Cyberinfrastructure for Cloud-Based Modeling

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Brigham Young University

Provo, Utah

CI-WATER

A Utah-Wyoming Cyberinfrastructure Water Modeling Collaboration

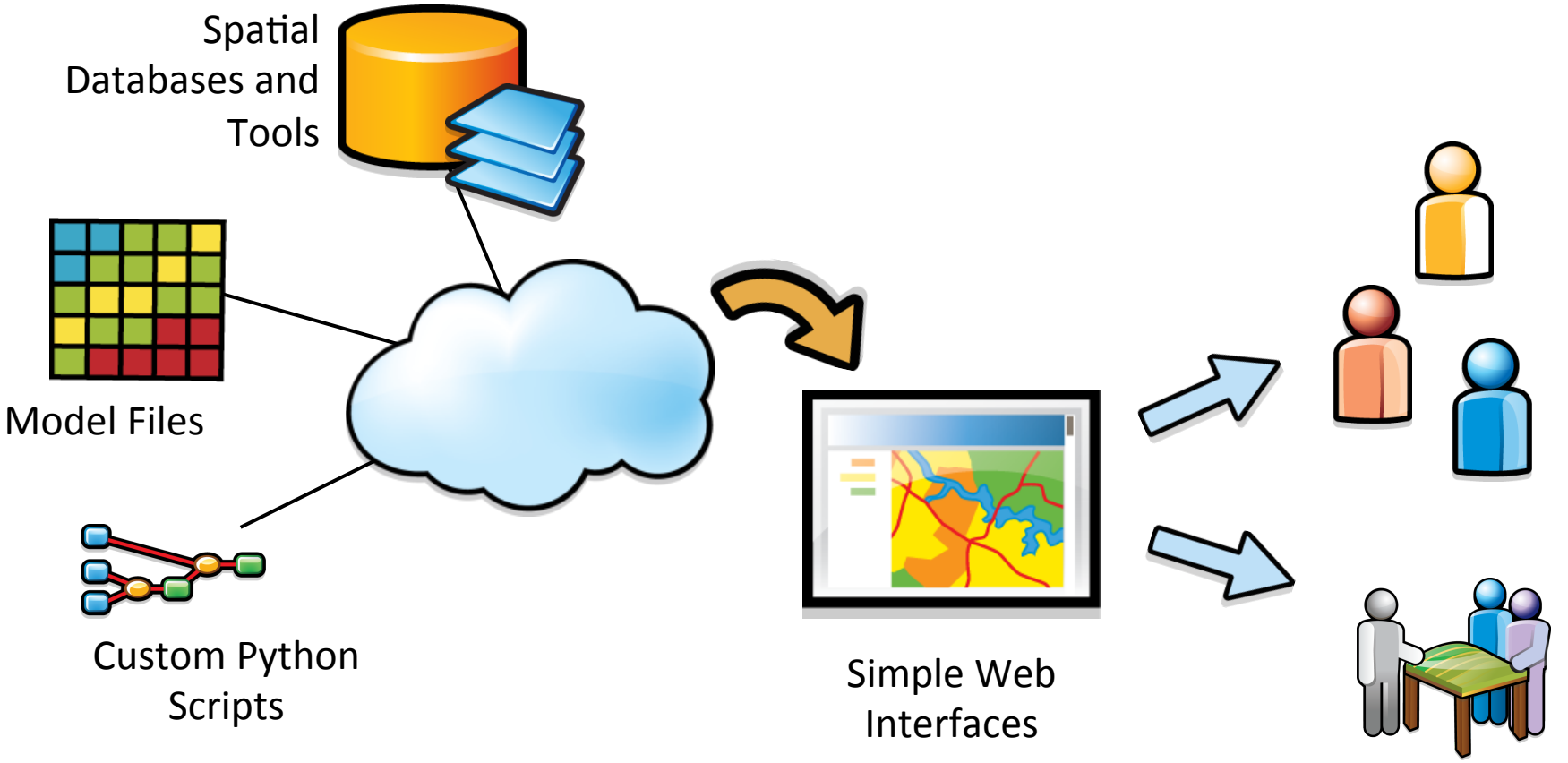
BYU

BRIGHAM YOUNG UNIVERSITY

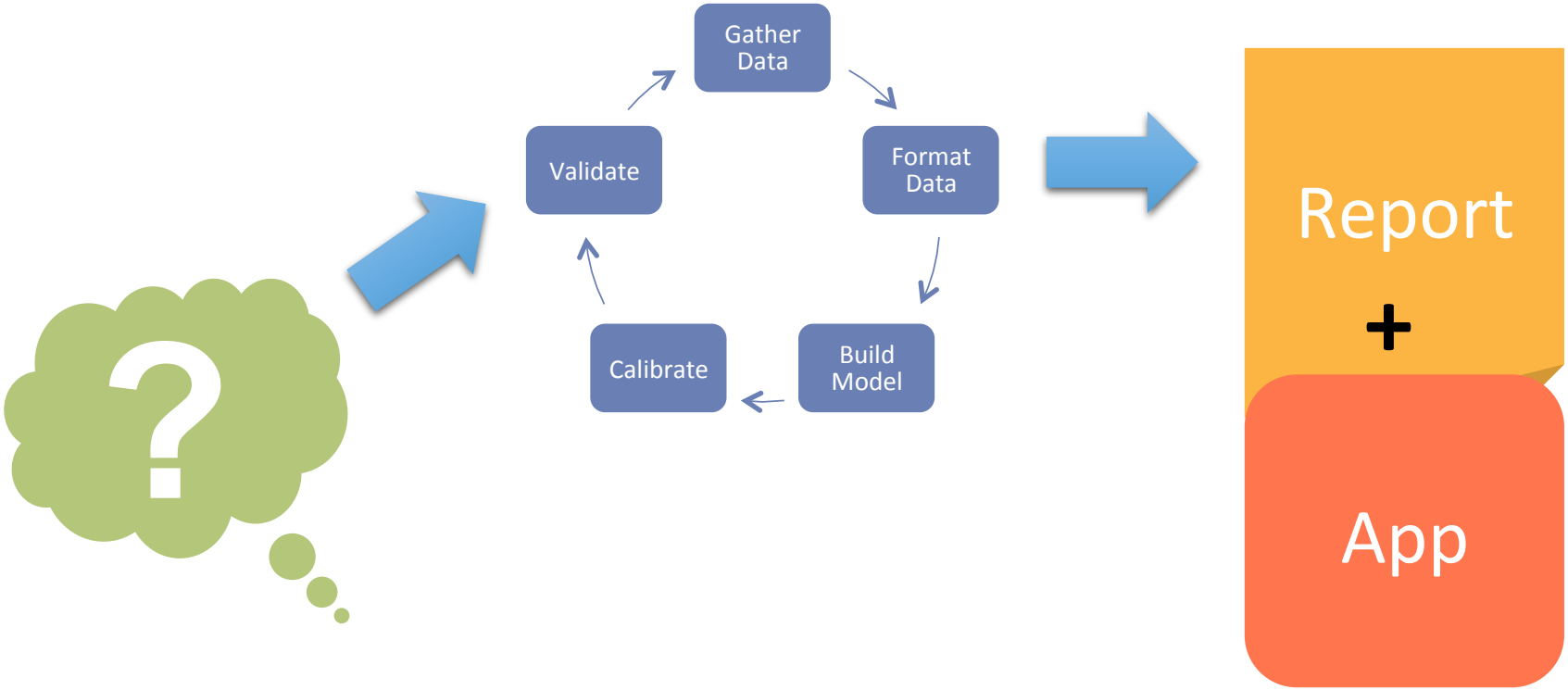
CI-WATER Project Objectives

- Enhance cyberinfrastructure facilities
- **Enhance access to data- and computationally-intensive modeling**
- Advance high-resolution multi-physics watershed modeling
- Promote STEM learning and water science engagement

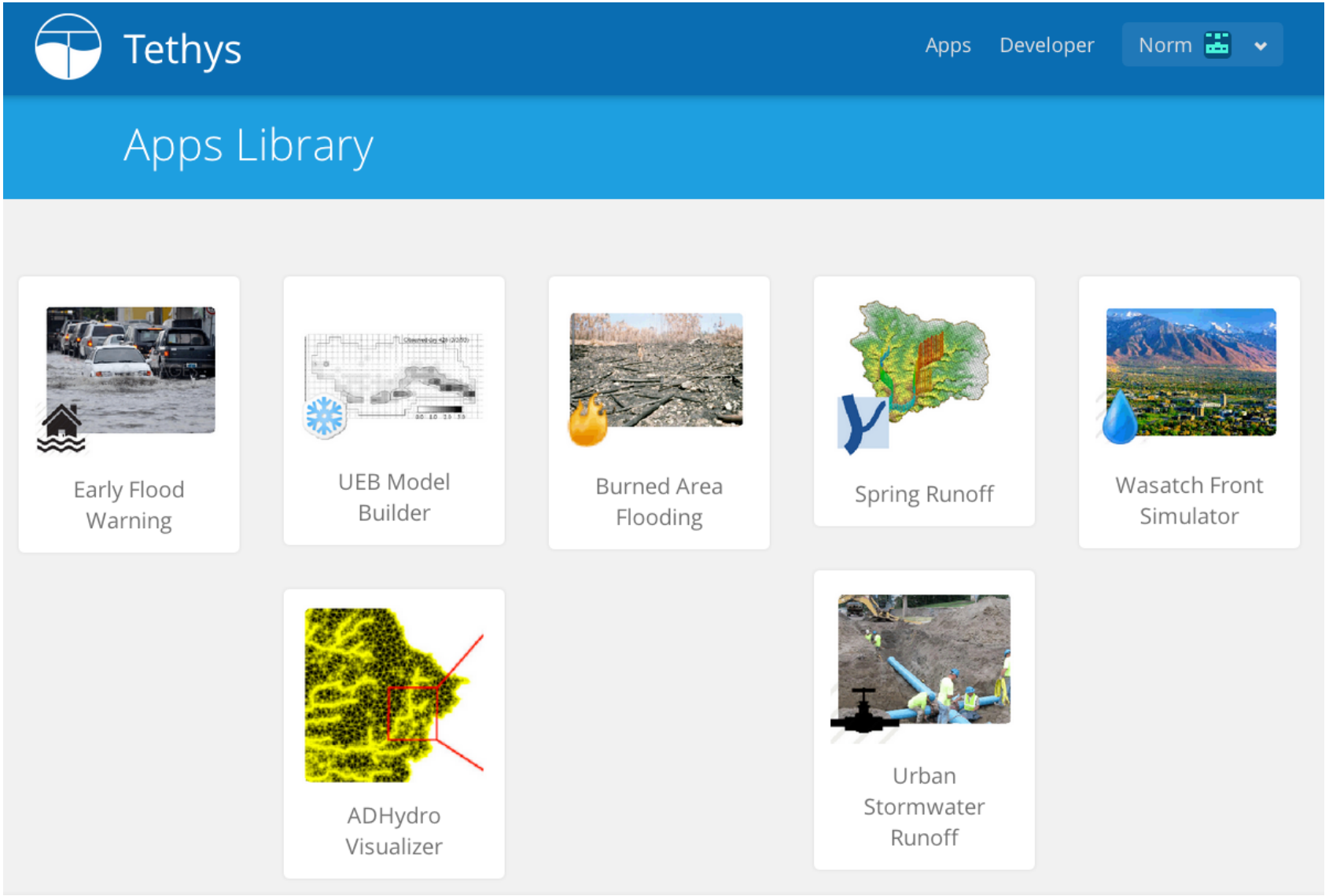
Cloud-Based Modeling for Decision Support



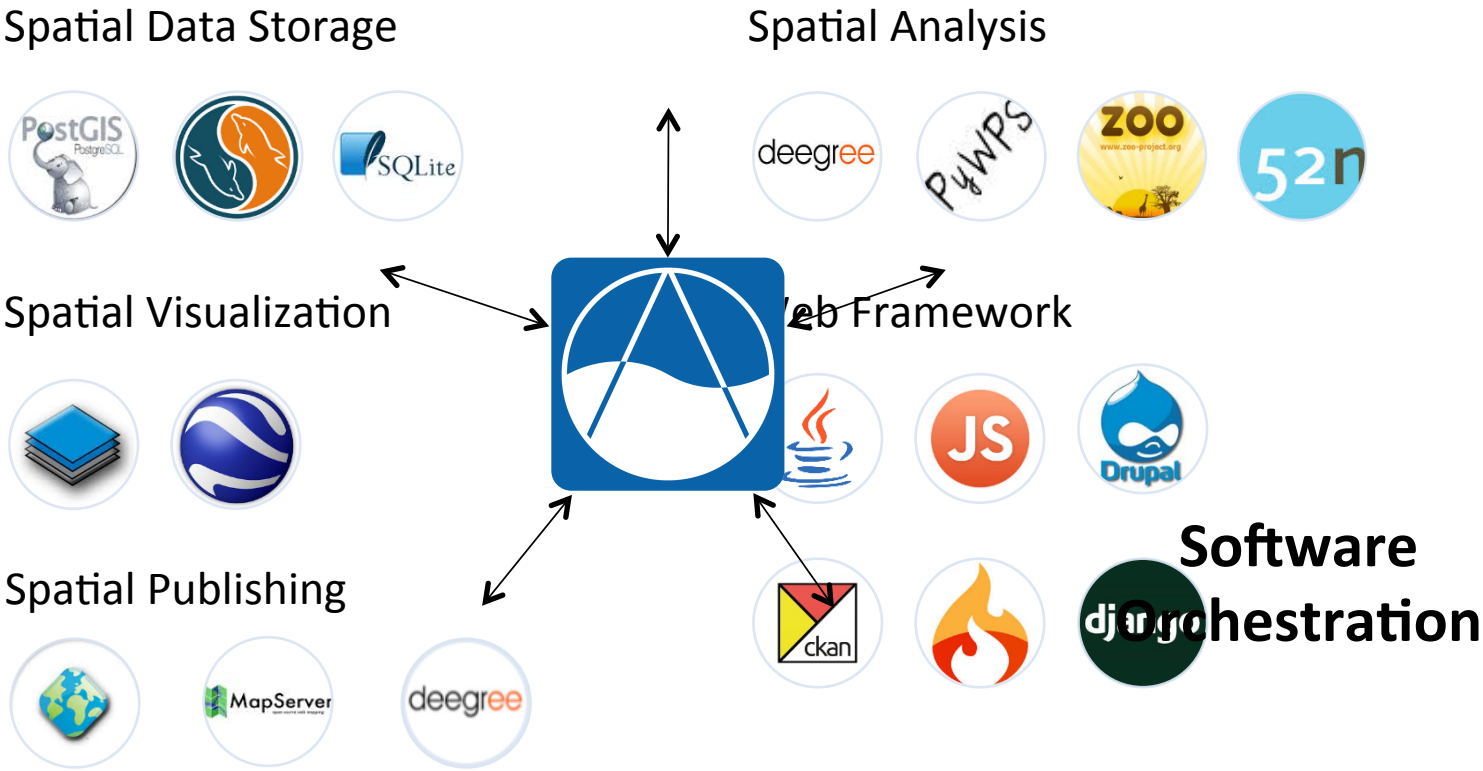
An App Approach



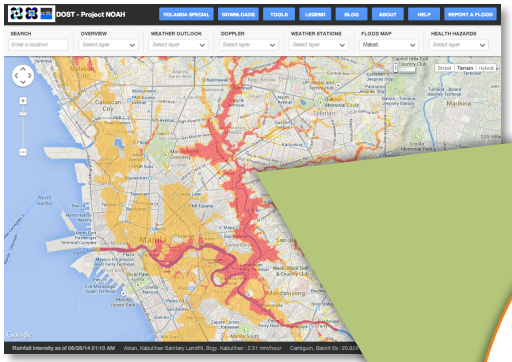
Tethys Platform



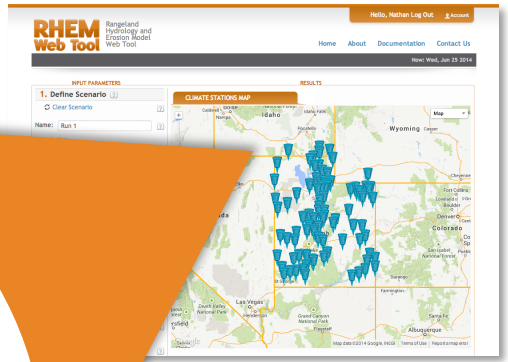
Barriers


Spatial Data Storage
Spatial Analysis
Spatial Visualization
Web Framework
Spatial Publishing
Software Orchestration
Software Selection

