CI-WATER

A Utah-Wyoming Cyberinfrastructure
Water Modeling Collaboration

# Enhance access to data- and computationally-intensive modeling.

Team 2 – David Tarboton

November 2014

Utah State University

The University of Utah

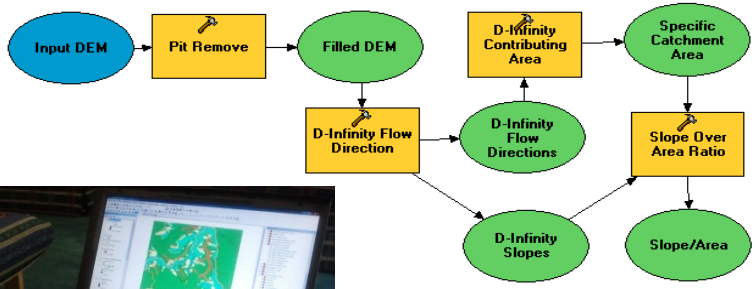
BYU Brigham Young University

University of Wyoming
New Thinking

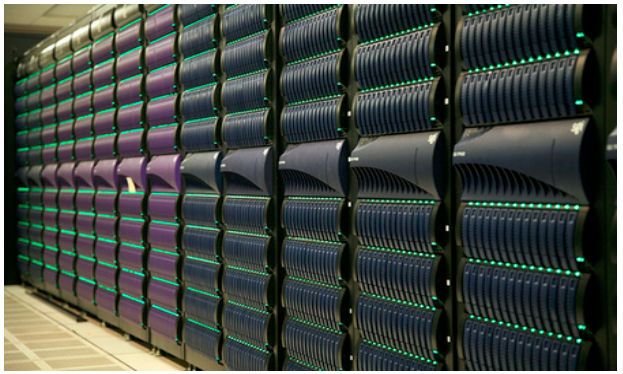
# A digital divide

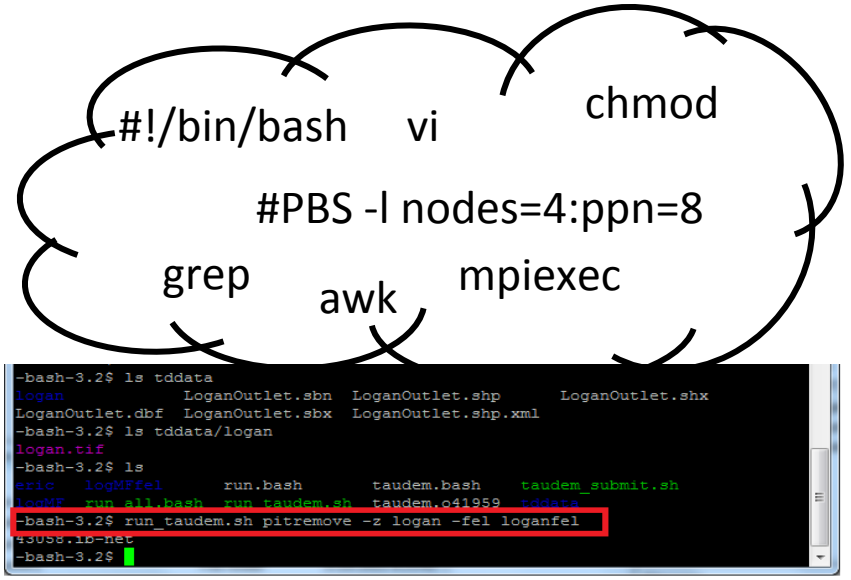
Researchers

- Experimentalists
- Modelers




Big Data and HPC






**Do you have the access or know how to take advantage of advanced computing capability?**

Gateways, Web Interfaces, Software services

# Goals

1. “Provide hydrologic researchers, modelers, water managers, and users access to HPC resources without requiring them to become HPC and CI experts”

2. “Reduce the amount of time and effort spent in finding and organizing the data required to execute the models”

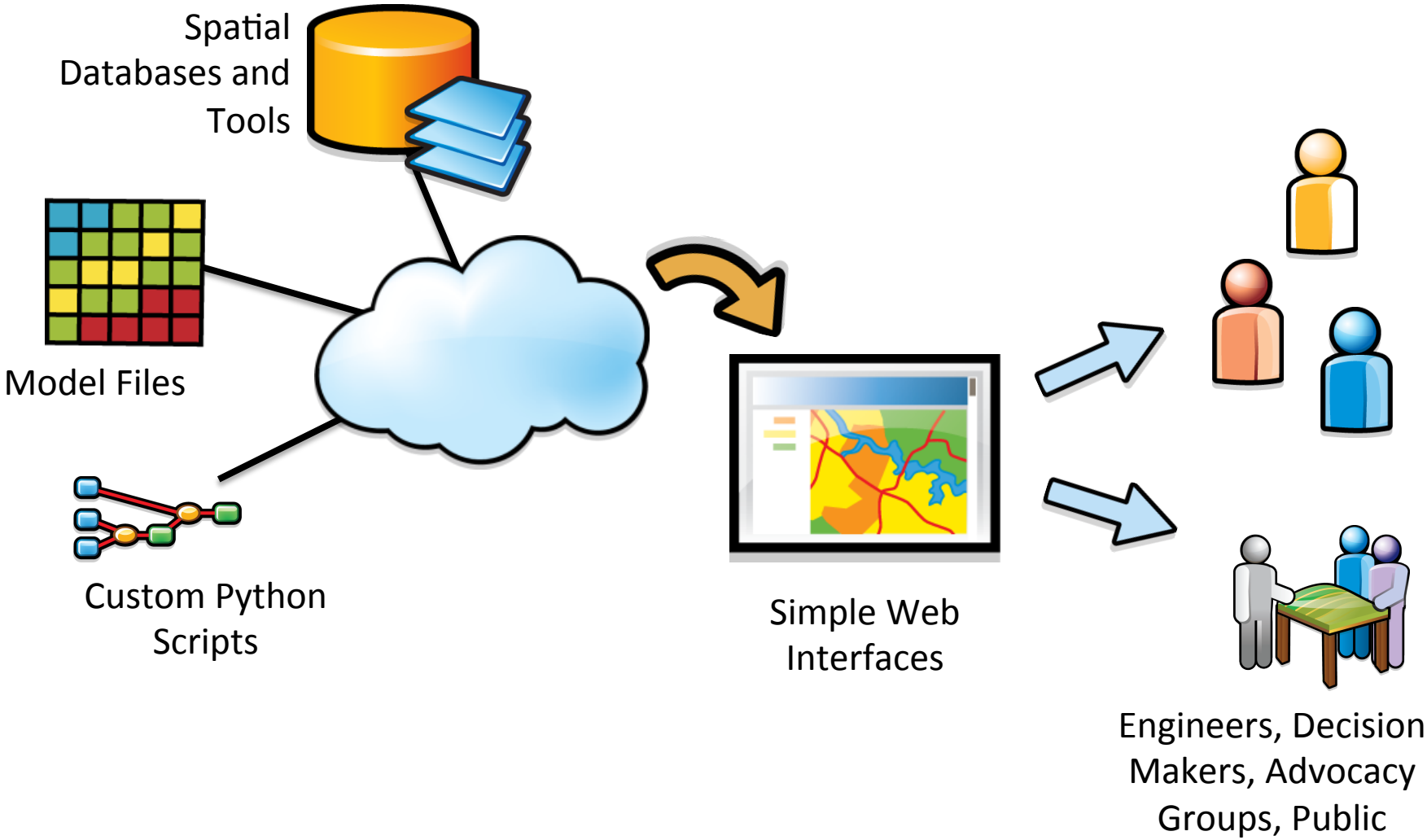
# Overview

- Data access services for modeling (USU)
- Python Client for HPC access via web services gateway (USU)
- Climate and Urban Water Systems (UU)
- Toolkit for cloud based water resources modeling (BYU)

# Proposal Timeline and Milestones

| CI-WATER Milestones and Timeline | Year 1 | | | | Year 2 | | | | Year 3 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (assumes 9/1/11 start) | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 |
| **Component 2. Enhance Access to Data- and Computationally-Intensive Modeling** | | | | | | | | | | | | |
| Water management components for data services | | | | | | | | | | | | |
| Develop data model design | ■ | ■ | | | | | | | | | | |
| Implement prototype data services | | | ■ | ■ | | | | | | | | |
| Test and refine prototype data services | | | | | ■ | ■ | | | | | | |
| Implement operational data services | | | | | | | ■ | ■ | | | | |
| Urban data components for data services | | | | | | | | | | | | |
| Develop data model design | ■ | ■ | | | | | | | | | | |
| Implement prototype data services | | | ■ | ■ | | | | | | | | |
| Test and refine prototype data services | | | | | ■ | ■ | | | | | | |
| Implement operational data services | | | | | | | ■ | ■ | | | | |
| Develop and deploy data services for datasets required by models | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Develop a HubZero instance that interfaces with Utah/Wyoming HPC resources | ■ | ■ | ■ | ■ | | | | | | | | |
| Develop HubZero functionality | | | ■ | ■ | ■ | ■ | | | | | | |
| Develop appropriate user interfaces within HubZero to enable user access to models | | | | | ■ | ■ | ■ | ■ | | | | |
| Develop model output post processing and visualization tools | | | | | | | ■ | ■ | ■ | ■ | | |
| Develop community model collaboration capabilities | | | | | | | | | ■ | ■ | ■ | ■ |

