

Exploring Earth: Remote Sensing and Spatial Analysis (Spring 2024)

Lecture Time: Mon/Wed 09:30 a.m. -10:45 a.m.

Location: 194 Mercer St, Room 304

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Prerequisites: Environmental Systems Science (ENVST-UA 100)

Please put “[[ENVST-UA 372](#)]” or “[[BIOL-UA 64](#)]” in the title when you email about the class.

Course Overview - Why should you care about remote sensing and spatial analysis?

Remote sensing is a fascinating field that allows us to understand and monitor Earth's environment from a distance. Have you ever marveled at a satellite image and wondered what secrets it holds? This course will guide you through the fundamentals of remote sensing, teaching you how to use satellite data to address real-world problems.

You'll learn how remote sensing helps us observe phenomena beyond our direct reach, from tracking urban expansion and vegetation dynamics to monitoring air quality, carbon emissions, and natural disasters.



We start with the basics of remote sensing, its principles, and its diverse applications. Essential skills in remote sensing data processing and spatial analysis will be taught through our hands-on labs, covering important tools such as Google Earth Engine, Geographic Information Systems (GIS) software, and open-source spatial analysis tools. These sessions will equip you with essential skills to solve a real-world problem of your interest for the final research project. Whether you're a beginner or have some experience in this field, this course will deepen your understanding and expand your ability to make a positive impact through remote sensing.

Building an inclusive learning environment

Welcome to our course. As your instructor, I am dedicated to creating an inclusive and welcoming learning environment. To better understand and support your needs, we'll start with a student survey. Your goals, expectations, and concerns are important to me, so I encourage you to share them openly. However, your input is crucial not just at the beginning but throughout our course. Please feel comfortable reaching out at any time with any barriers to learning or suggestions you might have.

I deeply value the diverse backgrounds and perspectives each of you brings to our classroom, and I believe in nurturing curiosity and embracing trial-and-error as vital aspects of your learning journey. It enriches our learning experience and helps us all grow. If you have specific learning needs, I am committed to providing the necessary accommodations to ensure accessibility for everyone.

We can build a collaborative learning environment where everyone feels heard and empowered.

How will this course help you succeed?

Remote sensing is a critical tool with wide-ranging applications in environmental studies, urban planning, agriculture, natural source management, and more. It offers a unique way to view the world, and in the age of big data, mastering data analysis and visualization is increasingly essential. By the end of this course, you will be equipped to:

1. Understand and explain basic concepts in remote sensing and their applications in solving real-world problems;
2. Use professional and open-source software, as well as online platforms, to process remote sensing data efficiently;
3. Use remote sensing to investigate real-world issues in a meaningful way;
4. Create compelling analysis and beautiful visualization of spatial data;
5. Present your project to your peers through a 15-minute oral presentation;
6. Write a concise, science news-style paper (2 pages) describing your final project.

This course is designed to provide you with practical skills and knowledge directly applicable to various professional fields, enhancing your ability to succeed in a data-driven world.

How do I evaluate your progress?

Major components of this class include lectures, labs, and a final research project. The grading structure is as follows:

1. Class participation + Reading (10%)

Active participation in class discussions is highly encouraged. Your presence and engagement are essential for an effective and engaging learning experience. Occasionally, questionnaires will be provided at the end of lectures to assess their effectiveness. These questionnaires are not graded; only your participation rate is considered.

No textbook is required for this course. However, supplemental reading materials will be provided weekly to support the lectures.

2. Lab assignments (30%)

You will complete 6 lab assignments, which will involve processing remote sensing data using Google Earth Engine and GIS software such as ArcGIS or Q-GIS (the latter being open source depending on the vote of the class). These labs are designed to help you gradually get familiar with remote sensing data and tools, building essential skills to prepare you for your final project. Tutorial and sample codes for Google Earth Engine and Python-based analysis will be provided.

3. Mid-term exam (15%)

The mid-term exam will consist of questions designed to test your understanding of key physical theories of remote sensing and your ability to apply these concepts to real-world problems.

4. Final project (45%)

The final research project is an opportunity for you to delve into a topic of your choice, utilizing remote sensing applications. I recommend discussing your chosen topic or study area with me around mid-term and iterating your ideas throughout the second half of the semester. This ensures you receive the necessary support as you develop your project. At the end of the term, you will present your project to the class with a 15-minute oral presentation, and a 2-page write-up, crafted in the style of a science news article.

Tentative Course Schedule

Week 1: Introduction to Remote Sensing and Spatial Analysis

- Class 1: Course Overview & Introduction to Remote Sensing (RS)
 - Course overview & learning goals
 - A brief history of RS & impactful application cases
 - Platforms for remote sensing: satellite, airborne, unmanned aerial vehicles, ground-based sensors (this course will focus on satellite)
- Class 2: Introduction to Spatial Analysis
 - What is Geographic Information System (GIS)
 - What are the major applications?

