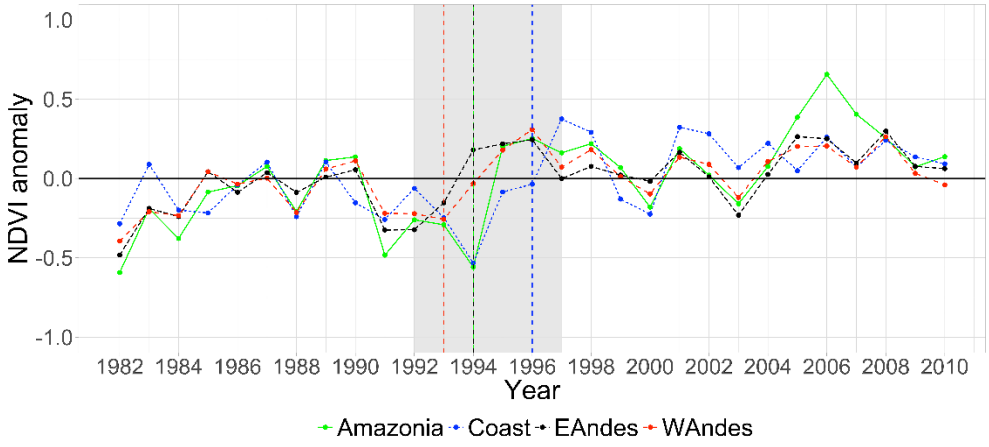
GEOG 372 / COMP 272: ADVANCED REMOTE SENSING



Time series analysis of NDVI anomaly data in three regions in Ecuador (Haro-Carrión et al. 2020).

Fall 2023

Hello and welcome!

You all know me, so I will just say that I am eager to have you again and looking forward to learning more advance RS and working on personal projects!

Email me at
xharocar@macalester.edu
Visit me in **CARN 104F**

Course learning outcomes

- Learn and apply advanced remote sensing approaches to a self-selected project.
- Develop a beginner's proficiency in utilizing Google Earth Engine for remote sensing analysis.
- Critically understand and analyze remote sensing literature, focusing on geographic areas and techniques selected by you based on the topics of your projects.
- Communique the results of your remote sensing research to a professional audience.

Prerequisites

Geog 362: Remote Sensing of the Environment

Course Description

This course builds upon the remote sensing concepts explored in "Geog362: Remote Sensing of the Environment" and is tailored for students seeking an in-depth exploration of remote sensing research aligned with their individual or collective interests. The course encompasses an introduction to advanced classification techniques, such as Random Forests and Time Series Analysis, along with an overview of the Google Earth Engine (GEE) platform. However, the course content will primarily be shaped by students' areas of curiosity. Participants will embark on personal projects, utilizing GEE for data analysis. They will lead discussions on scientific papers relevant to their project themes, engage in peer reviews of their peers' work,

and undertake various steps essential to producing a scientific paper. The ultimate objective of the course is to develop a "research manuscript" that closely resembles a submission intended for publication.

Meeting times and office hours

Time	Monday	Tuesday	Wednesday	Thursday	Friday
08:00-11:00					
09:30-11:10					
01:30 – 02:30					

	Class times
	Instructor Office hours

Textbook

This class has no required textbooks. The following text is a highly valuable freely available source of GEE code that we'll use during the semester.

Cardille, J.A., N. Clinton, M.A. Crowly, and D. Saah, eds. *Cloud-Based Remote Sensing with Google Earth Engine*. Accessed August 27, 2023. https://www.eefabook.org/.

There are many other freely available sources online. You are encouraged to look online and share your findings with the class.

Course Details

While the course is intended to be as flexible as possible to accommodate your research projects and needs, we will follow a basic structure that includes the following:

Short lectures and hands-on exercises to familiarize students with the Google Earth Engine (GEE). Throughout the course, I will conduct brief lectures and interactive exercises to introduce students to the Google Earth Engine (GEE). These sessions will cover fundamental approaches, functions, and processes within GEE. Additionally, each student will be expected to take the lead for at least one class session. During their session, they will present code from their own research or from Cardille et al. 2023, guide the rest of the class through examples or hands-on exercises, etc. Students can choose to work on their personal computers or use lab computers. GEE is Mac friendly ☺

Seminar style and student-lead class discussions of the scientific literature of remote sensing. Seminar-style discussions will be led by students, focusing on scientific literature in the field of remote sensing. This approach aims to collectively enhance our understanding of remote sensing case studies, encompassing both geographical expertise and remote sensing techniques. Guidance for selecting papers will be provided, and students are expected to lead

discussions about papers aligned with their research interests. Ideally, these papers will pertain to GEE use or specific research topics. Students should emphasize the methods used and their expected incorporation into their respective research projects, particularly with GEE if applicable.

