

Data Analysis and Generalizations

A Closer Look at Solar Wind Regime Speeds

MODEL STUDENT ACTIVITY

In this activity, you will design and conduct an investigation based on one of the questions that you had about solar wind as you completed the Student Activity, “A First Look.” As you follow the procedure below, you will be using the same method that scientific investigators use as they conduct research based on their observations. Have copies of your completed Student Activity, “A First Look,” and the Student Text, “Exploring Data,” available as you complete this student activity sheet.

Part 1. Designing Your Investigation

- 1) Select a question from your list of questions developed in Part 2 of the Student Activity, “A First Look.” Copy it in the space below.

From my observation and reading, it appears that the three solar wind regimes travel at different speeds. How different are the speeds of the three regimes?

- 2) Rewrite your question in the form of a **testable relationship** between two or more variables. The question should include the specific test group(s) or variables, the area to be covered, or the time limits during which you will test this relationship.

Was there a difference in the mean minimum and maximum speeds of the three solar wind regimes—slow, fast, and CME—as they interacted with the Genesis spacecraft during the month of December 2002?

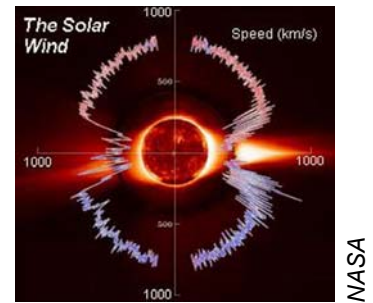
- 3) Now rewrite your question in the form of a **null hypothesis**.

There was no significant difference in the mean minimum and maximum speeds of the three solar wind regimes—slow, fast, and CME—as they interacted with the Genesis spacecraft during the month of December 2002?

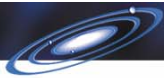
- 4) Describe a procedure for testing your hypothesis. Include the method that you will use to test your hypothesis, the materials and supplies that you will need, the variables to be tested and the variables that you will hold constant. Be sure to include any safety precautions that you will observe as you conduct your experiment.

Materials needed:

- Data print outs of solar wind summary plots from the [LANL Web site](#) for the month of December 2002.
- Data tables or spreadsheets in which to record date, solar wind regime, minimum and maximum solar wind speeds.
- Graph paper or computer software to graph data obtained.
- Statistical analysis software to determine the significance of the data.



The solar wind streams away from the sun in all directions.

**Variables to be tested:**

The regime of solar wind vs. the minimum and maximum speeds of the solar wind during the regime.

Variables that will not be considered or recorded:

- 1) The length of time that a specific solar wind regime interacted with the Genesis spacecraft.
- 2) What type of regime precedes or comes after the specific regime being studied.
- 3) The changes in speed that occur during the transition period, one hour prior to and one hour after a regime change, or when an interplanetary shock occurs.

Procedure: List the specific details of your procedure in the order in which you will carry out your investigation.

- 1) Collect your materials, set up your equipment, and start collecting data. Obtain printouts (or examine on the computer screen) of the solar wind summary plots from the [LANL Web site](#) for the month of December 2002.
- 2) Collect data. For each day, record the following.
 - a) Type(s) of solar wind regime present during the day.
 - b) Minimum and maximum speeds for the day of each type of regime. (Disregard anomalous readings that occur within one hour preceding and one hour after a change in regime or an interplanetary shock.)
- 3) Analyze data:
 - a) Determine the mean minimum and maximum solar wind speeds for each of the regimes—slow, fast, and CME.
 - b) Graph the mean minimum and maximum solar wind speeds as a function of each of the regimes.
 - c) Determine the statistical significance in the differences in the means of the minimum and maximum solar wind speeds between the regimes.
- 4) Draw conclusions with regard to the analyzed data.



Part 2. Carry out your procedure and record the results, including data tables and graphs resulting from your investigation, in the space below.

Results:

Table 1. Raw data recorded from the LANL Web site

Solar Wind Speeds (km/sec) by Regime for December 2002						
Regime	Slow Regime		Fast Regime		CME Regime	
Date	Minimum (km/s)	Maximum (km/s)	Minimum (km/s)	Maximum (km/s)	Minimum (km/s)	Maximum (km/s)
1			475	550		
2			450	550		
3			400	500		
4	400	500	400	500		
5	350	450				
6	350	425				
7	425	500	500	650		
8			500	700		
9			450	600		
10	400	425	400	500		
11	350	425				
12	350	400				
13	300	350				
14	350	500	450	600		
15			450	600		
16	400	450	400	450		
17	350	450			375	375
18					300	400
19	450	550			300	450
20	500	550	500	550		
21			550	800	400	425
22					350	450
23	425	425			450	600
24	450	550			425	500
25	400	550				
26	400	550				
27			550	800		
28			625	800		
29			550	700		
30			450	550		
31	400	425	400	500		



Part 3. Analyze your data. You will need to select the appropriate analysis package for your investigation. If you are using a computer software program, read the specific data qualifications for using the program. You may also consult your science instructor or your mathematics teacher for help in selecting the appropriate analysis program.

