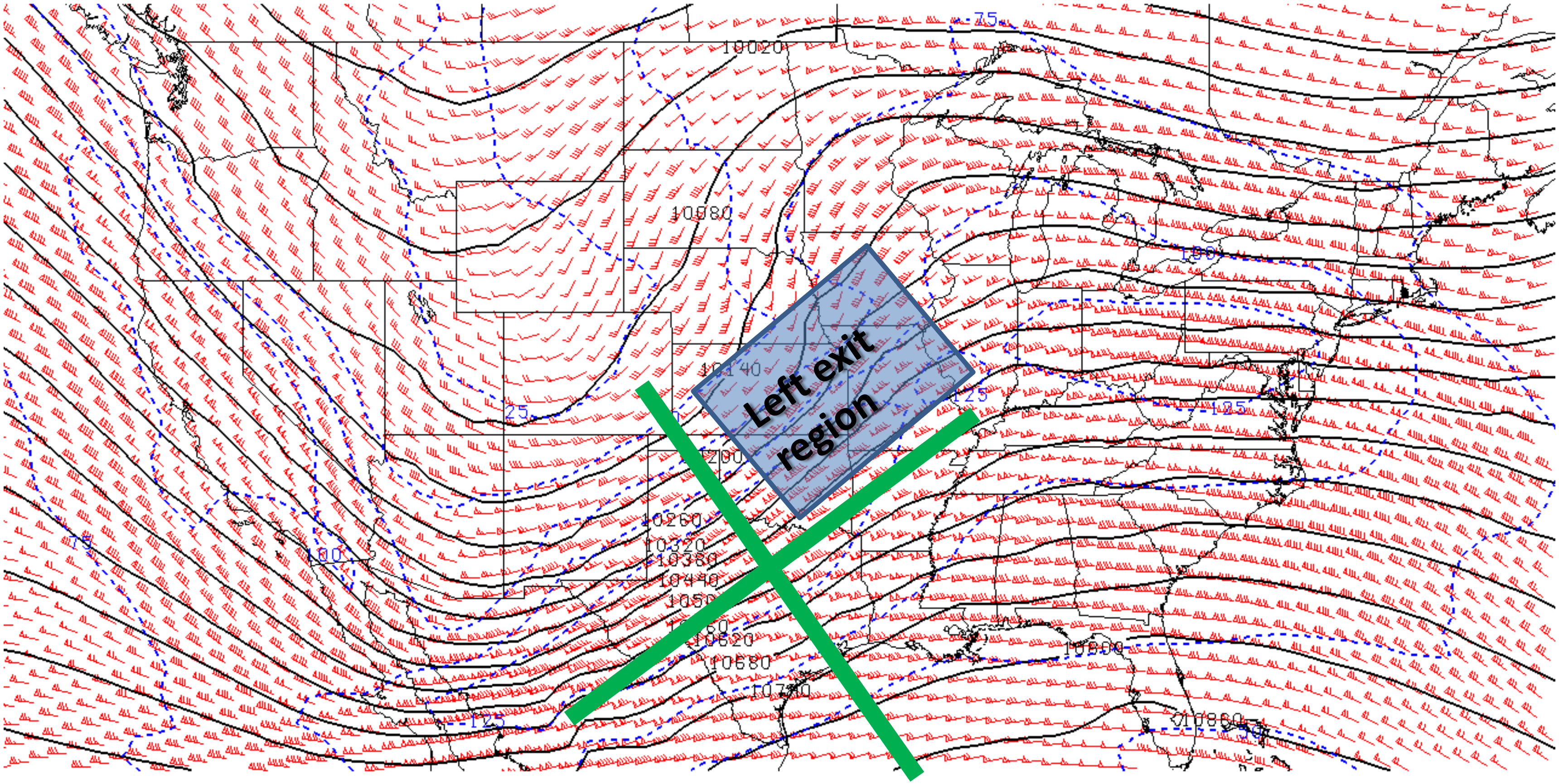
ATMO 574
Homework #2 Key
100 points Total

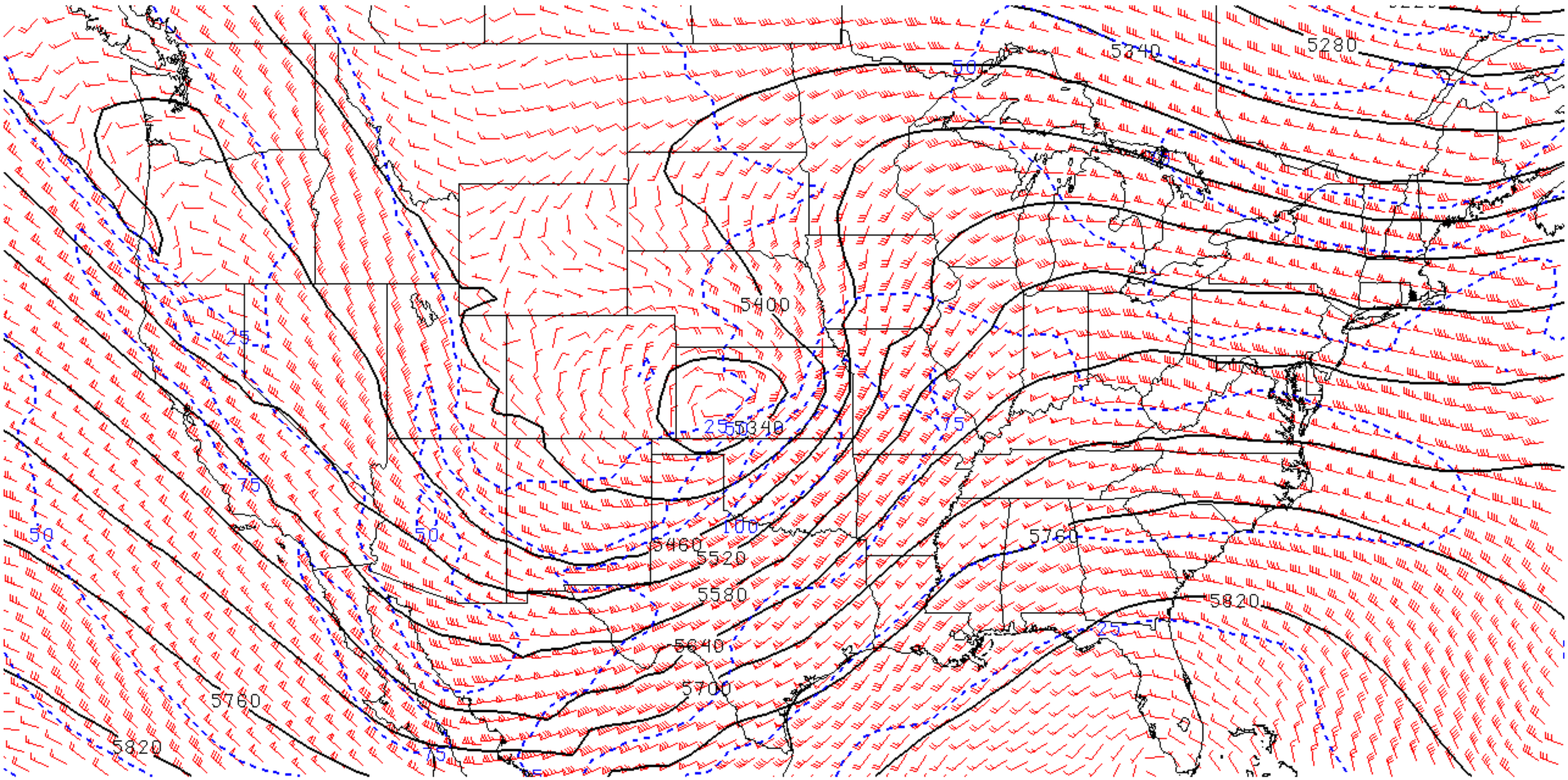
Part 1: Upper-air map plotting and discussion

25 points

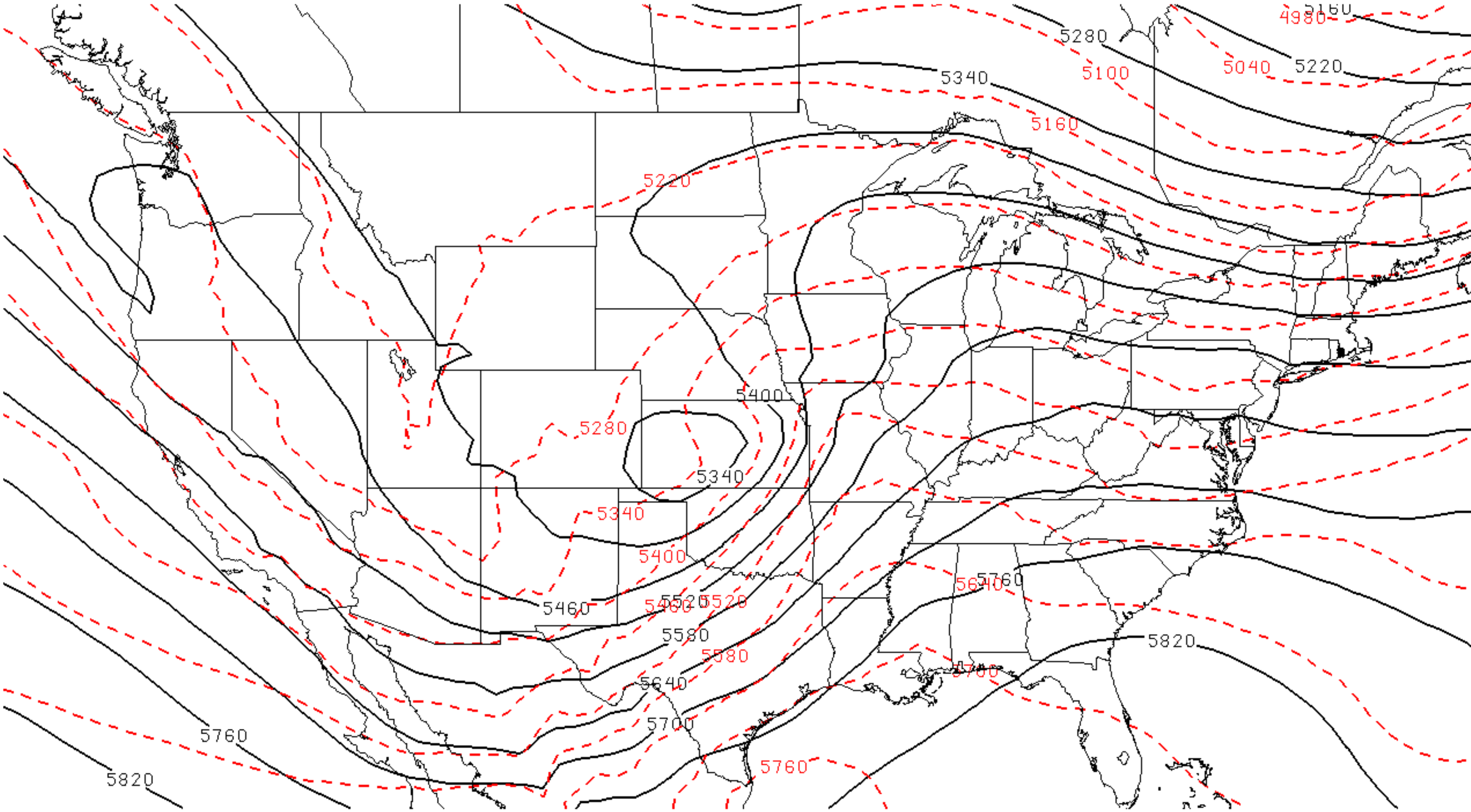
250-mb heights (m) and isotachs (kt)



