



OAC-1664061  
OAC-1664018  
OAC-1664119  
2017-2021

ACI-1148453  
ACI-1148090  
2012-2017

# Advancing the capability for collaborative discovery through data and model sharing: The HydroShare example.

Access these slides in HydroShare by searching for “OACWebinar”

David Tarboton, Ray Idaszak, Jeffery S Horsburgh, Daniel P Ames, Jonathan L Goodall, Alva Couch, Richard Hooper, Shaowen Wang, Martyn Clark, Pabitra Dash, Hong Yi, Christina Bandaragoda, Anthony Castronova, Tian Gan, Zhiyu Li, Mohamed Morsy, Maurier Ramirez, Jeffrey Sadler, Dandong Yin, Yan Liu.

HydroShare is operated by the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI) with ongoing development through a collaborative project among Utah State University, Brigham Young University, CyberGIS Center University of Illinois, Tufts, University of Virginia, and RENCI University of North Carolina.



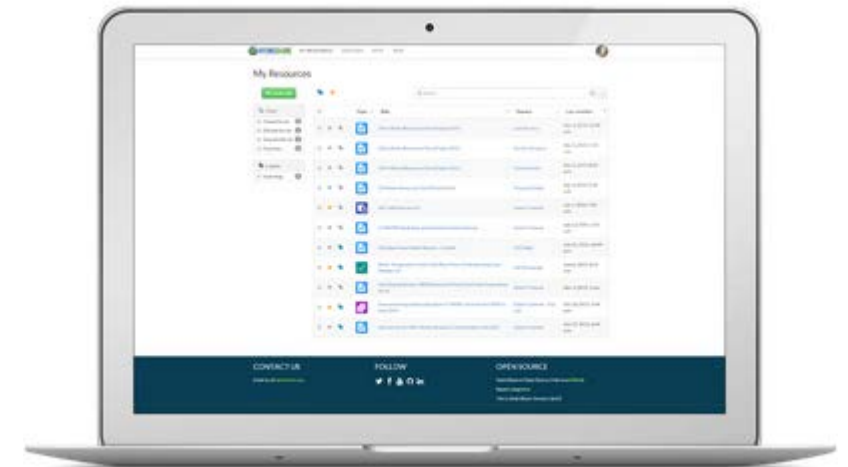
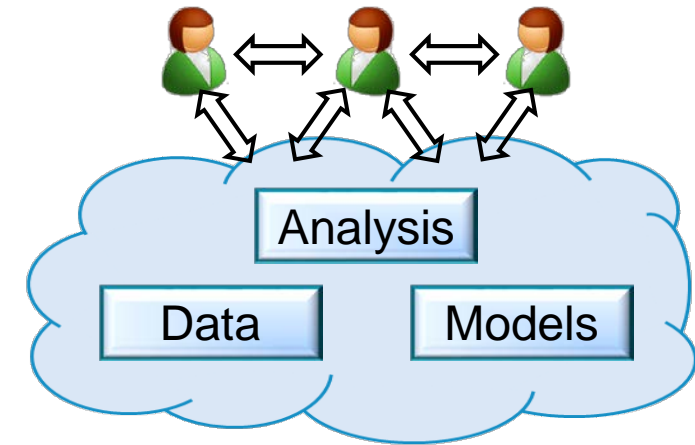
<http://www.hydroshare.org>



# Vision

Part of an ecosystem of cyberinfrastructure elements that make up an integrated cyberinfrastructure for collaboration and computation that integrates data storage, data organization, discovery, analysis and modeling through web applications (web apps) and that allows researchers to employ services beyond their desktop to make data storage and manipulation more reliable and scalable, while improving ability to collaborate and reproduce results.

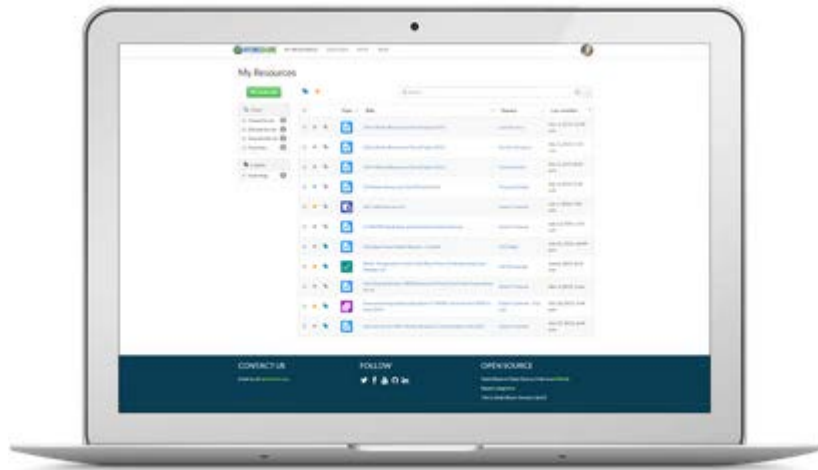
- Don't need your own software and platform to use
- Reduce installation, library and platform dependencies
- Data access and size, faster computation
- Re-use
- Reproducibility
- Transparency
- Trust
- Collaboration



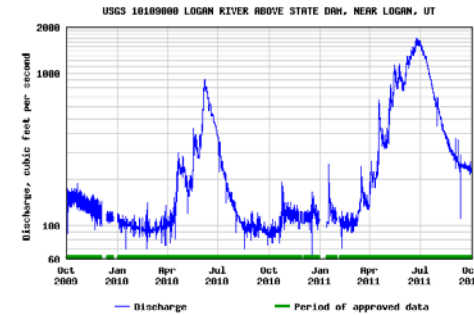
# Motivation: Collaborative research

## Advancing Hydrologic Understanding

- requires integration of information from multiple sources
- using diverse types of data and models
- may be data and computationally intensive
- requires collaboration and working as a team/community
- publication of data and models for transparency, reproducibility, and trust (open data)



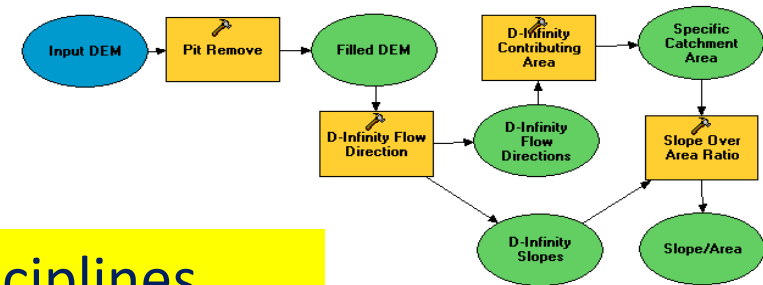
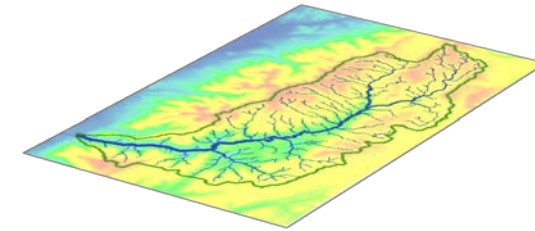
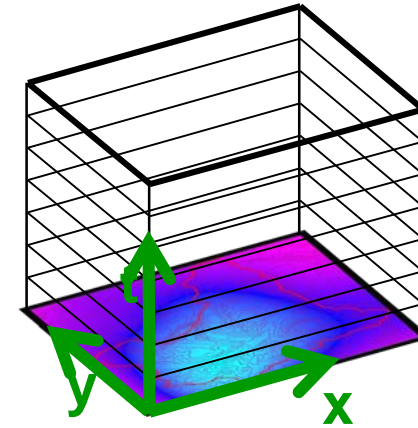
This applies for many NSF disciplines



Resources

Data and models

Social Objects



# Grand Challenge

Better hydrologic forecasting that quantifies effects and consequences of land surface change on hydrologic processes and conditions

by enabling access to and organizing data for integrated analysis and modeling



We want to be able to better forecast, plan for and mitigate the effects of floods.



We want to ensure sufficient water resources in times of shortage.

# Example from HydroShare: Data-driven methods model flood severity using crowd-sourced and environmental data.

Journal of Hydrology 559 (2018) 43–55



ELSEVIER

Contents lists available at ScienceDirect

Journal of Hydrology

journal homepage: [www.elsevier.com/locate/jhydrol](http://www.elsevier.com/locate/jhydrol)

Research papers

## Modeling urban coastal flood severity from crowd-sourced flood reports using Poisson regression and Random Forest

J.M. Sadler<sup>a</sup>, J.L. Goodall<sup>a,\*</sup>, M.M. Morsy<sup>a,b</sup>, K. Spencer<sup>c</sup>

<sup>a</sup>Dept. of Civil and Environmental Engineering, Univ. of Virginia, 351 McCormick Rd., P.O. Box 400742, Charlottesville, VA 22904, United States

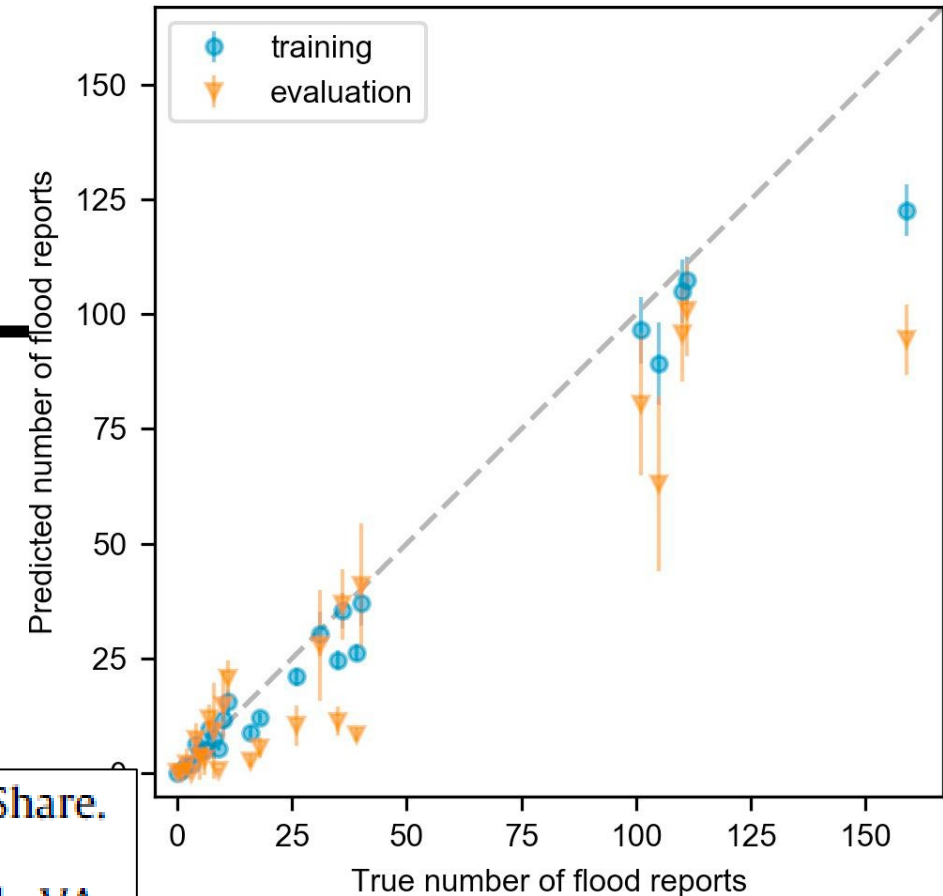
<sup>b</sup>Irrigation and Hydraulics Dept., Cairo University, P.O. Box 12211, Giza 12614, Egypt

<sup>c</sup>Deputy Resilience Officer, City Manager's Office of Resilience, City of Norfolk 501 Boush St., Norfolk, VA 23510, United States

Sadler, J., 2018a. Input data for flood severity modeling in Norfolk, VA. HydroShare. <https://doi.org/10.4211/hs.ff8be5aea3224c15b262bfddd5fb6033>.

Sadler, J., 2018b. Output from data-driven model of flood severity in Norfolk, VA. HydroShare. <https://doi.org/10.4211/hs.54df00b15c02458685fa3b622f2ecc7b>.

Sadler, J., 2018c. Data-driven model script for flood severity modeling in Norfolk, VA. HydroShare. <https://doi.org/10.4211/hs.712cd2ce8f604c8f824d6836ee3fcb53>.



# Data from 2017 US Hurricanes

HYDROSHARE MY RESOURCES DISCOVER COLLABORATE APPS HELP ABOUT

## Hurricane Harvey 2017 Collection

Authors:  
Owners:  
Resource type:  
Created:  
Last updated:

Abstract

HYDROSHARE MY RESOURCES DISCOVER COLLABORATE APPS HELP ABOUT

## Hurricane Irma 2017 Collection

Authors:  
Owners:  
Resource type:  
Created:  
Last updated:

HYDROSHARE MY RESOURCES DISCOVER COLLABORATE APPS HELP ABOUT

## Hurricane Maria 2017 Collection

Authors:  
Owners:  
Resource type:  
Created:  
Last updated:

HYDROSHARE MY RESOURCES DISCOVER COLLABORATE APPS HELP ABOUT

Find Groups **My Groups**



## CUAHSI 2017 Hurricane Data Community

To share data from Hurricanes Harvey, Irma and Maria that impacted the US and Caribbean region in 2017.

