USGS Award no. G12AP20104 Utilization of Regional Climate Science Programs in Reservoir and Watershed Impact Assessments

Basic Information

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Publication

1. Lei Qiao, Yang Hong, Renee McPherson, Mark Shafer, Sheng Chen, David Williams, David Gade, and Douglas Lilly, 2013, Climate change and hydrological response in the trans-state Oologah Lake watershed - Evaluating dynamically downscaled NARCCAP and statistically downscaled CMIP3 simulations with VIC model, Water Resources Management (in review)

Project Report for "Utilization of Regional Climate Science Programs in Reservoir and Watershed Impact Assessments"
through the Responses to Climate Change Program, U.S. Army Corps of Engineers

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Overview

The funded work sought to efficiently and effectively capitalize on information from federal and university climate science programs for reservoir yield analyses, reservoir water quality models, watershed models, and development of future drought contingency plans. Tasks completed were as follows:

- The University of Oklahoma (OU) collected downscaled climate projection datasets, using a variety of global climate models, regional climate models, and statistical downscaling. Data was extracted at or near the pilot location (Lake Oologah and its watershed).
- OU compared data from the historical runs for each climate model run and statistically downscaled dataset to observations from near Lake Oologah to verify that the corresponding climate projections represent feasible future projections.
- OU benchmarked the Variable Infiltration Capacity (VIC) model with an historical dataset for at least a 10-year period.
- OU input historical and projected gridded climate data into the VIC model and provided output from this model to the USACE for incorporation into their modeling efforts and decision tools. Output included time-series hydrographs for a 50-year planning horizon that could be used for reservoir simulation and yield studies.
- OU provided input to reports that would be disseminated USACE-wide and to other stakeholders through the Water Management and Reservoir Reallocation Studies Planning Center of Expertise by USACE.

One of the intents of this pilot study was to leverage climate-related resources available at the National Weather Center at the University of Oklahoma in Norman, OK. At the time the grant was funded, there was no straightforward mechanism to transfer funds between the U.S. Army Corps of Engineers–Tulsa District and OU. We strove for several months to find a pathway that would minimize administrative costs, including trying to transfer funds to the National Oceanic and Atmospheric Administration (NOAA), then to OU via an existing cooperative agreement that funds the Southern Climate Impacts Planning Program, a NOAA Regional Sciences and Assessments (RISA) program. Unfortunately, NOAA projected a 6-12 month process that involved lawyers at USACE and NOAA to transfer funding between these government entities. Finally, USACE was able to transfer funds via a standing agreement with the U.S. Geological Survey's (USGS) Oklahoma Water Science Center, which had an existing agreement with Oklahoma State University (OSU) for the transfer of funds related to water research (via their Oklahoma Water Resources Research Institute). From OSU, funding could be made available to OU, although additional indirect costs for administering the grant at OSU were taken, reducing the amount available for conducting the science at OU. We recommend that the USACE work with the USGS to allow the transfer of funds for climate-related research to the newly established USGS Climate Science Centers. OU is the host institution (as of March 2012) for the

South Central Climate Science Center and has a cooperative agreement with USGS that should allow for transfer of funds between USACE and OU with minimal additional overhead.

Another intent of this pilot study was to determine if there were additional opportunties for collaborative work, especially as related to future climate challenges faced by USACE. Related work in the Red River Basin has been proposed through the annual science supplemental funding process of the USGS for the Climate Science Centers, and we intend to work with USACE on other studies of interest to them for important basins within the Tulsa District. In all, this project has been successful at establishing dialogue and collaborative research between USACE and the National Weather Center, especially its climate science and climate impacts programs. These opportunities are critical for USACE to access experts in cutting-edge science in the university environments as well as for OU to help serve Oklahoma and the south-central region in actionable science.

Study Results

Simulated historical and projected climate data from the North American Regional Climate Change Assessment Program (NARCCAP) and Bias-Corrected and Spatially Downscaled – Coupled Model Intercomparison Phase 3 (BCSD-CMIP3) forced the hydrologic model. In North America, the North American Regional Climate Change Assessment Program (NARCCAP) is currently the most comprehensive regional climate-modeling project for climate change impact studies [*Mearns et al.* 2009; *Mearns et al.* 2012]. The NARCCAP ensemble comprises a set of regional climate models (RCMs) driven by a set of atmosphere-ocean general circulation models (GCMs) over a domain covering the conterminous United States and most of Canada. The GCMs have been forced with the Special Report on Emissions Scenarios (SRES) A2 scenario for the 21st century; hence, the global average CO_2 is projected to reach 850 ppm by 2100 [*IPCC* 2000]. The RCMs were nested within the GCMs for the period 1971-2000 and for the future period 2041-2070. For comparison of hydrological responses driven by different downscaled climate projections, the bias-corrected and spatially downscaled Coupled Model Intercomparison Phase 3 dataset (BCSD-CMIP3) was also incorporated (using the LLNL-Reclamation-SCU downscaled climate projections data derived from the World Climate Research Program's CMIP3 multi-model dataset that is stored and served at the LLNL Green Data Oasis). This multi-model dataset includes 112 World Climate Research Program CMIP3 members with the CO_2 emission scenarios of A1b, A2, and B1, and each climate projection was bias-corrected and spatially downscaled [*Maurer et al.* 2007; *Wood et al.* 2002]. The A1b and B1 scenarios in BCSD-CMIP3 were not considered for direct comparison with NARCCAP because only the A2 emission scenario is available from NARCCAP.

