SEA ICE PREDICTION NETWORK (SIPN)

Template for Pan-Arctic Sea Ice Outlook Core Contributions
June Report (Using May Data)

1. Chris Reynolds, amateur studying sea ice.

2. Statistical/Heuristic method. PIOMAS gridded data used to calculate Arctic Ocean sea ice volume.

3. NSIDC Extent: 4.06 +/-0.57 M km^2.

4. Using PIOMAS gridded data the volume of sea ice within the Arctic Ocean in May has been calculated, this is then linearly regressed against NSIDC Extent for September to develop a relating equation. After 2007 there is a changed behavior of the pack, however 2013 is viewed as atypical of the post 2007 period. So statistics from the period 2007 to 2012 only are used to establish the bounds of the prediction. The limits are based on past data, there is no associate statistical significance.

5. Upper limit 4.62M km^2, lower limit 3.48M km^2

6. The residuals from the linear regression (using 1979 to 2013) are examined for 2007 to 2012. The highest and lowest residuals are applied to the September extent predicted using May Arctic Ocean PIOMAS sea ice volume.

7. Because the decline in extent is due to increasing ease with which open water can be revealed by declining volume, a simple method is used to predict September sea ice extent based on May sea ice volume for the Arctic Ocean from the PIOMAS model.

Further Detail.

Regression of NSIDC September extent and May PIOMAS volume for the Arctic Ocean (including the Canadian Arctic Archipelago) has been carried out in Excel, using a linear fit (fig 1). This has then been used to develop a simple prediction method for September extent based on May volume.

Arctic sea ice volume has been calculated using monthly PIOMAS gridded data (.heff files), available here. The regional volume data has been calculated previously and is available here in CSV files.

The R^2 for the linear regression (0.7664) was marginally worse than that for the whole PIOMAS domain (0.7738). For the peripheral seas excluding the Central Arctic region the R^2 was 0.6998. This is to be expected because the regression uses all data from 1979 to 2013 and the largest part of the volume decline in the Arctic Ocean has been from thicker multi-year ice (PIOMAS data, Bitz & Roe), now concentrated in the Central region. This factor also explains the similarity between the Arctic Ocean and the whole PIOMAS domain. When originally calculated in April, the R^2 for the Arctic Ocean was larger than for the whole PIOMAS domain.

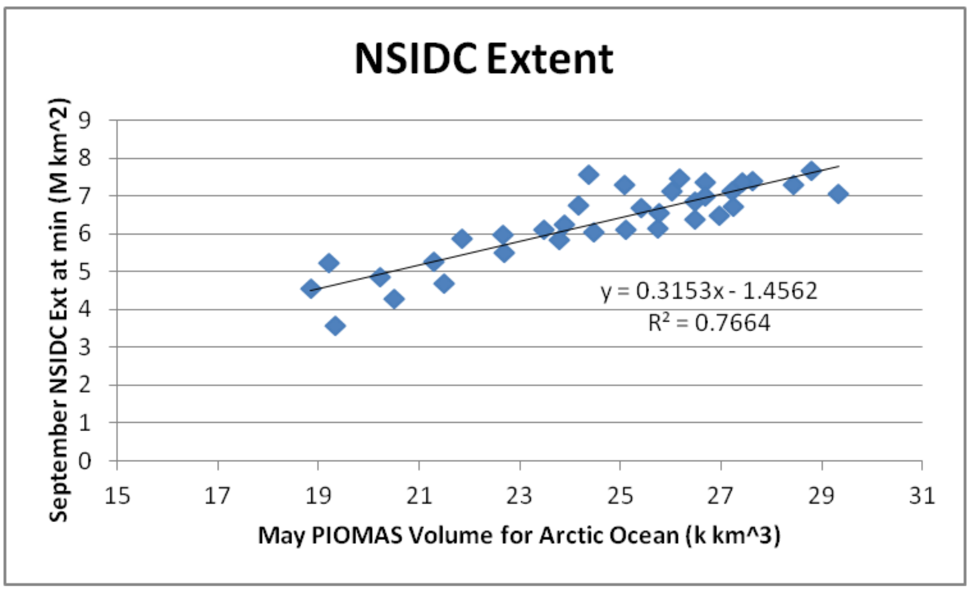

Figure 1. Regression of NSIDC September extent and May PIOMAS volume for the Arctic Ocean (including the Canadian Arctic Archipelago).

