1) The reason for doing analysis of Antarctic sea ice data is to determine if the data supports, or does not support, the idea of global warming.

2) The premise of global warming predicts that sea ice levels should be decreasing with time. That is, there should be a negative (inverse) correlation between sea ice levels, and the year (1978, 1979, ..., 2011, 2012).

3) The data from the National Snow and Ice Data Center (NSIDC) at the University of Colorado (United States), is perfectly suited for a statistical test of this correlation. The data is organized by month, with values from 1978 to the present. For example, the month of June has data values for the years 1979 to 2012.

4) The data is values for sea ice 'area', and sea ice 'extent'. Both values are in units of square kilometers * 10e6 (millions of square kilometers). For example, for the month of June, the area and extent values for the year 1986 are 9.62 and 13.31, respectively. The extent measurement includes regions under the ocean surface, that contain at least 15% ice; so, typically, the extent value is greater than the corresponding area value. The extent and area data for the month of June is in the plot below (plot 1).

5) Spearman's correlation test is a test for a data set with two variables. The null hypothesis, usually called 'H0', is that there is no correlation between the two variables; or, stated another way, any correlation between the two variables is due only to chance. The alternative hypothesis, usually called 'H1', is that there is a correlation between the two variables. The test returns the probability that the null hypothesis is not correct. When the probability is >= 0.95, the level of statistical significance, the null hypothesis is rejected, and the alternative hypothesis is accepted. Otherwise, (probability < 0.95) the null hypothesis is accepted.

6) For each month, Spearman's correlation test was run using the year as variable 1 and the area data as variable 2. Of the 12 months, 3 have a statistically significant correlation: May, June, and July. The results for all 12 tests are in the plot below (plot 2).

7) A correlation coefficient, usually called 'r', is easily calculated using two-variable statistics. The coefficient 'r' can have a value between -1 and 1. A value of 'r' < 0 indicates an inverse correlation (variable 2 decreases as variable 1 increases). A value of 'r' > 0 indicates a direct correlation (variable 2 increases as variable 1 increases). A value of 'r' = 0 indicates no correlation between the two variables. The closer the value of 'r' to -1 or 1, the stronger the correlation.

8) Spearman's correlation test does not indicate whether the correlation is positive or negative. For the 3 months that are statistically significant, the correlation coefficient 'r', was calculated. The coefficients, and corresponding statistical significance, are:

Month	'r'	significance
May	0.44193502	0.99112388
June	0.46193317	0.99404462
July	0.37123761	0.96935215

Notice that for each month that Spearman's test identifies as statistically significant, the correlation coefficient is also statistically significant. The coefficients, with confidence limits, are in the plot below (plot 3).

9) Spearman's correlation test was repeated for all 12 months, using the year as variable 1, and the extent data as variable 2. Of the 12 months, 6 have a statistically significant correlation: May, June, July, August, September, and October. The results for all 12 tests are in the plot below (plot 4).

10) For the 6 months that are statistically significant, the correlation coefficient 'r', was calculated. The coefficients, and corresponding statistical significance, are:

Month	'r'	significance
May	0.40172506	0.98147730
June	0.36938099	0.96844215
July	0.43456070	0.98977576
August	0.37743365	0.97223510
September	0.44355033	0.99139807
October	0.48128859	0.99604429

Notice that for each month that Spearman's test identifies as statistically significant, the correlation coefficient is also statistically significant. The coefficients, with confidence limits, are in the plot below (plot 5).

11) In all of the months that have a statistically significant correlation, for area data and extent data, the correlation coefficient is > 0. This indicates a direct correlation between the year and the sea ice levels; that is, as the year values increase, the sea ice levels increase. This is exactly opposite of what the premise of global warming predicts.

12) Wilcoxon's sum-of-ranks test was used to verify the results of Spearman's correlation test. Wilcoxon's test compares two data samples, and is used to answer the question: 'Are these two data samples different?'. The null hypothesis, H0, is that there is no difference between the two data samples (both samples are from the same parent population); or, stated differently, any difference between the two data samples is due only to chance. The alternative hypothesis, H1, is that the two data samples are different. The test returns the probability that the null hypothesis is not correct. When the probability is >= 0.95, the level of statistical significance, the null hypothesis is rejected, and the alternative hypothesis is accepted. Otherwise (probability < 0.95), the null hypothesis is accepted.