Independent and/or collective research. Independent and/or collaborative research is a key focus of this course, and I will ensure that ample time is allocated to advance your research project. Group projects, if pursued, are expected to tackle more complex tasks compared to individual projects.

YOUR RESEARCH PAPER

The following structure outlines a general scheme for organizing most remote sensing research papers. The ultimate goal for the semester is to develop a reasonable draft of your research paper. However, you will be actively working on the research as you write. Therefore, a strategic approach is necessary. The order indicated in parentheses reflects the logical sequence of actions you need to undertake to produce a paper draft by the end of the semester, outlining the order in which different sections of your paper will be due too. Keep in mind that a single semester might not be sufficient to finalize a paper, especially in a techniques-oriented class. Consequently, emphasis will be placed on fully completing the methods and results sections of your paper draft.

1. **Introduction** (Fifth or sixth)
   The introduction briefly situates your study within a broader context, highlighting its significance and purpose. It defines the study's aim, discusses its importance, reviews the current state of the research field, and references key publications. You may also address any controversial or divergent hypotheses. Concluding the introduction, you should briefly outline the primary objective of your work.

2. **Materials and Methods**
   2.1. **Study Area** (First)
   Describe the key biophysical and, if applicable, social characteristics of your study landscape. Accompany your description with a map (likely Figure 1) that supports your depiction, including landmarks to assist readers in visualizing the study area's location on the planet.
   2.2. **Data / Imagery** (Second)
   Detail the imagery used in your study. Depending on your research, consider incorporating general sensor characteristics such as resolutions. If image transformations or indices are applied, provide a description in this section.
   2.3. **to 2.n: Data Analysis Related Sections** (Fourth)
   Include significant protocols associated with analyzing your data. If necessary, divide this section into subheadings to ensure clarity.

3. **Results.** This section should offer a concise and precise description of the experimental outcomes, including statistics and values.
   3.1. **to 3.n: Subdivision of Results** (Third)
   For projects involving multiple analyses (particularly relevant for group projects), subdividing the Results section may be helpful.

4. **Discussion** (Fifth or sixth)
   Engage in a comprehensive discussion of your results, interpreting them in light of prior studies and your working hypotheses. Contextualize your findings broadly, and consider implications for future research directions.

5. **Conclusions** (Seventh)
   The Conclusions section should offer clear and specific results of your research, if available. Often, it can be integrated into the final paragraph of the Discussion. This part should encompass the main insights and significance of your study's discoveries.

6. **Acknowledgments** (Throughout)
   Recognize any support not covered by you or your coauthors, including auxiliary data, feedback, and more.

7. **References** (Throughout)
   Provide a properly formatted list of all references used in your paper.

Course policies and support

Resources

All course materials, including lecture slides, readings and book chapters, will be accessible on Moodle. We will utilize Module for submitting assignments that fall outside our regular class schedule, as well as for grade tracking purposes.

Attendance

This advanced class is intentionally designed with a low enrollment to optimize both collective engagement and one-to-one interactions. As a result, your attendance holds significant value. Being present during class discussions to delve into papers and offer support to fellow students in our projects is greatly encouraged.
I understand that there may be circumstances beyond your control that occasionally prevent you from attending class. In such cases, please inform me in advance via email at xharocar@macalester.edu. If you encounter conflicts due to religious observances, I kindly request that you reach out within the first two weeks of class. We can then explore potential solutions together.

Office Hours

I will maintain regular office hours to delve into any questions, issues or concerns about the course or your experience as first-year students. If your schedule clashes with the posted

office hours, we can coordinate an alternative meeting time. Beyond the designated office hours, feel free to contact me via email. I strive to respond promptly, mostly during work hours (8:00 am to 4:00 pm on weekdays).

Diversity
I recognize that the scientific content in this course has historically been shaped by a limited subset of privileged perspectives, potentially leading to both overt and covert biases. To achieve a more comprehensive understanding of science, I am committed to actively diversifying the range of voices and experiences integrated into the curriculum. Beyond course materials, I am dedicated to cultivating an inclusive learning environment that respects your unique identities, encompassing factors like race, gender, class, nationality, and religion. Your feedback is essential in this endeavor. Please don't hesitate to share suggestions for enriching course materials, promoting diversity, and enhancing inclusivity, either through direct communication or anonymous feedback.

Disabilities
I am dedicated to providing all students, including those with disabilities, equal access to course content. If you are facing obstacles that we can address, please let me know. I'm eager to collaborate with you to ensure your success in the course.
For students with documented disabilities, reasonable accommodations are available. To discuss your individual needs, please reach out to the Disability Services office via email at disabilityservices@macalester.edu or by calling 651-696-6874 to schedule an appointment to discuss your individual needs.

