A REAL TIME SYSTEM FOR IDENTIFYING FLOODED ROADS IN RURAL AREAS DURING SEVERE PRECIPITATION EVENTS

Tom C. Whitney, Stephen J. Katzberg, and Maria Hubbard
Civil and Mechanical Engineering Department
South Carolina State University, Orangeburg, SC 29117

During times of extreme storm events, access to rural areas involves bi-directional flow: (1) Evacuation of able-bodied individuals from affected areas and (2) Access to the affected areas by emergency and rescue personnel. Impediments to ready access to the affected areas vary from those associated with pre-storm such as road congestion/accidents and pristine road surface deterioration, to mid-storm effects such as downed trees, debris, etc., road deterioration from use, flooding accelerated deterioration, and direct flooding of roadways. Post-storm impediments include erosion of roadways, destruction of bridges, debris and destroyed road surfaces and continued flooding. One of the greatest difficulties associated with storm response in rural areas is accurate and timely information. With evacuation, support and emergency resources necessarily limited, the fundamental need is intelligent concentration of resources. Unfortunately synoptic information during and immediately after severe storms is frequently limited through effects of failed infrastructure.

The current state-of-the-art in static flood warning systems is characterized by regional scale predictions from the National Weather Service built on a suite of software called the Flash Flood Warning and Prediction system (Reference 1.) This suite of software produces hourly updates of the "Flash Flood Guidance" which is based on meteorological Weather Service data and surface hydrological models. The data is used to generate flash flood warnings and is not used in any direct sense to guide public safety personnel. Efforts to develop real-time data reporting of rural flood events to support transportation information decisions have been proposed. The Queensland Department of Main Roads, Queensland, Australia has proposed a "Road Flood Warning System" (Reference 2) which is a loosely coupled set of software applications with input from the Bureau of Meteorology forecasts, river height stations, and precipitation gauges. A prescient example of coupling of GIS to hydrology models was done by Louisiana State University in 1999 (Reference 3) in which an effort was made to produce a real time forecasting system of software elements to predict wind and flooding for New Orleans, Louisiana. Within the system were an extensive data base of topography, levees and cultural features, a calibrated hurricane wind and storm surge model, computer hardware capable of providing real time forecasts, real time data telecommunications linking Louisiana State University, Louisiana Office of Emergency Preparedness, St. Bernard Parish, Jefferson Parish and Orleans Parish and to other data sources and an automated real time display of the input data and forecast results. This system was not designed to assess road or other impacts of precipitation, but only hurricane wind and storm surge flooding predictions for metropolitan New Orleans. The Advanced Rural Traveler Information System (ARTIS) has been under development since 1995 in North Dakota (Reference 4.) This decision support system, a very large scale endeavor, had as its goal the provision of real-time motorist travel information derived from weather prediction software (from NOAA's National Center for Environmental Prediction), North Dakota and South Dakota surface weather network observations, satellite remote sensing data (e.g. AVHRR, GOES-8 and the NOAA polar orbiters, and road operational attributes. The focus for the North Dakota system is on the effects of winter weather (fog, ice, blowing snow, etc.), is based on weather prediction, is tailored to the Northern Plains, and not designed to focus on localized flooding or use radar information.

In an earlier report (Reference 5) the authors presented a paper describing the use of global satellite RADAR data to predict flooding in Botswana. This paper presents the results of a study to determine the utility of RADAR precipitation data to identify, in real time, roads in rural areas of the southeast U.S., which are flooded or likely to be flooded as the result of a severe precipitation event. The real time data source needed for the system comes from National Weather Service weather radar (NEXRAD) Level III data products. The NEXRAD RADAR gives frequent updates to rain rate and accumulated rainfall as a function of position. These data are available as grids for each time interval and are archived. It is well known that the NEXRAD precipitation data can have large errors, depending upon the characteristics of the rain. Real time report rain gage networks exist that can be used to calibrate the precipitation to improve the quality of the RADAR product. A gauge-corrected data product produced by a commercial company, One Rain, Inc., is also available for comparison to the NEXRAD result.

The occurrence of flooding in the rural Southeast is made more difficult to predict because of the low terrain relief. Much of the area is swampy with extensive bottom lands that do not fill rapidly to cause runoff. Even high resolution US Geological Survey digital elevation models are generally not accurate enough to define the myriad of small creeks and rivulets that comprise the river swamps of the Southeast. As an alternative, the USGS digital line graphs derived from orthophotographs have been used in this study with good results.

The end-to-end system developed as part of this work consists of a geographical information system, (GIS), the Gridded Surface Subsurface Hydrologic Analysis, (GSSHA) from the U.S. Corps of Engineers model, and the real-time precipitation data. To establish a model for each watershed, the necessary high resolution digital elevation data, land use/land cover and soils characteristics are collected to define the local watersheds of interest. Included in the completed terrain model are surveys of road culverts and embankments. Calibration of the model is done by selecting a set of known flooding events and the involved watersheds are modeled. Historical NEXRAD/One Rain precipitation data is used to establish a rainfall distribution for each event. The model is run, flooding spatial distribution is determined, and input as GIS 3-D maps. Road closure is determined by the flooded area elevations exceeding road elevation at crossing points. Archived road flooding reports developed from NOAA Local Storm Reports (LSA's) are used for verification of the model results. Three specific events from three different watersheds are reported here: (1) The flooding of Buckhead Creek, Ft. Motte, South Carolina (2) Bates Mill Creek, South Carolina, June 15-16, 2001 and (3) Colston Branch, Ehrhardt, South Carolina, August 25-26, 2006. Each of these events are characterized by low terrain relief and highly localized (approximately single watershed) precipitation, typical of the such flooding events in the rural Southeast.

It will be shown, that in the three investigated severe precipitation events, use of either precipitation data source produces valuable information with regard to road flooding during severe precipitation events. The degree to which using gauge-calibrated RADAR improves the model results will also be given. Finally, since obtaining surveyed elevation data from each road-stream crossing in any county would constitute an expensive and long term effort, suggestions of how to use the model relying on “best practices” used in road or bridge design will be given.

References

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