

### SALT RIVER + TONTO CREEK

| | |
|---|---|
| Basin area | 4981 square miles |
| Gage elevation | 2350 feet |
| Average water year flow | 726,160 acre feet |

# SALT RIVER + TONTO CREEK

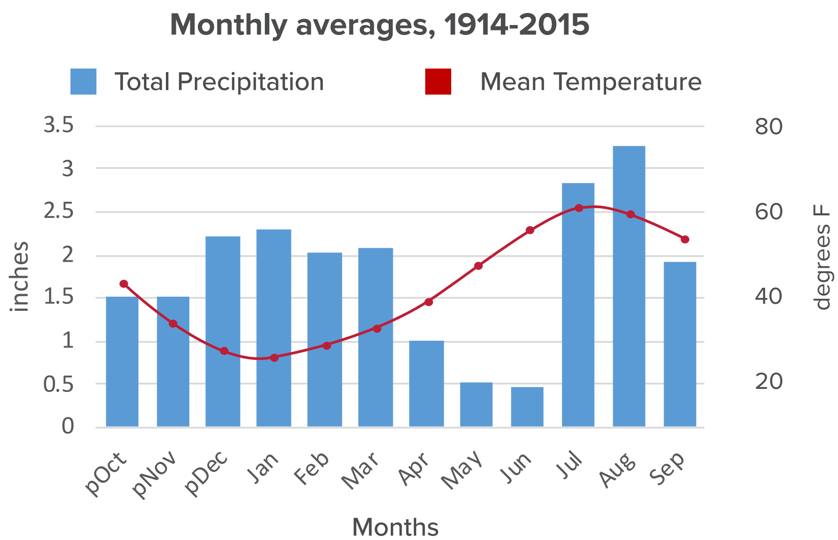
## Relationships between Climate and Streamflow

# Salt River + Tonto Creek:
# Relationships between Climate and Streamflow

## What are the main climatic controls on Salt River + Tonto Creek water year streamflow?

The relationships between water year streamflow and monthly or seasonal temperature and precipitation for the combined Salt River and Tonto Creek basins are examined for the years 1914-2015, along with two shorter snow-pack records, to determine the most important climatic influences on streamflow (data on P. 6). After identifying the most important climate factors related to water year flow, stepwise linear regression was used to determine the variance in streamflow accounted for by specific climate variables (P. 2). Trends in streamflow and climate were then assessed (P. 3). Droughts were identified, along with the average climate conditions that occurred during the years of each multi-year drought (P. 4). Finally, years for which streamflow and climate conditions were unusual were examined in greater detail (P. 5).

**The climate of the basin** is characterized by two peaks in precipitation: the cool season (October-March) and the mon-soon (June-September). Aver-age temperatures range from 36F in January to 75F in July.

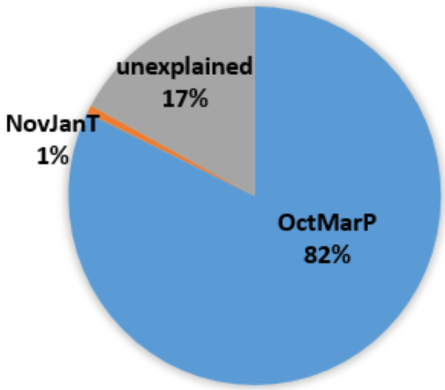



## Summary of Main Findings

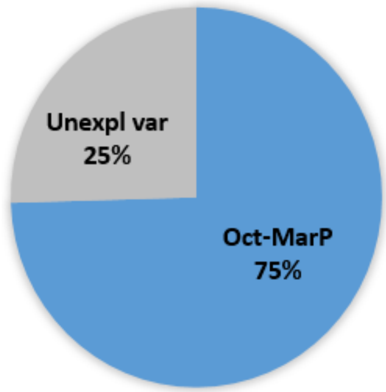
- When all years are considered, cool season (October-March) precipitation is the most important influence on streamflow, accounting for 82% of the variance in flow.
- In years with below median flow, spring temperatures become a more important factor, explaining a small but significant portion of the variability in flow.
- There is no evidence of long-term trends in flow, precipitation or snow (positive or negative), but significant warming has occurred over the past 100 years.
- Multi-year droughts are largely controlled by cool season precipitation, and even wet monsoons do not make up for cool season precipitation deficits.
- However, in some individual years, the monsoon is likely to have had an impact on flow relative to cool sea-son precipitation.
- More years with higher flows, and greater flow relative to precipitation, occurred early in the 20th century. More years with less flow than might be expected given precipitation occurred in recent decades. In both cases, temperature may be an influential factor.

