Use-Inspired Water Cycle Research

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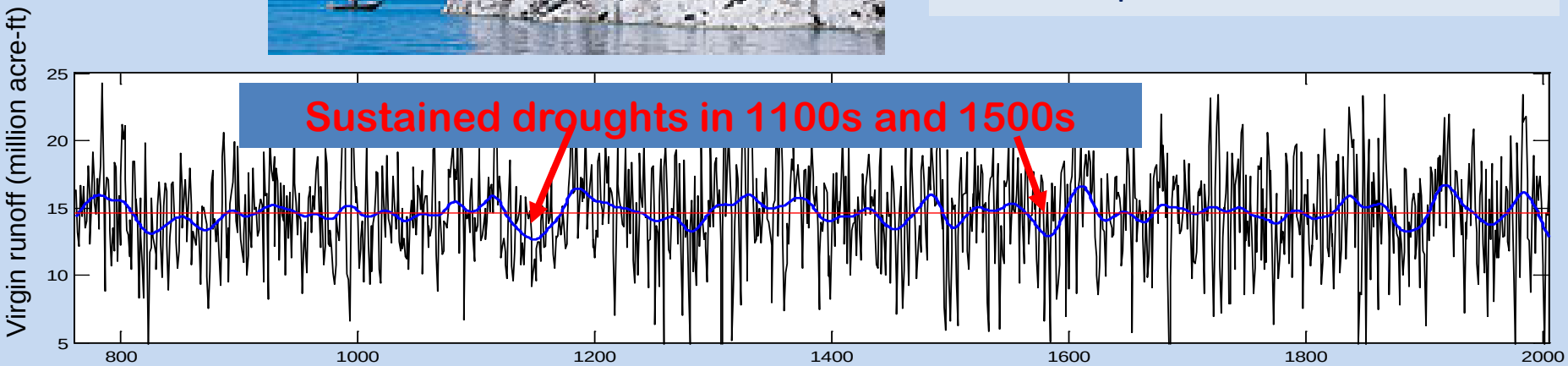
