Developing and Applying Next-Generation Watershed Models Using OMS

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Object Modeling System (OMS)

Initial Goal:

A computer framework and a library of modules that facilitates the assembly of a modular modeling package, specific to a region, problem, data constraints, or scale of application

Now: being extended as an application and delivery platform

Developed in collaboration with:

NRCS, USGS, Colorado State University,

Friedrich-Schiller University, Jena, Germany ++

Advantages of OMS

- Supports building of new models and decision tools from a library of reusable components.
- Uses the best or most appropriate science for each component.
- Improves code quality. Easier to follow by other modelers and pass on to the next generation.
- Makes long-term maintenance and update of models easier and less costly.
- Eliminates duplication of work by modelers. The library of modules serves as a reference and a coordination mechanism for future research and model improvements.

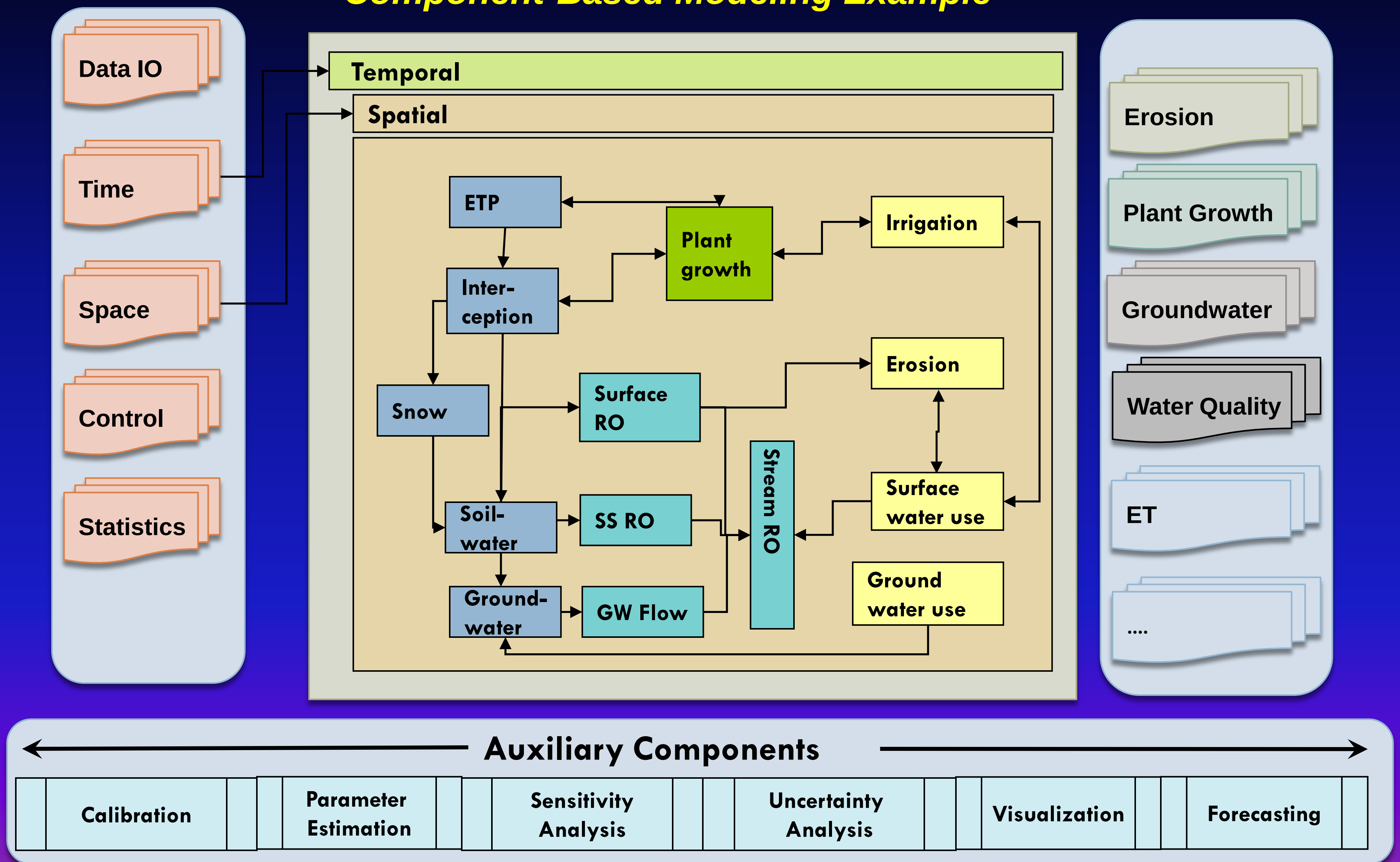
Advantages of OMS

- Streamlines model building and applications. Reduces IT integration challenges for researchers.

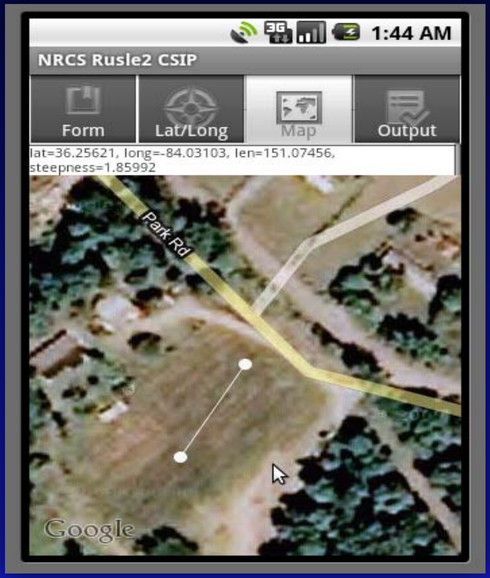
- Enhances deployment of new tools by action agencies (NRCS) with established databases.

