

# Mark S. Raleigh, Ph.D., P.E.

Research Scientist

NSIDC/CIRES, University of Colorado, Boulder

phone: (303) 492-3575 // email: [mark.raleigh@colorado.edu](mailto:mark.raleigh@colorado.edu) // web: <https://markraleigh.com>

---

## EDUCATION

---

- Ph.D. 2013 *Civil & Environmental Engineering* (focus: hydrology & water resources)  
University of Washington, Seattle, Washington  
Dissertation: Quantification of Uncertainties in Snow Accumulation, Snowmelt, and Snow Disappearance Dates (Advisor: Jessica Lundquist)
- M.S. 2009 *Civil & Environmental Engineering* (focus: hydrology & water resources)  
University of Washington, Seattle, Washington  
Thesis: A Statistical Evaluation of a Snow Water Equivalent Reconstruction Method Using Three Snowmelt Models at Daily and Hourly Time Steps (Advisor: Jessica Lundquist)
- B.S. 2005 *Civil Engineering, Magna Cum Laude*  
Gonzaga University, Spokane, Washington

---

## ACADEMIC APPOINTMENTS AND PROFESSIONAL EXPERIENCE

---

### Academic

- 7/2019 – 8/2020 *Courtesy Faculty (in advance of Assistant Professor appointment)*  
CEOAS, Oregon State University
- 11/2017 – Present *Research Scientist I*  
National Snow and Ice Data Center (NSIDC), CIRES
- 10/2015 – Present *Research Associate*  
Department of Geological Sciences, University of Colorado, Boulder
- 10/2015 – 10/2017 *Postdoctoral Visiting Fellow*  
Cooperative Institute for Research in Environmental Sciences (CIRES)
- 10/2013 – 9/2015 *Advanced Study Program Postdoctoral Fellow*  
National Center for Atmospheric Research (NCAR)
- 9/2007 – 8/2013 *Graduate Research Assistant, Co-Instructor, and Teaching Assistant*  
Civil & Environmental Engineering, University of Washington

### Consulting Engineering

- 6/2014 – Present *Registered Professional Engineer (P.E.)*  
State of Colorado, License 0048909
- 7/2005 – 8/2007 *Design Engineer*  
Civil Infrastructure Group, Merrick & Company

