



Using recent observations
to consider global warming
impacts on riparian areas

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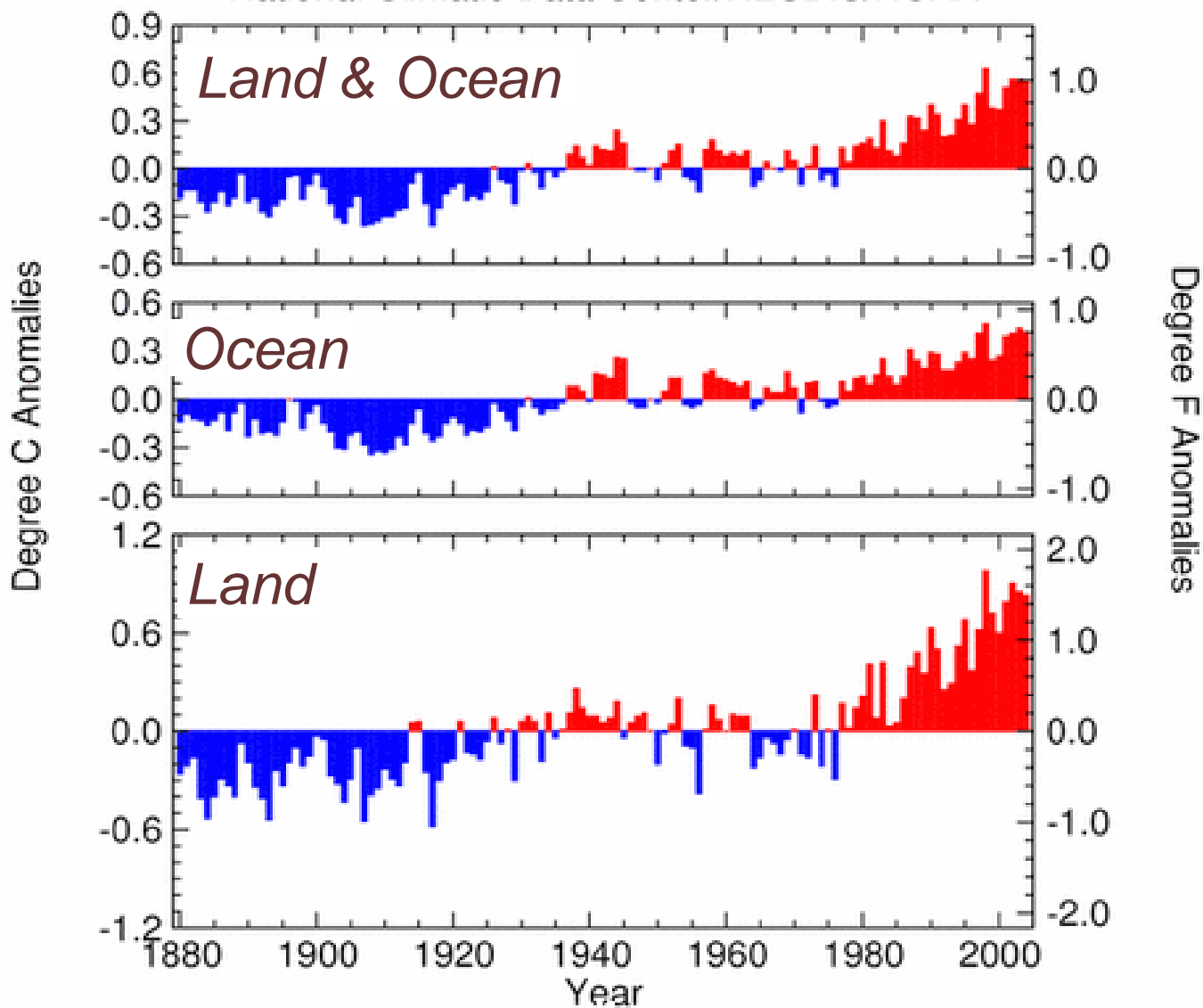
Climate Assessment for the Southwest

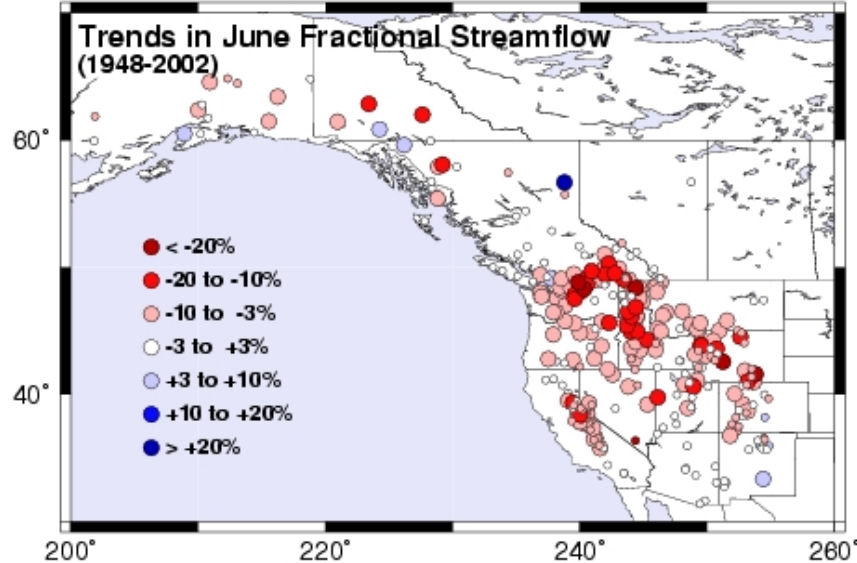
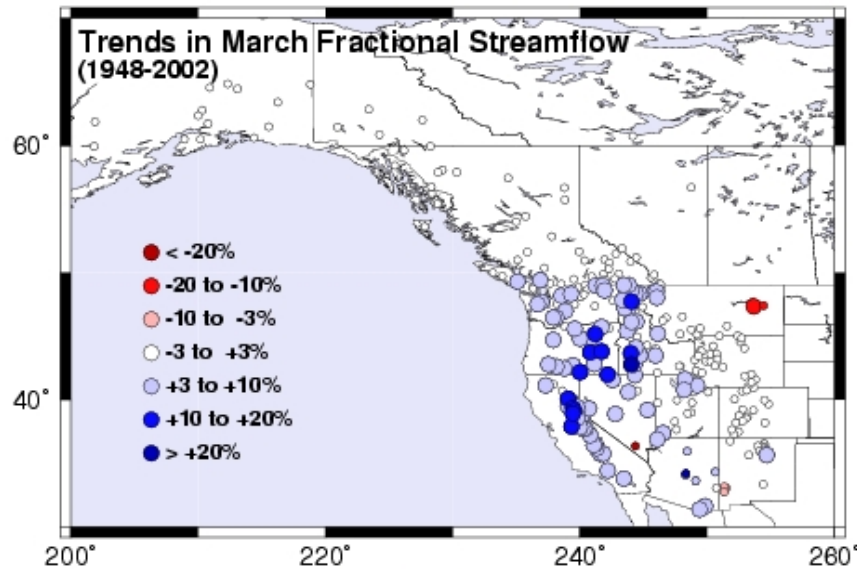
UA Institute for the Study of Planet Earth



