Approaches for Assessment of Sediment, Nutrient, and Hydrological Characteristics in the Lower Mississippi Alluvial Valley

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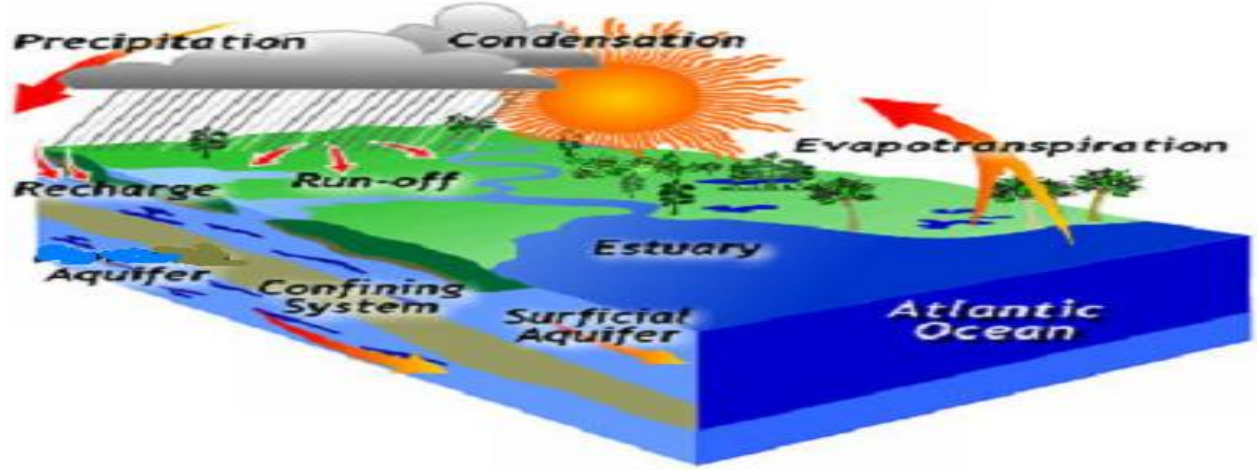


58th Annual Southern Hardwood Forest Research Group Meeting. Stoneville, Mississippi. March 15, 2011.

Goals

1. Estimate sediment and nutrient dynamics in the LMAV using BASINS-HSPF model
2. Monitor real-time variations of surface water quality using dynamic data driven application system (DDDAS)
3. Identify temporal patterns of watershed hydrology and water quality using Wavelet Analysis
4. Other relevant research projects and potential collaborations

1. Estimate Sediment and Nutrient Dynamics in the LMAV using BASINS-HSPF Model

Rationale

•Excess nutrients, elevated sediment, and other contaminants in the LMAV due to the agricultural and forest practices

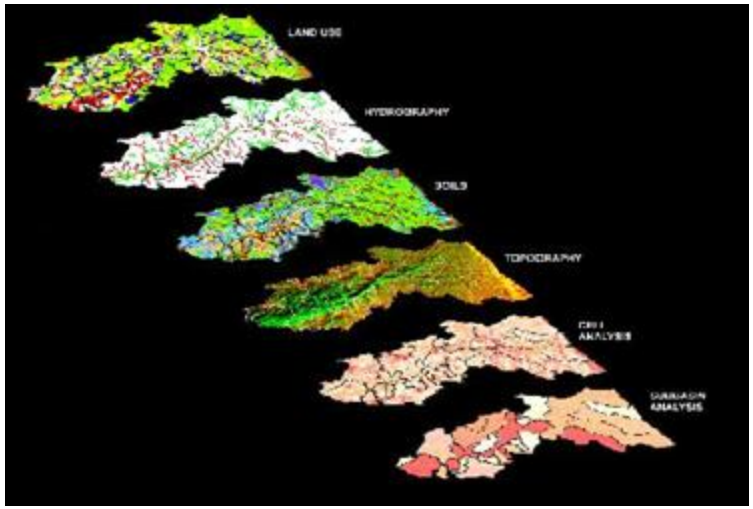
- High BOD, low DO, fish kills, and Loss of biodiversity
- Toxic algal bloom
- Interrupt navigation

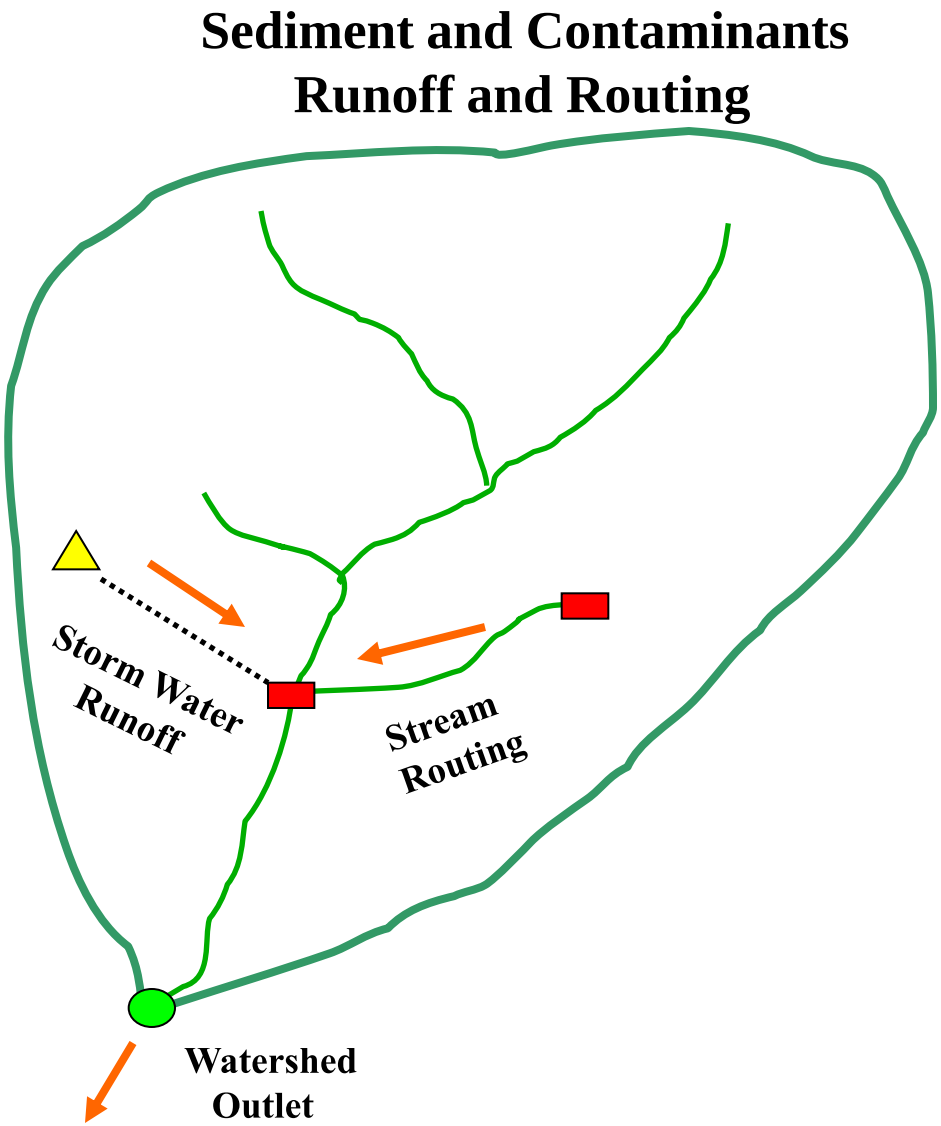
•Insufficient information on seasonal and annual loads of sediment, nutrients, and pesticides in the LMAV

