NSIDC Sea Ice Outlook Contribution, 16 June 2010

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Summary

NSIDC is using the same approach as last year: applying the survival fraction of ice of different ages determined from past seasons to the observed distribution of ice ages at the beginning of the melt season. Ice age fields are provided by Chuck Fowler and Jim Maslanik (Univ. Colorado, Boulder; see Fowler et al., 2004 and Maslanik et al., 2007).

Computing survival rates of the different ice age classes for each year, together with the observed ice age distribution from March 2010 and the "extra" ice not mapped by the ice age data during March 2010 gives the results shown in **Figure 1** based on survival rates for 1985-2009. Shown also are the minimum September extents for the last 3 years (horizontal lines). From this analysis it appears that a new record low will not be reached this year if the 2010 survival rates are within the range of historical ice survival rates. This is in part because there is more 2nd and 3rd year ice at the start of 2010 than has been seen the last few years. Also, winter extent was larger in 2010 than in previous years. If the 2010 survival rates are similar to 2007, however, the September 2010 extent will rival what was observed in 2007 (4.31 versus 4.13 million km^2).

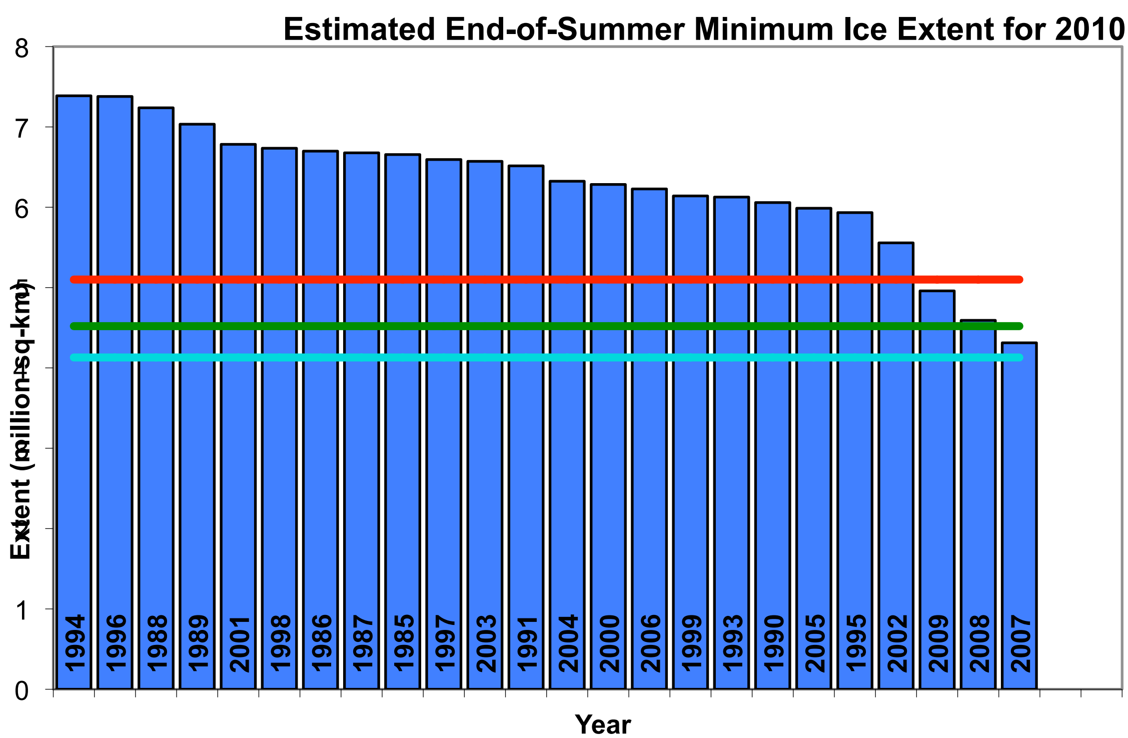

Figure 1. Estimated 2010 minimum extent based on ice age survival rates from previous years (1985-2007). Dashed lines are actual minimum extents for the past three years (red = 2009; green = 2008; blue = 2007).

