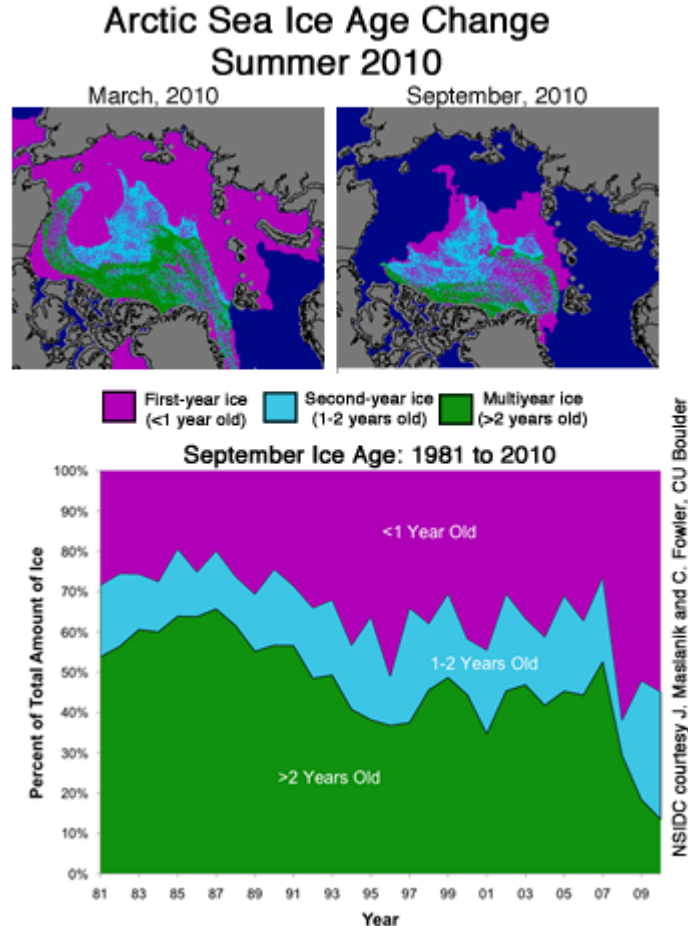


## NSIDC 2010 Sea Ice Outlook Retrospective

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NSIDC's initial estimate of 5.5 million square kilometers proved to be too high. This is not surprising because the initial method we employed relies on past statistics of the survivability of ice of different ages. However under a warmer climate and thinner sea ice conditions, past survivability rates are not likely to be applicable. And indeed this year saw considerable loss of old (5+ year old) ice due to summer melt in the Beaufort and Chukchi Sea (Figure 1). Over the previous summers, there was considerable retention of first-year ice (which had aged to 2<sup>nd</sup> and 3<sup>rd</sup> year ice at the beginning of this melt season). With the extreme negative AO mode this past winter, much of this ice was retained within the Arctic. It was thought that this young multiyear ice may buffer the loss of ice. However, much of the 3<sup>rd</sup> year ice either melted or was advected out of the Arctic.



