Tutorial 2: Atmospheric CO_2 vs. global temperature

Tutorial 2 teaches basic and advanced spectrum estimation using J-DSP/ESE while analyzing "near-time" Earth signals of great societal importance. This tutorial analyzes coherency between twentieth century CO_2 and global surface temperature time series, and demonstrates that a global temperature increase results in decreased CO_2 uptake by the ocean, and a (temporary) rise of CO_2 in the atmosphere. This exchange occurs over a frequency band that is closely associated with the El Niño-Southern Oscillation (ENSO). Further discussion appears in Ramamurthy et al. (Journal of Geoscience Education, August, 2014).

Step 1: Set up the blocks as shown in Figure 1. In the upper row, *E. Signal Read a* loads global temperature data (less seasonal component). In the lower row, *Signal Read b* loads CO_2 data (less seasonal component). The data may be plotted as in Figure 2 and Figure 3.

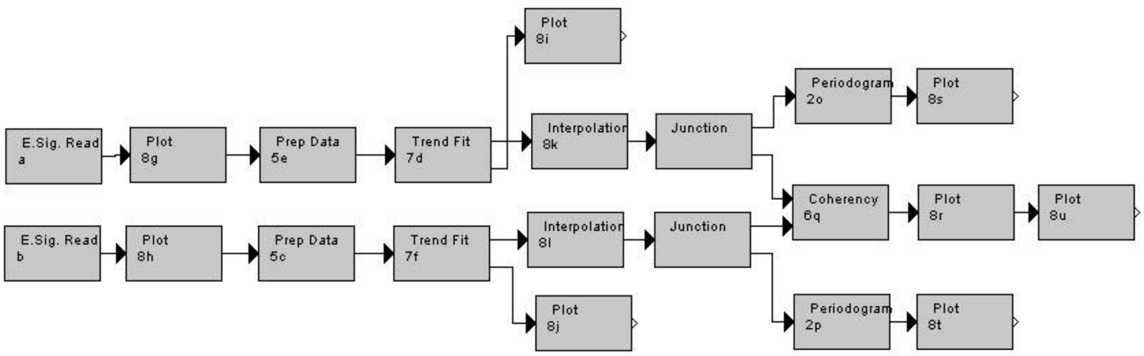
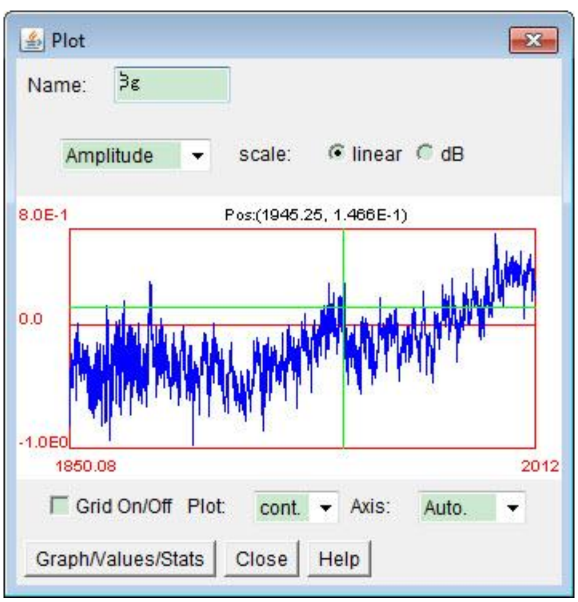


