

**METR 360 LAB BOOK**

**FALL, 2016**

NAME \_\_\_\_\_

## Fall, 2016: Weather Analysis and Forecasting I (METR 360)

**Lectures:** 1-1:50 Monday, Wednesday, Friday in S309. Labs: 2-4:50 p.m. Wednesday in S309  
**Instructor:** Dr. Jerome Blechman, 311B Sci I, campus phone: 3322, Jerome.Blechman@oneonta.edu  
**Office hours:** Monday, Wednesday, Friday 10-10:50

**“Text”:** Lab workbook (available first class period)

Good references: An Introduction to Dynamic Meteorology by James R. Holton; Mid-Latitude Weather Systems by T.N. Carlson; Synoptic-Dynamic Meteorology in Midlatitudes by Howard B. Bluestein

### Learning Outcomes:

- Students will apply principles of atmospheric synoptic and dynamic meteorology to the prediction of states of the atmosphere on time scales up to two weeks into the future
- Students will demonstrate their ability to communicate scientific and technical information effectively through appropriate oral, visual and written presentation.
- Students will demonstrate their ability to apply scientific reasoning, technology and collaborative skills to solve real world problems in the Earth and Atmospheric Sciences

### Emergency Evacuation/Shelter-in-Place Procedures

In the event of an emergency evacuation (i.e. fire or other emergency), classes meeting in Science I are directed to reassemble at **Chase Gymnasium** so that all persons can be accounted for. Complete details of the College’s emergency evacuation, shelter-in-place, and other emergency procedures can be found at [www.oneonta.edu/security](http://www.oneonta.edu/security).

### ADA (Americans With Disabilities Act) Statement

All individuals who are diagnosed with a disability are protected under the Americans with Disabilities Act, and Section 504 of the Rehabilitation Act of 1973. As such, you may be entitled to certain accommodations within this class. If you are diagnosed with a disability, please make an appointment to meet with Student Disability Services (SDS), 209 Alumni Hall, ext. 2137. All students with the necessary supporting documentation will be provided appropriate accommodations as determined by the SDS Office. It is your responsibility to contact SDS and provide the professor with your accommodation plan before a test. More information can be found at <http://www.oneonta.edu/development/sds/>

### Student responsibilities and my expectations for you

You, the student, are responsible for *earning* your grade in this class. I don’t “give” out grades.

In addition, I expect you to know and follow the student responsibilities established in the College Code of Student Conduct: <http://www.oneonta.edu/communitystandards/code-of-student-conduct.asp> I will follow the code as well whenever it applies to faculty.

**Grading:** Two exams: 20% each (total=40%, see schedule); Lab assignments: 30% Forecasting Contest: 10% (details to be announced), Final exam (cumulative): 20% (The Final Exam will be on Dec 14 at 2 p.m.)

**Grading Scale:**

93-100% = A	90-92% = A-	87-89% = B+	83-86% = B
80-82% = B-	77-79% = C+	73-76% = C	70-72% = C-
67-69% = D+	63-66% = D	60-62% = D-	0-59% = E

First Assignment: Read the article “With iPhones and computer models, do we still need weather forecasters?” The web link is: <http://arstechnica.com/science/2016/06/with-iphones-and-computer-models-do-we-still-need-weather-forecasters/>.

Think about it and be prepared to discuss the implications of the article’s assertions about your future profession.

**Lecture Topics (note: on any day with interesting weather, lecture may be pre-empted for a map discussion)**

1. Norwegian model review	5. Air masses (damming, lake effect)	9. Potential vorticity
2. Fronts	6. NCEP guidance products	10. Cyclogenesis
3. Stability	7. Waves in the westerlies	11. Jet streams
4. Upper air	8. Vertical motion	
EXAM (Oct 12)	EXAM (Nov 16)	FINAL EXAM (Dec 14)

(The Final exam is cumulative)

**Lab Topics**

Aug 31	Surface map analysis review (Not graded)
Sep 7	Synoptic code (Graded)
Sep 14	Radiosonde release and sounding plot (Not graded)
Sep 21	Upper air code and Sounding plotting (Graded)
Sep 28	Upper air maps I (Graded),
Oct 5	<b>Exam 1</b>
Oct 12	Upper air maps II (Graded)
Oct 19	Numerical Guidance (Graded)
Oct 26	METAR code (Graded)
Nov 2	Lake Effect snow forecasting
Nov 9	Forecast teams (Not graded)
Nov 16	<b>Exam 2</b>
Nov 30	IDV nor'easters (Graded)
Dec 7	Forecast teams (Not graded)

**Notes:**

1. As standard equipment for all labs, you will need the lab workbook, a calculator, colored pens and pencils, a regular pencil with eraser, a plotting pen, and a ruler. For colored pens, get some inexpensive felt tips. At a minimum, you will need black, blue, red and green. Also, get red, blue and green pencils for shading maps. You will need a fine-tipped black plotting pen (felt-tip is fine).

2. Since we have no required textbook, you must attend all labs and lectures. You should only miss a class or lab for a good reason. Sickness is a good reason. Softball practice is not. If you feel you must be absent or late, ask me first (whenever possible).

3. There will be no lab exam. The grades given for labs will be averaged and will count 30% toward the course grade. Labs are a major part of the course. Read the lab write-ups in the lab book before each lab. Graded labs must be turned in Monday following the lab, unless a different due date is announced during the laboratory period. If you are sick and miss the lab period, you must make up the assignment as soon as possible.

4. Everyone will enter the WxChallenge forecasting contest (forecasting is worth 10% of your grade). The entry fee is \$5.00 for the year. You must pay me and I will pay the Contest. Read the rules at <http://www.wxchallenge.com/info/rules.php> You will need a six-letter identifier. Mine is blechm. Yours can be anything such as kissme, Mickey, or SoGood (keep it clean). It can be your name. Notice that they are case-sensitive. You will type this identifier many times. Make it something you can type easily and remember, too. You also need a nine-character password. You can use any combination of 9 letters and numbers.

5. Everyone has a Linux PC account. Your username is firstnamel such as donaltdt. Change the password the first time you log on (temporary password to be announced first class period).

## Surface Map Analysis Review

Many of the labs this semester will involve plotting and analysis of weather data in different forms from different perspectives. The form most of you recognize is the analyzed surface map. You should have done this at least once in METR 110, so the basics will not be repeated here. However, now that you are advanced meteorology majors, you will be expected to be able to produce a smooth, readable analysis and therefore we will practice analyzing maps.

Some of you may be thinking that a computer plotter can draw a map and that this is a waste of time. You will think that about many of this semester's labs. It is, however, important to learn how analysis and plotting are done, so when, not if the computer breaks down or does something you think looks strange, you know the mechanics of the analysis and plotting processes.

This lab will not be graded, but lab 2 will use techniques learned here and that one will be graded. Your 28 September map (assignment 1) will be returned Friday in class with comments to help you improve your analysis technique.

Lab Assignment:

1. Analyze the map for 28 September in lab and turn it in before you leave. Remember to write your name on all maps to be turned in. Do the following analysis:

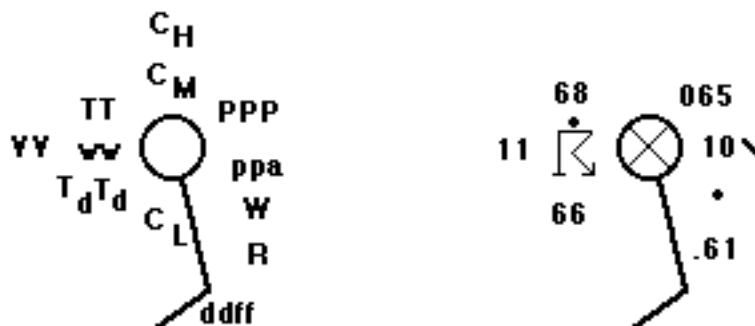
- Draw isobars in black every 4 mb, including the 1000 mb isobar (label them 92, 96, 00, etc.)
- Draw isotherms in red every 10°F (label them 60, 70, 80, etc.)
- Put in centers of High and Low pressure (H and L). Remember that winds must be cyclonic around the "L" and anticyclonic around the "H".
- Draw in the fronts, if any exist. This will be tough. Give it a try.

Color conventions for meteorological analyses are summarized on the next page.

2. After you get back the 28 September map, analyze the map for Dec 24, 2015, to be turned in next week. Do a, b, c, and d from above.

Remember - always draw isopleths lightly in pencil first, then ink over.

Review of the station model (where to look for pressure, temperature, precip, etc.):



TT-> temperature, T<sub>d</sub>T<sub>d</sub> -> dew point, PPP -> pressure, ww -> weather, dfff -> wind direction and speed. For this example: Temperature = 68°F, dew point = 66°F, pressure = 1006.5 mb, pressure dropped 1.0 mb in past 3 hours, current weather = thunderstorm, wind from 170° at 10 knots, sky obscured, rainfall = 0.61" in past 3 hours, past weather = rain. Note: not all reports have all this information.

## Color and contouring Conventions for Synoptic Analyses

### Surface (MSL) maps

Isobars - solid black felt tip pen (4 mb intervals, centered at 1000 mb.).

Isotherms - solid red felt tip pen (intervals of 5°C, centered on 10°C or 10°F, centered on 50°F).

Fronts - red felt tip pen for warm, cold for blue, purple for occluded.

Isallobars - lightly dashed red lines for falls, blue for rises.

Areas of continuous precipitation - shade lightly with green pencil. Outline shaded green area with heavier green line. Add a few weather symbols in heavier green (inside) showing type of precipitation.

Areas of showery precipitation - outline with heavy green line. Add weather symbols inside.

### 850 mb and 700 mb charts

Contours in solid black felt tip pen (60 m intervals centered on 1500 m for 850, 3000 m for 700).

Isotherms in red felt tip pen (5° intervals, centered on 0°C).

Shade areas where  $T-TD \leq 5^\circ\text{C}$ .

### 500 mb chart

Contours in solid black felt tip pen (60 m intervals centered on 5400 m).

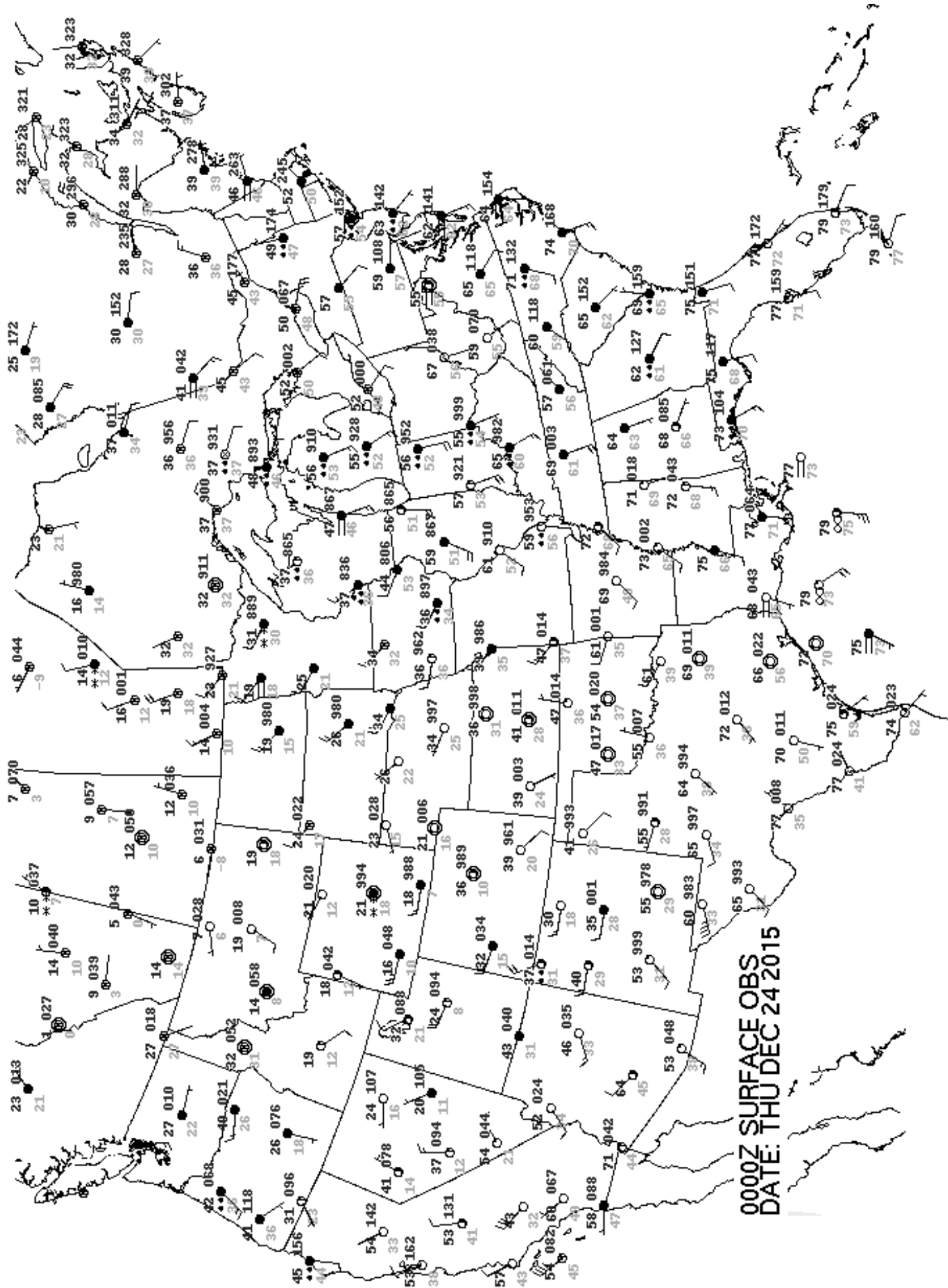
Isotherms in red felt tip pen (5° intervals, centered on -20°C).

### 300 mb, 250 mb, and 200 mb charts

Contours in solid black felt tip pen (120 m intervals centered on 9000 mb for 300 mb and 12000 m for 200 mb).

Isotachs in dashed light blue (20 kt intervals centered on 70 kts). Shade alternate 20 kt intervals.





0000Z SURFACE OBS  
DATE: THU DEC 24 2015

## The Synoptic Code

There are two types of code used to transmit surface weather data from Weather Forecast Offices (WFO's) to the National Center for Environmental Prediction (NCEP, the Weather Service's main office). The most commonly used code is known as METAR Code, but this code is a shorthand type, designed to send out an abbreviated weather message every hour, mainly for pilots. It will be the subject of a later lab.

The more complete code used by the Weather Service to send out synoptic type data is known as the **Synoptic Code**. It is the code used by first-order stations to report their observations every three hours for the weather maps at 00Z, 03Z, 06Z, etc. This is only Part 1 of the code. The complete code book can be found at <http://www.ofcm.gov/fmh2/fmh2.htm> (as a pdf document).

The Synoptic code is a message consisting almost entirely of numbers. This message contains an extraordinary amount of weather information. Deciphering the code is what today's lab is all about. Here is a sample line of code:

72518 SM 11212 82313 10165 20159 39923 40027 57022 69961 75154 8662/

You should notice that after the first three groups of five, each group starts with an identification number, 10165 20159 39923, etc. This is so you can rapidly decode the message. Use the identifiers with the symbolic form shown below. The code SM just indicates synoptic code and may be omitted on many reports.

Decoded observation: Albany, N.Y., precip included, measured at a manned (not automatic) station, base of the lowest cloud is 100-199 meters above ground, visibility 1.2 km (3/4 mile), sky completely overcast, wind from 230° at 13 knots, temperature 16.5°C, dew point 15.9°C, station pressure 992.3 millibars, sea level pressure 1002.7 mb, pressure has fallen 2.2 mb in the last three hours, precipitation = 0.6 millimeters and it began less than 1 hour ago, current weather is slight continuous drizzle, most significant past weather is drizzle, secondary past weather is fog.

As you can see, the Synoptic Code is a very efficient way to get an entire paragraph of data into one line. There could be much more additional information, but we will concentrate on the first section which ends with the cloud group, as above. For those of you who want complete details, the whole code is described in this lab.

**You do not have to memorize this code.** That is why we have reference tables, like this lab. Also there are computer programs to decode it. Once again, you are studying the code so that you understand it and that when the computer makes an error, you won't be helpless.

IMPORTANT - Note that whenever possible, the coded information is in metric units. The U.S. is alone in its persistent usage of English units. Even the English don't use them anymore. We will use a lot of metric units in this course.

The symbolic form of the message follows. You should compare this to the explanations and examples on the following pages:

Iiii i<sub>r</sub>xhVV Nddff 1s<sub>n</sub>TTT 2s<sub>n</sub>T<sub>d</sub>T<sub>d</sub>T<sub>d</sub> 3P<sub>o</sub>P<sub>o</sub>P<sub>o</sub>P<sub>o</sub> 4PPPP 5appp 6RRRt<sub>r</sub> 7wwW<sub>1</sub>W<sub>2</sub>

Depending on the weather, not all of the groups are reported at each synoptic observation. For example, if no precip occurs, the group 6RRRt<sub>r</sub> may be omitted.

In addition, on the first working day of each month, the 18Z SM will contain monthly mean and record breaking data.



## EXPLANATION OF SYNOPTIC CODE GROUPS

### Identification System (Iiii)

This group contains the WMO identification number of the station. The first two digits (II) represent the region (U.S.=72). The last three digits represent the station code.

### Cloud height- Visibility group (i<sub>R</sub>i<sub>x</sub>hVV)

The first identifier (i<sub>R</sub>) is the indicator for inclusion or omission of precipitation data. There are 3 possible code figures:

<u>Code Figure</u>	<u>Group 6RRRt<sub>R</sub> is:</u>
1	Included
3	Omitted (PRECIP=0)
4	Omitted (PRECIP amt not available)

If any precipitation falls (including a trace) during the 6 hour time interval between messages, code figure 1 will be used.

The second identifier (i<sub>x</sub>) indicates the type of station operation (manned or automatic) and indicates the inclusion of present or past weather data. There are 6 possible code figure, however the first three are most common:

<u>Code Figure</u>	<u>Type of Station</u>	<u>Group 7wwW<sub>1</sub>W<sub>2</sub> is:</u>
1	Manned	Included
2	Manned	Omitted (no significant phenomenon to report)
3	Manned	Omitted (Data not available)

Code figures 4 through 6 repeat the above for automatic stations. Code figure 2 is used if the present and past weather both only describe characteristic changes in the state of the sky. Code figure 1 is used (and therefore 7wwW<sub>1</sub>W<sub>2</sub>) is included) if any atmospheric meteors were observed during the previous 6 hours.

The third figure (h) reports the height above ground of the base of the lowest cloud seen. Check the following table for an interpretation of the code figures:

<u>CODE FIGURE</u>	<u>HEIGHT IN FEET</u>	<u>HEIGHT IN METERS</u>
0	0-149	0-49
1	150-299	50-99
2	300-599	100-199
3	600-999	200-299
4	1000-1999	300-599
5	2000-3499	600-999
6	3500-4999	1000-1499
7	5000-6499	1500-1999
8	6500-7999	2000-2499
9	8000 or higher or no clouds	2500 or higher or no clouds

VV is the coded form of the horizontal visibility at the surface. Table 3 is a complete chart of reportable visibilities and their associated code figures.

## Examples of Group $i_{RI}xhVV$

- 32866 No precip group in report (amount is zero).  
 Manned station with no significant weather group  
 Lowest cloud base 2000-2500 meters (6500-8000 ft)  
 Visibility 16 kilometers (10 miles)
- 46/// No precipitation group in report (not available)  
 Auto. station with no weather group (not observed)  
 No cloud height reported  
 No visibility reported

### Sky-cover – Wind Group (Nddff)

Sky covers amounts (N) are evaluated in terms of the fraction of celestial dome (entire sky area above the local horizon) covered by all types of clouds. The amounts are recorded in tenths and reported in accordance with Table 2. **Note:** currently, amounts recorded in eighths (octas). When an observer at the surface is unable to evaluate the sky cover due to atmospheric obstructions to vision such as fog, smoke, haze, precipitation, or any other phenomena other than clouds, an obstruction is reported by code figure 9.

Wind direction (dd) is defined as the direction from which the surface wind is blowing. Wind directions are made over a one minute average except for multiple registers, when a 5 minute average is used. The direction is determined with reference to true north and expressed to the nearest tens of degrees on the 01-36 scale. For example, a wind blowing from the north ( $360^\circ$ ) toward the south ( $180^\circ$ ) is called a north wind and code figure 36 is reported. When the air has no perceptible motion (calm), code figure 00 is reported. If neither an instrumental nor estimated direction is obtained, solidi (//) shall be reported for dd to indicate missing data.

Wind speed ff is determined to the nearest knot. As far as possible, the average wind speed observations are not made during a peak or lull in gusty winds or squalls. In general, observed wind speeds are a one minute average. When the air is calm, code figure 00 is reported. In the range 01-99 knots, inclusive, the speed is coded directly for ff. In the 100-199 knot range, the speed minus 100 is reported, along with a special revision to the direction (dd). In this range, 50 is added to the code figure normally reported for dd. Thus a 125 knot north wind is reported 8625 (i.e. dd is 36 (north) + 50 = 86, and ff is 125 - 100 = 25, so coded it is 8625).

- Other examples: 90000 Sky totally obscured, wind calm.  
 01506 Sky clear or partially obscured, wind SE at 6 knots.

### Temperature Groups ( $1s_n TTT$ and $2s_n T_d T_d T_d$ )

The character “1” identifies the air temperature group. The character  $s_n$  gives the sign of the temperature.

<u>Code Figure</u>	
0	Temperature positive or zero
1	Temperature negative

The characters TTT give the temperature of the air in tenths of Celsius degrees.  $T_d T_d T_d$  gives the dew point temperature to nearest tenth degree Celsius.

- Example: 10036 21036 Air temperature is  $+3.6^\circ\text{C}$   
 Dew point temperature is  $-3.6^\circ\text{C}$

Pressure Groups (3P<sub>o</sub>P<sub>o</sub>P<sub>o</sub>P<sub>o</sub> 4PPPP 5appp)

“3” is the code figure for the station pressure group. This is a non-reduced pressure corrected for instrument error. The pressure given to the nearest tenth of a millibar (e.g. 975.3mb is coded 39753; 1003.3 mb is coded 30033).

“4” is the code figure for surface pressure reduced to sea level given to the nearest tenth of a millibar.

The third group (5appp) is the three-hour pressure tendency and pressure change group. The characteristics of the pressure tendency, “a”, are described in Table 5.

The last three characteristics, ppp, are the actual change in the pressure (but with no decimal) during the 3 hours ending at the actual time of observation.

EXAMPLES OF PRESSURE GROUPS

39548	40176	54000	Station pressure = 954.8mb Sea-level pressure = 1017.6mb 3 hour pressure tendency is steady Pressure is the same now as 3 hours ago
39658	49984	57084	Station pressure = 965.8mb Sea-level pressure = 998.4mb Pressure falling steadily past 3 hours Pressure has fallen 8.4mb past 3 hours

Precipitation Group (6RRRtr)

“6” is the identifier for the precipitation group. RRR is the total six hour amount of liquid precipitation and water equivalent of solid precipitation. The precipitation is recorded in millimeters and is coded as in Table 4.

tr is the time precipitation began or ended as described in the following:

CODE FIGURE	TIME BEGAN OR ENDED	CODE FIGURE	TIME BEGAN OR ENDED
0	No precipitation	6	5-6 hrs ago
1	less than 1 hr ago	7	6-12 hrs ago
2	1-2 hrs ago	8	More than 12 hrs ago
3	2-3 hrs ago		
4	3-4 hrs ago	9	Unknown
5	4-5 hrs ago		








Past and Current Weather Group (7wwW<sub>1</sub>W<sub>2</sub>)

“7” is the group identifier. ww is weather occurring at the observation time and is shown in Table 1.

The last two characters in the group (W<sub>1</sub>W<sub>2</sub>) are used together to show the past weather. W<sub>1</sub> is the most significant past weather during the appropriate 6 hour period while W<sub>2</sub> is the second most significant. The figure on the next page shows how to decode the past weather group:

## Past Weather Symbols

These symbols represent the most significant weather within the past six hours of the observation but not during the most recent hour.

0	1	2	3	4	5	6	7	8	9
N/A	N/A	N/A							
Clear or Few Clouds (not plotted)	Partly cloudy (scattered) or variable sky (not plotted)	Cloudy (broken) or overcast (not plotted)	Sandstorm or dust storm, or drifting or blowing snow	Fog, or smoke, Drizzle or thick dust haze	Rain	Snow, or rain and snow mixed, or ice pellets (sleet)	Shower(s)	Thunderstorm, with or without precipitation	

## Cloud Group (8N<sub>h</sub>C<sub>L</sub>C<sub>M</sub>C<sub>H</sub>)

This group is rarely used on modern maps but it may appear in synoptic code data.

The fraction of the celestial dome covered by all the C<sub>L</sub> (or C<sub>M</sub>) clouds present is given as N<sub>h</sub>. When low clouds (C<sub>L</sub>) are present, the value reported for N<sub>h</sub> represents the total amount of all types of C<sub>L</sub> clouds present regardless of the number of C<sub>L</sub> types that may coexist at the time of the observation.

When no C<sub>L</sub> clouds are present and middle clouds (C<sub>M</sub>) are present, the value reported for N<sub>h</sub> represents the total amount of all C<sub>M</sub> clouds present. High cloud types (C<sub>H</sub>) are never reported for N<sub>h</sub>. Code figure 0 is reported for N<sub>h</sub> when there are no clouds of C<sub>L</sub> or C<sub>M</sub> types and celestial dome is not obscured. If the celestial dome is obscured, code figure 9 is reported. N<sub>h</sub> is coded using the same procedure as for coding N, presented in Table 2. Code figure 1 is thus reported when up to and including 1/10 of the sky is covered by all types of low clouds. The fraction of the celestial dome covered by the clouds which is reported for N<sub>h</sub> however, may never exceed the value reported for N in the Nddiff group. If, due to either an obscuration or an intervening cover (usually more than 9/10) of a lower altitude cloud type, the cloud type cannot be determined, a solidus (/) is reported.

The code figures for the characters C<sub>L</sub>C<sub>M</sub>C<sub>H</sub> are given in Table 2. For example, 86521 would indicate that ¾ of the sky is covered by stratocumulus type low clouds, with the remaining of the sky covered by altostratus type middle clouds and cirrus type high clouds.

Generally, synoptic maps plotted and transmitted by NCEP's Weather Prediction Center, or WPC, do not include cloud symbols so this group is unfortunately ignored. WPC maps can be found at <http://www.wpc.ncep.noaa.gov/html/sfc2.shtml>



CLOUD ABBREVIATION	CL	DESCRIPTION (Abridged From W. M. O. Code)	CM	DESCRIPTION (Abridged From W. M. O. Code)	CH	DESCRIPTION (Abridged From W. M. O. Code)
St or Fs-Stratus or Fractostratus	1	Cu of fair weather, little vertical development and seemingly flattened	1	Thin As (most of cloud layer semi-transparent)	1	Filaments of Ci, or "mares tails," scattered and not increasing
Ci-Cirrus	2	Cu of considerable development, generally towering, with or without other Cu or Sc bases all at same level	2	Thick As, greater part sufficiently dense to hide sun (or moon), or Ns	2	Dense Ci in patches or twisted sheaves, usually not increasing, sometimes like remains of Cb; or towers or tufts
Cs-Cirrostratus	3	Cb with tops lacking clear-cut outlines, but distinctly not cirriform or anvil-shaped; with or without Cu, Sc, or St	3	Thin Ac, mostly semi-transparent; cloud elements not changing much and at a single level	3	Dense Ci, often anvil-shaped, derived from or associated with Cb
Cc-Cirrocumulus	4	Sc formed by spreading out of Cu; Cu often present also	4	Thin Ac in patches; cloud elements continually changing and/or occurring at more than one level	4	Ci, often hook-shaped, gradually spreading over the sky and usually thickening as a whole
Ac-Alto cumulus	5	Sc not formed by spreading out of Cu	5	Thin Ac in bands or in a layer gradually spreading over sky and usually thickening as a whole	5	Ci and Cs, often in converging bands, or Cs alone; generally overspreading and growing denser; the continuous layer not reaching 45° altitude
As-Altostratus	6	St or Fs or both, but no Fs of bad weather	6	Ac formed by the spreading out of Cu	6	Ci and Cs, often in converging bands, or Cs alone; generally overspreading and growing denser; the continuous layer exceeding 45° altitude
Sc-Stratocumulus	7	Fs and/or Fc of bad weather (scud)	7	Double-layered Ac, or a thick layer of Ac, not increasing; or Ac with As and/or Ns	7	Veil of Cs covering the entire sky
Ns-Nimbostratus	8	Cu and Sc (not formed by spreading out of Cu) with bases at different levels	8	Ac in the form of Cu-shaped tufts or Ac with turrets	8	Cs not increasing and not covering entire sky
Cu or Fc-Cumulus or Fractocumulus	9	Cb having a clearly fibrous (cirriform) top, often anvil-shaped, with or without Cu, Sc, St, or scud	9	Ac of a chaotic sky, usually at different levels; patches of dense Ci are usually present also	9	Cc alone or Cc with some Ci or Cs, but the Cc being the main cirriform cloud
Cb-Cumulonimbus						

Rt	TIME OF PRECIPITATION	HEIGHT IN FEET (Rounded Off)	HEIGHT IN METERS (Approximate)	5 SKY COVERAGE (Total Amount)	6 SKY COVERAGE (Low And/Or Middle Clouds)	7 SKY COVERAGE
0	No Precipitation	0 - 149	0 - 49	No clouds	0	No clouds
1	Less than 1 hour ago	150 - 299	50 - 99	1/8	1	Less than one-tenth or one-tenth
2	1 to 2 hours ago	300 - 599	100 - 199	2/8	2	Two-tenths or three-tenths
3	2 to 3 hours ago	600 - 999	200 - 299	3/8	3	Four-tenths
4	3 to 4 hours ago	1,000 - 1,999	300 - 599	4/8	4	Five-tenths
5	4 to 5 hours ago	2,000 - 3,499	600 - 999	5/8	5	Six-tenths
6	5 to 6 hours ago	3,500 - 4,999	1,000 - 1,499	6/8	6	Seven-tenths or eight-tenths
7	6 to 12 hours ago	5,000 - 6,499	1,500 - 1,999	7/8	7	Nine-tenths or over-cast with openings
8	More than 12 hours ago	6,500 - 7,999	2,000 - 2,499	Completely overcast	8	Completely overcast
9	Unknown	At or above 8,000, or no clouds	At or above 2,500, or no clouds	⊗ Sky obscured	9	Sky obscured

Table 2

Symbol VV=Horizontal Visibility

Code Figure	Statute Mile	Code Figure	Statute Mile	Code Figure	Statute Mile
00	under 1/8	65	9 1/2	89	28 1/2
01	1/8	66	10	84	31 1/2
02	1/4	67	10 1/2	85	34 1/2
03	3/8	68	11 1/2	86	37 1/2
04	1/2	69	12 1/2	87	40 1/2
05	5/8	70	13 1/2	88	43 1/2
06	3/4	71	14 1/2	89	over 43 1/2
07	7/8	72	15 1/2	90	under 1/2
08	1	73	16 1/2	91	1/2
09	1 1/8	74	17 1/2	92	3/4
10	1 1/4	75	18 1/2	93	1
11	1 3/8	76	19 1/2	94	1 1/4
12	1 1/2	77	20 1/2	95	1 1/2
13	1 3/4	78	21 1/2	96	2
14	1 7/8	79	22 1/2	97	2 1/2
15	2	80	23 1/2	98	3
16	2 1/8	81	24 1/2	99	3 1/2
17	2 1/4	82	25 1/2		more

Norms:  
 (1) The values given are discrete values (i.e., not ranges). If the observed visibility is between two of the reportable distances as given in the table, the code figure of the lower reportable distance shall be reported.  
 (2) Only the code figures 00-99 shall be used in reports from land stations.  
 (3) In reporting visibility at sea the code 90-99 shall be used.

Table 3 - Horizontal visibility at the surface (VV)










Code Figure	Statute Miles	Kilometers	Code Figure	Statute Miles	Kilometers
00	<1/16	<0.1	40	2 1/2	4.0
01	1/16	0.1	44	2 3/4	4.4
02	1/8	0.2	48	3.0	4.8
03	3/16	0.3	57	4.0	7
04	1/4	0.4	58	5.0	8
05	5/16	0.5	60	6.0	10
06	3/8	0.6	61	7.0	11
08	1/2	0.8	63	8.0	13
10	5/8	1.0	65	9.0	15
12	3/4	1.2	66	10.0	16
14	7/8	1.4	68	11.0	18
16	1.0	1.6	69	12.0	19
18	1 1/8	1.8	71	13.0	21
20	1 1/4	2.0	73	14.0	23
22	1 3/8	2.2	74	15.0	24
24	1 1/2	2.4	81	20.0	35
26	1 5/8	2.6	82	25.0	40
28	1 3/4	2.8	84	30.0	50
30	1 7/8	3.0	85	35.0	55
32	2.0	3.2	87	40.0	65
36	2 1/4	3.6	89	>40.0	>70

Table 4 - Precipitation Amount

RRR - Amount of precipitation which has fallen during the period preceding the time of observation, as indicated by  $t_R$

Code Figure	Amount Millimeters	Code Figure	Amount Millimeters
000	Not used	990	Trace
001	1	991	0.1
002	2	992	0.2
003	3	993	0.3
004	4	994	0.4
005	5	995	0.5
etc.		996	0.6
		997	0.7
988	988	998	0.8
989	989 mm or more	999	0.9

Table 5: Pressure tendency (“a” in the 5apppp group)

	0		Rising, then falling
<b>Pressure higher than three hours ago</b>	1		Rising, then steady, or rising, then rising more slowly
	2		Rising steadily, or unsteadily
	3		Falling or steady, then rising, or rising, then rising more quickly
<b>Pressure the same as three hours ago</b>	4		Steady, same as 3 hours ago
	5		Falling, then rising, same or lower than 3 hours ago
<b>Pressure lower than three hours ago</b>	6		Falling, then steady, or falling, then falling more slowly
	7		Falling steadily, or unsteadily
	8		Steady or rising, then falling, or falling, then falling more quickly



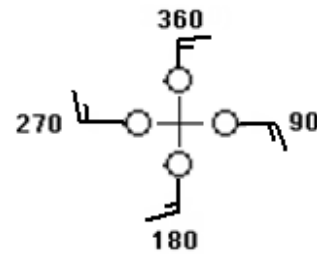
Lab Assignment (due next Wednesday)


On a U.S. base map, plot the synoptic code on the following pages, starting with Key West and ending with Seattle.

