Principles and Applications of Remote Sensing
CLIMATE/SPACE 485 - Winter 2024

Course Description

Instructor: Chris Ruf, cruf@umich.edu

Textbook: Elachi, C., J. van Zyl, Introduction to the Physics and Techniques of Remote Sensing, Wiley-Interscience, 2nd ed., 558 pp, 2006.
ISBN-13: 978-0-471-47569-9, ISBN-10: 047-147569-6
https://drive.google.com/file/d/1lfo0eKlMNmtjJ5AIFAhoNd73CGBlAdNE
PDF available on Canvas course site

Lecture: Mon/Wed/Fri at 1:30-2:30pm, Room 1012 EECS
Lecture Capture: https://leccap.engin.umich.edu/leccap/site/fy2jxr4sv0nk2gox5ac
Lecture Capture also available on Canvas course site

Office Hours: Wed 2:30-3:30pm (or by arrangement)

Overview:

This course is intended as an introduction to the use of electromagnetic remote sensing to study planetary atmospheres and surfaces from space. The course content is divided roughly evenly between three aspects of remote sensing: 1) interactions between geophysical properties of interest and propagating electromagnetic waves; 2) the design of orbiting sensors to measure those waves when they propagate to space; and 3) the interpretation of the measurements to estimate geophysical properties of interest.

Topics:

Principles of electromagnetic propagation, emission, absorption and scattering in the atmosphere, oceans and land. Fundamentals of active and passive remote sensing at radiowave, thermal infrared, and visible/near infrared wavelengths. Sensor design, determination of engineering measurement uncertainty, estimation of science data product qualities. Applications to the determination of terrestrial and oceanic surface properties and atmospheric profiles of temperature, humidity, clouds, precipitation and gaseous composition. Project-based case studies.

Prerequisites:

Familiarity with principles of electromagnetics at the level of a second year undergraduate physics course. Familiarity with atmospheric properties (gaseous composition, temperature and pressure profiles, atmospheric water as humidity, clouds and precipitation) at the level of an introductory undergraduate earth systems course.

Course Syllabus

Chapter	Topic	Lectures
1	Course Overview	1
2.1	Review of Electromagnetics	3
5.4	Review of Antennas & Sampling	2
5.2	Passive Microwave Surface Remote Sensing Theory	3
5.3	Microwave Radiometer Surface Applications	4
6	Active Microwave Surface Remote Sensing Theory	2
7	Radar Surface Applications	2
5-7	**Midterm Exam #1 (in class, 23 Feb 2024)**	1
4	Passive Infrared Surface Remote Sensing	3
8	Atmospheric Remote Sensing Theory	3
9.2	Microwave Atmospheric Profiling Applications	2
11.2	IR Atmospheric Profiling Applications	2
9.9	Volume scattering from hydrometeors and weather radar	2
various	Examples of Sensor Systems and Applications	3-5
9,11	**Midterm Exam #2 (in class, 22 Apr 2024)**	1
	Student Project Kick-off/Interim Status	3
	Student Project Final Presentations (in class, 15&17 Apr 2024)	2

Homework, Project, Exams and Grading

Homework Policies

- Homework should be handed in during or before lecture on the due date
- Informal discussion of homework problems with classmates is encouraged. Solutions must be prepared individually.
- Late homework will not be accepted unless arrangements are made with the instructor beforehand

Project Overview

- Projects are a design study of one particular remote sensing system. The design should include each of the following three components:
  1) Science - Why make the measurement? What are the spatial and temporal sampling requirements? What are the accuracy and precision requirements of the measurement?
  2) Forward Model - Why is the sensor sensitive to the desired science data? What masking variables? What sensor design maximizes sensitivity and minimizes confusion?
  3) Instrument - What frequency(ies)? polarization(s)? active/passive/both? Antenna type? Orbit parameters? Ancillary data?
- Projects to be done in teams of 3-4 people
- Final report of 5-10 pages
- Oral presentations will be given in class near the end of the semester

Midterm Exam Policies

- The textbook and lecture notes are permitted during the exams.

Grading Policy

50%	Homework (10%/each)
20%	Project
30%	Midterm Exams (15%/each)