Figure 1. Block diagram for **Tutorial 2**



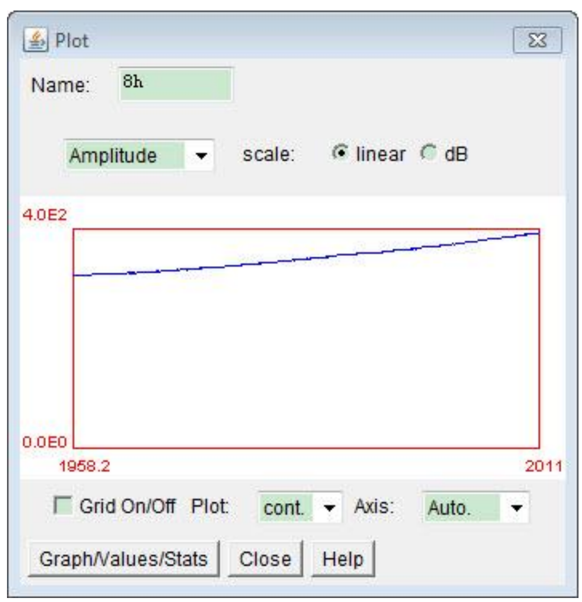


Figure 2. Global temperature time series data (less seasonal component)

Figure 3. CO_2 time series data (less seasonal component)

Interval 1: 1958.2 to 1988.0

Step 2: Use *Prep Data* block to restrict the data to the interval 1958.2-1988.0. In *Trend Fit* use weighted trend to get fitted trend for the data; set the smoothing parameter to 0.25 (25%); these functions are shown in Figure 4 and Figure 5. The fitted trends are plotted in Figure 6 and Figure 7.

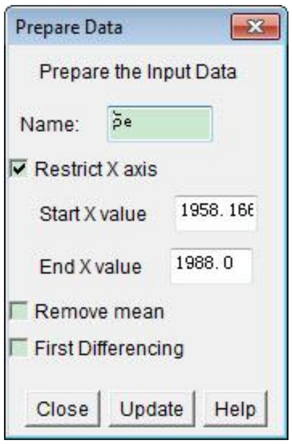


Figure 4. *Prep Data* parameters

Figure 5. *Trend Fit* parameters

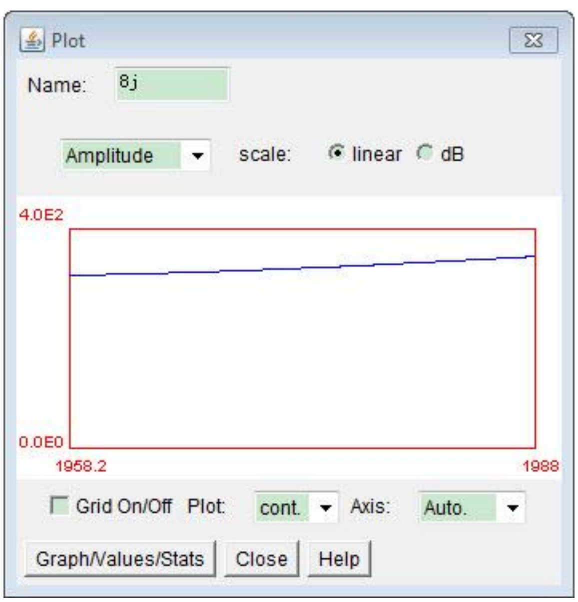


Figure 6. 25% weighted average trend of CO_2

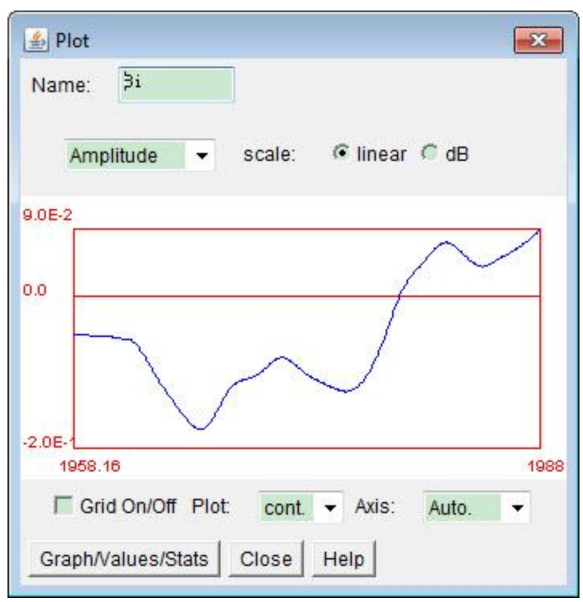


Figure 7. 25% weighted average trend of global temperature

Step 3: Use *Interpolation* to resample the data; set sampling interval to 0.05 (Figure 8).