FOSS Review



NOAH (Alconis et al., 2013)

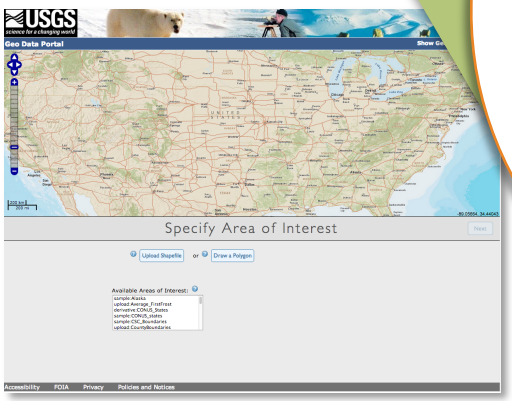


EM (Goodrich et al., 2008)

MySQL

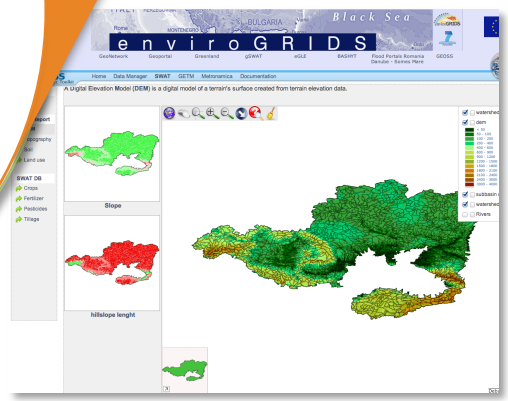
CodeIgniter

Google maps



GeoData Portal (Kunicki et al., 2011)

DEM Explorer (Han et al., 2012)



BASHYT (Cau et al., 2013)

FOSS Review

45 Earth Science Web Applications Reviewed

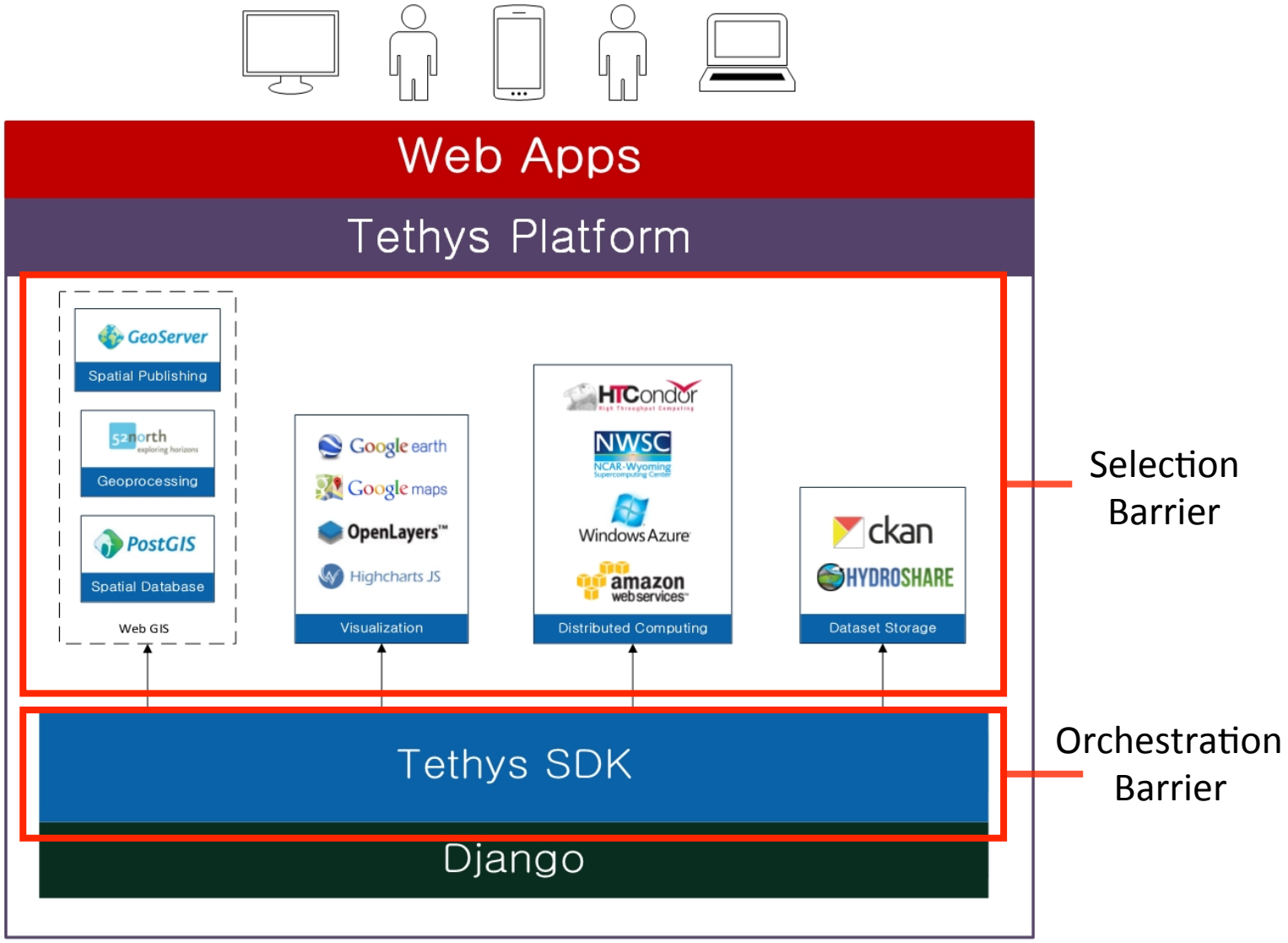
2 Categories of FOSS Software: Web GIS & Web Development

11 Web GIS **9** Web Development

Environmental Modelling & Software

Software Development Kit

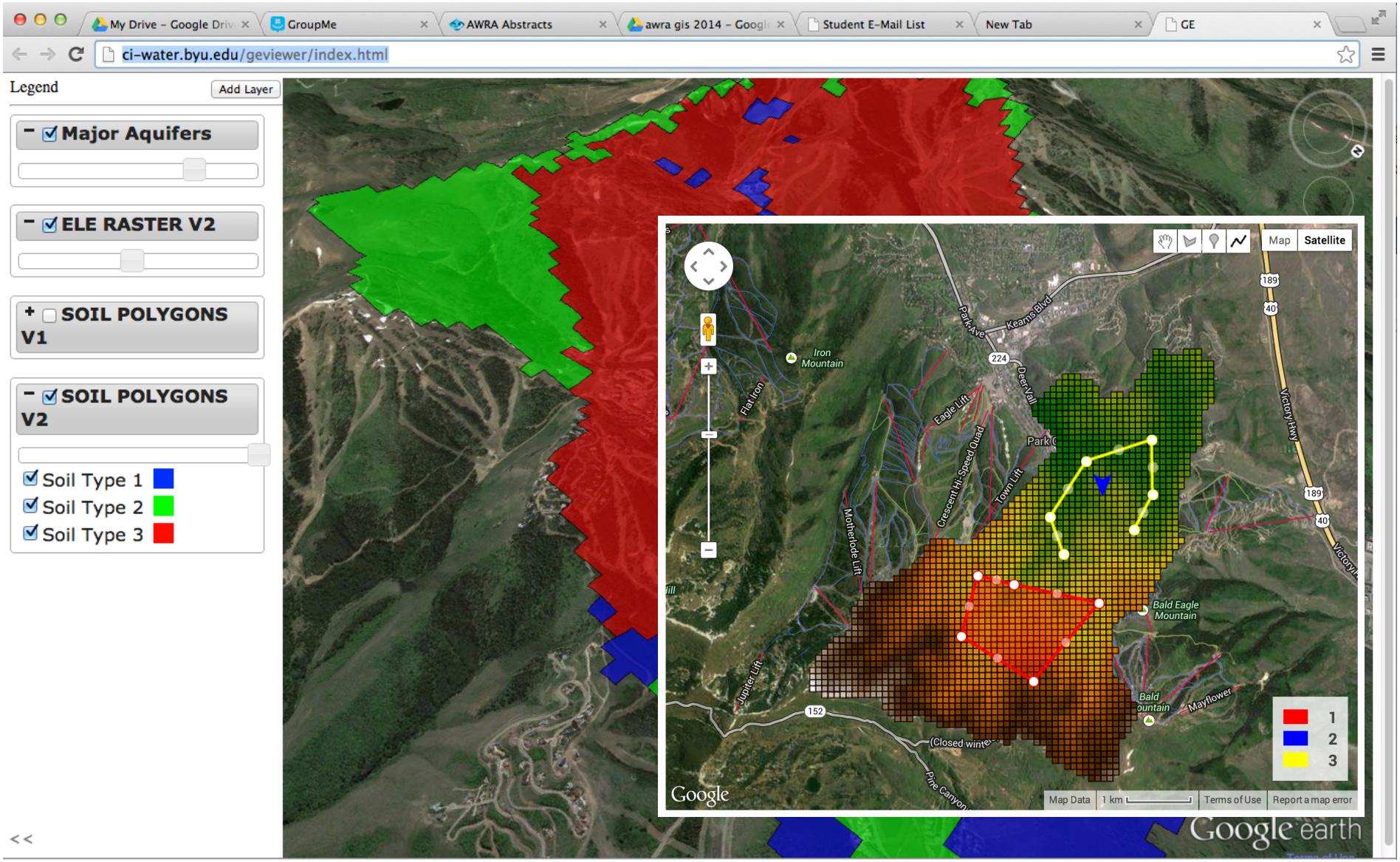
Tethys Platform Components



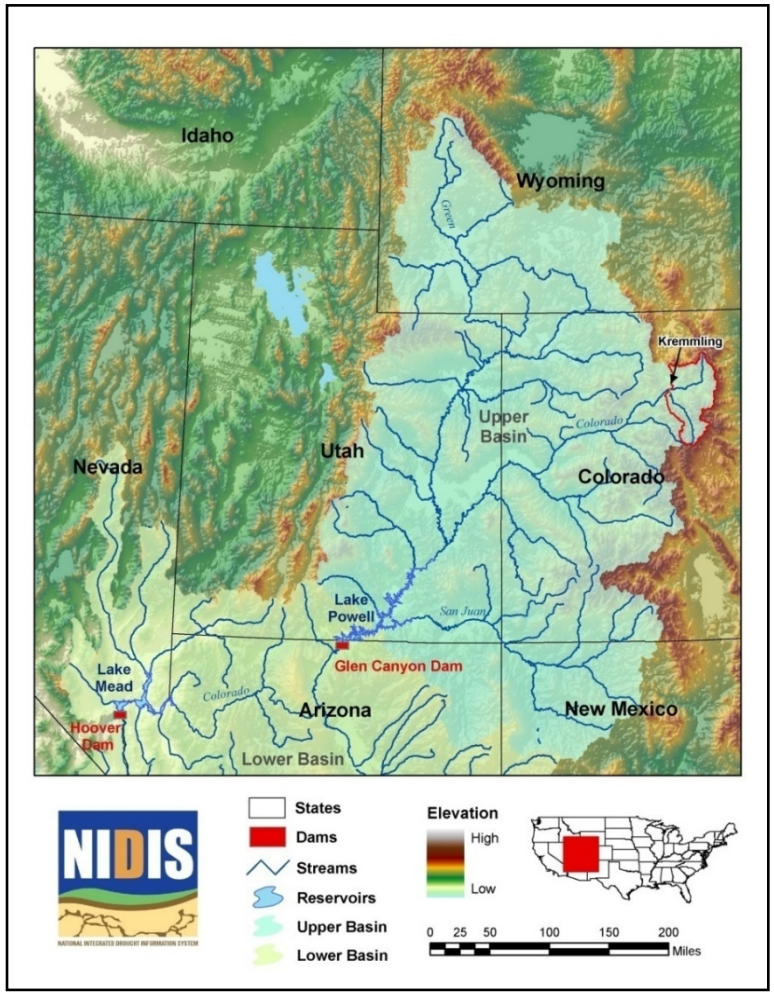
Tethys Platform Resources

- GitHub Repositories
  - https://github.com/CI-WATER/tethys
  - https://github.com/CI-WATER/django-tethys_apps
  - https://github.com/CI-WATER/django-tethys_gizmos
  - https://github.com/CI-WATER/django-tethys_datasets
- Documentation
  - http://tethys-platform.readthedocs.org/en/latest/
- Demo Tethys Servers
  - http://ciwweb.chpc.utah.edu
  - http://tethys.cloudapp.net

Mapping & Visualization



High Resolution Visualization for Transient Watershed Models



Challenge: How do you visualize ultra-high resolution model output in a simple web framework?

With <u>animation</u>?

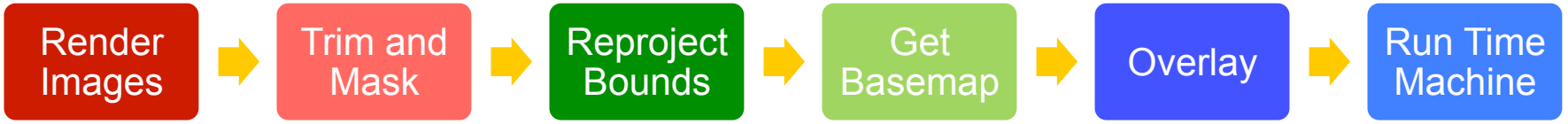
Solution

GigaPan's Time Machine

A code that was developed to tile time-lapse imagery so that the user could zoom and pan high resolution frames while maintaining an efficient viewing experience

http://timemachine.cmucreatelab.org/wiki/Main_Page

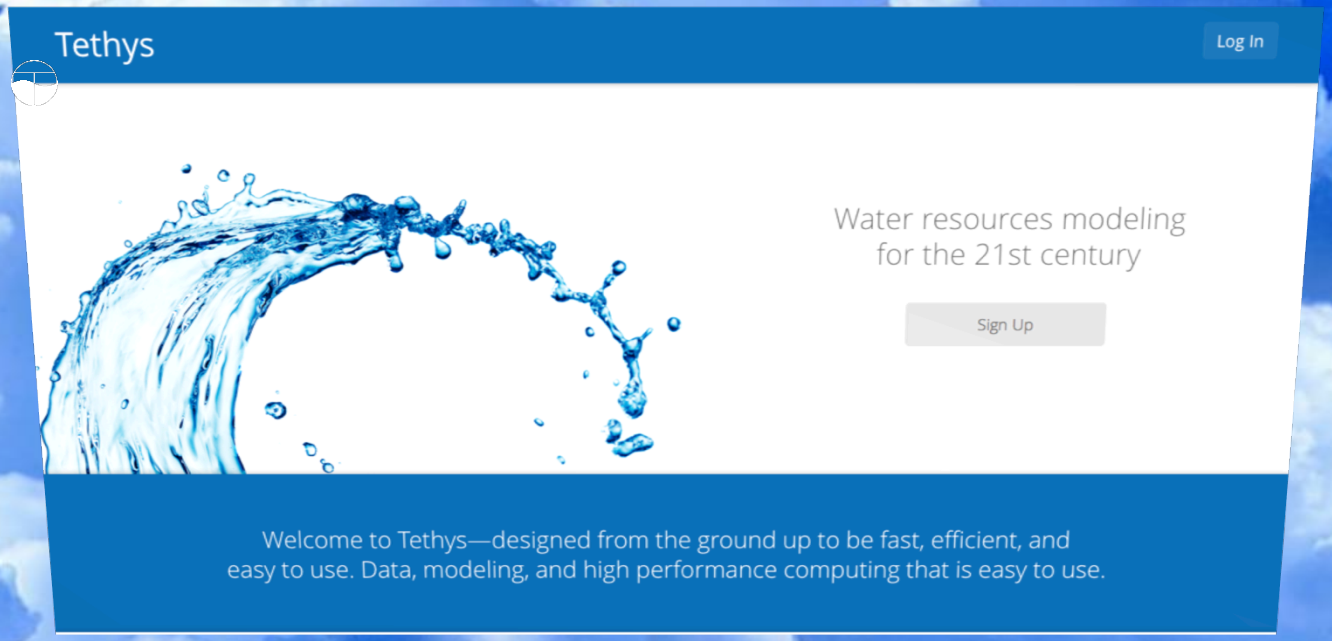
TMAPS: Time Machine Automated Python Scripts



