Dynamical downscaling of historical and projected winter precipitation in the Wasatch Range (for the CI-WATER project)

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NCAR

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Outline

- Background
  - The CI-WATER project
  - Wasatch Range precipitation
- Regional modeling using WRF
  - Model configuration
  - Historical validation for water year 2008
- Future research plans
- Summary

CI-WATER Project

- Purpose is to advance cyberinfrastructure for high performance water resource modeling
- Goal is to enhance the capacity for water resource planning and management in the Utah-Wyoming region
- Utah-Wyoming collaboration funded through the NSF Experimental Program to Stimulate Competitive Research (EPSCoR)
- http://www.uwyo.edu/ci-water/

Brigham Young University

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UNIVERSITY

Norm Jones, Jim Nelson, Gus Williams

Utah State University

UtahState University
COLLEGE OF ENGINEERING

David Tarboton, Jeff Horsburgh, David Rosenberg

The University of Utah

THE
UNIVERSITY
OF UTAH

Steven Corbato, Laura Hunter, Steve Burian, Christine Pomeroy, Court Strong

University of Wyoming

UNIVERSITY
OF WYOMING

Fred Ogden, Craig Douglas, Kristi Hansen, Scott Miller, Ye Zhang, Gi–Hyeon Park, Ginger Paige, Robert Aylward

CI-WATER Project

- My research goals for the Wasatch Range:
  - Quantify the spread and central tendency of projected orographic precipitation to 2060
    - Different global climate models
    - Different greenhouse gas scenarios
    - Different initial conditions
  - Provide software that civil engineers can use to quickly generate realistic future precipitation and temperature scenarios

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CI-WATER Project: my study region

I am currently focused on the Wasatch Range, and I plan to extend the study region to include portions of Wyoming and Colorado
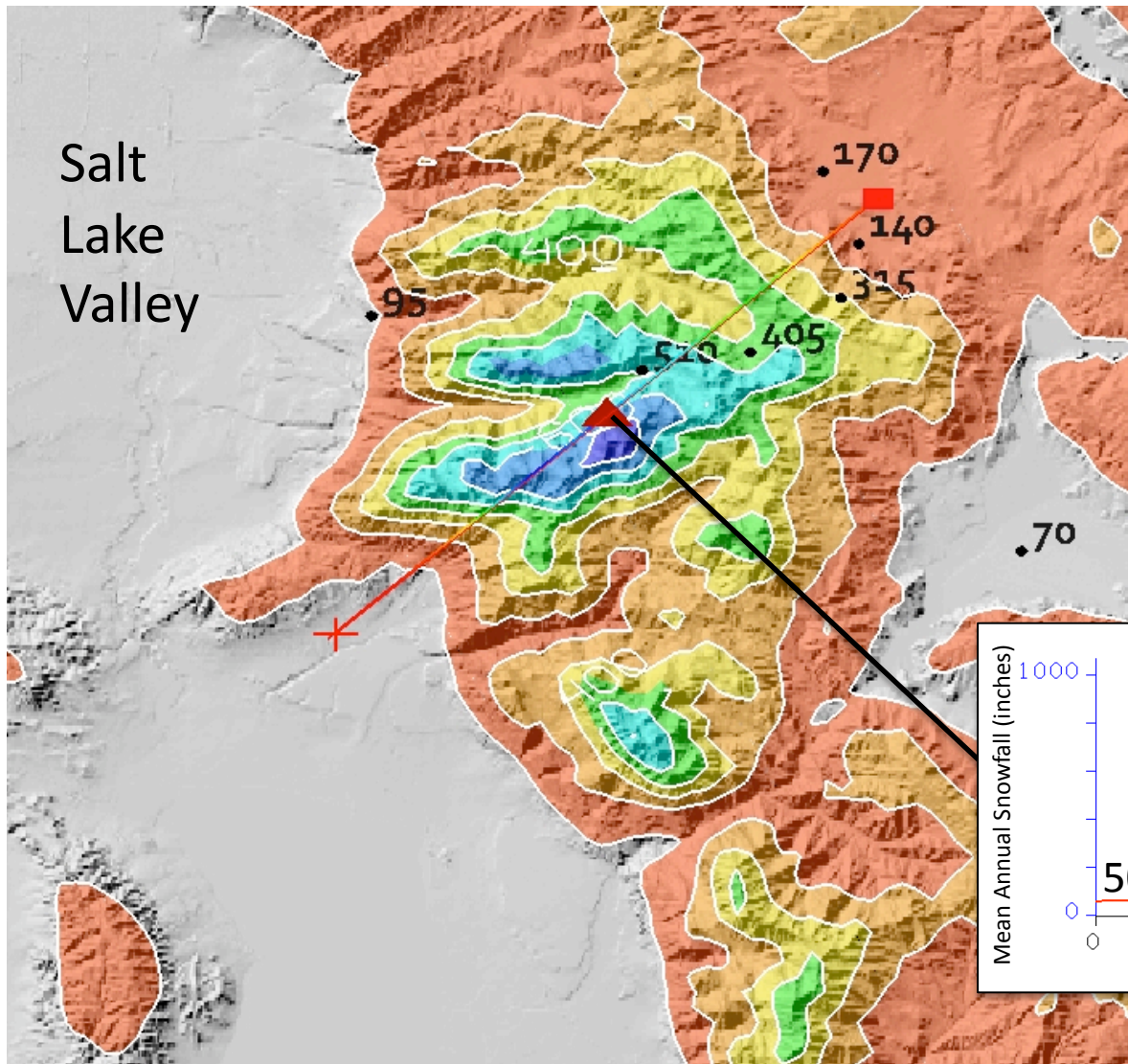