Following Hurricanes Harvey, Irma and Maria that had significant impacts to parts of the US and islands in the Caribbean there has been much activity to assemble, document and archive data from these events. This data is intended to support research to improve our understanding of and capability to prepare for and respond to such extreme events in the future. This group has been created as a community within HydroShare for anyone who joins and makes them



Submerged I-10 in Houston, Tx  
I-10, Houston, Texas, 77079

Portions of the Interstate 10 remains flooded in the wake of Hurricane Harvey after it dumped up to 50 inches of rain in Houston, Texas, on Aug. 29, 2017. (Photo: Marcus Yam / Los Angeles Times via Getty Images)

Look in HydroShare for keywords harvey2017, irma2017, maria2017

# Example: Support for CSDMS Landlab Earth Surface Modeling Toolkit community.



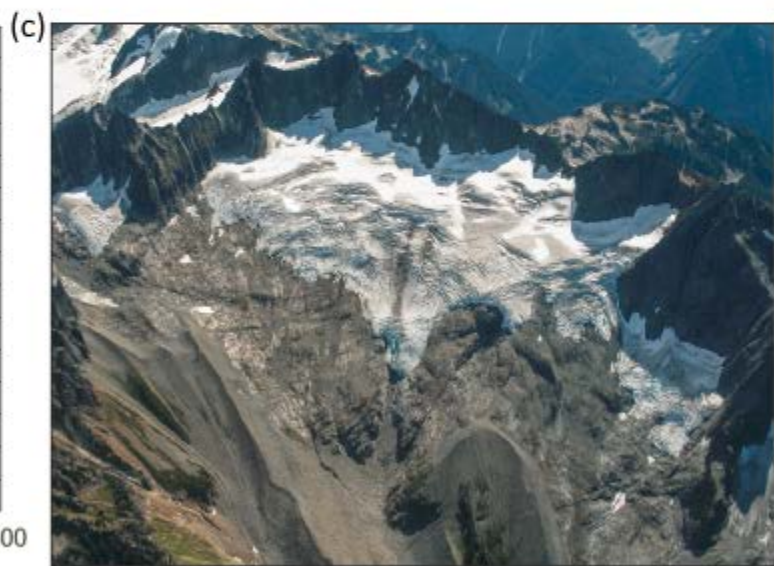
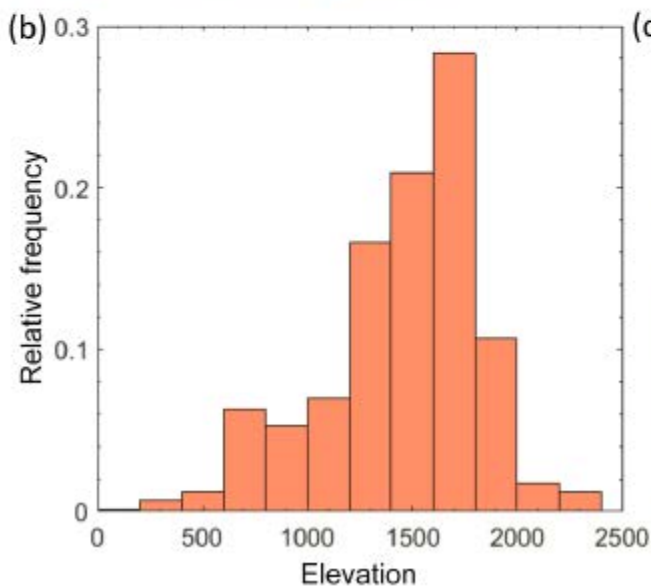
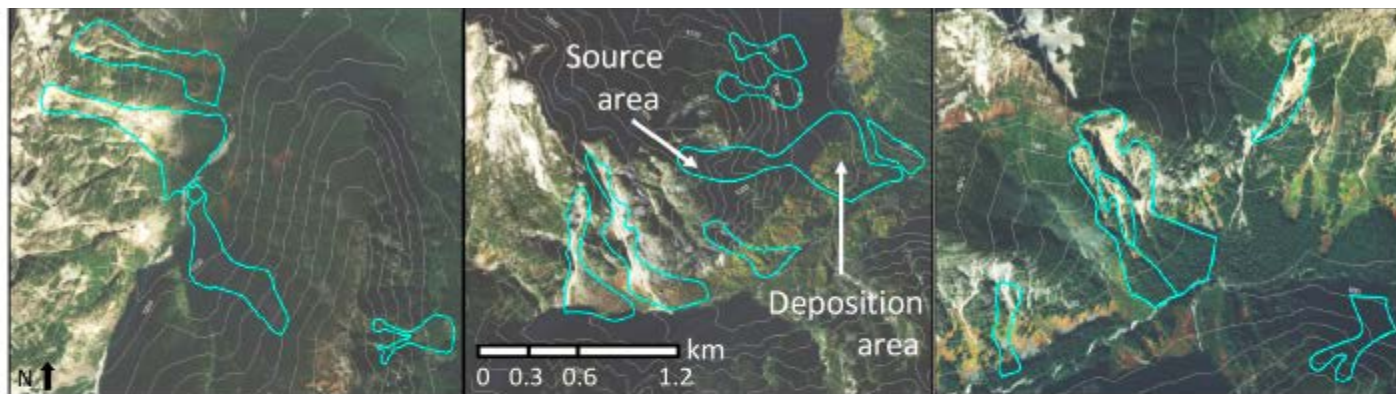
## Developers, Researchers & Students



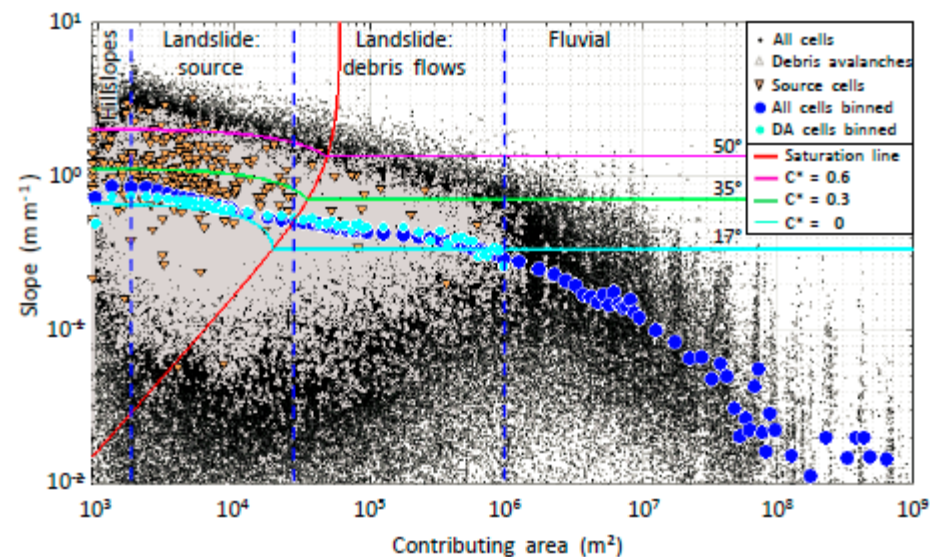
- 330 Users in Landlab **HydroShare Group**
- 6 National/International Conference Workshops running on **HydroShare JupyterHub App**
- 10+ university classroom lectures interacting with **HydroShare JupyterHub App**
- PhD Dissertation and Journal Articles

# A hydroclimatological approach to predicting regional landslide probability using Landlab

Ronda Strauch<sup>1</sup>, Erkan Istanbuluoglu<sup>1</sup>, Sai Siddhartha Nudurupati<sup>1</sup>, Christina Bandaragoda<sup>1</sup>, Nicole M. Gasparini<sup>2</sup>, and Gregory E. Tucker<sup>3,4</sup>



Earth Surf. Dynam., 6, 49–75, 2018  
<https://doi.org/10.5194/esurf-6-49-2018>  
© Author(s) 2018. This work is distributed under the Creative Commons Attribution 4.0 License.



NOCA Data, HydroShare,  
<https://doi.org/10.4211/hs.a5b52c0e1493401a815f4e77b09d352b>

Landlab: Model code and Users Manual, HydroShare,  
<https://doi.org/10.4211/hs.27d34fc967be4ee6bc1f1ae92657bf2b>

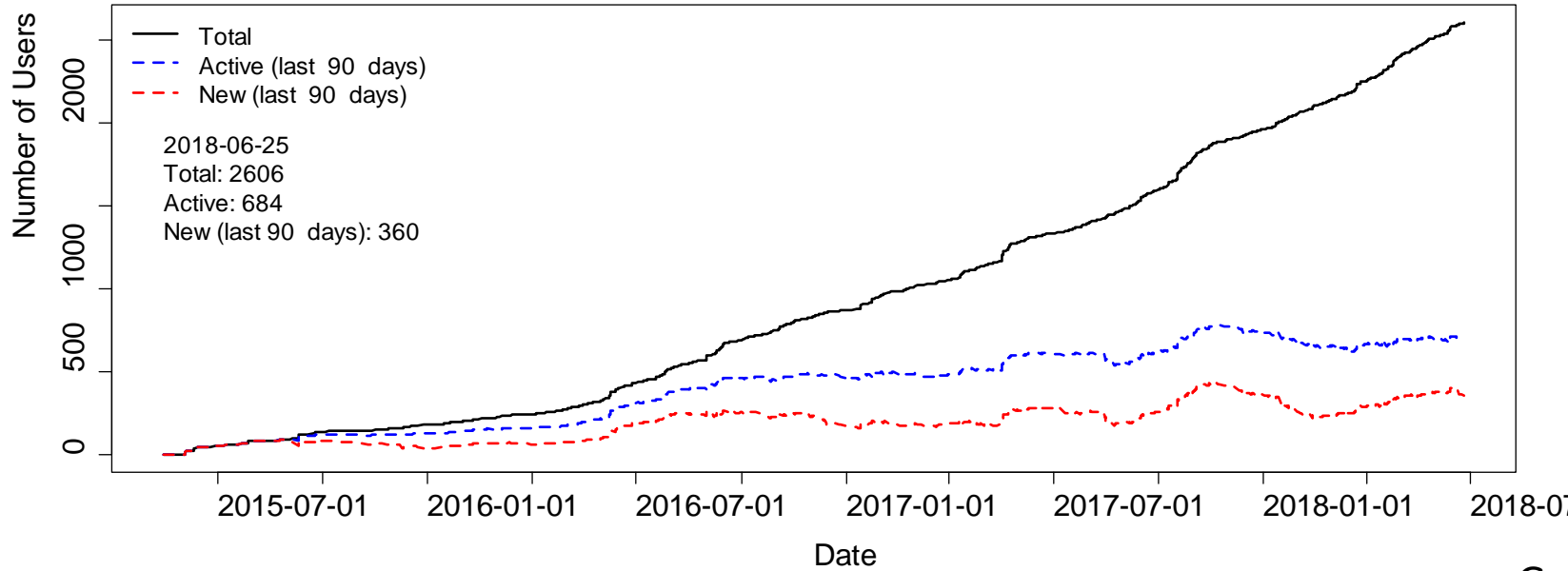
Debris avalanches mapped within NOCA



# Audience and User base

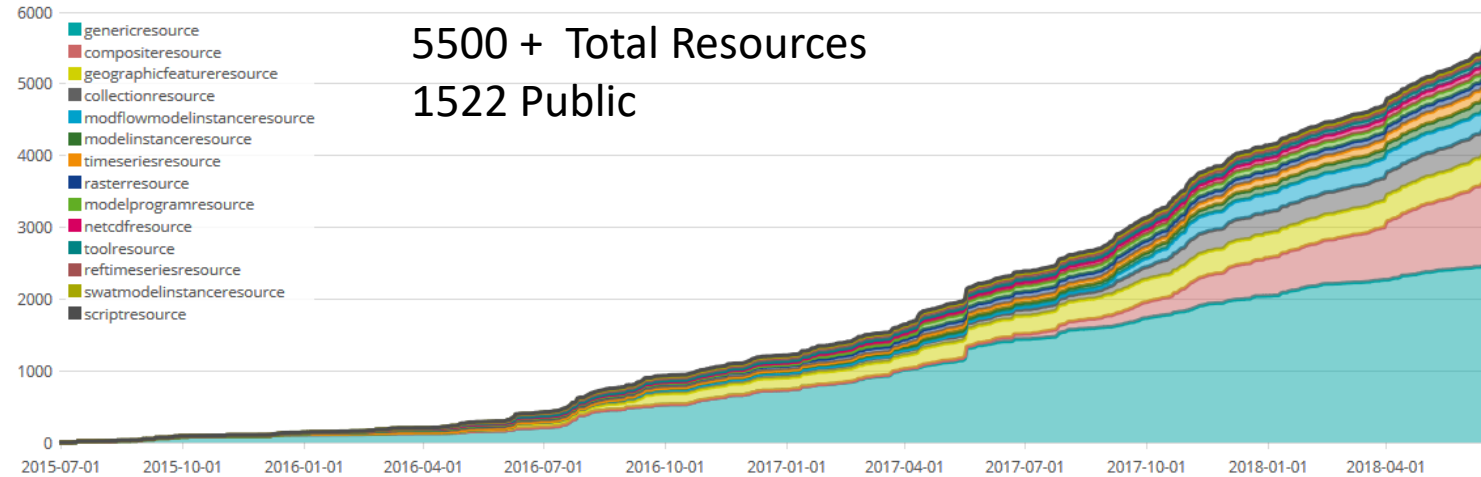
## Users

Hydroshare Users as of 2018-06-25

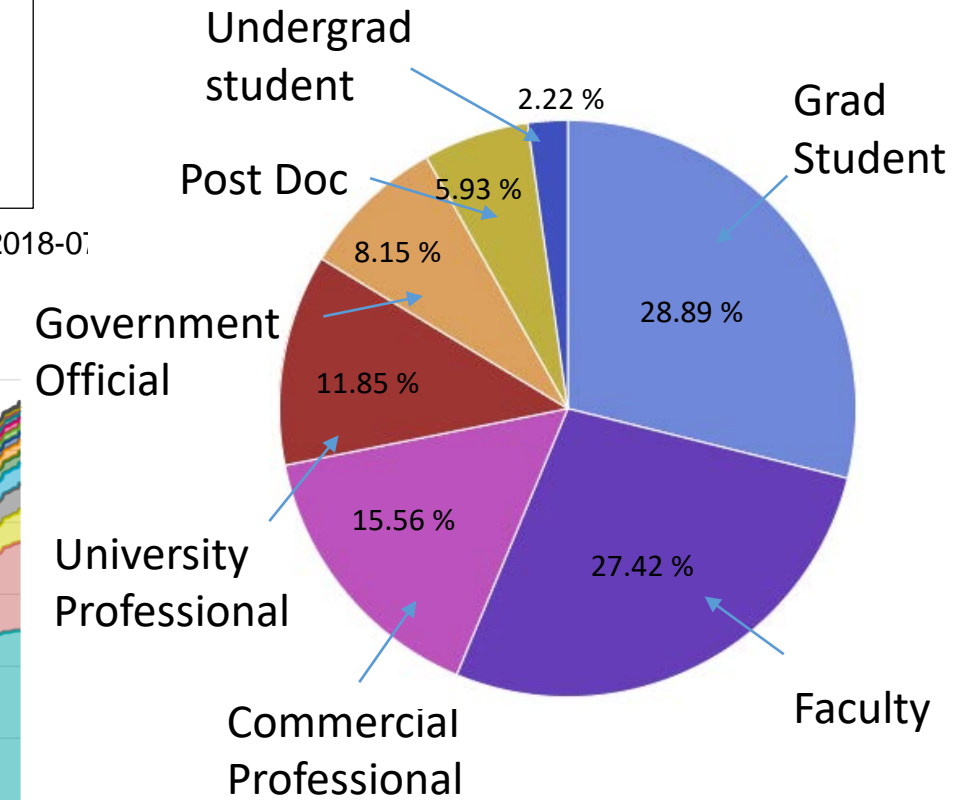


## Resources

Cur (latest)

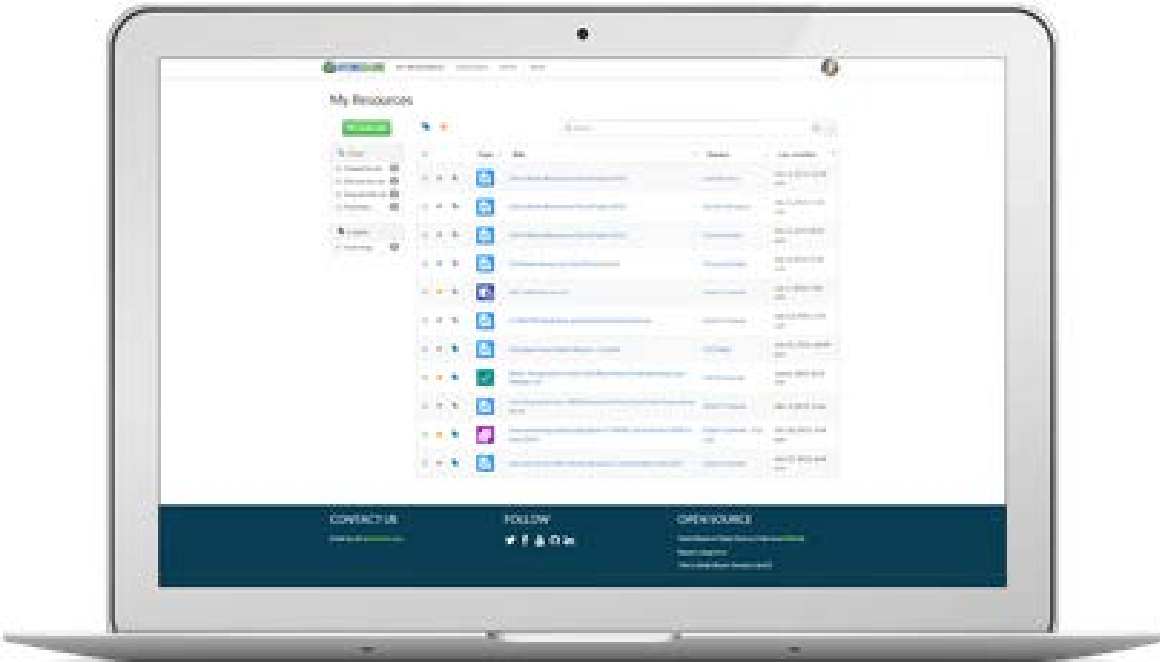


Primary audience is US Hydrologic Research community (NSF funding) but open to international use and use by water resource professionals, educators and citizen scientists



For users who have indicated type in their profile

# CyberInfrastructure Challenges



- The data deluge
  - Large datasets, data heterogeneity, Inadequate metadata
- Data Organization and Model Input preparation
- Reproducibility
- Software installation and configuration
  - Platform dependencies, Library dependencies, Licensing
- Computational resources
  - Memory, disk and processing

# Data Management

“All of the primary datasets collected as part of this project will be made freely and publicly available...”

