ESS 265
Introduction to Mx and Dynamic Spectral Analysis

C.T. Russell

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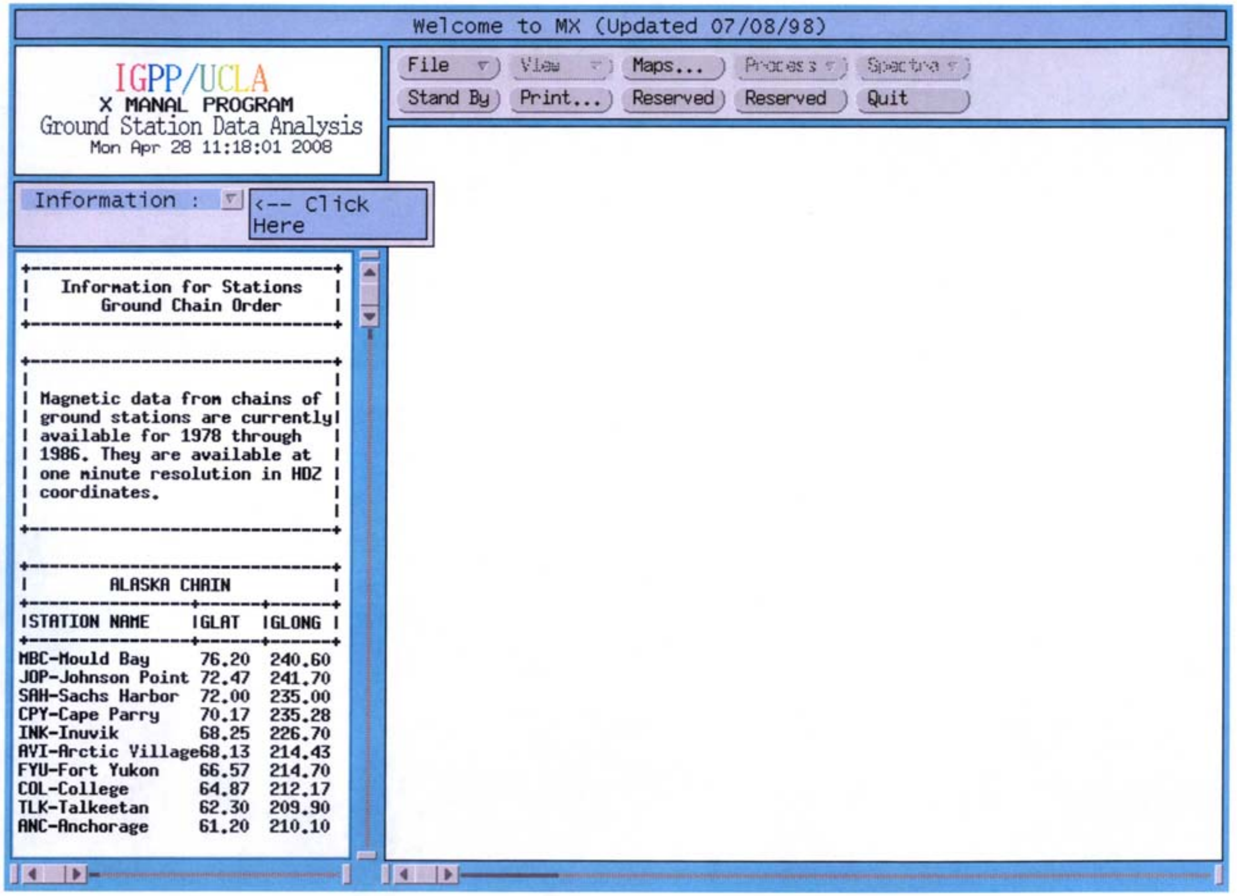
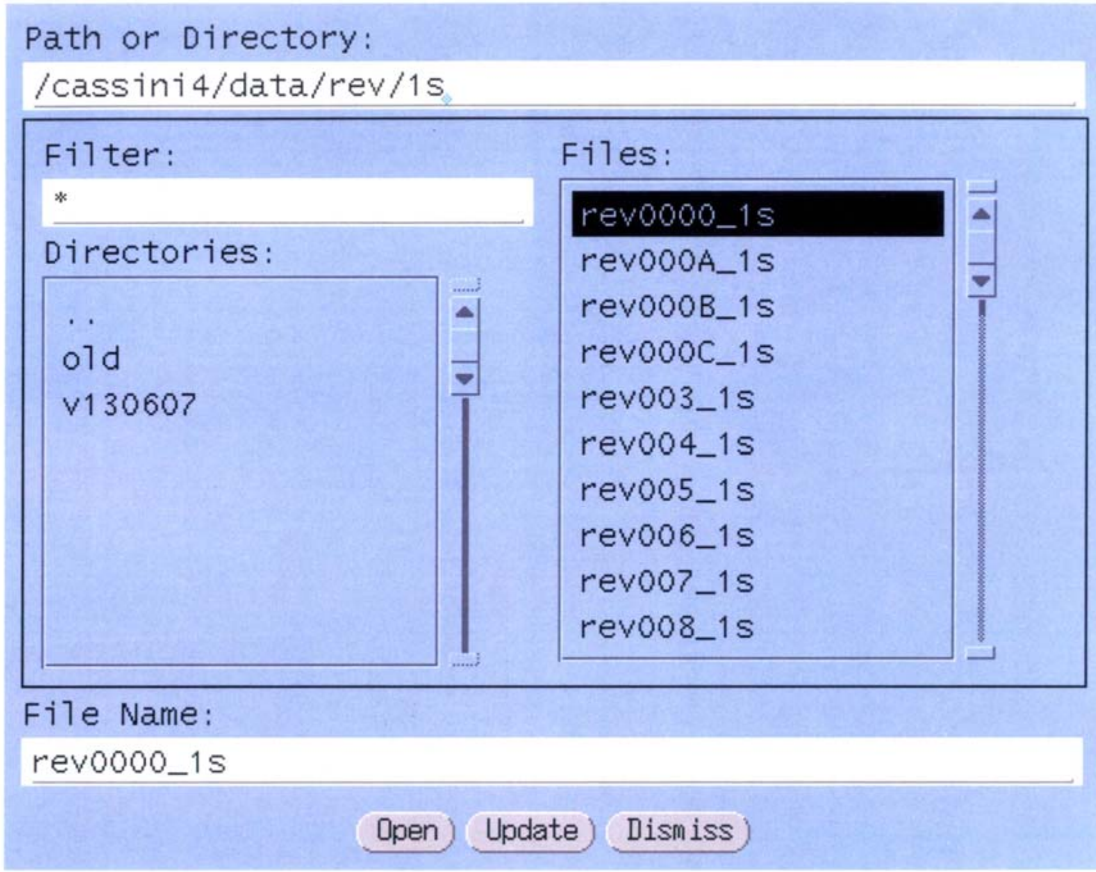
Mx – Dynamic Spectral Analysis



