# American Water Resources Association
# 2009 SPRING SPECIALTY CONFERENCE
# *Managing Water Resources Development in a Changing Climate*
## May 4-6, 2009
### Anchorage, AK

## Tuesday, May 5
## 1:30 PM – 3:00 PM
## Session 18: Addressing Uncertainty with Models III

**1. Climate Change Adaptation of Stormwater Management Systems Charging Water Supplies - Latham Stack**, Syntectic International, Portland, OR (co-authors: Michael Simpson, Thomas Crosslin, Derek Sowers, Colin Lawson)

Numerous studies have detected intensification of precipitation events consistent with climate change projections, as reported in the Fourth Assessment Report (AR4) of the International Panel on Climate Change. Communities may have a window of opportunity to prepare water resources infrastructures. However, information sufficiently reliable and specific to support local-scale adaptation programs is sparse: published literature is typically characterized by general capacity building or regional vulnerability assessments. The AR4 observed that adaptation can no longer be postponed pending perfect science, i.e. the effective elimination of uncertainty in coupled-climate model output and subsequent downscaling. Rather, methods must be developed that manage residual uncertainty in current-generation output and methods, providing community leaders with sufficient knowledge to enable the preparation and implementation of infrastructure adaptation plans. We report results of two studies that promote stakeholder-driven adaptation of vulnerable stormwater management systems that charge drinking water supplies. These studies demonstrate the implementation of a quantified, local-scale, and actionable protocol for maintaining historical risk levels for communities facing significant impacts from climate change and population growth. The study projects transferred coupled-climate model projections to existing stormwater infrastructure, in a form understandable to planners, resource managers and decision-makers. The projects modeled the capacities required for the infrastructure to convey peak flows from projected mid-21st century climate-changed precipitation and population growth, and the potential for Low Impact Development methods to provide more economical management of peak flows than drainage system upsizing. Utilizing model results, stakeholders developed recommendations for culvert improvements based on risk, cost, and infrastructure lifespan considerations. These studies posit a solution to arguably today's most significant challenge in civil infrastructure adaptation: translating the extensive corpus of adaptation policy theory and regional-scale impacts analyses into local-scale action.

**2. Weather Modification and Climate Variability Impacts on Streamflow - Haroon Stephen**, University of Nevada Las Vegas, Las Vegas, NV (co-authors: Cody Moser, Oubeid Aziz, Glenn Tootle)

The future challenges to provide water in the western U.S. are compounded by projections of continued population growth and forecasts of increased temperatures (climate change). The Intergovernmental Panel on Climatic Change (IPCC) noted the general pattern (trend) of drier conditions in the mid-latitudes (IPCC, 2007) and the consensus of these studies is increased temperatures will result in decreased streamflow. This is primarily attributed to precipitation occurring in the form of rainfall instead of snowfall and, in the western U.S., snowfall accounts for approximately 50 to 70% of total precipitation (Clark, et al., 2001). In a recent (June 16, 2008, Volume 453, Pages 957-958) editorial in Nature entitled "Change in the weather," it is stated that "a renewed push for scientific research into weather-modification technologies is long overdue." The editorial continues with "Today's rain-makers struggle with their own credibility issues. There has yet to be the definitive experiment that settles exactly how well cloud seeding… works (or not)." The editorial concludes with "Other countries, such as the United States, have simply given up; the most promising experiment in America is run not by the federal government but by the state of Wyoming, which is spending nearly U.S. $9 million on a five-year series of cloud-seeding experiments evaluated by experts from the National Center for Atmospheric Research (NCAR). That's the type of targeted and rigorous study that needs to be done in weather modification, but it took Wyoming to do it." A macroscale hydrological model (e.g., Variable Infiltration Capacity or VIC model) will be utilized to evaluate the impacts of weather modification on water resources, specifically snowpack and the resulting runoff (streamflow). The proposed research will incorporate NCAR's estimates of increased snowpack due to weather modification in target areas of the North Platte River Basin. Spatial and temporal uncertainty in snowpack (as a result of weather modification) and the resulting impacts on water supply will be examined. The proposed research addresses relevant and current issues such as: Does weather modification provide an adaptive tool, given climate change, to provide additional water availability and assist in drought management?

**3. Monthly Precipitation Prediction Using Cyclostationary EOF and an AR model - Gwangseob Kim**, Kyungpook National University, Daegu, South Korea (co-authors: Ming Dong Sun, Kun Yeun Han)

Precipitation time series is a mixture of complicate fluctuation and changes. In this study, the spatial and temporal variability of monthly precipitation was analyzed using eigen techniques and monthly precipitation prediction was conducted using eigen information and an autoregressive (AR) model. First of all, the variability of precipitation in Korea was investigated using EOF (empirical orthogonal function) and CSEOF (cyclostationary EOF) analysis and monthly precipitation data of 62 nationwide stations during 34 years (1973-2006). The main motivation for employing eigen techniques in this study is to investigate the dominant physical modes associated with the spatial and temporal variation of the precipitation from observation data. The twenty-five leading EOF modes account for 98.1% of the total monthly variance, the first mode exhibits traditional spatial pattern with annual cycle of corresponding PC time series and second mode shows strong North South gradient. First two modes account for 83.8% of total variation. In CSEOF analysis, the twenty-two leading CSEOF modes account for 98.2% of the total monthly variance, the first two patterns' spatial distribution show monthly spatial variation. The corresponding mode's PC time series reveals the annual and long-term fluctuation and first mode's PC time series shows increasing linear trend which represents that spatial and temporal variability of first mode pattern has strengthened. First two modes account for 79% of total variation. Compared with the EOFs analysis, the CSEOFs analysis preferably exhibits the spatial distribution and temporal evolution characteristics and variability of Korean historical precipitation. A moving autoregressive (AR) model with the eigen information from the CSEOF analysis is used to produce the forecasts of the twenty-two CSEOF principal components' time series. Through reversion process of CSEOFs, predictions of precipitation are obtained and verified by comparing them with the observation data. Results show improved performance in monthly precipitation prediction which is essential for optimal water resources planning and management.

**4. Adapting water management programs to climate change at the Toronto and Region Conservation Authority - Ryan Ness**, Toronto and Region Conservation Authority, Downsview, ON, Canada (co-author: Don Haley)

The Toronto and Region Conservation Authority (TRCA) is a watershed-based natural and water resources management agency that serves the City of Toronto and surrounding areas in Ontario, Canada. The TRCA, like other Conservation Authorities in Ontario, is responsible for water resources management initiatives such as watershed planning, stormwater management, flood control, flood forecasting and warning, and source water protection. The TRCA formally identified climate change as a potential significant impact to its operations as early as the mid-1990's, with particular concern regarding the future effectiveness of water resources management programs in protecting public safety, infrastructure and local ecosystems. As a result, the Authority has been investigating approaches to adapting the management of water resources to a potentially changing climate. This paper will elaborate on TRCA activities related to assessing the potential impacts of climate change on the Toronto area and to integrating climate change considerations into water resources management programs. Specific initiatives presented include a regional analysis of historic precipitation trends, efforts to connect future climate projections to potential local changes in the hydrologic regime, climate change scenario modelling in watershed planning, and updates to rainfall IDF analysis procedures to account for non-stationary climate. The challenges and uncertainties in utilizing the types of climate change projections currently available to assess impacts at local and watershed scales are also discussed.