The Arctic Ocean was chosen because sea ice conditions within the Arctic Ocean are able to play a role in the late summer. Whereas, by then, ice outside the Arctic Ocean has melted out so does not impact the minimum. By May the R^2 of the Arctic Ocean was lower than for the whole PIOMAS domain, but once the calculations for April were re-worked it was found that the bounds of the prediction were marginally smaller for May Arctic Ocean volume.

Following the prediction for September NSIDC extent using the May volume for the Arctic Ocean, the equation derived in figure 1 was used to calculate a series of hindcasts for each year from 1979 to 2013. The actual minimum was then deducted from the hindcast value for each year and a series of residuals was calculated.

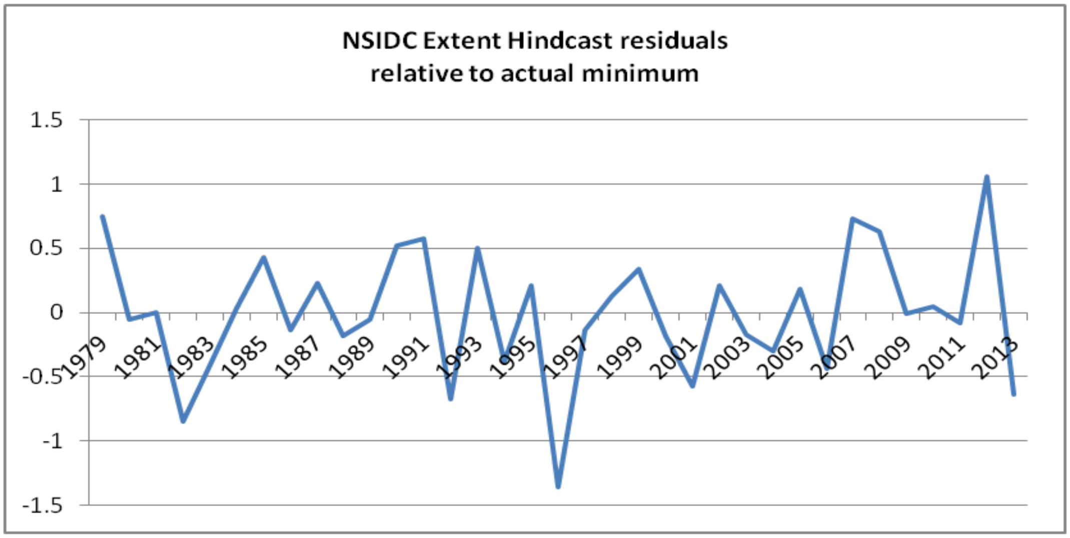

Figure 2. Residuals of hindcast for all available data, positive values imply that the hindcast is above the actual value, negative implies the hindcast is below.

The residuals after 2007 were found to be high, apart from 2013. All the years post 2007 (except 2013) have had an enhanced 500mb Greenland geopotential ridge, enhanced Beaufort High, and predominant low pressure tendency over the north of Siberia forming a dipole between the western and eastern Arctic. In 2013 the situation was reversed, and weather not conducive to ice melt, resulting in a year of reduced melt. The post 2007 years are also typified by increased extent loss during the summer, this includes 2013 (fig 3). So this is probably due to thinner ice and increased open water production efficiency.

