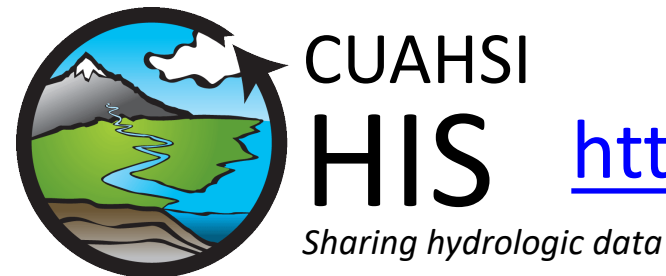


Combining Data From Multiple Sources Using the CUAHSI Hydrologic Information System

David Tarboton, Dan Ames, Jeffery S. Horsburgh, Jon Goodall
And the CUAHSI HIS development team



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



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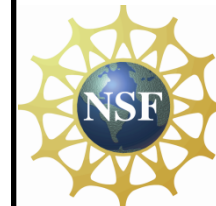


CUAHSI

HIS

Sharing hydrologic data

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



Support
EAR 0622374

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



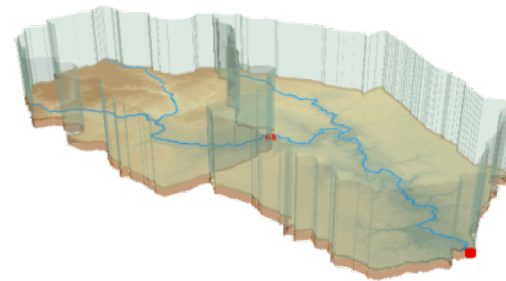
Rainfall and Meteorology



Soil water



GIS

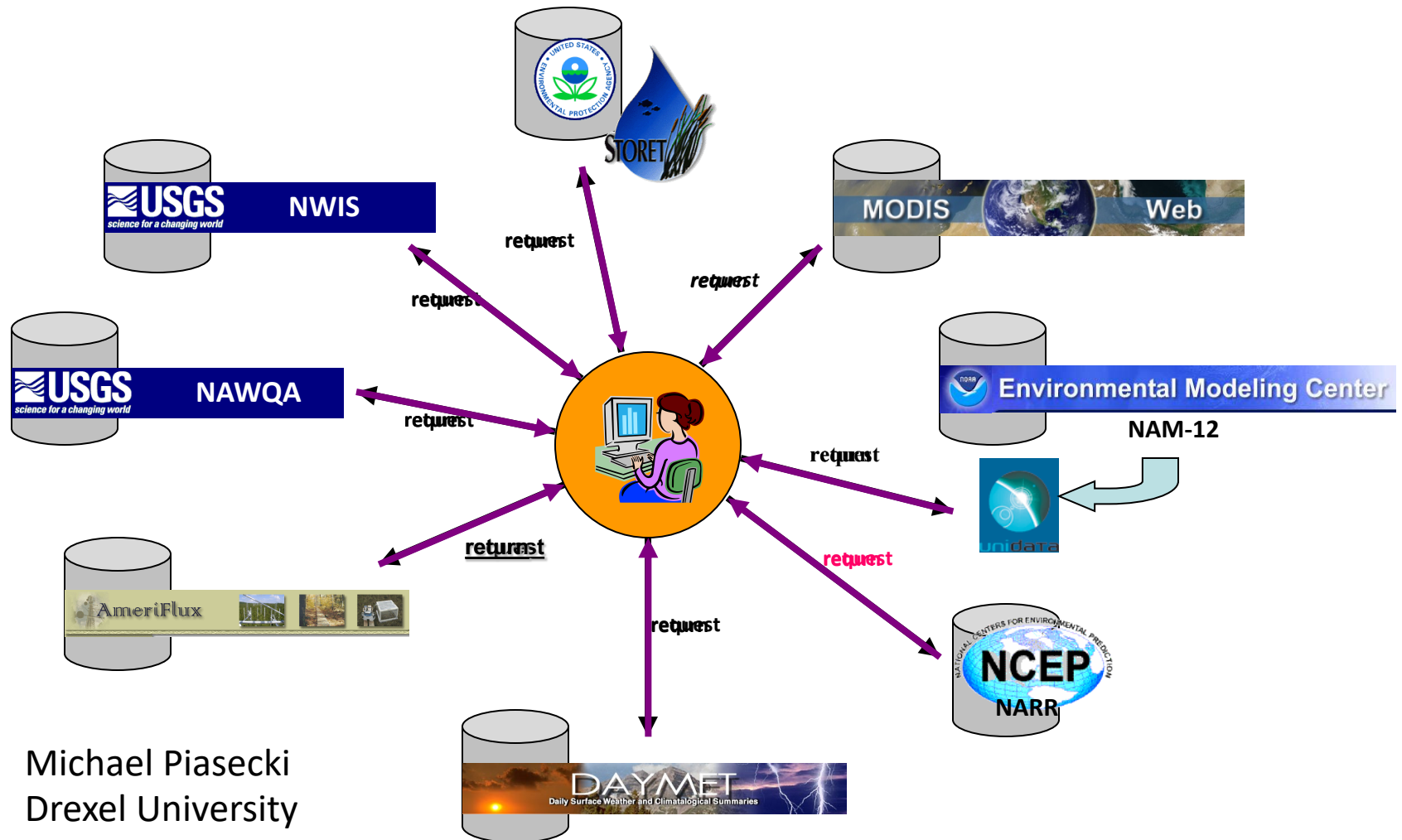


Groundwater



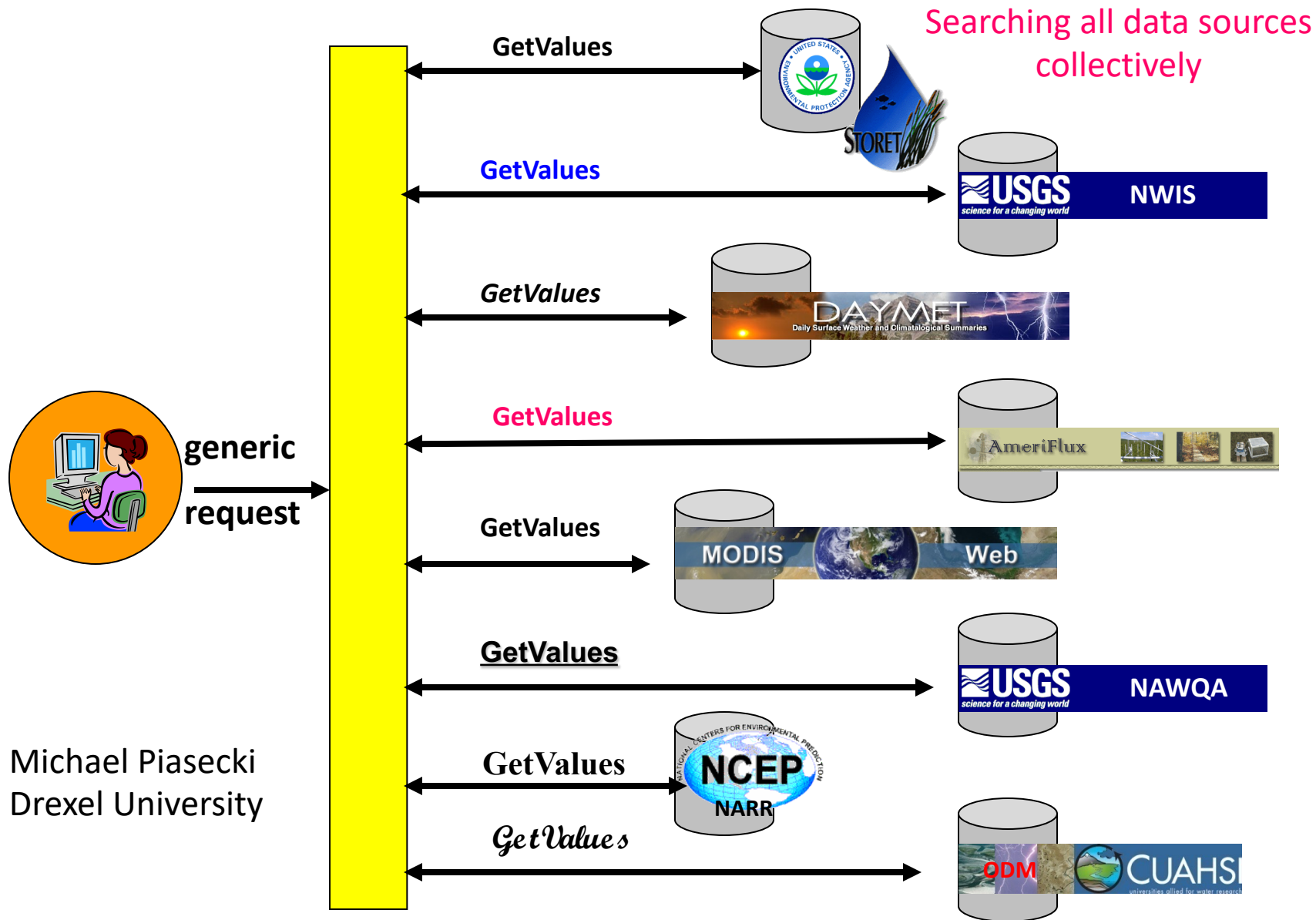
Data Searching – What we used to have to do