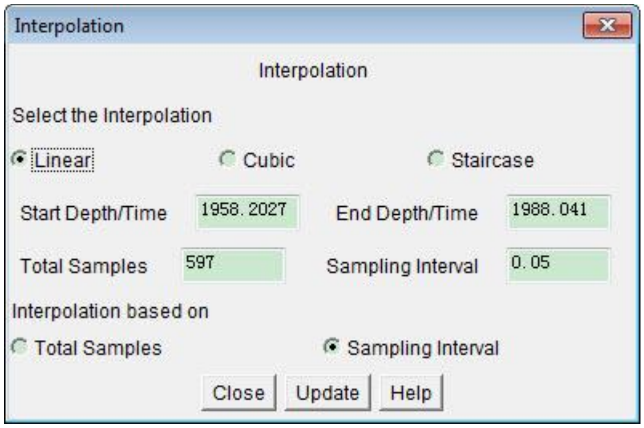


Figure 8. *Interpolation* parameters

Step 4: Use *Periodogram* to estimate the power spectra of the two data sets (Figure 9) and plot the power spectra (Figures 10 and 11).

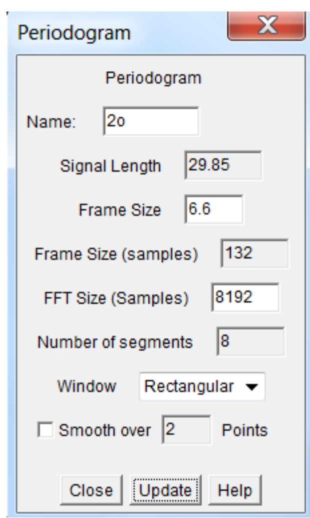


Figure 9. *Periodogram* parameters

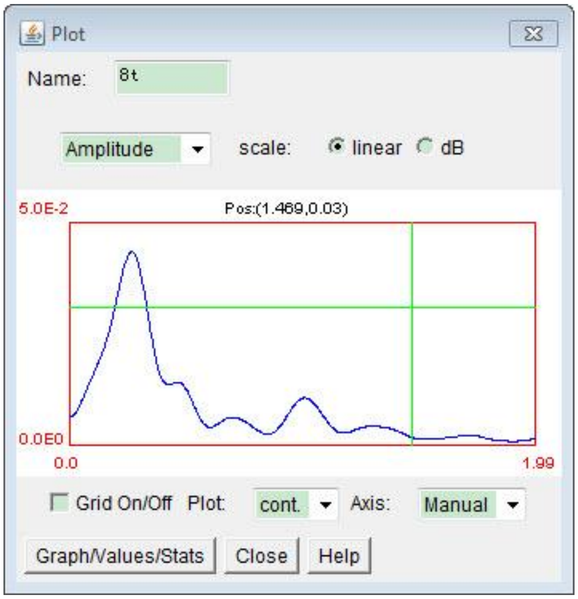


Figure 10. CO_2 power spectrum

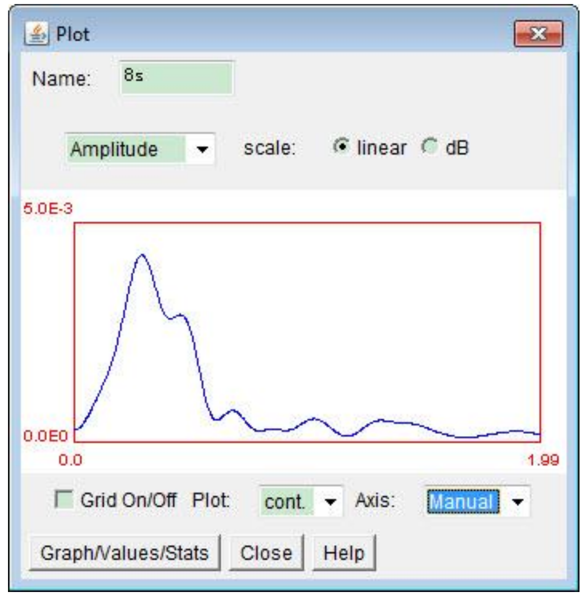


Figure 11. Temperature power spectrum

Step 5: Use *Coherency* (Figure 12) to estimate and plot coherency and cross-phase spectra (Figures 13 and 