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Managing Water in the West

Annual Progress Meeting on Reclamation Climate and Hydrology Research

Improving extreme precipitation estimation and climate change projections using regional and high-resolution model simulations

(BOR R11AC81334/CIRES 1548910)

Technical Lead: Kelly Mahoney (kelly.mahoney@noaa.gov)
CIRES/USBR Cooperative Agreement PI: Kristen Averyt

Project Goals:

- Advance understanding of appropriate applications of extreme precipitation data from both climate model and reanalysis-based sources
- Explore the utility of high-resolution downscaling of extreme events
- Evaluate the potential for changes in intensity of extreme warm-season precipitation events in future climate scenarios in the Colorado Front Range
- Consider potential for changes in elevation thresholds for storms, flooding, and hail

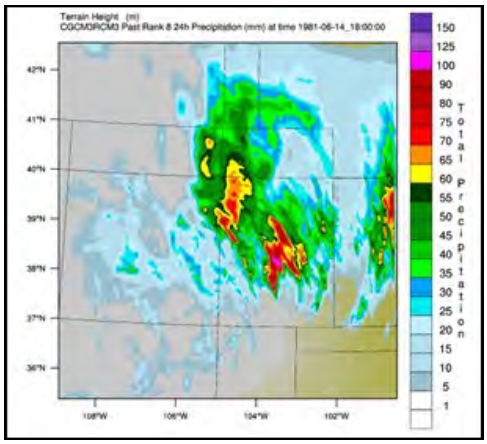
Motivation:

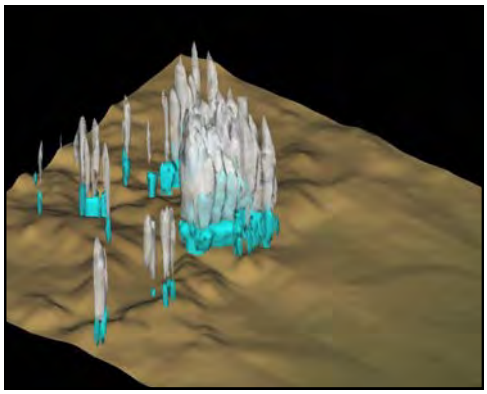
Climate models simulate large-scale patterns of change on relatively coarse spatial (10-100-km) and temporal scales. Processes that drive precipitation extremes occur at very small (<1-km) scales, rendering coarse-resolution modeling frameworks inappropriate for the simulation of extreme precipitation. High-resolution simulations are needed to understand specifically how small-scale precipitation processes may change in future climates.

High-resolution simulations are computationally expensive and often limited in duration and region. By simulating intense rainfall at cloud-scale resolution for specific events, the important small-scale physical processes can be resolved and analyzed with considerably less computational cost. Such an approach interfaces the large-scale effects of climate change and the small-scale processes that determine heavy rainfall and flooding. This research aims to provide detailed information regarding possible climate change scenarios to dam safety and flood hydrology studies, and also provide insight into the strengths and limitations of various types of dynamical downscaling.

Approach:

- Analyze seasonal and extreme precipitation from regional climate model ensemble (NARCCAP)
- Identify top extreme events in Colorado Front Range from regional models
- Further downscale all individual events to high-resolution (1.3-km grid spacing); test various model initialization methods
- Evaluate signal strength in projected changes in extremes and identify process-based explanations for changes





Top: Storm-total (24-h) precipitation from high-resolution downscaling of a "future" (projected) climate event. Bottom: Depiction of hail/graupel (white) and rain (blue) within an extreme precipitation event in the Colorado Front Range.

Related Projects:

- Green Mountain Dam Climate Change (DSO)
- Ingredients-based climatology and future projections of extreme precipitation events using a NWP framework (S&T)

Collaborators:

CIRES, Reclamation (RDO/S&T, TSC Flood Hydrology)

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Ingredients-based climatology and future projections of extreme precipitation events using a NWP framework

(S&T Project ID: 6917)

Principal Investigator: Jason Caldwell (rcaldwell@usbr.gov)

Project Goals:

- Identify atmospheric and geographic forcing of extreme rainfall events in the Colorado Front Range
- Evaluate the effects of climate change on extreme precipitation events in the Colorado Front Range
- Examine scale dependencies using NARCCAP and WRF model output

Motivation:

Extreme precipitation events drive decisions related to water resources, including: dam safety, flood risk and mitigation, and reservoir operations. These events are modulated by many environmental factors that are predicted to change (i.e., temperature, moisture) in future climates. Several recent modeling studies have focused on changes in extreme precipitation in the Colorado Front Range. This project utilizes the downscaled gridded output from the North American Regional Climate Change Assessment Project (NARCCAP) and reforecast data from the Colorado Headwaters Project to identify the primary meteorological ingredients and diagnostics contributing to extreme rainfall events from a historical and future climate perspective with a focus on warm-season convective storms (Figure 1). The gridded meteorological fields from the Weather Research and Forecasting (WRF) model offer the opportunity to evaluate changes in extreme precipitation events at different temporal and spatial scales.

