# NATIONAL WATER RESOURCES OUTLOOK

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#### ABSTRACT

The National Weather Service (NWS) is developing a national Water Resources Outlook (WRO) based on the NWS River Forecast System (NWSRFS) Ensemble Streamflow Prediction (ESP) system. ESP has been in use since the 1980s and used in the Western Region of the NWS to assist in water supply forecasts. With the creation of the Advanced Hydrologic Prediction Service (AHPS), River Forecast Centers (RFCs) have been issuing 30- to 90-day probabilistic hydrologic forecasts for river forecast points using the NWSRFS ESP system for about a decade now. However, there has been no national product with the capability to view streamflow forecasts to this point.

In 2005, the Ohio River Forecast Center (OHRFC) developed a WRO based on U.S. Geological Survey (USGS) observed streamflow percentile categories. In 2008, the WRO became an operational NWS product, available from www.weather.gov/ohrfc/WRO.shtml. The WRO uses current soil moisture states from the Sacramento Soil Moisture Accounting (SAC-SMA) model and short-range quantitative precipitation forecasts (QPF) from the National Center for Environmental Prediction's (NCEP) Hydrometeorological Prediction Center (HPC), the Climate Prediction Center's (CPC) 6- to 10-day, 30day and 90-day temperature and precipitation outlooks, and the day 1 to 7 temperature departures from normal, which are derived from the National Digital Forecast Database (NDFD).

Climate forecasts are now being integrated into the Water Resources Outlook at OHRFC. By using CPC forecasts, the OHRFC ESP forecasts are able to modify the historical data (normal conditions) and adjust to above or below normal categories to better reflect the current climate forecasts on a monthly to seasonal time-scale.

In 2008, the NWS Western Region (WR) began developing a WRO based on percent of normal flows for the coming months. In late 2008, the OHRFC and WR methods were merged into a national format that is being expanded across NWS RFCs. It is using Google GIS graphics combined with NWS forecast data for one to three months into the future. This merging of methods into a national product is being done based on a growing demand and positive feedback from customers at the federal, state, local website and private sectors. The is http://wateroutlook.nwrfc.noaa.gov. The goal of this national WRO is to provide a continuous water watch for future forecasts for customers in decision making processes. It allows the customers to drill down into climate hydrologic forecasts. Upgrades and expansion of this product are expected in 2010 and beyond.

## **1.0 INTRODUCTION**

There is a growing need for a continuous water watch from the weather-scale (1-7 day period) to the climate-scale (monthly to seasonal) timeframe. As population and water use increases water managers are relying more upon monthly and seasonal streamflow forecasts for planning and operations. Water managers are expecting high quality forecasts with greater lead-time. In addition, water managers and hydrologic partners expect these outlooks during peak floods, drought seasons and at all times to increase lead-times for their response.

The National Weather Service is moving toward a national Water Resources Outlook based on the Ensemble Streamflow Prediction system (Day, 1985). ESP has been in use since the 1980s and has been used in the Western Region of the NWS for years to assist in water supply forecasts (Brandon 1998). With the implementation of the Advanced Hydrologic Prediction Service (AHPS), River Forecast Centers (RFC's) have been issuing 30- to 90-day probabilistic hydrologic forecasts for river forecast points using the NWS River Forecast System (NWSRFS) (National Weather Service, 1972) ESP system for about a decade now. However, there has been no national NWS product that depicts extended streamflow forecasts, which are expected to change in the coming months, similar to what the USGS presents for real-time data (Fig. 1).

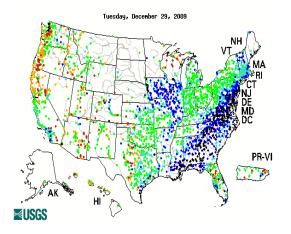


Fig. 1: USGS 28-day Average Streamflows

In 2005, the Ohio River Forecast Center (OHRFC) developed a WRO based on USGS observed streamflow percentile categories. In 2008, it became an operational product of the NWS (Fig. 2).