Searching each data source separately



Michael Piasecki
Drexel University

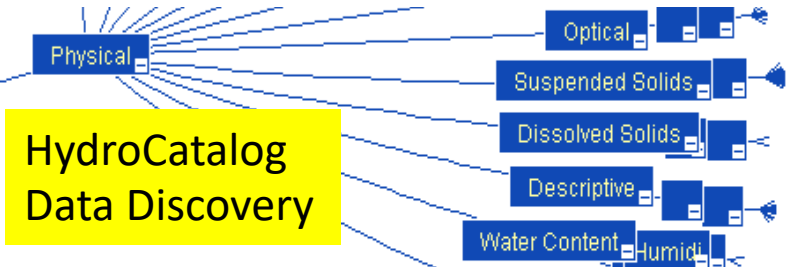
What CUAHSI HIS enables



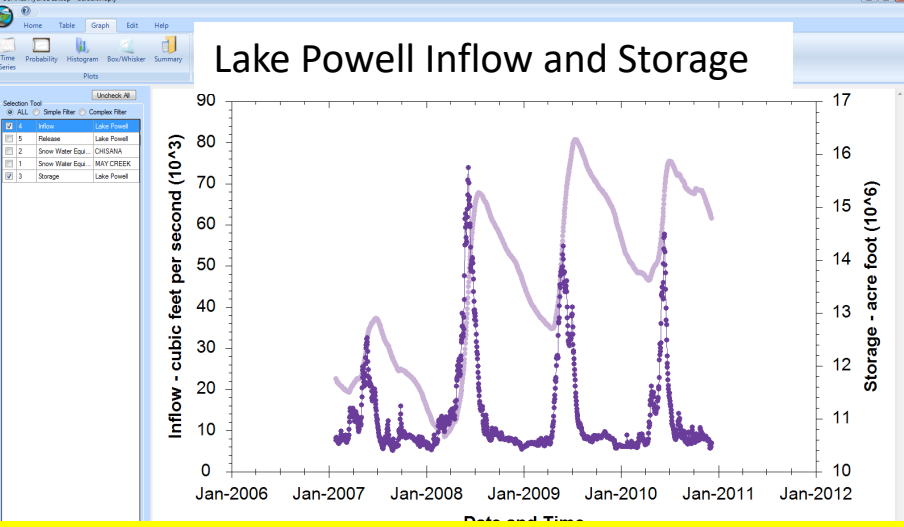
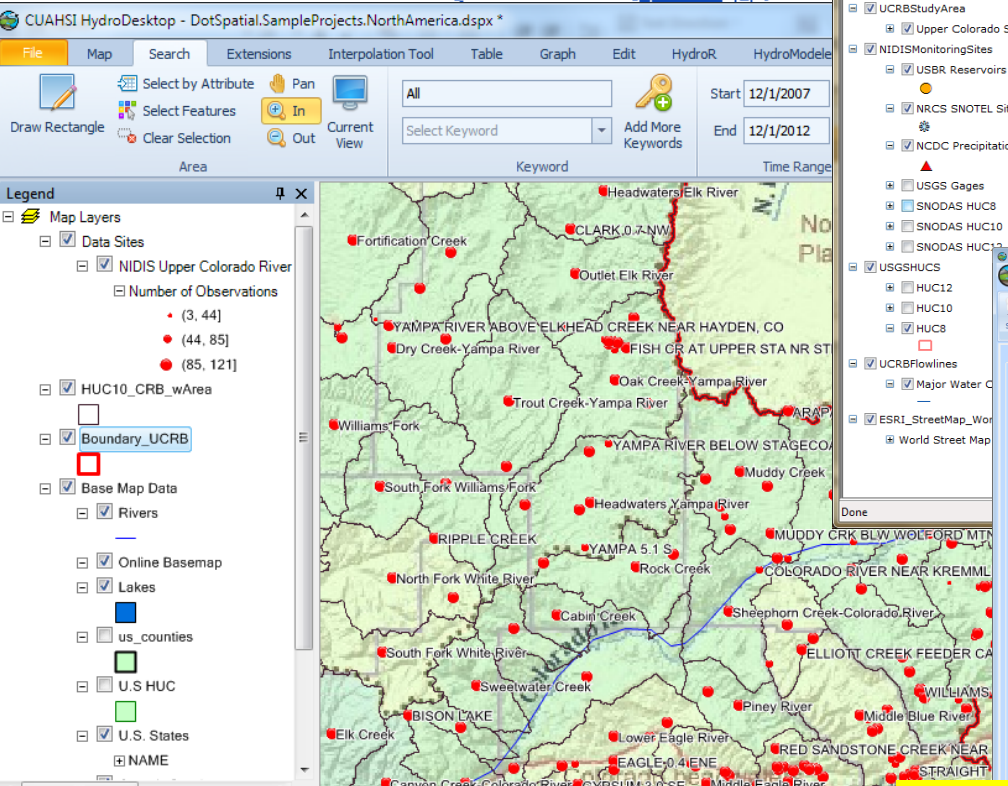
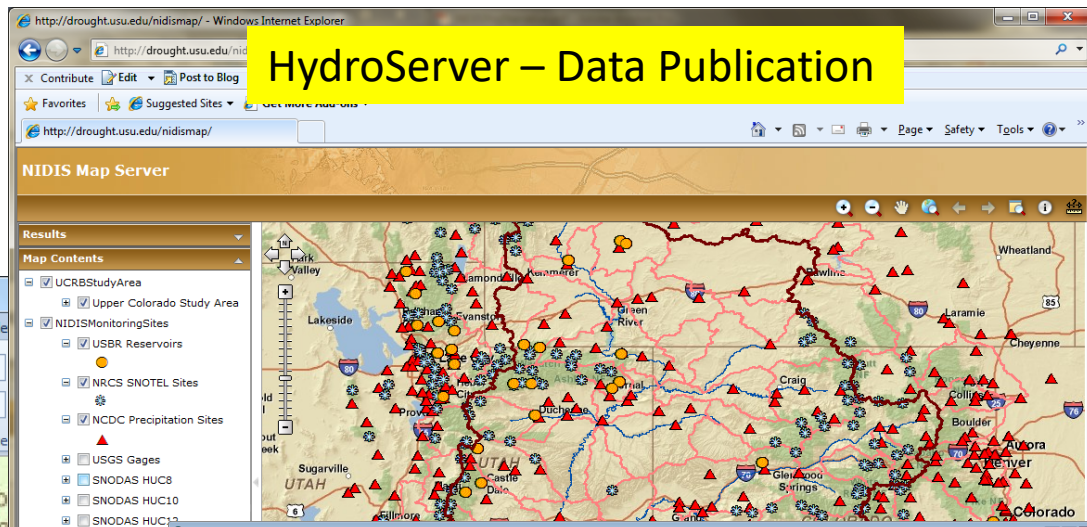
Michael Piasecki
Drexel University

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.



HydroCatalog
Data Discovery



HydroDesktop - Data Access and Analysis

HydroDesktop - Combining multiple data sources

HydroDesktop Demo

The screenshot displays the HydroDesktop desktop application window. The title bar reads "CUAHSI HydroDesktop - DotSpatial.SampleProjects.NorthAmerica.dspix *". The interface includes a menu bar with options: File, Map, Search, Extensions, Interpolation Tool, Table, Graph, Edit, HydroR, HydroModeler, and Help. Below the menu bar is a toolbar with icons for "Add Layer...", "Remove Layer", "Pan", "Zoom In", "Zoom Out", "Zoom To Extents", "Previous", "Next", "Zoom To Layer", "Select", "Deselect All", "Identify", and "View Attribute Table". On the right side of the toolbar, there are settings for "ESRI Hydro Base Map" (with an opacity of 40) and buttons for "Delineate" and "EPA Tool".