13) To use Wilcoxon's test, the area data for each month was divided into two parts; the oldest data was called 'data set 1', and the most recent data was called 'data set 2'. For example, for the month of May, data set 1 is the years 1979 to 1995, and data set 2 is the years 1996 to 2012.

14) Wilcoxon's test indicates that 4 months, May, June, July, and October show a statistically significant difference between data set 1 and data set 2. May, June, and July are the same 3 months that Spearman's correlation test identified as statistically significant. The results for all 12 tests on the area data are in the plot below (plot 6).

15) Wilcoxon's test does not provide a measure of the difference between data set 1 and data set 2. For the 4 months that are statistically significant, the mean (average) and standard deviation were calculated for data set 1, and data set 2. In each of the 4 months, the mean value for data set 2 (the most recent data) is greater than the mean value for data set 1 (the oldest data). The standard deviation values do not show a trend. The mean and standard

deviation values are:

May	data set 1	data set 2
mean	7.53470588	7.96235294
standard deviation	0.53097926	0.45191992

June	data set 1	data set 2
mean	10.19882353	10.64823529
standard deviation	0.43989889	0.48359636

July	data set 1	data set 2
mean	12.52000000	12.80823529
standard deviation	0.36881567	0.34491367

October	data set 1	data set 2
mean	13.84882353	14.07529412
standard deviation	0.34592055	0.32642223

The mean values, with confidence limits, are in the plots below (plots 7, 8, 9, 10).

16) Spearman's correlation test on the area data identifies the months May, June, and July as being statistically significant. In each case, the correlation coefficient indicates that the ice area increases as the years increase. Wilcoxon's test identifies the same 3 months as being statistically significant. In each case, the most recent half of the area data has a mean value that is greater than the oldest half of that data. In short, the results of Wilcoxon's test support the results of Spearman's test for the area data.

17) Wilcoxon's sum-of-ranks test was repeated, using the ice extent data for each month. As before, the oldest half of the extent data was used as 'data set 1', and the the most recent half of the data was used as 'data set 2'.

18) Wilcoxon's test indicates that 5 months, May, June, July, September, and October, show a statistically significant difference between data set 1 and data set 2. These are the same 5 months that Spearman's correlation test identified as statistically significant. The results for all 12 tests on the extent data are in the plot below (plot 11).

19) For the 5 months that are statistically significant, the mean (average) and standard deviation were calculated for data set 1, and data set 2. In each of the 5 months, the mean value for data set 2 (the most recent data) is greater than the mean value for data set 1 (the oldest data). The standard deviation values do not show a trend. The mean and standard deviation values are:

May	data set 1	data set 2
mean	10.55764706	10.98764706
standard deviation	0.54769437	0.48508413

June	data set 1	data set 2
mean	13.75000000	14.11823529
standard deviation	0.39996875	0.45233057

July	data set 1	data set 2
mean	16.30764706	16.57647059
standard deviation	0.29967752	0.28805254

September	data set 1	data set 2
mean	18.63588235	18.97235294

standard deviation	0.28315320	0.35442787

October	data set 1	data set 2
mean	18.20823529	18.51470588
standard deviation	0.31147302	0.30118760

The mean values, with confidence limits, are in the plots below (plots 12, 13, 14, 15, 16).