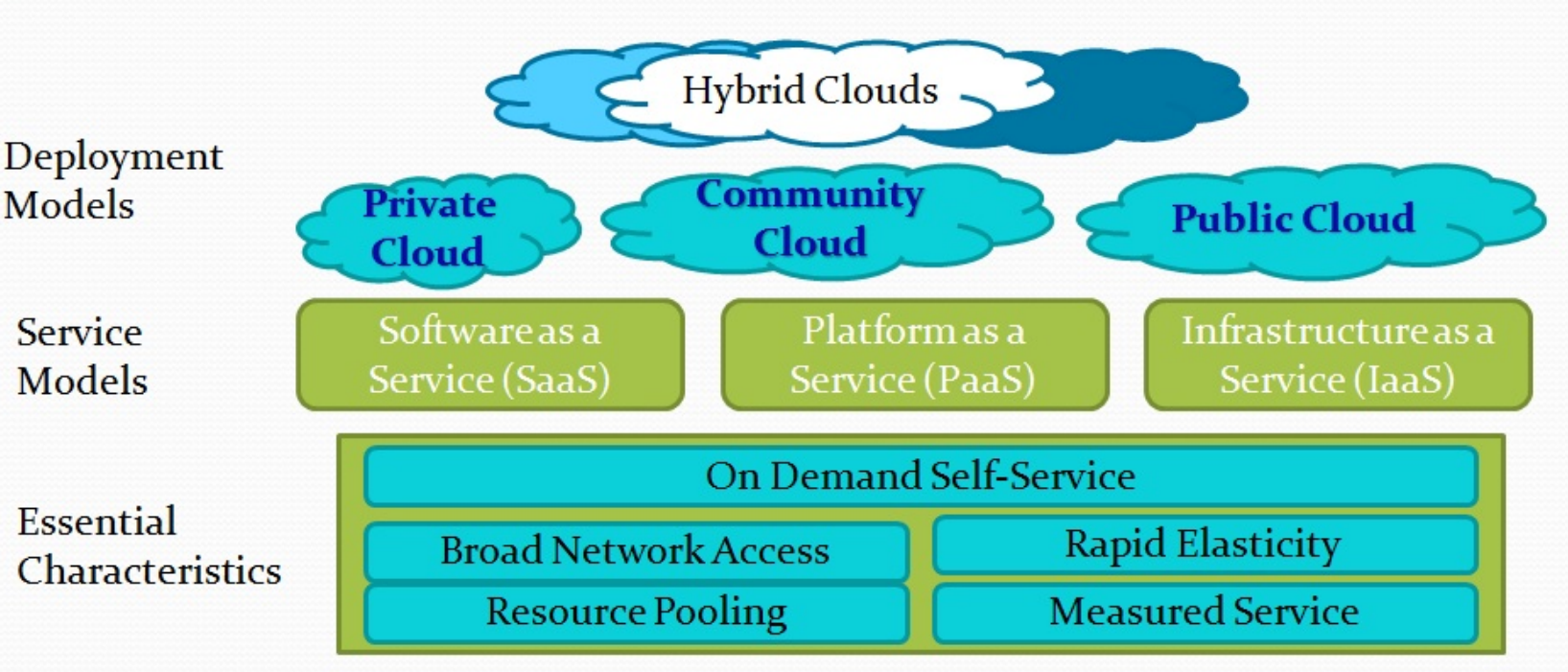
Python scripting tools designed to process ADHydro output and generate Time Machine animation files.

http://gme.byu.edu/index.html

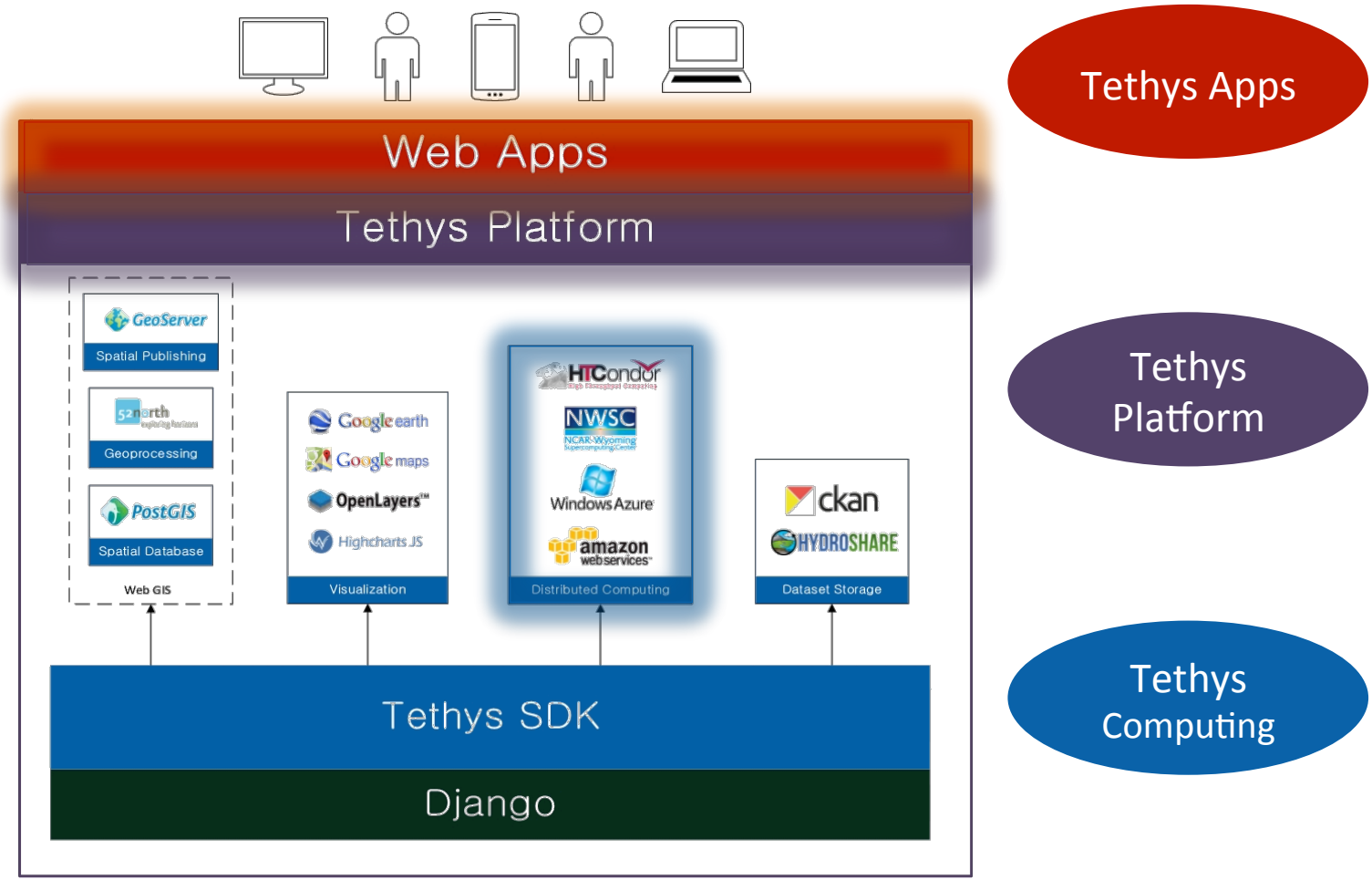
Tethys and the Cloud



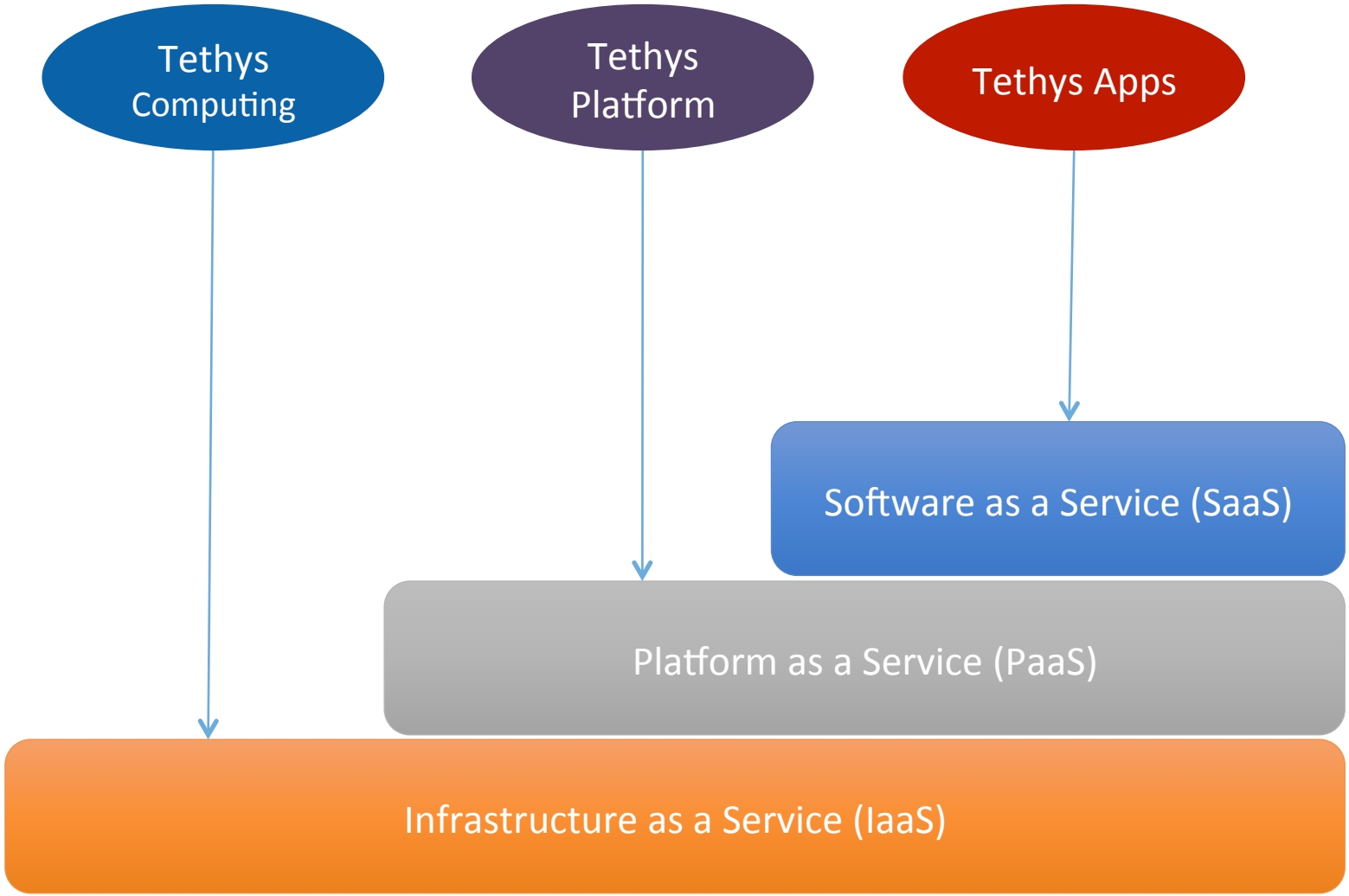
What exactly is “The Cloud”?



Tethys and the Cloud



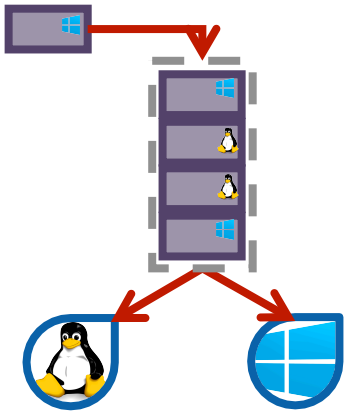
Tethys and the Cloud



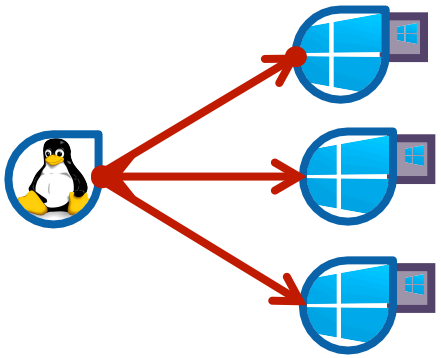
Features of the Tethys Cloud-modeling Tools

