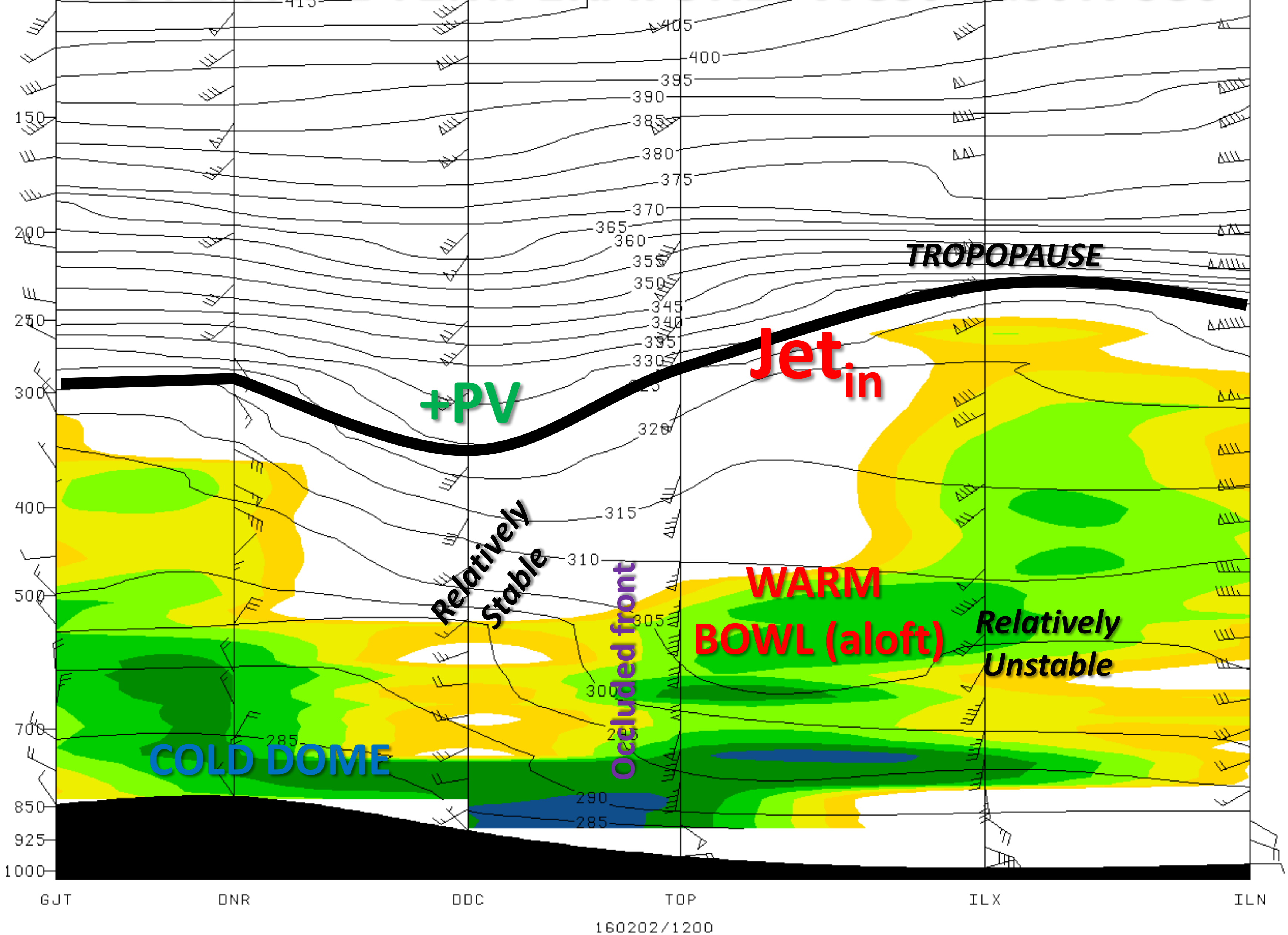
ATMO 574
Homework #3 Key
100 points Total

