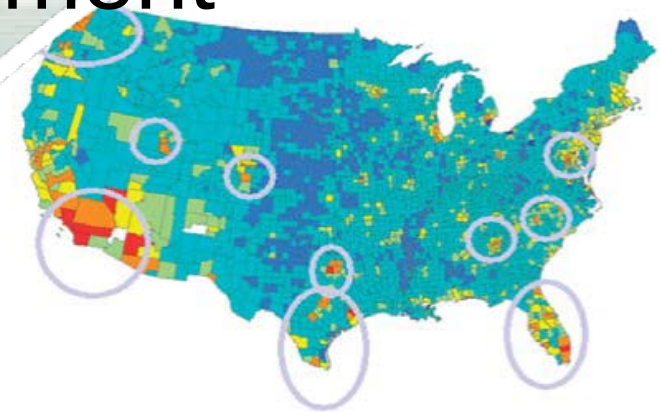
Flood frequency estimation in a changing climate, exploring how to address non-stationarity in contemporary water management activities

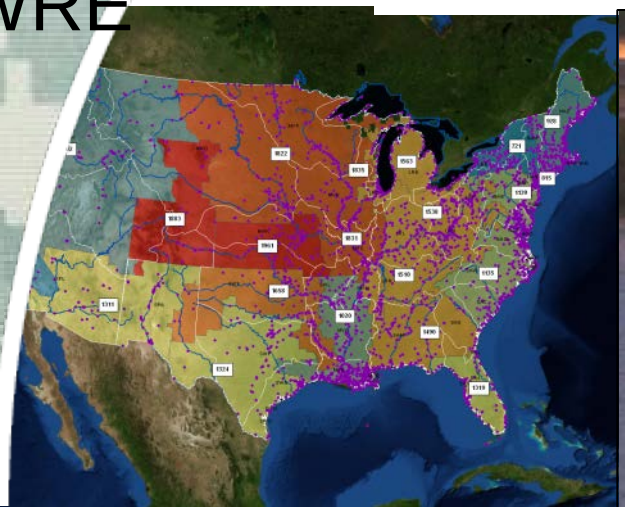


David Raff, PhD, PE, D.WRE

30 May 2013

US Army Corps of Engineers

BUILDING STRONG®



Bottom Line Upfront
Major Challenges to Adaptation

2012 Drought

Northeast Snow Storm Oct 2011

1. Flood experience high interannual variability.

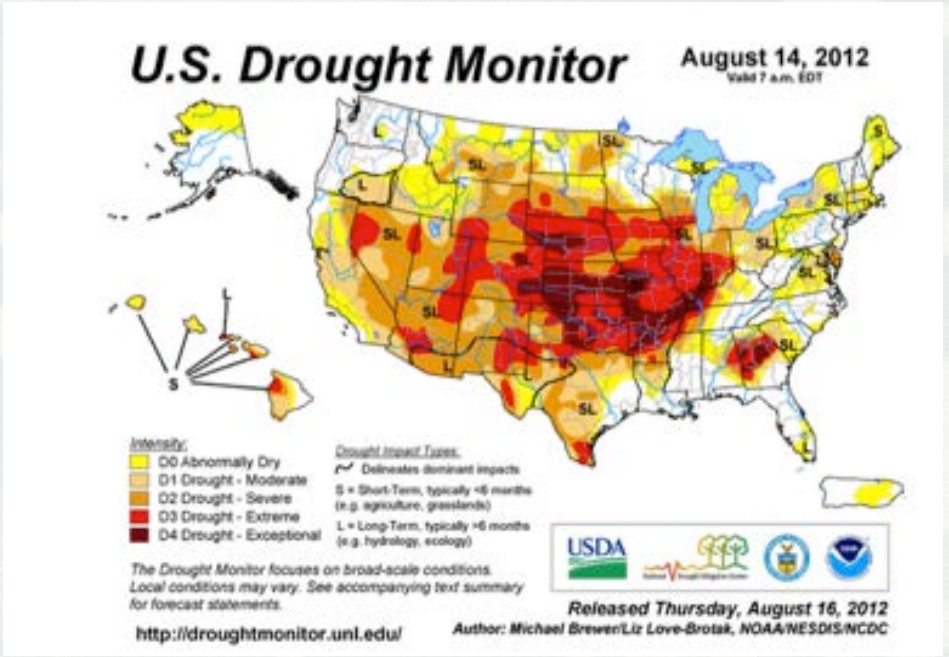
2. This leads to difficulty in detecting and attributing changes in flood frequencies due to climate change (or other factors).

