

**EAS 541 / ENVIRON 441 WINTER 2020
REMOTE SENSING OF ENVIRONMENT
SYLLABUS: PROCEDURES AND GRADING**

COURSE STAFF

Dr. Kathleen Bergen, SEAS
3506 Dana, kbergen@umich.edu
Office hours (lecture): M 2:30-3:30 pm, W 2:30-3:00 or by appt.

Dr. Silvia Cordero-Sancho, SEAS
3315 Dana, corderos@umich.edu
Office hours (lab): W 10:30-12 pm
And by Google Sheet for presentations appointments

GSI: Jared Barnett
3315 Dana, jbarne@umich.edu
Office hours (lab): M 2:30-4 pm, T 11-12:30 pm

LECTURE PERIODS

EAS 541 has two 1.5-hour Lecture periods on Monday and Wednesday, 1-2:30 p.m. Lectures meet in 2024 Dana Bldg. The *Schedule and Assignments* part of the syllabus lists the Lecture period topic for each day and reading assignments. Lecture periods start promptly at 1 p.m. It is important to be there and prepared to start on time. Bring your lecture outlines.

Lecture Outlines

Lecture Outlines will be posted on the class website in CANVAS. These outlines do not contain all material covered in Lecture periods, but contain main points, and graphics, and are provided by Dr. Bergen to assist you in efficient note-taking. You should bring these to class. In CANVAS make sure you are signed up to receive email announcements when Files/Resources are uploaded by your instructor to CANVAS and ready for download.

Readings

The textbook readings for the course are required: the course is designed with the expectation that students will keep up with the readings. Readings have been parsed (i.e. specific pages listed) for efficiency and to best correspond to Lecture and Lab topics. You may decide whether it is most useful for you to read the assigned Lecture material prior to or after the Lecture on the topic. (but always read material assigned for Lab before Lab)

Class Presentation

In the Lecture part of the course, there is one assignment for a structured class presentation by 3-4 person teams on a remote sensing application of the team's choice. This does not involve original research but rather synthesis of other scientists or groups existing work. Presentations are team PowerPoint presentations given during the last portion of the semester.

In-Class Exams

Two examinations will be given during Lecture class periods. Both will be cumulative "closed-book" exams covering Lecture and some Lab material during the term up to the date of the exam as noted on the *Schedule and Assignments* portion of the Syllabus.

Final Examination

The Final Examination will be a combined Lecture and Lab Exam. The Final Exam will cover material throughout the entire course and will be given **only** during the official course final exam time Wed April 29 4-6 pm.

LABORATORY PROCEDURES

There is one required Instructor-led 2-hour hands-on Lab week. Your Lab will be Wednesdays starting at 3 pm promptly or Thursdays starting at 10 am promptly. Meaning, be in your seat and ready to start right at 3 pm or 10 am. There are two types of

Labs: most are ERDAS IMAGINE/ArcGIS Computer Labs using digital photos & images; two are Print Labs using printed photos & images. The ERDAS IMAGINE Labs meet in the 3rd floor Dana/SEAS computer classroom 3325, next to the ESALab. The Print Labs meet in classroom 2520 Dana/SEAS. The Print Labs are distinguished by “Print” on the *Schedule and Assignments* document. Weekly attendance is **required** for all Labs and attendance at the two Print Labs during their scheduled times is part of the Lab grade and cannot be made up if missed. Further information for both Computer and Print Labs is given below.

ERDAS IMAGINE/ ArcGIS Computer Labs

Computer Labs and Lab Write-Ups are assignments that are **to be completed individually** to give you maximum hands-on exposure to the computer software and image processing techniques. Lab material **will** be on exams. All IMAGINE/ArcGIS Labs require that you have completed the Lecture and Lab readings on the topic BEFORE coming to Lab. You must attend your Lab section only. Computer Labs may start with a short presentation by the GSI on instructions; give the instructor your attention and do not use the computers during this time. The remainder of the Lab time is designated to work through the Computer Lab assignment at your computers. Your GSI will be available throughout the Lab time for consultation and problem-solving. You will need time outside of Lab period to finish the Labs and Write-Ups. We have reserved the SEAS/Dana classroom Wednesdays 3-6 pm and Thursdays 10-1 pm if you wish to stay somewhat longer after Lab ends, and/or you may finish your work in the SEAS or Shapiro open Sites Labs at other times during the week. Additionally, ArcGIS and IMAGINE are available to be loaded on student PC laptops as well.