•Water resource management, ecosystem protection, and TMDL development/refinement

Objective

Estimate the seasonal and annual loads of sediment, N, P, and pesticides from watersheds into rivers using BASINS-HSPF model

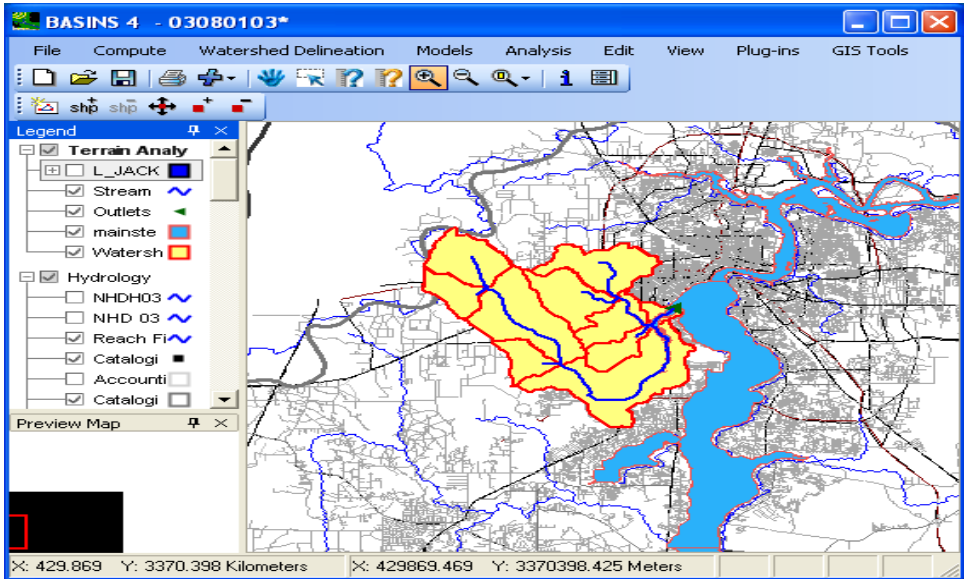




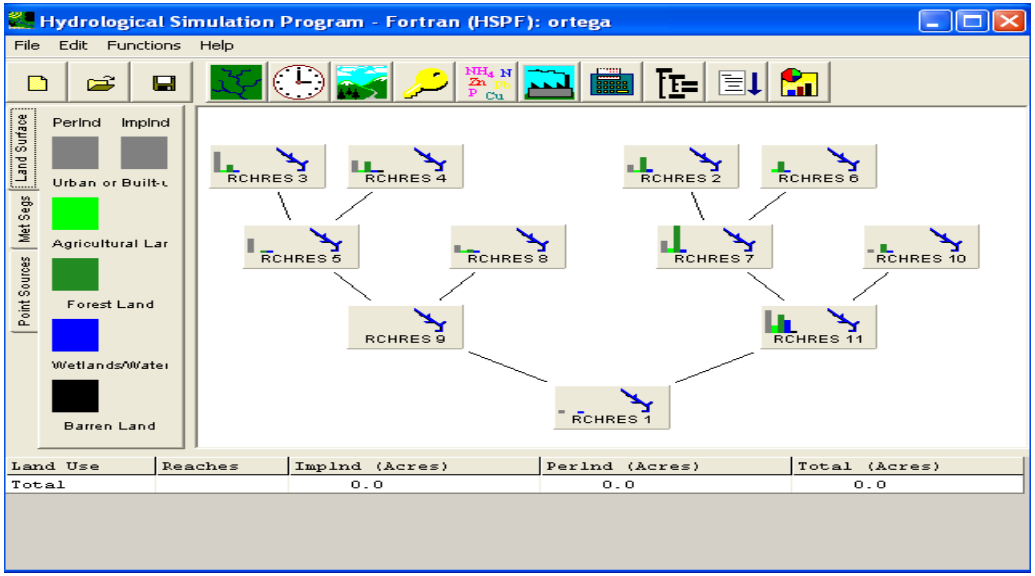
BASINS-HSPF Model

BASINS — EPA's modeling system integrating GIS and other modeling tools such as HSPF, PLOAD, QUAL2E, and SWAT

HSPF —— EPA's model for simulating many processes related to water quantity and quality in watersheds

