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Operational Interactive Hydrologic Forecasting with the National Weather Service River Forecast System

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Abstract

The National Weather Service River Forecast System (NWSRFS) consists of several major hydrometeorologic subcomponents to model the physics of the flow of water through the hydrologic cycle. The entire NWSRFS runs in both mainframe and minicomputer environments, using command oriented text input to control the system computations.

As computationally powerful and graphically sophisticated scientific workstations became available, the National Weather Service (NWS) recognized that a graphically based, interactive environment would enhance the accuracy and timeliness of NWS river and flood forecasts. Consequently, the operational forecasting portion of the NWSRFS has been ported to run under a UNIX operating system, with X-windows as the display environment on a system of networked scientific workstations. In addition, the NWSRFS Interactive Forecast Program was developed to provide a graphical user interface to allow the forecaster to control NWSRFS program flow and to make adjustments to forecasts as necessary.

Introduction

The mission of the National Weather Service (NWS) includes providing river and flood forecasts and warnings for protection of life and property, and providing basic hydrologic forecast information for environmental and economic well being. The NWS Office of Hydrology (OH) supports this mission through its physically-based hydrologic forecasting system - the National Weather Service River Forecast System (NWSRFS). This system is

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used to provide operational river and flood forecasts at over 3000 locations throughout the U.S. on a daily basis.

River forecasts for the U.S. are generated at the 13 NWS River Forecast Centers (RFC). The areas of responsibility for 12 of the RFCs covers the conterminous U.S. and the thirteenth RFC is responsible for the state of Alaska.

NWSRFS

The development of NWSRFS began in the early 1970's to (1) meet the forecasting needs of all RFCs, (2) be supported and documented at the National level, and (3) have enhancements and software configuration management coordinated by OH. One of the initial goals was to design a system which included existing techniques from many of the RFCs so that a single system could be used for river forecasting throughout the U.S.

NWSRFS is currently in its fifth major release (Version 5.0). Its system structure was designed to look toward the future of hydrometeorologic forecasting. The functional requirements which guided the design of NWSRFS Version 5 were to:

1. allow for a variety of models and procedures,
2. let the user control selection of models and sequence of use,
3. easily add new models and procedures to keep up with technological changes,
4. efficiently process large amounts of data to produce forecasts at hundreds of locations for each RFC, and
5. allow the user to flexibly control real-time processing.

Details of the design and development of NWSRFS Version 5 can be found in Smith and Page (1993).

The modular design of NWSRFS has allowed it to keep pace as computer technology has evolved. The initial NWSRFS design and development was on mainframe computers (NAS 9000s) at the National Oceanic and Atmospheric Administration (NOAA) Central Computer Facility (CCF). As minicomputers became powerful enough to support the system requirements of the NWSRFS, the NWSRFS Operational Forecast System (OFS) was ported to Prime minicomputers which are at OH and several of the RFCs. With the explosive growth in computational capabilities for scientific workstations, OH initiated a project in the late 1980's to prepare for modernization of the entire NWS by moving the scientific operations and forecast component of the NWSRFS onto UNIX-based scientific workstations.

When the NWSRFS is run from the NOAA CCF, command input is sent over Remote Job Entry (RJE) lines from RFCs to the CCF. Line printer results are sent back to the RFC for display on standard printers or on text display screens.

Beginning in 1989, graphical user interface (GUI) and graphical display capabilities were developed for the NWSRFS in the UNIX, X-window, scientific workstation environment. The result is the NWSRFS Interactive Forecast Program (IFP).

Interactive Forecast Program

In order to properly forecast a hydrologically connected series of subbasins, a forecaster must make decisions for each location along the river where observed river conditions are available. If values simulated by NWSRFS do not agree with observations, the forecaster must decide on the most likely source(s) of error, and make adjustments.

When a river system is forecast with NWSRFS on the NOAA CCF or a Prime minicomputer, a group of subbasins are processed in a single batch run. Errors in upstream subbasins propagate into downstream basins, making forecasts for those basins less reliable. The only way to avoid this problem is by making adjustments to reduce or remove the error in any subbasin before processing downstream subbasins. In an operational environment, the time delays between submitting an NWSRFS run and receiving the line printer output for analysis make it difficult for forecasters to make all of the proper adjustments before putting out forecasts.

The NWSRFS IFP helps to alleviate this situation by providing the forecaster with the ability to process one subbasin at a time in a local environment where the results are displayed in a matter of seconds. Adjustments are made interactively and the forecaster may make as many iterations as necessary before moving downstream (Adams and Smith, 1993). The IFP also takes advantage of the enhanced display capabilities of high-resolution color graphics display terminals above those of line printer output to provide forecasters with more visual information.

Data Activities

As the NWS moves forward with planned modernization activities, new data sources have begun to report data in greater quantities and more frequently than the current databases on the NOAA CCF or the Prime minicomputer can process. A crucial component of developing an integrated forecasting environment has been the establishment of real-time data collection and database activities in a UNIX-based relational database on the scientific workstations.

One major new data source in the modernized NWS is the WSR-88D radar data which provides high resolution quantitative estimates of rainfall.

The Stage III Precipitation Processing Program is an interactive graphical display of these data that has been developed for the workstations (Shedd and Fulton, 1993). These rainfall estimates are then processed into the time series that drive the NWSRFS OFS hydrologic models. The OH and the Arkansas-Red River Basin RFC (ABRFC) are currently demonstrating the operational use of Stage III and the IFP. Enhanced computational capabilities provided by the UNIX based workstations will allow OH and ABRFC to realize the benefits of this high resolution radar data for hydrologic forecasting.

Current Demonstration Forecast Environment

The NWSRFS OFS and IFP currently operate in a configuration where real-time data is collected by a UNIX fileserver through a communications port and automatically stored in the relational database. The fileserver runs the NWSRFS OFS to process the data and create a set of model conditions and time series. Forecasters at networked scientific workstations may then initiate simultaneous IFP sessions on different sets of subbasins. Each IFP session computes the operations table for the subbasins being forecast, allows the forecaster to display and analyze model results, and to make adjustments through the IFP GUI. At the end of an IFP session, adjustments made for any of the subbasins are transferred to the fileserver to be incorporated into further forecast activities.

The integration of the data collection and processing, scientific modelling, and graphical model output display on UNIX-based scientific workstations has produced a complete operational river forecast environment that enables forecasters to produce more timely and accurate river forecasts.

Appendix I. References

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