



A Utah-Wyoming Cyberinfrastructure  
Water Modeling Collaboration



EPS-1135482

# CI-WATER Component 2

Enhance Access to Data- and Computationally-  
Intensive Modeling

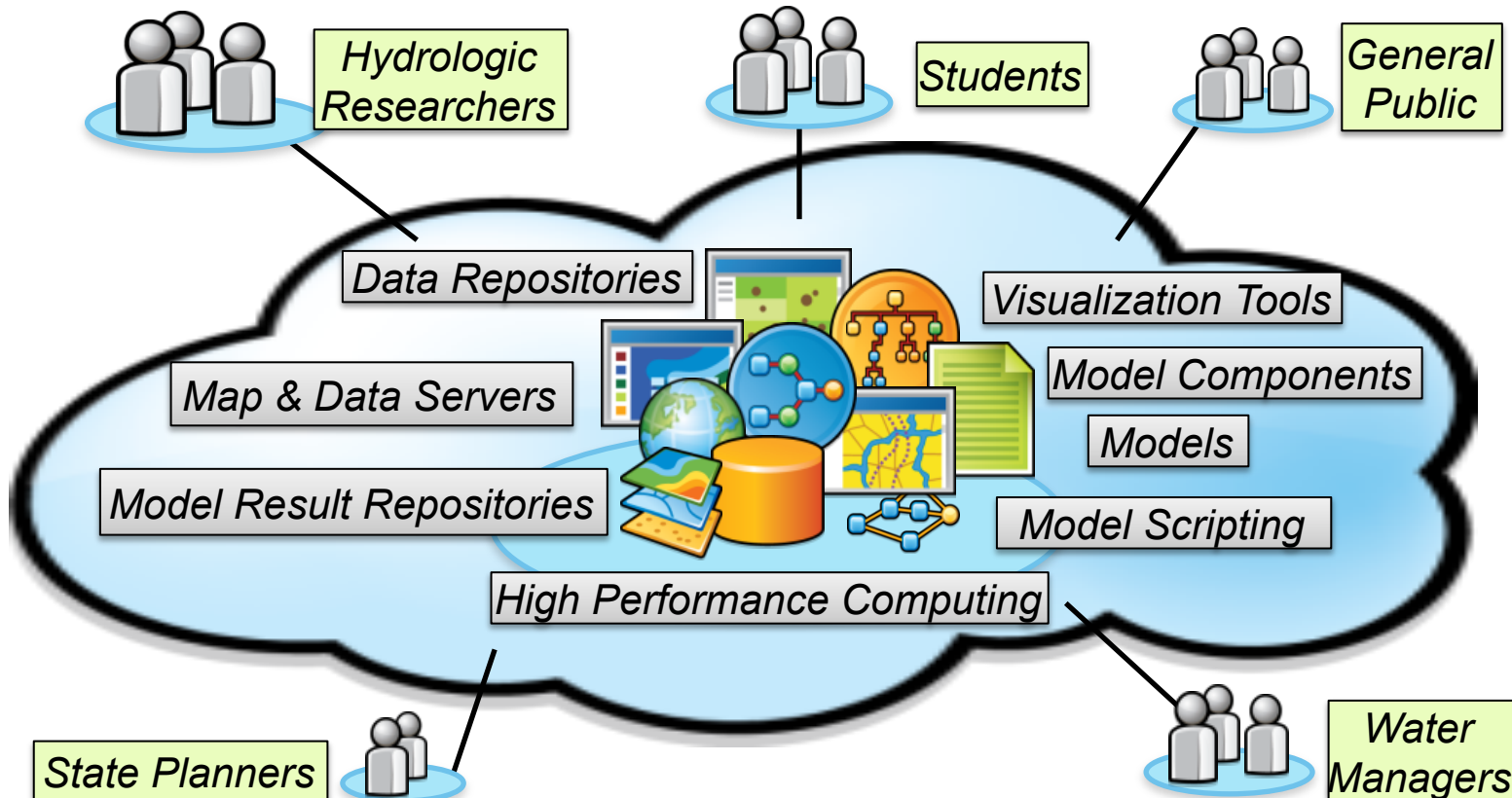
David Tarboton (USU)  
Jeff Horsburgh (USU)  
David Rosenberg (USU)  
Jim Nelson (BYU)

Norm Jones (BYU)  
Steve Burian (UU)  
Steve Gray (UWYO)  
Scott Miller (UWYO)

Kristi Hansen (UWYO)  
Courtenay Strong (UU)

# CI-WATER Component 2

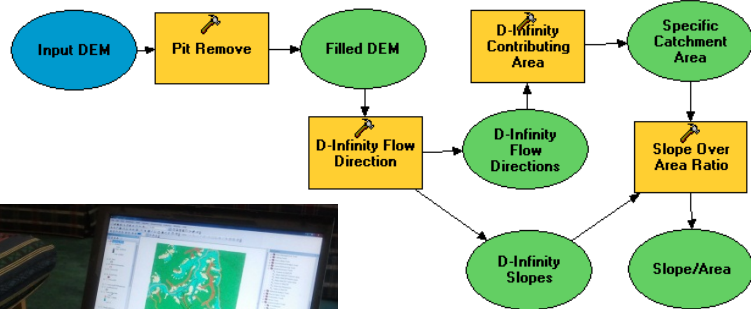
Enhance Access to Data- and Computationally-Intensive Modeling



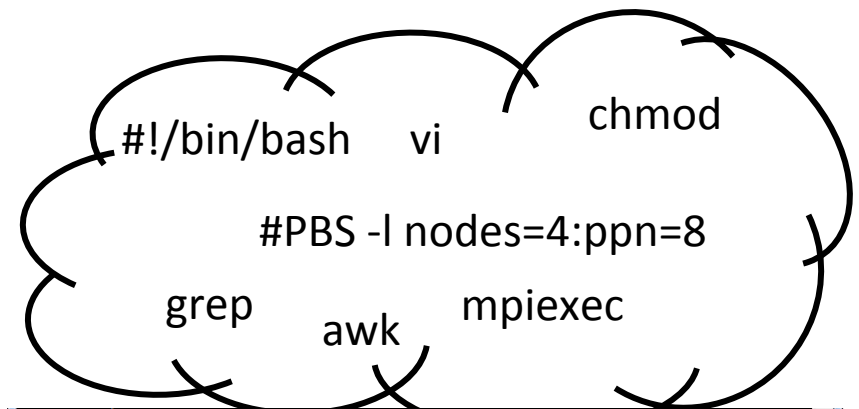
# A Digital Divide

## Researchers

- Experimentalists
- Modelers



## HPC Specialists



```
-bash-3.2$ ls tddata
logan      LoganOutlet.sbn  LoganOutlet.shp  LoganOutlet.shx
LoganOutlet.dbf  LoganOutlet.sbx  LoganOutlet.shp.xml
-bash-3.2$ ls tddata/logan
logan.tif
-bash-3.2$ ls
eric  logMffel  run.bash  taudem.bash  taudem_submit.sh
logMF  run_all.bash  run_taudem.sh  taudem_041959  tddata
-bash-3.2$ run_taudem.sh pitremove -z logan -fel loganfel
43058.ip-net
-bash-3.2$
```

# Challenges

- Provide scientists and water managers access to HPC resources without requiring they become HPC experts
- Reduce the time and effort to organize data for modeling and analysis
- Enable data intensive HPC for mere mortals