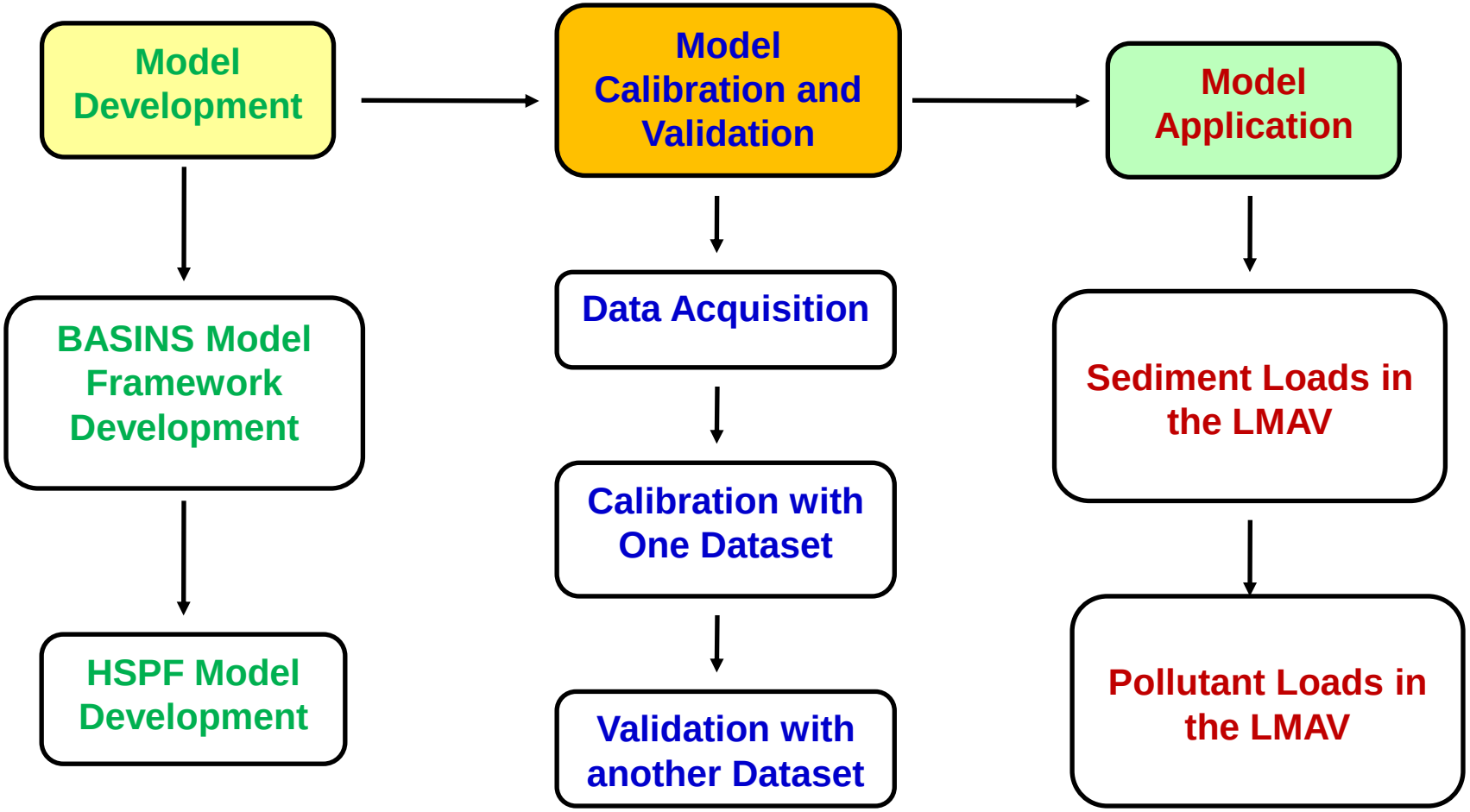


BASINS 4



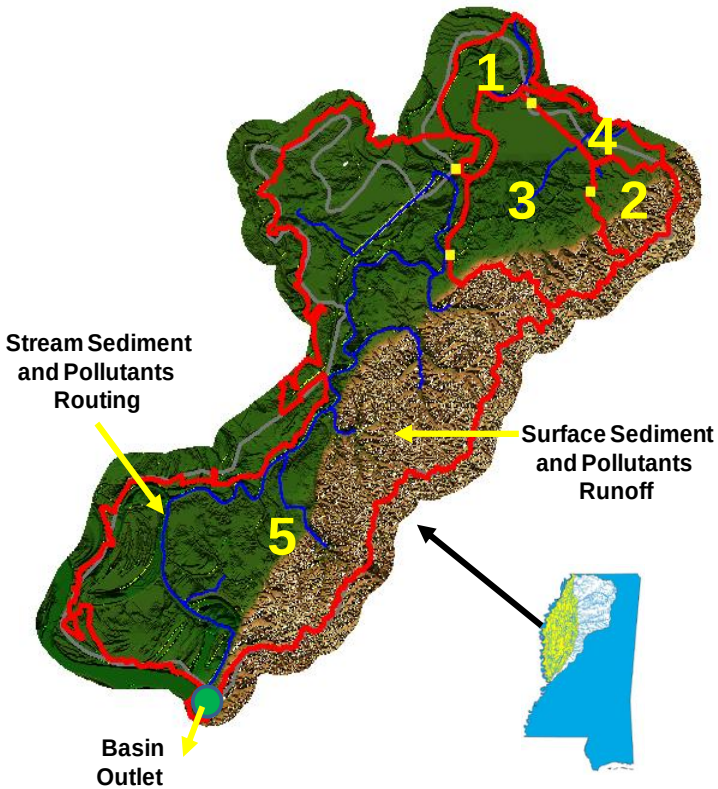
HSPF MODEL

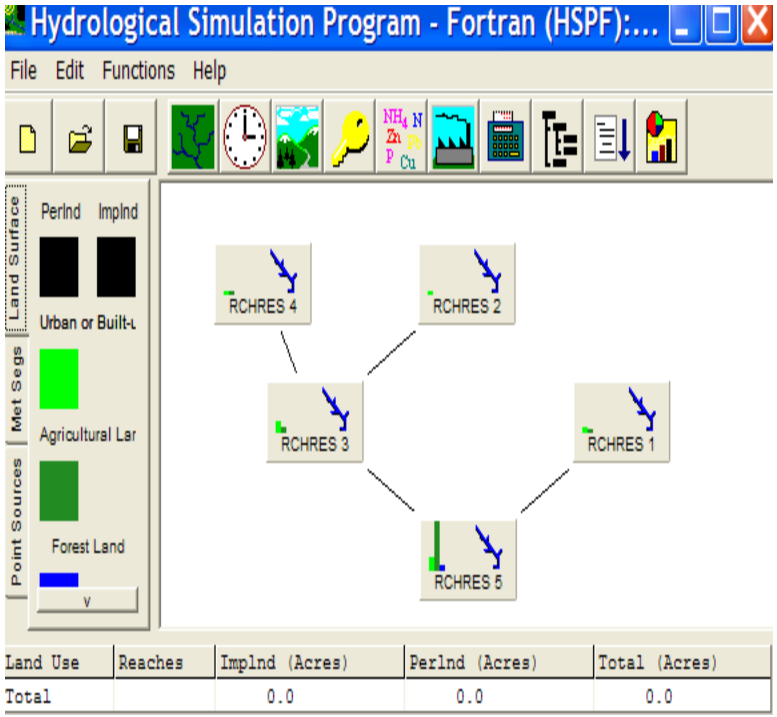
Approaches


Model Development
Model Calibration and Validation
Model Application
BASINS Model Framework Development
HSPF Model Development
Data Acquisition
Calibration with One Dataset
Validation with another Dataset
Sediment Loads in the LMAV
Pollutant Loads in the LMAV

Current Progress

BASINS-HSPF model for dynamic loads of sediment and pollutants in the Yazoo River Basin

