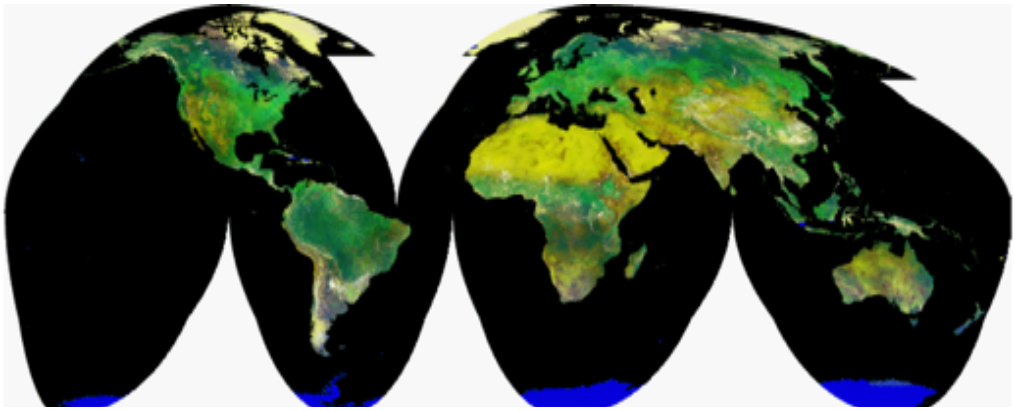
GEOG / ENVI 362: REMOTE SENSING OF THE ENVIRONMENT



A red± green composite of NDVI's annual range (red) and maximum (green) (Gutman, G., & A. Ignatov 1998).

Spring 2024

Hello and welcome!

I'm Dr. Xavier Haro-Carrión (he / him; you can call me Xavier if you wish), your course instructor, who is eager to help you understand some fundamental knowledge of Remote Sensing!

Email me at
xharocar@macalester.edu
Visit me in **CARN 104F**

Your TA will be Parker Summers
Email him at
psummers@macalester.edu

Course learning outcomes

- Understand the basic concepts, analytical methods and software of satellite remote sensing.
- Apply basic remote sensing and image processing techniques to enhance, analyze and extract information from imagery.
- Analyze environmental systems using satellite remote sensing data and the software Erdas Imagine.
- Implement methods presented in peer-reviewed and technical literature and generally be independent researchers and technicians with beginning expertise in remote sensing analysis.

Prerequisites

Basic knowledge of spatial data is desirable.

Course Description

This course introduces the use of remotely sensed data for research. Remote sensing is the science of acquiring information about Earth's surface without actual contact with the object or area being analyzed. Remote sensing is increasingly utilized and relied upon to solve complex physical, biological and social issues affecting our interconnected world. Most biophysical applications of remote sensing use instruments carried on satellites. In this course, we will focus on the interpretation and application of data from space-borne imaging systems (e.g.: Landsat OLI, Landsat ETM, Quickbird, MODIS, AVHRR and SPOT) with a brief introduction to unmanned aerial vehicles (UAVs). Focus will be given to the application of remote sensing data to environmental applications, but other topics will be covered when students work on their projects.

Meeting times and office hours

Time	Monday	Tuesday	Wednesday	Thursday	Friday
08:30-09:30		In CARN 109			
09:30-10:30					
10:50-11:50					
2:00 – 4:00					

	Class times
	Instructor Office hours
	TA Office hours

Textbooks

Jensen, J. 2015. Introductory Digital Image Processing: A Remote Sensing Perspective. 4th Edition. Pearson Publishing. 656 pp

The above book will be used as a main support textbook. It is available as an eTextBook (for rent or purchase) for a lower price than the hardcopy edition. We have two physical copies, one at the Department of Geography and one in the library.

These are other texts that I recommend. I have copies available. Particularly, if you feel like Jensen sometimes is too technical, I recommend Lillesand, which has a clearer language.

Jensen, J. 2006. Remote Sensing of the Environment: An Earth Resource Perspective. 2nd Edition. Pearson Publishing. 592 pp.

Lillesan, T.M. 2015. Remote Sensing and Image Interpretation. 7th Edition. Wiley Publishing. 720 pp.

In addition to these books, research papers and websites of specific topics are listed in the detailed weekly schedule at the end of this syllabus.