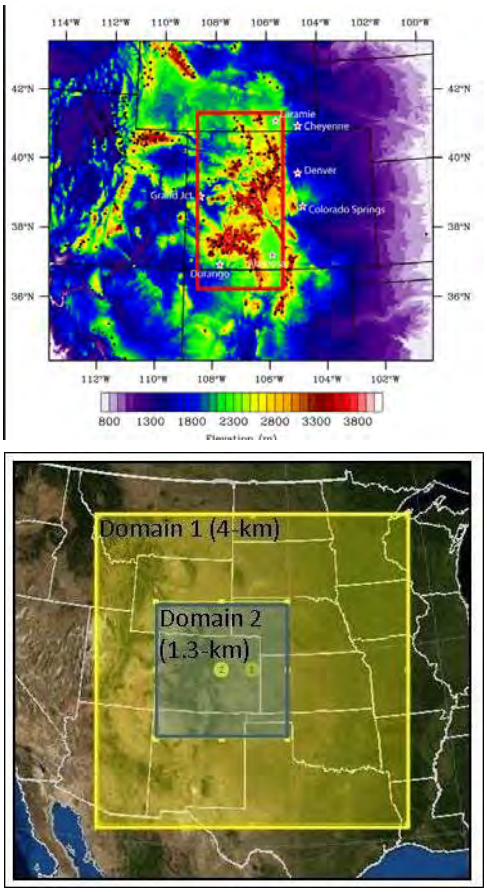

Figure 1 - Geographic extents of the Colorado Headwaters project (top) and PACE (bottom) WRF model domains

Approach:

- Collect and extract extreme storm events from downscaled NARCCAP and WRF reforecast datasets
- Diagnose ingredients contributing to extreme precipitation events in the Colorado Front Range using statistical methods
- Evaluate temporal and spatial variability in ingredients-based predictors of extreme precipitation

Related Projects:

- Methodology and Data for Quantifying Extreme Precipitation Events in a Changing Climate (RDO/S&T)
- Climate Change and Green Mountain Dam (DSO/Tech Development)
- CIRES/USBR Cooperative Agreement Extremes/Downscaling Project

Collaborators:

CIRES, NOAA-ESRL, NCAR/UCAR, Reclamation (RDO/S&T, DSO, TSC Flood Hydrology)

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Climate Change and Green Mountain Dam

(Dam Safety Research Project ID: CCGMD)

Principal Investigator: Victoria Sankovich
(vsankovich@usbr.gov)

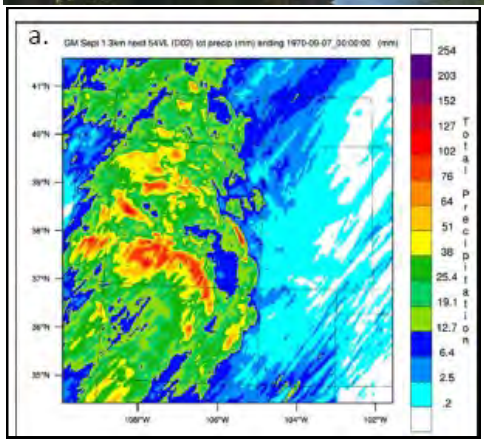
Project Goals:

- Evaluate the capabilities of the Weather Research and Forecasting Model (WRF) to analyze historic extreme storm events
- Examine the atmospheric conditions in which a storm with extreme rainfall magnitudes, or approaching PMP, could occur in the highly orographic Green Mountain watershed
- Examine the precipitation field in a future climate change environment

Motivation:

The Dam Safety Issue Evaluation for Green Mountain Dam (Figure 1) was previously finalized. While working on the project, questions arose concerning the validity of Hydrometeorological Report No. 49 Probable Maximum Precipitation amounts. Specifically, is a storm of PMP magnitude physically able to develop in the highly orographic region where Green Mountain Dam is located?

To answer these questions, an observed, historical large precipitation event that occurred previously in the area will be identified. The characteristics of this storm will be studied, and the storm will be modeled using WRF to 1) maximize moisture and 2) situate the storm in climate change conditions. The resulting, maximized storm will then be compared to HMR 49 PMP estimates.



Top: Green Mountain Dam, Colorado-Big Thompson Project
Bottom: Control simulation of Sept. storm event

Approach:

- Identification of two storms (Sept. 1970 and Oct. 1970) that produced significant rainfall in the Green Mountain Dam area
- Control simulations of both storms
- Moisture maximization simulation (iterative process) of Sept. event
- Climate change perturbation of Sept. event

Related Projects:

- Green Mountain Dam Hydrologic Hazard for Issue Evaluation (DSO)
- Methodology and Data for Quantifying Extreme Precipitation Events in a Changing Climate (RDO/S&T)
- CIRES/USBR Cooperative Agreement Extremes/Downscaling project

Collaborators:
CIRES, NOAA-ESRL, NCAR/UCAR, Reclamation (DSO, TSC Flood Hydrology)

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Linking Extreme Precipitation and Floods: Implications for Climate Change Scenarios

(S&T Project ID: 0879)

Principal Investigator: Jeanne Godaire (jgodaire@usbr.gov)

Project Goals:

- Examine basin response to extreme precipitation events in regions of the western U.S.
- Identify basin factors and storm conditions that produce the largest floods
- Apply results to regional climate change scenarios to determine potential changes in basin response

Motivation:

Changes in streamflow magnitude, frequency and volume as the climate changes will undoubtedly impact Reclamation structures from both a dam safety and water operations perspective. This study investigates the runoff response of watersheds to extreme precipitation (rainfall) recorded in basins of the western U.S. and to understand the basin and storm conditions that produce the largest floods. Simply stated, this study seeks to answer the question, "Do the largest precipitation events produce the largestfloods and if not, why?" While this question may seem relatively simple, there are many factors that can complicate the relationship between rainfall and floods. While rainfall runoff models are a useful predictive tool, they require intensive inputs to accurately portray complex topography, soils, geology, antecedant moisture and resultant runoff from storms that impact basins of the intermountain west. Historical data can be used in many basins to first understand how precipitation and runoff are related under recent historical conditions and then to apply this understanding to how basins might respond in the future given changes in climate.

