

David Risk, Earth Sciences

Research Report – September 1, 2015 to August 31, 2016

## JOURNAL ARTICLES

[journal article] Bhatia, S. (grad student), Risk, D. (2015). Speciation in Application Environments for Dissolved Carbon Dioxide Sensors. *Water, Air, & Soil Pollution* 226:154.

[journal article] Bowling, D., Egan, J. (grad student), Hall, S., Risk, D. (2015). Environmental forcing does not induce diel or synoptic variation in carbon isotope content of forest soil respiration. *Biogeosciences Discussions*. 12: 5143-5160.

[journal article] Hurry, J. (grad student), Risk, D., Lavoie, M., Brooks, B-G., Phillips, C., Goeckede, M. (2016). Atmospheric monitoring and detection of fugitive emissions for Enhanced Oil Recovery. *International Journal of Greenhouse Gas Control*. 45: 1-8.

[journal article] Kim, Y., Park, S.-J., Lee, B.-Y., Risk, D. (2016). Continuous measurement of soil carbon efflux with Forced Diffusion (FD) chambers in a tundra ecosystem of Alaska. *Science of The Total Environment* 566–567:175–184.

[journal article] Klapstein, S. (grad student), J., Ziegler, S.E., Risk, D., O’Driscoll, N.J. 2016. Quantifying the effects of photo reactive dissolved organic matter on methylmercury photodemethylation rates in freshwaters, *Environmental Toxicology and Chemistry*.

[journal article] Latimer, R. (undergrad student), Risk, D. (2015). An inversion approach for determining production depth and temperature sensitivity of soil respiration. *Biogeosciences Discussions* 12(13): 10137.

[journal article] Latimer, R. (undergrad student), Risk, D. (2015). An inversion approach for determining production depth and temperature sensitivity of soil respiration. *Biogeosciences* 13(7) 2111.

[journal article] Lavoie, M., Phillips, C.L., Risk, D. (2015). A practical approach for uncertainty quantification of high-frequency soil respiration using forced diffusion chambers. *Journal of Geophysical Research: Biosciences*. 120(1): 128-146.

[journal article] Liang, L., Riveros-Iregui, D., Risk, D. (2016). Spatial and seasonal variabilities of the stable carbon isotope composition of soil CO<sub>2</sub> concentration and flux in complex terrain. *Journal of Geophysical Research: Biogeosciences*. 121, 2328–2339

[journal article] Phillips, C.L., Bond-Lamberty, B., Desai, A.R., Lavoie, M., Risk, D., Tang, J., Todd-Brown, K., Vargas, R. (2016). The value of soil respiration measurements for interpreting and modeling terrestrial carbon cycling. *Plant Soil*.

[journal article] Risk, D., Lavoie, M., Nickerson, N. (2015). Using the Kerr investigations at Weyburn to screen geochemical tracers for near-surface detection and attribution of leakage at CCS/EOR sites. *International Journal of Greenhouse Gas Control*. 35: 13-17.

[journal article] Sizmur, T., McArthur, G., Risk, D., Tordon, R., O'Driscoll, N.J. (2016). Gaseous mercury flux from salt marshes is mediated by solar radiation and temperature. *Atmospheric Environment*, 153: 117-125.

[journal article] Webb, E., Schuur, E., Natali, S., Oken, K., Bracho, R., Krapek, J., Risk, D., Nickerson, N. (2016). Increased wintertime CO<sub>2</sub> loss as a result of sustained tundra warming. *Journal of Geophysical Research: Biosciences*. 121:249–265.

## **PATENT APPLICATIONS**

[patent application] Risk, D.A., Brooks, B.G.J., Lavoie, M., (2015) Gas emission detection device, system and method, US Patent App. 14/955,835.

## **CONFERENCE PAPERS**

[conference paper] Atherton, E (grad student), Risk, D., Lavoie, M., Marshall, A., Baillie, J., Williams, J. (grad student). Fugitive Emissions from Conventional and Hydraulically Fractured Natural Gas Developments in Western Canada. American Geophysical Union, San Francisco, CA, December 2015.

[conference paper] Baillie, J., Risk, D., Lavoie, M., Williams, J. (grad student). Mapping Fugitive Gas Emission Sources and Severity Across Southeastern Saskatchewan. American Geophysical Union, San Francisco, CA, December 2015.

[conference paper] Egan, J. (grad student), Natali, S., Alexander, H., Loranty, M., Risk, D., Spawn, S. Long-term Impacts of Fire on Permafrost Vulnerability and C loss in Siberian Larch Forests. American Geophysical Union Fall Meeting, San Francisco, CA, December 2015.

