Flood Hydroclimatology as a Flood Management Tool

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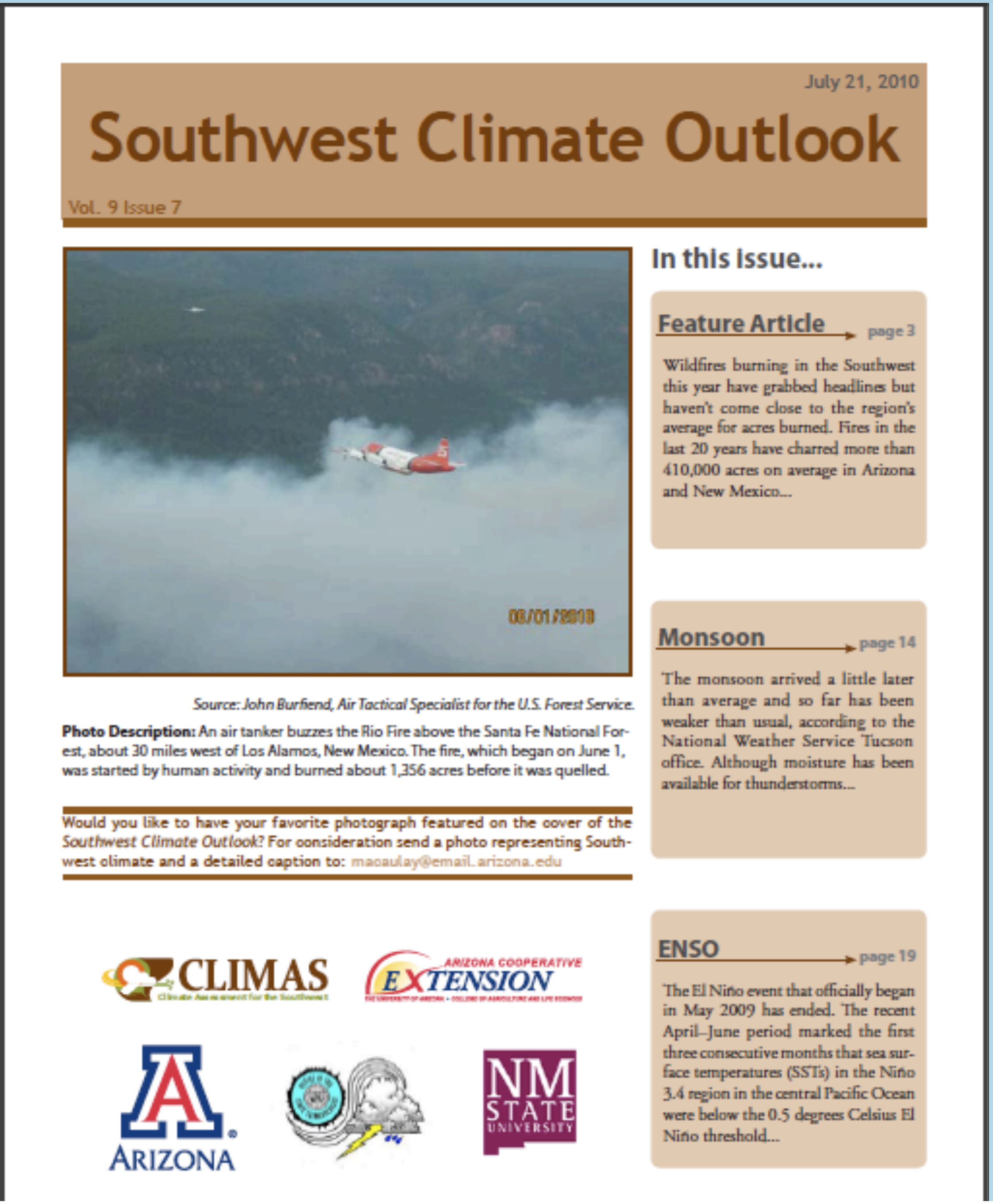
Climate Assessment for the Southwest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Source: John Burfiend, Air Tactical Specialist for the U.S. Forest Service.

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: macaulay@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...

CLIMAS Climate Assessment for the Southwest · Arizona Cooperative Extension · Arizona · NM State University

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

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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. Farfán, 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.

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 Culda
11 Pronóstico de Precipitación
12 ENOS

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

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 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

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

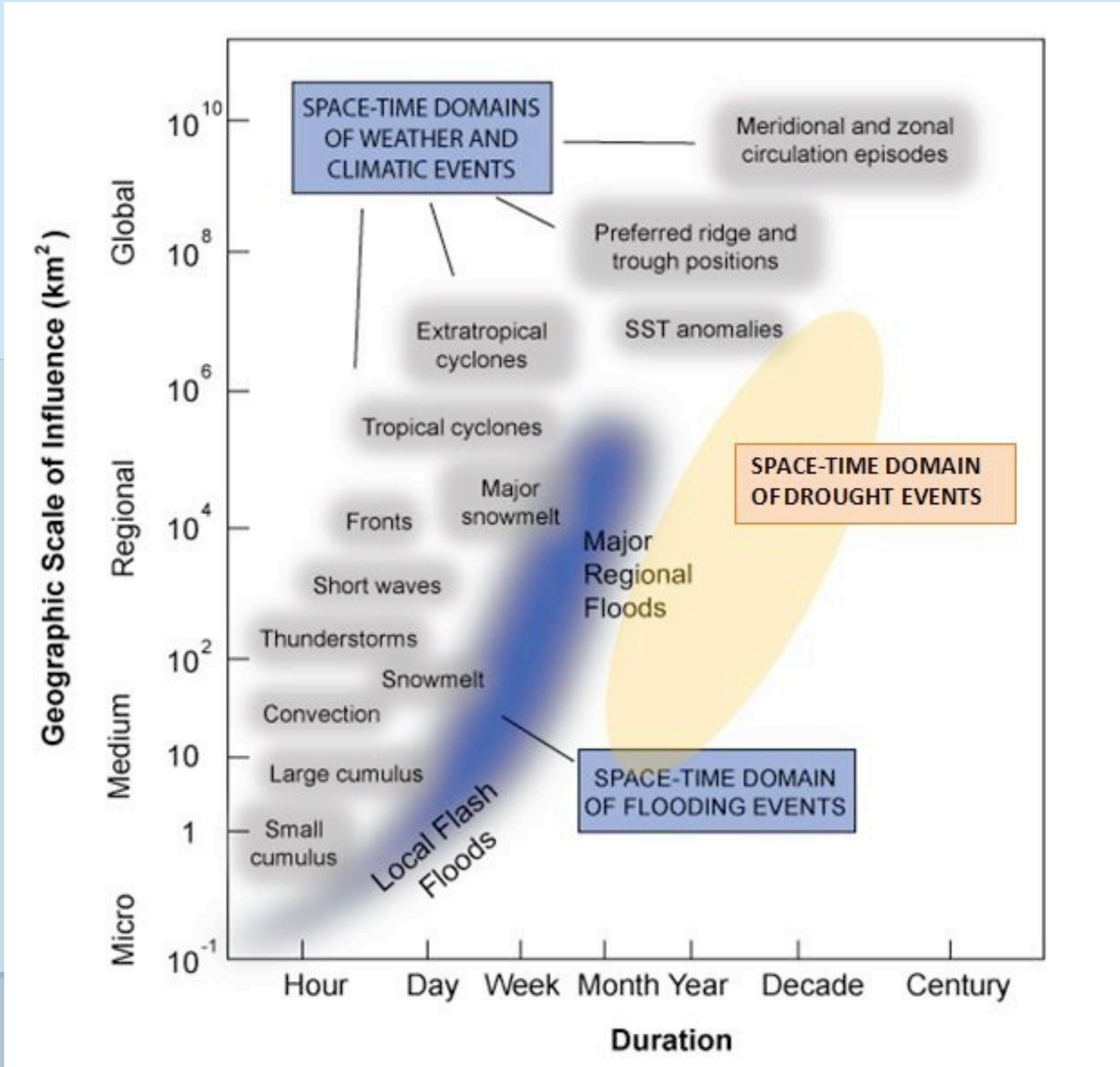
IPCC projections indicate that both droughts and floods are expected to increase with future climate change, yet those involved in the management of these two types of extreme events differ markedly in addressing this.

