NSIDC Sea Ice Outlook Contribution, 31 May 2012

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June Report based on May Data

Summary

NSIDC is using the same approach as the last 2 years: survival of ice of different ages based on ice age fields provided by Mark Tschudi (Univ. Colorado, Boulder) based on the ice age algorithm of *Fowler et al*. [2003]. As in 2011, we are using a revised ice age product, one based on a 15% sea ice concentration threshold rather than the version used in the 2010 Outlook, which used a threshold of 40% [see *Maslanik et al*., 2011 for more details]. The use of a 15% threshold on sea ice concentration captures greater detail within the marginal ice zone, matches NSIDC's threshold used for mapping overall sea ice extent and should therefore provide a better estimate of the September 2012 ice extent. Using this approach and taking into consideration that the survivability of ice during the summer melt season has changed in recent years, gives us an average estimate of 4.59 10^6 km^2, using ice survival rates from the last 5 summers. The expected range is 4.11 (2007 survival rates) to 5.19 10^6 km^2 (based on last 10 years of ice survival rates).

Method

At any time of the year, the total sea ice area can be defined as the sum of the areas of the individual ice age classes, such that the total ice area (SI) is defined as:

$$SI = F_1 + F_2 + F_3 + \ldots + F_n$$

Where F_1 is the area fraction of first-year ice, F_2 is the area fraction of second year ice, etc. The amount of ice left over at the end of summer (SI_{sep}) then depends on the survivability of the winter ice cover (SI_{mar}) which can be defined as the survivability of the ice of different ice age classes, i.e. s_1 equals the survivability of the winter first-year ice fraction (F_{mar_1}). Thus, SI_{sep} equals:

$$SI_{sep} = s_1 * F_{mar\_1} + s_2 * F_{mar\_2} + \ldots + s_n * F_{mar\_n}$$

where the survivability for a specific ice age class (e.g. s_1) is equal to the ratio of the September to March fraction of that age class (e.g. F_{sep_1}/F_{mar_1}). In this context, survivability includes melt and transport components.

As we did last year, we account for survival rates as a function of latitude to compensate for the fact that over the past few years', first-year ice has been found at much higher latitudes than has been typical during previous years. Breaking up the analysis into 2 degree latitude bands, the total September ice area is then the sum of all survival rates for each ice age category and for each latitude band:

$$SI_{sep} = \sum_{lat} s_{1\,lat} * F_{mar\_1_{lat}} + s_{2\,lat} * F_{mar\_2_{lat}} + \ldots + s_{n\,lat} * F_{mar\_n_{lat}}$$

One problem with this approach however, is that the ice age data are restricted to open ocean areas only, where ice motion can be resolved with the satellite passive microwave data. Thus, this data set does not cover the entire Arctic, such as passages in the Canadian Archipelago. In order to take into consideration the sea ice area of the Arctic not covered by the ice age data and where ice may remain during summer (i.e. the Canadian Archipelago), we additionally compute another survival rate for each year based on the total extent bias between the passive microwave sea ice extent and the ice age extent for both the maximum (March) and the minimum (September), i.e.

$$extra\_survival = September\_offset/March\_offset$$

so that the final equation can be written as:

$$SI_{sep} = (\sum_{lat} s_{1lat} * F_{mar\_1_{lat}} + s_{2lat} * F_{mar\_2_{lat}} + ... + s_{nlat} * F_{mar\_n_{lat}}) + extra\_survival * March\_offset$$

Computing this for every year, using each year's survival rates together with the ice age distribution from March 2012 and the "extra" ice not mapped by the ice age data gives the results show in Figure 1, which shows the predicted minimum September extent for 2012 as a function of individual yearly survival rates. For reference, the orange line indicates the predicted 2012 minimum based on the average survival rates from the last 10 years, and the red line shows the predicted minimum using the last 5 years of survival rates. The blue line shows the minimum for 2007.