# Cloud-Based Modeling for Decision Support



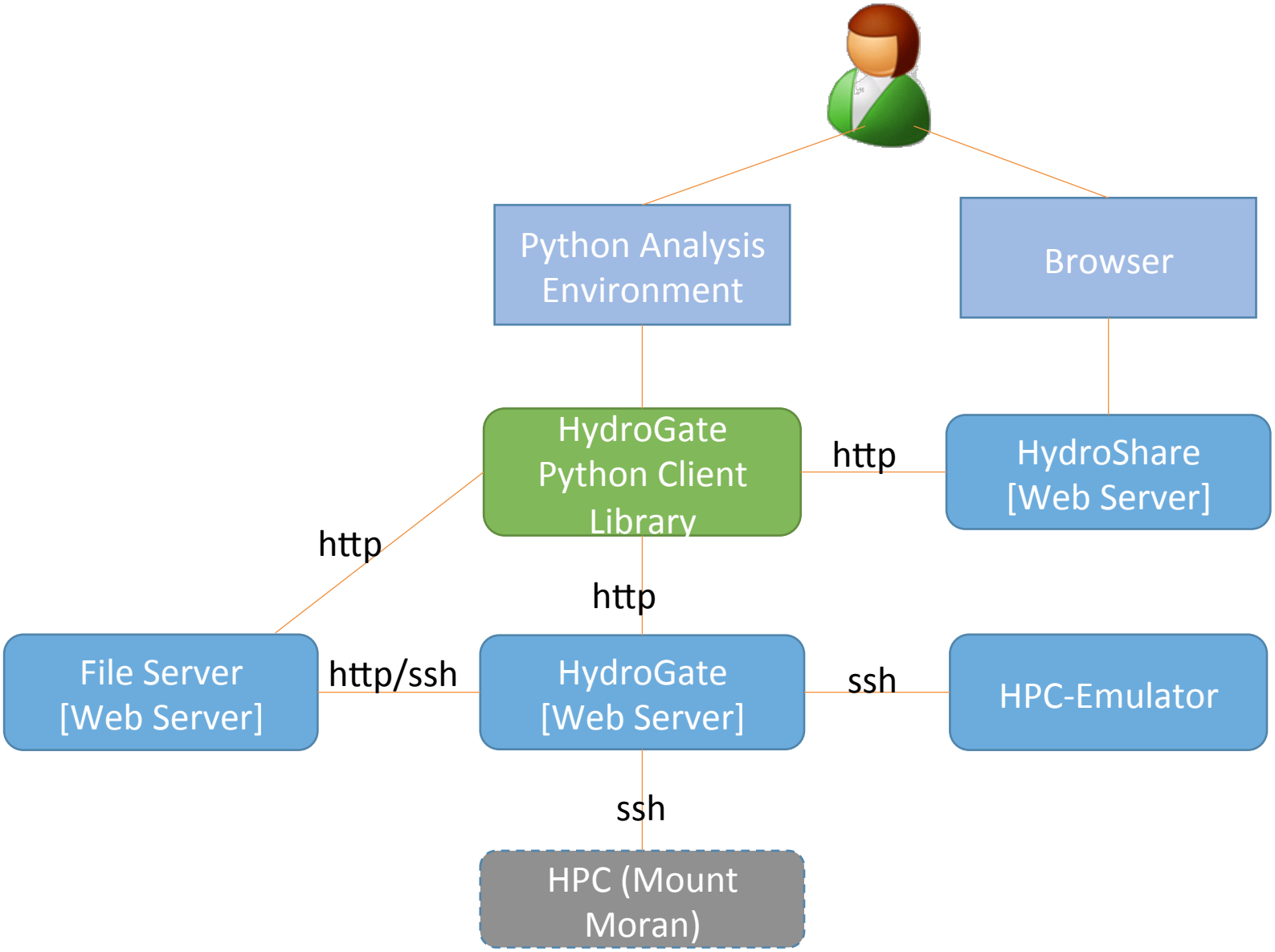
# USU Team

- David Tarboton, Jeff Horsburgh, David Rosenberg (co-PI's)
- Pabitra Dash (software engineer)
- Tseganeh Gichamo (CEE PhD student in hydrologic modeling)
- Ahmet Yildirim (Computer Science PhD student in parallel programming and gateways)
- Adel Abdallah (CEE PhD student in Water Resources Management)

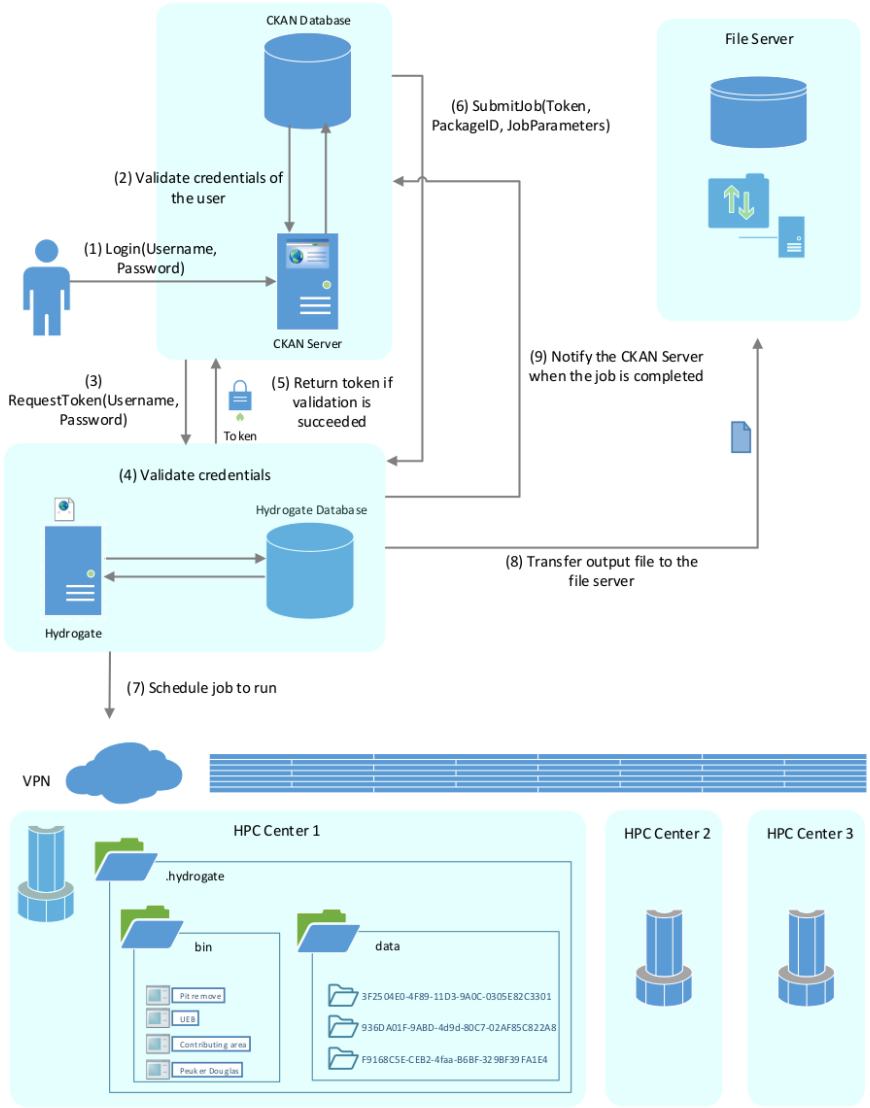
# Delivering Hydrologic Modeling functionality as a service over the web

- Services oriented scripting
  - Data services
  - Modeling services
- Web service gateway to HPC (HydroGate)
- Water Management Data Model (WamDam)
- Leverage (and contribute to) other related systems (HydroShare, CyberGIS)