- 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)

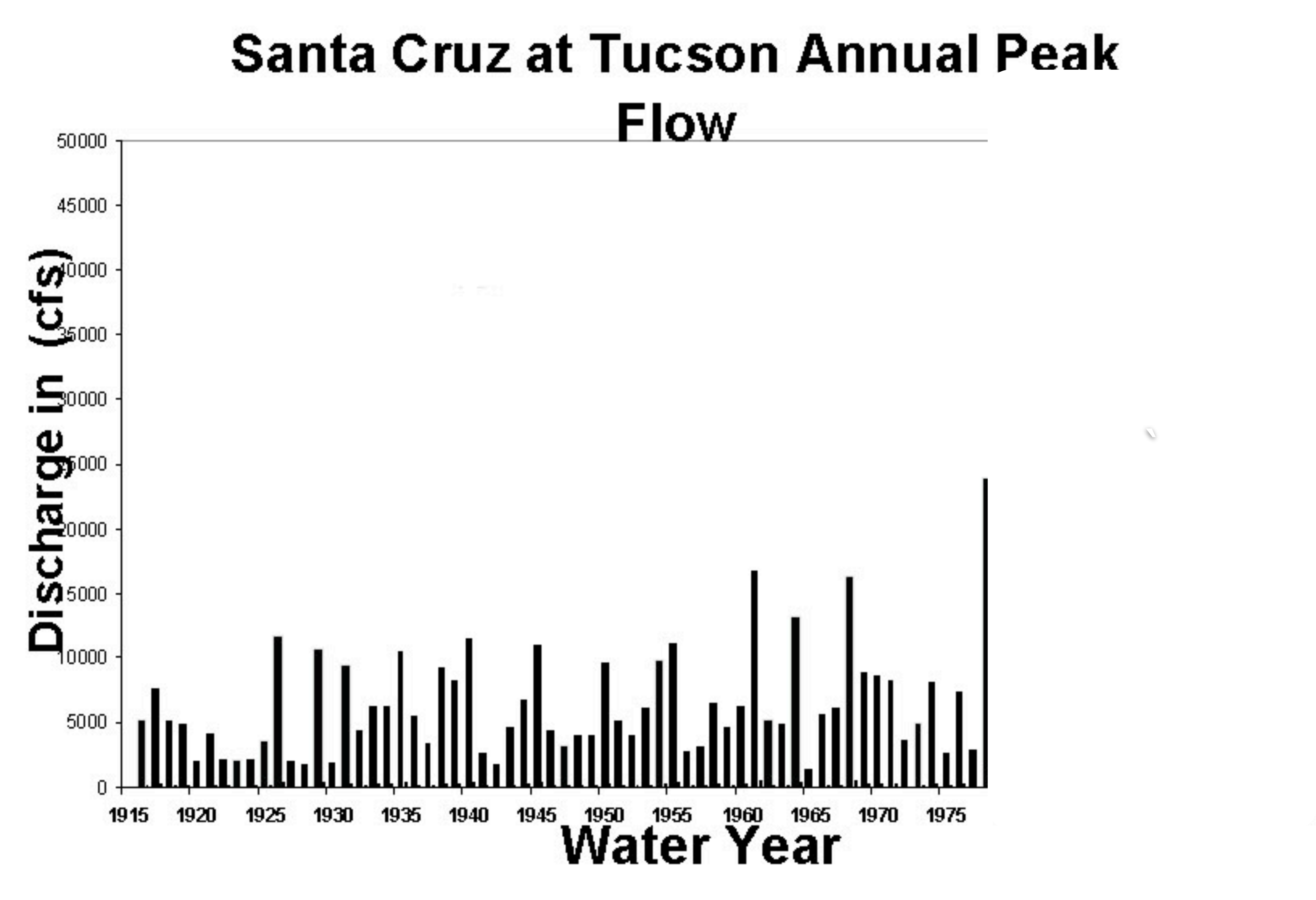
- Drought planning operates at climatic spatial & temporal scales
- Climatic variability is difficult to translate to flood management because of temporal and spatial scale mismatches
- Flood forecasters and floodplain managers are more attuned to weather-scale processes and information
- Yet, flood-generating 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

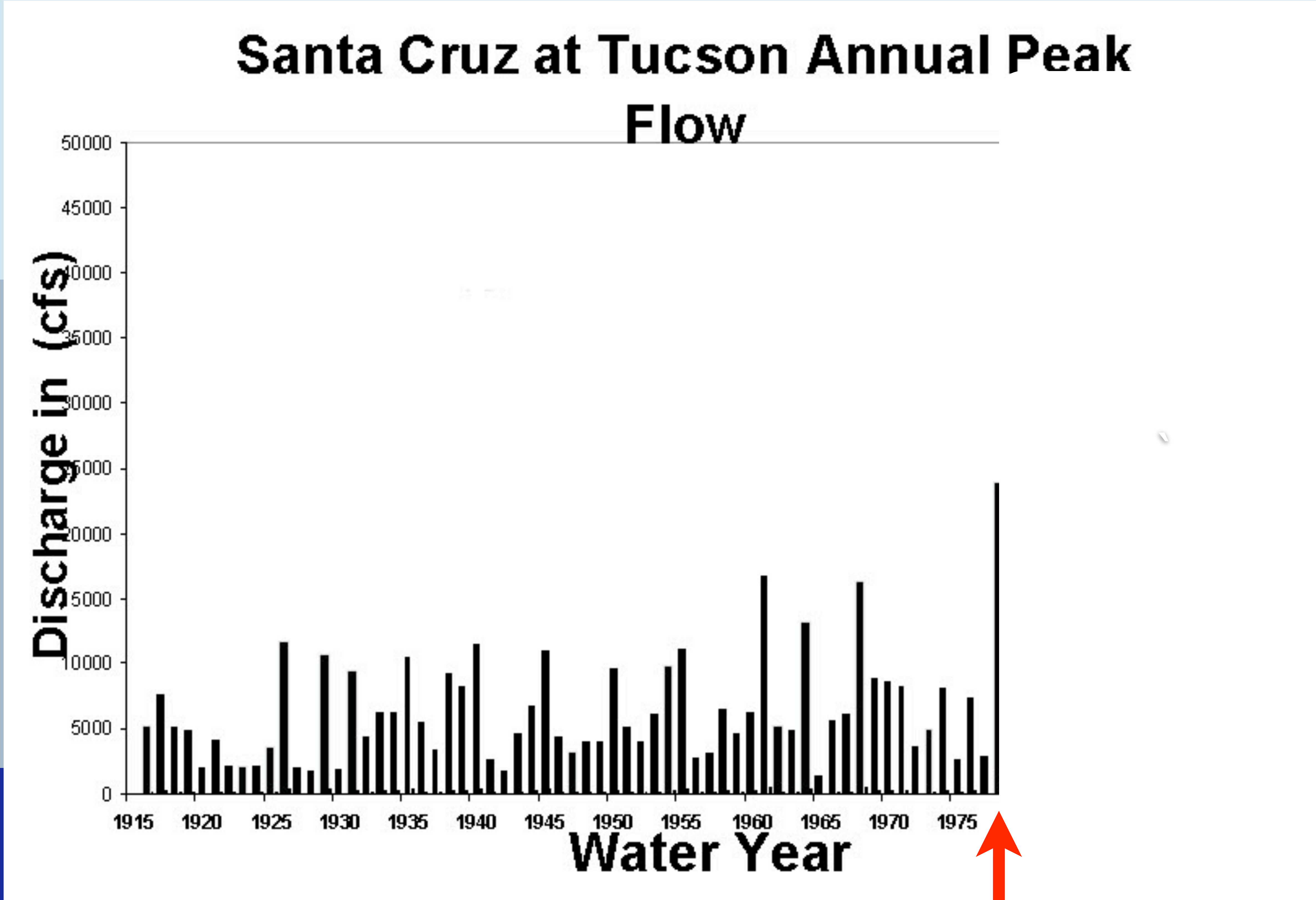
Flood Policy Shortfalls

- 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:

