GEOG 696C Physical Geography
Spatiotemporal Data Analysis
Spring 2026

This course is designed as a graduate level class in a *workshop* format to give students a theoretical framework, practical experience, expert knowledge, and statistical tools for analyzing spatiotemporal datasets. Topics include basic matrix algebra and statistics, exploratory data analysis, field correlation and regression analysis, autocorrelation and its statistical consequences in time and space, parametric and non-parametric significance testing and error analysis, empirical orthogonal functions including rotation, singular spectrum analysis, maximum covariance and canonical correspondence analysis, and traditional and multitaper spectral analysis. The course encompasses instruction and training in Python and in the use and manipulation of large multi-dimensional datasets.

The major outcome for the class for each student will be a new and independent analysis of a substantial space-time dataset, a formal manuscript describing the motivation, methods, and results of this analysis, and a professional oral presentation. Students are encouraged to bring with them or seek out data relevant to their research to use for their final project. Ideally, students' final projects will provide the material for a thesis chapter and/or peer-reviewed article.

This syllabus and course schedule are subject to change.
Please check regularly for updated information on D2L

Locations and Times

Tuesday and Thursday, 12:30PM to 1:45PM
Bannister Tree-Ring Laboratory Building, Room 424
Course materials online via D2L (`http://d2l.arizona.edu`)

Instructor Information

Kevin Anchukaitis
Professor, School of Geography, Development, and Environment
Laboratory of Tree Ring Research
Room 401, Bannister Tree-Ring Laboratory Building
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Office Hours

Office Hours: TBD and by appointment

Course Information

Prerequisites

Continuing graduate student status in a degree program at the University of Arizona or permission from instructor. Some prior mathematics or statistical courses are encouraged. Prior programming experience encouraged but not required.

Course Objectives

This course has the following objectives:

- Factual: You will acquire fundamental knowledge of mathematical and statistical methods for the analysis of space-time data, including the basics of linear algebra and matrix operations. You will become familiar with the terminology used to described space-time data and the statistical procedures and outcomes applied in spatiotemporal data analysis. You will be able to locate and acquire appropriate data.

- Conceptual: You will develop an understanding of the available spatiotemporal statistical tools and when to best or appropriately apply them to exploratory data analysis, hypothesis testing, and data reduction and regularization. You will cultivate a first-order understanding of the motivations, advantages, and disadvantages for different procedures and how uncertainties in the underlying data and methods potentially propagate through your analyses. You will be able to identify sources of both signal and noise in your data and analyses.

- Procedural: You will learn how to apply specific methodologies to the analysis of spatiotemporal data, including the practical, hands-on procedures for managing data and implementing these methods and approaches in a high level programming language (Python). You will be able to differentiate between the relative magnitudes and significance of effects or processes and recognize and remove errors associated with data or the implementation of your procedures ('debugging').

- Metacognitive: You will recognize the potential and limitation of statistical and data analytical methods with respect to the constraints from the underlying physical, deterministic processes you seek to explore. You will be able to identify reasonable (and unreasonable) inferences or conclusions from your analyses. You will develop an enhanced recognition of how potential biases – including both methodological as well as cognitive – enter into statistical analyses of both deterministic and stochastic systems and inference based on these results. You will practice deploying both quantitative analyses and qualitative reasoning using your methodological skills and systems-based knowledge. You will recognize how the mathematical basis of the methods used may limit the utility of these for some data types or dynamic systems.

Learning Outcomes

By the end of the semester, students will be able to design and conduct a complete statistical analysis of a spatiotemporal dataset. The students will be able to build and test their own analytical programs using a high-level computer language and apply their code to the quantitative analysis of a dataset relevant to their own research. Students will be able to make abductive inferences about the physical or social system they are studying by applying their analysis and their understanding of the magnitude and sources of uncertainty. Students will be able to describe, support, and defend their inferences in a public presentation to the class.

