CORPS OF ENGINEERS: CLIMATE CHANGE AND THE COLUMBIA RIVER BASIN

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CRITFC Future of Our Salmon Technical Workshop 2016

Spokane, WA

16 August 2016

US Army Corps of Engineers

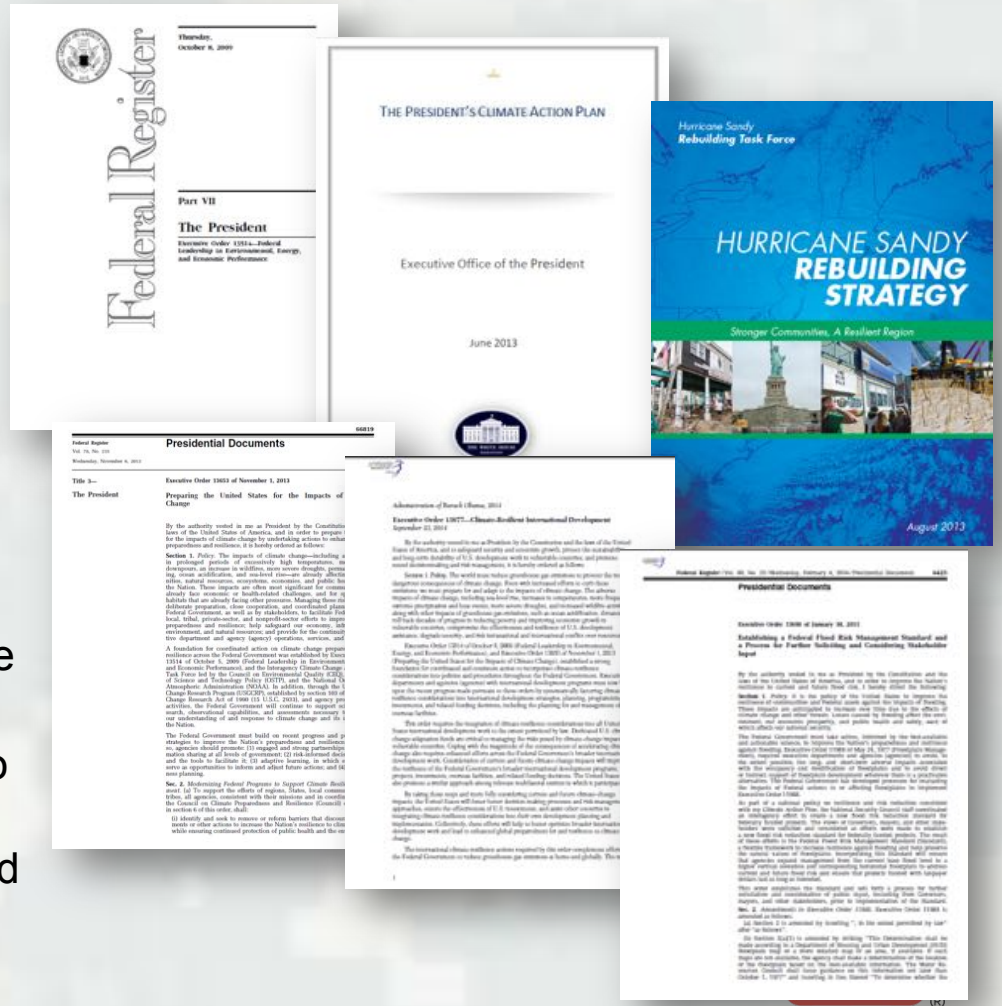
U.S.ARMY

Outline

- Corps of Engineers Nation Climate Change Plan
- Completed work in the Columbia Basin
- Future work in the Columbia Basin

Federal Government Climate Preparedness and Resilience (CPR)

- EO 13514 (2009): Begin adaptation planning (but mostly mitigation); superseded by EO 13653
- President's Climate Action Plan (2013)
- Sandy Rebuilding Task Force Report (2013)
- EO 13653 (2013): Prepare the US for the impacts of climate change (mostly adaptation)
- EO 13677 (2014): International climate preparedness and resilience
- Priority Agenda (2014)
  State, Local, Tribal Leaders Task Force Report (2014)
- EO 13690 (2015): Update EO 11988 to reflect future climate risks and develop federal flood risk management standard



