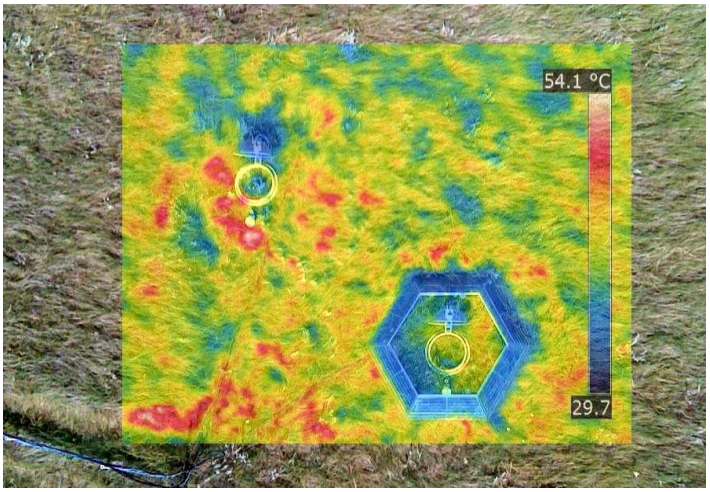
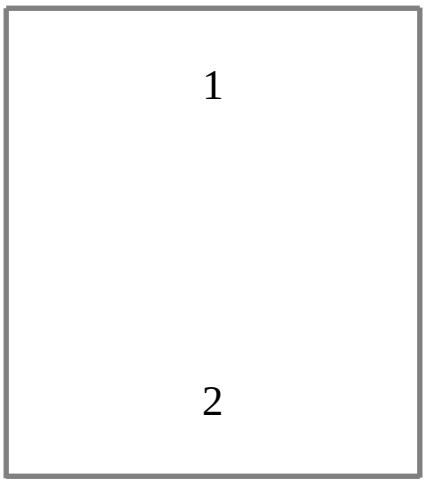
2012 R&D Report

University of Lethbridge
Faculty of Arts & Science

ATIC
Alberta Terrestrial Imaging Centre
University of Lethbridge





Front cover:

1. The University of Lethbridge, Lethbridge, Alberta, Canada
2. ATIC Microkopter XL UAV system in flight (left) and UAV-based thermal image of a grassland ecosystem (right)

ATIC
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University of Lethbridge

www.ulethbridge.ca/artsci/atic

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Alberta Terrestrial Imaging Centre 2012

Director

Dr. Karl Staenz, Professor, Department of Geography

Associate Director

Dr. Derek Peddle, Professor, Department of Geography

Core Members

Dr. Craig Coburn, Associate Professor, Department of Geography
Dr. Derek Peddle, Professor, Department of Geography
Dr. Adriana Predoi-Cross, Associate Professor, Department of Physics and Astronomy
Dr. Karl Staenz, Professor, Department of Geography

Research Members

Dr. Ron Hall, Canadian Forest Service, Edmonton, Alberta, Adjunct Professor, Department of Geography
Dr. Nadia Rochdi, Adjunct Professor, Department of Physics and Astronomy
Dr. Anne Smith, Agriculture and Agri-Food Canada, Lethbridge, Alberta, Adjunct Professor, Department of Geography
Dr. Philippe Teillet, Adjunct Professor, Department of Physics and Astronomy
Dr. Jinkai Zhang, Adjunct Professor, Department of Geography

Research Staff

Shu Chen, Research Associate, Department of Geography
David Rolfson, Research Associate, Department of Geography
Nicole Seitz, Research Associate, Department of Geography
Dr. Zhijie Wang, Research Associate, Department of Geography
Dr. Xiaohui Yang, Post-Doctoral Fellow, Department of Geography

