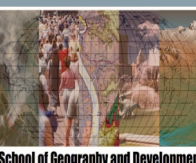
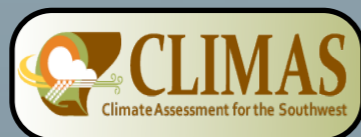


Flood Hydroclimatology as a Flood Management Tool

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CLIMAS

Climate Assessment for the Southwest

July 21, 2010

Southwest Climate Outlook

Vol. 9 Issue 7



Source: John Burfiend, Air Tactical Specialist for the U.S. Forest Service.

Photo Description: An air tanker buzzes the Rio Fire above the Santa Fe National Forest, about 30 miles west of Los Alamos, New Mexico. The fire, which began on June 1, was started by human activity and burned about 1,356 acres before it was quelled.

Would you like to have your favorite photograph featured on the cover of the Southwest Climate Outlook? For consideration send a photo representing Southwest climate and a detailed caption to: maoaulay@email.arizona.edu

In this Issue...

Feature Article → page 3

Wildfires burning in the Southwest this year have grabbed headlines but haven't come close to the region's average for acres burned. Fires in the last 20 years have charred more than 410,000 acres on average in Arizona and New Mexico...

Monsoon → page 14

The monsoon arrived a little later than average and so far has been weaker than usual, according to the National Weather Service Tucson office. Although moisture has been available for thunderstorms...

ENSO → page 19

The El Niño event that officially began in May 2009 has ended. The recent April-June period marked the first three consecutive months that sea surface temperatures (SSTs) in the Niño 3.4 region in the central Pacific Ocean were below the 0.5 degrees Celsius El Niño threshold...

Mission- to improve the ability of the region to respond sufficiently to climatic events and climate changes





Resumen del Clima de la Frontera

Border Climate Summary

Publicado: 21 de junio de 2010

Entrenamiento en los ciclones tropicales y su paso a través de la frontera

Por Luis M. Farrán, Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), Graciela B. Raga, and Fernando Oropeza, Universidad Nacional Autónoma de México (UNAM)

Los ciclones tropicales son sistemas del tiempo importantes que se desarrollan sobre varias regiones del globo. Mientras que ocurren sobre océanos relativamente cálidos, la cuenca del Pacífico nororiental es una región notable prolífica, donde se desarrollan más sistemas por unidad de área que en cualquier otra región en el mundo. Su desarrollo tiene el potencial de afectar países en Centro y Norteamérica. Generalmente el acercamiento de ciclones tropicales trae cambios en contenido de humedad atmosférica en áreas relativamente grandes y se convierten en una fuente significativa de precipitación sobre el terreno montañoso.

En promedio, 15 ciclones tropicales desarrollan cada estación, que se extiende de finales de mayo y hasta mediados de noviembre.

La costa del oeste de México es especialmente vulnerable a estos sistemas y, aún más, a los ciclones que se muevan cerca de la línea de costa.

La entrada a tierra se define como el paso del centro del sistema a través de la costa. Los ciclones tropicales que entran a tierra pueden estar acompañados por vientos fuertes, marea de tormenta costera, y precipitación intensa, con el potencial de daños materiales extensos e inundaciones en áreas costeras. El noroeste de México tiene la frecuencia más alta de entrada a tierra en toda la cuenca del Pacífico oriental. Esta región incluye los estados de Nayarit, Sinaloa, Sonora, y toda la península de Baja California. La mayoría de las entradas a tierra ocurren tardíamente en la temporada, entre agosto y octubre, y tienden para ocurrir sobre Baja California o sobre Sinaloa en la zona continental del país.

Cursos de entrenamiento

En comparación a los países desarrollados, en América Latina hay una falta de profesionales con un conocimiento adecuado de meteorología y climatología sobre ciclones tropicales, y se requieren de mejoras importantes para construir



Figura 1. Los participantes del curso del invierno del 2010 en La Paz, Sur de Baja California, México.

capacidad en estas disciplinas. Como parte de un proyecto de investigación internacional, financiado por el Instituto Inter-Americano para la Investigación Global del Cambio (IAI por sus siglas en inglés, <http://www.iai.int>), diseñamos una serie de cursos cortos basados en el conocimiento actual de ciclones tropicales en el Pacífico oriental. Nuestra meta principal es entrenar a estudiantes de instituciones de educación superior en México, el Caribe, Centro y Sudamérica, donde la construcción de capacidad está en sus primeras etapas de desarrollo. Estos cursos son de 4-5 días y se han ofrecido durante tres años consecutivos en México (La Paz, Baja California Sur, en 2008 y 2010 y Acapulco, Guerrero, en 2009).

Nuestro método incluye una breve revisión de características climatológicas en la formación, intensificación, y disipación de ciclones tropicales. Los aspectos clave son las etapas de la formación e intensificación, con énfasis en el desarrollo en la costa occidental de

continuación página 4

Mission- to improve the ability of the region to respond sufficiently to climatic events and climate changes

Contenido:

- 1 Entrenamiento en los ciclones tropicales y su paso a través de la frontera
- 3 Pronósticos de Inundaciones en Ambos Nogales

Condiciones Recientes

- 6 Temperatura
- 7 Precipitación
- 8 Monitor de la Sequía de América del Norte
- 9 Presas de Sonora

Pronósticos

- 10 Pronóstico de Cuidad
- 11 Pronóstico de Precipitación
- 12 ENOS

Objectives

- Develop an approach to flood frequency analysis that incorporates non-stationarity/climate variability into its framework.
- Create new flood probability distribution functions in a flood database
- Establish flood probability scenarios based on climate projections
- Collaborate with flood managers in strategy to operationalize climate data framework



DROUGHTS vs FLOODS



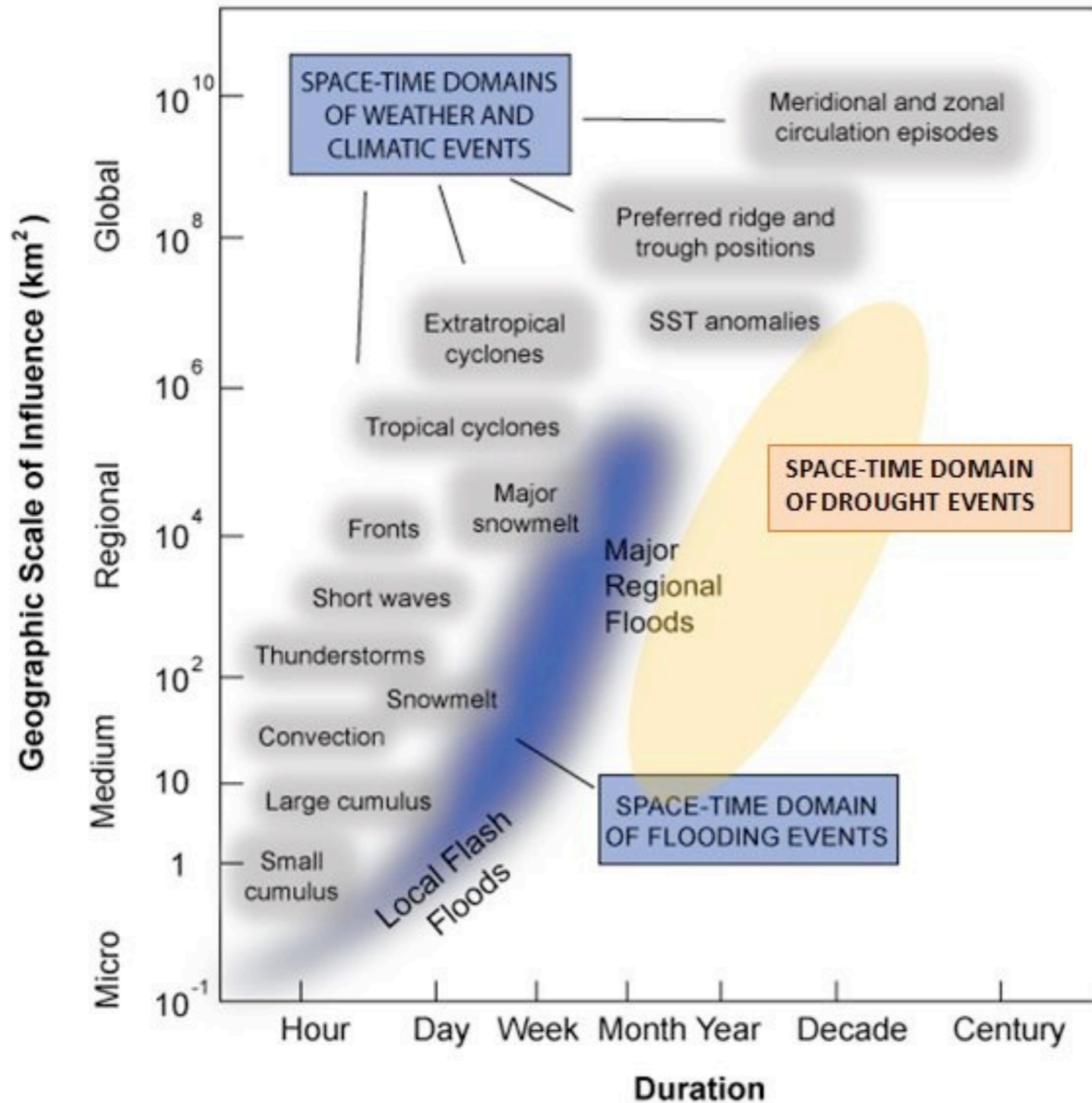
IPCC projections indicate that both droughts and floods are expected to increase with future climate change, yet those involved in the management of these two types of extreme events differ markedly in addressing this.

