

Integrated Modeling & Data Access — CUAHSI HIS HydroModeler

Jon Goodall, Assistant Professor

Department of Civil and Environmental Engineering



UNIVERSITY OF
SOUTH CAROLINA
College of Engineering
and Computing

CUAHSI HIS Team Members:

David Maidment (PI), David Tarboton (co-PI), Ilya Zaslavsky (co-PI), Dan Ames (co-PI), Jon Goodall (co-PI), Michael Piasecki (co-PI), Rick Hooper (co-PI), Tim Whiteaker, James Seppi, Fernando Salas, David Valentine, Tom Whitenack, Matt Rodriguez, David Tarboton, Jeff Horsburgh, Kim Schreuders, Justin Berger, Tony Castronova, Robert Boykin, Ben Felton, Shirani Fuller, Ted Dunsford, Jiri Kadlec, Yoori Choi, Jennifer Arrigo



<http://his.cuahsi.org>





CUAHSI supports the water science community by (among other things):

- developing, supporting, and operating research infrastructure;
- improving and promoting access to data, information and models



125 University Members

www.cuahsi.org

Support from NSF



Problem Statement

We need new ways of handling the growing quantity of diverse data resources

Sensor Networks



Remote sensing

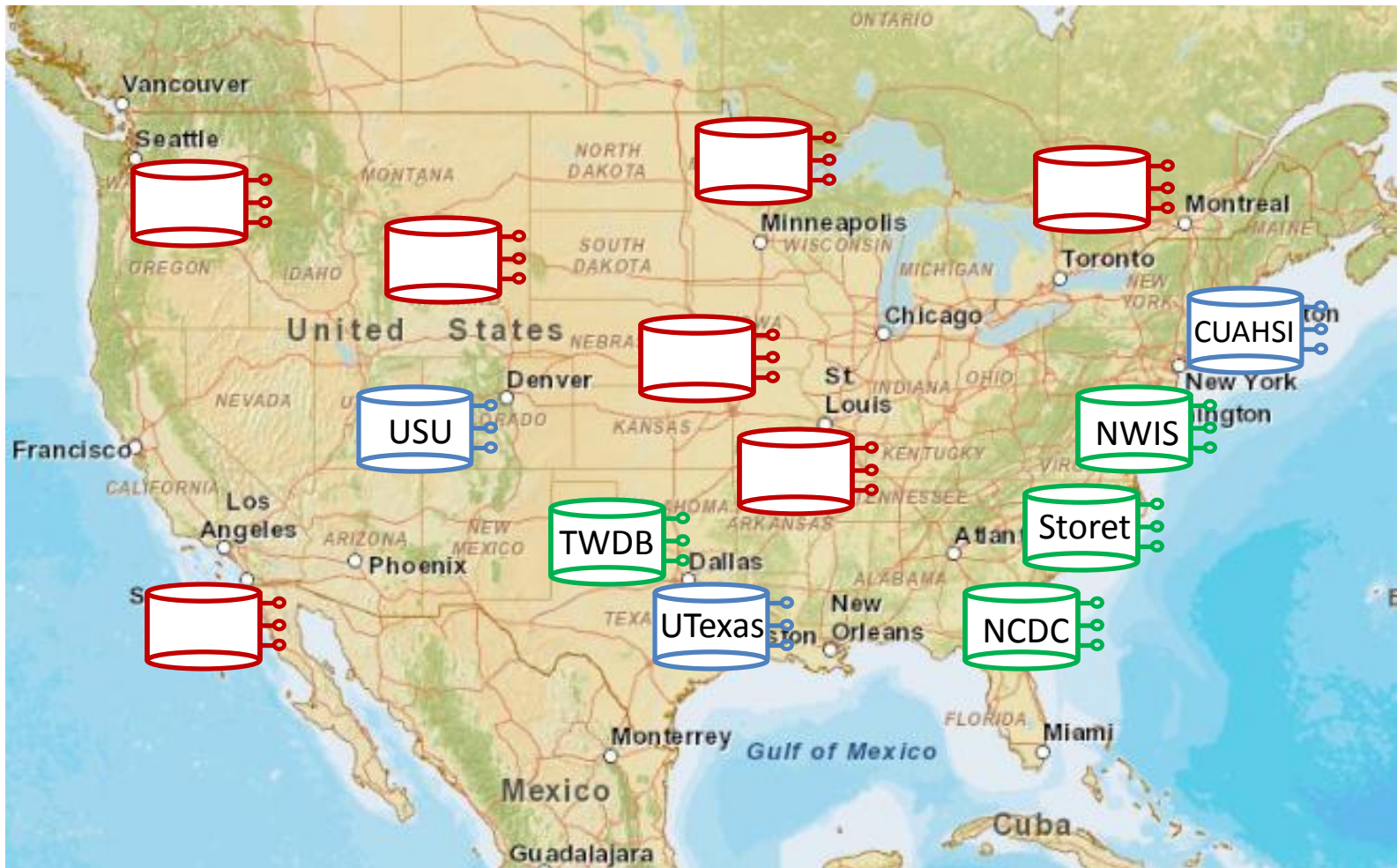


Model Output

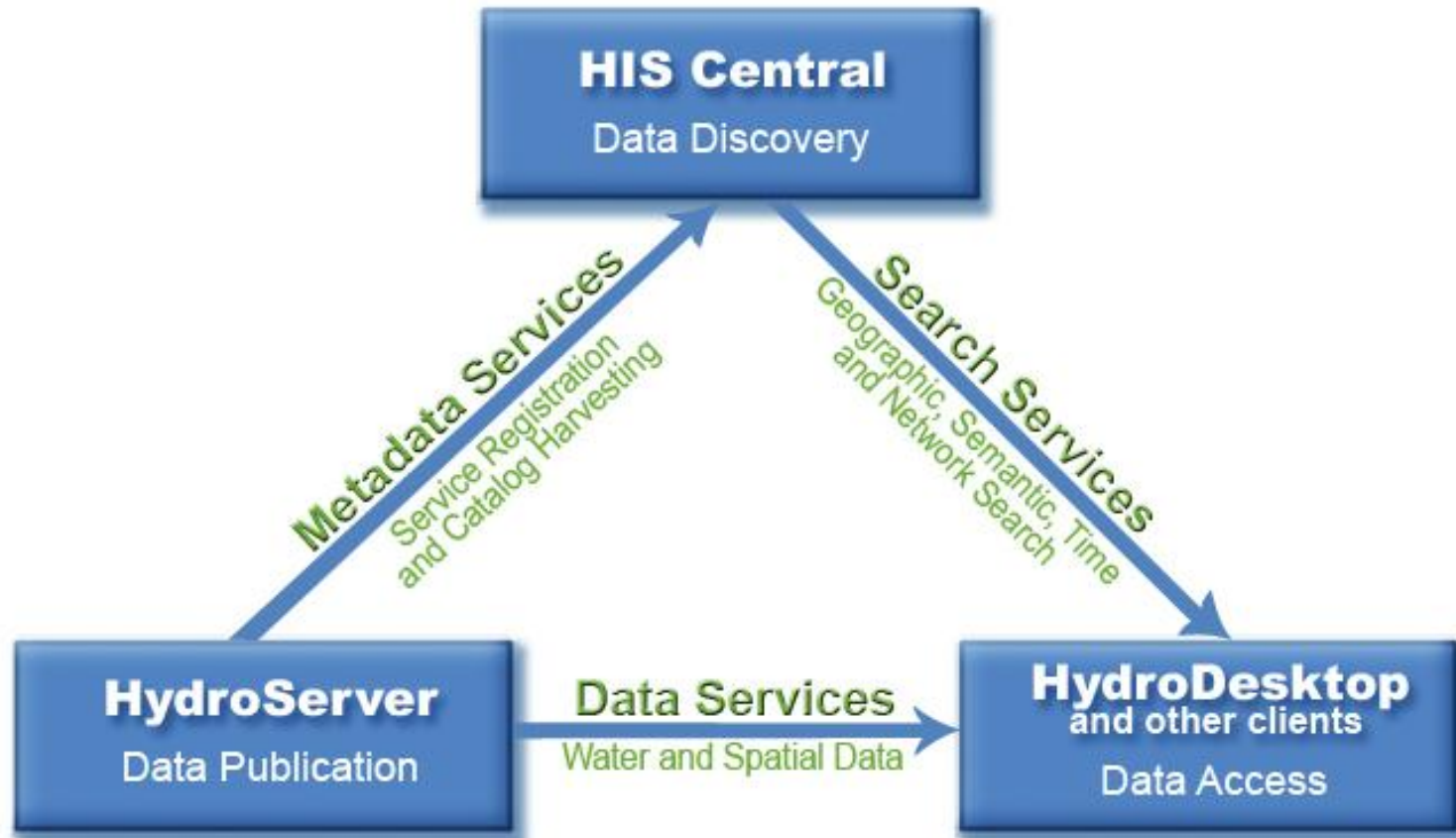


CUAHSI HIS Goal

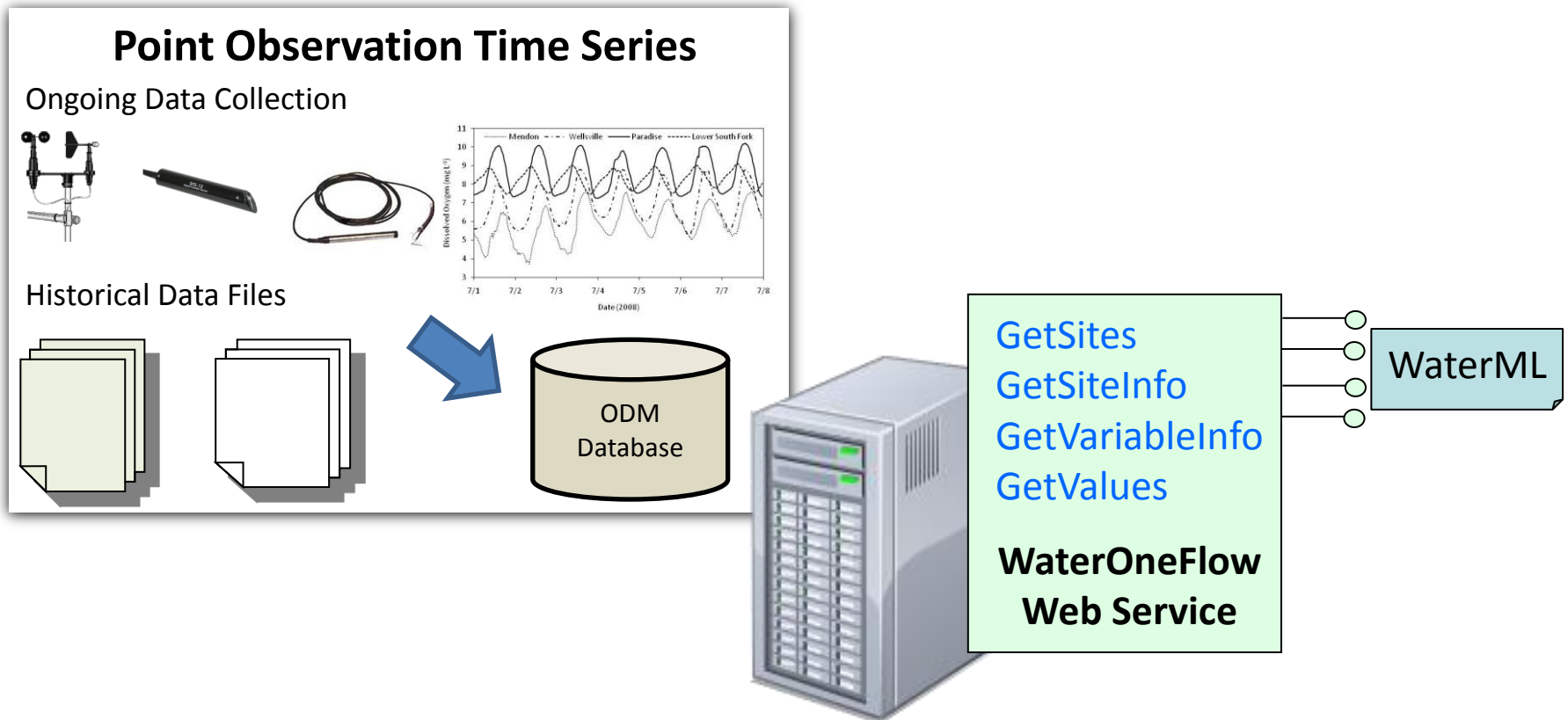
To enhance hydrologic science by **facilitating user access to more and better data** for testing hypotheses and analyzing processes



HIS Overview



HydroServer

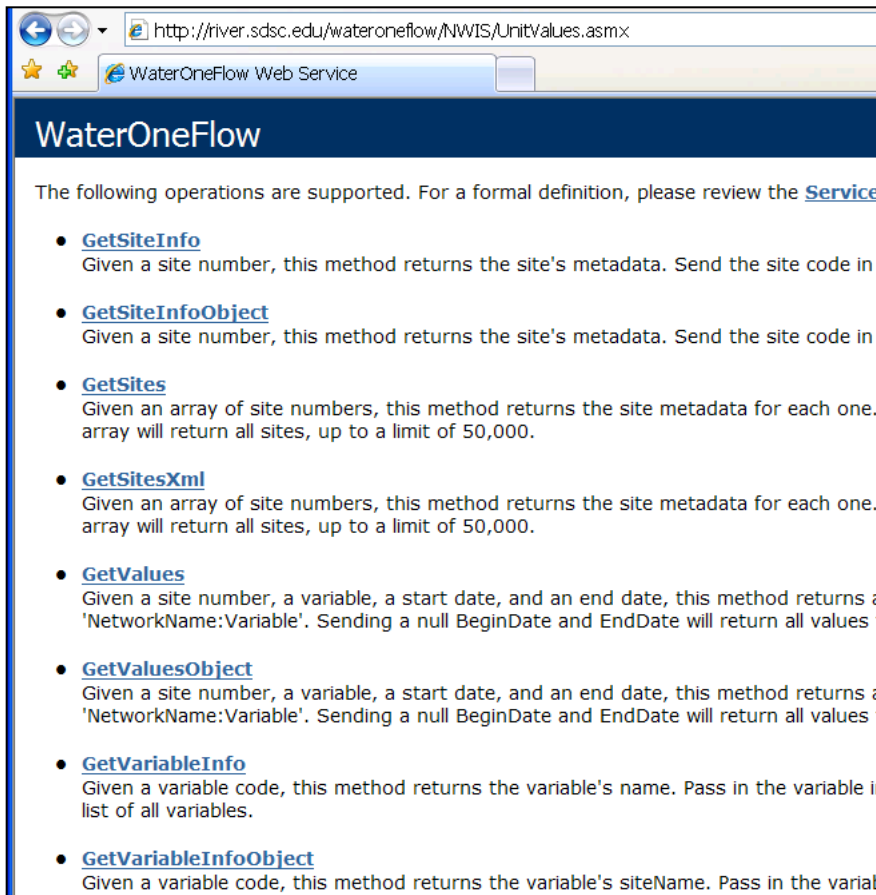


Horsburgh, J. S., D. G. Tarboton, D. R. Maidment and I. Zaslavsky, (2008), A Relational Model for Environmental and Water Resources Data, *Water Resour. Res.*, 44: W05406, doi:10.1029/2007WR006392

WaterML and WaterOneFlow

WaterOneFlow is a set of web services that return data in a WaterML format

- Set of query functions (API)
- Returns data in WaterML



The screenshot shows a web browser window with the URL `http://river.sdsc.edu/wateroneflow/NWIS/UnitValues.aspx`. The page title is "WaterOneFlow Web Service". The main heading is "WaterOneFlow". Below the heading, it states: "The following operations are supported. For a formal definition, please review the [Service](#)".

- **GetSiteInfo**
Given a site number, this method returns the site's metadata. Send the site code in the query string.
- **GetSiteInfoObject**
