

# GEOG 4303/5303 SPRING 2020

## GIS PROGRAMMING FOR SPATIAL ANALYSIS

**LECTURE:** M 4–6:50pm GUGG 2 / KESDA  
**INSTRUCTOR:** Stefan Leyk (Office: GUGG 201F)  
**E-MAIL/PHONE** [stefan.leyk@colorado.edu](mailto:stefan.leyk@colorado.edu) / 2-4695  
**OFFICE HOURS:** M 11am-12:15pm, or by appt.

**LABS:** T 12:30-3:20pm & W 4-6:50pm KESDA  
**TA:** Georgios Charisoulis  
[gech8478@colorado.edu](mailto:gech8478@colorado.edu)  
T 11-noon & R 1-2pm (KESDA), or by apt.

**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.

Homepage: [https://spot.colorado.edu/~leyk/classes/geog\\_4303\\_5303/Overview.html](https://spot.colorado.edu/~leyk/classes/geog_4303_5303/Overview.html)

**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 10x 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 register for one 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. Exceptions require the permission of the professor. **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 in time even if you did not finish (I'll explain).*

### MAIN READINGS & RESOURCES:

We have seen an explosion of Python books and tutorials, recently. Also, some books that combine programming and GIS appeared. However, in class we mainly rely on online tutorials, help sources and e-books. For each of the categories below, the main sources you should get used to, are indicated by \* (and you don't have to pay anything for them).

#### PYTHON INTRODUCTION

- \*Guido van Rossum and the Python development team. 2019. Python 2.7.16 documentation, <https://docs.python.org/release/2.7.16/> with download of references and tutorials from <https://docs.python.org/release/2.7.16/download.html>
- \*Guido van Rossum and the Python development team. 2019. The Python Tutorial (version 2.7.16), Python Software Foundation, <https://docs.python.org/release/2.7.16/tutorial/index.html> (**PyIntro**)
- \*Guido van Rossum and the Python development team. 2019. The Python Language Reference (version 2.7.16), Python Software Foundation. Find it as online source at <https://docs.python.org/release/2.7.16/reference/index.html> (**PyIntroR**)
- Mark Lutz. 2013, *Learning Python*, O'Reilly, 5<sup>th</sup> edition, pp. 1648. (**LP**)
- \*Swaroop. 2016. A Byte of Python. © Swaroop C H, <https://swaroop-c-h.gitbook.io/byte-of-python/>, 168 pp.; released under Creative Commons License (**BP**)
- TutorialsPoint. 2017. Learn Python (basic and advanced tutorials online) (<http://www.tutorialspoint.com/python/>) (**TP**)

#### PYTHON & GIS

- \*ArcGIS for Desktop Help Center. 2019. <https://desktop.arcgis.com/en/arcmap/10.6/get-started/introduction/whats-new-in-arcgis.htm> (**ArcHelp**)
- \*ArcGIS for Desktop: What is ArcPy? 2018: <https://desktop.arcgis.com/en/arcmap/10.6/analyze/arcpy/what-is-arcpy.htm> (**ArcPy**)
- \*ArcGIS for Desktop: What is Python? 2018: <https://desktop.arcgis.com/en/arcmap/10.6/analyze/python/what-is-python.htm> (**PyGP**)
- \*Python GDAL/OGR Cookbook 2019: <http://pcjericks.github.io/py-gdalogr-cookbook/> (**COOK**)
- \*Environmental Systems Research Institute (ESRI). 2014. ArcGIS 10.3 arcpy Wall Reference Poster. <http://www.arcgis.com/home/item.html?id=b1e16a7b04c64da591301a796fa044d0> (**GPM**)

#### PYTHON SCIENTIFIC COMPUTING & STATISTICS

- \*SciPy. 2019. SciPy Reference Guide. Release 1.2.1. available at <https://docs.scipy.org/doc/scipy-1.2.1/reference/> (**SciPy**)

