North American Floods & Climate Change : Perspectives from the US Army Corps of Engineers

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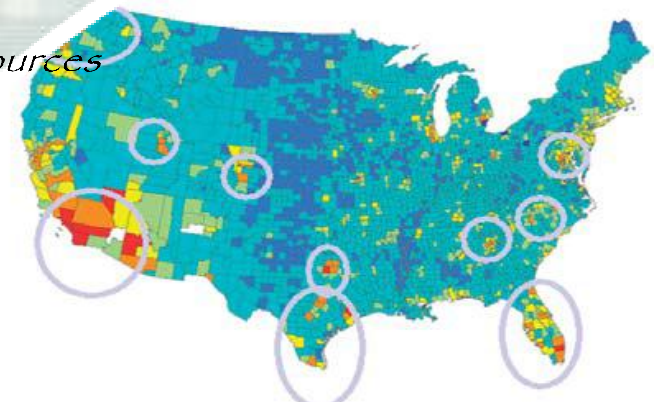
US Army Corps of Engineers | Institute for Water Resources

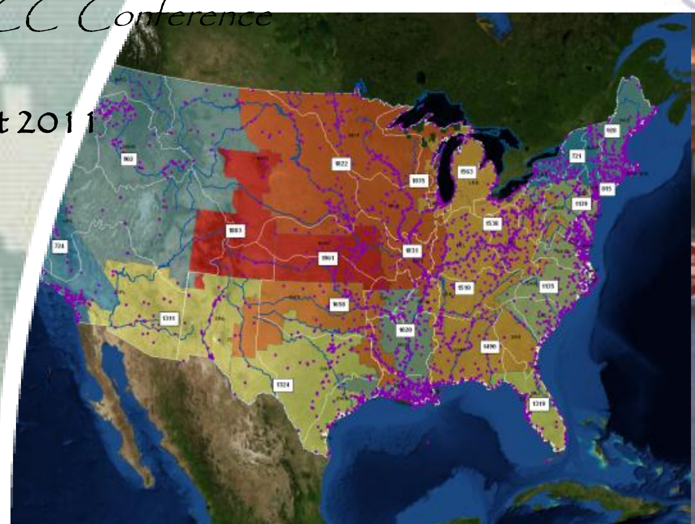
Washington, DC



Climate Change & Flooding in the Valley of Mexico : Perspectives from Local Stakeholders & the International Water Community

A SEMARNAT CONAGUA D4WCC Conference

Mexico City | 17 August 2011



US Army Corps of Engineers

BUILDING STRONG®

Climate Change-Forced Flooding Affects Nearly All USACE Missions & Programs

Military Programs

- MILCON for Modular Force Global Positioning
- BRAC
- Field Force Engineering
- MILCON Transformation
- Environmental Restoration

Real Estate

- DOD R... F...ities

Homeland Security

- Critical Infrastruc
- Anti-Terrorist Pl
- Intelligence
- Facility & Project

- Water Re
- Projects &
- Environm
- Warfighte

Civil Works

- Navigation
- Hydropower
- Flood Control & Shore Protection
- Reservoir Management & Water Supply
- Emergency & Disaster Response
- Environmental Restoration
- Recreation
- Regulatory Permitting

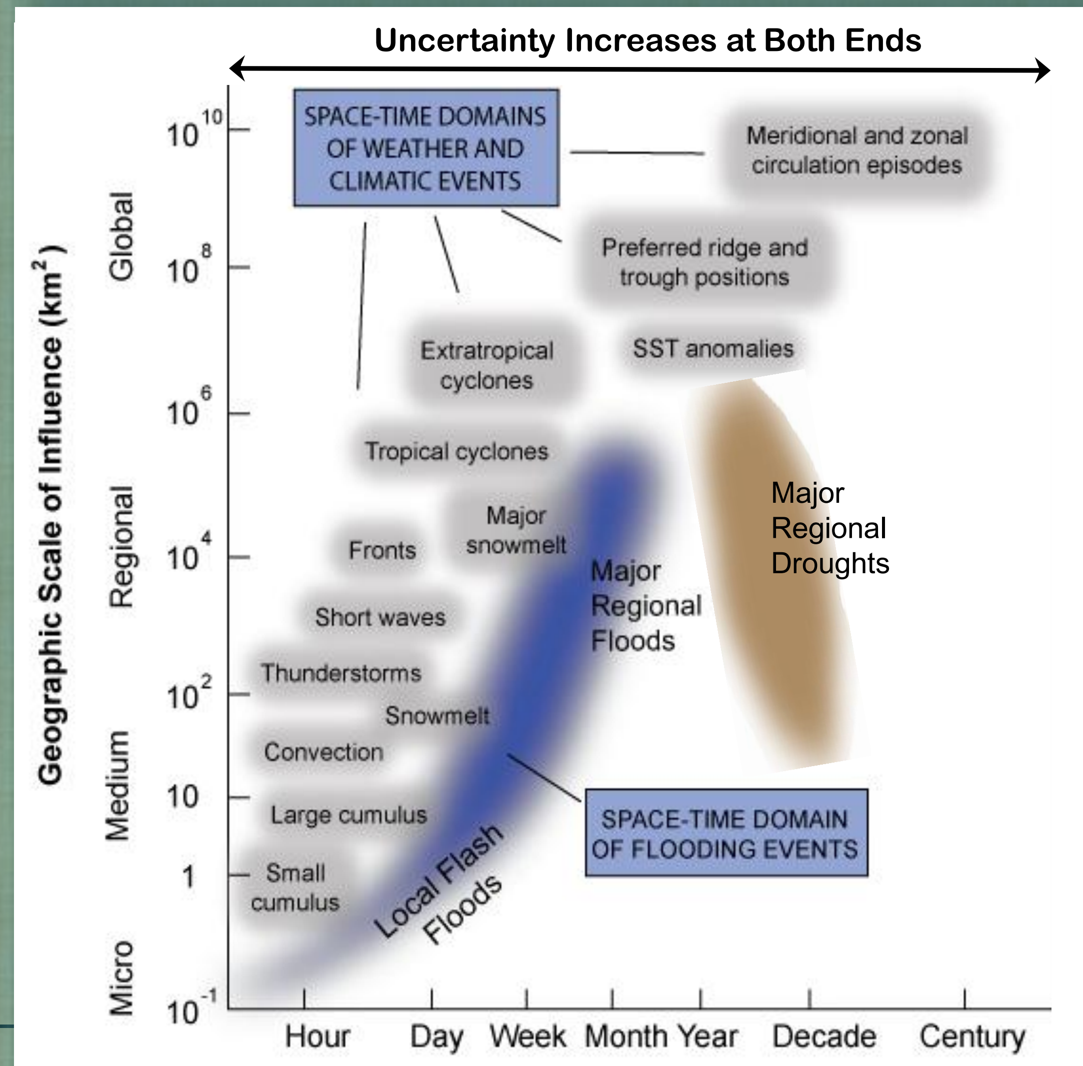
Interagency Support

- Federal
- State
- Local
- International

Climate & Weather Are Linked, But Scale Differently

This Means
Hydrologic Responses Differ
Over Space & Time, too

And That Means Our
Work to Characterize &
Understand Changes in Floods,
& to Construct Our
Effective Adaptation
Responses,
Must be Scaled to Match