wikipedia.org

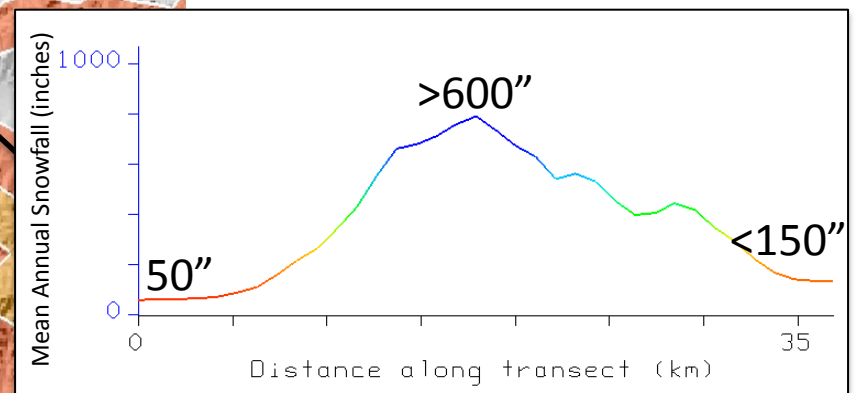# Wasatch Range precipitation

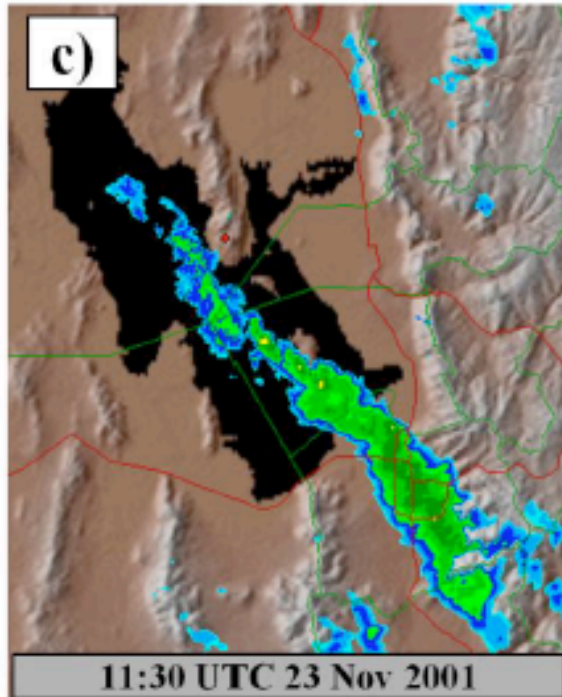Mountain versus valley floor annual cycles
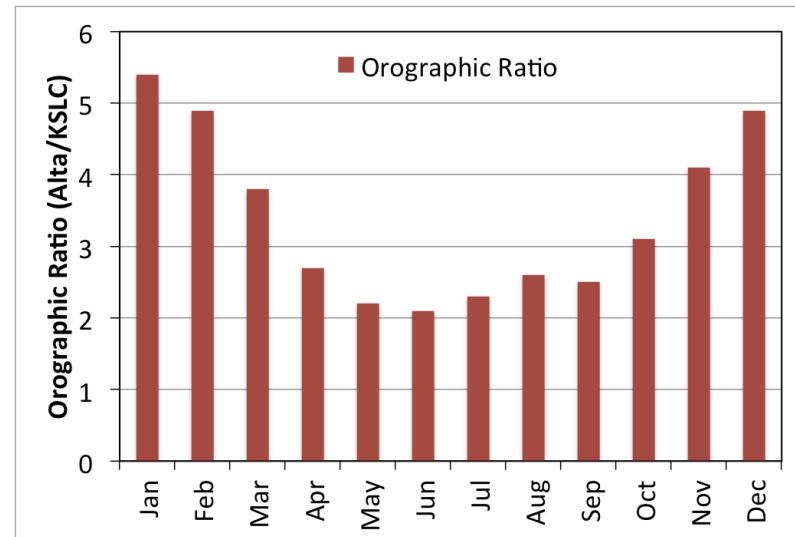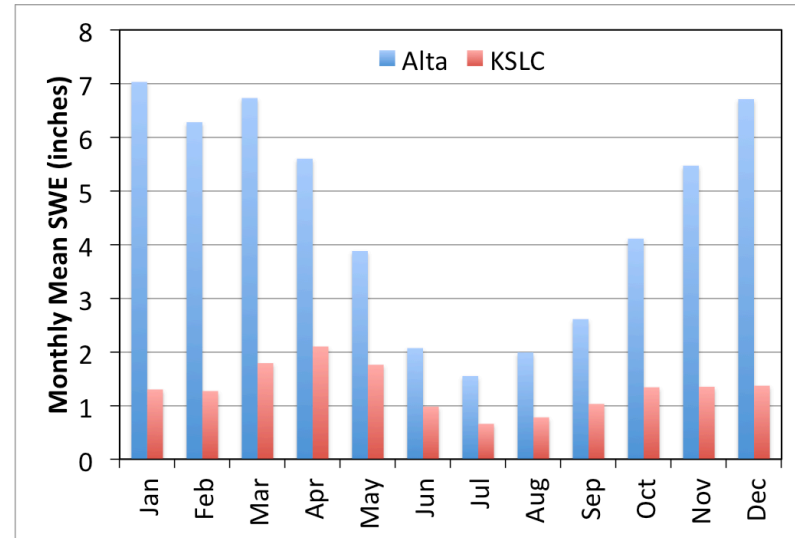
Wasatch Range precipitation
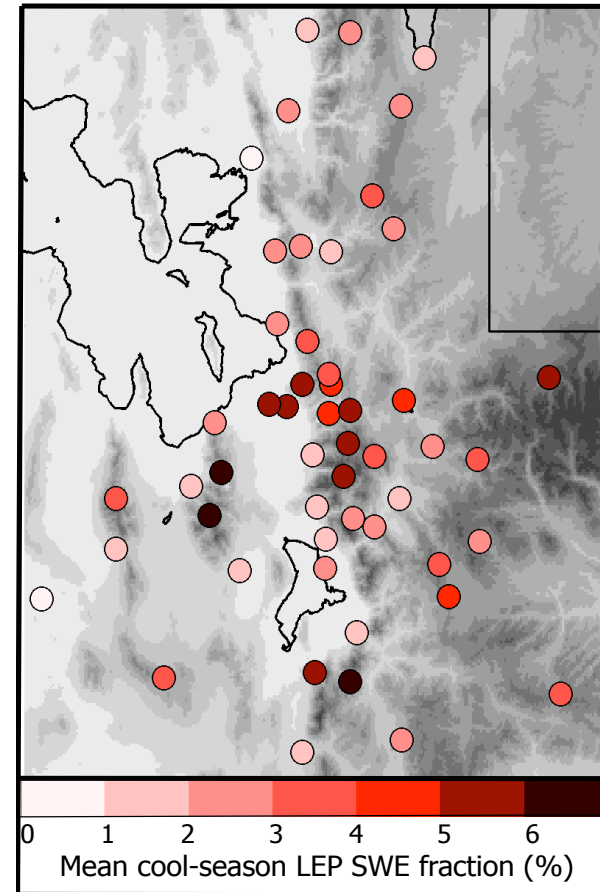

Spatial variability

Salt Lake Valley

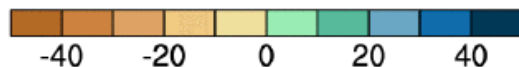Steenburgh, unpublished
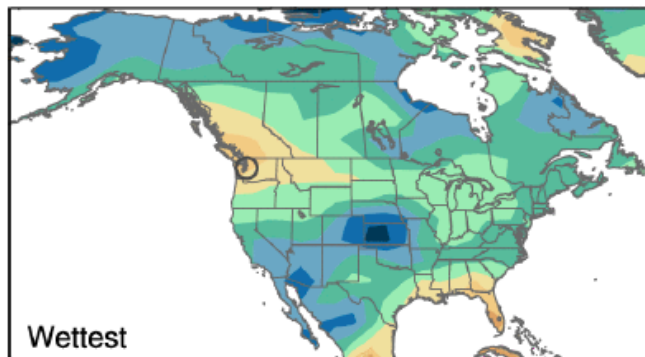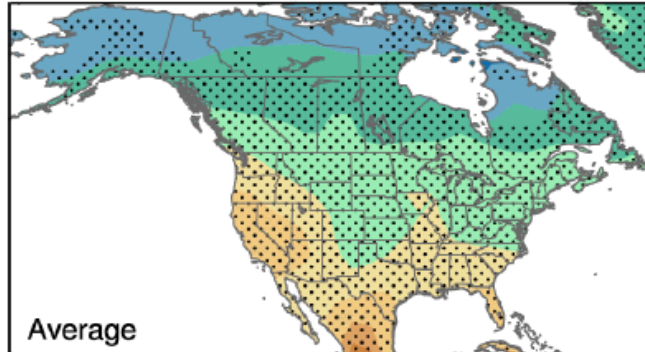
Wasatch Range precipitation

Lake effect snow

Alcott et al. (Submitted,
Mon. Wea. Rev.)