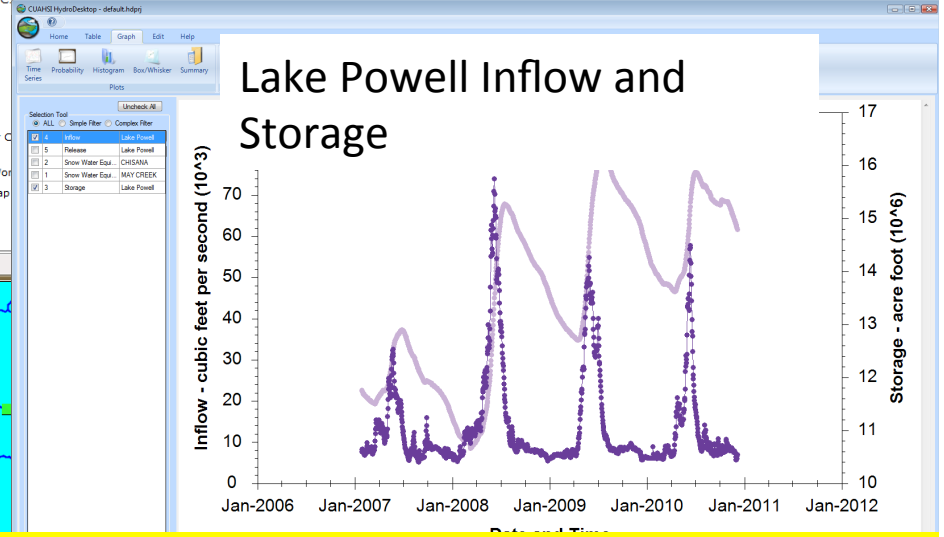
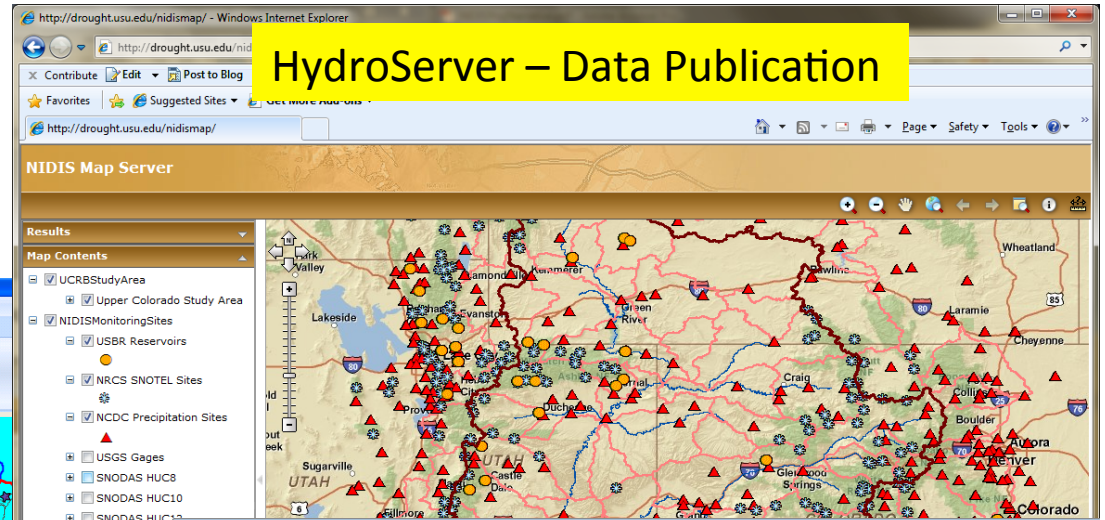
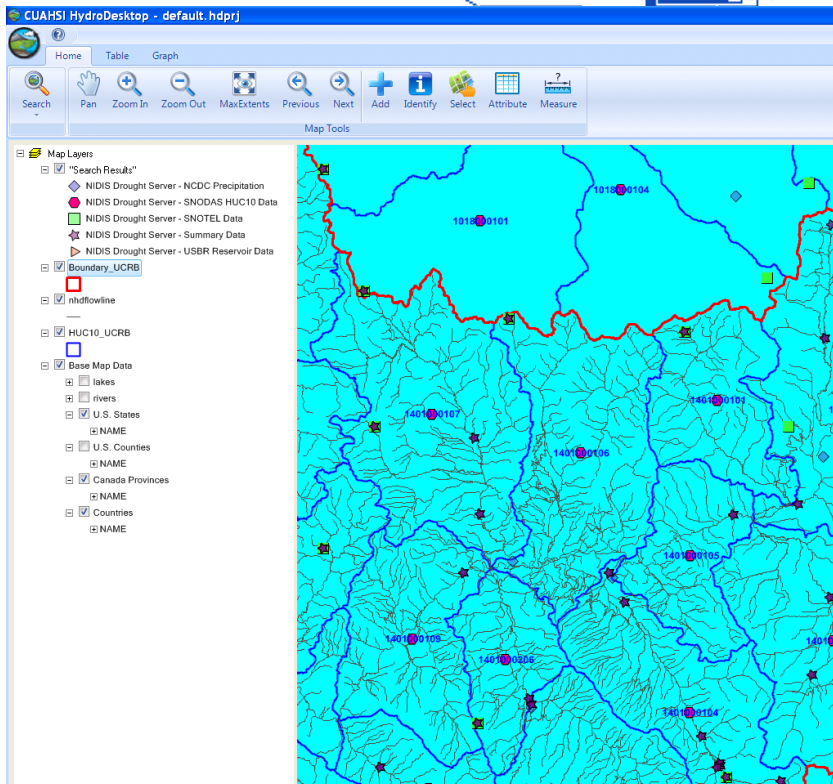
# Approaches

- A science gateway CyberCollaboratory (based on HUBzero and iRODS)
- Extend CUAHSI HIS to additional data types
- Collaborative “social networking” content management functionality (with HydroShare)
- Easy to use HPC tools

# CUAHSI HYDROLOGIC INFORMATION

## System

The CUAHSI Hydrologic Information System (HIS) is an internet based system to support the sharing of hydrologic data. It is comprised of hydrologic databases and servers connected through web services as well as software for data publication, discovery and access.

