

# MAST-811 Time Series Analysis (Fall 2022)

**Instructor:** Andreas Münchow ([muenchow@udel.edu](mailto:muenchow@udel.edu)), Robinson 112A

**Web-Site:** <https://muenchow.cms.udel.edu/classes/MAST811>

**Time:** Tuesday and Thursday 17:00-18:15

**Location:** 206 Robinson Hall

**Goal:** Provide each student with a set of tools to confidently handle common data analysis task in both the time (space) and frequency (wave number) domains.

**Synopsis:** The class is applied and focused on students to develop their own computer programs potentially used in the analysis of serial data drawn from real problems. Topics to be discussed include the nature of time series, stationarity, auto and cross covariance functions, power and cross spectra and the analysis of linear time-invariant relationships between pairs of series. The class emphasizes frequency/wavenumber over time/space domain techniques. It consist of standard lectures, but most learning takes place via a set of computer-based projects that translates theoretical lecture materials into tested codes to apply

- (1) Auto-spectral analysis,
- (2) Digital filters,
- (3) Linear systems.
- (4) Least-squares function fitting,
- (5) Empirical orthogonal functions, and
- (6) Grid interpolation techniques
- (7) Non-stationary Data Analyses

to data with known signal to noise properties and the uncertainties associated with these.

**Pre-requisites:** Fourier transforms, ability to code in C, Fortran, R, or Matlab

**Grades:** 80% analysis projects, 10% homework problems, 10% in-class participation

**Text:** The class has been developed over many years from extensive notes that Prof. Wong and I developed at the University of Delaware (to be posted online), but the following books are relevant (alphabetical order):

1. Bendat, J.S. and A. G. Piersol, 1986. Random Data: Analysis and Measurement Procedures, 2<sup>nd</sup> ed., John Wiley, New York, NY, 566 pp.
2. Emery, W.J. and R.E. Thompson, 2001. Data analysis methods in physical oceanography, 2<sup>nd</sup> ed., Elsevier Science, Amsterdam, Netherlands, 658 pp.
3. Press, W.H. et al., 2007. Numerical Recipes 3d edition: The Art of Scientific Computing. Cambridge University Press, Cambridge, UK, 1256 pp.

## MAST-811: Time Series Analysis (Fall 2022)

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112A Robinson Hall <https://muenchow.cms.udel.edu/classes/MAST811>

Grading: 80% computer exercises on (a) Random Numbers  
(b) Fourier transforms  
(c) Linear systems  
(d) Filtering, harmonic analysis  
(e) Empirical orthogonal functions  
10% home work exercises  
10% class room participation

Text Books: Bendat and Piersol (1986) Random Data: Analysis and measurement ...  
Emery and Thompson (1997) Data analysis methods in physical oceanography  
Press et al. (1992) Numerical recipes: The art of scientific computing

Course Outline (numbers indicate approximate number of weeks per topic)

### A. Introduction (1)

Definitions, data types, sources, and their sampling  
Review of basic concepts (Fourier series and transforms)

### B. Sampling (3)

Sampling theorem  
Discret Fourier transform, Fast Fourier Transform

### C. Digital Filters (1)

Non-recursive filters (Godin, raised-cosine, Lanczos)  
Recursive filters (Butterworth filter)

### D. Auto-spectral Analysis (1)

Probability density functions, central limit theorem  
Auto-correlation, Periodogram, Confidence limits

### E. Linear Systems (1)

One input – one output system (coherence and phase)  
Multiple input – one output system (partial and multiple coherence)

### F. Harmonic Analysis (1.5)

Tidal Analysis (time domain)  
Least squares function fitting (time and space domain)

### G. Empirical Orthogonal Function (Principal Component) Analysis (1)

Scalar and vector fields in time/space domain  
Scalars in frequency/wave number domain

### H. Grid Interpolation (1)

Objective Analysis; Kriging; Minimum curvature and biharmonic splines

### I. Non-stationary Data Analyses (1.5)

Statistics; Spectral techniques; Wavelets