CUAHSI
HIS
Sharing hydrologic data

Support EAR 0622374

Advancing an Information Model for Environmental Observations

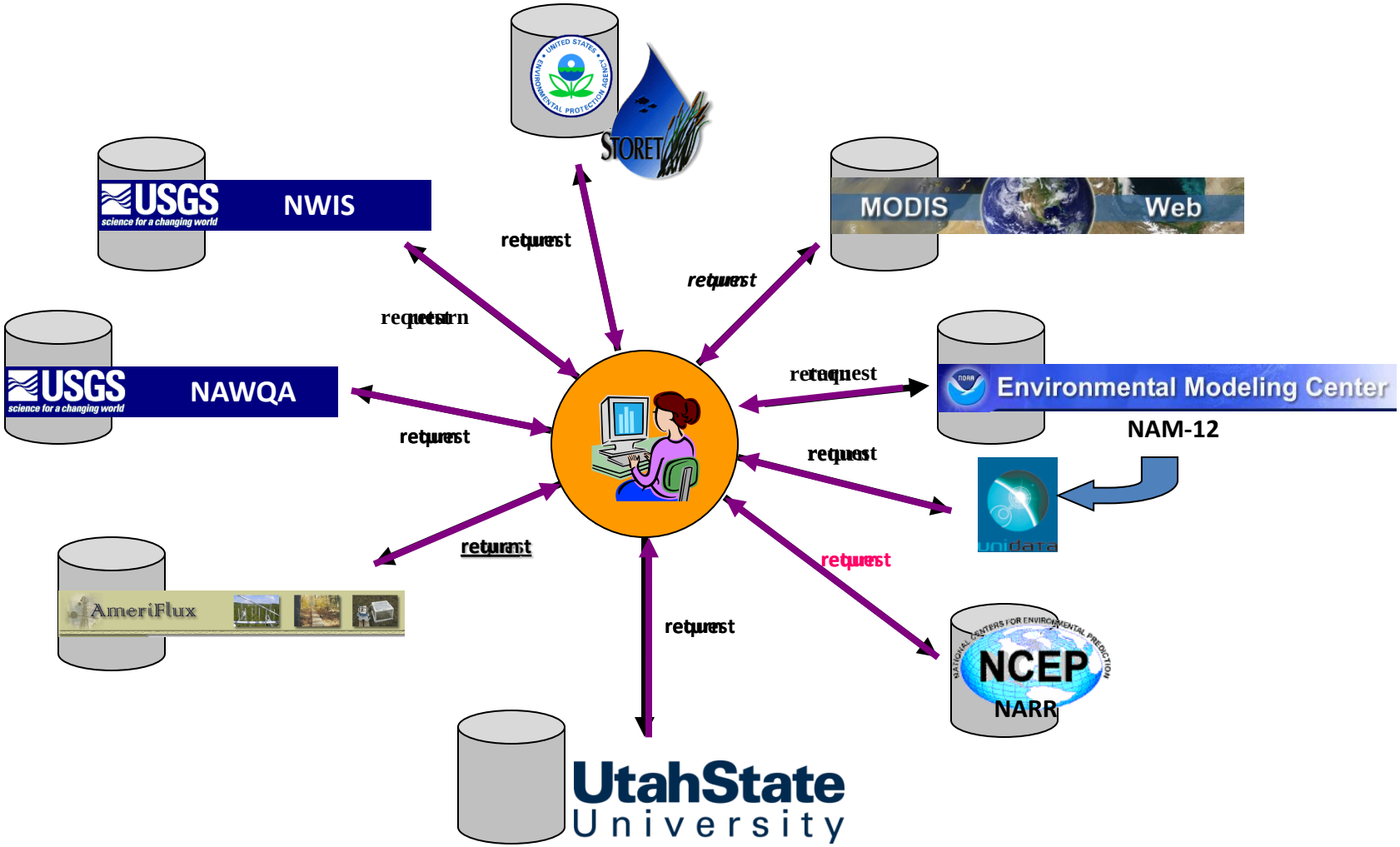
Jeffery S. Horsburgh

Anthony Aufdenkampe, Richard P. Hooper, Kerstin Lehnert, Kim Schreuders, David G. Tarboton