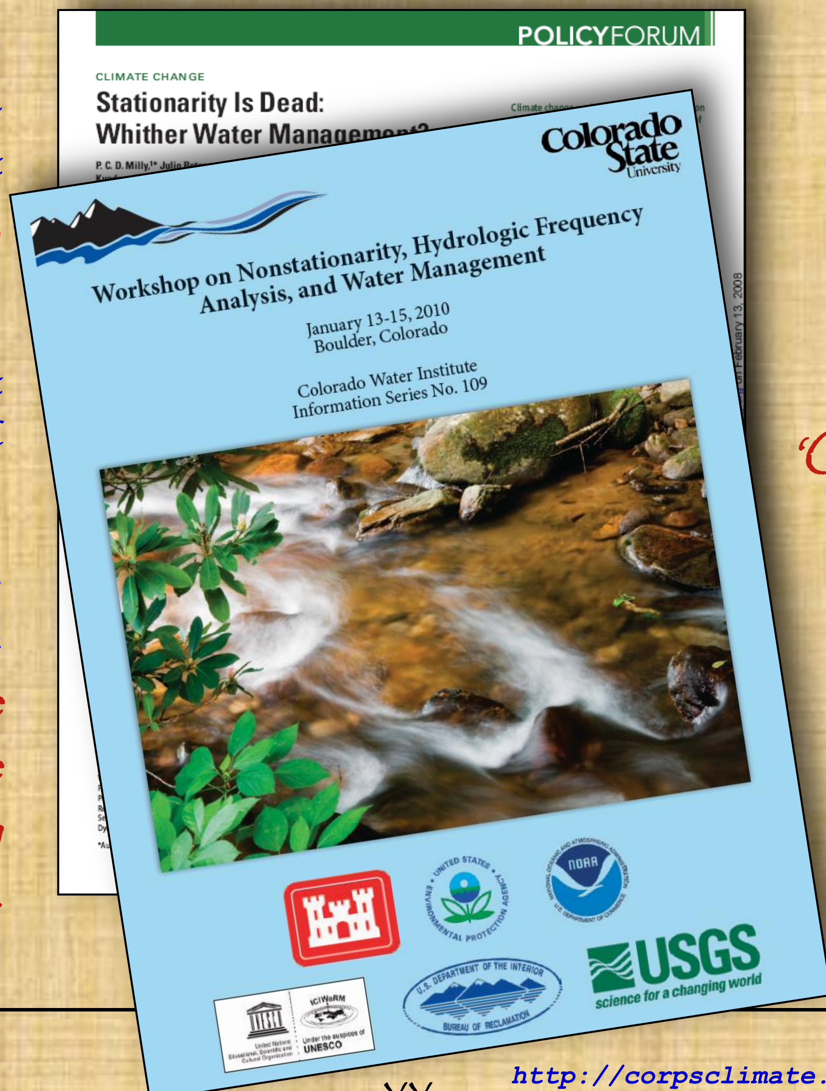
after Hirschboeck, 1988

Hydrologic Stationarity Is Dead

(if it even ever had been alive)

The assumption behind traditional hydrologic frequency analysis that climate is stationary

With the result that statistical properties of hydrologic variables in future time periods will be similar to past time periods; *i.e.*, that *future variation will be in the same range as variation in the past.*



'Stationarity is a foundational concept that permeates training & practice in water-resource engineering.'

'Climate change undermines a basic assumption that historically has facilitated management of water supplies, demands, & risks.'

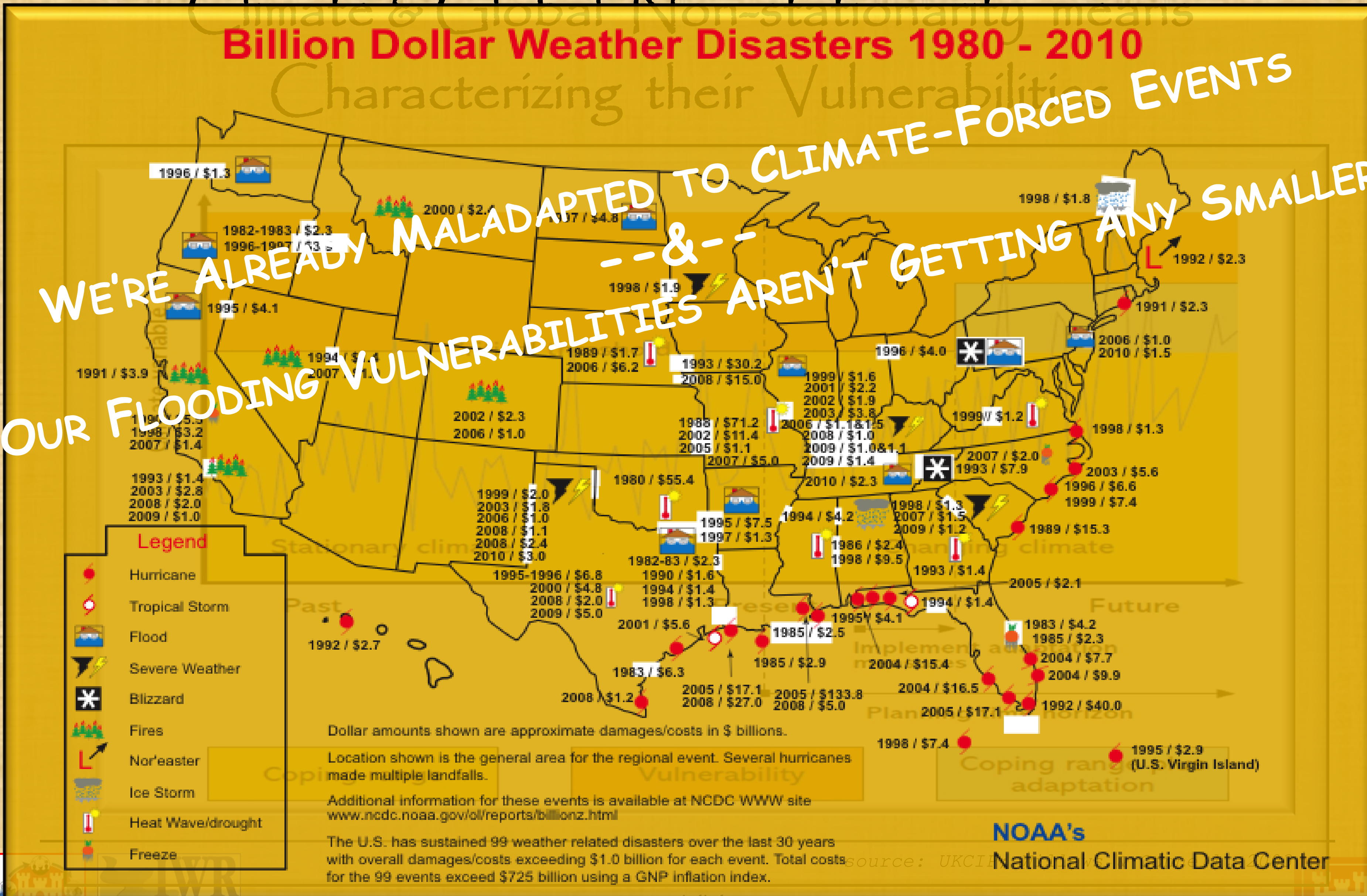
http://corpsclimate.us

Managing Water Resources under Climate & Global Non-stationarity means Characterizing their Vulnerabilities