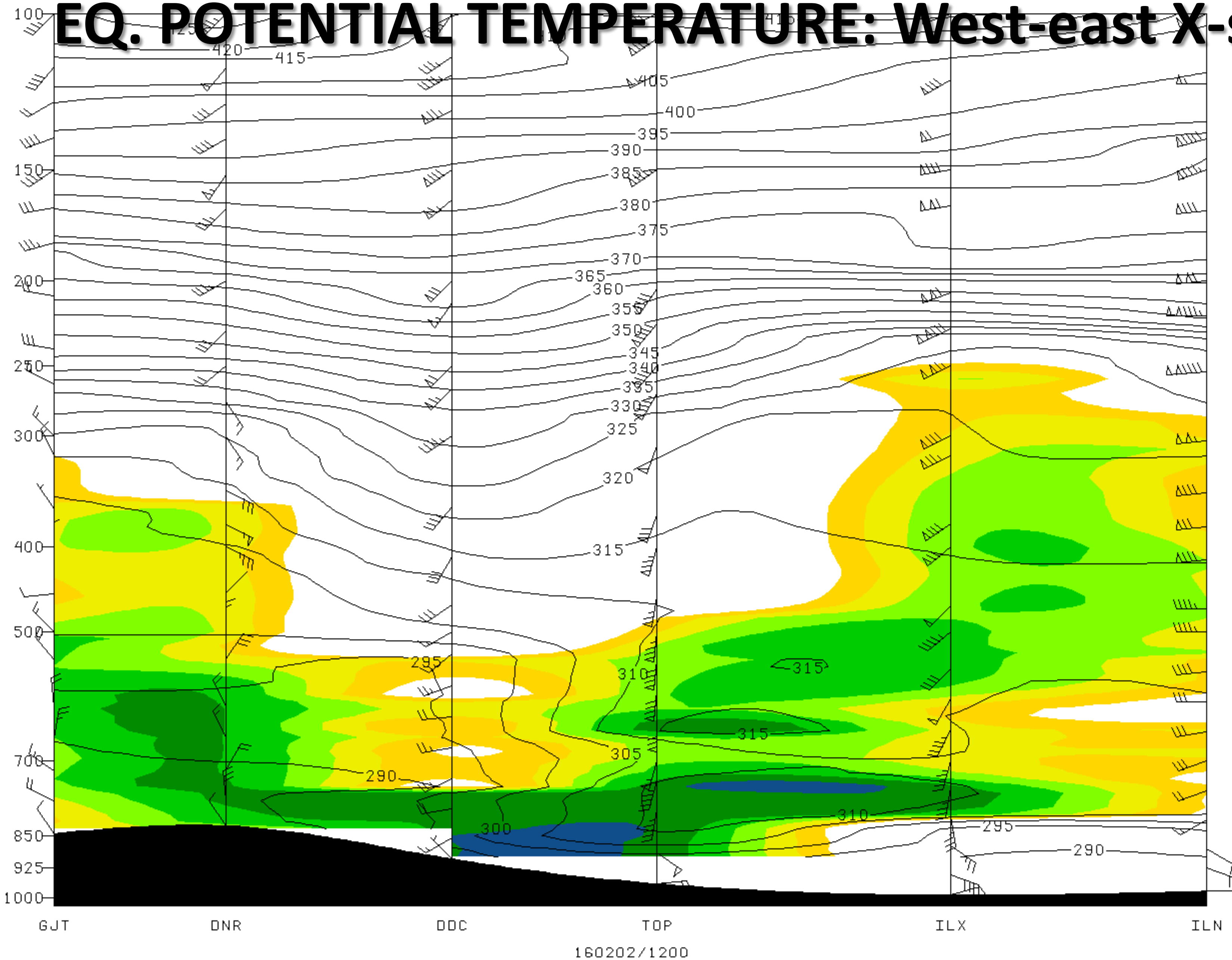
Part 1: Zonal and Meridional Cross Sections