Jan - Dec Global Surface Mean Temp Anomalies

National Climatic Data Center/NESDIS/NOAA



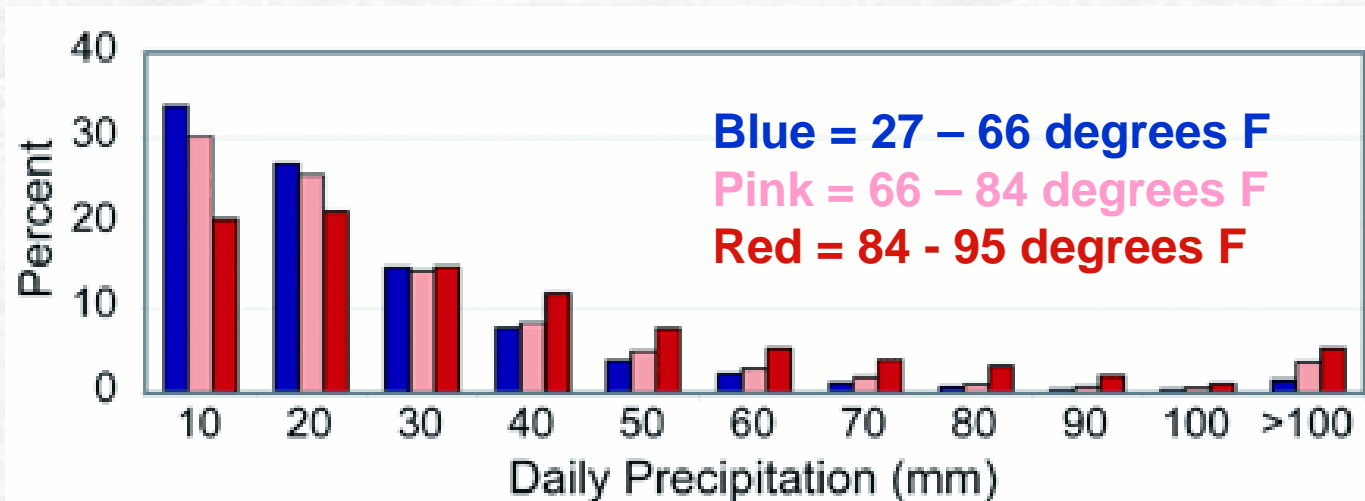


from:
 Stewart, I.T., D.R. Cayan, and M.D. Dettinger (2004)
 Changes toward earlier streamflow timing across western North America
J. Climate, in review

**March
 streamflow
 trends
 (1948-2002)**

**June
 streamflow
 trends
 (1948-2002)**

More extreme rainfall events



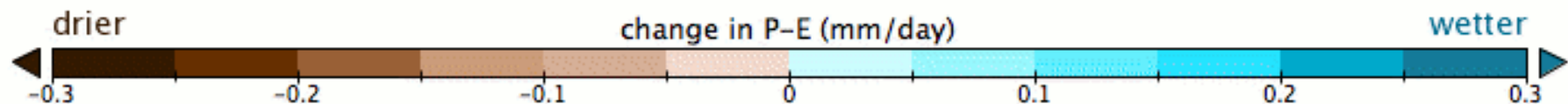
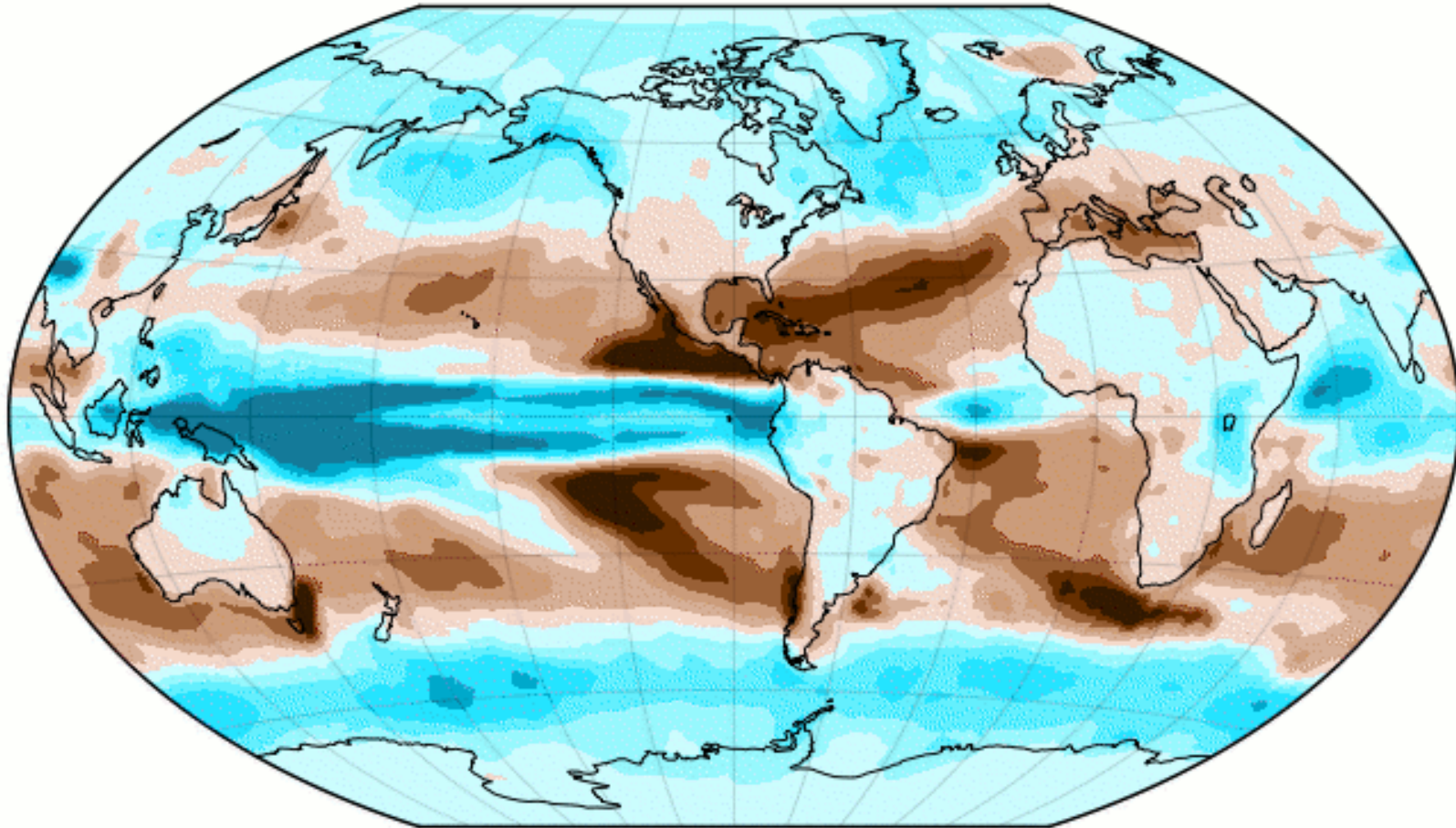
- Precipitation in warmer climates more likely to come in heavy events (> 40 mm, ~1.6 inches)
- Temperature range applies to season

Warming temperatures speed up hydrological cycle

- Evaporation rates rise, which potentially increases length of arid spells
- Warm air holds more moisture, increasing potential for extreme events
- Southwest quadrant of U.S. registering more springtime extreme rains **AND** more drying of soils over past 50 yrs
(Groisman et al. 2004, Journal of Hydrometeorology)

Southwest as future Dust Bowl

Change in P-E (2021-2040 minus 1950-2000)



Winkel Tripel projection centered on -90.0°E

Seager et al. 2007:

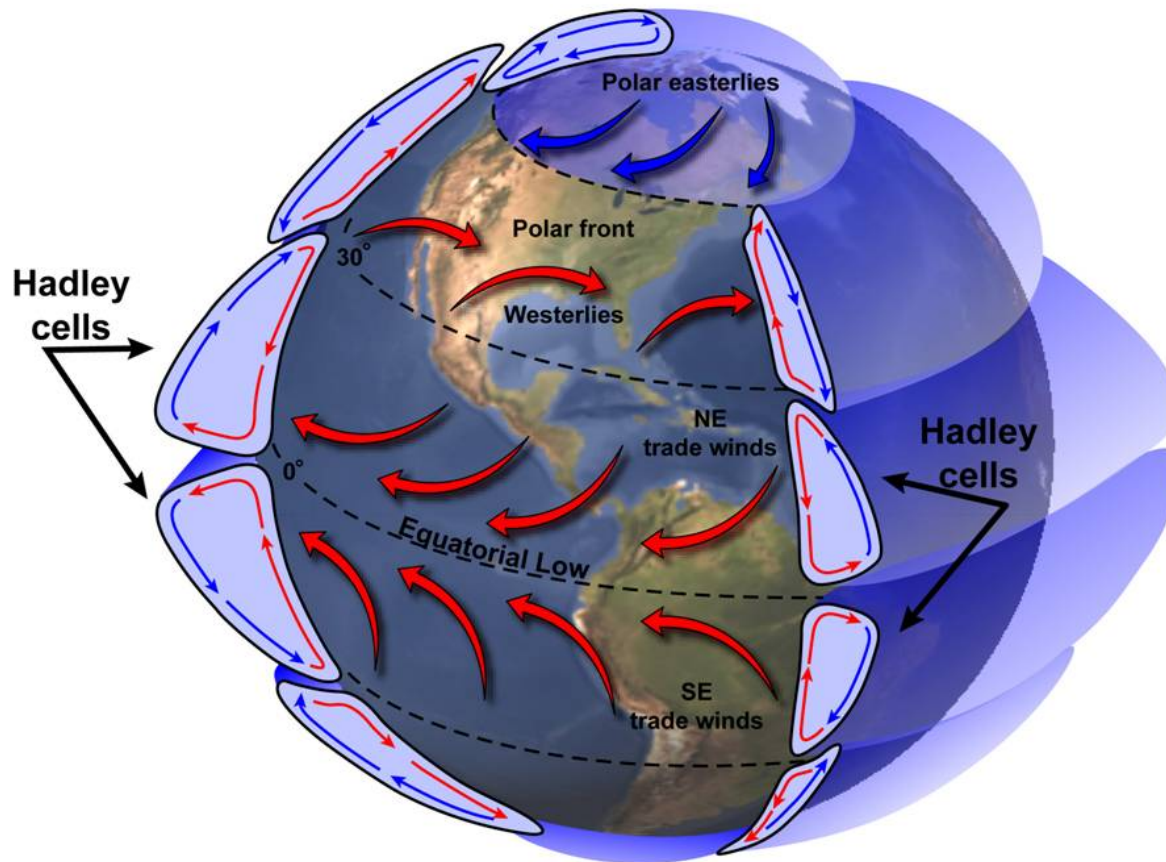
<http://www.ideo.columbia.edu/res/div/ocp/drought/science.shtml>

Precipitation changes often magnified in runoff, streamflow

- Earlier projections by Christensen et. al (2004) suggested a ~4% drop in precipitation could lead to a 16% drop in Colorado River flow (Climatic Change)
- Thomas and Pool (2006) compared measured streamflow of San Pedro to nearby precipitation; a 13% annual drop → a 66% drop in streamflow

(From Trends in Streamflow of the San Pedro River, Southwestern Arizona", by Blakemore E. Thomas. U.S. Geological Survey Fact Sheet 2006-3004)

Hadley Cell circulation & drought



Concern over drought on this account is based on projections rather than observations ...

but it raises important cause for concern

Credit: Barbara Summey, NASA Goddard VisAnalysis Lab

Southwest climate and its drivers vary by season

- Winter, Spring:

 - Will El Niño effects move north?

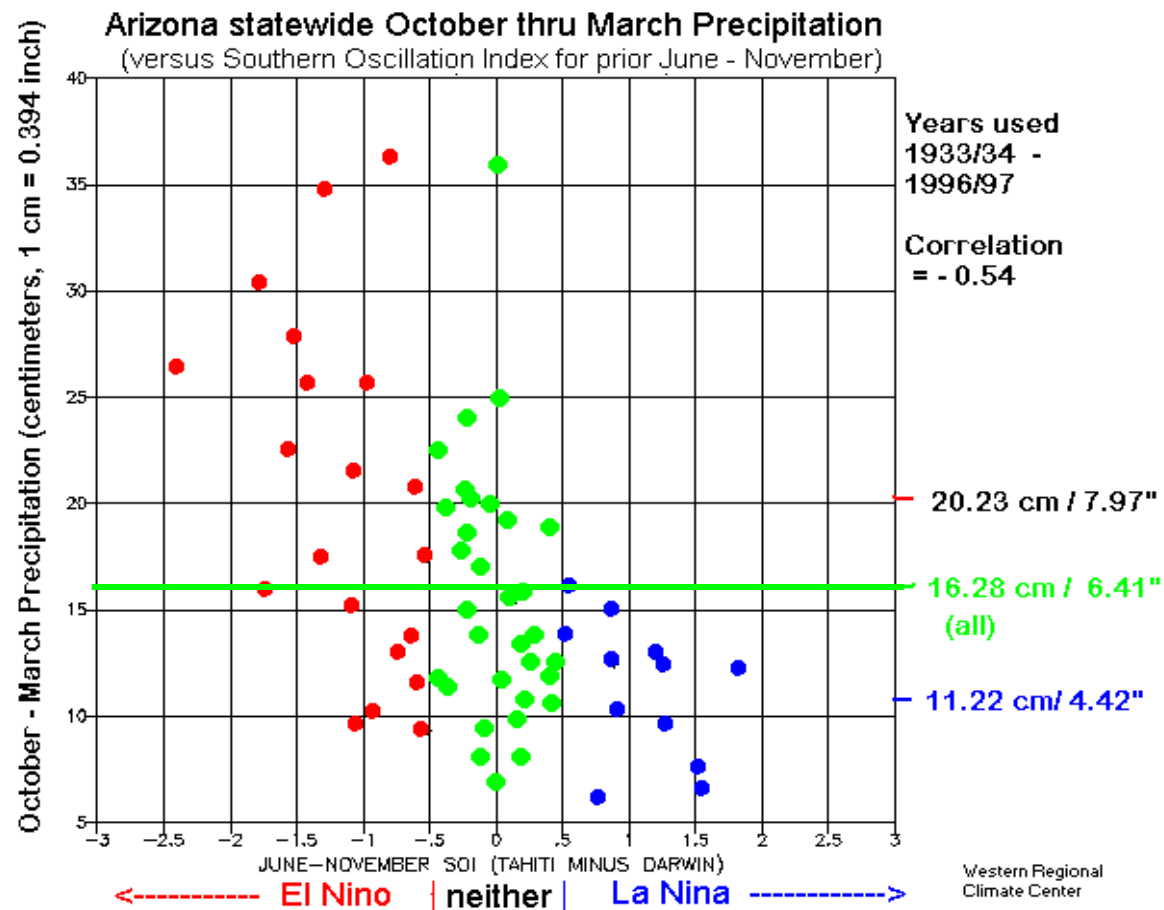
- Summer:

 - Stronger monsoons?

- Fall:

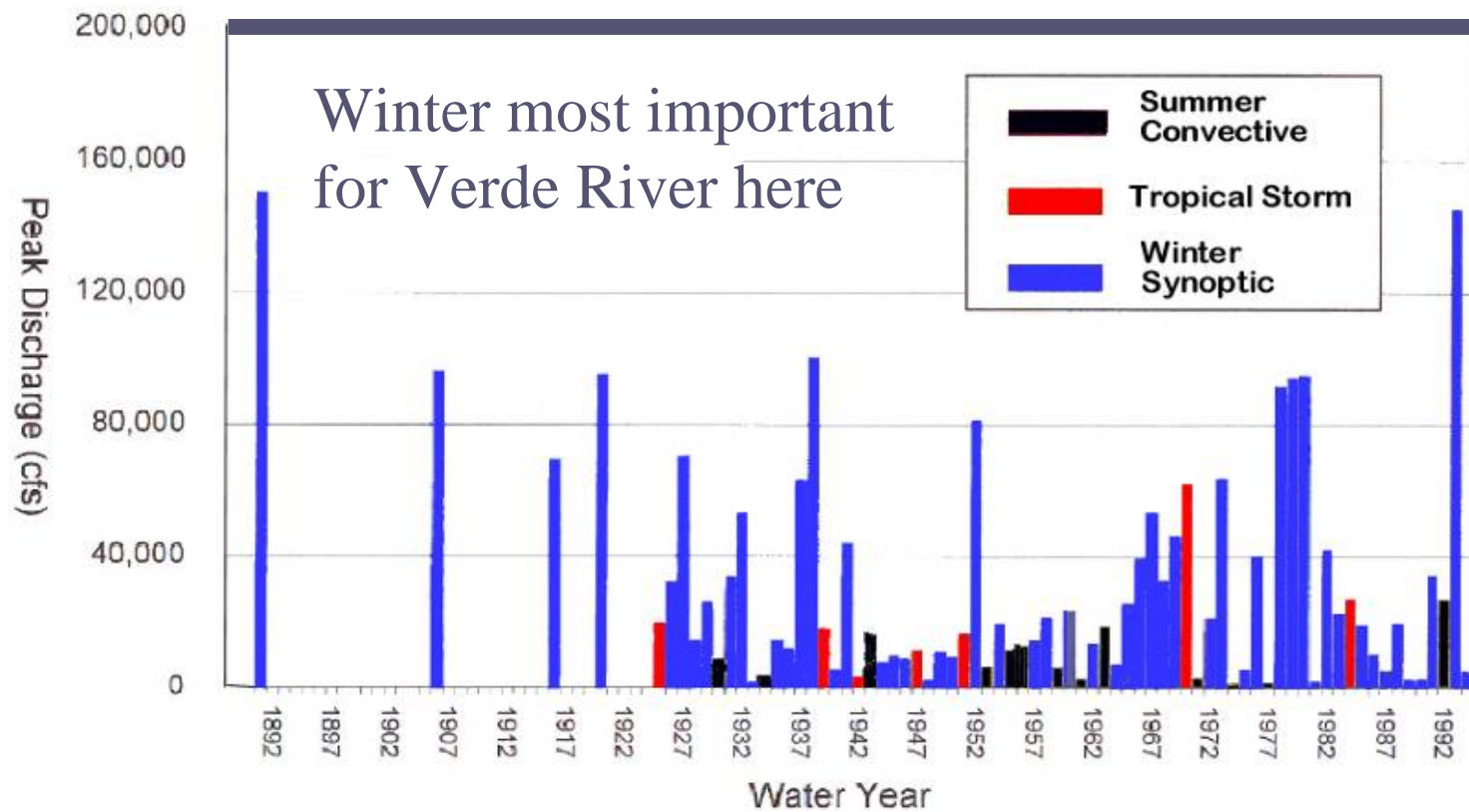
 - Stronger hurricanes/ tropical storms?

El Niño rules cool season rain & snow



Courtesy of the Western Regional Climate Center

*Annual Flood Series for the Verde River Below Tangle Creek
Coded by Hydroclimatological Type*

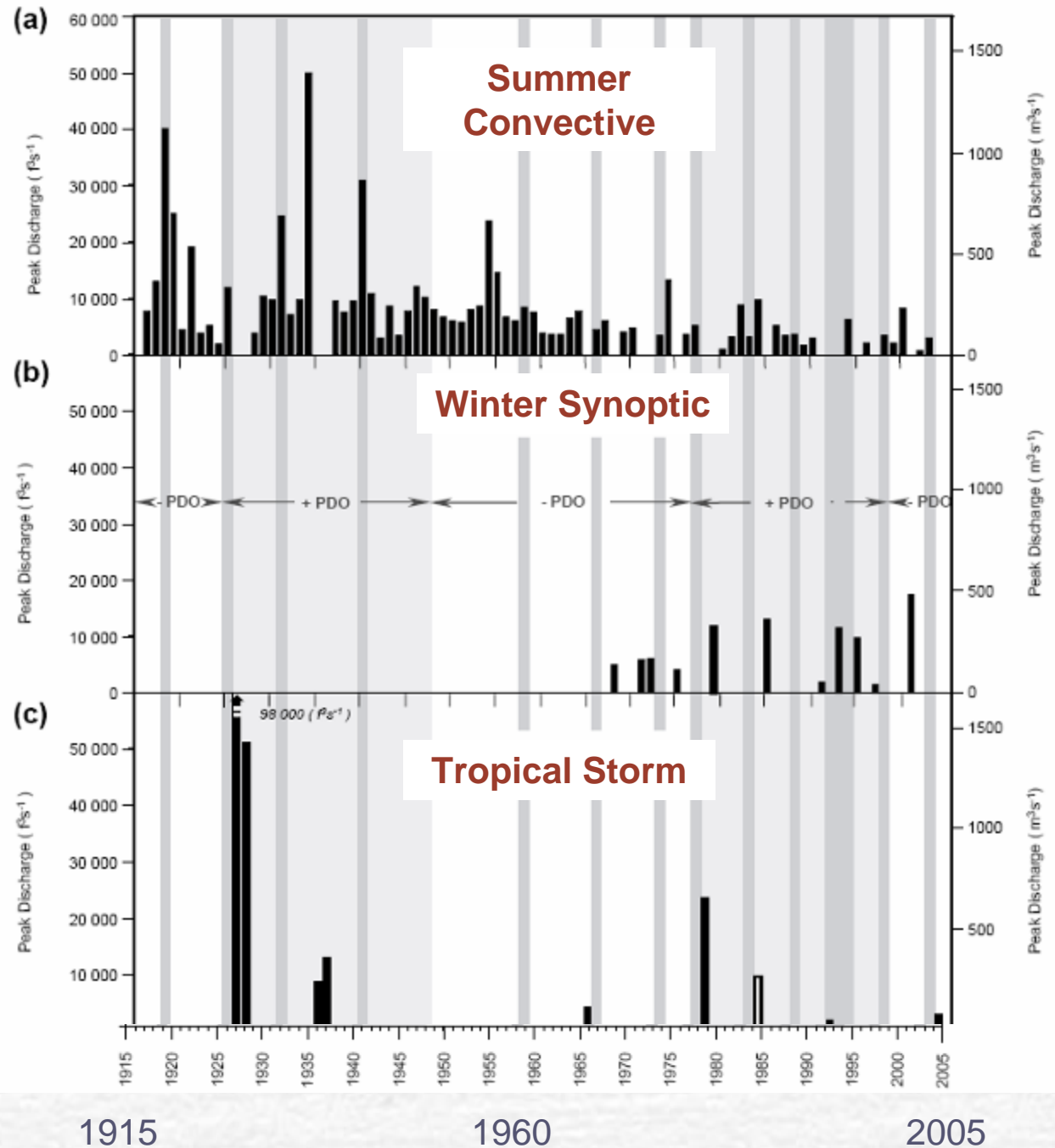


Slide credit: Professor Katherine Hirschboeck, UA LTRR

San Pedro at Charleston

Summer monsoon plays an important role here, as do tropical storms – but changing roles?