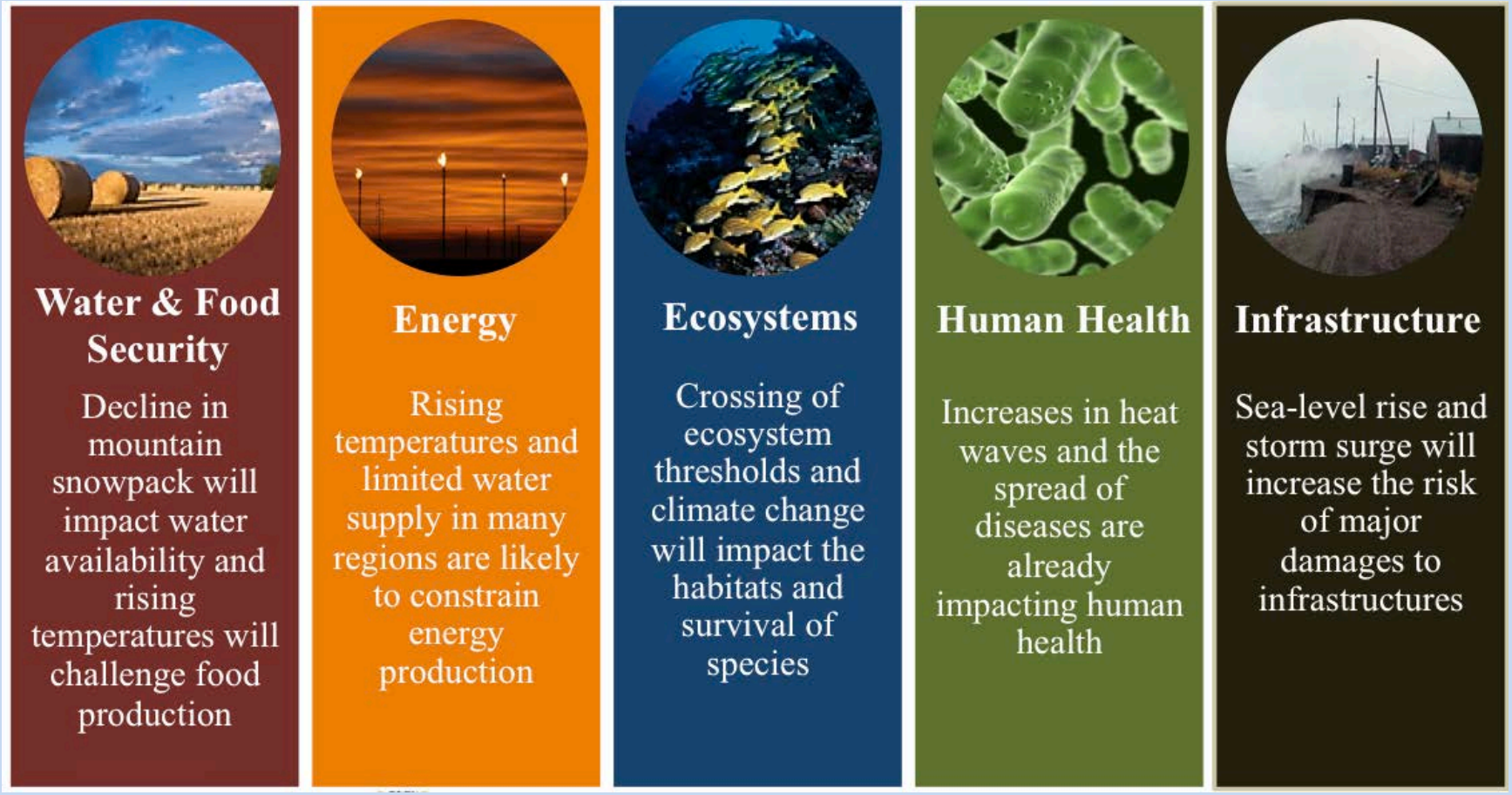
DOE Workshop on Community Modeling and Long-Term Predictions of the Integrated Water Cycle