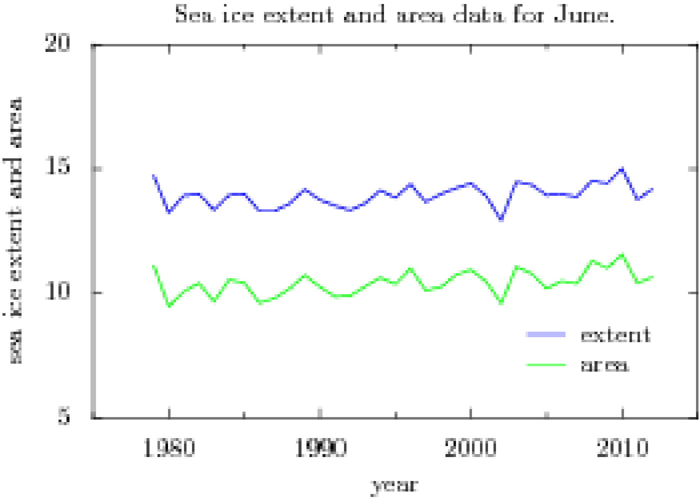
20) Spearman's correlation test on the extent data identifies the months May, June, July, September, and October as being statistically significant. In each case, the correlation coefficient indicates that the ice extent increases as the years increase. Wilcoxon's test identifies the same 5 months as being statistically significant. In each case, the most recent half of the extent data has a mean value that is greater than the oldest half of that data. In short, the results of Wilcoxon's test support the results of Spearman's test for the extent data.

21) Conclusions:
a) The Antarctic sea ice data shows that sea ice levels are increasing over a time period where the premise of global warming predicts that sea ice levels should be decreasing.
b) The Antarctic sea ice data does not support the idea of global warming.
c) The Antarctic sea ice data is a counter-example to the idea of global warming.

Tom Sweeney (B.S. Mathematics)
2 April 2013

Plot 1.

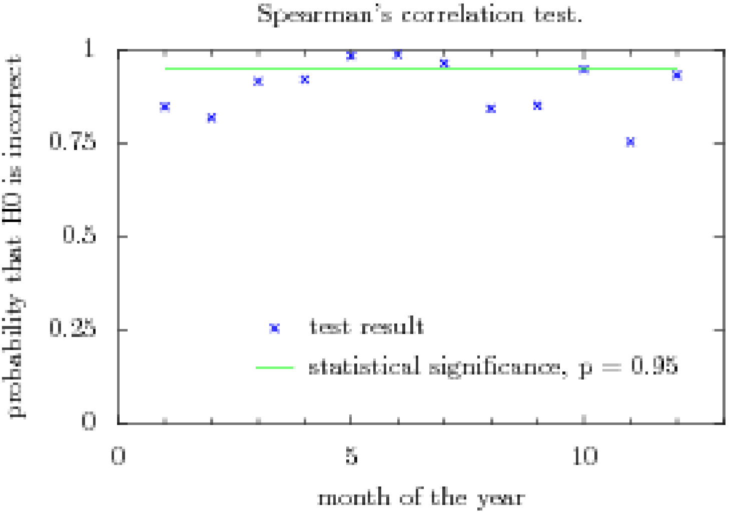
Extent and area data in square kilometers X 10e6.



Plot 2.

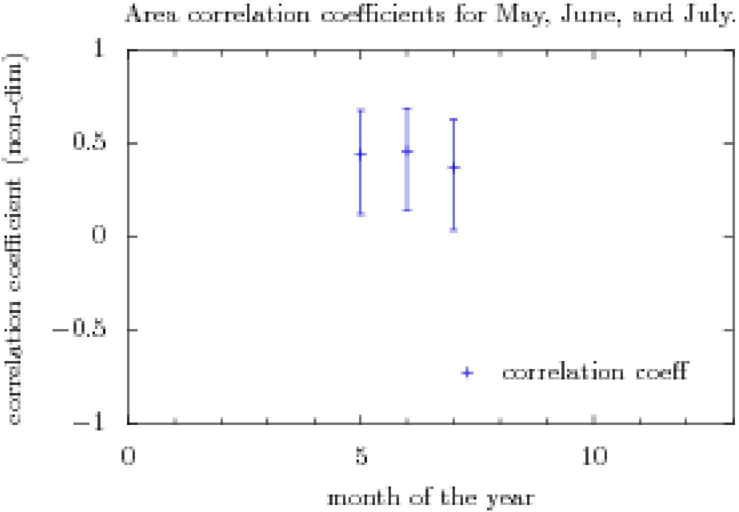
Correlation of ice area and the year.

Null hypothesis (H0): there is no correlation between ice area and the year.



Plot 3.

