Precipitation Rescaling Approach to Represent Snow Distribution in the iSnobal model and its Effects on the Snowpack Mass and Energy Balances

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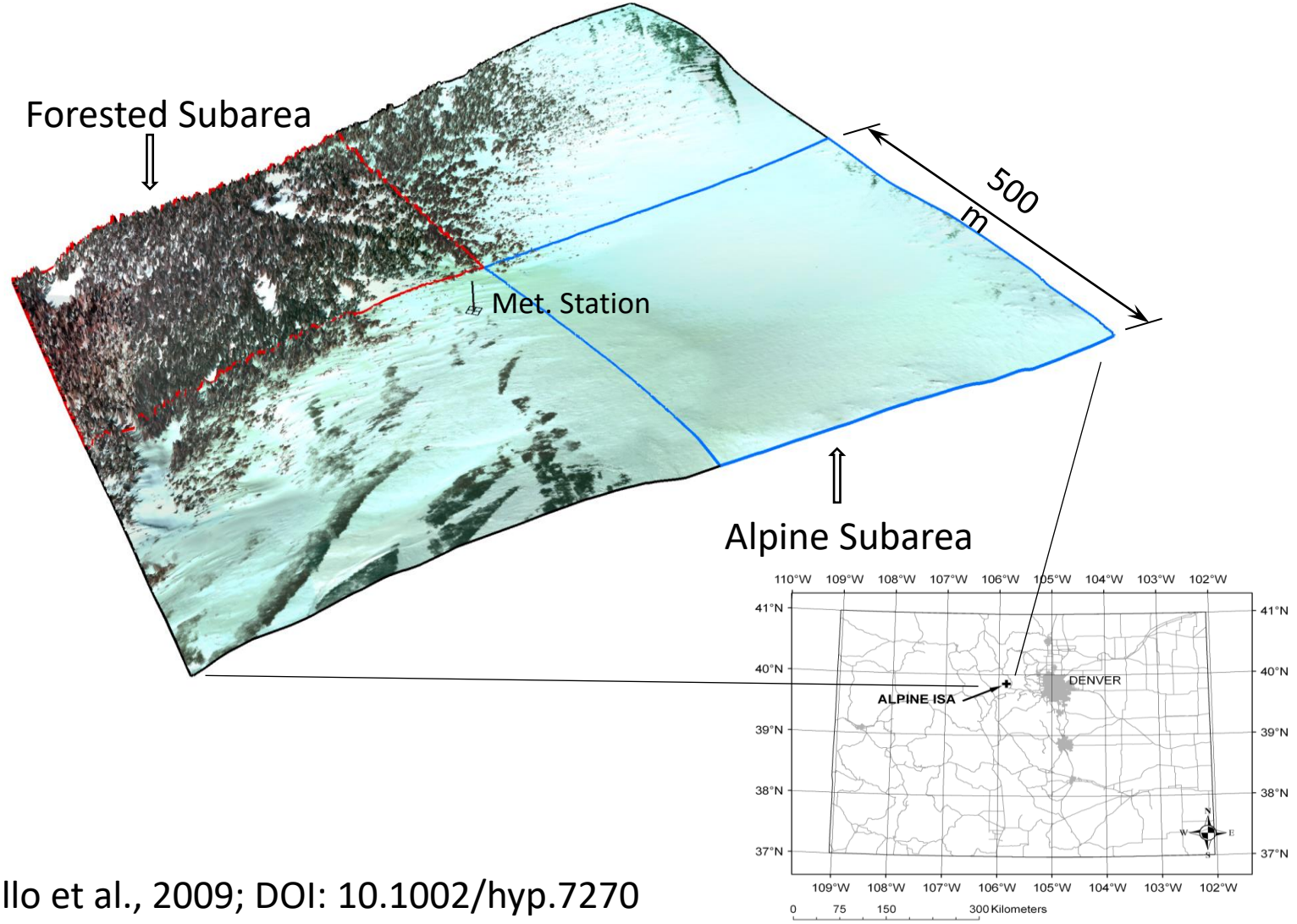
USDA Agricultural Research Service

Variability of Snowpack Properties
Snow Depth



Trujillo et al., 2009; DOI: 10.1002/hyp.7270

Variability of Snowpack Properties
Snow Depth

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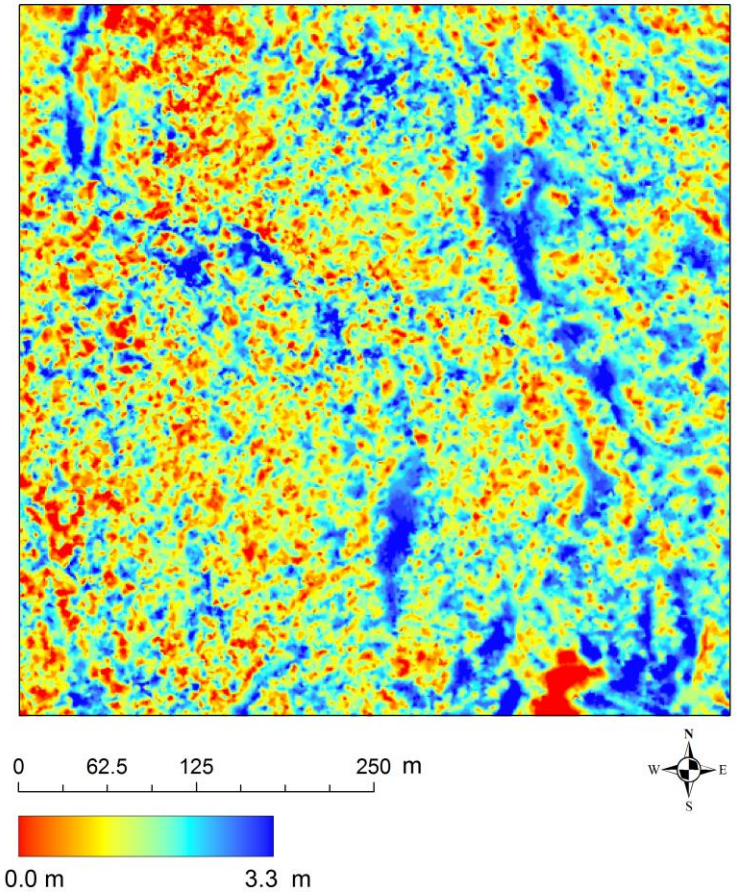
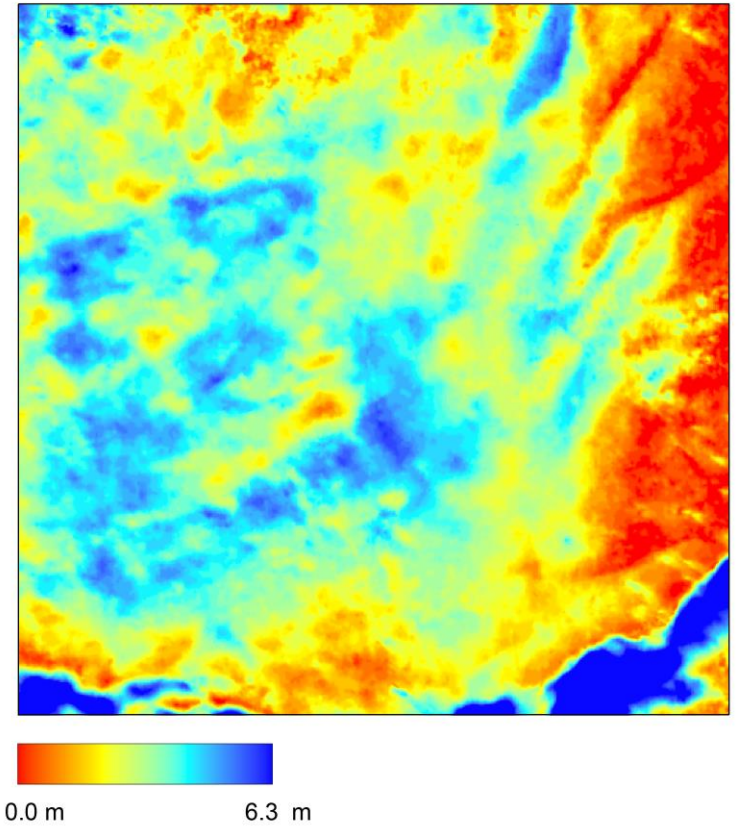
(a) Forested



(b) Alpine



Trujillo et al., 2009; DOI: 10.1002/hyp.7270

Representativeness of snow measurements Snow Depth

The Cryosphere, 9, 1249–1264, 2015
www.the-cryosphere.net/9/1249/2015/
doi:10.5194/tc-9-1249-2015