14). The first block that is selected (global temperature record) will record positive phase if delayed relative to the second block (CO_2 record).

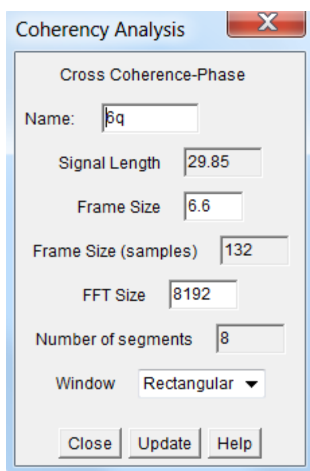


Figure 12. *Coherency* parameters

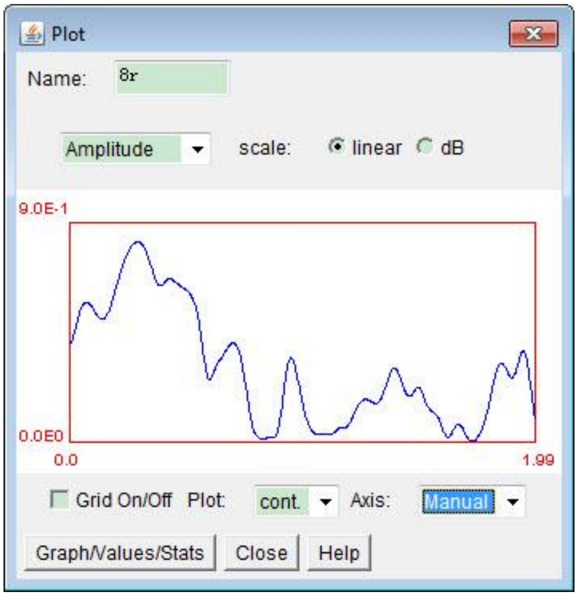


Figure 13. Coherency spectrum.

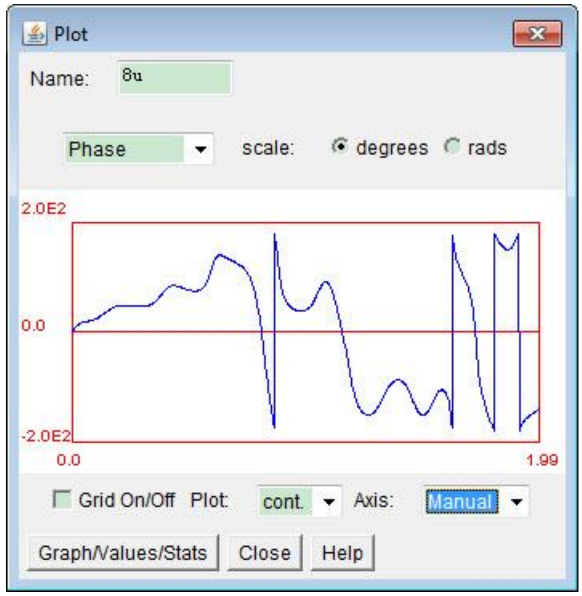


Figure 14. Cross-phase spectrum.

Interval 2: 1981.0 to 2011.8

Step 6. Use *Prep Data* to change the interval to 1981.0-2011.8 (Figure 15). Repeat steps 2 to 5. The corresponding outputs are given in Figures 16 to 26.

