SIO 217B Atmospheric and Climate Sciences II

Exercise #24

1. a) Download the files containing temperature and geopotential height of the 1000, 925, 850, 775, 700, 600, 500, 400, 300, 250, 200, 150, 100, 70, 50, and 30 hPa levels (a total of sixteen levels) for 1993 March 14 00Z. For each latitude point between 25-60°N along the 290°E longitude line, extract temperature and geopotential height from all pressure levels and interpolate temperature to regular vertical intervals between 0 and 24 km (as in Exercise #23). Calculate the meridional temperature gradient for each height level and latitude point and multiply by 10^6 for more convenient units (as in Exercise #23). Plot contours of temperature and meridional temperature gradient in a latitude-height cross-section figure for 25-60°N and 0-24 km elevation along the 290°E longitude line. Use contour intervals of 10 °C and 10 (actually 10×10^{-6} °C m^{-1}).

   b) Below 12 km elevation, is it warmer in the south or in the north? Above 12 km elevation, is it warmer in the south or in the north?

   c) Note the region of strong meridional temperature gradient that is located between 40°N and 45°N at the surface and slopes forward toward the north with height. With what weather map feature in Exercise #7 does this temperature gradient pattern correspond?

2. a) Download the files containing zonal wind component at the 1000, 925, 850, 775, 700, 600, 500, 400, 300, 250, 200, 150, 100, 70, 50, and 30 hPa levels (a total of sixteen levels) for 1993 March 14 00Z. For each latitude point between 25-60°N along the 290°E longitude line, interpolate zonal wind to regular vertical intervals between 0 and 24 km. Plot contours of temperature and contours of zonal wind in a latitude-height cross-section figure for 25-60°N and 0-24 km elevation along the 290°E longitude line. Use contour intervals of 10 °C and 10 m s^{-1}.

   b) Below 8 km elevation in the southern half of the plot, is the atmosphere baroclinic or nearly barotropic? Explain your reasoning in terms of the spatial distributions of temperature and zonal wind.

   c) With what weather map feature in Exercise #20 does the region of maximum zonal wind generally correspond?

   d) Note how eastward zonal wind at 45°N increases between the surface and 11 km elevation and then decreases above that. How is this related to the vertical pattern of meridional temperature gradient at 45°N?

   e) Note the strong gradient in zonal wind near 40°N at the surface that tilts northward with height. With what feature in Exercise #7 does this gradient correspond?

   f) Note the region of nearly vertical temperature contours that is at the surface near 40°N and tilts northward with height. What is the name of the general atmospheric property corresponding to vertical temperature contours? How stratified is the atmosphere in this region?

3. a) Calculate potential temperature at the 1000, 925, 850, 775, 700, 600, 500, 400, 300, 250, 200, 150, 100, 70, 50, and 30 hPa levels (a total of sixteen levels) for 1993 March 14 00Z. For each latitude point between 25-60°N along the 290°E longitude line, interpolate potential temperature to regular vertical intervals between 0 and 24 km. Plot contours of potential temperature and contours of zonal wind in a latitude-height cross-section figure for 25-60°N and 0-24 km elevation along the 290°E longitude line. Use contour intervals of 10 K and 10 m s^{-1}.

   b) Note how potential temperature contours generally tilt upward from south to north below 12 km elevation (where it is warm in the south and cold in the north) and generally tilt downward from south to north above 12 km elevation (where it is cold in south and warm in the north). Explain why potential temperature contours tilt upward toward cold for a warm-to-cold horizontal temperature gradient.

4. a) **Optional.** Download the files containing meridional wind component and pressure vertical velocity at the 1000, 925, 850, 775, 700, 600, 500, 400, 300, 250, 200, 150, 100, 70, 50, and 30 hPa levels (a total of sixteen levels) for 1993 March 14 00Z. Convert vertical velocity in pressure coordinates to vertical velocity in height coordinates as in Exercise #13. For each latitude point between 25-60°N along the 290°E longitude line, interpolate height vertical velocity to regular vertical intervals between 0 and 24 km. Plot contours of potential temperature and contours of zonal wind in a latitude-height cross-section figure for 25-60°N and 0-24 km elevation along the 290°E longitude line. Use contour intervals of 10 K and 10 m s^{-1}. Add vectors that show the combined direction and magnitude of meridional and vertical velocity. Note that you will need to multiply vertical velocity by a large constant in order to make vertical motions discernable on the plot. Try to use the same scaling as in Exercise #23.

   b) **Optional.** What area of the plot has the strong upward motion? How is this spatially related to the region of strong meridional temperature gradient?