Yeager et al.
(Submitted, *J. Appl. Meteor. Clim.*)

DJF Precipitation Trend 2005-2060

Average

Wettest

Driest

-40 -20 0 20 40
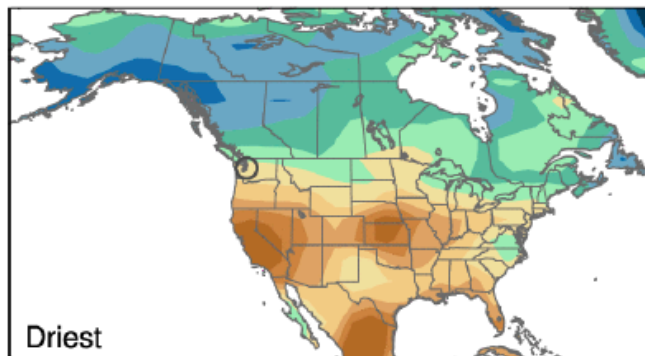
Deser et al. (submitted)

Wasatch Range precipitation
Sensitivity to initial conditions

- ## The Large Ensemble Project
  - One model: CCSM3 (T42)
  - One forcing: A1B 2000-2061
  - 40 simulations

Trends in precipitation [% per 55 years] expressed as a percentage of the model's ensemble-mean climatology for 2005-2060.
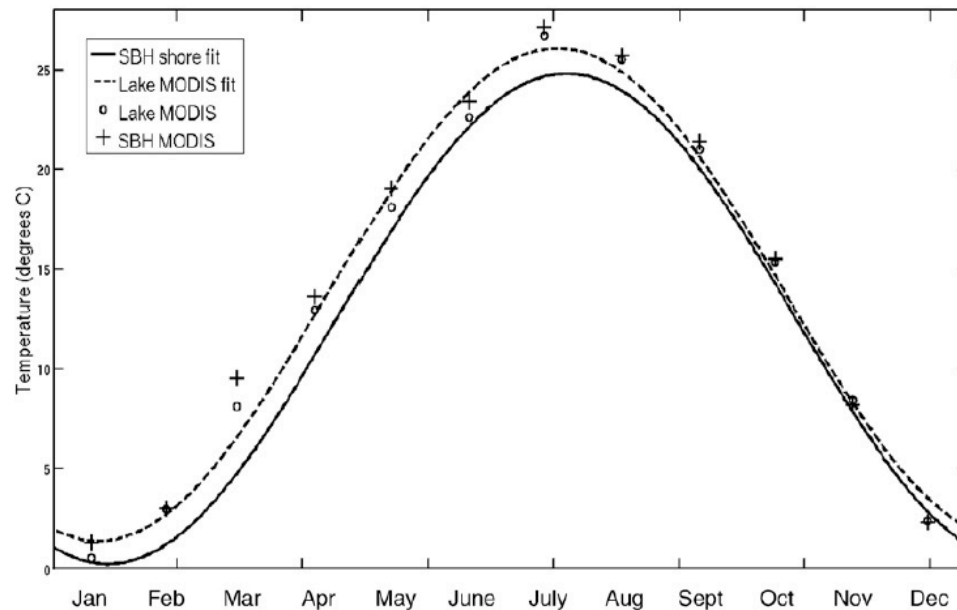
Regional modeling: model configuration

- The Weather Research and Forecasting (WRF) regional weather and climate model Version 3.3.1 (Skamarock et al. 2005)
- Configured following Headwaters Project (Rasmussen et al. 2011):
  - Noah land surface model
  - Mellor–Yamada–Janjic planetary boundary layer scheme
  - Community Atmosphere Model's (CAM) longwave and shortwave schemes
  - Thompson et al. (2008) cloud microphysics scheme

Regional modeling: model configuration

- Prescribed a mean annual cycle for the Great Salt Lake surface temperature (T_G) based on first harmonic of monthly median observations
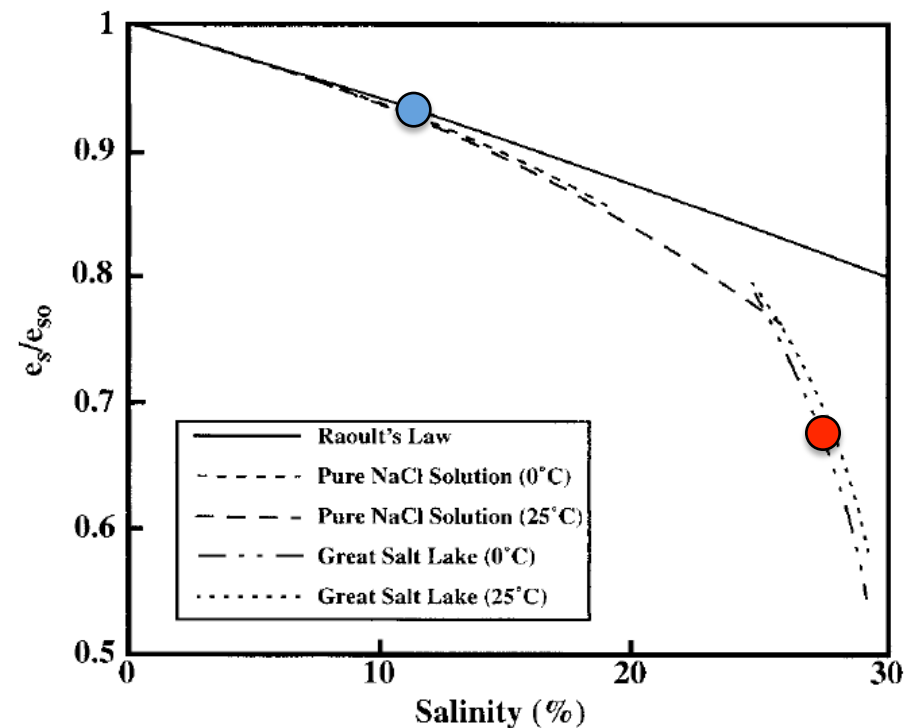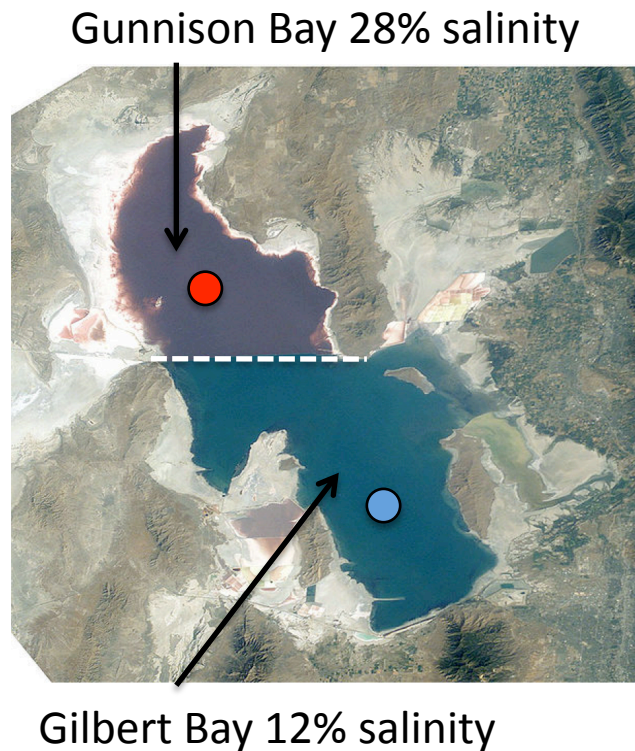
$$T_G = -12.1\cos(2\pi\, d/365) - 3.8\sin(2\pi\, d/365) + 287.3$$

