INTEGRATED PLANNING

The Challenging Climate of Water Supply and Stormwater Design

HDR's Meteorologists Provide a Bridge

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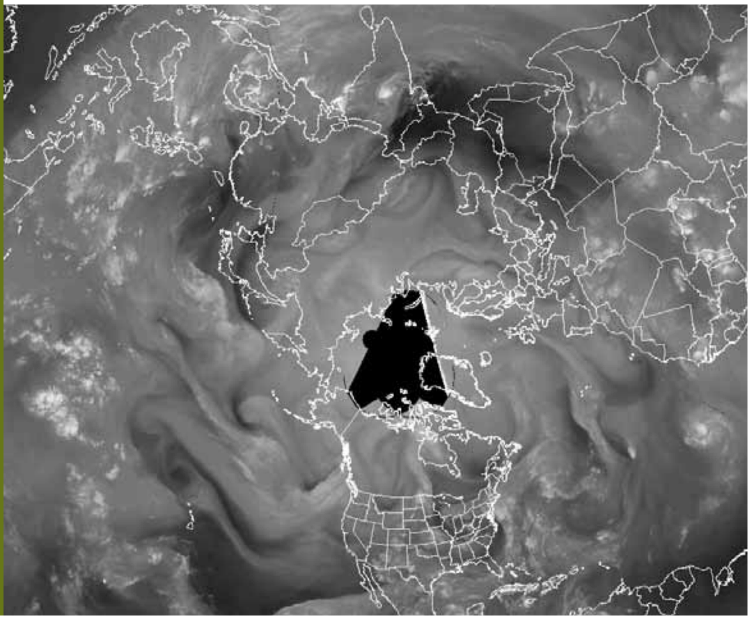

Water vapor channel-based satellite image of Northern Hemisphere cloud systems (9-8-09).

Over the past five years climate change has steadily gained a place in the minds of water planners and operators. First, planners and designers were told that "stationary climate" – the practice of using 20-30 years of data to define local climate – is dead.

Then, in rapid succession, the results of global circulation models (GCM) were used to present a future of dire water shortages due to drought and increasing temperatures, more intense and large precipitation events and a future rise in sea level that threatens many key coastal areas.

For most water systems and basins, the "on/in the ground" component is all that is examined. However, when looking at the full hydrologic cycle, a majority of the water that ultimately becomes available starts as rain or snow. This means the impacts of climate change will play an integral role in most water activities and plans.

HDR's Atmospheric Science Group has the expertise of trained, educated professionals who understand the atmospheric component of the hydrologic cycle and have worked on a variety of water-related projects for HDR clients for nearly a decade.

The HDR Climate Change and Atmospheric Tool box

HDR's Atmospheric Science Group has developed a series of analysis tools to assist in developing potential scenarios of climate change impacts to HDR's water resources, water supply, energy and planning projects. Most of these tools and the related analysis processes have been developed during projects over the past five years, and several are just in the stage of being completed. Several of these state-of-the-art tools are highlighted below.

Hydro-Climate Indices/Water Supply Prediction tools (Clim-WaS and Clim-Cast): This tool is used to define the relationship between hydro-climate indices (Multi-Variate ENSO Index, Pacific Decadal Oscillation, North Atlantic Oscillation, etc.) and basin precipitation and runoff. The tool is used to develop statistical relationships and produce a cyclical/trend analysis to develop water supply projections of periods of flood, drought and water year runoff.

This tool has been used for the Colorado River Water Conservation District Hydro-Climate Runoff Project; the Flathead Reservoir Drought Management Plan; the Colorado Water Conservation Board Water Availability Task Force Project 2000-2007; and recently, the Salina River/Salina Water Supply Projection Study.

The tool and process can be used to develop historical relationships and provide water supply projections for 20- to 50-year periods. In 2002 this tool was used to prepare a 50-year precipitation outlook for the eight Colorado major river basins as a percent of decadal precipitation.

Urban Heat Island Tool (UH-IT): HDR prepared a preliminary analysis of the Denver urban heat island's growth over the period of 1969-2005 for the Colorado Water Conservation Board to help estimate potential impacts of the heat island on precipitation patterns in the Denver metro area and associated water needs. The tool relies on defining changes in daytime and nighttime temperatures (highs, lows, period of hours above or below a threshold value) for a series of weather stations in metropolitan areas. The tool can be expanded to include precipitation, wind cloudiness, relative humidity and wind distributions analyses. The results are shown in a Geographic Information System (GIS).

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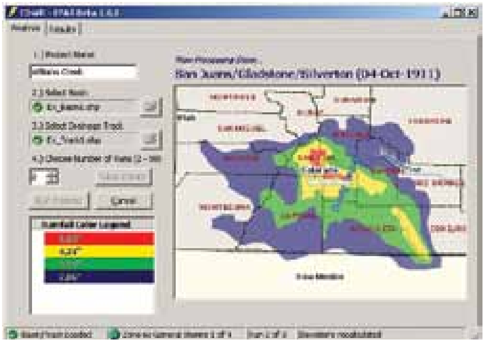
Hydro-climate and Atmosphere Indexed Runoff Prediction (HARP): The HDR Atmospheric Sciences Group has developed a hydro-climate and atmosphere indexed runoff prediction tool called HARP that focuses on the management of uncertainty and risk. Using the HARP tool allows us to address the issue of predicting the potential runoff, and the timing of peak and runoff volume in a given basin for both water year forecasting as early as October, and for flow predictions required to formulate an annual operation plan. Output from this tool yields not only forecast values, but, for each forecast value, confidence ranges are reported. This water supply prediction tool adds a realistic dynamic component to a classic stochastic (probabilistic) model.