# CIWATER Service Oriented Architecture



# HydroGate: An API for Authenticated Access to HPC Resources (Mt Moran)



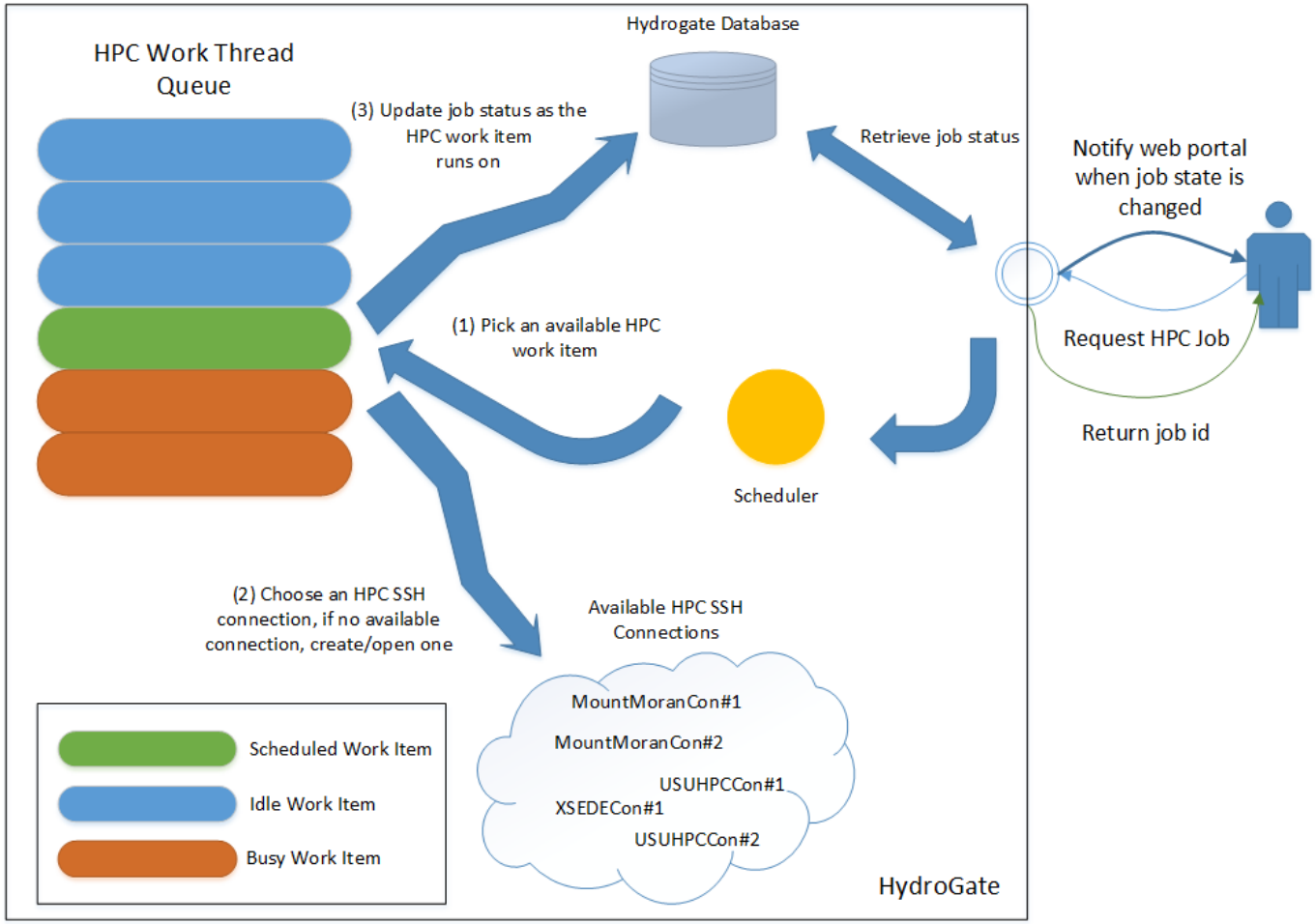

Uses standard secure shell (SSH) for communication so no software installation is needed.

Mt Moran access requires UWYO VPN

Methods

- RequestToken
- IsTokenValid
- SubmitPackage
- CheckPackageStatus
- DeletePackage
- SubmitJob
- CheckJobStatus
- DeleteJob
- GetProgramInformation

# Asynchronous HPC Job Execution




Yildirim, A. A., D. Tarboton, P. Dash and D. Watson, (2014), "Design and Implementation of a Web Service-Oriented Gateway to Facilitate Environmental Modeling using HPC Resources," in D. P. Ames, N. W. T. Quinn and A. E. Rizzoli (eds), Proceedings of the 7th International Congress on Environmental Modelling and Software, San Diego, California, USA, June 16-19, 2014, International Environmental Modelling and Software Society (iEMSs), ISBN: 978-88-9035-744-2, http://www.iemss.org/society/index.php/iemss-2014-proceedings.

# Data Sets Supported via Data Services

| Dataset | Server location |
|---|---|
| Elevation (USGS NED) | CI-WATER Server (Static) |
| Terrain Derivatives (Slope, Aspect, Flow Direction, Contributing area etc.) | CI-WATER Server (Static) |
| Land Cover (NLCD) | CI-WATER Server (Static) |
| Daymet Weather | CI-WATER Server (Dynamic, periodically updated) |
| NLDAS Weather | Dynamically retrieved from NASA |

Prototype services for Greater Salt Lake area complete.

Operational Services for Western US still to be done.

# Data Services Example

## Input

demo.py

```
from hydrogate import Client
client = Client()
client.subset_dem(left_top_x=432760, left_top_y=4662453, right_bottom_x=461700, right_bottom_y=4615000)
subset_dem_request = client.get_most_recent_request(service_name='subset_dem')
print subset_dem_request.file_path
client.download_file(file_url_path=subset_dem_request.file_path, save_as=r'C:\Users\dtarb\Desktop\HydroGateDemo\sub_dem.zip')
```

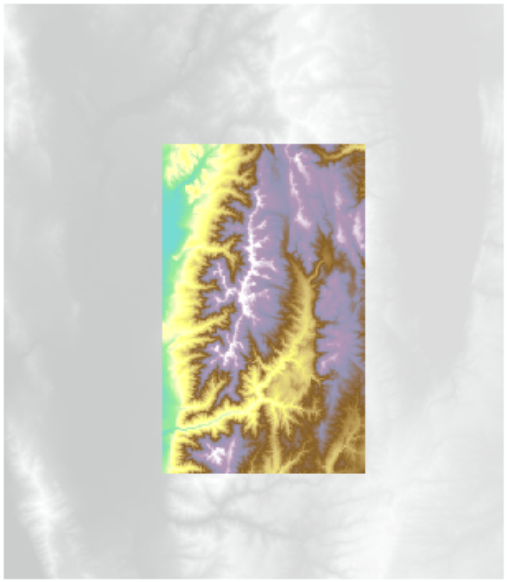
## Result

```
C:\Python27\ArcGIS10.2\python.exe C:/Users/dtarb/Desktop/HydroGateDemo/demo.py
subset_dem execution was successful.

Output file URL path:http://129.123.41.158:8080/dem/dem3504668463149717179.tif.zip

{
    "Output file path": "http://129.123.41.158:8080/dem/dem3504668463149717179.tif.zip",
    "Service status": "success",
    "Request time": "2014-11-15 23:53:20.538000",
    "Service name": "subset_dem",
    "Service ID name": "",
    "Service ID value": ""
}
http://129.123.41.158:8080/dem/dem3504668463149717179.tif.zip
Downloaded file saved successfully at:C:\Users\dtarb\Desktop\HydroGateDemo\sub_dem.zip

Process finished with exit code 0
```



# Modeling example

## Input

modeldemo.py × demo.py ×

```
from hydrogate import Client
client = Client()
client.subset_dem(left_top_x=410000, left_top_y=4682453, right_bottom_x=481700, right_bottom_y=4600000)
# Previously created shapefile
outlet_shapefile_url = "http://129.123.41.158:8080/dem/LoganOutlet.shp.zip"
subset_dem_request = client.get_most_recent_request(service_name='subset_dem')
print subset_dem_request.file_path
input_raster_url = subset_dem_request.file_path
client.generate_watershed_raster(input_raster_url_path=input_raster_url,
                                 outlet_shapefile_url_path=outlet_shapefile_url,
                                 save_as=r'C:\Users\dtarb\Desktop\HydroGateDemo\WS_Logan.tif')
```