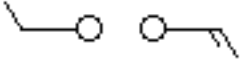
NOTES:

- (1) Plot a few in pencil until you feel comfortable with station plotting. Then ink over the first few and proceed in ink. Use a plotting pen.
- (2) Plot small enough that you don't overlap data from neighboring stations. However, plot large enough so I can easily read your numbers. You should draw a station circle over the small circle on the base map.
- (3) Be neat. After you plot all the stations, you must analyze the maps for isobars, Highs, Lows, and fronts. It will be graded for accuracy of plotting and isoplething.

The following parameters must be plotted (decode unless otherwise specified):  
sky cover (N), wind direction (dd), Note convention at right ----->



wind speed (ff) (Round to nearest 5 knots. Plot calm as . Note the barbs or feathers are always to

the left of the shaft  if you are facing the way the wind is going), temperature (TT) rounded to the nearest degree, dew point (T<sub>d</sub>) rounded to the nearest degree, coded sea level pressure (PPP), pressure tendency with no decimal (appp), present weather symbol (ww), and precipitation in millimeters with the decimal if 0.1-0.9 (see note 4), but not time (RRR<sub>t<sub>R</sub></sub>).

↑  
No

For precipitation, note that codes 991-999 are 0.1 – 0.9 millimeters. Plot the decimal. For codes 1-989, plot the whole number. Example: 60231 is plotted as 23 (the “1” is t<sub>R</sub>. Ignore it). 990 is Trace. Plot “T”.

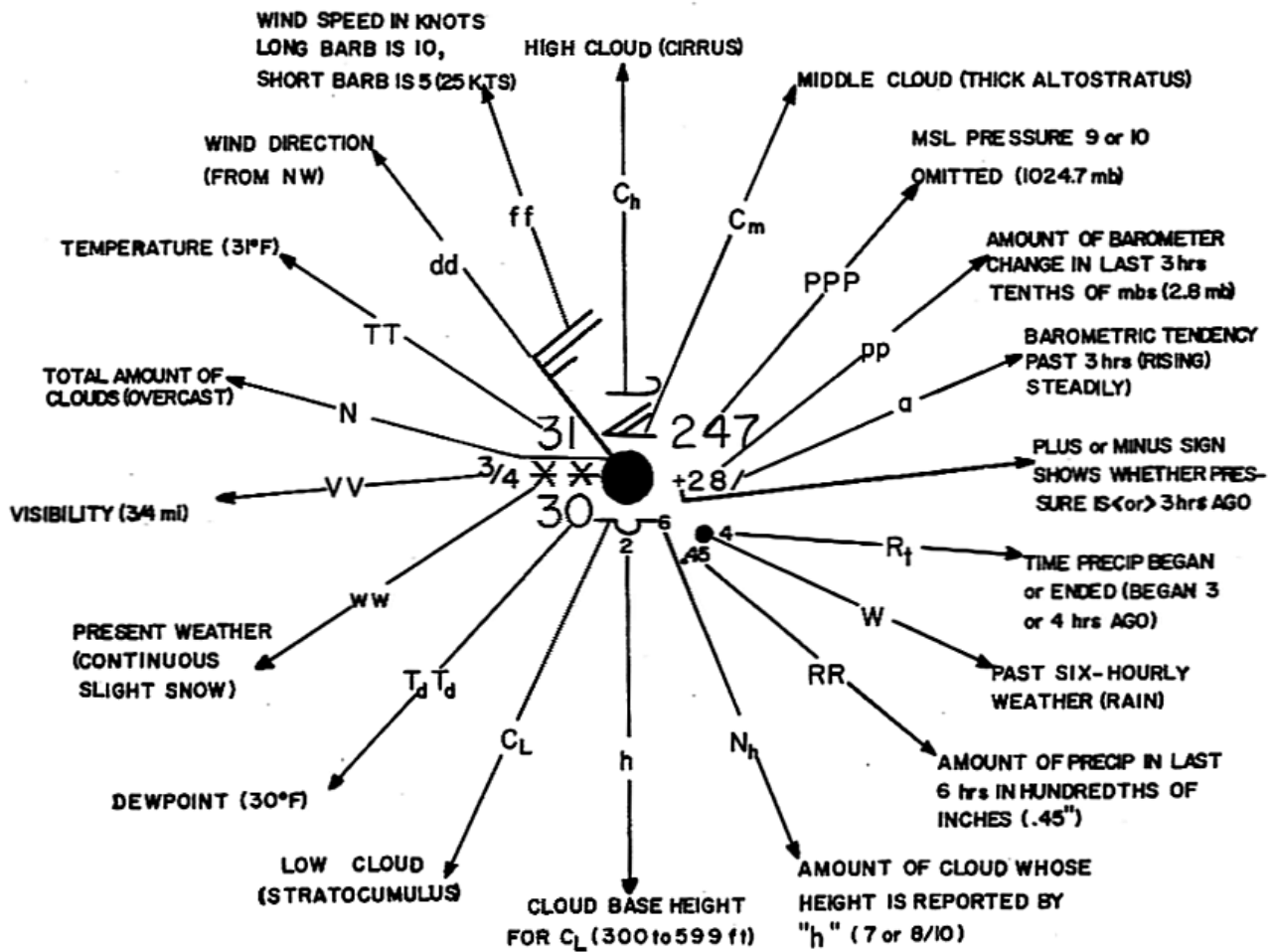
If a group is missing or slashes (///), plot “M” for missing. Exception: If the precipitation (6xxxx) or present weather (7xx//) groups are missing, just leave those areas blank.

Station 72203 is on the base map as PBI (in Florida). 72332 is TUP, plotted at 330 in Mississippi, 72371 is plotted at PGA in Arizona. 72304 is plotted at HAT in North Carolina. 72402 is plotted at WAL, in coastal Virginia. 72672 is plotted at RIW in Wyoming. Latitude and Longitude are provided.

**After you plot all the stations, do a standard analysis:**

- a) Draw isobars in black every 4 mb, including the 1000 mb isobar (label it 00)
- b) Put in centers of High and Low pressure (blue H and red L). Remember that winds must be cyclonic around the "L" and anticyclonic around the "H".
- c) Draw in the fronts, if any exist. Use the proper symbols.

Use the Station Model to plot (not all fields are to be plotted):



Data from 00Z February 6, 2010

72201, Key West, Key West International Airport | 24-33-13N | 081-45-13W | 1 m  
 201002052353 AAXX 06004 72201 11428 82716 10228 20217 30105 40110 53005 60031 765// =

72202, Miami, Miami International Airport | 25-47-26N | 080-18-59W | 3 m  
 201002052353 AAXX 06004 72202 12566 81710 10244 20217 30088 40096 58015 69901=

72203, West Palm Beach, Palm Beach International Airport | 26-41-05N | 080-05-58W | 5 m  
 201002052353 AAXX 06004 72203 12666 61711 10244 20200 30077 40082 56014 69951=

72205, Orlando, Orlando International Airport | 28-25-02N | 081-19-30W | 29 m  
 201002052353 AAXX 06004 72205 11366 82214 10194 20178 30029 40064 55003 60131 761// =

72206, Jacksonville, Jacksonville International Airport | 30-29-40N | 081-41-36W | 9 m  
 201002052356 AAXX 06004 72206 12466 62411 10189 20167 30018 40028 53001 60141=

72207, Savannah, Savannah International Airport | 32-07-08N | 081-12-08W | 15 m  
201002052353 AAXX 06004 72207 11261 82706 10172 20161 39990 40005 56012 60201 761//=

72208, Charleston, Charleston Air Force Base | 32-53-56N | 080-02-26W | 14 m  
201002052356 AAXX 06004 72208 11448 82214 10178 20167 39984 49998 55029 60241 761//=

72211, Tampa, Tampa International Airport | 27-57-41N | 082-32-25W | 8 m  
201002052353 AAXX 06004 72211 12366 62209 10183 20172 30068 40082 53006 60161=

72212, Cross City, Cross City Airport | 29-33-00N | 083-06-19W | 12 m  
201002052353 AAXX 06004 72212 15/// /2613 10167 20150 30046 40061 53009 60141=

72214, Tallahassee, Tallahassee Regional Airport | 30-23-35N | 084-21-12W | 24 m  
201002052353 AAXX 06004 72214 12566 62617 10161 20122 30035 40052 53007 60021=

72217, Macon, Middle Georgia Regional Airport | 32-41-16N | 083-39-16W | 107 m  
201002052353 AAXX 06004 72217 11132 83204 10083 20078 39901 40030 53006 60031 710//=

72218, Augusta, Bush Field | 33-21-52N | 081-57-48W | 44 m  
201002052353 AAXX 06004 72218 31232 83504 10067 20056 39968 40019 50017 763//=

72219, Atlanta, Hartsfield - Jackson Atlanta International Airport | 33-38-25N | 084-25-37W | 313 m  
201002052352 AAXX 06004 72219 11208 81103 10039 20039 39657 40034 51006 60041 751//=

72223, Mobile, Mobile Regional Airport | 30-41-18N | 088-14-44W | 66 m  
201002052356 AAXX 06004 72223 32566 62604 10122 20083 30001 40078 51011=

72226, Montgomery, Dannelly Field | 32-18-01N | 086-24-22W | 67 m  
201002052353 AAXX 06004 72226 12466 82405 10106 20089 39982 40055 51016 69931=

72231, New Orleans, New Orleans International Airport | 29-59-34N | 090-15-03W | 1 m  
201002052353 AAXX 06004 72231 32461 82811 10122 20078 30095 40103 53010=

72234, Meridian, Key Field | 32-20-17N | 088-44-52W | 90 m  
201002052358 AAXX 06004 72234 12466 82707 10089 20067 39968 40074 51011 69901=

72235, Jackson, Jackson International Airport | 32-19-11N | 090-04-39W | 105 m  
201002052354 AAXX 06004 72235 31332 82604 10078 20072 39978 40085 51010 710//=

72240, Lake Charles, Lake Charles Regional Airport | 30-07-34N | 093-13-24W | 5 m  
201002052353 AAXX 06004 72240 32966 03104 10117 20061 30111 40124 53003=

72243, Houston, Houston Intercontinental Airport | 29-59-33N | 095-21-50W | 29 m  
201002052353 AAXX 06004 72243 32566 43110 10117 20067 30092 40137 53011=

72248, Shreveport, Shreveport Regional Airport | 32-26-49N | 093-49-27W | 78 m  
201002052356 AAXX 06004 72248 32666 22705 10083 20039 30009 40106 51006=

72250, Brownsville, Brownsville / South Padre Island Int'l Airport | 25-54-51N | 097-25-23W | 7 m  
201002052353 AAXX 06004 72250 32966 01306 10178 20144 30132 40138 53002=

72251, Corpus Christi, Corpus Christi International Airport | 27-46-23N | 097-30-46W | 13 m  
201002052351 AAXX 06004 72251 32966 00906 10167 20128 30112 40132 55003=

72254, Austin City, Austin Camp Mabry | 30-19N | 097-46W | 200 m  
201002052351 AAXX 06004 72254 35966 03303 10133 20072 39913 40140 53001=

72255, Victoria, Victoria Regional Airport | 28-51-45N | 096-55-47W | 35 m  
201002052351 AAXX 06004 72255 32966 00208 10144 20100 30098 40136 53003=

72256, Waco, Waco Regional Airport | 31-37-02N | 097-13-40W | 157 m  
201002052351 AAXX 06004 72256 32966 02505 10122 20078 39952 40129 56002=

72259, Dallas / Fort Worth, Dallas / Fort Worth Int'l Airport | 32-53-49N | 097-01-19W | 183 m  
201002052353 AAXX 06004 72259 32966 03010 10133 20033 39911 40118 53003=

72261, Del Rio, Del Rio International Airport | 29-22-29N | 100-55-25W | 304 m  
201002052353 AAXX 06004 72261 35966 03405 10222 20061 39751 40112 55003=

72263, San Angelo, Mathis Field | 31-21-05N | 100-29-38W | 584 m  
201002052351 AAXX 06004 72263 32966 00000 10133 20050 39466 40146 55001=

72265, Midland, Midland International Airport | 31-56-52N | 102-12-31W | 875 m  
201002052353 AAXX 06004 72265 32966 03004 10161 20000 39137 40125 56003=

72266, Abilene, Abilene Regional Airport | 32-24-37N | 099-40-54W | 545 m  
201002052352 AAXX 06004 72266 32966 03203 10117 20022 39503 40141 53002=

72267, Lubbock, Lubbock International Airport | 33-40-03N | 101-49-17W | 1000 m  
201002052353 AAXX 06004 72267 32966 42405 10122 20006 39002 40127 55001=

72268, Roswell, Roswell Industrial Air Center Airport | 33-18-29N | 104-30-28W | 1118 m  
201002052351 AAXX 06004 72268 32966 01805 10139 20017 38868 40112=

72270, El Paso, El Paso International Airport | 31-48-40N | 106-22-33W | 1206 m  
201002052351 AAXX 06004 72270 32966 62309 10150 20006 38798 40126 56009=

72274, Tucson, Tucson International Airport | 32-07-53N | 110-57-19W | 805 m  
201002052353 AAXX 06004 72274 32966 00104 10189 20022 39257 40147 56010=

72278, Phoenix, Phoenix Sky Harbor International Airport | 33-26-03N | 112-03-04W | 345 m  
201002052351 AAXX 06004 72278 32766 62006 10194 20050 39754 40145 58010=

72290, San Diego, San Diego International-Lindbergh Field | 32-44-01N | 117-10-59W | 4 m  
201002052351 AAXX 06004 72290 32566 81910 10156 20089 30161 40175 58003=

72295, Los Angeles, Los Angeles International Airport | 33-56-17N | 118-23-20W | 38 m  
201002052353 AAXX 06004 72295 11328 81110 10128 20111 30103 40157 55006 60111 761//=

72302, Wilmington, NC. | 34-16N | 077-54W | 10 m  
201002052353 AAXX 06004 72302 17340 81519 10156 20139 3//// 40017 58057 60101 763//=

72304, Cape Hatteras | 35-16N 075-33W | 2 m  
201002052351 AAXX 06004 72304 11212 81115 10144 20089 30074 40076 56054 6//// 763// =

72306, Raleigh / Durham, Raleigh-Durham International Airport | 35-52-14N | 078-47-11W | 133 m  
201002052351 AAXX 06004 72306 11356 80818 10044 20028 39869 40024 58069 60171 761//=

72308, Norfolk, Norfolk International Airport | 36-54-13N | 076-11-31W | 8 m  
201002052351 AAXX 06004 72308 11459 81018 10039 20028 30088 40105 58059 60081 761//=

72309, Cherry Point, Marine Corps Air Station | 34-53-52N | 076-52-51 | 8 m  
201002052351 AAXX 06004 72309 11201 81015 10139 20128 30039 40040 57050 6//// 765//=

72310, Columbia, Columbia Metropolitan Airport | 33-56-31N | 081-07-05W | 71 m  
201002052356 AAXX 06004 72310 11156 80000 10072 20000 39913 40001 56019 60181 705//=

72314, Charlotte, Charlotte / Douglas International Airport | 35-12-48N | 080-56-55W | 228 m  
201002052352 AAXX 06004 72314 11132 80212 10028 20017 39747 40010 56043 60111 761//=

72315, Asheville, Asheville Regional Airport | 35-25-55N | 082-32-15W | 660 m  
201002052354 AAXX 06004 72315 11358 80000 10006 20006 39238 40015 58010 60101 763//=

72317, Greensboro, Piedmont Triad International Airport | 36-05-51N | 079-56-37W | 282 m  
201002052354 AAXX 06004 72317 11159 80309 10006 20000 39710 40037 55056 60141 761//=

72323, Huntsville, Huntsville International / Jones Field | 34-38-37N | 086-47-08W | 192 m  
201002052353 AAXX 06004 72323 12466 82605 10083 20072 39805 40029 51012 60021=

72324, Chattanooga, Lovell Field | 35-02-00N | 085-12-00W | 207 m  
201002052353 AAXX 06004 72324 11348 81906 10056 20044 39772 40021 51002 60041 751//=

72326, Knoxville, McGhee Tyson Airport | 35-49-05N | 083-59-09W | 299 m  
201002052353 AAXX 06004 72326 11248 82405 10061 20056 39649 40006 51002 60101 765//=

72327, Nashville, Nashville International Airport | 36-07-08N | 086-41-21W | 182 m  
201002052353 AAXX 06004 72327 11459 82606 10067 20056 39766 40012 53006 60021 710//=

72329, London, London-Corbin Airport | 37-05N | 084-04W | 369 m  
201002052353 AAXX 06004 72329 112// 81305 10050 20044 39760 49995 56009 6//// 761//=

72332, Tupelo, Tupelo Regional Airport | 34-16-05N | 088-46-12W | 106 m  
201002052353 AAXX 06004 72332 17359 82807 10067 20050 39929 40054 53017 69901 710//=

72334, Memphis, Memphis International Airport | 35-03-40N | 089-59-06W | 101 m  
201002052353 AAXX 06004 72334 11216 82710 10056 20039 39958 40061 53012 69931 761//=

72344, Fort Smith, Fort Smith Regional Airport | 35-20-01N | 094-21-54W | 142 m  
201002052353 AAXX 06004 72344 32666 83009 10067 20017 39934 40101 53012=

72351, Wichita Falls, Sheppard Air Force Base | 33-58-43N | 098-29-34W | 309 m  
201002052352 AAXX 06004 72351 32966 03209 10106 20017 39770 40134 53009=

72353, Oklahoma City, Will Rogers World Airport | 35-23-19N | 097-36-01W | 394 m  
201002052352 AAXX 06004 72353 32666 63416 10067 20006 39669 40133 53026=

72363, Amarillo, Amarillo International Airport | 35-13-12N | 101-43-02W | 1099 m  
201002052353 AAXX 06004 72363 32966 00106 10028 21022 38901 40163 53009=

72365, Albuquerque, Albuquerque International Airport | 35-02-30N | 106-36-53W | 1631 m  
201002052356 AAXX 06004 72365 32966 62904 10094 21028 38359 40144 56005=

72370, Kingman, Kingman Airport | 35-15-28N | 113-55-59W | 1050 m  
201002052351 AAXX 06004 72370 17666 80605 10089 20061 38983 40137 53001 69951 761//=

72371, Page, Page Municipal Airport | 36-55-14N | 111-26-53W | 1314 m  
201002052353 AAXX 06004 72371 35/66 /0000 10083 21011 38684 40183 5////=

72376, Flagstaff | 35-08-15N | 111-40-12W | 2135 m  
201002052356 AAXX 06004 72376 11459 82506 10022 20000 37859 40165 54000 69901 771//=

72384, Bakersfield, Meadows Field Airport | 35-26-01N | 119-03-24W | 155 m  
201002052354 AAXX 06004 72384 12866 61706 10161 20083 39935 40113 56014 69951=

72386, Las Vegas, McCarran International Airport | 36-04-44N | 115-09-19W | 663 m  
201002052356 AAXX 06004 72386 32766 61607 10144 20044 39388 40123 56007=

72389, Fresno, Fresno Air Terminal | 36-46-48N | 119-43-10W | 101 m  
201002052353 AAXX 06004 72389 11561 81208 10139 20111 30004 40125 58002 69981 761//=

72401, Richmond, Richmond International Airport | 37-30-40N | 077-19-24W | 51 m  
201002052354 AAXX 06004 72401 11248 80915 10011 21006 30038 40105 58061 60101 761//=

72402, Wallops Island, Wallops Flight Facility Airport | 37-56-26N | 075-27-47W | 12 m  
201002052354 AAXX 06004 72402 17012 80912 10006 21006 30138 40153 56041 60061 771//=

72403, Washington DC, Washington-Dulles International Airport | 38-56-05N | 077-26-51W | 95 m  
201002052352 AAXX 06004 72403 11204 80610 10000 21011 30030 40144 58039 60091 775//=

72406, Baltimore, Baltimore-Washington International Airport | 39-10-00N | 076-41-00W | 44 m  
201002052354 AAXX 06004 72406 11208 80612 11006 21006 30091 40163 56033 60061 773//=

72407, Atlantic City, Atlantic City International Airport | 39-27-53N | 074-35-12W | 23 m  
201002052354 AAXX 06004 72407 11559 80707 10017 21039 30144 40186 56028 69901 771//=

72408, Philadelphia, Philadelphia International Airport | 39-52-06N | 075-13-52W | 6 m  
201002052354 AAXX 06004 72408 11558 80507 10006 21028 30164 40185 56028 69901 771//=

72411, Roanoke, Roanoke Regional Airport | 37-19-01N | 079-58-27W | 358 m  
201002052354 AAXX 06004 72411 11224 81106 10000 21011 39645 40079 56025 60091 779//=

72414, Charleston, Yeager Airport | 38-22-46N | 081-35-29W | 299 m  
201002052354 AAXX 06004 72414 11232 80708 10028 20017 39657 40024 56037 60161 763//=

72417, Elkins, Elkins-Randolph County-Jennings Randolph Field | 38-53-07N | 079-51-10W | 605 m  
201002052351 AAXX 06004 72417 17532 8//04 10000 21033 39342 40063 56024 60101 771//=

72421, Covington / Cincinnati, Northern Kentucky Int'l Airport | 39-02-35N | 084-40-18W | 273 m  
201002052352 AAXX 06004 72421 11208 80513 10006 20000 39694 40013 56017 60061 771//=

72422, Lexington, Blue Grass Airport | 38-02-27N | 084-36-21W | 298 m  
201002052354 AAXX 06004 72422 11256 80000 10044 20044 39642 49996 55014 60071 761//=

72423, Louisville, Standiford Field | 38-10-38N | 085-43-47W | 151 m  
201002052356 AAXX 06004 72423 11361 83606 10028 20022 39831 40005 56012 60111 761//=

72428, Columbus, Port Columbus International Airport | 39-59-42N | 082-52-35W | 248 m  
201002052351 AAXX 06004 72428 11316 80613 10006 20006 39749 40047 56025 60061 771//=

72429, Dayton, Cox Dayton International Airport | 39-54-22N | 084-13-07W | 307 m  
201002052356 AAXX 06004 72429 11212 80517 10000 21011 39679 40047 56018 60051 771//=

72432, Evansville, Evansville Regional Airport | 38-02-35N | 087-31-13W | 127 m  
201002052354 AAXX 06004 72432 11264 83606 10017 20011 39878 40019 58004 60051 761//=

72434, St. Louis, Lambert-St. Louis International Airport | 38-45-09N | 090-22-25W | 184 m  
201002052351 AAXX 06004 72434 11316 80209 10011 20000 39861 40071 53005 60051 771//=

72438, Indianapolis, Indianapolis International Airport | 39-43-30N | 086-16-55W | 243 m  
201002052354 AAXX 06004 72438 11320 80421 10000 21011 39745 40037 56011 60051 771//=

72440, Springfield, Springfield Regional Airport | 37-14-23N | 093-23-23W | 386 m  
201002052352 AAXX 06004 72440 11340 83110 10000 21017 39624 40089 53014 69931 771//=

72445, Columbia, Columbia Regional Airport | 38-49-01N | 092-13-06W | 271 m  
201002052354 AAXX 06004 72445 11228 80109 10006 21006 39764 40090 53016 60041 771//=

72446, Kansas City, Kansas City International Airport | 39-17-50N | 094-43-50W | 312 m  
201002052353 AAXX 06004 72446 11312 83610 10011 21006 39740 40127 53021 69981 771//=

72450, Wichita, Wichita Mid-Continent Airport | 37-38-50N | 097-25-46W | 406 m  
201002052353 AAXX 06004 72450 12466 83412 10022 21006 39654 40145 51024 69901=

72451, Dodge City, Dodge City Regional Airport | 37-46-22N | 099-58-11W | 790 m  
201002052352 AAXX 06004 72451 35464 83613 10006 21022 39235 40167 53018=

72458, Concordia, Blosser Municipal Airport | 39-33-05N | 097-39-02W | 453 m  
201002052355 AAXX 06004 72458 37448 83510 11006 21033 39626 40166 53020 704//=

72462, Alamosa, San Luis Valley Regional Airport | 37-26-20N | 105-51-41W | 2297 m  
201002052352 AAXX 06004 72462 35966 03106 11017 21083 37669 40208 56004=

72464, Pueblo, Pueblo Memorial Airport | 38-17-24N | 104-29-54W | 1440 m  
201002052353 AAXX 06004 72464 32966 01408 10056 21050 38544 40158 53018=

72465, Goodland, Renner Field | 39-22-03N | 101-41-35W | 1114 m  
201002052353 AAXX 06004 72465 35566 83611 10000 21044 38878 40170 53008=

72469, Denver, Denver International Airport | 39-49-58N | 104-39-27W | 1655 m  
201002052353 AAXX 06004 72469 32866 41007 10028 21078 38305 40133 53007=

72476, Grand Junction, Walker Field | 39-08-02N | 108-32-19W | 1481 m  
201002052353 AAXX 06004 72476 35964 63205 10000 21033 38534 40196 58001=

72486, Ely, Ely Airport | 39-17-42N | 114-50-43W | 1907 m  
201002052353 AAXX 06004 72486 35666 81511 10022 21017 38048 40131 55001=

72488, Reno, Reno Tahoe International Airport | 39-29-02N | 119-46-16W | 1345 m  
201002052355 AAXX 06004 72488 32766 42013 10122 21167 38585 40074 56010=

72494, San Francisco, San Francisco International Airport | 37-37-11N | 122-21-53W | 3 m  
201002052356 AAXX 06004 72494 32566 82015 10150 20100 30077 40106 55004=

72503, New York, La Guardia Airport | 40-46-45N | 073-52-48W | 6 m  
201002052351 AAXX 06004 72503 32966 80705 10017 21078 30179 40191 57019=

72507, Providence, Theodore Francis Green State Airport | 41-43-26N | 071-25-41W | 16 m  
201002052351 AAXX 06004 72507 32966 83604 10006 21106 30170 40191 58013=

72508, Windsor Locks, Bradley International Airport | 41-56-17N | 072-40-57W | 53 m  
201002052351 AAXX 06004 72508 32966 80000 11006 21089 30120 40194 56012=

72509, Boston, Logan International Airport | 42-21-38N | 071-00-38W | 6 m  
201002052354 AAXX 06004 72509 32766 83309 10000 21122 30185 40191 58006=

72513, Wilkes-Barre-Scranton, Wilkes-Barre / Scranton Int'l Airport | 41-20-20N | 075-43-36W | 293m  
201002052354 AAXX 06004 72513 32966 80000 11017 21078 39830 40182 56023=

72514, Williamsport, Williamsport Regional Airport | 41-14-30N | 076-55-15W | 161 m  
201002052354 AAXX 06004 72514 32866 80000 10000 21083 39979 40182 56026=

72515, Binghamton, Binghamton Regional Airport | 42-12-28N | 075-58-53W | 496 m  
201002052353 AAXX 06004 72515 32566 80405 11033 21078 39593 40197 56018=

72518, Albany, Albany International Airport | 42-44-53N | 073-48-06W | 87 m  
201002052351 AAXX 06004 72518 32666 80209 11022 21106 30092 40202 57016=



72519, Syracuse, Syracuse Hancock International Airport | 43-06-33N | 076-06-12W | 128 m  
201002052354 AAXX 06004 72519 32966 83606 11044 21106 30057 40211 55016=

72520, Pittsburgh, Pittsburgh International Airport | 40-30-14N | 080-15-59W | 366 m  
201002052351 AAXX 06004 72520 11204 80713 10000 21011 39664 40104 56032 60061 775//=

72524, Cleveland, Cleveland-Hopkins International Airport | 41-24-18N | 081-51-10W | 241 m  
201002052351 AAXX 06004 72524 11316 80416 11006 21022 39841 40129 56020 60031 771//=

72528, Buffalo, Greater Buffalo International Airport | 42-56-27N | 078-44-09W | 220 m  
201002052354 AAXX 06004 72528 32466 80713 11039 21067 39921 40203 55012=

72530, Chicago, Chicago-O'Hare International Airport | 41-58-47N | 087-54-16W | 203 m  
201002052351 AAXX 06004 72530 11562 80518 10006 21039 39897 40142 55004 69951 771//=

72532, Peoria, Greater Peoria Regional Airport | 40-40-03N | 089-41-02W | 201 m  
201002052354 AAXX 06004 72532 11420 80312 10006 21017 39865 40114 53003 60011 771//=

72533, Fort Wayne, Fort Wayne International Airport | 40-58-42N | 085-11-43W | 248 m  
201002052354 AAXX 06004 72533 11312 80424 11017 21033 39794 40096 56010 60011 771//=

72537, Detroit, Detroit Metropolitan Wayne County Airport | 42-13-53N | 083-19-51W | 194 m  
201002052353 AAXX 06004 72537 11532 80516 10000 21039 39913 40150 58008 69901 771//=

72546, Des Moines, Des Moines International Airport | 41-32-16N | 093-39-58W | 291 m  
201002052354 AAXX 06004 72546 11532 80508 10006 21033 39802 40162 53014 69951 771//=

72547, Dubuque, Dubuque Regional Airport | 42-23-52N | 090-42-13W | 328 m  
201002052353 AAXX 06004 72547 11456 80415 11011 21028 39766 40165 51004 69901 771//=

72550, Omaha, Eppley Airfield | 41-18-37N | 095-53-57W | 299 m  
201002052352 AAXX 06004 72550 11432 83608 11006 21022 39792 40172 53021 69931 710//=

72556, Norfolk, Stefan Memorial Airport | 41-58-50N | 097-26-13W | 479 m  
201002052356 AAXX 06004 72556 37424 80208 11017 21039 39615 40186 53017 710//=

72562, North Platte, North Platte Regional Airport | 41-07-19N | 100-40-06W | 846 m  
201002052353 AAXX 06004 72562 35466 80108 11006 21033 39177 40179 51010=

72564, Cheyenne, Cheyenne Airport | 41-09-28N | 104-48-25W | 1876 m  
201002052353 AAXX 06004 72564 32866 43307 10033 21078 38075 40139 53011=

72567, Valentine, Miller Field | 42-51-31N | 100-33-05W | 789 m  
201002052352 AAXX 06004 72567 37220 83504 11028 21039 39255 40197 51012 710//=

72569, Casper, Natrona County International Airport | 42-53-51N | 106-28-23W | 1630 m  
201002052353 AAXX 06004 72569 32866 62005 10017 21078 38319 40143 52003=

72571, Craig, Craig-Moffat Airport | 40-29-36N | 107-31-25W | 1888 m  
201002052353 AAXX 06004 72571 17559 82503 10000 21050 38081 40209 53006 69901 771//=

72572, Salt Lake City, Salt Lake City International Airport | 40-46-41N | 111-58-10W | 1288 m  
201002052353 AAXX 06004 72572 12666 62007 10072 20006 38688 40139 57005 69931=

72578, Pocatello, Pocatello Regional Airport | 42-55-13N | 112-34-16W | 1356 m  
201002052353 AAXX 06004 72578 11556 80204 10011 20000 38608 40159 51005 69901 710//=

72583, Winnemucca, Winnemucca Municipal Airport | 40-54-07N | 117-48-26W | 1311 m  
201002052356 AAXX 06004 72583 35766 23610 10083 20011 38633 40101 56007=

72591, Red Bluff, Red Bluff Municipal Airport | 40-09-02N | 122-15-08W | 106 m  
201002052354 AAXX 06004 72591 35766 81608 10128 20094 39984 40106 56016=

72594, Eureka | 40-48N | 124-10W | 13 m  
201002052353 AAXX 06004 72594 35966 01909 10150 20033 30029 40054 56021=

72597, Medford, Rogue Valley International Airport | 42-22-52N | 122-52-20W | 405 m  
201002052353 AAXX 06004 72597 32966 01510 10144 20011 39593 40057 56011=

72606, Portland, Portland International Jetport | 43-38-32N | 070-18-16W | 22 m  
201002052351 AAXX 06004 72606 12966 03306 11039 21172 30171 40189 54000 69901=

72617, Burlington, Burlington International Airport | 44-28-05N | 073-09-01W | 101 m  
201002052354 AAXX 06004 72617 32966 00106 11078 21161 30090 40224 56009=

72635, Grand Rapids, Gerald R. Ford International Airport | 42-52-51N | 085-31-22W | 242 m  
201002052353 AAXX 06004 72635 32462 80522 11006 21044 39874 40168 58003=

72638, Houghton Lake, Roscommon County Airport | 44-21-04N | 084-40-27W | 350 m  
201002052353 AAXX 06004 72638 17464 80613 11044 21083 39783 40216 58002 69901 771//=

72641, Madison, Dane County Regional-Truax Field | 43-08-26N | 089-20-43W | 262 m  
201002052353 AAXX 06004 72641 11459 80313 10000 21022 39858 40178 55004 69901 710//=

72645, Green Bay, Austin Straubel International Airport | 44-28-46N | 088-08-12W | 211 m  
201002052353 AAXX 06004 72645 12566 80415 11028 21061 39964 40219 51001 69901=

72654, Huron, Huron Regional Airport | 44-23-17N | 098-13-42W | 392 m  
201002052355 AAXX 06004 72654 17728 80706 11006 21028 39734 40213 53009 69901 771//=

72658, Minneapolis, Minneapolis-St. Paul International Airport | 44-52-59N | 093-13-44W | 256 m  
201002052353 AAXX 06004 72658 11548 80308 10000 21028 39897 40222 53008 69901 771//=

72662, Rapid City, Rapid City Regional Airport | 44-02-44N | 103-03-14W | 976 m  
201002052352 AAXX 06004 72662 32666 83403 11056 21089 39053 40214 53006=

72666, Sheridan, Sheridan County Airport | 44-46-10N | 106-58-08W | 1225 m  
201002052353 AAXX 06004 72666 35966 40103 11028 21044 38772 40175 51003=

72672, Riverton, Riverton Regional Airport | 43-03-43N | 108-26-47W | 1684 m  
201002052353 AAXX 06004 72672 35966 00000 11033 21072 38275 40165 57001=

72677, Billings, Billings Logan International Airport | 45-48-25N | 108-32-32W | 1112 m  
201002052353 AAXX 06004 72677 32166 80605 11028 21039 38891 40171 53001=

72681, Boise, Boise Air Terminal | 43-34-00N | 116-14-26W | 871 m  
201002052353 AAXX 06004 72681 12966 01709 10100 20033 39115 40125 53004 69901=

72683, Burns, Burns Municipal Airport | 43-35-42N | 118-57-23W | 1263 m  
201002052353 AAXX 06004 72683 35966 00506 10039 20000 38679 40113 56003=

72688, Pendleton, Eastern Oregon Regional At Pendleton Airport | 45-41-54N | 118-50-03W | 455 m  
201002052353 AAXX 06004 72688 12966 00000 10117 20044 39564 40097 56003 69981=

72693, Eugene, Mahlon Sweet Field | 44-08-00N | 123-12-52W | 111 m  
201002052354 AAXX 06004 72693 32566 60000 10156 20039 39918 40054 55009=

72698, Portland, Portland International Airport | 45-35-27N | 122-36-01W | 8 m  
201002052353 AAXX 06004 72698 32766 61209 10117 20056 30062 40071 56009=

72712, Caribou, Caribou Municipal Airport | 46-52-02N | 068-00-48W | 191 m  
201002052354 AAXX 06004 72712 35766 63214 11139 21194 39931 40180 50009=

72745, Duluth, Duluth International Airport | 46-50-34N | 092-13-34W | 435 m  
201002052355 AAXX 06004 72745 12466 80817 11050 21078 39721 40262 51006 69901=

72747, International Falls, Falls International Airport | 48-33-43N | 093-23-52W | 361 m  
201002052355 AAXX 06004 72747 35966 20703 11072 21111 39828 40283 53004=

72753, Fargo, Hector International Airport | 46-55-31N | 096-48-40W | 274 m  
201002052353 AAXX 06004 72753 17528 80503 11006 21022 39896 40240 53008 69951 771//=

72764, Bismarck, Bismarck Municipal Airport | 46-46-57N | 100-45-26W | 511 m  
201002052352 AAXX 06004 72764 11308 80804 11017 21028 39610 40230 53008 60011 771//=

72767, Williston, Sloulin Field International Airport | 48-10-26N | 103-38-12W | 604 m  
201002052352 AAXX 06004 72767 11540 80804 11061 21078 39516 40233 53003 60011 771//=

72772, Helena, Helena Regional Airport | 46-36-20N | 111-57-49W | 1180 m  
201002052353 AAXX 06004 72772 11748 60000 11033 21050 38776 40186 51003 69901 710//=

72777, Havre, Havre City-County Airport | 48-32-34N | 109-45-48W | 789 m  
201002052353 AAXX 06004 72777 17128 80000 11100 21117 39243 40205 58001 69901 710//=

72785, Spokane, Spokane International Airport | 47-37-17N | 117-31-40W | 723 m  
201002052353 AAXX 06004 72785 11112 80507 10028 20022 39257 40123 53007 60011 761//=

72793, Seattle, Seattle-Tacoma International Airport | 47-26-41N | 122-18-49W | 130 m  
201002052353 AAXX 06004 72793 12766 61306 10144 20033 39922 40089 55004 69901=

### Radiosonde release

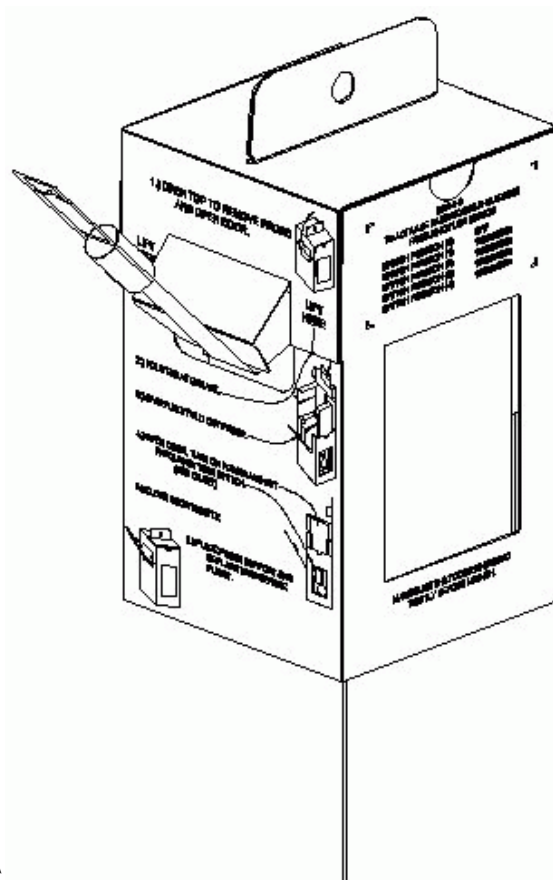
To obtain upper air winds, temperature, and dew point, we will set up and launch a radiosonde balloon with a functioning radiosonde package. These are not standard NWS radiosonde, but our InterMet -3150 system will give us a realistic taste of how it is done by the professionals. If you become a NWS student intern, perhaps you will get to launch one of their radiosondes as well.

