Why California May Expect another Dry Year in 2014

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Introduction

The fourth snow survey by the California Department of Water Resources (DWR) during 2012 showed that as of April 2, the water content of the State's mountain snowpack was about 55% of the April 1 peak season average (DWR 2012.) A similar snow survey of 2013 was reported on March 28, which showed that the water content in the State's snowpack was about 52% of normal for the season (DWR 2013.) Water content in California's snowpack is measured manually near or on the first day of every month from January to May and in real time using electronic sensors.

The 2012-13 period is about two Saros cycles from the 1976-77 period. The 1976-77 period is widely known among California's water resources experts and managers as one of the driest periods on record. A Saros cycle, which will be discussed below in more detail, is a period of about 18 years, 11 days, and 8 hours. The dry conditions in California during these two periods (1976-77 and 2012-13) appear additional validation of the recently uncovered association of similar hydrological conditions on Earth and analogous orbital geometries of the earth and moon (Ejeta 2012.) The following brief analysis presents this further validation exercise.

Methodology

The association of similar hydrological conditions on earth and analogous orbital geometries of the earth and moon was uncovered following analyses of long-term precipitation and estimated natural streamflow records in California (Ejeta 2012.) The fundamental physics behind this association, which is an ongoing investigation, is likely to be Newton's law of universal gravitation (Newton 1687.) The effect of this gravitational force is evident in ocean dynamics, which is known to be reflected in tide level fluctuations.

The conceptions of the existence of transient gravitational forces between distant objects such as the earth, moon, and sun as well as establishing definite orbital geometries of the earth and moon in the earth-moon-sun vector space may sound daunting at first thought. However, actual observations of geophysical realizations indicate that nature may have its own ways of revealing itself. Figure 1 is a schematic depiction of the moon orbiting the earth in tandem with the earth orbiting the sun, which was established a long time ago by early scientists.

Establishing approximate orbital geometries can be done by using apparent earth-moon-sun alignment records by the National Aeronautics and Space Administration (NASA.) It can be assumed that if the moon was at node N_1 in month M_1 when a solar eclipse event E_1 occurred and was at node N_2 in month M_2 when a subsequent solar eclipse event E_2 occurred, these nodal and time proxies can be used to establish an approximate orbital pathways of the earth and moon during the year in which these events occurred. There are, respectively, various recorded nodes and times of the year at which and when different solar eclipse events occur. The four recorded solar eclipse types are Total (T,) Annular (A,) Hybrid (H,) and Partial (P.) The month in which they occur can be designated with 1 for January, 2 for February, ..., and 12 for December. Two alignment events that are separated by one Saros cycle share very similar geometries. They occur at the same node with the moon at nearly the same distance from the earth and at the same time of year (NASA 2013.)