## Result

```
C:\Python27\ArcGIS10.2\python.exe C:/Users/dtarb/Desktop/HydroGateDemo/modeldemo.py
subset_dem execution was successful.

Output file URL path:http://129.123.41.158:8080/dem/dem3937079318519734987.tif.zip

{
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    "Service name": "subset_dem",
    "Service ID name": "",
    "Service ID value": ""
}
http://129.123.41.158:8080/dem/dem3937079318519734987.tif.zip
generate_watershed_raster execution was successful.

Output file URL path:http://129.123.41.158:8080/dem/dembfa12a4fdf924fa6b0896f892eb837c8WS.tif.zip

Downloaded file saved successfully at:C:\Users\dtarb\Desktop\HydroGateDemo\WS_Logan.tif
```
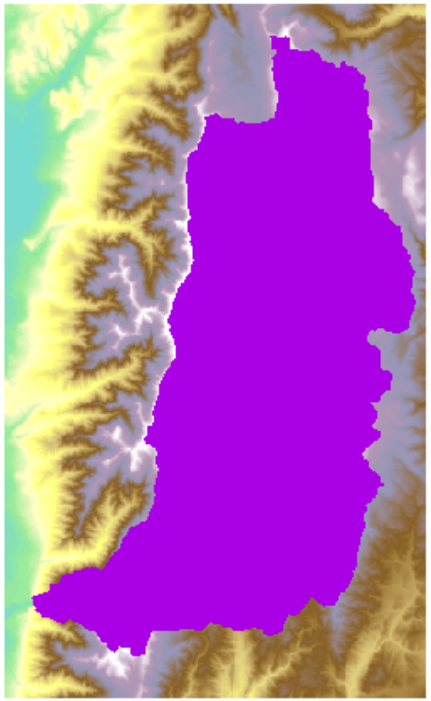
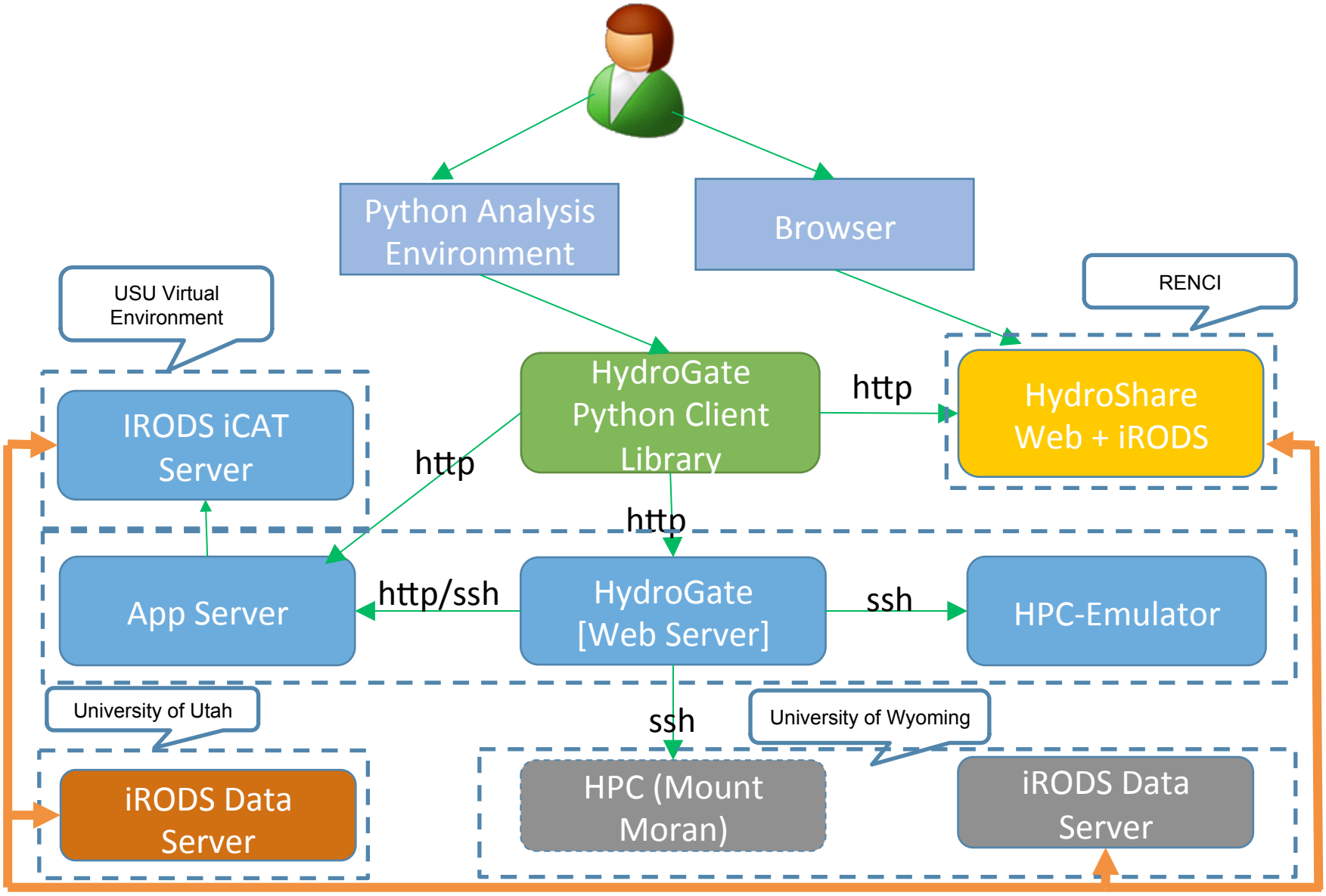



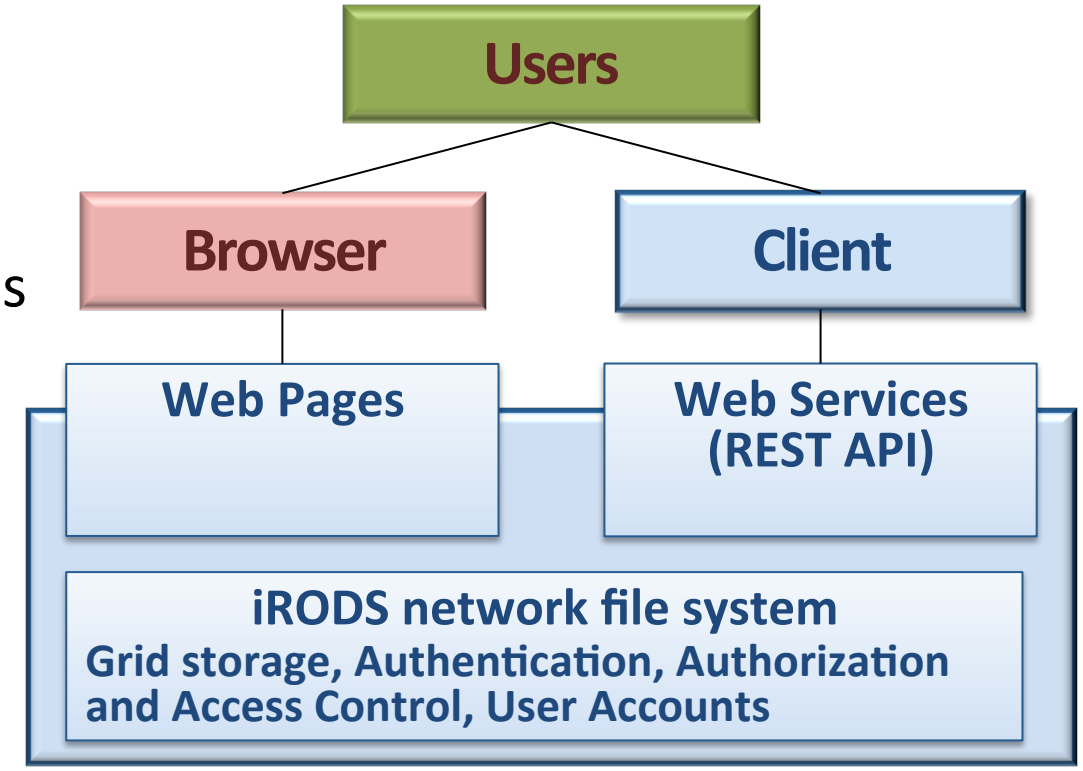
# Planned Fully Built CIWATER Service Oriented Architecture




iRODS Federated Data Grid Network File System

# HydroShare

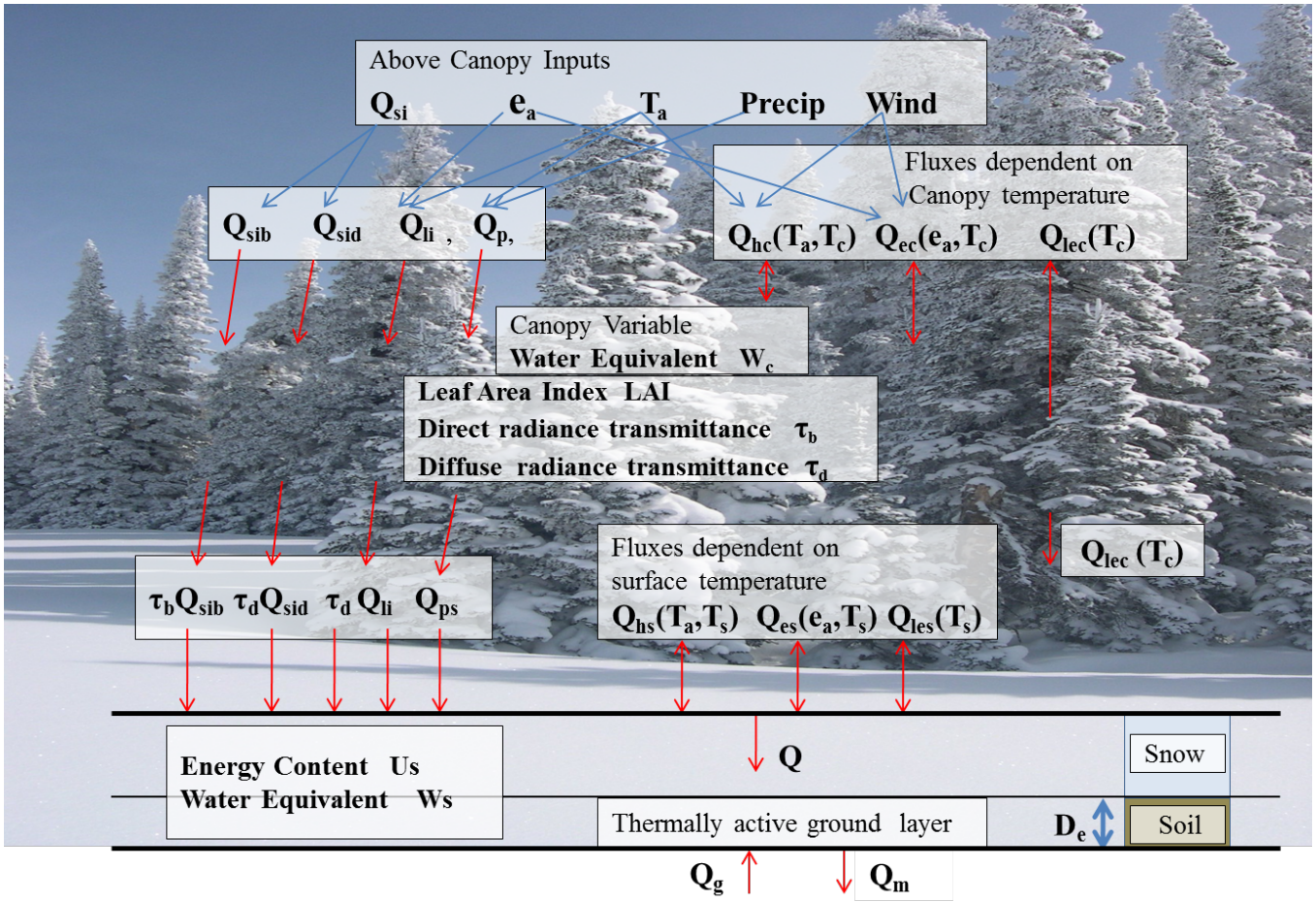
HydroShare is being developed as an online, collaborative environment for the sharing of hydrologic data and models




