Modeler:

The Increasingly Important Role of Land–Atmosphere Models for High Resolution Ecohydrologic Process Study

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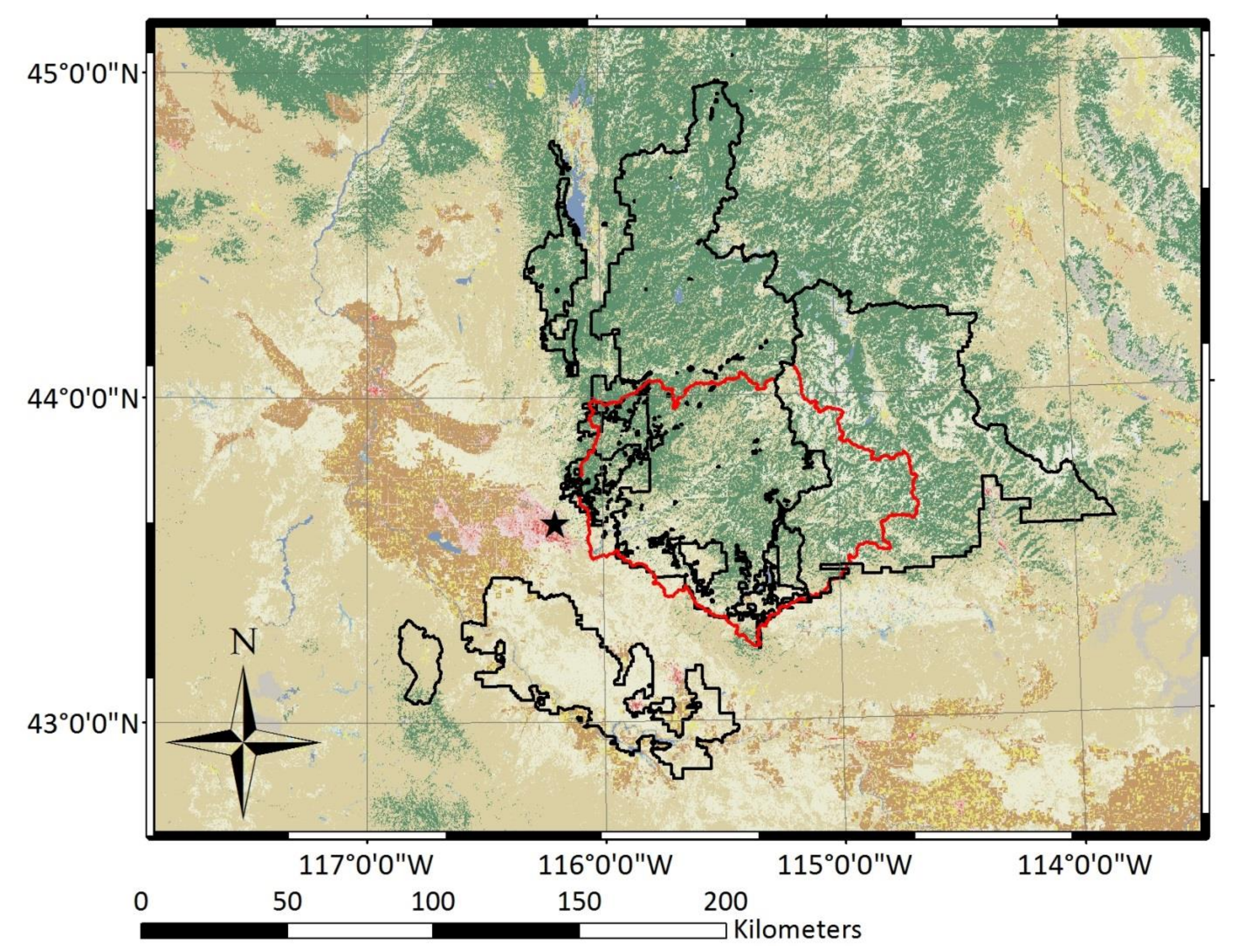
Talk Overview

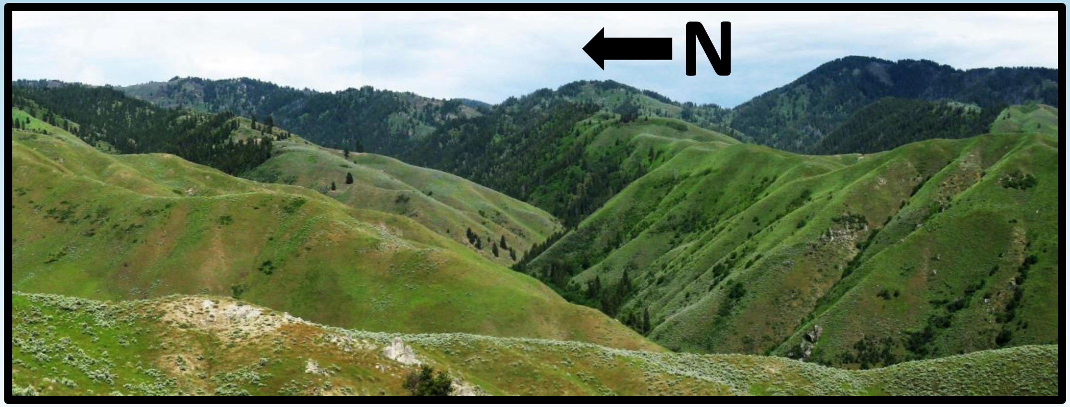
- Background, context, and science motivation
- Availability of forcing data to support these efforts
- Application of CPMs to synthesize forcing datasets
- Ramifications of CPM resolution on modeling hillslope scale hydrology
- Further outgrowth and use of CPM output

Study Region and Context



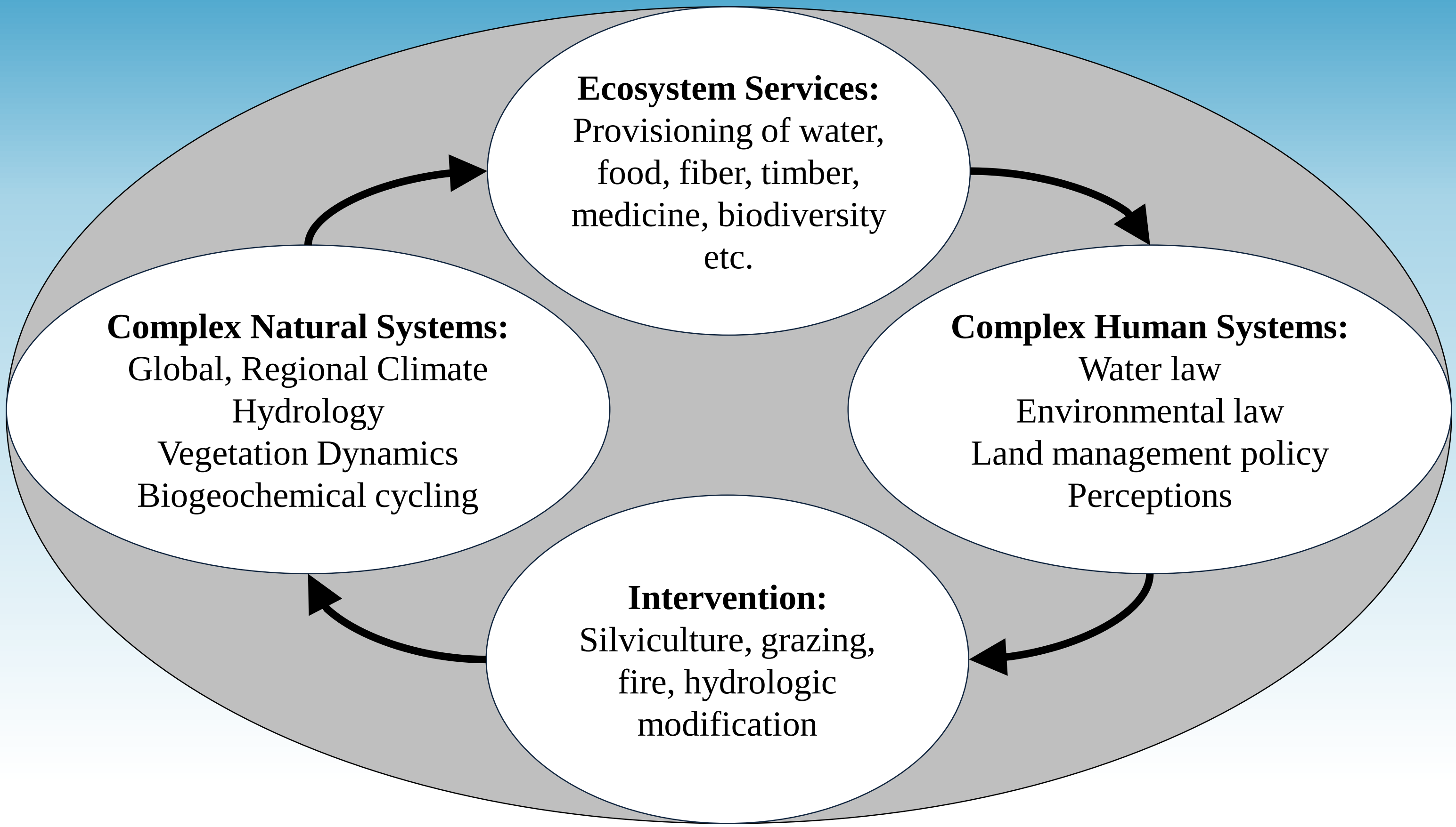
- Transition between Great Basin and Northern Rockies
- Irrigated agricultural areas being displaced by urbanization
- Lots of (beautiful) public lands managed by multiple agencies
- Stresses include climate change, invasive species, water/land use intensification

