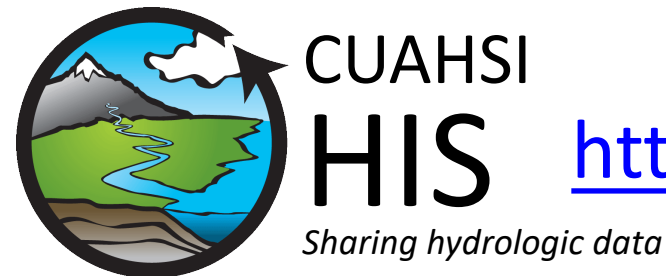


# The CUAHSI Community Hydrologic Information System

David Tarboton, David Maidment, Ilya  
Zaslavsky, Dan Ames, Jon Goodall,  
Richard Hooper, Jeffery Horsburgh



<http://his.cuahsi.org/>



# Hydrologic Data Challenges

- From dispersed federal agencies
- From investigators collected for different purposes
- Different formats
  - Points
  - Lines
  - Polygons
  - Fields
  - Time Series

## Data Heterogeneity

The way that data is organized can enhance or inhibit the analysis that can be done

Water quality



Water quantity



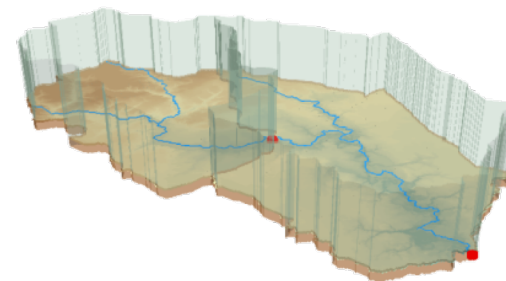
Rainfall and Meteorology



Soil water



GIS

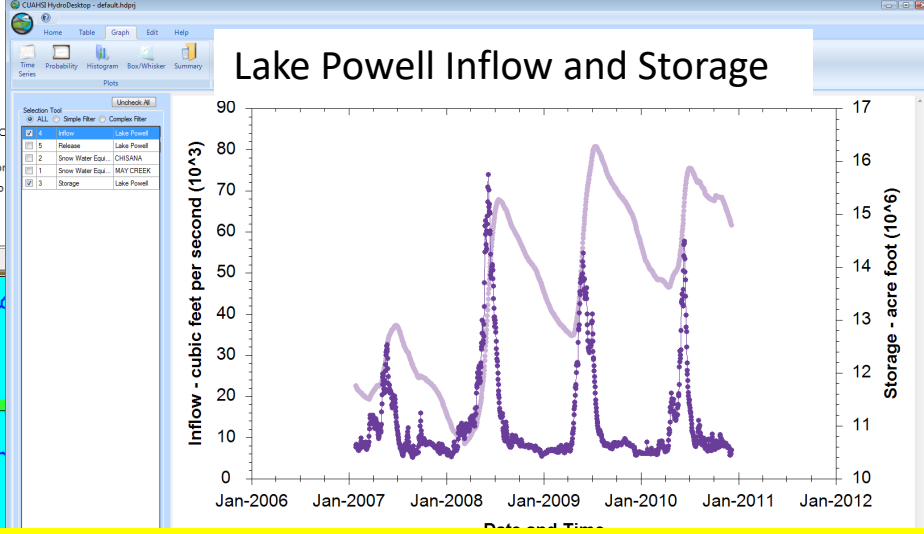
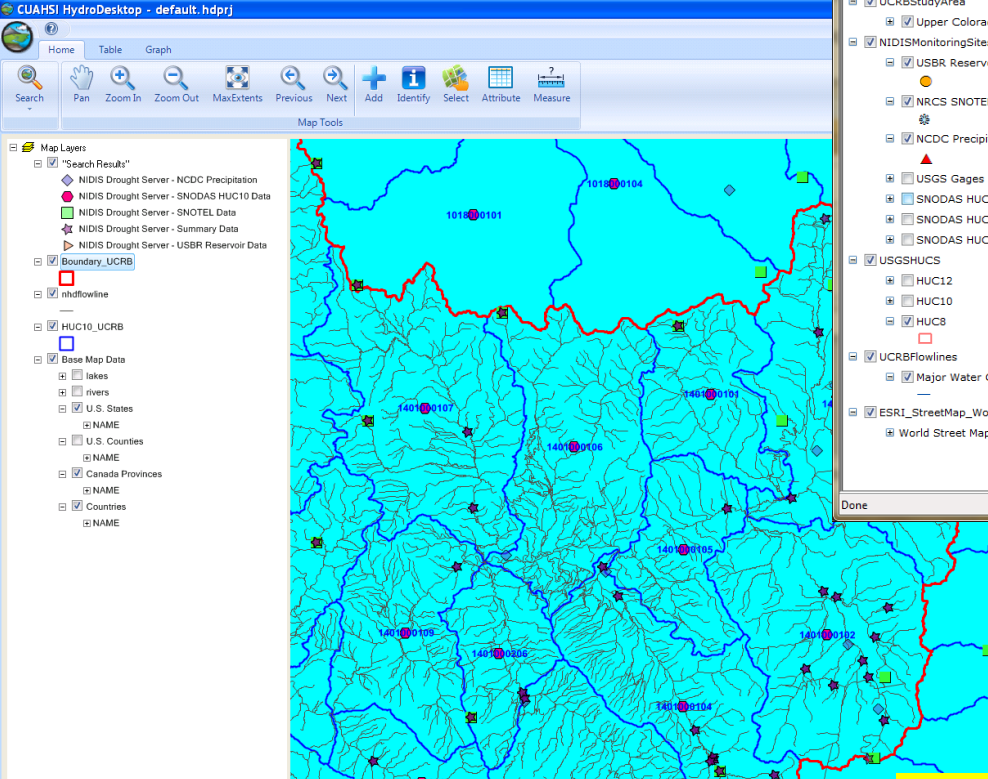
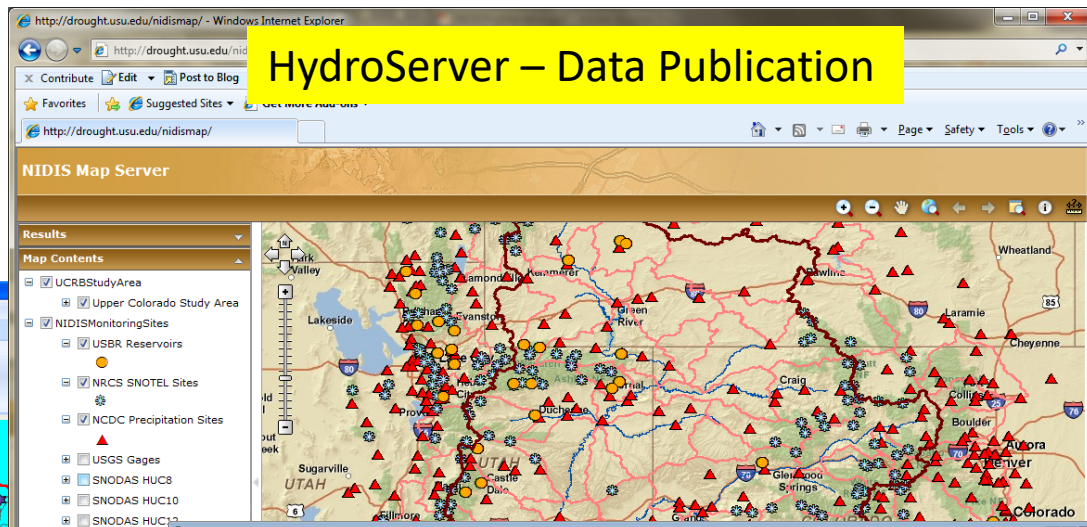
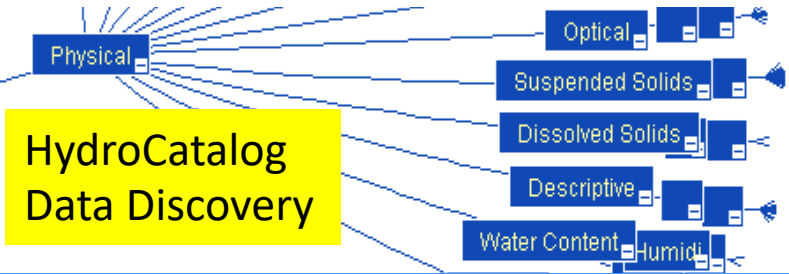