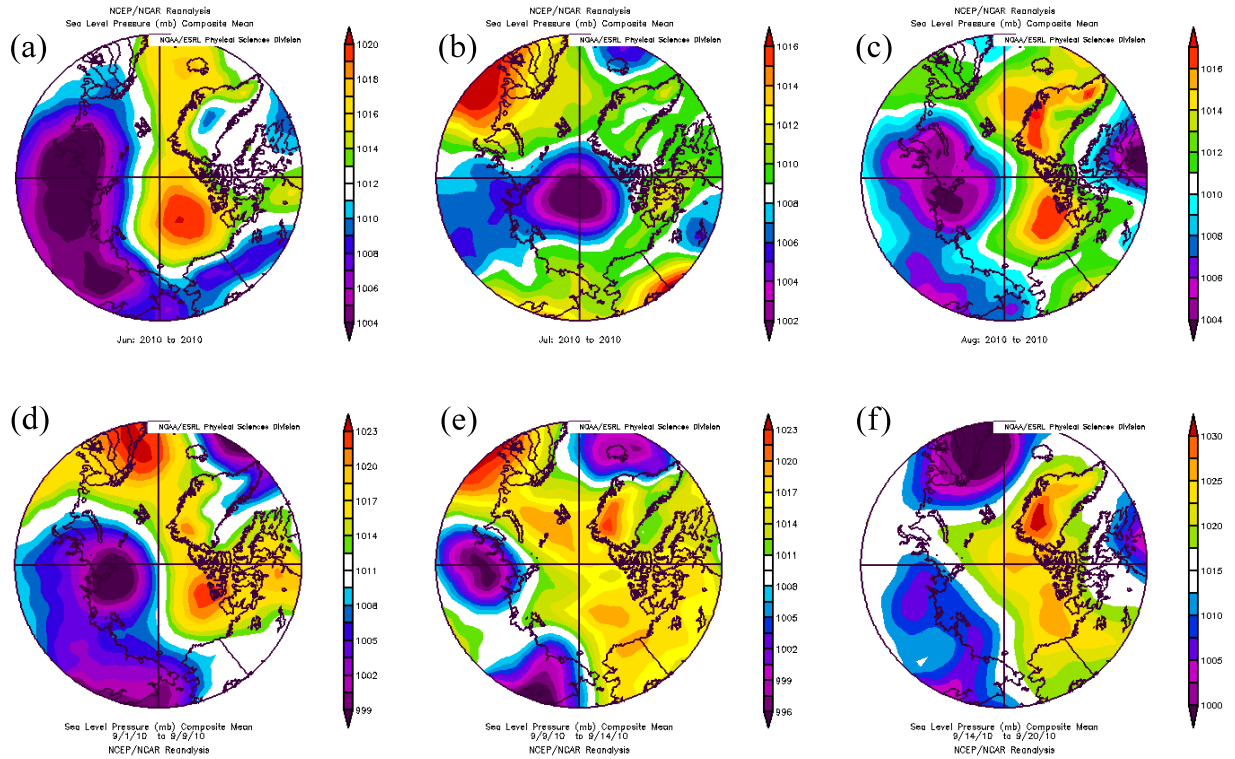
**Figure 1.** Change in ice age from spring 2010 to fall 2010. The negative phase of the Arctic Oscillation this winter slowed the export of older ice out of the Arctic in the winter, but a large amount of older ice melted out during the summer.

In July and August, NSIDC used a new method to project the September ice extent via projecting the extent through the summer using average decline rates. This proved to be more accurate because as the summer melt season precedes the variability in “meltable” ice declines with the setting sun. Our July and August estimate of 4.74 and 5.10 million square kilometers respectively were still too high compared to the daily minimum, due to a more rapid ice loss during August and September and a later than normal date of the minimum. This more rapid ice loss and late minimum was due to a combination of factors relating to atmospheric temperatures and circulation, ocean heat, and the thinner state of the ice cover. These are discussed in more detail below.

### **The atmosphere**

During the summer of 2010, atmospheric conditions shifted between warm conditions that favored melt, and stormy conditions that slowed the melt rate but helped break up the ice. The net effects of atmospheric conditions this season contributed to the low ice extent.

