Using CUAHSI HIS to Support Large Scale Collaborative Research in Utah

Jeffery S. Horsburgh

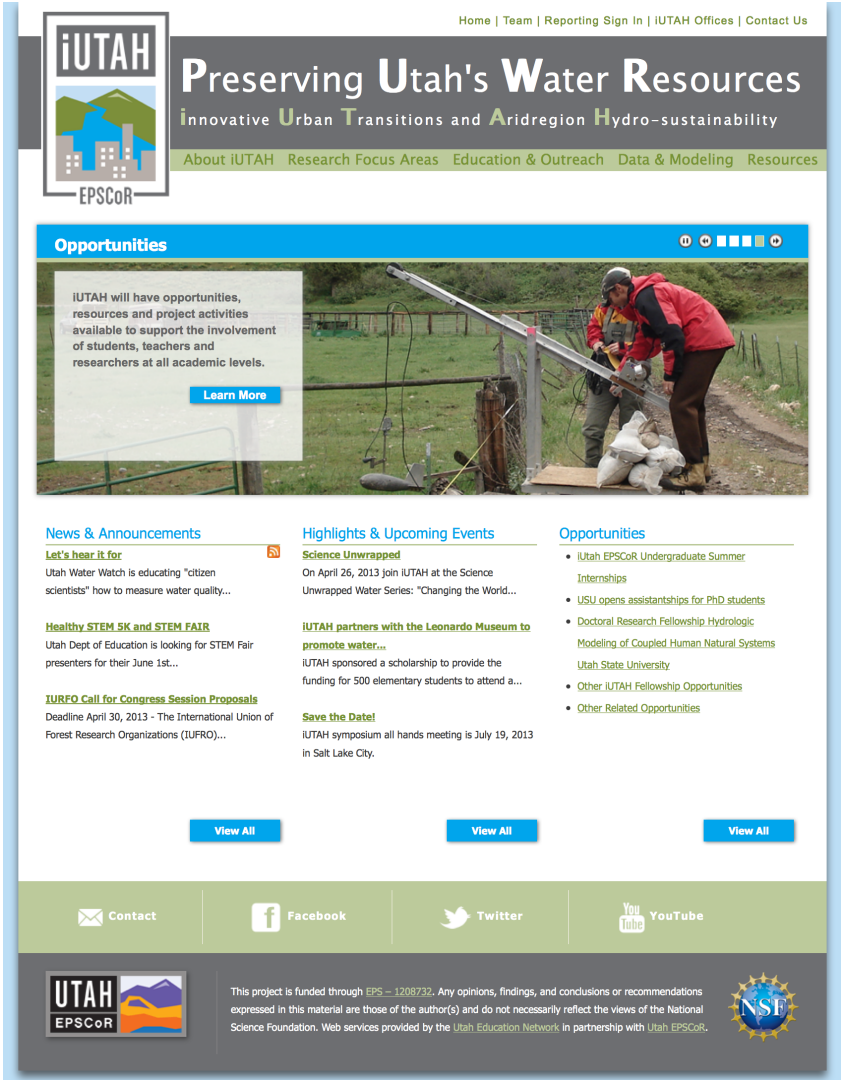
Amber Jones, Stephanie Reeder, James Patton, Juan Caraballo, Mauriel Ramirez, Nate Mouzon

CUAHSI HIS Cyberseminar

5-1-2013

innovative Urban Transitions and Aridregion Hydro-sustainability (iUTAH)

- Statewide effort
- $20 million competitive award from NSF EPSCoR
- Research capacity building
- Interdisciplinary and multi-institution
- Focused on sustainable management of Utah's water resources

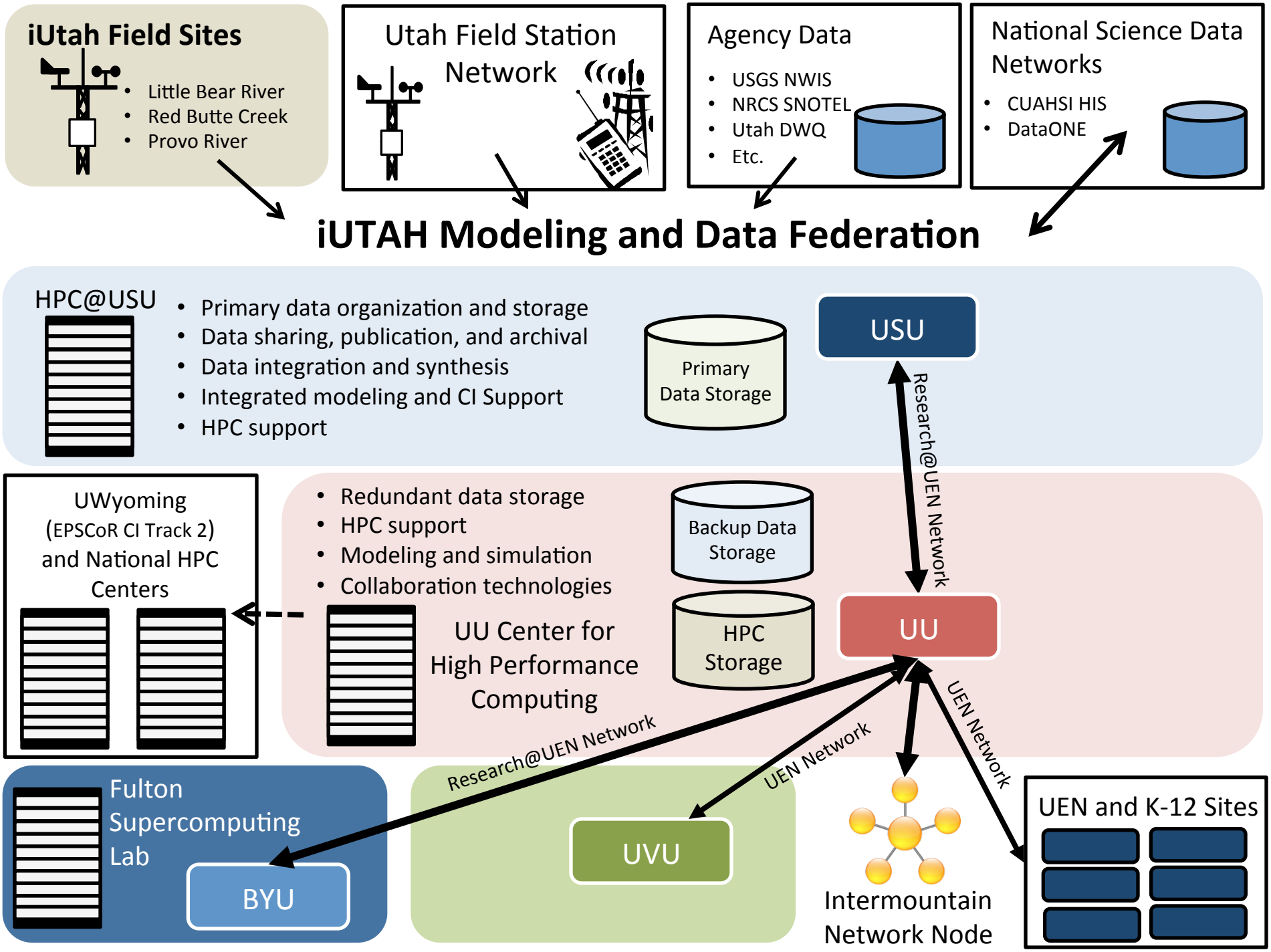


Support:
EPS 1208732

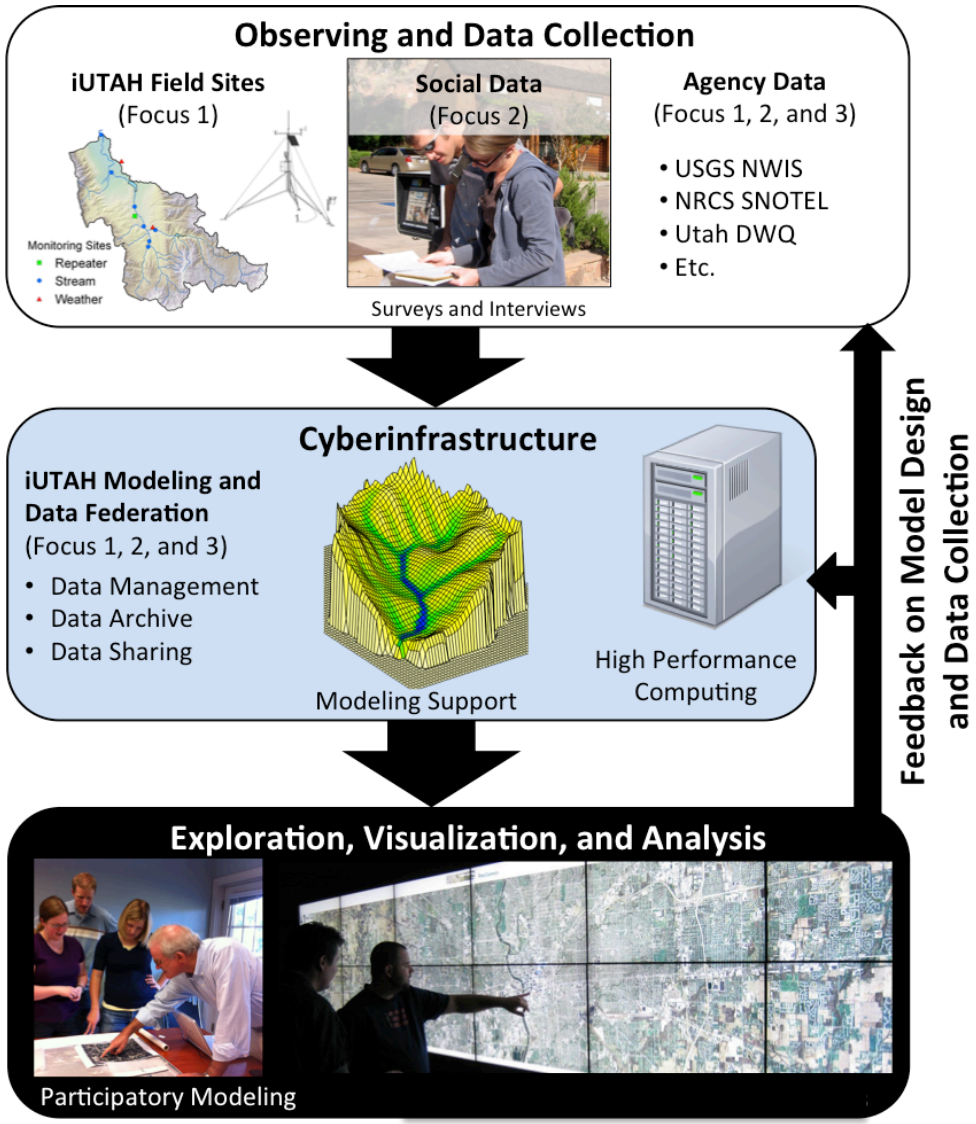
http://www.iutahepscor.org

iUTAH Research Focus Areas

1. Eco-hydrology
   - Expand Utah's capacity in the natural sciences through instrumentation of 3 watersheds
2. Social and Engineered Water Systems
   - Studying demographic characteristics, water use behaviors, water infrastructure, and other measures of urban form
3. Interdisciplinary Modeling and Visualization
   - Development of interdisciplinary models of socio-eco-hydrological systems to determine how changes in water availability and use alter water quantity and quality


iUtah Field Sites
Little Bear River
Red Butte Creek
Provo River
Utah Field Station Network
Agency Data
USGS NWIS
NRCS SNOTEL
Utah DWQ
Etc.
National Science Data Networks
CUAHSI HIS
DataONE
iUTAH Modeling and Data Federation
HPC@USU
Primary data organization and storage
Data sharing, publication, and archival
Data integration and synthesis
Integrated modeling and CI Support
HPC support
Primary Data Storage
USU
Research@UEN Network
UWyoming (EPSCoR CI Track 2) and National HPC Centers
Redundant data storage
HPC support
Modeling and simulation
Collaboration technologies
Backup Data Storage
HPC Storage
UU
UU Center for High Performance Computing
Research@UEN Network
UEN Network
UEN Network
Fulton Supercomputing Lab
BYU
UVU
Intermountain Network Node
UEN and K-12 Sites

iUTAH MDF – Information Flow



- Field sites and other data (e.g., agencies)
- iUTAH Modeling and Data Federation
- Modeling, visualization, and analysis

iUTAH MDF Focus Areas

1. Data management support for data from iUTAH facilities
   - GAMUT – Gradients Along Mountain to Urban Transitions
   - GIRF – Green Infrastructure Research Facility
2. Support for data discovery and access
   - iUTAH facility and investigator data
   - Agency data
   - National data networks
3. Support for integrated modeling
4. Data/model/resource sharing and collaboration

How can we create a hardware platform that supports the diverse cyberinfrastructure needs of iUTAH?

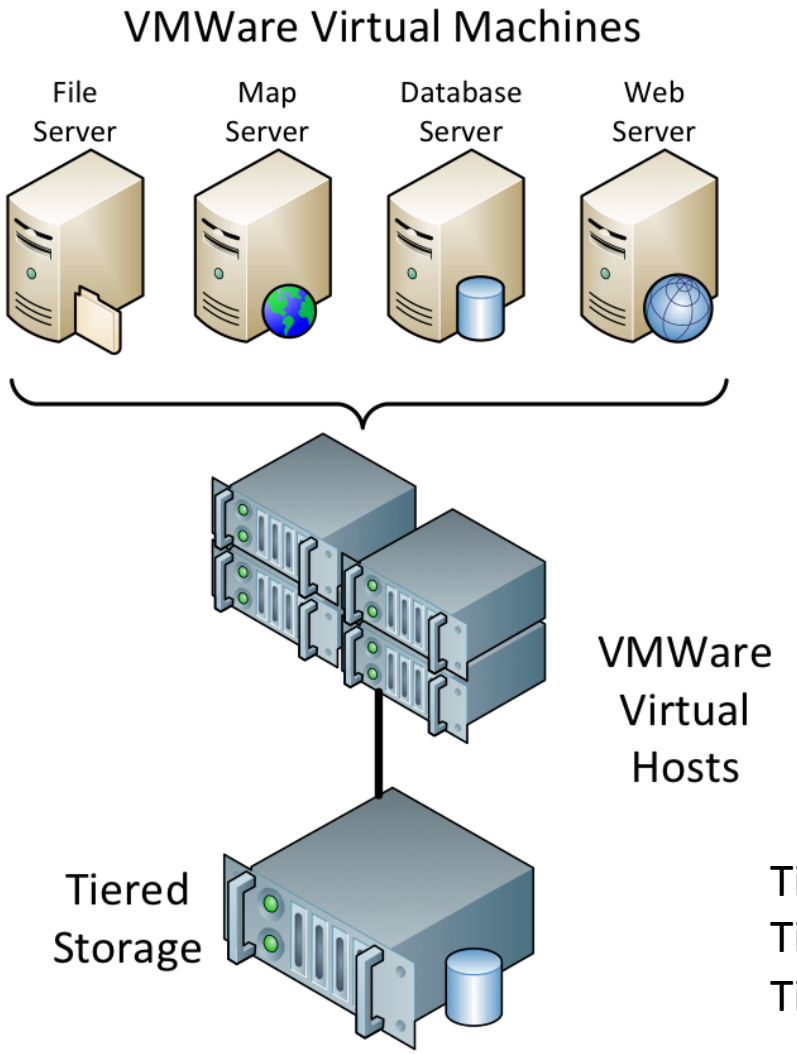
iUTAH CI Development Approach

- Where possible, leverage and adopt existing cyberinfrastructure components
- Collaborate with other CI development activities to get needed functionality
- Develop pieces that we need

