Advancing Cyberinfrastructure to Support High Resolution Water Resources Modeling

CI-WATER
A Utah-Wyoming Cyberinfrastructure Water Modeling Collaboration

http://ci-water.org/

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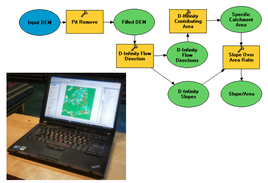
Abstract

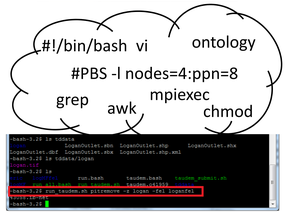
Addressing the problem of how the availability and quality of water resources at large scales are sensitive to climate variability, watershed alterations and management activities requires computational resources that combine data from multiple sources and support integrated modeling. Related cyberinfrastructure challenges include: 1) how can we best structure data and computer models to address this scientific problem through the use of high-performance and data-intensive computing, and 2) how can we do this in a way that discipline scientists without extensive computational and algorithmic knowledge and experience can take advantage of advances in cyberinfrastructure? This presentation will describe a new system called CI-WATER that is being developed to address these challenges and advance high resolution water resources modeling in the Western U.S. We are building on existing tools that enable collaboration to develop model and data interfaces that link integrated system models running within an HPC environment to multiple data sources. Our goal is to enhance the use of computational simulation and data-intensive modeling to better understand water resources. Addressing water resource problems in the Western U.S. requires simulation of natural and engineered systems, as well as representation of legal (water rights) and institutional constraints alongside the representation of physical processes. We are establishing data services to represent the engineered infrastructure and legal and institutional systems in a way that they can be used with high resolution multi-physics watershed modeling at high spatial resolution. These services will enable incorporation of location-specific information on water management infrastructure and systems into the assessment of regional water availability in the face of growing demands, uncertain future meteorological forcings, and existing prior-appropriations water rights.

A Digital Divide

Researchers
- Experimentalists
- Modelers



Big Data and HPC



We are developing cyberinfrastructure to make it easier to use HPC computers for water resources modeling

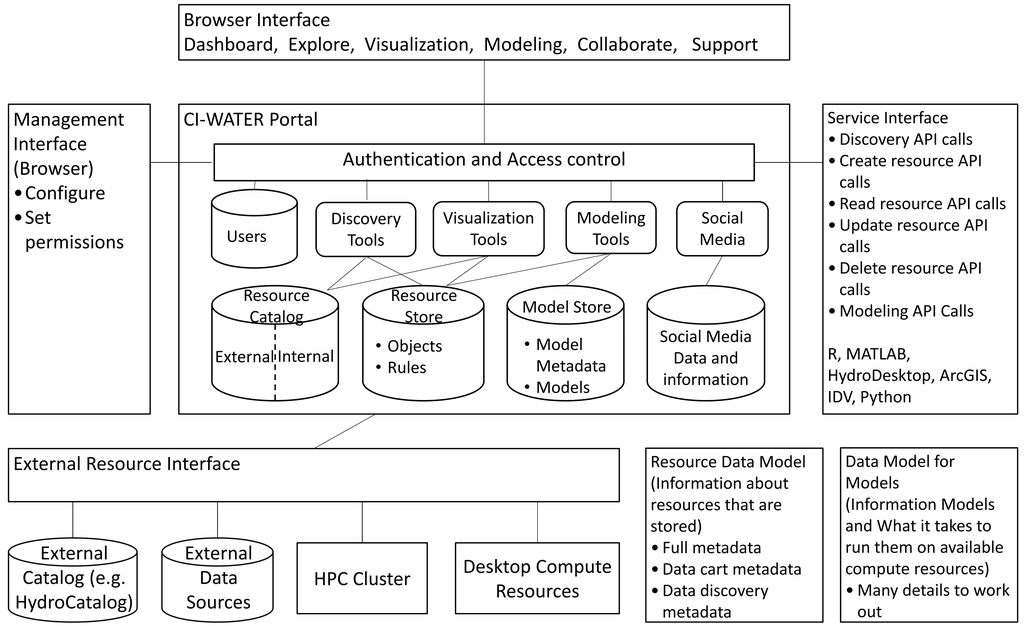
Why?
1. Increase scale
2. Multiple runs for calibration
3. Coupling with other models where the combination requires many CPU cycles

Motivating Questions

How are the quality and availability of water resources sensitive to climate variability, watershed alterations, and management activities?

How can we best structure data and computer models to address this scientific problem through the use of high-performance and data-intensive computing by discipline scientists coming to this problem without extensive computational knowledge and algorithmic experience?

Data System for Computationally Intensive Modeling (DASYCIM) overall system architecture

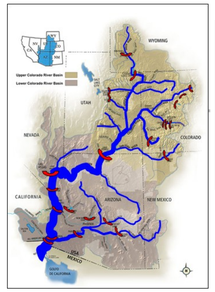


CI-WATER Multi-Physics Model

A high resolution multi-physics model that integrates hydrologic processes, engineered infrastructure and water resources policies and management into spatially distributed simulations.

