Applying Time Series Analysis in Fishery and Environmental Sciences
FISH 550 University of Washington

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Course overview

This course is intended to give students an overview of the theory and practical aspects of fitting time series models to fisheries and environmental data. The course will cover topics ranging from autocorrelation and crosscorrelation, autoregressive (AR) and moving average (MA) models, univariate and multivariate state-space models, and estimating model parameters. This course also covers various aspects of assessing model performance and evaluating model diagnostics. The course is focused almost exclusively on problems and analyses in the time domain, and only briefly addresses methods for the frequency domain. In general, students will focus on conceptualizing analyses, implementing analyses, and making inference from the results.

Learning objectives

By the end of the quarter, students should be able to:

- Identify and estimate the three basic elements of a classical decomposition model
• Explain the differences between the state and observation models that together form a state-space model

• Apply appropriate diagnostic measures to identify any shortcomings in model assumptions

• Use information theoretic methods and cross validation for formal model selection

Specifically, students should have the necessary hands-on skills to:

• Describe how to use differencing to remove trends or seasonal signals from a time series

• Use the autocorrelation and partial autocorrelation functions to identify orders of ARMA($p, q$) models for time series data

• Illustrate how to set up a multivariate state-space model to describe temporal patterns in $n$ observed time series as a function of $m$ unique states

• Use covariates in time series models to examine the influence of explanatory variables and seasonal effects on response variables

• Apply Dynamic Factor Analysis to identify common patterns among many time series

• Use Dynamic Linear Models to estimate changing relationships between a response variable and explanatory variable(s)

• Use the {MARSS} package in R to fit a variety of univariate and multivariate state-space models

Instructors

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Credits

This course is 5 credits.
Meeting times & locations

Note: This course will be offered during Spring Quarter of odd-numbered years.

Lectures
Tuesday & Thursday from 1:30-2:50 in FSH 203

Computer Lab
Thursday from 3:00-3:50 in FSH 203

Office hours
By appointment.

Pre-requisites

Students should have a working knowledge of the R computing software, such as that provided in FISH 552/553. Students should also have an understanding of basic probability and statistical inference, such as that covered in QSCI 482.

Classroom conduct

We are dedicated to providing a welcoming and supportive learning environment for all students, regardless of their background, identity, physical appearance, or manner of communication. Any form of language or behavior used to exclude, intimidate, or cause discomfort will not be tolerated. This applies to all course participants (instructor, students, guests). In order to foster a positive and professional learning environment, we ask the following:

- Please let us know if you have a name or set of preferred pronouns that you would like us to use
- Please let us know if anyone in class says something that makes you feel uncomfortable[1]

In addition, we encourage the following kinds of behaviors:

- Use welcoming and inclusive language
• Show courtesy and respect towards others
• Acknowledge different viewpoints and experiences
• Gracefully accept constructive criticism

Although we strive to create and use inclusive materials in this course, there may be overt or covert biases in the course material due to the lens with which it was written. Your suggestions about how to improve the value of diversity in this course are encouraged and appreciated.

Please note: If you believe you have been a victim of an alleged violation of the Student Conduct Code or you are aware of an alleged violation of the Student Conduct Code, you have the right to report it to the University.

Access & accommodations

All students deserve access to the full range of learning experiences, and the University of Washington is committed to creating inclusive and accessible learning environments consistent with federal and state laws. If you feel like your performance in class is being impacted by your experiences outside of class, please talk to the instructors.

Disabilities

If you have already established accommodations with Disability Resources for Students (DRS), please communicate your approved accommodations to us at your earliest convenience so we can discuss your needs in this course. If you have not yet established services through DRS, but have a temporary health condition or permanent disability that requires accommodations (e.g., mental health, learning, vision, hearing, physical impacts), you are welcome to contact DRS at 206-543-8924 or via email or their website. DRS offers resources and coordinates reasonable accommodations for students with disabilities and/or temporary health conditions. Reasonable accommodations are established through an interactive process between you, your instructor(s) and DRS.