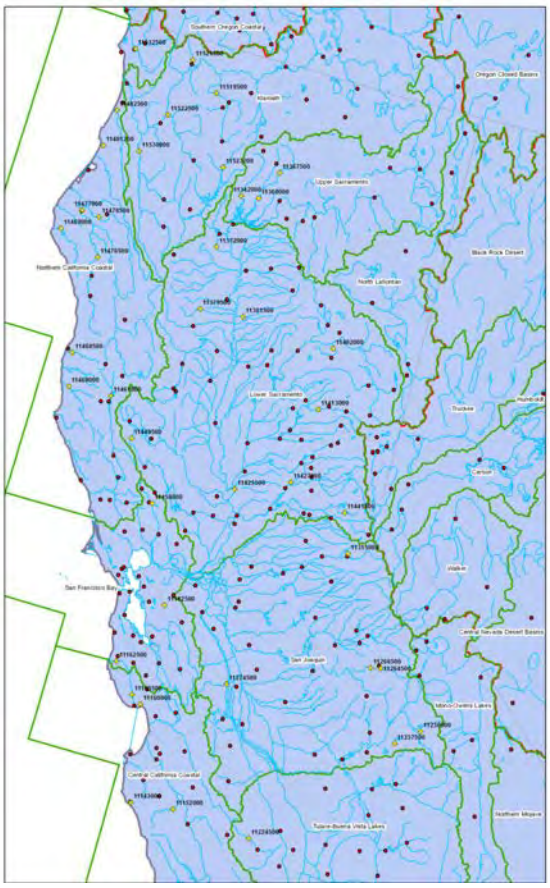

Figure 1 - Eample of streamgages and COOP precipitation gages used in the analysis for northern and central California

Approach:

- Compile the 10 largest rainfall and flood events from gages in the western U.S. for 1-, 3-, 5– and 7-day rainfall durations
- Develop relationships between extreme rainfall and streamflow
- Apply results to climate change scenarios and predicted changes in precipitation intensity, duration or seasonality

Related Projects:

- West-Wide Climate Risk Assessments (WWCRA) (RDO/S&T)
- Extreme Floods in a Changing Climate (DSO/ Tech Development)
- Methodology and Data for Quantifying Extreme Precipitation Events in a Changing Climate (RDO/S&T)

Collaborators:

NOAA-ESRL, USGS-SIO, Reclamation (RSD, Flood Hydrology)

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Diagnosing the Moisture Sources for Extreme Precipitation Events in the Intermountain West

(BOR R11AC81334/CIRES 1548911)

Technical Lead: Michael Alexande (Michael.Alexander@noaa.gov)
CIRES/USBR Cooperative Agreement PI: Kristen Averyt

Project Goals:

- Determine the preferred pathways for moisture to reach the intermountain west during winter.
- Advance our understanding of how moisture sources and synoptic processes, especially atmospheric rivers, influence extreme precipitation events.
- Use high-resolution models to simulate heavy precipitation events and conduct sensitivity experiments to understand the processes that generate them.
- Evaluate how climate factors influence the moisture pathways

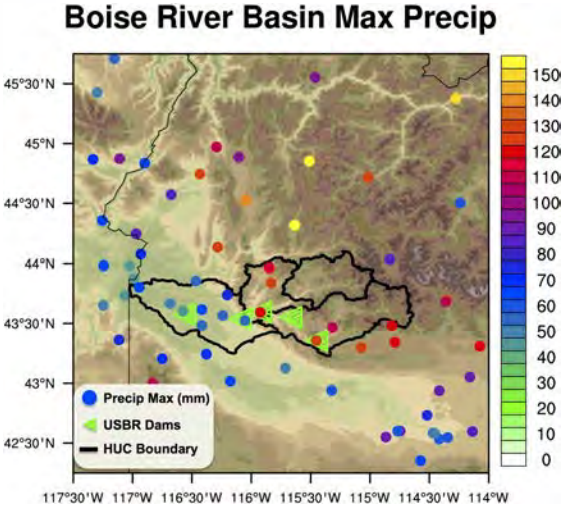
Motivation:

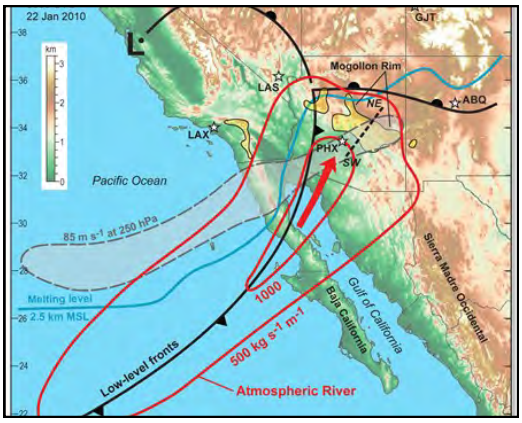
It is not clear how the large volume of water necessary to sustain intense precipitation events in the intermountain west reach their destination given the distance from the moisture source in the Pacific and the complex regional topography. Since flow over mountain causes air to cool and thus hold less moisture, air parcels may take unique pathways and/or have multiple moisture sources to retain enough water to have intense precipitation events in states such as Arizona, Colorado, and Idaho. It would be useful to both scientists and water mangers, to better understand the synoptic (weather-related) and climatic processes that influence heavy precipitation events in the US intermountain west especially in winter.

Atmospheric rivers (ARs), long narrow bands of enhanced water vapor transport, are the dominant mechanism for generating intense precipitation events along the west coast of the US during winter. While studies over the past 10 years have extensively explored the impact of atmospheric rivers on the temperature and precipitation west of the Sierra Nevada and Cascade mountains, their influence on the weather in the intermountain west remains an open question.

Approach:

- Obtain precipitation data and identify extreme wintertime precipitation events
- Diagnose processes contributing to extreme precipitation and AR events using trajectories and synoptic analyses based on recent reanalysis data sets
- Conduct in-depth case studies of extreme events
- Perform high-resolution model simulations and sensitivity studies





(Top) Max 3-day precipitation (Oct-Apr) in southwest Idaho for stations with at least a 30-year record. (Bot) Schematic of conditions leading to heavy precipitation over central Arizona on January 12, 2010.