[conference paper] Graham, L. (grad student), Natali, S., Rastetter, E., Shaver, G., Risk, D., Loranty, M., Jastrow, J. Long-term nutrient fertilization decreases CO<sub>2</sub> loss in Arctic tundra. American Geophysical Union. San Francisco, CA, December 2015.

[conference paper] Klapstein, S. (grad student), Risk, D., Ziegler, S., and O'Driscoll, N. Monitoring of methylmercury and DOM over 3 years: Implications for mercury contamination in Kejimikujik National Park. Mersey Tobeatic Research Institute Conservation Science Meeting. Caledonia, NS, November 2015.

[conference paper] Klapstein, S. (grad student), Risk, D., Ziegler, S., and O'Driscoll, N. Monitoring of methylmercury and DOM over 3 years: Implications for mercury contamination in Kejimikujik National Park. Society of Environmental Toxicology and Chemistry North America 36<sup>th</sup> Annual Meeting. Salt Lake City, UT, November 2015.

[conference paper] Klapstein S. (grad student), Risk, D., Ziegler, S., and O'Driscoll, N. Quantifying methylmercury photodemethylation rates in freshwater temperate lakes. Society

of Environmental Toxicology and Chemistry North America 36<sup>th</sup> Annual Meeting. Salt Lake City, UT, November 2015.

[conference paper] Klapstein, S. (grad student), Risk, D.R., Ziegler, S.E., and N.J. O'Driscoll. Influences of solar radiation on mercury in Kejimikujik National park lakes. Science Atlantic Environment Conference. St. Mary's University, Halifax, NS, March 2015.

[conference paper] Klapstein, S. (grad student), Risk D., Ziegler, S., and O'Driscoll, N. Dissolved organic matter controls mercury photoreactions in freshwater lakes. Canadian Society of Chemistry 99<sup>th</sup> Canadian Chemistry Conference and Exhibition, Halifax NS, June 9, 2016.

[conference paper] Klapstein, S. (grad student), Risk, D.R., Ziegler, S.E., and N.J. O'Driscoll. Photodemethylation in temperate freshwater and the effect of dissolved organic matter. International Conference on Mercury as a Global Pollutant. Jeju, South Korea, June 2015.

[conference paper] Klapstein, S. (grad student), Risk, D., Ziegler, S., and O'Driscoll, N. Seasonal shifts in water quality may have implications for mercury photodemethylation. International Conference on Mercury as a Global Pollutant. Jeju, South Korea, June 2015.

[conference paper] Laybolt, W. (grad student), Risk, D., Lavoie, M., Hurry, J. (grad student), MacIntyre, C. (grad student), O'Connell, E. Identification of surface leaks by combining vehicle-based observation, excess ratios, and signal amplification algorithms. IEAGHG Monitoring Meeting. Berkeley, CA, June 2015.

[conference paper] MacKay, K. (grad student), Risk, D., Hurry, J (grad student), MacIntyre, C. (grad student), Lavoie, M. A mobile-based approach to monitoring fugitive emissions at the Weyburn CO<sub>2</sub>-EOR site. Carbon Management Technology Conference. Sugarland, TX, November 2015.

[conference paper] MacIntyre, C. (grad student), Risk, D., Lee, C., Cary, C. Role of biotic and abiotic processes on soil CO<sub>2</sub> dynamics in the McMurdo Dry Valleys, Antarctica. Arctic Net Annual Meeting. Vancouver, BC, December 2015.

[conference paper] Marshall, A., Risk, D., Lavoie, M., Brooks, B-G., MacIntyre, C. (grad student), Baillie, J., Laybolt, W. (grad student), Williams, J. (grad student), Goeckede, M., Phillips, C. Mobile Detection of Fugitive Emissions using Computationally Optimized Geochemical Methods. American Geophysical Union. San Francisco, CA, December 2015.

[conference paper] Minions C. (undergrad student), Risk D., Graham L. (grad student), Measuring CO<sub>2</sub> flux through a snow pack using an automated sampling method, Cape Breton Highlands, NS. Science Atlantic. Fredericton, NB, March 2016.

[[conference paper] O'Connell E. Fugitive Emission Surveying on Apache's Midale Field. Apache field office, Saskatchewan, April 2016.

[conference paper] O'Connell E. Upstream Fugitive Emissions Detection and Attribution. Petroleum Technology Alliance of Canada, Technology for Emissions Reduction and Ecoefficiency committee, Calgary, AB, June 2016.

