Homework
Surface Map Analysis
Due Friday, 20 March 2020, 11:59 pm

Instructions

1. **Print a few copies of the weather map that has only the station plots** that is on page 11 of the document. Most will be used for practice versions, or "drafts", of your final product. Analyze the map according to the instructions on the Task pages that immediately follow. Keep colored pencils (blue, red) handy so that you can sketch each requested weather feature in the proper color.

2. **Upload your analysis to the Dropbox. It must be a pdf file.**
Only pdf files are acceptable. Only pdf files will be graded.
Once you finish your final analysis, scan or take a clear digital picture of your completed map. The file will likely be a jpg, or a png, or even pdf file. If it is a pdf file, you are done. On the other hand, you can convert a jpg or png image to a pdf file at no charge using many free online sites. Or you can insert your digital map file into a MS Word document or PowerPoint document as a graphic (gif, jpg, png) then convert the docx/pptx file to pdf using the "Save As" option. (It works on Mac and Windows versions of MS Word and PowerPoint.) If you have a Mac computer, you can use the Preview program to create a pdf from a jpg or png file. It is not important how you do the conversion; you just need to do it.

Make certain the map that you upload is oriented properly with north at the top of the page; improperly oriented maps that are rotated sideways, upside-down or cockeyed will receive a deduction. See the map on last page for example of properly rotated surface map.

3. **The due date is 11:59 pm Friday, 20 March 2020.**
This is a hard deadline. Nothing more needs to be stated.

4. **But why are no late submissions accepted, regardless of circumstances?**
A meteorologist/forecaster must finish, without exception, their analyses and forecasts before a hard deadline. And you will too.

5. **When to expect your grade on the assignment to be posted.**
It takes 10-15 minutes on average to grade a map. I will have about 100 maps to grade. Simple multiplication shows that it could take up to 20-25 hours to grade all the maps. Because I have other responsibilities, I am unable to work 24/7 on just grading maps. I may need a few weeks to complete the grading of every submission. If you submit your map early, I might be able to grade it long before the last week of term and post its score before the scores of the masses, but no promises. Regardless of when you submit your map, do not expect to see a grade any earlier than the last full week of the term (April 27-May 1). And please, do not email questions of the ilk, "Where is my grade for the map?" or "My friend got their map graded, why isn't my map graded?" I do not acknowledge such inquiries since taking the time to write a reply only serves to slow down the grading process.

6. **The assignment can be done as an individual or as a member of a group. Carefully read instructions on how to proceed.**

I have given this assignment for years, and historically, I dictated whether the entire class had to work either as individuals or as members of a pre-assigned group. Student feedback indicated that some students preferred working as individuals when forced to participate in a group, while other students commented how much they benefitted and enjoyed being part of *functional* team of peers. I am now convinced that the best option is to give students the opportunity to choose their preferred mode of operation…lone wolf or part of a team with members of their choosing…to account for differences in learning styles, time commitments outside of class, etc.

Whatever mode to choose, you must follow these instructions precisely.

Option 1: Work as an individual.

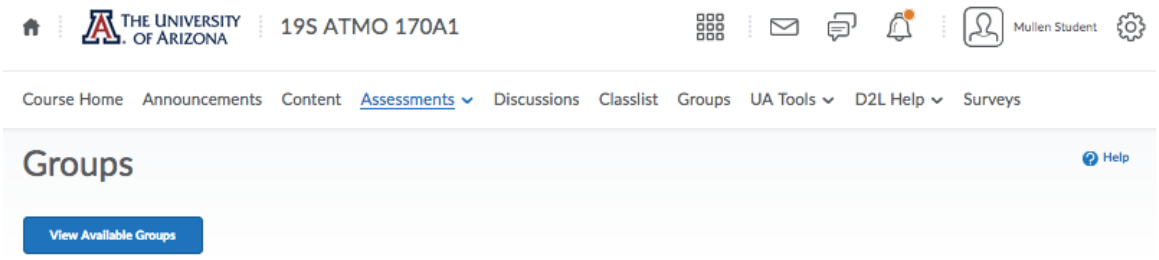
If you choose to work as an individual, the process involves just one simple step: Upload your pdf file with the map to the dropbox titled, **Maps for Individuals**. Your map must be uploaded to the correct dropbox to receive credit.

Option 2: Work as a member in a group of peers.

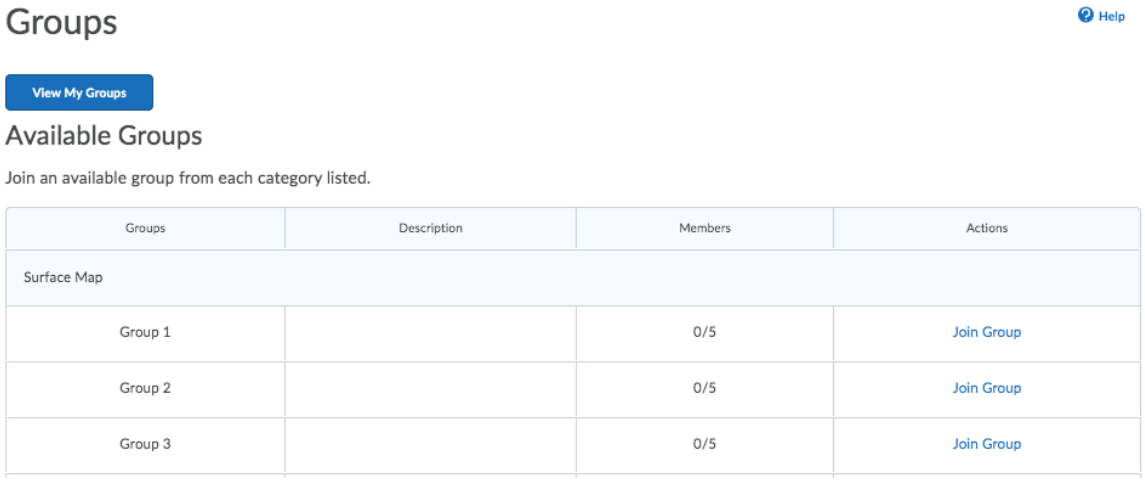
If you choose to be part of group with other students, then it is up to you to join a group and restrict its membership to only those students who you want to be in the group. How do you do that?