- iUTAH Proposal Data Management Plan

Many of us put statements like this in our Data Management Plan, but how do we really accomplish this?

# Ideal Investigator Data Workflow

- Easily create a digital instance of a dataset or model
- Quickly share it with colleagues (perhaps privately at first)
- Add value through collaboration, annotation, and iteration
- Describe with metadata
- Eventually...share publicly or formally Publish



**This is still not as easy as it should be!**



# HYDROSHARE

<http://www.hydroshare.org>

- Web-based Hydrologic Information System operated by the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI)
- Gives you a way to share datasets, models, and other research products
- Has capabilities for collaboration
- Has Links to computational resources
- Provides permanent publication of data and models with citable digital object identifiers that can link to literature

The screenshot displays the HydroShare website interface. At the top, there is a navigation bar with the HydroShare logo and links for 'MY RESOURCES', 'DISCOVER', 'COLLABORATE', 'APPS', 'HELP', and 'ABOUT'. Below the navigation bar is a large banner image of a landscape with a rainbow, overlaid with the text 'Discover' and 'Discover content shared by your colleagues and other users. Access a broad range of resource types used in hydrology.'

The main content area is divided into two columns. The left column is titled 'How it works' and contains a numbered list of steps: 1. Create data. Below this, it states: 'Collect your data using the same methods you use now. HydroShare supports a broad set of hydrologic data types.' Below the text is a circular icon with a plus sign. The right column is titled 'TW Daniels Experimental Forest (TWDEF) Lidar' and contains a detailed view of a dataset. It includes a 'SIGN IN' button, a list of metadata (Authors, Owners, Resource type, Created, Last updated), an 'Abstract' section, a 'Subject' section with tags, and a 'How to cite' section with a citation and a 'Copy' button.

**How it works**

- 1 Create data

Collect your data using the same methods you use now. HydroShare supports a broad set of hydrologic data types.

**What you can do with**

- ✓ Share your data and models with colleagues
- ✓ Manage who has access to the content
- ✓ Share, access, visualize and manipulate models
- ✓ Use the web services API to program a plan
- ✓ Publish data and models to meet the requirements
- ✓ Discover and access data and models

**TW Daniels Experimental Forest (TWDEF) Lidar** Open with...

Authors: Michaela Teich - David G. Tarboton  
Owners: Michaela Teich  
Resource type: Generic  
Created: Nov 17, 2016 at 9:11 p.m.  
Last updated: Dec 09, 2016 at midnight by Michaela Teich

**Abstract**

This resource contains lidar data, collected at the TW Daniels Experimental Forest (TWDEF) on six separate flights in 2008 and 2009 measuring surface and canopy properties during snow-on and snow-off conditions. It was collected for the purposes of obtaining a digital elevation model (DEM) to characterize the area for snowmelt modeling, and by differencing between snow-on and snow-off observations to characterize the spatial distribution of snow depth. Canopy lidar returns also characterize the vegetation. The data was collected by the Utah State University (USU) Lidar-Assisted Stereo Imaging (LASSI) laboratory. The data was initially processed at USU shortly after collection and additionally processed by the Space Dynamics Laboratory (SDL) in support of Utah lidar efforts in 2016.

The metadata report (sdi16-1363-pdf) gives details about the hardware used for data collection, the flight plans and resulting data, the data processing steps, and a brief error analysis.

Zip files are named by the collection date and contain:

- Terra Scan Binary Files
- LAS Files (one for each flight line and the combined file)
- KML Files (one for each flight line)
- ASC DEM file (1 m resolution)
- PNG Hillshade file

A complete list can be found on pp. 17-22 of the metadata report.

**Subject**

TW Daniels Experimental Forest TWDEF Lidar DEM Snow Depth

**How to cite**

Teich, M., D. G. Tarboton (2016). TW Daniels Experimental Forest (TWDEF) Lidar, HydroShare, <https://dx.doi.org/10.4211/hs.36f3314971a547bc8bc72dc60d6bd03c> Copy

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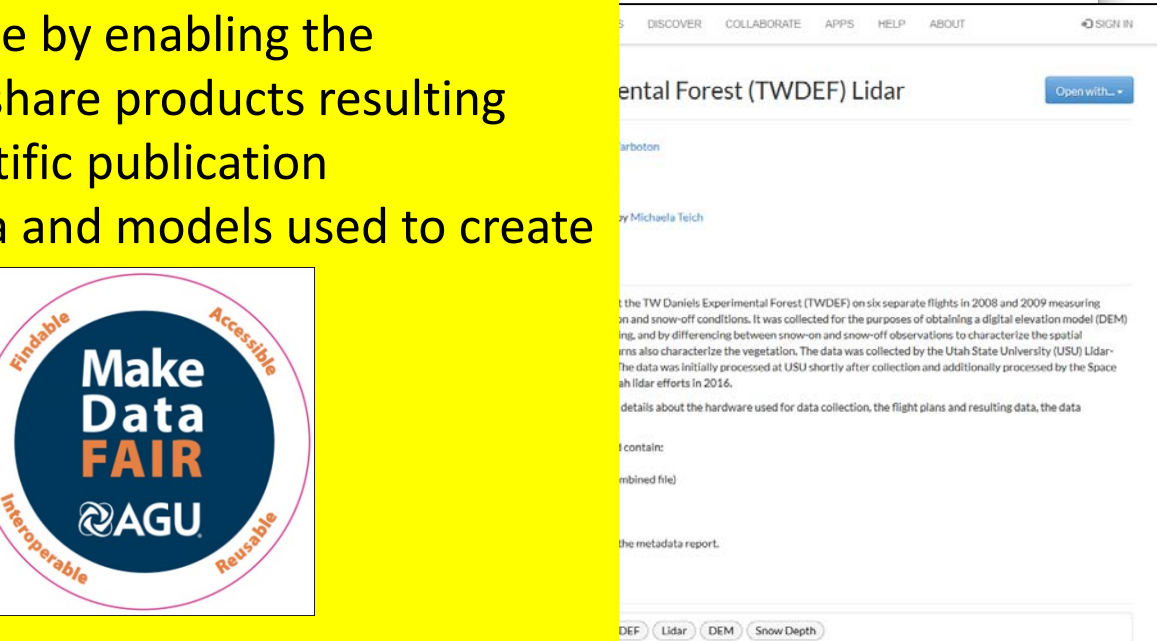
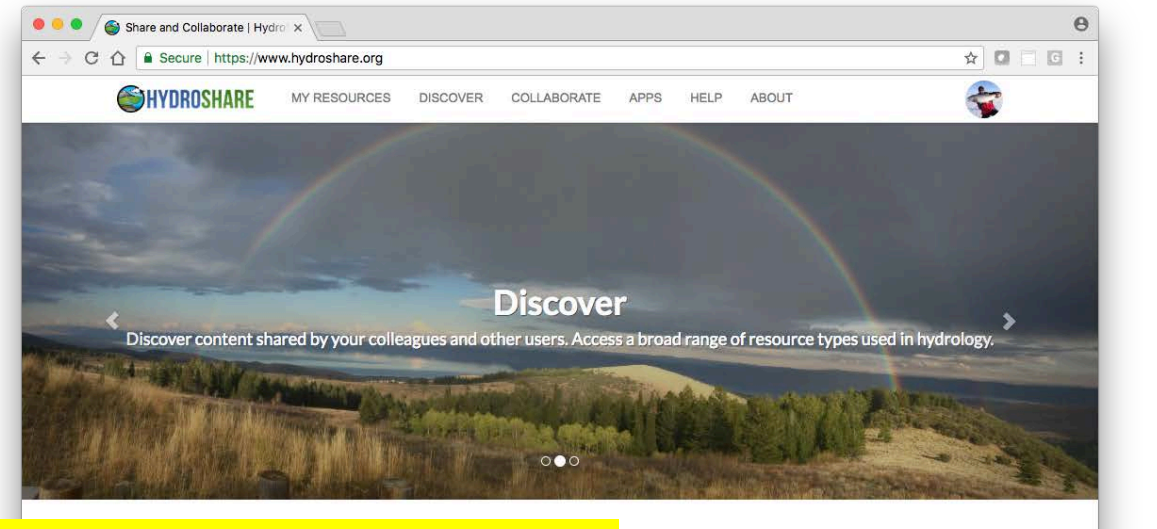
# HYDROSHARE

<http://www.hydroshare.org>

- Web-based Hydrologic Information System operated by the Consortium of Universities for the Advancement of Hydrologic Science, Inc. (CUAHSI)
- Gives you a way to share your research products
- Has capabilities for collaboration
- Has Links to computational tools
- Provides permanent and citable digital objects

A system to advance hydrologic science by enabling the community to more easily and freely share products resulting from their research, not just the scientific publication summarizing a study, but also the data and models used to create the scientific publication.

- Findable
- Accessible
- Interoperable
- Reusable



- ✓ Share, access, visualize and manipulate models
- ✓ Use the web services API to program a workflow
- ✓ Publish data and models to meet the requirements of a plan
- ✓ Discover and access data and models

**How to cite**

Teich, M., D. G. Tarboton (2016). TW Daniels Experimental Forest (TWDEF) Lidar, HydroShare, <https://dx.doi.org/10.4211/hs.36f3314971a547bc8bc72dc60d6bd03c>

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<http://creativecommons.org/licenses/by/4.0/>

# HydroShare is a platform for sharing **Hydrologic Resources** and **Collaborating**

- File Storage

DropBox-ish Functionality

- Meta Data Descriptions

- Data Access API

- Web Apps

Value Added Functionality

- Social Functions

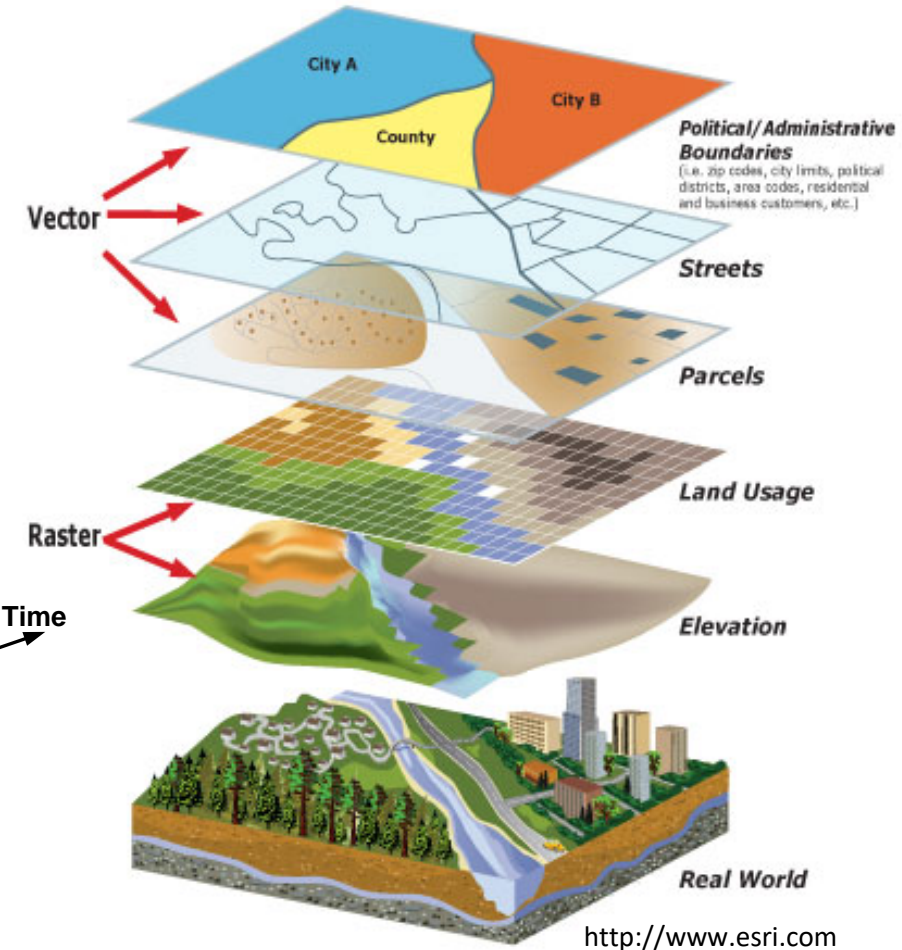
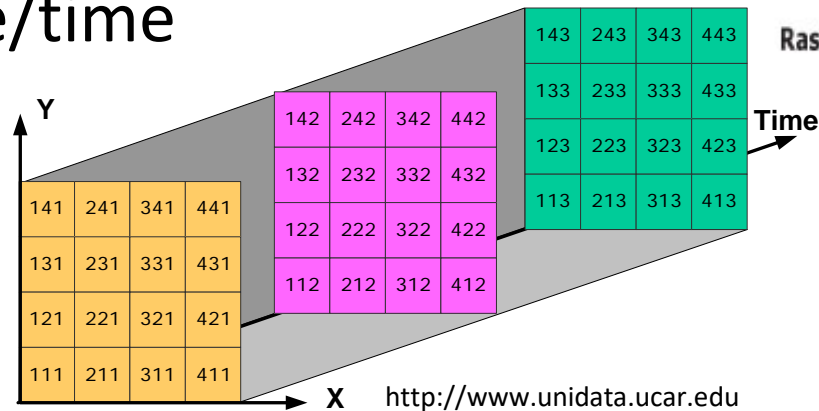
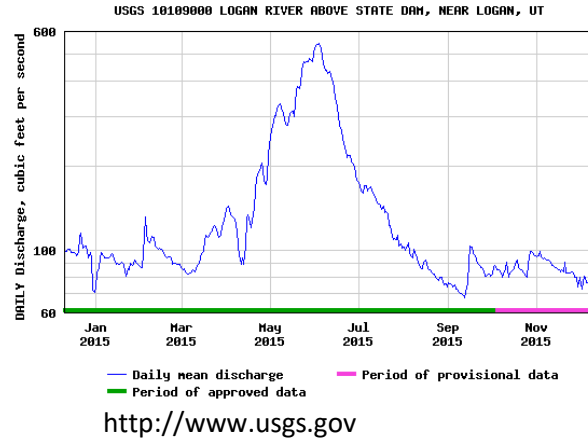
- DOI Data Publication



