AOS 452 Lab 3: Meteorological data decoding and forecast preparation

This semester we will be using a variety of programs and software specific to meteorology. The next program we will focus on is:

THE **WEATHER** PROGRAM

The **weather** program is a valuable tool for viewing a variety of text weather data, including station observations, model output, and National Weather Service forecasts. You will find the **weather** program to be particularly useful in preparing your national weather forecasting contest, WXChallenge (www.wxchallenge.com) forecasts. I have provided a handout which gives an overview of some of the commands typically used within the **weather** program. Please take some time and look over this handout to get an idea of some of the commands you may wish to use.

To start the `WEATHER` program, type `weather` at the UNIX prompt.

The first thing we may wish to look at is the latest hourly observation for a particular station. In order to do this, we will need to know the three-letter identifier of the station, such as Madison, WI. How do we find this?

Type `/stations` at the `WEATHER>` prompt.

The backslash indicates that you are entering a sub-command into the weather program. Once the new prompt appears, type **`@wi`** to get a listing of station identifiers for the state of Wisconsin, and look for Madison. Try finding some of the three letter identifiers for other cities around the United States by doing a search by state.

In order to view surface observations in the weather program, the *metar* sub-command must be used. After typing **`/metar`**, the station and time need to be entered for the surface observation desired. There are several ways to specify a specific time or set of times for listing observations. Here are some examples:

`msn l`	the latest observation for Madison
`grb t`	all observations for Green Bay taken today (from 0000 UTC until now)
`mke y`	all observations for Milwaukee taken yesterday
`eau` *n*	give the last *n* hours of observations for Eau Claire, WI; where *n* is an integer number of hours
`rst 6z-`	all observations for Rochester, MN including and since 0600 UTC today

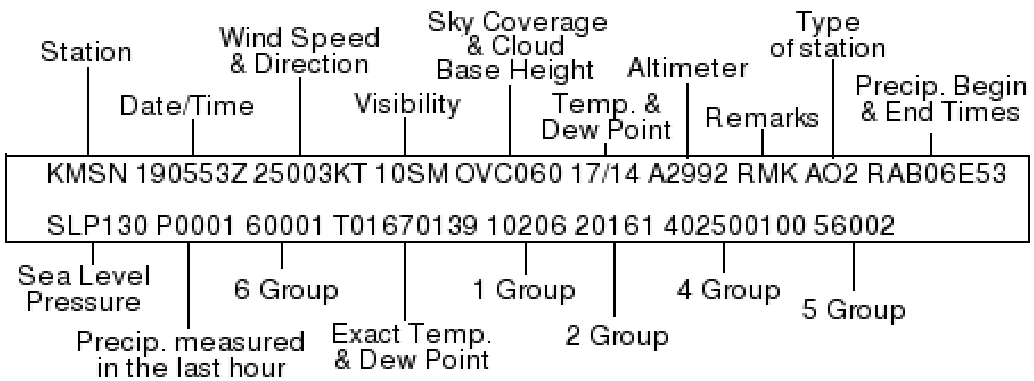
Experiment with the above examples to list various METAR reports. In addition, particular dates and times can be specified. See the quick guide help menu within the weather program for more information. The information included in the METARs will be discussed in further detail later in this lab.

NOTE: A *menu-driven format* of the **weather** program is also available on the Room 1411 workstations. After typing `weather` to start the **weather** program, type `line`. A menu will appear with five choices. To select a particular choice, simply type in the number next to the option you want and press ENTER. To move back a menu in this version of the **weather** program, press ENTER without entering any characters. Some of you may prefer this version of the **weather** program compared to the version discussed earlier.

DECODING METARs (SURFACE OBSERVATIONS)

MEteorological Terminal Air Report (roughly translated from French) or METAR is an international standard code format for hourly surface weather observations. All of this information is reported hourly from surface stations around the world, typically taken within 10 minutes before the top of the hour. For example, the 1300 UTC observation may be taken at 1253 UTC. So, when looking for a particular hourly observation, you need to look for the observation taken between **50 and **00. However, special observations are taken at any time if weather conditions that may be important to pilots change, such as visibility, falling precipitation or cloud cover.

Standards have been set in order to distribute all of this information in a compact format. A key to decoding METARs has been provided in a handout. The following is an example of a METAR and a brief explanation of the information each group contains:



<u>What exactly do the group numbers mean:</u>

1 Group: The 6-hour *maximum* temp. (Celsius), precise to convert to nearest degree Fahrenheit.
2 Group: The 6-hour *minimum* temp. (Celsius), precise to convert to nearest degree Fahrenheit.
4 Group: The *maximum* and *minimum* temperature (Celsius) of the last 24-hours.
5 Group: *Pressure tendency* information. See handout for more information.
6 Group: Precipitation measured in last 6 hours. 60000 indicated a trace amount. This group only appears on the 00, 06, 12, 18Z observations.
7 Group: Precipitation measured in last 24 hours. Typically appears only on the 12Z observation.