The VIC model of *Liang et al.* [1994, 1996, and 1999] was implemented for the Oologah Lake watershed (Figure 1). It is a semi-distributed, grid-based hydrological model that simulates land surface-atmosphere hydrometeorological processes with both the water and energy budgets. In our application, version 4.1.2.c was used with three soil layers defined according to the STASTGO dataset. Land use and cover was leveraged from the Land Data Assimilation System project (http://ldas.gsfc.nasa.gov/nldas/NLDASnews.php), originally derived from the University of Maryland's 13-land-cover-type scheme (Figure 1). Upscaling of routing phase parameters (e.g., flow direction) was conducted from the Hydro-1k digital elevation model using an algorithm provided by VIC developing group (http://www.hydro.washington.edu). The VIC model was first driven by atmospheric forcing from the University of Washington's gridded

dataset [*Maurer et al*., 2002]. The model was calibrated with the SP-UCI (shuffled complexes with principal component analysis) algorithm [*Chu et al*. 2010; *Chu et al*. 2011].

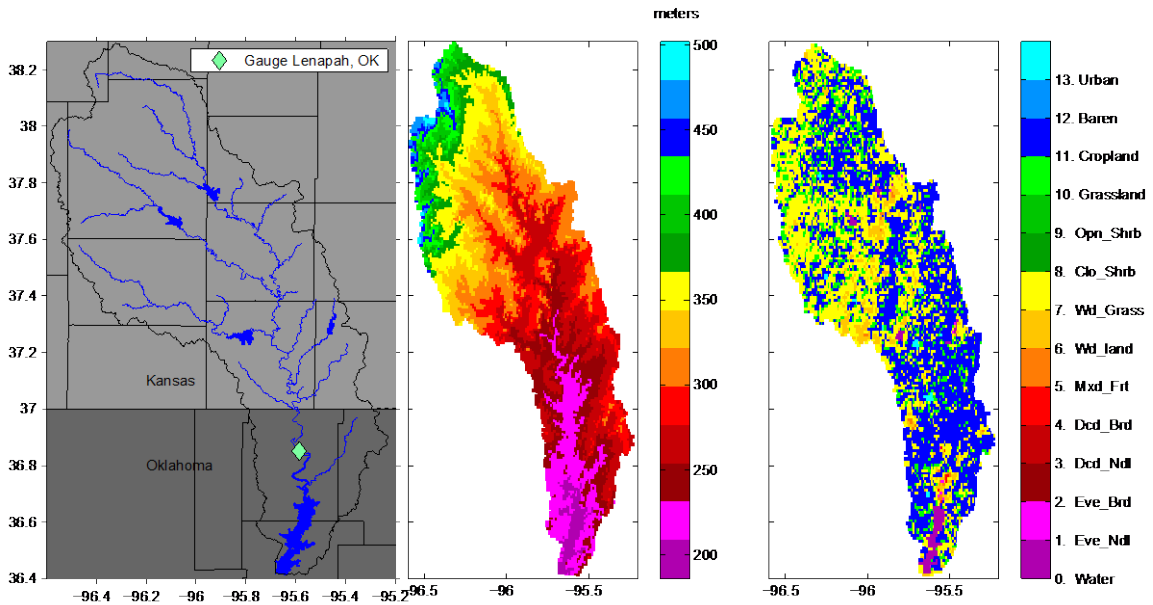

Figure 1. Study area with features of river, lakes, and political boundaries (left), elevation (middle), and land use and cover from the University of Maryland's 13-land-cover-type scheme (right).

Evaluation and comparison of the results shows the following: (1) From the hydrologic point-of-view, the dynamically downscaled NARCCAP projection performed better, most likely in capturing a larger portion of mesoscale-driven convective rainfall than the statistically downscaled CMIP3 projections; hence, the VIC model generated higher seasonal streamflow amplitudes that are closer to observations. (2) Future water availability (precipitation, runoff, and base flow) in the watershed would increase annually by 3-4%, suggested by both NARCCAP and BCSD-CMIP3. Temperature increases (2.5-3°C) are more consistent between the two types of climate projections both seasonally and annually. However, NARCCAP suggested 2-3 times higher seasonal variability of precipitation and other water fluxes than the BCSD-CMIP3 models. (3) The hydrologic performance could be used as a potential metric to comparatively differentiate climate models, since the land surface and atmosphere processes are considered integrally.

Detailed results of the study are provided in the companion journal article, submitted to Water Resources Research in March 2013 by Lei Qiao, Yang Hong, Renee McPherson, Mark Shafer, Sheng Chen, David Williams, David Gade, and Douglas Lilly.

Financial Update

As of April 15, 2013, the following expenses were incurred:

Item	Budgeted	Actual Expenses
PI and Co-PI salaries	$4,796	$XXX
Post-doctoral associate salary	$18,000	$20,000
Fringe benefits	$6,104	$XXX
University of Oklahoma indirect costs	$14,450	$XXX
Oklahoma State indirect costs	$10,515	$10,515

Expenses for Oklahoma State University were solely a result of the inability to transfer funding directly from the U.S. Army Corps of Engineers–Tulsa District to the University of Oklahoma.

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