ES4606B/PS9606B: Remote Sensing and Image Analysis for Earth and Planetary Science

WINTER 2024

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Class times: M 8:30-10:30 am, Th 8:30-9:30 am
Office hours: After class on Mondays (in my office)

Prerequisites (ES4606): Earth Sciences 2200A/B or Earth Sciences 2232F/G or Astronomy 2201A/B or Astronomy 2232F/G.

Prerequisites (PS9606): No specific prerequisites are required, but previous enrollment in at least one Earth Science or Planetary Science course is generally required. Please speak to the instructor if you have any concerns or are seeking an exception.

Course Objectives

The main objective of this course is to learn the technical and conceptual basis for applying remote sensing and image analysis to Earth and Planetary Science. During this course you will:

- Learn how the various wavelength ranges of the electromagnetic spectrum interact with matter, specifically pertaining to terrestrial and planetary applications (i.e., geologic processes and materials) and what their basic sensitivities and limitations are.
- Learn how to find, process, visualize, analyze and synthesize remote sensing observations for a wide variety of datasets.
- Gain practical hands-on experience in applying the learned knowledge, methods and techniques to diverse terrestrial and planetary datasets.
- Learn how to utilize software packages commonly used in remote sensing studies (e.g., ArcGIS, QGIS, etc.).

Course Description

This is a course for undergraduate and graduate students about remote sensing, image processing, and its applications in Earth and planetary science. The course will feature overview lectures on remote sensing, as well as hands-on exercises using remote sensing datasets and geological maps. Emphasis will be on the "core" remote sensing datasets, including visible to near-infrared, thermal infrared, and RADAR imagery, as well as elevation data (i.e., topography, morphometry and 3D analysis). This course is intended to provide the non-specialist with a working knowledge of the background and analytical tools needed when working with various types of remote sensing data. The labs will use software packages such as QGIS, JMARS and ArcGIS.

Course topics:

Topic 1: General introduction to Remote Sensing

- Electromagnetic radiation and matter
- Basics of remote sensing datasets
- Image basics and processing
- **Lab 1**: Image Processing Techniques: Spectral Mapping in QGIS

Topic 2: Remote Sensing: Reflectance and Emission Spectroscopy

- Introduction and Basics of Visible and Near-Infrared (VNIR) and Thermal Infrared (TIR) EM interactions with Matter
    - Atmospheric Limitations and Effects
    - Rocks and Minerals… and limitations for ID
    - Vegetation and Water
- GIS: JMARS Introduction and Tutorial
- **Lab 2**: An Introduction to CRISM: Hyperspectral Analysis of Mars from Orbit

Topic 3: Remote Sensing: Various Topics

- Uses for Thermal Infrared Data (temperature, thermal inertia, etc.)
- Introduction and Basics of Cosmic-Ray Spectroscopy
- Available multispectral sensors for the Earth and other planets
- Where to get data (both planetary and terrestrial)
- **Lab 3**: JMARS and Lunar Case Study

Topic 4: Remote sensing: RADAR

- Microwave to Radio EM Interactions with Matter
- Radar techniques: Imagery, sounding, and topography
- Target properties: Radar albedo and polarimetry
- Radar measurements of planetary bodies
- **Lab 4**: Radar remote sensing of the Earth and Moon

Topic 5: Remote sensing: Topography

- Techniques for producing topographic data sets
    - LiDAR, Stereophotogrammetry, Altimetry
- **Lab 5**: Topographic Processing Techniques: Impact Craters in ArcGIS

Course Materials

There is no assigned textbook for this course. However, the following references are recommended readings and can be used as guides during the duration of the course. Content covered in the lectures will form the basis for practical tutorials and exercises, and can be found on OWL.

- Drury, S. A. (2001). *Image interpretation in geology* (p. 304). London: Blackwell Science.
- Pieters, C. M., & Englert, P. A. (1993). *Remote geochemical analysis, elemental and mineralogical composition* (Vol. 1).
- Longley, P. A., Goodchild, M. et al. (multiple editions) *Geographic Information Systems and Science*.
- Campbell, B.A. (2002) *Radar remote sensing of planetary surfaces.*

Software:

Students are encouraged to download four software packages in advance of the class. These software packages are also available on the computers in the lab:

1. **JMARS** is a free planetary GIS package, which provides instant access to planetary data for almost every object visited by spacecraft in our Solar System. You can download JMARS from this link: https://jmars.mars.asu.edu/download. Extensive tutorials for visualizing planetary datasets, and some basic instructions on data manipulation, can be found here: https://jmars.asu.edu/jmars-tutorials.
2. **ESRI's ArcGIS** is a commercial software package that is available to all Western students. You must sign in with your Western credentials to download the program. See https://wts.uwo.ca/sitelicense/arcgis/activation.html for more information.
    a. **Important note #1:** ArcGIS is only available for the Windows operating system. If you have a Mac computer, you will need to install Parallels on your computer first (https://www.parallels.com/ca/products/desktop/trial/).
    b. **Important note #2:** The older version of ArcGIS is **ArcMap** and the newer version is **ArcGIS Pro**. You can only install ArcGIS Pro on your personal computer, but the lab computers have ArcMap installed. The labs will be taught using the ArcMap software, but it should be possible to complete them using ArcGIS Pro.
3. **QGIS** is a free GIS package, which can be installed on any operating system (Windows, Mac, Linux). I recommend downloading the Long Term Release, as it is the most stable platform (https://qgis.org/en/site/forusers/download.html).
4. **MapReady** is a freely available remote sensing toolkit made available by the Alaska Satellite Facility. It allows users to process SAR data from a variety of missions. You can download a version for Linux or Windows (https://asf.alaska.edu/how-to/data-tools/data-tools/).

