

# **Cyber-Infrastructure to Enhance Access to Data- and Computationally- Intensive Modeling for Water Resources Management**

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**Director, USAID-funded Pakistan Center for Advanced Studies in Water**

**Associate Director, Global Change and Sustainability Center**

**University of Utah**



A Utah-Wyoming Cyberinfrastructure  
Water Modeling Collaboration



# Collaboration Described Today



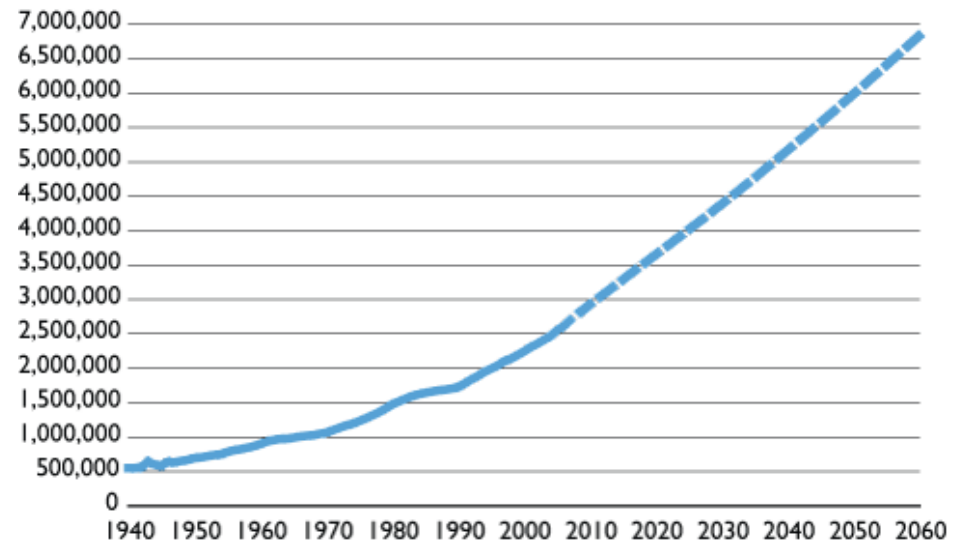
- **Norm Jones**, Jim Nelson, Chris Latu, Nathan Swain, Scott Christensen, Spencer Taylor
- David Tarboton, Jeffery Horsburgh, David Rosenberg, Pabitra Dash, Tseganeh Gichamo, Adel Abdallah
- Steve Burian, Steve Corbato, Court Strong, Christine Pomeroy, Erfan Goharian, Laura Hunter, Adam Kochanski
- **Fred Ogden**, Scott Miller
- Jeff Niermeyer, Laura Briefer, Tracie Kirkham

# Future Water Challenges

- **Low amount of and seasonal precipitation**
- **Warm and dry climate**
- **Data gaps and uncertainty**
- **Growing urban population**
- **Climate variability and change**

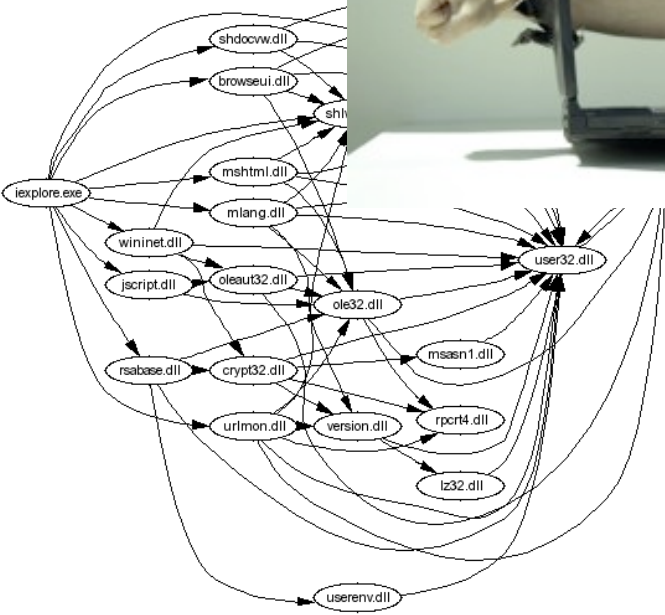
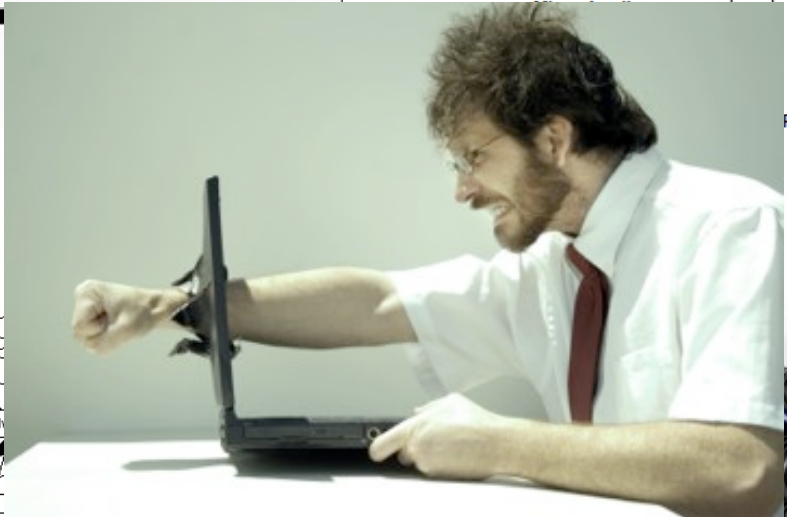
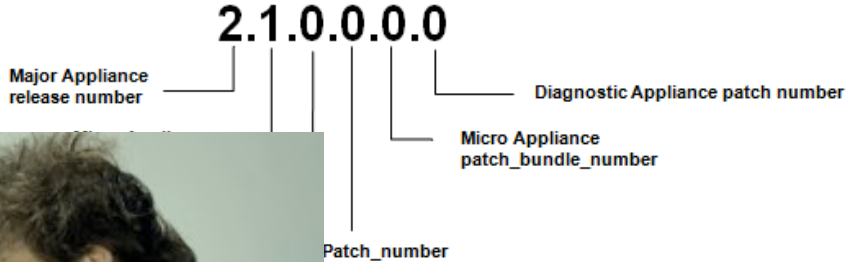
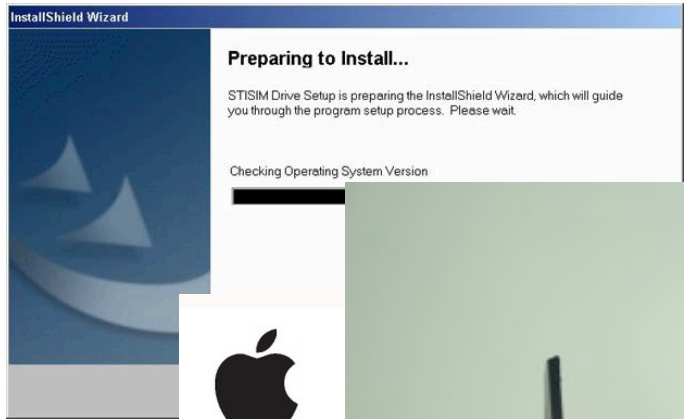


Figure 1: Utah's Population, 1940-2060



Source: Utah Population Estimates Committee.

