Making sense of event attribution: the decision-making and communication context

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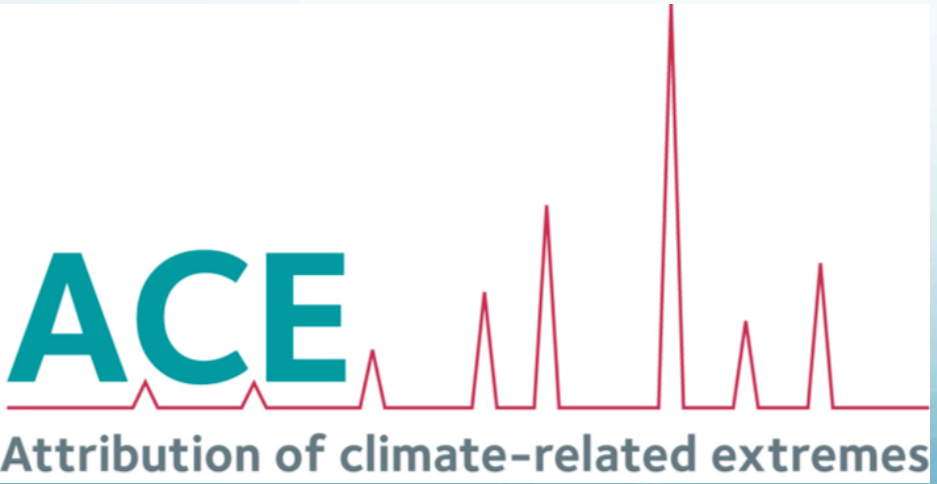
September, 2012



Knowing and Unknowing Collaborators:
John Stein NOAA
Doug Kluck NOAA
Martin Hoerling NOAA
Steve Lindley, NOAA
Patrick Rutten, NOAA
Kevin Grode, USBR
Dennis Todey, SDSU

Summary on attribution of trends in extremes

from IPCC SREX - *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (2012)*

Temperatures **– likely anthropogenic influence on trends in warm/cold days nights at the global scale. No attribution of trends at regional scale with few exceptions.**

Precipitation **– Medium confidence that anthropogenic influences have contributed to intensification of extreme precipitation at the global scale.**

Floods **– Low confidence that anthropogenic warming has affected the magnitude or frequency of floods at global scales**

Droughts **– Low confidence in attribution of changes in drought at the levels of single regions due to inconsistent or insufficient evidence**

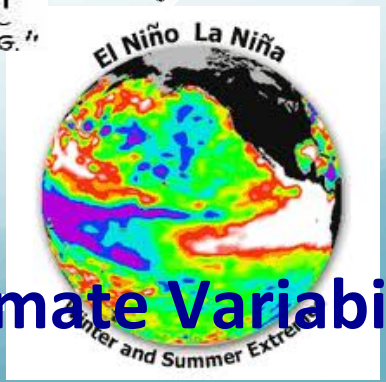
Tropical cyclones **– Low confidence in attribution of any detectable changes in tropical cyclones**

Tornadoes, other severe convective phenomena, extreme winds **– Low confidence in observed trends. No attribution statement provided.**

Goal: To provide climate attribution information to support preparedness, impact mitigation, as well as improved policy, planning and decision making

Policy, planning, and decisions to manage risks are made based on understanding (perception) of What has happened, Why it happened, & What is the likelihood of it happening again in the future

Environmental Interference



Climate Variability

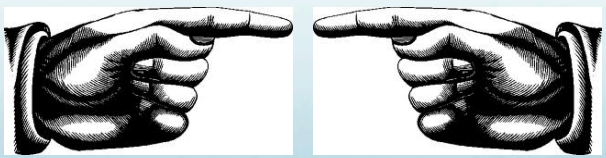
Missouri River Basin Flooding

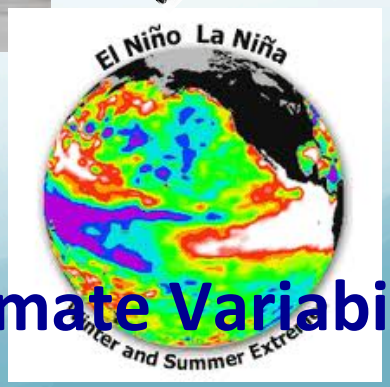
Climate Change

Reservoir System Purposes

Flood Control
Navigation
Hydropower
Irrigation
Recreation
Water Supply
Water Quality
Fish and Wildlife

