University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE

Environmental Statistics II

3 credits

MEES 708M
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).

INSTRUCTOR DETAILS:

Dong Liang
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CLASS MEETING DETAILS:
Dates: T, Th
Times: 3:30-5:00 p.m.
Originating Site: CBL
IVN bridge number:
(*******)
Phone call in number:
(***)
Room phone number:
(*****)

CURRICULUM FULLFILMENT:
PD or Elective

Prerequisites
MEES698B

Teaching Assistant
N/A

Tentative Weekly Course Schedule

Lecture	Topic	Reading
1	Review of multiple linear regression, Gauss-Markov theorem. Model assumptions and diagnostics (parametric and non-parametric).	C&H Ch. 3-4
2	Time series and its components (trend, cycles, seasonality, noise). Autocorrelation function. Smoothing. Trend- and difference-stationary time series.	B&D Ch. 1
3	Some approaches to regression on time series.	
4	Stationary time series: AR, MA, ARMA.	B&D Ch. 2, 3, 5
5	Stationary time series: AR, MA, ARMA (contd).	B&D Ch. 2, 3, 5
6	ARIMA	B&D Ch. 6
7	SARIMA	B&D Ch. 6
8	ARCH and GARCH.	K&W Ch. 7
9	Parametric and non-parametric methods for trend detection (Mann—Kendall, WAVK, unit-root test). Bootstrap.	B&D Ch.6.3, notes, Buhlmann (2002)
10	Time series synchronism and clustering.	notes
11	Granger causality.	K&W Ch. 3
12	Cointegration.	K&W Ch. 6
13	Regression with correlated errors (ARMAX), with seasonality (dummy variables, trigonometric regressors).	S&S Ch. 5.5-5.7
14	Spectral decomposition.	S&S Ch. 4
15	Review of regression model selection	Zuur Appendix A
Spring break		
16	Mixed effect model for nested data	Zuur Ch. 5
17	Generalized linear model for discrete data	Zuur Ch 8-10
18	Geostatistical process and variogram	W&O Ch. 3-6
19	Local estimation or prediction	W&O Ch. 8
20	Kriging in the Presence of Trend	W&O Ch. 9.1-3
21	Cross-Correlation, Co-regionalization and Cokriging	W&O Ch. 10
22	Spatial point processes, estimation	W&G Ch. 5
23	Spatial clusters of health events	W&G Ch. 6
24	Area, Raster and Network data, EDA	W&G Ch. 7.4
25	Cluster and clustering	W&G Ch. 7.3, 7.5
26	Spatial autoregressive models	W&G Ch. 9.3
27	Generalized linear spatial models	W&G Ch. 9.4
28	Approximate spatial data modeling	
29	Class presentations	

Required textbooks, reading and/or software or computer needs

Recommended reading:

- C&H: Chatterjee, S. and Hadi, A. S. 2006. Regression Analysis by Example. Wiley.

- B&D: Brockwell, P.J. and Davis, R. A. 2002. Introduction to Time Series and Forecasting. 2nd ed. Springer, New York.
- 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.
- Bühlmann, P. 2002. Bootstraps for Time Series. Statistical Science: 17(1), 52–72.
- W&G: Waller, L.A. and Gotway, C.A. 2004. Applied spatial statistics for public health data. Wiley.
- ASDAR: Bivand, R.S., Pebesma, E. and Gomez-Rubio, V. 2013. Applied Spatial Data Analysis with R. Springer
- W&O: Webster, R. and Oliver, M. A. 2007. Geostatistics for Environmental Scientists. 2nd ed. Wiley
- H&J: Hooten, M.B., Johnson, D.S., McClintock, B.T., Morales, J.M. 2017. Animal movement statistical models for telemetry data. CRC Press
- 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.