Keith N. Musselman, Ph.D.

CONTACT INFORMATION
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EDUCATION

University of California Los Angeles — Los Angeles, California
Doctor of Philosophy in Civil Engineering — 2012
- Minor in Atmospheric Sciences
- Emphasis in Hydrology & Water Resources
- NASA Earth System Science Fellowship Recipient

University of Arizona — Tucson, Arizona
Master of Science in Hydrology & Water Resources — 2006
- Emphasis in Surface Hydrology

University of Vermont — Burlington, Vermont
Bachelor of Science in Geology — 2003
- Emphasis in Surface Hydrology

PROFESSIONAL EXPERIENCE.

Institute of Arctic and Alpine Research, University of Colorado Boulder — Boulder, Colorado
Research Associate
October 2017 – Present

- Lead Principle Investigator on $3M project with NCAR and USGS scientists to the National Science Foundation Navigating the New Arctic program to strengthen understanding of terrestrial hydrologic change in the Arctic and the potential impacts on rivers, fisheries, and Indigenous communities. Lead PI on a NOAA Climate Program Office project with NCAR to downscale CMIP6 runs for assessment of projected changes in precipitation, snowpack, soil moisture and flood risk.
- Analyze the agricultural water supply-demand imbalance during the California drought using novel NASA satellite data, snow models, lidar, and GPS data. Oversee operational reports to California DWR and stakeholders. Reanalysis of the 2017 Oroville Dam flood disaster using diverse gridded historical weather and climate data. Supervise and mentor three graduate and two undergraduate students.
- Published high impact paper in *Nature Climate Change* on future rain-on-snow flood risk in western North America. Interviews carried by >10 news outlets, 250+ Tweets.

National Center for Atmospheric Research — Boulder, Colorado
Advanced Study Program Fellowship - Postdoctoral
October 2015 – October 2017

- Independently pursued research that collaboratively leveraged NCAR's world-class climate modeling capacity and multidisciplinary hydrologic team expertise. Analyzed high-res RCM output and led a high-impact paper in *Nature Climate Change* that alters conventional thought of how water resources may respond to climate change.
- Advanced the capability of hydrologic models to simulate dominant cold region processes in Alaska. As a member of a collaborative team, built propensity for research techniques using a model to achieve the Mission's goal of advancing hydrological model capacity and uncertainty characterization.

University of Saskatchewan Kananaskis, Alberta
Postdoctoral Fellow
October 2012 – October 2015
40 Hours/Week

- Developed new parsimonious model capacity of snow and forest hydrology to evaluate cold region process sensitivity to changes in land cover and climate. Creative use of technology (computational fluid dynamics, ray tracing) in solutions of challenging problems related to fine-scale numerical modeling of Earth System processes.
- Designed and supervised a large field campaign to evaluate how forest vegetation structure and disturbances influence water and energy availability. Mentored and developed graduate students, student interns, and supervised two technicians.

University of California Los Angeles Los Angeles, California
NASA Earth System Science Graduate Fellow
September 2008 – September 2012

- Conduct independent research using field measurements and numerical modeling to analyze snow accumulation and melt dynamics in the Sierra Nevada.
- Designed and supervised ten basin-scale snow surveys with five or more researchers including undergraduate and graduate students in the remote Sierra Nevada, California.
- Build future capabilities leveraging state-of-the-art lidar technology to estimate high-resolution solar radiation beneath a forest canopy in Sequoia National Park with a novel approach that remains an example of technical excellence.

CLASSROOM
TEACHING EXPERIENCE

University of Colorado Boulder Boulder, Colorado
Lecturer Spring and Fall Semesters, 2019

- Lecture three days per week a class of 160 undergraduates in Geography course *Environmental Systems: Landscapes and Water*; plan field excursions, design lectures, homework, and exams. Supervise three teaching assistants who held weekly labs.

