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

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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
“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

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

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

Academic Team
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
[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
[6] Upland Sediment Production and Delivery in the Great Lakes Region under Climate Change
[8] Climate Modeling and Stakeholder Engagement to Support Adaptation in the Iowa-Cedar Watershed
[10] Climate Change Impacts on Water Supply in Marion Reservoir Watershed, Kansas
[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
Hydrologic Projections – FY 2013

USACE Activities
- Drought Contingency Plans
- Sedimentation Analyses
- Planning Projects
- Vulnerability Analyses
Hydrologic Projections
Phase 1 Complete

(Example) HUC 0509 – Middle Ohio
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