1. Resource Provisioning

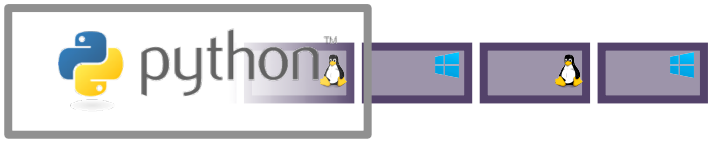
2. Batch Scheduling



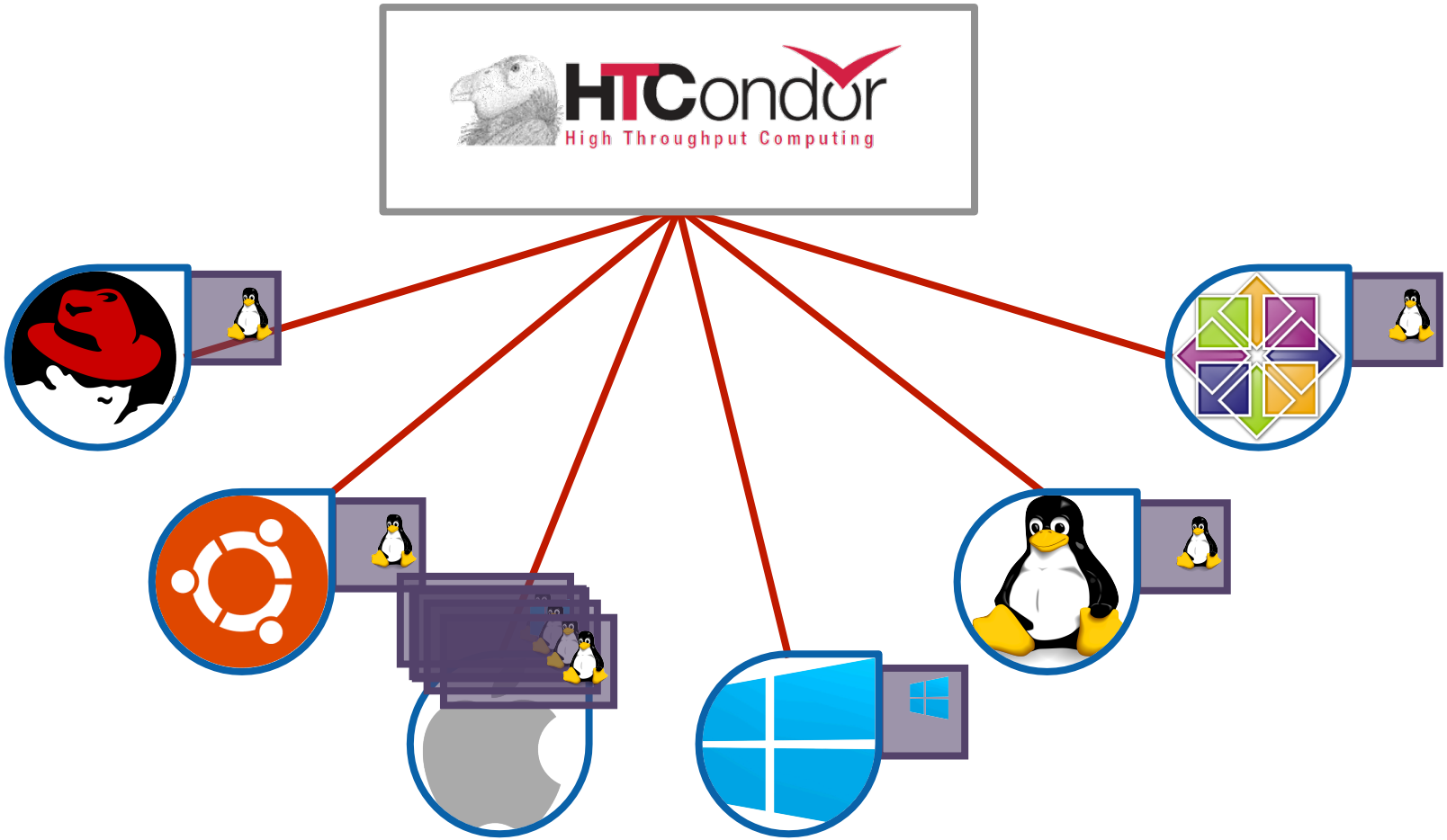
3. Data Management



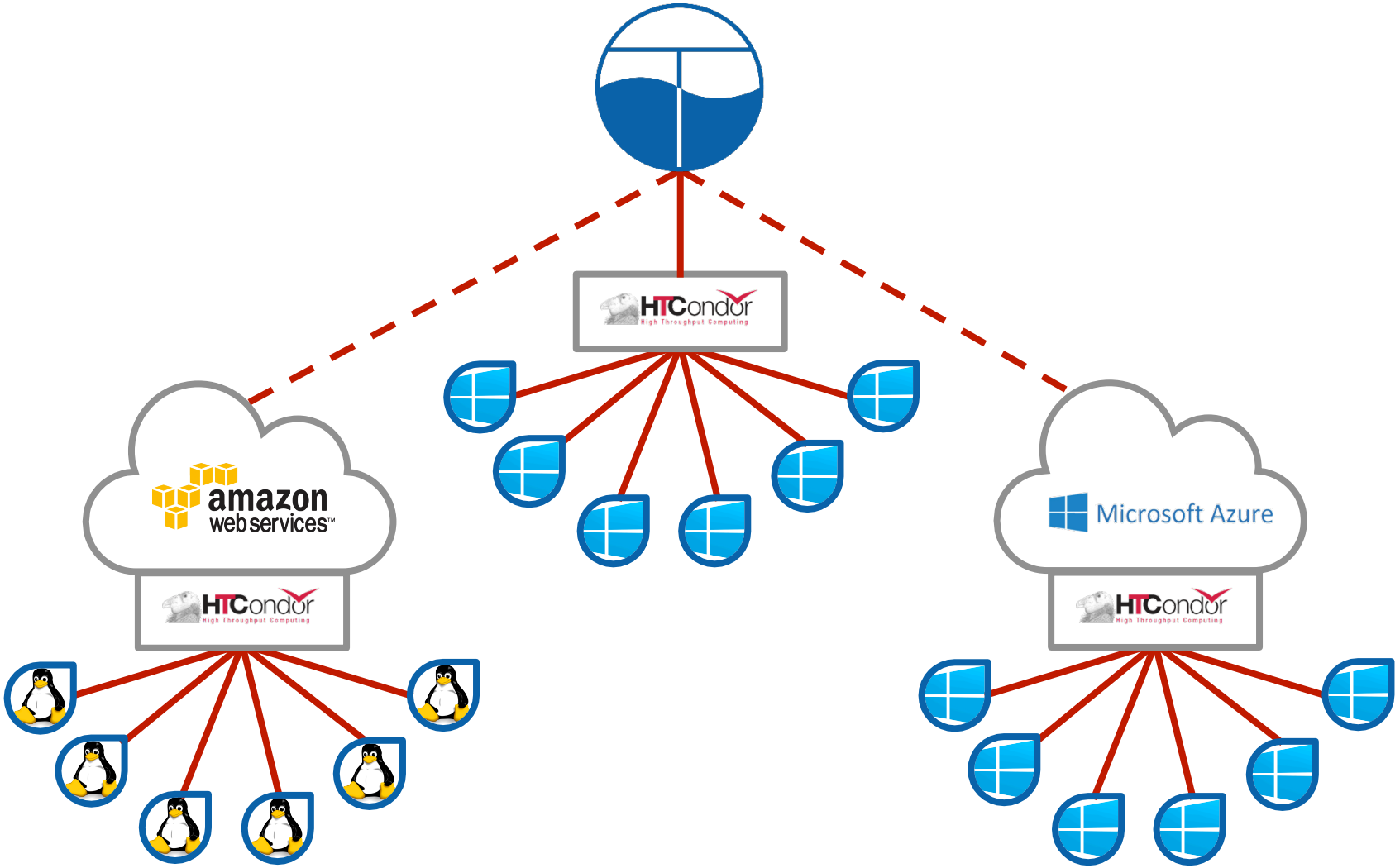
4. Job creation



HTCondor



HTCondor in Tethys



Applications

Cloud-Based Water Resource Modeling

Flood Early Warning System

- ✓ Food
- ✓ Water
- ✓ Fuel
- ✓ Clothes

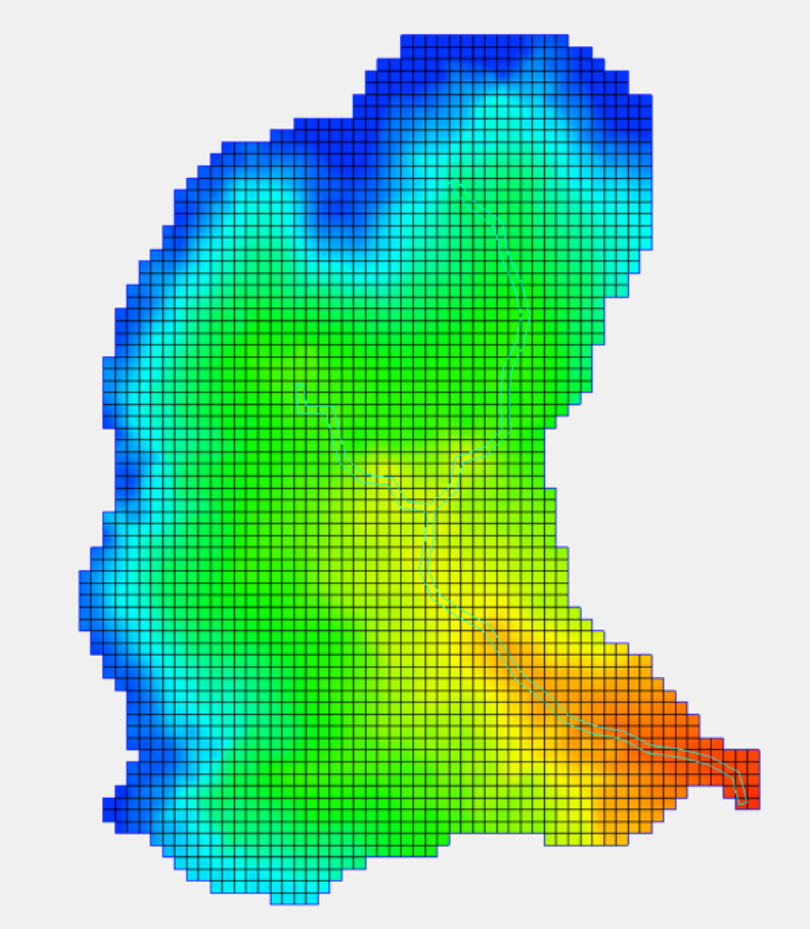
  Computation Time

Assumption:

"Similar conditions produce similar results"

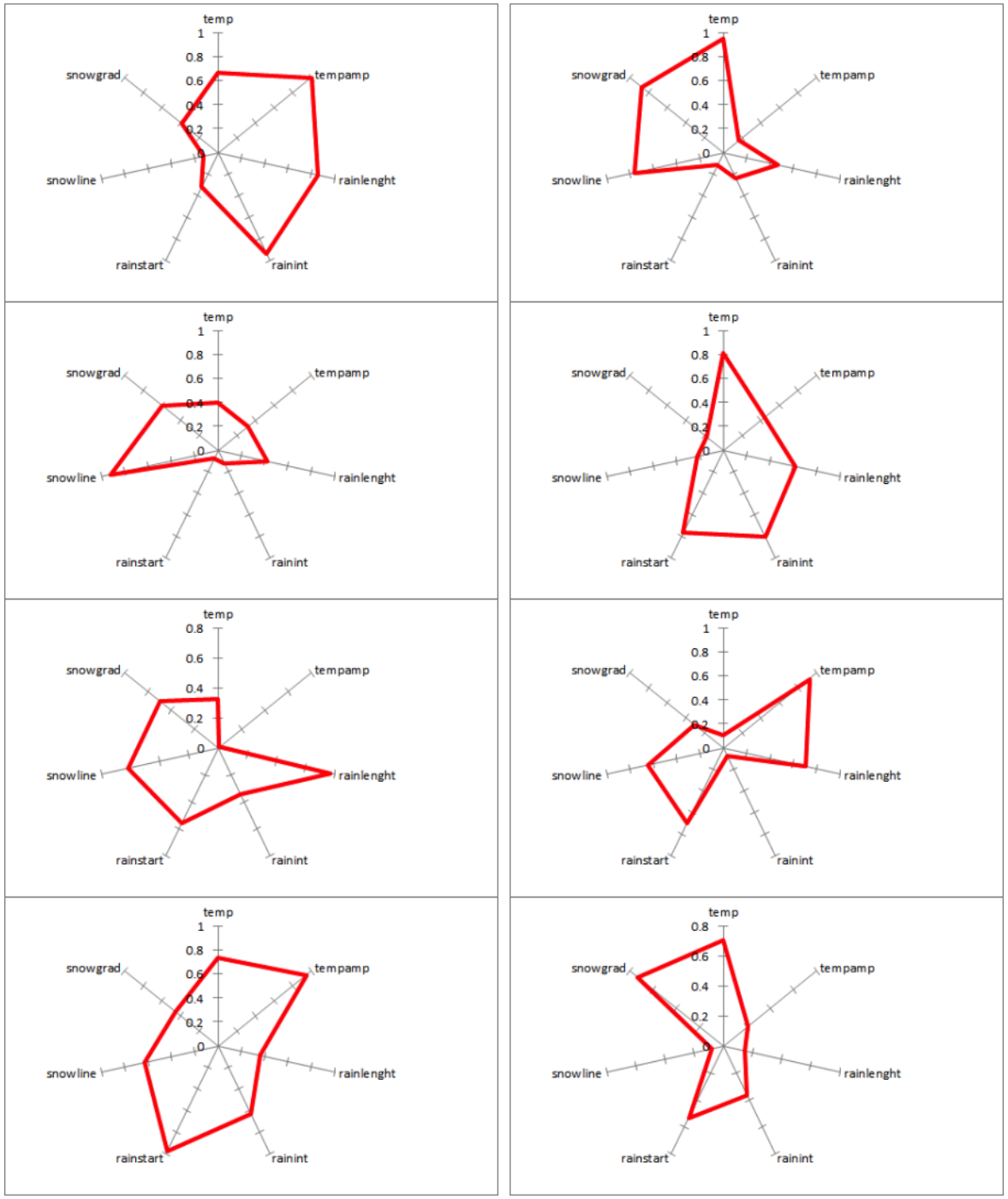
Our purpose will be to generate a large set of model runs to evenly cover the "variables space" and a technique to select the one that best fits the current conditions

Generate

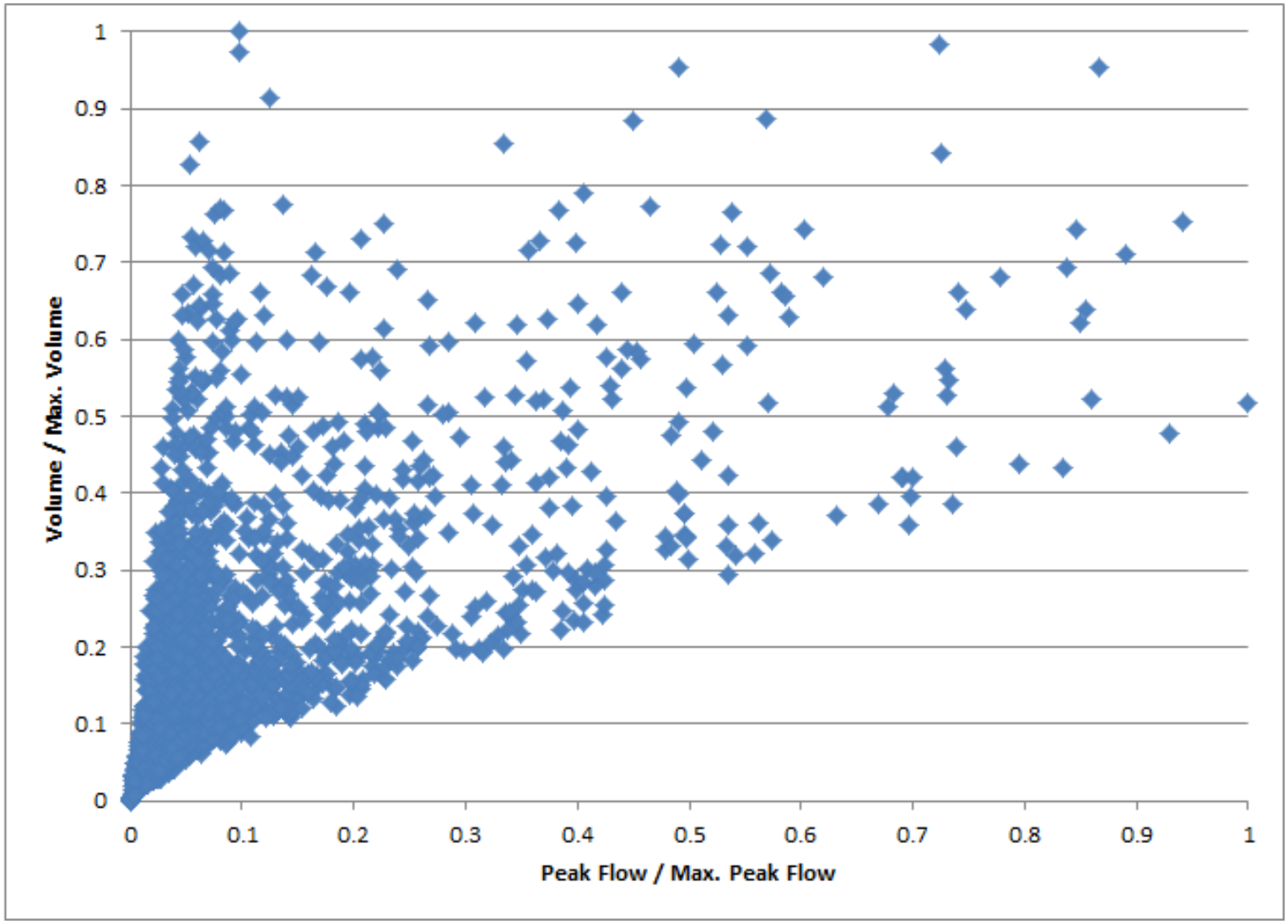


Variable	Min value	Max value	units
temp	20	100	°F
tempamp	5	20	°F
rainlenght	1	10	hs
rainint	10	100	mm
rainstart	0	24	hs
snowgrad	0	0.002	m/m
snowline	-100	400	m

