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REAL-TIME IMPLEMENTATION OF THE PENN STATE INTEGRATED HYDROLOGIC MODEL ---THE SHALE HILLS CRITICAL ZONE OBSERVATORY

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Introduction

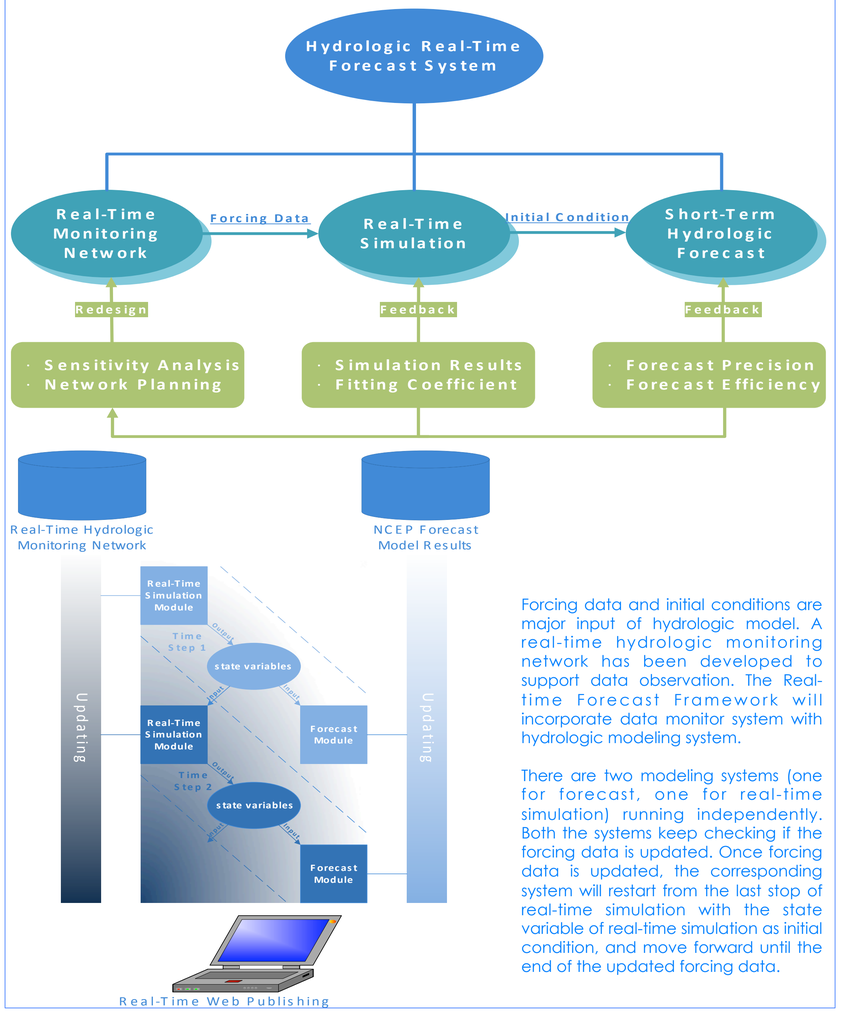
The future of river forecasting system will utilize monitoring station networks with continuous real-time measurement of hydrologic, atmospheric, and pedologic variables across diverse terrestrial water cycle. Physical model simulation is the best method to integrate abundant observation data and predict hydrologic variables directly. In recant years, physical-based distributed hydrologic models have evolved to be an up-and-coming trend of hydrology.

Initial conditions have been proved crucial to hydrological models in many studies. Initial unsaturated storage and saturated storage are important in numerical modeling of rainfall and runoff response at the event scale (Goodrich, 1994). The uncertainty in initial soil-water content estimates for event-based simulation is shown to be a major limitation for physics-based models (Loague, 2005). The research provides a framework to implement a physical-based integrated hydrologic model (Penn State Integrated Hydrologic Model) for real-time hydrologic forecasting, and targets a feedback strategies gaining model improvement from forecasting results.