3. Projections of future climate, particularly for flood inducing mechanisms, remains uncertain and is a scrutinized process with lack of agreement.

Motivation
Climate / Weather Stresses on USACE Projects
Example - Mississippi

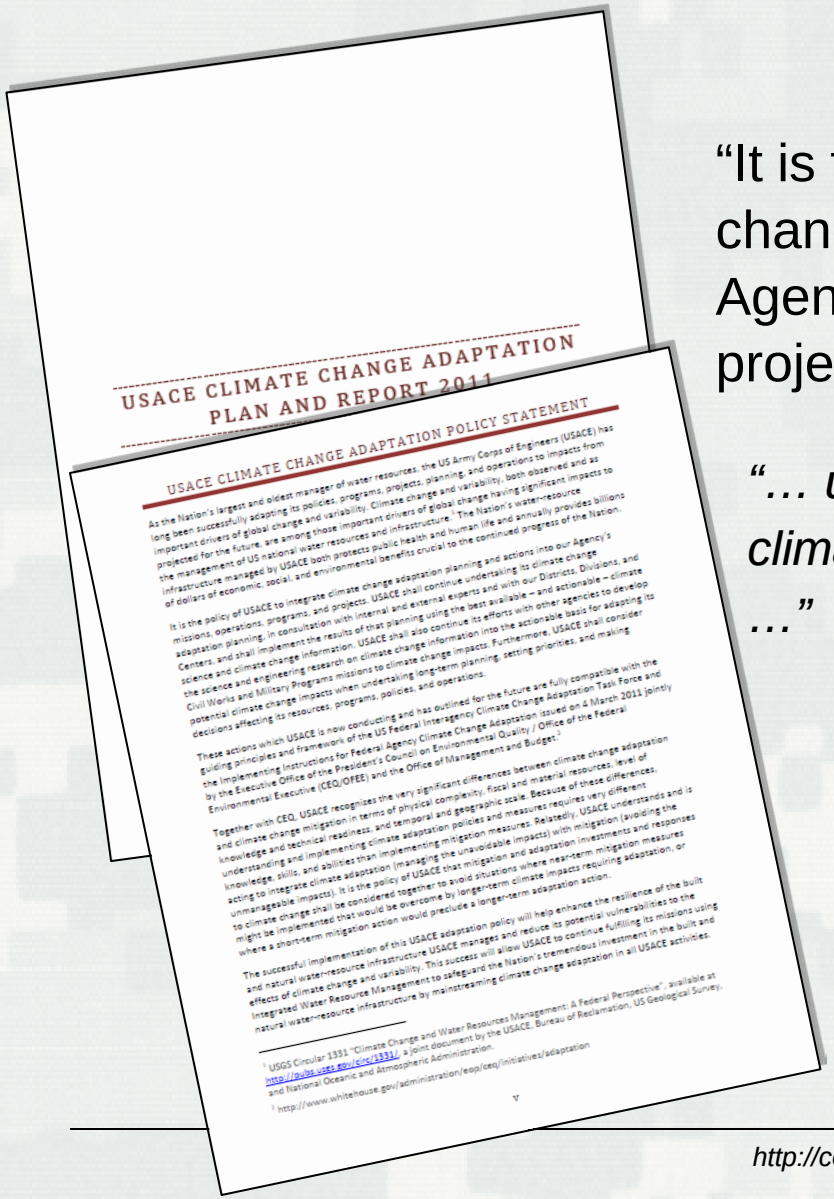
2011

2012



USACE Climate Change Adaptation Policy

June 2011


USACE CLIMATE CHANGE ADAPTATION PLAN AND REPORT 2011

USACE CLIMATE CHANGE ADAPTATION POLICY STATEMENT

As the Nation's largest and oldest manager of water resources, the US Army Corps of Engineers (USACE) has long been successfully adapting its policies, programs, projects, planning, and operations to impacts from important drivers of global change and variability. Climate change and variability, both observed and as projected for the future, are among those important drivers of global change having significant impacts to the management of US national water resources and infrastructure.[1] The Nation's water-resource infrastructure managed by USACE both protects public health and human life and annually provides billions of dollars of economic, social, and environmental benefits crucial to the continued progress of the Nation.

It is the policy of USACE to integrate climate change adaptation planning and actions into our Agency's missions, operations, programs, and projects. USACE shall continue undertaking its climate change adaptation planning, in consultation with internal and external experts and with our Districts, Divisions, and Centers, and shall implement the results of that planning using the best available – and actionable – climate science and climate change information. USACE shall also continue its efforts with other agencies to develop the science and engineering research on climate change impacts. Furthermore, USACE shall consider Civil Works and Military Programs missions to climate change impacts. Furthermore, USACE shall consider potential climate change impacts when undertaking long-term planning, setting priorities, and making decisions affecting its resources, programs, policies, and operations.

