4.1

Weather and Other Types of Balloons[1]

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Twice each day at the same time around the world, weather offices release balloons that make it possible to gather basic weather information about the atmosphere. As the balloon rises, it carries an instrument package called a "radiosonde" that measures different weather parameters. This snapshot of atmospheric conditions helps meteorologists predict everything from winter storms, floods, thunderstorms, and hurricanes, to freezing levels, aircraft icing, jet stream positions, and maximum temperatures. (See Figure 1 and Table 2)

Weather balloons come in a variety of sizes or weights, giving better accuracy and control in how high as fast a balloon will rise. Balloons can be made of latex or neoprene rubber.

Latex balloons tend to be more spherical when inflated and have a faster, more uniform rise rate into the atmosphere. Neoprene balloons are somewhat elongated, allowing their tops to flatten when rising, providing a slower, less uniform rise rate. Severe weather and fast-rising balloons are available, and are used for special purposes. Typical lighter-than-air gases are used in weather balloons and may consist of hydrogen, helium, or natural gas.

National Weather Service (NWS) balloons are mostly white in color. (Figure 4) However, weather balloons released by other entities such as the military, colleges and universities, can come in an variety of colors that include red, yellow, blue, green, black, etc.

A typical NWS weather balloon has an approximate diameter of five feet (and a volume of about 70 cubit feet) at ground level. The balloon gradually expands as it rises (Table 1). At 2,000 feet above the ground the diameter of the balloon would be about 5.2 feet. At 30,000 to 35,000 feet, the typical cruising altitude for a commercial aircraft, balloon diameter would be expected to be just over 8 and 9 feet with a volume of around 200 cubic feet.

A weather balloon can drift more than 125 miles from its release point. If a weather balloon and its attached cargo enter a strong jet stream it can travel at speeds exceeding 250 mph.

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[1] Additional information on lighter-than-air objects is presented in 4.2.

A weather balloon flight can last in excess of two hours. The balloon can rise over 100,000 feet or nearly 20 miles into the atmosphere, at which time it reaches a diameter of about 20 to 25 feet. At this extreme diameter the balloon material exceeds its limits of elasticity and bursts. The radiosonde suspended below the balloon is released and gently floated back to the ground with the assist of a small, orange parachute.

The radiosonde instrument package used for data collection is suspended about 80 feet below an inflated weather balloon. (Figure 2 and Figure 3) The radiosonde is a little larger than a can of soda, and consists of special sensors that take measurements of humidity, temperature, pressure, wind speed and wind direction. The radiosonde is tracked by ground-based radar that collects and processes the weather data. These data are gathered while the balloon is ascending. Thus the radiosonde gathers no data once it is released from the balloon.

A radio transmitter contained in the radiosonde sends sensor measurements to a ground tracking antenna. By tracking the position of the radiosonde in flight using GPS, data on wind speed and direction aloft are obtained. Only about 20 percent of the approximately 75,000 radiosondes released by the NWS each year are returned to the NWS for reconditioning. These radiosondes are used again, saving NWS the cost of a new instrument.[2]

The data retrieved from this instrumentation are used for local weather predictions. It is also sent to a supercomputer in Washington, D.C., where the weather measurements are used as input for computer modeling of our atmosphere.

Though the typical NWS weather balloon is of a size and shape as previously described - spherical, elongated, or elongated with a mushroom shaped top formed by the flatting of the balloon's topmost section - weather balloons also can come in a variety of sizes and shapes (Figure 8).

The Tetroon is a tetrahedral shaped balloon used for horizontal sounding. (Figure 6 and Figure 7) It was developed to withstand extremely low pressures of high-altitude flight, as it straight seals (joining its four triangular faces) are stronger than the curved seals of the more traditionally shaped balloons. Tetroons have been used extensively in tracing low-level atmospheric currents by following their movement with radar. The use of these balloons has thus increased understanding of atmospheric turbulence, low-level vertical motions, and air pollution dispersion.

Tetroon balloons generally measure approximately 5 to 13 feet from bottom to top. Solar powered Tetroon balloons (the air inside these balloons is heated by the sun causing them to rise) can be easily constructed by hobbyist and/or pranksters using black trash bags and tape (several internet web sites provide instructions for constructing Tetroon balloons). Tetroon balloons are observed nationwide, and due to their odd or somewhat triangular shape, are sometimes reported as unidentified aerial phenomena.

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[2] If you find a radiosonde, follow the mailing instructions printed on the side of the instrument.

Another unique type of balloon, known as the Tethered Aerostat Radar System (TARS), supports a balloon-borne radar system. (Figure 9) The primary mission of the TARS is to provide radar data in support of federal agencies involved in the nation's drug interdiction program.

The air drug interdiction program consists of land-based aerostat radar detection balloons along the U.S. southern border and in the Caribbean. The purpose is to seal off the border to illegal drugs being brought in by aircraft.

The aerostat is a large fabric envelope filled with helium. Its shape is similar to that of the Goodyear Blimp. It can rise up to 15,000 feet while tethered by a single cable. The smallest aerostat is about twice the size of the Goodyear Blimp. The 275,000 cubic foot, aerodynamically shaped balloon measures 175 feet long by 58 feet across the hull, with a tip-to-tip tail span of 81 feet.

