OVERVIEW OF USACE CLIMATE PREPAREDNESS AND RESILIENCE FOR THE PLANNING COP

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USACE CLIMATE PREPAREDNESS AND RESILIENCE COMMUNITY OF PRACTICE

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PCoP Webinar Series

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CONTEXT:

CLIMATE, POPULATION, AND INFRASTRUCTURE PERFORMANCE DRIVE OUR STRATEGIC RESPONSES

THESE ARE INHERENTLY UNCERTAIN

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If a man will begin with certainties, he will end in doubt; but if he will be content to begin in doubts, he will end in certainties.

– Sir Francis Bacon, 1605

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 Kalanithi, New York Times 26 Jan 2014

OUTCOME: RELIABLE INFRASTRUCTURE PERFORMANCE IN CHANGING CONDITIONS

WATER CHANGES AFFECT EVERYONE

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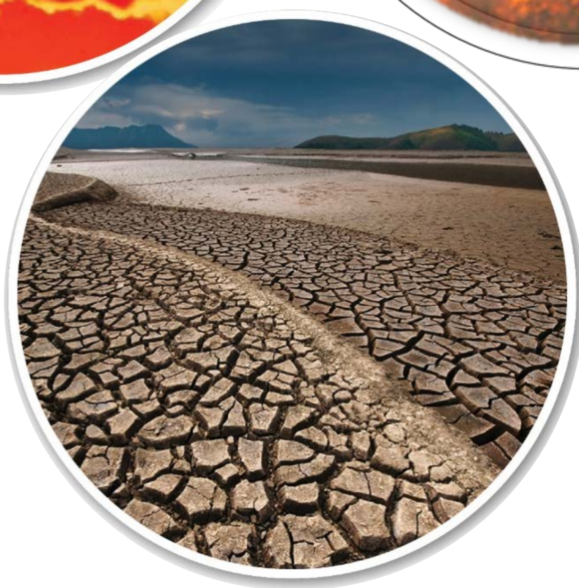
CLIMATE CHANGE INTERACTIONS



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MOTIVATION

- Water resources management missions and operations are very sensitive to changes in temperature and precipitation
- Climate change and variability can adversely impact our ability to provide services that support economic development and public health and safety
- Observed impacts to operating projects spurred USACE to begin activities to reduce USACE vulnerabilities and improve resilience to these impacts
  - Late 1970s: changes in drought intensity and frequency
  - Mid-1980s: changing sea levels
  - Early 1990s: economic impacts of climate change
  - Mid 2000s: plan and implement climate preparedness and resilience measures

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ADAPTATION POLICY, PLANS, AND GOVERNANCE

- ASA(CW) Policy Statements: 2011 updated 2014
- USACE Adaptation Plans: 2011-2014, update 2015, no submittal required 2016
- Governance
  - ASA(CW) is the DoD-designated agency Senior POC for Adaptation
  - ASA(CW) is the agency Principle to the White House Council on Climate Preparedness and Resilience
  - Chief of Engineering and Construction is the Chair, Committee on Climate Preparedness and Resilience
  - Lead, CPR CoP serves as the technical lead

http://www.corpsclimate.us/adaptationpolicy.cfm

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ADAPTATION POLICY, PLANS, AND GOVERNANCE

- USACE Adaptation roadmap is based on four strategies:
    1) Focus on Priorities to make progress
    2) Collaborate with internal and external experts
    3) Improve Knowledge about relevant processes, impacts, vulnerabilities, and adaptation measures
    4) Policy and Guidance to guide planning and implementation
- All are being applied to coastal climate change, climate hydrology, and impacts to reservoirs

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STRATEGY 1: FOCUS ON PRIORITIES

- Infrastructure Resilience
- Vulnerability Assessments
- Supply Chain
- Risk-Informed Decision-Making for Climate Change
- Updated Methods
- Metrics and Endpoints

✓ Nonstationarity

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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.

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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).