Damn Dams

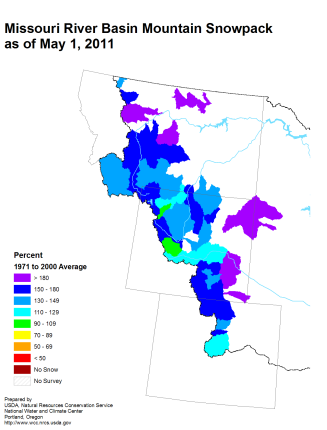


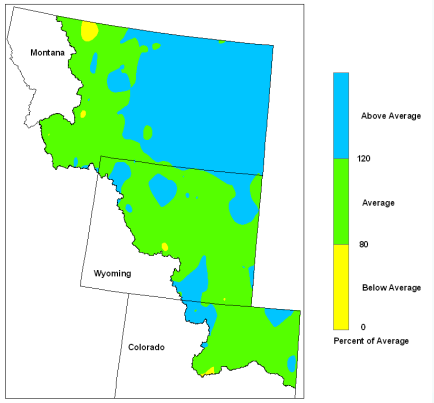


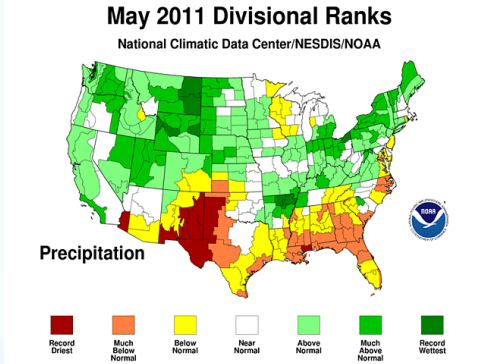
Climate Variability

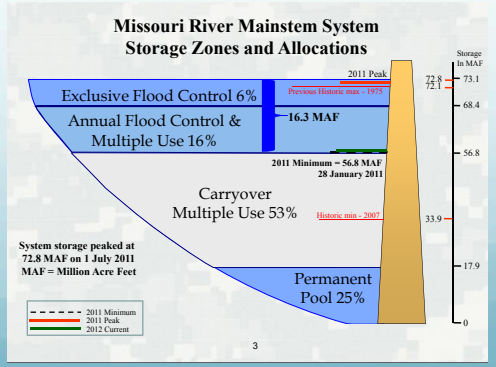
Missouri River Basin Flooding, Potential Factors

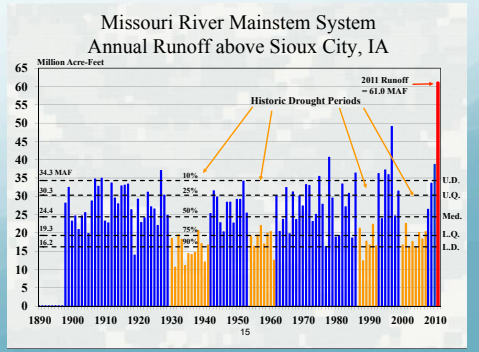
- June runoff was the highest month on record with 13.8 MAF of runoff
- May runoff was the third highest month on record, with 10.5 MAF of runoff and highest May ever
- July runoff was the fifth highest month on record, with 10.0 MAF of runoff and highest July ever
- Combined May and June runoff of 24.3 MAF is just short of a normal annual runoff of 24.8 MAF
- Previous late Summer and pre-freeze up Fall reservoir releases were based on climatology











Missouri River Basin Impacts > $1B

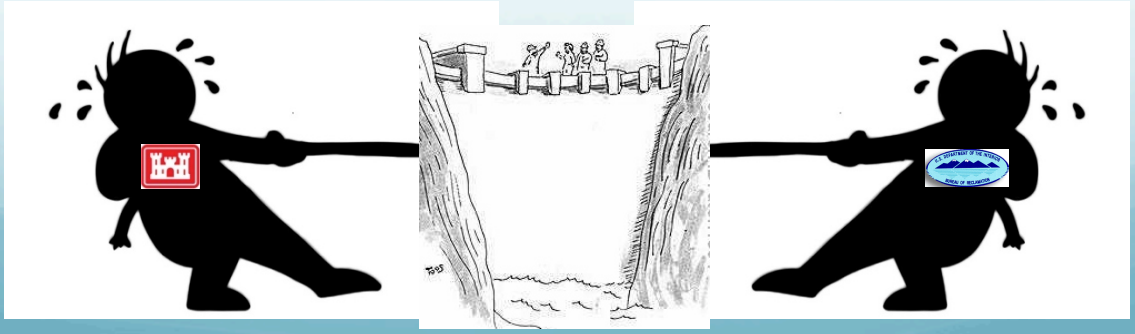
- Agriculture
- Infrastructure: Bridges, Levees, Energy Plants,
- Buried pipes (water, oil, etc…)
- Roads
- Ecosystems
- Sediment Transport
- Environmental
- Transportation Detours

Policy, planning and decision making issues:

Was extreme flooding event due to climate change, natural variability, odd sequence of extreme events, channel restrictions, operational flood control management decisions, ….. What should be planned for to avoid flooding in the future?