---

## PEER-REVIEWED PUBLICATIONS

---

\* *student author under my advisement*

17. Rittger, K., **Raleigh, M.S.**, Dozier, J., Hill, A.F., Lutz, J.A., and T.H. Painter (2019), Canopy adjustment and improved cloud detection for remotely sensed snow cover mapping, *Water Resources Research*, in press.
16. Ménard, C. B., Essery, R., Barr, A., Bartlett, P., Derry, J., Dumont, M., Fierz, C., Kim, H., Kontu, A., Lejeune, Y., Marks, D., Niwano, M., **Raleigh, M.S.**, Wang, L., and Wever, N. (2019), Meteorological and evaluation datasets for snow modelling at ten reference sites: description of in situ and bias-corrected reanalysis data, *Earth Syst. Sci. Data.*, accepted.
15. Smyth\*, E., **Raleigh, M.S.**, and E.E. Small (2019), Particle filter data assimilation of monthly snow depth observations improves estimation of snow density and SWE, *Water Resources Research*, 55.
14. Krinner, G., Derksen, C., Essery, R., Flanner, M., Hagemann, S., Clark, M., Hall, A., Rott, H., Brutel-Vuilmet, C., Kim, H., Ménard, C. B., Mudryk, L., Thackeray, C., Wang, L., Arduini, G., Balsamo, G., Bartlett, P., Boike, J., Boone, A., Chéruy, F., Colin, J., Cuntz, M., Dai, Y., Decharme, B., Derry, J., Ducharne, A., Dutra, E., Fang, X., Fierz, C., Ghattas, J., Gusev, Y., Haverd, V., Kontu, A., Lafaysse, M., Law, R., Lawrence, D., Li, W., Marke, T., Marks, D., Nasonova, O., Nitta, T., Niwano, M., Pomeroy, J., **Raleigh, M. S.**, Schaedler, G., Semenov, V., Smirnova, T., Stacke, T., Strasser, U., Svenson, S., Turkov, D., Wang, T., Wever, N., Yuan, H., and Zhou, W. (2018), ESM-SnowMIP: Assessing models and quantifying snow-related climate feedbacks, *Geosci. Model Dev.*, 11(12), 5027–5049.
13. Cristea, N.C., Breckheimer, I., **Raleigh, M.S.**, HilleRisLambers, J., & J.D. Lundquist (2017), An evaluation of terrain-based downscaling of fractional snow covered area datasets based on lidar-derived snow data and orthoimagery, *Water Resources Research*, 53.
12. **Raleigh, M.S.** & E.E. Small (2017), Snowpack density modeling is the primary source of uncertainty when mapping basin-wide SWE with lidar, *Geophysical Research Letters*, 44.
11. **Raleigh, M.S.**, Livneh, B., Lapo, K., & J.D. Lundquist (2016), How does availability of meteorological forcing data impact physically-based snowpack simulations?, *Journal of Hydrometeorology*, 17, 99-120.
10. **Raleigh, M.S.**, Lundquist, J.D., & M.P. Clark (2015), Exploring the impact of forcing error characteristics on physically based snow simulations within a global sensitivity analysis framework, *Hydrology and Earth Systems Sciences*, 19, 3153-3179.
9. Lapo, K., Hinkelman, L., **Raleigh, M.S.**, & J.D. Lundquist (2015), Impact of errors in the surface radiation balance on simulations of snow water equivalent and snow surface temperature, *Water Resources Research*, 51.
8. Dickerson-Lange, S.E., Lutz., J.A., Martin, K.A., **Raleigh, M.S.**, Gersonde, R., & J.D. Lundquist (2015), Evaluating observational methods to quantify snow duration under diverse forest canopies, *Water Resources Research*, 51.

7. Landry, C.C., K.A. Buck, **M.S. Raleigh**, & M.P. Clark (2014), Mountain system monitoring at Senator Beck Basin, San Juan Mountains, Colorado: A new integrative data source to develop and evaluate models of snow and hydrologic processes, *Water Resources Research*, 50.
6. **Raleigh, M.S.**, C.C. Landry, M. Hayashi, W.L. Quinton, & J.D. Lundquist (2013), Approximating snow surface temperature from standard temperature and humidity data: New possibilities for snow model and remote sensing evaluation, *Water Resources Research*, 49.
5. **Raleigh, M.S.**, Rittger, K., Moore, C.E., Henn, B., Lutz, J.A., & J.D. Lundquist (2013), Ground-based testing of MODIS fractional snow cover in subalpine meadows and forests of the Sierra Nevada, *Remote Sensing of Environment*, 128, 44-57.
4. Henn, B., **Raleigh, M.S.**, Fisher, A., & J.D. Lundquist (2013), A comparison of methods for filling gaps in hourly near-surface air temperature data, *Journal of Hydrometeorology*, 14, 929-945.
3. Ford, K.R., Ettinger, A.K., Lundquist, J.D., **Raleigh, M.S.**, & J. Hille Ris Lambers (2013), Spatial heterogeneity in ecologically important climate variables at coarse and fine scales in a high-snow mountain landscape, *PLoS ONE*, 8(6): e65008.
2. Slater, A.G., Barrett, A.P., Clark, M.P., Lundquist, J.D., & **M.S. Raleigh** (2013), Uncertainty in seasonal snow reconstruction: relative impacts of model forcing and image availability, *Advances in Water Resources*, 55, 165-177.
1. **Raleigh, M.S.** & J.D. Lundquist (2012), Comparing and combining SWE estimates from the SNOW-17 model using PRISM and SWE reconstruction, *Water Resources Research*, 48, W01506.

