Spectral User's Guide

This program performs spectral analysis on a time series. Key points are:

➢ The input file (tab-delimited text) must be a single column at a constant Δt. Exclude the time column.
➢ The analysis may be applied to the entire series, or in an iterative fashion on portions of the data.
➢ Any given spectral analysis may not exceed 30,000 data lines.
➢ If the time series has missing entries, replace the missing data values with -9999.
➢ There are 5 different graphs available, including 4 spectral analysis plots and 1 input data plot.
➢ The tab-delimited output file contains spectral density, integrated spectrum and frequency multiplied by spectral density for each frequency in the analysis.
➢ The program will analyze additional input files, but only one file is kept in memory at a time.

Explanation of the iterative feature:

➢ The iterative feature examines spectral density changes over the course of an input record. For example, instead of performing a single spectral analysis on a series of 10,000 values, the user may wish to analyze 2000 samples at a time with an increment of 1000 samples. In this case, if the series starts at 0 and has a Δt of 2, 8 iterations are performed at time ranges of 0-4000, 2000-6000, 4000-8000, and so forth, through 16,000-20,000. The program will calculate as many as 100 iterations.
➢ There are 2 output files. The first contains spectral density at every frequency for all iterations, similar to the non-iterative output. The spectral density column title identifies a given iteration by its midpoint time value. The second file contains spectral density and percentage of spectral density within the bandwidth for each user-provided period. These values are listed for each iteration.

File Menu:

Open Data File… Ctrl+D: This displays a dialog box to select the input file, which must be a single data column. Once it is chosen, the *Spectral Data File* dialog box (explained below) is displayed. Next, the *Spectral Input Parameters* dialog box (also explained below) displays the necessary analysis parameters.

Input Parameters… Ctrl+I: This menu item opens the *Spectral Input Parameters* dialog box (explained below). This dialog box may be viewed at any time to change the spectral analysis parameter settings.

Output Spectral Data… Ctrl+O: Use this menu item to write the spectral analysis output to a tab-delimited text file. A dialog box appears, allowing the user to name and save the file to disk. In the iterative mode, two output files are created. Note that the user is able to skip the second file, if desired, by canceling the second output file's dialog box. The first file will still be created.

Spectral Data File dialog box from Open Data File menu item:
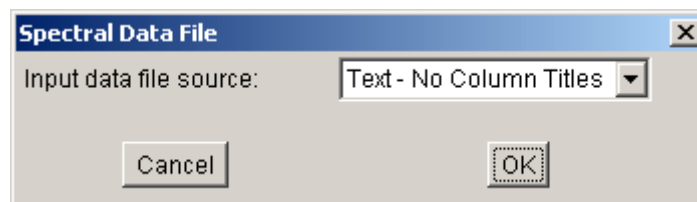
Input data file source:
  Text – Column Titles: The input file must be a tab-delimited text file with column titles on the first line.
  Text – No Column Titles: The input file must be a tab-delimited text file without column titles.

When the **OK** button is clicked, the *Spectral Input Parameters* dialog box (explained below) is displayed.

Spectral Input Parameters dialog box from Open Data File or Input Parameters:

Function choice:
    Autocorrelation: This function is simply each autocovariance value divided by the initial autocovariance value (which is the variance of the detrended time series). Autocovariance is explained below.

    Autocovariance: The biased autocovariance function is defined as $C_k = \dfrac{1}{n}\sum\limits_{i=1}^{n-k} X_i X_{i+k}$ where X is the

detrended input series, n is the series length and k is the total number of lags. The initial value equals the variance of the detrended input time series, which has a mean of zero.

Detrend option:
    Subtract Mean Only: Subtract the mean from all input data values. The mean of the new series is zero.
    Full Linear Detrend: Remove any linear trend in the data by calculating residuals from a linear regression. The mean is also subtracted, so the mean of the new series is zero.

Confidence level: Choose either 80% or 95% for the confidence interval level of the spectral analysis.

