# Nutrient Modeling Overview

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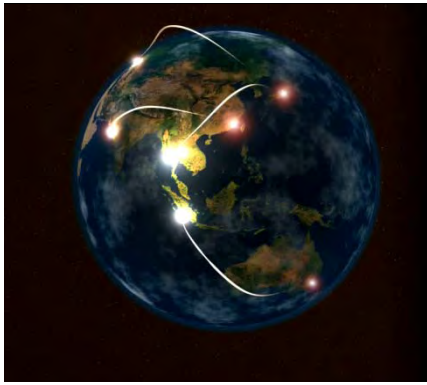
# Overview

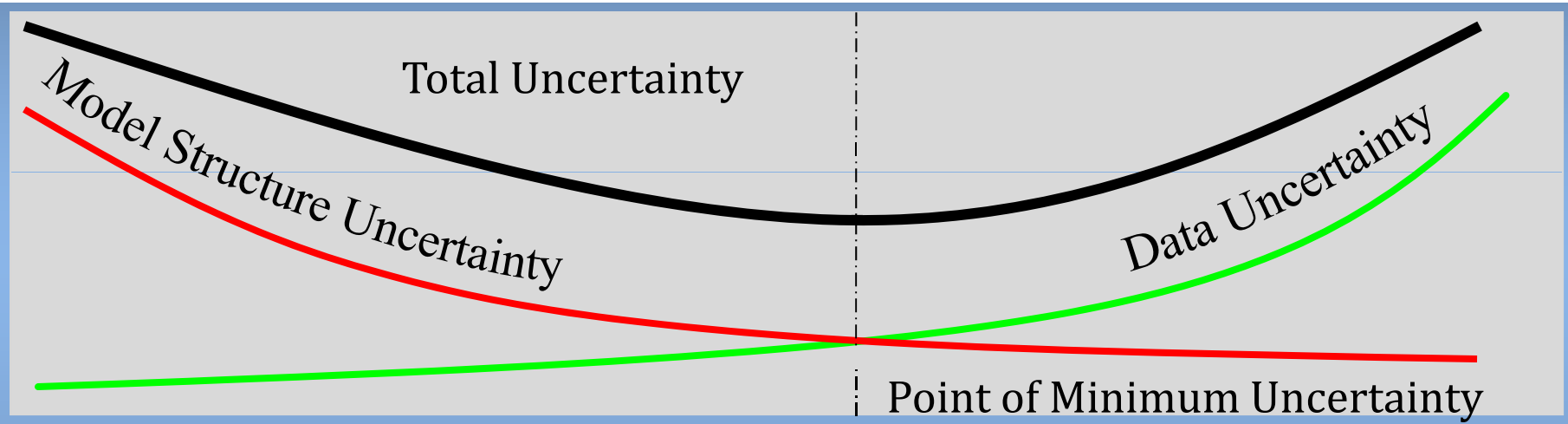
- Role of models in watershed management
- A simple continuum of model types
- Complexity and uncertainty
- Review of a few commonly used models
- Case study



# Model Application

- The implication of changing land use and climate
- The implication of anthropogenic activities
- Urban water management
- Nutrient trading
- Emerging contaminants
- Analysis of alternative management scenarios and policy

