The Effect of Altitude on Relative Humidity
2.4.06
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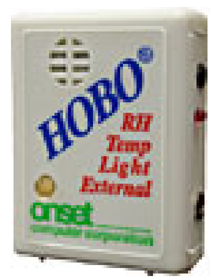
Objective:
What effect does altitude have on relative humidity?

Theory:
Relative Humidity (RH) is the amount of water in the air compared to how much water the air can hold. Temperature decreases higher in the atmosphere. Colder air can hold less water than warm air. If the air holds about the same amount of water at a higher and lower level altitude, the higher altitude should have greater relative humidity, because the ratio of water to the amount the air can hold would be greater.



Clouds can also effect the relative humidity readings. Clouds add moisture to the air, which increases the relative humidity. However, most clouds only reach the altitude of 18,288, so clouds should not affect the readings taken above that elevation.

Clouds under 3,048 meters produce little or no precipitation, which means that they are not as dense and should have very little effect on the RH. Clouds that range from 3,048 to 6,096 meters are common after storms or may become precipitating clouds and may cause small spikes. Clouds that are over 6,096 meters are common indicators of a coming storm and may also cause small spikes. Clouds that are up to 18,288 meters often cause large storms and will cause the biggest spikes in relative humidity.

To check and see if the readings were accurate, the data was compared to readings posted on a Wyoming web site. This web site shows several different kinds of readings including relative humidity, and altitude. Each reading corresponds with a time, which can be aligned with time from the HOBO data. Data from the web site can be found for certain days and times, making it easy to match up data from personal launches. The relative humidity data was plotted against altitude to see what the correlation is between the two.

Apparatus:
The device used to calculate relative humidity in this experiment was an RH HOBO, model H08-004-02 bought from Onset Comp.com.The HOBO uses a ceramic relative humidity element. Each time the HOBO takes a reading, the element blocks a certain amount of current. The amount of current that reaches the sensor is proportional to the amount of relative humidity in the air. Altitude readings were taken on both a HOBO that takes altitude readings and the GPS that was also used for tracking the balloon. The readings taken on the GPS were more accurate because the GPS used triangulation to measure the altitude while the HOBO measured barometric pressure.

This sensor was launched on a high altitude balloon. The balloon used was latex and can be bought in different sizes depending on what altitude the balloon should reach. The size used for this experiment was 3000 grams, and each of five launches went over 100,000 ft. in altitude. Boxes made with insulator Styrofoam were used to hold the equipment when the balloon was launched. Each box was covered with Mylar and a sewn nylon slip. Two boxes were used; one to hold communication equipment such as the STXe GPS, while the other was used to hold equipment used for the various experiments on the launch. The boxes were connected with string to a parachute, which was connected to the balloon for a safer descent.

Procedure:

1.Obtain all equipment needed to perform this experiment.

2.Build payload boxes using the Styrofoam insulation and seal with caulk. Glue on Mylar to the outside of the box and cover with a sewn nylon slip.

3.Next choose a site from which to launch the balloon. The best site is one that has very little wind, a lot of open space, and no mountains nearby. Before going on the launch, safely pack all equipment.

4. Upon arrival at the site, get the HOBO and GPS equipment ready. To start the HOBO, plug it into the computer and enter the software program, Box Car 3, which is the software program that controls the HOBO. Click the first button with an arrow pointing towards a box. Set the timing and any other settings needed. If you do this the night before you launch you can program a delayed start to save time on launch day. Once this is finished, press okay and unplug the HOBO. A blinking light on the HOBO should show that it is working.

5. Pack all the equipment into the boxes while inflating the balloon.

6.Use carabiners to attach the packed boxes to the parachute (which is attached to the balloon).

7.Release the balloon and payload.

8.Load into vehicles and track the balloon using the GPS Flight computer software and HAM radios. Use the latitude and longitude readings on both devices and consult detailed maps to decide which roads to take.

9.Recover the payload from the site where the balloon landed.

10.Offload the HOBO data using Box Car 3 and analyze it, etc. Box Car will show graphs of the data as well as high, low, and individual data points. Export the data to Microsoft Excel to graph relative humidity against altitude.