September 24, 2012



Data from Meko et al., Geophysical Res.

All of the major risks associated with Global Change have a water component



Water is the "delivery mechanism" of climate change impacts

Fundamental Issues in Integrated Hydrologic Research

- Complexity at every scale in every component of the water cycle; how to get to meaningful outcomes?
- Rate of change is very high; stakes are very high
- Major components are poorly understood, eg groundwater, soil moisture, high elevation snowpack
- Large implications and feedbacks of human activities (and lack of fundamental understanding of water management institutions/laws/policies)
- Lack of data for critical components of the cycle at the right time and space scales – e.g. hydrologic models for flooding require hourly or multi-hourly data, rarely available (and extremes are important)
- Limitations of links between climate models and hydrologic impact models

What do we mean by Use-Inspired?

- Trying to be useful and relevant adds a whole new layer of complexity to Hydrologic Research.
- The process is much simpler if you don't have to include the people – they just make everything more complicated!

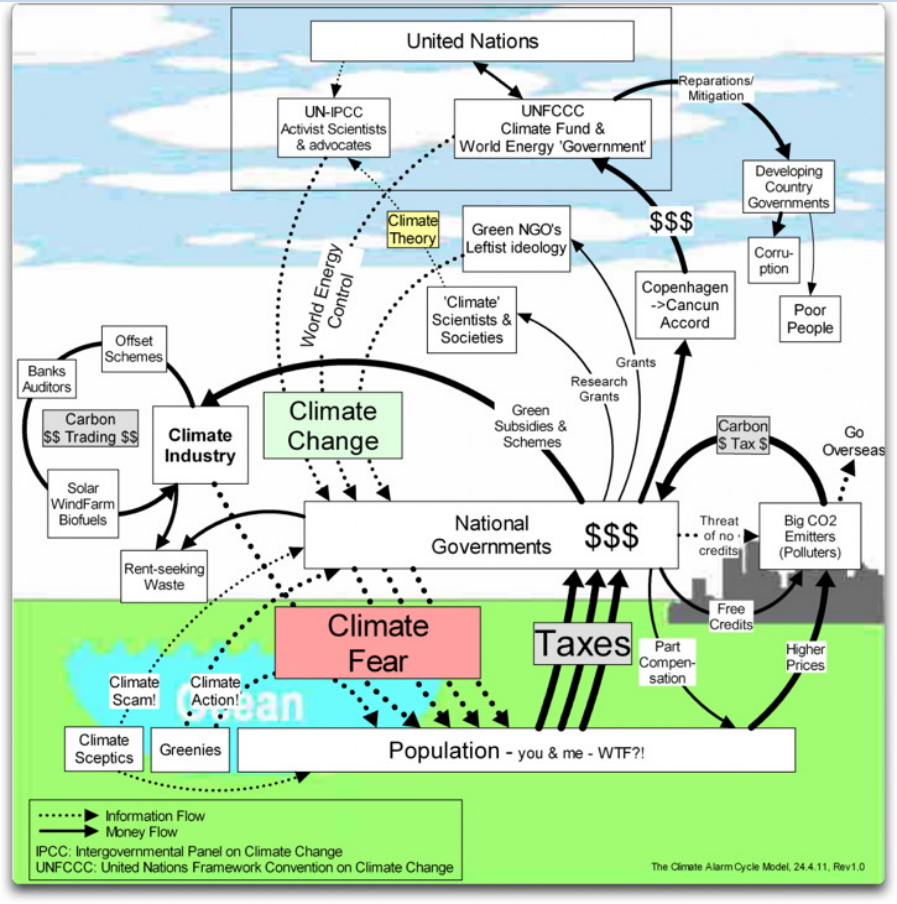
- Decision relevance is in the eye of the beholder!
- Knowledge of relevance only comes through long-term relationships.

What Water Managers Want

- A clear view of future water supply conditions; if not a deterministic projection, at least an envelope of likely futures for their specific watershed over time.
- A picture of “sustainable yield” for their watershed – eg how high can withdrawals go without significant damage to valued ecosystems, downstream users, etc.
- In general, they would rather NOT have academics modeling their decision processes and institutional rules – there are so many layers of overlapping jurisdiction and differences between utilities that models of decision processes often don’t work in the real world
- They want help from a credible, experienced source with translating data and uncertainties into useful knowledge in their particular decision context.

What we (often) give them

- Huge files of downscaled data for multiple GCMs using lots of scenarios
- Descriptions of all the uncertainties involved in understanding the future, the limitations of statistical downscaling, the huge costs of dynamical downscaling
- Assessments of their watershed or utility's situation that are flawed in ways that lead to credibility problems for researchers



The Decision Context of an Arizona Water Manager

UPPER BASIN DEVELOPMENT

ARSENIC STANDARD

INFRASTRUCTURE FINANCING

EMERGING CONTAMINANTS

INFRASTRUCTURE CAPACITY

RURAL SHORTAGES

"FOREST HEALTH"