Groundwater



# CUAHSI HIS

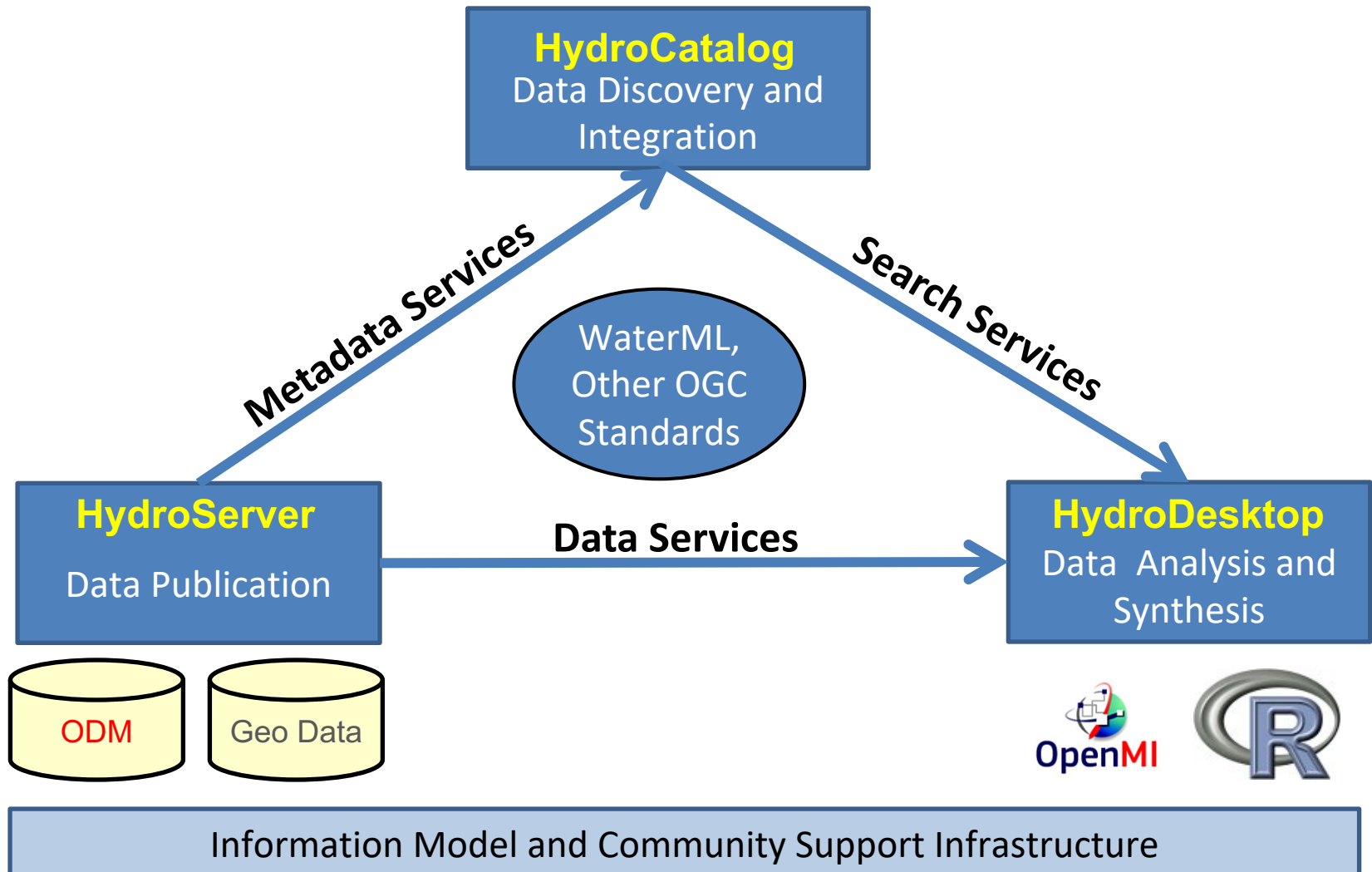
The CUAHSI Hydrologic Information System (HIS) is an internet based system to support the sharing of hydrologic data. It is comprised of hydrologic databases and servers connected through web services as well as software for data publication, discovery and access.