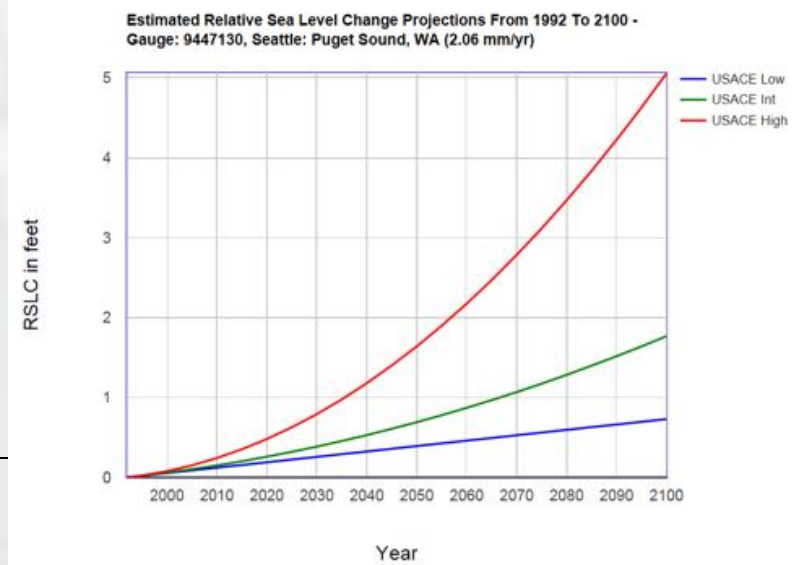
Sea Level Rise: ER 1100-2-8162

"Guidance for incorporating the direct and indirect physical effects of projected future sea level, change across the project life cycle in managing, planning, engineering, designing, constructing, operating, and maintaining USACE projects and systems of projects."

1) Use online sea level calculator to determine low, intermediate, and high rates of sea level change.

2) "…determine ***how sensitive alternative plans and designs*** are to these rates of future local mean SLC, how this sensitivity affects calculated risk, and what **design or operations and maintenance measures should be implemented to adapt to SLC** to minimize adverse consequences while maximizing beneficial effects…"

Calculator and User Manual updated in Sept. 2015



http://corpsclimate.us/ccaceslcurves.cfm

USACE Climate Hydrology Policy and Guidance

- ECB 2014-10: *Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects*
- ETL1100-2-2: *Appropriate Application of Paleoflood Information for Hydrology and Hydraulics Decisions*
- Two guidance docs being routed for signature
  - ECB 2014-10 guidance update, expected August 2016
  - ETL 1100-2-3, *Guidance for Detection of Nonstationarities in Annual Maximum Discharges*, expected September 2016


ENGINEERING AND CONSTRUCTION BULLETIN

US Army Corps of Engineers

No. 2014-10 Issuing Office: CECW-CE Issued: 2 May 2014 Expires: 2 May 2016

Subject: Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects

Applicability: Guidance

References: Required and related references are provided in Appendix A.

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, DC 20314-1000

ETL 1100-2-2

CECW-CE

Technical Letter
No. 1100-2-2

31 October 2014

EXPIRES 30 September 2019

Engineering and Design
APPROPRIATE APPLICATION OF PALEOFLOOD INFORMATION FOR HYDROLOGY AND HYDRAULICS DECISIONS

1. Purpose. This Engineer Technical Letter establishes guidance for the appropriate use of paleoflood analyses and information to support U.S. Army Corps of Engineers (USACE) Hydrology and Hydraulics (H&H) decision making.

2. Applicability. This Engineer Technical Letter applies to USACE commands having Civil Works planning, engineering design, operations, and maintenance responsibilities.

3. Distribution Statement. Approved for public release; distribution is unlimited.

4. References. References are listed in Appendix A.

ECB 2016-XX

(Update to ECB 2014-10)

Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects

"…applies to all hydrologic analyses supporting planning and engineering decisions ***having an extended decision time frame***."

"This ECB helps support the interpretation and use of climate change information for hydrologic analyses supporting planning and engineering decisions through a ***qualitative assessment***…"

ECB 2016-XX

"…the qualitative analysis is not expected to alter the numerical results of the calculations made for the other, non-climate aspects of the required hydrologic analyses.