dropbox.com

# Data and models used by hydrologists are diverse...

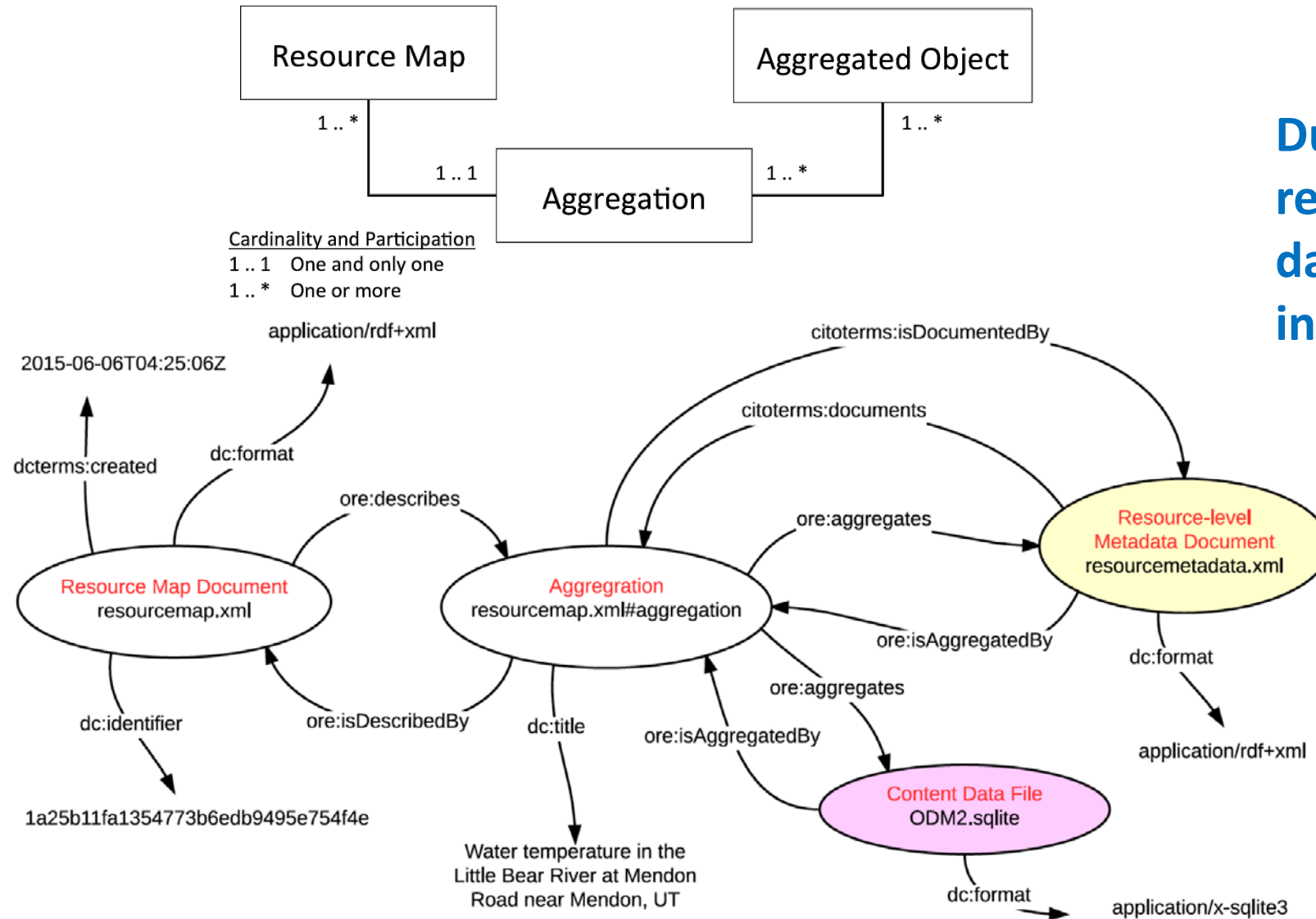
- Time series
- Geographic rasters
- Geographic features
- Multidimensional space/time
- Model programs
- Model instances
- ...



HydroShare can hold data in a wide variety of formats



# OAI-ORE standard based Resource Data Model



Dublin Core machine readable metadata and data model to make data in HydroShare FAIR

# Collaborative data sharing



MY RESOURCES

DISCOVER

COLLABORATE

APPS

HELP

## My Resources

Add content to HydroShare to share with your colleagues or permanently publish to document result reproducibility

+ Create new

Filter

- Owned by me 50
- Editable by me 58
- Viewable by me 63
- Favorites 0

Labels



Search

<input type="checkbox"/>	Type	Title	Owners
<input type="checkbox"/> ★ 🏷️	🔒 🔗	Great Salt Lake Level and Volume	David Tarboton
<input type="checkbox"/> ★ 🏷️	🔒 🔗	Collection of workshops using HydroShare at the CUAHSI biennial symposium, July 2016	David Tarboton
<input type="checkbox"/> ★ 🏷️	🔒 🔗	Material for HydroShare workshop at CUAHSI Biennial Symposium	David Tarboton

# Resources (data and models) in HydroShare are objects of collaboration (social objects)

## TW Daniels Experimental Forest (TWDEF) Lidar

Open with... ▾

**Authors:** [Michaela Teich](#) · [David G. Tarboton](#)  
**Owners:** [Michaela Teich](#)  
**Resource type:** Generic  
**Created:** Nov. 17, 2016, 9:11 p.m.  
**Last updated:** Dec. 9, 2016, midnight by [Michaela Teich](#)

### Abstract

This resource contains lidar data, collected at the TW Daniels Experimental Forest (TWDEF) on six separate flights in 2008 and 2009 measuring surface and canopy properties during snow-on and snow-off conditions. It was collected for the purposes of obtaining a digital elevation model (DEM) to characterize the area for snowmelt modeling, and by differencing between snow-on and snow-off observations to characterize the spatial distribution of snow depth. Canopy lidar returns also characterize the vegetation. The data was collected by the Utah State University (USU) Lidar-Assisted Stereo Imaging (LASSI) laboratory. The data was initially processed at USU shortly after collection and additionally processed by the Space Dynamics Laboratory (SDL) in support of iUtah lidar efforts in 2016.

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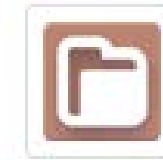
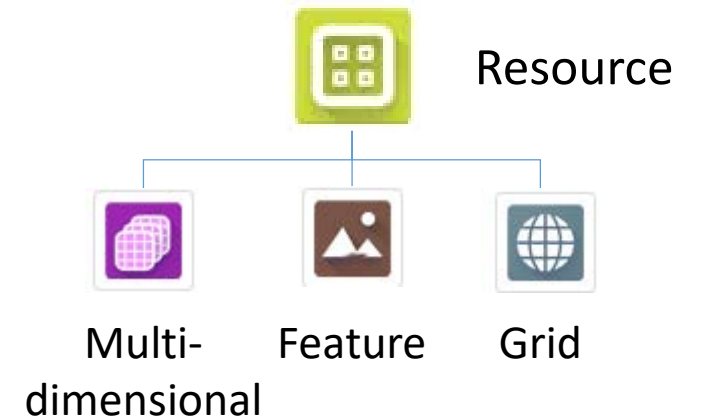
- For each resource you can
- Manage who has access
    - To edit
    - To view
  - Comment or rate
  - Obtain unique identifier
  - Describe with metadata
  - Organize into collections
  - Permanently publish with DOI
  - Version
  - Open with compatible web app

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# Resource Organization Concepts

- A **resource** can hold multiple aggregations
  - Each being a different type of data
  - Managed as one discoverable resource
  - One set of access controls (Owners, Editors etc.)
  - One unique identifier
  - One set of resource level metadata
- A **collection** can hold multiple resources
- Collections and their members may each be discovered separately
- Unique keyword tags form informal collections (e.g. “OACwebinar”)



Collection

## Collection Contents

Title
<a href="#">Great Salt Lake Area Volume Data</a>
<a href="#">Great Salt Lake Level and Volume</a>
<a href="#">Great Salt Lake Basin Digital Elevation Model</a>

# Automatic and simple metadata gathering eases some of the pain of metadata entry

For geographic raster WGS 84 Coverage information automatically harvested from GeoTIFF coordinate system information

For multidimensional netCDF data with CF convention metadata the HydroShare metadata can be fully and automatically completed

Contact Coverage Resourc...

**Spatial Reference:**

Coordinate Reference System: NAD\_1983\_Texas\_Centric\_Mapping\_System\_Albers  
Albers\_Conic\_Equal\_Area  
Unit: meter

Extent:

North	7345527.40052
West	1690845.73608
South	7336017.40052
East	1699695.73608

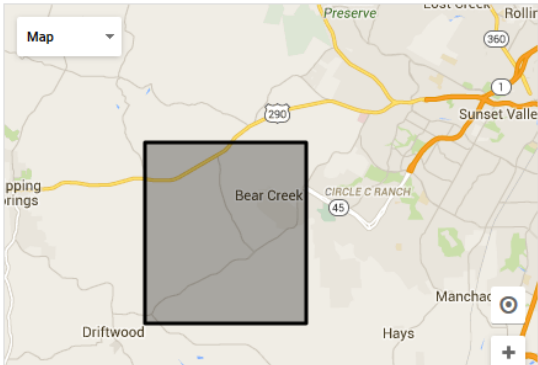
**Cell Information:**

Rows:	951
Columns:	885
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CellSizeYValue:	10.0
CellDataType:	Float32
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Contact Coverage Resourc...

**Spatial**

Coordinate System/Geographic Projection WGS 84 EPSG:4326  
Coordinate Units Decimal degrees



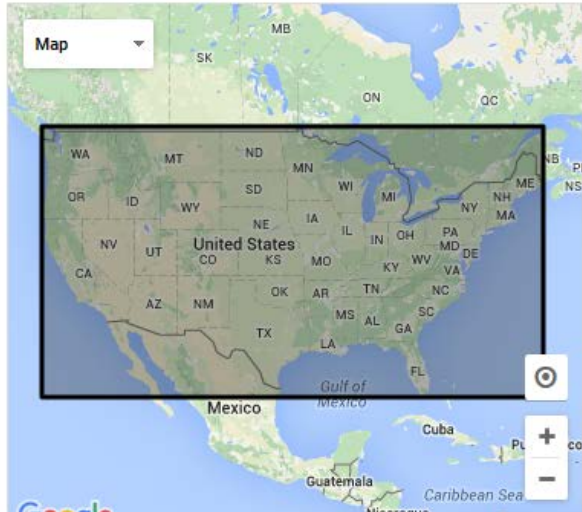
North Latitude 30.2145830036°  
East Longitude -97.9235643897°  
South Latitude 30.1275133327°  
West Longitude -98.0137920935°

WGS 84 decimal degrees

Contact Coverage Resource Spec...

**Spatial**

Coordinate System/Geographic Projection WGS 84 EPSG:4326  
Coordinate Units Decimal degrees



North Latitude 49.37468443°  
East Longitude -66.99293165°  
South Latitude 24.95415176°  
West Longitude -124.7123378°

WGS 84 decimal degrees

Apps act on resources to support web based visualization and analysis <http://www.hydroshare.org/apps>



MY RESOURCES

DISCOVER

COLLABORATE

APPS

HELP

ABOUT



## HydroShare Apps Library

HydroShare apps allow you to visualize, analyze, and work with resources (data and models) in HydroShare. Apps are hosted on separate web servers from the HydroShare website ([www.hydroshare.org](http://www.hydroshare.org)) and access HydroShare resources using web services via the REST applications programmers interface (API). Anyone can write an app and then create a "Web App" resource that holds the configuration information for launching the App from HydroShare. This page lists CUAHSI approved web apps that are supported as part of HydroShare.



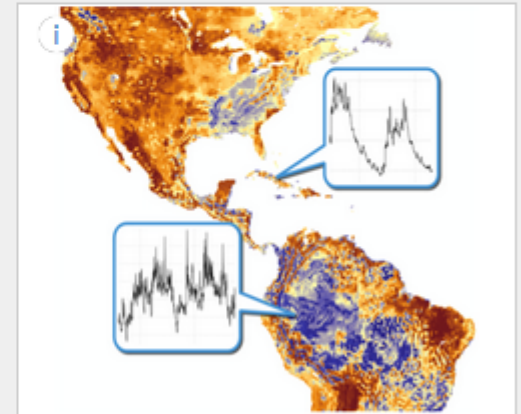
HydroShare GIS



JupyterHub



National Water Model F...



