# Clearing your Desk! Software and Data Services for Collaborative Web Based GIS Analysis

David Tarboton, Ray Idaszak, Jeffery Horsburgh, Dan Ames, Jon Goodall, Larry Band, Venkatesh Merwade, Alva Couch, Rick Hooper, David Maidment, Pabitra Dash, Michael Stealey, Hong Yi, Tian Gan, Tseganeh Gichamo, Ahmet Yildirim, Yan Liu

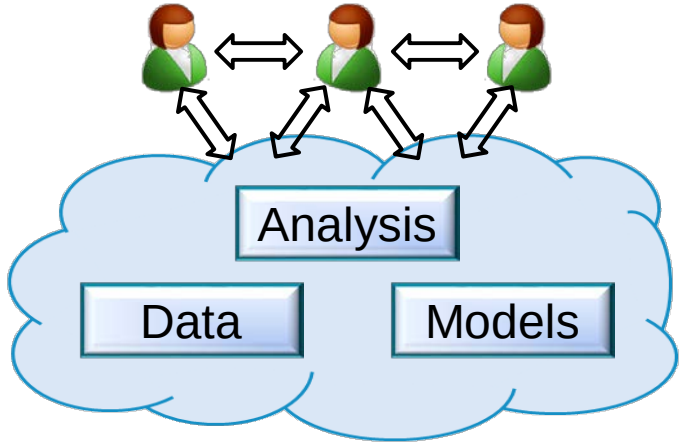
USU, RENCI, BYU, UNC, UVA, CUAHSI, Tufts, Texas, Purdue, Caktus

http://www.hydroshare.org

OCI-1148453
OCI-1148090
EPS-1135482

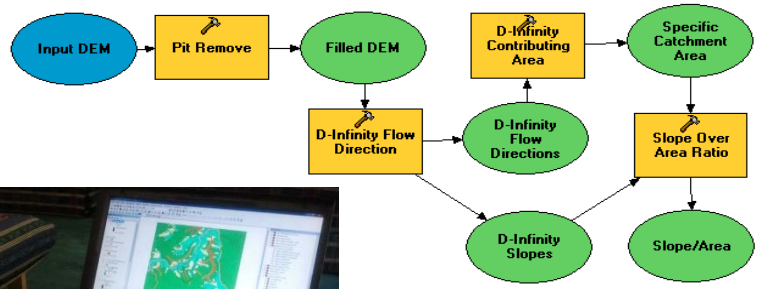
# Outline

- Data and computational challenges
- HydroShare
  - Goals
  - Resource data model
  - Architecture
- Terrain analysis and TauDEM in CyberGIS
- Data services for hydrologic modeling
- Summary

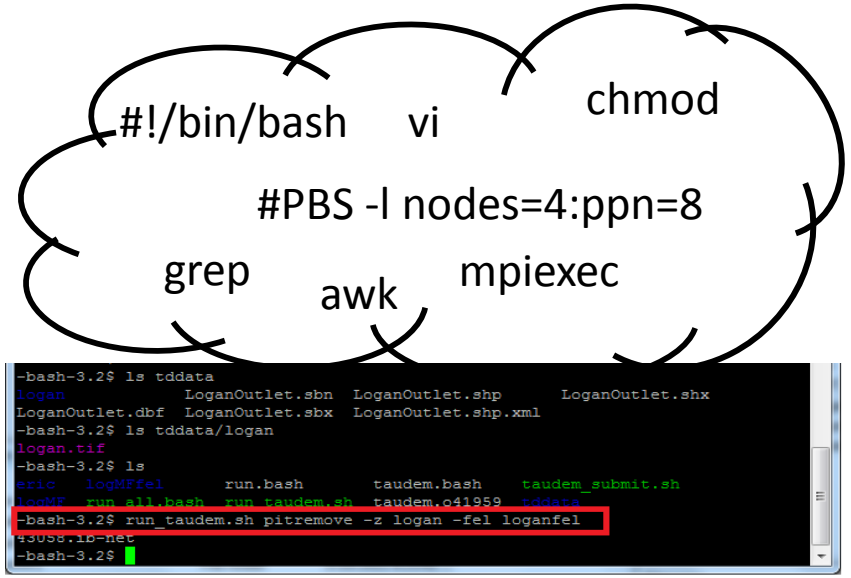


# Do you have the access or know how to take advantage of advanced computing capability?

## Hydrologic Experimentation and Modeling




## Data Intensive High Performance Computing




# A digital divide

Data and Software Services

# The challenge of increasing Digital Elevation Model (DEM) resolution

1980's DMA 90 m

$10^2$ cells/km$^2$

1990's USGS DEM 30 m

$10^3$ cells/km$^2$

2000's NED 10 m

$10^4$ cells/km$^2$

2010's LIDAR ~1 m

$10^6$ cells/km$^2$

e.g. 50,000 km$^2$ Watershed

27 MB

240 MB

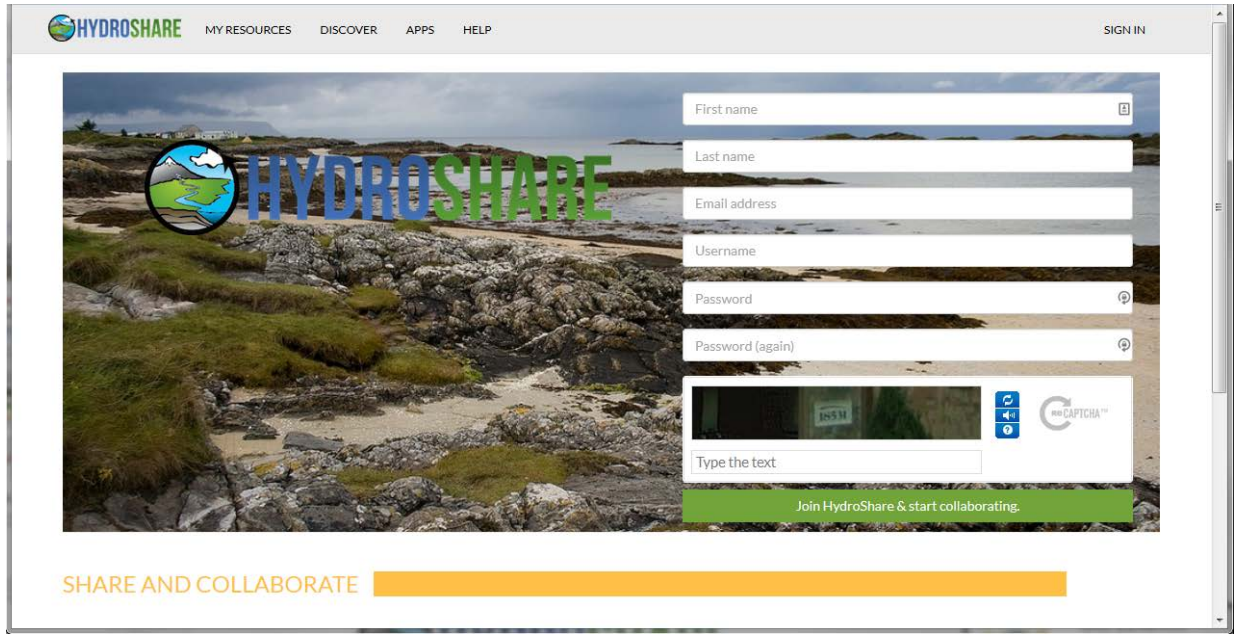
2 GB

200 GB

# HydroShare web based collaboration environment

- Share your data and models with colleagues
- Manage who has access to the content that you share
- Share, access, visualize and manipulate a broad set of hydrologic data types
- Sharing and execution of models
- Web services API to facilitate automated and client access to almost all functionality
- Access to and use of high performance computing
- Publication of data and models with a DOI