Maps: 10 points
Discussion: 10 points

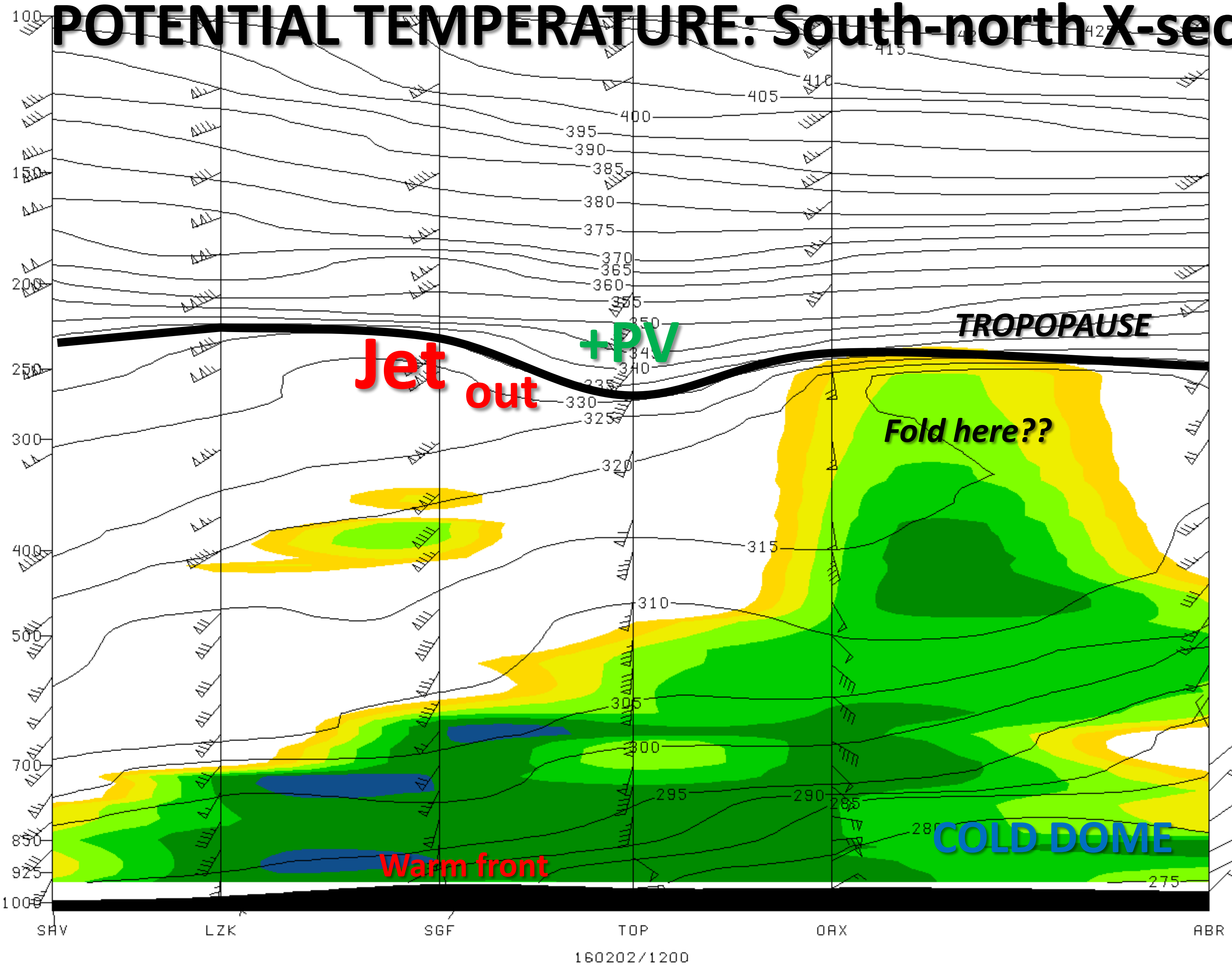
POTENTIAL TEMPERATURE: West-east X-sec



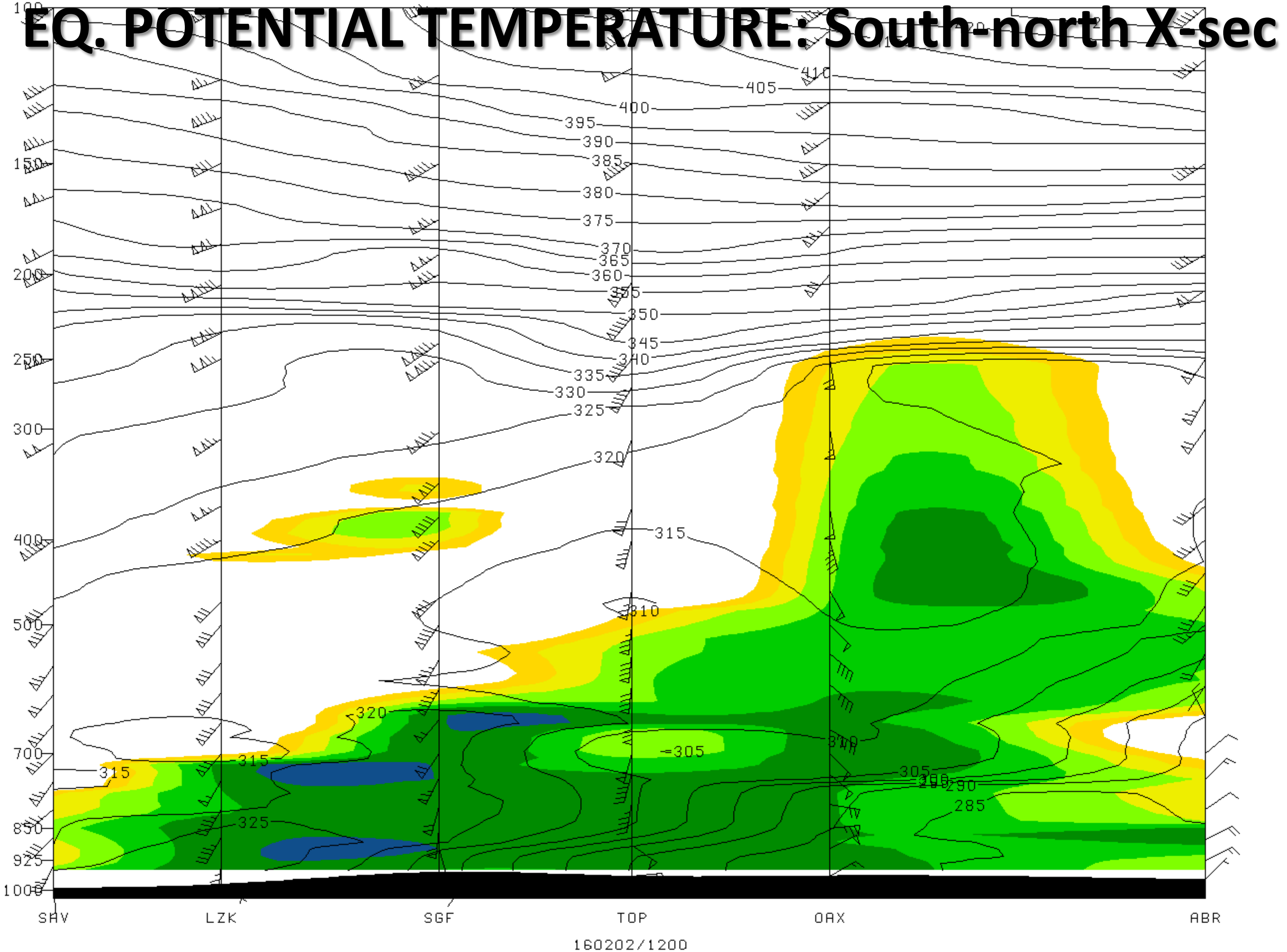
EQ. POTENTIAL TEMPERATURE: West-east X-sec



