

Observations of the Decline of Arctic Sea Ice

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The decline of Arctic sea ice in the last half century is reviewed together with the latest observations in 2009. Maps of sea ice classes derived from QuikSCAT (QS) scatterometer data and ice age derived from buoy observations showed that the extent of perennial sea ice (in March) rapidly reduced at a rate of 1.5×10^6 km² in this decade, triple the reduction rate during the three previous decades (1970-2000) (Nghiem et al., *Geophys. Res. Lett.*, vol. 34, 2007).

A record was set in the reduction of Arctic perennial ice extent in winter 2008, while the winter total sea ice extent has been stable compared to the average over the decade of the QS data record (1999-2009). By 1 March 2008, the extent of perennial sea ice was reduced by one million km² compared to that at the same time in 2007, which continued the precipitous declining trend observed in this decade. Beyond the QS satellite data time-series, the perennial sea ice pattern change was deduced by using the buoy-based estimates computed with 50 years of data from drifting buoys and measurement camps to track sea ice movement around the Arctic Ocean. The combination of the satellite and surface data records confirms that the reduction of winter perennial ice extent broke the record in 2008 compared to data over the last half century.

In the 2007-2008 ice season, perennial ice extent reduced by 1.2×10^6 km² between 10/1/2007 and 5/1/2008. Updated observations from QS data showed that perennial ice extent was 0.5×10^6 km² larger on 10/1/2008 compared to the same date in 2007 due to more plentiful survival of sea ice after summer 2008. Nevertheless, between 10/1/2008 and 5/1/2009, the reduction of sea ice extent was 50% more rapid than the reduction rate in the same period between 2007 and 2008. On 5/1/2009, perennial ice extent has reduced to 2.1×10^6 km², which is a virtual tie to 2.2×10^6 km² of perennial ice extent on 5/1/2008 given the uncertainty of $\pm 0.2 \times 10^6$ km² in QS measurements. Although the extent of perennial ice extent is similar, its distribution is quite different between the two years with a significant perennial ice pack in the Beaufort Sea in 2008 while there is a large perennial ice pack in the path of the Transpolar Drift Stream (TDS) in 2009 (Figure 1). The continuing drastic reduction of Arctic perennial ice significantly decreases the overall surface albedo resulting in enhanced solar heat absorption in spring and summer, which further decreases the Arctic ice pack through the ice-albedo feedback mechanism.

There is an imminent need for accurate mapping of the ocean floor (bathymetry) especially in the region around the North Pole (NP). Thus, the method to map sea ice using satellite scatterometer data is advanced to enable observations of Arctic sea ice classes as close as 42 km to the NP, which mitigates the problem of the NP data-blind area in other satellite datasets for operational applications. Results reveal a historical fact that the boundary of perennial sea ice already crossed the NP in February 2008, leaving the area around the NP occupied by seasonal sea ice. New QS observations in 2009 suggest a split between two main perennial ice packs (Figure 1), the TDS perennial ice pack and the north Greenland perennial ice pack, extending from the NP to Fram Strait, which may impact the rate of ice export in 2009 and, consequently, the overall state of Arctic sea ice in the coming summer season.