# Traditional Modeling Software Paradigm

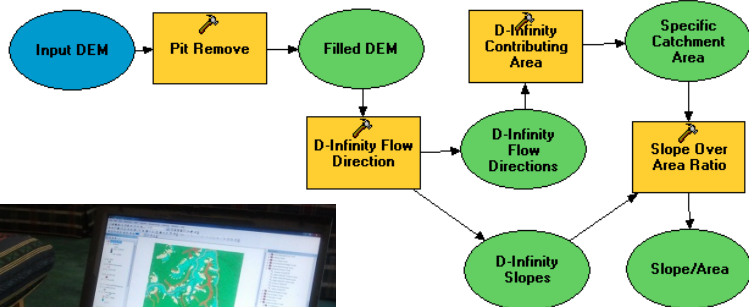


(Slide courtesy of Norm Jones)

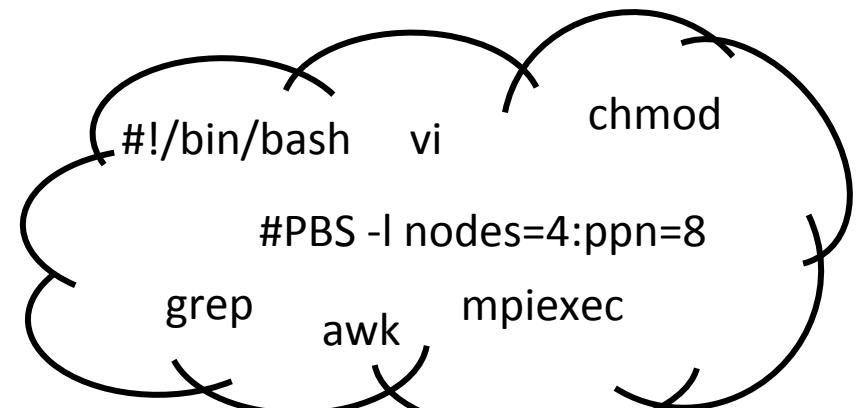
# A Digital Divide

## Researchers

- Experimentalists
- Modelers



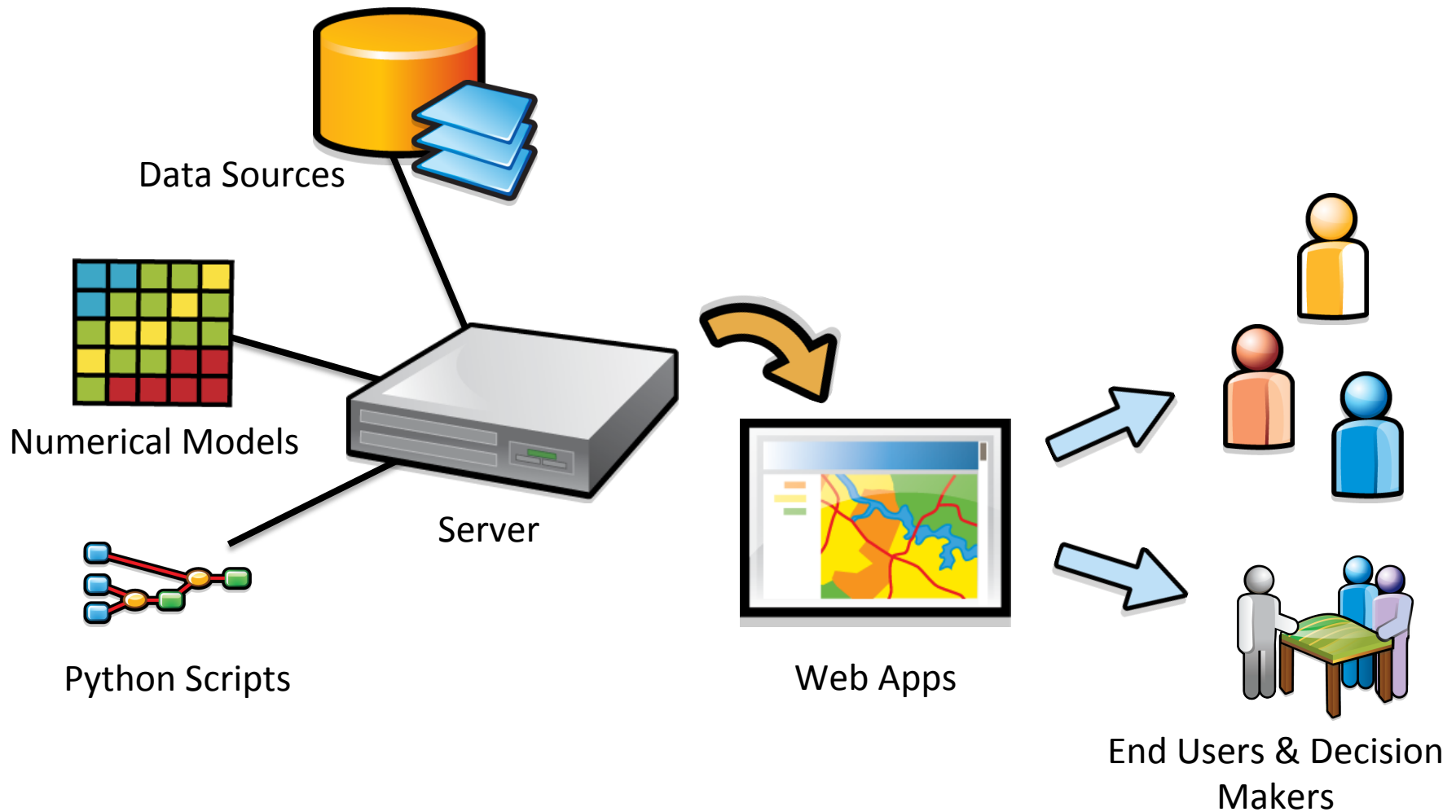
## HPC Specialists



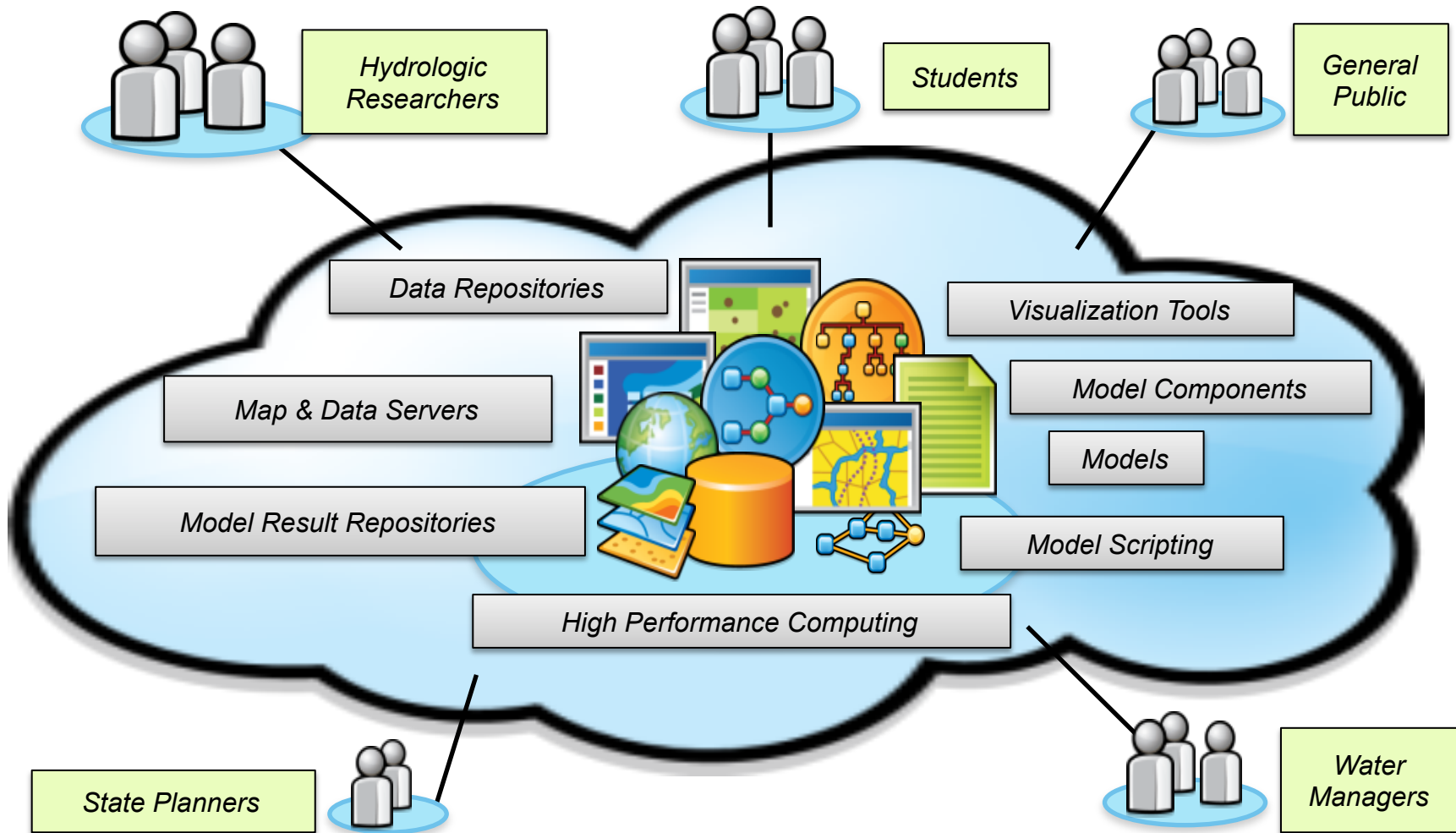
```
-bash-3.2$ ls tddata
logan      LoganOutlet.sbn  LoganOutlet.shp  LoganOutlet.shx
LoganOutlet.dbf  LoganOutlet.sbx  LoganOutlet.shp.xml
-bash-3.2$ ls tddata/logan
logan.tif
-bash-3.2$ ls
eric  logMffiel  run.bash  taudem.bash  taudem_submit.sh
logMF  run_all.bash  run_taudem.sh  taudem_041959  tddata
-bash-3.2$ run_taudem.sh pitremove -z logan -fel loganfel
43058.ip-net
-bash-3.2$
```

(Slide courtesy of David Tarboton)

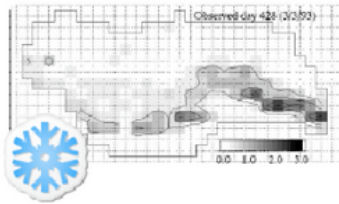
We are developing a suite of tools for building Cloud-based applications for modeling in support of water management decision-making.