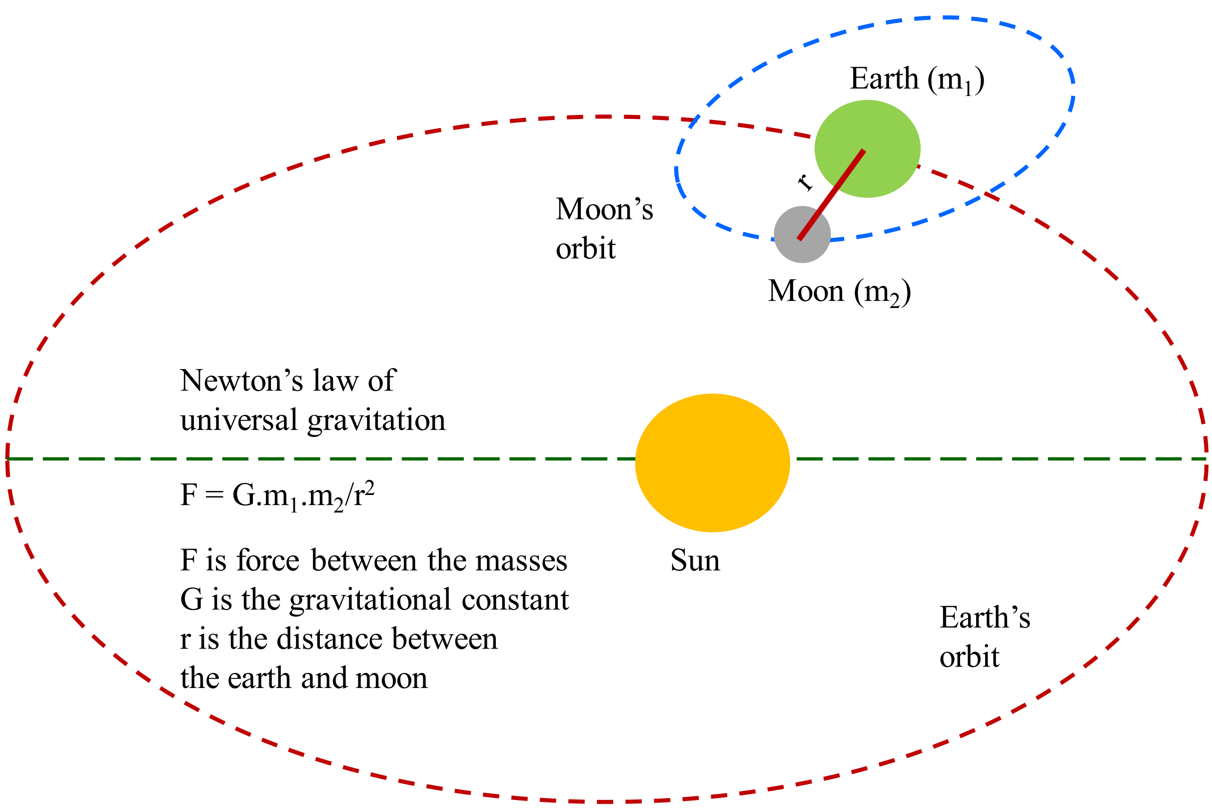

Figure 1. Schematic depiction of the moon and earth's orbits (not to scale)

We can also assume that the transient movements of the moon between two nodes N_1 and N_2 during two years that are separated by one Saros cycle are similar. It follows then that if we are able to identify similar solar eclipse events during two different years, we will be able to establish orbital geometries during those years and screen out the ones that are analogous.

Establishing Analogous Orbital Geometries

Using the approach discussed above, the analogous orbital geometries during the 1976-77 and 2012-13 dry periods in California can be established using NASA's records of solar eclipse events as proxies to gauge the transient movements of the earth and moon in the earth-moon-sun vector space during these periods. Table 1 shows NASA's solar eclipse records during these periods.

Table 1. Trajectories of similar solar eclipse events during the 1976-77 and 2012-13 dry periods in California (NASA 2013)

Period	Calendar Date	Type	Saros Series	Eclipse Magnitude*	Geographical Region of Eclipse Visibility	Lunar Orbital Pathway
1976-77	5/11/1975	Partial	118	0.864	Greenland, Europe, n Africa, n Asia	P5-**P11**-A4-**T10**-A4
	11/03/1975	Partial	123	0.959	s S. America, Antarctica	
	4/29/1976	Annular	128	0.942	Europe, Africa, Asia	
	10/23/1976	Total	133	1.057	e Africa, India, E. Indies, Australia, New Zealand	
	4/18/1977	Annular	138	0.945	Africa, s Asia	
2012-13	6/01/2011	Partial	118	0.601	e Asia, n N. America, Iceland	P5-**P11**-A5-**T11**-A5
	11/25/2011	Partial	123	0.905	s Africa, Antarctica, Tasmania, New Zealand	
	5/20/2012	Annular	128	0.943	Asia, Pacific, N. America	
	11/13/2012	Total	133	1.050	Australia, New Zealand, s Pacific, s S. America	
	5/10/2013	Annular	138	0.954	Australia, New Zealand, c Pacific	

The earth-moon-sun alignment data in Table 1 shows that during each of the identified periods, there were successions of similar solar eclipse events (column 3) at successive identical nodes (column 4) at nearly the same times of the year (column 2.)

Thus, it is presumed that the orbital pathways during these periods may be considered analogous. It should be noted here that it is assumed that the transient pathways are similar between the same nodes at which, for instance, Partial eclipses occurred in the fall season followed by Annular eclipses in the spring season. It is also assumed that the similarity of the pathways stays put for the entire length of the periods that have been identified to have analogous orbital forcings by using the solar eclipse event proxies.

