GEOG 4303/5303 SPRING 2018
GIS PROGRAMMING FOR SPATIAL ANALYSIS

LECTURE: **M 4–6:50pm GUGG 2 / KESDA**   **LABS:**   **T 12:30-3:20pm & W 4-6:50pm KESDA**
INSTRUCTOR: Stefan Leyk (Office: GUGG 201F)   TA: Mehran Ghandehari
E-MAIL/PHONE   stefan.leyk@colorado.edu / 2-4695   Mehran.Ghandehari@colorado.edu
OFFICE HOURS: Mon 11am-12:15pm, or by appt.   M 3-4pm & Tue 10-11am (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. 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 as well as for methods development. During the last weeks of the term students will work in small groups on a project, which has been proposed by the group leaders. The topics may be related to the research conducted by the group leaders.

Homepage: http://www.colorado.edu/geography/leyk/geog_4303/

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 is required. GEOG 4203/5203 or experience in using ModelBuilder would be advantageous. Programming experience is not a prerequisite but would certainly be helpful.

CLASS MEETINGS: Concepts and theoretical aspects will be covered and exercises/demos including linked discussions will help to better understand 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 the interest of students and needs for the class.

LABS: Students must register for one lab session every week. Programming 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. 2016. The Python Tutorial (version 2.7.14), Python Software Foundation, pp. 139. Find it at http://www.python.org/doc/ (**PyIntro**)

    *Guido van Rossum and the Python development team. 2016. The Python Language Reference (version 2.7.14), Python Software Foundation. Find it at http://www.python.org/doc/ (**PyIntroR**)

    *Mark Lutz. 2011, *Learning Python: Powerful Object-Oriented Programming,* O'Reilly, 4th edition, pp. 1216. (**LP**)

    *Swaroop. 2016. A Byte of Python. © Swaroop C H / released under Creative Commons License http://www.swaroopch.com/notes/Python , 168 pp.; as PDF from the class homepage (**BP**)

    TutorialsPoint. 2015. Learn Python (basic and advanced tutorials) (http://www.tutorialspoint.com/python/)

PYTHON & GIS

    *ArcGIS for Desktop Help Center. 2017. http://desktop.arcgis.com/en/arcmap/10.4/get-started/introduction/whats-new-in-arcgis.htm (**ArcHelp**)

    *ArcGIS for Desktop: What is ArcPy? 2017: http://desktop.arcgis.com/en/desktop/latest/analyze/arcpy/what-is-arcpy-.htm (**ArcPy**)

    *ArcGIS for Desktop: What is Python in Geoprocessing? 2017: http://desktop.arcgis.com/en/arcmap/10.4/analyze/python/what-is-python-.htm (**PyGP**)

    Nathan Jennings. 2011. A Python Primer for ArcGIS®. CreateSpace, pp. 458 (**JEN**)

    Nathan Jennings. 2015. A Python Primer for ArcGIS®: Workbook 1, The Fundamentals. CreateSpace, pp. 118 (https://www.createspace.com/5205001) (**JEN1**)

    Nathan Jennings. 2015. A Python Primer for ArcGIS®: Workbook 2, The Core Geoprocessing Functionality. CreateSpace, pp. 252 (https://www.createspace.com/5215222) (**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. 2013. Python Geospatial Development - Second Edition. Packt Publishing, pp. 508 **(WES)**

Paul Z. Zandbergen. 2013. Python Scripting for ArcGIS (10.1). ESRI Press, pp. 353 **(ZAN)**

*Environmental Systems Research Institute (ESRI). 2015. ArcGIS 10.3 arcpy Wall Reference Poster. http://www.arcgis.com/home/item.html?id=b1e16a7b04c64da591301a796fa044d0 **(GPM)**

Python GDAL/OGR Cookbook: http://pcjericks.github.io/py-gdalogr-cookbook/ **(COOK)**

PYTHON SCIENTIFIC COMPUTING & STATISTICS

*SciPy. 2015. SciPy Reference Guide. Release 0.15.1. available at http://docs.scipy.org/doc/scipy-0.15.1/reference/ **(SciPy)**

*Numpy. 2015. Numpy User Guide, Release 1.9.2. available at http://docs.scipy.org/doc/numpy-1.9.2/user/ **(NumPy)**

*Numpy. 2015. Numpy Reference, Release 1.9.2. available at http://docs.scipy.org/doc/numpy-1.9.2/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

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
Total	**180**	**180**

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 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 19*, and find at least one other student to work with you. Additionally, you must have GIS data at hand by *Mar 05* (otherwise come and talk to me or Alex early enough if you need advice). Each group will write a final paper on the work done (due on May 07, 2017).

W	Day	Lecture	Reading	Lab Exercise
1	01/15	*MLK - no lecture*		PC set up and installation
2	01/22	Introduction (cl 0) Programming & Python Basics, GP Scripting Basics in GIS (cl. 1)	BP, PyIntro, LP, ArcHelp	*Lab 0*: Intro to Python and ArcPy (5)
3	01/29	Variables, Properties & objects, Text files (cl. 2)	BP, PyIntro, LP,	*Lab 1*: Temporal trends in vector data (10)
4	02/05	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	02/12	Modules & Functions (cl. 4)	BP, LP, PyIntro	*Lab 3*: Sampling design with vector data (20)
6	02/19	Operators, Logic & Decisions, Debugging (cl. 5) **[Project proposals due]**	BP, LP, PyIntro	*Lab 3* cont.
7	02/26	Spatial Data Manipulation and Editing/ Sampling exercise (cl. 6)	ArcHelp, PyGP, ArcPy, JEN, ZAN, GPM	*Lab 4*: 3D Shape descriptors in raster & vector data (25)
8	03/05	Raster Processing & Numpy: Access, Neighborhood, Filtering (cl. 7) **[Proposal Presentations]** (prospective project leaders)	Numpy, NumpyR, SciPy, WES	*Lab 4* cont.
9	03/12	More Numpy & Raster Analysis (cl. 7b) **[Project group selection]**	Numpy, NumpyR, SciPy, WES, COOK	*Lab 5*: Raster convolution with Numpy (25)
10	03/19	Raster, data capture and modeling in Numpy & GDAL (cl. 8) Exercise: Distance Functions in Raster Data	GDALWeb Numpy, WES, COOK	*Lab 5* cont.
11	03/26	*Spring break – no classes*		
12	04/02	Objects and classes in Python (cl. 9)	BP, LP, OOP1-3	Work in project groups
13	04/09	Py Objects exercises, OOP in the context of Geometry and Arrays Project Advice		Work in project groups
14	04/16	**[Status Presentations]** Project Advice		Work in project groups
15	04/23	Extraction & Recognition (cl. 10) Project Advice		Testing of projects
16	04/30	**[Final Project Presentations]**		**Final report due 07 May 2018, 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. 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

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; 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.

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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WHAT CONCERNS DO YOU HAVE ABOUT TAKING THIS COURSE?

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