AST 555: Planetary Applications of Remote Sensing

College of the Environment, Forestry, & Natural Sciences
Department of Astronomy & Planetary Science
Semester: Spring 2020
Prerequisites: None
Location: Lectures: Bldg. 19, Rm. 111. Labs: Bldg. 19, Rm. 232
Meeting Time & Format: Lectures: Thursdays, 9:30am – 10:50am. Labs: Tuesdays, 9:30am – 10:50am

Instructors: Dr. Mark Salvatore, mark.salvatore@nau.edu, (928) 523-0324. Dr. Christopher Edwards, christopher.edwards@nau.edu, (928) 523-7234
Office Locations: Salvatore: Bldg. 19, Rm. 225A. Edwards: Bldg. 19, Rm. 205
Office Hours: Salvatore: (Tu) 8:00am - 9:30am. Edwards: (Th) 11:00am - 12:00pm. Both instructors are available by appointment upon request.

Course Purpose

This course will focus on the tools, techniques, and fundamental principles of the remote investigation of planetary surfaces and atmospheres. Particular emphasis will be placed on tracking energy from its source through its interactions with different forms of matter, its receipt by instruments of specific design, and its eventual processing and interpretation by humans on Earth. The majority of labs and exercises will be focused on the Earth, as data are widely available and easier to validate than more distant planetary bodies. Letter grade only.

Course Description

Every human is a natural expert in the science of remote sensing. We use our eyesight, our hearing, our sense of smell, and our sensitivity to temperature to continually investigate our surroundings. This skill allows us to explore distant objects or properties without making direct contact with those objects. For example, we are able to enjoy the multitude of colors in fall foliage without analyzing the chemical composition of each individual leaf.

By exploiting the unique properties of the electromagnetic spectrum, we have developed instruments that are capable of remotely identifying and recording many different properties of Earth and space. We are able to measure the chemistry of forests, the surface temperature of Mars, and the surface roughness of desert landscapes using different types of energy. Each of these remote sensing systems, however, comes with their own limitations. How small of an object can you study? How accurate is your sensor? How frequently can you measure the same location?

In this class, you will learn the different properties of the electromagnetic spectrum and how each type of energy can be used to investigate our surrounding environment. You will also learn how data are collected, stored, and analyzed, both by the instruments themselves and by the humans that process and analyze the data. Lastly, you will learn the skills (and art) behind aerial/satellite image enhancement and interpretation, which transform the data into useful final products.

Throughout class, we will be using a powerful computer program known as *ENVI*. *ENVI* is a remote sensing and image processing software package developed for remote sensing applications by remote sensing experts themselves. You will quickly learn the fundamentals behind *ENVI* and will be tasked with using this software in nearly all class assignments.

Course Objectives & Learning Outcomes

This course has several objectives and learning outcomes that will be addressed during lecture and assessed through in-class exercises, take-home lab assignments, and examinations. By the end of the semester, students will be able to:

1. Demonstrate an understanding of the properties and characteristics of the electromagnetic spectrum and how they are used to understand the physical and chemical properties of materials;
2. Describe how sensors record electromagnetic energy and how these records can be interpreted;

3. Identify and discuss the utility and limitations of different wavelength ranges for different planetary applications;
4. Explain and manually perform image processing and image manipulation techniques; and
5. Demonstrate proficiency in using image processing and remote sensing software to process, visualize, and manipulate remotely acquired data.

Assessment

Course assessment will include in-class exercises, take-home laboratory assignments, three examinations (two midterms and one final), and professionalism and engagement in class. Unless discussed with the professor beforehand, late assignments turned in within 24 hours after it is due will be penalized with a 30% reduction in grade. Assignments turned in more than 24 hours late will not be accepted.

In-Class Exercises: In-class exercises are designed to teach students how to put into practice the information that was previously discussed in lecture. These exercises will also help to familiarize students with the specific analytical techniques and how *ENVI* can be used in the context of this material. Students are encouraged to work collaboratively to complete these exercises, but to turn in their own assignments. The in-class exercises are worth a total of 250 points (25% of the total course grade).

Homework Assignments: Homework assignments build upon the in-class exercises and are designed to test each student's analytical and problem-solving skills. Each lab will require students to generate digital products to document their progress and will also ask students to describe or discuss different components of the work. The labs are worth a total of 400 points (40% of the total course grade).

Examinations: Three examinations will evaluate students' understanding of the fundamental concepts discussed in class as well as their ability to apply these principles to data generation, analysis, and interpretation using *ENVI*. Exams will not be cumulative. The exams are worth a total of 300 points (30% of the total course grade).

Professionalism & Engagement: Engagement in class is a critical part of the learning experience. Unless otherwise noted, students are encouraged to work together to improve their understanding of class materials and the image processing software. As a baseline, a student's professionalism and engagement grade will represent their average performance on in-class exercises, laboratory assignments, and examinations. Points can be deducted for habitual lateness, class interruptions, lack of effort, or academic misconduct. Oppositely, points can be added for engaging in discussions, attending office hours, and assisting fellow classmates, to name a few. Professionalism & Engagement is worth a total of 50 points (5% of the total course grade).

Grading System: The breakdown of points is as follows, and any changes to the class scoring rubric will be discussed with the class prior to implementation:

In-Class Exercises	*250 points*
Homework Assignments	*400 points*
Examinations (three total)	*300 points*
Professionalism & Engagement	*50 points*
Total	***1,000 points***

Your course grade will be based on the total points earned, and a letter grade will be assigned using the grading scale below:

A:	≥900 points	(≥90%)
B:	800 – 899 points	(80% – 89.9%)
C:	700 – 799 points	(70% – 79.9%)
D:	600 – 699 points	(60% – 69.9%)
F:	≤599 points	(<60%)

Required Materials & Technology

REQUIRED: No required course materials. Weekly reading materials will be provided to students via the course site on BBLearn.