Regional modeling: model configuration

- Adjusted the saturation vapor pressure to account for salinity of Great Salt Lake
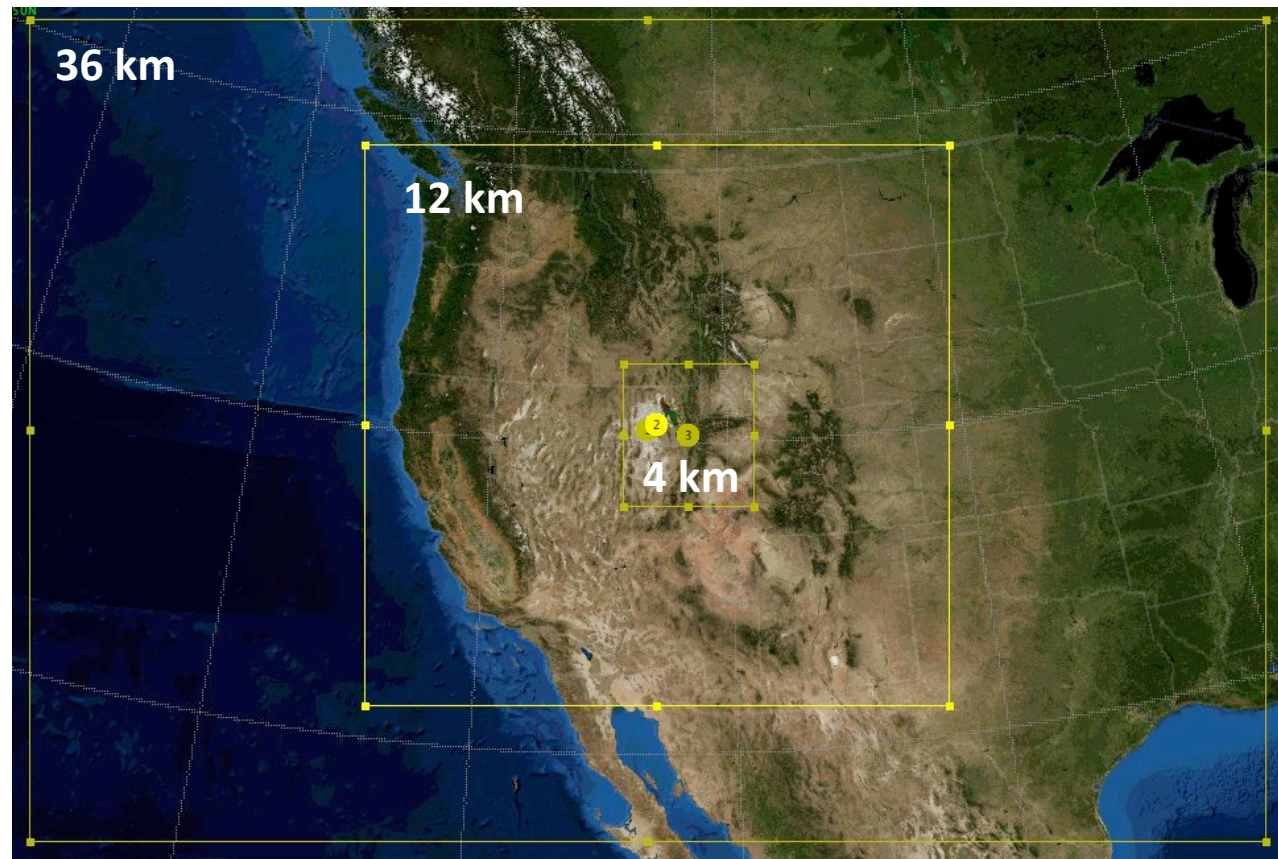