\*Numpy. 2019. Numpy User Guide, Release 1.16.1. available at <https://docs.scipy.org/doc/numpy-1.16.1/user/> (NumPy)  
 \*Numpy. 2019. Numpy Reference, Release 1.16.1. available at <https://docs.scipy.org/doc/numpy-1.16.1/reference/> (NumPyR)  
 Travis Oliphant . 2006. Guide to NumPy: 2nd Edition. CreateSpace, pp. 364  
 Ivan Idris. 2015. NumPy: Beginner's Guide - Third Edition. Packt Publishing, pp. 322

Additional, slightly outdated textbooks you would have to buy:

Nathan Jennings. 2015. A Python Primer for ArcGIS®: Workbook 1, The Fundamentals. CreateSpace, pp. 118 (JEN1)  
 Nathan Jennings. 2015. A Python Primer for ArcGIS®: Workbook 2, Core Geoprocessing Functionality. CreateSpace, pp. 252 (JEN2)  
 Silas Toms. 2015. ArcPy and ArcGIS - Geospatial Analysis with Python. Packt Publishing. pp. 210 (TOM)  
 Eric Pimpler. 2015. Programming ArcGIS (10.3) with Python Cookbook - Second Edition. Packt Publishing. pp. 380 (PIM)  
 Erik Westra. 2016. Python Geospatial Development - Third Edition. Packt Publishing, pp. 446 (WES)

**GRADING:** Grading for undergraduate or graduate students depends on whether you are a project leader or not.

	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
<b>Total</b>	<b>180</b>	<b>180</b>

**Project leaders** can earn an extra credit (20 pts) and can receive a maximum of 200 pts, respectively. *No incompletes!*

**GROUP PROJECTS:** During the final weeks of the term, students will work in small working groups on a chosen programming problem. Three presentations have to be given (a proposal presentation by the project leader, a progress report and a final presentation both by the whole group) to the class. To become a project leader, you must submit a written topic/case (abstract) by Feb 17, and find at least one other student to work with you. Additionally, you must have GIS data at hand by Mar 02 (otherwise come and talk to me or George early enough if you need advice). Each group will write a final paper on the work done (due on May 04, 2020).

W Day	Lecture	Reading	Lab Exercise
1 01/13	Introduction (cl. 0) Programming & Python Basics, Geoprocessing Scripting Basics (cl. 1)	BP, PyIntro, LP, ArcHelp, TP	Intro and first working steps; PC set up and installation
2 01/20	MLK - no lecture		Lab 0: Intro to Python and ArcPy (5)
3 01/27	Variables, Data & Data Objects, Text files (cl. 2)	BP, PyIntro, TP, LP,	Lab 1: Temporal trends in vector data (10)
4 02/03	Scripting with GP Tools and Methods, Geometry (cl. 3)	BP, LP, PyIntro ArcHelp, PyGP, ArcPy	Lab 2: Creating spatial data geometry from raw text (15)
5 02/10	Modules & Functions (cl. 4)	BP, LP, PyIntro, TP	Lab 3: Sampling design with vector data (20)
6 02/17	Operators, Logic & Decisions, Debugging (cl. 5) [Project proposals due]	BP, LP, PyIntro, TP	Lab 3 cont.
7 02/24	Spatial Data Manipulation and Editing/ Sampling exercise (cl. 6)	ArcHelp, PyGP, ArcPy, JEN, GPM	Lab 4: 3D Shape descriptors in raster & vector data (25)
8 03/02	Raster Data Access and Queries with Numpy (cl. 7) [Proposal Presentations] (prospective project leaders)	Numpy, NumpyR, SciPy, WES	Lab 4 cont.
9 03/09	Raster Overlay, Map Algebra, Neighborhood Functions (cl. 8) [Project group selection]	Numpy, NumpyR, SciPy, WES, COOK	Lab 5: Raster convolution with Numpy (25)
10 03/16	Raster Analysis, Modeling in Numpy & GDAL (cl. 9) Exercise: Distance Functions in Raster Data	GDALWeb Numpy, WES, COOK	Lab 5 cont.
11 03/23	Spring break – no classes		
12 03/30	Objects and classes in Python: Basics 1 (cl. 10a) Project Advice	PyIntro, TP, BP, LP	Work in project groups
13 04/06	Objects and classes in Python: Basics 2 (cl. 10b) Project Advice	PyIntro, TP, BP, LP	Work in project groups
14 04/13	[Status Presentations] Special Topic – Guest lecture & Project Advice		Work in project groups
15 04/20	Project Advice		Testing of projects
16 04/27	[Final Project Presentations]		Final report due 04 May, 2020, 8pm

