

EXAM #2
METR 5413
ADVANCED SYNOPTIC METEOROLOGY
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Thursday, 30 April 2020

home alone!

1 h 20 min or less

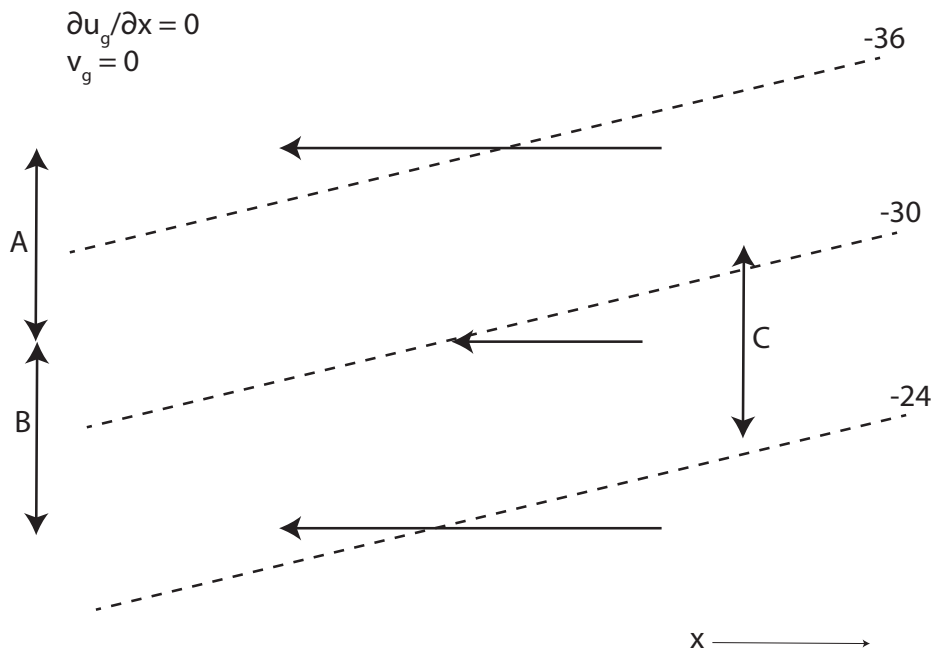
• Answers to exam may be scanned or photographed and must be e-mailed to me as attachments by 2:30 PM. If you have a special accommodation, then you will have until 4:30 PM. Please don't forget to put your name clearly on all the pages. Be sure to show all your work so I can give adequate partial credit. Problems or questions? E-mail me at hblue@ou.edu.

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.

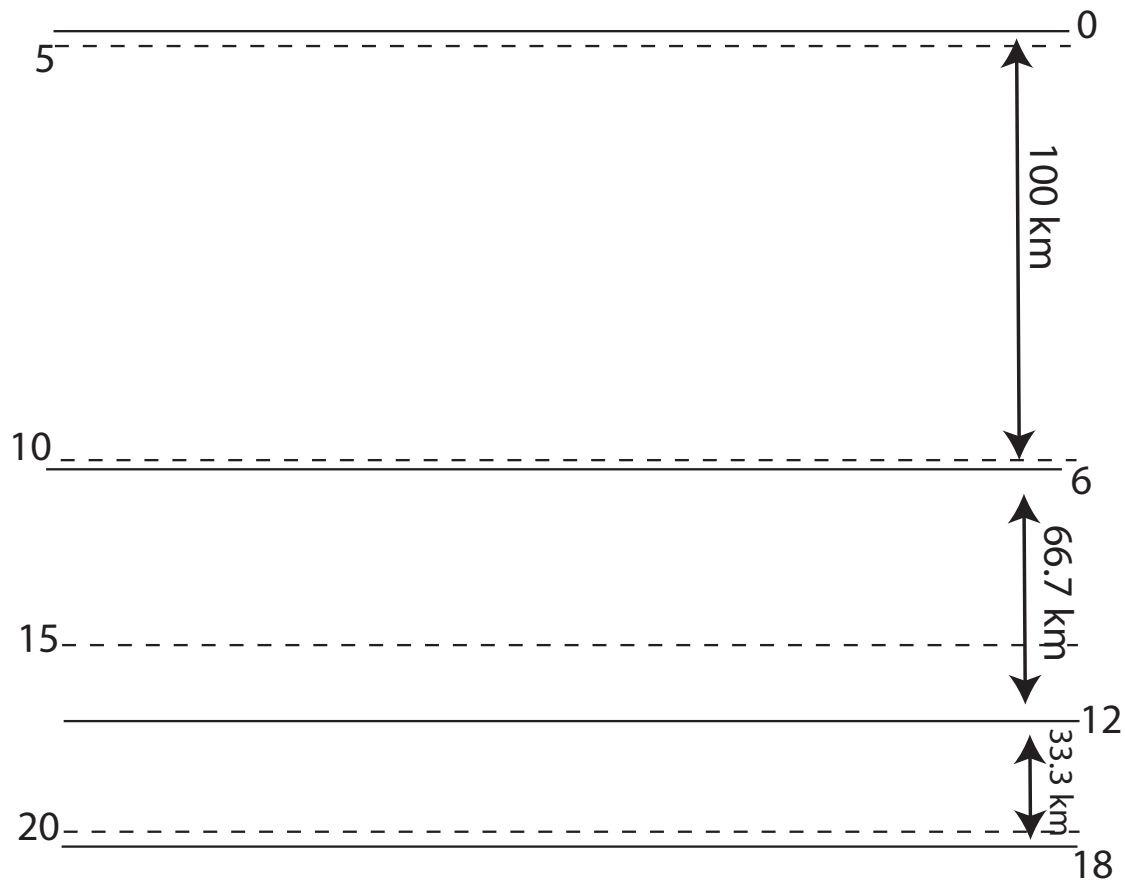
1. Consider the geostrophic wind vectors and the isotherms (dashed lines, °C) fields at 500 hPa sketched below. Note that $\partial u_g / \partial x = 0$ and $v_g = 0$. You may neglect diabatic heating and friction. Where (regions A, B, or C) will a mid-tropospheric front form? If none will form at all, why not?

