University of Maryland Baltimore County - UMBC
Phys650 - Special Topics in Experimental Atmospheric Physics
(Spring 2009)

J. V. Martins and M. H. Tabacniks

http://userpages.umbc.edu/~martins/PHYS650/

- Grading feedback:
  - Pay attention to the grading structure of the course
  - Schedule an appointment this Thursday for discussion on your grades so far.
  - Keep up with your project and with the quality of your short reports.
- Many short reports are inadequate and need more work
  - Students will be allowed to re-work two short reports (based on their notes) in order to improve their grades

Grading Structure:

Course Grading:

- Class participation and short weekly reports (typically 3-5 pages including figures and tables) of relevant results and analysis should be sent to the instructors in a PDF file the day before class until noon. These results will be discussed during class (50%).
- Project execution (25%).
- Oral presentation of the project in the last class (10%).
- Term paper describing the project and main results in a format similar to a Journal publication (15%).

Hint: Start early and keep up with the Course Project! The project is a great tool for learning and to expose you to new challenges. Work as much as you can with the course instructors in order to develop, design, and execute your project.

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Class 10 – Discussion on Short reports from previous classes (8 and 9)

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What you were asked to do:

Hands on component (from course's web page):

- **Group 1 – Development of an environmental chamber**
  - Students will develop an environmental chamber that can produce variable and stable relative humidities, which will be used for the intercomparison of all the hygrometers produced by the other groups. This group will also be responsible for running the VAISALA humicap sensor, which will provide the reference method for intercalibrating all other techniques.

- **Group 2 – Development of a wet/dry bulb psychrometer**
  - The wet/dry bulb psychrometer will be made out of two bulb thermometers, a wet wicking fabric, and an automated fan or pump system that will suck the air sample through the system.

- **Group 3 – Development of a passive chilled mirror hygrometer**
  - A chilled mirror device should be placed between two heat reservoirs (1 cooled and one heated). A distance scale between the two reservoirs must be calibrated as a function of temperature. The temperature of the heat reservoirs should be kept as constant as possible and must be constantly monitored to guarantee the integrity of the measurements.

- **Group 4 – Development of an active chilled mirror hygrometer**
  - A chilled mirror device should be built between a cooled heat reservoir (liquid Nitrogen) and a controlled heater device (resistor). The power applied to the resistor will determine the amount of heat on the heated side of the device and should be measured constantly. The power on the resistor must be varied in order to keep the dew (or frost) point always in the same position on the chilled mirror. The RH from the environmental chamber should be used as a reference to calibrate the power in the resistor.

Guidance for weekly report #8 & #9:

- Describe what you learned with the visit to the Beltsville facility and the balloon experiment
- Make a bibliographic review and research on methods to measure relative humidity in the atmosphere. Make sure you cover at least the following methods:
  - Capacitive measurements of Relative Humidity (RH)
  - The Vaisala Humicap sensor/methodology
  - Wet/Dry bulb psychrometers
  - Chilled mirror Hygrometers
- What are dew point and frost point temperatures?
- How can you determine the atmospheric RH based on dew point measurements?
- How can you determine the atmospheric RH based on the wet/Dry bulb psychrometer?
- Find out and describe the properties of different solutions and/or phase transitions you can use for the calibration of thermometers at different temperatures or for the construction of the heat reservoirs for your hygrometers
- Describe your week's experiment and the theory behind it. Make sure you use drawings and/or pictures to represent what you are trying to do
- Read and describe the reference: Vomel, H., D. E. David, and K. Smith (2007), Accuracy of tropospheric and stratospheric water vapor measurements by the cryogenic frost point hygrometer: Instrumental details and observations, J. Geophys. Res., 112, D08305, doi:10.1029/2006JD007224.
- Go to the waves webpage, download, plot, and describe any radiosonde data from there that you like.

Summary from Student Reports:

Experiment #1

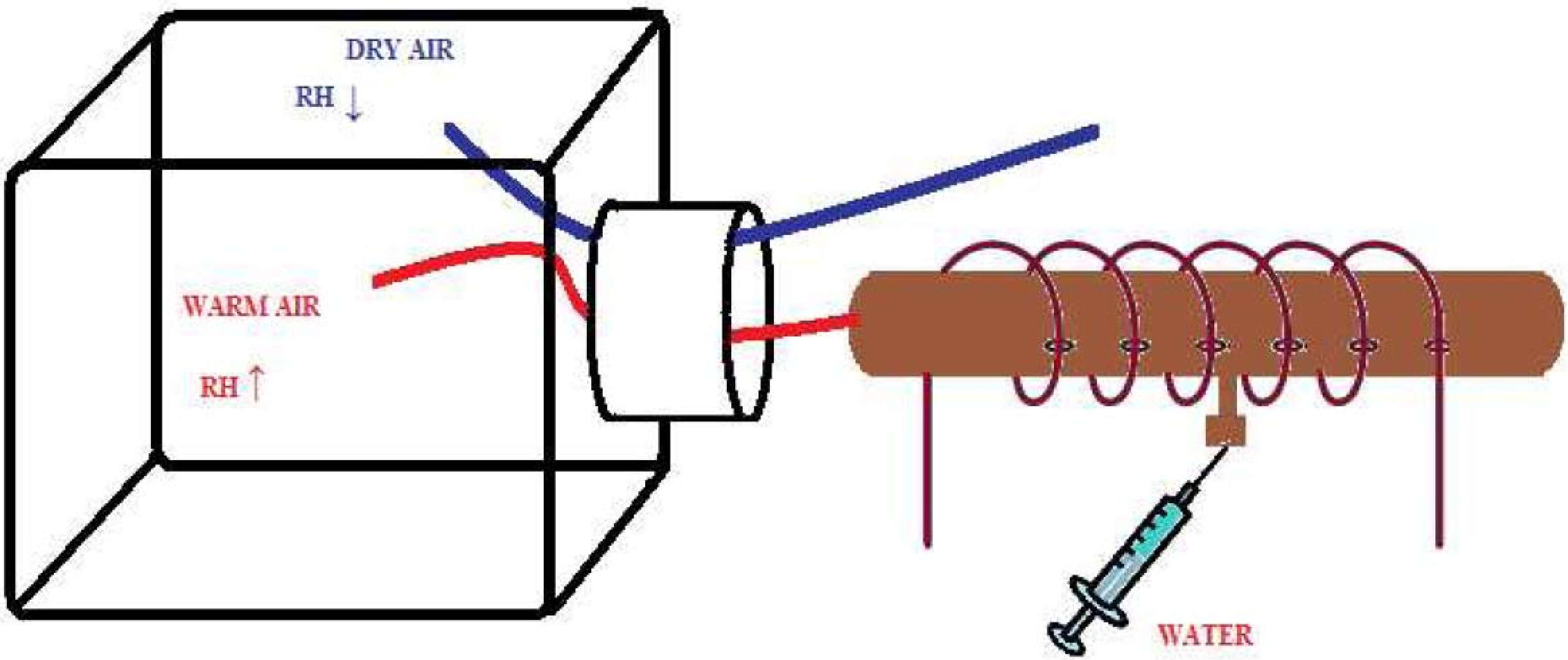


Fig.4 – Schematics of how the RH was controlled in the environmental chamber

Humidifier System:

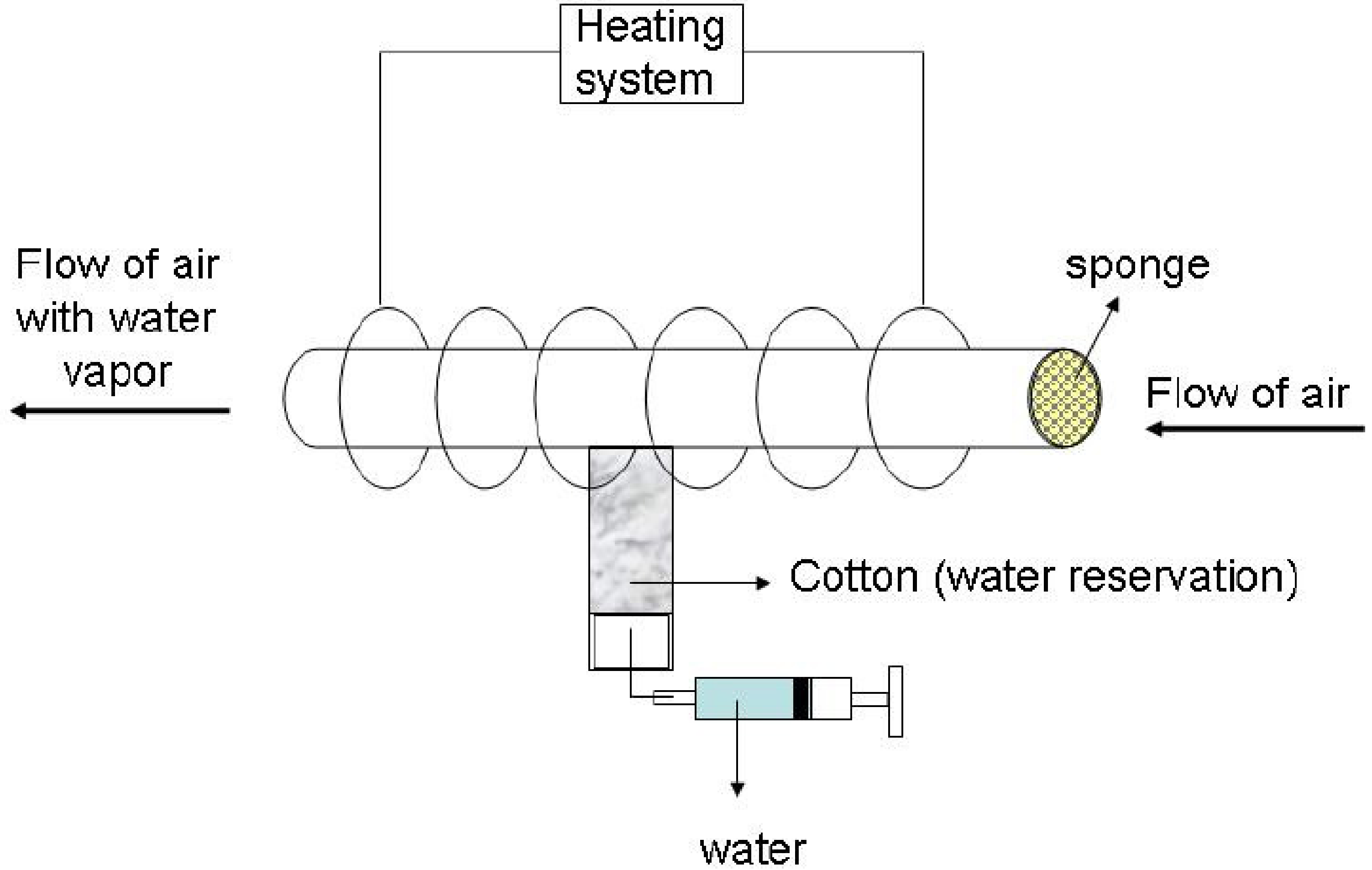


Figure 1. System to create air with high concentration of water vapor.