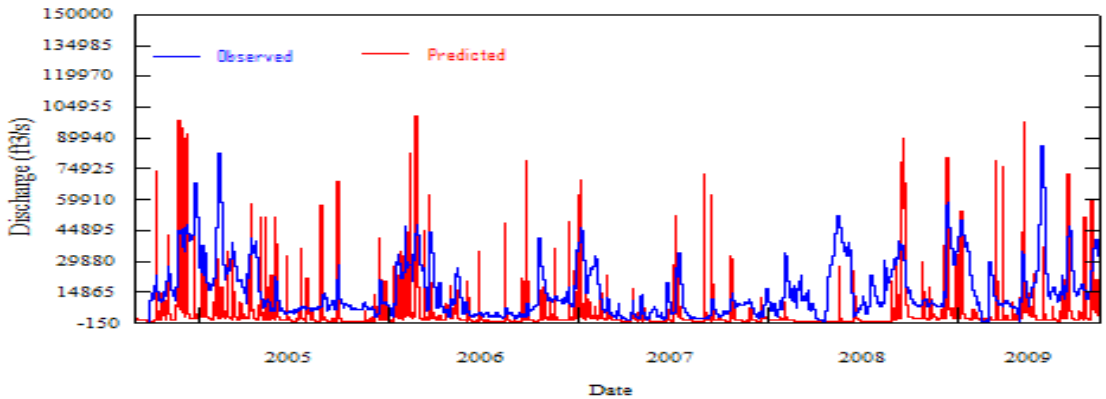




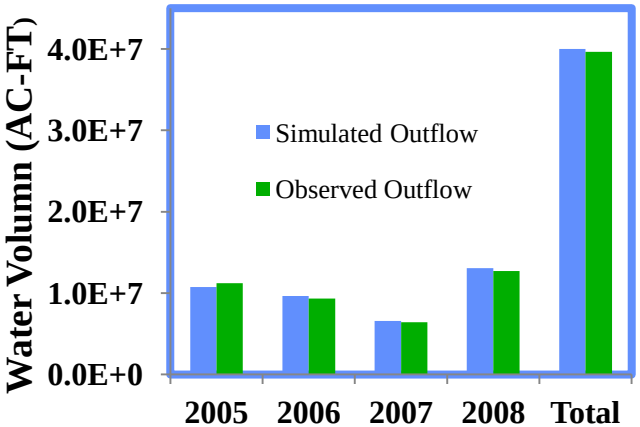
Preliminary Results

Hydrology Calibration

Daily Discharge of Water from Watershed Outlet



Volume of Water Outflow from Watershed Outlet



Year	Simulated Outflow	Observed Outflow	Percent Different
2005	1.07E+07	1.12E+07	-4.06
2006	9.65E+06	9.33E+06	3.35
2007	6.57E+06	6.42E+06	2.23
2008	1.31E+07	1.27E+07	2.80
Total	**4.00E+07**	**3.96E+07**	**0.90**

Further Study

- **Sediment, nutrient, and pesticide calibrations and validations**
- **Seasonal and annual loads of sediment, nutrients, and pesticides from the YRB into YR and its tributaries**
- **Extend to LMAV**

2. Real-Time Monitoring of Surface Water Quality Variations and Loads Using Dynamic Data Driven Application System

Rationale

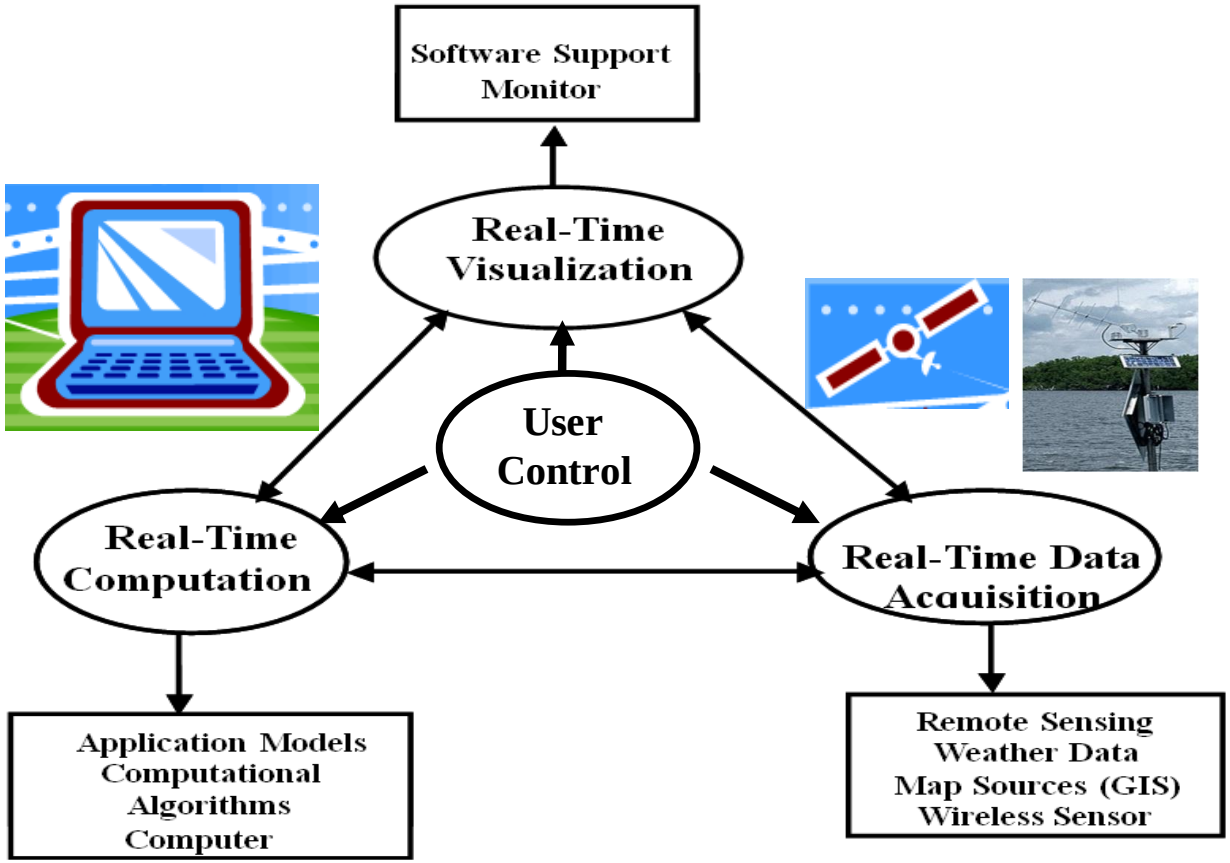
•Real-time data for chlorophyll, DO, pH, temperature, TSS, watercolor, etc in surface waters (USGS Website)

- No real-time data for N, P, sediments, and DOC due to the lack of suitable or cost-effective wireless sensors
- Take a week or longer for laboratory analysis
- Human health, carbon footprints, algal blooms, and surface water supply, the timely nutrients, sediment, and DOC information may be critical.

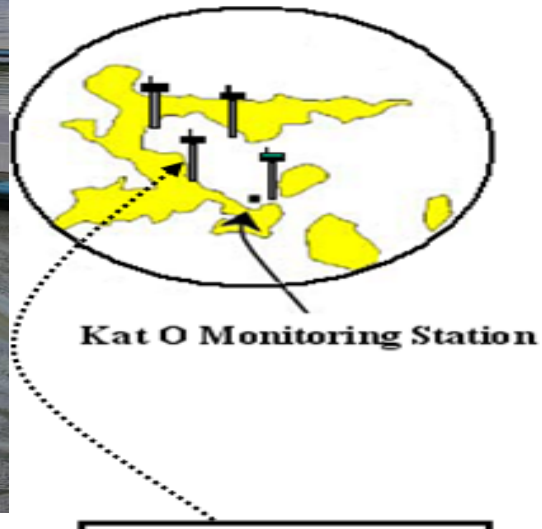
What Is Dynamic Data Driven Application Systems (DDDAS)?