- Cooperation between researchers* and drought managers have had some success in incorporating climate data into framework
- Some stakeholders have changed strategies in adaptation to climate variability

- Current flood strategies do not incorporate climate data
- Connection between flood-generating weather and the climate producing it is not defined for operationalizing

*CLIMAS and LTRR

A Problem of Scale



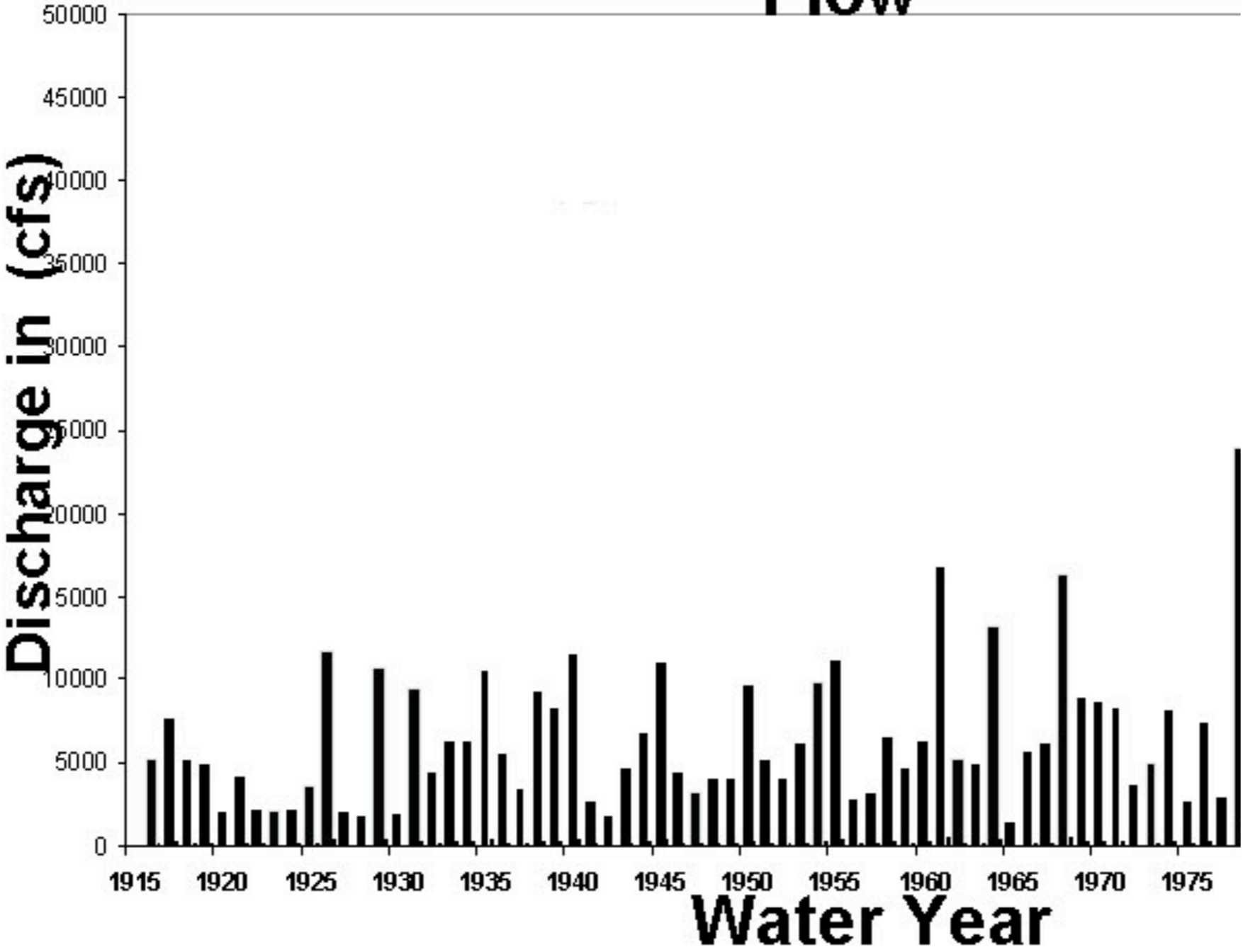
(Hirschboeck, 1988)

- Drought planning operates at climatic spatial & temporal scales
- Climatic variability is difficult to translate to flood management because of temporal and spatial scale mismatches
- Flood forecasters and floodplain managers are more attuned to weather-scale processes and information
- Yet, flood-generating storms emerge from larger synoptic patterns and climate-scale processes
- Incorporating long-term climate information into operational flood management is needed to address the challenges of future climate change

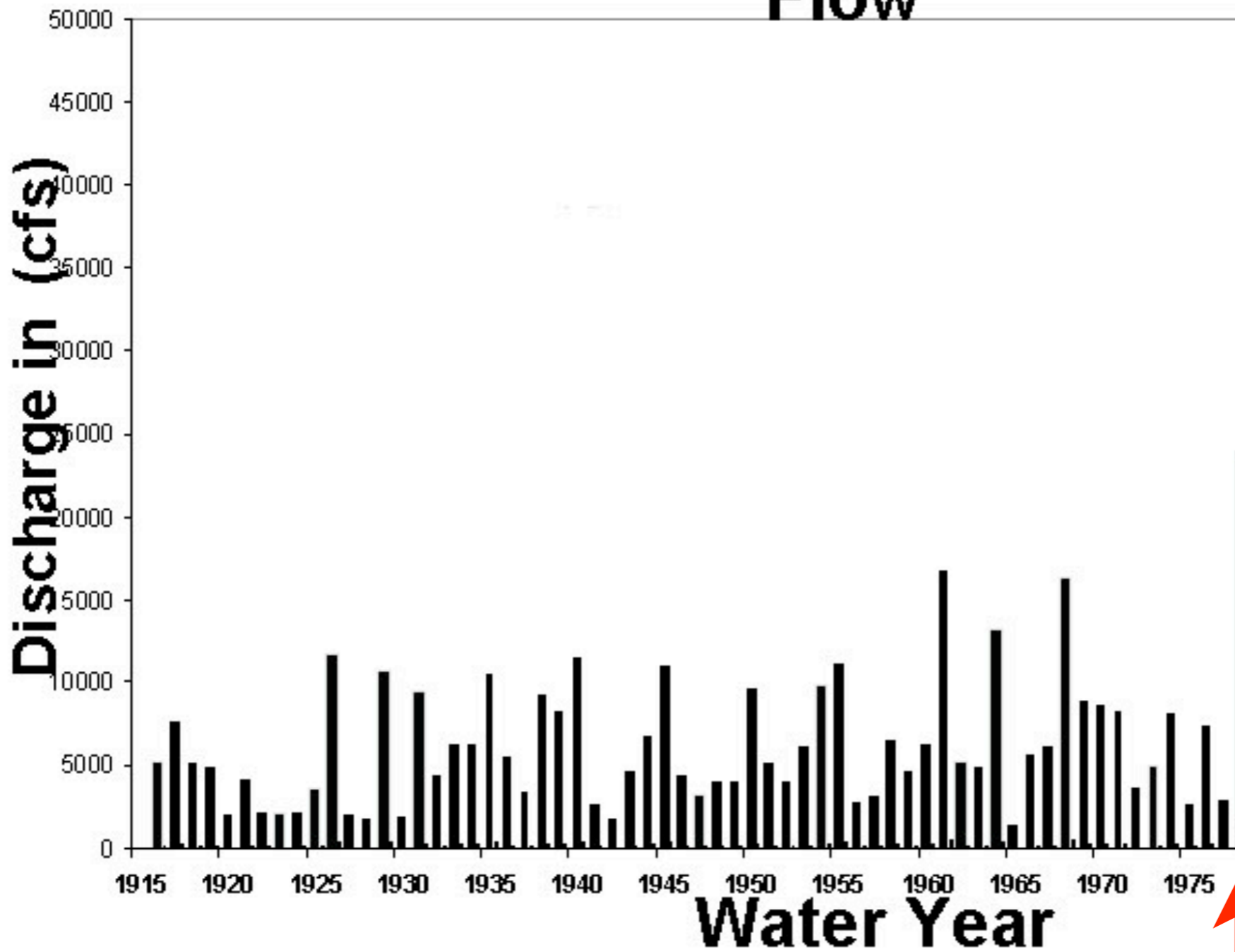
Flood Policy Shortfalls

- Current flood frequency analysis (100-year flood) does not include causal mechanisms
- The 100-year flood, used as a national standard for development and flood insurance, “is arbitrarily chosen for regulatory reasons and does not reflect anything fundamentally intrinsic to the floodplain” (Pielke, 1999 pp 416)
- Bulletin 17B assumes stationarity; such a constraint stifles management adaptation to future climatic conditions
- Current flood probability estimates:
 - are calculated assuming stationarity, “that natural systems fluctuate within an unchanging envelope of variability” (Milly et al. 2008, pp 1)
 - lack causal information, regional heterogeneity, and climate variability
- These are known problems for which flood researchers, decision makers, policy experts, and federal agencies are seeking practical solutions

