Problems on Chapter 5: Synoptic Scale Approximations

Q 5.1: **On a certain occasion at 45°N, the isobars on a surface chart were observed to be straight lines running from southwest to northeast, with isobars drawn at 4 hPa intervals separated by 100 km. Low pressure was to the NW and high to the SE. What was the geostrophic wind? Assume the density was 1.2 kgm^{-3}.**

(Note that the configuration here is the same as Q 4.3)

Q 5.2: Repeat Q 5.1, but for the following latitudes: (a) 80°N, (b) 20°N, (c) 10°N, (d) 30°S, (d) 60°S.

Q 5.3: Repeat Q 5.1, but instead of taking the density as given, take the pressure to be 1000 hPa and the temperature to be: (a) -20°C, (b) 0°C, (c) 35°C.

Q 5.4: (From the 2002 Hon Phys Finals) **In the vicinity of a point O at latitude 45°N, the analysed mean sea level pressure chart was found to consist of approximately steady, straight isobars running from west-northwest to east-southeast, with low pressure to the north-northeast. The spacing of the isobars drawn at 4 hPa intervals was observed to be 167 km. Estimate the magnitude and direction of surface wind. Take the density at the surface to be 1.2 kgm^{-3}.**

If the isobars had been getting closer together with time instead of being steady, would you expect the wind direction to be rotated clockwise or anticlockwise from the direction previously deduced?

(You may find the vector identity $a \times (b \times c) = (a \cdot c) b - (a \cdot b) c$ useful in answering some parts of this question, but it is not essential.)

Q 5.5: Near 45°S an isobar through a point P was observed to be a straight line running from NW to SE with low pressure to the SW and high to the NE. The other isobars in the vicinity were observed to be straight lines but diverging towards the NW. If O is a point 600 km NW of P and Q is 600 km SE of P, then the separation of isobars drawn at 4 hPa intervals was 400 km NW at O and 200 km at Q. What is your best estimate of the true wind?

Q 5.6: On a particular occasion the gradient wind 500 km from the centre of a steady stationary circular cyclone at 45°N was 15 ms^{-1}. What was the geostrophic wind? Repeat for an anticyclone.

Q 5.7: On a particular occasion the geostrophic wind 500 km from the centre of a steady stationary circular cyclone at 45°N was 8 ms^{-1}. What was the gradient wind? Repeat for an anticyclone.

Q 5.8 At 1000 km from the centre of a steady stationary circular anticyclone at 45°N the pressure was 1000 hPa. What is the maximum possible value for the pressure at the centre? Assume the density was 1.2 kgm^{-3}.

Data:

Radius of Earth 6371 km

Rate of Earth's rotation, $\Omega = 7.292 \times 10^{-5}$ s^{-1}