INSTITUTIONS

COLO. RIVER SHORTAGE SHARING

DROUGHT/ CLIMATE CHANGE

SURFACE WATER ADJUDICATION

GROUNDWATER DEPLETION

POPULATION GROWTH

ENDANGERED SPECIES

SALINITY

ASSURED WATER SUPPLY

GROUNDWATER CONTAMINATION

INDIAN SETTLEMENTS

CULTURAL ISSUES

COST OF WATER AND ENERGY

GROUNDWATER RIGHTS

ENVIRONMENT

CONSERVATION

INTERNATIONAL TREATIES

Steve Rossi
City of Phoenix

What we can do about it

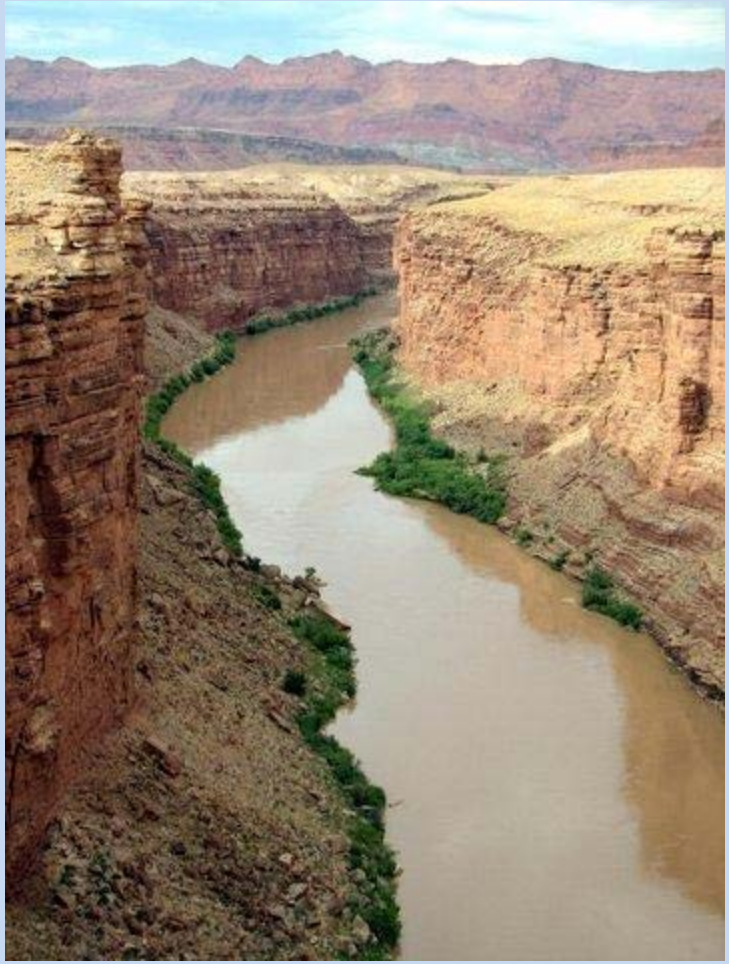
- Coproduction
- Science translation
- Boundary organizations
- Knowledge networks
- Decision support tools

But all of these approaches require resources. Is it always worth it to have engagement with stakeholders?

It is if you want decision-relevance, but there are lots of ways to do this right – and wrong!

One approach:
Arizona Water Institute-
Collaborative solutions for water sustainability

A consortium of Arizona's universities focused on water sustainability in Arizona and throughout the world through water research, technology transfer, education and capacity building…



400 water related faculty/staff
3 state agencies
Public and private partners

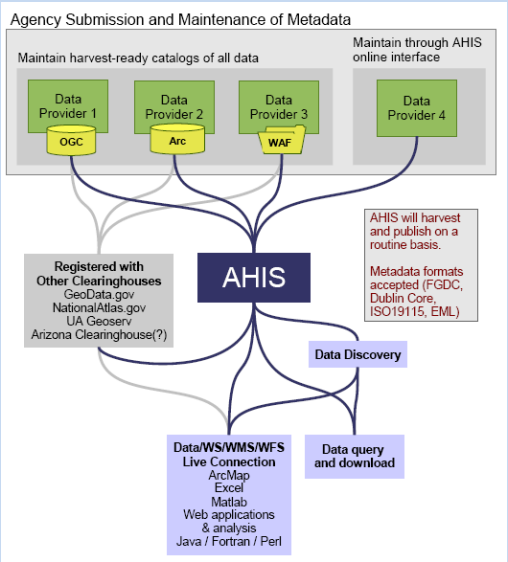
Starting with understanding emerging policy issues in the West