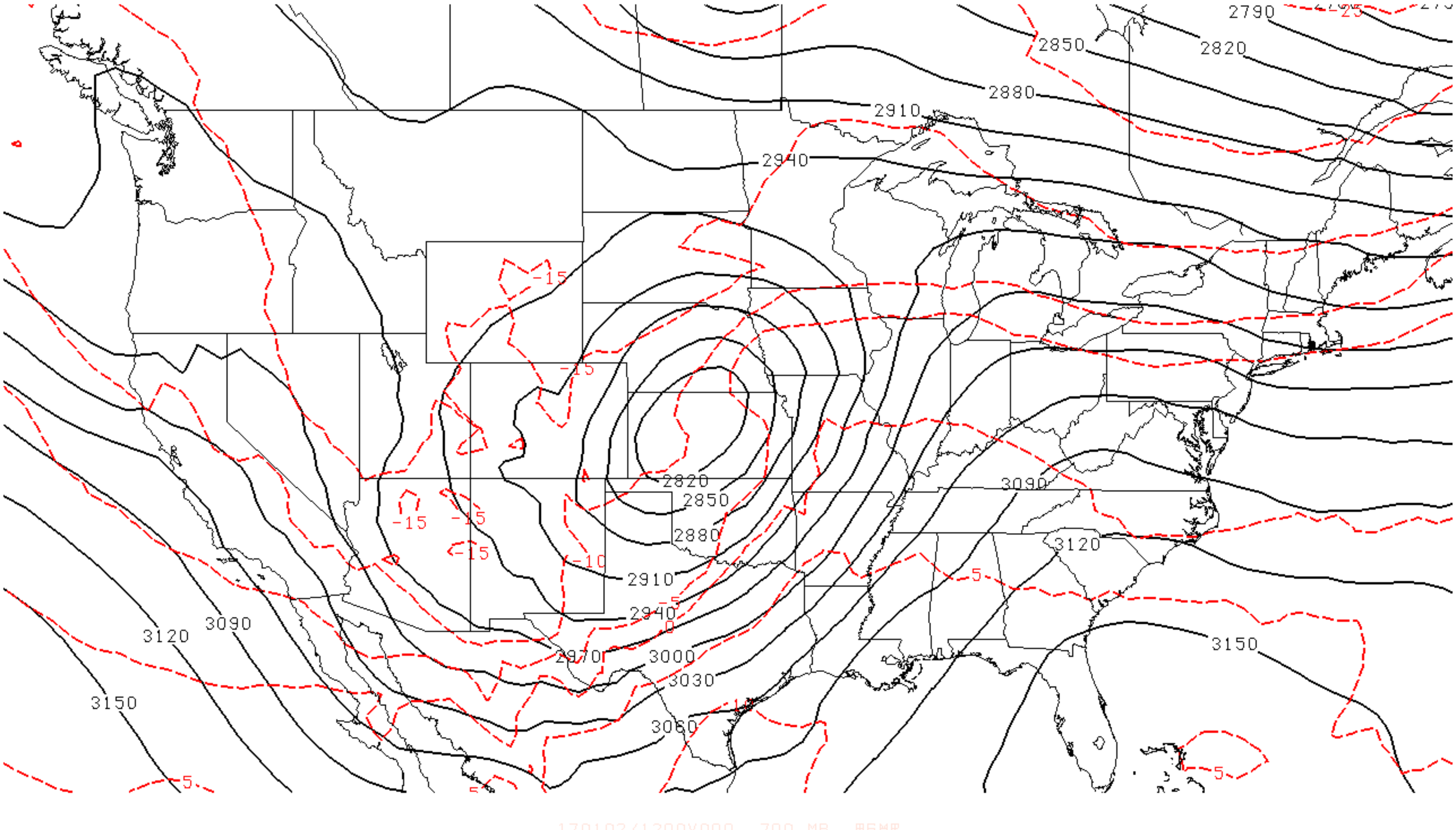
500-mb heights (m) and isotachs (kt)



500-mb heights (m)
1000 to 500-mb thickness (m)



700-mb heights (m) and temperature (°C)



Part 1: Summary points for discussion

Consistent with what we concluded earlier for HW #1, the upper-air analysis confirms that the mid-latitude cyclone is in a fully mature to advanced occluded stage of development. Still some baroclinicity evident by presence of temperature advection and (slight) westward tilt of the low.

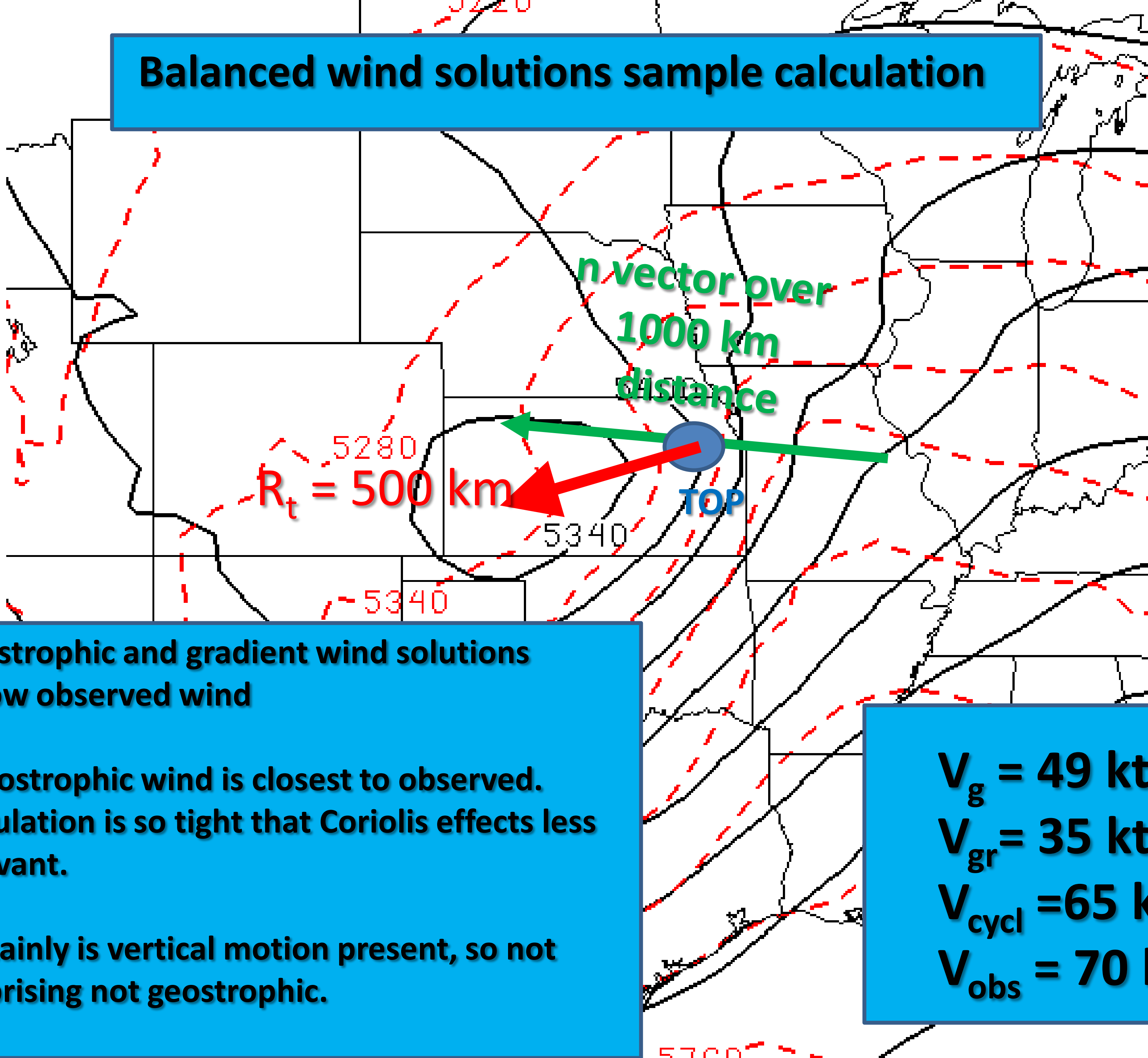
The upper-air trough tends to have a negative tilt, meaning it is tilting against the mean shear and able to import vorticity to intensify the strength of the eddy. This is characteristic of a very mature, strong mid-latitude cyclone.