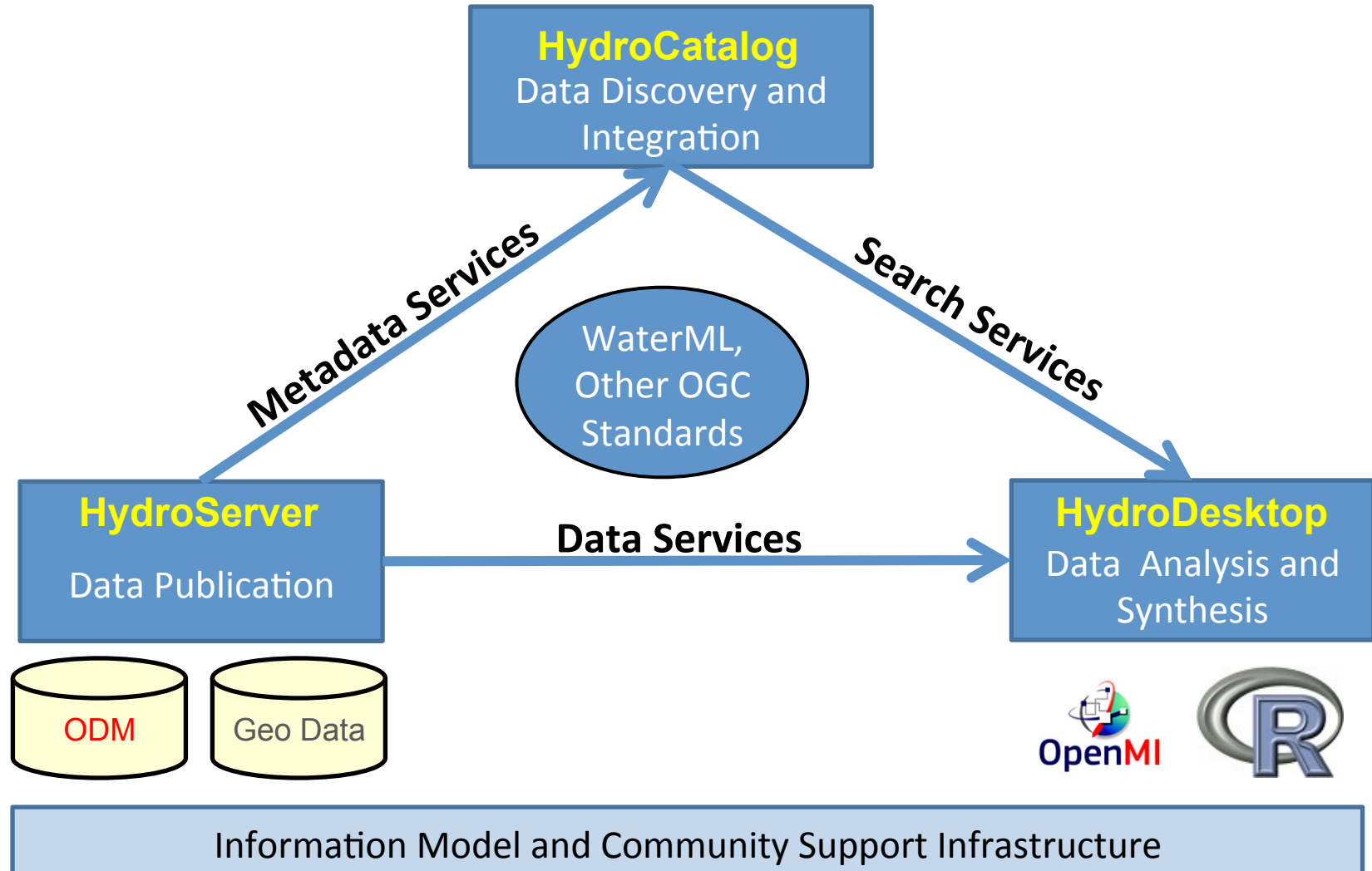


HydroDesktop - Data Access and Analysis

HydroDesktop - Combining multiple data sources

# CUAHSI HIS

## Services-Oriented Architecture



# CUAHSI HIS Key Aspects

- **Storage** in a community data model
- **Publication** from a server
- Data **access** through internet-based services using consistent language and format
- Tools for **access and analysis**
- **Discovery** through thematic and geographic search functionality
- **Integrated modeling and analysis** combining information from multiple sources



# Open Development Model



• <http://his.cuahsi.org>

• <http://hydrodesktop.codeplex.com>

• <http://hydroserver.codeplex.com>

• <http://hydrocatalog.codeplex.com>

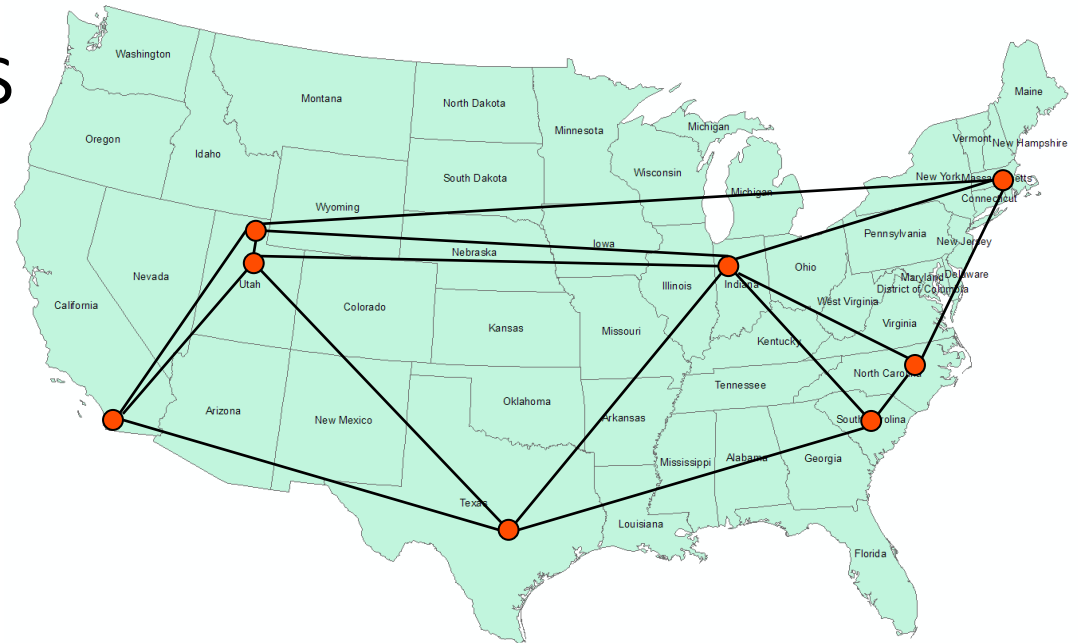
# Extend HIS Data Formats

- Point Observations (Time Series in ODM/WaterML)
- Feature data set (Shapefile of points, lines or polygons and attribute tables)
- Raster data set (GeoTIFF file)
- Multidimensional space/time data set (NetCDF file)
  
- Generalize catalog to include these formats
- Adopt or develop appropriate web services or data delivery mechanisms

# HydroShare

An online, collaborative environment for the sharing of hydrologic data and models

- sustainable
- expand data sharing capability of CUAHSI HIS
  - Additional data classes
  - Models, scripts, tools and workflows
  - Collaboration/social networking
- 5 Years 2012-2017



USU  
BYU  
SDSC

Texas  
Purdue  
USC

RENCI/UNC  
Tufts  
CUAHSI



OCI-1148453

## Share and Collaborate

HydroShare is an online collaboration environment for sharing data, models, and code. Join the community to start sharing.



[HydroShare Gallery](#)

[How HydroShare Works](#)

[Getting Started](#)

[Getting Started](#)  
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# HydroShare

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	Type ▲	Title ▲	Date ▲	Abstract▲
<input type="checkbox"/>		<a href="#">Little Bear River ODM Database</a>	6/6/2012	Utah State University is conducting continuous monitoring within the Little Bear River watershed of northern Utah, USA to investigate the use of surrogate ...
<input type="checkbox"/>		<a href="#">Little Bear River Sites</a>	6/6/2012	Shapefile of monitoirng sites in the Little Bear River watershed.
<input type="checkbox"/>		<a href="#">Watershed Delineation Workflow</a>	6/6/2012	TauDEM workflow to delineate watershed from DEM. Stream threshold is determined automatically to obtain objective drainage density estimate.
<input type="checkbox"/>		<a href="#">Little Bear River SWAT Model</a>	6/6/2012	This is a Soil and Water Assessment Tool model package that is ready to execute. All inputs and outputs are included in the model package.
<input type="checkbox"/>		<a href="#">Little Bear River DEM</a>	6/6/2012	2 m resolution Digital Elelevation Model derived from LIDAR.
<input type="checkbox"/>		<a href="#">Stream Metabolism R Script</a>	6/6/2012	This R script contains a set of functions that implement a one-station stream metabolism model
<input type="checkbox"/>				

