EES1132H: Climate Data Analysis

Class: 10:00 - 13:00 Tuesdays, BV471

1 Instructor

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3 Course

The course provides an overview of the statistical methods used to analyze and interpret data sets in climate science. This is a tools class: the objective is to provide a working knowledge of the data analysis tools most commonly used in the literature. Additional time will be spent on how to objectively present and review scientific results. During this course you will:
- become comfortable with basic statistical techniques,
- learn to break-down real science problems into testable hypotheses,
- learn to review and assess the analysis techniques presented in the literature,
- practice presenting scientific results in a professional manner.

4 Course Expectations

The following list presents the minimum requirements for passing this course:
- show-up to class and ask questions,
- keep up with the reading (when applicable),
- submit all assignments on time and at an acceptable level of quality.

5 Course Prerequisites

You are expected to be familiar with basic high-school and college-level mathematical concepts. Minimal time will be spent in lecture reviewing these topics:
- algebra (e.g. equations for lines, solving basic algebraic equations)
- basic calculus (e.g. how to take a derivative and an integral)
- basic matrix algebra (e.g. addition, subtraction, multiplication)
- sine and cosine functions

If you are concerned about your background in these areas, please speak with me. The UTSC Math and Stats Learning Centre has a excellent resources to help student excel in their course work. While the concepts, tools, and techniques explored in this course will be taught within the context of climate science, there are no climate science prerequisites.

You will be expected to write and implement computer code throughout this course. I do not care what software you use, but note, neither I nor the TA will spend office hours debugging your code for you.

6 Course Web Page
The course web site is available through Blackboard: https://portal.utoronto.ca. The Blackboard system is accessible using your UTORID which has been assigned to you as part of registration. All course information, resources, assignments and communications will be posted on Blackboard. It is your responsibility to check the information frequently. You must also ensure that you use your University of Toronto email address on Blackboard. If you are unfamiliar with Blackboard you can find a tutorial here and additional information at: http://www.utsc.utoronto.ca/technology/blackboard-portal

7 Evaluation

Your course grade will be made up of assignments and class participation only. That is, assignments (90%) and class participation (10%) will together cover 100% of your grade. The class participation mark will include occasional quizzes. There will be approximately 4 assignments throughout this course (although I maintain the right to increase or decrease this number), each of varying length. The first 3 assignments will be based on specific sections for the course, while the final assignment will integrate many of the tools used throughout the term and will be a longer assignment, worth more of your final mark. The final assignment will address a research question of the student’s choice. Details of the assignments will be posted on the course website. Here is the breakdown:

1. Class Participation 10%
2. 3 Term Assignments 60% (20% each)
3. Final Term Assignment 30%

If you need help completing an assignment, first ask your classmates for assistance and request help from your TA and instructor second. You are encouraged to interact with your classmates by sharing ideas and discussing the specifics of the material and assignments. You are, however, expected to hand-in your own assignment, and it should not be a direct copy of a classmate’s.

Your assignments must be typed-up and clearly written. Figures should be of publication quality - no low-resolution figures! By doing this, you are not just being nice to the me and the TA, who have to grade your work, but you will gain practice in presenting your results clearly and professionally as required for your careers.

In addition to being clear and neat, I expect all figures to include a descriptive caption, legend (if applicable) and labeled axes with units! Having axes without labels or units will automatically deduct points from your assignment.

8 Text Books & Resources

There is no required textbook for this course. Many of the materials, notes, assignments, etc. in this course are borrowed from the course materials of Prof. Elizabeth Barnes at Colorado State University and Prof. Dennis Hartmann at the University of Washington.

There is one required resource in this course - the internet. Google is amazing - use it. One of the most important things to learn in graduate school and in life is “how to look it up.”

9 Analysis and Plotting Software

You are required to have an analysis and plotting software package (often they are one in the same) with which you can do the assignments. I will be using Python for the lectures and notes, and strongly encourage you to use it as well. However, you are free to use other software packages such as, MATLAB, IDL, or R, if desired.
10 Late Assignments

Assignments submitted late will not be accepted without an accompanying UTSC illness verification form (http://www.illnessverification.utoronto.ca/document/Verification%20of%20Student%20Illness%20(VOI)%20-%20Oct%2027%202016.pdf). Late assignments without an illness verification form will be deducted 10% for each 24 hour period late (weekends included).

11 Academic Integrity

Academic integrity is fundamental to learning and achieving our course goals. The assignments in this course are designed to give you an opportunity to learn important skills and concepts by making honest attempts through your own thinking, writing, and hard work.

I am strongly committed to assigning grades based on my students’ honest efforts to demonstrate learning in this course. Academic dishonesty in any form will not be tolerated in my classes. All academic work in this course must adhere to the Code of Behavior on Academic Matters.

12 Accessibility

Students with diverse learning styles and needs are welcome in this course. In particular, if you have a disability/health consideration that may require accommodations, please feel free to approach me and/or the AccessAbility Services as soon as possible.

AccessAbility Services staff (located in Rm SW302, Science Wing) are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations 416-287-7560 or email ability@utsc.utoronto.ca. The sooner you let us know your needs, the quicker we can assist you in achieving your learning goals in this course.

13 Tentative Outline

Some of the topics may have very technical sounding titles, but don’t be intimidated. Our focus in this course is on applying these statistical tools, rather than deriving them from first principals.

Sept. 12:
1. Probability & statistics
   1.0. Introduction
   1.1. Basic statistics, probability distributions, Bayes Theorem

Sept. 19:
1. Probability & statistics cont’d
   1.2. Statistical decision making; hypothesis testing
   1.3. Monte Carlo techniques; bootstrap; jackknife

Sept. 26: 2. Regression & correlation
   2.1. Linear regression
   2.2. Compositing vs. regression

Oct. 3: 2. Regression & correlation cont’d
   (Assignment 1 due)
   2.2. Theory of correlation
   2.3. Autocorrelation/autoregressive methods; estimating the number of independent samples

Oct. 10: 2. Regression & correlation cont’d
   2.4. Multiple regression
   2.5. Granger Causality
Oct. 17: 3. Seeking Structure in Data
   3.1. Review of linear algebra
   3.2. Empirical orthogonal functions (EOF); singular value decomposition (SVD)

Oct. 24: (Assignment 2 due) 3. Seeking Structure in Data cont’d
   3.2. Empirical orthogonal functions (EOF); singular value decomposition (SVD)
   3.3. Application of EOFs to real data
   3.4. Other methods (MCA, CCA, clustering, etc.)

Oct. 31: (Final Assignment topic finalized) 4. Time series analysis
   4.1. Harmonic analysis; power spectra; methods of computing power spectra
   4.2. Significance testing of spectral peaks

Nov. 7: 4. Time series analysis cont’d
   4.3. Data windows

Nov. 14: (Assignment 3 due) 4. Time series analysis cont’d
   4.4. Filtering; Filter design; recursive/non-recursive filters; response functions

Nov. 21: 4. Time series analysis cont’d
   4.5. Trend detection

Nov. 28: 5. Communicating Effectively with Figures

Dec. 10: (Final Assignment due)