Mar 3, 2010

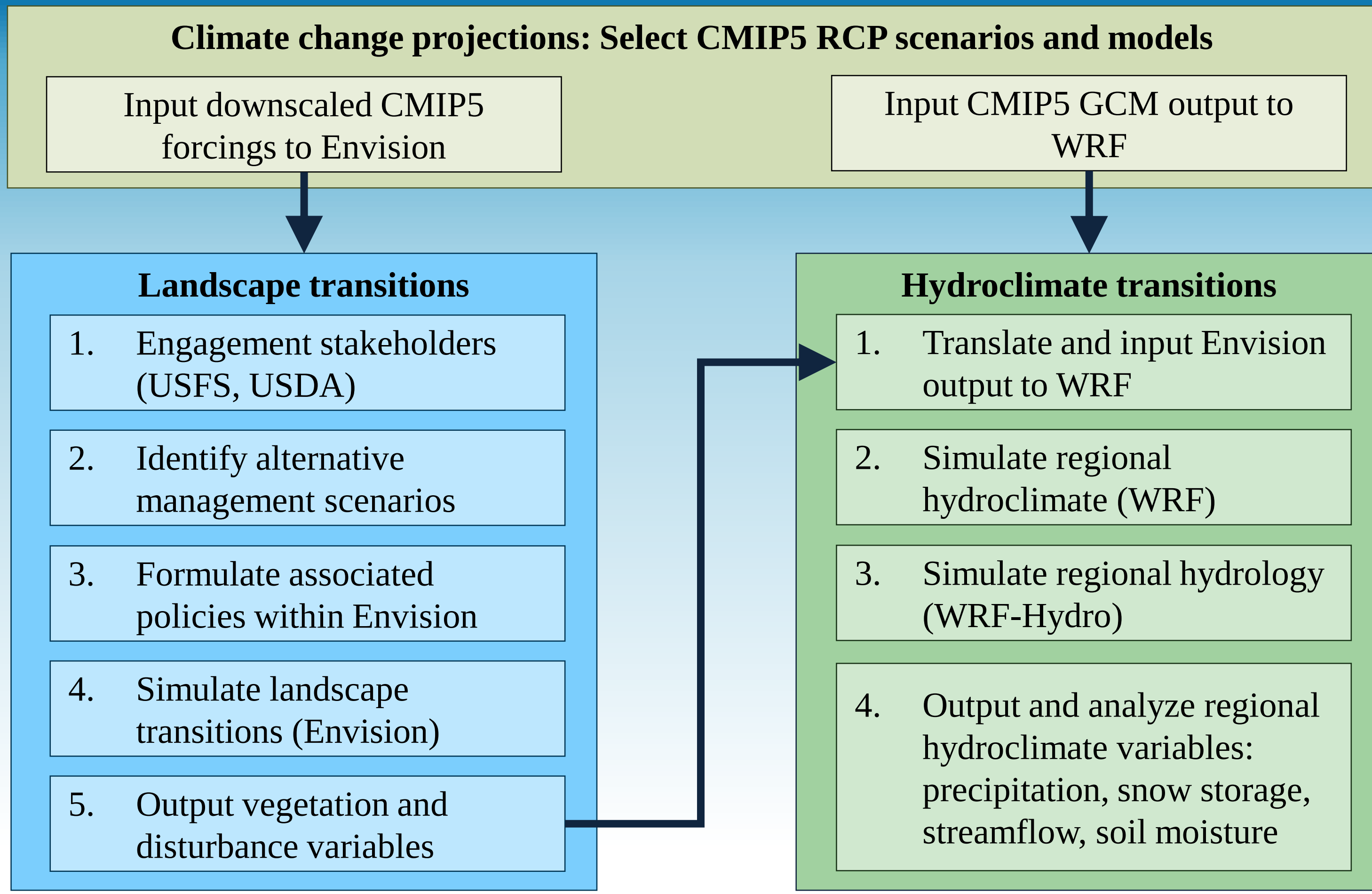


Three observations about slope aspect:

- Affects the steepness and geomorphology
- Affects the spatial distribution of vegetation communities
- Impacts the presence of seasonal snow cover