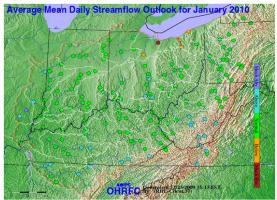


Fig. 2: Ohio River Forecast Center Monthly Water Resources Outlook

## 2.0 MODELS

The OHRFC uses the ESP component of NWSRFS to make monthly to seasonal forecast predictions. ESP model runs are initialized from current soil moisture states of the Sacramento Soil Moisture Accounting Model (SAC-SMA). In addition, the OHRFC WRO uses short-term quantitative precipitation forecasts (QPF) from National Center Environmental the for Prediction's (NCEP) Hydrometeorological Prediction Center (HPC) out to five-days, the Climate Prediction Center's (CPC) 6- to 10-day, 30-day and 90-day temperature and precipitation outlooks (Noel 2008). Finally, the OHRFC WRO uses the day 1 to 7 temperature departures from normal, which are derived from the National Digital Forecast Database (NDFD) (Fig. 3).

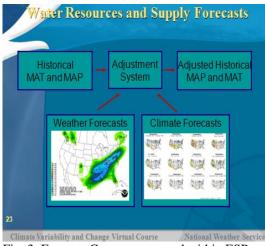


Fig. 3: Forecast Components used within ESP

# 3.0 NWS ENSEMBLE STREAMFLOW PREDICTION

NWSRFS allows forecasters to produce streamflow forecasts on timescales from hours to years. There are three main components to NWSRFS; the operational forecasting system (OFS), the calibration system, and the ensemble streamflow prediction system. All components are related through calibration to maintain compatibility between observed conditions and streamflow prediction. ESP is the component within NWSRFS that allows for ensemble streamflow prediction and probabilistic forecasting (Day 1985; Brandon 2005) (Fig. 4).

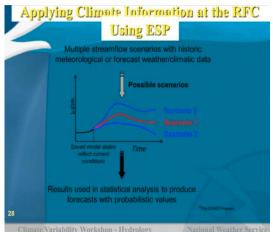


Fig. 4: Ensemble Streamflow Prediction within NWSRFS

ESP creates a historical simulation (HS) by making one continuous hydrologic simulation using the available historical precipitation and temperature records from the beginning of the period of record. A conditional simulation (CS) is created by treating each year of historical meteorological data for temperature and precipitation as a possible future outcome. By analyzing the simulated streamflow traces generated from the historical data, probabilistic information can be generated, including, for instance, the likelihood of not exceeding the 7day, 10-year low flow. A historical simulation when analyzed over a fixed period, May through June, for instance, will yield what could be thought of as "normal" conditions within that period. This can be done for any long range outlook.

Techniques are used that incorporate future temperature and precipitation forecasts. The OHRFC Water Resources Outlook uses the NOAA/Climate Prediction Center preadjustment technique. Historical mean-areal precipitation (MAP) and temperature (MAT)

time series are adjusted relative to the latest weather forecasts and climate outlooks. These adjusted MAP and MAT time-series are then run through ESP to generate streamflow traces based on the inputs. This is the conditional simulation used in the OHRFC WRO. The deviation between the historical simulation and the conditional simulation on the NWS's AHPS page is shown by the different traces where HS is the historical simulation and CS is the conditional simulation (Fig. 5). In Figure 4, the historical simulation (in blue) used at OHRFC is for about 50 years of data from 1950-2000. The conditional simulation, in black, uses the latest soil moisture states and short-range meteorological temperatures and rainfall forecasts and the one- to three- month temperatures and precipitation outlooks. In this example, the conditional simulation with CPC outlooks calls for an above normal likelihood for flooding compared to the historical simulation.