Class, Departmental, & University Policies

- Please disclose any disabilities or special requirements to the NAU Disabilities Resources Office, who will contact me privately regarding any accommodations. I want to make sure that every student has an equal opportunity to learn and succeed.
- Don't cheat. You're paying good money to learn, and if you don't appreciate the knowledge gained right now, you will in the future. *If you feel like you need to cheat in order to succeed in this class, come talk to the professor to establish a more sustainable plan for succeeding.* If we catch you cheating, we have a zero-tolerance policy, will fail you in the class, and will report you to the Dean's Office.
- While attendance in class is not mandatory, remember that 5% of your grade is dedicated to Professionalism & Engagement, which is directly reliant upon your attendance.
- As a courtesy to the instructor and to your fellow students, please come to class on time. Students who arrive late for exams will not be given extra time. In-class points missed due to tardiness cannot be made up.
- Please silence all cellular devices during class. Please refrain from any other "electronic distractions" (e.g., text messaging, browsing social media) during class. If you are anticipating cellular disruptions during class for any personal or professional reasons, please notify the professor prior to class.
- Class disruptions are defined as activities that distract the instructor or other students from delivering or learning the course materials. Such activities include talking or whispering during class, habitual tardiness or leaving class early, or "electronic distractions." Disruptive students will be asked to leave the classroom, while repeat offenders may be withdrawn from the class.
- Neither audio nor video recording will be permitted except under special circumstances prescribed by the NAU Disability Resources Office or discussed with the professor prior to class.
- **Additional departmental and university policies can be found at** **www.physics.nau.edu/SYLLABI/POLICY/policy.html**. This course falls under all departmental and university policies unless otherwise stated in this document.

<u>Course Schedule</u>

Textbooks:

(a) Introduction to Satellite Remote Sensing, Emery & Camps, 2017
(b) Remote Sensing Digital Image Analysis, 2006
(c) Optical Remote Sensing of Land Surfaces, Baghdadi & Zribi, 2016
(d) Principles of Remote Sensing, Tempfli et al., 2001

Week	Date	Location	Topic & Content	Materials Due	Required Readings
1	Tu, 1/14	19-232	Course Introduction		(a) 2.1-2.5, 2.8-2.9, Mustard (2017)
	Th, 1/16	19-111	Fundamentals of Electromagnetic Radiation		
2	Tu 1/21	19-232	Intro to ENVI and RS Data (*Exercise #1*)		(a) 2.6, (c) 1.1-1.2, Stephan et al. (2010)
	Th, 1/23	19-111	Atmospheric Phenomena		
3	Tu, 1/28	19-232	Atmospheric and Surface Properties (*Exercise #2*)		(a) 2.7, 3.1, 3.4, (b) 2.6-2.7, Asner et al. (2012)
	Th, 1/30	19-111	Energy and Radiance at Sensor	**HW #1 Due**	
4	Tu, 2/4	19-232	Surface Phenomena		
	Th, 2/6	19-111	Sensor Properties		(c) 2.2.3, Rogalski (2002, p61-95), Rogalski (2012)
5	Tu, 2/11	19-232	Resolution (*Exercise #3*)		
	Th, 2/13	19-111	"Create Your Own Sensor" (HW #2 Work Session)	**HW #2 Due**	
6	Tu, 2/18	19-232	**Exam #1**		
	Th, 2/20	19-111	Vibrational Absorptions		Clark (1999)
7	Tu, 2/25	19-232	Vibrational Absorptions (*Exercise #4*)		
	Th, 2/27	19-111	Electronic Absorptions		
8	Tu, 3/3	19-232	Planetary Remote Sensing (*Exercise #5*)	**HW #3 Due**	
	Th, 3/5	19-111	Thermophysics		Fergason et al. (2006), Presley & Christensen (1997), Piqueux & Christensen (2009)
9	Tu, 3/10	19-232	Thermophysics (*Exercise #6*)		
	Th, 3/12	19-111	Thermophysics (cont.)	**HW #4 Due**	(a) 5.1-5.2, 5.4-5.5
10	Tu, 3/17	***Spring Break, No Class***			
	Th, 3/19				
11	Tu, 3/24	19-232	Parameterization, Band Math, etc. (*Exercise #7*)		Lawrence et al. (1998), Viviano-Beck et al. (2014, *sections 4-7*), *other*
	Th, 3/26	19-111	Other Techniques		
12	Tu, 3/31	19-232	**Exam #2**		
	Th, 4/2	19-111	Intro to Signal Processing		Gillespie et al. (1986), (c) 2.5, (d) Ch. 5, *other*
13	Tu, 4/7	19-232	Advanced Signal Processing		
	Th, 4/9	19-111	Image Classification, Color Transformations	**HW #5 Due**	
14	Tu, 4/14	19-232	Data Manipulation (*Exercise #8*)		
	Th, 4/16	19-111	TIR Applications		Bandfield et al. (2000), Greenhagen et al. (2010), Rockwell & Hofstra (2008)
15	Tu, 4/21	19-232	TIR Applications (*Exercise #9*)		
	Th, 4/23	19-111	VNIR Applications	**HW #6 Due**	Mustard et al. (2008), Cheek et al. (2011), Kruse et al. (1990, Cuprite)
16	Tu, 4/28	19-232	VNIR Applications (*Exercise #10*)		
	Th, 4/30	19-111	Other Applications	**HW #7 Due**	*Other*
17	Finals Week	19-111	**Exam #3**		