ATOC 4500/7500
Scientific Programming and Data Visualization
Fall 2018

Instructor: Prof. Sebastian Schmidt, SPSC W132 (303) 492-6423
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Class: Tuesdays and Thursdays 12:30-1:45 pm, HUMN 1B35 (Mac lab)
Office hours: Wed SPSC W132 2-4:30pm + Thu Laughing Goat 2-3 pm
Directions: **http://lasp.colorado.edu/home/about/address-directions/spsc/**

Summary
This course will introduce programming and analysis techniques to process, interpret, and visualize data sets that are commonly used in the atmospheric and oceanic sciences. The main programming language is python, which will be taught in the lab component, along with the basics of linux operating systems. Applications include accessing, reading, and mapping of satellite, ground-based and aircraft Earth observations, as well as correlative/spectral data analysis, functional fitting, and data aggregation from the pixel level to global climatologies. The course will also touch on approaches for merging data sets from sources as different as reanalysis and satellite observations. Prerequisites: ATOC 1050 (or equivalent). Basic knowledge of calculus is strongly recommended. The course fulfills 3 credits of the ATOC minor.

Reading/Teaching Material: The course draws from multiple textbooks and online material, which is/will be posted on D2L. Here are the primary resources:

- **Johnny Wei-Bing Lin: A Hands-On Introduction to Using Python in the Atmospheric and Oceanic Sciences (on D2L;** http://www.johnny-lin.com/pyintro/**)**
- Hans Petter Langtangen: A Primer on Scientific Programming with Python (more comprehensive programming resource; includes numerical "recipes")
- **John R. Taylor: An Introduction to Error Analysis (on D2L; fundamentals of statistics, curve fitting, hypothesis testing, spectral analysis, …)**
- Philip R. Bevington: Data Reduction and Error Analysis (on D2L; more advanced)
- https://www.datacamp.com/
- Course material for ATOC6020-819: Python in Atmospheric and Oceanic Sciences

Programming Language and Environment: The primary programming language taught in this course is python. However, we will very briefly touch on IDL/Matlab (see also IDL/python xref on D2L). We will also look at Fortran and C because they remain indispensable programming languages in the geosciences.
Emphasis will be on embedding and understanding simple external code in python "wrappers". For installing python on personal laptops, download "anaconda" at https://www.anaconda.com/download/ **with python 3**.x (do *not* get 2).

Course Website: D2L (updated throughout semester)

Class philosophy and structure:

There are essentially two parts to this course:

(1) "Nuts and bolts" of learning the python language: As with any language, the best learning approaches can vary from person to person, but they all have in common that mastery comes with practice. For this reason, a significant part of the "memorization" work (learning by doing) should be done at home! Of course, we will introduce and discuss programming principles in class during the "lab part" (40-45 minutes) of each class. We will also work on specific science projects that require programming.

(2) "Methods": In the lecture part of the class (~30-35 minutes), we will get to know basic concepts of scientific data analysis/time series/correlative analysis, functional fitting/hypothesis testing, statistics and error propagation, image processing and mapping/visualization/re-projection (think: NASA WorldView), data aggregation and combination etc. Usually, the lecture part will be followed by hands-on application of the new concepts during the lab part (above).

Performance elements and grading

Homework	30%
Attendance	10%
In-class tests (on reading/online assignments)	20%
Midterm exam	20%
Project (groups of 2)	20%

Tentative Schedule

…Will be adjusted depending on students' needs and progress:

Week[1]	**Methods (lecture)**	**Programming (lab)** [reading Lin]
1	Introduction	"Hello World" – Programming Environment [1-2]
2-4	Curve Fitting	Python basics; packages; math; plotting; [3-6]
	Hypothesis Testing	data/file handling; curve fitting
	Statistics	program control structures
5(6)	Map projections	maps/cartopy, satellite/aircraft data plotting
6-7	Merging, aggregating,	visualizing data from different sources
8-9	Time series analysis	procedural vs. object-oriented programming [7-8]
	Correlative analysis	Fourier transforms; EOF/PCA analysis; sonogram
9-10	Image Processing	foray into fortran; embedding external code
	Machine Learning	notebook applications and web sharing
11	Remote Sensing	movies, interactive plots; met/sat plots
12-13	Numerical Methods	applications; work on projects
14-15	Project Presentations	applications

[1]Each week, we will look at method/package, data set, and/or visualization/analysis technique.

Mandatory Reading: Important Policies

Accommodation for Disabilities

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 email at dsinfo@colorado.edu. If you have a temporary medical condition or injury, see Temporary Injuries guidelines under the Quick Links at the 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. Please notify me in advance so that arrangements can be made to accommodate your schedule.
See the campus policy regarding religious observances for full details.

Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation

The University of Colorado Boulder (CU Boulder) is committed to maintaining a positive learning, working, and living environment. CU Boulder will not tolerate acts of sexual misconduct, discrimination, harassment or related retaliation against or by any employee or student. CU's Sexual Misconduct Policy prohibits sexual assault, sexual exploitation, sexual harassment, intimate partner abuse (dating or domestic violence), stalking or related retaliation. CU Boulder's Discrimination and Harassment Policy prohibits discrimination, harassment or related retaliation based on race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, political affiliation or political philosophy. Individuals who believe they have been subject to misconduct under either policy should contact the Office of Institutional Equity and Compliance (OIEC) at 303-492-2127. Information about the OIEC, the above referenced policies, and the campus resources available to assist individuals regarding sexual misconduct, discrimination, harassment or related retaliation can be found at the OIEC website.

Honor Code

All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the academic integrity policy of the institution. Violations of the policy may include: plagiarism, cheating, fabrication, lying, bribery, threat, unauthorized access, clicker fraud, resubmission, and aiding academic dishonesty. All incidents of academic misconduct will be reported to the Honor Code Council (honor@colorado.edu; 303-735-2273). Students who are found responsible for violating the academic integrity policy will be subject to nonacademic sanctions from the Honor Code Council as well as academic sanctions from the faculty member. Additional information regarding the academic integrity policy can be found at http://honorcode.colorado.edu.