The main map area shows a map of North America with various layers overlaid. The legend on the left side is titled "Map Layers" and includes the following items:

- Base Map Data
 - Rivers
- Online Basemap
- Lakes
- us_counties
- U.S HUC
- U.S. States
 - NAME
- Canada Province
- Countries
 - NAME

The map shows a color-coded grid overlaying the United States, with major rivers like the Columbia, Mississippi, and Ohio labeled. The text "United States" and "Mexico" are visible on the map. A yellow text box in the bottom right corner of the map area contains the text: "An open source dotSpatial GIS based desktop client that supports discovery and analysis of hydrologic observations data".

At the bottom of the window, there is a status bar showing "Longitude: 98°39'12\"W, Latitude: 50°31'50\"N" and "All Layers Selected". The bottom-most part of the interface has a row of buttons for "Map", "Table", "Graph", "Edit", "HydroR", and "HydroModeler".

Delineate Watershed using EPA web services

The screenshot displays the CUAHSI HydroDesktop software interface. The title bar reads "CUAHSI HydroDesktop - DotSpatial.SampleProjects.NorthAmerica.dsp *". The menu bar includes File, Map, Search, Extensions, Interpolation Tool, Table, Graph, Edit, HydroR, HydroModeler, and Help. The toolbar contains various tools: Add Layer..., Remove Layer, Pan, In, Out, To Extents, Previous, Next, Zoom To Layer, Select, Deselect All, Identify, and View Attribute Table. The EPA Tool section is highlighted with a red box, containing the Delineate tool icon. The Online Basemap section shows ESRI Hydro Base Map and Opacity: 100. The Legend panel on the left lists layers: Map Layers, Base Map Data, Rivers, Online Basemap, Lakes, us_counties, U.S HUC, U.S. States, NAME, Canada Provinces, and Countries. The main map area shows a topographic map of the Logan River watershed, with a red arrow pointing to the Logan River. The status bar at the bottom indicates "Longitude: 111°45'49"W, Latitude: 41°47'58"N" and "All Layers Selected".

Uses EPA WATERS Web, Mapping, and Database Services at <http://www.epa.gov/waters/geoservices/index.html>

Find data in and near this watershed

The screenshot displays the CUAHSI HydroDesktop interface. The main window title is "CUAHSI HydroDesktop - DotSpatial.SampleProjects.NorthAmerica.dspk *". The menu bar includes File, Map, Search, Extensions, Interpolation Tool, Table, Graph, Edit, HydroR, HydroModeler, and Help. The toolbar contains various tools categorized into Layers (Add Layer..., Remove Layer), View (Pan), Zoom (In, Out, To Extents, Previous, Next, Zoom To Layer), Map Tool (Select, Deselect All, Identify, View Attribute Table), Online Basemap (ESRI Hydro Base Map, Opacity: 100), and EPA Tool (Delineate).

The Tools panel on the left lists several tools, with "Buffer" highlighted in a red box. The Buffer tool dialog is open, showing the following configuration:

- Input**
 - Input Feature Set: Watershed
 - Buffer Distance: 5000
- Output**
 - Output Polygon Feature Set: loganbuffer

The dialog also includes "OK", "Cancel", and "Tool Help" buttons. A preview pane on the right shows the text: "Buffer" and "This will add the buffer Polygon FeatureSet with Specified Distance".

At the bottom of the interface, the status bar shows "Longitude: 111°08'41"W, Latitude: 41°52'21"N" and "layer: Watershed Selected: 0".

Resulting buffer around the watershed

The screenshot displays the CUAHSI HydroDesktop interface. The title bar reads "CUAHSI HydroDesktop - LoganDemo.dspk *". The menu bar includes File, Map, Search, Extensions, Interpolation Tool, Table, Graph, Edit, HydroR, HydroModeler, and Help. The Search menu is highlighted with a red box. The toolbar contains icons for Add Layer..., Remove Layer, Pan, In, Out, To Extents, Previous, Next, Zoom To Layer, Select, Deselect All, Identify, View Attribute Table, ESRI Hydro Base Map, Opacity (set to 100), Delineate, and EPA Tool. The Tools panel on the left lists Analysis, Terrain Analysis, Conversion, Spatial Reference, Vector Overlay, Raster Overlay, Interpolation, Statistics, and Generalization. The main map area shows a topographic map with a stream network. A central watershed is highlighted in light blue, and a buffer around it is shown in light brown. Labels on the map include "Bear", "Bear Lake", "Logan R.", "Cub R.", and "Malad R.". The status bar at the bottom shows "Longitude: 112°03'43\"W, Latitude: 42°09'33\"N", "layer: Loganbuffer Selected: 0", and "Ready.".

Search last 22 years for all data in buffer around watershed

The screenshot displays the CUA software interface. The top menu bar includes File, Map, Search, Extensions, Interpolation Tool, Table, Graph, Edit, HydroR, HydroModeler, and Help. The toolbar contains various tools, with 'Select Features' highlighted in a red box. The 'Search' panel is active, showing a search for 'All' in the 'Keyword' field, a time range from '11/23/1990' to '11/23/2012', and the 'Search' button highlighted in a red box. The map area shows a watershed boundary in cyan, with a buffer around it. The legend on the left lists map layers, including Watershed Point, Reaches, Watershed, Loganbuffer, Base Map Data, Rivers, Online Basemap, Lakes, us_counties, U.S. HUC, U.S. States, NAME, Canada Provinces, and Countries. The status bar at the bottom indicates 'All Layers Selected' and 'Ready.'

Data Discovered

The screenshot displays the CUAHSI HydroDesktop software interface. The main window title is "CUAHSI HydroDesktop - LoganDemo.dspx". The interface includes a menu bar (File, Map, Search, Extensions, Interpolation Tool, Table, Graph, Edit, HydroR, HydroModeler, Help) and a toolbar with various tools like "Draw Rectangle", "Select by Attribute", "Select Features", "Clear Selection", "Pan", "In", "Out", "Current View", "Add More Keywords", "Select Dates", "Select Data Sources", "Search", and "Download Selected".