Well-Being
At Macalester, valuing your well-being is paramount. By dedicating time to self-care, you'll enrich your academic experience. Remember, you're more than a student – you carry your own experiences, emotions, and identities. Acknowledge any stressors you face, whether mental, emotional, physical, or financial, and understand their potential academic impact. Recognize your body's needs. During class, stay hydrated, take breaks as needed, and prioritize emotional well-being. Beyond class, prioritize sleep, movement, and connections with peers to foster resilience at Macalester. If well-being challenges arise, feel free to contact me or explore support resources here.

Academic Support
You can access personalized tutoring, academic support, and study skills assistance through Macalester Academic Excellence (MAX). These resources are designed to aid you, and I strongly urge you to utilize them.

Academic Integrity
Students are required to independently complete and submit their own work, adhering to established academic conventions for appropriately using and citing external materials and ideas. Participating in cheating or plagiarism will lead to a failing grade for the course. Further

details about Macalester's academic integrity can be accessed here. I recommend thoroughly reviewing this information.

Public Health
If you do not feel well, please do not come to class. When we're on campus for class, we will be following the Mac Stays Safer Community Commitment.

Title IX
Macalester prioritizes a secure and inclusive environment for all. Those experiencing sexual harassment, violence, or stalking are encouraged to seek help. As faculty, I must report such disclosures to the Title IX Office to ensure support. Rest assured, your privacy is respected, and the report is confidential. You can contact Macalester's Title IX Coordinator directly at titleixcordinator@macalester.edu.

Grading

Assignment	Points
Student-lead paper discussion	10%
Student-lead GEE exercise	10%
Research Paper:	80%
• Introduction	• 6%
• Materials and Methods	• 30%
○ Study Area	○ 5%
○ Data / Imagery	○ 5%
○ Data analysis related sections	○ 20%
• Results	• 25%
• Discussion	• 7%
• Conclusions	• 5%
• Acknowledgments	• 2%
• References	• 5%

Scale Letter	Range
A	93.0% to 100 %
A-	90.0% to < 93.0 %
B+	87.0% to < 90.0 %
B	83.0% to < 87.0 %
B-	80.0% to < 83.0 %
C+	77.0% to < 80.0 %
C	73.0% to < 77.0 %

C-	70.0% to < 73.0 %
D+	67.0% to < 70.0 %
D	63.0% to < 67.0 %
D-	60.0% to < 63.0 %
F	0.0% to < 60.0 %

Detailed Weekly Schedule

Disclaimer: This schedule outlines an overview of my current plan and objectives. As we move through the semester, I may incorporate additional details to enrich your learning experience. Daily specifics will be tailored to suit our collective requirements.

Week 1: Welcome, Introduction & Decision Tree Classifiers

September 5 and 7

Learning outcomes.

- Define the scope and objectives of the course.
- Identify potential research ideas for semester projects, including those presented by the instructor and from your own exploration.
- Begin reviewing a scholarly paper.
- Understand the fundamentals of Decision Trees classifiers and Random Forests as machine learning techniques, including their applications and limitations

To do:

- **Tuesday.**
  Come to class having "skimmed" the following: Haro-Carrión. (2023). Advanced RS Syllabus Fall 2023 (Focus on course details and policies)
  GEE Lab1.
- **Thursday.**
  Lecture: Decision trees and Random Forest classification.
  Come to class having "skimmed" the following: Chalmers et al. *In review for Remote Sensing*

Week 2: Decision Trees & the Java Script and API of Google Earth Engine (GEE)

September 12 and 14

Learning outcomes.

- Understand the functioning of the GEE API.
- Finalize the reviewing of a scholarly paper, providing a comprehensive evaluation of the research presented in the paper, including its strengths and weaknesses.

To Do:

- **Tuesday.**
  Come ready to discuss and start drafting a collective review response for Chalmers et al. *In review in Remote Sensing*

- **Thursday.**
  Final review of letter to the editor RE: Chalmers et al. *In review for Remote Sensing*
  Cardille et al. section F1.0
  NOTE: Cardille et al. sections F1.1 to F1.3 offer a nice review of the concepts learned in Geog 362 and might be good sources of code for your projects.

Week 3: Cloud Free Composites & Random Forest in GEE

September 19, 21, and 23

Learning outcome:

- Understand the concept and the step-by-step process of creating cloud-free images in GEE.
- Independently conduct a Random Forest classification analysis using GEE.
- Learn now to upload vector data in GEE.
- Start working on the Study Area section of your personal research

To Do:

- **Tuesday.**
  GEE Lab 2: Random Forest.
  NOTE: Cardille et al. section F2 offers a source of code for other types of classification analysis and accuracy assessments, and additional code for RF.
- **Thursday.**
  Individual (in-class) work time – Study Area. Before class, please choose a study area that interests you, prepare a shapefile for uploading vector data in GEE, and gather relevant key literature to aid in describing your selected study area during the class.
- **Saturday.**
  Optional field trip to Common Harvest farm.

