MEK4350, fall 2014
Exercises 8

Power laws for ocean surface waves

Read the paper by Phillips (1958) availble for download from the course web page.

Problem 1

Suppose the sea surface can be differentiated n times with respect to space before a Dirac delta function appears. Derive the expected power law for the frequency spectrum $S(\omega) \propto \omega^{3-4n}$ assuming gravity waves on deep water, which have dispersion relation $\omega^2 = gk$.

Hint: Remember that the sea surface has two horizontal dimensions, thus the wave vector is $\boldsymbol{k} = (k_x, k_y)$ and the wavenumber is $k = |\boldsymbol{k}|$.

Check that the paper by Phillips (1958) discusses the special case $n = 2$.

Problem 2

Take the Fourier transforms of the two time series that can be downloaded from the course web page. Plot the spectrum with `loglog` scales. Check the power law for the frequency spectra.

Hint: Can you show that the Draupner time series seems to come from a continuous surface with sharp edges, while the Spanish time series seems to come from a smoother sea surface? This probably makes a lot of sense, since the Draupner series was measured in storm conditions, while the Spanish series was measured in swell conditions.