Course Details

Structure

Throughout the semester, I will use various teaching approaches. While lectures will be prominent due to the content, some classes will follow a "flipped-classroom model," where students will interact with the material before class. At times, a "blended-learning model" will be applied, integrating pre-provided material with in-class lectures. Your feedback on the teaching techniques that you find most beneficial and engaging is encouraged as the semester unfolds!

Labs

Lab time will be dedicated to demonstrating remote sensing analysis and applications using ERDAS IMAGINE and other geography software. Lab manuals will be provided for each lab class, and lab reports are expected the week following a lab session. Most labs will necessitate additional time beyond the class period.

At least one lab will involve short field visits to collect data in the areas around Saint Paul and Minneapolis. For this lab, students should anticipate staying after hours during one or more class periods or having a weekend day available for fieldwork. Further details will be provided as fieldwork locations are defined. For fieldwork, students will need approximately 50 MB of data on their smartphones to download and operate a data-collecting app. GPS and printed copies of data-collecting sheets will be available for students without smartphones. Additional details about a field lab will be provided as the semester progresses.

All lab materials will already be accessible on the GIS drive. It is HIGHLY RECOMMENDED that you save the original data and intermediate steps in a cloud storage unit of your choice, such as the H drive or Google Drive. You can also use this drive to store the material you need to download for your personal research projects.

Labs will typically be due before the next lab session.

Class Activities

Some classes will include associated activities/exercises like exit tickets, opening questions, summaries of previous classes, paper discussions, and quizzes on previous topics. These activities aim to continuously review class content, foster class participation, build a sense of community, and maintain a connection and commitment to one another.

Exams

A midterm exam will consist of short answers, essays, figure interpretation, and applied problem-solving questions. It will be an in-class, closed-notes assessment, covering all topics studied up to that point in the semester. The purpose is to evaluate your knowledge and develop soft skills, such as the ability to work under time-limited and potentially stressful scenarios. People respond differently to these circumstances, and I am open to considering options to make the exam-taking experience as comfortable as possible, including scheduling exams outside of class in the Max Center or adjusting proposed exam dates to better accommodate other academic commitments.

The final exam will be take-home, open-notes, but individual. It will mainly focus on the application of remote sensing analysis to real-world scenarios or problems, encompassing all class topics.

Research Project
Throughout the semester, students will embark on a research project of their choice. The goal is to apply learned techniques to address a research question that aligns with their personal interests. In the first half of the semester, we will collaborate to define a suitable and feasible research question for a class project. Students will then choose and acquire the most appropriate data (such as imagery) to address this question, along with selecting the best methodological approach. The final results will be presented orally at the end of the semester. Past student projects are available on the Remote Sensing Webpage of the Department of Geography. I encourage you to explore these projects, ask questions about them from the first day of class, and even reach out to former students for more insights.

NOTE: Students who decide to present their projects in the Midwest Undergraduate Geography Symposium (MUGS) will automatically earn 100% in their research project assignment. However, it is still expected that all students will present their project in class.

Course policies and support

Resources
All course materials, including lecture slides, readings and book chapters, will be accessible on Moodle. We will utilize Module for submitting assignments that fall outside our regular class schedule, as well as for grade tracking purposes.

Artificial Intelligence (AI)
In the field of remote sensing, artificial intelligence (AI) has significantly contributed to faster, more accurate, and generally more efficient satellite imagery analysis. While we will primarily use software in this course, students are welcome to explore the use of AI for satellite image analysis. AI is also acceptable for checking grammar and proofreading, as long as the content reflects the student's ideas. It can also be utilized as a translation tool to facilitate comprehension and communication in English. However, caution is suggested for other uses, such as retrieving concepts, case studies, and answering application questions entirely. I strongly recommend against the use of AI to search for information within the scientific literature or generate complete discussions that must be supported by the scientific literature. Instead, use search engines (e.g., Google Scholar).

Attendance
You're warmly invited and encouraged to attend all classes, as attendance is key to our learning journey. Your participation in in-class activities is essential, and these are generally unalterable. Yet, exceptions for academic/sports commitments, illness, or special circumstances can be considered. If religious observances create conflicts, kindly reach out

within the first two weeks of class for possible solutions. Your engagement enriches our shared experience!