HydroDesktop – Data Access and Analysis

HydroDesktop – Combining multiple data sources

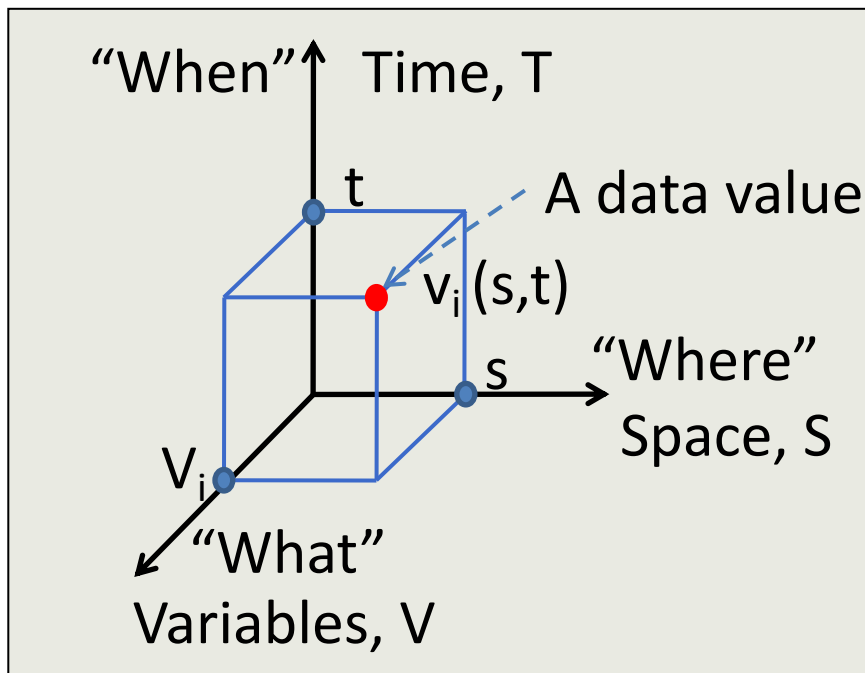
# CUAHSI Hydrologic Information System Services-Oriented Architecture



# What are the basic attributes to be associated with each single data value and how can these best be organized?

DateTime
Interval (support)

Variable
Method
Quality Control Level
Sample Medium
Value Type
Data Type
Source/Organization