Required Functionality

- Research platform
  - Development, prototyping, and testing of servers, software applications, and services on multiple platforms (e.g., Windows, Linux)
  - Host machines allocated for modeling, analysis, and computational tasks
- Production data service and application hosting platform
  - Web servers
    - Data web services
    - Web applications
  - Database servers
  - Map servers
  - File servers
  - Data harvesters and automated data processing applications

Hardware



Required servers and software stacks implemented on virtual machines

Many virtual machines can be hosted on a single virtual host server

Tiered storage
Tier 1 and 2: Databases and operating systems
Tier 3: Lower demand file storage and access

Hardware Capabilities

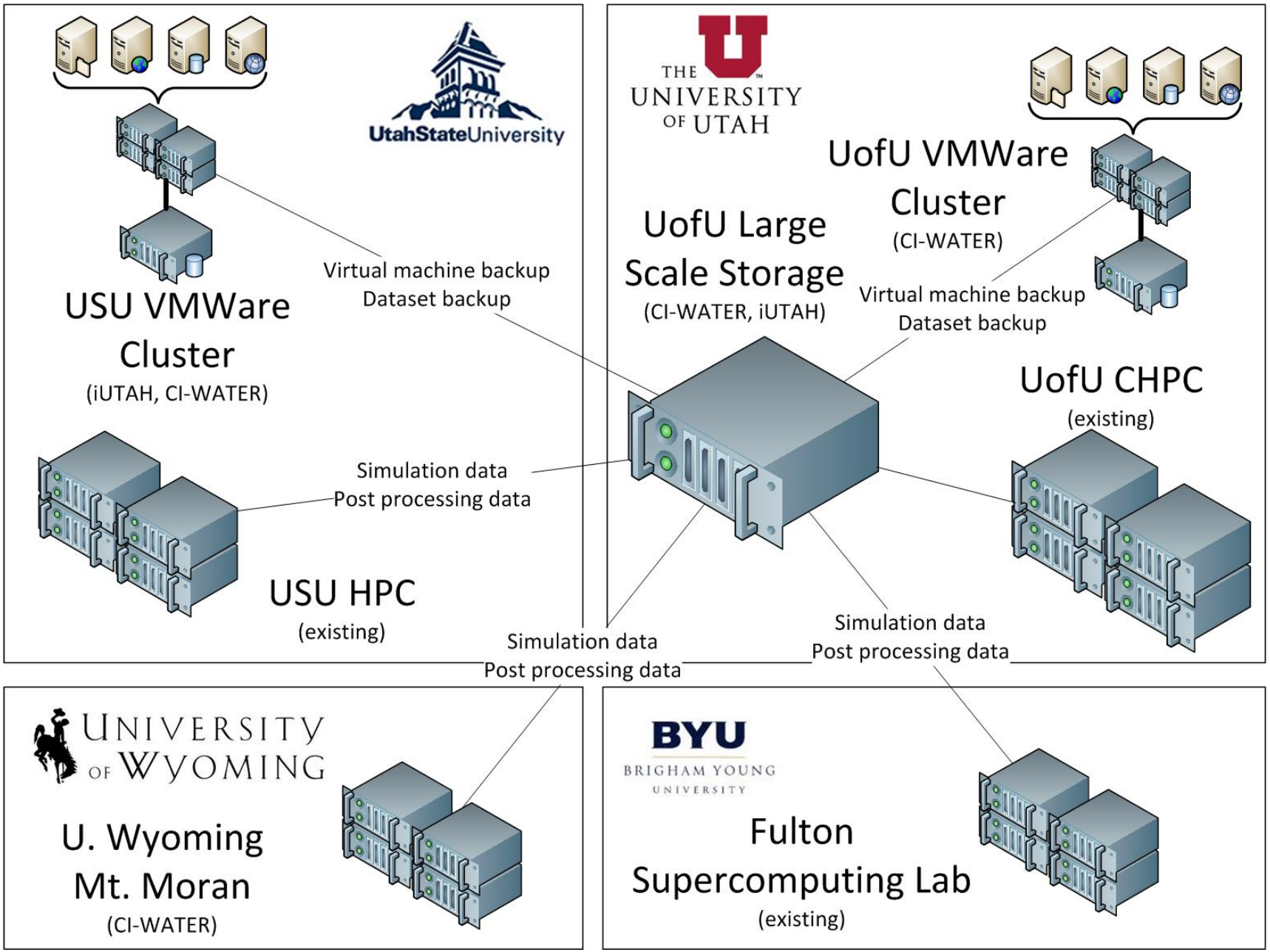
- Quickly spin up virtual machines that implement different operating systems and platforms (e.g., Windows, Linux)
- Use shared computational and storage resources rather than requiring a physical machine for each purpose
- Create and manage both development and production servers using shared hardware
- Hot-swap virtual machines across physical host machines using virtualization software
  - Ensure failover for production virtual servers
  - Efficiently allocate resources to multiple machines

Initial Specifications

- 3 virtual host servers using shared storage arrays
  - Dual 8 core processors
  - 128 GB RAM
- 7.2 TB high performance shared storage array
  - Virtual machine operating systems
  - Relational databases
- 72 TB high capacity shared storage array
  - File storage
  - Archival
- Integrated with USU Central IT VMWare infrastructure and enterprise data center

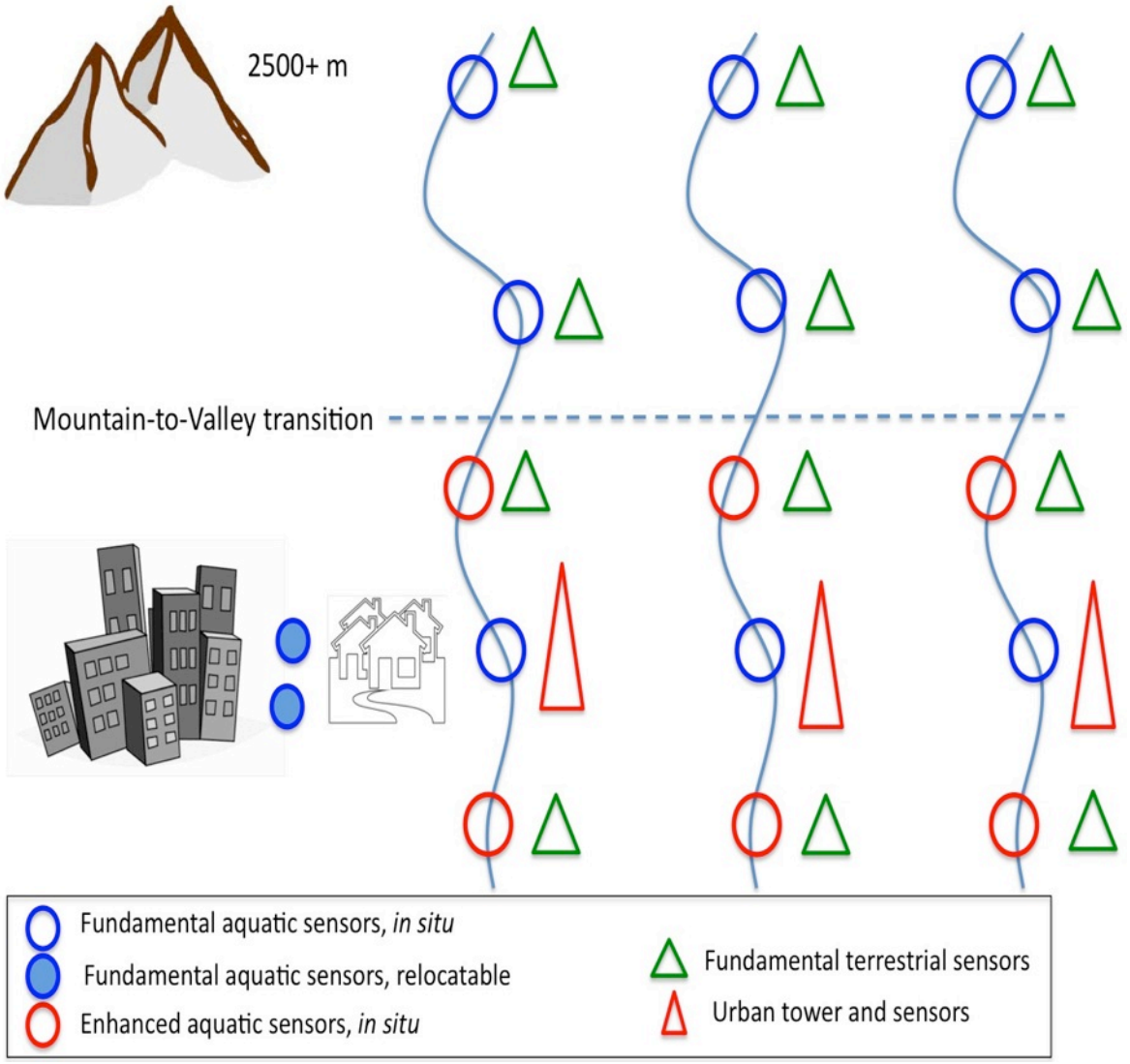
Available storage will be expanded in subsequent years

The Larger Utah EPSCoR Cyberinfrastructure Picture



What is the design of a cyberinfrastructure that enables standardized data collection and management for a network of aquatic and terrestrial monitoring sites managed by a consortium of disparate organizations?

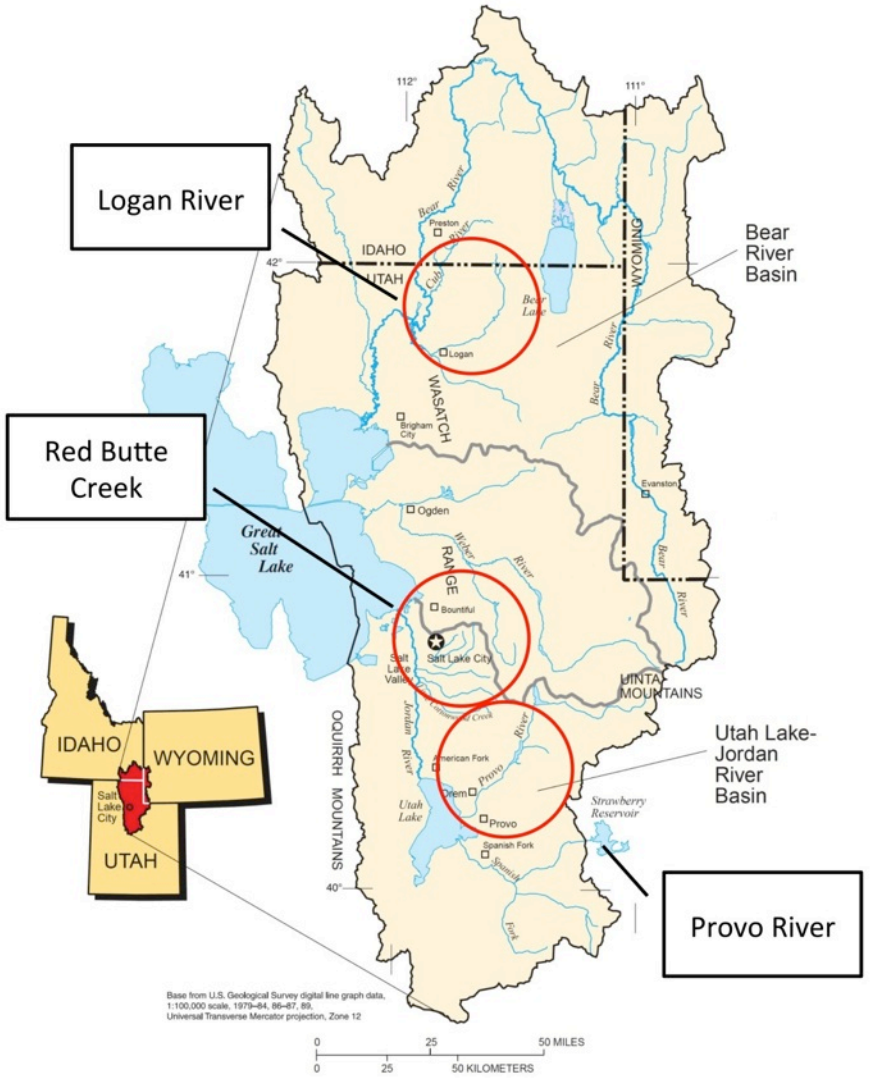
Gradients Along Mountain to Urban Transitions (GAMUT) Network



- Sensor network developed between USU/UofU/BYU
- Mix of aquatic and terrestrial *in situ* and re-locatable sensors
- Measure aspects of water inputs and outputs and water quality over gradient
- Deployed in three watersheds

EPSCoR iUTAH

Gradients Along Mountain to Urban Transitions (GAMUT) Network



- 3 watersheds have similar water source (high elevation snow) but different land use transitions
- Logan River: irrigated agriculture transitioning to moderate density urban at moderate pace
- Red Butte Creek: highly urbanized
- Provo River: irrigated agriculture transitioning to low density urban at rapid pace

Gradients Along Mountain to Urban Transitions (GAMUT) Network

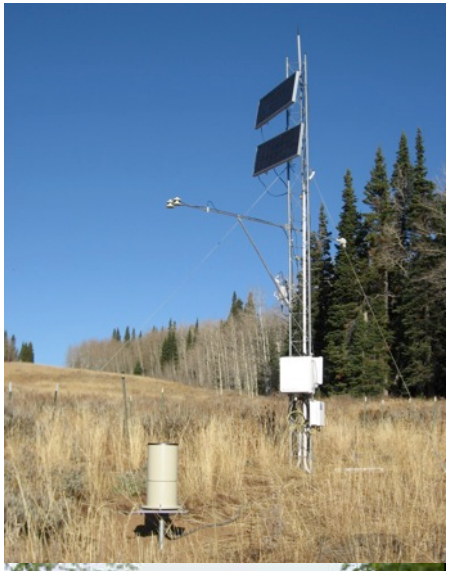


Table 1. Parameters to be measured by the iUTAH Climate and Ecohydrology Sensor Network.

