Introduction to Remote Sensing
(Fall 2020, 4 credit)
EVSC 4010/7010

Time:
Lecture: TuTh 12:30 p.m. -1:45 p.m.
Lab: Mo 3:30 p.m. – 4:45 p.m. or We 3:30 p.m. – 4:45 p.m.

Location:
Lecture: Chemistry Bldg 206
Lab: Bryan Hall 203

Instructor: Xi Yang
Office Location: Clark Hall 390
Office Hours: Tuesday 2 p.m. – 3 p.m. or by appointment
Email address: xiyang@virginia.edu

Graduate TA: TBD
Office Location: TBD
Office Hours: TBD
Email Address:

Please put "[EVSC 4010/7010]" in your title when you send emails about the class.

Why should you care about remote sensing (a.k.a.: course description)?

Ever wondered how was this intriguing satellite image collected[1]? What can we use satellite images for the benefit of the planet, including you, me, everyone, and every living creature on Earth? Can we use remote sensing to see things that our eyes cannot see? Can we measure drought, flood, hurricane, urban growth or crop yield? These are the questions we will address in the class.

Earth is made of four interconnected global systems (spheres): geosphere (or lithosphere), biosphere, atmosphere, and hydrosphere. In the past three decades, we started to realize that many of the environmental problems are global or regional in scope, for example, climate change, El Niño, and deforestation. Yet our understanding of these spheres and the related

[1] Source: Wikipedia

environmental problems is limited by the ability to acquire needed information at a proper scale. Remote sensing, which we will learn in this class, can help.

Remote sensing is the technique to obtain data about an object without physical contact with it. It is a powerful tool for extracting quantitative information of Earth's surface and even subsurface. This course will provide a detailed understanding of remote sensing from physical principles to applications. Common platforms and tools for remote sensing will be introduced. Necessary skills to work on remote sensing data will be taught through labs. You will have the freedom to solve the real-world problem that you are interested in from the final independent research project. Past student projects include assessing the environmental impact of Chernobyl nuclear meltdown, analyzing the extent of California Drought during 2012-2017, quantifying the impact of 2018 California fire. In each week before week 11, there is a session named "Data of the week", during which we learn certain aspects of remote sensing by examining various remote sensing data.

How will this course help you succeed?

Remote sensing is not only an important tool that is useful in many aspects of our life, for example, urban planning, environmental monitoring, or agriculture, but also a new way to view the world. At the end of the class, you will be able to do the following:

- Explain basic concepts in remote sensing and how do remote sensing instruments work (to non-experts);
- Use one or two software to process remote sensing data;
- Explain how remote sensing can solve real-world problems using oral presentation;
- Use remote sensing to solve real-world problems;
- Learn how to write a proposal, provide peer reviews, and write a scientific paper.

How do I evaluate your progress?

Major elements in this class consist of lectures, labs, and a final research project. In addition, there will be several lab assignments and one mid-term exam. The final grade will be based on the following: a final project – both research paper and presentation (40%), lab assignments (25%), the mid-term (25%) and in-class participation (10%).

1. Final project – *Solving real-world problems using remote sensing*
The final independent research project is designed to allow you to freely pursue the application of remote sensing to a topic of interest or to an area of your concentration. It consists of a one-page proposal, a paper and an oral presentation. Graduate students are expected to provide a more in-depth analysis that will be reflected in the proposal, the paper, and the presentation. See the section "Independent Research Project" for detailed information.

The goal of this final project is to help you to learn how to use remote sensing to solve real-world problems, and also learn how scientists conduct research.

2. Lab assignments
These assignments include the use of remote sensing software, primarily ENVI. Labs are designed to help you get familiar with ENVI, which will be the software used for the final project. The first lab starts on Week 2. There are 6-8 labs. During the week when there is no lab, you are encouraged to use the time to explore ENVI for their final project.

3. Mid-term exam
To help you prepare the exam, one review session will be arranged before the exam. The mid-term exam will be a set of questions that test your understanding of key physical theories of remote sensing and ability to apply these concepts to real-world problems. The exam aims to help you to achieve the first and the fifth objectives.

4. Class participation
In-class discussion is highly encouraged. Each of you is also required to summarize one of the reading assignments and present to the class. You will be grouped into small reading groups (2-3 people) that are responsible of summarizing the reading assignment and give a brief presentation at the beginning of the classes. Doing so will help you to understand the concepts and also improve your communication skills.

Occasionally, I will give you an index card to write down your thoughts on a specific question, which helps me to gauge the effectiveness of the lectures (the questions will not be graded based on whether the answer is correct or wrong, but your will earn participation credits if you submit your response). You will earn the full class participation credit when you participate all the activities.