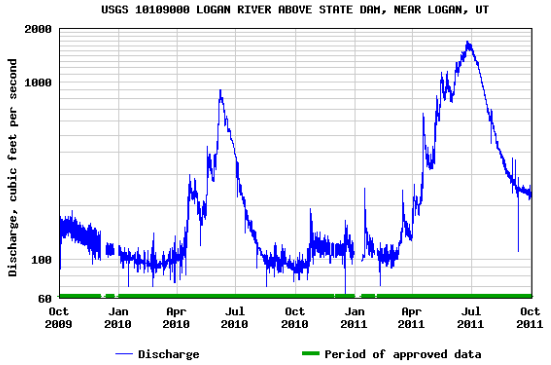
www.hydroshare.org

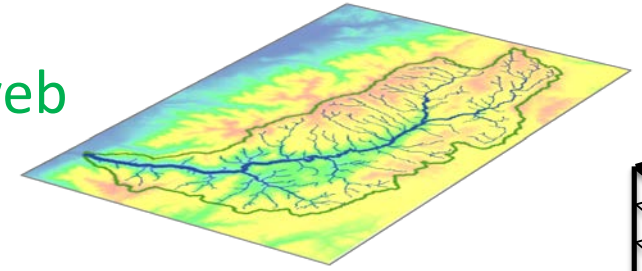


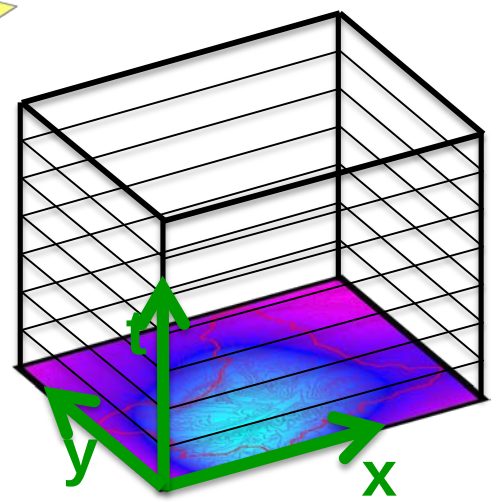

Enable more rapid advances in hydrologic understanding through collaborative data sharing, analysis and modeling.

# Types of data supported as resources

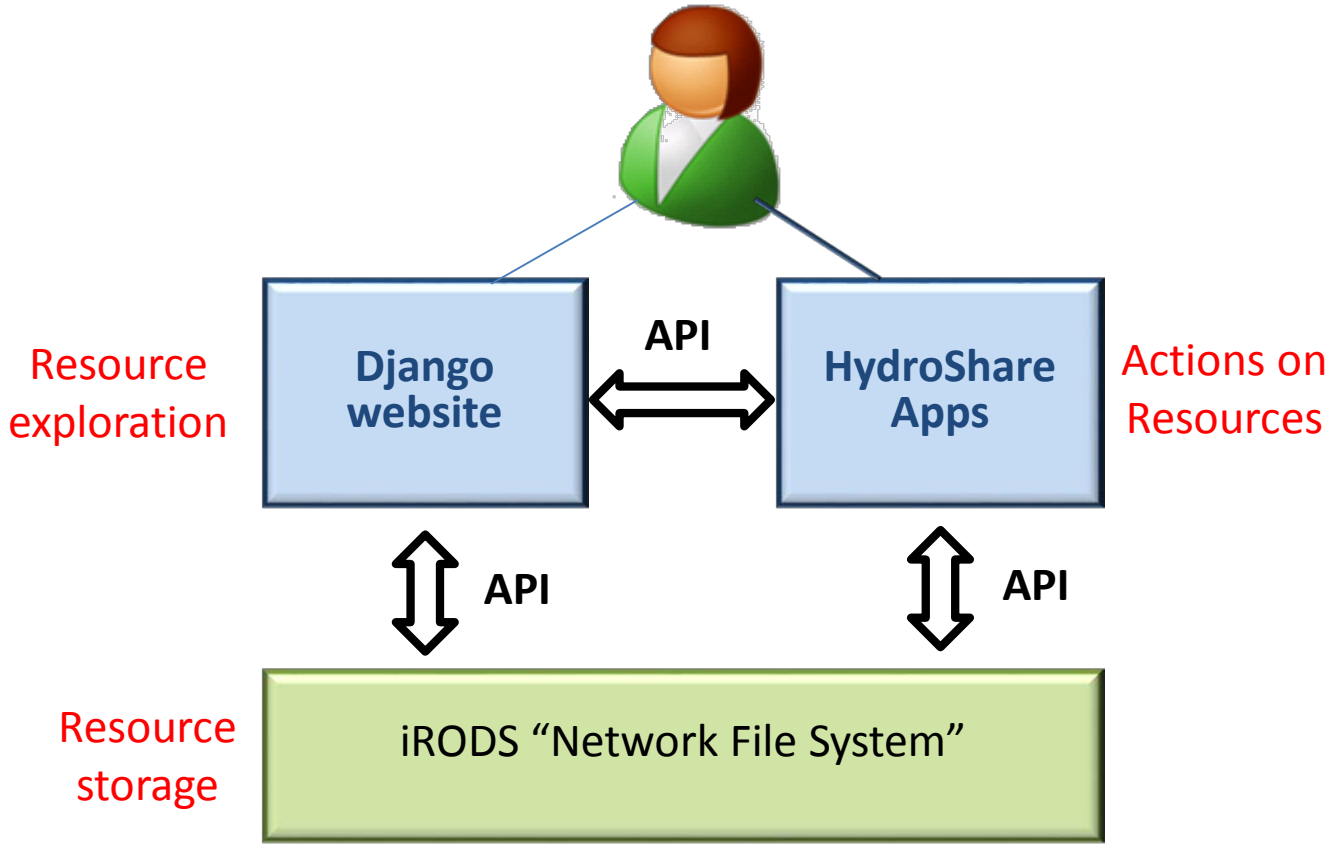
- Generic ✓
- Geographic Raster (GeoTIFF) ✓
- Time Series ✓
- Multidimensional (netCDF) ✓
- Model program ✓
- Model instance ✓
  - SWAT Model Instance ✓
- Web App ✓
- Geographic Feature (Shapefile) ✓
- Referenced Time Series (CUAHSI HIS web service link)
- River Geometry
- Sample based observations (ODM2 and CZO)
- Composite resources (Collections of resources)





