IC5.3: Optional Job Sheet Answer Key

The Effect of Stability on the Response to Internal Forcing in the Atmosphere

Question 1. Based on the shape of the circulation and pattern of the vertical motion streamlines, what would you infer about the static stability and inertial stability?

This question is extremely subjective and the answer in this key is not necessarily the only answer or even the most correct answer. Part of the problem is that the D2D ageostrophic circulation streamlines need to be taken with a grain of salt. Because there is deep rising motion across a large area of this cross section, static stability and intertial stability are likely to be low.

Question 2. Does this agree with model's assessment in #1 of the vertical circulation and thus the inertial and static stability? Why or why not?

Geostrophic momentum lines are basically vertical, thus there is very little vertical wind shear so to get CSI there needs to be strongly sloped theta-es lines. In our cross section, there is some CSI in eastern Nebraska, and static stability is quite low all across this region.

Question 3. How does this compare with what you saw with momentum surfaces and saturated equivalent potential temperature regarding static stability?

Not surprisingly, negative MPVg exists in the layer from 600-300 mb, coincident with steeply sloped theta-es lines.

Question 4. Where is the strongest conditional or symmetric instability in this cross section? Is it deep?

Across eastern Nebraska, and it is pretty deep extending from 600-300 mb.

Question 5. What is the likely cause of the MPV_g minimum in the 700-300 mb layer across the southern end of the cross section?

Looks like a dry slot.

Question 6. Where is the smallest vertical separation between the maximum in frontogenesis and MPV_g minimum located?

The maximum in frontogenesis is at 750 mb and located over eastern Nebraska, while MPVg in the region is located in a layer between 600 and 300 mb.

Question 7. Where would the north and south extents of the heavy snow band likely occur? (Hint, examine the horizontal distance from the maximum frontogenesis at 600 mb to the northeast and at 900 mb to the southwest)

This question is purposely open-ended without much information to base your answer on. Our answers may no be the most correct. Based only on the cross section, we select the heaviest snow fall to occur from NE Kansas north to southeast South Dakota.

Question 8. Where, if anywhere, is the MPV_g minimized above the frontogenesis?

Panhandles of OK/TX: This is a dry slot so MPVg not valid and we can neglect this as a region of MPVg and frontogenetical coupling.
Western Iowa into northern Missoui appears to be the best answer.

Question 9. Based on your answer in #8, where do you expect the heaviest snowfall to occur and what is the primary forcing mechanism in that region?

Subjective. We like eastern South Dakota and the Missouri River Valley of Nebraska and Iowa, and southwest Iowa as the region where the heaviest snowfall will occur. Strong low level frontogenesis and low static stability above the frontogenesis is the primary forcing mechanism, although another correct answer would be to mention the addition of positive differential vorticity advectoin increasing with height across the same region.

Case #2—A different perspective

Question 10. Based on the shape of the circulation and pattern of the vertical motion streamlines, what would you infer about the static stability and inertial stability?

This question is extremely subjective and the answer in this key is not necessarily the only answer or even the most correct answer. Part of the problem is that the D2D ageostrophic circulation streamlines need to be taken with a grain of salt. There are indications of deep rising motion and thus strong instability in the northern part of this cross section. Compared to the March 15 event the rising motion due to ageostrophic circuations is shallow across much of the cross section, especially the southern half.

Question 11. Now overlay geostrophic momentum and saturated equivalent potential temperature. Does this agree with model's assessment in #11 of the vertical circulation and thus the inertial and static stability? Why or why not?

There is conditional instability all along the front and just above the frontal surface. This instability is deep. Momentum surfaces are not vertical, resulting in neutral conditions for CSI around 500 mb above Nebraska. To the north across South Dakota, a deep layer has neutral static stability so there is decent agreement with what the ageostrophic vertical circulation streamlines showed from #11.

Question 12. How does this compare with what you saw with momentum surfaces and saturated equivalent potential temperature regarding static stability?

Not surprising, MPVg is lowest in the conditionally unstable layer above the frontal zone and in the neutral CSI layer over South Dakota.

Question 13. Where is the strongest conditional or symmetric instability in this cross section? Is it deep?

There is deep conditional instability above the frontal zone across Nebraska and Kansas, and is also deep with neutral CSI conditions across South Dakota.

Question 14. Where do you see the potential for deep convection to develop?

Across eastern South Dakota and again across southeast Nebraksa and notheast Kansas.

Question 15. Where is the smallest vertical separation between the maximum in frontogenesis and MPV_g minimum located?

The frontogenesis fields are messy, especially across South Dakota. Although the frontogenesis is shallow, across Kansas and Nebraska there is a pretty good signature of MPVg above the shallow low level frontogenesis. In South Dakota, the frontogenesis field doesn't appear to be tied to a surface boundary and may be due to an elevated front. This frontogenesis is coincident with the minimum in MPVg. Would need to see more information to determine what is going on in South Dakota in terms of the relationship between MPVg and frontogenesis.

Question 16. Where would the north and south extents of the precipitation band likely occur?

This is a tough question and there really isn't a right or wrong answer. The heaviest precip is likely to occur across northeast Nebraska and western Iowa and across southeast South Dakota.

Question 17. Where, if anywhere, is the MPV_g minimized above the frontogenesis?

Northwest Kansas to southeast Nebraska

Question 18. Based on your answer to #18, where do you expect the heaviest precipitation to occur and what is the primary forcing mechanism in that region?

Southeastern Nebraska will see the heaviest precipitation. Very shallow frontogenesis, so the primary forcing mechanism will be convection due to the deep conditionally unstable layer above the frontal boundary.