Gunnison Bay 28% salinity

Gilbert Bay 12% salinity

Steenburgh et al. (2000), *Mon. Wea. Rev.*
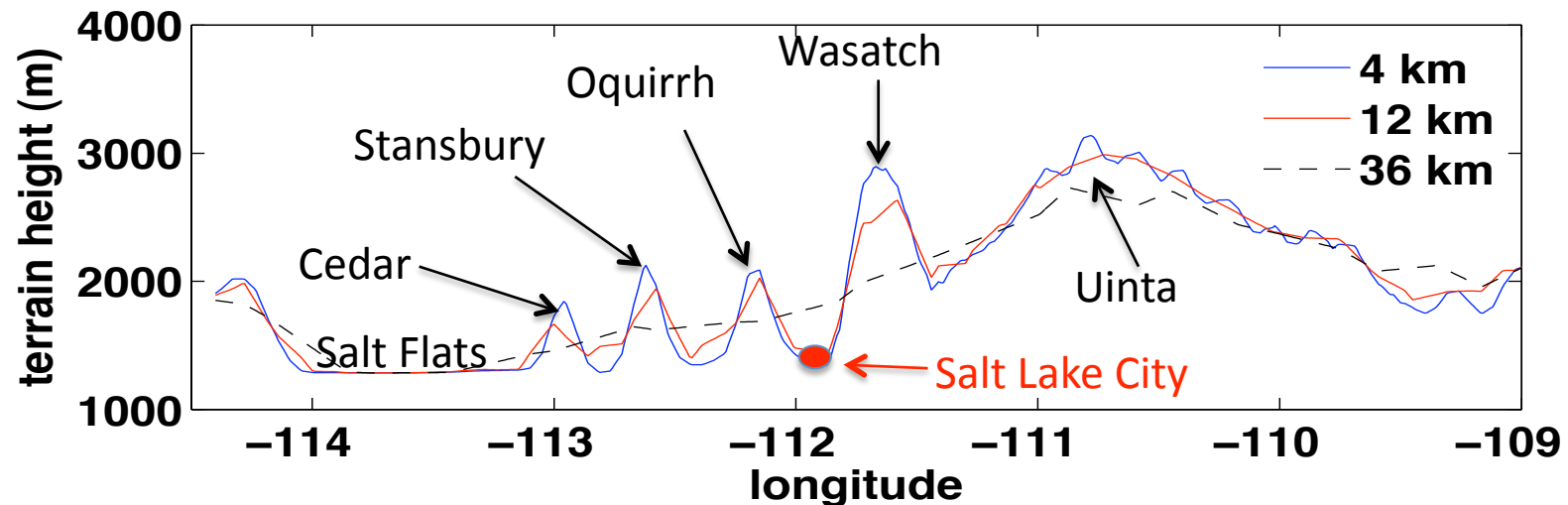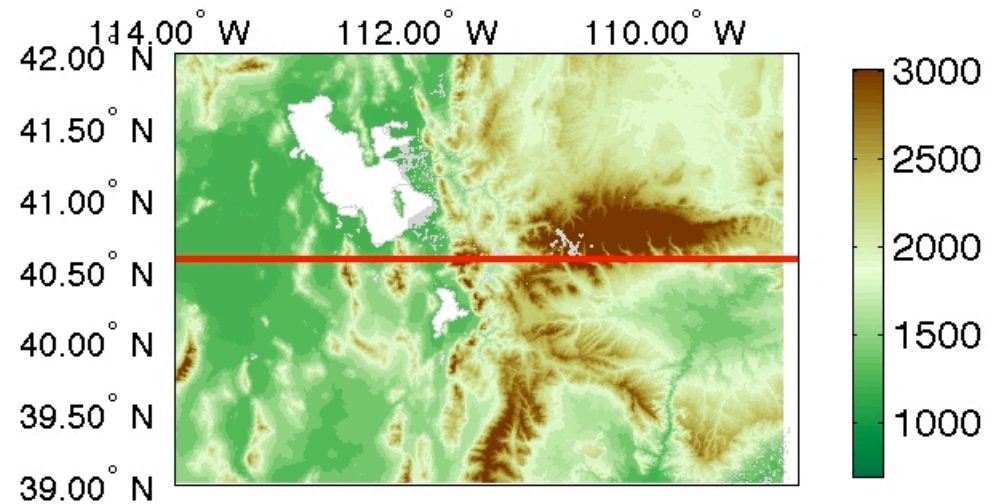
Regional modeling: model configuration

- Lambert conformal projection, three domains

Boundary conditions:
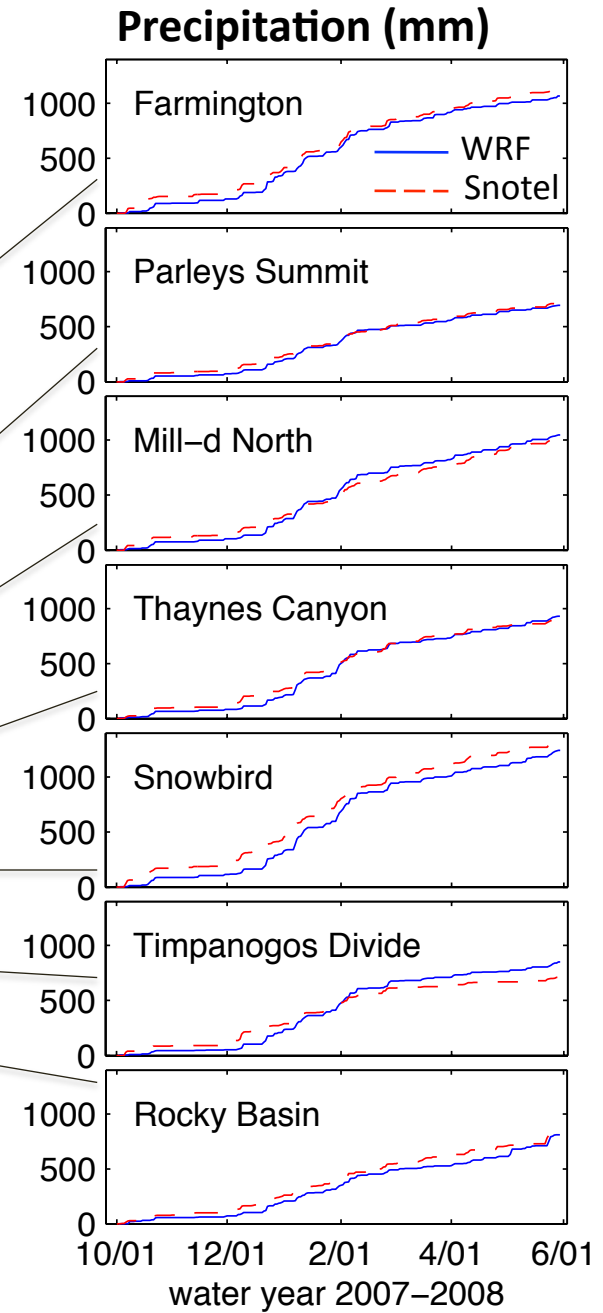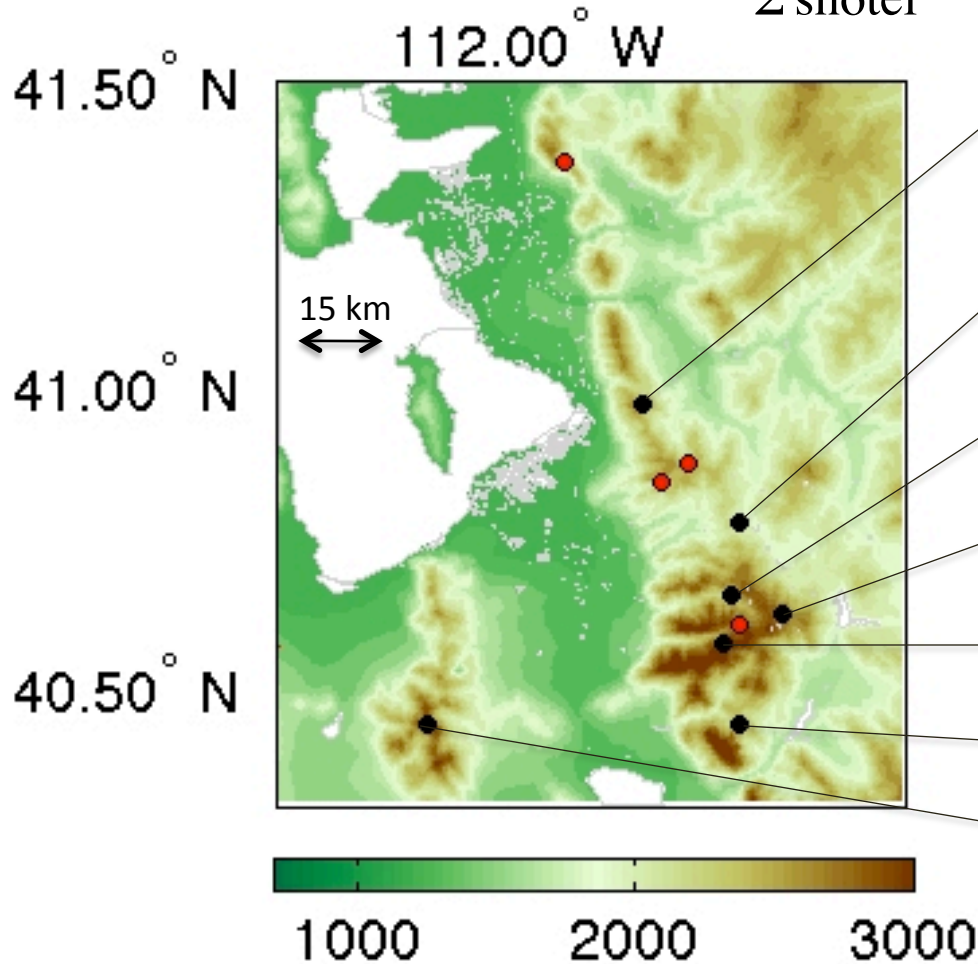6-houlry NCEP Climate Forecast System Reanalysis (38-km resolution). Water year 2007-2008

