September 2009 Sea Ice Outlook: August Report
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Summary
NSIDC's original assessment of 4.6 million square kilometers, based on the initial amount and distribution of ice age types, remains unchanged. An alternative statistically-based method, using projected rate of sea ice extent decline from previous years' data, was implemented for an updated, complementary estimate. Simply applying statistical averages of rates of decline was deemed to likely yield too high of an estimate because the averages do not take into account the changed nature of the younger, thinner summer ice cover. Thus, a weighted average, subjectively weighting more recent years higher, was calculated. This approach yields a ***best estimate of 4.69 million square kilometers, with a range of 4.38 – 4.91 million square*** **kilometers**.

Rationale
NSIDC based its first two extent outlooks on the survival rate through the summer of the amount of ice age categories at the end of winter; the location of the ice age types relative to the pole was also taken into consideration to account for the varying amount of solar energy received through the summer.

Since that method is based only on the initial condition of the ice cover heading into summer, that estimate of 4.6 million square kilometers is unchanged. However, as discussed in our previous submissions, there are two main factors that determine the September sea ice extent: pre-conditioning of the ice cover before the summer begins and the magnitude of the dynamic and thermodynamic forcing (e.g., winds, air/ocean temperatures, clouds, etc.) through the summer.

Our earlier assessments were based solely on pre-conditions. However, now the summer has progressed enough so that we can begin to take into account the effect of atmospheric forcing. NCEP reanalysis fields indicate that the summer so far has been similar to 2007 in featuring a prominent Beaufort Sea anticyclone. This has promoted warm southerly to southeasterly winds west of the high along with fairly clear skies under the high, both of which favor melt over the western Arctic.

The impact of the forcing to date is realized through the effect so far on the sea ice extent, as shown in the figure below. We did not see an acceleration in the decline this year as occurred during early July 2007. However, the rate of decline during the second half of July 2009 was faster compared to the same period in 2007, though the rate slowed considerably the last couple days of the month due to a change in wind patterns.

Some of the effect of future forcing through the rest of the melt season cannot be forecast because it is due to synoptic activity over the next several weeks. However, as we have now passed the summer solstice, the effect of forcing starts to become constrained by the amount of solar insolation. As the sun sets in the Arctic, the amount of solar energy becomes less and starts to constrain the amount of further melt possible.

Methodology

Thus, current conditions start to become better correlated with the final September conditions and extrapolating forward is more appropriate. Here, we implement such a method by projecting the daily sea ice extent forward from 31 July through the end of September based on the daily rate of decline from previous years. The projected daily September extents are then averaged to calculate a monthly projection (Figure 1).