Most of the time, this is what the group numbers mean. There are exceptions, such as when you see 4/ for snow depth.
Below is a table of the information described by the second character of the “5” group:

Table: Characteristics of Barometer Tendency

Primary Requirement	Description	Code Figure
Atmospheric pressure now higher than 3 hours ago.	Increasing, then decreasing	0
	Increasing, then steady, or increasing then increasing more slowly.	1
	Increasing steadily or unsteadily.	2
	Decreasing or steady, then increasing; or increasing, then increasing more rapidly.	3

Atmospheric pressure now same as 3 hours ago.	Increasing, then decreasing	0
	Steady	4
	Decreasing, then increasing.	5
Atmospheric pressure now lower than 3 hours ago.	Decreasing, then increasing.	5
	Decreasing then steady; or decreasing then decreasing more slowly.	6
	Decreasing steadily or unsteadily.	7
	Steady or increasing, then decreasing; or decreasing then decreasing more rapidly.	8

Precipitation Type Help, sometimes followed by begin and end times:

QUALIFIER		**WEATHER PHENOMENA**		
INTENSITY OR PROXIMITY **1**	**DESCRIPTOR** **2**	**PRECIPITATION** **3**	**OBSCURATION** **4**	**OTHER** **5**
- Light Moderate (see note 2) **+** Heavy **VC** In the Vicinity (see note 3)	**MI** Shallow **PR** Partial **BC** Patches **DR** Low Drifting **BL** Blowing **SH** Shower(s) **TS** Thunderstorm **FZ** Freezing	**DZ** Drizzle **RA** Rain **SN** Snow **SG** Snow Grains **IC** Ice Crystals **PE** Ice Pellets **GR** Hail **GS** Small Hail and/or Snow Pellets **UP** Unknown Precipitation	**BR** Mist **FG** Fog **FU** Smoke **VA** Volcanic Ash **DU** Widespread Dust **SA** Sand **HZ** Haze **PY** Spray	**PO** Well-Developed Dust/Sand Whirls **SQ** Squalls **FC** Funnel Cloud Tornado Waterspout (see note 4) **SS** Sandstorm **SS** Duststorm

Cloud Type and Base Height:

Cloud base is reported hundreds of feet. If Towering CUmulus or CumulonumBus are reported TCU or CB will be reported.

Cloud cover is based on coverage in terms of octas of the sky.

SKC Sky clear
CLR Sky clear below 12,000 feet
FEW 1-2 octas obscured by clouds
SCT 3-4 octas obscured by clouds
BKN 5-7 octas obscured by clouds
OVC 8 octas obscured by clouds

KMSN 190553Z 25003KT 10SM OVC060 17/14 A2992 RMK AO2 RAB06E53 SLP130 P001 60001 T01670139 10206 20161 402500100 56002

Follow along with each piece of information as this METAR observation is decoded:

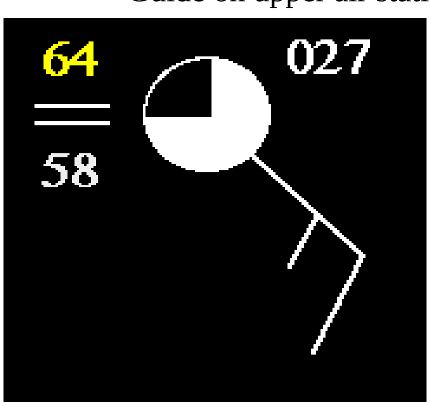
Location: KMSN (Madison, WI)
Time/Date: 0600 (0553) UTC on the 19th of the month.
Wind (direction/speed): 250 degrees (or west-southwest) at 3 knots.
Visibility: 10 (statute) miles.
Sky cover: Overcast, cloud base height at 6,000 feet
Temperature: 17 degrees Celsius
Dew point temperature: 14 degrees Celsius

