Syllabus

GEOG 4303|5303 GIS Programming for Spatial Analysis

Instructor:

Phil White, Earth, Environment & Geospatial Librarian

Office Hours: 12:00–2:00 PM Thursdays, or by **appointment** **(https://bit.ly/phil-appt)** .

Teaching Assistant:

Caitlin McShane, PhD Student, Department of Geography

Office Hours:

Overview: This course focuses on the extension of geographic information systems (GIS) through programming as well as on the development of algorithms for spatial analysis and information extraction in vector and raster data. We will cover different concepts, principles and techniques of programming that help you to solve a variety of spatial problems in physical and human Geography. You will learn how to work with Python for Geoprocessing in ArcGIS as well as for spatial programming in gridded data using Numpy and other open source modules. Furthermore, you will understand the basic ideas of object-oriented and procedural programming. You will develop skills to explore, handle, manipulate and model spatial data and for methods development. During the last weeks of the term students will work in small groups on a project, proposed by the group leaders. The topics may be related to the group leader's research.

Prerequisites: At least GEOG 4103/5103 or comparable is required. Students are expected to be familiar with GIS principles and concepts. Working experience with ArcGIS or different GIS software is required. Programming experience is not a prerequisite.

Class meetings: Programming concepts and technical aspects will be covered and combined with hands-on exercises and demos including follow-up discussions that will help to better understand application examples and the implementation of some key issues. Lectures are linked to lab assignments (labs 0-5, see below). Part of the class meetings will be used for ***student presentations***. Please, switch off cell phones! Attendance in lecture is required if presentations of other students are scheduled. You are fully responsible for getting the information covered in lectures. The last weeks of the term are devoted to project work where students are working in small groups to create a program that solves a given problem and write a final paper. During these weeks class meetings are used for special topics and feedback or advice regarding the ongoing project work. The schedule given below is subject to some minor changes depending on students' interest and needs for the class.

Labs: Students must attend the lab session every week. Learning how to program is hard work which you have to practice. For this reason, attendance in labs is REQUIRED.* ***Three points will be taken off your final score*** for each missed lab. **Lab assignments** have to be submitted at the beginning of the next exercise. For late assignments ***10% of your points*** are taken off the final score for each working day they are late (note: even if you submit late the day your assignment is due you will lose 10% of your points). *It is important that you submit on time even if you did not finish*.

**Exceptions: please communicate with the instructor and TA if you are unable to attend.*

Objectives

1. Demonstrate proficiency in general purpose Python scripting
2. Design automated workflows using the ArcPy library
3. Develop an understanding of how, why, and when to apply a programmatic approach to answer spatial and other technical problems

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Readings and Docs

Readings

Swaroop, 2016. A Byte of Python. © Swaroop C H, **https://python.swaroopch.com (https://python.swaroopch.com)** .

Python.org, 2021. PEP 8 -- Style Guide for Python Code. **https://www.python.org/dev/peps/pep-0008 (https://www.python.org/dev/peps/pep-0008)** .

Esri, 2021. What is ArcPy? **https://desktop.arcgis.com/en/arcmap/latest/analyze/arcpy/what-is-arcpy-.htm. (https://desktop.arcgis.com/en/arcmap/latest/analyze/arcpy/what-is-arcpy-.htm)**

Esri, 2021. A quick tour of ArcPy. **https://desktop.arcgis.com/en/arcmap/latest/analyze/arcpy/a-quick-tour-of-arcpy.htm. (https://desktop.arcgis.com/en/arcmap/latest/analyze/arcpy/a-quick-tour-of-arcpy.htm) (https://desktop.arcgis.com/en/arcmap/latest/analyze/arcpy/a-quick-tour-of-arcpy.htm) (https://desktop.arcgis.com/en/arcmap/latest/analyze/arcpy/a-quick-tour-of-arcpy.htm)**

Documentation

Python 2.7 Documentation: **https://docs.python.org/2/ (https://docs.python.org/2/)**

ArcGIS Desktop 10 Tool Reference: **https://desktop.arcgis.com/en/arcmap/latest/tools/main/a-quick-tour-of-geoprocessing-tool-references.htm (https://desktop.arcgis.com/en/arcmap/latest/tools/main/a-quick-tour-of-geoprocessing-tool-references.htm)**

SciPy Documentation: **https://docs.scipy.org/doc/scipy/reference/tutorial/index.html#user-guide (https://docs.scipy.org/doc/scipy/reference/tutorial/index.html#user-guide)**

NumPy Documentation: https://numpy.org/doc/ (https://numpy.org/doc/)

Course Schedule (subject to change)