UtahState University

Utah Water Research Laboratory
UWRL

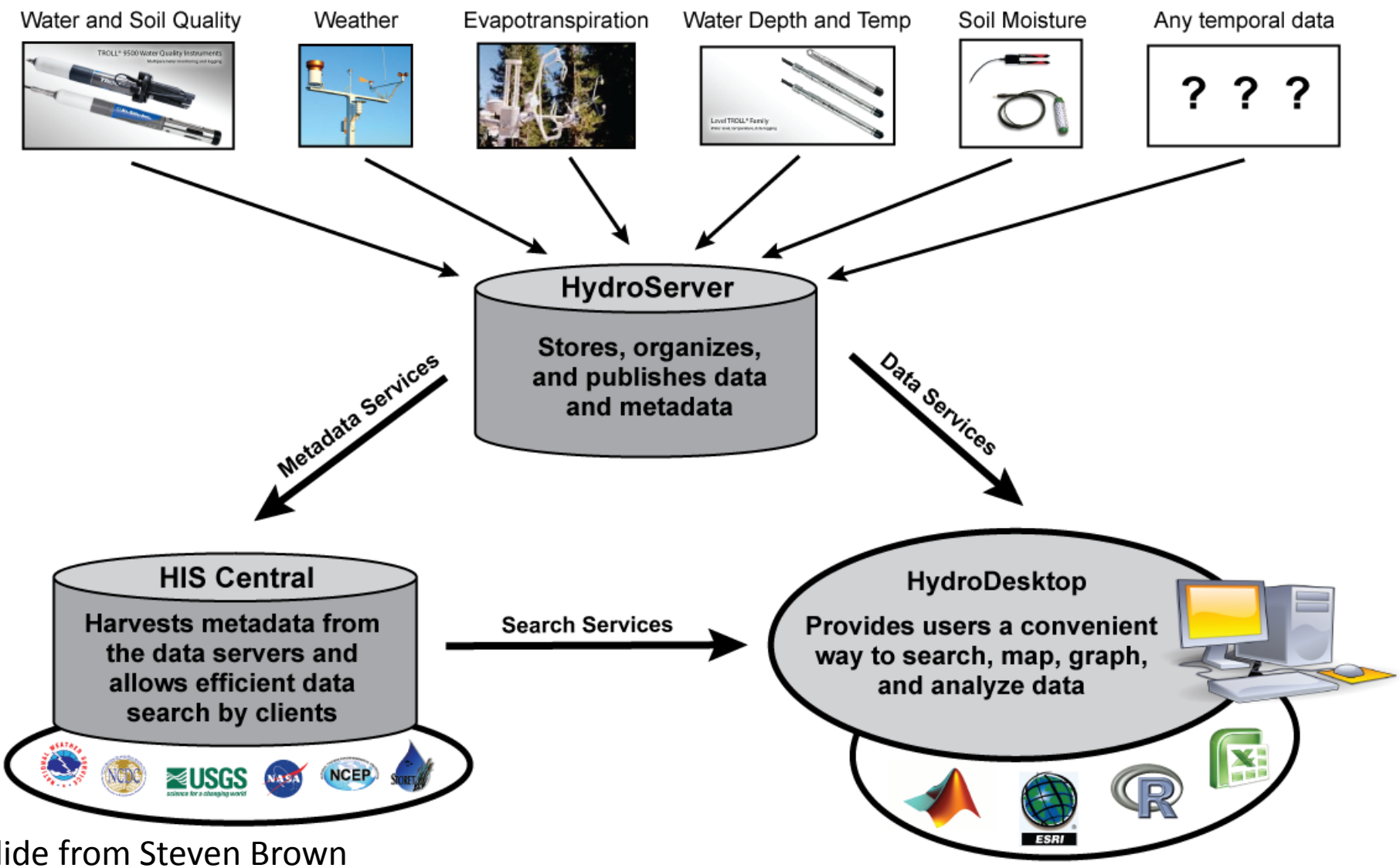
The Original Problem
Combining Similar Data from Disparate Sources



