1 Instructions

Please save your code for the following exercises as an m-file or Jupyter Notebook file and email the file to me (at `m3becker@ucsd.edu`). Download a file called `lab7start.m` (at `http://topex.ucsd.edu/rs/labs2019/lab7/lab7start.m`), which includes some lines of MATLAB code to get you started. Please be sure to provide an answer for each and every component of each exercise!

2 Exercise: Radar Altimetry Waveform

A radar altimeter emits a short pulse that is reflected by a surface—which here we will say is the ocean surface—and returns to the antenna. The recorded power is the convolution of the outgoing pulse with the ocean surface height distribution (i.e., waves), which is well approximated by a Gaussian function. The form of the return power is an error function, which is the integral of a Gaussian function. A simple model for the expected power versus time is

$$M(t, t_0, \sigma, A) = A\left[1 + \operatorname{erf}\left(\frac{t - t_0}{\sqrt{2}\sigma}\right)\right], \tag{2.1}$$

where t is the time since the pulse was transmitted, t_0 is the arrival time of the half-power point, σ is the rise time parameter, and A is the amplitude of the returned waveform. Since the pulse travels from the satellite to the ocean surface and back again, the altitude of the satellite is

$$r = \frac{ct_0}{2}, \tag{2.2}$$

where c is the speed of light.

1) The file `waveforms.dat` (which can be downloaded at `http://topex.ucsd.edu/rs/labs2019/lab7/files/waveforms.dat`) is a file of 20 waveforms collected by the radar altimeter aboard the ERS-1 satellite. The first column of the file is the time (in nanoseconds) since the altimeter started recording (5.3×10^{-3} seconds). The second column is the recorded power. Load the data and plot these waveforms as points.

2) Generate a model waveform from the function given above and plot it over the waveform data. Estimate the three unknown parameters A, t_0 , and σ. What is the altitude of the satellite in meters? What is the standard deviation of the ocean wave height in meters? In addition to the class lecture slides, you can use the additional notes on the interaction between radar pulses and the ocean found here: `http://topex.ucsd.edu/rs/altimetry.pdf`.

3 Exercise: Using Altimetry Data

Durmid Hill is a small uplifted region of the mostly-below-sea-level Imperial Valley. Until about 300 years ago, the entire Imperial Valley was flooded under a freshwater lake called Lake Cahuilla, and Durmid Hill was just high enough to be an island. When the lake was no longer being fed by river water, it slowly dried up over 50 years, leaving annual (i.e., one per year) recessional terraces around Durmid Hill that look a little like bathtub rings. By measuring the elevation of successive terraces, we can estimate the recession rate of the lake.

3) Go to `http://topex.ucsd.edu/rs/labs2019/lab7/files` and download the files `DurmidHill.kmz` and `durmid.dat` (or `durmid.mat` for Python users). Open the `kmz` file in Google Earth and get a feel for the regional context of Durmid Hill and Lake Cahuilla. Can you see the recessional terraces around Durmid Hill in the shaded altimetry? Can you see them in the Google Earth imagery?

4) Load the topography data and look at it with `imagesc()` in MATLAB or Matplotlib's `imshow()` in Jupyter Notebook. Look at a histogram of the data, specifying 1200 bins, using the `hist()` function (or a Python equivalent). (You will first need to reshape the data into a single column, as you did in Lab 6.) Can you see regularly spaced peaks? The elevation of these peaks corresponds to the elevation of the recessional terraces. Why? Identify the elevation of several of these peaks. What is the recession rate of Lake Cahuilla (i.e., how fast did the waters recede)?