The Cryosphere Open Access

Theoretical analysis of errors when estimating snow distribution through point measurements

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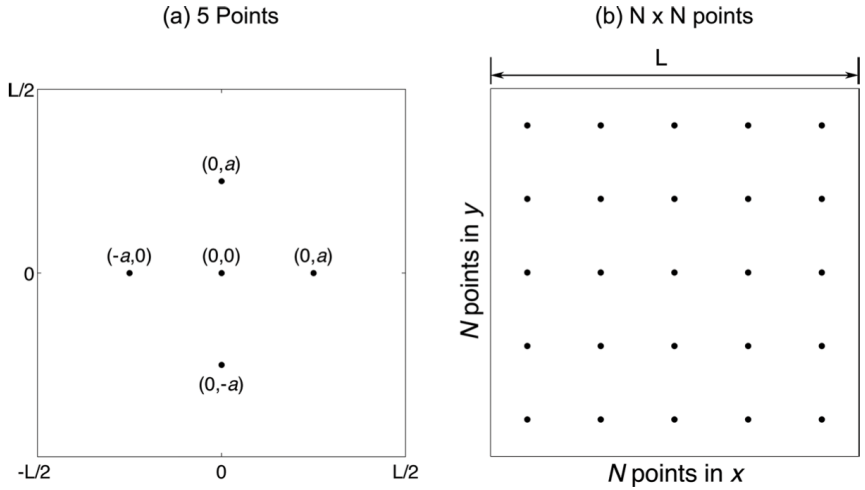
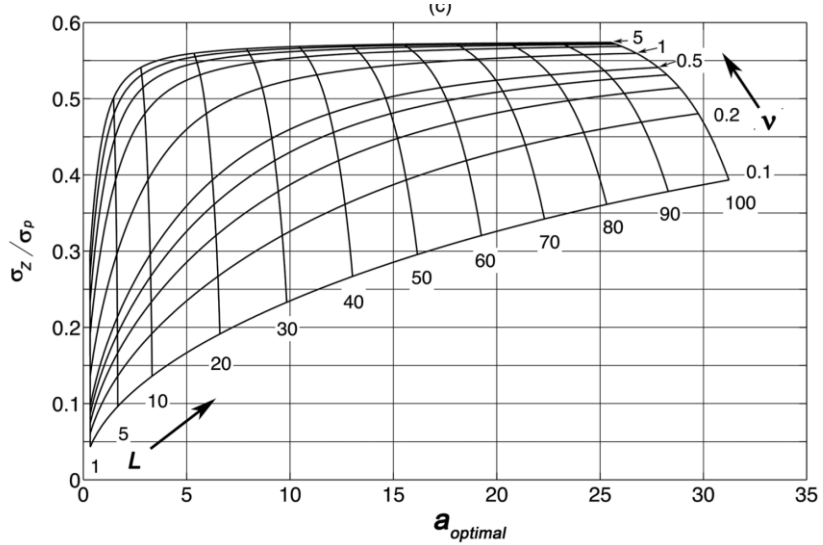
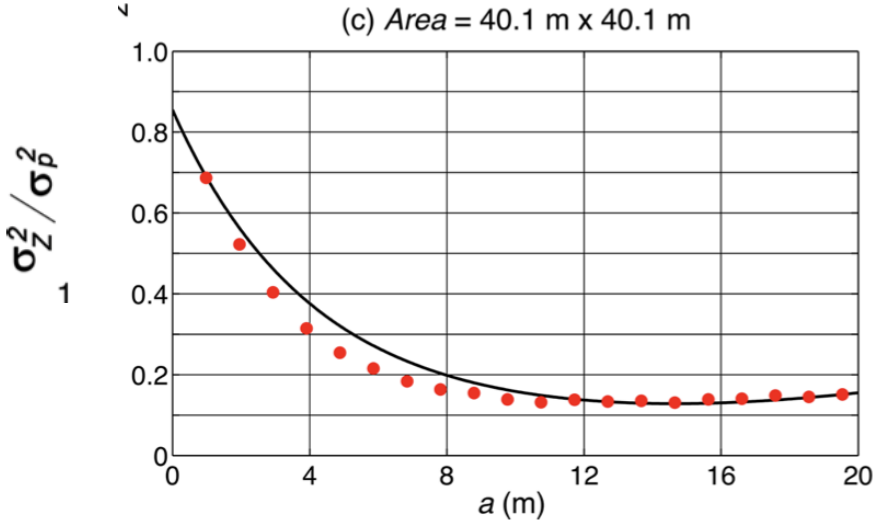
[2]WSL Institute for Snow and Avalanche Research SLF, Davos, Switzerland