Administrative Staff

Trevor Armstrong, AMETHYST Program Coordinator, University of Lethbridge
Cathy Ward, Alberta Water and Environmental Science Building, University of Lethbridge
Cathy Ward, Charlene Sawatsky, and Margaret Cook, Department of Geography, University of Lethbridge
Laurie Scott, Department of Physics and Astronomy, University of Lethbridge

Graduate Students[♦]

James Banting, Department of Geography, AMETHYST Award Student
Ashley Bracken, Department of Geography, AMETHYST Award Student
Subir Chowdhury, Department of Geography
Peter Kennedy, Department of Geography, AMETHYST Award Student
Chelsea King, Department of Geography, AMETHYST Award Student
Cathy Kloppenburg, Department of Geography
Becky Leppington, Department of Geography
Aaron Mullin, Department of Geography
Steve Myshak Department of Geography, AMETHYST Award Student
Ilia Parshakov, Department of Geography, AMETHYST Award Student
Chad Povey, Department of Physics and Astronomy, AMETHYST Award Student
Logan Pryor, Department of Geography, AMETHYST Award Student
Gairik Roy, Department of Physics and Astronomy
Kevin Riddell, Department of Geography, AMETHYST Award Student
Hoimonti Rozario, Department of Physics and Astronomy, AMETHYST Award Student
Jurjen van der Sluijs, Department of Geography, AMETHYST Award Student
Shiyong Xu, Department of Geography, AMETHYST Award Student

Undergraduate Students[♦♦]

Shu Chen, Department of Computer Science, AMETHYST Award Co-op Student
Jolene Garber, Department of Physics and Astronomy, AMETHYST Award Co-op Student
Gordon Logie, Department of Geography, AMETHYST Award Co-op Student
Christopher Martin, Department of Computer Science, AMETHYST Award Co-op Student
Reed Parsons, Department of Neuroscience, AMETHYST Award Co-op Student

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♦ *AMETHYST Graduate Awards are funded by the NSERC Collaborative Research and Training Experience (CREATE) Program and the School of Graduate Studies, University of Lethbridge*

♦♦ *AMETHYST Undergraduate Awards are funded by the NSERC CREATE Program*

ATIC Overview

Mandate

The purpose of ATIC is to advance scientific knowledge in remote sensing and imaging spectroscopy and apply this knowledge to the monitoring of natural resources and the environment in the context of global sustainability. In particular, the Centre integrates strategic research and development (R&D) in these areas at the University of Lethbridge. The Centre's R&D supports new applications utilizing cutting-edge remote sensing technologies developed at the Centre. The terrestrial focus encompasses R&D on the remote sensing of surface and atmospheric properties. While the primary emphasis is on imaging, the Centre's R&D involves a wide variety of non-imaging measurements and methodologies, including field spectroradiometry, atmospheric spectroscopy, and scene physics and analysis.

Due to its increased knowledge and expertise in remote sensing, the Centre has the capacity to collaborate consultatively with all levels of governments and industry, especially in the area of imaging spectroscopy. This enlarged capacity is also used to enhance training and teaching programs at the undergraduate and graduate levels to develop highly-qualified personnel (HQP). Within this framework, the Centre further enhances national and international collaboration to augment its research, training and teaching capabilities.

Scope of Activities

- *Methodology Research*: Undertaking research and development on methodologies in the remote sensing and imaging spectroscopy of the Earth's surface and atmosphere.
- *Applications Development*: Finding new applications in remote sensing and imaging spectroscopy to resource and environmental monitoring, neuro-imaging, kinesiology, computer science, and other disciplines.
- *Imaging Science Driver*: Creating and maintaining structured and multi-disciplinary institutional approaches to imaging science research and education from undergraduate to post-graduate levels.
- *Research Training*: Providing enhanced multi-disciplinary learning experiences that enable graduates to pursue science and technology careers in industrial, government or academic settings.