University of California Los Angeles Los Angeles, California
Teaching Assistant (TA) Fall Semester, 2009

- Lead weekly discussion sessions, designed homework and held office hours for class of 100+ in Civil Engineering course 150 *Introduction to Hydrology*. Prof. S. Margulis

WORKSHOPS & FIELD COURSES TAUGHT

UCB Science Discovery, Family Engineering Day; 1000+ attendees (2020)
NSF-funded workshop LiDAR Applications in Critical Zone Sciences (2014)
TA for *Advanced Field Methods in Snow Science*, Prof. Noah Molotch (2011)
TA for *Snow Hydrology and Field Camp*, Prof. Paul Brooks (2006)

FUNDING

- (Pending) **NASA, Commercial Small-Satellite Data Analysis** 2021-2022
  "Towards improved representation of snow in forests for NASA global snow mapping" (role: ***co-PI, $27K***)
- (Pending) **Bureau of Reclamation, Research and Development** 2021-2023
  "Assessing historical and projected future flood mechanisms for headwater basins of the western U.S." (role: ***PI, $220K***)
- (Awarded) **NASA, Applied Sciences** 2021-2022
  "Satellite-based Snowpack Information to address COVID-19 impacts on water resources" (role: ***co-PI, $21K***)
- (Awarded) **NSF, Navigating the New Arctic Program** *2020-2024*
  "The climate impacts on Alaskan and Yukon rivers, fish, and communities as told through co-produced scenarios" (*role: **PI, $3M***)
- (Rejected) **Department of Energy, Subsurface BioGeoChem Research** *2019-2022*
  "Consequences of winter perturbations on hydro-biogeochemical connectivity in contrasting ecosystems" (*role: **co-I, $60K***)
- (Awarded) **NOAA, Climate Program Office** *2019-2021*
  "Assessing the predictability and probability of 21st century rain-on-snow flood risk for the conterminous U.S." (*role: **PI, $200K***)
- (Awarded) **NASA, GEO, supplemental funding** *2019*
  "Optimizing the Indus Basin Irrigation System and reservoir operations using remotely sensed snow surface properties in the ParBal model" (*role: **co-I, $22K***)
- (Rejected) **NOAA, OAR, Remote Sensing for Snowpack and Soil Moisture** *2018*
  "Development of an operational multi-platform snow water equivalent testbed" (*role: **PI, $800K***)
- (Awarded) **National Science Foundation, Hydrologic Sciences** *2018-2020*
  "Extending the vadose zone: characterizing the role of snow for liquid water storage and transmission in streamflow generation" (*role: **co-PI, $142K***)
- (Awarded) **University of Colorado Outreach Award** *2019-2020*
  "Past, Present, Future: Exploring Boulder's Natural Environment" (*role: **co-I, $24K***)
- (Past Award) **NCAR Advanced Study Program Fellowship** *2015-2017*
  *"Slower snowmelt in a warmer world" (**$136K**)*
- (Past Award) **NASA Earth and Space Science Fellowship Program** *2008-2012*
  *"Remote Sensing and Ground Data Assimilation Using A Basin-Scale Snow Water Equivalent Reconstruction Method" (**$90K**)*

Student Mentorship

Graduate Student co-Advisor

Dylan Blaskey, Ph.D. Student, Civil Engineering, CU Boulder

Ph.D. Committee Member

Kehan Yang, University of Colorado, Boulder
Hamideh Safa, University of Nevada, Reno
Dylan Blaskey, University of Colorado, Boulder

Undergraduate Research Mentor

Siobhan Ciafone, University of Colorado, Boulder
Ella Hall, University of Colorado, Boulder

Awards Received

Best Presentation
Western Snow Conference Annual Meeting, Reno, NV *2019*

Best Student Poster Presentation
Eastern Snow Conference Annual Meeting, Montreal, Quebec *2010*

Graduate College Fellowship Award (merit-based)
University of Arizona *2005 and 2006*

David Hawley Undergraduate Research Scholarship
University of Vermont *2003*

Refereed Publications

24+ Peer-reviewed publications | *H*-index of 18+

In Review | In Press

Musselman, K.N., N. Addor, J.A. Vano, and N.P. Molotch, Melt trends protend widespread declines in snow water resources. In Review at Nature Climate Change.

