EE 270 – Data, Models, and Analysis in Earth & Environment

Spring 2021

Instructor:	Christoph Nolte chrnolte@bu.edu		Office Hours: Thu & Fri 3:30-5pm Sign-up required: bit.ly/3iEsCLW	
Teaching Fellow:	Adam Pollack abpoll@bu.edu		Office Hours: Mon 4-5:30pm, Fri 2-3:30pm Sign-up required: bit.ly/2N1X885	
Lecture:	Tue/Thu	2:00-3:15pm	CAS B20	Zoom: bit.ly/3qDCl9m
Lab:	B1: Mon B2: Tue	12:20-2:05pm 9:00-10:45 am	CAS 327	Zoom: bit.ly/3p8cMNd

In line with Boston University's Learn *from* Anywhere format, lectures & labs will be both live (in person + remote) and asynchronous. Videos will be posted on Blackboard within 24 hours

Course Description

This course introduces students to the quantitative methods that are foundational to analysis of natural- and social science data in Earth & Environment. The goals are to: (1) introduce students to the ways in which natural and social science disciplines use different kinds of data to explain environmental phenomena and elucidate their workings, and (2) develop basic literacy in the methods used to analyze such information. Students will be introduced to common paradigms that are used to organize and visualize data, develop and test hypotheses, and explore relationships among variables using correlation, analysis of variance, and statistical regression. Example problems, with accompanying data, from the fields of economics, sociology, ecology, geology, remote sensing, and geography applied to the environment will be explored in class and in the labs. Many datasets will be based on research published by Earth & Environment faculty. Excel will be the primary tool for analysis.

Student Learning Outcomes

- Demonstrate a basic understanding of the overall research process, as well as skill in formulating well-posed research questions and null hypotheses, analyzing information, and interpreting and communicating analytical findings.
- Demonstrate understanding of core statistical conceptual and theoretical tools used in quantitative reasoning.
- Interpret quantitative models and understand a variety of methods of communicating them (e.g. graphs, tables, formulae).
- Communicate quantitative information symbolically, visually, numerically, and in writing.
- Recognize the power and limitations of statistical data analysis methods.

Prerequisites

EE 100 and EE 107 (or equivalent) are required.

Assessment

27% 9 online quizzes (3% each)

These weekly quizzes are designed to test and deepen your knowledge of the concepts discussed in readings and in class. Each quiz will be administered via Blackboard, and tests concepts that were covered in class the week before. You will see your scores immediately and can repeat the quiz as often as you'd like until you get full points. Quizzes are due on Fridays.

45% 9 lab writeups (5% each)

There will be nine labs and associated writeups over the course of the semester. Labs are "hands-on" using Microsoft Excel and illustrate core concepts discussed in class. Each lab exercise is devoted to analyzing real data sets related to phenomena from both the natural- and social-science disciplines that make up Earth & Environment. The last lab is a collective "Great Literature Review": partner up with a classmate, review a published scientific article, and share your findings with your classmates in a brief, one-slide presentation.

8% Participation

As part of the participation grade, each student will submit an 'environmental' statistic from the news each week. 1-2 of these statistics will be discussed in class on Tuesdays.

20% Take-home final exam

Textbook

Readings will draw heavily from two free statistics textbooks available online:

- Illowsky & Dean (2018) Introductory Statistics (view online, download PDF)
- Seltman (2018) Experimental Design and Analysis (download PDF, individual chapters)

These books cover the essentials, but their exposition of key concepts is sometimes brief. If you anticipate difficulties absorbing statistical concepts from dense readings, consider purchasing one of these books, which provide more extensive explanations of the underlying concepts:

- Warne (2017) Statistics for the social sciences: a general linear model approach
  $37 on Amazon – likely more valuable for social science students (e.g. EAP)
- Gotelli & Ellison (2018) A primer of ecological statistics. 2nd edition.
  $82 on Amazon – likely more valuable for natural science students (e.g. E&E)

Course Policies

Participation: Participation is crucial to learning. Under the *Learn from Anywhere* model participation can take many different forms, including: asking and answering questions in class; engaging with the teaching staff through office hours; participating in online discussion exchanges; and other forms. Although in-person or synchronous participation is not required, active engagement with the classroom community is required for full participation credit.

Attendance & Rotations: CAS B20 has a LfA capacity of 22 (out of 40) students. Rotations will be managed using the InClassLfA App.