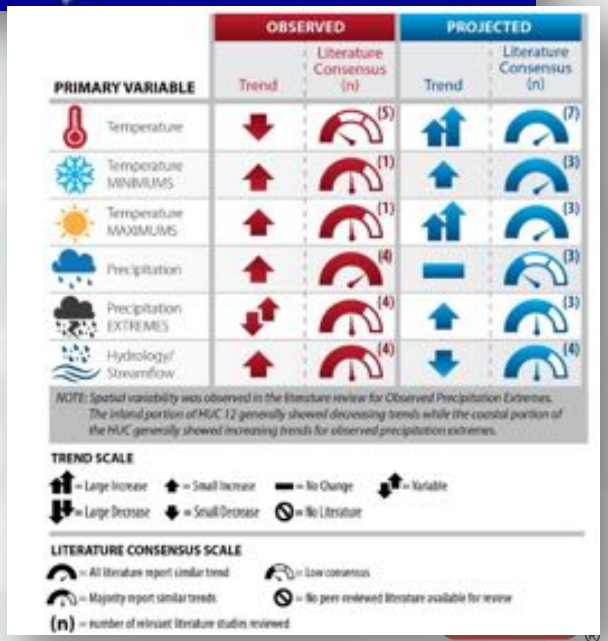
However, the qualitative analysis can inform the decision process related to future without project conditions, formulation and evaluation of alternative plans, and other decisions related to project planning, engineering, operation, and maintenance"

Tools and Resources Supporting CPR Policy and Guidance

- Existing:
  - Tools should shift emphasis from data management to analyzing potential risks and adaptation
  - Sea level calculator
  - Nonstationarity detection tool, released March 2016
- Two tools in prep based on archive of climate and hydrology data:
  - ECB 2014-10 update tool released May 2016
  - Annotated bibliography of nonstationarity, EndNote expected May 2016, web app later FY 2016
  - Sea level tracker, expected FY2016
- Three guidance docs in prep
  - ECB 2014-10 guidance update, in review May 2016
  - ETL 1100-2-3, nonstationarity, HQ review May-June 2016, release 2016
  - ETL 1100-2-4, total water levels for coastal analyses, expected CY2016

Tools: Regional Information Produced in 2015

- Regional climate literature syntheses for the 21 USGS Watershed Regions
  - Mid-Atlantic Region: 02
  - South Atlantic-Gulf Region: 03
  - Great Lakes Region: 04
  - Ohio Region: 05
  - Tennessee Region: 06
  - Upper Missouri Region: 07
  - Lower Mississippi River Region: 08
  - Souris-Red-Rainy Region: 09
  - Missouri River Region:10
  - Arkansas, White and Red Rivers Region: 11
  - Texas Gulf Region: 12
  - Rio Grande Region: 13
  - Upper Colorado Region: 14
  - Lower Colorado Region: 15
  - Great Basin Region: 16
  - Pacific Northwest Region: 17



PRIMARY VARIABLE	OBSERVED Trend	OBSERVED Literature Consensus (n)	PROJECTED Trend	PROJECTED Literature Consensus (n)
Temperature	↑	(6)	↑	(3)
Temperature MINIMUMS	↑	(1)	↑	(1)
Temperature MAXIMUMS	↑	(1)	↑↑	(3)
Precipitation	↑	(6)	↓↑	(5)
Precipitation EXTREMES	↓↑	(3)	↑	(3)
Hydrology/ Streamflow	↓	(5)	↓↑	(5)

NOTE: Trend variability was observed (both magnitude and direction) in the literature review for Observed Precipitation Extremes. Trend variability (both magnitude and direction) was observed in the literature review for Projected Precipitation and Projected Hydrology.

TREND SCALE

- ↑↑ = Large Increase
- ↑ = Small Increase
- ▬ = No Change
- ↓↑ = Variable
- ↓↓ = Large Decrease
- ↓ = Small Decrease
- ⊘ = No Literature

LITERATURE CONSENSUS SCALE

- = All literature report similar trend
- = Low consensus
- = Majority report similar trends
- ⊘ = No peer-reviewed literature available for review
- (n) = number of relevant literature studies reviewed

Progress: Hydrologic Nonstationarity

From this…….

POLICYFORUM

CLIMATE CHANGE

Stationarity Is Dead: Whither Water Management?