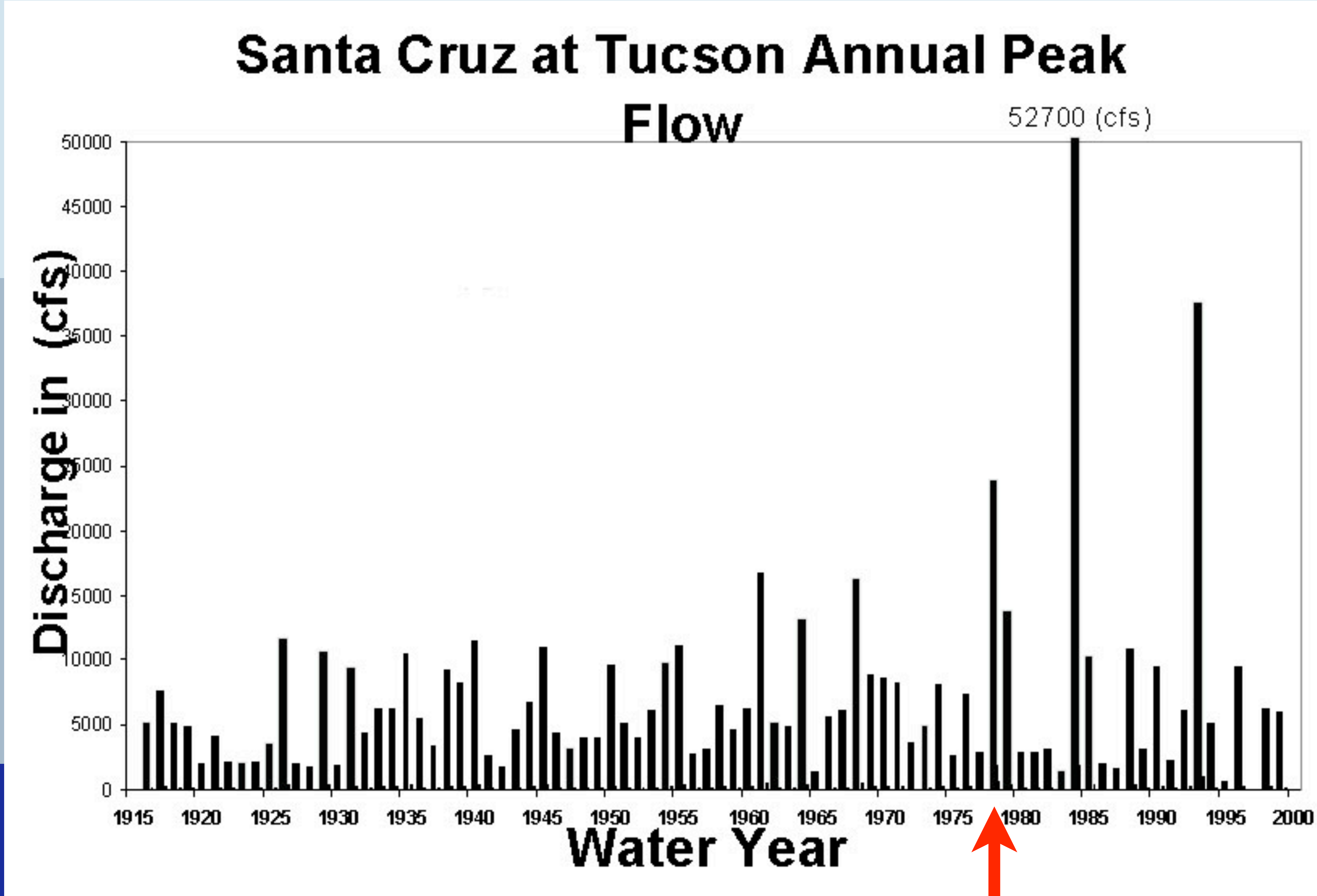
  -- are calculated assuming stationarity, "that natural systems fluctuate within an unchanging envelope of variability" (Milly et al. 2008, pp 1)

  -- 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

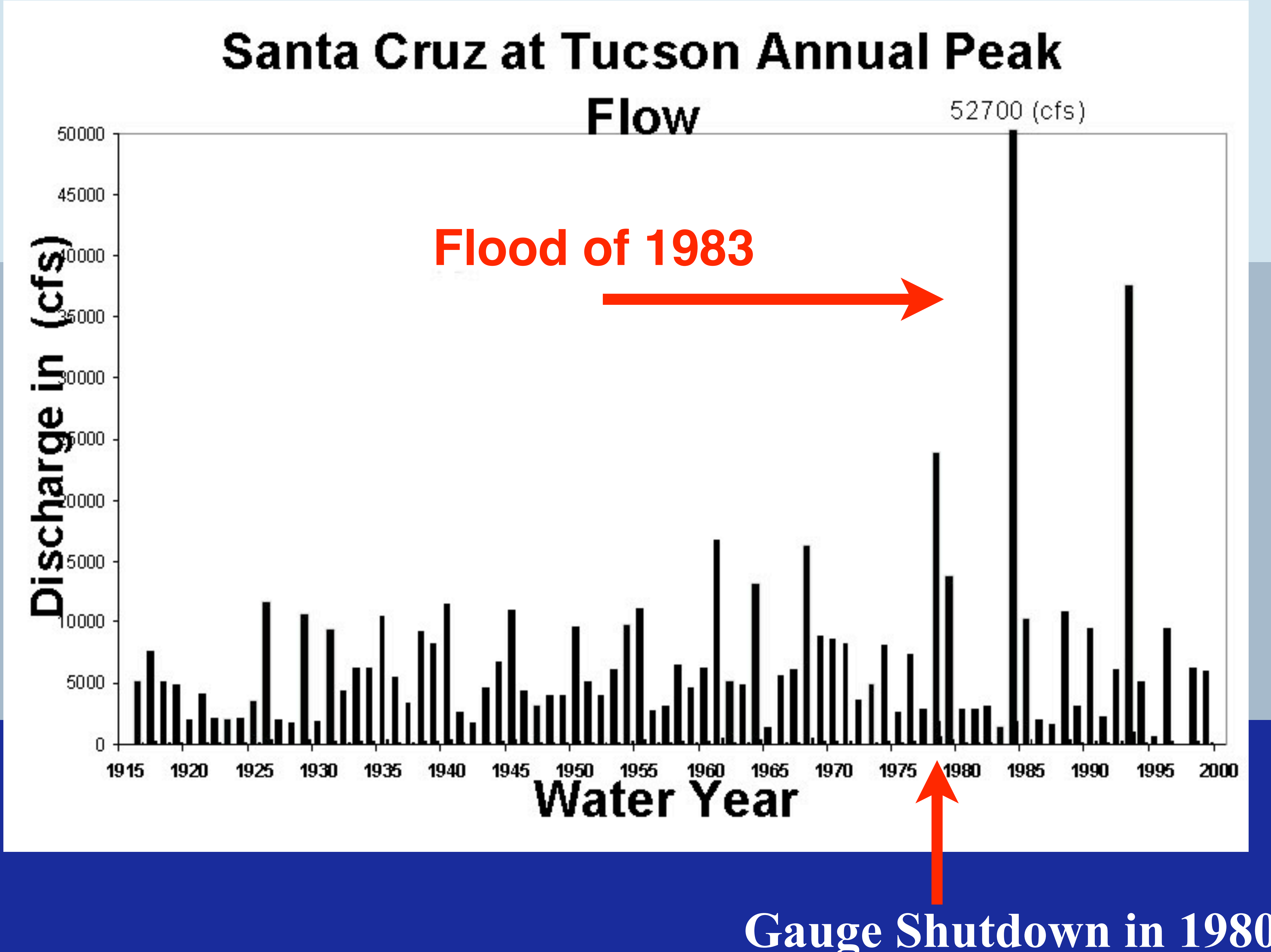

Santa Cruz at Tucson Annual Peak Flow
Discharge in (cfs)
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
Water Year