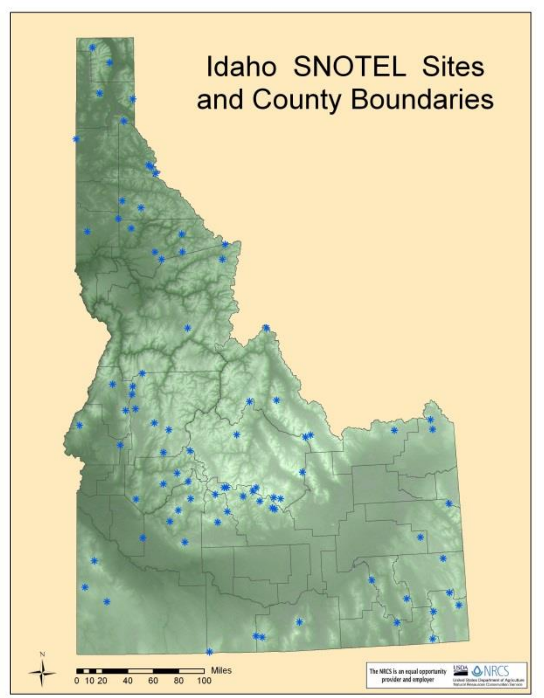


Regional ecohydrologic/climate systems are coupled natural and human systems

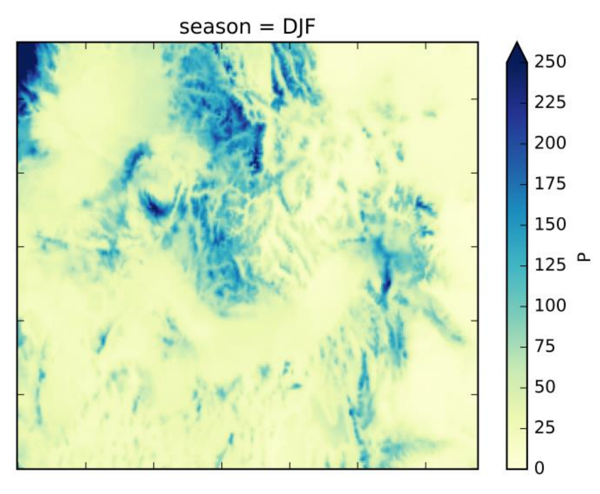


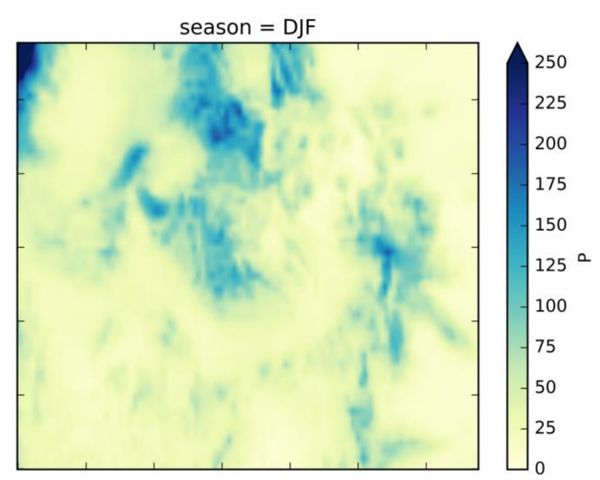
Advance fundamental understanding of coevolution of eco-hydro-geomorphic systems and their management in complex terrain, feedbacks to regional hydroclimate using models and data

Existing forcings well-suited to applications?



SNOTEL:
- Hourly
- Point-only
- Representativity issues





PRISM:
- Daily
- 4 km
- Geostatistical interpolation (ANN?)

NLDAS2:
- Hourly
- 0.125° (~12 km)
- Data assimilation product

Can we model as well as we observe?

HOW WELL ARE WE MEASURING SNOW?

The NOAA/FAA/NCAR Winter Precipitation Test Bed

BY ROY RASMUSSEN, BRUCE BAKER, JOHN KOCHENDORFER, TILDEN MEYERS, SCOTT LANDOLT, ALEXANDRE P. FISCHER, JENNY BLACK, JULIE M. THÉRIAULT, PAUL KUCERA, DAVID GOCHIS, CRAIG SMITH, RODICA NITU, MARK HALL, KYOKO IKEDA, AND ETHAN GUTMANN

NOAA, FAA, and NCAR work together at the NCAR Marshall Field Site to understand the relative accuracies of different instrumentation, gauges, and windshield configurations to measure snowfall and other solid precipitation.

MOTIVATION: AVIATION AND CLIMATE NEEDS. Precipitation is one of the most important atmospheric variables for ecosystem research, hydrologic and weather forecasting, and climate monitoring. Despite its importance, accurate measurement of precipitation remains challenging. Measurement errors for solid precipitation, which are often ignored for automated systems, frequently range from 20% to 50% due to undercatch in windy conditions.

Although measurement accuracy can be difficult to obtain and quantify for precipitation, it is extremely important for monitoring and assessing climate variability and change. Reducing measurement uncertainties is essential given the projected increases in precipitation over land over the next 100 yr (IPCC 2007). Obtaining climate-quality pre-

High-Resolution Coupled Climate Runoff Simulations of Seasonal Snowfall over Colorado: A Process Study of Current and Warmer Climate

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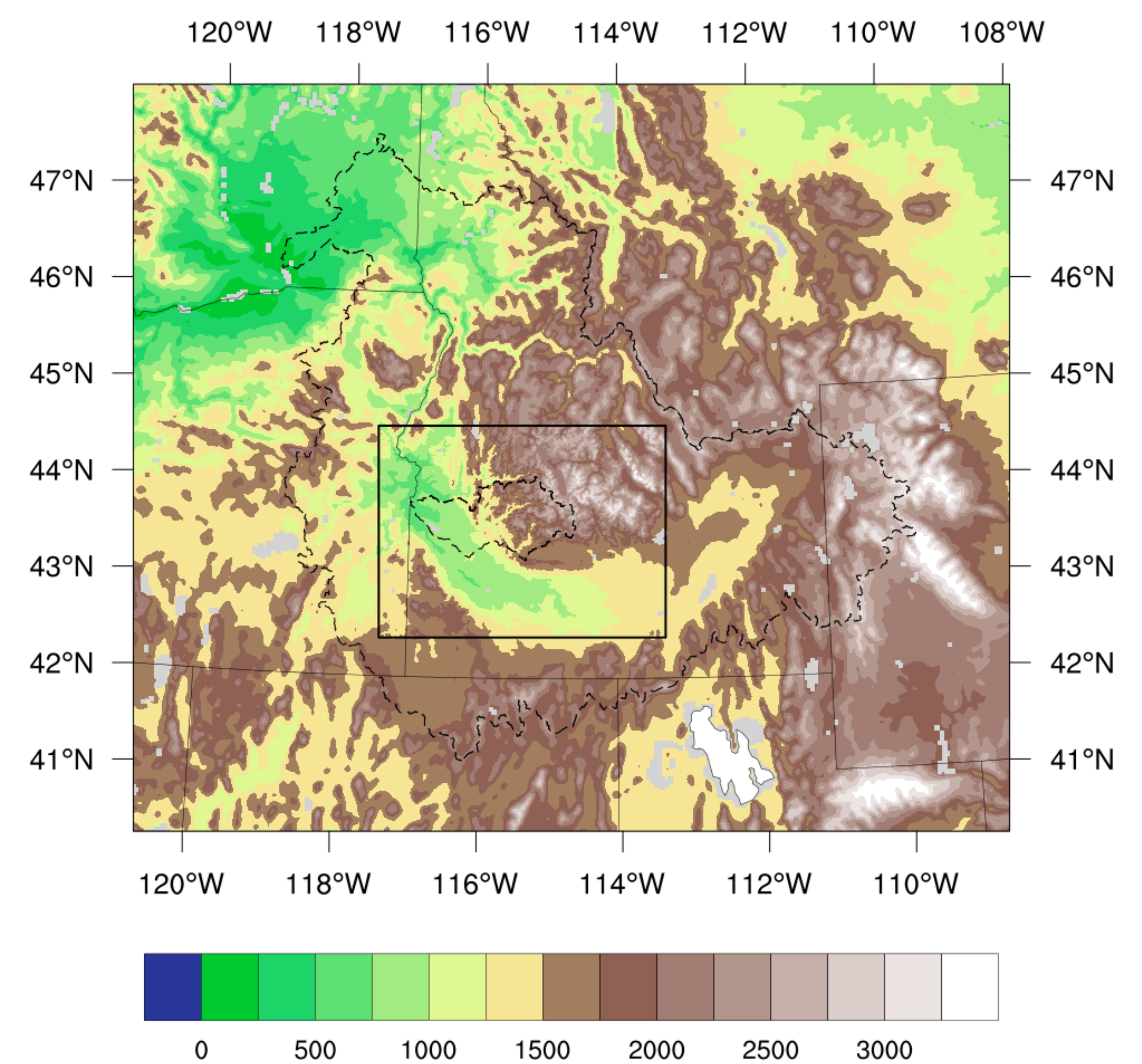
(Manuscript received 9 August 2010, in final form 17 December 2010)