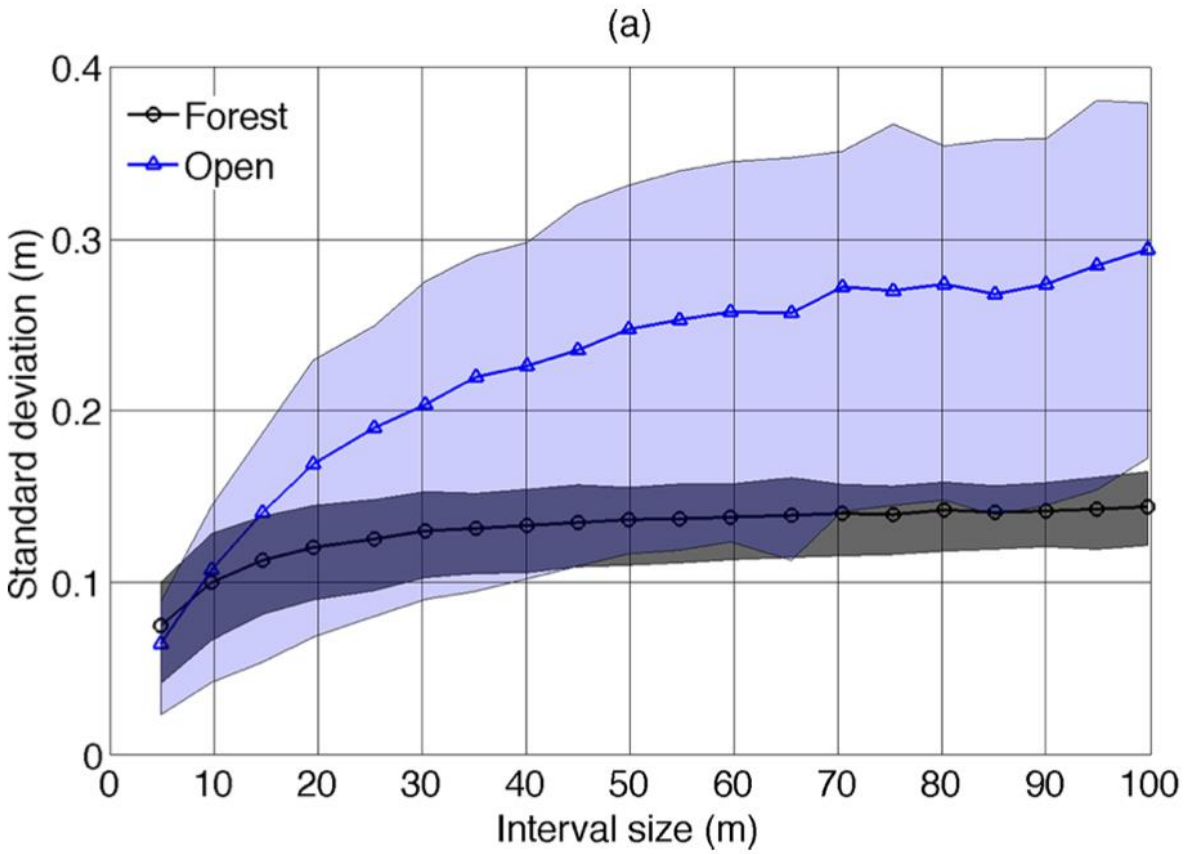


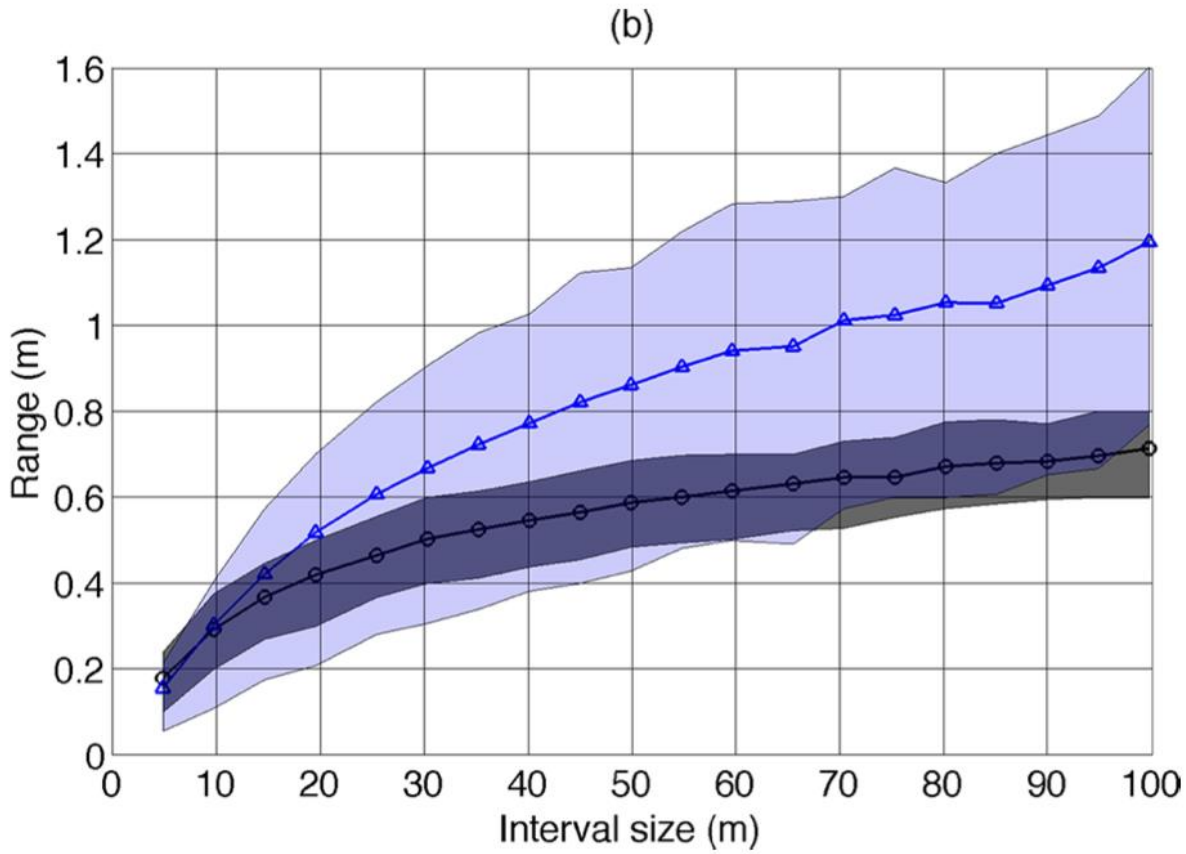




https://tc.copernicus.org/articles/9/1249/2015/tc-9-1249-2015.pdf

Variability of Snowpack Properties
Snow Depth

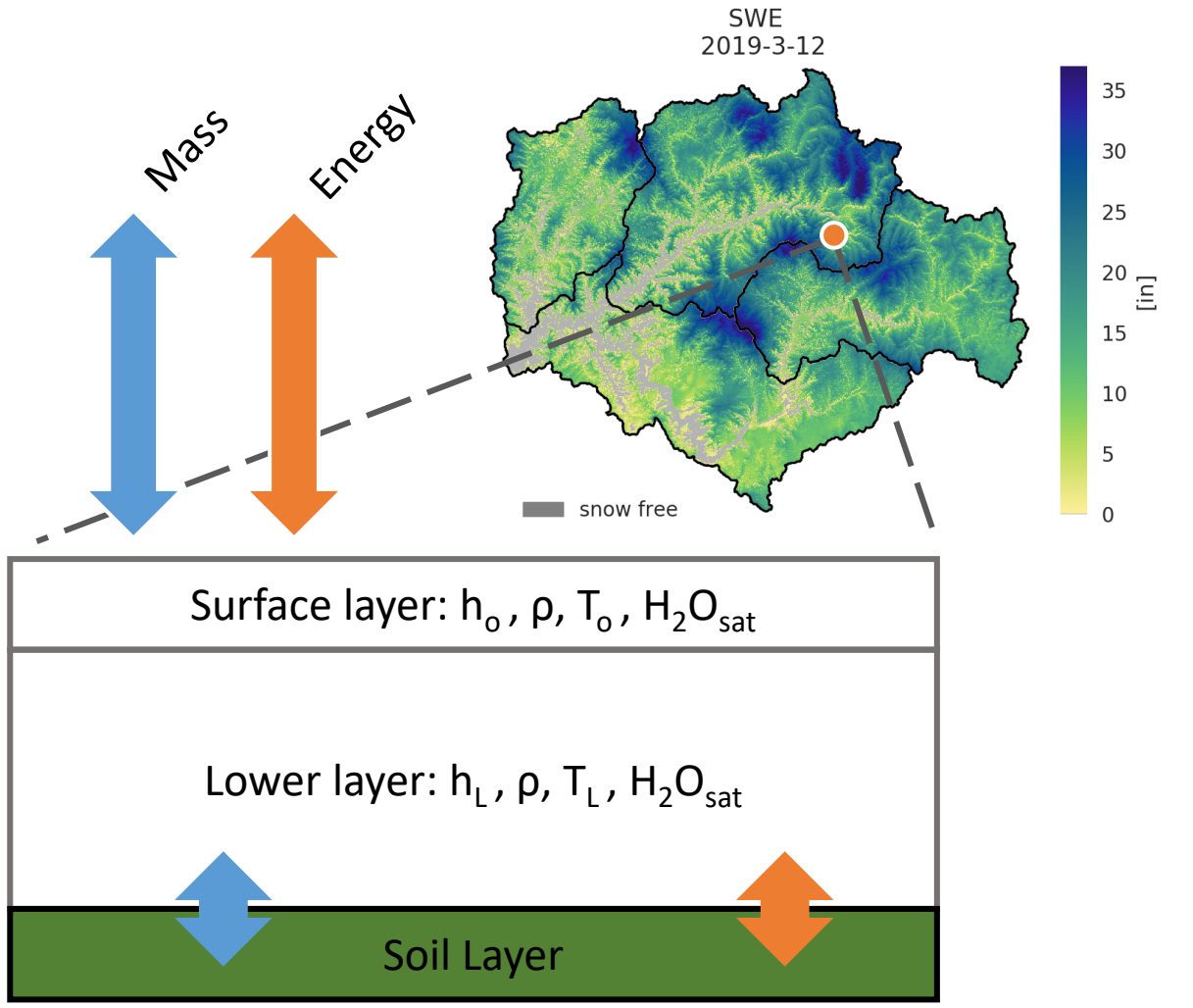




https://tc.copernicus.org/articles/9/1249/2015/tc-9-1249-2015.pdf

iSnobal
Snow Model Overview

- USDA-ARS developed model
- Physically based snow model (Marks et al., 1999)
  - Mass and energy balance of the snowpack
- Varying spatial and temporal resolution
  - 50-meter spatial, hourly timestep
- Input data
  - Cooperative measurement network
  - Using atmospheric model (HRRR) since WY2018