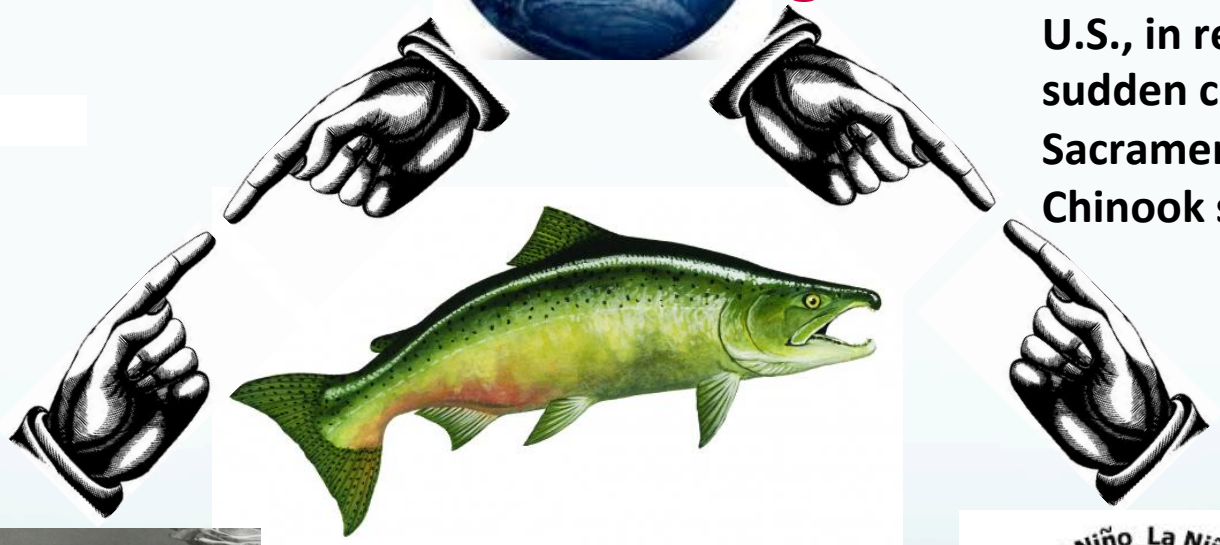
Missouri River Basin Policy Options informed by climate science

- Invest in flood control options: new or enlarged dams, move, raise or remove levees $
- Enhance wetlands as natural buffers $
- Expand floodplain $
- Dredge river channels $
- Congressional changes in reservoir rule curves recognizing the tension of flood control (empty reservoirs) and water supply (full reservoirs)

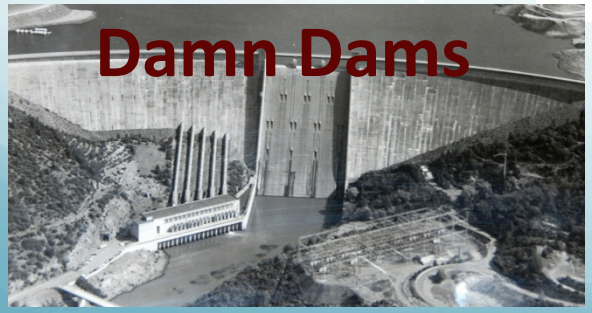


Sacramento River Fall Chinook salmon stock collapse

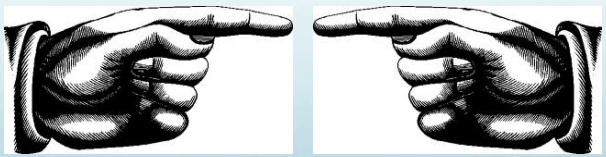
Climate Change

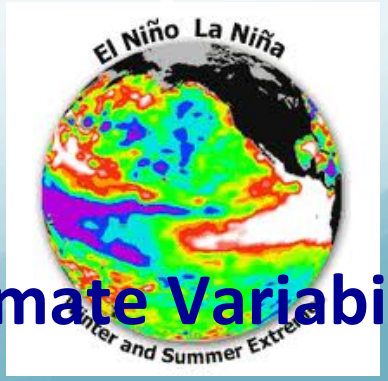


In April 2008 the Pacific Fishery Management Council (PFMC) adopted the most restrictive salmon fisheries in the history of the west coast of the U.S., in response to the sudden collapse of Sacramento River fall Chinook salmon