Slide from Michael Piasecki

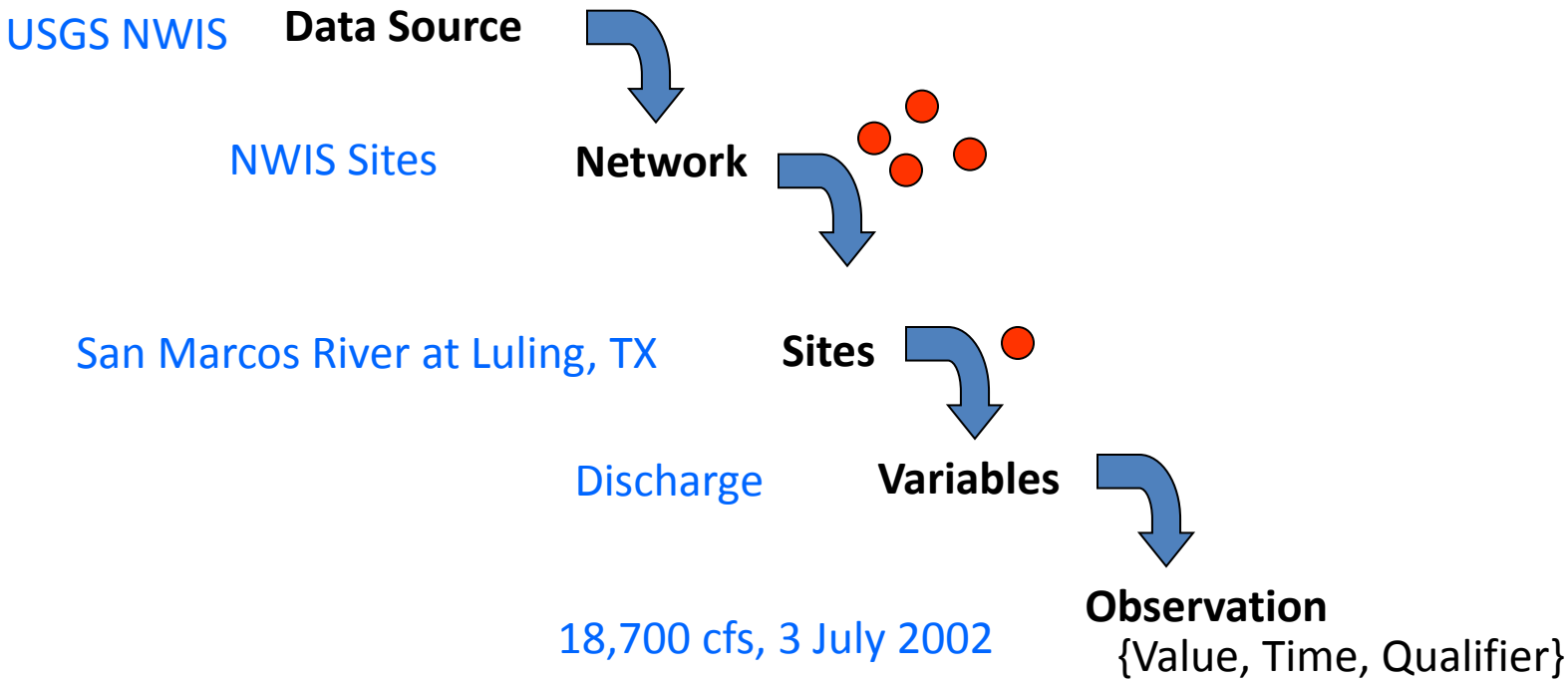
CUAHSI Hydrologic Information System

A Services Oriented Architecture for Sharing Hydrologic Observations



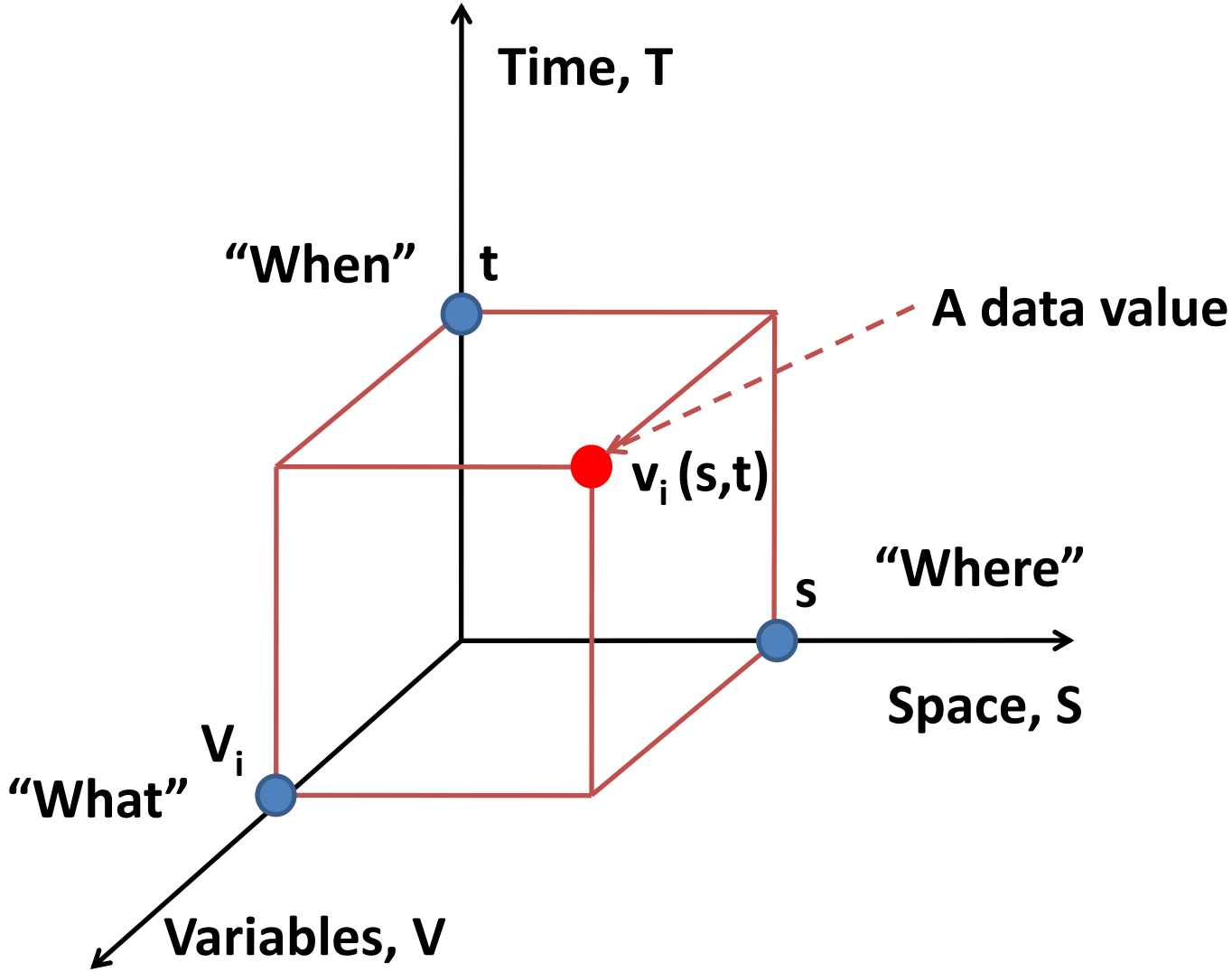
Slide from Steven Brown

Point Observations-Network Information Model

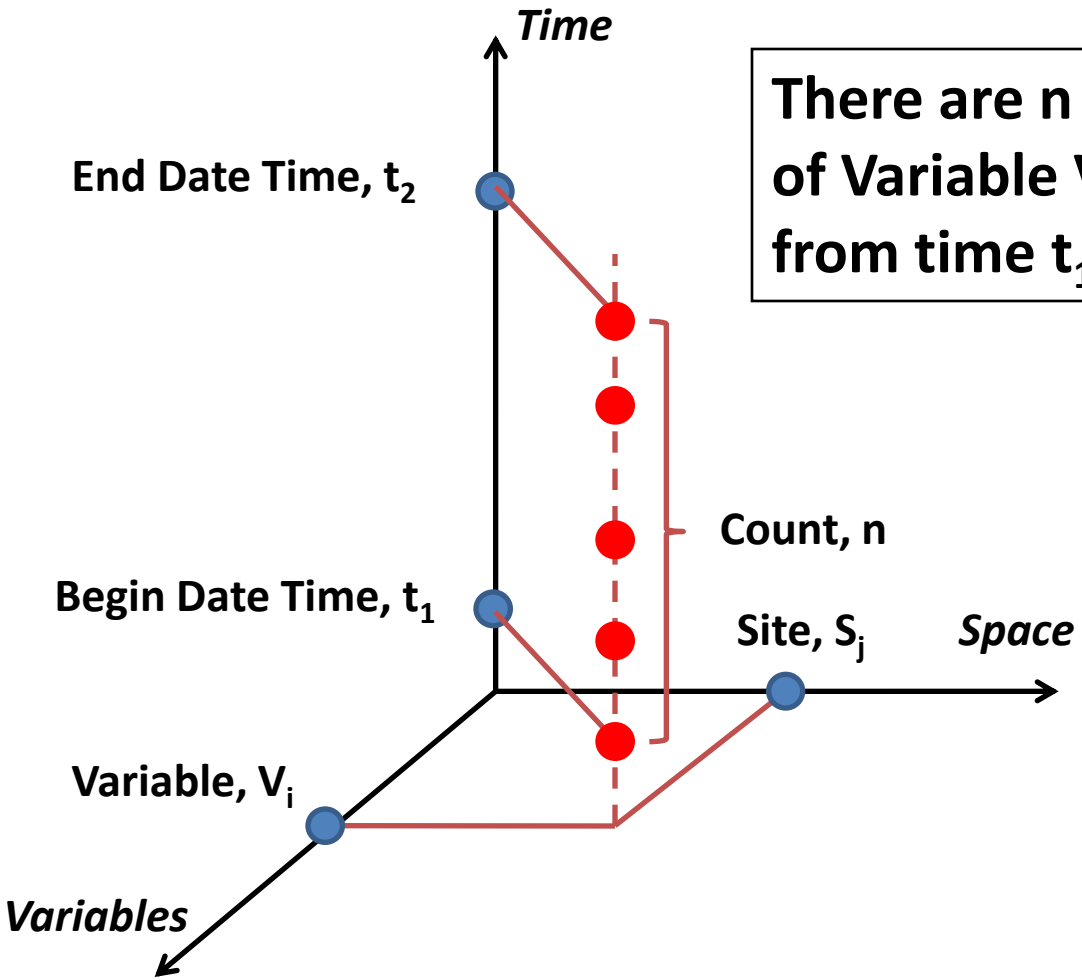


- A data source operates an observation network
- A network is a set of observation sites
- A site is a point location where one or more variables are measured