Given a site number, this method returns the site's metadata. Send the site code in the query string.
- **GetSites**
Given an array of site numbers, this method returns the site metadata for each one. The query string will return all sites, up to a limit of 50,000.
- **GetSitesXml**
Given an array of site numbers, this method returns the site metadata for each one. The query string will return all sites, up to a limit of 50,000.
- **GetValues**
Given a site number, a variable, a start date, and an end date, this method returns an array of values for the variable. Sending a null BeginDate and EndDate will return all values for the variable.
- **GetValuesObject**
Given a site number, a variable, a start date, and an end date, this method returns an array of values for the variable. Sending a null BeginDate and EndDate will return all values for the variable.
- **GetVariableInfo**
Given a variable code, this method returns the variable's name. Pass in the variable code in the query string to get a list of all variables.
- **GetVariableInfoObject**
Given a variable code, this method returns the variable's siteName. Pass in the variable code in the query string to get a list of all variables.

```
<timeSeries>
- <sourceInfo xsi:type="SiteInfoType">
  <siteName>Colorado Rv at Austin, TX</siteName>
  <siteCode network="NWIS" siteID="4619631">08158000</siteCode>
- <geoLocation>
  - <geogLocation xsi:type="LatLonPointType" srs="EPSG:4326">
    <latitude>30.24465429</latitude>
    <longitude>-97.694448</longitude>
  </geogLocation>
</geoLocation>
</sourceInfo>
- <variable>
  <variableCode vocabulary="NWIS" default="true" variableCode="08158000">08158000</variableCode>
  <variableName>Discharge, cubic feet per second</variableName>
  <units unitsAbbreviation="cfs" unitsCode="35">cubic feet per second</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>
```

GetVariables

```
<variablesResponse xmlns="http://www.cuahsi.org/waterML/1.0/">
```

```
- <variables>
```

```
- <variable>
```

```
  <variableCode vocabulary="NWIS" default="true"
```

```
    variableID="12578">00060</variableCode>
```

```
  <variableName>Discharge, cubic feet per second</variableName>
```

```
  <units unitsAbbreviation="cfs" unitsCode="35">cubic feet per second</units>
```

```
</variable>
```

```
</variables>
```

```
</variablesResponse>
```