There are a limited set of IMAGINE floating licenses. Therefore, students who are not in the Wed. 3-5 Lab should not use IMAGINE at other campus sites during that time it is needed for Lab; conversely students who are not in Thurs. 10-12 Lab should not use IMAGINE at other campus sites during that time it is needed

for Lab. Complete the IMAGINE part of your Lab assignments any other time during the week. Plan ahead with this in mind. If you load IMAGINE on your laptop (Windows OS) you may use it anytime as it is not a floating license.

Computer Lab Write-Ups

Your results from the Computer Labs and your Lab Write-Ups will be handed in (due) at the beginning of the following week’s Lab period unless otherwise noted. Late assignments will lose 10 pts/day off the initial down to 50 points out of 100 in addition to any points lost for quality/correctness (see Course Policies below). Assignments are graded for completeness and accuracy of results, maps, discussions and interpretation (with evidence of familiarity with reading assignments), meeting requirements, and clarity of image and written presentation. Computer Labs and Lab Write-Ups are assignments that are **to be completed individually**.

Disk/Storage Space

For this course, you will use your University of Michigan AFS space to save Lab instruction documents, GIS/Image data, your work and WriteUps. You should always also bring a USB/thumb drive as well for backup and because GSI office does not have access to AFS space should you want to visit office hours and look at your work. If you do not already have your AFS space, it is important for you to **REQUEST YOUR AFS SPACE PRIOR TO LAB 1** using the AFS Self-Provisioning Tool found at:

<http://mfile.umich.edu/>

For an AFS overview see:

<http://documentation.its.umich.edu/node/234/>

We recommend that you keep your AFS space and course materials well-organized. Later 541 labs rely on performing tasks that are described in detail in earlier labs materials.

Computing Resources

There are multiple places/ways to access IMAGINE and ArcGIS software outside of Lab to complete your Lab assignments. We

have the IMAGINE and ArcGIS software installed for you in the Dana Bldg. computer classroom (3325), the Dana Bldg 2nd floor open computer lab (2315), and the Shapiro Library open PC Lab (4th floor). ArcGIS is also installed in all Sites labs on campus. For Google Earth Engine Labs you must request a login/account at the beginning of the semester. See caveat above about not using IMAGINE during scheduled Lab times (unless you are in the Lab).

You may do all your homework outside of Lab at the above locations, but you may also have some additional options to install software on your PC laptop. You are responsible for installing the software and all of its systems administration. If you have a PC/Windows OS laptop you may get a license for a student version of IMAGINE – contact Dr. Cordero-Sancho and Shannon Brines (sjbrines) in ESALab for the license. It is also possible to install a student copy of ArcGIS on your personal computer (Windows OS) by following the instructions at:

<http://www.itcs.umich.edu/sw-info/gis/arcgis.php> You can also access ArcGIS by logging into virtualsites.umich.edu or using Apps Anywhere (link at virtualsites.umich.edu). Some students have found ways to configure ArcGIS on Macs, however you would also need to figure this out on your own.

Print Labs

The Print Lab periods are an exploration (guided In-Class discussion by course staff) of maps and images related to the Lab topics. These are followed by a graded Practice Problem homework. Print Lab class periods are full, with plenty of work to do. Be on time & ready to work before 3 pm / 10 am. **Attendance for full the two print labs is required** as much in-class work cannot be repeated outside of the lab period and will be part of your grade. Complete any advance readings before coming to class. Always bring a calculator and **pencil (not pen)**.

Print Labs Practice Problems

Map & image materials for graded Practice Problems homework

will be provided on Canvas. Copies of materials used for the In-Class exercises will be available for review after Lab in the ESALab (top drawer in right-most map case; do not remove materials from the ESALab and re-file them when done). Like Computer Labs Write-Ups, Practice Problems are **to be completed individually** and due by the following week's Lab period and subject to similar grading procedures. Attendance, accuracy, precision, attention to detail and methods are important criteria. Always show your work.

