ISE 599 Temporal & Spatial Data Analytics
4 Units

Day/Time: Spring 2025, Mon/Wed 2:00-3:50 PM
Location: TBA

Instructor: Dr. Tao Ma
Office: GER 216
Office Hours: TBA or by appointment via email

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Teaching Assistants: TBA
Office Hours:
Email:

Course Description

This course aims to introduce theory and application of temporal and spatial data analytics. It consists of two parts. **Part I** is temporal data analytics that introduce both Box-Jenkins statistical methods and deep learnings techniques for time series modelling and forecasting. **Part II** is spatial data analytics that introduce modern spatial statistical methods and emerging computational approaches for spatial data analysis. The course covers the following topics:

- **Part I** covers model identification, estimation, diagnostics and forecasting techniques for stationary and non-stationary univariate and multivariate time series. The statistical models include ARMA, (seasonal) ARIMA, and VAR; the large-scale forecasting with deep learning models include RNN, LSTM, and CNN.
- **Part II** covers descriptive methods for spatial data, spatial autocorrelation, point patterns and clustering, spatial regression, interpolation, and prediction, model-based spatiotemporal geostatistics.

All data analysis in the course is performed with Python or R using real world examples.

Learning Objectives and Outcomes

After successfully completing the course, the students should be able to:

- diagnose and evaluate time series models; use Box-Jenkins methods to develop statistical models for time series data with the principle and procedures learned from the class.
- apply deep learning models to high-dimension time series data for large-scale forecasting.
- create spatial statistical models and compute model-based spatial statistics; understand, analyze, synthesize and interpret spatial patterns and dynamics, distributions, and relationships.
- Apply spatial modelling techniques to spatial data for prediction and identify insights hidden within data.

Prerequisite(s):

Working knowledge on Python/R programing, probability and statistics

Recommended Preparation:

ISE 150 Python programing, ISE 220/225 Probability/Engineering Statistics
https://www.datacamp.com/courses/intro-to-python-for-data-science

Course Policies

All course materials (lecture slides, homework, labs/exercises, etc.) will be distributed via Brightspace. They are only for the students who are enrolled in the course. Do **NOT** post or duplicate the course materials online or distribute them electronically or in print without prior explicit permission from the instructor. All assignments will be submitted through Brightspace.

Technological Proficiency and Hardware/Software Required

The course requires Python/R programming language and several of its key data science packages. Jupyter Lab and RStudio are used as the main interface for documenting the scripts and results. These are all open source and can be downloaded by the student for no cost. The computing platform can be personal laptop, the Viterbi VDI (virtual desktop) or HPC in USC CARC

Textbooks

Recommended Textbooks:
- C. Huang and A. Petukhina, Applied Time Series Analysis and Forecasting with Python, Springer 2022, ISBN 978-3-031-13583-5 (**Ref 1**)
- M. Peixeiro, Time Series Forecasting in Python, 2022 Manning Publications, ISBN 9781617299889 (**Ref 2**)
- S. J. Rey, at el., Geographic Data Science with Python, 2023 CRC, ISBN 9780367263119 (**Ref 3**)
- E. Pebesma and R. Bivand, Spatial Data Science With Applications in R, 2023 CRC, ISBN 978-1-032-47392-5 (**Ref 4**)
- P. Moraga, Spatial Statistics for Data Science: Theory and Practice with R, 2024 CRC, ISBN 978-1-032-64148-5 (**Ref 5**)

Description and Assessment of Assignments

The course grade distribution is as follows:
- Homework assignments (approximately 10) – 50% of final grade
- Midterm exam (in class) – 20% of final grade
- Final exam – 30% of final grade

Grading Scale

Course final grades will be determined using the following scale

A	95-100
A-	90-94.9
B+	87-89.9
B	83-86.9
B-	80-82.9
C+	77-79.9
C	73-76.9
C-	70-72.9
D+	67-69.9
D	63-66.9
D-	60-62.9
F	59.9 and below

Up to two points may be added to the overall grade based on class participation.

Assignment Submission Policy

Assignments will all be prepared and submitted in PDF format and scripts are submitted in .ipynb or .py or .R file as directed. Any other file format (e.g., jpeg) will not be accepted for grading. They should be submitted via Brightspace by the due date. No make-up exams are considered.