First step: one person of the nascent team serves as the initial enrollee in a group that is still vacant. I have created 50 groups. When the initial enrollee first joins a group, they must always pick the lowest group number that is vacant.

To form or join a group, go to "Groups" on the Navbar to get to the following page.



Then click “View Available Groups”. A vacant group has a 0/5 designation. There are a total of 50 groups, which is more than enough for our class size.



Second step: after the initial enrollee secures a group #, that student gives the number to the other desired group members who then enroll in the group.
The two steps must be coordinated to ensure everyone enrolls in the proper group.

Third step: After the group finishes their analysis. one member of the group uploads the pdf file with the analysis to the dropbox titled, **Maps for Groups**. Again, your map must be uploaded to the correct dropbox to receive credit. You will submit your map to the dropbox titled “Maps for Groups”.

Each group may have up to five members. *Take note that once you join a group, there is no switching to another group or changing to lone wolf status… i.e. you must stay in the group that you originally joined. So, do take care to choose the status or group.*

If you join a team of your peers, I understand that you may not know all members of your group. In fact, it is possible that you might now know any of them. And it is irrelevant whether you do. You are striving for a working professional relationship among peers, and that is doable regardless of “know or like” issues. If you choose to be part of group, it is important that you make a positive contribution by pulling your weight.

If you work in a multimember group, the entire group will submit just one analysis that represents the joint efforts of the team, and each member of the team will be assigned the same score on the map. Scores will be assigned solely from considering the quality of the analysis. The grading rubric is described later in this document and is also on D2L.

It is the responsibility of the team members to determine how to contact each other (email addresses for the class are found in “Classlist” on the D2L Navbar), to set times and hold meetings/discussions (e.g. in person or virtual), to partition work, etc. Please set up a separate account (e.g. Facebook) for your intragroup communications.

If you are in a group and are stuck coming up with ideas on how to divide work in an equitable manner among group members, one potential plan could be:

- One or two students work on drafting isobars and identifying the low center.
- One or two students work on identifying fronts and air masses.
- Group meets (online, or in person if on-campus) to integrate the positions of the isobars, fronts, air masses and center of the cyclone in a physically consistent manner.
- One student (the most artistic or computer savvy) could do the final draft of the analysis then submit it after a final review by the entire group.

This is a potential plan. Other options would work too.

I expect every member of a group to make a significant contribution to the project. If your group is functional and every member is a serious contributor, then the assignment should go smoothly with the end-result usually being an analysis superior to what individuals would average on their own. If not, problems can arise. However, you decide to partition tasks, distribute the load in an equitable manner so each student pulls a fair share of the load.

This assignment is worth about 6% of your course grade. Whether working as an individual or as collaborator on a team, I expect to see a high-quality analysis that is professional in terms of neatness and clarity. A professional touch to consider is having isobars, frontal symbols and labels done by the computer. There are many programs that could do this. One could use the crude drawing tools in PowerPoint (or any other presentation program) to draw curves and place labels on top of the map with only the station plots. PowerPoint is the program that I use to produce analyses such as the one that appears in this document, and while it is clunky to use, it works. There are undoubtedly programs for iPads and tablets that convert hand-drawn lines on the screen to draftsperson quality curves. The electric pens for touch screens such the iPad and MS Surface (among others) come to mind.

Weather Map Tasks

Your charge is to analyze the surface map toward the end of this document. Temperature, dew point, SLP (sea-level-pressure), total cloud cover, wind direction and speed are plotted following the surface station model. You are to draw isobars of SLP, locate fronts (type and position), indicate the center of a cyclone and identify the locations of cP and mT air masses. You may want to review material in the reading and the ppt slides, which discuss extratropical cyclones and fronts.

1. Perform a SLP analysis by drawing isobars to define the pressure pattern. Isobars are analyzed at 4 mb intervals. Permissible values for isobars are any value that is divisible by 4. (e.g. … 992 mb, 996 mb, 1000 mb, 1004 mb, 1008 mb, 1012 mb, 1016 mb, 1020 mb, …) Depending on the actual pressure values plotted on your map, you may need to use only some of these values or you may need to use values that are larger or smaller than those listed. I recommend that you find the station with the lowest SLP observation and the station with the highest SLP observation; this could help you determine which isobars must be analyzed.