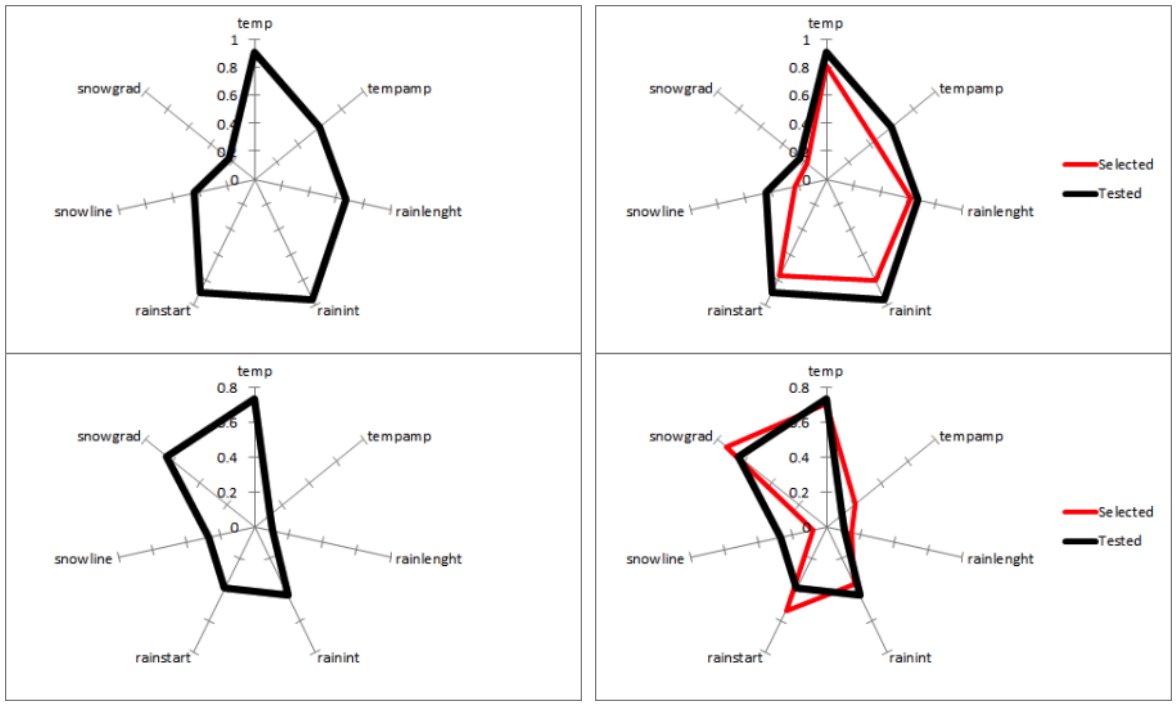
Generate


temp
tempamp
rainlenght
rainint
rainstart
snowline
snowgrad
1
0.8
0.6
0.4
0.2
0

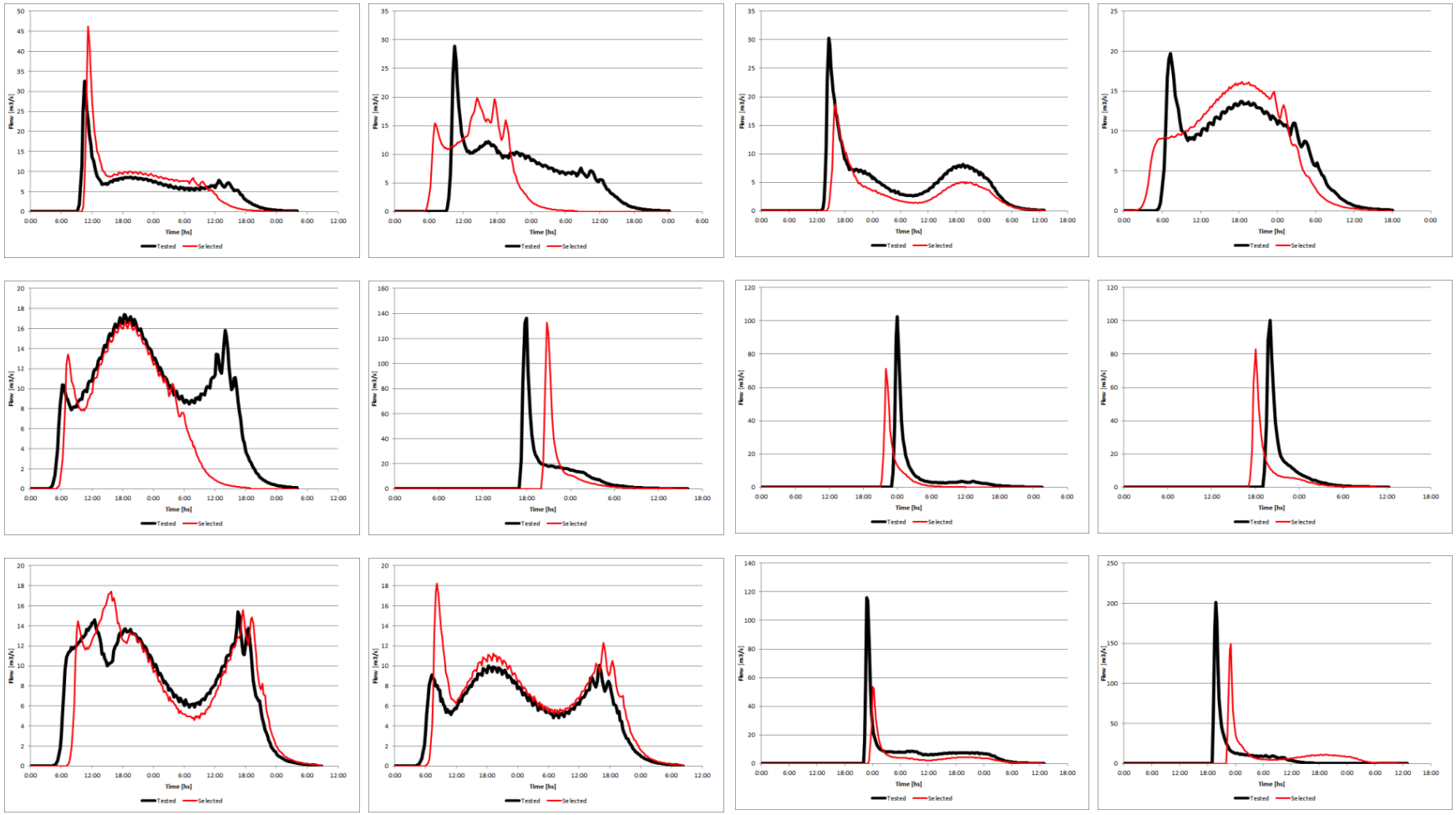
Generate


Volume / Max. Volume
Peak Flow / Max. Peak Flow
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

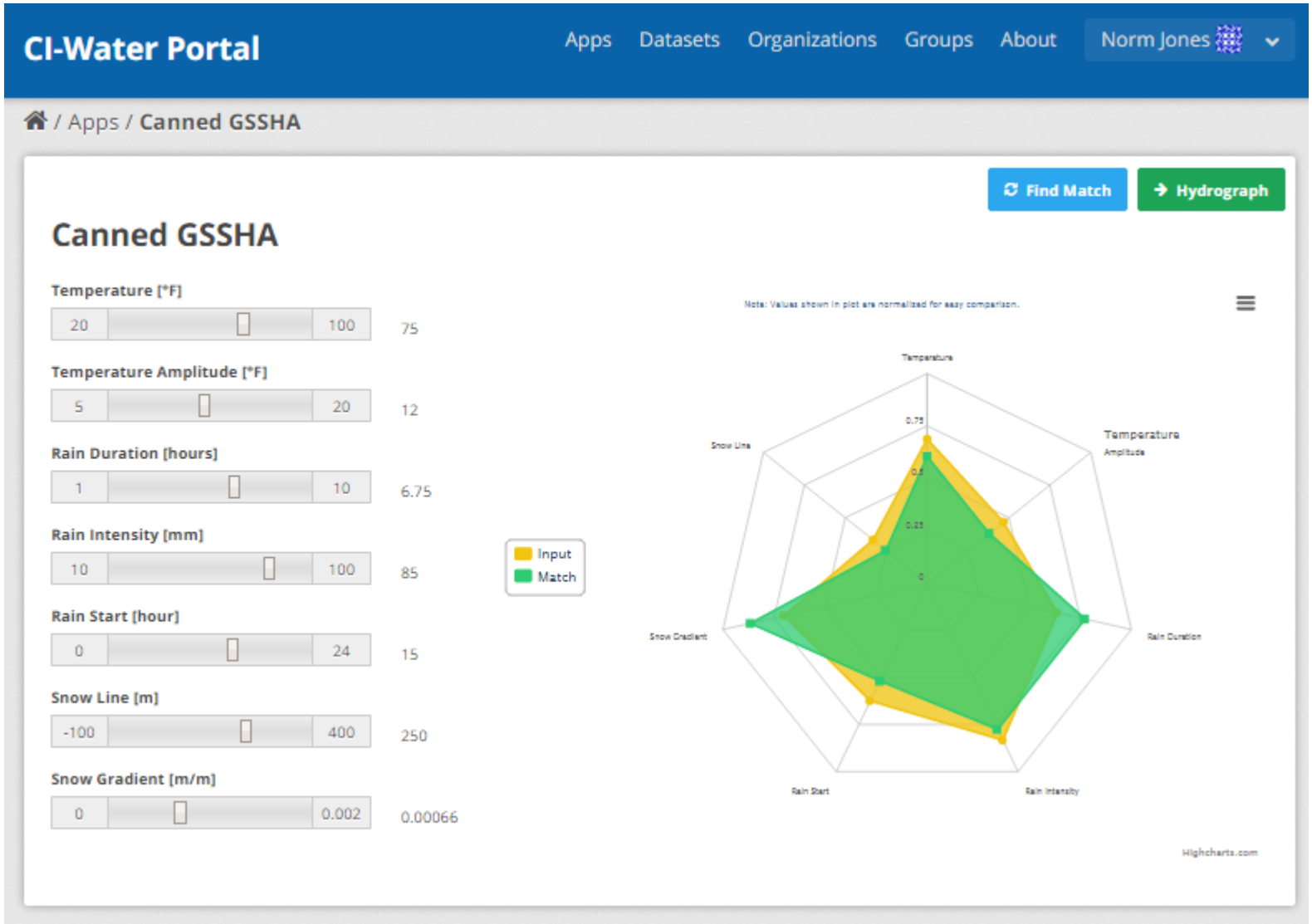
Select


temp
tempamp
rainlenght
rainint
rainstart
snowline
snowgrad
1
0.8
0.6
0.4
0.2
0
Selected
Tested

Select



Similar conditions produced similar results?



http://ciwweb.chpc.utah.edu/apps/canned-gssha

GSSHA Index Map Editor

Land Use Change Impact Simulator

Select a Model

Below is a list of GSSHA models stored in the datasets. Please select which one you would like to edit.

- Ice_Age
- Ice_Age VERIFIED
- No_Ice_Age VERIFIED
- No_Modification
- No_Modification VERIFIED
- No_Modification VERIFIED
- No_Modification__modifi VERIFIED

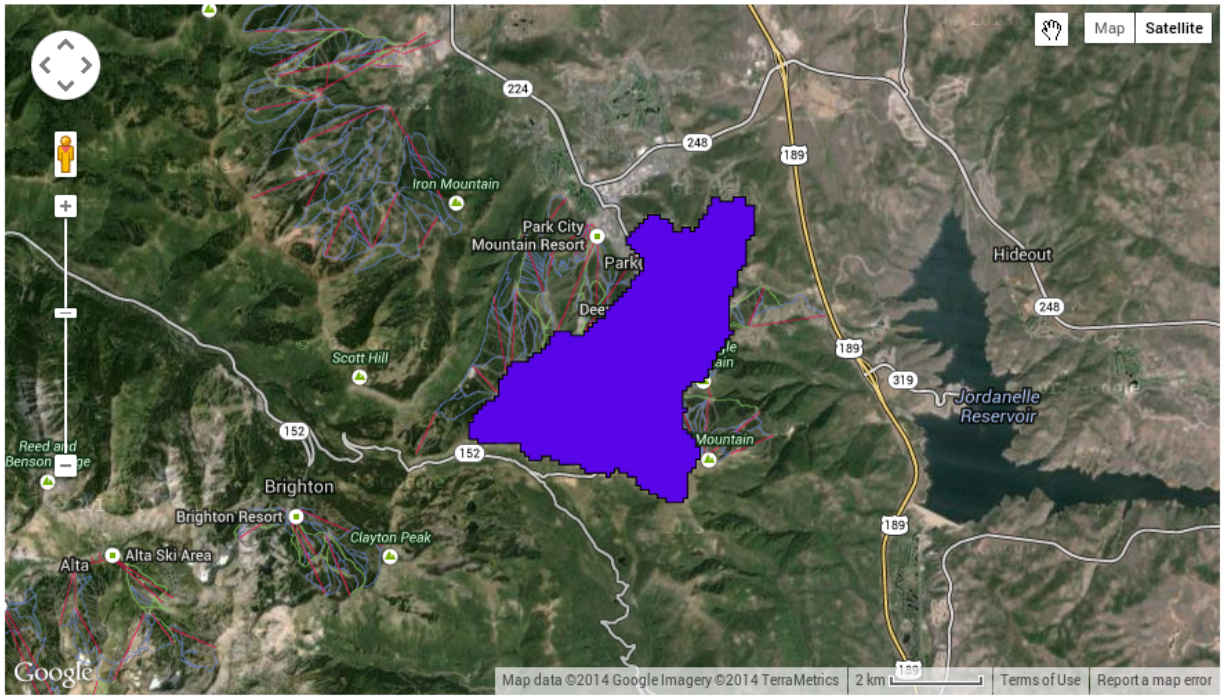
Select

See Past Comparisons

GSSHA Model: Ice_Age

Model Description

This is what would happen if Park City was attacked by a glacier.



Tethys

Apps Datasets Organizations Groups About admin

/ Apps / GSSHA Index Map Editor / **Edit Mapping Tables**

Edit Index Mapping Table Values

Below is a list of mapping tables you can edit tha related to this index m After making changes t values, click "Save Edits Then click "Next" to continue and review th mapping tables.

GREEN AMPT INITIAL SOIL MOISTURE

Save Edits

Back: Edit Map and Descriptions

Next: Review

Index Map: soil

Tethys

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/ Apps / GSSHA Index Map Editor / **Edit Index File**

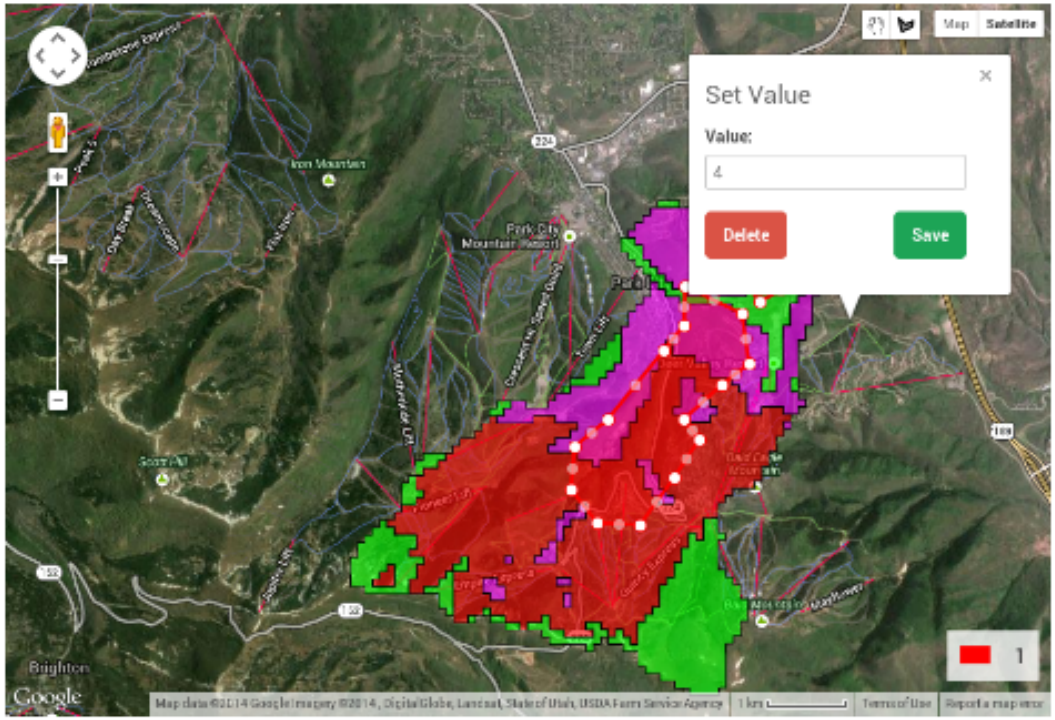
Edit Manually

Draw polygons over locations of the index map that are changing and assign the areas ids. Click "Update Map" after drawing to update the index map and click "Next" after adding descriptions to continue and edit the mapping table.