- A variable is a property describing the flow or quality of water
- A value is an observation of a variable at a particular time
- A qualifier is a symbol that provides additional information about the value

Data Values – Indexed by "What-Where-When"



Data Series – Time Series of Data Values



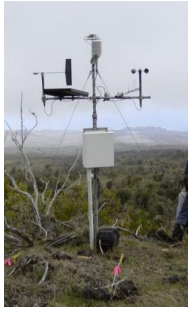
There are n measurements of Variable V_i at Site S_j from time t_1 to time t_2

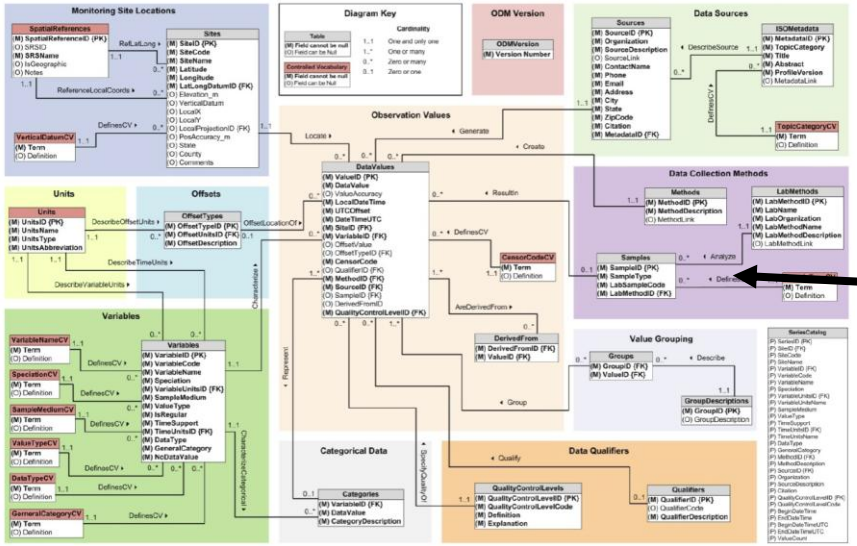
Observations Data Model (ODM)