# CI-WATER System



# What is an app?



**UEB Model Builder**



**GSSHA Explorer**



**ADHydro Explorer**



**Early Flood Warning**



**Parleys Creek  
Management Tool**

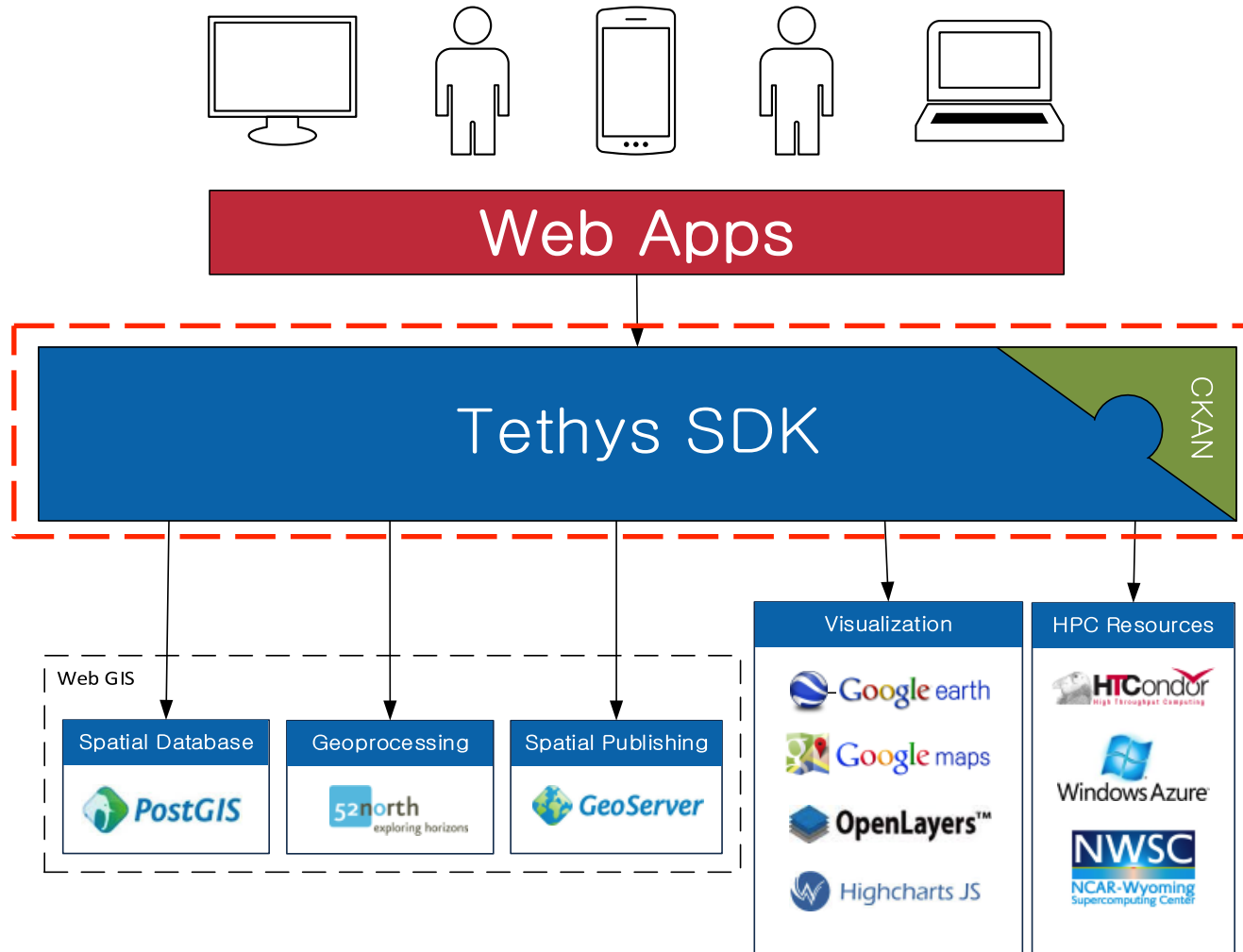