GetValues

```
<values count="15">
```

```
  <value qualifiers="A" dateTime="2006-01-01T00:00:00">237</value>
```

```
  <value qualifiers="A" dateTime="2006-01-02T00:00:00">252</value>
```

```
  <value qualifiers="A" dateTime="2006-01-03T00:00:00">154</value>
```

qualifier

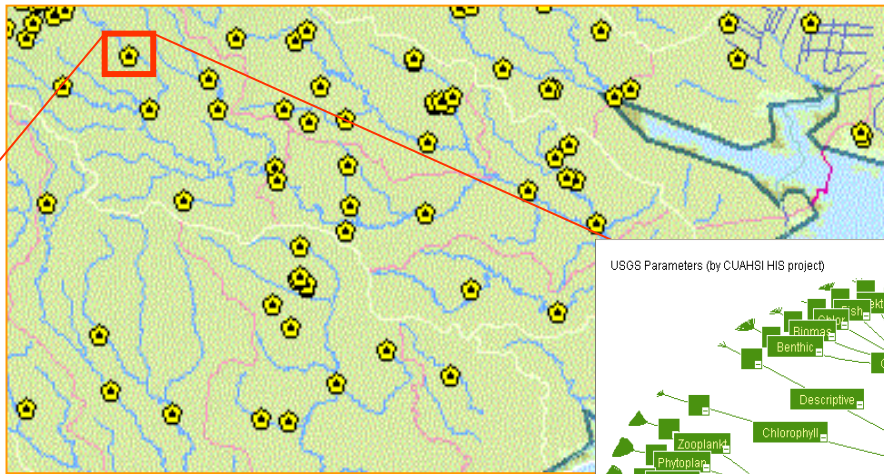
ISO Time

value

HIS Central

Centralized Observation Catalog with semantic mediation to enable search web services

Metadata catalog

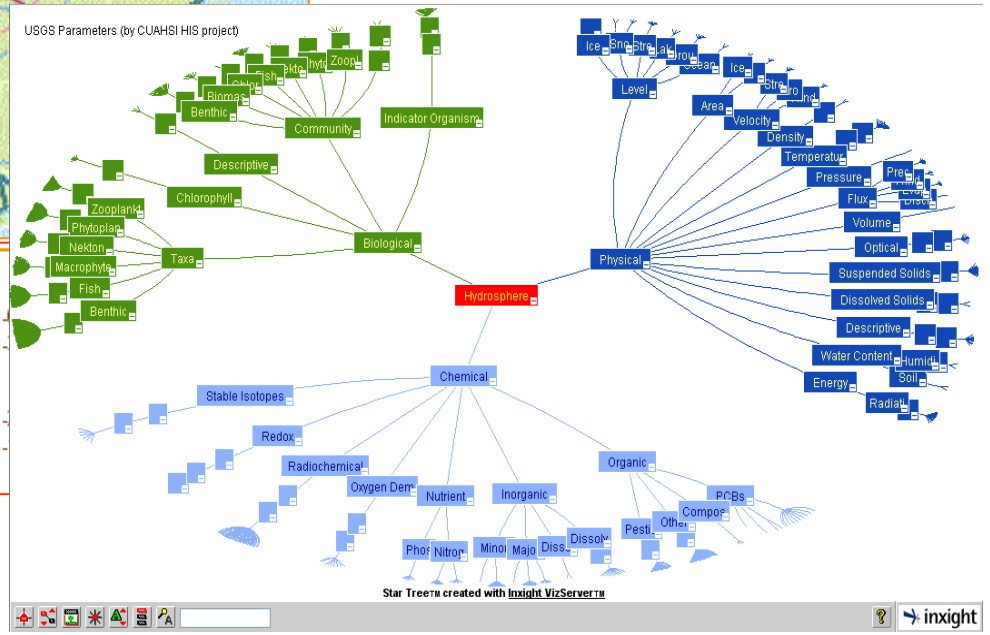


Station Name : NEUSE RIVER NEAR CLAYTON, NC
Station # : 02087500
Agency Code : USGS

Discharge begin date : 1927-08
Discharge end date : 2004-09
Discharge count number : 28186

Coord. accuracy Code : S
Lat & Long Datum Code : NAD83
Latitude (dd) : 35.64722220
Longitude (dd) : -78.40527780

Peak begin date : 1919-07
Peak end date : 2004-08
Peak count number : 78



66 services; 18,000 variables; 1.9 million sites; 29 million series; 5.1 billion data Values ... and growing

USGS Instantaneous Data

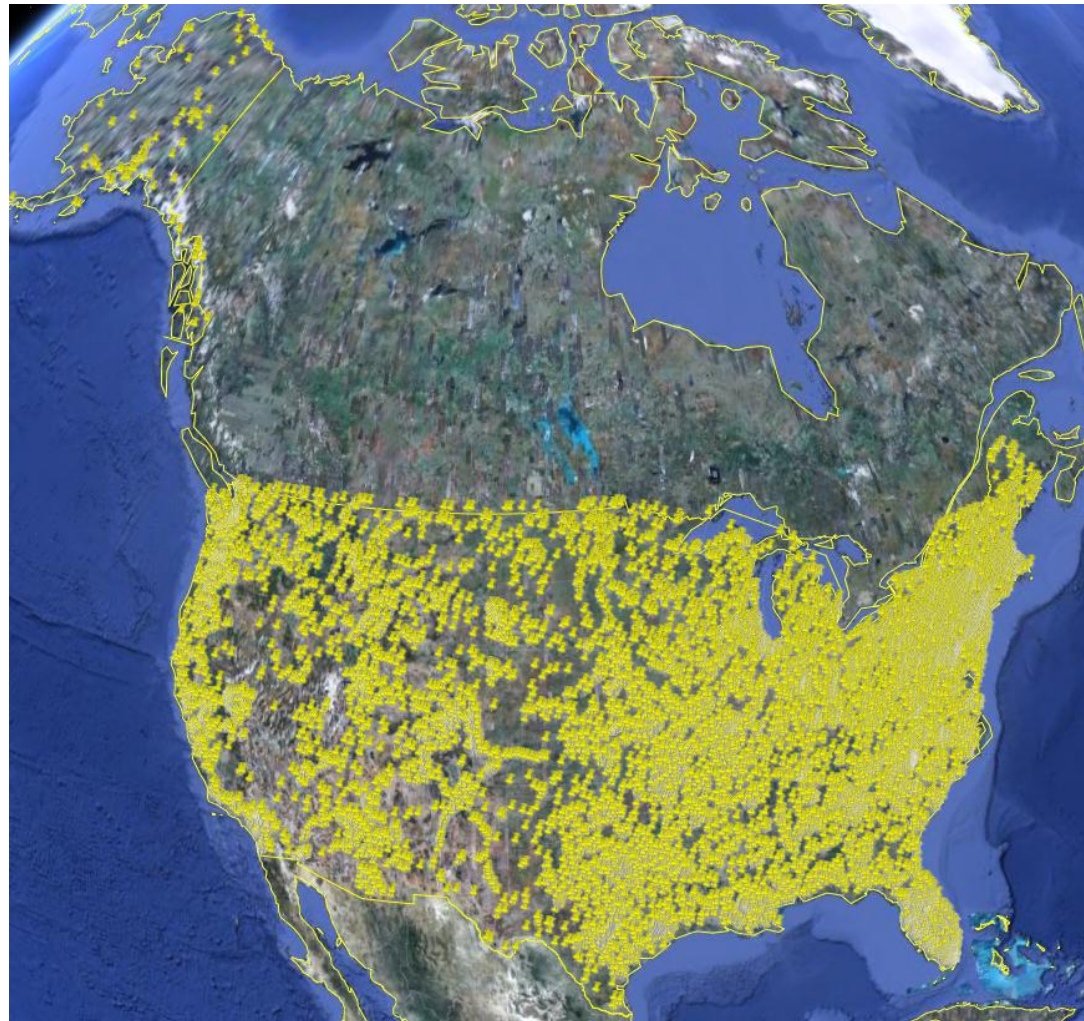


Real time,
instantaneous data over
the last 60 days

11188 sites, nationally
for the US

80 variables

Published by **USGS**
National Water
Information System



NCDC Integrated Station Hourly Data

**National Climatic
Data Center**

Hourly weather data up
to 36 hours ago

13,628 sites across globe

34 variables

Published by **National
Climate Data Center**
and populated with
weather observations
from national weather
services