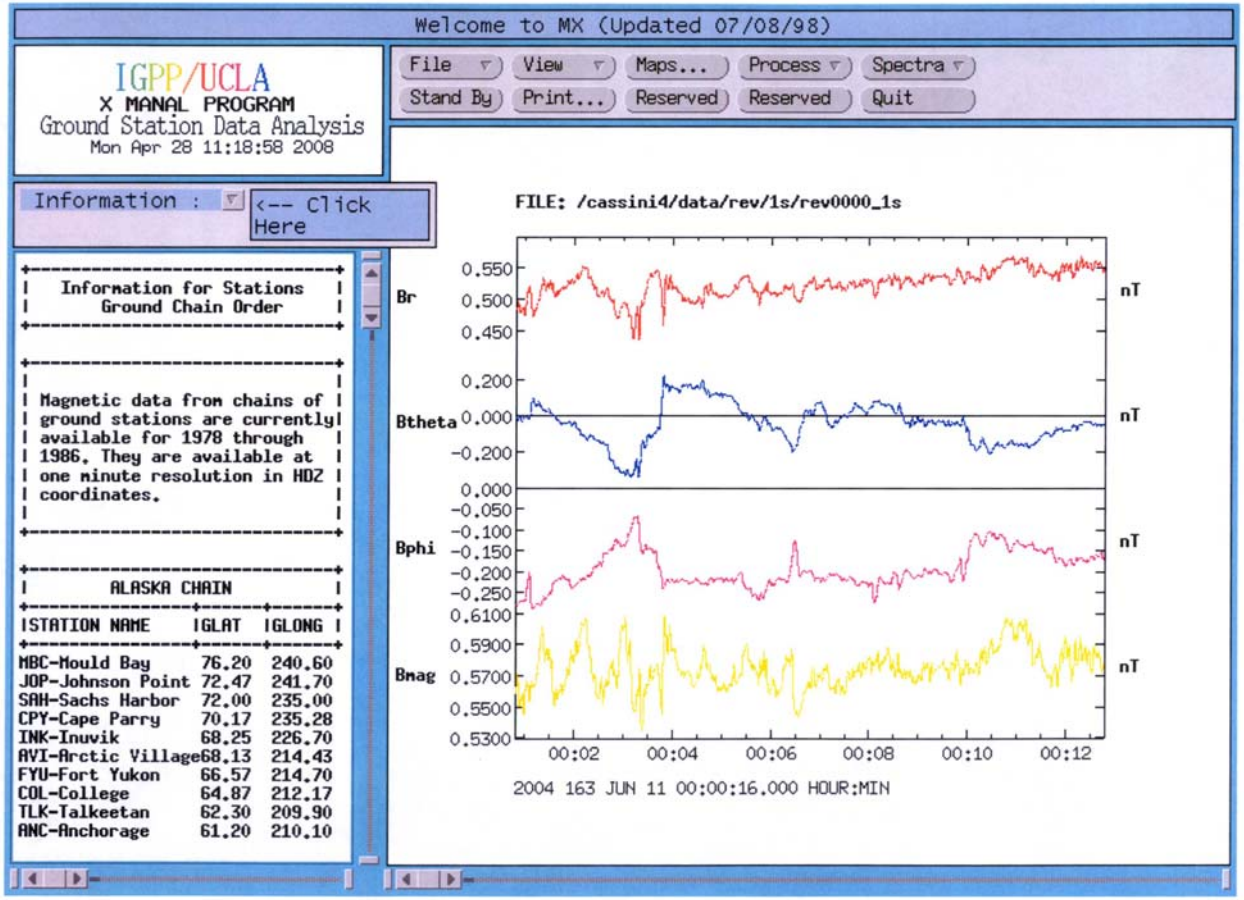
- Mx is designed to examine multiple magnetic field data sets.
- It combines capabilities for studying ground-based arrays and for studying dynamic spectra of varying wave properties.
- First, we need to obtain a file of data to analyze.