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iSnobal

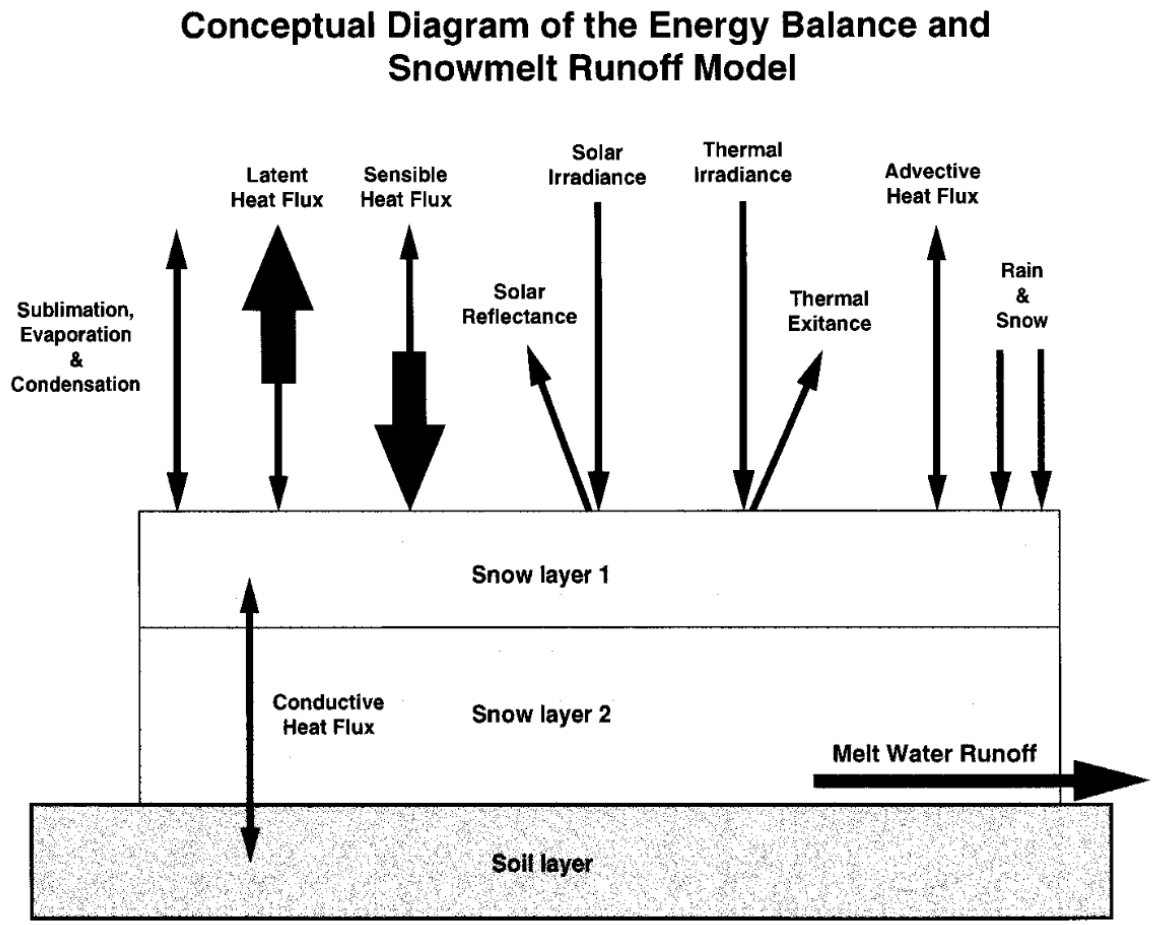

Figure 1. Conceptual diagram of the ISNOBAL energy balance snowmelt runoff model, showing the energy and mass fluxes considered and calculated at a single grid point, and the layering structure of the simulated snow cover

Marks et al (1999), https://doi.org/10.1002/(SICI)1099-1085(199909)13:12/13<1935::AID-HYP868>3.0.CO;2-C

AWSM/iSnobal Model

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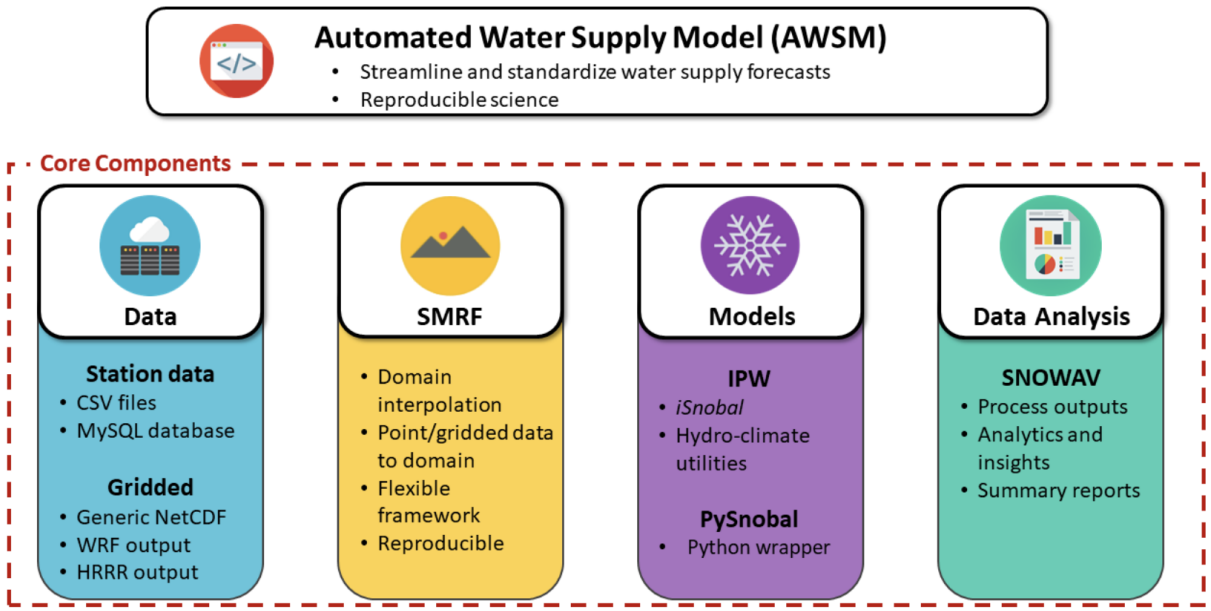
Automated Water Supply Model

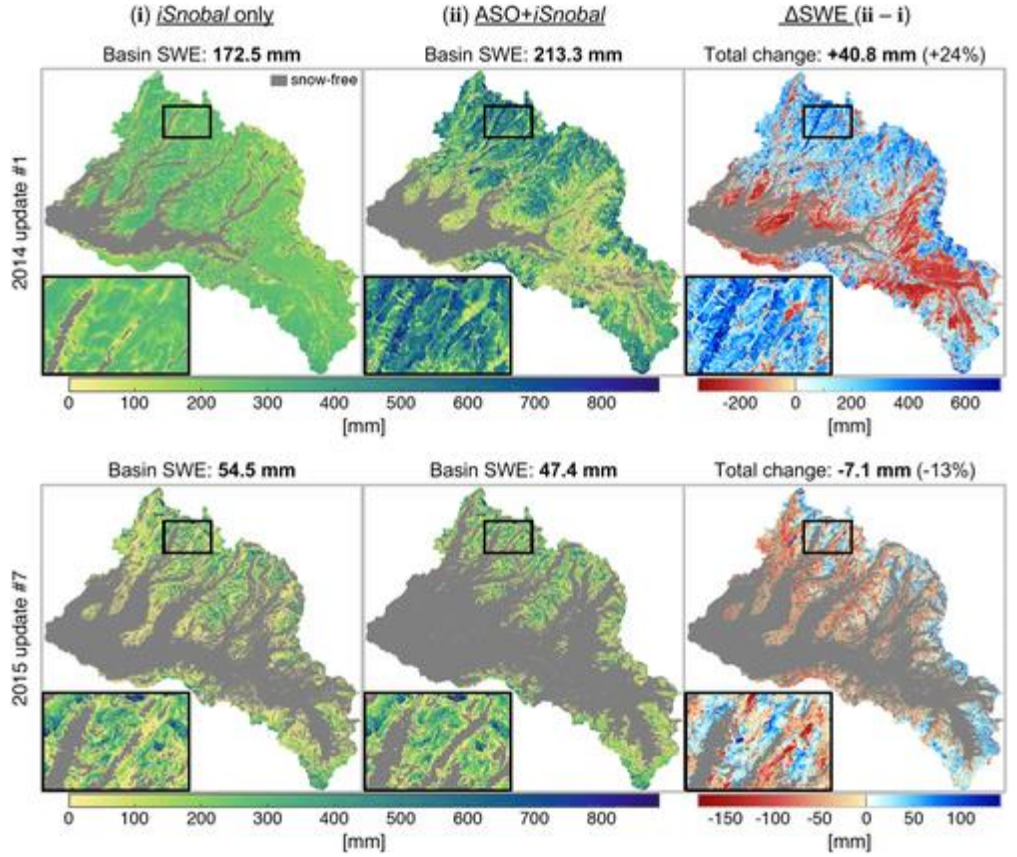
stable version v0.10 | pypi v0.11.2 | DOI 10.5281/zenodo.898158 | coverage 88% | maintainability B

Automated Water Supply Model (AWSM) was developed at the USDA Agricultural Research Service (ARS) in Boise, ID. AWSM was designed to streamline the work flow used by the ARS to forecast the water supply of multiple water basins. AWSM standardizes the steps needed to distribute weather station data with SMRF, run an energy and mass balance with iSnobal, and process the results, while maintaining the flexibility of each program.