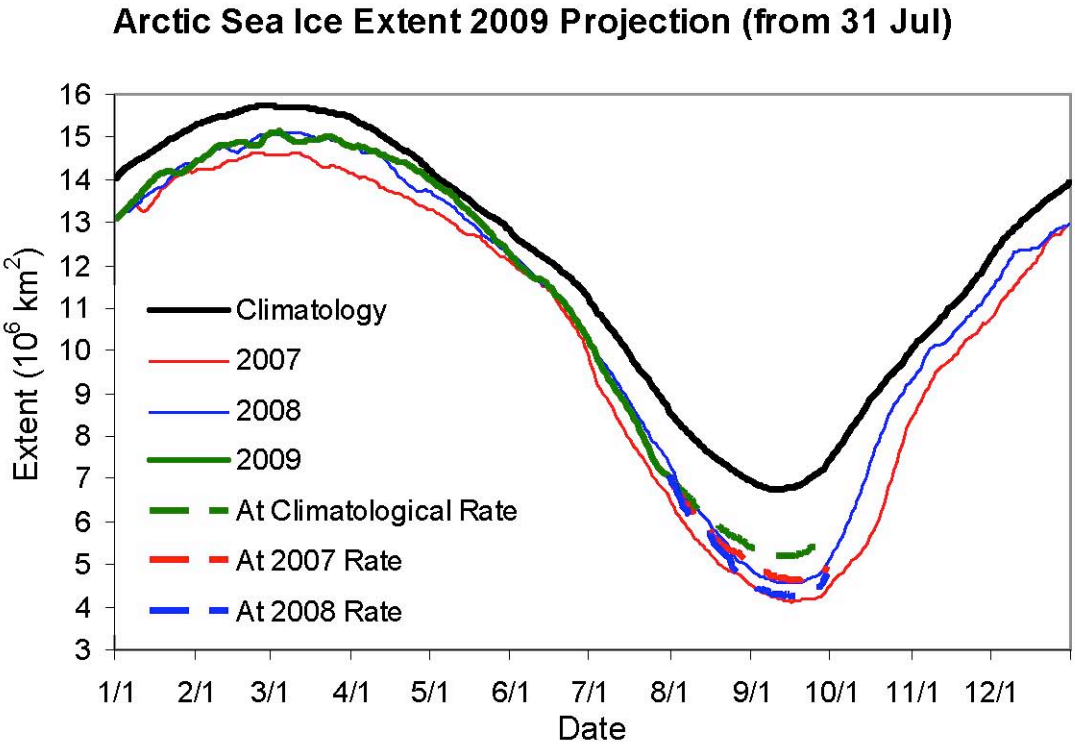

Figure 1. Daily sea ice extent (solid lines) and projections (dashed lines) based on daily rates of decline from (1) climatology (1979–2000) [green], (2) 2007 [red], and (3) 2008 [blue].

First we made an estimate based on the 1979–2000 climatological daily rate of decline, with a one-standard deviation range (Figure 2). However, in light of the known large area of thinner first-year ice (pre-conditioning) more likely to melt completely by the end of summer (Figure 3), the climatological rate seems too slow and unrepresentative of recent conditions.

Because of the changing ice conditions, we made projections based on rates for each year from 2002 to 2008. These recent years are more indicative of this year's conditions, and thus are likely to provide a more realistic range than the standard deviation around the 1979–2000 climatology. We also calculate an average for 2002–2006 as potential estimate.

Period	Weight	Average	Range
1979–2000	0.05	5.31	4.39–6.22 (s.d.)
2002–2006	0.15	5.22	4.75–5.56 (min–max)
2007	0.4	4.73	
2008	0.4	4.38	
Weighted Estimate		**4.69**	4.38–4.91 (2008–avg. all 4 periods)

Table 1. Estimate of 2009 September extent based on daily decline rates for 1 August–30 September from previous years or averages of years. The range gives high and low estimates, based on standard deviation or minimum to maximum values.

Of the seven years, only the 2008 rate would near a new record low (4.38 million square kilometers), though 3 of the 7 years result in an extent that is at or near second lowest of the 1979–2008 data period. The faster rate during late summer of 2008 appeared to be due in large part to the substantial amount of first-year ice. This first-year ice thinned through the summer and even though the summer insolation decreases by August, there was enough energy that much of the vast amount of thinner first-year ice in 2008 reached the threshold at which it disappeared completely and the extent decline rate was faster than previous years. With yet again a substantial amount of first-year ice apparently remaining (Figure 3), it is possible that a similar situation will occur again. Thus, a new record may not be as unlikely as an average decline rate projection would seem to indicate.

As such, we feel that a simple statistical average using this approach is not valid. Thus, we produce a weighted average based on different years, or averages of years, with the most recent years weighted most heavily (Table 1). This is an ad hoc and subjective weight, based on our judgment of the character of the ice, but we feel this will be more accurate than any average over several years.

The weighted average uses equal weights for 2007 and 2008 of 40%, with the remaining 20% comprised from average rates for 1979–2000 and 2002–2006. This yields a ***best estimate of 4.69 million square kilometers*** for the 2009 September minimum. To provide a range for the estimate, we use the 2008 rate since that was the fastest observed rate of decline and current ice age conditions are similar to those at this time last year. For the upper bound of the range, we simply used an equal weighting between all four time periods. The approach yields a ***range of 4.38–4.91 million square kilometers***.