Regional modeling: model configuration
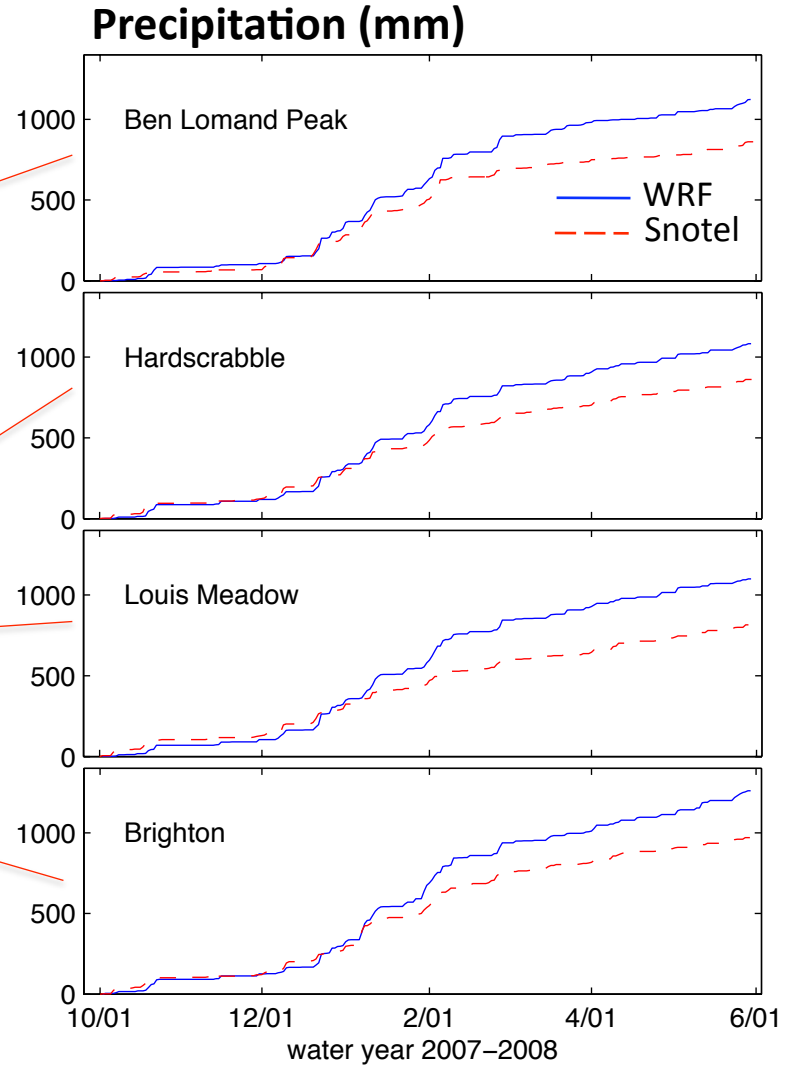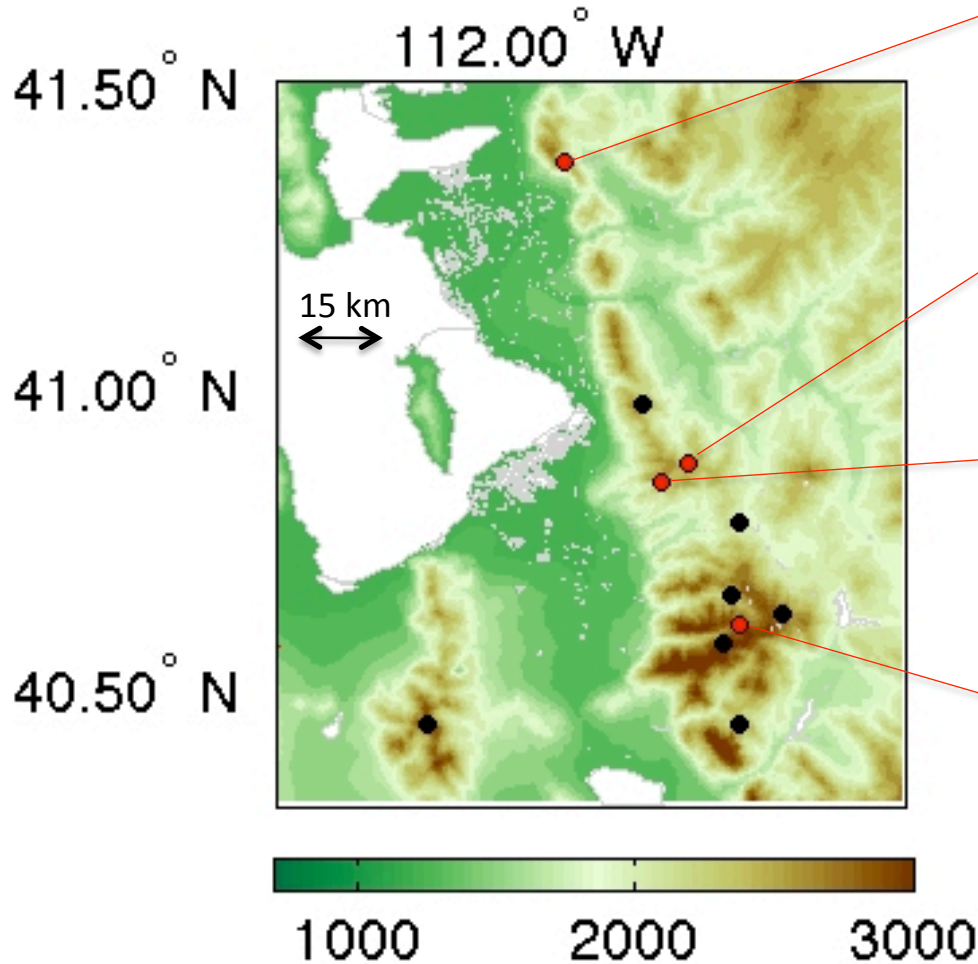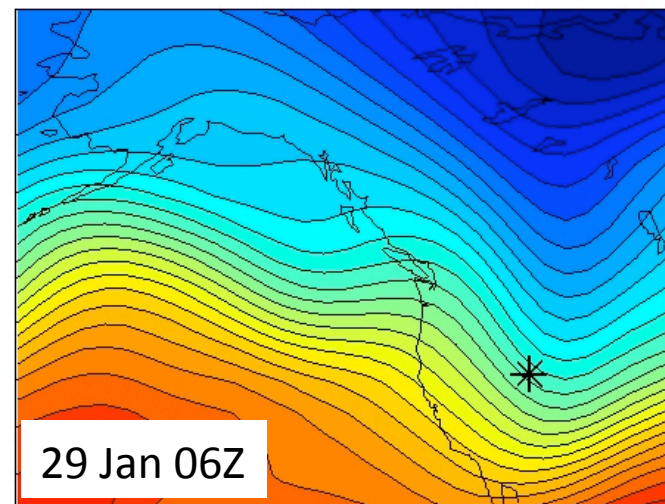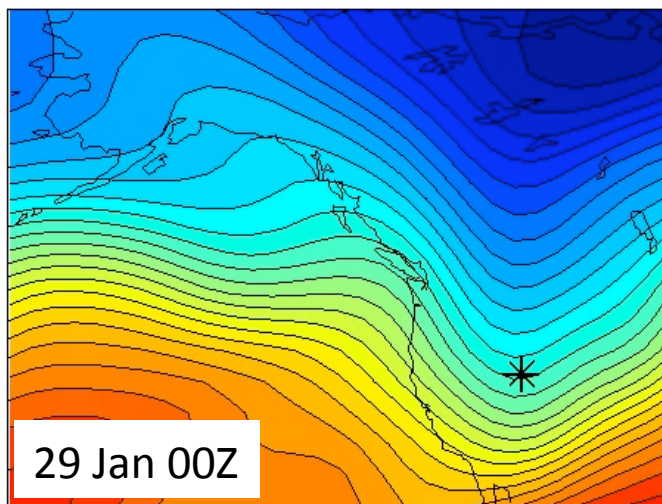
- Resolution of topography