Gauge Shutdown in 1980

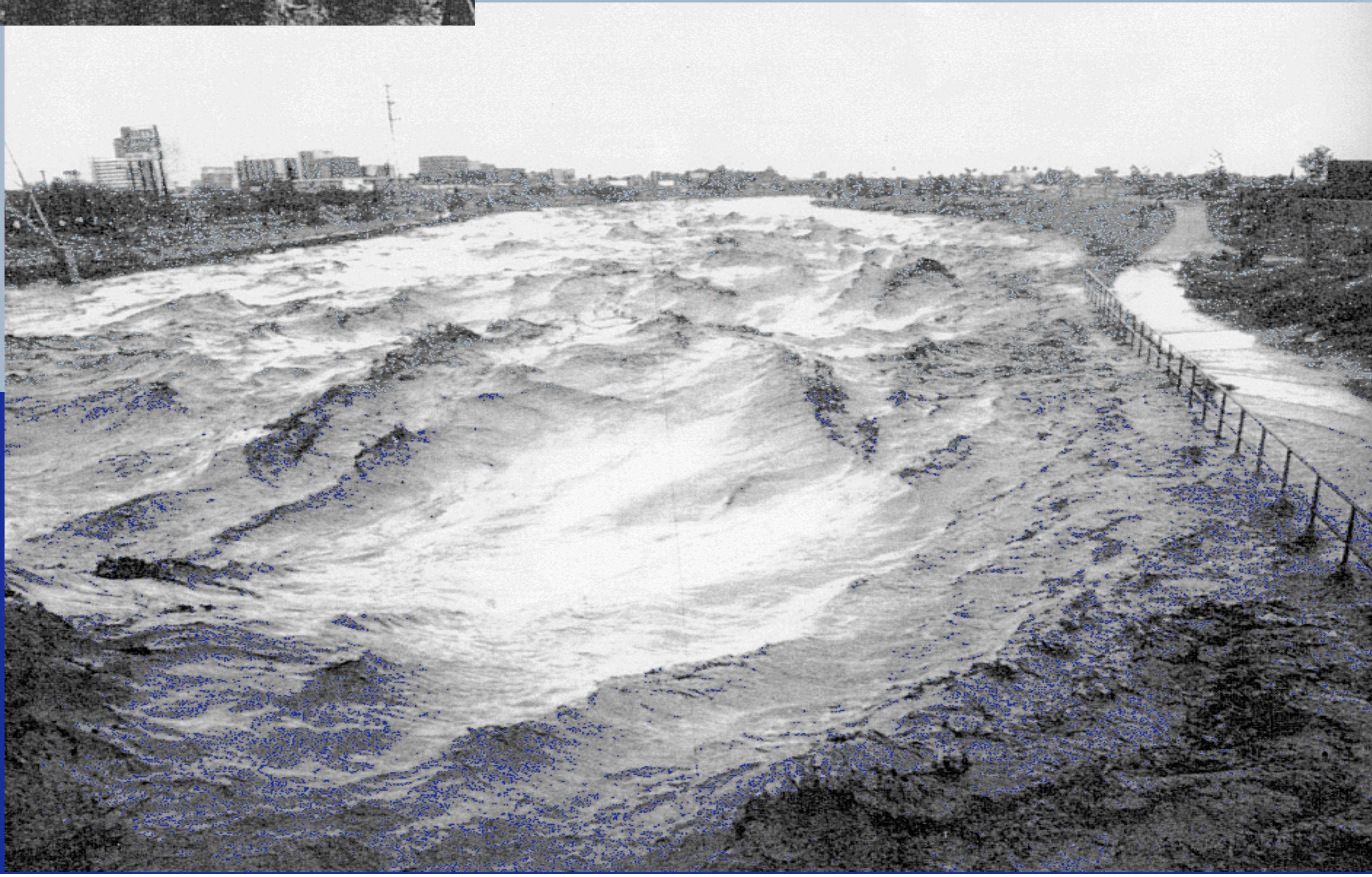


Gauge Shutdown in 1980

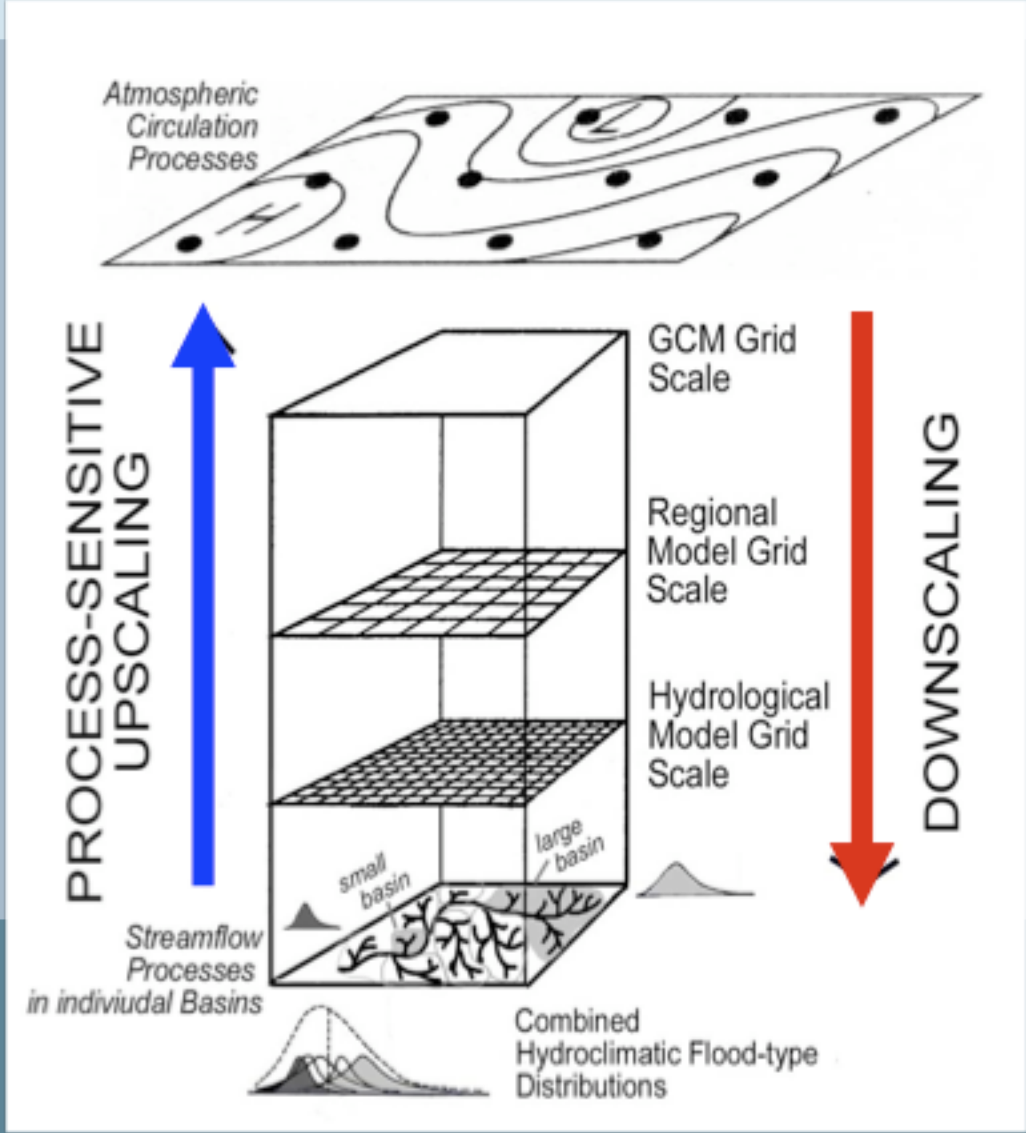

Santa Cruz at Tucson Annual Peak Flow
52700 (cfs)
Flood of 1983
Discharge in (cfs)
50000
45000
40000
35000
30000
25000
20000
15000
10000
5000
0
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
2000
Water Year
Gauge Shutdown in 1980

