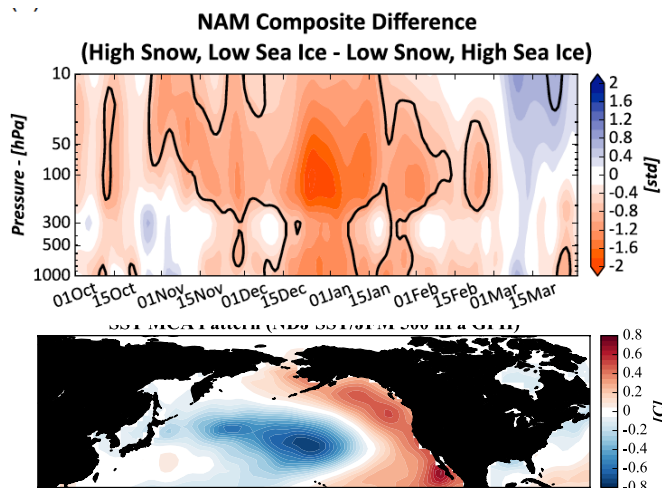




METR 5433

Advanced Statistical Meteorology

Spring 2023

Time: T/Th 2:30 - 3:45 PM
NWC 5930

Instructor

Dr. Jason C. Furtado (he/him)

NWC 5240

Email: jfurtado@ou.edu

Twitter: @wxjay

Office Hours: By appointment.

Course Description

Data analysis is a routine part of research in the atmospheric sciences. As such, having the right set of tools and the prowess on how to use those tools is an important part to understanding the behavior of the Earth climate system.

This course offers an overview of some advanced statistical methods used to interpret data in the atmospheric and oceanic sciences. The course is designed to be an **applied**

course: i.e., the goal is to gain a working knowledge of the statistical tools most commonly used in the atmospheric sciences. Major topics include: (A) regression/correlation and epoch analyses; (B) time series analysis (e.g., power spectra, filtering); (C) matrix methods for signal decomposition (e.g., EOFs, CCA); and (D) objective mapping and covariance modeling.

The course is intended for graduate students and senior undergraduates (with permission). Although previous knowledge of probability and statistics is preferable, a short review of statistical measures will be provided. You will also need knowledge of a software package to analyze data (e.g., Python, MATLAB, NCL). In-class examples will be done using Python / Jupyter Notebooks.

GOALS

1. Apply statistical theory directly to real-world meteorological and climate data to discern spatiotemporal characteristics.
2. Gain further statistical (and dynamical) understanding of the environmental system of interest and answer real world research questions in the atmospheric sciences.
3. Evaluate critically journal articles and research presentations which employ these techniques.
4. Develop a personal data “toolkit” of statistical methods that can be applied to your own research problems and tasks.

Required Text

There is no required text for the class. Most of the class will be taught with my own personal notes. However, there are several sources and texts that will be useful:

- Dennis Hartmann class notes on objective analysis: http://www.atmos.washington.edu/~dennis/552_Notes_ftp.html
- *Statistical Methods for Climate Scientists* - Timothy M. DelSole & Michael K. Tippett
- *Statistical Methods in the Atmospheric Sciences* (4th Edition) - Daniel Wilks, Academic Press
- *Discrete Inverse and State Estimation Problems* - Carl Wunsch, Cambridge Press

Course Web Page

The web page will be accessible via <https://canvas.ou.edu> (log on using your OU 4+4). There you will find course materials (e.g., class notes, assignments, and in-class coding examples), grades, and other news and announcements about the course.

Grading

Homework Assignments: 70%

Final Project: 30%

Homework Assignments. There will be about 6 homework assignments throughout the semester. Homework assignments must be **typed** and electronically submitted through Canvas. All plots included with your assignment must have proper units, labels, colorbars, and informative captions. The figures should also be aesthetically pleasing (e.g., don't oversaturate your colorbars or make the images/font hard-to-read). The homework assignments are intended for you to apply the knowledge you learn in the course directly to either synthetic or real data. You may work with others on the assignments, but you must turn in your own work. Late homework submissions will be assessed **5% per day** in penalty points unless prior approval has been given for turning in an assignment late. Assignments will **not** be accepted 7 days past the original due date without prior approval.

Final Project. The final project will involve you using statistical techniques learned in the course to answer a research problem. The project must be chosen based on one or more research questions that you would like to answer, **not** the type of data analysis you would like to apply to a given dataset. Approval of the project by the instructor is required. More details will be provided in class.



Computing

A main goal of the course is to have you work with data using computer software packages and develop your own “statistical toolbox” for later use. All students who do not have a School of Meteorology (SoM) computer account may obtain one from Shawn Riley (NWC 5640). **I will use Python in this course for in-class coding exercises and solution sets.** Python is also open-source and can be installed on your own machine. Instructions on installing Python on your local machine and other access (including Jupyterhub) will be provided in class. **NOTE:** Although I will be using Python in class, you are free to use whatever software package with which you feel comfortable for your homework assignments. Your grade will be based on the results, not on the coding language.