	Fundamental Suite	**Enhanced/Urban Suite**
Terrestrial Sensors	Barometric pressure Wind speed and direction Air temperature Relative humidity Precipitation Snow depth Soil temperature, moisture, conductivity Solar radiation (net radiation and PAR)	Barometric pressure Wind speed and direction Air temperature Relative humidity Precipitation Snow depth Soil temperature, moisture, conductivity Solar radiation (net radiation and PAR)
Aquatic Sensors	Stream stage Temperature Electrical Conductivity pH Dissolved oxygen Turbidity	Stream stage Temperature Electrical Conductivity pH Dissolved oxygen Turbidity Total algae (chlorophyll a + phycocyanin) fDOM Nitrate

Challenges to Managing Sensor Data

- Volume of data
- Data heterogeneity
- Multiple watersheds
- Multiple institutions
- Scale
- Synchronize timing, data access, equipment tracking
- Standardize data QA/QC

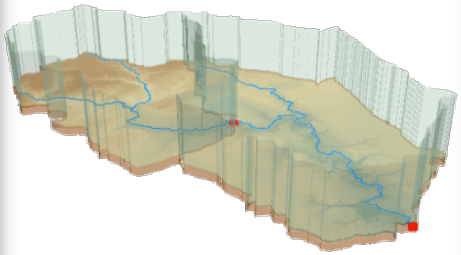
Rainfall and Meteorology

Water quantity

Soil water

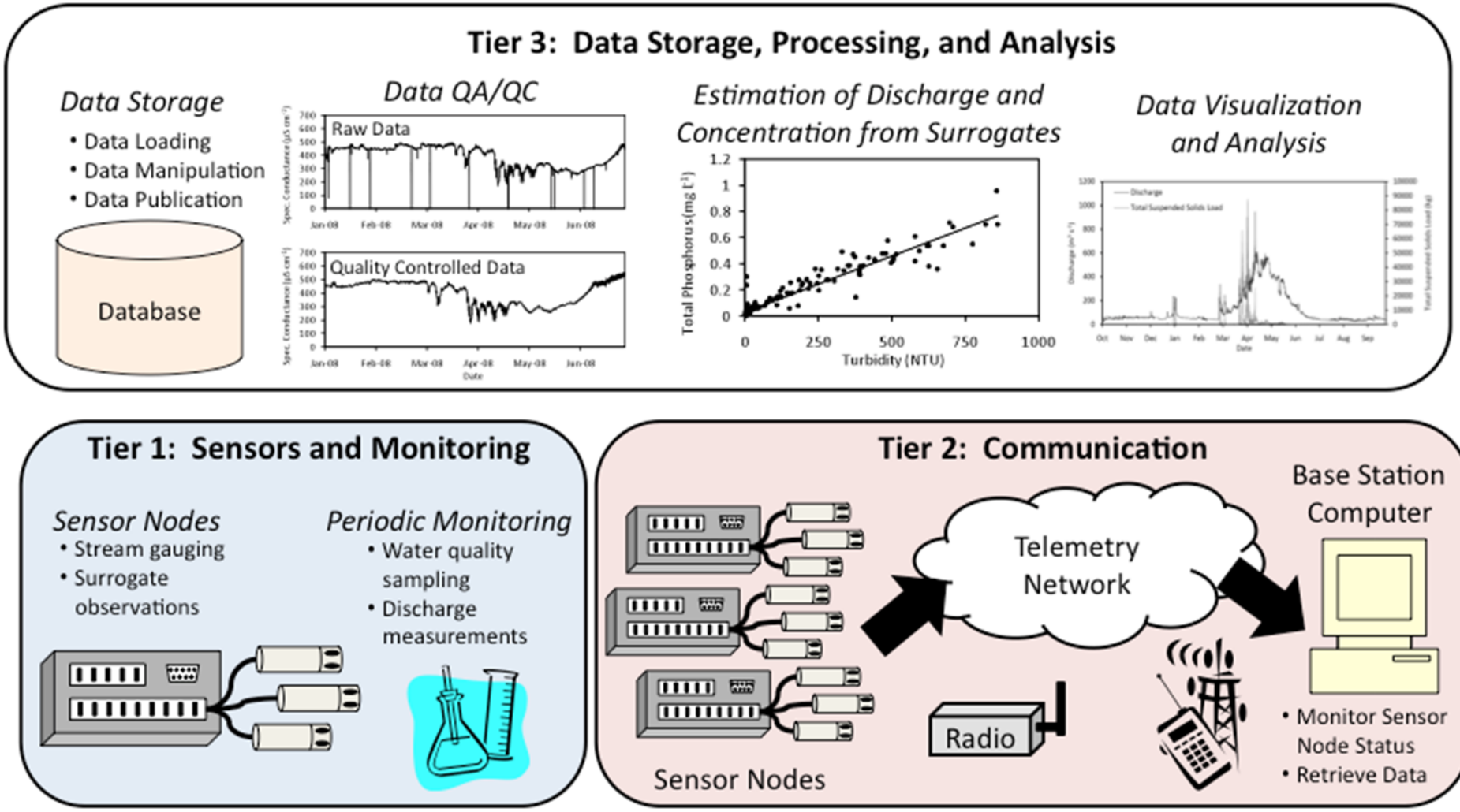
Water quality

GIS



Groundwater

Cyberinfrastructure

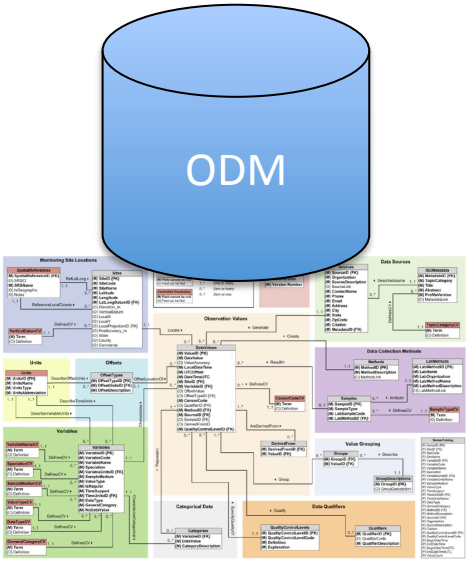


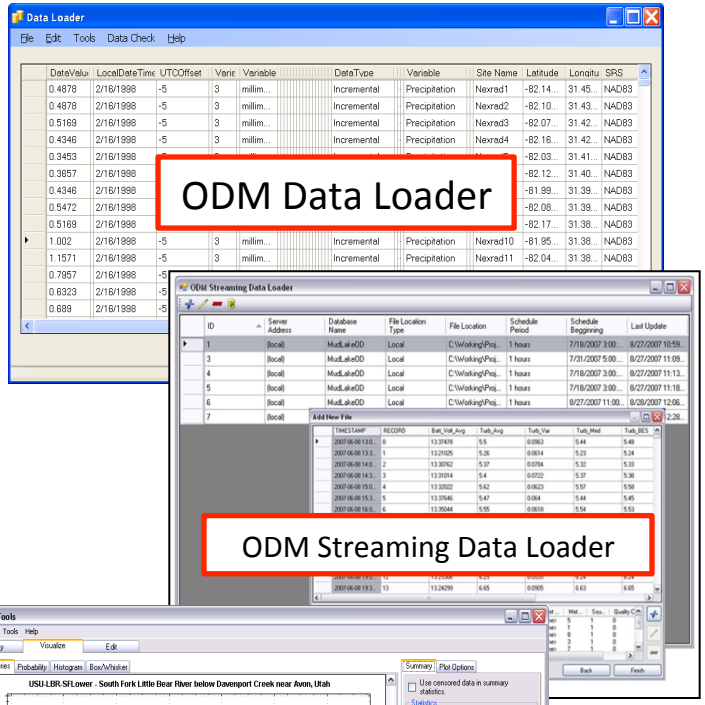
Horsburgh, J. S., A. Spackman Jones, D. G. Tarboton, D. K. Stevens, and N. O. Mesner (2010), A sensor network for high frequency estimation of water quality constituent fluxes using surrogates, *Environmental Modelling & Software*, 25, 1031-1044, doi:10.1016/j.envsoft.2009.10.012.

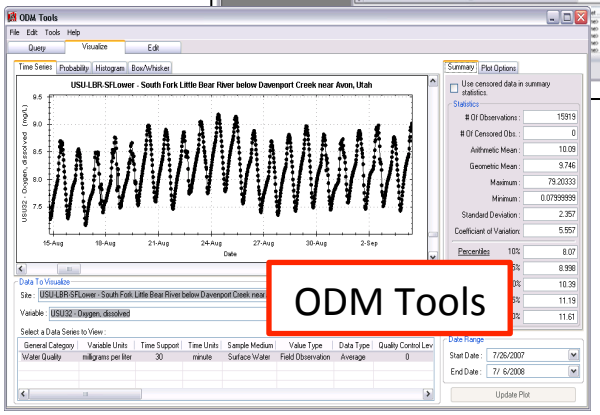
HydroServer

CUAHSI Open Source Hydrologic Data Tools

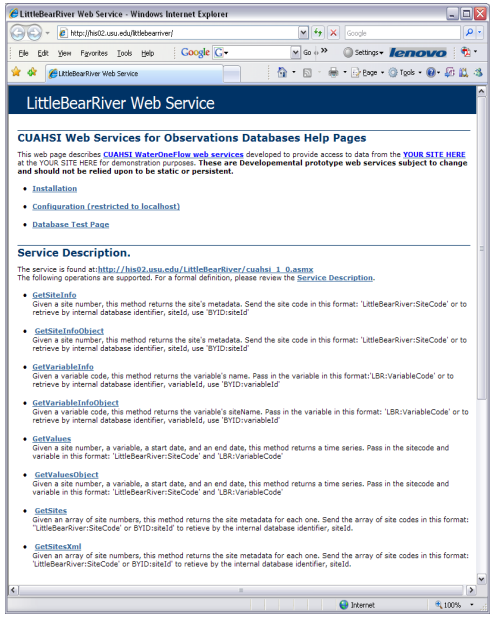
Observations Data Model







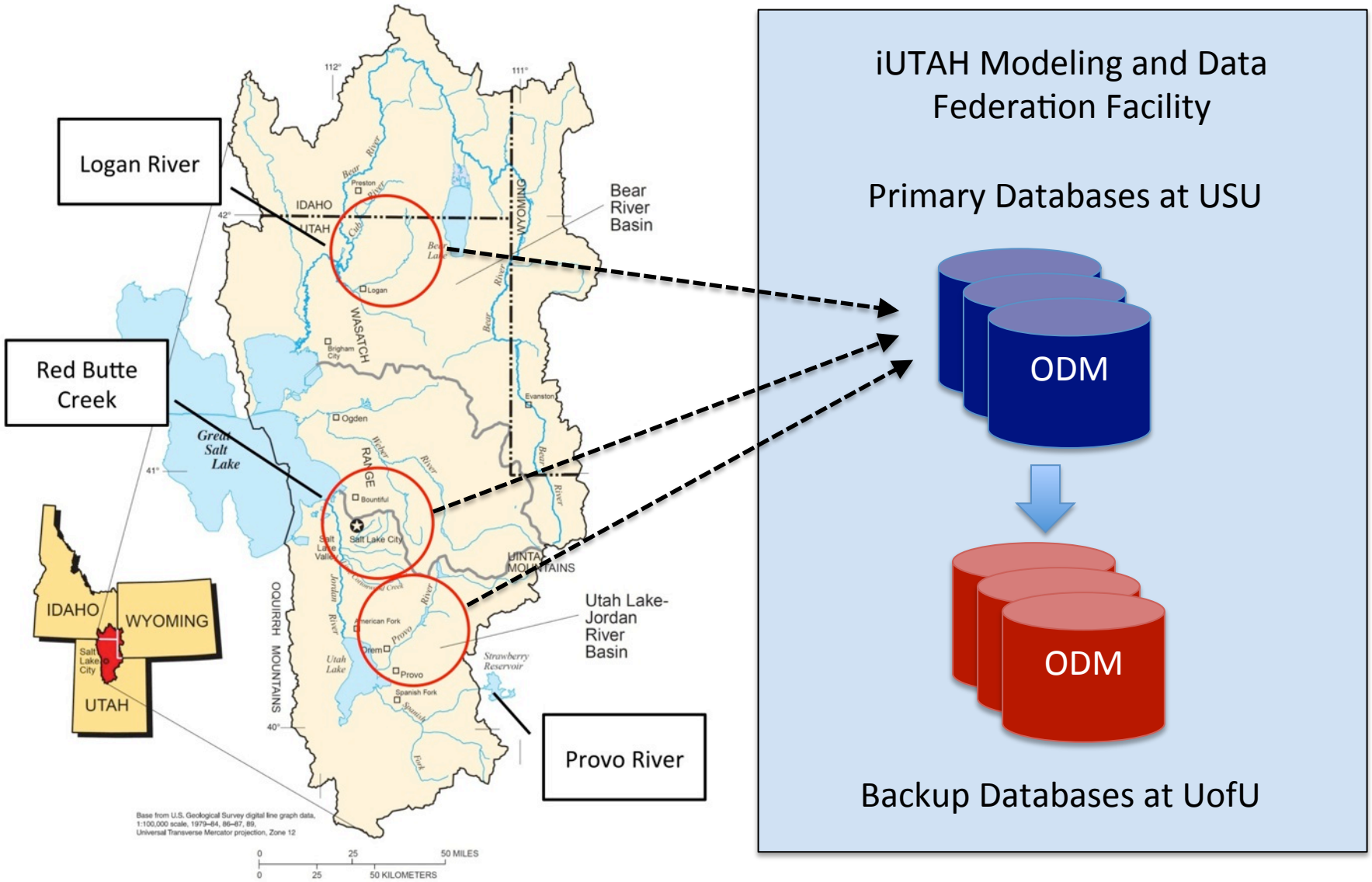
WaterOneFlow and WaterML



CUAHSI HIS

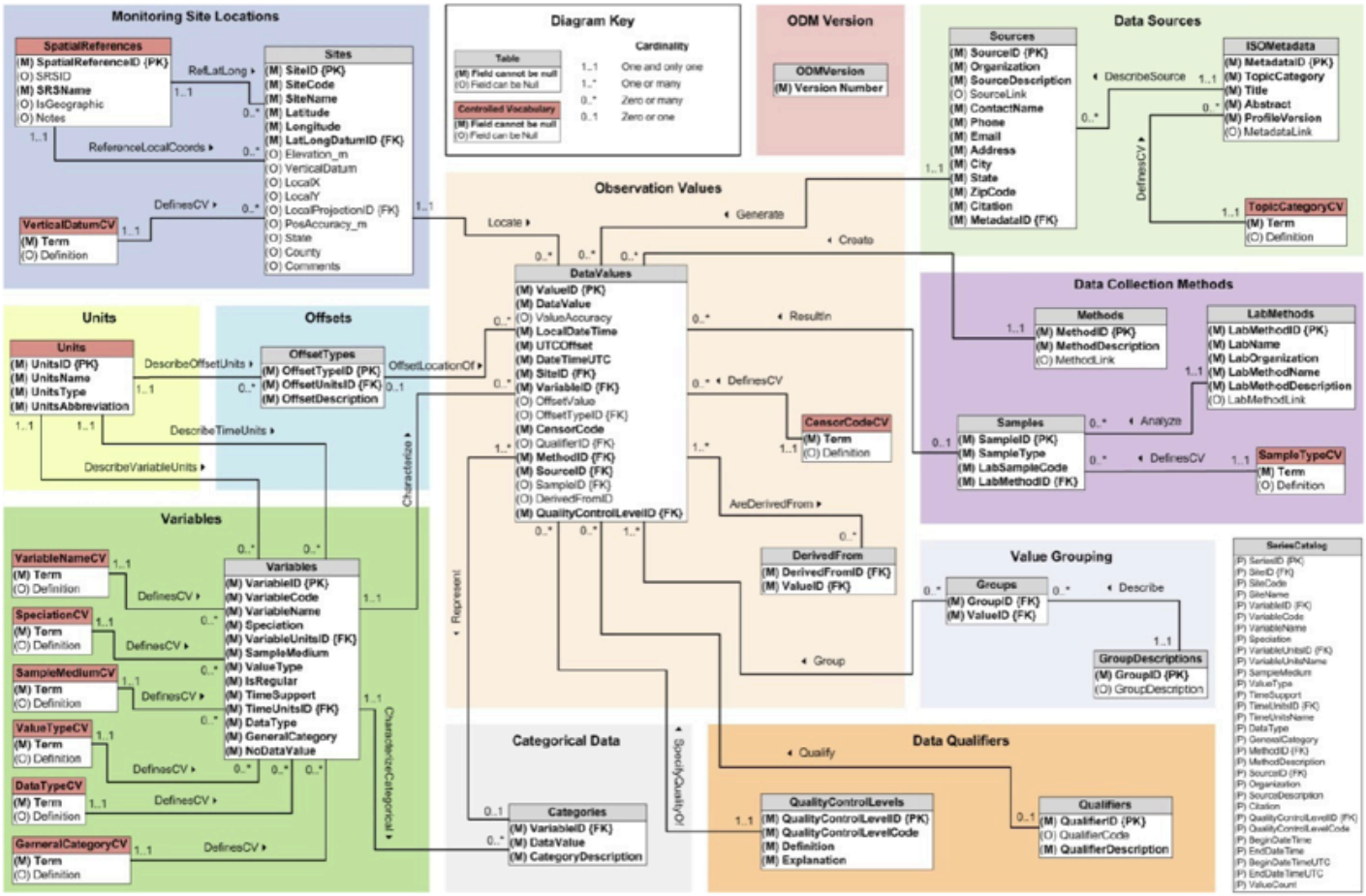
Sharing hydrologic data

Data Loading and Storage



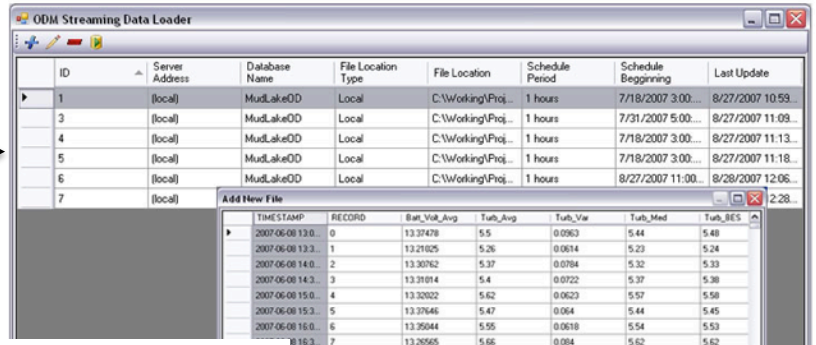
Data Loading and Storage

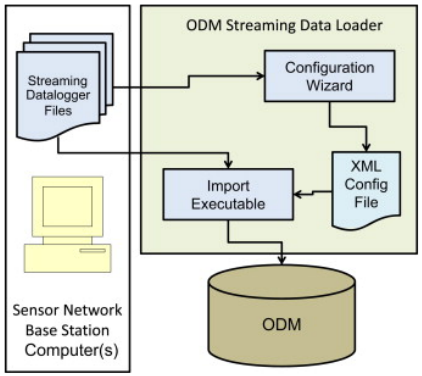
- Observations Data Model (ODM): relational database at the single observation level
- Metadata for unambiguous interpretation
- Traceable heritage from raw measurements to usable information
- Promote syntactic and semantic consistency
- Cross dimension retrieval and analysis