Details

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, at any time of the year, the total sea ice area (SI) can be defined as the sum of the areas of FYI and MYI, or breaking it into the individual ice age classes:

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

Where F_1 is the area fraction of first-year ice, F_2 is the 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}) such that $s_1 = F_{sep\_1}/F_{mar\_1}$. In this way, SI_{sep} equals:

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

As we did last year, we account for survival rates at different latitude bands 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 and this more northerly first-year ice likely has a better chance of surviving summer melt than more southerly located first-year ice. 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

$$SI_{sep} = \Sigma_{lat} (s_1 * F_{mar\_1} + s_2 * F_{mar\_2} + \dots + s_n * F_{mar\_n})$$

Thus the equation above gives the September minimum as defined by the ice age data.

However, the ice age data does not cover the entire Arctic, nor does the ice edge as defined by the ice age data match that provided by the SMMR and SSM/I time-series of ice extent archived and distributed by NSIDC. This is because the ice age product uses a 40% threshold for the ice edge whereas NSIDC uses a threshold of 15%. The higher threshold is required for accurate ice motion tracking, which is the basis for the age determination. On average the March winter extent from NSIDC is 5.07 ($\pm$0.37) million km^2 larger than that from the ice age product. Similarly, during September, the ice age September minimum is underestimated on average by 1.56 ($\pm$0.21) million km^2. Nearly all of the extra ice in the NSIDC extent is first-year ice at low latitude, and therefore unlikely to survive. For September, we anticipate that almost all of the ice remaining at the end of the melt season – including that not mapped by the ice age grid -- will survive, although we do not know the age of the extra ice in the NSIDC minimum extent.

In order to account for the area of Arctic ice not covered by the ice age data, we additionally compute another survival rate for each year based on the extent bias between the two data sets, i.e.

$$s_{extra} = offset_{sep}/offset_{mar}$$

where $offset_{sep}$ = September ice extent from NSIDC minus that from the ice age data. The same is true for March. Since the majority of this ice is likely first-year ice (except for the Canadian Archipelago) and located in a relatively southerly location, the latitudinal dependence of survival of this "extra" ice is not considered. Including the "extra" ice, the final equation can be written as:

$$SI_{sep} = ?_{lat} (s_1*F_{mar\_1} + s_2*F_{mar\_2} + \ldots + s_n*F_{mar\_n}) + s_{extra}*offset_{mar}$$

This represents a correction to the algorithm from the last two years, where we did not properly account for the offset of ice area between the ice age determination and the NSIDC ice extent. Computing this for every year, using each year's survival rates together with the ice age distribution from March 2010 and the "extra" ice not mapped by the ice age data during March 2010 gives the results shown in **Figure 1** based on survival rates for 1985-2009.

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 2009, we provide a reasonable range of potential minimum extent based on the range of survival rates through previous summers. However, it is clear from this analysis that survival rates have changed in recent years. For example, if we use an average of survival rates for 2000-2010, then the prediction for 2010 would be for a September minimum of 5.76 million km^2. If instead an average from the last 5 years is used, the prediction would be for 5.21 million km^2 (just above the 5.10 million km^2 observed last summer). While using average survival rates can be useful, it is clear that these rates have been changing in recent years, which may in part reflect thinning of the ice in different age classes, warming atmospheric and ocean temperatures and changes in wind patterns that impact on summer ice survival.

This year presents an interesting challenge. A significant amount of high-latitude FY ice was retained at the end of the previous two summers, which has since aged and thickened into 2nd and 3rd year ice [**Figure 2**]. A tongue of this relatively older ice was advected westward to the northern coast of Alaska due to a strong Beaufort Gyre through the winter (a result of the high negative AO phase this year). This offshore Alaskan 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 this ice will melt out completely by September. However, during the melt season (and possibly even at the end in September) we forecast that the MYI will melt more slowly, possibly leading to a situation similar to 2006, where thinner ice north of MYI melted earlier, forming a large polynya-like feature at high latitude in the Beaufort. The fate of this thicker older ice is a bit of a wildcard in 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 NSIDC sea ice group forecasts are:

5.76 million square km based on the mean age- and latitude- corrected ice survival rates for **2000-2009;**

