How Often Should I Measure the Weather?

John Pickle

Introduction

Computers run many of today's weather instruments automatically. Data can be measured and saved at very short time intervals and at any time of day. But what happens when you don't have fancy electronic weather instruments? Will you still be able to have useful weather records if you don't measure every 5 minutes?

What is the least number of measurements needed to have accurate details of the weather? If you have an automated weather station, think of an experiment you can do to measure how often you should measure.

For a complete day, 24 hours, measure the temperature, dewpoint temperature, relative humidity, and air pressure as often as your instruments can accomplish. In this case, the weather station could make measurements every 15 minutes.

Question: If measurements were made every 15 minutes for a complete day, how many measurements will be made?

Answer:

(60 minutes/hour) / (15 minutes/measurement) = 4 measurements/hour

24 hours/day * 4 measurements/hour = 96 measurements/day

Procedure: Using a copy of the data, eliminate every other measurement so you have one measurement every 30 minutes. Make a copy of this new data and eliminate every other measurement, resulting in one measurement per hour. Repeat this so you have data sets ranging from 96 to 3 measurements per day. The amount of time between a series of measurements should be the same throughout the day.

Question: By halving the number of observations for each data set, how many data sets will you have if you start with 96 measurements per day in the first data set and the final data set has 3 measurements per day.

Answer: Data set 1 has 96 measurements, data set 2 has 48, set 3 has 24, set 4 has 12, set 5 has 6, and set 6 has 3. There are 6 data sets to examine.

Question: In order to have 3 equally spaced measurements throughout the day, how much time must occur between each measurement?

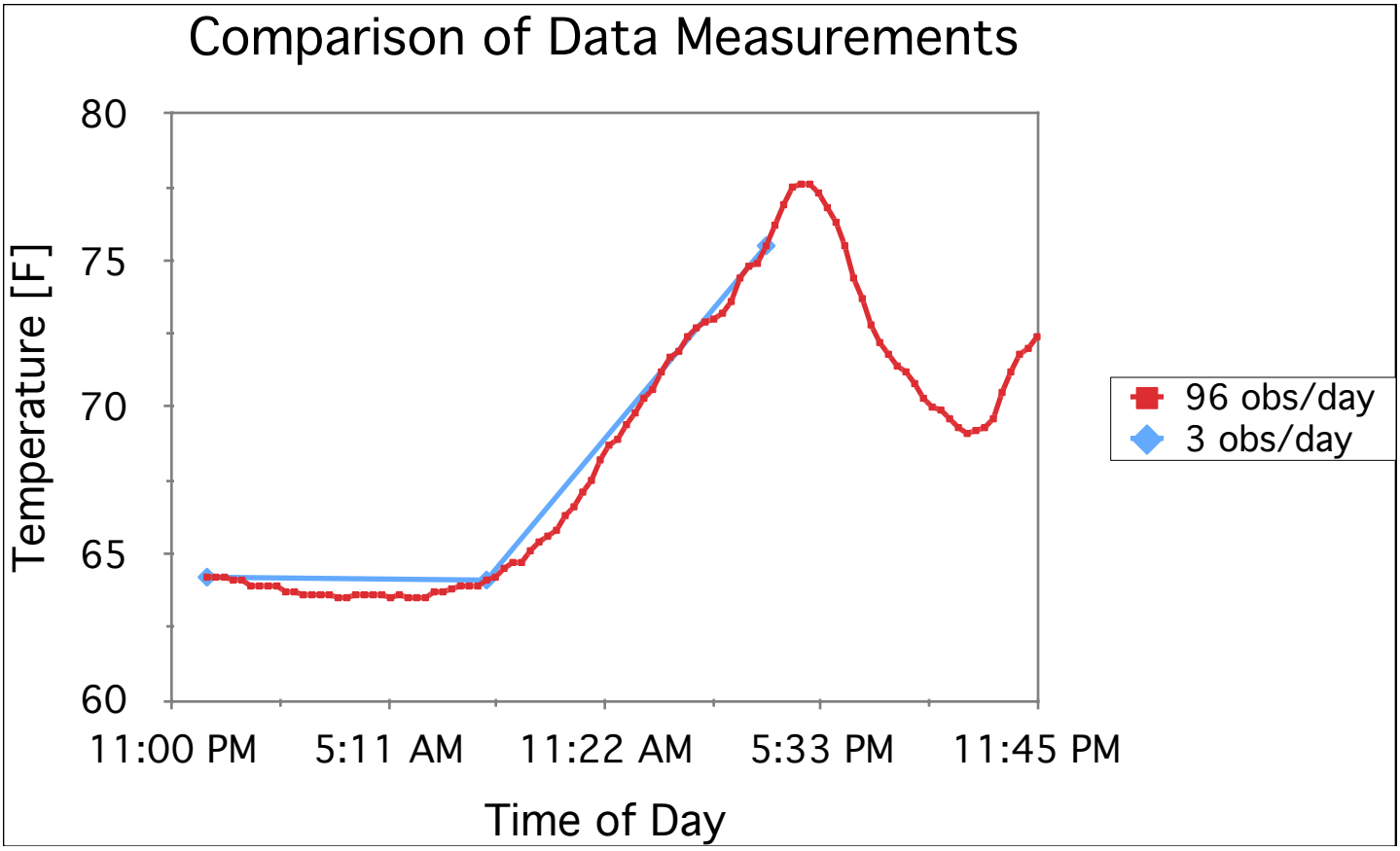
Answer:

24 hours / 3 measurements = 8 hours / measurement

Graphing Data

Using the Excel data that has time measurements for the same data but with different time intervals: 15 minutes, 30 minutes, 1 hour, 2 hours, 4 hours, and 8 hours.

Question: Plot the 15-minute data and the two sets of 8-hour data on the same graph and describe the similarities and differences between the three plots.

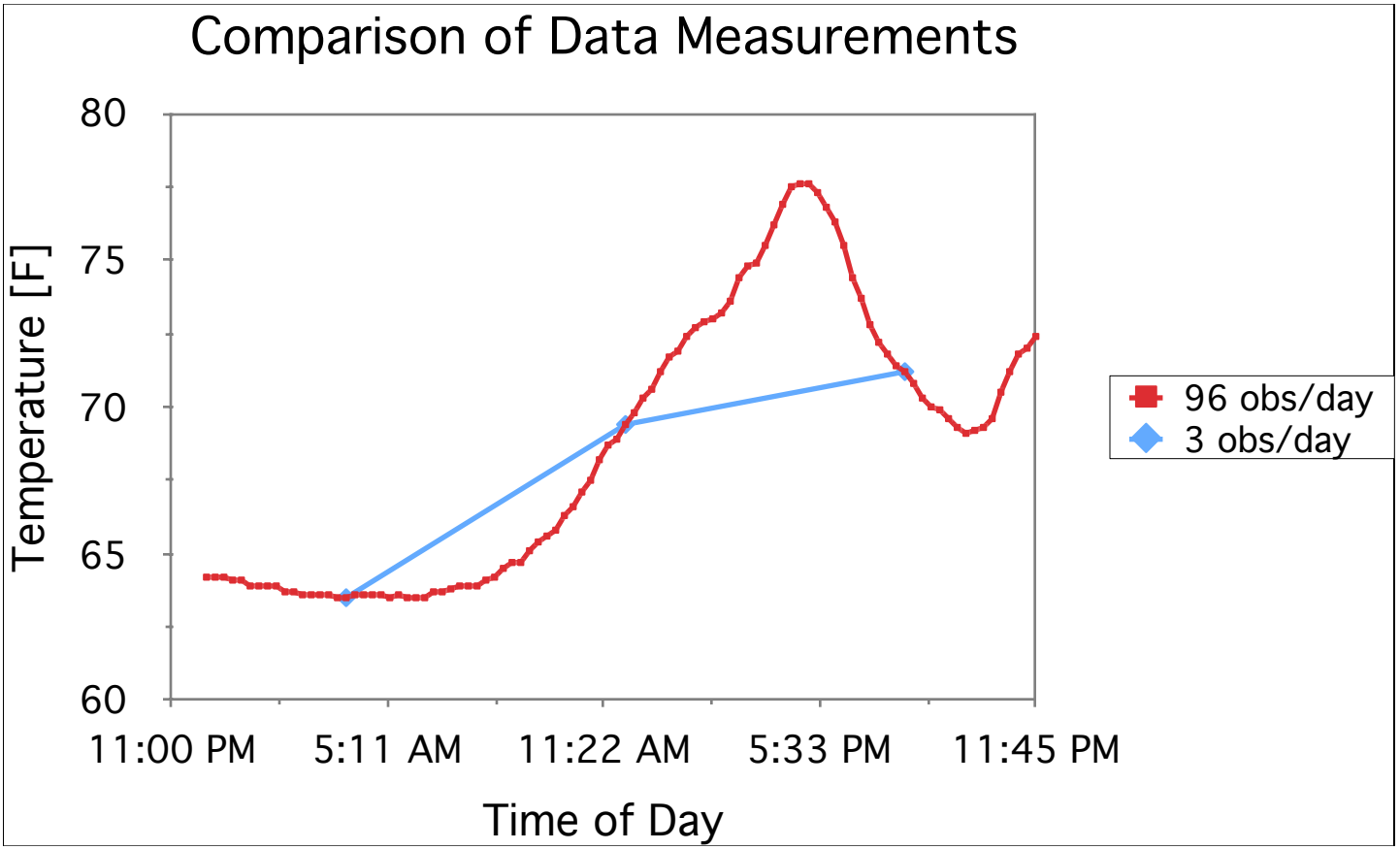


Question: Even though the 3 observations per day have 8 hours between observations, is there another way to distribute the data so it is spread more equally throughout the day starting and ending at midnight?

Answer: Try 4 AM, 12 PM (noon), and 8 AM.

Next is to numerically describe each set of data with one number to find out how different they are from each other. First try comparing daily averages of values for the different data sets. Create a table to compare the average values for temperature, dew point temperature, relative humidity, and air pressure for the first 6 data sets (use the

first of the 8-hour data sets). 'Obs' means observation or measurement of the weather conditions at a particular time.



Time Spacing of Obs	Number of Obs Per Day	Temp Average	Dew Pt Average	RH Average	Pressure Average
15 min	96	68.6	66.6	93.6	1017.2
30 min	48	68.5	66.5	93.5	1017.2
1 hour	24	68.5	66.4	93.5	1017.3
2 hour	12	68.3	66.2	93.3	1017.4
4 hour	6	67.3	65.6	94.6	1018
8 hour	3	67.9	66	94	1017.9

Question: What is the range of average values of the 4 variables for the 6 data sets?
Hint: The range is the maximum value minus the minimum observed value.

Answer:

Time Spacing of Obs	Number of Obs Per Day	Temp Average	Dew Pt Average	RH Average	Pressure Average
15 min	96	68.6	66.6	93.6	1017.2
30 min	48	68.5	66.5	93.5	1017.2
1 hour	24	68.5	66.4	93.5	1017.3
2 hour	12	68.3	66.2	93.3	1017.4
4 hour	6	67.3	65.6	94.6	1018
8 hour	3	67.9	66	94	1017.9
	Maximum	68.6	66.6	94.6	1018
	Miniumum	67.3	65.6	93.3	1017.2
	Range	1.3	1	1.3	0.8

