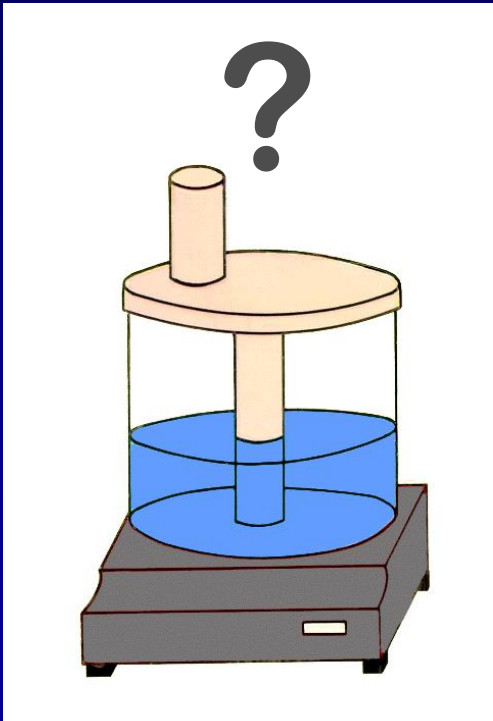


Floods, Climate and “Cuisinart” Hydrology: A Recipe for Disaster?



Dr. Katie Hirschboeck
Laboratory of Tree-Ring Research
&
Chair, Global Change
Graduate Interdisciplinary Program

QUESTIONS, QUESTIONS!

1. WHAT IS A FLOOD?

... and what is a 100-Year Flood?

2. WHY DO WE NEED TO WORRY ABOUT THEM?

... our Arizona rivers are dry most of the time!

3. WHAT CAUSES FLOODS ?

... and what difference does this make?

4. WHAT CAN WE LEARN FROM THE PAST?

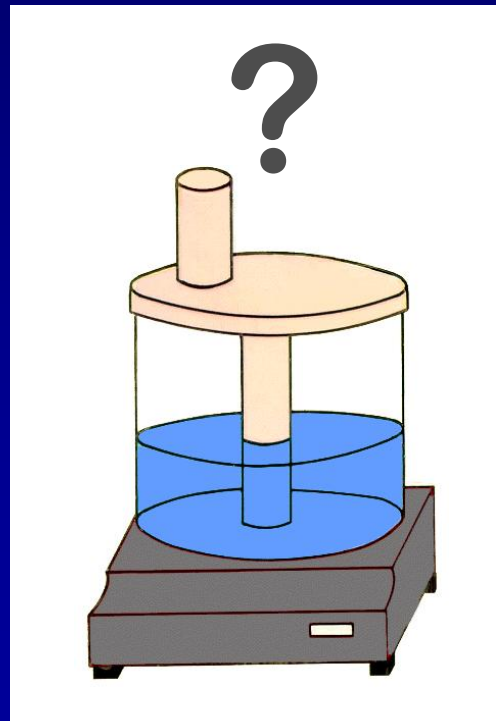
... Are there such things as “Paleofloods”?

5. WHAT WILL THE FUTURE HOLD?

... will climate change make floods more extreme? or will they get smaller?

... and what the heck is

“CUISINART” HYDROLOGY ????



WHAT IS A FLOOD?

Definition: “Any relatively high streamflow that overtops the natural or artificial banks of a river”



What about steep-sided arroyo channels? These banks aren't overtopped!



Flooding on the Santa Cruz River

WHAT IS A FLOOD?

Another: “An overflowing of water onto land that is normally dry”



SOURCE: David Rankin video, posted at
Flood Control District of Maricopa County
<http://www.fcd.maricopa.gov/Education/education.aspx>

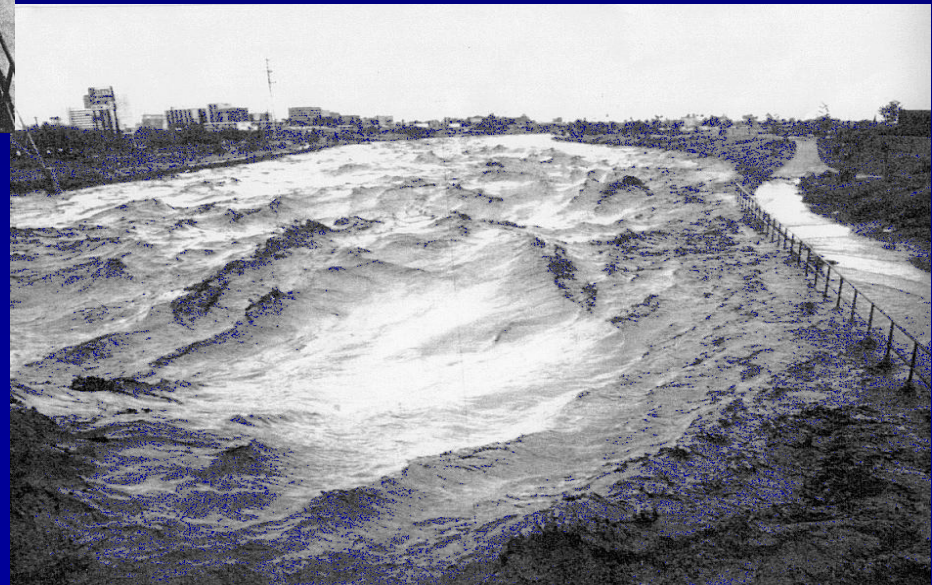
WHAT IS A FLOOD?

Yet another: “The state of a river that is at an abnormally high level”



The typically dry
Santa Cruz River at
very low flow

vs.



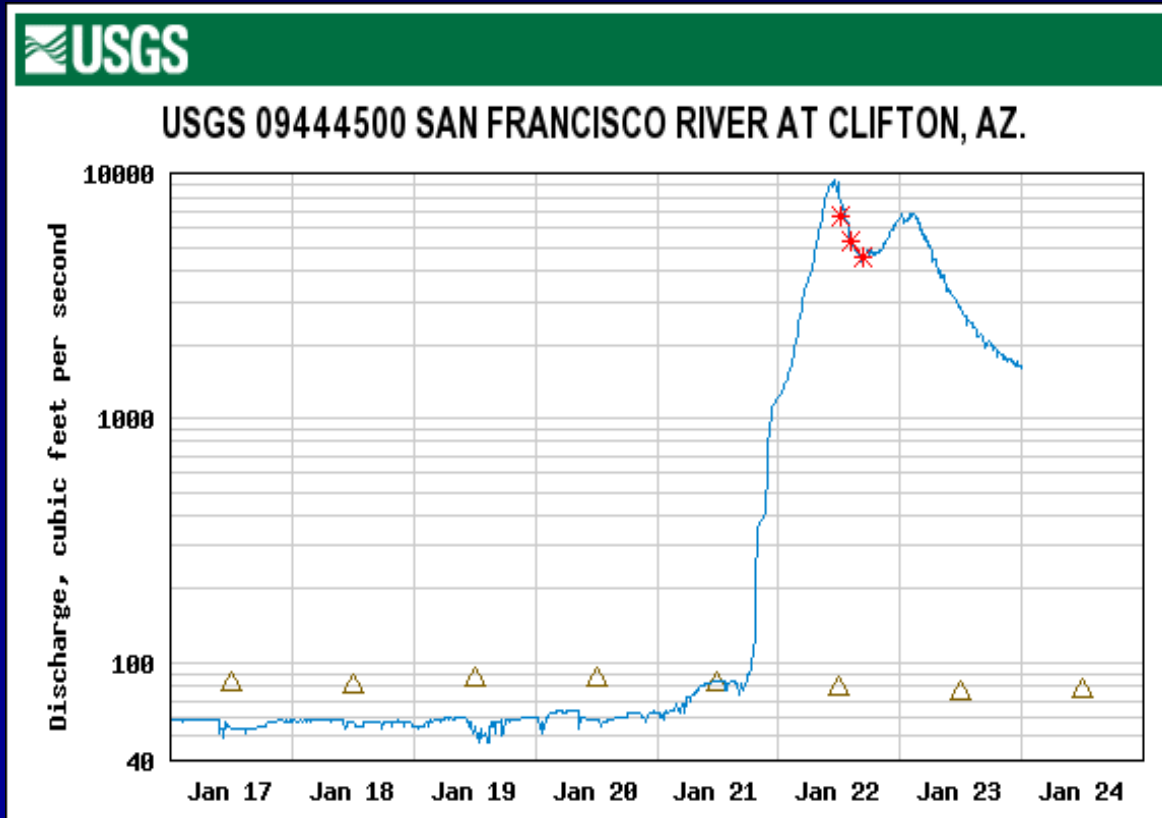
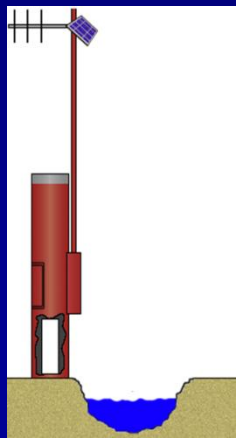
Santa Cruz River at Tucson, Arizona

The record
flood of
October 1983!

A rapid rise in flood level during the January 2010 flooding in Arizona



Automatic gaging station



Taking a discharge measurement during a flood

△ Median daily statistic (84 years) * Measured discharge
— Discharge



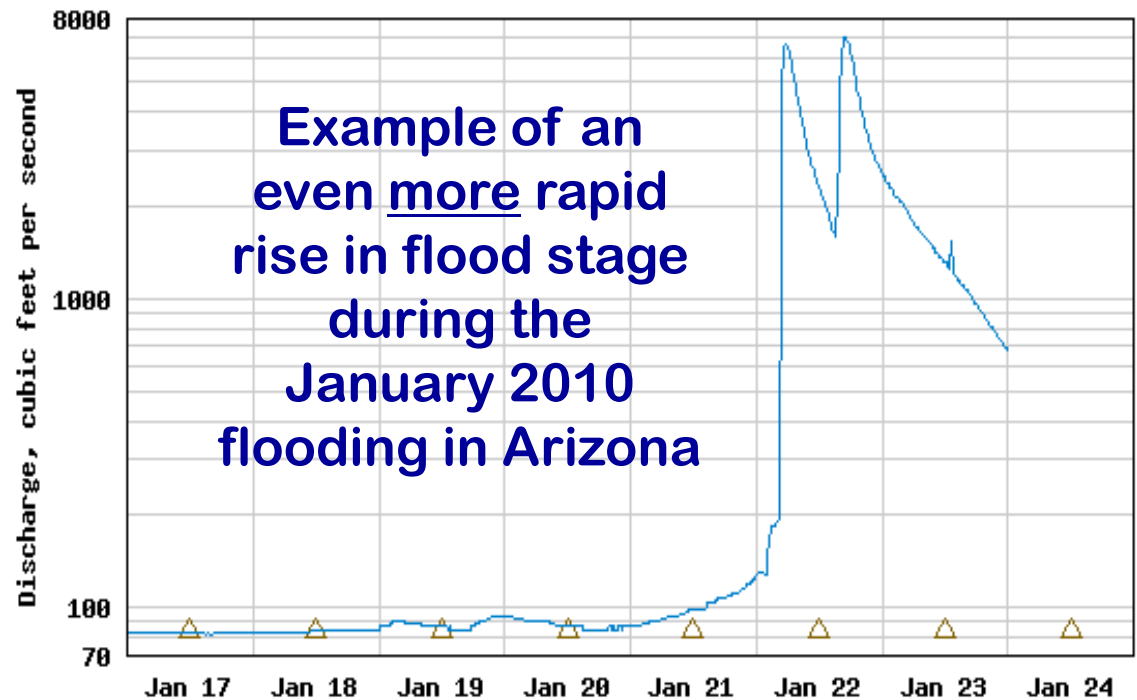
Photos show low flow in Verde River near Clarkdale during July 2009



streamflow gage



USGS 09504000 VERDE RIVER NEAR CLARKDALE, AZ



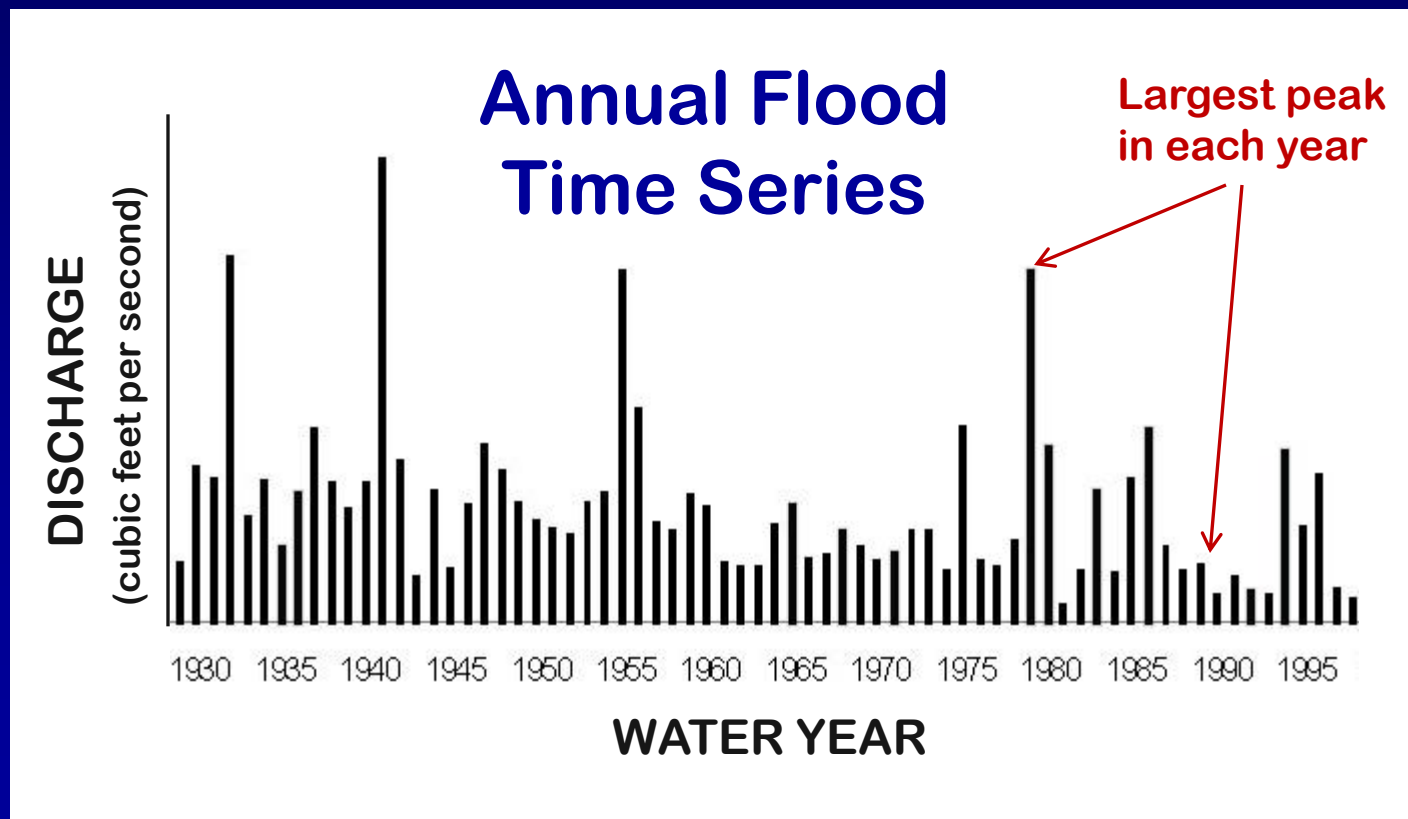
Why do we need to worry about floods in Arizona when our rivers are dry most of the time? . . . **WATCH SOME OF THESE VIDEOS OF DESERT FLOODING**