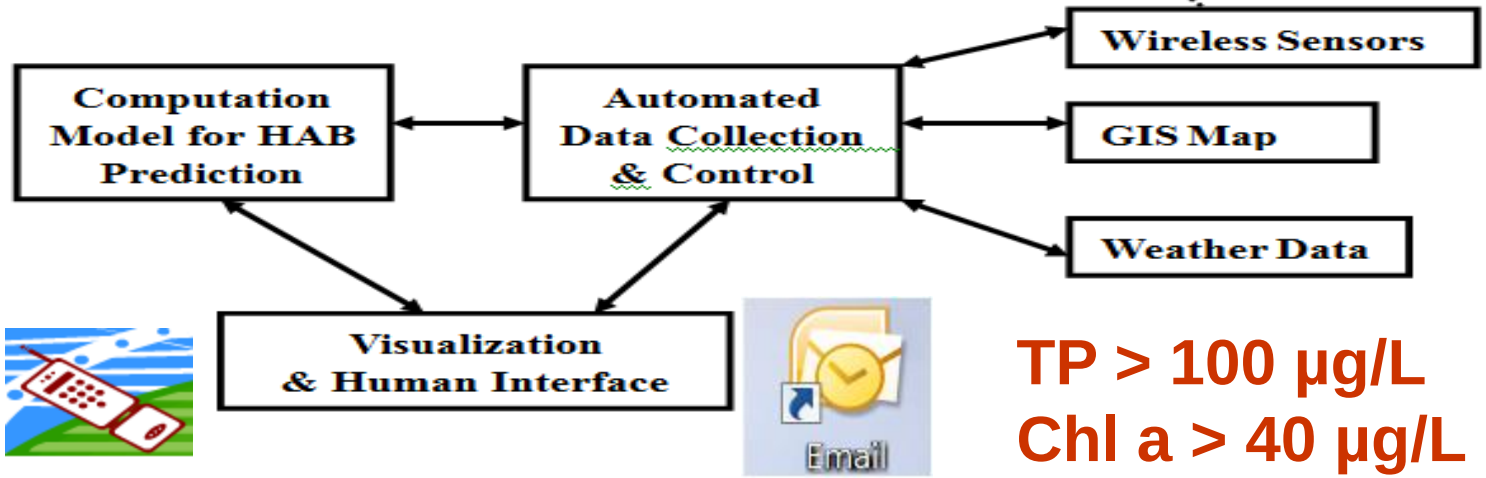
- A real-time symbiotic field measurement and computer simulation system
- Measurements provide timely data for simulations
- In reverse, simulations can guide the measurements on when and where to collect data
- Coined by National Science Foundation (NSF) in 2000

What Is DDDAS (Continued)?



Hypothetical DDDAS Example for Harmful Algal Bloom





TP > 100 µg/L
Chl a > 40 µg/L

Statement of Problem and Basic Idea

Problem:

1. No real-time data in streams for N, P, DOC, and sediments
2. Monitor them in a real-time manner?

Basic Idea:

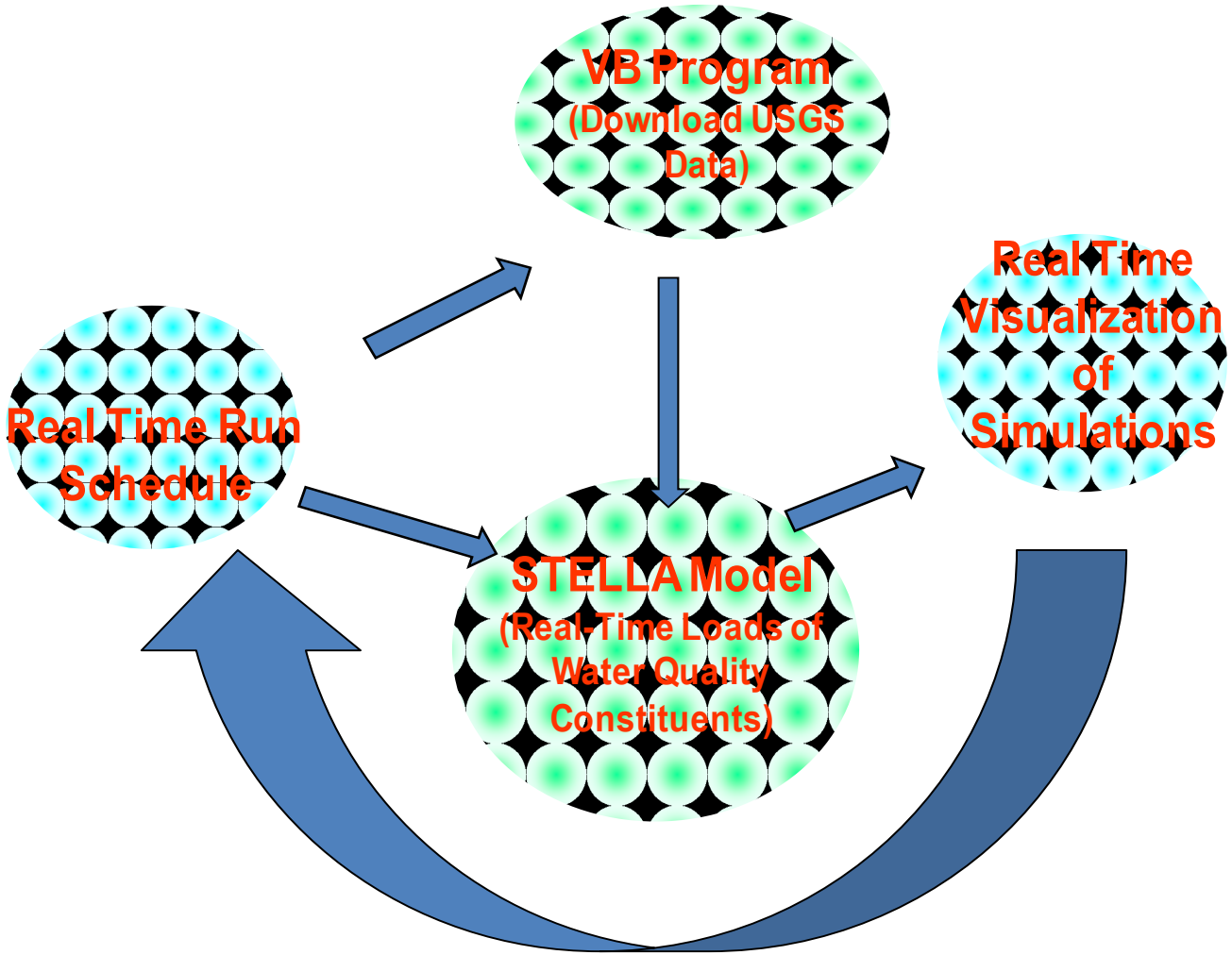
1. Several agencies have daily (non real-time) water quality data
2. USGS has real-time data for chlorophyll, TSS, watercolor and discharge
3. Obtain relationships from non-real-time data:

Chl a vs. P: $Y_p = aX_{chl\text{-}a} + b$; Watercolor vs. DOC: $Y_{DOC} = aX_{watercolor} + b$

Real-Time Prediction (indirectly):

Real-time variations and loads of N, P, DOC, and sediment in streams using the relationships and USGS real-time data

Approaches


VB Program
(Download USGS Data)
Real Time Run Schedule
STELLA Model
(Real-Time Loads of Water Quality Constituents)
Real Time Visualization of Simulations