Pre-whitening: This option emphasizes high frequency over low. It's useful if a dominant low-frequency peak needs to be suppressed. Choose a positive constant, C. The pre-whitened series is $W_i = X_{i+1} - CX_i$, where X is the input series of length n. The new series W will be length n-1. Skip this feature by entering 0.

Number of frequencies: The number of frequencies calculated is usually 101. The maximum is 1000.

Starting frequency: Enter the starting frequency, usually 0, for the spectral analysis.

Final frequency: This is the last frequency to be calculated for the analysis. The highest frequency that can be resolved is the Nyquist frequency (1/2Δt).

Delta-t: Enter the sample interval (Δt) of the time series data. The input series must have a constant Δt.

Number of lags: Enter the number of lags. Bandwidth is inversely related to the lag value. Lagging at a higher percent of the series length results in higher frequency resolution, but greater sampling error for spectral estimates. Try lagging around 1/3 the time series length, then increase or decrease the lag value as needed.

The following four dialog box choices are only available when the using the iterative mode:

Iterative start time: Enter the starting time of the input data series. This value is used to keep track of the time range per iteration. It does not skip data values at the start of the time series.

Samples per iteration: Enter the number of samples per iteration. The maximum is 30000.

Sample increment: Each iterative analysis increments further into the data by the number of samples entered for this value. In the iterative feature explanation above, the value used in the example was 1000.

Periods (four or fewer): Enter as many as 4 periods in descending order. Enter 0 to skip one or more periods. Spectral density and percentage of spectral density within the bandwidth is provided for each period in the second iterative output file. If 0 is entered for all 4 periods, then the second output file will be omitted.

Click the **Run** button to perform the spectral analysis. This activates all choices in the **Graphs** menu, as well as the **Output Spectral Data** choice in the **File** menu.

Graphs Menu:

Plot Input Time Series… Ctrl+1: This plots the input series after detrending and pre-whitening. The x-axis is in time units. It defaults to a start time of 0. If that is not the case, simply change the x-axis minimum.

Plot Linear-Linear… Ctrl+2: This plots frequency and period on a linear x-axis versus spectral density on a linear y-axis.

Plot Log-Log… Ctrl+3: This plots frequency and period on a log x-axis versus spectral density on a log y-axis.

Plot Linear-Log… Ctrl+4: This plots frequency and period on a linear x-axis versus spectral density on a log y-axis.

Plot Freq x Spec Den… Ctrl+5: This plots frequency and period on a log x-axis versus frequency multiplied by spectral density on a linear y-axis.

Save Graph/Printer Options… Ctrl+S: This option offers a full print dialog box, giving the user the ability to save the plot as a PDF, switch printers and change other properties. To save the graph as a PDF, choose a PDF writer from the dropdown list in the *Print* dialog box and proceed as if printing. At that point, the next dialog box allows the user to save the PDF to disk. Refer to section 6 in ReadMe.pdf for more information on obtaining a PDF writer.

Print Graph Ctrl+P: This menu item prints the plot, in landscape mode, to the default printer. No print dialog box is displayed. The graph is sent directly to the printer in the background without prompting the user.

Plot Options dialog box from any of the five plot menu items above:

Data Markers:
>   **Show**: A plus sign (+) marks each data point on the plot.
>   **Hide**: No data points are marked. A smooth curve is plotted.

X-Axis and **Y-Axis Min** and **Max:** Change the defaults to view different axis ranges.

Plot Title: Enter a title to describe the plot.

Iterative Menu:

Iterative Mode Ctrl+M: Check this item to activate the iterative mode. This feature allows examination of spectral density changes over time by performing a series of analyses on subsets of the input file. The default mode, a standard single spectral analysis on the entire input file, is performed when this item is not checked.

Plot Next Iteration Ctrl+N: Use this menu item to plot the next analysis when the program is in the iterative mode. This option only becomes available after one of the five plots is chosen in the **Graphs** menu.

Plot Previous Iteration Ctrl+B: Use this item to view the previous analysis when in the iterative mode.

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