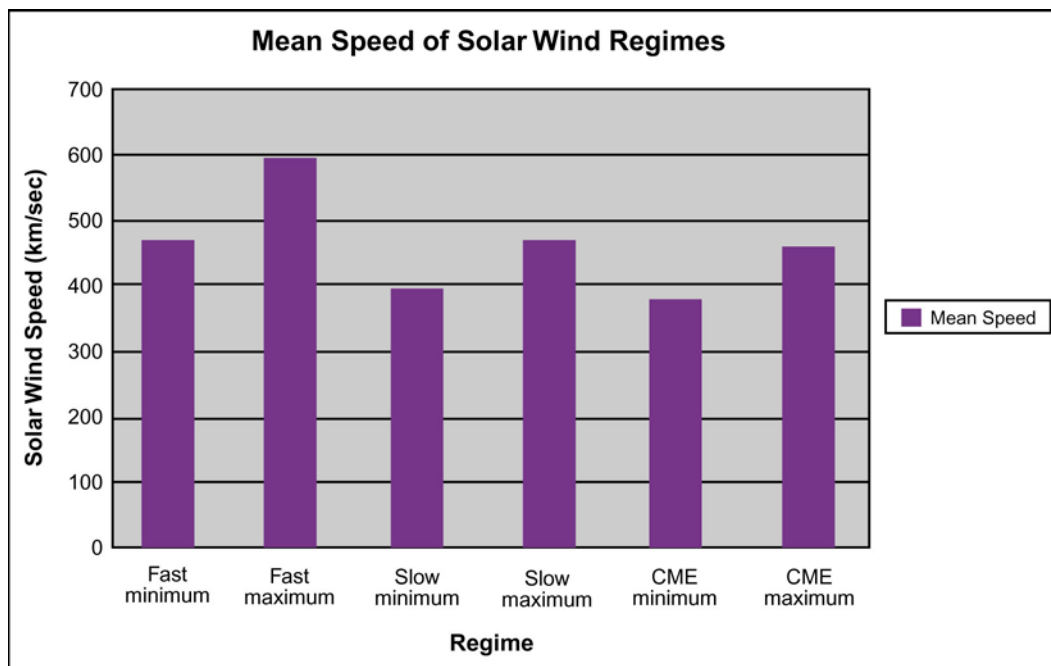
Analysis of Data:

- 1) Determination of mean minimum and maximum wind speeds for the three solar wind regimes. We used a descriptive statistical package that calculated the mean for each type of solar wind data. In addition, it determined the standard error, standard deviation, and sample variance—factors that we needed to continue the analysis. We show this information in Table 2.

Table 2. Preliminary Statistical Analysis

	Fast Solar Wind		Slow Solar Wind		CME	
Preliminary Statistical Results	Minimum Mean Speed (km/s)	Maximum Mean Speed (km/s)	Minimum Mean Speed (km/s)	Maximum Mean Speed (km/s)	Minimum Mean Speed (km/s)	Maximum Mean Speed (km/s)
Mean	469	594	391	469	371	457
Standard Error	16	25	12	15	22	28
Standard Deviation	65	104	50	63	59	76
Sample Variance	4182	10901	2495	4025	3422	5565
Minimum	400	450	300	350	300	375
Maximum	625	800	500	550	450	600
Count	17	17	17	17	7	7

- 2) Graph of the mean minimum and maximum wind speeds for the three solar wind regimes.





Testing for Significance:

There is an obvious difference in the mean minimum speeds of CME and Fast, and between Fast and Slow, but are these differences significant? There are also differences in the mean maximum speeds of all three regimes, but are they significant? To determine the significance of these differences at the 0.05 level, we used a two-tailed *t*-Test for each pair of means. Table 3 contains the relevant results of these calculations.

Table 3. Results of the two-tailed *t*-tests for Wind Speed Means

Mean Pairs	df	Significance Level	<i>t</i> -Stat	<i>t</i> -Critical two-tail at $\alpha = 0.05$
Minimum Fast and Slow	17	>.20	0.649	2.119
Minimum Fast and CME	9	.01< <i>t</i> <0.02	3.222	2.262
Minimum Slow and CME	7	>.20	0.706	2.364
Maximum Fast and Slow	16	>.20	0.863	2.120
Maximum Fast and CME	13	.001< <i>t</i> <0.01	3.192	2.160
Maximum Slow and CME	8	>.20	0.052	2.306

According to this analysis, there were significant differences only between all means of minimum fast and CME regime speeds and maximum fast and CME regime speeds. These differences were significant at the 95% confidence level.

The differences in speeds between other pairs were not significant, even at the 80% confidence level.

Conclusions:

Therefore, we can reject the null hypothesis for both minimum and maximum fast and CME regime speeds, and conclude that the three solar wind regimes were traveling at significantly different speeds during the month of December 2002.

The null hypothesis was supported for the other pairs of compared regime speeds.