Data Files



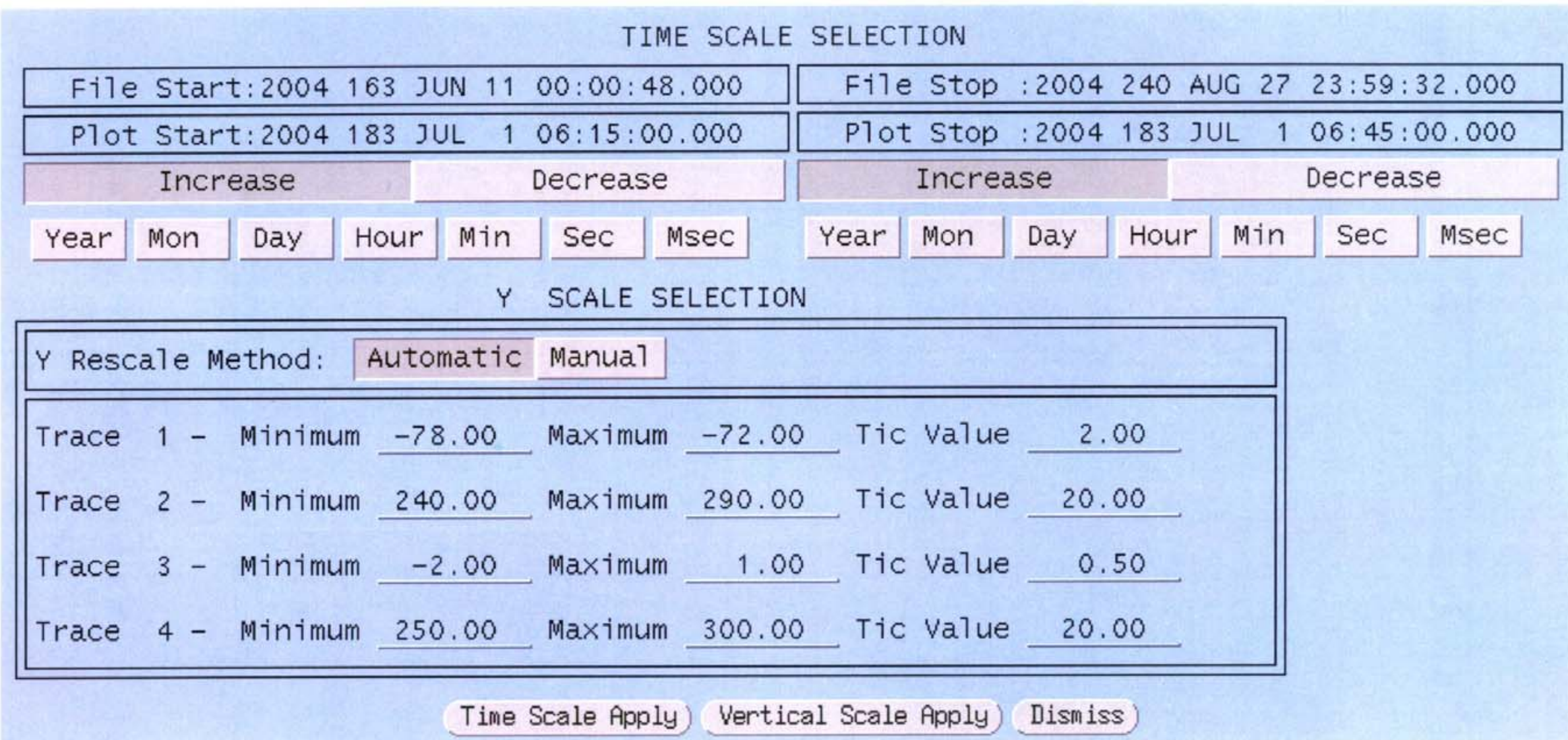
- For this exercise, we examine a file of Cassini magnetometer data from the initial passage of Cassini through the Saturn magnetosphere. These data were acquired just hours after Cassini fired its engine.
- The data are on the cassini4 disk in the data directory of full rev files at 1s resolution.