The full radiosonde setup includes a balloon, parachute, the radiosonde itself, a receiver for the sounding data being transmitted from the radiosonde, a decoder to change radio signals into binary data, and a computer program to interpret the data. We will need to set up the entire system, although parts of it have been initialized prior to this lab. For example, the software has been installed and its parameters initialized.

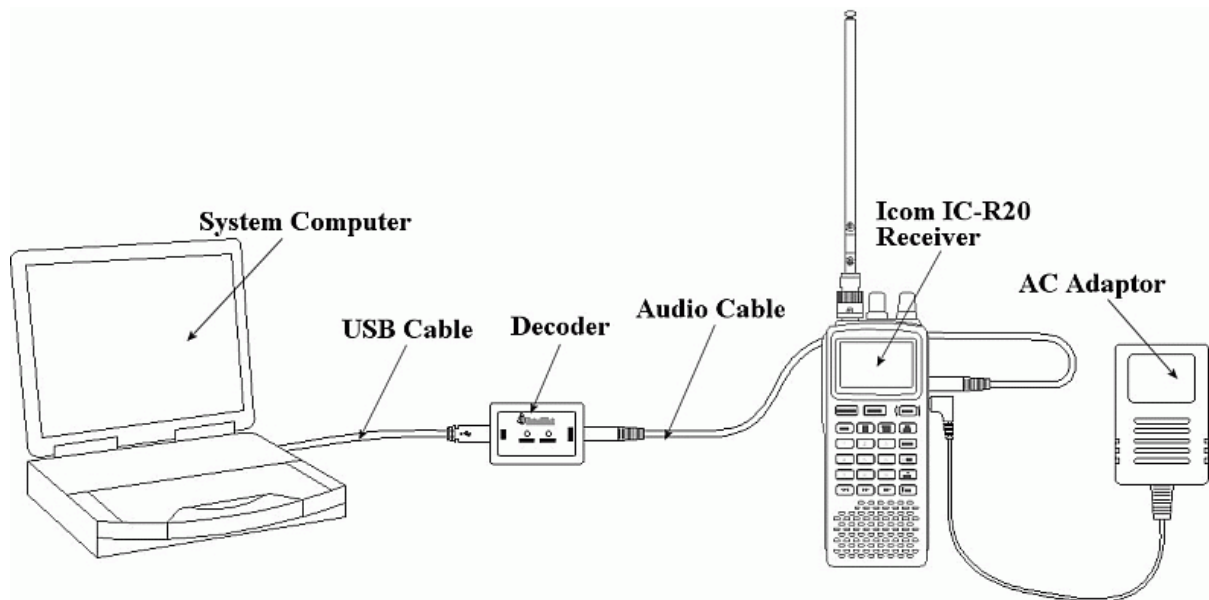
The computer we will use is a Panasonic “Toughbook” which, as its name implies, is a special laptop that can function while outdoors in the elements. We will perform this operation even during inclement weather since that’s when you need the data the most! If, however, there is a thunderstorm or winds greater than Tropical Storm strength, i.e., 40 mph, we will not go out on the roof today.

Note that you cannot release radiosondes without a meteorology professor being present. Do not invite your friends, either unless they are meteorology students. This is a meteorology-only activity.

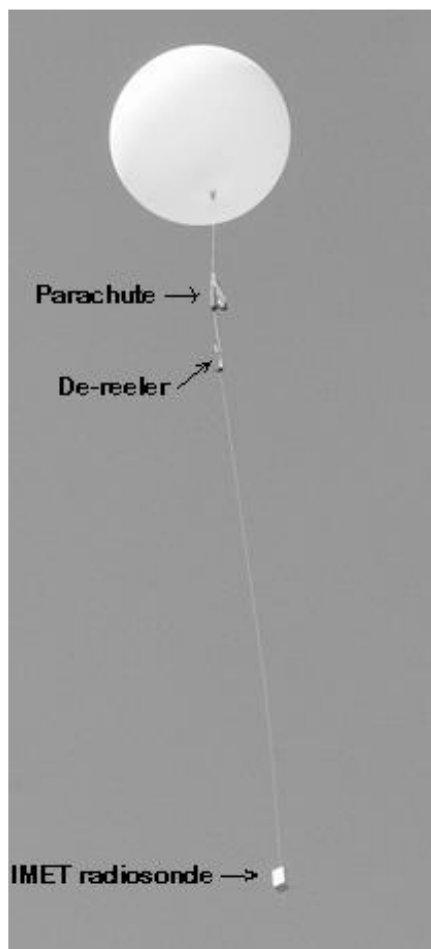
InterMet portable radiosondes are small, disposable packages, about 5 inches high (plus the antenna which is on the bottom):



The ground station, consisting of the receiver, decoder, and Toughbook (System Computer) looks like this:



The “weather balloon” will be inflated with helium until it rises at a rate of  $5 \text{ m s}^{-1}$ . We have an inflation kit to do that. Then a parachute will be attached to bring the device down safely, a small “de-reeler” to pay out the string, and finally, the radiosonde instrument itself:



Here's the launch sequence:

1. Your professor will connect the receiver, decoder, and Toughbook.
2. One student in the class will complete the pre-flight baseline data entry. This means checking the station pressure in hPa, also known as mb. This is not sea-level pressure – get station pressure directly from the mercury barometer in the meteorology lab. Also, baseline data includes Temperature in °C, humidity in %, wind direction in °, and wind speed in knots.
3. A student will start the iMetOS software (it's the blue icon on the desktop) and enter the preflight conditions.
4. Two students will set up the radiosonde. They will also activate the receiver and tune to the radiosonde. Verify that a strong signal is being received.
5. The class will cooperate to inflate the balloon and set up the Flight Train (balloon, parachute, de-reeler, and radiosonde).
6. When everything is ready and it is verified that the iMetOS software is receiving data, the balloon will be launched. Take pictures!

If all goes well, it may be a while before the balloon bursts and parachutes back to Earth. Once that occurs, the data recording is terminated in the software. Upper level data will be downloaded from the Toughbook and made available on the course homepage.

For **Monday Sep 19**, you are to plot today's Oneonta soundings of temperature and dew point on a Skew T Log P diagram to be supplied. This will not be graded but next week's lab will also involve plotting soundings. I will correct your mistakes for today's plot so you will know what to do next week.

Here is how you do this on a Skew T Log P diagram:

Today's data will be made available on the course webpage once the instrument stops sending or when it reaches a sufficiently high elevation. Plot these in black ink. Use dots for the plotted temperatures and x's for dew points. Make them big enough to see, about 1 mm diameter.

Connect the temperature observations with straight red lines and the dew point observations with straight green lines. Use ink, not pencil.

Draw wind flags in black ink on the right side of each chart on one of the vertical axes with circles. For all winds, put the wind barbs on the correct side.

## Upper Air Code (soundings)

## 1. Introduction

Observations of the atmosphere above the surface are made with the help of radiosondes like the one we launched last week. Radiosonde observations or RAOBS are released from some 70 U.S. stations and from hundreds of special stations throughout the world. Signals from the rising radiosonde allow plotting of temperature, pressure and relative humidity. In addition, the balloons are tracked as they rise, giving information about wind velocity and direction. When the observations include wind data they may be called Rawinsondes (RAWIN).

The radiosonde stations report their data at 00Z and 12Z, by World Meteorological Organization (WMO) convention. The transmission of the data is usually made approximately two hours after the observation is begun, i.e., about 02Z and 14Z. On request, additional RAOB observations may be made at 06Z and/or 18Z. The National Weather Service (NWS) posts the radiosonde data in coded form. One convenient site with raw data is <http://weather.rap.ucar.edu/upper/Current.rawins>

Each coded RAOB report is divided into several reporting sections, each section being transmitted separately. The first transmission is identified by the group TTAA. This transmission consists of data at specified levels called mandatory levels. These are the surface, 1000 mb, 925 mb, 850 mb, 700 mb, 500 mb, 300 mb, 250 mb, 200 mb, 150 mb, 100 mb, the tropopause and the level of maximum wind. You always get these levels.

The second transmission contains data at nonstandard levels. These are called significant levels. A significant level can be any pressure where something of meteorological interest happens, such as the beginning of an inversion. The radiosonde operator decides which levels to report as significant, within guidelines published by the NWS. This transmission is identified by the group TTBB.

Wind data are transmitted after the significant data and this is identified by the group PPBB. Late transmissions contain data above 100 mb and are identified by the groups TTCC and TTDD for mandatory and significant levels, followed by PPDD wind data.

## 2. The form of the TTAA code (mandatory levels)

The TTAA transmission always starts with three groups to identify the station and date:

TTAA YYGGI<sub>d</sub> Iiiii

Following the three initial groups will be a number of data groups, clustered in threes. These clusters will always start with a two-number identifier for each mandatory level. The form is as follows:

99P <sub>o</sub> P <sub>o</sub> P <sub>o</sub>	T <sub>o</sub> T <sub>o</sub> T <sub>ao</sub> D <sub>o</sub> D <sub>o</sub>	d <sub>o</sub> d <sub>o</sub> f <sub>o</sub> f <sub>o</sub> f	(Surface data)
00hhh	TTT <sub>a</sub> DD	ddfff	(1000 mb)
92hhh	TTT <sub>a</sub> DD	ddfff	(925 mb)
85hhh	TTT <sub>a</sub> DD	ddfff	(850 mb)
70hhh	TTT <sub>a</sub> DD	ddfff	(700 mb)
50hhh	TTT <sub>a</sub> DD	ddfff	(500 mb)
40hhh	TTT <sub>a</sub> DD	ddfff	(400 mb)
30hhh	TTT <sub>a</sub> DD	ddfff	(300 mb)
25hhh	TTT <sub>a</sub> DD	ddfff	(250 mb)
20hhh	TTT <sub>a</sub> DD	ddfff	(200 mb)
15hhh	TTT <sub>a</sub> DD	ddfff	(150 mb)
10hhh	TTT <sub>a</sub> DD	ddfff	(100 mb)

88P<sub>t</sub>P<sub>t</sub>P<sub>t</sub> T<sub>t</sub>T<sub>t</sub>T<sub>at</sub> D<sub>t</sub>D<sub>t</sub> d<sub>t</sub>d<sub>t</sub>f<sub>t</sub>f<sub>t</sub>f<sub>t</sub> (Tropopause data)

77P<sub>m</sub>P<sub>m</sub>P<sub>m</sub> d<sub>m</sub>d<sub>m</sub>f<sub>m</sub>f<sub>m</sub>f<sub>m</sub> 4V<sub>b</sub>V<sub>b</sub>V<sub>a</sub>V<sub>a</sub> (Max wind data)

66 is sometimes used instead of 77 as the maximum wind identifier

For translating parameters such as TTT and DD, refer to the "definition of symbols" in part 5.

Example (translation follows):

72520 TTAA 68121 72520 99981 09013 04008 00196 // // // // 85543 08471 03014 70132 04075 30021  
 50580 11368 28037 40747 23364 27043 30951 38959 26558 20216 593// 25560 15399 589// 27056  
 10651 625// 26539 88202 597// 25560 77279 26064=

Decoded mandatory levels for station 72520 (Pittsburgh): 12Z observation on the 18th of the month, wind in knots, last group = 100 mb. Surface data -> pressure = 981 mb, temperature = 9.0°C, dew point depression = 1.3°C (actual dew point = 7.7°C), wind at 8 knots from 40E. No 1000 mb level. Other levels are:

Level	Height (m)	Temperature (°C)	Dew point depression (°C)	Wind speed + Direction
850 mb	1543	8.4	21	14 kts from 30°
700 mb	3132	4.0	25	21 kts from 300°
500 mb	5800	-11.3	30	37 kts from 280°
400 mb	7470	-23.3	14	43 kts from 270°
300 mb	9510	-38.9	9	58 kts from 265°
200 mb	12160	-59.3	no dew point	60 kts from 255°
150 mb	13990	-58.9	no dew point	56 kts from 270°
100 mb	16510	-62.5	no dew point	39 kts from 265°
Trop=202 mb		-59.7	no dew point ----->	60 kts from 255°
max wind at 279 mb			----->	64 kts from 260°

### 3. The form of the TTBB code (significant levels)

The TTBB transmission always starts with three groups which are very similar to those of the TTAA part:

TTBB YYGG/ Iiii

Following the three initial groups will be a number of data groups as in the TTAA code. Unlike the TTAA's, the TTBB's consist of two-group clusters. The clusters always start with a numerical identifier, like 11, 22, 33, etc. The form is as follows:

00P<sub>o</sub>P<sub>o</sub>P<sub>o</sub> T<sub>o</sub>T<sub>o</sub>T<sub>o</sub>D<sub>o</sub>D<sub>o</sub> (Surface data)  
 11PPP TTT<sub>a</sub>DD  
 22PPP TTT<sub>a</sub>DD  
 33PPP TTT<sub>a</sub>DD (significant level data)  
 44PPP TTT<sub>a</sub>DD  
 ..... ....., etc.

Note that PPP means pressure in whole millibars at the significant levels.



Example:

UJUS1 061200 GRB TTBB 5612/ 72645 00985 17830 11978 16415 22920 16257 33850 13270 44627  
04565 55582 06377 66500 12375 77425 21325 88400 23568 99320 35356 11189 619// 22124 603//  
33100 615//

Decoded significant levels for station 72645 (Green Bay, WI): 12Z observation on the 6th of the month, wind in knots. Surface data -> pressure = 985 mb, temperature = 17.8°C, dew point depression = 3.0°C. First significant level = 978 mb, temperature = 16.4°C, dew point depression = 1.5°C. Second significant level = 920 mb, temperature = 16.2°C, dew point depression = 7°C, etc. Other levels are listed:

Level (mb)	Temp (°C)	Dew point depression (°C)
850	13.2	20
627	-4.5	15
582	-6.3	27
500	-12.3	25
425	-21.3	2.5
400	-23.5	18
320	-35.3	6
189	-61.9	no dewpoint
124	-60.3	no dewpoint
100	-61.5	no dewpoint

Note that mandatory levels (from TTAA) like 850 mb and 500 mb may also be significant levels (in TTBB), but not all mandatory levels will be included. It depends on the operator.

#### 4. The form of the PPBB group

The PPBB transmission also starts with a three-group identification cluster:

PPBB YYGGa<sub>4</sub> Iiii

(a<sub>4</sub> - indicator for type of equipment used. 0 is Rawinsonde)

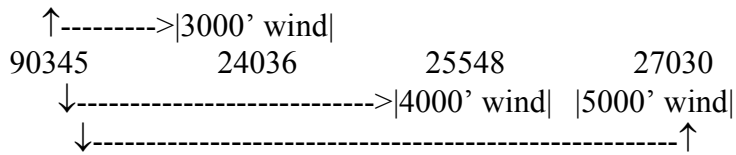
Unlike the first two types, in the PPBB part the clusters consist of two, three or four groups. The initial group in the cluster is the most important and is ALWAYS indicated by a leading "9". The rest of the initial group tells you what altitudes the winds are. The other groups give the actual wind data. The form is:

9t<sub>n</sub>u<sub>1</sub>u<sub>2</sub>u<sub>3</sub>      ddfff      ddfff      ddfff

The ddfff symbols are the same as in the TTAA and TTBB parts. The most confusion arises from the altitude indicator group. Again, it will always be identified by the leading 9. The next symbol, t<sub>n</sub>, gives the digit of the altitude in ten-thousands. For example, if the altitude of the observation is 10000 feet, t<sub>n</sub> = 1. If the altitude is 20000 feet, t<sub>n</sub> = 2, etc.

To get more than just increments of 10000 feet, we use the u's. These give the digit of the altitude in thousands. For convenience, consider only u<sub>1</sub>. Suppose t<sub>n</sub> = 1 and u<sub>1</sub> = 2. The indicated altitude is 12,000 feet. If t<sub>n</sub> = 0 and u<sub>1</sub> = 3, this indicates 3000 feet (0 ten-thousands and 3 thousands).

The u<sub>1</sub> altitude is the height of the wind of the first ddfff group immediately following the 9-altitude indicator group. Similarly, u<sub>2</sub> applies to the second ddfff group after the 9-group and u<sub>3</sub> applies to the third ddfff group after the 9-group. The t<sub>n</sub> refers to all three groups. For example (next page):



At 3000, 4000, 5000 feet the wind is 240E at 36 kts, 255E at 48 kts and 270E at 30 kts.

IMPORTANT - There may NOT be three groups after the 9-group. For example,

929//            24624

Here the altitude is 29000 feet with a wind of 124 kts from 245°. Note that the next thousand foot level would be 30000 feet, which must go in the next cluster because the tens indicator,  $t_n$  for the 929// cluster is 2. The next cluster would follow immediately. Its initial group might be something like 93024. Remember also the ddfff convention when the wind goes over 100 kts or m/s add 1 to the third digit, making it 1 or 6.

## 5. Definition of Symbols

**TTAA (mandatory levels)** – message identifier stating that the following data are for the standard isobaric surfaces up to 100 mb (hPa). These standard levels are as follows: the surface, 1000 mb, 850 mb, 700 mb, 500 mb, 400 mb, 300 mb, 200 mb, 150 mb, and 100 mb.

**yy** – day of the month in Greenwich and the wind speed indicator (either knots or m/s). The day of the month is indicated with the code figures 01-31. When the wind speed is given in knots, 50 is added to the day of the month, but if the wind speed is given in m/s, the date is coded directly. For example, 53 – third day of the month with wind speed in knots. 03 – third day of the month with wind speed in m/s.

**gg** – actual time of observation to the nearest whole hour in GMT. This is usually 00Z or 12Z but soundings can also occur at 06Z and/or 18Z.

**I<sub>d</sub>** – indicator of the last standard isobaric level for which the wind group is included in the TTAA and TTCC groups.  $I_d$  is usually 1 which means the last level is 100 mb.

**99** – indicator that surface data follow. The subscript “o” on any symbol in the following description indicates that the value is for the surface, i.e.,  $T_o$  means surface temperature.

**P<sub>o</sub>P<sub>o</sub>P<sub>o</sub>** – surface (station) pressure not corrected to sea level in while millibars (mb) with only the hundreds, tens, and units digits given. For example, 981 → 981 mb; 015 → 1015 mb.

**TTT<sub>a</sub>** - observed temperature and approximate tenths value ( $T_a$ ). TT reported in while degrees Celsius at the specified pressure level. Incorporated in the figure  $T_a$  is the information as to the sign of the temperature (+ or -). If the reported value of  $T_a$  is even, the temperature is positive and if odd, the temperature is negative.

**DD** – dew point depression. The difference between the temperature and the dew point temperature. When the depression is 5° or less, the units and tenths digits of the depression in degrees Celsius are reported. When the depression is greater than 5°, 50 is added to the tens and units digits. Thus, 65 would be the code for a depression of 15°, while 49 would be the code for a depression of 4.9°. Codes 51-55 are not used (1° would be reported as 10, rather than 51 for example). A code of 50 means a 5° depression.

**dd(f)** – the true direction in tens of degrees of the observed direction rounded to the nearest 5° from which the wind is blowing at the specific level (see ff).

**(f)ff** – wind speed in knots or m/s, depending on the the indicator yy. The first digit of this group is incorporated into the direction group and will always be reported as either 5 or 0 unless the speed is in excess of 99 knots (or m/s) in which case 1 will be added to the first digit of this group and it will therefore be reported as a “1” or a “6”. For example, 35610 would indicate a north wind of 110 knots.

The next series of levels is reported in groups of three for the standard isobaric surfaces with the first two digits indicating the level for which the following information is given (00 – 1000 mb level, 85 – 850 mb level, etc.)

**hhh** – geopotential altitude of the standard isobaric surfaces given in geopotential meters. Only certain digits of the entire height is given. Which digits are reported depends on the surface.

**88** – indicator for the tropopause data.

**77** – indicator for the data of the maximum wind. The maximum wind group will only be reported if the wind speed is in excess of 60 knots.

\*\* NOTE: Be aware that when upper level winds are missing, the wind group may be omitted. In that case, the group which follows should not be mistaken for a wind group. Instead it will be the next level height indicator group, starting with 85, 70, 50, etc. This can be misleading if the 300 mb group is missing since the next indicator is 25 (250 mb) and that can look like a wind direction.

**TTBB (significant levels)** – This message is coded substantially the same as the TTAA type, except that the wind group is eliminated and information as to the altitude of the pressure surface is also absent. Note that the indicators 11, 22, 33, 44, etc. are used to mark successive significant levels. When there are more than 9 significant levels, the numbers 11 to 99 are repeated until all the levels are given. PPBB follows TTBB with wind data.

Lab Assignment (due next Wednesday)

1. Translate the upper air data shown after these instructions for stations 72305 (MHX), 72403 (IAD), 72520 (PIT), 72518 (ALB), and 72747 (INL). Make five tables, one for each station. It can be done in Excel (MS Office), CALC (Open Office) or Numbers (Apple). Lay them out as follows:

Station:

Pressure (mb)                      Temperature (°C)      Dew Point (°C)      Wind (degrees, knots)

a) It is easiest to do the TTAA's (mandatory levels) first, then the TTBB's (significant levels). You will probably find your first copies are messy or out of order after adding significant levels between the mandatory levels. So copy it over neatly or sort if it is digital. Put the PPBB winds into a separate table.

b) Remember the reports give dew point depressions. Convert them to the actual dew points.

2. On a set of 5 thermodynamic diagrams, plot the radiosonde data from your tables in black ink. Use dots for the plotted temperatures and x's for dew points. Make them big enough to see, about 1 mm diameter.

a) Connect the temperature observations with straight red lines and the dew point observations with straight green lines. Use ink, not pencil.

b) Plot TTAA winds in black ink on the right side of each chart on one of the vertical axes with circles. Place a wind flag for each observation in the PPBB part on the axis marked ICAO Standard Atmosphere Altitude. For all winds, put the wind barbs on the correct, left side. Be sure to plot the tropopause wind and the max wind.

Turn in all five thermodynamic diagrams **and** the printed data tables. Put your name on all sheets.

RAOB data 00Z Feb 6, 2010

USUS42 KMHX 060000

72305 TTAA 56001 72305 99005 13600 11509 00053 13201 13013 92710  
 11806 16054 85414 08406 17049 70001 01606 22555 50565 11523 25066  
 40733 22139 24573 30939 34556 24601 25064 45557 24106 20209 56358  
 24634 15389 62359 26098 10636 68959 26073 88999 77193 25136=

72305 TTBB 56000 72305 00005 13600 11946 12606 22820 06806 33758  
 04006 44721 03206 55653 01306 66650 00705 77641 02106 88479 13326  
 99380 24742 11375 24541 22347 27147 33315 31756 44240 48157 55208  
 55558 66194 57358 77179 57559 88160 61759 99153 61959 11141 63759  
 22138 63359 33130 65159 44124 65359 55122 63559 66119 63359 77107  
 67959 88105 67559=

72305 PPBB 56000 72305 90012 11509 15543 16054 90345 16053 16550  
 16552 90678 18548 20047 20544 909// 21551 91024 22555 23062 23065  
 9167/ 23555 24054 92057 25066 24580 23577 93016 24599 24606 24107  
 94067 25136 26098 25608 9501/ 26572 26064=

72403 TTAA 56001 72403 99006 00104 06504 00133 00520 07507 92753  
 01904 10525 85423 03906 12518 70954 07509 18025 50556 13719 25055  
 40722 24743 25080 30925 38350 24089 25047 47357 24613 20191 59357  
 24663 15370 57559 26601 10625 63363 27566 88183 61757 25153 77200  
 24663=

72403 TTBB 56000 72403 00006 00104 11005 00328 22991 01111 33953  
 02909 44930 01904 55852 03906 66838 02303 77812 03704 88799 03103  
 99742 05105 11695 07709 22674 07505 33637 09109 44580 08704 55523  
 11511 66430 20732 77420 21943 88312 38156 99301 38350 11268 44556  
 22238 49757 33206 58357 44193 60557 55183 61757 66170 61358 77162  
 62158 88158 58958 99153 57159 11147 58359 22143 55960 33138 54961  
 44126 57762 55116 58363 66110 59763=

72403 PPBB 56000 72403 90012 06504 08515 09528 90345 10526 11020  
 14518 90678 18030 17535 17022 909// 16521 91024 19031 20056 22076  
 9168/ 23067 24555 92058 24564 24585 24069 93049 24088 24603 24663  
 94368 25638 26590 26566 950// 26075=

72518 TTAA 56001 72518 99009 01157 00000 00160 02158 31003 92774  
 07350 34016 85426 12536 34518 70925 10373 31036 50546 24756 28552  
 40707 31940 27075 30906 42747 27125 25028 48343 26171 20171 59338  
 26679 15355 53176 29078 10614 605// 27566 88200 59338 26679 88166  
 58175 29089 77215 26181=

72518 TTBB 56006 72518 00009 01157 11852 12534 22840 11957 33831  
 09977 44806 09777 55743 08175 66578 17577 77563 17377 88501 24757  
 99482 23728 11363 35743 22345 35541 33294 43347 44270 45745 55200

59338 66194 57750 77191 53957 88186 50577 99166 58175 11154 53176  
22133 54376 33130 53176 44116 56775 55100 605//=

72518 PPBB 56006 72518 90012 00000 31012 32514 90346 34516 35013  
32528 90789 31532 31035 31035 91246 30543 30045 29549 92025 27564  
27568 26592 9279/ 26110 27122 93025 27130 26661 26176 9379/ 26181  
26676 9438/ 29088 28065 9502/ 27560 27065=

72520 TTAA 56001 72520 99967 00000 08007 00090 /////  
02306 09533 85387 01103 11533 70921 05903 15019 50550 16119 22037  
40715 26541 22559 30916 40156 23111 25040 46757 22143 20183 58557  
22650 15364 59759 24590 10620 59162 27555 88203 58957 22651 77206  
22651=

72520 TTBB 56000 72520 00967 00000 11955 00303 22906 03105 33889  
02905 44881 01303 55866 00703 66769 03703 77717 06707 88689 05903  
99611 11710 11552 15120 22545 15119 33535 14110 44523 14312 55467  
17923 66341 35556 77304 40356 88288 40756 99282 39956 11278 40156  
22249 46958 33216 55757 44203 58957 55193 59357 66181 57758 77172  
58159 88168 57159 99157 59159 11146 59760 22143 56760 33139 56960  
44137 56160 55123 57561 66119 56962 77109 59962 88107 59762 99105  
60562=

72520 PPBB 56000 72520 90023 08007 09027 12043 90456 12038 11531  
13527 90789 13024 11527 12023 91024 18020 17031 20044 9168/ 20029  
22542 92015 22550 22554 23058 9268/ 23556 23075 93018 23110 22635  
22651 943// 24593 950// 26577=

72747 TTAA 56001 72747 99983 06156 07004 00224 /////  
08549 11019 85490 07964 10515 70984 13358 33509 50548 273// 30012  
40706 381// 29022 30897 529// 28539 25012 605// 28042 20154 519//  
28028 15342 495// 29022 10605 533// 30022 88259 601// 27544 77999=

72747 TTBB 56000 72747 00983 06156 11970 06356 22925 08549 33922  
08345 44914 07561 55909 06962 66877 06965 77855 07968 88851 07964  
99827 09160 11823 09159 22819 08761 33817 08765 44809 08766 55796  
08962 66794 08959 77792 08959 88764 10956 99753 11143 11728 12756  
22698 13358 33692 13160 44687 13560 55683 13956 66676 13756 77666  
13964 88654 14173 99615 16774 11596 18575 22589 19367 33555 22563  
44543 239// 55408 371// 66332 489// 77304 525// 88259 601// 99248  
605// 11244 589// 22240 587// 33237 571// 44234 573// 55229 553//  
66212 521// 77186 515// 88167 491// 99149 493// 11132 509// 22127  
503// 33119 523// 44107 529// 55103 539//=

72747 PPBB 56000 72747 90023 07004 09015 11521 90467 10016 10010  
06514 9089/ 03508 00503 91124 33516 34012 34012 91569 34512 31006  
29514 92024 29516 30519 29022 9258/ 29027 29530 93026 28040 28045  
28525 950// 28525=

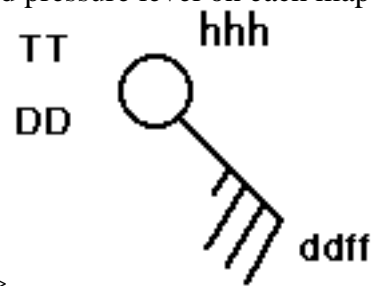
## Upper Air Maps (Analysis I)

This will be a detailed upper air analysis, starting from RAOB data transmissions. Since the TTAA's give the mandatory upper air levels, we could, on any given day, draw our own upper air maps from that data. Suppose the network breaks down? It's certainly possible, even likely at least once or twice a month. How would you get upper air maps? It is important not to be too dependent on computers to analyze data and draw maps. After these next two labs, you should be pretty good at plotting and analyzing from RAOB data.

We will start this week with two upper tropospheric maps and finish next week with two lower tropospheric maps.

Lab Assignment (due next Monday. Remember, exam 1 is next Wednesday):

1. On an upper air base map, plot the data for 300 mb and 500 mb from TTAA's. Use the stations on the pages following this one. Write your name, the date, time, and pressure level on each map.



Upper air data is plotted on a simplified station model —>

Here TT is temperature in °C, DD is dew point depression (not dew point itself) in °C and hhh is the height of the pressure surface, as coded for the TTAA. Refer to the Definition of Symbols in lab 4. Plot the height digits as coded on your maps without translation.

**Notes:** Some stations have changed since your upper air base maps were designed. If the stations or their locations have changed, such as 72231 changing to 72230, that is noted just above the TTAA data.