Santa Cruz River

1983 Flood



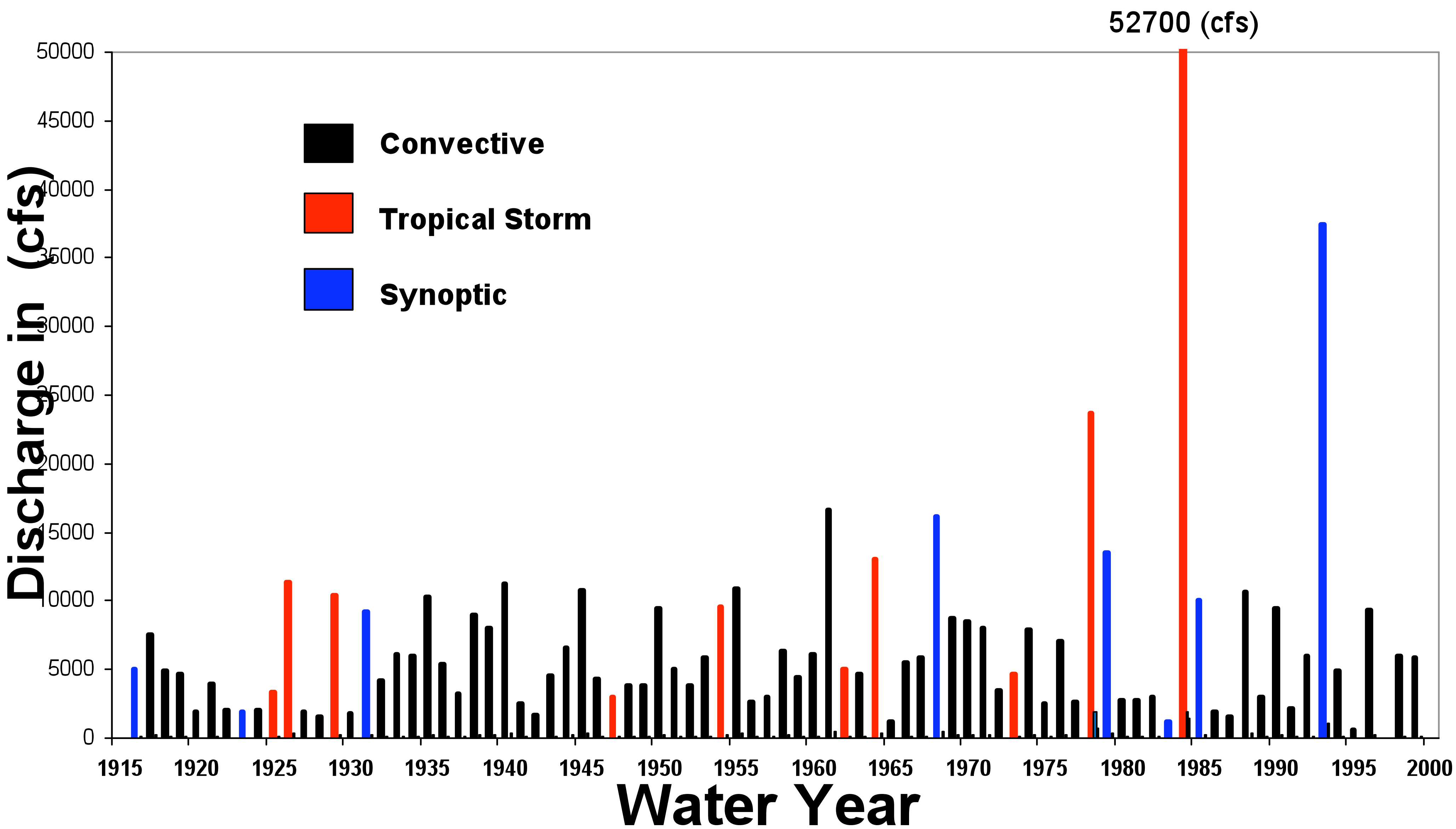
Watershed Upscaling

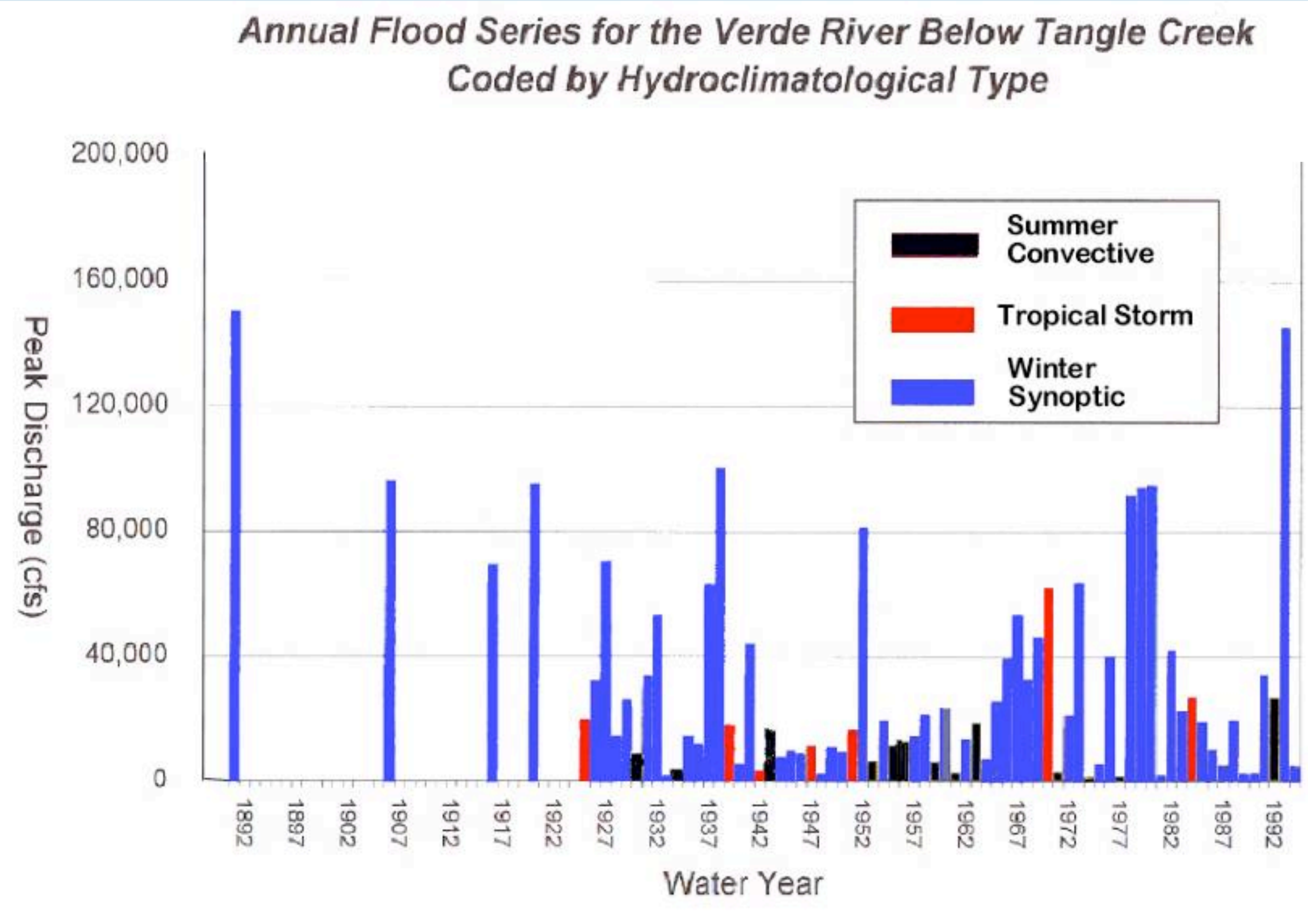


(Hirschboeck, 1988)

- 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
200,000
160,000
120,000
80,000
40,000
0
Peak Discharge (cfs)
Summer Convective
Tropical Storm
Winter Synoptic
1892
1897
1902
1907
1912
1917
1922
1927
1932
1937
1942
1947
1952
1957
1962
1967
1972
1977
1982
1987
1992
Water Year

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

DESCRIPTION:
This worksheet combines the annnual and parital series peaks for all 4 Santa Cruz gages, listed in chronological order from the earliest station record thru 2005

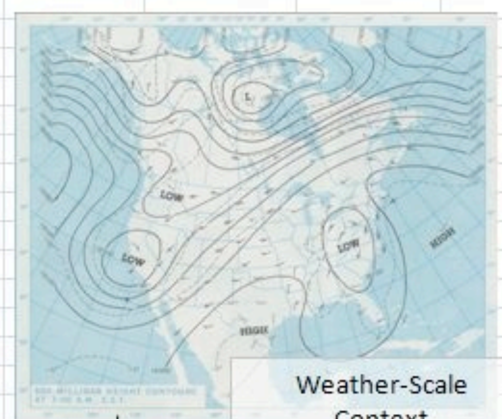
SYNOPTIC CLASSIFICATION
1 = Tropical Storm-related
2 = Convective storm
3 = Synoptic storm
(1.2 or 3.2 = w/ cutoff low)

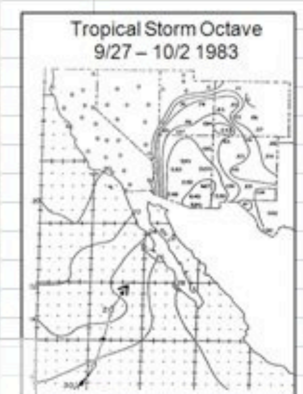
A= annual flood
P = partial series flood

STATION CODE
9480000 Santa Cruz nr Lochiel
9480500 Santa Curz nr Nogales
9482000 Santa Cruz at Continental
9482500 Santa Cruz at Tucson

** Hurricane/ Tropical Storm designation based on W.K. Smith NOAA Pub.

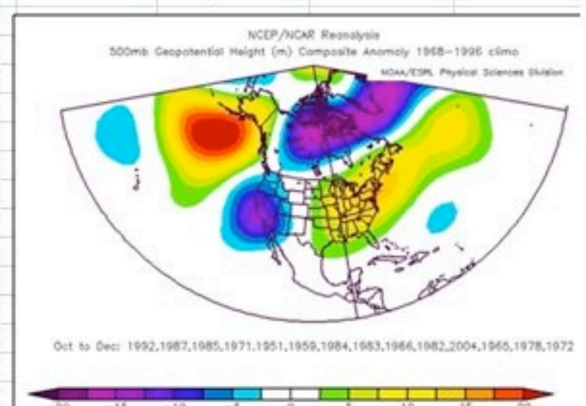
	WYEAR	CYEAR	MONTH	DAY	SYNOP	Q (CFS)	SERIES	STATION	Prior Days	Flood Date	Afterward	COMMENTS
635	1981	1981	8	31	3	805	P	9480000				
636	1981	1981	9	3	2	789	P	9480000				
637	1981	1981	9	3	2	3220	A	9480500				
638	1981	1981	9	5	2	3350	A	9482000				
639	1981	1981	9	5	2	2660	P	9482500				
640	1981	1981	9	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				

