RECLAMATION Managing Water in the West

September 2013
Research and Development Office
Bulletin 2013-21

The Knowledge Stream
Research Update

Assessing the Assessment Methods: Climate Change and Hydrologic Impacts

Are our perceptions about adaptation needs sensitive to our methods for assessing future weather and hydrologic impacts?

Bottom Line

This project identifies strengths and weaknesses of current techniques for downscaling climate projections and assessing hydrologic conditions that inform adaptation planning and investments. Results from this evaluation steer research and development investments to develop improved techniques.

Better, Faster, Cheaper

The comprehensive analysis of methodological shortcomings provides the user community with guidance on appropriate methods for climate impact assessments. It also informs research to develop improved downscaling and hydrologic modeling approaches that will both improve handling of uncertainty in climate change assessments and more effective support of adaptation planning and decisionmaking.

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Collaborators

Reclamation

- **Technical Service Center**
- **WaterSMART Basin Studies Program**

National Center for Atmospheric Research (NCAR)

U.S. Army Corps of Engineers

University of Colorado

Problem

Reclamation, U.S. Army Corps of Engineers (USACE), and other water management agencies have an interest in developing reliable, science-based methods for incorporating climate change information into longer-term water resources planning. Such planning assessments must quantify projections of future climate and hydrology. The common practice is to begin by developing relationships between current observed climate and climate projections over the assessment region. Because the spatial resolution and biases of climate projections developed by global climate models is not adequate for local to regional hydrologic assessments, this step relies on some form of spatial downscaling and bias correction, which produces watershed-scale weather information to drive simulations of hydrology and other water resource management conditions (e.g., water demands, water quality, environmental habitat).

Water agencies continue to face decisions about the selection of downscaling method(s), the selection and configuration of hydrological models, and of observational datasets. There is a critical need to understand the ramification of these methododownsclogical decisi as they affect the signal and uncertainties produced by climate change assessments and, thus, the effectiveness of these results to support adaptation planning and decisionmaking.

Solution: Assessment of Uncertainties

The project has found that there is indeed reason for concern over methodological choices. Initial results indicate that selection of downscaling methods and the selection and configuration of hydrologic models can substantially alter the portrayal of climate change impacts on hydrology. Specifically,

1. The choice of methods to produce historical, spatially distributed weather estimates over the Western United States (U.S.)—which is foundational for guiding climate

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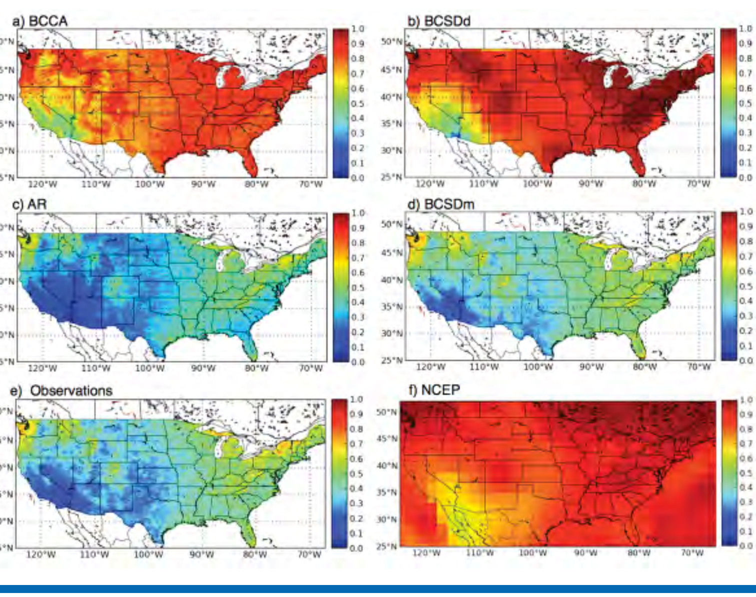

Historical fraction of wet days from four statistical downscaling techniques (plots a-d), all of which have different wet day fractions compared to observations (plot e). The low-resolution data they are downscaled from are provided for reference (plot f). Figure from Gutmann, et al., 2013.

