GEOS F659: Visible and Infrared Remote Sensing

Spring 2022, 3 credits
In person or online synchronous
Lecture: Mon/Wed 2:00-3:00, room: WRRB 004/online
Lab: Mon/Wed 3:00-4:30, room: WRRB 004/online

Instructor: Dr. Simon Zwieback
Office: WRRB 106C
Email: szwieback@alaska.edu
Office Hours: TBA, or by appointment

Course Description

The course covers the principles and practice of remote sensing in the visible and infrared region, including spectral signatures, radiative transfer, image analysis, and information extraction. The laboratory part provides hands-on experience with multispectral, thermal, hyperspectral, and LiDAR data sets. Practical examples are drawn from geology, hydrology, and forestry.

Pre-requisites

Graduate standing. A basic remote sensing class, such as Geoscience Applications of Remote Sensing (GEOS 422, is recommended. Basic data analytical skills (e.g., regression analysis) are required, but no programming experience is expected.

Course Content

The first half of the course introduces the physical principles of remote sensing in the visible and infrared region. We will cover the electromagnetic spectrum, radiation laws and radiative transfer. We will learn how the interaction of radiation with the atmosphere influences remote sensing observations and how the influence of the atmosphere can be corrected for to characterize the land surface and the ocean.
In the second half of the course, we will extract quantitative information from remote sensing observations. Examples include the estimation of surface temperatures, mineral composition, vegetation characteristics and water quality parameters. We will cover a wide range of observational modalities in the visible and infrared region, including multispectral data such as those provided by the Landsat satellite program; hyperspectral observations; and light detection and ranging (LiDAR) data.

Student Learning Outcomes

After completing the course, you will be able to

- Make quantitative predictions of electromagnetic radiation using radiometric concepts and radiation laws
- Contrast spectral signatures and identify the underlying physical phenomena
- Perform and appraise atmospheric corrections of visible and infrared remote sensing observations
- Independently identify suitable remote sensing techniques, data, and algorithms to answer a given geoscientific question
- Extract information from remote sensing data using state-of-the-art analysis techniques and assess the quality of the results

In contrast to the undergraduate students, graduate students are expected to answer applied research questions with limited supervision, to solve challenging quantitative problems and to transfer the learned material to novel situations. In particular, graduate students will

- Design remote sensing solutions (from data acquisition to data analysis workflows) for specific geoscientific problems

Course Readings/Materials

Textbooks:

- Gupta, R. V, Remote Sensing, Third Edition, Springer-Verlag Berlin Heidelberg, 2018. (Recommended)
- Manolakis, D. G., Lockwood, R. B., Cooley, T. W., Hyperspectral Imaging Remote Sensing | Physics, Sensors, and Algorithms, Cambridge University Press, 2016.

Journal Articles:

Additional readings will be posted on blackboard. They will predominantly be drawn from peer-reviewed remote sensing journals such as Remote Sensing of Environment, International Journal of Applied Earth Observation and Geoinformation, and Science of Remote Sensing.

Software

All necessary software tools will be available through the computing facilities of the remote sensing computer lab in WRRB 004 or via the university's Virtual Private Network (VPN). Upon request, you will be provided with swipe card access to WRRB 004.

Instructional Methods

Lecture and lab: The course comprises 2 hours of lecture and 3 hours of lab each week. Distance students will be able to join remotely via Zoom. The lectures will be partly interactive, including group-based image analyses and discussions. Participation in the discussions is required. The labs will focus on remote sensing data processing and analysis using software packages such as ENVI. Lectures and labs will be online synchronous for distance delivery.

Assignments: Students will complete (approximately) bi-weekly homework assignments. The graduate-level assignments of the class are distinct from the undergraduate-level assignments in this stacked class. Only the graduate-level assignments include questions that require independent research or a deep understanding of physical or mathematical concepts.

Project: Graduate students will conduct an individual term project. The students will independently decide on the problem, objectives, methods and data of their projects. The only requirements are that the project relate to visible and infrared remote sensing, and that it comprise a data analysis component, to be conducted independently and specifically for this course. The outcomes will be presented at the end of the semester in a poster session. The student is expected to:

- Identify relevant literature and summarize the underlying principles and defining characteristics
- Present a compelling rationale
- Design a remote sensing solution to the problem
- Analyze and interpret remote sensing data to achieve their objectives
- Appraise the strengths and limitations of their approach

Evaluation

There will be five assignments every two to three weeks throughout the semester. The assignment with the lowest score will be dropped. All assignments are closely aligned with the learning outcomes, allowing the student to build a broad skill set in remote sensing data processing, analysis, and interpretation.
Participation credit will be based on the quality and frequency of the student's contribution to discussions in class and on the discussion board and on the quality and quantitative of the feedback and assistance provided to other students. The graduate students are encouraged to proactively and constructively support their undergraduate peers. Attendance is not a sufficient for a student to receive participation credit. A rubric is provided below.
Evaluation of the project poster will be based on the design and clarity of the poster, the rationale, the remote sensing analysis, the critical appraisal, and the question and answer session. A rubric is provided below.