Santa Cruz at Tucson Annual Peak Flow



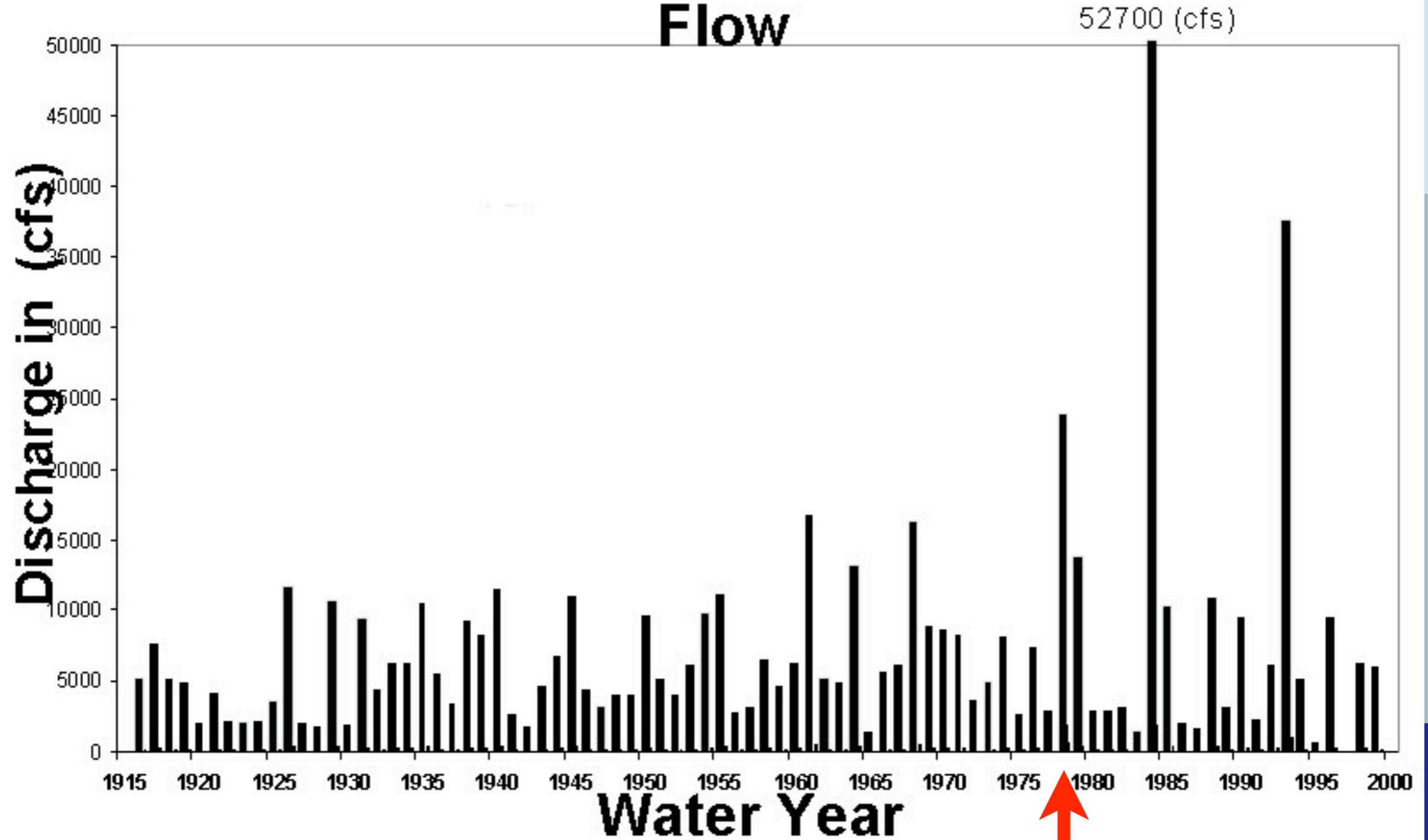
Santa Cruz at Tucson Annual Peak Flow



Gauge Shutdown in 1980

Santa Cruz at Tucson Annual Peak

Flow

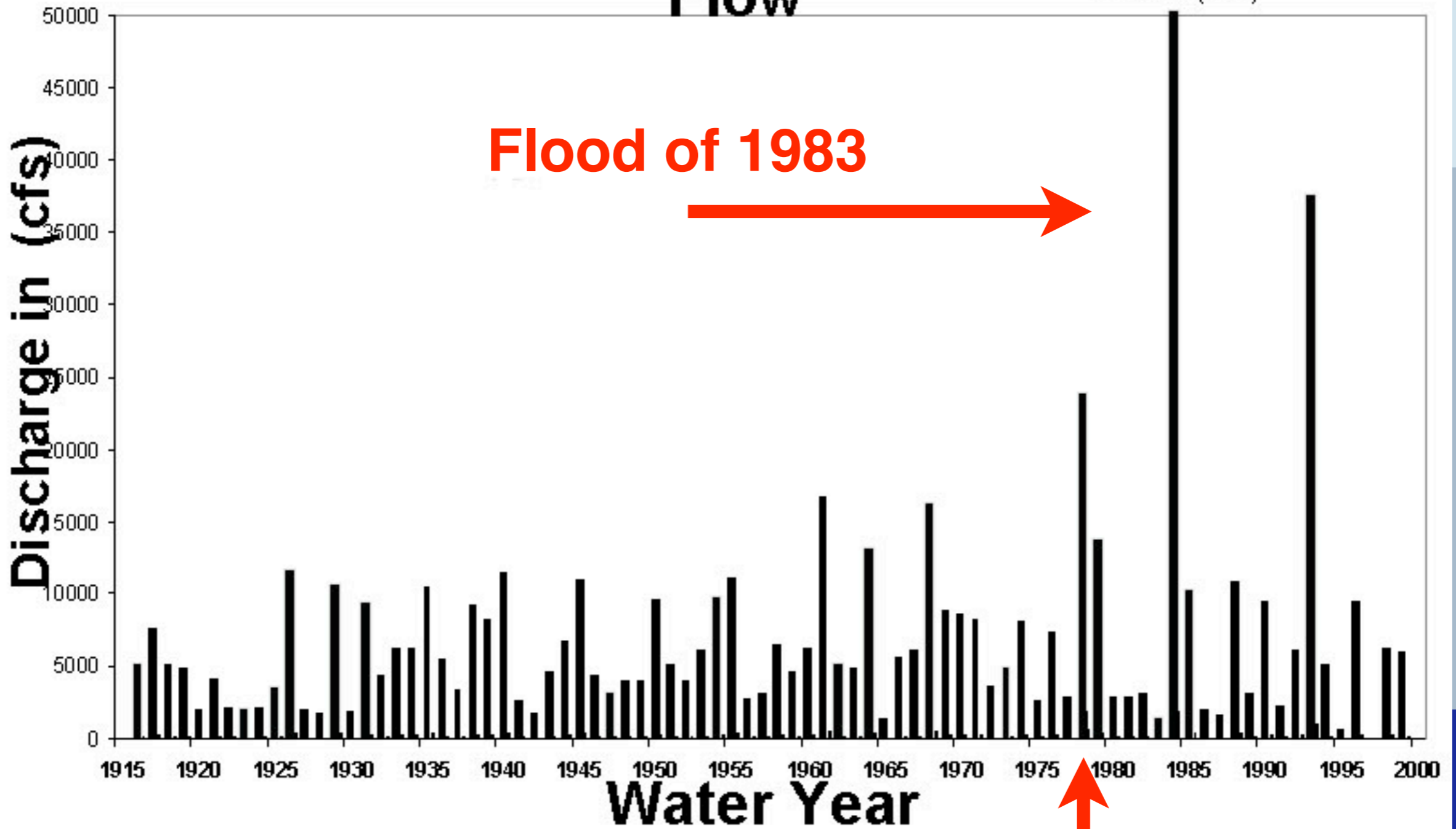


Gauge Shutdown in 1980

Santa Cruz at Tucson Annual Peak

Flow

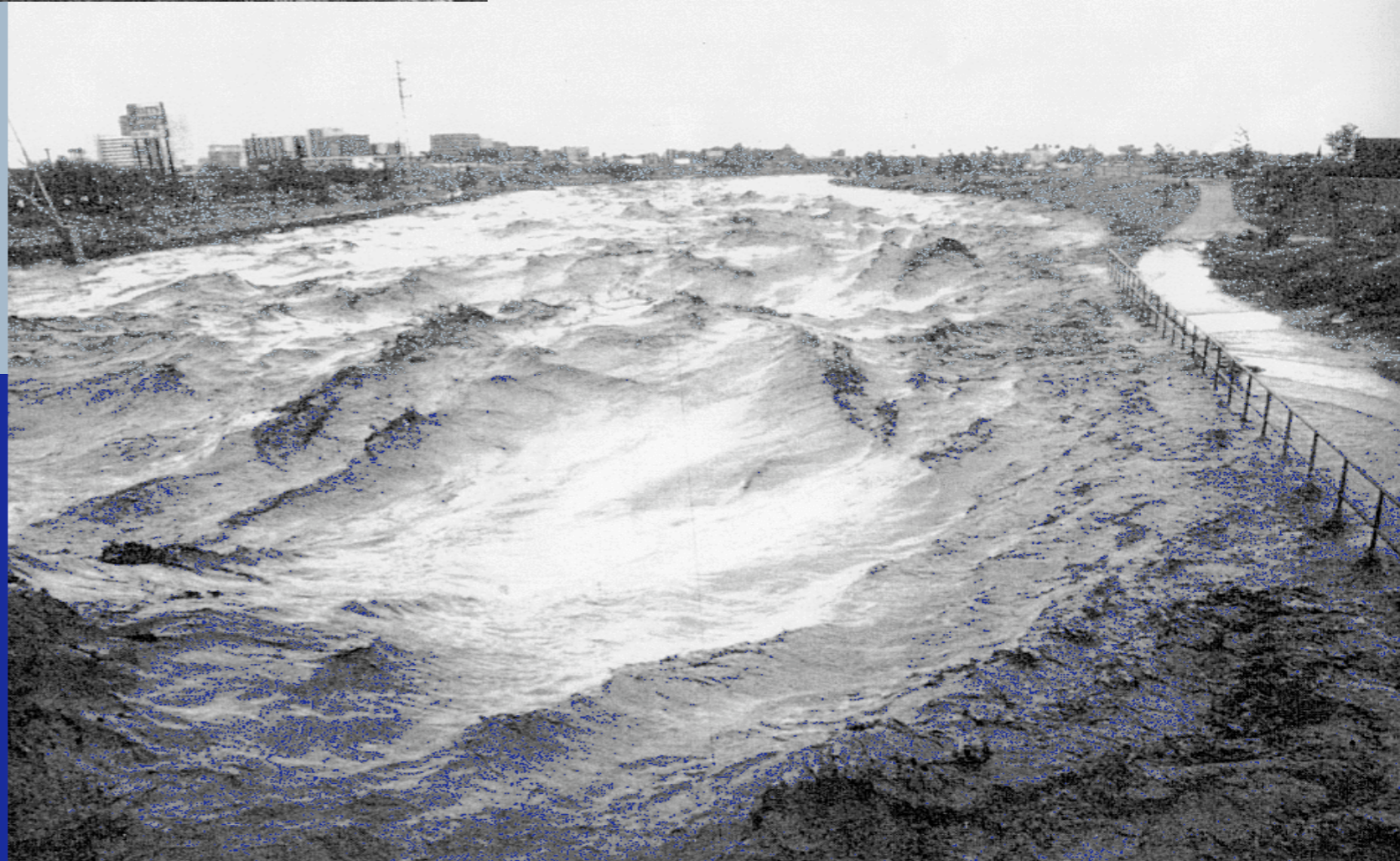
52700 (cfs)