Penn State Integrated Hydrologic Model (PIHM)

PIHM(Penn State Integrated Hydrologic Model) represents a strategy for the formulation and solution of fully-coupled process equations at the watershed and river basin scales, and includes a tightly coupled GIS tool for data handling, domain decomposition, optimal unstructured grid generation, and model parameterization. PIHM has been successfully applied at different scales of watersheds.
http://www.pihm.psu.edu/

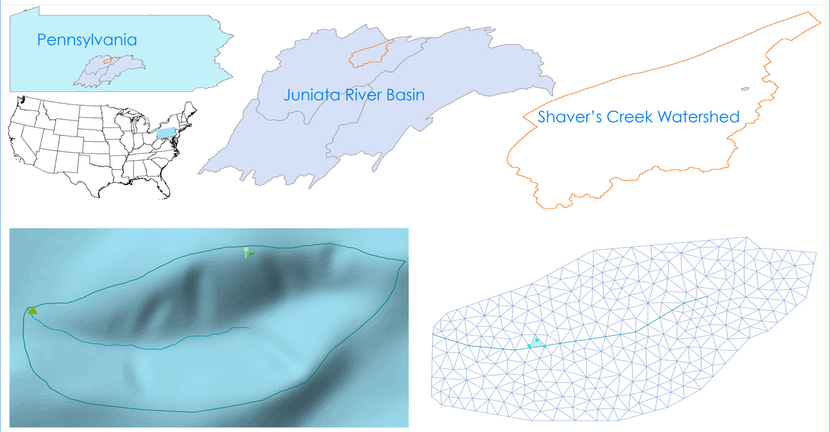
Real-time Forecast Framework



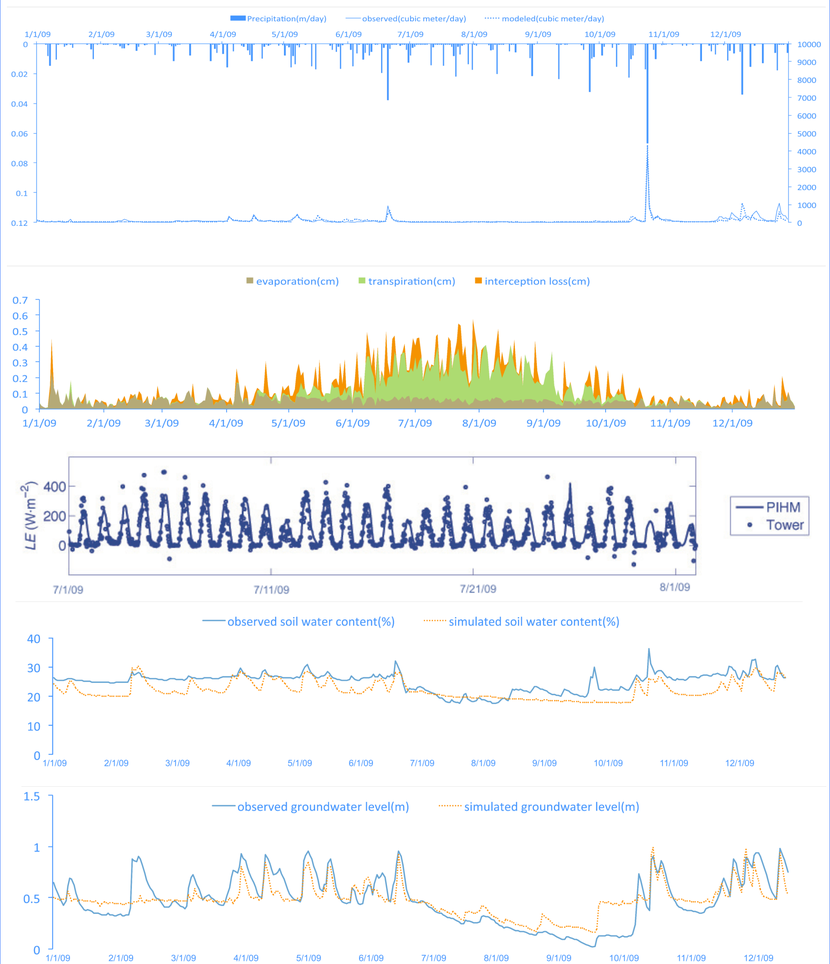
Forcing data and initial conditions are major input of hydrologic model. A real-time hydrologic monitoring network has been developed to support data observation. The Real-time Forecast Framework will incorporate data monitor system with hydrologic modeling system.

