Understanding Water-Human interaction through an Intelligent Digital Watershed: Initial development and Implementation

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Introduction

Why CNH?

- Human activity is intricately linked to the quality and quantity of water resources. Although many studies have examined human-water dynamics, the complexity of such coupled systems is not well understood.
- Do decision-makers understand the tradeoffs among economic return and environmental impact given alternative assumptions about the application of nutrients? Does such understanding change the way farmers manage the landscape or regulators set policies?

Objectives: Built framework of linked socioeconomic and biophysical processes:
1. Understand the connections that exist between the expanding biofuel economy, land management, and water quality impacts
2. Develop CI-enabled technologies to assist:
   - researchers transform data into knowledge about interrelated socioeconomic and biophysical processes
   - stakeholders transform data into more informed decision-making through an understanding of these processes
Modeled decisions are linked to an existing watershed simulation model to understand the impact these scenarios on indicators of water quality (nitrate, phosphate, dissolved oxygen)
Model management and analysis

Internet Information Server (IIS) -> Business Interface (Application-Programming Interface) -> Simulated (Graphical-User Interface) -> IDW User Input/Actions

HTTP Request -> IIS WebServer -> HTTP Response

User-Interface Layer/Presentation

Workstations, Laptops

IDW User Input/Actions
Examples:
- Run ABM Scenarios
- Run SWAT Scenarios
- Run ABM-SWAT Loops
- View and Save Scenarios
- Report & Visualize Results

Business Layer

Other Objects, SWAT Objects, CDI Objects, ABM Objects

Persistence Objects (ABM, SWAT), Metadata (ABM, SWAT Results & Operations), Other Data Objects, Scenario Results Data

Data Layer

Data Repository (SQL Server 2008)
Implementation: Prototype Clear Creek IDW

Study area:
- The Clear Creek watershed is a 267 km² HUC (Hydrologic Unit Code) 10 units located in east-central Iowa.
- Approximately 85% of the land cover in the watershed is agricultural or grassland, 8% is forest, 6% is roads or urban, and the remaining area is water or barren (Iowa DNR 2008).
Agent Based Model (ABM):

Agent-Based Model (ABM) is a cyber-enabled approach of simulating the actions and interactions of heterogeneous autonomous agents in complex adaptive systems (CAS) such as a land-use system (Bennett and McGinnis, 2008). Agents in the system make decisions and behave based on specific decision-making heuristic, learning and adaption rules.

**ABM of farmers’ decision on:**
- Crop: corn, soybean, corn & stover, switchgrass, CRP (Conservation Reserve Program)
- Tillage: conventional, mulch, no
- Fertilizer application: N, P, K
- Decision rules: Profit/Utility maximization subject to environmental constraints

**Exogenous variables:**
- Market prices for commodities, fuel, and fertilizer
- Policies about conservation practices and biofuels
- Weather scenarios
To better define “agents” we surveyed rural residents of Clear Creek Watershed.

Questions on biofuel production:

38. Do you sell any of your corn to an ethanol plant?  Yes  No
39. Have you ever invested in the ethanol industry?  Yes  No
40. How knowledgeable are you about the harvesting and marketing of Corn stover (stem residue) (not at all knowledgeable)
   | 1  2  3  4  5 (very knowledgeable)
   Switchgrass (not at all knowledgeable)
   | 1  2  3  4  5 (very knowledgeable)
41. In 2009, did you harvest and sell any corn stover?  Yes  No
42. In the past 5 years, have you harvested or hired someone to harvest your hay?  Yes  No  No hay harvested in past 5 years
43. How much did you spend on a special insurance to cover the risk of a wind storm?  What are the costs of using a crop insurance to handle the delivery of feed?

Clear Creek Watershed

2010 Agricultural Land Survey
Issue of HRU and CLU scales:

How to map them to bring in same scale?
Building a CLU based modeling framework for ABM-SWAT multimodel simulation

- DEM
- Initial HRU and all other configuration files created by ArcSWAT Interface
- Land use map (IDNR)
- Rebuild HRU and other files based on CLUs
- Soil (SSURGO)
- Climate data (NCDC)
- Incorporate crop rotation, land use, Soil, management operations, fertilizer application and other data Coming from ABM

Execute SWAT2005

HRU CLU conversion algorithm

Old HRUs

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New HRUs

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Prototype Clear Creek IDW

Scenario selection

Agent Based Model (ABM) Process

- ABM Scenario Type:
  - Select Scenario
    - Market
    - Policy
    - Climate
  - Scenario Values:
    - M1 (Market)
    - P1 (Policy)
    - C1 (Climate)

ABM Simulation Input Files:

1. Price Info File: [Browse]
2. Parcel Info File: [Browse]
ModelBase schema:
Visualization in IDW: Market scenario

Choose price year
Multi model simulation steps:
Multimodel simulation and Visualization:

Multimodel simulation visualization at different scales: Watershed, Subwatershed, Reach and CLU
Expected outcomes:

The IDW should also be able to:

- Find all scenarios that result in water quality that exceeds a user specified threshold level
- Find all scenarios that result in economic return exceeds a user specified threshold level

And help answer such questions as:

What characteristics do the scenarios that meet environmental and economic goals have in common?

Under alternative scenarios

- What agricultural land use patterns will emerge in the Clear Creek Watershed
- What is the likely impact of this land use pattern on water quality in the Clear Creek Watershed
- What is the likely impact of this land use pattern on economic return from grain and biofuel crops production in the Clear Creek Watershed
Thank You

For your kind attention
Have a question?

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