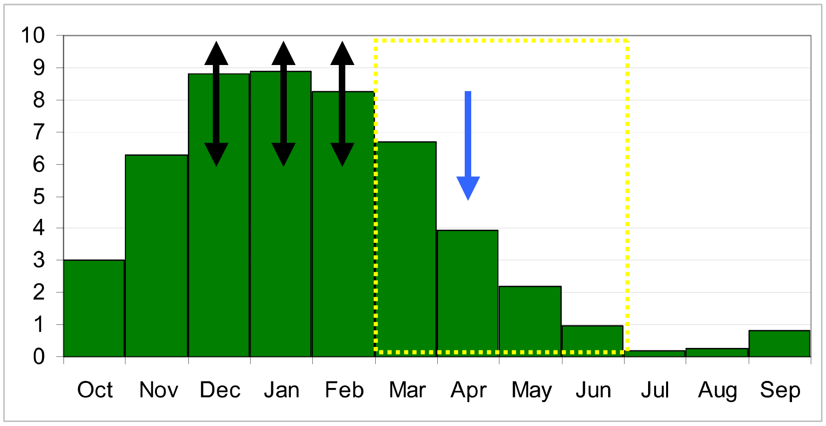
Climate Change Impacts

- Less Precipitation Falling as Snow
- Drier Springs
- Increased Variability

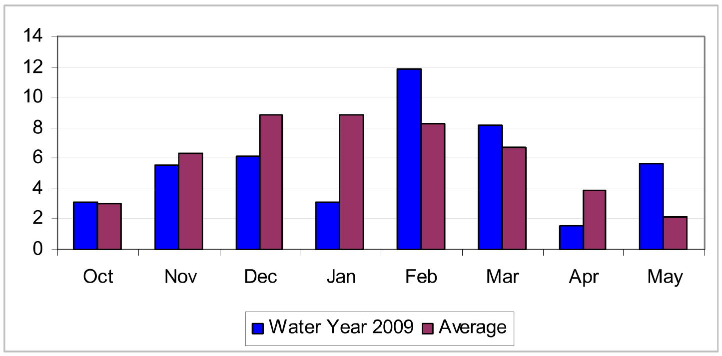


Climate change is expected to increase temperatures which will cause the percentage of precipitation falling as rain to increase which will decrease the size of the snowpack. Warmer, drier springs will initiate snowmelt earlier and decrease the volume of runoff traditionally used to refill reservoirs for the summer's water supply. In addition to these changes, the variability is expected to increase meaning greater fluctuations in what is observed relative to average conditions.

The graph shown here is of the monthly 8 station index precipitation distribution. The black arrows indicate the increasing varaibiltiy while the yellow box with the blue arrow is used to illustrate the expectation that this portion of the distribution will decrease. All of these features can have profound impacts on the drought characteristics we have discussed so far.

Signs of Change?

- Driest Precipitation Year Southern CA 2007
- Driest Spring Northern Sierra 2008
- Water Year 2009 Precipitation Distribution



Some of our expectations for the future have made an appearance in this latest drought. Two years ago, several locations in southern California experienced their driest precipitation year which is July 1st through June 30. This comes two years after one of the wettest years on record and five years after the previous low record was set. Last year, many sites in northern California, including the 8 station index, experienced their driest spring ever. An average snowpack for April 1 produced only 58% of the expected April through July runoff.

Finally, this water year has seen some big shifts in conditions from month to month. In January and the beginning of February, dry conditions were setting the stage for record low runoff values. Conditions then changed abruptly in the latter half of February and beginning of March with a series of storms with subtropical taps that greatly improved the situation. The latter half of March and April returned to very dry conditions which changed again in the beginning of May with a series of storms that hit northern California. Is this a preview of what is to come?

Future Drought Characteristics

- Fall runoff decreases due to drier antecedent conditions in watershed
- Decrease in Spring precipitation decreases odds of “March Miracles”
- Smaller snowpacks and drier springs decrease April-July runoff

Looking at climate change and drought characteristics, we can start to make some qualitative assessments. First, we might expect fall flows to decrease due to drier antecedent conditions in the watershed. Second, a drier spring might lead to the expectation that the probability of a so-called March Miracle or Awesome April will decrease. Another component leading to lower spring flows is the expectation of a smaller snowpack on average. The net effect of these changes is a greater reliance on winter precipitation to make up the bulk of the seasonal total. A dry winter month in the future would then be expected to cause more of a drought impact.

What If Drought Year – 8 Station Index

- Blend elements of past drought years to represent climate change drought year
- Low 10 Monthly Average: 6.91 inches
- Low 10 Seasonal Total Average: 17.10 inches
- 1977/1991/1924 Seasonal Mix: 11.07 inches

Given this picture of future conditions, we can start to imagine what-if scenarios for a dry year. One way of doing this is to combine elements of the historical record that mimic our expectation of future conditions. As a starting point, for the 8 station index, I averaged the lowest 10 monthly values and summed these low months together to get an annual value. The total only amounted to 6.91 inches. This is likely an extreme situation as it assumes the worst conditions will be present for all months. Backing off a step, I looked at the seasonal totals and averaged the lowest 10 values for each season. The annual sum for this event came out to be 17.10 inches which is in the ball park of the 1924 and 1977 water years. While extreme, it has already been demonstrated that such outcomes are plausible.

Another alternative I explored was to look at the lowest 10 winters and combine the lowest winter (1991) with the lowest fall from this subset (1977) and the lowest spring (1924). This generated an annual total of 11.07 inches. Note that 1977 is not the driest fall, but the driest fall associated with the 10 driest winters and 1924 is the driest spring associated with the 10 driest winters. This would also be an extreme case, but may be plausible given our expectations for climate change.

What If Drought Year - Runoff

- No snowpack for spring runoff
- Fall runoff decrease due to drier antecedent conditions
- Winter flows maintained only with continued precipitation
- Average of 10 Lowest Drought Flows:
  Oct-Mar: 3.8 MAF (10.4 MAF)
  Apr-Jul: 2.6 MAF (6.8 MAF)
  Water Year: 7.5 MAF (18 MAF)

In terms of runoff, the extreme condition would be no snowpack and a fall that requires more precipitation to see an increase in river flows. In this scenario, winter flows would likely rise with an event, but fall back to lower values than they would under current conditions. In terms of quantifying low runoff, the average of the 10 lowest Oct-March flows for the Sacramento Basin yielded only 3.8 million acre feet compared to the current average of 10.4 MAF. The spring runoff would only be 2.6 MAF instead of the current expectation of 6.8 MAF. The average of the 10 lowest water year totals yields only 7.5 MAF compared to the current average of 18 MAF. Note that these numbers assume that the future drought will look like the average of today's most extreme conditions. This may not be the case due to the expectation that variability will increase and month to month fluctuations may become the norm.