Primary Research Areas

- Analysis of atmospheric trace gases
- Atmospheric correction of satellite image data
- Automation of data preprocessing and information extraction chains
- Bidirectional reflectance properties of Earth surfaces
- Development of dedicated mapping/monitoring systems
- Development of remote sensing applications in agriculture, rangeland, forestry, oil sands, water resources
- Hyperspectral imaging / imaging spectroscopy
- Image classification, texture analysis, and spectral mixture analysis
- Image processing and analysis methodologies
- Investigations of molecular structures
- Remote sensing laboratory and field analyses
- Remote sensing instrumentation (field/airborne/atmospheric sensors)
- Sensor radiometric calibration
- Vegetation canopy reflectance modeling and inversion

Current Research Projects (Principal Investigator)

- Advanced Methods, Education and Training in Hyperspectral Science and Technology (AMETHYST), NSERC CREATE (K. Staenz)
- Extraction of Fractional Cover from Spaceborne Hyperspectral Data for Rangeland Monitoring, NSERC Discovery (K. Staenz)
- Food Security Assessment System (FSAS), Tecterra Inc. (W. Xu)
- Geomatics for Integrated Resource Management of Disturbed Landscapes, NWT, Tecterra (D. Peddle)
- Molecular Spectroscopic Studies for Remote Sensing of Earth and Planetary Atmospheres, NSERC Discovery (A. Predoi-Cross)
- Monitoring System for Mapping Non-Cultivated Areas in the Agricultural Landscape of Alberta Using Remote Sensing, Agriculture and Food Council of Alberta (K. Staenz)
- Monitoring Procedure for Site Reclamation in Alberta (MOPRA), Tecterra/AESRD/OSRIN (K. Staenz)
- Spectroscopic Study of Carbon Dioxide to Enable Isotopic Fractionation Studies of the Martian Atmosphere, University of Lethbridge Research Fund (A. Predoi-Cross)

R&D Contract Agencies

- Alberta Environment and Sustainable Resource Development
- ASL Environmental Sciences Inc.
- Canada Centre for Remote Sensing
- Canadian Space Agency

Multi-Disciplinary Major in Remote Sensing

The University of Lethbridge offers a Multi-Disciplinary Major in Remote Sensing, combining the strengths of the university's Department of Geography and Department of Physics and Astronomy. The program prepares B.Sc. graduates for a broad spectrum of job opportunities as well as graduate education and research.

NSERC CREATE AMETHYST Program

The University of Lethbridge holds a prestigious NSERC Collaborative Research and Training Experience (CREATE) grant for an Advanced Methods, Education and Training in Hyperspectral Science and Technology (AMETHYST) Program. AMETHYST provides excellent support for research training and exposes students to the broader context of imaging science and technology, with research foci in remote sensing methodologies, resource and environmental monitoring, greenhouse gas studies, and neuro-imaging. Student internships are offered at the undergraduate and graduate levels in academic laboratories, government agencies and industry settings. In addition to periodic and ongoing research and training events, AMETHYST offers workshops on hyperspectral imaging science and technology and on career development and workforce preparation, open to participants from across Canada and internationally. More information is available on the AMETHYST web site: www.ulethbridge.ca/artsci/amethyst/. AMETHYST internship placements in 2012 were as follows:

- Ashley Bracken, M.Sc. Student, Helmholtz Centre Potsdam - GFZ German Research Centre for Geoscience, Germany
- Logan Pryor, M.Sc. Student, ESRIN - European Space Agency, Italy
- Hoimonti Rozario, M.Sc. Student, Justus University Giessen, Germany
- Jurjen van der Sluijs, M.Sc. Student, Canadian Forestry Service, Canada
- Chad Povey, Ph.D. Student, Synodon Inc., Canada

Major R&D Funding Sources

- Agriculture and Agri-Food Canada
- Agriculture and Food Council of Alberta
- Alberta Innovation – Environmental Energy Solutions

- Government of Alberta
- Natural Sciences and Engineering Research Council of Canada Grants: Discovery, CREATE
- Oil Sands Research and Information Network (OSRIN)
- Tecterra, Inc.
- University of Lethbridge Faculty of Arts and Science