Religious observances

Washington state law requires that UW develop a policy for accommodation of student absences or significant hardship due to reasons of faith or conscience, or for organized religious activities. The UW’s policy, including more information about how to request an accommodation, is available at Religious Accommodations Policy. Accommodations must be requested within the first two weeks of this course using the Religious Accommodations Request Form.
Technology

This course will revolve around hands-on computing exercises that demonstrate the topics of interest. Therefore, students are strongly recommended to bring their own laptop to class, although students are certainly free to work with one another. **For students without access to a personal laptop:** it is possible to check out UW laptops for an entire quarter (see the Student Services office for details).

All of the software we will be using is free and platform independent, meaning students may use macOS, Linux, or Windows operating systems. We will be using the free R software and the desktop version of the R Studio integrated development environment (IDE). We will also be using various packages not contained in the base installation of R, but we will wait and install them at the necessary time. The instructors will be available during the first week of class to help students troubleshoot any software installation problems.

We will be using Git, a free and open source version control system for tracking changes to our files.

Students will also be required to have a user account on GitHub, which we will be using for file hosting and communications via “issues”. If you do not already have an account, you can sign up for a free one here. The instructors will provide training on how to use the intended features in GitHub.

Teaching methodology

This course will introduce new material primarily through prepared slides and hands-on demonstrations. Students will be expected to work both individually and collaboratively (to the extent possible given the current conditions); course content and evaluation will emphasize the communication of ideas and the ability to think critically more so than a specific pathway or method. Other areas of this website provide an overview of the topics to be covered, including links to weekly reading assignments, lecture materials, computer labs, and homework assignments.

Communication

This course will involve a lot of communication between and among students and the instructor. Short questions should be addressed to me via email; we will try my best to respond to your message within 24 hours. Under more normal circumstances, detailed questions would be addressed to me in person–either after class or during a scheduled meeting. In this case, however, we will schedule one-on-one or group Zoom calls as needed.

In addition to email and Zoom, we will use the “Issues” feature in GitHub to ask questions and assist others. Specifically, questions and answers can be posted to the issues in the course’s “assistance” repository here.
Evaluation

Students will be evaluated on their knowledge of course content and their ability to communicate their understanding of the material via individual homework assignments (30%), a final project (40%), peer reviews (20%), and class participation (10%). There will be 6 homework assignments, each of which will count toward 5% of the final grade. Please note, all assignments must be turned in to achieve a passing grade.

Homework (30%)

Homework will be assigned each Thursday and is due by 11:59 PM on the following Thursday. It will consist of some short answers and R code based on topics covered in lab. There will be 6 assignments worth 5% each. Your learning in the class will be greatly enhanced by doing the homework, which consists of applying the material you learn in each lecture to a data set.

Individual project (50%)

Each student will have to write a complete, publishable (<20 page) paper that may, or may not, serve as a component of their thesis/dissertation. Given that some students might not have their own data, students may also use data from the instructors, public datasets, or datasets included in R libraries. See the list of prior student projects for the types of projects done in prior years.

Project components

Student projects will consist of 3 components accounting for the following parts of your grade:

1) one-page proposal (5%)
2) in-class presentation (10%)
3) final paper (35%)

Peer reviews (20%)

Each student is expected to provide 2 anonymous peer-reviews of their colleagues’ papers (10% each). Students will be provided with review template, which includes numerical scores and written comments. Grades for the peer reviews will be based upon a student’s assessment of the following elements of the paper:
### Grades

The percentage of points obtained by a student will translate into a numeric grade for the course according to the following table.