Late Assignments
Late assignments will be accepted, but there will be a 10% reduction in the final grade for each 24-hour period they are overdue. If you encounter any difficulties that might necessitate adjustments to this policy, please feel free to discuss them with me.

Office Hours
I will maintain regular office hours to delve into any questions, issues or concerns about the course or your experience as first-year students. If your schedule clashes with the posted office hours, we can coordinate an alternative meeting time. Beyond the designated office hours, feel free to contact me via email. I strive to respond promptly, mostly during work hours (8:00 am to 4:00 pm on weekdays).

Diversity
I recognize that the scientific content in this course has historically been shaped by a limited subset of privileged perspectives, potentially leading to both overt and covert biases. To achieve a more comprehensive understanding of science, I am committed to actively diversifying the range of voices and experiences integrated into the curriculum. Beyond course materials, I am dedicated to cultivating an inclusive learning environment that respects your unique identities, encompassing factors like race, gender, class, nationality, and religion. Your feedback is essential in this endeavor. Please don't hesitate to share suggestions for enriching course materials, promoting diversity, and enhancing inclusivity, either through direct communication or anonymous feedback.

Disabilities
I am dedicated to providing all students, including those with disabilities, equal access to course content. If you are facing obstacles that we can address, please let me know. I'm eager to collaborate with you to ensure your success in the course.
For students with documented disabilities, reasonable accommodations are available. To discuss your individual needs, please reach out to the Disability Services office via email at disabilityservices@macalester.edu or by calling 651-696-6874 to schedule an appointment to discuss your individual needs.

Well-Being
At Macalester, valuing your well-being is paramount. By dedicating time to self-care, you'll enrich your academic experience. Remember, you're more than a student – you carry your own experiences, emotions, and identities. Acknowledge any stressors you face, whether mental, emotional, physical, or financial, and understand their potential academic impact. Recognize your body's needs. During class, stay hydrated, take breaks as needed, and prioritize emotional well-being. Beyond class, prioritize sleep, movement, and connections with peers to foster resilience at Macalester. If well-being challenges arise, feel free to contact me or explore support resources here.

Academic Support
You can access personalized tutoring, academic support, and study skills assistance through Macalester Academic Excellence (MAX). These resources are designed to aid you, and I strongly urge you to utilize them.

Academic Integrity
Students are required to independently complete and submit their own work, adhering to established academic conventions for appropriately using and citing external materials and ideas. Participating in cheating or plagiarism will lead to a failing grade for the course. Further details about Macalester's academic integrity can be accessed here. I recommend thoroughly reviewing this information.

Public Health
If you do not feel well, please do not come to class. When we're on campus for class, we will be following the Mac Stays Safer Community Commitment.

Title IX
Macalester prioritizes a secure and inclusive environment for all. Those experiencing sexual harassment, violence, or stalking are encouraged to seek help. As faculty, I must report such disclosures to the Title IX Office to ensure support. Rest assured, your privacy is respected, and the report is confidential. You can contact Macalester's Title IX Coordinator directly at titleixcordinator@macalester.edu.

Grading

Assignment	Points
Laboratory Exercises	40% (averaged)
Midterm Exam	15%
Student Project	20%
Class Activities and Class Participation	10% (averaged)
Final Exam	15%

