University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE

Environmental Statistics 2

3 credits

MEES 713
Each Spring

Course Objectives / Overview

This course extends statistical training of the students to advanced topics of time series analysis and spatial statistics. Aiming at the broad audience of students in the environmental sciences, we incorporate as many modern methods of analysis as possible.

Expected Learning Outcomes

After taking this course, students will be familiar with a variety of state-of-the-art approaches for quantitative analysis of time- and space-dependent data. Moreover, students will become competent users of these methods by practicing them in class and in their homework assignments using the statistical programming language R.

Course Assessment / Grading

Grades are based on performance on two take home exams, an individual project, and homework problem sets. Each exam and individual project represents 30% of the grade and should be done individually by the student. The homework problem sets make up the remaining 10%. Whereas plagiarism is not tolerated, students are encouraged to work together to learn from one another and solve homework problems in a collaborative and collegial way (aside from the take home exams).

Zoom Information

First section of the course is on time series analysis, taught by V. Lyubchich. Zoom link for these lectures

Second section of the course is on spatial statistics, taught by D. Liang. Zoom link for these lectures

V. Lyubchich's office hours: 11 a.m.-noon every Thursday Feb 3 – March 17, 2022; just use the link below, no need to make an appointment.
https://umd.zoom.us/j/98844499448?pwd=dUtEWUVHWjdldmR3dWNKUVM3Y0gyUT09
Meeting ID: 988 4449 9448
Passcode: 314999
D. Liang's office hours: 11 a.m.-noon every Thursday, or by appointment,
https://umd.zoom.us/j/94681658051?pwd=MkRyeS91bWV1RVI1NjFIeVZrTG03UT09
Meeting ID: 946 8165 8051
Passcode: 2022

INSTRUCTORS:

Dong Liang
dliang@umces.edu
410-326-7452

Vyacheslav Lyubchich
lyubchich@umces.edu
410-326-7413

CLASS MEETING DETAILS:
Dates: T, Th
Times: 9:30-10:50 a.m.
Originating Site: CBL
(see **Zoom Information** for details)

CURRICULUM FULLFILMENT:
PD or Elective

Prerequisites
MEES 698B

Teaching Assistant
None

Tentative Course Schedule 2022

Lecture	Topic	Reading
1 (01-25)	Review of multiple linear regression, Gauss-Markov theorem. Model assumptions and diagnostics (parametric and non-parametric).	C&H Ch. 3-4
2 (01-27) 3 (02-01)	Time series and its components (trend, cycles, seasonality, noise). Autocorrelation function. Model comparison.	B&D Ch. 1
4 (02-03)	Smoothing. Trend- and difference-stationary time series.	
	Homework 1	
5 (02-08)	Stationary time series: AR, MA, ARMA.	B&D Ch. 2, 3, 5
6 (02-10)	Stationary time series: AR, MA, ARMA (contd).	B&D Ch. 2, 3, 5
7 (02-15)	ARIMA and SARIMA.	B&D Ch. 6
8 (02-17)	ARCH and GARCH.	K&W Ch. 7
	Homework 2	
9 (02-22)	Parametric and non-parametric methods for trend detection (t, Mann–Kendall, WAVK, unit-root test). Bootstrap.	B&D Ch.6.3, notes, Buhlmann (2002)
10 (02-24)	Time series regression when trends are present.	
11 (03-01)	Cointegration and time series synchronism.	K&W Ch. 6
12 (03-03)	Spectral decomposition	S&S Ch. 4
13 (03-08)	Regression with correlated errors (ARMAX), with seasonality (dummy variables, trigonometric regressors).	S&S Ch. 5.5-5.7
14 (03-10)	Granger causality or machine learning, in time series context (TBD)	K&W Ch. 3 / HTF Ch. 9
	Midterm on time series	
15 (03-15)	Spatial data and the types, introduction to R-spatial	S&G Ch. 1
16 (03-17)	Introduction to Generalized Linear Model, Poisson regression	C Ch. 14, Zuur Ch 8-10
Spring break		
17 (03-29)	Spatial point processes, estimation	W&G Ch. 5
18 (03-31)	Spatial point processes, bivariate case control point data	W&G Ch. 6
19 (04-05)	Spatial point process model for present only analysis	
	Homework 3	
20 (04-07)	Geostatistics, Semivariogram and covariance function	W&O Ch. 3-4
21 (04-12)	Geostatistics, Classical semivariogram estimation	W&O Ch. 5-6
22 (04-14)	Geostatistics, Spatial prediction and kriging	W&O Ch. 8
23 (04-19)	Geostatistics, Kriging in the presence of trend	W&O Ch. 9.1-3
	Homework 4	
24 (04-21)	Mixed models, Spatial regression model	D&R Ch3
25 (04-26)	Mixed models, Spatial Generalized Linear Model	D&R Ch. 4, W&G Ch. 9.4
26 (04-28)	Geostatistical simulation of spatial random fields	W&O Ch 12
27 (05-03)	Spatial autoregressive model on areal data, or rasters	W&G Ch. 9.3

