RECLAMATION Managing Water in the West

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The Knowledge Stream
Research Update

Choosing the Right Meteorological Dataset for Hydrologic Simulations

How meteorological datasets affect model simulations and portrayal of climate sensitivity

Bottom Line

This research project determined that spatially distributed meteorological datasets affect calibration of the Variable Infiltration Capacity (VIC) model and corresponding streamflow simulations and may also affect characterization of runoff changes due to climate change.

Better, Faster, Cheaper

Federal natural resource management and conservation agencies, including Reclamation, have mandates for incorporating climate change into long-term planning. Greater understanding of the implications associated with using a particular meteorological dataset in hydrologic modeling is important, not only for historical hydrologic studies, but also for characterizing the uncertainty associated with projected future hydrologic conditions.

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Problem

For water and environmental management decisions, understanding the uncertainty associated with various underlying modeling application choices is critical. Sophisticated physical process models informed by climate change scenarios are increasingly becoming an integral part of long-term natural resources planning. Studies using these models are often the best available science to be used for decisionmaking. For example, the proposed listing of the North American wolverine in 2013 as threatened under the Endangered Species Act relied on evaluations of climate change impacts on this distinct population, which depends heavily on contiguous snowpack.

Choices in conducting a study to support environmental and water management decisions may include historical and projected future meteorological datasets and a hydrologic modeling framework, which involves choice of model structure and calibration methods. In short, choosing a historical meteorological dataset is one of many modeling application decisions to be made that affects the water budget.

Shasta Lake on the Sacramento River, a case study watershed that compared streamflow simulations based on four meteorological datasets. Photograph courtesy of Mid-Pacific Regional Office.

Understanding the methods, assumptions, and analyses going into developing these datasets is vital to using these applications for subsequent analysis. Moreover, understanding uncertainty associated with various underlying modeling applications is critical for environmental management decisions. Thus, to better determine the implications of using a particular historical dataset and to characterize the uncertainty associated with projections of future hydrologic conditions, the following questions need to be answered:

- Is there an optimal distributed meteorological forcing dataset to be used in simulating streamflow through a hydrological model, specifically the Variable Infiltration Capacity (VIC) model?
- How does the choice of distributed meteorological data affect hydrologic model calibration and sensitivity analysis, particularly for changes in climate?

Solution

This Reclamation Science and Technology Program research project compared four meteorological forcing datasets commonly used in natural resources planning studies. It compared precipitation and temperature (maximum, minimum, and diurnal range) from these datasets over a common time period (water years 1980 - 1999), spatial resolution (1/8 degree), and domain. Domains generally covered the United States portions of four major western hydrologic regions, including: the Pacific Northwest

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(Columbia River Basin plus coastal drainages in Oregon and Washington), California, the Great Basin, the Colorado River Basin, and the Missouri River Basin (west of 93 degrees west longitude).

These direct comparisons allow better understanding of the implications of these datasets with respect to long-term planning studies. Hydrologic model calibrations (using each of the four compared datasets) and resulting simulations were examined on seven case study watersheds (see map) to answer:

- Does a model calibrated to one meteorological dataset yield significantly different calibration parameters than a model calibrated using a different meteorological dataset?
- Do results from a model calibrated to one meteorological dataset differ significantly when the model is run with a different meteorological dataset?
- How sensitive is runoff to changes in climate (as represented by differences between calibration and validation periods)?

Map of basins covered, along with seven case study watersheds: 1–Animas River, Durango, CO; 2–Dolores River, Cisco, UT; 3–Green River, Green River, UT; 4–Missouri River, Toston, MT; 5–Sacramento River, Red Bluff, CA; 6–Salt River, Chrysotile, AZ; 7–Snake River, Heise, ID.

This study found that, of the four commonly used datasets considered, each meteorological dataset differs, particularly in forecasting minimum and maximum temperatures in high elevation regions such as the Rocky Mountains. However, this study also found that no single dataset stands out as the best for simulating streamflow—each was developed for a specific purpose and set of applications and used different approaches. Key findings in the context of various uncertainties in long-term natural resources planning studies included:

- Evaluating runoff sensitivity to changes in climate indicates that the choice of meteorological dataset may be as important in characterizing potential changes in runoff as climate change itself.
- The choice of meteorological forcing dataset will influence statistical downscaling of projected climate scenarios from coarser scale (in space and time) global climate models, thereby influencing the uncertainty associated with climate projections downscaled to forecast local conditions.
- Although there are substantial differences among these datasets, no single dataset is superior to the others with respect to VIC model simulations of streamflow.
- There is no apparent relationship between optimal calibration parameter values and meteorological dataset or watershed, suggesting that the quality of the datasets is comparable or there is enough flexibility in the model parameters to compensate for differences among forcing datasets and potential biases in process representation.

Future Plans

Further studies exploring the sensitivity of other hydrologic variables beyond streamflow (e.g., snowpack, evapotranspiration) to the particular meteorological forcing dataset, changes in runoff sensitivity due to hydrologic model calibration, as well as studies using ensembles of approaches and techniques (including additional hydrologic models), will enhance understanding of uncertainties and are critical for identifying best practices for applications.

"This work supports previous findings, demonstrating that we need to consider many facets of datasets and ways to analyze them, as all of these factors play a role in how climate change impacts are portrayed in long-term natural resources planning studies."

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More Information

www.usbr.gov/research/projects/detail.cfm?id=675

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