# Salt River + Tonto: Climatic Controls on Streamflow

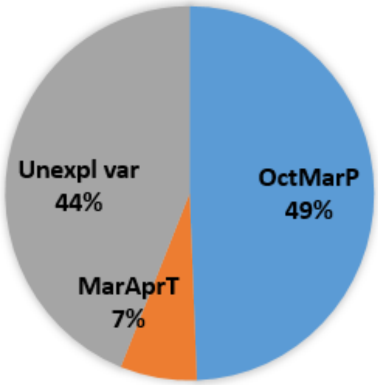
**Pie charts below** show the seasonal precipitation and temperature variables that are most important for water year streamflow.




All years

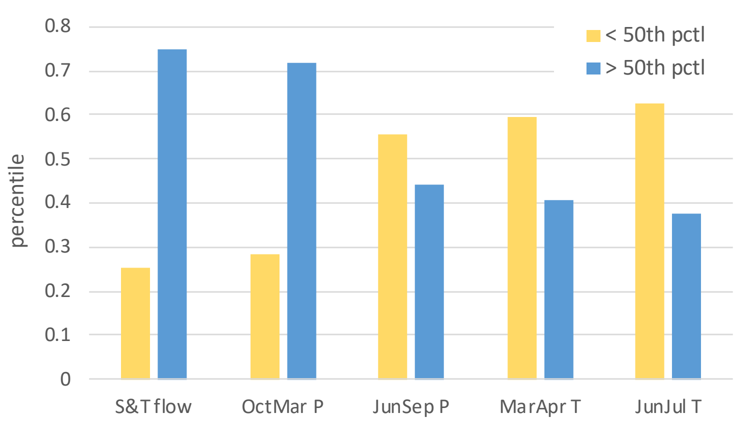



Above median years (high flow)



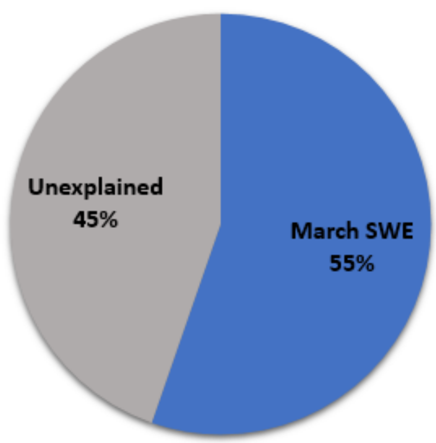

Below median years (low flow)

**Climate averages (in percentile) for streamflow years above and below the median** show similar results, but add some information regarding the climate conditions that accompany these two sets of years.  Lower flow years are very dry in the cool season, and warm in both spring and monsoon seasons. However, there is less difference in monsoon precipitation and it is actually wetter in below median flow years.




**What about snow?**

The snow water equivalent (SWE) snowpack on March 1 at Ft. Apache explains just over half of the variance in flow.  Note that this is based on one snow course site. However, an additional record at a lower elevation (Coronado Trail) shows a very similar relationship.