Initial Data View



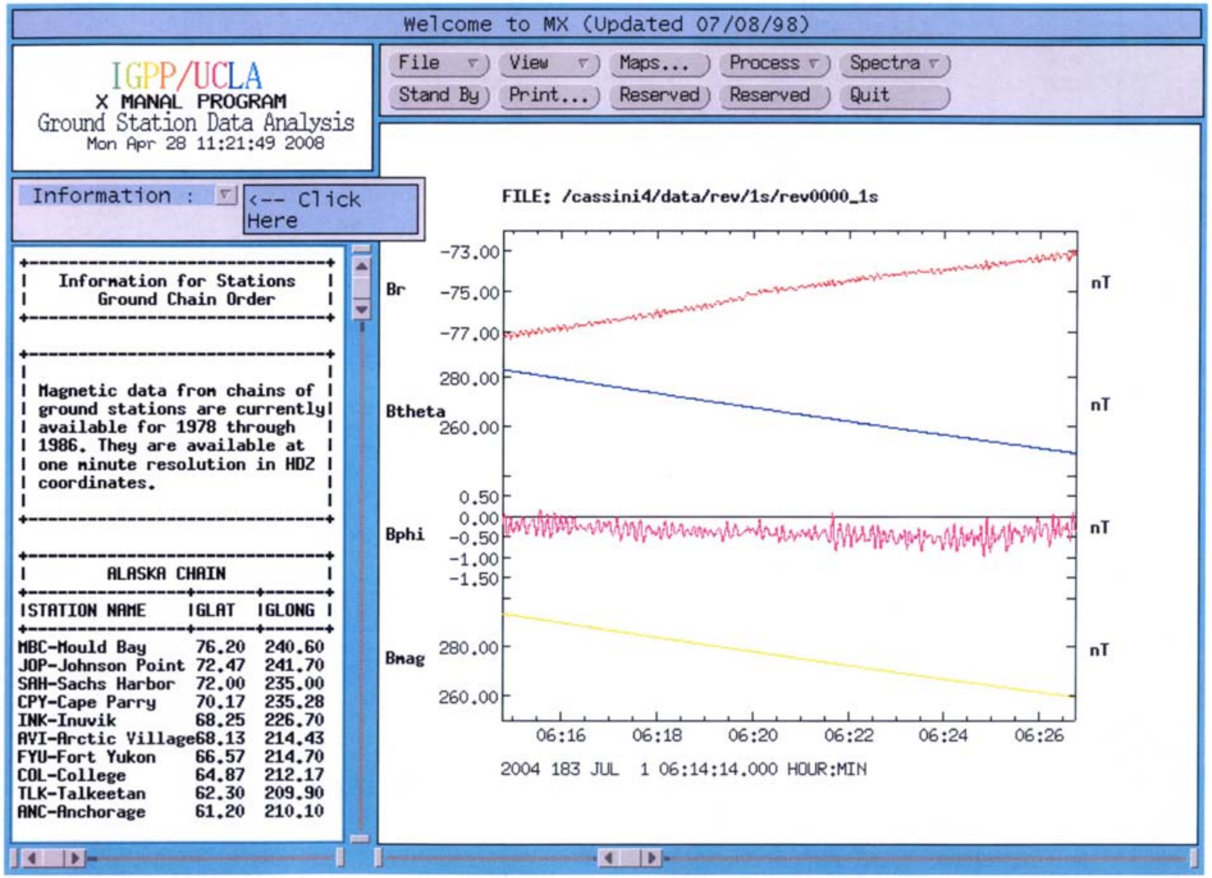
- The program shows the first data in the file. Use the slider bar to reach approximately the part of the file you wish to examine.
- Then use the View pull-down menu and the second option to do fine-scale positioning.

Time Selection



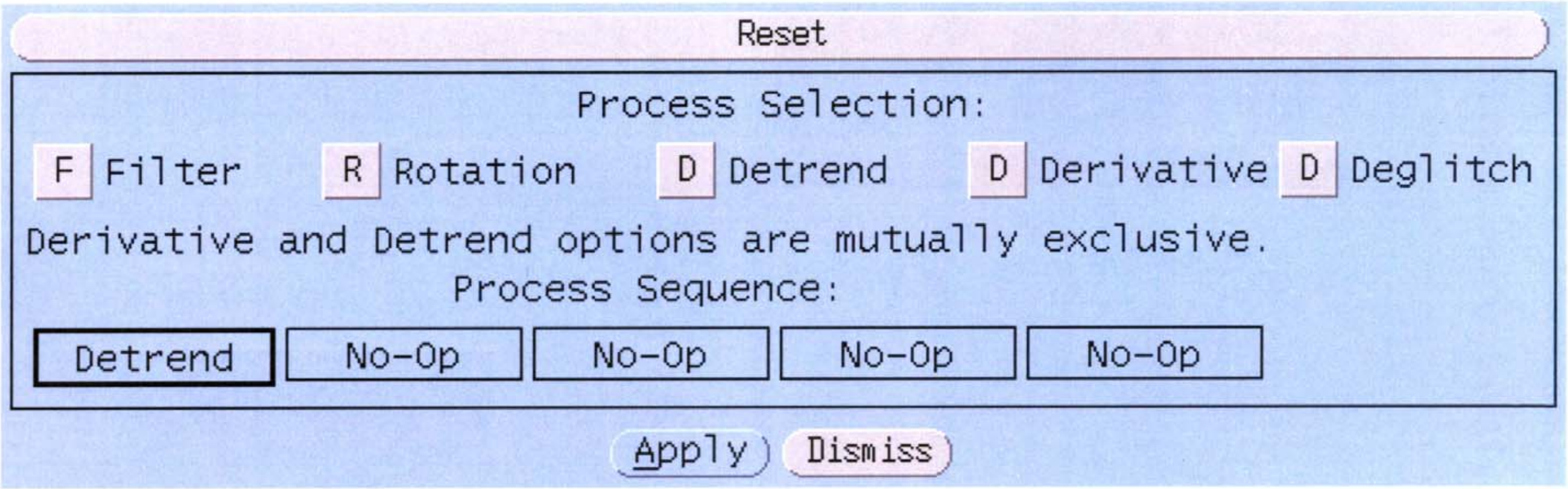
- Use the Increase and Decrease buttons to move the time series forward or backward.
- The time units can be clicked repeatedly to step through the data.
- The lower part of the box can be used to adjust the plots vertically.