Covid-19 Safety: We are committed to offering the best possible class in keeping with the principles of Learn *from* Anywhere. To succeed, we need your help. We all must be responsible and respectful, which means wearing face coverings and social distancing while in class together. Here is what we expect from you:

- comply with University-mandated COVID-19 testing and health attestation requirements;
- wear a face covering at all times during class, inside the building, and in campus public places;
- maintain physical distancing of 6 feet at all times from the nearest person, including when you come in and leave our classroom or other meeting spaces; and,
- contact Student Health Services at 617-353-3575 if you experience symptoms of COVID-19 (see https://www.cdc.gov/coronavirus/2019-ncov/symptoms-testing/symptoms.html).

If any student shows up without a face covering and refuses to leave, the class or meeting will be dismissed to protect everyone. You can choose not to follow those guidelines. But if you make that choice, please do not show up for in-person learning, so that you do not put your classmates in danger. You are welcome to take the class remotely to make it possible for us to safely offer in-person learning to others.

Assignment Completion & Late Work: Assignments will be submitted through Blackboard. On-time submission is a prerequisite for full credit. Late work will be accepted up to one week beyond the due date, but the grade for such an assignment will be reduced by 50%. No assignments will be accepted more than 1 week beyond this grace period. The final exam must be handed in by the due date. If you anticipate difficulties due to documentable extenuating circumstances, please notify me as soon as possible.

Recordings: All class sessions will be recorded for the benefit of registered students who are unable to attend live sessions (either in person or remotely) due to time zone differences, illness or other circumstances. Recorded sessions will be made available to registered students via their Blackboard account. Students may not share these recordings with anyone not registered in the course and may not repost them in a public platform. Students have the right to opt-out of being part of the class recording. Please contact me to discuss options for participating in the course while opting out of the class recording. No student may record any classroom or other academic activity without the instructor's express written consent. Unauthorized use of classroom recordings – including distributing or posting them – is prohibited. If you have (or think you may have) a disability such that you need to record classroom activities, or need other assistive services, you should contact Disability & Access Services to request an appropriate accommodation. More information may be found here.

Religious Observances: Campus policy regarding religious observances requires that faculty make every effort to reasonably and fairly deal with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. Please notify me as soon as possible so that the proper arrangements can be made. For details, consult http://www.bu.edu/chapel/religion/ and http://www.interfaithcalendar.org/

Academic Conduct: All Boston University students are expected to maintain high standards of academic honesty and integrity. Lab writeups, quiz answers and exam responses must be completed without collaboration, unless explicitly directed otherwise by instructors. Graded work must be completed individually. Lab writeups must be written in the students' own words and prepared specifically for this course. Copying phrases, sentences, or paragraphs in written work from any source (including the internet) without quotation and specific attribution is plagiarism. Providing answers to, or receiving answers from, other students on quizzes or lab assignments is cheating, will be treated as academic misconduct, and will be referred to the Dean's Office. It is your responsibility to be familiar with the Academic Conduct Code, which describes the ethical standards to which BU students are expected to adhere and students' rights and responsibilities as members of BU's learning community. All instances of cheating, plagiarism, and other forms of academic misconduct will be addressed in accordance with this policy. Penalties for academic misconduct can range from failing an assignment or course to suspension or expulsion from the university http://www.bu.edu/academics/policies/academic-conduct-code/

Diversity & Inclusion: Diversity enriches all research and education, and is realized only with all voices, views, and perspectives operating within a supportive and respectful community. For this reason, the Department of Earth & Environment, including myself and the students in this course, are committed to fostering diverse, inclusive, and equitable living, learning, and working environments that are supportive and free from violence, harassment, disruption, and intimidation. The Department of Earth & Environment recognizes that creating a safe environment and a culture of respect is the shared responsibility of all members of our community. To ensure an equitable environment that values and respects the unique experiences and perspectives of our community, the Department, including myself and the students in this course, are dedicated to promoting diversity, inclusion, and equity among all members of our departmental community and encouraging open, honest, and compassionate communication. See also: http://www.bu.edu/earth/about/diversityinclusion/

Schedule

Week	Topics	Readings*	Labs & Quizzes
I. Preliminaries: From Samples to Descriptive Statistics to Probabilities			
Jan 25-29	Course introduction	I&D Ch. 1; GCF Global (2020a)	*no lab*
	Sampling and data		
Feb 1-5	Data visualization and descriptive statistics	I&D Ch. 2; GCF Global (2018b); Raciti et al. (2012)	Excel Lab Quiz 1

