CLIMATE 586 : Climate Data Analysis

Instructor: Xianglei Huang
(xianglei@umich.edu)

Winter 2020
Time: M/F 3-5pm
Location:2424CSRB

Grading:
Homework (60%)
Term projects (35%)
Class performance (5%)

Prerequisite

College-level statistics, calculus, linear algebra, and basic Matlab programming

Course description:

The goals of this course are (1) to provide a working knowledge of the objective methods used in diagnosis analysis of geophysical data featured with high dimensionality and strong correlation scale over temporal and spatial domains and (2) to make students capable of critically evaluating published studies utilizing these methods. We will cover techniques for extracting information from data such as time series analysis, composite analysis, spatial and temporal pattern recognition. Statistical modeling approach will also be covered. While the goal here is to seek a broadening of outlook and experience, we will also try to tailor the course to the needs and interests of the students in the class.

Emphases: (1) hands-on experiences and extensive Matlab programming; (2) methods of analyzing high-dimensional data sets with strong auto-correlations, which are frequently needed in geosciences and environmental sciences but not covered in standard statistics courses as much as other topics.

Syllabus:

(1) Review of basic statistics
Basic concepts, parametric and non-parametric hypothesis tests, Monte-Carlo method and bootstrapping

(2) Spectral analysis
Fundamentals of spectral analysis: discrete Fourier transform, power spectrum, AR process and its power spectrum, Welch's method.

Advanced spectral analysis: wavelet analysis, singular spectral analysis, multi-taper method, maximum entropy method, singular spectral analysis, 1-D empirical model decomposition & Hilbert-Huang transform.

Filtering of time series, filter design and usage.

(3) Linear regression and data modeling
Fundamentals of linear regression; assessing the significance and uncertainty of regression results from correlated data sets; multi-variate linear regression; robust linear regression; composite analysis; and neural-network based data modeling.

(4) Pattern recognitions
Principal component analysis, rotation of PCA, the significance test and uncertainty estimation, various applications of PCA. Nonlinear PCA and other pattern-extraction techniques. Cluster analysis. Multi-channel singular spectral analysis. Canonical correlational analysis.