Detrending Data



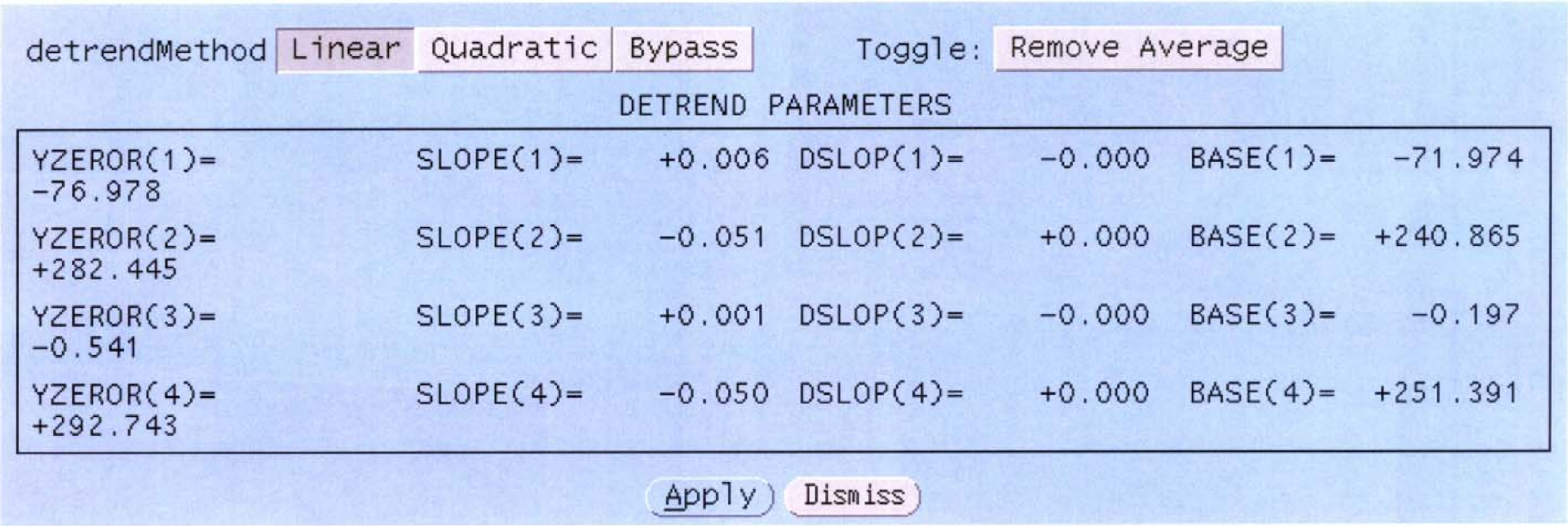
- Often, the motion of the spacecraft through a planetary magnetosphere creates a trend that will add power to a spectrum that is not really present.
- This occurs because Fourier analysis assumes that the signal repeats forever both before and after the period in question. This turns a smooth line into a saw tooth.
- Detrending removes the smooth variation, leaving only the waves.