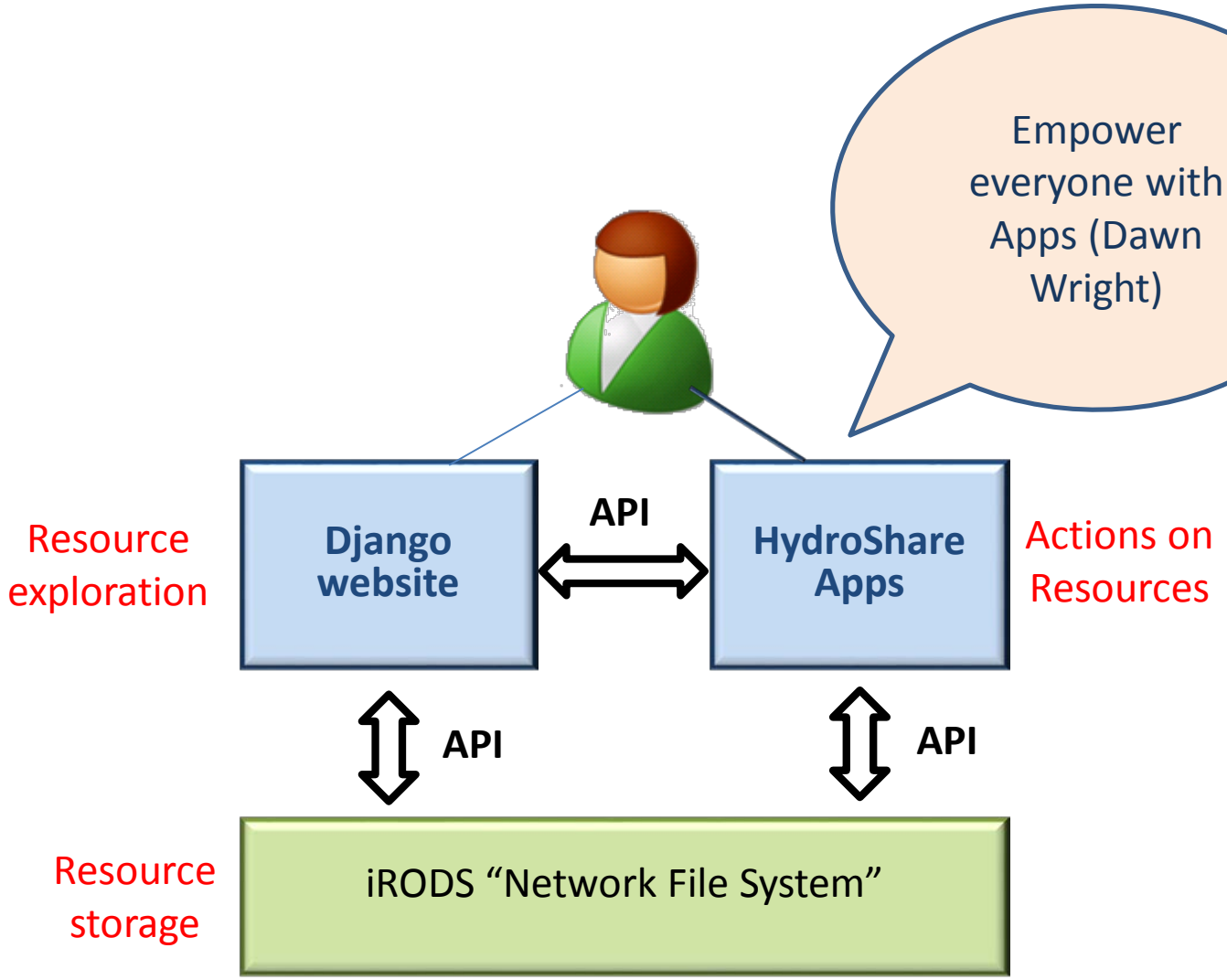
# Architecture




- Can this web based (cloud) computing approach deliver GIS and hydrologic analysis and modeling functionality as services over the web?

  and address

- Platform independence
- Big data
- Reproducibility
- Reduce needs for software installation and configuration

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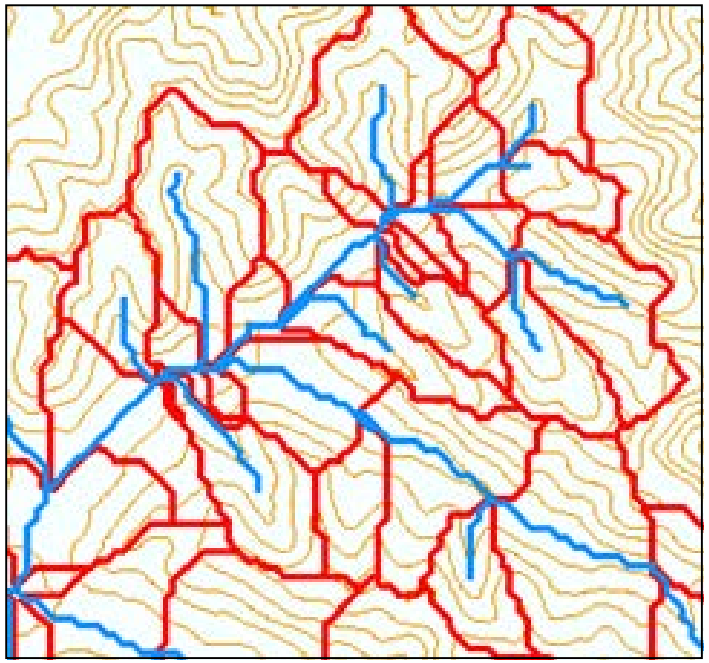
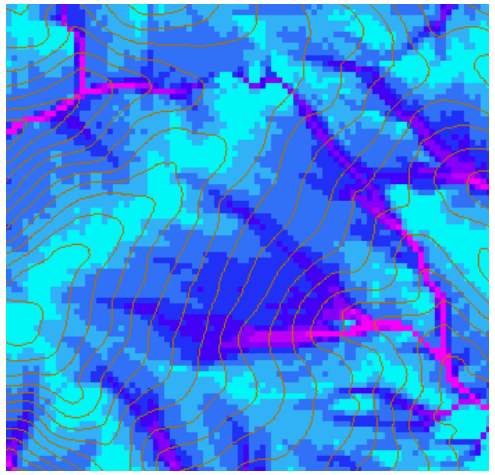
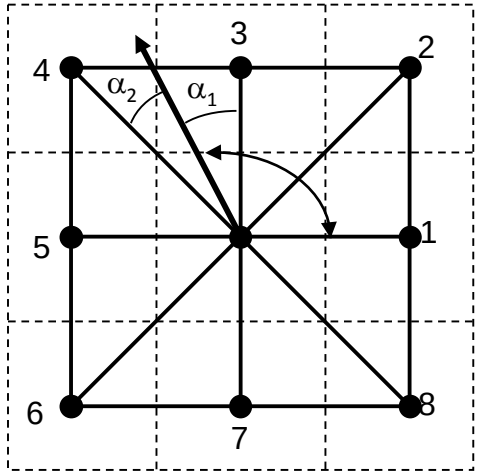
**Anyone can set up a server/app platform (software service) to operate on HydroShare resources through iRODS and API**