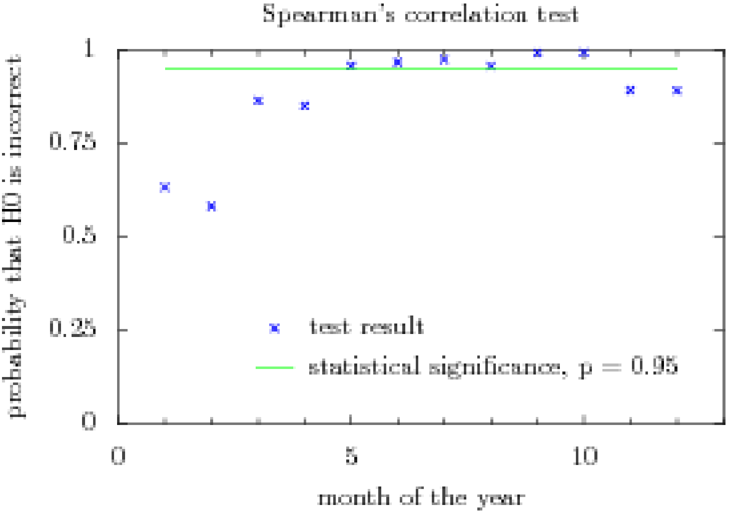
Confidence limits are for probability 0.95.



Plot 4.

Correlation of ice extent and the year.

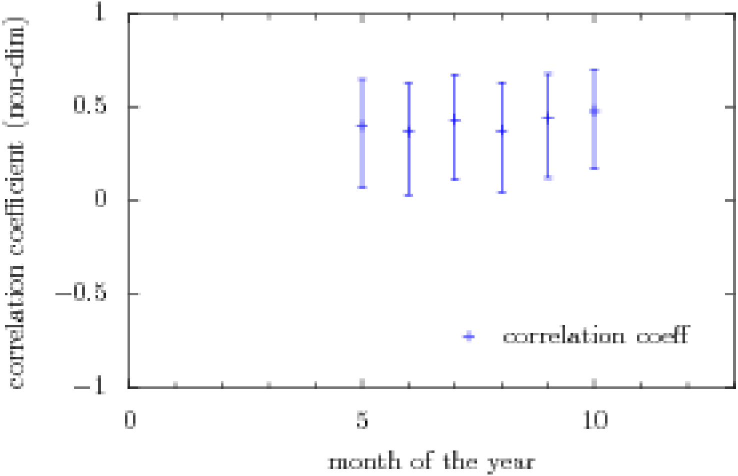
Null hypothesis (H0): there is no correlation between ice extent and the year.



Plot 5.

Confidence limits are for probability 0.95.

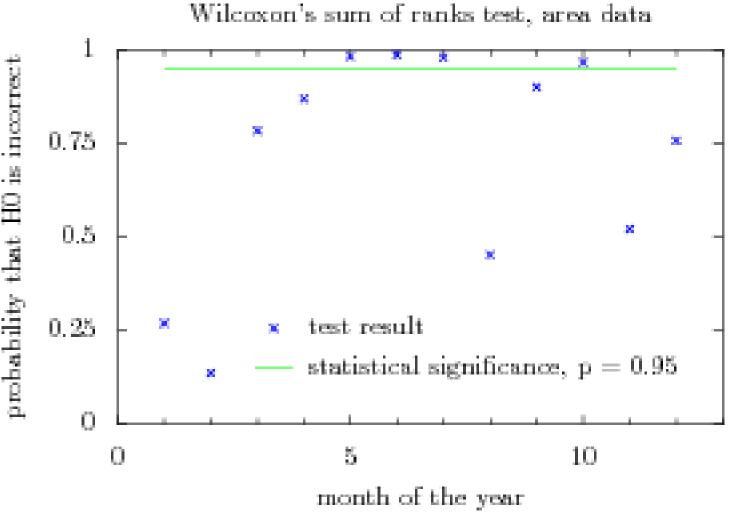
Extent correlation coefficients for May, June, July, August, September, and October.



Plot 6.

Data set 1: oldest half of the data; data set 2: newest half of the data.

Null hypothesis (H0): both data sets are from the same population.