SWE = (*depth*)(*density*)

ΛS❄ iSnobal



Havens et al.(2019) : https://doi.org/10.1016/j.cageo.2020.104571, https://github.com/USDA-ARS-NWRC/awsm

Applying modeling and remote sensing in Idaho

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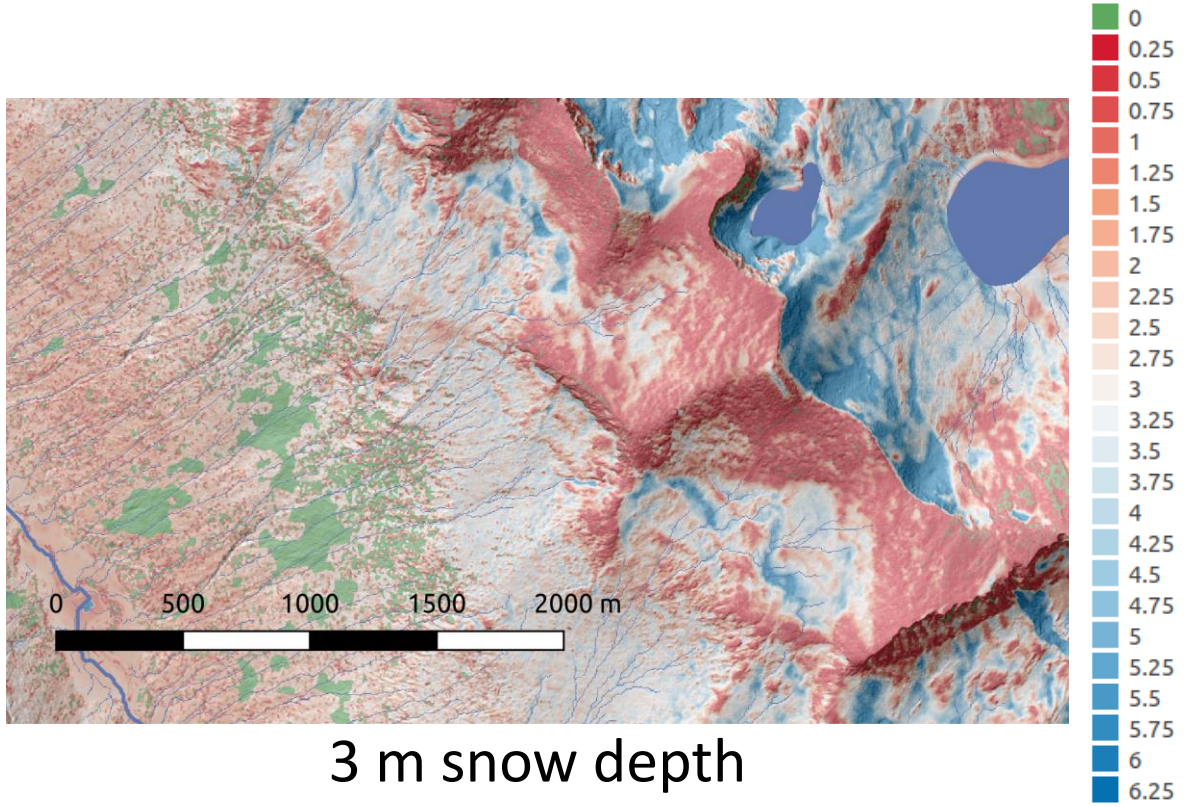
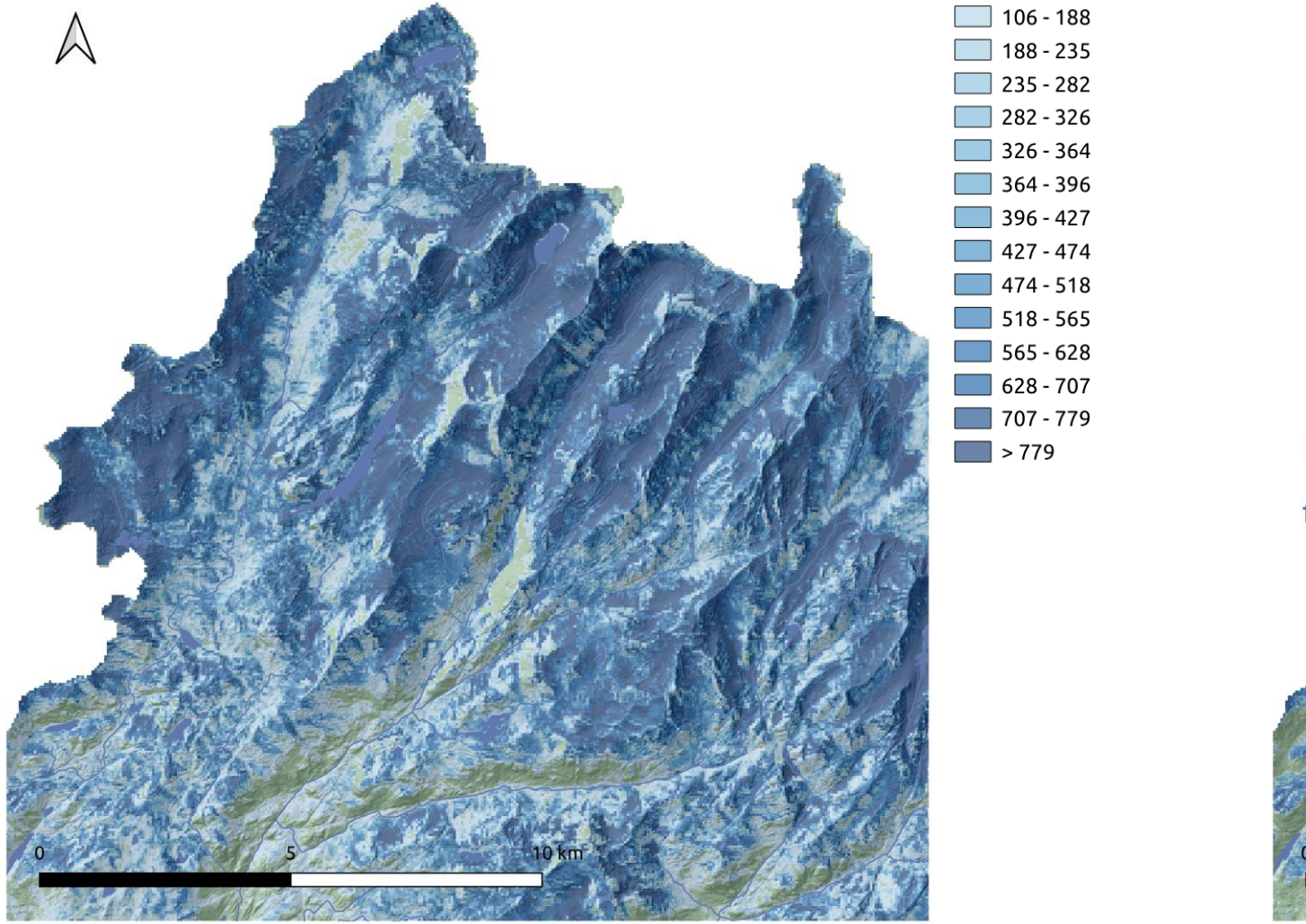
- Snow tends to deposit in the same places year after year
  - Drifting, scour and precipitation gradients
- Utilize lidar/SfM to define a “standard” snow distribution
  - Can we also use a single flight to define that distribution?
- Use snow distribution to scale precipitation (put it in the right places)