# Model Continuum

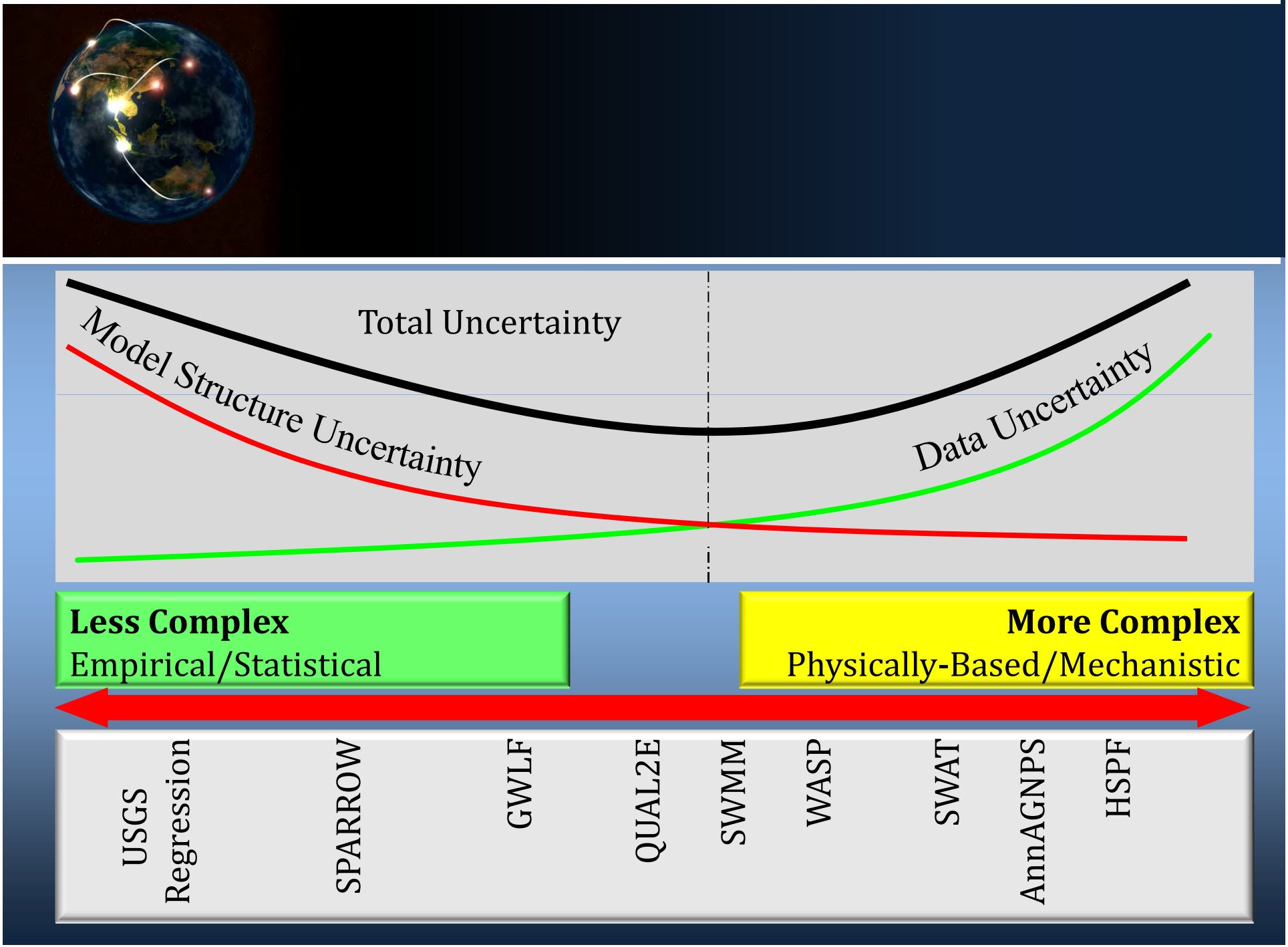


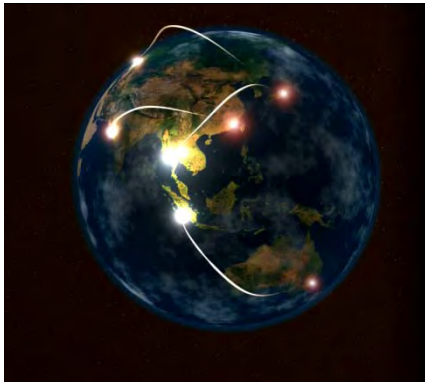

**Less Complex**
Empirical/Statistical

**More Complex**
Physically-Based/Deterministic

Less Data Intensive
Rigid
Trend Analysis

More Parameters
More Data Intensive
Flexible
Process Specific Analysis

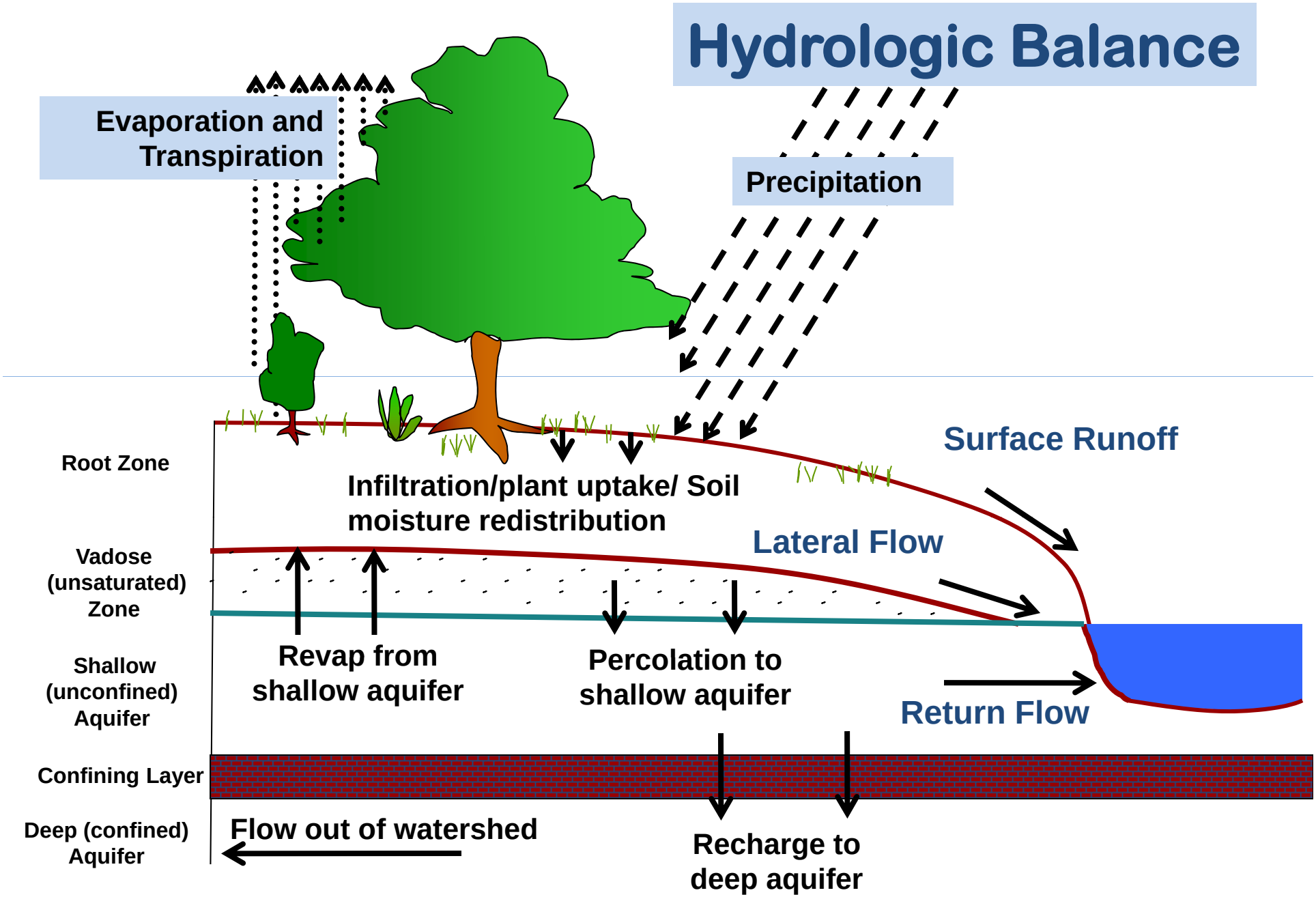

Total Uncertainty
Model Structure Uncertainty
Data Uncertainty
Less Complex
Empirical/Statistical
More Complex
Physically-Based/Mechanistic
USGS Regression
SPARROW
GWLF
QUAL2E
SWMM
WASP
SWAT
AnnAGNPS
HSPF