DD and TT must be rounded to whole °C for the map. If 0.5°C, round to 1°C, if -0.5°C, round to -1°C.

2. Analyze the 500 mb map. Do the standard analysis:

a) height contours every 6 decameters, in black. Include a 540 line. For example plot 528, 534, 540, 546, etc.

Try to make your height contours follow the wind directions. Label all contours and isopleths. Do not analyze where you have no data. Make all contours and isopleths smooth. If you have a closed contour, it must have a center, either "L" or "H".

b) isotherms every 5°C in red dashed lines. Include a -10°C isotherm.

3. Analyze the 300 mb map. Do this analysis:

a) height contours every 12 decameters, in black. Include a 900 line. For example, 888, 900, 912, 924, etc.

b) isotachs (lines of constant wind speed) in dashed blue lines, every 20 knots, starting at 30, i.e., 30, 50, 70, 90, etc. Also, at 70 knots and higher, shade lightly in blue.

4. Compare your upper air maps to the surface map. Comment on what you see, meteorologically. (Extra)

Radiosonde Data 06 Feb 2010 00Z

72201 TTAA 56001 72201 99008 25436 18009 00086 25231 /////  
 20835 21535 85495 15211 23539 70119 08060 25541 50581 07769 23067  
 40751 18166 23578 30960 32545 24080 25086 42549 24072 20233 51758  
 23596 15415 62958 24579 10657 74757 26053 88999 77177 24099 40826=

TTBB 56000 72201 00008 25436 11978 24650 22815 12610 33742 09212  
 44718 08231 55707 08860 66656 04456 77638 05068 88593 00675 99547  
 05156 11540 05508 22535 05910 33529 05365 44527 05368 55500 07769  
 66479 10361 77473 10766 88443 14368 99439 14757 11434 15323 22422  
 16711 33414 17311 44410 17166 55400 18166 66379 21756 77373 21534  
 88355 23540 99220 50556 11204 50957 22155 62558 33100 74757 31313  
 05102 82302=

72202 56001 TTAA 99009 25250 15006 00087 24434 16512 92766 20223  
 21536 85492 15223 23540 70113 07266 24543 50580 07598 24074 40750  
 18594 24079 30959 32150 24071 25085 43157 24074 20232 51960 24593  
 15413 64960 24596 10655 73759 26061 88999 77181 24596 41601 31313  
 58708 82303=

72202 TTBB 56000 72202 00009 25250 11977 22415 22939 20209 33929  
 20619 44856 15827 55819 12808 66761 09401 77743 08809 88733 08633  
 99732 08656 11714 07662 22679 06678 33671 05876 44665 05068 55661  
 04661 66652 03457 77639 02259 88637 02260 99633 02274 11628 01867  
 22622 01698 33600 01082 44580 00193 55562 02379 66556 02968 77554  
 03359 88540 04961 99534 05163 11531 04980 22530 05193 33491 08597  
 44490 08580 55487 08397 66440 14595 77438 14793 88435 14760 99434  
 14759 11428 15165 22425 15565 33424 15594 44418 15995 55394 20188  
 66392 20169 77391 19958 88390 19747 99387 19333 11380 20341 22351  
 24724 33326 27747 44302 31750 55282 35757 66221 49757 77208 51759  
 88197 52160 99174 58360 11166 59560 22150 64960 33139 64960 44127  
 69160 55116 70560 66108 72159 77106 71959=

72206 TTAA 56001 72206 99002 19412 26505 00027 19411 24011 92695  
 15416 25042 85407 11600 23536 70008 00664 23542 50566 11173 24085  
 40735 19547 22612 30943 33956 21597 25068 44150 21609 20214 53960  
 23629 15395 61163 24611 10643 68162 25557 88999 77190 23629 43117  
 31313 58708 82317=

72206 TTBB 56000 72206 00002 19412 11911 14417 22875 12000 33841  
 11400 44767 07404 55757 06219 66744 05614 77738 05200 88722 03801  
 99720 03607 11718 03438 22713 02658 33711 02261 44701 00864 55683  
 00669 66657 00265 77649 00068 88633 01569 99615 03164 11608 03567  
 22599 03773 33595 03799 44565 03999 55563 04396 66554 05565 77553  
 05762 88551 05956 99545 06540 11527 07925 22523 08356 33518 08957  
 44513 09562 55503 10765 66497 11388 77482 12396 88465 14795 99444  
 14981 11442 15168 22439 15362 33430 16359 44424 16736 55421 16935  
 66416 17356 77392 20540 88385 21324 99375 22549 11371 23159 22365  
 24160 33351 25559 44343 26546 55329 28343 66292 35357 77266 40557



88249 44350 99225 50357 11220 50557 22207 53359 33180 56762 44160  
60563 55141 61763 66122 66362 77117 66362 88116 64763 99111 63163  
11109 63363=

72208 TTAA 56001 72208 99999 18010 21013 00009 /////  
16638 22049 85390 11209 21552 70990 02808 23047 50565 09922 23062  
40734 20737 23074 30940 35156 23093 25065 45358 23109 20210 55358  
23636 15390 61762 25116 10639 67764 24569 88158 62161 25125 88103  
68763 24562 77187 24637=

72208 TTBB 56000 72208 00999 18010 11997 17610 22966 16005 33958  
17008 44941 17836 55915 15835 66884 13210 77748 06009 88707 02806  
99699 02809 11694 03034 22679 02456 33645 00750 44638 00257 55633  
00757 66619 00758 77562 07337 88543 08316 99534 08306 11519 08308  
22496 10330 33480 12331 44460 13736 55426 17932 66309 34356 77284  
37556 88219 53758 99208 53558 11196 56558 22158 62161 33146 61762  
44137 62562 55136 62162 66135 59563 77134 58963 88125 59164 99116  
62565 11103 68763 22102 67564=

Plot at 211

72210 TTAA 56001 72210 99006 19205 19506 00068 18802 21513 92735  
15400 24032 85450 11800 25539 70055 04826 25554 50573 10559 24077  
40742 19519 23595 30950 33358 22598 25075 43186 22092 20222 53383  
24115 15403 62580 25107 10648 68978 25042 88999 77159 24616=

72210 TTBB 56000 72210 00006 19205 11979 17600 22811 10200 33801  
09203 44787 07458 55766 07858 66745 06660 77724 06256 88715 05457  
99709 05443 11699 04824 22676 02802 33605 01302 44531 07511 55499  
10760 66488 11556 77469 12757 88459 13537 99447 14722 11439 14712  
22432 15119 33406 18919 44394 19519 55386 21321 66385 21934 77380  
22357 88377 22957 99356 25557 11333 29350 22326 28742 33317 30357  
44311 31156 55291 35161 66277 38161 77273 38965 88270 39387 99219  
50184 11207 51783 22177 58981 33169 59781 44165 59381 55158 61181  
66154 61181 77144 64780 88133 67379 99127 66179 11118 69178 22116  
68779 33113 65979 44110 65579=

72214 TTAA 56001 72214 99998 17631 26510 00038 /////  
11603 25526 85406 10456 25539 70996 00871 26035 50562 14595 25081  
40729 20393 22125 30937 34189 22123 25062 43186 22134 20210 50584  
23127 15393 59181 24110 10643 65575 25059 88999 77232 22635=

TTBB 56000 72214 00998 17631 11992 16830 22934 12205 33905 10205  
44897 12236 55892 12650 66837 10258 77822 09259 88809 08258 99772  
05858 11767 05858 22764 05862 33757 05261 44739 04265 55736 04471  
66732 04272 77679 01368 88660 02975 99652 03199 11629 03799 22512  
14795 33462 15195 44433 18994 55425 19594 66415 18994 77375 22593  
88355 26191 99347 24992 11290 36388 22265 39787 33235 45785 44198  
50784 55176 55782 66148 59181 77139 62380 88135 61581 99127 63578  
11122 63777 22119 64975 33115 64376 44113 62378 55108 62180=

Plot at 219

72215	TTAA	56001	72215	99974	06009	00000	00031	/////	/////	92669
06003	25022	85362	04801	26038	70931	00763	24040	50552	19194	24551
40716	26191	23088	30921	35388	21132	25046	41786	22132	20195	48984
22622	15381	54782	24586	10635	63180	26068	88999	77262	21637=	

72215	TTBB	56000	72215	00974	06009	11964	04617	22948	04005	33932
05602	44906	07004	55857	04202	66843	06002	77820	05207	88769	02016
99748	00448	11734	00057	22732	00158	33730	00364	44729	00565	55718
00967	66707	00563	77692	01163	88676	01959	99664	03159	11641	05921
22628	07142	33610	09511	44605	09721	55602	09750	66599	10157	77588
11149	88585	11356	99578	11568	11559	13562	22517	18957	33516	18957
44514	18766	55511	18579	66506	18594	77499	19394	88493	18394	99427
24992	11406	25592	22373	28791	33349	28791	44287	37188	55269	39587
66261	39787	77229	45585	88187	50984	99167	52983	11158	55382	22154
54383	33151	55182	44142	54183	55134	55782	66125	59581	77119	60981
88103	63780=									

Plot at 72228

72230	TTAA	56001	72230	99984	08817	28009	00039	/////	/////	92681
05404	27022	85370	03811	29036	70930	01760	27042	50553	175//	27548
40716	291//	27561	30915	399//	24072	25039	407//	23098	20190	451//
23097	15378	531//	24082	10634	627//	24560	88318	421//	26063	77218
23104=										

72230	TTBB	56000	72230	00984	08817	11971	07814	22913	04805	33867
03005	44858	04008	55820	02436	66753	00336	77709	01957	88702	01760
99694	01759	11655	05357	22631	07758	33627	07760	44625	07566	55623
07392	66618	07198	77586	10196	88578	10975	99574	11195	11568	11177
22555	11596	33552	117//	44523	153//	55417	281//	66410	279//	77396
295//	88318	421//	99307	411//	11301	399//	22293	401//	33288	385//
44281	397//	55271	393//	66259	411//	77249	405//	88239	423//	99221
439//	11212	433//	22196	461//	33193	457//	44180	485//	55168	499//
66163	511//	77160	509//	88155	523//	99144	539//	11127	579//	22122
565//	33113	581//	44110	593//=						

Plot at 231

72233	TTAA	56001	72233	99008	12435	26008	00076	11434	27016	92722
06408	29021	85416	06043	27531	70993	00869	28037	50562	15983	28049
40726	28591	27557	30924	44572	26056	25047	41583	24587	20197	45978
24597	15385	54368	25590	10640	63963	26564	88305	44572	26554	77161
25603=										

TTBB	56000	72233	00008	12435	11980	10030	22907	05405	33893	07208
44883	07034	55868	06442	66843	05840	77833	05625	88824	05833	99822
06250	11814	06458	22749	02059	33738	01860	44736	02063	55731	02264
66728	02269	77725	02269	88691	00070	99663	00395	11478	18986	22414
26391	33356	36381	44305	44572	55293	44772	66287	42775	77273	43176
88261	42180	99257	42579	11253	41382	22227	43581	33216	43582	44187
46976	55168	51170	66163	52169	77158	52169	88143	56166	99140	55567
11132	56166	22113	60564	33110	60564=					

72240 TTAA 56001 72240 99011 11850 32010 00093 11258 31513 92738  
05215 30519 85428 06259 31536 70011 01275 29038 50564 16162 28052  
40728 28763 27560 30926 46563 28567 25048 43968 26062 20197 44572  
26582 15386 54567 26103 10640 63764 28066 88297 46963 28566 77149  
26603=

72240 TTBB 56000 72240 00011 11850 11005 11659 22923 05013 33895  
03413 44879 04023 55873 05041 66857 06257 77840 06662 88812 06866  
99793 06467 11785 06472 22765 06276 33706 01474 44676 00675 55622  
03173 66523 13966 77511 14965 88504 15562 99446 22367 11424 25164  
22297 46963 33286 47163 44276 43964 55235 44169 66205 45372 77202  
44372 88190 46771 99173 48770 11164 51369 22160 51369 33152 54367  
44142 55167 55135 57766 66134 57366 77128 57966 88113 62164 99110  
62364=

72248 TTAA 56001 99000 10656 29505 00089 10456 28008 92732 04636  
29520 85417 05064 32041 70972 04772 30043 50558 17368 28564 40721  
29367 29070 30919 47765 28072 25040 46965 28560 20187 47166 26576  
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27072 77170 27583 40918 77281 27579=

TTBB 56000 72248 00000 10656 11970 08257 22885 01416 33866 01833  
44855 04661 55850 05064 66774 01070 77747 01769 88674 06972 99662  
07173 11633 03377 22622 03977 33585 07770 44502 17168 55460 20169  
66292 48964 77276 49364 88268 46365 99265 45965 11254 47365 22244  
47165 33233 48765 44224 49365 55222 48365 66212 48365 77206 47166  
88182 47566 99174 48965 11168 48166 22154 51165 33149 51365 44138  
54964 55135 54364 66123 55164 77104 62562=

Plot at FWH (Dallas-Ft Worth, next to 259)

72249 TTAA 56001 72249 99989 14060 31011 00105 // // // // // 92756  
08659 31016 85448 04266 33030 70001 05377 31542 50560 17766 30051  
40724 29172 29559 30922 47369 29066 25041 49968 28571 20189 47972  
29063 15376 53769 28091 10632 63765 27565 88270 52966 28067 77148  
28091=

72249 TTBB 56000 72249 00989 14060 11982 13463 22908 07458 33906  
07260 44895 06459 55885 05860 66872 05665 77854 04266 88828 04069  
99806 02465 11763 01567 22724 03175 33690 05979 44663 05596 55652  
02599 66642 02979 77515 16567 88469 20365 99432 24172 11363 34977  
22301 47169 33270 52966 44266 52766 55259 50167 66249 50168 77247  
47369 88244 46370 99228 44972 11215 47172 22194 48372 33188 49771  
44183 49372 55171 51570 66162 51970 77158 50971 88150 53769 99141  
54369 11135 56168 22134 56168 33132 55168 44130 55168 55116 60166  
66108 60366=

72250 TTAA 56001 72250 99012 20050 13508 00113 17038 11508 92777  
14244 27006 85484 08629 31515 70090 040// 29525 50574 135// 28041  
40740 27376 27052 30941 349// 27070 25068 373// 28069 20220 463//  
27066 15405 58769 27071 10652 71163 29070 88322 39173 27557 77309  
27077=

72250 TTBB 56000 72250 00012 20050 11003 17441 22992 16427 33978  
17029 44946 15641 55863 09221 66844 08436 77836 09860 88832 10669  
99829 11071 11827 12099 22824 128// 33808 126// 44718 048// 55601  
027// 66558 075// 77546 077// 88494 143// 99438 209// 11419 24183  
22388 29371 33367 31779 44331 38775 55322 39173 66307 34183 77300  
34988 88299 351// 99287 339// 11264 365// 22247 375// 33209 439//  
44184 507// 55175 52776 66159 57171 77132 62567 88118 67164 99114  
67364 11111 68764 22107 68764=

72251 TTAA 56001 72251 99011 19256 00000 00108 17856 29501 92769  
14259 30020 85476 09870 30525 70071 03676 29037 50571 15177 27550  
40736 27764 27558 30935 45565 27058 25060 38772 28578 20211 45171  
28067 15398 55966 26071 10647 70562 28073 88298 45965 27059 77115  
26581=

72251 TTBB 56000 72251 00011 19256 11002 18056 22958 14444 33928  
14459 44882 11059 55854 10269 66819 08676 77795 08686 88756 07487  
99667 01874 11615 03373 22565 07371 33540 10569 44524 12177 55500  
15377 66463 18574 77445 21172 88435 22765 99421 24963 11369 31967  
22298 45965 33292 44765 44289 41766 55276 39968 66270 38169 77263  
37570 88257 37971 99219 42572 11208 42972 22186 49169 33181 49369  
44170 52967 55163 54367 66159 53767 77115 66163 88109 66163=

72261 TTAA 56001 72261 99975 23069 31010 00098 // // 92770  
18470 31016 85485 11664 29517 70072 01666 30033 50569 13771 29033  
40734 27765 26537 30933 45762 28542 25056 391// 28582 20207 453//  
29081 15394 571// 28062 10644 691// 27564 88297 46361 28542 77191  
28585=

72261 TTBB 56000 72261 00975 23069 11936 19470 22925 18470 33870  
13465 44773 04458 55725 02869 66710 02465 77685 00267 88650 03563  
99634 04765 11626 05373 22619 05592 33609 05795 44562 09972 55553  
10768 66547 11562 77536 12764 88529 12764 99527 12758 11525 12958  
22511 12968 33497 13972 44387 29965 55372 32559 66339 38362 77297  
46361 88288 45962 99283 43163 11272 43167 22262 39780 33259 39786  
44254 389// 55237 397// 66211 443// 77188 473// 88176 515// 99170  
523// 11162 545// 22155 555// 33145 589// 44128 623// 55124 621//  
66121 631// 77116 627// 88110 653//=

72265 TTAA 56001 72265 99914 16668 29007 00113 // // 92770  
// // 85479 10065 30512 70054 01575 31532 50567 15763 30535  
40731 28565 29035 30929 46765 28537 25048 46766 28071 20198 45782  
29092 15385 55972 28069 10636 67165 27057 88279 51364 28539 77202  
29093 40713 77135 27089=

TTBB 56000 72265 00914 16668 11897 14470 22873 12268 33763 02060  
44725 00666 55709 00967 66700 01575 77692 02170 88685 02162 99650  
05160 11636 04362 22582 09163 33557 10362 44535 12961 55494 16164  
66420 26363 77361 34770 88279 51364 99262 51164 11250 46566 22239

43569	33226	42774	44212	45178	55205	44981	66197	46182	77168	52377
88158	53575	99141	58970	11125	60369	22112	64766	33110	64766=	
72274	TTAA	56001	72274	99929	18267	00000	00127	/////	/////	92790
17466	33003	85502	10262	30005	70082	01488	25019	50569	18165	25536
40731	29350	26545	30929	46957	26039	25051	43968	27567	20200	48173
28108	15386	57368	28101	10636	66964	27072	88295	47957	26544	77207
28612=										
72274	TTBB	56000	72274	00929	18267	11916	16266	22889	13865	33758
02057	44742	01257	55740	01659	66739	01863	77736	02876	88720	03092
99621	05985	11582	09972	22569	11369	33560	11778	44525	14979	55517
15770	66506	17370	77498	18564	88468	23160	99458	24356	11451	25358
22433	27956	33420	27541	44401	29350	55295	47957	66284	46759	77281
45560	88278	45760	99273	44162	11263	43365	22256	44366	33239	43770
44234	44770	55232	43571	66225	43573	77205	47773	88190	49573	99177
52371	11173	52970	22171	52371	33148	57768	44145	58367	55139	57168
66118	64365	77112	64965	88110	64365=					
Plot at 309										
72305	TTAA	56001	72305	99005	13600	11509	00053	13201	13013	92710
11806	16054	85414	08406	17049	70001	01606	22555	50565	11523	25066
40733	22139	24573	30939	34556	24601	25064	45557	24106	20209	56358
24634	15389	62359	26098	10636	68959	26073	88999	77193	25136=	
TTBB	56000	72305	00005	13600	11946	12606	22820	06806	33758	04006
44721	03206	55653	01306	66650	00705	77641	02106	88479	13326	99380
24742	11375	24541	22347	27147	33315	31756	44240	48157	55208	55558
66194	57358	77179	57559	88160	61759	99153	61959	11141	63759	22138
63359	33130	65159	44124	65359	55122	63559	66119	63359	77107	67959
88105	67559=									
72317	TTAA	56001	72317	99970	01010	06021	00033	/////	/////	92659
01704	06528	85337	07205	15054	70927	02050	21046	50557	11539	22081
40724	22548	21573	30929	37957	22590	25052	46359	23111	20196	58159
23648	15376	57967	25614	10631	637//	26066	88190	60359	23654	77193
23655=										
TTBB	56000	72317	00970	01010	11943	01107	22886	02104	33869	00204
44862	03804	55854	06805	66837	08205	77818	08004	88791	06004	99754
04848	11720	03656	22651	01943	33634	03525	44628	02519	55609	05513
66574	08118	77543	08518	88515	10948	99489	12134	11375	26356	22310
36356	33252	45959	44204	58159	55197	58159	66190	60359	77176	60761
88160	59964	99155	58366	11150	58167	22147	56170	33143	56571	44136
54981	55135	55182	66109	623//=						
72327	TTAA	56001	99980	06603	26505	00010	/////	/////	92648	03208
28022	85328	00905	28015	70872	04506	27036	50545	20769	23537	40707
313//	25057	30904	425//	24062	25028	425//	23072	20177	459//	23078
15367	511//	24079	10626	613//	25566	88305	435//	23561	77191	22588=

72327 TTBB 56000 72327 00980 06603 11975 06203 22888 01007 33822  
02305 44809 00903 55794 01103 66759 02703 77740 02302 88690 05305  
99660 06105 11628 08717 22616 09956 33581 12756 44572 13963 55545  
15960 66532 17364 77502 20569 88479 22372 99474 22765 11470 23167  
22463 23761 33454 24361 44437 26966 55435 27172 66328 415// 77305  
435// 88293 413// 99281 433// 11272 423// 22268 433// 33258 417//  
44250 425// 55236 415// 66217 451// 77204 455// 88190 477// 99184  
477// 11181 467// 22173 487// 33167 487// 44160 509// 55158 499//  
66151 511// 77148 505// 88145 515// 99138 511// 11132 531// 22127  
537// 33122 551// 44116 551// 55109 587//=

72340 TTAA 56001 72340 99987 06423 27510 00065 // // 92700  
01811 29032 85376 03106 30534 70899 08563 28039 50543 25567 28055  
40704 313// 28088 30902 425// 28090 25025 439// 26561 20174 459//  
26574 15364 503// 26550 10624 603// 25046 88291 433// 28085 88100  
603// 25046 77380 28108 43410 77188 27079=

TTBB 56000 72340 00987 06423 11981 06023 22930 02011 33831 04705  
44825 02707 55822 02525 66816 02749 77808 03356 88762 06157 99733  
07560 11682 09164 22672 08975 33642 10997 44611 13793 55606 14373  
66595 15175 77550 20393 88513 24391 99509 24974 11498 25766 22486  
26765 33484 26366 44483 25788 55478 251// 66466 253// 77414 309//  
88397 313// 99325 407// 11291 433// 22286 425// 33262 423// 44226  
463// 55220 455// 66208 465// 77196 449// 88186 463// 99176 461//  
11172 453// 22154 501// 33144 513// 44138 511// 55126 535// 66125  
531// 77116 561// 88111 563// 99104 595//=

72363 TTAA 56001 72363 99890 04656 32504 00147 // // 92782  
// // 85467 03261 30010 70023 02366 31525 50561 19756 33545  
40724 29564 29053 30922 47161 29561 25039 55960 29062 20184 48366  
28576 15373 54371 28579 10628 62767 27556 88255 56760 29563 77149  
28579 42122 77213 28579=

72363 TTBB 56000 72363 00890 04656 11880 04261 22811 02262 33792  
01265 44754 01162 55740 00767 66726 00766 77695 02766 88659 06561  
99653 06361 11624 08960 22599 09761 33503 19756 44484 18957 55458  
22357 66449 23158 77440 23562 88426 25565 99384 32364 11364 35365  
22346 38360 33255 56760 44251 56560 55247 53961 66244 54561 77239  
53361 88232 53961 99223 50362 11219 49563 22211 50363 33206 48764  
44200 48366 55196 47367 66193 47767 77182 46770 88172 48173 99158  
52572 11150 54371 22144 54771 33134 57569 44129 56770 55116 60168  
66113 58569 77110 58369=

72365 TTAA 56001 72365 99836 09461 25004 00132 // // 92785  
// // 85484 // // 70055 02559 28518 50564 19335 28551  
40727 29159 28032 30925 46757 27544 25043 55757 27545 20187 49161  
28080 15375 54165 26578 10628 64163 26033 88252 57157 27544 77189  
28086=

72365 TTBB 56000 72365 00836 09461 11829 08064 22823 07263 33762  
01458 44723 00959 55692 03358 66677 04560 77665 05358 88634 06777  
99610 08976 11599 09566 22594 10158 33588 10759 44586 10765 55582  
10969 66541 15965 77534 16562 88530 16759 99528 16956 11523 17345  
22516 18135 33512 18548 44508 18940 55495 19935 66485 19349 77454  
23147 88445 23550 99441 23558 11379 32560 22355 36757 33252 57157  
44250 55357 55246 54757 66231 56158 77228 55358 88220 50959 99194  
48962 11180 50363 22161 51765 33159 51365 44150 54165 55146 53965  
66135 57564 77131 57764 88126 60164 99114 61163 11109 63163 22106  
62363=

Plot at 374. Do NOT plot at 376 in New Mexico.

72376 TTAA 56001 72376 99782 03229 19504 00158 // // 92808  
// // 85503 // // 70063 05112 23012 50565 19138 27029  
40727 31558 25537 30923 48159 25058 25042 50163 27551 20187 50781  
27084 15373 55182 27596 10627 62780 25553 88279 52359 26052 88114  
62780 26567 77158 27106=

72376 TTBB 56000 72376 00782 03229 11776 02659 22763 01456 33701  
05112 44633 08109 55547 14331 66486 20739 77429 27757 88279 52359  
99273 51559 11257 52161 22249 49963 33245 49964 44236 51966 55230  
51567 66219 52370 77203 50379 88168 50984 99142 57182 11136 56982  
22129 59581 33118 60781 44114 62780 55112 62580 66110 60381 77104  
61980 88102 61780=

Plot at 394

72393 TTAA 56001 99000 15245 14017 00103 // // 92756 09614  
16517 85454 04618 20010 70017 00088 23021 50561 21570 24540 40721  
34759 25050 30916 46175 23569 25036 48780 25583 20184 47379 26608  
15372 53374 26108 10627 61370 25066 88276 49172 25569 77167 26118=

TTBB 5600/ 72393 00000 15245 11991 13612 22964 11416 33862 05402  
44850 04618 55843 04025 66833 03632 77811 03009 88800 03041 99793  
02637 11765 00115 22749 01705 33746 01911 44745 01913 55742 00364  
66741 00270 77740 00475 88732 01086 99728 01088 11709 00492 22699  
00187 33692 00585 44452 27768 55435 30360 66424 31557 77379 36567  
88378 36567 99341 42757 11339 43158 22322 44567 33307 46373 44301  
45975 55276 49172 66268 46575 77248 48979 88237 47377 99204 46380  
11174 49377 22157 52974 33152 52374 44135 57572 55123 57772 66113  
61370 77110 61571=

Plot at NKZ in the Delmarva peninsula

72402 TTAA 56001 72402 99016 00209 06020 00140 00105 07518 92765  
00707 10525 85440 00907 16033 70984 03906 22031 50560 14117 25077  
40726 24937 25069 30930 36950 25098 25054 46348 25626 20197 59146  
25153 15376 58158 26610 10629 66172 27577 88170 62950 26141 77196  
25156=

72402 TTBB 56006 72402 00016 00209 11920 00907 22799 00908 33736  
04306 44706 03706 55544 10110 66386 26739 77305 35950 88202 58946  
99170 63150 11150 57958 22133 57963 33119 59973 44100 66172=

Plot at NYG in eastern Virginia

72403 TTAA 56001 72403 99006 00104 06504 00133 00520 07507 92753  
01904 10525 85423 03906 12518 70954 07509 18025 50556 13719 25055  
40722 24743 25080 30925 38350 24089 25047 47357 24613 20191 59357  
24663 15370 57559 26601 10625 63363 27566 88183 61757 25153 77200  
24663=

72403 TTBB 56000 72403 00006 00104 11005 00328 22991 01111 33953  
02909 44930 01904 55852 03906 66838 02303 77812 03704 88799 03103  
99742 05105 11695 07709 22674 07505 33637 09109 44580 08704 55523  
11511 66430 20732 77420 21943 88312 38156 99301 38350 11268 44556  
22238 49757 33206 58357 44193 60557 55183 61757 66170 61358 77162  
62158 88158 58958 99153 57159 11147 58359 22143 55960 33138 54961  
44126 57762 55116 58363  
66110 59763=

Plot at ILN in southwest Ohio

72426 TTAA 56001 72426 99964 00406 07016 00027 // // 92653  
01306 07540 85326 01905 13531 70868 05505 18005 50546 17741 21552  
40710 27749 18555 30909 439// 21059 25031 465// 20608 20177 513//  
22092 15363 517// 24069 10620 613// 26056 88212 51983 21611 77214  
21612=

72426 TTBB 56000 72426 00964 00406 11922 01506 22883 02106 33848  
01905 44834 00905 55772 02105 66650 08306 77609 07705 88595 08305  
99565 11112 11556 12736 22536 14947 33510 17348 44484 18530 55441  
22537 66393 28750 77321 41358 88306 43376 99296 44586 11281 45785  
22273 44386 33258 46385 44244 46985 55212 51983 66206 51184 77194  
51184 88181 53383 99171 53383 11166 54583 22162 53583 33157 54183  
44153 51783 55143 53383 66140 53183 77136 54383 88131 52983 99127  
53183 11121 55982 22117 56382 33103 61181=

Lincoln, IL. Plot at 439

74560 TTAA 56001 74560 99987 00613 04519 00074 // // 92696  
03307 05546 85366 03505 08543 70886 09312 05029 50543 20927 06018  
40705 32742 08502 30900 495// 14018 25019 505// 23023 20166 471//  
26037 15356 487// 24536 10617 563// 26043 88284 523// 15020 88115  
553// 25541 77999=

74560 TTBB 56000 74560 00987 00613 11923 03507 22900 02705 33792  
04906 44508 20126 55436 27937 66310 47757 77300 49557 88284 523//  
99278 525// 11267 501// 22257 511// 33247 501// 44238 507// 55227  
477// 66216 475// 77211 461// 88201 475// 99196 463// 11189 461//  
22181 477// 33171 465// 44166 477// 55155 475// 66143 503// 77138  
501// 88127 519// 99115 553// 11107 553// 22105 545//



72440 TTAA 56001 72440 99962 00203 31011 00077 /////  
02310 31024 85370 04910 30528 70889 09720 31518 50540 27391 36009  
40697 37762 08024 30894 407// 29533 25018 427// 29039 20168 437//  
27044 15358 485// 28050 10619 591// 26029 88374 39187 06516 77999=

72440 TTBB 56000 72440 00962 00203 11956 00316 22889 04110 33841  
05110 44821 04707 55793 06109 66775 05709 77726 07509 88713 08721  
99676 11315 11668 12518 22661 13563 33658 13765 44616 16974 55565  
20973 66540 23570 77509 26791 88483 28788 99477 28966 11472 28768  
22459 29959 33454 30557 44441 32150 55432 33358 66400 37963 77392  
37787 88374 39187 99363 38587 11341 39387 22328 40787 33320 40387  
44313 41387 55306 40587 66282 42186 77238 42586 88222 44586 99210  
42786 11204 43786 22198 43586 33192 44786 44172 46785 55157 49584  
66149 48584 77139 49384 88134 51184 99119 54383 11114 56182 22106  
57182=

72451 TTAA 56001 72451 99923 01021 36013 00141 /////  
/////  
85442 04709 35025 70965 06361 33044 50553 19977 33558  
40715 30766 /////  
30912 47761 /////  
25030 55560 30080 20176 48363  
30059 15365 51164 29557 10624 57362 29047 88252 56559 30580 77241  
30081=

72451 TTBB 56000 72451 00923 01021 11850 04709 22775 06157 33728  
04761 44680 06364 55632 10180 66587 12571 77537 16581 88400 30766  
99252 56559 11234 48962 22223 50762 33191 47563 44100 57362=

72456 TTAA 56001 72456 99981 00611 34507 00111 /////  
03307 36021 85400 04505 02522 70918 07542 03521 50546 24158 36024  
40704 37778 02513 30897 483// 34022 25017 473// 32038 20164 461//  
29542 15355 497// 28041 10615 58381 26527 88304 49584 34523 77999=

72456 TTBB 56000 72456 00981 00611 11933 02908 22885 04907 33837  
04305 44811 05506 55779 05905 66725 09308 77713 07911 88699 07544  
99685 08350 11647 10134 22608 13557 33563 17750 44558 18356 55523  
21756 66497 24558 77448 30760 88443 31564 99427 33772 11384 40181  
22332 47585 33304 49584 44294 47185 55278 49384 66272 49584 77267  
48384 88251 47185 99240 48384 11235 47185 22210 48384 33200 46185  
44195 46385 55192 45585 66186 46585 77183 45985 88176 47585 99159  
48184 11152 49984 22151 49584 33145 50384 44141 49384 55137 50784  
66135 49784 77118 55182 88112 54982 99110 55782=

72469 TTAA 56001 72469 99833 07067 11507 00114 /////  
/////  
85448 /////  
70006 04162 28525 50557 20950 30026  
40719 30973 31026 30916 491// 30041 25033 553// 31030 20175 531//  
29045 15361 519// 28550 10620 569// 28539 88234 579// 28033 77159  
28066=

72469	TTBB	56000	72469	00833	07067	11819	05269	22802	03468	33736
02962	44728	02362	55709	03362	66637	09358	77613	11356	88576	14343
99556	15556	11515	19942	22477	22548	33474	21550	44470	21358	55418
28370	66400	30973	77379	34769	88359	38159	99340	41556	11300	49157
22279	535//	33275	531//	44265	549//	55260	543//	66234	579//	77226
575//	88224	555//	99218	535//	11214	539//	22209	529//	33192	529//
44179	551//	55168	535//	66166	519//	77161	527//	88159	513//	99158
511//	11151	517//	22137	557//	33129	571//	44128	569//	55127	553//
66125	535//	77122	523//	88104	573//	99102	563//=			

72476	TTAA	56001	72476	99851	02457	29004	00180	/////	/////	92810
/////	/////	85486	02457	29001	70031	05956	25011	50559	19348	28522
40721	32160	27036	30917	49559	25542	25034	55560	28042	20177	52562
28055	15363	52764	27067	10620	61563	25535	88231	57560	28041	77153
27068	43124	77213	26064=							

72476	TTBB	56000	72476	00851	02457	11826	01260	22806	00460	33801
00458	44790	00550	55768	02342	66755	02738	77751	02750	88736	03756
99715	05133	11711	05140	22685	07556	33633	10750	44617	11558	55610
12157	66605	12343	77562	15914	88523	19315	99519	19516	11515	18317
22511	18326	33500	19348	44480	21350	55459	23941	66426	28359	77404
31560	88352	40160	99291	51160	11277	53160	22267	53160	33245	56560
44231	57560	55225	56960	66219	53960	77213	53561	88208	54361	99205
53161	11190	51562	22176	53163	33171	51963	44156	51764	55136	55764
66129	56364	77123	56764	88120	55764	99118	54365	11110	57164=	

Plot at 488

72489	TTAA	56001	72489	99841	11673	17509	00063	/////	/////	92723
/////	/////	85430	/////	/////	70999	05161	22509	50554	24770	24537
40712	38356	23543	30904	51559	24554	25021	54759	24064	20166	46962
25048	15354	51763	24051	10614	58762	24540	88248	55159	24066	77234
24574	41421	77164	25062=							

72489	TTBB	56000	72489	00841	11673	11831	08674	22770	02472	33739
00968	44732	01764	55696	05561	66690	06361	77689	06363	88687	06559
99686	06759	11685	06764	22684	06761	33681	07164	44666	08761	55649
10365	66639	11563	77631	11165	88592	14568	99571	17166	11563	17767
22560	17973	33555	18365	44521	21968	55493	25571	66429	34564	77420
35557	88404	38156	99371	41559	11342	46959	22320	50159	33306	50559
44295	52159	55283	51759	66268	53359	77260	53159	88248	55159	99228
53760	11222	52160	22219	49760	33211	47361	44202	46562	55196	46962
66181	50763	77173	51363	88166	53562	99161	51763	11157	51163	22151
51763	33145	51164	44140	52163	55138	50764	66133	50964	77129	51764
88120	55363	99105	56763=							

72493	TTAA	56001	99010	16250	26504	00087	14850	23506	92741	09015
22508	85435	03635	18011	70982	06173	20524	50554	24562	22032	40713
35759	23041	30906	52758	24553	25023	54763	23069	20167	50374	25579
15355	52183	26065	10615	59781	23547	88300	52758	24553	88100	59781
23547	77193	25582=								

TTBB 56000 72493 00010 16250 11987 13649 22918 08411 33877 05209  
 44857 04024 55854 04037 66837 02426 77822 01850 88786 00956 99784  
 00956 11781 00961 22777 00964 33776 00771 44775 00775 55770 00973  
 66692 06974 77679 07594 88639 09197 99622 10775 11604 11590 22591  
 12580 33508 23363 44493 25559 55485 25743 66476 25734 77434 30950  
 88407 34759 99303 52558 11297 52758 22292 50959 33285 50760 44266  
 53962 55247 54963 66240 53963 77231 54764 88225 53165 99208 52368  
 11205 50770 22202 50772 33197 49379 44192 50183 55183 50184 66181  
 49184 77175 49184 88172 48184 99166 49584 11162 49384 22146 53183  
 33140 53983 44132 53983 55129 51983 66124 53383 77118 52783 88110  
 56582 99107 56782=

This is Upton. Plot just north of the "A" in LGA.