Undergraduate Awards (AMETHYST Awards Noted Separately)

Garber, J., German Academic Exchange Service (DAAD) Research Internships in Science and Engineering (RISE) Award (Euro 1,950)
Garber, J., Alberta International Travel Award ($750)
Logie, G., Dorner Award ($750)
Martin, C., University of Lethbridge President's Scholarship ($1,000)
Moxon, J., Teillet Remote Sensing/Physics Award ($1,750)
Weiler, V., Teillet Remote Sensing/Physics Award ($1,750)

Graduate Awards (AMETHYST Awards Noted Separately)

Kennedy, P., University of Lethbridge Entrance and Continuing Award ($3,000)
McCreary, K., University of Lethbridge Entrance Award ($3,000)
McCreary, K., University of Lethbridge Graduate Student Scholarship ($3,000)
Riddell, K., University of Lethbridge Entrance and Continuing Award ($3,000)
Van der Sluijs, J., John & Catherine Robbins Graduate Scholarship (Brandon University) ($4,250)

Other Awards

Best Paper, *Canadian Journal of Remote Sensing* 2011 (awarded in 2012): Smith, A.M., and J.R. Buckley. 2011. Investigating RADARSAT-2 as a tool for monitoring grassland in Western Canada. *Canadian Journal of Remote Sensing*, 37(1): 93-102.

Best Student Poster Award, GIScience Study Group, Canadian Association of Geographers (CAG): Van der Sluijs, J. 2012. Annual Conference and Meeting, Wilfrid Laurier University and University of Waterloo, Waterloo, Ontario.

Laboratories

The ***Remote Sensing Laboratory*** in the Alberta Water and Environmental Science Building (AWESB) consolidates various elements of the University of Lethbridge remote sensing research. Methods of spectroradiometric measurement and imaging are developed and tested for real-world application. The laboratory provides space and lighting for the measurement of samples in a controlled environment. It is the home base for the University of Lethbridge goniometer systems, a variety of laboratory and field-deployable sensors and experimental target systems, 3-D structural measurement devices, and other specialised field equipment.

The ***Remote Sensing Calibration Spectrometry Laboratory*** is a highly-specialized critical facility unique to Canada. The laboratory carries out spectroradiometric calibration of instrumentation used to support a variety of Earth and environmental science studies. There are four rooms that make up this laboratory space: a dark calibration room, a spectrometer room, a goniometer room, and a field preparation room. The laboratory houses a wide array of new spectroradiometric instrumentation for remote sensing research in the laboratory as well as equipment for use in field campaigns. It also offers equipment calibration services to the remote sensing community and will be equipped to seek contract opportunities that support space missions.

The ***Atmospheric Spectroscopy Laboratory*** in University Hall undertakes laboratory spectroscopy of terrestrial and planetary atmospheric molecules. The main instrument is a three-channel home-made laser

spectrometer, tuneable from 1.48 to 3.8 micrometers. A variable-temperature single-pass absorption gas cell was designed and built in-house for the spectroscopic study of gases. This setup enables highly sensitive line shape studies and fundamental spectroscopic studies of molecular interactions. Tuneable diode laser absorption spectroscopy has also been used to develop an instrument capable of high-accuracy measurements of greenhouse gases such as N_2O, CO_2, and CH_4. The field-portable instrument can be deployed in remote locations and used to measure greenhouse gas concentrations in real time.