http://water.sdsc.edu/wateroneflow/NCDC/ISH_1_0.aspx?WSDL

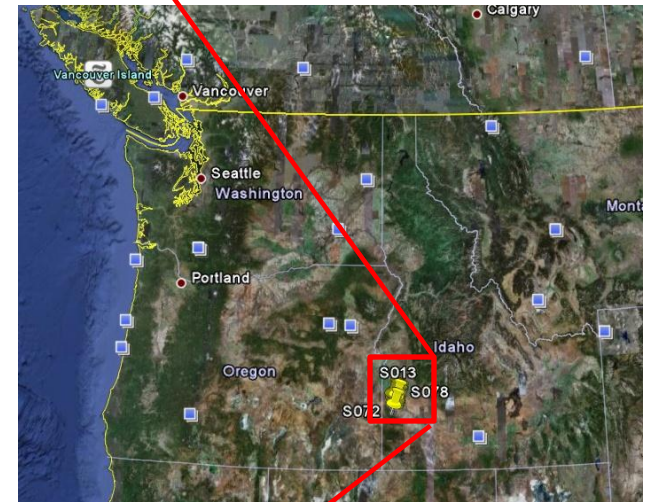
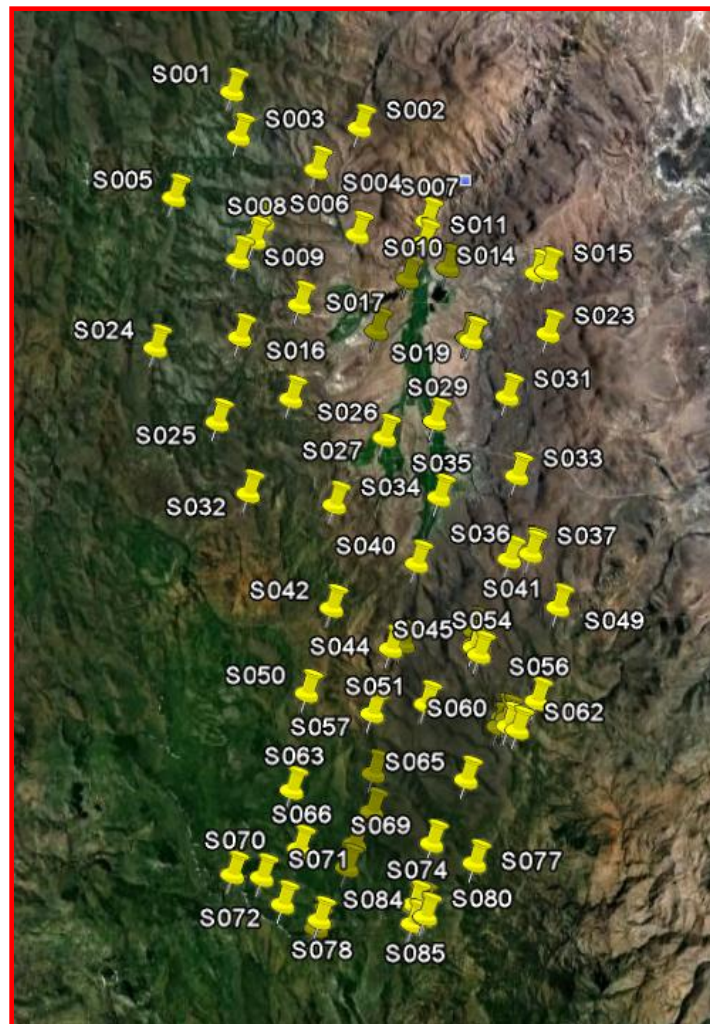
Reynolds Creek Experimental Watershed



United States Department Of Agriculture
Agricultural Research Service

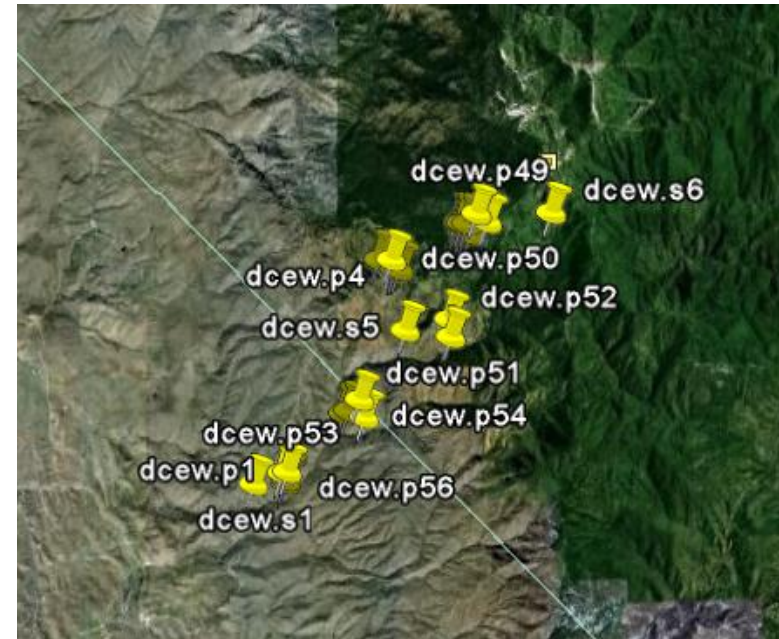
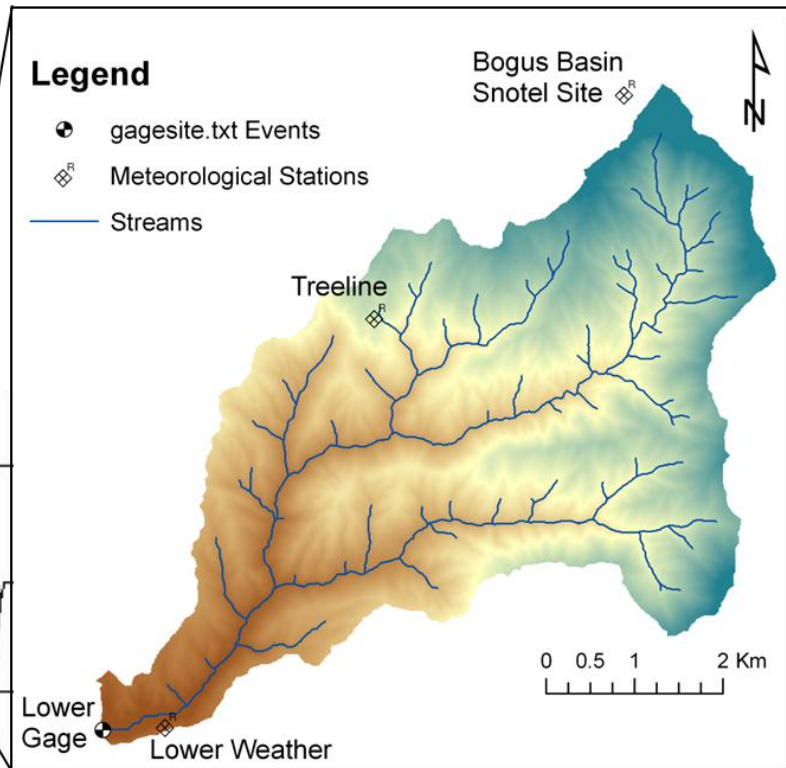
1 data service
84 sites
65 variables
372 series
17.8 million data

Published by **USDA-ARS** as part of an
Idaho Waters project



Dry Creek Experimental Watershed (DCEW)

(28 km² semi-arid steep topography, Boise Front)



68 Sites
20 Variables
5924511 values

Published by Jim McNamara,
Boise State University

HydroDesktop

The screenshot displays the HydroDesktop software interface. At the top, there is a menu bar with 'Home', 'Table', 'Graph', 'Edit', and 'Help'. Below the menu is a toolbar with various map tools: Search, Pan, Zoom In, Zoom Out, MaxExtents, Previous, Next, Add, Identify, Select, Attribute, and Measure. There are also buttons for 'Enable Basemap', 'Online Basemap' (with 'Opacity 100' and 'ESRI Hydro Base Map' dropdown), 'Delineate', and 'EPA Tool'.

The main area is divided into three panels:

- Map Layers:** A list of layers on the left side, including 'Watershed Point', 'Reaches', 'watershed', '"Search Results"', 'Themes', 'Jacob's Hy...', 'NWISC', 'Online Basemap', 'Base Map Data', and 'lakes'. A yellow box labeled 'Metadata' has an arrow pointing to the 'watershed' layer.
- Map:** A central map showing a watershed area highlighted in cyan. A yellow box labeled 'Data' has an arrow pointing to the map area.
- Search Results:** A panel on the right with tabs for 'Area', 'Options', 'Keywords', 'Results', and 'Search Management'. It contains 'Start Date' (10/ 1/2009) and 'End Date' (9/30/2010) fields, a 'Show Web Service Selection Panel' checkbox, and a 'Web Services' list. A yellow box labeled 'Catalog' has an arrow pointing to the 'Web Services' list. The list includes: 'NWIS Ground Water Level', 'NWIS Instantaneous Irregular Data', 'NWIS Unit Values', 'NWS-WGRFC Daily Multi-sensor Precipitation Estimates' (checked), and 'NWS-WGRFC Dallas and Tarrant Counties'. Below the list is a 'Selected Web Services' section containing 'NWS-WGRFC Daily Multi-sensor Precipitation Estimates'.

HydroModeler: A HydroDesktop Plug-in

CUAHSI HydroDesktop *
Home Table Graph Edit Help HydroModeler

Open Save Save As... Add Component Add Trigger Add Connection Run Clear Composition

C:\Program Files\CUAHSI HIS\HydroDesktop\Plugins\H ...
Current Directory

Pan Help

Double click, or drag the desired model to add it to the HydroModeler composition window.