Detrending Continued



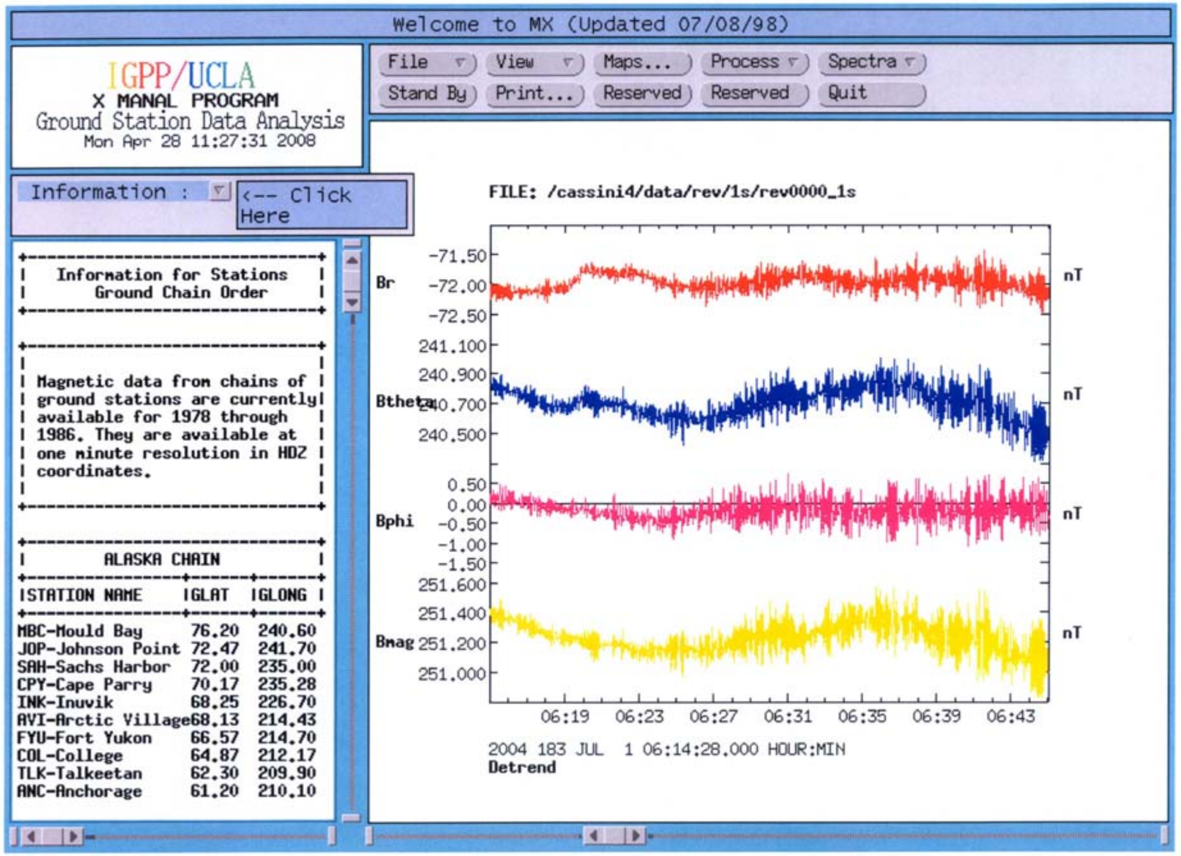
- Select the Process option and click on Detrend. Then press Apply.
- You then have options on how you wish you detrend.

Detrending Concluded



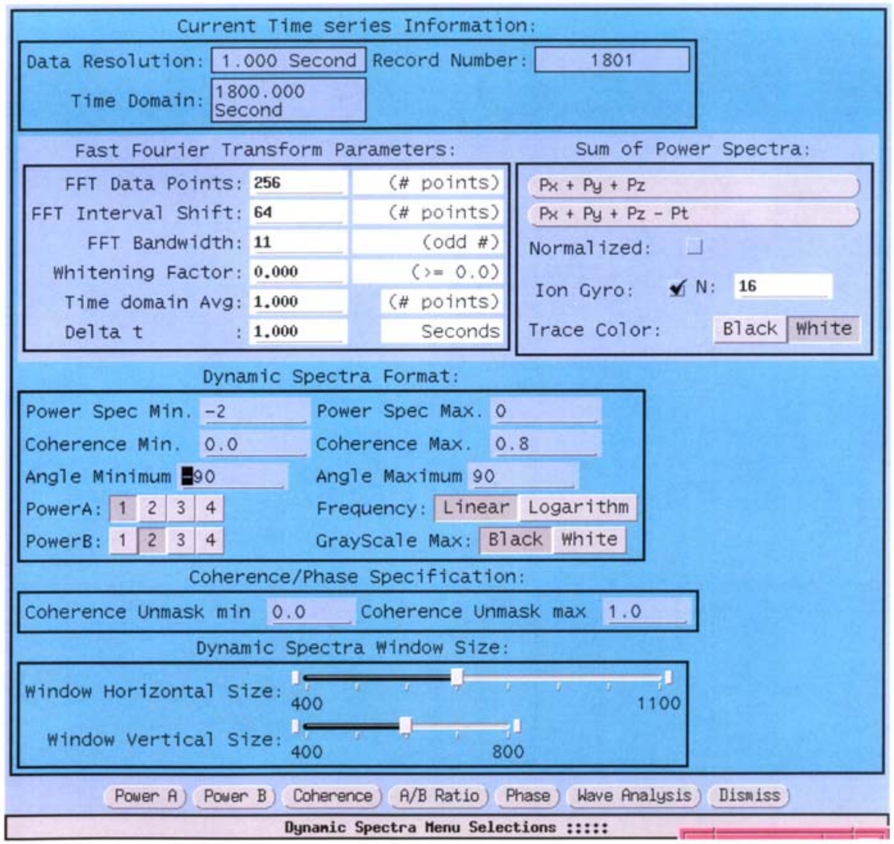
- A sufficiently short interval can be detrended linearly, but if the spacecraft goes far during the analysis interval, the data may need to be detrended quadratically.
- If you are going to relate the analysis to the background magnetic field, say to find left-hand and right-hand waves, then you do not wish to remove the average field value.