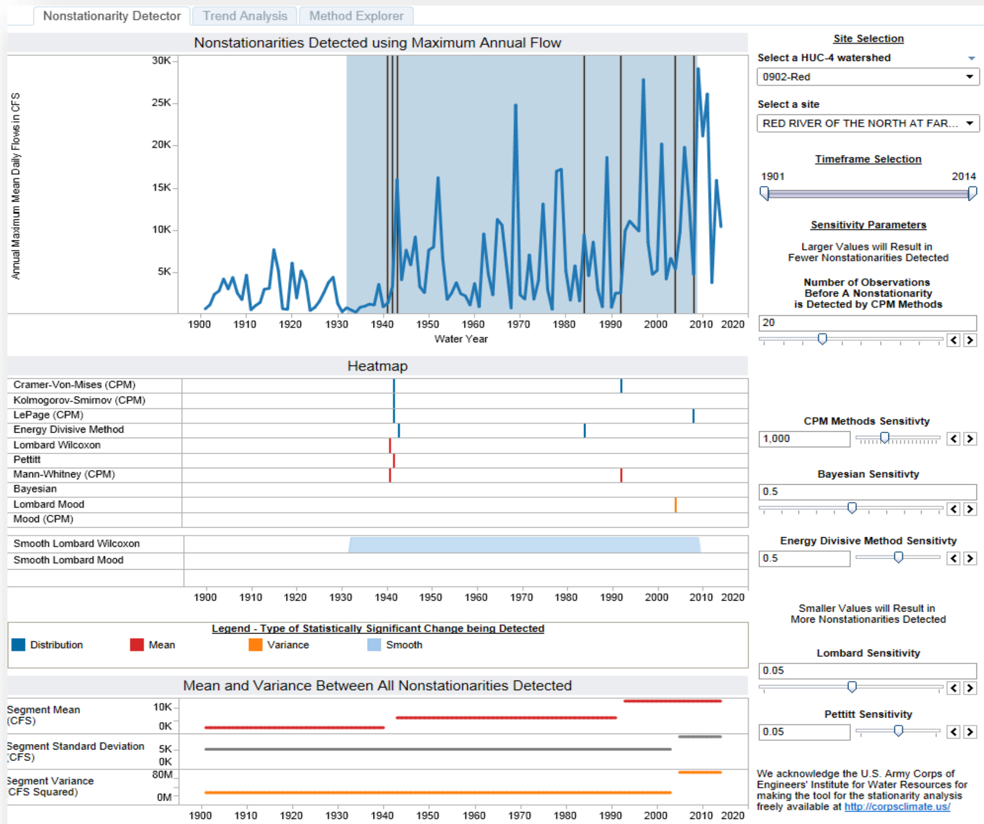
Recent developments have led us to the opinion that the time has come to move beyond the wait-and-see approach. Projections of runoff changes are bolstered by the recently demonstrated retrodictive skill of climate models. The global pattern of observed annual streamflow trends is unlikely to have arisen 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