There is evidence of a jet streak in the 250-mb analysis centered in central Texas with winds in excess of 125 kts. The location of the surface low and all the significant weather that merited watch, warning criteria (e.g. heavy snow in Nebraska) are located in the left exit region of the jet streak. This is favorable for cyclone development and weather because upward vertical motion is favored there in a thermally indirect transverse circulation.

Part 2: Hand calculations of balanced winds, thermal wind, and kinematic properties

25 points

Balanced wind solutions sample calculation



Geostrophic and gradient wind solutions below observed wind

Cyclostrophic wind is closest to observed. Circulation is so tight that Coriolis effects less relevant.

Certainly is vertical motion present, so not surprising not geostrophic.

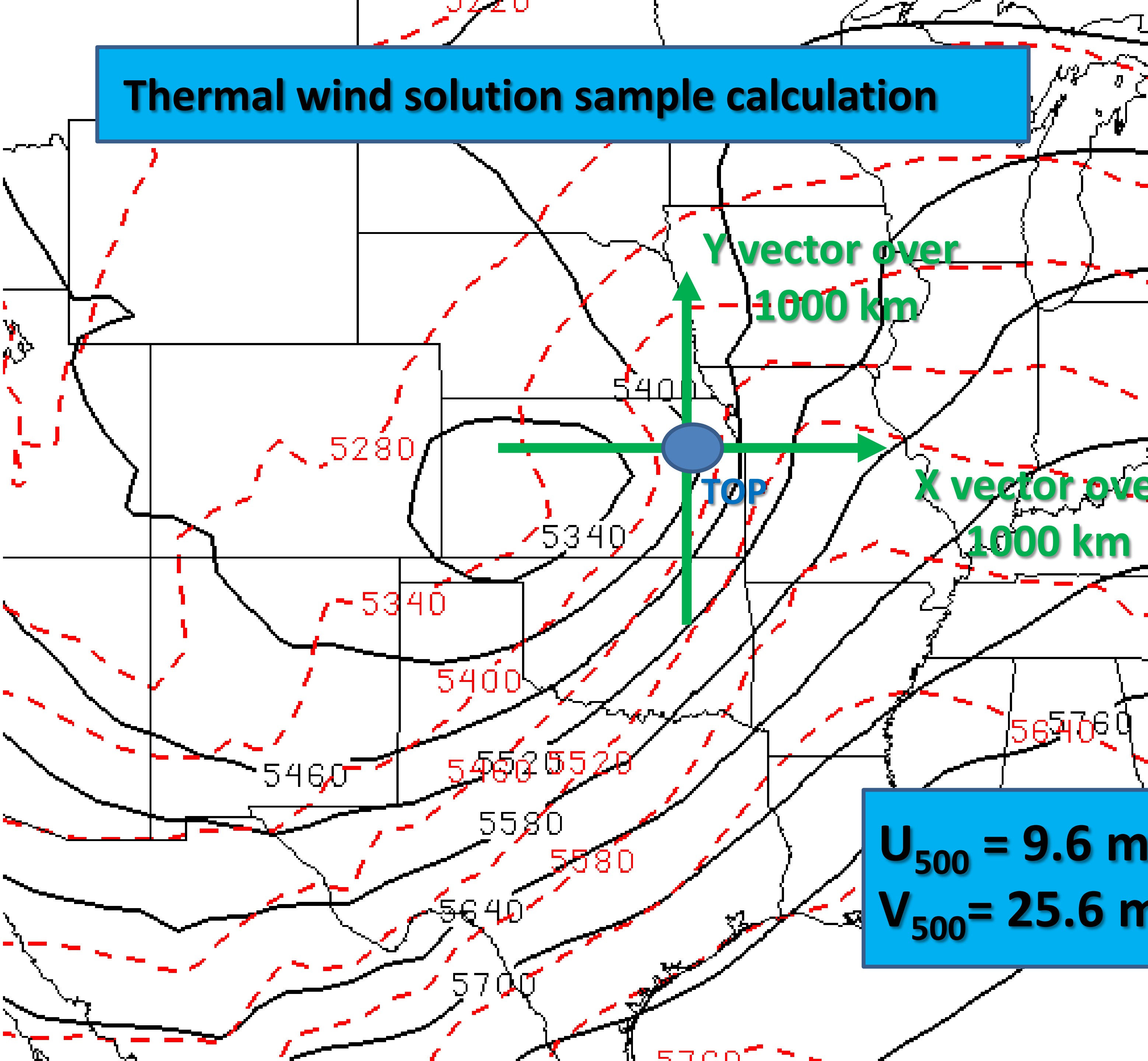
V_g = 49 kts

V_{gr} = 35 kts

V_{cycl} =65 kts

V_{obs} = 70 kts

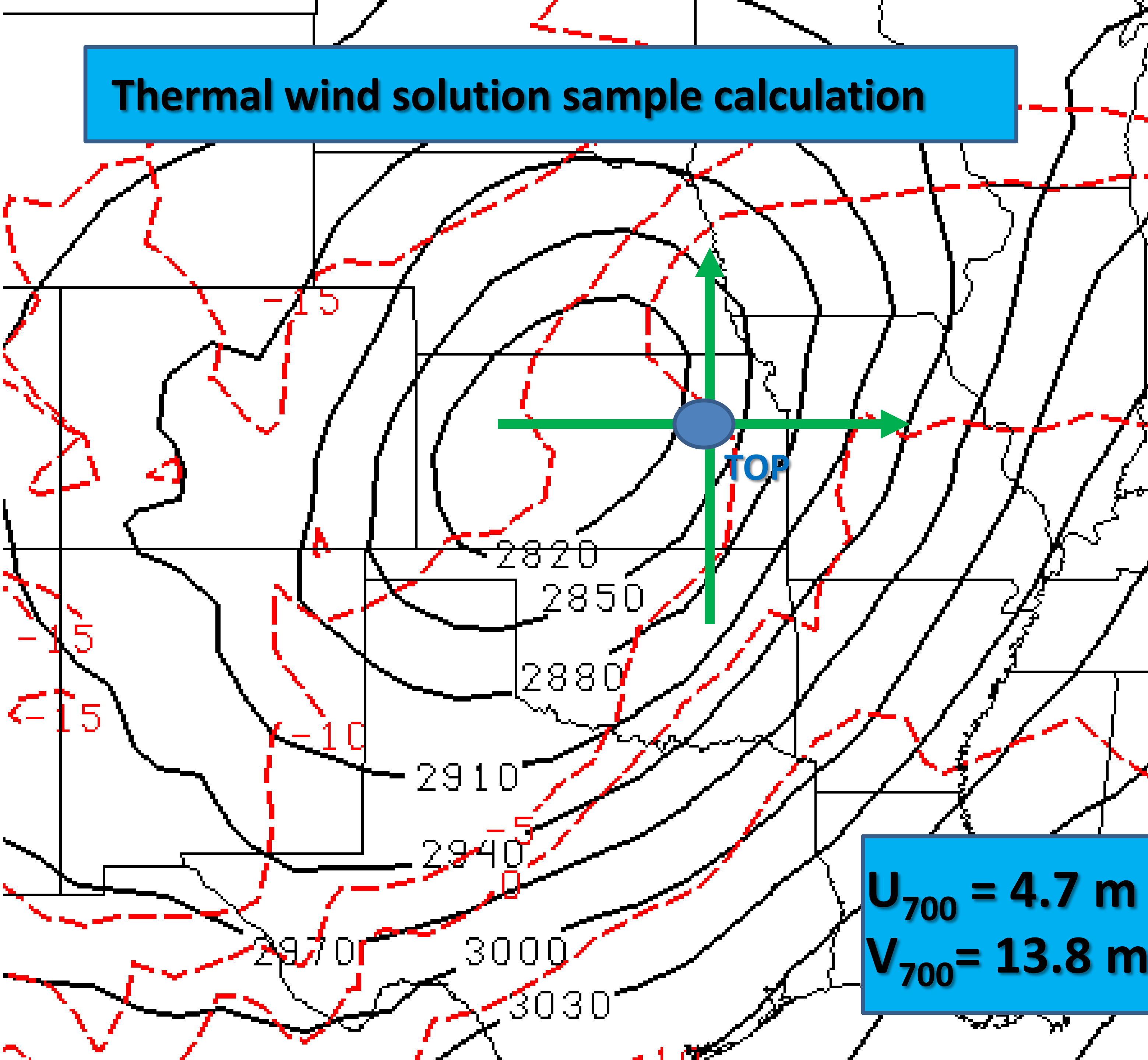
Thermal wind solution sample calculation