Slide credit:
Katherine Hirschboeck,
UA LTRR

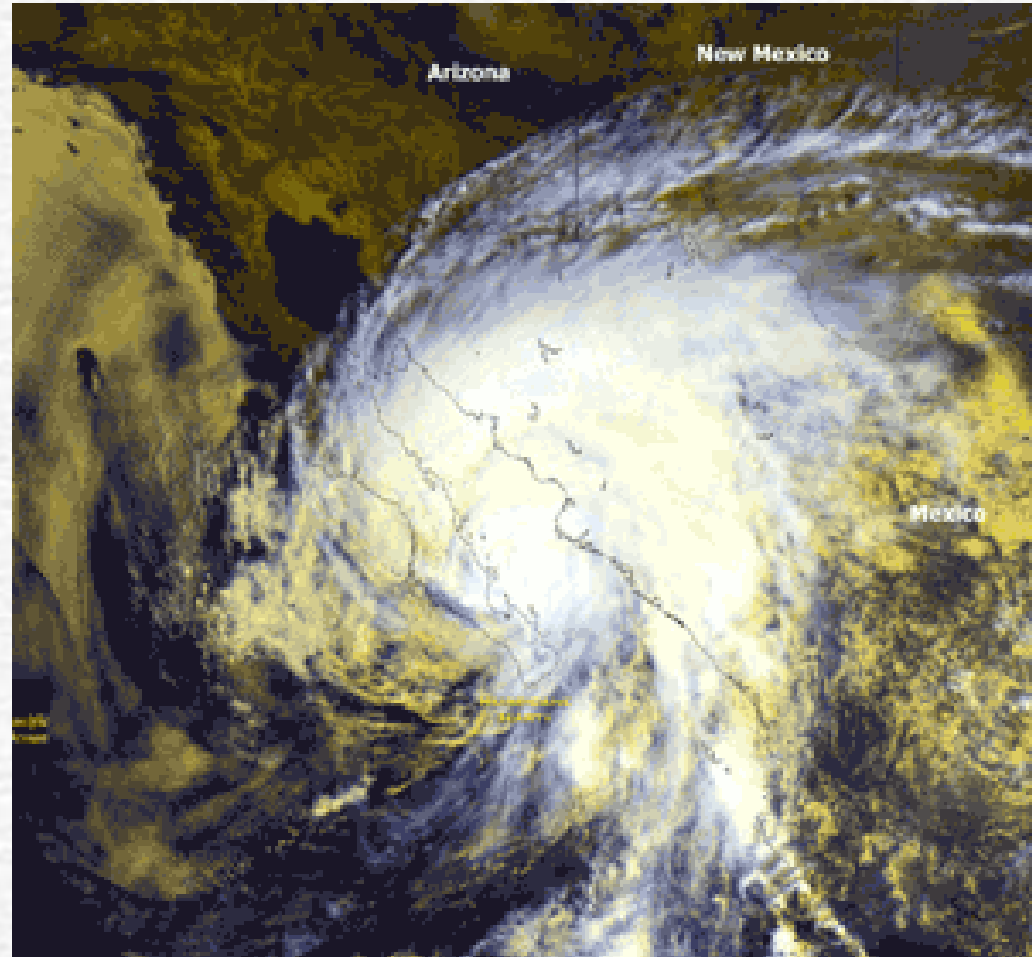


East Pacific hurricanes impact SW

East Pacific hurricanes bring moisture to Southwest.

Hurricane Marty (right) brought rain to Arizona in September of 2003, Javier to SW in 2004, John in 2006

2.2 remnants of named tropical storms reach SW (AZ, NM, CA) each year.
(Elizabeth Ritchie, UA)



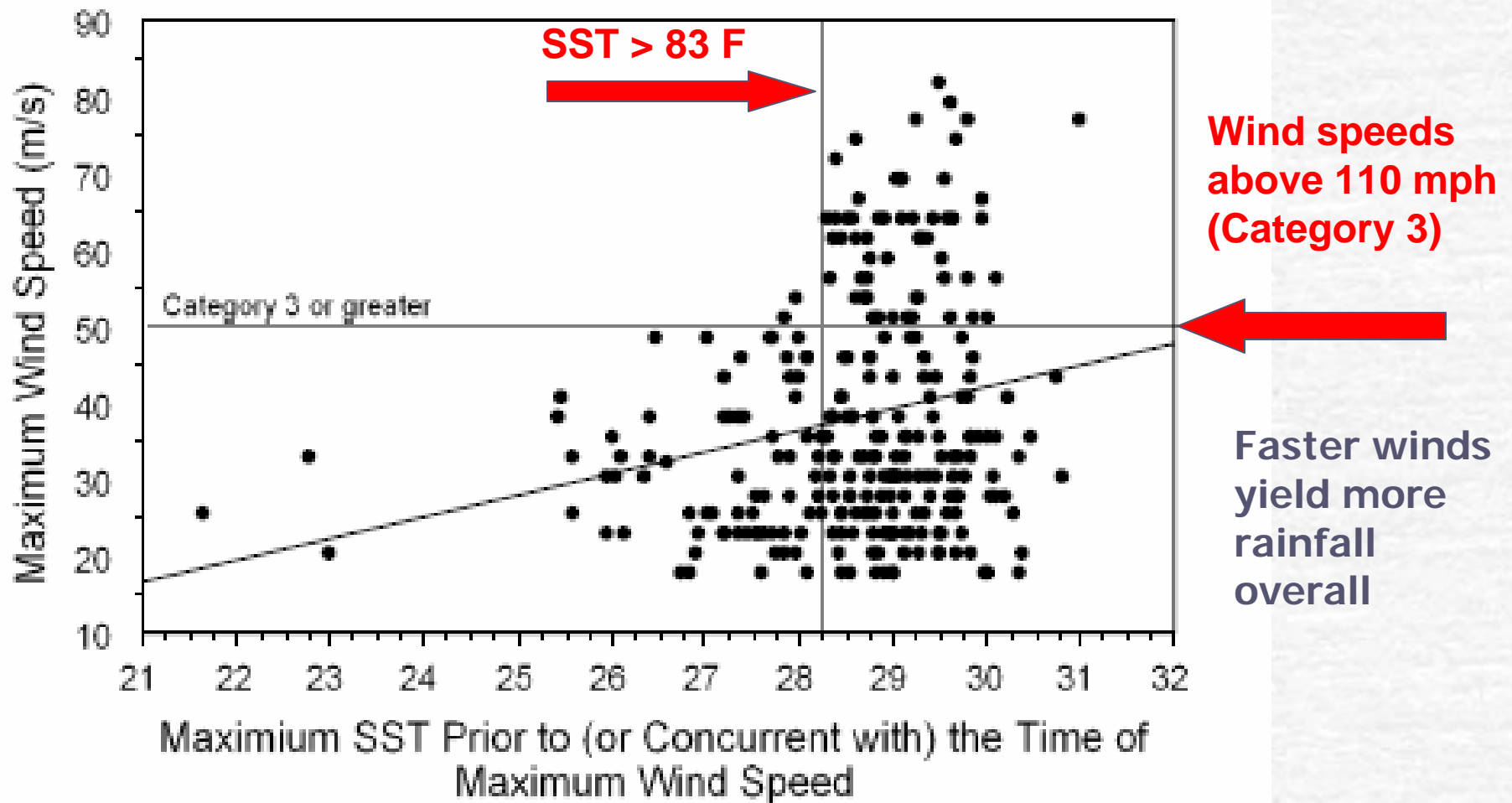
1983 flood in Tucson



1983 flood followed rains from remnant of Hurricane Octave – only one of four remnants of named tropical storms affected the SW in the fall of '83

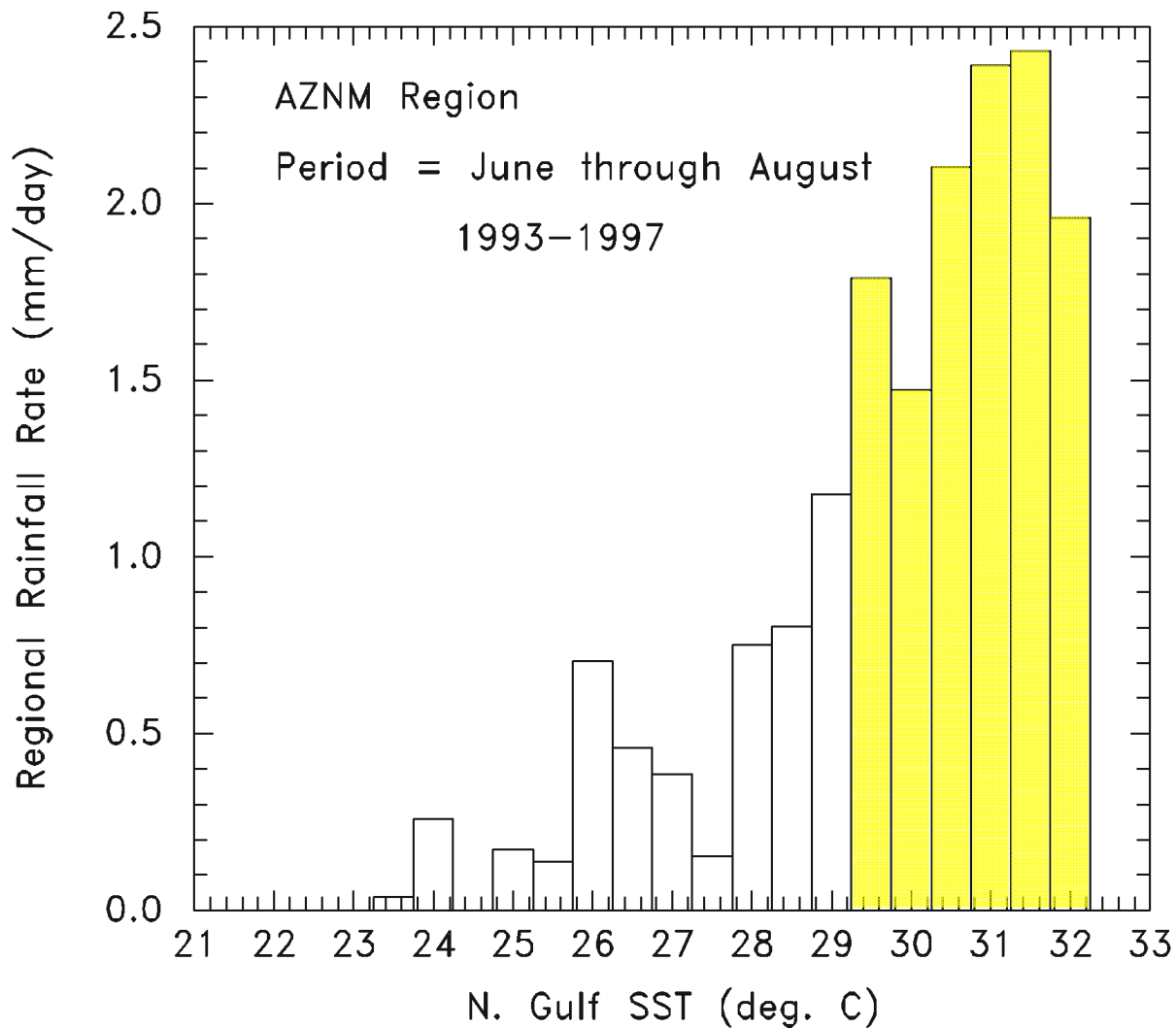
Santa Cruz River at St. Mary's bridge looking south, Oct. 2, 1983
Photo Credit: Peter Kresan