OMS Principal Architecture

Component-Based Modeling Example

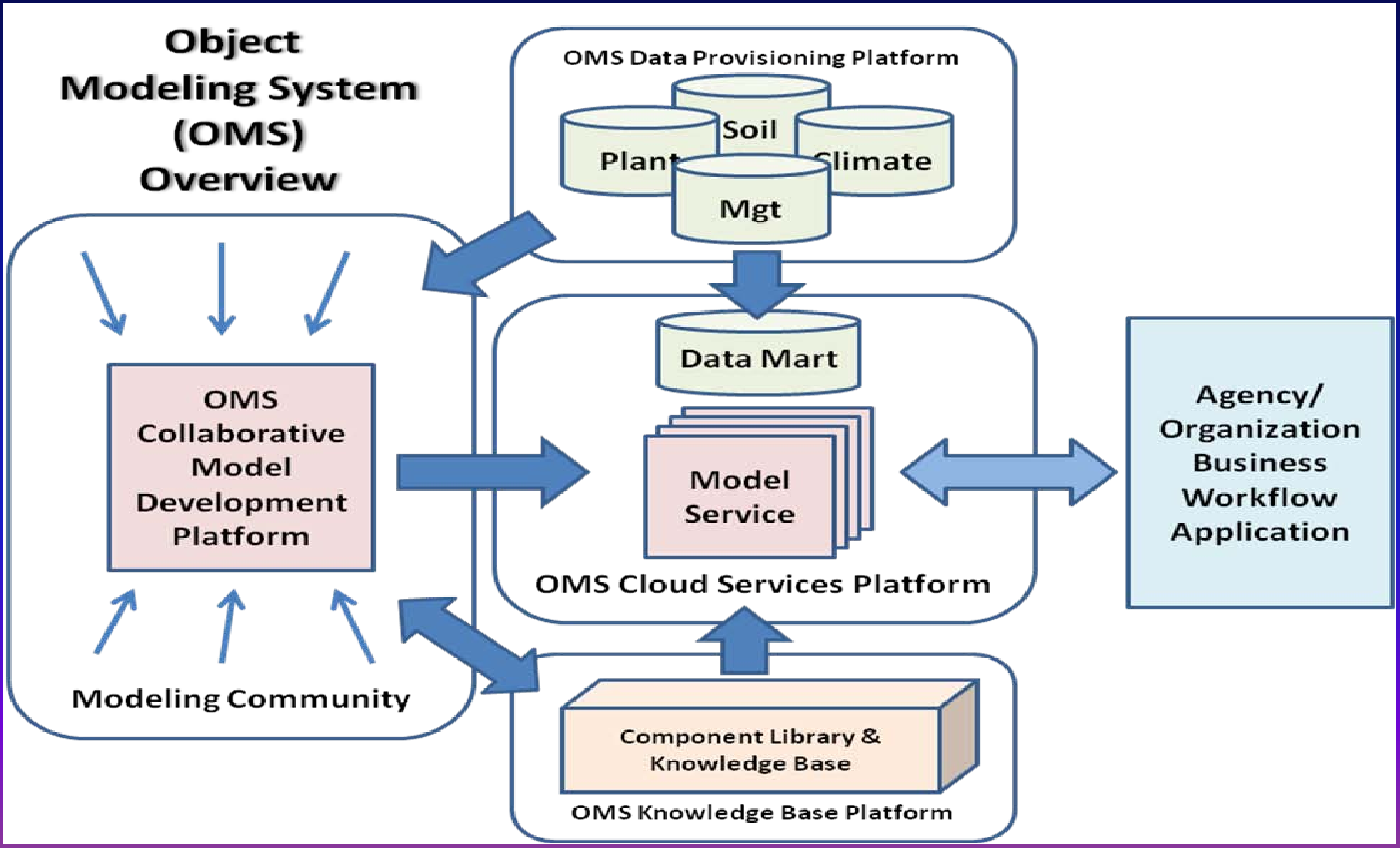


Cloud Services Innovation Platform (CSIP) for Remote Applications of Models



- Implement Modeling Infrastructure that is:
  - Cost effective (→ Cloud)
  - Highly interoperable
  - Component-based (→ OMS3)
  - Computational scalable
  - Scalable for data (→NoSQL)
- Prototype Selected Models Via CSIP
  - RUSLE2, AgES-W, …

The OMS Greatly Facilitates the Development and Use of Models and Conservation Tools by Action Agencies



A Next-Generation, Process-Based AgES Model for Delivering Precision Conservation at Landscape and Watershed Scales

