Name: ______________________

MEA 443 SYNOPTIC WEATHER ANALYSIS AND FORECASTING
Midterm Exam, Wednesday 10/6/2010

1.) (5 pts) The following observations were taken at Flagstaff, AZ recently. Use these to answer the following questions. Include units.
a.) What was the 6-h rainfall total ending 00 UTC? ______
b.) How much precipitation fell during the 6-h ending at 18 UTC? ____
c.) What was the maximum temperature during the 6-h ending 00 UTC? ______
d.) What was the minimum temperature during 6-h ending 00 UTC? ______
e.) What was the largest hourly rainfall total during this time period? _____

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KFLG 052356Z 10004KT 4SM RA BR SCT022 BKN036 OVC046 09/08 A3020 RMK
AO2 RAB38 SLP162 P0005 60047 T00940078 10144 20089 51010

KFLG 052256Z 00000KT 10SM FEW012 BKN055 BKN090 10/08 A3019 RMK AO2
RAE55 SLP161 P0039 T01000083

KFLG 052251Z 00000KT 6SM -RA BR FEW009 SCT017 BKN035 09/08 A3019 RMK
AO2 PRESFR P0039

KFLG 052246Z 00000KT 3SM RA BR FEW010 BKN023 OVC050 09/08 A3020 RMK
AO2 P0038

KFLG 052236Z 20008KT 1SM +RA BR SCT010 BKN018 OVC027 09/08 A3022 RMK
AO2 P0034

KFLG 052225Z 19011G21KT 3/4SM +RA BR SCT012 BKN021 OVC030 10/08 A3022
RMK AO2 P0022

KFLG 052214Z 18004KT 1 3/4SM +RA BR FEW012 BKN028 OVC045 10/08 A3021
RMK AO2 PRESRR P0005

KFLG 052156Z 21008KT 4SM RA FEW022 BKN030 OVC045 10/07 A3018 RMK AO2
RAB35 SLP164 P0003 T01000072

KFLG 052056Z 19012G17KT 10SM FEW025 SCT045 13/08 A3016 RMK AO2 SLP146
60000 T01330083 58014

KFLG 051956Z 19014G25KT 10SM FEW025 13/08 A3018 RMK AO2 RAE1857B28E40
SLP148 P0000 T01330078

KFLG 051937Z 18012G20KT 150V210 10SM -RA FEW021 SCT027 BKN038 13/07
A3019 RMK AO2 RAE1857B28 P0000

KFLG 051856Z 17009G21KT 10SM -RA BKN021 BKN028 OVC045 13/09 A3021 RMK
AO2 RAB46 SLP160 P0000 T01330089

KFLG 051756Z 19009G20KT 170V230 10SM BKN014 BKN020 OVC045 12/09 A3021
RMK AO2 SLP164 60016 T01220089 10122 20106 50001
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2.) (8 pts) The expression below is for the x-component of the Q-vector (minus the leading stability factor). $\vec{Q}_1 = -\left[\frac{\partial \vec{V}_g}{\partial x} \cdot \nabla\theta\right]$

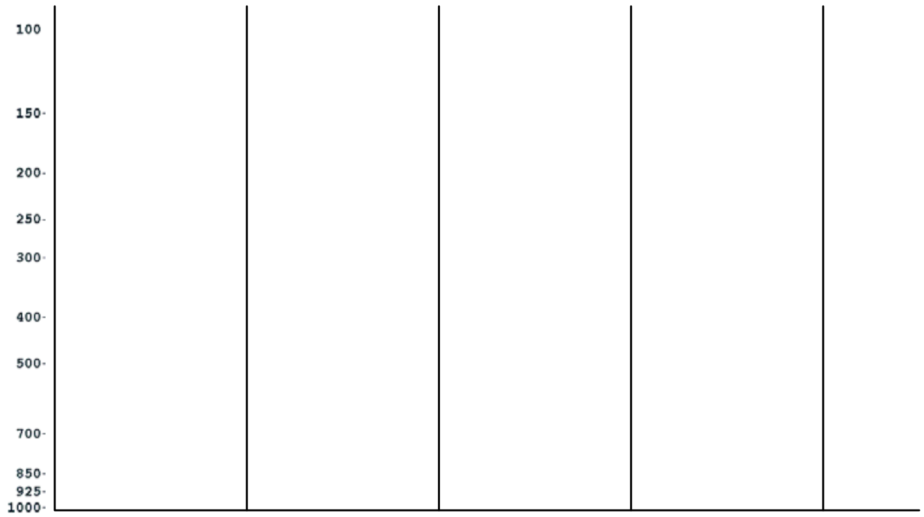
a.) What are the *mks units* of this quantity? ______