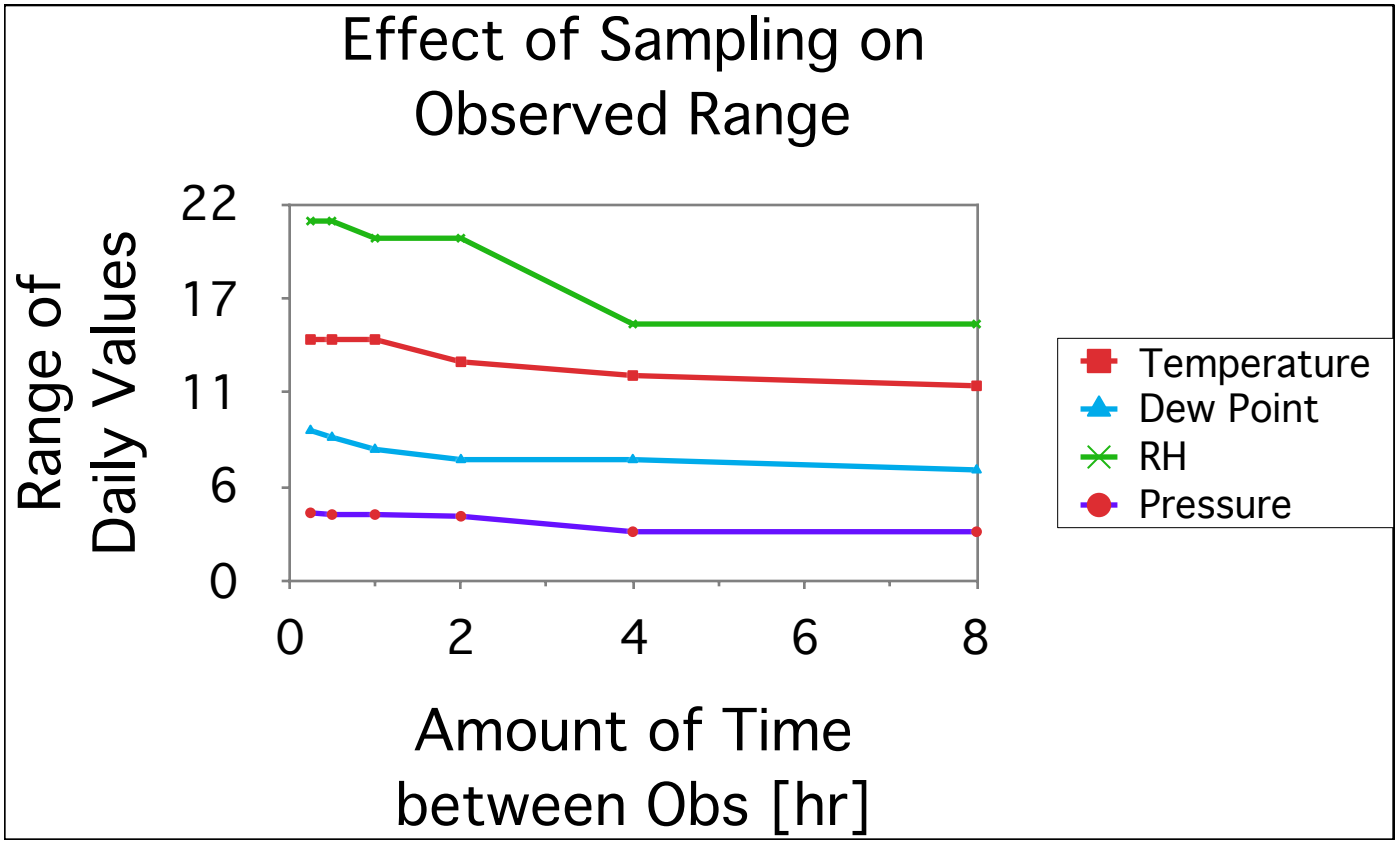
The range of average values for the 4 variables is not very much. The average values tend to differ more from the rest of the averages when there are fewer measurements. But is it worth making the extra measurements for an average value that differs by one degree in temperature, one percent relative humidity, or one millibar of pressure?

Try another number that describes a series of numbers to see if this is affected by the spacing of measurements over time. Examine the observed range of the observed maximum and minimum values for the different data sets. Do the ranges differ more than the averages when there are fewer points?

Time [hour]	Number of Obs Per Day	Temp Range	Dew-Point Range	RH Range	Pressure Range
0.25	96	14.1	8.8	21.0	4.0
0.5	48	14.1	8.4	21.0	3.9
1	24	14.1	7.7	20.0	3.9
2	12	12.8	7.1	20.0	3.8
4	6	12.0	7.1	15.0	2.9
8	3	11.4	6.5	15.0	2.9

Question: What is the range of these values for the 6 data sets? Is this a larger difference than observed for the average values?

Answer:



Time Spacing [hour]	Number of Obs Per Day	Temp Range	Dewpoint Range	RH Range	Pressure Range
0.25	96	14.1	8.8	21.0	4.0
0.5	48	14.1	8.4	21.0	3.9
1	24	14.1	7.7	20.0	3.9
2	12	12.8	7.1	20.0	3.8
4	6	12.0	7.1	15.0	2.9
8	3	11.4	6.5	15.0	2.9
	Maximum	14.1	8.8	21.0	4.0
	Miniumum	11.4	6.5	15.0	2.9
	Range	2.7	2.3	6.0	1.1

Question: Plot the range of temperature, dew point temperature, relative humidity, or pressure to examine what happens when fewer measurements are made over time. Describe any observed trends.

Answer: As the amount of time between observations increases, the observed range of daily values for decreases. Why? As the first graph showed, with fewer data points during the day, more of the weather is not observed, so the observed range must decrease.

Why do relative humidity and temperature have a larger daily range than dew point and pressure? Both temperature and relative humidity are most effected by the heating of the sun; dew point and pressure do not change much during the day because they vary more with the character of air masses (large pools of air that move across the globe slowly changing properties).