Name	Type	Details
...	Folder	
bin	Folder	
data	Folder	
models	Folder	
PET_Model	Model	opr

Model Directory Explorer

Property	Value
Link id=2	
Providing Model	PET: Penman-Monteith2
Quantity	PET
Element Set	SC_NC Study
Accepting Model	Oatc.OpenMI.Gui.Trigger
Quantity	TriggerQuantityID
Element Set	TriggerElementID
Data	
Link i	
Propert	

Model Attributes

Save Add Item >>

Database: C:\Users\jg-local\AppData\Local\Temp\HydroDesktop\NewProject_2011-06-22_714.sqlite

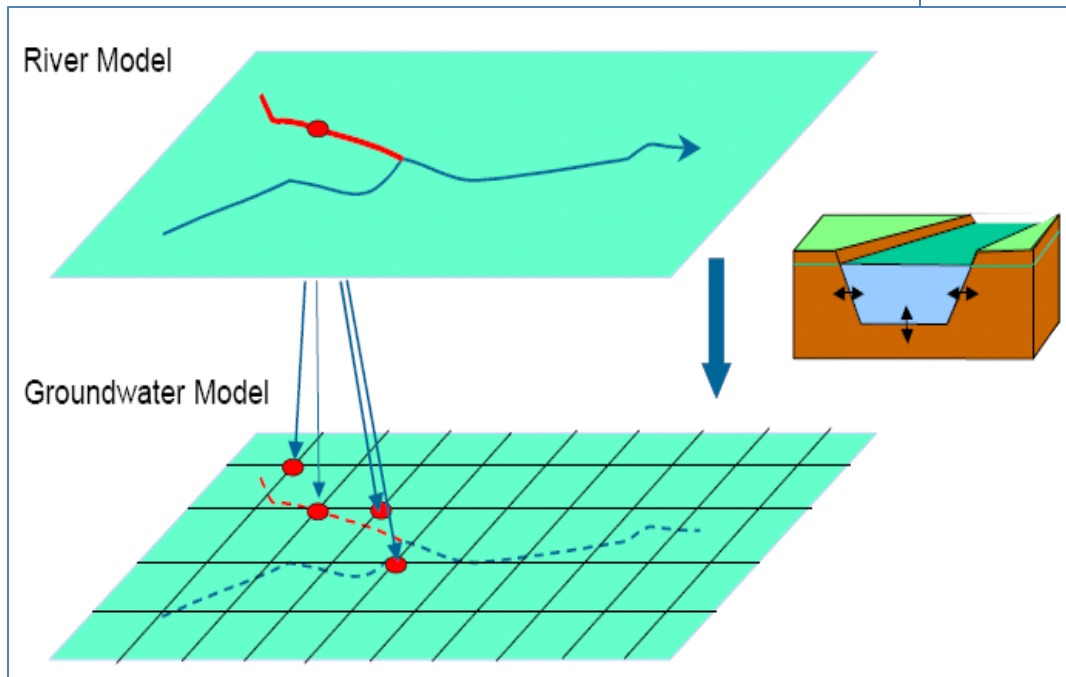
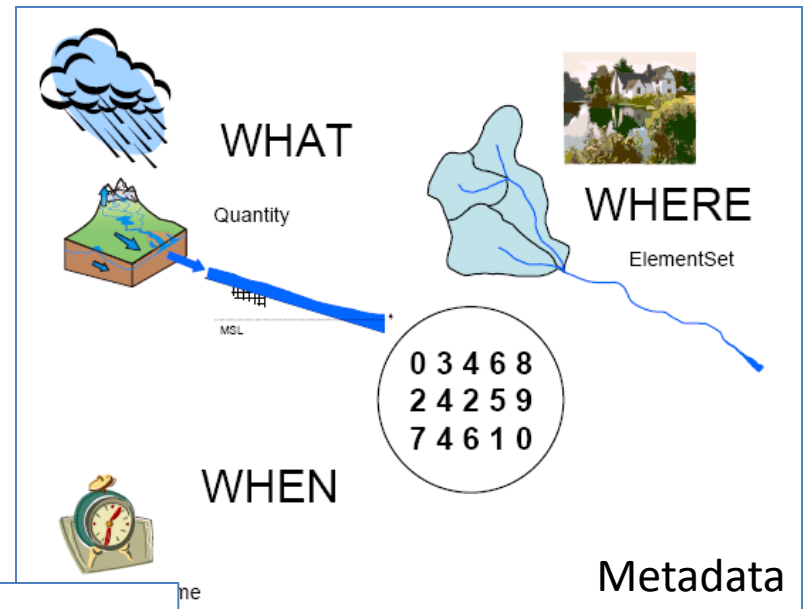
```
graph TD; SolarRadiation((Solar Radiation)) --> PET((PET: Penman-Monteith2)); DbReader((Db Reader)) --> PET; PET --> DbWriter((Db Writer)); PET --> Trigger{Trigger}
```

Model Configuration

Open Modeling Interface

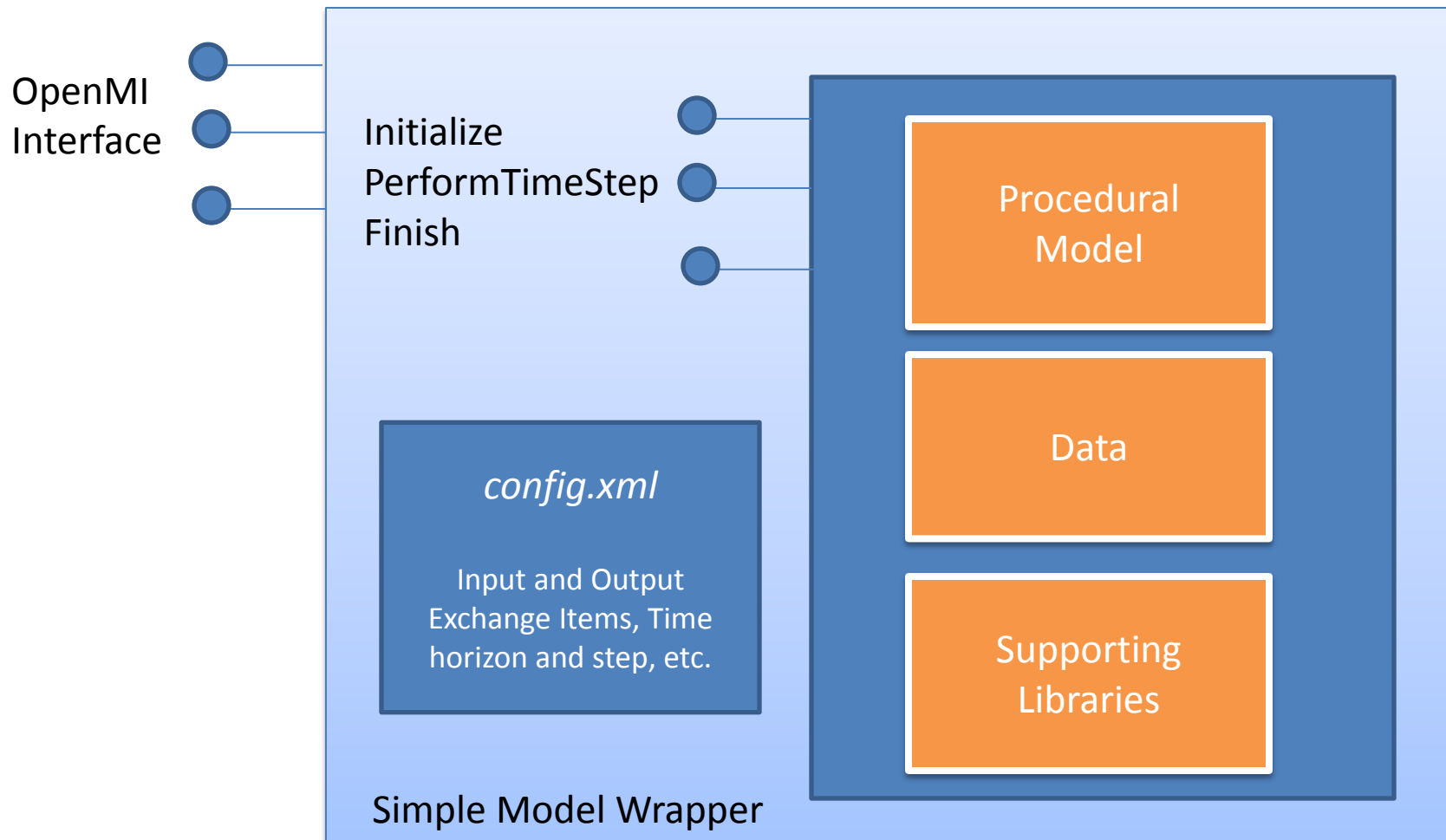
allows models to exchange on a time basis

- standard
- Software Development Kit (SDK)