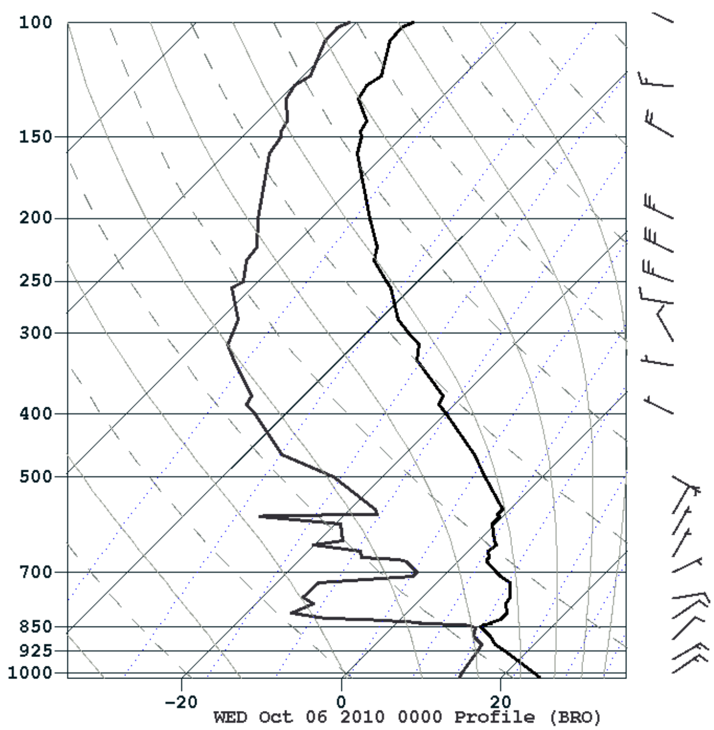
b.) For synoptic-scale motions in the troposphere, use scale analysis to determine the approximate magnitude of this quantity. Show your work.

3.) (8 pts) Examine the recent Brownsville sounding shown below.

a.) Sketch on the blank diagram the *approximate* profile of ***potential temperature*** as a solid line, and the profile of ***equivalent potential temperature*** as a dashed line on the same graph. Label the abscissa (x-axis) on the diagram to correspond to appropriate values for these quantities.

b.) What is the approximate pressure level marking the top of the mixed layer? ____



