

## Problems Week 7

*Due Wednesday, November 25, 2020*

For this set of problems, we'll consider ocean temperatures from the Ocean Station Papa mooring at 50.1°N, 144.9°W in the Pacific Ocean. Use hourly data from June 1, 2009 through May 31, 2017. You can download the data here:

<https://www.pmel.noaa.gov/ocs/data/disdcl/index.html>

or I'll put a copy in Canvas (in the Lecture 12 folder). The goals of this exercise are to show that you can compute spectra of real data using three different approaches and interpret the results.

1. **Inspect the data.** Retrieve the data, plot time series of sea surface temperature (identified as 'T\_25'), with appropriately labeled axes. Be sure to check for values that might be flagged as bad data and treat them as NaN. Are there gaps in the data? (If so, replace missing values (NaN) by interpolating across the gaps. (In Matlab, you can use 'interp1' to do this fairly efficiently.) What do you notice about the data?
2. **Compute a spectrum for the SST.** Use the Welch's overlapping segment method that we discussed in class to compute the spectra. Please follow the "best" practices that we have discussed and explain your approach. Be sure to do the following:
  - a Verify Parseval's theorem.
  - b Be attentive in labeling your x axis.
  - c Be attentive in labeling your y axis.
  - d Provide an uncertainty estimate.
  - e Compute the Nyquist frequency.
  - f Identify the frequency resolution.
  - g Identify and discuss the spectral peaks.
  - h Ignoring spectral peaks, roughly what is the spectral slope?
3. **Compute a spectrum by Fourier transforming the full record and averaging/filtering in the frequency domain.** Use the Daniell filter approach, by Fourier transforming to compute the periodogram, computing spectral amplitudes (just as you would for segments) and then filtering in frequency. (You can use a boxcar filter, in which case degrees of freedom are just two times the number of frequencies that you average.) Do the results differ?
4. **Compute a spectrum using the autocovariance approach.**
  - a Compute the autocovariances of the data. You might want to remove the annual cycle (or choose an analysis approach that suppresses the annual cycle), as it will dominate the autocovariance. (But you can obtain spectra even if you don't think about the annual cycle.) You can segment the data before computing the autocovariance, or work from the full record. (In what ways does it make a difference?)

- b Choose a window width over which to compute the spectra. Decide if you will apply a window to the data, and explain your decision.
- c Fourier transform the windowed auto-covariances and plot the resulting spectra.
- d Estimate the degrees of freedom. Add error bars to your spectra.
- e Comment on differences and similarities between the spectra computed using the three approaches.