Gauge Shutdown in 1980

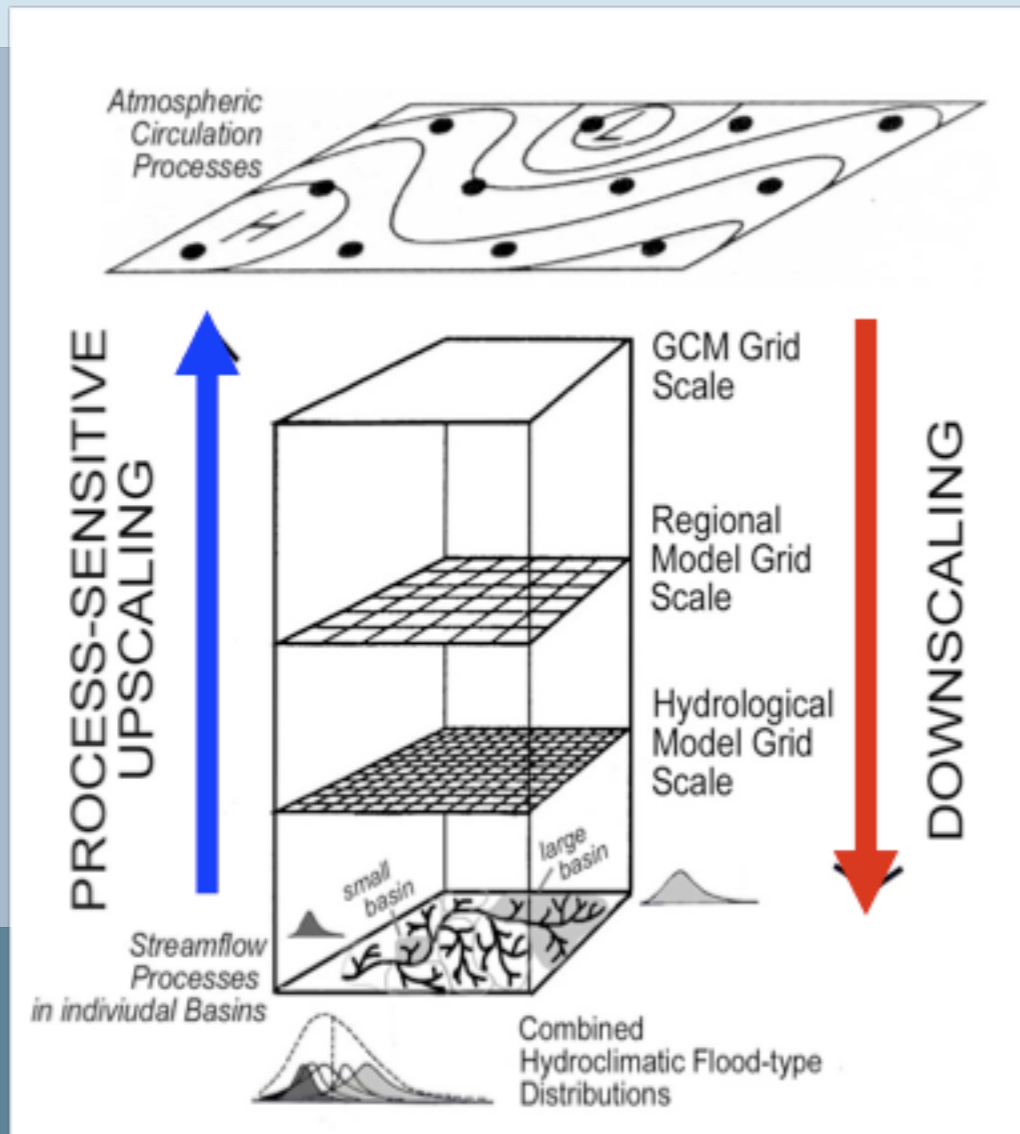


Santa Cruz River



1983 Flood

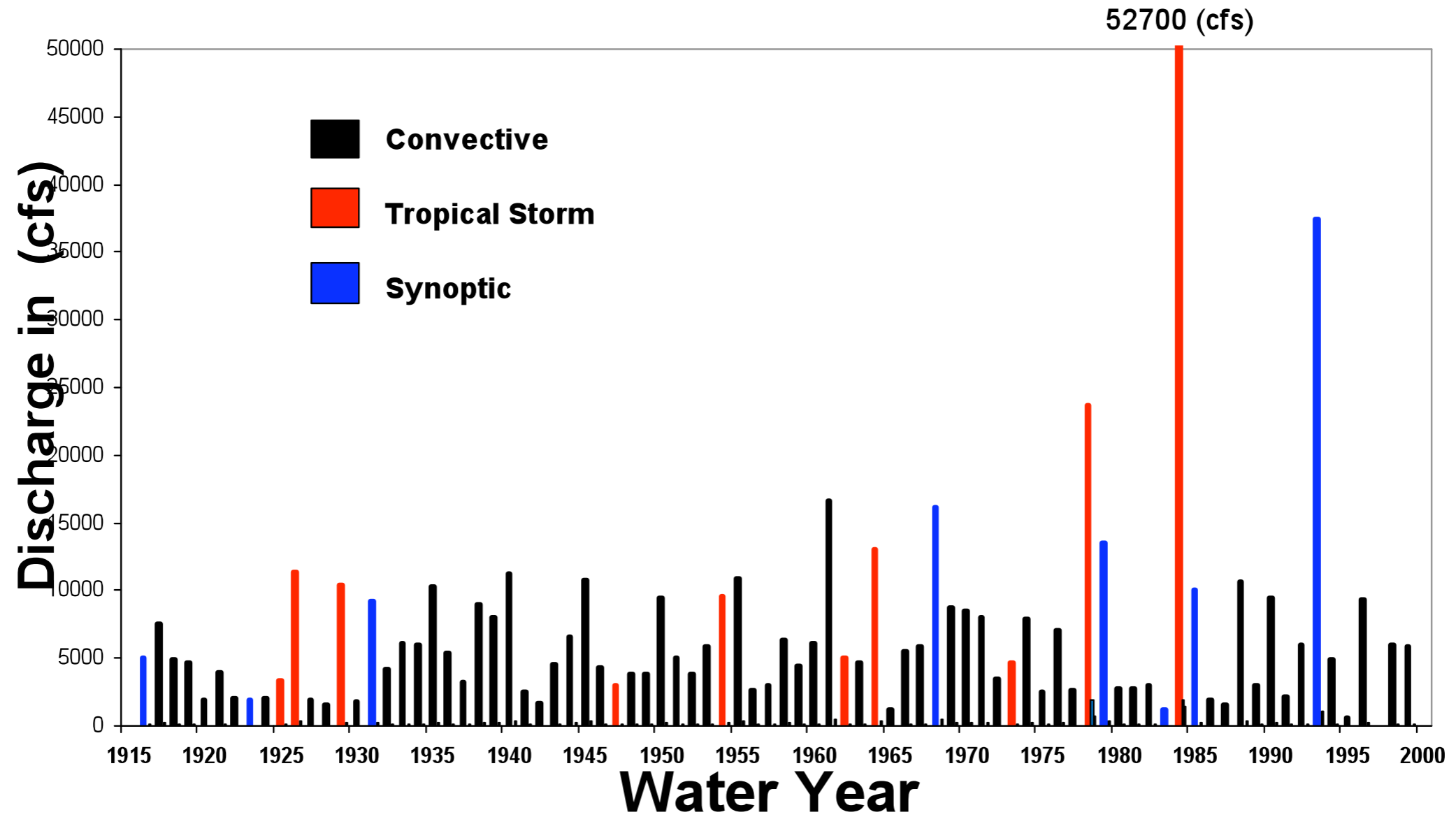
Watershed Upscaling



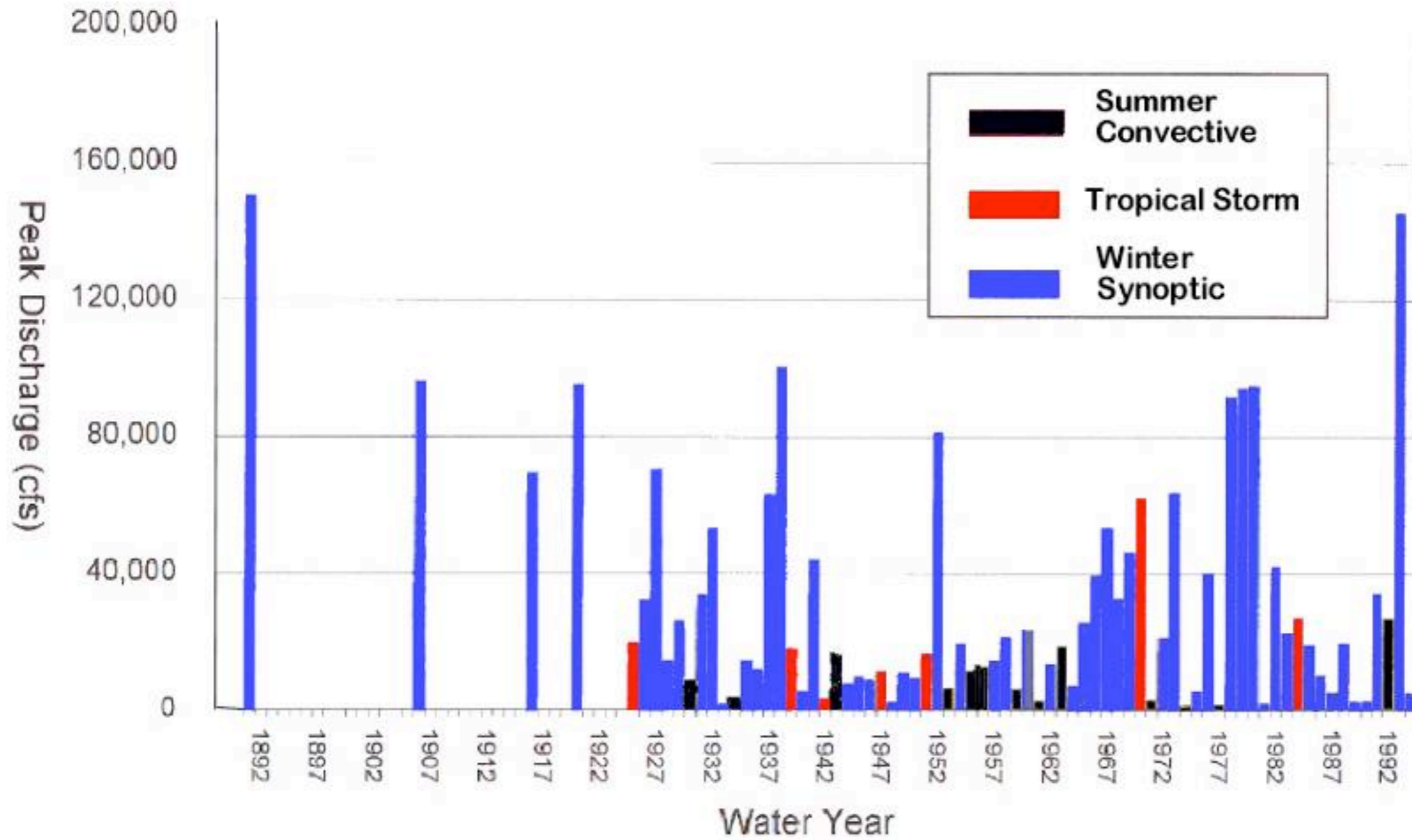
(Hirschboeck, 1988)

- Linking climate, weather and flood information across spatial and temporal scales is needed
- The flood hydroclimatology database will allow a process-sensitive upscaling approach that complements traditional downscaling approaches from General Circulation Models
- This “bottom up” approach can more directly involve flood managers working at watershed scales

Santa Cruz at Tucson



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



Data Sources

- Peaks-above-base data from U.S. Geological Survey dating back to 1915
- Supplementary data from National Weather Bureau, National Oceanic and Atmospheric Administration, NCAR/NCEP Reanalysis, and other sources

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	DESCRIPTION:				SYNOPTIC CLASSIFICATION			A= annual flood		STATION CODE		** Hurricane/ Tropical Storm designation based on W.K. Smith NOAA Pub.	
2	This worksheet combines the annual and partial series peaks for all 4 Santa Cruz gages, listed in chronological order from the earliest station record thru 2005				1 = Tropical Storm-related 2 = Convective storm 3 = Synoptic storm (1.2 or 3.2 = w/ cutoff low)			P = partial series flood		9480000 Santa Cruz nr Lochiel 9480500 Santa Cruz nr Nogales 9482000 Santa Cruz at Continental 9482500 Santa Cruz at Tucson			
7	WYEAR	CYEAR	MONTH	DAY	SYNOP	Q (CFS)	SERIES	STATION	Prior Days	Flood Date	Afterward	COMMENTS	
635	1981	1981	8	31	3	805	P	9480000					
636	1981	1981	9	3	2	789	P	9480000					
637	1981	1981	9	3	2	3220	A	9480500					
638	1981	1981	9	5	2	3350	A	9482000					