Regional modeling:
historical validation

$$\frac{\Sigma \text{ WRF}}{\Sigma \text{ snotel}} = 1.003$$

Regional modeling: historical validation

Precipitation (mm)

$$\frac{\Sigma \text{ WRF}}{\Sigma \text{ snotel}} = 1.302$$

250-mb geopotential height 2008

28 Jan 12Z

28 Jan 18Z

29 Jan 00Z

29 Jan 06Z
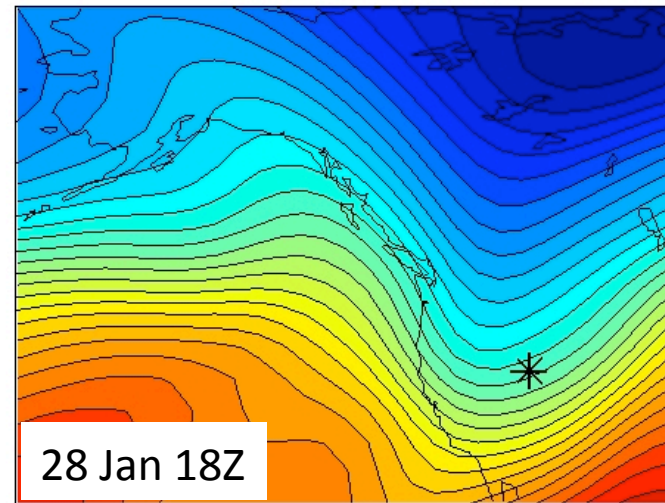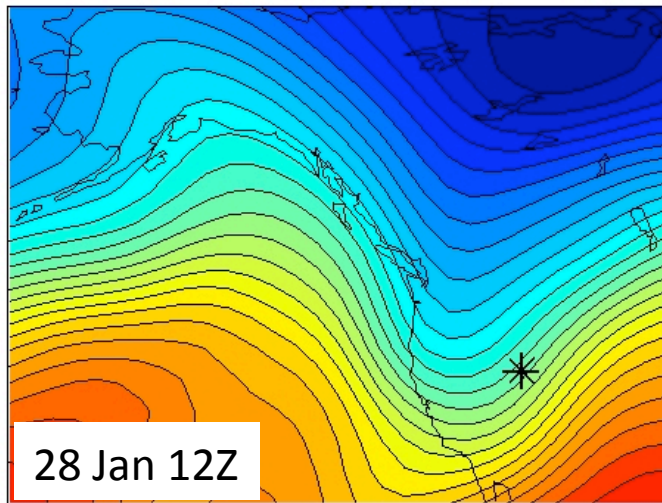
NCEP / NCAR Reanalysis

28 Jan 2008 12Z

mesowest.utah.edu

Most recent observation within 6 hrs ending at **12:00 UTC** 1/28/2008
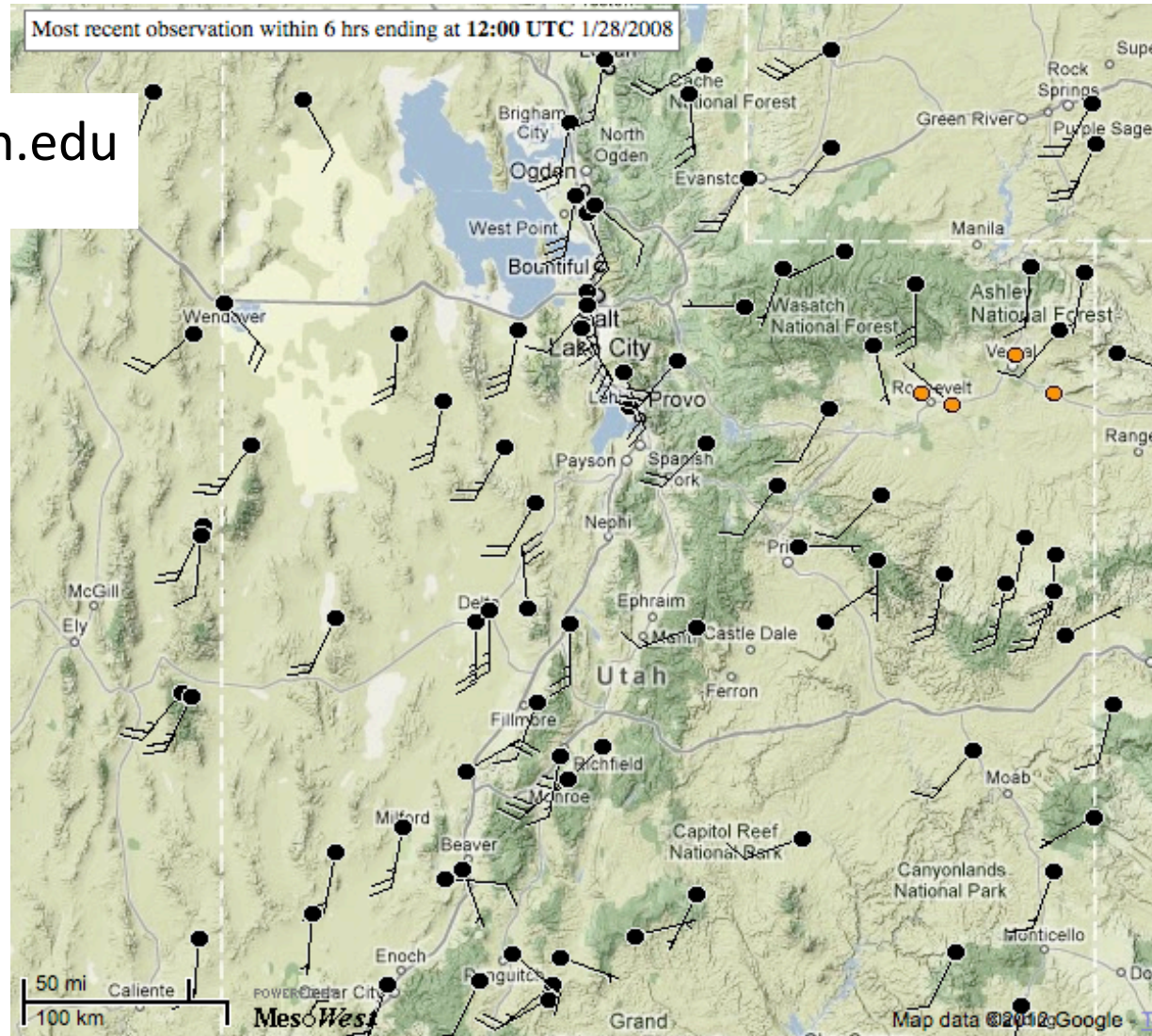
Sites where WRF overestimated

Louis Meadow

Ben Lomand

Hardscrabble

Brighton

Future research plans

- Additional historical validation runs

- Boundary force WRF with climate model projections (CMIP5 runs)

- Develop software that civil engineers can use to quickly generate realistic future precipitation and temperature scenarios