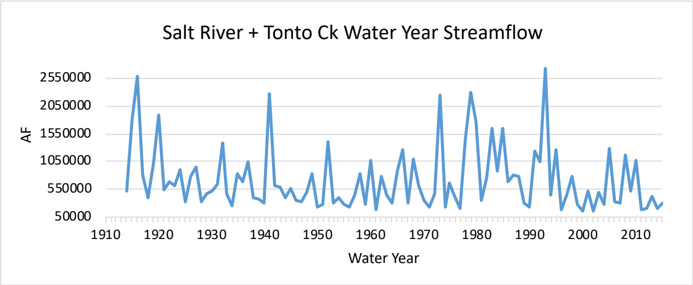

## Main findings

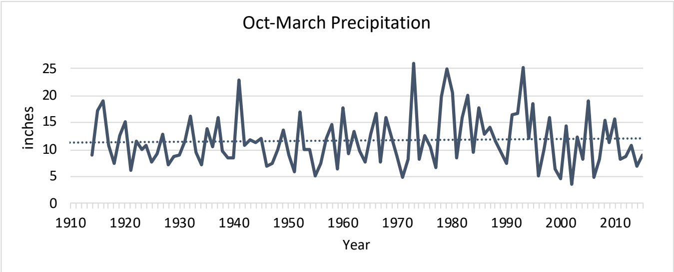
**All years:** cool season precipitation explains most of the variance, with just 1% explained by winter temperatures.

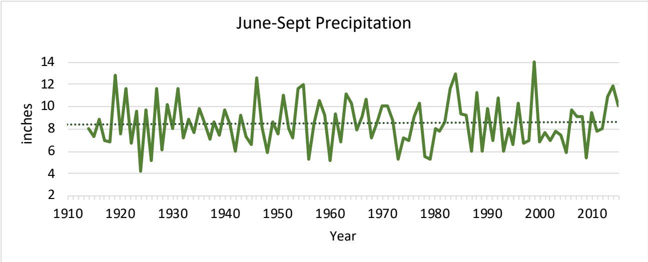
**Above median flow years:** cool season precipitation is the only climate variable that explains a significant amount of streamflow variability

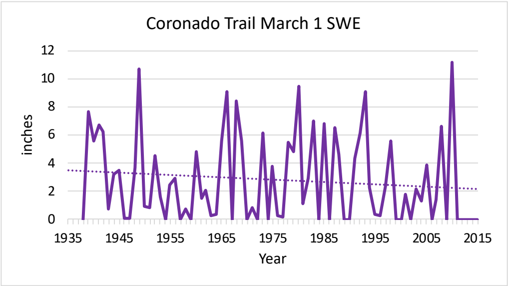
**Below median flow years:** cool season precipitation explains less of the variance than in higher flow years, while spring temperatures explain a small but significant portion of the variability.

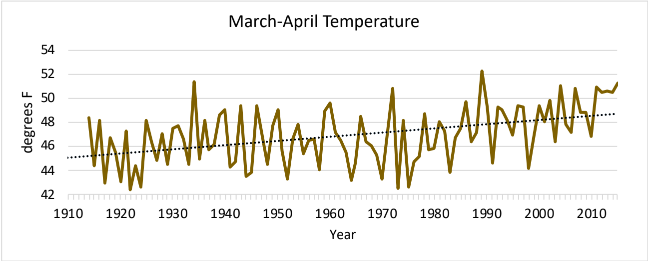
# Salt River + Tonto Creek Streamflow and Climate: Trends Over Time