Streamflow

Groundwater levels

Precipitation & Climate





Soil moisture data

Water Quality

Flux tower data

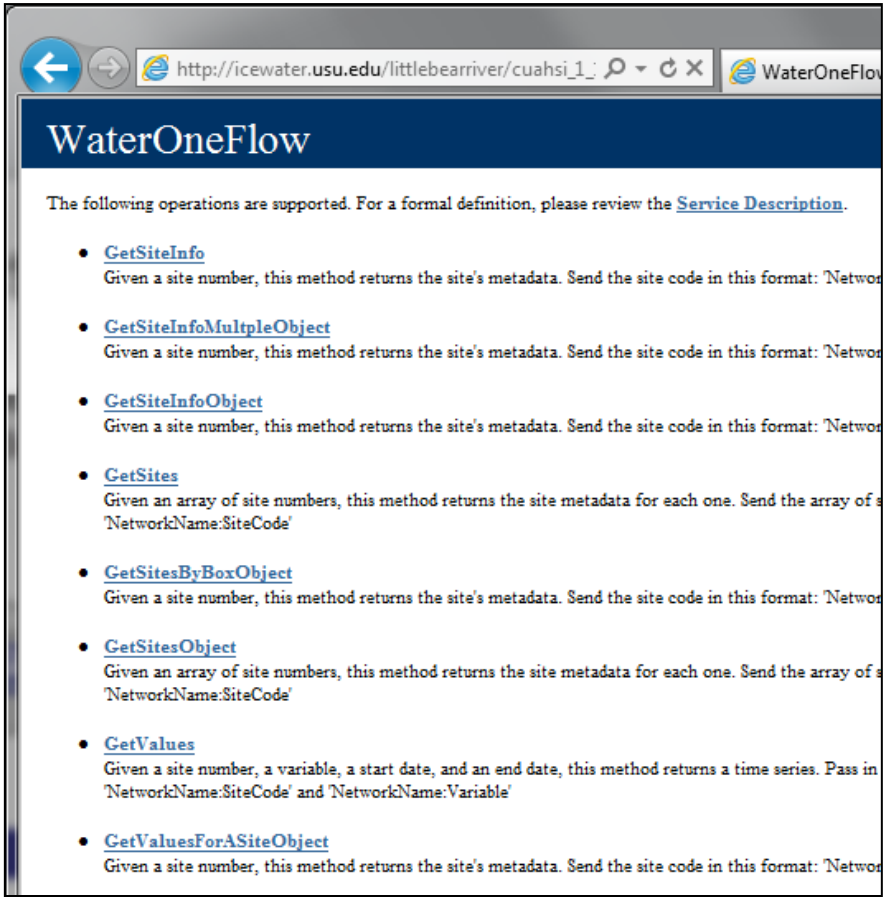
- A relational database at the single observation level
- Metadata for unambiguous interpretation
- Traceable heritage from raw measurements to usable information
- Promote syntactic and semantic consistency

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.