Damn Dams





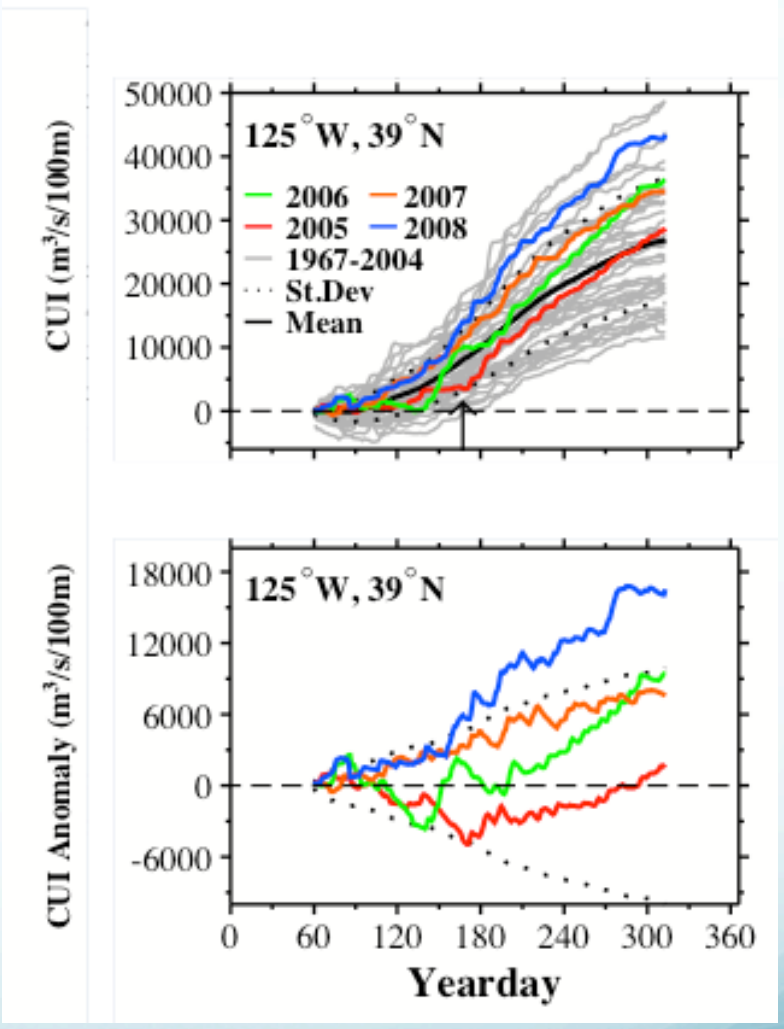
Climate Variability

Relevant Ocean Conditions for Fall Chinook Salmon

Conditions in the California Current were quite unusual in the spring of 2005 and 2006, when juvenile salmon from the 2004 and 2005 broods entered the ocean

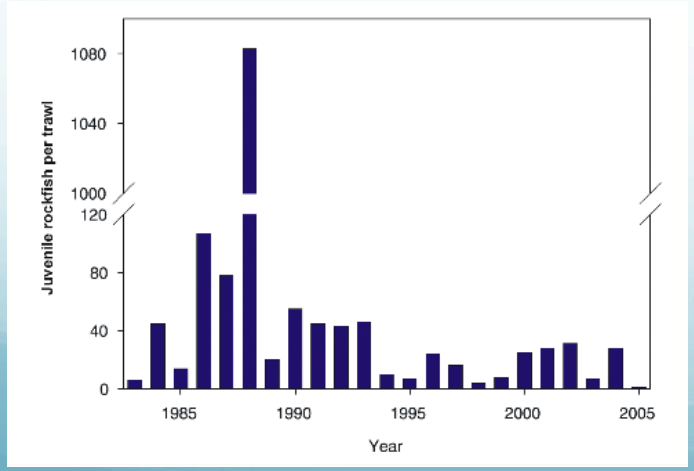
The spring transition was delayed, and sea-surface temperatures were warmer than normal

In terms of available nutrients, the ocean was like a desert



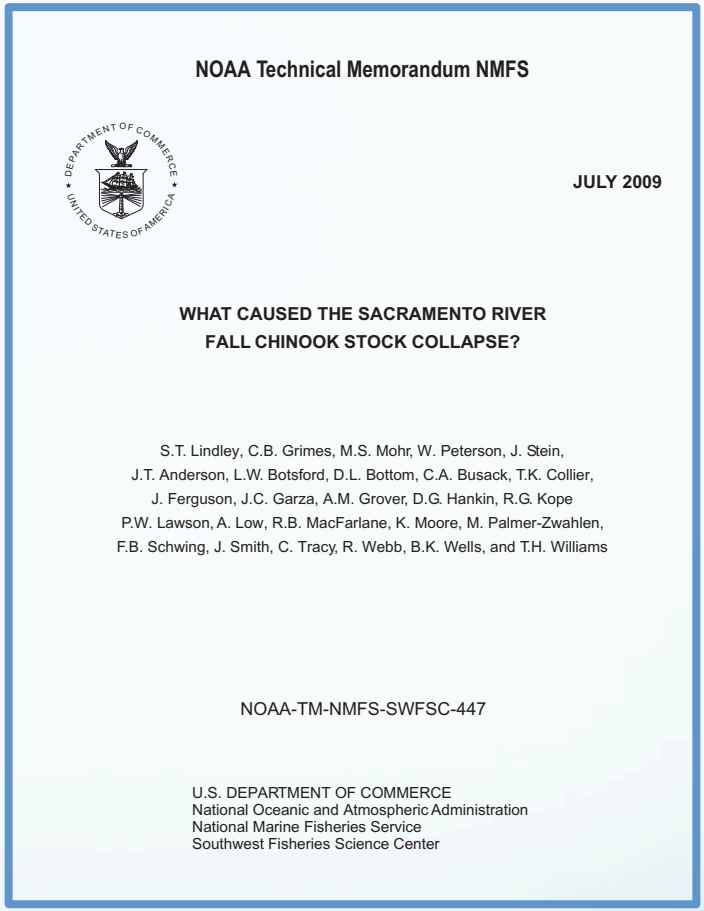
Cumulative Upwelling and Upwelling Anomalies

Sparse Salmon Prey



Fall Chinook Salmon, Potential Factors

- Low upwelling ocean conditions
- Dams and other structural impediments to migration
- Climate change impacts on nutrient source waters
- Climate variability or change impact on freshwater conditions: temperature and/or volume
- Decision making process for hatchery smolt releases
- Loss of Estuarine Habitat
- Freshwater exports
- Pollution
- Disease
- Hatchery
- Over Fishing



NOAA Technical Memorandum NMFS

JULY 2009

WHAT CAUSED THE SACRAMENTO RIVER FALL CHINOOK STOCK COLLAPSE?