Experiment #2

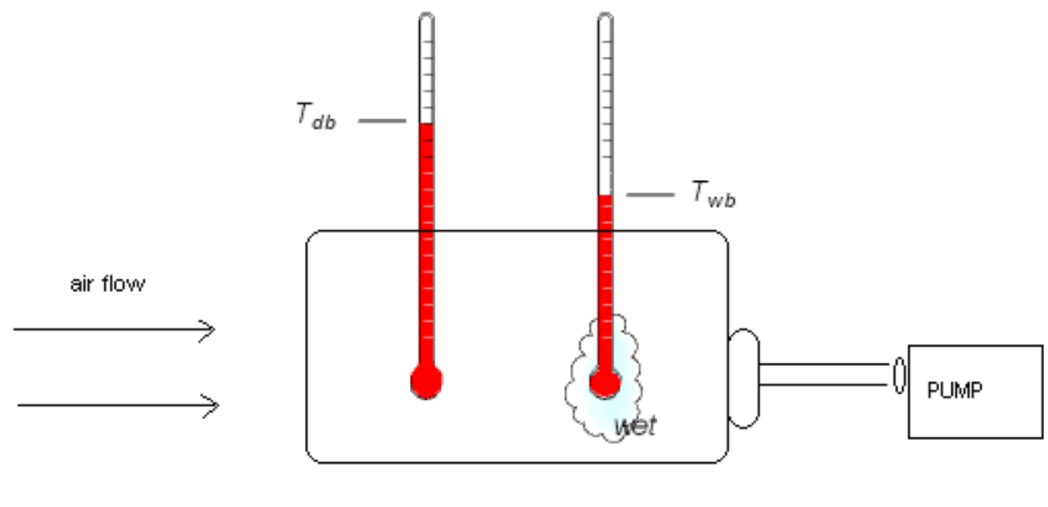


Fig 1. – Wet/Dry bulb illustration (modified from www.engineeringtoolbox.com)

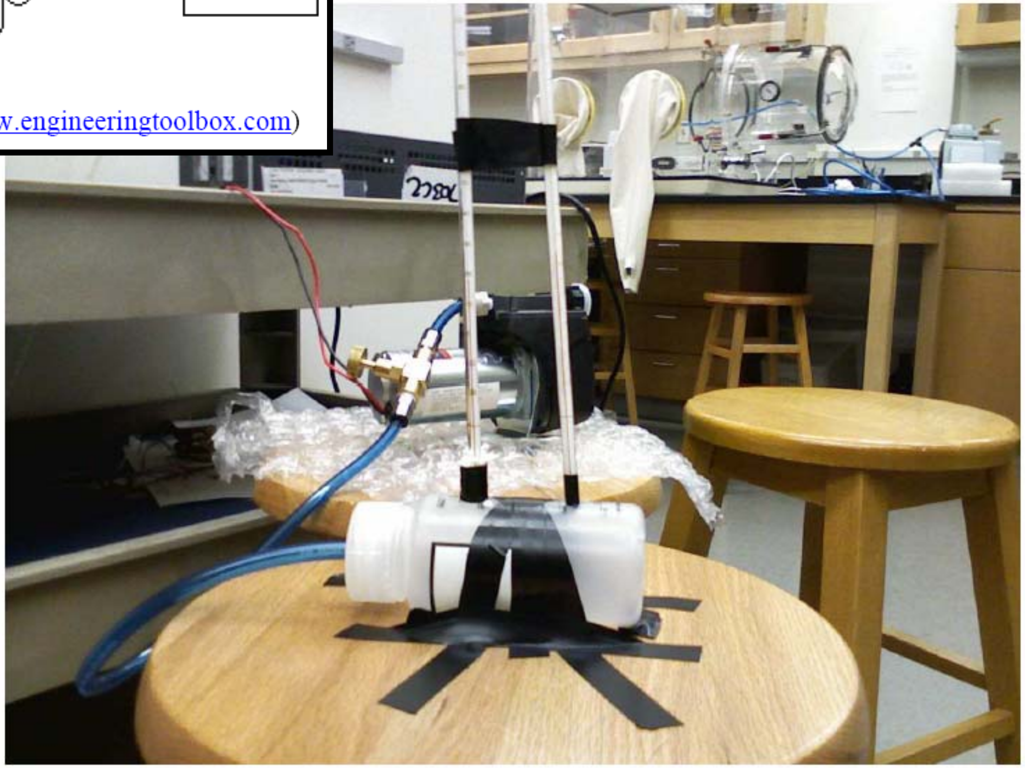
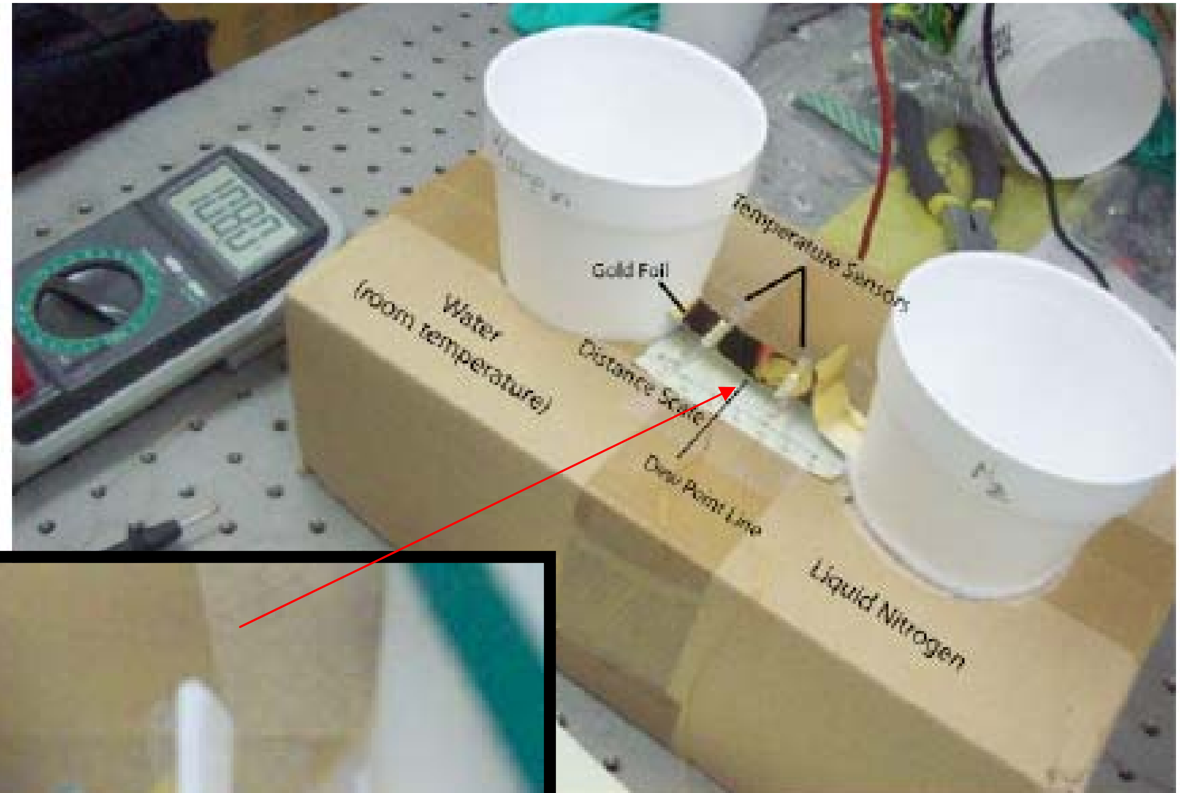
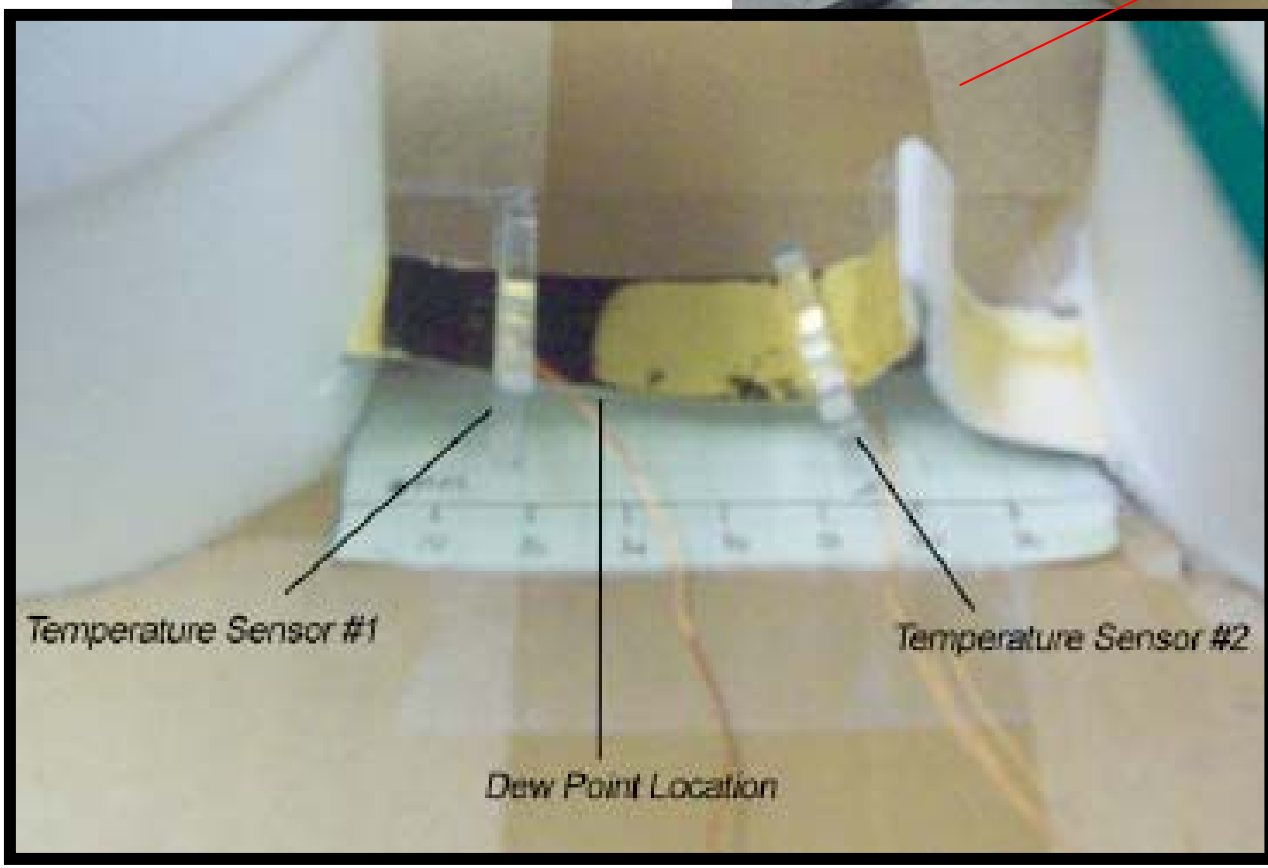