These actions which USACE is now conducting and has outlined for the future are fully compatible with the guiding principles and framework of the US Federal Interagency Climate Change Adaptation Task Force and the Implementing Instructions for Federal Agency Climate Change Adaptation issued on 4 March 2011 jointly by the Executive Office of the President's Council on Environmental Quality / Office of the Federal Environmental Executive (CEQ/OFEE) and the Office of Management and Budget.[2]

Together with CEQ, USACE recognizes the very significant differences between climate change adaptation and climate change mitigation in terms of physical complexity, fiscal and material resources, level of knowledge and technical readiness, and temporal and geographic scale. Because of these differences, understanding and implementing climate adaptation policies and measures requires very different knowledge, skills, and abilities than implementing mitigation measures. Relatedly, USACE understands and is acting to integrate climate adaptation (managing the unavoidable impacts) with mitigation (avoiding the unmanageable impacts). It is the policy of USACE that mitigation and adaptation investments and responses to climate change shall be considered together to avoid situations where near-term mitigation measures might be implemented that would be overcome by longer-term climate impacts requiring adaptation, or where a short-term mitigation action would preclude a longer-term adaptation action.

The successful implementation of this USACE adaptation policy will help enhance the resilience of the built and natural water-resource infrastructure USACE manages and reduce its potential vulnerabilities to the effects of climate change and variability. This success will allow USACE to continue fulfilling its missions using Integrated Water Resource Management to safeguard the Nation's tremendous investment in the built and natural water-resource infrastructure by mainstreaming climate change adaptation in all USACE activities.

[1] USGS Circular 1331 "Climate Change and Water Resources Management: A Federal Perspective", available at http://pubs.usgs.gov/circ/1331/, a joint document by the USACE, Bureau of Reclamation, US Geological Survey, and National Oceanic and Atmospheric Administration.

[2] http://www.whitehouse.gov/administration/eop/ceq/initiatives/adaptation

v

"It is the policy of USACE to integrate climate change adaptation planning and actions into our Agency's missions, operations, programs, and projects."