[conference paper] O'Connell E., Laybolt W. (grad student), Mapping Gas Variability for Energy Development Monitoring. Atlantic Research Institute for Sustainable Energy meeting, Halifax, NS, June 2016.

[conference paper] Risk D., Lavoie M., Marshall A., Ballie J., Atherton E. (grad student), Laybolt, W. (grad student). Time series signal processing for Enhanced Mobile Surveys: Learning from Field Studies. American Geophysical Union. San Francisco, CA, December 2015.

[conference paper] Risk D., Egan J. (grad student). *Using radiocarbon –CO<sub>2</sub> to assess the utility as a proxy for bioremediation effectiveness.* Saskatchewan Environment Industry and Managers Association Sustain Tech 2016. Saskatoon SK, April 12, 2016.

## LECTURES

[invited lecture] Risk D. *Mapping gas leaks from the Canadian energy sector.* Dalhousie Earth Sciences. Halifax, NS, September 24, 2015.

[invited lecture] Risk D. *Mapping fugitive gas emission sources and severity across southeastern Saskatchewan.* Dalhousie Physics and Atmospheric Science. Halifax NS, November 6, 2015.

[invited lecture] Risk D. *Soil Greenhouse Gas Production in the Cold.* Lecture NSAC/Dalhousie. Truro, NS, February 12, 2016.

[invited lecture] Risk D. *Geochemical Attribution at Carbon Capture and Storage Sites.* International Energy Agency Greenhouse Gas Monitoring Meeting. Berkeley, California. June 8, 2015.

[invited lecture] Risk D. *New technologies and methods for measurement and assessment of air impacts.* University of Calgary Tighrock Roundtable. Calgary, Alberta. November 12, 2016.

[invited keynote lecture] Risk D. *Soil Greenhouse Gas Production in the Cold.* Canadian Geophysical Union and Canadian Meteorological and Oceanographic Society Joint Meeting. Fredericton, New Brunswick. June 2, 2016.

[invited presentation] Risk D. Natural Resources Canada Carbon Sequestration Leadership Forum. *Engaging Industry on Carbon Capture and Storage.* London, England, June 17, 2016.

## AUTHORED INDUSTRY REPORTS

[industry report] Aquistore Project Summary Report 1, prepared for Petroleum Technology Research Center, submitted September 2015, 45 pages.

[industry report] Fugitive and Vented Emission Surveying at Apache's Midale EOR Field, prepared for Apache Corporation, November 2016, 23 pages

[industry report] Differentiating between hydrocarbon-derived carbon dioxide from native soil-derived carbon dioxide in the development of a new metric of hydrocarbon degradation effectiveness, prepared for Federated Co-operatives Limited, November 2015, 16 pages.

[industry report] Aquistore Project Summary Report III, prepared for Petroleum Technology Research Center, (data from February 2016) submitted March 2017, 53 pages.

[industry report] Aquistore Project Summary Report II, prepared for Petroleum Technology Research Center, submitted March 2016, 49 pages.

[industry report] Gas Migration at the Christina Lake Project Summary Report, prepared for MEG Energy, submitted March 2016, 9 slides.

[industry report] MSEEL, West Virginia Report, prepared for Marcellus Shale Energy and Environment Laboratory (MSEEL), (data from Spring 2016) submitted May 2017, 25 pages.

[internal report] An analysis of atmospheric gas concentrations and the implications of abandoned oil and gas infrastructure at the Stoney Creek oilfield, New Brunswick, prepared for FluxLab, submitted June 2016, 19 pages.

[industry report] An analysis of atmospheric gas concentrations in relation to industrial facilities associated with Shell Quest Carbon Capture and Storage Project, prepared for Shell, submitted June 2016, 22 pages.

[industry report] Fugitive and vented emissions surveying at the Weyburn CO<sub>2</sub>-EOR site, prepared for Cenovus Energy Inc., submitted July 2016, 19 pages.

[industry report] Survey of Vermont Gas Natural Gas system, prepared for Vermont Gas, submitted July 2016, 37 pages.

[industry report] G2210-*i* beta test report, prepared for Picarro Inc., submitted August 30, 2016, 27 pages.

[government report] Saskatchewan Research Council Final Report, 2016, prepared for Saskatchewan Ministry of the Economy, (data from August 2016) submitted September 2016, 30 pages.

[industry report] Aquistore Project Summary Report IV, prepared for Petroleum Technology Research Center, (data from August 2016) submitted March 2017, 25 pages.