Rubrics

The project poster and associated Q&A session will be evaluated based on the following criteria:

	Exemplary	**Good**	**Fair**	**Poor**
Design and clarity (20%)	Logical organization with clearly defined sections. Visually appealing presentation. Compelling and effective use of figures.	Poster conveys the key points but effort is required to follow the presentation. Figures convey information but are incomplete or unintuitive.	Substantial effort is required to .understand the poster Text and figures are intelligible but difficult to read.	Lacks organization. Text and figures are very hard to read or incomprehensible. Inappropriate or no figures.

Rationale (15%)	Compelling rationale with clearly defined knowledge gap and objectives. Claims backed up by comprehensive evidence.	Rationale is clear and easy to follow but lacks depth. Claims backed up by evidence.	A rationale is provided, but it is difficult to follow, incomplete or partially based on erroneous reasoning.	Rationale is very hard to follow or contains multiple major errors or omissions.
Remote sensing analysis (25%)	Remote sensing solution is rigorous and addresses the problem. Analysis and interpretation are correct and compellingly presented.	Remote sensing solution is useful but contains minor flaws. Analysis and interpretation are mostly appropriate.	Remote sensing solution partially addresses the problem. Analysis and interpretation provide insight but contain errors or lack clarity.	Remote sensing solution is not relevant or appropriate Analysis and interpretation contain major conceptual or statistical errors.
Critical appraisal (20%)	Identifies at least three strengths or limitations. Cogent appraisal based on theory or empirical evidence.	Identifies at least two strengths or limitations. Appraisal is logical and some evidence is provided.	Identifies at least one strength or limitation. Appraisal is difficult to follow or makes limited use of evidence.	Appraisal does not present a logical argument.
Q&A session (20%)	Student provides clear and correct answers Student can give a detailed account that goes beyond the presented material.	Student answers most questions correctly. Student can provide some additional information beyond the presented material.	Student can provide satisfactory answers to some of the questions.	Student does not provide satisfactory answers to the questions.

Participation credit will be allocated based on the following rubric:

	Exemplary	**Good**	**Fair**	**Poor**
Contribution to discussions (70%)	Proactively and frequently participates in discussions.	Regularly and voluntarily participates in discussions.	Rarely contributes to discussions, even when prompted.	Almost never contributes to discussions.

	Initiates discussions and poses thoughtful questions. Makes at least 6 relevant in-depth contributions in class or on the discussion board.	Contributions reveal familiarity with the material. Makes at least 4 relevant in-depth contributions in class or on the discussion board.	Contributions are related to the topic but superficial. Makes at least 2 relevant in-depth contributions in class or on the discussion board.	Contributions are off-topic or distracting. Makes fewer than 2 relevant in-depth contributions in class or on the discussion board.
Support and feedback to peers (30%)	Proactively and regularly assists peers in the labs. Provides at least three constructive suggestions to other students' questions on the discussion board or posters.	Occasionally assists peers in the labs. Provides at least two constructive suggestions to other students' questions on the discussion board or posters.	Rarely assists peers in the labs. Provides at least one constructive suggestion to other students' questions on the discussion board or posters.	Never assists peers in the labs. Does not provide constructive suggestions to other students' questions on the discussion board or posters.

Grading

The course grade will be a weighted average of the absolute scores obtained in:

- Assignments: 52% (the assignment with the lowest score will be dropped)
- Participation: 10%
- Project poster: 38%

The final weighted scores (in percent) will be translated to letter grades (with +/-) as follows:

A+ = 97-100% A = 93-96% A– = 90-92%
B+ = 87-89% B = 83-86% B– = 80-82%
C+ = 77-79% C = 73-76% C– = 70-72%
D+ = 67-69% D = 63-66% D– = 60-62%
F = 60% or below

I follow the University of Alaska Fairbanks Incomplete Grade Policy, which states that the letter "I" (Incomplete) is a temporary grade used to indicate that the student has satisfactorily completed (C or better) the majority of work in a course but for personal

reasons beyond the students control, such as sickness, has not been able to complete the course during the regular semester. Negligence or indifference are not acceptable reasons for an ”I" grade.

