METR 5433 - Advanced Statistical Meteorology
Spring 2020 – Homework #4
Due: 2 April 2020

(#1) Download the following paper:

`http://ifurtado.org/wp-content/uploads/Publications/YouFurtado2017.pdf`.

This paper details a newly-identified mode of variability: the South Pacific Oscillation (SPO), a sea level pressure (SLP) dipole in the southeast Pacific Ocean, and its role in the development of El Niño events. Following the methodology in the paper, (e.g., Sections 2 and 3.1 and the caption to Figure 1), **recreate Figures 1a and 1c (blue line only) of the manuscript**. Pay special note to the treatment of the data prior to EOF analysis (see Section 2, first paragraph). The necessary files for the analysis are provided for you: **slp.mon.mean.nc**, **sst.mon.mean.nc**, **uwnd.10m.mon.mean.nc**, and **vwnd.10m.mon.mean.nc**. Note that the data files are full fields, not anomalies. Also note the domain of the plot and how this relates to the domain used for EOF analysis.

Include snippets of your code, with (brief) comments, showing the steps for the EOF analysis. Also include your two plots. For the colorbar in Fig. 1a, you can choose a different one if you want, but make sure it makes sense and has the proper units. Also, to mask the SLP and wind fields over continents, you can use the "m.fillcontinents(color='gray')", which will block out data over land (don't worry about the SLP data over land - you can ignore it for your reproduction). Finally, write a paragraph describing how well your figures match, or don't match, the figures in the paper and what could be the reason(s) for the difference.

(#2) Use maximum covariance analysis (MCA) to find the leading structures of covariability in North Pacific geopotential heights and North Pacific sea surface temperatures. For this problem, use the files **GPH500.nc** and **sst.mon.mean.nc**, which both contain monthly-mean values of the fields. Choose the period 1950 – 2010, use all months, and use the domain 15°-70°N, 80°E - 65° W for both fields.

Data Preparation:

- Remove the seasonal cycle from the data. Use 1981 – 2010 as the base period from which to compute monthly-mean anomalies.
- Linearly detrend the fields at each grid point.
- Weight each grid point by the square root of the cosine of latitude.
- Because you are working with SSTs, there will be missing / NaN values (i.e., over land). You may/will need a strategy to deal with these missing values when doing MCA.

(a) Calculate the root-mean-squared covariance (RMSC) metric discussed in class. Based on your value, should we expect to find "important" structures of covariability between the two fields?

(b) Regardless of the answer in (a), find the first three (3) modes of covariability in the fields. Present your results as the homogenous regression maps - i.e., each field regressed onto its respective expansion coefficient (EC) time series. Remember to use the unweighted anomalies and to standardize the EC time series prior for regression. Produce three plots, each of which will have four panels: (a) the regression map of the 500 hPa height anomalies; (b) the regression map of the SST anomalies; (c) the corresponding standardized EC time series for geopotential heights and (d) the corresponding EC time series for SST. Make sure to caption the plots appropriately (i.e., left vs. right field) as well as use proper plot titles, units, etc. Include the covariance explained by each mode.

(c) Write 2-3 paragraphs discussing your results, including physical interpretations of the MCA modes. Do the modes make sense from a physical perspective? Is there any periodicity you can see in the time series (qualitatively)? If you want (translation: not necessary), you may search online to discover names for the modes that come out of the MCA in either field.