#### Conference Proceedings Papers

4. **Raleigh, M.S.**, & J.S. Deems (2018), Filling the holes in the space-time cube of snowpack evolution with lasers, cameras, computers, and snow shovels, 86<sup>th</sup> Western Snow Conference, Albuquerque, New Mexico.
3. **Raleigh, M.S.**, & J.S. Deems (2016), Investigating the response of an operational snowmelt model to unusual snow conditions and melt drivers, 84<sup>th</sup> Western Snow Conference, Seattle, Washington.
2. **Raleigh, M.S.**, & M.P. Clark (2014), Are temperature-index models appropriate for assessing climate change impacts on snowmelt? 82<sup>nd</sup> Western Snow Conference, Durango, Colorado.
1. **Raleigh, M.S.**, K. Rittger, & J.D. Lundquist (2011), What lies beneath? Comparing MODIS fractional snow covered area against ground-based observations under forest canopies and in meadows of the Sierra Nevada, 79<sup>th</sup> Western Snow Conference, Stateline, Nevada.

---

#### **GRANTS & FUNDING**

---

## Funded Proposals

1. May 2017 – May 2022. *Improving in situ snowpack sampling strategies for constraining modeled density and SWE from Lidar-based snow depth across landscapes in SnowEx*, NASA THP NNX17AL41G, **PI: M.S. Raleigh**, Co-PI: E.E. Small, \$528,408.
2. March 2018 – February 2021. *Improved process understanding of snow density and SWE across forested mountain landscapes from coordinated field observations and model analyses*, NSF Hydrologic Sciences #1761441, **PI: M.S. Raleigh**, Co-PI: E.E. Small, \$531,033.
3. November 2018 – October 2021. *Multiscale, process-based seasonal snowpack dynamics observations and modeling to support water and solute storage and flux accounting in the LBNL Watershed Function SFA*, DOE SBR, **PI: Deems, Co-I: M.S Raleigh**, \$590,980.
4. October 2018 – September 2020. *Improving subseasonal water supply prediction across the Western United States through assimilation of remotely sensed snow cover, snow albedo, and snow water equivalent in the NOAA National Water Model*, NOAA JTTI, **PI: Rittger, Dugger, Bair, Co-I: M.S Raleigh, McCreight**, \$412,419.
5. August 2018 – December 2019. *Satellite-based snow persistence maps for SNOTEL site characterization*, Colorado Water Conservation Board, **PI: Deems, Co-PI: M.S. Raleigh**, \$44,351.
6. June 2019 – June 2022. *NASA/NSIDC near-real-time snow analyses*, NASA Terrestrial Hydrology, **PI: Rittger, Co-I: M.S. Raleigh, Serreze**, \$380,000.

## Fellowships and Scholarships

2013 – 2015	<i>CIRES Visiting Postdoctoral Fellowship</i>
2013 – 2015	<i>NCAR Advanced Study Program Postdoctoral Fellowship</i>
2012 – 2013	<i>Hydro Research Foundation Fellowship</i>
2009 – 2012	<i>NASA Earth and Space Science Graduate Fellowship</i>
2012	<i>University of Washington Ronald E. Nece Fellowship</i>
2012	<i>U.S. Society on Dams Grand Scholarship</i>
2012	<i>CH2M Hill Engineers Without Borders (EWB) USA Scholarship</i>
2010	<i>American Water Works Association – Ameron International Scholarship</i>
2008 – 2009	<i>American Water Resources Association Washington Section Scholarship</i>
2007 – 2008	<i>University of Washington Valle Scholarship</i>

---

## **TEACHING & STUDENT ADVISING**

---

### University of Colorado, Boulder

Spring 2019            *Instructor*, GEOL 4725 Surface Hydrology Field Class

### University of Washington, Seattle

Spring 2012            *Co-Instructor*, CEE 345 Hydraulic Engineering

Spring 2009            *Teaching Assistant (TA), CEE 345 Hydraulic Engineering*  
 Fall 2009 – 2012      *Grader / TA, CEE 424 GIS for Civil Engineers*