"… using the best available – and actionable – climate science and climate change information …"

"… it shall be considered at every step in the project life cycle for all USACE projects, both existing and planned, … to *reduce vulnerabilities and enhance the resilience of our water-resource infrastructure.*"

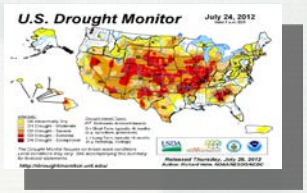
NEED TO USE BOTH OBSERVATIONS AND PROJECTIONS FOR ADAPTATION

1) Detect and Attribute Hydrologic Changes (Yes / No)
   - This is the PAST
2) Will available projections of change alter hydrology (Yes / No)
   - This is the FUTURE

Detect and Attribute Change	Project Change	Adjustment DRAFT NUMBERS BEING EVALUATED
Yes	No	XX%
No	Yes	XX -- %
Yes	Yes	XX ++ %
No	No	0% (Business as Usual)

3) Conduct hydrology analysis per existing USACE guidance
4) Adjust uncertainty levels per Climate Change Guidance

Inland Hydrology Climate Change Adaptation Guidance Development



2012 Drought

Northeast Snow Storm
Oct 2011

1. Identify Available Information that is relevant to decision at hand and potential impacts to USACE Business Lines

2. Use available observed and historical information to attempt to detect and attribute changes to climate for hydrologic metric of interest

3. Use climate projection information to evaluate if changes are projected to occur in the future for hydrologic metric of interest (e.g. peak flood flows, annual water supply, hydropower production, …)

4. Adjust hydrologic inputs into decision criteria (planning, design, construction) based on whether changes are detected and / or projected.

Coordination and Guidance Teams – Key Guidance

Professor Richard Vogel
Tufts University

Hydrologic, hydraulic and statistical methods for analyzing water resource systems

Professor Upmanu Lall
Columbia University

Hydroclimatology, climate change adaptation, risk analysis and mitigation.

Professor Gabriele Villarini
University of Iowa

Flood hydrology, extreme events, remote sensing of rainfall, seasonal forecast, and statistical modeling.

Non-Stationarity and Floods Work Team

Internal Work Team

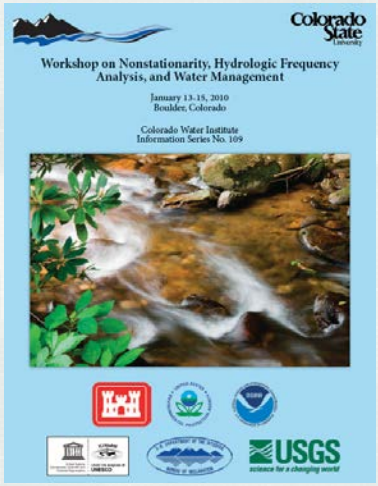
Inter-Agency Work Team

RECLAMATION
US Army Corps of Engineers
USGS science for a changing world
FEMA

Academic Team

SIGILLUM UNIVERSITATIS TUFTENSIS PAX ET LUX 1852
IN LUMINE TUO VIDEBIMUS LUMEN
THE UNIVERSITY OF IOWA ORGANIZED FEB. 25TH 1847

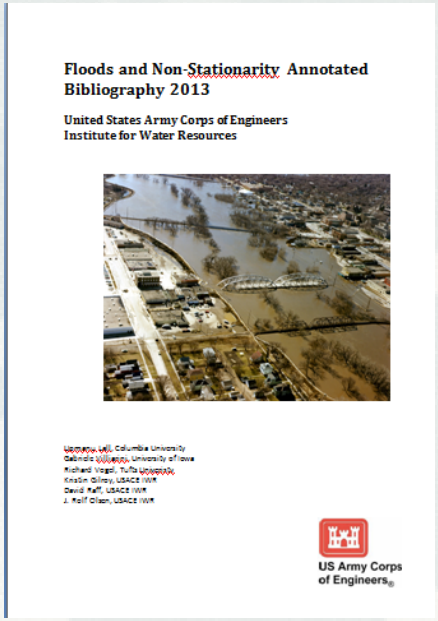
Initial Product from this team supporting adaptation as building block : Annotated Bibliography