- CI-WATER will leverage HydroShare user accounts and web system for federated file management
- CI-WATER apps will contribute to HydroShare functionality

# Utah Energy Balance Snowmelt Model

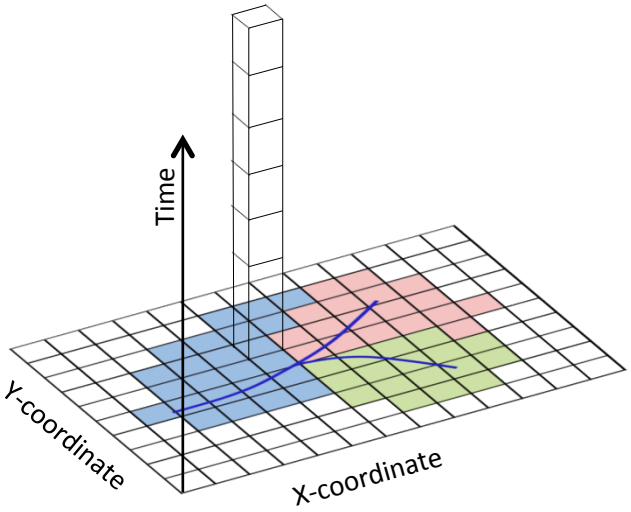
## Used in CI-WATER to address what are the impacts of land cover change on watershed snowmelt inputs

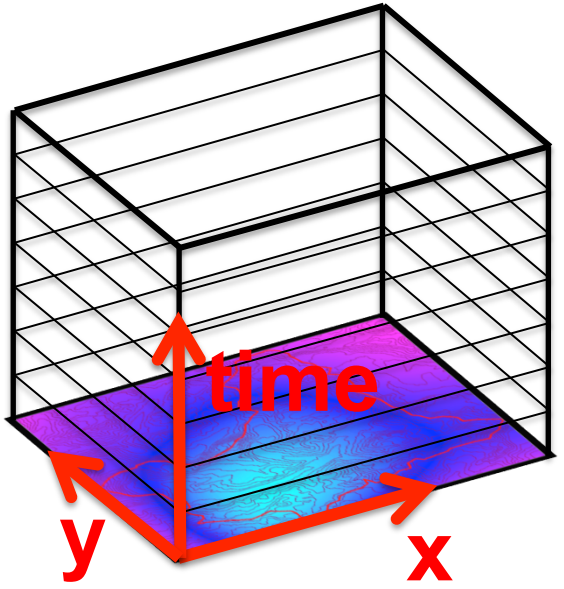



Mahat, V. and D. G. Tarboton, (2012), "Canopy radiation transmission for an energy balance snowmelt model," Water Resour. Res., 48: W01534, http://dx.doi.org/10.1029/2011WR010438.

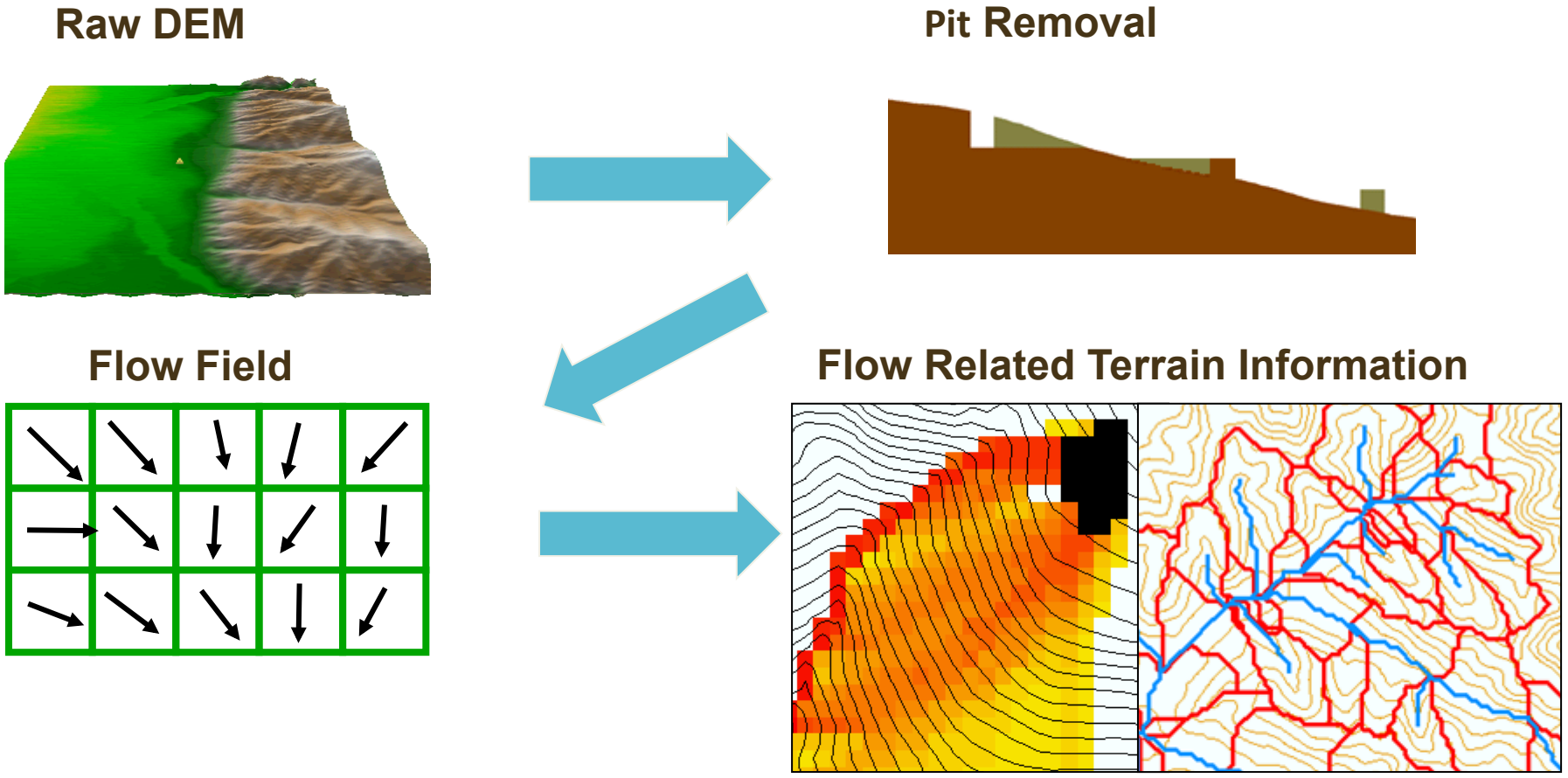
# UEB use case

- Model run separately at each active grid cell
- Parallel implementation for large areas using HPC
- Data services to provide input data
- Data services to configure model inputs
- Modeling services to execute model