We're Already Maladapted to Climate-Forced Events

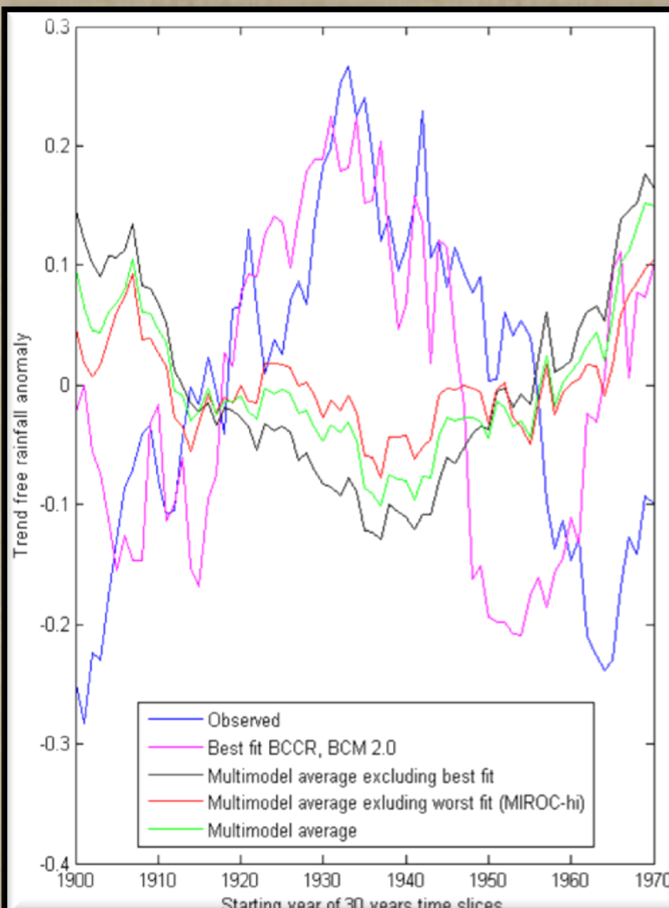
--&--

Our Flooding Vulnerabilities Aren't Getting Any Smaller

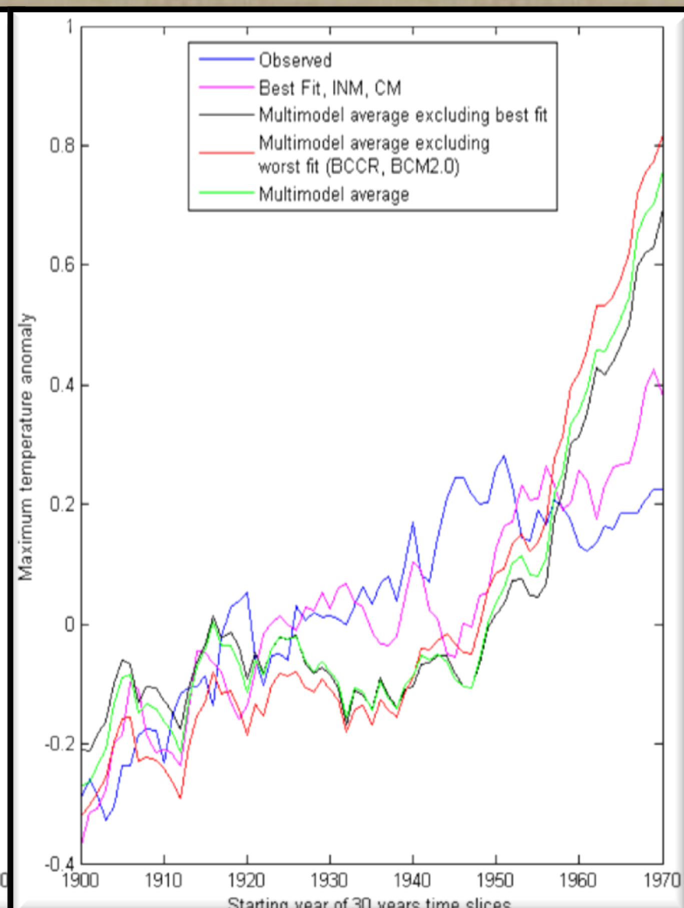


So, Don't Start with the AOGCMs …

Individual Models & Multi-model Averages Perform Differently for Different Variables in Different Places



(a) monsoon rainfall anomaly



(b) T max anomaly

Best-fit models outperform multi-model averages for a seven-member AOGCM ensemble in a domain over India

<u>Best-fit models</u>

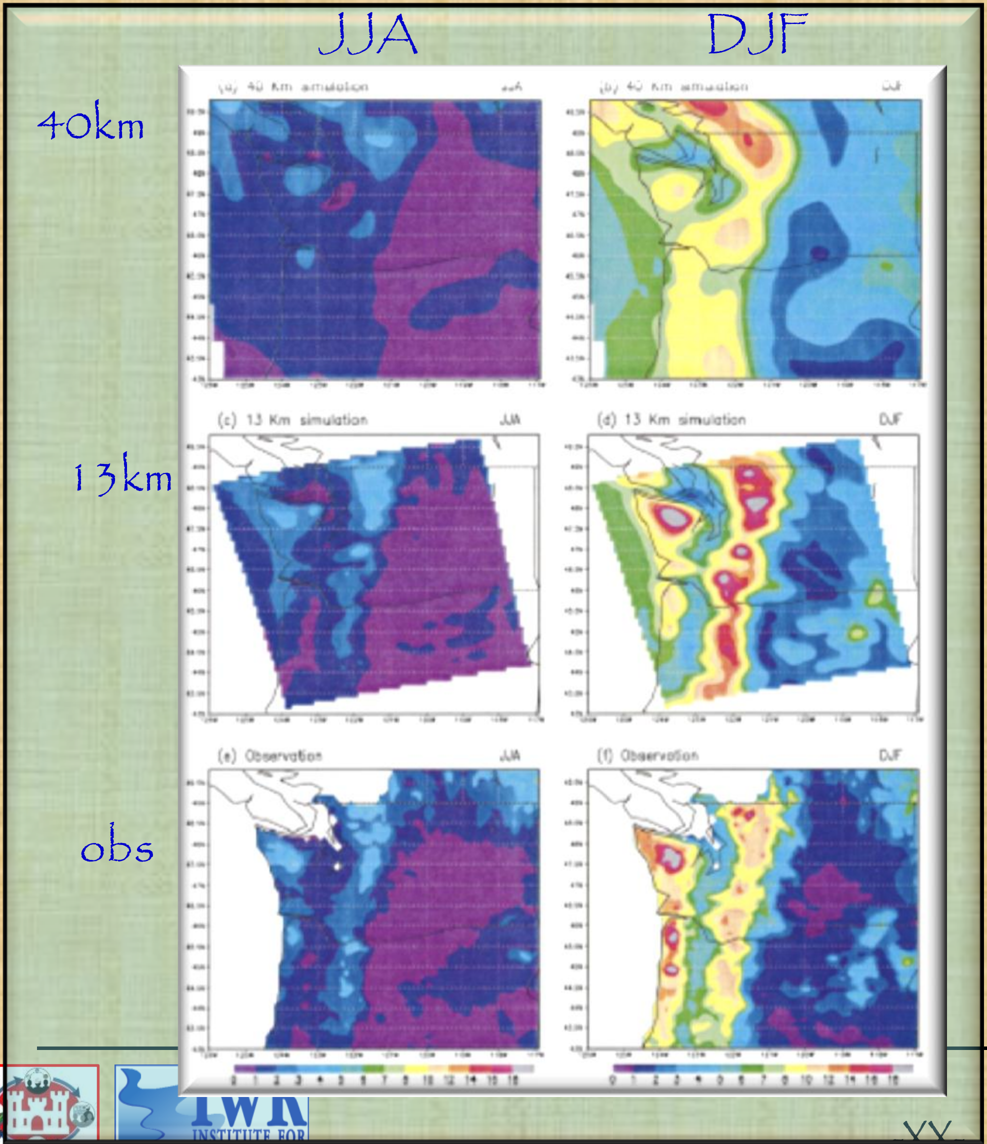
Rainfall: BCCR

T max: INM

source: Santer et al., & Pierce et al., PNAS, 2009

slide courtesy: Aroop Ganguly, DoE / ORNL

… And Don't Start with the Scenarios, Or the Downscaling Method …



more terrain detail gives more structure in precipitation

while some seasonal patterns can improve with higher resolution, *magnitude often overestimated*

figure from Leung & Qian, 2003; Rauscher et al., 2009, & Caldwell et al., 2010, showed similar relationships

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Start with your Applications Decision

Decision scaling » derive the *climate response function* of the syst[…]
being managed, & tailor climate sci[…]
the decision problem at that scale

» moves the emphas[…]
from *'reduce scientific uncertainty'* […]
& the information needed to suppo[…]

