ACE Network Subject Information Guide

Statistical and Time Series Analysis of Climate Variables

Semester 2, 2023

Administration and contact details

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Host institution	**University of South Australia**
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Subject details

Handbook entry URL	TBD
Subject homepage URL	TBD
Honours student hand-out URL	TBD
Teaching period (start and end date):	**27/07/2023-10/11/2023**
Exam period (start and end date):	**TBA**
Contact hours per week:	**4**
ACE enrolment closure date:	**TBA**
Lecture day(s) and time(s):	**Workshop - Tuesday – 9-11 (Central)**
	Computer Practical - Tuesday – 11-1 (Central)
Description of electronic access arrangements for students (for example, LMS)	**Zoom.**

Subject content

1. **Subject content description**

Recent developments in two areas have underlined the importance of a robust approach to the statistical and time series analysis of climate variables and their derivative series.

1. I was an investigator in a recent Australian Renewable Energy Agency (ARENA) project to enhance the short term (5 minute) forecasting of solar farm output, to help ensure grid stability. The project involved the use of techniques from many disciplines such as atmospheric physics and cloud motion vector models, but also statistical time series tools developed by my team. This is now being extended from point forecasting to interval forecasting.
2. Climate and land use change are affecting both rainfall and temperature time series, in most cases decreasing rainfall and increasing temperature. But, in some situations for rainfall in particular, the opposite is occurring. It is necessary to both perform trend analysis on these variables but also attempt to generate present and future synthetic series of these variables, as well as solar radiation. This is done in order to evaluate the performance of systems dependent on these variables.

We will be studying the necessary tools to be able to perform such analyses.

Detailed Information

In the National Electricity Market (NEM) in Australia, short term forecasting is an important endeavour. Every five minutes, generator companies submit a bid stack, that is the electrical energy they can supply to the grid at a number of price bands. The Australian Energy Market Operator (AEMO) then runs a mathematical algorithm to see how far up the bid stacks they have to go to supply their forecasted load. This then determines the spot price for electricity.

Renewable energy, in the form of wind and solar, are becoming significant contributors to the electricity supply mix. In this course we will examine statistical tools to forecast output from wind and solar farms at these time scales. In particular, we will study how to not only forecast the expected wind or solar farm output but also put error bounds on those predictions.

We will also study the three components of solar radiation, global or total, direct and diffuse, the diffuse radiation being that which is received at a location after being scattered by particles in the atmosphere.

The prevailing wisdom is that the changes in rainfall totals over time are linked to climate change, and there is substantial evidence in the literature to support this view. However, there is also literature to support the thesis that some of the change can be attributed to land use change. We will examine some of the trends and also try to look at the

contributions of the two factors. Aligned with this, we will also examine some local trends in temperature, and look at the implications of those trends.

2. Week-by-week topic overview

- The components of a time series model.
- Additive and multiplicative models.
- Additive and multiplicative seasonality.
- Box-Jenkins models.
- Forecasting techniques.
- ARCH/GARCH and other volatility models.
- Probabilistic forecasting, including distributional transformations and quantile regression.
- Error analysis.
- Spatial-Temporal statistical and time series models.
- Synthetic generation.
- Rainfall modelling.
- Further applications.
- Student presentations.

3. Assumed prerequisite knowledge and capabilities

Statistical decision making in the frequentist inference paradigm.

4. Learning outcomes and objectives

On completion of this course, students should be able to:

- Apply the techniques of time series analysis to climatic data
- Prepare a summary of the scientific literature in a particular topic of interest
- Create and interpret statistical and time series questions and develop strategies for testing these questions
- Perform calculations and interpret the results of a range of testing and estimation procedures, paying particular attention to the underlying assumptions
- Use software packages to analyse data

- Write a short summary report of investigation
- Present the results of an investigation.