Data Rods Explorer App

# Conceptual Architecture

## Resource exploration

- Organize and annotate your content
- Manage access



Django Website

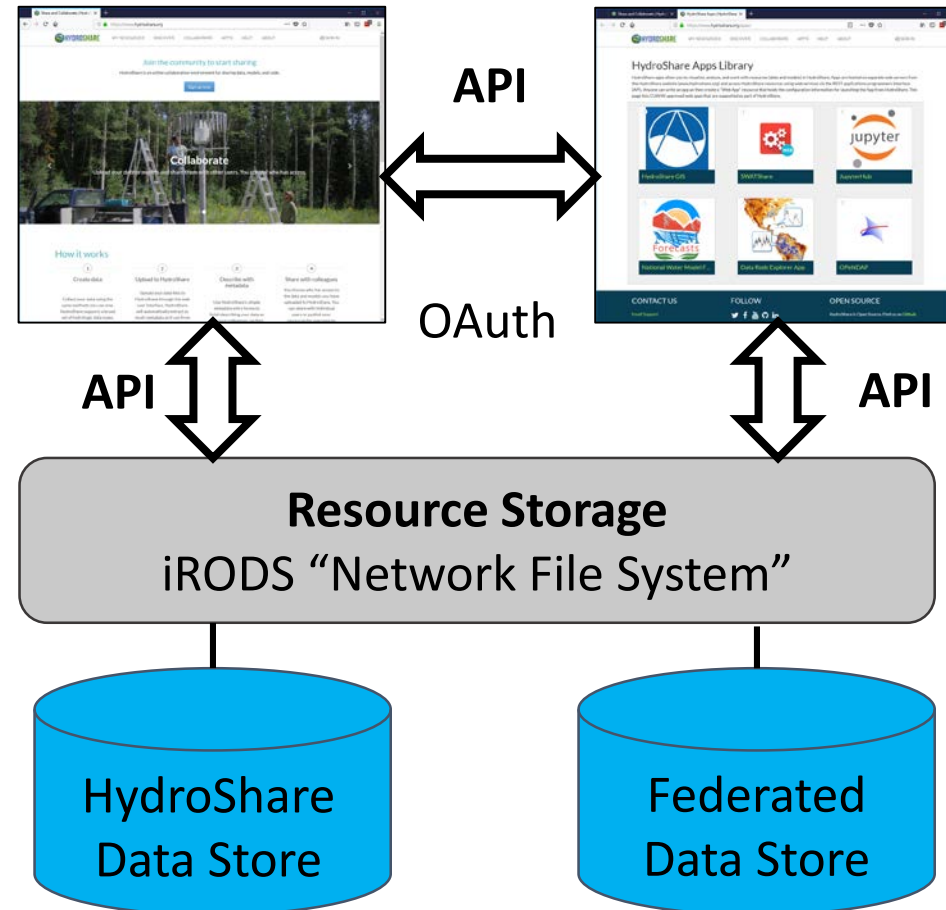
HydroShare Apps

## Actions on Resources

- Web software to operate on content you have access to (Apps)
- Extensibility

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

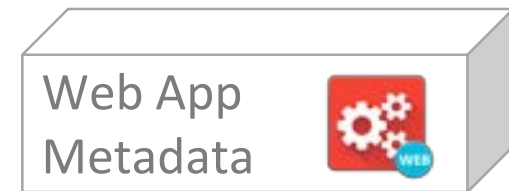
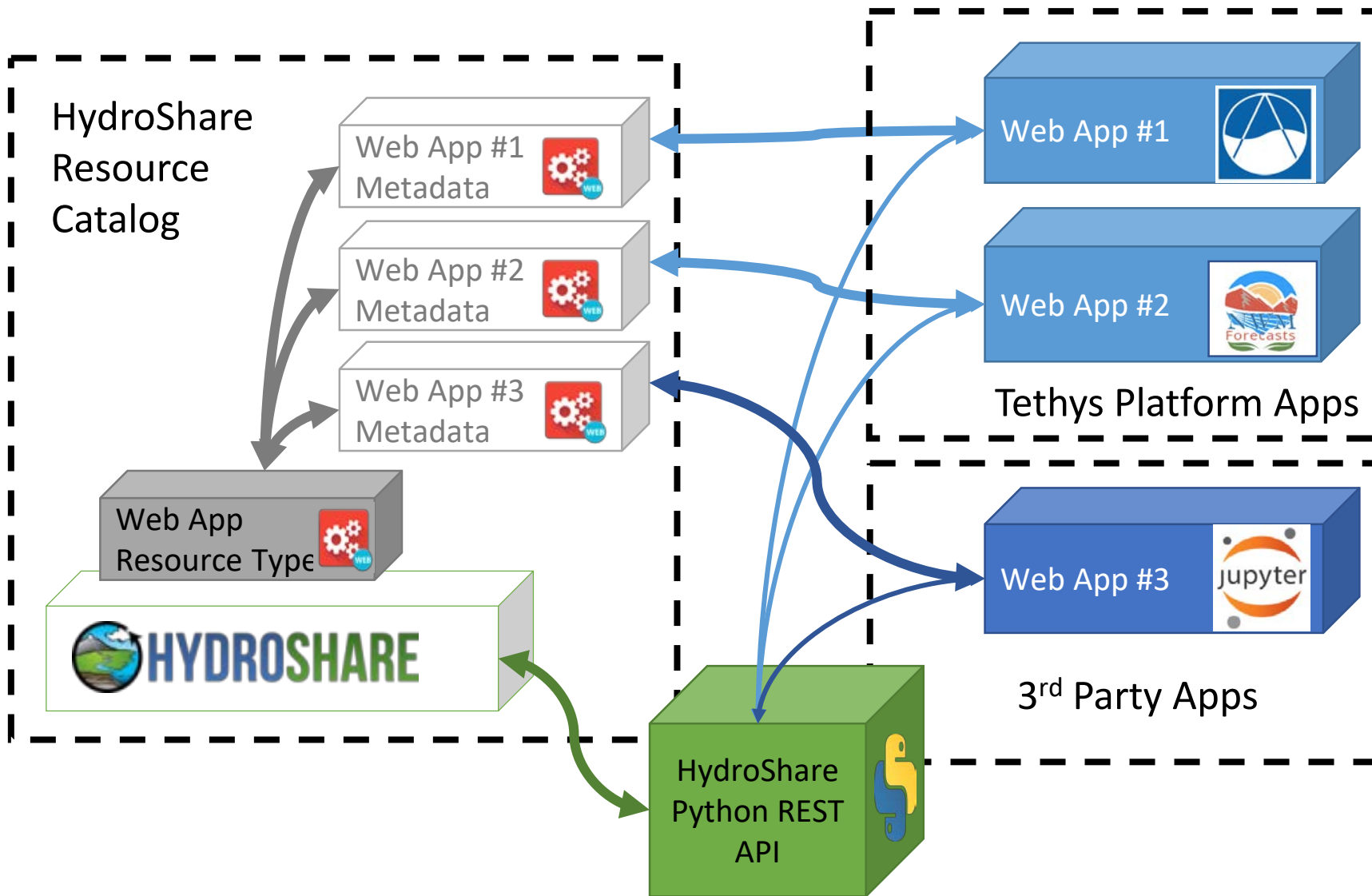
## Distributed file storage



- SWATShare (Hubzero)
- JupyterHub
- Unidata – THREDDS
- NWM Viewer
- Tethys Apps

# HydroShare Web App Linkage

Anybody can create a web app on any web server and configure a web app resource for it to be launched from HydroShare



Predefined URL Launch Parameters:  
Resource ID:  $\${HS\_RES\_ID}$   
Resource Type:  $\${HS\_RES\_TYPE}$   
HydroShare username:  
 $\${HS\_USR\_NAME}$

Examples:

[https://apps.hydroshare.org/apps/hydroshare-gis/?res\\_id=\\${HS\\_RES\\_ID}](https://apps.hydroshare.org/apps/hydroshare-gis/?res_id=${HS_RES_ID})

[https://mygeohub.org/.../?res\\_id=\\${HS\\_RES\\_ID}&usr=\\${HS\\_USR\\_NAME}&src=hs](https://mygeohub.org/.../?res_id=${HS_RES_ID}&usr=${HS_USR_NAME}&src=hs)

[http://hyrax.hydroshare.org/opendap/\\${HS\\_RES\\_ID}/data/contents/](http://hyrax.hydroshare.org/opendap/${HS_RES_ID}/data/contents/)



# JupyterHub App

Hydrologic Terrain Analysis Jupyter Notebook

Open with...  
HydroShare GIS  
JupyterHub

Authors: David Tarboton · Anthony Michael Castronova  
Owners: Anthony Castronova · David Tarboton  
Resource type: Generic  
Created: Jun 03, 2018 at 8:10 p.m.  
Last updated: Jun 05, 2018 at n

## Abstract

Hydrologic Terrain Analysis Jupyter  
To use the Jupyter Notebook click o  
Welcome page. These cells establish  
main code and the inputs are retriev  
inputs, outputs, and the main code i

## Content

Search current directory

Sort By

contents

TauDEM.ipynb	13.4 KB	ipynb File
--------------	---------	------------

# JupyterHub App Analysis



TauDEM (autosaved)



Logout

Control Panel

Welcome dtarb

File Edit View Insert Cell Kernel Widgets Help

Not Trusted

Python 3



## Hydrologic Terrain Analysis Using TauDEM

The purpose of this notebook is to introduce **Digital Elevation Models (TauDEM)** software for watershed delineation and extraction and

This notebook is intended as a brief introduction to the functions required to delineate a stream network, the documentation on the use of each TauDEM function, and construct other analyses to meet your needs.

The notebook is organized into the following

1- Preparation, libraries and

2- Digital Elevation Model an

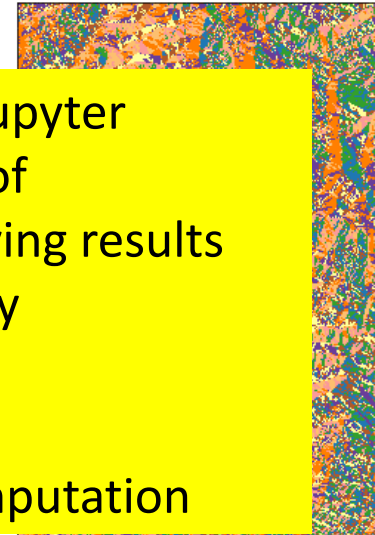
3- Save the Results back into

Write and execute code in a Jupyter Notebook, acting on content of HydroShare resources and saving results back to HydroShare Repository

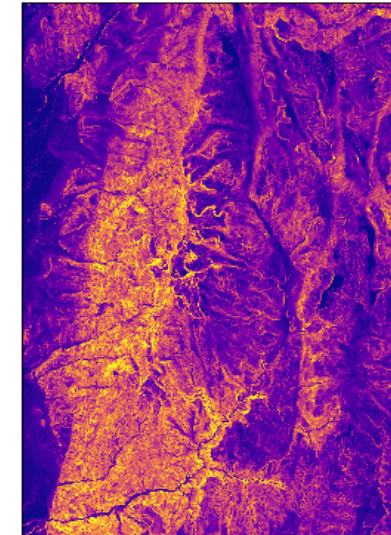
- Reproducibility
- Collaboration
- Access to enhanced computation

```
In [7]: grid.plot(raster=['demp.tif', 'demsd8.tif'],  
                title=['D8 Flow Direction', 'D8 Slope'],  
                cm=['Paired', 'plasma'],  
                cm_scale=[(None, None), (0, 1)])
```

D8 Flow Direction



D8 Slope



```
In [11]: # Find the files that are not folders. (The initial folders are already there)
```

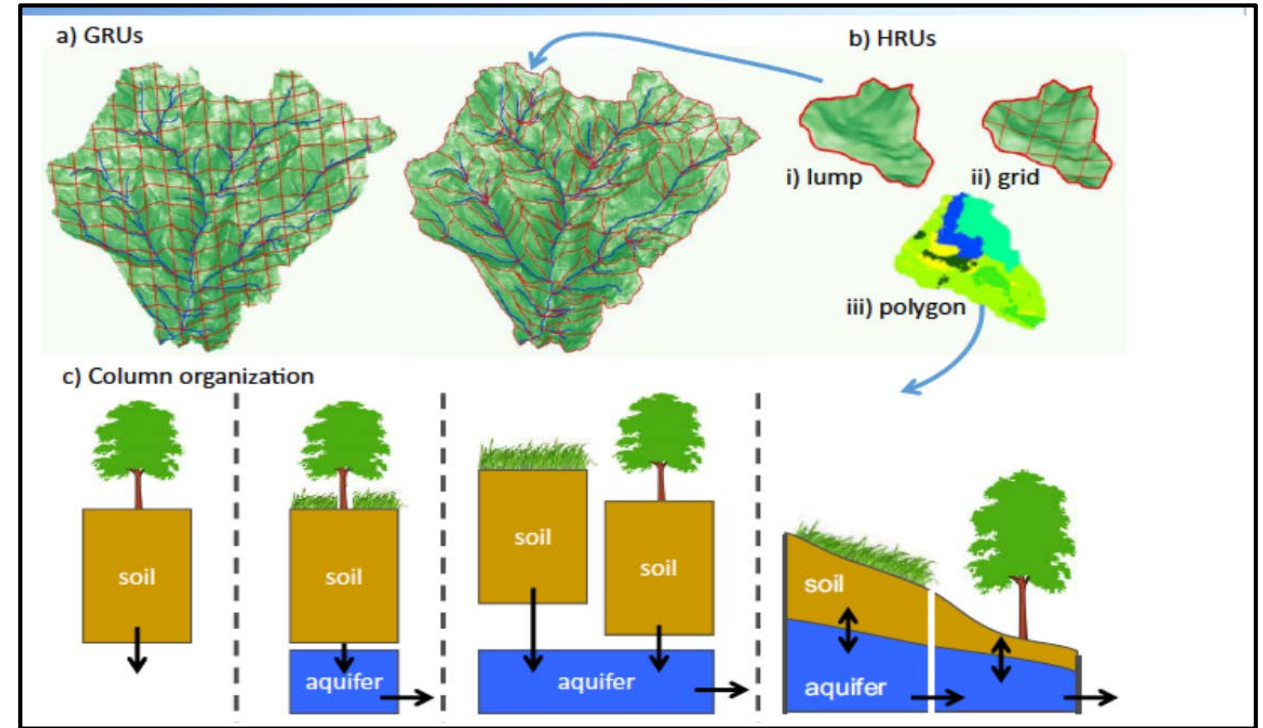
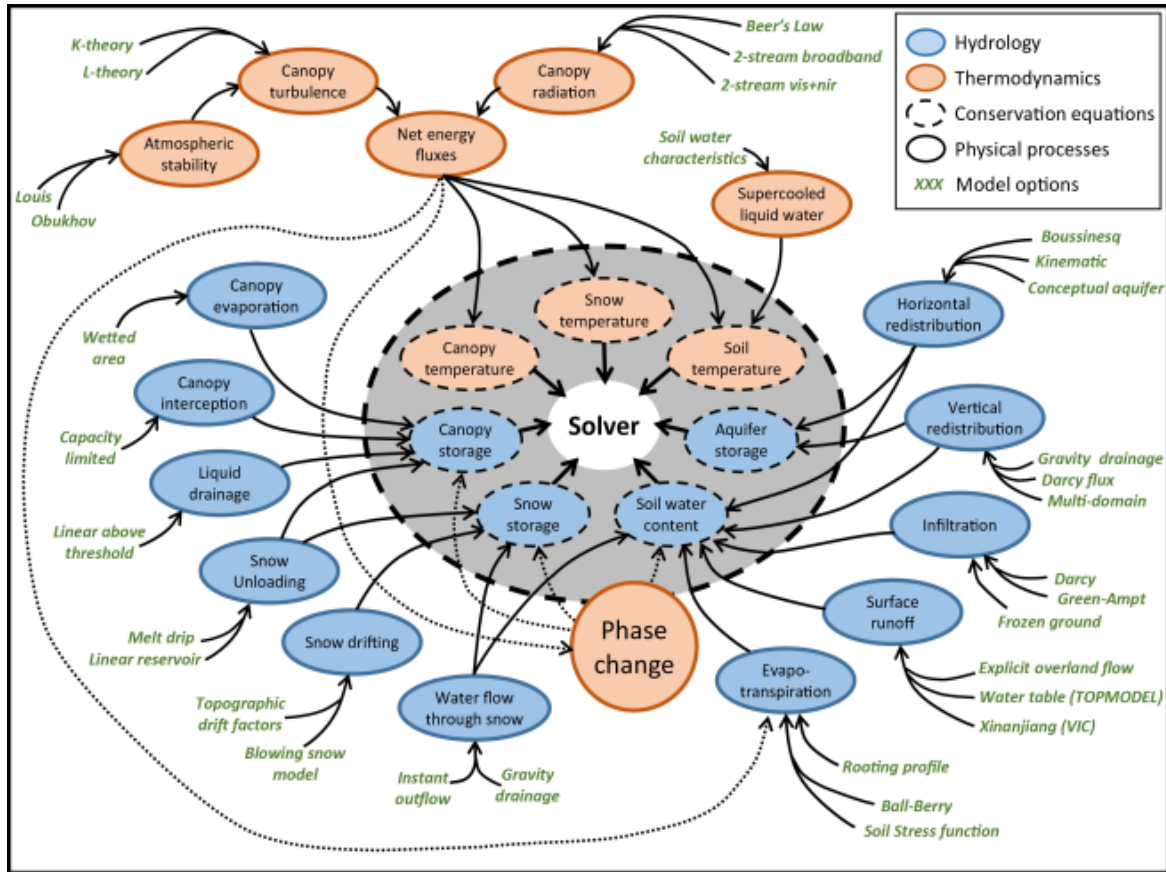
```
files = !find . -maxdepth 1 -type f  
print(files)
```

```
hs.addContentToExistingResource(resid, files)
```

```
['./demfel.tif', './demsd8.tif', './demp.tif', './demad8o.tif', './demsrc.tif', './demptree.dat',  
 './demcoord.dat', './demnet.shp', './demnet.shx', './demnet.dbf', './demnet.prj', './demw.tif', './  
 demord3.tif']
```

