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; minor in Atmos. Sci.
- Dissertation: "Estimating the Spatial and Temporal Distribution of Snow in Mountainous Terrain"

University of Arizona — Tucson, Arizona

Master of Science in Hydrology — *2006*

- Emphasis in Surface Hydrology
- Thesis: "Quantifying the effects of forest vegetation on snow accumulation, ablation, and potential meltwater inputs, Valles Caldera National Preserve, NM."

University of Vermont — Burlington, Vermont

Bachelor of Science in Geology — *2003*

- Emphasis in Surface Hydrology
- Senior research project: "Analysis of spatial variability of precipitation and snow accumulation on Mount Mansfield, Stowe, VT."

PROFESSIONAL EXPERIENCE

Institute for Arctic and Alpine Research — Boulder, Colorado

Research Associate — *Oct 2017 – present*

- Model development and data analysis related to the distribution of snow and water fluxes in the Sierra Nevada and Rocky Mountains
- Analysis of satellite data and hydrologic model information to characterize climatic and drought sensitivity of water availability.

National Center for Atmospheric Research — Boulder, Colorado

Advanced Study Program Postdoctoral Fellow — *Oct. 2015 – Oct. 2017*

- ASP fellowship to independently pursue research that collaboratively leveraged NCAR's climate modeling capacity and multidisciplinary team expertise. Analyzed results and first-authored a paper in *Nature Climate Change*.
- Advance the capability of hydrologic models to simulate dominant cold region processes in Alaska through conceptual and mechanistic studies. Build propensity for novel research techniques using a model for multiple working hypotheses to achieve the mission's goal of advancing cold region hydrological model accuracy and capacity.

University of Saskatchewan Kananaskis, Alberta

Postdoctoral Fellow *Oct. 2012 – Sep. 2015*

- Develop 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.

- Design and supervise a large field campaign to evaluate how forest vegetation structure and disturbances influence micrometeorology and the spatial patterns of meltwater availability. Mentor and develop graduate students, student interns, and supervise two technicians.

Institute for Arctic and Alpine Research Boulder, Colorado

Visiting Graduate Researcher and Teaching Assistant Sep 2010 – Sep 2012

- Conduct independent research in coordination with supervisors and colleagues at the Univ. of Colorado Boulder and UCLA
- Provide lectures and daily field instruction for the graduate level course GEOG 5241 "Advanced Methods in Snow Measurement"

University of California at Los Angeles Los Angeles, California

NASA Earth System Science Graduate Fellow *Sep. 2008 – Sep. 2012*

- Develop a proposal that garnered full financial support to conduct independent research using field measurements and numerical modeling to analyze snow accumulation and melt dynamics in a forested and alpine region of the Sierra Nevada
- Design and manage ten basin-scale snow surveys with five or more researchers including undergraduate and graduate students

- Build future capabilities leveraging state-of-the-art lidar technology to estimate high-resolution solar radiation beneath a forest canopy with novel approach that remains an example of technical excellence.

University of California at Los Angeles Los Angeles, California

Teaching Assistant *Fall, 2009*

- Teach weekly discussion sessions, design homework, and hold open office hours for class of 100+ students in CEE 150 "Introduction to Hydrology"

AWARDS RECEIVED

Best Student Poster Presentation

Eastern Snow Conference Annual Meeting, Montreal, Quebec *2010*

- The use of hemispherical photos to estimate radiation beneath a forest canopy improve results from a physically based snow model

Graduate College Fellowship Award

University of Arizona *2005 and 2006*

- Merit-based (GPA) cash award through Dean's office of the College of Engineering to recruit and retain top graduate students

David Hawley Undergraduate Research Scholarship

University of Vermont *2003*

- Financial support for an independent research project studying the spatial variability of precipitation on a paired watershed.