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projection downcaling and hydrologic model application—can have as large an impact on projected hydrologic outcomes as the climate change signal. Compounding the issue, hydrologic model calibration yields model parameter sets that inappropriately compensate for the biases in the model forcing data (different model parameter sets for different model forcing data), influencing climate change sensitivities in unappreciated ways.

2. Many statistical downscaling methods that are popular in the water management community produce hydroclimate representations with too much drizzle, too small extreme events, and improper representation of spatial scaling characteristics that are relevant to hydrology. These deficiencies vary by method, significantly impacting results.

3. The choice of statistical versus dynamical downscaling is important: the climate sensitivities obtained from 4-kilometer (km) dynamically downscaled simulations from the Weather Research and Forecasting (WRF) model differ from current statistically-based guidance being provided to water managers. WRF shows wintertime increases in precipitation in the Colorado River Headwaters that are consistent with a warmer and moister atmosphere, and occur when topography is adequately resolved by the regional climate model.

4. The resolution used in dynamical downscaling matters. While the 4-km WRF simulations match observed precipitation well, WRF simulations at 12- and 36-km have a poor correspondence to observations and, importantly, the coarser-resolution WRF simulations have very different change signals compared to the 4-km WRF simulations. The impact of WRF resolution on hydrology is primarily due to differences in precipitation among multi-resolution WRF simulations, although differences in the spatial resolution of the hydrology model are still important.

5. The choice of hydrologic model also affects projection outcomes, though less so if a hydrology model is well calibrated. Calibration is successful in reducing climate change impact uncertainty, particularly for metrics that are closely related to the objective function used in calibration, thus the use of uncalibrated hydrology models, as is common in regional or larger-scale assessments, is ill-advised. There is a clear need to implement comprehensive (multi-objective) calibration schemes that consider multiple, application-relevant attributes of hydrologic model behavior.

6. Finally, outcomes depend significantly on subjective decisions made in calibrating hydrologic models, such as the choice of forcing data, the choice of calibration scheme, and the choice of objective function. Work is continuing to quantify the effect of calibration decisions in more detail.

Taken together, the methodological sensitivities found thus far reveal that the current practice of impact assessment unwittingly includes an array of unintended effects—artifacts resulting from the method, data, and model choices—prompting practitioners to seek a new path.

Future Plans

The project team is currently scoping follow-on efforts to develop and demonstrate improved downscaling methods and hydrologic modeling applications. On downscaling, the effort will consider advanced hybrid statistical-dynamical downscaling methods to provide a realistic depiction of physical processes at a low computational cost. These methods improve hydrologically relevant metrics, such as the spatial representation of extreme precipitation events, and can be applied to a large range of climate scenarios. On hydrologic assessment, the effort will employ a multi-model approach with multiple advanced calibration strategies to reduce simulation errors and improve characterization of uncertainty in hydrologic models. Improved hydrologic models and more physically realistic downscaling implementation will lead to more dependable projections, and ultimately improve decision support.

"Water resource managers are significantly increasing their use of hydrologic models forced by climate-changed future conditions in our planning for responding to climate change. The need for better understanding uncertainties in the models used for assessments is acute, and that understanding can be put to immediate use."

Jeff Arnold
Co-Director, Climate and Global Change Programs, U.S. Army Corps of Engineers

More Information

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Mizukami, N., M. Clark, A. Slater, L. Brekke, M. Elsner, J. Arnold, and S. Gangopadhyay. 2013. *Hydrologic Implications of Different Large-Scale Meteorological Model Forcing Datasets in Mountainous Regions.* Journal of Hydrometeorology. In press. DOI:dx.doi.org/10.1175/JHM-D-13-036.1

Rasmussen, R., et al. 2013. *Climate Change Impacts on the Water Balance of the Colorado Headwaters: High-Resolution Regional Climate Model Simulations.* Journal of Hydrometeorology. In review.

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