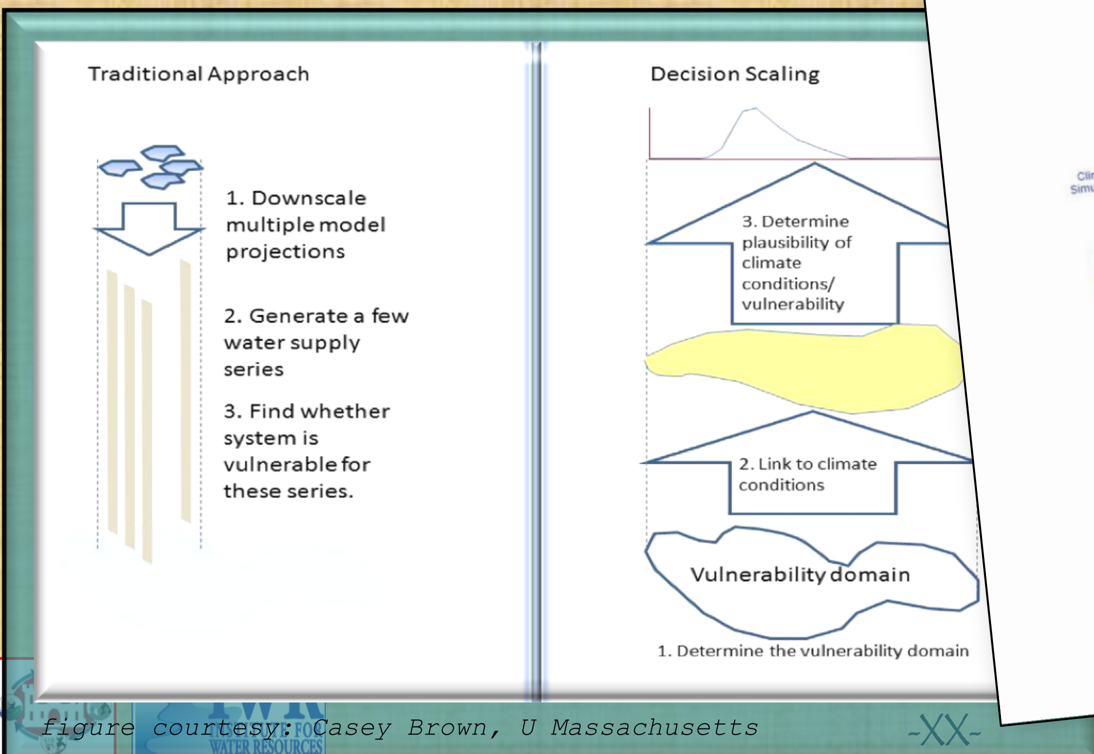
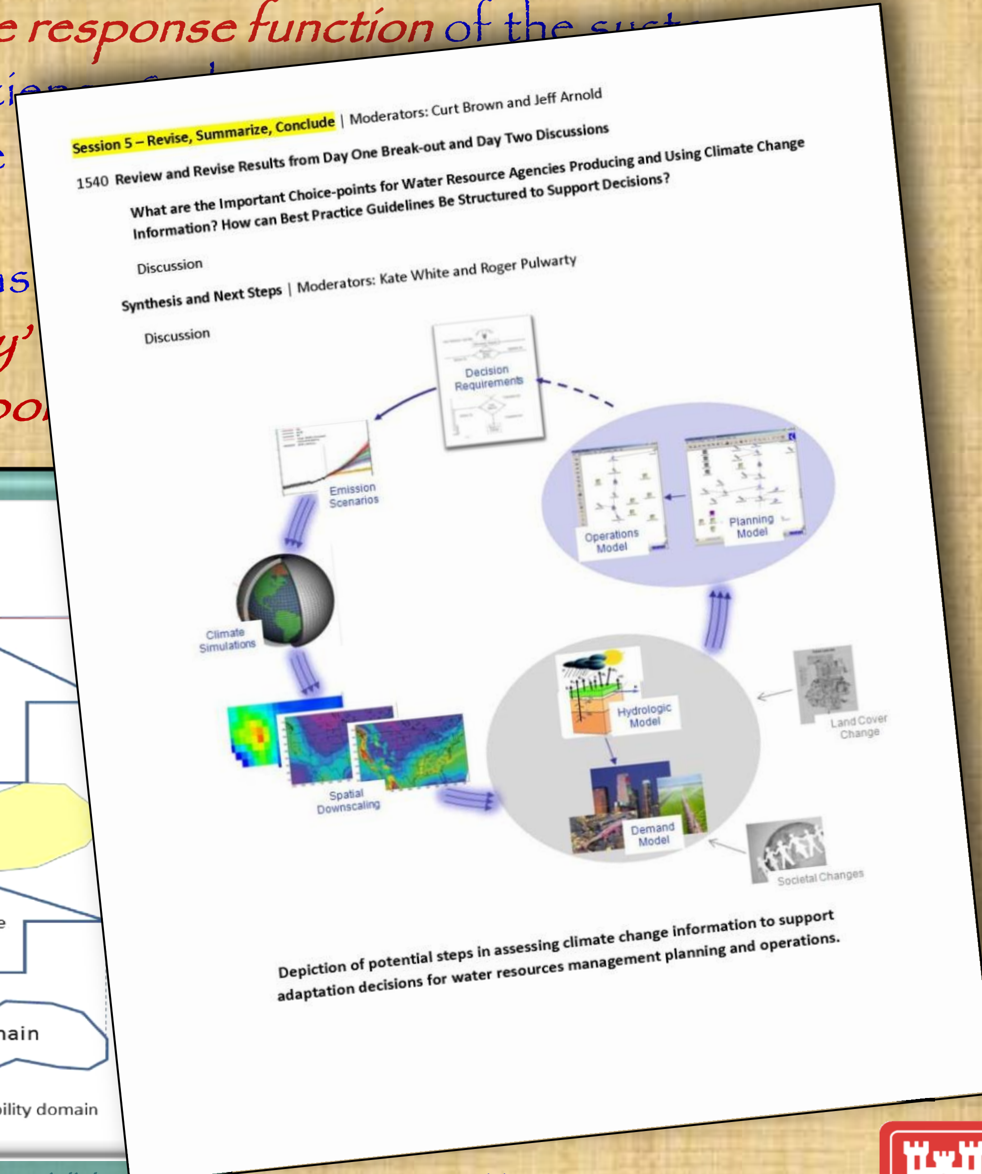


figure courtesy: Casey Brown, U Massachusetts


Session 5 – Revise, Summarize, Conclude | Moderators: Curt Brown and Jeff Arnold

1540 **Review and Revise Results from Day One Break-out and Day Two Discussions**

What are the Important Choice-points for Water Resource Agencies Producing and Using Climate Change Information? How can Best Practice Guidelines Be Structured to Support Decisions?

Discussion

Synthesis and Next Steps | Moderators: Kate White and Roger Pulwarty

Discussion

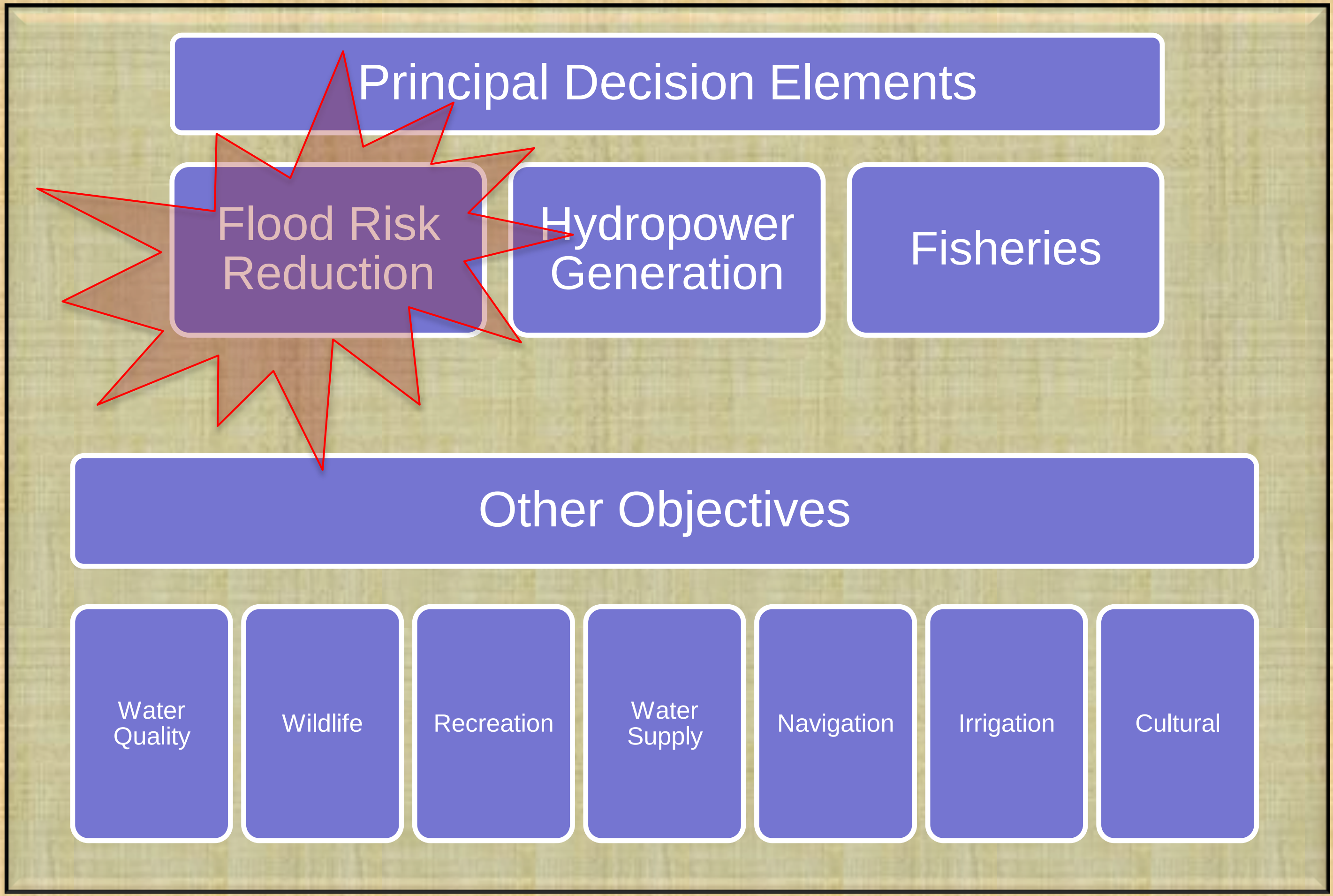
Depiction of potential steps in assessing climate change information to support adaptation decisions for water resources management planning and operations.

http://corpsclimate.us

What Types of Decisions are Required?