Course Evaluation and Course Credit:

Undergraduate students registered in the course will be evaluated as follows:

- **Laboratory Exercises** (5 labs at 15% of the total grade) **75%**
- **In Class Quizzes** (5 quizzes; 5% each) **25%**

Graduate students registered in the course will be evaluated as follows:

- **Laboratory Exercises** (5 labs at 10% of the total grade) **50%**
- **In Class Quizzes** (5 quizzes; 5% each) **25%**
- **Individual Project** **25%**

Five assignments related to work conducted during lab time will be assigned during the course. These **Laboratory Exercises** will be due two weeks after they were assigned. At the end of the term, students may select one Laboratory Exercise to revise, and turn in for regrading. This will be due on **April 18**.

Six **In-class Quizzes** will be given throughout the semester, held every other Thursday. They will be used to determine how well you understand the material, and will serve as a random check on attendance. No make-ups are allowed, except for serious extenuating circumstances (see *Course Policies* below). However, you may drop one quiz to cover any unexpected absences. Those students who turn in all quizzes will be able to drop the quiz with the lowest score.

At the conclusion of the short course, graduate students are required to produce an **Individual Project**. Students have the freedom to pursue an independent research project that utilizes data from two different planetary objects. The results of this project will be presented as a scientific poster, following the specifications outlined for the Lunar and Planetary Science Conference:

https://www.hou.usra.edu/meetings/lpsc2023/poster-presenters/

The requirements for the project are relatively open-ended, but must include:

1. Data from (at least) two different objects in the solar system.
2. Data from (at least) two different wavelength regions in the electromagnetic spectrum (i.e., UV, Visible, Infrared, TIR, RADAR, etc.).
3. Use of (at least) one of the software packages we learned in the course (ArcGIS, QGIS, and/or JMARS) for all or part of your methodology.

I recommend reading this article about how to design an effective scientific poster:

https://www.planetary.org/articles/design-sci-poster

Students must upload a one paragraph project proposal to OWL by **February 8**. The final poster must be uploaded to OWL by **April 1**, and will be presented in class on **April 1 or 4**. The project will be graded in the following manner:

▪ Project proposal	5 pts
▪ Adherence to project requirements	2 pts
▪ Scientific justification	12 pts
▪ Description of methodology	10 pts
▪ Visual appeal	5 pts
▪ Grammar and style	5 pts
▪ References	1 pt
▪ **Total**	**40 pts**

Special NOTES on course credit:

If you are a Western student who seeks permission to take this graduate level course (*i.e., its outside your major/program),* you will need to fill out this form to get the relevant approvals to receive a grade in the course:
https://grad.uwo.ca/doc/academic_services/course/course_outside_program.pdf

Course Policies:

Contingency Plan:

Although the intent is for this course to be delivered in person, should any university-declared emergency require some or all of the course to be delivered online, either synchronously or asynchronously, the course will adapt accordingly. The grading scheme will not change. Any assessments affected will be conducted online as determined by the course instructor.

Student Absences:

If you are unable to meet a course requirement due to illness or other serious circumstances, please follow the procedures below.

Assessments worth less than 10% of the overall course grade: Please contact the course instructor to discuss an extension or make-up opportunity.

Assessments worth 10% or more of the overall course grade: For work totalling 10% or more of the final course grade, you must provide valid medical or supporting documentation to the Academic Counselling Office of your Faculty of Registration as soon as possible. For further information, please consult the University's medical illness policy at

https://uwo.ca/univsec/pdf/academic_policies/appeals/academic_consideration.pdf

The Student Medical Certificate is available at

https://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf

After receiving the documentation, students will be eligible for an extension or make-up opportunity.

Accommodation and Accessibility:

Religious Accommodation: When a course requirement conflicts with a religious holiday that requires an absence from the University or prohibits certain activities, students should request accommodation for their absence in writing at least two weeks prior to the holiday to the course instructor and/or the Academic Counselling office of their Faculty of Registration. Please consult University's list of recognized religious holidays (updated annually) at

https://multiculturalcalendar.com/ecal/index.php?s=c-univwo.

Accommodation Policies: Students with disabilities are encouraged to contact Accessible Education, which provides recommendations for accommodation based on medical documentation or psychological and cognitive testing. The policy on Academic Accommodation for Students with Disabilities can be found at:

https://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic Accommodation_disabilities.pdf.

Please contact the course instructor if you require lecture or printed material in an alternate format or if any other arrangements can make this course more accessible to you.

Academic Policies:

Academic Honesty: Scholastic offences are taken seriously, and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at the following Web site:

http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf.

Students must write their assignments in their own words. Whenever students take an idea, or a passage from another author, they must acknowledge this both by using quotation marks where appropriate and by proper referencing such as footnotes or citations. Plagiarism is a major academic offence. APA style is the approved style of writing for all assignments produced for this course. Please refer to the University of Western Ontario Library webpage for information on citation style and format or consult the APA publication manual: Publication manual of the American Psychological Association (6th ed.). (2009). Washington, DC: American Psychological Association.

Classroom Behaviour: Disruptive behavior will not be tolerated in class or on the course website. Please respect the rights of your classmates to benefit from the lecture by limiting your conversations to those essential to the class. Students who persist in loud, rude or otherwise disruptive behavior will be asked to leave. Cellular phones, pagers, and text-messaging devices are not to be used in class and must be placed in silent mode. Laptops for the purpose of typing lecture notes are permitted in class, but please be respectful to your fellow students and turn the sound off. Audio and/or videotaping of lectures is not permitted unless approval has been sought from the instructor in advance.