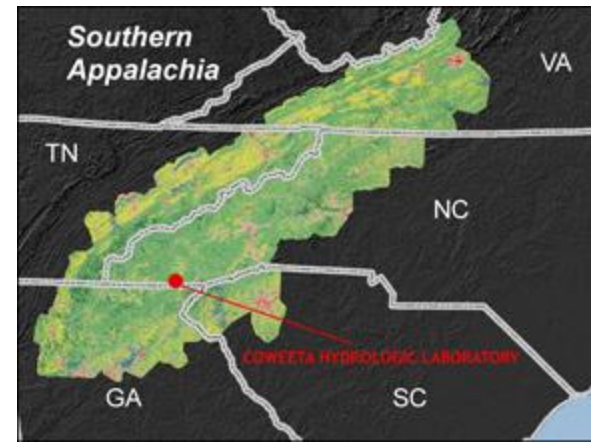
www.openmi.org

The Architecture of a Model Component



Example Application

- Modeling rainfall/runoff for Coweeta Watershed #18



- HIS Server includes publically available Coweeta data
 - Precipitation: daily accumulated
 - Air temp: daily min, max, and mean
 - Stream discharge: daily average

Mostafa Elag and
Tony Castronova, USC

Coweeta HIS Server

CUAHSI
HIS
Sharing hydrologic data

Home All Data Services

Coweeta Hydrologic Laboratory Public Data

Coweeta Hydrologic Laboratory and LTER
COWEETA
http://river.sdsc.edu/WaterOneFlow/Coweeta/cuahsi_1_1.asmx

Contact: Jon Goodall
goodall@cec.sc.edu
803-777-8184

Service Statistics:	
Sites:	2
Variables:	5
Values:	129663
Geographic Extent:	
	35.06667
	-83.436
	35.05116
Last Harvested on 6/12/2011 8:37:31 PM (updated weekly, assumed static)	

Abstract

A portion of the publicly available data from Coweeta Hydrologic Laboratory included in HIS for testing and demonstration purposes. Coweeta is one of the oldest continuous environmental studies in North America. Coweeta is based in the eastern deciduous forest of the southern Appalachian Mountains, and the centerpiece of a long-term cooperation between the University of Georgia and the USDA Forest Service. The Coweeta Hydrologic Laboratory is an experimental forest within the USDA Forest Service Southern Research Station. USFS scientists have monitored streamflow and climate on several gaged watersheds within the Coweeta basin since 1934, and atmospheric deposition and stream chemistry since 1972. In addition, the Coweeta Hydrologic Lab is a National Science Foundation LTER site. The Coweeta LTER has evolved from a site-based to a site- and region-based project centering on the effects of

Citation

Please see the following website for citation information. <http://coweeta.uga.edu/policies/publication>

http://river.sdsc.edu/WaterOneFlow/Coweeta/cuahsi_1_1.asmx?WSDL

Coweeta Watershed #18

CUAHSI HydroDesktop * [Minimize] [Maximize] [Close]

Home Table Graph Edit Help HydroModeler

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

Map Layers

- coweeta_streams
- WS18_streams
- Themes
 - Coweeta Streamflow
 - Coweeta Precipitation
 - Coweeta Ave Temp
 - Coweeta Min Temp
 - Coweeta Max Temp
- WS18
- coweeta_basin

Watershed #18 Area:
12.48 ha (0.12 km²)
650m by 300 m

Area Options Keywords Results Search Management

Start Date: 6/20/2010 End Date: 6/20/2011

Show Web Service Selection Panel

Web Services

Refresh Select All Select None

- Christina River Basin Critical Zone Observatory
- Cosmic-ray Soil Moisture Observation System
- Coweeta Hydrologic Laboratory Public Data
- Crown of the Continent Observatory Snow
- Great Smoky Mountains