Update Map

Next: Save and Edit Mapping Tables

Index Map: soil



ID	Description 1	Description 2
1	Clay loam	

Tethys

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/ Apps / GSSHA Index Map Editor / **Select Index File**

Select an Index File

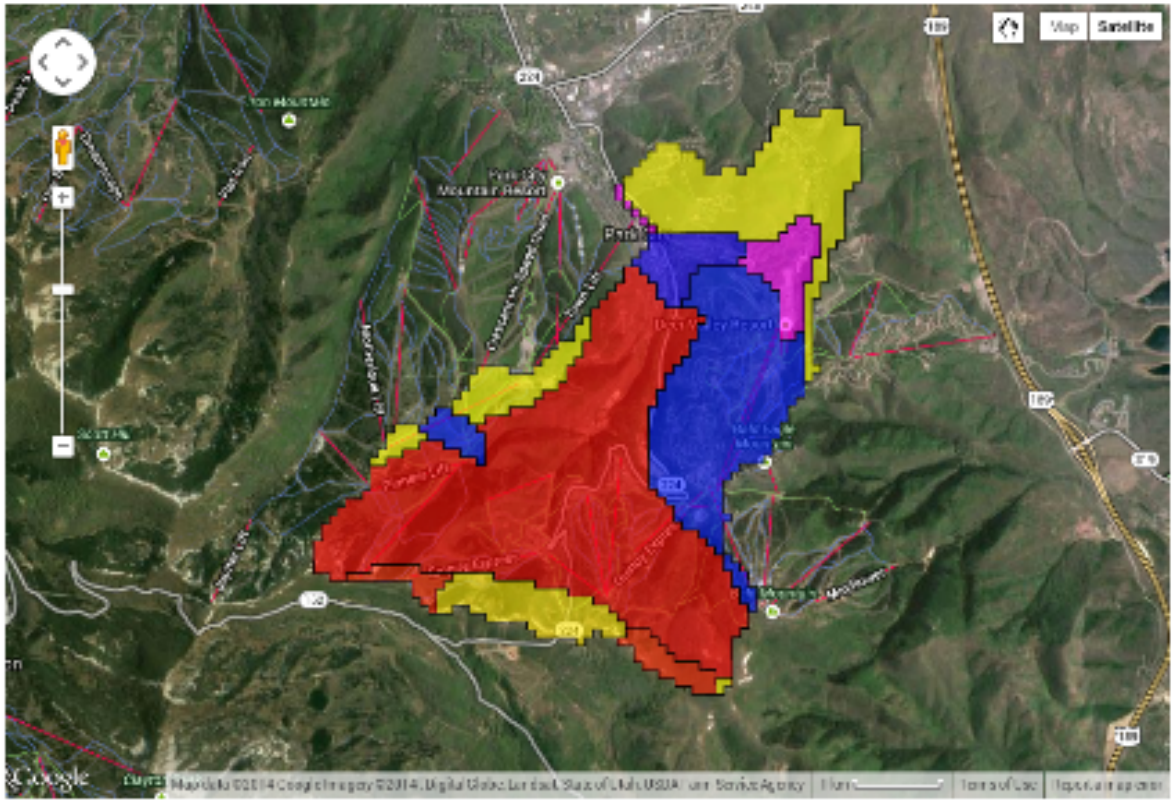
Below is a list of index maps for this GSSHA file. Please select one to edit.

- soil
- luse
- combo

Edit Selected Index Map

Submit New GSSHA File for Comparison

Index Map: soil



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/ Apps / GSSHA Index Map Editor / **Compiled Files**

Comparison Results

These are the results of the GSSHA project comparison.

Return to Start

See Past Comparisons

Swap Maps

Difference between new and old models

Max Depth

Time Series

New Development:

Max Depth

Time Series

No Modification:

Max Depth

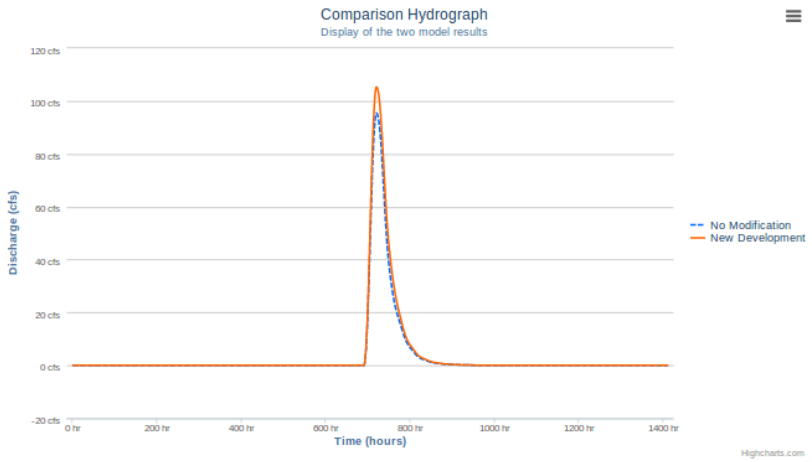
Time Series

Click on the files below if you'd like to download the results.

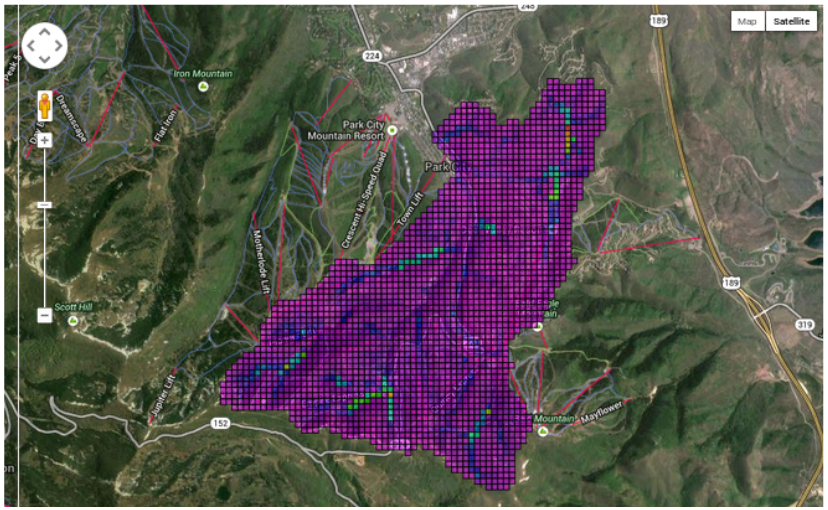
No Modification

New Development

Results



Depth Map



Parley's Creek Water Management Tool

Tethys Cloud-Based Modeling Application

CI-Water

Apps Datasets Organizations Groups About Nathan Swain

/ Apps / **Parleys Creek Management Tool**

Ready? Let's get Started.

Click on the "New Scenario" button to begin.

+ New Scenario

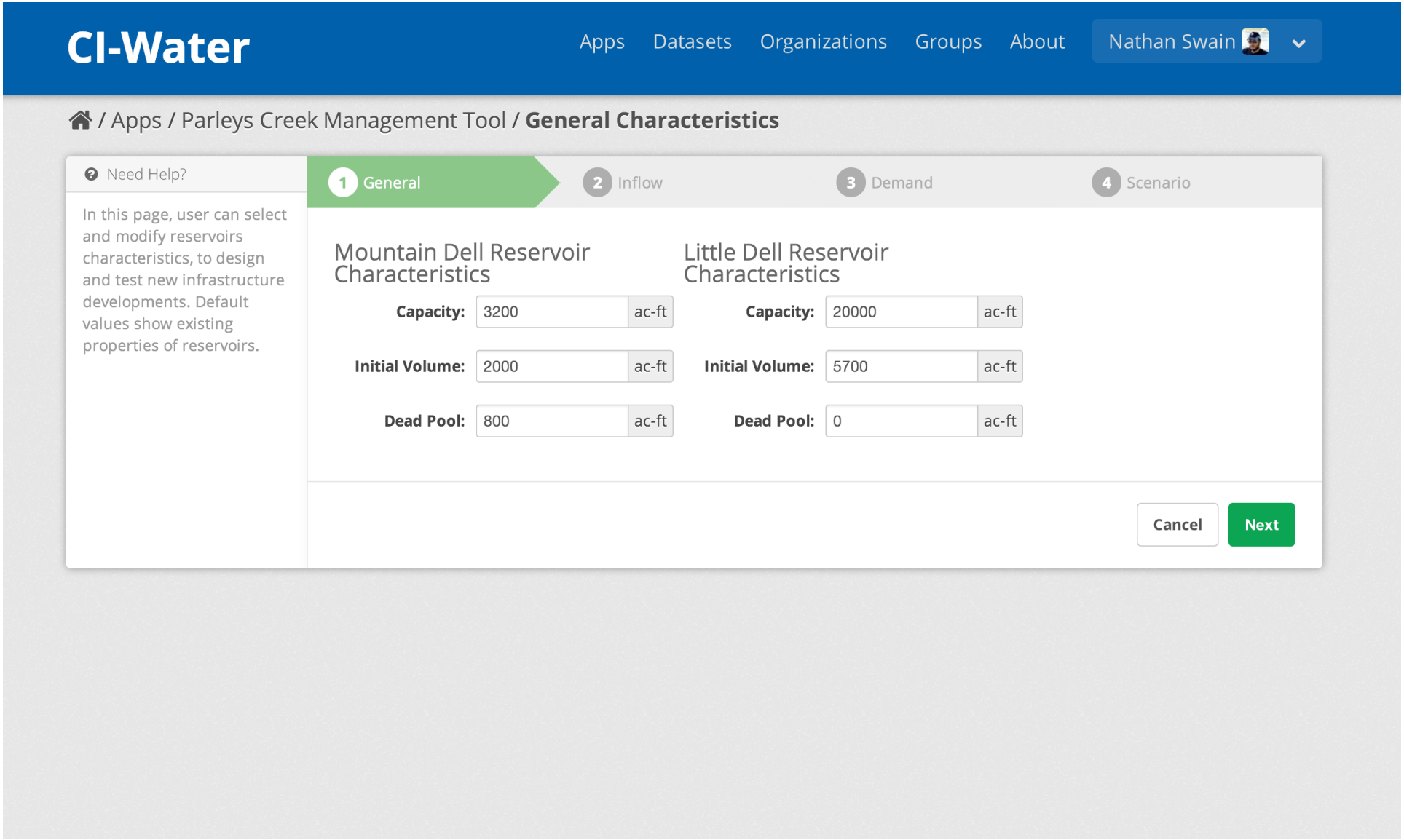
Want to review past scenarios? Click here to view them.

Scenarios

Parleys Creek Management Tool

The Parleys Watershed is one of four drainages that are included in Salt Lake City's "Protected Watershed" Canyons. Parley's Creek Basin, located on western slope of Wasatch Mountains, includes two reservoirs, Little Dell and Mountain Dell. The reservoirs were developed with the primary use of municipal and industrial water supply and secondary use of flood control. The primary inflows are generated from Lamb's and Dell Creek.

This application can be used to evaluate various management scenarios for the Parley's Creek system to give this ability to managers, stakeholders, and users to test different alternatives. This also can be used to test climate change scenarios (uncertain future extreme climate conditions) to evaluate the reservoirs' performance. Click on the "New Scenario" button to get started.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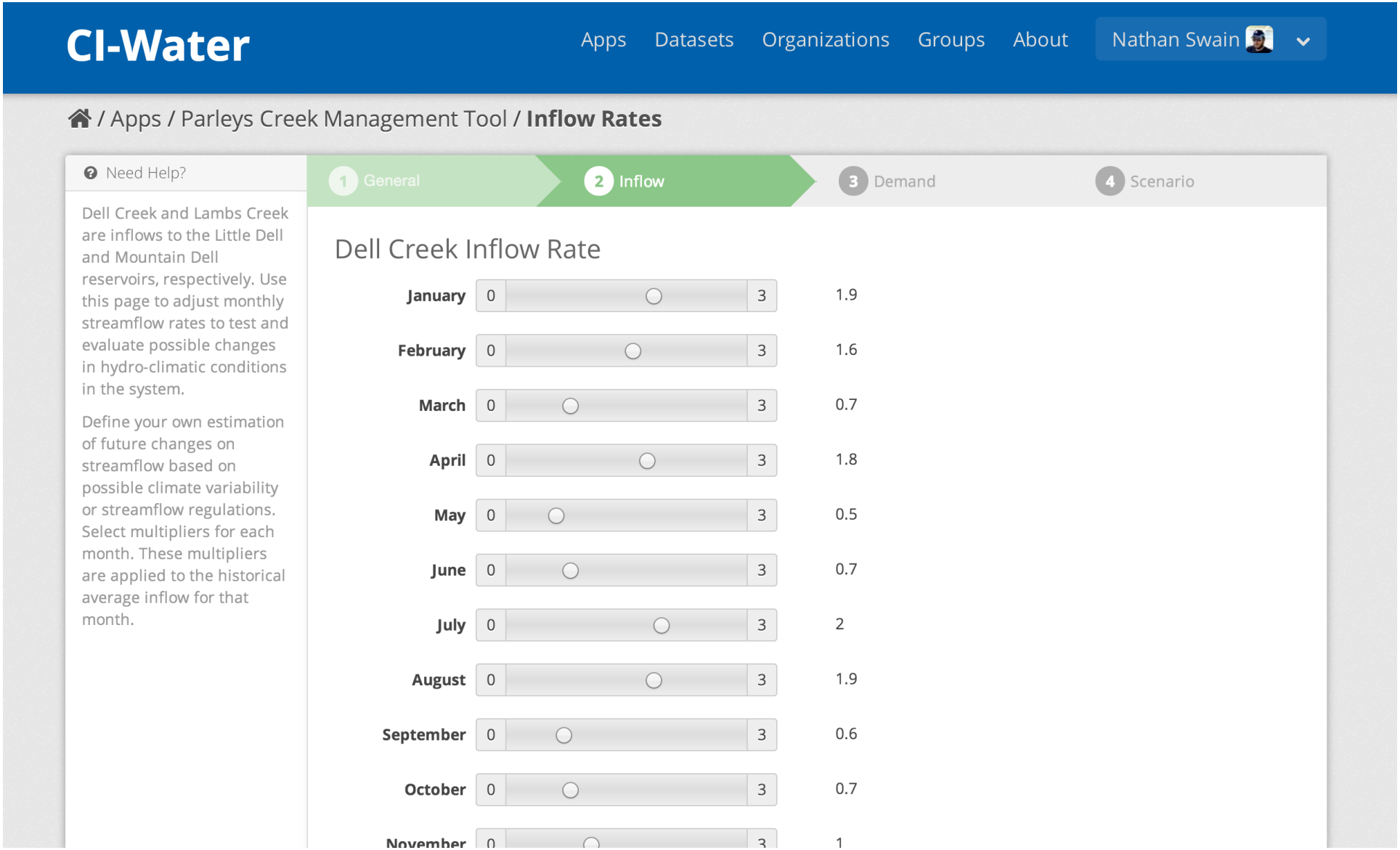
/ Apps / Parleys Creek Management Tool / General Characteristics
Need Help?
In this page, user can select and modify reservoirs characteristics, to design and test new infrastructure developments. Default values show existing properties of reservoirs.
1 General
2 Inflow
3 Demand
4 Scenario
Mountain Dell Reservoir Characteristics
Capacity: 3200 ac-ft
Initial Volume: 2000 ac-ft
Dead Pool: 800 ac-ft
Little Dell Reservoir Characteristics
Capacity: 20000 ac-ft
Initial Volume: 5700 ac-ft
Dead Pool: 0 ac-ft
Cancel
Next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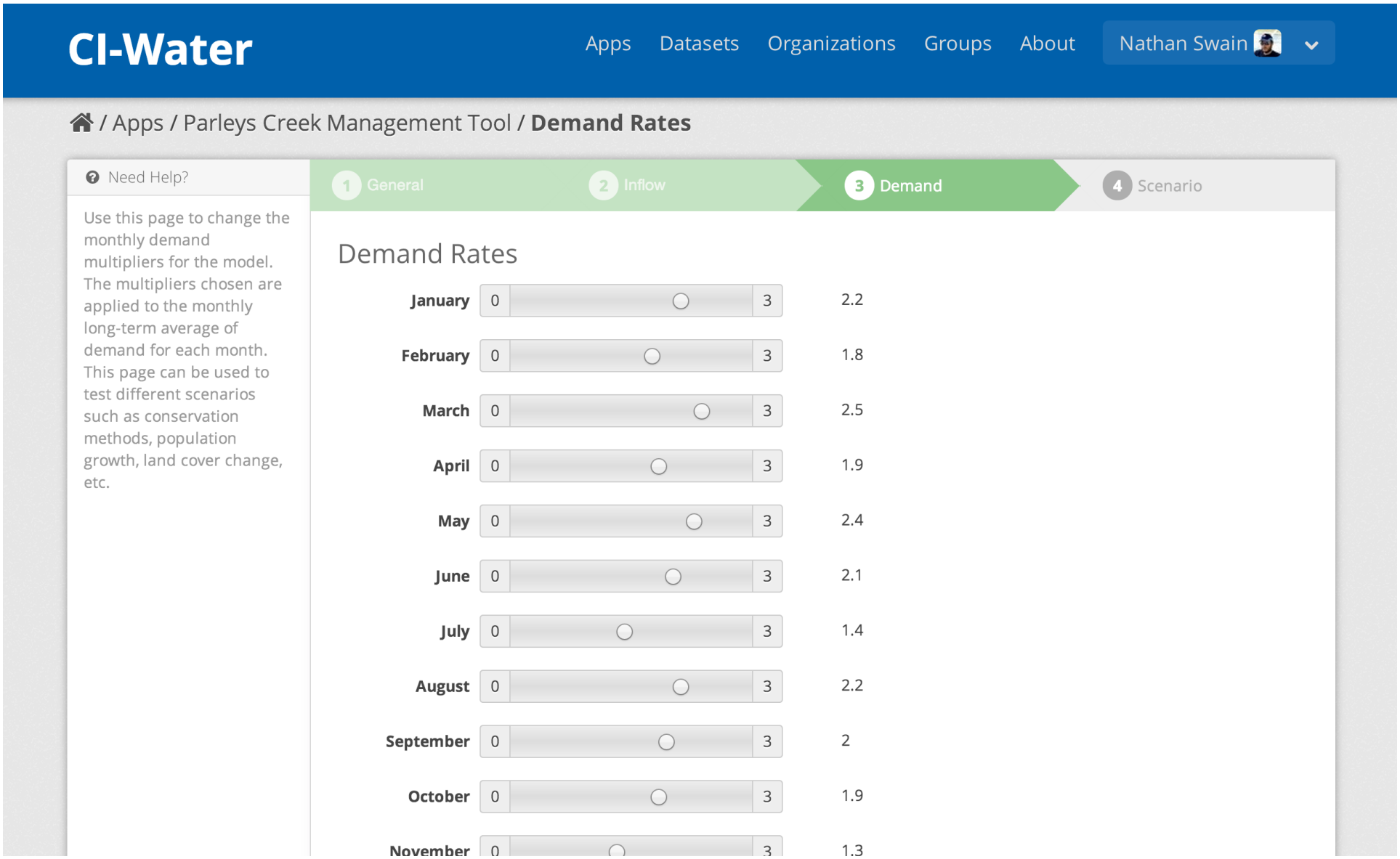
/ Apps / Parleys Creek Management Tool / Inflow Rates
Need Help?
Dell Creek and Lambs Creek are inflows to the Little Dell and Mountain Dell reservoirs, respectively. Use this page to adjust monthly streamflow rates to test and evaluate possible changes in hydro-climatic conditions in the system.
Define your own estimation of future changes on streamflow based on possible climate variability or streamflow regulations. Select multipliers for each month. These multipliers are applied to the historical average inflow for that month.
1 General
2 Inflow
3 Demand
4 Scenario
Dell Creek Inflow Rate
January 0 3 1.9
February 0 3 1.6
March 0 3 0.7
April 0 3 1.8
May 0 3 0.5
June 0 3 0.7
July 0 3 2
August 0 3 1.9
September 0 3 0.6
October 0 3 0.7
November 0 3 1