Print Lab Cautionary Notes

In these printed materials Labs there will be a number of images and maps to handle. It is necessary to collect them and use them again. Some are also valuable historical materials. You can continue this cooperation by:

- A. Not using any type of pen or felt-tip marker in class. We all tend to use any writing implement we have as a pointer, and may accidentally mark the image or map we are using. So, **use only pencils during Print Lab periods.**
- B. Making no marks on any of the images or maps. Any accidental marks should be erased before materials are turned in, or before you leave class for the day.
- C. Do not write on a piece of paper placed on top of a photographic image. Photographic emulsions are thin layers of gelatin and are quite soft. They will hold an impression if you write on them with a hard pencil, even if there is a sheet of paper between the pencil and the image.

Course Policies

It is **strongly advised** not to miss Labs and Exams.

Labs: You are expected to attend Labs weekly. We will only grade your Lab assignments if you regularly attend each Lab each week. After three missed labs, excused or otherwise, we may not grade any further missed labs. If you attend Lab but your WriteUp is turned in late, it will lose 10 pts for each day off your score to a maximum of 50 pts out of 100 for 'late submission'. If during the

course of the semester a circumstance beyond your control results in missing a Lab (e.g. extended illness, hospitalization), and these circumstances prevent you from completing the Lab by its due date, you must provide formal documentation of such circumstances and, if approved, complete the Lab by the end of the first week of your return to class. If not turned in by the end of the first week of your return to class, the assignment will lose 10 pts per day off your score to a maximum of 50 pts out of 100 for 'late submission'. Non-documented misses of a Print Lab cannot be made up. Non-adherence to the IMAGINE usage policy during Lab times would affect your Lab grade.

Exams: Generally missed Examinations **will not** qualify for make-up procedures. Should serious circumstances beyond your control result in missing an Examination, further formally documented verifiable evidence needs to be presented in advance. We will give **ONLY** one final exam and that will take place during the official University final exam period for this class.

GRADING

Term Average

Scores on all EAS 541 graded materials will be used to calculate a Term Average, computed as one-tenth of the sum of the following scores. The Term Average is the basis for the final letter grade.

In-Class Exam 1	150 points
In-Class Exam 2	150 points
Labs (term average x 4)	400 points
In-Class Presentation	100 points
Final Examination	200 points

Letter Grades

Letter grades will be based on the Term Average. Letter grades will be assigned in accord with the following scale:

<u>Course Score</u>	<u>Grade</u>	<u>Course Score</u>	<u>Grade</u>
97.0 or above	A+	75.5 to 79.4	C+
91.0 to 96.9	A	71.0 to 75.4	C
89.5 to 90.9	A-	69.5 to 70.9	C-
85.5 to 89.4	B+	65.5 to 69.5	D+
81.0 to 85.4	B	61.0 to 65.4	D
79.5 to 80.9	B-	59.5 to 60.9	D-

Instructors:

Dr. Kathleen Bergen, SEAS
 3506 Dana, kbergen@umich.edu
 Dr. Silvia Cordero-Sancho, SEAS
 3315 Dana, corderos@umich.edu
 GSI: Jared Barnett
 3315 Dana, jbarne@umich.edu

Course rooms:

2024 Dana (class lecture section)
 2520 Dana or as announced (print labs)
 3325 Dana computer classroom (computer labs)

L&K = textbook; PL = color plates in L&K; CP = coursepack material on Canvas

Lecture number & date	Lecture Subject	Lecture & Lab Readings, Exams, Presentations
1. Wed Jan. 8	Introduction to the Course Introduction Syllabus/Requirements	Lecture: Acquire textbook; Fill out Student Questionnaire; Read Syllabus (<i>Lab 0: Lab Preparation</i>)
2. Mon Jan. 13	The E-M Spectrum Energy Flow Profile Energy Sources	Lecture: Student Questionnaire due; L&K: Chap 1 pp 1-9; Read Syllabus
3. Wed Jan.15	Energy Flow Profile Interactions with the Atmosphere Reflectance Characteristics of Land Cover I	Lecture: L&K Chap 1 pp 9-25, 57-58 Lab: L&K Chap 1 pp 30-42, 49-58 (<i>Lab 1: Intro to ERDAS IMAGINE/ArcGIS</i>)
Mon Jan. 20	MLK Day – no class	Do/review readings through Lecture 4 during the first part of this week
4. Wed Jan. 22	Energy Flow Profile Reflectance Characteristics of Land Cover II	Lecture: L & K Chap 1 pp 25-30; Chap 8 pp 609-610, 619-628, 639-640, 646-649; PL #2 (<i>Lab 2: Spectral Reflectance/Spectral Curves</i>)
5. Mon Jan. 27	Remote Sensing with Film Camera Systems Black & White Color and Color-IR Elements of Image Interpretation (EIs)	Lecture: L&K Chap 1 pp 59-72, 77-84; Chap 2 pp 85-92, 95-100, 105-117, 119-121, 142-143 (“detection section”); Chap 8 pp 658-662, 665-668; PL #3,4,5,6
6. Wed Jan. 29	Basic Principles of Photogrammetry Digital Imagery Introduction	Lecture: L&K Chap 1 pp 30-35, 49-58; Chap 3 pp 146-175; Chap 7 pp 485-490; Chap 8 pp 682-686 Lab: Read CP_Maps_Images_Projections pp 15-19, 23-27, 29-34; CP_FilmsFilters&Spectral Bands pp 1-16, 21-23, 25-27 (<i>Lab 3: Image Interpretation - Print</i>)
7. Mon Feb. 3	Resolutions in Remote Sensing: Spatial, Spectral, Temporal, & Radiometric Multi-Spectral Optical Line-Scanner Systems	Lecture: L&K Chap 1 pp 72-76; Chap 4 pp 218-242; Chap 5 pp 283-295; Chap 7 604-608; PL #36,37,38, 40

8. Wed Feb. 5	Moderate spatial resolution satellite sensors including Landsat, SPOT, Sentinel Image Enhancements	Lecture: L&K Chap 5 pp 295-349, 375-378; PL #12,13; Chap 7 499-506; (<i>Lab 4: Landsat Data Import and Spectral Image Enhancement</i>)
9. Mon Feb. 10	Coarse spatial resolution satellite sensors including AVHRR, MODIS and others Vegetation Indices	Lecture: L&K Chap 5 pp 359-375; Chap 7 pp 517-530; PL #18,19
10. Wed Feb. 12	Sensors Through Time Geometric Correction	Lecture: Chap. 7 pp 495-499 (<i>Lab 5: Geometric Correction</i>)
Mon Feb. 17	EXAM 1	Exam covers material through Lecture period 10 and Lab 4.
11. Wed Feb. 19	Introduction to Radar Remote Sensing Case Study: Lost City of Ubar Intro to Google Earth Engine	Lecture: L&K Chap 6 pp 385-389; 409-413, 425-435; Chap 8 pp 662-665 (<i>Lab 6 Intro Google Earth Engine / NDVI</i>)
12. Mon Feb. 24	Introduction to Classification Classification Schemes Manual Classification Class Presentation Groups Assigned	Lecture: L&K Chap 8 pp 611-618, 654-657; Read/Skim MI_LCLU_Classif_2012; Anderson_USGS
13. Wed. Feb 26	Digital Land-Cover Classification Unsupervised Classification Class Presentation Groups Assigned	Lecture: L&K Chap 7 pp 537-563, 568-569, 591-597; Class presentation signups due Lab: Read CP_ Interpretation of Land/Cover Use - all; Read/Skim MI_LCLU_Classif_2012; Anderson_USGS (<i>Lab 7: Land-Cover Classification – Manual</i>) Can also start Lab 8 early
	SPRING BREAK	
14. Mon Mar. 09	Digital Land-Cover Classification II Supervised Classifications Accuracy Assessment	Lecture: L&K Chap 1 pp 39-45; Chap 7 pp 575-582; PL #30
15. Wed. Mar 11	Change Detection Case Study: <i>Land-Cover Change in Siberia 1975-2010</i>	Lecture: L&K Chap 7 pp 582-591, Chap 8 pp 640-645, 649-652 (<i>Lab 8: Land-Cover Classification – Digital</i>)
16. Mon Mar. 16	Radiometric/Atmospheric Correction	Lecture: L&K Chap 7 pp 489-495
17. Wed Mar. 18	High Spatial Resolution Sensors Satellite Sensors Digital Airborne Sensors	Lecture: L&K Chap 5 pp 349-356; Chap 2 pp 124-132; 140-143; Chap 8 pp 628-631, 652-653; PL #17,35,39 Lab: Read L&K Chap 7 pp 582-587; Read Bergen_etal2008_SiberiaLCLUC (<i>Lab 9: Post Classification Change Detection</i>)