Teaching Workshops and MOOCs

Summer 2016            *Summer Teaching-as-Research Institute for Postdocs in Engineering*  
                                  *University of Colorado Boulder & CIRTL Network*

Spring 2014            *An Introduction to Evidence-Based Undergraduate STEM Teaching*  
                                  *Center for the Integration of Research, Teaching and Learning (CIRTL)*

Guest Lectures

- *Graduate:* Terrestrial Hydrology; Snow Hydrology; Hydrological Modeling; Water Seminar
- *Undergraduate:* Hydraulic Engineering, Open Channel Hydraulics

Graduate Students Advised

<b>Student</b>	<b>Department</b>	<b>University</b>	<b>My Role</b>	<b>Status</b>
Eric Smyth	Geo. Sciences	CU Boulder	Co-Advisor	<i>Ph.D., exp. 2022</i>
Alex Mitchell	Geo. Sciences	CU Boulder	Co-Advisor	<i>M.S., exp. 2019</i>
Hannah Bonner	Geo. Sciences	CU Boulder	Co-Advisor	<i>M.S., exp. 2020</i>
Thomas Enzminger	Geo. Sciences	CU Boulder	Committee	<i>Ph.D. exp. 2019</i>
Keith Jennings	Geography	CU Boulder	Committee	Ph.D. 2018

**AWARDS & HONORS**

2018                      *Runner-up for best paper presented at the 86<sup>th</sup> Western Snow Conference*

2012, 2013              *Recipient of an Editor’s Citation for Excellence in Reviewing from the American Geophysical Union (journal: *Water Resources Research*)*

2013                      *Recipient of the Dean’s Award from the University of Washington College of Engineering (Community of Innovators Awards Program)*

2011                      *Recipient of the Dr. James E. Church Memorial Award for best student paper at the 79<sup>th</sup> Western Snow Conference*

**SERVICE, OUTREACH, & LEADERSHIP**

Service Activities

2018 – Present            *Co-chair of SnowEx Science Plan Working Group, NASA SnowEx*

2017 – Present            *Member, NASA SnowEx THP16 Science Team*

2018 – Present            *Member, National Snow and Ice Data Center - User Working Group*

2017 – Present            *Associate Editor, Journal of Hydrometeorology*

2017                        *Reviewer: National Aeronautics and Space Administration*

2012                        *Student Member, University of Washington Hydrologic Extremes Faculty Search Committee*

2011 – 2013 Columnist for *PRISM Magazine*, the flagship publication of the *American Society for Engineering Education*

#### K-12 Outreach

2015 – 2019 Science Fair Judge, *Colorado State Science and Engineering Fair*

2016 Science Fair Judge, *Colorado STEM Academy*

2015 Guest Speaker, Weather and Climate Class, *New Vista High School*

#### Humanitarian and Environmental Outreach

2012 Watershed restoration volunteer, Duwamish Alive! (Seattle, WA)

2008 Design and implementation team, *Engineers Without Borders* Roadway Improvement Project (Acasio, Bolivia)

#### Leadership

2007 – 2013 *American Water Resources Association*, University of Washington chapter

- President (2008-2009), Professional Liaison (2009-2010), Webmaster (2007-2013)

2008 – 2011 *Engineers Without Borders*, University of Washington chapter

- President (2009-2011), Vice President (2008-2009)

2004 – 2005 *Tau Beta Pi Engineering Honor Society*, Gonzaga University

- President (2005), Vice President (2004)