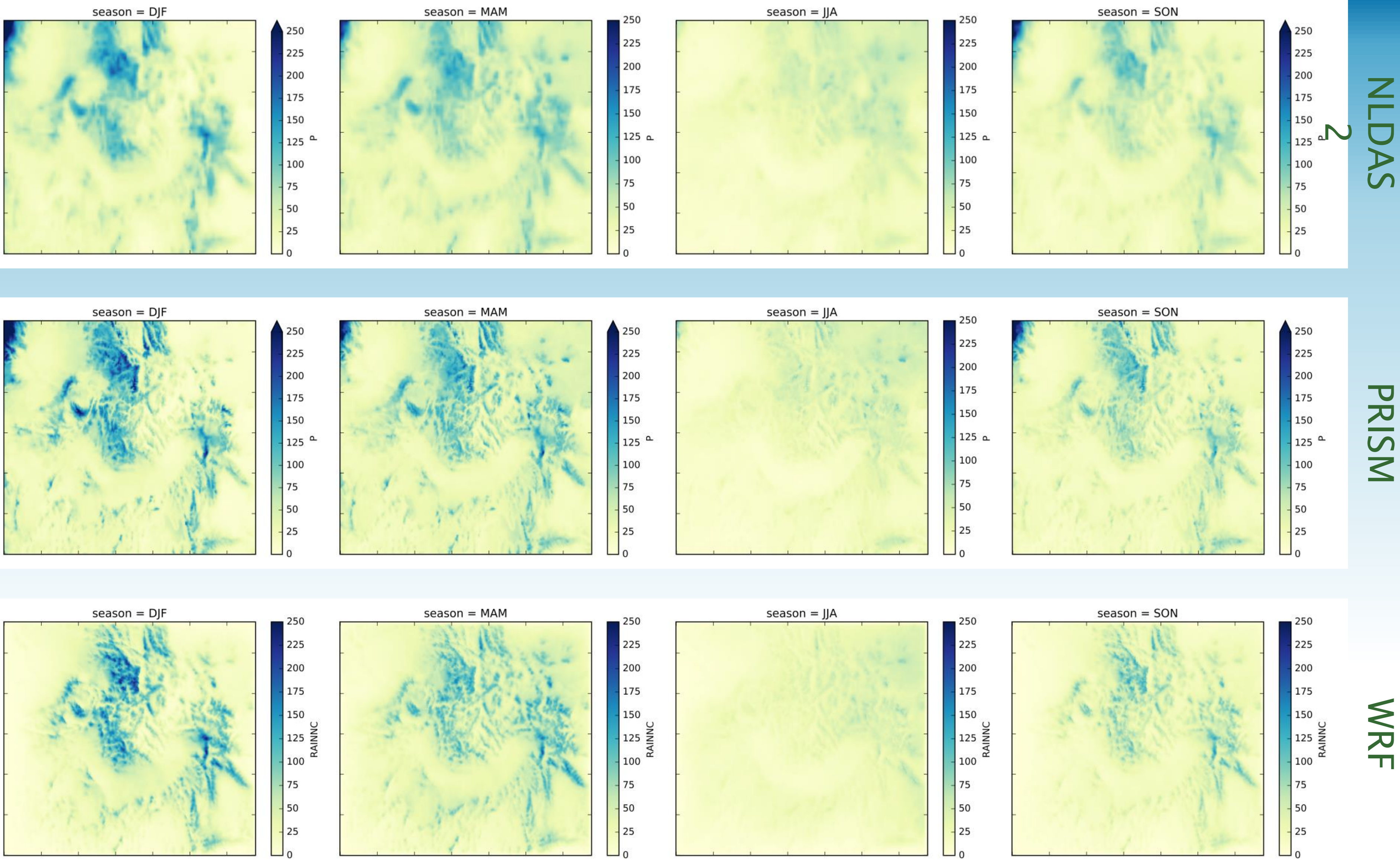
ABSTRACT

Climate change is expected to accelerate the hydrologic cycle, increase the fraction of precipitation that is ain, and enhance snowpack melting. The enhanced hydrological cycle is also expected to increase snowfall nounts due to increased moisture availability. These processes are examined in this paper in the Colorado headwaters region through the use of a coupled high-resolution climate–runoff model. Four high-resolution simulations of annual snowfall over Colorado are conducted. The simulations are verified using Snowpack Telemetry (SNOTEL) data. Results are then presented regarding the grid spacing needed for appropriate simulation of snowfall. Finally, climate sensitivity is explored using a pseudo–global warming approach. The results show that the proper spatial and temporal depiction of snowfall adequate for water resource and climate change purposes can be achieved with the appropriate choice of model grid spacing and parameterizations. The pseudo–global warming simulations indicate enhanced snowfall on the order of 10%–25% over the Colorado Headwaters region, with the enhancement being less in the core headwaters region due to the topographic reduction of precipitation upstream of the region (rain-shadow effect). The main climate

Rasmussen et al. J. Climate (2011)
Rasmussen et al. BAMS (2012)



- Katelyn Watson (see poster)
- Develop a 30 year regional historical run
- WRF v 3.7.1
- 3 km/3 hr output – Snake River Basin
- 1 km/1 hr output – Boise River Basin
- Model configurations largely follow Rasmussen et al.
- In progress…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season = MAM
season = JJA
season = SON
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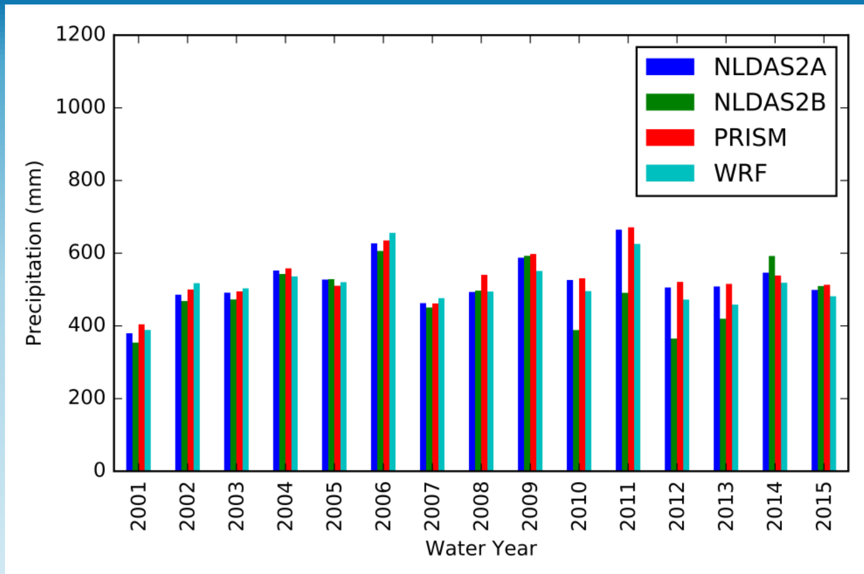
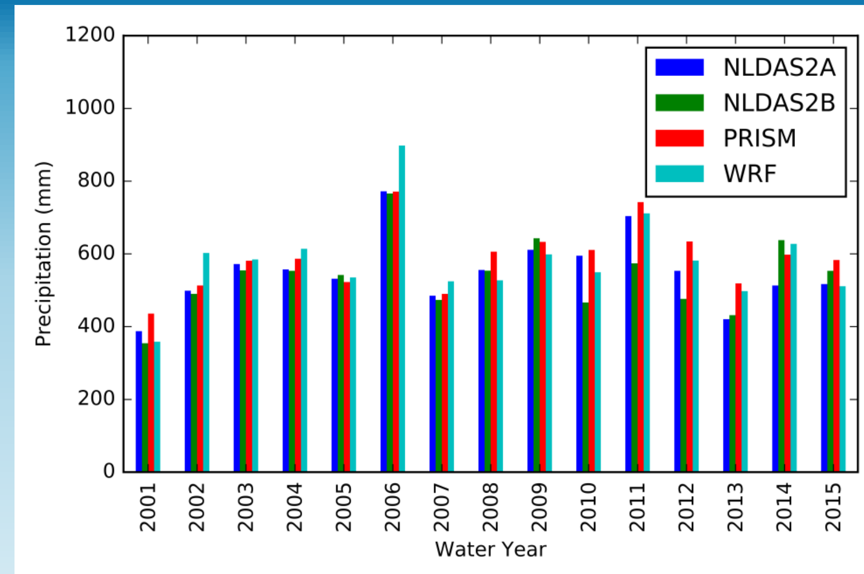
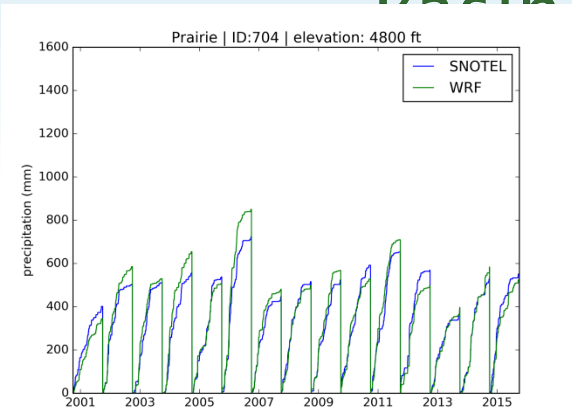
p
RAINNC
NLDAS 2
PRISM
WRF