Units
Accuracy
Censoring
Qualifying comments

Location
Feature of interest
Latitude
Longitude
Site identifiers

# Observations Data Model (ODM)

Provides a common persistence model for data storage

Streamflow

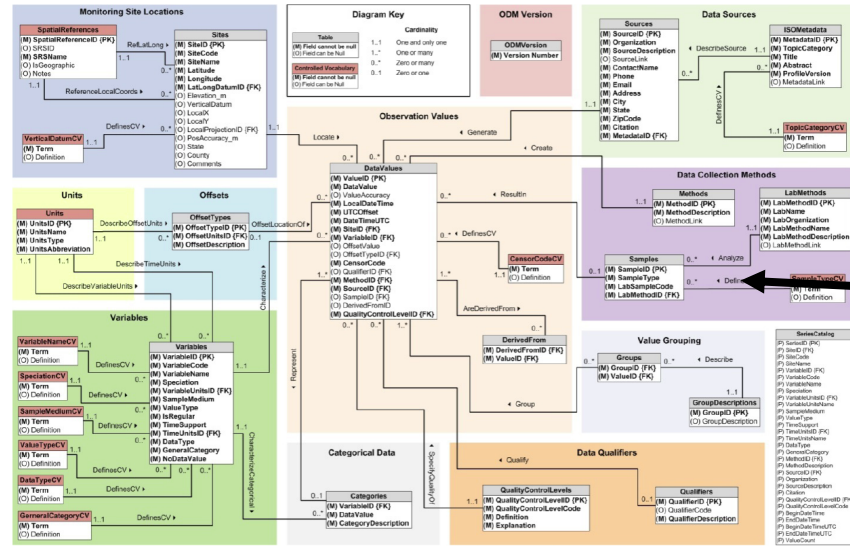
Groundwater levels



Precipitation & Climate



Water Quality



Soil moisture data



Flux tower data



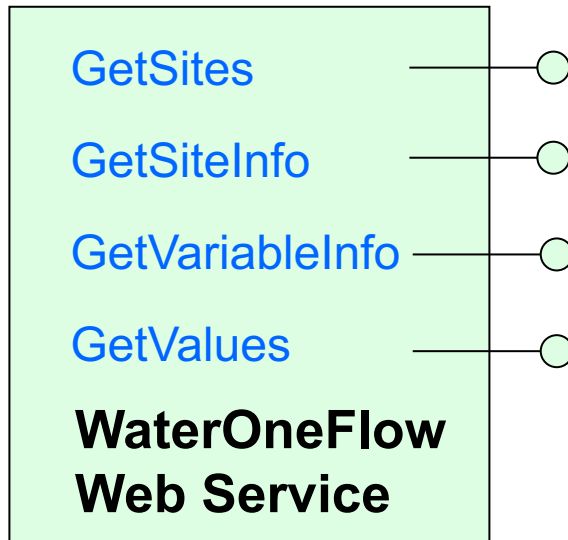
- A **relational database** at the single observation level
- Metadata for **unambiguous interpretation**
- Traceable heritage from **raw** measurements to **usable** information
- Promote **syntactic** and **semantic** consistency
- **Cross dimension** retrieval and analysis

# WaterML and WaterOneFlow

**WaterML** is an XML language for communicating water data

**WaterOneFlow** is a set of web services based on WaterML

- Set of **query** functions



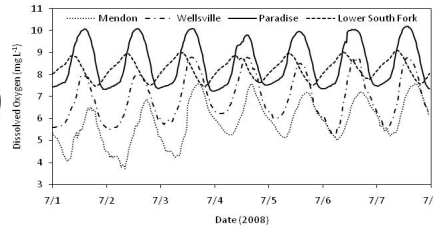
- Returns data in **WaterML**

```
<timeSeries>
- <sourceInfo xsi:type="SiteInfoType">
  <siteName>Colorado Rv at Austin, TX</siteName>
  <siteCode network="NWIS" siteID="4619631">08158000
- <geoLocation>
  - <geogLocation xsi:type="LatLonPointType" srs="EPSG"
    <latitude>30.24465429</latitude>
    <longitude>-97.694448</longitude>
  </geogLocation>
  </geoLocation>
</sourceInfo>
- <variable>
  <variableCode vocabulary="NWIS" default="true" variable
  <variableName>Discharge, cubic feet per second</variableName>
  <units unitsAbbreviation="cfs" unitsCode="35">cubic feet</units>
</variable>
- <values count="2545">
  <value dateTime="2006-12-31T00:00:00">129</value>
  <value dateTime="2006-12-31T00:15:00">129</value>
  <value dateTime="2006-12-31T00:30:00">129</value>
  <value dateTime="2006-12-31T00:45:00">129</value>
  <value dateTime="2006-12-31T01:00:00">124</value>
  <value dateTime="2006-12-31T01:15:00">129</value>
  <value dateTime="2006-12-31T01:30:00">124</value>
  <value dateTime="2006-12-31T01:45:00">124</value>
  <value dateTime="2006-12-31T02:00:00">124</value>
```

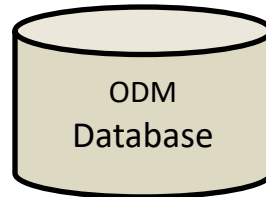
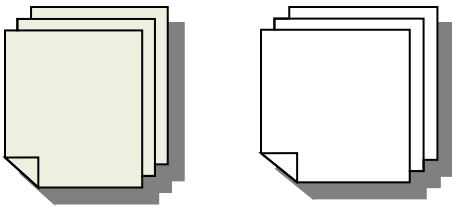
# HydroServer – Data Publication