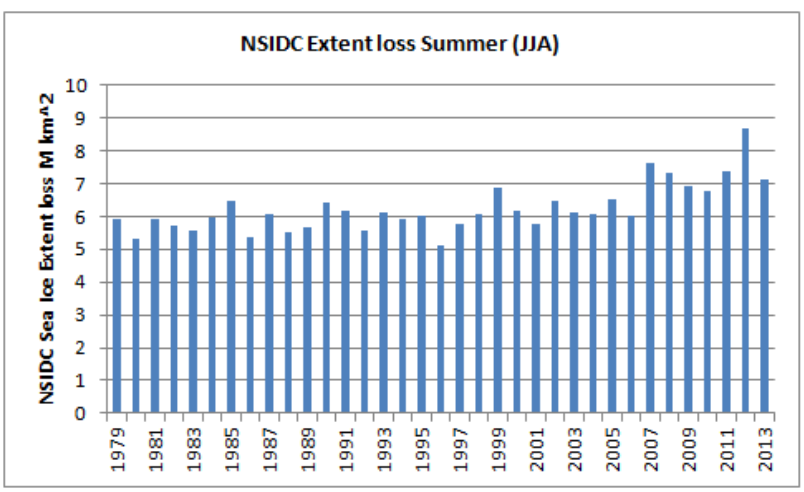

Figure 3, NSIDC Extent summer loss increases after 2007, including 2013.

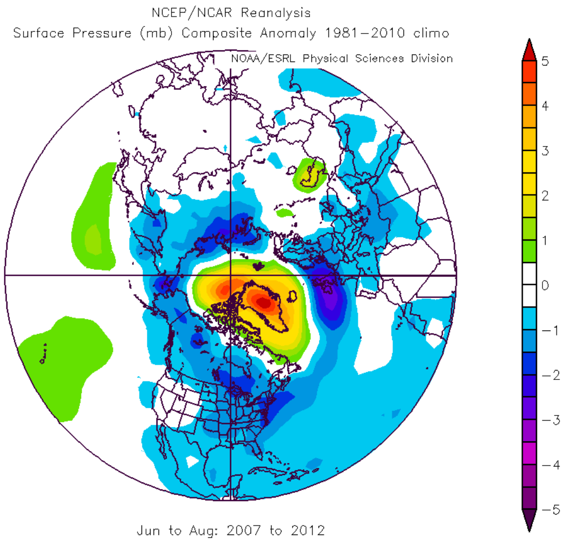

Figure 4a. Summer (JJA) average NCEP/NCAR sea level pressure (SLP) for 2007 to 2012.

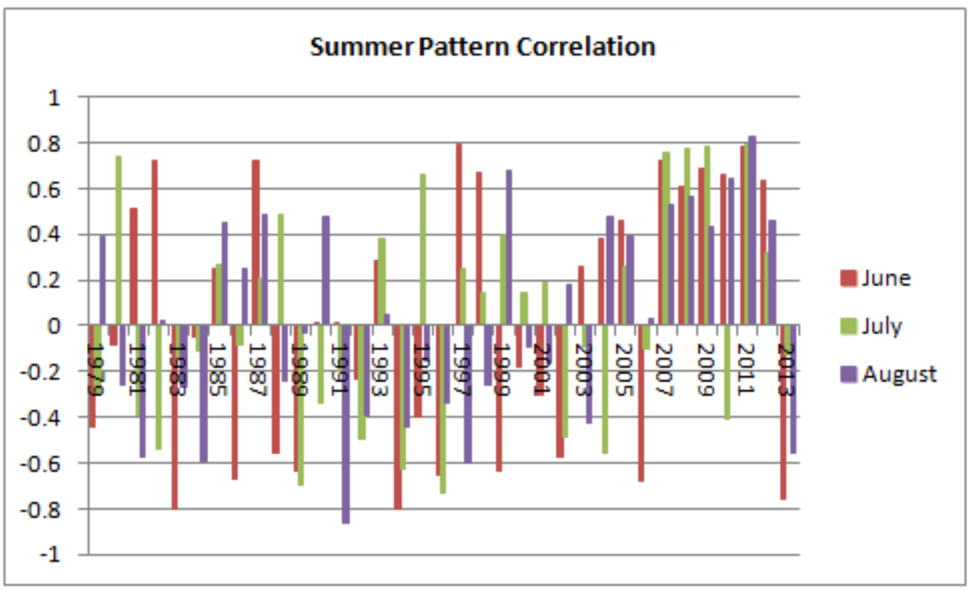

Figure 4b. Pattern correlation of the SLP pattern in fig 4a with each shown month's average SLP from 1979 to 2013, summer months.