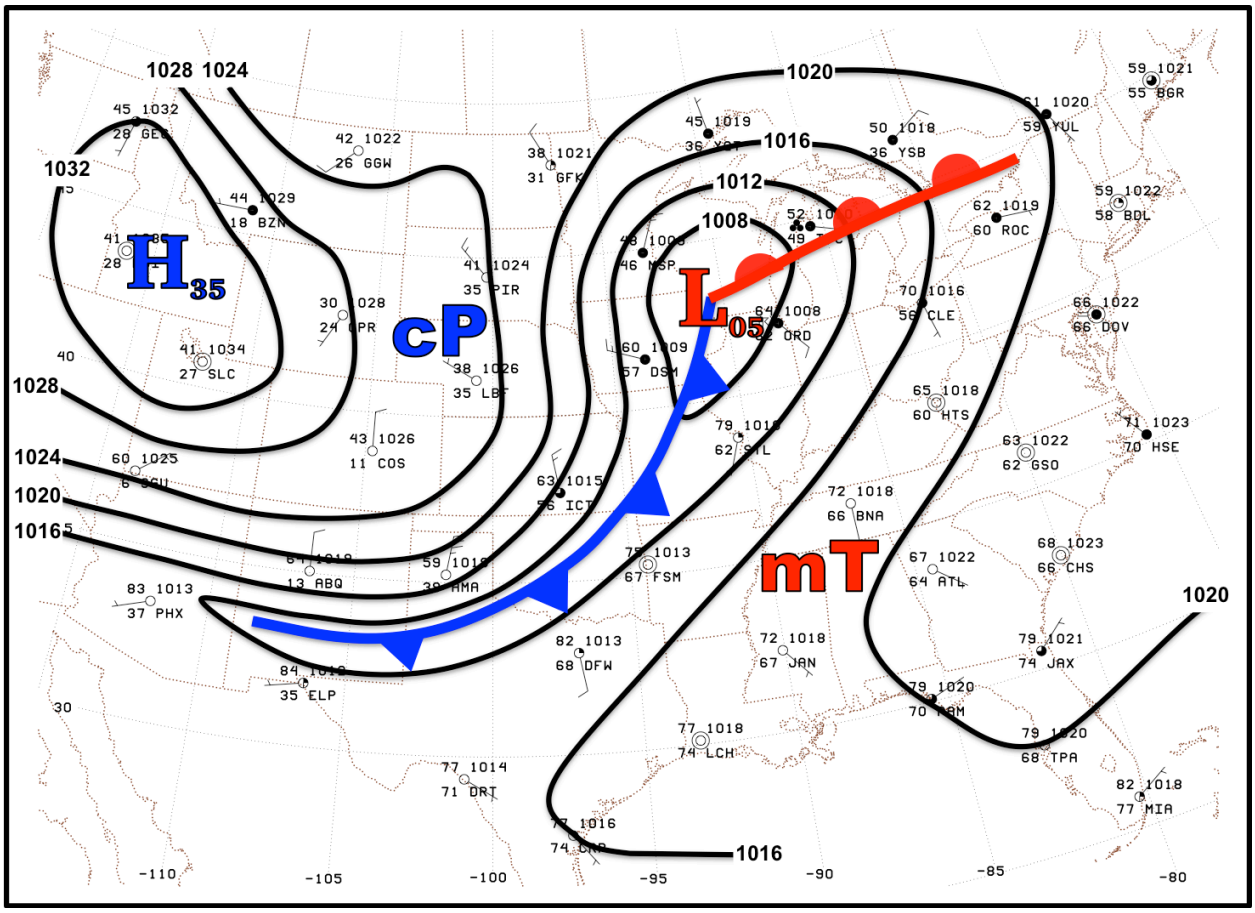
2. Label the low-pressure center in red pencil with a large "L" including the value of the central pressure. There is a low that is surrounded by at least one (and maybe more) closed isobar(s).

3. Properly position the cold front on the map. (The map has a southeastward progressing cold front.) *The cold front (and warm front) must originate at the center of cyclone on your map*. The cold front extends southwestward from the low. Cold fronts are found at the leading edge of a cold, dry air mass that is advancing eastward and equatorward and is replacing a warmer, moister air mass. Try to identify large air masses on the map with distinct temperature and moisture (dew point) differences. The boundary between different air masses is always the place to locate any fronts. From your reading (and lectures for the classroom section) you know also that winds blow from different directions on the two sides of a front. Clouds, precipitation and thunderstorms are often found along a cold front. (This map does not have an occluded front.)

4. Properly position the (very slow moving) warm front on the map. The western end of the warm front originates at the center of the low and extends northeastward. Warm fronts are found where warm, humid air is moving poleward and is replacing a colder/drier air mass. Again, you need to identify large air masses with distinct differences in temperature and moisture and concentrate on the boundary between these air masses to try to locate the front. You then use the wind direction, and perhaps even cloud and precipitation data to adjust the location of the front. (This map does not have an occluded front.)

5. Label the locations of a continental polar air mass and a maritime tropical air mass with a large "cP" and "mT" respectively.

I give an example of a portion of a finished analysis from a prior semester. Your analysis should, *in general terms,* look something like this one. (This is a same weather system that you are to analyze, but the analysis below is valid three hours earlier than your map.) Note how I have entered the value of SLP at the center of the low (the red 05), which stands for 1005 mb. Ditto the center of the high pressure over southern Idaho.



This assignment is given with the hope that you find analyzing a weather map fun. That said a quality analysis takes time, thought and effort. For that reason, I urge you to not procrastinate until the last moment to start the assignment. I want all of you to score well on this assignment. Hence, if you have any questions, please email them ASAP over the class listserv so than entire class can benefit from my reply.

Grading Rubric (percentage value)

Isobar analysis (40%) – Properly position isobars between the SLP reports. This means:

- Every SLP observation that is lower than the value of an isobar must lie on the opposite side of the contour than every SLP report that is higher than the value of same isobar.
-Spacing of isobars is consistent the wind speed. Isobar spacing tends to be closer where wind speeds are faster; wider apart where wind speeds are slower.
-Orientation of isobars is consistent with the wind direction blowing slightly toward lower pressure with lower pressure to the left of the wind. (There are exceptions to this that we will ignore.)

Frontal analysis (30%) – Properly identify any fronts (besides the positions of ones that I might have analyzed for you). This means:

-Identify the type of front. Your concern is a cold front and slow moving warm (or arguably stationary) front.
-Position fronts between the proper stations.
-Draw fronts using…
The correct color. (Blue-cold; red-warm; stationary-blue/red; occluded-purple.)
The correct type of teeth. (Triangular "icicles" or circular "blisters".)
Orient "teeth" properly to reflect direction that front is advancing.

