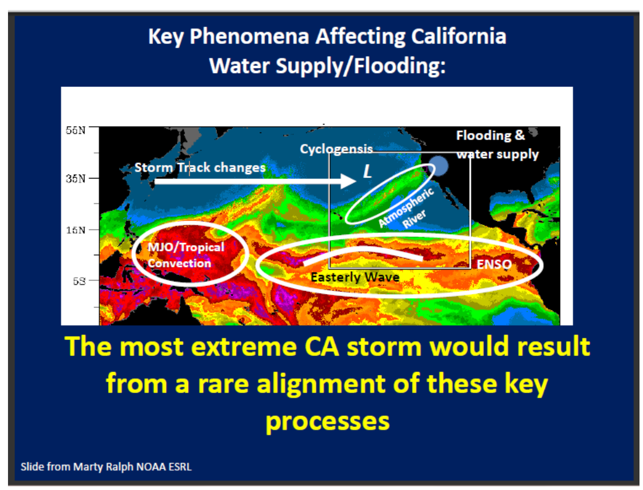

Figure 7. Alignment of contributing factors can lead to rainfall extremes such as in Dec. 2010.

References

Monteverdi, J. and J. Null (1997). El Niño and California Precipitation. Western Region Technical Attachment No. 97-37, Salt Lake City, UT.

Weatherwise (2011). Weatherwatch: March 2011. Weatherwise 64, 46-52.