Results 1 – 10 of 100 << 1 2 3 4 5 6 7 8 9 10 >>

# HydroShare

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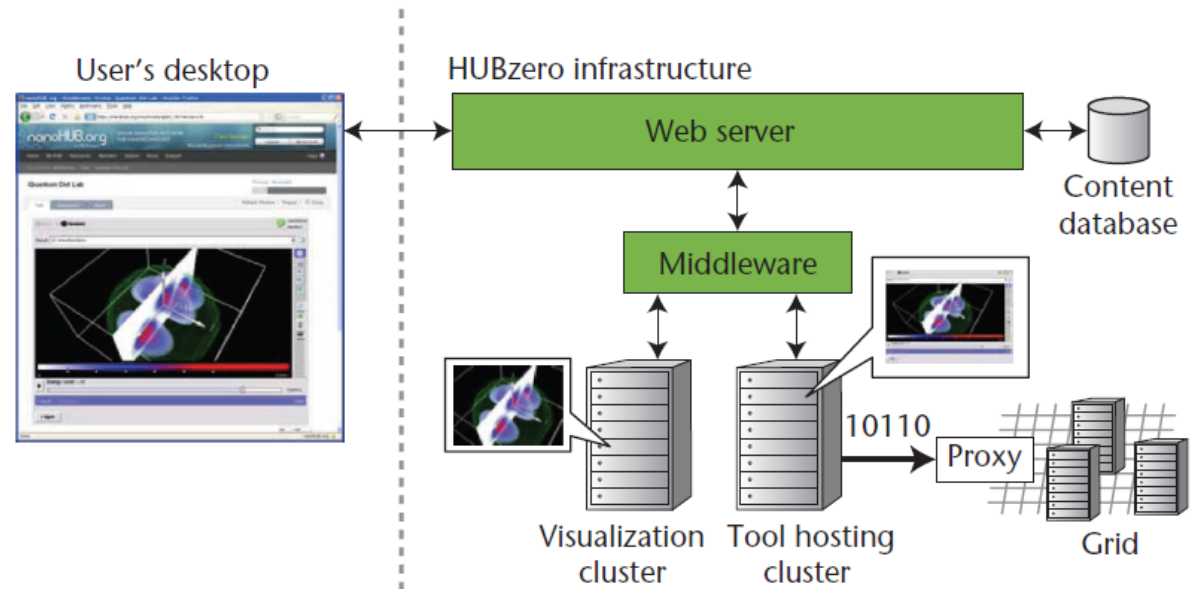
# HUBzero Gateway

## Data & Model Resources

- Discovery & access
- Development
- Execution on local VM
- Execution on remote HPC
- Publishing
- Collaboration

## Web Portal

- Social networking
- Community collaboration
- Resource rating
- Documents & videos
- Learning modules



Architecture of HUBzero platform used to create dynamic web sites for scientific research and educational activities from McLennan and Kennell, (2010),

<http://dx.doi.org/10.1109/MCSE.2010.41>

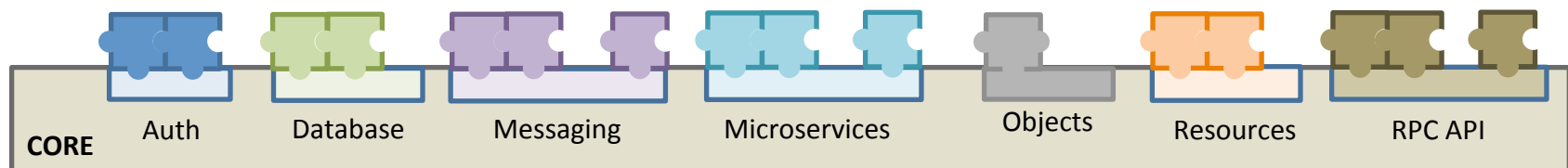
<http://hubzero.org>



# integrated Rule-Oriented Data System

- Micro-Services

- Ability to look inside and program actions on uploaded files
- Rules can tell iRODS to automatically register data into Metadata Catalog and write to Data Server
- Access control model
- Create resources for visualizing and manipulating data
- Convert the format of data objects
- Automatically assign unique and persistent identifiers
- Automatically parse metadata for semantic content and to tag with additional semantic content



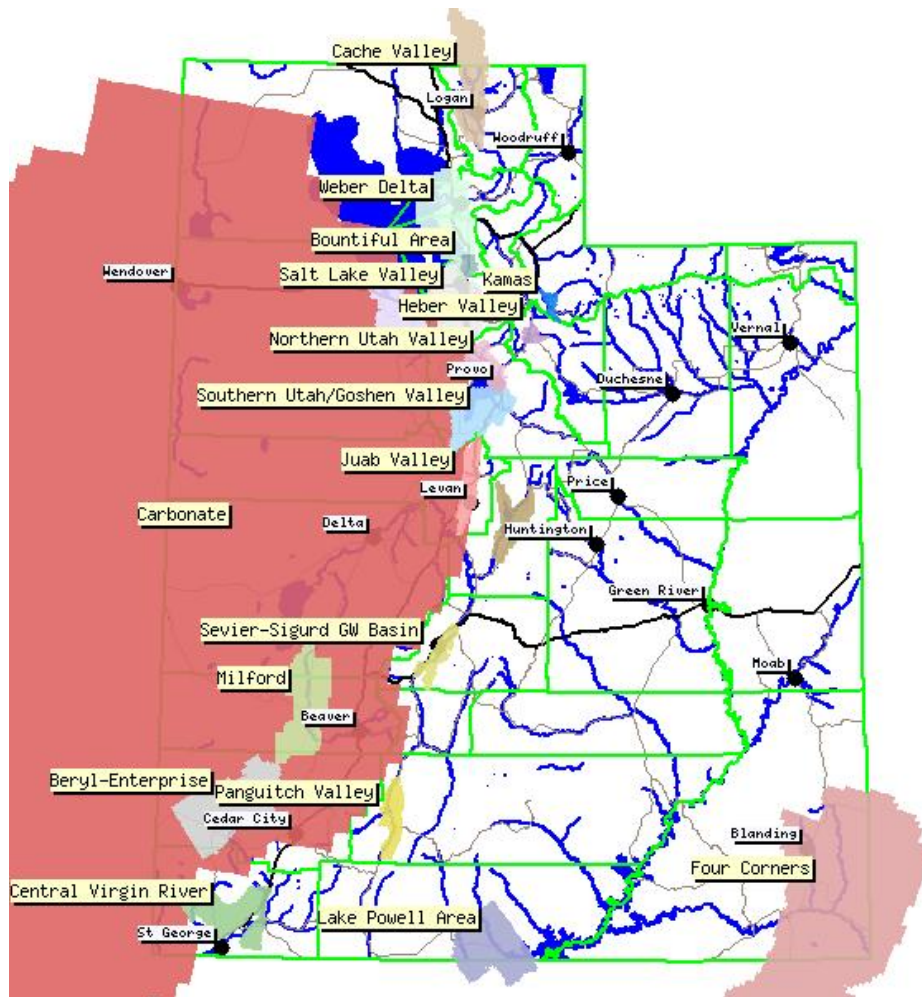
<http://www.irods.org/>

# Modeling Use Cases

- Utah DWR Modflow (BYU)
- Urban Water Management (UU)
- Snow and Distributed Hydrologic and Water Resources Modeling (USU)
  - Discover general aspects of data requirements
  - Drive general functional requirements