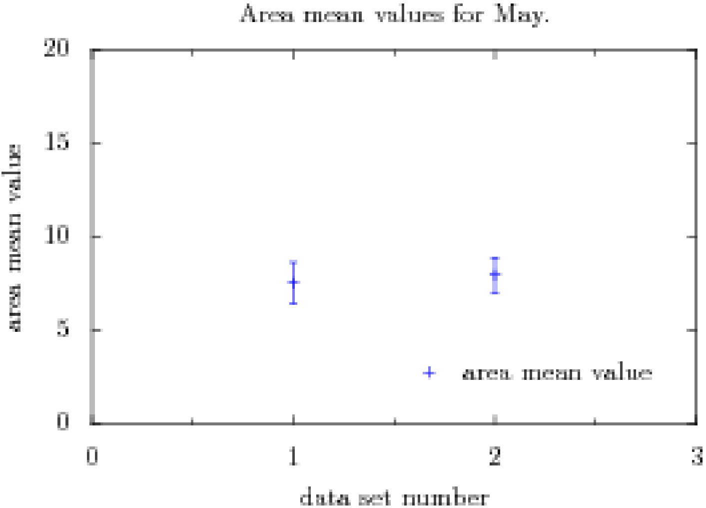


Plot 7.

Area data in square kilometers X 10e6.

Data set 1: 1979-1995, data set 2: 1996-2012.

Confidence limits are for probability 0.95.

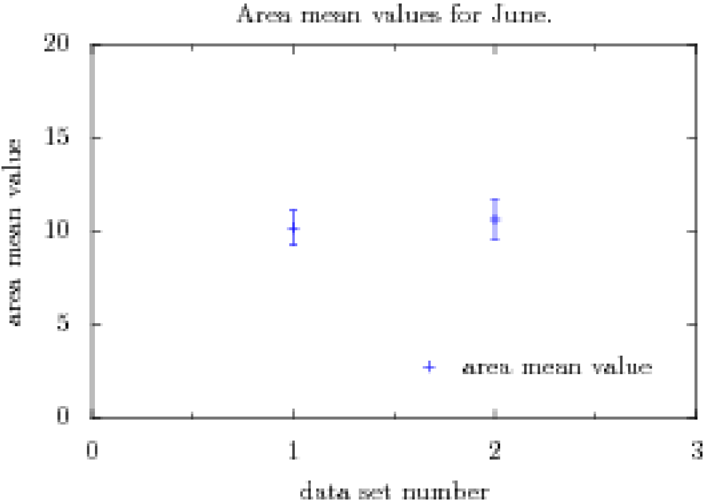


Plot 8.

Area data in square kilometers X 10e6.

Data set 1: 1979-1995, data set 2: 1996-2012.

Confidence limits are for probability 0.95.

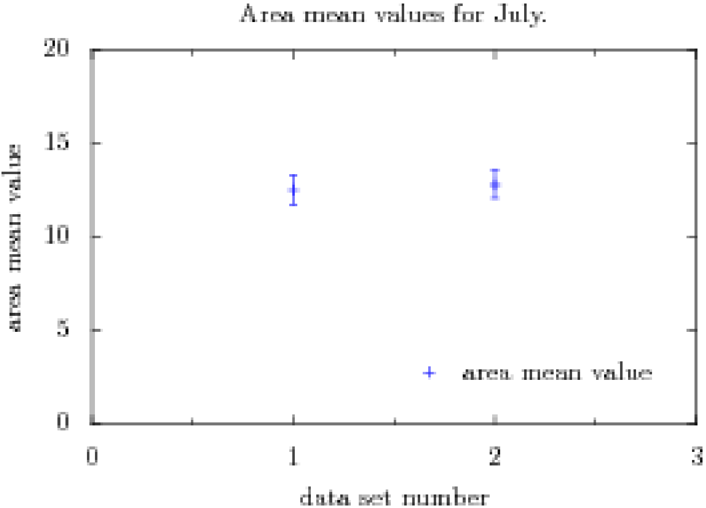


Plot 9.

Area data in square kilometers X 10e6.

Data set 1: 1979-1995, data set 2: 1996-2012.

Confidence limits are for probability 0.95.