Course Mechanics

COURSE STYLE. The overall structure of the class will consist of lectures, both traditional and interactive, covering the major topics. The course will also feature in-class coding sessions, whereby students will work in teams and use Jupyter Notebooks (i.e., Python-based interactive coding templates) to practice techniques and develop code. Questions and interactions during class are welcome and highly encouraged. If you don’t ask questions when things are unclear, then neither of us benefit from classroom lecture.

OFFICE HOURS. Office hours are **by appointment**. Use the Bookings site to set up an appointment:

<https://outlook.office365.com/owa/calendar/METR5433AdvancedStatisticalMeteorology@ou.edu/bookings/>

COMMUNICATION PLAN. Email will be the primary form of communication. I will respond to emails within 24 hours if sent on weekdays; 48-72 hours if sent on weekends or holidays. To make things easier, please start the subject line of your email with **[METR 5433]**.

- Arrive to class on time and prepared to learn.
- Submit assignments timely. **Late submissions without prior approval will receive a penalty.**
- Take an **active role** in the learning process and **ask questions** when needed.
- Seek assistance from me if you do not understand the material or need help with an assignment.
- Be courteous to other students. Place all phones on vibrate/silence, do not text/use social media during class, and keep talking to a minimum.

EXPECTATIONS OF THE STUDENT



Land Acknowledgement

Long before the University of Oklahoma was established, the land on which the University now resides was the traditional home of the “Hasinai” Caddo Nation and “Kirikirʔi:s” Wichita & Affiliated Tribes. We acknowledge this territory once also served as a hunting ground, trade exchange point, and migration route for the Apache, Comanche, Kiowa and Osage nations. Today, 39 tribal nations dwell in the state of Oklahoma as a result of settler and colonial policies that were designed to assimilate Native people. The University of Oklahoma recognizes the historical connection our university has with its indigenous community. We acknowledge, honor and respect the diverse Indigenous peoples connected to this land. We fully recognize, support and advocate for the sovereign rights of all of Oklahoma’s 39 tribal nations. This acknowledgement is aligned with our university’s core value of creating a diverse and inclusive community. It is an institutional responsibility to recognize and acknowledge the people, culture and history that make up our entire OU Community.



Copyright Statement for Recordings of Course Sessions

Sessions of this course may be recorded or live-streamed with permission of the instructor. These recordings are the intellectual property of the individual faculty member and may not be shared or reproduced without the explicit, written consent of the faculty member. In addition, privacy rights of others such as students, guest lecturers, and providers of copyrighted material displayed in the recording may be of concern. Students may not share any course recordings with individuals not enrolled in the class or upload them to any other online environment.

Reasonable Accommodation Policy

The Accessibility and Disability Resource Center (ADRC) is committed to supporting students with disabilities to ensure that they are able to enjoy equal access to all components of their education. This includes your academics, housing, and community events. If you are experiencing a disability, a mental/medical health condition that has a significant impact on one or more life functions, you can receive accommodations to provide equal access. Possible disabilities include, but are not limited to, learning disabilities, AD(H)D, mental health, and chronic health. Additionally, we support students with temporary medical conditions (broken wrist, shoulder surgery, etc.) and pregnancy. To discuss potential accommodations, please contact the ADRC at 730 College Avenue, (ph.) 405.325.3852, or adrc@ou.edu.

Academic Misconduct

Cheating is strictly prohibited at the University of Oklahoma. Simply put, it devalues your degree and ends up marring your character and reputation. As a member of the OU community, it is your responsibility to protect your educational investment by knowing and following the rules. For specific definitions on what constitutes cheating, review the Student's Guide to Academic Integrity at <http://integrity.ou.edu/students.html>.

To be successful in this class, all work on examinations and assignments must be **yours and yours alone**. You may work together on homework assignments and in-class group exercises, but you must submit your own original work for grading. On exams, you **are not** permitted to use your notes or textbooks. Should you see someone else engaging in this behavior, I encourage you to report it to myself or directly to the Office of Academic Integrity Programs. That student is devaluing not only their degree, but yours, too. Be aware that I am obligated to report academic misconduct, which I will not

hesitate to do. Sanctions for academic misconduct can include expulsion from the University and an F in this course. **BOTTOM LINE:** Don't cheat - it's not worth it.

Religious Observances

It is the policy of the University to excuse the absences of students that result from religious observances and to reschedule examinations and additional required classwork that may fall on religious holidays, without penalty.

