EAS 541: REMOTE SENSING OF ENVIRONMENT
SYLLABUS: PROCEDURES AND GRADING

COURSE STAFF

Dr. Bergen, SEAS
3506 Dana, kbergen@umich.edu
Office hours: M 2:30-3:30 pm, W 2:30-3:00
GSI: Zijun Yang
3315 Dana, zjyang@umich.edu
Office hours: M 5-6 pm, Tu 1-2 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. Lecture periods start promptly at 1:10 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 material prior to or after the lecture on the topic.

Class Presentation
In the Lecture part of the course, there is an 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 PowerPoint presentations given during the last portion of the semester.

In-Class Exams
Two examinations will be given during the semester during Lecture class periods. Both will be cumulative "closed-book" exams covering all/most 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 Laboratory Exam. The Final Exam will cover material throughout the entire course and will be given during the official course final exam time.

LABORATORY PROCEDURES

There is one required Instructor-led 2-2.5-hour hands-on Lab each week (except no Lab the last full week of the semester). Labs are Wednesdays starting at 3:10 pm promptly. There are two types of Labs: most are ERDAS IMAGINE/ArcGIS Computer Labs using digital photos & images (3-5 pm); three are Print Labs using printed photos & images (3-5:15 pm). The ERDAS IMAGINE Labs meet in the 3rd floor Dana/SEAS computer classroom 3325, next to the ESA Lab. The Print Labs meet in classroom 2520 Dana/SEAS. The Print Labs are distinguished by “Print” on the Schedule and
Assignments document. Attendance is required each week for all Labs and attendance at the three Print Labs during their scheduled Wednesdays 3-5:15 pm time is required and cannot be made up if missed.

**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. Some Lab material will be on the closed-book exams. All IMAGINE/ArcGIS Labs require that you have completed the Lecture readings BEFORE coming to Lab. 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 Wednesday Lab time for consultation and problem-solving. You will need some time outside of Lab period to finish the Lab and Write-Up. We have reserved the SEAS/Dana classroom from 5-6 pm inclusive if you wish to stay a bit longer, and/or you may finish your work in the SEAS or Shapiro open Sites Labs at other times during the week.

**Computer Lab Write-Ups**

Your results from the Computer Labs and your Lab Write-Up 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. Assignments are graded for completeness and accuracy of results, maps, discussions and interpretation (with evidence of familiarity with reading assignments), & clarity of image and written presentation. Computer Labs and Lab Write-Ups are assignments that are to be completed individually.

**Print Labs - Overview**

The Print Lab periods are an exploration (guided discussion by course staff) of maps and images related to the Lab topics plus measurements/interpretation. These are followed by a graded Practice Problem (homework). All Print Lab class periods are full, with plenty of work to do. Be on time & ready to work before 3:10 p.m. Attendance during the three print labs Wednesday 3-5:15 pm periods is required as much in-class work cannot be repeated outside of the lab period. Complete any advance readings before coming to class. You may want to bring a 6-power, or stronger magnifier or hand lens if you have one. Always bring a calculator and pencil. You will want to organize all Lab materials including all CP (coursepack) materials from CANVAS and CM (color maps pack) materials from Dollar Bill and bring them and your cumulative Lab materials to every Lab to use as reference. Always bring A PENCIL to Print Labs class! No Pens.

**Print Labs Practice Problems**

Map & image materials for graded Practice Problems homework will be provided in Lab and/or made available outside of class. Materials will be on Reserve in the Clark Map Library (2nd floor Graduate Library). 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 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.

**GRADING**

**Term Average**
Scores on all EAS 541 graded materials plus Exams will be used to calculate a Term Average, computed as one-ninth 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 3): 300 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:

<table>
<thead>
<tr>
<th>Course Score</th>
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<th>Grade</th>
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<tbody>
<tr>
<td>96.0 or above</td>
<td>A+</td>
<td>75.5 to 79.4</td>
<td>C+</td>
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<tr>
<td>91.0 to 95.9</td>
<td>A</td>
<td>71.0 to 75.4</td>
<td>C</td>
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<tr>
<td>89.5 to 90.9</td>
<td>A-</td>
<td>69.5 to 70.9</td>
<td>C-</td>
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<tr>
<td>85.5 to 89.4</td>
<td>B+</td>
<td>65.5 to 69.5</td>
<td>D+</td>
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<tr>
<td>81.0 to 85.4</td>
<td>B</td>
<td>61.0 to 65.4</td>
<td>D</td>
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<tr>
<td>79.5 to 80.9</td>
<td>B-</td>
<td>59.5 to 60.9</td>
<td>D-</td>
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The course staff reserve the right to give higher grades than this computation would indicate, but will not give a lower grade than indicated by the Term Average.