- Drought and climate change implications for water management and safe-yield/sustainability: adding stress to a system already stressed
- Increasing complexity and legal challenges to management system/limited adaptive capacity of institutions
- Scientific uncertainty used as a rationale for inaction
- Need for more focus on groundwater

Lake Powell's decline
J. Dohrenwend, USGS

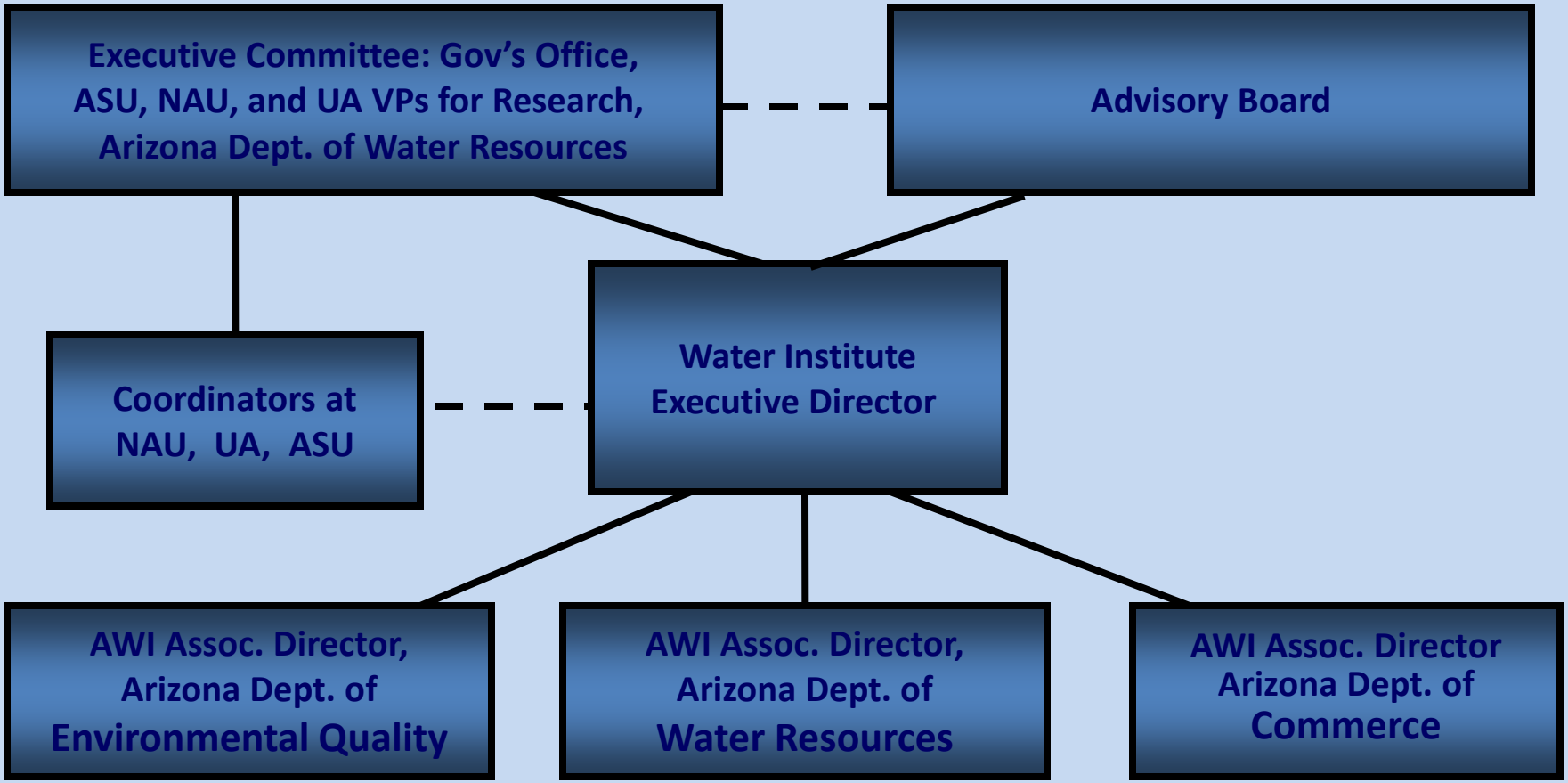
And focusing on scientific strengths: AWI Themes for 2007-2008