639	1981	1981	9	5	2	2660	P	9482500					
640	1981	1981	9	5	2	2660	P	9482500					
641	1982	1981	10	2	3.2	1620	A	9480500					
642	1982	1982	7	30	2	670	P	9480000					
643	1982	1982	8	11	2	2640	A	9480000					
644	1982	1982	8	15	2	2160	A	9482000					
645	1983	1982	12	10	3.2	4440	P	9480500					
646	1983	1983	1	30	3	3840	P	9480500					
647	1983	1983	2	3	3	613	P	9480000					
648	1983	1983	2	4	3	6410	A	9480500					
649	1983	1983	2	4	3	4800	A	9482000					
650	1983	1983	3	4	3.2	1120	A	9480000					
651	1983	1983	3	4	3.2	4460	P	9480500					
652	1983	1983	9	22	3.2?	563	P	9480000					
653	1983	1983	9	22	3.2?	3950	P	9482000					
654	1984	1983	10	2	1.2	3880	P	9480000				Tropical Storm Octave :September 27-October 2 ,1983	
655	1984	1983	10	2	1.2	16200	A	9480500				Tropical Storm Octave :September 27-October 2 ,1983	
656	1984	1983	10	2	1.2	45000	A	9482000				Tropical Storm Octave :September 27-October 2 ,1983	
657	1984	1983	10	2	1.2	52700	A	9482500				Tropical Storm Octave :September 27-October 2 ,1983	
658	1984	1984	6	30	3	2200	P	9480500					
659	1984	1984	7	17	2	1200	P	9480000					
660	1984	1984	7	17	2	4200	P	9482000					
661	1984	1984	7	18	2	2800	P	9480500					
662	1984	1984	7	21	2	3070	P	9480000					
663	1984	1984	7	21	2	3500	P	9480500					
664	1984	1984	7	21	2	3500	P	9480500					
665	1984	1984	7	21	2	2590	P	9482000					
666	1984	1984	7	23	2	803	P	9480000					
667	1984	1984	7	28	2	1240	P	9480000					
668	1984	1984	7	29	2	813	P	9480000					
669	1984	1984	8	9	2	2400	P	9480000					
670	1984	1984	8	10	2	4100	P	9480500					
671	1984	1984	8	10	2	4100	P	9480500					
672	1984	1984	8	10	2	3410	P	9482000					
673	1984	1984	8	13	2	4220	P	9480000					
674	1984	1984	8	13	2	4980	P	9480500					
675	1984	1984	8	13	2	4980	P	9480500					
676	1984	1984	8	13	2	4200	P	9482000					