- 130+ components selected from J2000, SWAT, WEPP, RZWQM, and other models

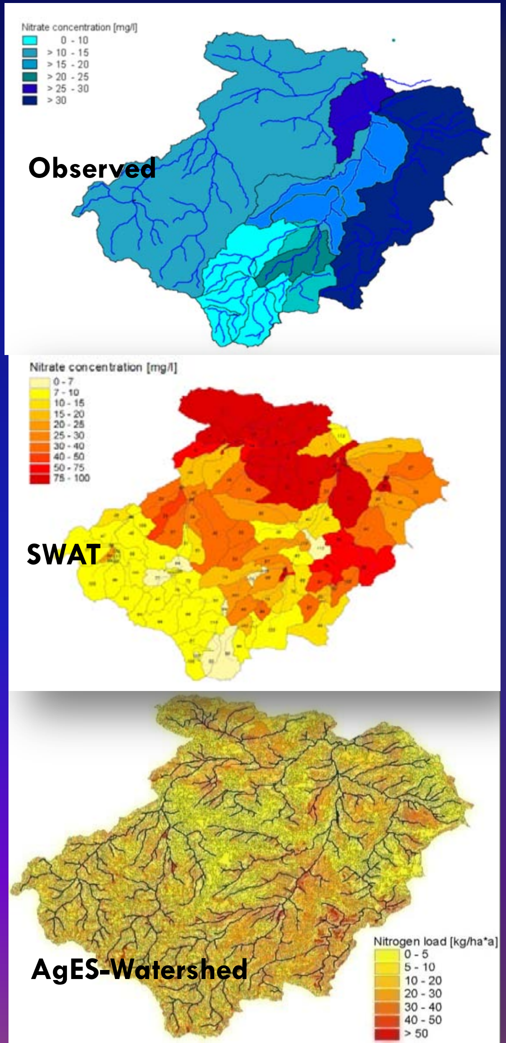
✓RUSLE/MUSLE/WEPP erosion

✓Updated water & N Dynamics for soil/groundwater/stream

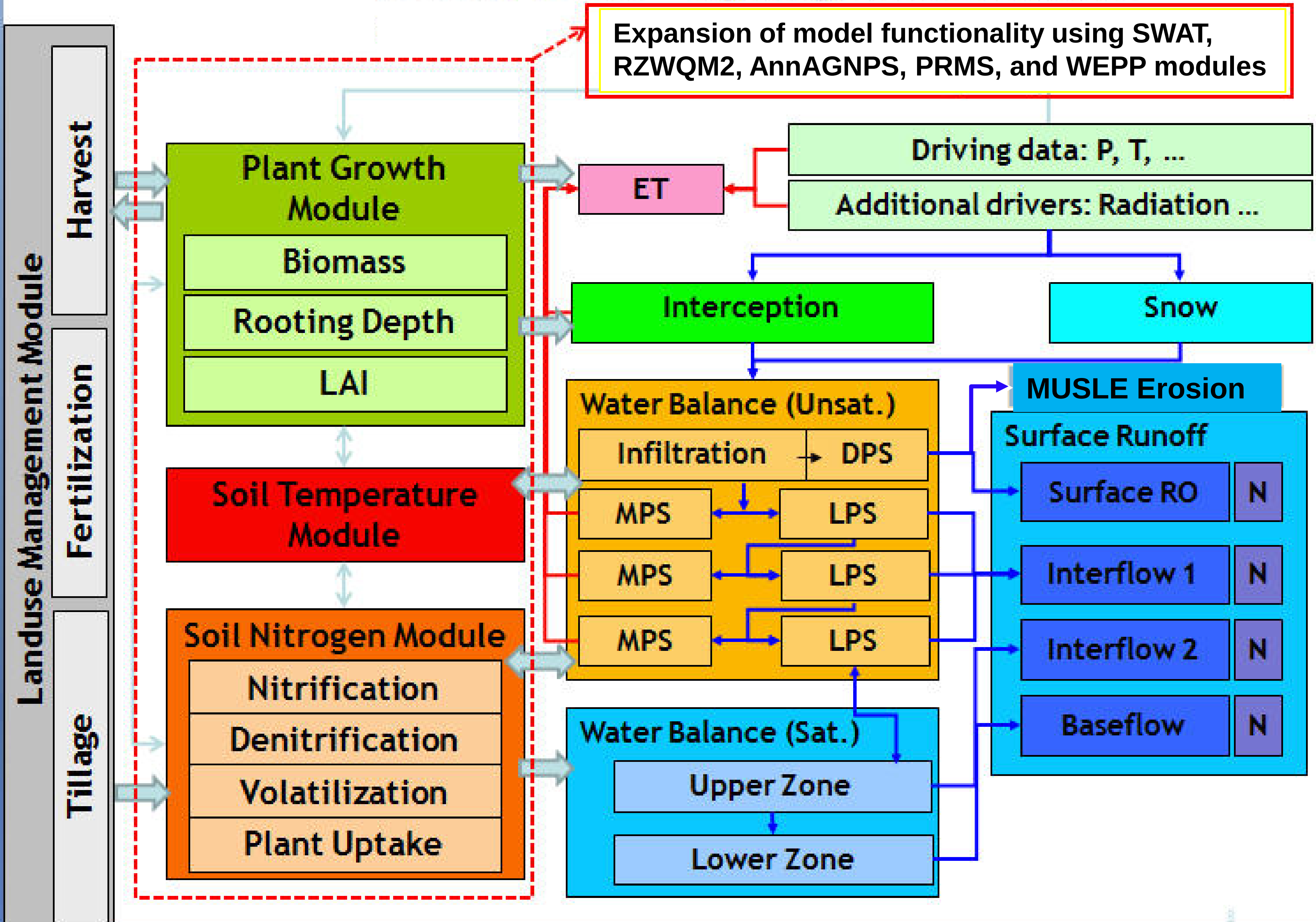
✓Land use/tillage management

✓Tile drainage

✓Crop production, economics!