Air mass locations (20%) – Label the general area of the cP (10%) and mT (10%) air masses.

Cyclone location (10%) – Properly identify the location of the center of the cyclone and label the central pressure of the low with a red, upper case "**L**".

Additional Guidance for Analyzing Your First Weather Map
Analysis of SLP and Identification of Fronts

Ackerman and Whitaker (1997) summarize the basic rules of contouring http://cimss.ssec.wisc.edu/wxwise/contour/contour1.html. I quote verbatim. Just substitute the word *isobars* for *isopleths* as you read what follows.

> "1. isopleths should never cross,
> 2. isopleths should not branch or fork,
> 3. only the area on the map that has data should be contoured,
> 4. you should label your isopleths…"

I suggest you read the link and follow its advice. Closely. There are other excellence sites that have useful tutorials on how to contour isobars.

Drawing SLP contours can be challenging in that observations of two weather elements, SLP and wind (speed and direction), must be jointly considered at each station to define the placement, orientation and spacing of the isobars. I recommend trying the applets from Department of Meteorology at Pennsylvania State University (UA locally hosted)
http://www.atmo.arizona.edu/~mullen/atmo170A1/flash/contour_tool_t0203.swf
or from the University of Illinois, Urbana-Champagne (remote hosted)
http://www.atmos.illinois.edu/courses/atmos100/program_lists/jnlp/Contour.jnlp
if you would like some practice drawing contours (specifically isotherms) before starting your analysis.

Sketch *lightly* in ordinary pencil on one of your (many) practice maps the position of the isobars. You will be making frequent changes in the position of the isobars, so keep a big eraser handy. It is only after you are 100% satisfied with all aspects of your final analysis (isobars, cyclone location, air masses and frontal positions) that you darken and label the isobars, i.e. "pretty up" your map.

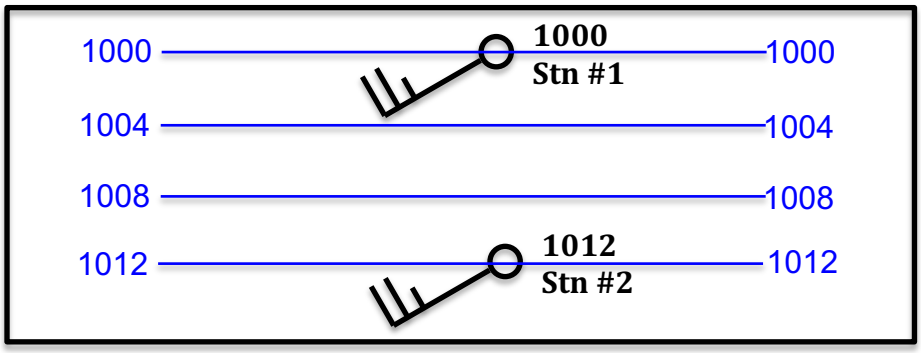
1. To help facilitate your first isobar analysis, ***I plotted SLP reports to the nearest whole millibar.*** Hence, you do not have to decode the three-digit, coded SLP values that appear on operational weather maps.

2. Look for the stations with the highest and lowest SLP values on your map. The region on your map with lowest SLP's is near the Kansas-Missouri border. The highest SLP's are located along the periphery of the map.

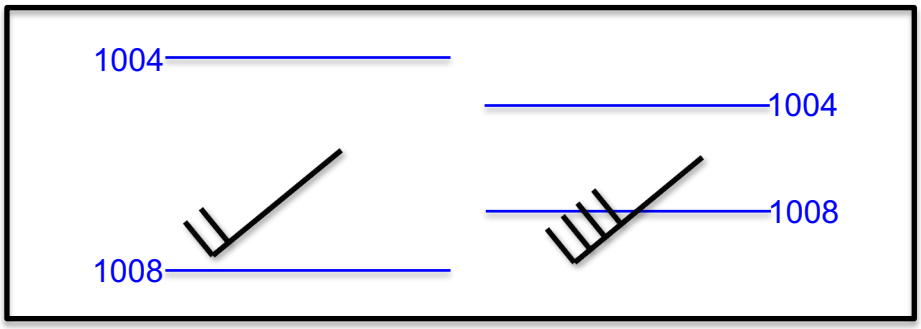
3. Permissible values for SLP contours are …996 mb, 1000 mb, 1008 mb, 1012 mb, 1016 mb, 1020 mb, 1024 mb**…** etc. That is, only contours that are divisible by 4 are drawn. To start your analysis, I recommend that you pick the smallest permitted contour that is consistent with the lowest SLP observation and the largest permitted contour that is consistent with the highest SLP observation. These contour values and all mandatory values in between are the ones that you must draw. For example, if the lowest (highest) SLP report on your map is 1007 mb (1035 mb), the smallest (highest) contour value that you must analyze would be 1008 mb (1032 mb). Take special note of SLP reports that are the same value as a mandatory

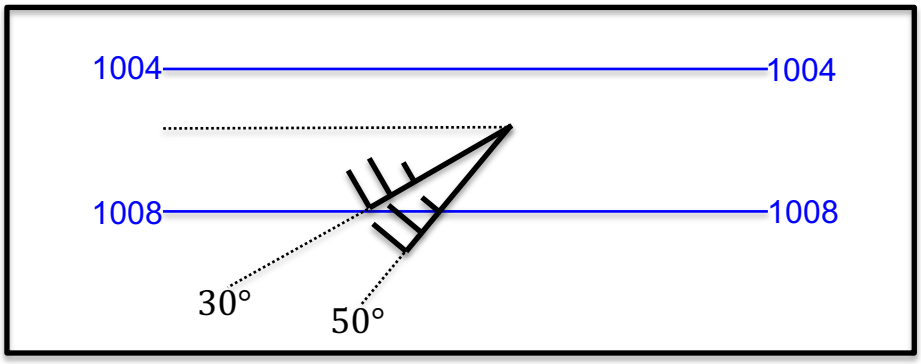
contour value (*e.g.* 1016) since an isobar (1016 mb) goes through that station (or very, very close to that station). Your weather map has several observations that have the same value as a mandatory contour value.