To this……



Science

Tool, guidance forthcoming

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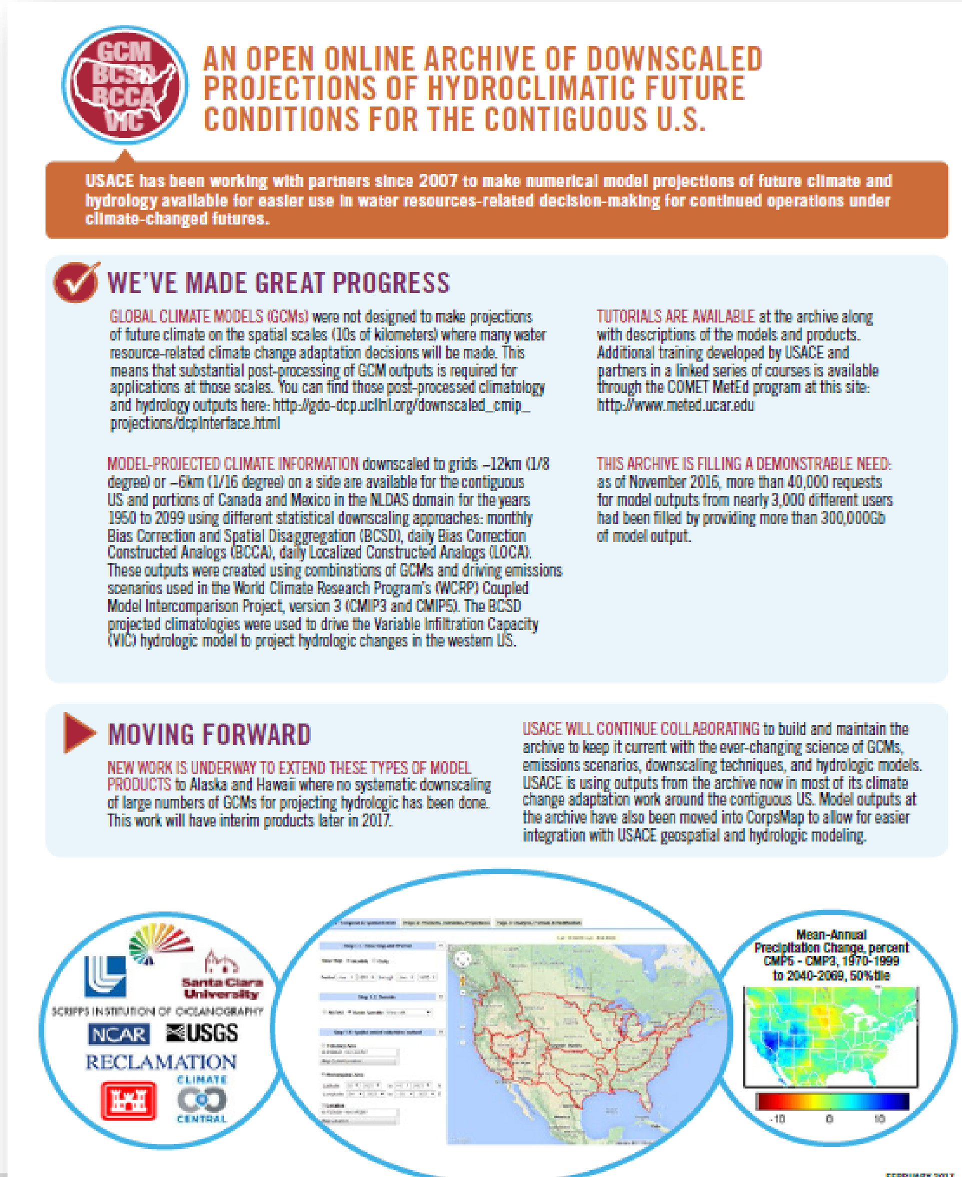
STRATEGY 2: COLLABORATE

- Interagency archive of downscaled climate and hydrology
- Include national and international experts, interagency, academics, NGO, and private sector in developing technical guidance, tools, methods, and external peer review
- Interagency Climate Change and Water Working Group and coastal interagency groups support consistent approaches



GCM BCSD BCCA VIC

AN OPEN ONLINE ARCHIVE OF DOWNSCALED PROJECTIONS OF HYDROCLIMATIC FUTURE CONDITIONS FOR THE CONTIGUOUS U.S.

USACE has been working with partners since 2007 to make numerical model projections of future climate and hydrology available for easier use in water resources-related decision-making for continued operations under climate-changed futures.

WE'VE MADE GREAT PROGRESS

GLOBAL CLIMATE MODELS (GCMs) were not designed to make projections of future climate on the spatial scales (10s of kilometers) where many water resource-related climate change adaptation decisions will be made. This means that substantial post-processing of GCM outputs is required for applications at those scales. You can find those post-processed climatology and hydrology outputs here: http://gdo-dcp.ucllnl.org/downscaled_cmip_projections/dcpInterface.html

MODEL-PROJECTED CLIMATE INFORMATION downscaled to grids ~12km (1/8 degree) or ~6km (1/16 degree) on a side are available for the contiguous US and portions of Canada and Mexico in the NLDAS domain for the years 1950 to 2099 using different statistical downscaling approaches: monthly Bias Correction and Spatial Disaggregation (BCSD), daily Bias Correction Constructed Analogs (BCCA), daily Localized Constructed Analogs (LOCA). These outputs were created using combinations of GCMs and driving emissions scenarios used in the World Climate Research Program's (WCRP) Coupled Model Intercomparison Project, version 3 (CMIP3 and CMIP5). The BCSD projected climatologies were used to drive the Variable Infiltration Capacity (VIC) hydrologic model to project hydrologic changes in the western US.