Mendoza, P.A., T.E. Shaw, J. McPhee, **K.N. Musselman**, J.R. Revuelto, and S. MacDonell, Seasonal and annual variability of snow depth fractal behavior in a sub-alpine catchment. In Review at Water Resources Research.

Rasmussen, R., K. Ikeda, C. Liu, F. Chen, M. Barlage, A.J. Newman, E. Gutmann, J. Dudhia, D. Gochis, A. Dai, C. Luce and **K.N. Musselman**, Projected future changes in snowfall and snowpack in the western U.S. as captured by a convection resolving climate simulation: mesoscale and microphysical factors. In Review at Journal of Climate.

Published

[24] Uecher, T.M., S.D. Kaspari, **K.N. Musselman** and S.M. Skiles (2020), The post-wildfire impact of burn severity and age on black carbon snow deposition and implications for snow water resources, Cascade Range, Washington, USA. Journal of Hydrometeorology. *21*(8), 1777-1792.

[23] Henn, B., **K.N. Musselman**, L. Lestak, F.M. Ralph, and N.P. Molotch (2020), Extreme runoff generation from atmospheric river driven snowmelt during the 2017 Oroville Dam spillways incident. Geophysical Research Letters, 47(14).

[22] Mendoza, P.A., **K.N. Musselman**, J.S. Deems, J.R. Revuelto, I. Lopez-Moreno, and J. McPhee (2020), Seasonal and annual variability of snow depth fractal behavior in a sub-alpine catchment. Water Resources Research, 55(7).

[21] Girotto, M., **K.N. Musselman,** and R.L. Essery (2020), Data Assimilation Improves Estimates of Climate-Sensitive Seasonal Snow. Current Climate Change Reports, 6, 81–94.

[20] **Musselman**, **K.N.**, F. Lehner, K. Ikeda, M.P. Clark, A.F. Prein, C. Liu, M. Barlage and R. Rasmussen (2018), Projected increases and shifts in rain-on-snow flood risk over western North America. Nature Climate Change, 8, 808-812.

[19] Isabelle, P.E., D.F. Nadeau, M.H. Asselin, R. Harvey, **K.N. Musselman**, A.N. Rousseau, F. Anctil (2018), Solar radiation transmittance of a boreal balsam fir canopy: Spatiotemporal variability and impacts on growing season hydrology, Agricultural and Forest Meteorology, 263, 1-14.

[18] **Musselman**, **K.N.**, M. P. Clark, C. Liu, K. Ikeda and R. Rasmussen (2017), Slower snowmelt in a warmer world. Nature Climate Change, 7(3), 214-219.

[17] **Musselman**, **K.N.**, N.P. Molotch, and S.A. Margulis, Snowmelt response to simulated warming across a large elevation gradient, southern Sierra Nevada, California. (2017) The Cryosphere, 11(6) 2847-2866.

[16] López-Moreno, I., S. Gascoin, J. Herrero, E. Spoles, M. Pons, E. Alonso, J. Sickman, **K.N. Musselman**, A. Boudhar, L. Hanich, N. Molotch, J. Pomeroy (2017), Different sensitivities of snowpack to warming in Mediterranean climate mountain areas. *Environmental Research Letters*, 12(7), 074006.

[15] **Musselman**, **K.N.** and J.W. Pomeroy (2017), Estimation of needleleaf canopy and trunk temperatures and longwave contribution to melting snow. Journal of Hydrometeorology. 18, 555-572.

[14] **Musselman**, **K.N.,** J.W. Pomeroy, R. Essery, and N. Leroux (2015), Impact of windflow calculations on simulations of alpine snow accumulation, redistribution and ablation. Hydrological Processes, 29(18), 3983-3999.