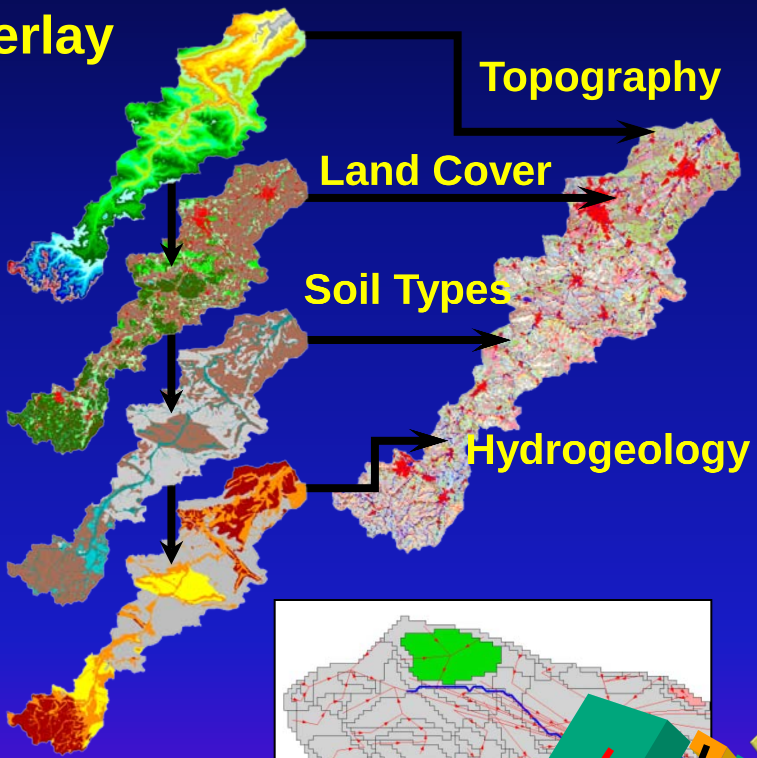


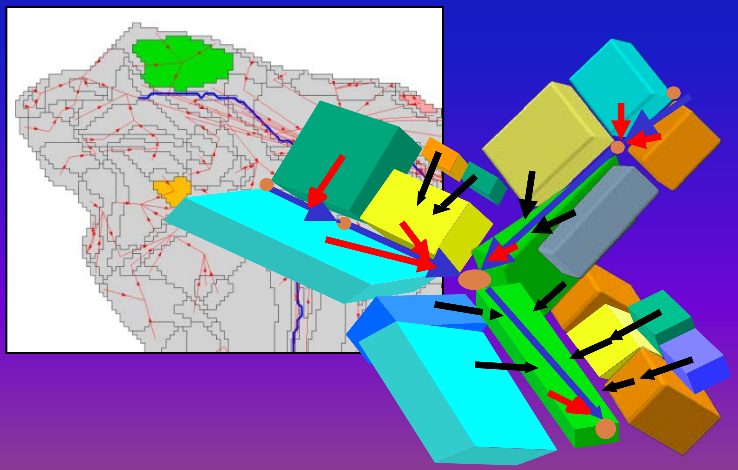
AgES Watershed Model



Hydrologic Response Units in AgES

Delineation Based on GIS Overlay

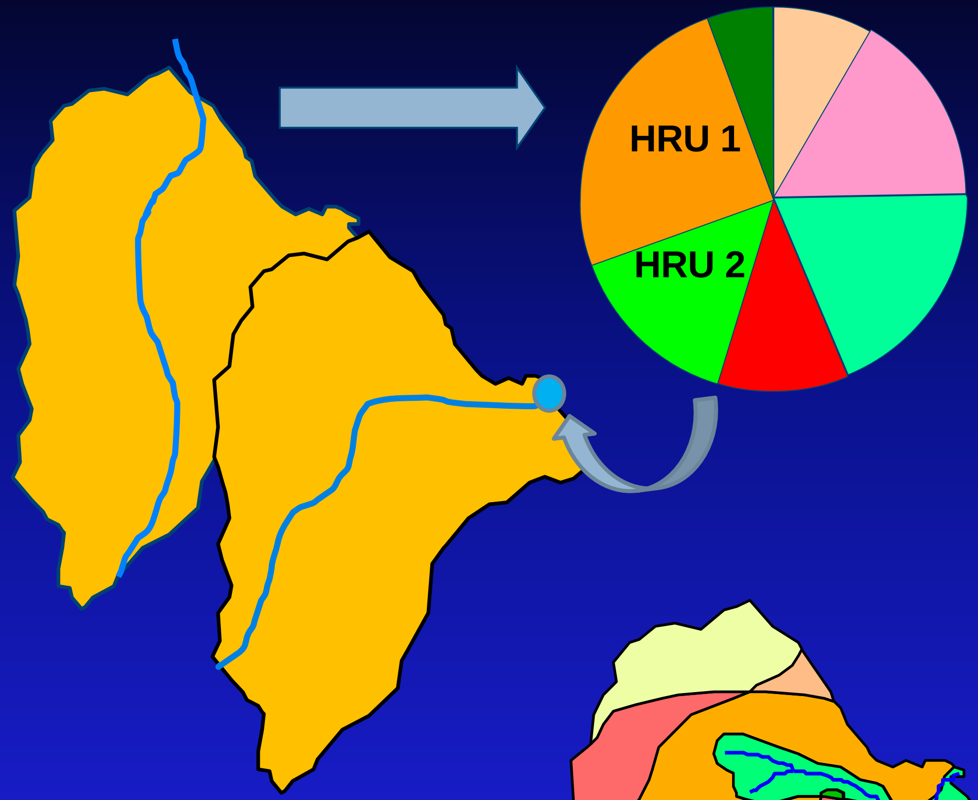




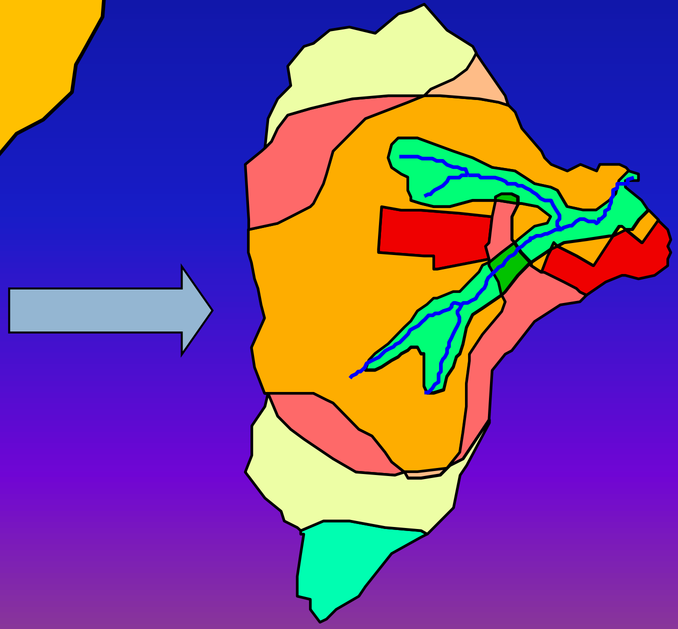
- **This process-oriented classification of catchments does not lose any important information**
  - **Combined with a <u>topological routing scheme</u>, vertical and lateral processes can be modeled fully distributed by HRUs**

AgES Compared to SWAT Model

- The semi-distributed SWAT concept averages HRU information within a sub-watershed
- Important processes, e.g., lateral water /nutrient transport, and specific management and conservation effects cannot be simulated for individual HRUs