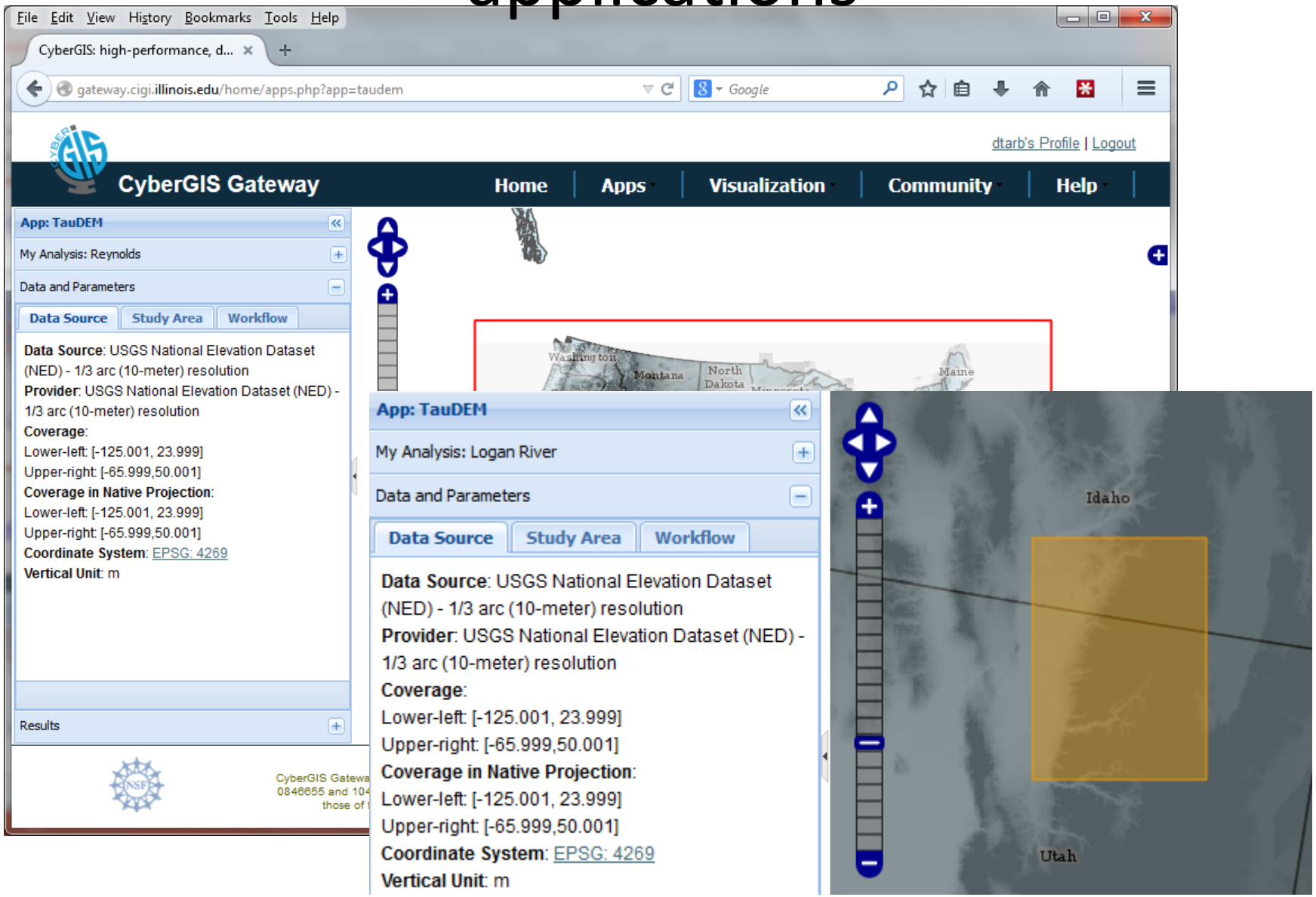



# TauDEM is software for deriving Hydrologically Useful Information from Digital Elevation Models

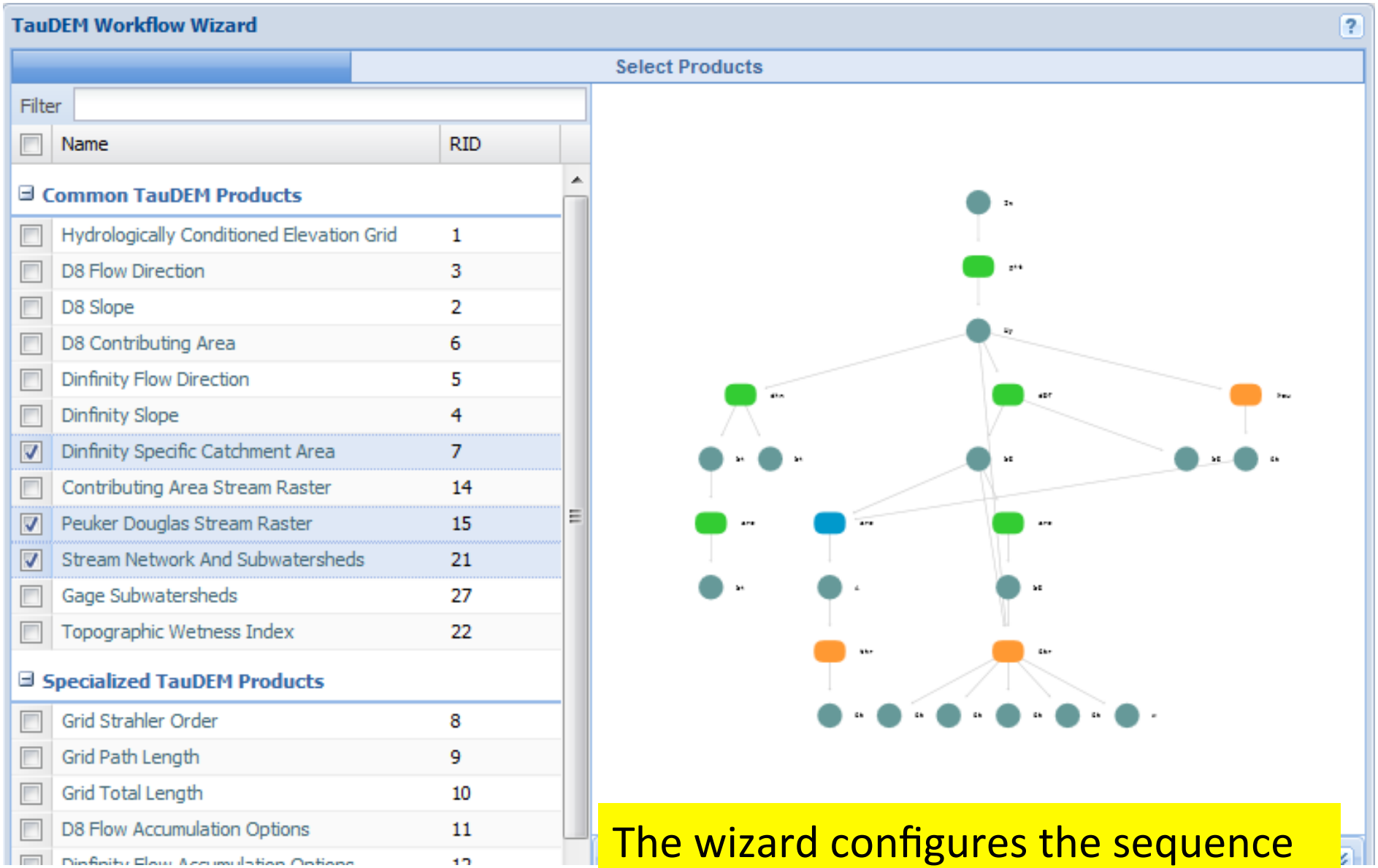



Used in CI-WATER for terrain analysis and watershed delineation

# CyberGIS Platform for Web GIS applications

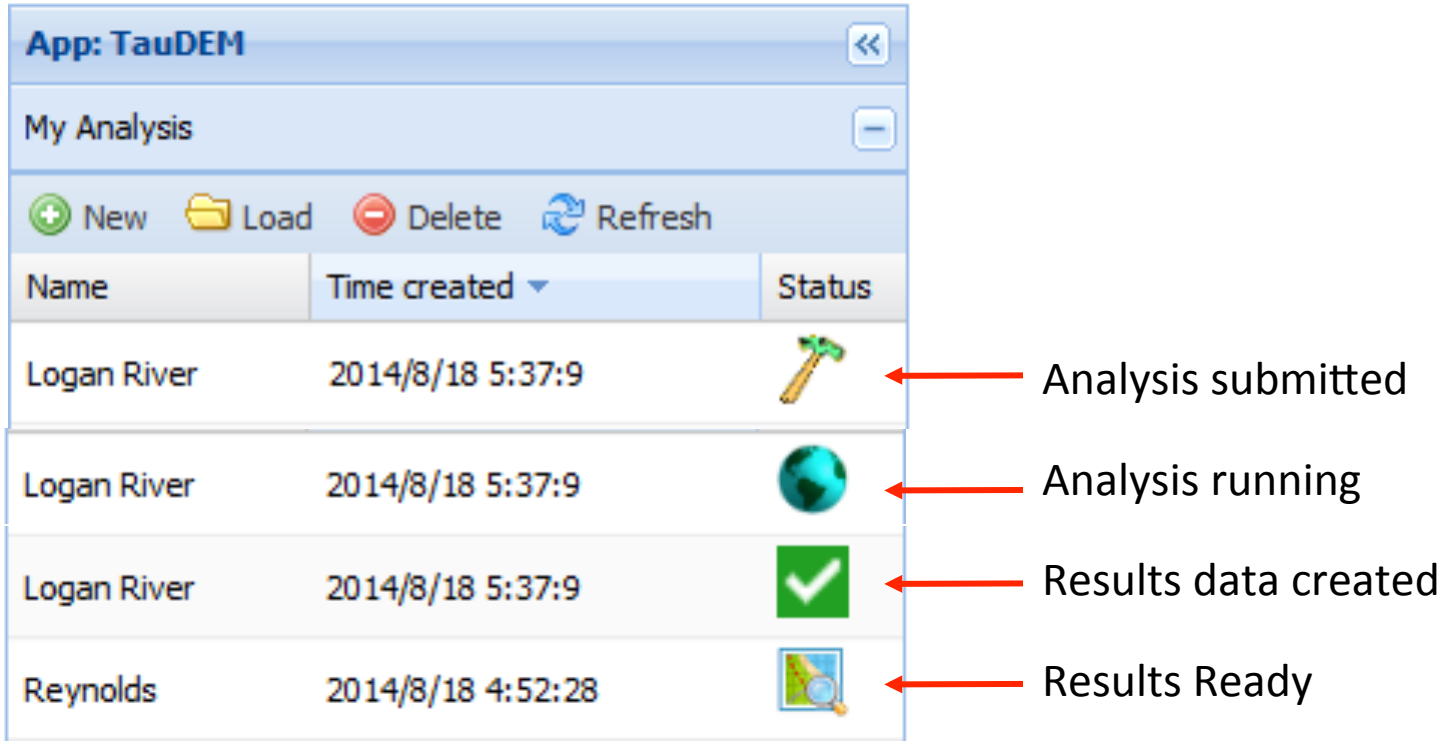


# Select the products you want



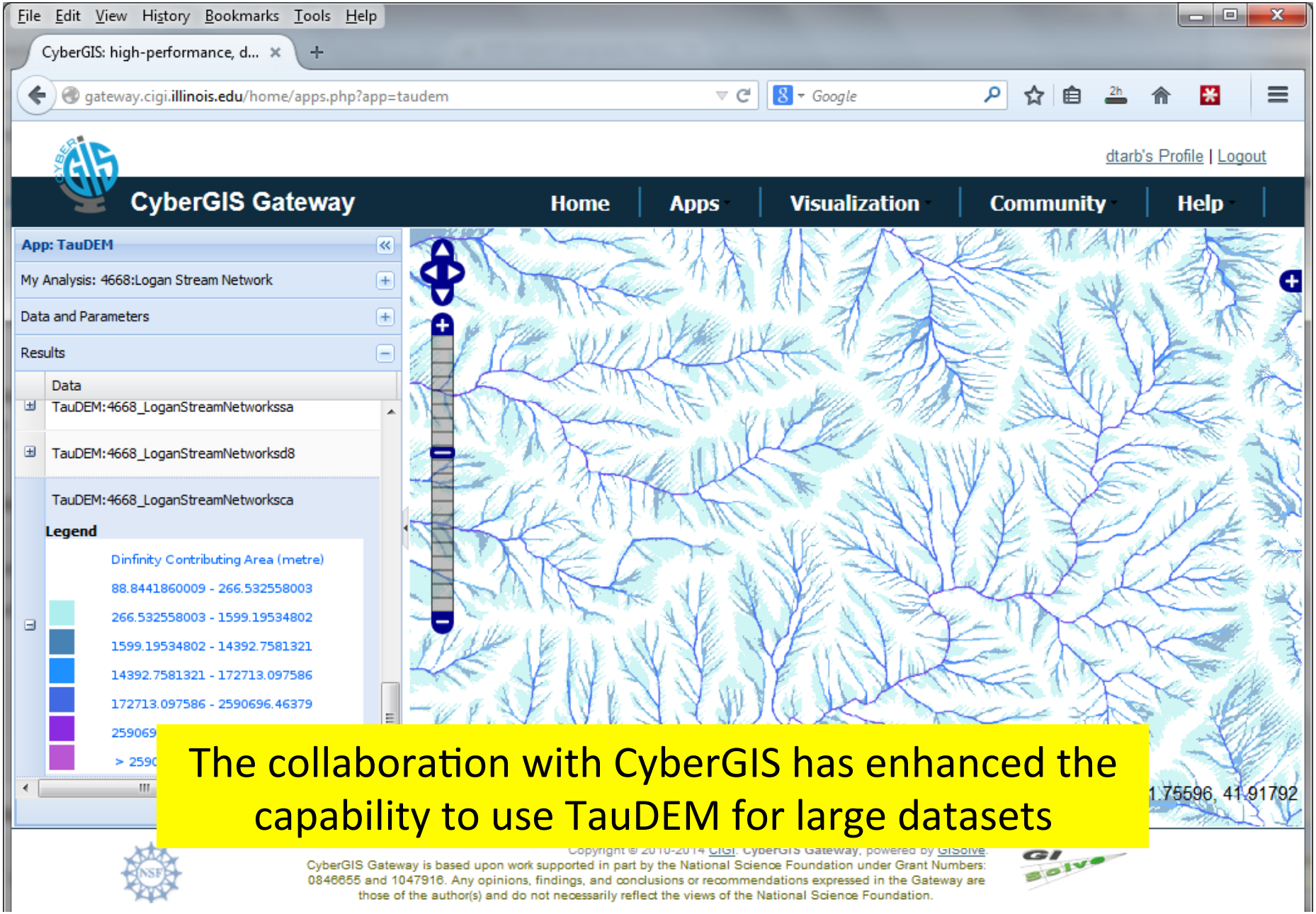

The wizard configures the sequence of functions to run to get the result

# The job progresses through the system




Execution is on XSEDE behind the scenes

# Results displayed in browser




The collaboration with CyberGIS has enhanced the capability to use TauDEM for large datasets

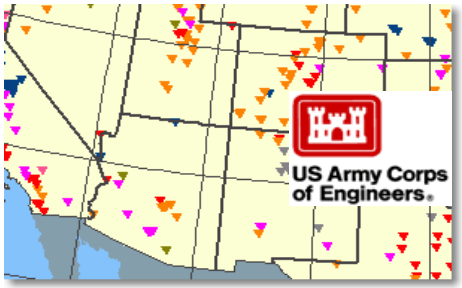
# Water Management Problem

Water management data resides in different data sources, uses different firmware, formats, terminology, and applies to various domains and contexts with various available metadata

- What are the water system components and attributes in a geographic and domain area of interest?
- How are these components physically connected to each other?
- What data is available to run a particular model in a particular place?

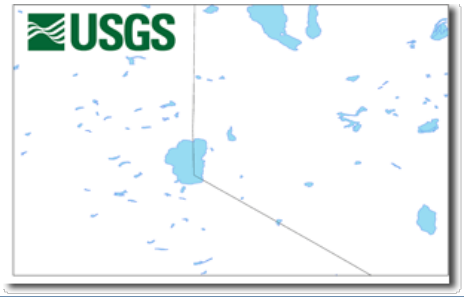


# How to organize all these together?



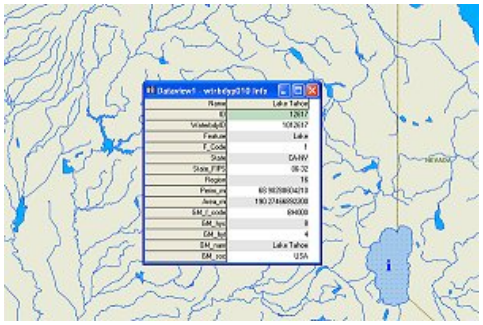

