NAM Composite Difference
(High Snow, Low Sea Ice - Low Snow, High Sea Ice)

SST MCA Pattern (NDJ SST/JFM 500 hPa GPH)

METR 5433 Advanced Statistical Meteorology

Spring 2020
Time: T/Th 2:30 - 3:45 PM
Room: NWC 5930

Instructor

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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 (Textbooks will be available on reserve or you can purchase them if you would like resources for the future):

- Dennis Hartmann class notes on objective analysis: http://www.atmos.washington.edu/~dennis/552_Notes_ftp.html
- *Discrete Inverse and State Estimation Problems* - Carl Wunsch, Cambridge Press
- *Statistical Methods in the Atmospheric Sciences* (3rd or 4th Edition) - Daniel Wilks, Academic Press
- S*tatistical Analysis in Climate Research* - Hans von Storch and Francis W. Zwiers

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 should have proper units, labels, colorbars, and informative captions. As figures are ways to convey information, they 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.

Final Project. The final project will involve you using *at least two (2) 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 technique 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). Python is readily available for use on the MetLab workstations. Python is also open-source and can be installed on your own machine. **NOTE:** You are free to use whatever software package with which you feel comfortable for your homework assignments. I will use Python in this course for in-class coding exercises and solution sets. If there are questions or issues with access to software, please see me ASAP.

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.

- Arrive to class on time and prepared to learn.

- Submit assignments timely. **No late submissions are allowed without prior approval.**

- 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

Reasonable Accommodation Policy

The University of Oklahoma is committed to providing reasonable accommodation for all students with disabilities. Students with disabilities who require accommodation in this course are requested to speak with me as soon as possible. Students with disabilities must be registered with the Accessibility and Disability Resource Center (ADRC) prior to receiving accommodations in this course. The ADRC is located in University Community Center (730 College Ave). Phone: 405.325.3852. E-mail: drc@ou.edu. Once registered, please notify the instructor if you wish to use this space for assignments.

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. For specific definitions on what constitutes cheating, review the Student's Guide to Academic Integrity at http://integrity.ou.edu/students.html. If you are caught cheating, I am obligated to report it. 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.

To be successful in this class, all work 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 any and all grading.

Religious Holidays

University policy allows for excused absences for students that result from religious observances and to provide without penalty for the rescheduling of examinations and additional required classwork that may fall on religious holidays. Any student who has a religious holiday fall on one of the exam days, please see the instructor no later than one week before the exam so as to make other arrangements.

Title IX Resources and Reporting Requirement

For any concerns regarding gender-based discrimination, sexual harassment, sexual assault, dating/ domestic violence, or stalking, the University offers a variety of resources. To learn more or to report an incident, please contact the Sexual Misconduct Office at 405.325.2215 or smo@ou.edu. Incidents may also be reported confidentially to OU Advocates (405.615.0013) 24 hours a day, 7 days a week. Please be advised that a professor/GA/TA is required to report instances of sexual harassment, sexual assault, or discrimination to the Sexual Misconduct Office. Inquiries regarding non-discrimination policies may be directed to: Bobby J. Mason, University Equal Opportunity Officer and Title IX Coordinator at 405.325.3546 or bjm@ou.edu. For more information, please visit http://www.ou.edu/eoo.html.

Adjustments for Pregnancy/Childbirth Related Issues

Should you need modifications or adjustments to your course requirements because of documented pregnancy- or childbirth-related issues, please contact the instructor or the Disability Resource Center at 405.325.3852 as soon as possible. Also, see http://www.ou.edu/eoo/faqs/pregnancy-faqs.html 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).

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

I. Introduction, Fundamental Statistics, and Least Squares Methods
  (a) Review of fundamental statistical measures / Statistical tests
  (b) Linear algebra review
  (c) Composite / Epoch analysis
  (d) Regression / correlation theory and its applications (e.g., covariance modeling)
  (e) Significance Testing

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) Filtering and filter designs

IV. Additional Topics (as time allows)
  (a) Wavelet analysis
  (b) Objective Mapping / Kriging
  (c) Other topics based on student interest

<u>FINAL EXAM PERIOD:</u> THURSDAY, MAY 7, 2019 1:30 - 3:30 PM