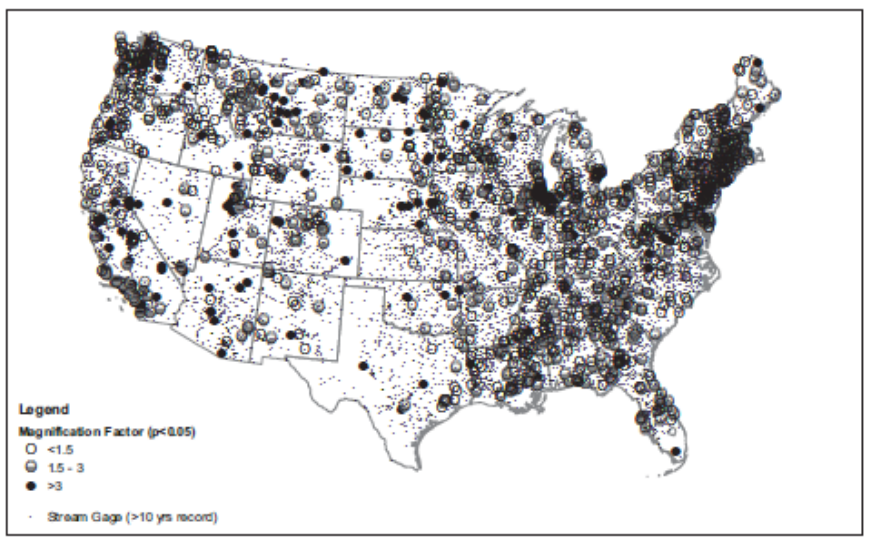
Non-Stationarity Workshop and Proceedings 2010

USACE Annotated Bibliography
2013

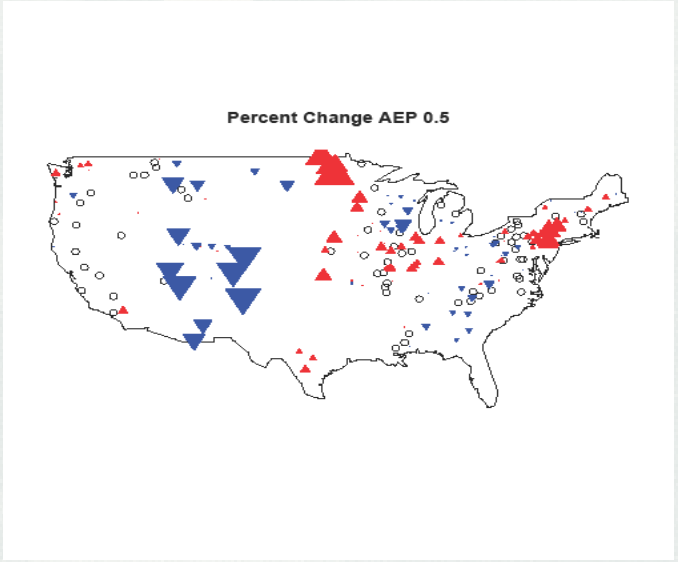
1. Detection / Attribution
2. Characterizing the Future for Engineering Analysis
3. Projections of Future Change
4. Non-Stationarity in a Risk Framework



Detection and Attribution Difficulties



From Vogel et al. 2011



After Hirsch and Ryberg 2012

•Utilize Detection / Attribution Chapter from Annotated Bibliography to develop template for USACE guidance