Timeline and Rules for Submission

Homework assignments will be posted on Brightspace.All assignments must be submitted by the due date. No late assignments will be accepted. Any student who fails to submit an assignment on time will receive a zero grade for that assignment.

Course Schedule

This following table is a weekly breakdown tentative schedule and subject to change according to the actual class situation throughout the semester. Please follow the announcement in class or Brightspace for the latest update.

Week	Mon/Wed	Topics/Contents	Homework	Reading Reference
1	1/13	Introduction to Time Series Data		
	1/15	Stationarity and Autocorrelation		
2	1/20	No class		
	1/22	Autoregressive & Moving Average Processes	HW 1	
3	1/27	Modelling Stationary Time Series (ARMA)		
	1/29		HW 2	
4	2/3	Modelling Non-Stationary Time Series (ARIMA)		Ref 1
	2/5		HW 3	
5	2/10	Accounting for Seasonality (SARIMA)		
	2/12	Multivariate Time Series (VAR)		
6	2/17	No class		
	2/19	Forecasting	HW 4	
7	2/24	Review Session		
	2/26	Midterm Exam		
8	3/3	Deep learning for time series analysis		
	3/5	Neural Network Architecture (MLP)	HW 5	
9	3/10	Recurrent Neural Network (RNN)		
	3/12	Long-Short Term Memory (LSTM) Neural Network	HW 6	Ref 2
10	3/17	Spring Recess		
	3/19			
11	3/24	Convolutional Neural Network (CNN)		
	3/26	Large-scale forecasting with deep learning	HW 7	
12	3/31	Introduction to Spatial Data		
	4/2	Statistical Modelling of Spatial Data		
13	4/7	Point Pattern Analysis	HW 8	
	4/9	Spatial Interpolation		
14	4/14	Spatiotemporal Geostatistics	HW 9	Ref 3, 4, 5
	4/16	Spatial Autocorrelation		
15	4/21	Clustering and Regionalization		
	4/23	Spatial Regression	HW 10	
16	4/28	Review Session		
	4/30	Final Exam		

Statement on Academic Conduct and Support Systems

Academic Conduct:

Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. Other forms of academic dishonesty are equally unacceptable. See additional information in SCampus and university policies on scientific misconduct, policy.usc.edu/scientific-misconduct.

Discrimination, sexual assault, and harassment are not tolerated by the university. You are encouraged to report any incidents to the Office of Equity and Diversity http://equity.usc.edu or to the Department of Public Safety http://capsnet.usc.edu/department/department-public-safety/online-forms/contact-us. This is important for the safety of the whole USC community. Another member of the university community – such as a friend, classmate, advisor, or faculty member – can help initiate the report, or can initiate the report on behalf of another person. The Center for Women and Men http://www.usc.edu/student-affairs/cwm/ provides 24/7 confidential support, and the sexual assault resource center webpage http://sarc.usc.edu describes reporting options and other resources.

Support Systems:

Student Health Counseling Services - (213) 740-7711 – 24/7 on call
engemannshc.usc.edu/counseling
Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call
suicidepreventionlifeline.org
Free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week.

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-4900 – 24/7 on call
engemannshc.usc.edu/rsvp
Free and confidential therapy services, workshops, and training for situations related to gender-based harm.

Office of Equity and Diversity (OED) | Title IX - (213) 740-5086
equity.usc.edu, titleix.usc.edu
Information about how to get help or help a survivor of harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants. The university prohibits discrimination or harassment based on the following protected characteristics: race, color, national origin, ancestry, religion, sex, gender, gender identity, gender expression, sexual orientation, age, physical disability, medical condition, mental disability, marital status, pregnancy, veteran status, genetic information, and any other characteristic which may be specified in applicable laws and governmental regulations.

Bias Assessment Response and Support - (213) 740-2421
studentaffairs.usc.edu/bias-assessment-response-support
Avenue to report incidents of bias, hate crimes, and microaggressions for appropriate investigation and response.

The Office of Disability Services and Programs - (213) 740-0776
dsp.usc.edu
Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Support and Advocacy - (213) 821-4710
studentaffairs.usc.edu/ssa
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.
Diversity at USC - (213) 740-2101
diversity.usc.edu
Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
dps.usc.edu, emergency.usc.edu
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call
dps.usc.edu
Non-emergency assistance or information.