



# METR 5433 Advanced Statistical Meteorology

Spring 2017

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

Room: NWC 5930

## Instructor

**Dr. Jason C. Furtado**

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**Office Hours:** By appointment.

## Course Description

***Data analysis is a routine part of many types 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 climate system.***

This course offers an overview of some advanced statistical methods used to interpret data in the atmospheric and oceanic sciences. It 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 to be covered include: (A) regression/correlation and epoch analyses; (B) time series analysis (e.g., power spectra, filtering, wavelet analysis); (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 required, a short background review will be provided at the start of the course. You should also have a working knowledge of a software package to analyze data (e.g., Python, MATLAB, IDL, NCL, etc.). This will be important because of the highly-applied nature of the course.

# GOALS

1. Apply statistical theory directly to real-world climate data to discern spatiotemporal characteristics.
2. Gain further statistical (and dynamical) understanding of the environmental / climate system of interest and answer real world research questions in the atmospheric sciences.
3. Critically evaluate 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):

- Dennis Hartmann class notes on objective analysis: [http://www.atmos.washington.edu/~dennis/552\\_Notes\\_ftp.html](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 Second Edition* - Daniel Wilks, Academic Press
- *Statistical 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 even useful code snippets), grades, and other news and announcements about the course.

## Grading

**Homework Assignments:** 65%

**Final Project:** 35%

**Homework Assignments.** There will be about 6-7 homework assignments throughout the semester. Homework assignments must be **typed and stapled** and electronically submitted through Canvas. All plots included with your assignment should have proper units, labels, colorbars, and captions. These homework assignments are intended for you to apply the knowledge you learn in the course directly to data (either synthetic or real). Sometimes, I will allow you to substitute your own research data (if applicable) in lieu of the provided data to complete a problem in the assignment. This is done so that you have a chance to actually see how to apply these techniques to your own research work. You may work with others on the assignments, but you must turn in your own work.

**Final Project.** The final project will be a paper and oral presentation in which you must use *one or more statistical techniques learned in the course* to answer a real research question. The project is to be chosen based on a set of questions that you would like to answer rather than the type of data analysis technique you would like to apply. You will be required to submit an abstract of your work for prior approval. 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). MATLAB is readily available for use on the MetLab workstations. Python is open-source and can be installed on your own machine.

**Note:** You are free to use whatever software package with which you feel most comfortable. I will primarily use Python and some MATLAB in this course for in-class examples, solutions, etc. If there are questions or issues with access to software, please see me during the first week of class.

## **Course Style**

The overall structure of the class will consist of lectures, both traditional and interactive, covering the major topics. I will also present examples in class of using the actual techniques to analyze climate data. 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 Office of Disability Services ( prior to receiving accommodations in this course. The Office of Disability Services is located in Goddard Health Center, Suite 166 (Phone: 405.325.3852 or TDD only 405.325.4173).

## **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 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, but you must submit your own original work for grading.

## **Religious Holidays**

It is the policy of the University is to excuse absences of 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 a day an assignment is due, please see me no later than one week before the deadline 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 (8 AM to 5 PM, Monday-Friday) or [smo@ou.edu](mailto:smo@ou.edu). Incidents can 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](mailto: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-related or childbirth-related issues, please contact me 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.

## **Course Outline - Emphasis will be on applying techniques to data!**

### **I. Review of Basic Statistics + Least Squares Methods**

- (a) Fundamental statistical measures / Statistical tests
- (b) Correlation theory / Regression and correlation analysis / Multi-variate regression
- (c) Composite / Epoch analysis
- (d) Significance Testing
- (e) Applications of regression / correlation theory, (e.g., function-fitting and interpolation).

### **II. Matrix Methods**

- (a) Linear algebra review (vector spaces, rank, orthogonality)
- (b) Empirical orthogonal functions (EOFs) / principal component analysis (PCA)
- (c) Extended and multivariate EOFs
- (d) 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 - Best practices to use

### **IV. Additional Topics (as time allows)**

- (a) Covariance modeling and simple regression models (space and time)
- (b) Objective Mapping / Kriging
- (c) Inverse modeling and methods
- (d) Wavelet analysis

**Final Presentations will be done during the final week of classes and during the Final Exam Period - WEDNESDAY, MAY 10, 2017 1:30 - 3:30 PM**

**\*\*\*\*NO CLASS:** Jan 24, 26 (AMS Conference) —> Makeup classes will be scheduled.