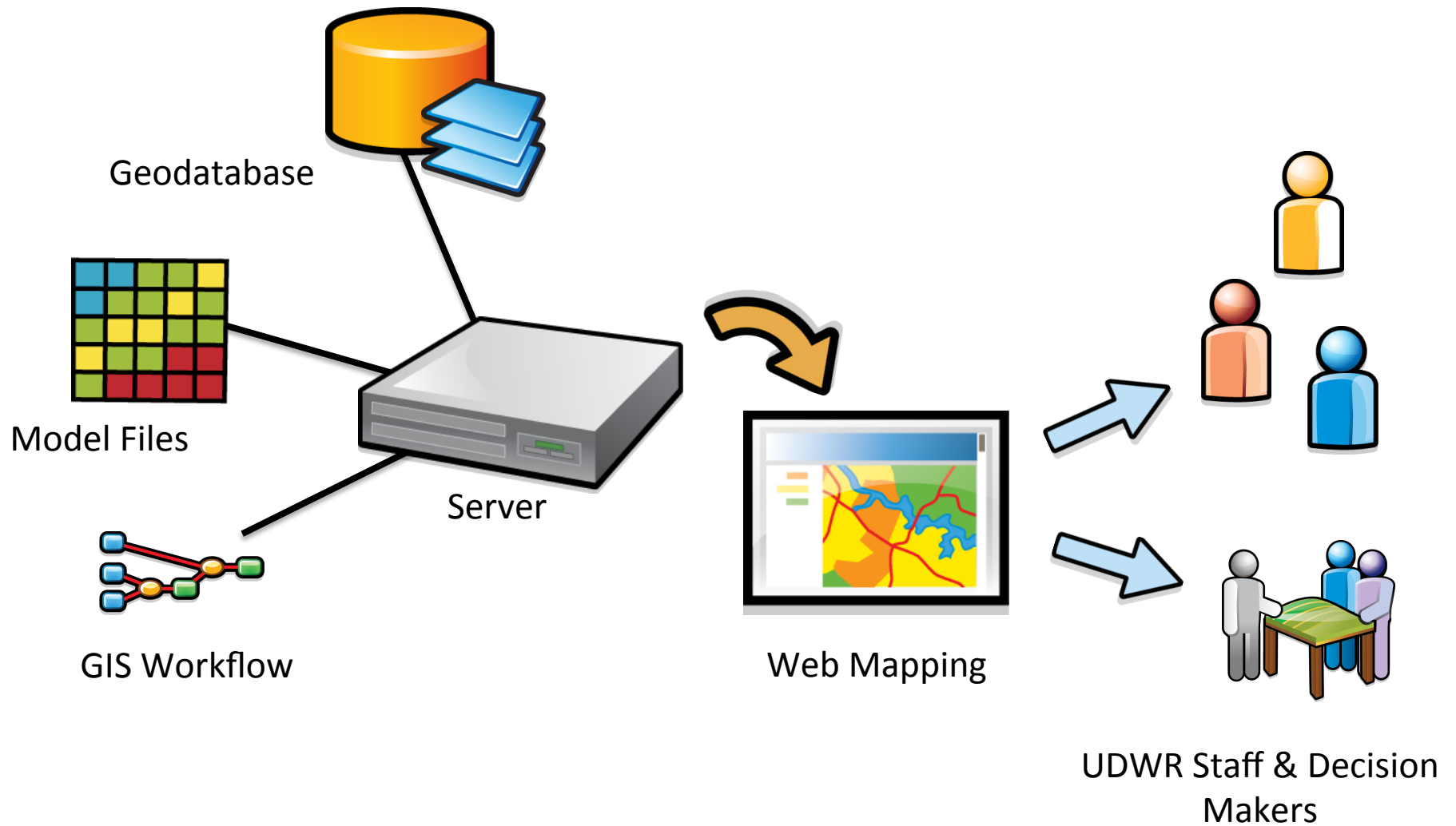
# Utah Division of Water Rights Modflow Example



- Prototype application
- 31 MODFLOW models used for impact analysis
- Challenges
  - Modeling expertise
  - Software installation and maintenance
  - User error
  - Cost
- Objective: Develop a cloud-based modeling solution

From Norm Jones

# Server-Based Solution



From Norm Jones

# Web Interface

Well Permitting Tool

utahdwr.groups.et.byu.net/app3/

### Automated Well Permitting Tool

Tool Input and Map View | Table of Well Applications | Documentation

Tool: Analyze Permit Application with MODFLOW

Application ID:

Output Options

Tool Results

N. Utah County MODFLOW Model

Layer 1

Grid Geometry

- Model Boundry
- Active Grid with Elevation Data (Polygon Features)
- Active Grid (Image Overlay)

Hydraulic Conductivity

- Horizontal Conductivity
- Vertical Conductivity (Upper Interface)

Baseline Conditions and Flows

Static Model Properties

- Wells
- Drain Conductance
- Recharge Flows

Conductivity (ft/day)

0
1 - 2
3 - 5
6 - 10
11 - 20
21 - 50
51 - 100
101 - 200
201 - 500
501 - 1000
1001 - 3000

<http://utahdwr.groups.et.byu.net/app3/>

Image: USDA Farm Service Agency

Google earth

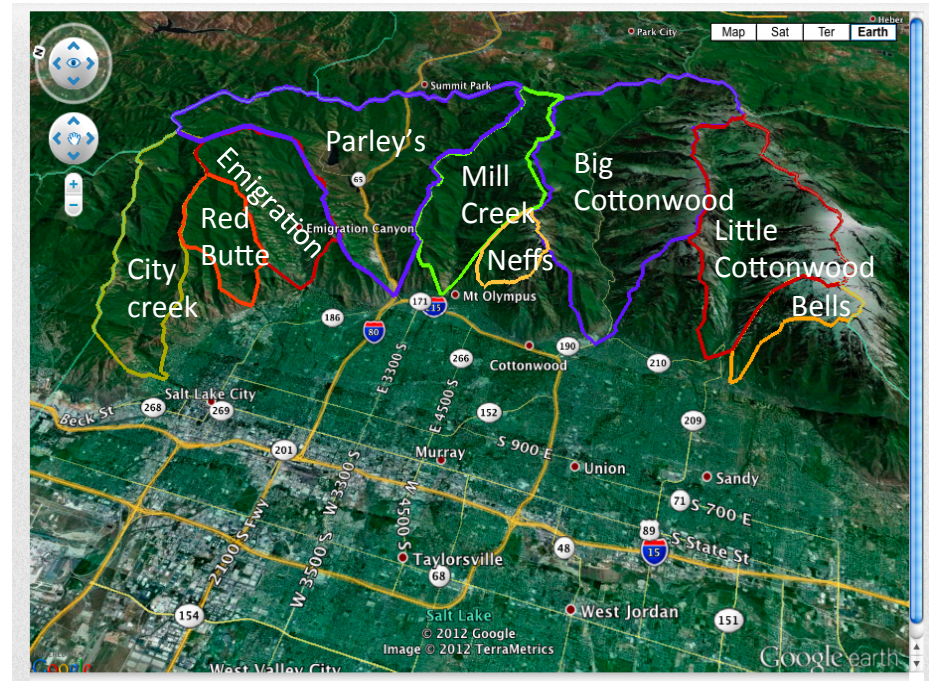
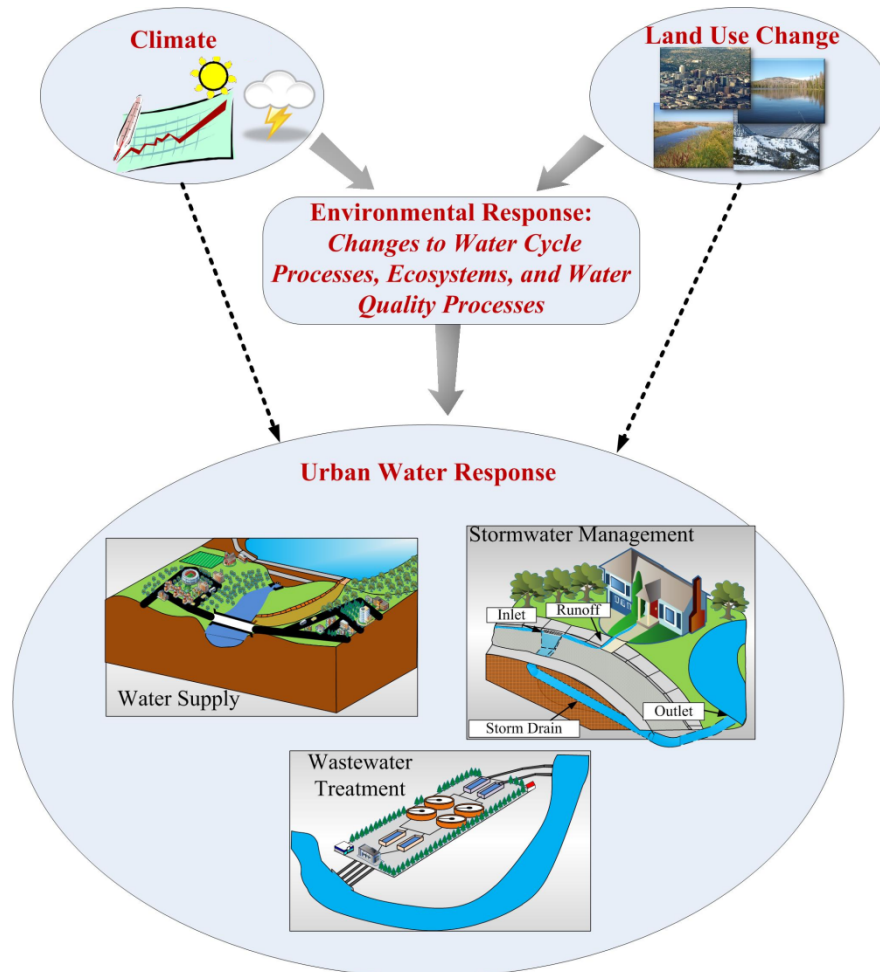
Terms of Use