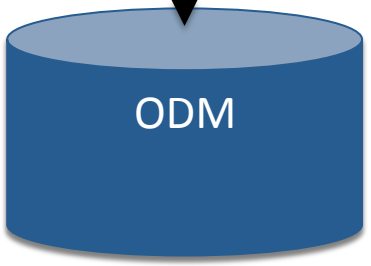


Horsburgh, J. S., D. G. Tarboton, D. R. Maidment, and I. Zaslavsky (2008), A relational model for environmental and water resources data, *Water Resources Research*, 44, W05406, doi:10.1029/2007WR006392.

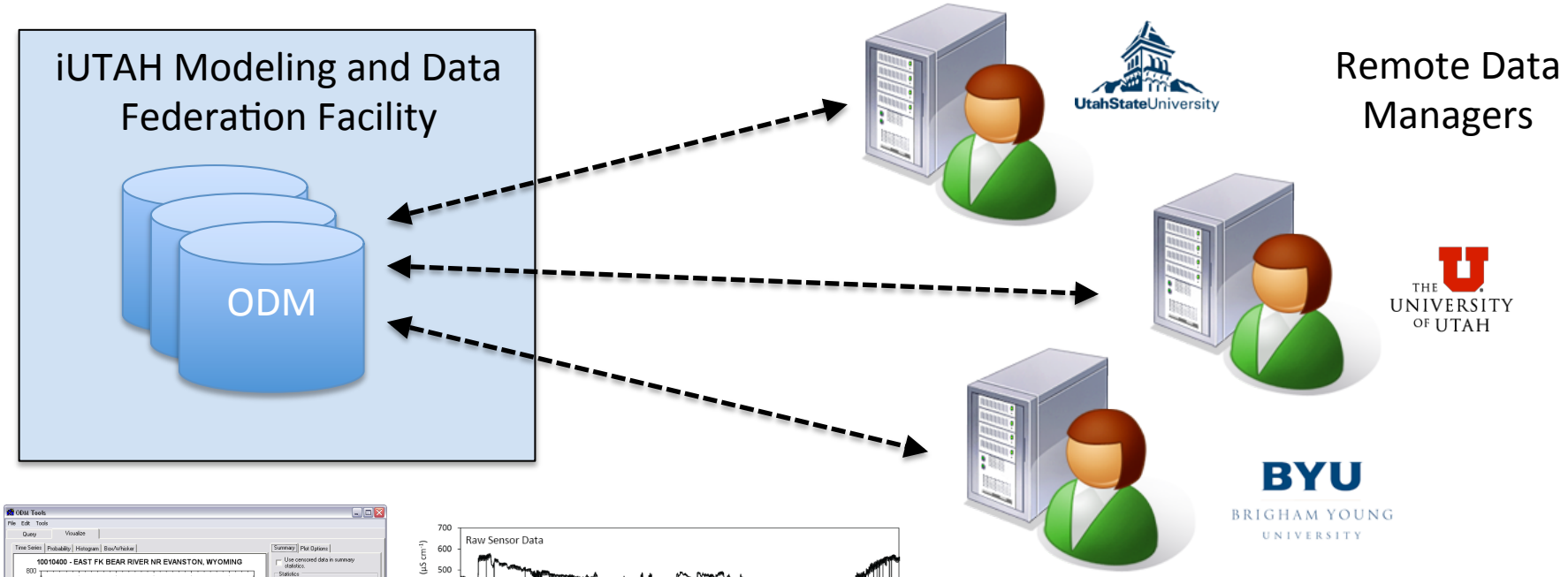
Loading Data Streams

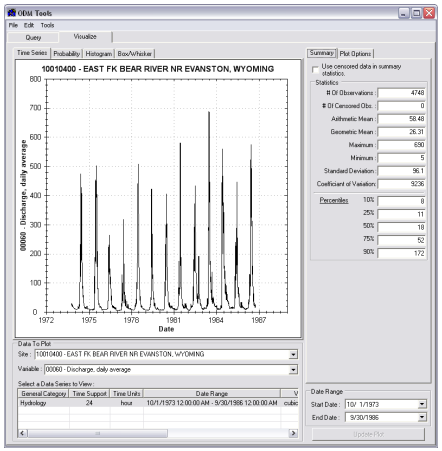


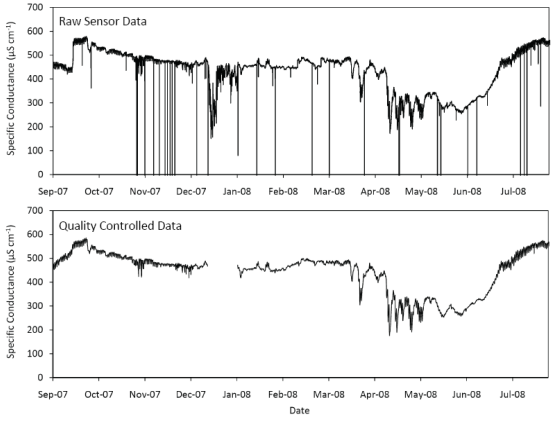




Data Visualization and Management

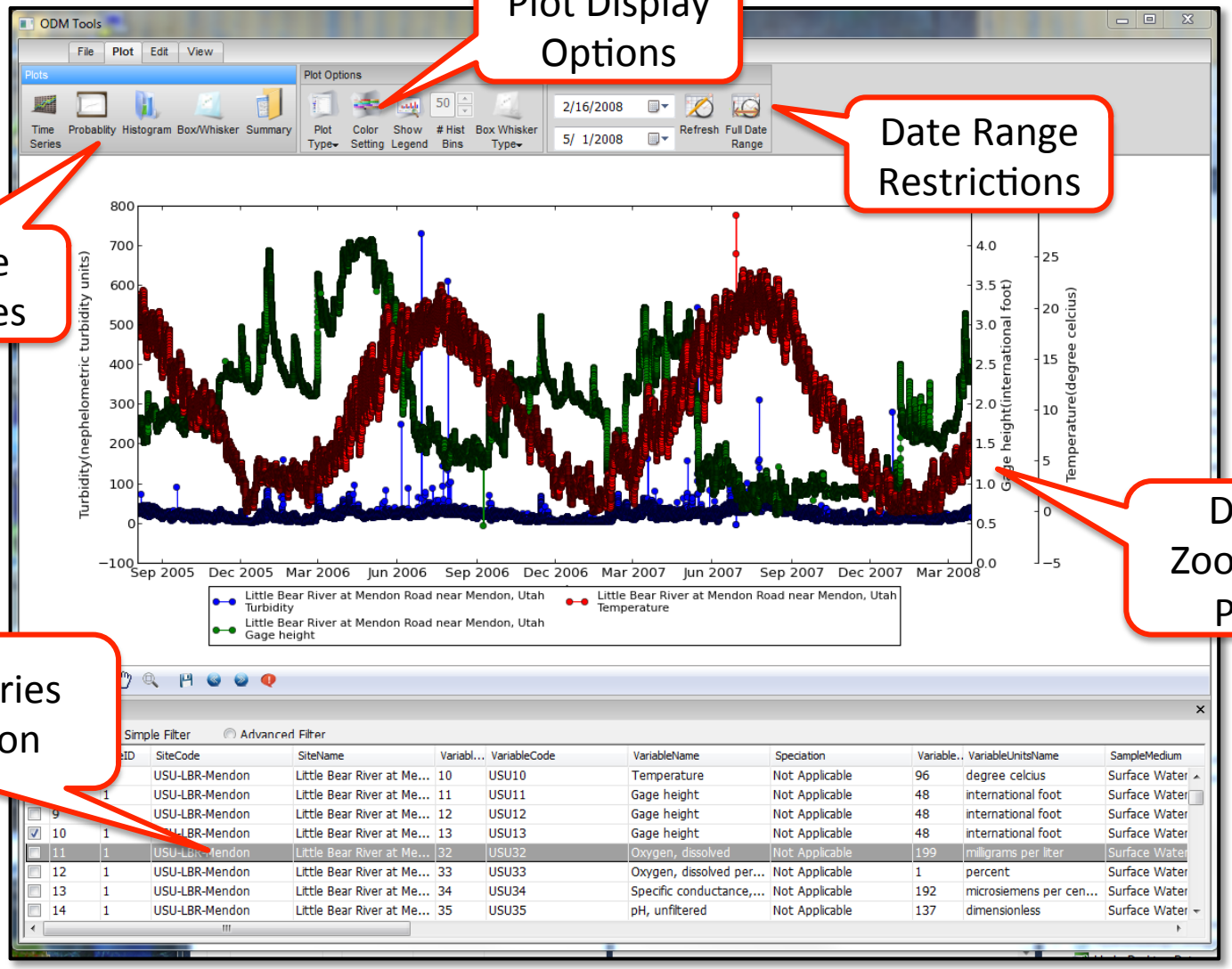






ODM Tools

ODM Tools Python
Data Visualization and Management



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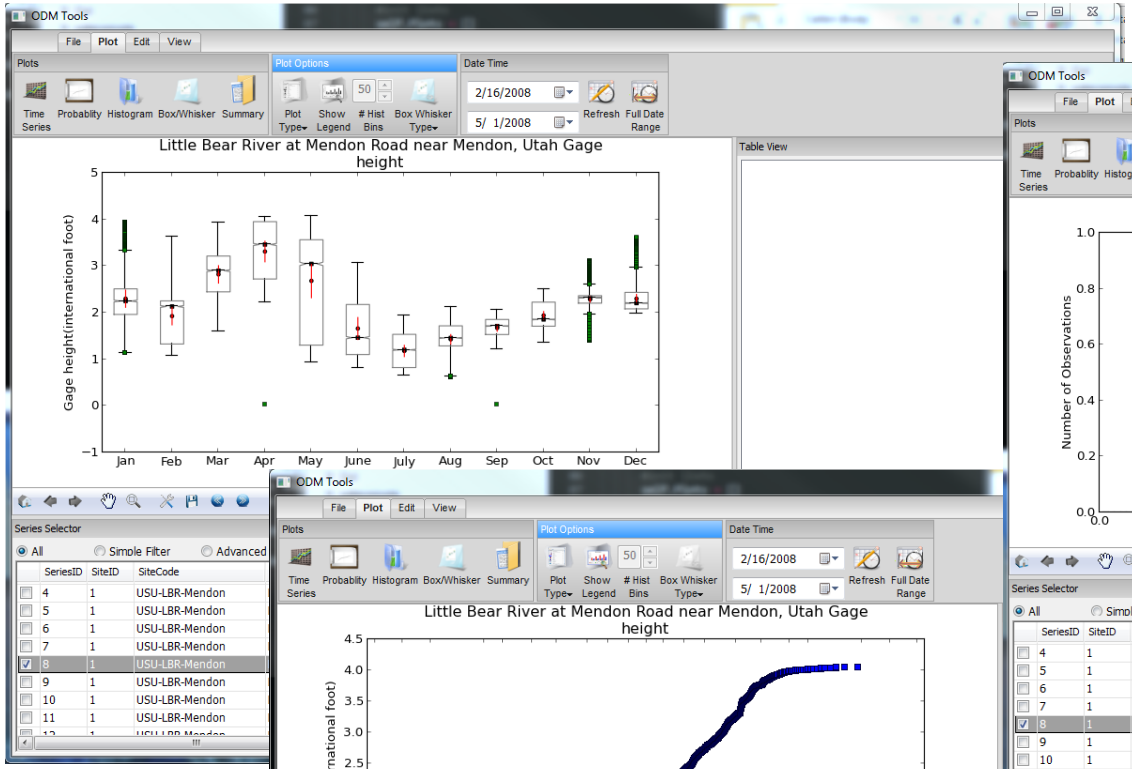
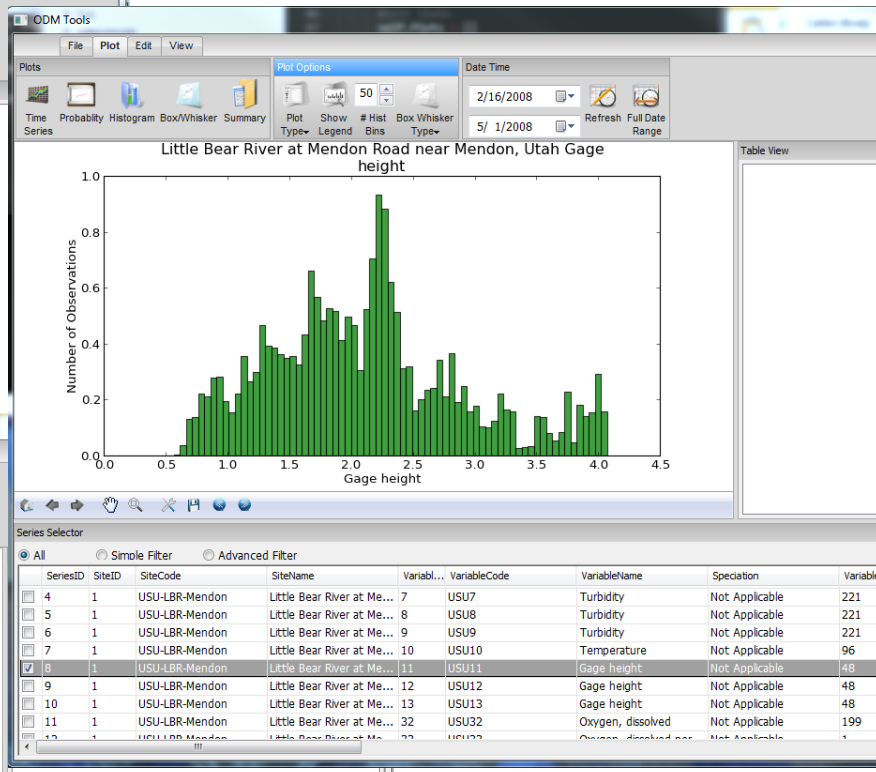
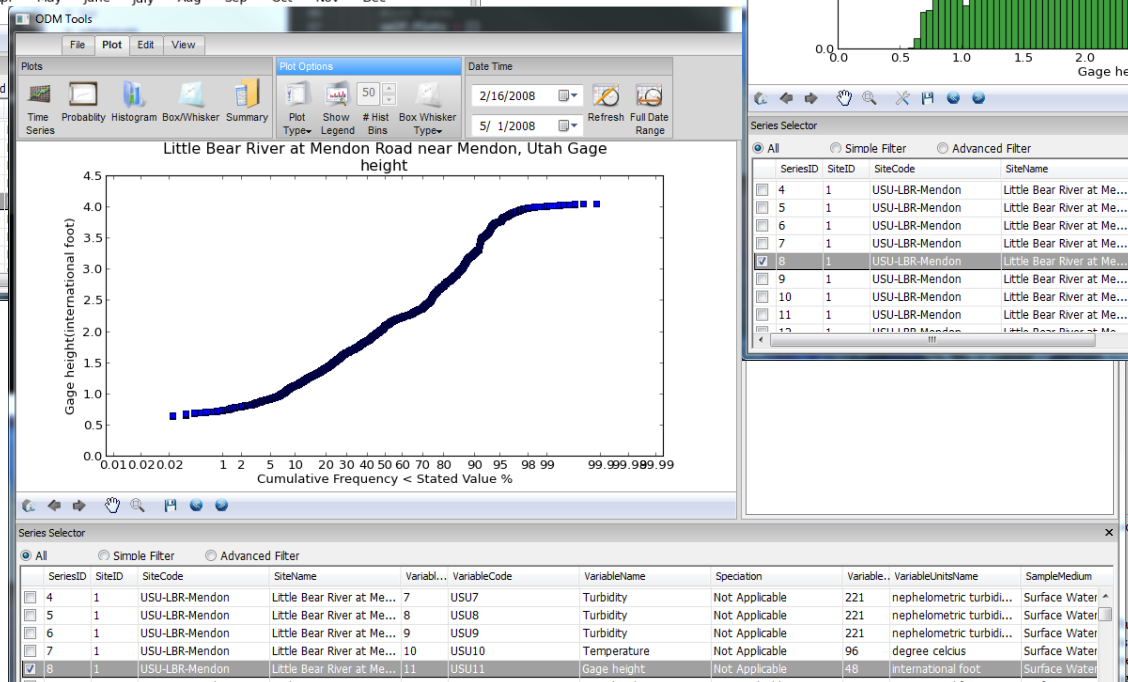
1	USU-LBR-Mendon	Little Bear River at Me...	11	USU11	Gage height	Not Applicable	48	international foot	Surface Water
9	USU-LBR-Mendon	Little Bear River at Me...	12	USU12	Gage height	Not Applicable	48	international foot	Surface Water
10	1	USU-LBR-Mendon	Little Bear River at Me...	13	USU13	Gage height	Not Applicable	48	international foot	Surface Water
11	1	USU-LBR-Mendon	Little Bear River at Me...	32	USU32	Oxygen, dissolved	Not Applicable	199	milligrams per liter	Surface Water
12	1	USU-LBR-Mendon	Little Bear River at Me...	33	USU33	Oxygen, dissolved per...	Not Applicable	1	percent	Surface Water
13	1	USU-LBR-Mendon	Little Bear River at Me...	34	USU34	Specific conductance,...	Not Applicable	192	microsiemens per cen...	Surface Water
14	1	USU-LBR-Mendon	Little Bear River at Me...	35	USU35	pH, unfiltered	Not Applicable	137	dimensionless	Surface Water