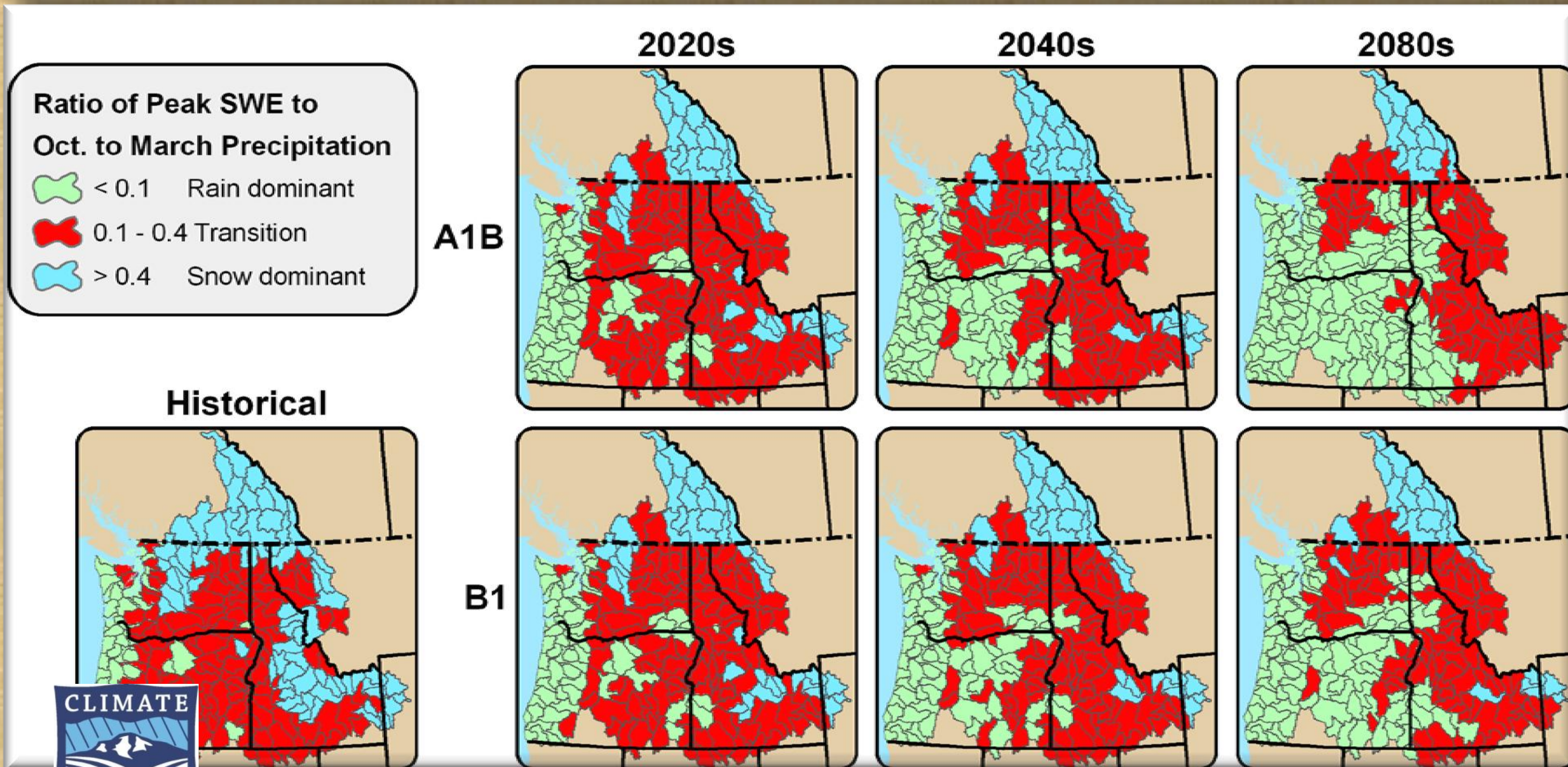
Typical Watershed Examples for USACE & Others

Still Require Integrated Water Resources Management to Balance



Seasonal Watershed Precipitation Classes will Continue Changing

Example: Snow-to-Rain-Dominated HUCs in PacNW

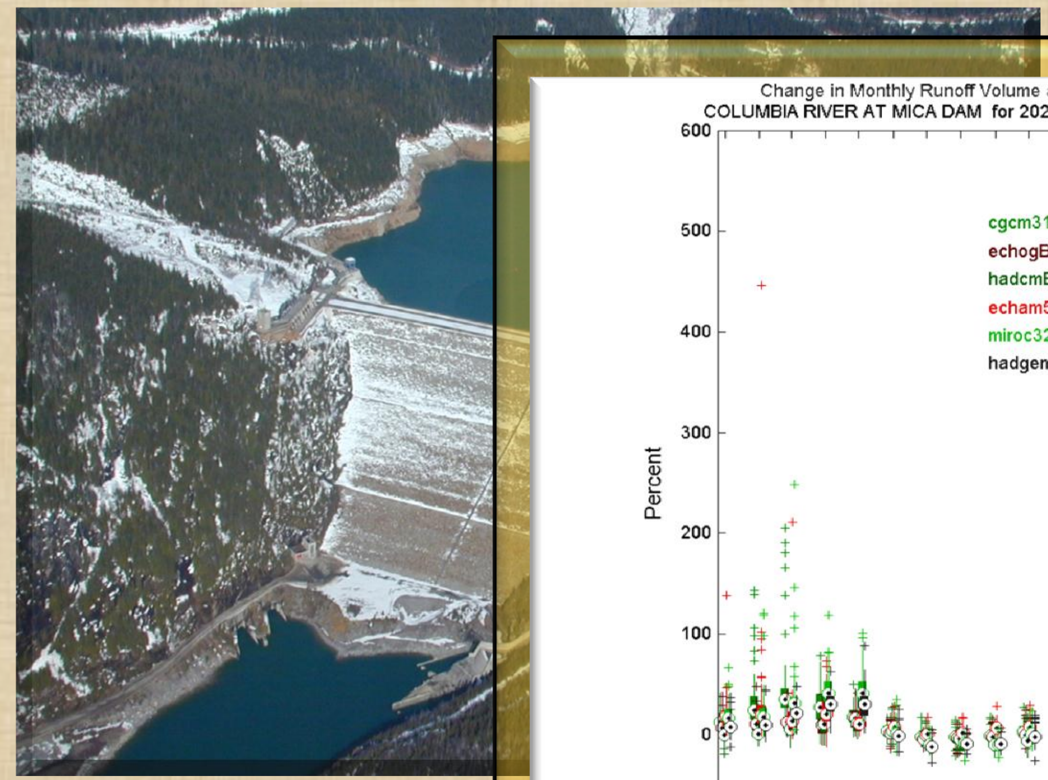


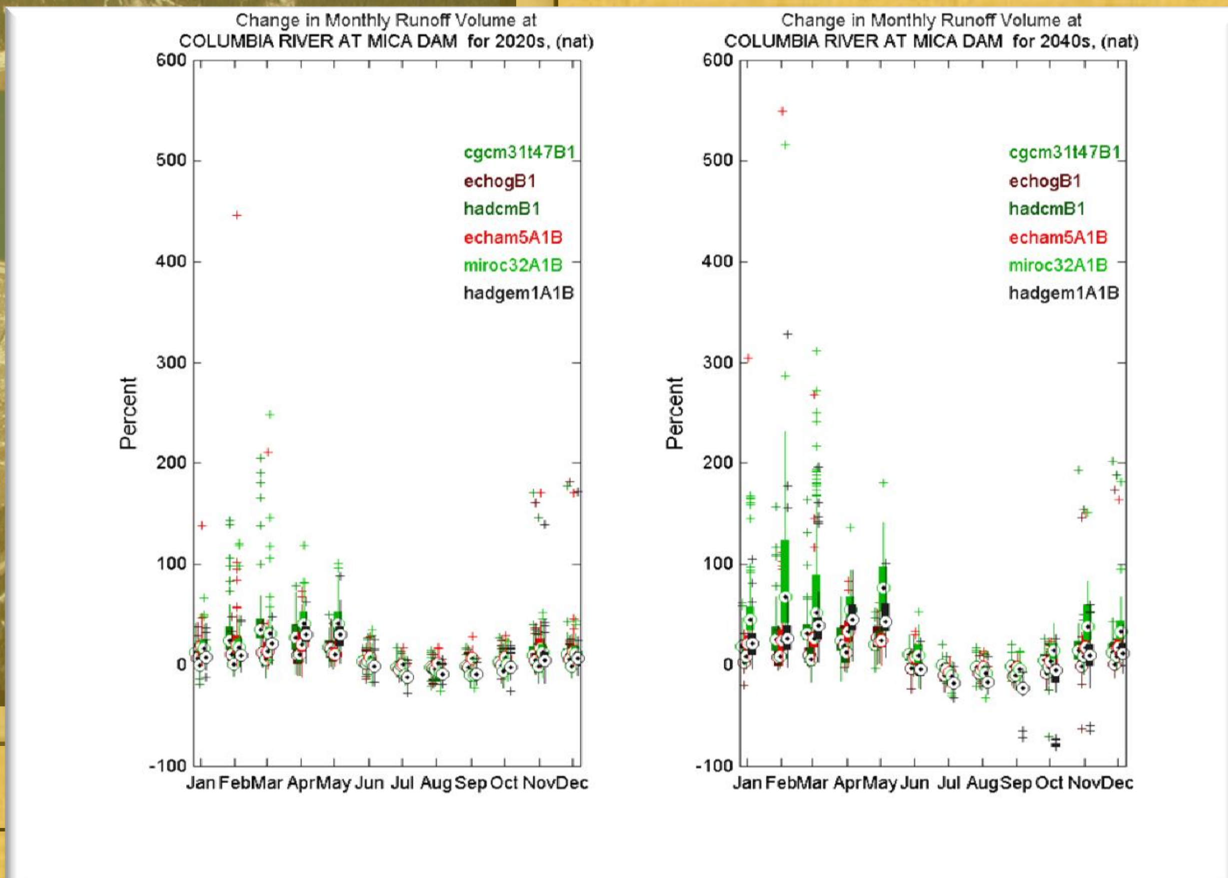
** Based on Composite Delta Method scenarios (multi-model average change in T & P)*