Related Projects:

- Ingredients-based climatology & future projections of extreme precipitation (RDO/S&T)
- Quantifying extreme precipitation events in a changing climate (RDO/S&T)
- CIRES/USBR Cooperative Agreement Extremes/Downscaling Project

Collaborators:

CIRES, Reclamation (RDO/S&T, TSC Flood Hydrology)

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Annual Progress Meeting on Reclamation Climate and Hydrology Research

Methodology and data for quantifying extreme precipitation events in a changing climate

(S&T Project ID: 1385)

Principal Investigator: John England (jengland@usbr.gov)

Project Goals:

- Assess relative magnitude, areal extent, and intensity of recent storms compared to historical PMP storms
- Evaluate storm maximization concepts under future climate conditions
- Investigate historical storms using future climate conditions to identify changes in intensity

Motivation:

Probable Maximum Precipitation (PMP) data sets and methodologies have remained unchanged since 1986, and are critical to flood hazard, flood control and water supply infrastructure assessments. The extreme storm precipitation event Depth-Area-Duration (DAD) data base used in PMP was originally developed by the NWS, USACE and Reclamation from the 1940s through the 1980s. The small sample and short record of the largest extreme storms may be sensitive to climate variations and change, and is largely unexplored. Crucially, recent extreme storms, such as February 1996 (OR), December 1996-January 1997 (CA), November 2006 (ID), and October 2009 (CA), among many others are not included.

The data base and PMP methodology do not reflect current knowledge on hydrometeorology, do not incorporate modern meteorological datasets, and do not make use of future climate projection information. This study investigates the application of modern datasets in performing extreme storm analyses and the potential impacts of projected climate change on the character of extreme storm events.

Approach:

- Develop a recipe for conducting extreme precipitation event analyses (e.g., Figure 1)
- Document and quantify events at high spatial and temporal resolution
- Apply climate projection information to maximization concepts for historical extreme precipitation events

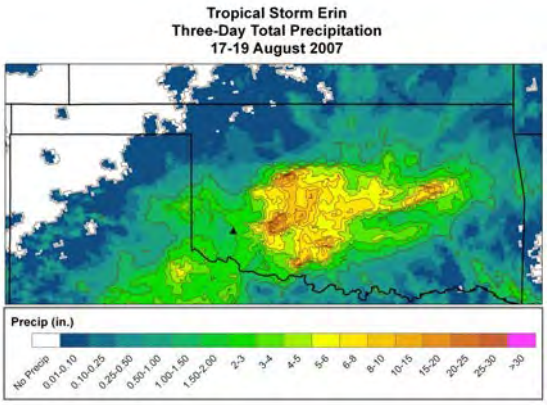

Figure 1 - Locations of existing storms used in PMP (top) and recent event (Tropical Storm Erin 2007), not in data base (bottom).

Related Projects:

- Ingredients-based Climatology and Future Projections of Extreme Precipitation using a NWP Framework (RDO/S&T)
- Climate Change and Green Mountain Dam (DSO/Tech Development)
- CIRES/USBR Cooperative Agreement Extremes/Downscaling Project

Collaborators:

CIRES, NOAA-ESRL, NCAR/UCAR, Reclamation (RDO/S&T, DSO, TSC Flood Hydrology), USACE -NWO (Omaha District, Doug Clemetson)

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Sensitivity of Hydrologic Impacts Assessment to the Downscaling Methodology and Spatial Resolution

Principal Investigator: Martyn Clark (mclark@ucar.edu)

Project Goals:

The overall objective of this project is to determine the extent to which the portrayal of climate impacts depends on methodological choices, understand why different methods produce different results, and provide guidance on the suitability of different methods to provide state-of-the-art intelligence for water resources planning. Specific science questions include:

- Is the portrayal of hydrologic impacts under climate change dependent on the chosen downscaling method (i.e. dynamical downscaling using regional climate simulation versus non-dynamical downscaling using statistical or empirical methods)?
- At what space and time scales does impacts portrayal begin to be sensitive to methods class, and for what types of hydrologic metrics?
- How do the responses to these questions vary with the spatial resolution of dynamical downscaling and the adequacy of process representation in atmospheric and hydrologic models?

Motivation:

The science community has developed a range of different methods to study the impact of climate change on water resources. Different climate impact studies have made different methodological choices – there is diversity in the choice of method to define the climate perturbations (e.g., emission scenarios and global climate model), diversity in the choice in downscaling method (e.g., different forms of statistical and dynamical downscaling), and diversity in the choice and configuration of the hydrologic model(s) used in the impact assessments (e.g., model structure, forcing data, and parameter estimation methodology). There is currently little guidance on the advantages and limitations of different methods, including which methods are better suited to address specific science questions and which methods are more robust.

Approach:

The project includes the following tasks:

- Conduct multi-year dynamical and non-dynamical downscaling at 36km, 12km, and 4km over the Colorado Headwaters region, for both historical climate conditions and perturbed historical climate conditions. Evaluate the impact of the choice of downscaling method on simulations of hydroclimatic variability and change.
- Use process-based hydrologic models to evaluate hydrologic changes under method- and resolution-dependent downscaled climate.
- Document the results of this study in both peer-reviewed journal publications and work with the USBR, USACE, and hydroclimate scientists to define follow-up studies and evaluate how the results of this study impact water resource operations and planning.

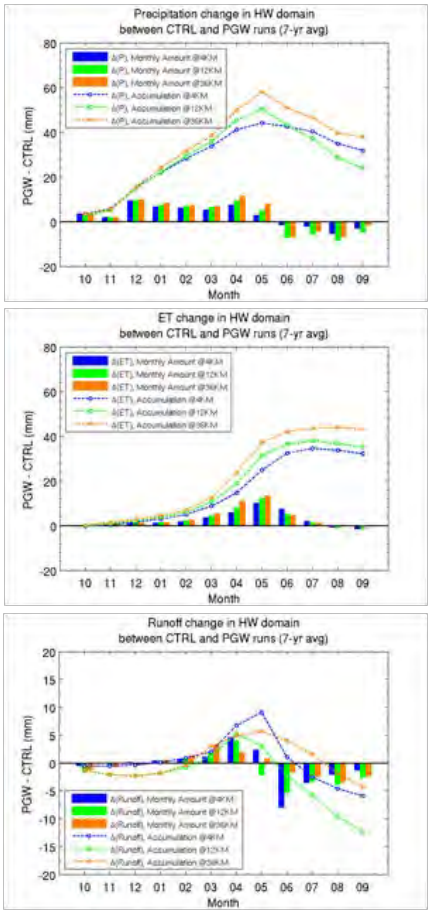

Figure 1 - Changes in coupled land-atmosphere simulations of precipitation, evapotranspiration and runoff, as obtained in WRF simulations at 4-km, 12-km, and 36-km resolution.