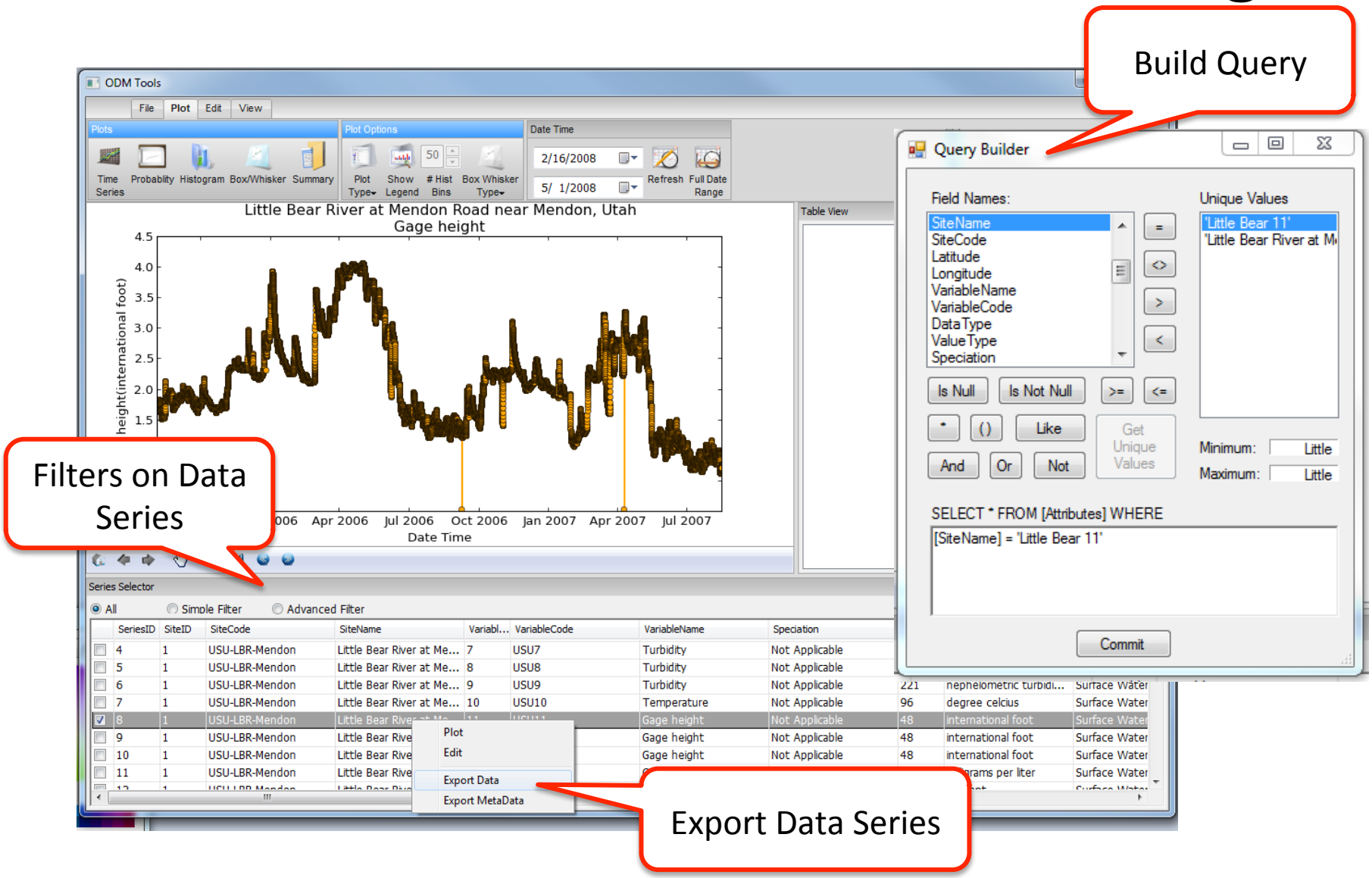
ODM Tools Python
Multiple Plot Types







ODM Tools Python
Time Series Selection and Filtering



ODM Tools Python Dockable Windows

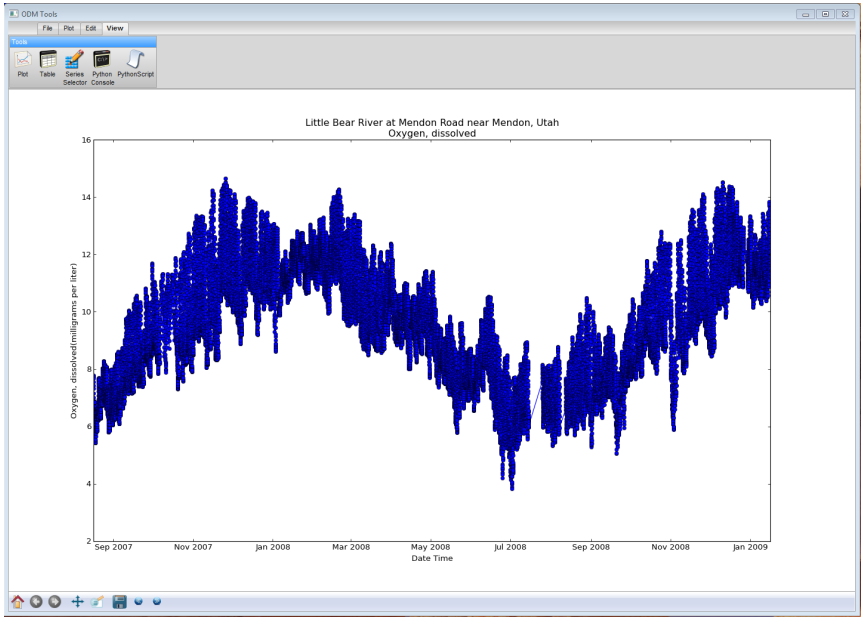


Table View

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8628198	4.28373167164		2008-07-01 05:30:00	-7.0	2008-07-01 12:30:00	1	32		
8630093	4.78889435821		2008-07-02 10:00:00	-7.0	2008-07-02 17:00:00	1	32		
8630222	4.37667031343		2008-07-02 04:30:00	-7.0	2008-07-02 11:30:00	1	32		
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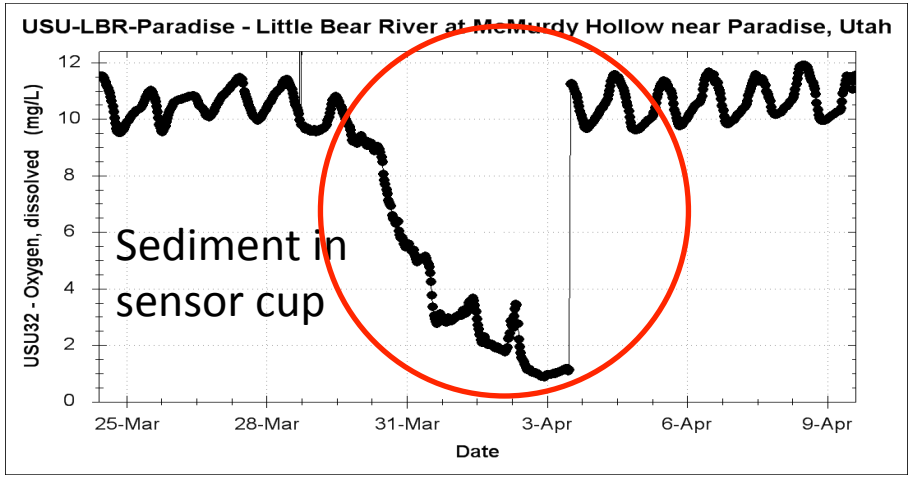
8634276	4.48706534328		2008-06-25 05:00:00	-7.0	2008-06-25 12:00:00	1	32		

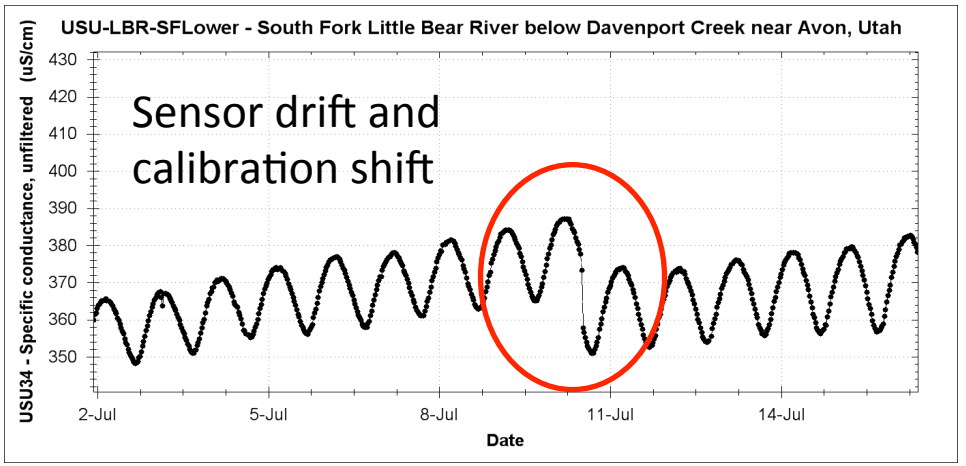
Series Selector

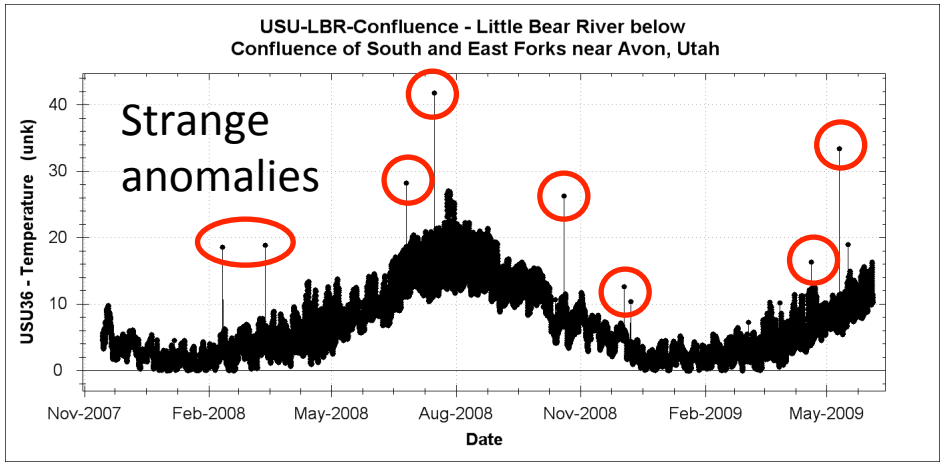
All Simple Filter Advanced Filter

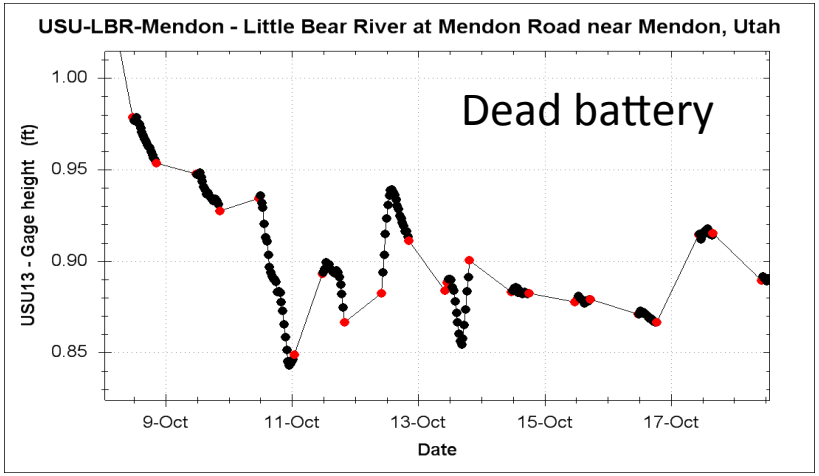
SeriesID	SiteID	SiteCode	SiteName	Variabl...	VariableCode	VariableName	Speciation	Variab
12	1	USU-LBR-Mendon	Little Bear River at Me...	13	USU13	Gage height	Not Applicable	48
13	1	USU-LBR-Mendon	Little Bear River at Me...	13	USU13	Gage height	Not Applicable	48
14	1	USU-LBR-Mendon	Little Bear River at Me...	13	USU13	Gage height	Not Applicable	48
15	1	USU-LBR-Mendon	Little Bear River at Me...	32	USU32	Oxygen, dissolved	Not Applicable	19
16	1	USU-LBR-Mendon	Little Bear River at Me...	32	USU32	Oxygen, dissolved	Not Applicable	19
17	1	USU-LBR-Mendon	Little Bear River at Me...	33	USU33	Oxygen, dissolved per...	Not Applicable	1
18	1	USU-LBR-Mendon	Little Bear River at Me...	34	USU34	Specific conductance	Not Applicable	19