<http://www.fcd.maricopa.gov/Education/education.aspx>

SOURCE: David Rankin video, posted at
Flood Control District of Maricopa County
<http://www.fcd.maricopa.gov/Education/education.aspx>

More Definitions:

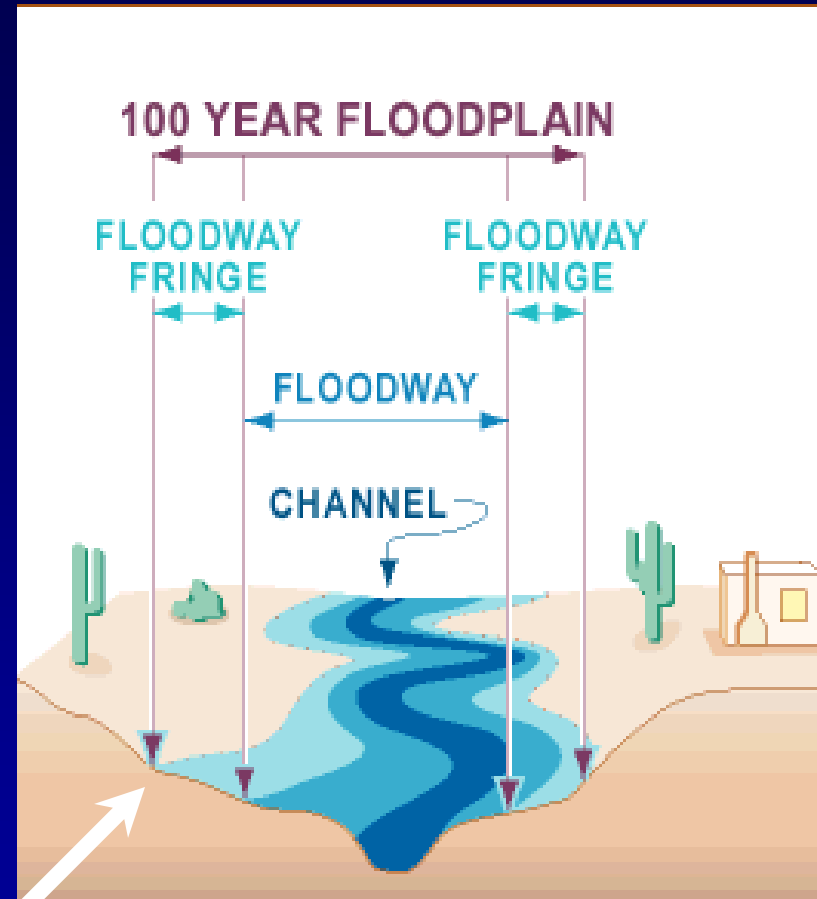
“The **ANNUAL FLOOD** for a given stream is the highest flow recorded at a point on a stream during any particular calendar year or water year.”



SO WHAT IS A 100-YEAR FLOOD?

Def: “The **100-YEAR FLOOD** is a flood event that statistically has a 1 out of 100 (or one percent) chance of being equaled or exceeded on a specific watercourse in any given year.”

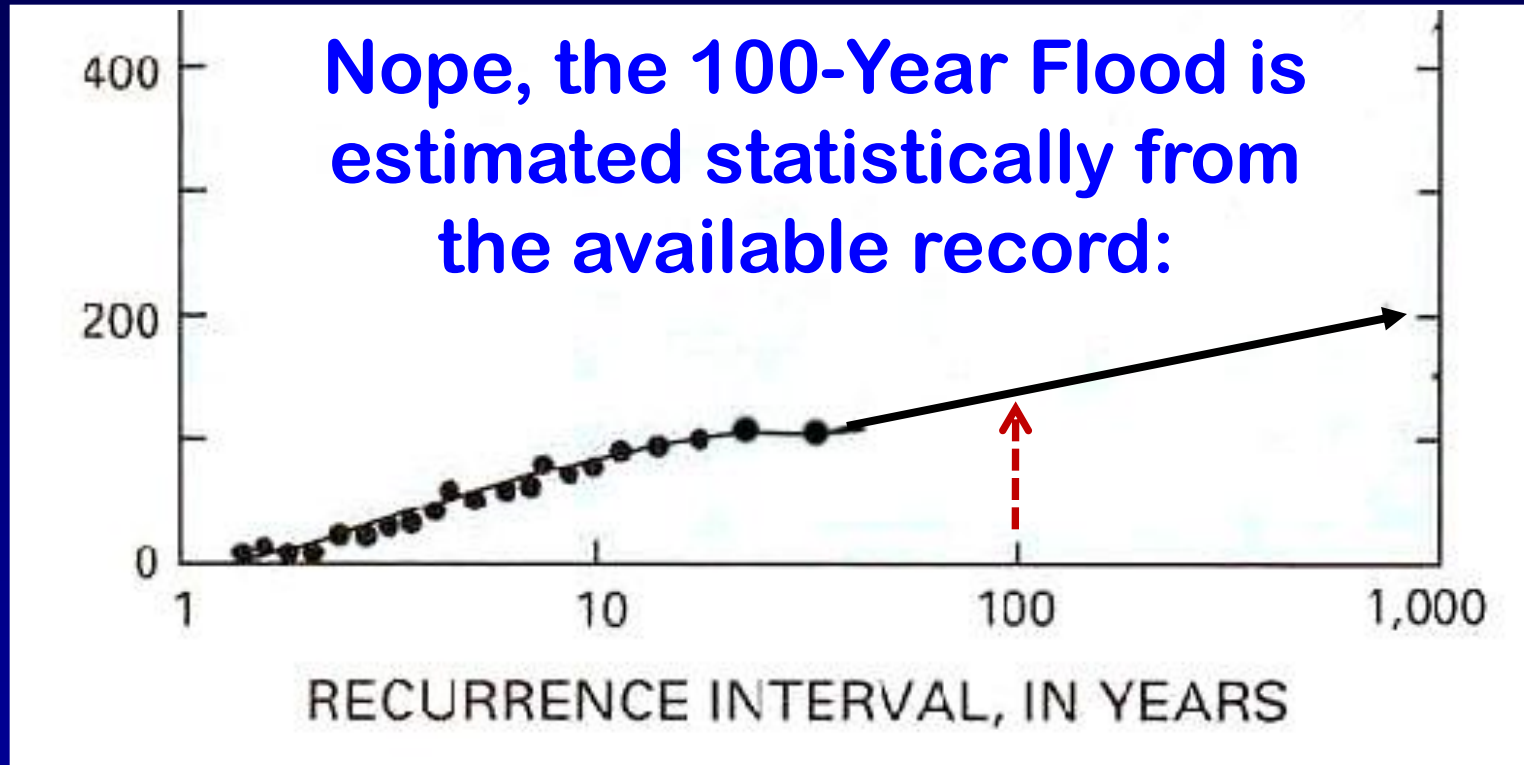
Flood Insurance Rate Maps are based on the 100-Year Floodplain (the area that will be inundated by a 100-Year Flood)



SOURCE: Pima County Regional
Flood Control District
<http://rfcd.pima.gov>

DO WE NEED 100 YEARS OF FLOOD RECORDS TO ESTIMATE IT?

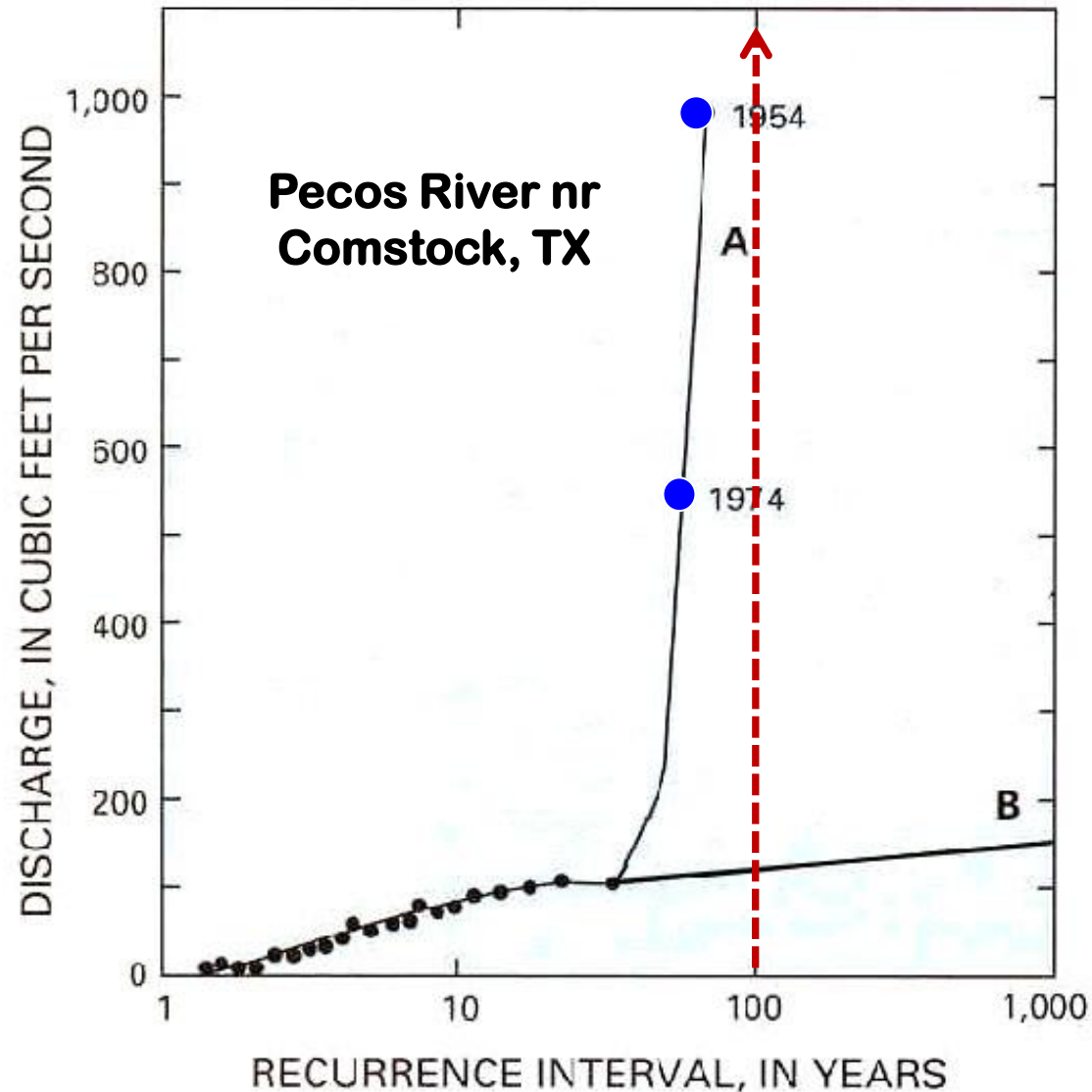
DISCHARGE, IN CUBIC FEET PER SECOND



SOURCE: modified from Jarrett, 1991 after Patton & Baker, 1977

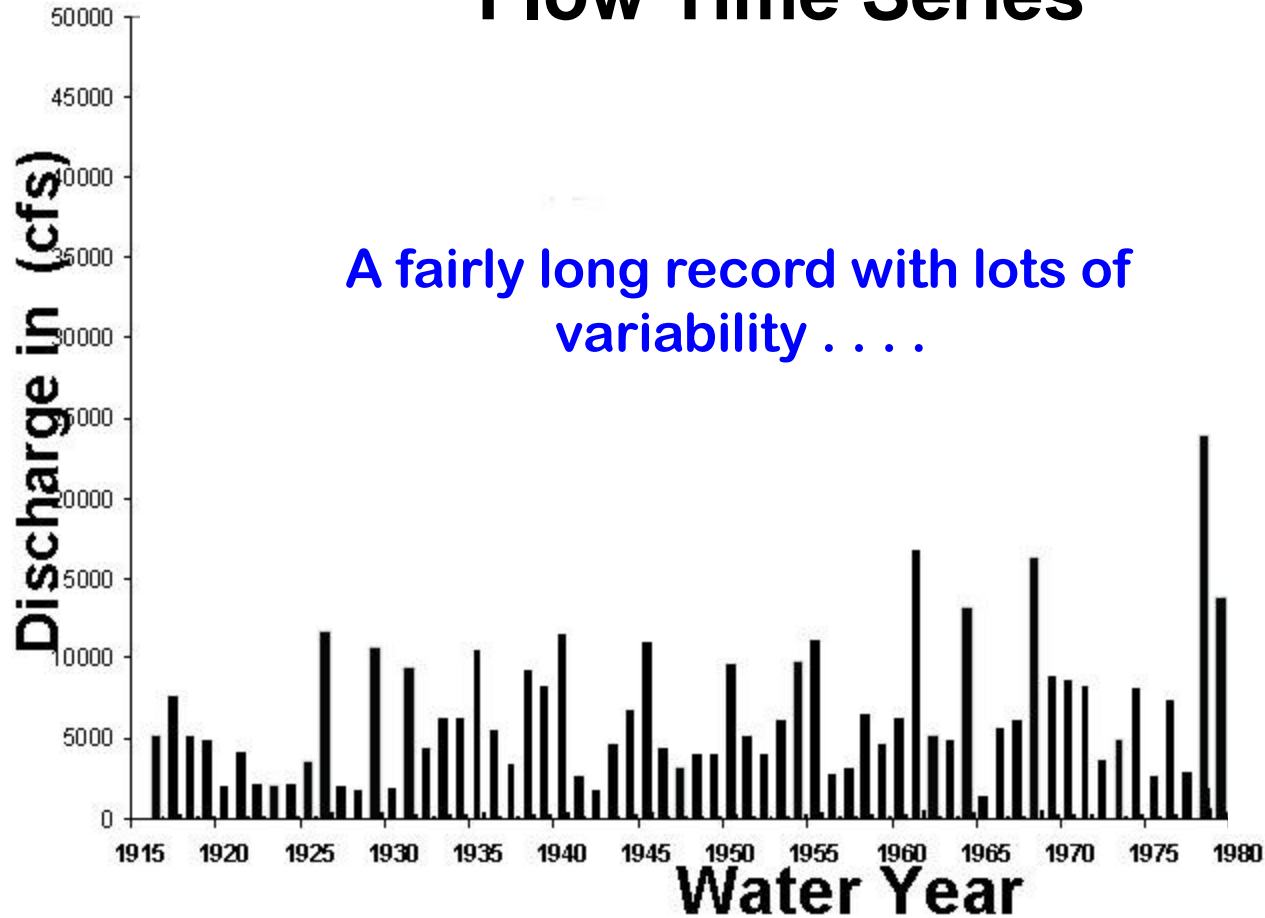
... but
sometimes
there are
problems
due to
“outliers”

Is this a
recipe
for
disaster?