- Arizona Hydrologic Information System
- Emerging contaminants and treatment technologies
- Capacity building/ watershed support
- Energy and water sustainability
- Salinity management & technologies
- Climate change/drought/ adaptation



Lower Santa Cruz Replenishment Project

Arizona Water Institute: A Boundary Organization



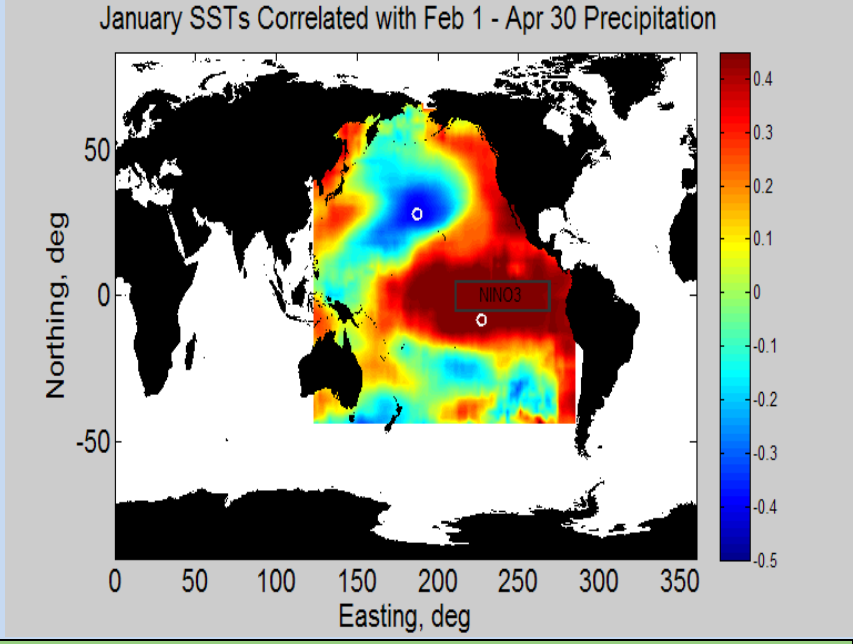
AWI Project Prioritization Criteria

- Evidence of need for project (clear benefits to stakeholders);
- Strategic importance to water management and the Arizona Water Institute;
- Scientific/technical/intellectual excellence and innovation;
- Collaborative approach: 2 universities/agencies;
- Qualifications of investigators;
- Availability of matching funds and other contributions;
- Commercialization, economic development and technology transfer opportunities;
- Interdisciplinary and boundary-spanning opportunities.