18. Mon Mar. 23	Hyperspectral Sensors Drone-Based Sensing	Lecture: L&K Chap 4 pp 271-282; Chap 5 pp 356-359; Chap 7 pp 598-602; PL #10,11,22
19. Wed Mar. 25	Thermal Remote Sensing Case Studies: Boreal Forest Fires, Urban Heat Islands	Lecture: L&K Chap 4 pp 243-270; Chap 8 668-677; PL #9,20,21 (<i>Lab 10: Radiometric/Atmospheric Correction</i>)
20. Mon Mar. 30	EXAM 2	Exam material covers up through Lecture period 18 and Lab 9
Wed Apr. 1	Active Sensors Lidar Remote Sensing	Lecture: L&K Chap 1 pp 35-39; Chap 6 pp 471-484; PL #1,28 Lab: L&K Chap 5 pp 371-375; Chap 6 pp 475-482; Chap 7 pp 587-591 (<i>Lab 11: MODIS Land Surface Temperature & Urban Heat Effect using Google Earth Engine</i>)
21. Mon Apr. 6	Active Sensors Radar Remote Sensing	Lecture: L&K Chap 6 pp 385-434, 441-464 (some reading duplicates Lec 11 – review)
22. Wed Apr. 8	Mapping Quantitative Biophysical Properties Case Study: Radar-Derived Forest Height & Biomass in Northern Michigan	Lecture: L&K Chap 7 pp 602-608 (<i>Lab 12: LiDAR & DEM/DSM at La Selva</i>) (<i>extended time, due April 24</i>)
23. Mon Apr. 13	Class Presentations	Lecture: Class Presentations PPT presentations & Summaries due
24. Wed Apr. 15	Class Presentations	Lecture: Class Presentations PPT presentations & Summaries due Lab: Class Presentations PPT presentations & Summaries due
25. Mon Apr. 20	Class Presentations	Lecture: Class Presentations PPT presentations & Summaries due
	FINAL EXAM	Final exam held ONLY during scheduled final exam period Wed April 29 4-6 pm

Required Text

- (L&K) Lillesand, Kiefer & Chipman. *Remote Sensing and Image Interpretation*, 7th ed. Campus bookstores have ordered some for purchase or rent, they also recommend checking Amazon.com or Abebooks.com or other resale site; if you order from a resale site, be sure you get the 7th or latest edition and not an earlier edition.

CANVAS (download and print from Canvas as needed):

- (CP) Olson, excerpts from Coursepack for Map and Image Interpretation.
- Additional PDFs of Lab reading materials will be provided on Canvas prior to advance reading date.

RESERVE

- Print Lab In-Class Exercise Materials will be on reserve for review in the ESALab 3315 Dana Bldg (top map drawer in right-most map cabinet); do not remove from room and re-file when done.

Labs cover: image properties, image interpretation, image classification and analysis; applications of remote sensing, as well as integration of remotely sensed data into GIS and image processing software.

Lab format: One required 2-hour Lab per week, Lab readings (most on CANVAS), in-Lab exercises, completion of Labs outside of Lab, Write-Up or Practice Problem due before or at beginning of next Lab time. All Lab Write-Ups **to be completed individually**.

Two Print labs (*): classroom 2520 Dana Wed. 3-5 pm (sec 002) or Thurs. 10-12 am (sec 003). **Attendance is required for credit.** Be in your seats prior to the start of class, we start promptly.

Ten Computer labs: SEAS computer classroom 3325 Dana, Wed. 3-5 pm (sec 002) or Thurs. 10-12 am (sec 003).

CP = coursepack material on Canvas

Lab 0. Lab Preparation

There will be no Lab homework, however you will attend Lab in the Computer Classroom and work with course staff to be sure that a) you have your AFS space and test that you are able to download and save course material to that space; b) that you are able to access IMAGINE and ArcGIS; c) make your Google Earth Engine account request; and d) get an ERDAS IMAGINE student license and software for a PC/Windows laptop (optional); other preparatory matters. Bring your Windows OS laptop to this lab, if you have one.