POTENTIAL TEMPERATURE: South-north X-sec



EQ. POTENTIAL TEMPERATURE: South-north X-sec



Discussion points: Zonal Cross Section

Cold dome located behind the occluded front. Warm bowl (aloft) ahead. This is referred to as trough of warm air aloft (TROWAL). The front aloft where the isentropes slope down does not reach the surface in W-E cross section.

Jet stream located between TOP and ILX, about where upper-air wind maxima would be expected from isotach analysis on HW#2 and where the tropopause is steeply sloped.

Generally speaking the horizontal gradients are larger in θ_e field than θ field, especially in the vicinity of occlusion. These steeper gradients would suggest even an stronger magnitude of downward vertical motion in Kansas west of the occluded front (katafront)

Tropopause located below 300-mb in vicinity of upper low. Goes up to 250-mb to east of the surface low where air is warmer.

Upper-level positive PV anomaly where the upper-level low is located at DDC. Compacting isentropes below in troposphere and expanding above in stratosphere.

No obvious indication of tropopause folding, but that is very hard to say given the resolution of the data.

Discussion points: Meridional cross section

Warm front is indicated on this cross section where the isentropes are closely packed near the surface near Springfield, MO. This is about where the warm front was analyzed on HW #1.

Upward motion indicated throughout the troposphere through slope of the isentropes (anafront)

Large region of overrunning and deep moisture north of warm front.

Tropopause about 200-300-mb, with some indication of positive PV anomaly near Topeka where the upper-level low is.

Similar to zonal cross section, the horizontal gradients are larger in θ_e field than θ field, where there is moisture and (in this case) overrunning. Note that the most enhanced upward vertical motion suggested by θ_e field is between TOP and OAX, precisely where the most significant weather (heavy snow) is observed.

Tropopause folding in the vicinity of where heavy snow observed??

Part 2: Adiabatic vertical motion calculations in cross sections

40 points

Zonal Cross Section: Sample calculations

Station

	U ($m\ s^{-1}$)	Grad T ($K\ m^{-1} \times 10^{-5}$)	$-d\theta/dp$ ($K\ Pa^{-1} \times 10^{-4}$)	ω ($Pa\ s^{-1} \times 10^{-1}$)	w ($cm\ s^{-1}$)
DNR	-5.0	0.2	4.5	**-0.2**	**0.2**
DDC	11.0	1.2	3.0	**4.4**	**-4.8**
TOP	7.9	0.8	6.5	**0.9**	**-1.0**
ILX	4.0	0	5.0	**0**	**0**

Meridional Cross Section: Sample calculations

Station

	V ($m\ s^{-1}$)	**Grad T ($K\ m^{-1} \times 10^{-5}$)**	**-dθ/dp ($K\ Pa^{-1} \times 10^{-4}$)**	**ω ($Pa\ s^{-1} \times 10^{-1}$)**	**w ($cm\ s^{-1}$)**
LZK	27.3	-0.6	7.0	**-2.3**	**2.6**
SGF	23.4	-0.6	6.0	**-2.3**	**2.6**
TOP	30.1	-0.6	6.0	**-3.0**	**3.4**
OAX	14.7	-0.8	10.0	**-1.1**	**1.2**

Discussion points

The adiabatic vertical motion derived in cross section mostly agrees with vertical motion conclusions from the QG omega and Q-vector framework of HW#2, as it should!