Week 4: Reducers and Regression

September 26 and 28

Learning outcome:

- Learn about GEE reducers.
- Use GEE reducers to implement regression between image bands.
- Evaluate regression models visually and numerically.

To Do:

- **Tuesday.**
  Lecture and exercise of Cardille et al. section F3.0
- **Thursday:**
  Cardille et al. section F3.0 Part II
  NOTE: Cardille et al. section F3.1 to F2.1 offer sources of code for image transformations, which might be useful for your projects.

Due: Study Area section of your paper

Week 5: Time Series Analysis
October 3 and 5

Learning outcome:

- Understand the fundamentals of time series analysis.

This week:

To Do:

- **Tuesday.** Come to class having read the following: Haro-Carrión, Xavier, Peter Waylen, and Jane Southworth. "Spatiotemporal Changes in Vegetation Greenness across Continental Ecuador: A Pacific-Andean-Amazonian Gradient, 1982–2010." *Journal of Land Use Science* 16, no. 1 (January 2, 2021): 18–33. https://doi.org/10.1080/1747423X.2020.1866705.
  Cardille et al. section F4 (Specific subsection TBD)
- **Thursday.**
  Cardille et al. section (Specific subsection TBD)

Week 6: Time Series Analysis & Project discussion
October 10 and 12

Learning outcome:

- Expand your understanding of time series analysis.

This week:

To Do:

- **Tuesday.** Cardille et al. section (Specific subsection TBD)
- **Thursday.** Project discussion. By this point you should have clear what research question you will attempt to answer and the data you will use. We will focus the discussion on providing feedback for data analysis and in learning about each other's work for potential collaborations.
  Individual (in-class) work time – Data / Imagery.

Week 7: Project Work & Case Studies
October 17 and 19

Learning outcome:

- Critically evaluate scientific case studies in student-determined fields.
- Advance in data analysis in personal projects.

This week:

- **Tuesday.**
  Student-led paper discussion: Students 1 and 2
- **Thursday.**
  Individual and collective work time – work on your code and help each other!

Due: Data / Imagery section of your paper

Week 8: Case Studies
October 24

Learning outcome:

- Critically evaluate scientific case studies in student-determined fields.

This week:

- **Tuesday.**
  Student-led paper discussion: Students 3 and 4

Week 9: Project Work & Case Studies
October 31 and November 2

Learning outcome:

- Critically evaluate scientific case studies in student-determined fields.
- Advance in data analysis in personal projects.

This week:

- **Tuesday.**
  Student-led paper discussion: Students 5 and 6
- **Thursday.**
  Individual and collective work time – work on your code and help each other!

Week 10: Project Work & Case Studies
November 7 and 9

Learning outcome:

- Critically evaluate scientific case studies in student-determined fields.
- Advance in data analysis in personal projects.

This week

- **Tuesday.**
  Student-led paper discussion: Students 7 and 8
- **Thursday.**
  Individual and collective work time – work on your code and help each other!

Week 11: Selected Topics in GEE
November 14 and 16

Learning outcome:

- Enhance our knowledge of remote sensing and practical skills using GEE.

This week:

- **Tuesday.**
  Student-led GEE exercises and/or Invited Speaker
- **Thursday.**
  Student-led GEE exercises and/or Invited Speaker

Week 12: Selected Topics in GEE
November 21

Learning outcome:

This week:

- Enhance our knowledge of remote sensing and practical skills using GEE.
- **Tuesday.**
  Student-led GEE exercises and/or Invited Speaker

Week 13: Selected Topics in GEE & Writing a Scientific Paper
November 28 and 30

Learning outcome:

- Enhance our knowledge of remote sensing and practical skills using GEE.
- Craft clear and concise sections of a scientific paper.

This week:

- **Tuesday.**
  Student-led GEE exercises and/or Invited Speaker
- **Thursday.**
  Individual (in-class) work time – Results

Week 14: Writing a Scientific Paper
December 5 and 7

Learning outcome:

This week:

- Craft clear and concise sections of a scientific paper.

This week:

- **Tuesday.**
  Individual (in-class) work time – Introduction and Data Analysis.
- **Thursday.**
  Individual (in-class) work time – Conclusions and Discussion.

Due: Paper first draft

Week 15: Wrap-up & Course Evaluations
December 12

Learning outcome:

- Provide constructive criticism and feedback for each other's projects.

This week:

- **Tuesday.** Peer-review discussion and course evaluations.

DUE ON WED.12/20: Final Draft