# Terrain Analysis as a use case

- Topography is fundamental to hydrology
- Watersheds are the most basic hydrologic landscape elements








TauDEM http://hydrology.usu.edu/taudem/ is software for deriving hydrologically useful information from Digital Elevation Models

- Stream and watershed delineation
- Multiple flow direction flow field
- Calculation of flow based derivative surfaces
- MPI Parallel Implementation for speed up and large problems
- Open source platform independent C++ command line executables for each function
- Deployed as an ArcGIS Toolbox with python scripts that drive command line executables

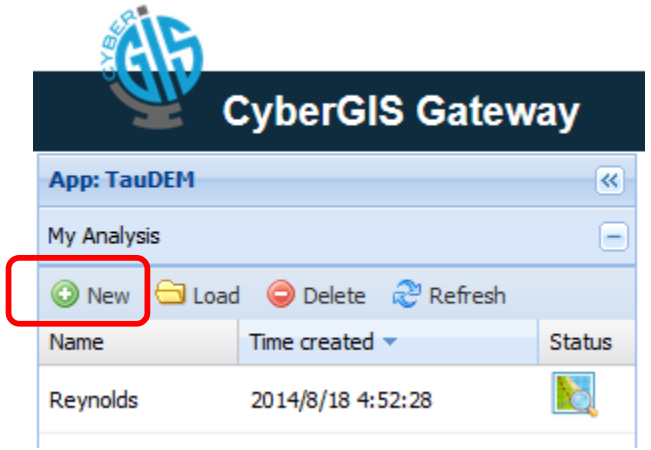
# Using TauDEM today requires

- Expertise in Hydrologic DEM analysis
- The software
  - ArcGIS licenses (for ArcGIS plugin)
  - The ability to install software
  - TauDEM command functions with MPI installation
  - Compilation for other platforms

- Sufficient Hardware (RAM and Disk)
- The data (GDAL formatted rasters with consistent grid size and spatial reference)

# Moving TauDEM to the cloud, CyberGIS TauDEM App

http://gateway.cigi.illinois.edu/



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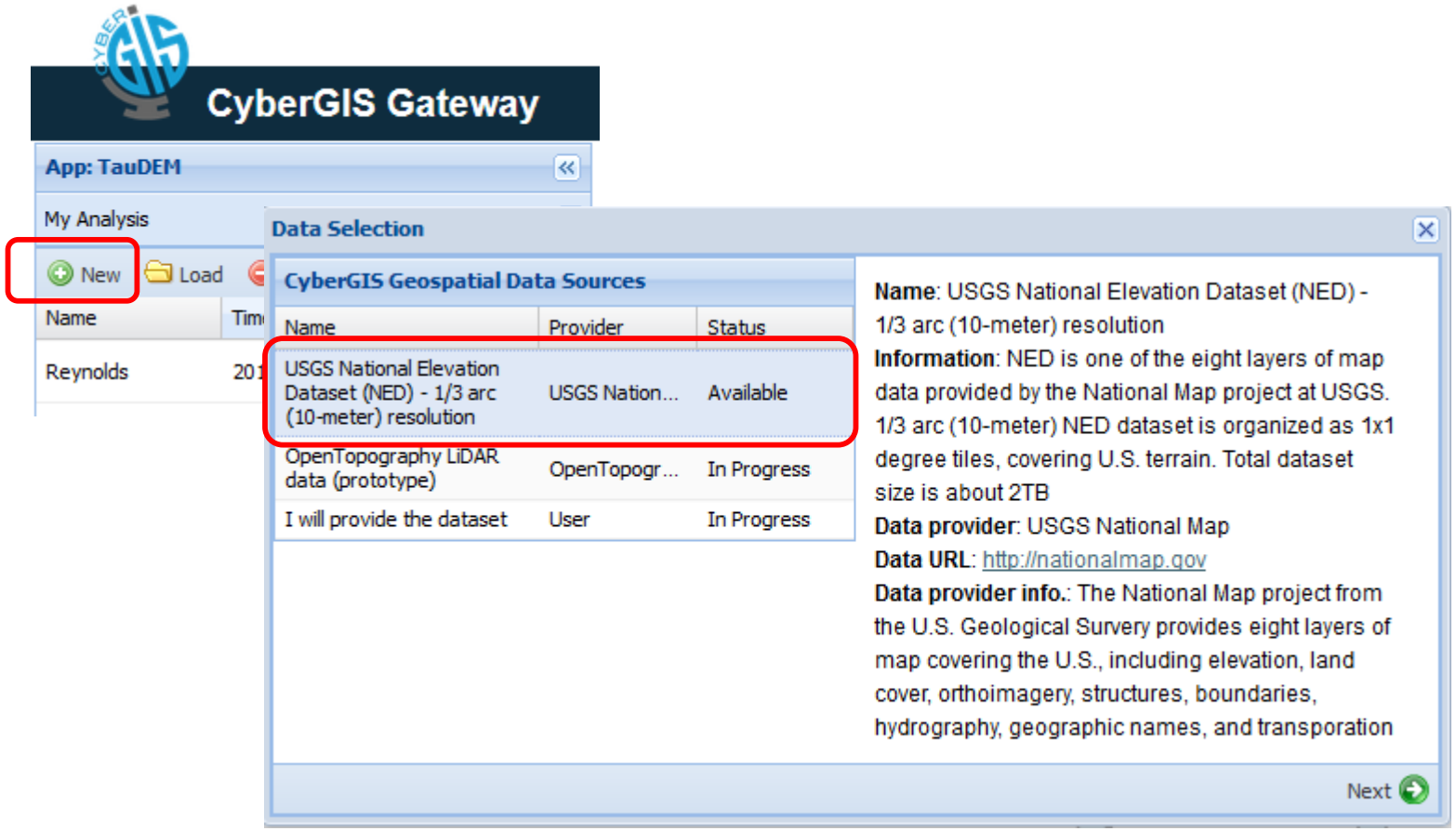

