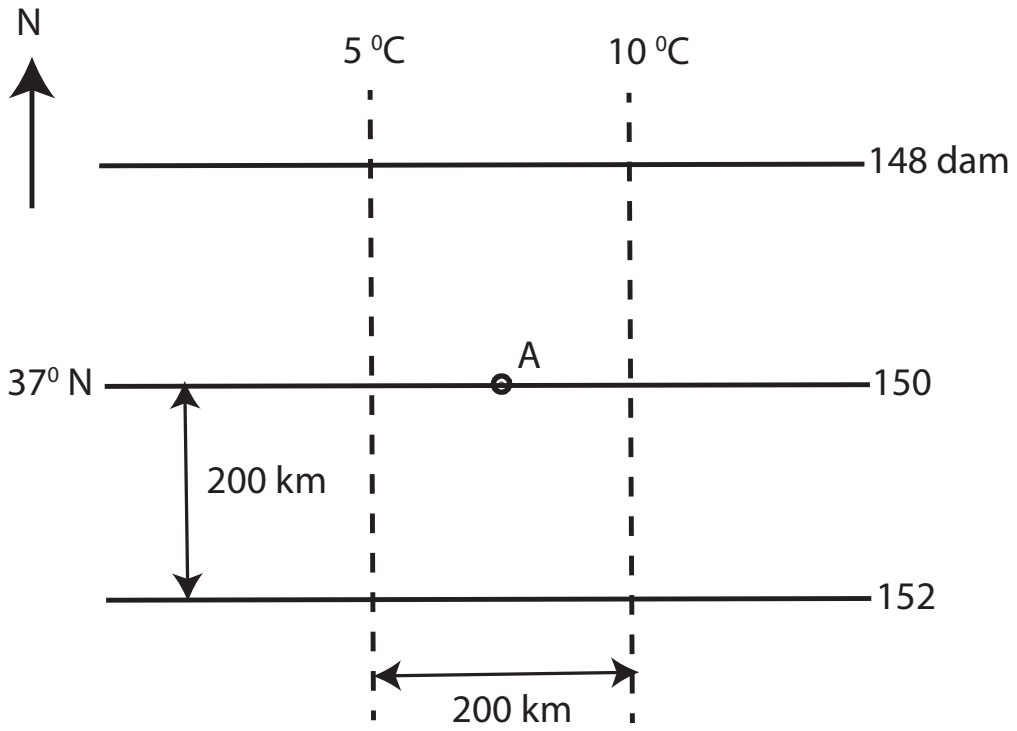
EXAM #1
METR 5413
ADVANCED SYNOPTIC METEOROLOGY
Howie "Cb" Bluestein

Thursday, 10 March 2022 1 h 15 min or less

Please show all your work clearly so I can give partial credit. Be sure to write your name on each page of your exam. When you are finished, scan the exam and e-mail it to me (hblue@ou.edu) by 11:30, unless you have special accommodation; if you have special accommodation, e-mail it to me by 3 PM. Give the originals to Debbie Barnhill at the front desk. If she is not in, then leave them with any other administrative person in the main office. Assume all problems are given for the Northern Hemisphere.

1. Consider the height field (solid lines in dam, tens of meters) and temperature field (dashed lines in ºC) at 850 hPa in the figure below. At point A, suppose that the vertical velocity in pressure coordinates is + 3.25 X 10^{-4} kPa s^{-1}. What must the temperature (º C) be at 750 hPa if the temperature at point A does NOT change with time and if the temperature at 950 hPa is 8º C. Neglect diabatic heating. Be sure your units are correct. Assume that the atmosphere is quasi-geostrophic. Hint: Consider the quasi-geostrophic thermodynamic equation. (25 points)