Related Projects:

- Jason Caldwell: Extremes.
- John England: Dam Safety.

Collaborators:

- University of Colorado (lead: Balaji Rajagopalan)
- Bureau of Reclamation (lead: Levi Brekke)
- Corps of Engineers (lead: Jeff Arnold)

Participants:

Roy Rasmussen, Levi Brekke, Jeff Arnold, Changhai Liu, Kyoko Ikeda, Ethan Gutmann, Tom Pruitt, David Gochis, Naoki Mizukami, Pablo Mendoza, and Balaji Rajagopalan.

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A Quantitative Assessment Framework for Potential Climate Change Impacts on National Hydropower Generation

Principal Investigator: Shih-Chieh Kao, ORNL (kaos@ornl.gov)

Project Goals:

- Design a quantitative assessment method for climate change impacts on national and regional hydropower generation.
- Construct a computationally-intensive framework for multi-GCM/RCM/HM hydro-climate projections with refined model accuracy and spatial resolution.
- Project the change of annual/seasonal hydropower generation to support decisions on future hydropower marketing and contracting activities.

Motivation:

Hydropower generation is mainly influenced by streamflow availability, which may be directly affected by climate change and variability. Using a series of hydro-climatic models and statistical techniques, including General Circulation Models (GCMs), Regional Climate Models (RCMs), bias correction techniques, Hydrological Models (HMs), historic runoff-generation relationships and a newly-organized national hydropower dataset, a regional assessment framework is being developed to quantify the potential climate change impacts on hydropower generation to support decisions on future hydropower marketing and contracting activities. Efforts are undertaken to refine the spatial resolution, enhance the model calibration, and investigate new regional water balance approaches that incorporates water storage and competing water uses to provide better understanding of future conditions and improve mitigation strategies .

Approach:

- Dynamical downscaling for multiple CMIP5 climate projections using both WRF and RegCM4 at 18-km spatial resolution for the entire U.S.
- Recalibration of VIC model at 4-km spatial resolution using Daymet and USGS WaterWatch observation for all HUC08 Subbasins in the conterminous U.S.
- Compute the multi-GCM/RCM/HM hydro-climate ensemble projection and the corresponding change on national and regional hydropower generation.

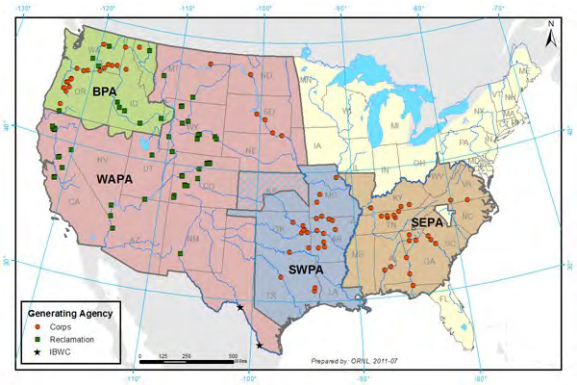


Figure 1 - The 132 federal hydropower plants that were recently accessed in the Secure Water Act Sec. 9505 study

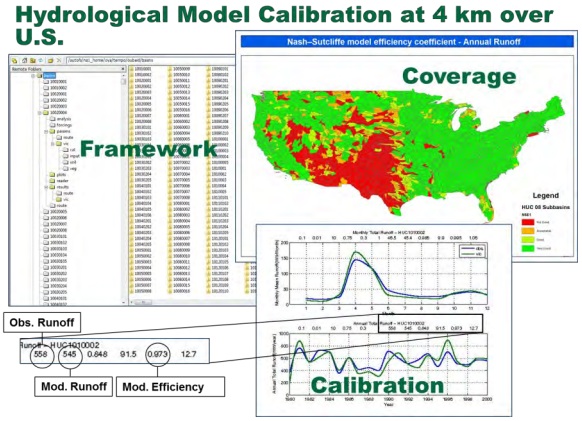


Figure 2 - Recalibration of VIC model at 4-km spatial resolution for all HUC08s in the U.S.

DOE/ORNL Co-PIs:
Mike Sale, DOE Subcontractor
Moetasim Ashfaq, ORNL
Abdoul A. Oubeidillah, ORNL

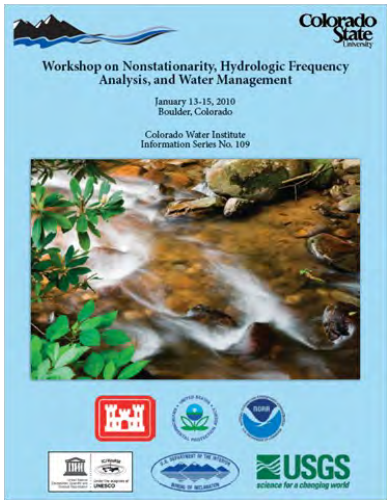
Collaborators:
DOE Power Marketing Administrations (BPA, WAPA, SWPA, SEPA), Reclamation, and USACE

Sponsors:
DOE Wind and Water Power Program,
Oak Ridge National Laboratory LDRD Program

Annual Progress Meeting on Reclamation Climate and Hydrology Research

USACE Non-Stationarity

David Raff, PhD, PE david.a.raff@us.army.mil



Project Goals:

- Coordinate with Federal and Non-Federal Water Management Entities on Non-Stationarity and Flood Frequency
- Develop methodologies to address non-stationarity for flood frequency estimation
- Establish implementation guidance for USACE District and Division application.