Instrumentation

- Airborne multispectral camera system
- ASD mercury argon calibration source assembly ALZSOLO
- ASD RTS-3ZC reflectance/transmittance integrating spheres (2)
- ASD spectrometers (4): ASD FieldSpec 3 (2), ASD FieldSpec 3 Hi-Res, and ASD FieldSpec Pro
- Campbell Scientific weather stations (2)
- Cimel CE-318 AERONET/AEROCAN node autonomous Sun-tracking photometer
- Cimel CE-318 science mode autonomous sun-tracking photometer
- FEL irradiance standards (2)
- HEMI digital hemispherical photography system
- Labsphere USS-1200C integrating sphere
- Labsphere reflectance standards (6)
- LAI-2000 plant canopy analyzer system
- Microtops sun photometers (2)
- Microkopter XL (2)
- Ocean Optics VNIR spectrometer
- Pulnix AccuPiXEL cameras (6)
- SVC HR-1024 field spectrometer
- SWIR imaging spectrometer: Specim VN25E / MCT camera / Specim mirror scanner
- TRAC (Tracing Radiation and Architecture of Canopies) system
- Trimble TSCL and ProXRS DGPS receivers
- VNIR imaging spectrometers (2): Specim V10E / Hamamatsu C8484 / Specim mirror scanner
- Yankee Environmental Systems SPUV sun photometer

Unmanned Aerial Vehicle (UAV) Systems

The University of Lethbridge has recently added UAV capability, consisting of two Microkopter XL systems imaging in the visible/infrared and thermal regions. These systems are used in support of various on-going research projects, as test beds for new systems, and in teaching.

Field Goniometer Systems

The University of Lethbridge Goniometer System version 2 (ULGS-2) apparatus has a unique design that incorporates a number of advancements over other goniometers for measuring bi-directional reflectance data that are used to support remote sensing analyses. It is the most advanced field goniometer system in the world. The ULGS-2 uses a quarter circle positioning arc with a 2-m radius and no part of the apparatus touches the ground in the target area. This new design reduces the weight of the apparatus, increases portability, allows positioning over a wider variety of surfaces, and facilitates significantly faster data acquisition. ULGS-2 incorporates a computer-controlled motor-driven instrument payload that rapidly samples target bidirectional reflectance distribution functions. A new manual ULGS developed in 2011 has 10-degree resolution in both zenith and azimuth, and is light weight and portable.

2012 Bibliography, Alberta Terrestrial Imaging Centre

Publications in Refereed Journals

Grant, K.M., D.L. Johnson, D.V. Hildebrand, and D.R. Peddle. 2012. Quantifying grassland biomass production from southern Alberta rangeland using SPOT imagery: vegetation indices and transformations. *Canadian Journal of Remote Sensing*, 38(6) in press.

Hugenholtz, C.H., K. Whitehead, O.W. Brown, T.E. Barchyn, B.J. Moorman, A. LeClair, K. Riddell, and T. Hamilton. 2012. Geomorphological mapping with a small unmanned aircraft system (sUAS): feature detection and accuracy assessment of a photogrammetrically-derived terrain model. *Geomorphology*, in press.

Povey, C., A. Predoi-Cross, and D.R. Hurtmans. 2012. Low pressure line shape study of acetylene transitions in the ν1+ν2+ν4+ν5 band over a range of temperatures. *Molecular Physics*, 110(21/22): 2633-2644.

Predoi-Cross, A., M. Herman, L. Fusina, and G. Di Lonardo. 2012. The far infrared spectrum of trans-formic acid: An extension up to 175 cm^{-1}. *Journal of Quantitative Spectroscopy & Radiative Transfer*, 113: 1034-1137.

Predoi-Cross, A., M. Herman, L. Fusina, and G. Di Lonardo. 2012. The infrared spectrum of $^{13}C_2H_2$ in the 60 - 2600 cm^{-1} region: bending states up to ν4 + ν5 = 4. *Molecular Physics*, 110(21/22): 2621-2632.

Rozario, H., J. Garber, C. Povey, D. Hurtmans, J. Buldyreva, and A. Predoi-Cross. 2012. Experimental and theoretical study of N_2-broadened acetylene line parameters in the ν1+ν3 band over a range of temperatures. *Molecular Physics*, 110(21/22): 2645-2663.