Warming seas affect hurricanes



Michaels, Knappenberger and Davis, 2006 / Geophysical Research Letters

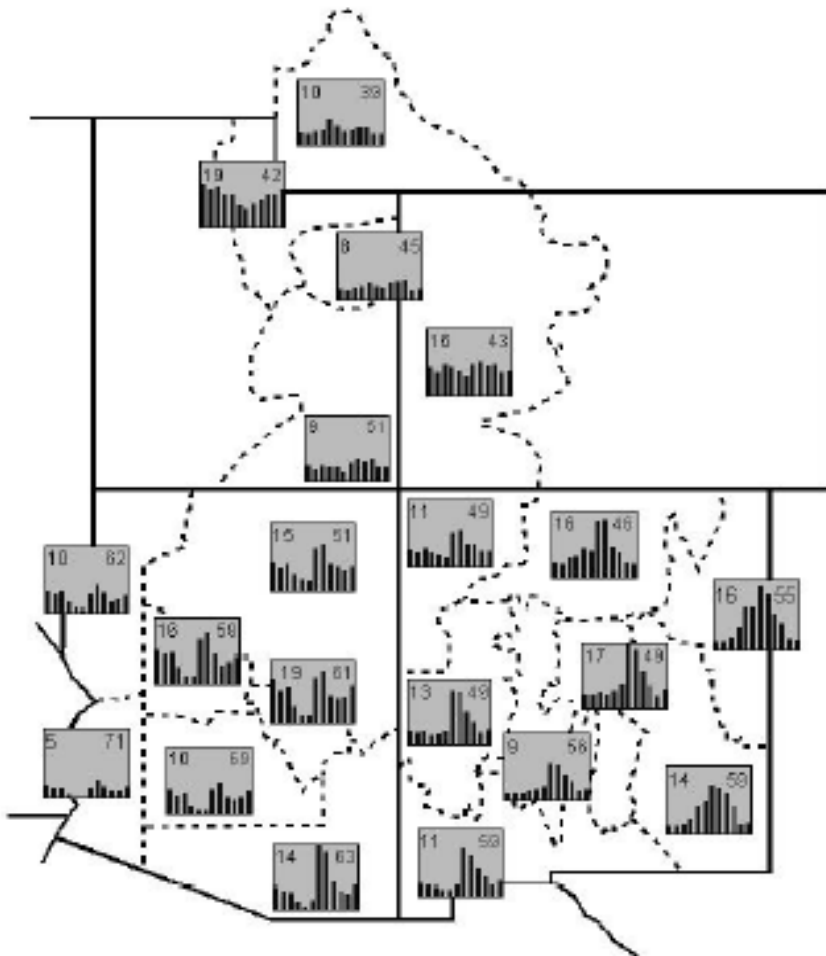
Warm seas also assist monsoon rains



Mean rainfall rates for the AZNM region for N. GC SST intervals of 0.5°C based on five June-August seasons. 29.5 d C = 85 d F

Figure author:
David Mitchell
(*Journal of Climate*,
Sept. 1, 2002)

Heated land helps pull in monsoon

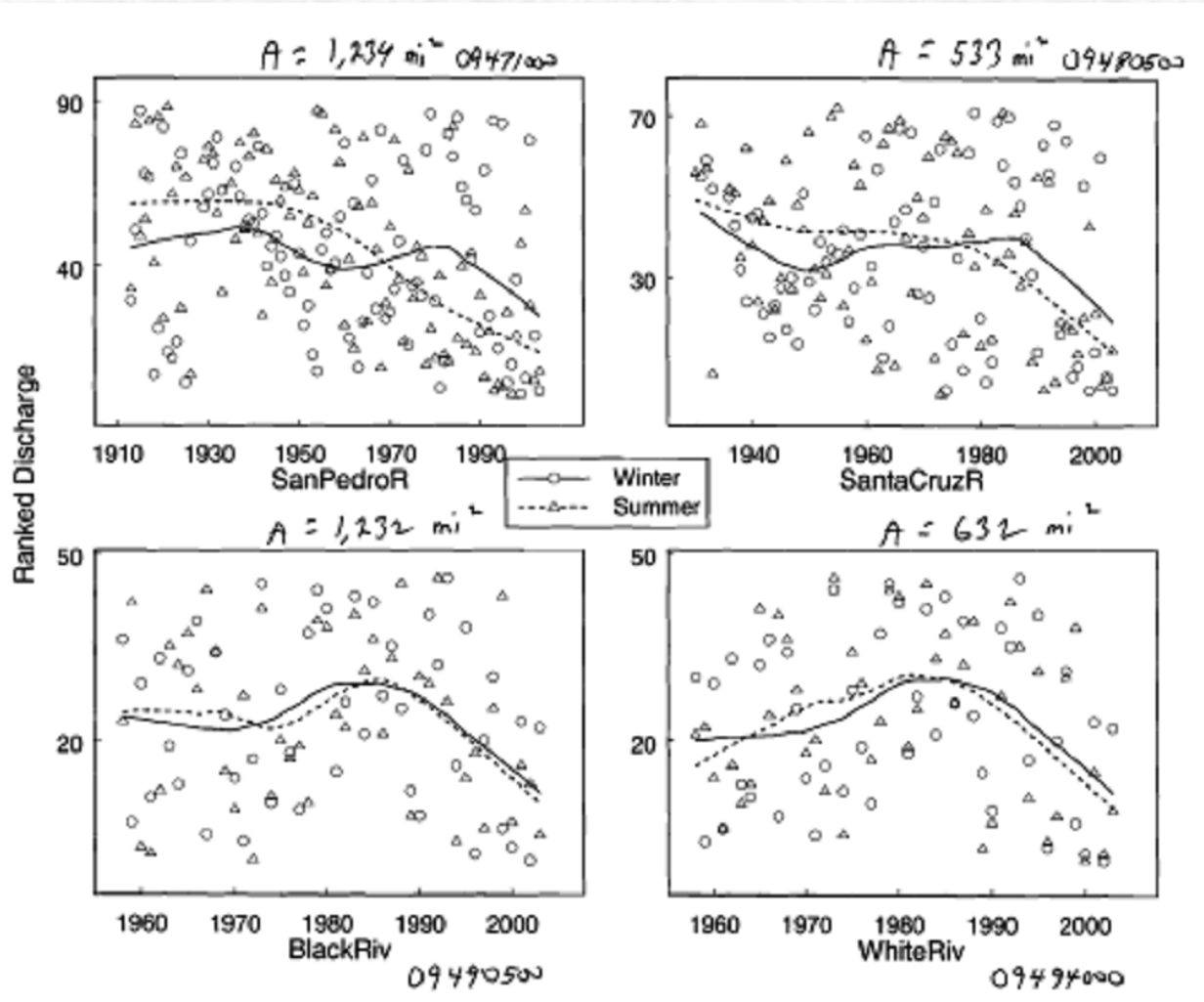


Tucson's Prince Road and Rillito River, 8 a.m. July 31, 2006
Photo: AZ Geological Survey