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

P. C. D. Milly,[1*] Julio Betancourt,[2] Malin Falkenmark,[3] Robert M. Hirsch,[4] Zbigniew W. Kundzewicz,[5] Dennis P. Lettenmaier,[6] Ronald J. Stouffer[7]

Systems for management of water throughout the developed world have been designed and operated under the assumption of stationarity. Stationarity—the idea that natural systems fluctuate within an unchanging envelope of variability—is a foundational concept that permeates training and practice in water-resource engineering. It implies that any variable (e.g., annual streamflow or annual flood peak) has a time-invariant (or 1-year–periodic) probability density function (pdf), whose properties can be estimated from the instrument record. Under stationarity, pdf estimation errors are acknowledged, but have been assumed to be reducible by additional observations, more efficient estimators, or regional or paleohydrologic data. The pdfs, in turn, are used to evaluate and manage risks to water supplies, waterworks, and floodplains; annual global investment in water infrastructure exceeds U.S.$500 billion (*1*).

The stationarity assumption has long been compromised by human disturbances in river basins. Flood risk, water supply, and water quality are affected by water infrastructure, channel modifications, drainage works, and land-cover and land-use change. Two other (sometimes indistinguishable) challenges to stationarity have been externally forced, natural climate changes and low-frequency, internal variability (e.g., the Atlantic multidecadal oscillation) enhanced by the slow dynamics of the oceans and ice sheets (*2*, *3*). Planners have tools to adjust their analyses for known human disturbances within river basins, and justifiably or not, they generally have considered natural change and variability to be sufficiently small to allow stationarity-based design.

An uncertain future challenges water planners.

In view of the magnitude and ubiquity of the hydroclimatic change apparently now under way, however, we assert that stationarity is dead and should no longer serve as a central, default assumption in water-resource risk assessment and planning. Finding a suitable successor is crucial for human adaptation to changing climate.

How did stationarity die? Stationarity is dead because substantial anthropogenic change of Earth's climate is altering the means and extremes of precipitation, evapotranspiration, and rates of discharge of rivers (*4*, *5*) (see figure, above). Warming augments atmospheric humidity and water transport. This increases precipitation, and possibly flood risk, where prevailing atmospheric water-vapor fluxes converge (*6*). Rising sea level induces gradually heightened risk of contamination of coastal freshwater supplies. Glacial meltwater temporarily enhances water availability, but glacier and snow-pack losses diminish natural seasonal and interannual storage (*7*).

Anthropogenic climate warming appears to be driving a poleward expansion of the subtropical dry zone (*8*), thereby reducing runoff in some regions. Together, circulatory and thermodynamic responses largely explain the picture of regional gainers and losers of sustainable freshwater availability that has emerged from climate models (see figure, p. 574).

Why now? That anthropogenic climate change affects the water cycle (*9*) and water supply (*10*) is not a new finding. Nevertheless, sensible objections to discarding stationarity have been raised. For a time, hydroclimate had not demonstrably exited the envelope of natural variability and/or the effective range of optimally operated infrastructure (*11*, *12*). Accounting for the substantial uncertainties of climatic parameters estimated from short records (*13*) effectively hedged against small climate changes. Additionally, climate projections were not considered credible (*12*, *14*).

Recent developments have led us to the opinion that the time has come to move beyond the wait-and-see approach. Projections of runoff changes are bolstered by the recently demonstrated retrodictive skill of climate models. The global pattern of observed annual streamflow trends is unlikely to have arisen from unforced variability and is consistent with modeled response to climate forcing (*15*). Paleohydrologic studies suggest that small changes in mean climate might produce large changes in extremes (*16*), although attempts to detect a recent change in global flood frequency have been equivocal (*17*, *18*). Projected changes in runoff during the multidecade lifetime of major water infrastructure projects begun now are large enough to push hydroclimate beyond the range of historical behaviors (*19*). Some regions have little infrastructure to buffer the impacts of change.

Stationarity cannot be revived. Even with aggressive mitigation, continued warming is very likely, given the residence time of atmospheric CO_2 and the thermal inertia of the Earth system (*4*, *20*).

A successor. We need to find ways to identify nonstationary probabilistic models of relevant environmental variables and to use those models to optimize water systems. The challenge is daunting. Patterns of change are complex; uncertainties are large; and the knowledge base changes rapidly.