Required Texts or Readings

There is no required textbook for this course. Required readings will be posted on D2L.

Precedent and Acknowledgement

This course and its structure and content was inspired and influenced by spatiotemporal data and objective analysis classes taught by Mike Evans (University of Maryland) and John Chiang (Berkeley).

Assignments and Methods of Assessment

Prework: [20%] These assignments will consist of readings and guided responses and will provide the theoretical or practical motivation or background for topics studied in this class. The assignments (including necessary readings) will be available a week or more prior to their due date, which will be indicated on the Course Schedule. These are individual assignments and students must prepare and submit to D2L an individual (non-collaborative) document. These assignments will be graded by the instructor. A rubric will be provided with each assignment. **The use of Generative AI or Large Language Models (LLM) such as ChatGPT are forbidden for these assignments.**

Homework: [20%] These assignments will include mathematical, statistical, and programming problems intended to provide practical and hands-on learning in Python, and to prepare students to conduct their own analyses of their own chosen dataset. Assignments will be posted one week (or more) before they are due. In most cases classroom workshop time will be available for students to query the instructor.

These are individual assignments and students must prepare and submit to D2L an individual (non-collaborative) document, although students are encouraged to discuss programming challenges they encounter. These assignments will be *self-graded* (*Edwards*, 2007) using the D2L online quiz system and a suggested solution set provided by the instructor.

Final Project (Paper): [50%] This assignment will be a manuscript, appropriately formatted for a significant peer-reviewed journal in the student's field of interest. Specific length and content (figures and tables) depend both on the analysis, the data, the hypothesis and research question, and the standard of the target journal and scientific field, but should reflect a substantial body of work, reflect the standards of the field and journal, be free of errors, and be of appropriate quality and significance that the manuscript could reasonably be finalized for actual submission. This is an individual assignment and students must prepare and submit to D2L an individual (non-collaborative) manuscript. This assignment will be graded by the instructor. A rubric will be provided. The assignment is **due on D2L no later than Monday, May 11th at 5:00pm Arizona time**. Students planning to attend AGU that week are encouraged to turn their assignment in early.

Final Project (Presentation): [10%] This assignment is a 15 minute (12 minute talk, 3 minutes for questions) professional talk describing the motivations and findings of the students' paper and manuscript. The presentation schedule will be determined and a rubric. Students are expected to prepare and give a talk reflecting the standards and practices of their field and to run within the given time window (15 minutes). This is an individual assignment. This assignment will be graded by the instructor with input from the student's peers. ***Attendance is required for all students for the student presentation days.***

Grade polices and Letter Grade Distribution:
University policies regarding grades and grading systems are available at:
`https://catalog.arizona.edu/policy/courses-credit/grading/grading-system`

Grade distribution for this course:
A: 90% and above
B: 80% to 89%
C: 70% to 79%
D: 65% to 69%
E: below 65%

Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at `https://catalog.arizona.edu/policy/courses-credit/grading/grading-system`. Please be aware of deadlines for requesting these grades. Requests for reconsideration of a grade received on a paper, project, or exam must be made to the instructor no later than 1 week after the assignment is made available to be returned to the student. Whether a reconsideration will be granted is entirely at the discretion of the instructor.

Late Work Policy
Assignments that are not completed or handed in on time, without prior arrangement with the instructor, can receive no more than 50% of the assigned points and may receive an automatic zero depending on the assignment (e.g. it will not be possible to complete in-class exercises late). Assignments not completed within 1 week of the original deadline, without prior arrangement with the instructor, will always receive no points for the assignment.

University Policies

Course Communications
All communications concerning class are via your official UA email addresses. It is the student's responsibility

to regularly check for email communications concerning class information and policies, and to contact the instructor from the student's official UA email address.