Motivation:

Continue motivation of January 2010 Workshop "•One objective of the January 2010 "Workshop on Nonstationarity, Hydrologic Frequency Analysis, and Water Management" was to facilitate Federal interagency efforts to account for nonstationarity in hydrologic frequency analysis. "

Address the proposed Bulletin 17C language ""There is much speculation about changes in flood risk over time. Available evidence indicates that major changes may be occurring over decades or centuries. While time invariance was assumed when developing this guide, where changes in climate and flood risk over time can be accurately quantified, the impacts of such changes should be incorporated in frequency analysis by employing time-varying LP3 parameters or using other appropriate and statistically justified techniques. All such methods need to be thoroughly documented and justified."

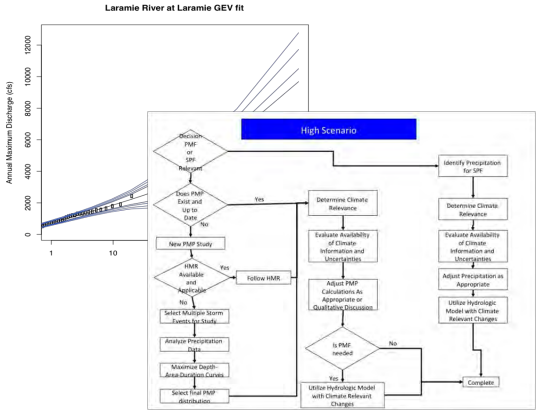


Figure 1 - Project focus is to build upon 2010 CCAWWG Workshop on Non-Stationarity and develop practical implementation guidance

Approach:

- Develop Internal USACE H&H Project Delivery Team including Districts and Division Staff
- Work with Inter-agency Team comprised of Reclamation, USACE, USGS, FEMA, Federal Highways, others welcome.
- Develop External Expert Guidance Team: Upmanu Lall (Columbia University), Richard Vogel (Tufts University), Gabriele Villiarini (University of Iowa)

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USGS science for a changing world
FEMA

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Understanding How Different Versions of Distributed Historical Weather Data affect Hydrologic Model Calibration and Climate Projections Downscaling

PIs: Subhrendu Gangopadhyay (sgangopadhyay@usbr.gov), Marketa M Elsner (melsner@usbr.gov) [S&T Project ID: 0675]

Project Goals:

- Quantify differences between available historical meteorological datasets
- Determine sensitivity of hydrologic model simulations to meteorological dataset
- Evaluate climate change sensitivity to hydrologic model calibration and choice of historical meteorological

Motivation:

Spatially distributed historical meteorological datasets are commonly used as the basis for statistical downscaling of general circulation model projections. Numerous historical datasets have been developed over the Western US, each using different methodologies. Climate change impacts studies relying on downscaled climate scenarios have been used to inform water resources planning, yet we do not have a good understanding of the sensitivity of the projections to chosen baseline historical data. This study directly compares four historical datasets and evaluates corresponding calibrated hydrologic model simulations over seven case study watersheds. This work allows us to understand the uncertainty associated with use of any individual forcing dataset and to evaluate the implications of these datasets on downscaling efforts and climate change impacts studies.

Approach:

- Compare statistics and spatial characteristics of four historical meteorological datasets (including Maurer et al. 2002)
- Calibrate the VIC hydrologic model using each dataset and evaluate calibrated model simulations forced with other datasets
- Explore implications of dataset use in statistical downscaling through sensitivity analysis

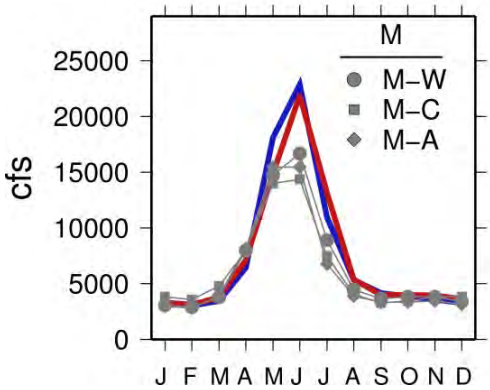

Figure 1 - Domain of dataset comparison (top, purple dashed line) and mean hydrographs for the Snake River basin headwaters (top, basin #7; bottom, blue = natural flow, red = calibrated flow using Maurer et al 2002, gray = simulated flow forced with other datasets)

Related Projects:

- Methodology and Data for Quantifying Extreme Precipitation Evens in a Changing Climate (RDO/S&T)
- Evaluating Contributions to Extreme Events in Historical and Projected Future Climate (RDO/S&T)

Collaborators:
NOAA, CBRFC

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The Predictability of Streamflow across the Contiguous United States

Principal Investigator: Martyn Clark (mclark@ucar.edu)

Project Goals:

The overall goal of the proposed project is to quantify the impact of different sources of uncertainty on different types of forecasts (e.g., 1-day stage forecasts, 3 month volume forecasts), at different forecast initialization times (e.g., forecasts initialized on October 1st versus April 1st), and in different hydroclimate regions (e.g., regions with/without substantial snow storage; regions with varying degrees of climate predictability).

Motivation:

The US Bureau of Reclamation (USBR) and the US Army Corps of Engineers (USACE) are currently conducting an assessment of the use of hydrologic forecasts for short-term water management. This assessment is being conducted to support development of the report "*Short-Term Water Management Decisions: User Needs for Improved Weather and Climate Prediction Information*" (ST-Doc). The ST-Doc aims to identify research, development and demonstration needs related to better use of climate, weather and hydrologic information (i.e. monitoring and/or forecasts) in short-term water management decisions. Short-term decisions in this case are those associated with look-ahead periods of generally 1-year or less. To complement the USBR-USACE assessment of information use, the purpose of this study is to undertake a comprehensive predictability assessment to quantify and document the major sources of uncertainties in hydrologic monitoring and prediction products. This study will support the USBR-USACE assessment of user needs with an assessment of the opportunities to improve hydrologic prediction products, and to identify and prioritize future research projects.

