ATSC 5160 HW 2 due Fri 27 Feb (6% of the course grade)

Please hand in this sheet, as you will answer question (6) on the map on page 4. The color version is available on http://www.atmos.uwyo.edu/~geerts/atsc5160/

(1) (20%) QG theory

(a) Why is the **Q**-vector form of the QG omega equation more meaningful than the traditional equation involving two separate forcing terms? (hint: the **Q**-vector convergence, a scalar field, obviously should equal those two forcing terms combined. The question regards the value of **Q**-vectors themselves. What do these vectors quantify?)

(b) Why can't any QG forcing terms (CVA, WAA, or DIV(Q)) be interpreted as drivers of vertical motion for features that are small, say less than 100 km across, like cold fronts?

(c) Why do these QG forcing terms (CVA, WAA, or DIV(Q)) reveal so much fine-scale structure in high-resolution model output, at least when they are computed from the GP height field?

(d) Typically only the RHS of the omega equation is shown, i.e. the QG forcing terms. Do you expect the QG omega field to look smoother, or even more textured, than these QG forcing terms? Explain.

(2) (10%) Use the QG framework to explain vertical motion in Rossby wave trough-ridge pattern in the northern hemisphere. Draw two equidistant height contours, and two isotherms. Recall that Rossby waves move westward, against the prevailing flow. Thus the wind blows through the wave pattern from west to east.

(a) Write out the Q vector definition *in natural coordinates*, evaluate **Q** at four phases (in the trough, in the ridge and between the trough/ridge), draw the Q vectors at these four points, and estimate regions of **Q** convergence/divergence (rising/sinking motion).

(b) Using a Lagrangian perspective (following an air parcel), use the QG momentum eqn to explain the ageostrophic motion in the trough/ridge, and the resulting vertical motion, assuming a level in the upper troposphere. Check consistency with the vertical motion pattern obtained in (a).

(3) (10%)

How will the 700 mb height in the southern half of Indiana evolve according to Fig. 1? Explain, using QG theory.