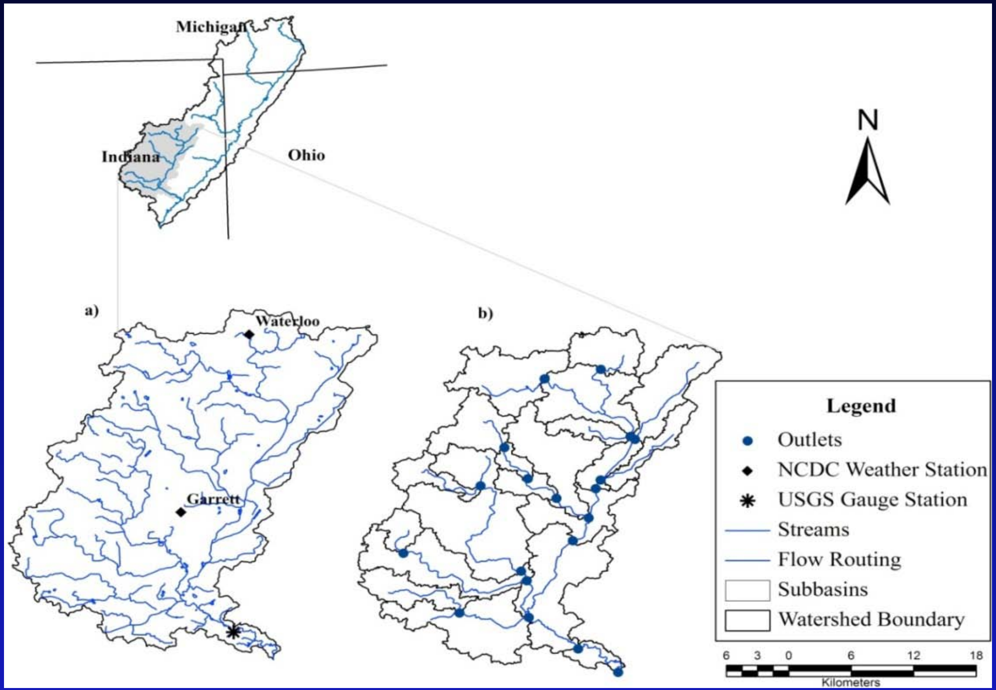


The fully distributed AgES Watershed Model contains updated state-of-the-science code and allows distributed simulation of important processes by HRUs

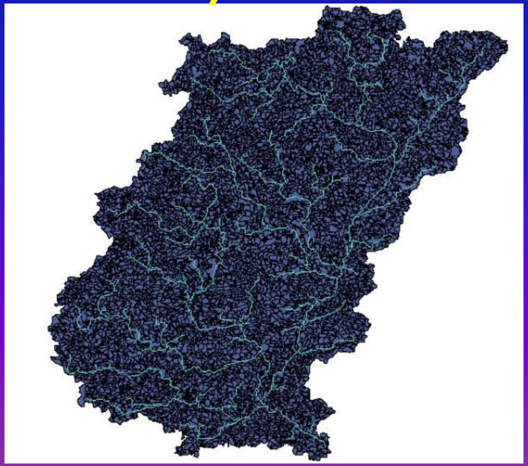


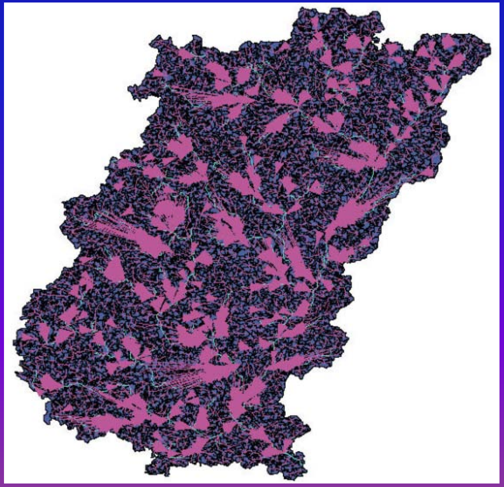
AgES Hydrological and Water Quality Modeling - Cedar Creek Watershed, IN

- Cedar Creek Watershed (CCW), Indiana
  - Basin area: 707 km^2
  - Avg. precip: 900 mm (35”)
  - 76% of watershed agricultural, 21% forest, 3% urban
- GIS Inputs:
  - 30 m DEM (USGS)
  - STATSGO and SSURGO soils (NRCS)
  - Land use (NASS 2001)



