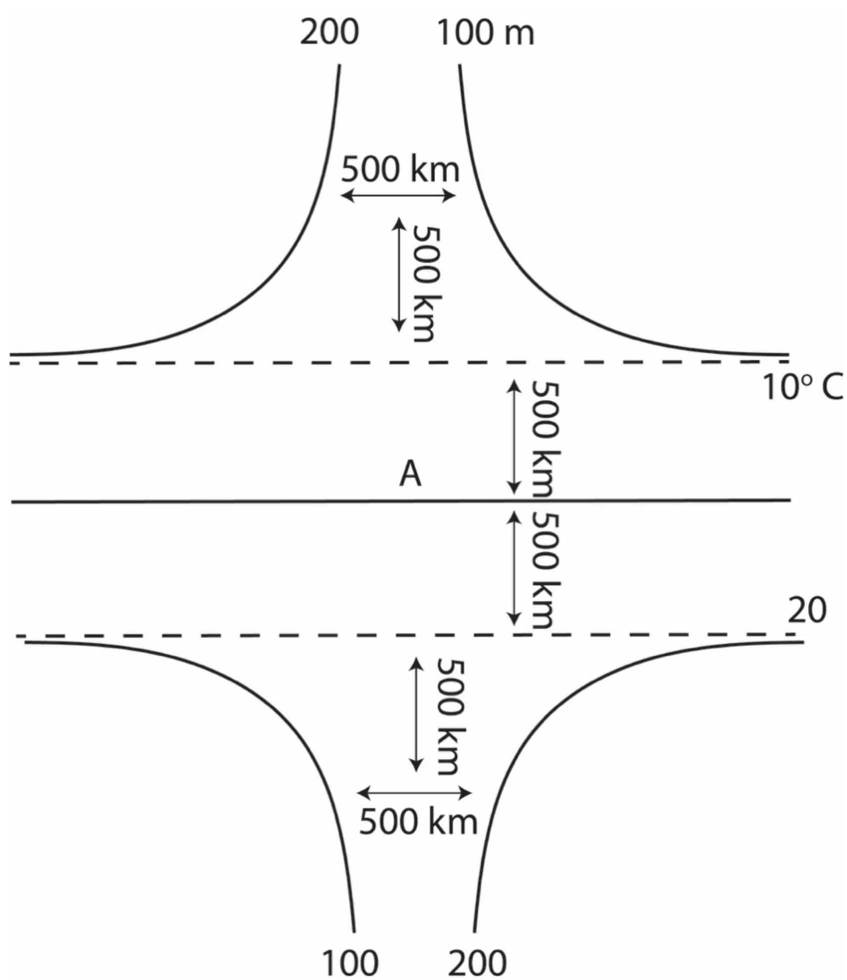
EXAM #2
METR 5413
ADVANCED SYNOPTIC METEOROLOGY

Howie "Cb" Bluestein

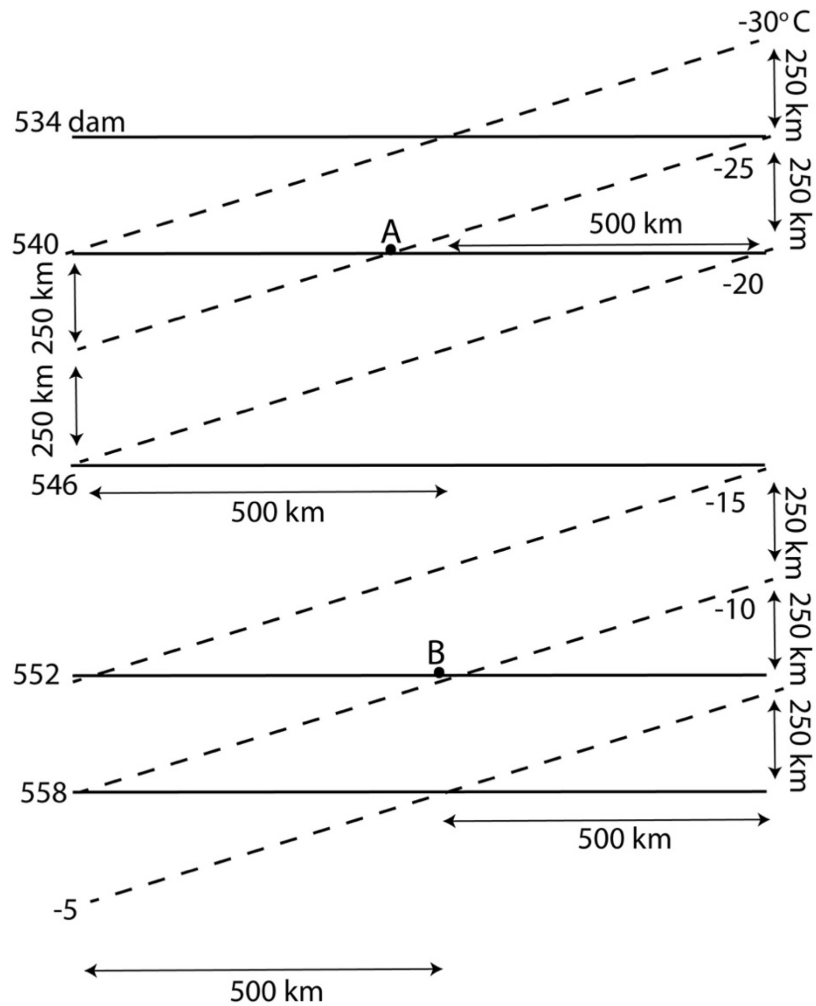
Thursday, 5 May 2022 your home or office 1 h 20 min or less