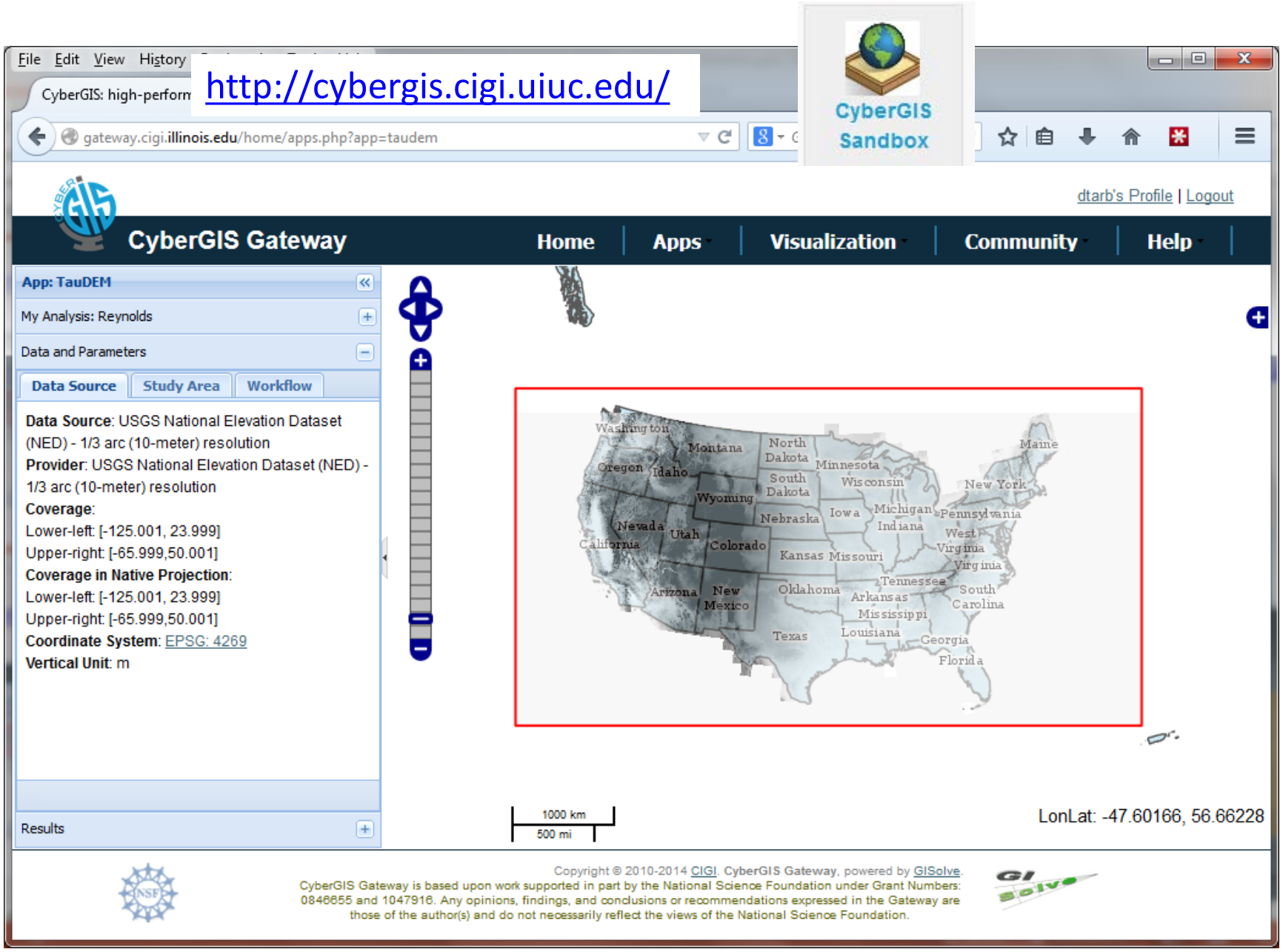
File Edit View History
CyberGIS: high-perform
http://cybergis.cigi.uiuc.edu/
CyberGIS Sandbox
gateway.cigi.illinois.edu/home/apps.php?app=taudem
dtarb's Profile | Logout
CyberGIS Gateway
Home
Apps
Visualization
Community
Help
App: TauDEM
My Analysis: Reynolds
Data and Parameters
Data Source
Study Area
Workflow
Data Source: USGS National Elevation Dataset (NED) - 1/3 arc (10-meter) resolution
Provider: USGS National Elevation Dataset (NED) - 1/3 arc (10-meter) resolution
Coverage:
Lower-left: [-125.001, 23.999]
Upper-right: [-65.999,50.001]
Coverage in Native Projection:
Lower-left: [-125.001, 23.999]
Upper-right: [-65.999,50.001]
Coordinate System: EPSG: 4269
Vertical Unit: m
Results
Washington
Montana
North Dakota
Minnesota
Maine
Oregon
Idaho
South Dakota
Wisconsin
New York
Wyoming
Michigan
Pennsylvania
Nebraska
Iowa
Indiana
Nevada
Utah
West Virginia
California
Colorado
Kansas
Missouri
Virginia
Tennessee
Arizona
New Mexico
Oklahoma
Arkansas