4. Estimate where an isobar should be placed by interpolation between stations. Consider the figure below. Neighboring stations report a SLP of 1000 mb at station #1 and SLP of 1012 mb at station #2 and have similar wind speeds. Because site #1 has a SLP closer to 1004 mb than site #2, the 1004 mb isobar should be much closer to site #1 than site #2. The same reasoning can be applied to the 1008 mb which would be much to site #2 than #1.



5. Use the wind observation to guide 1) the spacing between isobars and 2) the orientation of isobars. *Spacing is closest where wind speeds are fastest*. The top panel of the schematic below illustrates the relationship. *The wind direction points somewhat to lower pressure* at the surface. The angle between the isobar and wind vector over land stations typically lies between 30°-50° as shown below, but there are exceptions. The angle can be nearly perpendicular (90°), a situation commonly occurs when cold air advances southward along the Upper Plains (your map) or when the PGF is weak. Other times, it can be parallel. Under





special circumstances, you can even have winds that are directed toward higher pressures; such nuances are not considered in this course and do not occur on your map.

6. Next, locate the positions of fronts. Fronts are located where the wind abruptly changes direction over a short distance, and where the temperature and dew point temperature changes rapidly over a short distance. I recommend that you closely examine the isotherm and streamline analysis at the end of this document. The fronts will be located near where the isotherms tend to be closely spaced together.
   a) Cold fronts typically advance toward the east, southeast or south. Warm fronts typically advance toward the north, northeast or east. Again, there are exceptions not considered here.
   b) They will both originate from the center of the low (prior to formation of the occluded front).
   c) The "teeth" of the front point in the direction that the front is advancing.
      i) Cold fronts are colored blue and have triangular "icicles" for "teeth". The triangles point in the direction that the cold front is moving, toward the warmer air.
      ii) Warm fronts are colored red with semicircular "blisters". The semicircles point in the direction that the warm front is advancing, toward the colder air.

Summary of five rules for identifying fronts (following College of DuPage)

1. Look for elongated zones with a strong temperature gradient or stations undergoing rapid changes in temperature over a short period of time.

2. Look for a similar region with a strong dew point gradient or stations that experience rapid changes in dew point.

3. Look for a strong pressure gradient or change. Look for stations with falling pressures that are followed by rising pressures. Fronts, especially cold fronts, tend to lie in sharp pressure troughs.

4. Look for a line of abrupt wind shifts. Wind shifts can be 90° and greater, especially wind shifts associated with sharp cold fronts.

5. Check cloud cover and any significant weather (e.g. rain, snow, blowing sand…) for patterns that are consistent with frontal models. Point 5 is the least reliable "rule".

To facilitate your analysis of isobars and fronts, I have included at the end of the document two additional maps: one with isotherms and streamlines (wind direction arrows) valid for the time of your analysis and the other with the positions of fronts prior to your map. You are to do your analysis on a copy of the map that only shows station plots (next page).

Questions? Send them over the class list serve so my reply can be of benefit to the entire class.

Additional References

Synoptic Meteorology and Analyzing Surface Maps:
https://www.weather.gov/jetstream/synoptic_intro

