

# Jennifer D. Watts

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## Research Interests

My research focuses on monitoring Earth System properties, integrating information from optical/infrared and microwave satellite remote sensing, biophysical modeling and flux tower eddy covariance measurements to identify and understand the patterns and mechanisms driving ecosystem changes in landscape thermal properties, vegetation, hydrology and carbon flux ( $\text{CO}_2$ ,  $\text{CH}_4$ ) dynamics. Recent projects include developing a 14+ year 1-km resolution record of daily net ecosystem  $\text{CO}_2$  exchange, vegetation productivity, ecosystem respiration and  $\text{CH}_4$  fluxes for pan-Arctic wetlands. I also use remote sensing/GIS to spatially map and explore linkages between the terrestrial carbon cycle and changing environmental conditions including landscape freeze-thaw, soil moisture, temperature, surface water inundation and land disturbances in Alaska and Canada. As my pre-doctoral training includes soils, agricultural systems and land rehabilitation, I welcome opportunities for diverse collaborative research.

## Education

Ph.D., Systems Ecology, The University of Montana 2016

Dissertation: *Potential contrasts in  $\text{CO}_2$  and  $\text{CH}_4$  flux response under changing climate conditions: a satellite remote sensing driven analysis of the net ecosystem carbon budget for Arctic and boreal regions*

M.S., Environmental Sciences and Land Reclamation, Montana State University 2008

Thesis: *Satellite monitoring of cropland-related carbon sequestration practices in North Central Montana*

B.S., Land Resources and Environmental Sciences, Montana State University 2006

Undergraduate Thesis: *Quantifying soil mineral and organic carbon properties using visible and near-infrared spectroscopy*

## Research Experience

PHD RESEARCH ASSISTANT — NTSG (NUMERICAL TERRADYNAMICS SIMULATION GROUP);  
THE UNIVERSITY OF MONTANA, MISSOULA, MONTANA. 2016-present

I am linking information from multiple satellite remote sensing platforms (e.g. SMAP, MODIS, Landsat, GeoEye) and airborne retrievals to examine spatial and temporal patterns of vegetation productivity and soil respiration within Arctic and boreal ecosystems in Alaska and western Canada. A deeper understanding of driving mechanisms and ecosystem response gained from this study will inform carbon flux scaling from flux tower footprints to larger geographic regions and will provide the scientific basis to guide future NASA airborne campaigns and NASA Arctic Boreal Vulnerability Experiment (ABOVE) Phase II/II activities. Collaboration with Federal, State and Tribal agencies and stakeholders during ABOVE Phase I will guide the production of value added science products for the study region.

PHD RESEARCH ASSISTANT — NTSG (NUMERICAL TERRADYNAMICS SIMULATION GROUP);  
THE UNIVERSITY OF MONTANA, MISSOULA, MONTANA. 2010-present

I am using multi-sensor passive microwave and optical-infrared satellite remote sensing data to evaluate changes in surface hydrology, vegetation productivity and environmental land surface conditions within northern permafrost and wetland regions. I have developed a satellite remote sensing based CO<sub>2</sub> and CH<sub>4</sub> flux model to evaluate terrestrial net ecosystem carbon budgets for pan-Arctic peatlands and tundra wetlands. Other project responsibilities include model calibration and sensitivity analyses using tower eddy covariance data. Geospatial products resulting from this project include maps of terrestrial CO<sub>2</sub> and CH<sub>4</sub> fluxes for the pan-Arctic region.

RESEARCH ASSOCIATE — BIG SKY CARBON SEQUESTRATION PARTNERSHIP, BOZEMAN, MONTANA.  
2009-2010

I developed methodology to detect land surface disturbances at soil carbon sequestration credit sites, through the spectral blending of MODIS and Landsat optical satellite imagery to generate synthetic high resolution time series. I interacted with land owners and stakeholders to develop in situ data acquisition and data sharing plans used to validate remote sensing products.

RESEARCH ASSOCIATE — UNITED STATES GEOLOGICAL SURVEY, BOZEMAN, MONTANA. 2008-2009

I was responsible for satellite image processing for animal migration studies. I also conducted field data collection using wildlife telemetry and large ungulate monitoring (e.g. *Cervus canadensis*) through global positioning system technology.