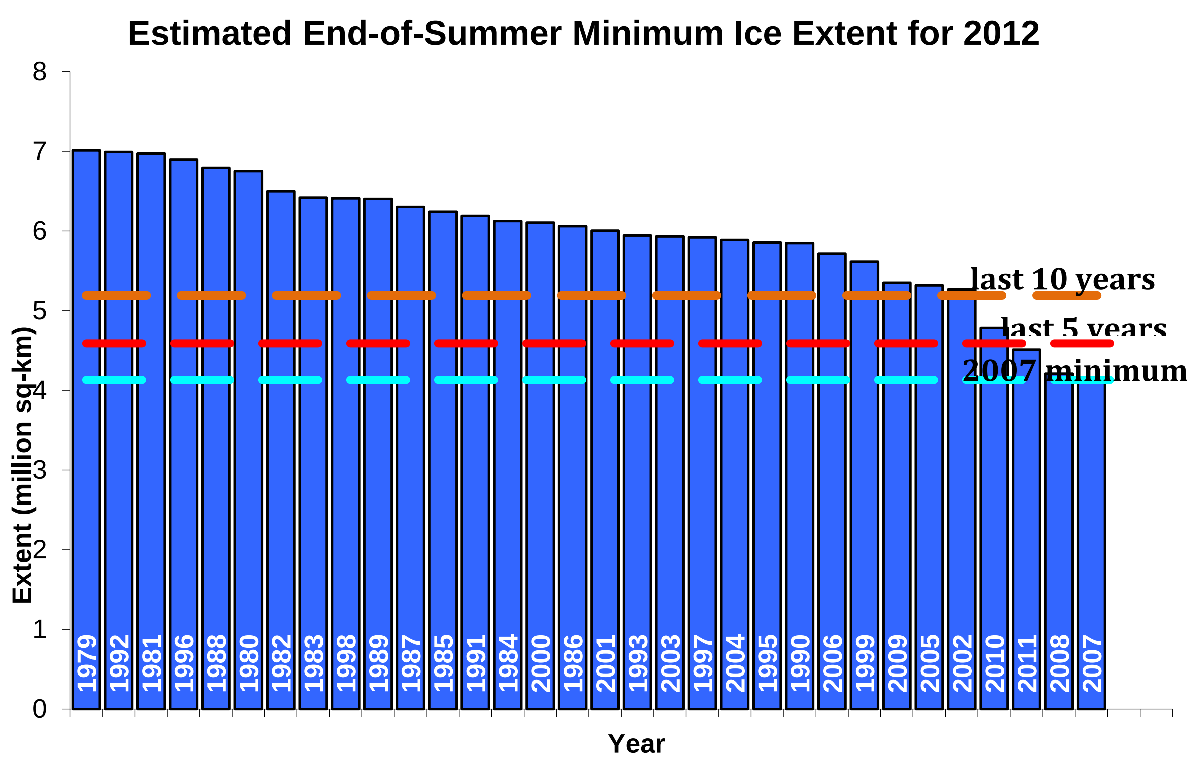

Figure 1. Estimated 2012 minimum extent based on ice age survival rates from previous years (1979-2011). Blue line shows the 2007 September minimum, red line shows the predicted minimum using an average of the last 5 years of survival rates, whereas the orange line shows the predicted minimum using an average of the last 10 years of survival rates.

The first result is that given the distribution of ice age this March (Figure 2), a new record minimum would occur if this coming summer saw ice loss rates for each ice age category similar to that observed in 2007 (predicted minimum of 4.11 10^6 km^2). If ice loss rates were similar to that observed in 2008, the minimum would be the second lowest at 4.21 10^6 km^2. This potential for a new record, or near-record minimum reflects the loss of the oldest and thickest ice (5 years +) in the Arctic Basin during recent years, which in March 2012 made up only 2% of the total ice cover, whereas in the 1980s it made up more than 20%.

The second result is that if we took an average of survival rates over the last 30 years, the minimum is forecasted to be 5.88 10^6 km^2. However, it is clear that climate conditions have changed during the last several years, which impacts on the survivability of the winter ice cover. The Arctic atmosphere has warmed in all months during the last decade [e.g. *Stroeve et al*., 2011a], melt onset begins earlier in the year and the ice freezes later [e.g. Markus et al., 2009], resulting in an enhanced the ice-albedo feedback [*Perovich et al*., 2011] and increased the sensible heat content of the ocean. While ice that is sequestered and aged within the clockwise Beaufort Gyre has historically provided a source of old, thick ice to replenish multiyear ice lost from the Arctic each year through melt and export, this replenishment is becoming less viable, case in point being the year 2010. While the winter of 2009/2010 saw an especially strong transport of multiyear ice from the Canadian coasts into the Beaufort Sea, nearly all of it melted away during summer [*Stroeve et a*l., 2011b].