**US Dams dataset**
**23 attributes**
**8,121 instances**

- Consistent semantics and syntactic structure
- Supportive metadata

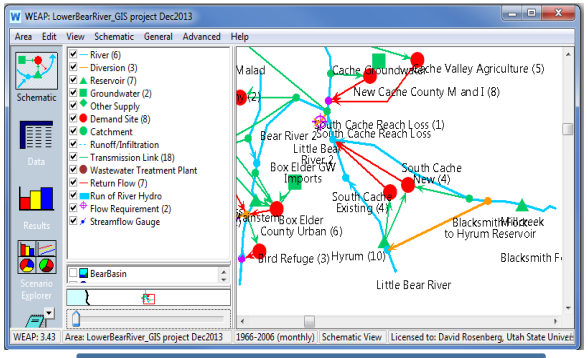



**US Water Bodies and Wetlands Dataset**
**15 attributes**
**26,872 instances**

**Time Series Data**
**32 attributes**



**Streams Network**
**22 attributes**



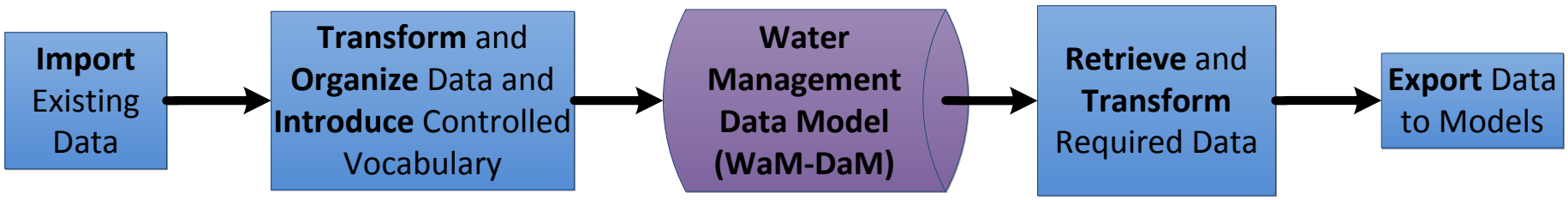

**WEAP Model**
**Lower Bear River, UT**
**53 instances**

# We a need a data model to supports all these common features

| Model | Flexible and extensible | Networks | Scenarios | conditional query | Dynamic controlled vocabulary | Descriptive and explicit metadata | Multiple data formats | Open source envir. |
|---|---|---|---|---|---|---|---|---|
| Arc Hydro | ■ | ■ | | ■ | ■ | ■ | ■ | |
| ODM | ■ | | | ■ | ■ | ■ | | ■ |
| HydroPlatform | ■ | ■ | | | | | ■ | ■ |
| WEAP | | ■ | ■ | | | | ■ | |
| HEC-DSS | | ■ | ■ | | | | ■ | |
| WaDE | | | | ■ | | | | ■ |
| WISKI Kisters | | | | | | | ■ | |
| GoldSim | | ■ | ■ | | | | ■ | |
| SWMM | | ■ | ■ | | | | ■ | ■ |
| CALVIN | | ■ | ■ | | | | | ■ |
| ArcSWAT | | ■ | ■ | | | | ■ | |
| GSSHA | | ■ | | | | | | |
| MODSIM | | ■ | ■ | | | | | |
| TOPNET | | ■ | | | | | ■ | ■ |
| AdHydro | | ■ | | | | | ■ | ■ |