Seasonal precipitation is variable

- El Niño vs. La Niña fluctuations wield strong year-to-year influence on winter precipitation
- El Niño can have weak positive correlation to East Pacific hurricanes
- El Niño can have weak negative correlation to monsoon activity in Southwest
- Dry winters (western-wide) →
weak potential for stronger monsoon

Winter vs. summer flow



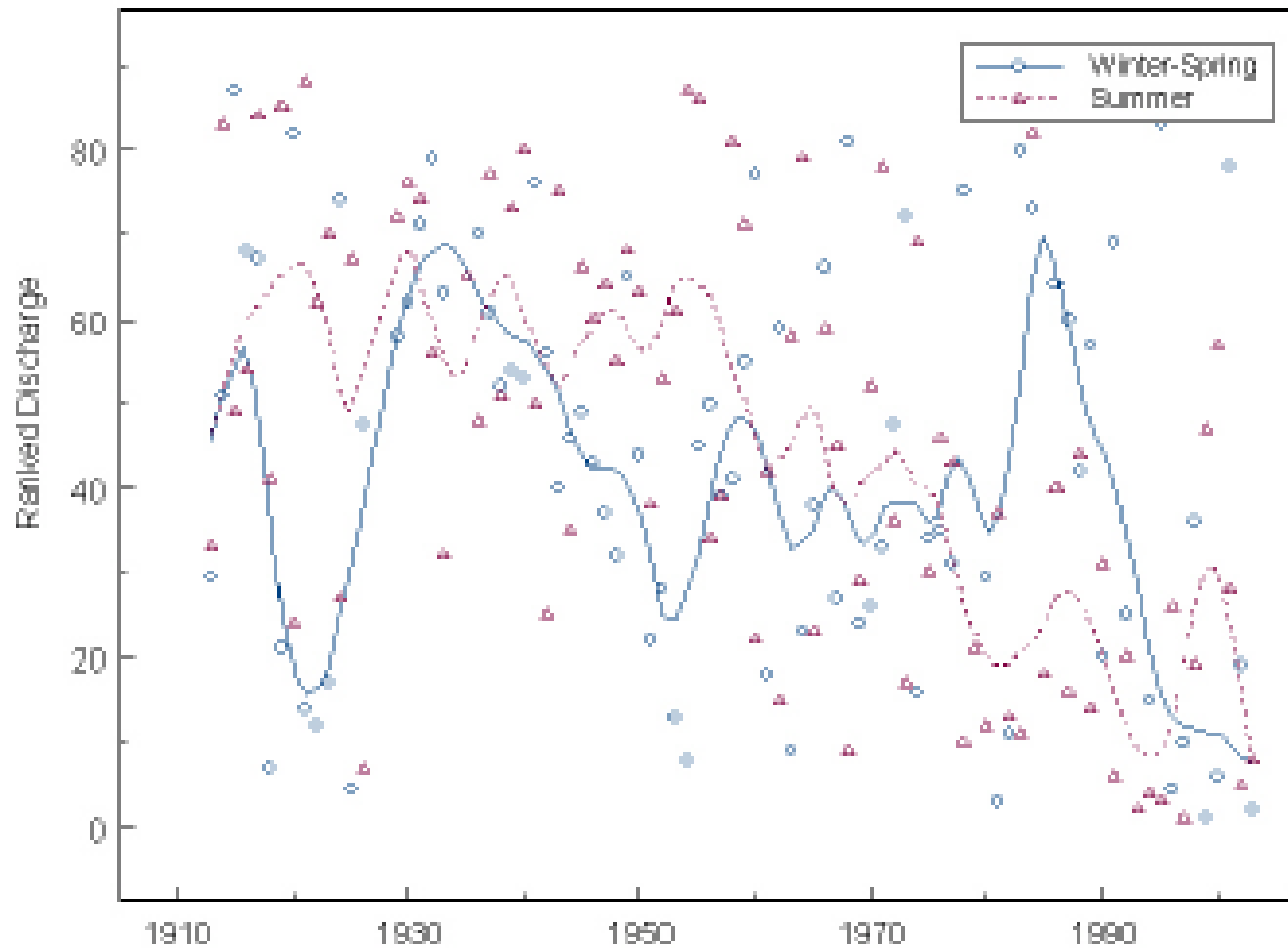
Winter vs. summer
flow in large
watersheds