Air Masses and Fronts:
https://www.e-education.psu.edu/meteo3/l3.html

Mid-latitude Cyclones and Fronts:
https://www.e-education.psu.edu/meteo3/l7.html

Student Analysis Map

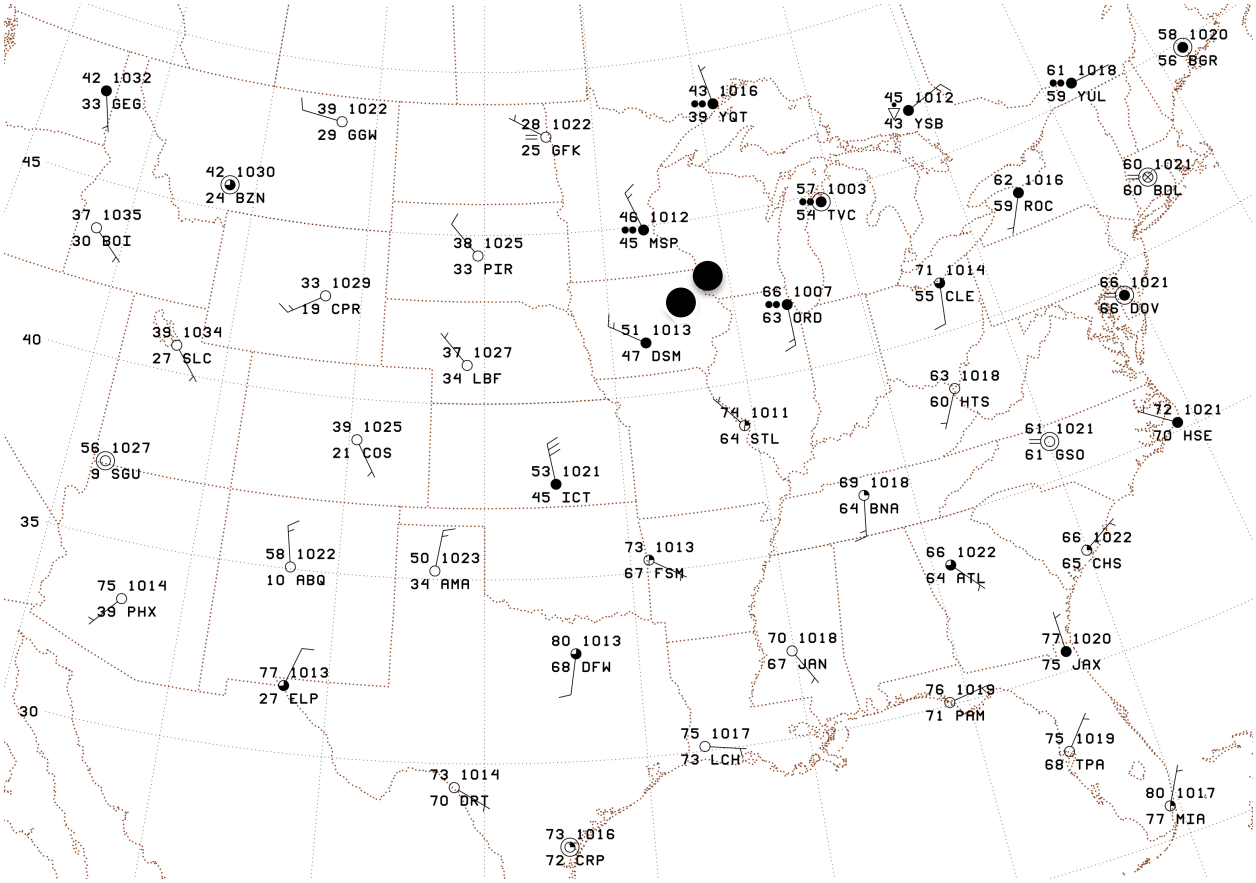
October Conditions for 0600 UTC

Download the larger version of the map (link on next line) on which to draw your analysis.
http://www.atmo.arizona.edu/~mullen/atmo170A1/homework/SFC_analysis_spring.png.

Print several copies of the map to use for your many early drafts.

Sea-level-pressure is plotted to the nearest whole millibar.

Black dots denote the position of the center of the low 3 hours and 6 hours prior to 0600 UTC

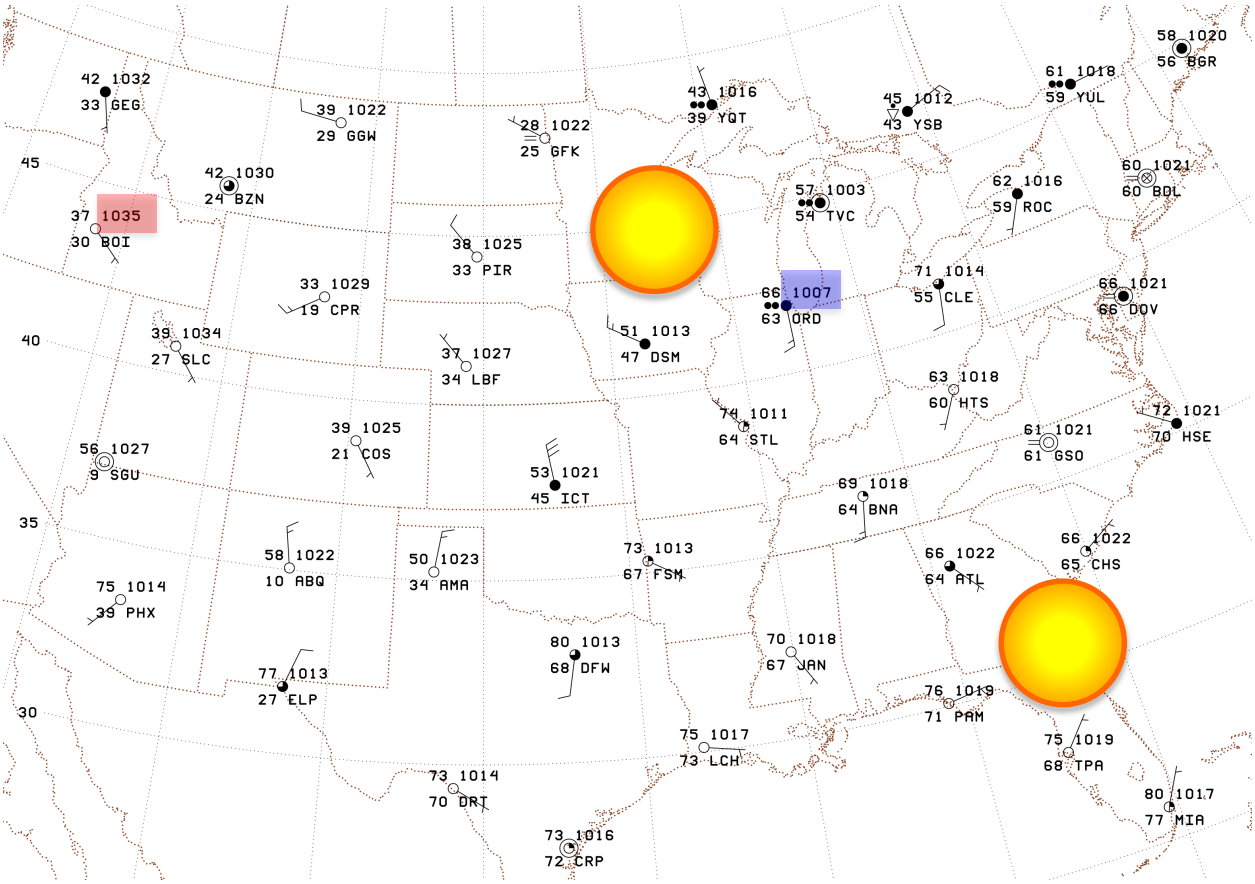


ABQ-Albuquerque NM
AMA-Amarillo TX
ATL-Atlanta GA
BGR-Bangor ME
BDL-Hartford CT
BNA-Nashville TN
BOI-Boise ID
BZN-Bozeman MT
GGW-Glasgow MT
CHS-Charleston SC
CLE-Cleveland OH
COS-Colorado Springs CO
CPR-Casper WY
CRP-Corpus Christi TX
DFW-Dallas/Ft. Worth TX
DOV-Dover DE