Weather-Scale Context

Tropical Storm Octave 9/27 - 10/2 1983

Tropical Storm Octave :September 27-October 2 ,1983

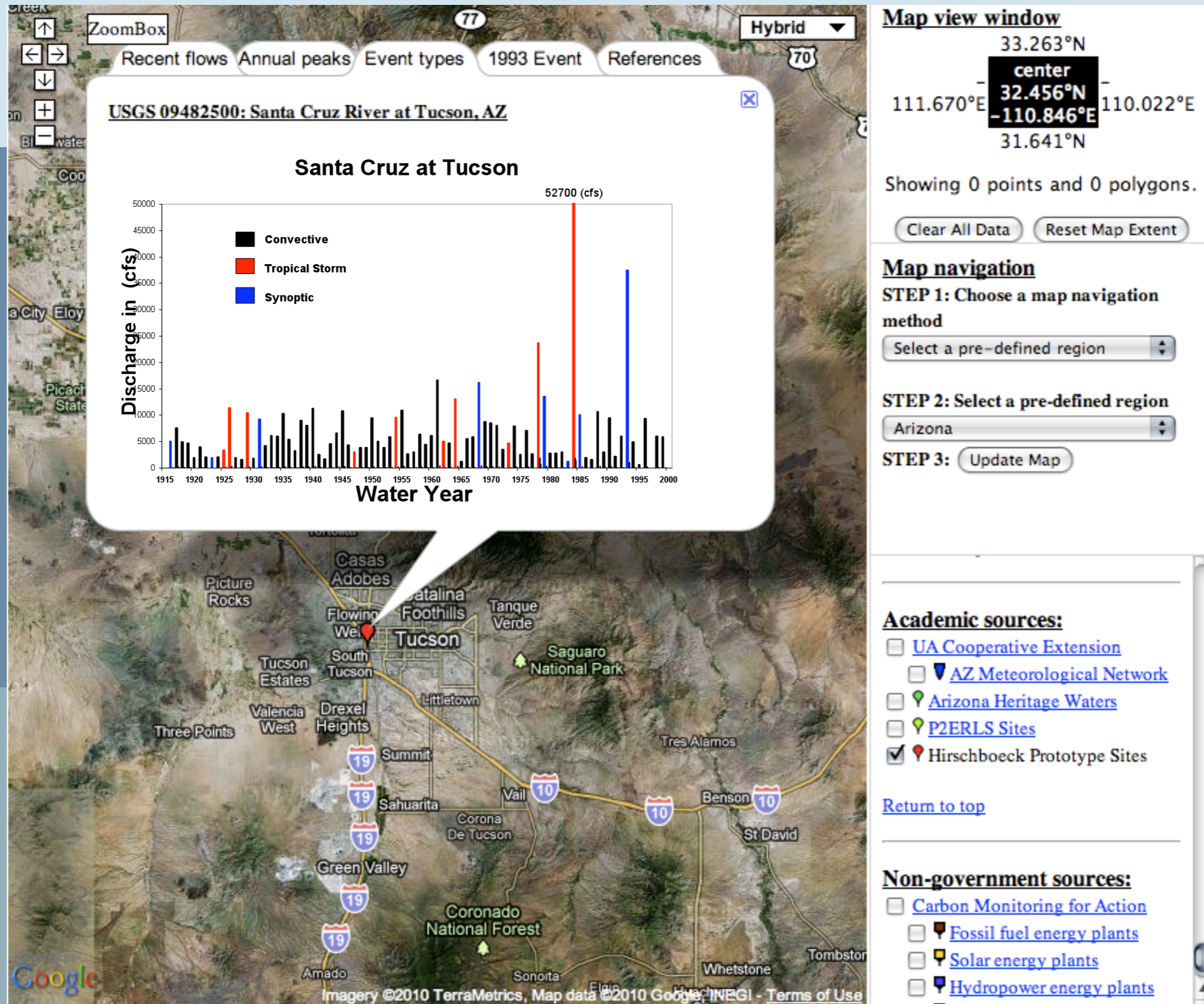
Tropical Storm Octave :September 27-October 2 ,1983

NCEP/NCAR Reanalysis
500mb Geopotential Height (m) Composite Anomaly 1968-1996 climo

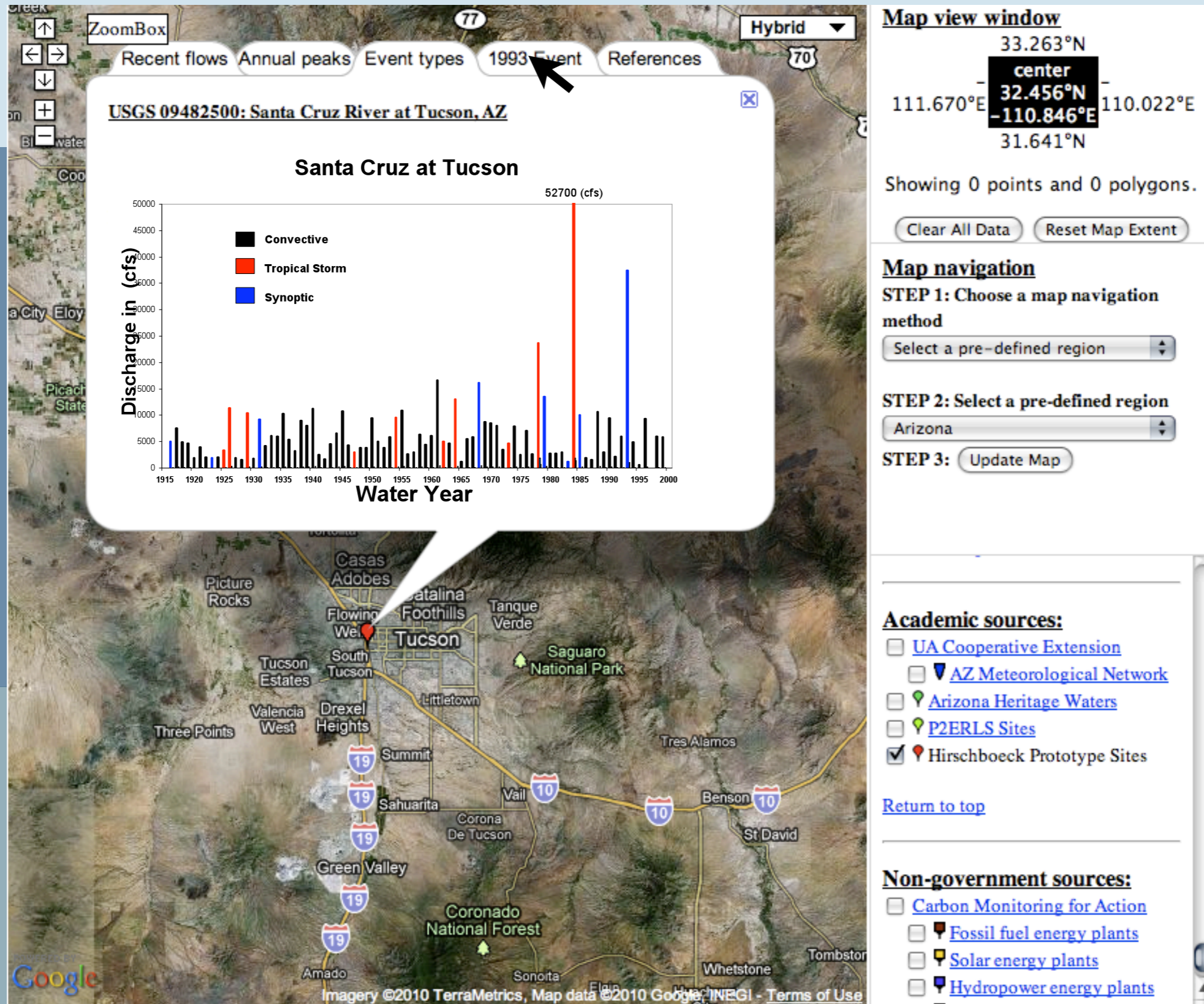
SOI vs. PNA

Legend: Low Flow Years (orange), High Flow Years (blue)

Interactive Map



Interactive Map



Interactive Map

The screenshot displays an interactive map interface for the Santa Cruz River at Tucson, AZ. The main map is a satellite-style map showing the river and surrounding areas. A white callout box in the center contains a detailed topographic map of the river area, with a red dot indicating the location of the river at Tucson. The callout box is titled "USGS 09482500: Santa Cruz River at Tucson, AZ" and includes a "ZoomBox" and navigation controls. The sidebar on the right contains several sections:

- Map view window:** Displays coordinates for the center of the map: 33.263°N, 111.670°E, 32.456°N, -110.846°E, and 31.641°N. It also shows "Showing 0 points and 0 polygons." and buttons for "Clear All Data" and "Reset Map Extent".
- Map navigation:** Includes a dropdown menu for "Select a pre-defined region" and a "Update Map" button.
- Academic sources:** A list of sources with checkboxes: UA Cooperative Extension, AZ Meteorological Network, Arizona Heritage Waters, P2ERLS Sites, and Hirschboeck Prototype Sites (checked).
- Non-government sources:** A list of sources with checkboxes: Carbon Monitoring for Action, Fossil fuel energy plants, Solar energy plants, and Hydropower energy plants.

At the bottom of the map, there is a "Return to top" link and a "Google" logo. The footer text reads: "Imagery ©2010 TerraMetrics, Map data ©2010 Google, INEGI - Terms of Use".

Interactive Map

The screenshot displays an interactive map interface. At the top, there are navigation controls including a 'ZoomBox' with directional arrows and a 'Hybrid' map style selector. Below these are tabs for 'Recent flows', 'Annual peaks', 'Event types', '1993 Event', and 'References'. A central white box contains a detailed map titled 'USGS 09482500: Santa Cruz River at Tucson, AZ', showing contour lines and a grid. Two blue arrows point horizontally from this box towards the right. To the right of the main map is a control panel with the following sections:

- Map view window**: Displays coordinates: 33.263°N, center 32.456°N, -110.846°E, 110.022°E, 31.641°N. Below the coordinates, it says 'Showing 0 points and 0 polygons.' and includes buttons for 'Clear All Data' and 'Reset Map Extent'.
- Map navigation**:
 - STEP 1: Choose a map navigation method. A dropdown menu shows 'Select a pre-defined region'.
 - STEP 2: Select a pre-defined region. A dropdown menu shows 'Arizona'.
 - STEP 3: An 'Update Map' button.
- Academic sources:**
 - [UA Cooperative Extension](#)
 - [AZ Meteorological Network](#)
 - [Arizona Heritage Waters](#)
 - [P2ERLS Sites](#)
 - [Hirschboeck Prototype Sites](#)
- [Return to top](#)
- Non-government sources:**
 - [Carbon Monitoring for Action](#)
 - [Fossil fuel energy plants](#)
 - [Solar energy plants](#)
 - [Hydropower energy plants](#)

The main map shows a satellite view of Tucson, Arizona, with various neighborhoods and landmarks labeled, including Picture Rocks, Casas Adobes, Catalina Foothills, Tanque Verde, Saguaro National Park, Tucson Estates, South Tucson, Littletown, Summit, Sahuarita, Corona De Tucson, Green Valley, Coronado National Forest, Amado, Sonora, Whetstone, Tombstone, Benson, and St David. Major highways like I-19 and I-10 are also visible. The Google logo is in the bottom left corner, and copyright information for TerraMetrics and Google is at the bottom.