Current Progress and Further Study

Ecological Engineering 37 (2011) 616–621

Contents lists available at ScienceDirect

Ecological Engineering

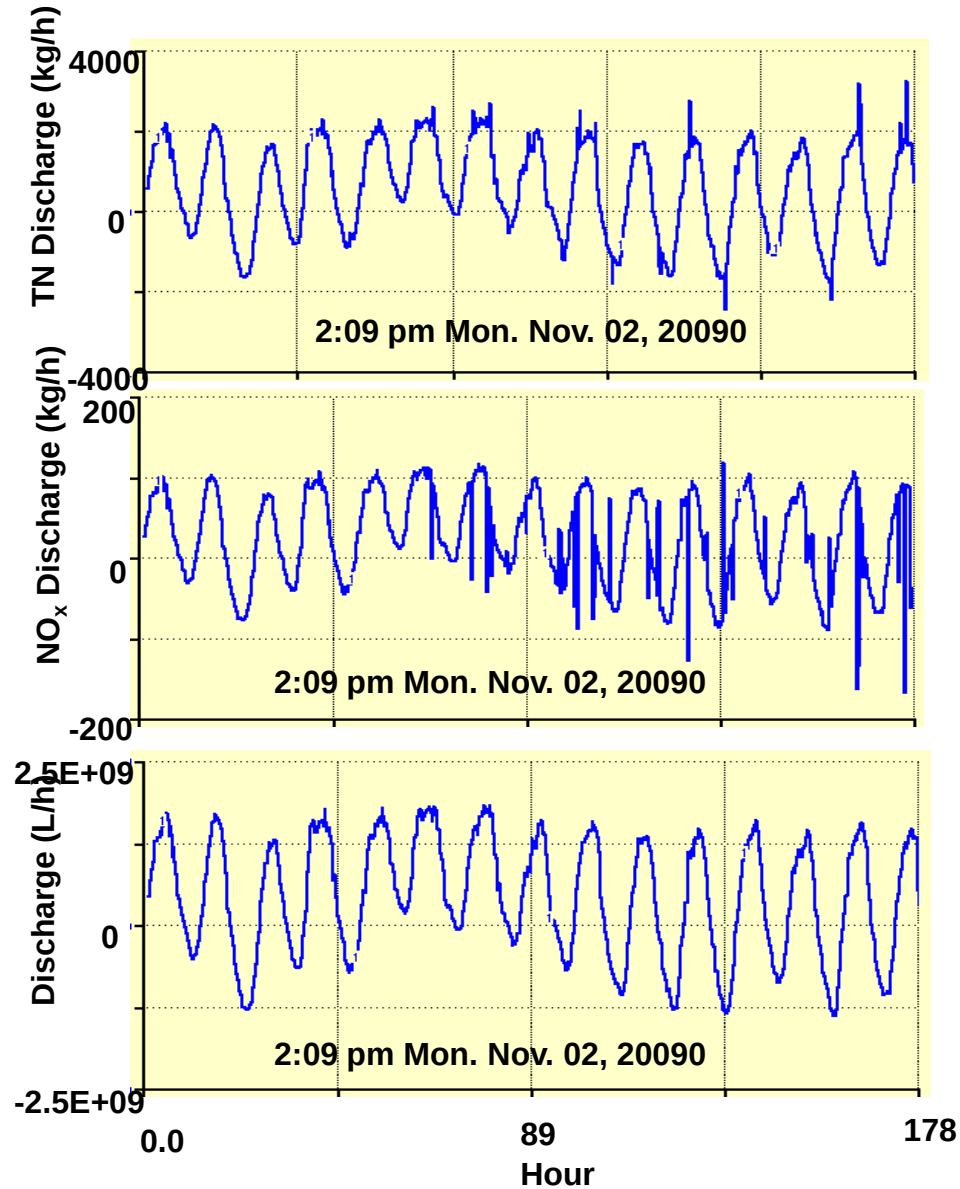
journal homepage: www.elsevier.com/locate/ecoleng

Estimation of real-time N load in surface water using dynamic data-driven application system

Y. Ouyang[a,*], S.M. Luo[b], L.H. Cui[b,c], Q. Wang[d], J.E. Zhang[b]

Further Study

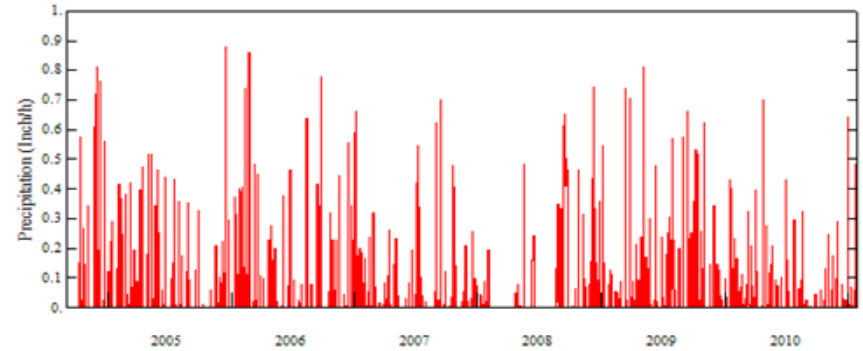
- **Real-time loads of sediment in rivers from the LMAV**
- **Real-time variations and loads of P and DOC in surface waters from southeast area**

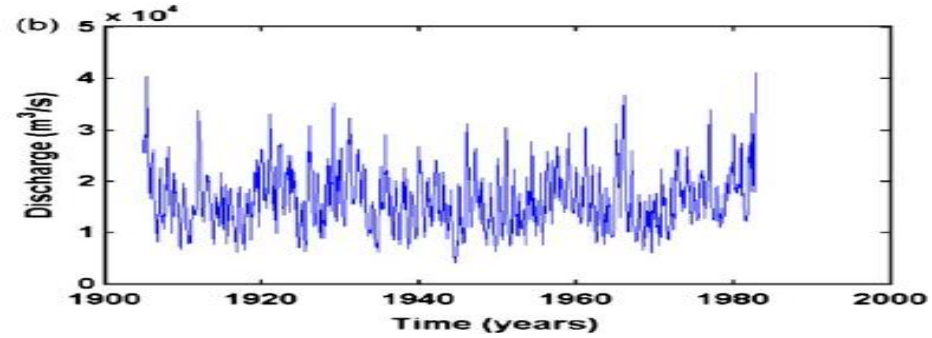


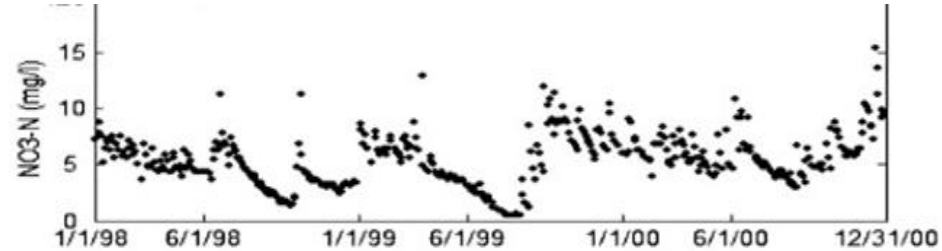
3. Identify temporal patterns of watershed hydrology and water quality using Wavelet Analysis