$U_{500} = 9.6 \text{ m s}^{-1}$

$V_{500} = 25.6 \text{ m s}^{-1}$

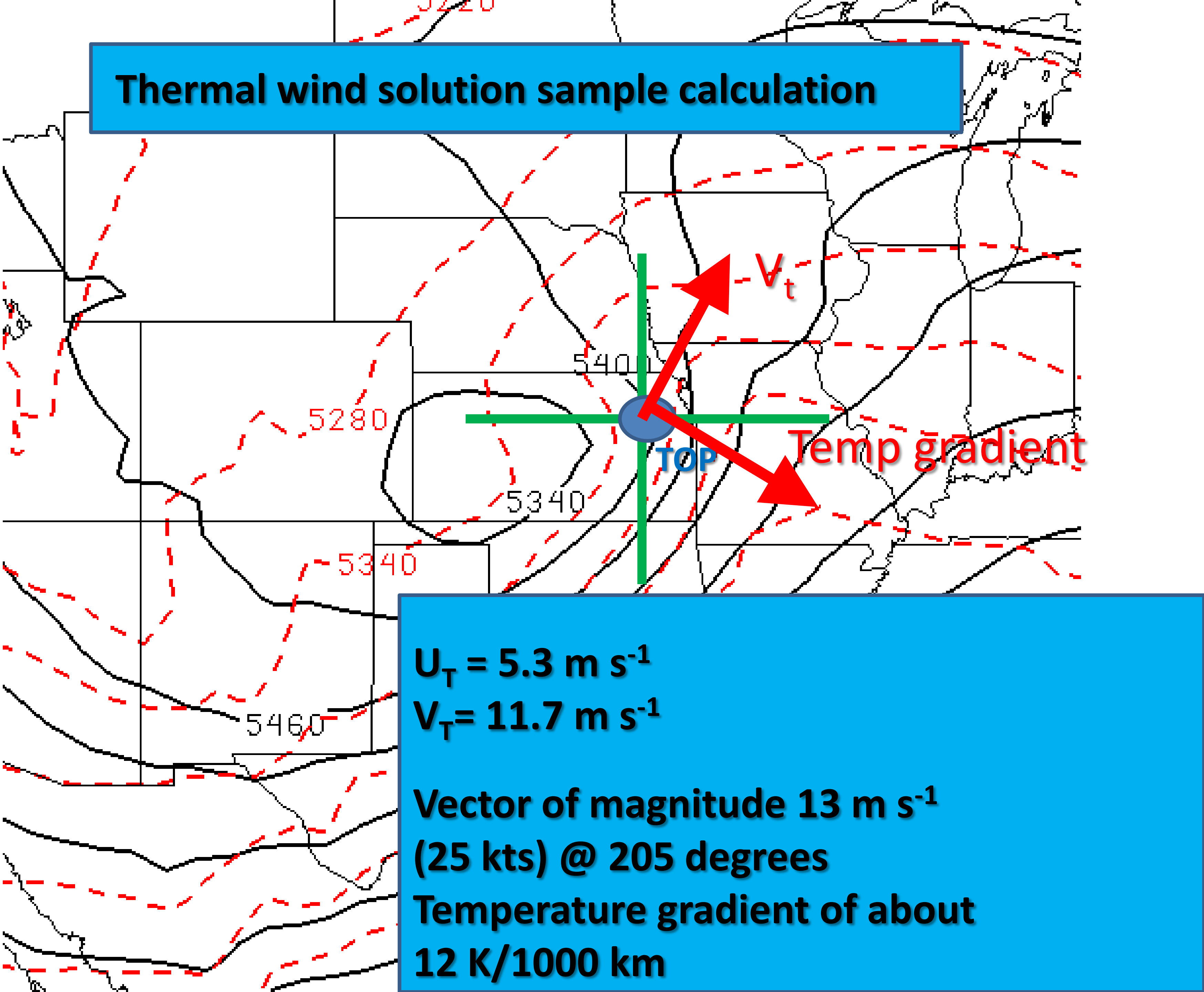
Thermal wind solution sample calculation



$U_{700} = 4.7 \text{ m s}^{-1}$

$V_{700} = 13.8 \text{ m s}^{-1}$

Thermal wind solution sample calculation

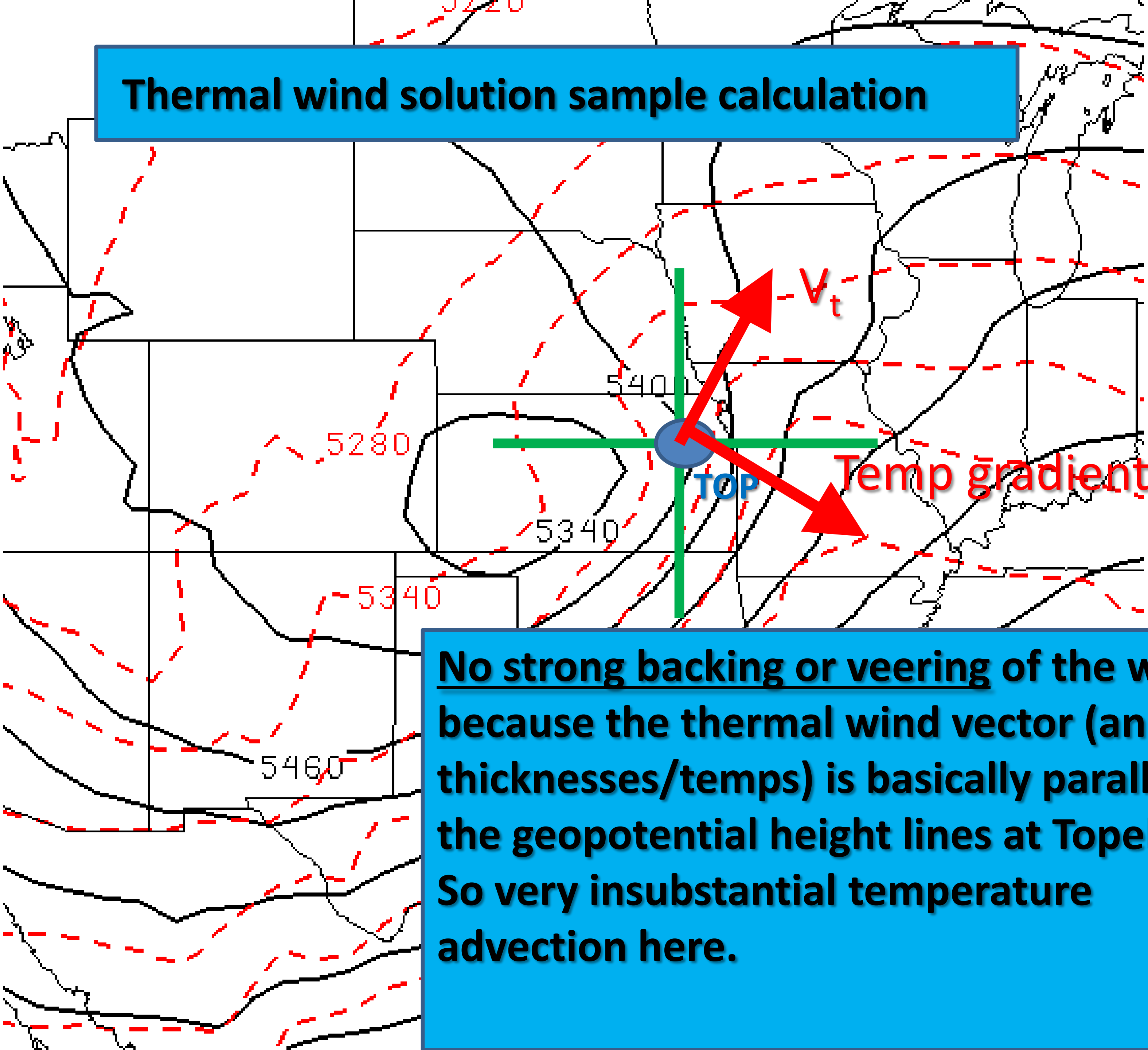


U_T = 5.3 m s^{-1}
V_T = 11.7 m s^{-1}

Vector of magnitude 13 m s^{-1} (25 kts) @ 205 degrees

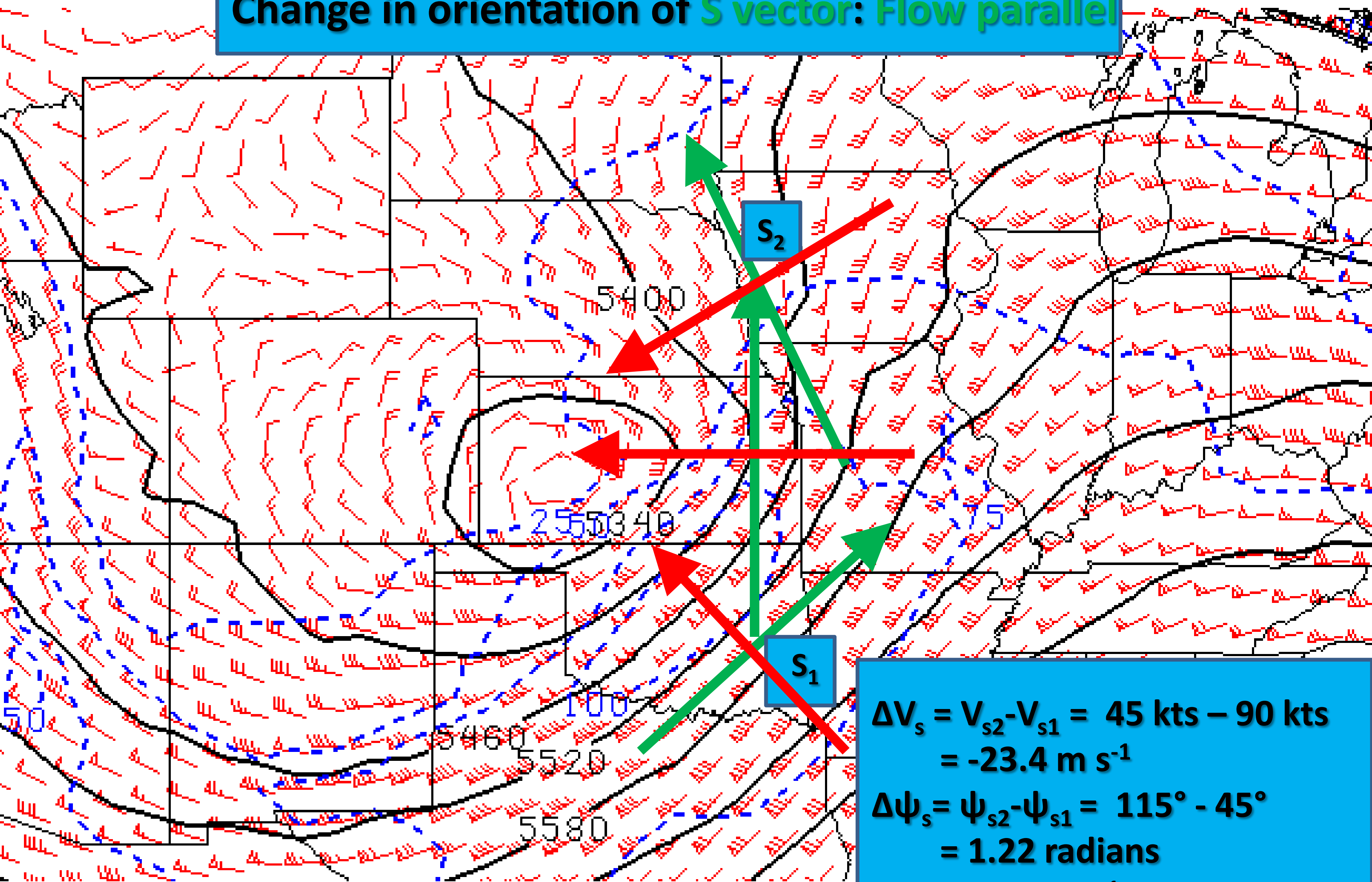
Temperature gradient of about 12 K/1000 km