Under the rational planning framework advanced by the Harvard Water Program (*21*, *22*), the assumption of stationarity was

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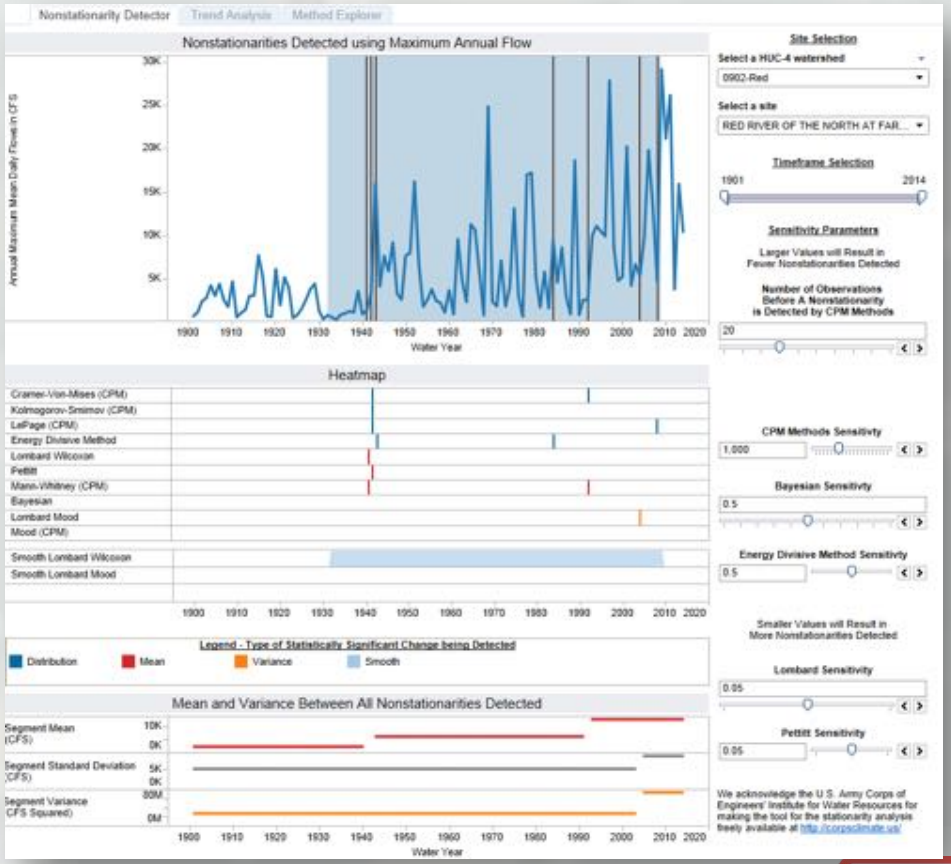
Science

To this…….