Utilization of Projections

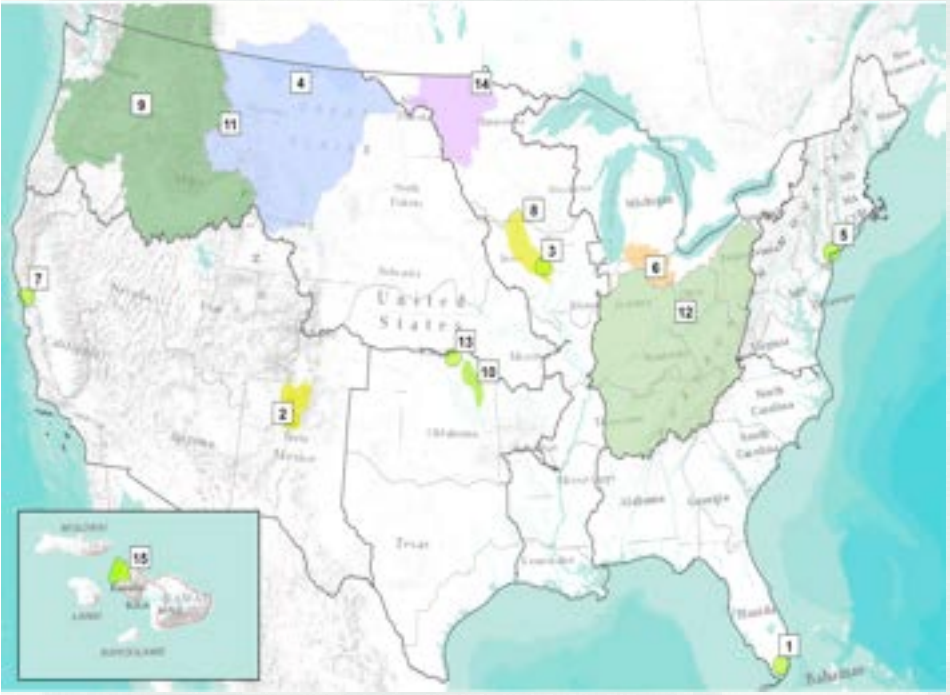
Provide some level of familiarity with the use of projections

Provide opportunity for consistency of use of projections

- Downscaling methodology
- Model Availability
- Hydrologic Analysis

Adaptation pilots

- **USACE is conducting climate change adaptation pilots:**
  - **Assessing Impacts**
  - **Identifying Adaptation Options**
  - **Refining data dissemination and methodologies**
- **Geographic distribution has additional benefit of getting staff knowledgeable and familiar with climate change information.**



KEY

[1] Application of Sea-Level Change Guidance to C-111 Spreader Canal, Florida

[2] Climate Change Associated Sediment Yield Impacts on the Rio Grande, Cochiti Dam and Lake

[3] Climate Change Impacts on the Operation of Coralville Lake, Iowa

[4] Climate Change Associated Sediment Yield Impacts and Operation Evaluations at Garrison Dam, North Dakota

[5] East Rockaway Inlet to Rockaway Inlet, New York, Collaboration Framework Development

[6] Upland Sediment Production and Delivery in the Great Lakes Region under Climate Change

[7] Risk-Informed Decision-Making for Potential Sea-Level Rise Impacts on the Hamilton Wetland Restoration Project, California

[8] Climate Modeling and Stakeholder Engagement to Support Adaptation in the Iowa-Cedar Watershed

[9] Framework for Building Resiliency into Restoration Planning – Lower Columbia River Estuary

[10] Climate Change Impacts on Water Supply in Marion Reservoir Watershed, Kansas