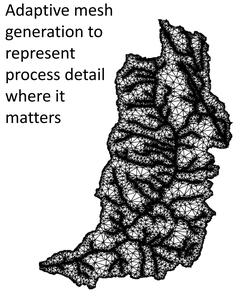
Building blocks
- Finite element computational kernel derived from USACE-ERDC ADH model
- ERDC Computational model builder
- ERDC ezVIZ HPC visualization tools
- ezHPC user interface toolkit
- Parallel TauDEM watershed delineation and model element discretization
- Utah Energy Balance Snowmelt model
- SWAT/WEAP water management functionality

A big watershed problem: Colorado River Basin

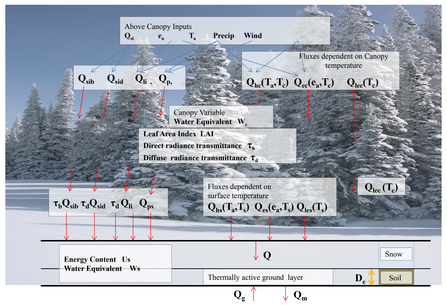


Basin Area: 288,000 km²
Streams: 467,000 km
Population: 900,000 (USBR)
Area above 2700 m: 14.5% (9,000 ft)
Area above 3050 m: 3.2% (10,000 ft)

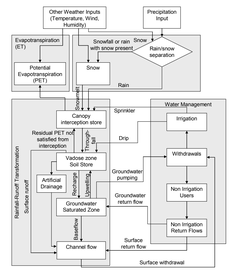
Adaptive mesh generation to represent process detail where it matters



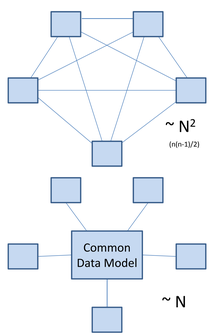
High Altitude Complexity – UEB snowmelt model



Integrated model of Hydrologic, Water Management and Consumption processes

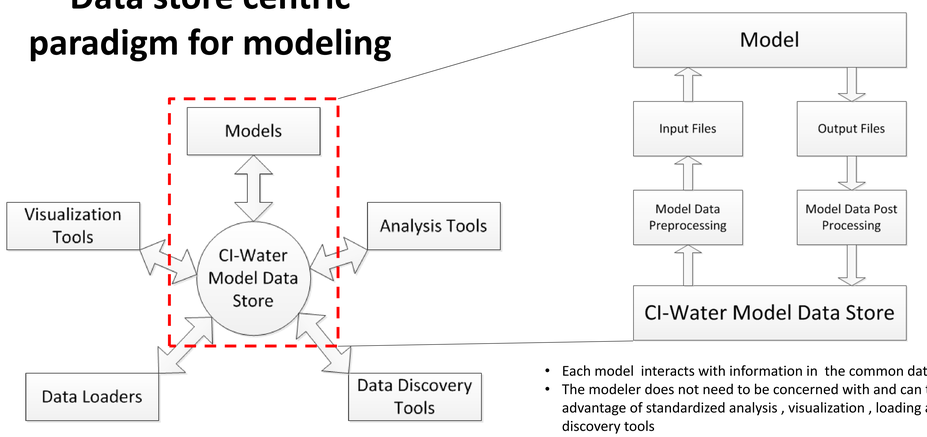


The number of translations required for interoperability



Standardizing on common ways to represent data enables re use by different models and common tools for working with the data

Data store centric paradigm for modeling



- Each model interacts with information in the common data store
- The modeler does not need to be concerned with and can take advantage of standardized analysis , visualization , loading and discovery tools

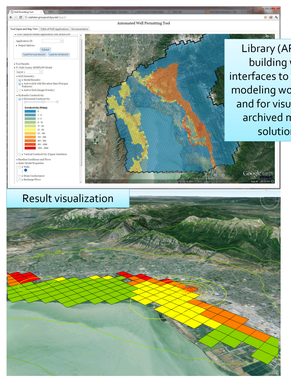
Common Data Requirements

- Digital Elevation Model (and derivatives)
  - Slope, Watersheds, ...
- Soils (and pedotransfer functions)
- Geology (and hydrogeological parameters)
- Vegetation (and parameter mapping tables)
- Streams
- Water Management Infrastructure
- Dynamic input Variables
  - Precipitation, Humidity, Wind, Radiation, Temperature
- Water Use and Management process parameters

Data Formats

- Data series at a point (CUAHSI ODM/WaterML)
- Feature data set (Shapefile of points, lines or polygons and attribute tables)
- Raster data set (GeoTIFF)
- Multidimensional space/time data set (NetCDF)
- Water Resources Management (to be determined)

Web Based Tools For Model Configuration, Result Generation and Visualization



Result visualization

Library (API) for building web interfaces to scripted modeling workflows and for visualizing archived model solutions