Week 2: GIS Fundamentals

- Class 1: Understanding Vector and Raster Data
 - Introduction to the two primary types of data models in GIS: Vector and Raster.
 - Map projections and coordinate systems
- Class 2: Lab - Introduction to GIS software (ArcGIS or Q-GIS)
 - **Lab Assignment 1: Make your first global map using two of your favorite map projections** (could use either class-provided data or your findings)

Week 3: Principles of Satellite Remote Sensing

- Class 1: Basics of Electromagnetic Spectrum
 - What is the electromagnetic spectrum and why it is important in RS
 - Overview of different regions of the EMS, including visible light, infrared, ultraviolet, microwave, and radio waves
- Class 2: Satellites and Orbits
 - Types of satellite sensors: passive and active
 - Types of satellite orbits: geostationary vs. sun-synchronous orbits
 - Overview of major space agencies, satellite missions, and platforms
 - Lab: Explore NASA [Earthdata](#) and understand different levels of products (L1-L4)

Week 4: Optical Remote Sensing

- Class 1: Basics for Optical Remote Sensing (Visible, NIR, MIR)
 - Reflectance and spectral signatures
 - Angular effect on surface reflectance
 - Atmospheric correction (absorption & scattering)
- Class 2: Lab - Introduction to Google Earth Engine (GEE)
 - **Lab Assignment 2: familiarize with GEE and explore Landsat data**

Week 5: Land Cover and Biodiversity Remote Sensing

- Class 1: Mapping Land Cover and Biodiversity
 - Supervised and unsupervised classification
 - RS for biodiversity
- Class 2: Lab - Image Classification and Visualization
 - Urban growth
 - Nightlight index
 - **Lab Assignment 3: Explore land use change in your hometown based on Landsat data - has the urban area expanded?**

Week 6: Vegetation Remote Sensing

- Class 1: Vegetation Indexes
 - Vegetation reflectance spectrum
 - Band ratio and vegetation indexes
 - Greening & browning of the earth's surface
- Class 2: Solar-induced chlorophyll fluorescence (SIF)
 - Basic principles
 - Crop yield monitoring and prediction
 - **Lab Assignment 4: Analyze spatial-temporal variations in vegetation indexes for an area of your choice**

Week 7: Integration of Remote Sensing and GIS

- Class 1: integration of RS and GIS for effective environmental analysis
- Class 2: Lab - Zonal and Buffer Analysis
 - **Lab Assignment 5: Spatial analysis of VI across different zip codes building on Assignments 3 & 4**

Week 8: Mid-term Review and Exam

- Class 1: Mid-term review
- Class 2: Mid-term exam

Week 9: Spring break

Week 10: Thermal Remote Sensing

- Class 1: Fundamentals of Thermal Remote Sensing
 - Overview of thermal infrared (TIR) radiation and its properties
 - Emissivity and its importance in accurate temperature measurement

- Class 2: Applications in urban heat and agricultural stress
 - Urban heat islands
 - Agriculture & Irrigation
 - **Lab Assignment 6: Analyze spatial correlations between LST and vegetation cover for a city of your interests**

Week 11: LiDAR, Radar, and Passive Microwave

- Class 1: LiDAR (Light Detection and Ranging)
 - Principles of LiDAR: How LiDAR uses light pulses to measure distances
 - Application in topographic mapping, forestry, urban planning, and archaeology
- Class 2: Radar & Passive Microwave
 - Basics of radar systems and Synthetic Aperture Radar (SAR)
 - Applications in land cover classification, biomass estimation, and monitoring soil moisture and geological hazards
 - **Now that we have introduced the major data types, it is time to conceptualize your final project**

Week 12: Remote Sensing for the Atmosphere

- Class 1: Principles of Atmospheric Observation
 - How gases, particles, and clouds interact with electromagnetic radiation
 - Key satellite missions for atmospheric observations (e.g., GOES, OCO-2/3, Copernicus Sentinel missions).
- Class 2: Remote Sensing of Atmospheric Composition
 - Gases and aerosols
 - Air quality and greenhouse gas monitoring

Week 13: Remote Sensing for Fire Monitoring and Water Resources

- Class 1: Active Fire, Burned Area, and Fire Emission
- Class 2: Monitoring of Water Surface and Quality

Week 14: Advanced Topics in Remote Sensing Application

- Class 1: Terrestrial Carbon Cycle: Combining Information from the Land Surface (bottom-up) and the Atmosphere (top-down)
- Class 2: Environmental Justice: Air Quality and Heat Extremes

Week 15: Project Workshops and Consultations

- Class 1 & 2: Work on Final Projects, Individual Consultations

Week 16: Final Presentations and Course Wrap-up