[13] **Musselman**, **K.N.,** J.W. Pomeroy, and T.E. Link (2015), Variability in shortwave irradiance caused by forest gaps: Measurements, modelling, and implications for snow energetics. Agricultural and Forest Meteorology, 207, 69:82.

[12] Harpold, A.A., J.A. Marshall, S.W. Lyon, T.B. Barnhart, B. Fisher, M. Donovan, K.M. Brubaker, C.J. Crosby, N.F. Glenn, C.L. Glennie, P.B. Kirchner, N. Lam, K.D. Mankoff, J.L. McCreight, N.P. Molotch, **K.N. Musselman**, J. Pelletier, T. Russo, H. Sangireddy, Y. Sjöberg, T. Swetnam, and N. West (2015), Laser Vision: LiDAR as a Transformative Tool to Advance Critical Zone Science. Hydrology and Earth System Sciences. 19, 2881–2897.

[11] Meromy, L., N.P. Molotch, M. Williams, **K.N. Musselman**, and L. Kueppers (2015), Snowpack-climate manipulation using infrared heaters in subalpine forests of the Southern Rocky Mountains, USA. Agricultural and Forest Meteorology, 203, 142-157.

[10] Harpold, A.A., N.P. Molotch, **K.N. Musselman**, R.C. Bales, P.B. Kirchner, M. Litvak, and P.D. Brooks (2015), Snowmelt infiltration in mixed conifer subalpine forests. Hydrological Processes, 29(12), 2782-2798.

[9] Harpold, A.A., Q.Guo., N. Molotch, P.D. Brooks, R. Bales, J.C. Fernandez-Diaz, **K.N. Musselman**, T.L Swetnam, P. Kirchner, M. Meadows, J. Flanagan, and R. Lucas (2014), LiDAR-derived snowpack datasets from mixed conifer forests across the Western U.S., Water Resources Research. 50(3), 2749-2755.

[8] Perrot, D.O., N.P. Molotch, **K.N. Musselman**, and E.T. Pugh (2014), Modeling the effects of the Mountain Pine Beetle on snowmelt rates in a subalpine forest. Ecohydrology. 7(2), 226-241.

[7] **Musselman, K.N.**, S.A. Margulis, and N.P. Molotch (2013), Estimation of solar direct beam transmittance of conifer canopies from airborne LiDAR. Remote Sensing of Environment. 136, 402-415.

[6] Huang, C., S.A. Margulis, M.T. Durand, and **K.N. Musselman** (2012), Assessment of snow grain-size model and stratigraphy representation impacts on snow radiance assimilation: Forward Modeling Evaluation, IEEE Transactions on Geoscience and Remote Sensing. 50(11) 4551 – 4564.

[5] López-Moreno, J.I., S.R. Fassnacht, J.T. Heath, **K.N. Musselman**, J. Revuelto, J. Latron, E. Morán-Tejeda, T. Jonas (2012), Small scale spatial variability of snow density and depth over complex alpine terrain: Implications for estimating snow water equivalent, Advances in Water Resources, 55, 40-52.

[4] **Musselman, K.N.**, N.P. Molotch, S.A. Margulis, M. Lehning, and D. Gustafsson (2012), Improved snowmelt simulations with a canopy model forced with photo-derived direct beam canopy transmissivity, Water Resources Research, 48(10).

[3] **Musselman, K.N.**, N.P. Molotch, S.A. Margulis, P.B. Kirchner, and R.C. Bales (2012), Influence of canopy structure and direct beam solar irradiance on snowmelt rates in a mixed conifer forest. Agricultural and Forest Meteorology, 161, 46 – 56.