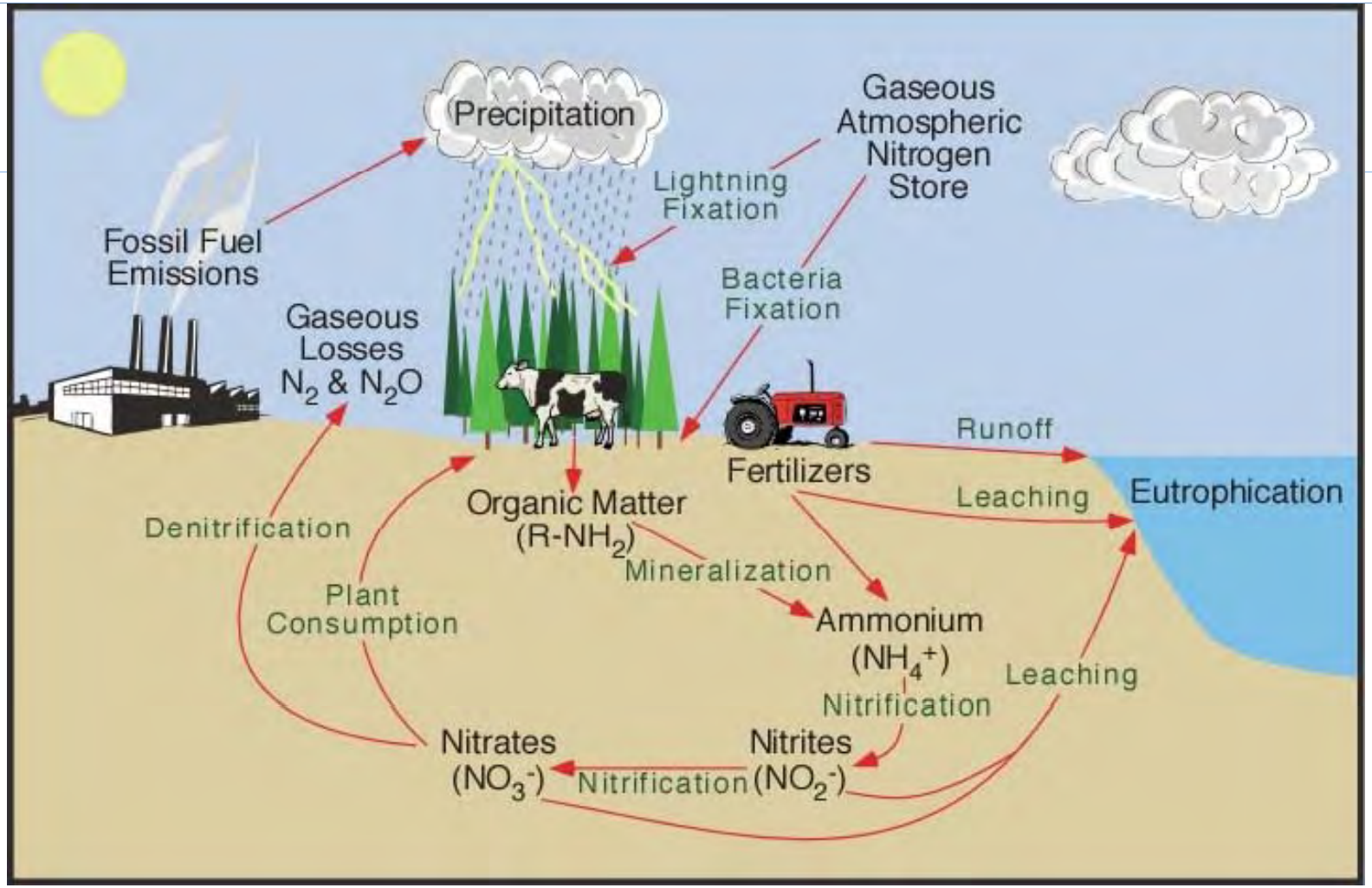
# Important Considerations in Selection of A Model

- Type  of analysis: trend analysis or process details
- Critical hydrologic and water quality processes