[11] Missouri River Basin Mountain Snowpack – Accumulation and Runoff

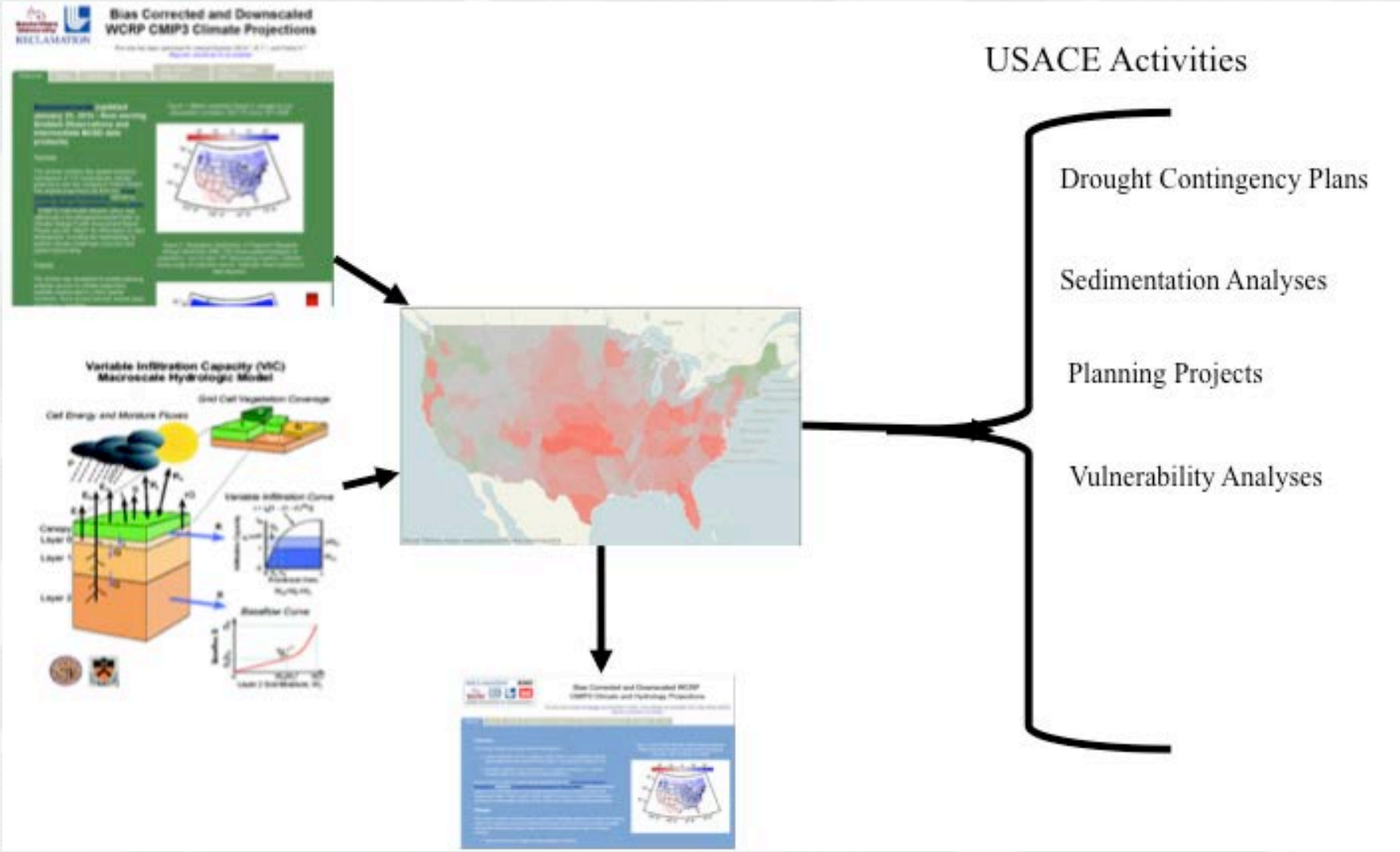
[12] Formulating Mitigation/Adaptation Strategies through Regional Collaboration with the Ohio River Basin Alliance

[13] Utilization of Regional Climate Science Programs in Reservoir and Watershed Risk-Based Assessments, Oologah Lake and Watershed

[14] Red River of the North Flooding at Fargo, North Dakota

[15] Risk-Informed Decision-Making for Integrated Water Resource Management Planning, West Maui Watershed