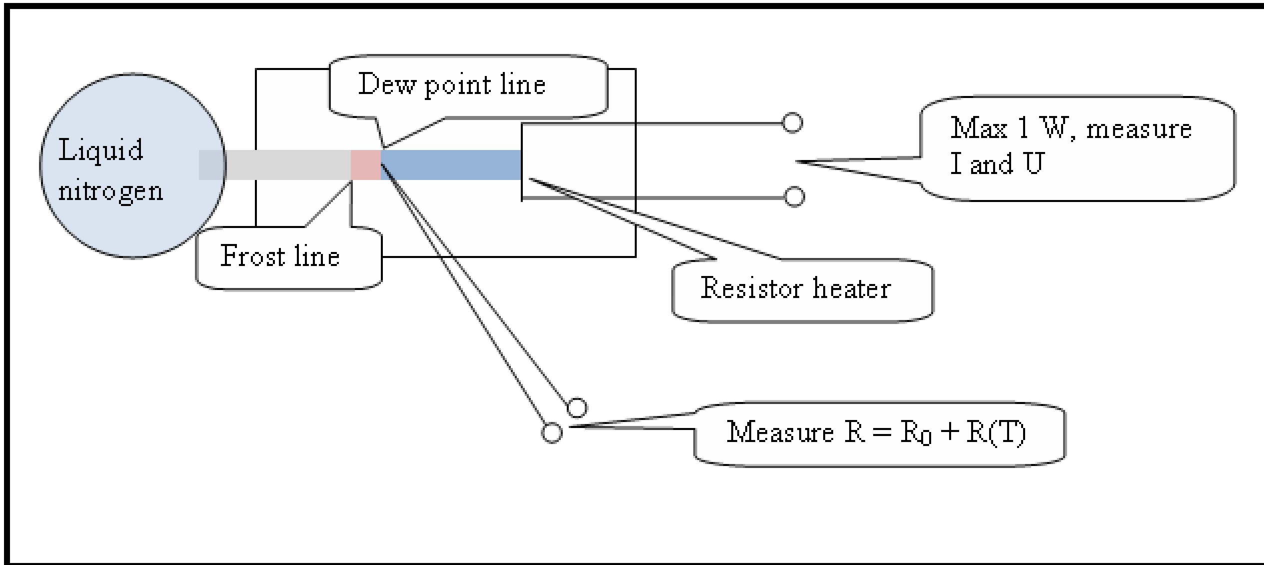
Fig 2. – The wet/dry bulb psychrometer built in class using a bottle, electric tape, two alcohol thermometers a piece of wet cloth and a vacuum pump to suck air through the thermometers.

Experiment #3





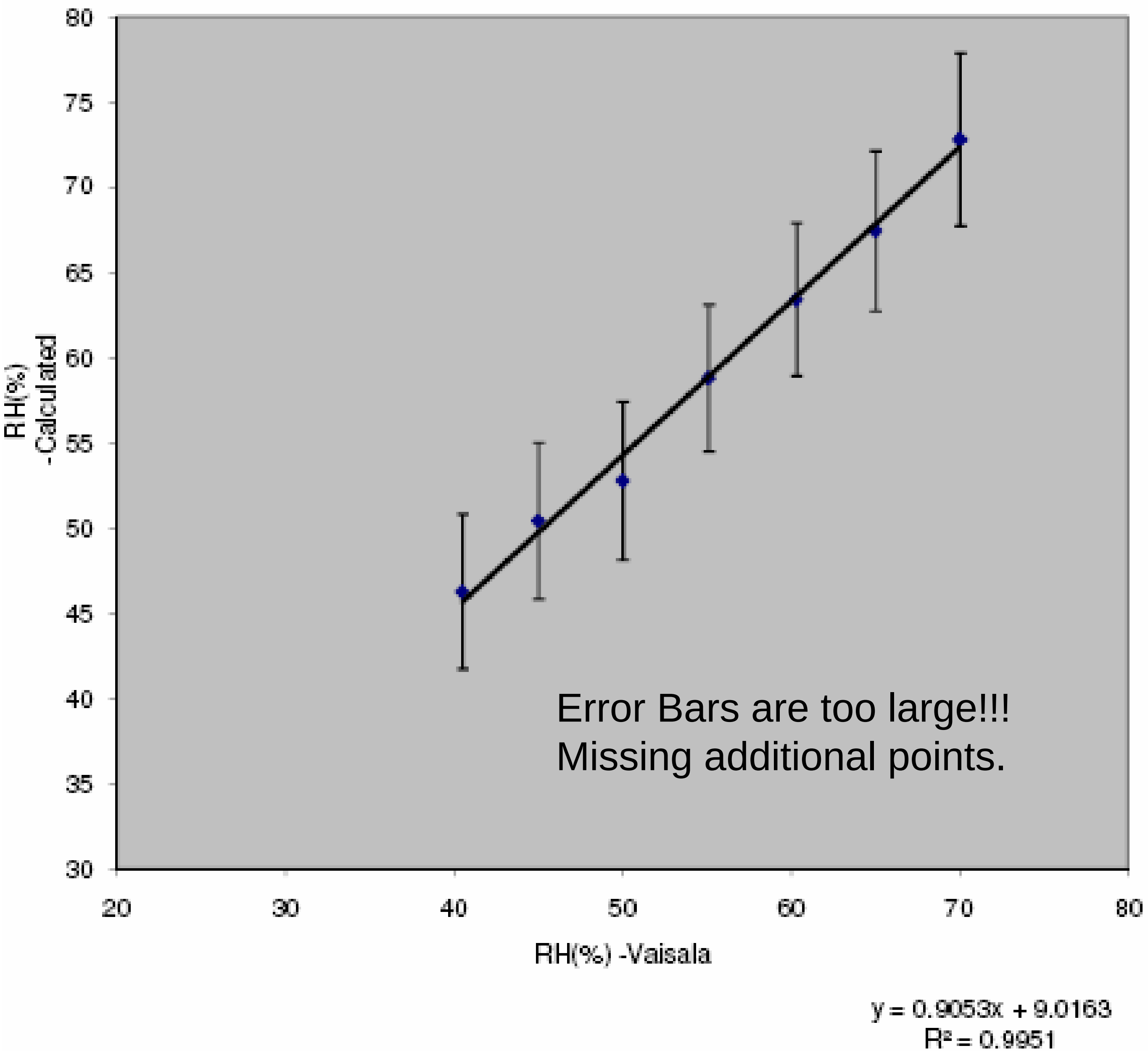
Experiment #3



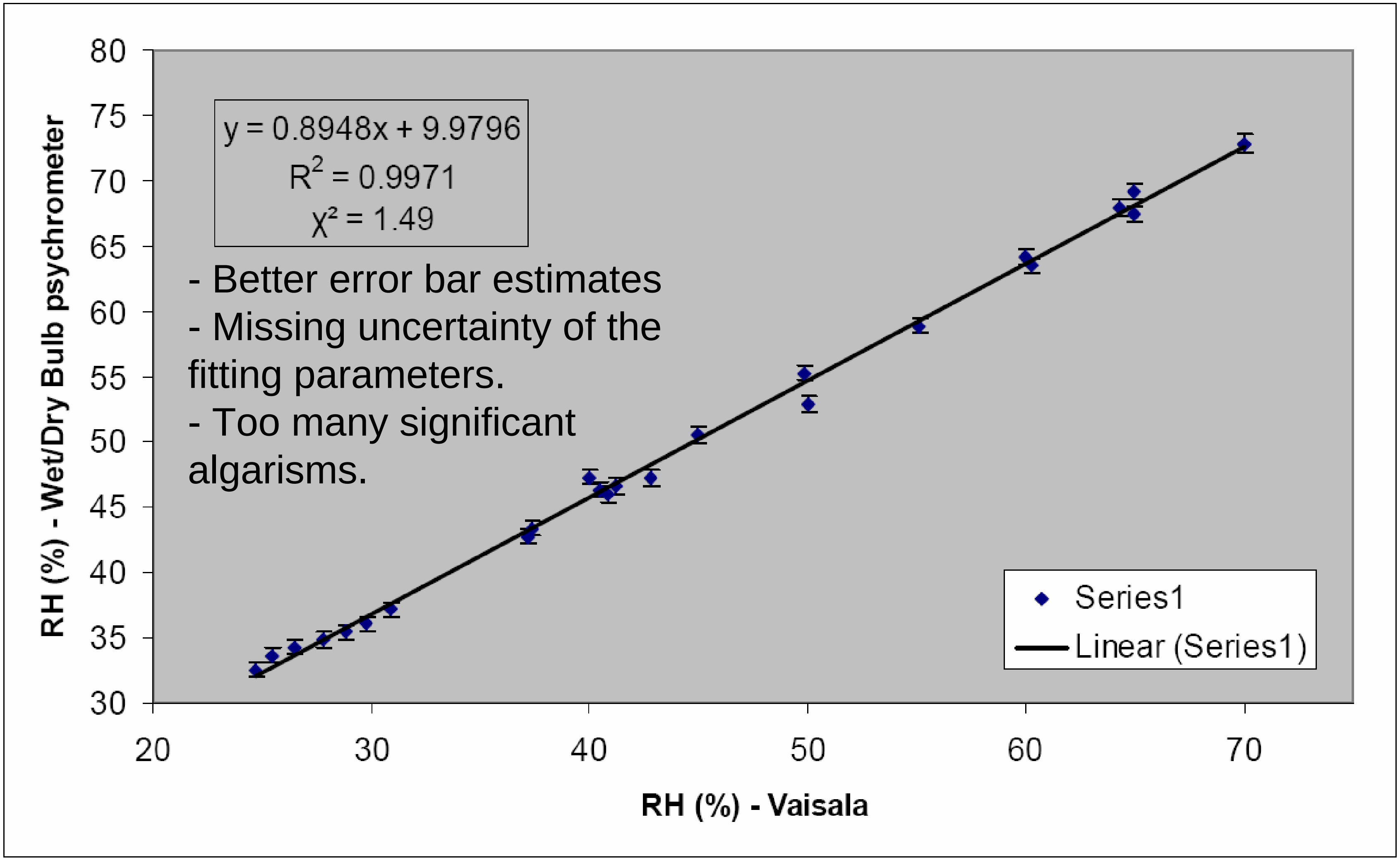
Experiment #4

Data Analysis:

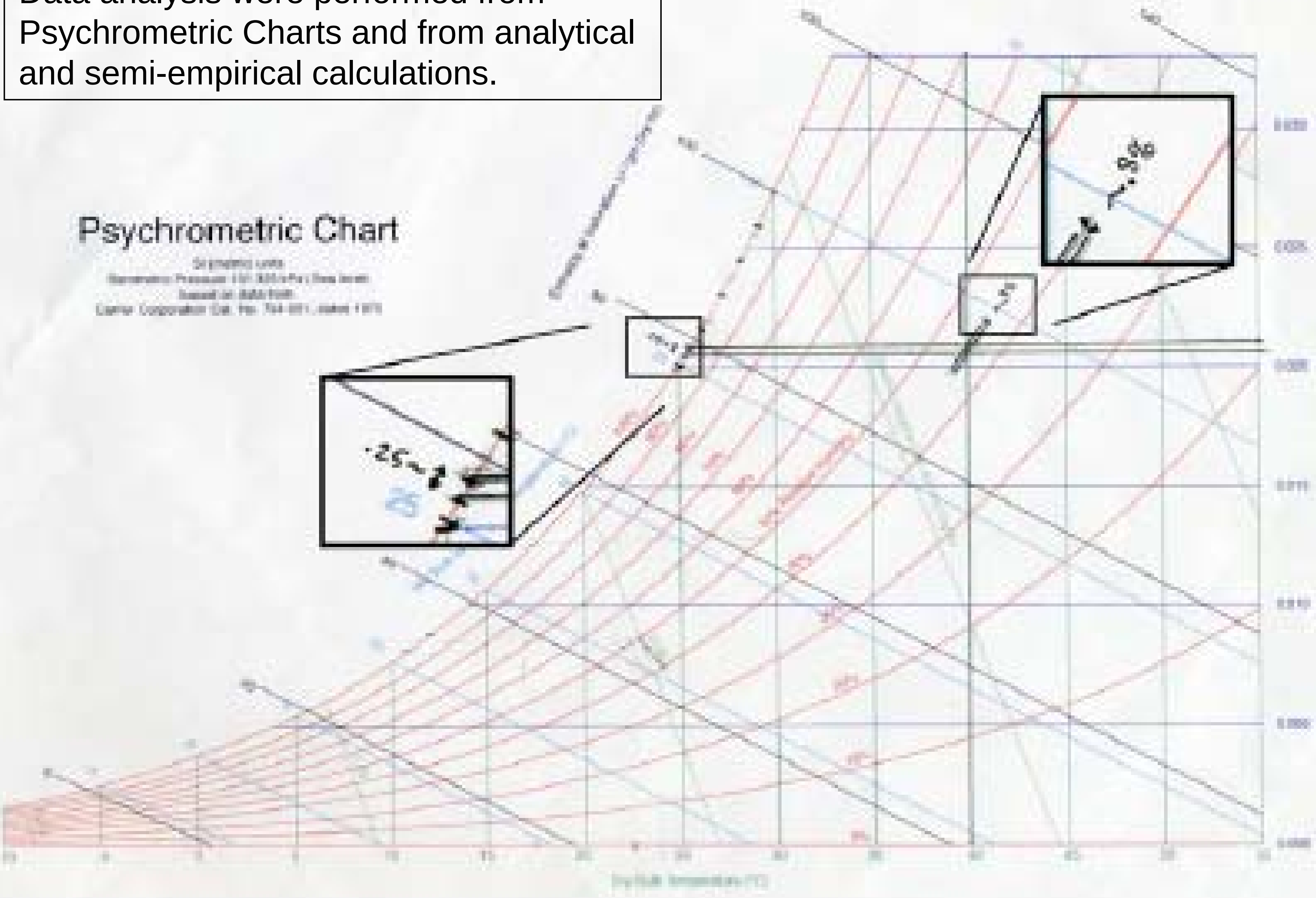
Results from Dry-Wet Psychrometer:

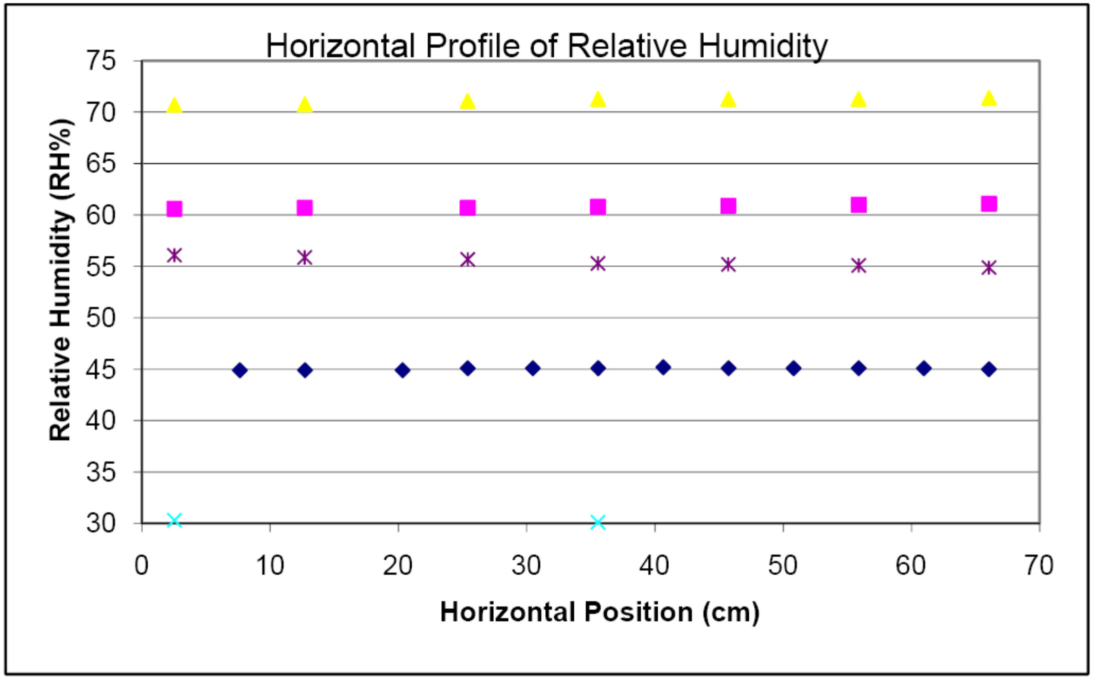


Results from Dry-Wet Psychrometer:

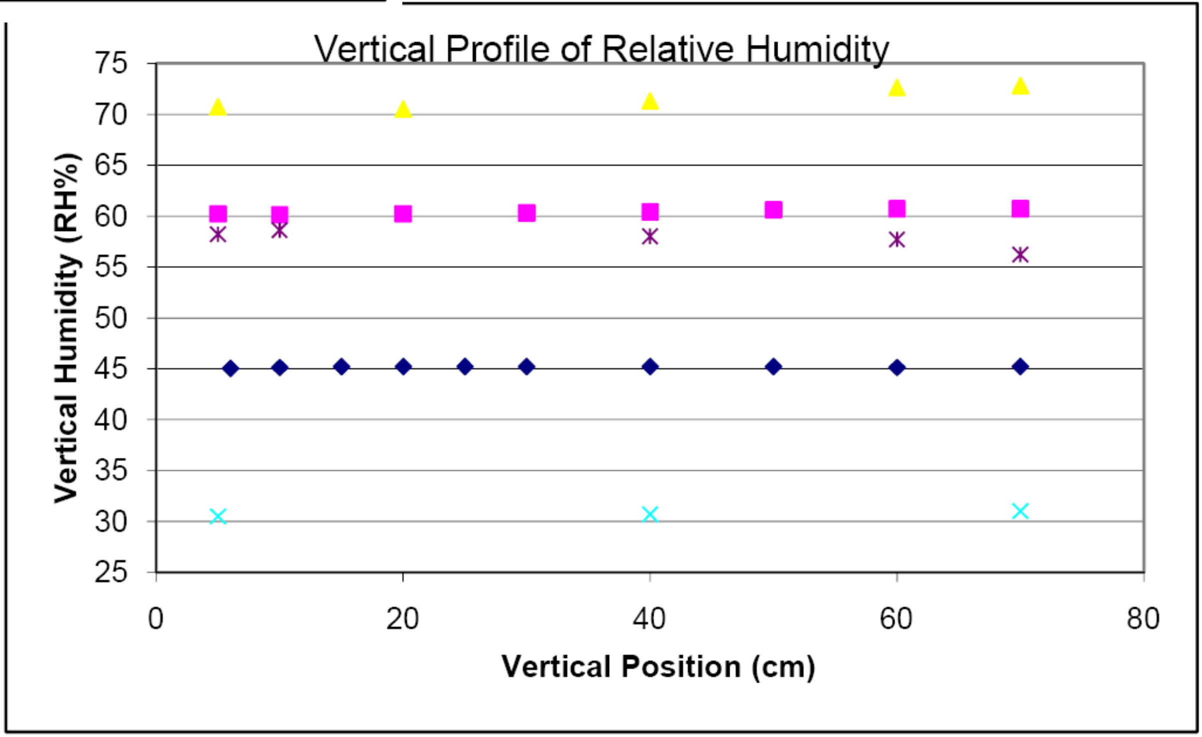


Data analysis were performed from Psychrometric Charts and from analytical and semi-empirical calculations.

