Geography 5120/6120 Advanced Optical Remote Sensing

Tuesday and Thursday, 10:45-12:05pm

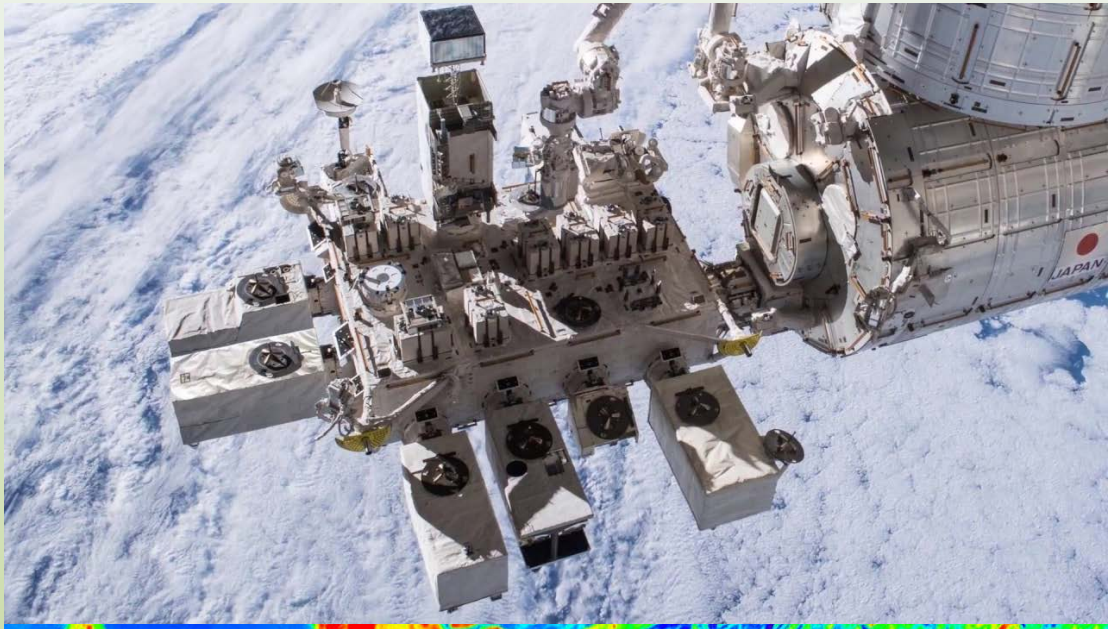
Instructor: Dr. Phil Dennison, dennison@geog.utah.edu

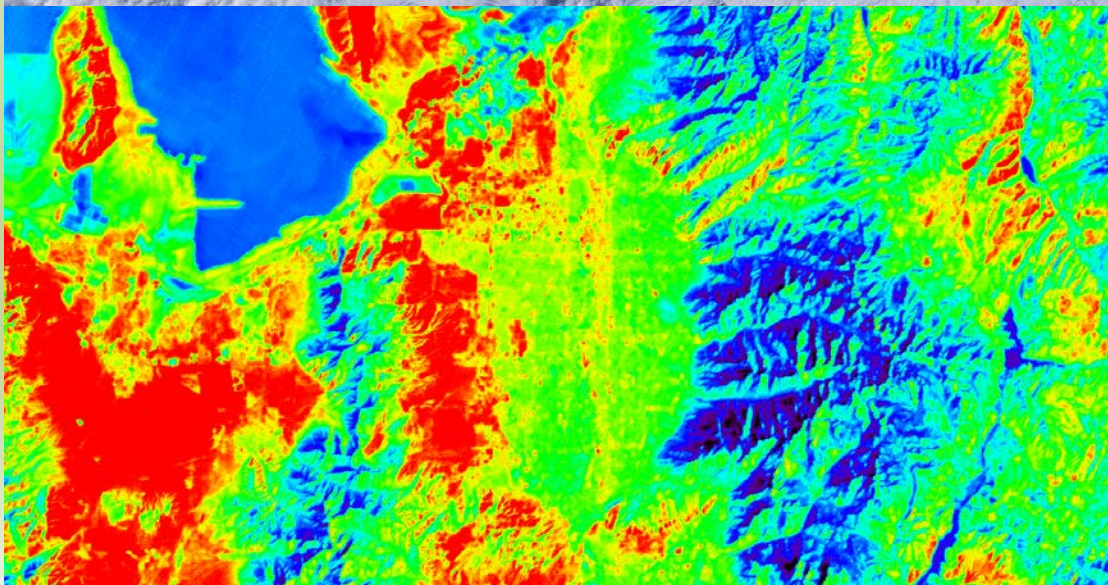
This course covers remote sensing theory that determines how light and matter interact, and also covers advanced visible, near IR, thermal IR, and hyperspectral remote sensing techniques. Course topics include:

- The Electromagnetic Spectrum
- Reflection, Refraction, Absorption and Transmission of Light
- Modeling Transmission of Light through the Atmosphere (Radiative Transfer)
- Hyperspectral remote sensing techniques like spectral mixture analysis and partial least squares regression
- Thermal infrared remote sensing theory and techniques

Quantitative labs make measurements that demonstrate remote sensing theory, which will be applied to state-of-the-art data from aircraft and satellites. This class is perfect for students who want to the opportunity to learn advanced remote sensing techniques and who are curious about how remote sensing really works.

Course syllabus is on following pages...





Syllabus
Advanced Optical Remote Sensing
Geography 5120/6120, Fall 2019

Instructor: Dr. Phil Dennison
Class Time and Location: Tuesday and Thursday, 10:45am-12:05pm
Office Hours: Tuesday and Thursday, 12:05-1:35pm, or by appointment
Office: Gardner Commons Rm 4848
Office Phone: 801-585-1805
E-mail: dennison@geog.utah.edu

Course Description
Optical remote sensing uses reflected sunlight and emitted thermal infrared radiation to measure the Earth's surface and atmosphere. This course covers remote sensing theory that determines how light and matter interact. It also investigates applications of visible, near IR, thermal IR, and hyperspectral remotely sensed data. Quantitative labs make measurements that demonstrate remote sensing theory, and also work with state-of-the-art data from aircraft and satellites. Topics include modeling absorption and emission of electromagnetic radiation, directional reflectance, spectroscopy, and hyperspectral remote sensing techniques. This class is perfect for students who want to the opportunity to learn advanced remote sensing techniques and who are curious about how remote sensing really works.

Learning Outcomes
- Verbally and mathematically describe interactions between electromagnetic radiation and matter.
- Integrate conceptual and mathematical descriptions of interactions with remote sensing applications.
- Calculate radiometric unit conversions, Lambert's Law, Planck's Equation, and Beer's Law.

Prerequisites
For the undergraduate section (5120), completion of Geography 5110 or equivalent experience is required for this course. For the graduate section (6120), no formal prerequisites are required. For both sections some knowledge of trigonometry is expected. For this reason, a basic trigonometry (MATH 1060) or physics (PHYS 1010) course, or equivalent experience (e.g. high school trigonometry), is required. Since we will be using trigonometry in the class, labs, and exams, I strongly recommend that you have access to a scientific calculator or computer that can calculate cosines, sines, tangents, etc.

While all calculations in the class can be done using a scientific calculator, knowledge of a software program or scripting language capable of doing trigonometric calculations could be useful for the calculation sets.

Course Fee
A course fee of $25 per student is assessed to purchase supplies and software for the labs.

Textbooks
There are no textbooks for this course. Reading materials will be provided on Canvas.

Labs
There will be five labs in this class. Each lab will consist of two parts: an in-class measurement or computer exercise, and several questions on the lab and lecture material. Answers to lab questions are due at the beginning of class on the day they are due. Labs turned in late will lose 10% of their value each day they are late. Students are encouraged to work together on lab questions. Students enrolled in the graduate section (6120) are required to answer additional questions at the end of each lab.

Calculation Sets
There will be four calculation sets due during the semester. Each calculation set requires that you apply equations we discuss in lecture to a given problem. Partial credit will be given on calculations if you show correct reasoning in solving a problem, even if your ultimate answer is incorrect. For me to give this credit, you must show your work in addition to your final answers. If you have questions regarding how much work needs to be shown or how partial credit will be given, please see the instructor. Students are encouraged to work together on calculation sets, but please show your work. Students enrolled in the graduate section (6120) are required to solve additional calculations at the end of each calculation set. Advice: Do not put off solving calculations until the day before they are due.

Final Projects
Each student in the class will work on a project that analyzes imaging spectrometer or thermal infrared remote sensing data. A half page project proposal is due October 31st. I will encourage you to think about your final project well in advance of this deadline, because it may take significant time to receive the data and master the methods you need to complete the project. November 21st and 26th class periods are set aside for you to work on your project. During class on December 3rd or December 5th, you will give a 10 minute presentation on your analysis. Required content for your presentation includes:

- Background information on the phenomenon you are examining
- A theoretical explanation of how the phenomenon is expressed in remotely sensed data
- The methodology you used to analyze the data, including justification of why this approach is appropriate
- Your results

I am requiring individual projects, although collaboration with other students in the class using the same analysis methods or datasets is permitted.