REFEREED PUBLICATIONS

Musselman, **K.N.**, F. Lehner, K. Ikeda, M.P. Clark, A. Prein, C. Liu, M. Barlage and R. Rasmussen, Projected increases and regime shifts in rain-on-snow flood potential over western North America. Nature Climate Change, in review.

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

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. DOI: 10.1038/nclimate3225

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), p.074006.

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, DOI: 10.1175/JHM-D-16-0111.1.

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.

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.

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, N. West (2015), Laser Vision: LiDAR as a Transformative Tool to Advance Critical Zone Science. Hydrology and Earth System Sciences.

Meromy, L., N.P. Molotch, M. Williams, **K.N. Musselman**, 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.

Harpold, A.A., N.P. Molotch, **K.N. Musselman**, R.C. Bales, P.B. Kirchner, M. Litvak, and P.D. Brooks (2014), Snowmelt infiltration in mixed conifer subalpine forests. Hydrological Processes, doi: 10.1002/hyp.10400

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, doi:10.1002 /2013WR013935.

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.

Perrot, D.O., N.P. Molotch, **K.N. Musselman**, and E.T. Pugh (2013), Modeling the effects of the Mountain Pine Beetle on snowmelt rates in a subalpine forest. Ecohydrology. DOI: 10.1002/eco.1329

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. ISSN 0196-2892.

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, ISSN 0309-1708, doi:10.1016/j.advwatres.2012.08.010.

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 Resour. Res., 48, W10509, doi:10.1029/2012WR012285

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, doi: 10.1016/j.agrformet.2012.03.011.

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, doi:10.1002/eco.48.

Musselman, K.N., N.P. Molotch, and P.D. Brooks, (2008), Quantifying the effects of forest vegetation on snow accumulation, ablation and potential meltwater inputs, Valles Caldera National Preserve, NM, USA, Hydrological Processes, Vol 22, doi: 10.1002/hyp.7050.

Conference Proceedings (last 3 years)

Musselman, K.N., M.P. Clark, Changhai Liu, Kyoko Ikeda and R. Rasmussen (2017), Slower snowmelt in a warmer world. Oral presentation at the European Geophysical Union General Assembly, Vienna, Austria.

Musselman, K.N., M.P. Clark, A. Endalamaw, W.R. Bolton, B. Nijssen and J. Arnold (2017), Assessing the effects of modeling decisions on cold region hydrologic model performance. Interactive Poster presentation at the European Geophysical Union General Assembly, Vienna, Austria.

Musselman, K.N., M.P. Clark, Changhai Liu, Kyoko Ikeda and R. Rasmussen (2016), Slower snowmelt in a warmer world. Oral presentation at the American Geophysical Union Fall Meeting, San Francisco, CA. Invited.

Musselman, K.N., M.P. Clark, A. Endalamaw, W.R. Bolton, B. Nijssen and J. Arnold (2016), Effects of model decisions on cold region hydrologic model performance: snow, soil and streamflow. Poster presentation at the American Geophysical Union Fall Meeting, San Francisco, CA.

Monaghan, A.J., M.P. Clark, J.R. Arnold, A.J. Newman, **K.N. Musselman**, M.J. Barlage, L. Xue, C. Liu, E.D. Gutmann and R. Rasmussen (2016), High resolution regional climate change simulations over Alaska. Poster presentation at the American Geophysical Union Fall Meeting, San Francisco, CA.

Musselman, **K.N.**, M.P. Clark, Changhai Liu, Kyoko Ikeda and R. Rasmussen (2016). Evidence for slower snowmelt in a warmer world. Oral presentation at the Mountain Climate Conference, Leavenworth, Washington.

Musselman, K.N., M.P. Clark, A. Endalamaw, W.R. Bolton, B. Nijssen (2016), A Multi-Decadal Analysis of Cold Region Hydrological Model Performance and Challenges at the Caribou – Poker Creeks Research Watershed, oral presentation at the American Water Resources Association Spring Specialty Conference 'Water – Energy – Environment', Anchorage, Alaska

S. Gascoin**,** J.I. López-Moreno, J. Herrero, E. Sproles, L. Hanich, A. Boudhar, M. Pons, E. Alonso-González, and **K.N. Musselman** (2016), Spatio-temporal variability of the snow cover in different Mediterranean mountain regions from in situ and remote sensing data, oral presentation at the European Geosciences Union General Assembly, Vienna, Austria.