Data and Computations:

Export the data from Box Car to Excel to organize the data into neat tables. From here, add altitude readings to the table and graph Relative Humidity vs. Altitude. For data from this experiment, see charts and graphs on the following pages. To compare the data, a web site was used that gave RH readings for certain days and times. When the data from this experiment was compared, some of the days followed the same pattern. The web site used in this experiment was; "Maps Sounding Profilers." University of Wyoming College of Engineering Department of Atmospheric Science. University of Wyoming. 25 June 2005 <http://www.weather.uwyo.edu/upperair/sounding.html>.
Also, take into account the fact that the HOBO has a 5% margin of error.

Results:

In this experiment, the balloon was launched five times. Three out of these five times had results that proved our hypothesis that RH would increase as altitude increased correct. However, two of those days did not have data that followed the pattern of the Wyoming Sounding data, which we believe to be more accurate. Clouds also caused spikes in relative humidity because they carry more water vapor than the air around them. On August 16th a tube that was attached to the HOBO and extended to the outside of the box. The tube was attached to give the sensor a more direct contact to the outside air since the HOBO had to be kept in the box. Water vapor condensed in the tube after it passed through clouds, causing the RH to spike. This made the pattern very hard to follow. Another day did not follow the hypothesis because of the weather. There was a lot of low fog that day, which caused the lower levels of altitude to have a high amount of relative humidity. The day was also cloudy and rainy, causing the relative humidity to spike at irregular points in the atmosphere. Take into account that the HOBO works best in certain temperatures and that the hand-warmers placed in the box to keep the HOBO warm may have influenced some of the readings taken.

References:

"Maps Sounding Profilers." University of Wyoming College of Engineering Department of Atmospheric Science. University of Wyoming. 25 June 2005 <http://www.weather.uwyo.edu/upperair/sounding.html>.

"Predicting Weather." www.ussartf.org. 25 June 2005 <http://www.ussartf.org/predicting_weather.htm>.