The first anti-drug aerostat went operational in 1985 at High Rock Grand Bahama Island. The second site was built at Fort Huachuca, Ariz., in 1986. Overall responsibility for the program was assigned to the Defense Department, with the Air Force as the executive agency.

Commercial uses for balloons include the tethering of miniature blimp shaped objects used for advertising, particularly by car dealerships. Sony Electronics also uses a somewhat downsized motorized version of the Goodyear Blimp over city centers during the summer months for advertising purposes.

Calculating Balloon Diameter at Various Altitudes

When released, the standard NOAA balloon is about 5 feet in diameter and gradually expands as it rises. When the balloon reaches about 20 feet in diameter, it bursts. The balloon rises at about 1,000 feet/minute. Most balloon flights last for around two hours and rise to over 100,000 feet altitude.

More precisely, given the above data, we can calculate the following (assuming that the end of the flight results in the balloon bursting):

$$120 \text{ minutes} \quad \times \quad \frac{1{,}000\text{ft}}{\text{minute}} \quad = \quad 120{,}000 \text{ feet at burst}$$

Given what we know, the balloon will grow an additional 14 ft. in diameter before bursting, (20 ft. – 5 ft. = 15 ft.). (Table 1) Therefore, the balloon expands by 15 ft. in 120 minutes. The rate of expansion is therefore:

$$\frac{15 \text{ ft}}{120 \text{ minute}} \quad = \quad \frac{0.1250 \text{ ft}}{\text{minute}} \text{ expansion rate}$$

Then,

Given	Rate of Climb	Rate of Expansion	Starting Diameter	
[(Altitude in ft.) x	$\frac{\text{minute}}{1{,}000\text{ ft.}}$ x	$\frac{0.1250\text{ ft.}}{\text{minute}}$] +	5 ft. =	Diameter at Given Altitude

Table 1. Balloon Diameter vs. Altitude

Altitude (ft.)	Balloon Diameter (ft.)
2,000	5.25
5,000	5.63
10,000	6.25
15,000	6.88
20,000	7.50
25,000	8.13
30,000	8.75

Balloon Color

The Commerce Department's National Oceanic and Atmospheric Administration (NOAA) has awarded a contract to Kaysam Worldwide, Inc. of Totowa, N.J., to manufacture weather balloons used to gather data for daily weather forecasts. After reviewing photographic data, it appears that the colors of the balloons currently being used by NOAA are white and a natural latex tan. However, weather balloons can be purchased in a variety of colors that include red, black, white, yellow, blue and natural latex tan (Figure 5).

Typical Weather Service Sounding Balloon

Table 2 shows a sample of radiosonde data collected during a balloon flight.

Riverton Observations at 12Z 20 Aug 2001

PRES hPa	HGHT m	TEMP C	DWPT C	RELH %
1000.0	15			
925.0	718			
850.0	1469			
828.0	1703	16.6	-2.4	27
814.0	1849	21.0	-4.0	18
807.0	1923	21.0	-4.0	18
804.0	1955	23.4	-5.6	14
759.9	2438	20.0	-6.2	17
733.3	2743	17.8	-6.5	18
700.0	3141	15.0	-7.0	21
656.9	3658	10.3	-8.9	25
609.4	4267	4.7	-11.2	31
565.3	4877	-0.8	-13.4	38
544.5	5182	-3.6	-14.6	42
521.0	5541	-6.9	-15.9	49
500.0	5860	-9.5	-20.5	40
484.8	6096	-11.5	-22.5	40
464.0	6432	-14.3	-25.3	39
429.4	7010	-18.8	-32.9	28
400.0	7540	-22.9	-39.9	20

Table 2. Example of Data Collected From a National Weather Service Sounding Balloon. (National Weather Service)

PRES = Air Pressure (hPa)
HGHT = Height above ground (meters)
TEMP = Temperature (centigrade)
DWPT = Dew Point (centigrade)
RELH = Relative Humidity (percent)