72501 TTAA 56001 72501 99018 01156 00000 00158 00558 29504 92776  
 05756 34509 85440 043// 31022 70955 079// 29524 50550 20122 28057  
 40713 28129 26595 30914 40549 26115 25037 47956 26648 20180 58557  
 26673 15363 55160 28580 10617 64160 27583 88204 58357 26670 88100  
 64160 27583 77200 26674=

72501 TTBB 56000 72501 00018 01156 11008 00057 22979 01760 33920  
 05956 44919 05956 55888 057// 66881 047// 77856 041// 88812 071//  
 99789 081// 11756 069// 22744 071// 33736 065// 44703 081// 55693  
 077// 66612 169// 77597 14713 88544 18921 99476 20923 11402 28329  
 22389 27927 33296 41350 44255 46756 55204 58357 66194 58557 77183  
 57358 88180 55958 99170 55758 11166 54359 22158 55359 33154 54760  
 44150 55160 55148 54160 66141 54960 77132 57961 88119 58961 99106  
 62760=

72518 TTAA 56001 72518 99009 01157 00000 00160 02158 31003 92774  
 07350 34016 85426 12536 34518 70925 10373 31036 50546 24756 28552  
 40707 31940 27075 30906 42747 27125 25028 48343 26171 20171 59338  
 26679 15355 53176 29078 10614 605// 27566 88200 59338 26677 88166  
 58175 29089 77215 26181=

72518 TTBB 56006 72518 00009 01157 11852 12534 22840 11957 33831  
 09977 44806 09777 55743 08175 66578 17577 77563 17377 88501 24757  
 99482 23728 11363 35743 22345 35541 33294 43347 44270 45745 55200  
 59338 66194 57750 77191 53957 88186 50577 99166 58175 11154 53176  
 22133 54376 33130 53176 44116 56775 55100 605//=

72520 TTAA 56001 72520 99967 00000 08007 00090 // // // // // 92714  
 02306 09533 85387 01103 11533 70921 05903 15019 50550 16119 22037  
 40715 26541 22559 30916 40156 23111 25040 46757 22143 20183 58557  
 22650 15364 59759 24590 10620 59162 27555 88203 58957 22651 77206  
 22651=

72520 TTBB 56000 72520 00967 00000 11955 00303 22906 03105 33889  
 02905 44881 01303 55866 00703 66769 03703 77717 06707 88689 05903  
 99611 11710 11552 15120 22545 15119 33535 14110 44523 14312 55467  
 17923 66341 35556 77304 40356 88288 40756 99282 39956 11278 40156

22249 46958 33216 55757 44203 58957 55193 59357 66181 57758 77172  
58159 88168 57159 99157 59159 11146 59760 22143 56760 33139 56960  
44137 56160 55123 57561 66119 56962 77109 59962 88107 59762 99105  
60562=

72528 TTAA 56001 99993 03119 04011 00164 /////  
07019 85435 06171 04514 70942 08972 01509 50548 22341 26526 40709  
31950 24544 30908 42357 25106 25030 47557 23660 20173 57158 24651  
15355 55564 27085 10613 58778 28048 88211 57157 24170 77215 23671=

72528 TTBB 56000 72528 00993 03119 11988 03518 22960 05708 33886  
09513 44885 09520 55884 09350 66882 08765 77881 08173 88877 06178  
99873 05580 11831 06966 22795 08365 33766 08965 44759 08370 55749  
08166 66720 08171 77668 09973 88574 18169 99570 18567 11564 19358  
22555 20159 33550 20156 44534 21548 55521 20533 66495 22741 77471  
23738 88402 31950 99355 34950 11315 40757 22296 42557 33281 44957  
44255 46557 55211 57157 66206 56757 77188 58359 88177 58160 99163  
56361 11156 56962 22152 55363 33146 56764 44141 55565 55132 56167  
66129 55169 77123 56171 88119 55773 99110 58374 11107 56977 22105  
58177 33103 57778=

Plot at 553

72558 TTAA 56001 72558 99974 01111 36008 00144 /////  
04306 04016 85429 04505 06514 70945 08906 08517 50549 23959 35013  
40708 36159 32009 30900 50963 32511 25018 52774 32532 20164 491//  
30031 15353 493// 28531 10615 569// 25022 88275 53768 32021 77999=

TTBB 56000 72558 00974 01111 11970 01711 22952 02909 33900 05506  
44857 04305 55764 06905 66723 09307 77693 08708 88660 09523 99643  
10935 11608 13530 22497 24359 33443 30757 44432 31961 55422 33160  
66403 35758 77384 38760 88355 43757 99333 47559 11313 50161 22275  
53768 33259 51972 44251 52973 55240 51583 66221 497// 77213 499//  
88208 487// 99201 493// 11193 477// 22187 477// 33181 487// 44172  
485// 55168 495// 66158 483// 77141 505// 88135 499// 99123 535//  
11121 527// 22112 543// 33108 533//=

72562 TTAA 56001 72562 99917 00514 35508 00154 /////  
/////  
85453 04923 29515 70959 10334 33516 50550 22391 32529  
40711 32389 32557 30907 49367 32560 25024 55365 31554 20168 50369  
31051 15355 51372 29541 10615 56369 29029 88267 55165 31556 88105  
57368 27541 77355 32565=

72562 TTBB 56000 72562 00917 00514 11913 01115 22881 03711 33870  
03121 44786 09909 55776 08507 66742 09127 77704 10333 88664 10357  
99636 11358 11614 12758 22604 12960 33582 15162 44577 15566 55567  
16568 66550 18568 77529 20963 88514 22764 99508 22375 11501 22389  
22447 26191 33386 33986 44289 51566 55267 55165 66262 54565 77244  
55365 88240 54565 99230 55565 11224 53766 22220 53766 33215 51567  
44209 52367 55207 50568 66204 49769 77190 52768 88184 49970 99177  
50371 11167 52170 22160 50772 33149 51172 44142 52371 55136 51972  
66128 54770 77118 53571 88110 55370 99105 57368=

72572 TTAA 56001 72572 99869 06449 00000 00125 // // 92774  
// // 85468 05258 18009 70020 06108 29006 50558 20973 26532  
40718 35171 26042 30912 49365 25052 25029 55764 26567 20172 53966  
25556 15358 53575 26550 10615 56177 24539 88235 57763 26543 88121  
57573 26055 77257 26073=

72572 TTBB 56000 72572 00869 06449 11850 05258 22784 00523 33772  
00523 44661 08908 55655 08710 66645 09941 77635 10356 88612 11950  
99600 12758 11556 17343 22542 17565 33541 17572 44535 17988 55530  
18168 66528 18188 77525 18367 88513 19173 99466 25389 11439 29172  
22383 37970 33354 41967 44311 50163 55307 49164 66290 49566 77258  
55564 88250 55764 99235 57763 11228 57364 22222 55564 33210 53766  
44203 54366 55196 52967 66194 51768 77185 52169 88179 50772 99165  
52773 11161 52175 22155 53374 33149 53175 44140 55574 55121 57573  
66119 56974 77112 58173 88110 56775 99109 55377 11107 54778=

72582 TTAA 56001 72582 99836 03021 18010 00128 // // 92772  
// // 85461 // // 70008 05915 21508 50556 24356 22537  
40714 37160 23053 30907 50161 23569 25025 55963 24566 20169 51779  
23563 15356 537// 23539 10615 555// 26538 88243 56363 24062 88142  
553// 24045 77267 24078=

72582 TTBB 56000 72582 00836 03021 11821 01219 22763 02111 33592  
13929 44546 18536 55540 19556 66506 23542 77490 25962 88478 26980  
99462 28382 11441 31372 22432 32163 33418 34359 44358 43560 55315  
50159 66299 50161 77293 49162 88265 54163 99243 56363 11237 55963  
22236 54164 33234 53764 44225 53565 55222 51366 66218 50768 77215  
49370 88199 51779 99196 50783 11195 50783 22190 505// 33186 487//  
44178 501// 55175 499// 66163 515// 77142 553// 88132 539// 99127  
547// 11124 527// 22118 539// 33110 573// 44108 573// 55107 563//  
66103 563// 77102 553//=

72597 TTAA 56001 72597 99960 15063 13510 00051 // // 92706  
11665 15018 85404 05060 17015 70951 06561 19530 50549 25371 19531  
40707 38172 21031 30897 55360 24038 25012 59360 24537 20154 49365  
23542 15342 48375 23043 10606 55177 22519 88268 61359 24547 77999=

TTBB 56000 72597 00960 15063 11951 13866 22894 08862 33826 03059  
44797 00256 55756 03357 66734 04758 77718 04762 88710 05563 99656  
10950 11645 11556 22630 12947 33619 13956 44605 14563 55581 16762  
66562 18568 77526 22762 88505 25366 99490 25982 11475 27187 22407  
36975 33347 46960 44268 61359 55261 59560 66247 59360 77241 60360  
88234 59560 99232 58160 11225 56561 22222 56761 33213 52362 44207  
50163 55191 48367 66176 51168 77157 50771 88156 49772 99152 49573  
11150 48375 22146 48776 33144 48377 44136 50976 55134 49578 66123  
49981 77120 48983 88111 50383 99102 54978=

Plot at 606

74389 TTAA 56001 74389 99003 04964 31506 00149 04965 32011 92756  
09764 31026 85404 11589 33528 70869 18378 31043 50535 25392 29582  
40695 34178 29103 30894 42957 28156 25016 47158 27204 20162 52559

29652 15347 52760 28567 10604 57960 28564 88173 56159 30094 88108  
59359 27567 77255 27706=

74389 TTBB 56000 74389 00003 04964 11995 05167 22933 09564 33893  
11564 44867 12969 55855 11785 66846 11187 77839 11185 88765 16594  
99728 17994 11702 18581 22687 16786 33664 16994 44589 23189 55569  
23592 66557 20593 77554 20593 88491 26391 99476 25192 11465 25792  
22403 34182 33394 33377 44379 33577 55341 38960 66325 39358 77298  
43157 88279 43357 99262 44757 11235 50358 22232 49758 33227 50358  
44219 49158 55211 51358 66205 50959 77198 53159 88191 52759 99180  
54359 11173 56159 22168 55359 33166 53359 44163 52359 55158 52159  
66144 53360 77134 55560 88132 54760 99124 55160 11108 59359=

Gaylord, MI. Draw a station circle at 45°N, 85°W

72634 TTAA 56001 72634 99967 04928 08007 00183 // // 92796  
08320 07018 85448 07765 04015 70947 10967 07012 50547 24758 35011  
40706 35358 28529 30901 49160 24053 25018 55359 23559 20162 51364  
24566 15349 51970 26048 10609 56970 27529 88259 56559 23559 77225  
23574=

72634 TTBB 56000 72634 00967 04928 11876 11910 22873 11717 33871  
11356 44870 11162 55868 10765 66859 08566 77839 07363 88796 09761  
99785 09762 11764 10159 22750 10562 33732 09567 44710 10767 55675  
11168 66652 12367 77610 15967 88565 19165 99544 20960 11527 21961  
22485 26556 33466 28348 44446 29957 55427 32359 66381 37956 77373  
37159 88360 38961 99317 46961 11287 50559 22259 56559 33251 55559  
44247 54160 55236 54560 66230 53361 77217 52962 88214 52162 99209  
52963 11204 51164 22185 51766 33172 51168 44166 51768 55160 50770  
66156 51370 77154 50770 88149 52170 99141 53370 11134 52172 22127  
52772 33120 54771 44110 54572=

72645 TTAA 56001 72645 99996 02927 03513 00176 // // 92790  
06724 04534 85450 07110 07527 70949 10772 03519 50547 24556 02508  
40706 35358 28516 30901 50573 24035 25017 60364 23031 20160 491//  
26535 15348 513// 25534 10610 555// 26529 88249 60564 23031 77999=

TTBB 56000 72645 00996 02927 11994 02727 22930 06724 33915 06931  
44896 07108 55890 06305 66876 06104 77816 09107 88773 09708 99759  
10718 11740 11912 22736 11720 33731 11362 44727 10769 55716 09968  
66695 10970 77692 10967 88686 10776 99682 10773 11666 11974 22658  
12567 33647 13166 44634 13568 55618 15360 66607 16563 77603 16762  
88598 17167 99594 17562 11587 17763 22584 17975 33579 18363 44570  
18957 55560 19550 66510 23556 77476 27156 88462 28539 99431 32344  
11409 34556 22396 35760 33388 36369 44374 37180 55274 55766 66249  
60564 77242 55765 88239 55966 99234 54767 11227 55169 22221 53574  
33216 53779 44215 537// 55209 521// 66207 493// 77204 487// 88185  
497// 99181 487// 11170 497// 22166 491// 33160 505// 44148 515//  
55141 509// 66131 521// 77127 517// 88119 531// 99116 525// 11110  
539//=

Minneapolis. Draw a station circle at 44.8°N, 93.5°W.

72649	TTAA	56001	72649	99986	00339	05003	00178	/////	/////	92798
04510	07521	85463	04105	07014	70971	12320	07013	50549	24140	29007
40708	36550	31012	30900	52357	28005	25016	57557	32508	20159	49984
29020	15348	50184	29028	10610	54183	27522	88269	57757	28008	77999=

72649	TTBB	56000	72649	00986	00339	11983	00734	22958	02310	33909
05310	44847	04105	55775	08508	66751	09710	77742	09514	88727	10522
99686	13318	11568	18717	22520	22131	33492	24946	44445	30349	55357
43356	66269	57757	77253	58357	88239	56558	99235	56959	11232	56359
22224	52961	33222	52761	44218	51362	55213	51765	66208	50569	77202
50584	88183	48784	99175	48784	11166	50184	22135	50584	33124	52783
44116	52183	55110	53383							

Aberdeen, SD. Draw a station circle north of HON at 45.5°N, 98.5°W

72659	TTAA	56001	72659	99973	00914	01006	00182	/////	/////	92803
03712	12512	85471	05321	14014	70974	12916	13529	50549	23926	25505
40708	36956	24016	30900	52357	23510	25016	56957	27521	20159	52163
29021	15346	51172	29524	10607	56372	28528	88259	59757	24516	88103
56372	28523	77999								

72659	TTBB	56000	72659	00973	00914	11945	03117	22928	03712	33903
02317	44893	02719	55839	05917	66824	06508	77752	10319	88682	14315
99675	13311	11657	13714	22587	18926	33527	22112	44507	23122	55422
34149	66390	38156	77369	40548	88292	53757	99259	59757	11252	58357
22249	56757	33240	55358	44235	55559	55228	53760	66224	53960	77214
52361	88202	52563	99196	52164	11194	51164	22177	52566	33167	51168
44139	50775	55126	53174	66120	53175	77103	56372			

72662	TTAA	56001	72662	99898	04928	36004	00179	/////	/////	92795
/////	/////	85457	06519	33507	70965	09950	34509	50549	23592	31041
40710	32189	31059	30906	49774	31053	25022	56368	30043	20164	52976
30046	15351	51383	29027	10611	55982	29028	88231	58168	30554	88134
54982	28026	77365	31567							

72662	TTBB	56000	72662	00898	04928	11882	06724	22868	05918	33850
06519	44841	05114	55785	08707	66775	08109	77734	10509	88726	10111
99706	09550	11683	11346	22643	12756	33570	18958	44549	20782	55532
22793	66470	23592	77389	33785	88275	55169	99260	56168	11255	55769
22245	57168	33238	56569	44231	58168	55224	57768	66215	58968	77210
55970	88208	53972	99205	52774	11198	53176	22194	52179	33189	52979
44185	50784	55173	49584	66164	51184	77162	50184	88153	50384	99147
52183	11141	52783	22134	54982	33132	53583	44126	54183	55124	53583
66110	54583									

Plot at 576

72672	TTAA	56001	99824	03140	04002	00155	/////	/////	92781	/////
/////	85452	/////	/////	70988	05358	27514	50555	22727	27532	40716
32567	27542	30911	50761	26531	25028	55760	26550	20169	54562	28535
15355	53765	28522	10615	56166	27037	88263	57560	26032	77999	=

TTBB	56000	72672	00824	03140	11818	03759	22813	04158	33804	04156
44795	03556	55790	02556	66788	02158	77773	02160	88767	01358	99762
00958	11754	01561	22724	04160	33689	05558	44654	08550	55631	09950
66615	10158	77579	13957	88508	22527	99498	22528	11473	24543	22452
25356	33433	28161	44400	32567	55302	50362	66263	57560	77257	55960
88251	55760	99233	58360	11228	58360	22224	57561	33218	53961	44207
54962	55198	54562	66190	56362	77186	56362	88183	55962	99181	54363
11173	50764	22166	48765	33162	49165	44151	53565	55142	55165	66136
55165	77129	53366	88124	54366	99122	53566	11118	54566	22111	54567
33110	53567	44102	56366=							
72681	TTAA	56001	72681	99912	10257	04506	00105	/////	/////	92753
/////	/////	85448	03417	15509	70990	07737	26016	50552	26163	25526
40709	39562	25035	30900	50161	24043	25018	54761	24038	20163	50162
25040	15350	51762	24536	10612	54162	24519	88247	55161	23540	77999=
72681	TTBB	56000	72681	00912	10257	11905	08456	22866	04827	33828
01611	44809	00820	55782	01916	66770	02534	77724	06525	88674	09746
99623	12960	11590	16561	22578	17957	33566	19156	44551	20757	55540
21961	66486	27563	77409	38962	88344	47162	99325	47762	11294	50761
22276	53761	33247	55161	44243	54161	55235	54361	66230	53361	77224
50361	88221	50162	99220	48962	11215	47762	22199	50162	33182	50162
44164	52162	55157	50962	66151	51762	77147	51562	88141	52762	99139
51962	11132	52962	22131	51762	33128	52362	44123	51362	55117	53562
66115	51762	77108	53562	88102	55961=					
72694	TTAA	56001	72694	99999	17263	00000	00050	/////	/////	92704
09862	14008	85399	03860	16019	70942	07157	20031	50547	24968	20536
40705	38758	21530	30895	55957	24540	25009	61957	22538	20152	49762
23025	15340	47768	20020	10606	50774	23009	88254	62757	22534	77999=
72694	TTBB	56000	72694	00999	17263	11991	15063	22947	11261	33880
06462	44799	00758	55786	01357	66778	01760	77762	02760	88754	03357
99742	04359	11736	04556	22706	06957	33705	06959	44702	06958	55690
08146	66662	11129	77654	11730	88641	12556	99637	12950	11631	13557
22627	13762	33620	13961	44600	15958	55584	17361	66553	20762	77520
22568	88450	31567	99429	34564	11413	36759	22387	40758	33273	61357
44254	62757	55250	61957	66248	59757	77241	55958	88236	56158	99234
55358	11225	54159	22217	51360	33214	51560	44205	49761	55190	50563
66183	49764	77164	50765	88162	49766	99156	49367	11151	47768	22143
49968	33141	48569	44129	50170	55120	48372	66106	49175=		
72712	TTAA	56001	99994	13156	32010	00142	/////	/////	92730	17750
31022	85356	23127	31531	70781	23558	31040	50517	35360	30559	40672
35560	30065	30872	38360	29124	25996	46159	/////	20142	50359	/////
15331	49359	29567	10593	55558	29548	88472	36560	30561	77999=	
TTBB	56000	72712	00994	13156	11984	13558	22850	23127	33839	23525
44822	20913	55788	23910	66778	21920	77753	22159	88700	23558	99545
34759	11512	35760	22332	35760	33219	49959	44155	49159	55100	55558=



72747 TTAA 56001 72747 99983 06156 07004 00224 /////  
08549 11019 85490 07964 10515 70984 13358 33509 50548 273// 30012  
40706 381// 29022 30897 529// 28539 25012 605// 28042 20154 519//  
28028 15342 495// 29022 10605 533// 30022 88259 601// 27544 77999=

72747 TTBB 56000 72747 00983 06156 11970 06356 22925 08550 33922  
08345 44914 07561 55909 06962 66877 06965 77855 07968 88851 07964  
99827 09160 11823 09159 22819 08761 33817 08765 44809 08766 55796  
08962 66794 08959 77792 08959 88764 10956 99753 11143 11728 12756  
22698 13358 33692 13160 44687 13560 55683 13956 66676 13756 77666  
13964 88654 14173 99615 16774 11596 18575 22589 19367 33555 22563  
44543 239// 55408 371// 66332 489// 77304 525// 88259 601// 99248  
605// 11244 589// 22240 587// 33237 571// 44234 573// 55229 553//  
66212 521// 77186 515// 88167 491// 99149 493// 11132 509// 22127  
503// 33119 523// 44107 529// 55103 539//=

72764 TTAA 56001 99960 01508 09003 00185 /////  
12012 85469 06707 14014 70972 12118 16013 50548 26133 23012 40706  
37549 21013 30897 52756 29527 25014 54562 28023 20158 50984 29525  
15345 51383 30022 10607 54583 29523 88289 53957 20028 77999=

TTBB 56000 72764 00960 01508 11957 02108 22935 03307 33835 07309  
44763 08913 55682 12918 66503 25932 77420 34544 88360 43756 99298  
53156 11289 53957 22230 54566 33202 50984 44191 52183 55186 51184  
66173 50784 77154 51783 88144 50384 99132 52383 11118 52783 22109  
55182 33104 53983=

72768 TTAA 56001 72768 99937 06918 10010 00182 /////  
08128 11511 85452 05905 08003 70968 09745 08001 50548 27563 31009  
40704 387// 30014 30898 497// 30065 25016 545// 30538 20159 535//  
28030 15345 51983 28023 10607 539// 28015 88247 55182 30539 77304  
30067=

72768 TTBB 56000 72768 00937 06918 11930 07740 22923 08125 33903  
08710 44884 07307 55866 04701 66845 06305 77835 04106 88822 04918  
99794 06512 11785 05509 22779 05324 33766 06332 44744 08116 55733  
08332 66711 09532 77672 11356 88608 16358 99576 19557 11529 24160  
22508 26561 33485 29567 44463 32565 55447 34771 66440 35188 77406  
38387 88387 38787 99371 40187 11274 53583 22260 53383 33247 55182  
44241 54782 55235 53183 66226 53983 77216 53183 88208 54982 99205  
54782 11201 53183 22196 54183 33192 52983 44185 53183 55178 50984  
66172 50584 77157 50784 88148 52383 99146 51583 11142 51983 22131  
51384 33123 51983 44117 53783 55110 53983 66107 55182 77103 53583=

Plot at 775

72776 TTAA 56001 72776 99884 10115 09003 00174 /////  
/////  
85438 01145 19011 70966 09112 23006 50550 23125 28021  
40710 34540 29519 30905 51156 26523 25020 59356 28515 20161 52358  
26028 15348 52566 27520 10609 54369 26018 88258 59756 27020 77999=

72776 TTBB 56000 72776 00884 10115 11865 07507 22863 04905 33857  
01716 44850 01145 55629 12716 66500 23125 77368 38543 88258 59756  
99242 60356 11190 51360 22100 54369=

Plot at 785

72786 TTAA 56001 72786 99927 02800 03505 00106 /////  
02400 04504 85424 00001 22513 70958 08313 22015 50548 26961 19524  
40706 37767 16030 30898 53562 24530 25014 55566 18021 20156 53379  
21028 15344 503// 18009 10606 527// 25017 88273 56363 15524 77999=

72786 TTBB 56000 72786 00927 02800 11890 00602 22867 00801 33827  
01102 44816 00702 55805 02104 66758 04303 77637 12726 88581 17739  
99508 25958 11496 27563 22493 27564 33492 27591 44465 29390 55419  
35188 66400 37767 77396 37963 88392 38569 99386 38971 11346 45563  
22295 54362 33273 56363 44262 55165 55230 56368 66220 58168 77215  
56969 88212 55371 99206 54773 11203 53376 22197 53183 33187 521//  
44186 511// 55177 511// 66176 501// 77170 497// 88167 485// 99159  
499// 11155 491// 22142 521// 33126 533// 44120 523// 55115 531//  
66110 513// 77105 513//=

Plot at 798

72797 TTAA 56001 72797 99000 10028 16008 00054 /////  
05210 16029 85382 00105 17038 70913 08715 17536 50543 26958 20029  
40700 39962 21535 30889 55962 24044 25004 59161 19030 20147 50773  
17020 15335 46585 20030 10601 49584 21513 88274 59760 21530 77999  
31313 58708 82302 51515 10164 00004 10194 16530 18038=

72797 TTBB 56000 72797 00000 10028 11996 09628 22938 06009 33851  
00106 44806 02107 55607 15929 66522 24543 77514 25550 88512 25957  
99496 27558 11437 34758 22420 37164 33406 39162 44383 42564 55332  
50763 66274 59760 77267 58961 88265 57361 99262 56961 11246 59761  
22240 58761 33235 56562 44223 55363 55220 52164 66213 49966 77204  
51369 88201 50572 99195 51376 11189 50584 22184 51583 33168 49784  
44161 50584 55159 49184 66155 48984 77152 46985 88147 46585 99145  
45785 11133 48184 22129 48184 33112 51583 44110 50584 55102 50784  
31313 58708 82302 41414 85500=

## Upper Air Maps (Analysis II)

This week we will continue working on upper air analysis with the 700 mb and 850 mb maps of the same case. As you may have guessed, these are the upper air maps for the surface map you analyzed in lab 3.

You should look over your surface and upper air maps when you are done, noting the meteorological features. Review the Norwegian cyclone model from class notes. This case is a good example of intense cyclone activity at all levels in the troposphere.

Lab Assignment (due next Wednesday):

1. On an upper air base map, plot the data for 700 mb and 850 mb from TTAA's as you did last week. Use the same RAOB transmissions, pp 41-59.
2. Analyze the 700 mb map. Do the standard analysis:
  - a) height contours every 30 gpm in black. Include a 300 line (3000 gpm). Note that the "hhh" in the RAOB data for 700 mb gives the height minus 3000 meters. Plot the transmitted numbers (024, not 302; 940, not 294). The contours on the 700 mb map, however, look like this: ...294, 297, 300, 303, 306, etc. If you have a closed contour, it must have a center, either "L" or "H".
  - b) isotherms every 5°C in red dashed lines. Include a 0°C isotherm.
3. Analyze the 850 mb map. Do the standard analysis:
  - a) height contours every 30 gpm in black. Include a 150 line (1500 gpm). Note that the "hhh" in the RAOB data for 850 mb gives the height minus 1000 meters, i.e., 1482 gpm is transmitted in hhh as 482, not 148. Plot the transmitted numbers (such as 430, not 143; 524, not 152). The contours on the 850 mb map, however, look like this: ... 147, 150, 153, 156, etc. If you have a closed contour, it must have a center, either "L" or "H".
  - b) isotherms every 5°C in red dashed lines. Include a 10°C isotherm.
4. Compare the 700 mb and 850 mb maps to each other and to the 300 mb and 500 mb maps from the last graded lab. Provide a significant meteorological commentary.

## Numerical Guidance Exercise

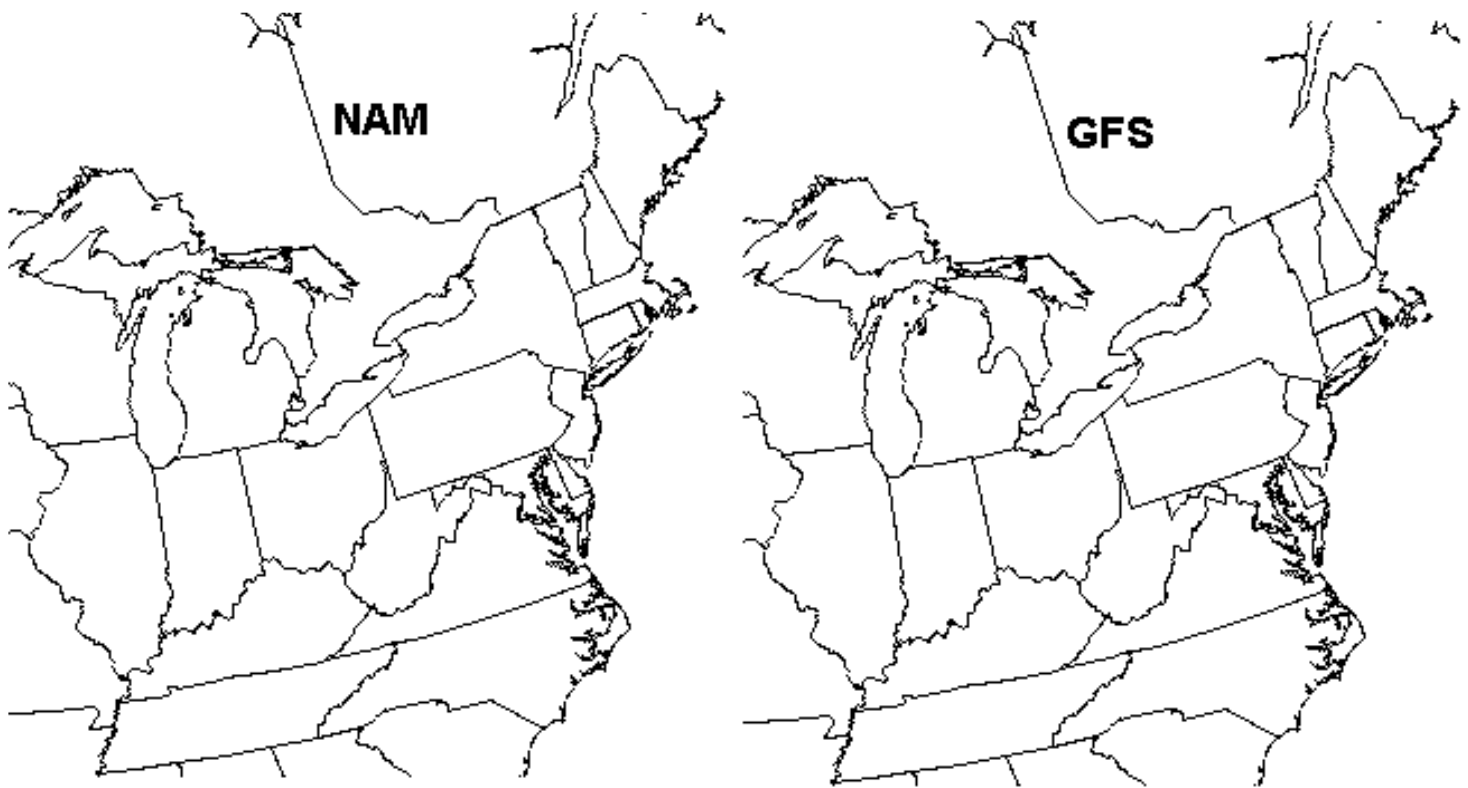
Assignment (Due next Monday):

On the next three pages you have been given NAM and GFS-based MOS forecasts and NAM Direct Model Output from the model run initialized at 12Z on June 12, 2009. Based solely upon this information, you are to complete the blank tables given below. Write in the predicted values requested from the source shown (GFS MOS, NAM MOS or NAM direct model output) and the parameter name (TMP, P06, CLD, etc.) Be sure to include the proper units in your answers. An example is done for you (00Z forecast temperature)

<u>36 Hour Forecast (00Z June 14)</u>	<u>Prediction</u>	<u>Parameter Name</u>	<u>Source</u>
Surface Temperature	66°F	TMP	NAM MOS
Surface Temperature			GFS MOS
Surface Dew Point			NAM MOS
Surface Dew Point			GFS MOS
Surface Wind (speed and direction)			NAM MOS
Surface Wind (speed and direction)			GFS MOS
850 mb wind (speed and direction)			NAM Direct
850 mb wind (speed and direction)			GFS Direct
1000-500 mb thickness			NAM Direct
1000-500 mb thickness			GFS Direct
700 mb Vertical Velocity			NAM Direct
700 mb Vertical Velocity			GFS Direct
Total precipitation 12Z June 12 to 12Z June 14			NAM Direct
Total precipitation 12Z June 12 to 12Z June 14			GFS Direct

Answer the following questions about the DIRECT and MOS data on a separate sheet:

1. Your answers to part one should have shown the 48 hour total precipitation predicted by the NAM model to be different from the total precipitation in the first 48 hours of the GFS model. Give three reasons from any parts of the numerical guidance in this lab which can physically explain the differences in the forecasts. The word “physically” in that assignment means you can’t use the probability of precipitation which is higher in the NAM forecast. That doesn’t physically explain why the model forecasts more or less precipitation; it just describes the chances, given the physics. (For physics, think about what causes precipitation).
2. What would the forecasted surface maps look like for the NAM and for the GFS at 00Z on June 14? These can be and probably are different from each other. On the blank base maps below, draw two simple maps of fronts, Highs, Lows, and air masses, based on the guidance you have for each model:



3. This is a June forecast so thunderstorms are a possibility. What is the maximum probability for any thunderstorm in each model? What day and 6-hour time period did each model pick for their maximum probability? Finally, for each model, find three forecast elements (other than probability) that are favorable for thunderstorms.
4. From the guidance and observations alone, try to devise a reasonable meteorological explanation for the differences in the NAM and GFS forecasts. In other words, what happened in the real atmosphere that the models forecast differently? Was a frontal passage forecast to happen earlier? Was it forecast to be later? Maybe the front washed out? This is an essential part of forecasting, doing post-event analysis with the eventual aim of improving the models. You don’t need to explain why the model was wrong or fix it but you must identify what the model tried to do.