slide courtesy: Alan Hamlet & Rob Norheim, UW CIG

Decisions & Adaptation Responses Have to Continue Changing, too

Percent Change in Monthly Flow Volume at Mica Dam, BC





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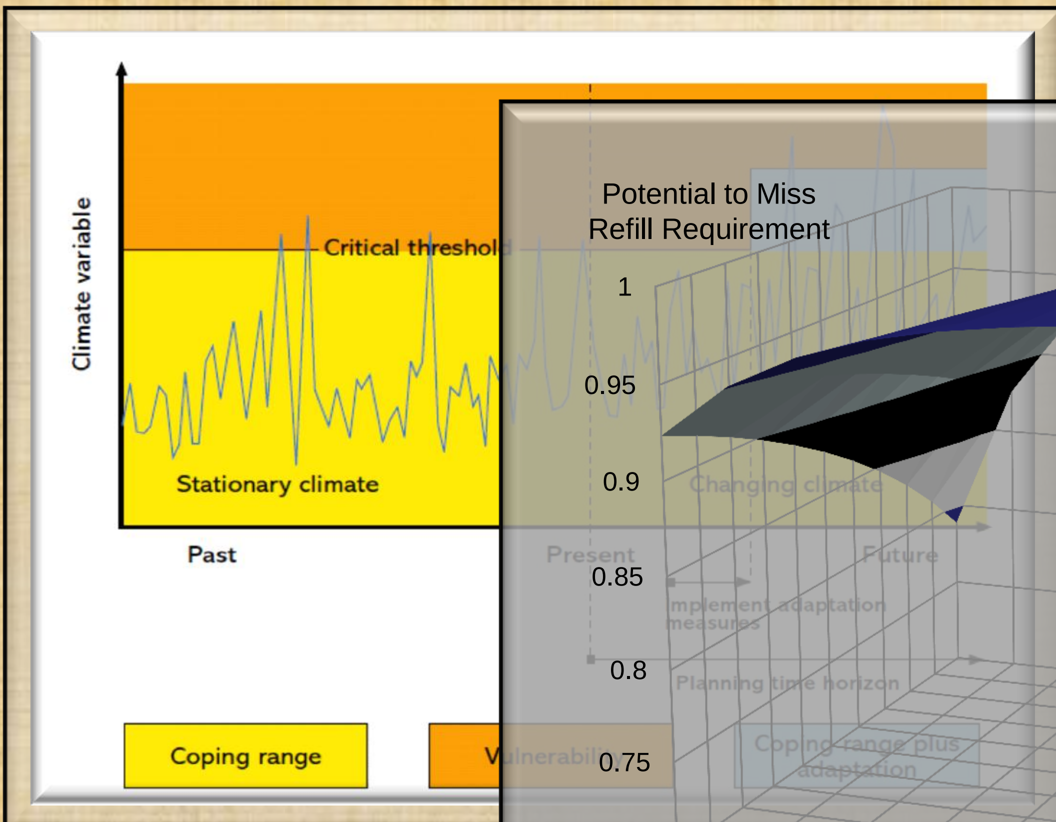
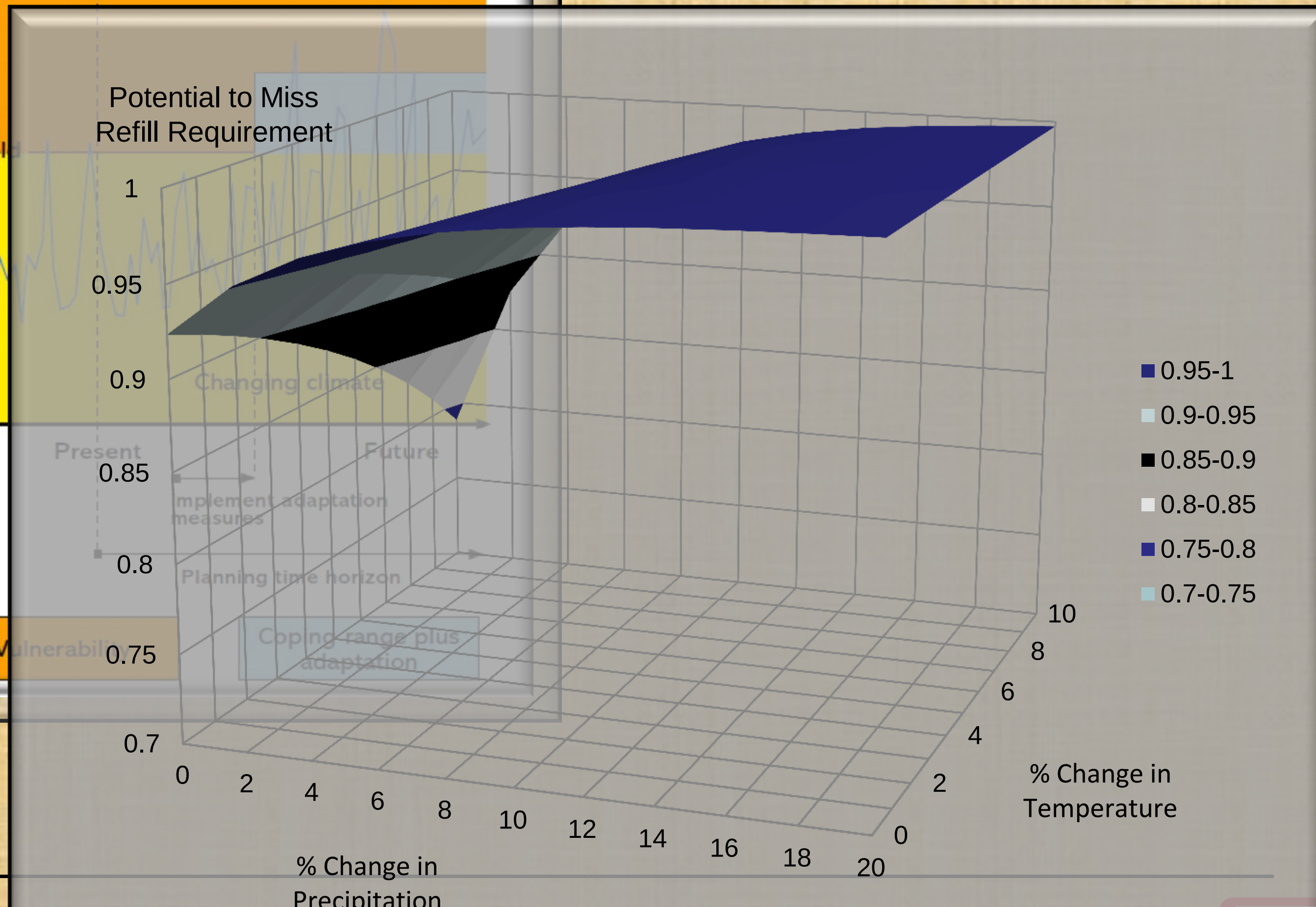
Example Product: Assessment of Future Flooding Vulnerability & Reservoir Implications