The central map shows a topographic view of the Logan River watershed, highlighted in cyan. The watershed boundary is irregular and follows the river's course. Several data sites are marked with red dots and labeled:

- FRANKLIN BASIN
- BEAVER CK AB BEAVER MTN SKI RESORT
- LOGAN R AB BEAVER CK
- TONY GROVE LAKE 01
- SUMMIT CK @ USFS BNDY
- TEMPLE FK AB LOGAN R
- LOGAN RIVER
- LOGAN R AB RIGHT FK LOGAN R
- LOGAN:HYD FK AND SMTHFLD CANAL AT HEAD NR LOGAN UT
- (A-11-1) 3dcd-S1
- (A-12-1) 3dcd-1

The left sidebar contains a "Legend" panel with "Map Layers" and "Data Sites". The "Data Sites" list includes:

- NIDIS Upper Colorado R
- Number of Observation
- NCDL Upper Colorado F
- Number of Observation
- NRCS SNOTEL Standar
- Number of Observation
- NWIS Daily Values
- Number of Observation
- Logan River Observation
- Number of Observation
- NWIS Unit Values
- Number of Observation
- GHCN Daily Climate Da
- Number of Observation
- EPA STORET
- Number of Observation
- NWIS Ground Water Lev
- Number of Observation
- NWIS Instantaneous Irr
- Number of Observation
- Watershed Point

The bottom status bar shows "layer: Loganbuffer Selected: 1" and "Ready." The bottom navigation bar includes "Map", "Table", "Graph", "Edit", "HydroR", and "HydroModeler".

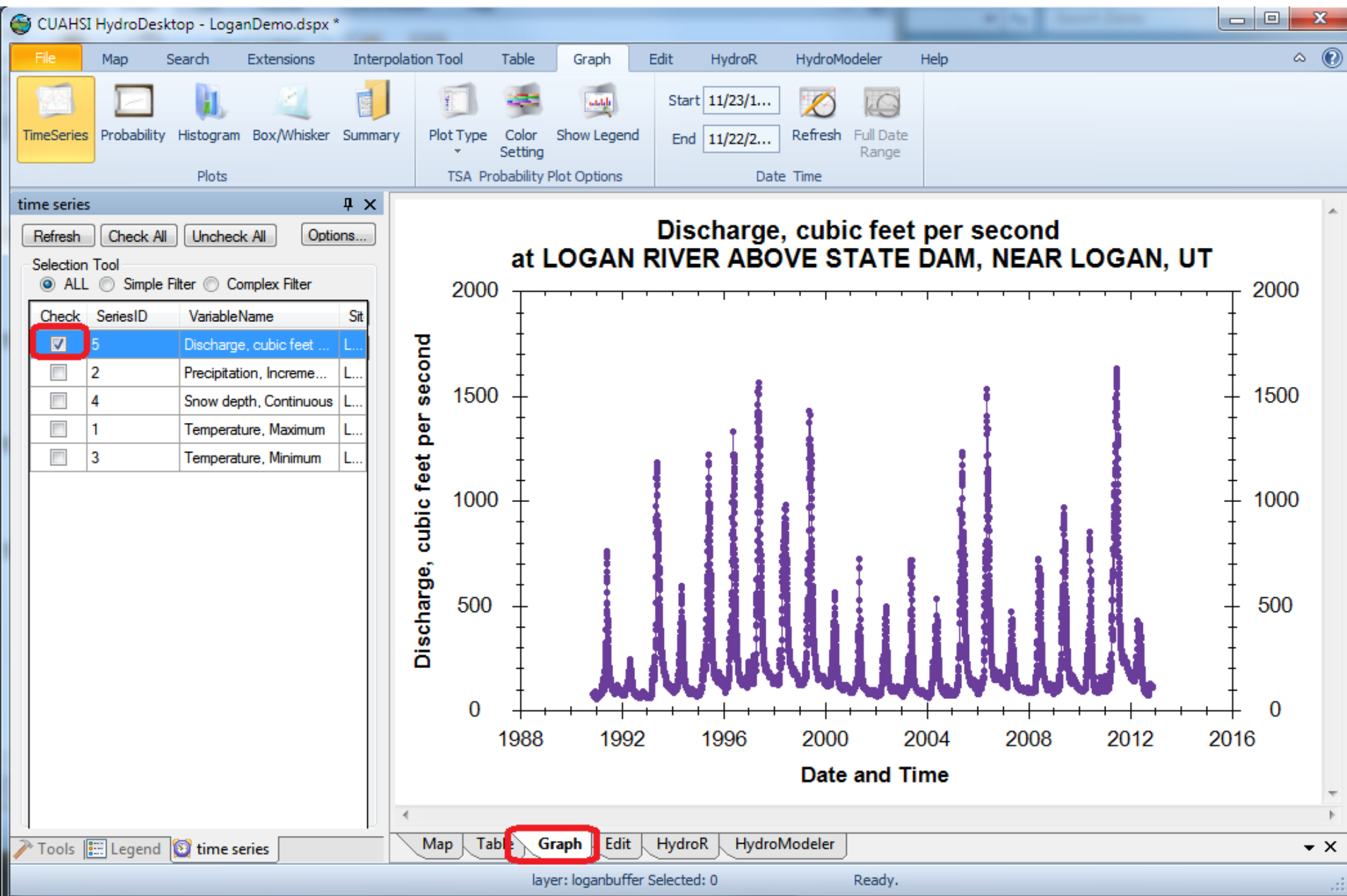
Download USGS Daily Value Streamflow Data

The screenshot displays the CUAHSI HydroDesktop interface for a Logan River basin analysis. The main map shows the Logan River and its tributaries, with several data sites marked by red dots and blue triangles. A pop-up window for the NWISDV site is open, showing the following information:

- Site Name:** NWISDV
- Description:** LOGAN RIVER ABOVE STATE DAM, NEAR LOGAN, UT
- Discharge:** cubic feet per second - 7998 Values (estimated)
- Action:** [Download data](#)

The interface includes a menu bar (File, Map, Search, Extensions, Interpolation Tool, Table, Graph, Edit, HydroR, HydroModeler, Help) and a toolbar with various analysis tools. The legend on the left lists several data layers, including Data Sites, NWIS Daily Values, and Watershed. The status bar at the bottom indicates the current layer is 'loganbuffer' and the system is 'Ready'.