M.S. RESEARCH ASSISTANT — MONTANA STATE UNIVERSITY SPATIAL SCIENCES CENTER, BOZEMAN,  
MONTANA. 2006-2008

I conducted an object-based Random Forest classification of Landsat time series for mapping surface soil disturbances and land management patterns to support carbon credit programs in northern agricultural regions. I assessed soil carbon (CO<sub>2</sub>) sequestration budgets and carbon cycle vulnerability in human degraded ecosystems. I was also responsible for monthly progress reports and presentations to the funding agencies.

RESEARCH ASSISTANT — MONTANA STATE UNIVERSITY SOIL SCIENCES LAB, BOZEMAN, MONTANA.  
2005-2006

My work in joint soil physics and landscape pedology labs involved comparing x-ray diffraction and visible-near infrared diffuse reflectance spectroscopy (VNIR-DRS) techniques to examine clay mineral species and organic carbon content in soils. I also co-taught a 400 level soil pedology course.

## Science Training and Development

2016 – Alaska Science Communication workshop participant (NSF sponsored). Sitka Sound Science Center, Sitka, Alaska.

2016 – Session Chair; *XI International Conference on Permafrost*. Potsdam, DE, June 17-24

2016 – Selected participant in the ARCUS (Arctic Research Consortium of the United States) Make an Impact: The Arctic in the Classroom workshop, Fairbanks, Alaska

2015 – FluxCourse Training Program, University of Colorado.

2015 – Arctic Permafrost Training Program, North Central Siberia, Russia

2014 – Greenhouse Gas Data Workshop, Observatoire de Haute-Provence, France. Hosted by the International Carbon Observing Program (ICOS) and the US National Ecological Observatory Network

(NEON). This workshop included training for science project management and budgeting.

## Science Training and Development (Cont.)

**2014** – Summer Field Campaign, North Slope, Alaska. CO<sub>2</sub> and CH<sub>4</sub> carbon flux measurements at NASA SMAP partner Cal./Val. and Amerflux tower eddy covariance sites using a LGR Ultraportable Greenhouse Gas Analyzer and collection of ancillary field data including vegetation spectral (visible and infrared) profiles, leaf area index (LAI), soil thermal/moisture profiles. Participation with San Diego State University and the University of Sheffield, UK.

**2013** – Circumpolar Active Layer Monitoring (CALM) Network, Alaska. Thaw Depth Measurement Team. Participation with George Washington University.

**2012** – NASA SMAP-VEX12 Field Campaign, Winnipeg, CN. Cropland and Forest Science Team.

**2012** – LI-COR Eddy Covariance Training Workshop. Berkeley, CA.

**2011** – Arctic Climate System Modeling Summer Program. International Arctic Research Center (IARC), Fairbanks, Alaska.

## Research Awards

### Graduate:

NASA Earth and Space Science Fellowship (NESSF) \$90,000 (2013-2016)

Title: Potential Contrasts in CO<sub>2</sub> and CH<sub>4</sub> Flux Response under Changing Climate Conditions: Satellite Driven Analysis of the Net Ecosystem Carbon Budget for Arctic and Boreal Regions. Award ID: 14-EARTH14R-25.

United States Permafrost Association Travel Grant \$2,000 (2016)

ARCUS Travel Grant (Make An Impact Workshop) \$1,300 (2016)

NASA Montana EPSCoR Visiting Speaker/Scientist \$500 (2016)

International P.E.O. Scholar Award \$15,000 (2015)

AmeriFlux Training Award \$2,500 (2015)

NASA Montana EPSCoR Research Travel Grant \$900 (2015)

University of Montana Office of Sponsored Programs Travel Grant \$150 (2012)