Course policies

Attendance: All students are expected to attend and participate in all classes and labs. Active participation in class (e.g., group discussions) forms part of the grade. Should reasons emerge that prevent a course participant from attending a lecture or lab, they should consult with the instructor in advance.
Late submission: Unless arrangements are made with the instructor prior to the due date, work that is submitted late will be penalized 10% per day past the deadline.
Independent work: Students are welcome to discuss the assignments with one another. However, the write-up must be individual work. The poster needs to be based on independent work.

Tentative course calendar

Week	Topics	Labs	Due
1	Overview and recap	Remote sensing images	
2	Physical principles	Physical principles (GA1)	
3	Spectral signatures and reflectance	Field spectroscopy (GA2)	
4	Radiative transfer and atmosphere	Corrections	GA1
5	Multispectral remote sensing	Image interpretation	
6	Multispectral image analysis	Spectral indices (GA3)	GA2
7	Thermal remote sensing	Vegetation stress	
8	Hyperspectral remote sensing	Hyperspectral for mineral exploration (GA4)	GA3
9	Spring Break		
10	Hyperspectral processing	Hyperspectral processing (G5)	GA4
11	Principles of LiDAR	LiDAR point clouds	
12	Profiling LiDAR	LiDAR forest structure	GA5
13	Solar-induced fluorescence	Solar-induced fluorescence	
14	Project work		
15	Poster presentations		Poster

GA1–GA5 are the graduate assignments.

COVID-19 statement

Students should keep up-to-date on the university's policies, practices, and mandates related to COVID-19 by regularly checking this website: https://sites.google.com/alaska.edu/coronavirus/uaf?authuser=0
Further, students are expected to adhere to the university's policies, practices, and mandates and are subject to disciplinary actions if they do not comply.

Student protections statement

UAF embraces and grows a culture of respect, diversity, inclusion, and caring. Students at this university are protected against sexual harassment and discrimination (Title IX). Faculty members are designated as responsible employees which means they are required to report sexual misconduct. Graduate teaching assistants do not share the same reporting obligations. For more information on your rights as a student and the resources available to you to resolve problems, please go to the following site: https://catalog.uaf.edu/academics-regulations/students-rights-responsibilities/.

Disability services statement

I will work with the Office of Disability Services to provide reasonable accommodation to students with disabilities.

Student Academic Support

Speaking Center (907-474-5470, uaf-speakingcenter@alaska.edu, Gruening 507)
Writing Center (907-474-5314, uaf-writing-center@alaska.edu, Gruening 8th floor)
UAF Math Services, uafmathstatlab@gmail.com, Chapman Building (for math fee paying students only)
Developmental Math Lab, Gruening 406
The Debbie Moses Learning Center at CTC (907-455-2860, 604 Barnette St, Room 120, https://www.ctc.uaf.edu/student-services/student-success-center/)
For more information and resources, please see the Academic Advising Resource List (https://www.uaf.edu/advising/lr/SKM_364e19011717281.pdf)

Student Resources

Disability Services (907-474-5655, uaf-disability-services@alaska.edu, Whitaker 208)
Student Health & Counseling [6 free counseling sessions] (907-474-7043, https://www.uaf.edu/chc/appointments.php, Whitaker 203)
Center for Student Rights and Responsibilities (907-474-7317, uaf-studentrights@alaska.edu, Eielson 110)
Associated Students of the University of Alaska Fairbanks (ASUAF) or ASUAF Student Government (907-474-7355, asuaf.office@alaska.edu, Wood Center 119)

Nondiscrimination statement

The University of Alaska is an affirmative action/equal opportunity employer and educational institution. The University of Alaska does not discriminate on the basis of race, religion, color, national origin, citizenship, age, sex, physical or mental disability, status as a protected veteran, marital status, changes in marital status, pregnancy, childbirth or related medical conditions, parenthood, sexual orientation, gender identity, political affiliation or belief, genetic information, or other legally protected status. The University's commitment to nondiscrimination, including against sex discrimination, applies to students, employees, and applicants for admission and employment. Contact information, applicable laws, and complaint procedures are included on UA's statement of nondiscrimination available at www.alaska.edu/nondiscrimination. For more information, contact:

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