plot adapted from Casey Brown, U Massachusetts

HUC-4 CONUS Vulnerability Assessment for all USACE Mission Areas

-- Underway! Experimental Products & Preliminary Results!! --

Indicator ID #	Indicator Name	Unit	Value Same for Current and Future?	Direction of Vulnerability (which values indicate higher vulnerability?)
8	At-Risk Freshwater Plant Communities	HUC4	Yes	Higher values indicate higher vulnerability
26	Coastal wetlands (extent/acreage)	Coastal	No	Lower values indicate higher vulnerability
130	Population (human) susceptible to flood risk	HUC4	No	Higher values indicate higher vulnerability
192	Urban and Suburban Areas (extent/acreage)	HUC4	No	Higher values indicate higher vulnerability
297	Macroinvertebrate Index of Biotic Condition	HUC4	Yes	Lower values indicate higher vulnerability
441	Closeness to inundation area	HUC4	Yes	Higher values indicate higher vulnerability
442	Population close to coastal areas	Coastal	No	Higher values indicate higher vulnerability
443	Population under poverty	HUC4	No	Higher values indicate higher vulnerability
447	Percent Disabled	HUC4	Yes	Higher values indicate higher vulnerability
448	Past experience	HUC4	Yes	Lower values indicate higher vulnerability
450	Communities Enrolled in NFIP (OLD NAME: Preparedness/awareness)	HUC4	Yes	Lower values indicate higher vulnerability
552	Mean tidal range	Coastal	Yes	Lower values indicate higher vulnerability
590	Urban Area in Floodplain	HUC4	No	Higher values indicate higher vulnerability
65	Freshwater input to coastal ecosystems	HUC4	No	Lower values indicate higher vulnerability
95	Meteorological drought indices	HUC4	No	Higher values indicate higher vulnerability
156	Sediment discharge (river to coast)	HUC4	No	Higher values indicate higher vulnerability
175	Stream flow variability	HUC4	No	Higher values indicate higher vulnerability
221	Flow regime	HUC4	No	Higher values indicate higher vulnerability
244	Stream baseflow	HUC4	No	Lower values indicate higher vulnerability
277	Precipitation Elasticity of Streamflow	HUC4	Yes	Higher values indicate higher vulnerability
566	Flood recurrence reduction factor	HUC4	No	Lower values indicate higher vulnerability
568	Flood magnification factor	HUC4	No	Higher values indicate higher vulnerability
570	Navigation low flows	HUC4	No	Lower values indicate higher vulnerability
571	Navigation flood flows	HUC4	No	Higher values indicate higher vulnerability

HUC-4 CONUS Vulnerability Assessment *(cont'd)*

-- Underway! Experimental Products & Preliminary Results !! *(still!)* --

ID #	Normalized Importance Weight	Indicator Name	Definition	Data Source
8	0.0976	At-Risk Freshwater Plant Communities (% area at risk) (Heinz Center, 2002); Threatened & Endangered Plant Species (USEPA, 2008a)	This indicator reports on the percentage of wetland and riparian plant communities that are at risk of extinction. These status ranks are based on such factors as the remaining number and condition of occurrences of the community, the remaining acreage, and the severity of threats to the community type.* (Heinz Center, 2002)	NatureServe - Explorer (customized dataset).
130	0.1500	Population (human) susceptible to flood risk (Hurd et al., 1999); Vulnerability to floods (Intergovernmental Panel on Climate Change, 2007); Population in flood area (Balica et al., 2009)	Population within the 500-year flood plain (Hurd et al., 1999). Percent of population that lives in floodplains (Intergovernmental Panel on Climate Change, 2007). Social exposure indicator used for calculating Flood Vulnerability Index (FVI) (Balica et al., 2009).	FEMA – 500y Flood Zones EPA - Integrated Climate and Land Use Scenarios (ICLUS)
175C	0.1220	Stream flow variability (annual) (Hurd et al., 1999); Coefficient of Variation (Lane et al., 1999)	The coefficient of variation (CV) of unregulated streamflow is an indicator of annual streamflow variability. It is computed as the ratio of the standard deviation of unregulated annual streamflow (σQs) to the unregulated mean annual streamflow (QS)'. (Hurd et al., 1999). Measure of variability in region's hydrology; standard deviation of regional annual internal water flow divided by the mean annual internal water flow in each region (Lane et al., 1999). (Cumulative)	CDM

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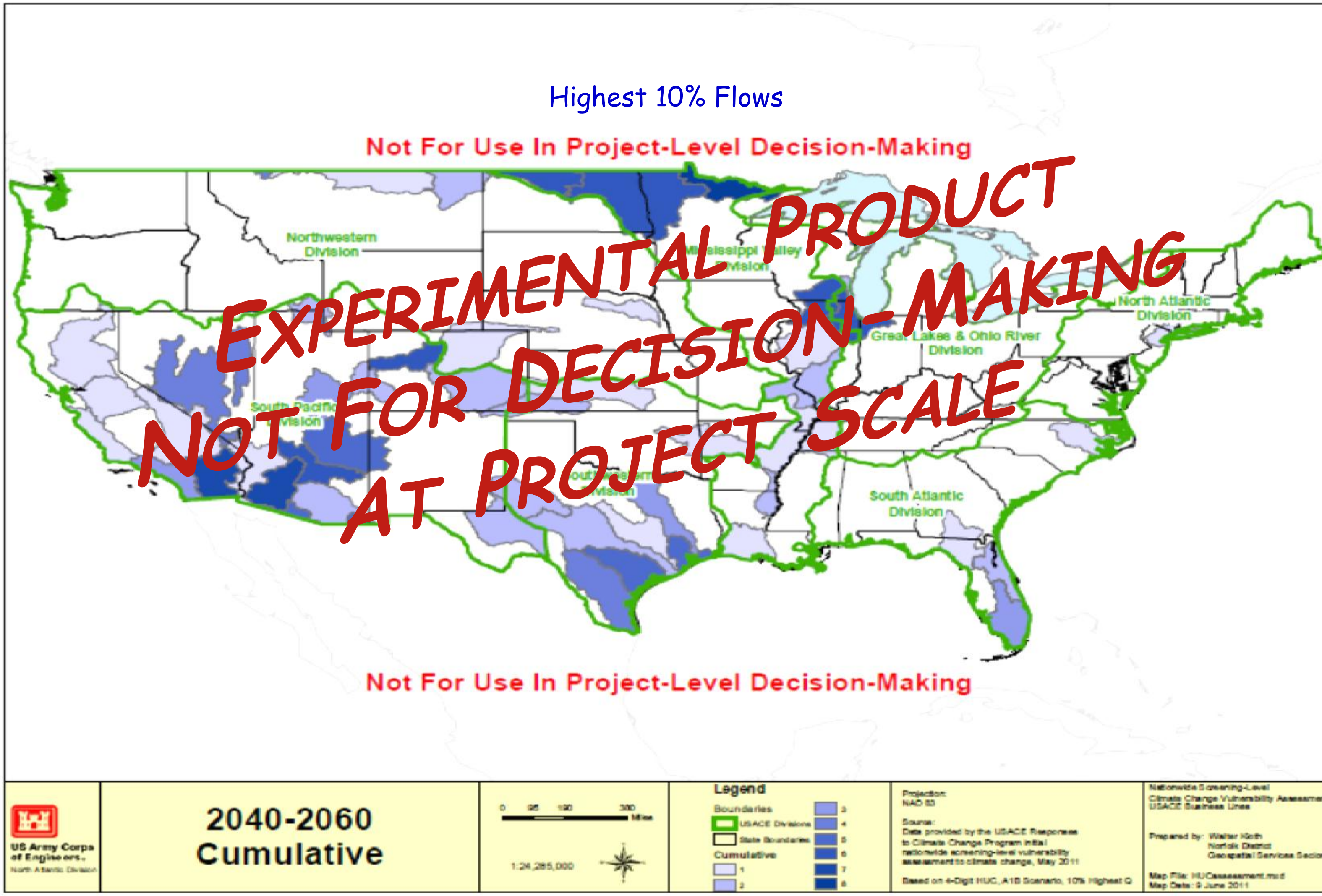
HUC-4 CONUS Vulnerability Assessment *(cont'd)*

-- Underway! Experimental Products & Preliminary Results !! *(still!)* --



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HUC-4 CONUS Vulnerability Assessment *(cont'd)*

