1. Preface

Time series analysis is a sub-field of statistical estimation methods. It is a mature subject with a long history and very large literature. For anyone dealing with processes evolving in time and/or space, it is an essential tool, but one usually given short-shrift in oceanographic, meteorological and climate courses. It is difficult to overestimate the importance of a zero-order understanding of these statistical tools for anyone involved in studying climate change, the nature of a current meter record, or even the behavior of a model.

There are many good textbooks in this field, and the refusal of many investigators to invest the time and energy to master a few simple elements is difficult to understand. These notes are not meant to be a substitute for a serious textbook; rather they are intended, partly through a set of do-it-yourself exercises, to communicate some of the basic concepts, which should at least prevent the reader from the commonest blunders now plaguing much of the literature. Many of the examples used here are oceanographic, or climate-related in origin, but no particular knowledge of these fields is required to follow the arguments.

Two main branches of time series analysis exist. Branch 1 is focussed on methodologies applied in the time domain (I will use "time" as a generic term for both time or space dimensions.) and the second branch employs frequency (wavenumber) domain analysis tools. The two approaches are intimately related and equivalent and the differences should not be overemphasized, but one or the other sometimes proves more convenient or enlightening in a particular situation. Frequency domain methods employ (mostly) Fourier series and transforms. *Algorithmically,* one can identify two distinct eras: those before and after the (re-) discovery of the Fast Fourier transform (FFT) algorithm about 1966. For numerical purposes, with some very narrow exceptions (described later), the pre-FFT computer implementations are now obsolete and there is no justification for their continued use.

Out of the huge literature on time-series analysis, I would recommend Bracewell (1978) for its treatment of Fourier analysis, Percival and Walden (1993) for spectra, and Priestley (1981) as a general broad reference incorporating both mathematical and practical issues. (Percival and Walden do not treat coherence, whereas Priestley does). Among the older books (pre-FFT), Jenkins and Watts (1968) is outstanding and still highly useful for the basic concepts. For time-domain methods, Box, Jenkins and Reinsel (1994) is generally regarded as the standard. Another comprehensive text is Hamilton (1994), with a heavy economics emphasis, but covering some topics not contained in the other books. Study of one or more of these books is essential to anyone seriously trying to master time series methods.

Additional copies of these notes can be obtained through MIT's OpenCourseware project (http://ocw.mit.edu). Please report to me the inevitable remaining errors you may encounter.