Decoding Upper-Air Data, Plotting Soundings

Section 1.1 of the Merritt and Forbes course notes briefly describes how upper-air data is collected from balloon-borne instrument packages called radiosondes. In this lesson we will learn how to decode the raw radiosonde data. Data collected by the radiosonde are commonly called "soundings" of the atmosphere.

The primary measurements taken by the radiosonde are air temperature, relative humidity, and pressure. The raw upper-air temperature and relative humidity, therefore, are reported as a function of pressure rather than height. Since pressure is one of the measured variables, and pressure always decreases with height in the atmosphere, it is a good substitute for height as a vertical dimension. Pressure serves as a substitute for height in many meteorological applications. As we shall see in more detail later, the relationship between pressure and height is non-linear, and is a function of air density (temperature), so that if we are given the distribution of temperature and relative humidity as a function of pressure, we can determine how the heights at which the various radiosonde data are found. In other words, we can find the heights of the various pressure levels. In fact, the heights of the pressure levels are one type of data contained within the upper-level data sets. Because gravity decreases slightly with height, a modified type of height called "geopotential height" is used that takes the variation of gravity into account. We won't worry about this slight difference in this class, except to note that most meteorological heights are strictly in units of "geopotential meters".

Radiosonde data are reported in 5 sections. Links give details on how to decode these sections.

1. TTAA or Mandatory Level Data

This section contains data from the so-called "mandatory" levels: surface, 1000 mb, 925, 850, 700, 500, 400, 300, 250, 200, 150, and 100 mb. Temperature, dew-point depression, height of the pressure level, wind direction and wind speed are reported.

2. TTBB or Significant Level Data

This section contains data from the so-called "significant" levels. These are levels selected from portions of the sounding where the vertical profile of temperature or relative humidity direction vary appreciably from a straight line. Enough significant points are included such that the sounding can be reconstructed reasonably accurately by drawing lines between significant levels. In other words, temperature and relative humidity can be estimated to vary linearly with height between significant level data points. The TTBB data contains temperatures and dew point depressions as significant level pressures.

3. PPBB or Significant Level Wind Data

This section contains wind direction and speed data as a function of height for "significant" levels. Enough significant levels are chosen in non-linear portions of the sounding so that the sounding can be reproduced reasonably accurately by drawing straight lines between significant level data points. In other words, wind variations can be approximated as linear between significant levels.

4. TTCC data

This section is similar to the TTAA section, except that it contains mandatory level data for pressures less than 100 mb. The levels are 70, 50, 30 and 10 mb, if the weather balloon makes it that high!

5. TTDD data

This section is the significant level data section for pressures less than 100 mb. Subsequent sections describe how to decode TTAA, TTBB, and PPBB data. Upper-air data are plotted on a variety of types of maps. Data from all stations at a particular mandatory level pressure are plotted on maps or constant pressure analysis charts. Read *Gleim*, chapter 24 (pp. 355-366). We'll deal more with these later. **Study the supplemental materials and examples on the web.**

Sounding data from a particular station are plotted on sounding diagrams. Though there are several different types, a common one is called the Skew-T Log P chart. A hand-plotted sounding from Pittsburgh, PA (PIT -- 72520) at 1200 UTC on 12 February 1996 (corresponding to the example data above) is included in the course notes with the lesson 5 assignment material.

Decoding Upper-Air Data:

MANDATORY LEVEL DATA (TTAA)

A		**B**	**A**	**C**	**D**	**E**	**F**	**G**	**H**
72520	TTAA	60121	72520	99973	15644	19003	00120	/////	/////
I	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**
92791	18258	28008	85508	12221	26508	70108	02240	29019	50575
S	**T**	**U**	**V**	**W**	**X**	**Y**	**Z**	**AA**	**BB**
13965	30534	40740	26363	31044	30941	44359	32038	25060	50158
CC	**DD**	**EE**	**FF**	**GG**	**HH**	**II**	**JJ**	**KK**	**LL**
30360	20205	52359	32539	15391	54559	31033	10649	57559	30520
MM	**NN**	**OO**	**PP**	**QQ**	**RR**	**SS**	**TT**	**UU**	**VV**
88216	53158	33548	77248	34061	42715	51515	10164	00000	10194
WW	**XX**								
26507	27014								

A = station identifier (in this example, Pittsburgh)

B = day/time group; subtract 50 from the first 2 digits to obtain day (here 60-50=10); the "12" indicates the 1200 UTC rawinsonde; the "1" denotes wind data up to 100 mb.

C = "99" is an identifier for surface data; the next 3 digits give the surface station pressure in whole millibars (mb); in this example 973mb.

D = The temperature/dewpoint depression group associated with the preceding pressure level; the first 3 digits are the tens, ones, and tenths digits for temperature; if the tenths digit is an odd number, the temperature is negative; the other 2 digits are dewpoint depression (DD); if the DD is =< 5.0 degrees, the code will give the ones and tenths digits (in this example temperature is 15.6^{o}C, DD is 4.4^{o}C, and hence the dewpoint is 15.6 - 4.4 = 11.2^{o}C). Note that DD > 5 are in whole degrees and are encoded by adding 50 to the value, e.g. 62 = 62 - 50 = 12.

E = Wind direction and speed (in this example, from 190^{o} at 3 kt); the middle digit in the group can be a 5 for direction resolution, or a 1 if the speed is >= 100 kt; if this digit needs to express both direction and speed data, add 500 to the wind, e.g. 22645 = wind from 225^o at 145 kt.