Natural Streamflows in California

Water year types in the Sacramento and San Joaquin Valleys of the California Central Valley are determined using the estimated natural streamflows of four major rivers in each valley. These rivers, which are shown in Figure 1, include: 1) Sacramento River at Bend Bridge near Red Bluff; 2) Feather River near Oroville; 3) Yuba River at Smartsville; 4) American River at Folsom Dam; 5) Stanislaus River at New Melones Dam; 6) Tuolumne River at New Don Pedro Dam; 7) Merced River at Lake McClure; and 8) San Joaquin River at Friant Dam. The first four rivers are used to compute Sacramento Valley's water year type index whereas the remaining four rivers are used to compute San Joaquin Valley's water year type index. In each Valley, water year types are categorized as Wet, Above Normal, Below Normal, Dry, and Critically Dry. In North America and various other regions of the world, a water year runs from the beginning of October of the previous calendar year to the end of September of the current calendar year.

Much of the flows in the above rivers comes as snowmelt runoff from the northern Cascade and Sierra Nevada mountain ranges. Thus the estimated natural flows in these rivers are directly related to the water contents of California's mountain snowpack, which are measured every year in order to get some insight about the State's water delivery outlook. Low snow water contents are associated with dry meteorological conditions and potentially low water deliveries.

Figure 3 shows a comparison of estimated natural flows of the eight rivers during water years 1976, 1977, and 2012 to the observed maximum, minimum, and long-term average flows, in million acre-feet (MAF.) This comparison shows that the flows of all the eight major rivers during water years 1976, 1977, and 2012 are lower than the corresponding long-term average flows. In fact, for seven of the eight major rivers, the 1977 flows were the lowest on record and it has been widely established that the 1976-77 period was the driest on record in California during the 20th century.

Even though water year 2013's natural flows of the eight major rivers of California are yet to be fully estimated, indications so far are that it is likely to be one of the driest years in California, as already evidenced by the results of monthly snow surveys conducted so far. According to the National Weather Service of the National Oceanic and Space Administration (NOAA,) precipitation across northern and central California during the months of January and February were extremely low and in record territory (NOAA 2013.)

