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Managing Water Resources Development in a Changing Climate
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Tuesday, May 5
3:30 PM – 5:00 PM
Session 22: Addressing Uncertainty with Models IV

1. Survey of NOAA Downscaling Approaches and Applications – Lynn E. Johnson, University of Colorado Denver, Superior, CO (co-author: Timothy Schneider)

The topic of downscaling has been a focus for NOAA research and development in order to make maximum use of global climate and other large area model outputs. Global climate models (GCMs) are run at coarse spatial resolution (typically of the order 50,000 km^2) and are unable to resolve important sub-grid scale features such as clouds and topography. As a result it is problematic to use GCM outputs for local impact studies. Similar motivations arise for downscaling numerical weather forecasts generated by medium range forecast (MRF) models. To overcome these problems downscaling methods are developed to obtain local-scale surface weather from regional-scale atmospheric variables that are provided by the large area models. This paper presents results of a survey of the downscaling approaches used by various NOAA operations and research programs. The methods are categorized per the primary approach (e.g. statistical, dynamical) and summarized to explain the approach and domain of application. Guidelines are posited to assist readers in selecting an appropriate downscaling approach for their application.

2. An Automated Statistical Downscaling Approach for Hydrologically-Based Climate-Change Studies Across the Nation - Christian Ward-Garrison, U.S. Geological Survey, Lakewood, CO (co-authors: Lauren E. Hay, Steven L. Markstrom)

The U.S. Geological Survey Global Change study "An integrated watershed scale response to climate change in selected basins across the United States" was initiated in 2008. The long term goal of this study is to provide the foundation for hydrologically-based climate-change studies across the nation. Fourteen basins which have been modeled, calibrated, and evaluated using the Precipitation Runoff Modeling System (PRMS) were selected as study sites and automated procedures were developed to generate ensembles of climate change scenarios from General Circulation Models (GCMs). GCMs are numerical models that simulate predominant large-scale climatic features. The spatial resolution of GCMs is too coarse for direct application in studies examining the hydrological response to climate change. Thus, a method was developed to downscale data from the coarse resolution produced by GCMs to the finer resolution required by PRMS. Monthly precipitation and temperature simulations from six GCMs were obtained from the World Climate Research Programme's Coupled Model Intercomparison Project phase 3 multi-model dataset archive, which was referenced in the Intergovernmental Panel on Climate Change Fourth Assessment Special Report on Emission Scenarios. For each GCM, one current and three future scenarios were selected. Climate change fields were derived by calculating the change in climate from current to future conditions simulated by each GCM. Climate change scenarios were generated for PRMS by modifying PRMS precipitation and temperature inputs with the mean monthly climate change fields derived from the GCMs. The main advantage of this downscaling method is that it is simple and easy to automate. However, the method is not sensitive to possible changes in daily extremes or the frequency of wet days. For this study, downscaling of mean climate was the primary objective and therefore the downscaling procedure is adequate. The simple statistical downscaling procedure was automated for this study. This procedure provides a consistent approach for hydrologically-based climate-change studies across the nation.

3. Coupled Surface-Water/Ground-Water Model Response to Climate and Land-Use Change: Black Earth Creek, Wisconsin - Stephen Westenbroek, U.S. Geological Survey, Middleton, WI (co-authors: Randall J. Hunt, Lauren E. Hay, Steve L. Markstrom)

Black Earth Creek in southern Wisconsin is a popular recreation area recognized for its cold, clear waters that support a much-valued trout fishery. Located in a rapidly urbanizing part of Dane County, Black Earth Creek is one of 17 sites included in a recent U.S. Geological Survey project that examines integrated watershed-scale response to climate change. In this work we examine the potential impact of various climate and land-use change scenarios on surface water and ground water resources in the Black Earth

Creek Basin. For Black Earth Creek, hydrologic models were developed using both the Precipitation-Runoff Modeling System (PRMS) and Ground-Water/Surface-Water Flow (GSFLOW) frameworks. A combination of six general circulation models (GCMs) and four carbon-dioxide emissions scenarios were used to develop an ensemble of climate change scenarios; the scenarios were used as input to PRMS and GSFLOW by applying mean monthly climate change fields to historical precipitation and temperature time series data. Results of this work suggest that in the future we will experience earlier snowmelt and groundwater recharge events, as well as significant alterations in environmental-flow components of stream flow. In addition, this work demonstrates a case where a fully-coupled surface-water/ground-water model such as GSFLOW is required in order to accurately simulate groundwater dynamics, stream low-flow characteristics, and streamflow/high-capacity pumping relations.

4. Development of a Distributed Hydrological Model for Accurate Estimation of Watershed Response - Kun-Yeun Han, Kyungpook National University, Daegu, DG, South Korea (co-authors: Gwangseob Kim, Keuksoo Kim)

The regional impact of climatic change has caused more frequent several storms in Korea. The tendency of spatial and temporal variability of heavy storms can be summarized that rainfall intensity increases and storms become more localized events. Therefore the necessity of advances in the rainfall observation system and an advanced rainfall-runoff model has increased. The development of remote sensing technology of rainfall using weather radars allows us to obtain rainfall data which have more accurate spatial variability information. Also we have fine resolution surface information such as DEM, land use, soil type etc. Those available data turn the distributed hydrological modeling feasible for more accurate estimation of extreme watershed responses. This study aims to develop a distributed rainfall-runoff model using the multi-directional flow allocation algorithm and the real-time updating algorithm in order to perform the accurate and efficient rainfall-runoff modeling. It includes the improvement of the problems related to the selection of resolution in distributed model by designing multi-directional flow allocation algorithm and making a better solution for the problems related to calibration of model parameters through developing real-time updating algorithm. Multi-directional flow allocation algorithm transforms the single-directional flow to multi-direction flow, reflecting detailed flow information on the single-directional low resolution flow. Applying this algorithm to the distributed rainfall-runoff modeling, the total simulation time is expected to be reduced with more accuracy of the flow routing. The real-time updating algorithm calculate recursively the distributed cell's depths in the basin by using the ratio between the calculated(a priori) discharge and the observed discharge. Applying this algorithm, the accuracy of the model will improve. In order to evaluate suggested model in this study, it was applied to experimental data and real world basins. The performance of used methods was evaluated by applying to real watersheds, which include Andong and Namgang dam basin. From these results, the ability of predicting runoff and required simulation time of model were improved. Also, the prediction of model has become more accurate by the application of real-time updating algorithm to the Andong and Namgang dam basins.