**Burned Area Flooding**



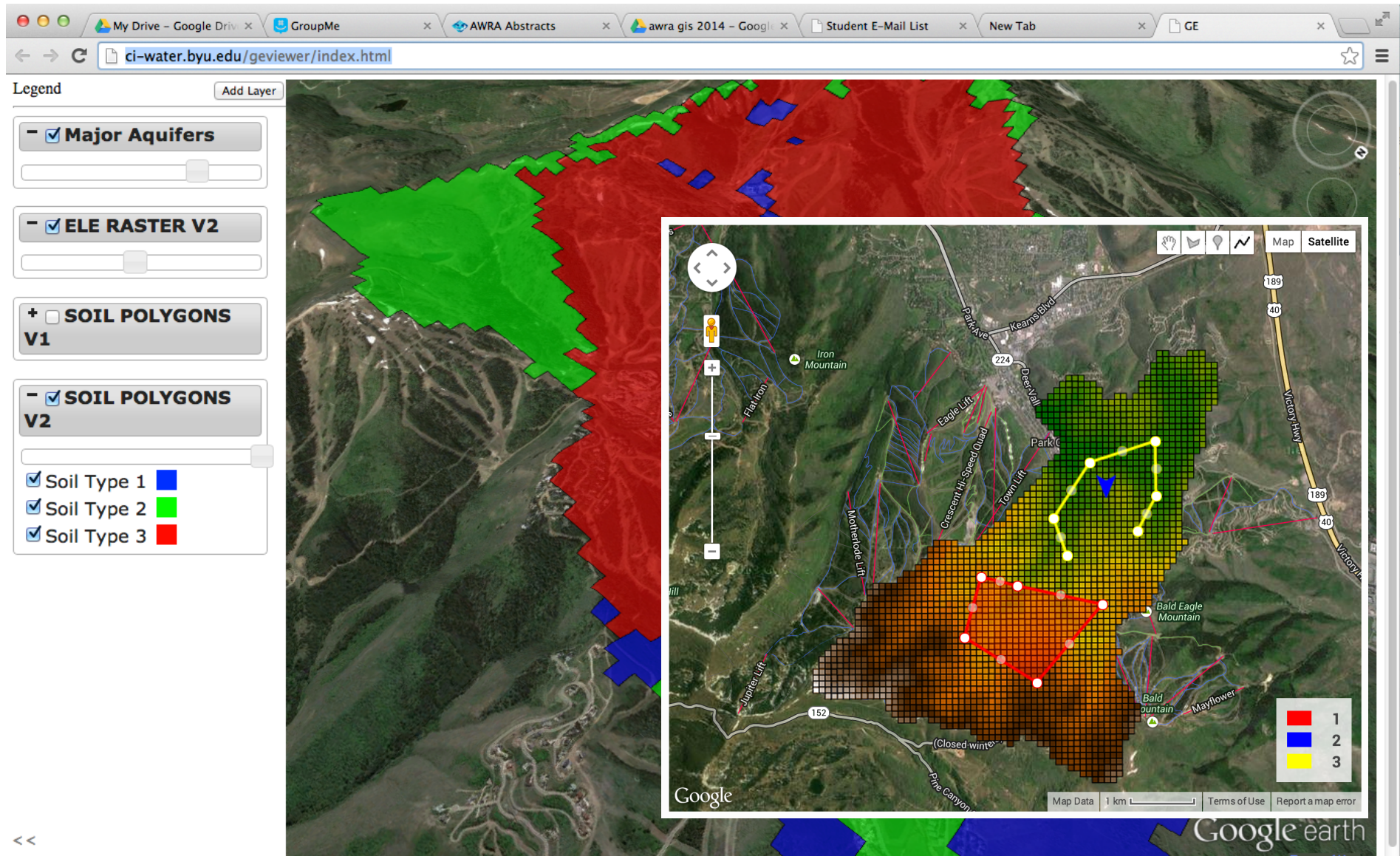


# Tethys Software Framework

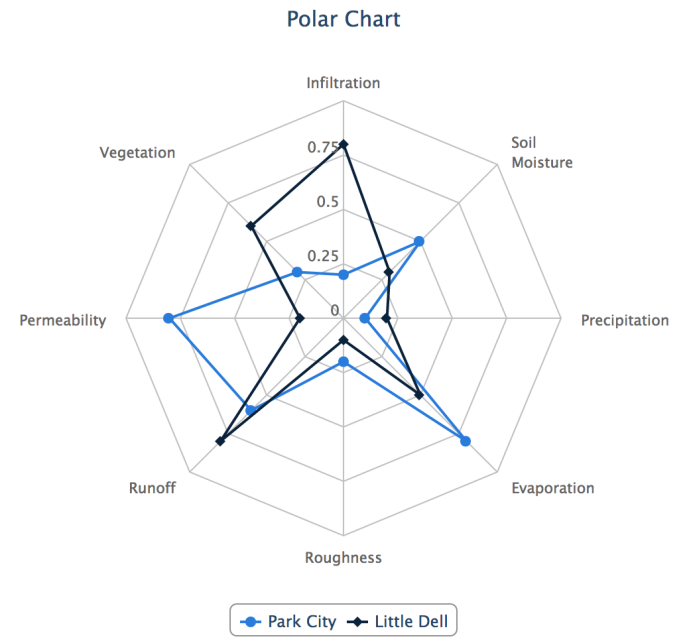
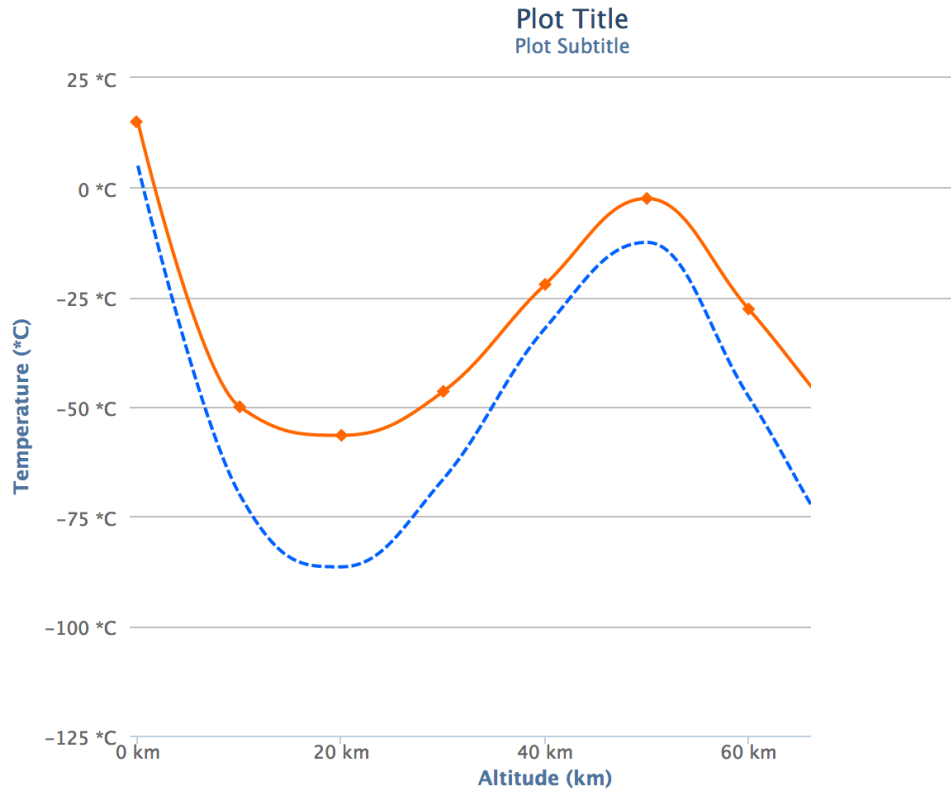