SOURCE: modified from Jarrett,
1991, after Patton & Baker, 1977

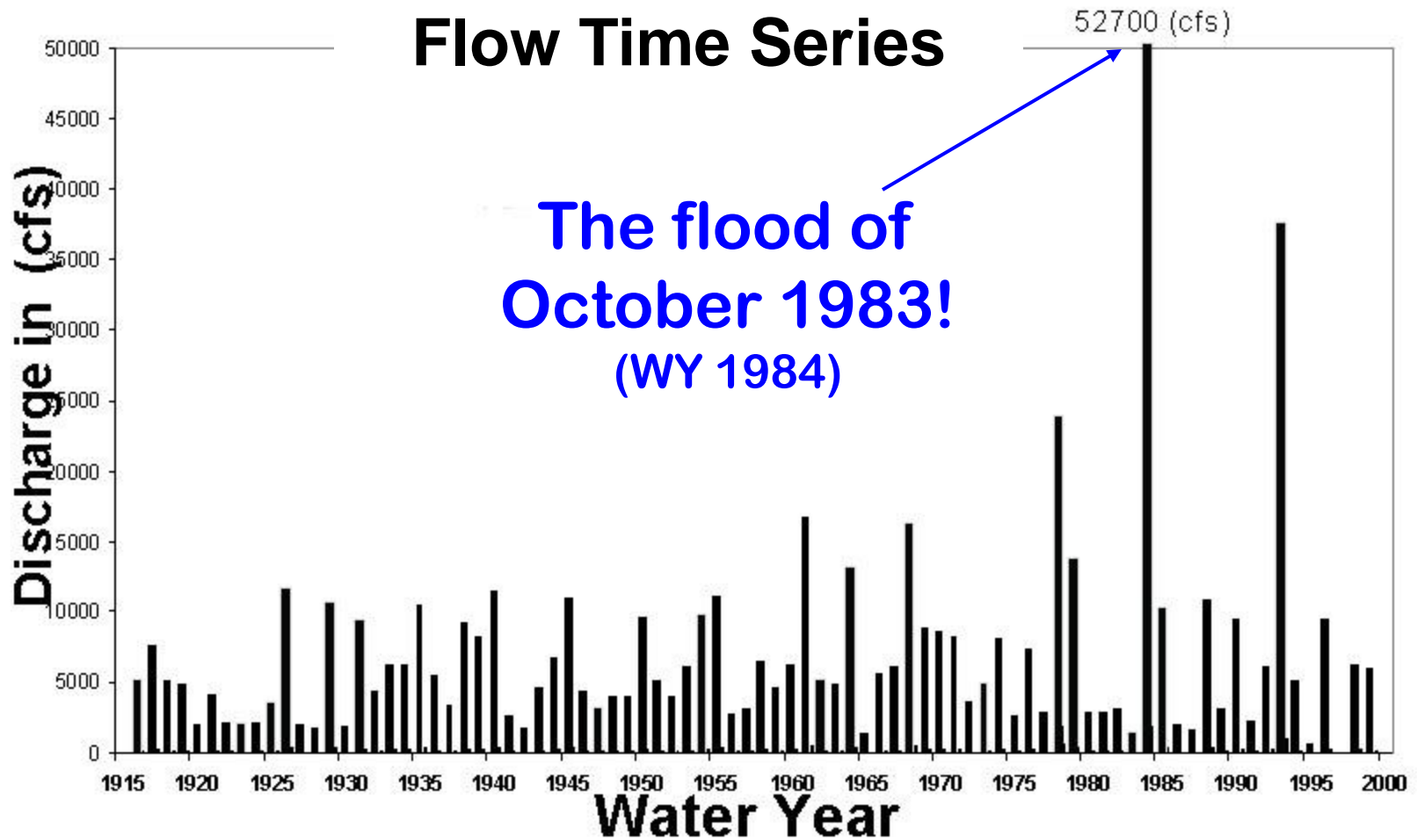
Santa Cruz at Tucson Annual Peak Flow Time Series



A fairly long record with lots of variability

The gage was shut down in 1980

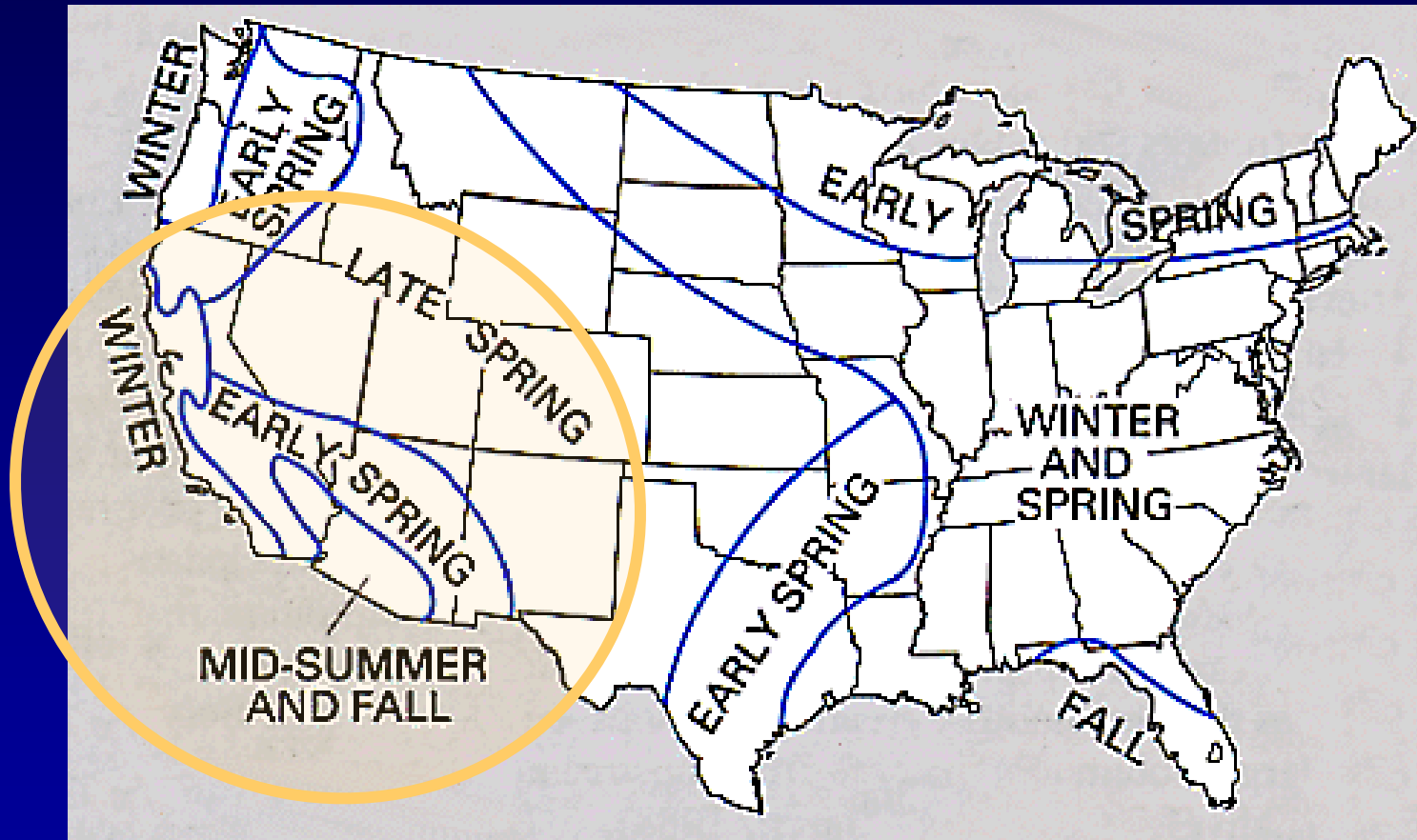
Santa Cruz at Tucson Annual Peak Flow Time Series



The flood of
October 1983!
(WY 1984)

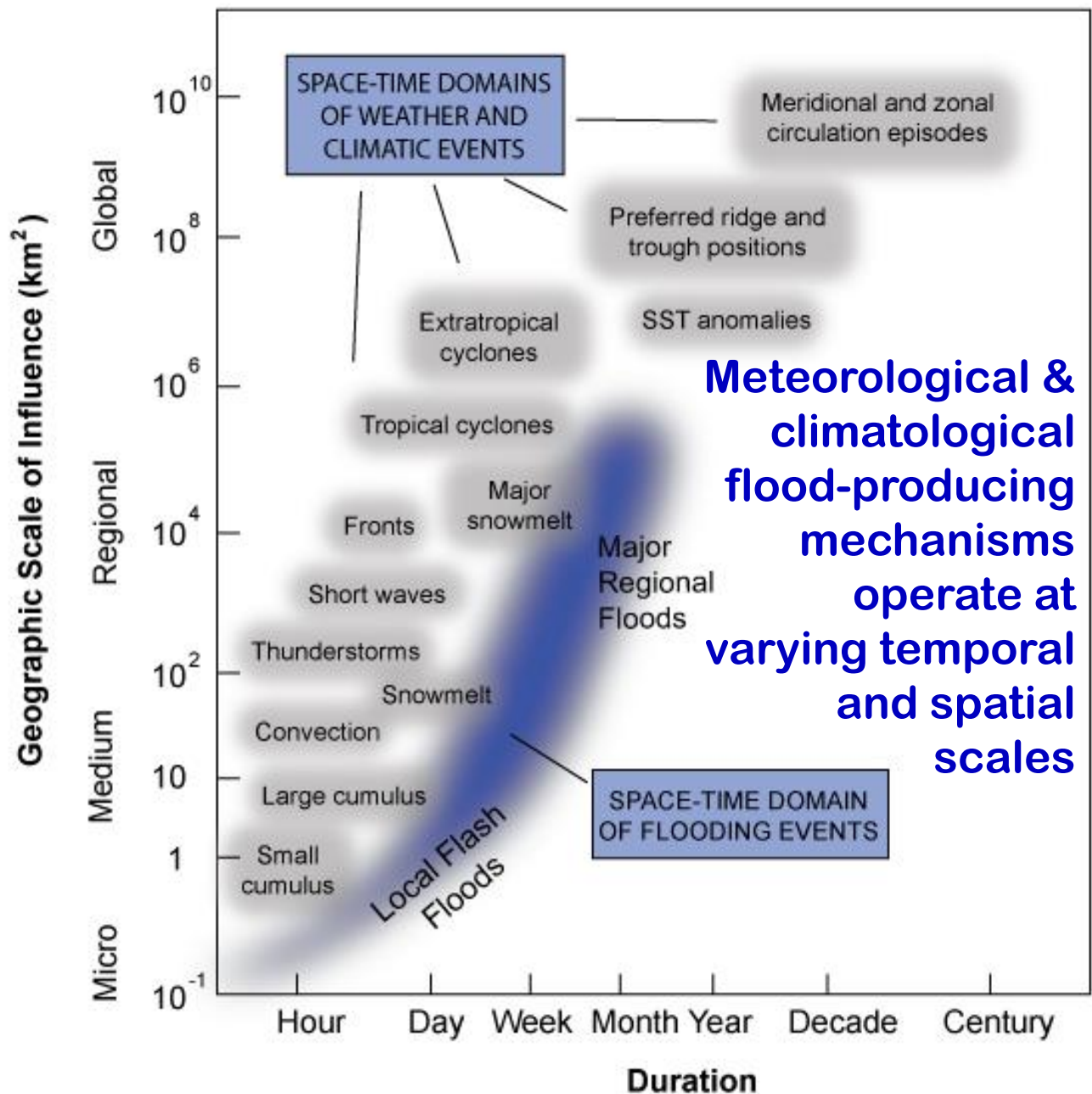
WHAT CAUSES FLOODS ?

... and what difference does this make?

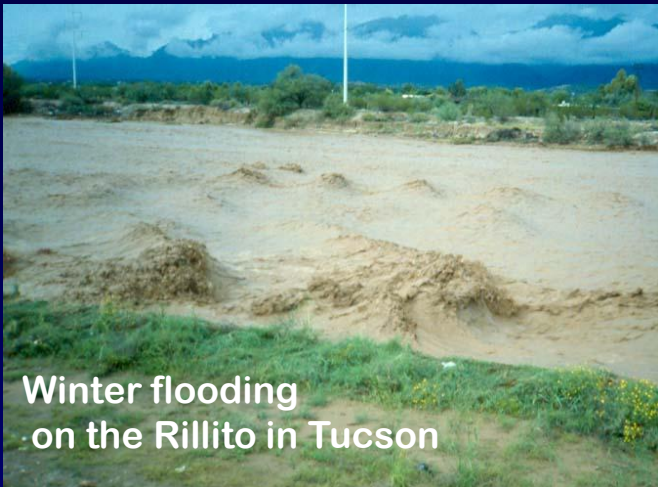


Seasonality of Peak Flooding

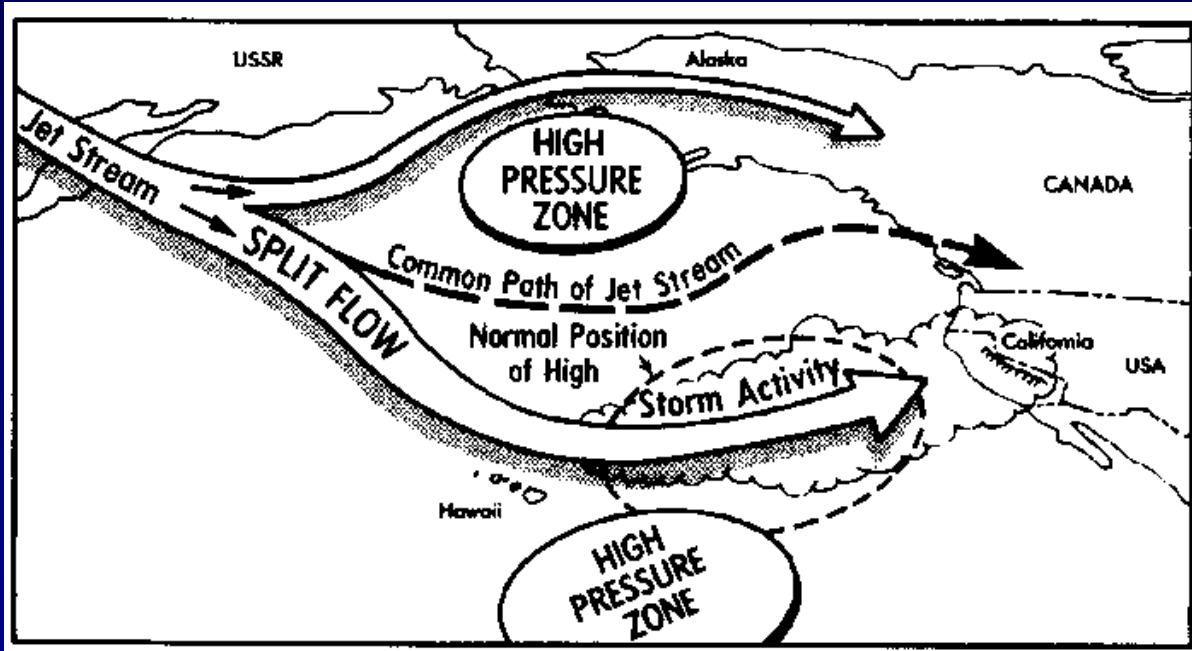
FLOOD-CAUSING MECHANISMS



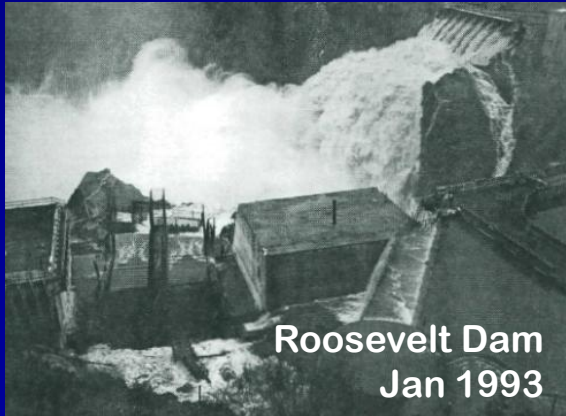
WINTER & SPRING FRONTAL ACTIVITY



Winter flooding
on the Rillito in Tucson



Canada del Oro flooding
of La Cholla Road Jan 2008



Roosevelt Dam
Jan 1993



SUMMER CONVECTIVE “Monsoon” THUNDERSTORMS



Rillito July 2006



Sabino Canyon
flooding July 1999



Typical urban flash
flooding in Arizona

ENHANCED PRECIPITATION FROM EASTERN NORTH PACIFIC TROPICAL STORMS



IMPORTANT FLOOD- GENERATING TROPICAL STORMS



 AREA RECEIVING SUBSTANTIAL TROPICAL STORM RAINFALL

Tropical Storm Norma &
the Labor Day flood
of Sep 1970

Tropical Storm Heather
Oct 1977

Tropical Storm Octave
Oct 1983

**SO HOW DO WE
ADDRESS
FLOOD HAZARDS?**

WICP

Water Information Coordination Program

ACWI

Advisory Committee on Water Information

Advisory Committee on Water Information

**Subcommittee on Hydrology, Hydrologic Frequency Analysis Work Group,
Bulletin 17-B Guidelines for Determining Flood Frequency
Frequently Asked Questions**