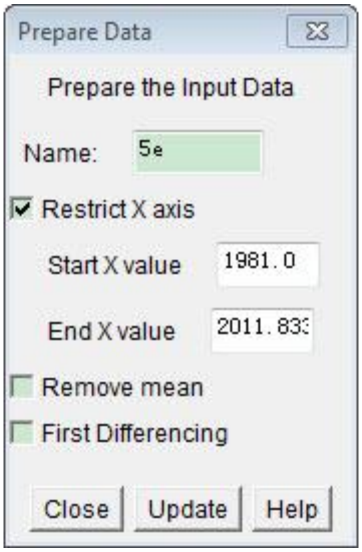


Figure 15. *Prep Data* parameters

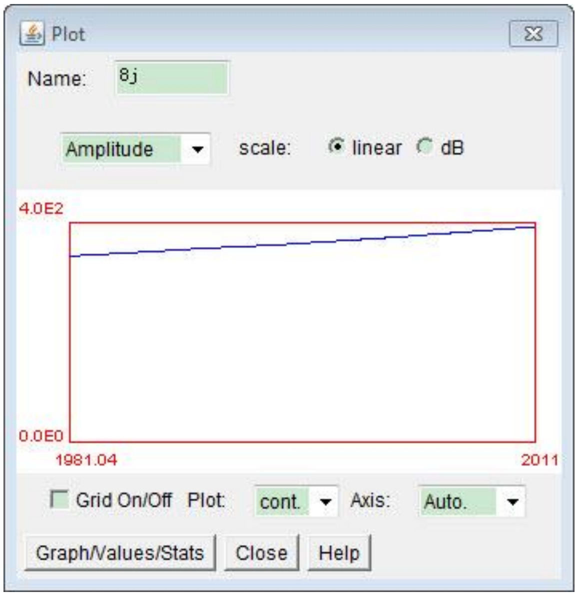


Figure 16. 25% weighted average trend of CO_2

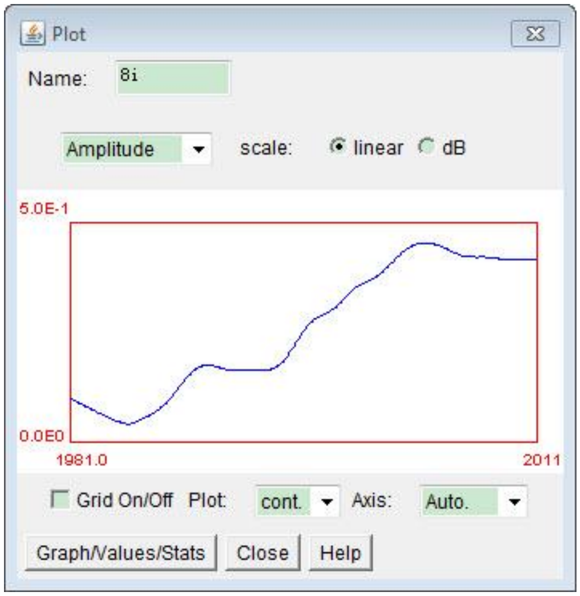


Figure 17. 25% weighted trend of global temperature.