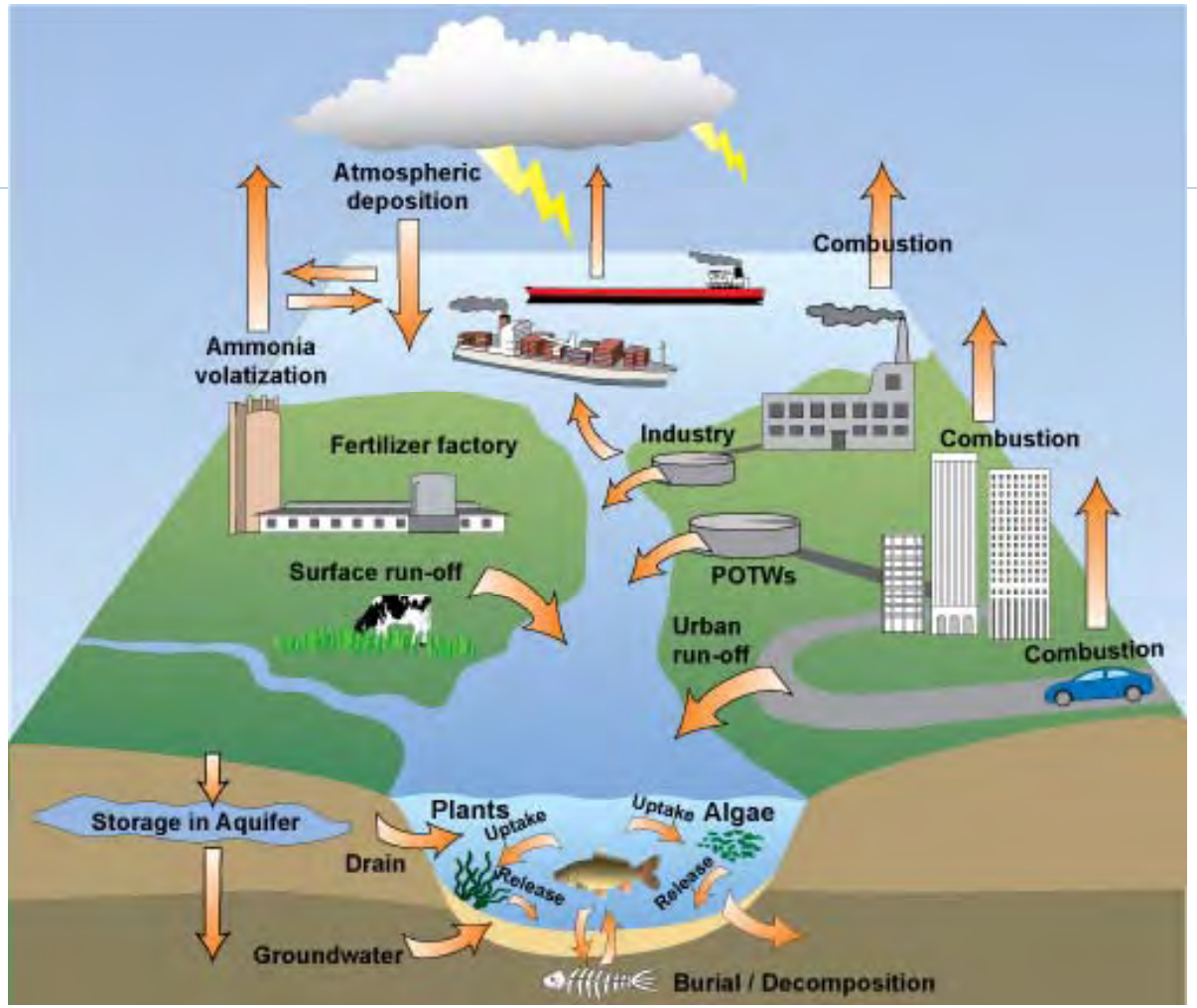
# Hydrologic Balance

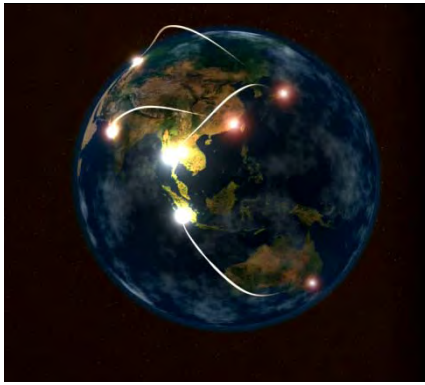


# Upland Processes



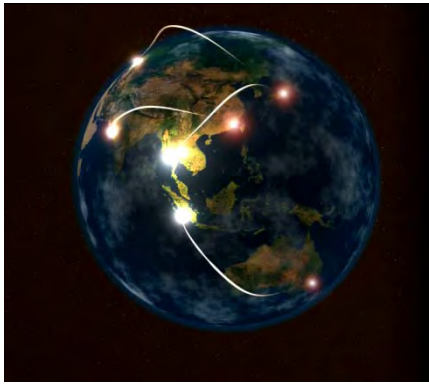
# In-Stream Processes & Point Sources





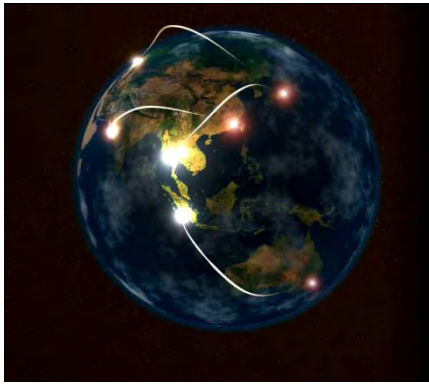
# Important Considerations in Selection of Models

- Type of analysis: trend analysis or process details
- Critical hydrologic and water quality processes
- Time-step: hourly (or less) to annual, storm event, steady-state
- Spatial scale: field-scale versus watershed scale
- Lumped $_{versus}$ distributed: grids, HRUs
- Urban, agricultural, and forested systems
- Point and nonpoint sources
- Representation of BMPs and conservation practices
- Level of expertise, data requirement, user interface, tech support, …



# Scale and Water Quality Variables

| MODEL | Time Step | Spatial Scale | Water Quality |
|---|---|---|---|
| USGS Regression | Annual | Large basins | Nutrients |
| SPARROW | Annual | Large basins | Sediment, Nutrient, Pesticides |
| GWLF | Monthly | HUC12, 8 | Sediment, Nutrient |
| QUAL2E | Steady-St. | Water body | TN, TP, $NH_3$, DO, chlorophyll a, pathogens |
| WASP | Hourly | Water body | TN, TP, $NH_3$, DO, chlorophyll a,TSS, Toxics |
| SWMM | Sub-Daily | Small basins | Sediment, Nutrient, Pesticide, Metals, BOD |
| SWAT | Daily | M-L basins | Sediment, Nutrient, Pesticide, Metals, BOD |
| HSPF | Sub-Daily | M-L basins | Sediment, Nutrient, Pesticide, Metals, BOD |