Approach:

The project includes the following tasks:

- Evaluate current capabilities in hydrological modeling skill across a large range of basins, and how hydrologic model skill depends on basin characteristics (climate, topography, vegetation, soils), and station density.
- Conduct idealized predictability experiments to evaluate the relative impacts of uncertainty in both basin initial conditions and weather-climate forecasts.
- Develop realistic estimates of uncertainty in weather data used in model spin-up, and in hydrologic model structure and parameters.
- Quantify uncertainty in weather and climate forecasts, downscaled to local scales used in basin-scale hydrologic models
- Assess the value of state-of-the-art forecasting methods to reduce forecast uncertainties, including improved hydrologic models, data assimilation, and statistical post-processing methods.
- Conduct case studies to evaluate the value of improved forecasts on water management decisions.
- Disseminate results in peer-reviewed journal articles, etc.

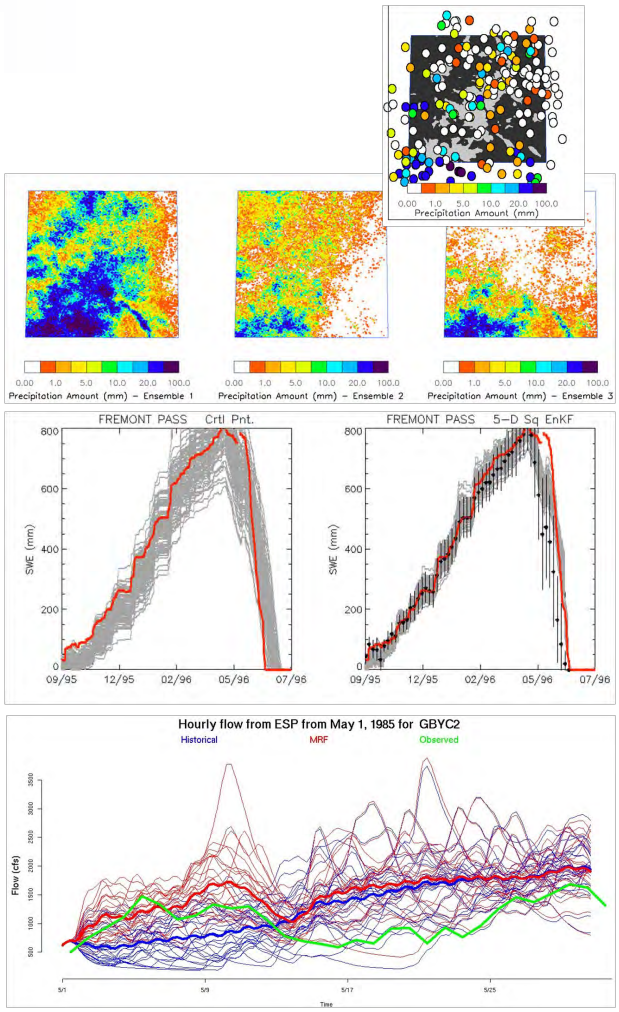

Figure 1 - Collage of different historical efforts to improve skill in streamflow forecasts, showing ensemble precipitation estimation and corresponding observations, ensemble snow simulations and data assimilation, and ensemble streamflow forecasts in NWS operational systems using downscaled data from global-scale numerical weather predicition models. Key contributions from Drew Slater, Kevin Werner, David Brandon, and Subhrendu Gangopadhyay.

Collaborators:

- University of Adelaide (lead: Dmitri Kavetski)
- Bureau of Reclamation (lead: Levi Brekke)
- Corps of Engineers (lead: Jeff Arnold)

RECLAMATION
Managing Water in the West

Annual Progress Meeting on Reclamation Climate and Hydrology Research

Evaluating the Relevance, Reliability, and Applicability of CMIP5 Climate Projections for Water Resources and Environmental Planning

Principal Investigators: Ian Ferguson (iferguson@usbr.gov), Jamie Scott, Jeffrey Arnold, Michael Alexander

Project Goals:

- evaluate new CMIP5 projections for use in water and environmental resources planning contexts
- develop and demonstrate a framework for evaluating CMIP5 information for relevance and reliability to determine applicability in these contexts

Motivation:

Water managers need knowledge of the relevance, trustworthiness, and applicability of climate projection information to support decision-making. This requirement occurs as new global climate projections are being released through the World Climate Research Programme's Coupled Model Intercomparison Project Phase 5 (WCRP CMIP5) effort, presenting new opportunities and challenges for the climate change adaptation community.

Project outcomes are expected to inform discussion of information credibility, which is emerging as a challenging issue when rationalizing adaptation investments or decisions to delay investment. In addition to considering CMIP5 21st century projection information, the framework will be developed to support evaluation of CMIP5 decadal predictability experiment simulations and reconcile those simulations with 21st century projections.

Approach:

- Preliminary #1) Conduct a broadband quality evaluation of CMIP5 historical simulations and develop online portal to serve results
- Preliminary #2) Conduct water resources system sensitivity analyses to identify relevant climate metrics
- Applicability Pilots: merge preliminary results, arrive at applicability judgments, observe process
- Scope evaluation of effect of spatial downscaling on CMIP5 historical simulations

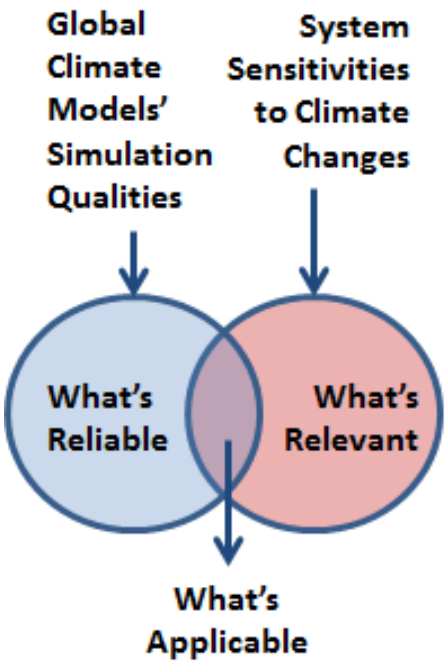

Figure 1 - The project involves piloting applicability discussions that are framed by the dual considerations of information reliability and relevance. Applicability discussions will be piloted using the federal-state-local reservoir systems in California's Central Valley.

