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Advanced Hydrologic Prediction Services and Technology Transfer to the International Community

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I. INTRODUCTION

The United States Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), National Weather Service (NWS), has the responsibility to provide river and flood forecasts and warnings for the protection of life and property within the United States. These forecast services also provide for economic and environmental well-being through improved water resources management. NOAA's hydrologic forecast capability is being advanced through the Water Resources Forecasting System program. While the NWS is advancing its forecasting capabilities within the United States, the NWS, in partnership with the governments of Egypt and the People's Republic of China, are implementing state-of-the-art flood and water resources forecasting technologies for the Nile River Basin in Egypt and the Huai River Basin in China. The NWS Office of Hydrology has the lead responsibility to provide technical assistance to develop the hydrological forecasting systems for these basins.

II. BACKGROUND

The Great Flood of 1993 in the Upper Mississippi Basin, which devastated 500 counties in nine states, was unprecedented since the United States began providing weather services in the mid-1800s. In terms of precipitation amounts, record river stages, persons displaced, crop and property damages, and flood duration, this event, or sequence of events, surpassed all floods in the Nation during modern times.

In view of the magnitude of losses associated with The Great Flood of 1993, it is imperative that every effort should be made to reduce potential future losses. Many lessons were learned from The Great Flood of 1993. A NOAA disaster survey team was formed to identify opportunities to improve NOAA's weather and flood forecast and warning systems, not only for the affected region but also throughout the United States. A principal finding of the subsequent NOAA Natural Disaster Survey Report (NWS, 1994) is the need to accelerate the implementation of an Advanced Hydrologic Prediction System (AHPS, Fig. 1). A significant system functionality for AHPS must be more effective linkage of meteorological and climatological forecast and outlook information with the hydrologic forecast system; this is especially important with regard to future precipitation. The inability to adequately incorporate precipitation forecasts was the single largest source of error in long-term hydrologic forecasts during The Great Flood of 1993.

In 1988, the United States experienced a major drought over many of the same parts impacted by The Great Flood of 1993. Agriculture, navigation, and water supply problems amassed damages in the billions of dollars. The drought emphasized NWS deficiencies in its current hydrologic forecasting capabilities for responding to such an emergency. Through the extreme natural conditions manifested by floods and droughts, a hydrologic forecasting system undergoes its greatest test.

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In addition to hydrological extremes, the importance of water cannot be highlighted enough both nationally or internationally. Although the United States has experienced local water supply problems, the situation is critical internationally. For example, several African countries have recently experienced catastrophic loss of life through water shortages. The demand for fresh water is rising to meet the needs of an increasing worldwide population, urbanization, industrial development, ecosystem management, and the natural tendencies to obtain improved living standards. As the population continues to grow, the demands for fresh water will increase and water will become more precious, which increases the likelihood of a water crisis in some countries. Therefore, it is imperative that methods to optimize the allocation of available water supplies be developed. The NWS in the United States is developing an Advanced Hydrologic Prediction System which will go a long way towards achieving this goal.

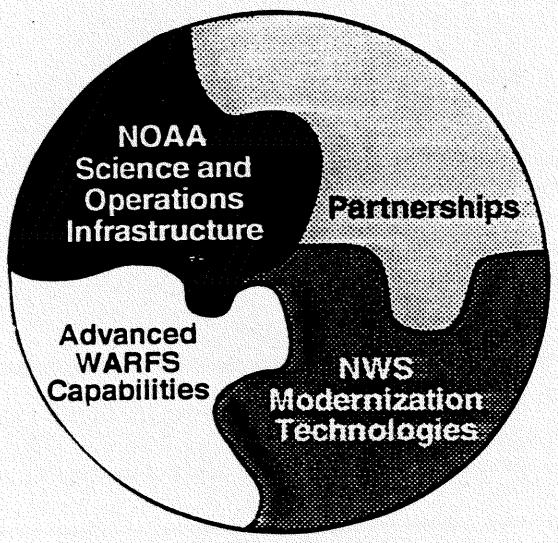

Figure 1. Major programmatic components of the Advanced Hydrologic Prediction System (AHPS).