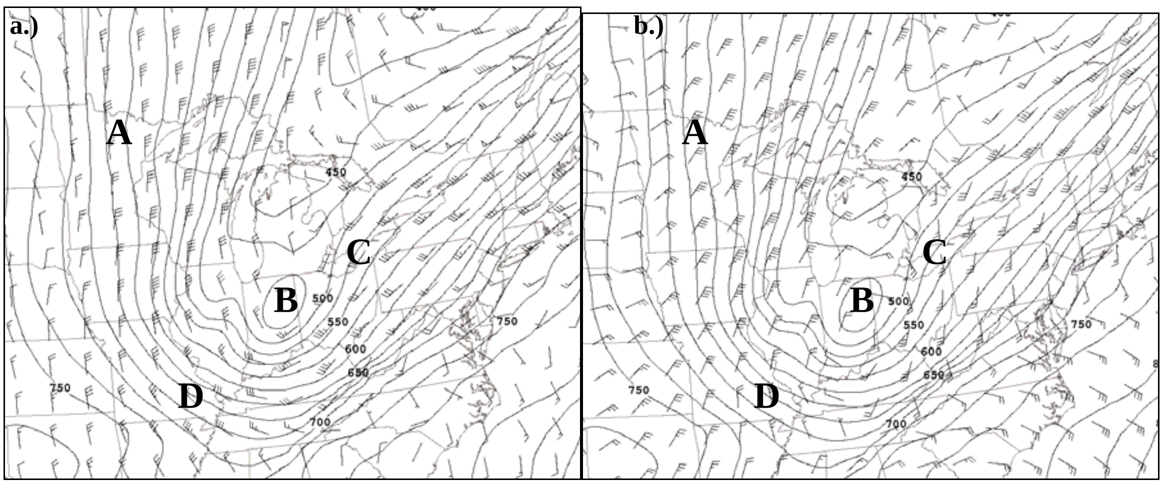


4.) (6 pts) Below are two isentropic analyses showing pressure and winds on the 304 K isentropic surface, valid at the same time. The isentropic pattern was moving east-southeastward at approximately 20 kts at the time of the analysis. One of the plots shows the full wind field, the other shows the storm-relative flow.

a.) Which of the charts shows the storm-relative flow? ____ (a. or b.)

b.) At which one of the points would you most expect to observe ***ascent***? ____

c.) Which one of the points would most likely correspond to the center of *an upper-level trough*? ____



5.) (10 pts total)

a.) List three main assumptions underlying the quasigeostrophic equations.

i.)

ii.)

iii.)

b.) Describe at least one synoptic or meteorological situation in which one or more of these assumptions is violated, and briefly explain why.

6.) (5 pts) Suppose you are a hurricane forecaster at the National Hurricane Center (NHC), and you show up for a shift to discover the weather system shown in the series of plots below. You need to decide whether to name the storm. Based on the evidence in the plots provided, would you classify this system as "tropical", "extratropical", or "subtropical"?

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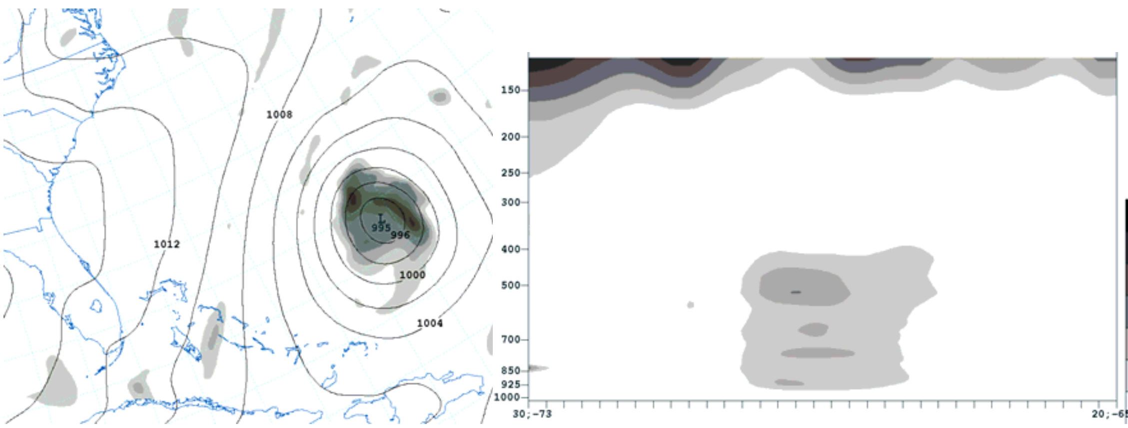
Briefly justify your answer below.