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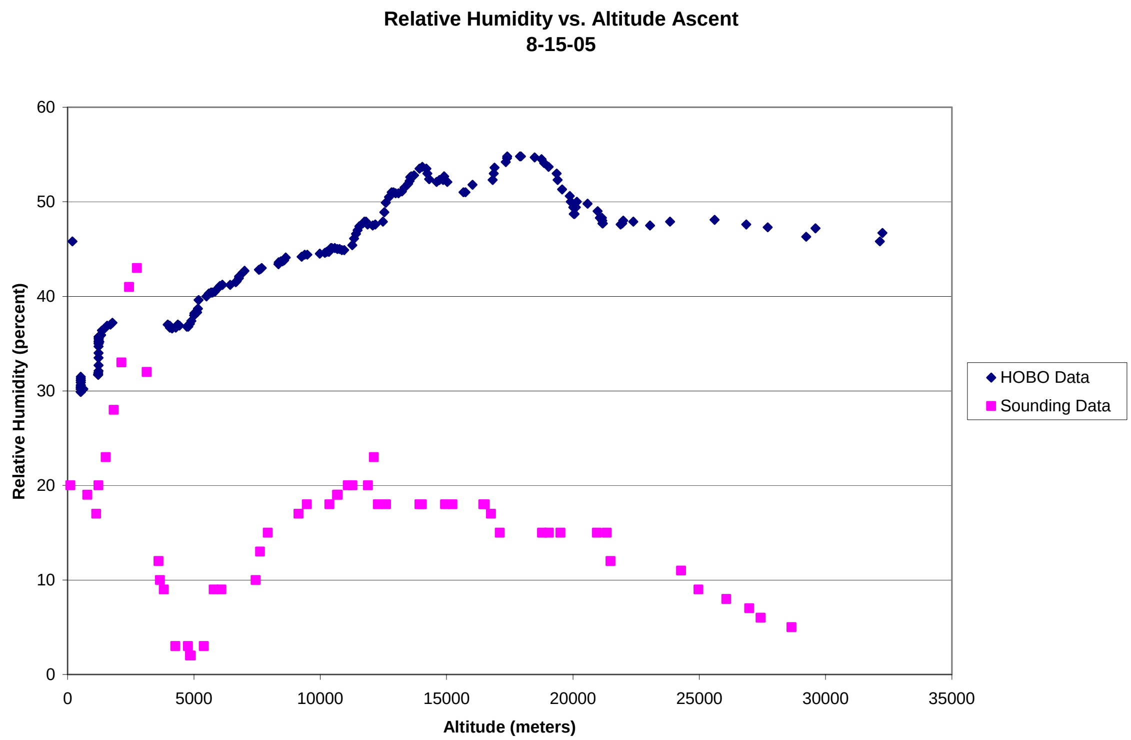
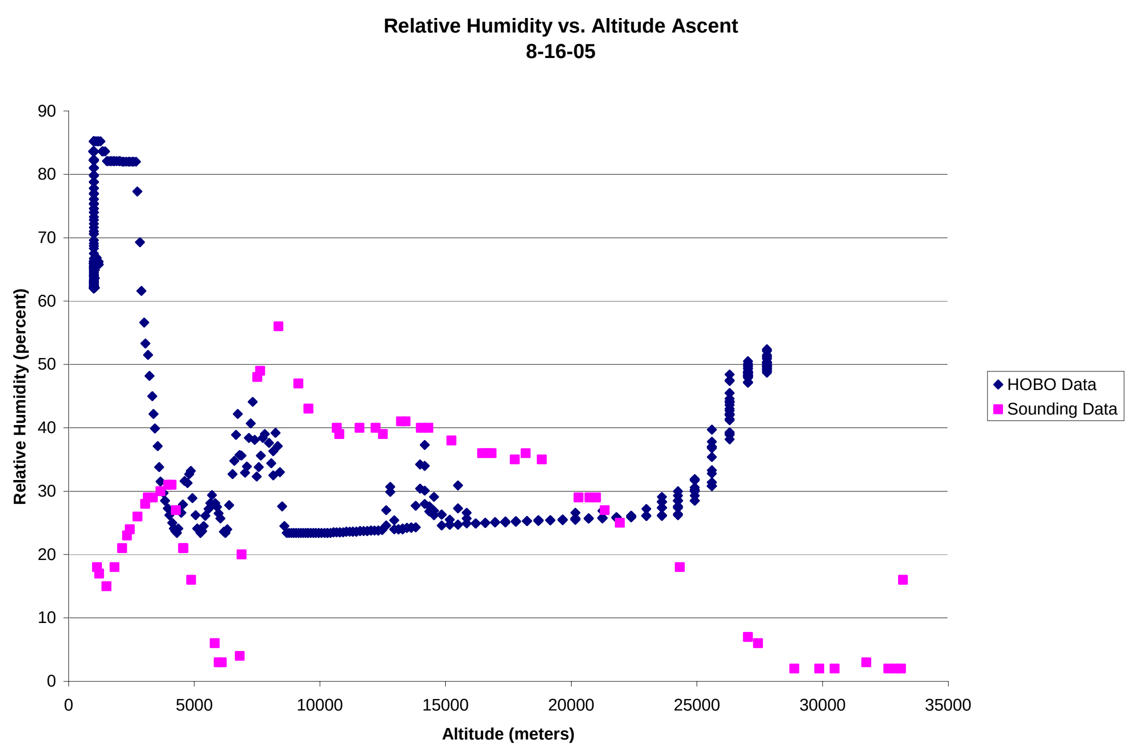
"Weather 101-Cloud Formations." 28 Aug. 2000. 25 June 2005 <http://www.boatsafe.com/nauticalknowhow/weather1.htm>.