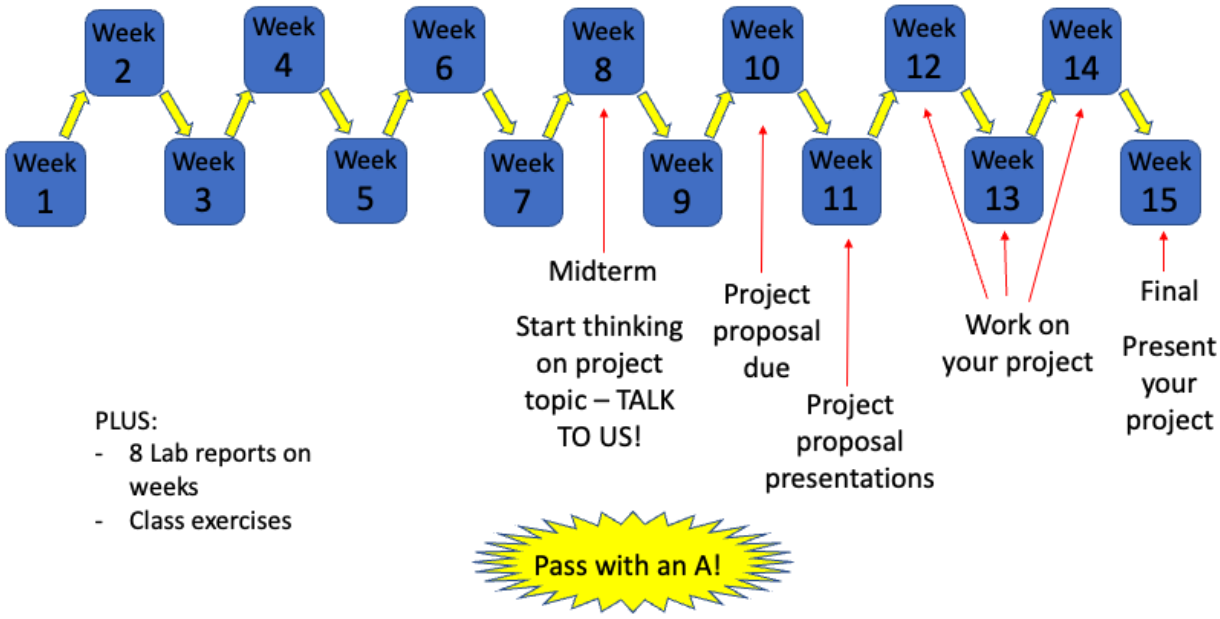
Scale Letter	Range
A	93.0% to 100 %
A-	90.0% to < 93.0 %
B+	87.0% to < 90.0 %
B	83.0% to < 87.0 %
B-	80.0% to < 83.0 %
C+	77.0% to < 80.0 %

C	73.0% to < 77.0 %
C-	70.0% to < 73.0 %
D+	67.0% to < 70.0 %
D	63.0% to < 67.0 %
D-	60.0% to < 63.0 %
F	0.0% to < 60.0 %

Detailed Weekly Schedule

Disclaimer: This schedule represents my current plan and objectives. Details about pre-class assignments, readings and specific dates might be added / adjusted as we progress in the semester with the goal of enhancing your learning experience.

At glance, key milestones:



Week 1: Welcome
January 18

Learning outcome: Welcome! This week we will understand what this class is about and get to know each other.

- **Thursday.** Course Introductions. Come to class having read the following:

  Haro-Carrión, X. 2024. Remote Sensing of the Environment Syllabus Spring 2024

Week 2: Introduction and Foundations of Remote Sensing I
January 23 and 25

Learning outcome: Learn about remote sensing history and start becoming familiar with the software Erdas Imagine.

- **Tuesday.** Lecture: Remote sensing history. No readings.
- **Thursday.** Lab 1: Introduction to Erdas Image and Map Composition.

Week 3: Introduction and Foundations of Remote Sensing II
January 30 and February 1

Learning outcome: Understand basic principles of electromagnetic theory as the foundational principles of remote sensing research. Continue learning about basic functions of Erdas Imagine.

- **Tuesday.** Lecture: Electromagnetic Theory and Imagery Discussion. To prepare for this class, you will be assigned an image from Jensen as a pre-class activity. More details through Moodle as this date approaches.
- **Thursday.** Lab 2: Image Interpretation, Analysis and Display

  Due: Lab 1: Introduction to Erdas Image and Map Composition Report.

Week 4: Sensor characteristics
February 6 and 8

Learning outcome: Learn about sensors and sensor resolutions. We will also start a lab that has a field and computer components that we will finish later in the semester. We'll start by doing the computer-based part.

- **Tuesday.** Lecture and Discussion: Sensors and Resolutions

  Presentation: Landsat (Xavier)
- **Thursday.** Lab 6: Training Data Collection Part A (Google Earth Pro)

  Due: Lab 2: Image Interpretation, Analysis and Display report.

Week 5: Color Composite Theory & Sensors
February 13 and 15

Learning outcome: Understand color composite theory and how it is used in remote sensing to display images. Students will start presentations on different sensors. We will review examples and applications of remote sensing research.

- **Tuesday.** Lecture: Color Models and Composite Imagery.

  Student presentations: sensors 1 and 2

- **Thursday.** Discussion: Applications of Remote Sensing. To prepare for this class, listen to the Podcasts posted in Moodle.
  Student presentations: sensors 3 and 4
  Due: Kml of Lab6 Part A.