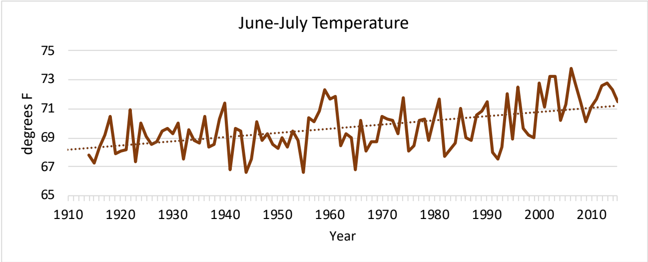


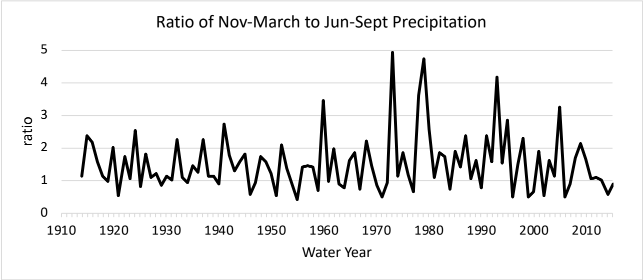



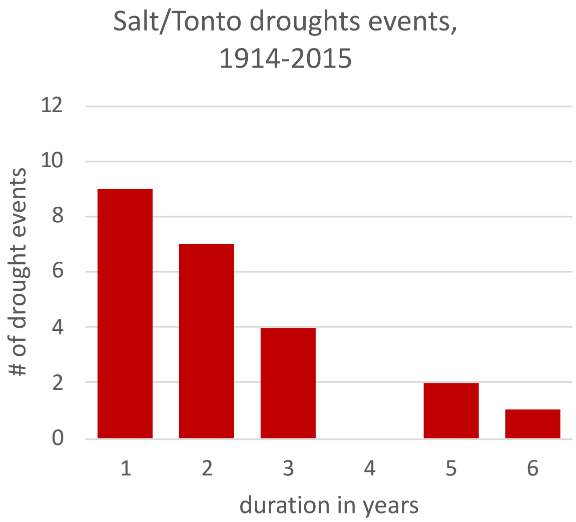

**The ratio of cool season precipitation to monsoon precipitation** contains no trend. Ratios are often but not always greater than one because cool season precipitation tends to be greater than monsoon precipitation. Ratios are quite variable, ranging from 0.4 (1955) to almost 5 (1973).




## Main findings

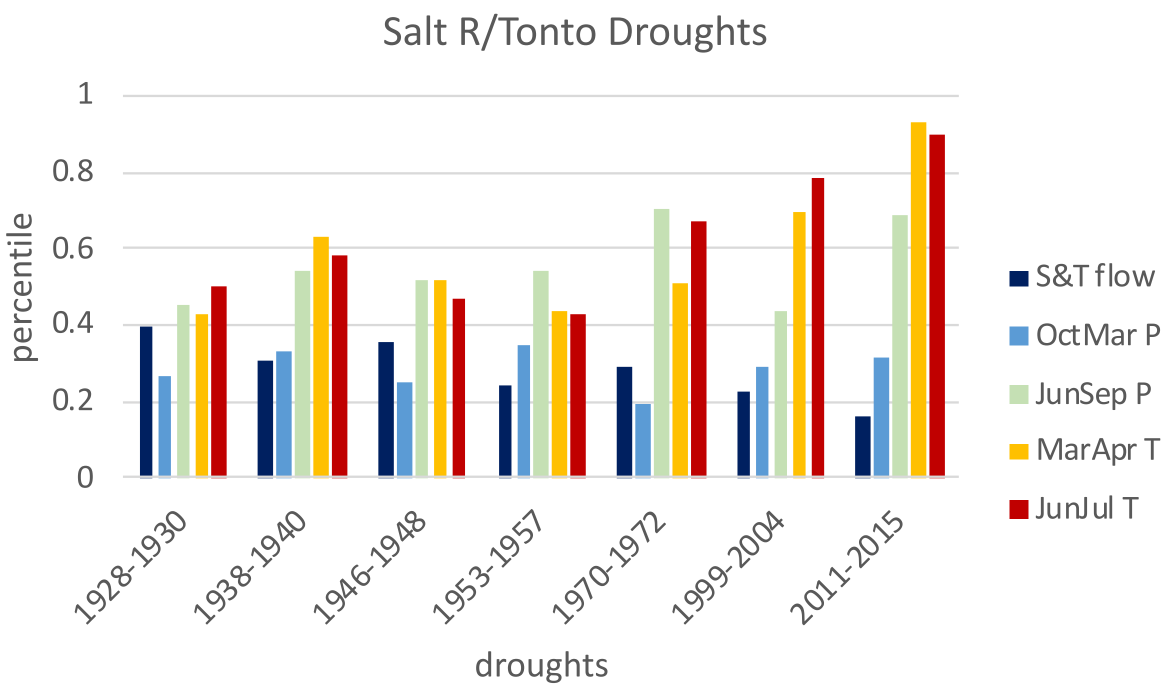
- **Streamflow and seasonal precipitation:** No significant trends
- **March 1 snow water equivalent (SWE):** No statistically significant trend in this shorter record (starts in 1938) yet, although a non-significant decreasing SWE trend is visible.
- **Seasonal temperature:** Positive and statistically significant (> 99%) warming trends in both spring and monsoon season temperatures (warming about 0.35°F/decade in spring and nearly 0.3°F/decade in summer).