Musselman, K.N., N.P Molotch, and S.A. Margulis (2015), Snowpack response to warmer temperatures: a southern Sierra Nevada case study, **invited** oral presentation at the American Geophysical Union Fall Meeting, San Francisco, CA.

Musselman, K.N. and J.W. Pomeroy (2015), The influence of tree temperatures on potential snowmelt energy in a discontinuous coniferous forest, poster presentation at the American Geophysical Union Fall Meeting, San Francisco, CA.

Arnold, J., M. Clark, J. Cherry, T. Giambelluca, E. Gutmann, G. Liston, M. Sturm, A. Monaghan, **K.N. Musselman**, A. Newman, R. Rasmussen, A. Wood (2015), New tools and data to understand and adapt to hydroclimatic variability and change in Alaska and Hawaii, poster presentation at the American Geophysical Union Fall Meeting, San Francisco, CA.

Musselman, K.N. and J.W. Pomeroy (2015), A snow – canopy energy balance model for disturbed forested environments, oral presentation at the Joint Canadian Geophysical Union and American Geophysical Union Spring Meeting, Montreal.

Professional Affiliations & Service Activities

Peer Review Panelist

- NASA Terrestrial Hydrology
- NASA Applied Sciences Program

Manuscript Reviewer:

- Advances in Water Resources
- Agricultural and Forest Meteorology
- Earth System Science Data
- Ecohydrology
- Frontiers of Earth Science
- Geophysical Research Letters
- Hydrological Processes
- Journal of Advances in Modeling Earth Systems
- Journal of Geophysical Research – Atmospheres
- Journal of Hydrology
- Journal of Hydrometeorology
- Remote Sensing of Environment
- Science Advances
- The Cryosphere
- Water Resources Research

Discussion Panelist

- The Future of Skiing: The Science Behind Snow; sponsored by Arapahoe Basin and Protect Our Winters. Arapahoe Basin, Colorado

Society Member:

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

Committee Member:

- NCAR Advanced Study Program Seminar Series

Fieldwork Experience

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

TEACHING EXPERIENCE

NSF-funded workshop LiDAR Applications in Critical Zone Sciences (2014)
TA for *Advanced Field Methods in Snow Science*, Prof. Noah Molotch (2011)
TA for *Introduction to Hydrology*, Prof. Steve Margulis (2009)
TA for *Snow Hydrology and Field Camp*, Prof. Paul Brooks (2006)

GUEST LECTURES (LAST 5 YEARS)

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

Title: *Slower snowmelt in a warmer world: Using observations and modeling to develop a new theory of hydrologic change*
Hydrology & Water Resources Seminar, Winter 2017
Dept. of Civil, Environmental & Architectural Engineering
University of Colorado

Title: *Slower snowmelt in a warmer world*
Geology Visiting Lecture Series, Winter 2016
University of Vermont

Title: *LiDAR: a transformative tool for hydrological sciences* Canadian Society for Hydrological Sciences, Short Course Principles of Hydrology, Winter 2015
University of Saskatchewan
Canadian Rockies, Alberta

Title: *Snow Measurements*
Canadian Society for Hydrological Sciences, Short Course Principles of Hydrology, Winter 2014
University of Saskatchewan
Canadian Rockies, Alberta

Title: *Hydrology and Landscape Processes in Kananaskis*
Ecology 413: Field Ecology. Summer 2013
University of Calgary, Alberta, Canada

Title: *Snow and Forest Hydrology*
4th-year Ecology course. Spring 2013
University of Calgary, Alberta, Canada