AOSC-630 STATISTICAL METHODS IN METEOROLOGY AND OCEANOGRAPHY Updated January 2018 (Eugenia Kalnay/Huug vanden Dool)

Prerequisite: STAT 400 or equivalent, or approval by instructor.Grading: Homeworks, 30%; Mid-term take home exam, 30%; Final take home exam: 40%.

Syllabus: Review of the most widely used statistical methods currently used in meteorology and oceanography including tests of significance; time series analysis; linear multiple regression; neural networks; wavelets; Model Output Statistics. Notes discussing the syllabus subjects are available at http://www.aosc.umd.edu/~ekalnay/#AOSC630.

Note: Some of these lectures are presented by world leaders in the field. The class notes prepared for this course by Dr. Huug van den Dool became the basis for the textbook "Empirical Methods in Short Term Climate Prediction" (Oxford University Press, 2007).

Required Text: Daniel Wilks: Statistic Methods in the Atmospheric Sciences (2006) Academic Press. (3rd edition). You can use the first or second editions as well).

Recommended reference textbooks: Empirical Methods in Short-Term Climate Prediction. Huug van den Dool (2007) Oxford University Press ISBN 0-19-920278-8. Hans von Storch and Francis Zwiers (1999): Statistical Analysis in Climate Research. Cambridge University Press (now in paperback).

Approximate schedule:

1. Introduction, probability distributions, tests of significance (3 weeks)

. (1) Introduction - concepts of probability, random variables and probability distributions. Wilks: Chapters 2, 3, 5.1

. (2) Probability distributions, discrete, continuous - the normal distribution, Central Limit theorem, X^2 -distribution, t-distribution, and Fisher's F-distribution. Gumbel, Gamma and other distributions. Wilks: 4.1-4.5; 4.7

. (3) Tests of hypothesis - Type I error, Type II error, level of significance, one tailed tests and two tailed tests. Parametric tests of significance against non-parametric tests and Monte Carlo methods. Bootstrapping. Wilcoxon-Mann-Whitney non-parametric test. Wilks: 5.1-5.4

II. Regression, Statistical Weather forecasting, MOS, Neural Networks, Ensemble forecasting (3.0 weeks) Wilks: Chapter 6; other refs.

. (1) Simple regression - estimation of regression line, analysis of variance, confidence interval for regression coefficients, and confidence band for regression line.

. (2) Multiple regression - estimation of regression plane, partial correlation, and multiple correlation.

. (3) Screening regression - explained variance and incrementally explained variance, all possible regression, forward selection, stepwise regression, and stagewise regression.

. (4) Model Output Statistics, Adaptive Regression (Kalman Filtering). **Guest Lecturer: Mark Antolik**.

. (5) Nonlinear regression, neural networks (**Guest lecturer: Vladimir Krasnopolsky**).

. (6) Probabilistic forecasting and verification from ensembles (Guest lecturer: **Malaquías Peña-Méndez/EmilyBecker**).

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III. Time series (2.0 weeks) Wilks: Chapter 8, plus additional refs.

(2) Time series models, analysis of discrete time series. Stationarity. Markov chains. Testing for persistence. Harmonic analysis, smoothing and filtering, frequency response of smoothing and filtering functions, and construction of low- pass, band pass and high-pass filters. Example of using X^2 for testing goodness of fit.

(3) Time series models, continuous data. Statistical models. Autoregressive models. Applications. Variance of time series with persistence. Auto regressive, moving average models.

(4) Time series: Frequency domain. Fourier transform for continuous data. Power spectrum. Fourier transform for discrete time series. Time filtering. Low and high pass filters. Lanczos filter.

(5) Wavelets (Guest lecturer: **Andy Tangborn**)

IV. Statistical methods for climate prediction (5.0 weeks, lecturer: **Huug van den Dool**)

(1) Introduction: Empirical orthogonal functions (principal components) - rotated and complex empirical orthogonal functions. Coupled fields: Singular Value Decomposition, Canonical Correlation Analysis. Clustering (Wilks, Chapter 9)

(2) Applications developed at CPC: Empirical Wave Propagation; Natural analogues; Constructed analogues; Empirical Basis Functions; Teleconnections; Empirical Orthogonal Teleconnections: examples from reanalysis; Empirical Orthogonal Functions; Compact representation of data sets

V. Forecast verification (0.5 week):

(6) Currently used operational forecast scores