DRT-Del Rio TX
DSM-Des Moines IA
ELP-El Paso TX
FSM-Fort Smith AR
GEG-Spokane WA
GFK-Grand Folks ND
GSO-Greensboro NC
HON-Huron SD
HSE-Hatteras NC
HTS-Huntington WV
ICT-Wichita KS
JAN-Jackson MS
JAX-Jacksonville FL
LBF-North Platte NE
LCH-Lake Charles LA
MIA-Miami FL

MSP-Minneapolis/St Paul MN
ORD-Chicago IL
PAM-Panama City FL
PHX-Phoenix AZ
PIR-Pierre SD
ROC-Rochester NY
SGU-St. George UT
SLC-Salt Lake City UT
STL-St. Louis MO
TVC-Traverse City MI
YQT-Thunder Bay Canada
YSB Sudbury Canada
YUL-Montreal Canada
YYZ-Toronto Canada

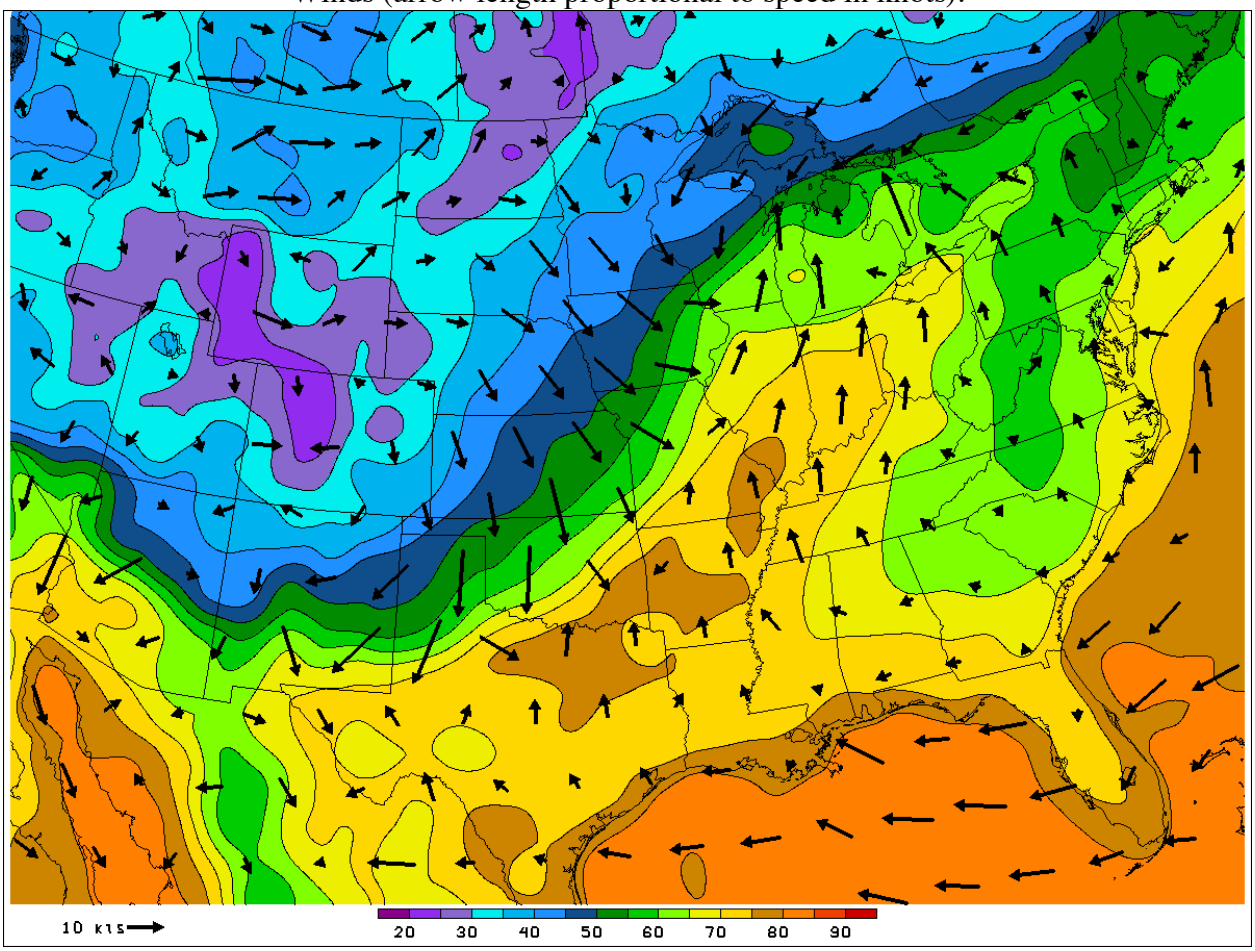
If you feel too overwhelmed to start your isobar analysis, consider doing the following on a preliminary draft of your analysis. Shade all stations with SLP values between two adjacent isobar values (e.g. 1032 mb – 1036 mb) with the same color. In the below example, I shaded in red a station (BOI) that reports SLP's between 1032 mb -1036 mb; only that station lies on the higher pressure side of the 1032 mb isobar. I also shaded in blue the one station (ORD) with a SLP value between 1004 mb – 1008 mb; ORD must lie on the lower pressure side of the 1008 mb isobar. If you find this suggestion helpful, I leave it to you do a similar shading of all stations that lie between all adjacent isobar pairs, in different colors of course.