TUTORIALS ARE AVAILABLE at the archive along with descriptions of the models and products. Additional training developed by USACE and partners in a linked series of courses is available through the COMET MetEd program at this site: http://www.meted.ucar.edu

THIS ARCHIVE IS FILLING A DEMONSTRABLE NEED: as of November 2016, more than 40,000 requests for model outputs from nearly 3,000 different users had been filled by providing more than 300,000Gb of model output.

MOVING FORWARD

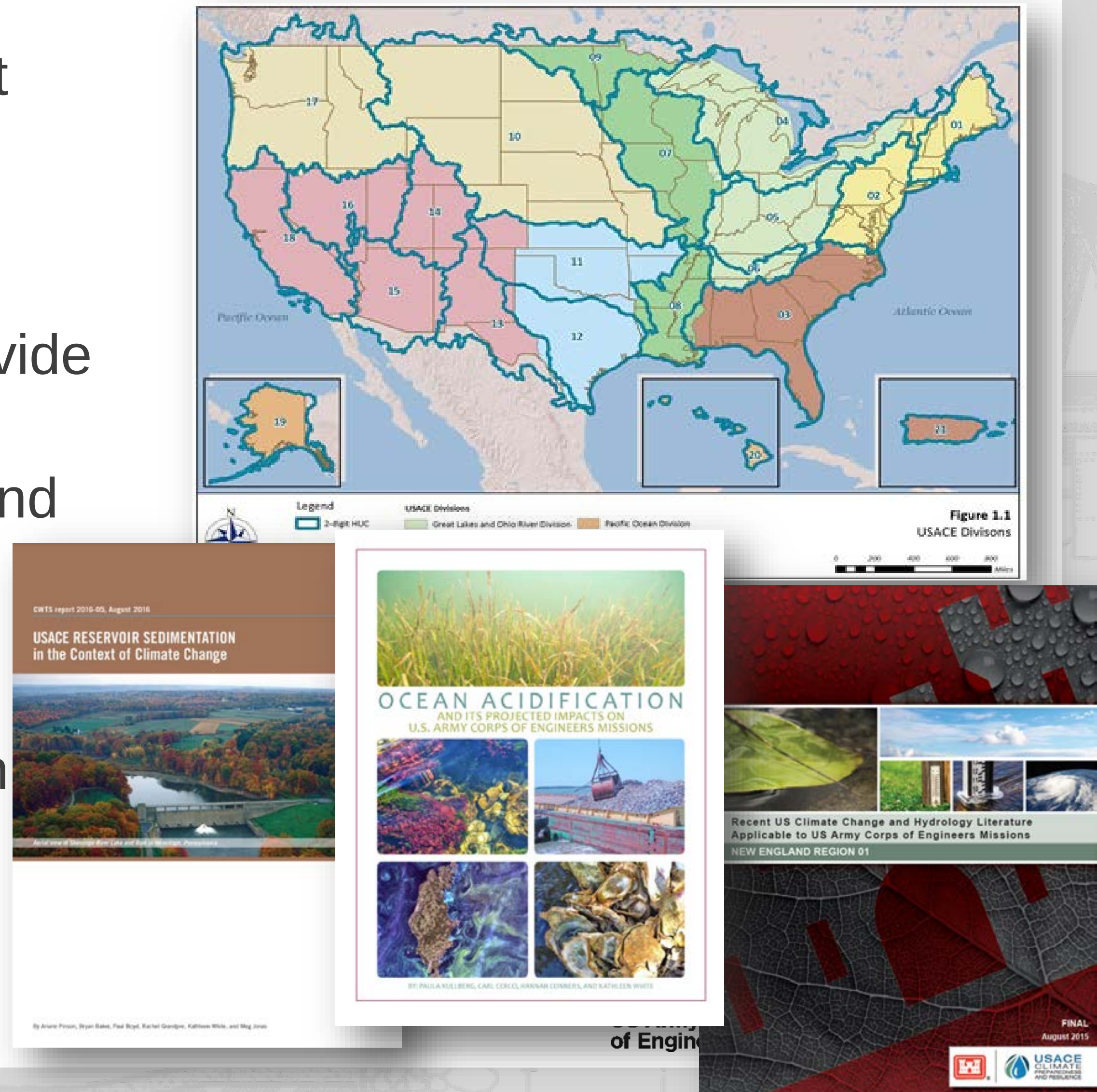
NEW WORK IS UNDERWAY TO EXTEND THESE TYPES OF MODEL PRODUCTS to Alaska and Hawaii where no systematic downscaling of large numbers of GCMs for projecting hydrologic has been done. This work will have interim products later in 2017.