Selected Web Services

Search Summary

Server: HIS Central Area: Parameters

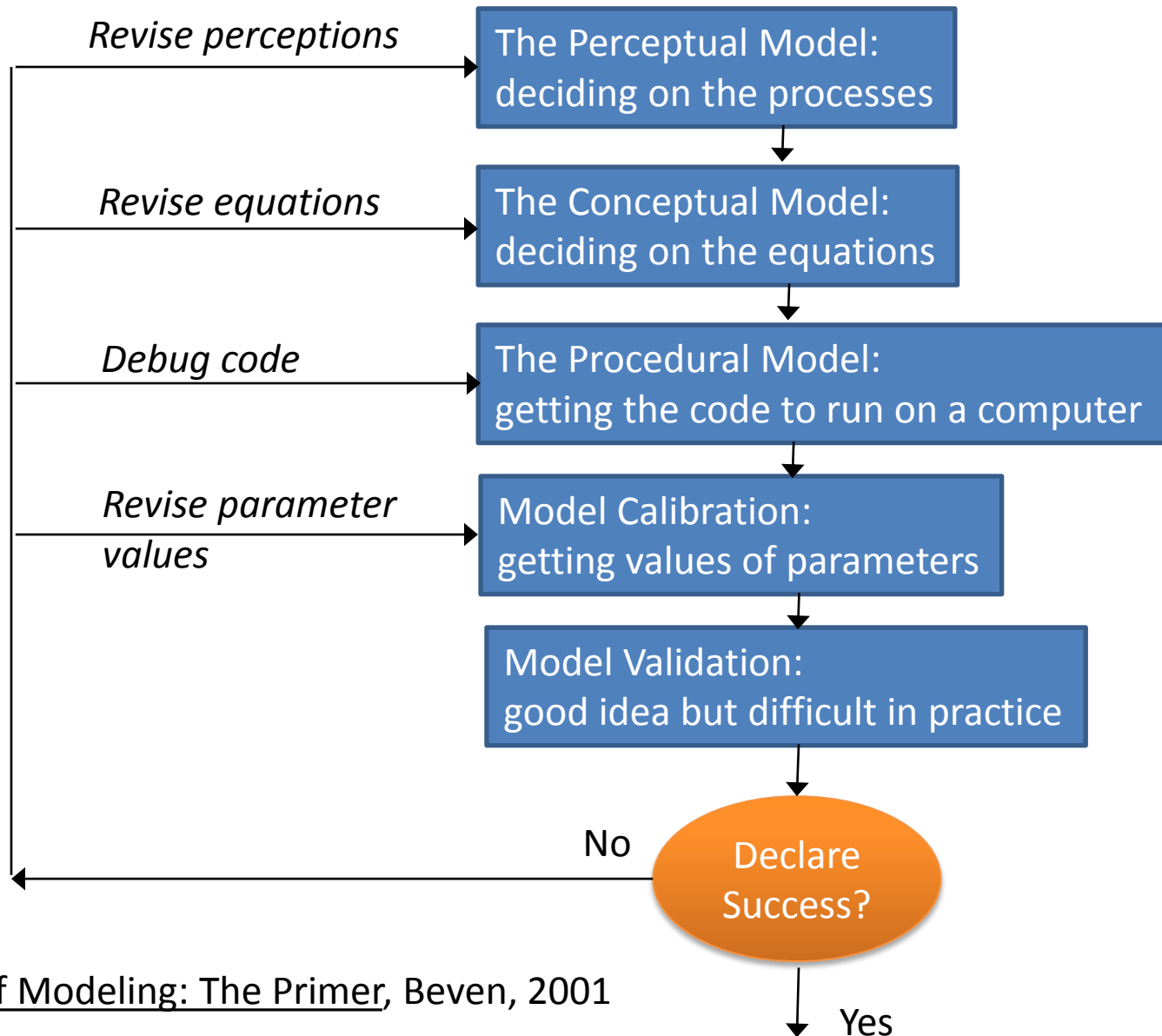
Web Services

Keywords Date Range: 6/20/2010 :: 6/20/2011

Run Search

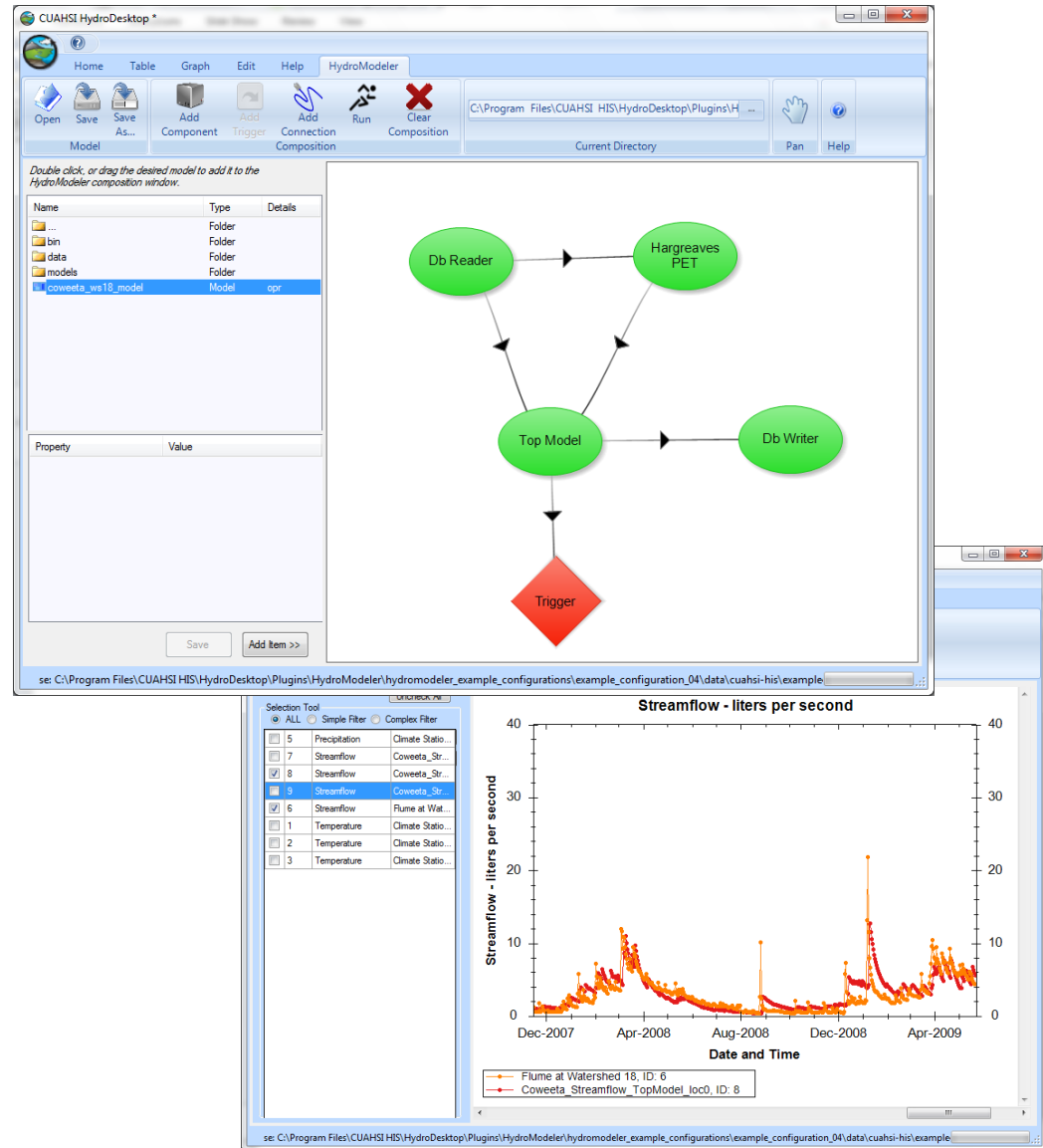
Longitude: 83°27'12"W, Latitude: 35°05'02"N

Steps in the Hydrologic Modeling Process



Model Development and Application

- Do I have the important processes?
- Is my mathematical representation of processes sufficient?
- Are there bugs in my numerical solution?
- Do I have an acceptable parameterization?



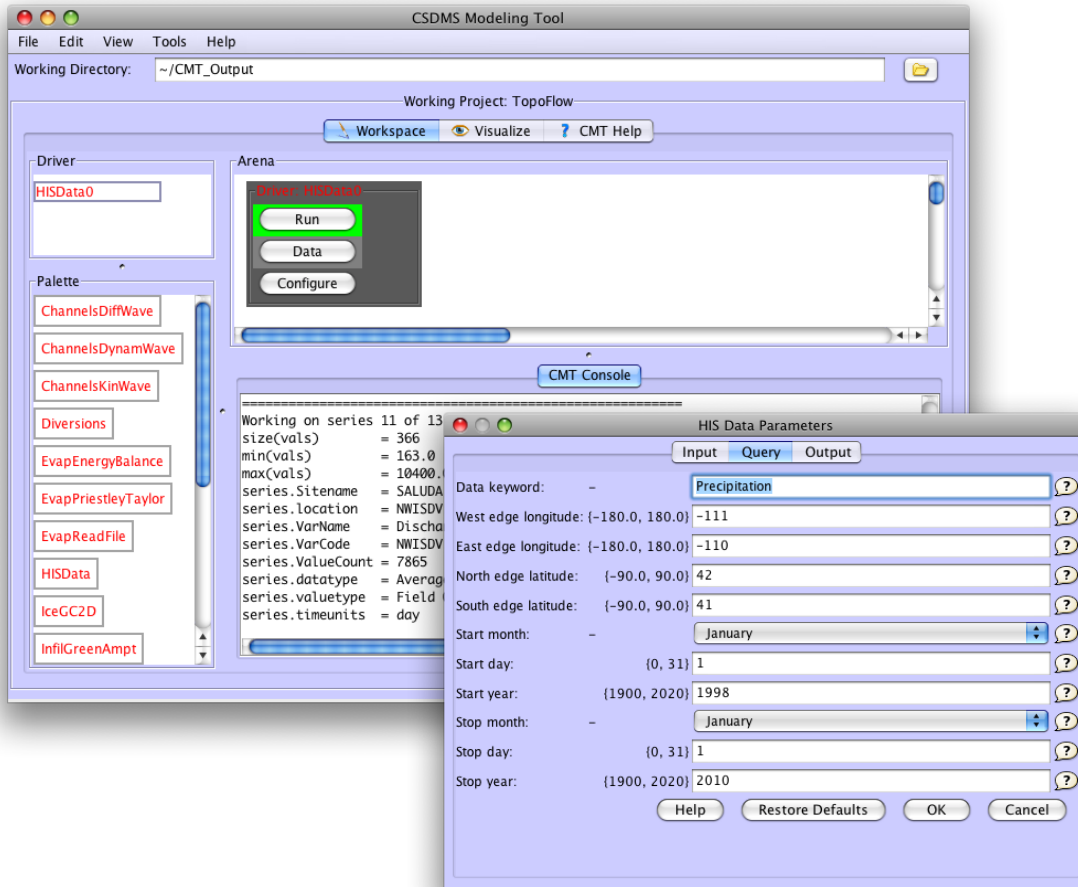
HIS Data can be used in other Modeling Systems



Object Modeling System v3.0



Example: Accessing HIS Data from within CMT

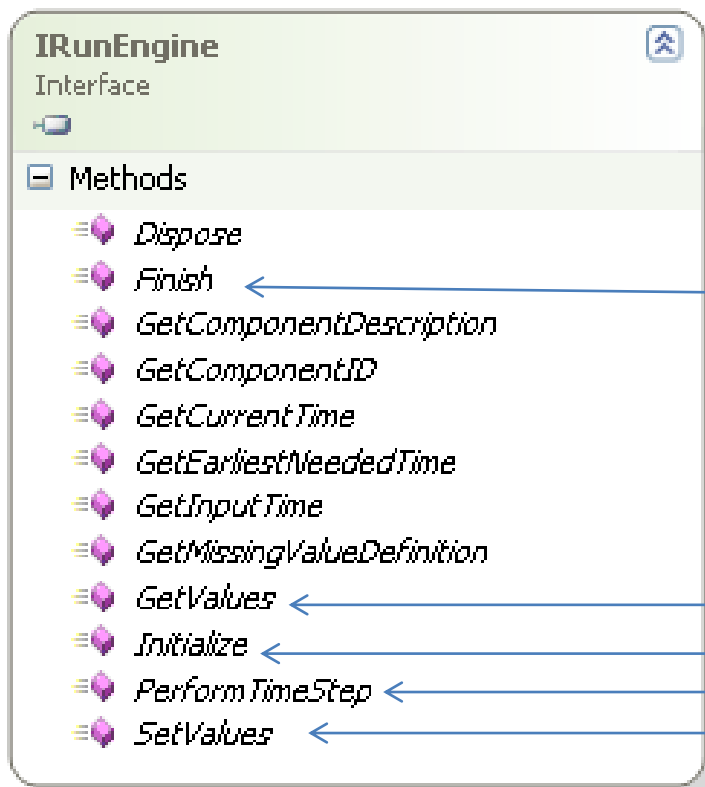


- HISData is a CMT component that can search HIS Central and download data from WaterOneFlow web services
- It allows HIS data to serve as input to CMT models