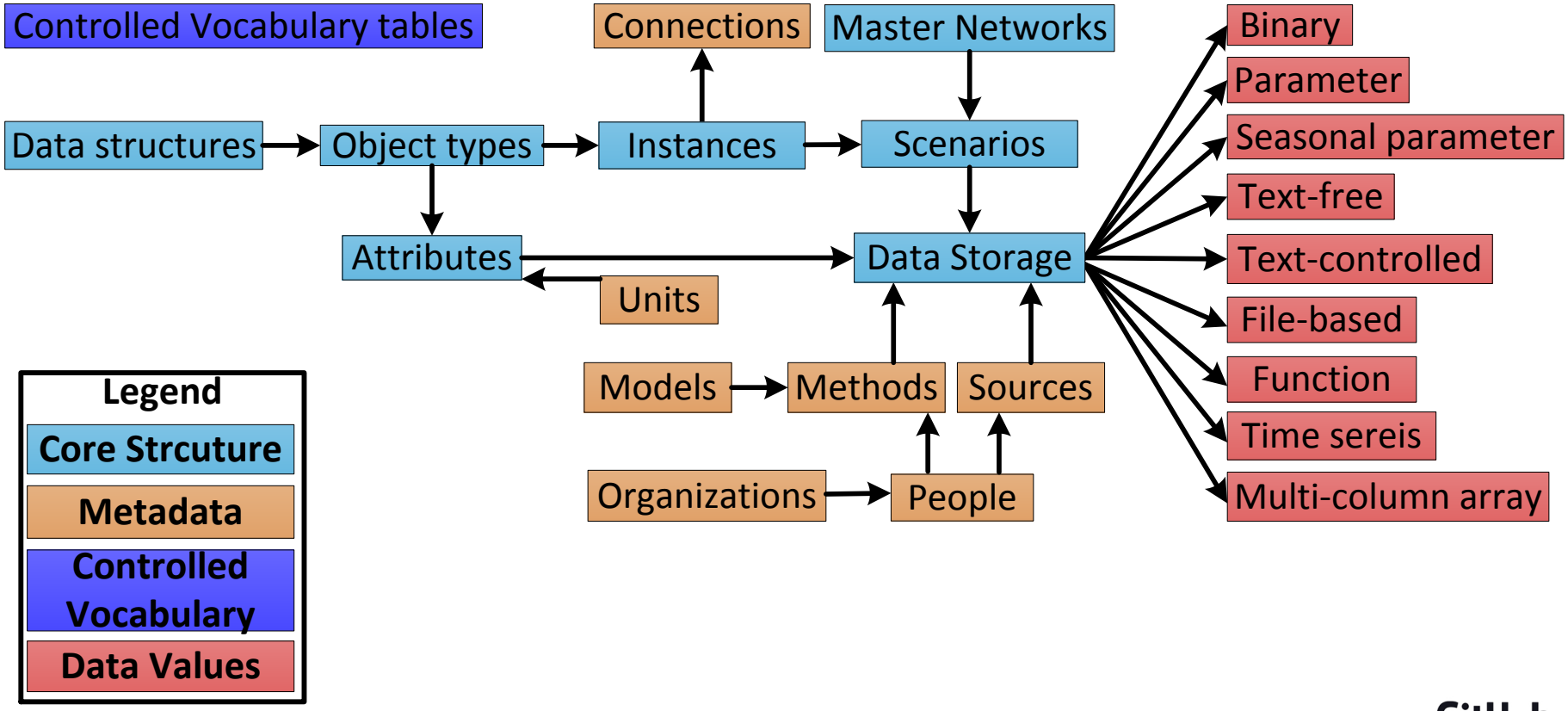
# Water Management Data Model (WaM-DaM)

1. Organize water management data
2. Synthesize data across domains and sources
3. Compare data from different scenarios
4. Serve data to run models
5. Publish model data and share with others




Abdallah, A. M. and D. E. Rosenberg, (2014), "WaM-DaM: A Data Model to Organize and Synthesize Water Management Data," in D. P. Ames, N. W. T. Quinn and A. E. Rizzoli (eds), Proceedings of the 7th International Congress on Environmental Modelling and Software, San Diego, California, USA, International Environmental Modelling and Software Society (iEMSs), ISBN: 978-88-9035-744-2, http://www.iemss.org/society/index.php/iemss-2014-proceedings.

# WaM-DaM Conceptual Design

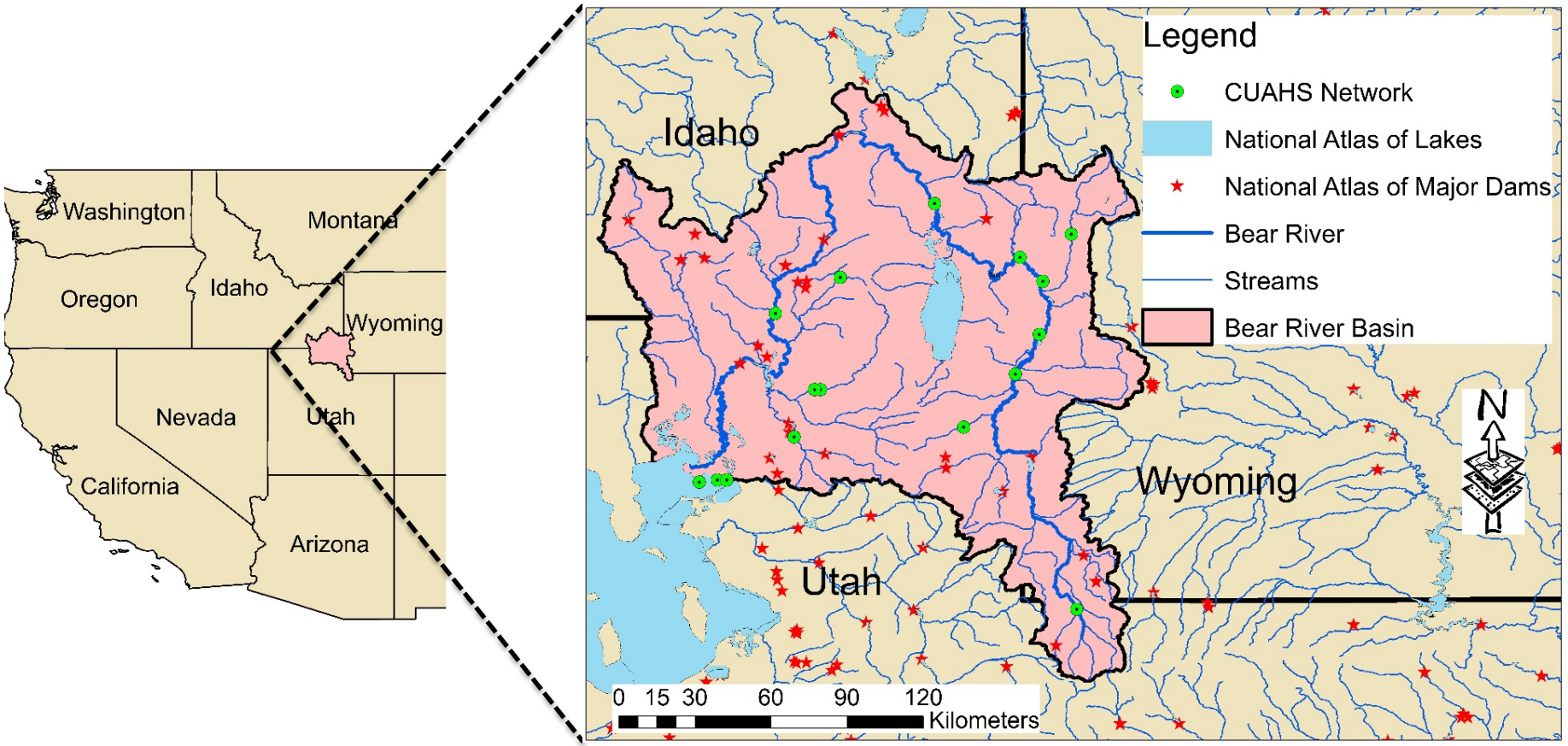



Follow WaM-DaM development @
https://github.com/amabdallah/WaM-DaMv1.0

GitHub

# Use cases

1. Integrate disparate water management data for the Bear River Basin, Utah



# Use cases (cont.)

2. Identify differences in topology, metadata, and data between two WEAP scenarios in the lower Bear River basin

3. Serve data from WaM-DaM to WEAP, SWAT, and GoldSim models

4. Use HydroGate to run city water/energy simulation/optimization model on HPC resource

# Accomplishments

- Prototype capability for supporting access to data required to support data intensive physically based distributed modeling
- HydroGate- Web based access to HPC resources
- Python Client Tool – Easy access to CI-WATER Web Services Tool and app prototypes and ongoing development

# WaM-DaM Accomplishments

- Provides a common persistence model for water management data
- Support syntactic and semantic consistency
- Allow interoperability of data across models

# Next Steps

- Complete data access and modeling services development
- Set up operational data services over Western US
- Use iRODS and federate across data services to provide “network file system” and transparent transport layer
- Use HydroShare for user management and access control (and thereby leverage other HydroShare capabilities available through federation with HydroShare iRODS data grid)
- Further cultivate partnerships to sustain development and functionality past end of grant (HydroShare, CyberGIS)