Dynamic Spectral Analysis



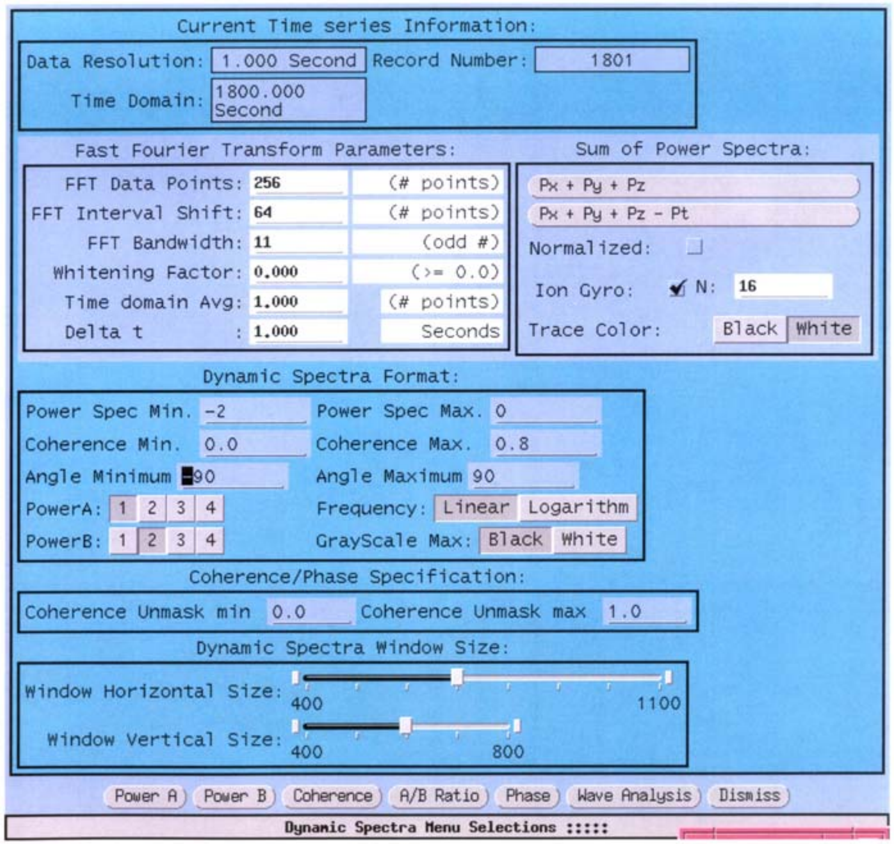
- Dynamic spectra are used to follow temporal changes in a signal, for example, the change in frequency of waves at different radial distance, or amplitude changes or directional changes, etc.
- We proceed by slicing the time series into short segments of time and calculating Fast Fourier Transforms over these segments, move a fraction of the length of the segment and repeat and repeat until one reaches the end of the time interval.

Control of the Dynamic Spectral Analysis



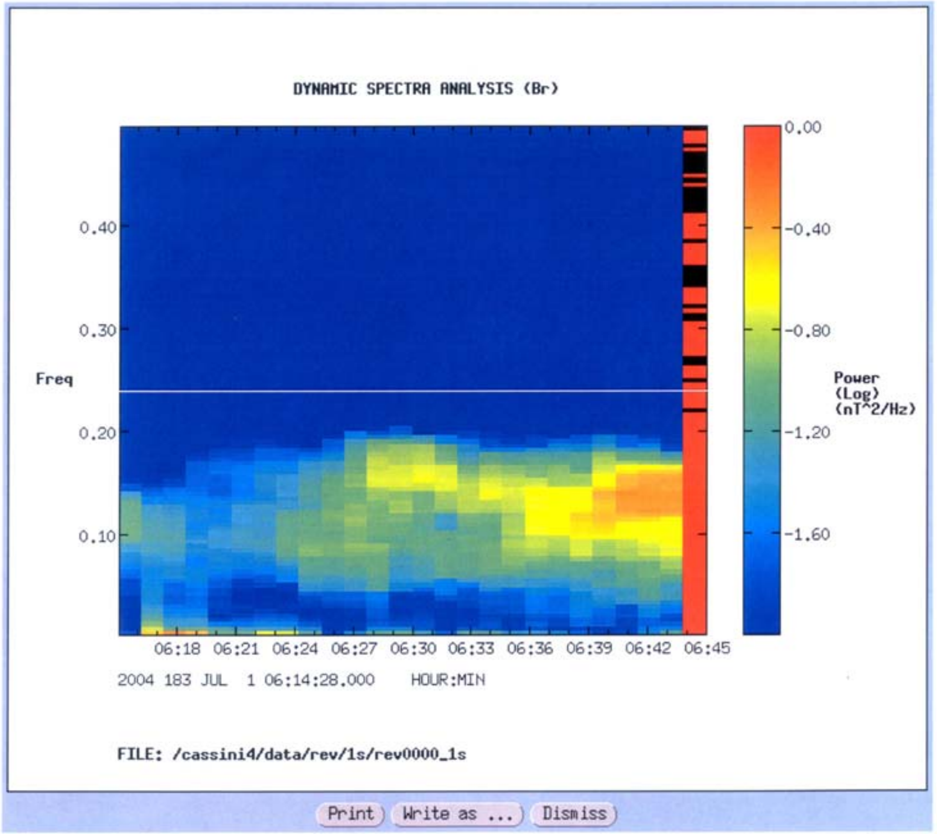
- After selecting the Dynamic Spectra option, the program allows you to adjust its default settings.
- The number of points in each spectrum, say 256, determines the frequency range of the analysis and the frequency resolution. The shift determines the pixel size of the analysis segments. This smoothes the results in time.
- The bandwidth smoothes in the frequency direction.