Strongest downward motion occurs behind the occluded front at DDC where CAA and NVA is present, Q-vector divergence → characteristic of katafront

Upward motion at least in meridional cross section associated with overrunning the vicinity of the warm front, where vertical motion is indicated most strongly by WAA and Q-vector convergence → characteristic of anafront

Strengths vs. QG omega: adiabatic vertical motion relatively computationally simple; can be done with just radiosonde data (no gridded data required); just switch track to thetae if diabatic processes. Gridded data could show more mesoscale features…

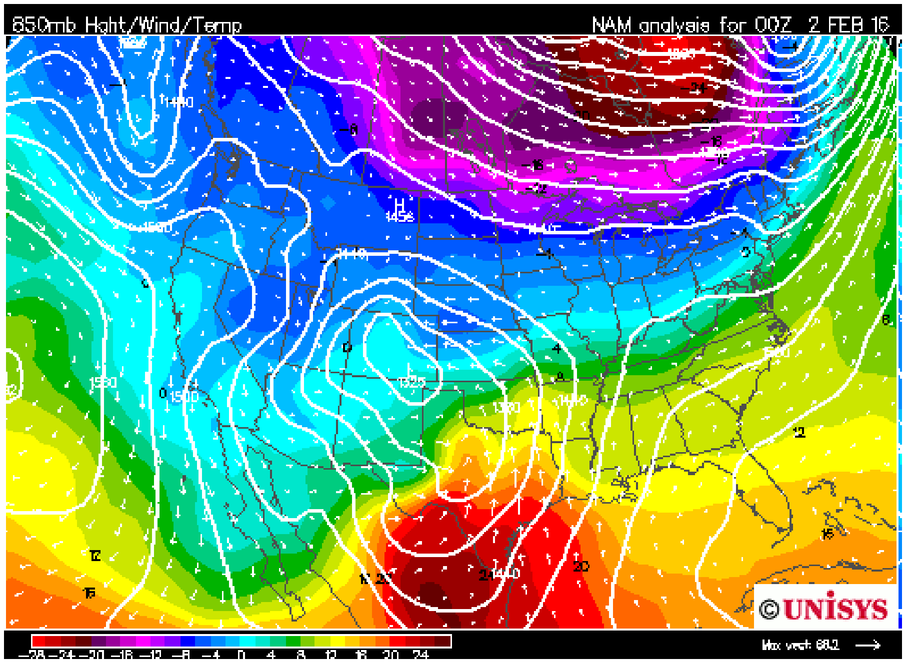
Weaknesses vs. QG omega: only able to consider the vertical “slices” in one dimension, doesn’t account dynamical processes that would lead to vertical motion, computing gradients can be problematic if isentropes are steep.

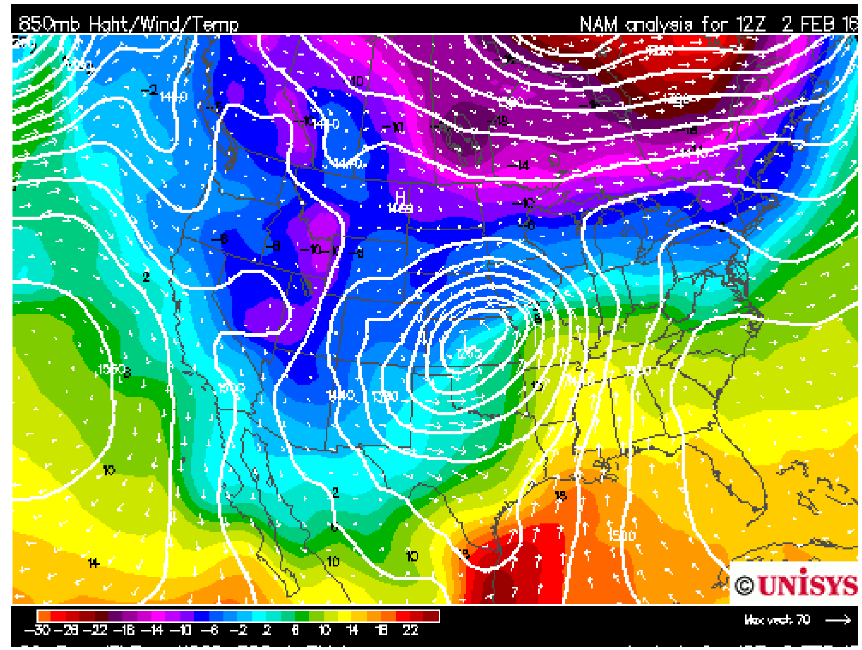
Diabatic processes may be a factor. Would likely increase the magnitude of vertical motion estimates because thetae lines are more steeply sloped. Especially the case between TOP and OAX where heaviest precipitation observed.