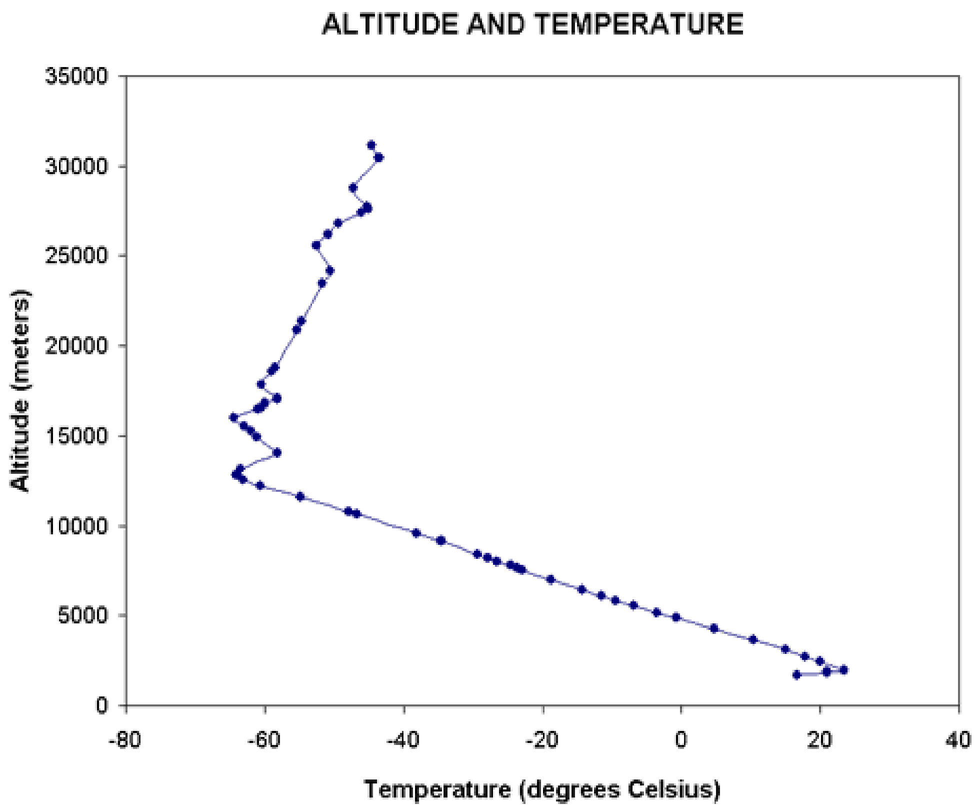

Figure 1. Balloon Sounding Data from Riverton, Wyoming 12Z, August 20, 2001 (Data from National Weather Service Chart)

Figure 2. Radiosonde Instrument Package
(National Weather Service)

Figure 3. Balloon launch from the National
Weather Service's Baltimore-Washington
Forecast Office (National Weather Service)

Figure 4. Launching a Balloon in Antarctica
(National Weather Service)

Figure 5. Radiosonde and Balloon Prior to Release
(National Weather Service)

Figure 6. Tetrahedron Constructed by Tracy Barnes
(Courtesy: Steve Griffin Enterprises)

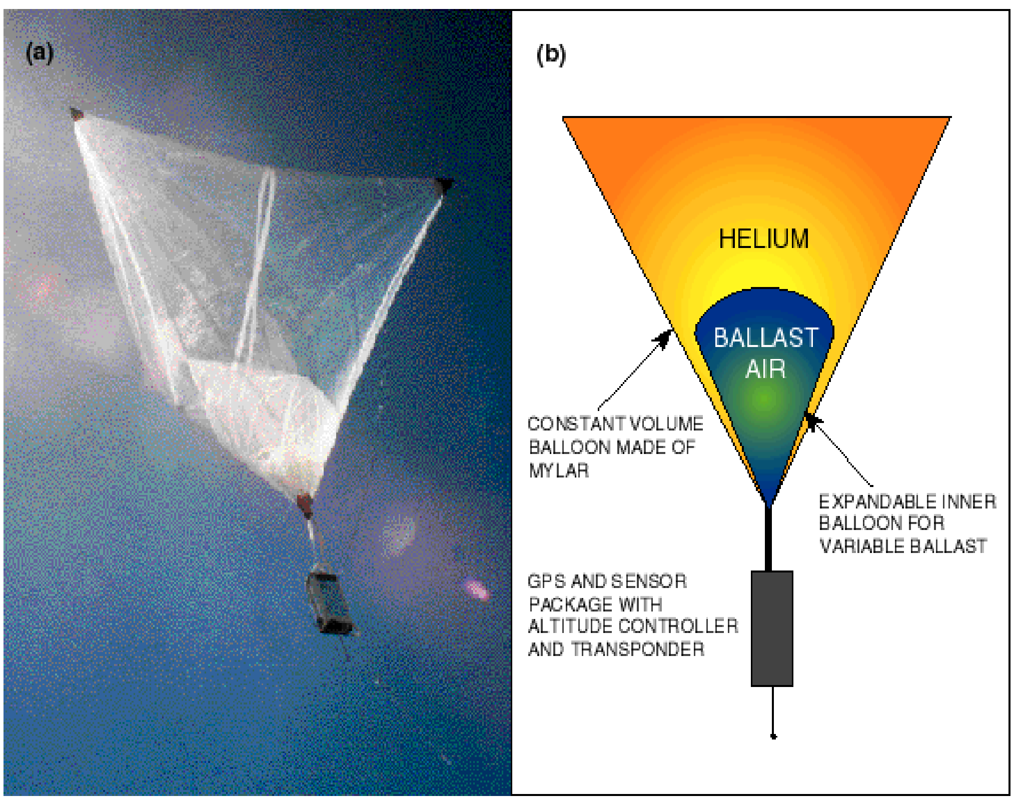

Figure 7. (Left) Ballasted Tetroon in Flight. (Right) Sketch of the “Smart” Tetroon
Showing Primary Components.
(Johnson, Carter, and Businger 1998, Businger et al. 1998)

Figure 8. Shipboard Towing System
(National Weather Service)

Figure 9. Tethered Aerostat Radar System Balloon-Borne Radar