### **Disability**

If you qualify for accommodations because of a disability, please submit to your professor a letter from Disability Services in a timely manner (for exam accommodations provide your letter at least one week prior to the exam) so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities. Contact Disability Services at 303-492-8671 or by e-mail at [dsinfo@colorado.edu](mailto:dsinfo@colorado.edu). If you have a temporary medical condition or injury, see Temporary Medical Conditions: Injuries, Surgeries, and Illnesses guidelines under Quick Links at Disability Services website and discuss your needs with your professor.

### **Religious observances**

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. In this class, please let the instructor know about such conflicts as soon as you studied the schedule for this semester in particular the exam dates.

### **Policy on Classroom Behavior**

Students and faculty each have responsibility for maintaining an appropriate learning environment. 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 differences of race, color, culture, religion, creed, politics, veteran's status, sexual orientation, gender, gender identity and gender expression, age, disability, and nationalities. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. See policies at <http://www.colorado.edu/policies/classbehavior.html> and at [http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student\\_code](http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student_code)

### **Policy on Discrimination and Harassment**

The University of Colorado Boulder (CU-Boulder) is committed to maintaining a positive learning, working, and living environment. The University of Colorado does not discriminate on the basis of race, color, national origin, sex, age, disability, creed, religion, sexual orientation, or veteran status in admission and access to, and treatment and employment in, its educational programs and activities. (Regent Law, Article 10, amended 11/8/2001). CU-Boulder will not tolerate acts of discrimination or harassment based upon Protected Classes or related retaliation against or by any employee or student. For purposes of this CU-Boulder policy, "Protected Classes" refers to race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, or veteran status. Individuals who believe they have been discriminated against should contact the Office of Discrimination and Harassment (ODH) at 303-492-2127 or the Office of Student Conduct (OSC) at 303-492-5550. Information about the ODH, the above referenced policies, and the campus resources available to assist individuals regarding discrimination or harassment can be obtained at <http://www.colorado.edu/odh>

### **Policy on Plagiarism**

All students of the University of Colorado at Boulder are responsible for knowing and adhering to the academic integrity policy of this institution. Violations of this policy may include: cheating, plagiarism, aid of academic dishonesty, fabrication, lying, bribery, and threatening behavior. All incidents of academic misconduct shall be reported to the Honor Code Council ([honor@colorado.edu](mailto:honor@colorado.edu); 303-735-2273). Students who are found to be in violation of the academic integrity policy will be subject to both academic sanctions from the faculty member and non-academic sanctions (including but not limited to university probation, suspension, or expulsion). Other information on the Honor Code can be found at <http://www.colorado.edu/policies/honor.html> and at <http://www.colorado.edu/academics/honorcode/>

### **Department of Geography 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 completed, and that students pay attention. This means no conversations with friends, reading the newspaper, coming late, or leaving early. Such behavior is disruptive to the instructor and 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 it is that is bothering you and center the discussion on that issue.
- Address issues that concern you early. Problems are easier to resolve before they fester.
- 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.

**Spring 2020**

**QUESTIONNAIRE**

**NAME** \_\_\_\_\_ **YEAR** \_\_\_\_\_  
(leave blank if you prefer)

**MAJOR** \_\_\_\_\_ **CONCENTRATION** \_\_\_\_\_

**WHAT OTHER COURSEWORK** have you taken related to GIS, Cartography, Remote Sensing or Programming? **WHAT WORKING EXPERIENCE** do you have related to those fields?

1. \_\_\_\_\_ 2. \_\_\_\_\_

3. \_\_\_\_\_ 4. \_\_\_\_\_

**WHAT DO YOU EXPECT TO LEARN BY TAKING THIS COURSE?**

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**ANY CONCERNS ABOUT TAKING THIS COURSE?**

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Thank you very much. This information is important for me to know who you are.