Altimeter reading: 29.92 inches of mercury.
---RMK: *Remark Section* ----
Station Type: AO2 (type of automated station)
Precipitation Type: Rain
Begin time: 06 minutes past the hour (at 0506 UTC)
End time: 53 minutes past the hour (at 0553 UTC)
Sea Level Pressure: 1013.0 mb
Recorded Precip this hour/last 6 hours: .01 inches/.01 inches
Precise temperature: 16.7 degrees Celsius
Precise dew pt. temperature: 13.9 degrees Celsius
Maximum temperature in the previous 6 hours: 20.6 degrees Celsius
Minimum temperature in the previous 6 hours: 16.1 degrees Celsius.
Maximum (minimum) temperature for the 24-hour period: 25.0 (10.0) degrees Celsius.
Pressure tendency: decreasing, then became steady.
Pressure change in last 3 hours: fell 0.2 mb

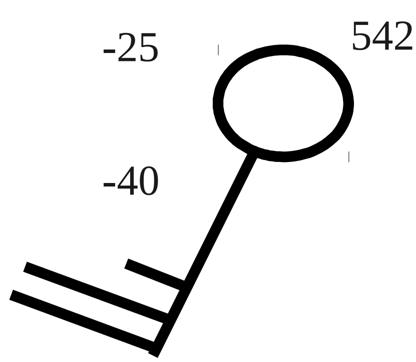
If you want a more in-depth look at METAR decoding, visit the following URL: ***http://www.met.tamu.edu/class/metar/quick-metar.html***.
The official guide to METAR code is chapter 12 of Federal Meteorological Handbook No. 1, which can be found online at ***http://www.mrx.net/weather/fmh1/fmh1ch12.htm***.

STATION MODELS
Meteorologists need a way to get the detailed information collected into the smallest area possible on a weather map so that several stations can be plotted for the same observation time on the same map, thus giving the "big picture" of what the weather is doing at a particular moment in time. Weather conditions observed at a particular location are best represented on a map using station models. Most station models depict the same important observations found in METARs. It will be to your benefit to become familiar with station models as you will see them in map discussions and case study projects. If you're not familiar with station models or just need a refresher, take a look at the following web sites:

http://cimss.ssec.wisc.edu/wxwise/station/
-- Guide on surface station models
http://ww2010.atmos.uiuc.edu/(Gh)/guides/maps/sfcobs/home.rxml
-- Another guide on surface station models
http://ww2010.atmos.uiuc.edu/(Gh)/guides/maps/upa/home.rxml
-- Guide on upper air station models



Surface Station Model



Upper Air Station Model

DECODING NWP MODEL OUTPUT

In addition to surface observations, the **weather** program is a useful way to access numerical weather prediction (NWP) model output. Many of you likely are familiar with some of the operational models such as the North American Mesoscale (NAM, formerly the Eta) and the Global Forecast System (GFS; a combination of the old Aviation [AVN] and Medium Range Forecast [MRF] models).

The output from these models can be useful in providing *guidance* while preparing a forecast. However, one must be extremely careful not to follow model guidance blindly, as that could certainly lead to poor forecasts. *(Keep this in mind for the forecast contest!)*

There are three types of model output you will learn to decode:

- **FOUS** (raw model output data)
- **EXT** (extended model output data)
- **MOS** (model output statistics)

Information below is provided to help you in decoding each type of data. Most model data are available in 12-hour increments (at 0000 UTC and 1200 UTC), and some of the model data are now available in more frequent time increments (such as six hours for the GFS model and hourly for the RUC [Rapid Update Cycle] model).

FOUS

One form of coded model data is FOUS (Forecast Output United States). This product takes forecast information directly from the model output and displays the information in a compact manner. The forecasts are provided in six-hourly intervals from 6 to 48 hours after either 0000 or 1200 UTC. Information given includes six-hour accumulated precipitation, relative humidity, vertical velocity, lifted index, sea level pressure, direction and speed of the mean wind in the boundary layer, 1000 to 500 hPa thickness, and three model-layer temperatures. FOUS is generally found to be most useful in precipitation forecasting. The general format for the raw data can be found below:

```
The general format:
------------------
OUTPUT FROM NAM HHZ MMM DD YY
TTPTT R1R2R3 VVVLI PSDDFF HHT1T3T5
----------------------------------
NNN// R1R2R3 VVVLI PSDDFF HHT1T3T5
06PTT R1R2R3 VVVLI PSDDFF HHT1T3T5
12PTT R1R2R3 VVVLI PSDDFF HHT1T3T5
18PTT R1R2R3 VVVLI PSDDFF HHT1T3T5
24PTT R1R2R3 VVVLI PSDDFF HHT1T3T5
30PTT R1R2R3 VVVLI PSDDFF HHT1T3T5
36PTT R1R2R3 VVVLI PSDDFF HHT1T3T5
42PTT R1R2R3 VVVLI PSDDFF HHT1T3T5
CODE    EXPLANATION
=====   =================
HH      Hour in which forecast was run in UTC.
MMM     Three letter month ID (e.g. SEP).
DD      Day of the month forecast was issued.
YY      Two number year ID (e.g. 13).
NNN     Forecast station three letter identifier.
```