Rationale

- How does the climate change affect the characteristics of precipitation, river discharge, and water quality in a large basin?
- Duration curve and frequency distribution analysis
- Wavelet analysis

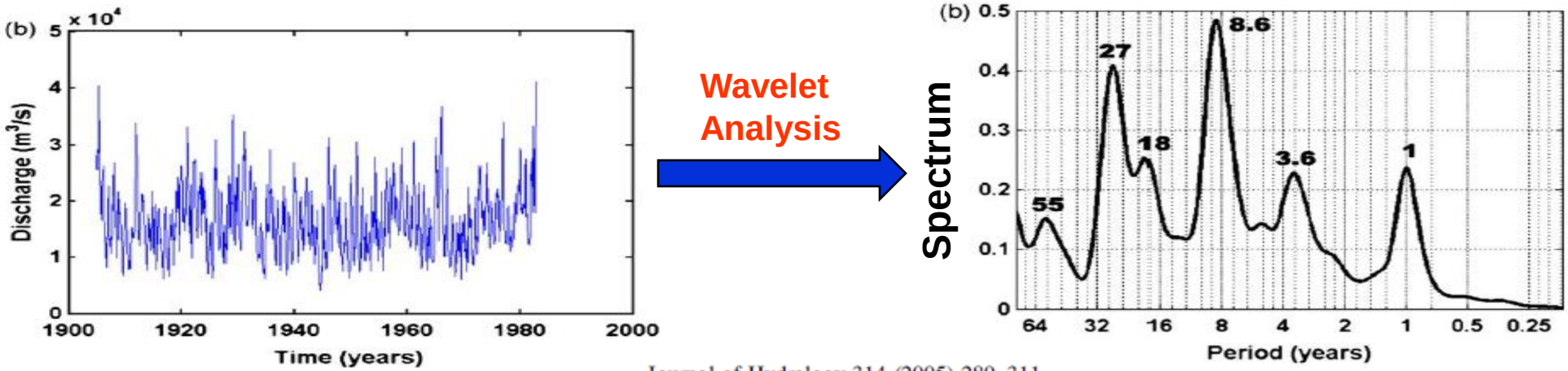






Wavelet Analysis

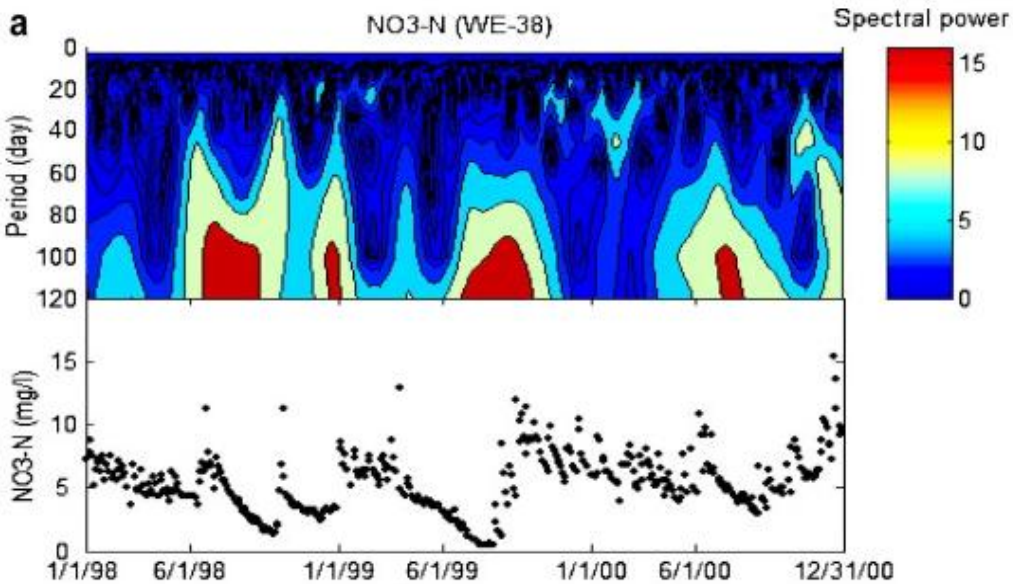
- **Wavelet analysis is a tool for analyzing time series (or signals) data**
- **Temporal patterns for hydrology (precipitation, stream flow, and water level), water quality, and CO_2 flux**
- **Signal analysis in medical science**
- **Better than Fourier Series analysis**



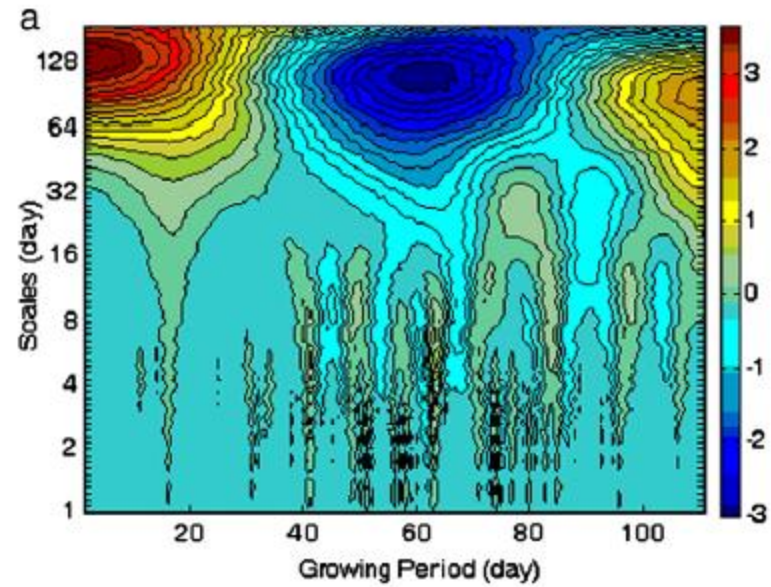
Journal of Hydrology 314 (2005) 289–311

David Labat[a,*], Josyane Ronchail[b], Jean Loup Guyot[b,c]

Wavelet Analysis



Kang and Lin, 2007; Journal of Hydrology, 338:1-14



Characterization of CO_2 and water vapor fluxes in a summer maize field with wavelet analysis

Zhong Qin[a], Ying Ouyang[b], Gao-li Su[c], Qiang Yu[d,*], Jun Li[d], Jia-en Zhang[a], Zhi-yi Wu[e]