## Point Observations Data

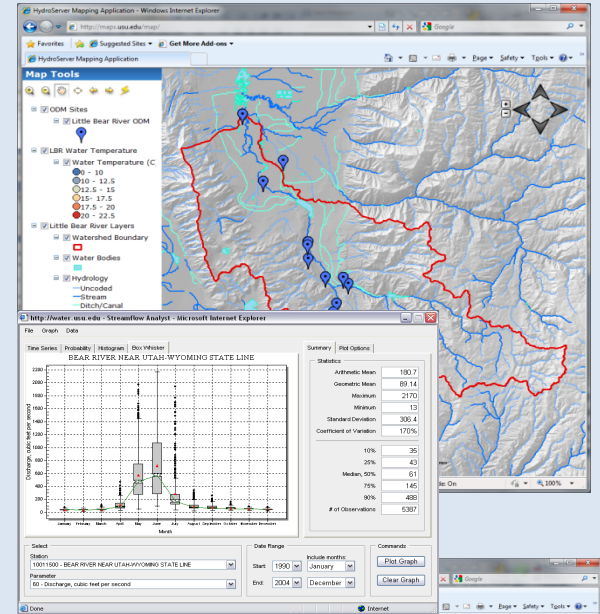
### Ongoing Data Collection



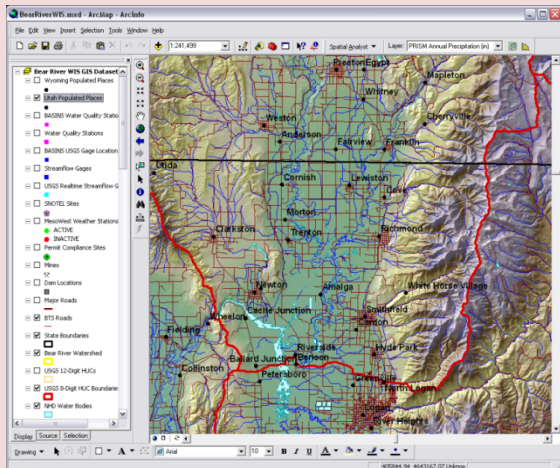
### Historical Data Files



## Internet Applications



## GIS Data

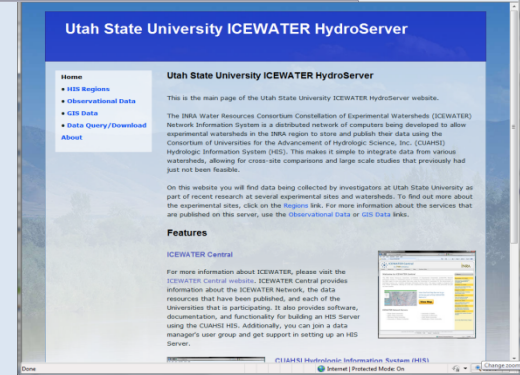


- GetSites
- GetSiteInfo
- GetVariableInfo
- GetValues

WaterML  
WaterOneFlow  
Web Service

OGC Spatial  
Data Service  
from ArcGIS  
Server

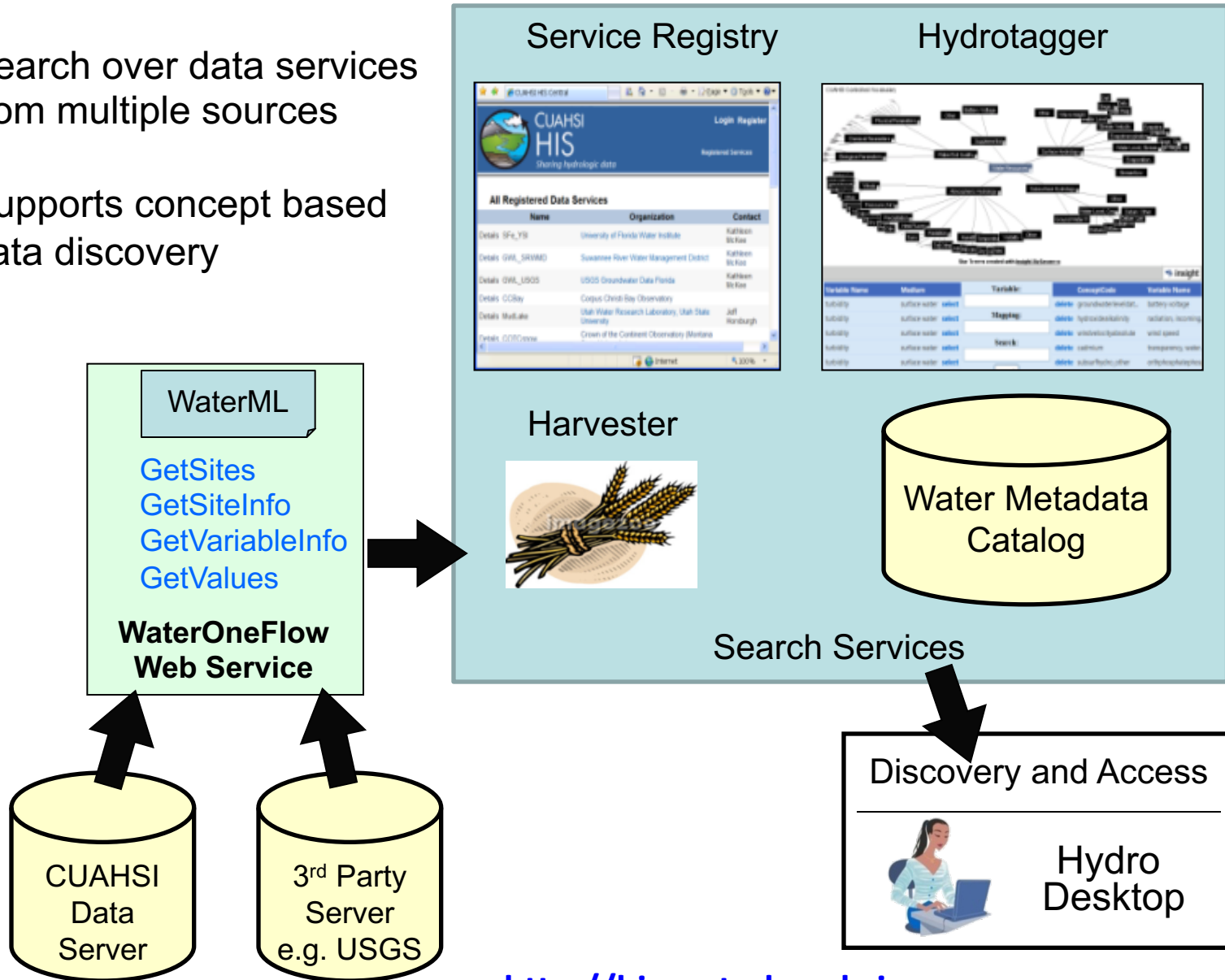
Data presentation, visualization, and analysis through Internet enabled applications