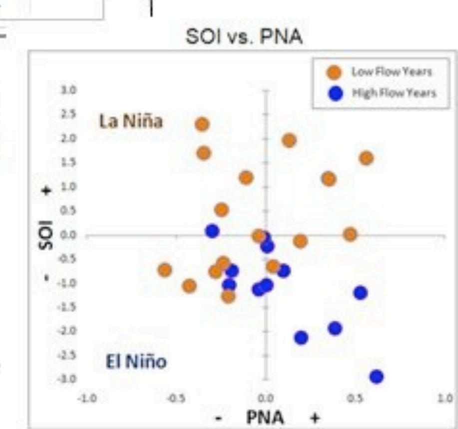




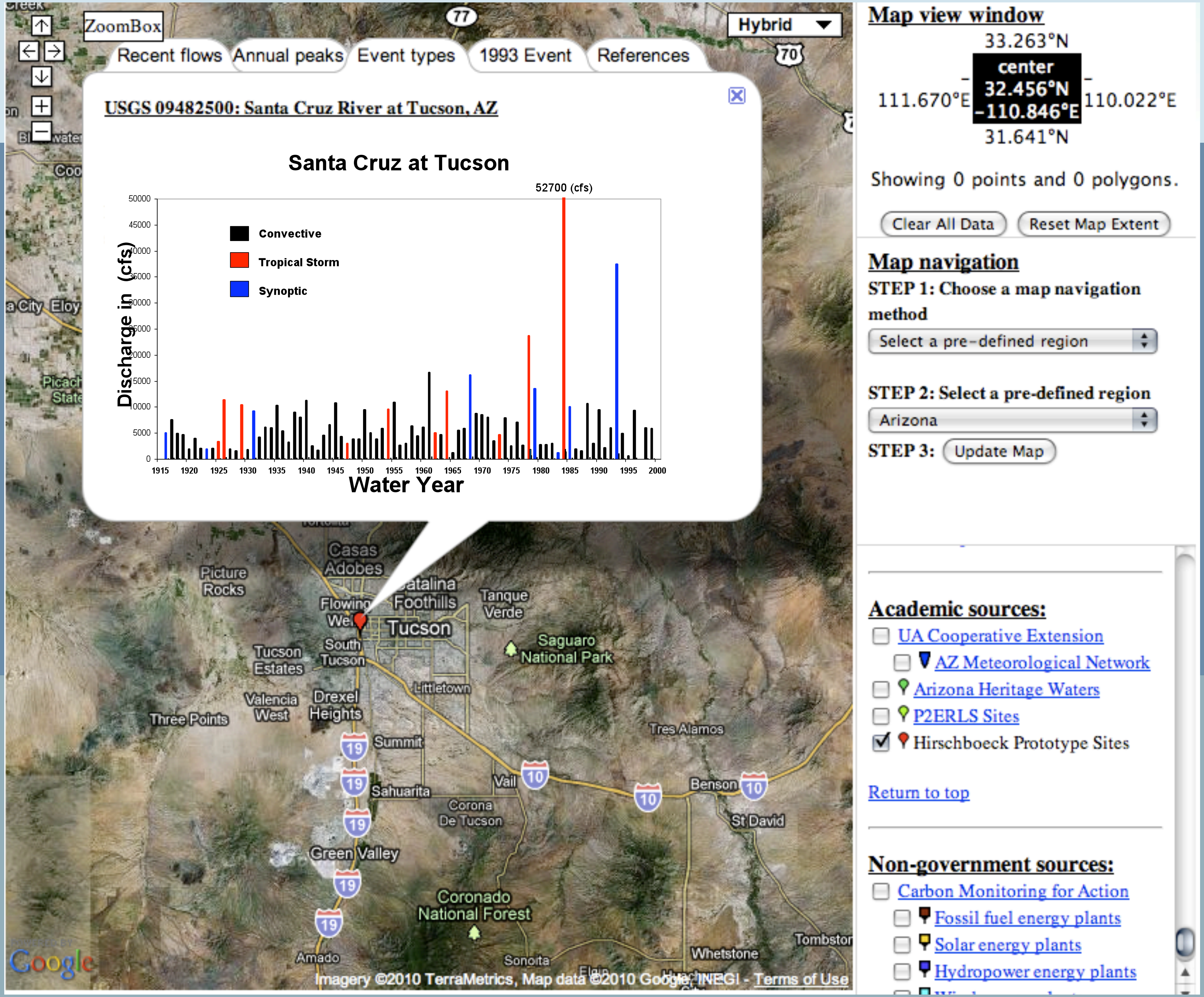
Weather-Scale Context

Climatic -Scale Context

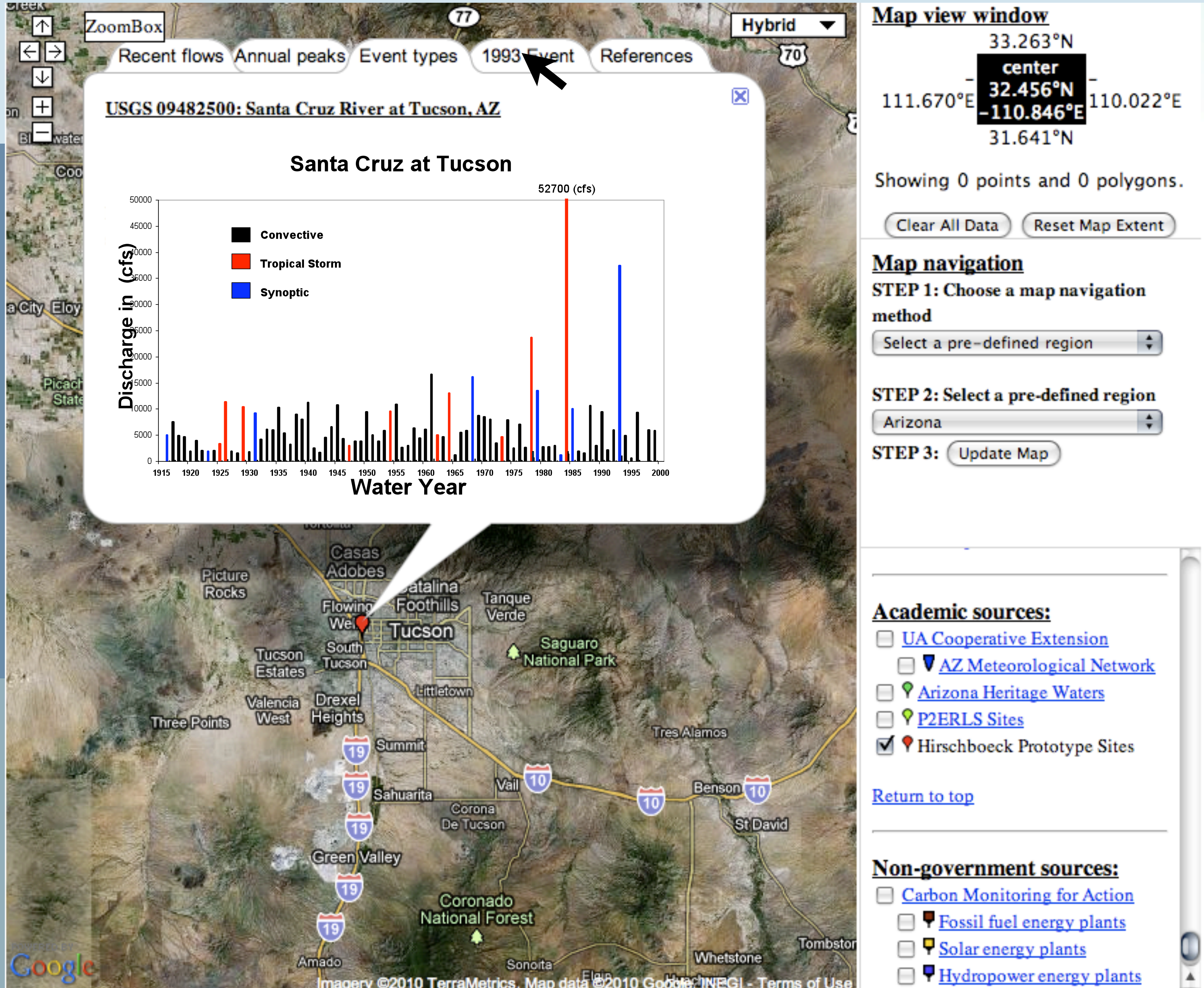