III. DEVELOPMENT OF ADVANCED HYDROLOGIC PREDICTION SYSTEM

NOAA, in partnership with other major cooperators, is committed to the development and implementation of an Advanced Hydrologic Prediction System. Components of the AHPS are: 1) NOAA's current scientific and operational infrastructure, including the National Weather Service River Forecasting System (NWSRFS); 2) cooperative and supportive partnerships with other government agencies, universities, and the private sector; 3) NWS modernization technologies, especially the Weather Surveillance Radar - 1988 Doppler (WSR-88D) and the Advanced Weather Interactive Processing System (AWIPS); and (4) the Water Resources Forecasting System (WARFS).

The NWSRFS (Fread et al., 1991) is a software system (over 350,000 lines of computer code) consisting of many components, including deterministic hydrologic/hydraulic models, which are used to perform all steps necessary to generate streamflow forecasts. The system includes the Calibration System (CS), the Operational Forecast System (OFS), the Extended Streamflow Prediction (ESP) System and the Interactive Forecast Program (IFP). The CS performs the tasks needed to process historical hydrometeorological data and to estimate model parameters for a specific basin. The OFS enables the processing of data and the development of forecasts of hydrologic variables using operations (models/procedures) selected by the forecaster. ESP is the portion of the NWSRFS which enables a hydrologist to make extended probabilistic forecasts of streamflow and other hydrologic variables, such as soil moisture and snow water content. The IFP combines the OFS with a graphical user interface in order to provide forecasters the visual capability to easily and quickly make changes and decisions.

NOAA's partnerships compose the second component of AHPS. In the United States, the NWS regularly interacts with many partners in data and information exchanges. The U.S. Army Corps of Engineers, U.S. Geological Survey, the Federal Emergency Management Agency, Susquehanna River Basin Commission, the private sector, universities, and state and local agencies involved with hydrological and water resources are some of NOAA's many partners. The AHPS is geared toward decision making for flood preparation and providing information for improved management of water supplies. These

partnerships proved invaluable during The Great Flood of 1993.

The third AHPS component is modernization technologies involving new sources of information and processing systems and realignment of the NWS into a new organizational structure (Friday, 1994). The principal goal of the modernization of the NWS is to improve the quality and reliability of NOAA services.

WARFS, the fourth AHPS component, is the operational program providing for the modernization of NOAA's hydrologic forecasting services. It is an integrated real-time modeling and data management/analysis system which includes provisions for the use of historical hydrological/hydrometeorological data and meteorological/climatological forecasts for input to ESP simulations. WARFS (see Fig.2), including ESP enhancements, will provide for analyses of streamflow trace ensembles within specified future time windows, objectively couple meteorological/climatological forecasts in the ensemble analysis, provide for a variety of probabilistic analyses of ensembles, and package probabilistic streamflow forecast products with extended lead-times (out to several months). Thereby, WARFS will provide river forecasts which not only account for precipitation already on the ground but will also probabilistically account for estimates of future precipitation.

IV. BENEFITS OF ADVANCED HYDROLOGIC PREDICTION SYSTEM

Presently, the NWS River Forecast Centers (RFC) typically issues stage forecasts for only 1, 2, and 3 days into the future at most forecast points and crest forecasts out to about 1 week for a few selected forecast points. WARFS products with extended forecast lead-times will greatly improve the capability of emergency managers to take timely and effective actions that will significantly mitigate the impact of major floods and droughts. Furthermore, the allocation of water among competing demands (e.g., fisheries, irrigation, hydropower and municipalities) looms as a national problem that requires improved water quality forecasts for sustainable development.

V. BENEFITS FROM INTERNATIONAL TECHNOLOGY TRANSFER

NOAA and the NWS is committed to sharing its technological advances with other countries. Through the Hydrological Operational Multipurpose System (HOMS), the NWS has transferred numerous operational hydrology HOMS components (software, nomographs, technical proceedings, etc.) throughout the world. The NWS Office of Hydrology director is presently leading the effort to enhance HOMS. Additionally, the NWS and other water resource