5.21 million square km based on the mean age- and latitude- corrected ice survival rates for **2005-2009.**

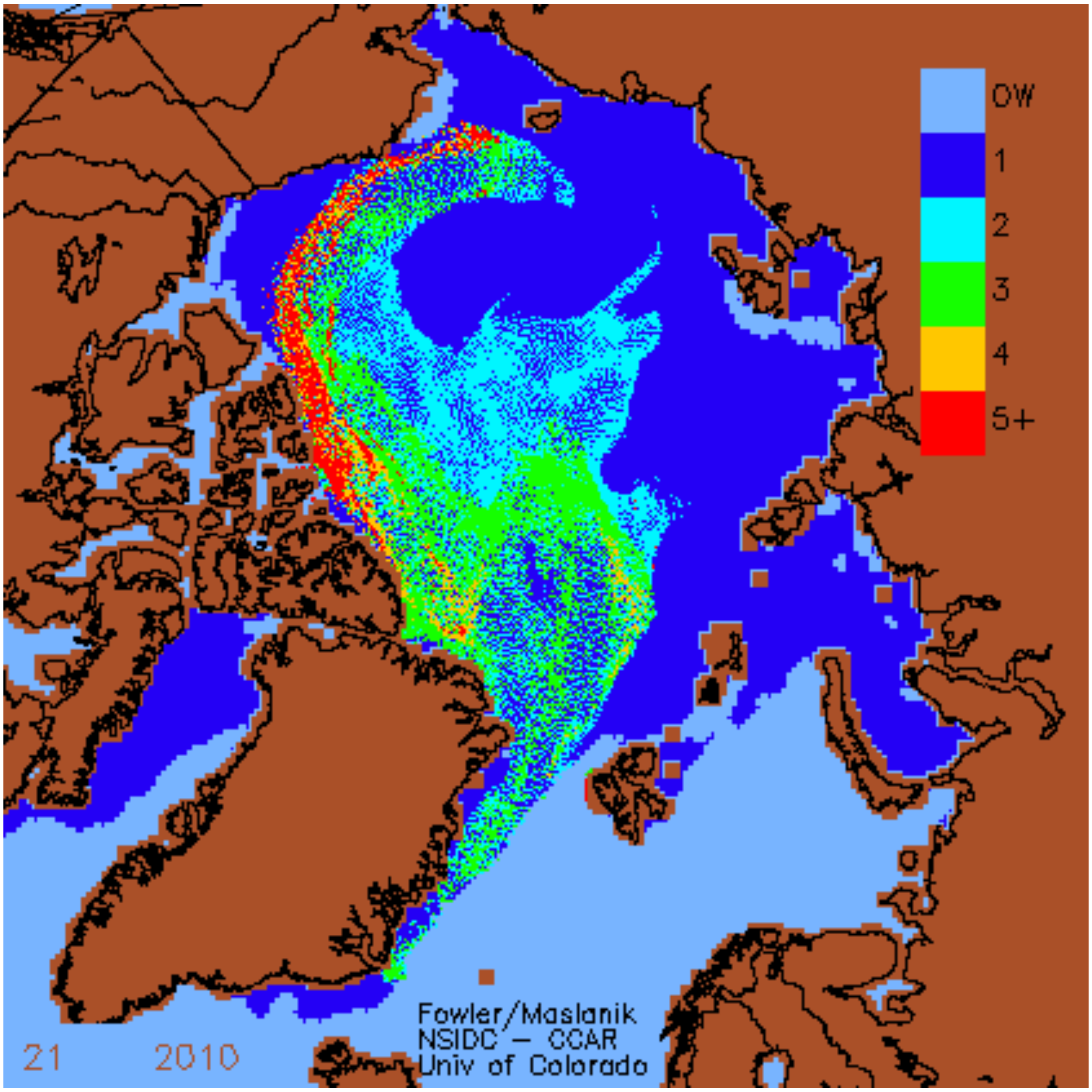

Figure 2. Ice age distribution from early May 2010 showing the substantial amount of 2nd and 3rd ice around the pole and the tongue of older ice stretching into the Beaufort Sea. Data/image provided by Chuck Fowler and Jim Maslanik, University of Colorado at Boulder.