# Salt River + Tonto Streamflow and Climate: Drought




Droughts are defined as single or consecutive years below the median water year flow. Drought duration and number of events are shown to the left.

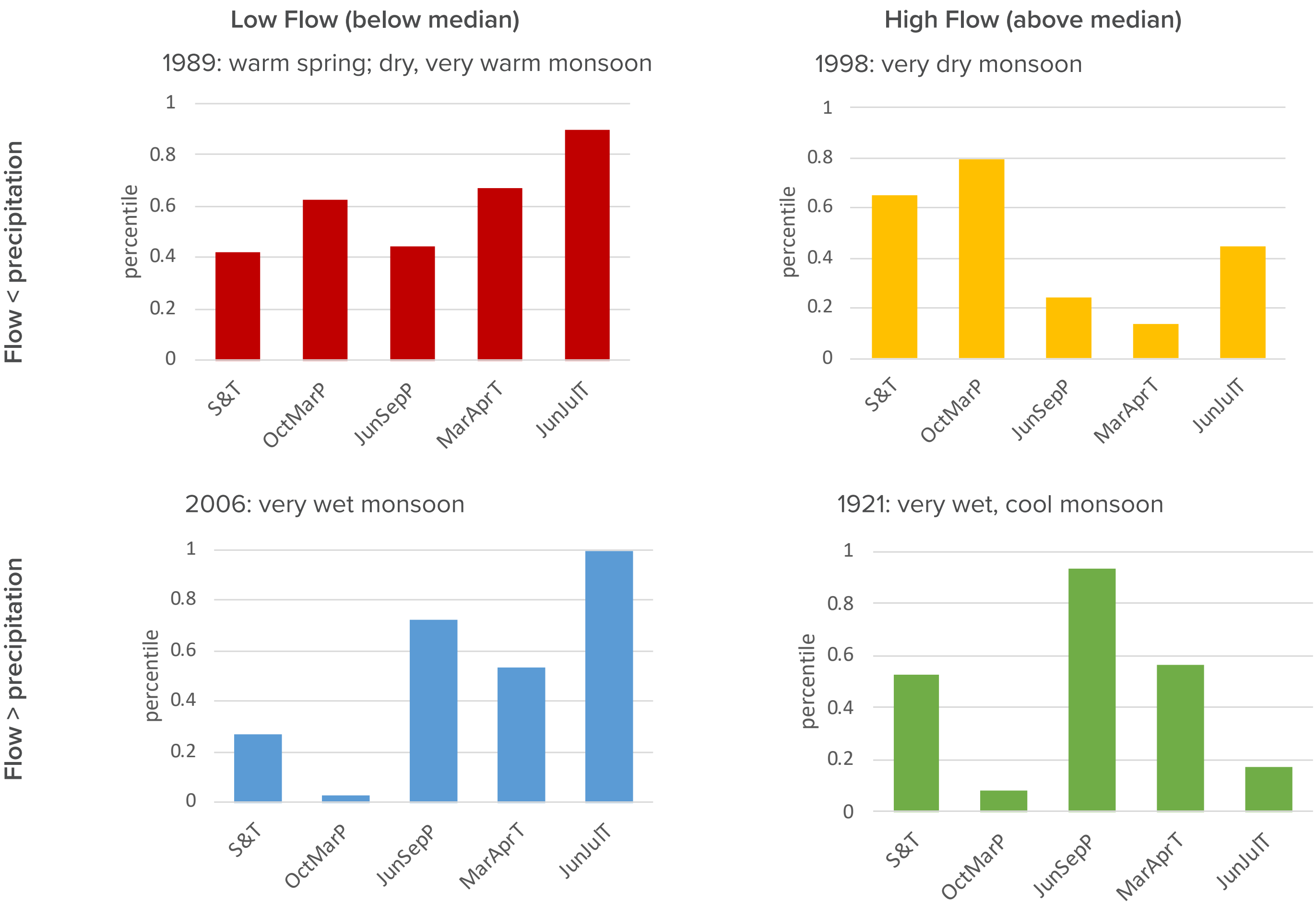
The **major climate drivers of the six drought events that last three or more years are examined in the graph** (below). Flow is averaged over the course of the drought years, along with corresponding cool and monsoon season temperature and precipitation. Values are in percentile.



