EART119 - HW#2
– Plots and Animations -

This assignment focuses on creating plots and animations with matplotlib. You will visualize earthquake data and fluid injection wells in Oklahoma, an area known for its many human-induced earthquake sequences. One main piece of evidence for the induced nature of the earthquakes was that seismic activity started to accelerate significantly beyond what was observed historically. You will be able to visualize this by looking at a simple histogram of earthquake rates and different snap-shots of earthquakes and wells over time.

1. **Earthquake rates, earthquake and well locations in map-view (30 points)**
   a) Load the two data files injWell_OK.txt and seism_OK.txt using the numpy method numpy.loadtxt. Note that by default numpy loads the data as column vectors analogous to matlab. To convert this into a more standard python format you will have to transpose the data matrix.
   b) Convert the date-time columns to decimal years using:
      a. DecYear = YR + (MO-1)/12 + (DY-1)/365.25 + HR/(365.25*24) + MN/(365.25*24*60) + SC/(365.25*24*3600). You can write this into a separate function in a stand alone module so it can be used easily in future homework assignments.
   c) Determine earthquake rate. You can use the function we created in class with k=`200` or use plt.hist for which you have to create a monthly binned time vector as second input variable. Determine the cumulative number (use `np.cumsum( np.ones( N))`) of earthquakes and plot everything as a function of time on two different subplots.
   d) Plot active wells (select wells with start dates before the beginning of the current time window) and earthquakes within Δt = 6 months. Write a for loop that updates the current time window so it goes from 2005 to 2018 (take a look at np.logical_and to select events within Δt). Instead of saving each figure and creating an animation with an external software, you can simply use plt.pause(<time interval>) to create an animation at run time when your script is executed.
   e) From your analysis of earthquake rates and locations, in what year did seismicity rates start to significantly exceed historic values? When did earthquake rates start to again decrease? Can you speculate on why?

2. **Compute the surface area affected by induced seismic activity (15 points)**
   a. Use the `ginput` function to determine a polygon that encapsulates the seismically active areas.
   (`https://matplotlib.org/api/_as_gen/matplotlib.pyplot.ginput.html`)
   Use only seismicity that occurred after the date determined in 1. Save the ginput output in two vector X_i, Y_i. One way of doing this is:

   ```
   >> tCoord = plt.ginput( nPoints)
   >> X = np.array( tCoord).T[0]
   >> Y = np.array( tCoord).T[1]
   ```

   After you clicked n-times you have to close the figure for the program to continue to run.
   b. Use `matplotlib basemap` to project X_i, Y_i into an equal-distance coordinate system, see for example:
   `https://matplotlib.org/basemap/users/aea.html`
   The resulting coordinates have to be converted from meter to kilometer.
   c. Compute the total area of the region affected by induced seismicity using the previously created function `area_polygon.py.` How does that compare to the total area of Oklahoma (181,000 km ^{2})?