Here is your guidance:

KBGM NAM MOS GUIDANCE		6/12/2009 1200 UTC																			
DT	/JUNE 12/JUNE 13					/JUNE 14					/JUNE 15										
HR	18	21	00	03	06	09	12	15	18	21	00	03	06	09	12	15	18	21	00	06	12
N/X							56					75			55				65	52	
TMP	70	69	66	63	60	58	60	69	72	72	66	61	58	57	56	58	61	62	60	55	55
DPT	59	58	58	57	55	54	55	55	54	55	57	58	57	55	54	53	52	51	51	48	49
CLD	OV	BK	BK	SC	CL	BK	BK	SC	BK	OV	OV	OV	OV	OV	OV	OV	OV	OV	OV	BK	OV
WDR	33	34	34	34	35	36	06	12	20	20	17	26	25	28	28	31	31	32	33	29	31
WSP	08	08	06	04	04	03	03	05	05	06	04	06	06	05	05	08	09	10	07	04	06
P06			15		3		4		6		41		68		52		53		27	13	7
P12							6				67				81				58		18
Q06			0		0		0		0		1		3		1		1		0	0	0
Q12							0				1				3				1		0
T06		18/	6	2/	2	2/	0	4/	6	37/16	35/	9	4/	2	7/	4	15/12	2/			0
T12				18/10				4/	6		57/17				10/	4	23/12				
CIG	3	7	8	8	8	8	8	8	8	6	6	2	3	2	2	2	6	6	7	7	4
VIS	7	7	7	7	7	7	7	7	7	7	5	5	5	6	5	7	7	7	7	7	7
OBV	BR	N	N	N	N	N	N	N	N	N	BR	BR	BR	BR	BR	BR	N	N	N	N	N

KBGM GFS MOS GUIDANCE		6/12/2009 1200 UTC																			
DT	/JUNE 12/JUNE 13					/JUNE 14					/JUNE 15										
HR	18	21	00	03	06	09	12	15	18	21	00	03	06	09	12	15	18	21	00	06	12
N/X							57					71			52				69	52	
TMP	73	72	67	63	60	58	59	66	68	66	62	58	55	53	54	61	66	67	63	56	56
DPT	59	58	58	56	55	54	55	57	57	56	56	54	52	51	52	52	51	50	50	51	52
CLD	BK	SC	FW	CL	CL	FW	BK	BK	OV	OV	OV	OV	OV	OV	OV	OV	BK	OV	BK	CL	SC
WDR	35	34	34	36	35	36	01	05	32	35	36	35	33	30	30	34	34	34	36	27	21
WSP	09	07	06	05	04	04	03	04	05	05	05	04	04	04	05	06	08	07	05	03	03
P06			12		4		7		21		71		62		46		26		13	11	11
P12							10				71				64				29		17
Q06			0		0		0		0		2		2		1		0		0	0	0
Q12							0				2				2				0		0
T06		15/	6	6/	0	3/	0	10/	0	34/	7	21/	0	5/	0	4/	0	10/	8	3/	0
T12				15/	6			12/	0		44/	7			7/	0		12/	8		
CIG	6	7	8	8	8	8	6	6	6	6	6	6	5	4	3	6	6	7	8	8	8
VIS	7	7	7	7	7	7	5	7	7	5	5	5	5	5	5	7	7	7	7	7	7
OBV	N	N	N	N	N	N	BR	N	N	N	BR	BR	BR	BR	BR	N	N	N	N	N	N

**NAM grid interpolations (Direct Model output)**

Station: KBGM Lat: 42.22 Lon: -75.98 Elev: 490 Closest grid pt: 21.3 km.  
 Initialization Time: 09-06-12 1200 UTC

PARAMETER/TIME	000	006	012	018	024	030	036	042	048
DAY / HOUR	12/12	12/18	13/00	13/06	13/12	13/18	14/00	14/06	14/12
<b>TEMPS</b>									
2 M (F)	62	67	68	58	62	75	67	59	56
850 MB (C)	13	12	13	12	11	12	12	10	7
700 MB (C)	5	4	4	3	2	1	2	1	0
500 MB (C)	-11	-10	-12	-13	-13	-13	-13	-14	-15
1000-500 THCK	565	565	565	563	561	563	563	559	556
<b>MOISTURE</b>									
2 M DEW POINT (F)	61	63	62	54	58	59	63	58	55
850 MB DP(C)/RH	13/99	10/89	7/66	5/62	4/59	8/79	11/93	9/92	7/99
700 MB DP(C)/RH	3/87	-1/68	-5/51	-8/43	-6/58	-3/76	1/92	1/98	-1/91
500 MB DP(C)/RH	-17/63	-25/28	-24/38	-24/40	-21/51	-17/73	-13/99	-18/73	-38/12
PRCPABLE WTR (IN)	1.52	1.19	1.01	0.84	0.88	1.09	1.41	1.25	1.00
CONV PRECIP (IN)		0.04	0.01	0.00	0.00	0.00	0.10	0.29	0.02
TOTAL PRECIP (IN)		0.05	0.01	0.00	0.00	0.00	0.10	0.55	0.11

PARAMETER/TIME	000	006	012	018	024	030	036	042	048				
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----				
DAY / HOUR	12/12	12/18	13/00	13/06	13/12	13/18	14/00	14/06	14/12				
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----				
WIND DD/FFF (Kts)													
10 M	33/008	35/009	35/006	34/003	06/002	15/004	16/001	27/004	29/005				
850 MB	35/014	02/019	02/012	34/006	32/002	17/006	19/012	26/018	32/013				
700 MB	28/017	33/013	29/014	28/020	29/016	25/018	22/016	25/030	27/031				
500 MB	26/029	27/032	29/026	27/018	25/025	25/031	24/034	25/032	26/038				
250 MB	24/052	25/058	25/048	27/039	26/053	25/046	25/040	24/043	27/052				
PRESS/HEIGHTS													
MSL PRESSURE	1007.0	1008.1	1010.3	1013.3	1014.3	1012.2	1011.1	1011.0	1012.2				
850 MB HGT	144	145	148	149	150	150	148	146	146				
700 MB HGT	305	306	308	308	309	309	308	305	304				
500 MB HGT	571	572	573	574	574	573	572	569	566				
250 MB HGT	1065	1065	1065	1064	1064	1065	1062	1056	1051				
VERTICAL VEL (uB/S)													
850 MB	-7	-1	-9	1	-13	22	55	60	2				
700 MB	-1	0	-7	-12	0	22	73	107	12				
500 MB	3	2	5	-16	4	5	39	5	3				
CONVECTION PARAMS													
LIFT INX SFC	2	2	-1	3	4	0	-2	2	4				
LIFT INX 4LYR	-1	2	-1	2	4	0	-2	1	3				
CAPE SFC	12	68	303	0	11	109	933	73	21				
<b>GFS grid interpolations (Direct Model output)</b>													
Station: KBGM Lat: 42.22 Lon: -75.98 Elev: 490 Closest grid pt: 21.3 km.													
Initialization Time: 09-06-12 1200 UTC													
PARAMETER/TIME	000	006	012	018	024	030	036	042	048	054	060	066	072
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
DAY / HOUR	12/12	12/18	13/00	13/06	13/12	13/18	14/00	14/06	14/12	14/18	15/00	15/06	15/12
-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
TEMPS													
SFC (2 M) (F)	62	75	67	54	60	73	59	54	52	67	61	45	57
850 MB (C)	13	12	12	11	11	12	11	10	8	8	9	9	8
700 MB (C)	4	4	4	3	2	2	1	1	0	-1	-1	-1	-3
500 MB (C)	-11	-11	-12	-12	-13	-13	-14	-15	-16	-18	-18	-19	-21
1000-500 THCK	565	566	565	563	561	562	560	558	556	555	555	554	551
MOISTURE													
30 M AVG RH	99	66	72	87	89	64	90	100	97	62	64	72	76
850 MB DP/RH	11/87	11/91	9/80	7/75	7/77	10/87	10/93	9/96	7/98	6/88	5/77	2/63	3/71
700 MB DP/RH	3/96	0/72	-3/60	-2/70	-4/69	-2/74	0/90	-1/87	-3/80	-5/73	-8/62	-15/32	-11/54
500 MB DP/RH	-16/66	-22/40	-25/33	-26/30	-23/42	-16/79	-19/68	-17/84	-39/11	-36/18	-30/37	-31/33	-22/94
TOTAL PRECIP (IN)													
	0.01	0.01	0.00	0.00	0.04	0.26	0.09	0.07	0.02	0.01	0.00	0.00	0.00
WIND DD/FFF (Kts)													
30 M AVG	32/010	35/013	36/015	01/010	02/004	02/003	02/009	34/011	34/014	02/014	02/011	33/004	27/002
850 MB	01/012	00/014	01/013	01/006	06/003	35/002	16/004	28/005	02/013	02/017	01/011	35/009	00/006
700 MB	30/013	33/012	30/012	27/017	27/013	24/013	25/019	25/014	29/012	35/014	36/013	32/011	34/012
500 MB	27/027	27/028	28/024	26/018	25/026	23/037	26/035	27/026	27/032	28/027	32/025	29/017	28/020
250 MB	25/050	25/057	25/052	27/046	25/048	25/052	26/053	25/058	27/058	27/049	30/053	29/054	29/076
VERTICAL VEL (uB/S)													
850 MB		-10	1	-28	1	64	20	30	14	6	-8	-7	14
700 MB		-1	-3	-34	12	73	22	19	-8	-24	-2	-15	11
500 MB		0	2	-19	8	15	20	1	9	-23	-25	10	22
OTHER													
TROP PRES (MB)	205	204	206	211	200	209	219	221	236	250	236	226	218
MSL PRES (MB)	1007	1008	1010	1013	1014	1013	1013	1013	1014	1014	1015	1016	1017
500 MB HGT (DM)	571	573	574	574	573	573	571	568	567	567	568	567	566
500 MB ABS VORT	15.7	12.7	7.4	7.1	9.5	5.5	13.1	19.3	13.5	19.4	9.4	10.1	13.3

Observations for BINGHAMTON BROOME, NY (BGM)  
 Location: 42.22N 75.98W 0 meters

STN	TIME	PMSL	ALTM	TMP	DEW	RH	DIR	SPD	GUS	VIS	CLOUDS	Weather	MIN	MAX	PCP
	DD/HHMM	hPa	inHg	F	F	%	deg	kt	kt	mile			F	F	in
====	=====	=====	=====	====	====	====	====	====	====	====	=====	=====	====	====	=====
BGM	14/1353	1016.7	30.04	64	50	60	40	5	10.0	CLR					
BGM	14/1253	1017.0	30.04	61	53	75	330	4	10.0	CLR					
BGM	14/1153	1016.6	30.03	59	52	77	0	0	10.0	CLR			53	59	
BGM	14/1053	1015.9	30.01	55	51	86	10	4	10.0	CLR					
BGM	14/0953	1015.5	29.99	53	51	93	20	4	10.0	CLR					
BGM	14/0853	1014.9	29.98	56	49	77	30	4	10.0	SCT040	BKN100				
BGM	14/0753	1014.4	29.97	56	50	80	350	3	10.0	BKN040					
BGM	14/0653	1014.2	29.97	57	50	77	340	6	10.0	FEW100	SCT120				
BGM	14/0553	1014.7	29.99	57	50	77	330	5	10.0	OVC100			56	61	
BGM	14/0453	1015.2	30.00	56	52	87	300	4	10.0	OVC100					
BGM	14/0353	1015.0	29.99	57	53	87	350	6	10.0	BKN110					
BGM	14/0253	1015.3	30.00	59	53	81	30	4	10.0	BKN049	OVC060				
BGM	14/0153	1015.4	30.00	59	54	83	30	5	10.0	SCT043	BKN065	OVC110			
BGM	14/0053	1014.8	29.98	60	56	86	20	5	10.0	BKN060	OVC085				
BGM	13/2353	1014.6	29.98	61	56	83	30	7	10.0	FEW007	OVC060		61	75	0.00
BGM	13/2253	1013.9	29.95	62	59	90	20	9	10.0	BKN007	OVC075				
BGM	13/2153	1013.7	29.95	63	57	81	360	12	10.0	BKN080	BKN100	R-			
BGM	13/2053	1013.4	29.94	66	56	70	350	14	10.0	OVC090					
BGM	13/1953	1012.8	29.93	73	54	51	360	7	10.0	SCT055	SCT065	BKN100			
BGM	13/1853	1012.7	29.93	74	53	48	0	0	10.0	FEW100					
BGM	13/1753	1013.5	29.95	72	55	55	270	6	10.0	BKN090			62	74	
BGM	13/1653	1014.1	29.97	72	55	55		3	10.0	FEW041	SCT055	BKN070			
BGM	13/1553	1014.3	29.97	70	55	59	0	0	10.0	FEW075					
BGM	13/1453	1014.8	29.99	67	56	68	0	0	10.0	OVC075					
BGM	13/1353	1015.0	29.99	65	56	73	60	4	10.0	OVC070					
BGM	13/1253	1014.7	29.98	65	56	73	50	4	10.0	CLR					
BGM	13/1153	1014.4	29.97	62	54	75	20	4	10.0	CLR			56	62	
BGM	13/1053	1014.2	29.97	59	54	83	40	4	10.0	FEW065					
BGM	13/0953	1014.1	29.96	56	53	90	30	5	10.0	CLR					
BGM	13/0853	1014.1	29.96	56	54	93	0	0	9.0	CLR					
BGM	13/0753	1013.5	29.95	57	54	89	0	0	10.0	CLR					
BGM	13/0653	1013.4	29.94	58	54	87	20	3	10.0	CLR					
BGM	13/0553	1013.3	29.94	59	54	83	360	4	10.0	CLR			59	68	
BGM	13/0453	1013.1	29.94	60	55	83	360	5	10.0	CLR					
BGM	13/0353	1012.8	29.93	62	55	78	350	6	10.0	CLR					
BGM	13/0253	1012.6	29.93	63	55	75	330	5	10.0	CLR					
BGM	13/0153	1012.7	29.93	64	55	73	340	5	10.0	CLR					
BGM	13/0053	1011.9	29.90	65	55	70	360	7	10.0	CLR					
BGM	12/2353	1011.5	29.89	67	58	73	330	5	10.0	CLR			67	72	
BGM	12/2253	1011.5	29.89	69	58	68	340	8	10.0	CLR					
BGM	12/2153	1010.8	29.87	71	59	66	320	9	10.0	FEW047	BKN060	BKN075			
BGM	12/2053	1010.4	29.86	71	59	66	310	7	10.0	FEW026	SCT044				
BGM	12/1953	1010.2	29.86	70	61	73	340	6	10.0	BKN018	BKN029	OVC042			
BGM	12/1853	1010.0	29.85	68	61	78	310	7	10.0	SCT016	BKN023	OVC070			
BGM	12/1753	1009.9	29.84	68	60	76	340	9	10.0	BKN017	BKN028	OVC044	62	71	



## Description of the GFS MOS MAV Alphanumeric Message

The short-range GFS-Based MOS MAV guidance is generated from 0000, 0600, 1200, and 1800 UTC model output from NCEP's Global Forecast System(GFS). This guidance is valid for stations in the United States, Puerto Rico, and the U.S. Virgin Islands.

Forecast elements are valid from 6 to 72 hours in advance.

### Sample Message

```

KDEN      GFS MOS GUIDANCE      3/04/2010  1200 UTC
DT /MAR    4/MAR    5              /MAR    6              /MAR    7
HR   18 21 00 03 06 09 12 15 18 21 00 03 06 09 12 15 18 21 00 06 12
N/X                                     27                 53                 28                 51    24
TMP  48 52 51 40 35 32 30 35 47 50 48 40 38 35 32 36 45 48 45 31 27
DPT  25 25 27 29 29 27 25 25 21 17 18 20 21 21 20 21 21 22 22 23 21
CLD  BK SC SC SC SC OV OV OV BK BK BK SC BK SC SC SC SC SC SC SC SC
WDR  19 14 13 16 20 20 25 25 28 28 28 22 23 23 22 21 12 10 10 17 21
WSP  05 12 11 08 08 07 07 07 08 10 11 08 08 07 07 07 07 10 10 08 07
P06      1      6      14      20      14      25      8      4      2  3  2
P12      15      27      26      4      3
Q06      0      0      0      0      0      0      0      0      0  0  0
Q12      0      0      0      0      0      0      0      0      0  0  0
T06      5/11  1/ 2  0/ 1  1/ 2  8/ 3  1/ 1  0/ 0  0/ 0  2/ 8  0/ 0
T12      7/11      1/ 2      8/ 4      0/ 1      2/ 8
POZ   1  1  3  2  2  7  8  3  4  2  3  0  3  3  4  6  3  1  2  0  3
POS  27 16 18 24 28 65 74 72 31 20 37 57 94 87 95 65 41 18 28 50 91
TYP   R  R  R  R  R  S  S  S  R  R  R  S  S  S  S  S  R  R  R  R  S
SNW      0      0      0      0      0      0      0      0      0  0  0
CIG   8  8  8  8  8  8  8  7  8  8  7  8  8  8  8  8  8  8  8  8  8
VIS   7  7  7  7  7  7  7  1  7  7  7  7  7  7  7  7  7  7  7  7  7
OBV   N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N

```

- \* \*DT \* = The day of the month, denoted by the standard three or four letter abbreviation
- \* \*HR \* = Hour of the day in UTC time. This is the hour at which the forecast is valid, or if the forecast is valid for a period, the end of the forecast period.
- \* \*N/X\* = nighttime minimum/daytime maximum surface temperatures.
- \* \*TMP\* = surface temperature valid at that hour.
- \* \*DPT\* = surface dewpoint valid at that hour.
- \* \*CLD\* = forecast categories of total sky cover valid at that hour.
- \* \*WDR\* = forecasts of the 10-meter wind direction at the hour, given in tens of degrees.
- \* \*WSP\* = forecasts of the 10-meter wind speed at the hour, given in knots.
- \* \*P06\* = probability of precipitation (PoP) during a 6-h period ending at that time.
- \* \*P12\* = PoP during a 12-h period ending at that time.
- \* \*Q06\* = quantitative precipitation forecast (QPF) category for liquid equivalent precipitation amount during a 6-h period ending at that time.
- \* \*Q12\* = QPF category for liquid equivalent precipitation amount during a 12-h period ending at the indicated time.

- \* \*SNW\* = snowfall categorical forecasts during a 24-h period ending at the indicated time.
- \* \*T06\* = probability of thunderstorms/conditional probability of severe thunderstorms during the 6-hr period ending at the indicated time.
- \* \*T12\* = probability of thunderstorms/conditional probability of severe thunderstorms during the 12-hr period ending at the indicated time.
- \* \*POZ\* = conditional probability of freezing pcp occurring at the hour.
- \* \*POS\* = conditional probability of snow occurring at the hour.
- \* \*TYP\* = conditional precipitation type at the hour.
- \* \*CIG\* = ceiling height categorical forecasts at the hour.
- \* \*VIS\* = visibility categorical forecasts at the hour.
- \* \*OBV\* = obstruction to vision categorical forecasts at the hour.

#### Definitions of Categorical Elements

##### MAV Ceiling Height Categories

- 1 < 200 feet
- 2 200 - 400 feet
- 3 500 - 900 feet
- 4 1000 - 1900 feet
- 5 2000 - 3000 feet
- 6 3100 - 6500 feet
- 7 6600 - 12,000 feet
- 8 > 12,000 feet or unlimited ceiling

##### MAV Cloud (CLD) Categories

- CL clear
- FW few > 0 to 2 octas
- SC scattered > 2 to 4 octas
- BK broken > 4 to < 8 octas
- OV overcast

##### MAV Visibility (VIS) Categories

- 1 < 1/2 miles
- 2 1/2 - < 1 miles
- 3 1 - < 2 miles
- 4 2 - < 3 miles
- 5 3 - 5 miles
- 6 6 miles
- 7 > 6 miles

##### MAV Obstruction to Vision (OBV) Categories

- N none of the following
- HZ haze, smoke, dust
- BR mist (fog with visibility  $\geq$  5/8 mile)
- FG fog or ground fog (visibility < 5/8 mile)
- BL blowing dust, sand, snow

##### MAV QPF Categories

- 0 no precipitation
- 1 0.01 to 0.09 inches
- 2 0.10 to 0.24 inches
- 3 0.25 to 0.49 inches
- 4 0.50 to 0.99 inches
- 5 1.00 to 1.99 inches
- 6 2.00 inches or greater

##### MAV Snow Fall Amount Categories

- 0 no snow or a trace expected
- 1 > a trace to < 2 inches
- 2 2 to < 4 inches
- 4 4 to < 6 inches
- 6 6 to < 8 inches
- 8  $\geq$  8 inches

##### MAV Precipitation Type (TYP) Categories

- S pure snow or snow grains
- Z freezing rain/drizzle, ice pellets, or anything mixed with freezing precip
- R pure rain/drizzle or rain mixed with snow

## Description of the NAM MOS Alphanumeric Message

The NAM-Based MOS guidance is generated from 0000 UTC and 1200 UTC model output from the Environmental Modeling Center's NAM Model. This guidance is valid for stations in the Continental United States, Alaska, Hawaii, Puerto Rico, and the U.S. Virgin Islands. Forecast elements are valid from 6 to 72 hours in advance.

### Sample Message

```

KDCA    NAM MOS GUIDANCE    1/24/2008    1200 UTC
DT /JAN  24/JAN  25                /JAN  26                /JAN  27
HR   18 21 00 03 06 09 12 15 18 21 00 03 06 09 12 15 18 21 00 06 12
N/X                15                24                20                30  28
TMP   36 35 30 24 21 18 16 21 23 22 23 21 20 21 22 24 27 29 29 29 30
DPT   14  9  3  0 -2 -4 -3 -3 -2  2  8 12 15 17 19 22 24 25 25 24 21
CLD  CL CL FW FW SC SC BK OV OV OV OV OV OV OV OV OV OV OV OV BK FW
WDR   34 33 34 35 34 36 36 06 14 08 05 04 02 02 03 05 05 06 03 35 34
WSP   07 14 14 11 10 10 08 03 02 05 07 11 11 12 10 07 04 04 07 11 10
P06                0      0      0      0      55      76      60      34      36 13  9
P12                0                58                86                48  25
Q06                0      0      0      0      1      1      1      0      1      0
Q12                0                1                2                1      0
T06                0/ 0  0/ 9  0/ 1  1/ 0  3/ 0  0/ 0  0/ 1  0/ 0  3/ 0  0/ 0
T12                1/ 9                1/ 1                3/ 0                1/ 1  1/ 0
SNW                0                6                0
CIG   6  8  8  8  8  7  7  7  7  4  4  3  2  3  3  2  2  1  1  2  8
VIS   7  7  4  5  5  5  6  7  7  7  7  7  7  7  7  7  7  7  7  6  5
OBV   N  N BR BR BR BR  N  N  N  N  N  N  N  N  N  N  N  N  N  N HZ BR
    
```

- \* \*DT\* = The day of the month, denoted by the standard three or four letter abbreviation
- \* \*HR \* = Hour of the day in UTC time. This is the hour at which the forecast is valid, or if the forecast is valid for a period, the end of the forecast period.
- \* \*N/X\* = nighttime minimum/daytime maximum surface temperatures.
- \* \*TMP\* = surface temperature valid at that hour.
- \* \*DPT\* = surface dewpoint valid at that hour.
- \* \*CLD\* = forecast categories of total sky cover valid at that hour.
- \* \*WDR\* = forecasts of the 10-meter wind direction at the hour, given in tens of degrees.
- \* \*WSP\* = forecasts of the 10-meter wind speed at the hour, given in knots.
- \* \*P06\* = probability of precipitation (PoP) during a 6-h period ending at that time.
- \* \*P12\* = PoP during a 12-h period ending at that time.
- \* \*Q06\* = quantitative precipitation forecast (QPF) category for liquid equivalent precipitation amount during a 6-h period ending at that time.
- \* \*Q12\* = QPF category for liquid equivalent precipitation amount during a 12-h period ending at the indicated time.
- \* \*T06\* = probability of thunderstorms/conditional probability of severe thunderstorms during the 6-hr period ending at the indicated time.
- \* \*T12\* = probability of thunderstorms/conditional probability of severe thunderstorms during the 12-hr period ending at the indicated time.

- \* \*SNW\* = snow fall categorical forecasts during a 24-h period ending at the indicated time.
- \* \*CIG\* = ceiling height categorical forecasts at the hour.
- \* \*VIS\* = visibility categorical forecasts at the hour.
- \* \*OBV\* = obstruction to vision categorical forecasts at the hour.

Definitions of Categorical Elements

QPF Categories

0 no precipitation  
 1 0.01 to 0.09 inches  
 2 0.10 to 0.24 inches  
 3 0.25 to 0.49 inches  
 4 0.50 to 0.99 inches  
 5 1.00 to 1.99 inches  
 6 2.00 inches or greater

Cloud (CLD) Categories

CL clear  
 FW > 0 to 2 octas of total sky cover  
 SC > 2 to 4 octas of total sky cover  
 BK > 4 to < 8 octas of total sky cover  
 OV 8 octas of total sky cover or totally obscured

Snow Fall Amount Categories

0 no snow or a trace expected  
 1 > a trace to < 2 inches  
 2 2 to < 4 inches  
 4 4 to < 6 inches  
 6 6 to < 8 inches  
 8 >= 8 inches

MAV Obstruction to Vision (OBV) Categories

N none of the following  
 HZ haze, smoke, dust  
 BR mist (fog with visibility >= 5/8 mile)  
 FG fog or ground fog (visibility < 5/8 mile)  
 BL blowing dust, sand, snow

Visibility (VIS) Categories

1 < 1/2 miles  
 2 1/2 - < 1 miles  
 3 1 - < 2 miles  
 4 2 - < 3 miles  
 5 3 - 5 miles  
 6 6 miles  
 7 > 6 miles

Ceiling Height (CIG) Categories

1 < 200 feet  
 2 200 - 400 feet  
 3 500 - 900 feet  
 4 1000 - 1900 feet  
 5 2000 - 3000 feet  
 6 3100 - 6500 feet  
 7 6600 - 12,000 feet  
 8 > 12,000 feet

## Hourly Surface Observations Code (METAR)

## 1. Introduction

In lab 2 we learned how weather data is transmitted using the synoptic code. This code, while very complete, is not the one used routinely by most meteorologists. The most commonly available weather observations are taken every hour at both FAA and Weather Service stations. Sometimes they are called **hourlies**. Hourlies are transmitted to NCEP and are available from many weather data sources such as the University of Wyoming (<http://weather.uwyo.edu/surface/meteorogram/>) or the Aviation Weather Center (<http://www.aviationweather.gov/metar>).

These readings are taken in addition to the Weather Service's synoptic observations (lab 2). With the inclusion of the FAA stations, a very dense network of surface reports is obtained every hour, giving information of primary interest to aviation. This information is also useful to the meteorologist for making more detailed and timely surface weather analysis. Hourlies are transmitted in a somewhat simpler form than synoptic code. The code used is called METAR (Meteorological Aviation Routine) code. This is an internationally recognized standard. It was adopted by NCEP on July 1, 1996 in order to be consistent with international standards for weather reporting. Everyone uses METAR.

In this lab we will plot from code and analyze a map. You do not have to memorize METAR code. Use the following pages to help you translate it.

## 2. METAR code - translation key and explanation of groups

The following is the format of a line of code:

```
METAR NNNN DDTTTT (AUTO) (COR or CCA) DDDFFFGnnKT VVVV Rnna/vBBBB X
SSSHHCC tt/dd Qpppp RMK text =
```

**EXPLANATION OF CODE GROUPS:**

METAR - OPTIONAL, may be given at beginning of message (SPECI for Special Report)

NNNN - 4 letter ICAO location indicator; for example: KALB for Albany, NY

DDTTT - Date and Time of observation followed by Z (Zulu)

AUTO - included if METAR is from an automatic, e.g. ASOS station, otherwise omitted.

COR - correction to observation (CCA for Canada)

DD - Wind direction in tens of degrees, VRB means variable; if direction varies 60 degrees or more, variability is appended, e.g. 180V260

FFF - Wind speed in knots (KT), meters per second, or kilometers per hour

Gnn - Wind gusts in knots (KT), meters per second, or kilometers per hour, omitted if wind is steady

VVVV - Visibility in meters (statute miles for the U.S.)

R - Runway information for pilots, often omitted. Be careful not to confuse R with RA (rain)

- nn - Two digit runway designator
- a - Left (L), right (R), or center (C) runway as needed
- v - M (lower) or P (higher) indicates that Runway Visual Range (RVR) value is either lower or higher than the RVR reportable values.
- BBBB - Runway visual range in meters (feet for the U.S.) Range value may be followed by a trend (D - down, U - up, N - no change, V - variable) for non-U.S. stations
- X - Weather and/or obstruction to visibility
- SSS - Cloud cover - SKC (sky clear) or CLR (clear below 12,000 feet for automatic stations), FEW (1-2 octas), SCT (3-4 octas), BKN (5-7 octas), or OVC (8 octas).
- HHH - 3-digit cloud height in hundreds of feet; obscured sky given as VV (vertical visibility), height in hundreds of feet; unknown height reported as ///; more than one layer may be reported
- CC - Cloud type, given if either TCU (towering cumulus) or CB (cumulonimbus) are present
- tt - Temperature in degrees Celsius (including U.S.)
- dd - Dew point in degrees Celsius (including U.S.)
- Q - Indicator for altimeter setting in hecto Pascals
- A - Indicator for altimeter setting in hundredths of inches (U.S. only)
- pppp - Altimeter setting
- RMK - Remarks consisting of recent operationally significant weather as well as additive and automated maintenance data (mainly used in the U.S. and Canada). **IMPORTANT:** The sea level pressure (SLP) will always be in the remarks. SLP is given in millibars and tenths, i.e., SLP098 -> 1009.8 mb.
- = or \$ denotes end of report

**QUALIFIERS - Intensity/Proximity:**

- Light (no sign) Moderate + Heavy
- VC - in Vicinity (within 8000 meters but not at airport)

Descriptor

- MI - Shallow BC - Patches DR - Drifting TS - Thunderstorm
- BL - Blowing SH - Shower FZ - Freezing PR - Partial

**WEATHER PHENOMENA (X):**

Precipitation:

- DZ - Drizzle RA - Rain SN - Snow SG - Snow grains IC - Ice crystals PE - Ice pellets
- GR - Hail GS - Small hail/snow pellets UP - Unknown (automatic station only)

Obscuration:

BR - Mist      FG - Fog      FU - Smoke      VA - Volcanic ash  
SA - Sand      HZ - Haze      BY - Blowing spray      DU - Widespread Dust

Other:

SQ - Squall      SS - Sandstorm      DS - Duststorm      PO - Dust devils  
FC - Funnel cloud(s)/tornado/waterspout

Remarks - one or more remarks may appear after the code RMK in the following order:

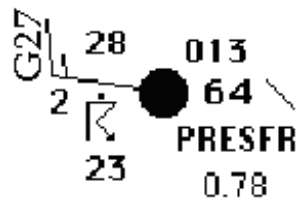
Volcanic eruption  
Tornadoic activity (B/E\_(hh)mm\_LOC/DIR\_(MOV)  
Type of automated station (AO1, AO2)  
Peak Wind (PK\_WND\_dddff(f)/(hh)mm)  
Wind Shift (WSHFT\_(hh)mm\_FROPA)  
Tower Visibility (TWR\_VIS\_vvvvv)  
Surface Visibility (SFC\_VIS\_vvvvv)  
Variable Prevailing Visibility (VIS\_vvvvv\_[LOC]  
Sector Visibility (VIS\_[DIR]\_vvvvv)  
Visibility at second location (VIS\_vvvvv\_[LOC]  
Lightning ([FREQ]\_LTG[type]\_[LOC]  
Begin/End Pcpn (w'w'B(hh)mmE(hh)mm)  
Begin/End Thunderstorm (TSB(hh)mmE(hh)mm)  
Thunderstorm location (TS\_LOC\_(MOV\_DIR)  
Hailstone size (GR\_[size]  
Virga (VIRGA\_(DIR)  
Variable Ceiling Height (CIG\_hhhVhhh)  
Obscurations (w'w'\_[NNN](hhh)  
Variable Sky Condition (NNN(hhh)\_V\_NNN  
Significant Cloud Types  
Ceiling Height at 2nd Location (CIG\_hhh\_[LOC]  
Pressure Rising/Falling Rapidly (PRESRR,PRESFR)  
Sea-level Pressure (SLPppp or SLPNO)  
Aircraft mishap (ACFT MSHP)  
No SPECI reports taken (NOSPECI)  
Snow increasing rapidly (SNINCR\_[inches-hr/inches on ground]  
Other significant information, e.g. LAST  
Hourly Precipitation Amount in hundredths of inches (Prrrr)  
3- and 6-hour precipitation amount (6RRRR)  
24-hour precipitation amount (7RRRR)  
Snow depth on the ground in inches (4/sss)  
Water equivalent of snow on ground (933RRR)  
Cloud Types (8/CICmCh)  
Duration of sunshine in minutes (98mmm)  
Hourly temperature and dew point in tenths degrees C (SnTTTSnDDD)  
6-hour maximum temperature in tenths degrees C (1SnTTT)  
6-hour minimum temperature in tenths degrees C (2SnTTT)  
24-hour max/min temperature in tenths degrees C (4SnTTTSnTTT)  
3-hour pressure tendency (5appp)  
Sensor status indicators (RVRNO, PWINO, PNO, FZRANO, TSNO, VISNO\_LOC, CHINO\_LOC  
Maintenance check indicator: \$

**EXAMPLE:**

METAR KDAL 101855Z 28013G27KT 2SM TSRA OVC010CB 28/23 A2993 RMK SLP013 PRESFR 60078 57064

METAR observation from Dallas, Texas. Date and Time of observation is 1855 Zulu on the 10th day of the month. Wind is from 280 degrees at 13 knots with a gust to 27 knots. Visibility is 2 statute miles. Current weather is a thunderstorm with moderate rain. Sky is overcast with a cloud height of 1000 feet. The temperature is 28°C. The dew point is 23°C. Altimeter setting is 29.93 inches of Mercury. The sea level pressure is 1001.3 mb, falling rapidly. The pressure has fallen 6.4 mb in the last three hours. For the last 3 (or 6) hours 0.78" of rain has fallen.

