A dynamic data driven application system for real-time monitoring of surface water TP in a Missisippi Delta stream

BACKGROUND

Clean water is vitally important for human societies and natural ecosystems. There is abundant evidence that the water quality in the Mississippi Delta is deteriorating. Additionally, the extensive usage of groundwater for agricultural industry in the region has resulted in water shortages, which are more likely to become severe in the future. Such poor water quality and water shortage are linked to each other since contamination reduces the supply of water and increases the cost of water treatment for use. With an increased understanding of the importance of drinking water quality to public health and raw water quality to terrestrial life, there is a greater need to assess water quality in the region.

Common water contaminates include debris from litter or flooding and pesticides used in crop dusting.

Phosphorus (P) is an essential nutrient in aquatic systems as it is required for all forms of life. Most surface water bodies have low P concentrations because of its low water solubility. Therefore, a small increase in P concentration would result in toxic algal blooms, hypoxia, fish kills, and loss of biodiversity. Currently, little effort has been devoted to monitoring real-time variation and load of total P (TP) in surface waters due to the lack of suitable and/or cost-effective wireless sensors. However, when considering human health, drinking water supply, and rapidly developing events such as algal blooms, the availability of timely P information is very critical. To this end, a dynamic data driven application system (DDDAS) is employed to circumvent the obstacle.

DDDAS

Most of the computer models used to date only allow input data that are fixed and measured previously when the simulations are launched. These modeling and measurement approaches are static but not synchronized or adaptive. The limitations in simultaneously injection of the measured data into simulation models restrict the dynamic requirements for simulations in response to the real-time changing conditions, and therefore are often unable to catch the instantaneous reactions and occurrences in nature. DDDAS is a real-time symbiotic field measurement and computer simulation system, where measurement provides timely data for simulation; and in reverse, simulation can guide the measurement on when and where to collect data (Darema, 2004).

RESEARCH

In this research, we design a DDDAS for monitoring the real-time variation and load of TP in a stream. This DDDAS consists of the following three major components (Fig 1): (1) a User Control that interacts with Schedule Run to implement the DDDAS with starting and ending times; (2) a Schedule Run that activates the Hydstra model; and (3) a Hydstra model that downloads the real-time data from a US Geological Survey (USGS) website that is updated every 15 minutes with data from USGS monitoring stations, predicts real-time variation and load of TP, graphs the variables in real-time on a computer screen, and sends email alerts when the TP exceeds a prescribed value.

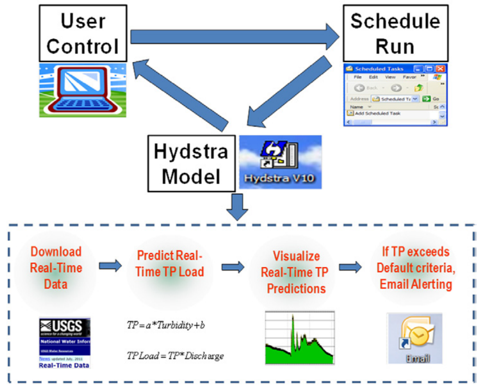

Figure 1. A DDDAS for monitoring real-time variation and load of TP in surface waters.

Figure 2. Location of USGS surface water monitoring station # 0728875070 in Deer creek east of Leland, MS.

The DDDAS is applied to monitor real-time variation and load of TP for 30 days in Deer Creek, a stream located east of Leland, Mississippi (Fig. 2). Results show that the TP contents in the stream range from 0.24 to 0.48 mg L-1 with an average of 0.30 mg L-1 for a 30-day monitoring period (Fig. 3), whereas the cumulative load of TP from the stream is about 2.8kg for the same monitoring period (Fig. 3). Our study suggests that the DDDAS developed in this study is useful for estimating the real-time variation and load of TP in surface water ecosystems (Ouyang et al., 2012).

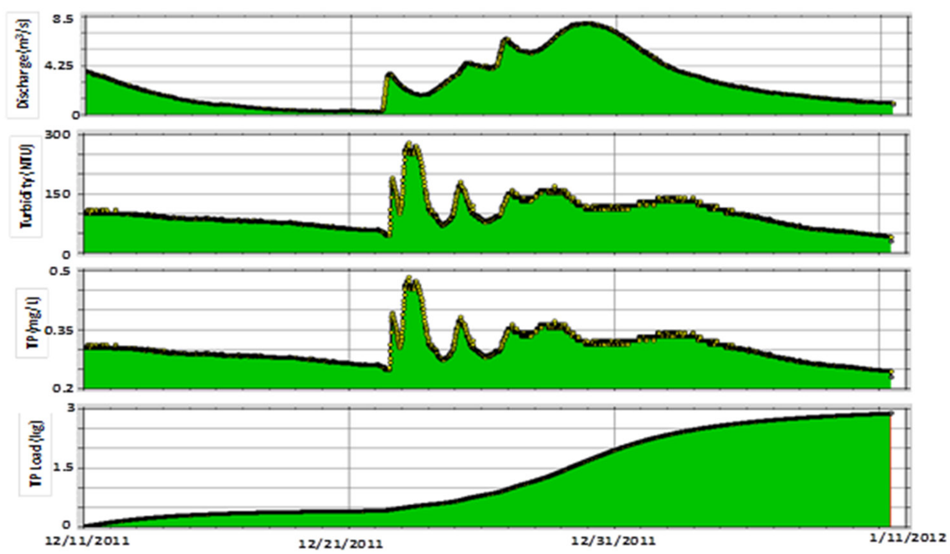

Figure 3. Real-time variations of discharge (A) and turbidity (B) measured by USGS and real-time variations of TP content (C) and load (D) predicted from the DDDAS for a 30-day monitoring period from December 11, 2011 through January 10, 2012.

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