South Carolina
Mississippi
Texas
Louisiana
Georgia
Florida
1000 km
500 mi
LonLat: -47.60166, 56.66228
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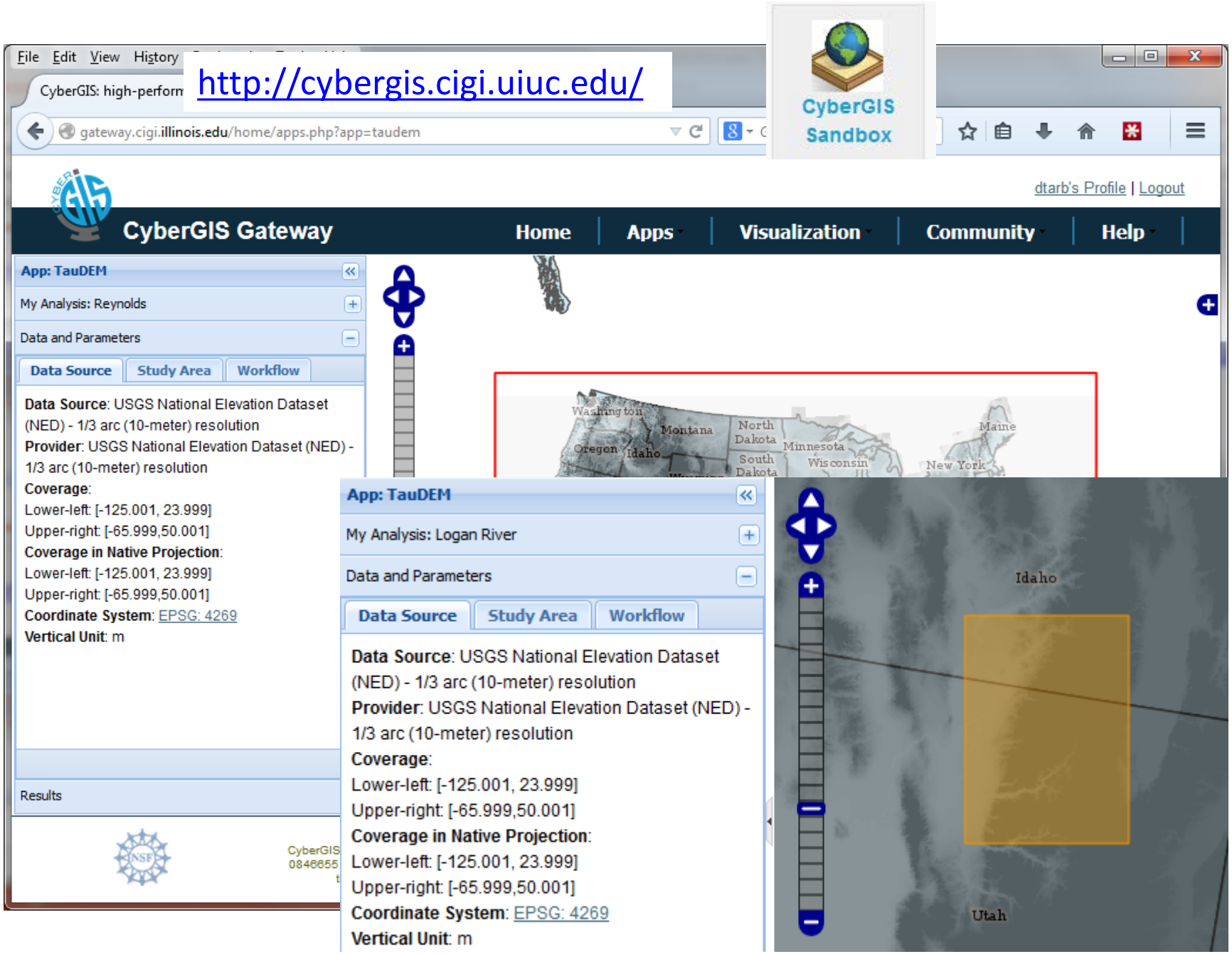
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Coordinate System: EPSG: 4269
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North Dakota
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Wisconsin
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App: TauDEM
My Analysis: Logan River
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Data Source: USGS National Elevation Dataset (NED) - 1/3 arc (10-meter) resolution
Provider: USGS National Elevation Dataset (NED) - 1/3 arc (10-meter) resolution
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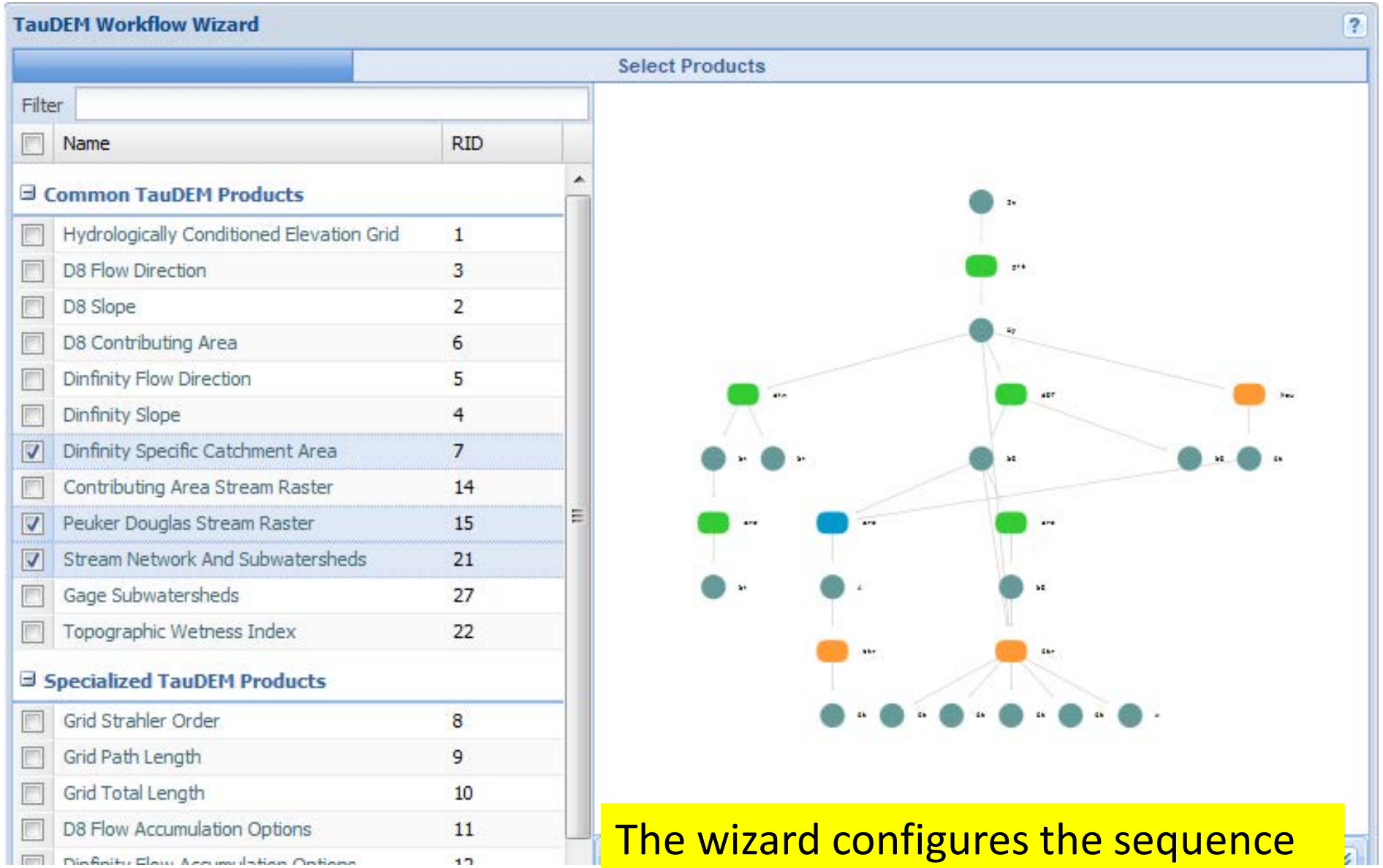
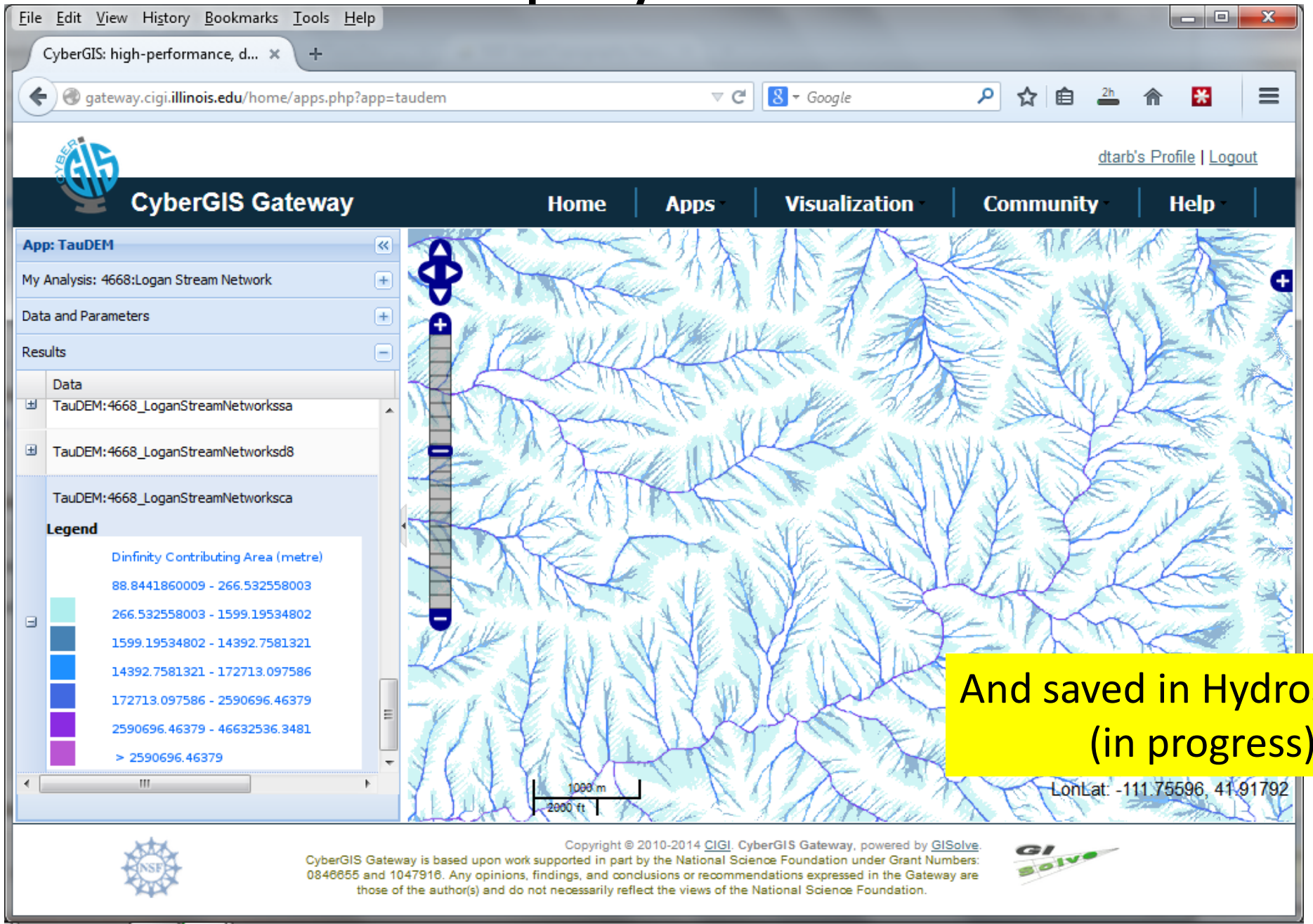
Coverage in Native Projection:
Lower-left: [-125.001, 23.999]
Upper-right: [-65.999,50.001]
Coordinate System: EPSG: 4269
Vertical Unit: m
Idaho
Utah