Part 3: Adiabatic vertical motion calculations on 300 K surface

40 points

Storm motion vector



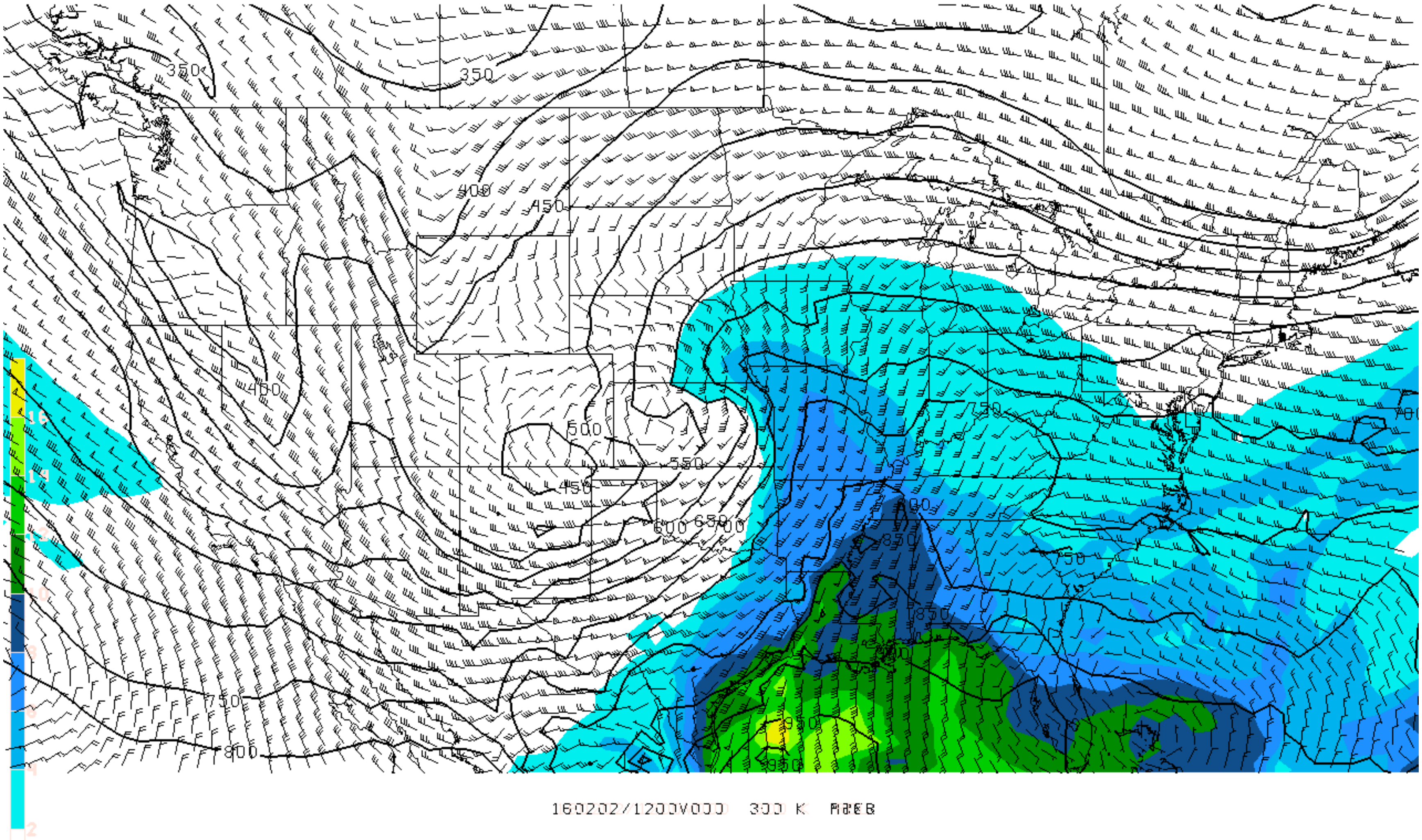


In 12h the center of the 500-mb low moves from Trinidad, CO to Hays, KS.

Distance traveled is approximately ~500 km

Resultant storm motion is 12 m s^{-1} to ENE.
Estimated vector motion in m s^{-1} is (u = 9.2, v = 7.7)

300 K Isentropic surface pressure, winds and specific humidity (g kg^{-1})



Zonal Cross Section: Sample calculations

Station	U ($m\ s^{-1}$)	V ($m\ s^{-1}$)	Grad p_x ($Pa\ m^{-1} \times 10^{-2}$)	Grad p_y ($Pa\ m^{-1} \times 10^{-2}$)	ω ($Pa\ s^{-1} \times 10^{-1}$)	w ($cm\ s^{-1}$)
GJT	4.8	1.7	-0.02	-1.0	**1.0**	**-1.0**
DNR	-5.4	-5.4	0.08	-1.0	**0.1**	**-0.2**
DDC	20.0	3.5	2.4	-0.9	**2.9**	**-4.0**
TOP	5.3	30.1	2.3	-1.5	**-3.2**	**5.0**
ILX	4.0	22.6	0.5	-2.5	**-4.0**	**4.5**
ILN	12.0	4.35	-0.7	-1.5	**0.3**	**-0.3**

Meridional Cross Section: Sample calculations

Station	U ($m\ s^{-1}$)	V ($m\ s^{-1}$)	Grad p_x ($Pa\ m^{-1} \times 10^{-2}$)	Grad p_y ($Pa\ m^{-1} \times 10^{-2}$)	ω ($Pa\ s^{-1} \times 10^{-1}$)	w ($cm\ s^{-1}$)
SHV	16.3	19.5	0.9	-1.5	**-1.1**	**1.0**
LZK	11.5	19.8	1.1	-1.5	**-1.5**	**1.6**
SGF	15.3	26.5	2.5	-0.7	**0.1**	**-0.1**
TOP	5.3	30.1	2.3	-1.5	**-4.2**	**5.0**
OAX	-7.8	21.5	1.5	-1.2	**-4.2**	**4.8**
ABR	1.3	7.5	1.3	-1.8	**-0.7**	**0.9**

Discussion points

Results are generally consistent with prior cross section analysis, at least in terms of the sign of vertical motion and order of magnitude, so both approaches would yield a fairly consistent result for purposes of operational forecasting of vertical motion associated with isentropic lift/descent.

Strongest downward motion behind the occluded front at DDC, similar to part #2, if consider a wind that blows down the isentropes.

The analysis is able to very effectively discriminate between areas experiencing upward and downward synoptic-scale vertical motion (e.g. consider meridional cross section, SGF where the occluded front is located or past vs. the other stations).

Upward motion throughout the stations on the meridional cross section in the vicinity of the anafront.

There is a clear moisture conveyor from the Gulf of Mexico transporting moisture up the isentropes, ahead of the warm front. The isentropic lifting of the moist air cools it, condensing moisture to from rain and snow and intensifying vertical motion by latent heat release. The heaviest snow occurs where isentropic lift is strongest (between TOP and OAX).