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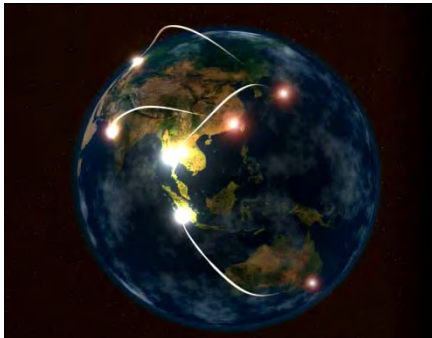
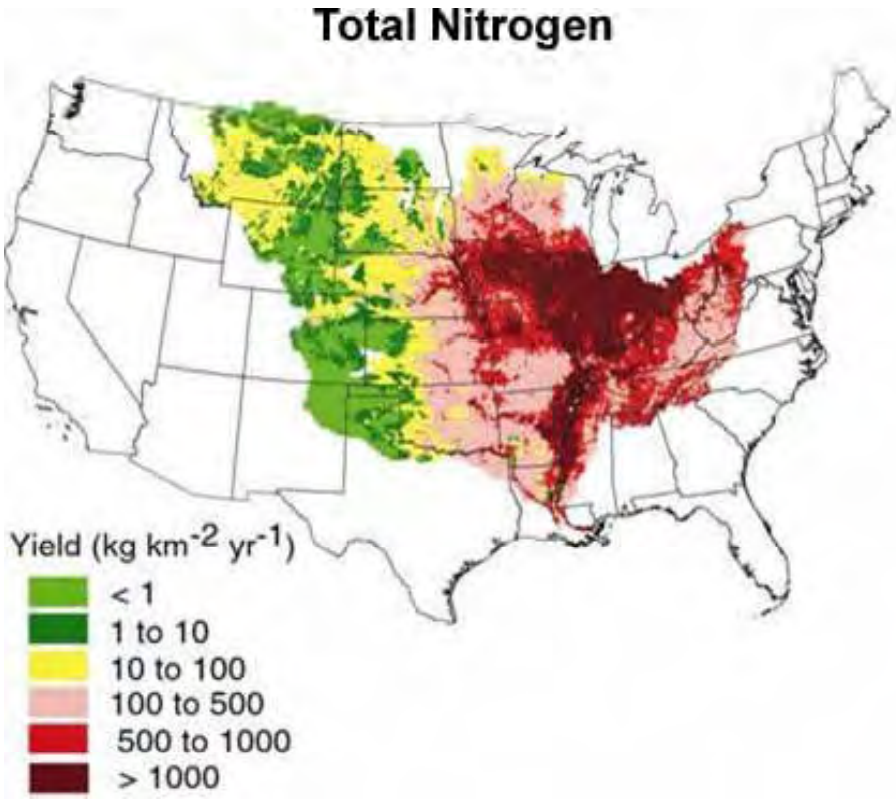
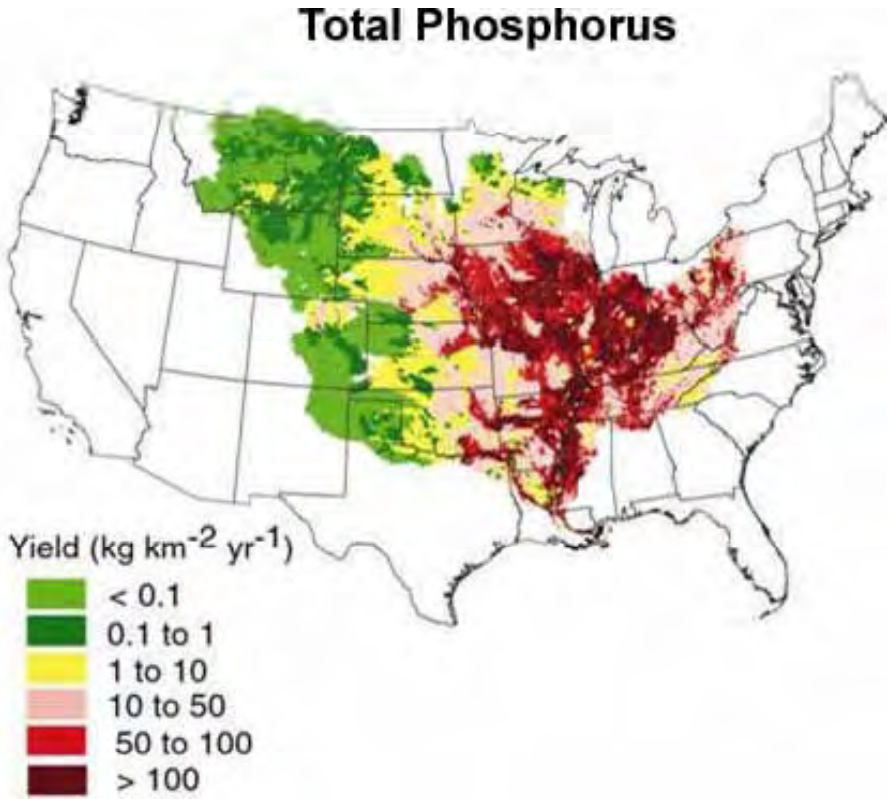
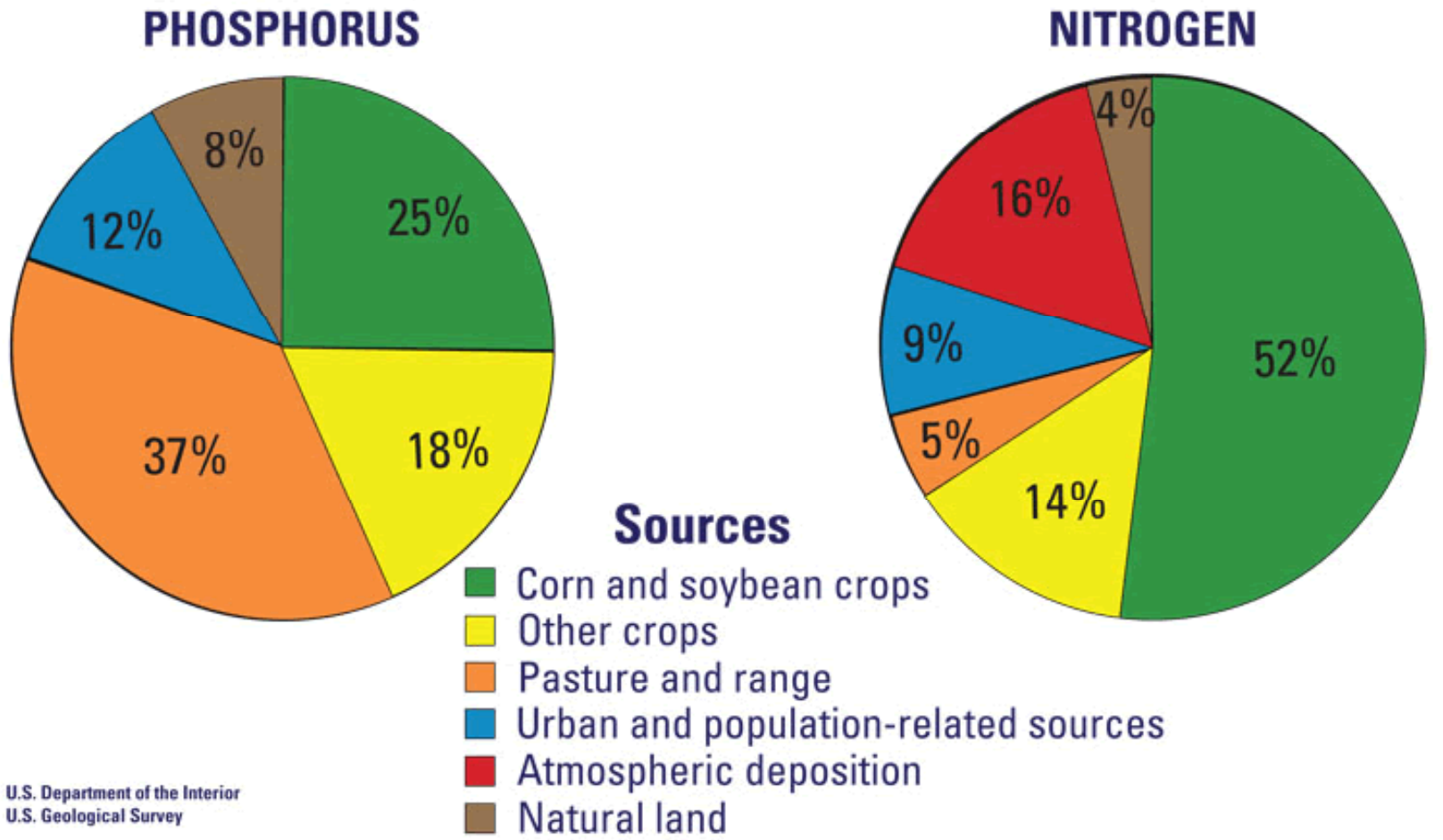


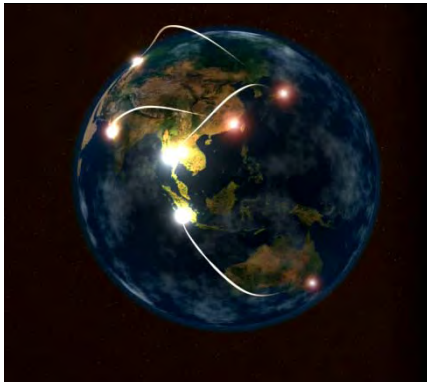
# Delivery of N and P to the Gulf of Mexico: SPARROW



# Sources of Nutrients Delivered to the Gulf of Mexico: SPARROW





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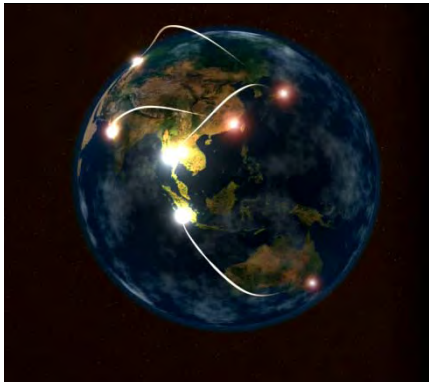
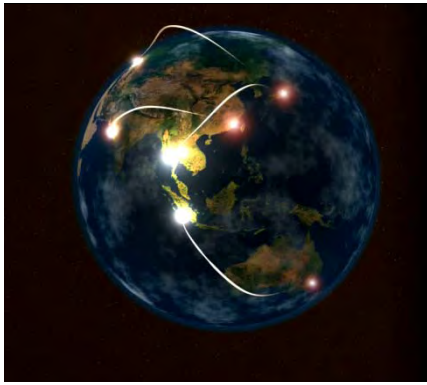