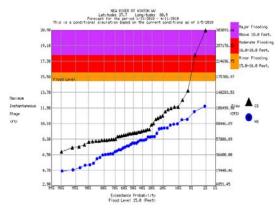


Fig. 5: ESP 90-day Historical (blue) and Conditional (black) Simulations

# 4.0 NATIONAL WATER RESOURCES OUTLOOK

The OHRFC began working with the NWS Western Region (WR) in 2007 to merge the OHRFC WRO with the WR water supply forecast efforts. In 2008 the NWS WR began developing a WRO based on percent of normal flows for the coming months. By late 2008, the OHRFC and WR methods were merged into an experimental national format that is being expanded across NWS RFCs. Since all NWS River Forecast Centers (RFCs) run ESP for monthly to seasonal forecasts, the concept of a national WRO was a logical next step. The process requires good calibrations of the SAC-SMA model and output from the historical and conditional simulations in order for the percent of normal flow to be generated. The WR WRO combines Google GIS graphics with NWS forecast data to present one to three month forecasts into the future. Merging of the OHRFC and WR methods into a national product is fueled by a growing need from many customers at the federal, state, local and private sector levels. The experimental website is located at http://wateroutlook.nwrfc.noaa.gov (Fig. 6).

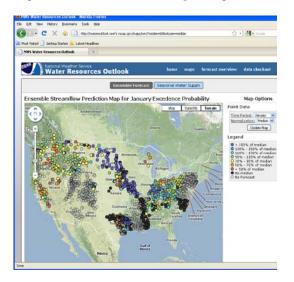


Fig. 6: Experimental National Water Resources Outlook Website

The NWS is working through a formal process to move the WRO product from experimental to operational. A transition to the Community Hydrologic Prediction System, Flood Early Warning System (CHPS-FEWS) and the Hydrologic Ensemble Forecasting System (HEFS) (Schaake 2005) is under way with modernization of the hydrologic forecasting system used by RFCs. The experimental national WRO should continue during and after this transition.

Finally, the NWS is moving toward an Integrated Water Resources Science and Services (IWRSS) (http://www.nws.noaa.gov/oh/docs/IWRSS\_1p\_s ummary.pdf) in the future and will partner with other federal agencies and partners. IWRSS will include point based water resource information and gridded hydrologic information. The experimental national WRO may serve as one component of IWRSS in some form.

### **5.0 SUMMARY**

OHRFC began developing a WRO in 2005 to better serve hydrologic customers and partners for seasonal hydrologic outlooks. In 2008, OHRFC partnered with NWS WR to develop an experimental national WRO. The goal of the national WRO is to provide a continuous water watch for customer's use in the decision making processes. The experimental national Water Resources Outlook allows customers to drill down to point ensemble hydrologic forecasts . Upgrades and expansion of this product is expected in 2010 and beyond. Finally, NOAA/NWS is working toward moving this project from experimental to operational and this project may also blend into a part of the IWRSS project which is a long-term vision of the NOAA/NWS.

### 6.0 REFERENCES

Brandon, D. G. 1998. "Forecasting streamflow in the Colorado and Great Basins using El Nino indices as predictors in a statistical water supply forecast system. Winter 97/98: Year of the Great El Nino. Floodplain Management Association, San Diego, Ca.

Burnash, R.J.C. 1995. "The NWS River Forecast System - Catchment modeling," *Computer Models of Watershed Hydrology*, Singh, V.P., ed., 311-366.

Brandon, D.G. 2005. "Using NWSRFS ESP for making early outlooks of seasonal runoff volumes into Lake Powell." AMS Annual Meeting 2005. AMS Forum: Living with a Limited Water Supply.

Day, G.N., 1985: Extended streamflow forecasting using NWSRFS. J. Water. Res. Plann. And Management, **111**, 157-170.

Noel, J.J. 2008. "National Water Resources Outlook." *Climate Prediction Application Science Workshop. Norman, OK.* 

National Weather Service, 1972: National Weather Service River Forecast System river forecast procedures. *Hydrologic Research Laboratory, U.S. National Weather Service, NOAA Tech. Memo.* NWS HYDRO-14, 251 pp.

Schaake, J.C. 2005. "Hydrological ensemble prediction experiment." AMS Annual Meeting

2005. AMS Forum: Living with a Limited Water Supply.