EAS 4480: Environmental Data Analysis

Course Summary:

The primary objective of this course is to equip students with fundamental statistical and time series analysis skills, enabling them to effectively apply these methods and their extensions to address environmental challenges. Through practical examples and MATLAB demonstrations, students gain hands-on experience in analyzing research data from atmospheric and earth sciences. The course emphasizes the practical application of these methods in data processing and interpretation, complementing lectures with hands-on exercises and an independent student project where students apply data analyses to environmental data.

Instructor: Yuhang Wang

Textbook: *Matlab Recipes for Earth Sciences*, by M. H. Trauth, Springer-Verlag Berlin Heidelerg, 2010.

Course Content:

1. Introduction to data analysis and MATLAB: programming, data handling, and data visualization.

Examples: Visualization of seismology data; Golden section; Estimating π; Butterfly effects – Lorenz attractor; fractals – Mandelbrot set.

2. Univariate statistics: Empirical distributions, theoretical distributions, central limit theorem, the statistical tests (t, F, and χ^2), extremal types theorem, extreme value distributions.

Examples: Organic matter measurements; aerosol distributions

3. Bivariate statistics: Linear regression/prediction and its error estimate; linear correlation, confidence level, and error estimate; analysis of variance – forecast skill; principal component regression and EOF analysis; reduced major axis regression; curvilinear regression; nonlinear regression; analysis of residuals; cross validation; bootstrap and Jackknife estimates of regression coefficients; cross validation.

Examples: Depth-age relationship of sediment; climate “hockey-stick”; ozone-temperature relationship in Atlanta.

4. Time-series analysis: Auto correlation, red noise; fast Fourier transform and periodogram; unevenly-spaced data processing; wavelet spectrum; least-squares spectral

analysis; singular spectrum analysis; wavelet analysis; higher-dimension spectral analysis; crossspectral analysis.

Examples: Sunspots – solar cycle; ENSO index.

5. Signal processing: linear time-invariant systems; convolution and filtering; filtering functions; impulse/frequency response; filter design and adaptive filtering; inversion filter and data assimilation.

Examples: Climate indices.

6. Spatial data: Gridding, contouring, and mapping; map projections; Gridding – 2-D interpolation.

Examples: Visualization of Earth topography; GSHHS shoreline data set; ETOPO2/GTOPO30/SRTM elevation data; satellite measurements of tropospheric NO_2.

7. Multivariate statistics: principal component analysis.

Examples: Minerals in sediments; air quality measurements in Mexico City.

Honor code for student responsibilities:

Students are expected to act according to the highest ethical standards.

Academic misconduct is any act that does or could improperly distort student grades or other student academic records. Such acts include but need not be limited to the following:

- Possessing, using or exchanging improperly acquired written or verbal information in the preparation of any essay, laboratory report, examination, or other assignment included in an academic course;
- Substitution for, or unauthorized collaboration with, a student in the commission of academic requirements;
- Submission of material that is wholly or substantially identical to that created or published by another person or persons, without adequate credit notations indicating authorship (plagiarism);
- False claims of performance or work that has been submitted by the claimant;
- Alteration or insertion of any academic grade or rating so as to obtain unearned academic credit;
- Deliberate falsification of a written or verbal statement of fact to a member of the faculty so as to obtain unearned academic credit;
- Forgery, alteration or misuse of any institute document relating to the academic status of the student.