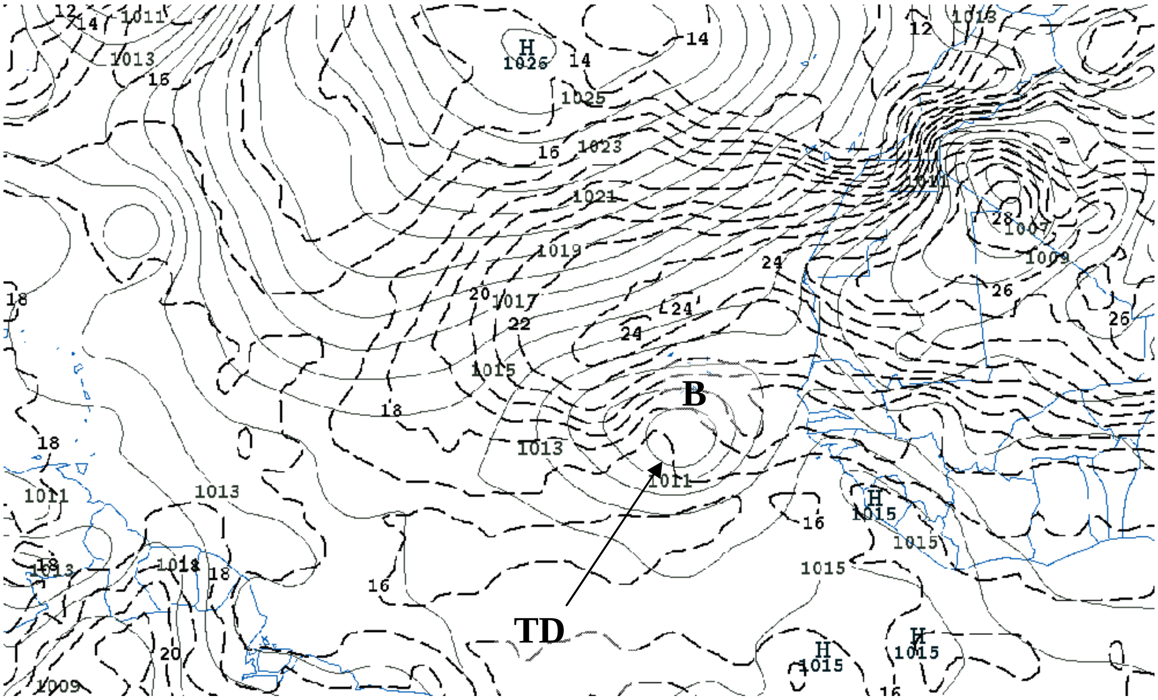
Sea level pressure, 500-mb height, lower PV. Cross section: PV (shaded).

7.) (5 pts) Consider v-momentum equation shown below.

$$\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+\omega\frac{\partial v}{\partial p}+fu=0$$

Write the **quasigeostrophic form** of this equation by applying the main QG assumptions. Show your work, and circle and clearly label your final answer.

8.) (6 pts) In a past discussion from the NHC (of a tropical depression), it was stated that "THE METEOSAT-8 SPLIT WINDOW CHANNEL DIFFERENCING PRODUCT PRODUCED BY UW-CIMSS SHOWS A LARGE SAHARAN AIR LAYER NORTH OF THE SYSTEM. THERMAL WIND BALANCE WOULD ARGUE FOR A MID-LEVEL JET ALONG THE SOUTHERN EDGE OF THAT VERY WARM AND STABLE AIRMASS." Use the GFS data provided to answer the questions below.



Above: GFS analysis, showing sea level pressure (solid contours) and 850-mb temperatures (dashed, every 1°C). Assume that the temperature pattern at 850 mb is roughly consistent with that at the 700-mb level as well as below 850 mb.

a.) For the location corresponding to point "B" indicated on the diagram, draw 3 arrows, one corresponding to the **surface geostrophic wind**, one to the **wind at the 700-mb level**, and one corresponding to the **thermal wind**. Draw these vectors below.

b.) Briefly explain why the this synoptic setting would not be conducive to strengthening of the TD.

9.) (10 pts) Consider a situation in which an upper-level trough is located to the west of a surface cyclone. The upper trough is steady in intensity, but the surface low is characterized by increasing vorticity with time. The initial value of vorticity at the low center is 2.5 x 10^{-5} s^{-1}. Following the motion of the low center, and neglecting vorticity advection, friction and tilting, the approximate vorticity equation shown below applies to the tendency of vorticity at the low center.

$$\frac{d\zeta_a}{dt} = (\zeta_a)\left(\frac{\partial \omega}{\partial p}\right)$$

a.) Assume a *constant value* of $\left(\frac{\partial \omega}{\partial p}\right)$ of -10^{-5} s^{-1} ahead of the upper trough, and that the Coriolis parameter is ~1 x 10^{-4} s^{-1} at the low center. Derive a mathematical expression of the absolute vorticity at the low center as a function of time.

b.) How long would it take for the value of absolute vorticity at the low center to *double in strength*? ______ (hours)

___ 10.) (5 pts) Which of the following best explains why Rossby waves move more slowly than the average wind speed blowing through them?