Plot the Data



Download NRCS SNOTEL data

The screenshot displays the CUAHSI HydroDesktop software interface. The main window shows a map of the Logan River watershed, with various data sites marked. A popup window is open over the TONY GROVE LAKE SNOTEL site, providing detailed information about the data available for download.

Legend:

- Data Sites
 - NIDIS Upper Colorado River Basin
 - Number of Observations
 - NWIS Daily Values
 - Number of Observations
 - NWIS Unit Values
 - Number of Observations
 - Logan River Observations, Northern
 - Number of Observations
 - NRCS SNOTEL Standard Variables
 - Number of Observations
 - NCDC Upper Colorado River Basin
 - Number of Observations
 - EPA STORET
 - Number of Observations
 - GHCN Daily Climate Data
 - Number of Observations
 - NWIS Ground Water Level
 - Number of Observations
 - NWIS Instantaneous Irregular Data
 - Number of Observations
- Watershed

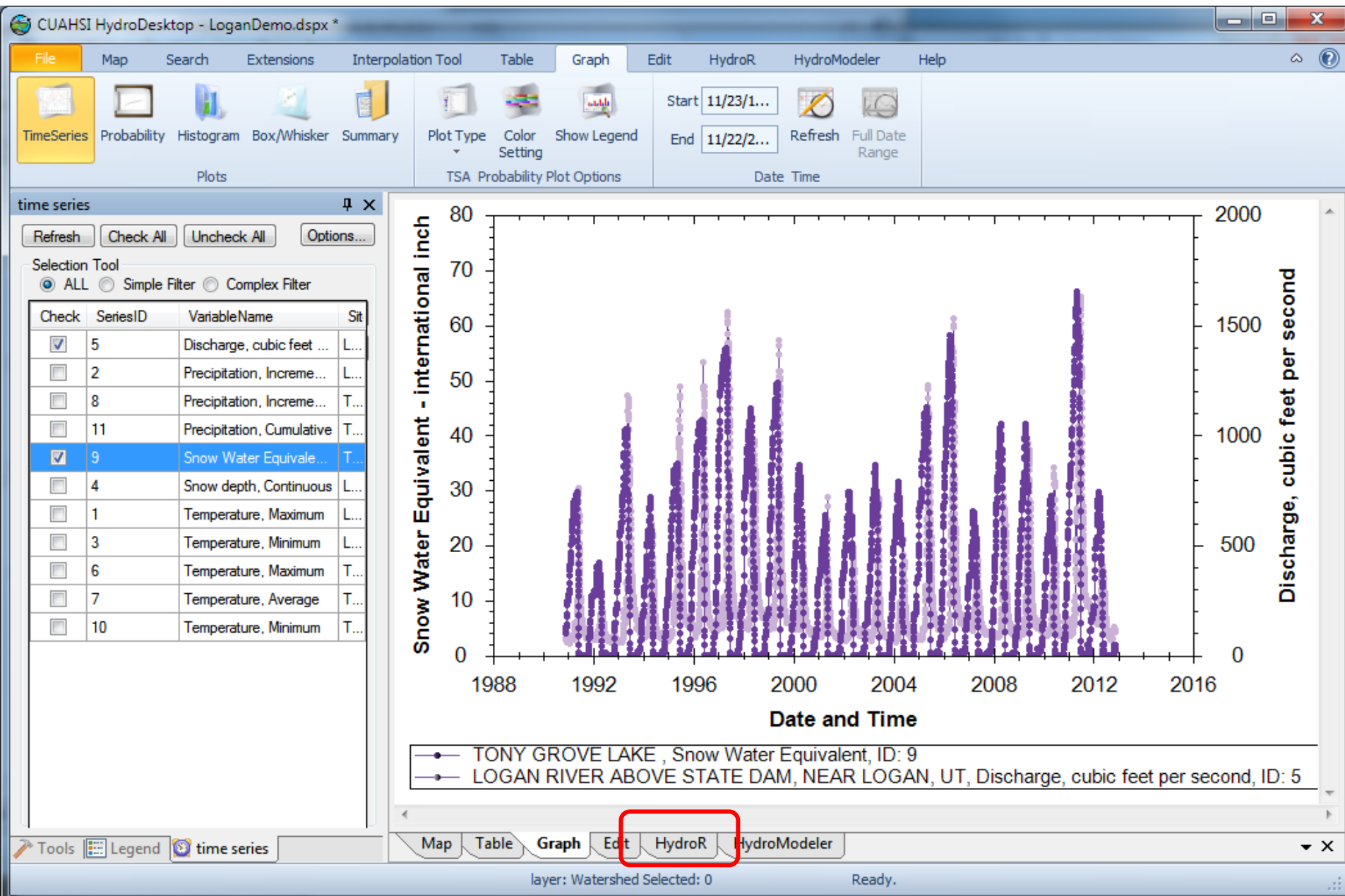
SNOTEL Data:

- TONY GROVE LAKE
- Precipitation, Cumulative - 8029 Values (estimated)
- Temperature, Maximum - 7348 Values (estimated)
- Temperature, Average - 7348 Values (estimated)
- Precipitation, Incremental - 8029 Values (estimated)
- Snow Water Equivalent, Average - 8029 Values (estimated)
- Temperature, Minimum - 7348 Values (estimated)

[Download data](#)