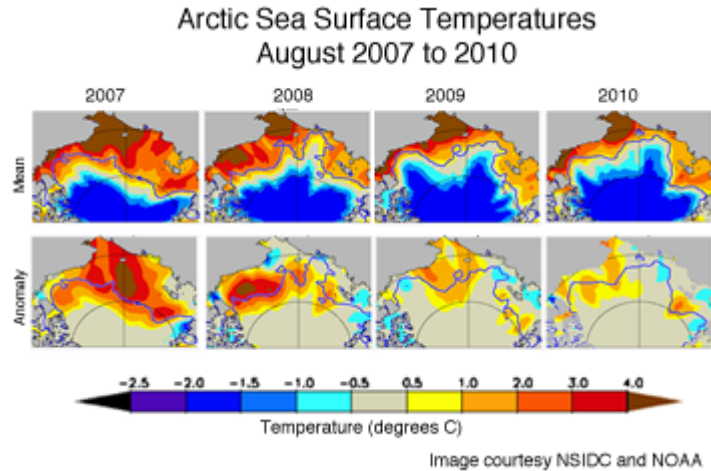
At the beginning of the melt season, ice extent was relatively high after a long winter dominated by an extreme negative phase of the Arctic Oscillation. Historically, these winter conditions would favor retention of ice through the summer. But in June, a combination of high pressure over the central Arctic Ocean and unusually low pressure over Siberia gave rise to warm conditions over much of the Arctic Ocean and strong westward ice motion off the Siberian Coast, favoring rapid ice melt (Figure 2). In contrast, a series of low-pressure systems moved into the central Arctic Ocean in July. While slowing the melt rate, the stormy conditions helped to break up the sea ice cover. August saw a return to the basic pattern seen in June, although not as prominent. This pattern persisted through the first week of September, helping to drive the sea ice toward what appeared to be its seasonal minimum on September 10. After ice extent started to climb, a change in atmospheric conditions caused it to fall again, to reach its final value of 4.60 million square kilometers (1.78 million square miles) on September 19.



**Figure 2.** Sea level pressure over the Arctic for (a) June, (b) July, (c) August, and three periods in September: (d) 1-9 September, (e) 9-14 September, and (f) 14-20 September. Note that there are slight differences in scales in the different images. A dipole pattern is evident in June, August, and early and late September, low pressure dominates in July, and high pressure dominates in mid-September.

## The ocean

As in recent years, sea surface temperatures this summer were higher than normal in much of the Arctic Ocean, according to researchers at the University of Washington. Mike Steele, Wendy Ermold, and Ignatius Rigor found that temperatures in the Beaufort/Chukchi Seas and the region north of the Laptev Sea were particularly high (Figure 3). The high sea surface temperatures resulted largely from the loss of sea ice: dark open water areas absorb more solar radiation than reflective ice. The warmer water in turn helps to melt more sea ice. This positive feedback likely contributed to the ice loss through summer 2010, especially late in the season when surface melt had largely ceased.



**Figure 3.** This summer, sea surface temperatures were higher than average, but lower than in the last three years. The maps above show average sea surface temperatures and anomalies for August 2007 to 2010. Image provided by W. Ermold and M. Steele, University of Washington.

## The ice

Last winter, the wind patterns associated with the negative phase of the Arctic Oscillation transported a great deal of multiyear ice from the coast of the Canadian Arctic into the Beaufort and Chukchi seas. We speculated that much of this ice, some five years or older, would survive the summer melt period. Instead, it mostly melted away. At the end of the summer 2010, under 15% of the ice remaining the Arctic was more than two years old, compared to 50 to 60% during the 1980s. There is virtually none of the oldest (at least five years old) ice remaining in the Arctic (less than 60,000 square kilometers [23,000 square miles] compared to 2 million square kilometers [722,000 square miles] during the 1980s). As mentioned above, there was retention of first-year ice after the past two summers, but much of the now 3<sup>rd</sup> year ice was lost due to advection through Fram Strait or melt. There was still a substantial amount of 2<sup>nd</sup> year ice (which will now age to 3<sup>rd</sup> year ice as the freeze-up starts).

Whether younger multiyear ice (two or three years old) in the Arctic Ocean will continue to age and thicken depends on two things: first, how much of that ice stays in the Arctic instead of exiting into the North Atlantic through Fram Strait; and second, whether the ice survives its transit across the Beaufort and Chukchi Seas or instead melts away.