Evaluation
The following weights will be assigned to labs and exams to determine grades for the course:

Calculation Sets: 40%
Lab Questions: 40%
Final Project: 20%

Academic Misconduct Statement
Academic misconduct will not be tolerated. Penalties may include failure of an assignment, the entire course, and/or the filing of formal charges with appropriate university authorities. Academic misconduct includes, but is not limited to, cheating, misrepresenting one's work, and plagiarism:

- Cheating involves the unauthorized possession or use of information in an academic exercise, including unauthorized communication with another person during an exercise such as an examination.
- Misrepresenting one's work includes, but is not limited to, representing material prepared by another as one's own work or submitting the same work in more than one course without prior permission of all instructors.
- Plagiarism means the intentional unacknowledged use or incorporation of any other person's work in one's own work offered for academic consideration or public presentation.

The Americans with Disabilities Act
The University of Utah seeks to provide equal access to its programs, services, and activities for people with disabilities. If you will need accommodations in this class, reasonable prior notice needs to be given to the Center for Disability Services, 162 Olpin Union Building, (801) 581-5020. CDS will work with you and the instructor to make arrangements for accommodations. All written information in this course can be made available in an alternative format with prior notification to the Center for Disability Services.

University Safety Statement
The University of Utah values the safety of all campus community members. To report suspicious activity or to request a courtesy escort, call campus police at 801-585-COPS (801-585-2677). You will receive important emergency alerts and safety messages regarding campus safety via text message. For more information regarding safety and to view available training resources, including helpful videos, visit safeu.utah.edu.

Addressing Sexual Misconduct
Title IX makes it clear that violence and harassment based on sex and gender (which Includes sexual orientation and gender identity/expression) is a civil rights offense subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories such as race, national origin, color, religion, age, status as a person with a disability, veteran's status or genetic information. If you or someone you know has been harassed or assaulted, you are encouraged to report it to the Title IX Coordinator in the Office of Equal Opportunity and Affirmative Action, 135 Park Building, 801-581-8365, or the Office of the Dean of Students, 270 Union Building, 801-581-7066. For support and confidential consultation, contact the Center for Student Wellness, 426 SSB, 801-581-7776. To report to the police, contact the Department of Public Safety, 801-585-2677(COPS).

Class Schedule
The following schedule lists the anticipated dates for class topics, assignment due dates, and final project deadlines. Updates to the schedule may be provided in class and/or on Canvas.

Date	Topic	Reader	Due
Tue Aug 20	Introduction		
Thu Aug 22	Electromagnetic radiation	Ch 1	
Tue Aug 27	Radiometric units		
Thu Aug 29	Spectral radiance, zenith & azimuth angles, solar geometry	Ch 2	
Tue Sep 3	Solar geometry		
Thu Sep 5	Lambert's cosine law, reflectance	Ch 3	
Tue Sep 10	BRDF, refraction		
Thu Sep 12	Lab 1 – Empirical measurements of BRDF		Calculation Set 1
Tue Sep 17	Refraction, specular reflection		
Thu Sep 19	Absorption processes, Beer's Law	Ch 4	Lab 1 Questions
Tue Sep 24	Beer's Law examples		
Thu Sep 26	Imaging spectroscopy		
Tue Oct 1	Lab and field spectroscopy (**location to be announced in class**)		Calculation Set 2
Thu Oct 3	Spectral matching methods		
Tue Oct 8	**No Class (Fall Break)**		
Thu Oct 10	**No Class (Fall Break)**		
Tue Oct 15	Lab 2 – Spectral matching methods (**GC 1855**)		
Thu Oct 17	Spectral mixing		
Tue Oct 22	Lab 3 – Spectral mixture analysis (**GC 1855**)		Lab 2 Questions
Thu Oct 24	Atmospheric absorption and scattering	Ch 5	
Tue Oct 29	Optical depth and radiative transfer		Lab 3 Questions
Thu Oct 31	Lab 4 – Sun photometry experiment		Final project proposal
Tue Nov 5	Emission processes	Ch 6	Calculation Set 3
Thu Nov 7	Emission equations		Lab 4 Questions
Tue Nov 12	Emissivity, Kirchoff's Law		
Thu Nov 14	Radiative energy balance, Spectral mixing in the mid- and thermal-IR		
Tue Nov 19	Lab 5 – Empirical thermal IR measurements		
Thu Nov 21	Final project work		Calculation Set 4
Tue Nov 26	Final project work		Lab 5 Questions
Thu Nov 28	**No Class (Thanksgiving)**		
Tue Dec 3	Final project presentations		
Thu Dec 5	Final project presentations		