2005 *Comprehensive Leadership Program Certificate*, Gonzaga University

---

#### **PEER REVIEWER FOR ACADEMIC JOURNALS**

---

- Arctic, Antarctic, and Alpine Research
- Cold Regions Science and Technology
- Computers and Geosciences
- Frontiers of Earth Science
- Geophysical Research Letters
- Geoscientific Instrumentation, Methods and Data Systems
- Geoscientific Model Development
- Hydrological Processes
- Hydrology
- Hydrology and Earth Systems Science
- Journal of the American Water Resources Association
- Journal of Applied Meteorology and Climatology
- Journal of Atmospheric and Oceanic Technology
- Journal of Hydrology
- Journal of Hydrometeorology
- Nature
- Nature – Scientific Reports
- Remote Sensing

- Remote Sensing of Environment
- Science Advances
- The Cryosphere
- Water Resources Research

---

## CONFERENCE ACTIVITIES & PRESENTATIONS

---

### Conference Organization and Volunteering

2018 – Present	Member, <i>Western Snow Conference</i> , S. Continental Committee
2014 – Present	OSPA Judge, <i>AGU Fall Meeting</i>
2013 – Present	Session Co-convenor/Chair, <i>AGU Fall Meeting</i> (multiple hydrology & cryosphere sessions)
2012	Chair, Terrestrial Impacts Session, <i>Graduate Climate Conference</i>
2010	Planning Committee, <i>Graduate Climate Conference</i> (Pack Forest, WA)
2009	Planning Committee, <i>AWRA National Conference</i> (Seattle, WA)
2008	Planning Committee, <i>EWB International Conference</i> (Seattle, WA)

### Oral Presentations (\*presenting author)

2019	<b>Raleigh, M.S.*</b> et al., Field data reveal the opportunities and pitfalls of assimilating snow remote sensing for SWE, <i>NASA SnowEx 2019 Workshop</i> , September 16-19.
2018	<b>Raleigh, M.S.*</b> , & E. Gutmann, What can tree sway tell us about snow interception?, <i>MtnClim 2018</i> , September 17-21.
2017	<b>Raleigh, M.S.*</b> , E. Smyth, & E.E. Small, Improving snow density estimation for mapping SWE with Lidar snow depth: assessment of uncertainty in modeled density and field sampling strategies in NASA SnowEx, <i>American Geophysical Union Fall Meeting</i> , December 11-15.
2015	<b>Raleigh, M.S.*</b> , K. Lapo, D. Marks, A. Hedrick, G. Flerchinger, & M.P. Clark, Propagation of uncertainty in atmospheric longwave radiation to modeled snowpack and summer evapotranspiration at mountain research sites, <i>International Conference on Alpine Meteorology</i> , August 31 – September 4.
2014	Landry, C.C., K.A. Buck, <b>M.S. Raleigh*</b> , & M.P. Clark, High elevation headwaters hydrology and snow monitoring at Senator Beck Basin, San Juan Mountains, Colorado, USA: a 7 year dataset, Mountain Observatories Global Fair and Workshop on Long-Term Observing Systems of Mountain Social-Ecological Systems, July 16-19.
2013	<b>Raleigh, M.S.*</b> , C.C. Landry, M. Hayashi, W.L. Quinton, & J.D. Lundquist, Approximating snow surface temperature from standard temperature and humidity data: New possibilities for snow model and remote sensing evaluation, <i>American Geophysical Union Fall Meeting</i> , December 9-13.

- 2013 **Raleigh, M.S.\***, & J.D. Lundquist, Modeling in the dark: how data scarcity and uncertainty impact snowmelt modeling, Davos Atmosphere and Cryosphere Assembly (DACA-13), July 8-12.
- 2012 **Raleigh, M.S.\***, & J.D. Lundquist, Different yet Similar: Studying Snow Cover Patterns in Wet and Dry Years Using Distributed Temperature Sensors in the Sierra Nevada, *Yosemite Hydroclimate Meeting*, October 11-12.
- 2010 **Raleigh, M.S.\***, & J.D. Lundquist, An alternative approach to predicting snowfall across the Sierra Nevada, *American Meteorological Society, 14<sup>th</sup> Conference on Mountain Meteorology*, August 30 – September 3.
- 2009 **Raleigh, M.S.\***, & J.D. Lundquist, Calculating snowmelt backwards – using the date of snowpack disappearance to determine how much snow fell over a season, 2009 *Geological Society of America Meeting*, October 18-21.
- 2009 **Raleigh, M.S.\***, & J.D. Lundquist, Rain-on-snow events in a warmer world: hydrologic implications for the Sierra Nevada, *Graduate Climate Conference*, April 17-18.

