AT 655: Objective Analysis in the Atmospheric Sciences
Homework 1: The impact of ENSO on surface temperature.
Due Feb. 1

Data needed: Global gridded surface temperature data; ENSO index.

Notes:
- The gridded data set includes missing values, particularly in the early part of the record. You will need to account for the missing data when calculating the global mean and all regression coefficients.

1) Global mean temperatures and ENSO

a) Calculate the time series of global mean temperature. Be sure to use cosine weighting as appropriate. Plot the resulting global mean time series alongside standardized values of the ENSO index for the period Jan 1958-Dec 2005.

For parts *b-e*, restrict the analysis to the months of December, January and February and the period January 1958-December 2005 (the resulting time series should both be length 144). Note you will need to standardize the ENSO index for the period being considered.

b) Display the scatter plot for standardized values of the ENSO index vs. global-mean temperature anomalies.

c) Calculate the correlation and regression coefficients between global mean temperature and standardized values of the ENSO index (the regression should be in units of global mean temperature). Estimate the statistical significance of the relationship.
- What fraction of the variance in global-mean temperature is explained by ENSO variability?
- Explain why the correlation coefficient does not depend on the amplitude of the ENSO index.
- Explain why the regression coefficient does depend on the amplitude of the ENSO index.
- Explain why it is useful to standardize the ENSO index before calculating the regression coefficient.

d) Using composite analysis, calculate the global mean temperature anomaly for months when the ENSO index exceeds +1 and -1 standard deviations, respectively. Estimate the statistical significance of the corresponding values.

e) Explain how the regression coefficient from c) and the composite difference from d) can be visualized using the scatter plot from b).

f) Provide a short (1-2 paragraph) physical interpretation of your results.

2) Gridded temperatures and ENSO.

a) Calculate the regression and correlation coefficients between surface temperature anomalies and standardized values of the ENSO index at grid points throughout the globe (the regression cofficients should be in units of temperature). Show the resulting correlation and regression maps on separate plots. In the correlation plot, highlight regions where the results exceed the 95% confidence level.

b) Provide a short physical interpretation of your results.

c) What are the relative merits of displaying regression versus correlation coefficients?

3) Estimating the incidence of extreme events

(You do not need data to answer this question). Say you were interested in estimating the number of extreme cold events in Missoula during winters corresponding to the opposing phases of the ENSO cycle. In this case, you define extreme cold events as days when Missoula temperatures dip 2 standard deviations below their long-term climatological mean, and the contrasting phases of the ENSO cycle as winters when the standardized ENSO index exceeds 1 standard deviations about its long term mean. Assume Missoula temperatures are normally distributed. Explain how you can use the correlation coefficient between Missoula temperatures and the ENSO index to estimate the ratio between the number of extreme cold days that falls during the warm and cold phases of the ENSO cycle, respectively. What correlation coefficient yields a ratio of 2:1? 3:1? 4:1?