**Make-Up Procedures**
It is **strongly advised** not to miss Labs and Exams. We will only grade your Lab assignments if you regularly attend each Lab each week. Non-documented misses or misses of a Print Lab due to a course conflict may not be made up. The following is intended for a rare exception only: If during the course of the semester a documented circumstance beyond your control results in missing a Lab, the Lab may be made up [excused] by presenting your documented circumstances and completing the Lab by the end of the first week of your return to class. Turn in the completed Lab and attach the documentation of what caused you to miss class. If not turned in by the end of the first week of your return to class, the assignment will lose 10 pts for each day off your score to a maximum of 50 pts out of 100 for ‘late submission’ with final score also adjusted for quality/correctness. Should serious circumstances beyond your control result in missing an Examination, further documented verifiable evidence needs to be presented in advance. Generally missed Examinations **will not** qualify for make-up procedures.
<table>
<thead>
<tr>
<th>Lecture number &amp; date</th>
<th>Lecture Subject</th>
<th>Lecture &amp; Lab Readings, Exams, Presentations</th>
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<tbody>
<tr>
<td>1. Wed Jan. 3</td>
<td>Introduction to the Course</td>
<td>Acquire textbook &amp; CM coursepack</td>
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<td>Syllabus/Requirements</td>
<td>Fill out Student Questionnaire</td>
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<td>2. Mon Jan. 8</td>
<td>The E-M Spectrum</td>
<td>Lecture: Student Questionnaire due; L&amp;K:</td>
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<td>Energy Flow Profile</td>
<td>Chap 1 pp 1-9</td>
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<td>Energy Sources</td>
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<td></td>
<td>Interactions with the Atmosphere</td>
<td>Lab: Read L&amp;K Chap 1 pp 57-58; Read</td>
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<td>Reflectance Characteristics of Land Cover I</td>
<td>CP_MapsImages&amp;Projections pp 6-17, 22-27,</td>
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<td></td>
<td></td>
<td>CP_MapInterp_supplement all pgs; Review</td>
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<td>CP_PhotometricMaps, CM Color Maps, CM</td>
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<td>TopoMapSymbols; Organize Lab materials,</td>
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<td>bring all Lab materials to Lab</td>
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<td>(Lab 1: Intro to Map &amp; Image Interpretation-</td>
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<td>Print)</td>
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<td>Mon Jan. 15</td>
<td>MLK Day – no class</td>
<td>Do/review readings through Lecture 4</td>
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<td>during the first part of this week</td>
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<td></td>
<td>Reflectance Characteristics of Land Cover II</td>
<td>619-628, 639-640, 646-649; Chap 8 pp 609-610;</td>
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<td>PL #2</td>
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<td>(Lab 2: Intro to ERDAS IMAGINE/ArcGIS)</td>
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<td>5. Mon Jan. 22</td>
<td>Remote Sensing with Film Camera Systems</td>
<td>Lecture: L&amp;K Chap 1 pp 59-72; Chap 2 pp 85-</td>
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<td></td>
<td>Black &amp; White</td>
<td>95-100, 105-118, 119-121, 142-143 (“detection section”); Chap 8 pp 658-662,</td>
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<td>Color and Color-IR</td>
<td>665-668; PL #3,4,5,6</td>
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<td>6. Wed Jan. 24</td>