Title IX Resources and Reporting Requirement

Anyone who has been impacted by gender-based violence, including dating violence, domestic violence, stalking, harassment, and sexual assault, deserves access to resources so that they are supported personally and academically. The University of Oklahoma is committed to offering resources to those impacted, including: speaking with someone confidentially about your options, medical attention, counseling, reporting, academic support, and safety plans. If you would like to speak with someone confidentially, please contact OU Advocates (available 24/7 at 405.615.0013) or another confidential resource (see "Can I make an anonymous report?"). You may also choose to report gender-based violence and discrimination through other means, including by contacting the Institutional Equity Office (ieo@ou.edu, 405.325.3546) or police (911). Because the University of Oklahoma is committed to the safety of you and other students, I, as well as other faculty, Graduate Assistants, and Teaching Assistants, are mandatory reporters. This means that we are obligated to report gender-based violence that has been disclosed to us to the Institutional Equity Office. This includes disclosures that occur in: class discussion, writing assignments, discussion boards, emails and during Student/Office Hours. For more information, please visit the Institutional Equity Office.

Adjustments for Pregnancy/Childbirth Related Issues

Should you need modifications or adjustments to your course requirements because of documented pregnancy-related or childbirth-related issues, please contact your professor or the Accessibility and Disability Resource Center at 405.325.3852 as soon as possible. Also, see the Institutional Equity Office FAQ on Pregnant and Parenting Students' Rights (<https://www.ou.edu/eoo/faqs/pregnancy-faqs>) for answers to commonly asked questions.

Final Exam Preparation Period

NOTE: *There is no final exam in this course, but there is a final project.*

Pre-finals week will be defined as the seven calendar days before the first day of finals. Faculty may cover new course material throughout this week. For specific provisions of the policy please refer to OU's Final Exam Preparation Period policy (<https://apps.hr.ou.edu/FacultyHandbook#4.10>).

Mental Health Support Services

If you are experiencing any mental health issues that are impacting your academic performance, counseling is available at the University Counseling Center (UCC). The Center is located on the second floor of the Goddard Health Center, at 620 Elm Rm. 201, Norman, OK 73019. To schedule an appointment call 405.325.2911. For more information please visit <http://www.ou.edu/ucc>.



Emergency Protocol

During an emergency, there are official university [procedures](#) that will maximize your safety.

Severe Weather: If you receive an OU Alert to seek refuge or hear a tornado siren that signals severe weather

1. **LOOK** for severe weather refuge location maps located inside most OU buildings near the entrances.
2. **SEEK** refuge inside a building. Do not leave one building to seek shelter in another building that you deem safer. If outside, get into the nearest building.
3. **GO** to the building's severe weather refuge location. If you do not know where that is, go to the lowest level possible and seek refuge in an innermost room. Avoid outside doors and windows.
4. **GET IN, GET DOWN, COVER UP.**
5. **WAIT** for official notice to resume normal activities.

[Link to Severe Weather Refuge Areas](#) , [Severe Weather Preparedness - Video](#)

Armed Subject/Campus Intruder: If you receive an OU Alert to shelter-in-place due to an active shooter or armed intruder situation or you hear what you perceive to be gunshots:

1. **GET OUT:** If you believe you can get out of the area WITHOUT encountering the armed individual, move quickly towards the nearest building exit, move away from the building, and call 911.
2. **HIDE OUT:** If you cannot flee, move to an area that can be locked or barricaded, turn off lights, silence devices, spread out, and formulate a plan of attack if the shooter enters the room.
3. **TAKE OUT:** As a last resort fight to defend yourself.

For more information, visit <http://www.ou.edu/emergencypreparedness.html>

[Shots Fired on Campus Procedure - Video](#)

Fire Alarm/General Emergency: If you receive an OU Alert that there is danger inside or near the building, or the fire alarm inside the building activates:

1. **LEAVE** the building. Do not use the elevators.
2. **KNOW** at least two building exits.
3. **ASSIST** those that may need help.
4. **PROCEED** to the emergency assembly area.
5. **ONCE** safely outside, **NOTIFY** first responders of anyone that may still be inside building due to mobility issues.
6. **WAIT** for official notice before attempting to re-enter the building.

[OU Fire Safety on Campus](#)

Course Outline (Tentative)

I. Introduction, Fundamental Statistics, and Least Squares Methods

- (a) Review of fundamental statistical measures / Statistical tests
- (b) Linear algebra review [VIDEO]
- (c) Composite / Epoch analysis
- (d) Regression / correlation theory and its applications
- (e) Covariance Modeling

II. Matrix Methods

- (a) Empirical orthogonal functions (EOFs) / principal component analysis (PCA)
- (b) Extended and multivariate EOFs
- (c) Maximum covariance analysis (MCA) & canonical correlation analysis (CCA)

III. Time Series Analysis

- (a) Autocorrelation
- (b) Harmonic analysis, power spectral analysis, and significance testing for spectral peaks
- (c) Cross-spectral analysis
- (d) Low-pass, high-pass, and bandpass filtering

IV. Potential Additional Topics (as time allows)

- (a) Clustering (k -Means)
- (b) Objective Mapping / Kriging
- (c) Linear Inverse Modeling
- (d) Wavelet analysis

FINAL EXAM PERIOD: THURSDAY, MAY 11, 2023 1:30pm - 3:30pm