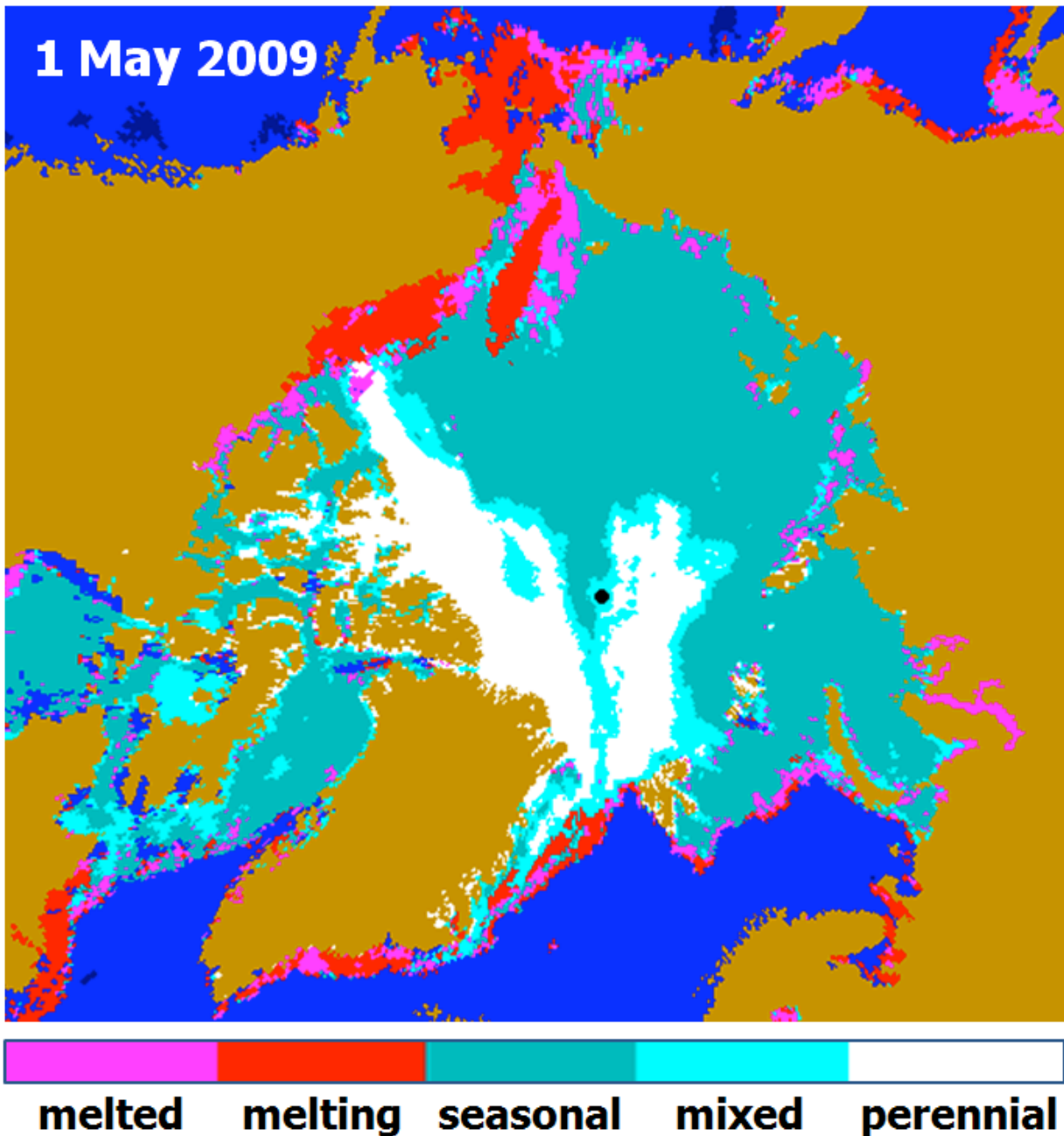


Figure 1. Arctic sea ice distribution for perennial ice (white), mixed ice (aqua), seasonal ice (teal), ice with current melting surface (red), and ice with melted surface within the previous ten days (magenta). Blue is for open water and brown for land. The extent of perennial ice was about the same on 1 May 2009 and 1 May 2008, while there is more second year ice in 2009 due to more ice survived summer 2008. Springtime perennial ice extent was the lowest in 2008 as observed by QuikSCAT data in the decade of 2000s and by the buoy-based estimates in the last half century. In winter and spring, not only the rapid reduction rate but also the temporal characteristics are similar in this year and in 2007 when the drastic decrease of perennial ice preconditioned the record low of the total ice extent in summer 2007. Extensive areas of melt occurred on 1 May (red) as well as early melt in April (magenta) leading to lower ice albedo and more solar heat absorption.