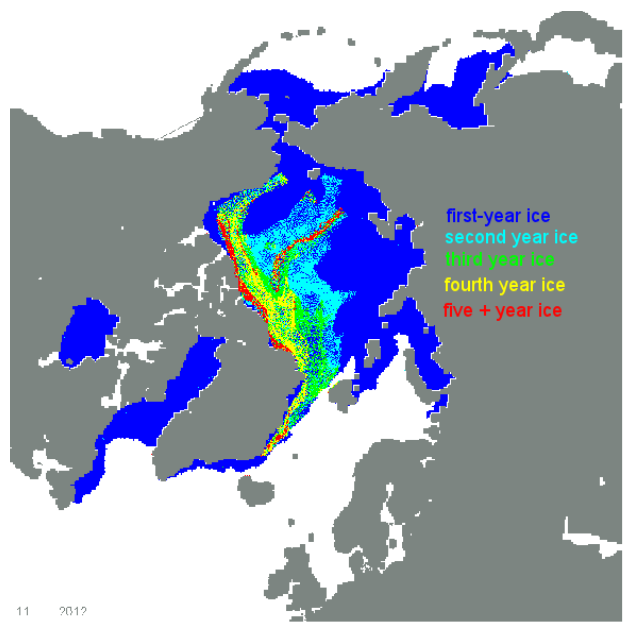

Figure 2. Ice age from week 11 (March) 2012.

Given the changing nature of survivability of multiyear ice in the Canada Basin and the Beaufort Sea in recent years, it is likely more appropriate to use survival rates from recent years to forecast the 2012 minimum. The forecasted minimum is 5.19 10^6 km^2 using the last decade of ice loss rates, and drops further to 4.59 10^6 km^2 based on the last 5 years of ice survival rates. Thus, our estimate for 2012 ranges from 4.11 - 5.19 10^6 km^2, with an average of 4.59 10^6 km^2.

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Details

Our first Outlook contribution in 2008 employed ice age fields provided by Chuck Fowler and Jim Maslinik (Univ. Colorado, Boulder). Because most of the summer ice loss is due to first-year ice (FYI), the survival of FYI is an important component of the end-of-summer minimum extent. How much FYI survives the summer melt season depends on a number of factors, e.g., the amount of FYI at the start of the melt season, the location of the FYI within the Arctic, advection of FYI ice (within and out of the Arctic basin), and of course the evolution of summer atmospheric and oceanic conditions. Though less of a percentage than FYI, some older multiyear ice (MYI) also does not survive the melt season due to the same factors. Thus, we accounted for the survival rates of all ice age types.

Historically, different summers have had substantially different survival rates. If we assume that conditions during the forthcoming summer will fall somewhere between the extremes of the historical period between 1985 and 2007, we provide a reasonable range of potential minimum extent based on the range of survival rates through previous summers.

In 2008 our range was too high and largely overestimated the minimum extent. We assessed that this was due to the fact that after the extreme low of 2007, there was far more FYI much farther north than normal. This FYI, though likely of similar thickness as previous years, was subject to lower solar forcing because of the high latitude. Thus, for 2009, we adjusted our method by calculating survival rates in 2 degree latitude bins. This also overestimated the minimum extent, perhaps because the low amount of FYI at high latitudes in previous did not provide robust statistics. In addition, conditions (winds/temperatures) through the summer were not as conducive to ice loss.

This year presents an interesting challenge. Unlike recent winters, there was much less advection of ice across and out of the Arctic due to a persistent strong negative mode of the Arctic Oscillation. Thus, the significant amount of FYI that was retained at the end of the previous two summers, which has since aged (and thickened) into 2nd and 3rd year ice largely stayed within the Arctic (Figure 2). However, there continued to be loss of older ice types. In addition, a tongue of relatively older ice spread across the northern coast of Alaska due to a strong Beaufort Gyre through the winter. This tongue contains considerable old ice, but this ice is relatively far south and largely in shallow shelf regions that will likely receive considerable heating from both the ocean and atmosphere. It is quite possible that most of this ice will melt out completely, but it is also possible that some that ice will survive and we may see a situation similar to 2006 where a large region of open water within the ice pack (i.e., a polynya-like feature) in the Beaufort/Chukchi region. The fate of this thicker older ice is a bit of a wildcard our estimates because if much of this ice does melt out completely, our estimates for older ice survival will be too high.

On the other hand, because of the retention of 2nd of 3rd year ice within the Arctic, FYI is mostly found at more typical latitudes closer to the coasts. Thus, FYI retention estimates may be more accurate this year compared to the past two years.

The minimum extent for 2010 based on the average of the previous years is 4.5 million square kilometers, with a one-standard deviation range of 3.9-5.2 million square kilometers. Based on the -

extremes of survival rates from previous years give a range between 2.9 millions square kilometers (based on 2007 survival rates) and 5.5 million square kilometers (based on 1996 survival rates). Survival rates from 4 out of 25 previous years (16%) will result in a new record minimum; 10 out of 25 (40%) result in a minimum below 2008 and 21 of 25 (84%) result in a minimum below 2009.

Figure 2. Ice age distribution from early May 2010 showing the substantial amount of 2nd and 3rd ice around the pole and the tonight of older ice stretching into the Beaufort Sea. Data/image provided by Chuck Fowler and Jim Maslanik, University of Colorado at Boulder.