Malathy Devi, V., D. Benner, M.A.H. Smith, A.W. Mantz, K. Sung, L.R. Brown, and A. Predoi-Cross. 2012. Spectral line parameters including temperature dependences of self- and air-broadening in the 2←0 band of CO at 2.3 μm. *Journal of Quantitative Spectroscopy & Radiative Transfer*, 113: 1013-1033.

Wang, Z., C.A. Coburn, X. Ren, and P.M. Teillet. 2012. Effect of soil surface roughness and scene components on soil surface BRF. *Canadian Journal of Soil Science*, 92: 297-313.

Xu W., X. Ren, and A. Smith. 2012. Remote Sensing, Crop Yield Estimation and Agricultural Vulnerability Assessment: a Case of Southern Alberta. *The Open Hydrology Journal*, 6: 68-77.

Xu, W., X. Ren, T. Johnston, Y. Yin, K. Klein, and A. Smith. 2012. Spatial and temporal variation in vulnerability of crop production to drought in southern Alberta. *Canadian Geographer*, 56: 474-490.

Zhao, C., Z. Wang, J. Wang, and W. Huang. 2012. Relationships of leaf nitrogen concentration and canopy nitrogen density with spectral features parameters and narrow-band spectral indices calculated from field winter wheat (Triticum aestivum L.) spectra. *International Journal of Remote Sensing*, 33(11): 3472-3491.

Conference Proceedings Publications

Chowdhury, S., J. Zhang, K. Staenz, and D.R. Peddle. 2012. Spectral Mixture Analysis of Hyperspectral Data Using Genetic Algorithm and Spectral Angle Constraint (GA-SAC). *Proceedings of the 4th Workshop on Hyperspectral Image and Signal Processing: Evolution in Remote Sensing (WHISPERS) Conference*, Shanghai, China, 4 pages, in press.

Chowdhury, S., K. Staenz, D.R. Peddle, and J. Zhang. 2012. A Genetic Algorithm Based Spectral Mixture Analysis Method for Hyperspectral Data. *Proceedings of the 33rd Canadian Symposium on Remote Sensing*, Ottawa, Ontario, Canada, 8 pages, in press.

Kloppenburg, C., A.M. Smith, K. Staenz, R. Bourchier, C.A. Coburn, and N. Rochdi. 2012. Detecting leafy spurge in native grassland using hyperspectral image analysis. *Proceedings of the 33rd Canadian Symposium on Remote Sensing*, Ottawa, Canada, in press.

Parshakov, I., K. Staenz, C.A. Coburn, S.W. Kienzle, and A. Predoi-Cross. 2012. Automatic Class Labelling of Classified Imagery Using a Hyperspectral Library. *Proceedings of the 33rd Canadian Symposium on Remote Sensing*, Ottawa, Canada, 8 pages, in press.

Pryor, L., C.A. Coburn, K. Staenz, J. Zhang, and D.R. Peddle. 2012. Simulating Sentinel-2 Data from Airborne Hyperspectral Sensor Data. *Proceedings of the 33rd Canadian Symposium on Remote Sensing*, Ottawa, Canada, 7 pages, in press.

Riddell, K.D., C.H. Hugenholtz, B.J. Moorman, K. Whitehead, and D.R. Peddle, 2012. A new eye in the sky: lightweight remotely-piloted aircraft platforms for remote sensing. *Proceedings of the Canadian Water Resources of Canada and Canadian Geophysical Union (CWRA-CGU) Conference on Earth, Wind, Water – Elements of Life*, Banff, Alberta, 8 pages, in press.

Smith. A.M. 2012. Detecting Grassland Change. State & Trends of Canadian Grasslands Workshop, Saskatoon, Saskatchewan.http://www.pcapsk.org/docs/9_upcomingeventswo/Anne_Smith_Part1.pdf; http://www.pcap-sk.org/docs/9_upcomingeventswo/Anne_Smith_Part2.pdf. Accessed January 30, 2013.