(a) Answer for just quasi-geostrophic processes. Justify your answer. (15 points)

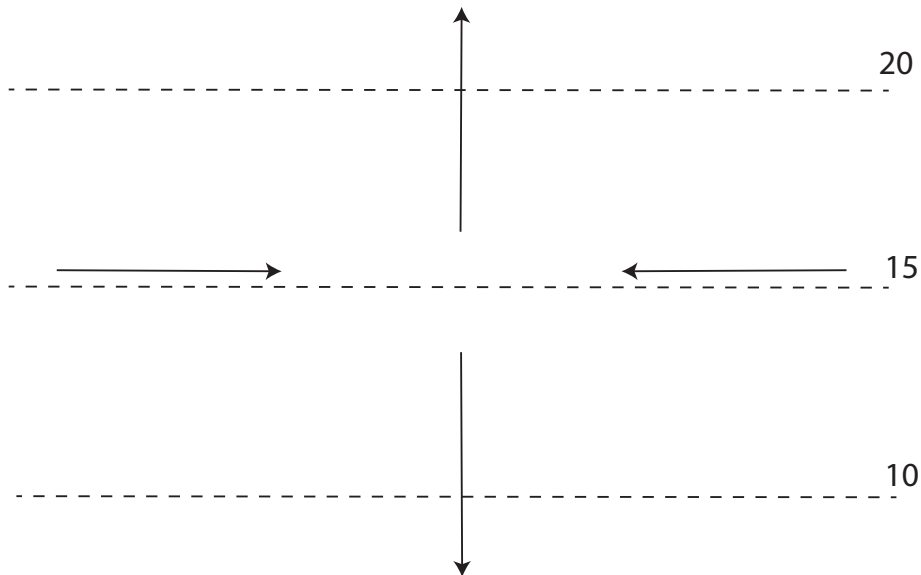
(b) Answer for processes subject to the geostrophic-momentum approximation. If a front forms, will it form more slowly or more quickly than in (a)? Justify your answer. (15 points)



2. What is the slope (in kPa km^{-1}), in the lowest 200 hPa, of a surface of constant geostrophic vorticity $[-(dp/dy)_g]$ associated with the frontal zone (region of enhanced temperature gradient) depicted below? The solid lines are contours of constant height in dam at 1000 hPa, near the surface, and the dashed lines are isotherms in $^{\circ}\text{C}$ at 1000 hPa. Assume that the geostrophic wind and temperature gradients shown are representative of the lowest 200 hPa. The latitude at the center of the domain is 37° N and the Coriolis parameter may be treated as a constant. (Hints: Refer to the derivation of the slope of a surface of constant Y or m as a guide and use the thermal wind relation.) (25 points)



3. Consider the temperature [isotherms in $^{\circ}\text{C}$ (dashed lines)] and geostrophic wind field (vectors) near the surface, at 1000 hPa, shown below. Assume there is no diabatic heating and no friction and that the atmosphere is statically stable.



- (a) Use quasi-geostrophic theory: Is the (scalar) frontogenesis function $\mathcal{F} > 0$ or < 0 ? Use Q vectors to diagnose the vertical motion and the ageostrophic wind in a qualitative sense. What will a vertical cross section of temperature look like at a later time? Why? What will the field of geostrophic vorticity at the surface look like? (15 points)
- (b) Use the geostrophic-momentum approximation: What will a vertical cross section of temperature look like at a later time? Why? What will the field of geostrophic vorticity at the surface look like? How is your answer different from the answer to (a)? (15 points)

4. Suppose that there is a negative, anticyclonic potential vorticity anomaly at the tropopause of ~ 2 PVU and that $\Delta\theta$ is around 60 K. Suppose also that at the surface there is a temperature gradient that points towards the west. If there is no diabatic heating or friction and no mean wind, what how will the wind field at the surface evolve? That is, where will there be cyclones and/or anticyclones, and in what direction(s) will they propagate? Why? (15 points)

Hints, useful facts, and red herrings:

$$R = 287 \text{ m}^2 \text{ s}^{-2} \text{ K}^{-1} \quad C_p = 1004 \text{ m}^2 \text{ s}^{-2} \text{ K}^{-1} \quad 1 \text{ min} = 60 \text{ s} \quad \theta = T (p_o/p)^{R/C_p}$$

$$\sigma = -RT/p \quad \partial \ln \theta / \partial p \quad \text{Gaul as a whole is divided into three parts.}$$

The earth revolves about its axis once every day.

$$M = C_p T + g z \quad Y = y - u_g / f_o$$

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

STORM SEASON IS HERE!