Eye alt 50.53 km

40°32'52.96" N 111°43'50.08" W elev 3118 m

From Norm Jones

# University of Utah – Urban Water Management

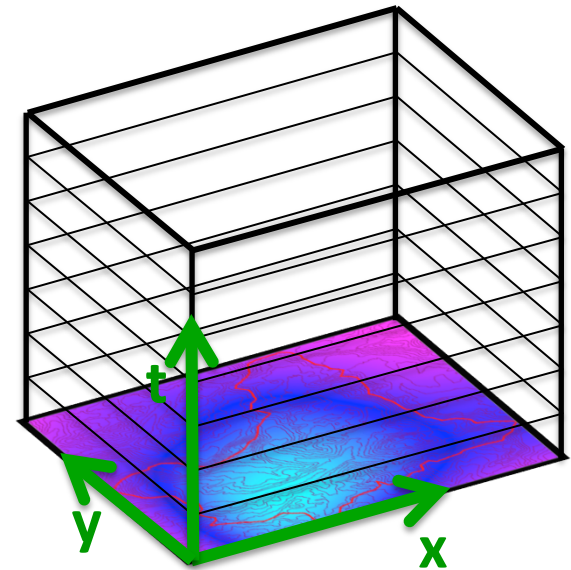
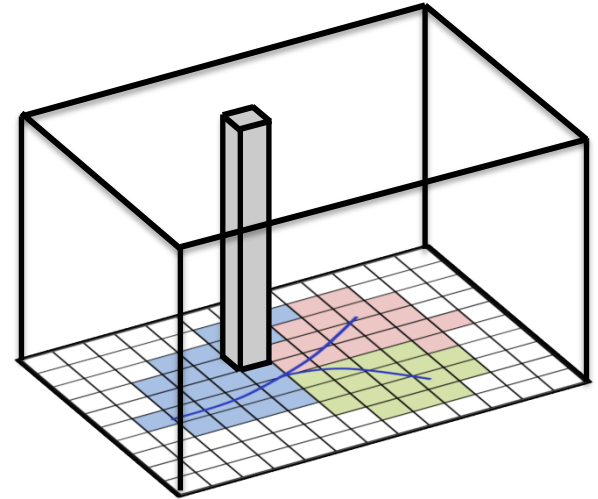


<http://www.hiddenwaters.org/>

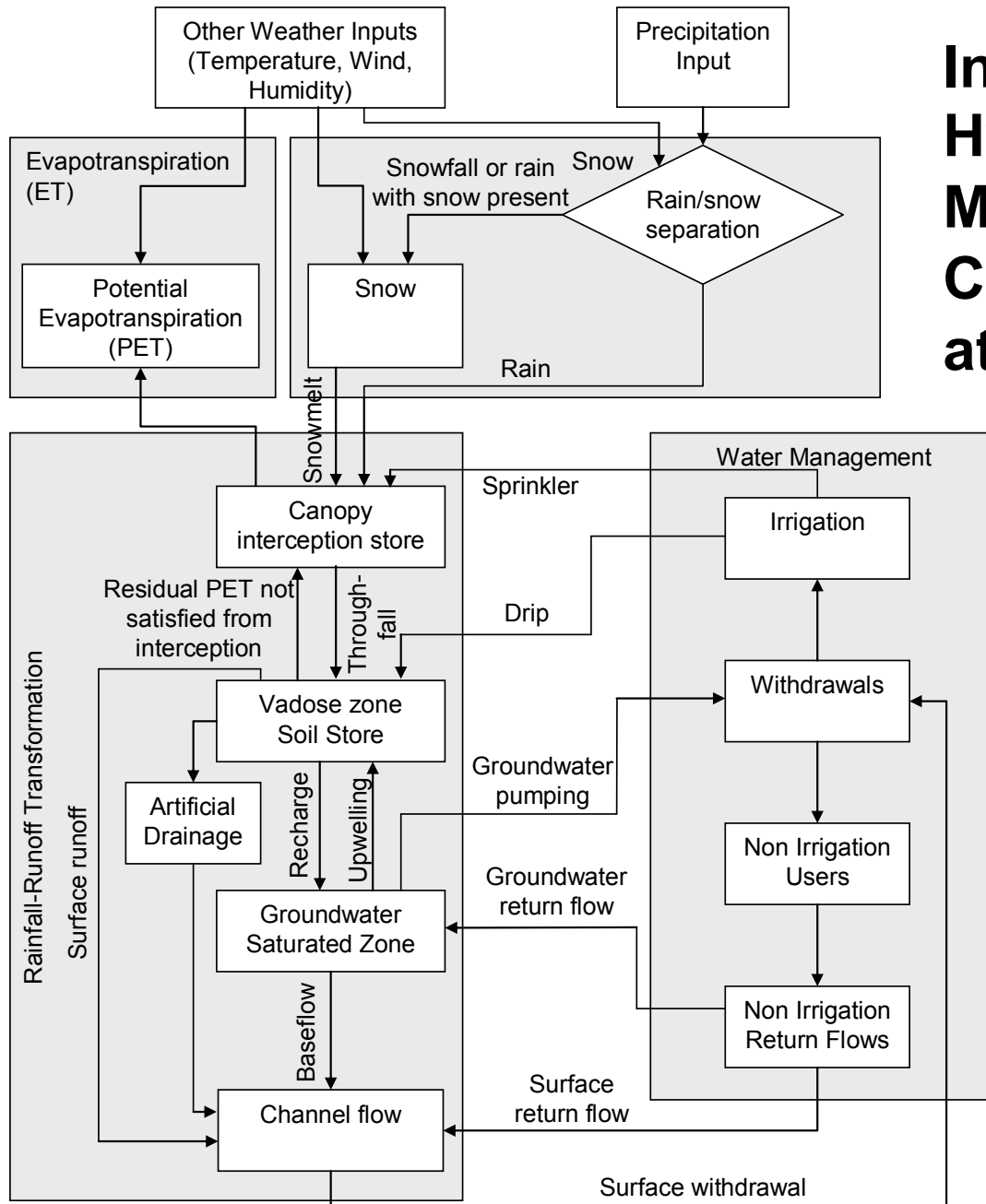
From Steve Burian

# Grid Snow Model

- Model run separately at each active grid cell
- Melt outputs aggregated for subwatersheds
- Structured File based IO for linking with EPA BASINS
- ASCII for non spatial data
- NetCDF for geospatial data



