SIO 217B Atmospheric and Climate Sciences II

Exercise #1

1. a) Download the file containing surface pressure data for 1993 March 14 00Z and plot it in the domain 20-55°N, 230-310°E.

   b) Briefly explain why you think that surface pressure over the western U.S. is much lower than surface pressure over the eastern U.S.

2. a) Download the file containing the spatial distribution of surface geopotential height in the model (i.e., topographic elevation) and plot it in the domain 20-55°N, 230-310°E. Note that topography in the model is smooth due to low spatial resolution.

   b) Briefly explain why there a correspondence between regions of low surface pressure and high elevation.

3. **Optional.** If you examine the topographic data carefully, you will see that the surface of the ocean is "wavy" rather than flat with a constant value of 0 gpm above mean sea level. This is because the model atmosphere and surface are represented by spherical harmonics (similar to sines and cosines in Fourier analysis) rather than a spatial grid. Fitting a limited set of sines and cosines to data that exhibits an abrupt change produces waviness extending beyond the region of the actual feature. To see a prime example of this, plot how surface geopotential height varies along the 19°S latitude line between 280-300°E. Also plot a line for Z = 0 gpm. Note that the spectral model must create a –177 gpm trough offshore in order to fit the sharp Andes Range with spherical harmonics.

4. a) Since we are interested in pressure variations related to weather rather than topography, we want to convert surface pressure to pressure at a uniform height such as mean sea level. Write down an equation for calculating pressure at sea level (Z = 0 gpm) in terms of surface pressure p_{sfc} at a specified elevation Z_{sfc} (hint: hypsometric equation). We also need to know the mean layer temperature $\langle T \rangle$ between Z = 0 and Z_{sfc}, which is tricky considering that solid earth exists between mean sea level and the surface of land regions.

   b) Using the previous data files, calculate sea level pressure (SLP) for 1993 March 14 00Z and plot it in the domain 20-55°N, 230-310°E. For convenience, use a uniform temperature of 275 K for $\langle T \rangle$. Following conventional practice, plot with a contour interval of 4 hPa (e.g., 996, 1000, 1004, etc. hPa). Apply smoothing to reduce the noisiness of the data. For example,

$$\mathrm{SLP}_{\mathrm{smooth}}(i, j) = [4\times\mathrm{SLP}(i, j) + \mathrm{SLP}(i+1, j) + \mathrm{SLP}(i-1, j) + \mathrm{SLP}(i, j+1) + \mathrm{SLP}(i, j-1)] / 8$$

   where i and j are indices of latitude and longitude. I applied this smoothing procedure three times. Note the strong low pressure center on the eastern coast of the U.S.

   c) Download the file containing SLP data for 1993 March 14 00Z and plot it over your calculated SLP using a different color or line pattern. Due differing methods, we do not expect perfect correspondence, but there should be good agreement between the two datasets for the eastern U.S. The poor agreement that occurs over the western U.S. demonstrates the difficulty of obtaining reliable SLP in regions of high topography.