5. Readings
There will be 20-50 pages of reading each week. These readings will be uploaded to Collab each week.

The final grading will be based on the table below:

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: Less than 60		

What do we do in this class?
Below you will find a schedule of our class. Each week we will cover a topic. There are a few *QoW (Questions of the Week) for you to consider each week.

Date	*Topics*	*Readings and QoW**	*Lab*
Theme 1: Do you want to see the Earth from the outer space?			
Week 1	Introduction to Remote Sensing	Reading material 1 • What is remote sensing? • Who took the first image of the Earth?	No Lab
Week 2	Basic Physical Principles of Remote Sensing	Reading material 2 • What does Max Planck have to do with satellites?	No Lab
Theme 2: How many man-made satellites are circling around the Earth? What are they doing up there?			
Week 3	Remote Sensing Systems	Reading material 3 • Why there are different satellite orbits? What does it mean for the Earth-Observing satellites?	Lab 1: Learn the basics of ENVI; Logistics.
Week 4	Radiative Transfer Theory	Reading material 4 • What is Beer's law about? • Why is the sky blue?	Lab 2: Atmospheric correction and radiometric correction
Theme 3: What can we do with these beautiful satellite images besides making posters?			
Week 5	Reflectance Spectroscopy of Materials	Reading material 5 • Why leaves are green (or not green)? And what are in that leaf?	Lab 3: Reflectance, Band Ratio, and Vegetation Indices
Week 6	Image Interpretation and Data Analysis (I)	Reading material 6 • Can we find plants in a desert?	Lab 4: Spectroscopy hands-on experience
Week 7	Image Interpretation and Data Analysis (II)	Reading material 7 • What is that red object in the image?	Lab 5: Find your data source
Week 8	Mid-term review and mid-term exam		
Week 9	Thermal remote sensing	Reading material 8 • What is that red object in the image?	Lab 6: Land use classification: Has the city extend changed in the past three decades?

Date	*Topics*	*Readings and QoW*	*Lab*
Week 10	Hyperspectral remote sensing	• Wow! So many information in the image!	Lab 7: Thermal Imageries: Estimating Fire Extent
Week 11	Microwave remote sensing	• What does a microwave oven and a satellite have in common? • Can I see what is in the clouds?	Final project period
Week 12	Ground and airborne remote sensing	• Do you want to fly a drone?	Final project period
Week 13	Advanced Remote Sensing Topics (I)	• What are the other cool applications of remote sensing?	Final project period
Week 14	Advanced Remote Sensing Topics (II)	• What will remote sensing be like in 50 years?	Final project period
Week 15	Wrap-up and Final presentation	• If NASA gives you 100 million dollars, what kind of remote sensing observation you want to make?	Final project period

Independent Research Project

The independent research project is designed to allow you to explore, in depth, the application of remote sensing on a topic of interest. You will be more knowledgeable to a specific area of remote sensing by working on the project. You are encouraged to talk with me (Prof. Xi Yang) earlier in the semester to find a suitable project. Several examples of projects will be given at the end of this document. The examples are used to help/inspire you to find your own project.

The research project should be based on the analysis of ***real data***, which include 1) freely available satellite images (see the section Data Sources); 2) data collected using instruments owned by me. For example, a portable field spectrometer or a drone. It is also possible to work collaboratively and in groups. The scope of the collaborative project is expected to be larger than an individual's project.

A successful project entails two components: 1) imagination, creativity, and a motivated you! The topic is something that you are excited about! 2) guidance, feedback, and help from the faculty, TA, and your peers. A timeline for the project includes the following:

Steps	***Time Frame***
I. Conceive the project and discuss with Prof. Xi Yang	Aug-Sep
II. Deliver the research proposal (1-page)	Sep 15.
III. Peer review and project evaluation	Sep 15st-25th
IV. Working on the project	Oct – Nov.
V. Submit final project and present results	Last week

Throughout the process, we want you to use all the available resources to you, including me, your TA, your peers, the library, and the internet. During step I, think about the interesting and cool questions that you want to solve and potentially solvable using remote sensing. Discuss several times with me, TA, and your peers. Write down your idea like a research proposal (***see an example in the end***), and submit to me (Due March 1st), who will group the proposals based on the similarity of the research interests. Each group consists 3-4 students. And each student will review others' proposals and provide feedbacks like what scientists do. After receiving the feedbacks, you can start to work on their final projects. At the end of the semester, you will write a term paper and give an oral presentation. All students are required to attend the oral presentation.

Undergraduate students: The term paper is an eight-pages double-spaced paper (12 pt Times New Roman), and a 10-minutes presentation (8-minutes oral presentation + 2-minutes questions).

There is a different requirement for graduate students according to the rules set by A&S. Scientific communication is also a very important aspect of academia, and this assignment will help you to further develop your skills.

Graduate students: The term paper is a 12-pages double-spaced paper (12 pt Times New Roman), and a 15-minutes presentation (12-minutes oral presentation + 3-minutes questions).