Thermal wind solution sample calculation



<u>No strong backing or veering</u> of the wind because the thermal wind vector (and thicknesses/temps) is basically parallel to the geopotential height lines at Topeka. So very insubstantial temperature advection here.

Change in orientation of S vector: Flow parallel



$\Delta V_s = V_{s2} - V_{s1} = $ 45 kts – 90 kts

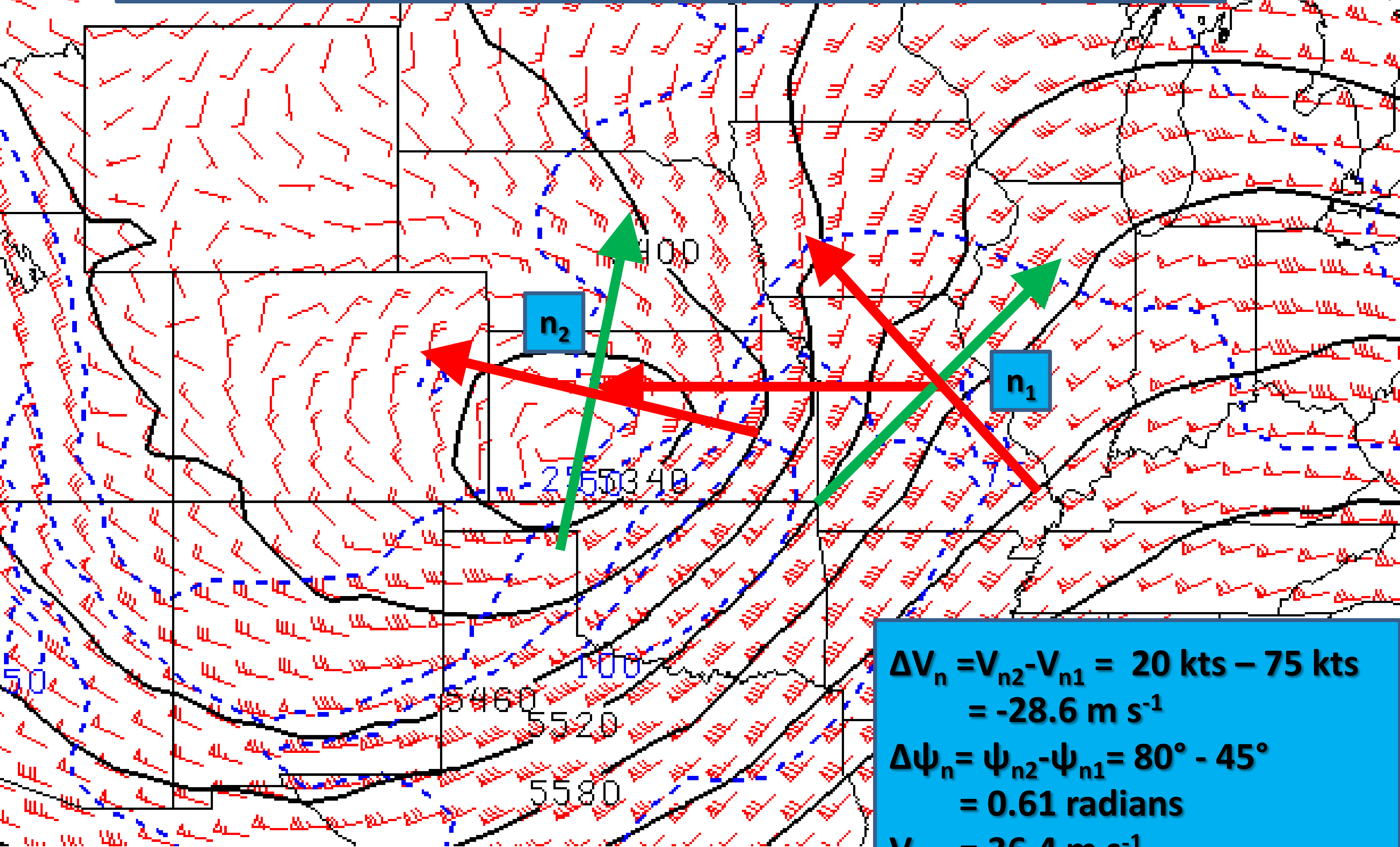
$= -23.4 \text{ m s}^{-1}$

$\Delta\psi_s = \psi_{s2} - \psi_{s1} = 115° - 45°$

$= 1.22$ radians

$V_{Top} = 36.4 \text{ m s}^{-1}$

Change in orientation of n vector: flow perpendicular



$\Delta V_n = V_{n2} - V_{n1} =$ 20 kts – 75 kts

$= -28.6\ \mathrm{m\ s^{-1}}$

$\Delta\psi_n = \psi_{n2} - \psi_{n1} = 80° - 45°$

$= 0.61$ radians

$V_{Top} = 36.4\ \mathrm{m\ s^{-1}}$

Sample results for kinematic quantities (10^{-5} s^{-1})

Shear: 2.86
Curvature: 4.45
Vorticity: 7.31

Flow has positive curvature which is greatest contributor to positive (cyclonic vorticity)

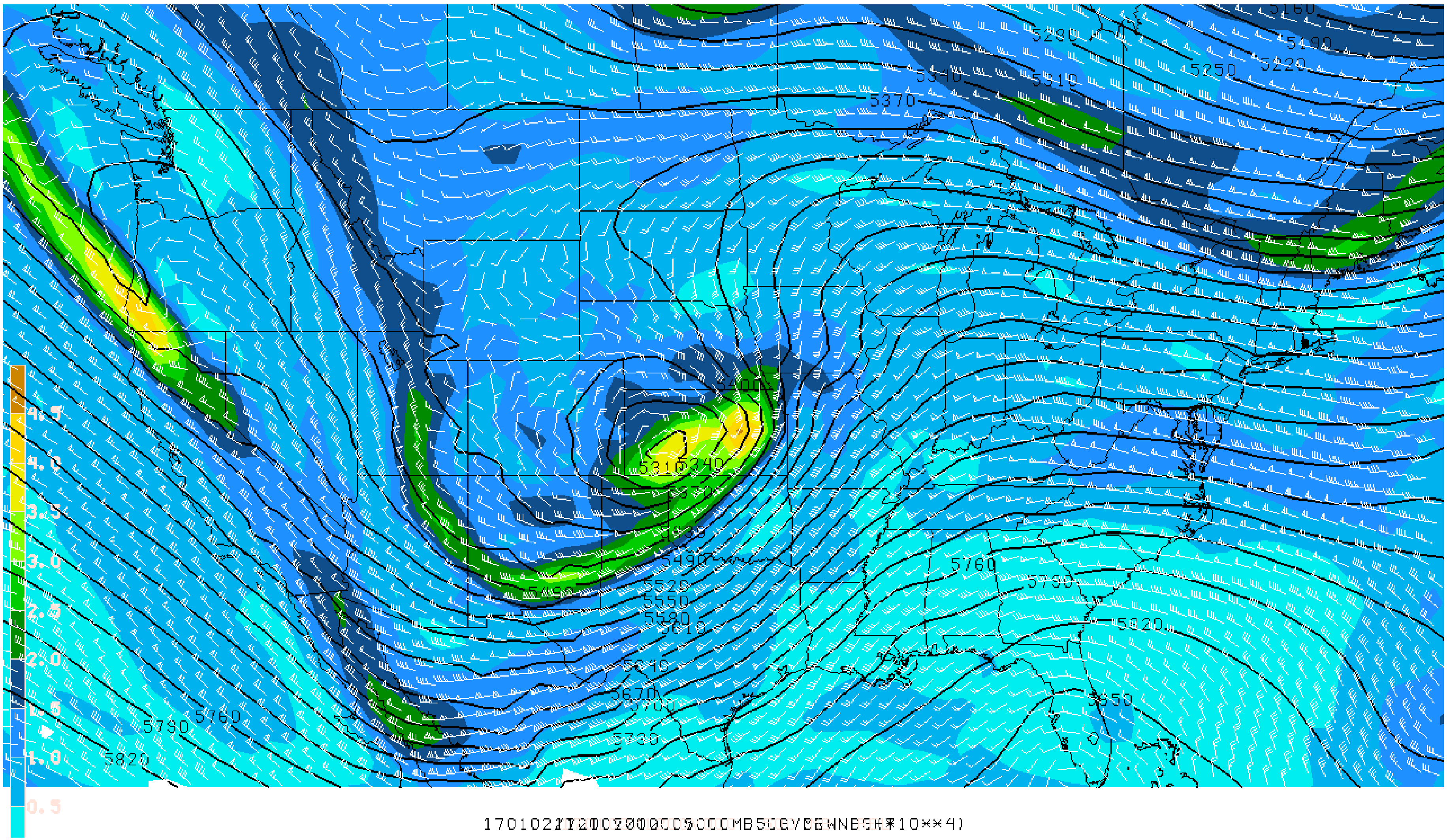
Diffluence: 2.27
Stretching: -2.34
Divergence: -0.16

Flow is diffluent but negative stretching, so divergence is less in magnitude than vorticity.