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

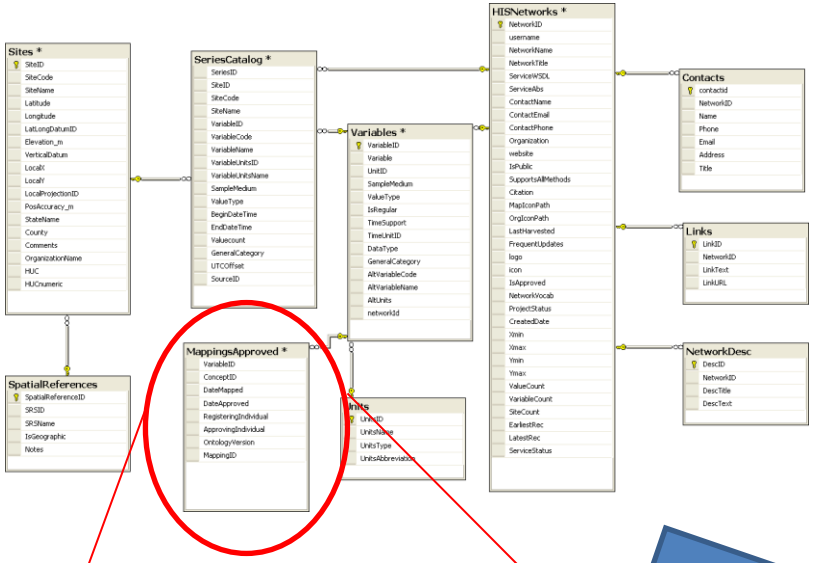

```
<timeSeries>
- <sourceInfo xsi:type="SiteInfoType">
    <siteName>Colorado Rv at Austin, TX</siteName>
    <siteCode network="NWIS" siteID="4619631">08158000
  - <geoLocation>
    - <geogLocation xsi:type="LatLonPointType" srs="EPSG
        <latitude>30.24465429</latitude>
        <longitude>-97.694448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

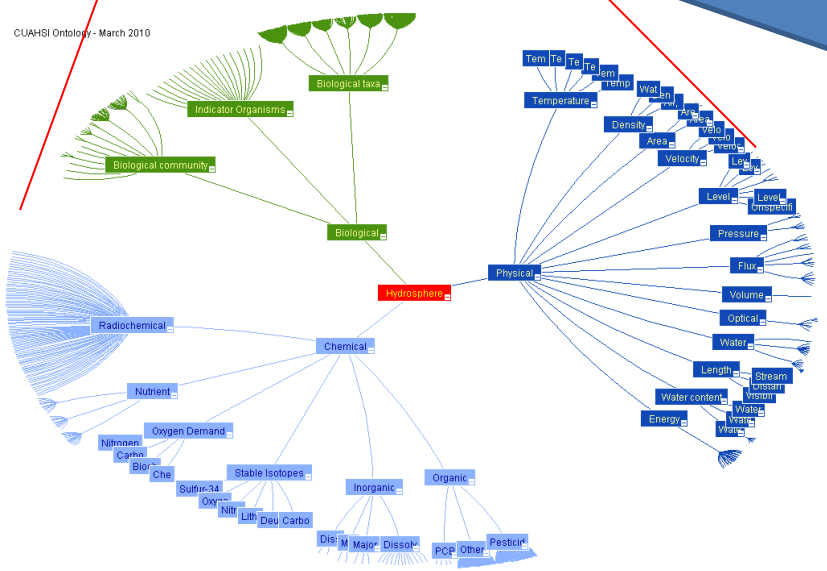
HydroCatalog

http://hiscentral.cuahsi.org

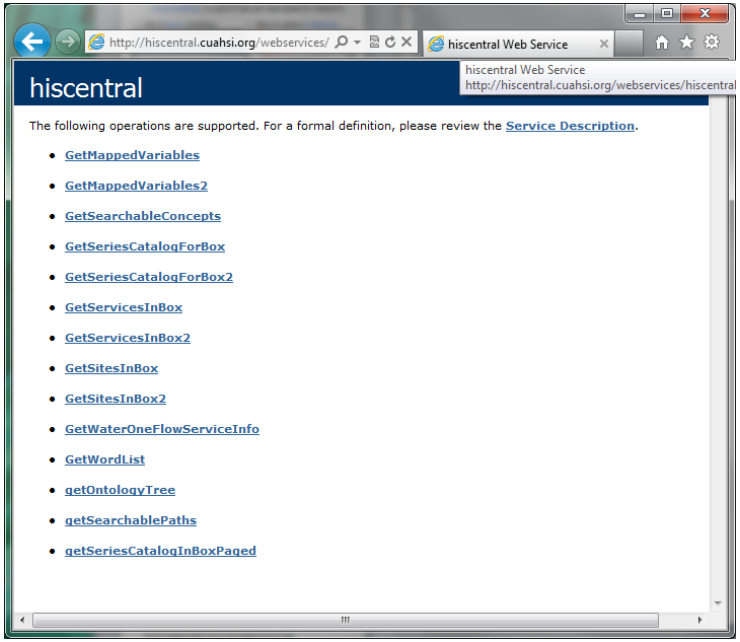
- Service registry
- Metadata harvester
- Catalog database
- Semantic tagging application
- Data discovery services

Metadata Catalog Database



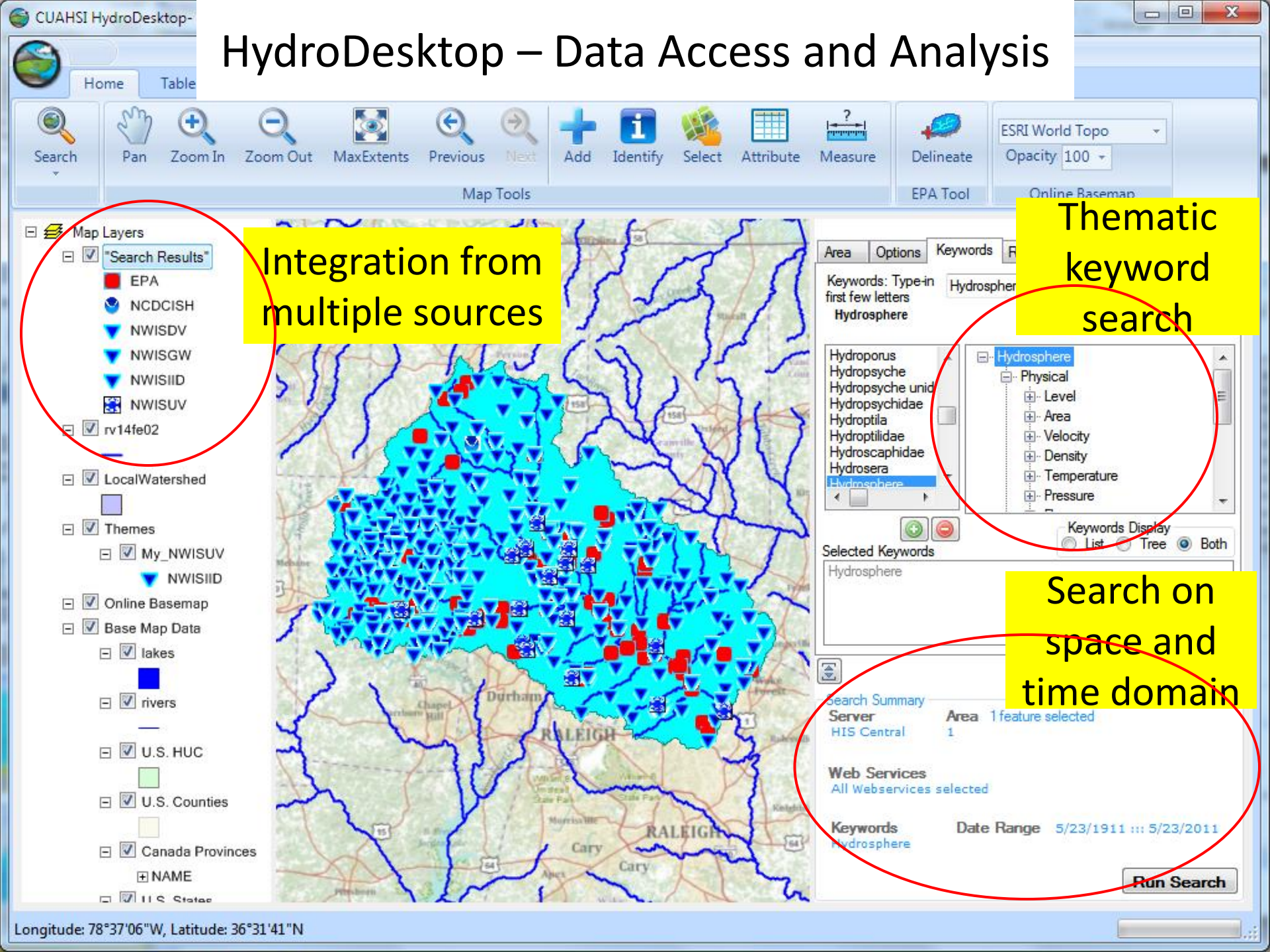


Hydrologic Concept Ontology



Data Discovery Web Services

HydroDesktop – Data Access and Analysis



A Common Information Model Has Enabled

- A greater degree of semantic and syntactic homogeneity across data sources
- Ability to catalog and provide semantically enabled search services across multiple disparate data sources
- Evolution toward community standards for sharing hydrologic data

Limitations

- Works great for a limited class of hydrologic observations (e.g., point time series), BUT…
  - Does not adequately support some types of *ex situ* observations