Sensor Data Quality Control

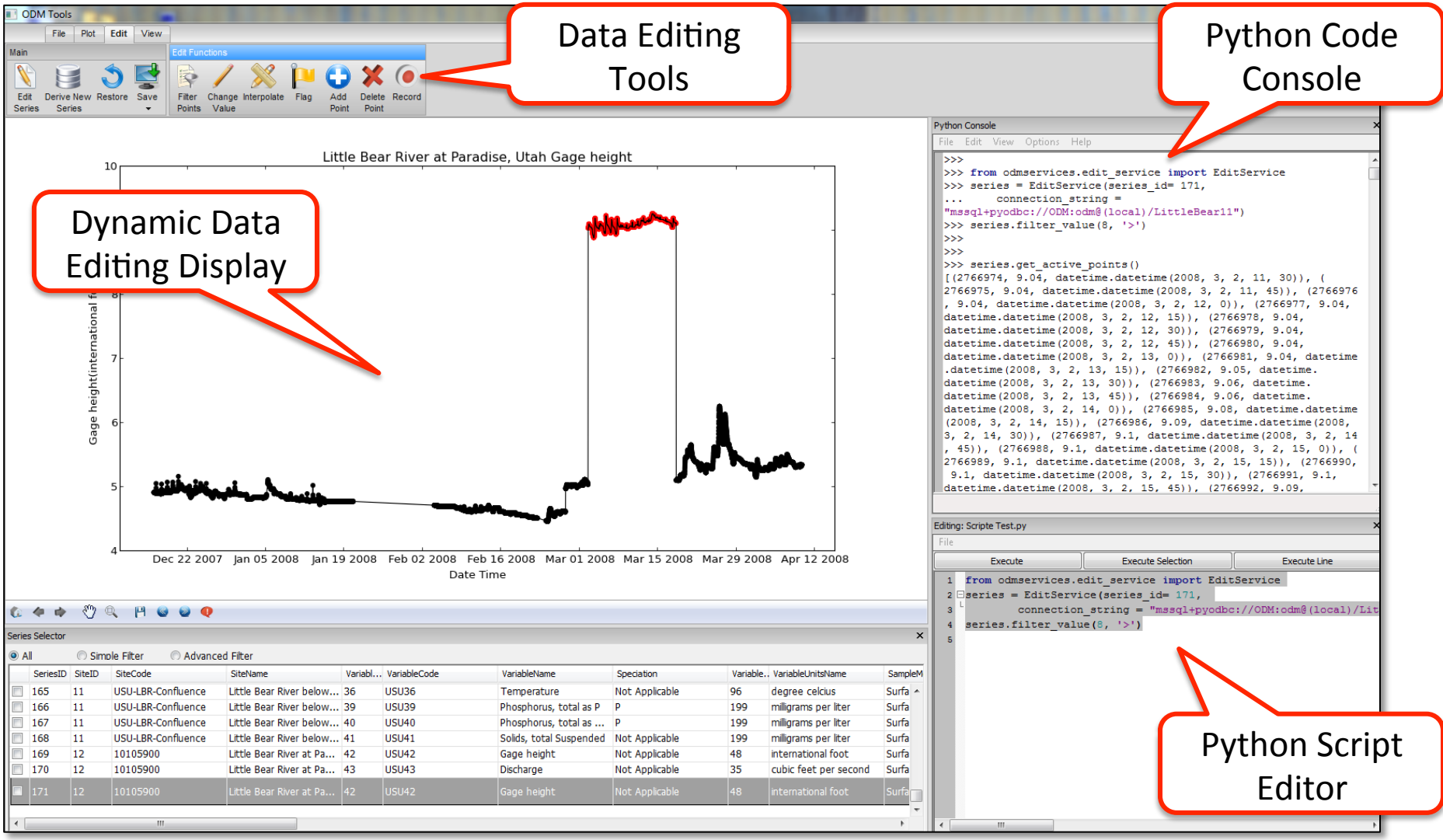




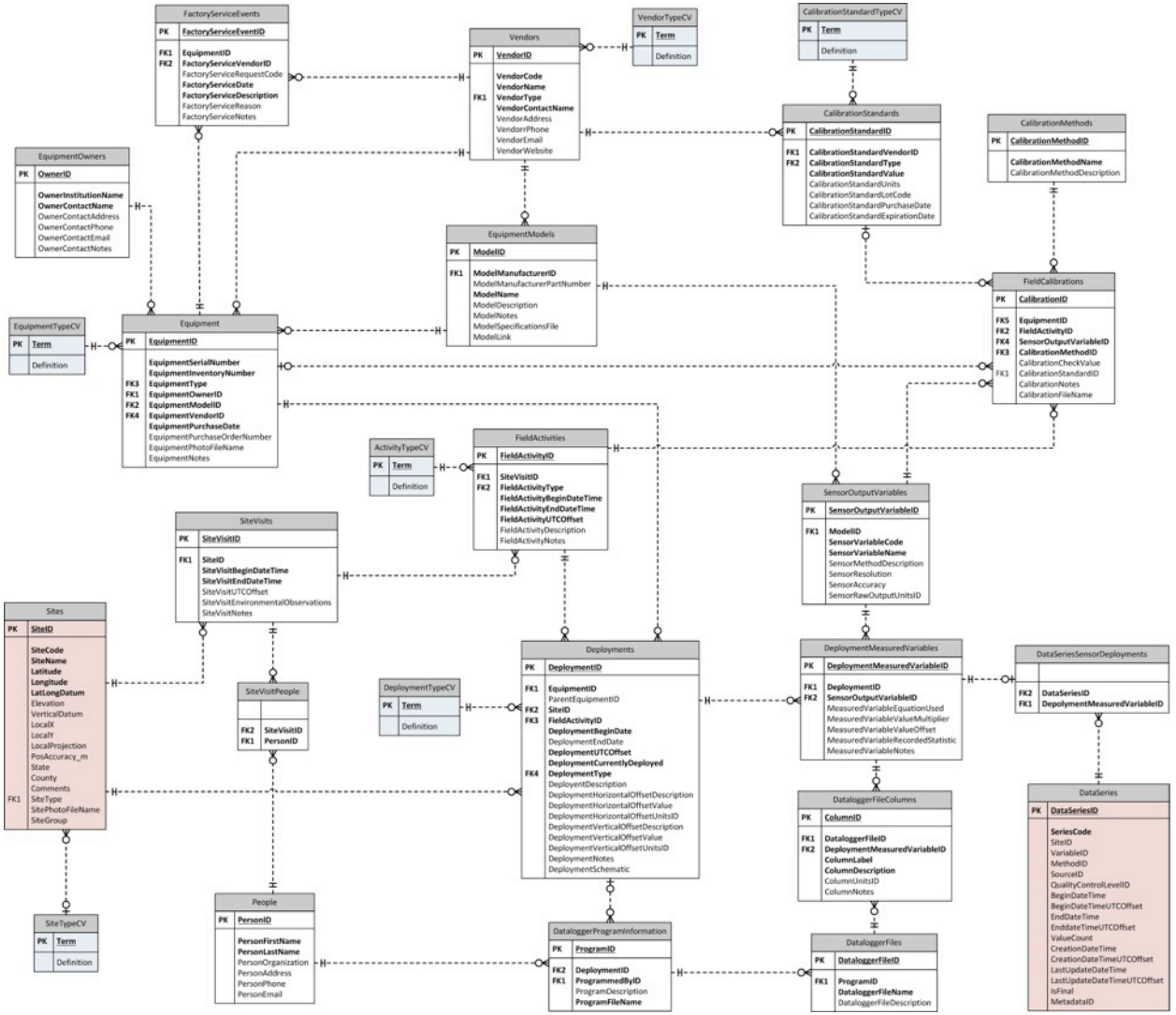




ODM Tools Python
Sensor Data Quality Control



Equipment Management



- Track physical infrastructure: sensors, data loggers, batteries, etc.
- Track events: deployments, calibrations, site visits, factory servicings, etc.
- Connects to ODM where streaming data is stored
- Web interface

Equipment Details | View full equipment details

Edit Description | Delete

Equipment Description

Equipment ID: 99999999999
Serial Number: 9999999999
Model Name: DTS-12
Description: Forest Technology Systems DTS-12 Digital Turbidity Sensor
Purchase Date: 1/20/2013
Notes: Measures water turbidity and water temperature.
Link: http://www.ftsenvironmental.com/products/sensors/dts12/
Owner Institution: Utah State University
Owner Contact: Michelle Baker
Owner Address: 5305 Old Main Hill, Logan, UT 84322-5305
Owner Phone: 1.435.797.7131
Email: michelle.baker@usu.edu

Manufacturer

Vendor Name: Forest Technology Systems
Contact Name: Someguy Thatworksthere
Address: 1123 Fir Avenue, Suite C., Blaine, WA, 98230**Phone:** 1.800.548.4264
Email: sales@ftshydrology.com
Web Address: http://www.ftsenvironmental.com/

Vendor

Vendor Name: Forest Technology Systems
Contact Name: Someguy Thatworksthere
Address: 1123 Fir Avenue, Suite C., Blaine, WA, 98230
Phone: 1.800.548.4264
Email: sales@ftshydrology.com
Web Address: http://www.ftsenvironmental.com/

View Deployment History | View Factory Service History | View Calibration History

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Any opinions, findings, conclusions, or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the NSF.

Site Visit Details | View full site visit details

Edit Description | Delete | View Full Site Visit History for this Site

Site Visit Location

Site Code: USU-LR-UWRL
Site Name: Logan River at the Utah Water Research Laboratory
Latitude: 43
Longitude: -111
Elevation: 4355 m

Site Visit Description

Crew: Jeff Horsburgh, Amber Jones
Begin Date Time: 2/22/2013 1:00 PM MST
End Date Time: 2/22/2013 2:00 PM MST
Environmental Observations: The weather was sunny. The river was low. Water was clear.
Site Visit Notes: None.

Field Activities Performed (click the activity type to view details)

Activity Type	Begin Date/Time	End Date/Time	Description	Notes
Calibration	2/22/2013 1:00 PM MST	2/22/2013 1:10 PM MST	Sensor Calibration	None
Deployment	2/22/2013 1:30 PM MST	2/22/2013 2:00 PM MST	Sensor Deployment	None

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Calendar | Click on activities to view details

◄ ► February ▼ 2013 ▼

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
			Logan River Site1			
	Red Butte Creek Site3	Logan River Site2	Red Butte Creek Site1			
			Provo River Site1	Logan River Site3		
	Red Butte Creek Site2		Provo River Site1			

Display: ☑ Site Visits ☐ Factory Service Events

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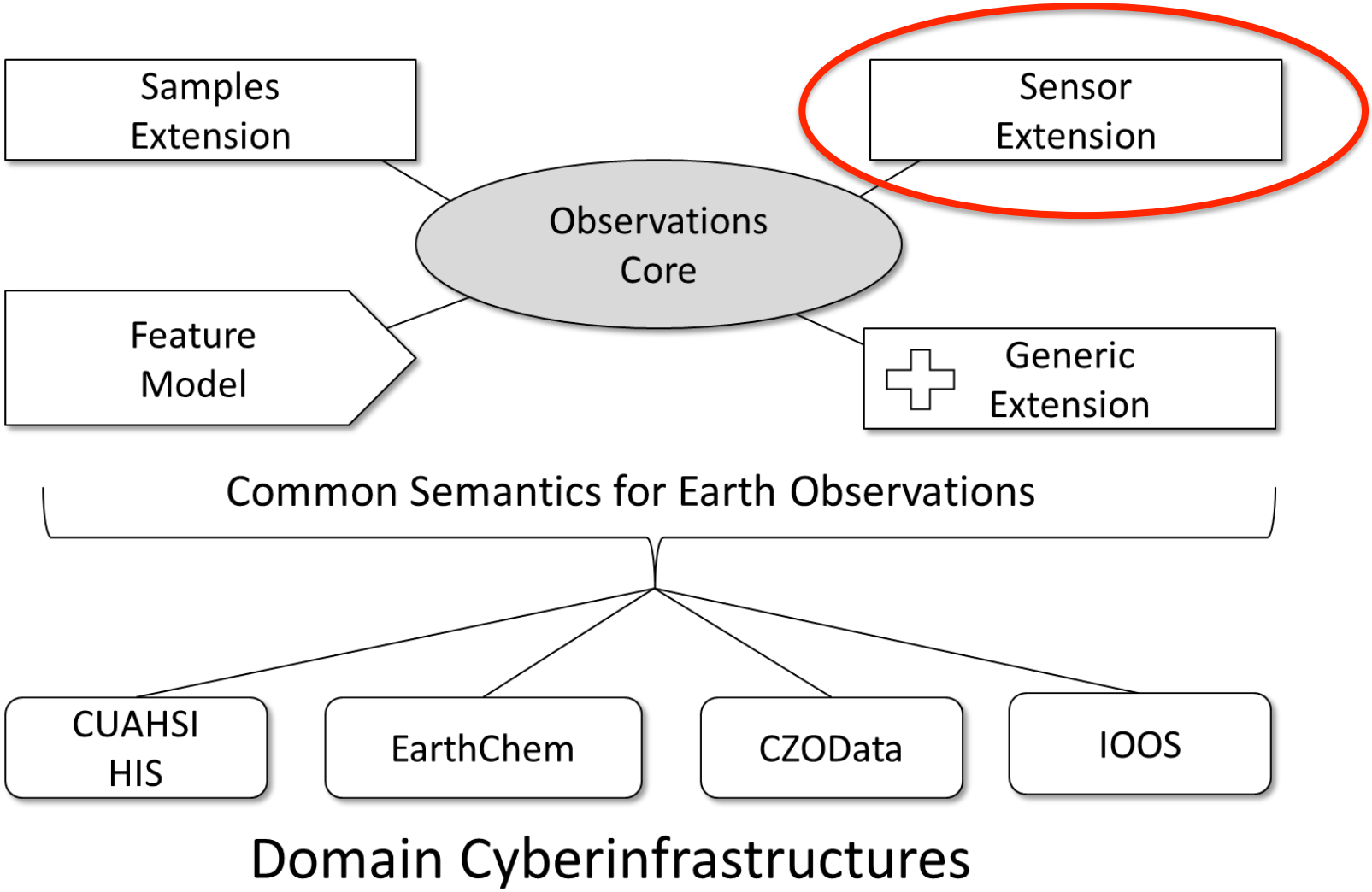
ODM2


Samples Extension
Sensor Extension
Observations Core
Feature Model
Generic Extension
Common Semantics for Earth Observations
CUAHSI HIS
EarthChem
CZOData
IOOS
Domain Cyberinfrastructures

How can we enable and increase collaborative research and sharing of data and models through the innovative use of cyberinfrastructure?

iUTAH Modeling and Data Federation

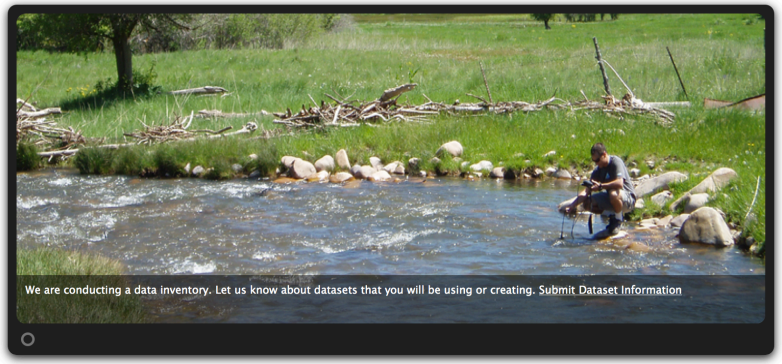
data.iutahepscor.org

iUTAH EPSCoR

Modeling and Data Federation

innovative Urban Transitions and Aridregion Hydro-sustainability

Home | Development | Group Discussions | Inventories | Contact Us | About Us



The iUTAH Modeling and Data Federation is an online system for sharing data, models, and other digital resources. Activities of the iUTAH Cyberinfrastructure Team (CI Team) are focused on developing hardware and software systems and tools that improve iUTAH participants' capacity for data collection, organization, management, sharing, synthesis to higher-level products, and integration with models.