(Slide courtesy of Norm Jones)

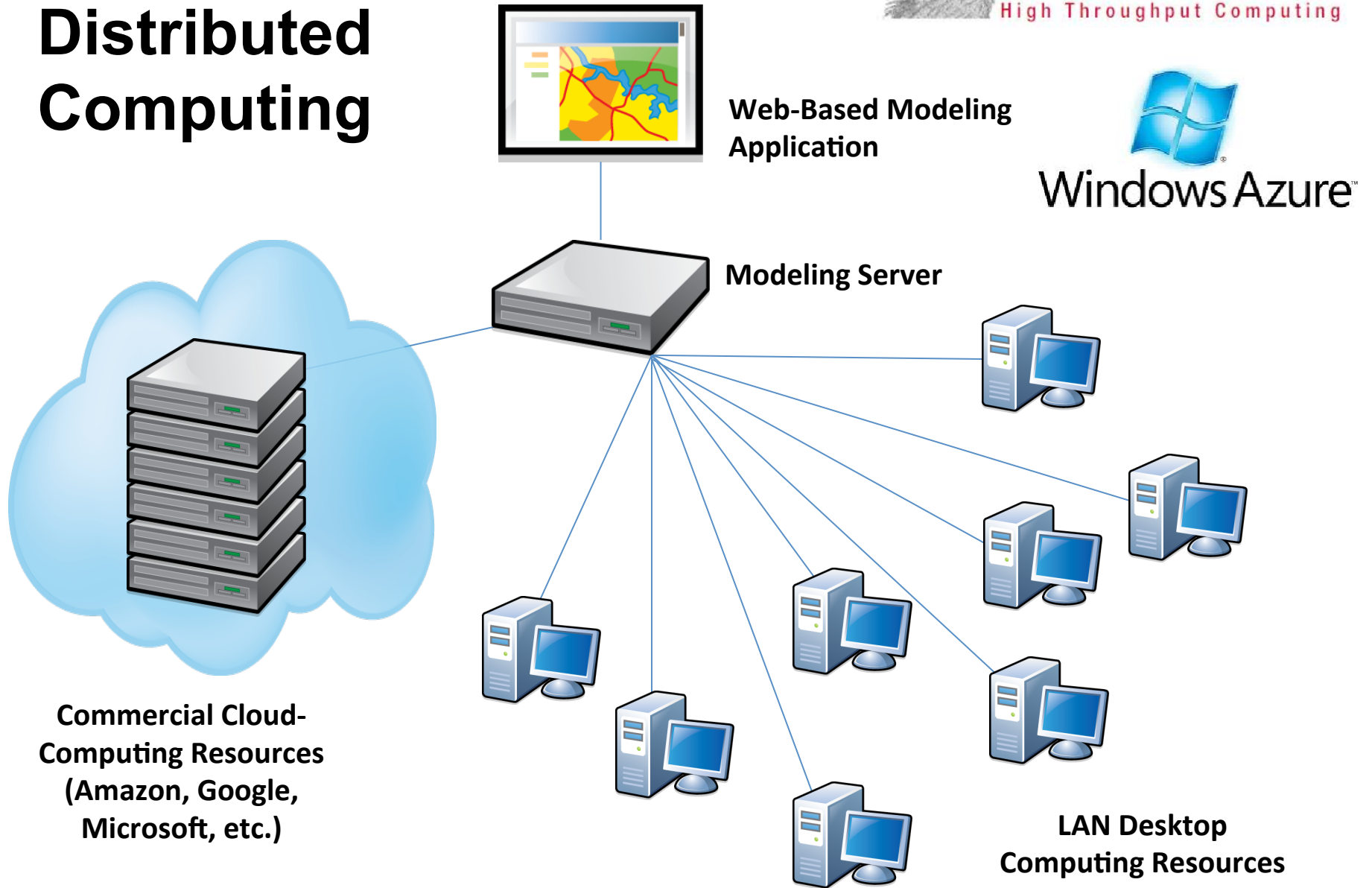
# Web Mapping and Modeling



# Plotting



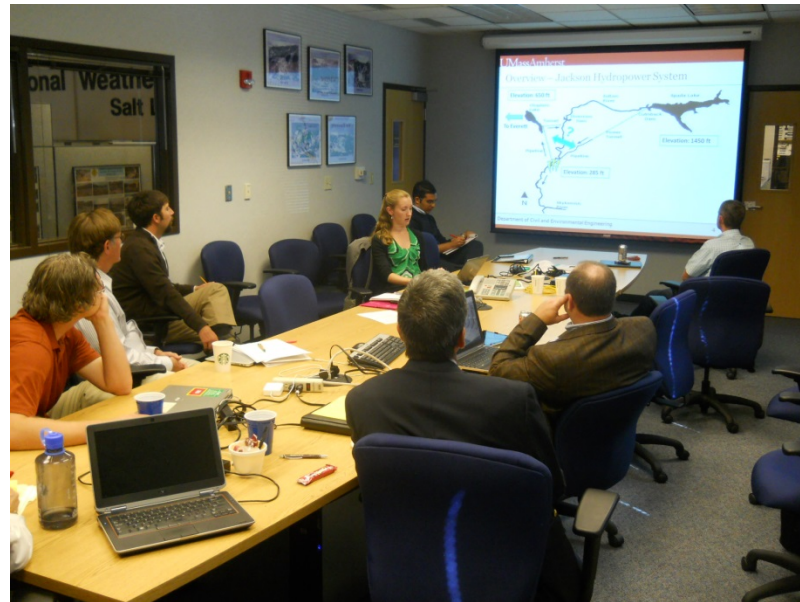
# Distributed Computing



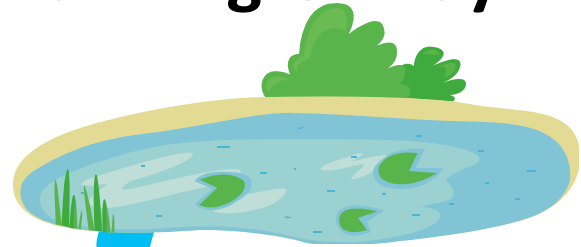
**CASE STUDY: SALT LAKE CITY  
WATER MANAGEMENT**

# Stakeholders

- **SLCDPU:** J. Niermeyer, L. Briefer, T. Kirkham
- **University of Utah:** Burian/Goharian (Civil Engineering), Strong (Atmospheric Sciences), Stoker (Planning), Christensen (Biology/Ecosystems), Ehleringer (Biology), Harper (CHPC), McCool (PoliSci), Hunter (Utah Education Network)
- **WWA:** T. Bardsley