Interactive Map



Interactive Map



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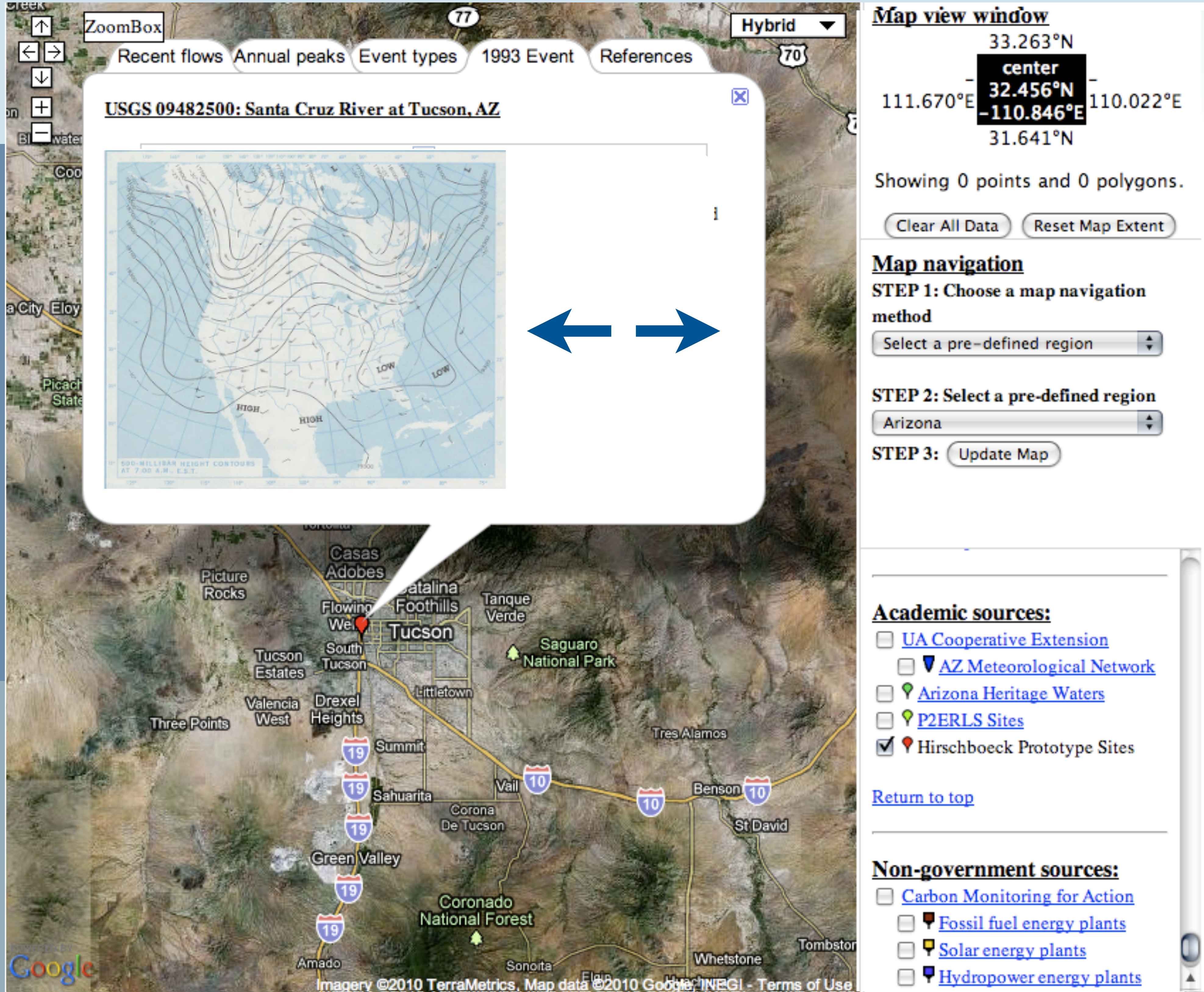
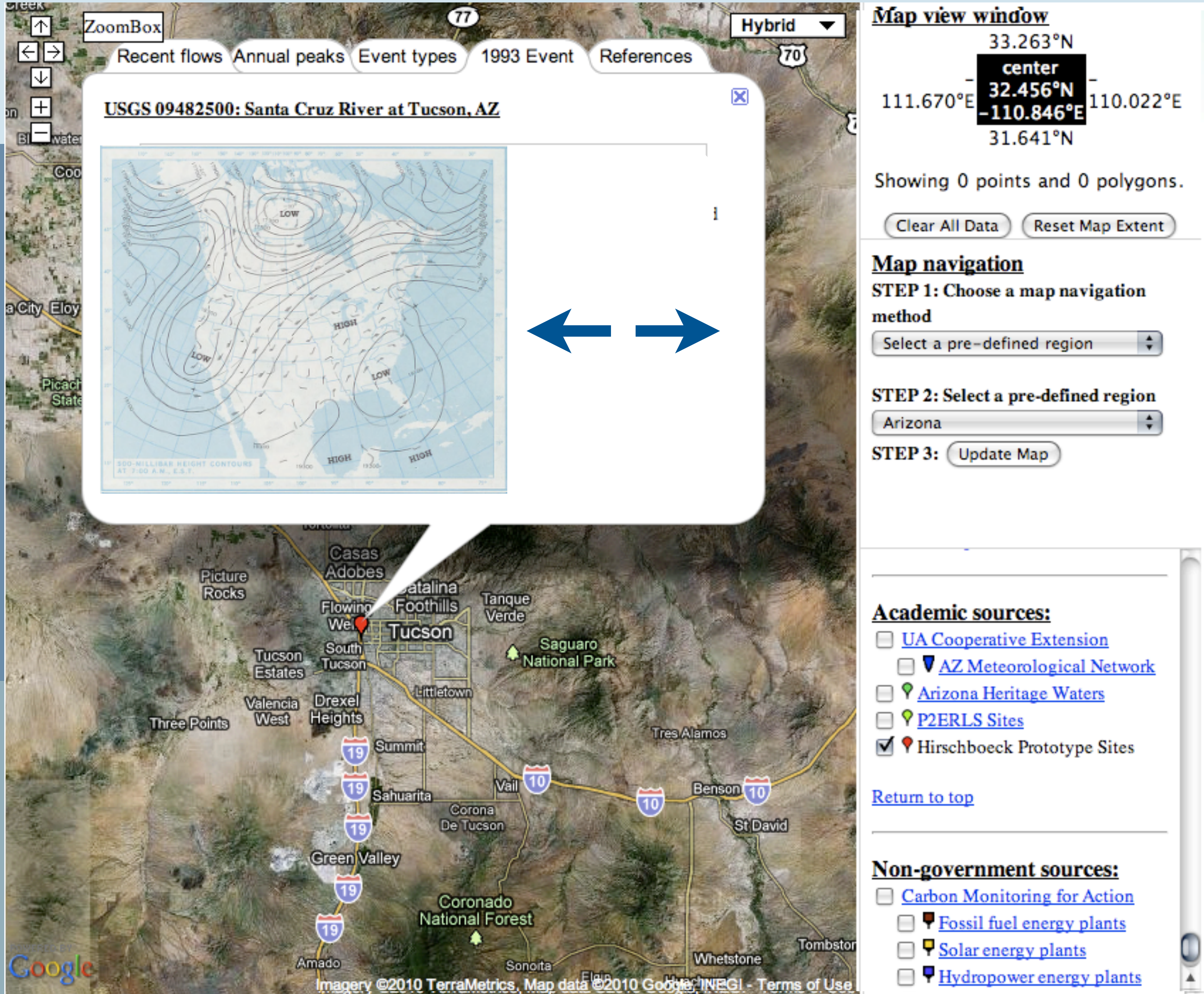