CI-Water
Apps
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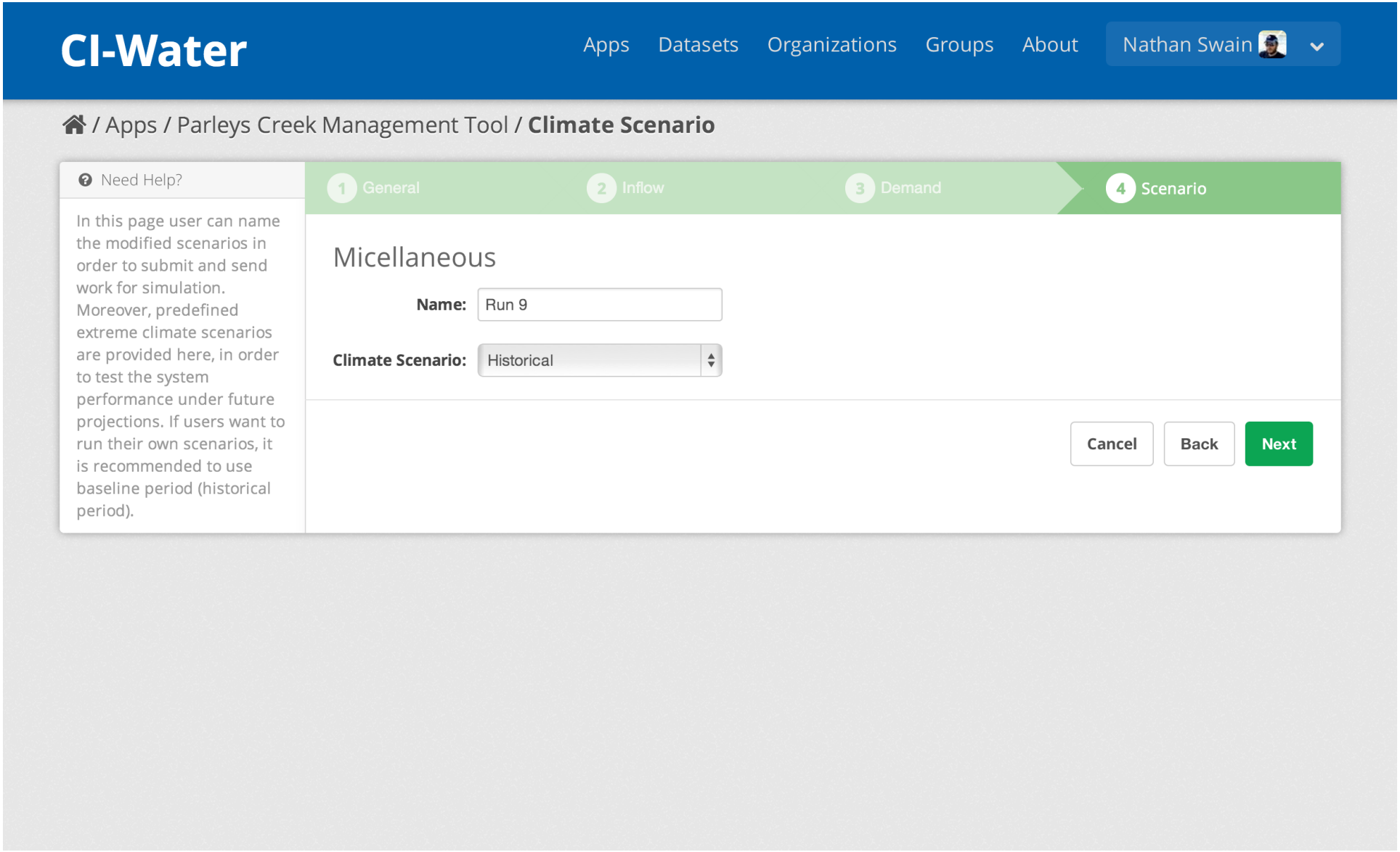
Groups
About
Nathan Swain
/ Apps / Parleys Creek Management Tool / Demand Rates
Need Help?
Use this page to change the monthly demand multipliers for the model. The multipliers chosen are applied to the monthly long-term average of demand for each month. This page can be used to test different scenarios such as conservation methods, population growth, land cover change, etc.
1 General
2 Inflow
3 Demand
4 Scenario
Demand Rates
January 0 3 2.2
February 0 3 1.8
March 0 3 2.5
April 0 3 1.9
May 0 3 2.4
June 0 3 2.1
July 0 3 1.4
August 0 3 2.2
September 0 3 2
October 0 3 1.9
November 0 3 1.3


CI-Water
Apps
Datasets
Organizations
Groups
About
Nathan Swain
/ Apps / Parleys Creek Management Tool / Climate Scenario
Need Help?
In this page user can name the modified scenarios in order to submit and send work for simulation. Moreover, predefined extreme climate scenarios are provided here, in order to test the system performance under future projections. If users want to run their own scenarios, it is recommended to use baseline period (historical period).
1 General
2 Inflow
3 Demand
4 Scenario
Micellaneous
Name:
Run 9
Climate Scenario:
Historical
Cancel
Back
Next

Need Help?

A summary of this scenario is prvoided here.

Use the "Clone" button to create a copy of this scenario as a starting point for the next scenario run.

Delete Clone Done

Summary for Run 9

Reservoir Characteristics

Little Dell

Capacity	20000
Deadpool	0
Initial Volume	5700

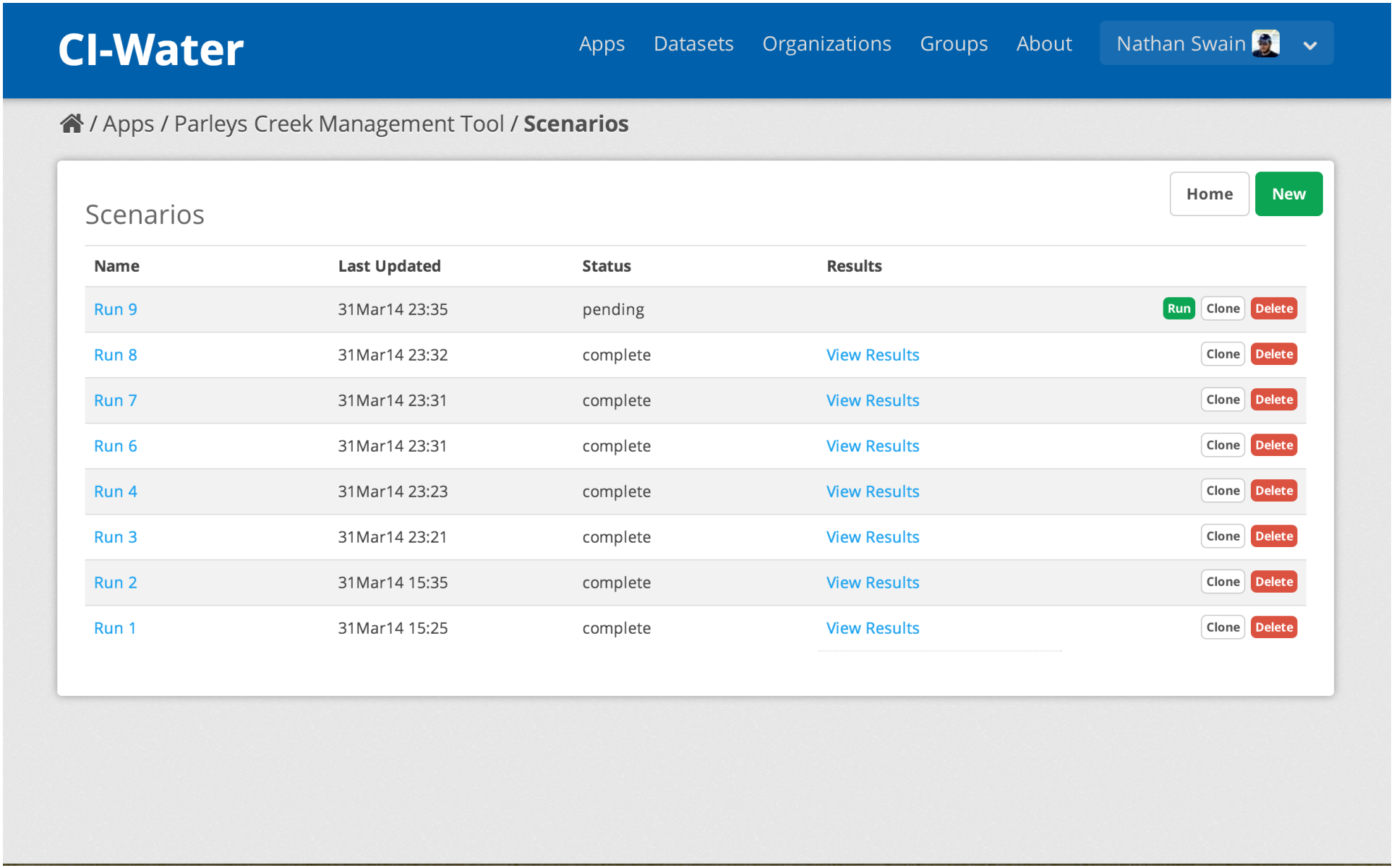
Mountain Dell

Capacity	3200
Deadpool	800
Initial Volume	2000

Inflow Multipliers

Dell Creek

January	1	July	1
February	1	August	1
March	1	September	1


CI-Water
Apps
Datasets
Organizations
Groups
About
Nathan Swain
/ Apps / Parleys Creek Management Tool / Scenarios
Home
New
Scenarios
Name
Last Updated
Status
Results
Run 9
31Mar14 23:35
pending
Run
Clone
Delete
Run 8
31Mar14 23:32
complete
View Results
Clone
Delete
Run 7
31Mar14 23:31
complete
View Results
Clone
Delete
Run 6
31Mar14 23:31
complete
View Results
Clone
Delete
Run 4
31Mar14 23:23
complete
View Results
Clone
Delete
Run 3
31Mar14 23:21
complete
View Results
Clone
Delete
Run 2
31Mar14 15:35
complete
View Results
Clone
Delete
Run 1
31Mar14 15:25
complete
View Results
Clone
Delete