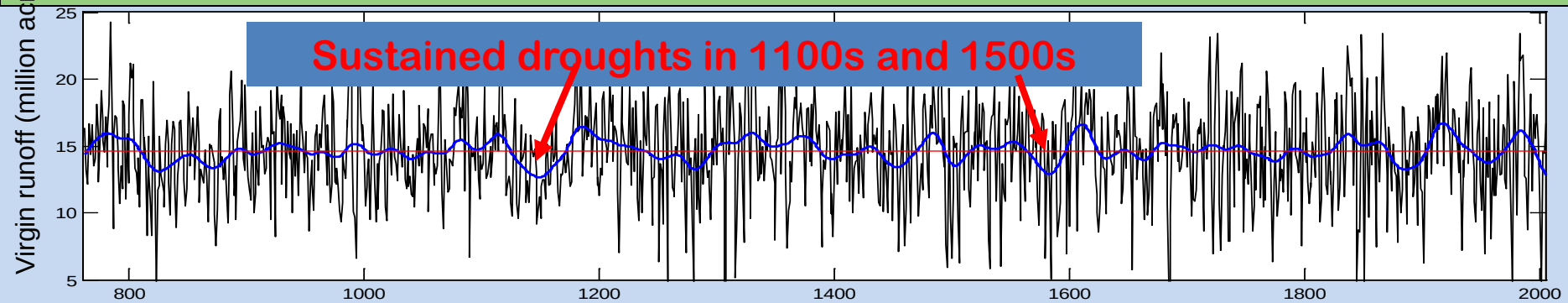
Research Highlights

Enhancing Water Supply Reliability on the Colorado River

- climate and hydrologic modeling;
- economics;
- water management and policy;
- dendrochronology



- 1,000-year extension of the tree ring record for the Upper Colorado to 762 AD.
- Method for projecting precipitation and temperature within watersheds based on sea surface temperatures.
- Inputs to the economics and climate-change portions of the EIS for shortage sharing on the Colorado River.



Data from Meko et al., Geophysical Res.

Goals for the 2013 National Climate Assessment and the Sustained Process

U.S. Global Change Research Program
National Climate Assessment

- **Sustainable process** with multiple products over time
- New topics, **cross-sectoral studies, risk-based framing**
- Consistent national matrix of **indicators**
- Central coordination, multiple **partners**
- Regional and sectoral **networks** building assessment **capacity**
- Recognizes **international context**
- Engagement and communications focus
- Web-based data and **tools for decision support**
- Process workshops to establish **methodologies**

NCA Water Chapter Research Needs*: A preview

- Development and deployment of methods and models for assessing how groundwater recharge rates are likely to be influenced by climatic changes.
- More comprehensive monitoring and compilation of measurements and indicators of actual ET variability, suitable for regional and larger evaluations.
- More comprehensive and consistent tracking, process modeling, and projections of water use at local to regional scales, nationwide and at weekly-to monthly time scales.
- Understanding how water quality and sedimentation characteristics depend on climatic variables and how dependencies may evolve in a changing climate.

*Thanks to: Aris Georgakakos, Paul Fleming, TC Richmond, Kate White, David Yates, Mike Dettinger, Christa Peters-Lidard, Ken Reckhow+

NCA Water Chapter Research Needs

- Analytical methods and practical applications of remotely-sensed soil moisture data, and integration with in situ soil moisture monitoring networks to improve understanding of how soil moisture is likely to be influenced by climate changes.
- Developing an understandable post-stationarity “new normal” paradigm that is useful for planning, design, operation and management of water systems.
- Basis for estimating extreme weather event probabilities in a changing climate.

NCA Water Chapter Research Needs

- Improved information and communication about uncertainties in climate system science, implications in climate models, emissions scenario development, and simulation methods.
- Higher resolution models and downscaling of global climate change models to apply at the appropriate scale for utilities.
- Improved understanding of climate change impacts on riparian ecosystems in the context of longer-term water budgets and ecological resources, and translation into frameworks for assessing climate change implications for fisheries, nonnative riparian vegetation, and other species or habitat conditions

NCA Water Chapter Research Needs

- Decision support planning and management methods for incorporating climate change information into planning, infrastructure (including evolving engineering design criteria), resource use, and water treatment decisions.
- Assessment of the ability of existing water regulatory structures to support flexible and adaptive responses to climate change.
- Guidance on how to conduct an adaptation evaluation that efficiently explores and ranks strategy options, potentially using optimization techniques

NCA Water Chapter Research Needs

Analysis of how economic valuation techniques and tools, such as cost/benefit analysis, discount rates and evaluations of tradeoffs, that are used for projects involving long lived assets, such as infrastructure, may need to be altered given the long term implications of climate change.