Most rivers
~synchronous
at this scale

San Pedro shown
top left

Graphic courtesy of Blakemore Thomas (unpublished) USGS Tucson

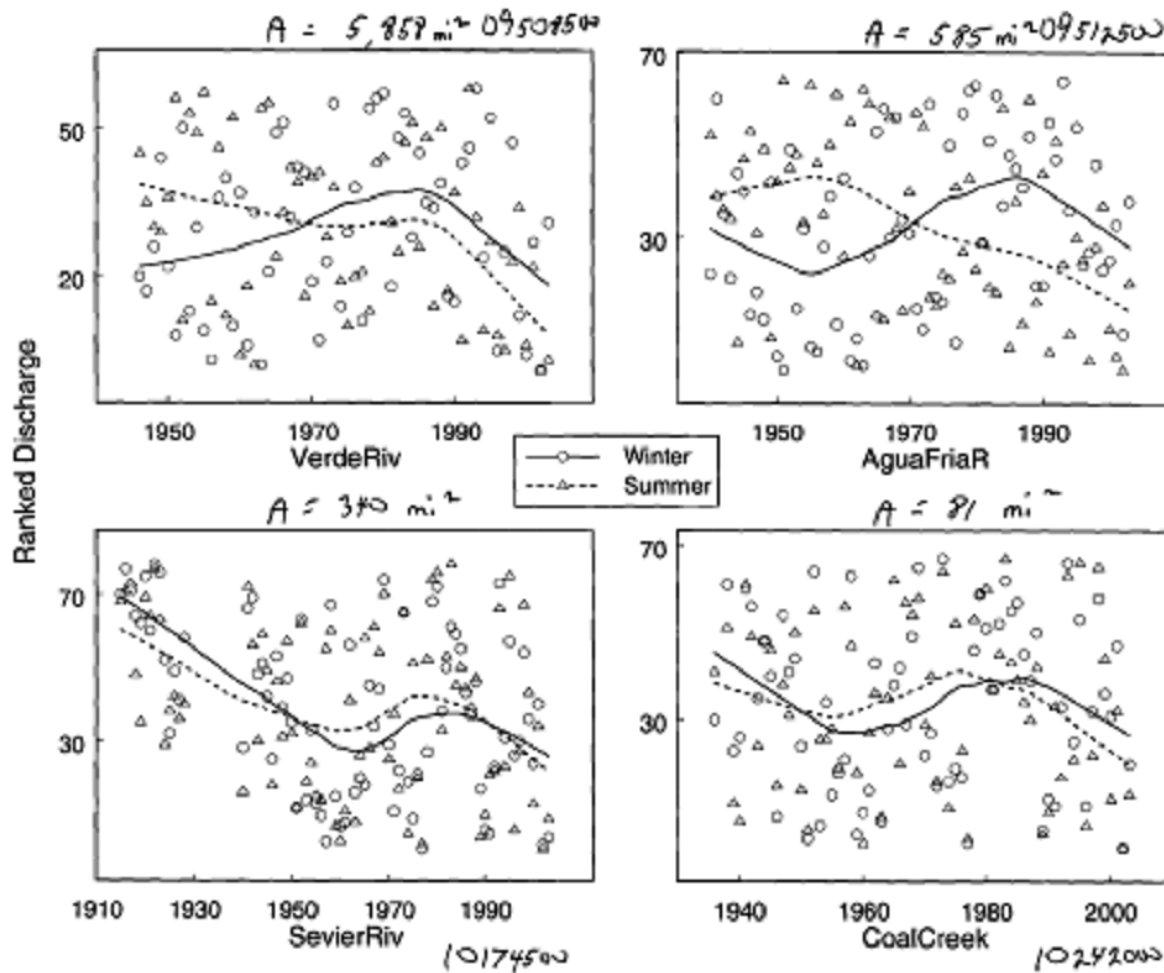
Winter vs. summer flow



San Pedro
Getting closer
to an annual
scale

Graphic courtesy of Blakemore Thomas (unpublished) USGS Tucson

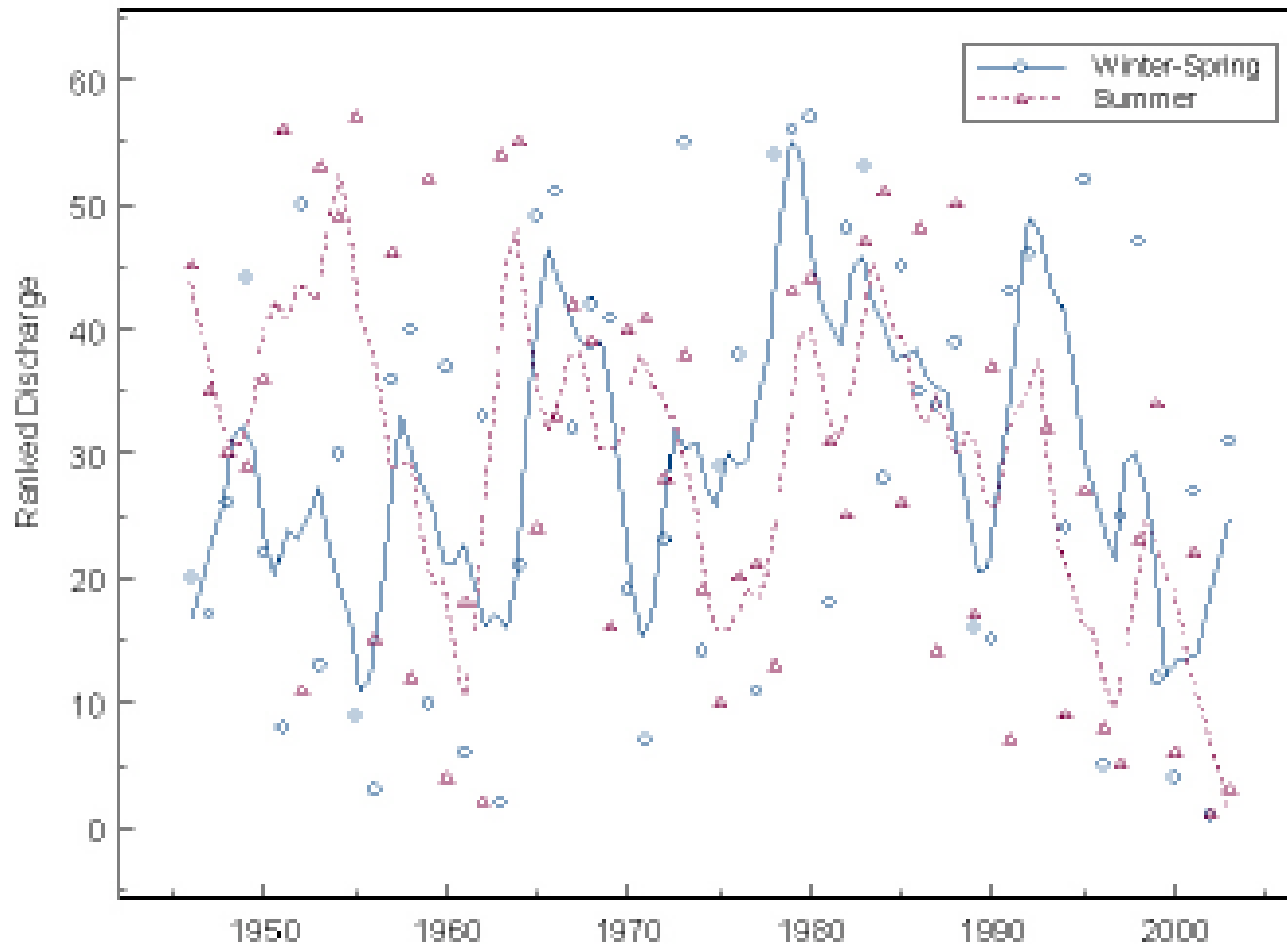
Winter vs. summer flow



Verde shown
top left

Graphic courtesy of Blakemore Thomas (unpublished) USGS Tucson

Winter vs. summer flow



Verde River,
Getting closer
to an annual
scale

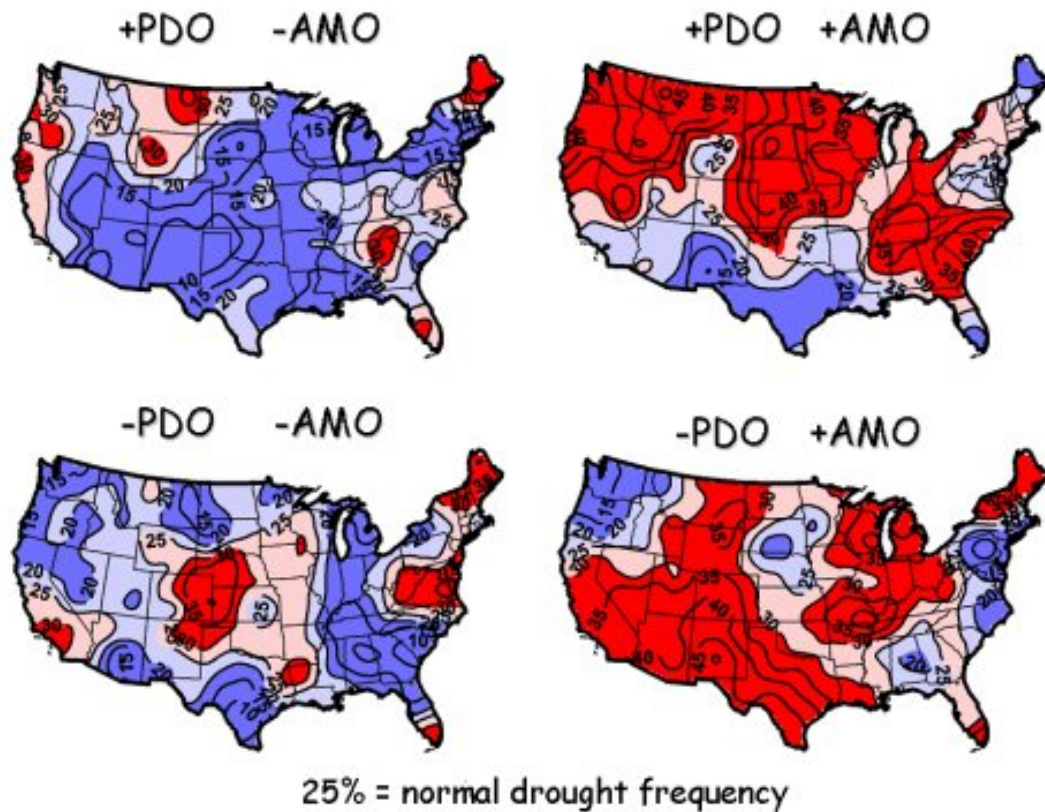
Notice:
Rather
anti-correlated
during 1950s
drought ...
Low winter
flows, high
summer flows

Graphic courtesy of Blakemore Thomas (unpublished) USGS Tucson

Observations vs. Models

- The observational record would suggest the potential for increased variability as the climate warms
- Recent variability as analog?
 - 2004-05 wet winter / 2005 mediocre summer
 - 2005-06 dry winter / 2006 wet summer
 - 2006-07 dry winter (AZ; NM wet)
- Long-term drought could still become the norm even if interspersed with extreme rainfall events

Keep an eye on the AMO



Evidence growing that the Atlantic Multidecadal Oscillation exerts an influence on western climate

Michael Mann & Kerry Emanuel link AMO to northern hemisphere temperature (Eos, 2005)

Thanks for your attention



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