The sample report from Dallas shown on the previous page would be plotted as follows:



**3. ASSIGNMENT (due next Wednesday)**

**I.** On the following pages you will find METAR code from October 30, 2012. On a blank base map, plot all stations listed by decoding the METAR reports. Use the standard plotting model (lab 2). Plot the wind speed and direction, visibility, present weather, sky coverage, temperature, dew point, sea level pressure, pressure change, precipitation and PRESFR or PRESRR if they are observed.

Notes: Sky cover is plotted with these symbols:



If you have two sky indicators, use the most cloudy one (e.g., if BKN and OVC, plot OVC). If you have no sky indicators, plot missing as shown in the last station circle.

Plot the steady wind with the standard flags. Plot the gusts as Gxx at the end of the wind flag.

The present weather symbols can be found in Table 1 in Lab 1. If you have two weather indicators, plot only the first one. Do not plot cloud height or runway information.

Plot temperature and dew point in Celsius degrees.

Sea level pressure is found in the remarks (RMK) section. The only other remarks you plot are the 3 or 6 hour precipitation amount (6RRRR, e.g., 60198 -> 1.98 inches of rain, plot as 1.98), the pressure tendency (5app, e.g., 57012 -> 12 \) and PRESFR/PRESRR (pressure falling or rising rapidly).

**II.** Do the following analyses:

- a) Draw isobars in black every 4 mb, including the 1000 mb isobar (labeled 00).
- b) Draw isotherms in red every 5°C, including the 20°C isotherm.
- c) Put in centers of High and Low pressure (H and L).



**III.** Answer the following: This is “Superstorm” Sandy from October 30, 2012. Sandy had both tropical and extratropical characteristics. Briefly describe three surface characteristics of Sandy that were likely to be from her tropical origins. Then describe two surface characteristics of Sandy that were definitely extratropical. All of the characteristics you name must be evident from the map you just plotted and analyzed. Use specific station examples to provide evidence for your answers.

**METARS to Plot:**

**Vermont**

KBTV 300254Z 08021G31KT 10SM -RA FEW041 BKN050 OVC065 18/11 A2932 RMK AO2  
PK WND 10031/0248 DZE17RAB25 SLP929 P0000 60000 T01830111 56027  
KMPV 300330Z AUTO 07006KT 2 1/2SM +RA BR FEW013 BKN027 OVC033 13/13 A2938  
KRUT 300335Z 10018G24KT 9SM BKN026 OVC032 16/13 A2923 RMK AO1 P0009  
K614 300354Z AUTO 14/12 A2940 RMK AO1 PRESRR SLP951 P0003 T01440122

**New Hampshire**

KAFE 300252Z AUTO 10015G27KT 4SM -RA OVC008 17/14 A2927 RMK AO2 PK WND  
12027/0226 CIG 005V011 SLP915 P0010 60138 T01670139 51015  
KBML 300317Z AUTO 10017G28KT 3SM RA OVC033 14/12 A2950 RMK AO2 PK WND 12028/0316 P0007  
KLCI 300335Z AUTO 08014G26KT 8SM BKN014 OVC019 14/12 A2937 RMK AO1 P0017  
KLEB 300253Z AUTO 10007G23KT 050V140 3SM -RA FEW018 OVC034 16/13 A2930 RMK  
AO2 PK WND 06029/0218 SLP915 P0013 60021 T01560128 55009  
KMWN 300354Z 11076G102KT 0SM +RA FG VV000 05/05 RMK PK WND 100111/0250  
KPSM 300251Z AUTO 10021G37KT 4SM RA BR BKN008 OVC013 16/14 A2938 RMK AO2 PK  
WND 10041/0219 SLP945 P0034 60053 T01560139 53003

**Maine**

KPWM 300332Z 10024G39KT 3SM -RA BR OVC005 14/13 A2947  
KAUG 300337Z AUTO 08017G28KT 3SM -RA BR SCT010 OVC015 14/13 A2956  
KBGR 300253Z 08015G29KT 5SM -RA BR BKN012 OVC017 14/13 A2973 RMK AO2 PK WND  
08029/0250 DZE10RAB43 SLP066 P0001 60001 T01390128 56009

**Connecticut**

KBDL 300251Z 13018G26KT 5SM R06/6000VP6000FT -RA SCT025 BKN033 OVC085 17/14  
A2912 RMK AO2 PK WND 13035/0154 RAE04B31 SLP860 P0002 60021 T01670139 51025  
KGON 300339Z AUTO 14020KT 6SM HZ FEW024 BKN030 OVC039 17/14 A2918

**Massachusetts**

KACK 300253Z AUTO 12014KT 4SM BR OVC027 16/15 A2928 RMK AO2 SLP917 60004  
T01610150 53027 TSNO  
KEWB 300253Z AUTO 11013G22KT 7SM BKN037 OVC047 18/15 A2925 RMK AO2 PK WND  
11029/0200 SLP904 60016 T01780150 53023 TSNO  
KBOS 300254Z 11017G27KT 3SM BR OVC005 15/14 A2931 RMK AO2 PK WND 11034/0200 SFC VIS 3  
RAB10E30 SLP923 P0002 60053 T01500144 53024=  
KBAF 300253Z 10009G26KT 070V140 10SM BKN037 OVC047 18/12 A2913 RMK AO2 PK  
WND 08026/0245 RAB0159E14B34E47 SLP864 P0000 60002 T01830122 53023  
KORH 300254Z AUTO 11013G20KT 7SM -RA OVC005 16/15 A2924 RMK AO2 SLP902  
P0002 60030 T01560150 53019

**Rhode Island**

KPVD 300251Z 12012KT 4SM -RA BR FEW014 BKN034 OVC041 17/15 A2923 RMK AO2  
RAB00 SLP898 P0000 60027 T01720150 53027

## New York

KJFK 300251Z 16040G46KT 5SM BR OVC017 16/13 A2889 RMK AO2 PRESRR SLP784  
6/// T01560133 53089 PNO \$  
KISP 300304Z AUTO 15030G45KT 10SM FEW018 OVC035 15/10 A2900 RMK AO2 PK WND  
15045/0303 PRESRR  
KSWF 300345Z 13032G47KT 4SM -RA BR OVC035 14/11 A2901 PRESRR SLP796  
KELZ (*plot at 523*) 300256Z AUTO 34019G33KT 6SM -RA BR BKN006 OVC011 08/06 A2900 RMK AO2 PK  
WND 34039/0227 SLP825 P0009 60036 T00780061 56056  
KELM 300253Z AUTO 01023G42KT 10SM BKN034 OVC043 12/10 A2889 RMK AO2 PK WND  
01047/0205 RAE25 SLP783 P0000 60015 T01220100 58016 \$  
KBGM 300346Z AUTO 07013G18KT 7SM -RA FEW014 BKN025 OVC047 13/12 A2891  
KALB 300251Z 07013G24KT 10SM FEW040 SCT047 BKN060 17/14 A2909 RMK AO2 RAE09  
SLP849 P0000 60004 T01720139 53003  
KBUF 300345Z 35021G34KT 3SM -RA BR BKN006 OVC013 07/06 A2918  
KSYR 300254Z 03016G22KT 4SM RA BR OVC027 14/13 A2904 SLP826=  
KROC 300340Z 03024G41KT 3SM RA BR OVC008 11/11 A2910  
KRME 300253Z AUTO 06021G32KT 10SM SCT046 BKN110 17/12 A2903 RMK AO2 PK WND  
08039/0207 RAB12E32 SLP828 P0000 60000 T01720117 56023  
KGFL 300253Z AUTO 04014G22KT 10SM -RA FEW049 SCT075 OVC100 15/14 A2919 RMK  
AO2 SLP886 P0020 60028 T01500139 55011  
KART 300323Z AUTO 04026G36KT 10SM -RA SCT027 BKN060 OVC080 14/11 A2922 SLP896  
KSLK 300354Z AUTO 06020G29KT 2 1/2SM -RA BR SCT012 OVC019 12/11 A2927 RMK  
AO2 VIS 2V3 P0000 TSNO  
KMSS 300253Z AUTO 05019G34KT 10SM FEW025 SCT032 OVC041 15/10 A2939 RMK AO2  
PK WND 04041/0233 SLP953 T01500100 56022

## New Jersey

KMIV 300346Z AUTO 18016G34KT 150V210 4SM RA BR OVC012 09/08 A2865 RMK AO2  
PK WND 16035/0318 P0007  
KACY 300354Z AUTO 18026G45KT 10SM BKN017 OVC029 11/08 A2878 RMK AO2  
PK WND 16050/0338 PRESRR SLP743 P0003 T01060078 TSNO  
KNEL 300330Z AUTO 13026G38KT 8SM R06/5000VP6000FT -RA OVC011 11/10  
A2867 RMK AO2 PK WND 13039/0317 PRESRR SLP720  
KEWR 300351Z 11040G60KT 06SM -RA BR SCT015 BKN025 OVC035 14/12 A2890 RMK AO2 PRESRR  
SLP787 P0006 T01430124=

## Pennsylvania

KPHL 300254Z 12026G34KT 3SM -RA BR BKN009 OVC015 13/12 A2837 RMK AO2 PK WND 10039/0159  
PRESRR SLP608 P0007 60014 T01330122 53072 \$=  
KHAR 300256Z AUTO 34013G16KT 2SM +RA BR FEW014 BKN022 OVC027 12/12 A2853  
RMK AO2 PK WND 33030/0202 SLP661 P0018 60030 T01220122 56010  
KRDG 300254Z AUTO 08018G37KT 2 1/2SM -RA BKN014 OVC020 13/ A2839 RMK AO2 PK  
WND 06047/0207 SLP612 P0005 60011 T0128 53004 TSNO \$  
KAOO 300253Z AUTO 33025G42KT 7SM BKN019 BKN025 OVC033 06/02 A2886 RMK AO2  
PK WND 33045/0224 PRESFR SLP776 P0003 60014 T00560022 56050  
KJST 300254Z AUTO 29025G34KT 2SM -SN BR OVC004 01/01 A2897 RMK AO2 PK WND  
30038/0221 TSE0159RAB0155E44SNE0155B44 PRESFR SLP824 P0014 60044 T00060006 55024  
KPIT 300251Z 32020G34KT 5SM RA BR OVC012 04/02 A2922 RMK AO2 PK WND  
32039/0210 SLP908 P0015 60044 T00390022 58048  
KDUJ 300256Z AUTO 34019G37KT 5SM -RA BR OVC012 04/02 A2899 RMK AO2 PK WND  
35039/0222 SLP824 P0003 60053 T00390022 56066  
KIPT 300254Z AUTO 01008G16KT 10SM -RA FEW030 BKN038 OVC049 13/11 A2871 RMK  
AO2 SLP721 P0002 60008 T01330111 56037

KAVP 300354Z 07011G28KT 8SM -RA SCT027 OVC035 13/08 A2877 RMK AO2 PK  
WND 06038/0258 SLP737 P0000 T01280083  
KERI 300349Z AUTO 36025G37KT 2 1/2SM BR OVC010 06/04 A2928

**Maryland**

METAR KNHK 300352Z AUTO 21020G33KT 7SM RA BKN013 BKN020 OVC028 08/06 A2879  
RMK AO2 PK WND 21036/0254 SLP750 P0013 T00830061 \$  
KOXB (*plot at 595*) 300253Z AUTO 23021G32KT 7SM -RA BKN015 OVC019 09/08 A2880 RMK AO2 PK  
WND 22041/0231 PRESRR SLP751 P0003 60012 T00890083 51064 TSNO  
KADW 300354Z AUTO 27024G35KT 4SM R01L/4000V4500FT +RA BR BKN013 OVC021  
07/06 A2866 RMK AO2 PK WND 29043/0309 SLP706  
KBWI (*plot at BAL*) 300254Z 28029G42KT 1 3/4SM RA BR FEW025 OVC038 08/07 A2849 RMK AO2  
PK WND 29052/0223 SLP649 P0019 60065 T00830067 58016=  
KHGR 300315Z AUTO 07/05 A2869 RMK AO2 RAEMM P0001 PWINO \$

**Delaware**

KDOV 300351Z AUTO 18027G40KT 3SM R01/3500V4000FT -RA BR BKN009 OVC014 08/08  
A2861 RMK AO2 PK WND 17040/0343 PRESRR SLP690  
KILG 300346Z AUTO 15032G40KT 2 1/2SM RA BR BKN005 BKN013 OVC020 11/10  
A2845

**Quebec** (only selected station shown)

CYUL 300300Z 04027G40KT 15SM FEW020 BKN120 OVC210 14/10 A2947 RMK CF1AC6CI1  
SLP980

**Ontario** (only selected stations shown)

CYTR 300300Z AUTO 01027G34KT 9SM BKN017 BKN066 BKN090 11/08 A2929 RMK SLP921=  
CYYZ 300300Z 36023G38KT 5SM -RA BKN012 OVC025 03/03 A2942 RMK SF6SC2 PRESFR SLP967=  
CYOW 300300Z 04019G26KT 15SM SCT032 BKN040 OVC110 15/10 A2945 RMK SC3SC3AC2  
SLP974 DENSITY ALT 900FT  
CYPQ 300300Z AUTO 01019G30KT 9SM BKN018 BKN023 OVC030 07/05 A2939 RMK  
MAX WND 02031KT AT 0235Z PRESFR SLP958

## Lake Effect Snow Forecasting

Forecast models have become very accurate on the synoptic scale, although human forecasters can usually improve on their accuracy. The more difficult 21<sup>st</sup> century weather forecast challenges occur with smaller, mesoscale forecasts, mainly due to problems with model resolution and assumptions. Lake effect is a classic example of a local forecasting problem in which a synoptic situation can be well understood and forecast but the scale of the weather phenomena make individual location forecasts problematic. In this lab, we will study three cold season examples and in each case, lake effect was a significant element. After studying the synoptic maps, data, and numerical guidance, you will be asked to think about the lake effect component. To see the maps, go to the web version and click on the links.

### Case 1: Classic set up over Lake Michigan

In Fall 2013, the lake effect station chosen for WxChallenge was Grand Rapids, MI (KGRR). Downwind from Lake Michigan, this city experienced [light snow overnight and during the day on December 7](#). [Click here for the radar loop](#). [KGRR is east of the lake](#). The [12Z surface map](#) showed an Arctic High west of Michigan with a pressure gradient over the lake ([click here for loop](#)). Other information and observations can be found on the [850 hPa map](#), [500 hPa vorticity map](#), and [250 hPa map](#), all from 12Z on December 7. The [Great Lakes water temperature map](#) from Dec 5 is also available.

For this lab you must answer questions 1-7 in a text or Word file. Start here:

1. Based on the observed and forecast conditions from the map links already given, write a discussion in the NWS format. Your discussion must describe what's happening in enough detail so that a professional meteorologist will understand both the general synoptic situation and the nuances that pertain to lake effect.
2. Based on the forecasts for 12Z December 7, both graphical ([NAM 24 hour MSLP](#) and the [24 hour surface prog](#)) and digital for Grand Rapids in particular ([NAM MOS](#) and [Grid Extracts](#)), what is an appropriate and consistent forecast for Grand Rapids, MI from 00Z Dec 7 to 00Z Dec 8? Include all the usual elements, i.e., temperature, precipitation type, precipitation amount, wind, and sky cover.

### Case 2: Buffalo lake effect “Snow Blast”

On November 18, 2014, Buffalo experienced one of the most intense lake effect squalls in history. Images of the wall of snow across Lake Erie are still iconic on the Internet:



[The radar loop for this case](#) shows a very different reaction than you saw in the Grand Rapids case and the [observations show a prolonged period of measureable snowfall](#).

As in the first case, you must become familiar with the [surface map for 00Z Nov 18](#), [surface map loop](#), [850 hPa map](#), [500 hPa vorticity map](#), and [250 hPa map](#). You also have, as before, the [Great Lakes water temperatures from Nov 15](#).

For this Buffalo case, the resulting lake effect squalls were very different in terms of intensity as well as structure. Here are your questions:

3. How is the synoptic setup different from the Grand Rapids case? Wherever possible, be quantitative.
4. How do these conditions work to create such a different lake effect event?
5. Was the forecast guidance ([MOS in an Excel spreadsheet](#), and [24 hour surface prog](#)) helpful in guiding you to the correct forecast? Why or why not?

### **Case 3: Syracuse 2012**

In the Fall of 2012, WxChallenge chose Syracuse, NY as their northeast station. Late in the day on Nov 28, [radar showed what appeared to be a long single lake effect band](#) set up on the south shore of Lake Ontario. [Observations from 12Z Nov 28 to 12Z Nov 29](#) featured a number of hours with S- but little accumulation which may indicate that the long shoreline band was not as strong as it looked.

You again have [a surface map loop](#) for the same times as the observations and, for 00Z Nov 29, the [U.S. surface analysis](#), [850 hPa map](#), [500 hPa vorticity map](#), and [250 hPa map](#). The [Great Lakes water temperatures](#) were from Nov 29. Your [MOS digital forecast](#) was from the [NAM that was initialized at 00Z Nov 28, 2012](#) and the [24 hour surface prog](#) was based on the same 00Z initialization.

Please answer the following:

6. Was this pure lake effect, lake-enhanced precipitation, or not lake effect at all? Or was it something other than those choices? Justify your answer using the information given.
7. Assess the [MOS guidance](#) for this case, knowing what the observations were. Would you have made an accurate forecast using this guidance? Why or why not?

Send your text or Word file to [Jerome.Blechman@oneonta.edu](mailto:Jerome.Blechman@oneonta.edu) by Monday, Nov 14.

## Team Map Discussion

For this lab, members of the class will split into teams. Teams will be announced at the beginning of the period. Each team is to prepare a detailed map discussion and conduct it, starting at 3:45 p.m. There will be three teams: Surface, Upper Air, and Forecast. For lab 12 and next semester, the jobs will be rotated so everyone gets to do all aspects of map diagnosis and forecasting.

The responsibilities of the Surface discussion team are:

1. Get a series of surface maps, starting with the most recent U.S. surface from the WPC. Go back at least 24 hours. In your discussion, you are specifically looking for fronts, Highs, Lows, troughs, observed weather conditions like temperatures, dew points, present weather etc., and anything special that may be significant (dryline, outflow boundaries, etc.)
2. Get current radar loops for the entire U.S. and for the northeast U.S. Get a loop for our WxChallenge city too.
3. What is this morning's snow cover, if any? Find a chart. Include Canada.
4. What was the 24-hour precipitation in the U.S.?
5. This morning's minimum temperature chart and yesterday's maximum chart should be shown
6. Show the latest surface plot for the northeast U.S. Wait until after 3 p.m. to get this so it is current.

The responsibilities of the Upper Air team will be:

1. Get the following conventional upper air charts from this morning: 850 hPa, 300 hPa, 200 hPa, and 500 hPa chart with vorticity from weather.unisys.com.
2. Get the latest visible, IR, and Water Vapor satellite pictures. Get IR and Water Vapor satellite loops of at least 24 hours.
3. Show a map of 1000-500 hPa thickness. A model initialization panel will work.
4. Get and highlight sounding plots for Albany, the WxChallenge station, and a sounding from any part of the U.S. where important weather is occurring. What's important? Tornadoes, heavy rain, drought, heavy snow, severe cold or heat, etc.

The Forecast team has following responsibilities:

1. Get the 12Z NAM forecasts for the surface, 500 hPa, and 300 hPa. Do the same for the GFS.
2. Note discrepancies between the NAM and the GFS.
3. How has the NAM been doing lately? Show the forecast for today, for which you have a verification.
4. Are there any watches or warnings currently in effect anywhere in the U.S.?
5. Be prepared to discuss the 12, 24, 36, and 48 hour surface forecast as well as the Day 4,5,6 and 7 surface forecasts from WPC.

Everyone is expected to report on their responsibilities to the class. Be efficient in your presentation, as we must be done by 4:50 p.m. Know what you are going to say before you get up there. Practice using the tools – a viewing program like Irfanview, the browser, or perhaps PowerPoint for loops.

## The Integrated Data Viewer – Nor’easter Study

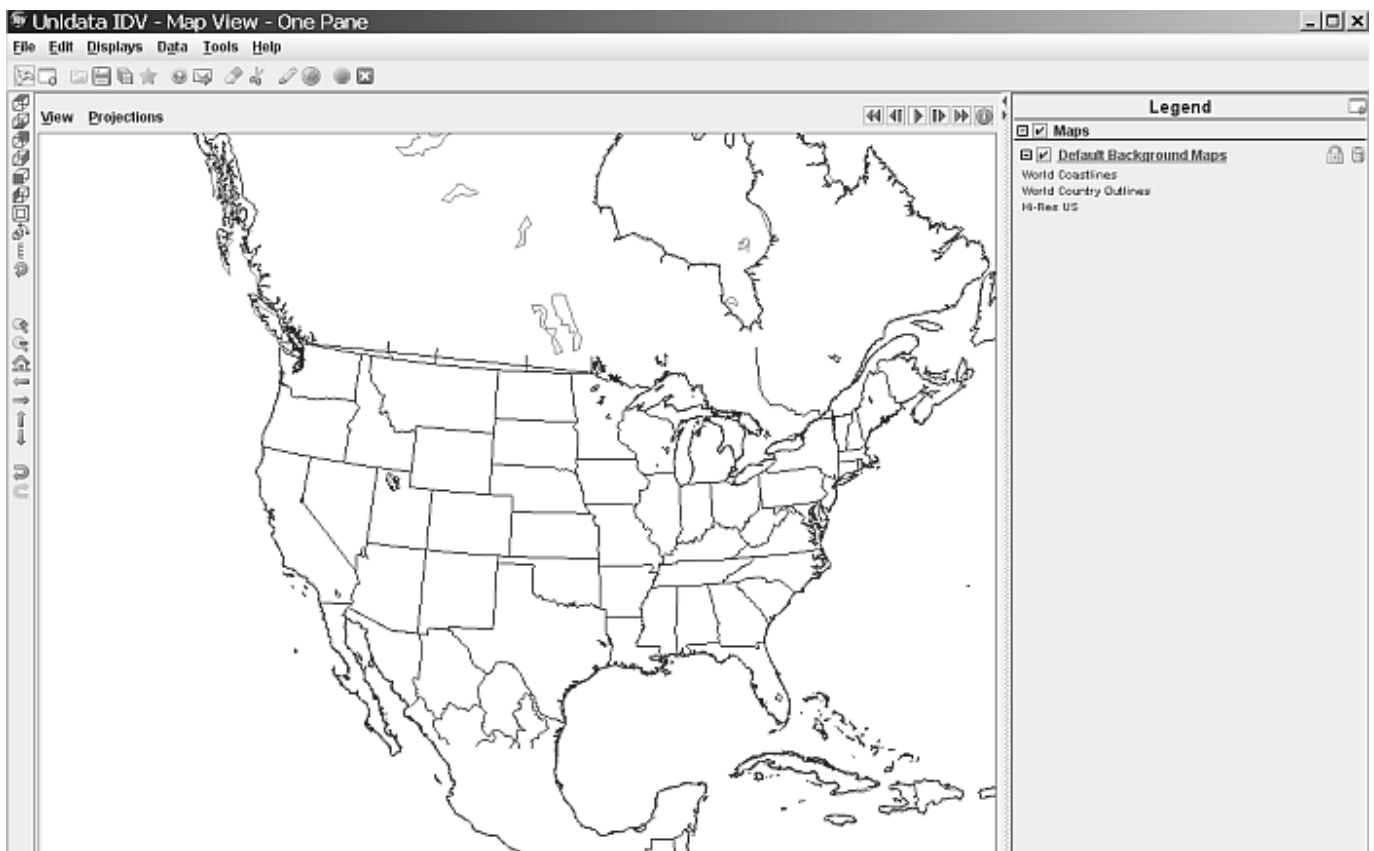
Unidata’s Integrated DataViewer, or IDV is a very useful tool for visualization of atmospheric properties. It can also be used for determining quantities at high resolution for forecasting or research. Learning to use the IDV is, however, not simple. It has a graphical user interface but there are so many possible viewing options, it can be daunting. I can show it to you but that certainly wouldn’t give you any expertise in using the IDV. As always, practice is the key. So the purpose of this lab is to get your hands “dirty” and test out the IDV for yourself.

Procedure – You will get the IDV running and use it to diagnose an archived storm as follows:

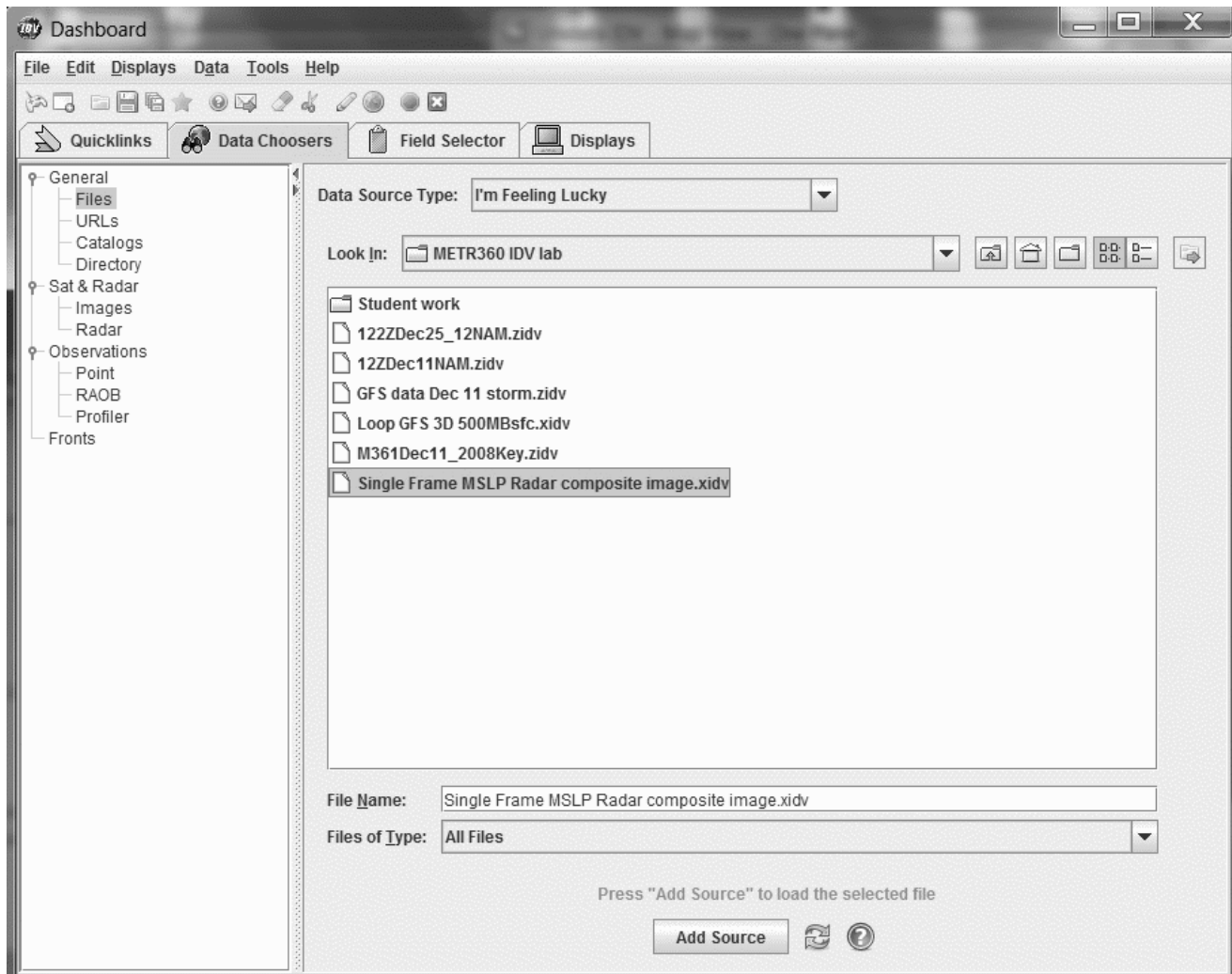
1. Go into the computer lab, room 308 and pick any computer other than the older one in the front used for maps and observations only. Log on using your username and password.

### 2. Quick Start

To start the IDV, click on the Applications menu and choose IDV 5.3 at the bottom. It will take a few seconds to initialize, then put up two windows. These are the main operating windows that you need. The one on top is the map view window:



The other window is called the Dashboard. Here is where you control where you get the data and how you display it:



### 3. Working with the IDV









In the Dashboard, click the tab marked “Data Choosers, as shown above.” That will show a number of “bundles.” A bundle is just a saved IDV state. Once you have set up the displays the way you want them, you can save what you see as a bundle. With the IDV, you can also design your own bundles and save them and you can add to or change the bundles that you find. If you open a regular bundle you see the same types of displays every time, like pressure and temperature, but each time you open the IDV it uses new, current data. You can decide what you want to see. Some bundles carry their own data and are basically case studies. These are called Zipped Bundles. We’ll work with one of those today. By the way, if you make changes to bundles, please save them under a different name so the original is maintained

#### a. Get Started





To get familiar with the way the IDV works, in the Dashboard click on Files, then open the folder “metr360” (it might already be open - see example above) and click the bundle “Single Frame MSLP




Satellite composite image.xidv”. Then click the Add Source button at the bottom of the Dashboard screen. You get an Open Bundle dialog box. The top box should be checked. If it is, click the OK button. Wait a few minutes for the data to load and displays to be created.

Now look at the other window, which is called the Map View. The Single Frame MSLP Satellite composite bundle is a 2-D display of mean sea level pressure (MSLP) as colored isobars with a non-enhanced GOES-E IR image superimposed. Depending on the time of day, you may need to advance the frame to see the IR image. To do that you use the frame advance arrow. The IDV can do much more but we will practice simple navigation using the MSLP Satellite display. Click the top bar of the Map View window to activate it. Along the left margin there is a series of icons. To get the map to a view from the top and aligned with the screen, click the little Home icon (). Depending on how big a change this is, the display may reload, taking a few seconds. Clicking the + magnifier icon () makes it bigger and the – magnifier makes it smaller (). Moving the whole display must be done with the arrows    and , not the mouse which is for 3-D. To undo any display change, use . For practice, try zooming in and centering on New York State. By the way, the mouse wheel will also work for magnifying.

## b. Other bundles

Go to the top of the map view screen. Under the menu headings (File, Edit, Displays, etc.), there is a series of small icons. Click the one that looks like a pair of scissors, . All the isobars and satellite information will disappear. The scissors icon removes all displays and data sources from the dashboard. Go back to the Dashboard. Click Data Choosers. Click the bundle “Loop GFS 3D 500MBsfc.xidv” and click the Add Source button. When the Open bundle dialog box comes up, click OK and wait a bit. On the Map view screen you will see a multicolored 500 mb animation. This is a 5-day forecast from the latest GFS run. It can be animated if you click the forward arrow (). You can stop it with the pause icon, . Advance one frame at a time with the frame advance arrow (.

Now, do this carefully: Put the cursor anywhere in the map itself, click AND HOLD the right mouse button, and move the mouse slowly forward while holding the button. The map will be rotated so that you can appreciate the fact that this is a 3-D 500 mb surface. By holding the right mouse button and moving the mouse, you can rotate the map view all the way around the even view it from underneath. Try moving in various ways, even while the map is looping. Notice how the yellow areas are high (ridges) while the blue areas are low (troughs).

Having trouble getting it right-side up again? Click the Home icon, above the movement arrows. It might take a few seconds for the black contours to reappear. The data is all loaded but you changed the view so the IDV has to re-map them. You probably will want to zoom in ( or use the mouse wheel).

On the right side of the Map View is the Legend. Each display is shown. The 500 mb surface is obscuring the GFS precipitation forecast which is also part of this bundle. To see the precipitation, click the two boxes for Geopotential height isobaric to uncheck them.

What happens if you load in another bundle but “forget” to clear the display using the scissors icon? Go back to the Dashboard. Click Data Choosers again. Click the bundle named “Composite Radar.xidv” and the Add Source button. This is the radar loop for the last two hours. You could add to this display, superimposing the MSLP, radar, 500 mb, or any other field by unchecking the Remove box on the Open bundle dialog box now on the screen. Keep the check on the second box to add displays. Advance the frames until you see radar echoes. Compare them to the forecast precipitation.

### c. Designing displays

You can make 2D and 3D displays of your own choice. First, click the scissors icon. As we now know, that removes the old displays and any data sources previously loaded when you chose the bundle. The map remains. Now we're going to add Fields.

Go to the Dashboard. Click the Data Choosers tab. Now go down the menu past Files and URLs to Catalogs. Click it. The first catalog listed is Unidata Model Data.

There's a small lever icon next to each folder. Choose the Unidata Model Data and click the lever. It now points down and there are more choices. Choose Forecast Model Data and click the lever. Choose the North American Model which is the NAM (Turn the lever down). You get a number of variations. Choose NAM CONUS 12 km from CONDUIT. That's the 12 km grid over the Continental U.S from the NAM, a very dense dataset. Click the line "Latest Collection for NAM CONUS 12km from CONDUIT" then click the Add Source button.