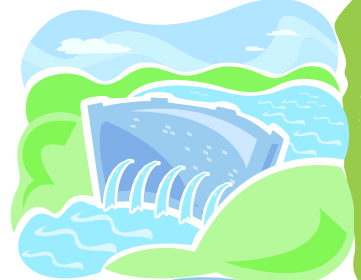
**Farmington Bay**



**Jordan River**



**Salt Lake City**



**Wasatch front**

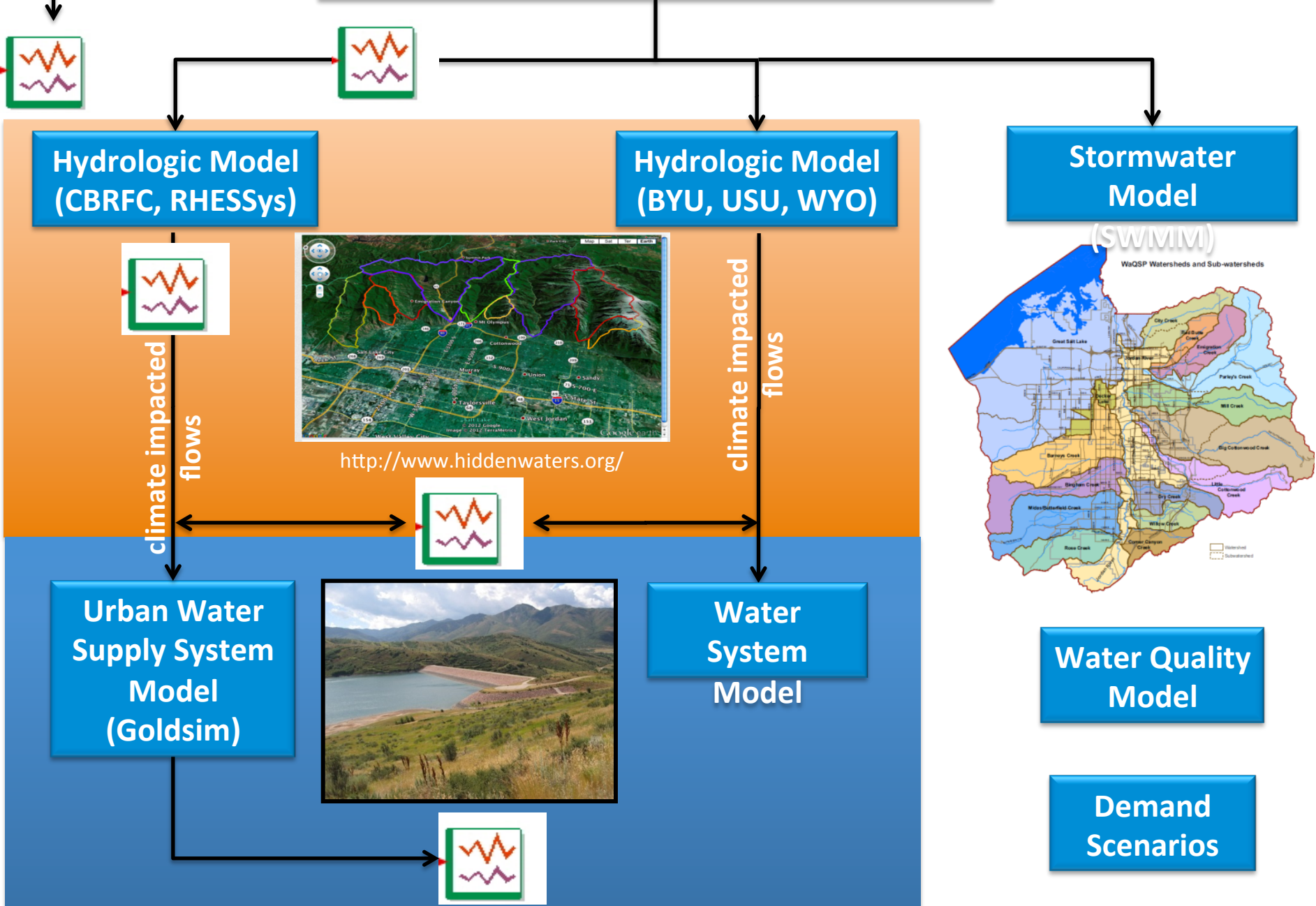
# Water Supply

- 60% from the four of the seven canyons above the City:  
City Creek,  
Parleys Creek,  
Big Cottonwood and  
Little Cottonwood
- 20% Deer Creek and Provo System
- Rest from wells, springs and groundwater

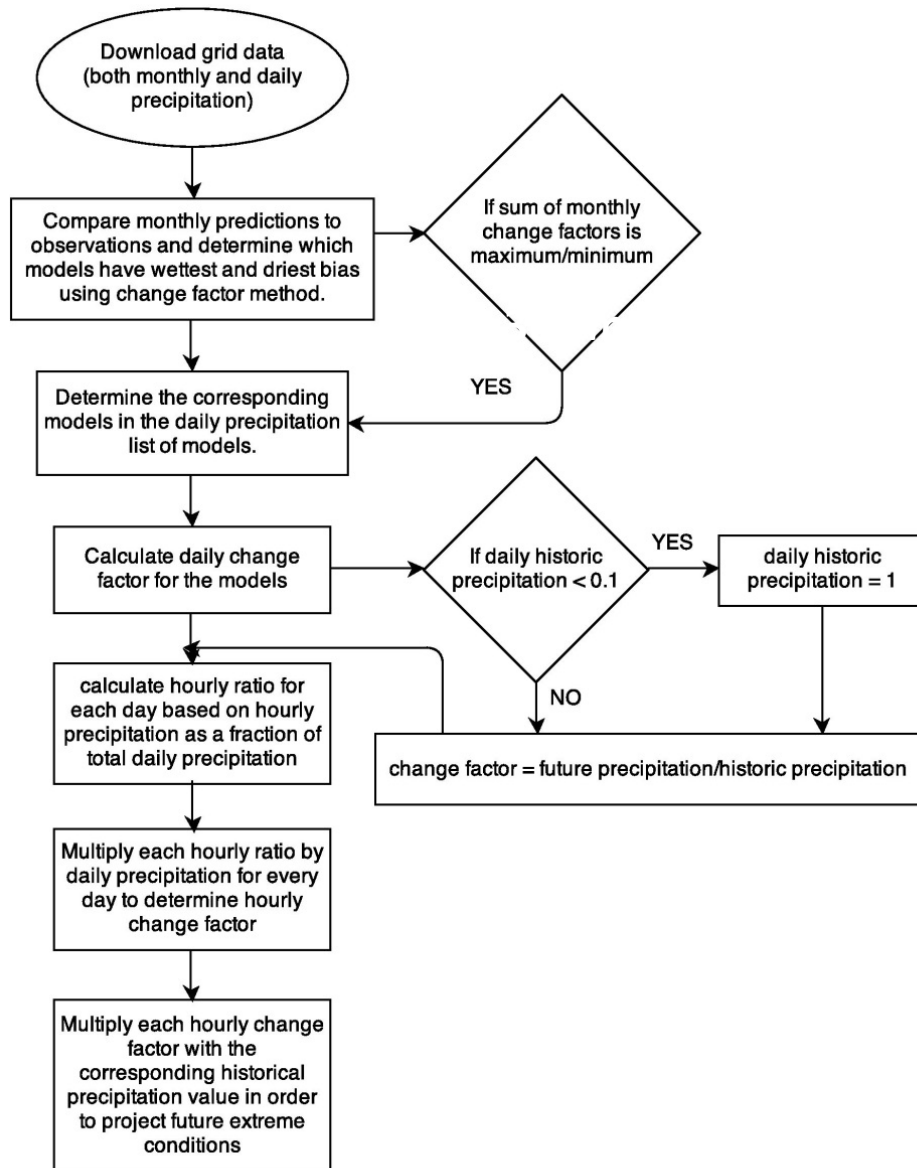




# Climate Modeling and Data Access



# Climate Data Access



- **CMIP5 projections**
- **Code identifies GCM with wettest and driest bias (BCSD 5)**
- **Disaggregates wettest & driest scenarios to hourly (BCCA 5)**
- **Applicable for U.S.**