# Select the products you want




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

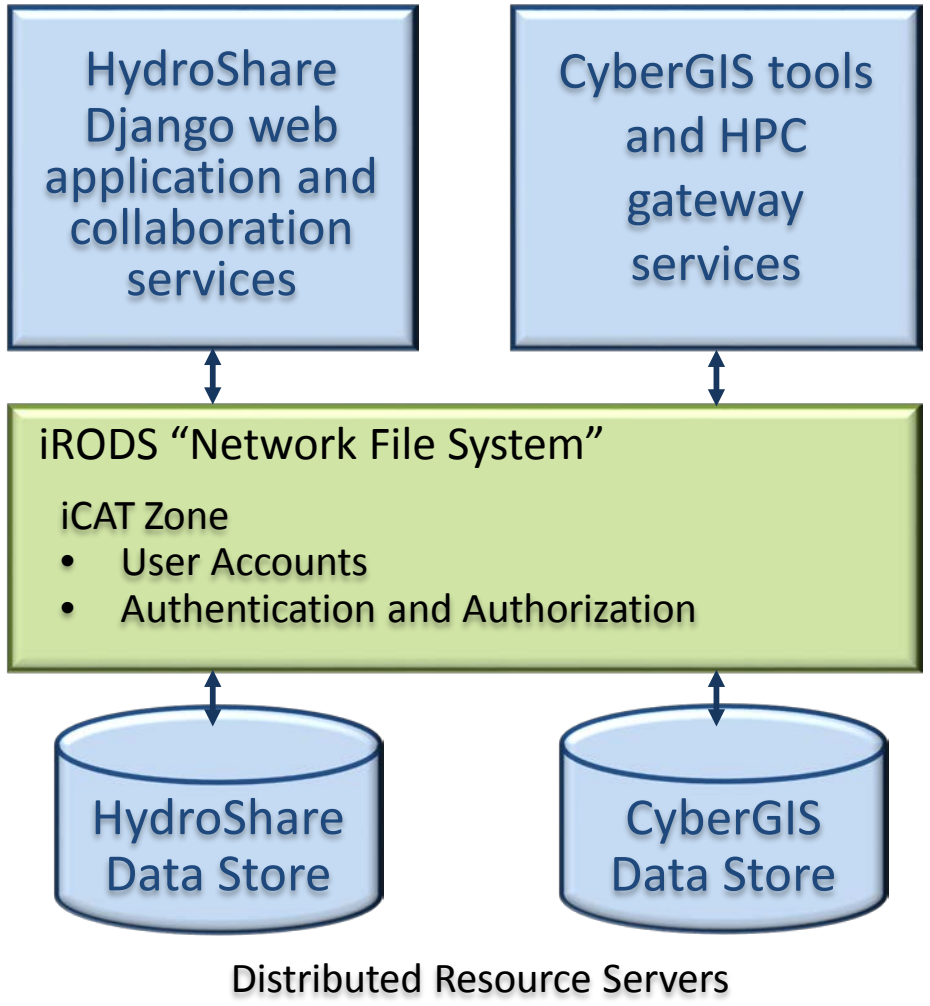
# Results displayed in browser




And saved in HydroShare (in progress)

# CyberGIS HydroShare Coupling

- CyberGIS data holdings shared as HydroShare resources
- HydroShare user resources staged at CyberGIS for input to computation
- Results persisted as resources in HydroShare to support
  - Collaboration
  - Input for further analysis and models



# Advancing Data Services for Modeling and Analysis

## Assumptions

1. GIS and hydrologic modelers have to learn and become comfortable using a modern scientific programming language (e.g. Python or R)
2. Modeling is increasingly data intensive (large datasets from a range of sources) demanding more data and computing resources than is in most PC's
3. Reproducibly installing and configuring models on different platforms is a challenge
4. Should not have to become expert in HPC systems and learning them is a barrier to using HPC and research with big data and computationally intensive models

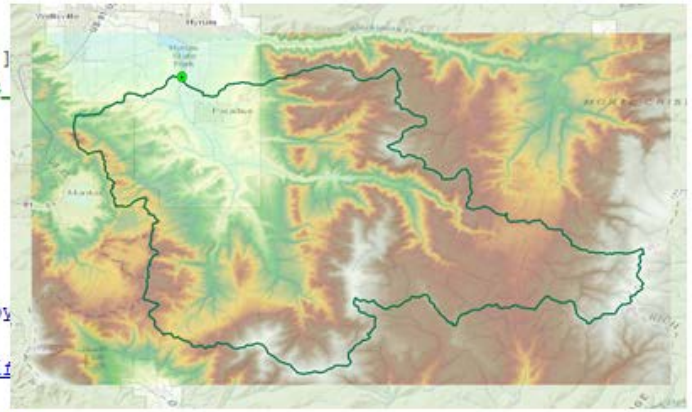
# Computation via Python Client calling Data and Modeling Services