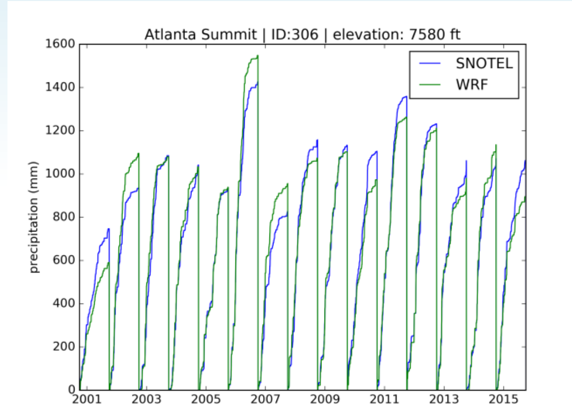


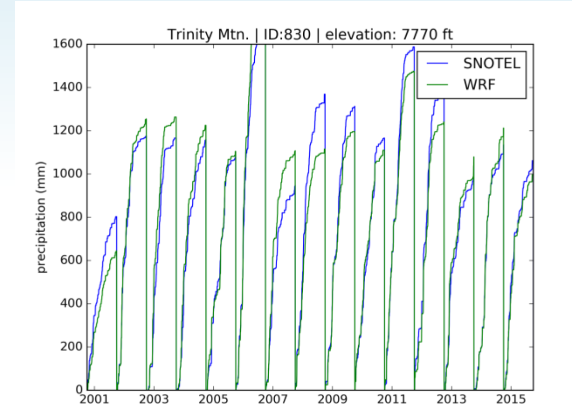


Snake River Basin

Boise River Basin







Increasing elevation

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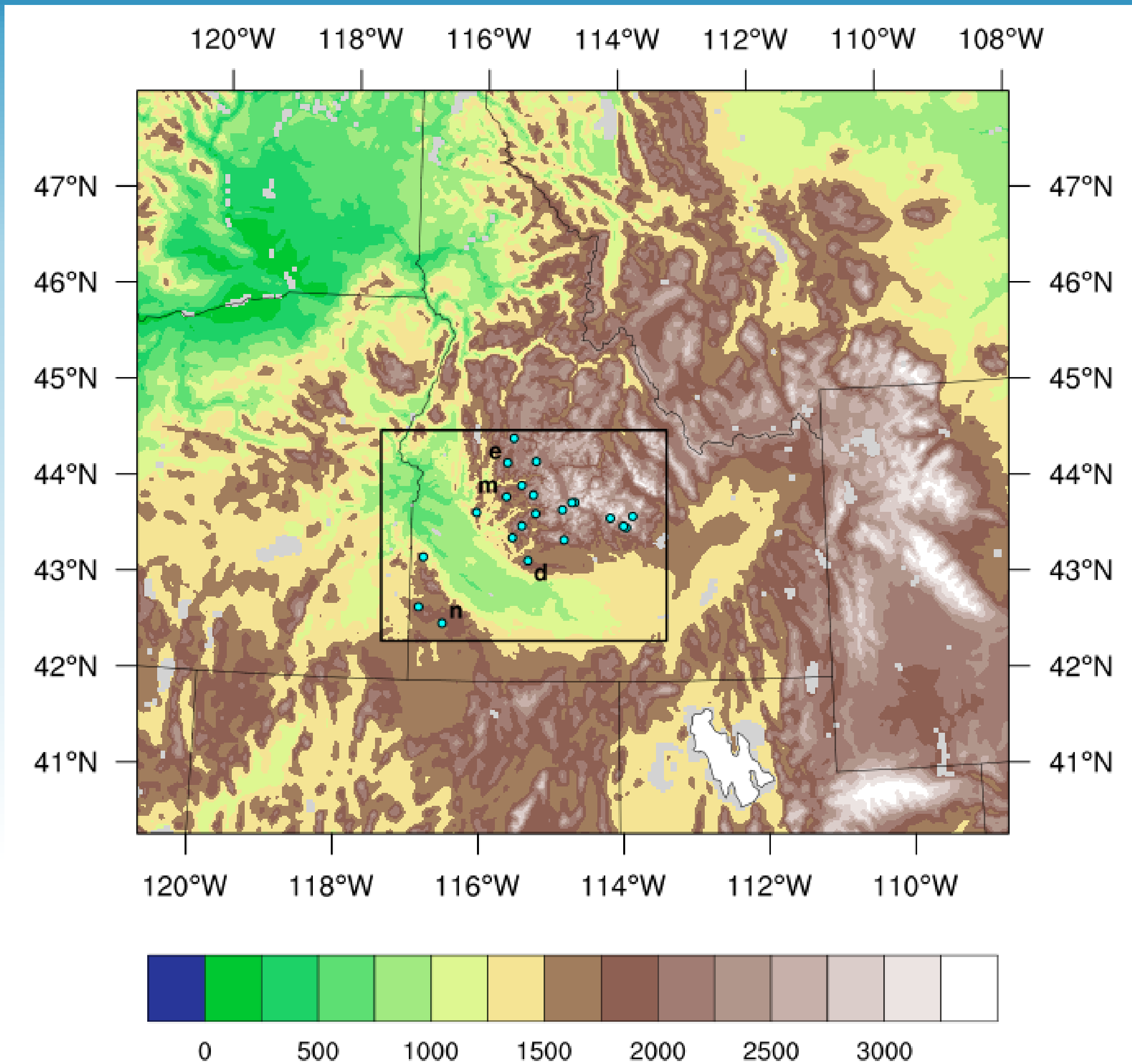
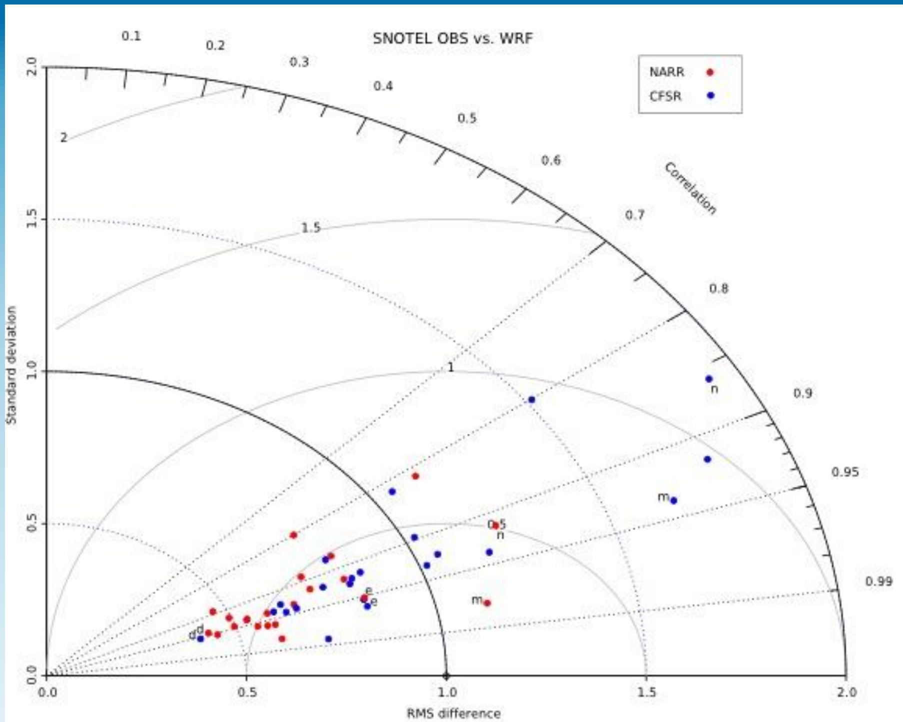
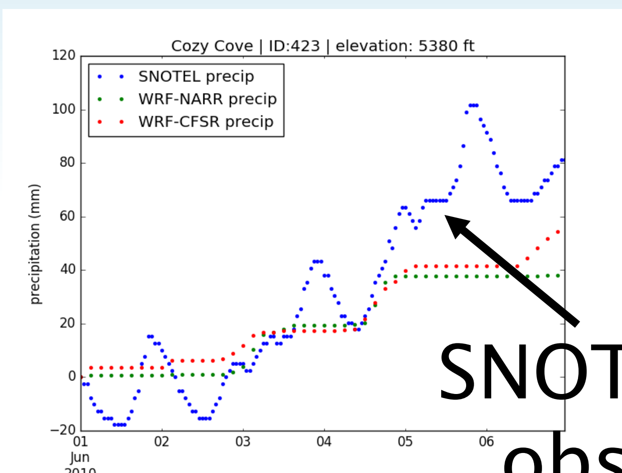