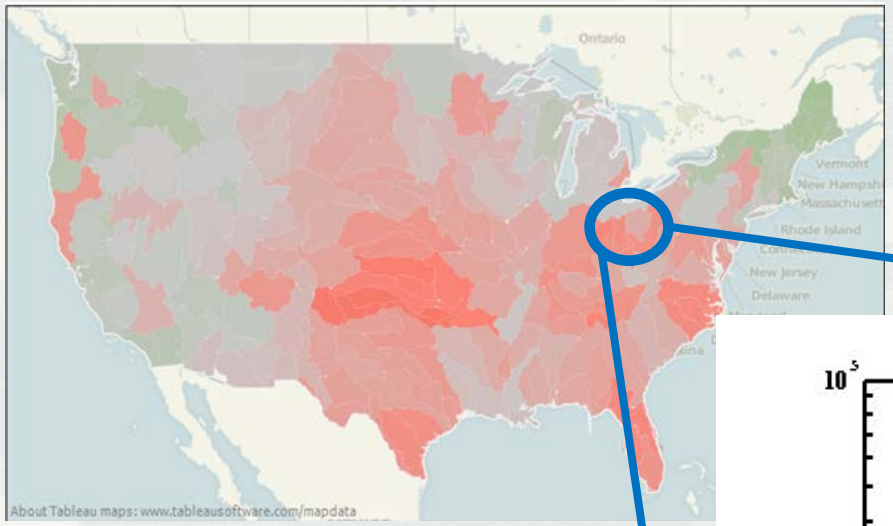
Hydrologic Projections – FY 2013

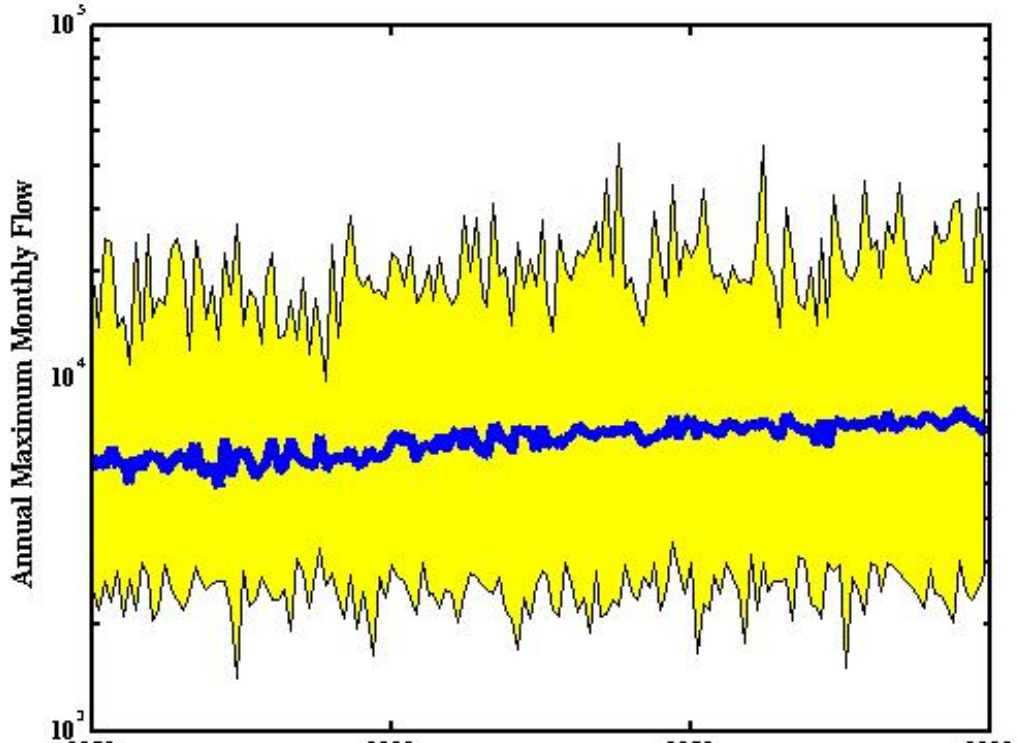


Hydrologic Projections

Phase 1 Complete

(Example) HUC 0509 – Middle Ohio





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