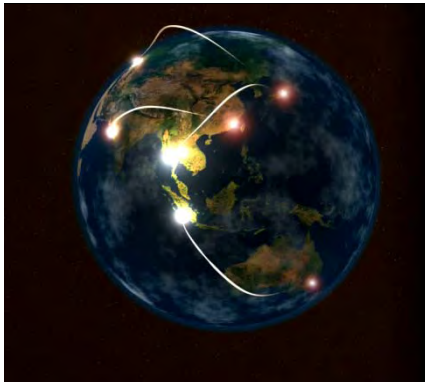
# Land and Water Features Supported

| MODEL | Urban | Ag / Rural | Forest | River | Lake | Reservoir | Coastal / Estuary |
|---|---|---|---|---|---|---|---|
| USGS Regression | ○ | ○ | ○ | | | | |
| SPARROW | ◑ | ◑ | ◑ | ◑ | ◑ | ◑ | |
| GWLF | ◑ | ◑ | ◑ | ○ | | | |
| QUAL2E | | | | ● | | | |
| WASP | | | | ● | ● | ● | ● |
| SWMM | ● | ○ | ○ | ○ | ○ | ◑ | |
| SWAT | ○ | ● | ● | ● | ○ | ○ | |
| HSPF | ◑ | ● | ● | ● | ◑ | ◑ | |



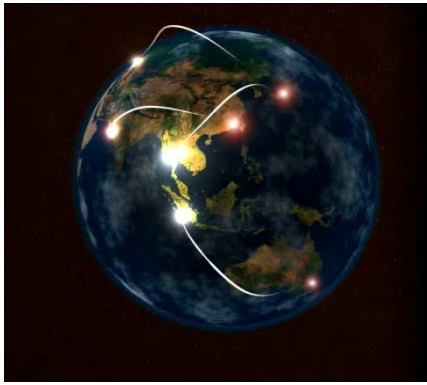
# Management Practices

| MODEL | BMPs |
|---|---|
| USGS Regression | |
| SPARROW | Wetlands |
| GWLF | Vegetative practices |
| SWMM | Detention basins, Infiltration practices, Wetlands, Ponds, Stormwater |
| SWAT | Agricultural conservation practices, Detention basins, Infiltration practices, Ponds, Vegetative practices, Irrigation, Tile drains, Street sweeping, Wetlands |
| HSPF | Nutrient management, Contouring, Terracing, Ponds, Wetlands |



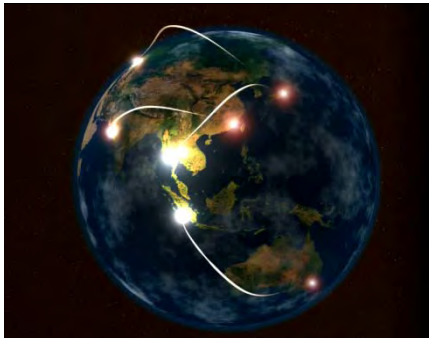
# Model Application: Standard Protocol

- Application of watershed models requires rigorous planning.
- Use of a modeling protocol serves a number of benefits
  - Reduce potential modeler bias
  - Providing a roadmap to be followed
  - Allow others to assess decisions made in modeling
  - Allow others to repeat the study, and
  - Improve acceptance of model results