Tool

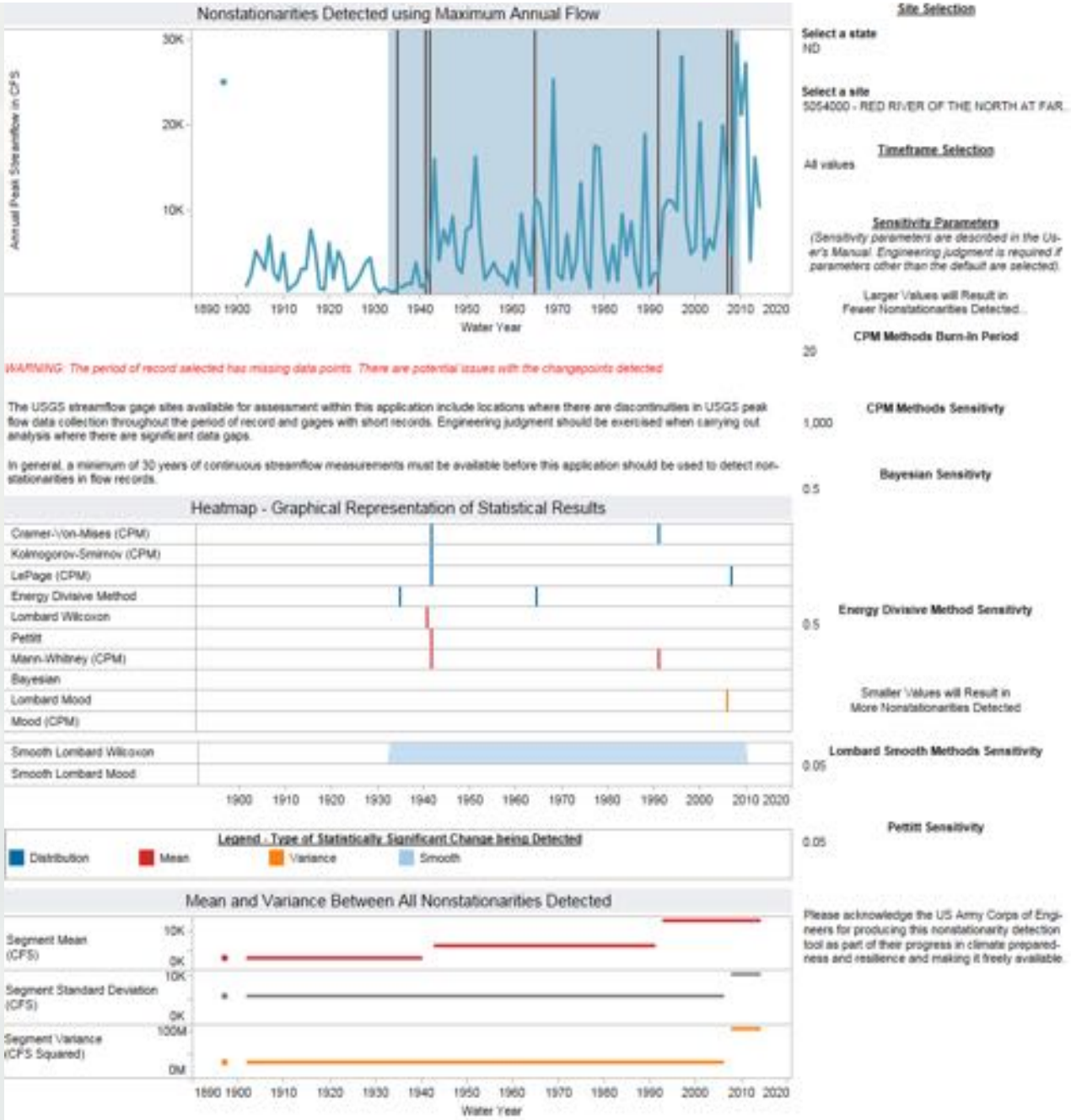
Detecting Trends

Looking for:

Consensus – Agreement between multiple statistical methods that detect the same type of nonstationarity

Robust – Agreement between multiple statistical methods that detect different types of nonstationarity

Magnitude – The size of the change in the streamflow before and after the detected nonstationarity



https://maps.crrel.usace.army.mil/apex/f?p=257:2:0::NO:::

Cochiti Canyon Flood
Dixon's Apple Orchard

August 22, 2011

Essentially, all models are wrong, but some are useful.

-Sir RA Fisher quoted in George E.P. Box 1987

It's impossible, irresponsible even, to be more precise than you can be accurate.

-Paul Kalanthi, New York Times 26 Jan 2014

CRT 2014/2024 Treaty Review

- The Columbia River Treaty has no specified end date
- In 2024 flood risk operations change
- 10 years prior written notice is required for either country to terminate the treaty
- Recommendation to U.S. State Department from U.S. Entity delivered December 2013
  - flood risk management
  - hydropower
  - ecosystem based function

Previous Climate Change Work

- RMJOC-I
- CRT 2014/2024 Review

RMJOC-I

- RMJOC – BPA, USACE, BOR
- Used IPCC 2007 GCM data
  - 2020's & 2040's
  - Med (A1B) & Low (B1) Emission Scenario
  - Statistical Downscaling
    - Hybrid-Delta/BCSD
    - Transient
    - Delta
- Calibrated VIC hydrology model to PNW
  - 13 locations
  - Modified flows
- System monthly reservoir model studies
  - 6 projections for 2020's & 2040's
  - C, MW/W, LW/W, MW/D, LW/D, & MC