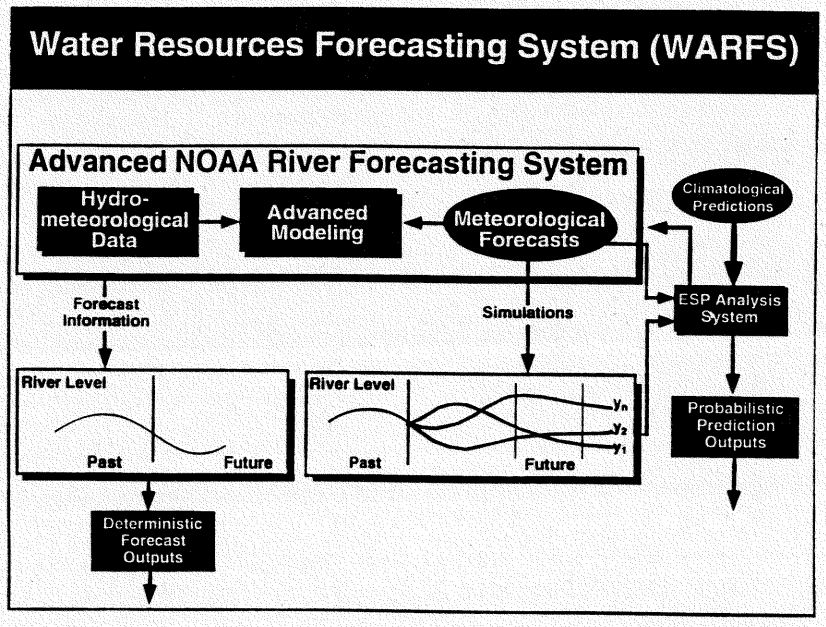

Figure 2. Schematic of the Water Resource Forecasting System (WARFS) integrated real-time modeling and data management /analysis system.

agencies are actively striving to transfer hydrologic technology to support the International Decade for National Disaster Reduction. The System for Technology Transfer for Natural Disasters (STEND) will provide assistance to developing and developed countries in the earth sciences of hydrology, volcanology, and seismology.

NOAA is proud of its AHPS and is in a limited position to transfer technology internationally. For example, ongoing projects with the Peoples' Republic of China and Egypt to provide AHPS in these countries support NOAA's claim to assist others in international technology transfer. Technology transfer for the Nile River Project in Egypt is a five year project funded by the U.S. Agency for International Development. NOAA is providing technical assistance to design and to develop data analysis and hydrologic modeling techniques to predict inflow into the high Aswan Dam in Egypt. A similar project is also underway to implement state-of-the-art flood and water resources forecasting technologies in China on the Huai River. Unfortunately, NOAA/NWS resources are limited and future international technology transfer activities will depend on funding and personnel ceilings. The major benefit associated with NOAA's AHPS is to improve the accuracy and lead-time of streamflow forecasting, which will aid in the mission of minimizing the loss of life, property, and economic and environmental costs resulting from extreme weather events. Exchanging flood forecasting technologies throughout the international community is key in advancing such state-of-the-art capabilities. Technologies involved in flood forecasting include hydrometeorological data observations and processing algorithms, hydrometeorological modeling and forecasting systems, telecommunications, and commercial computer hardware and software. The potential for future international technological exchange is heightened as NOAA advances its hydrologic forecast capability through the WARFS program structure.

VI. SUMMARY

The NWSRFS includes commercial computer workstations and software and hydrometeorological software developed over two decades by NWS scientists to forecast floods and droughts along rivers in the United States. Sophisticated computer models incorporate past weather and hydrological data with a system of hydrologic/hydraulic models that predict flows along a river. Similar technologies should assist water resource managers in other nations in making critical decisions involving the protection of lives, property, and the environment in a flood plain.

The Department of Commerce and NOAA, in partnership with other major cooperators, are now advancing their forecasting technologies in the United States through the development and implementation of the WARFS. WARFS' extended forecast lead-times (up to several months) will allow for more effective mitigation of extreme events (e.g., floods and droughts), improved operations of water resource facilities (e.g., irrigation and hydropower facilities), and enhanced ecosystem management (e.g., fisheries and wetlands management). As these advanced technologies are developed, the Department of Commerce and NOAA/NWS can exchange information with other governments in order to meet sustainable development needs. These exchanges may be executed through memoranda of agreements or other technological exchange mechanisms as appropriate.

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