S.T. Lindley, C.B. Grimes, M.S. Mohr, W. Peterson, J. Stein, J.T. Anderson, L.W. Botsford, D.L. Bottom, C.A. Busack, T.K. Collier, J. Ferguson, J.C. Garza, A.M. Grover, D.G. Hankin, R.G. Kope P.W. Lawson, A. Low, R.B. MacFarlane, K. Moore, M. Palmer-Zwahlen, F.B. Schwing, J. Smith, C. Tracy, R. Webb, B.K. Wells, and T.H. Williams

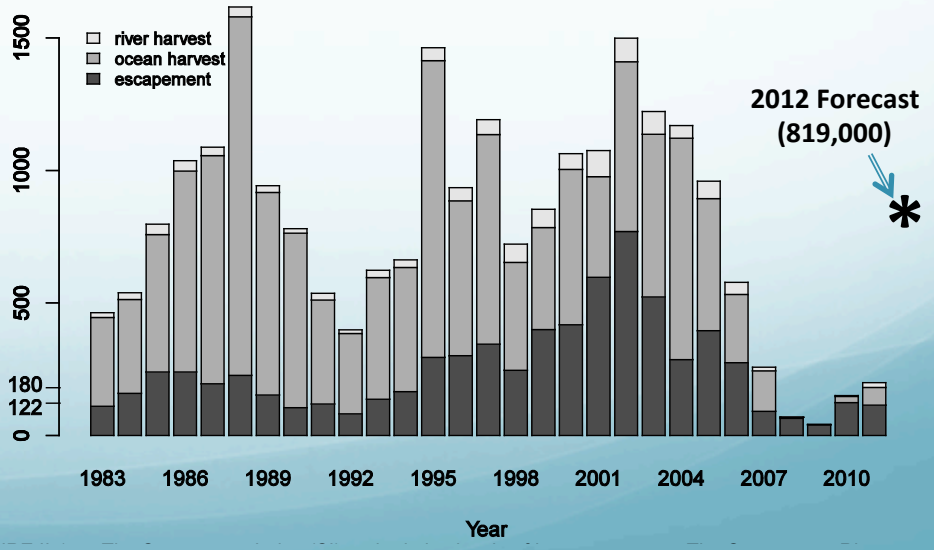
NOAA-TM-NMFS-SWFSC-447

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center

Policy, planning and decision making issues: *Was collapse of the due to climate change, natural variability, degraded habitat, over fishing, hatch management decisions, ….. Should the fishery be managed differently in the future and why?*

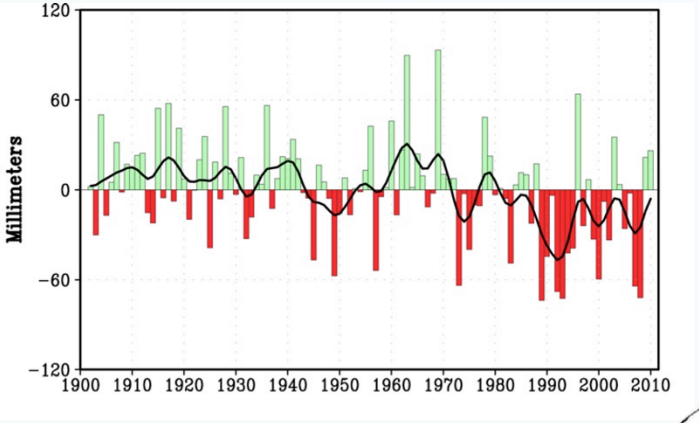
Fall Chinook Salmon Fishery Policy, Planning and Management Options

- Invest in estuarine habitat restoration
- Restore habitat diversity and complexity throughout the river basins
- Limit freshwater diversions and allocate more water supply for streamflow augmentation
- Integrate ocean conditions/productivity information into hatchery smolt release decision making process
- Adjust season length, quotas, bag limits, and implement gear restrictions
- Emergency compensation payouts for fishermen and fishing-related businesses
- Temporarily close ocean fisheries
- Buy out fishing vessels to downsize or eliminate fishing fleets
- Remove dams and other structures

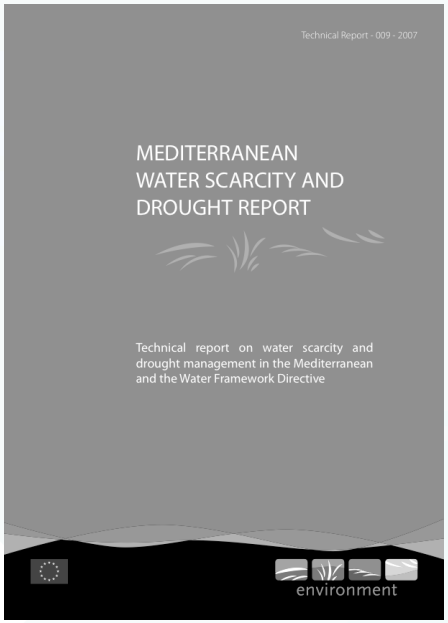


Mediterranean Drought

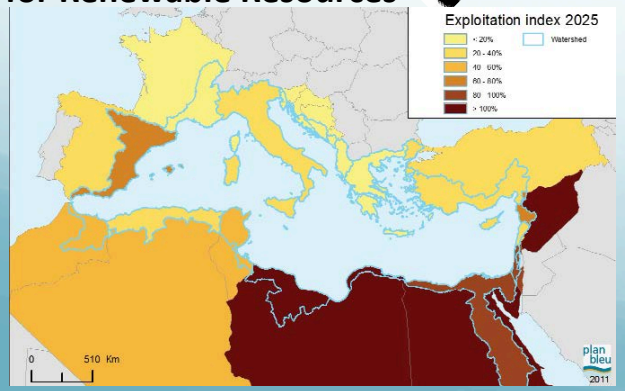
Mediterranean winter precipitation anomalies from 1902 - 2010.