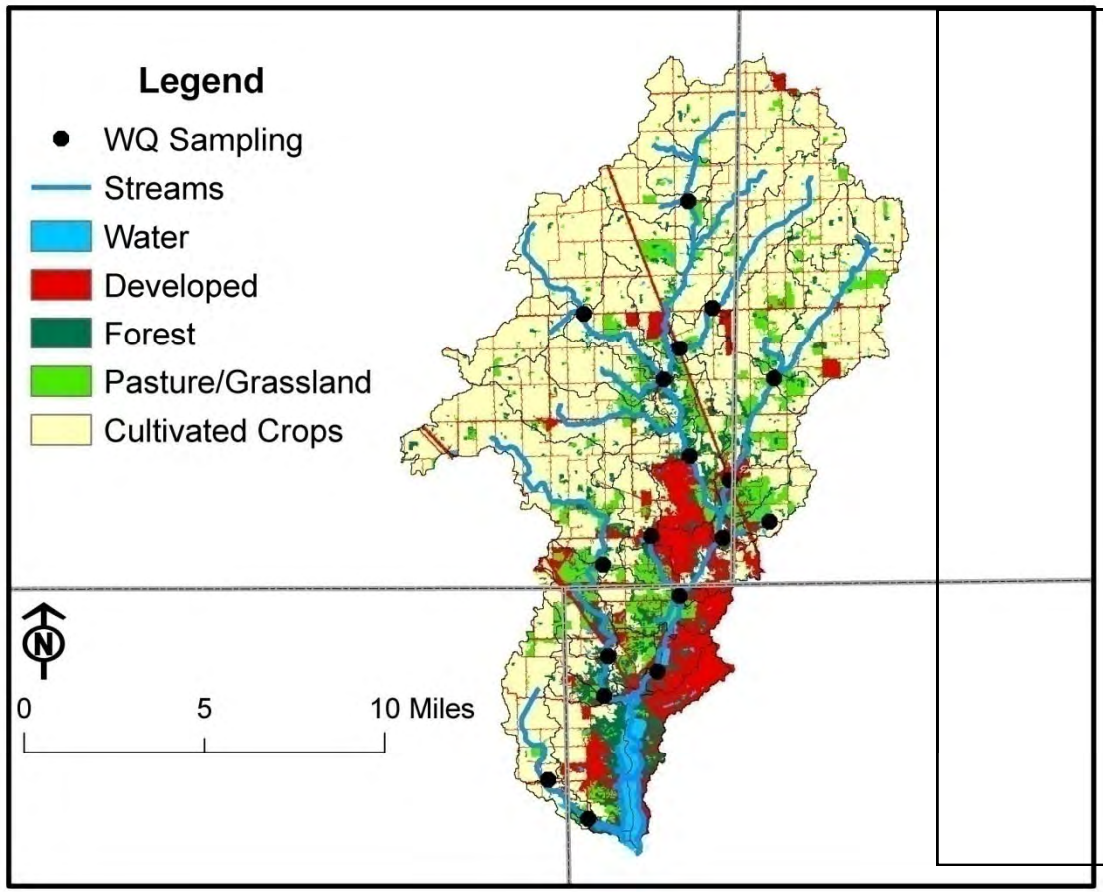
# Modeling Protocol

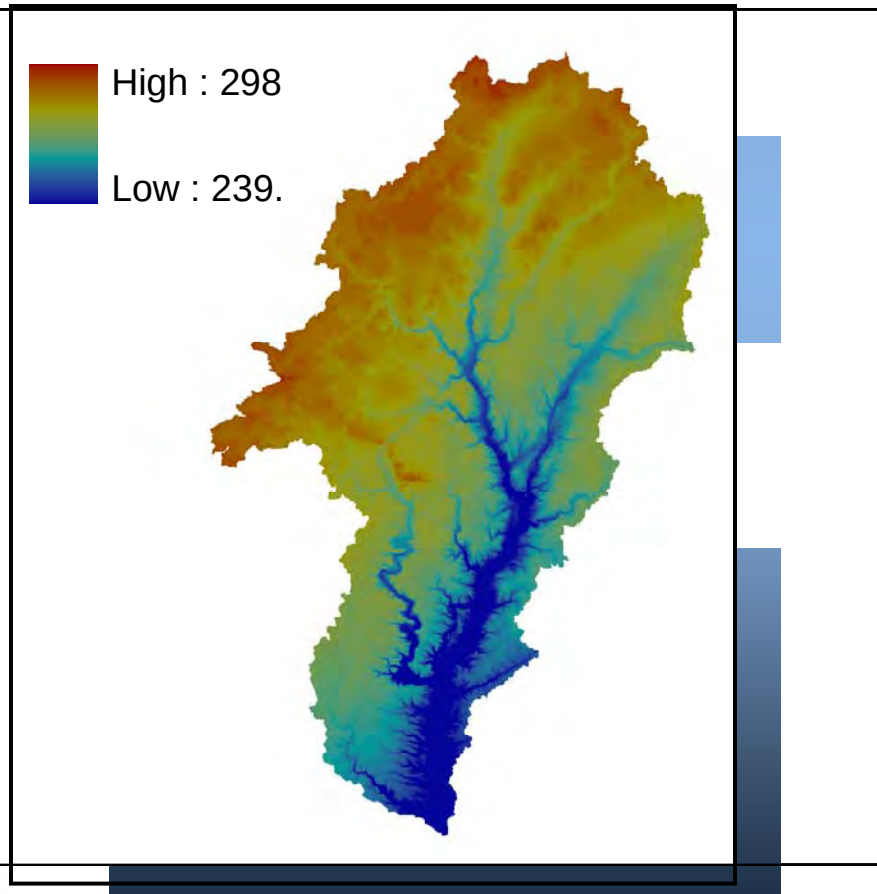
- Define Purpose
- Select Model
- Collect Data
- Sensitivity Analysis
- Calibration and Corroboration (Testing)
- Uncertainty Analysis
- Scenario Analysis
- Results Interpretation and communication of uncertainty
- Postaudit



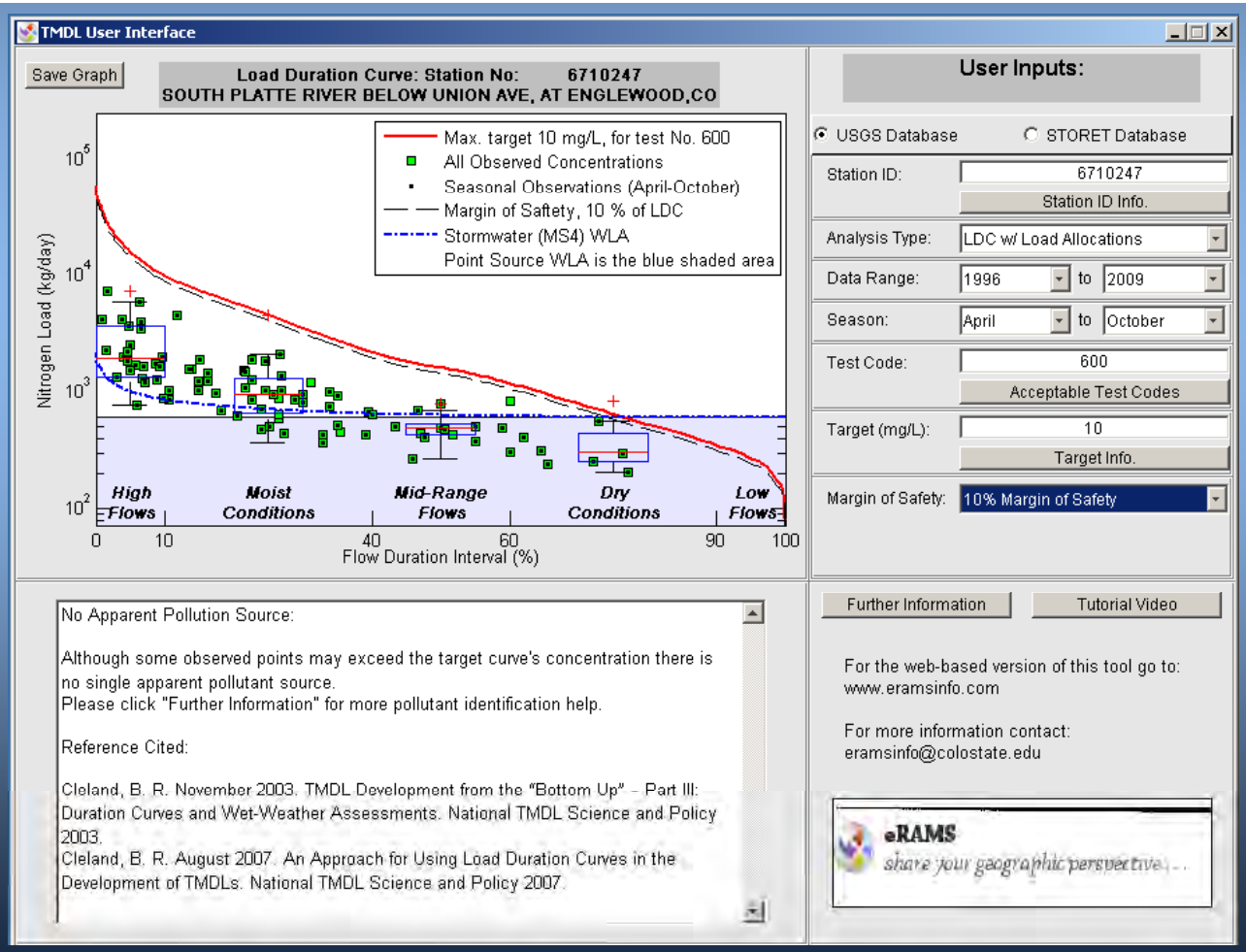
# Eagle Creek Watershed, IN

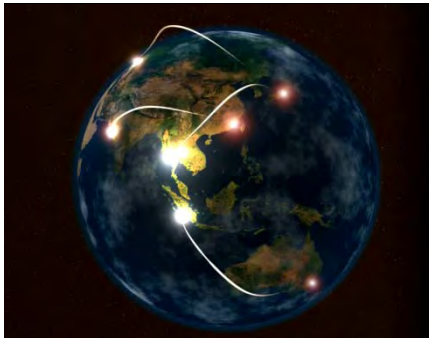
## Source of drinking water for city of Indianapolis