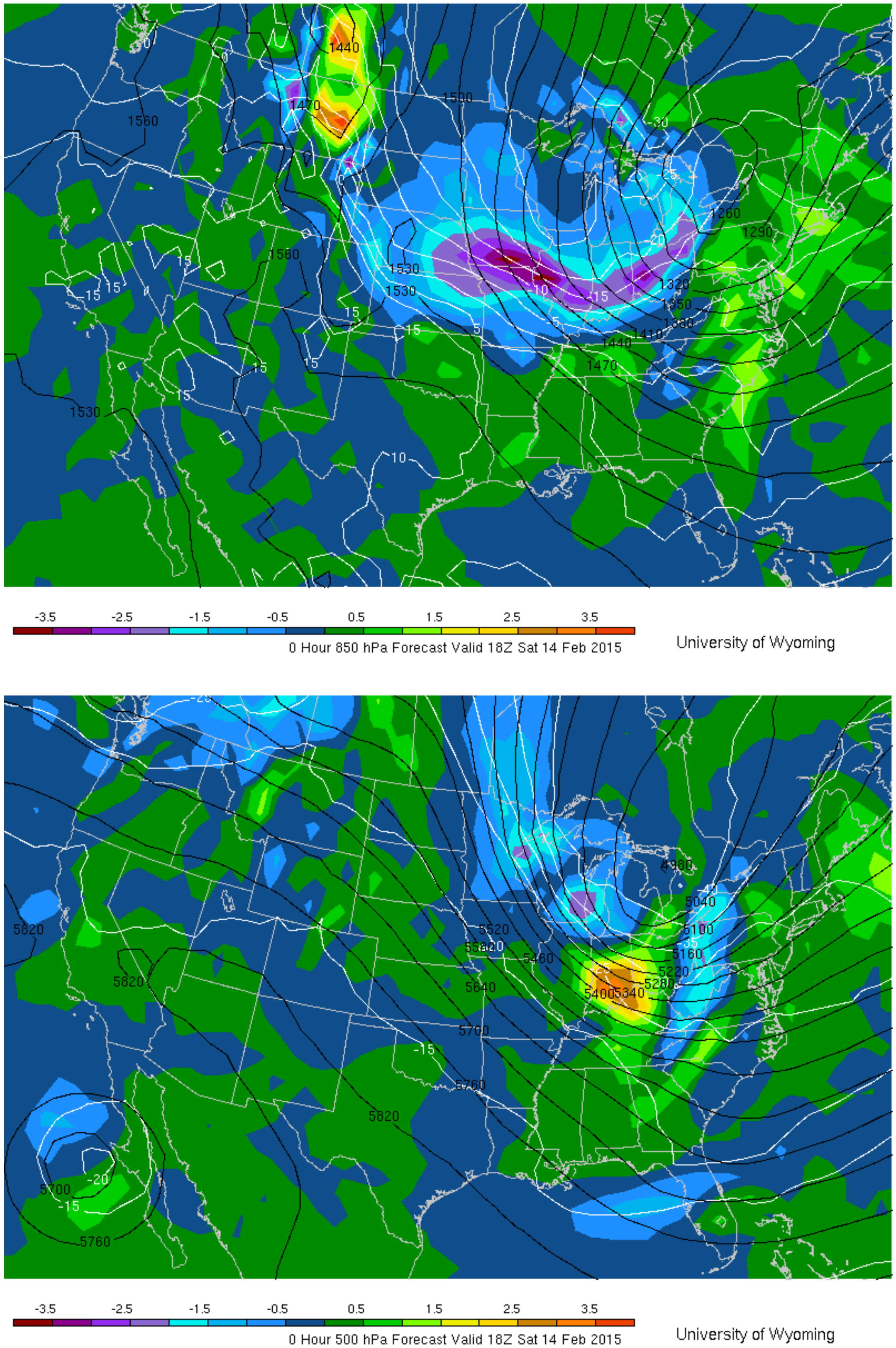

Fig. 1: height (m, black contours) temperature advection (K hr^{-1}, color fill), and temperature (°C, white contours) at 850 mb (top) and 500 mb (bottom).

(4) (10%)
Should there be rising or sinking motion at the level shown in Fig. 2, in Ohio? Explain, using QG theory.