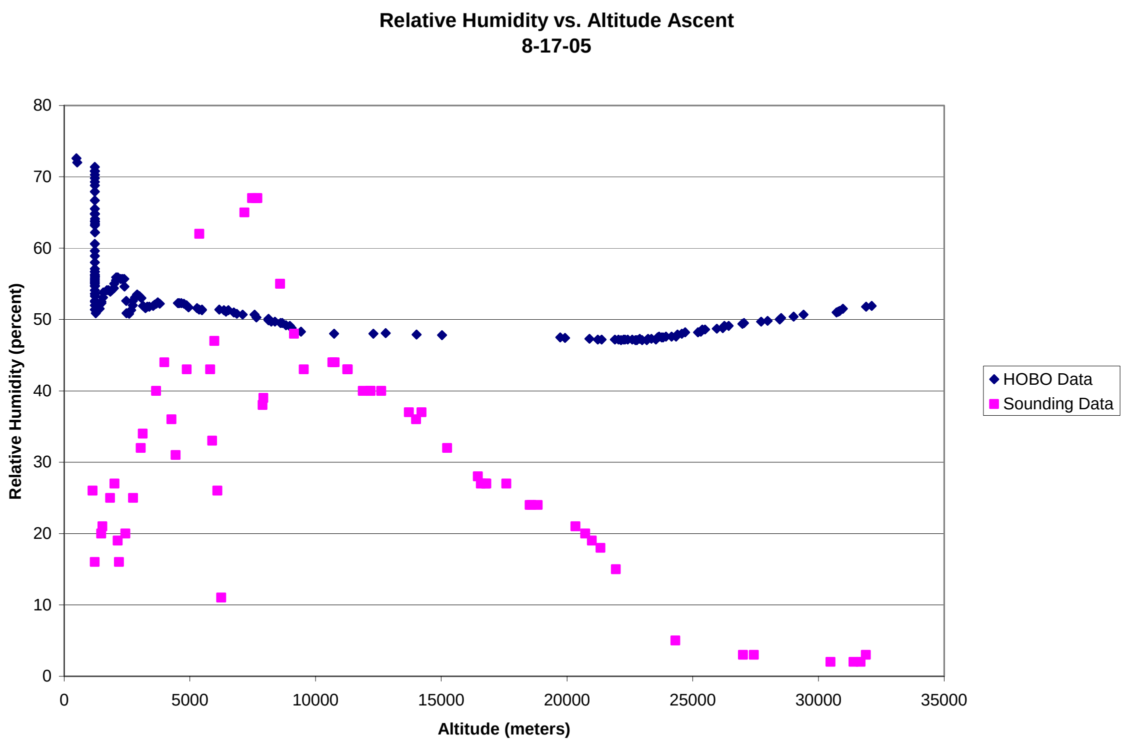
Williams, Jack. "Understanding Humidity." USA Today. USA Today. 25 June 2005 <http://www.usatoday.com/weather/whumdef.htm>.