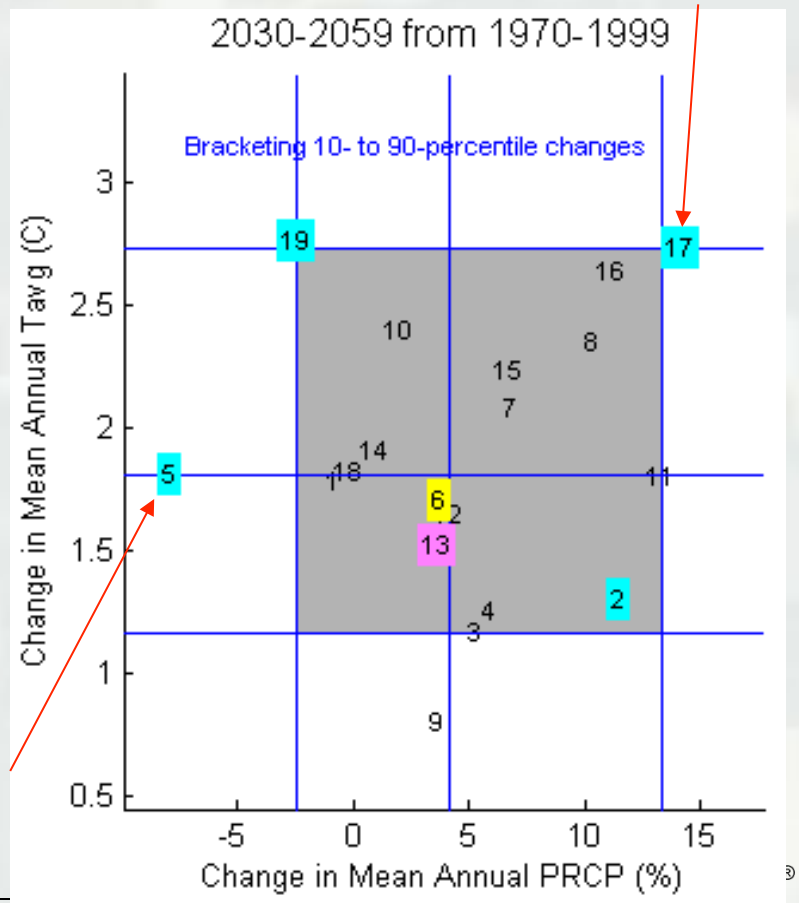
RMJOC-I Outcomes

- Produced 4 multi-agency reports
  - http://www.usbr.gov/pn/climate/planning/reports/
  - Finished 2011
- Provided data for CRT 2014/2024 Review
- Provided valuable lessons learned for future work
- Was used as a FYI study

CRT 2014/2024 Review

- RMJOC-I data
  - ▶ Improved bias correct data
  - ▶ Bookend Study
- Improved Forecasts
- Daily Spring FRM modeling

Wet Scenario



Dry Scenario

BUILDING STRONG®

CRT 2014/2024 Review

- FYI Study
  - Schedule, resource, and guidance issues
  - Greatest benefits: increased understanding and technical competence for future work
  - Primary conclusion: adaptive management required in a future Treaty

CRT 2014/2024 Review – Climate Change Results

- Key Findings:
  - High winter flows increased risk to winter flooding
  - Reduction in summer flows
  - Harder to balance all reservoir objectives
- Outcomes:
  - Further model improvements required for future work, BiOp and winter FRM
  - Better defined vulnerabilities, but difficult to apply to CRT defined decisions

Future Work – RMJOC-IIPNW datasets

- IPCC 5: ~180 datasets
  - ▶ University of Washington/Oregon State team
  - ▶ 2 RCPs, 4.5 (Med Low) & 8.5 (High)
  - ▶ Glacial modeling
  - ▶ Multiple downscaling methods
  - ▶ Multiple Hydrologic models
- Available end of 2016

Real-time Realities

- BiOps in the Columbia River Basin need to include updated climate change analysis

- Currently scoping modeling analysis
  - ▶ RMJOC modeling team members
  - ▶ Monthly modeling

RMJOC-II Study

- New UW datasets are being created as a RMJOC-II study
- Year-round modeling with forecasts
  - Flood Risk Management
  - Hydropower
  - Environmental
- Modeling to start FY2017, finish FY2019
- Significant interest by Tribes, stakeholders, States, other Federal agencies

CRT 2024 Implementation

- Follow on from RMJOC-II work
- Results will be used for BiOp and NEPA
- Results should be used in Treaty Updates
  - Treaty could go to 50 or more years
  - Modify reservoir operations for climate change
  - Complete a vulnerability assessment
  - Adaptive management is a top priority for Treaty Updates
  - Likely to be one of the first major studies used for implementation

Question/Discussion

Sauvie Island, February 1996,
http://koin.com/2016/02/02/willamette-valley-flood-of-1996-20-years-later/