Successfully Added Content Files

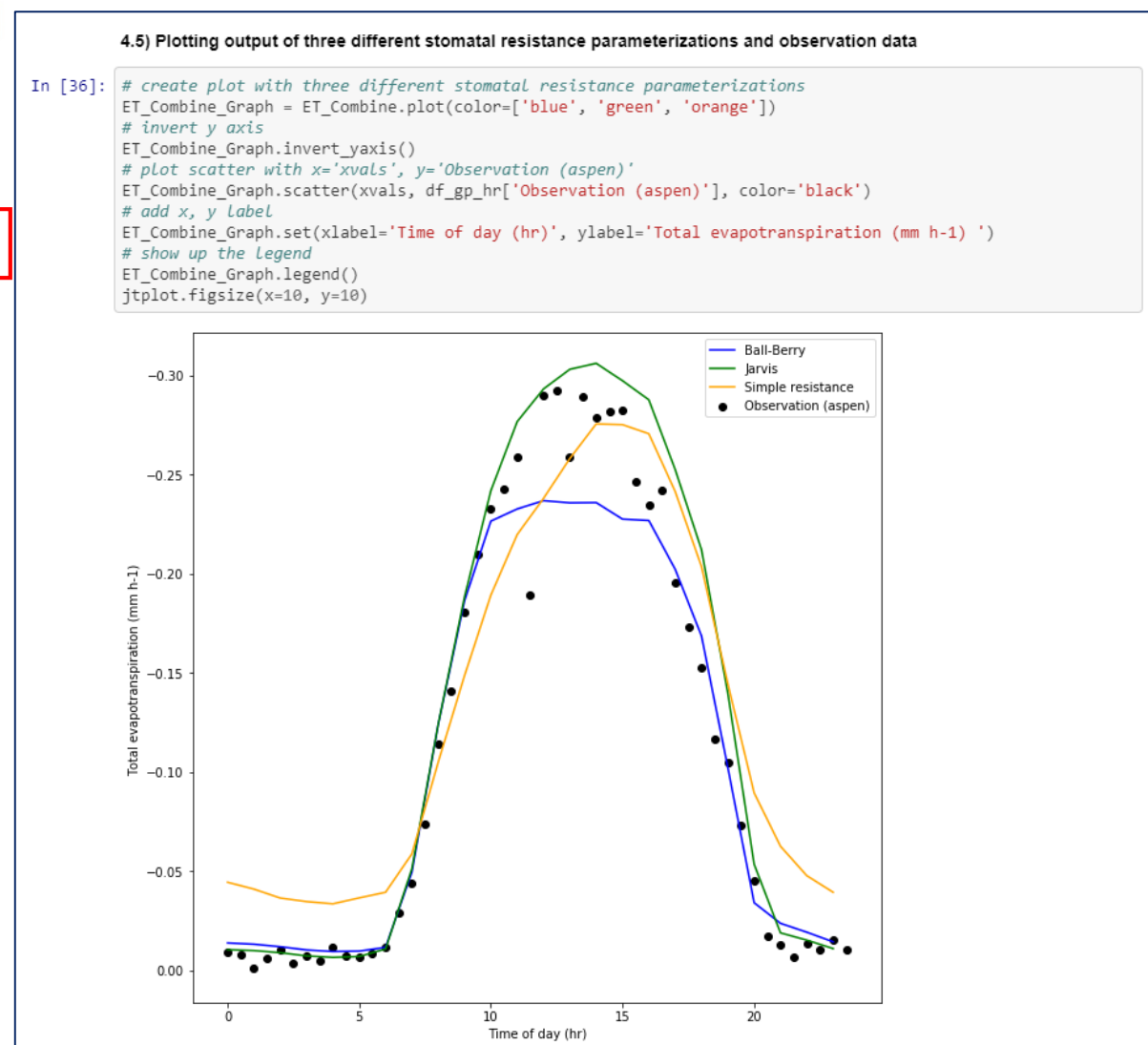
# The Structure for Unifying Multiple Modeling Alternatives (SUMMA)



Enable systematic evaluation of multiple working hypotheses on model representations of physical processes, encourage hydrologic modeling best practices, and elevate the state of practice of hydrologic modeling science.

JupyterHub SUMMA implementation used to replicate a study in published paper where three different Evapotranspiration parameterizations are used to explore their impact on the modeled Evapotranspiration in comparison to observed Evapotranspiration rates.

Name	Selection	description
simulStart	'2007-07-01 00:00'	(01) simulation start time -- must be in single quotes
simulFinsh	'2007-08-20 00:00'	(02) simulation end time -- must be in single quotes
soilCatTbl	ROSETTA	(03) soil-category dataset
vegeParTbl	USGS	(04) vegetation category dataset
soilStress	NoahType	(05) choice of function for the soil moisture control on stomatal resistance
<b>stomResist</b>	<b>simpleResistance Ballbery Jarvis</b>	<b>(06) choice of function for stomatal resistance</b>
num_method	iterative	(07) choice of numerical method
fDerivMeth	analytic	(08) method used to calculate flux derivatives
LAI_method	specified	(09) method used to determine LAI and SAI
f_Richards	mixdform	(10) form of Richard's equation
groundwatr	noXplicit	(11) choice of groundwater parameterization
hc_profile	constant	(12) choice of hydraulic conductivity profile
bcUpprTdyn	nrg_flux	(13) type of upper boundary condition for thermodynamics
bcLowrTdyn	zeroFlux	(14) type of lower boundary condition for thermodynamics
bcUpprSoiH	liq_flux	(15) type of upper boundary condition for soil hydrology
bcLowrSoiH	drainage	(16) type of lower boundary condition for soil hydrology
veg_traits	CM_QJRMS1988	(17) choice of parameterization for vegetation roughness length and displacement height
canopyEmis	difTrans	(18) choice of parameterization for canopy emissivity
snowIncept	lightSnow	(19) choice of parameterization for snow interception
windPrfile	logBelowCanopy	(20) choice of wind profile through the canopy
astability	louisinv	(21) choice of stability function
canopySrad	BeersLaw	(22) choice of canopy shortwave radiation method
alb_method	varDecay	(23) choice of albedo representation
compaction	anderson	(24) choice of compaction routine
snowLayers	CLM_2010	(25) choice of method to combine and sub-divide snow layers
thCondSnow	jrdn1991	(26) choice of thermal conductivity representation for snow
thCondSoil	mixConstit	(27) choice of thermal conductivity representation for soil
spatial_gw	localColumn	(28) choice of method for the spatial representation of groundwater
subRouting	timeDlay	(29) choice of method for sub-grid routing



JupyterHub SUMMA implementation used to replicate a study in published paper where three different Evapotranspiration parameterizations are used to explore their impact on the modeled Evapotranspiration in comparison to observed Evapotranspiration rates.

#### 4.6) Validation between the observation and simulation data.

```
In [37]: from sklearn.metrics import mean_absolute_error, mean_squared_error
         from math import sqrt
         from pysumma.Validation import validation
```

```
In [38]: # defind simulation data
         BallBerry_simulation = ET_Combine ['Ball-Berry']
         Jarvis_simulation = ET_Combine ['Jarvis']
         Simple_resistance_simulation = ET_Combine ['Simple resistance']
```

```
In [39]: # defind observation data
         obs = df_gp_hr.groupby('level_0').mean()
         observation_data = obs['Observation (aspen)']
```

```
In [40]: # analyze validation between BallBerry simulation and observation data.
         validation.analysis(observation_data, BallBerry_simulation)
```

```
Mean Absolute Error: 0.014720
Mean Squared Error: 0.000434
Root Mean Squared Error: 0.020833
```

```
In [41]: # analyze validation between Jarvis simulation and observation data.
         validation.analysis(observation_data, Jarvis_simulation)
```

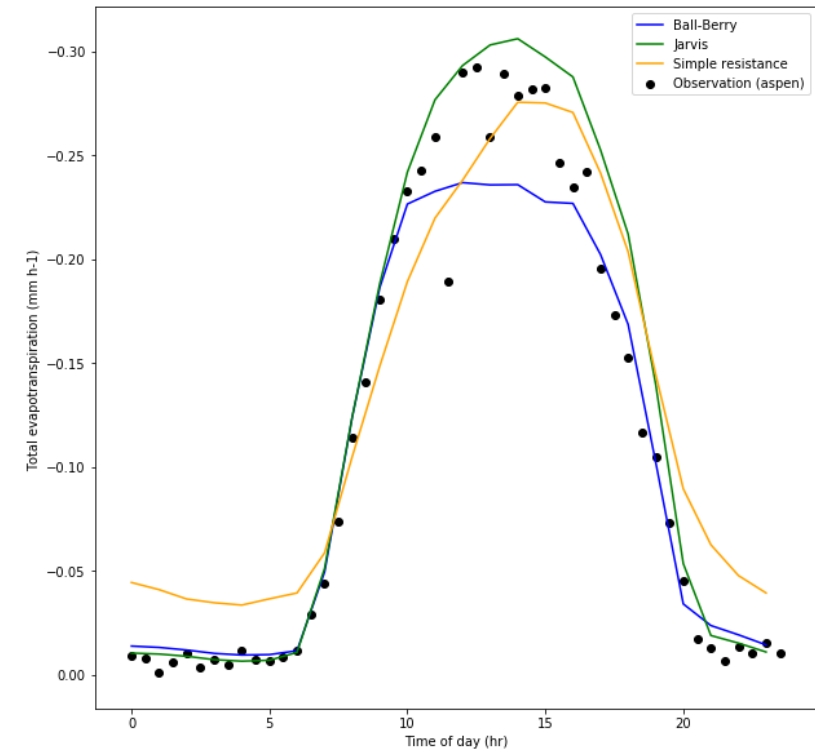
```
Mean Absolute Error: 0.019703
Mean Squared Error: 0.000915
Root Mean Squared Error: 0.030249
```

```
In [42]: # analyze validation between Simple resistance simulation and observation data.
         validation.analysis(observation_data, Simple_resistance_simulation)
```

```
Mean Absolute Error: 0.033234
Mean Squared Error: 0.001449
Root Mean Squared Error: 0.038060
```

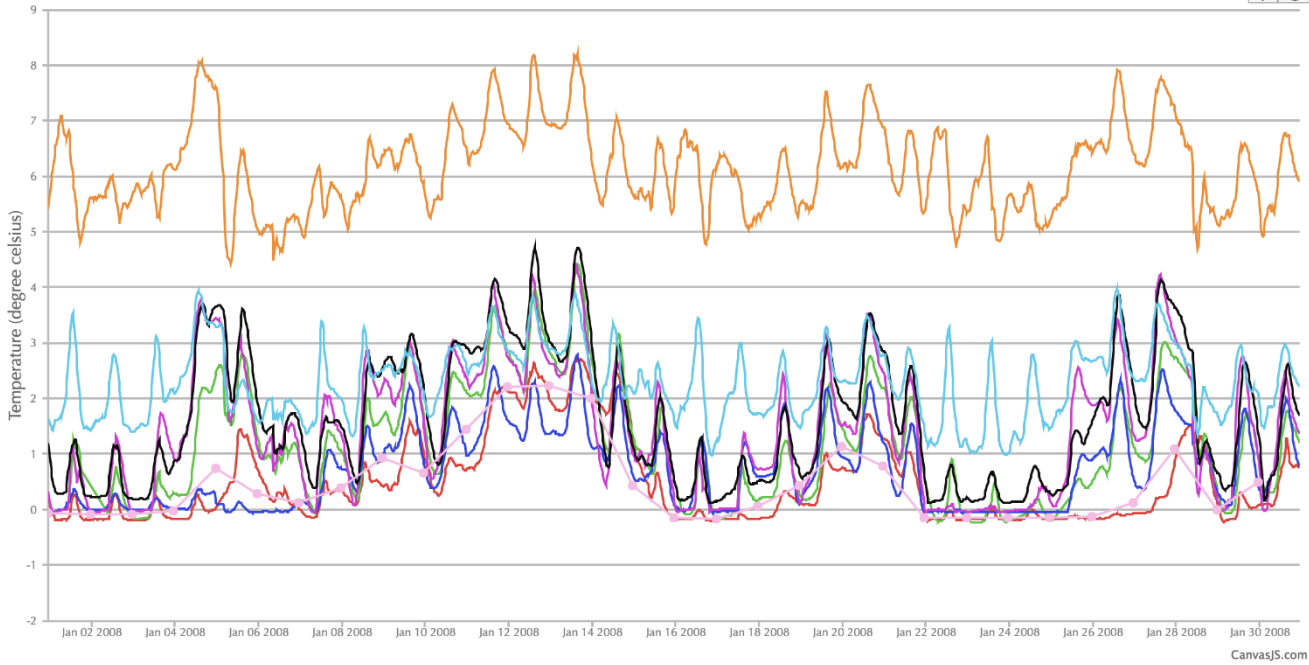
#### 4.5) Plotting output of three different stomatal resistance parameterizations and observation data

```
In [36]: # create plot with three different stomatal resistance parameterizations
         ET_Combine_Graph = ET_Combine.plot(color=['blue', 'green', 'orange'])
         # invert y axis
         ET_Combine_Graph.invert_yaxis()
         # plot scatter with x='xvals', y='Observation (aspen)'
         ET_Combine_Graph.scatter(xvals, df_gp_hr['Observation (aspen)'], color='black')
         # add x, y label
         ET_Combine_Graph.set(xlabel='Time of day (hr)', ylabel='Total evapotranspiration (mm h-1) ')
         # show up the legend
         ET_Combine_Graph.legend()
         plt.plot(figsize(x=10, y=10))
```





### CUAHSI Data Series Viewer



Organization	Site Name	Variable	Variable Unit	Quality Control	Value Count
Utah State University Utah Water Research Laboratory	Little Bear River at Mendon Road near Mendon, Utah	Temperature	degree celsius	(1) Quality ...	1440

Sample Medium: Surface Water

Method: Quality Control Level 1 Data Series created from raw QC Level 0 data using ODM Tools.

Data Type: Average

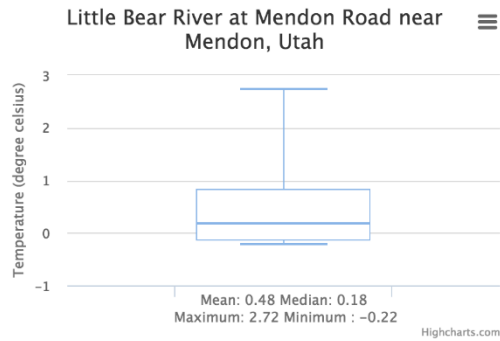
Value Type: Observation

Time Support: 30

Time Units: Minute

Source Description: Utah State University Utah Water Research Laboratory

Line Plot  Scatter Plot



Utah State University Utah Water Research Laboratory	Little Bear River at McMurdy Hollow near Paradise, Utah	Temperature	degree celsius	(1) Quality ...	1333
Utah State University Utah Water Research Laboratory	Little Bear River near Wellsville, Utah	Temperature	degree celsius	(1) Quality ...	1440

# CUAHSI Data Series Viewer

Display one or more time series and metadata from time series resources.