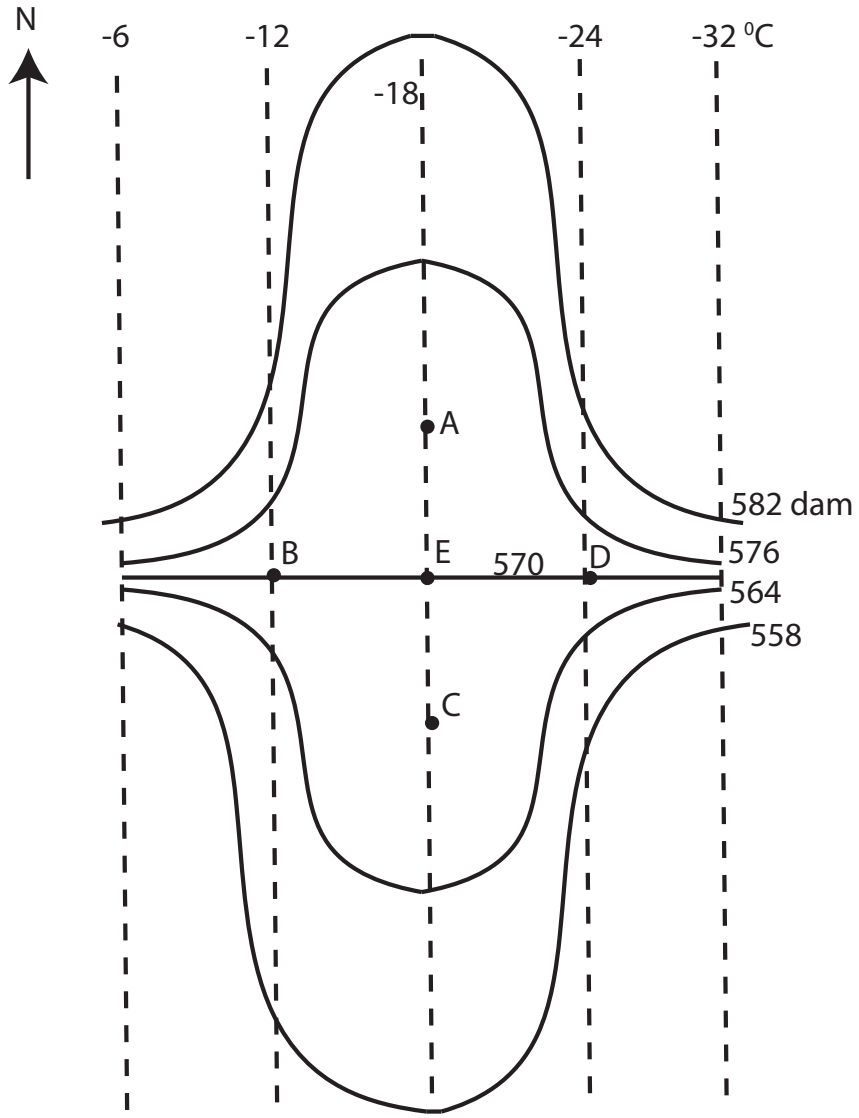


2. Consider the height field (solid lines in dam) and temperature field (dashed lines in ºC) at 500 hPa below. Assume that there is no diabatic heating and neglect the β effect.

   (a) Sketch the Q vector at points A, B, C, D, and E. Be sure to show clearly how you arrived at your answer. (15 points)

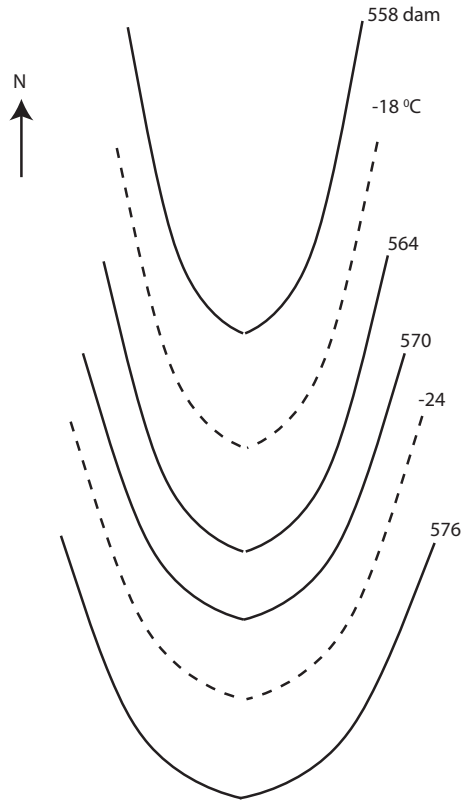
   (b) What is the vertical velocity *qualitatively* at point E, at 500 hPa according to quasi-geostrophic theory? Upward? Downward? Zero? Why? (5 points)

   (c) Using the Trenberth formulation of the quasi-geostrophic ω equation, repeat (b). Be sure to justify your answer. (10 points)



3. What is the a typical synoptic-scale, mid-latitude value (include the correct units) during the cold season of each adiabatic and frictionless forcing function in the traditional form of the quasi-geostrophic height tendency equation? Be sure to justify your answer. (20 points total; 10 points for each forcing function)

4. See the figure below showing the height field (solid lines in dam) and temperature field (dashed lines in ° C) at 500 hPa. Where will a *surface* (~ 1000 hPa) cyclone form, if any? Why? Be sure to state your assumptions. Use quasi-geostrophic theory. Hint: The Trenberth form of the ω equation is easier to use than the other ω equations in this case. Assume that the isotherms are representative of the mean temperature in a layer centered at 500 hPa. Neglect friction and diabatic heating. (25 points)



Hints, useful facts, and irrelevant nonsense: $R = 287\ m^2\ s^{-2}\ K^{-1}$; $C_p = 1004\ m^2\ s^{-2}\ K^{-1}$;
1 min = 60 s; one day = 24 h.
The Earth revolves around its axis once every day.
The average radius of the Earth is 6371 km.
1000 m = 1 km; 1 mb = 1 hPa; 1 kPa = 10 hPa.
Gaul as a whole is divided into three parts (from Caesar's *War Commentaries*)