## **AWARDS**

[award] Clean Air Leadership Award, Southeastern Saskatchewan Airshed Association, 2015. [Shared award with Cenovus Energy.]

[award] Best Innovation of 2016 Runner up, Natural Resources Magazine, December 31, 2015.

## **FUNDING**

[research contract] Risk D. *Fugitive Emissions Surveying for the Energy Sector*. Atlantic Canada Opportunities Agency, Atlantic Innovation Fund, 2016-2019 (\$1,993,448).

[research contract] Risk D. *Emissions Attribution via Computational Techniques (ExACT)*. Early Stage Commercialization Fund, 2016-2017 (\$47,900).

[technical services agreement] Risk D. *Leak Survey Mapping, VGS Natural Gas lines in St. Albans, VT*. Vermont Gas, 2016 (\$12,500).

[technical services agreement] Risk D. *NASA Arctic Boreal Vulnerability Experiment (ABOVE)*. Woods Hole Research Centre, 2015 (\$98,700).

[research contract] Woods N (principal investigator), Risk D (co-applicant) et al. Winter respiration in the Arctic: Constraining current and future estimates of CO<sub>2</sub> emissions during the non-growing season. NASA Arctic Boreal Vulnerability Experiment (ABOVE), 2015-2019 (\$100,000 [Risk portion]).

[research grant] Risk D. *Vehicle based measurement of fugitive and vented emissions on Apache's Midale enhanced oil recovery field*. Engage Grant, Natural Sciences and Engineering Research Council of Canada, 2015-2016 (\$25,000).

[research grant] Risk D. *Cost reduction for a new multi-scale fugitive gas detection tool*. Idea to Innovation Grant, Natural Sciences and Engineering Research Council of Canada, 2015-2016 (\$120,882).

[research grant] Risk D. *Addressing the problem of methane release from unconventional energy sites*. Discovery Grant, Natural Sciences and Engineering Research Council of Canada, 2014-2019 (\$185,000).

[research grant] Risk D. *Differentiating between hydrocarbon-derived carbon dioxide from native soil-derived carbon dioxide in the development of a new metric of hydrocarbon degradation effectiveness*. Engage Grant, Natural Sciences and Engineering Research Council of Canada, 2014-2015 (\$25,000).

[research grant] Beltrami H (principal investigator); Ferguson G, Kellman L, O'Driscoll N, Risk D, Sushama L, Tarasov L & Ziegler S (co-applicants). *NSERC CREATE Program in Training strategies to meet the challenges imposed by a changing climate: Preparing for societal impacts and adaptation*. Collaborative Research and Training Experience Grant, Natural Sciences and Engineering Research Council of Canada, 2010-2016 (\$1,400,000).

[research grant] Risk D. *Surface containment monitoring for carbon capture and storage*. Natural Resources Canada, ecoENERGY Innovation Initiative, 2012-2015 (\$756,000).

[research contribution agreement] Risk D. *Atmospheric leak detection as a tool for bitumen steam chamber and well integrity risk analysis*. Natural Resources Canada, ecoENERGY Innovation Initiative, 2015-2016 (\$451,024).

[technical services agreement] Risk D. *Montney Natural Gas Study*. David Suzuki Foundation, 2015-2016 (\$68,418).

[technical services agreement] Risk D. & Kellman L. *Surface measurement, monitoring, and verification research at the Aquistore Carbon Capture and Storage Site, Saskatchewan*. Petroleum Technology Research Centre, 2014-2017 (\$151,000).

[research grant] Risk D. *Fugitive gas detection technology and procedure for enhanced oil recovery (Leak Detection Technology-LDT)*. Innovation Mobilization Fund, Springboard Atlantic, 2014-2015 (\$22,883).

[research grant] Risk D. *Engaging UK oil and gas industry, UK government regulators and academics in field demonstrations of gas detection equipment for shale gas, EOR, on shore O&G infrastructure applications in the UK*. Innovation Mobilization Fund, Springboard Atlantic, 2014-2015 (\$10,000).

[market analysis funding] Risk D. *Market analysis and commercialization plan*. Commercialization Consulting and Mentoring (CCM) Program, Learnsphere, 2015-2016 (\$16,750).

[technical services agreement] Risk D. *Advancing permafrost carbon climate feedback – improvements and evaluations of the Norwegian Earth System Model with observations*. Uni Research Klima, 2015-2018 (\$75,000).

[technical services agreement] Risk D. *Bakken Fugitive and Vented Emissions Study*. Environment Canada, 2015- 2016. (\$15,000).