Activity: But are these values very large? Compare the ranges to those of the largest observed range by calculating the percent range of the values:

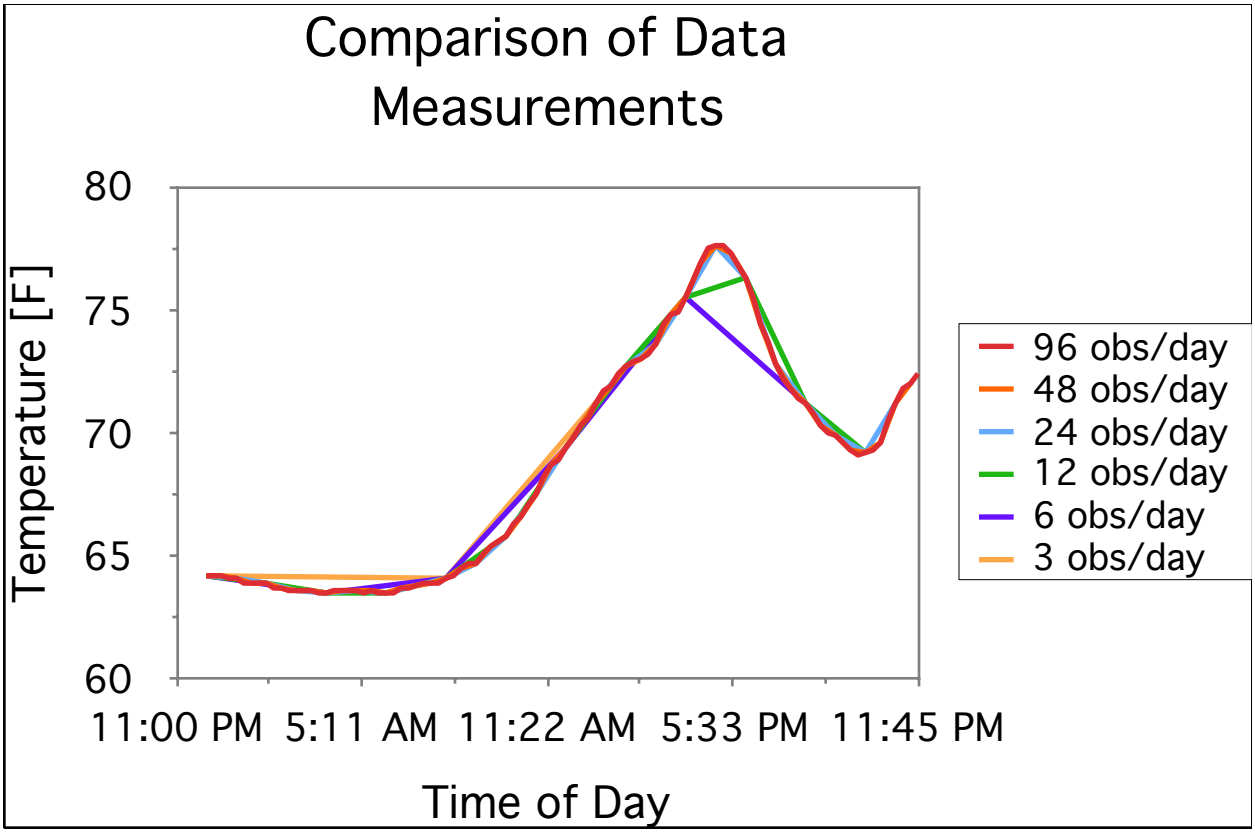
Percent Range = 100 * (Range / Maximum Range)

Answer: The observed difference in daily range of values was quite large, with the largest almost one-third of the maximum observed range. If the range in daily values is important to you, then you must be concerned about making frequent measurements. Who uses these types of weather records? Farmers watch these values to calculate the health and growth of their crops and prepare for the emergence of specific pests. At certain times of year, construction companies, outdoor painters, and energy companies all follow these values to predict problems or special consideration to their work.

Time Spacing of Obs	Number of Obs Per Day	Temp % Range	Dewpoint % Range	RH % Range	Pressure % Range
15 min	96	0.0	0.0	0.0	0.0
30 min	48	0.0	-4.5	0.0	-2.5
1 hour	24	0.0	-12.5	-4.8	-2.5
2 hour	12	-9.2	-19.3	-4.8	-5.0
4 hour	6	-14.9	-19.3	-28.6	-27.5
8 hour	3	-19.1	-26.1	-28.6	-27.5

Activity: Study the graphs and tables you have generated, and decide what is an adequate rate of sampling the weather.