II. Probability and Distributions			
Feb 8-12	Probability fundamentals	I&D Ch. 3	Lab 1 Quiz 2
Feb 15-19 *no class Tuesday*	Discrete random variables	I&D Ch. 4; Templer et al. (2015)	Lab 2 Quiz 3
Feb 22-26	Continuous random variables	I&D Ch. 5-8 (selection)	Lab 3
III. Statistical Inference: Putting Probability Distributions to Work			
Mar 1-5	Hypothesis testing: principles, one-sample tests	I&D Ch. 9	Lab 4 Quiz 4
Mar 8-12	Hypothesis testing: two-sample tests, means and variances	I&D Ch. 10; Kittredge et al. (2015)	*no lab* Quiz 5
Mar 15-20	Hypothesis testing: Chi-square	I&D Ch. 11	Lab 5 Quiz 6
IV. Bringing It All Together: Modeling Relationships, Inferring Causation			
Mar 22-26	ANOVA (Analysis of Variance)	S Ch. 7	*no lab* Quiz 7
Mar 29 – Apr 2	Regression: basic concept, simple regression	S Ch. 9; Harrison & Rubinfeld (1978)	Lab 6 Quiz 8
Apr 5-9	Regression: non-linear and categorical relationships	TBD	Lab 7 Quiz 9
Apr 12-16	Multivariate regression	TBD; Friedl et al (2014)	*no lab*
Apr 19-23	Advanced topics & applications		Lab 8
Apr 26-30	The Great Literature Review		
	Course wrap-up (Take home final distributed)		
TBD	Take home final due by NOON!		

* I&D: Illowsky & Dean, S: Seltman

Readings

Friedl, M.A., J.M. Gray, E.K. Melaas, A.D. Richardson, K. Hufkens, T.F. Keenan, A. Bailey and J. O'Keefe (2014) A tale of two springs: using recent climate anomalies to characterize the sensitivity of temperate forest phenology to climate change. *Environmental Research Letters* **9**:054006

GCF Global (2020a). Microsoft Excel tutorial: https://edu.gcfglobal.org/en/excel/

GCF Global (2020b). Excel Formulas tutorial: https://edu.gcfglobal.org/en/excelformulas/ (Youtube playlist)

Harrison, D. and Rubinfeld, D.L. (1978) Hedonic prices and the demand for clean air. *Journal of Environmental Economics and Management* 5:81–102.

Kittredge, D. B., Short Gianotti, A. G., Hutyra, L. R., Foster, D. R., and Getson, J. M. (2015). Landowner conservation awareness across rural-to-urban gradients in Massachusetts. *Biological Conservation 184*: 79–89.

Raciti, S.M., Hutyra, L.R., Finzi, A.C. (2012) Depleted soil carbon and nitrogen stocks under impervious surfaces. *Environment Pollution* 164: 248-251, 2012.

Templer, P. H., Toll, J. W., Hutyra, L. R., & Raciti, S. M. (2015). Nitrogen and carbon export from urban areas through removal and export of litterfall. *Environmental Pollution* 197:256–261.

Supplemental Multimedia Resources

Descriptive statistics

Measures of Central Tendency: https://www.youtube.com/watch?v=NM_iOLUwZFA
Measures of Variation: https://www.youtube.com/watch?v=Cx2tGUze60s
Sample Variance and Degrees of Freedom: https://www.youtube.com/watch?v=9ONRMymR2Eg

Probability fundamentals

Probability Basics (Unions, Intersections and Complements): https://www.youtube.com/watch?v=B1v9OeCTlu0
Conditional Probability: https://www.youtube.com/watch?v=bgCMjHzXTXs
Independent Events: https://www.youtube.com/watch?v=1wuRV5z0PPE
Conditional Probability Example Problems: https://www.youtube.com/watch?v=ES9HFNDu4Bs
Law of Total Probability: https://www.youtube.com/watch?v=7t9jyikrG7w
Law of Total Probability Application: https://www.youtube.com/watch?v=Pu33eESSczU

Discrete random variables

Discrete Random Variables and Probability Distributions: https://www.youtube.com/watch?v=0P5WRKihQ4E
Correlation and Coefficient of Determination: https://www.youtube.com/watch?v=dCgIavyFWIo

Continuous random variables

Continuous Probability Distributions: https://www.youtube.com/watch?v=OWSOhpS00_s
Uniform Distribution: https://www.youtube.com/watch?v=-qt8CPIadWQ
Normal Distribution: https://www.youtube.com/watch?v=iYiOVISWXS4
t Distribution: https://www.youtube.com/watch?v=Uv6nGIgZMVw
Chi-square Distribution: https://www.youtube.com/watch?v=6Z4MBxye5VA
F Distribution: https://www.youtube.com/watch?v=G_RDxAZJ-ug
Normal Q-Q Plots: https://www.youtube.com/watch?v=X9_ISJ0YpGw
Standard Normal Distribution: https://www.youtube.com/watch?v=4R8xm19DmPM