Staenz, K., and A. Held. 2012. Summary of Current and Future Terrestrial Civilian Hyperspectral Spaceborne Systems. *Proceedings of the International Geoscience and Remote Sensing Symposium (IGARSS'12)*, Munich, Germany, 4 pages, in press.

White, H.P., K. Omari, K. Staenz, and D.J. King. 2012. Inversion of the PROFLAIR Leaf-Canopy Reflectance Model for Retrieval of Forest Canopy Parameters. *Proceedings of the 4th Workshop on Hyperspectral Image and Signal Processing: Evolution in Remote Sensing*, Shanghai, China, 4 pages, in press.

External Reports

Hall, R.J., R.S. Skakun, M. Filiatrault, M. Gartrell, E. Arsenault, and M. Voicu. 2012. *Multi-sensor remote sensing for forest inventory: extending the value of satellite land cover maps*. Report prepared for Government of Northwest Territories, 133 pages.

Rochdi, N. 2012. Monitoring Procedures for Site Reclamation in Alberta - Temporal Monitoring of Reclamation Success Using Satellite Remote Sensing. Report No. ATIC-2012-004, Alberta Terrestrial Imaging Centre, University of Lethbridge, Lethbridge, Alberta, Canada, 34 pages.

Rochdi, N. 2012. Monitoring Procedure for site Reclamation in Alberta – Algorithm Report. Report No. ATIC-2012-007, Alberta Terrestrial Imaging Centre, University of Lethbridge, Lethbridge, Alberta, 22 pages.

Staenz, K., T.A. Armstrong, P.M. Teillet, D.R. Peddle, C.A. Coburn, A. Predoi-Cross, and A. Cross. 2012. AMETHYST NSERC CREATE Progress Report. Alberta Terrestrial Imaging Centre, University of Lethbridge, Lethbridge, Alberta, 22 pages.

Staenz, K., J. Banting, X. Yang, C. King, D. Rolfson, J. Zhang, and N. Rochdi. 2012. Monitoring Procedure for site Reclamation in Alberta – Interim Report. Report No. ATIC-2012-008, Alberta Terrestrial Imaging Centre, University of Lethbridge, Lethbridge, Alberta, 47 pages.

Teillet, P.M. (Editor). 2012. *Remote sensing and Imaging Spectroscopy at the University of Lethbridge – A Cumulative Five-Year Bibliography (2007-2011)*. Alberta Terrestrial Imaging Centre, University of Lethbridge, Lethbridge, Alberta, 16 pages.

Teillet, P.M. (Editor). 2012. *2011 Annual R&D Report*. Alberta Terrestrial Imaging Centre, University of Lethbridge, Lethbridge, Alberta, Canada, 12 pages.

Zhang, J., and K. Staenz. 2012. MODTRAN Simulations. Report No. ATIC-2012-005, Alberta Terrestrial Imaging Centre, University of Lethbridge, Lethbridge, Alberta, 6 pages.

Zhang, J., and K. Staenz. 2012. Study on impact of SNR, spatial resolution & spectral cross-talk on hyperspectral imagery for applications in agriculture, forestry & water body mapping – Noise model.

Report No. ATIC-2012-006, Alberta Terrestrial Imaging Centre, University of Lethbridge, Lethbridge, Alberta, 5 pages.

Zhang, J., and K. Staenz. 2012. Monitoring Procedure for site Reclamation in Alberta – System Design. Report No. ATIC-2012-009, Alberta Terrestrial Imaging Centre, University of Lethbridge, Lethbridge, Alberta, 23 pages.