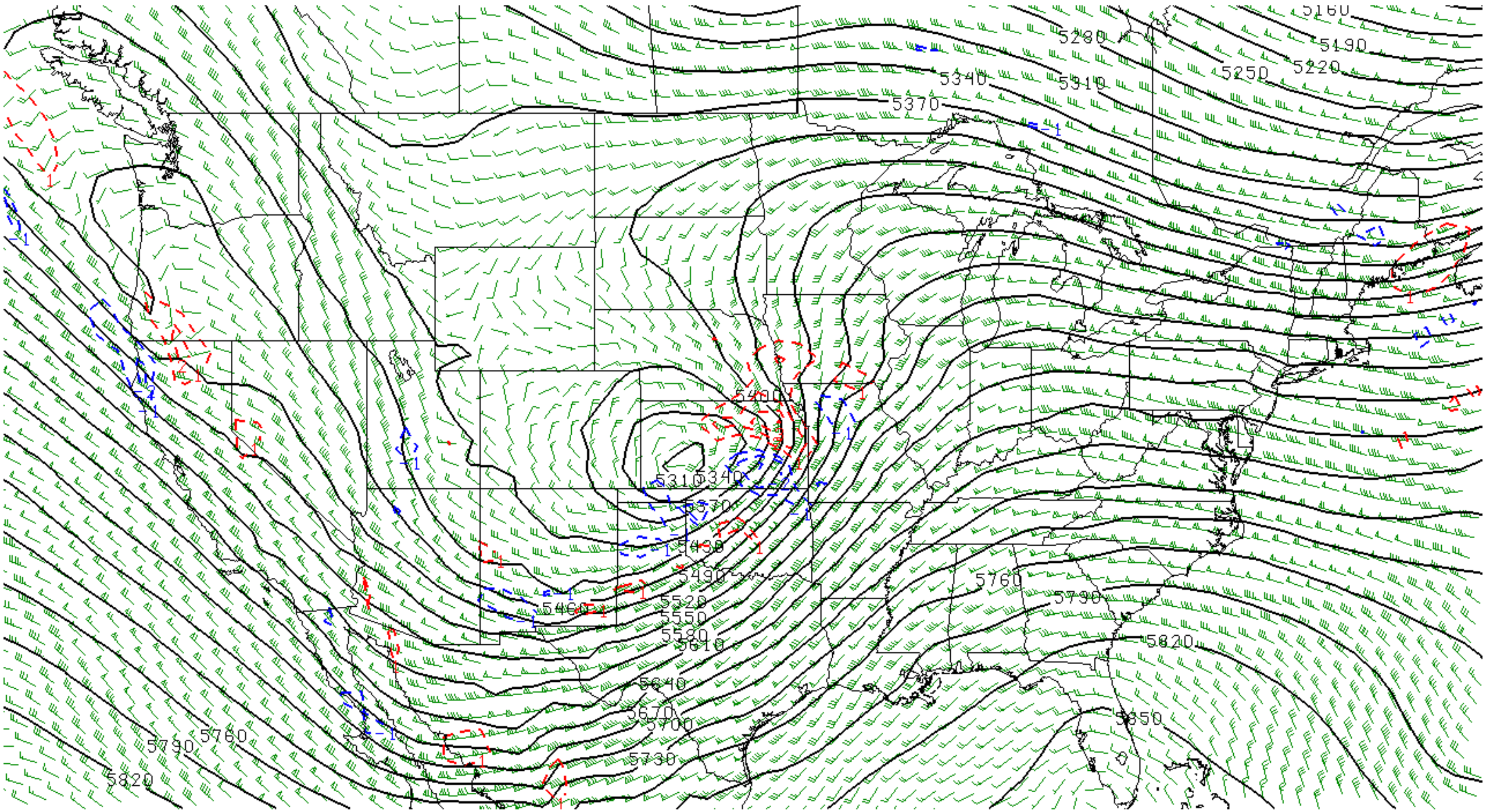
Part 3: Analysis of terms in QG-omega equation from GEMPAK maps

25 points

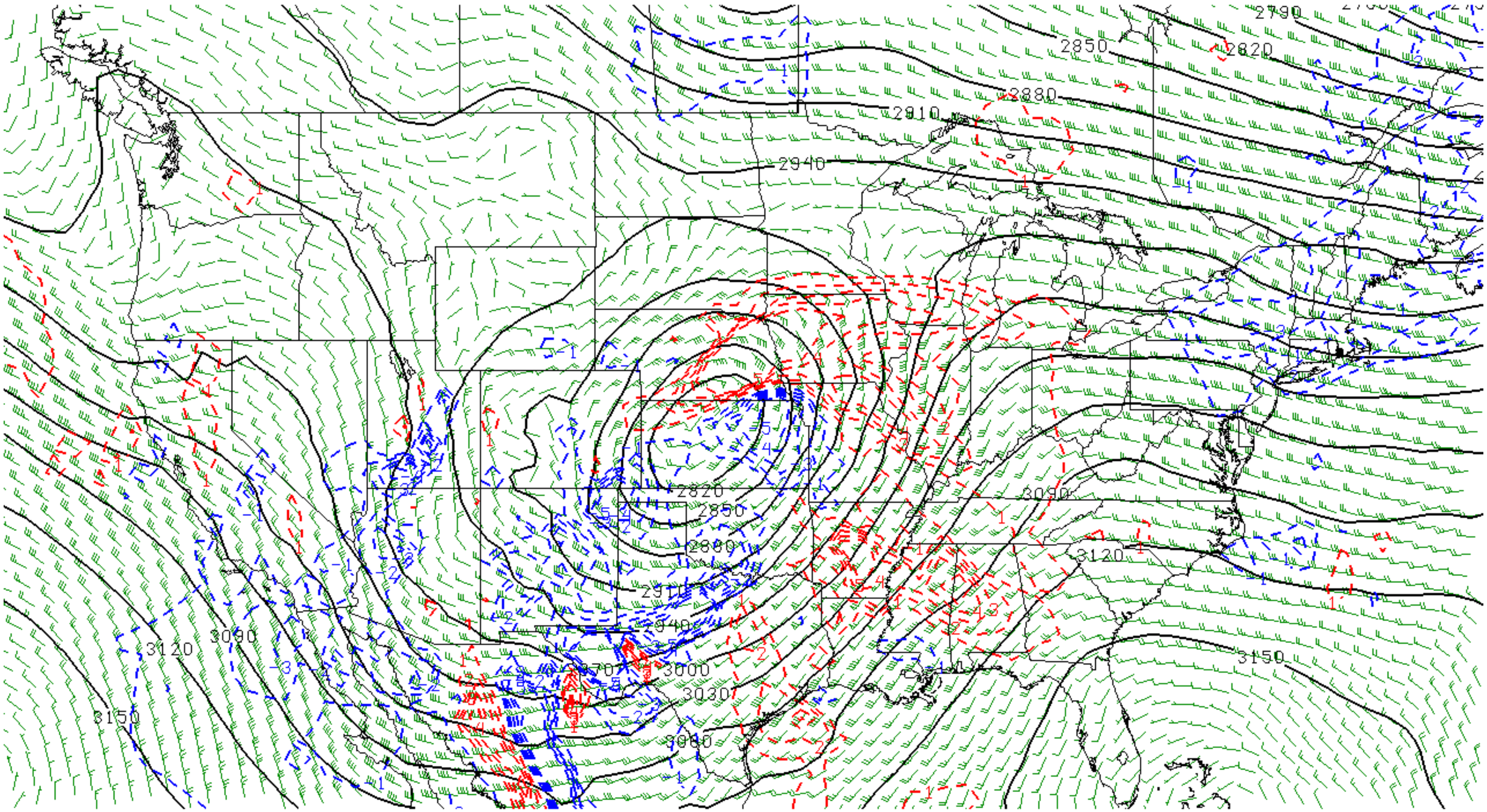
500-mb Vorticity



500-mb Vorticity Advection



700-mb Temperature Advection



170102/1200V000 700MB ADVTMBKUBBBT(*10**4)

Part 3: Summary points for discussion

Strongest PVA to the north and east of the upper-level low in northeast Kansas, southwest Nebraska. Strongest NVA just south of that.

Strongest WAA advection in the vicinity of where heaviest precipitation is observed in Nebraska.

Where WAA, PVA coincide in southeastern Nebraska corresponds to where most significant weather is occurring in relation to this mid-latitude cyclone. Recall the "worst'' weather occurring at Offutt AFB (thundersnow)

Coinciding CAA, NVA correspond to the dry slot area wrapping around the surface low.

Overall, the QG approach works well here in terms of correspondence of significant weather and synoptic scale upward vertical motion.