Control of Dynamic Spectral Analysis



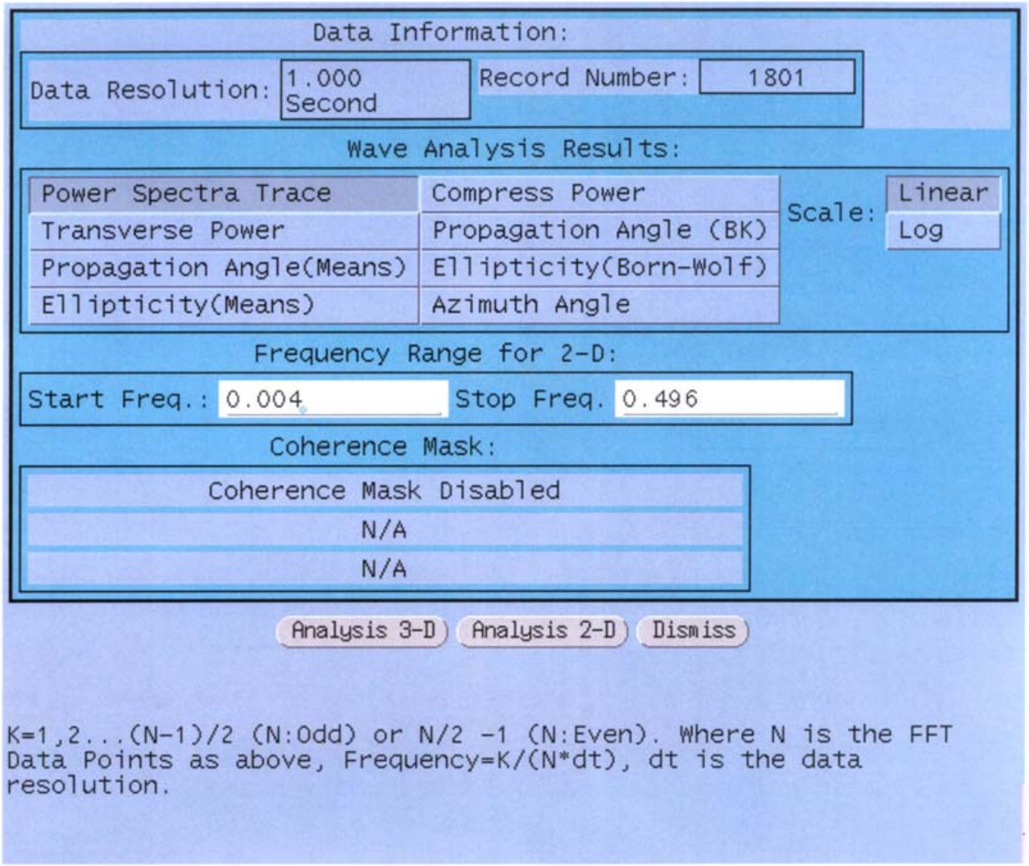
- The format box gives you control of the ranges of the color plot and what you are analyzing. You can Fourier analyze the first four quantities in your file.
- You can calculate the power in any of the four time series or the coherence between any two time series or the phase or the ratio of the power. These could be used for finding the resonant frequency of magnetospheric field lines in ground-based records, for example.

Dynamic Spectra



- Linear and logarithmic frequency axes are both available.
- You can draw a line at a frequency equal to the gyrofrequency of an ion. If you detrend the field, the gyrofrequency will be detrended, too.
- Sometimes artifacts appear in the last spectrum.
- This analysis is good for one or two component waves, but for three components, we need to use “wave analysis.”

Three-Dimensional Analysis



- In the bx program, you may select a frequency range and find the in-phase and quadrature phase cross spectral matrices. From this, you can do minimum variance analysis and get the direction of minimum variance. You can also get the propagation direction and ellipticity from the quaspectrum.
- The program also allows the user to block out (mask) the spectrum when the coherence between any two parameters is low.