# HydroCatalog

- Search over data services from multiple sources
- Supports concept based data discovery



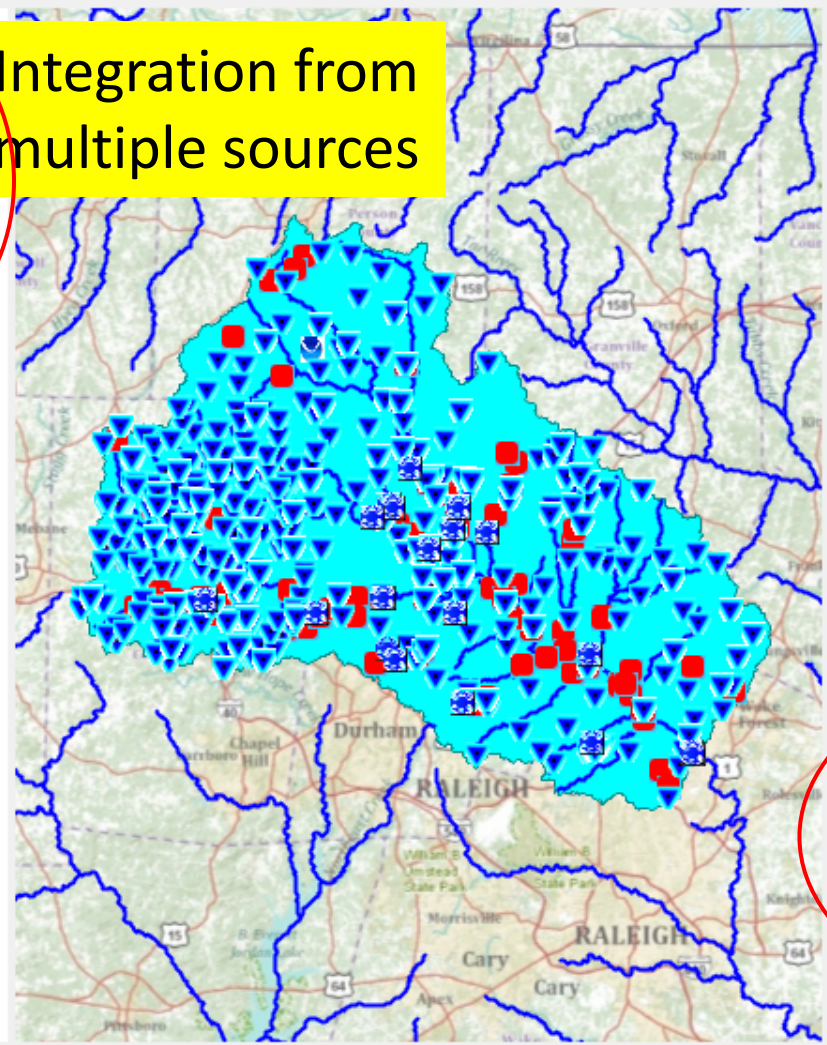
# HydroDesktop – Data Access and Analysis

Map Tools: Search, Pan, Zoom In, Zoom Out, MaxExtents, Previous, Next, Add, Identify, Select, Attribute, Measure, Delineate, EPA Tool, Online Basemap

Map Layers

- "Search Results"
  - EPA
  - NCD CISH
  - NWISDV
  - NWISGW
  - NWISIID
  - NWISUV
- rv14fe02
- LocalWatershed
- Themes
  - My\_NWISUV
  - NWISIID
- Online Basemap
- Base Map Data
  - lakes
  - rivers
- U.S. HUC
- U.S. Counties
- Canada Provinces
- NAME
- U.S. States

Integration from multiple sources



Thematic keyword search

Keywords: Type-in first few letters  
Hydrosphere

Hydrosphere

- Physical
  - Level
  - Area
  - Velocity
  - Density
  - Temperature
  - Pressure

Keywords Display: List, Tree, Both

Selected Keywords: Hydrosphere

Search on space and time domain

Search Summary

Server: HIS Central | Area: 1 feature selected

Web Services: All Webservices selected

Keywords: Hydrosphere | Date Range: 5/23/1911 :: 5/23/2011

Run Search



# Integration with "R" Statistics Package

The screenshot displays the R GUI interface with several windows open:

- R Console:** Shows R commands for creating a 3D surface plot:

```
rgl.sr> ylen <- ylim[2] - ylim[1] + 1
rgl.sr> colorlut <- terrain.colors(ylen)
rgl.sr> col <- colorlut[y - ylim[1] + 1]
rgl.sr> rgl.clear()
rgl.sr> rgl.surface(x, z, y, color = col)
```
- R Data Editor:** Displays a data table with columns 'height' and 'weight':

height	weight
58	115
59	117
60	120
61	123
62	126
63	129
64	132
65	135
66	139
67	142
68	146
69	150
70	154
71	159
72	164
- R Workspace Browser:** Lists objects in the workspace:

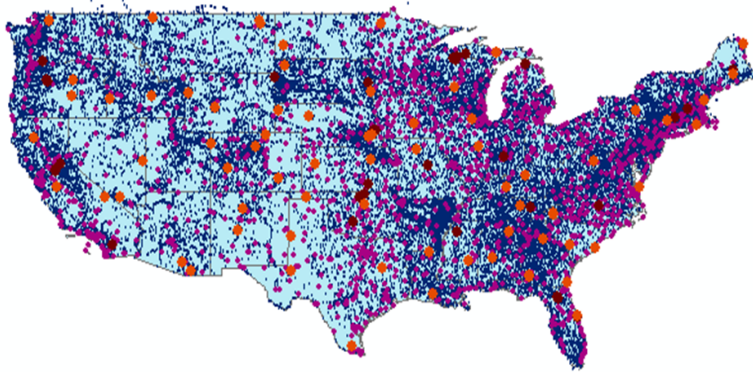
Object	Type	Structure
dati	data.frame	dim: 20 4
g	factor	levels: 10
l	numeric	length: 12
n	numeric	length: 1
opar	list	length: 2
pie.sales	numeric	length: 6
pin	numeric	length: 2
scale	numeric	length: 1
usr	numeric	length: 4
women	data.frame	dim: 15 2
height	numeric	length: 15
weight	numeric	length: 15
x	numeric	length: 87
- R Package Manager:** Shows installed and available packages:

status	Package	Description
<input checked="" type="checkbox"/> loaded	graphics	The R Graphics Package
<input type="checkbox"/> not loaded	grid	The Grid Graphics Package
<input type="checkbox"/> not loaded	lattice	Lattice Graphics
<input checked="" type="checkbox"/> loaded	methods	Formal Methods and Classes
<input type="checkbox"/> not loaded	mgcv	CAMs with GCV smoothness estimation
- RGL device 1 (active):** Shows a 3D surface plot of the terrain data.

# Open Geospatial Consortium Web Service Standards

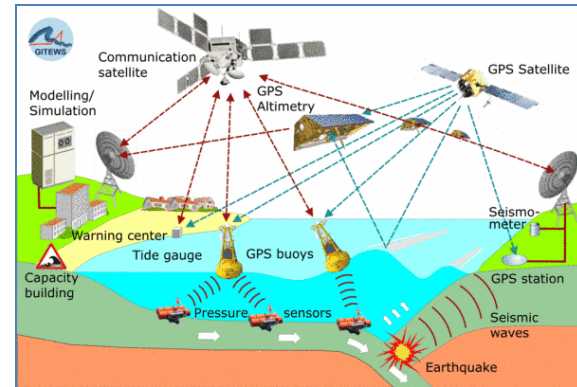
These standards have been developed over the past 10 years ....  
.... by 400 companies and agencies working within the OGC

- **Map Services**



- Web Map Service (WMS)
- Web Feature Service (WFS)
- Web Coverage Service (WCS)
- Catalog Services for the Web (CS/W)

- **Observation Services**



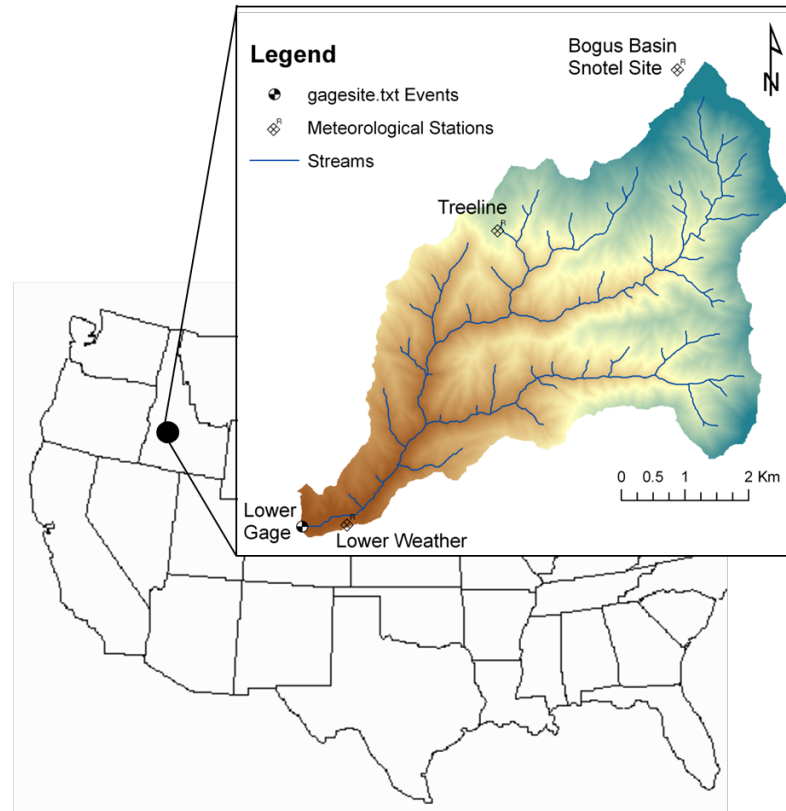
- Observations and Measurements Model
- Sensor Web Enablement (SWE)
- Sensor Observation Service (SOS)

OGC Hydrology Domain Working Group evolving WaterML into an International Standard  
<http://www.opengeospatial.org/projects/groups/waterml2.0swg>

# A growing collection of HydroServers and community of users

- University of Maryland, Baltimore County
- Montana State University
- University of Texas at Austin
- University of Iowa
- Utah State University
- University of Florida
- University of New Mexico
- University of Idaho
- Boise State University
- University of Texas at Arlington
- University of California, San Diego
- Idaho State University