USACE WILL CONTINUE COLLABORATING to build and maintain the archive to keep it current with the ever-changing science of GCMs, emissions scenarios, downscaling techniques, and hydrologic models. USACE is using outputs from the archive now in most of its climate change adaptation work around the contiguous US. Model outputs at the archive have also been moved into CorpsMap to allow for easier integration with USACE geospatial and hydrologic modeling.

FEBRUARY 2017

STRATEGY 3: IMPROVE KNOWLEDGE

- Community of Practice builds capacity at district and division level
- Certified subject matter experts assist Project Delivery Teams and provide technical review
- Extensive interagency and expert team improving quality of downscaled climate information and hydrology for application at project/system level



STRATEGY 4: POLICY AND GUIDANCE

- Drought: Engineer Regulation (ER) 1110-2-1941 (1981)
- Sea Level Change: Engineering Circular (EC) 1105-2-186 (1989), Planning Guidance Notebook: ER 1105-2-100 (2000), EC 1165-2-211 & 212 (2009, 2011), ER 1100-2-8162 (2013) and Engineer Technical Letter (ETL) 1100-2-1 (2014)
- Datums: ER 1110-2-8160 (2009) and Engineer Manual (EM) 1110-2-6056 (2010)
- Climate-Impacted Hydrology: ETL 1100-2-2 (2014). Engineering and Construction Bulletin (ECB) 2010-10 (2014) updated by ECB 2016-10 (2016), ETL 11-2-3 in publishing process (2017)

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IMPLEMENTATION

- All Civil Works coastal projects are datum-compliant and incorporate changing climate as part of planning and engineering
- Web accessible tools provide consistent, repeatable analytical results for incorporation of climate change impacts in hydrologic and hydraulic analyses performed by districts
- District staff conducting phased vulnerability screening assessments for existing infrastructure to account for sea level change, drought, and changing reservoir sediment

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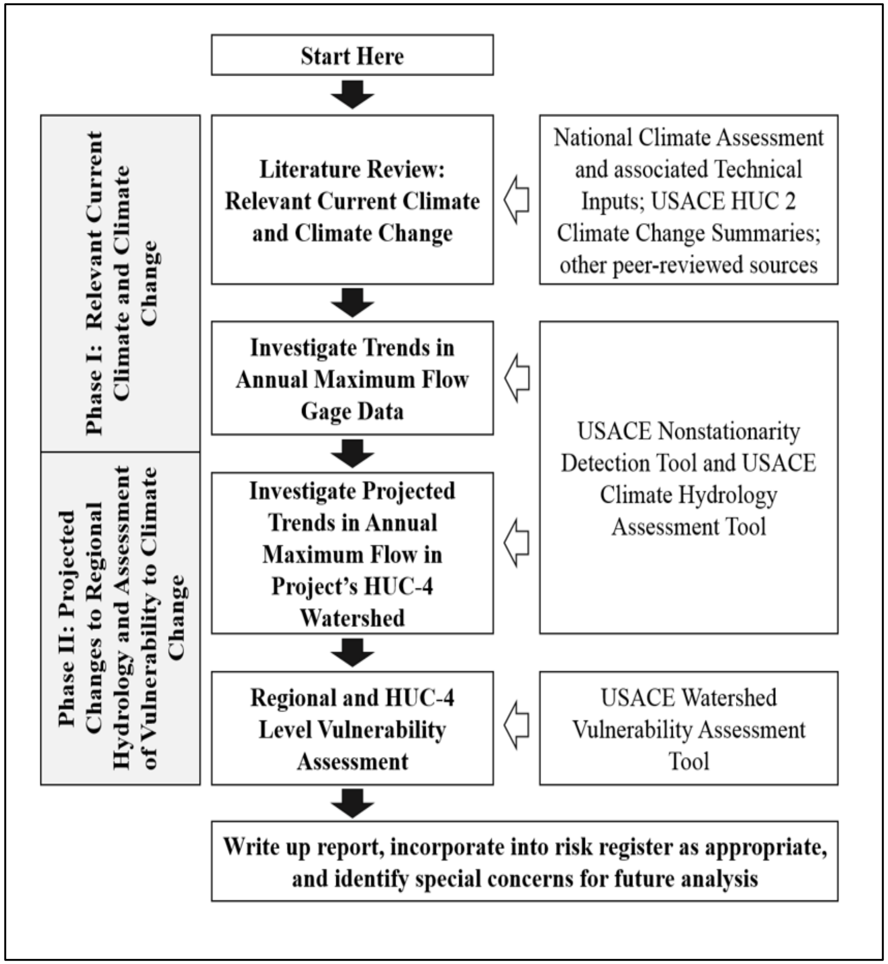
ECB 2016-25: GUIDANCE FOR INCORPORATING CLIMATE CHANGE IMPACTS TO INLAND HYDROLOGY IN CIVIL WORK STUDIES, DESIGNS, AND PROJECTS