Longitude: 111°37'27"W, Latitude: 41°53'18"N
layer: Watershed Selected: 0

Combined plot



R Interoperability

The screenshot displays the CUAHSI HydroDesktop interface with several key components highlighted in red:

- File Menu:** The 'File' menu is open, showing options like 'Start R' and 'Generate R Code'.
- HydroR Tools:** A toolbar containing 'Open Script' and 'Save Script' buttons.
- Script Editor:** A text area containing R code for data retrieval. The code is as follows:

```
data0 <- getDataSeries(connectionString="C:/Users/dtarb/Demo/LoganDemo.sqlite",
  seriesID=5,
  SQLite=TRUE,
  startDate= "1990-11-23",
  endDate="2012-11-22")
data1 <- getDataSeries(connectionString="C:/Users/dtarb/Demo/LoganDemo.sqlite",
  seriesID=9,
  SQLite=TRUE,
  startDate= "1990-11-23",
  endDate="2012-11-15")
```
- R Console:** A console window showing the execution of the R code:

```
> library(HydroR)
Loading required package: DBI
Loading required package: RSQLite
Loading required package: tcltk
Loading Tcl/Tk interface ... done
>
```

The interface also includes a 'time series' panel on the left with a table of data series and a 'Selection Tool' with radio buttons for 'ALL', 'Simple Filter', and 'Complex Filter'.

Check	SeriesID	VariableName	Sit
<input checked="" type="checkbox"/>	5	Discharge, cubic feet ...	L...
<input type="checkbox"/>	2	Precipitation, Increme...	L...
<input type="checkbox"/>	8	Precipitation, Increme...	T...
<input type="checkbox"/>	11	Precipitation, Cumulative	T...
<input checked="" type="checkbox"/>	9	Snow Water Equivale...	T...
<input type="checkbox"/>	4	Snow depth, Continuous	L...
<input type="checkbox"/>	1	Temperature, Maximum	L...
<input type="checkbox"/>	3	Temperature, Minimum	L...
<input type="checkbox"/>	6	Temperature, Maximum	T...
<input type="checkbox"/>	7	Temperature, Average	T...
<input type="checkbox"/>	10	Temperature, Minimum	T...

Plot the data using R

The screenshot displays the CUAHSI HydroDesktop interface. The 'HydroR Tools' menu is open, and the 'Send Line' button is highlighted with a red box. The 'time series' panel on the left shows a list of variables, with 'Snow Water Equivale...' (SeriesID 9) selected. The 'R Graphics: Device 2 (ACTIVE)' window shows a line plot of 'Flow cfs' over 'Date' from 1995 to 2010. The plot shows a highly variable time series with peaks reaching up to 1500 cfs.

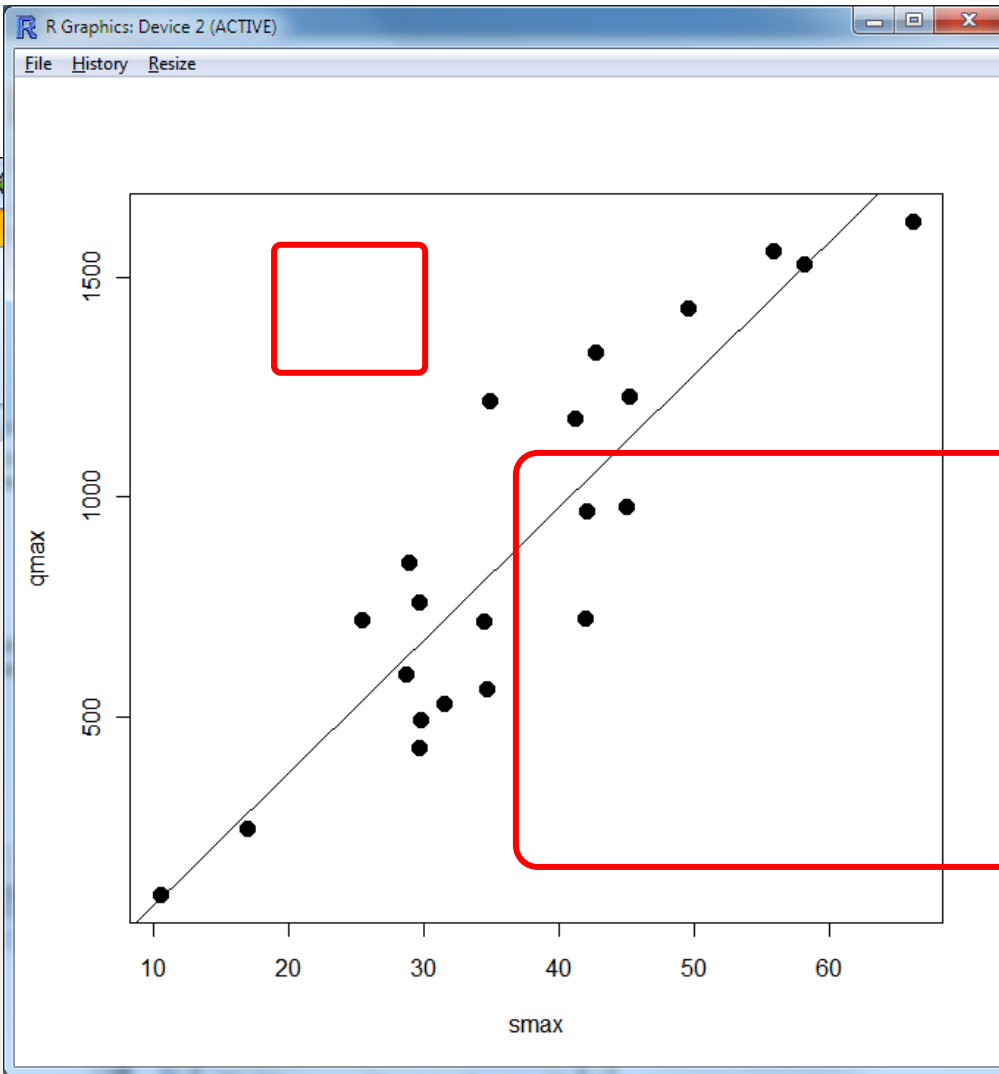
Check	SeriesID	VariableName
<input checked="" type="checkbox"/>	5	Discharge, cubic feet ...
<input type="checkbox"/>	2	Precipitation, Increme...
<input type="checkbox"/>	8	Precipitation, Increme...
<input type="checkbox"/>	11	Precipitation, Cumulative
<input checked="" type="checkbox"/>	9	Snow Water Equivale...
<input type="checkbox"/>	4	Snow depth, Continuous
<input type="checkbox"/>	1	Temperature, Maximum
<input type="checkbox"/>	3	Temperature, Minimum
<input type="checkbox"/>	6	Temperature, Maximum
<input type="checkbox"/>	7	Temperature, Average
<input type="checkbox"/>	10	Temperature, Minimum