Answer: Using the variables with the largest daily change, temperature and relative humidity, measuring once an hour each hour introduces only a small error into the observed data records. Is it a coincidence that weather observations are made once an hour around the globe?



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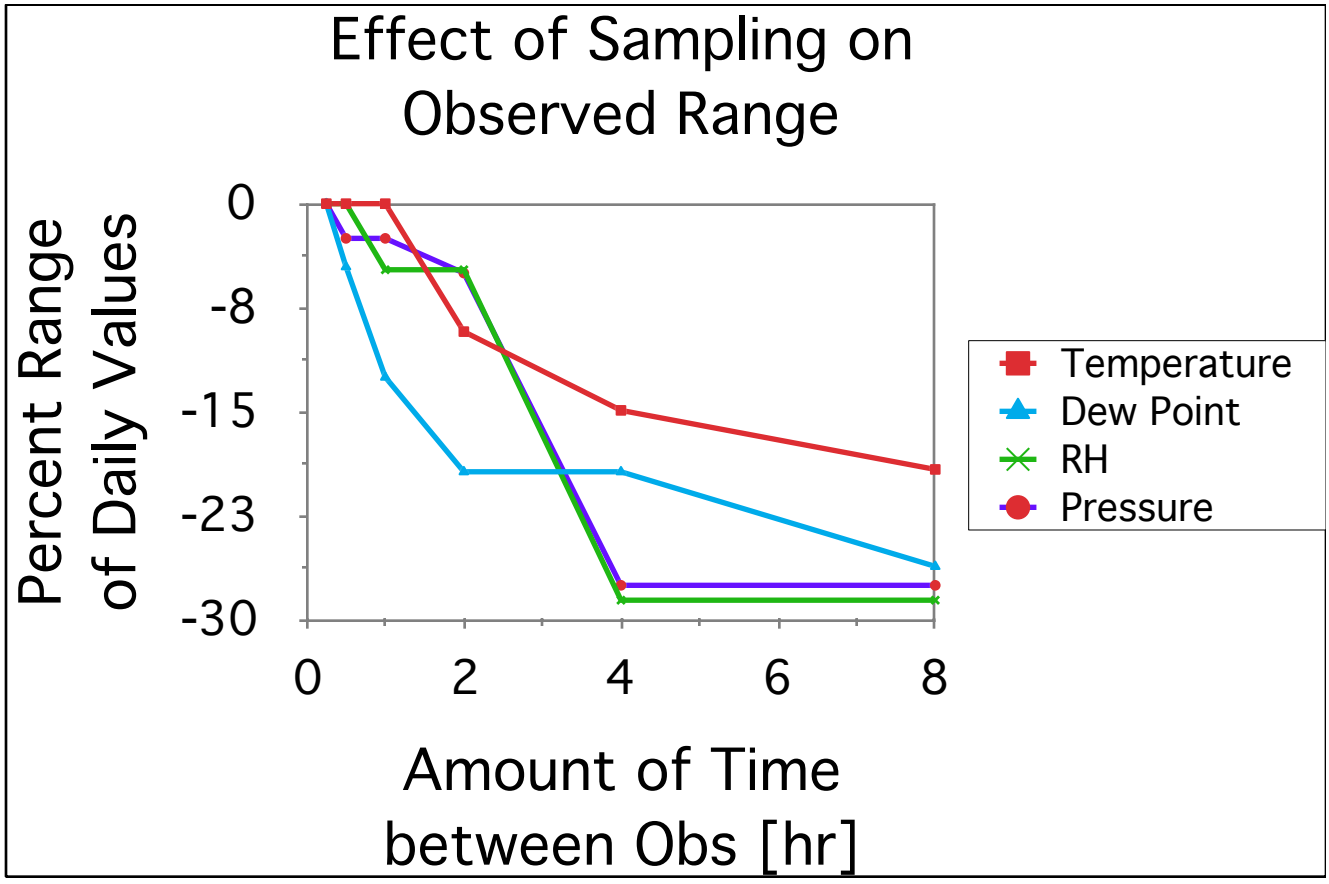
Effect of Sampling on Observed Range
Percent Range of Daily Values
0
-8
-15
-23
-30
0
2
4
6
8
Amount of Time between Obs [hr]
Temperature
Dew Point
RH
Pressure