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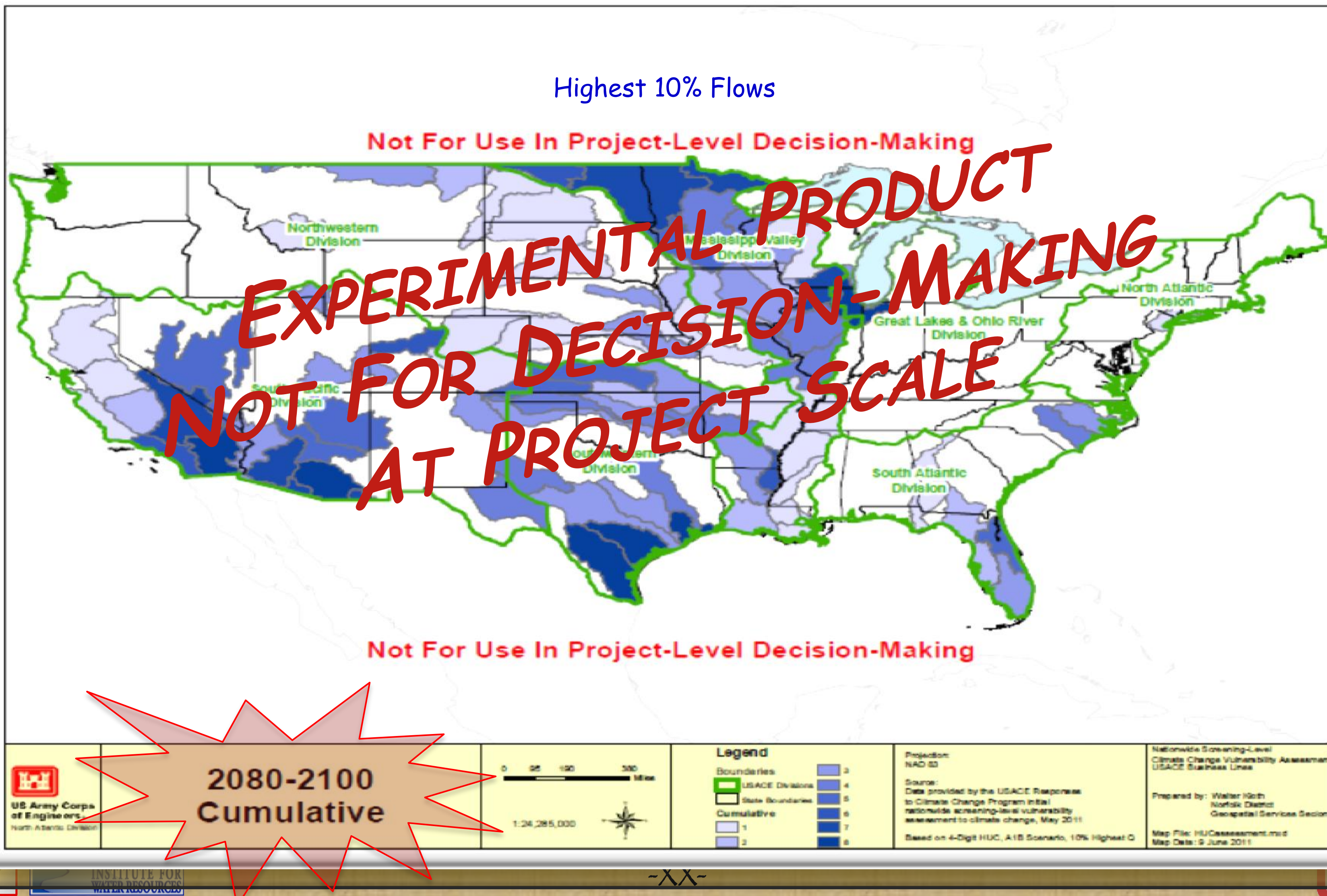

HUC-4 CONUS Vulnerability Assessment *(cont'd)*

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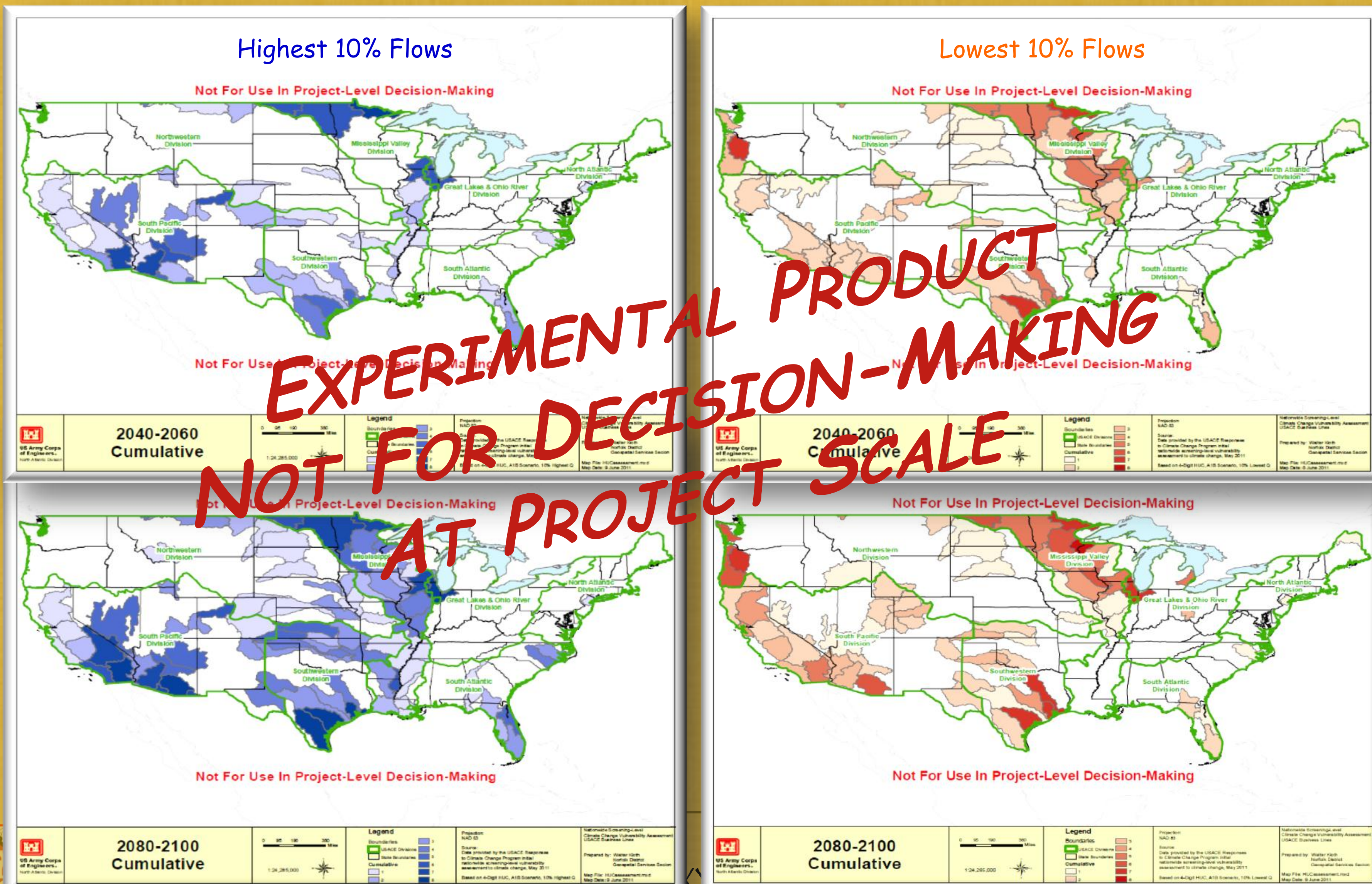

Summary

1- Climate change-forced floods are one part of the larger problem of global change-forced floods: lots of ***demographic & land-use changes & feedbacks drive flood losses***. An early good step is to characterize & understand the different ranges of these drivers.

2- Start with the ***applications decision***, the integrated water management question, before selecting climate change information. Flood risk reduction & emergency response have different questions & may need different types of climate data & climate change information.

3- Starting with numerical climate model products does not yield useful decision support.

4- Uncertainty about future changes will persist: ***decision-scaling*** moves the emphasis to adaptive management of residual risks & to engineering systems to look for surprise.

5- Start with observed data & test for skill in flood detection in historical & recent past using precipitation forecasts & water-on-the-ground gauge networks: simple precipitation forecasts aren't sufficient to detect floods. Better skill will mean more resilience in the future.

6- USACE is finishing its HUC-4, CONUS, screening assessment of its climate vulnerabilities using flood risk indicators. Even this high-order assessment of climate effects & potential impacts is useful. One early result for the future: floods still don't end droughts.

Thanks for your invitation & interest

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