The Extreme Precipitation Analyses Tool (EPAT): The EPAT is a GIS-based developed software that provides an automated objective application of accepted Probable Maximum Precipitation (PMP) analysis techniques to a specific basin, based on analyses of state-approved extreme precipitation event climatology. The application works by inputting a basin into the software in shapefile format. The software then runs a number of calculations using stored historical storms over that basin based on location and elevation of the basin.

In the end, the application determines the controlling storm that creates the greatest amount of volume due to the elevation change and spatial extent of the storm in the basin. The EPAT essentially takes the guess work out of basin-specific PMP and creates reproducible results. The output of the EPAT gives the user the watershed peak rainfall amounts, total volumes and temporal distributions for both local storms and general storms. It also allows the user to save the controlling storms in shape-file format. This tool is the Best Practice for PMP calculation in Colorado and New Mexico.



Sample output screen of the Extreme Precipitation Analysis Tool (EPAT), developed by HDR, during processing.

Atmospheric Sciences Group meteorologists currently are completing tools that create Depth-Area-Duration (D-A-D) tables, frequency-spatial distributions and temporal distributions of design storms for floodplain delineation and stormwater design based on WSR-88D Doppler radar data that incorporate climate change uncertainty for storms between two and 500 years.

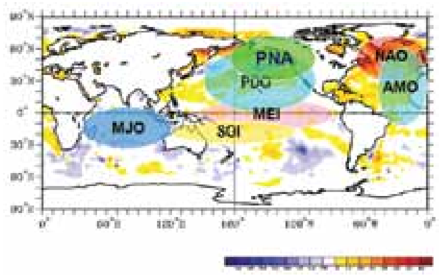
These tools make use of the IPCC Global Circulation Model global and regional projections of temperature and precipitation for use in infrastructure planning for periods of 20 to100 years. However, the tool also benefits from stable, long-term projections of climate variability to reduce climate uncertainty. It is being developed in concert with atmospheric scientists at the Research Applications Laboratory of the National Center for Atmospheric Research.

Studying the Past to Predict the Future

Analysis of historic climate indices and patterns shows the coincident development of these two climate regimes about every 12 to 20 years with dramatic impact. Following this predictable pattern, the summer drought in the Southeast increased in severity as moist south winds off the Gulf of Mexico steered into the Great Plains and Midwest, leaving the Southeast high and dry. The moist sub-tropical air pooled in the Midwest until it was lifted by the La Nina-induced northern storm track into lines of flood-producing thunderstorms. The La Nina also acted to weaken the Southwestern monsoon and interacted with the NAO pattern to weaken Atlantic hurricane tracks.

HDR's Atmospheric Sciences Group can help clients understand how summer floods in the Midwest, drought in the Southeast and fierce Southern California fires are interrelated parts of a climate pattern. Providing evidence of natural climate variability is perhaps not as enticing as blaming wild weather on global warming, but, when backed by solid science, this data can arm clients with valuable tools to allocate resources and priorities.

For the past five years, the Atmospheric Sciences Group has worked to identify and develop prediction tools, including reliable forecast techniques being used to predict water supply in major river systems of Montana and Colorado.



Map with generalized locations of various climate indices measured across the world.

In Montana, these techniques have been embraced as critical inputs to a successful drought management plan for the Flathead Lake reservoir on the upper Columbia River system.

The Bureau of Reclamation and the U.S. Army Corps of Engineers have evaluated and accepted (in modified form) the techniques developed by HDR scientists for use in water supply predictions. In Colorado, hydro-climate index techniques were enhanced to produce basin-specific water supply forecasts for snow water equivalent and volumetric runoff forecasts for the Colorado, Gunnison, Arkansas, South Platte and Rio Grande river systems.

Real World Impacts

While developing a design storm for Colorado's South Boulder Creek floodplain delineation study, HDR meteorologists evaluated

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waterscapes

Waterscapes is a technical publication produced and distributed by HDR. Address changes and correspondence should be sent to the attention of:

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September 2009

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Water-Energy Nexus

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HDR projects also reflect experience with water quality analysis and design solutions based on operational constraints in compliance with discharge regulations, such as National Pollutant Discharge Elimination System or the Clean Water Act, Section 316(a). Water supply availability analyses may also include treated and reclaimed wastewater, brackish water or remediation project water, which may require additional treatment for specific uses.

It is evident that the power sector will continue to draw upon water as a resource in energy production. Meeting energy needs in high growth areas with limited supplies will require innovative and sustainable solutions and integrated management of water and energy resources. Development of new approaches to managing water supplies and energy needs are critical, as limitations due to droughts, population growth, competing water use interests, public pressures, water rights and regulatory mandates affect supply. Future climate uncertainty and resulting impacts on water resources further exaggerate the need for efficient management of these resources.

The following individuals assisted in writing the HDR research document entitled "Energy and Water" that was used as a basis for this article: Brooke Garcia, Adam Kessler and Seth Turner.

Climate Challenges

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climate impacts on design criteria. As a result, they found that the quantitative values of the 100-year storm changed more than 20 percent in the past 30 years. They also used weather surveillance radar WSR-88D Doppler data to provide observed spatial and temporal distributions for a 100-year design storm that had previously been synthetically estimated for design.

Another impact of climate on design was detected during calculations of PMP for a Colorado dam safety project. To counter the use of outdated and general hydro-meteorological report procedures, Atmospheric Sciences Group team members developed an objective GIS-based EPAT to provide a basin-specific PMP calculation for the Colorado Division of Water Resources. The EPAT is now a Colorado standard of practice that incorporates an updated storm library and state-of-practice analysis techniques that reflect climate change.