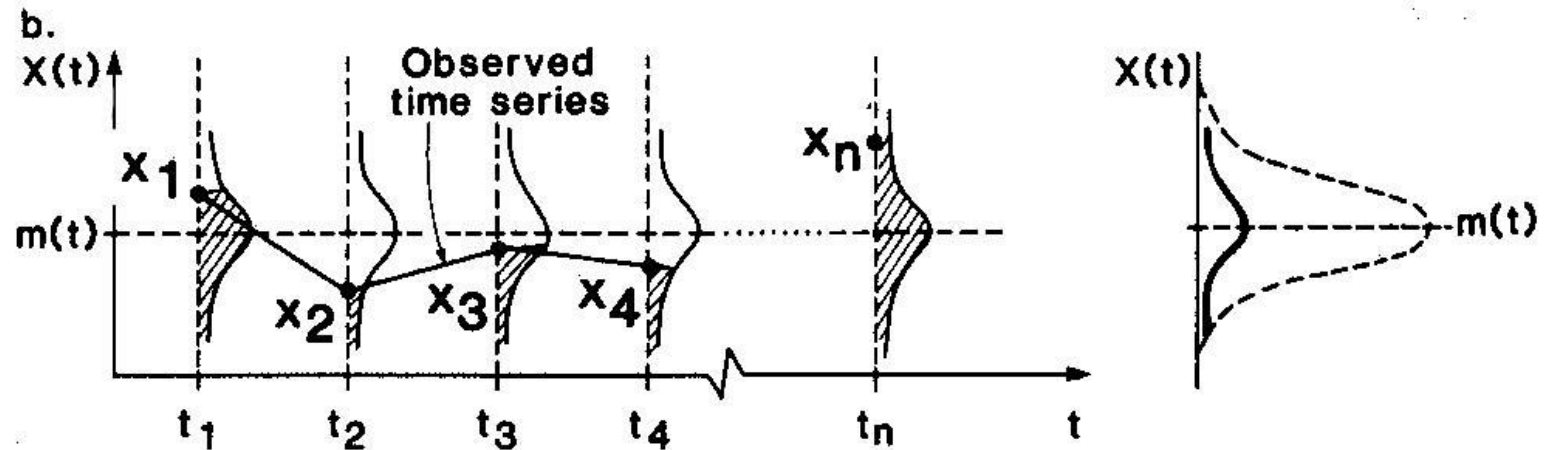
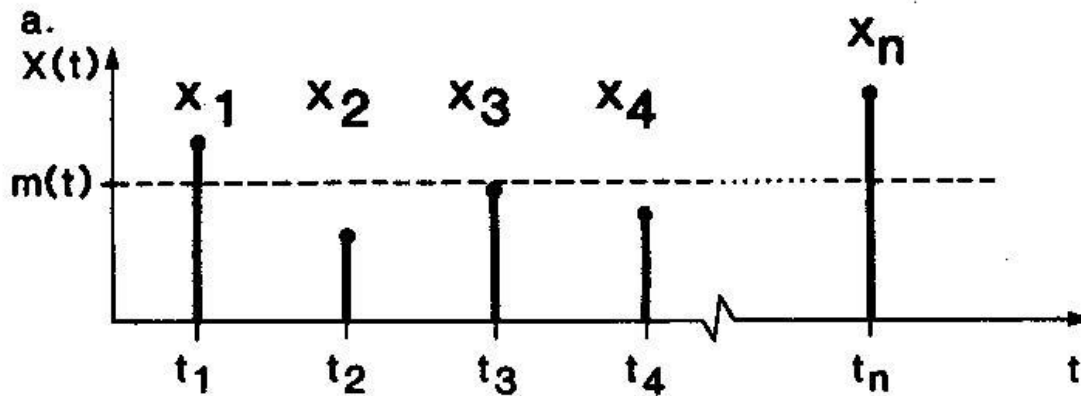
<http://acwi.gov/hydrology/Frequency/B17bFAQ.html#mixed>

“Flood magnitudes are determined by many factors, in unpredictable combinations.

It is conceptually useful to think of the various factors as "populations" and to think of each year's flood as being the result of random selection of a "population", followed by random drawing of a particular flood magnitude from the selected population.”

The Standard iid Assumption for FFA

The standard approach to Flood Frequency Analysis (FFA) assumes stationarity in the time series & "iid"

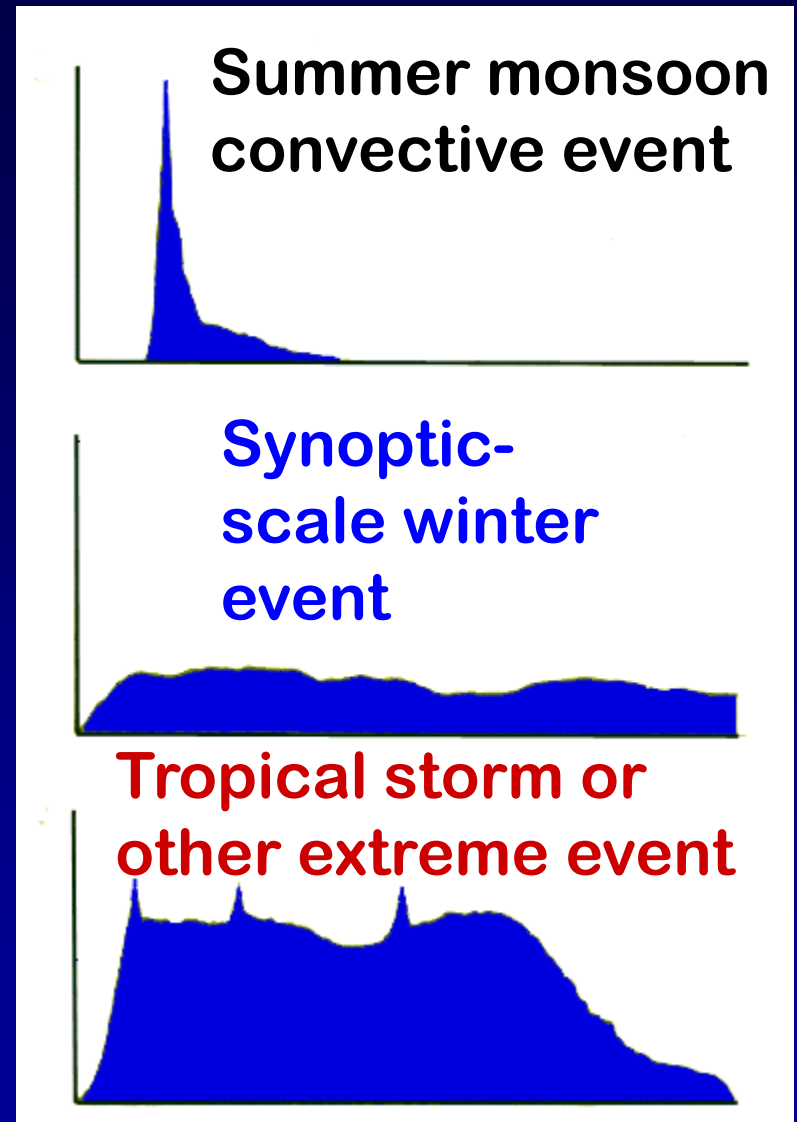


"iid" assumption: independently, identically distributed

Different storm types produce different flood hydrographs:

The type of storm influences the shape of the streamflow hydrograph and the magnitude & persistence of the flood peak

Discharge →



Time →

Therefore:

CLIMATIC CAUSE + FLOODS =

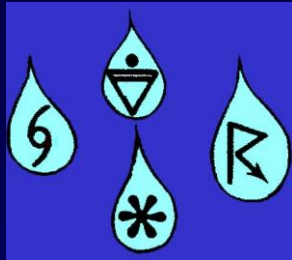
NEW & USEFUL
INFORMATION
FOR
EVALUTING
FLOOD RISK!

It all started with a newspaper ad

\$99 just \$8 a month*

Cuisinart flood processor

Reg. \$130. Model DLC-10E with expanded feed tube; includes steel chopping, medium slicing and grating blades plus plastic mixing blade.



Current practice analyzes floods using “CUISINART” HYDROLOGY!

“FLOOD PROCESSOR”

With expanded feed tube

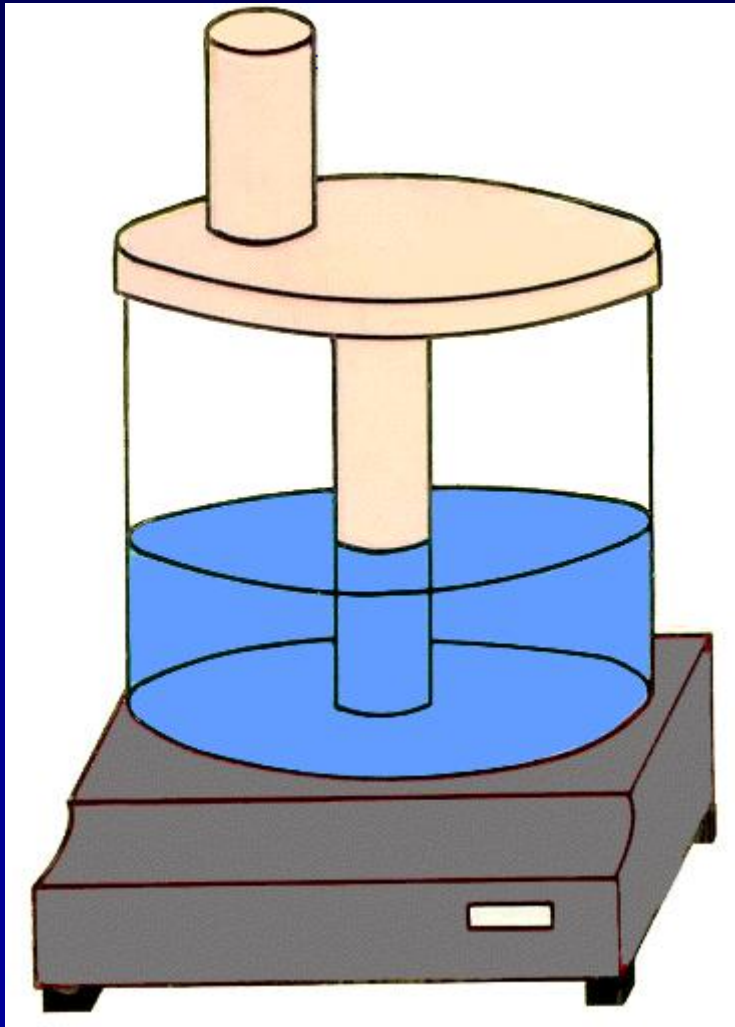
- for entering all kinds of flood data

including steel chopping, slicing
& grating blades

- for removing unique physical characteristics, climatic information, and outliers

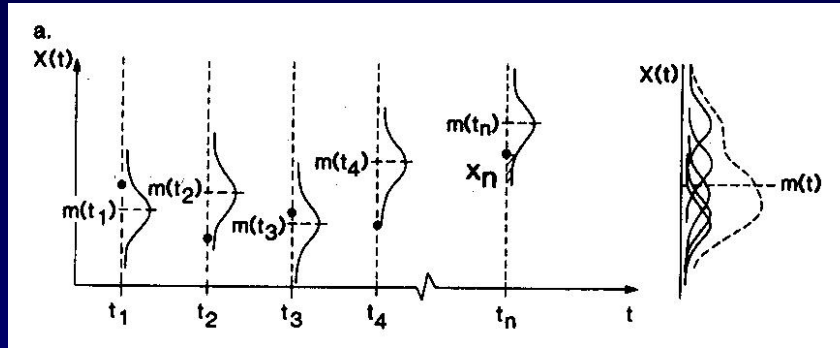
plus plastic mixing blade

- to mix the populations together

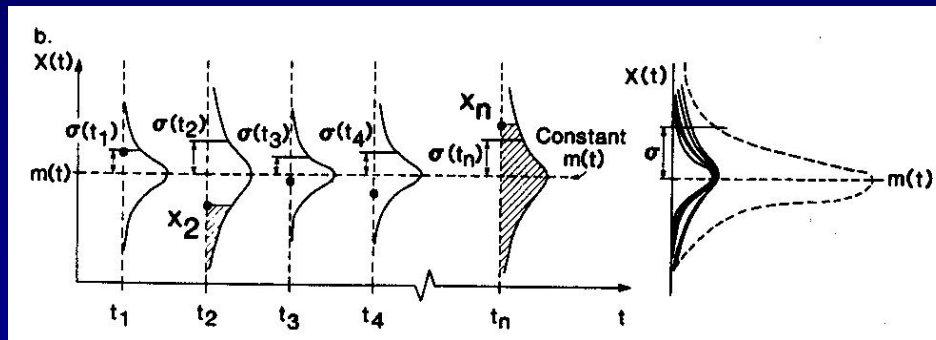


Alternative Conceptual Framework:

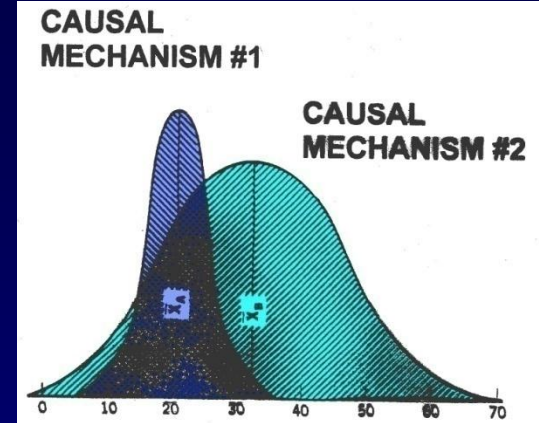
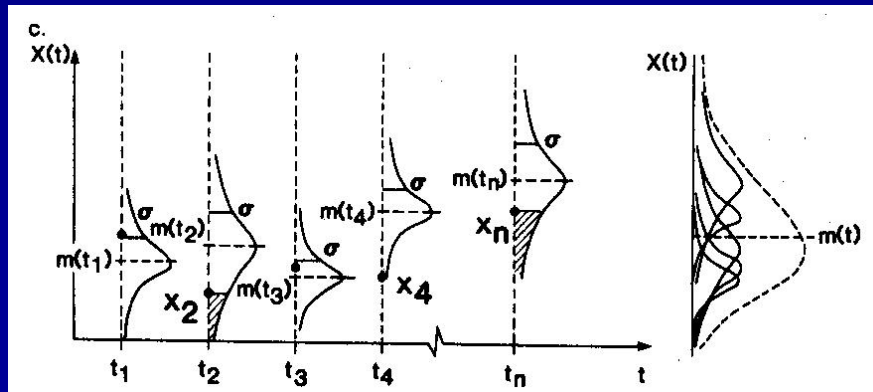
Time-varying means



Time-varying variances



Both

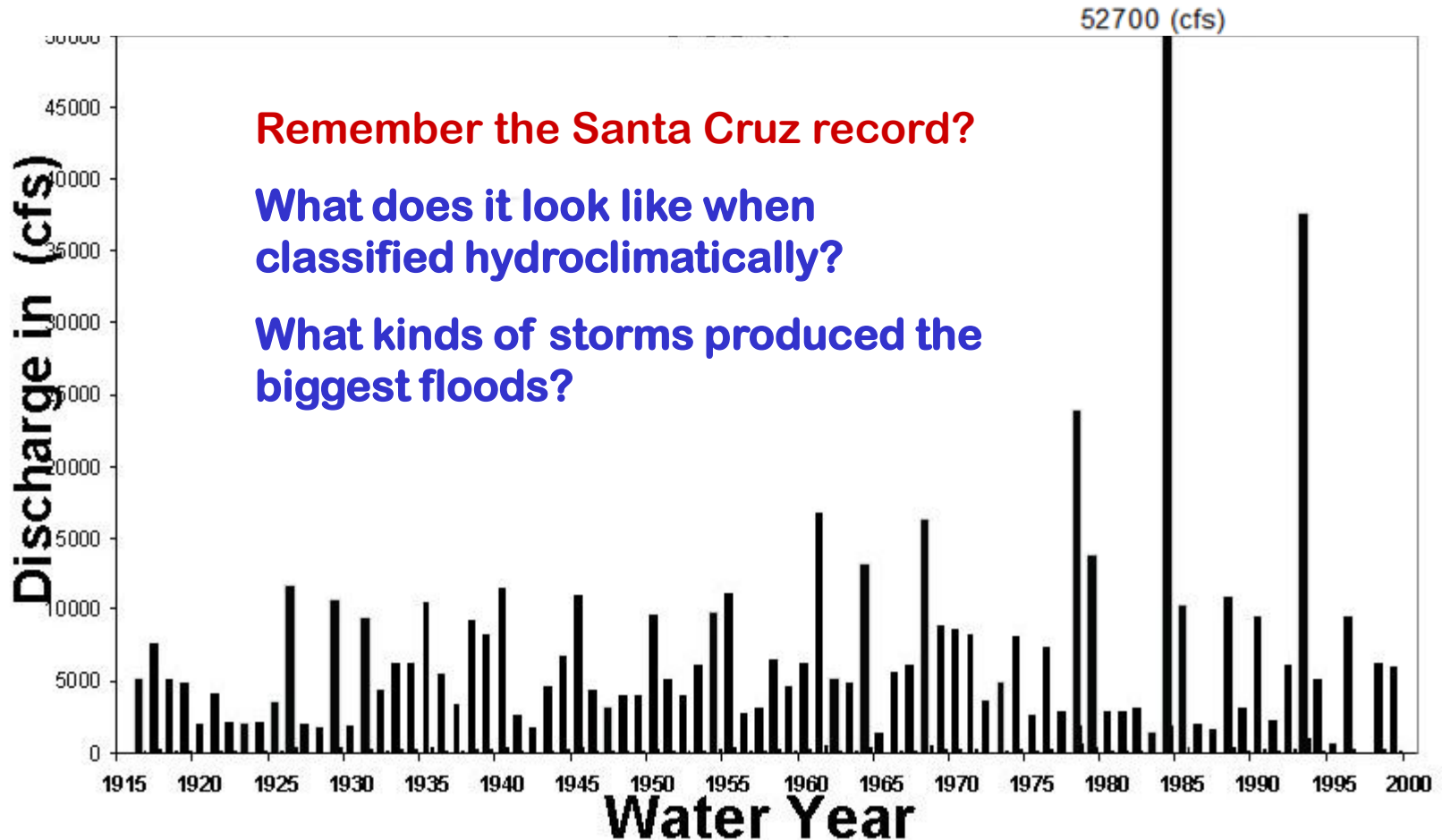


Mixed frequency distributions may arise from:

- storm types
- synoptic patterns
- ENSO, etc. teleconnections
- multi-decadal circulation regimes

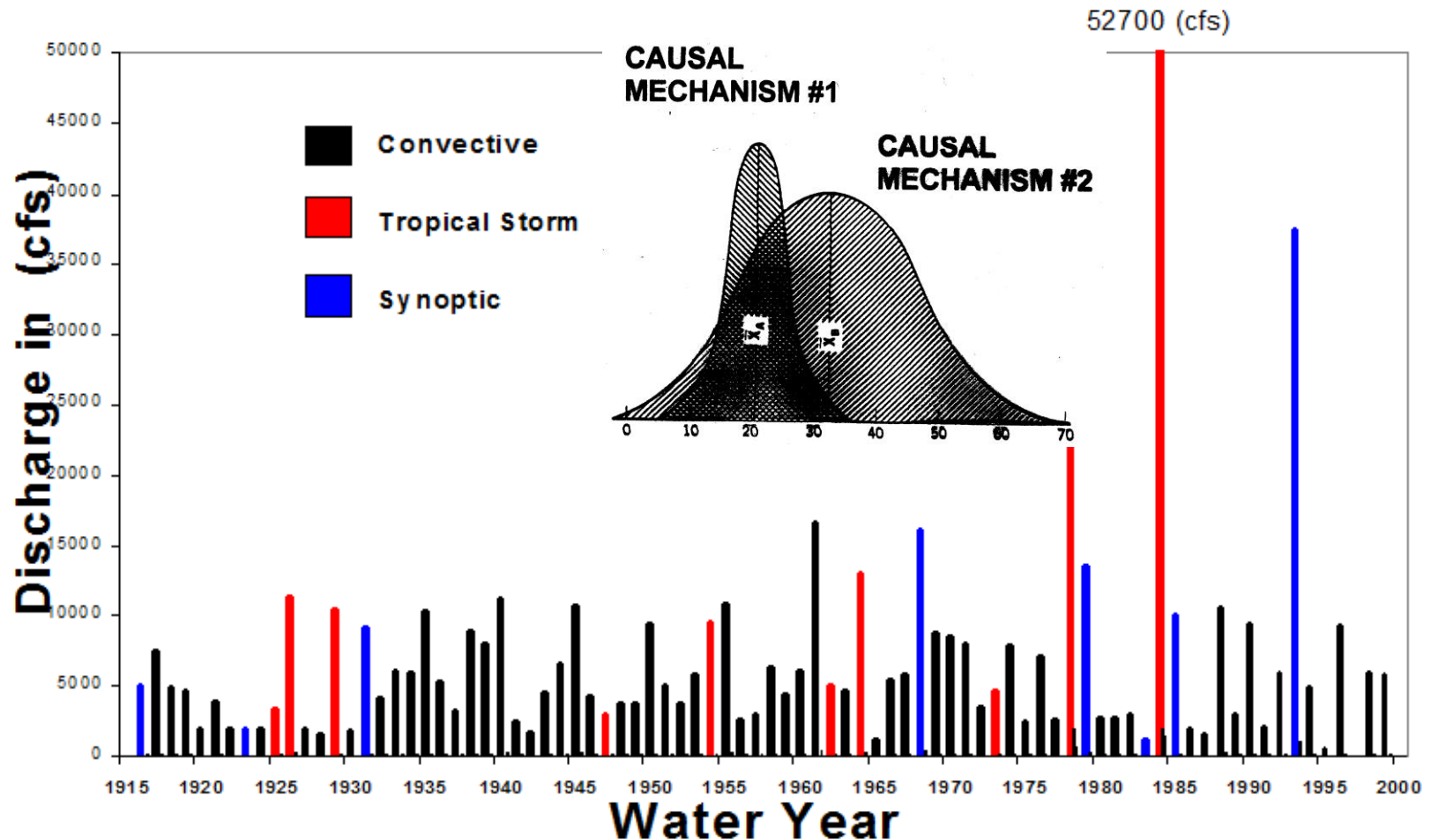
Can we find out more about what drives this history of flooding?

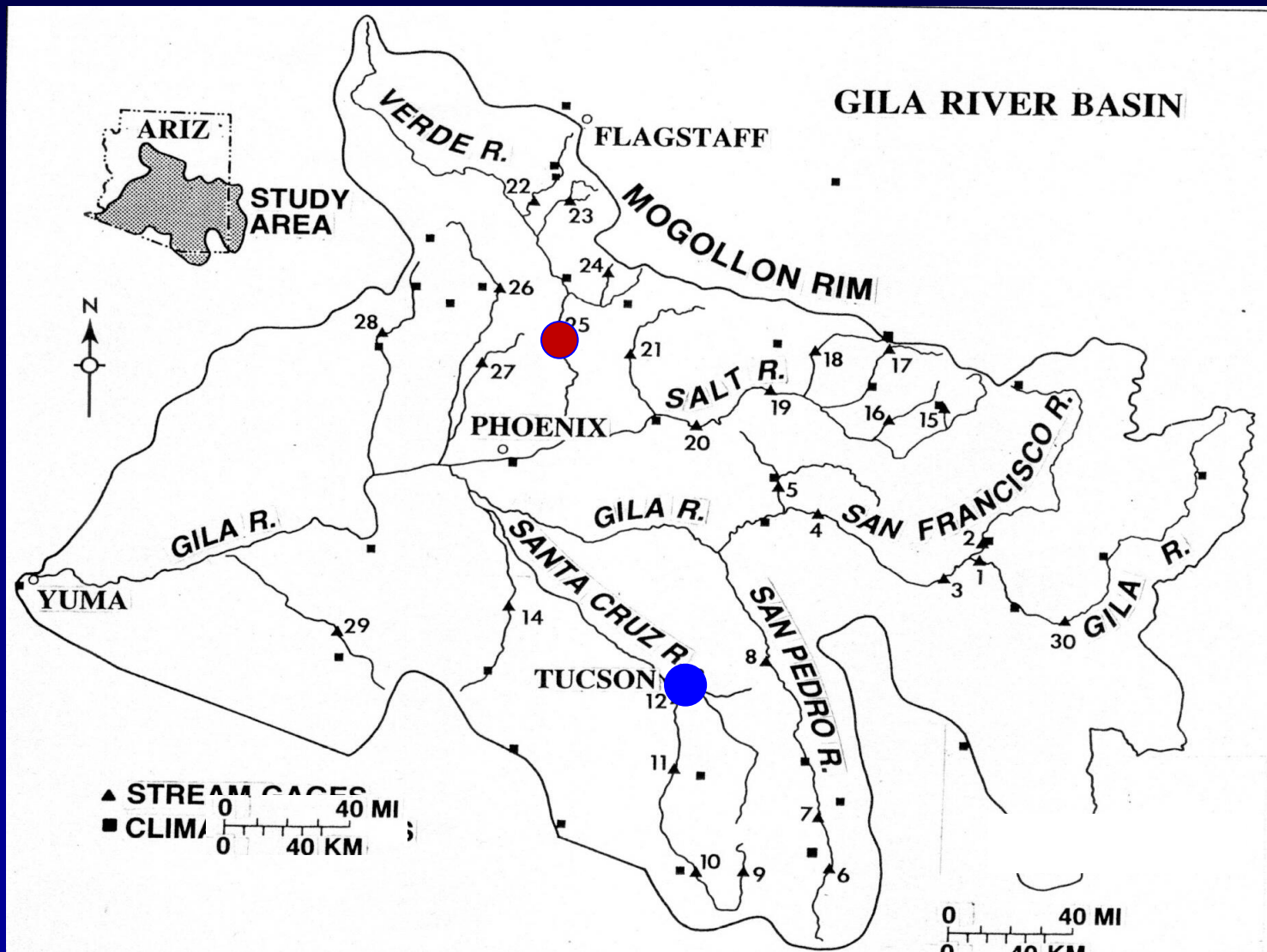
Santa Cruz at Tucson



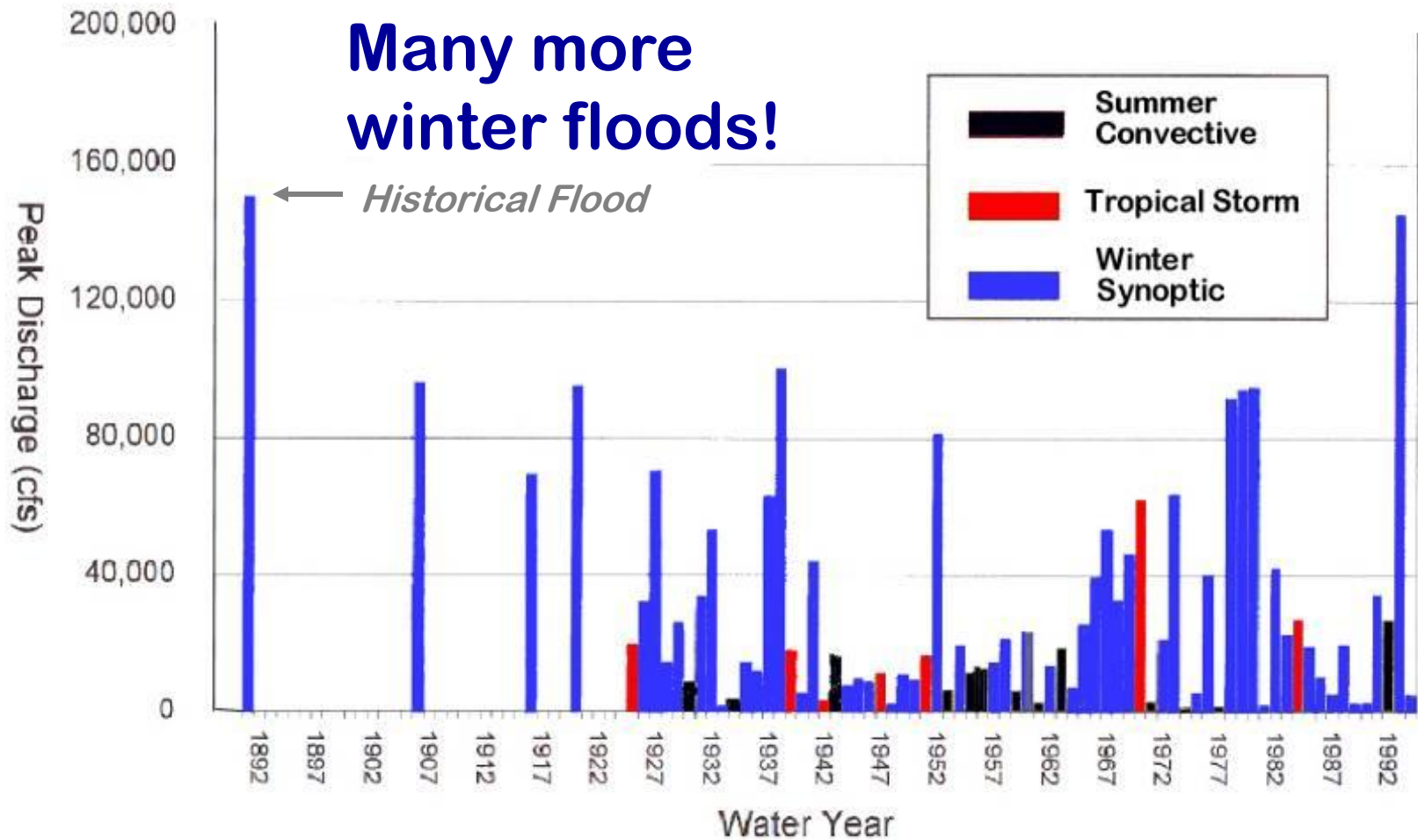
FLOOD HYDROCLIMATOLOGY = classifying each flood in the record according to cause