- Matt Masarik (see poster)
- Reservoir managers have an information gap in the 10-30 day horizon
- To what extent is there any predictability?
- Pilot project to attempt to extract precipitation information in extended range
- Dynamically downscale CFSv2 data to 3 km
- Progress:
    - Reanalysis done
    - Reforecasts coming…

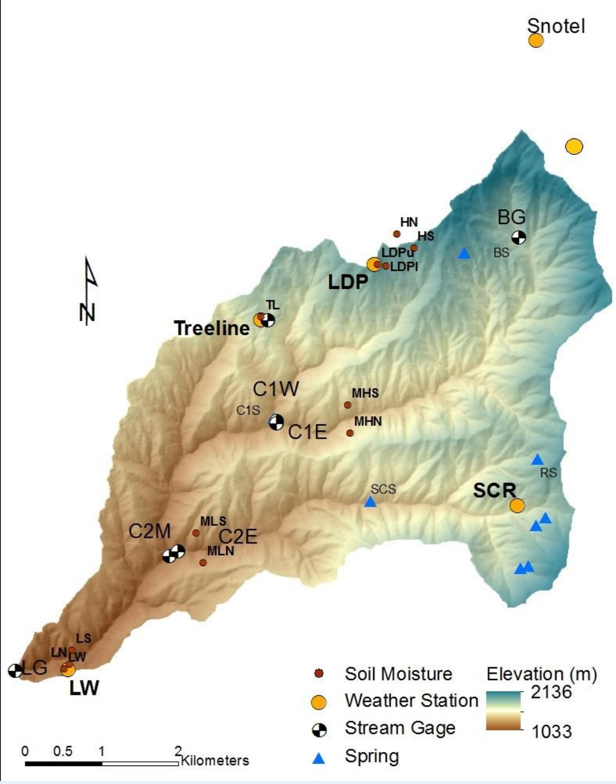


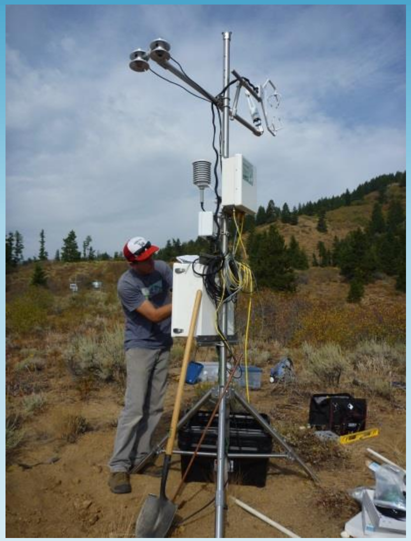
- Plume of moisture from the tropics brought heavy rains and flooding to parts of Oregon and Idaho in early June 2010
- Caught WFO and water managers somewhat off guard
- To what extent/when can a CPM add value for



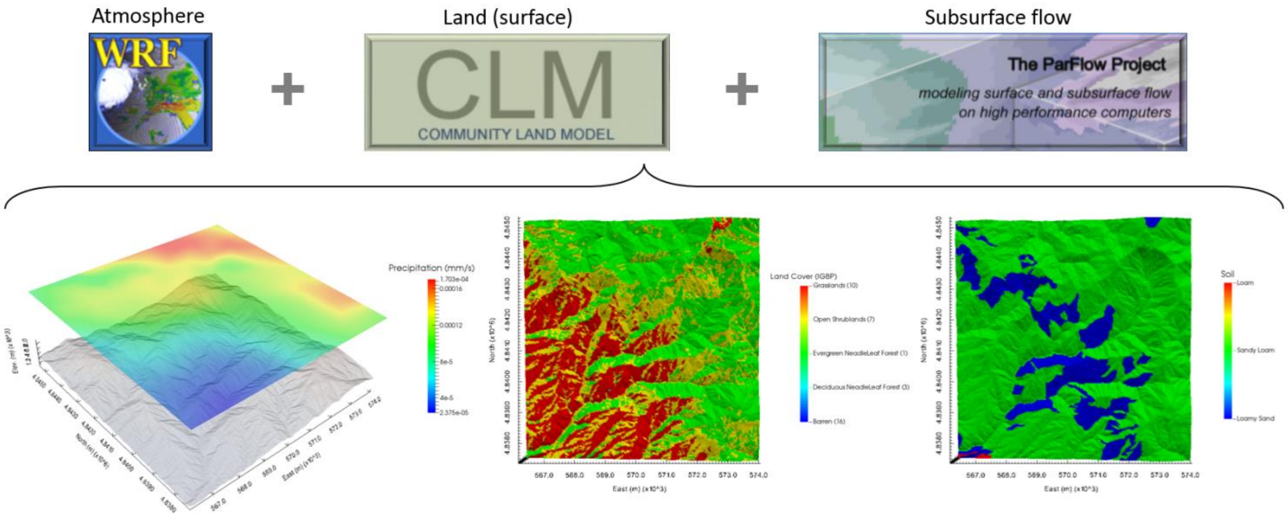
SNOTEL obs.