PTT	6 hour accumulated precipitation in hundredths of inches.
R1	Mean relative humidity of the lowest model layer (lowest 35 mb), in percent.
R2	Mean relative humidity of model layers 2 through 9 (up to 500 mb), in percent.
R3	Mean relative humidity of model layers 10 through 13 (500 to 200 mb), in percent.
VVV	Vertical velocity at 700 mb, in tenths of a microbar per second, weighted average of three hourly values at forecast time, one hour before, and one hour after (double weighted at forecast time). Minus sign represents downward motion.
LI	Lifted index in degrees Celsius. Negative values are designated by subtracting from 100; e.g. -4= 96. Taken from the lowest (most unstable) of four possible values. The values derived from lifting parcels from the four lowest model layers up to 500 mb.
PS	Sea level pressure calculated from lowest sigma level (based on the contour base map).
DD	Direction in tens of degrees of the mean wind in the lowest model layer (35 mb).
FF	Wind speed in knots of the lowest model layer (lowest 35 mb).
HH	1000-500 mb thickness in decameters with the first digit (5) omitted.
T1	Temperature in model layer 1 (lowest 35 mb) in degrees Celsius.
T3	Temperature in model layer 3 (approximately 900 mb).
T5	Temperature in model layer 5 (approximately 800 mb).

FOUS data are available from the Eta for a select number of cities in the United States. The sub-commands in the **weather** program for these products is `/eta`. To get the latest output, enter the three-letter station identifier and the letter “l” (e.g. ord l, for Chicago).

EXT

The extended model data (EXT) format is similar to FOUS data, but is shown in an easy to read, tabular format. Here is a sample (for Madison, WI at 1200 UTC 8 September 2008):

```
EXTETA> msn l

Station: MSN     Lat: 43.13  Lon: -89.35  Elev: 261  Closest grid pt: 18.7 km.
Initialization Time: 08-09-08 1200 UTC
PARAMETER/TIME      000    006    012    018    024    030    036    042    048
------------------- ------ ------ ------ ------ ------ ------ ------ ------ ------
  DAY / HOUR        08/12  08/18  09/00  09/06  09/12  09/18  10/00  10/06  10/12
------------------- ------ ------ ------ ------ ------ ------ ------ ------ ------
TEMPS
  2 M (F)               49     59     57     45     40     67     64     50     46
  850 MB (C)             7      4      5      5      4      5      7      7      6
  700 MB (C)            -2     -3     -3     -6     -5     -2     -1      1      2
  500 MB (C)           -15    -13    -16    -20    -14    -14    -11    -12    -11
  1000-500 THCK        554    553    552    547    549    554    557    557    558

MOISTURE
  2 M DEW POINT (F)     48     49     49     42     37     40     40     38     38
  850 MB DP(C)/RH    -3/50   1/79   1/74  -1/65  -2/63   0/68   0/62  -2/55  -5/45
  700 MB DP(C)/RH    -9/59  -3/94  -5/84 -15/52 -18/37 -23/18 -24/15 -23/16 -23/14
  500 MB DP(C)/RH   -19/72 -13/98 -19/76 -51/04 -42/08 -23/47 -26/27 -27/27 -33/15
  PRCPABLE WTR (IN)
  CONV PRECIP (IN)           0.00   0.00   0.00   0.00   0.00   0.00   0.00   0.00
  TOTAL PRECIP (IN)          0.10   0.11   0.00   0.00   0.00   0.00   0.00   0.00

WIND DD/FFF (Kts)
  10 M              29/006 29/005 27/006 27/008 29/005 33/007 18/003 16/005 15/004
  850 MB            28/014 30/010 32/016 32/020 32/017 33/008 25/002 16/006 15/014
```

```
  700 MB            27/033 25/030 27/027 30/018 30/022 31/023 33/017 25/008 27/016
  500 MB            26/051 25/066 25/073 27/049 30/068 29/054 28/048 29/034 28/027
  250 MB            27/106 24/096 24/100 26/083 30/083 29/077 29/060 28/040 27/035

PRESS/HEIGHTS
  MSL PRESSURE      1020.7 1020.5 1017.1 1019.2 1020.9 1021.1 1020.0 1022.2 1024.1
  850 MB HGT           152    152    150    151    152    154    154    155    155
  700 MB HGT           309    308    305    306    307    309    310    312    313
  500 MB HGT           571    570    566    563    566    571    574    576    578
  250 MB HGT          1060   1062   1054   1048   1055   1062   1066   1068   1069

VERTICAL VEL (uB/S)
  850 MB               -21    -52    -44    -12     -8    -10     28    -23      4
  700 MB               -10    -17    -37    -18    -20    -38    -14     -5      3
  500 MB                -3    117     56     -3    -49    -21    -25      8     -4

CONVECTION PARAMS
  LIFT INX SFC
  LIFT INX 4LYR
  CAPE SFC               0     31     44     12      0      0      0      0      0
  CAPE 4LYR
  CIN SFC                2     -6     -5    -40     -1      0      0      1     -1
  CIN 4LYR
  HELICITY (0-3 KM)    135     17    -65     23     49     27     17     46     82
```