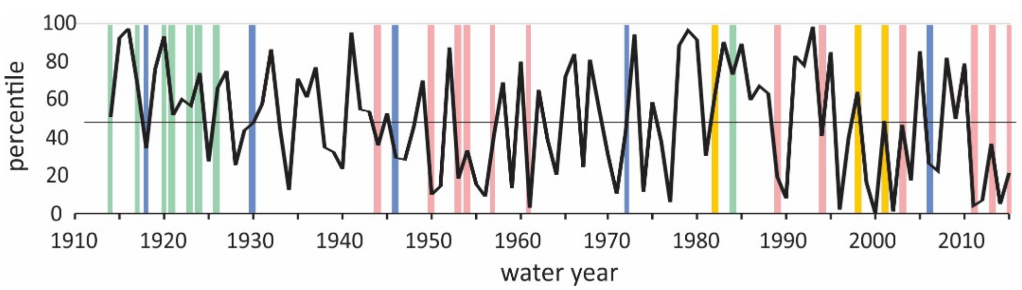

## Main findings

- **Droughts typically last** 1-2 years. The longest drought is a 6-year event, 1999-2004.
- **Average** temperatures during droughts have become warmer in both spring and monsoon seasons since the 1950s.
- **Average streamflow is less impacted by cool season precipitation** deficits when spring temperatures are cooler (1928-30, 1946-48, and 1970-72).
- **Droughts are largely controlled by cool season precipitation**, and even wet monsoons do not make up for cool season precipitation deficits (i.e., 1970-72, 2011-2015).
- **The 1999-2004 drought event stands out as a dual season drought**, with respect to precipitation.

# Salt River + Tonto Creek Streamflow and Climate: Unusual Years




All years in which the difference between water year flow and cool season precipitation is greater than one standard deviation from the mean difference are show below, in vertical bars color-coded to match the year types shown above. While each year is unique in terms of the climate conditions that cause flow to be less or more than expected given precipitation, more years with above median flow and flow greater than precipitation (like 1921, green bars) occurred early in the 20th century, while more years with less flow than might be expected given precipitation (like 1989 and 1998, pink and yellow bars) occurred in recent decades.




## Main findings

While streamflow closely tracks cool season precipitation in most years, a few years have larger differences between these two variables. In these years, climate factors other than cool season precipitation may play a more important role with respect to water year streamflow. Four examples of such years are 1921, 1989, 1998, and 2006.

## DATA USED IN THESE ANALYSES

| | |
|---|---|
| **Water Year Streamflow** | |
| Salt R. near Roosevelt (USGS Gage 09498500) | 1914-2015 |
| Tonto Ck. near Roosevelt (USGS Gage 09499500) | 1914-1940 |
| Tonto Ck. above Gun Ck. (USGS Gage 09499000) | 1941-2015 |
| **March 1 snow water equivalent (SWE)** | |
| Ft. Apache snow course site | 1951-2015 |
| Coronado Trail snow course site | 1938-2015 |
| **Monthly precipitation & temperature** | |
| PRISM gridded data, area abv gage | 1914-2015 |

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