[research grant] Risk D. *Engaging US Oil & Gas Industry*. Innovation Mobilization Fund, Springboard Atlantic, 2015-2016 (\$15,000).

[research grant] Risk D. *Developing large-footprint leak detection strategies for Enhanced Oil recovery*. Natural Sciences and Engineering Research Council of Canada, Collaborative Research & Development, 2015-2017 (\$87,000).

[research grant] Risk D. *Fugitive Gas Detection*. Springboard Atlantic, 2015-2016 (\$5,000).

[research grant] Risk D. *Vehicle based fugitive emission detection and attribution within Alberta energy developments*. Petroleum Technology Alliance Canada. 2016-2017 (\$85,000).

## **MEDIA**

[media] Eight StFX graduate students awarded Nova Scotia Graduate Scholarships for innovative research. Springboard Atlantic, 17 May 2016. Retrieved from <http://springboardatlantic.ca/news/story/eight-stfx-graduate-students-awarded-nova-scotia-graduate-scholarships-for>

[media release] Government of Canada Invests In Innovation at St. FX. Government of Canada, 9 August 2016. Retrieved from <http://news.gc.ca/web/article-en.do?nid=1109299>

[media] Government of Canada Invests in Innovation at St.FX. Canada Business News, 9 August 2016. Retrieved from <http://www.business-support-network.org/canbiz/category/persons/page/6/>

[media] Government of Canada Invests in Innovation t St. FX. Atlantic Canada Opportunities Agency, 9 August 2016. Retrieved from <http://www.acoa-apeca.gc.ca/eng/Agency/mediaroom/NewsReleases/Pages/4876.aspx>

[media] Dr. Dave Risk and Flux Lab team receive \$1.8 million for gas leak detection technology. St. Francis Xavier University, Antigonish, NS, 9 August 2016. Retrieved from <https://www.stfx.ca/about/news/dr-david-risk-and-flux-lab-team-receive-18-million-gas-leak-detection-technology>

[media] Government of Canada Invests in Innovation at St.FX. Canada Business News, 9 August 2016. Retrieved from <http://www.business-support-network.org/canbiz/category/persons/page/6/>

[media] Government of Canada Invests In Innovation t St. FX. Atlantic Canada Opportunities Agency, 9 August 2016. Retrieved from <http://www.acoa-apeca.gc.ca/eng/Agency/mediaroom/NewsReleases/Pages/4876.aspx>

[media] Dr. Dave Risk and Flux Lab team receive \$1.8 million for gas leak detection technology. St. Francis Xavier University, Antigonish, NS, 9 August 2016. Retrieved from <https://www.stfx.ca/about/news/dr-david-risk-and-flux-lab-team-receive-18-million-gas-leak-detection-technology>

[media] Canada: Government of Canada Invests in Innovation at St.FX. High Beam Research, 11 August 2016. Retrieved from <https://www.highbeam.com/doc/1G1-462411199.html>

[media] Investing in innovation at St.F.X. The Casket, 18 August 2016. Retrieved from <http://www.thecasket.ca/archives/51922>

[media] Gas detection campaigns launching. CBC Radio (Main Street), CTV Television (Breakfast Television with Heidi Petracek), September 2015.

[media] Thesis work turns into paper accepted in a leading international scientific publication for StFX physics student. St.Francis Xavier University, 12 February 2016. Retrieved

from: <https://www.stfrancisxavieruniversity.ca/about/news/thesis-work-turns-paper-accepted-leading-international-scientific-publication-stfx>

## COMPLETED THESIS

[completed PhD thesis] Bhatia, S. *Fibre Optic Applications for Dissolved Carbon Dioxide Monitoring of Marine Geologic Sequestration Sites*. Dalhousie University. Graduation May 2016.

[completed MSc thesis] Graham L. *Controls on terrestrial CO<sub>2</sub> emissions from seasonally snow-covered ecosystems*. St. Francis Xavier University. Recipient of Natural Sciences and Engineering Research Council of Canada, Canada Graduate Scholarships-Master's Award, 2015-2016 (\$17,500). Graduation May 2016.

[completed undergraduate thesis] Latimer R. (Physics). *An inversion approach for determining production depth and temperature sensitivity of soil respiration*. Graduation May 2015.

[completed MSc thesis] MacIntyre, C. *Patterns and process driving soil CO<sub>2</sub> variability in the McMurdo Dry Valleys, Antarctica*. St. Francis Xavier University. Recipient of Natural Sciences and Engineering Research Council of Canada, Canada Graduate Scholarships-Master's Award, 2014-2015 (\$17,500). Graduation May 2016.