There are two modeling systems (one for forecast, one for real-time simulation) running independently. Both the systems keep checking if the forcing data is updated. Once forcing data is updated, the corresponding system will restart from the last stop of real-time simulation with the state variable of real-time simulation as initial condition, and move forward until the end of the updated forcing data.

The Shale Hills



Hindcast Results



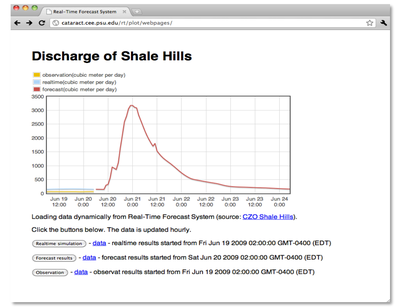
Forecast Results

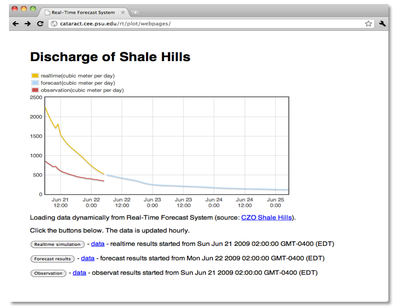
2009 data is used as a prototype, before we implement the actual weather forecast.

The model started at 2009-1-1. Weather forecasting data came from the observation data with a slight random fluctuation in precipitation and temperature. We are adding to forcing data with one-day records every hour. The forcing data for forecast is three days longer than that of real-time simulation, which represents the weather forecasting results. So we are doing one-day real-time simulation and three-day forecast.

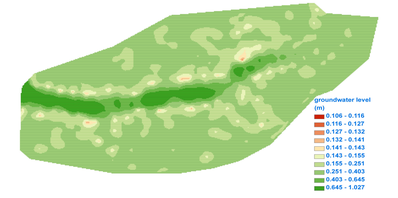
A simple webpage of discharge rate figure shows system output. Real-time simulation starts one day ahead, and forecast model ends three days after.

http://cataract.cee.psu.edu/rt/plot/webpages/index.html

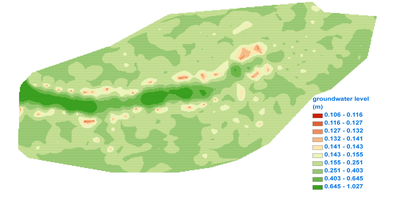




Spatial forecasting result: average from 6/20/09 to 6/22/09

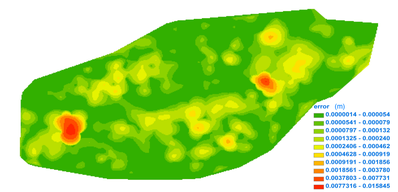


Spatial forecasting result: average from 6/22/09 to 6/24/09

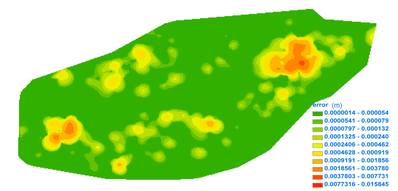


Forecast error is represented by the variance between real-time simulation and forecast results.

Forecast error of groundwater level on 6/20/09



Forecast error of groundwater level on 6/22/09



The regions with large errors can be future monitor sites.

Future Work

- Test on simulation and forecast efficiency
- Incorporating feedback strategies of simulation and forecast efficiency
- Web design of spatial figures and temporal serials of unsaturated storage, saturated storage, evapotranspiration and discharge rate.
- River basin scale application with improvement of the the computational performance. PETSc is being implemented for large-scale application.

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