Assignment 4: Empirical Orthogonal Function

1. In this question, you will be conducting an EOF analysis of 5 different batches of test data. The data are located in the class folder `/ulteosrv1/s0/meteo515/data` and are called `sine_wave_data1.nc` etc. Also in this folder is the Matlab script that was used to create the data `create_sine_data.m` (in case you are interested). The goal is to explore how EOF analysis identifies patterns of variability and it's sensitivity to changes in patterns with time. Each of the toy data sets is some variation of a sine wave (in space) that is propagating in time.

1. Propagating sine wave
2. Propagating sine wave that stalls when it is either a positive or negative sine curve
3. Propagating sine wave with stalling and additional random noise
4. Propagating sine wave with stalling and increasing amplitude with time
5. Propagating sine wave with stalling and increasing frequency with time

For each of these 5 simple dataset complete the following steps:

- Animations of the data have been created and are also in the class data folder. Watch the animations so that you have a good appreciation for the variability in the data. You can also use this to ensure that you are loading in the data correctly.
- Compute the EOF of the data to obtain the principal component, eigenvectors, and eigenvalues. You are welcome to use built-in functions to do this.
- Select a subset of EOFs/principal components that you would like to retain.
- Compute and plot the standardized principal component time series for the selected principal components. Include their fraction of variance explained in the legend.
- Compute and plot the standardized principal component time series regressed onto the original data. This provides one visualization of the pattern of variability associated with the EOFs.
- Compute and plot the selected EOFs scaled by the square root of their eigenvalues. This provides a second visualization of the EOF patterns.

Include all of these figures in your final report and summarize your findings. What do these results tell you about how well the EOF method is able to capture what you know about the behavior of each of these sets of toy data. Be sure to describe the selected EOF patterns you have produced, the associated principal component time series, and both of their correspondence to the actual data. Include some discussion of the percent of explained variance you have identified. Be sure to point out any issues with the EOF analysis you have conducted.

2. Read Horton 1981 "A Rotated Principal Component Analysis of the Interannual Variability of the Northern Hemisphere 500mb Height Field". Write a brief description of what rotated principal component (EOF) analysis is, how it is conducted in general terms, why this might be useful, and what drawbacks their may be.