## Dry Creek Experimental Watershed (DCEW) (28 km<sup>2</sup> semi-arid steep topography, Boise Front)



68 Sites  
24 Variables  
4,700,000+ values

Published by Jim  
McNamara, Boise  
State University

# Open Development Model

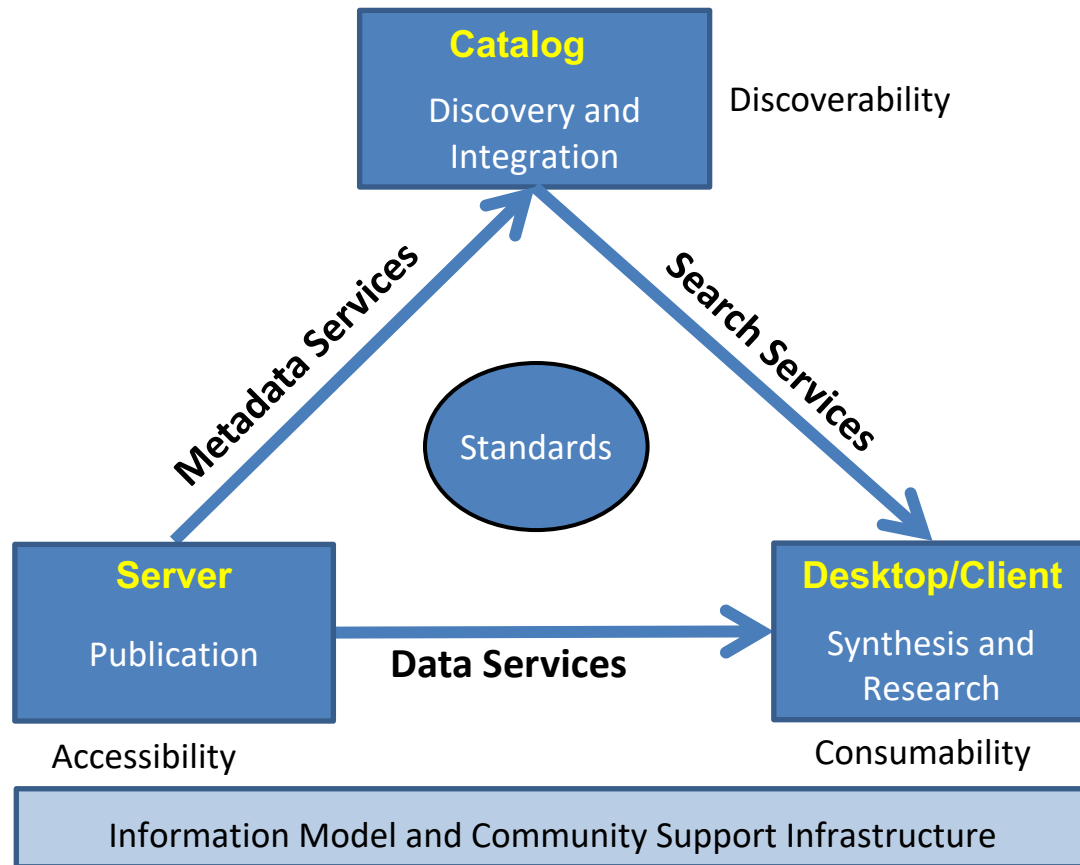
<http://hydrodesktop.codeplex.com/>

- [http://hydrodesktop.codeplex.com](http://hydrodesktop.codeplex.com/)
- [http://hydroserver.codeplex.com](http://hydroserver.codeplex.com/)
- [http://hydrocatalog.codeplex.com](http://hydrocatalog.codeplex.com/)

# General aspects of the approach

- **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

## Common functional components



# Looking to the Future

- Move from prototype to operations
  - Operational support of software and systems
  - User support and training
  - Repositories
  - CUAHSI Data Center (**User Solutions Engineer**)
  - NSF Data Management Requirements
- Research and development of new functionality
  - data and model sharing “hub” to enhance interactive collaboration (**pending**)
- Community
  - HIS has become bigger than one project (**emerging software ecosystem**)
  - Open Development Model (**inspire, enable and incorporate broad contributions**)
  - The community is the infrastructure that persists (**is sustainable**)



# Thanks! HIS Project Team and Sponsors

- [University of Texas at Austin](#) – David Maidment, Tim Whiteaker, James Seppi, Fernando Salas, Jingqi Dong, Harish Sangireddy
- [San Diego Supercomputer Center](#) – Ilya Zaslavsky, David Valentine, Tom Whitenack, Matt Rodriguez
- [Utah State University](#) – David Tarboton, Jeff Horsburgh, Kim Schreuders, Stephanie Reeder
- [University of South Carolina](#) – Jon Goodall, Anthony Castronova
- [Idaho State University](#) – Dan Ames, Ted Dunsford, Jiří Kadlec, Yang Cao, Dinesh Grover
- [Drexel University/CUNY](#) – Michael Piasecki
- [WATERS Network](#) – Testbed Data Managers
- [CUAHSI Program Office](#) – Rick Hooper, Yoori Choi, Conrad Matiuk
- [ESRI](#) – Dean Djokic, Zichuan Ye

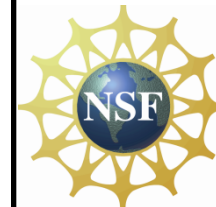


CUAHSI

HIS

*Sharing hydrologic data*

<http://his.cuahsi.org/>



Support  
EAR 0622374