<table>
<thead>
<tr>
<th>Percent</th>
<th>Grade</th>
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<tbody>
<tr>
<td>100-98%</td>
<td>4.0</td>
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<tr>
<td>97-96%</td>
<td>3.9</td>
</tr>
<tr>
<td>95-94%</td>
<td>3.8</td>
</tr>
<tr>
<td>93-92%</td>
<td>3.7</td>
</tr>
<tr>
<td>91%</td>
<td>3.6</td>
</tr>
<tr>
<td>90-89%</td>
<td>3.5</td>
</tr>
<tr>
<td>88-87%</td>
<td>3.4</td>
</tr>
<tr>
<td>86%</td>
<td>3.3</td>
</tr>
<tr>
<td>85%</td>
<td>3.2</td>
</tr>
<tr>
<td>84%</td>
<td>3.1</td>
</tr>
<tr>
<td>83%</td>
<td>3.0</td>
</tr>
<tr>
<td>82%</td>
<td>2.9</td>
</tr>
<tr>
<td>81%</td>
<td>2.8</td>
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<tr>
<td>80%</td>
<td>2.7</td>
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<tr>
<td>79%</td>
<td>2.6</td>
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<tr>
<td>78%</td>
<td>2.5</td>
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<tr>
<td>77%</td>
<td>2.4</td>
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<tr>
<td>76%</td>
<td>2.3</td>
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<tr>
<td>75%</td>
<td>2.2</td>
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<tr>
<td>74%</td>
<td>2.1</td>
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<tr>
<td>73%</td>
<td>2.0</td>
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<tr>
<td>72%</td>
<td>1.9</td>
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<tr>
<td>71%</td>
<td>1.8</td>
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<tr>
<td>70%</td>
<td>1.7</td>
</tr>
<tr>
<td>69-0%</td>
<td>0.0</td>
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- writing and organization (3%)
- methods (4%)
- figures and tables (3%)

**Note:** These peer reviews will not factor into the other students’ grades, but they will be useful to the students in further preparing their papers for publication or part of their thesis/dissertation.
Academic integrity

Faculty and students at the University of Washington are expected to maintain the highest standards of academic conduct, professional honesty, and personal integrity. Plagiarism, cheating, and other academic misconduct are serious violations of the Student Conduct Code. We have no reason to believe that anyone will violate the Student Conduct Code, but We will have no choice but to refer any suspected violation(s) to the College of the Environment for a Student Conduct Process hearing. Students who have been guilty of a violation will receive zero points for the assignment in question.

Grievance procedures

The College of the Environment Student Academic Grievance Procedures provide mechanisms for enrolled students to address academic problems or grievances in an equitable, respectful and timely manner. Academic grievances are defined as those involving conflicts between a student or students and their course instructors (including faculty and teaching assistants) or research mentor(s) with respect to differences arising within credit-bearing work and while the student is registered at the University of Washington. If you have or are experiencing such a conflict in this class, and have not, cannot, or do not wish to attempt resolution with me, we encourage you to explore additional options open to you by accessing the website above.

Mental health

We are in the midst of an historic pandemic that is creating a variety of challenges for everyone. If you should feel like you need some help, please consider the following resources available to students.

If you are experiencing a life-threatening emergency, please dial 911.

Crisis Clinic
Phone: 206-461-3222 or toll-free at 1-866-427-4747

UW Counseling Center
Phone: 206-543-1240
Immediate assistance

Let’s Talk

Hall Health Mental Health

Safety

If you feel unsafe or at-risk in any way while taking any course, contact SafeCampus (206-685-7233) anytime–no matter where you work or study–to anonymously discuss safety and
Week | Topics
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1 | Classical decomposition; (Partial) Autocorrelation; White noise; Random walks
2 | ARMA & ARIMA models; Box-Jenkins Method
3 | Univariate & multivariate state-space models
4 | Covariates in state-space models; Dynamic Factor Analysis (DFA)
5 | Dynamic linear models (DLMs); Models with discrete hidden states
6 | Introduction to Bayesian inference
7 | Cross-validation; Model selection & multi-model inference
8 | Semi- and non-parametric models; Frequency domain models
9 | Spatio-temporal models
10 | Student presentations

well-being concerns for yourself or others. SafeCampus can provide individualized support, discuss short- and long-term solutions, and connect you with additional resources when requested. For a broader range of resources and assistance see the Husky Health & Well-Being website.

**Food Pantry**

No student should ever have to choose between buying food or textbooks. The UW Food Pantry helps mitigate the social and academic effects of campus food insecurity. They aim to lessen the financial burden of purchasing food by providing students access to shelf-stable groceries, seasonal fresh produce, and hygiene products at **no cost**. Students can expect to receive 4 to 5 days’ worth of supplemental food support when they visit the Pantry, located on the north side of Poplar Hall at the corner of NE 41st St and Brooklyn Ave NE. Visit the Any Hungry Husky website for additional information, including operating hours and additional food support resources.

**Schedule & topics**

**Endnotes**

[1] If an instructor should be the one to say something that makes a student uncomfortable, the student should feel free to contact the Director of the School of Aquatic and Fishery Sciences.