Announcements

Data Inventory: As an initial step in developing the iUTAH Modeling and Data Federation, we are conducting a survey of existing and planned datasets.
Click here to submit dataset information to the iUTAH data inventory or view the list of datasets that have been submitted.

Model Inventory: We are collecting information about models from a variety of disciplines that may be of interest to your iUTAH-related research.
Click here to submit model information to the iUTAH data inventory or view the list of models that have been submitted.

iUTAH Homepage	Data Inventory	About
Utah EPSCoR	Model Inventory	Hardware Development
CI-WATER EPSCoR	Year 1 Scope of Work	Software Development

UTAH EPSCoR

This project is funded through EPS - 1208732. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

NSF

iUTAH EPSCoR

Modeling and Data Federation

innovative Urban Transitions and Aridregion Hydro-sustainability

Home | Development | Group Discussions | Inventories | Contact Us | About Us

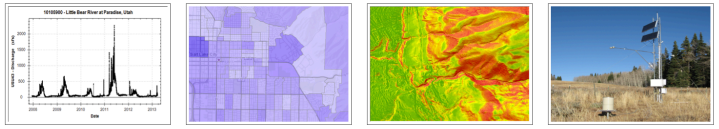
Software Development

UTAH Modeling and Data Federation

The beginnings of the iUTAH Modeling and Data Federation have been implemented at http://data.iutahepscor.org. This website will continue to be fleshed out as we develop new functionality of the next couple of years.

Data and Model Inventories

The iUTAH research teams will be developing new datasets and models to support iUTAH's research goals. However, there will also be extensive reuse of existing data resources and models from many different sources. The CI Team is developing tools that will help facilitate the process of identifying existing datasets and models that may be useful to the iUTAH efforts. For example, we are compiling a database of metadata describing existing and planned data resources. iUTAH participants can access an online metadata submission form via http://data.iutahepscor.org to submit metadata describing datasets that they know about. Users can also view details of datasets that have been submitted by others. The database of metadata that we compile will enable us to both prioritize efforts for providing access to specific datasets through the iUTAH Modeling and Data Federation and will serve as an initial corpus of data that we can use to develop data discovery and access services needed by iUTAH partners.

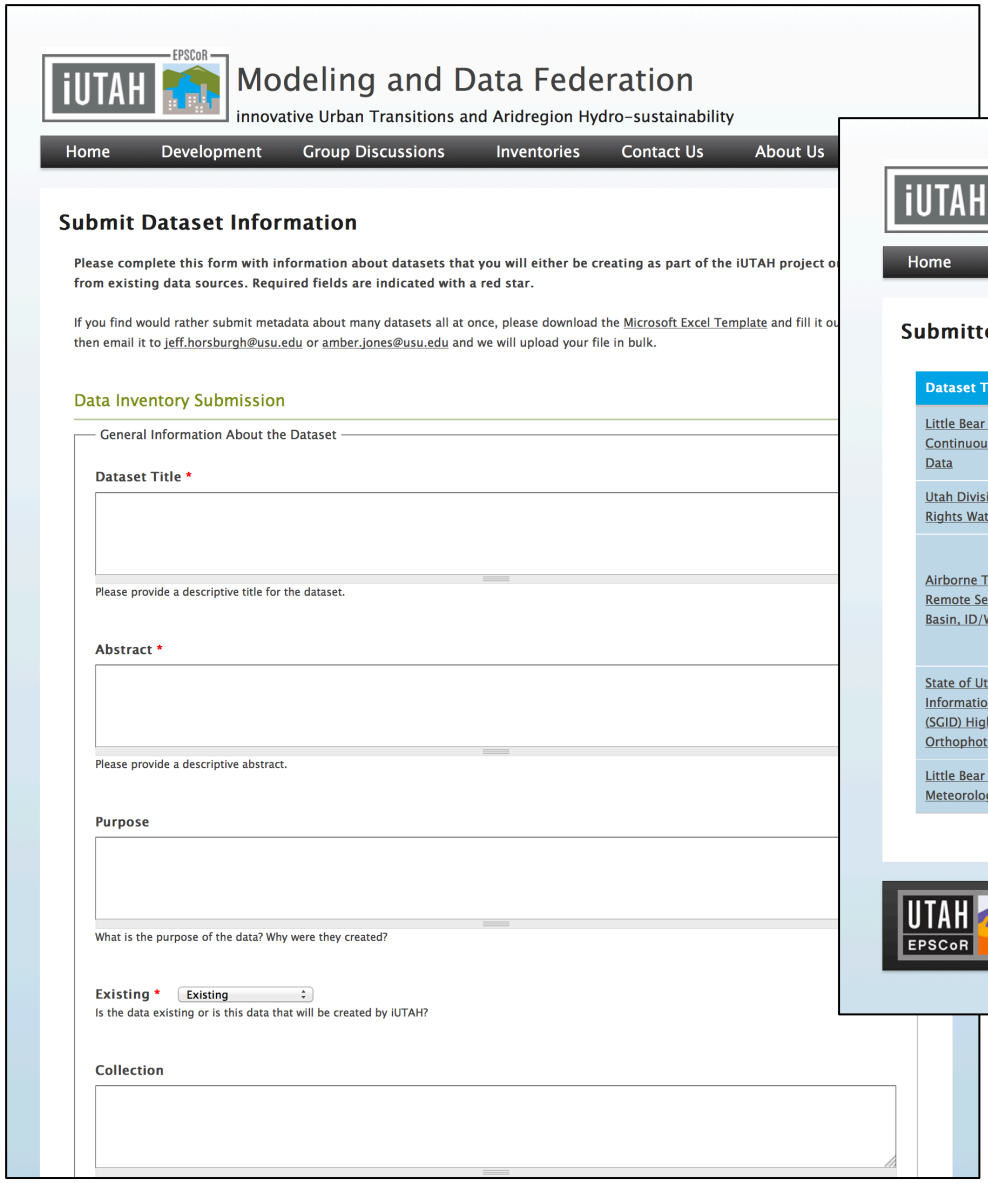


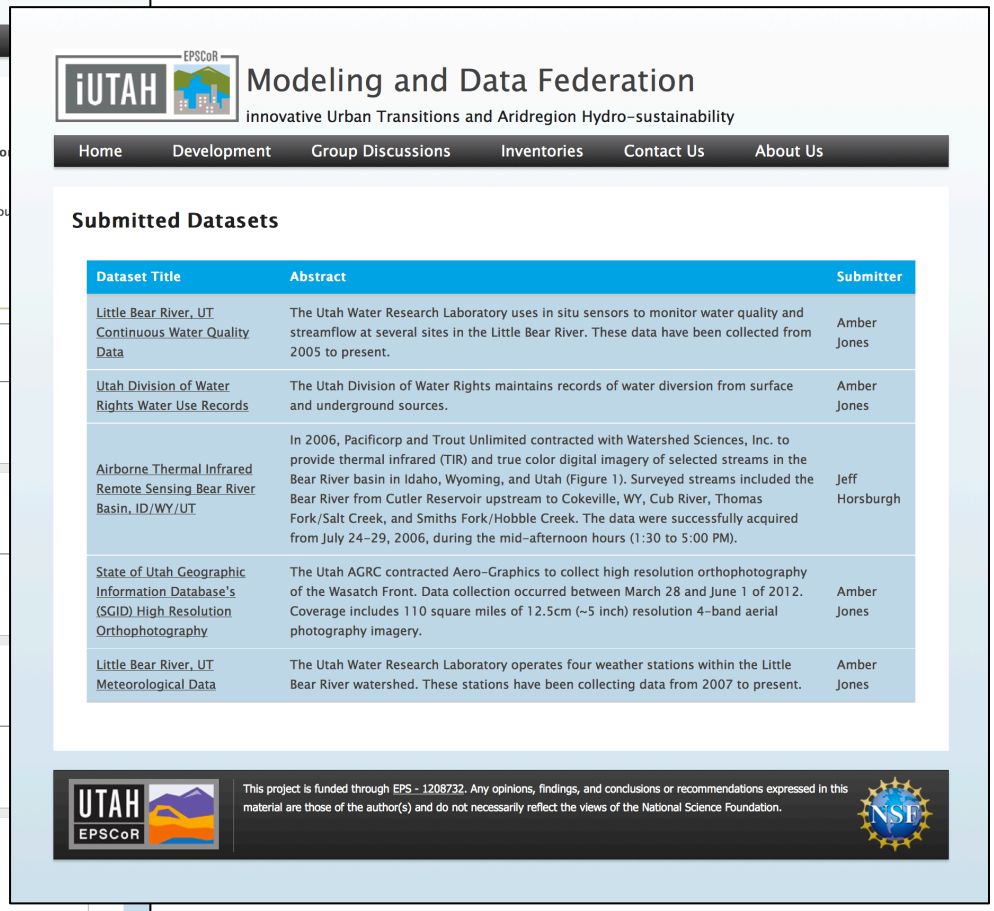
Sensor Data Management

One of the immediate goals of the iUTAH CI team is to support management of the streaming sensor data from the iUTAH aquatic and terrestrial monitoring sites that will be installed as the GAMUT network is built. The CI Team is assisting in the planning for telemetry connections to each of the iUTAH monitoring sites as well as implementing tools that will facilitate the automated loading of the streaming sensor data into relational databases where they can be more easily managed by the iUTAH watershed technicians and ultimately and shared on the Internet. Much of the required sensor data management functionality is being implemented using existing tools from the CUAHSI Hydrologic Information System.

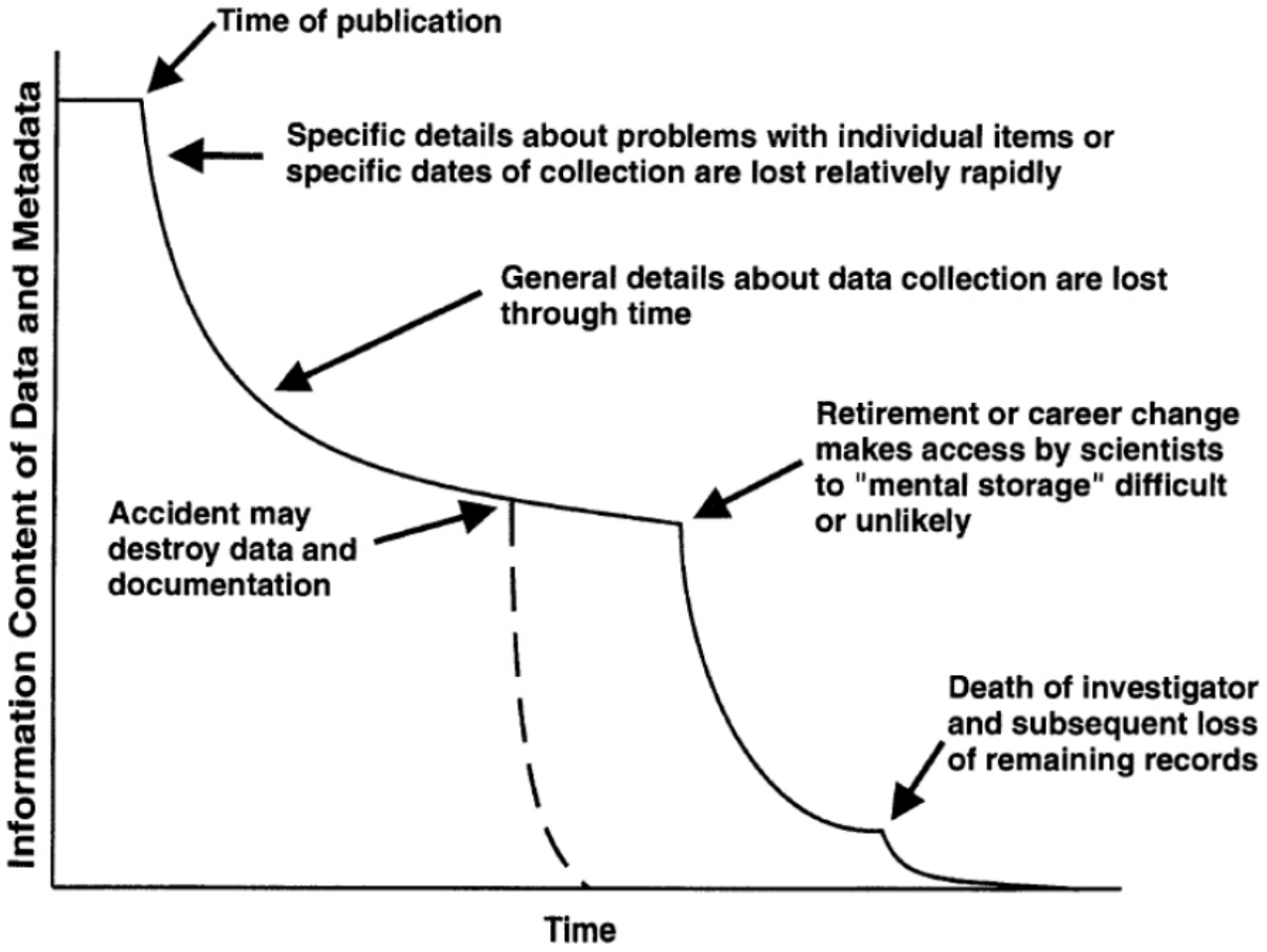
Extended Data Models

Model and Data Inventories





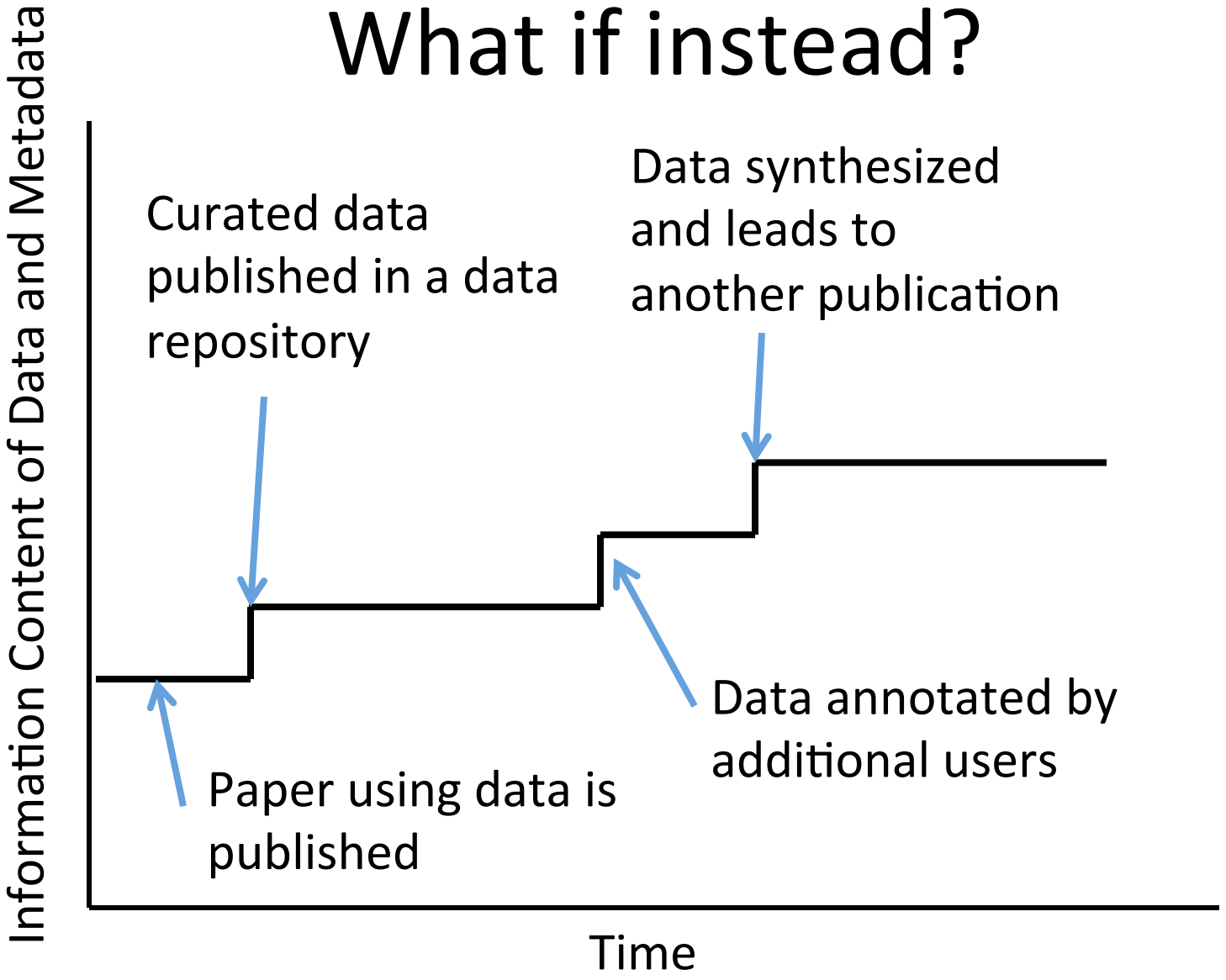
Information Entropy



Example of the normal degradation in information content associated with data and metadata over time ("information entropy").