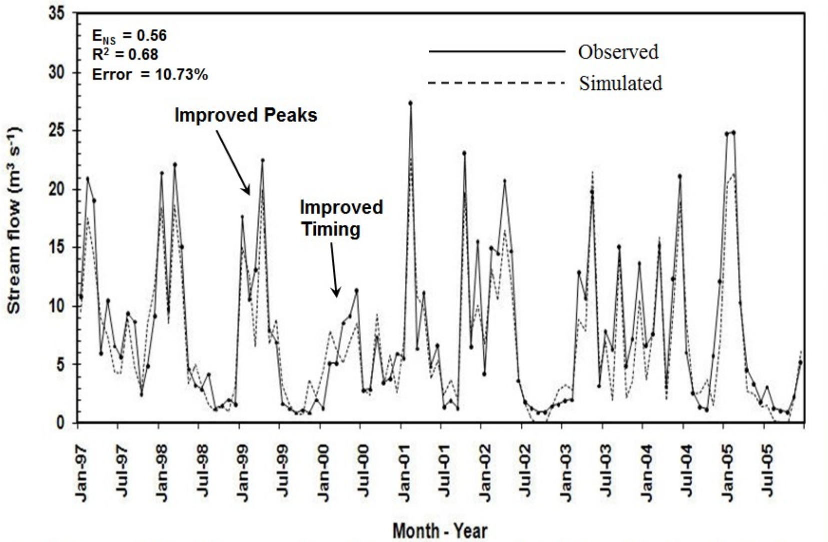
HRU Delineation





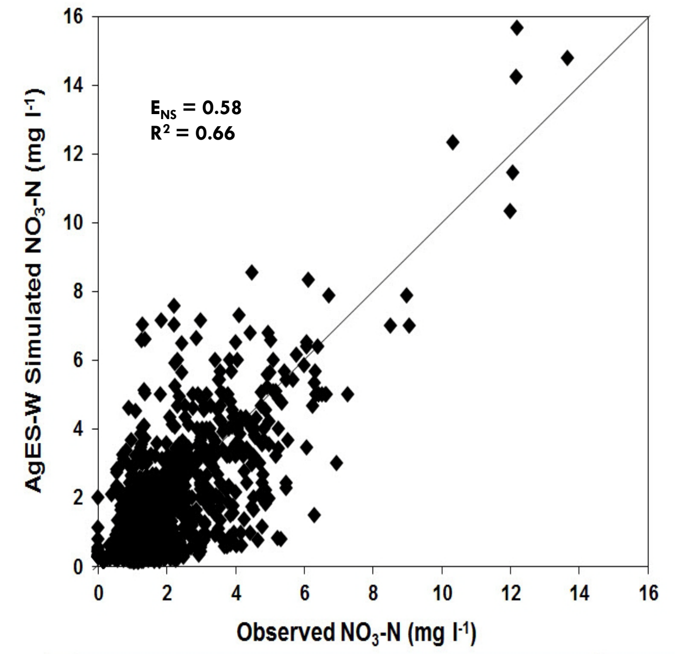
Flow Topology

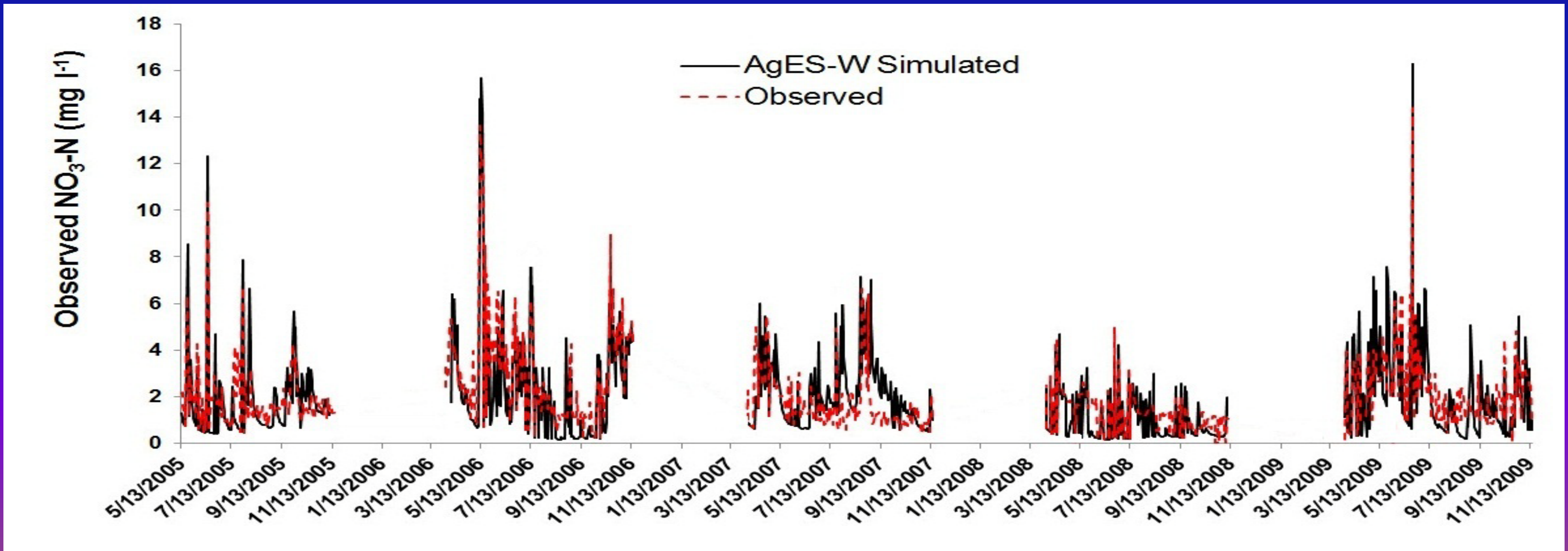
AgES Evaluation



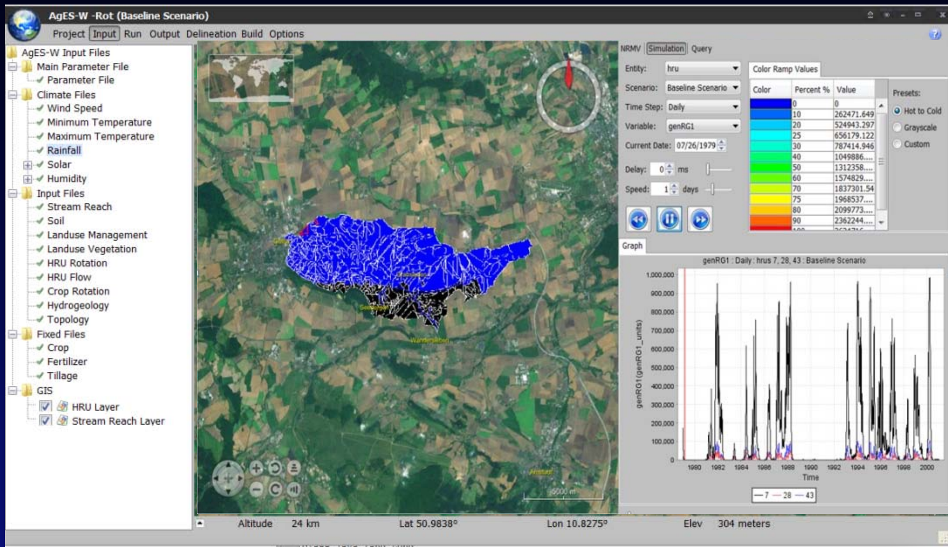
CCW monthly observed and AgES Watershed Model simulated stream flow (1997-2005) using a manually calibrated parameter set