AQF specific Program Learning Outcomes and Learning Outcome Descriptors (if available):

AQF Program Learning Outcomes addressed in this subject	Associated AQF Learning Outcome Descriptors for this subject
Insert Program Learning Outcome here	Choose from list below
Insert Program Learning Outcome here	Choose from list below
Insert Program Learning Outcome here	Choose from list below
Insert Program Learning Outcome here	Choose from list below
Insert Program Learning Outcome here	Choose from list below
Insert Program Learning Outcome here	Choose from list below
Insert Program Learning Outcome here	Choose from list below

Learning Outcome Descriptors at AQF Level 8

Knowledge

K1: coherent and advanced knowledge of the underlying principles and concepts in one or more disciplines

K2: knowledge of research principles and methods

Skills

S1: cognitive skills to review, analyse, consolidate and synthesise knowledge to identify and provide solutions to complex problem with intellectual independence

S2: cognitive and technical skills to demonstrate a broad understanding of a body of knowledge and theoretical concepts with advanced understanding in some areas

S3: cognitive skills to exercise critical thinking and judgement in developing new understanding

S4: technical skills to design and use in a research project

S5: communication skills to present clear and coherent exposition of knowledge and ideas to a variety of audiences

Application of Knowledge and Skills

A1: with initiative and judgement in professional practice and/or scholarship

A2: to adapt knowledge and skills in diverse contexts

A3: with responsibility and accountability for own learning and practice and in collaboration with others within broad parameters

A4: to plan and execute project work and/or a piece of research and scholarship with some independence

5. **Learning resources**

There are a number of texts that can be of aid, including

- Tsay, RS 2010, *Analysis of Financial Time Series*, 3rd edition, John Wiley & Sons.
- Brockwell, P. and Davis, R., An Introduction to Time Series and Forecasting, Springer-Verlag, 1996.
- Chatfield, C., The Analysis of Time Series, An Introduction, Chapman and Hall, 1989.

Journal articles and book chapters

- John Boland, Sleiman Farah and Lei Bai, 2022, Forecasting of Wind and Solar Farm Output in the Australian National Electricity Market: A Review, *Energies*, doi={10.3390/en15010370}.
- Boland, John, and Sleiman Farah. 2021. Probabilistic Forecasting of Wind and Solar Farm Output, *Energies* 14, no. 16: 5154. https://doi.org/10.3390/en14165154
- John Boland, Characterising Seasonality of Solar Radiation and Solar Farm Output (2020), *Energies*, **13**, 471; doi:10.3390/en13020471
- John Boland and Adrian Grantham (2018) Nonparametric Conditional Heteroscedastic Hourly
- Probabilistic Forecasting of Solar Radiation, *J Multidisciplinary Journal,* pp. 174–191*; doi:10.3390/j1010016*
- Grantham AP, Pudney PJ, Boland JW (2018), Generating synthetic sequences of global horizontal irradiation, *Solar Energy*, vol. 162, pp. 500-509.
- Piantadosi, J; Boland, J; Howlett, P (2009) Generating synthetic rainfall on various timescales - daily, monthly and yearly, *Environmental Modeling and Assessment*, **14** (4), pages 431-438.
- John Boland, (2011) Box-Jenkins time series models, *International Encyclopedia of Statistical Science,* Editor Miodrag Lovrich, Springer, pp. 178-180.
- Boland J. (2008) Time series and statistical modelling of solar radiation, *Recent Advances in Solar Radiation Modelling*, Viorel Badescu (Ed.), Springer-Verlag, pp. 283-312.
- Manju Agrawal, John Boland and Barbara Ridley, (2013), Analysis of wind farm output: estimation of volatility using high frequency data, *Environmental Modeling and Assessment,* http://dx.doi.org/10.1007/s10666-013-9357-3

We will use a number of software packages for the analysis, and students can use any combination of Excel, Minitab, R, Python.

6. Assessment

Exam/assignment/classwork breakdown					
Exam	60%	**Project**	40%	**Class work**	Enter %
Assignment due dates		01/09	13/10	02/11	10/11
Approximate exam date				Click here to enter a date.	

Institution honours program details – To Be Determined

Weight of subject in total honours assessment at host department	Click here to enter text.
Thesis/subject split at host department	Click here to enter text.
Honours grade ranges at host department	
H1	Enter range %
H2a	Enter range %
H2b	Enter range %
H3	Enter range %

Institution masters program details – To Be Determined

Weight of subject in total masters assessment at host department	Click here to enter text.
Thesis/subject split at host department	Click here to enter text.
Masters grade ranges at host department	
H1	Enter range %
H2a	Enter range %
H2b	Enter range %
H3	Enter range %