### Undergraduate:

Montana Access Grant (2005-2006): \$2,000

Montana Baker Grant (2005-2006): \$900

Clyde & Helen Erskine Memorial Grant (2005-2006): \$300

Montana State University Scholars Program Research Grant (2003-2004): \$3,000

Montana State University Scholars Program Travel Grant (2004): \$1,000

Bryson L. James Student Competition Research Award (2004): \$300

Campbell Family Foundation Scholarship (2003-2004): \$750

## Select Publications

- Zona D, Gioli B, Commane R, Lindaas J, Wofsy S C, Miller C E, Dinardo S J, Dengel S, Sweeney C, Karion A, Chang R Y-W, Henderson J M, Murphy P C, Goodrich J P, Moreaux V, Liljedahl A, **Watts J D**, Kimball J S, Lipson D A, and Oechel W C. (2016) Cold season emissions dominate the Arctic tundra methane budget. *Proc. Nat. Acad. Sci.* 113: 40-45
- Davidson S J, M J Santos, V L Sloan, **J D Watts**, G K Phoenix, W C Oechel, D Zona. (In Prep). Remote sensing of arctic tundra vegetation communities along a latitudinal gradient in North Alaska, USA. For submission to *Remote Sensing*.
- Du J, J S Kimball, L A Jones, and **J D Watts** (2016) Implementation of satellite based fractional water cover indices in the pan-Arctic region using AMSR-E and MODIS. *Remote Sens. Environ.* 184, 469-481
- Du J., J S Kimball, C Duguay, Y Kim, **J D Watts** (In Review) Satellite microwave assessment of northern hemisphere lake ice phenology from 2002 to 2015. Submitted to *Cryosphere*.
- Hursh A, A Ballantyne, L Cooper, M Maneta, J S Kimball, **J D Watts** (2016) The sensitivity of soil respiration to soil temperature, moisture, and carbon supply at the global scale. *Global Change Biology*. Doi:10.1111/gcb.13489
- Watts J D**, Kimball J S, Bartsch A, and McDonald K C (2014) Surface water inundation in the boreal-Arctic: potential impacts on regional methane emissions. *Environ. Res. Lett.* 9: 1-13
- Watts J D**, Kimball J S, Parmentier F J W, Sachs T, Rinne J, Zona D, Oechel W, Tagesson T, Jackowicz-Korczyński M, and Aurela A (2014) A satellite data driven biophysical modeling approach for estimating northern peatland and tundra CO<sub>2</sub> and CH<sub>4</sub> fluxes. *Biogeosciences* 11: 1961-1980
- Watts J D**, Kimball J S, Jones L A, Schroeder R, and McDonald K C (2012) Satellite microwave remote sensing of contrasting surface water inundation changes within the Arctic-Boreal region. *Remote Sens. Environ.* 127: 223-236
- Watts J D**, Powell S, Lawrence R L, and Hilker T (2011) Improved classification of conservation tillage adoption using high temporal and synthetic satellite imagery. *Remote Sens. Environ.* 115: 66-75
- Watts J D**, Lawrence R L, Miller P, and Montange C (2011) An analysis of cropland carbon sequestration estimates for North Central Montana. *Climatic Change* 108: 301-331
- Watts J D**, Lawrence R L, Miller P, and Montange C (2009) Monitoring of cropland practices for carbon sequestration purposes in north central Montana by Landsat remote sensing. *Remote Sens. Environ.* 113: 1843-1852

## Select Presentations

*Conference Presentations (oral)*

**Watts J D**, Kimball J S, et al. (2016) Monitoring a decade of change in pan-Arctic CO<sub>2</sub> and CH<sub>4</sub> exchange through integrated satellite remote sensing. *XI International Conference on Permafrost*. Potsdam, DE, June 17-24

**Watts J D**, Kimball J S, Kim Y, Du J, Oechel W, and Zona D (2015) Integrating tower eddy covariance, satellite remote sensing and ecosystem modeling to identify changes in hydrology and carbon fluxes across the Alaskan Arctic. *Arctic Observing Open Science Meeting*. Seattle, WA, November 17-19

**Watts J D**, Kimball J S, Bartsch A, and McDonald K C (2014) Satellite microwave detection of boreal-Arctic wetland inundation changes and their impact on regional methane emission estimates. *American Geophysical Union Fall Meeting*. San Francisco, CA, December 15-19 (Invited)

**Watts J D**, and J S Kimball (2014) Using satellite remote sensing to monitor changing CO<sub>2</sub> and CH<sub>4</sub> emission constraints in Boreal-Arctic wetland regions. *International Association of Landscape Ecology Meeting*. Anchorage, AK, May 18-22 (Invited)

**Watts J D**, Kimball J S, Parmentier F J, Sachs T, Rinne J, Zona D, and Oechel W (2013) Evaluating CO<sub>2</sub> and CH<sub>4</sub> fluxes in Arctic peatland and tundra using a satellite remote sensing driven biophysical model. *American Geophysical Union Fall Meeting*. San Francisco, CA, December 9-13

**Watts J D** (2009) The potential for carbon sequestration on degraded lands within North Central Montana. The 26<sup>th</sup> Annual Meeting of the *American Society of Mining and Reclamation*; 11<sup>th</sup> Billings Land Reclamation Symposium. Billings, MT, May 30–June 5

**Watts J D**, and Lawrence R L (2008) Estimating cropland carbon potential: a meta-analytical approach aided by satellite analysis. *Association of American Geographers Annual Meeting*. Boston, MA, April 15– 19