RELIABILITY

1.0

LITTLE DELL RESERVOIR

Volume

Release

Spill

MOUNTAIN DELL RESERVOIR

Volume

Release

Spill

DELL CREEK

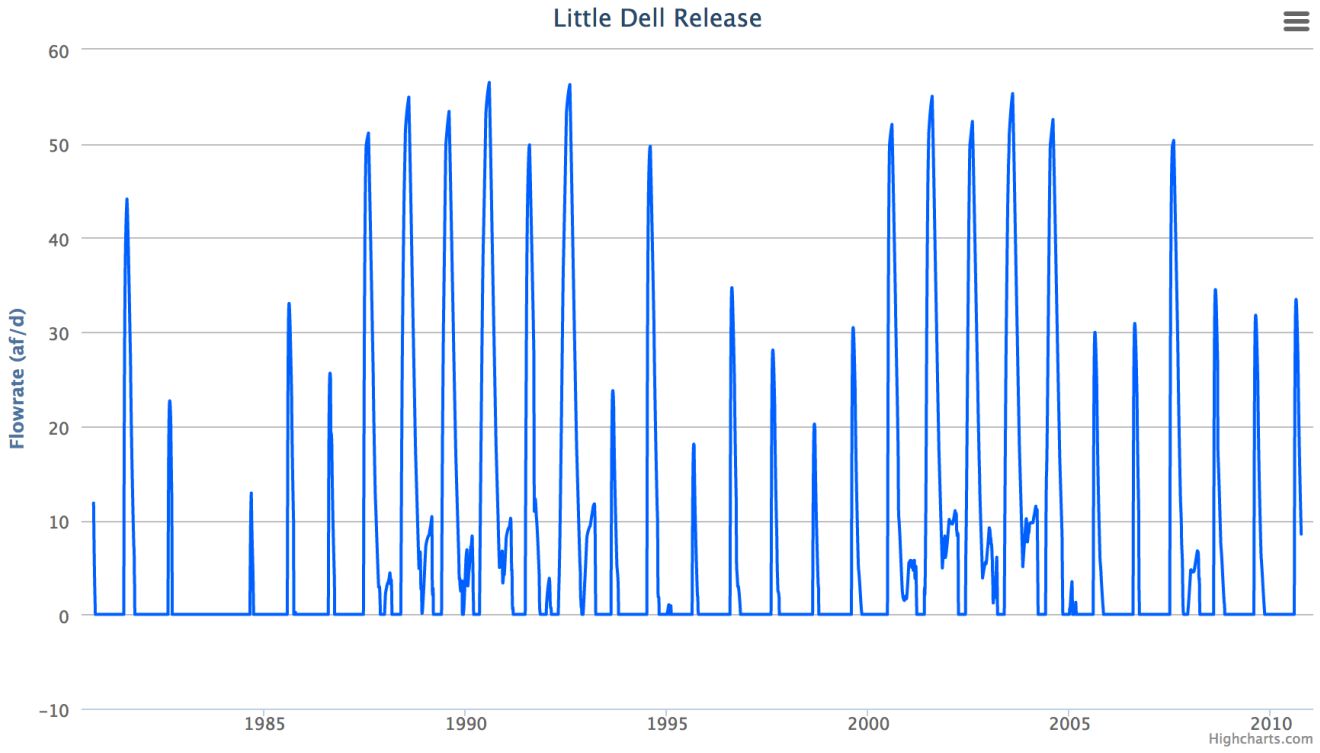
Inflow

LAMBS CREEK

Inflow

Back Download Results

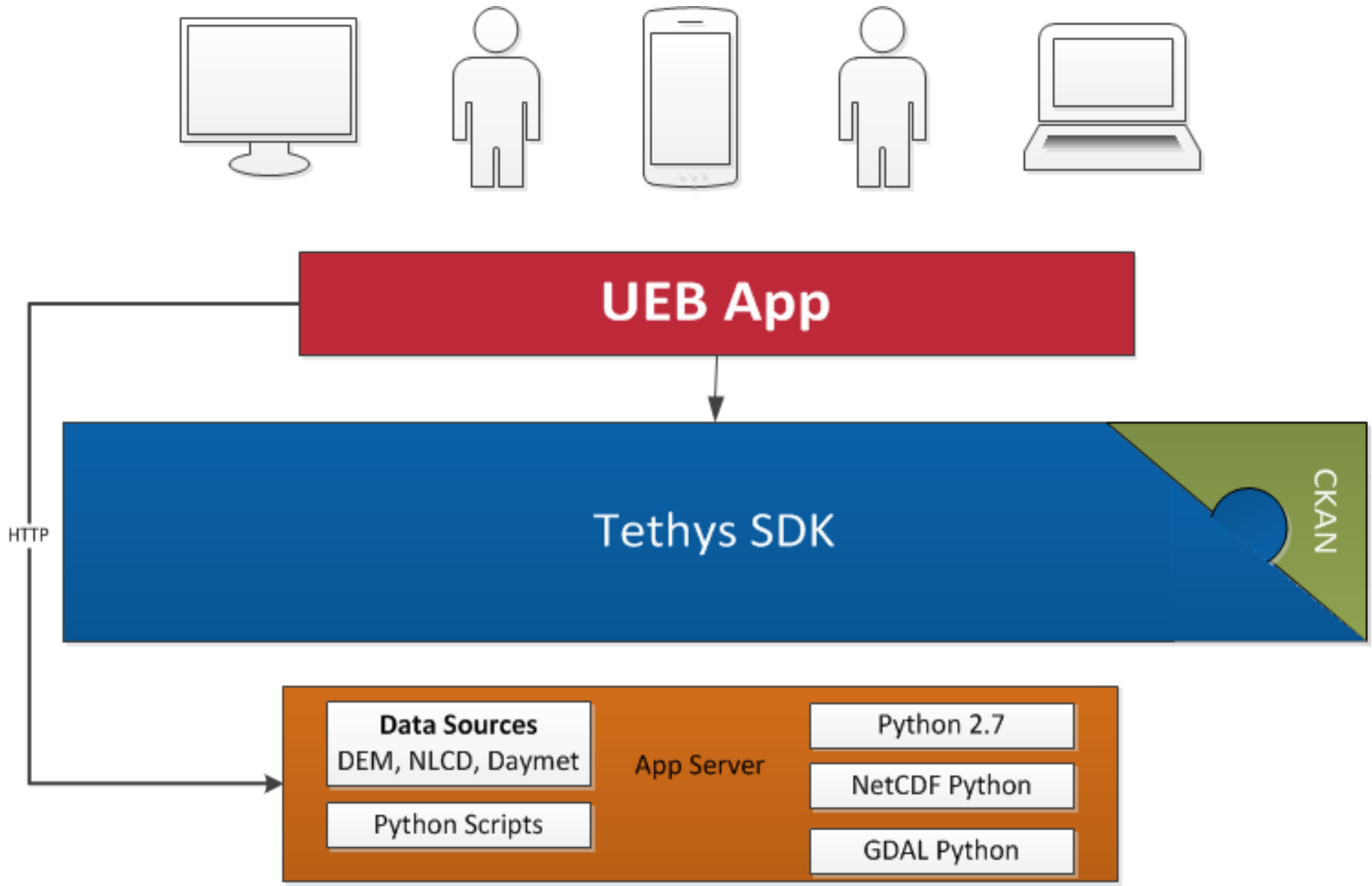
Results for Run 9

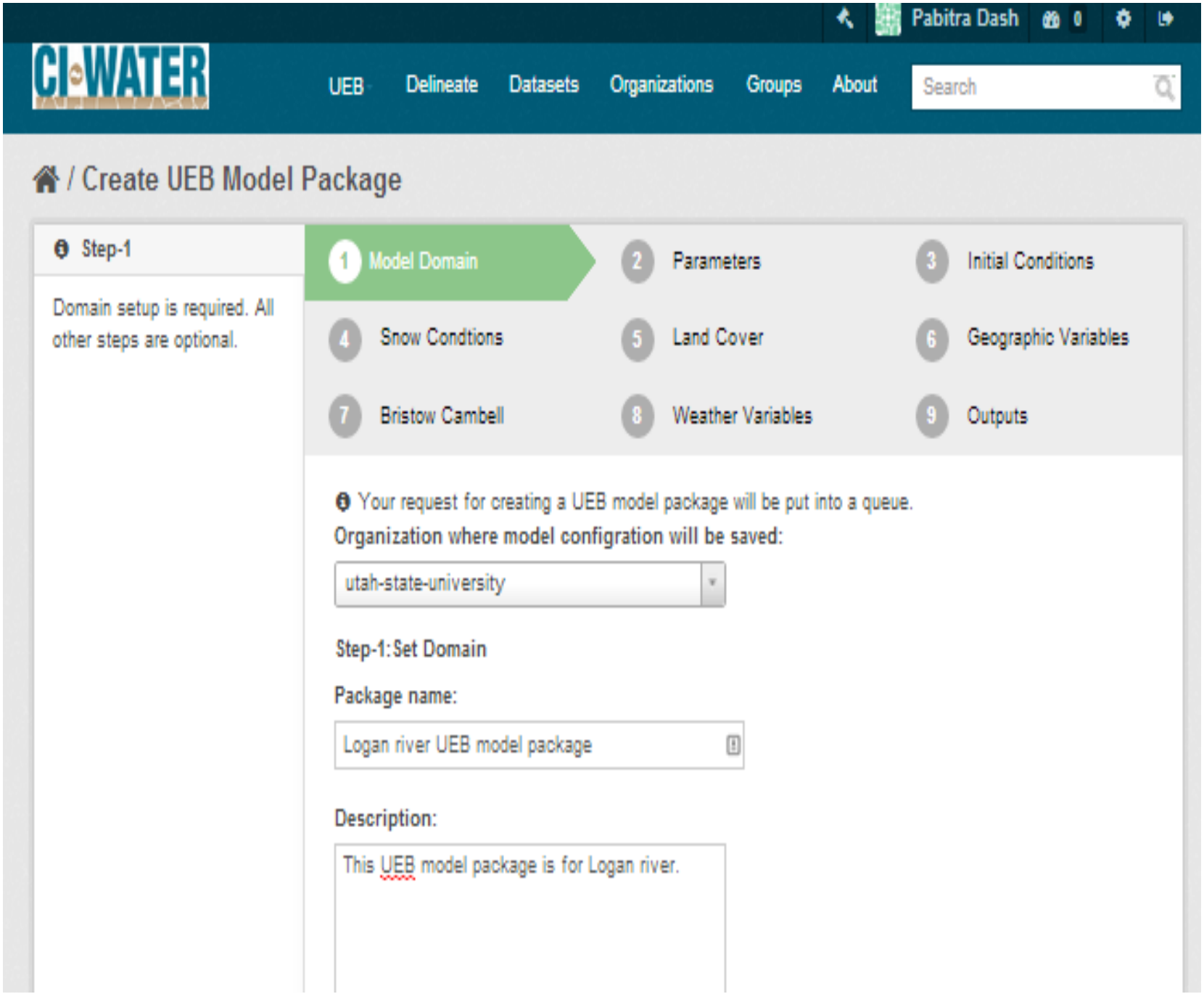


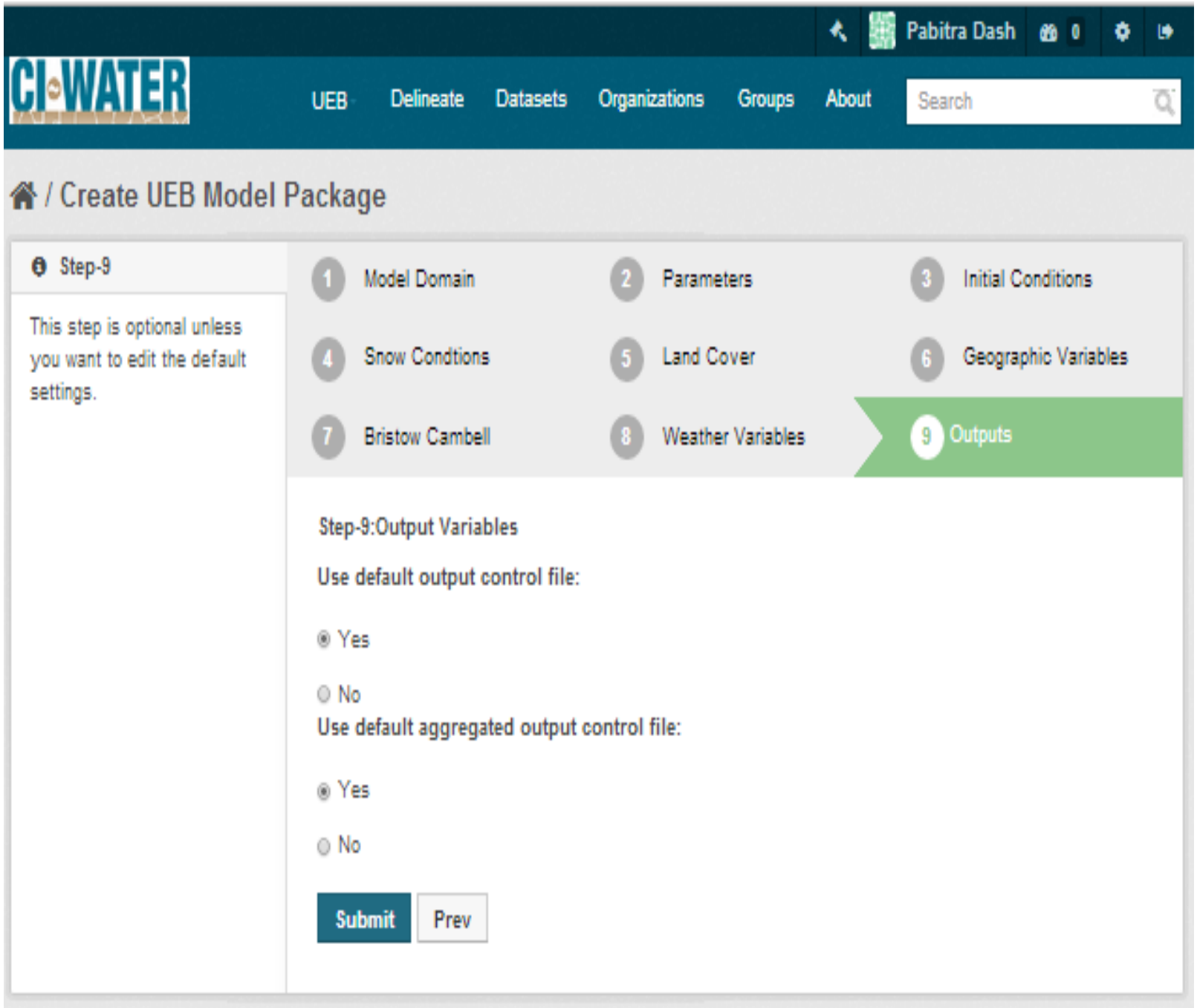
Utah Energy Balance Model Interface

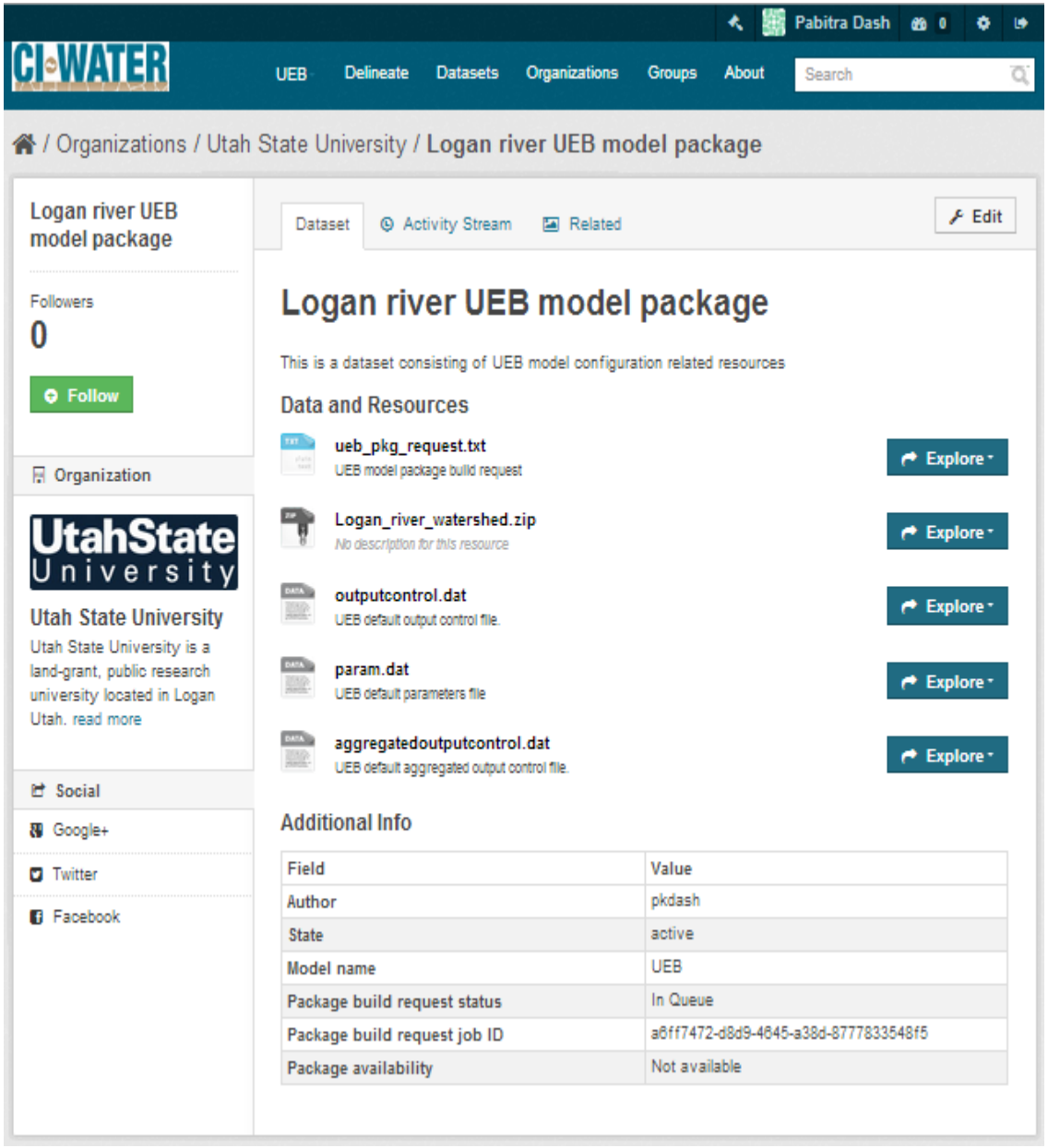
Tethys Cloud-Based Modeling Application

Case Study #2


UEB App
Tethys SDK
CKAN
HTTP
Data Sources
DEM, NLCD, Daymet
Python Scripts
App Server
Python 2.7
NetCDF Python
GDAL Python


Pabitra Dash
0
CI-WATER
UEB
Delineate
Datasets
Organizations
Groups
About
Search
/ Create UEB Model Package
Step-1
Domain setup is required. All other steps are optional.
1 Model Domain
2 Parameters
3 Initial Conditions
4 Snow Condtions
5 Land Cover
6 Geographic Variables
7 Bristow Cambell
8 Weather Variables
9 Outputs
Your request for creating a UEB model package will be put into a queue.
Organization where model configration will be saved:
utah-state-university
Step-1: Set Domain
Package name:
Logan river UEB model package
Description:
This UEB model package is for Logan river.


Pabitra Dash
0
CI-WATER
UEB
Delineate
Datasets
Organizations
Groups
About
Search
/ Create UEB Model Package
Step-9
This step is optional unless you want to edit the default settings.
1 Model Domain
2 Parameters
3 Initial Conditions
4 Snow Condtions
5 Land Cover
6 Geographic Variables
7 Bristow Cambell
8 Weather Variables
9 Outputs
Step-9:Output Variables
Use default output control file:
Yes
No
Use default aggregated output control file:
Yes
No
Submit
Prev



UEB Model Package Build Request is Stored as a Dataset

Summary

Enhance access to data- and computationally-intensive modeling

- Tethys is a development and hosting platform for deploying water resource models on the cloud for decision support
- Tethys significantly "lowers the barrier" for cloud-based app development
- Tethys simplifies the process of accessing scalable distributed cloud computing resources
- We are actively pursuing several follow-on projects that will leverage these tools.

Thank You
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