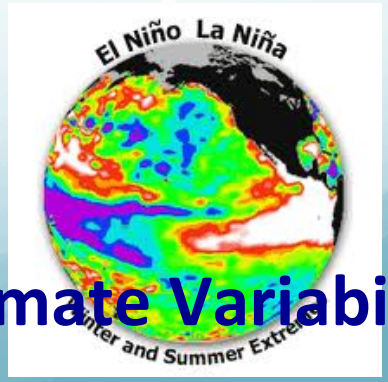


Climate Change



Exploitation Index for Renewable Resources





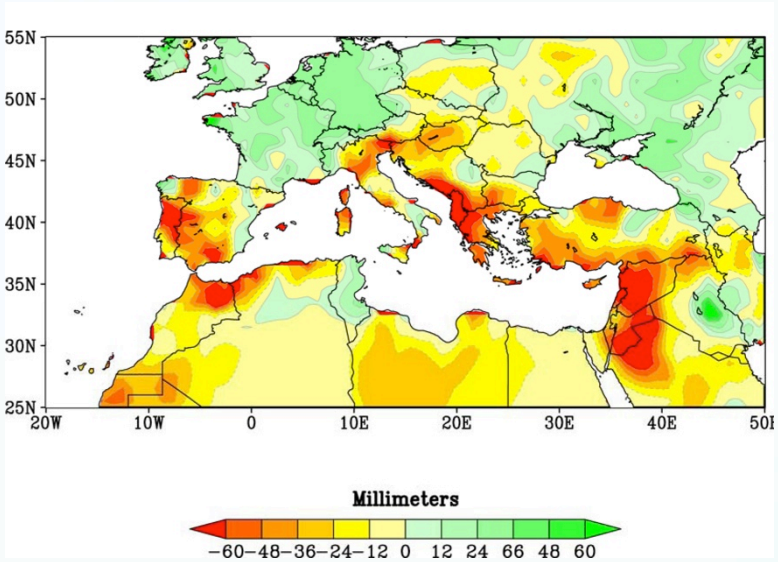
Climate Variability

Climate and the recent Mediterranean Drought

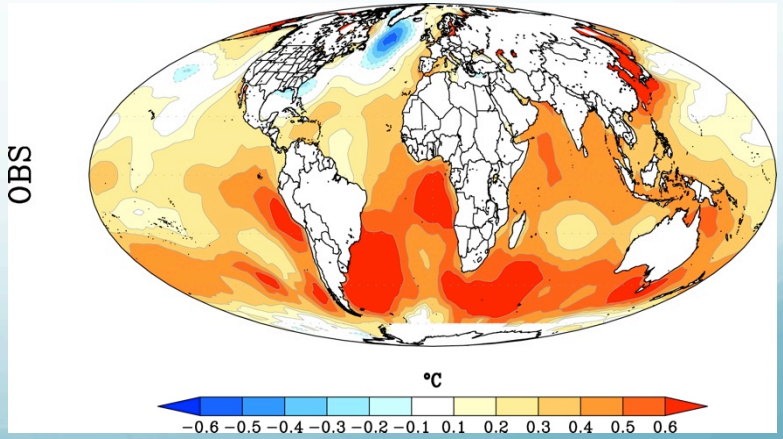
The Mediterranean Region Has Experienced Increasingly Severe and More Frequent Droughts Since About 1980.

The Observed Drying Trend [(1971-2010) vs (1902-1970)] Very Likely Represents a Change In the Region's Cold Season Climate

The Greater Warming of Tropical versus Extratropical SSTs Since 1902 Has Been an Especially Effective Pattern of Ocean Change for Driving Mediterranean Drying



Mediterranean region change in winter precipitation for the 1971-2010 relative to 1902 - 2010.



Observed Cold Season (Nov-Apr) SST departures for 1971-2010 relative to 1902-1970

Mediterranean Drought Impacts

- Agriculture
- Water supply quantity and quality
- Urbanization
- Wildfire
- Soil Degradation and Desertification
- Energy Production
- Tourism
- Transportation

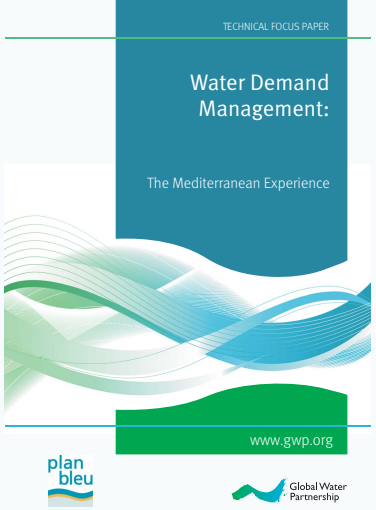
Water scarcity and drought in the Mediterranean

Imported drinking water

Policy, planning and decision making issues:
Has the persistent drought been due to climate change, natural variability, odd sequence of extreme events, or land use practices, ….. What can be done to mitigate future drought impacts?