Path Forward

- Cross-disciplinary science: Interoperability across modeling systems

OpenMI Model Interface



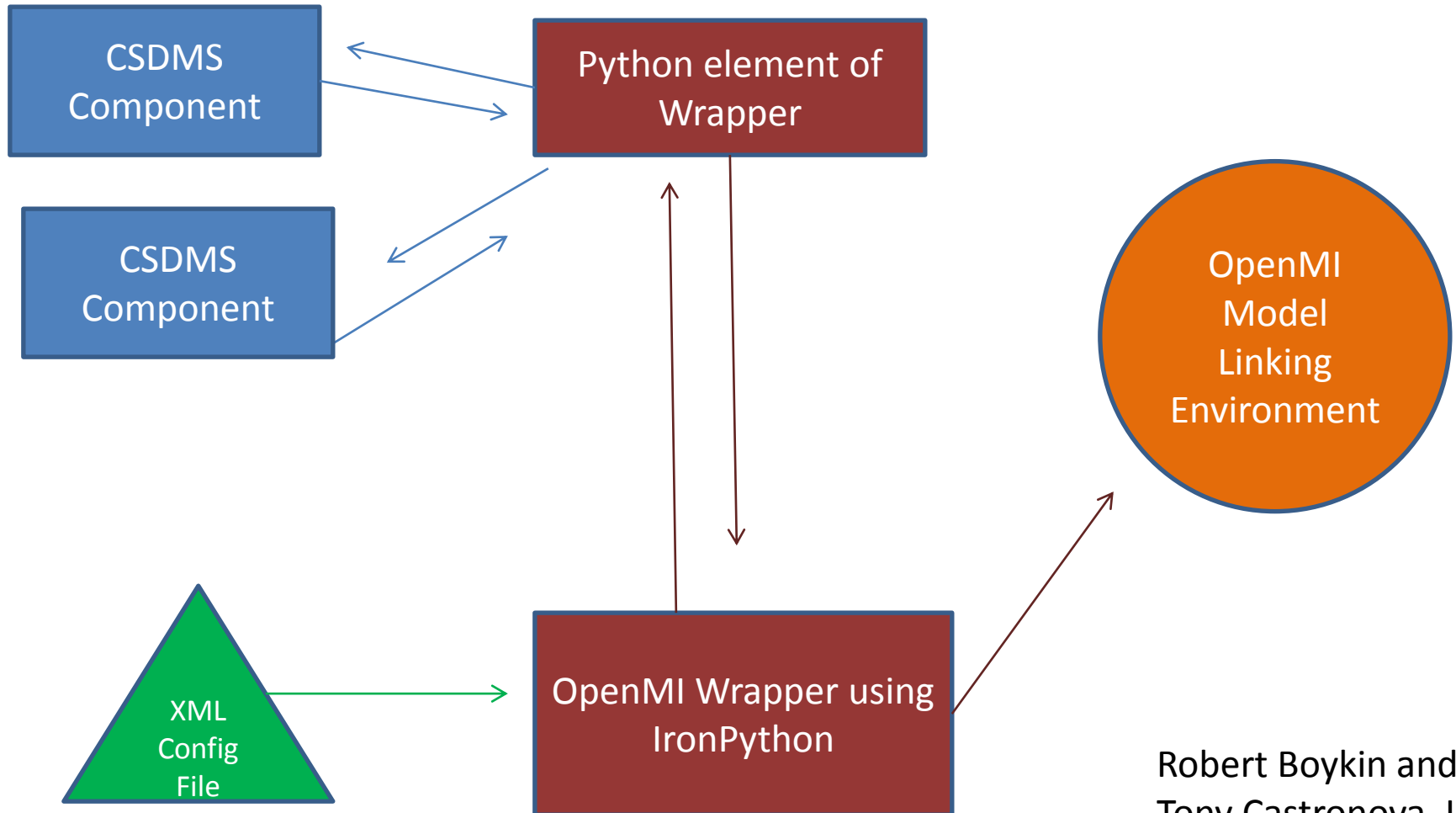
CSDMS Basic Modeling Interface (BMI)

Finalize

Getter
Initialize
Run
Setter

CSDMS/OpenMI Interoperability

Goal: Import CSMDS Components into an OpenMI modeling environment



Robert Boykin and
Tony Castronova, USC

ESMF/OpenMI Interoperability

Goal:

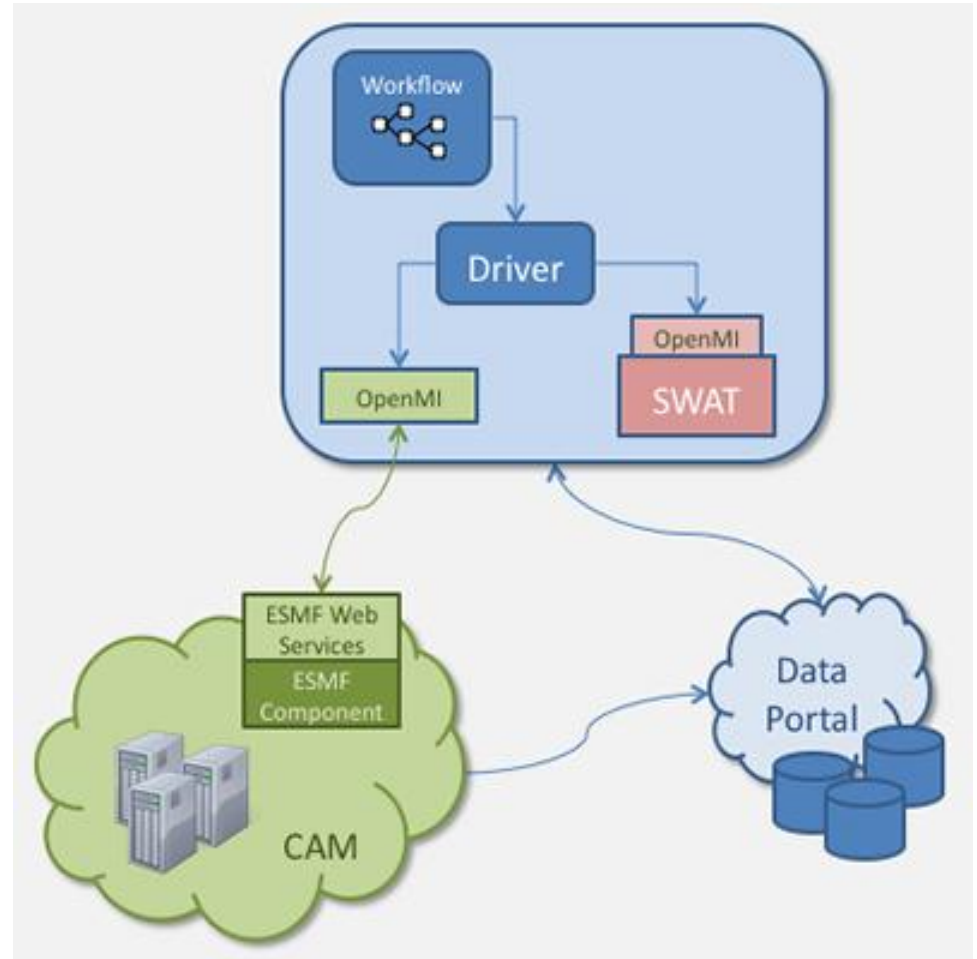
Scientific Workflow that couples desktop hydrologic models (wrapped using OpenMI) with HPC climate models (wrapped using ESMF) through web services

Project Team:

Kathy Saint, Sylvia Murphy, and Cecelia DeLuca -- ESMF Core Team

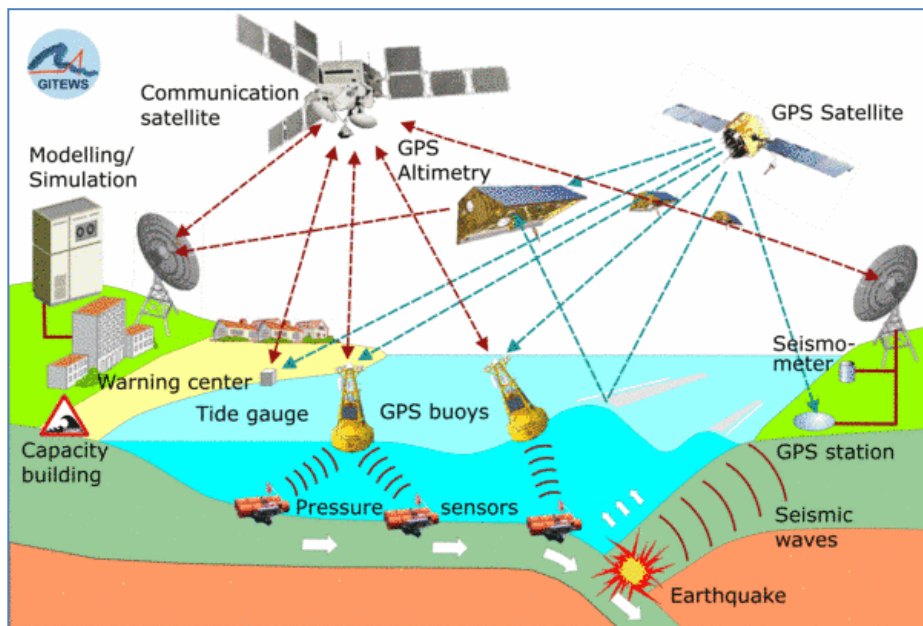
Jon Goodall and Mehmet Ercan -- University of South Carolina

Ricky Rood and Laura Briley -- University of Michigan



Common Standards across Earth Science Modeling and Information Systems

Open Geospatial Consortium (OGC)



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

The Open Geospatial Consortium (OGC®) and the **OpenMI Association** announced that they recently signed a memorandum of understanding (MOU) to cooperate in standards development and promotion of open standards related to computer modelling.

<http://www.opengeospatial.org/pressroom/pressreleases/1450>

WaterML 2.0 is a candidate Open Geospatial Consortium encoding standard for the representation of in-situ hydrological observations data.

<http://www.opengeospatial.org/projects/groups/waterml2.0swg>

The **THREDDS Data Server (TDS)** is a web server that provides metadata and data access for scientific datasets, using OPeNDAP, **OGC WMS** and **WCS**, HTTP, and other remote data access protocols.

www.unidata.ucar.edu/projects/THREDDS

Summary

- HIS provides
 - *standards* for accessing hydrologic observational data
 - WaterML, WaterOneFlow API, ODM
 - *software* to simplify access and use of hydrologic observational data
 - HydroServer, HydroCatalog, HydroDesktop, HydroModeler
- Agreed upon standards and protocols for component interfaces and data exchanges will facilitate interoperability across earth science modeling and information systems