Use-Inspired Water Cycle Research

- A whirlwind tour of approaches to “being inspired” by users
- Some high priorities for water cycle research in the context of adapting to climate change
- Some ideas about connecting science and decision-making

National Climate Assessment Update

Stay tuned for the first draft of the National Climate Assessment (Dec 1!) with a number of innovations:

- a focus on decision support and a sustained assessment process,
- new topics, eg adaptation and mitigation,
- traceable accounts and transparent on-line access to data,
- multiple contributions to the new 10-year USGCRP strategic plan implementation:
  - Annual updates to research needs,
  - science integration and synthesis,
  - engagement capacity and partnerships across the US,
  - information to support new “Informing Decisions” and “Communicate and Educate” goals,
  - a commitment to indicators and scenarios,
  - and integration of social/behavioral science

CLIMATE
SUMMIT
WHAT IF IT'S A BIG HOAX AND WE CREATE A BETTER WORLD FOR NOTHING?
• ENERGY INDEPENDENCE
• PRESERVE RAINFORESTS
• SUSTAINABILITY
• GREEN JOBS
• LIVABLE CITIES
• RENEWABLES
• CLEAN WATER, AIR
• HEALTHY CHILDREN
• ETC. ETC.
JOEL PETT

Adaptation: Evaluate and Incorporate New Technologies

Expand portfolio of technology solutions:

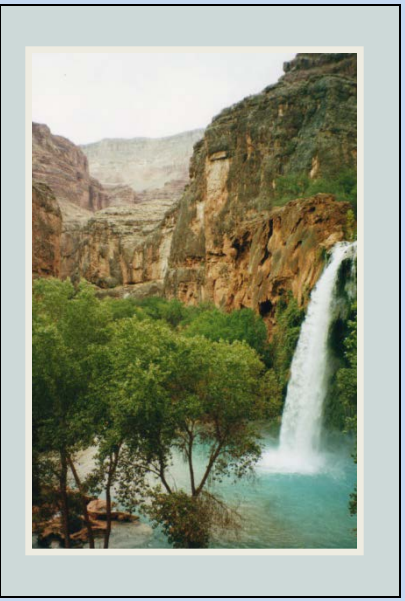
- desalination,
- reuse and recharge of municipal wastewater,
- weather modification,
- rainwater harvesting,
- improved management of floodflows,
- integration/redundancy of delivery systems for reliability

Challenges: The “Watergy” Perspective

- Most water technology solutions are energy-intensive:
  - inter-basin transfers,
  - desalination,
  - cloud seeding,
  - dry cooling
- Energy-intensive options will be less attractive in the future.
- Evaluate capital and water rights decisions re: short and long-term energy and water supply requirements

Triple bottom line analysis: consider economic, social and environmental costs, carbon emissions, multi-generational considerations

Watershed research and support projects



- Environmental Flow Requirements in the Verde River (2007)
- Identify and Characterize Arizona Heritage Waters (2007)
- Integrated Riparian Area Monitoring: Floods, Water Source and Biological Response (2007)
- Impacts of Forest Thinning on Water Balance (2008)
- Verde River Flows Study Phase II: Integrated Research for Refining Flow-Ecology Response Models (2008)
- Developing a Process for Identifying and Prioritizing At-Risk Water Resources for the Coconino Plateau (2008)

Capacity-building and Conservation

- Approaches to Water Management by Tribes in Arizona (2007)
- Arizona's Agricultural Economy – Future Scenarios and Water Management Implications (2008)
- Hydroclimate Management Capacity Building and Watershed-Based Precipitation-Runoff Modeling in the Navajo Nation (2008)
- Status of Generation, Reuse and Recharge of Treated Wastewater in Arizona: Evaluation of Programs, Data Sources and Utilization Options 2008
- Biosphere 2 Energy and Water Conservation Workshop (2008)