F = 00 identifies the 1000 mb data; the height of the 1000mb level is 120 m above sea level. (**see "Calculating 1000 mb heights" for additional info**)

G&H = the slashes represent a lack of data; in this case since PIT's station pressure is 973 mb the 1000 mb level is below ground.

I = 92 identifies the 925 mb data; in this case the height of the 925 mb level is 791 m.

J&K = similar to groups D and E

L = 85 identifies the 850 mb level; in this case the height of the 850 mb level is 1508 m (note that the thousands digit is omitted).

M&N = similar to groups D and E

O = 70 identifies th 700mb level; in this case the height of the 700 mb level is 3108 m (again, the thousands digit is omitted).

P&Q = similar to groups D and E

R = 50 identifies the 500mb level; in this case the height of the 500 mb level is 5750 m (Note the height is now encoded in decameters).

S&T = similar to groups D and E

U = 40 identifies the 400 mb level; in this case the height of the 400 mb level is 7400 m.

V&W = similar to groups D and E

X = 30 identifies the 300 mb level; in this case the height of the 300 mb level is 9140 m.

Y&Z = similar to groups D and E

AA = 25 identifies the 250 mb level; in this case the height of the 250 mb level is 10,600 m.

BB&CC = similar to groups D and E

DD = 20 identifies the 200 mb level; in this case the height of the 200 mb level is 12,050 m.

EE&FF = similar to groups D and E

GG = 15 identifies the 150 mb level; in this case the height of the 150 mb level is 13,910 m.

HH&II = similar to groups D and E

JJ = 10 identifies the 100 mb level; in this case the height of the 100 mb level is 16,490 m.

KK&LL = similar to groups D and E

MM = 88 indicates that the pressure of the tropopause follows; in this case it's 216 mb.

NN&OO = similar to groups D and E

PP = 77 indicates that the pressure level of the maximum wind follows; in this case it's 248 mb.

QQ	=	similar to group E
RR	=	4 indicates that the vertical wind shear data follow; the next 4 digits represent the shear (in kt) 3,000 feet below and 3,000 feet above the level of maximum wind.
SS	=	51515 indicates that additive data follow
TT	=	10164 indicates that the additive data to follow in the next group represent stability data.
UU	=	Showalter Stability Index indicator; first 3 digits always zero; last 2 digits give index value; negative values have 50 added, e.g. 55 = -5 (Note the lower the value, the more unstable the sounding is).
VV	=	10194 indicates that the additive data to follow in the next 2 groups represent mean wind.
WW	=	Mean wind from surface to 5,000 feet; similar to group E
XX	=	Mean wind from 5,000 feet to 10,000 feet; similar to group E.

- ## Calculating 1000 mb heights

If the code value for 1000 mb height is 500 or greater, then the actual 1000 mb height is below sea level (negative).

This only tends to happen

a. **for stations near sea level and**
b. **when there is a strong low-pressure system nearby with sea-level pressure below 1000 mb.**

To compute the 1000 mb height,

1. **subtract 500;**
2. **put a negative sign on the remainder.**

Example:

coded 1000 mb height value = 521
Actual 1000 mb height = -(521-500) = -21 m

Decoding Upper-Air Data:

SIGNIFICANT LEVEL DATA (TTBB)

A		B	A	C	D	E	F	G	H
72520	TTBB	60121	72520	00973	15644	11967	19050	22961	20057
33784	07413	44700	02240	55654	02508	66650	02917	77643	02164
88626	01568	99400	26363	11273	49758	22216	51358	33178	50749

44100 57559 31313 01102 81102 51515 10181=

A = station identifier (in this example, Pittsburgh)

B = day/time group; same as in TTAA, but the final "0" indicates an equipment code.

C = "00" indicates that surface pressure follows; the next 3 digits give the surface station pressure in whole millibars (mb); in this example 973mb.

D = The temperature/dewpoint depression group associated with the preceding pressure level; same as in TTAA.

E = 11 indicates the first significant level above the surface, in this case 967 mb; significant levels are labeled sequentially "11" through "99" then start again at "11" [11,22,...,88,99,11,22,...]; "00" is used only for surface data.

F = similar to group D

G = 22 indicates the second significant level at 961 mb

H = similar to group D.

Decoding Upper-Air Data:

WINDS ALOFT (PPBB)

These data are found on the PSU Meteo system under DISOBS category 10 (NWS distribution) and under DISOBS category 15 (FAA distribution). File headers look like: FAA333 F604 101211; UJUS81 KWBC 101200 - these are headers of the files transmitted by the FAA604 data circuit (FAA333 F604) and the NWS data circuit (UJUS81 KWBC). 1012 indicates that the data are from 1200 UTC on the 10th of the month, in this case February 1996.

	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**
PPBB	60121	72520	90023	19003	26009	29007	90467	27006	26012
J									
25514	9089/	26514	28516	91246	29523	29024	30528	92045	30535
31543	31043	93025	32037	32538	34061	939//	33540	945//	31034
9503/	31035	31021=							

A = day/time group; same as in TTBB data

B = station identifier (in this example, Pittsburgh)

C = the 9 indicates that wind data follow; the next digit is a tens thousands digit (in this case we're below 10,000 feet); the next 3 digits indicate the levels, in thousands of feet, for the following 3 wind groups (in this case surface, 2000, and 3000 feet).

D,E,F = wind groups for the surface, 2000 ft., and 3000 ft., respectively

G = like group C, but here the announced levels are 4000 ft., 6000 ft., and 7000 ft.

H,I,J = wind groups for the levels announced in G