Survey Year	Ice area in millions of square km
1979	7.2
1980	7.9
1981	7.3
1982	7.5
1983	7.5
1984	7.2
1985	6.9
1986	7.5
1987	7.5
1988	7.5
1989	7.0
1990	6.2
1991	6.6
1992	7.6
1993	6.5
1994	7.2
1995	6.1
1996	7.9
1997	6.7
1998	6.6
1999	6.2
2000	6.3
2001	6.8
2002	5.9
2003	6.2
2004	6.1
2005	5.6
2006	5.9
2007	4.3
2008	4.7
2009	5.4
2010	4.9
2011	4.6

The data table to the left shows the minimum ice cap area for the Arctic during the month of September. At this time, the ice cap volume is at an annual minimum during the Arctic Summer. Global warming theory predicts that the polar regions will experience the largest impacts from continued planetary warming.

In this exercise, we will use regression techniques to examine the trends in this tabular data, and examine how reliable forcasts will be for the year 2030 given the current data.

In the problems below, perform the calculations using your choice of technology, or by hand.

Problem 1 - Graph the tabular data using convenient scaling of the horizontal (Year since 1979) and vertical (Area) axes.

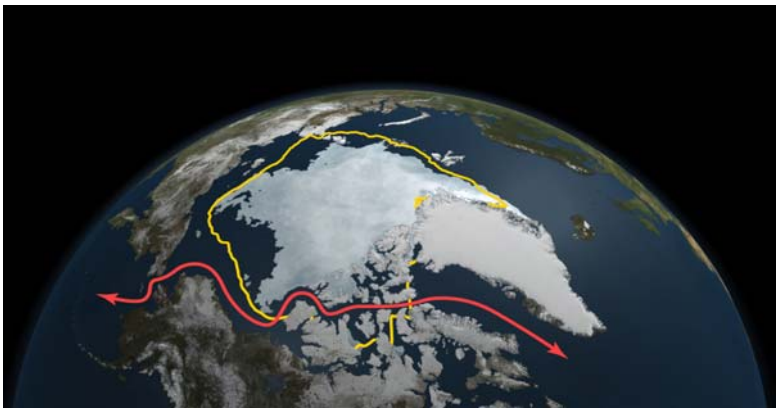
Problem 2 - Use a linear regression to model the data between 1979-2011 and compute the R^2 value of the fit.

Problem 3 - Use a quadratic regression to model the data between 1979-2011 and compute the R^2 value of the fit.

Problem 4 - To the nearest 100,000 km^2, what would you predict as the area of Arctic sea ice in the year 2030 using each regression model?

Problem 5 - Which of the two forecasts would you consider more statistically reliable? Which would you consider more believable?

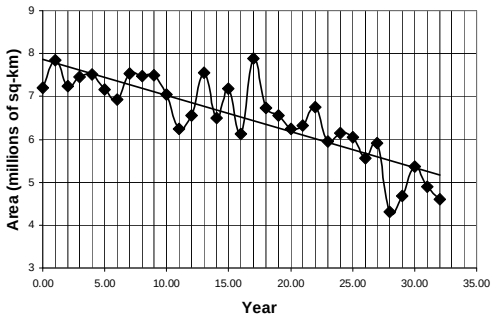
NASA satellite data reveals how this year's minimum sea ice extent, reached on Sept. 9, 2011 as depicted here, declined to a level far smaller than the 30-year average (in yellow) and opened up Northwest Passage shipping lanes (in red). ***(Credit: NASA Goddard's Scientific Visualization Studio)***

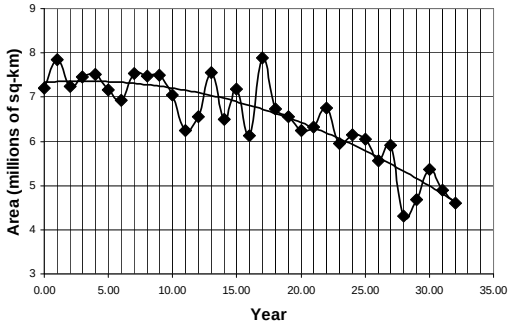


The tabular data was obtained from the NOAA, National Snow and Ice Data Center archive at ftp://sidads.colorado.edu/DATASETS/NOAA/G02135/Sep/
The archive of sea ice data can be assessed at http://nsidc.org/data/seaice_index/archives/index.html

NASA Press Release:
Arctic Sea Ice Continues Decline, Hits 2nd-Lowest Level
October 4, 2011
URL = http://www.nasa.gov/topics/earth/features/2011-ice-min.html

Problem 1 - Graph the tabular data using convenient scaling of the horizontal (year since 1979) and vertical (Area) axes.





Note: For regression purposes, because the year numbers are so large, convert X axis to X = 'Years since 1979'.

Problem 2 - With Excel Spreadsheet, a linear regression (top left) gives **A = 7.9561 -0.0847 (X)** with $R^2 = 0.71$.

Problem 3 - With Excel Spreadsheet, a quadratic regression (top right) gives **$A = -0.0033 (X)^2 + 0.0264(X) +7.308$** with $R^2 = 0.79$

Problem 4 – To the nearest 100,000 km^2, what would you predict as the area of Arctic sea ice in the year 2030 using each regression model?

X = (2030-1979) = 51, then

Linear: A = 7.9561 – 0.0847 (51) so **A = 3.6 million km^2**.
Quadratic: A = -0.0033 $(X)^2$ + 0.0264(X) +7.308 so **A = 0.1 million km^2.**

Problem 5 - Which of the two forecasts would you consider more statistically reliable? Which would you consider more believable?

Answer: The quadratic regression has the better regression coefficient, but if we had removed the last three points (2009, 2010 and 2011) the regression coefficient would be similar to the one for the linear regression, so the quadratic regression is not as 'believable'. More data beyond 2011 is needed.