<td>Basic Principles of Photogrammetry</td>
<td>Lecture: L&amp;K Chap 1 pp 77-84; Chap 3 pp 146-</td>
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<td>Elements of Image Interpretation (EIIs)</td>
<td>175; Chap 8 pp 682-686</td>
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<td>Lab: Read CP_FilmsFilters&amp;SpectralBands pp 1-</td>
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<td>16, 21-23, 25-27; Review CM; Bring Lab</td>
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<td>materials to Lab</td>
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<td>(Lab 3: Image Interpretation – Films &amp; Filters;</td>
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<td>Image Interpretation - Print)</td>
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<tr>
<td>Date</td>
<td>Title</td>
<td>Lecture</td>
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<td>7. Mon Jan. 29</td>
<td>Digital Imagery Introduction Resolutions in Remote Sensing</td>
<td>Lecture: L&amp;K Chap 1 pp 30-35, 49-58, 72-77; Chap 7 pp 485-490; 604-608; PL #36,37,38, 40</td>
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<tr>
<td>9. Mon Feb. 5</td>
<td>AVHRR and MODIS Satellite Sensors Vegetation Indices</td>
<td>Lecture: L&amp;K Chap 5 pp 359-375; Chap 7 pp 517-530; PL #18,19</td>
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<tr>
<td>Mon Feb. 12</td>
<td>EXAM 1</td>
<td>Exam covers material through Lecture period 10 and Lab 5</td>
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<tr>
<td>12. Mon Feb. 19</td>
<td>Class Presentation Groups Assigned Introduction to Classification Classification Schemes</td>
<td>Lecture: L&amp;K Chap 8 pp 611-618, 654-657; Read/Skim MI_LCLU_Classif_2012; Anderson_USGS</td>
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</table>
Lab: Read CP_ Interpretation of Land/Cover Use - all; Read/Skim MI_LCLU_Classif_2012; Anderson_USGS  
(Lab 7: Land-Cover Classification – Print) |
| SPRING BREAK   |                                                                      |                                                                                             |
| 14. Mon Mar. 5  | Land-Cover Classification I Supervised Classification Accuracy Assessment | Lecture: L&K Chap 1 pp 39-45; Chap 7 pp 575-582; PL #30                                      |
| 15. Wed. Mar 7  | Radiometric/Atmospheric Correction                                   | Lecture: L&K Chap 7 pp 489-495 (Lab 8: Land-Cover Classification – IMAGINE I)               |
**Case Studies:** Boreal Forest Fires, Urban Heat Islands | Lecture: L&K Chap 4 pp 243-270; Chap 8 668-677; PL #9,20,21 |
| 19. Wed Mar. 21 | Change Detection  
**Case Study:** Land-Cover Change in Siberia 1975-2000 | Lecture: L&K Chap 7 pp 582-591, Chap 8 pp 640-645, 649-652  
Lab: Read L&K Chap 7 pp 582-587; Read Bergen_etal2008_SiberiaLCLUC (Lab 10: Radiometric/Atmospheric Correction) |
| 20. Mon Mar. 26 | EXAM 2 | Exam material covers up through Lecture period 18 and Lab 9 |
| Wed Mar. 28 | Active Sensors  
Lidar Remote Sensing | Lecture: L&K Chap 1 pp 35-39; Chap 6 pp 471-484; PL #1,28 (Lab 11: Post Classification Change Detection) |
| 21. Mon Apr. 2 | Active Sensors  
Radar Remote Sensing | Lecture: L&K Chap 6 pp 385-434, 441-464 (some duplicates Lec 14 – review this) |
| 22. Wed Apr. 4 | Mapping Quantitative Biophysical Properties  
**Case Study:** Radar-Derived Forest Height & Biomass | Lecture: L&K Chap 7 pp 602-608 (Lab 12: LiDAR) |
| 23. Mon Apr. 9 | **Class Presentations** | **Class Presentations PPT presentations & Summaries due** |
| 24. Wed Apr. 11 | **Class Presentations** | (No Lab)  
**Class Presentations PPT presentations & Summaries due** |
| 25. Mon Apr. 16 | **Class Presentations** | **Class Presentations PPT presentations & Summaries due** |
|  | **FINAL EXAM** | Final exam held during scheduled final exam period Tuesday April 24, 4-6 pm |