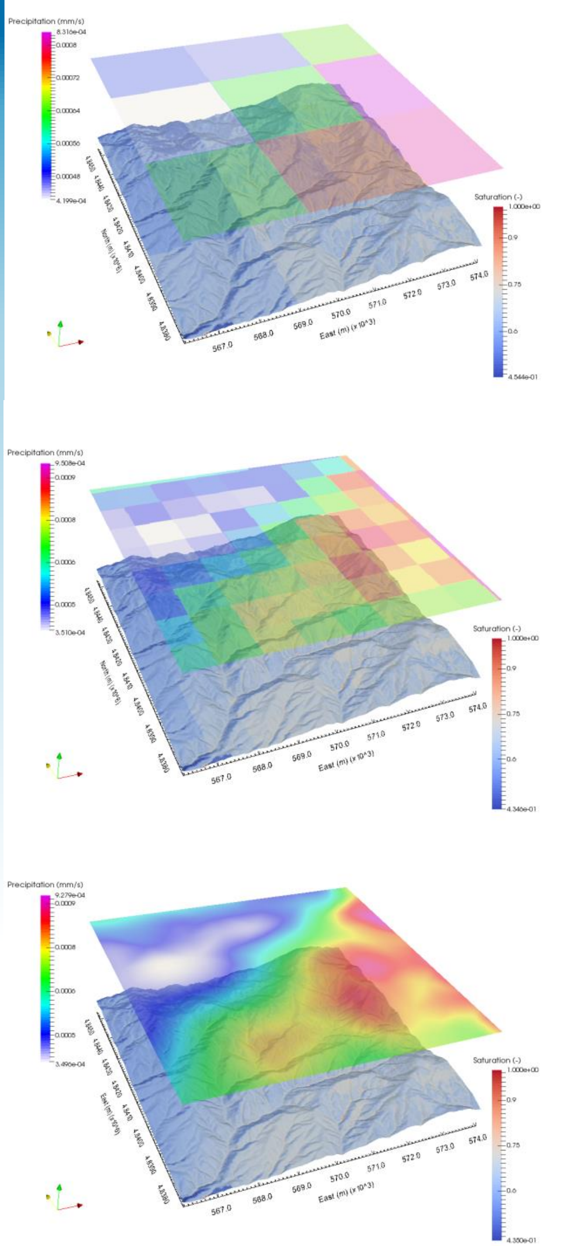
Floodwaters along the Payette River in Emmett

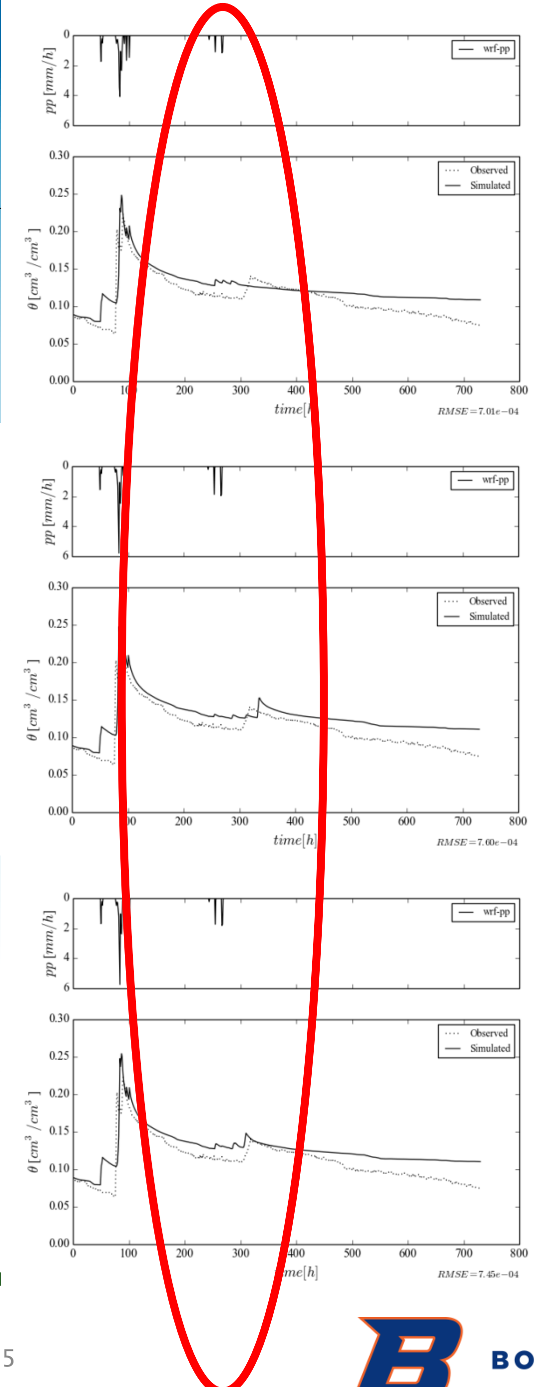




- Miguel Aguayo
- Hillslope hydrological simulation using ParFlow
- Simultaneous evaluation of simulated soil moisture, SWE, discharge in 27 km² watershed

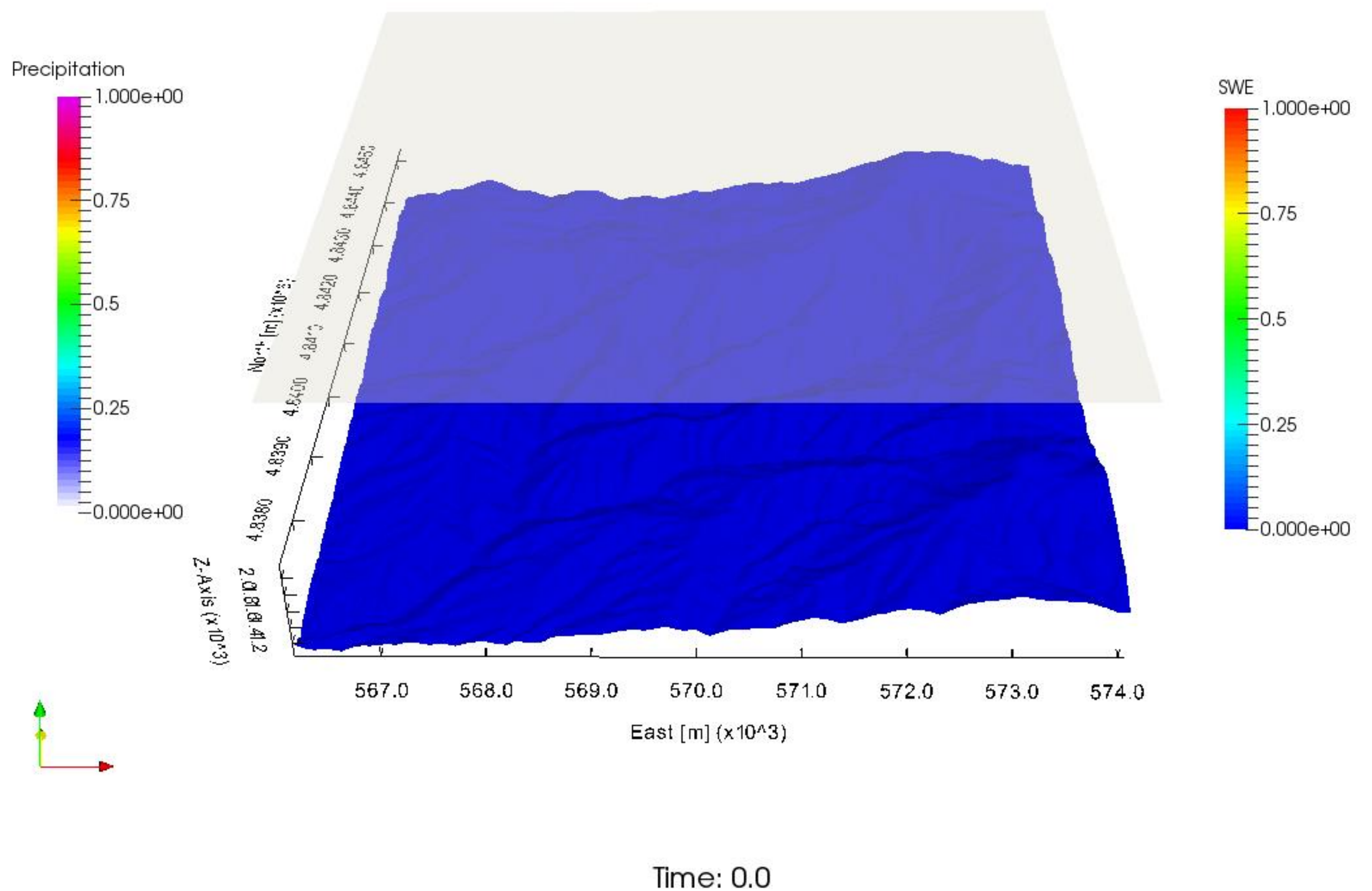






Do we really need <3 km resolution?