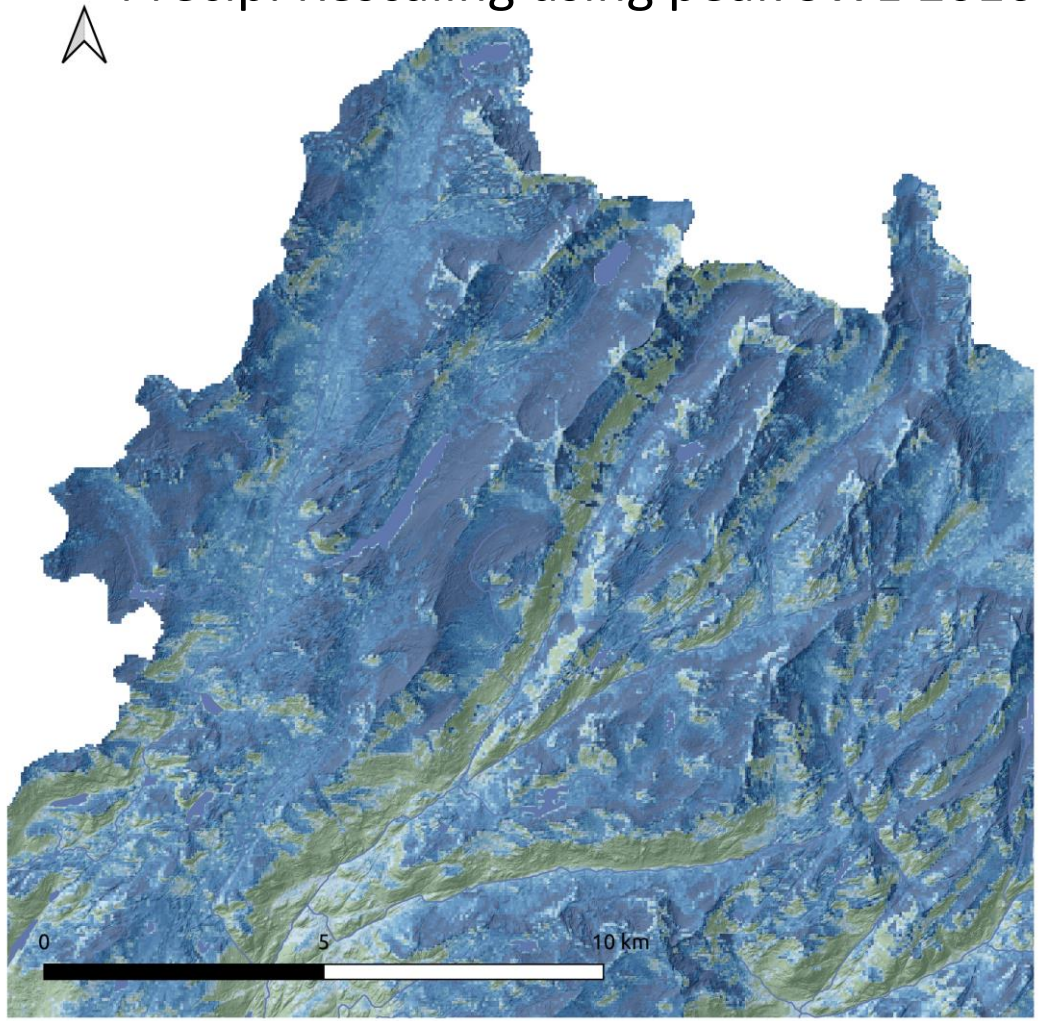
3 m snow depth

Precipitation rescaling – Preliminary results (Northern subarea in Tuolumne)

2013-04-03 ASO/iSnobal SWE

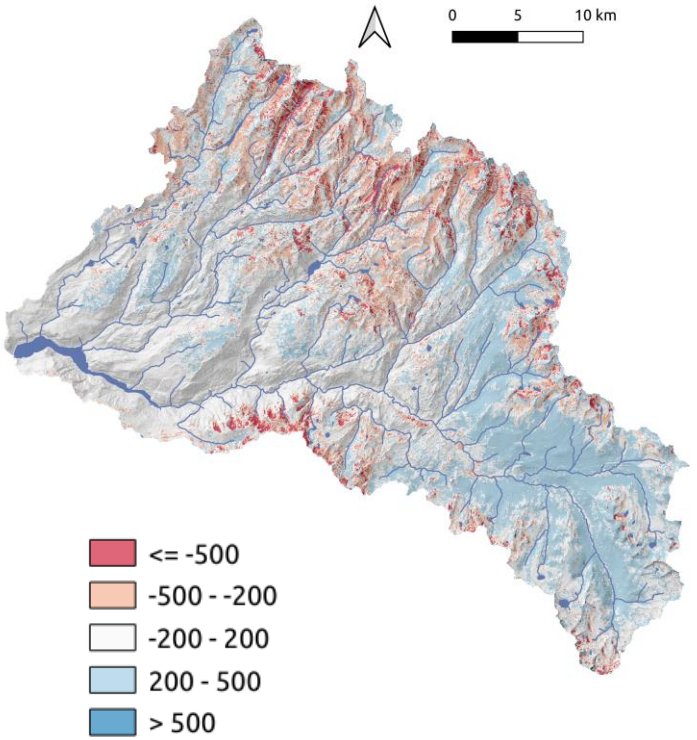


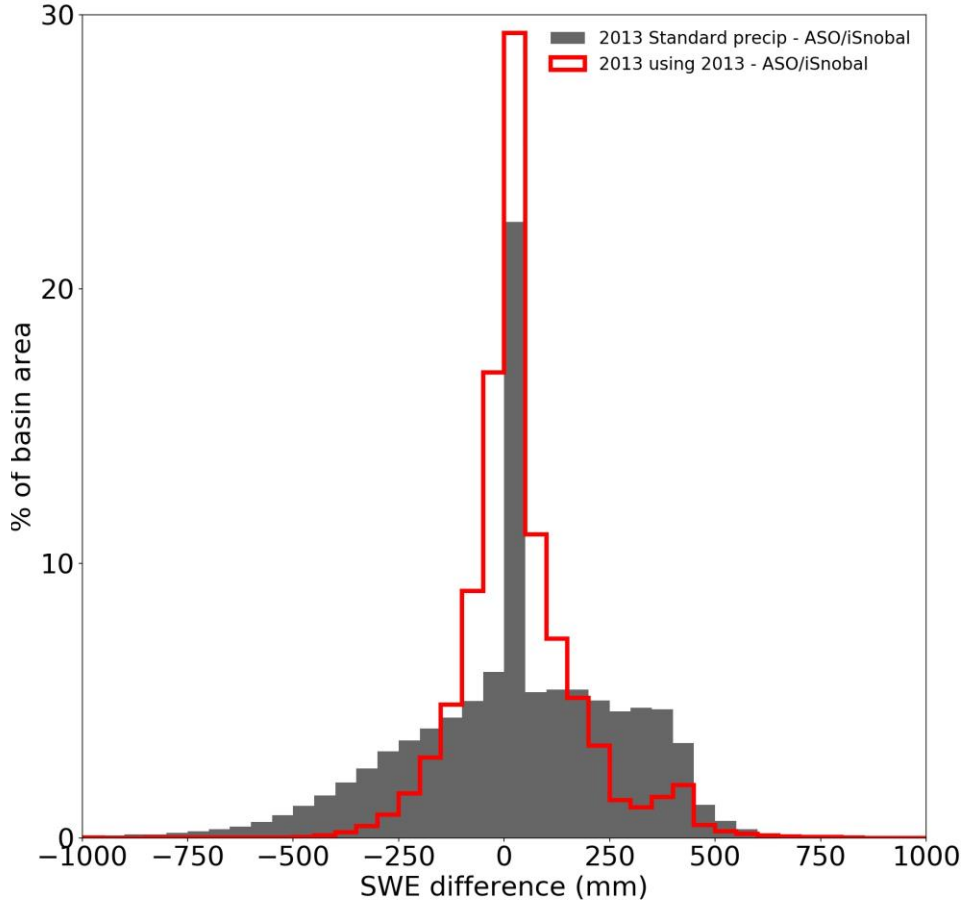
2013-04-03 iSnobal SWE – no updates
Precip. Rescaling using peak SWE 2016



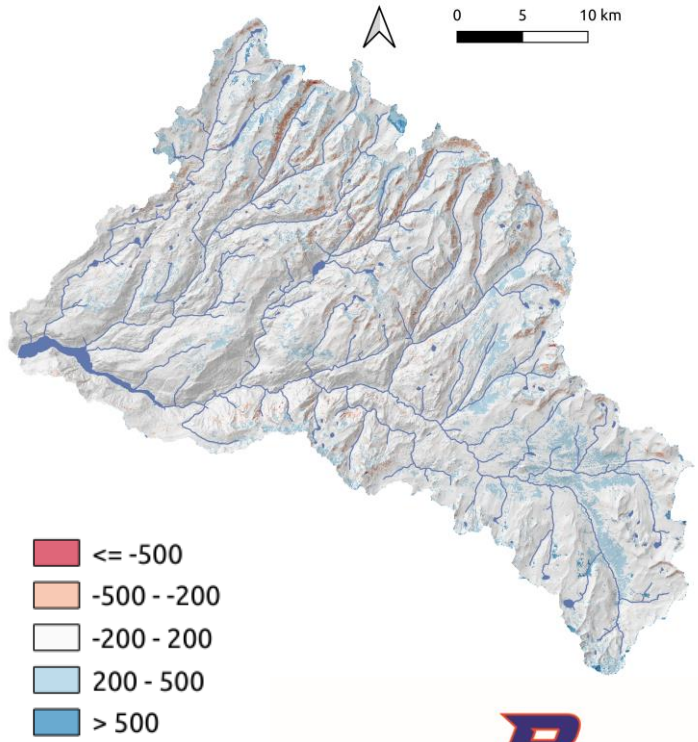
Modeled – ASO/iSnobal SWE

Difference
2013-04-03 Std Precip – ASO/iSnobal





Difference
2013-04-03 using 2013 – ASO/iSnobal



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Rain-Snow Transition Zone
Johnston Draw iSnobal modeling work