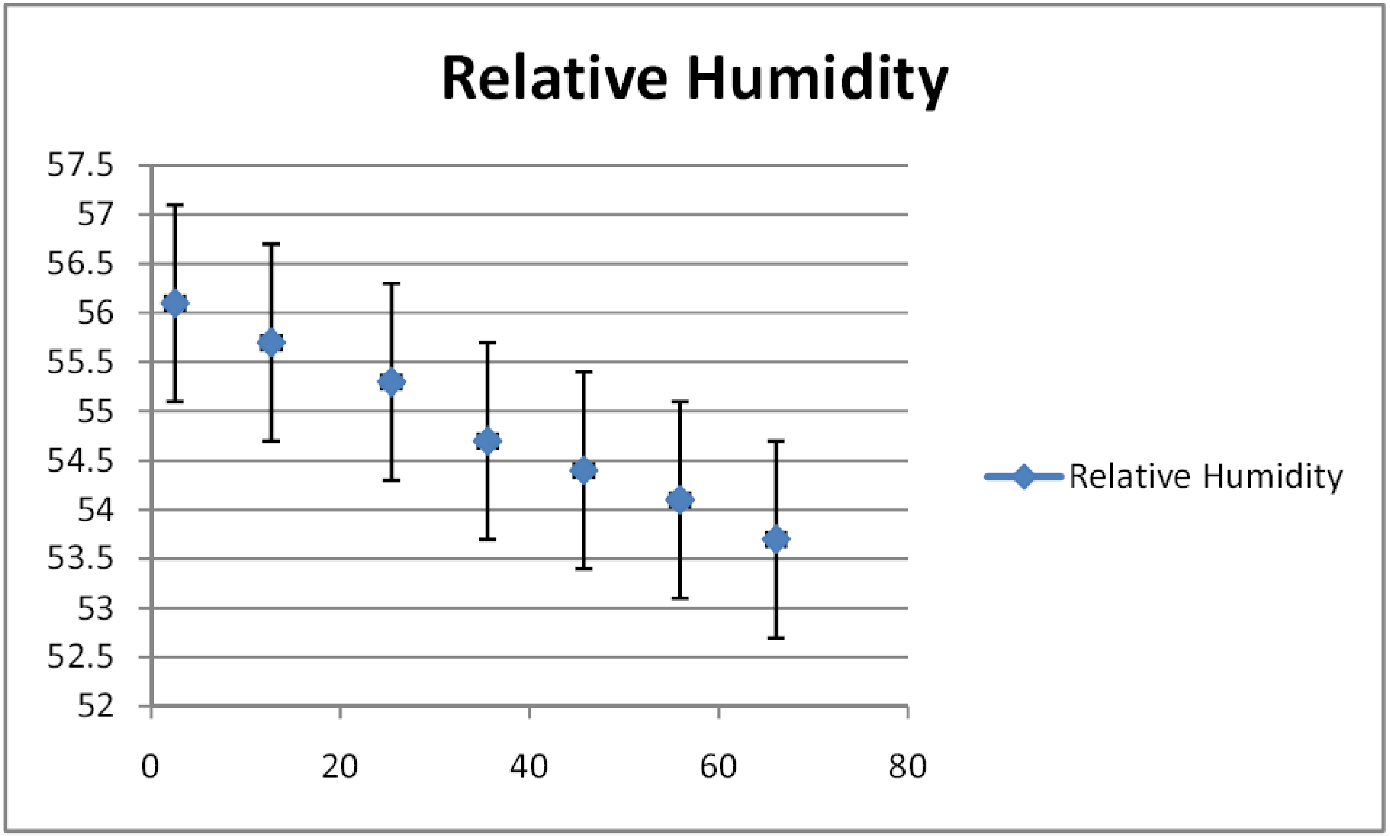




Results from the Environmental Chamber:



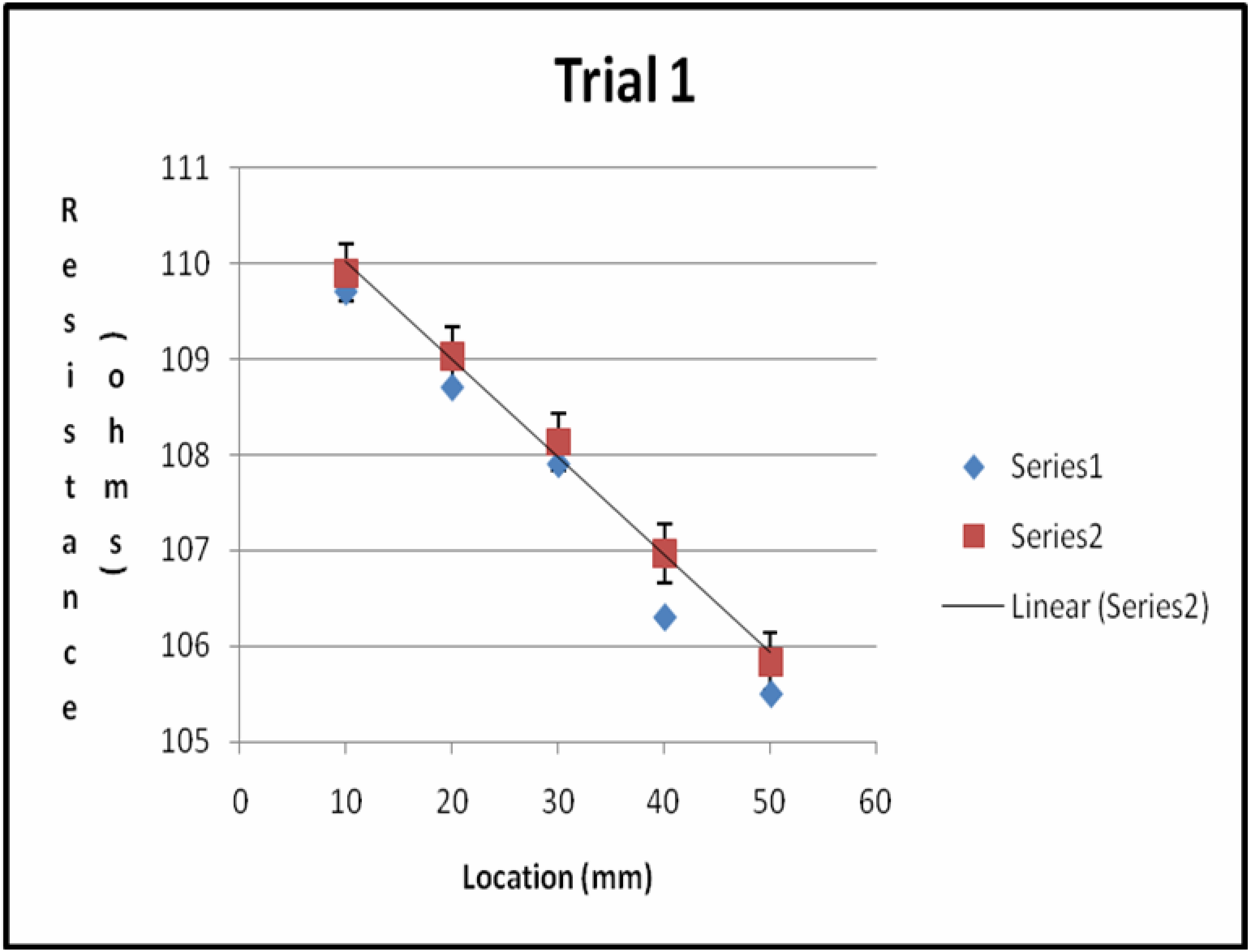
RH profile inside Chamber with Fan Off:



If appears that, in this case, diffusion was not enough. The positions were distances away from the fan, so it appears as though relative humidity was higher near the fan. Apparently it was well placed! I suspect that humidity was higher on the fan side (with the fan off) because there was

Experiment #3

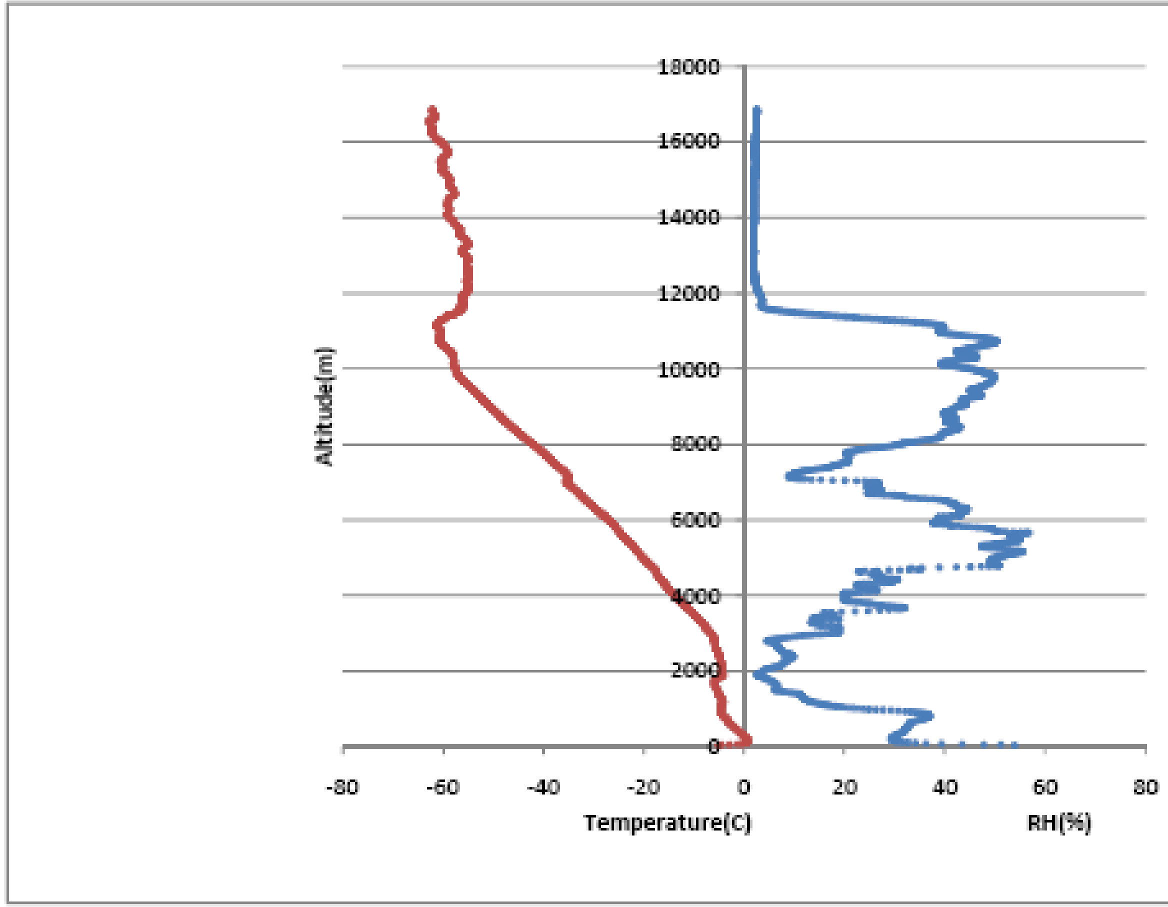
Measuring Temp. profile along the Gold foil



Results from Beltsville Radionsondes:

From Student's report:

Analysis of a graph from the wave page of Radiosonde Data:



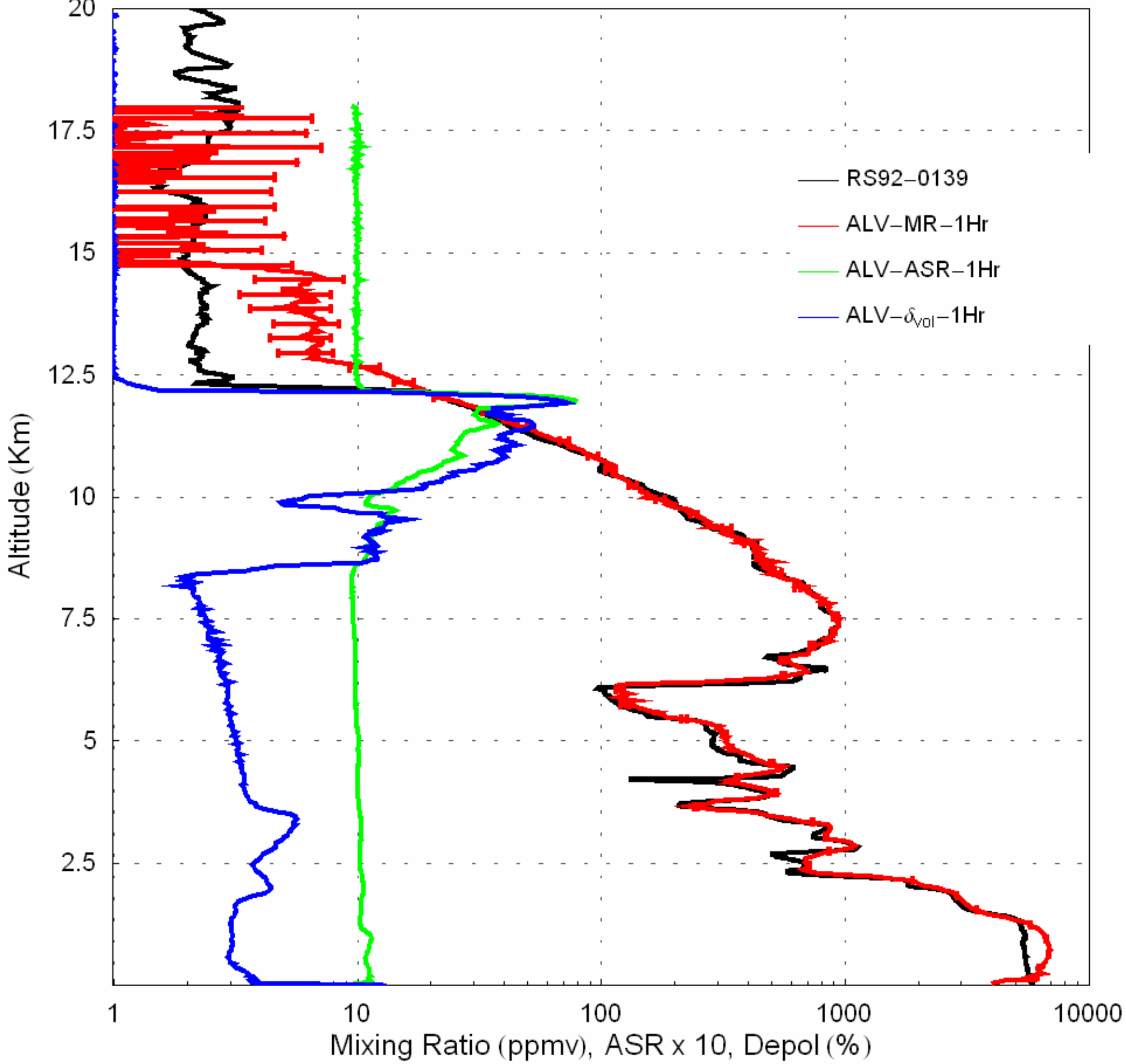
The graph above in the right shows how the relative humidity varies with the change in altitude. The relative humidity at the ground level is very high and up to 1 kilometer. It is increasing as wet air is lighter than dry air. But between 0-100 m the relative humidity is decreasing. It may be due to the rise in temperature. From 1 to 2 km relative humidity is again decreasing. This may be due to the nearly constant vertical temperature profile so that there is less convection of air going on .Above 2 km upto 6 km altitude and 8 km to 10 km the temperature decrease sharply as a result the the relative humidity also increases sharply. But I couldn't explain why from 6 km to 8 Km the relative humidity decrease despite of decrease in temperature. Around 11 km the temperature starts to increase again as a result the relative humidity decreases. This is above tropo-pause where there is very little vertical mixing. Above 12 km the temperature is relatively constant and the relative humidity is also constant. At these height the air is very thin and is also very dry. So the relative humidity doesn't much change and remain constant. May be I should have better explained it if I have vertical mixing ratio profile from LIDAR but there is no datas for the day .I couldn't copy the plot of mixing ratio from the site either.

ALV-MR(ASR, Depol)-1Hr : ALVICE water vapor mixing ratio (aerosol scattering ratio, aerosol volume depolarization) averaged over a 1 hour period

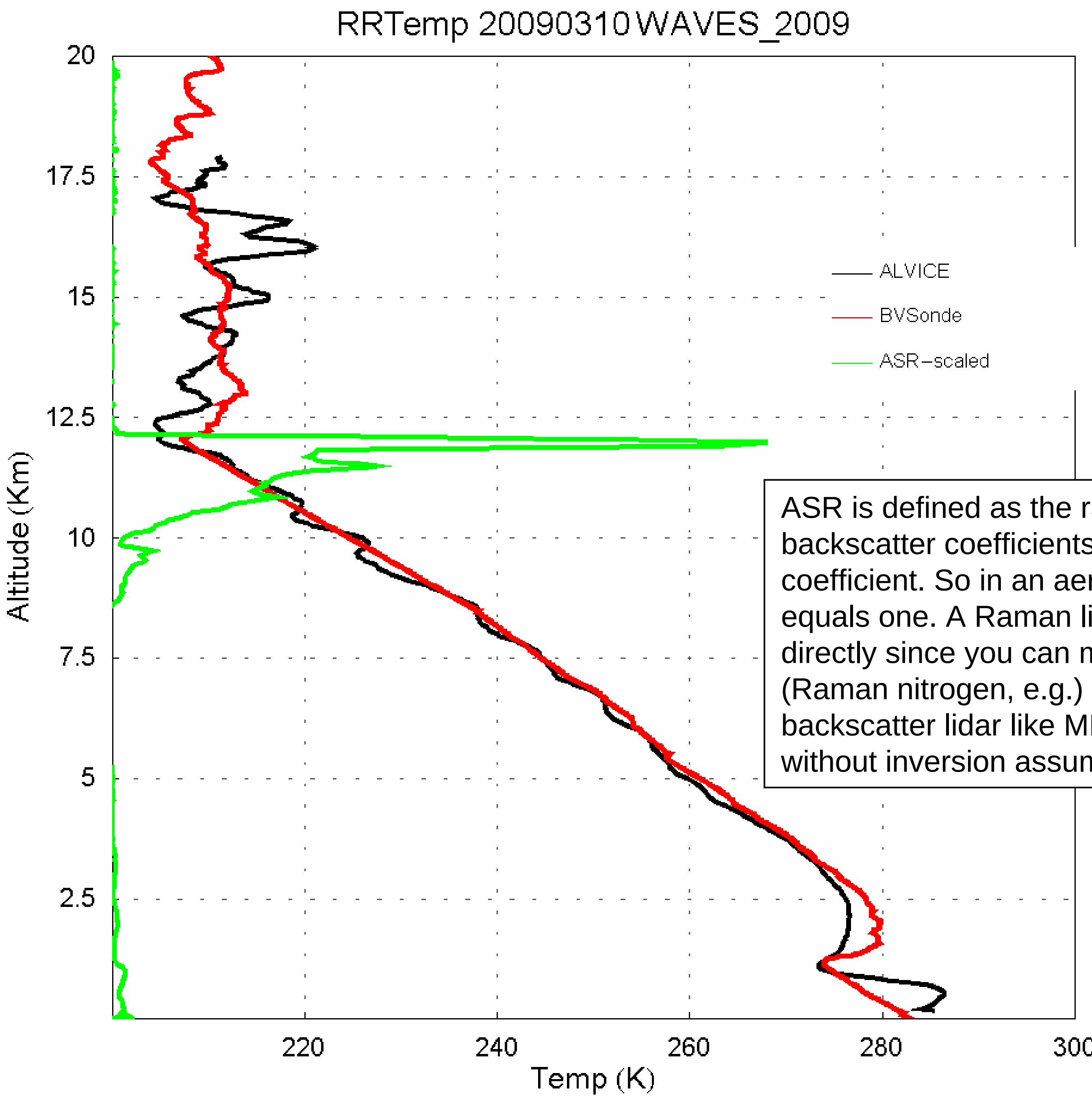
RHorig : original RH data from Vaisala sonde