**Required Text**
- (L&K) Lillesand, Kiefer & Chipman. *Remote Sensing and Image Interpretation*, 7th ed. 2015. 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 edition and not an earlier edition.

**Coursepack** (CM) Color Maps: small packet of Lab color materials/maps is available at Dollar Bill Copying on Church St.

**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.

**Reserves:**
Any print materials needed for finishing print Lab exercises outside of Lab will be available on reserve in the Clark Library in Hatcher Graduate Library 2nd floor south, see website for hours: http://www.lib.umich.edu/clark-library.
EAS 541 REMOTE SENSING OF ENVIRONMENT

LABORATORY SCHEDULE

Winter 2018

Labs cover: Interpretation and measurement using air photos; interpretation and analysis using satellite remote sensing images; classification of land cover/use; digital image processing and computer classification of land-cover/use; integration of remotely sensed data in GIS; ERDAS IMAGINE and ArcGIS software.

Lab format: One required 2-2.5-hour Instructor-led Lab per week, readings (most on CANVAS), in-class exercises, completion of Labs and Practice Problems/Write-Ups outside of Lab, Lab Practice Problems/Write-Ups due before or at beginning of next Lab time. All Lab Practice Problems/Write-Ups to be completed individually.

Print labs (*): classroom 2520 Dana/SNRE Wed. 3-5:15 pm attendance required.

Computer labs: SNRE computer classroom 3325 Dana/SNRE, Wed. 3-5 pm

CP = coursepack material on Canvas; CM = color maps coursepack from Dollar Bill

Lab 1.* Introduction to Map & Image Interpretation  (*Print)  Jan. 10

Topographic maps and properties; scale as a factor in interpreting map and image data; making scale and ground distance measurements; accuracy and precision in image measurements; measurement tools.

Reading/Lab prep: Read: CP_MapsImages&Projections pp 6-17, 22-27, CP_MapInterp_supplement, L&K Chap 1 pp 57-58; Review/Skim: CP_PhotoMetrics; CM Topo MapSymbols

Bring to Class: Color CM images (at Dollar Bill Copying on Church St.), pencil, calculator, magnifier (optional) and all above-listed CANVAS CP Lab materials (printed or electronic version).

Clark Map Library: 3 sets of materials for completing the Practice Problem homework for this lab are on reserve in the Clark Map Library (2nd floor South Grad Library; see website for hours). Best to go early in the week!

Lab 2. Introduction to ERDAS IMAGINE and ArcGIS Jan. 17

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

Lab 1 Practice Problem due (always at beginning of class)

Lab 3.* Image Interpretation: Films & Filters; Elements of Image Interpretation  (*Print)  Jan. 24

Types of imagery and spectral properties: black & white, black & white infrared, color & color-infrared; elements of image interpretation (EIIs) common to all sensors; “convergence of evidence” in interpretation of unknown features.

Reading: CP_FilmsFilters&Spectral Bands pp. 1-16, 21-23, 25-27; CM

Bring to Class: same as Lab 1 plus those for this Lab 3 (bring cumulative Lab materials).

Lab 2 Write-Up Due
Lab 4. Spectral Reflectance/Spectral Curves  
Jan. 31  
Introduction to multi-spectral satellite imagery (Landsat); creating and interpreting spectral curves for different land-cover types using Landsat data and ERDAS IMAGINE  
Lab 3 Practice Problem due

Lab 5. Landsat Spectral Properties, Image Enhancement & NDVI  
Feb. 7  
Further Exploration of Landsat data using ERDAS IMAGINE software; multi spectral bands and properties; interpreting histograms; image enhancements; spectral plots.  
Lab 4 Write-Up due

Lab 6. Geometric Correction  
Feb. 14  
Importing scanned imagery into IMAGINE; image georectification  
Lab 5 Write-Up due

Lab 7. *Land-Cover Classification (Print)  
Feb. 21  
Introduction to use of land-cover classification systems; classification of image land cover features.  
Reading/Lab prep: Read CP_Interpretation of Land/Cover Use; skim Anderson_USGS; MI_LCLU_Classif_2012; CM.  
Bring to Class: same as Lab 1 &2 plus this Lab (bring cumulative Lab materials).  
Lab 6 Write-Up due

SPRING BREAK

Lab 8. Land-Cover Classification- IMAGINE I  
Mar. 7  
Unsupervised land-cover classification of Landsat data using ERDAS IMAGINE; ISODATA algorithm  
Lab 7 Practice Problem due

Lab 9. Land-Cover Classification- IMAGINE II  
Mar. 14  
Landsat; unsupervised land-cover classification of Landsat data using ERDAS IMAGINE; classification accuracy; land-cover map compositions.  
[no lab due – 8 & 9 will be turned in together]
Lab 10. Radiometric/Atmospheric Correction
Radiometric and atmospheric correction of Landsat digital satellite data
Advance Reading: L&K Chap 7 pp 489-495; Chander_etal_2009 (optional)
Labs 8 & 9 Write-Up due

Lab 11. 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 10 Write-Up due

Lab 12. LiDAR
Processing LiDAR data; creating DEM and DSM using LiDAR point data
Lab 11 Write-Up due
This Lab 12 Write-Up will be due before or by Fri. April 20 11:59 p.m. (note provision of this optional extended time)

No formal Lab period final full week of class

Combined Lecture-Lab Final Exam during finals week NRE541 official final exam time