You may also encounter stations with a SLP report that is the exact value of an isobar that must be drawn. If you encounter such stations, I suggest that you cirle each one because they are meteorological equivalent of analysis gold. Why? An isobar with the same value of SLP as the observation goes through (or goes very, very close to) that station! I counted eight such stations on the map that satisfy the condition. I have circled in orange-gold shading two such stations for you. I recommend that you find the remaining ones to make beginning your analysis a tad easier.

Temperatures and Wind Direction

Isotherms (contours and shading every 5°F)
Winds (arrow length proportional to speed in knots).

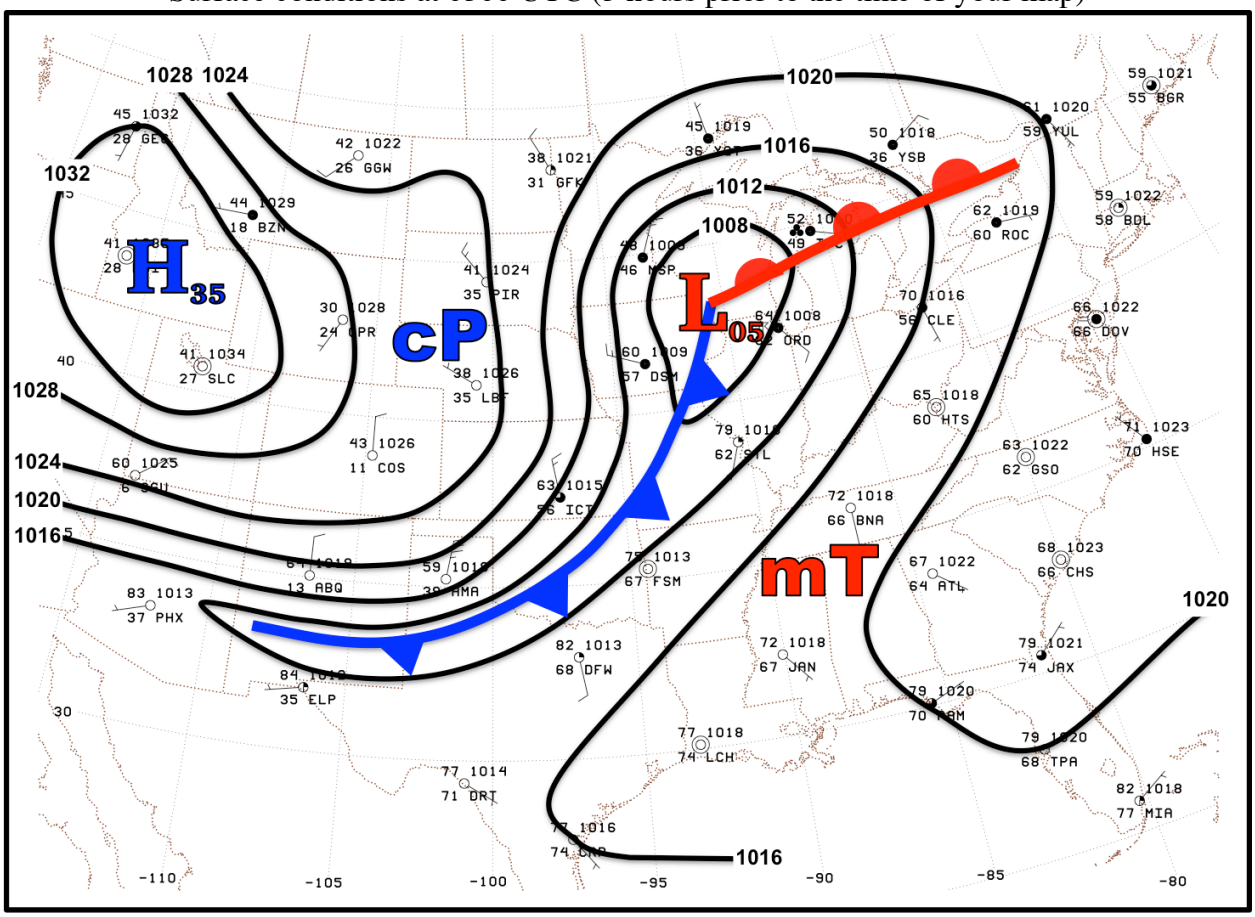


Fronts are located along zones of strong temperature contrast that coincide with an abrupt change in the wind direction. Can you find such a zone where colder air is replacing warmer air? That would be near the position of the cold front. Where warmer air is replacing colder air? That would be near the warm front.

The center of the low is located close to where the winds spiral counterclockwise inward and converge toward a point. Do you see such a region on the above map where the winds spiral inward to a point? Look carefully, there is one!

Prior Position of Cyclones and Fronts

Surface conditions at 0300 UTC (3 hours prior to the time of your map)



Cyclones and fronts tend to move with a uniform velocity over short periods of time (3 hours). In other words, cyclones and fronts exhibit time continuity. If a cyclone has been propagating eastward at 20 knots the past 3 hours, it will likely continue to propagate in approximately the same direction with approximately the same speed over the next 3 hours. Fronts also exhibit the same behavior. Remember, lows tend to move to the northeast, cold fronts to the east or southeast, and warm fronts to north or northeast. Time continuity from 0300 UTC to 0600 UTC implies that your analysis should look similar, very similar, to the above map with the center of cyclone and fronts shifted 100-200 kilometers from their positions on the 0000 UTC map.

As discussed earlier, note how stations with a SLP report with the same value as a mandatory isobar must have that isobar go through the station or go very close to the station. Examples on the 0300 UTC analysis above include Cleveland OH (CLE), Corpus Christi TX (CRP), Tampa Bay FL (TPA) and Panama City FL (PAM), among others.

Final point: you would need to add the air mass labels **cP** and **mT** to your analysis.

--------END--------