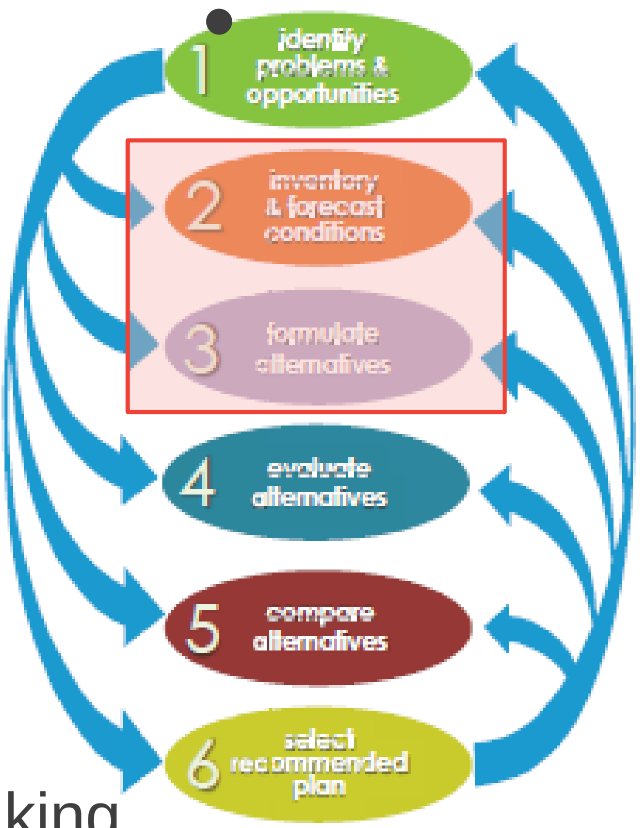
- Requires **Qualitative** Analysis
- **Resilience** & **Adaptability** in Design & Decision making
- Key Components:
  - ➢ Literature Review
  - ➢ Considers Trends in both past (observed) & projected (future) changes to hydrologic inputs
  - ➢ Vulnerability Assessment
  - ➢ Nonstationarity Detection



LESSONS LEARNED FROM ATR: INCORPORATE CLIMATE AT THE START

- **When?**
  - ➢ Upfront
  - ➢ Fully Integrated
- **Who?**
  - ➢ PDT Member
  - ➢ Appropriate Expertise
  - ➢ Collaboration
- **Expected Impact?**
  - ➢ Risk Informed Decision Making
  - ➢ Build Resilience → Reduce Vulnerabilities

FIGURE 1: THE CORPS' ITERATIVE SIX STEP PLANNING PROCESS



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BACKGROUND FOR CPR COP COASTAL REVIEWS APPROACH, ASSESSMENT METHODOLOGY

– **BACKGROUND**

1. CPR CoP reviewer with HQ team
2. Most reviews are feasibility studies in the three major business lines – Flood Risk, Navigation and Ecosystem Restoration