Week	Day	Class Discussion	Readings	Lab Exercise
0	1-11/13	Introduction, Programming & Python Basics, Geoprocessing Basics	A Byte of Python: Basics, Control Flow; PEP 8	PC setup, installation, first steps
1	1-18/20	Variables, Data & Data Objects, Text Files	A Byte of Python: Data Structures	Lab 0: Intro to Python and ArcPy
2	1-25/27	Scripting with GP Tools	What is ArcPy; A Quick Tour of ArcPy	Lab 1: Temporal trends in vector data
3	2-1/3	Modules & Functions	A Byte of Python: Functions, Modules	Lab 2: Creating spatial data geometry from raw text
4	2-8/10	Operators, Logic & Decisions, Debugging	A Byte of Python: Operators & Expressions, Problem Solving	Lab 3: Sampling design with vector data
5	2-15/17	Spatial Data Manipulation, editing, sampling	Stuff	Lab 3 Continued
6	2-22/24	Raster Data, queries with Numpy	Stuff	Lab 4: 3D shape descriptors in raster & vector data
7	3-1/3	Raster Overlay, Map Algebra Neighborhood Functions	Stuff	Lab 4 Continued
8	3-8/10	Raster Analysis and Modeling w/ Numpy & GDAL	Stuff	Lab 5: Raster convolution with Numpy
9	3-15/17	Buffer week	Stuff	Lab 5 Continued
Spring Break	3-22/24	Spring Break	Spring Break	Spring Break
10	3-29/31	More FOSS Tools	Stuff	Lab 6: Open source tools and geospatial analysis
11	4-5/7	Objects & Classes	A Byte of Python: Object Oriented Programming	Work in project groups
12	4-12/14	Objects & Classes	Stuff	Work in project groups
13	4-19/21	Special Topic/Project Advice	Stuff	Work in project groups
14	4-26/28	Presentations	None	Work in project groups

Grading

	Undergraduate	**Graduate**
Lab Assignments (labs 0–5)	100 pts	100 pts
Lab Participation	10 pts	10 pts
Class Participation	10 pts	10 pts

Group Project (Team)	30 pts	30 pts
Group Project (Individual)	30 pts	30 pts
Total	**180 pts**	**180 pts**

Project Leaders can earn up to 20 extra points and can receive a maximum of 200 pts.

Geography Department Policies

Code of Conduct

In the Department of Geography, instructors strive to create an atmosphere of mutual trust and respect in which learning, debate, and intellectual growth can thrive. Creating this atmosphere requires that instructors and students work to achieve a classroom in which learning is not disrupted. At the most basic level, this means that everyone attend class, be prepared with readings and assignments, and that students pay attention. This means no conversations with friends, reading the newspaper, coming late or leaving early without a reason. Such behavior is disruptive to your fellow classmates.

These basics of classroom etiquette are an important means of building and showing mutual respect. Inevitably, however, disagreements will arise. Sometimes these disagreements will be about content, sometimes about grades or course procedures, and sometimes they will be about the treatment of participants in the class. In order to facilitate the resolution of these disagreements, the following guidelines should be followed by everyone:

- All interactions must be guided by mutual respect and trust.
- If you are bothered by some aspect of the class, identify what is bothering you and center discussion on that issue.
- Address issues that concern you early. Problems are easier to resolve early on.
- Consider whether it is best to address your concerns in class or in a separate appointment with the instructor. Remember, behavior that disrupts your fellow classmates is not acceptable.
- Abusive speech or behavior will not be tolerated in any interaction between students or between student and instructor. If an instructor feels that your speech or behavior is abusive, you will be asked to leave the room. If you believe an instructor has become abusive, you may leave the room and talk with the department chairperson. Debate and discussion can continue when all parties proceed with mutual respect.
- If mutual respect cannot be restored, either you or the instructor may take the issue to the department chairperson or the Campus Ombuds Office.

Geography Department Statement of Inclusivity

CU Boulder Geography acknowledges that racism, classism, ableism, homophobia, transphobia, sexism, casteism, and other forms of oppression exist on our campus and impact the learning environment of our students. This department also recognizes that our diversity can deepen our understanding of one another and the world around us, rather than divide us. All races/ethnicities, genders and gender identities, religions, ages, sexual orientations, disabilities, socioeconomic backgrounds, and nationalities are welcome here.

Building an inclusive environment where all students can share their rich array of perspectives and experiences is key to the learning experience at CU Boulder. For our class to be successful, everyone should feel they can

contribute and learn in a supportive environment. Each and every voice in the classroom is important and brings with it a wealth of experiences, values and beliefs. To the extent that we each bring forward our unique and full selves, we will deepen the learning for ourselves and each other. Each of us shares the responsibility for making our classroom and the university a positive and better place to live, work, and learn and, as such, we will treat every individual with respect, dignity, and civility. In the time we share together over the semester, please honor the uniqueness of your fellow classmates, and appreciate the opportunity we have to learn from each other. There is zero tolerance for racist, sexist, homophobic, xenophobic, or other discriminatory language or exclusionary behavior on our campus. If you feel a sense of isolation from the CU Boulder community or if you need any specific accommodations, please speak with the instructor early in the semester about your concerns and what we can do to support you.