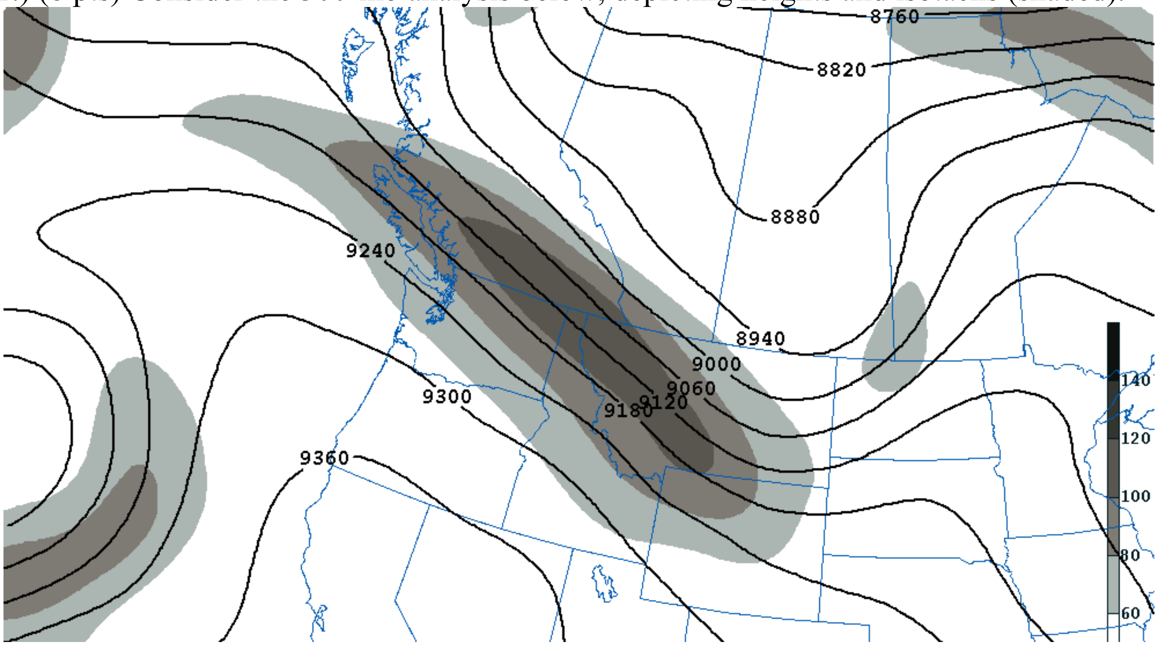
a.) Rossby waves actually move at the same speed as the advecting wind blowing through them.

b.) The advection of planetary vorticity causes the wave to propagate against the flow.

c.) The differential thermal advection term in the QG height-tendency equation leads to system motion that is slower than the wind speed.

d.) The advection of relative vorticity associated with the wave itself is inefficient, leading to a slower wave motion than the wind speed.

11.) (8 pts) Consider the 300-mb analysis below, depicting heights and isotachs (shaded).



a.) Is the trough centered over eastern Montana “digging” or “lifting”? ___________

b.) Considering the jet centered over eastern Montana, indicate regions of expected ascent in the vicinity of this feature with a large, bold A for ascent or D for descent.

c.) Indicate the region of largest expected *cyclonic shear vorticity* on this chart with a large plus sign. Indicate the region of largest expected *anticyclonic shear vorticity* on this chart with a large minus sign.

d.) In addition to the jet streak, list any other factors or processes that might be influencing the vertical motion pattern over Montana and vicinity at this time.

e.) Do you expect vertical motion pattern over Montana and Wyoming to be thermally direct or thermally indirect? __________________________

12.) (12 pts) Consider the graphics shown below. The left panel shows 250-mb height (dark solid lines), and sea-level pressure (lighter contours), the right panel shows 250-mb height and 250-mb isotachs (shaded). Use these to determine the expected subsequent behavior of the trough system labeled “T” on the diagram. Assume that the mean zonal wind speed is maximum at a latitude of 55°N for this time.

a.) Assess the following:

i.) Is the trough digging or lifting?

ii.) Is thermal advection favorable, neutral, or unfavorable for intensification of the trough: __________

iii.) Is barotropic energy conversion favorable, neutral, or unfavorable for intensification: _____________