# Dynamical Downscaling

- CI-WATER simulations use WRF model with three nested domains

## Boundary conditions:

6-hourly NCEP CFSR

~38 km resolution

1985-1994

1995-present

CMIP5 (~1°)

2025-2035

2055-2065

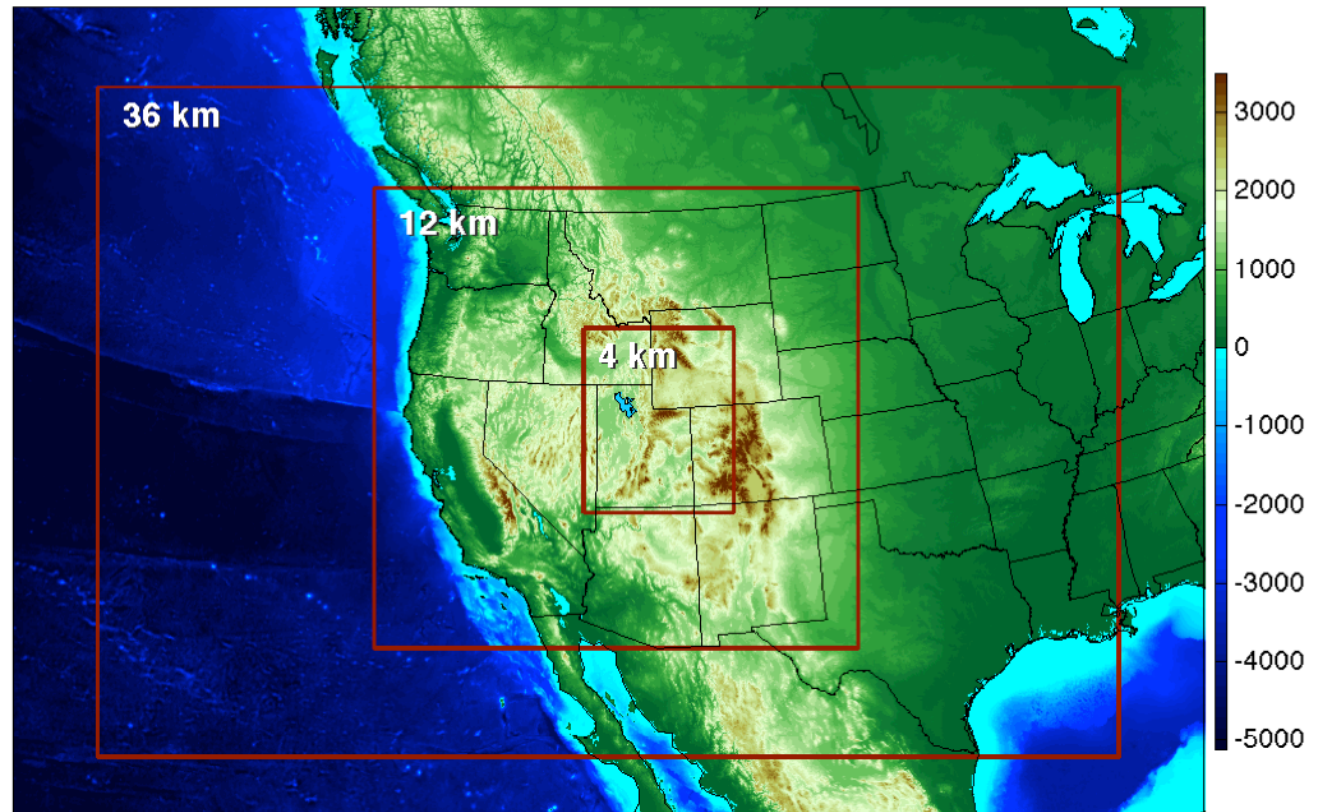
2085-2095

## Customizations related to water:

Saturation vapor pressure

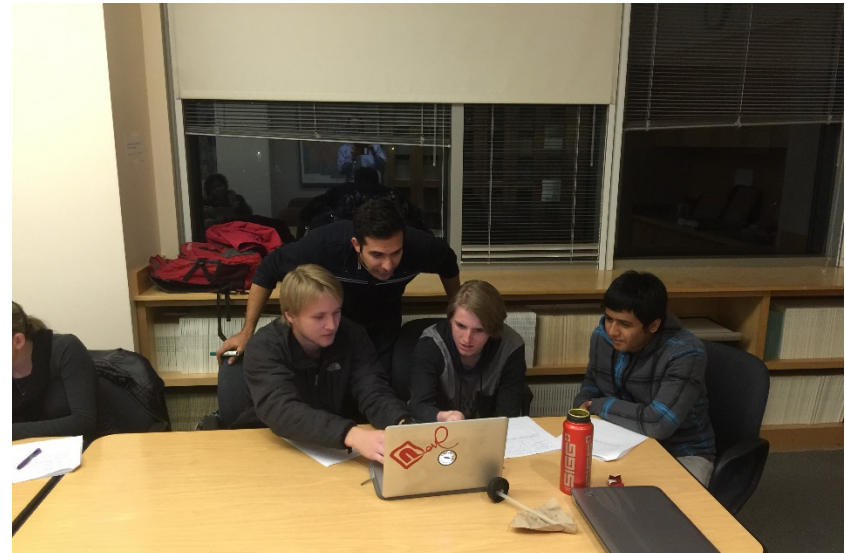
Urban irrigation

Lake model

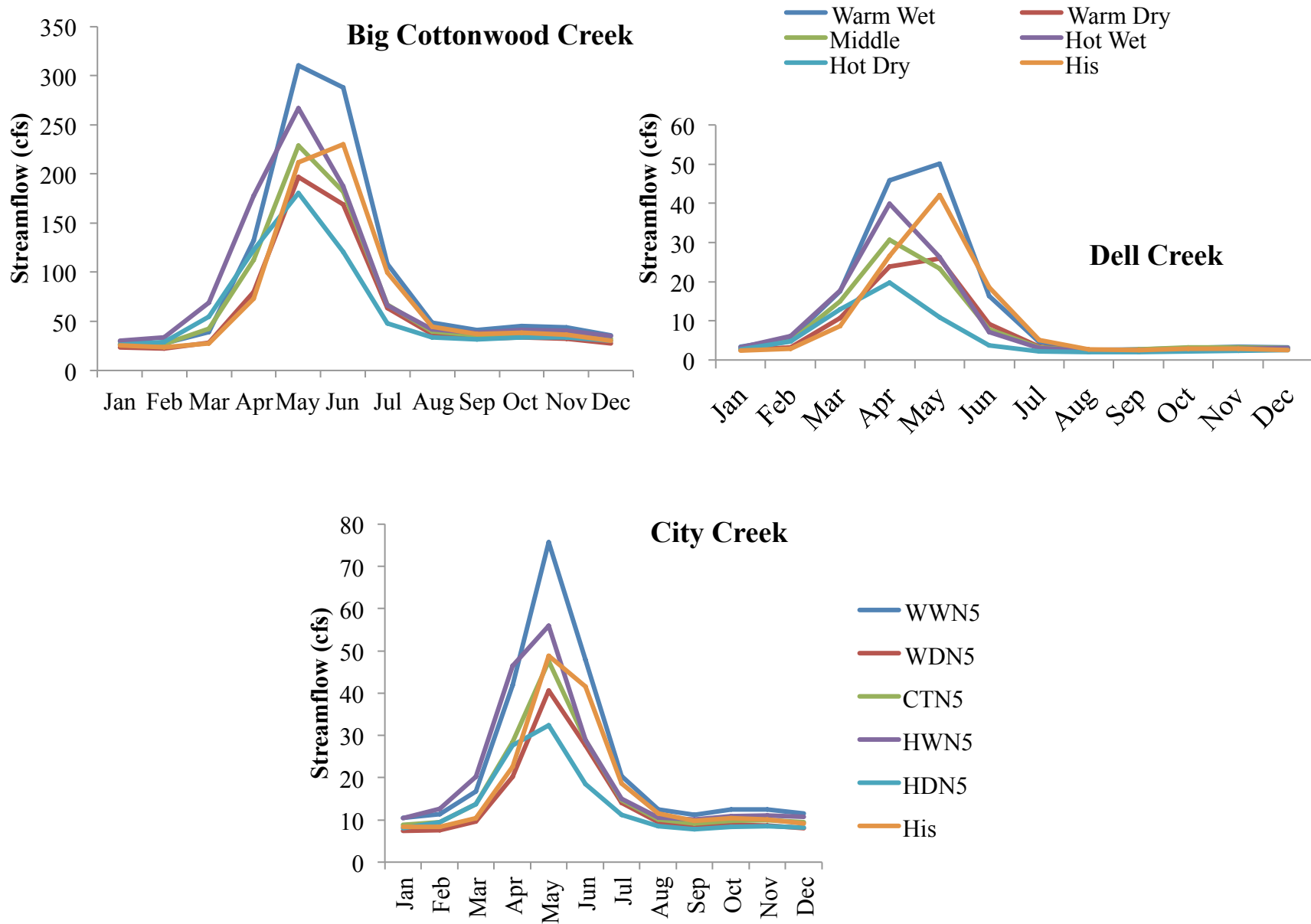


# Research Questions

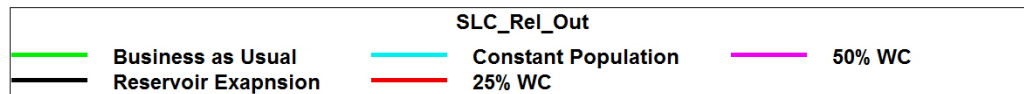
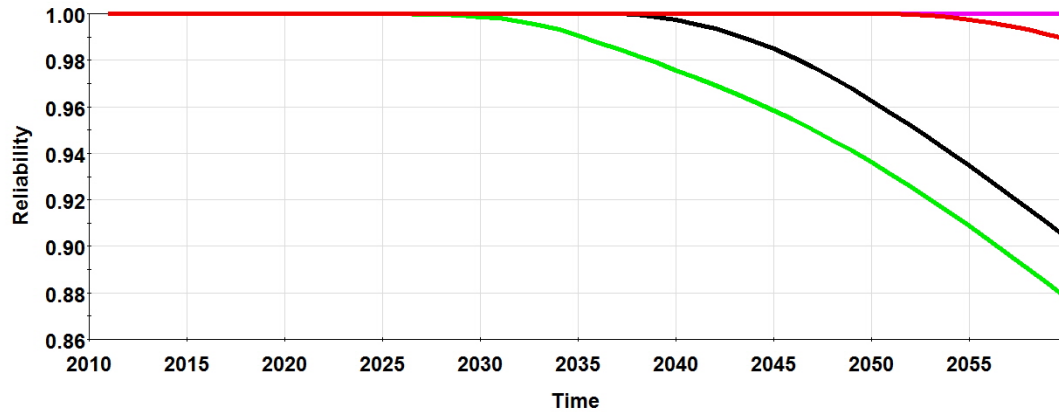
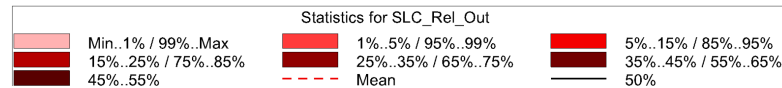
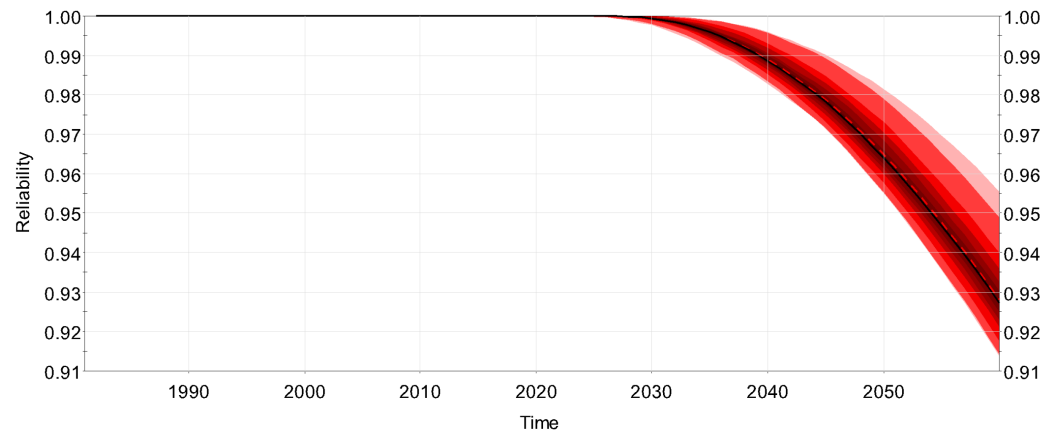
- **What is impact of climate change on Salt Lake City's water supply system performance?**
- **Future reliability and vulnerability of SLC water supply system?**
- **What impact will Rainwater Harvesting (RWH) have on SLC's integrated urban water system performance?**



# #1. Climate Impacts



# #2. Future of water in SLC



# Sustainability



# #3. RWH

**Jordan River Subbasin**

Rainbarrel Numbers  
200 Gal    2,500 Gal  
   

Percentage of roofs from Imperv area

**LCC Subbasin**

Rainbarrel Numbers  
200 Gal    2,500 Gal  
   

Percentage of roofs from Imperv area

**LRB Subbasin**

Rainbarrel Numbers  
200 Gal    2,500 Gal  
   

Percentage of roofs from Imperv area

**LEM Subbasin**

Rainbarrel Numbers  
200 Gal    2,500 Gal  
   

Percentage of roofs from Imperv area

**LPC Subbasin**

Rainbarrel Numbers  
200 Gal    2,500 Gal  
   


Percentage of roofs from Imperv area

RWH 1    Run    +    -


Outdoor Supply SLC

Bypass

Total RWH used for outdoor demand (Gal)



2 containers with the maximum size of 100 gallons each on-site  
Price: ~ \$200 each one



Underground storage and the law permits up to 2,500 gallons in one container.  
Price: ~ \$2500-\$3000

About 80,000 buildings, parks and properties serviced by the Public Utilities. I'd say use 75,000 to exclude industrial users and multiple users per building.



# SLCDPU Observations (so far)

- Salt Lake City's surface water sources show significant sensitivities to increasing temperature
- Earlier runoff timing presents challenges in meeting late summer demands
- Sources have different vulnerabilities
- RWH can benefit broader IWRM goals



# Thank You!



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