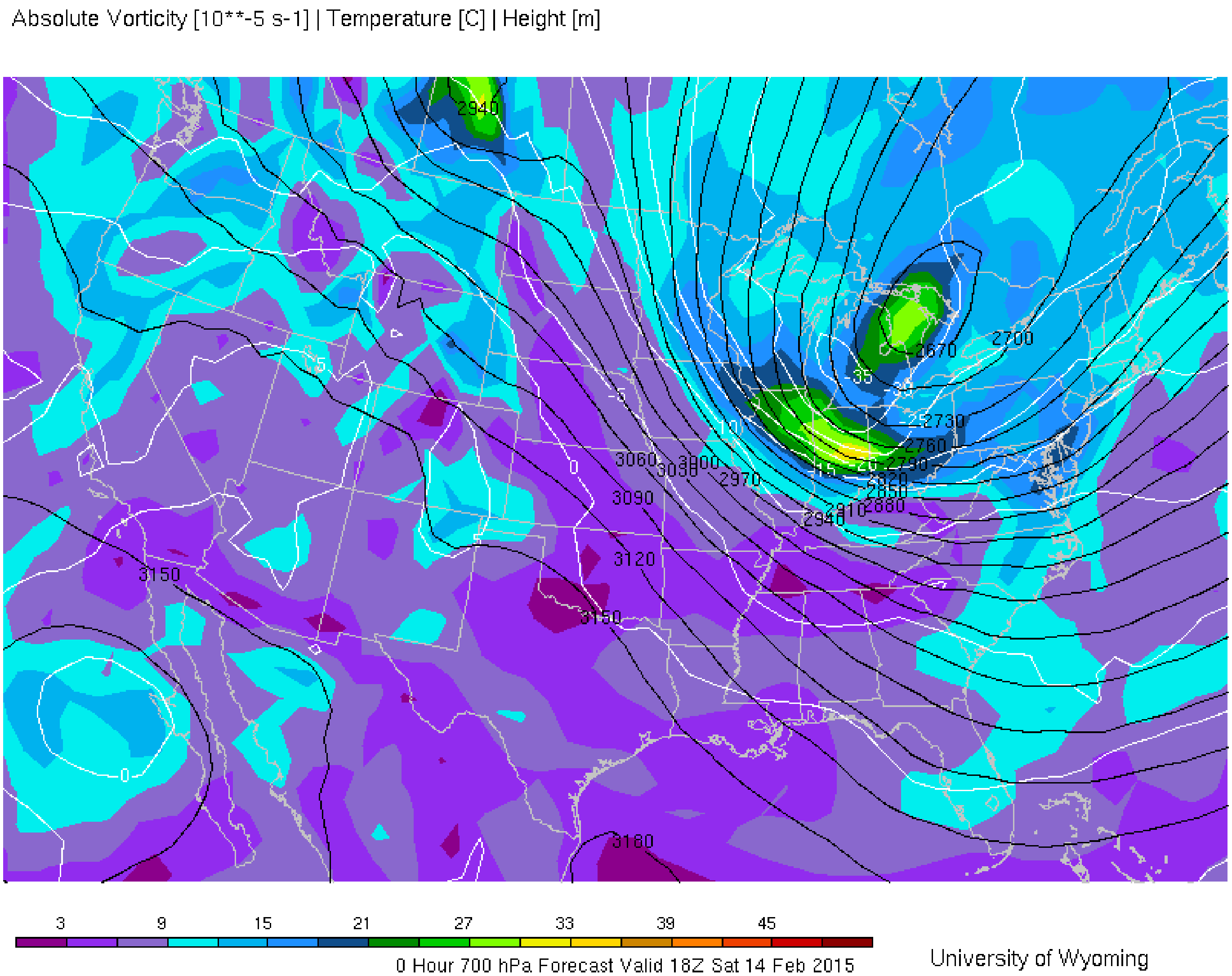

Fig. 2: height (m, black contours) absolute vorticity (10^{-5} hs^{-1}, color fill), and temperature (°C, white contours) at 700 mb (top).

(5) (10%)

(a) Imagine a series of Rossby wave troughs that are "positively-tilted" (eastward-tilted) on the south side of the polar jet, say between 30-40°N across the Pacific. Using (2.44) in the textbook, explain why such wave eddies decrease the eddy kinetic energy in that latitude belt.

(b) Find an example from real-time (last few days, or near-term forecast) weather data where tilted Rossby wave troughs alter the eddy kinetic energy as predicted by (2.43). (hint: look at some weather maps at any level in any place over two consecutive times to make your point)

(6) (40%) On the map below (Fig. 3), two troughs are drawn (dashed blue lines). The questions below focus on the 500 hPa trof over the western US.

a) (3%) Place red arrows on appropriate isolines to indicate the direction of the 600-400 hPa thermal wind. (no need to do this over the entire map; just focus on Colorado & vicinity)