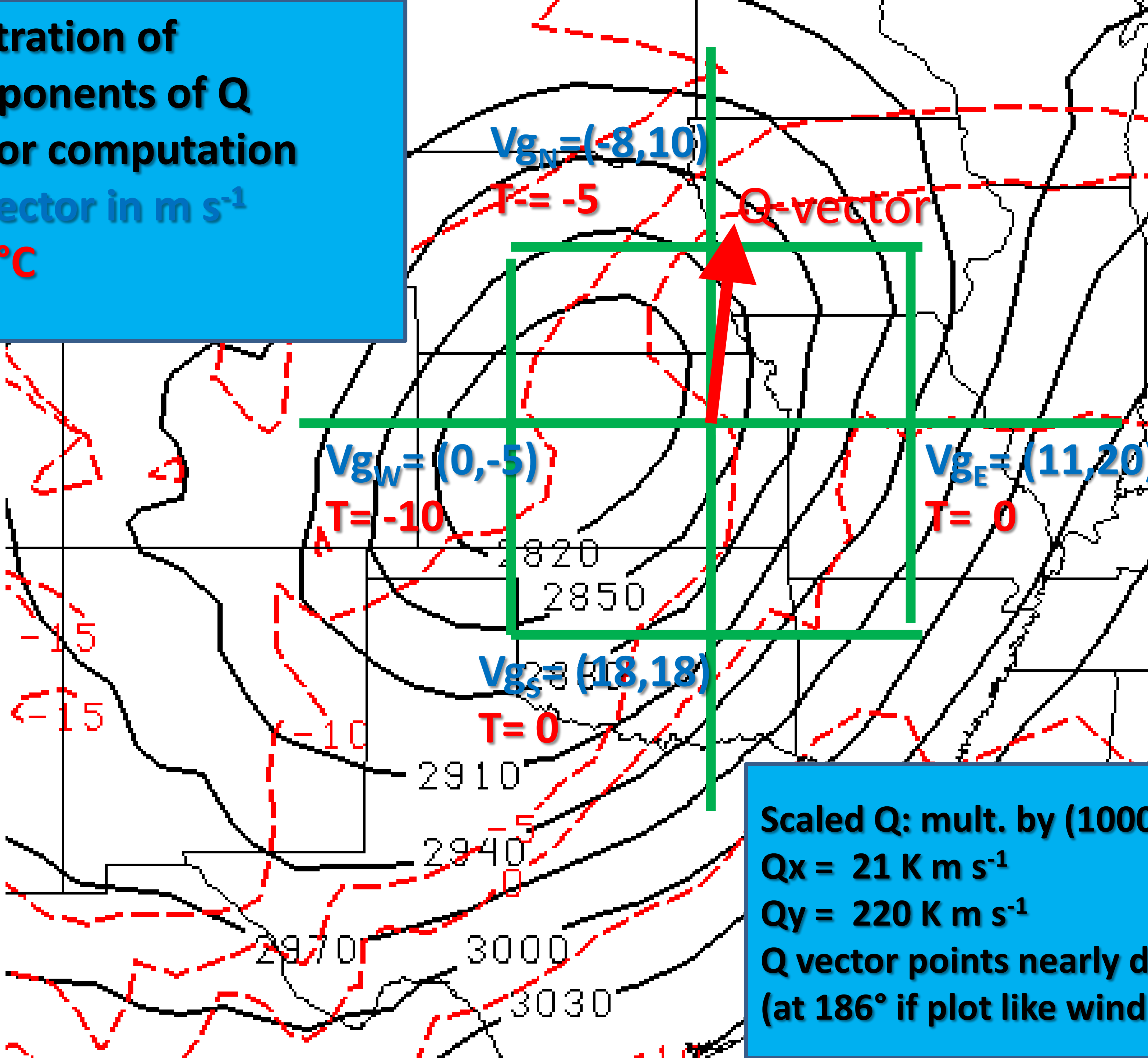
Part 4: Analysis of Q-vector

25 points

Illustration of components of Q vector computation

Vg vector in m s^{-1}

T in °C



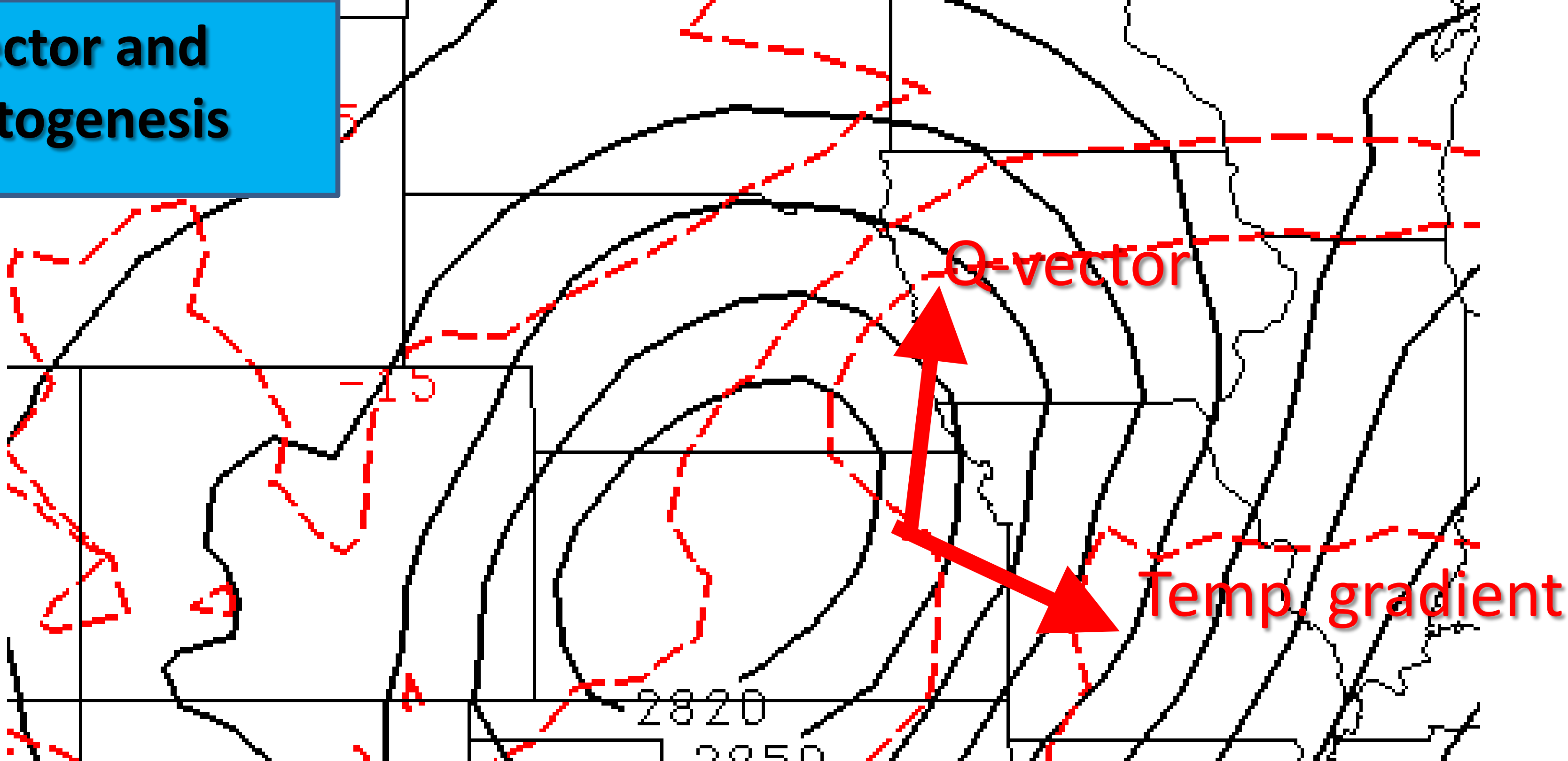
Scaled Q: mult. by $(1000\ km)^2$

Qx = 21 K m s^{-1}

Qy = 220 K m s^{-1}

Q vector points nearly due (at 186° if plot like wind barb)