Irrigation Practices

Mediterranean Drought Policy Options Informed by Climate Science



The Probability of Mediterranean Drying -- as Large As Observed Since 1902-- Increased 10-Fold Due to External Radiative Forcing During 1902-2010: Attribution

SST Response to External GHG Forcing has been Key to Inducing Mediterranean Drying

- **Pursue a Water Demand Management (WDM) for sustainable development**
- **Invest in water infrastructure, developing interregional and international transfers, increased 'mining' of non-renewable groundwater reserves, or using non-conventional water resources**
- **Optimize water use, minimize losses and reduce misuses**
- **Promote integrated management of watersheds**

Attribution-like statements to support policy, planning and decision making

Communication challenges and opportunities

- 'Undoubtedly, this extreme event ***was influenced by*** climate change.' *(At what timescales does this statement provide information for early warning to protect lives or property?)*

- 'This kind of event *is consistent with* what we would expect with climate change.' *(What is the null hypothesis: climate change is not happening or the event did not happen?)*

- "I think people have to appreciate how very bizarre the weather has been this year (2011). And it's pretty clear that for some of those events like heat waves, droughts, really big intensive rainfall events—***those we can connect the dots*** *to climate change* pretty convincingly." *(Is the personal experience in the lifetime of an individual sufficient?)*

Communicating attribution of extreme weather events

A key concept: the Signal-to-Noise Ratio (SNR)

- The SNR is a measure of the ratio between the mean change and intrinsic background variability
- For increases in CO_2, this ratio is very large ~ 50-100
- For increases in global-average, annual mean temperatures, it's ~ 0.8/0.2 ~ 4 (easily detectable)

What is the SNR for extreme events?

Key point or Issue for discussion

The signal-to-noise ratio for global and annual-average surface temperatures evaluated over a suitably long time period (e.g., decades) can be large.

However, this does not imply that the signal-to-noise ratio for short-term weather or extremes, will also be large. In fact, the latter may be quite small (< 10%).

Large signal in long-term global average climate

$\not\Rightarrow$ Large signal in weather or extremes

Different approaches, different questions when communicating Extreme Event Attribution

***Paraphrasing the 'Accident investigation analogy' (credit to Bob Henson*)**

Adding just a little bit of speed to your highway commute each month can substantially raise the odds that you'll get hurt some day. But if an accident does occur, the primary cause may not be your speed itself: it could be a wet road or a texting driver. In this approach looks at accident-causing mechanisms of all types, including speed,

An alternative approach is to measure how much that extra 5 or 10 mph hikes the odds that you'll get into a wreck.

Meanwhile, others are playing the role of safety experts pointing out that, as a rule, extra speed is dangerous.

From a UCAR post "Doping the Atmosphere?", part of an In Depth series "Weather on Steroids".
www2.ucar.edu/atmosnews/attribution/doping-atmosphere

N The Cat Did It :y

THANK YOU

BACKUP SLIDES

Attribution of NOAA Climate Forecast Performance

7 October 2005 *the US House Committee on Science met to have NOAA explain its hurricane prediction.*

What Caused the Record 2005 Hurricane Season?

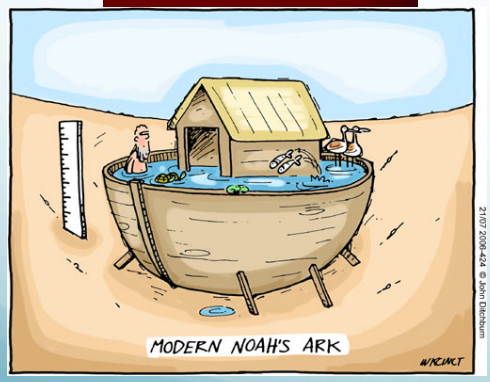
Predictions of tropical activity in the 2005 season

Source	Date	TropicalSt	Hurricanes	Major Hurricanes	
CSU	*Avge1950–0*	9.6	5.9	2.3	
NOAA	*Avg*	11	6	2	
CSU	3 Dec 2004	11	6	3	
CSU	1 April 2005	13	7	3	
NOAA	16 May 2005		12–15	7–9	3–5
CSU	31 May 2005		15	8	4
NOAA	2 Aug 2005	18–21	9–11	5–7	
CSU	5 Aug2005	20	10	6	
Actual activity		28	15	7	