  - Does not adequately support observations on geometries other than points
  - Does not adequately describe the “feature of interest” or the “sampled feature” or “Site Type”
  - Does not provide adequate ability to record provenance and annotate observations
  - …

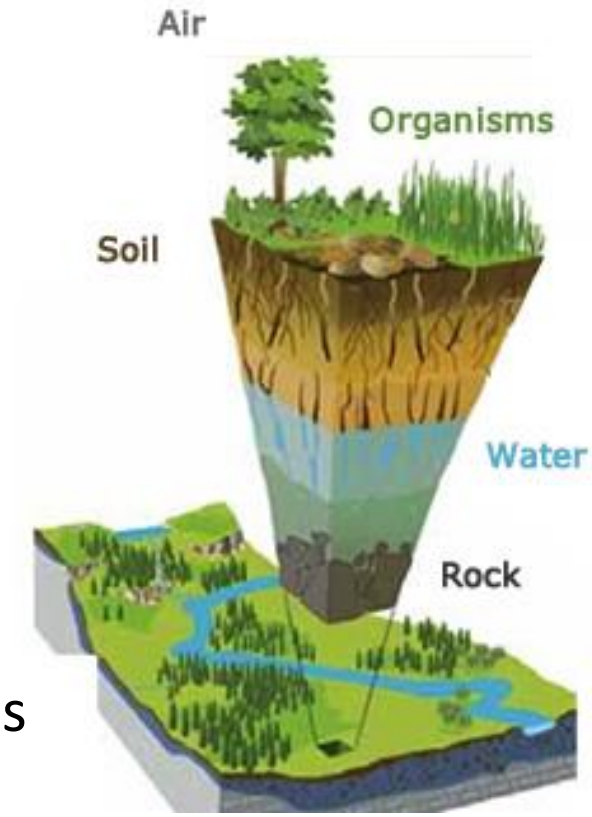
Critical Zone Research

Precipitation

Streamflow

Soil moisture

Groundwater levels



Stream chemistry

Soil chemistry

Groundwater chemistry

Solid earth chemistry

http://criticalzone.org/Research.html

Both *in situ* and *ex situ* data are critical for analysis of the critical zone.

Coupled Human/Natural Systems

Snow depth,
distribution, density

Precipitation

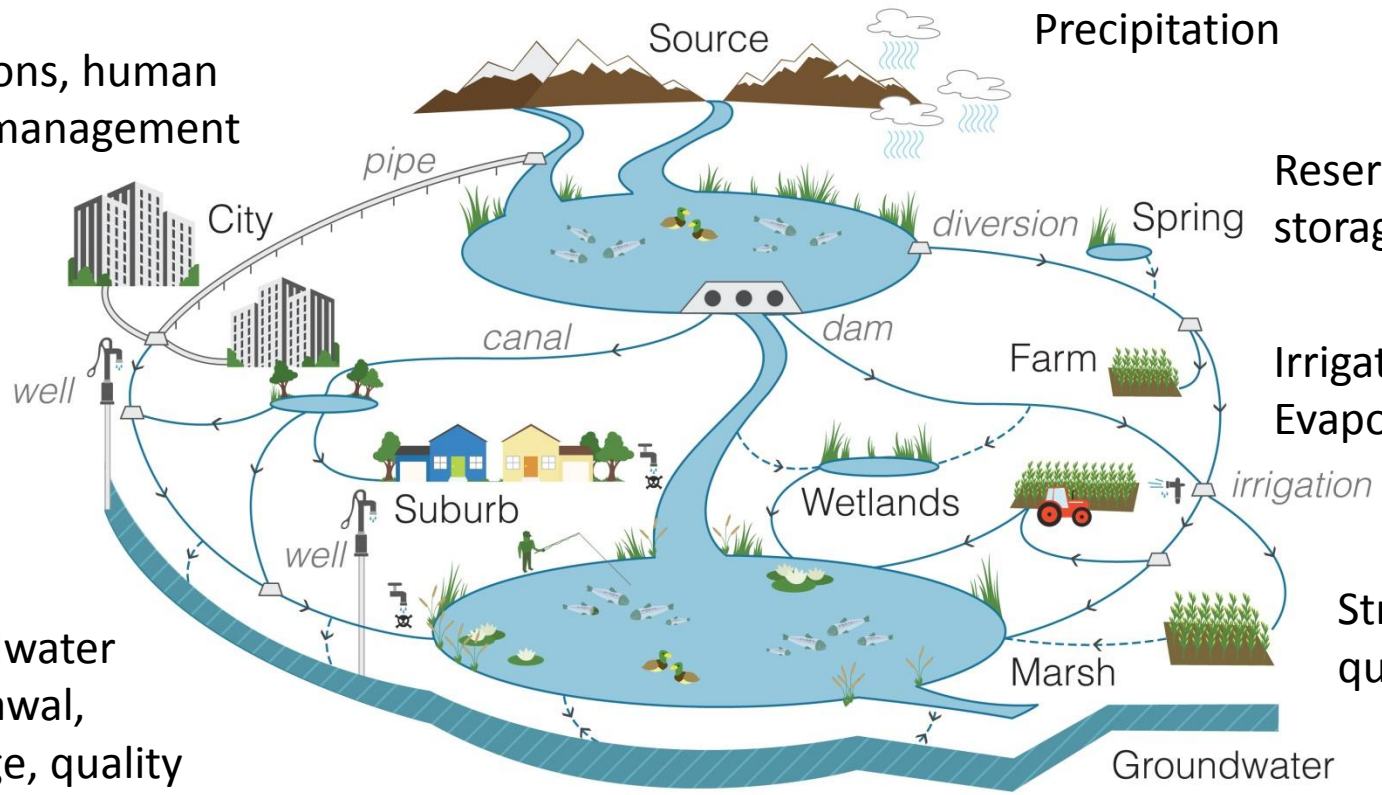
Diversions, human
water management

Reservoir inflows,
storage, releases

Irrigation,
Evapotranspiration

Streamflow
quantity, quality

Groundwater
withdrawal,
recharge, quality



Data representing multiple hydrologic features with complex geometries.

A More Flexible Information Model for Observations

- A number of important advancements have emerged
  - ***Information Model***
    - Open Geospatial Consortium Observations & Measurements
  - ***Service Interfaces***
    - Open Geospatial Consortium Standards – particularly Sensor Observation Services (SOS)
  - ***Semantics and Integration***