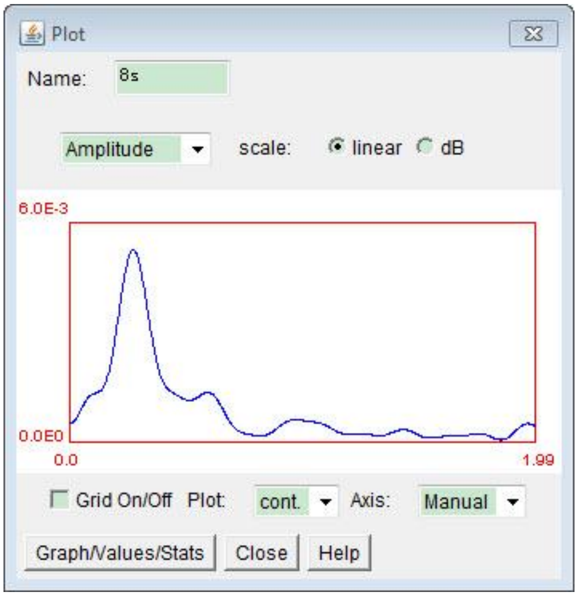


Figure 18. Global temperature power spectrum

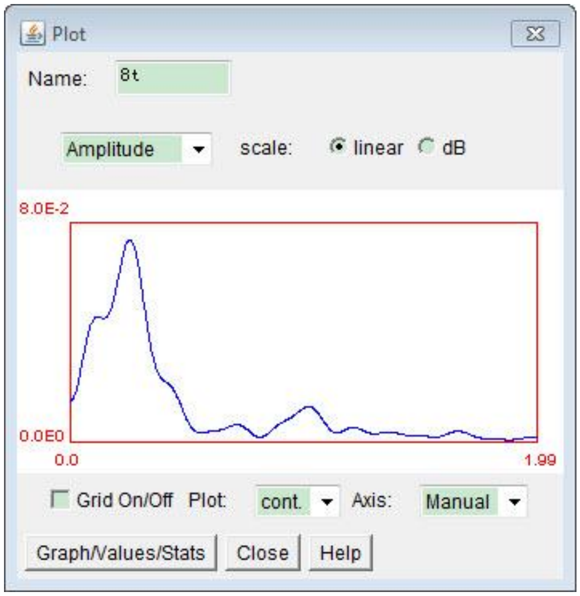


Figure 19. CO_2 power spectrum

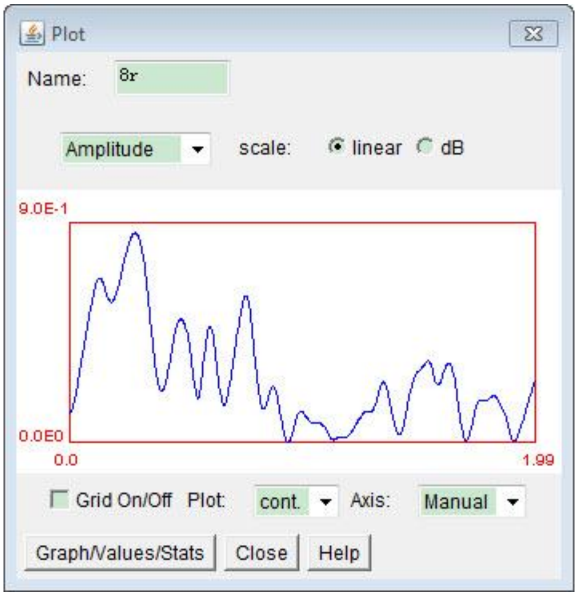


Figure 20. Coherency spectrum.

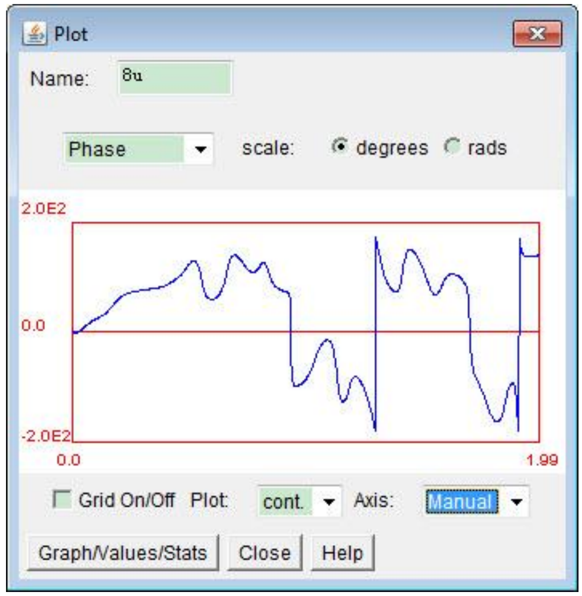


Figure 21. Cross-phase spectrum