**Input**

```
__author__ =
import ...
""" Illustration of Watershed Delineation using CI-WATER data services"""
HDS = HydroDS(username=settings.USER_NAME, password=settings.PASSWORD)
subsetDEM = HDS.subset_raster(input_raster='nedWesternUS.tif', left=-111.97, top=41.629,
            right=-111.48,bottom=41.36,output_raster='MyDEM.tif')
projectDEM = HDS.project_resample_raster(input_raster_url_path=subsetDEM['output_raster'],
            cell_size_dx=30, cell_size_dy=30, epsg_code=26912,
            output_raster='MyDemProj.tif',resample='bilinear')

# Create outlet point
outlet = HDS.create_outlet_shapefile(point_x=-111.855, point_y=41.596,
            output_shape_file_name='Outlet.shp')
outletProj = HDS.project_shapefile(outlet['output_shape_file_name'],'OutletProj.shp',
            epsg_code=26912)

##  Delineate watershed
Watershed = HDS.delineate_watershed(projectDEM['output_raster']
            input_outlet_shapefile_url_path=outletProj['output_
            threshold=1000, epsg_code=26912,
            output_raster='Watershed.tif',
            output_outlet_shapefile='movedOutlet.shp')
ListMyFiles()
```

**Result**

```
C:\Python27\ArcGIS10.3\python.exe D:/Scratch/CI-WATERDemos/demo.py
http://hydro-ds.uwrl.usu.edu:20199/files/data/user_4/MyDEM.tif
http://hydro-ds.uwrl.usu.edu:20199/files/data/user_4/MyDemProj.tif
http://hydro-ds.uwrl.usu.edu:20199/files/data/user_4/Outlet.zip
http://hydro-ds.uwrl.usu.edu:20199/files/data/user_4/OutletProj.zip
http://hydro-ds.uwrl.usu.edu:20199/files/data/user_4/movedOutlet.zip
http://hydro-ds.uwrl.usu.edu:20199/files/data/user_4/Watershed.tif

Process finished with exit code 0
```



Python session on desktop but data and analysis on server with results pushed to iRODS/HydroShare for storage and collaboration

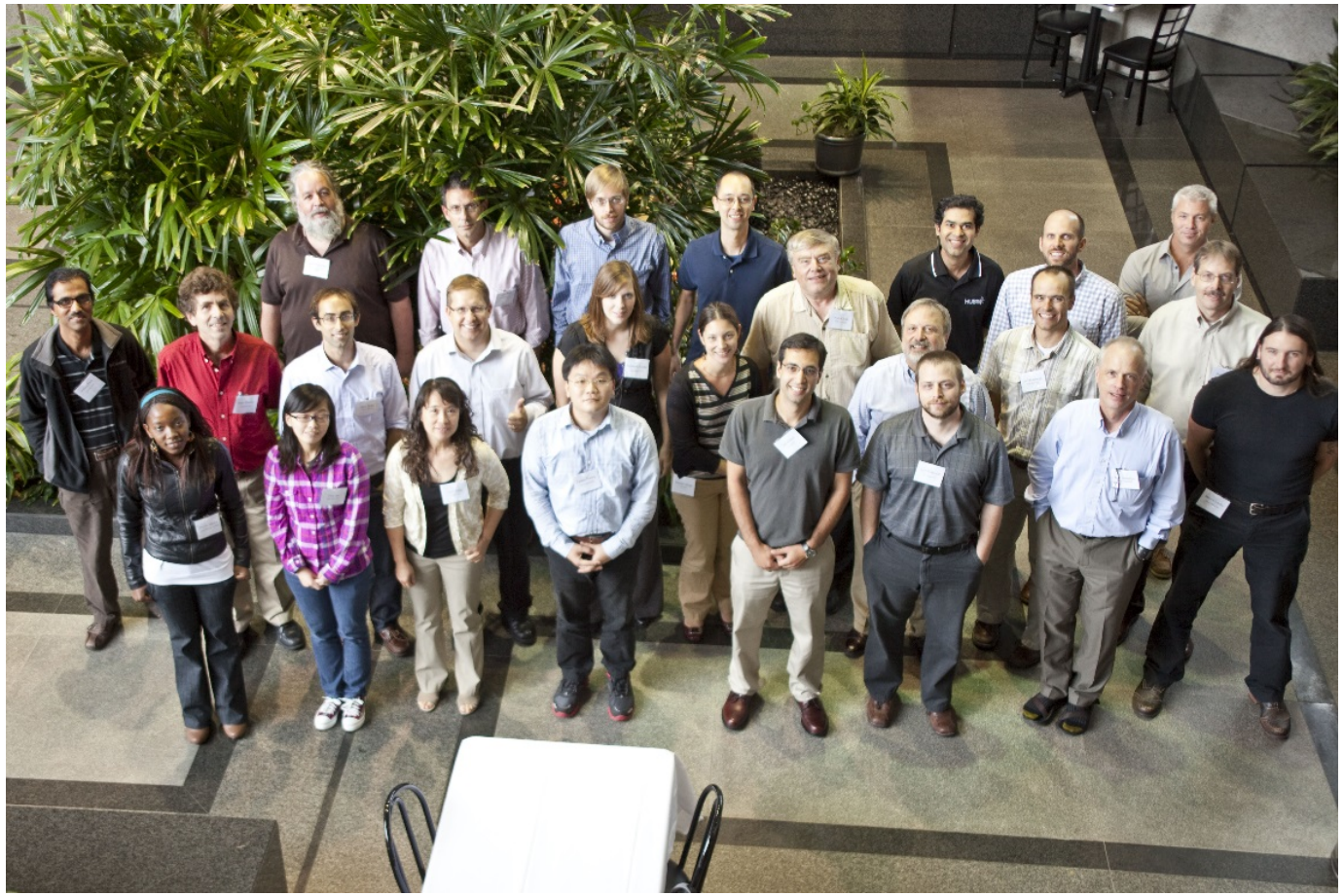
Details in https://www.hydroshare.org/resource/cfb8d71b7f1f4e75a44f5e634f4730d4/ or search for HydroGate in HydroShare

# Summary

1. Web based Cyberinfrastructure for GIS and Hydrologic Data and Modeling is emerging to support
   - Large datasets
   - Collaboration
   - Reproducible workflows and results
   - And reduce software installation and configuration limitations.
2. HydroShare and CyberGIS are part of this.
   - Interoperability is key to leveraging full potential of multiple emerging cloud cyberinfrastructure systems

# Thanks to the HydroShare, CyberGIS and CI-WATER teams!

- USU
- RENCI/UNC
- CUAHSI
- BYU
- Tufts
- UVA
- Texas
- Purdue
- SDSC



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