## 16. Spectrograms

If one has a long enough record, it is possible to Fourier analyze it in pieces, often overlapping, so as to generate a spectrum which varies with time. Such a record, usually displayed as a contour plot of frequency and time is known as a "spectrogram". Such analyses are used to test the hypothesis that the frequency content of a record is varying with time, implying a failure of the stationarity hypothesis. The inference of a failure of stationarity has to be made very carefully: the $\chi^2_\nu$ probability density of any spectral estimate implies that there is expected variability of the spectral estimates made at different times, even if the underlying time series is strictly stationary. Failure to appreciate this elementary fact often leads to unfortunate inferences (see Hurrell, 1995 and the comments in Wunsch, 1999).

The need to localize frequency structure in a time-or space-evolving record is addressed most generally by wavelet analysis. This comparatively recent development is described and discussed at length by Percival and Walden (2000) but often conventional spectrogram analysis is completely adequate (if seemingly less sophisticated).