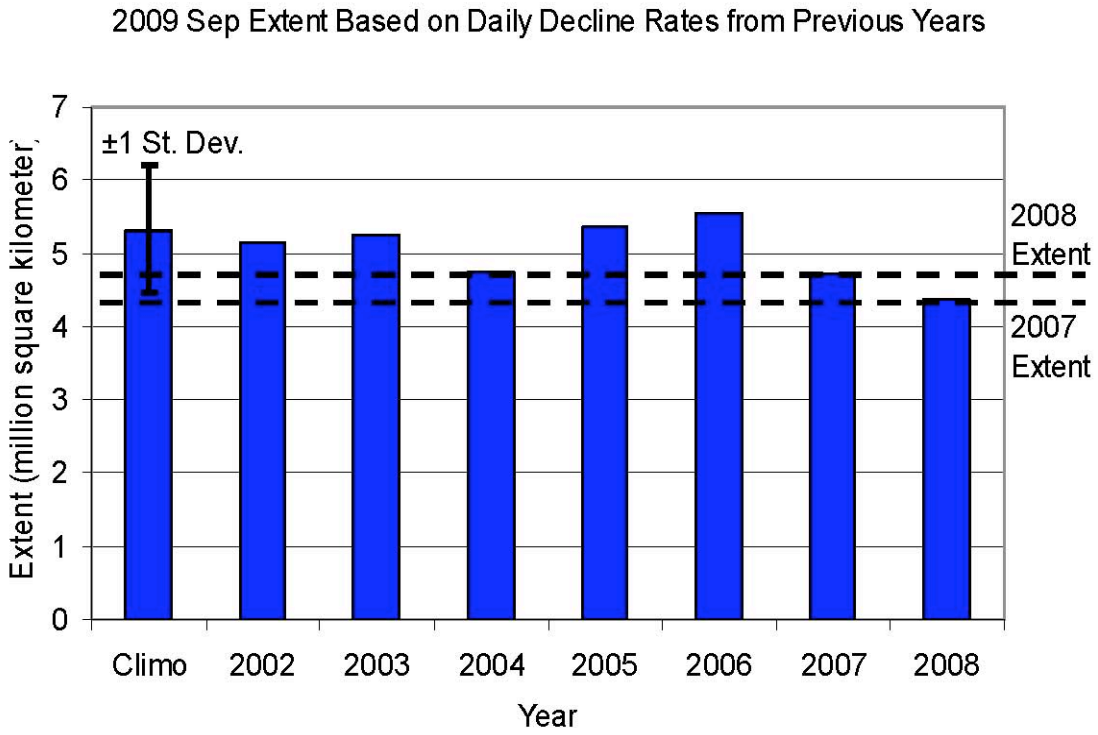

Figure 2. 2009 September sea ice extent based on the rate of decline from climatology (1979-2000) daily rates and rates from the past seven years.

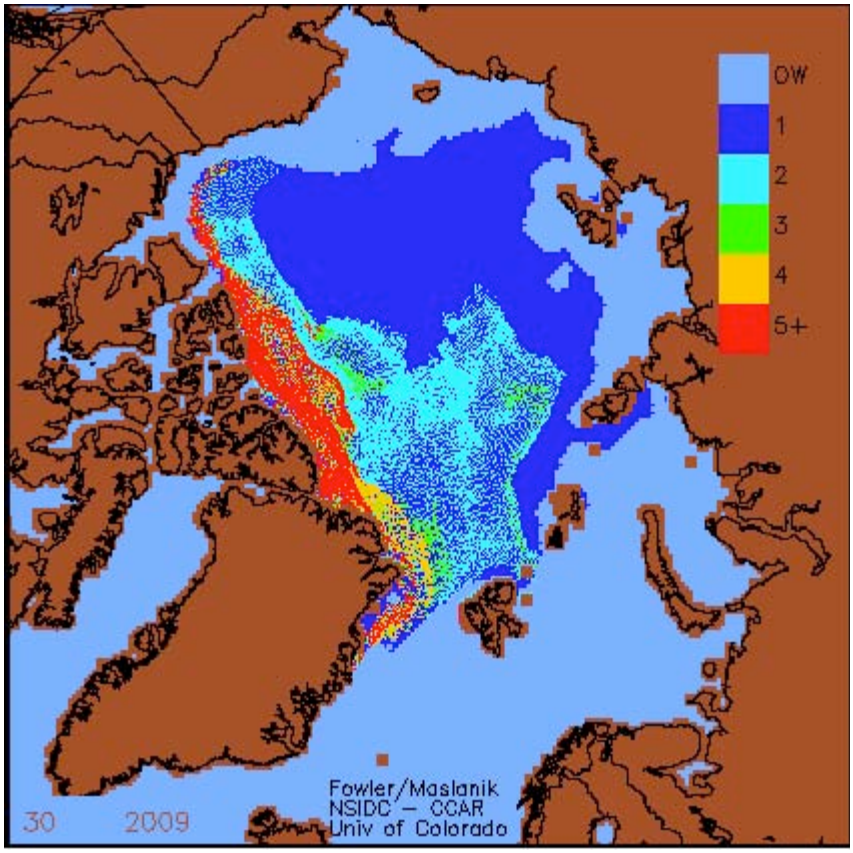

Figure 3. Ice age map for late July 2009 indicating the large area of first-year ice through the Alaskan-Siberian sector of the Arctic. Such ice is vulnerable to melting completely, even though the summer solar input is decreasing. Thanks to C. Fowler and J. Maslanik, Univ. of Colorado for image.