Course materials
Course materials will be available online via D2L (`http://d2l.arizona.edu`)

Absence and Class Participation Policy
The UA's policy concerning Class Attendance, Participation, and Administrative Drops is available at `https://catalog.arizona.edu/policy/registration-tuition-fees/registration-enrollment/change-schedule`. The UA policy regarding absences for any sincerely held religious belief, observance or practice will be accommodated where reasonable: `http://policy.arizona.edu/human-resources/religious-accommodation-policy`. Absences pre-approved by the UA Dean of Students will be honored.

Participating in the course and attending lectures and other course events are vital to the learning process. As such, attendance is required at all class meetings. Absences may affect a student's final course grade. If you anticipate being absent, are unexpectedly absent, or are unable to participate in class online activities, please contact me as soon as possible. To request a disability-related accommodation to this attendance policy, please contact the Disability Resource Center at (520) 621-3268 or `drc-info@email.arizona.edu`. If you are experiencing unexpected barriers to your success in your courses, the Dean of Students Office is a central support resource for all students and may be helpful. The Dean of Students Office is located in the Robert L. Nugent Building, room 100, or call 520-621-7057.

Assignment and Grading Policy for Students Who Register Late
Students who register late for the course will be required to complete all assignments. Due dates for assignments given prior to the student adding the course will be agreed upon my both student and the instructor.

Classroom Behavior Policy
To foster a positive learning environment, students and instructors have a shared responsibility. We want a safe, welcoming, and inclusive environment where all of us feel comfortable with each other and where we can challenge ourselves to succeed. To that end, our focus is on the tasks at hand and not on extraneous activities (e.g., texting, chatting, reading a newspaper, making phone calls, web surfing, etc.). Students observed engaging in disruptive activity will be asked to cease this behavior. Those who continue to disrupt the class will be asked to leave lecture or discussion and may be reported to the Dean of Students.

Threatening Behavior Policy
The UA Threatening Behavior by Students Policy prohibits threats of physical harm to any member of the University community, including to oneself. See `https://policy.arizona.edu/education-and-student-affairs/threatening-behavior-students`. Your instructor takes this extremely seriously.

Accessibility and Accommodations
Our goal in this classroom is that learning experiences be as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, please let me know immediately so that we can discuss options. You are also welcome to contact the Disability Resource Center (520-621-3268) to establish reasonable accommodations. For additional information on the Disability Resource Center and reasonable accommodations, please visit `http://drc.arizona.edu`. If you have reasonable accommodations, please plan to meet with me by appointment or during office hours to discuss accommodations and how my course requirements and activities may impact your ability to fully participate.

Code of Academic Integrity
Students are encouraged to share intellectual views and discuss freely the principles and applications of course materials. However, graded work/exercises must be the product of independent effort unless otherwise instructed. Students are expected to adhere to the UA Code of Academic Integrity as described in the UA General Catalog. See `https://deanofstudents.arizona.edu/student-rights-responsibilities/academic-integrity`.

The University Libraries have some excellent tips for avoiding plagiarism, available at:
`https://lib.arizona.edu/research/write-cite/plagiarism`.

Selling or posting without permission class notes and/or other course materials for other students or to a third party (e.g. such as Chegg) is not permitted without the instructor's express written consent. Violations to this are subject to the Code of Academic Integrity and may result in sanctions to anyone providing or using such materials, including loss of credit in the class. Additionally, students who use D2L or UA e-mail to sell or buy these copyrighted materials are subject to Code of Conduct Violations for misuse of student e-mail addresses. Finally, this conduct may also constitute copyright infringement.

UA Nondiscrimination and Anti-harassment Policy
The University is committed to creating and maintaining an environment free of discrimination; see `https://policy.arizona.edu/human-resources/nondiscrimination-and-anti-harassment-policy`. Our classroom is a place where everyone is encouraged to express well-formed opinions and their reasons for those opinions. We also want to create a tolerant and open environment where such opinions can be expressed without resorting to bullying or discrimination toward others.

Additional Resources for Students
UA Academic policies and procedures are available at:
`http://catalog.arizona.edu/policies`.