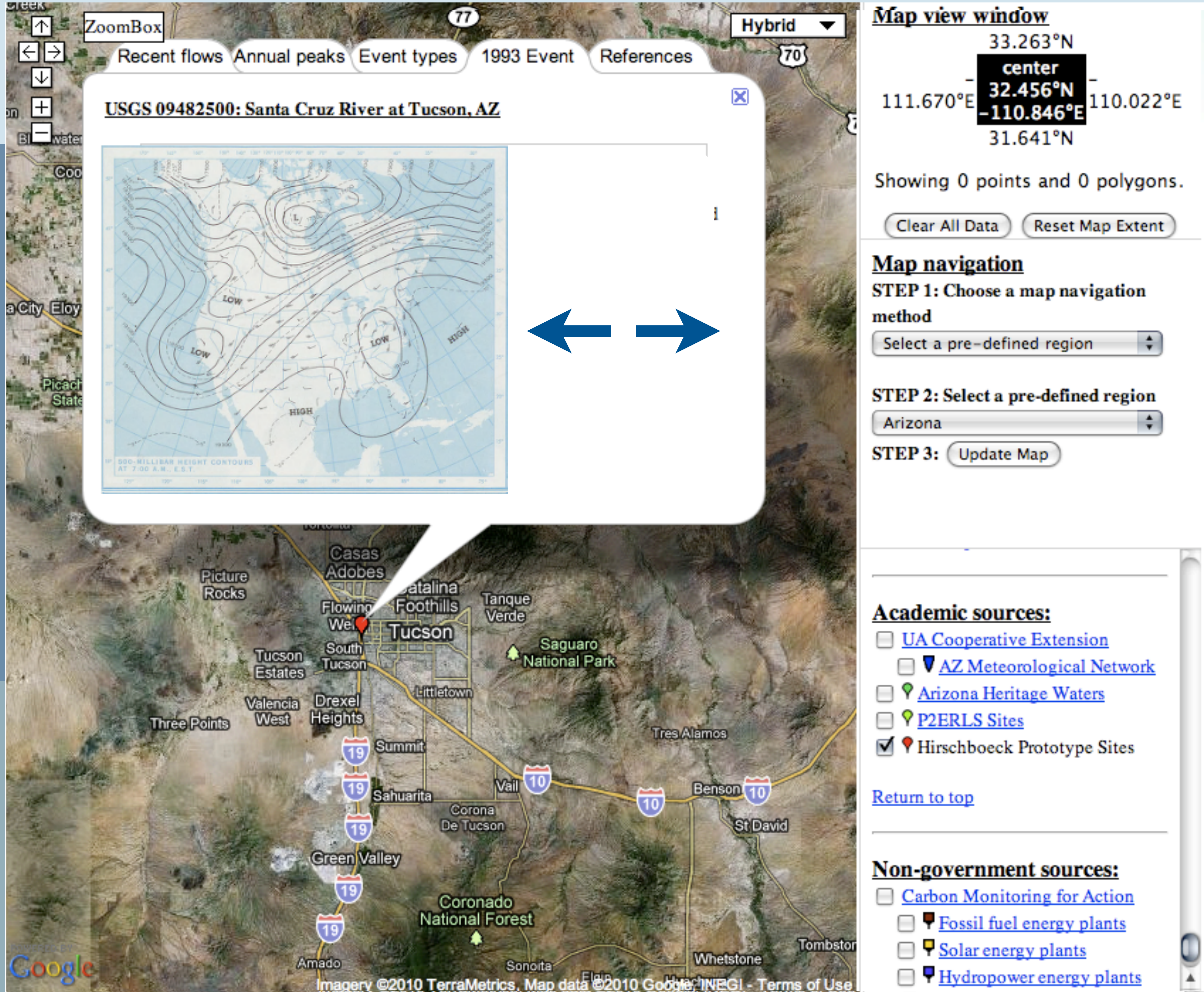
Interactive Map

Sunday, August 8, 2010

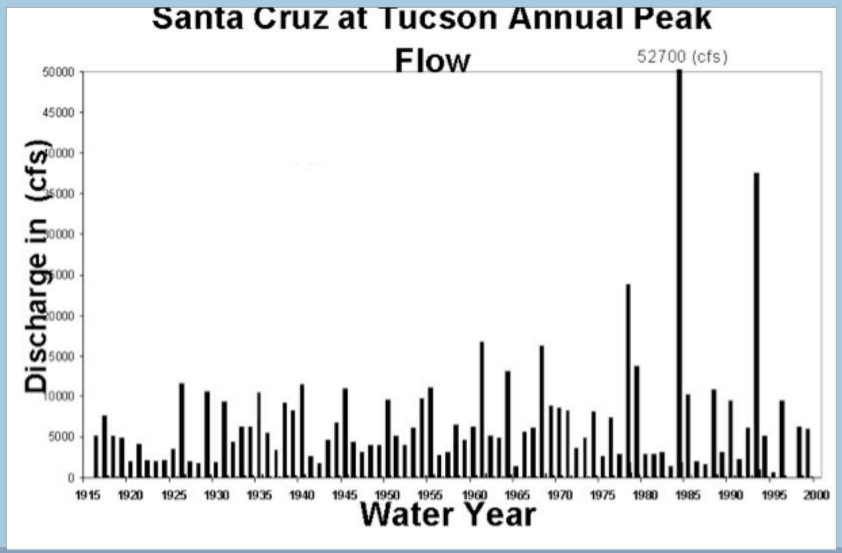
Interactive Map

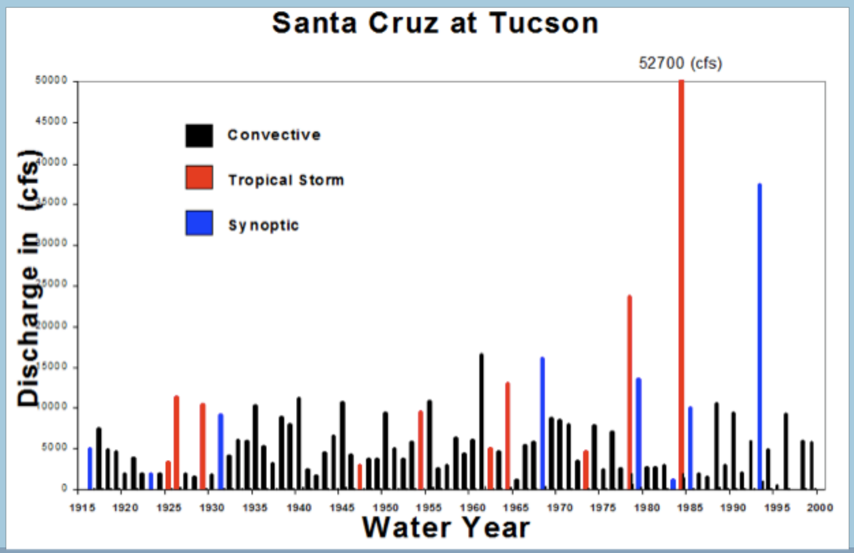


Interactive Map

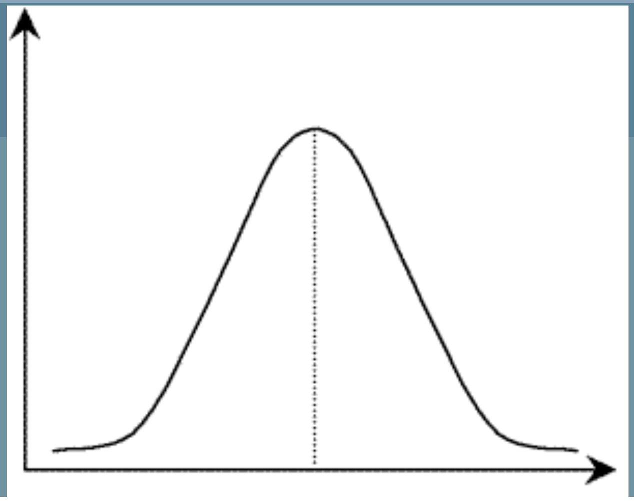


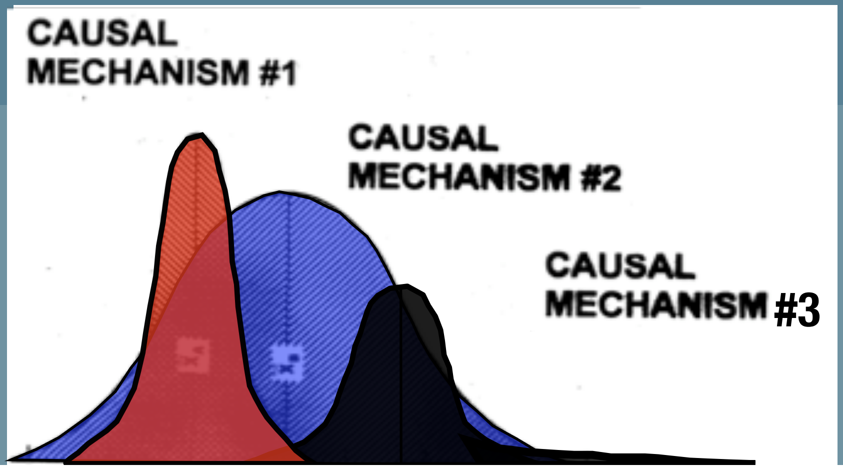
Causal Relationships





- 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:

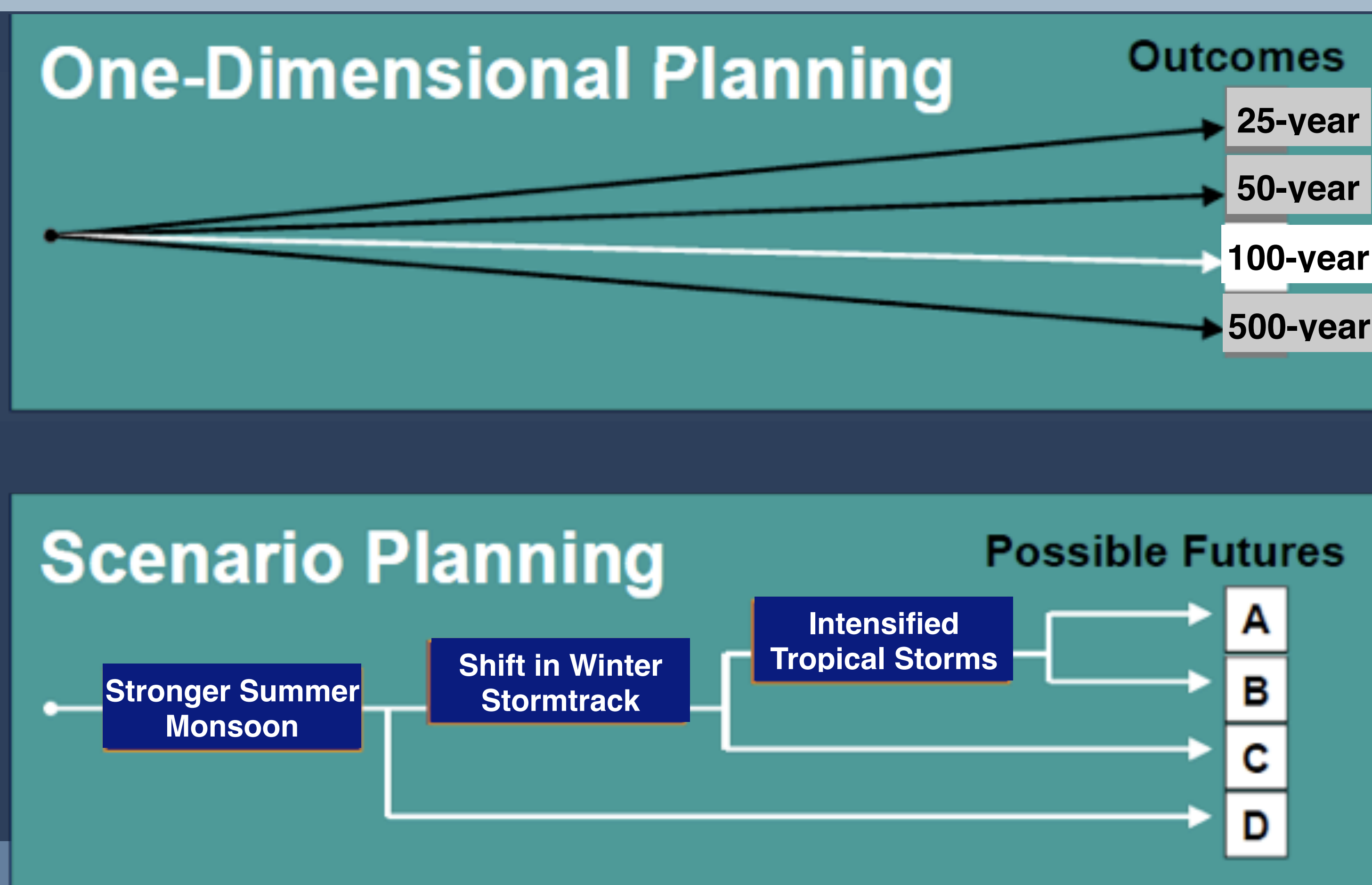
  -- winter synoptic events,
  -- summer convective events
  -- tropical storm events

- 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

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Thank you!

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