MAKING SENSE OF SEA ICE DATA – PREDICTING THE TREND

The Arctic Survey's measurements will allow us to better characterise the current state of the Arctic sea ice cover and predict its declining trend.

The Arctic sea ice extent is the area of the Arctic that is covered by at least 15% of sea ice, including areas of the Arctic ocean completely covered by ice, and those that are only partially covered. Scientists have used satellites to measure sea ice extent every September in the years from 1979 through to 1996.

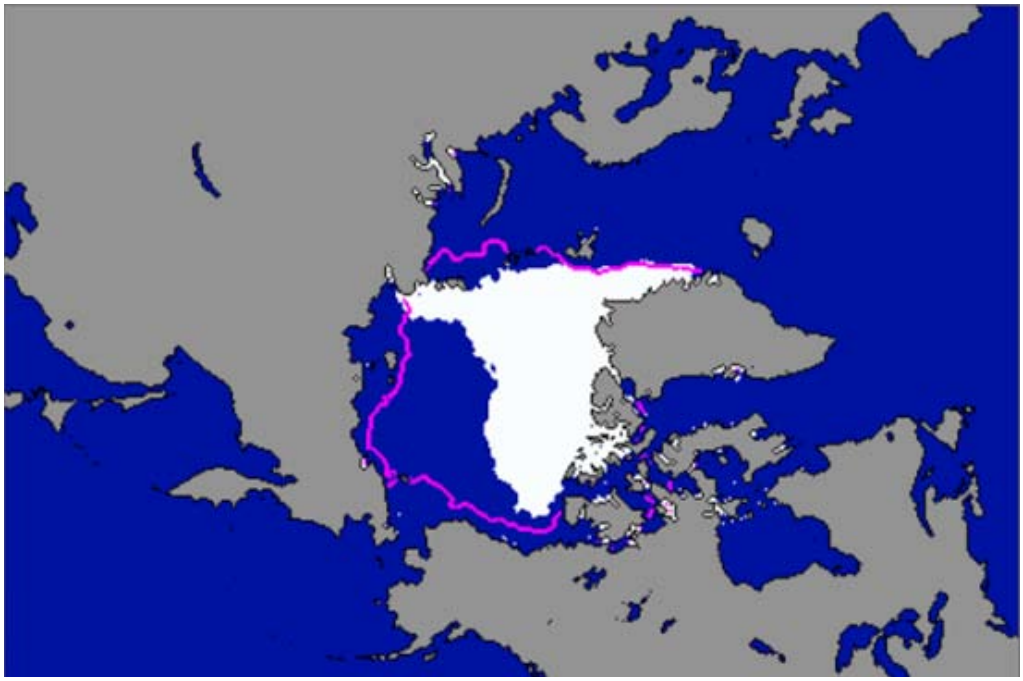

Image courtesy National Snow and Ice Data Center

Sea ice extent in September 2007. The pink line indicates the average extent over the years 1979 to 2000.

The sea ice extent in the years from 1979 until 1996 data is given in the table below. The second column shows you how many years have passed since measurements began in 1979.

Year	Years from start of measurements	Sea ice extent in million km^2
1979	0	7.20
1980	1	7.85
1981	2	7.25
1982	3	7.45
1983	4	7.52
1984	5	7.17
1985	6	6.93
1986	7	7.54
1987	8	7.48
1988	9	7.49
1989	10	7.04
1990	11	6.24
1991	12	6.55
1992	13	7.55
1993	14	6.50
1994	15	7.18
1995	16	6.13
1996	17	7.88

Question 1: Plot the data points in a coordinate system, with the x-axis labelled by column 2 (0 year, 1 year, 2 years, etc) and the y-axis by column 3. Can you discern a trend?

Answer: *This is an open-ended question designed to stimulate discussion around year-to-year variations and long-term trends. A slight downward trend can be discerned in the data.*

Question 2: In your coordinate system, draw a straight line which you think best approximates the data. Using two points on your line, work out its equation. What does this line predict for the sea ice extent in the years 2000, 2005 and 2010?

Answer: *Answers will depend on students' interpretation of data and choice of line. For guidance, the least squares method of fitting a line (one of the mathematical techniques for finding a line of best fit) gives*

$$y = -0.04x + 7.47$$

predicting that the sea ice extent will be 6.66 million square kilometers for 2000 (year 21), 6.46 million square kilometers for 2005 (year 26) and 6.26 million square kilometers for 2010 (year 31).

Question 3: The table below gives additional data from 1997 through to 2006. Add the new points to the existing data on your coordinate system. How does the new data compare to your predictions? Can you discern a new trend in the data from 1979 to 2006?

Year	Years from start of measurements	Sea ice extent in million km^2
1997	18	6.74
1998	19	6.56
1999	20	6.24
2000	21	6.32
2001	22	6.75
2002	23	5.96
2003	24	6.15
2004	25	6.05
2005	26	5.57
2006	27	5.92

Answer: *The downward trend has become a lot more marked.*

Question 4: Draw a new line to approximate the data and work out its equation. How does this compare to the line you found in question 2? What does this predict for 2007, 2008 and 2010?

Answer: *Answers vary according to the line chosen by students. For guidance, the least squares method of fitting a line gives*

$$y = -0.06x+7.64,$$

predicting a sea ice extent of 5.96 square kilometers for the year 2007, 5.9 square kilometers for the year 2008, and 5.78 square kilometers for the year 2010. The new line has a steeper slope, reflecting the change in the trend.

Question 5: The measurements of September sea ice extent for 2007 and 2008 are 4.30 and 4.67 million square kilometers respectively. How does this tally with your observations so far? Should we be worried?

Answer: *This is an open-ended question designed to stimulate discussion. There was a dramatic drop in sea ice extent in 2007, followed by a slight recovery in 2008. Discuss that a single unusual result may not indicate a change in the overall trend (compare to the unusually large sea ice extent in 1994), but that two results that are out of line with predictions may indeed indicate a change in the trend. Point out that more information is needed to predict the future.*

Question 6: Based on what you have learned so far, what predictions would you make for the future of the Arctic ice cap?

Answer: *This is an open-ended question designed to stimulate discussion. The data very strongly indicates a decrease in sea ice extent, so it seems reasonable to assume that this decrease will continue. The new data from 2007 and 2008 may indicate an alarming acceleration in the rate at which the extent is shrinking.*

The process of fitting a straight line to a set of data points is called *linear modelling*. In reality, statisticians do not simply guess the straight line as we have just done, but use mathematical techniques to minimise the discrepancy between the data point and the line. The straight line they choose then indicates future trends. When data points are way out of line with predictions, as happened here with the years 2007 and 2008, statisticians use mathematical techniques to determine whether the unusual result is just a blip, or gives true cause for concern.