Lab 1. Introduction to ERDAS IMAGINE and ArcGIS

ERDAS IMAGINE & ArcGIS interfaces & basic operation; raster and vector data formats; intro to Landsat images; data manipulation; map compositions in ArcGIS. You will download all Lab instructions and materials at the beginning of all computer Labs.

Advance Reading: L&K Chap 1 pp 1-25, 30-42, 49-58 (lecture and lab)

Lab 2. Spectral Reflectance/Spectral Curves

Further introduction to multi-spectral satellite imagery (Landsat); creating and interpreting spectral curves for different land-cover types using Landsat data and ERDAS IMAGINE

Advance Reading: Have done the readings assigned for lecture through lecture 4

Lab 1 WriteUp due

Lab 3.* Image Interpretation: Spectral Bands; Elements of Image Interpretation (*Print)

Maps and photo/image grids; types of traditional aerial imagery: black & white, black & white infrared, color & color-infrared; Elements of Image Interpretation (EIs) common to all sensors; “convergence of evidence” in interpretation of unknown features.

Advance Reading: CP_Maps_Images_Projections pp 15-19, 23-27, 29-34; CP_FilmsFilters&SpectralBands pp 1-16, 21-23, 25-27;

Bring to Class: pencil, calculator, magnifier (optional).

Lab 2 WriteUp due

Lab 4. Landsat Data Acquisition & Import; Spectral Properties & Image Enhancement

How to acquire and import Landsat data into image processing software such as IMAGINE; further Exploration of Landsat multi-spectral bands and properties; interpreting histograms; image enhancements; spectral plots.

Advance Reading: Have done the readings assigned for lecture through lecture 8

Lab 3 WriteUp (Practice Problem) due

Lab 5. Geometric Correction

Importing scanned imagery (scanned historic aerial photo) into IMAGINE; image georectification

Lab 4 Write-Up due

Lab 6. Introduction to Google Earth Engine & NDVI

Use Google Earth Engine to download Landsat data and combine it with shapefile data of the UMBS; how to calculate NDVI and NDVI landscape patterns over UMBS

Lab 5 Write-Up due

Lab 7. *Land-Cover Classification - Manual (*Print)

Introduction to use of land-cover classification systems; manual classification of image land cover features.

Advance Reading/Lab prep: Read CP_Interpretation_of_Land/Cover_Use (all); skim Anderson_USGS; MI_LCLU_Classif_2012

Bring to Class: pencil, calculator, magnifier (optional)

Lab 6 WriteUp due

SPRING BREAK

Lab 8. Land-Cover Classification - Digital (worth 200 pts)

Unsupervised land-cover classification of Landsat data using ERDAS IMAGINE; ISODATA algorithm; classification accuracy; land-cover map compositions. Can start this Lab early. [This lab functions as a take-home lab midterm].

Lab 7 Write-Up due

Lab 9. Post Classification Change Detection

Post classification change analysis; IMAGINE modeler module

Advance Reading (required): L&K Chap 7 pp 582-587; Bergen et. al (2008)

Lab 8 Write-Up due Fri. March 20 11:59 p.m.

Lab 10. Radiometric/Atmospheric Correction

Radiometric and atmospheric correction of Landsat digital satellite data

Advance Reading: L&K Chap 7 pp 489-495; Chander *et al* 2009 (optional)

Lab 9 Write-Up due

Lab 11. MODIS LST/Urban Heat using Google Earth Engine

Selection and import of MODIS Land Surface Temperature Time Series using Google Earth Engine in order to assess patterns of LST in urban and non-urban areas and over time

Advance Reading L&K 371-375

Lab 10 Write-Up due

Lab 12. LiDAR

Processing LiDAR data; creating DEM and DSM using LiDAR point data for the Lab Selva Costa Rica site

Advance Reading L&K 475-482

Lab 11 Write-Up due

[This lab 12 will have an optional extended completion time and will be due by 10 pm Friday April 24]

Lab period 13 – This Lab time will be used for 2-3 of our group presentations. Attendance required, but only for your regular lab period.

Combined Lecture-Lab Final Exam during finals week EAS 541 official final exam time.