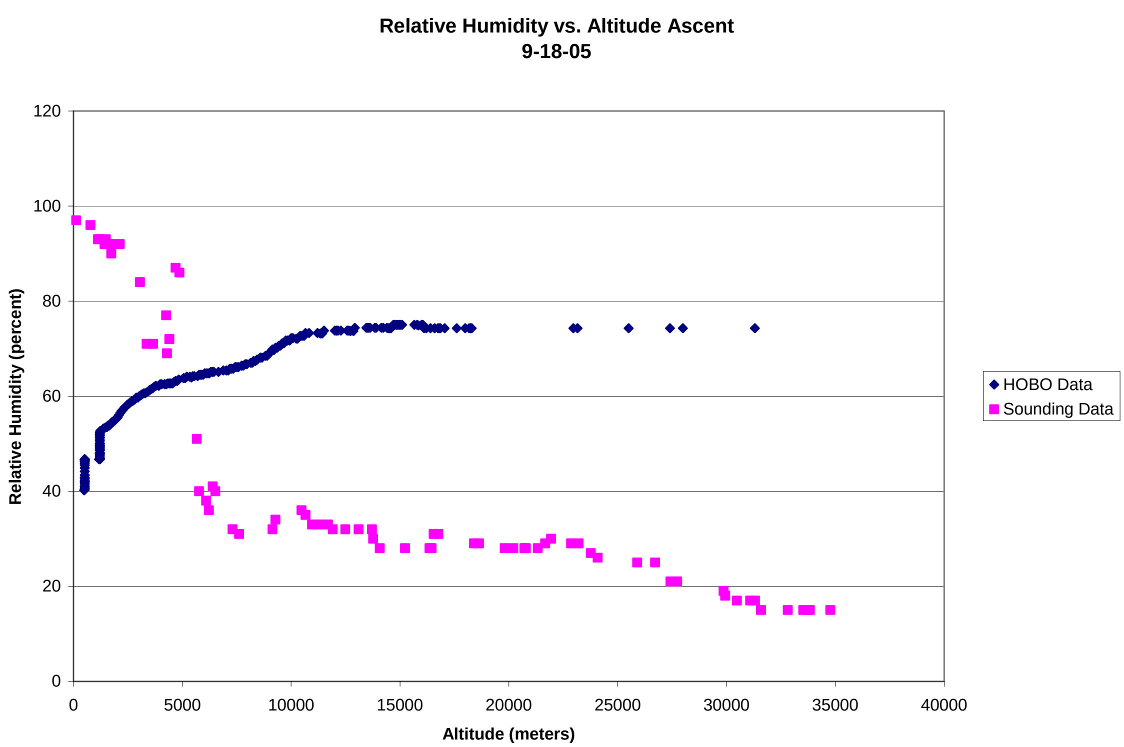


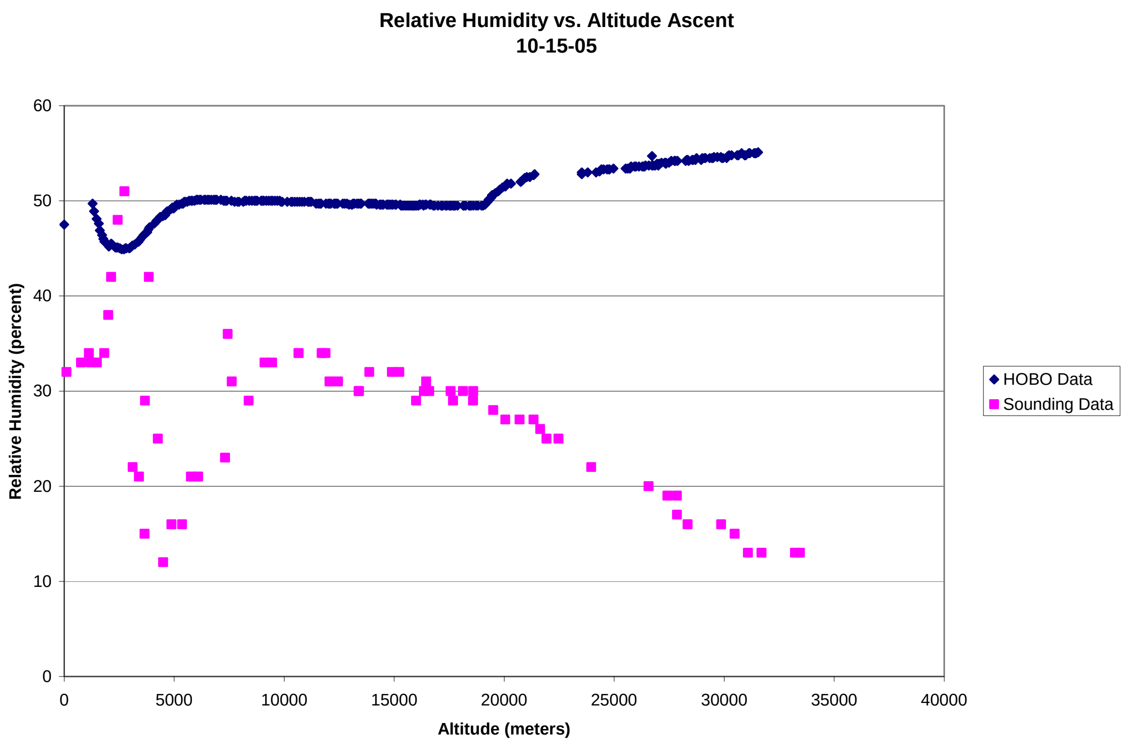
Relative Humidity vs. Altitude Ascent
8-15-05
Relative Humidity (percent)
Altitude (meters)
HOBO Data
Sounding Data
0
10
20
30
40
50
60
0
5000
10000
15000
20000
25000
30000
35000



Relative Humidity vs. Altitude Ascent
8-16-05
Relative Humidity (percent)
Altitude (meters)
HOBO Data
Sounding Data
0
10
20
30
40
50
60
70
80
90
0
5000
10000
15000
20000
25000
30000
35000


Relative Humidity vs. Altitude Ascent
8-17-05
Relative Humidity (percent)
Altitude (meters)
0
10
20
30
40
50
60
70
80
0
5000
10000
15000
20000
25000
30000
35000
HOBO Data
Sounding Data


Relative Humidity vs. Altitude Ascent
9-18-05
Relative Humidity (percent)
Altitude (meters)
0
20
40
60
80
100
120
0
5000
10000
15000
20000
25000
30000
35000
40000
HOBO Data
Sounding Data


Relative Humidity vs. Altitude Ascent
10-15-05
Relative Humidity (percent)
60
50
40
30
20
10
0
0
5000
10000
15000
20000
25000
30000
35000
40000
Altitude (meters)
HOBO Data
Sounding Data