For our applications, absolutely!


Precipitation
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East [m] (x10^3)
4.8380
4.839C
4.8400
Z-Axis (x10^3)
Time: 0.0

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THE LAB FOR ECOHYDROLOGY AND ALTERNATIVE FUTURING (LEAF)

A 30-Year, Multi-Domain High-Resolution Climate Simulation Dataset for the Interior Pacific Northwest and Southern Idaho

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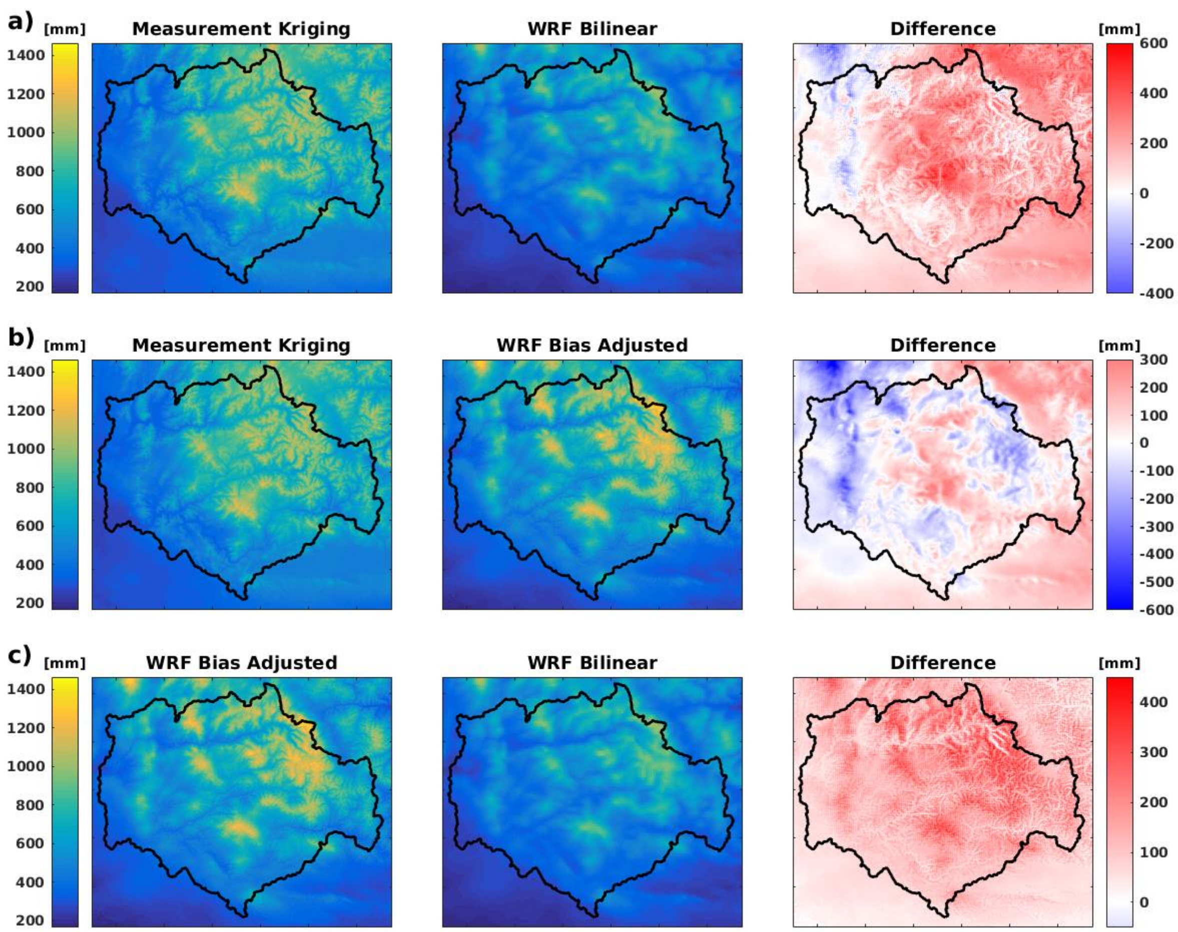
Proof of Concept Collaboration for Water Supply



From Havens et al., in review

- Automated daily WRF 3 day, 3 km forecast for "fun"
- Runs on unused Cisco UCS cycles (don't tell legal)
- Output made available via OPeNDAP server
- USDA ARS staff use Thursday forecast
- WRF output bias adjusted (simple CDF matching)
- Input to iSNOBAL model for Boise River Basin at 100 m
- Weekly report to NRCS and Reclamation Snake River Area Office

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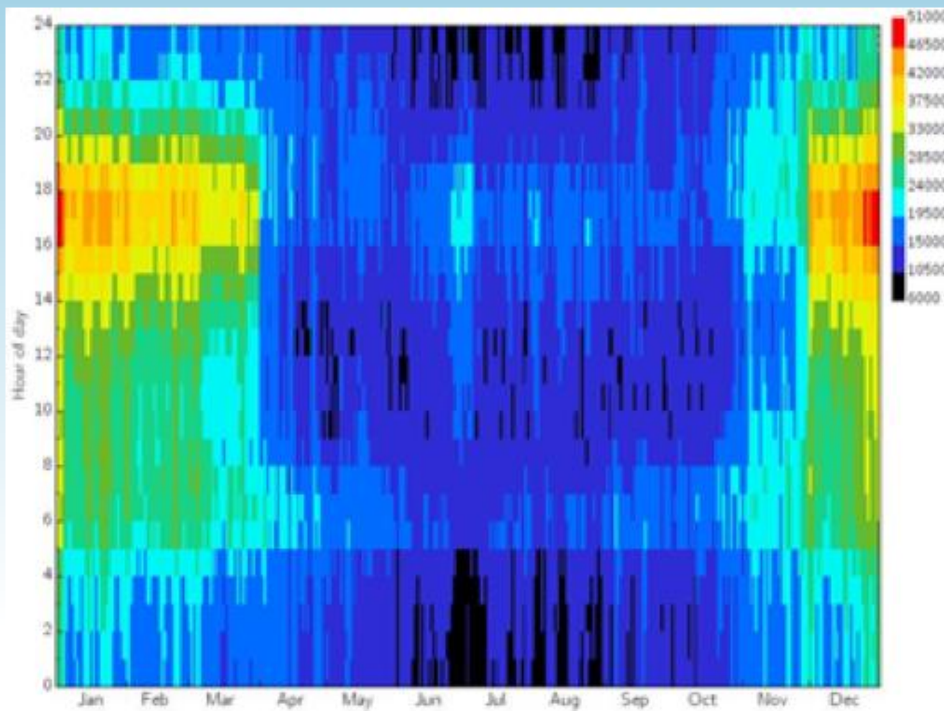
Finding additional applications



Heatmap of building heating/cooling demand in the Wood River Valley (courtesy J. Gardner, E. Ramirez, N. Johnson)

- Microgrids seen as a way to increase penetration of renewables
- Energy sector discussing "demand management"
- Heating/cooling comprise ~50% of building energy use
- Demand is a function of hourly air temperature

Conclusions

- CPMs provide a useful alternative for creating forcings for downstream applications… even for a simple hydrologist ☺
- Historical simulations largely appear to be within the errors of observations
- Demonstrably better results in hillslope-scale models (so far)
- Sharing data is kludgy, but works (for now)
- Additional applications crop up when we talk to people

Acknowledgements

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  - NASA NNX14AN39A: Monitoring Earth's Hydrosphere: Integrating Remote Sensing, Modeling, and Verification
  - US Bureau of Reclamation R15AC00008: Intermediate-range Climate Forecasting to Support Water Supply and Flood Control with a Mesoscale Model