# Flow and Load Duration Curves

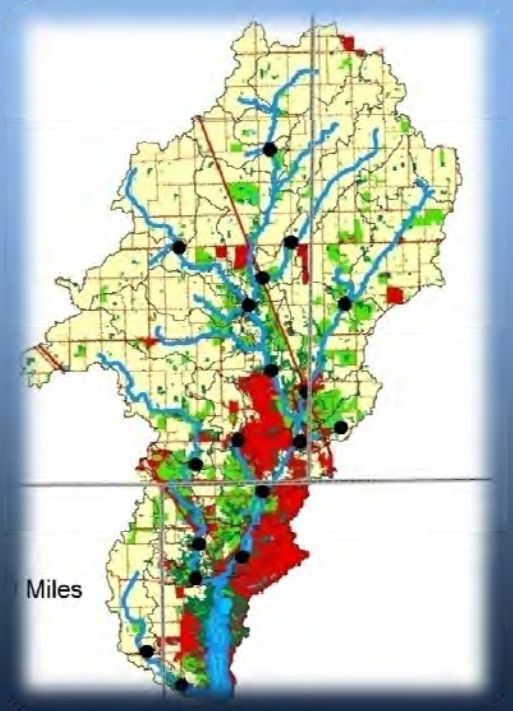




# Calibration and Testing

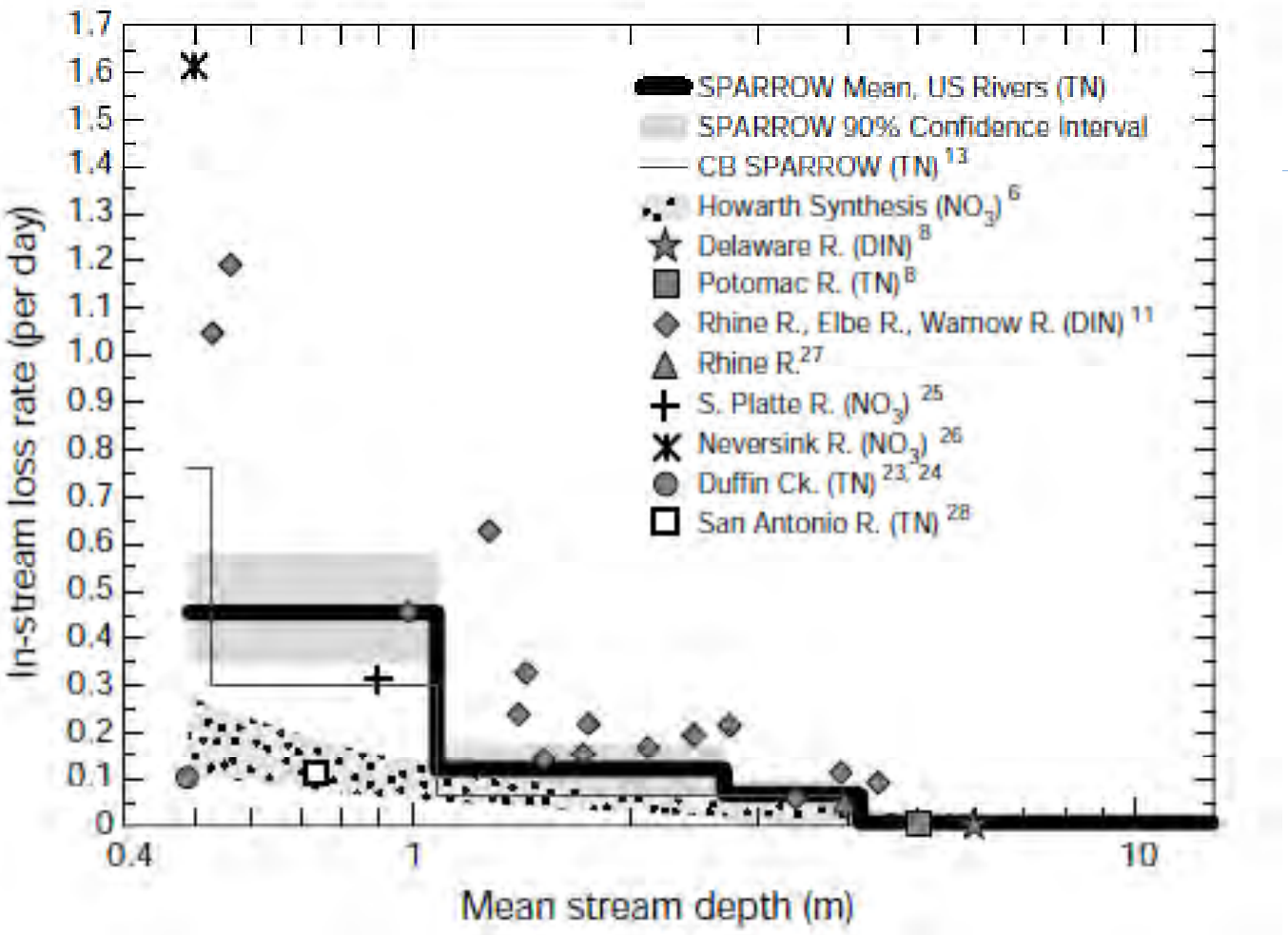
## Importance of rule of thumb measures

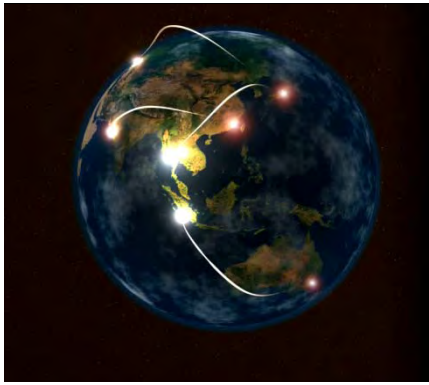
- Calibration is typically performed based on simulation of fluxes of flow, particles and chemicals at stream locations
- Error statistics: relative error, $R^2$, Nash-Sutcliffe efficiency coefficient, …
- Multisite multivariable calibration
- Rule of thumb measures, e.g.,
  - Nitrate from tile drains
  - Denitrification
  - Management implications



# Nitrogen Loss Rate in Streams

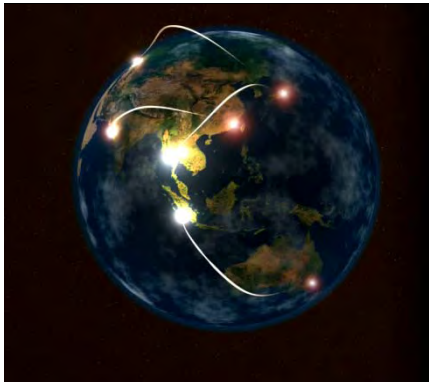
## Alexander et al., 2000, Nature





# Closing Remarks

- Data collection and assimilation is challenging, in particular management data
- Despite significant progress, comprehensive models require extensive knowledge of GIS and model components
- Existing models rarely provide outputs that can be easily communicated with stakeholders
- The need for a standard modeling approach



# Questions? Comments?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