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Hydrologic Forecasting in the 21st Century: Challenges and Directions of Research

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Traditionally, the role of the Hydrology program of the National Weather Service has been centered around forecasting floods, in order to minimize loss of lives and damage to property as a result of floods as well as water levels for navigable rivers, and water supply in some areas of the country. A number of factors, including shifting population patterns, widespread drought and concerns about climate change have made it imperative to widen the focus to cover forecasting flows ranging from drought to floods and anything in between. Because of these concerns, it is imperative to develop models that rely more on the physical characteristics of the watershed for parameterization and less on historical observations. Furthermore, it is also critical to consider explicitly the sources of uncertainty in the forecasting process, including parameter values, model structure, forcings (both observations and forecasts), initial conditions, and streamflow observations. A consequence of more widespread occurrence of low flows as a result either of the already evident earlier snowmelt in the Western United States, or of the predicted changes in precipitation patterns, is the issue of water quality: lower flows will have higher concentrations of certain pollutants.

This paper describes the current projects and future directions of research for hydrologic forecasting in the United States. Ongoing projects on quantitative precipitation and temperature estimates and forecasts, uncertainty modeling by the use of ensembles, data assimilation, verification, distributed conceptual modeling will be reviewed. Broad goals of the research directions are: 1) reliable modeling of the different sources of uncertainty. 2) a more expeditious and cost-effective approach by reducing the effort required in model calibration; 3) improvements in forecast lead-time and accuracy; 4) an approach for rapid adjustment of model parameters to account for changes in the watershed, both rapid as the result from forest fires or levee breaches, and slow, as the result of watershed reforestation, reforestation or urban development; 5) an expanded suite of products, including soil moisture and temperature forecasts, and water quality constituents; and 6) a comprehensive verification system to assess the effectiveness of the other 5 goals.

To this end, the research plan places an emphasis on research of models with parameters that can be derived from physical watershed characteristics. Purely physically based models may be unattainable or impractical, and, therefore, models resulting from a combination of physically and conceptually approached processes may be required

With respect to the hydrometeorological forcings the research plan emphasizes the development of improved precipitation estimation techniques through the synthesis of radar, rain gauge, satellite, and numerical weather prediction model output, particularly in those areas where ground-based sensors are inadequate to detect spatial variability in precipitation. Better estimation and forecasting of precipitation are most likely to be achieved by statistical merging of remote-sensor observations and forecasts from high-resolution numerical prediction models. Enhancements to the satellite-based precipitation products will include use of TRMM precipitation data in preparation for information to be supplied by the Global Precipitation Mission satellites not yet deployed.

Because of a growing need for services in water resources, including low-flow forecasts for water supply customers, we will be directing research into coupled surface-groundwater models that will eventually replace the groundwater component of the existing models, and will be part of the new generation of models.

Finally, the research plan covers the directions of research for probabilistic forecasting using ensembles, data assimilation and the verification and validation of both deterministic and probabilistic forecasts.