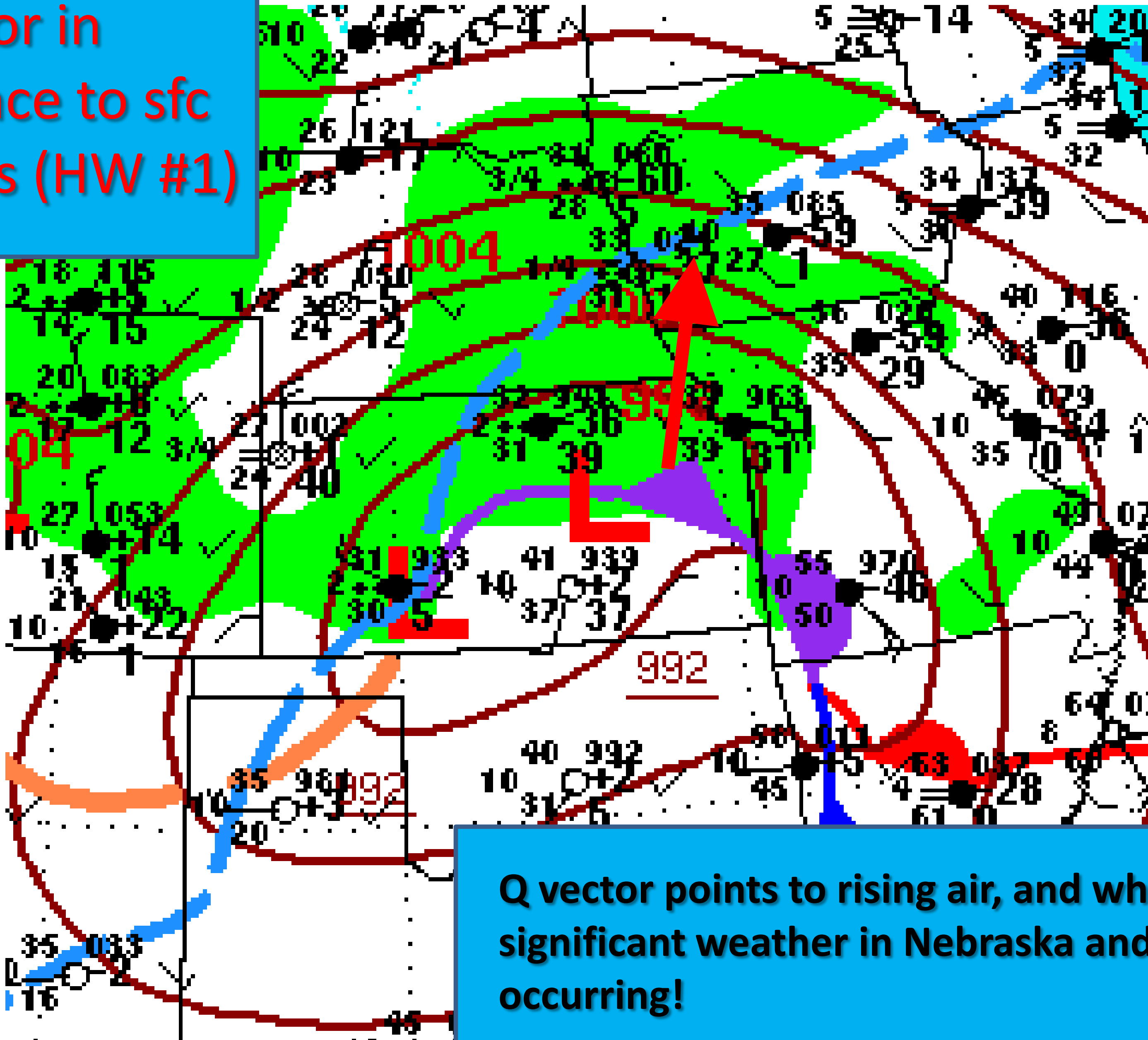
Q vector and frontogenesis



At least at Topeka, the calculated orientation of the Q vector is basically out of phase with the orientation of the temperature gradient in the y direction (from the earlier thermal wind analysis).

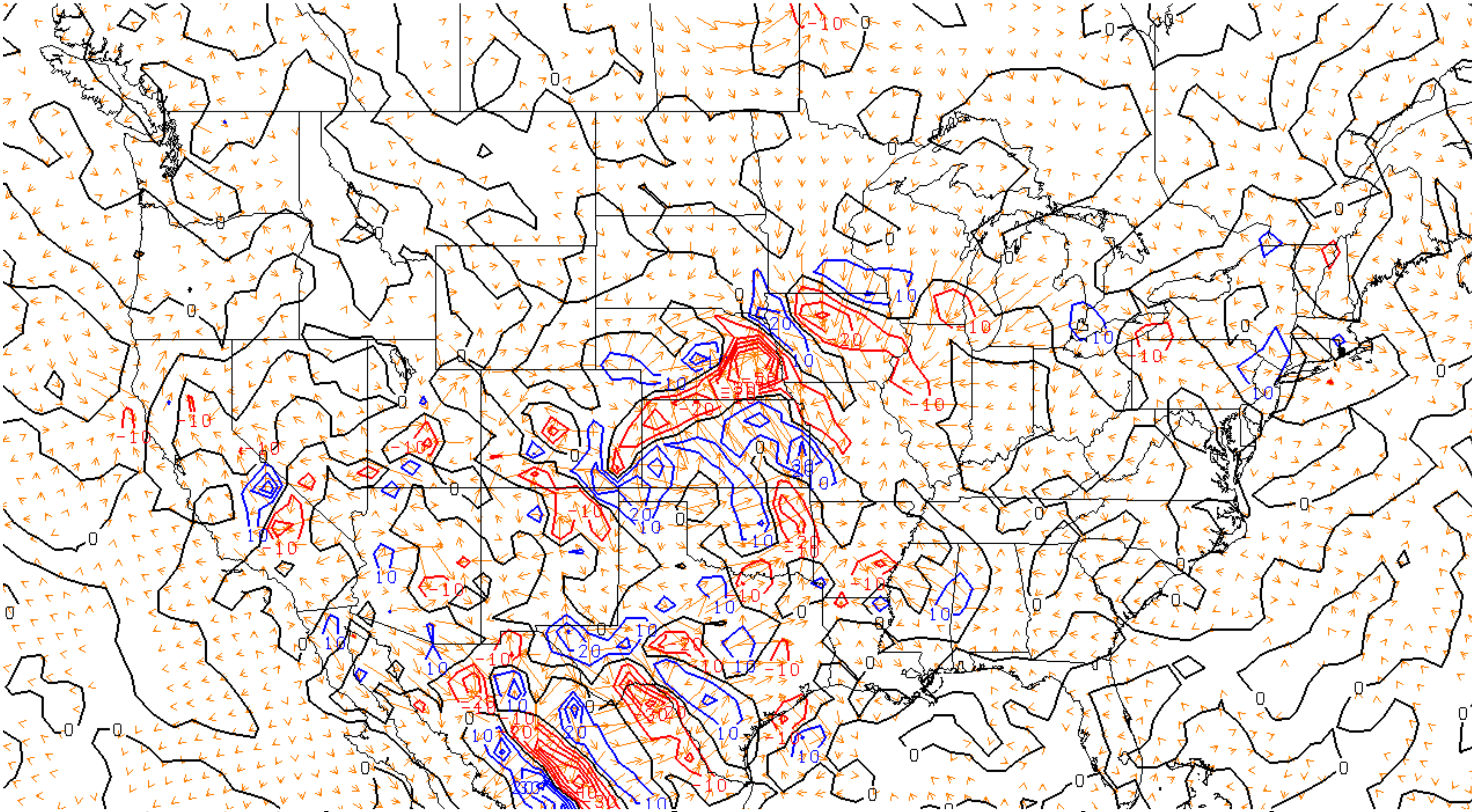
Therefore the effect of the geostrophic advection of temperature is frontolytic at this location, tending to weaken the temperature gradient. The compensating ageostrophic circulation is thermally indirect, with cold air rising where it relatively colder, sinking where warmer.

Q-vector in reference to sfc analysis (HW #1)

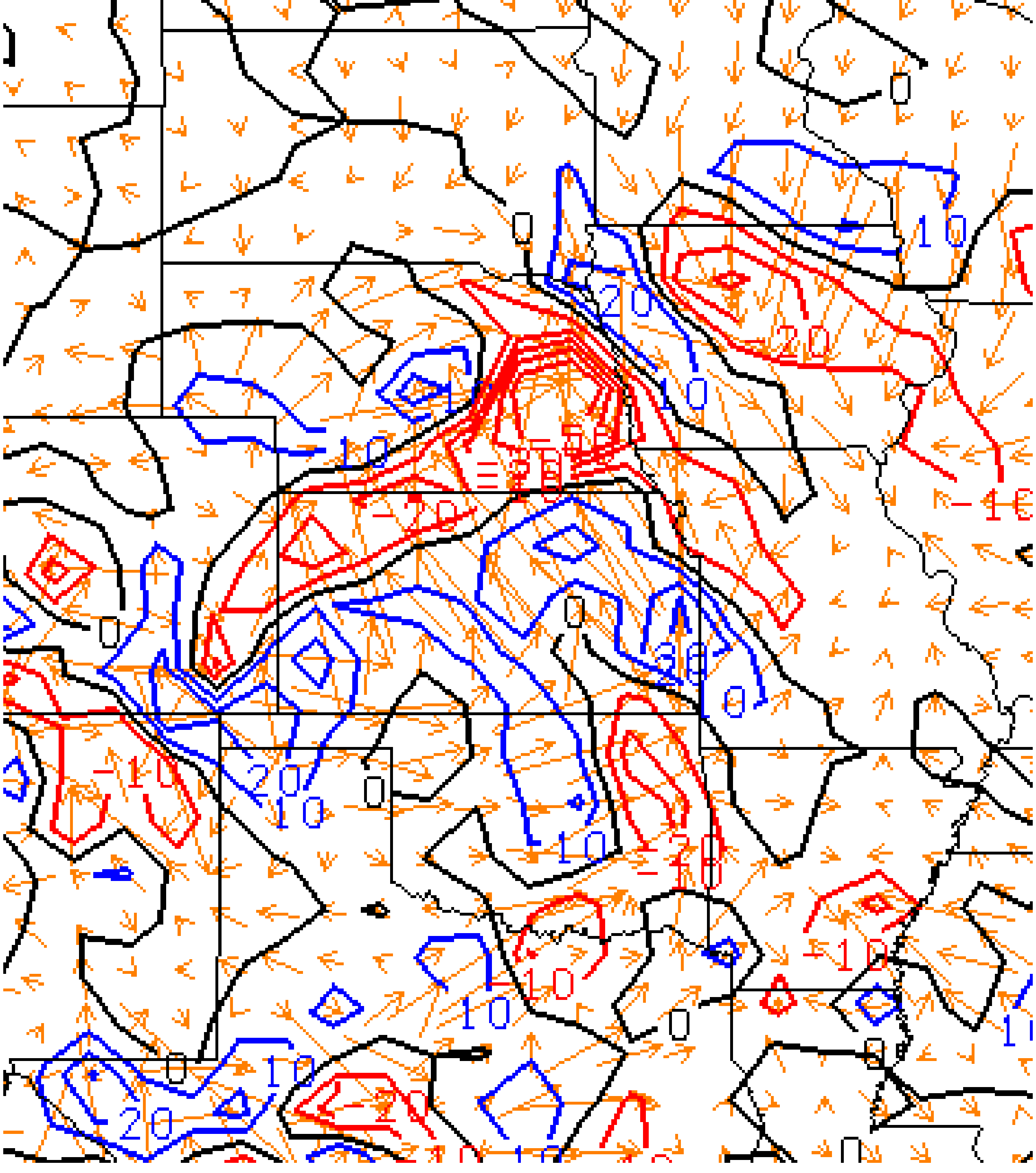


Q vector points to rising air, and where most significant weather in Nebraska and Iowa is occurring!

GEMPAK Q Vector Analysis: Extra credit



Basic point is that strongest areas of convergence correspond to areas where heaviest precipitation occurring. Needed to additional comment on strengths, weaknesses of Q vectors vs. QG omega for full credit.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