RHTlag : RH after correction for the timelag of the humidity sensor

RHfinal : RH after correcting for timelag and empirical calibration correction



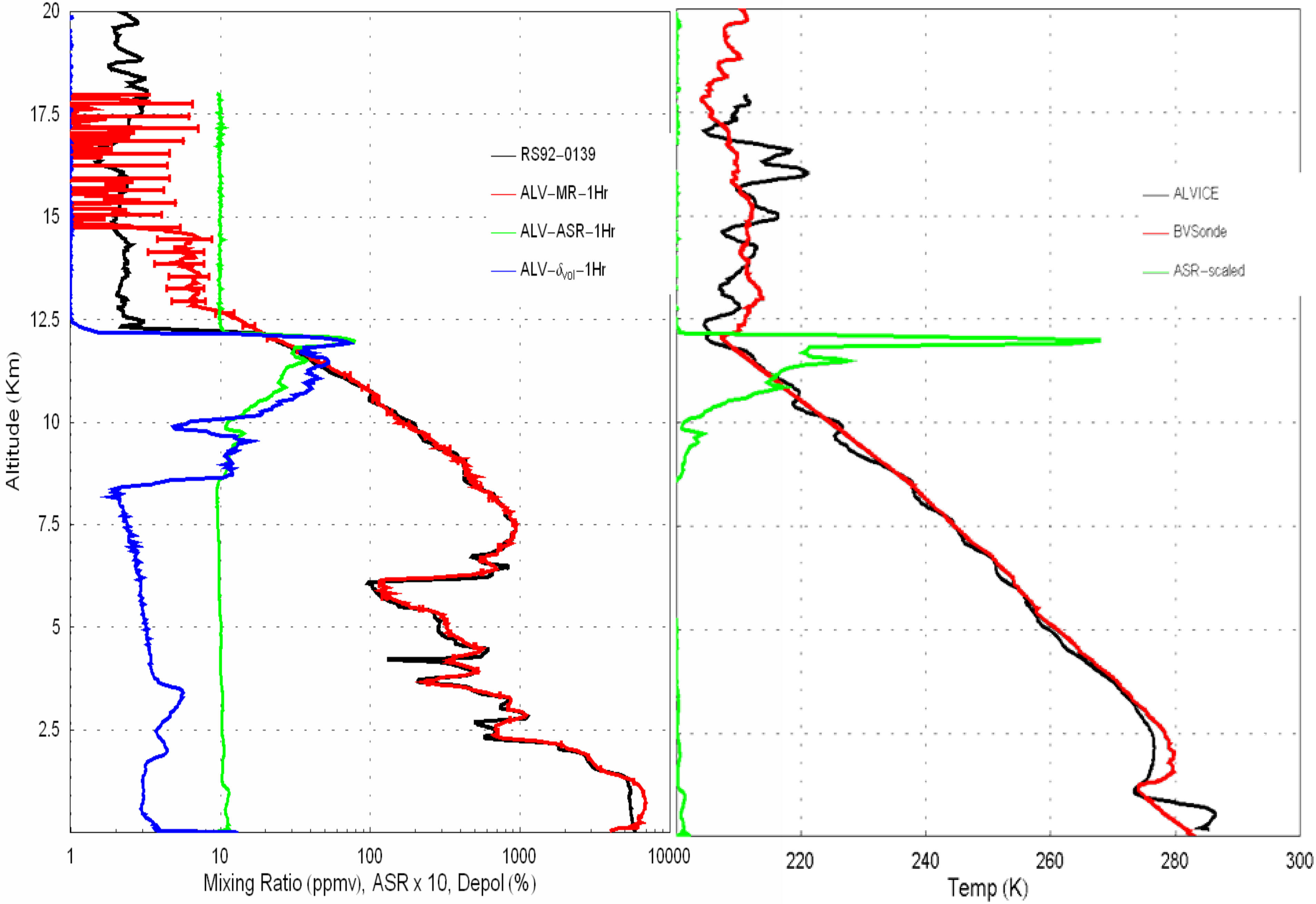
Thanks to Dave Witheman NASA GSFC and Belay Demoz Howard University



ASR is defined as the ratio of molecular + aerosol backscatter coefficients and molecular backscatter coefficient. So in an aerosol free atmosphere it equals one. A Raman lidar can calculate this directly since you can measure the molecular (Raman nitrogen, e.g.) scattering directly. A backscatter lidar like MPL, EFL, etc cannot do this without inversion assumptions.

Thanks to Dave Witheman NASA GSFC and Belay Demoz Howard University

Beltsville Radiosonde Profile – Waves Experiment



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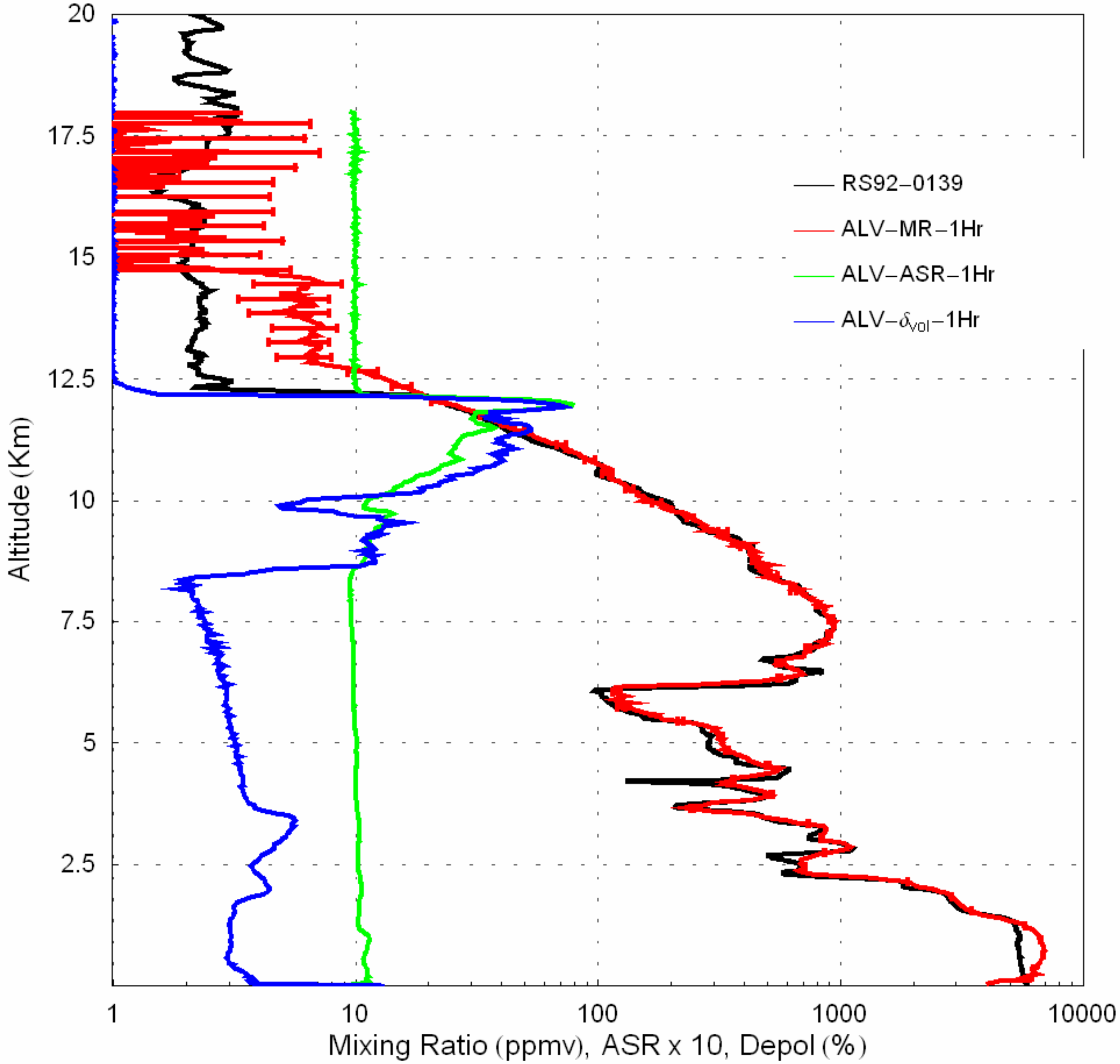
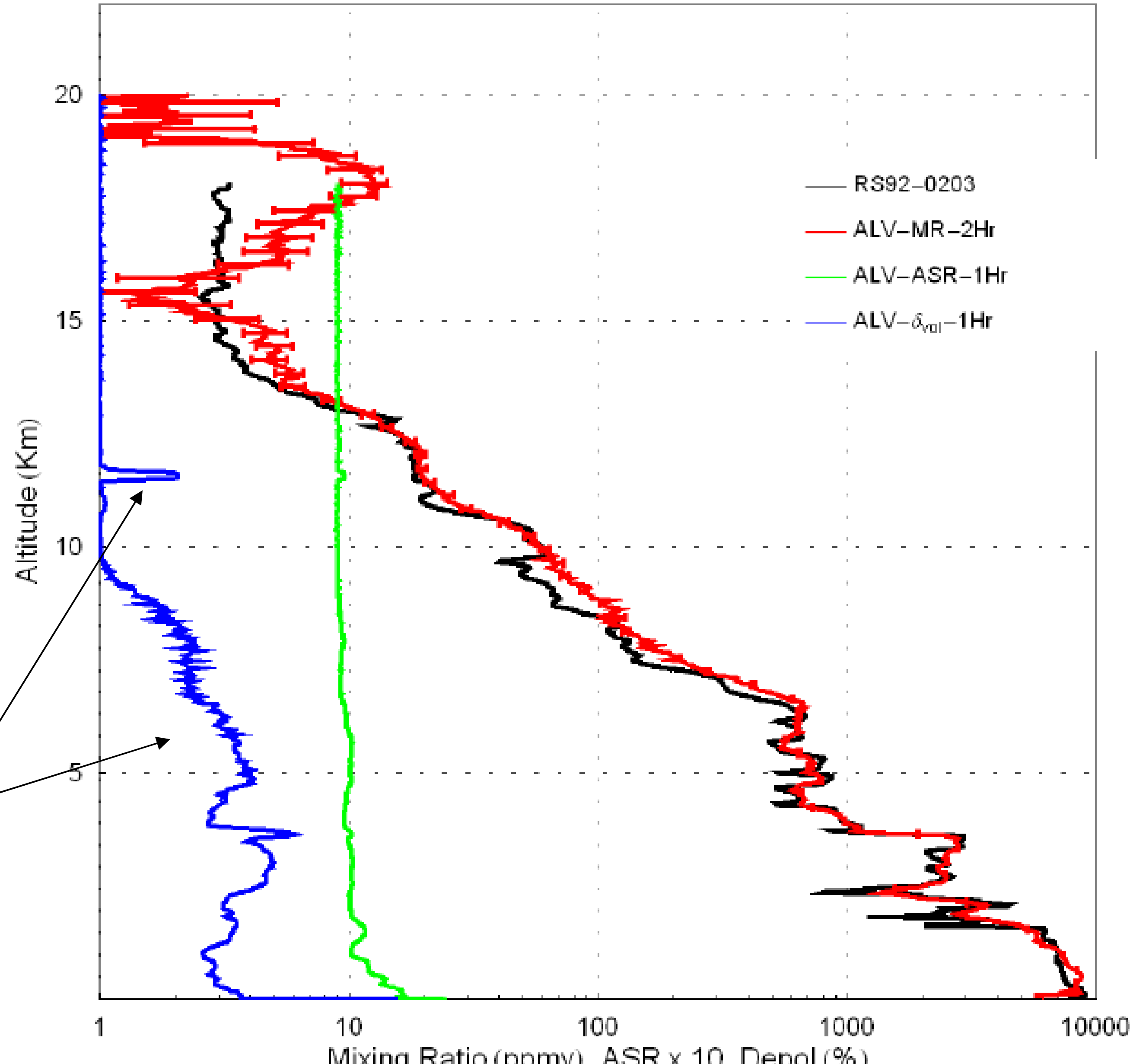


Thanks to Dave Witheman NASA GSFC and Belay Demoz Howard University

Another day from a student's report:



Notice the difference in Depolarization as compared to the previous case:

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Class 10 – Tiger Team Work on Course Project