It is hard to establish the precise roles of atmosphere and ice state in the post 2007 change in seasonal cycle. However my working assumption is that the atmospheric changes seen in 2007 to 2012 (figs 4a & 4b) are typical of what we can expect in years to come, I suspect that the Arctic Dipole typical of 2007 to 2012 (Overland et al) is being caused by the same process at work in 2007 (i.e. Bluthgen et al), so a recurrence is likely in 2014. Therefore I am treating 2007 to 2012 as indicating a new atmospheric regime conducive to ice loss and fitting the prediction method to this period, accepting the loss of statistical significance by only using six years. In any year where this pattern fails to manifest the prediction method will under-predict September extent.

In 2010 there was a large volume loss event in PIOMAS which has led to increased volume loss from May through June, and an increase in NSIDC extent June losses. Considering all indices of extent and area, 2011 was arguably a tie with 2007, 2012 was a substantial new record, it remains to be seen what will happen this year with regards the post 2010 situation, however it should be borne in mind that May PIOMAS data already shows the start of a large volume loss similar to 2010 to 2013.

Having decided to concentrate on 2007 to 2012 the residuals were used to make bounds for the prediction. This was done simply by taking the maximum and minimum residuals and applying these to the prediction (and hindcasts). This means that apart from 2013 (which is treated as an outlier), all years from 2007 to 2012 are within the bounds applied to the hindcast. This does not of course give any information about future behavior, the six year period used is too short for statistical significance.

The hindcasts are shown below in figure 5. 2013 is clearly a fail, all other years would be a success with this simple method.

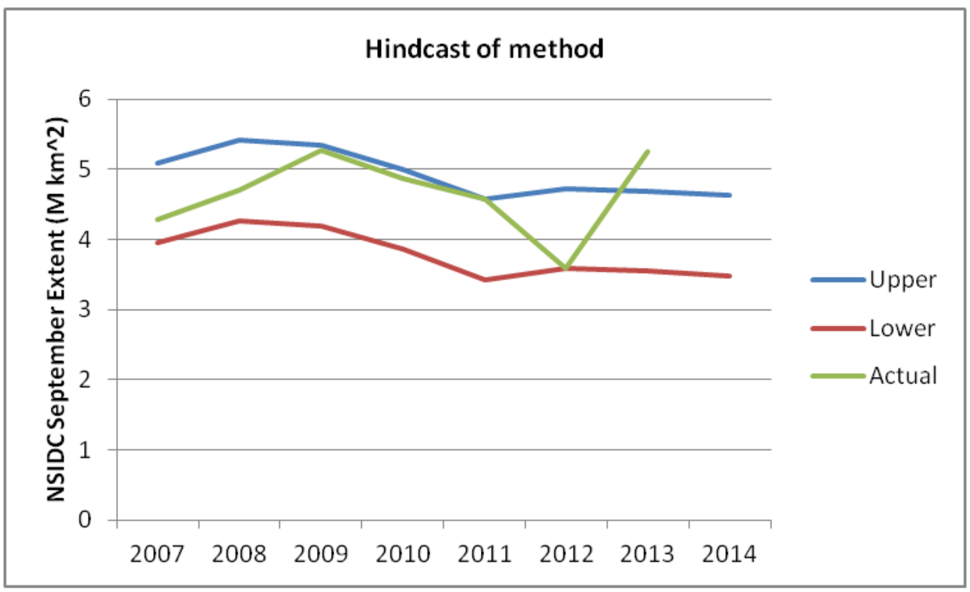

Figure 5, Hindcast September minimum. Actual September minimum for each year, and upper and lower bounds of hindcast for each year.

Comparing this method to a quadratic fit to September average extent (without involving volume) has been done. The quadratic fit has been used in place of the equation derived in figure 1, otherwise calculations are identical. The range between the upper and lower bounds for the quadratic fit to extent alone are 1.31M km^2, in comparison the range between the upper and lower bounds for the prediction method used here is 1.14M km^2.

References.

Bitz & Roe, 2004, A Mechanism for the High Rate of Sea Ice Thinning in the Arctic Ocean.
Bluthgen et al, Atmospheric response to the extreme Arctic sea ice conditions in 2007.
Overland et al, 2012, The recent shift in early summer Arctic atmospheric circulation.