SIO 217B Atmospheric and Climate Sciences II

Exercise #4

1. a) Download the file containing SLP data for 1993 March 14 00Z and plot it in the domain 20-50°N, 270-310°E. Use the conventional contour interval of 4 hPa. Download the files containing zonal and meridional wind components for 10 m above the surface ($u_{10\text{-m}}$ and $v_{10\text{-m}}$), and plot these as vectors over the SLP contours. It may be necessary to plot every other vector to reducing crowding in the plot. The 10-m winds are intended to represent winds that would be measured at a surface weather station and are largely determined by the model's parameterization for the surface layer of the atmosphere. Winds 10 m above the surface feel friction much more strongly than winds at higher elevation.

   b) Even when SLP contours are equally spaced, winds are stronger over ocean than over land. Why is this?

2. a) Write down equations for calculating the zonal and meridional components of geostrophic wind from the gradient of pressure (p) computed in spherical coordinates (e.g., spherical geometry with latitude and longitude in radian units as spatial variables rather than Cartesian x and y). Let a be the radius of the Earth.

   b) Using a centered finite difference method, calculate geostrophic wind from the SLP data. For convenience, assume density has a uniform value of 1.2 kg m^{-3}. Plot geostrophic wind vectors over SLP contours. Because the geostrophic wind is stronger than the 10-m wind, it may be necessary to reduce the vector length for a given wind speed relative to that in the first plot.

   c) Note how geostrophic winds are parallel to the SLP contours. Why are geostrophic winds stronger than 10-m winds?

   d) Why are geostrophic winds generally stronger where SLP contours are more closely spaced?

   e) Why do 10-m winds cross SLP contours towards lower SLP, unlike the geostrophic winds?