Hydrol. Earth Syst. Sci., 26, 2779–2796, 2022
https://doi.org/10.5194/hess-26-2779-2022

Hydrology and Earth System Sciences
Open Access
EGU

Effects of spatial and temporal variability in surface water inputs on streamflow generation and cessation in the rain–snow transition zone

Leonie Kiewiet[1,2], Ernesto Trujillo[3,4], Andrew Hedrick[4], Scott Havens[4], Katherine Hale[5,6], Mark Seyfried[4], Stephanie Kampf[1], and Sarah E. Godsey[2]

Contents lists available at ScienceDirect

Journal of Hydrology

journal homepage: www.elsevier.com/locate/jhydrol

Research papers

Drivers of spatiotemporal patterns of surface water inputs in a catchment at the rain-snow transition zone of the water-limited western United States

K. Hale [a,b,*], L. Kiewiet [c], E. Trujillo [d,e], C. Krohe [f,g], A. Hedrick [e], D. Marks [e], P. Kormos [h], S. Havens [e,i], J. McNamara [d], T. Link [j], S.E. Godsey [g,j]

Rain-Snow Transition Zone
Johnston Draw iSnobal modeling work

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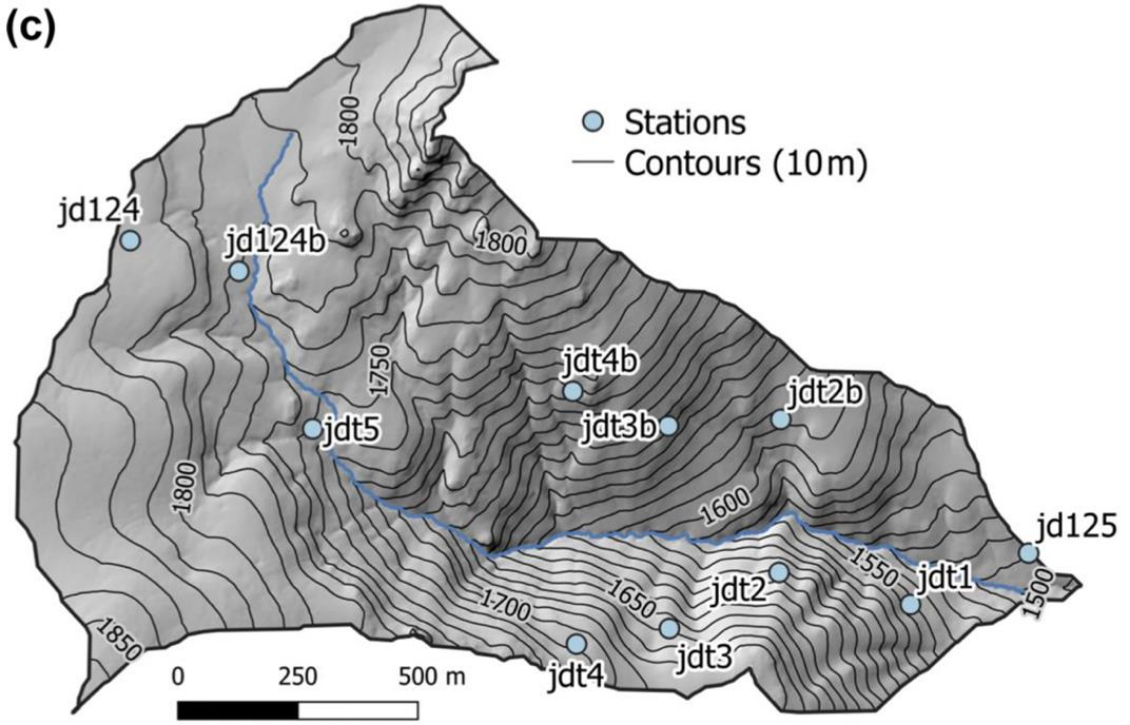
- Studying the spatial and temporal patterns of surface water inputs (SWI) across 4 hydroclimatically different years
- Johnston Draw: 1.8 km^2, elev. range of 1497 m to 1869 m, MAP ~600 mm
- 2005: rainy, 2010: snowy, 2014: dry, and 2011: wet
- iSnobal: 10-m resolution, hourly timesteps, using a precipitation rescaling approach



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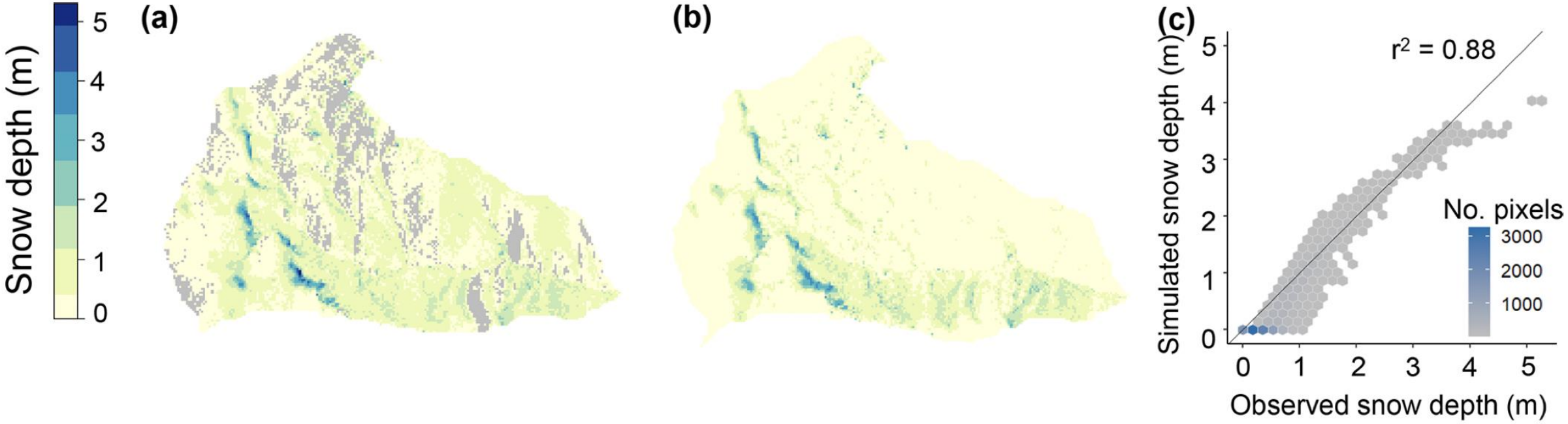
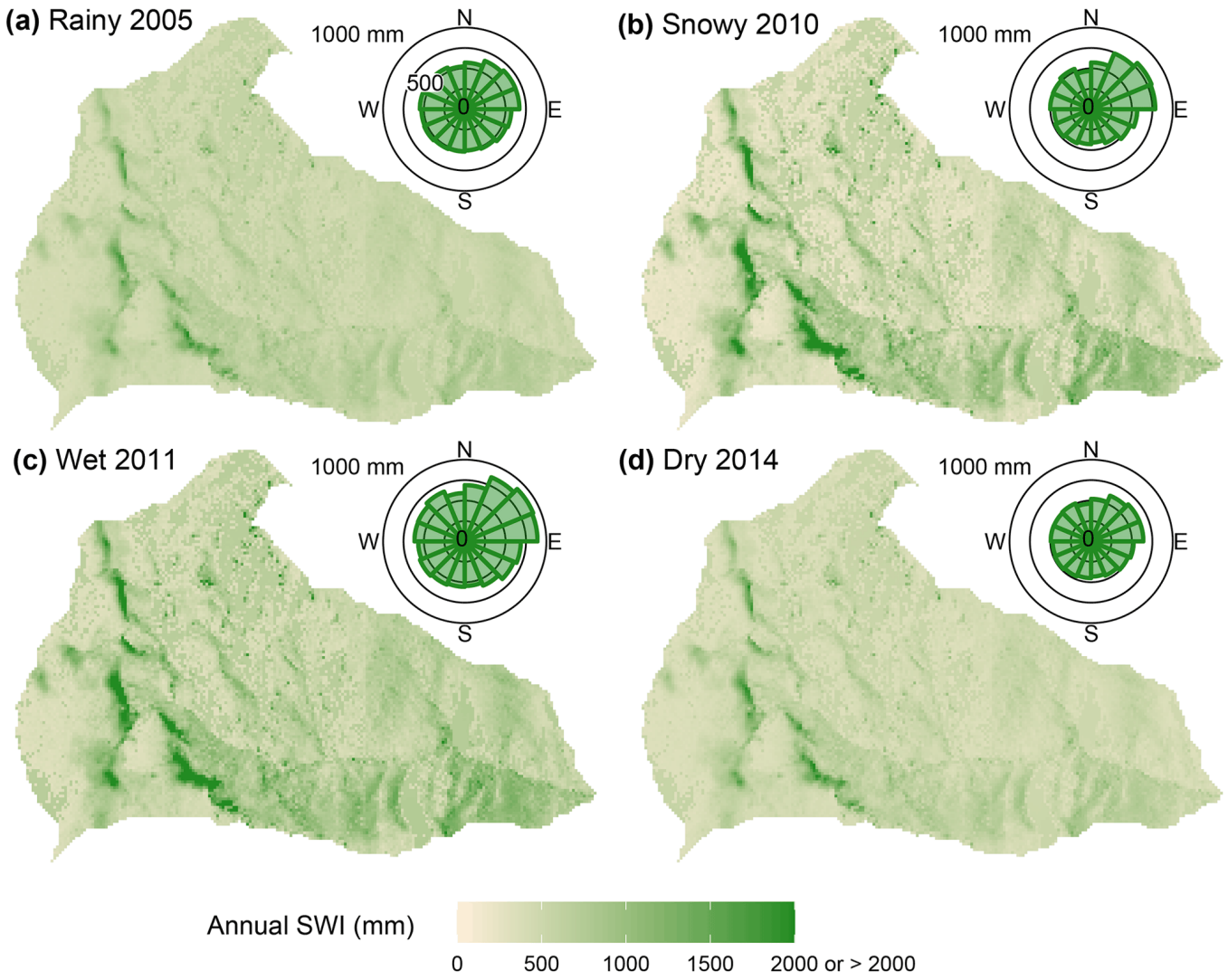
Modeled