Current AgES-W focus is on evaluating N and sediment (MUSLE erosion) components

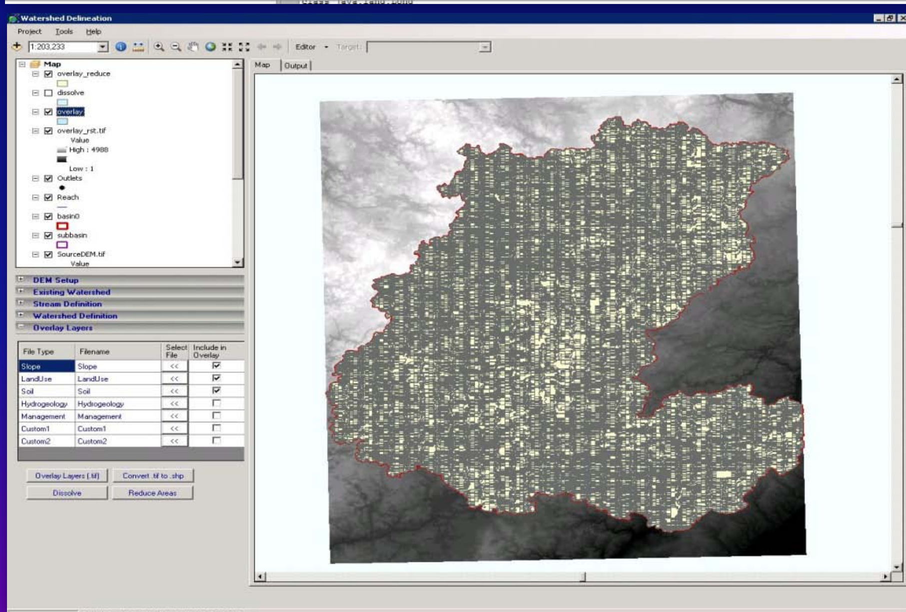


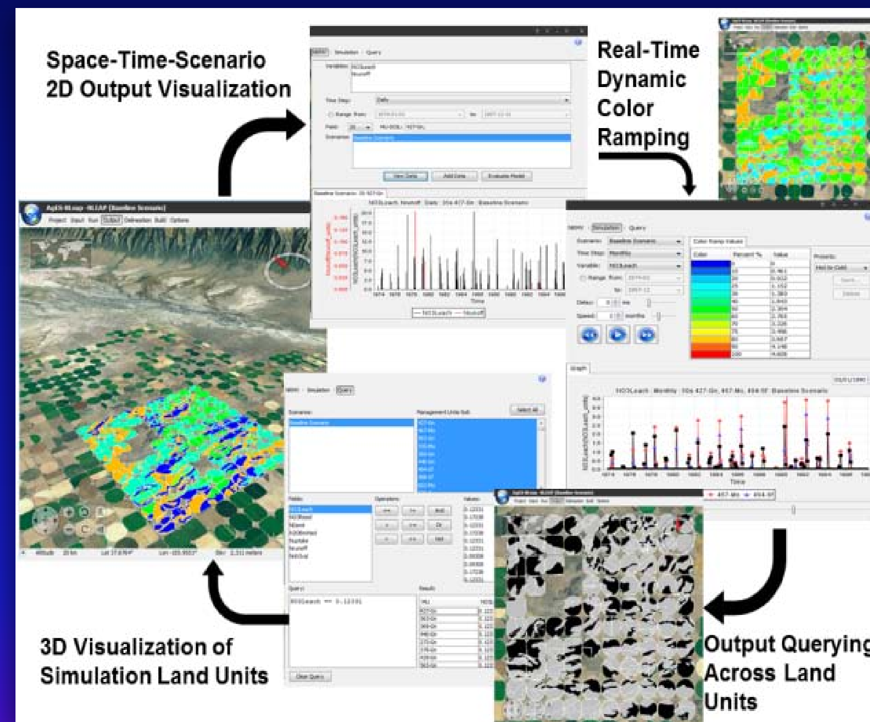


AgES Auxiliary Tools



AgES GUI (NASA WorldWind™)





Natural Resource Model Visualizer (NRMV) Tool

ArcGIS 10 Watershed Delineation Tool

AgES Future Research (2011-2015)

Objective 1: Further develop and apply AgES-W to evaluate the long-term effects of management on water quantity/quality and production in Colorado and the Midwest

Objective 2: Evaluate effects of spatially targeted conservation effects on water quantity/quality;

Objective 3: Evaluate the effects of projected climate change on water use, water quality, and production; develop potential adaptations

GPFARM-Range Functions

- **Forage Crop Growth**

  Simulating biomass production of cool season grasses, warm season grasses, legumes, shrub, and forbs with animal grazing.

- **Animal Production**

  Simulating animal weight gain/loss.

- **Hydrology**

  Crop ET, soil water, runoff, and seepage.

- **Carbon-Nitrogen Cycling**
- **Climate Change**

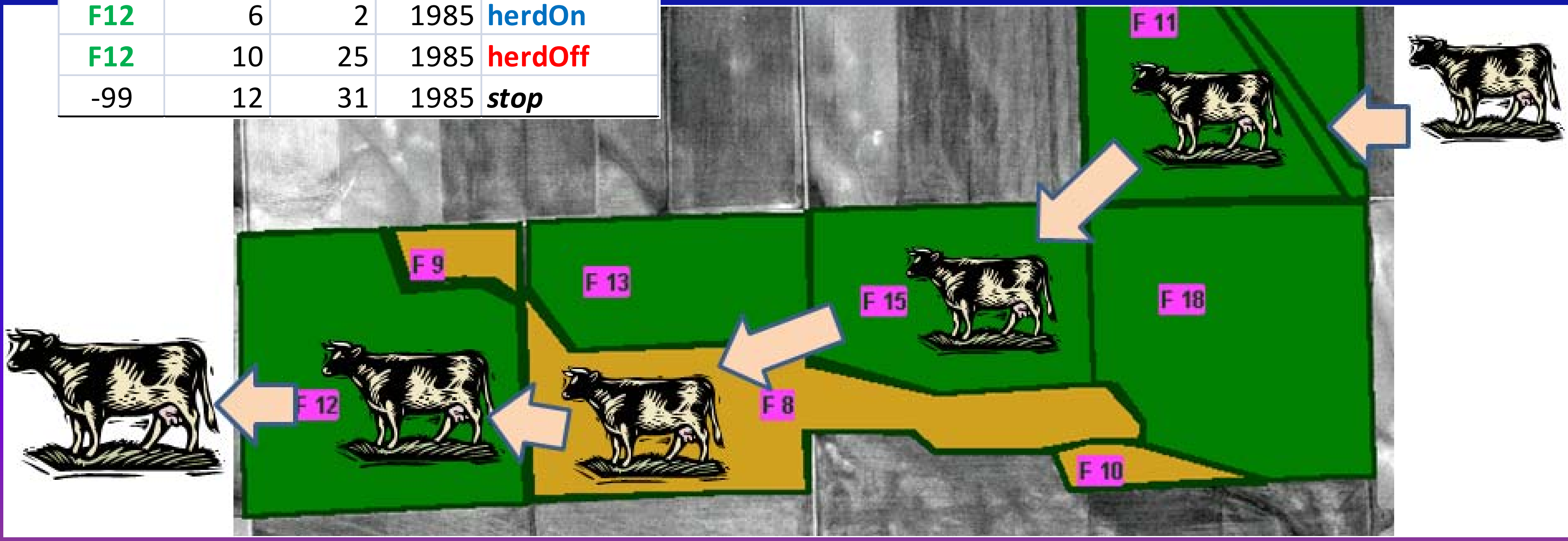
  CO_2 impacts on forage growth, response of crop and CN to temperature and rainfall.