Week 6: Image Transformation & Sensors
February 20 and 22

Learning outcome: Students will continue presentations on different sensors. We will explore the use of vegetation indices, image transformation and spectral enhancements in remote sensing analysis.

- **Tuesday.** Lecture and Discussion: Spectral Enhancements and Vegetation Indices.

  Student presentations: sensors 5 and 6

- **Thursday.** Lab 3: Spectral Enhancement, Image Indices and Image Transformations**.**

Week 7: Classification Analysis
February 27 and 29

Learning outcome: Understand what is considered probably the "flag" topic of remote sensing, we will learn image classification!

- **Tuesday.** Lecture: Image transformations and classification analysis.

  Student presentations: sensors 7, 8 and 9

- **Thursday.** Lab 4: Image Classification.
  Due: Lab 3: Spectral Enhancement, Image Indices and Image Transformations Report.

Week 8: Change Detection and MIDTERM
March 5 and 7

Learning outcome: Considered also a "flag ship" of remote sensing, we will learn about change detection or land-cover change analysis.
We will also test our knowledge of the topics studied in class until this point.

- **Tuesday.** Lecture: Land-cover change.
  Q & A in preparation for the midterm.

Research Project conversation. Think about research ideas for your project. Come ready to share in very general terms what you would like to do, ask questions about feasibility, etc.

- **Thursday.** MIDTERM EXAM.
  Due: Lab 4: Image Classification Report.

Week 9: Spring Break
March 12 and 14

Learning outcome: Appreciate the importance of taking a break, enjoying doing things outside of academic commitments and taking care of yourself. Enjoy the break!

Week 10: Classification and Accuracy Assessments
March 19 and 21

Learning outcome: Learn about accuracy assessment and some additional classification approaches.

- **Tuesday.** Lecture: Fuzzy Classification and Accuracy Assessments.
- **Thursday.** Lab 5: Change detection and Introduction to Spatial Modeler
  Due: Project Proposals.

Week 11: Student Project & Landscape Ecology and Remote Sensing
March 26 and 28

Learning outcome: Remote sensing has direct applications in many other fields. This week we will study the applications of remote sensing in landscape ecology as an example. We will also provide feedback to each other's project proposals with the purpose of making them better.

- **Tuesday:** Lecture and case-studies: landscape ecology and remote sensing. Introductions to Unmanned aerial vehicles (UAVs)
  Due: Project Proposal Peer-reviews
- **Thursday.** Project Proposal Presentations
  Due: Lab 5. Change detection and Introduction to Spatial Modeler Report.

Week 12: Project work and Unmanned aerial vehicles (UAVs)
April 2 and 4

Learning outcome: Start our personal projects. We will also explore the use of unmanned aerial vehicles (UAVs) for remote sensing research.

- **Tuesday.** Lab 8. Unmanned aerial vehicles (UAVs) (This is a field lab)
- **Thursday.** Project work.

Week 13: Training Data Collection and Accuracy Assessments
April 9 and 11

Learning outcome: Learn about field techniques to collect training data. Reinforce the concepts previously learned in lecture about accuracy assessment with a lab.

- **Tuesday.** Lab 6: Training Data Collection Part B (This is field lab)
  Due: Lab 8. Unmanned aerial vehicles (UAV) Report.
- **Thursday.** Lab 7. Accuracy Assessment.
  Due: Lab 6: Training Data Collection Report.

Week 14: Project work
April 16 and 18

Learning outcome: We'll finalize our projects.

- **Tuesday.** Project work.
- **Thursday.** Project work.

Week 15: Project Presentations and What's Next?
April 23, 25, and 27

Learning outcome: The End! This week we will apply all knowledge acquired during the semester into solving social / environmental problems in the Final. We will learn about each other's projects and about opportunities to continue studying in remote sensing research at Macalester.

- **Tuesday.** Short Introduction to Advance Remote Sensing Analysis

  Project presentations.
- **Thursday.** Project presentations.

  Final exam (take-home) is released.
  Course Evaluations.
  Due: Lab 7: Accuracy Assessments.
- **Saturday.** Midwestern Undergraduate Geography Symposium (MUGS). Gain valuable experience presenting at conferences. Present your RS project at this conference and earn 100% in the project grade.