# Apps that facilitate and ease access to community value datasets

Not all data for which HydroShare facilitates access will be formal resources

- National Water Model Data (NWM forecast viewer and Data Explorer apps)
- NASA Modis Snow Cover (Snow inspector app)
- NASA NLDAS data (Data Rods Explorer app)
- GRACE Satellite total water storage from gravity (GRACE App)



Home

Subset

Add Watershed

Archive  
40-Day Rolling Window

Model Configuration  
Long Range

Model Output File  
Channel

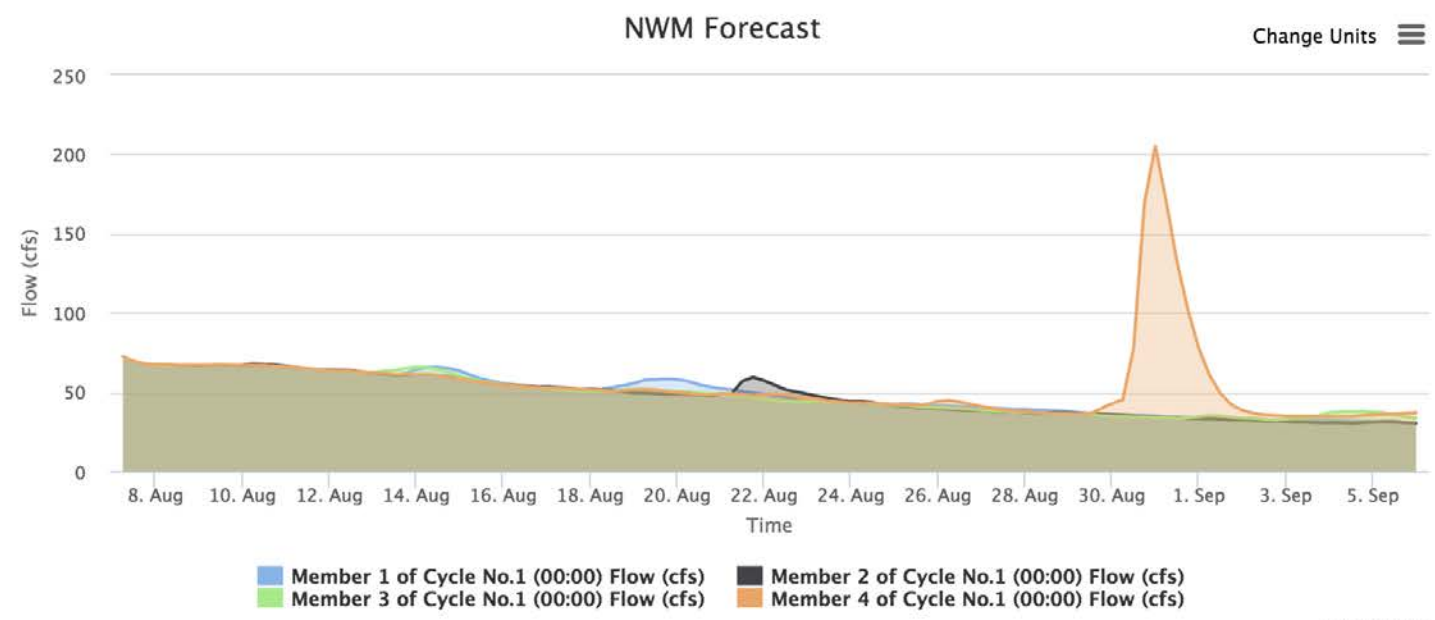
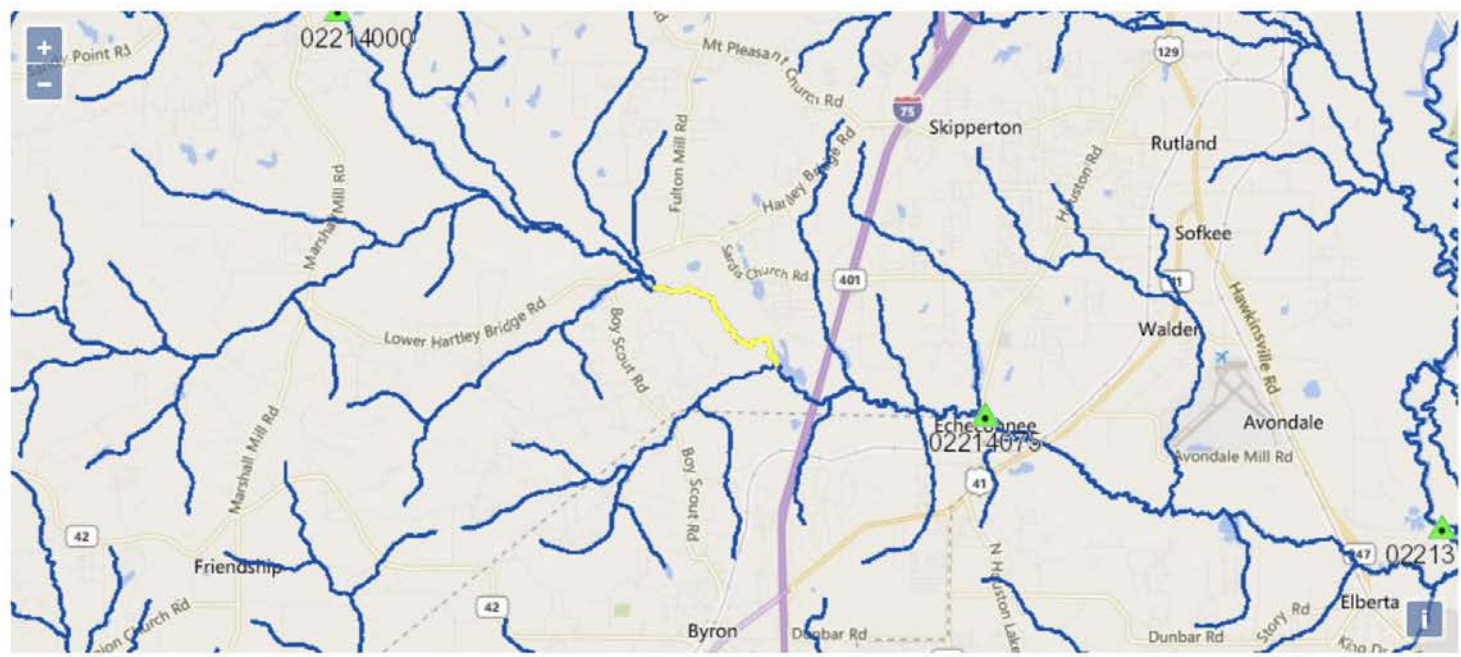
Variable  
Streamflow

COMID  
6341414

Begin Date  
2018-08-07

Ensemble Model Initialization Time (UTC)  
00:00 ON 06:00 OFF  
12:00 OFF 18:00 OFF

View Forecast



## Enhancing access to community data products

- View a time series forecast for any stream segment, model variable, and forecast period.
- Download a NetCDF file of a subset of forecasts for any polygon provided.
- Access data via web API – with auth token.

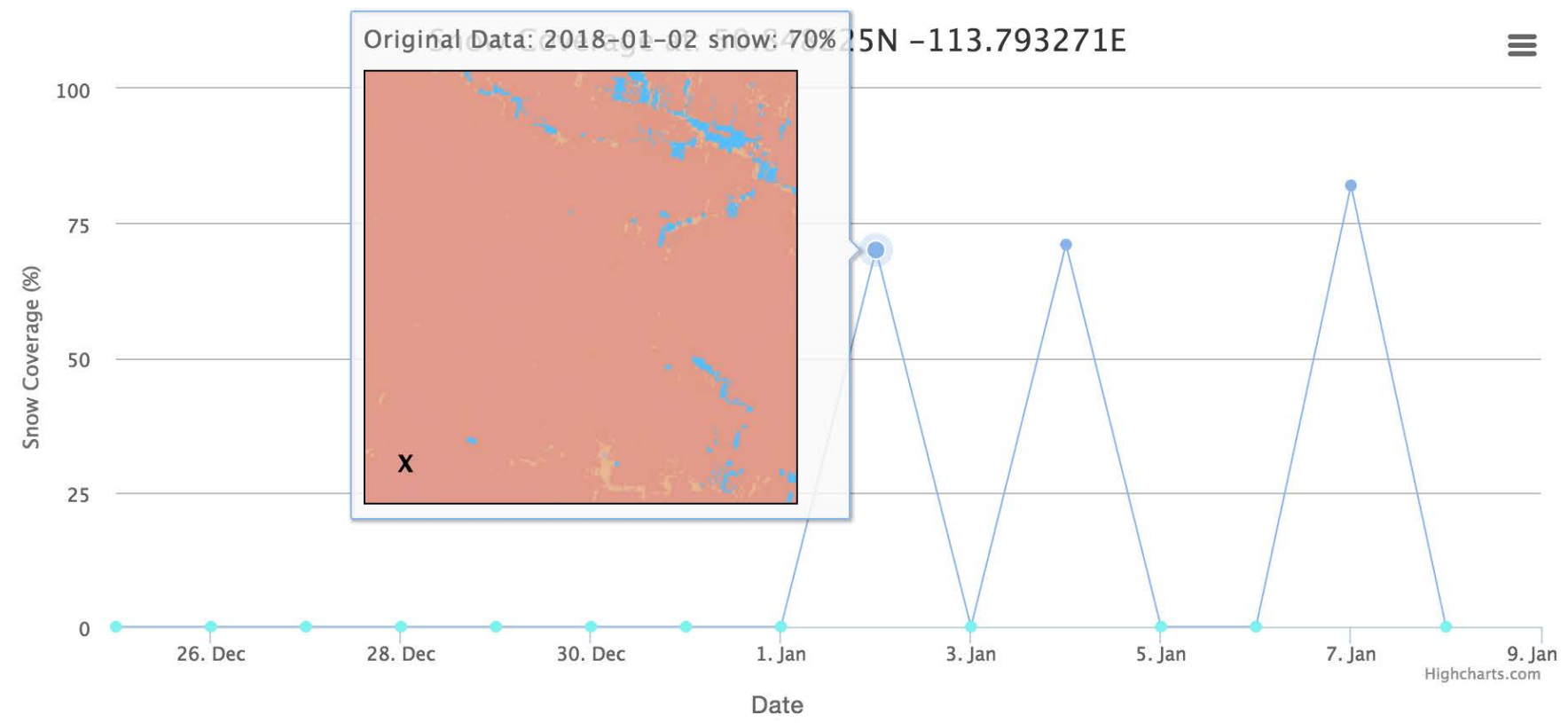
Change Dates, Location & Layer



Estimated data value per cell

Layer Selected: **Snow Cover**

Graph For: 50.848225 -113.793271 time period: 2017-12-25 - 2018-01-09



- Missing Data
- No Decision
- Night
- Inland Water
- Ocean
- Cloud
- Detector Saturated
- Fill

View a time series of percent snow cover for any location on the globe based on the MODIS snow cover product.

California

Home

Global Map

**Regional Map**

Select Signal Processing Method

CSR Solution

Select Storage Component

Total Water Storage (GRACE)

Select a day

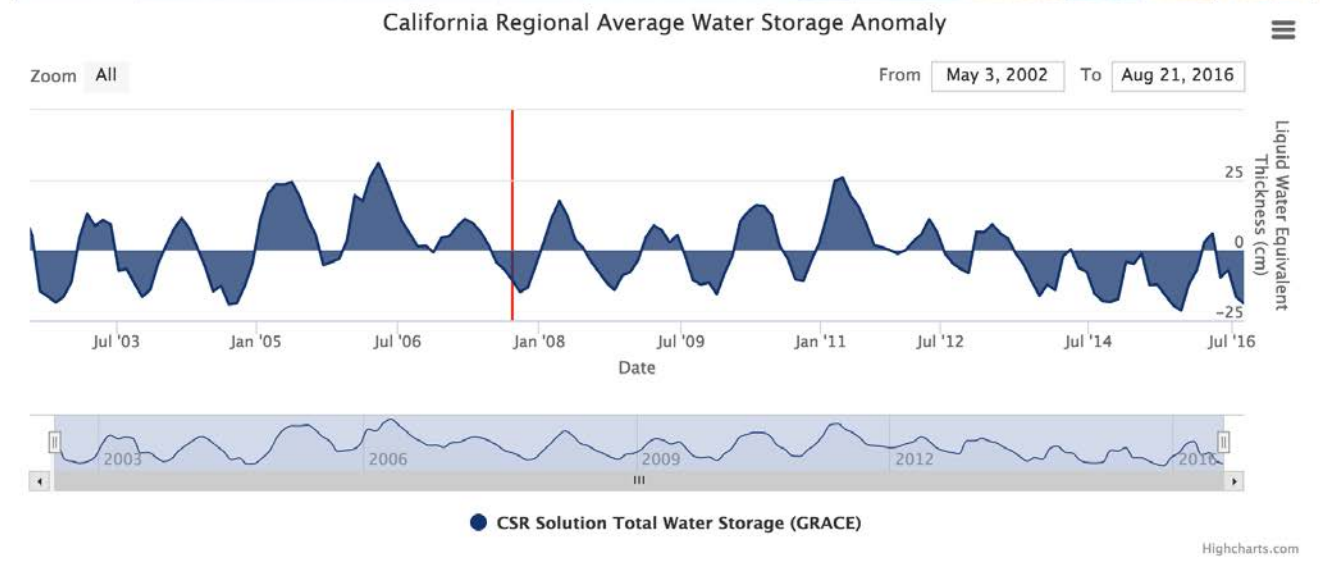
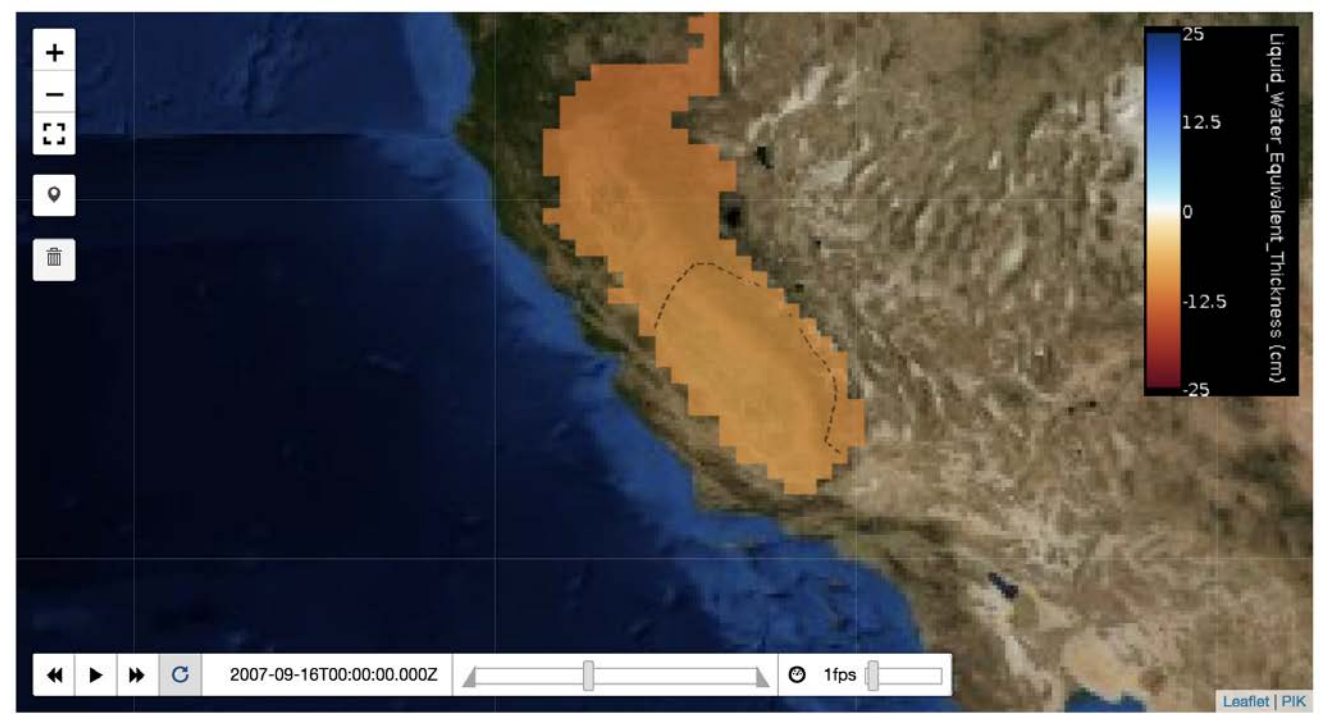
2002 April 16

**Time Series Generator**

To generate a time series for a specific location, click on the **Marker Icon** on left side of the map. Then place the marker at the location for which you wish to extract a time series from the current map layer.