ECOLOGICAL INFORMATICS 3 (2008) 397–409

Approaches

1. Obtain hydrology, water quality, and climate data for LMAV

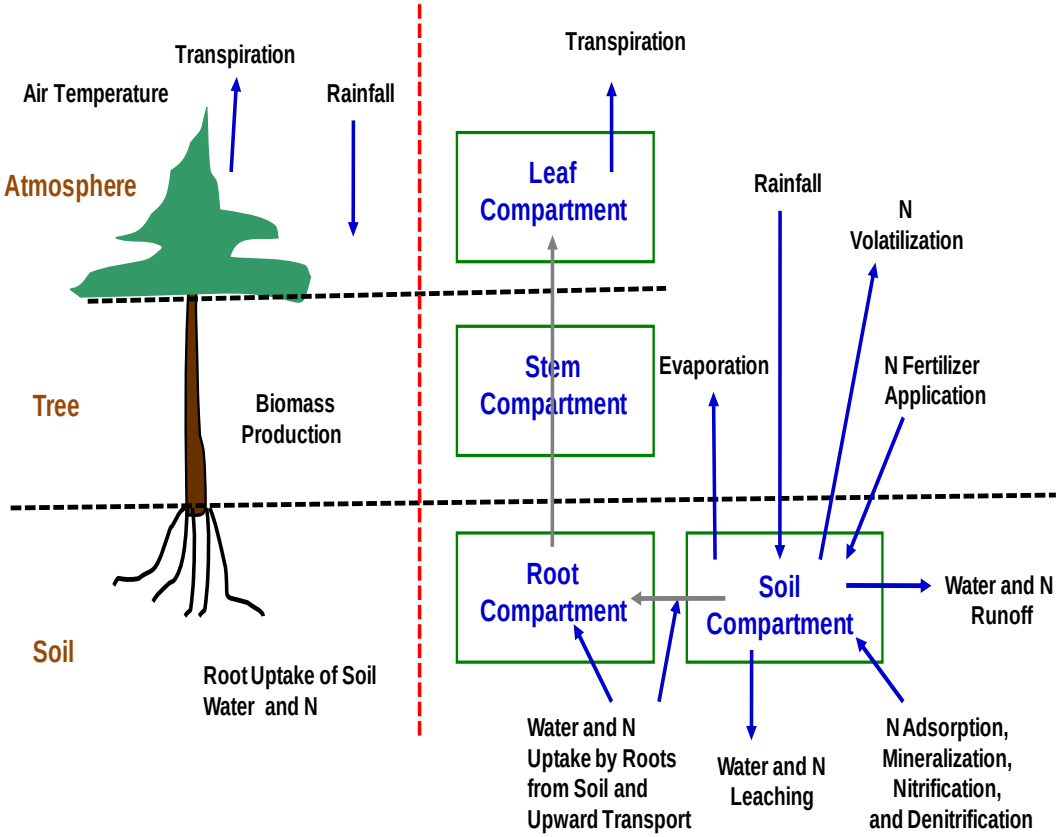
2. Perform Wavelet Analysis using MATLAB Wavelet Analysis Package

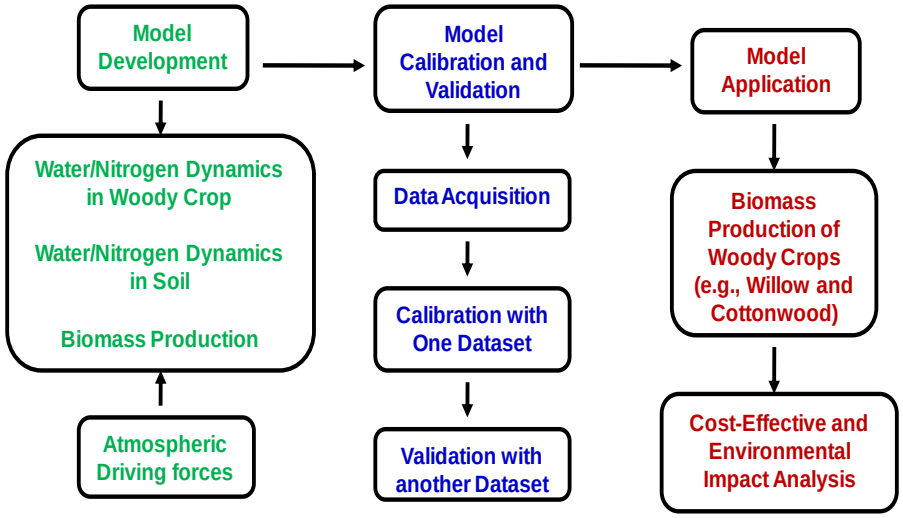
3. Identify temporal patterns of precipitation, temperature, river discharge, groundwater flow, and water quality

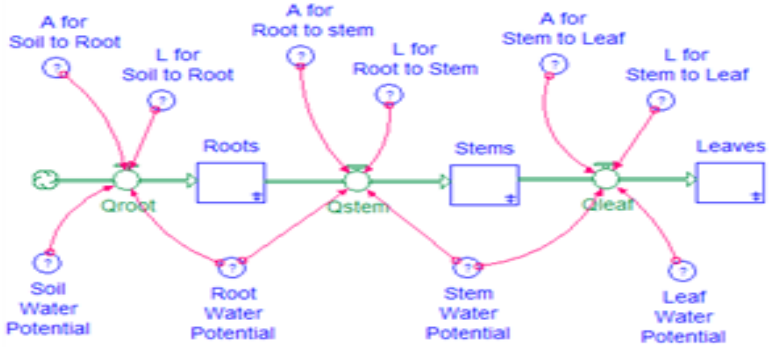
4. Relate the temporal patterns to climate change

Other Relevant Research Projects

1. Simulation of short-rotation woody biomass production in a soil-tree-atmosphere system with STELLA



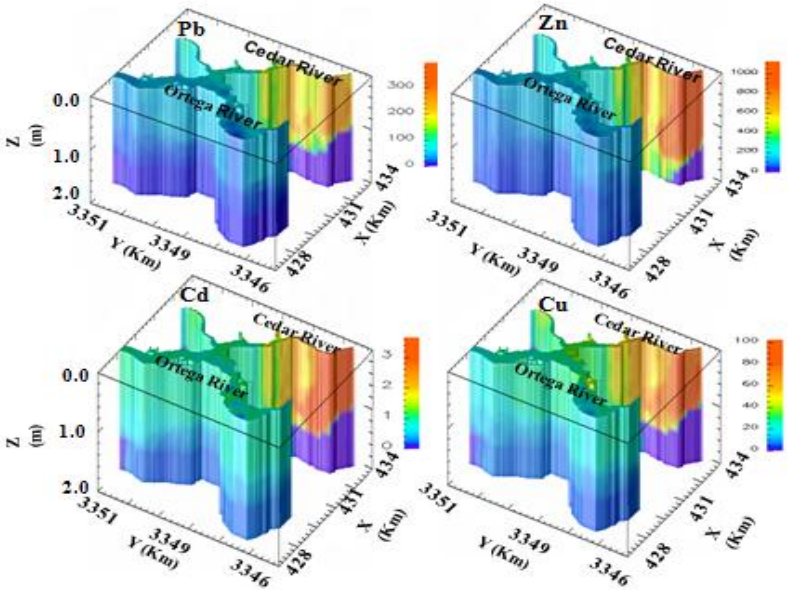




Other Relevant Research Projects

2. Determination of most important water quality, ecological, and environmental factors using Principal Component Analysis

3. Spatial Distribution of water quality constituents using 3D Kriging method



Summary

1. Estimate sediment and nutrient dynamics using BASINS-HSPF model
2. Monitor real-time variations of water quality constituents using DDDAS
3. Identify temporal patterns of watershed hydrology due to climate change using Wavelet Analysis
4. Other relevant research projects
5. Potential collaborations