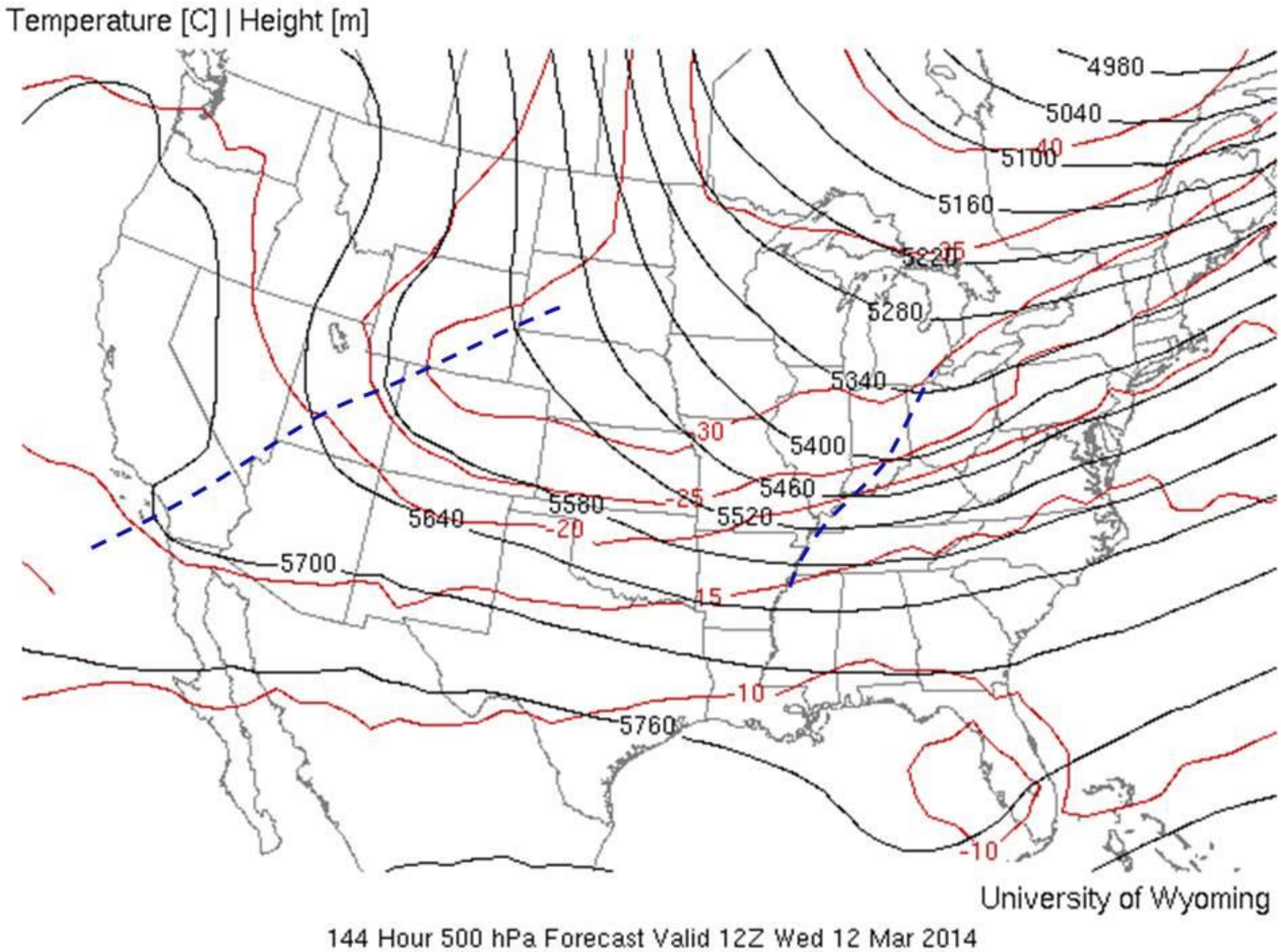

Fig. 3: 500 hPa height (black lines) and the 500 hPa temperature (red lines)

b) (3%) Also place blue arrows between appropriate lines to indicate the direction and speed of the 500 hPa geostrophic wind.
c) (5%) Mark the location of strongest WAA and strongest CAA at 500 hPa with the initials WAA and CAA.
d) (5%) Using the omega equation (temperature advection "forcing" only), write a U and D (blue) for centers of ascent & descent, resp., at 500 hPa.
e) (5%) Indicate the location of maximum geostrophic absolute vorticity at 500 hPa with a red cross.
f) (5%) Mark the location of strongest CVA and strongest AVA at 500 hPa, and, using the omega equation (vorticity advection "forcing" only), write a U and D (red) for centers of ascent & descent, resp., at 500 hPa. Remain focused on the short wave over the Rockies.
g) (5%) Compare the two estimates of rising/sinking motion (TA, VA), and explain any differences.
h) (4%) Locate the sea level low (L) and high (H) associated with the trof over the western US.
i) (5%) There is another short-wave trof shown to the east in Fig. 2. Which one of the two disturbances is more intense, in terms of all parameters you looked at (TA, VA, vertical velocity, and SLP minimum)?