# Integrated model of Hydrologic, Water Management and Consumption processes at each “catchment”

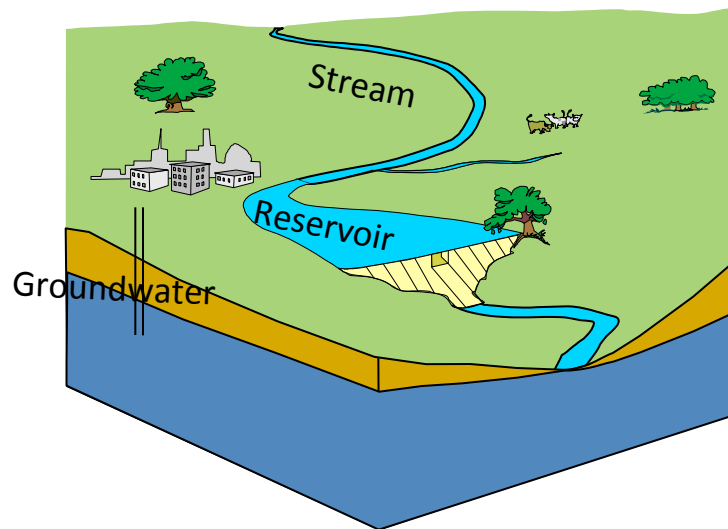


- Competition for water resources among users
- Human activities can alter water balance having effects on stream ecosystems and water quality
- Simulation modeling used to quantify the likely impacts of water management choices

# Water Management

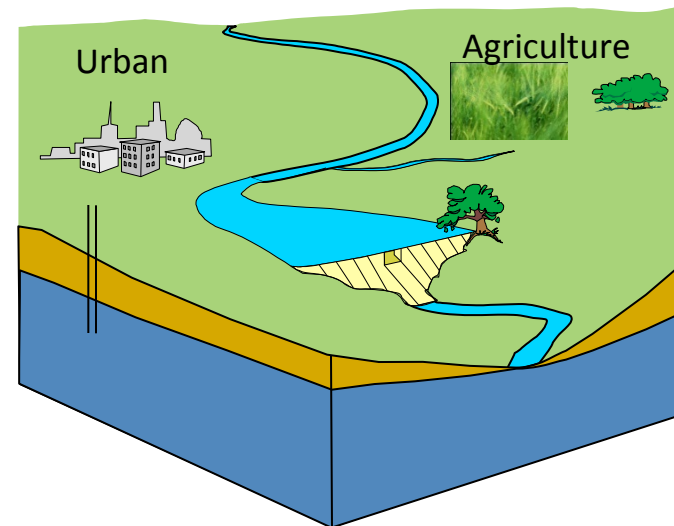
## Sources

- Reservoir
- Groundwater
- Stream
  
- Withdrawal limited by availability and right priority

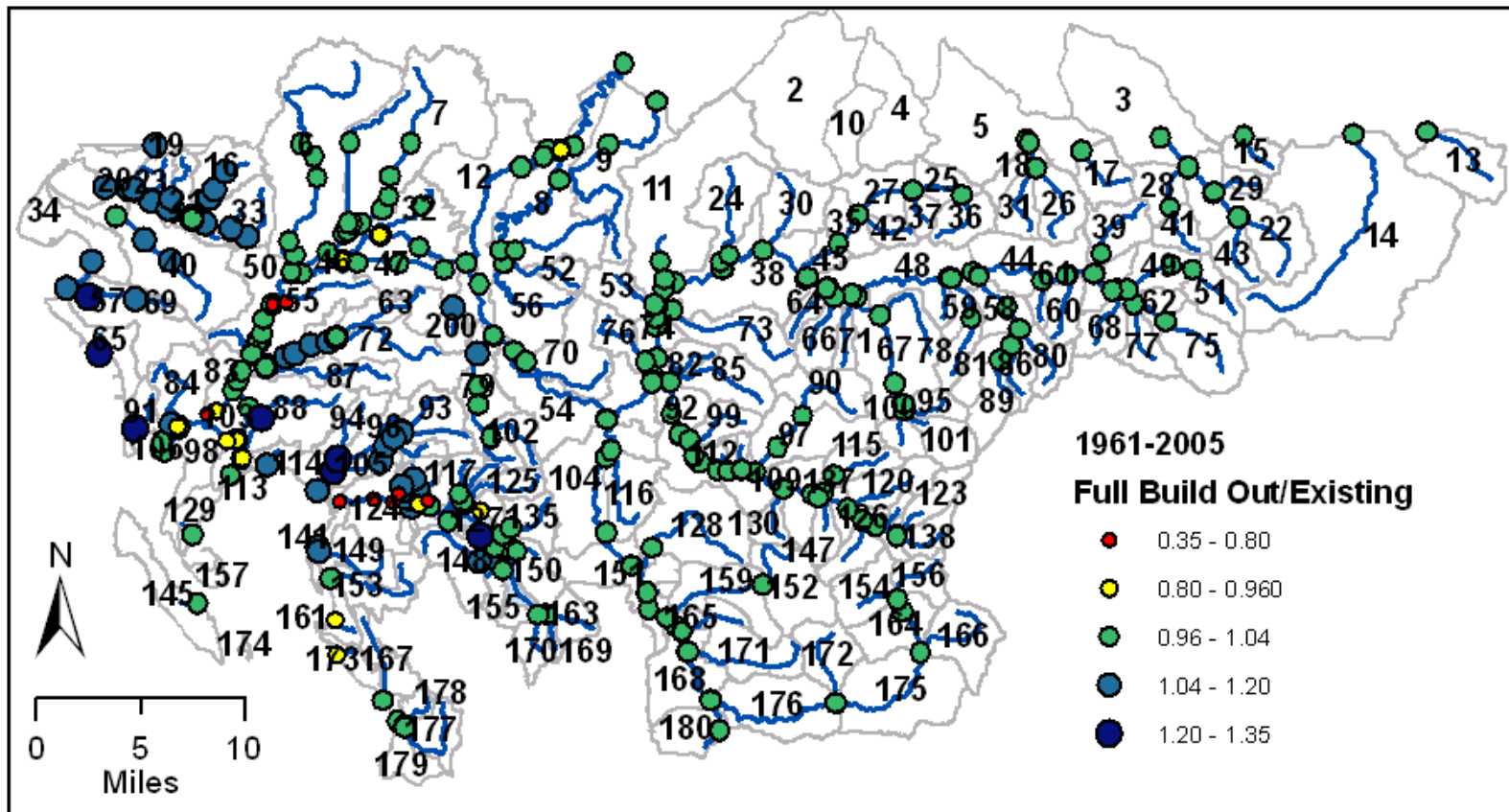


## Uses

- Irrigation
  - Soil moisture demand driven
- Non Irrigation
  - Per capita driven
- Diversions



# The impact on streamflow of future development



Ratio of mean streamflow simulated under Full Buildout conditions to mean streamflow simulated under existing conditions.



