Hydrologic Forecasting - What are the Issues?

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Introduction

The purpose of this paper is to briefly describe hydrologic forecasting techniques that are being used today and raise issues that should be addressed as new hydrologic forecast systems are developed and implemented. The issues represent concerns that will become more important as operations begin to take advantage of some of the new technology that is becoming available to make better forecasts. A list of references on hydrologic forecasting is provided at the end of the text.

Hydrologic Forecasting Techniques

Hydrologic forecasting is the estimation of hydrologic conditions for a given time in the future. Forecasting techniques are often categorized into short- or long-term procedures. Short-term forecasts typically range from a few minutes to a few days in the future. They are based heavily on initial conditions and are used for flood warning or real-time hydrologic system operations. Long-term forecasts usually have lead times greater than a week and often are for periods extending several months into the future. Long-term forecasts are used for planning or water management considerations.

Hydrologic forecasting techniques usually involve the use of some type of rainfall-runoff model and may also include models for simulation of snowpack and channel routing. The discussion in this paper will focus primarily on rainfall-runoff modeling. The models may be classified many ways. Rainfall-runoff models are typically physical, physically-based (mathematical or conceptual), or stochastic. The

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physical models are scaled representations of the true physical processes. Conceptual or physically-based models represent the physical components with mathematical equations describing the hydrologic processes. Stochastic models provide a statistical treatment of the systems on the basis of the stochastic properties of the hydrologic variables. Models also can be categorized according to the types of necessary inputs and processing. Early models were typically driven with lumped inputs. As data processing speeds have increased and data resolution has become more refined, models are being developed to utilize enhanced distributed inputs.

Hydrologic forecasting techniques are also categorized according to the application of the models or systems. The systems may be used for real-time operations or as planning tools. In some cases the same models can be used for both applications. Similarly, rainfall-runoff models may also be categorized as being intended for use in research or operational forecasting. Research models are used to study concepts or provide a better understanding of the hydrologic cycle. Operational forecasting models usually represent mature technology that can be used to provide information about the future occurrence of hydrologic conditions.

The performance of a model is limited by the quality of its input, e.g., precipitation, temperature, evaporation, river stage/discharge, snow water equivalent, and soil moisture. The models often require distributed or areal estimates of these variables, and the estimates are dependent on the ability to observe the variables and to perform spatial interpolation and averaging. Spatial and temporal resolution are improving in many of these measurements; however, great care is necessary to maintain the quality of the data.

Issues

Several issues need to be addressed in the evaluation of a hydrologic modeling or forecasting system.

- What kind of forecast information do users need?
  - Timeliness
  - Frequency
  - Accuracy
  - Uncertainty

- How should procedures, systems, and/or models for hydrologic forecasting be selected?

- Should users (utilities, water supply agencies) invest in better forecast models or better system operations models for optimization and simulation?

- What are the economics of using a particular model?
  - Resources to calibrate?
  - Long-term maintenance?
  - Can simple models provide enough information?
  - How is the hydrologic system defined, and are reasonable inputs available?

- Who will operate the system?

- How easily can the system be updated to represent current conditions accurately?
  - Continuous simulation versus event-driven?

- What is the value of hydrologic forecast information?
  - How can the value be estimated?

- How should performance in hydrologic forecasting be measured?

- How can the proper resolution be selected to describe the problem?
  - Use of GIS information?
  - Does a better understanding need to be made in varying space-time scales before utilizing models of higher resolution?

- How should forecast information be used effectively in operations?

- How can probabilistic forecast information be integrated into operations?

- How can hydrologic and meteorologic forecast information be integrated?

- How will improved data sources (i.e., NEXRAD) affect hydrologic forecasting?
  - Long-term forecasts - QPF?
  - Estimation of snow data - optimal interpolation?

Future Research

Technology has played a major role in shaping the evolution of hydrologic forecasting techniques. The advent of the digital computer encouraged the development of conceptual models that continuously simulate the hydrologic states of a system. High-powered, UNIX-based workstations have led to the development of forecast systems that provide forecasters with an interactive windowing environment for the graphical display and analysis of real-time hydrometeorological data. Although some data networks are seriously deteriorating, more data are now available for forecasting than in the past. In particular, new automated gage networks, radar, satellite, and airborne data are now available for operational forecasting. These data provide information about the spatial variability of hydrometeorological fields that will improve forecasts as well as understanding of the processes. The availability of these data will undoubtedly influence the future development of hydrologic forecasting models and systems. Several research areas important to the future of hydrologic forecasting are the linkage of hydrologic and atmospheric models, the incorporation of meteorological forecast information, the use of distributed modeling, the estimation of forecast uncertainty, the optimal assimilation of data, the updating of model states, and the use of hydrologic forecasts in water management operations.

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Dear Colleague:

Your participation in the 1993 ASCE Water Resources Planning and Management Division 20th Anniversary Conference is most appreciated. You should have now received the brightly colored conference brochure with program details. If you have not, please call me and one will be sent immediately. Here are a few reminders for your consideration:

- Please register early if possible. It is much cheaper to register before March 15, and somewhat cheaper to register before April 27.

- Make plans to come early, if you are interested in the Mount St. Helen's field trip, as this will be starting at 8:00 on Saturday, May 1.

- If you are a primary author (listed first in the program), please call your co-authors to be sure they have received all the conference materials. Getting complete addresses for co-authors has been a bit problematic. Also, be sure to read the conference materials and author's packet you have received, as they contain a lot of useful information.

- If you are a moderator of a session you or your committee organized, please call the primary authors in your session to be sure they have received all conference materials, have completed their bio forms, and are ready to present their papers. Please call me immediately if someone in your session cancels participation in the conference. We still have potential authors who missed the deadlines but would like to be a part of the program.

- Similarly, if you are a confirmed author in the technical or poster sessions and find that you cannot attend the conference, please call me so we can fill in your place.

- If you are presenting a poster, please note all authors are to be at their presentations from 3:00 to 3:30 on Monday, May 3 and Tuesday, May 4. At these times, we will be asking attendees to come to Evergreen 3 and 4 to discuss posters with authors. Also, remember to bring all materials you may need to mount your display on the poster boards provided (e.g.: push pins, tape, etc.). Each poster board consists of a white acoustical material panel with an 8 foot long by 4 foot wide surface area for you to mount your photos and text. The boards are free standing, and the working area is at

eye level. Note that this is a different arrangement than I may have told some authors- I thought there would be tables and the posters would have to be mounted on foam core board and be free-standing, but this is not the case. You will be able to mount material directly on the poster board provided. Feel free to call me if you have questions about your poster presentation.

- Please plan on attending the Author's Breakfast on the day of your presentation. It will be an excellent opportunity to meet the moderator and other speakers, as well as discuss timing and other presentation issues.

- Finally, please plan on having a wonderful time. See you in Seattle!

Sincerely,

Katherine Hon

Katherine Hon
Technical Program Chair

cc: Jack Mowreader
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