At this point, the Dashboard switches you to the Field Selector tab automatically. Turn down the lever on the 2D grid and again on Temperature. Pick Temperature@Ground or water surface. Over on the right, you should pick a display type. Let's do Color-filled Contour Plan View.

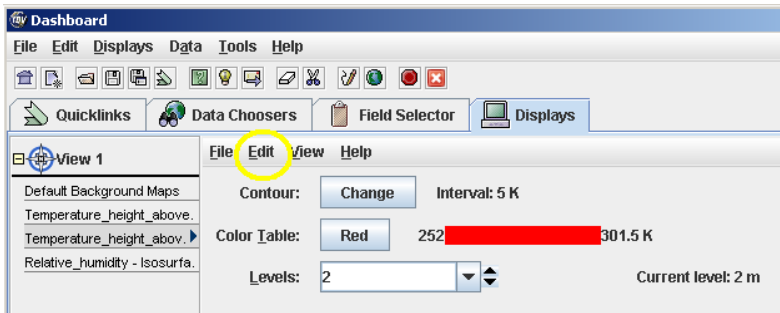
You need to choose a time or series of times or the IDV will use all available times by default. Remember, the NAM data is very dense so be careful about times. The full default is 29 times from initialization. That can take a while to load.

To remedy that, first click the Use Default box and make it Use Selected. For this example, click just the first time shown, probably 12:00:00Z. Click the Create Display button. The map will very quickly be colored. These are the surface temperatures at the model initialization time. Zoom in for more detail. It would be nice to see the isotherms where the colors change and some numbers, too!

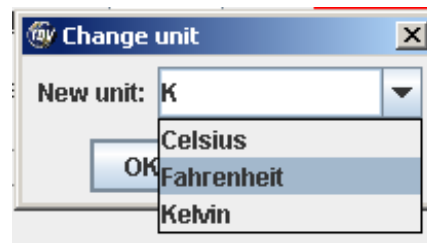
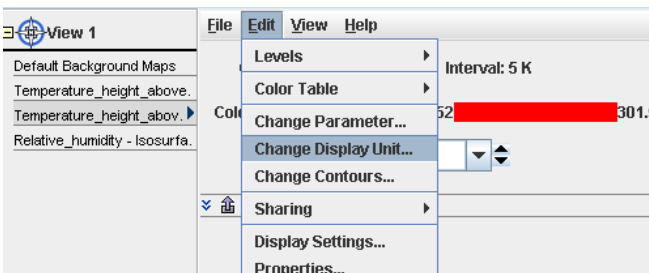
Go back to the Dashboard (that happens a lot, doesn't it? The Dashboard is your main control on what gets shown). The IDV is now showing the Display tab. Click the Field Selector tab. We're going to leave everything the same as shown, except change Color-filled Contour Plan View to Contour Plan view and click Create Display.

Other than a bit of flashing, nothing seemed to change. That's because the IDV is using the same color scheme for the isotherms as it did for the fill colors. Let's change that. Go back to the Dashboard. The Display tab is now showing and it's for the Contour Plan View that you just created.

The Color Table is showing the word "Temperature". Click it once and you will see more choices for a Color Table. Pull the cursor down to Solid, hold it there a second, then carefully move the cursor right to pick Red. Click it. Go back to the Map view to see your red isotherms. Hopefully some of them will be labeled with their value. If not, do this: Where it says "Contour:", click the button marked Change. In the Contour Properties Editor that you get, move the Frequency slider from Lo to Hi. Click OK. Now you have lots of labels. They are probably in Celsius degrees. To change that, go to the dashboard display view, pull down the Edit menu next to the View line:



Choose Change Display unit and pick Fahrenheit from the menu which results. You might want to change the contour interval. The default is 9 degrees F. You can change it in the Contour Properties Editor.



By the way, if you do the right-mouse motion again, you will see that this display is NOT 3D. It's flatter than a pancake since 2D is what you requested. Not seeing state boundaries? On the Map View, click Default Background Maps and check Hi-Res US to get a better U.S. map.

Of course, you could choose more than one time and get an animated display. If you do that, remember, it will take longer to load, especially using NAM data. You are creating displays, not loading canned displays from the Internet. Give the computer time to work. For faster loops, try the GFS or lower resolution NAM grids, like 40 km or even 80 km. And it's best not to load all 29 NAM times.

Now that you know the basics, play with it. Load other types of data and different types of displays. The IDV can do a tremendous variety of tasks and show you lots of displays.

#### 4. Assignment (due next Wednesday)

Clear all displays and data. Go to Data Choosers. Under the word "General" click Files. Open the folder IDVLab. Click GFS Jan 27 2015.zidv and click Add Source. When the Open Bundle dialog box comes up, check the Remove box and click OK. Then another dialog box asks you if you want to write files to a temporary directory. Click OK again. We're using the GFS for fast loading. This display is only sea-level pressure and 6-hour precipitation forecast but most of the GFS is available by using the Field Selector. You should add whatever displays you need to answer the questions. This is graded:

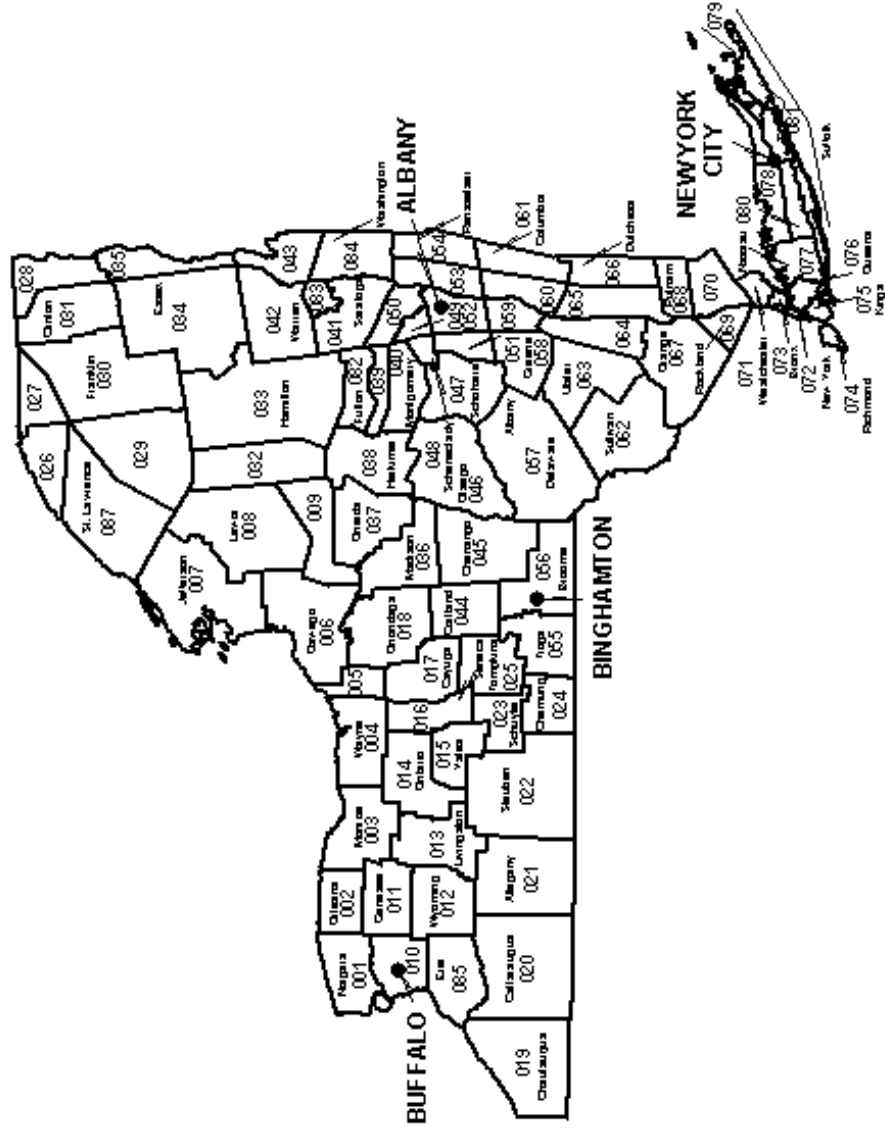
**Based on the GFS forecast, answer the following questions on a separate sheet of paper or in a text file. If you write a text file, send it to me via email (Jerome.Blechman@oneonta.edu):**

1. The storm we are studying occurred on January 27, 2015. When and where is that surface Low most intense? Be specific and quantitative (use numbers!)
2. You have a paper copy of the isobars, isotherms, and 1000 mb wind flags for 00Z on Jan 27, 2015. Draw in the fronts in the places consistent with those data fields. Use the standard symbols and colors.

3. Add 500 hPa heights for all times. (Hint: 500 hPa is a Geopotential height. Find that using the Field Selector) When and where is the 500 hPa Low most intense? Again, give numbers. You might find this easier if you uncheck all boxes in the Legend, except for the Geopotential Heights and Default Background Maps.
4. In the Dashboard under “Derived”, add wind barbs at 300 hPa. You may need to skip some winds to make it readable. What can you say about the winds? Make at least two observations about what you see. Whenever possible, make them quantitative.
5. The upper air pattern you see over the eastern U.S. is a cut-off Low. What characteristics of this upper air trough tell you it is cut off?
6. Add the 2D 1000-500 hPa thickness (again under the Derived menu). I like to make these solid red since the default 500 mb height line color is blue. You can choose the color table as we did before. Remember you can uncheck the precipitation and put it back when you need it. Notice that the thickness pattern does not match the 500 hPa pattern exactly, although it is very close in most places. At 12Z on Jan 27, the two fields differ the most over southern New England where the impacts were greatest. That is not a coincidence. How does the difference between thickness and height cause the heavy snowfall?
7. Go back to the first frame at 00Z on Jan 25. How is the 500 hPa pattern different at that time from the one at the time of the greatest intensity in the blizzard? There are several important differences. Find two and describe them completely.
8. In cities such as Philadelphia and Atlantic City, schools were closed in advance and the governors issued states of emergency. Based on the sequence of maps shown by this GFS forecast made two days in advance, what would have been the proper forecast? Based solely on this GFS forecast, give a short summary of the expected synoptic situation. Then use the GFS to forecast the snowfall total for Philadelphia for January 26 and 27, 2015. Do not look up what actually fell. Your forecast must be based on the guidance you have.

Next: Appendices

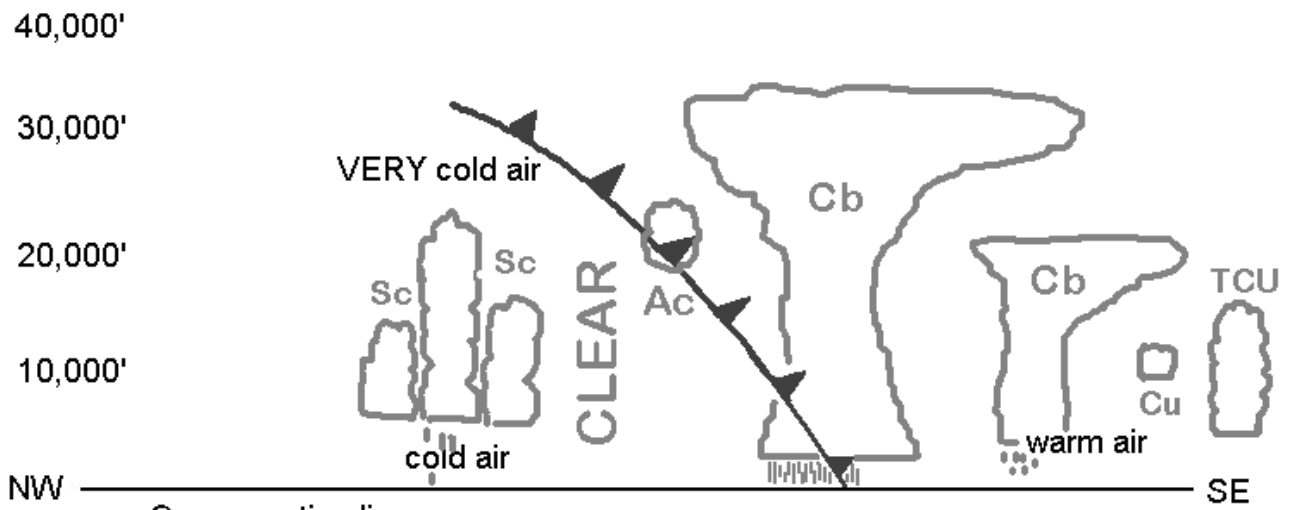
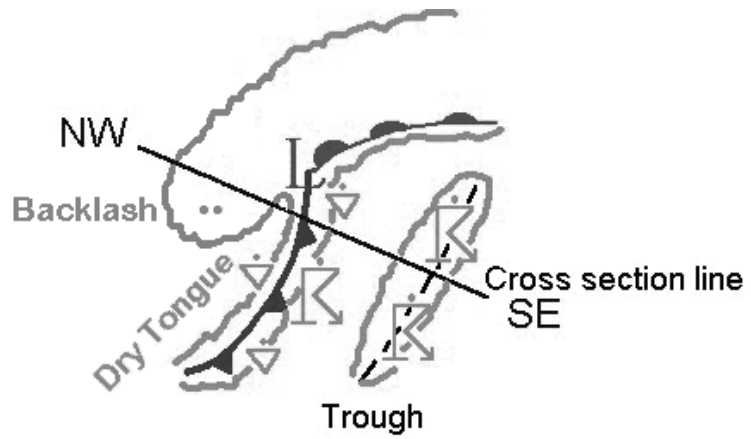
# NEW YORK PUBLIC FORECAST ZONE BOUNDARIES



- Weather Forecast Office
- County Boundary
- ▭ Forecast Zone Boundary

# NATIONAL WEATHER SERVICE EASTERN REGION

# Cold Front

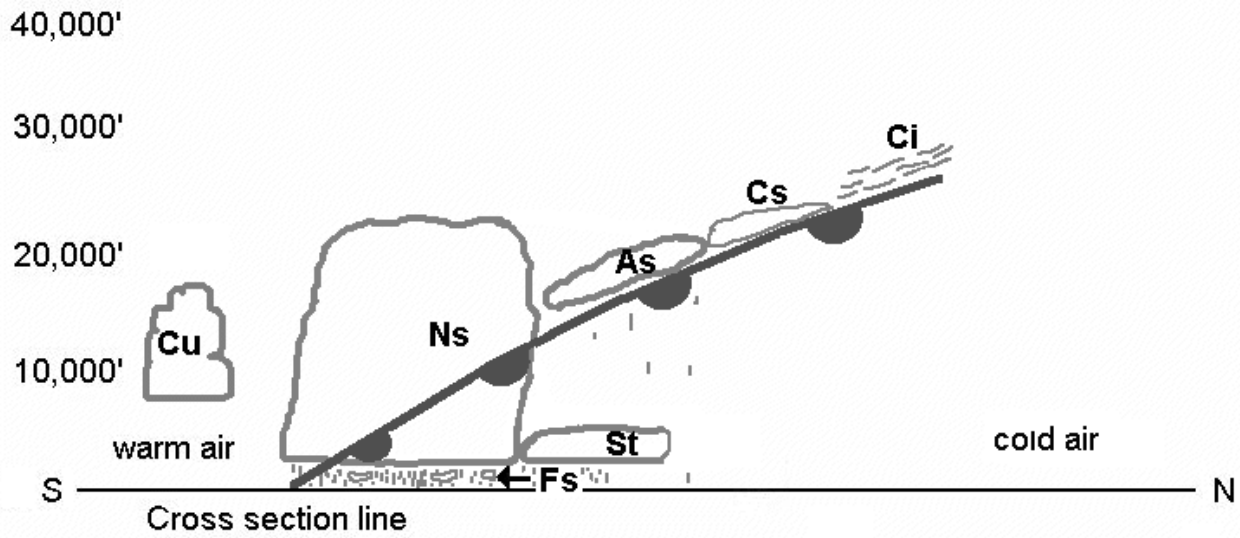
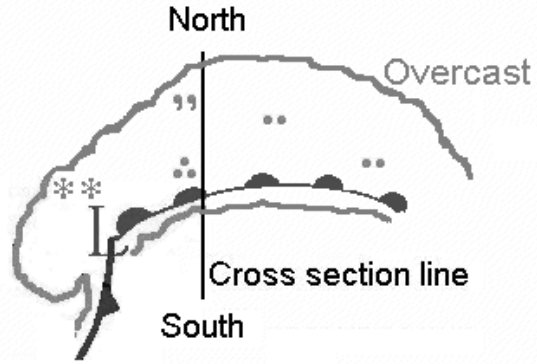


Cross section line

## Sequence of Clouds and Weather

Time (start with 0)	7	6	5	4	3	2	1	0
Clouds	Sc	Sc	No Clouds	Ac	Cb	Cu	Cb	Cu + TCU
Weather	▽/..				⌞		⌞	

# Warm Front

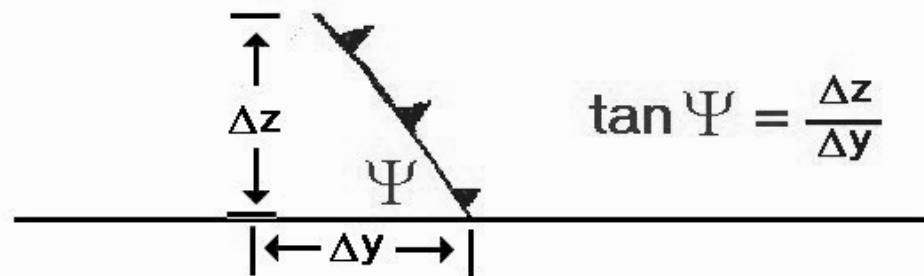


7

## Sequence of Clouds and Weather

6	5	4	3	2	1	0	Time (start with 0)
Cu	Clearing	Ns/Fs	St	As	Cs	Ci	Clouds
▽	Clearing	☁/☁	☁/☁	☁			Weather

## FRONTAL SLOPES (MARGULES)



$$\tan \Psi = \frac{f\bar{T}}{g} \frac{W_{gD} - W_{gL}}{T_D - T_L}$$

where  $f$  = the Coriolis parameter =  $2\Omega \sin \Phi$

$g$  = the acceleration of gravity ( $=9.8 \text{ m/s}^2$ )

$W_{gD}$  = the geostrophic wind in the dense air

$W_{gL}$  = the geostrophic wind in the light air

$\bar{T}$  = the overall mean temperature

$T_D$  = the temperature at the front in the dense air

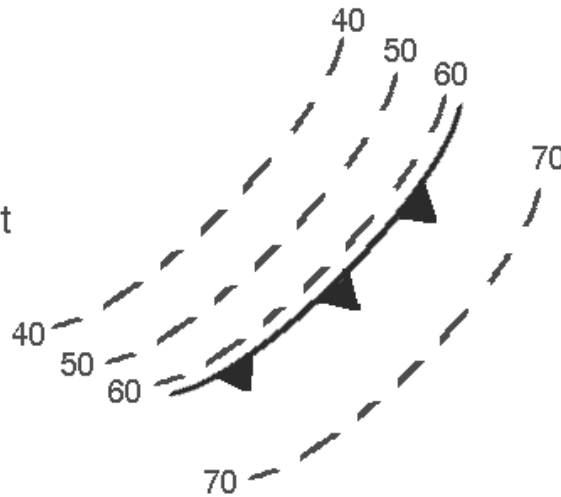
$T_L$  = the temperature at the front in the light air



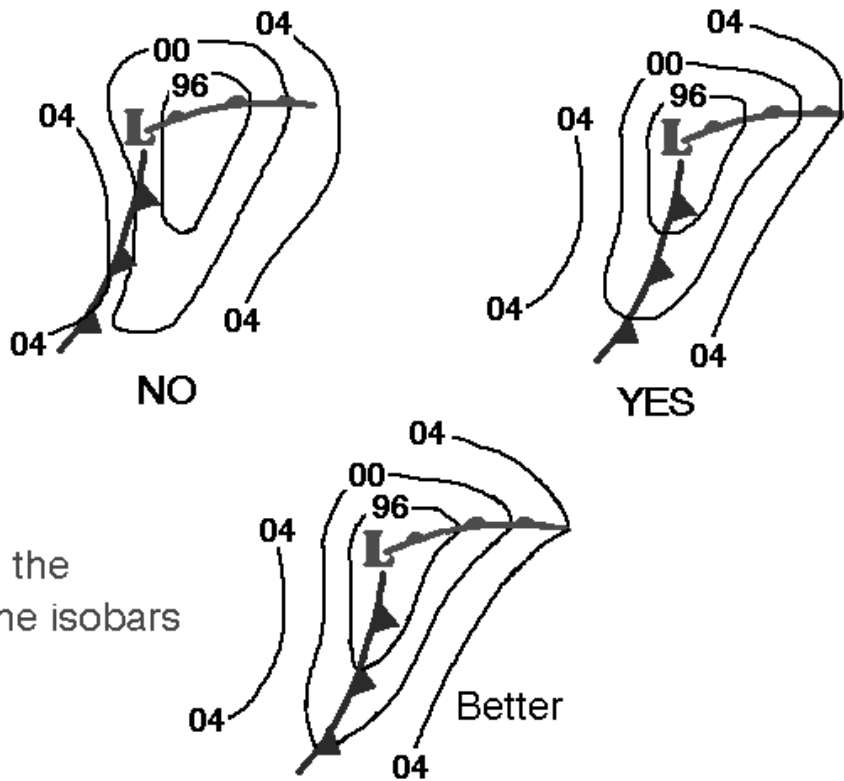
# Analyzing Fronts

## 1. Temperature gradient

Place the front at the edge of the isotherm packing. It is not necessary to get every isotherm behind the front.

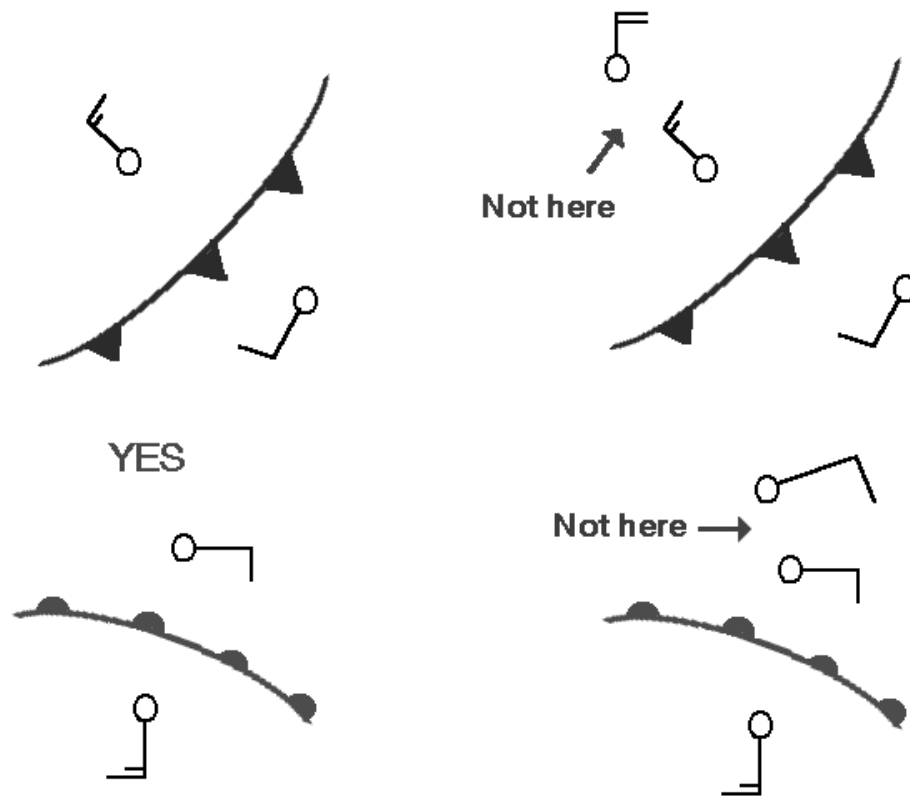


## 2. Use the fact that fronts always lie in troughs.



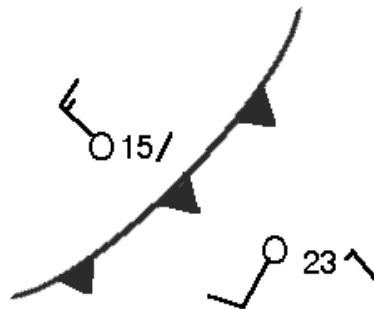
After drawing the front, "kink" the isobars

3. Look for an abrupt wind shift.

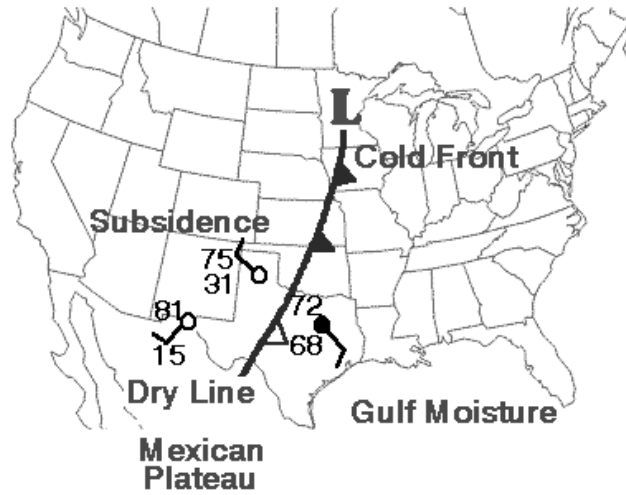


Remember, fronts always have wind convergence.

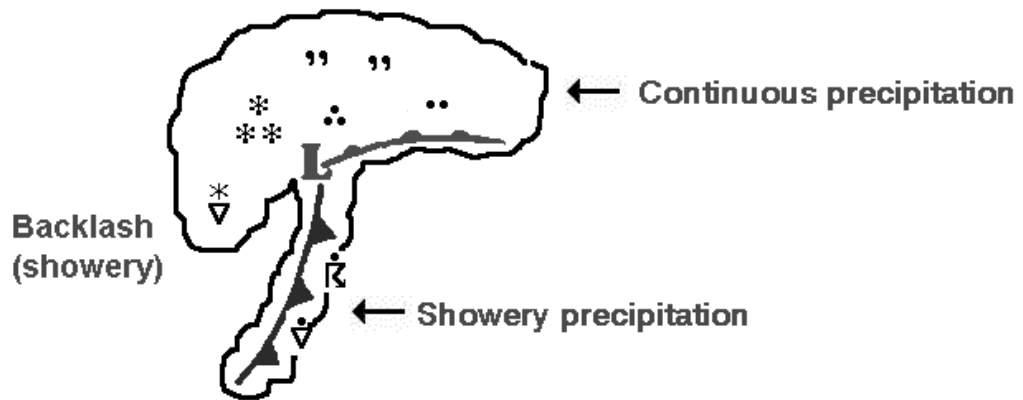
4. Since fronts are in troughs, the pressure tendency will be negative as it approaches, positive after frontal passage.



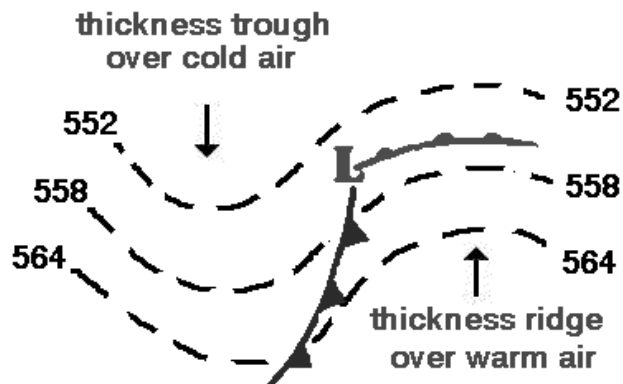
5. In the southwest and south-central U.S., look for big dew point decreases.



6. Fronts have characteristic weather and cloud types.



7. Surface temperatures may be misleading. Check the upper air thickness pattern.



## Principles of Convection II: Using Hodographs

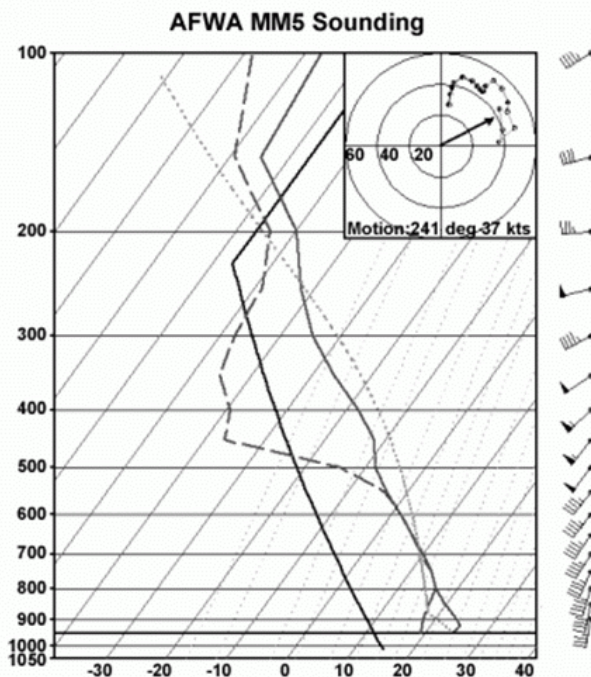
Find this tutorial at <http://deved.meted.ucar.edu/mesoprim/hodograf/print.htm>

### 1. Introduction

#### 1.1 The Importance of Shear

The hodograph is a graphical tool that helps forecasters evaluate vertical wind shear. In a convective environment, an understanding of the vertical wind shear is tremendously important for anticipating convective storm type, where new storms may form, the likelihood of supercell storms, and even storm and storm system motion. For example, these figures show the simulated radar returns for a series of modeled storms that evolved under different vertical wind shear conditions, which are depicted by the idealized hodographs in the lower left.

#### 1.2 The Hodograph

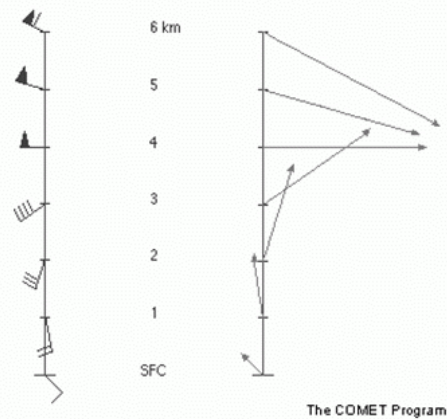


AFWA The ability to anticipate possible storm

structures is critical in managing your activities before and during a convective event. Having the right set of expectations for a given storm environment will make you a more efficient and accurate forecaster. The hodograph depicts the environmental wind shear, which profoundly influences storm evolution. Thus, a representative hodograph combined with a representative buoyancy profile can greatly enhance forecast skill. This figure shows an AFWA MM5 model sounding, along with the associated hodograph, downloaded from the Joint Army-Air Force Weather Information Network (JAAWIN) Website. Similar sounding/hodograph plots are available from many sources.

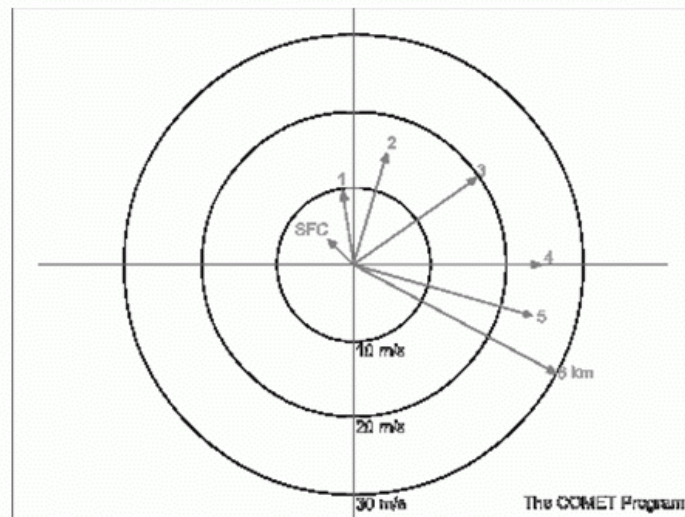
## 2. Plotting a Hodograph

### 2.1 Wind Barbs vs. Wind Vectors



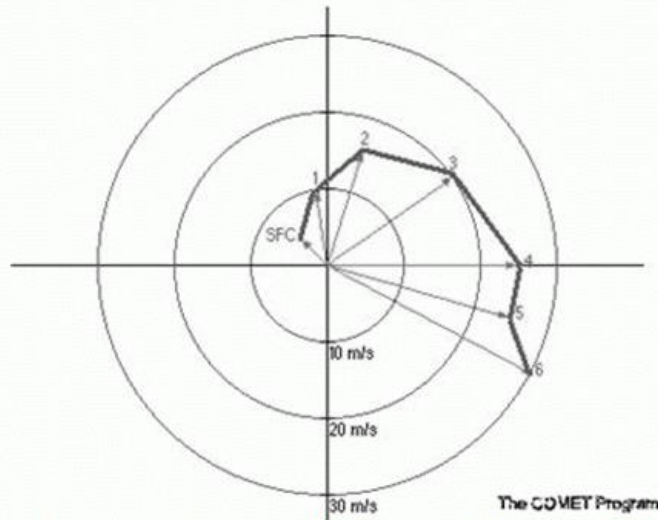
Meteorologists are all familiar with the traditional vertical wind profile from a radiosonde that uses barbed lines to indicate wind direction and speed at various levels. The hodograph communicates the same information. However, since its primary purpose is to reveal vertical wind shear, the hodograph is based on wind vectors. Unlike the wind barb, a vector indicates speed by its length rather than a combination of barbs.

### 2.2 The Polar Coordinate Chart



For a hodograph, wind vectors are plotted on a polar coordinate chart. The axes of the chart represent the four compass directions. All the wind vectors extend from the origin and point in the direction of the wind's movement. Since the vector length indicates speed, concentric circles drawn around the origin represent constant wind speeds. For example, this hodograph shows that both the 4- and 5-km winds are 25 m/s, although their wind directions are from the west and west-northwest, respectively.

### 2.3 The Hodograph



Typically, the actual wind vectors are not drawn on the hodograph, but are indicated only by their endpoints on the polar coordinate chart. The hodograph is plotted by connecting the endpoints of each of the wind vectors.