Institutional Policies

Classroom Behavior

Both students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote or online. Those who fail to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. For more information, see the policies on **classroom behavior** (http://www.colorado.edu/policies/student-classroom-and-course-related-behavior) and the **Student Conduct & Conflict Resolution policies** (https://www.colorado.edu/sccr/student-conduct).

Requirements for COVID-19

As a matter of public health and safety, all members of the CU Boulder community and all visitors to campus must follow university, department and building requirements and all public health orders in place to reduce the risk of spreading infectious disease. Students who fail to adhere to these requirements will be asked to leave class, and students who do not leave class when asked or who refuse to comply with these requirements will be referred to **Student Conduct and Conflict Resolution** (https://www.colorado.edu/sccr/). For more information, see the policy on **classroom behavior** (http://www.colorado.edu/policies/student-classroom-and-course-related-behavior) and the **Student Code of Conduct** (http://www.colorado.edu/osccr/). If you require accommodation because a disability prevents you from fulfilling these safety measures, please follow the steps in the “Accommodation for Disabilities” statement on this syllabus.

CU Boulder currently requires masks in classrooms and laboratories regardless of vaccination status. This requirement is a precaution to supplement CU Boulder’s COVID-19 vaccine requirement. Exemptions include individuals who cannot medically tolerate a face covering, as well as those who are hearing-impaired or otherwise disabled or who are communicating with someone who is hearing-impaired or otherwise disabled and where the ability to see the mouth is essential to communication. If you qualify for a mask-related accommodation, please follow the steps in the “Accommodation for Disabilities” statement on this syllabus. In addition, vaccinated instructional faculty who are engaged in an indoor instructional activity and are separated by at least 6 feet from the nearest person are exempt from wearing masks if they so choose.

If you feel ill and think you might have COVID-19, if you have tested positive for COVID-19, or if you are unvaccinated or partially vaccinated and have been in close contact with someone who has COVID-19, you should stay home and follow the further guidance of the **Public Health Office** (https://www.colorado.edu/health/public-health/quarantine-and-isolation) (**contacttracing@colorado.edu** (mailto:contacttracing@colorado.edu)). If you are fully vaccinated and have been in close contact with someone who has COVID-19, you do not need to stay home; rather, you should self-monitor for symptoms and follow the further guidance of the **Public Health Office** (https://www.colorado.edu/health/public-health/quarantine-and-isolation) (**contacttracing@colorado.edu** (mailto:contacttracing@colorado.edu)).

Accommodation for Disabilities

If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the **Disability Services website** (https://www.colorado.edu/disabilityservices/) . Contact Disability Services at 303-492-8671 or **dsinfo@colorado.edu** (mailto:dsinfo@colorado.edu) for further assistance. If you have a temporary medical condition, see **Temporary Medical Conditions** (http://www.colorado.edu/disabilityservices/students/temporary-medical-conditions) on the Disability Services website.

Preferred Student Names and Pronouns

CU Boulder recognizes that students' legal information doesn't always align with how they identify. Students may update their preferred names and pronouns via the student portal; those preferred names and pronouns are listed on instructors' class rosters. In the absence of such updates, the name that appears on the class roster is the student's legal name.

Honor Code

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code academic integrity policy. Violations of the Honor Code may include, but are not limited to: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code (**honor@colorado.edu** (mailto:honor@colorado.edu)); 303-492-5550). Students found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code as well as academic sanctions from the faculty member. Additional information regarding the Honor Code academic integrity policy can be found on the **Honor Code website** (https://www.colorado.edu/osccr/honor-code) .

Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation

CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. The university will not tolerate acts of sexual misconduct (harassment, exploitation, and assault), intimate partner violence (dating or domestic violence), stalking, or protected-class discrimination or harassment by or against members of our community. Individuals who believe they have been subject to misconduct or retaliatory actions for reporting a concern should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127

or email **cureport@colorado.edu (mailto:cureport@colorado.edu)** . Information about university policies, **reporting options (https://www.colorado.edu/oiec/reporting-resolutions/making-report)** , and the support resources can be found on the **OIEC website (http://www.colorado.edu/institutionalequity/)** .

Please know that faculty and graduate instructors have a responsibility to inform OIEC when they are made aware of incidents of sexual misconduct, dating and domestic violence, stalking, discrimination, harassment and/or related retaliation, to ensure that individuals impacted receive information about their rights, support resources, and reporting options. To learn more about reporting and support options for a variety of concerns, visit **Don't Ignore It (https://www.colorado.edu/dontignoreit/)** .

Religious Holidays

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance.

See the **campus policy regarding religious observances (http://www.colorado.edu/policies/observance-religious-holidays-and-absences-classes-andor-exams)** for full details.