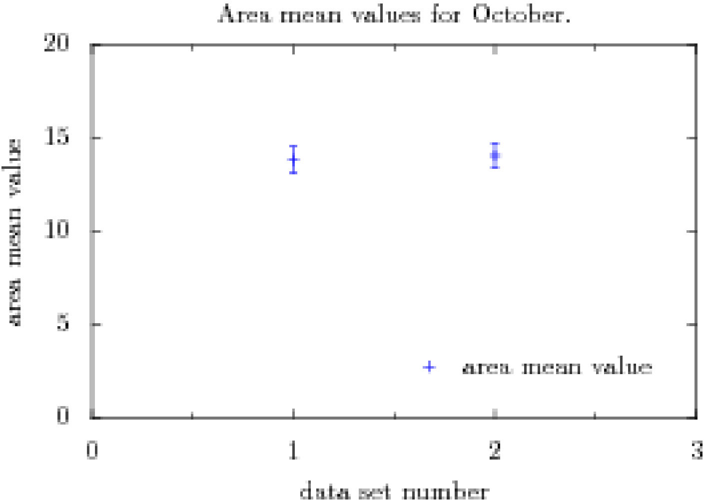


Plot 10.

Area data in square kilometers X 10e6.

Data set 1: 1979-1995, data set 2: 1996-2012.

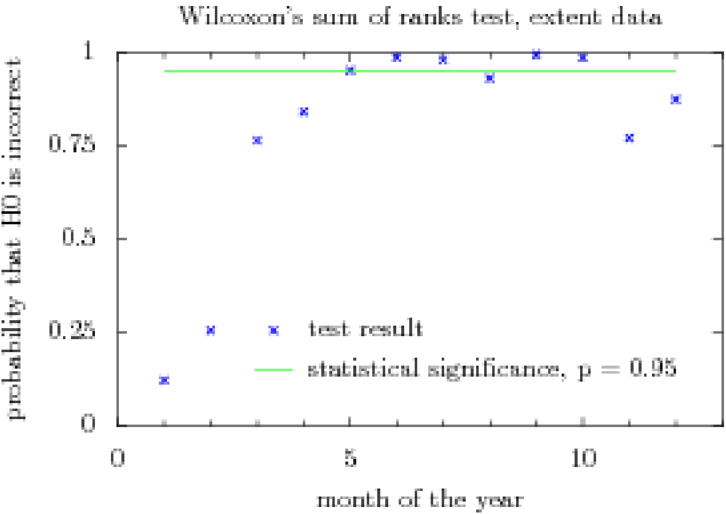
Confidence limits are for probability 0.95.



Plot 11.

Data set 1: oldest half of the data; data set 2: newest half of the data.

Null hypothesis (H0): both data sets are from the same population.

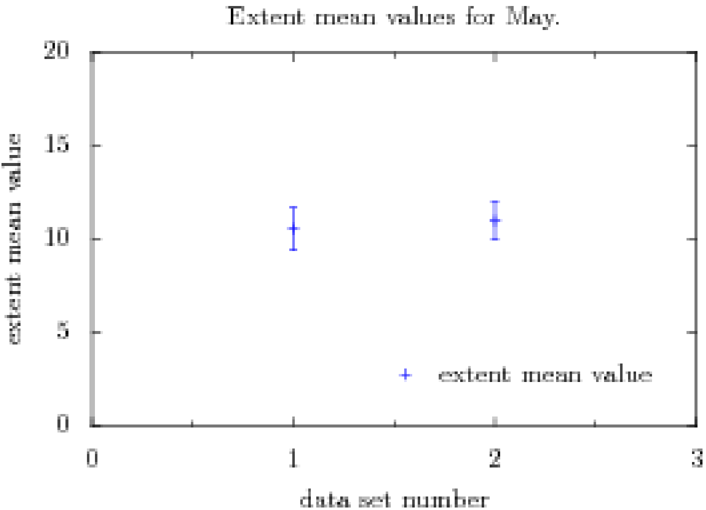


Plot 12.

Extent data in square kilometers X 10e6.

Data set 1: 1979-1995, data set 2: 1996-2012.

Confidence limits are for probability 0.95.