Santa Cruz at Tucson





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



FLOOD HYDROCLIMATOLOGY

is the analysis of flood events **within the context** of their history of variation

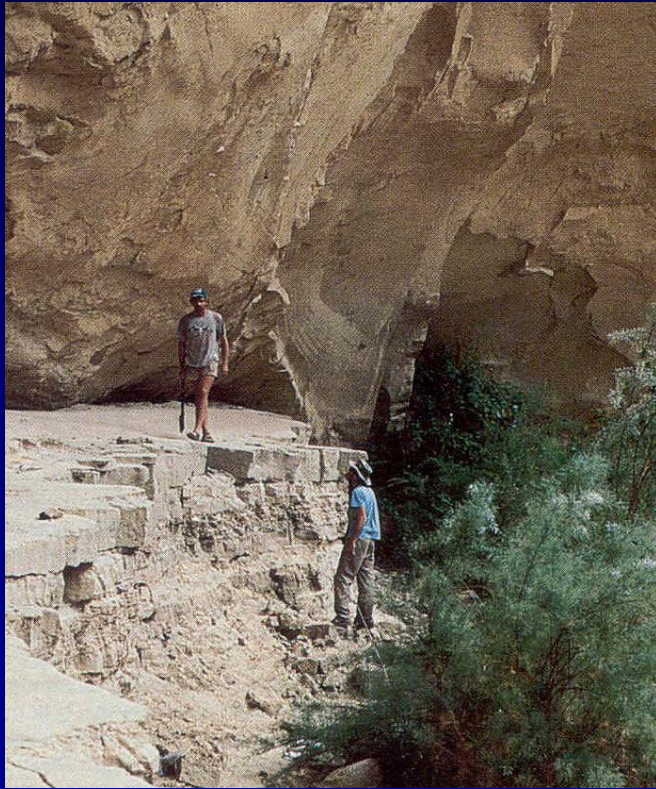
- in magnitude, frequency, seasonality
- over a relatively long period of time
- analyzed within the spatial framework of changing combinations of meteorological causative mechanisms

SOURCE: Hirschboeck, 1988

This framework of analysis allows a flood time series to be combined with climatic information . . .

To arrive at a mechanistic understanding of long-term flooding variability and the likelihood of different types of floods occurring.

WHAT CAN WE LEARN FROM LARGE FLOODS OF THE PAST?



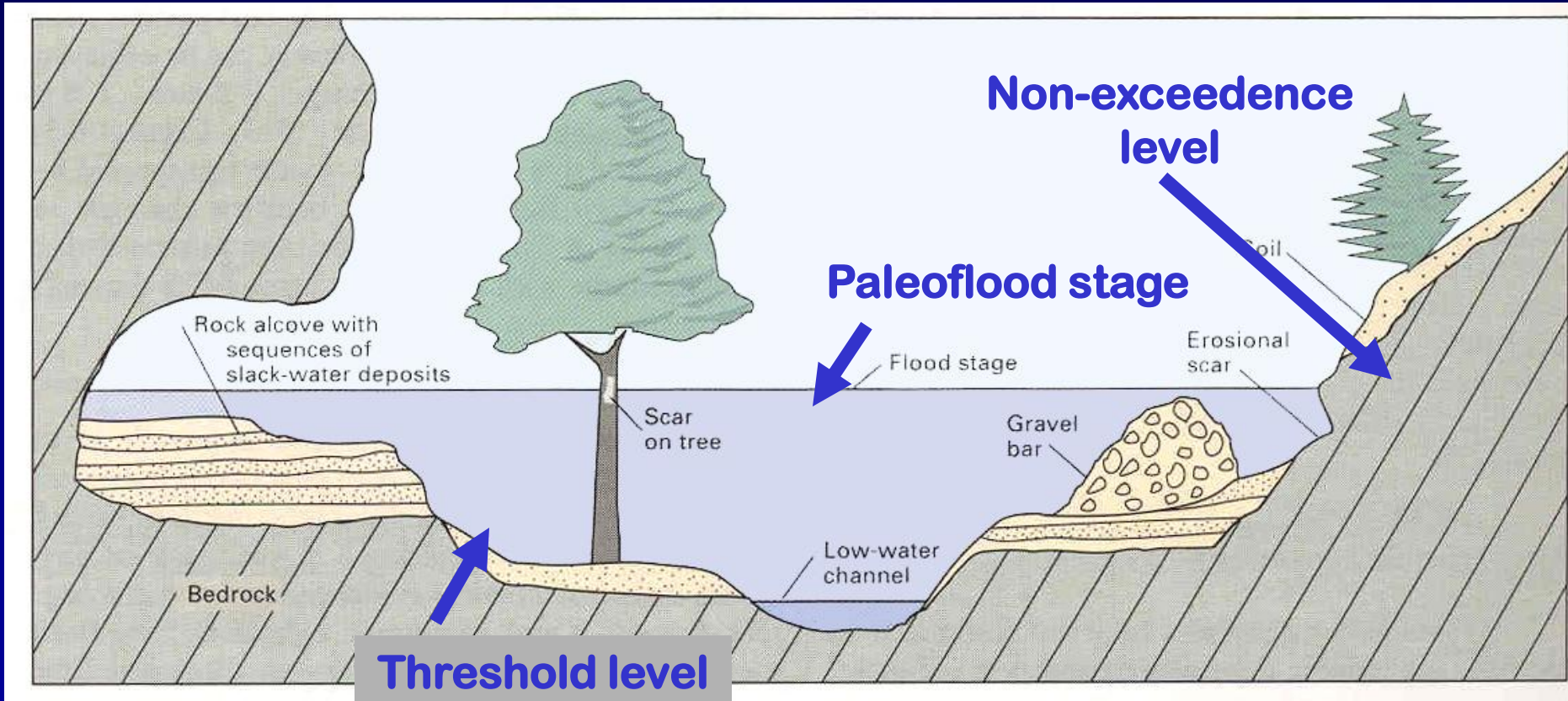
Datable flood deposits layers show how many larger floods occurred here

Here's evidence that a large flood moved this huge boulder to this height on the floodplain:

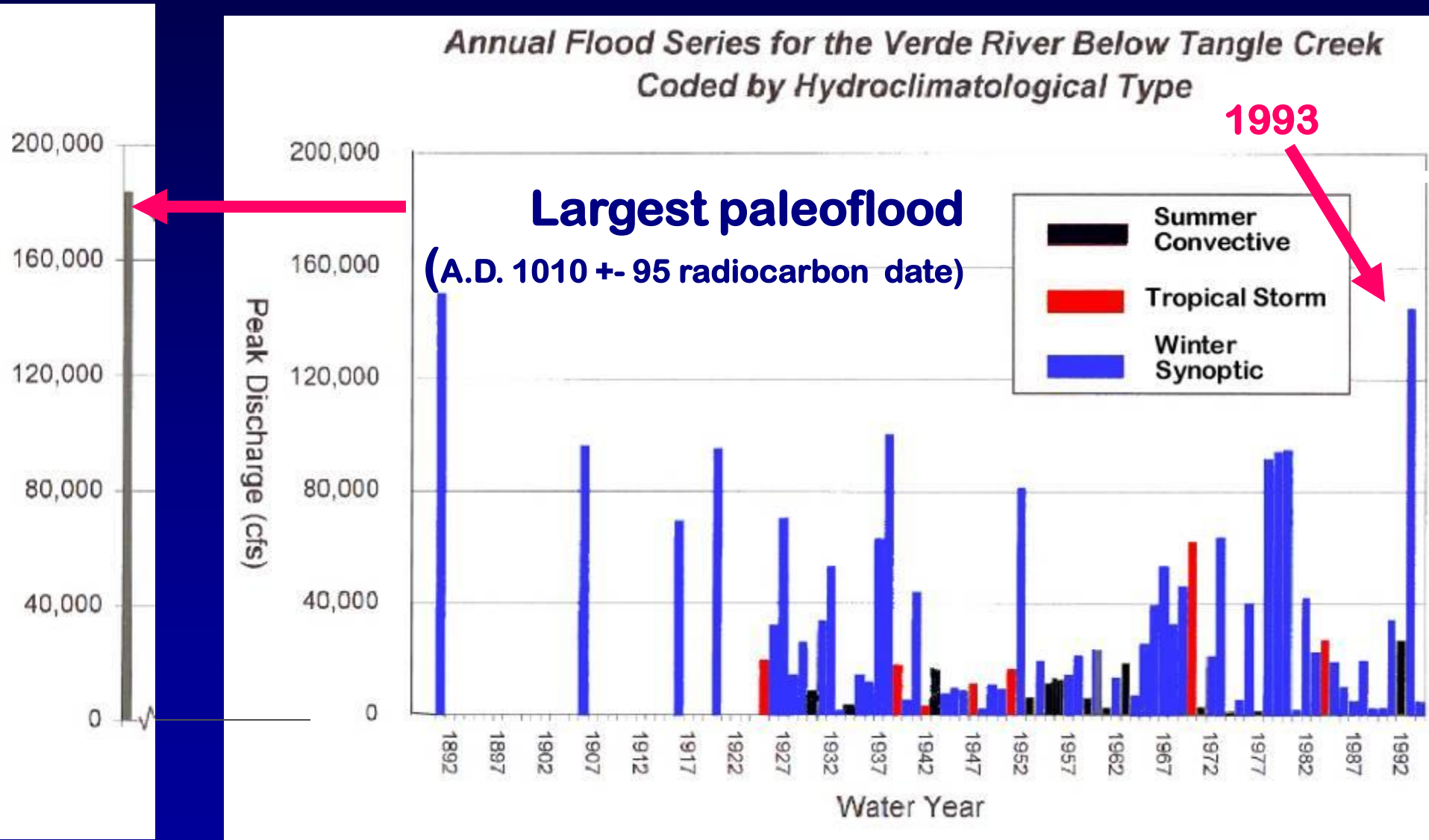


Scar on tree from flood damage can be dated with tree-ring analysis; also reveals the height of the floodwaters

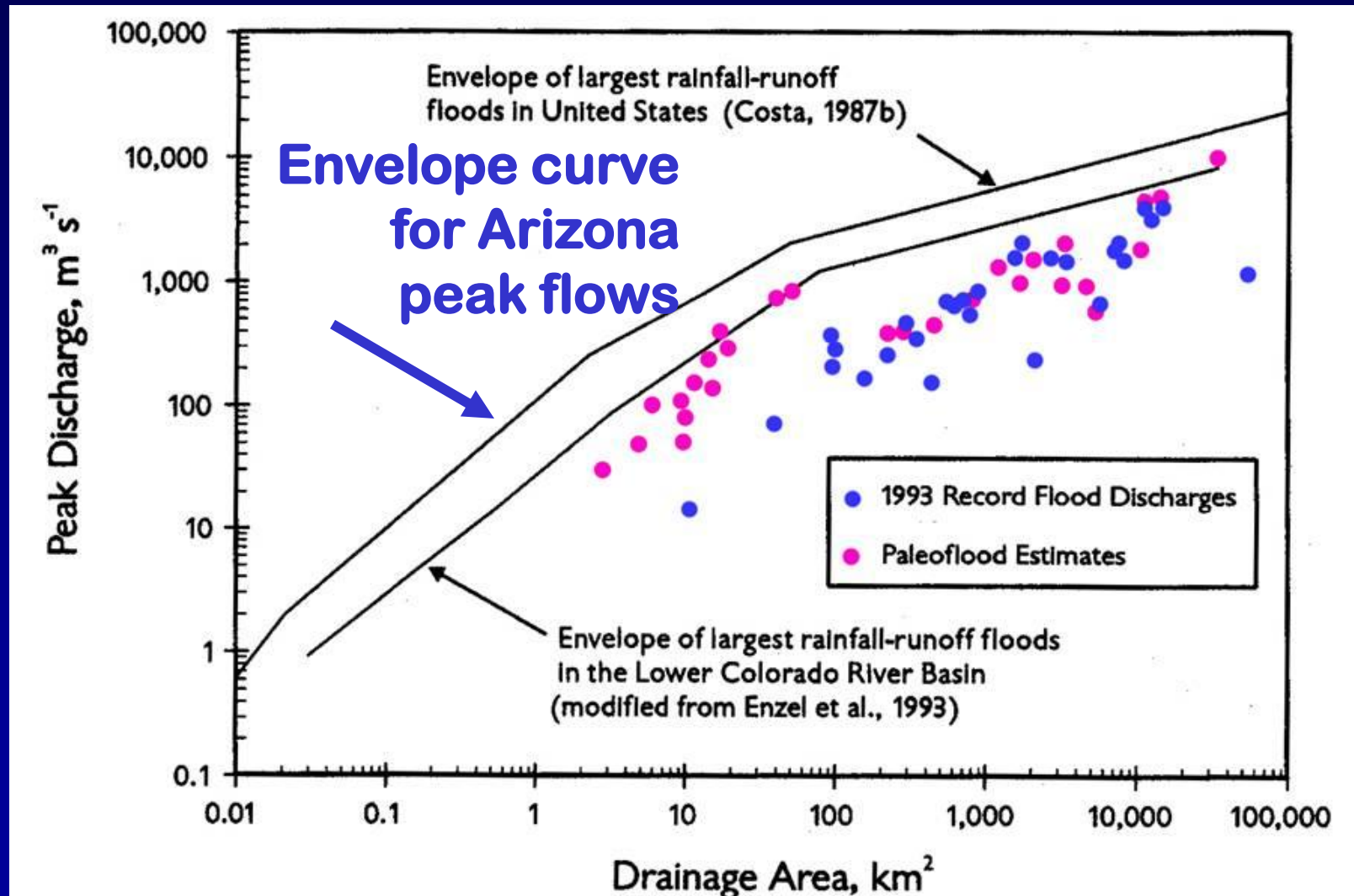
PALEOFLOOD RESEARCH!



FLOOD HYDROCLIMATOLOGY → evaluate likely hydroclimatic causes of pre-historic floods



Compilations of **paleoflood records** combined with gaged records suggest there could be a **natural, upper physical limit** to the magnitude of floods in a given region
--- will this change if the climate changes?




CLASS ACTIVITY !

