Homework 6

due Oct. 21, 2015

[50 pts.]

Name: ____

Estimate of Time Spent: ________________ Actual Time Spent: ________________

Problem 1: Vertical winds under geostrophy

Consider the momentum equations in Cartesian height-coordinates for geostrophic flow assuming that $\rho = \rho(z)$. What can you say about the vertical gradient of the vertical velocity (w) in the case of:

(a) an f-plane approximation

(b) a beta-plane approximation

Please provide the necessary derivations to support your conclusions.
Hint: start with the horizontal momentum equations, then combined them to get an equation for the horizontal divergence of the flow and then apply the continuity equation.

Problem 2: Rossby number and Geostrophic balance

Use the data file from previous homeworks (ERA-interim_300hPa_2014-Jan1-8.nc), and the newly provided data file that provides partial time derivatives and advection terms for u and v (ERA-interim_uvtnds-300hPa_2014-Jan1-8.nc). For this problem, focus on the *zonal momentum equation* (i.e. u), however, you can look at v as well if you would like.

(a) Pick a box somewhere in the mid-latitudes roughly 60 degrees in longitude and from 30-60 degrees in latitude. Compute and plot Rossby number fields by taking the ratio of the magnitudes of (i) the local acceleration of u and the Coriolis acceleration, (ii) the horizontal advection of u and the Coriolis acceleration, and (iii) the vertical advection of u and the Coriolis acceleration. Plot the corresponding u wind field in another graph. Discuss the overall size and variability of your Rossby number in relation to your flow pattern. Feel free to explore different regions.

(b) Average the individual terms used in (a) in time over (i) 1 day, (ii) 3 days, (iii) 7 days and repeat the analysis. For example, average the local acceleration of u and the Coriolis acceleration over the requested number of days, and *then* calculate the Rossby number. Briefly discuss the differences for different averaging periods.

(c) Repeat (b) but for a box of roughly same size somewhere in the tropics.

Problem 3: Upper- and lower-level synoptic charts

Figure 0.1a shows a 500 hPa (upper-level) chart of wind vectors and contours of constant geopotential heights from NOAA's Global Forecasting System (GFS). The colors denote the absolute vorticity. Panel 2 shows a near-surface (10-meter) chart of wind vectors and contours of constant mean sea-level pressure (black contours; MSLP). The shading denotes the precipitation, and the red and blue lines denote the 2-meter temperatures.

(a) For which chart does geostrophic balance appear to hold best? Why?

(b) Does geostrophy appear to hold better over land or ocean for near-surface flows? Why?

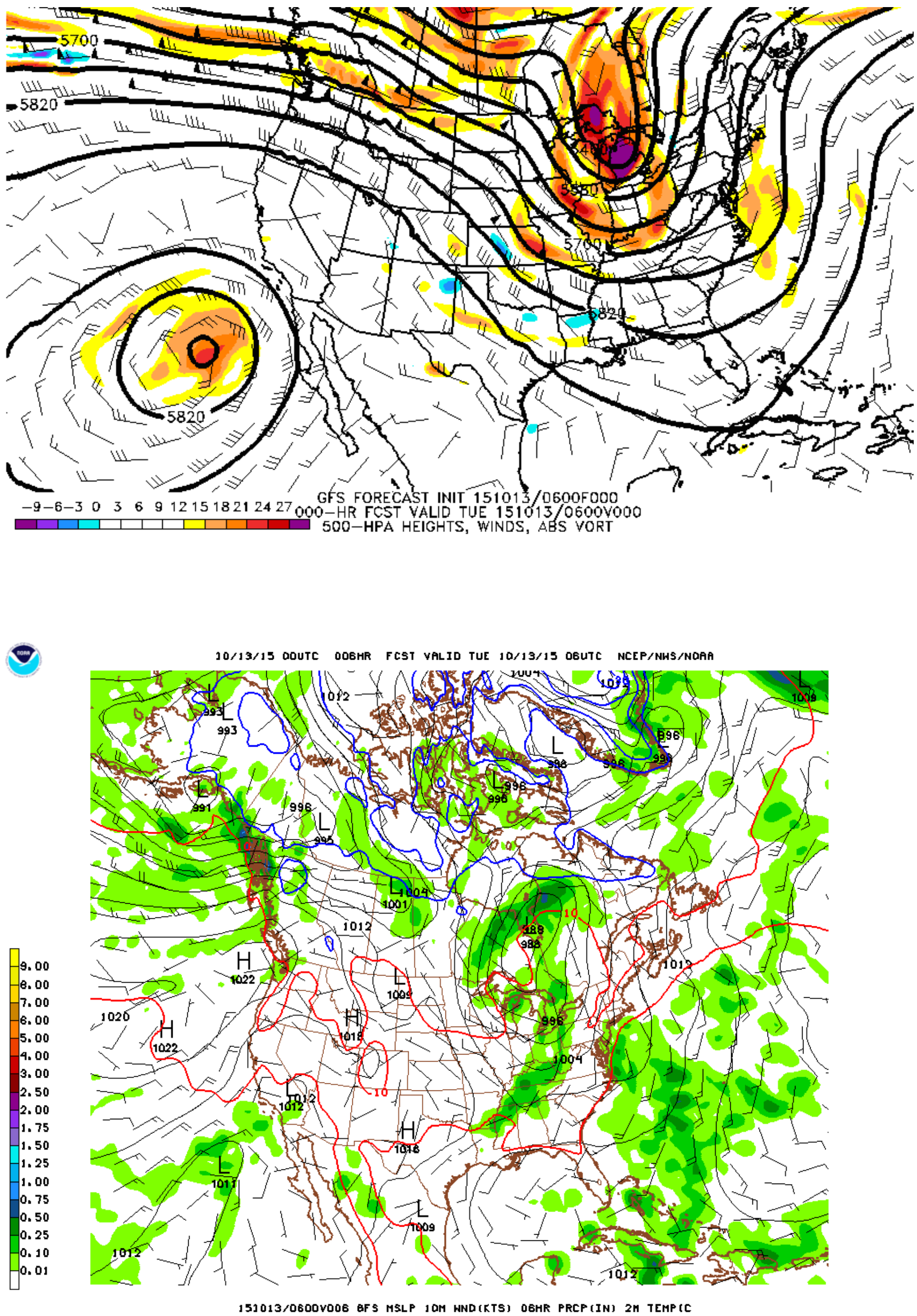

Figure 0.1: (a) 500-hPa GFS forecast. Black contours denote the geopotential heights, barbs denote the wind vectors and colored shading denotes the absolute vorticity. (b) Near-surface GFS forecast. Black contours denote the mean-sea-level pressure (MSLP), barbs denote the 10-meter wind vectors, green shading denotes precipitation and red/blue contours denote the 2-meter temperatures.