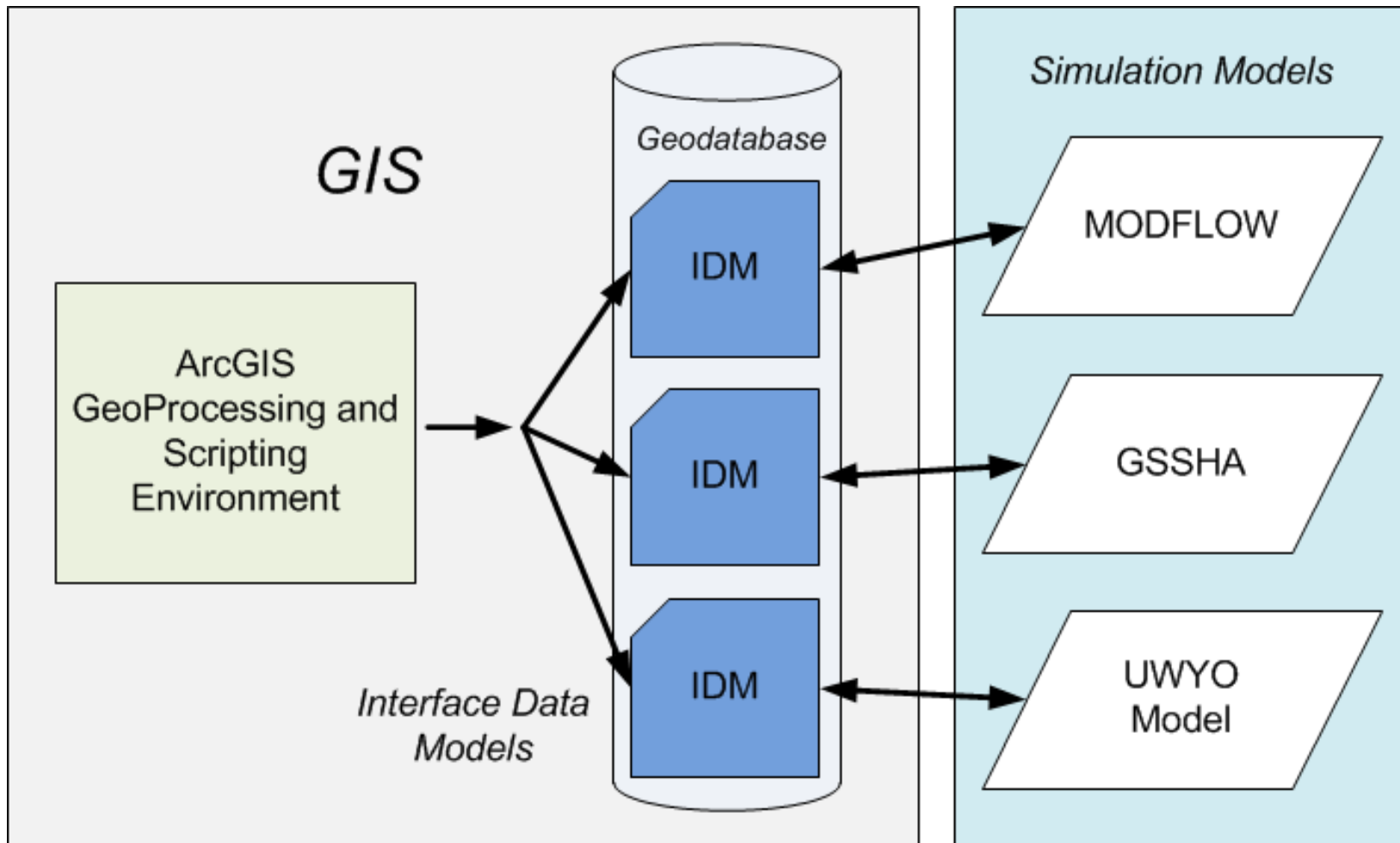
# Some Common Data Requirements

- Digital Elevation Model (and derivatives)
  - Slope, Watersheds, ...
- Soils (and pedotransfer functions)
- Geology (and hydrogeological parameters)
- Vegetation (and parameter mapping tables)
- Streams
- Water Management Infrastructure
- Dynamic input Variables
  - Precip, Humidity, Wind, Radiation, Temperature
- Water Use and Management process parameters

# Some Common Functional Requirements

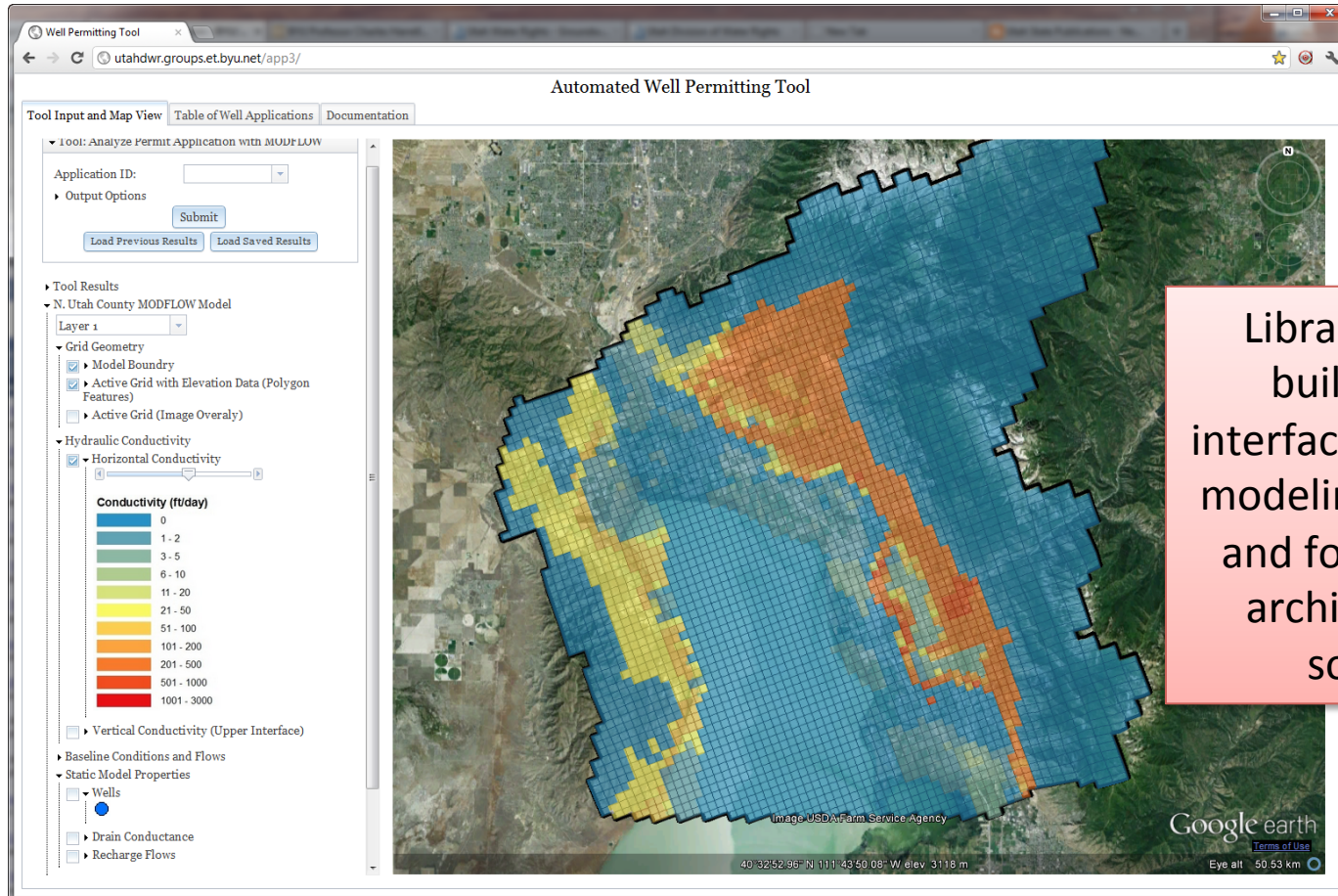
- Metadata catalog for modeling data
- Automated access to required terrestrial variables for model setup
- Watershed delineation and connectivity
- Model element zonal averaging for discrete (lookup table) and continuous parameters
- Model element interpolation for dynamic input variables
- Tools for essential functionality (calibration, missing data correction)

# Model Scripting Tools



From Norm Jones

# Web-Mapping API



Library (API) for building web interfaces to scripted modeling workflows and for visualizing archived model solutions

# Our work ahead

- Water management data components
  - Data model design, prototyping and implementation
- Urban data components
  - Data model design, prototyping and implementation
- Deploy data services for additional data formats
  - [Point observations], Feature, Raster, Space Time
- Develop HUBzero capability and interfaces
- Develop post processing and visualization tools
- Develop community collaboration capabilities

# Applications

- Snowmelt
- Drought
- Water Resources
- Urbanization
- Flooding