Poster Presentations (\*presenting author)

- 2019 **Raleigh, M.S.**, G. Collao-Barrios, & J.S. Deems, Snowpack patterns in the East River, Colorado: Interannual Consistency and Associated Landscape Processes, *American Geophysical Union Fall Meeting*, December 9-13.
- 2018 **Raleigh, M.S.\***, E. Smyth, & E.E. Small, Do snow models represent differences in snow density between forests and open areas for remote sensing of SWE?, *American Geophysical Union Fall Meeting*, December 10-14.
- 2016 **Raleigh, M.S.\***, J.S. Deems, K. Rittger, & A. Pope, Shedding light on the hazy history of dust-on-snow in the Upper Colorado River Basin with snow measurements, modeling, and remote sensing, *American Geophysical Union Fall Meeting*, December 12-16.
- 2015 **Raleigh, M.S.\***, K. Lapo, D. Marks, A. Hedrick, G. Flerchinger, & M.P. Clark, Cascading impacts of longwave radiation uncertainty on modeled snowmelt and summer evapotranspiration at mountain research sites, *American Geophysical Union Fall Meeting*, December 14-18.
- 2015 Fairfax, E., E. Small, C. Chew\*, **M.S. Raleigh\***, & K. Larson, PBO H<sub>2</sub>O: Monitoring the terrestrial water cycle with reflected GPS signals recorded by the Plate Boundary Observatory Network, *American Geophysical Union Fall Meeting*, December 14-18.
- 2014 **Raleigh, M.S.\***, Lundquist, J.D., & M.P. Clark, Which forcing data errors matter most when modeling seasonal snowpacks?, *American Geophysical Union Fall Meeting*, December 15-19.
- 2014 **Raleigh, M.S.\***, Spatial and interannual variability of snow interception in forest canopies, *CU Hydrologic Science Research Symposium*, April 3-4.

- 2012 **Raleigh, M.S.\***, Rittger, K., & J.D. Lundquist, Buried Treasure: Using distributed ground temperature sensors to test remote sensing of fractional snow cover, *American Geophysical Union Fall Meeting*, December 3-7.
- 2012 **Raleigh, M.S.\***, Improving representation of high-elevation snowpack for summer water supply forecasting, *United States Society on Dams, 2012 Annual Meeting and Conference*, April 23 – 27.
- 2010 **Raleigh, M.S.\*** & J.D. Lundquist, Snowfall Accumulation in the Western United States: Comparing estimates from SWE reconstruction and PRISM, *American Geophysical Union Fall Meeting*, December 13-17.
- 2010 **Raleigh, M.S.\*** & J.D. Lundquist, A snow hydrologist’s time machine: determining winter snow accumulation with springtime mass and energy exchanges at the snow-air interface, *CUAHSI Biennial Colloquium*, July 19-21.
- 2009 **Raleigh, M.S.\*** & J.D. Lundquist, Calculating snowmelt backwards – using the date of snowpack disappearance to determine how much snow fell over a season, *American Geophysical Union Fall Meeting*, December 14-18.
- 2008 **Raleigh, M.S.\***, F.C. Lott, & J.D. Lundquist, Evaluation of Precipitation Scaling Using the Observed Snow Cover Disappearance Date, *American Geophysical Union Fall Meeting*, December 15-19.

---

## PROFESSIONAL MEMBERSHIPS AND SOCIETIES

---

- American Geophysical Union
- American Meteorological Society
- American Society for Engineering Education
- American Water Resources Association
- Engineers Without Borders
- Tau Beta Pi
- United States Society on Dams