Michener, W.K. (2006). Meta-information concepts for ecological data management, Ecological Informatics, 1(1), 3-7, http://dx.doi.org/10.1016/j.ecoinf.2005.08.004.

What if instead?



Support for Sharing and Collaboration

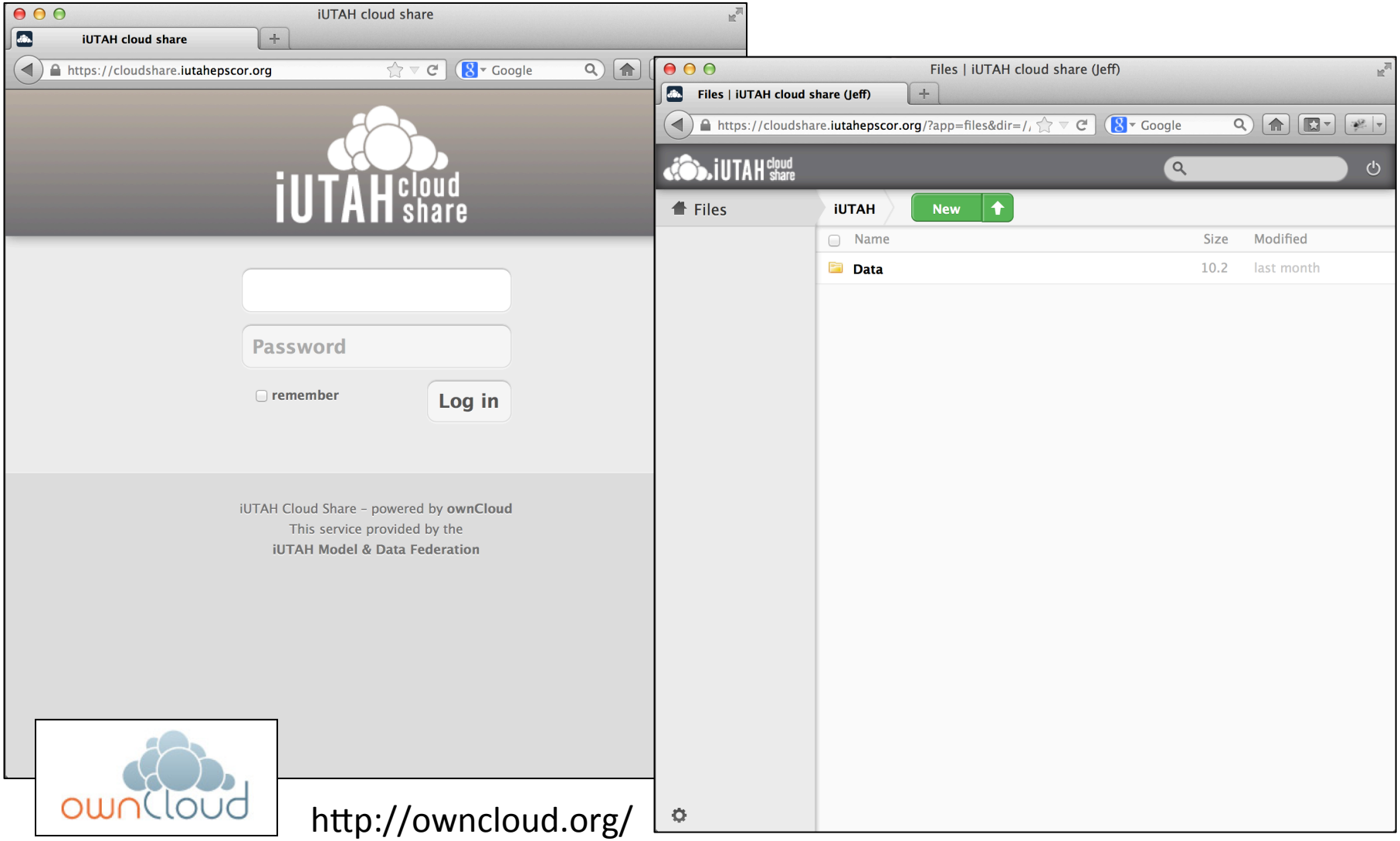
- Collaboration
  - Datasets as shared "social objects"
  - Formation of collaborations
  - Social networking features
- Requirements
  - What data resources are available? (metadata catalog)
  - How do I get them? (search interface)
  - How can I share what I have? (data repository)

Accessing Agency and National Data Networks

- Challenges
  - Multiple sources, websites, systems
  - Multiple data formats, schemas, semantics
  - Building consistent metadata to support data discovery
  - Prioritizing where to allocate our resources
- Solutions
  - **Partnerships!!!**

Collaborative Data Sharing

cloudshare.iutahepscor.org



http://owncloud.org/

Data Publication in National Networks

- Collaboration with:
  - CUAHSI Data Center
  - HydroShare
  - NSF DataONE Network

- Focus: publishing data products in a way that they can be cited and easily accessed

CUAHSI HIS
Sharing hydrologic data

HYDROSHARE

DataONE

HydroShare: Collaborative Sharing of Data and Models

- Collaboration environment and social media website
  - Social objects – data, models, digital content
  - HydroShare aims to change the way we do science
  - We are working to make collaboration easier
    - Sharing data
    - Sharing models and other research products
    - Providing new communication and social media capabilities
- 5 Year, $5 Million collaboration among USU, RENCI, BYU, Purdue, U. Texas, San Diego Supercomputer Center, Tufts, U. of North Carolina Chapel Hill, U. of South Carolina

Support:
OCI 1148453

HYDROSHARE

HYDROSHARE
Share and Collaborate

SHARE AND COLLABORATE

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

Get Started with HYDROSHARE

HYDROSHARE GALLERY

HOW HYDROSHARE WORKS

GETTING STARTED

Help
Getting Started
What's New
Partners

HydroShare Blog
Developers
What's New
Developers

CUAHSI
CUAHSI HIS
CUAHSI Water Data Center

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RECENT ACTIVITY

ALL ACTIVITY | ONLY MY ACTIVITY

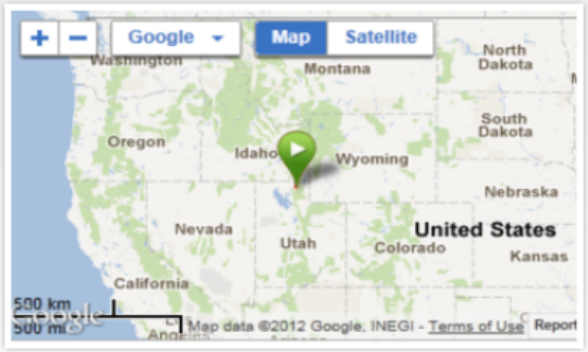
LITTLE BEAR RIVER ODM
Database 6/6/2012

LITTLE BEAR RIVER SHEETS
6/6/2012

LITTLE BEAR RIVER EXCEL
File 6/6/2012

WATERSHED DELINEATION
Workflow 6/6/2012

MORE...



ABSTRACT

Time series of water quality sensor date in the Little Bear River, Utah, USA.

KEYWORDS

Temperature, Dissolved Oxygen, pH, Specific Conductance, Turbidity

ANNOUNCEMENTS

What's New at HydroShare

Click here to visit the HydroShare blog to learn more about recent updates and new HydroShare features.

What's New at HydroShare

Click here to visit the HydroShare blog to learn more about recent updates and new HydroShare features.

Jeff Horsburgh
Utah State University
jeff.horsburgh@usu.edu

RESOURCES YOU MAY LIKE

LITTLE BEAR RIVER SWAT MODEL
Shared by: David Tarboton

LITTLE BEAR RIVER DEM
Shared by: David Tarboton

LITTLE BEAR RIVER DEM
Shared by: David Tarboton

YOU SHOULD FOLLOW

People Groups

Jeff Horsburgh
Utah State University
Follow

David Tarboton
Utah State University
Follow

David Tarboton
Utah State University
Follow

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KEYWORD: Search Activities Show Filters

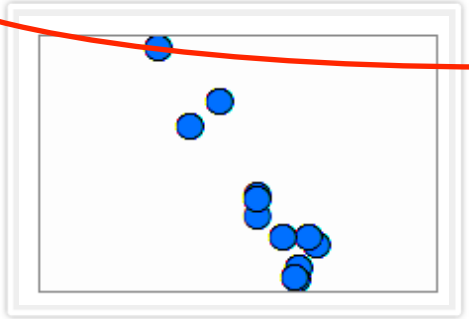
UPLOAD DELETE SHARE CREATE MASHUP EXPORT

	Type	Title	Date	Abstract
☐		Little Bear River ODM Database	6/6/2012	
☐		Little Bear River Sites	6/6/2012	
☐		Watershed Delineation Worflow	6/6/2012	
☐		Little Bear River SWAT Model	6/6/2012	
☐		Little Bear River DEM	6/6/2012	
☐		Little Bear River Excel File	6/6/2012	
☐		Little Bear River Word .doc	6/6/2012	

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

LITTLE BEAR RIVER MONITORING SITES | Resource Details

OPEN | SHARE | EXPORT | EDIT | DELETE



Resource Type: ESRI Shapefile

Created by: Jeff Horsburgh

Created: 6/10/2012

Keywords: observations catalog, data cart, little bear river, utah, CUAHSI, Water, Utah State University, Contnuous Monitoring, Water Quality, Streamflow.

Size: 250 KB

Extent: Left: -111.95 Right: -111.79 Top: 41.73

Resource Description

Abstract: Utah State University is conducting continuous monitoring within the Little Bear River watershed of northern Utah, USA to investigate the use of surrogate measures such as turbidity in creating high frequency load estimates for constituents that cannot be measured continuously. This shapefile contains location of USU's continuous monitoring sites.

Citation: Horsburgh, J. S., D. K. Stevens, D. G. Tarboton, N. O. Mesner, A. Spackman Jones, and S. Gurrero, (2009), Monitoring data collected within the Little Bear River Experimental Watershed, Utah, USA, Utah State University.

COMMENTS

Jeff Horsburgh 11.11.12
This shapefile is really helpful if you want to know where my monitoring sites are located.

Jeff Horsburgh 11.21.12
Have you thought about re-writing the script so that it can access data using web services instead?

SIMALAR RESOURCES

LITTLE BEAR RIVER SITES
Shared by: Jeff Horsburgh

LITTLE BEAR RIVER ODM DATABASE
Shared by: Jeff Horsburgh

LITTLE BEAR RIVER DEM
Shared by: David Tarboton

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EXPLORE | Discover and access resources published by others

KEYWORD: Little Bear River

Search | Hide Filters

Resource Type: Geospatial dataset

Date: 1.1.2012 – 6.12.2012

Sort by: Relevance | Title | Owner | Rating | Date

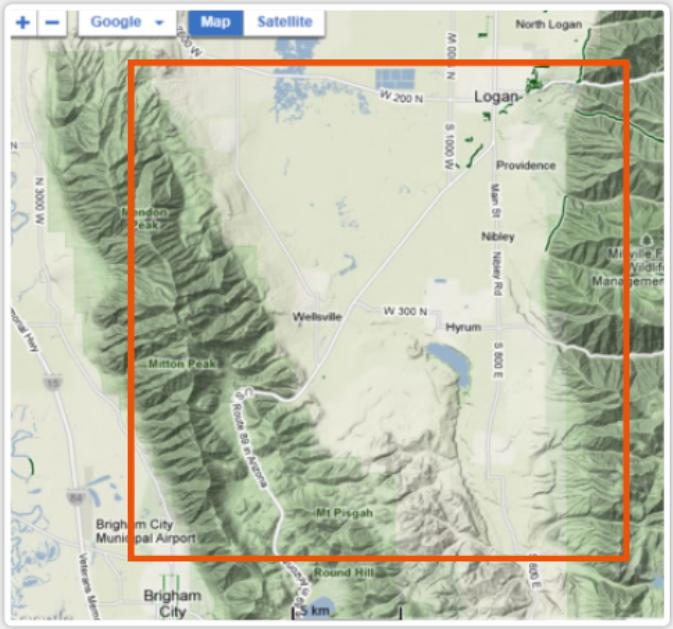
Title: Little Bear River Sites — 6.6.2012
Shared by: Jeff Horsburgh

Title: Little Bear River DEM — 6.10.2012
Shared by: David Tarboton

Title: National Land Cover Dataset — 6.10.2012
Shared by: United States Geological Survey

Title: National Elevation Dataset — 6.10.2012
Shared by: United States Geological Survey

Results 1 - 10 of 100 << 1 2 3 >>



FILTER GROUPS:

Groups Created by User
- All Groups
- Groups You Created
- Groups You Follow

CREATE GROUP +

SEARCH GROUPS:

By Keyword

Groups You Created | Results

Name: Little Bear River Research Group
Description: This group is studying water quality in the Little Bear River, Utah, USA.
Created by: Jeff Horsburgh

Name: CUAHSI
Description: This group shares resources related to hydrologic science.
Created by: Rick Hooper

Name: Little Bear River Research Group
Description: This group is studying water quality in the Little Bear River, Utah, USA.
Created by: Jeff Horsburgh

GROUPS YOU MIGHT BE INTERESTED IN

Name: USU Hydrology Group
Created by: David Tarboton
View Group

Name: Little Bear River Junkies
Created by: Jeff Horsburgh
View Group

Next Steps

- Accessing agency and national datasets
  - Developing tools for automatically accessing data
  - Partnerships with data providers
- Supporting data discovery and access across iUTAH and external data sources
  - Mediating across sources, formats, semantics
- Enhanced tools for collaboration and sharing of models and data
- Data publication within national networks
  - publishing data products in a way that they can be cited and easily accessed

EPSCoR iUTAH

Support: EPS 1208732

Questions?

Jeff Horsburgh

jeff.horsburgh@usu.edu

Support: EAR 0622374