J.D. CONLEY
Broker

778-5550



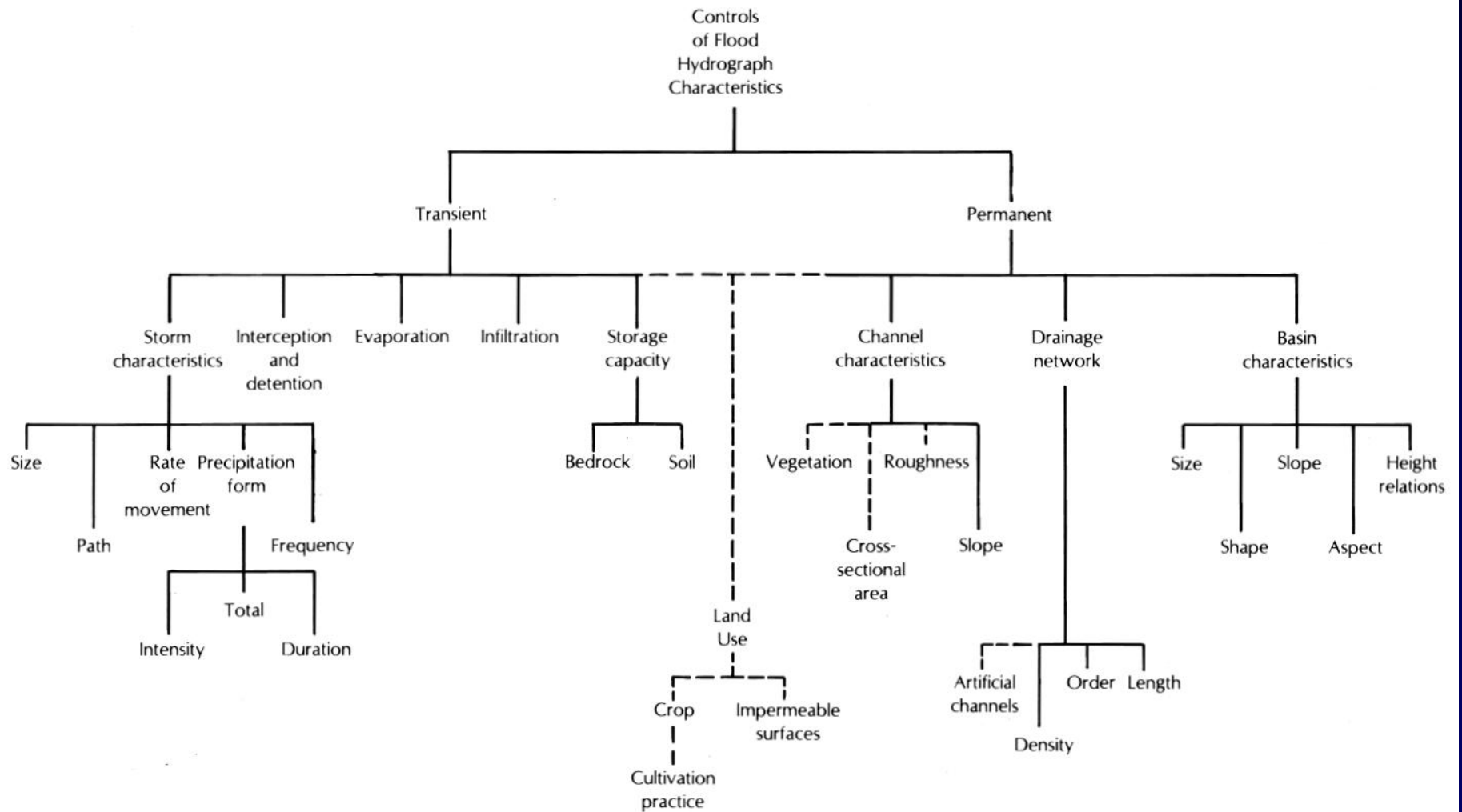
1124 E. GURLEY ^{MLS} 



Two "Problem" Lots

In Flood Plain: Probably not as bad as everyone else imagines. You can probably build 8 or more apartments. Very little site preparation. Only \$45,500⁰⁰. Drive by 300 block S. Virginia then call J.D. Conley. 778-0009.

CONTROLS OF FLOOD HYDROGRAPH CHARACTERISTICS TO HELP YOU IN YOUR ASSESSMENTS

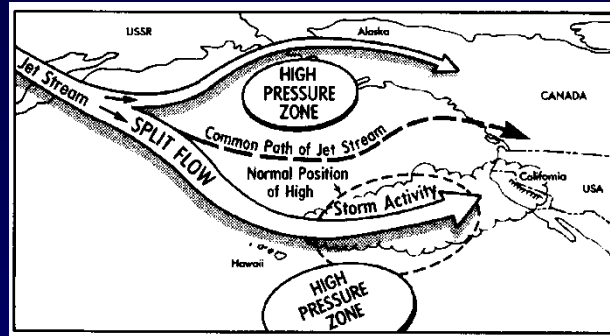
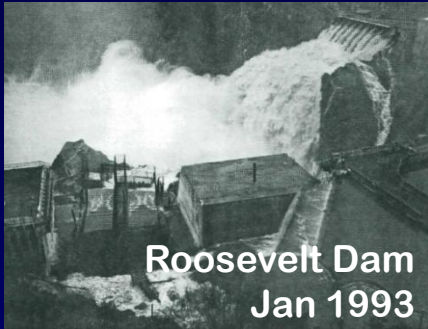


WHAT WILL THE FUTURE HOLD?

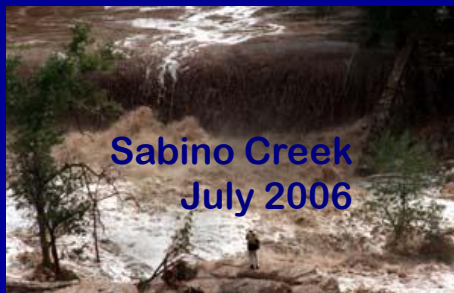
... will climatic change make
floods more extreme?

or will they get smaller?

(1) A Northward Shift in Winter Storm Track?



(2) A Change in Frequency or Intensity of Tropical Storms?

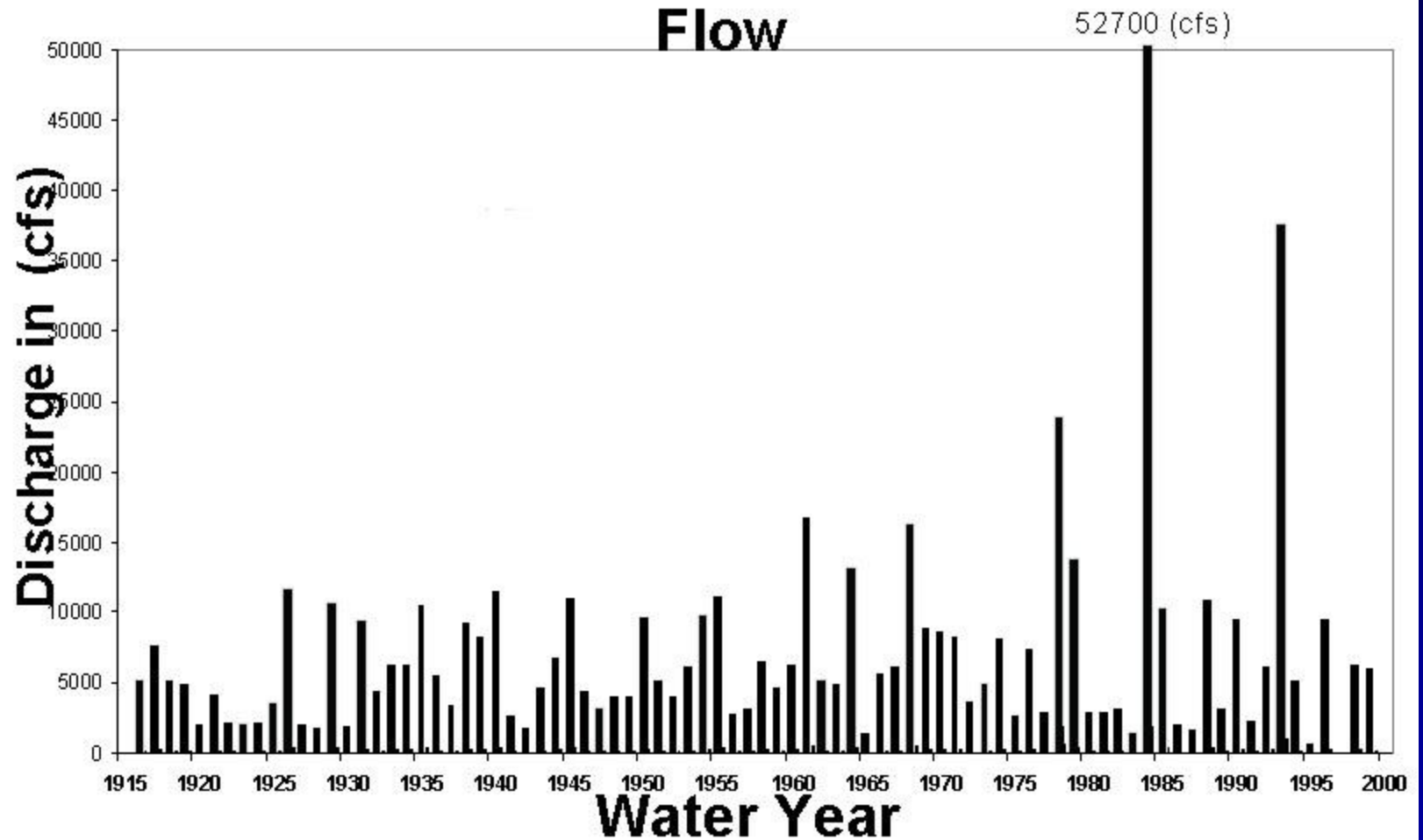


(3) A More Intense Summer Monsoon?



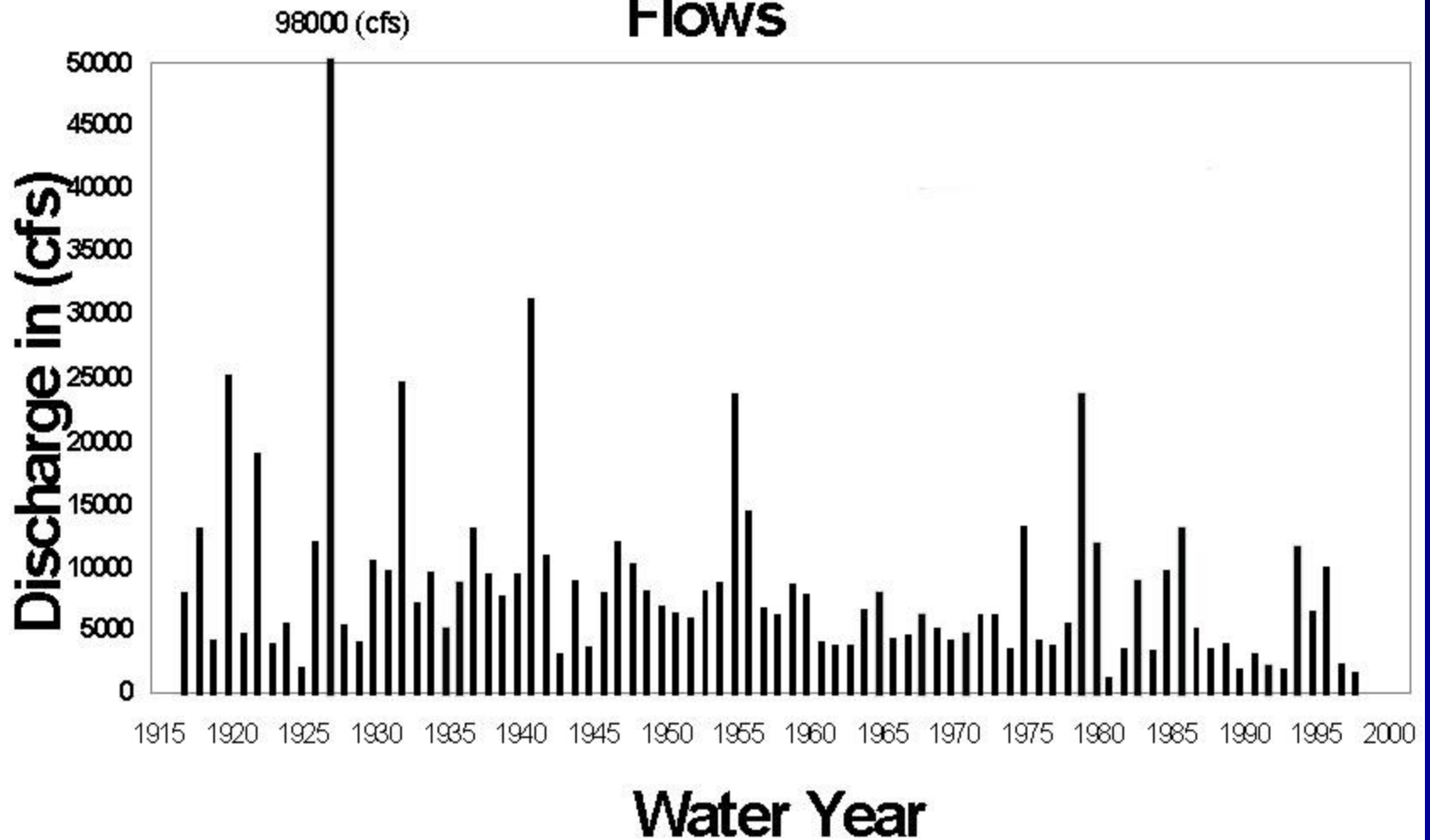
Is this evidence of climate change?