– **APPROACH**

3. Check Technical Areas (Engineering/H&H): Datum, water levels important to the project, SLC projections
4. Check planning assumptions and information required by policy
   A. 100 year planning horizon used
   B. FWOP mapping of SLC impacts (NOAA SLC Viewer) for 100 year planning horizon

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BACKGROUND FOR CPR REVIEWS APPROACH, ASSESSMENT METHODOLOGY

– **ASSESSMENT**

5. FWP - 0 to 50 year – economic justification
6. Design/target performance is typically optimized to year 50 for one of the SLC scenarios
7. Years 50-100 questions –
   A. Can all or some elements of TSP be adapted?
   B. Does TSP have adaptive capacity included in designs and costs
8. Vet TSP Performance (mini-vulnerability assessment) in 50-100 year time horizon against 3 SLC scenarios
   A. Use 4 planning metrics (efficiency, effectiveness, completeness and acceptability) to relate to climate policy

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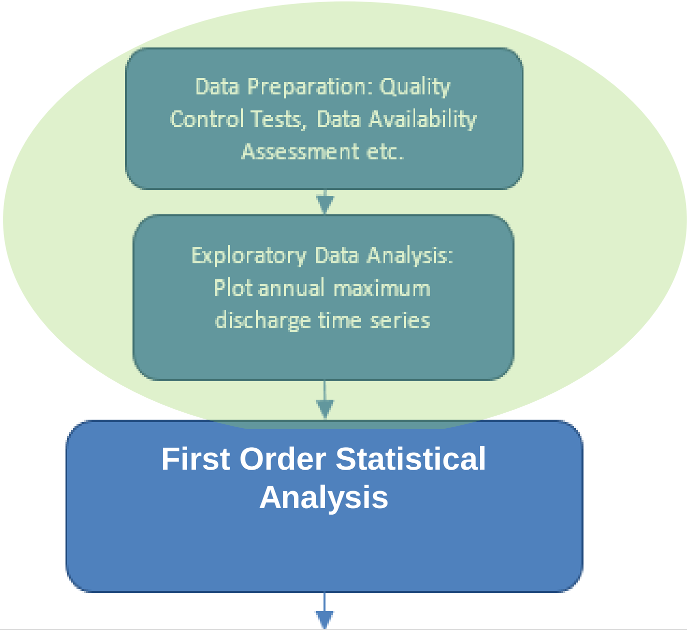
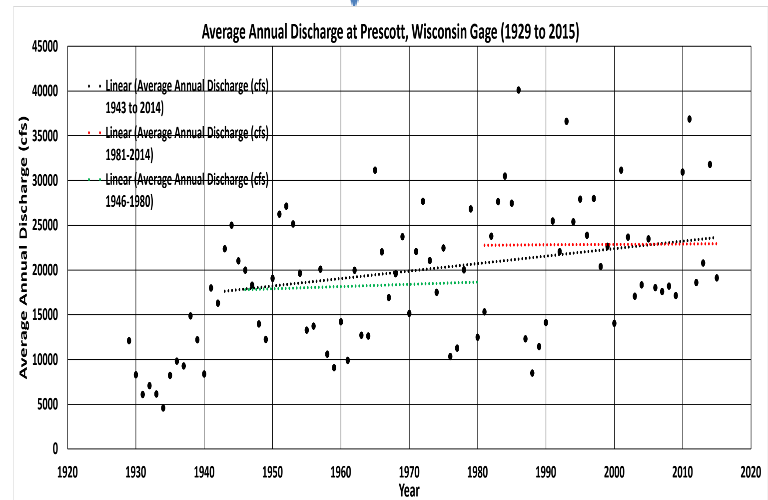
INLAND: KNOW YOUR STUDY AREA & DATA/TOOL AVAILABILITY



- History of Regulation, Land Use Changes, Data Quality
- What variables are critical to assessing the impact of your project on the hydrology of the basin?
- What data is available in your basin?
- Many resources have been developed for studies primarily affecting high flows
- For other flow regimes:
  - Literature Review
  - Vulnerability Tool
  - Reach out to CPR POCS for guidance



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