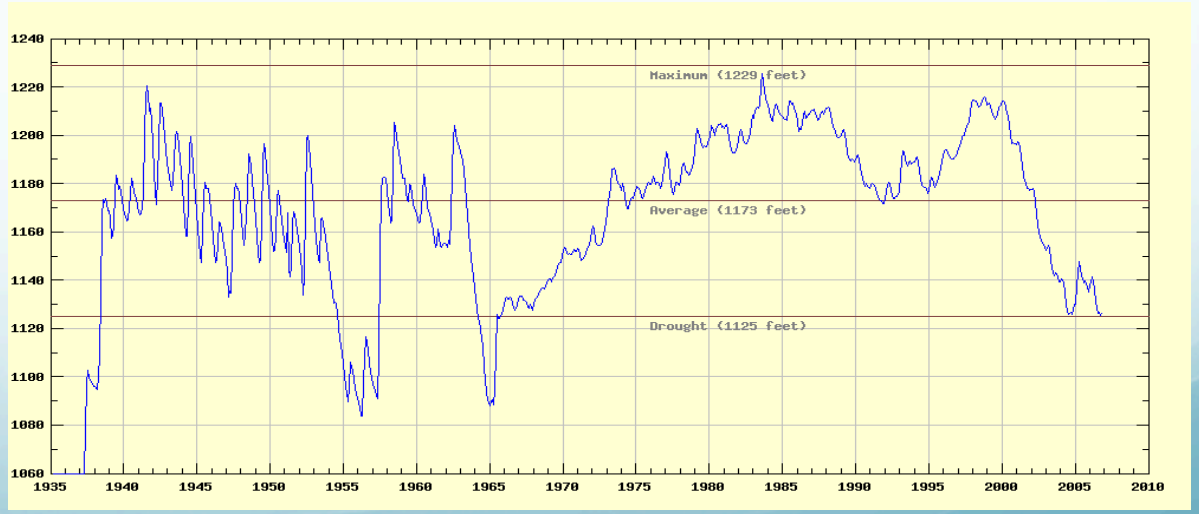
Attribution of US Drought

Spring 2006 *Senate Commerce Disaster Prevention & Prediction Subcommittee requested NOAA to explain persistent drought conditions in the West.*

Current *US Dep. of Interior is seeking NOAA's climate expertise to explain the current decline in Colorado River Flow, and implications for future EIS.*



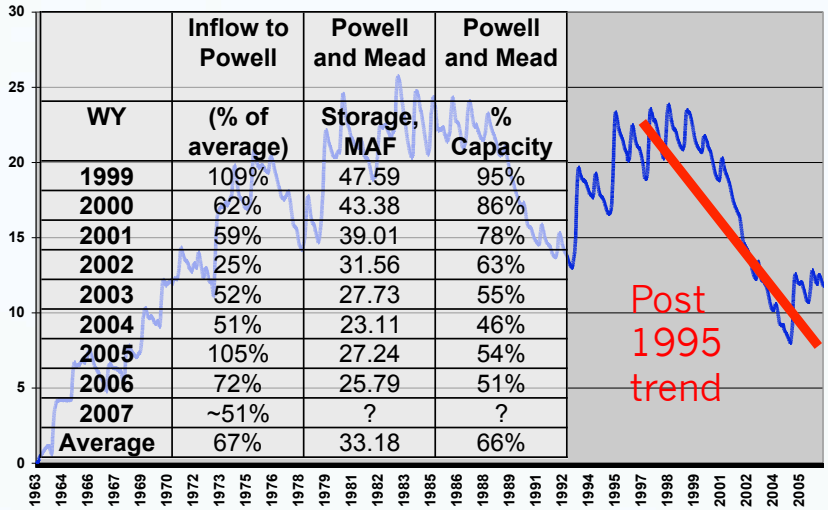
Are We Past Peak Water in the West?



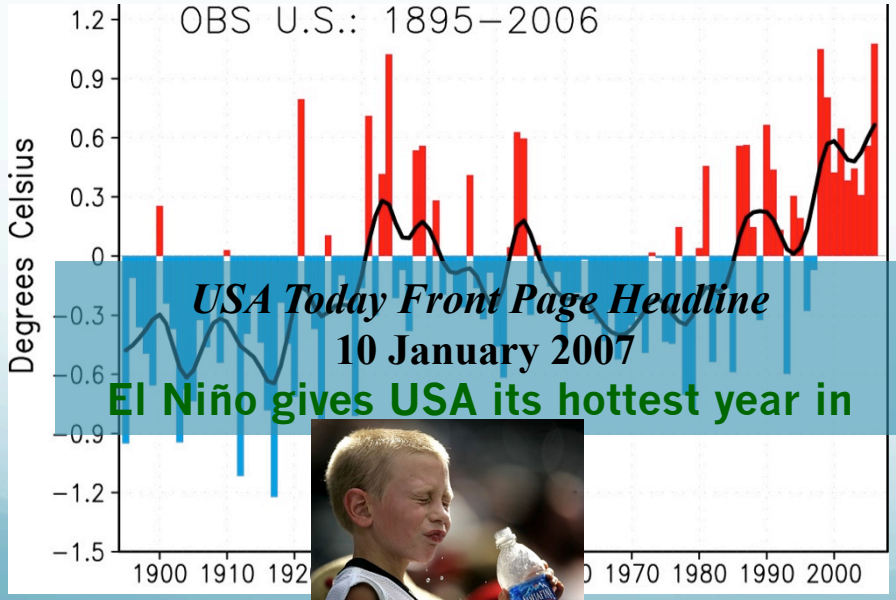
Key Question: Natural Variability or Climate Change

Lake Powell Volume in MAF 1963-2007

WY	Inflow to Powell (% of average)	Powell and Mead Storage, MAF	Powell and Mead % Capacity
1999	109%	47.59	95%
2000	62%	43.38	86%
2001	59%	39.01	78%
2002	25%	31.56	63%
2003	52%	27.73	55%
2004	51%	23.11	46%
2005	105%	27.24	54%
2006	72%	25.79	51%
2007	~51%	?	?
Average	67%	33.18	66%



The credibility by providing improved by offering understandings of the origin of regional climate impacts including known unknowns



USA Today Front Page Headline
10 January 2007
El Niño gives USA its hottest year in

Seasonal values of the Accumulated Cyclone Energy (ACE) index for the North Atlantic