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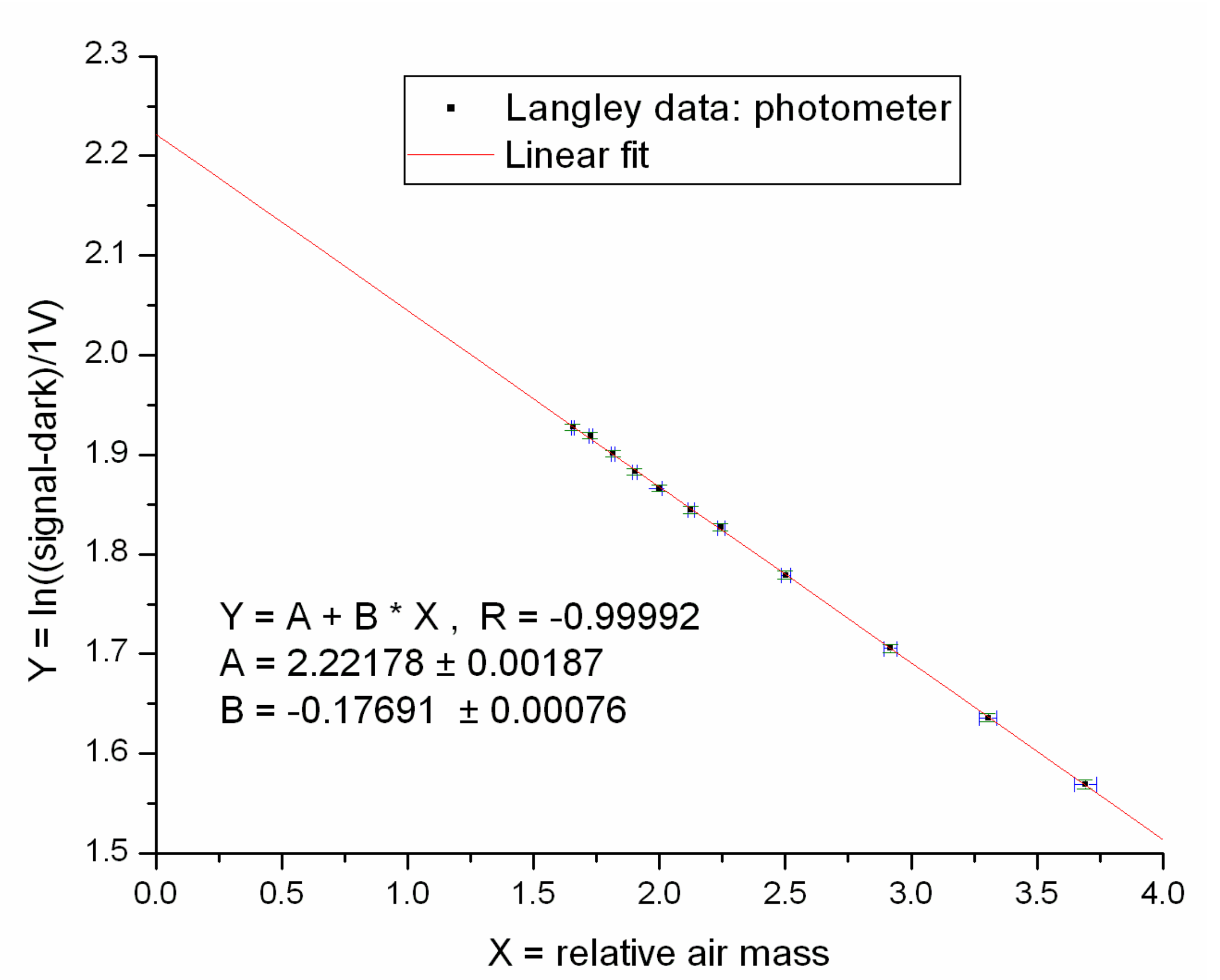
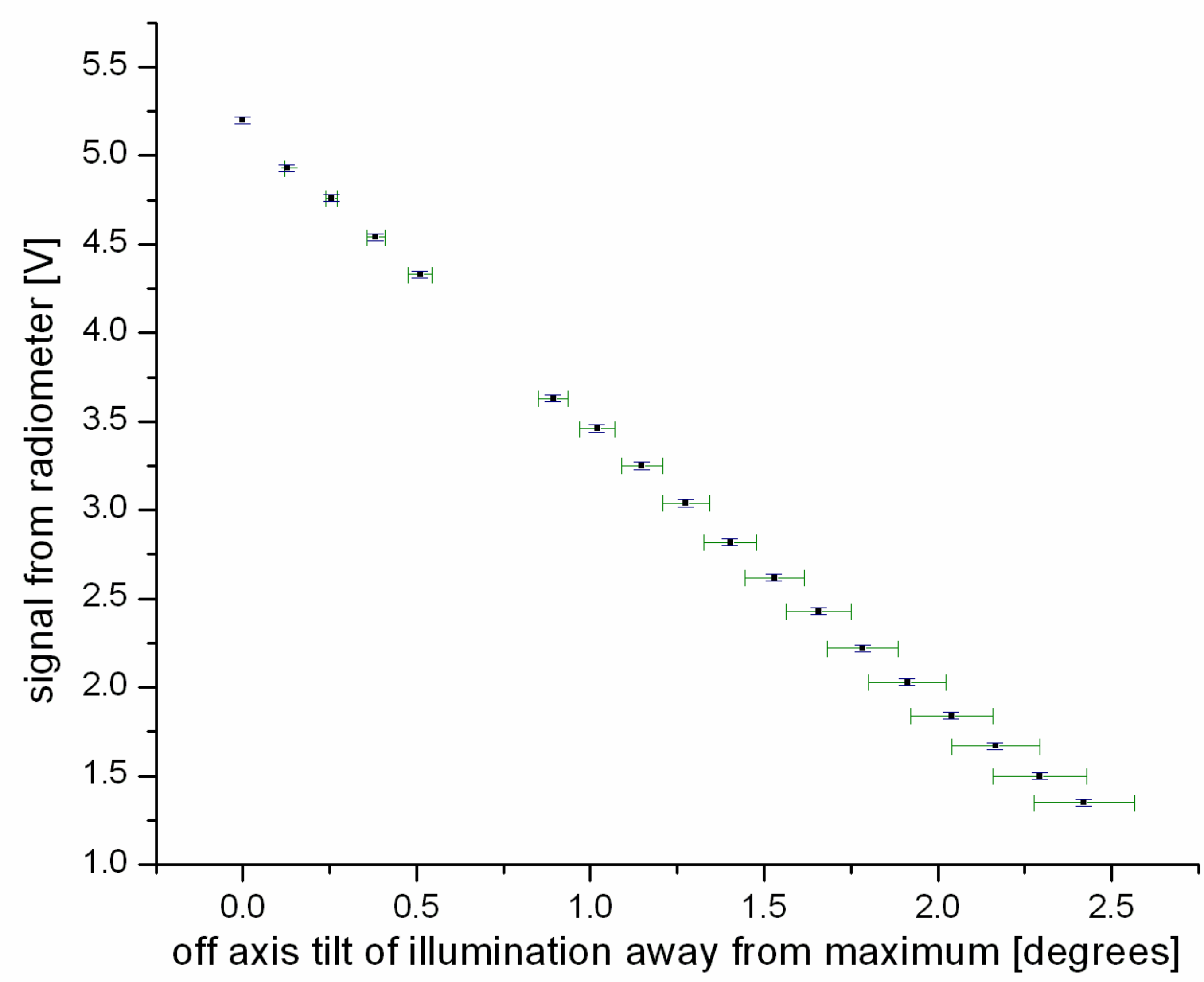
Langley Plot from Student's Report:



FOV Measurement using the Sun



Langley Plot from Student's Report:

The direct measurements were as follows:

Time			signal		time		
value		Error	value	error	value	error	value+error
[hour]	[minute]	[minute]	[V]	[V]	[hour]	[hour]	[hour]
3	55	1	6.94	0.02	19.917	0.017	19.933
4	6	1	6.88	0.02	20.100	0.017	20.117
4	18	1	6.76	0.02	20.300	0.017	20.317
4	28	1	6.64	0.02	20.467	0.017	20.483
4	38	1	6.53	0.02	20.633	0.017	20.650
4	49	1	6.39	0.02	20.817	0.017	20.833
4	58	1	6.28	0.02	20.967	0.017	20.983
5	14	1	5.99	0.02	21.233	0.017	21.250
5	33	1	5.57	0.02	21.550	0.017	21.567
5	46	1	5.20	0.02	21.767	0.017	21.783
5	56	1	4.87	0.02	21.933	0.017	21.950

I could not measure time better than to one minute, but this precision proved to be adequate. As I was gathering data I was simultaneously plotting it.

Based on the time I calculated the zenith angle and air mass, by the "Sun Position Algorithm, (Michalsky, 1988; Solar Energy, 40: 227-235)" Excel worksheet.

zenith angle			air mass		
at time	at time + error	error	at time	at time + error	error
[deg]	[deg]	[deg]	[unitless]	[unitless]	[unitless]
52.856	53.013	0.158	1.6561	1.6622	0.0060
54.614	54.776	0.162	1.7269	1.7338	0.0069
56.591	56.758	0.167	1.8162	1.8242	0.0081
58.280	58.451	0.171	1.9020	1.9112	0.0092
60.004	60.178	0.174	2.0002	2.0108	0.0106
61.935	62.112	0.177	2.1255	2.1380	0.0124
63.540	63.720	0.180	2.2443	2.2585	0.0142
66.441	66.624	0.183	2.5019	2.5204	0.0185
69.952	70.139	0.187	2.9172	2.9435	0.0263
72.389	72.578	0.188	3.3053	3.3399	0.0346
74.279	74.469	0.190	3.6908	3.7347	0.0439

Langley Plot from Student's Report:

I subtracted the dark current from the signal:

signal		dark		signal-dark		ln(signal-dark)	
value [V]	error [V]	value [V]	error [V]	value [V]	error [V]	value [V]	error [V]
6.94	0.02	0.065	0.002	6.875	0.022	1.927892	0.003195
6.88	0.02	0.065	0.002	6.815	0.022	1.919126	0.003223
6.76	0.02	0.065	0.002	6.695	0.022	1.901361	0.003281
6.64	0.02	0.065	0.002	6.575	0.022	1.883275	0.00334
6.53	0.02	0.065	0.002	6.465	0.022	1.866403	0.003397
6.39	0.02	0.065	0.002	6.325	0.022	1.84451	0.003472
6.28	0.02	0.065	0.002	6.215	0.022	1.826966	0.003534
5.99	0.02	0.065	0.002	5.925	0.022	1.779181	0.003706
5.57	0.02	0.065	0.002	5.505	0.022	1.705657	0.003988
5.2	0.02	0.065	0.002	5.135	0.022	1.63608	0.004275
4.87	0.02	0.065	0.002	4.805	0.022	1.569657	0.004568