Please show all your work so I can give partial credit. Assume that all problems are given for the Northern Hemisphere. Try to pace yourselves so you don't get hung up on a problem and miss others completely! Note that there are only four problems. Be sure your name is on each solution page.

1. Consider the distribution of height contours (solid lines, m) and isotherms (ºC) at 1000 hPa shown below. If the height-contour distribution remains constant, how long (hours) will it take the temperature gradient to increase by a factor of five at point A? Neglect diffusion and diabatic heating. Assume that the latitude is 42º N and ignore variations in latitude across the domain shown in the analysis below. (25 points)

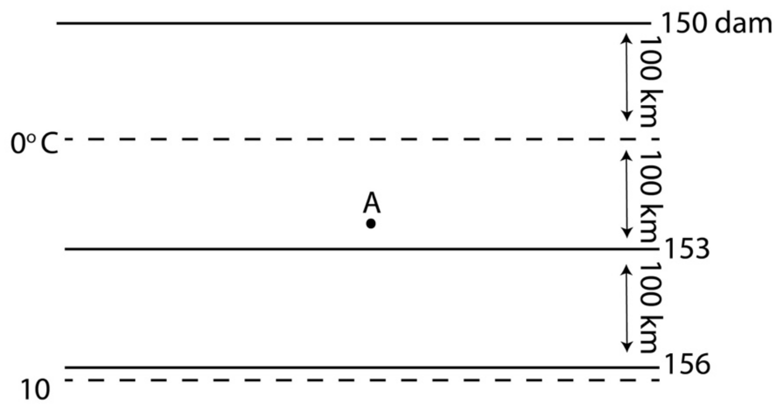


2. Consider the distribution of height contours (solid lines, dam) and isotherms (ºC) at 500 hPa shown below. What is the instantaneous (only at the time the analysis is valid, not in the future) rate of increase/decrease in the y-component of the temperature gradient at points A and B [$^{\circ}$ C(1000 km)$^{-1}$ day^{-1}]? Your estimate should be quantitative, i.e. based on the analysis. Neglect diffusion and diabatic heating. The latitude is 42º N and neglect variations in f across the domain. Hint: The y-component of the Q vector.



(a) Consider only quasi-geostrophic theory and ignore the effects of vertical motion (tilting). Assume that the coordinate system is oriented so that the x axis is along the geostrophic flow and that the y axis points normal to the geostrophic flow. (25 points)
(b) According to semi-geostrophic theory (i.e., in real space, using the geostrophic-momentum approximation), where will mid-level frontogenesis occur? Why? Assume that the coordinate system is oriented so that the x axis is along the flow, the y axis is perpendicular and to the left of the flow, and that Dv_g/Dt is small and can be neglected. (10 points)

3. What is the slope of a front at 850 hPa, at 42° N, at point A for the distribution of height contours (solid lines, m) and isotherms (°C) at 850 hPa shown below? Neglect variations in f across the domain.



(a) Assume that the front obeys the physical laws consistent with the geostrophic-momentum approximation. Neglect friction and diabatic heating. (20 points)

(b) Repeat the problem, but assume that the front obeys the physical laws consistent with quasi-geostrophic theory. (5 points)

4. Suppose that there is IPV of 3 PVU on the 350 K isentropic surface at a location at 42° N and that there is relative vorticity of $5 \times 10^{-5}\ s^{-1}$ on this isentropic surface at this location.

(a) What is the static stability ($-\partial\theta/\partial p$) in units of K $(1000\ hPa)^{-1}$? (20 points)

(b) Suppose you know that at another location, but at the same latitude, IPV is also 3 PVU. Can you also conclude that the relative vorticity and static stability are the same as in (a)? Why or why not? (5 points)

Hints, useful facts, and red herrings:

$R = 287\ m^2 s^{-2} K^{-1}$

$C_p = 1004\ m^2 s^{-2} K^{-1}$

1 min=60 s

$\theta = T(p_o/p)^{R/Cp}$

$\sigma = -RT/p\ \partial \ln \theta/\partial p$

Gaul as a whole is divided into three parts.

The earth revolves about its axis once every day.

$M = C_p T + g z$

$Y = y - u_g/f_O$

$- \partial u_g/\partial p = [- R/(f_O p)] \partial T/\partial y$

STORM SEASON IS HERE!