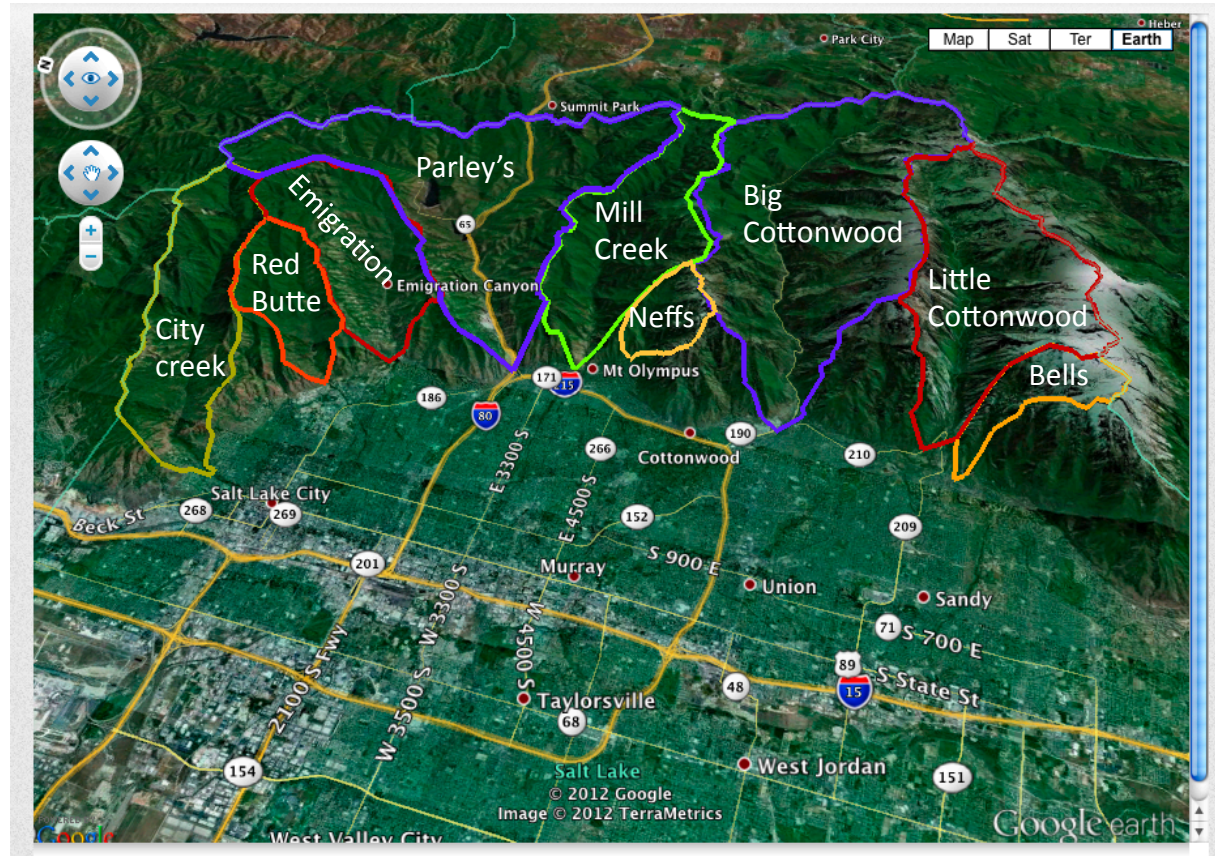
Future research plans

Software will generate stochastic precipitation and temperature scenarios that

1) are consistent with downscaled climate projections

2) exhibit realistic spatial correlations among basins

Richardson et al. (1984)
Wilks (1999)
Khalili et al. (2011)

http://www.hiddenwaters.org/

Summary

- Within CI-WATER project, my goals are
  - quantify the spread and central tendency of projected Wasatch Range precipitation to 2060
  - develop stochastic hydrology scenario software for engineers
- Regional modeling: first results
  - WRF configured following Headwaters Project
  - Modifications for the Great Salt Lake
  - Historical validation for 2008 water year: overestimates at four sites, realistic at seven sites