**\*\*\*NOTE: The point time series will appear below the regional average time series plot.**

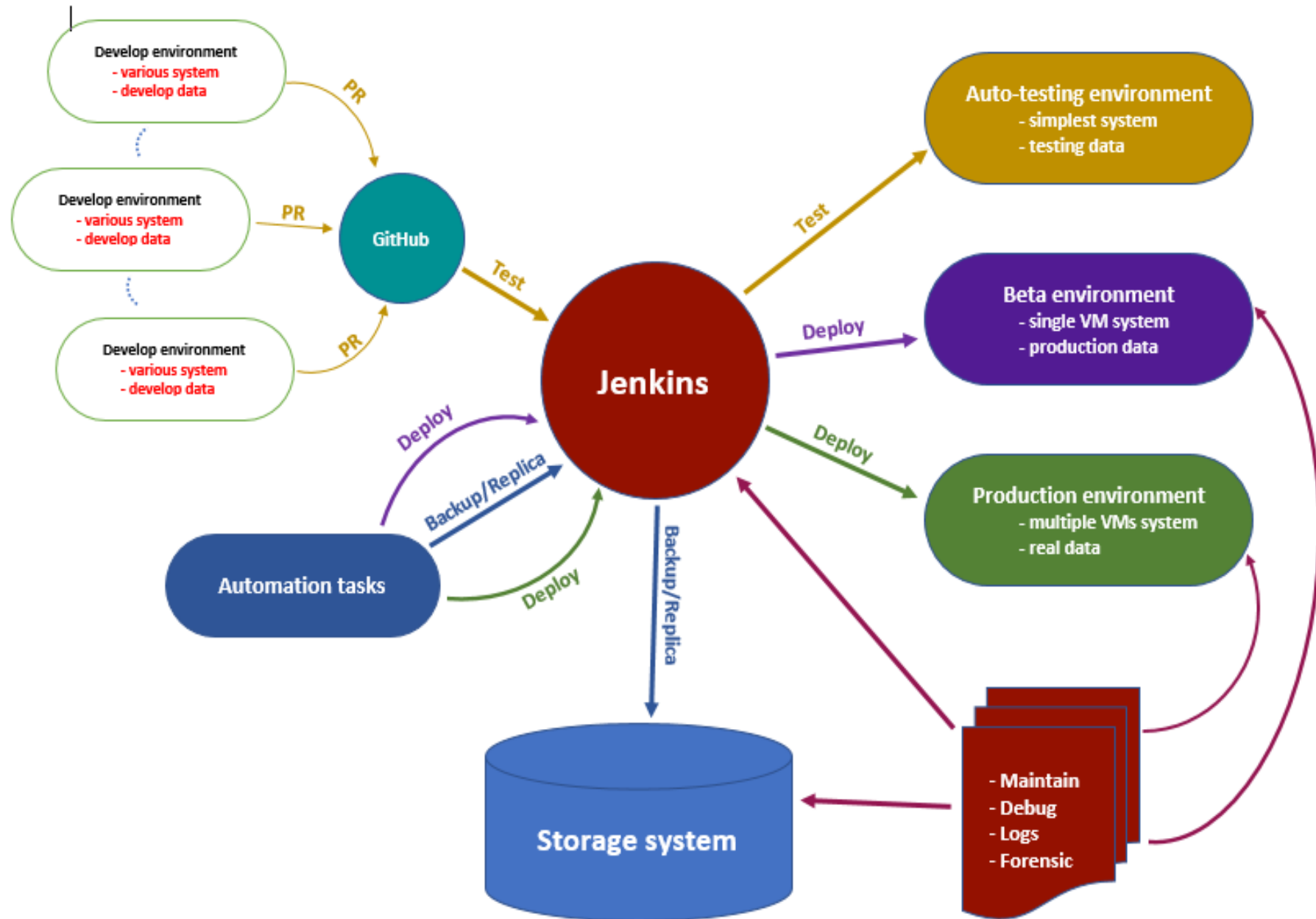
Switch Region: California    Select Symbology: Grace    Min: -25    Max: 25    Opacity: 0.7



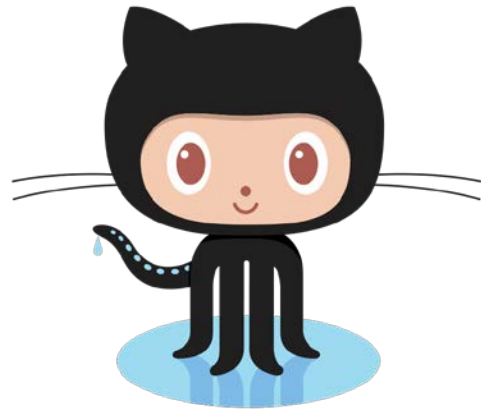
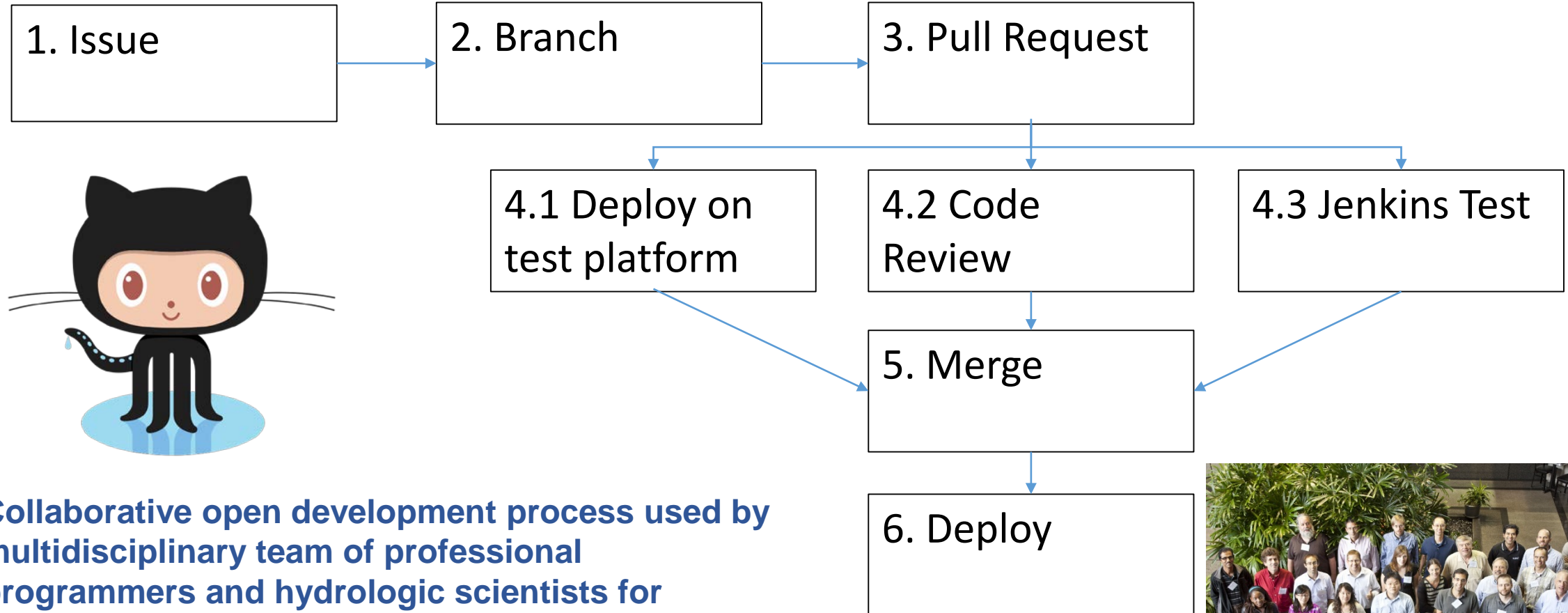
# NASA GRACE Groundwater App

View global GRACE satellite results including surface water, groundwater, soil moisture. Extract time series and animate data over selected time periods and locations using THREDDS.

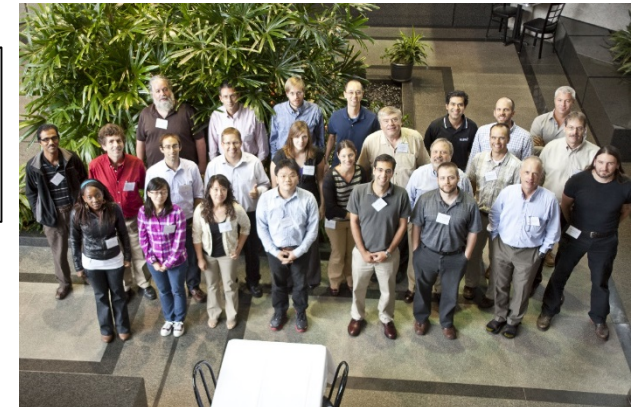
# HydroShare Infrastructure



# Software Engineering Process



**Collaborative open development process used by multidisciplinary team of professional programmers and hydrologic scientists for HydroShare development.**



# HydroShare User Experience Redesign


Leveraging user-oriented design practices to inform future design decisions to the HydroShare interface

## Design practices:

- Talking to users
- Co-design
- Design frameworks e.g. personas, journey maps, etc.
- Wireframing




Keenan, Patrick, Andrew, Mackenzie, & Celina




**Resolute Riley**  
 BS, Civil Engineering  
 PhD, Environmental Systems Analysis  
 Researcher - age 49  
*"I'll share my data when I'm done with it!"*  
*"Publish or perish."*

DEMOGRAPHICS			BEHAVIORS			ATTITUDES		
Parents pressure them to a doctor	Works and publishes with a sub group	Gets funding from the NSF	Pushes hard to be the first to publish	Steps in academic world of one	Publishes requested research to HS	Competitive	Values prestige	Results win not over-see tool efficiency
NEEDS/ CHALLENGES			GOALS/ MOTIVATIONS			HOW CAN WE HELP?		
Data needs to be credible	Academic research is highly competitive	Organizing data can be difficult	To be first to publish	To make a name for themselves	To lead a research group or lab	Allow for data to be reviewed & shared	Keep data private before it's shared	Options for viewing within stream



**Purposeful Parker**  
 BS, Ecology  
 MS, Data Science  
 Researcher/Developer - age 28  
*"Citizen scientists rock!"*  
*"I really care about where my data goes and how it gets used."*

DEMOGRAPHICS			BEHAVIORS			ATTITUDES		
Government employees don't publish	Loves using Python	Active in the water community	Includes local and citizen scientists	Often collect their own data	Uses HS every step of the way	People are their first priority	Values team diversity	Data privacy doesn't matter
NEEDS/ CHALLENGES			GOALS/ MOTIVATIONS			HOW CAN WE HELP?		
HS appears to lack reviewing	Easy sharing within groups	Clear, strong to use interface	To make an impact as a community	To do personal work	To make resources and data available	Make HS a tool to their work spot	Allow for data to be reviewed & shared	Make it easy to find other users



**Idealistic Ira**  
 BS, Computer Science  
 MS, Ecohydrology  
 Researcher/Developer - age 35  
*"Academia is way too competitive."*  
*"I want to be able to share my data without my publishing rights getting stolen."*

DEMOGRAPHICS			BEHAVIORS			ATTITUDES		
Students what they find interesting	Researcher with an independent group	Loves GitHub	Publishes in journals, talks HS	Gets data directly from the source	Uses Jupyter notebooks & GitHub	Considers open source & reusable	Values working with others	Is nervous to share computer atmosphere
NEEDS/ CHALLENGES			GOALS/ MOTIVATIONS			HOW CAN WE HELP?		
"Discover" is difficult to navigate	Research organization is important	New tools need to be useful	To collaborate over research	To make useful data models	To improve academic culture	Clear and reusable open source	Support for sharing with others	Integrate open source in workflow

# Example: Recommendation for Dashboard and “Search all of HydroShare”

The screenshot shows the HydroShare website interface. At the top, there is a browser address bar with the URL <https://www.hydroshare.org/>. Below the address bar is a navigation menu with the following items: HydroShare (with a logo), My Content, Explore, Groups, Apps, Help, and Profile. A search bar is located in the navigation menu, containing the text "Search all HydroShare", and this search bar is highlighted with a red rectangular border. Below the navigation menu, the main content area is divided into two sections: "My Content Preview" and "Quick Links".

### My Content Preview

Status	Title	Author	Views	Last Modified
private	Utah Lake Water Sample	Andrew Deaver	332	02/21/18
published	Utah pH Levels	Andrew Deaver	156	02/20/18
public	Lake Pollution Levels	Celina Bekins	3	02/15/18
public	Stream Runoff	Mackenzie Frackleton	56	01/4/18
public	Utah Watershed Model	Andrew Deaver	12	8/24/15

Access the Rest of Your Content

### Quick Links

- Create New Resource
- Open Jupyter Hub
- Open National Water Model

# Summary

HydroShare is a web based collaboration environment to enable more rapid advances in hydrologic understanding through collaborative data sharing, analysis and modeling

- Sharing and publication of data (DOI)
- Social discovery and added value
- Model sharing
  
- Model input data preparation
- Model execution
- Visualization and analysis (best of practice tools)



Collaboration, Reproducibility,  
Credit, Transparency



Server/Cloud Computation

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





OAC-1664061  
OAC-1664018  
OAC-1664119  
2017-2021

# Thanks to the HydroShare team!

HydroShare is operated by CUAHSI with ongoing development through a collaborative project among Utah State University, RENCI University of North Carolina, CyberGIS Center University of Illinois, Tufts, University of Virginia, Brigham Young University, National Center for Atmospheric Research and the University of Washington.



To learn more

- Publications <https://help.hydroshare.org/about-hydroshare/publish/>
- Online Help <https://help.hydroshare.org/>



<http://www.hydroshare.org>