GPFARM-Range to Manage Herd size and Grazing Intensity on a Landscape

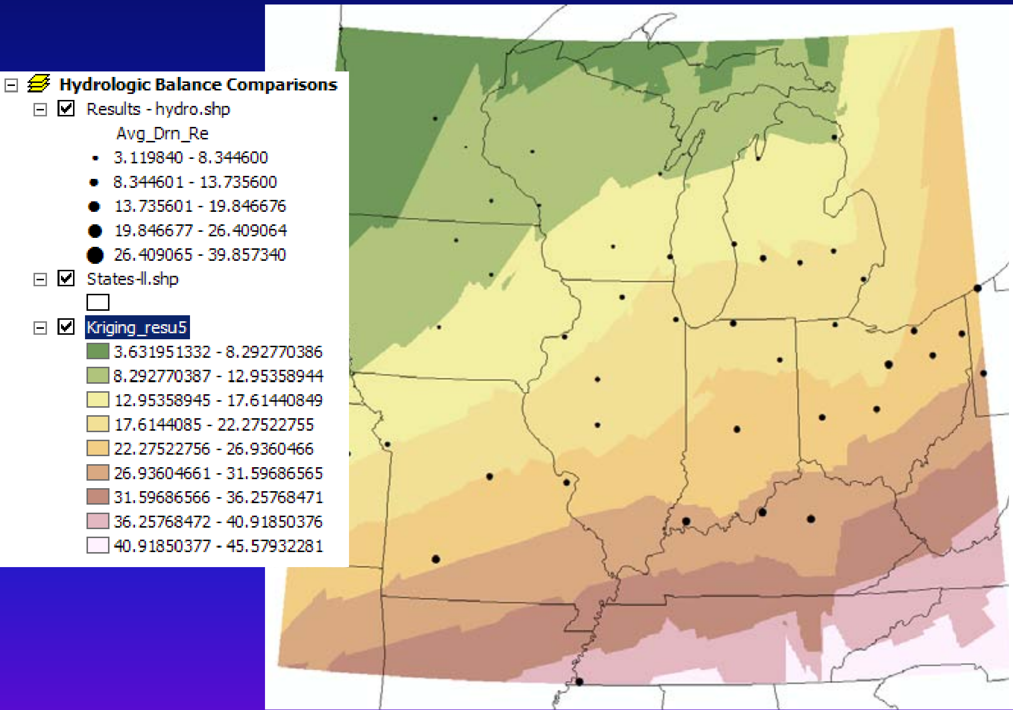
Event Tab

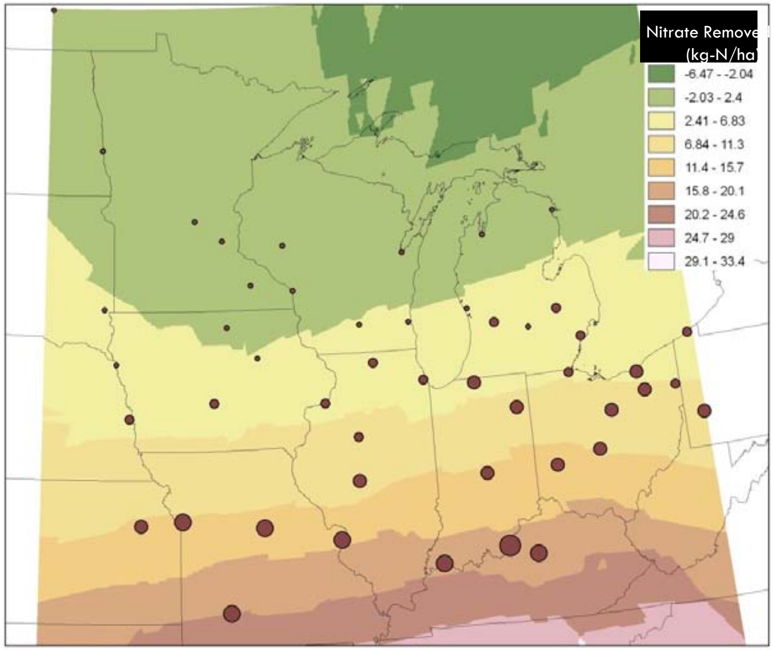
MUId	Month	Day	Year	eventType
-99	1	1	1982	***start***
F11	5	4	1982	**herdOn**
F11	10	20	1982	**herdOff**
F15	3	1	1983	**herdOn**
F15	11	15	1983	**herdOff**
F8	5	10	1984	**herdOn**
F8	10	31	1984	**herdOff**
F12	6	2	1985	**herdOn**
F12	10	25	1985	**herdOff**
-99	12	31	1985	***stop***

- **Can simulate 10 paddocks and rotational grazing**



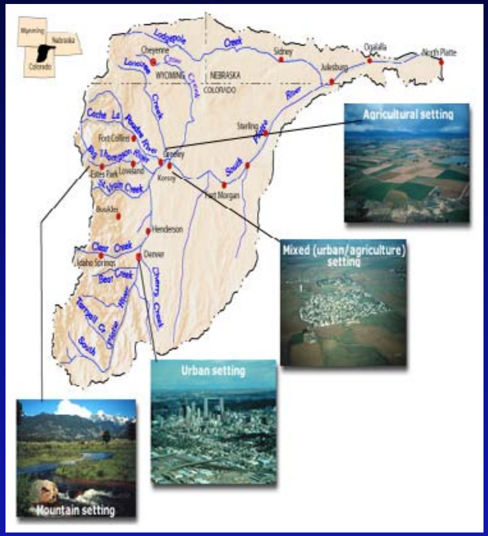
RZWQM calculated annual nitrate reduction (kg N/ha) in tile water by "Controlled Drainage" (left) and "cover crop" (right) in the U.S. Midwest- Regional scale





SUMMARY

- OMS-based AgES and GPFARM-Range represent next generation models that can be customized to deliver system-based, site-specific precision conservation.
- Identify/deliver spatially targeted conservation.
- Allow fast remote applications via smart phones and ‘CLOUD COMPUTING.’
- Provide uncertainties and economic risk associated with conservation effects.
- Allow quick updates with improved model components and new management options, contributed by experts world-wide.
- Use common quality data and analysis tools.



Thanks Very Much for Your Attention!

We Seek Your Thoughts!