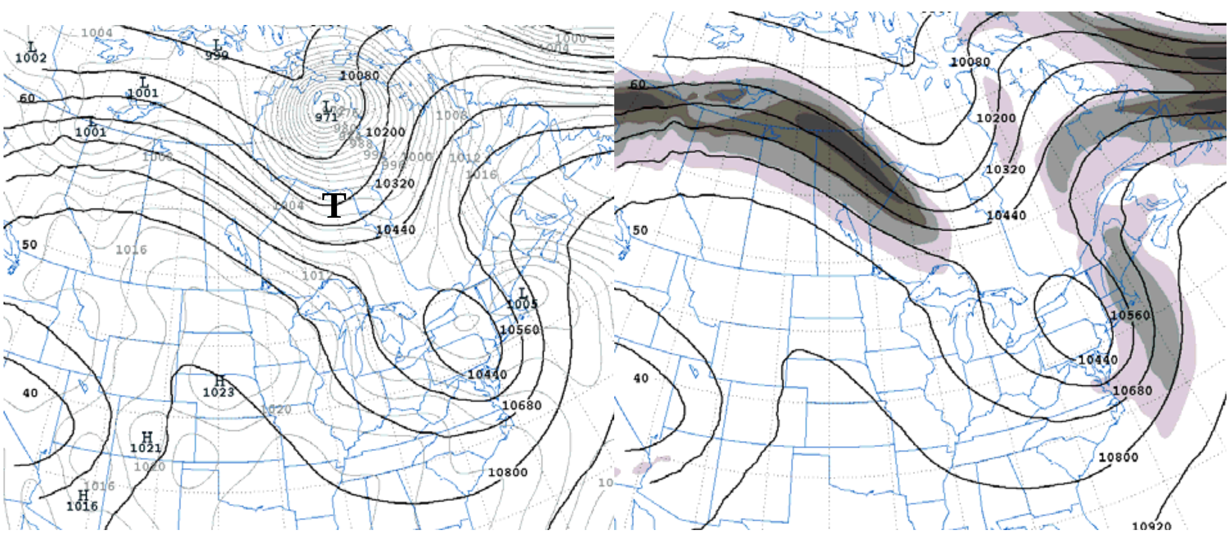
___ b.) Based on the assessment above, which of the following is the most likely outcome for the trough in question?

i.) Trough will weaken and move east, by-passing the closed low to the south.

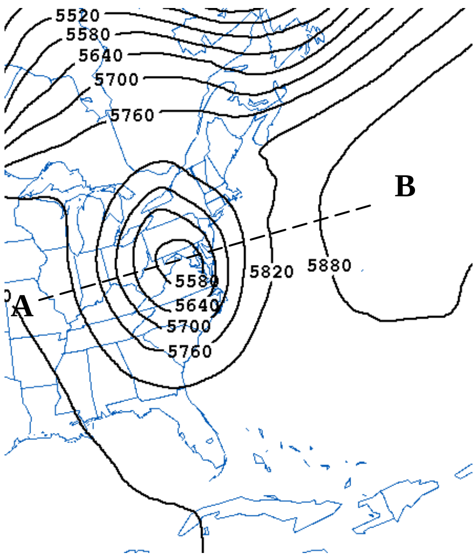
ii.) Trough will amplify, drop southeast, and “absorb” the closed low to the south.

iii.) Trough will remain about the same intensity and move due eastward.

iv.) Trough will lift to the northeast and rapidly weaken.



13.) (12 pts) The 500-mb GFS height analysis from 06 UTC today is shown below. A cut-off low is located over the Mid-Atlantic region. We will use this sytem to answer the following questions. The cross-section line indicated on the analysis shows the orientation of the blank cross-section at right.



A ———————————————— **B**

a.) On the blank cross section at right above, sketch a pattern of 5-6 isentropes that would be consistent with thermal wind balance and the expected flow associated with the system.

b.) Sketch *isotachs* consistent with your isentropes from a.)

c.) Label expected regions of large and small PV with "PV+" and/or "PV-" as needed.

d.) On the blank map at below, sketch an approximate *isentropic chart* for a lower-tropospheric isentrope in the vicinity of this weather system. Sketch approximate contours of pressure at 50 mb intervals. Just qualitative accuracy is needed.