**Data Excercise 3 - Exploring teleconnections in eastern Pacific (EP) and central Pacific (CP) ENSO events**

Assigned 2/20/2018

Due 3/1/2018 by 5PM

OK, in this data exercise, we’re going to calculate some ENSO indices, and then see how they affect precipitation in North America. We’ll be working in IRIDL again.

We’ll be using this [SST **anomaly** dataset](http://iridl.ldeo.columbia.edu/SOURCES/.NOAA/.NCDC/.ERSST/.version3b/.anom/) to calculate all of our ENSO indices; and we’ll be using [this precipitation dataset](http://iridl.ldeo.columbia.edu/expert/SOURCES/.UEA/.CRU/.TS3p21/.monthly/.pre/) to look at teleconnections. Also, for all of the analyses limit your data to only look from November 1960 through April 2012.

1. Let’s create our own versions of the Nino3 and Nino4 indices.
	1. Remember, these indices are just average SST anomalies over a box in the equatorial Pacific. Use google to find where those boxes should be. Use the functions *[X] average* and *[Y] average* to calculate your timeseries
	2. Let’s average over the months of the year where ENSO is best expressed, to come up with a single value for each year. Use the function: *T (Nov-Apr) seasonalAverage* to do this.
	3. Plot the timeseries for both of these indices.
	4. Compare the peak years in both plots to those in the Yeh et al., 2009 paper we read (see table from their supplementary material for event listings). Do these indices do a good job of picking out the major CP and EP events?
2. Now let’s correlate those time series with precipitation.
	1. Start with the precipitation dataset, and restrict the time range and calculate the same seasonal average you did for #1.
	2. Then copy and paste in the code for your Nino4 index.
	3. Then use the function *[T] correlate* (yep, it’s that easy).
	4. Take a look at the map… it’s a little confusing since red means more rain during El Nino. Let’s change the colorscale. Copy and paste this section below to the bottom of your code to get more meaningful colors.

 *startcolormap*

 *-0.7 0.7 RANGE*

 *SlateGrey grey SaddleBrown*

 *-1 VALUE*

 *FloralWhite*

 *0 VALUE*

 *DarkGreen*

 *1 VALUE*

 *grey endcolormap*

If you’d like to customize your colormap, go for it - just replace the color names with [others from here](https://www.w3schools.com/colors/colors_names.asp). Just make sure the colors are intuitive!

* 1. Zoom in to North America, and save the map and the color bar, for both the correlation maps (with Nino 3 and Nino 4).
	2. Describe the primary patterns for both indices - what regions are affected by ENSO events of each type? What are the differences between the CP and EP events in the US?
1. If the two maps look similar, it could be because the two indices are also very similar. Let’s test that explicitly.
	1. Load up both of your indices (The Nino3 and Nino4 indices you calculated in number 1) into expert mode.
	2. Then use the command *fig: scatter :fig* to make a scatter plot (save the scatter plot)

[When you use *fig: scatter :fig* it will take you to a new page. Go to *Options → Viewer* to get back to the page you’re used to. You can also save by clicking on the figure and hitting the download button, second from the right]

* 1. Now calculate the correlation, by deleting the scatter plot command and using the *correlate* command above.
	2. Now, correlate should just be a single value, not a map. What’s the r-value for these two series (given on the “Description” page)? What does that mean?
1. Another approach is to use EOFs to create CP and EP indices, as these two types of ENSO events are the leading modes of tropical Pacific climate variability.
	1. Start with the SST data again, for the same time range
	2. This time restrict your SSTs to the 15S-15N, 140E- 80W. **Make sure to restrict the spatial range of the SST data before you calculate the EOF.**
	3. To calculate the EOFs, use the command *{Y cosd}[X Y][T]svd*
	4. Click on the map, this will load the EOF loading maps. The 1st EOF map will be first, but you can click to the second at the top of the panel.
	5. Does the first EOF seem like a good match for CP or EP ENSO events? If so which one?
	6. Does the second EOF seem like a good match for the other? Compare it to figure 2 of Capotondi et al. 2015.
	7. Now the cool thing about EOFs, is that they also have a timeseries. Click on the “timeseries” link that’s now on the “Description” page. Now restrict the range to just the EOF (ev) of interest (1 or 2).
	8. **NOTE: Either (or both) of your EOFs may come up as cool (negative values) in the equatorial Pacific. If this happens, you should multiply it by -1 (add *-1 mul*) to make it comparable to the Nino 3 or 4 index. We want to compare *warm events* (either CP or EP type).**
	9. Now calculate the seasonal average, same as before.
	10. Make time series graphs for both of these new indices.
	11. Compare these new time series graphs with their companions that you plotted in #1. How similar/different are they?
	12. For your CP Nino index, how well does it represent the CP El Nino years?
	13. Lastly, calculate the correlation coefficient between the CP and EP EOF time series (PCs), as in 3.
	14. Speculate about what the difference in the correlation between indices using this method (relative to #3) might mean for your correlations with US precipitation.
2. OK, now repeat 2, but using the two new indices you calculated.
	1. Describe the primary patterns for both your new indices - what regions are affected by ENSO? What are the differences between the CP and EP indices (using this EOF method) in the US?
	2. Describe the differences between your the correlation maps for the two different CP Nino indices? Why are they so different? What does this mean for climate?
	3. Which indexing approach is more useful for understanding the impacts of CP El Ninos? (Both have pros and cons, so describe those pros and cons).
	4. Imagine a future where CP El Ninos become more common, and EP El Ninos less common. What do your results teach us about future water availability in the desert southwest?

**Deliverables**

**4 timeseries plots**

**4 correlation maps (and scales) of the US**

**1 scatter plot**

**Answers to the questions in purple**