Santa Cruz at Tucson Annual Peak

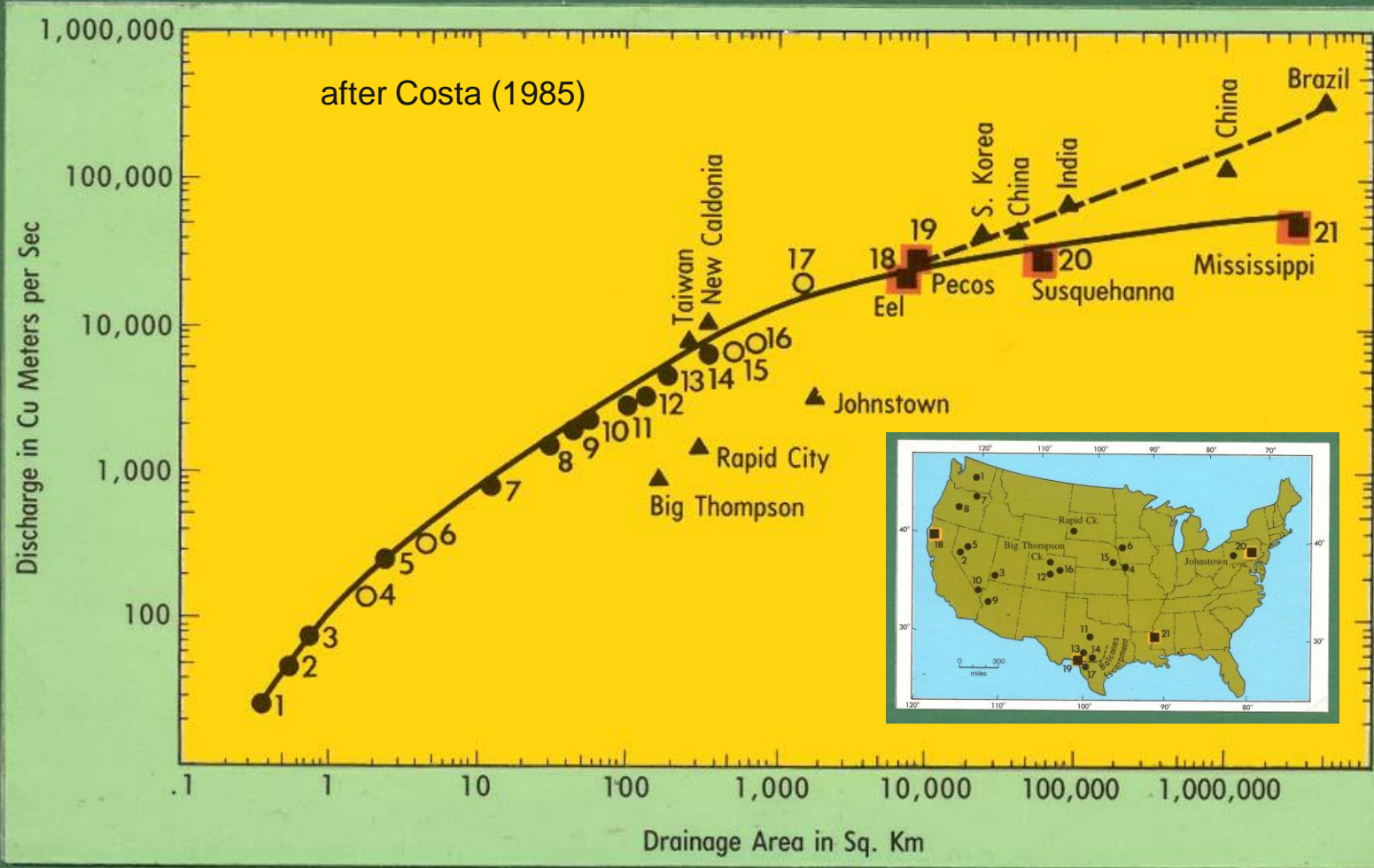


Extreme events have a legacy of confounding us!

San Pedro at Charleston Annual Peak Flows



LOOKING AT FLOODS NATIONALLY & GLOBALLY



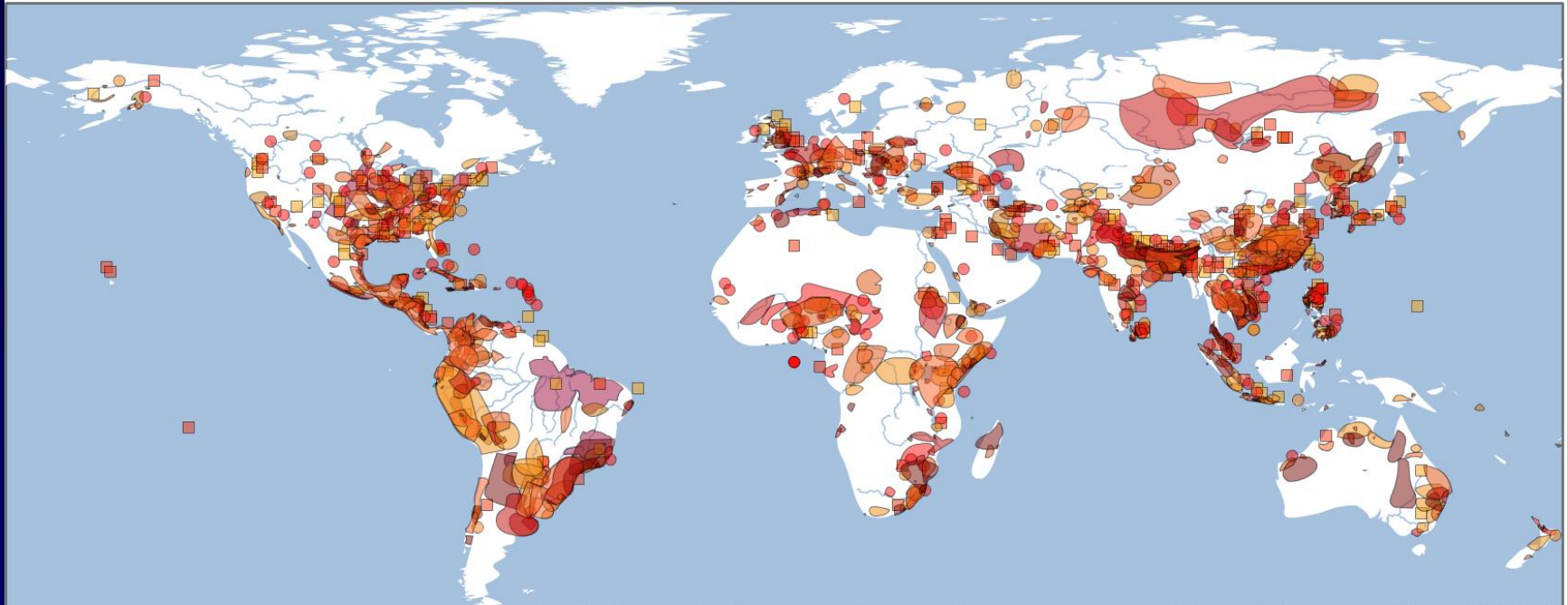
Extreme Floods of Record evolved from:

- uncommon (or unseasonable) locations of typical circulation features
(a future manifestation of climate change?)
- unusual combinations of atmospheric processes
- rare configurations in circulation patterns (e.g. extreme blocking)
- exceptional persistence of a specific circulation pattern.

THE GLOBAL PERSPECTIVE!

<http://floodobservatory.colorado.edu/index.html>

Global Archive Map of Extreme Flood Events since 1985



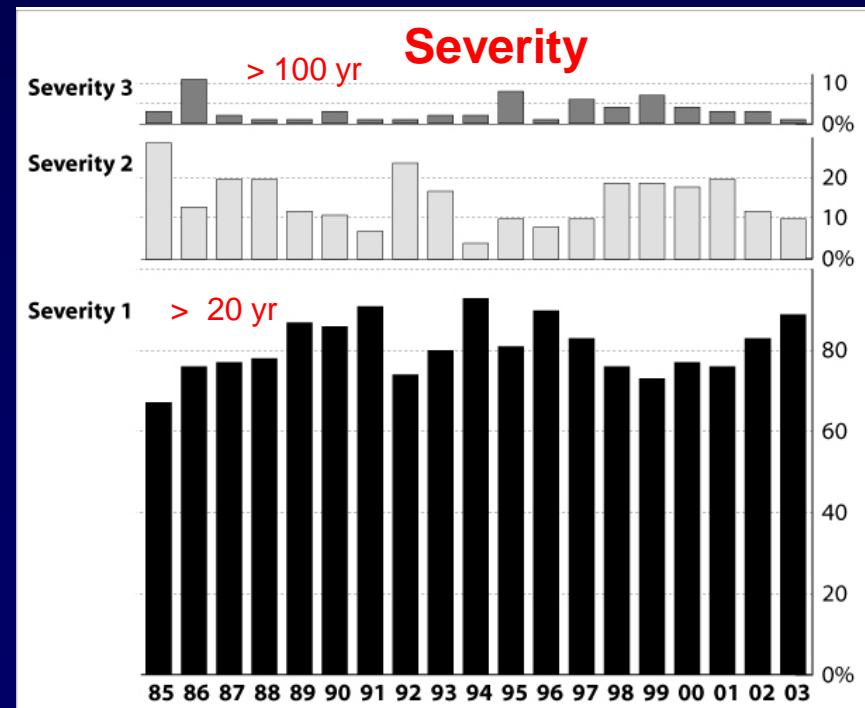
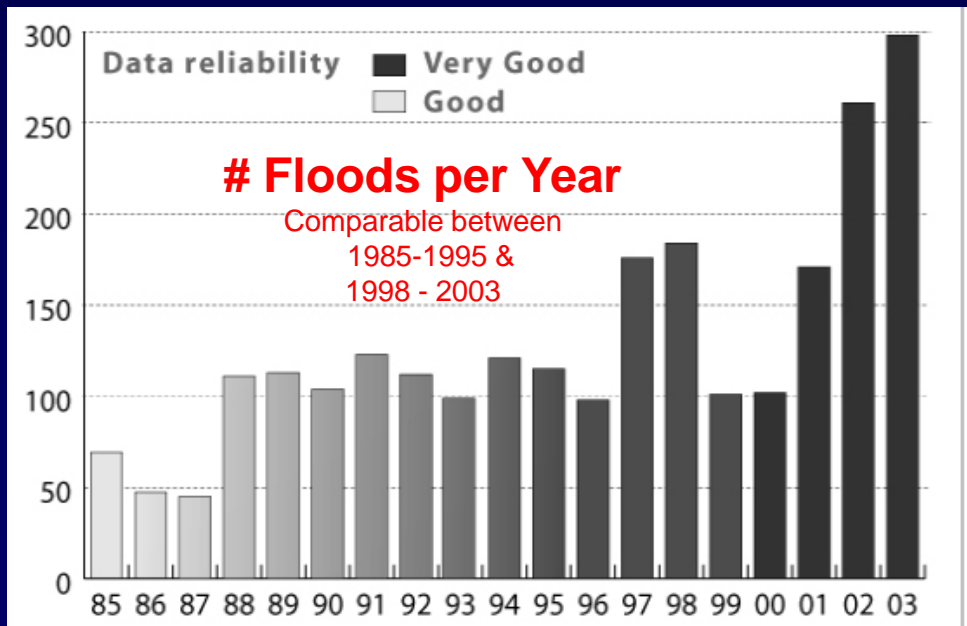
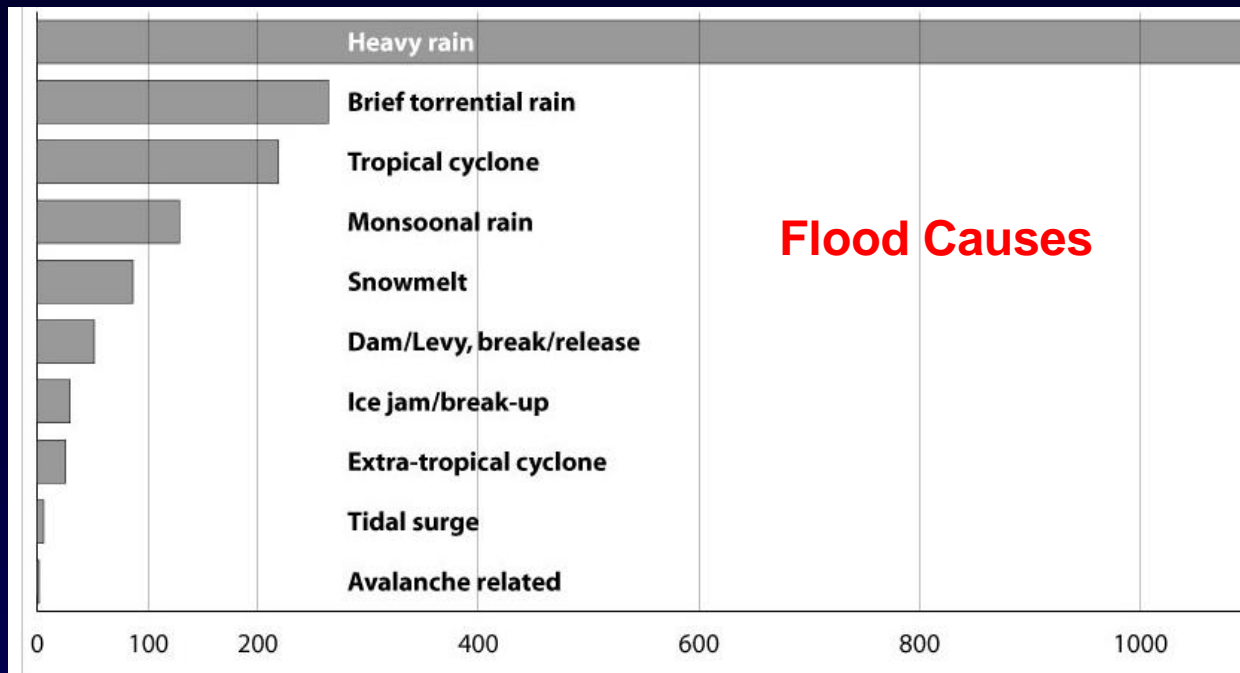
© 2002 - Dartmouth Flood Observatory - G.R. Brakenridge, Elaine Anderson - Cartography: S. Caquard - Work supported by NASA grant NAG5-9470

To Show or hide the flood events: Click on the boxes

2002	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	1990	1989	1988	1987	1986	1985
					No data	No data				No data			No data				
							No accurate data				No accurate data						

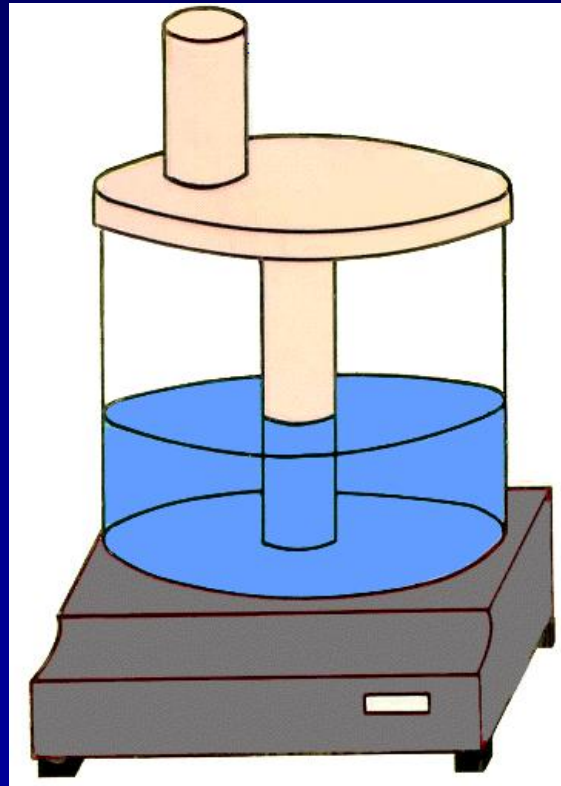
<http://floodobservatory.colorado.edu/Archives/GlobalArchiveMap.swf>

<http://floodobservatory.colorado.edu/archiveatlas/floodrecurrence.htm>





SUMMARY



Hydroclimatic Regions

- Rivers can be grouped according to how their floods respond to different types of mechanisms and circulation patterns.**
- This grouping may change from season to season and might possibly rearrange itself due to climate change and shifting storm tracks.**

A Mixture of Flood Causes:

Data from key flood subgroups could be better for estimating the probability and type of extremely rare floods than a single “100-Year Flood” calculated from all the flood data combined!

Projecting How Floods May Vary Under A Changing Climate

Climatic change affects floods through time-varying atmospheric circulation patterns

Different weather and climate patterns (e.g., Tropical Storms, El Niño, La Niña) generate a mixture of shifting streamflow probabilities over time.

Flood Hydroclimatology provides a way to evaluate future extreme flooding scenarios in terms of shifting frequencies of known flood-producing synoptic patterns, ENSO, etc.

... ONE MORE FLOOD
An urban flooding event!



Near Silvercroft Neighborhood In Tucson AZ
(East of Silverbell Rd,
South of Grant Rd & North of Speedway)

**SOURCE: Pima County Regional
Flood Control District**
<http://rfcd.pima.gov/outreach/hank/>