    - Scientific Observations Network (SONet)
  - ***Data Storage Model***
    - Microsoft Research and SDSC Environmental Data Model (EDM)

International Standardization of WaterML

http://external.opengis.org/twiki_public/bin/view/HydrologyDWG/WebHome

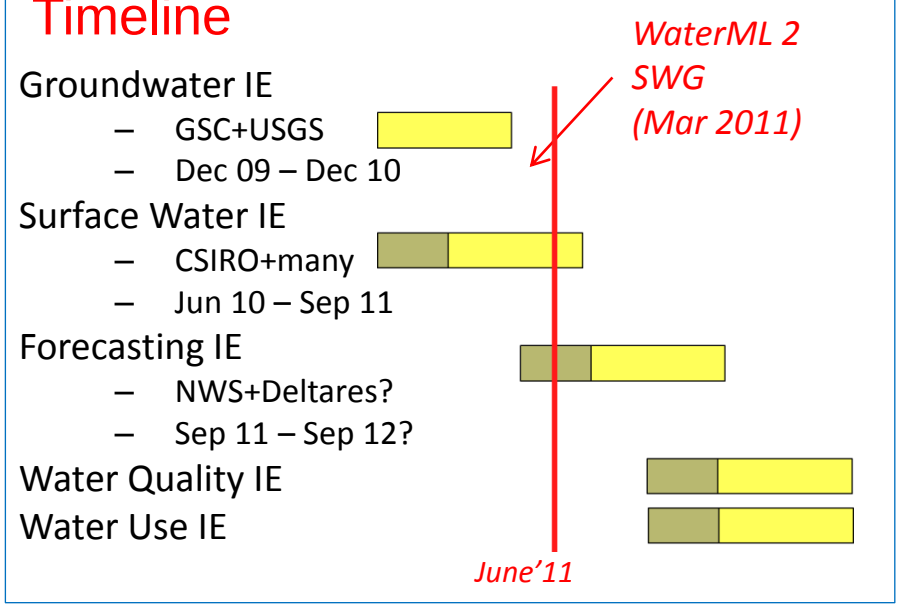
Hydrology Domain Working Group

- working on WaterML 2.0
- organizing Interoperability Experiments focused on different sub-domains of water
- towards an agreed upon feature model, observation model, semantics and service stack

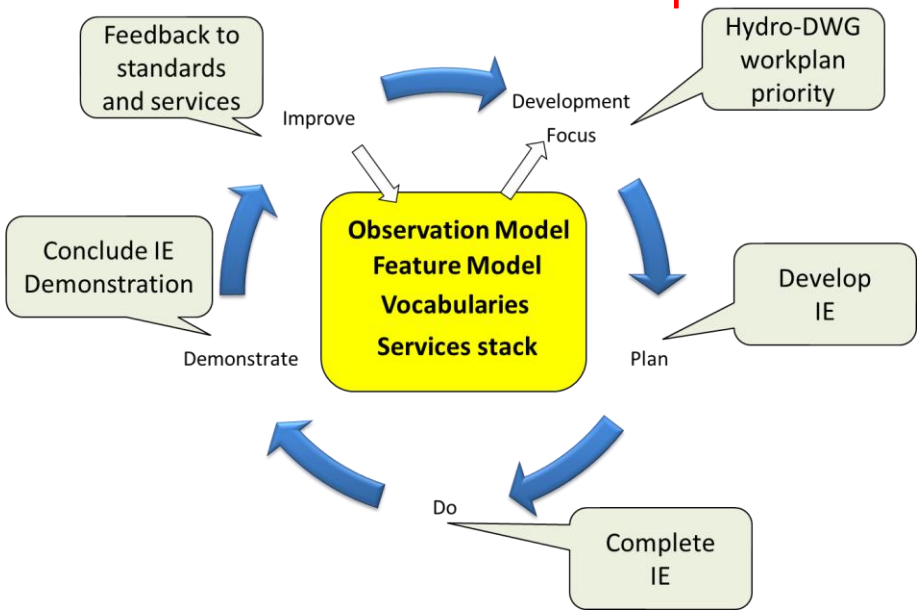
World Meteorological Organization
Working together in weather, climate and water

OGC®
Open Geospatial Consortium, Inc.

Timeline



Iterative Development



Slide from Ilya Zaslavsky

ODM 2.0

- Approach: a core observational data model with flexible extensions
  - ***Samples extension*** – better handle storage of sample information and observations derived from *ex situ* analyses
  - ***Field sensor extension*** – better handle storage of sensor deployment information and *in situ* observations
  - ***Provenance and annotation*** – capturing more of the context of observations
- A more robust "feature model" to better describe the geographic context of observations
- Enhanced semantics
- Harmonization with WaterML

Thank you!

CUAHSI
HIS
Sharing hydrologic data

Support EAR 0622374