Flow cfs

Date

layer: Watershed Selected: 0

Capability of R



```
> lsline
$coefficients
Intercept      X
-235.15849    30.29332
```

```
HydroModeler Help
```

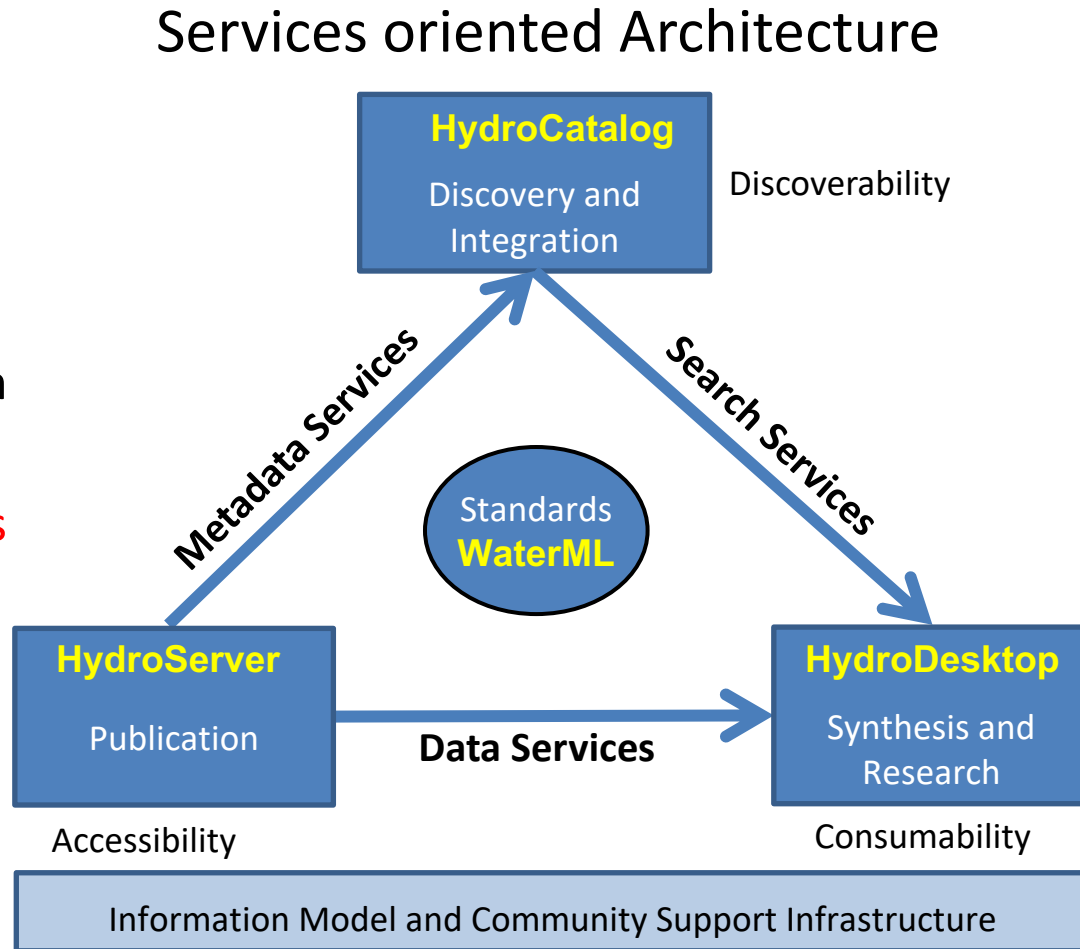
```
flow$DataValues$DataValue.type="1", xlab="Date", vlab="Flow")
[flow$DataValues$DataValue==snow$Variable$NoDataValue)] = NA

("2012/1/1"), by="year")

ue[(snow$DataValues$LocalDateTime >= yr) & (snow$DataVa
ue[(flow$DataValues$LocalDateTime >= yr) & (flow$DataVa
```

Conclusions

- **Standards based** architecture to enhance adoption and interoperability
- **Publication** from distributed servers
- Discovery through **catalog** search services
- **Integrated modeling and analysis** combining information from multiple sources
- Data sources include agencies and universities
- Open source extensibility
- CUAHSI governance



The combination of these capabilities creates a common window on water observations data for the United States unlike any that has existed before.

Open Development Model

http://hydrodesktop.codeplex.com/

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- <http://hydrodesktop.codeplex.com>
- <http://hydroserver.codeplex.com>
- <http://hydrocatalog.codeplex.com>

★ 24 people are following this project (follow)

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DATE	Wed Jan 26 2011 at 7:00 AM
STATUS	Stable
RATING	No Ratings
	530 downloads
MORE	View all downloads

Activity 7 30 All c

Page Views

Visits

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Stats

DOT SPATIAL MAP WINDOW

100%