28 (05-05)	Class presentations	
29 (05-10)	Class presentations -- last day of classes spring 2022	
	Midterm on spatial statistics	

Required textbooks, reading and/or software or computer needs

Recommended reading:

- B&D: Brockwell, P.J. and Davis, R. A. 2002. Introduction to Time Series and Forecasting. 2nd ed. Springer, New York.
- Bühlmann, P. 2002. Bootstraps for Time Series. Statistical Science: 17(1), 52–72.
- C&H: Chatterjee, S. and Hadi, A. S. 2006. Regression Analysis by Example. Wiley.
- HTF: Hastie, T., Tibshirani, R., and Friedman, J. 2009. The Elements of Statistical Learning. 2nd ed.
- K&W: Kirchgässner, G. and Wolters, J. 2007. Introduction to Modern Time Series Analysis. Springer-Verlag, Berlin.
- S&S: Shumway, R. H. and Stoffer, D. S. 2014. Time Series Analysis and Its Applications. With R Examples. EZ – 3rd Edition.
- C: Crawley, M.J. 2007. The R Book. John Wiley and Sons. ISBN 9780470510247
- W&G: Waller, L.A. and Gotway, C.A. 2004. Applied spatial statistics for public health data. Wiley.
- S&G: Schabenberger, O. and Gotway, C.A. 2005. Statistical Methods for Spatial Data Analysis, Chapman & Hall/CRC
- W&O: Webster, R. and Oliver, M. A. 2007. Geostatistics for Environmental Scientists. 2nd ed. Wiley
- D&R: Diggle, P.J. and Ribeiro Jr., P.J. 2007. Model-based Geostatistics. Springer.
- Zuur: Zuur, A.F., Ieno,E.N., Walker, N.J., Saveliev, A.A, Smith, G.M. 2009. Mixed Effects Models and Extensions in Ecology with R. Springer.

Software: We use R (https://cran.r-project.org/) and RStudio (https://www.rstudio.com/products/rstudio/download/) in this course. For faster completion of assignments (homeworks, take-home exams) using knitr package in RStudio, a LaTEX distribution is also needed, e.g., TeX Live (https://www.tug.org/texlive).

Course Communication

UMCES Courseware Server (Moodle, https://moodle.cbl.umces.edu)

Resources

See textbooks and software above.

Campus Policies

The University of Maryland Center for Environmental Science has drafted and approved of various academic and research-related policies by which all students and faculty must abide.

Please visit http://www.umces.edu/consolidated-usm-and-umces-policies-and-procedures for a full list of campus-wide academic policies.

Course-Specific Policies and Expectations

Late submission penalty is 25% of the total grade per each 12-hour delay (thus, a submission with a delay of 12–24 h will receive only a half of earned points).

Individual project on time series or spatial data analysis*

1. Decide on a series of questions of interest and the associated hypotheses and predictions that you will attempt to test and answer with inferential statistics covered in class.
2. Design an experiment/study or analysis (if using an existing dataset) to answer these questions.
3. Identify and obtain or generate a dataset to analyze.
4. Analyze the data and prepare a report as you would for the scientific journal 'Ecology'. Include in the Discussion a section on how you might better design the study/experiment if you had the opportunity to do things over again.

Report limited to 10 double spaced pages of text (including literature cited) with 1" margins and 12 pt font. Title page, tables, and figures are in addition to the page limit. Be concise yet informative, organized, and well written.

The last days of classes will be reserved for project presentations. Everyone will have a chance to present their project findings in the standard (10-15 minutes talk, including questions). Exact time for each presentation will depend on the total enrollment and will be determined during the course. This should be a good exposure to giving talks at scientific meetings. The time limit will be rigidly enforced.

*Well done projects are sometimes good enough to publish or may become a chapter in your thesis, so keep this in mind during your project.