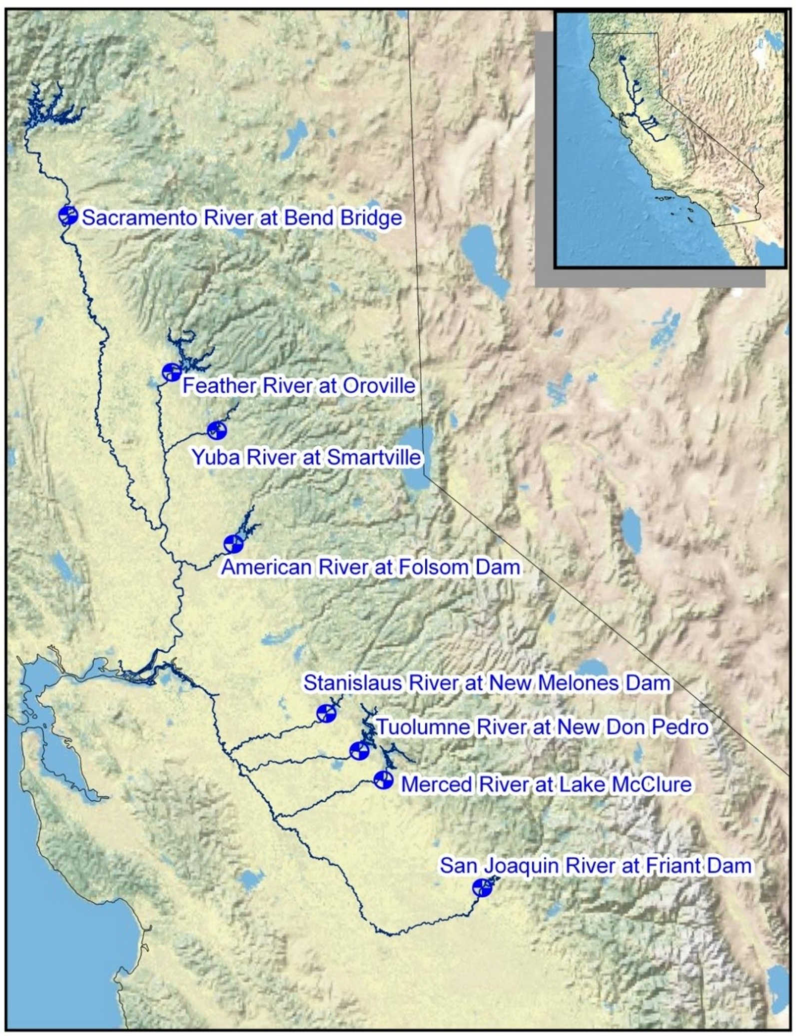

Figure 2. Locations of estimated natural flows of California's eight major rivers, which are used for the determination of water year type classifications in the Sacramento and San Joaquin Valleys

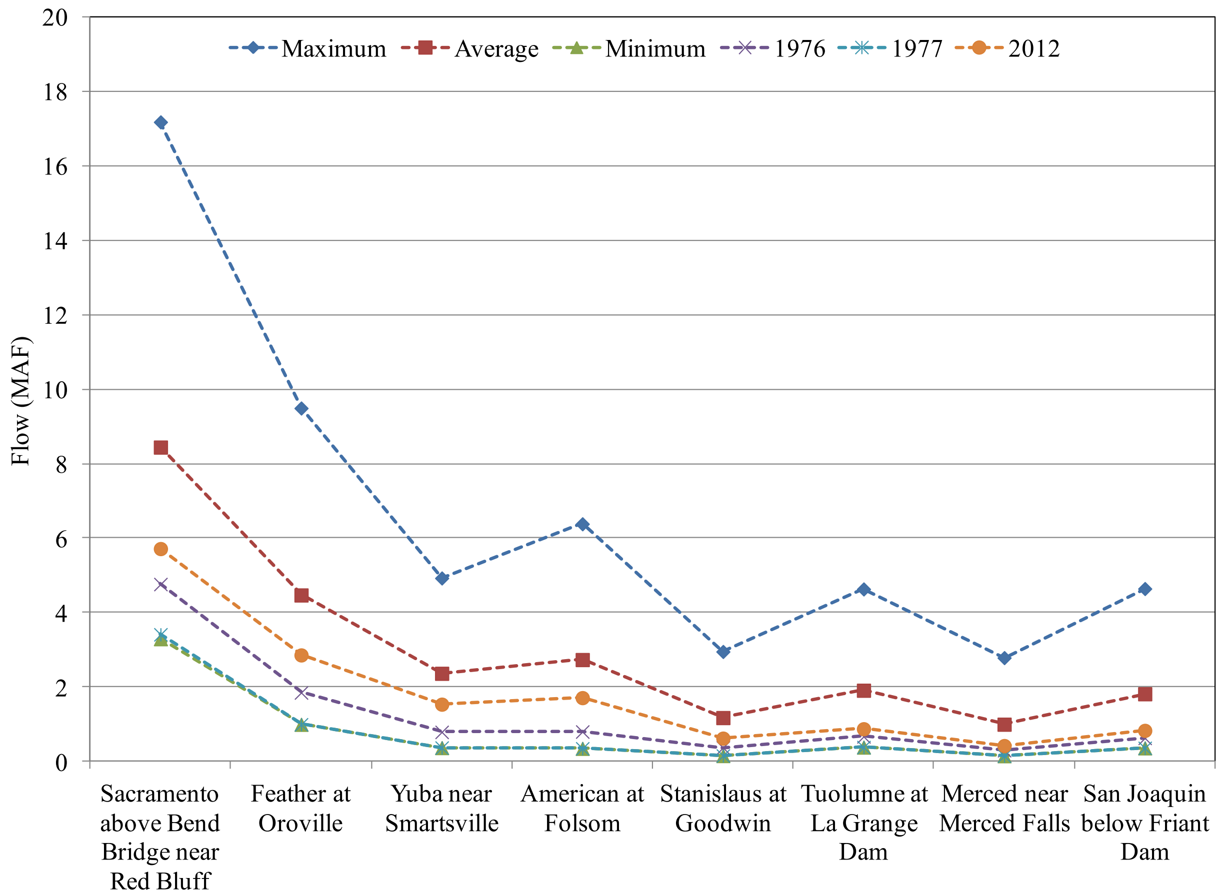

Figure 3. Comparison of estimated natural flows during water years 1976, 1977, and 2012 to the observed maximum, long-term average, and minimum flows in the major rivers of the California Central Valley