Observed



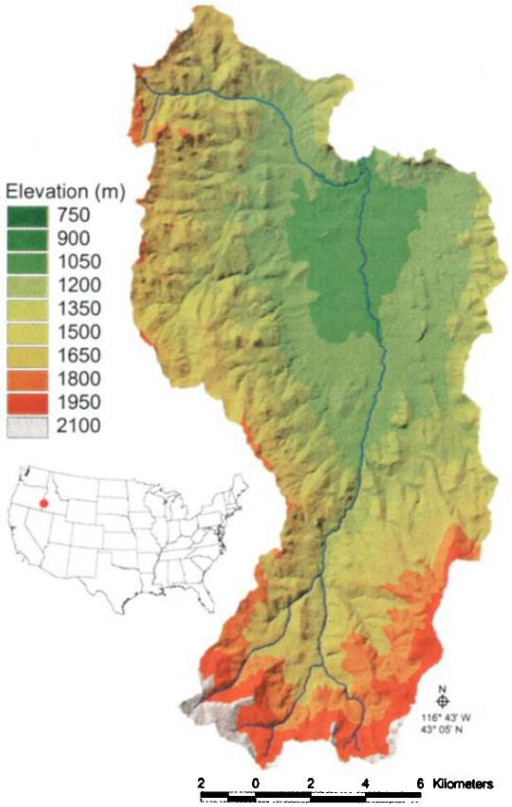
Rain-Snow Transition Zone
Johnston Draw iSnobal modeling work



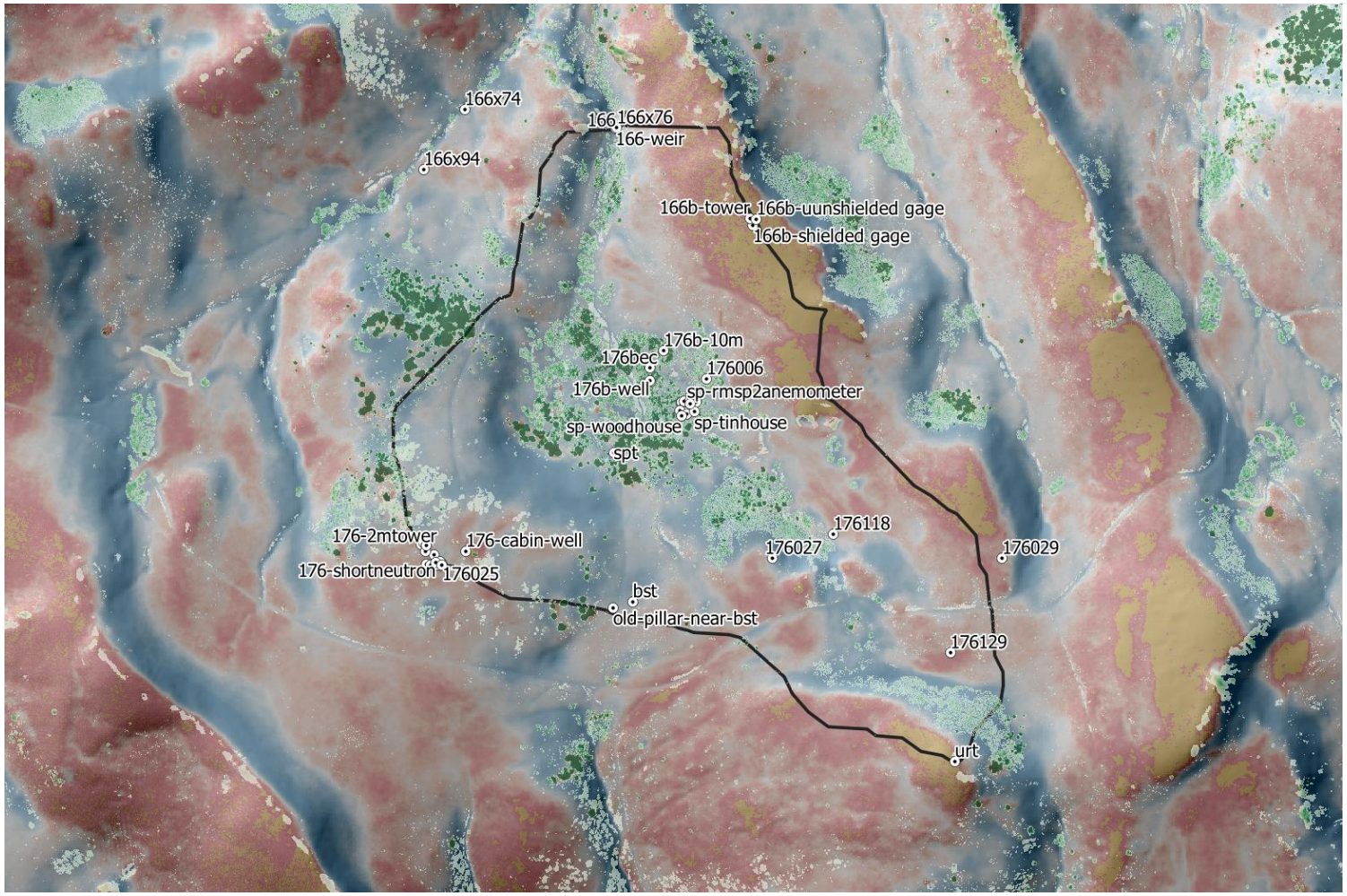
Maps showing the yearly sum of surface water inputs (SWI, mm), with polar diagram insets showing the average sum of SWI per 10 m grid cell for each aspect

Small scale study areas

Reynolds Creek Experimental Watershed (RCEW)



Reynolds Mountain East (RME)



SnowEx 2020 – TLS

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SnowEx 2020 – Reynolds Mountain East

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- 0.38 km^2 snow dominated headwater catchment
- *Elevation range: 2028 – 2137 m*
- 1983-present : Meteorological, soil and snow measurements
- Snow courses during winter at one of the instrument sites adjacent to snow pillow and snow depth sensors
- The two main measurement sites:
  - A sheltered site located within a clearing in an aspen/fir grove near the center of the catchment
  - An exposed site is located on the western catchment divide in an area dominated by mixed sagebrush
- A streamflow weir is located at the outlet of the catchment

Questions?