Sampling Distribution of the Sample Mean: https://www.youtube.com/watch?v=q50GpTdFYyI
Central Limit Theorem: https://www.youtube.com/watch?v=Pujol1yC1_A

Hypothesis testing
Hypothesis Testing: https://www.youtube.com/watch?v=tTeMYuS87oU
Hypothesis Tests on One Mean, Rejection Region in a z Test: https://www.youtube.com/watch?v=60x86lYtWI4
z Test of One Mean: https://www.youtube.com/watch?v=pGv13jvnjKc
Type I and Type II Errors: https://www.youtube.com/watch?v=7mE-K_w1v90
What is a p-value? https://www.youtube.com/watch?v=UsU-O2Z1rAs
One-Sample z Test, p-value: https://www.youtube.com/watch?v=Z_pwYU5FVIs

Hypothesis testing: one mean
Confidence Intervals for One Mean: Appropriate z-value: https://www.youtube.com/watch?v=PTIIGJxlW7g
Confidence Intervals for One Mean (Known Sigma): https://www.youtube.com/watch?v=7I-HCHg2eTE
Confidence Intervals and Hypothesis Tests: https://www.youtube.com/watch?v=k1at8VukIbw
t Test of One Mean: https://www.youtube.com/watch?v=kQ4xcx6N0o4
Hypothesis Tests of One Mean: t test or z test? https://www.youtube.com/watch?v=vw2IPZ2aD-c

Hypothesis testing: variances and two means
Hypothesis Tests for One Population Variance: https://www.youtube.com/watch?v=PweabcpqzYI
Using Chi-square Tables: Areas and Percentiles: https://www.youtube.com/watch?v=C-0uN1inmcc
Confidence Intervals for One Population Variance: https://www.youtube.com/watch?v=qwqB5a7_W44
Confidence Intervals for the Ratio of Population Variances: https://www.youtube.com/watch?v=64hFiLSq3Fg
Using F Tables: Areas and Percentiles: https://www.youtube.com/watch?v=mSn55vREkIw
Hypothesis Tests for Equality of Two Variances: https://www.youtube.com/watch?v=7GJkxSYsX70
Sampling Distribution of the Difference in Sample Means: https://www.youtube.com/watch?v=4HB-FL529ag
Inference for Two Means: https://www.youtube.com/watch?v=86ss6qOTfts
Pooled-Variance t Tests and Confidence Intervals: https://www.youtube.com/watch?v=NaZBdj0nCzQ
Pooled-Variance t Tests and Confidence Intervals Example: https://www.youtube.com/watch?v=Q526z1mz4Sc
Unpooled Variance t Tests and Confidence Intervals: https://www.youtube.com/watch?v=2-ecXltt2vI
Unpooled Variance t Tests and Confidence Intervals Example: https://www.youtube.com/watch?v=gzrmHpA54Sc
Pooled vs Unpooled Variance t Tests and Confidence Intervals (To Pool or Not to Pool?):
https://www.youtube.com/watch?v=7GXnzQ2CX58

Hypothesis testing: Chi-square
Chi-square Tests for One-Way Tables: https://www.youtube.com/watch?v=gkgyg-eR0TQ
Chi-square Tests of Independence (Two-Way Tables): https://www.youtube.com/watch?v=L1QPBGoDmT0

ANOVA
Introduction to One-Way ANOVA: https://www.youtube.com/watch?v=QUQ6YppWCeg
One-Way ANOVA Formulas: https://www.youtube.com/watch?v=fFnOD7KBSbw
One-Way ANOVA Example: https://www.youtube.com/watch?v=WUoVftXvjiQ
One-Way ANOVA p-value: https://www.youtube.com/watch?v=XdZ7BRqznSA

Regression
Introduction to Linear Regression: https://www.youtube.com/watch?v=LLeOVxODSls
Least Squares Regression Line: https://www.youtube.com/watch?v=VvQ-QkU8DPs
Linear Regression Inference on the Slope Formulas: https://www.youtube.com/watch?v=8FwO89CXpsQ
Linear Regression Inference on the Slope Example: https://www.youtube.com/watch?v=TFkdFV_MgXs
Checking Regression Assumptions with Residual Plots: https://www.youtube.com/watch?v=_NkWG1M69CI
Linear Regression Example: https://www.youtube.com/watch?v=gJCFk-s80iI