**Watts J D**, and Lawrence R L (2007) A comparison of multi-resolution segmentation strategies for the object-oriented delineation of agricultural fields within moderate-resolution imagery. *GIS in the Rockies*. Denver, CO, September 12– 15

*Conference Presentations (Poster)*

**Watts J D**, Kimball J S, et al. (2016) Monitoring dynamic changes in pan-Arctic land surface water coverage. *XI International Conference on Permafrost*. Potsdam, DE, June 17-24

**Watts J D**, Kimball J S, and Du J (2015) Monitoring surface water changes across North American Arctic-boreal regions and associated impacts on ecosystem carbon fluxes. Poster Presentation. *NASA Carbon Cycle & Ecosystems Joint Science Workshop*, Hyattsville, MD, April 20– 23

Jafarov E E, Schaefer K M, and **Watts J D** (2015) Estimation of the permafrost carbon

feedback using the SiBCASA model. 5<sup>th</sup> North American Carbon Program (NACP) Principal Investigators Meeting, Washington DC, January 26– 29

Jafarov E E, Schaefer K M, **Watts J D**, and Zhang T (2013) Vulnerability of permafrost carbon to climate change. *American Geophysical Union Fall Meeting*. San Francisco, CA, December 9– 13

**Watts J D**, Kimball J S, Jones L A, Schroeder R, and McDonald K C (2013) Detecting recent changes in surface water inundation across Arctic-Boreal permafrost zones using satellite microwave remote sensing. 7<sup>th</sup> International Workshop on the *Analysis of Multi-temporal Remote Sensing Images* (MultiTemp). Banff, CN, June 25– 27

**Watts J D**, Kimball J S, Jones L A, and Moghaddam M (2013) Recent variability in surface water inundation within Arctic permafrost zones: potential implications for regional methane emissions. *NASA Terrestrial Ecology Science Team Meeting*. La Jolla, CA, April 30 – May 2

**Watts J D**, Kimball J S, Jones L A, Schroeder R, and McDonald K C (2012) Satellite microwave detection of contrasting changes in surface inundation across pan-Arctic permafrost zones. *American Geophysical Union Fall Meeting*. San Francisco, CA, December 2– 7

**Watts J D**, Kimball J S, Jones L A, Schroeder R, and McDonald K C (2011) Analysis of surface inundation changes within Arctic permafrost zones using AMSR-E fractional land cover retrievals. *NASA Carbon Cycle & Ecosystem Joint Science Workshop*. Alexandria, VA, October 3– 7

**Watts J D**, and Lawrence R L (2008) The object-oriented analysis of agricultural practices for carbon sequestration purposes in north central Montana. *The American Society for Photogrammetry and Remote Sensing Conference*. Portland, OR, April 28 – May 2

## Invited Lecturer/Speaking Engagements

- Barrow Arctic Research Center, Barrow, Alaska, July 2014
- Department of Geography (GPHY 487, Remote Sensing/Raster Analysis), The University of Montana, November 2013
- Department of Land Resources and Environmental Sciences (LRES 525, Applied Remote Sensing), Montana State University, Spring 2008
- Department of Land Resources and Environmental Sciences (LRES 426, Remote Sensing; Multispectral and Hyperspectral), Montana State University, Autumn 2007
- Department of Land Resources and Environmental Sciences (LRES 454, Landscape Pedology), Montana State University, Autumn 2006

## Programming Languages/Software

ArcGIS, IDL, ENVI, ERDAS IMAGINE, Python, R, C, eCognition, STARFM

## **Professional Activities (Reviewer)**

*Global Change Biology*

*Biogeosciences*

*Remote Sensing of Environment*

*Remote Sensing*

*Wetlands Ecology & Management*

*USDA Small Business Innovation Research Program*

## **Professional Affiliations**

*The American Geophysical Union*

*Interagency Arctic Research Policy Committee*

*NASA Carbon Cycle & Ecosystems*

*Young Permafrost Research Network (PYRN)*

*United States Permafrost Association (USPA)*

*Arctic Research Consortium of the United States (ARCUS)*

## **Science Working Groups (Member)**

*NASA ABoVE Science Implementation Plan*

*NASA ABoVE Permafrost & Hydrology; Carbon Dynamics; Core Variables & Standards;*

*NASA ABoVE Students and Citizen Science*

*ARCUS Arctic Science in the Classroom Program (Alaska)*