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The data in Table 1 shows that the closely analogous orbital geometries during water years 1976 and 2012 as well as 1977 and 2013 had Partial or Total eclipse alignments of the earth, moon, and sun in the early period of the wet season in California and Annular alignments after the wet season. These alignments contrast against those during the wettest months of December, January, and February, which appear to be generally associated with wetter conditions. Table 2 shows data of solar eclipse events for water years 1977, 2013, and 2014 (NASA 2013.) According to the data in this table, water year 2014's lunar orbital pathway (LOP) is generally similar to that of 2013. The major difference is the Partial solar eclipse in November for water year 2013 and Hybrid solar eclipse in November for water year 2014. While how these differences may play out in terms of meteorological realizations in 2014 in California remains to be seen, it is unlikely to cause a major shift from those observed during water years 1977 and 2013. Given the close similarities in the LOP during these years, it may be likely that California may expect to experience a drier than normal meteorological condition in 2014.

Table 2. Solar eclipse data for establishing Lunar Orbital Pathways for water years 1977, 2013, and 2014 (NASA 2013)

Water Year	Calendar Date	Type	Saros Series	Eclipse Magnitude	Geographical Region of Eclipse Visibility	Lunar Orbital Pathway
1977	4/29/1976	Annular	128	0.942	Europe, Africa, Asia	A4-**T10**-A4
	10/23/1976	Total	133	1.057	e Africa, India, E. Indies, Australia, New Zealand	
	4/18/1977	Annular	138	0.945	Africa, s Asia	
2013	5/20/2012	Annular	128	0.943	Asia, Pacific, N. America	A5-**T11**-A5
	11/13/2012	Total	133	1.050	Australia, New Zealand, s Pacific, s S. America	
	5/10/2013	Annular	138	0.954	Australia, New Zealand, c Pacific	
2014	5/10/2013	Annular	138	0.954	Australia, New Zealand, c Pacific	A5-**H11**-A5
	11/3/2013	Hybrid	143	1.016	e America, s Europe, Africa	
	4/29/2014	Annular	148	0.987	s Indian, Australia, Antarctica	

Discussion

Several insights can be gained from the results shown in Figure 3. First, the estimated natural flows of each of the rivers during all the three years are invariably below the long-term average flows. This suggests that a LOP that is characterized by a Partial or Total solar eclipse event in the early part of the wet season followed by an Annular solar eclipse event in the spring season is generally associated with a dry hydrological condition in California. Second, based on hydrological data gathered so far for water year 2013, the 2012-13 period meteorological condition in California appears to be similar to that during 1976-77. Noting that the 2012-13 period is two Saros cycles from the 1976-77 period, the similarity in the meteorological conditions during these two periods is in agreement with a previous observation that two Saros cycles may be more instructive than one Saros cycle for the predictability of hydrological conditions on earth. While water year 1994, which was one Saros cycle from water years 1976 and 2012, was also a dry year in California, the meteorological condition during water year 1995 was markedly different from that of 1977 or 2013. Even though such anomalies are a subject of further investigation, it can be fairly said that analogous orbital pathways are significant in the predictability of hydrological conditions on earth. The gap of a few days between Saros cycles could be challenging and at times appears to obscure the periodicity of the Saros cycle. However, closer examinations of the orbital pathways can lead to apparently analogous ones. For example, water years 1939 and 1957 were found to have similar orbital pathways as water year 1976. California had also experienced periodical dry conditions during these years even though water year 1976 was 19 years from 1957.

These results, which are part of an ongoing investigation, have far reaching implications beyond the validation of the predictability of hydrological conditions on earth. They are likely to address convincingly the uncertainty in general circulation modeling, which doesn't appear to have put climate variability to rest scientifically.

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Note: This analysis is published as part of an ongoing validation exercise of previous finding of the association of hydrological conditions on earth and lunar orbital pathways in tandem with the earth orbiting the sun. Any and all decisions that are based on the information provided in this report are at the sole discretion and responsibility of its users.