2012 Professional Activities, Alberta Terrestrial Imaging Centre

Conferences, Workshops and Specialist Meetings

- 1st ABBY-Net Workshop on Natural Resource Management and Energy Systems under Changing Environmental Conditions, Munich, Germany
- 2nd Annual Alberta Graduate Conference – Today's Ideas, Tomorrow's Innovators, Edmonton, Alberta
- 6th Annual University of Lethbridge GSA Conference, Lethbridge, Alberta
- 10th Meeting of the EnMAP Scientific Advisory Group, Potsdam, Germany
- 24th Meeting of the Infrared Visible Optical Sensors (IVOS) Subgroup, Working Group on Calibration and Validation (WGCV), Committee on Earth Observation Satellites (CEOS), Sioux Falls, South Dakota
- 33rd Canadian Symposium on Remote Sensing, Ottawa, Ontario
- Congress of the Canadian Association of Physicists, Calgary, Alberta
- Femto-, Astro-, Spectro-Ethyne (FASE) Solvay Workshop, Brussels, Belgium
- International Geoscience and Remote Sensing Symposium (IGARSS'12), Munich, Germany
- LiDAR Workshop, Edmonton, Alberta
- PTAC/LOOKNorth Workshop on Remote Sensing for Remote-Resources - Northern and Oil Sands Development, Calgary, Alberta
- State & Trends of Canadian Grasslands Workshop, Saskatoon, Saskatchewan

Service Activities and Memberships

- Alberta Geomatics Group
- American Society of Photogrammetry and Remote Sensing
- Canadian Association of Physicists
- Canadian Institute of Forestry, Rocky Mountain Section Council member, Program and Membership Committees
- Canadian Remote Sensing Society
- Chair, Master of Science Program Committee, University of Lethbridge
- Co-Chair, IEEE International Spaceborne Imaging Spectroscopy (ISIS) Working Group
- College of Alberta Professional Foresters
- Editorial Board, *Canadian Journal of Forest Research*
- Editorial Board, *Canadian Journal of Physics*
- Editorial Board, *Canadian Journal of Remote Sensing*
- Editorial Board, *Physics in Canada*
- Editorial Board, *The Forestry Chronicle*

- Environmental Mapping and Analysis Program Scientific Advisory Group (EnSAG) for a spaceborne hyperspectral mission, German Aerospace Centre, Germany
- IEEE Geoscience and Remote Sensing Society
- NSERC Industrial R&D Fellowships College of Reviewers
- Organising Committee, 33rd Canadian Symposium on Remote Sensing
- Organising Committee, International Geoscience and Remote Sensing Symposium (IGARSS)
- Organising Committee, International Multi-Temp Workshop and Conference on the Analysis of Multi-Temporal Remote Sensing Images
- Past-President, Canadian Remote Sensing Society
- Scientific Advisory Committee (SAC), Tecterra, Canadian Networks of Centres of Excellence (NCE) and Alberta Innovates – Technology Futures
- Secretary-Treasurer of the Western Division of the Canadian Association of Geographers
- Society of Range Management
- Technical Program Committee, 33rd Canadian Symposium on Remote Sensing
- Technical Program Committee, International Multi-Temp Workshop and Conference on the Analysis of Multi-Temporal Remote Sensing Images
- Technical Program Reviewer, 2012 IEEE International Geoscience and Remote Sensing Symposium
- Vice-President, Canadian Remote Sensing Society

Courses Taught

- Advanced Remote Sensing, Geography 4725
- Cartography, Geography 3700
- Experimental Physics, Physics 5850/7850
- Field Research in Geography, Geography 3780
- Field Techniques in the Earth Sciences, Geography 3710
- Fundamentals of Physics III, Physics 2120
- Imaging Science and Technology in Today's World, Physics 2850
- Introduction to Geographical Information Science, Geography 2735
- Introduction to Physical Geography, Geography 1000
- Physics of Remote Sensing, Physics 4650
- Remote Sensing, Geography 3720
- Seminar in Remote Sensing, Geography 4753/5753
- Soils, Geography 3080
- Spatial Modelling, Geography 4751


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