[2] Molotch, N.P., P.D. Brooks, S.P. Burns, M. Litvak, R.K. Monson, J.R. McConnell, and **K.N. Musselman** (2009), Ecohydrological controls on snowmelt partitioning in mixed-conifer sub-alpine forests, Ecohydrology, 2, 129–142.

[1] **Musselman, K.N.**, N.P. Molotch, and P.D. Brooks, (2008), Effects of vegetation on snow accumulation and ablation in a mid-latitude sub-alpine forest, Hydrological Processes, Vol 22 (15), 2767-2776.

Conference Proceedings

Presented extensively (>60 led and co-authored talks and posters) in Europe and North America

Professional Affiliations & Service Activities

Peer Review Panelist

- NASA Terrestrial Hydrology
- NASA Applied Sciences Program

Journal Peer Review

- Advances in Water Resources
- Agricultural and Forest Meteorology
- Arctic, Antarctic, and Alpine Research
- Earth System Science Data
- Ecohydrology
- Frontiers of Earth Science
- Geophysical Research Letters
- Hydrological Processes
- Hydrology Research
- J. of Applied Met. and Climatology
- J. Advances Modeling Earth Systems
- JGR – Atmospheres
- Journal of Hydrology
- Journal of Hydrometeorology
- Nature Climate Change
- Remote Sensing of Environment
- Science Advances
- The Cryosphere
- Water Resources Research

Society Member:

- American Geophysical Union (2006-present)
- Canadian Geophysical Union (2013-2015)

- European Geophysical Union (2017)
- American Meteorological Society (2017)
- USGS Rocky Mountain Hydrologic Research Center
- Sigma Gamma Epsilon Earth Sciences Honor Society
- Changing Cold Regions Network

Committee Member:

- Executive Board Member, Western Snow Conference

Fieldwork Experience

2019 - 2020	NASA SnowEx field campaign, Niwot Ridge, Colorado
2019	Snow distribution in a forested South American Catchment, Valle Hermoso, Chile
2019	Snowmelt pathway study, Niwot Ridge Long Term Ecological Observatory, Colorado
2017	NASA SnowEx field campaign, Grand Mesa, Colorado
2016	Photogrammetric monitoring of SNOTEL sites snow depth dynamics, Colorado
2013 - 2015	Terrestrial laser survey of 4-D snowpack dynamics, Rocky Mountains, Canada
2012 - 2015	Hydrometeorological impacts of forest clearings, Kananaskis, Alberta, Canada
2011	NASA Goddard grain size measurement campaign, Steamboat Springs, Colorado
2010	NASA JPL vegetation biomass survey, Grand Mesa, Colorado
2010	Basin scale variability of snow properties, Pyrenees, Spain and France
2007 - 2009	Plot and basin scale snow surveys, Sequoia National Park, California
2005 - 2006	Snow-vegetation interactions, Valles Caldera, NM
2002 - 2003	Precipitation gauge deployment and maintenance, Stowe, VT

Guest Lectures

(Selected from >10 last three years)

Title: Snow water resources in a warmer American West
Department of Civil Engineering, July, 2019
Universidad de Chile, Santiago, Chile

Title: Climate change impacts on snow water resources
Mountain Meteorology, ATOC 4550, Fall 2018
Department of Atmospheric & Oceanic Sciences
University of Colorado, Boulder, CO

Title: Snow water resources in a warmer American West
Rocky Mountain Association of Professional Geologists, Fall 2018
Denver, Colorado

Title: The Feb. 2017 Oroville Dam Atmospheric River Event: the role of rain-on-snow.
Earth System Research Laboratory, Spring 2018
NOAA, Physical Sciences Division, Boulder, Colorado

Title: The science of snow and snow-cover persistence
Cross Country Ski Area Association, Spring 2018
Snow Mountain Ranch, Granby, Colorado

Title: Applications in mountain and forest hydrology: Observation, models and advances
Engineering Hydrology CVEN 4333, Fall 2017
Dept. of Civil, Environmental & Architectural Engineering
University of Colorado, Boulder