Interactive Map

The screenshot displays an interactive map interface. At the top, there are navigation controls including a 'ZoomBox' with zoom in/out arrows, a 'Hybrid' map style selector, and a menu with options: 'Recent flows', 'Annual peaks', 'Event types', '1993 Event', and 'References'. A central pop-up window titled 'USGS 09482500: Santa Cruz River at Tucson, AZ' contains a topographic map with contour lines and labels for 'LOW' and 'HIGH' elevations. Below this window are two blue arrows pointing left and right. To the right of the main map is a 'Map view window' showing coordinates: 33.263°N, center 32.456°N, -110.846°E, and 31.641°N. Below the coordinates, it says 'Showing 0 points and 0 polygons.' and includes 'Clear All Data' and 'Reset Map Extent' buttons. Further down is a 'Map navigation' section with three steps: 'STEP 1: Choose a map navigation method' with a dropdown menu, 'STEP 2: Select a pre-defined region' with a dropdown menu set to 'Arizona', and 'STEP 3: Update Map' button. At the bottom right, there are two sections: 'Academic sources:' with checkboxes for 'UA Cooperative Extension', 'AZ Meteorological Network', 'Arizona Heritage Waters', 'P2ERLS Sites', and 'Hirschboeck Prototype Sites' (checked); and 'Non-government sources:' with checkboxes for 'Carbon Monitoring for Action', 'Fossil fuel energy plants', 'Solar energy plants', and 'Hydropower energy plants'. The main map shows Tucson, AZ, with various neighborhoods and landmarks labeled, including 'Saguaro National Park' and 'Coronado National Forest'. The Google logo is visible in the bottom left corner.

ZoomBox Hybrid

Recent flows Annual peaks Event types 1993 Event References

USGS 09482500: Santa Cruz River at Tucson, AZ

33.263°N
center
32.456°N
-110.846°E
31.641°N

Showing 0 points and 0 polygons.

Clear All Data Reset Map Extent

Map navigation

STEP 1: Choose a map navigation method

Select a pre-defined region

STEP 2: Select a pre-defined region

Arizona

STEP 3: Update Map

Academic sources:

- UA Cooperative Extension
- AZ Meteorological Network
- Arizona Heritage Waters
- P2ERLS Sites
- Hirschboeck Prototype Sites

[Return to top](#)

Non-government sources:

- Carbon Monitoring for Action
- Fossil fuel energy plants
- Solar energy plants
- Hydropower energy plants

Google Imagery ©2010 TerraMetrics, Map data ©2010 Google, INEGI - Terms of Use

Interactive Map

The screenshot displays an interactive map interface for the Santa Cruz River at Tucson, AZ. The main map shows a satellite view of the Tucson area with a red pin marking the river location. A white callout box is open, showing a detailed topographic map of the river area with contour lines and labels for 'LOW' and 'HIGH' water levels. The callout box has a title 'USGS 09482500: Santa Cruz River at Tucson, AZ' and a close button. Below the callout box, two blue arrows point left and right, indicating navigation options. The sidebar on the right contains several sections: 'Map view window' with coordinates (33.263°N, 111.670°E, 32.456°N, 31.641°N, -110.846°E, 110.022°E) and buttons for 'Clear All Data' and 'Reset Map Extent'; 'Map navigation' with steps for choosing a navigation method, selecting a pre-defined region (currently 'Arizona'), and an 'Update Map' button; 'Academic sources' with a list of checkboxes for various sources, including 'Hirschboeck Prototype Sites' which is checked; and 'Non-government sources' with a list of checkboxes for energy plants.

Map view window

33.263°N
center
32.456°N
-110.846°E
111.670°E 110.022°E
31.641°N

Showing 0 points and 0 polygons.

Clear All Data Reset Map Extent

Map navigation

STEP 1: Choose a map navigation method

Select a pre-defined region

STEP 2: Select a pre-defined region

Arizona

STEP 3: Update Map

Academic sources:

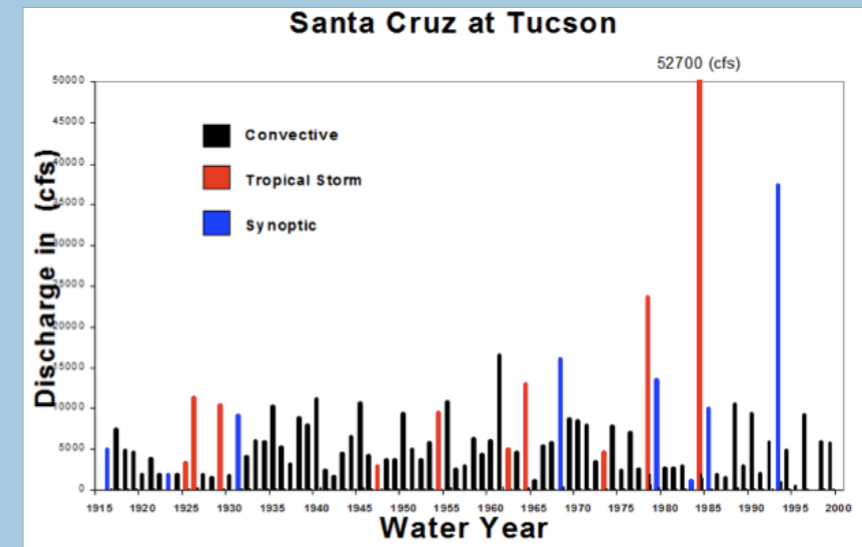
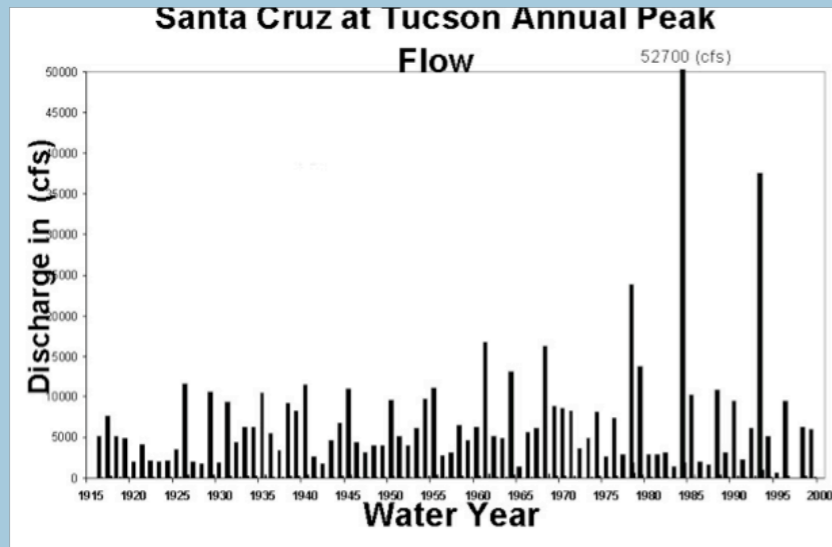
- UA Cooperative Extension
- AZ Meteorological Network
- Arizona Heritage Waters
- P2ERLS Sites
- Hirschboeck Prototype Sites

[Return to top](#)

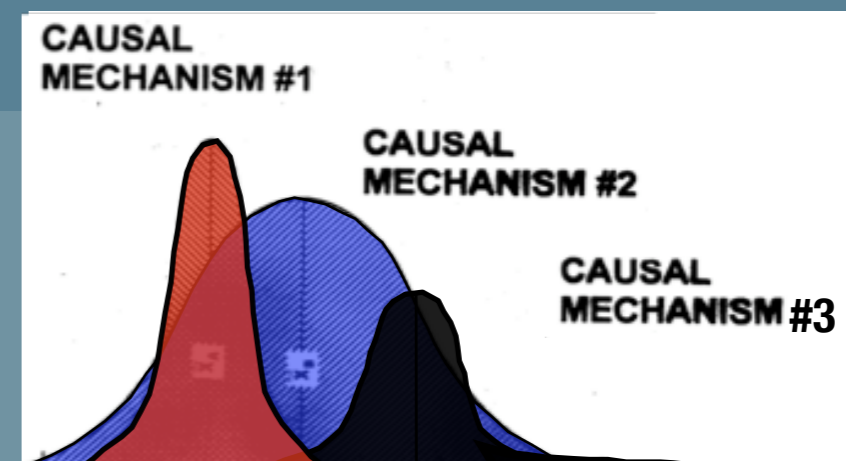
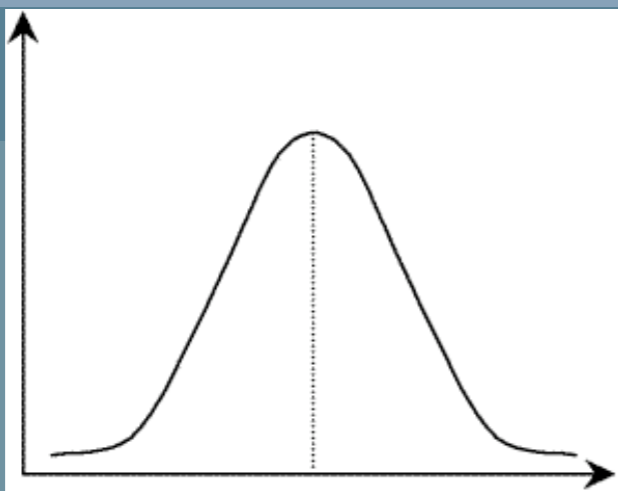
Non-government sources:

- Carbon Monitoring for Action
- Fossil fuel energy plants
- Solar energy plants
- Hydropower energy plants

Causal Relationships



- Each flood in database is classified by causal mechanism and linked to larger climatic drivers
- Natural variability in the gauged record is sensitive to changes in seasonality and locations of storms, resulting in variation in flood frequency, magnitude, and duration
- Future flooding will be driven by same causal mechanisms, however, global climate change will affect local and regional atmospheric circulation patterns driving these mechanisms

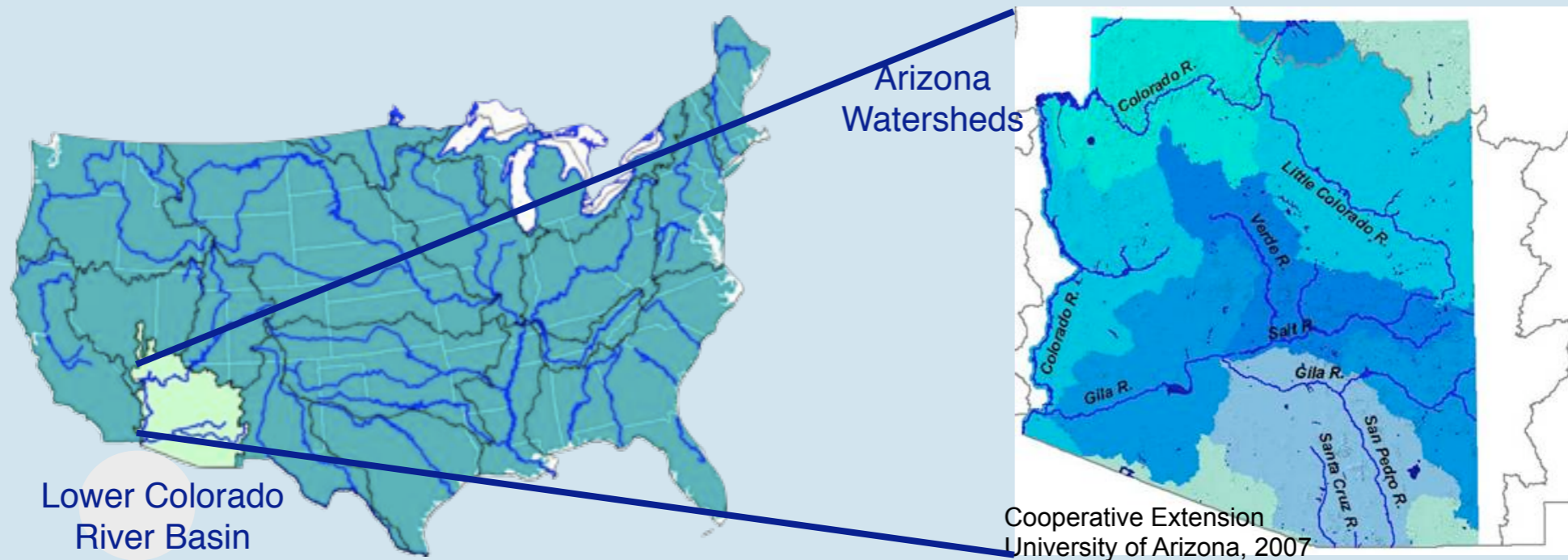


Methods I

Data assessment will include:

- Visually assessment of weather maps and reanalysis images
- Manually categorizing historical flood data by storm type
- Creating probability distribution functions for each category using log Pearson type III distribution

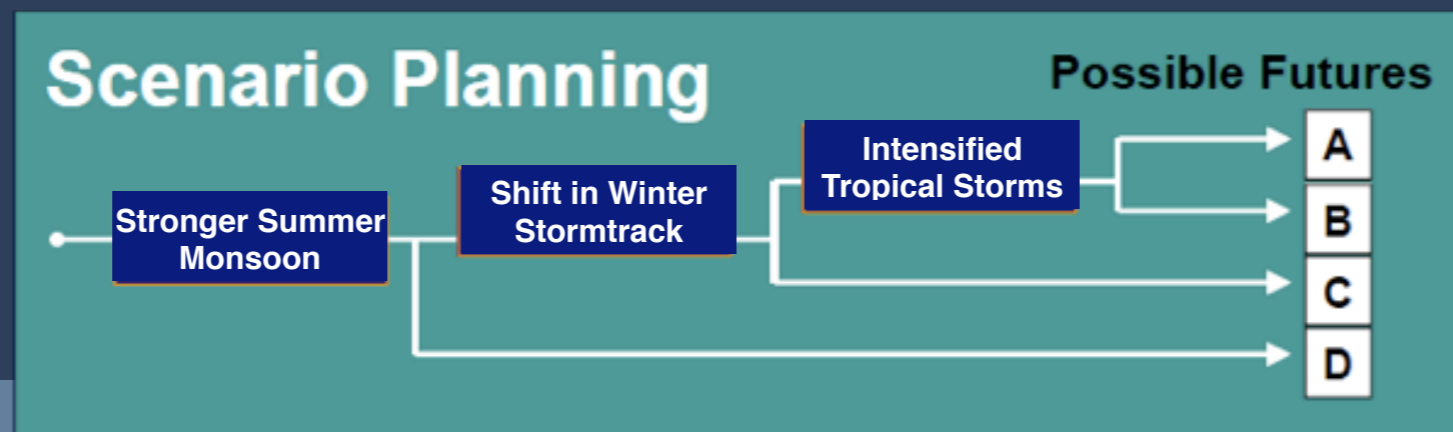
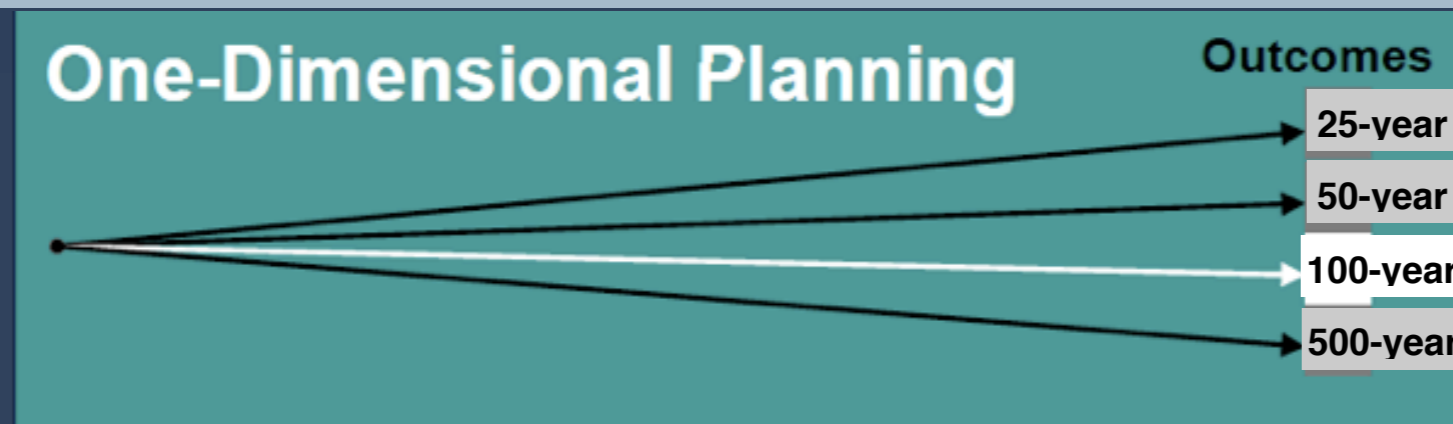
Study Area



- In Arizona, three main storm types contribute to the flooding:
 - winter synoptic events,
 - summer convective events
 - tropical storm events
- Possible future climate scenarios that could dramatically alter flooding in Arizona:
 - a poleward shift in the winter storm track, more frequent tropical storms, or an enhanced summer monsoon

Data Driven Scenarios

- A scenario is “a coherent, internally consistent and plausible description of a possible future state of the world... not a forecast; rather, each scenario is one alternative image of how the future can unfold” (IPCC, 2007)
- Scenarios can integrate large uncertainties, will be more robust and adaptable in situations where the extent of variability is unknown.
- May provide a framework for flood management and decision-making to move forward in addressing floods and climate change



Modified from Holly Hartman, SAHRA, University of Arizona

Methods II

Scenario Development:

- Adjust PDFs to input from multiple model forecasts
- Develop several scenarios of future flooding for each watershed

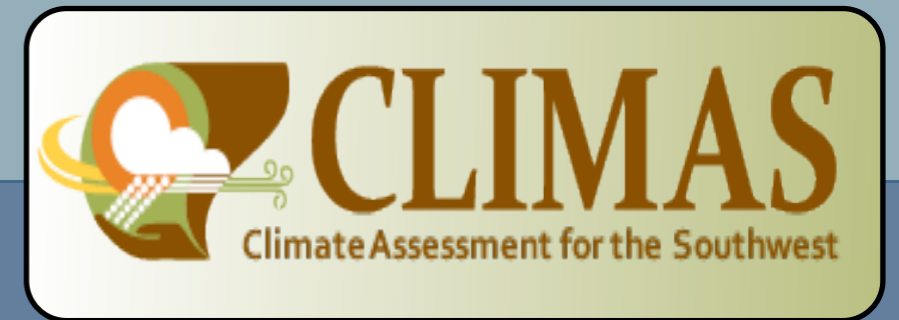
Collaboration:

- 2 workshops will be scheduled with local and region flood managers and stakeholders
- Discuss ability to incorporate data into current policy restrictions
- At what scales can data best be operationalized

Selected References

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Thank you!



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