Related Projects:

- Bias Corrected and Downscaled WCRP CMIP3 Climate and Hydrology Projections (RDO/S&T)
- SECURE West-wide Climate Risk Assessments (PMO/WaterSMART)
- SECURE Basin Studies (PMO/ WaterSMART)
- SECURE Feasibility Studies (PMO/ WaterSMART)

Collaborators:

USACE, NOAA, University of Colorado CIRES, Reclamation Mid-Pacific Region, California Department of Water Resources

PROJECT PLAN

Project Title: Training-Integrating Climate Information into Water Resource Technical Studies

Project Objective 1/: Establish a training program that will increase the ability of technical practitioners to incorporate climate change information in the studies they conduct that inform water and water related resource management decisions.

Approach: Reclamation, USACE, NOAA, EPA, USGS, and NOAA-funded Regional Integrated Science and Assessment (RISA) programs will sponsor and lead this effort as an activity of the Climate Change and Water Working Group. The Denver Water Board and the Water Utility Climate Alliance are collaborating sponsors capable of representing a broad cross section of non-federal water management needs and perspectives. A pilot phase will be used to develop and test course content and delivery mechanisms. The results of the pilot phase will be used to inform the design of a long-term, sustainable program that could be relevant and useful to a broader community of technical practitioners. Pilot phase activities will be the focus of 2012 activities; and the design and proposal of a broader, long-term framework will be the focus of 2013 activities.

Pilot Phase

Step 1: Secure sufficient funds to develop and host an initial pilot training course(s).

Step 2: Obtain the collaborative assistance of the well established expertise within the University Corporation for Atmospheric Research (UCAR) COMET Program for developing and delivering multi-media, professional development courses to technical practitioners. Distance learning modules will be central to the effort in order to bring the training to the user to the extent possible, thereby reducing associated travel time and costs.

Step 3: Form a team of subject matter experts (SMEs) from the sponsoring CCAWWG agencies, NOAA - funded RISA programs, and the DOI Climate Science Centers (CSCs) program to collaborate with the UCAR COMET Program. SMEs will be responsible for developing course curriculum based upon their experience in applying climate change information into technical studies related to the pilot training topics.

Step 4: Form a small user group of technical practitioners that have experience applying climate change information to water issues. The user group will be responsible for helping the SMEs ensure that course content is well targeted to the needs of the broader learner audience. The user group will be populated with individuals identified by the project sponsors.

Step 5: The *"Addressing Climate Change in Long-Term Water Resources Planning and Management – User Needs for Improving Tools and Information"* will be used as a guide for understanding where customized training could help practicing professionals better access and apply current capabilities for assessing natural system responses to a changing climate. One or two pilot training topics will be

identified that have broad appeal across the water management and water related natural resources community of practice. (http://www.usbr.gov/climate/userneeds/docs/LTdoc.pdfthe LT Doc, pages 46-56).

Step 6: Define learning objectives for the pilot training course(s).

Step 7: Subject matter experts and UCAR-COMET work together to develop course content and instructional learning support aides for the pilot courses.

Step 8: Presentation of the pilot courses will be used to test and refine learning objectives and course content through interactions with the user group.

Step 9: Provide the pilot training courses to a broad audience of practicing professionals from the federal/non-federal water and water related natural resources community of practice. The participation of the US Fish and Wildlife Service and other natural resource organizations at this stage is key to forming collaborative efforts and leveraging capabilities with the natural resources community of practice for the Implementation Phase.

Implementation Phase

Step 1: Use the results and feedback from the pilot phase to:

- Gauge the success of the training; identify what works well and to refine what needs to be improved.
- Better understand the scope of training needs and interests of the broader water and water related natural resources community of practice.

Step 2: Use *"Addressing Climate Change in Long-Term Water Resources Planning and Management – User Needs for Improving Tools and Information"* to help comprehensively frame the range of relevant training topics related to the response of water and other natural systems to a changing climate(e.g. watershed hydrology, ecosystems, land cover, water quality, crop water demands, sedimentation and river hydraulics) (http://www.usbr.gov/climate/userneeds/docs/LTdoc.pdfthe LT Doc, pages 46-56)

Step 3: Propose a long-term, sustainable training program capable of providing professional development for the topics identified in step 2. The long-term plan will include:

- Proposed scope
- Level of effort
- Identify collaborators
- Identify collaborator contributed/leveraged capability
- A strategy to update training material and provide a continuing education process to keep practitioners informed of most current understanding and application approaches.
- Annual costs and business model options that ensures annual program costs are funded.

Step 4: Interested organizations make decisions on long-term implementation

Schedule -The schedule is subject to change, and will be further refined as the scope and required level of effort for the pilot phase becomes better defined. It is anticipated that Steps 1 through 8 of the Pilot Phase will be completed by the end of calendar year 2012, and that Step 9 of the Pilot Phase and the Implementation Phase will be completed during calendar year 2013.

1/ Associated Objective: This CCAWWG project will also serve to address Recommendation 6-Supporting Action #21 from the Interagency Climate Change Adaptation Task Force--*National Action Plan Priorities for Managing Freshwater Resources in a Changing Climate, October 2011.* http://www.whitehouse.gov/sites/default/files/microsites/ceq/2011_national_action_plan.pdf