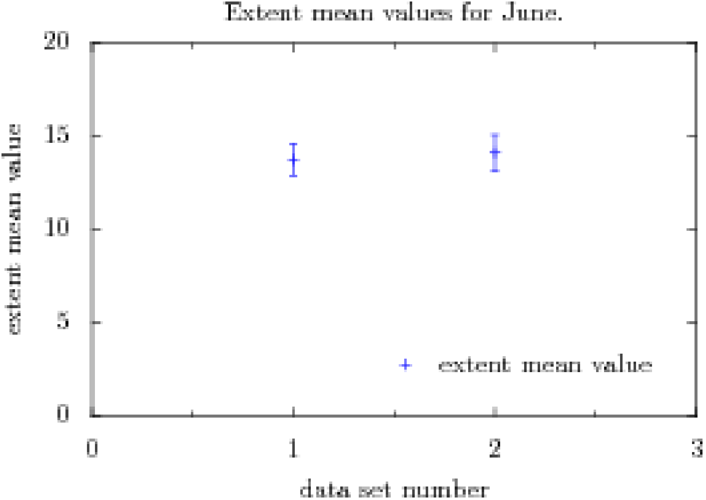


Plot 13.

Extent data in square kilometers X 10e6.

Data set 1: 1979-1995, data set 2: 1996-2012.

Confidence limits are for probability 0.95.

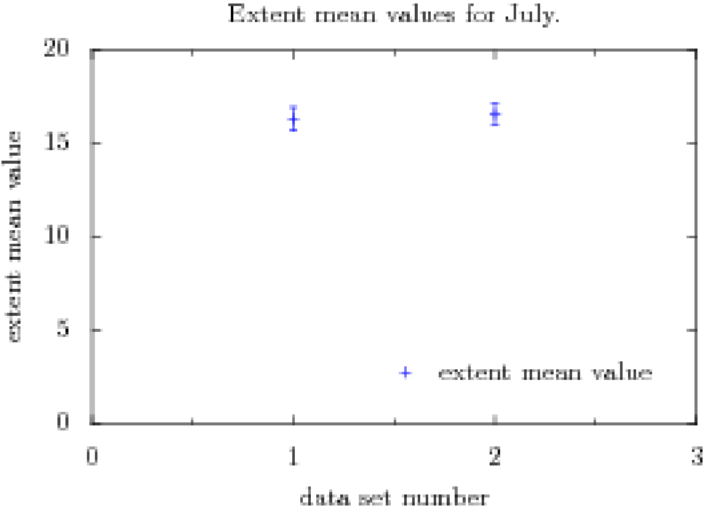


Plot 14.

Extent data in square kilometers X 10e6.

Data set 1: 1979-1995, data set 2: 1996-2012.

Confidence limits are for probability 0.95.

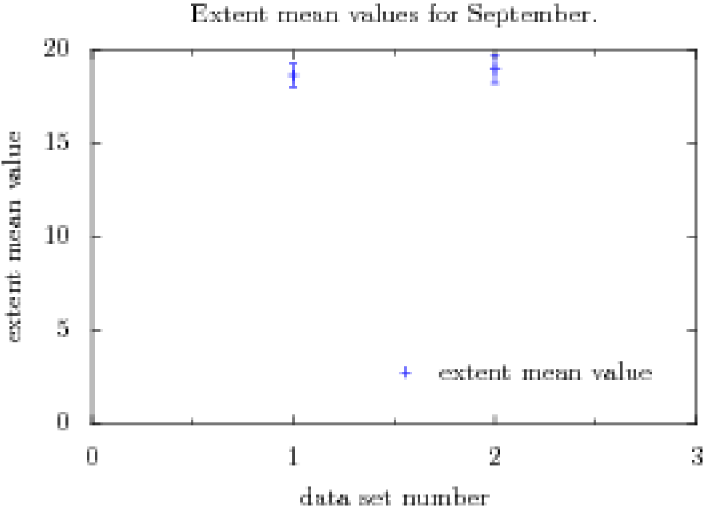


Plot 15.

Extent data in square kilometers X 10e6.

Data set 1: 1979-1995, data set 2: 1996-2012.

Confidence limits are for probability 0.95.



Plot 16.

Extent data in square kilometers X 10e6.

Data set 1: 1979-1995, data set 2: 1996-2012.

Confidence limits are for probability 0.95.