Student Assistance and Advocacy information is available at:
`https://deanofstudents.arizona.edu/support/student-assistance`

Confidentiality of Student Records
Please see the University's policy on the confidentiality of student records here: `https://registrar.arizona.edu/privacy-ferpa/ferpa`

Subject to Change Statement
Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.

Course Schedule

Date	Content and Assignments
Thursday, January 15	Course introduction and overview, class survey Philosophy, statistics, inference, programming, and Python. Setting up your system for Python
Tuesday, January 20	Spatiotemporal Data Introduction to Python; Data handling, formats, and sources **Pre-Work #1** due at start of class (Uncertainty and error models)
Thursday, January 22	Spatiotemporal data as arrays and matrices Introduction to matrix algebra & statistics Matrices and Linear Algebra in Python
Tuesday, January 27	*No class – Kevin in New York*
Thursday, January 29	*No class – Kevin in New York*
Tuesday, February 3	**Prework #2** due at start of class (Linear Algebra) Matrix algebra & statistics in Python, continued Variance and covariance *Homework #1* assigned (Covariance and Correlation)
Thursday, February 5	Covariance and Correlation Matrices Toward Empirical Orthogonal Functions Working with multidimensional data in `xarray`
Tuesday, February 10	**Homework #1** due at start of class Introduction to Empirical Orthogonal Functions *Homework #2* assigned (Empirical Orthogonal Functions I)
Thursday, February 12	Empirical orthogonal functions continued
Tuesday, February 17	Empirical orthogonal functions workshop and code review *Homework #3* assigned (Empirical Orthogonal Functions II)
Thursday, February 19	**Homework #2** due at start of class Workshop - Missing data and random data
Tuesday, February 24	Empirical orthogonal functions, Significance Testing, and Noise **Prework #3** due at start of class (Selection, Significance, Meaning)
Thursday, February 26	Empirical orthogonal functions (rotation) **Prework #4** due at start of class (Orthogonal Rotation and Interpretation) EOF Rotation Workshop
Tuesday, March 3	Empirical orthogonal functions and compositing **Prework #5** due at start of class (EOF interpretation) **Homework #3** due at start of class *Homework #4* assigned (Significance and Compositing)
Thursday, March 5	*No class - Kevin in Guatemala*
Tuesday, March 10	*No class - Spring Break*
Thursday, March 12	*No class - Spring Break*

Date	Content and Assignments
Tuesday, March 17	Maximum Covariance Analysis (MCA) **Prework #6** due at start of class (coupled fields) **Homework #4** due at start of class *Homework #5* assigned (Coupled patterns and Field Significance)
Thursday, March 19	Coupled fields workshop and code review
Tuesday, March 24	*No class - Earthweek*
Thursday, March 26	*No class - Earthweek*
Tuesday, March 31	Field correlation and significance workshop
Thursday, April 2	**Prework #8** due at start of class (Spectral analysis) Introduction to Spectral Analysis
Tuesday, April 7	Spectral analysis workshop
Thursday, April 9	**Homework #5** due at start of class Spectral analysis, continued Singular Spectrum Analysis and temporal autocovariance *Homework #6* assigned (Singular spectrum analysis)
Tuesday, April 14	Singular Spectrum Analysis workshop and code review
Thursday, April 16	**Homework #6** due by the start of class A coherent framework for spatiotemporal data analysis
Tuesday, April 21	Student Project Work
Thursday, April 23	Student Project Work
Tuesday, April 28	Student Project Work
Thursday, April 30	Student Presentations
Tuesday, May 5	Student Presentations

Final Paper
The final paper will be due no later than Wednesday, May 6th by 5pm.

Workshop topics
Depending on the interests of the students and the type of data analysis questions posed during the course, additional optional instruction may be designed for workshop days

References

Edwards, N. M. (2007), Student self-grading in social statistics, *College Teaching*, *55*(2), 72–76.