As you can see, the extended data are easy to decode. Note that the precipitation numbers will include only the precipitation that is forecast to fall in the forecast increment (for this example, the 6 hour period) just like FOUS. Also note that for the wind forecast, the direction is given first (simply add a zero to get the direction from which the wind is forecast to come), and the speed is given second in knots. If you should have any more questions regarding the extended model output, feel free to ask.

> Example sub-commands in the **weather** program for these products include *`/extavn`* and *`/exteta`*.

<u>MOS</u>

Another form of coded meteorological data found in the **weather** program is model output statistics, or MOS. The MOS products are a bit different than the aforementioned model products, as they take into account past model performance, model biases, and other model statistics. The MOS output includes forecasts for three- and/or six-hourly temperature and dew point temperature, maximum and minimum temperature, cloud cover, surface wind, precipitation probability, visibility, and sometimes a variety of other products. The Eta MOS numbers are available twice daily (0000 and 1200 UTC) and the AVN MOS numbers are available four times daily (0000, 0600, 1200, and 1800 UTC).

A sample MOS product from the Eta is given below:

```
KMSN   ETA MOS GUIDANCE    9/08/2008  1200 UTC
DT /SEPT  8/SEPT  9                /SEPT 10                 /SEPT 11
HR   18 21 00 03 06 09 12 15 18 21 00 03 06 09 12 15 18 21 00 06 12
N/X                    41          67          44          71    55
TMP  56 56 53 49 44 43 43 57 64 65 61 53 48 46 47 61 67 69 65 59 58
DPT  48 47 47 45 41 40 40 44 43 43 45 46 45 44 45 50 50 50 52 53 54
CLD  OV OV OV SC CL CL CL CL SC SC CL CL CL CL CL SC SC SC BK SC OV
WDR  25 24 29 28 27 28 29 30 31 28 14 16 16 13 12 14 16 16 15 15 17
WSP  05 04 03 03 03 02 02 05 06 05 03 02 02 02 03 08 10 11 07 09 06
P06        86    22     5     1     1     3     2     5     7 14 20
P12                    28           1           6           7    28
```

```
Q06         3     0     0     0     0     0     0     0     0  0  0
Q12                     0           0           0           0     0
T06     21/ 0  2/ 0  2/ 0  0/ 0  0/ 0  0/ 0  0/ 0  0/ 0  0/ 0999/99
T12           21/ 0        2/ 0        0/ 0        0/ 0   999/99
SNW                     0                       0                 0
CIG   6  5  6  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  8  6
VIS   7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  7  5
OBV   N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N  N HZ
```

To decode the MOS product, visit the following website:
http://www.aos.wisc.edu/~hopkins/aos100/mos-doc.htm.
Much of the information is self-explanatory (e.g., temperature, dew point, etc.). The values in a certain column represent the statistically derived forecast values at that time for a specific variable.

The sub-commands in the **weather** program for these products are `/newavnmos` and `/etamos`.

Blindly following what the model statistics show will lead to large forecast errors, so do not get in the habit of "MOScasting". If you have thoroughly analyzed the weather situation and came up with temperatures and precipitation values similar to the model output, you *may* have a higher degree of confidence in your forecast.

Note that getting each type of output for a particular station is the same as for getting surface observations. First you type the subcommand for the product that you wish to view, then get the data using the same format as before:

`msn 12z` -- get the most current 1200 UTC product for Madison, WI
`mke l` -- get the latest product for Milwaukee, WI

<u>Forecast Discussions</u>

Forecast discussions can be found using the `/forediss` subcommand. NWS forecast discussion are issued by local NWS offices. The easiest find the discussion for a region is to search by state or if you know the three-letter station office code you can enter that as well.

`@wi l` This will give you the latest discussion for any region of Wisconsin.
`mkx l` This will give you the latest discussion from MKX, the forecast office in Milwaukee, WI