September 2009 Regional Sea Ice Outlooks: August Report

Community Contributions

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September 2009 Regional Sea Ice Outlook: August Report
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A regional perspective on ice evolution in the Pacific Arctic sector (SIZONet project)—August Report

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(1) Region of interest: Bering-Chukchi-Beaufort Seas
(2) Ice development and status in early August 2009
Ice extent:
Passive microwave data (SSM/I) distributed by the National Snow and Ice Data Center (NSIDC) indicate above-normal ice extent in the Bering Sea for April 2009 (Figure 1). Starting in early May, vigorous and early melt resulted in rapid northward retreat of the ice edge to below normal extent in June and July (Figure 2). Compared to 2008, this year has somewhat more extensive ice in the eastern Beaufort in late July and less extensive ice in the East Siberian Sea.

Ice thickness and ice characteristics:
Eastern Chukchi/Western Beaufort Sea: End-of-winter ice thickness distribution as presented in our June Report, i.e., much less multiyear ice of thickness comparable to previous years (3.6 m total level ice thickness mode) and first-year ice thicknesses comparable to or thicker than past years (1.7 m total level ice thickness mode with thicker deformed ice).

Coastal sea ice:
At *Wales*, in Bering Strait, local ice experts reported the last ice on 26 June, roughly two weeks later than in previous years. A surface drifter placed on an ice floe in May at Wales continued its rapid northward drift, moving to well north of Wrangell Island by the end of July.

At *Barrow*, the ice cover experienced early melt onset in late April, resulting in much superimposed ice formation similar to Wales (see June Report) and early onset of decay. However, in June, a balance appears to have been struck between the effects of such early-melt preconditioning and overall cool, and unusually overcast weather conditions. As a result, early onset of ice decay did not result in early break-up of landfast ice. Break-up east of town occurred around July 11 (Figure 3) and was among the latest in the past decade, mostly driven by lack of clear skies promoting melt and ocean heating. With ice lingering off town through the third week in July, access to marine mammals was reported to be very good by local hunters. The last grounded ridge near town drifted loose in the last few days of July.

(3) Outlook for the summer ice season and potential impacts
Break-up and onset of seasonal ice retreat:
Earlier, revised estimates for normal to late break-up proved to be on target. A detailed discussion of the break-up season is available at http://www.gi.alaska.edu/snowice/sea-lake-ice/Brw09/forecast. While this year has not necessarily been cooler in terms of cumulative above-freezing degree-days, the lack of sunny weather has resulted in sluggish melt. This contrasts somewhat with pan-arctic conditions, which are sunnier than normal as discussed in the report by Hori et al. for the pan-arctic sea ice outlook.

Summer conditions:
As detailed in the June and July Reports, offshore ice retreat is estimated to proceed less rapidly during the initial phase due to cooler weather and thicker first-year ice. However, the lack of multiyear ice will lead to more substantial retreat later in the season, suggesting **lighter ice conditions than in 2008.** This earlier statement remains valid, and the next few weeks will demonstrate whether the assessment was accurate, as ice loss typically slows down in late August.

Last year, multiyear ice lingered and presented a platform for feeding walrus throughout summer and a hazard for vessels bound for the eastern Beaufort Sea. This year, such lingering ice is less of a problem. Sea level atmospheric pressure patterns continue to develop similar to 2005 and 2007 with persistent high pressure over the Beaufort Sea and easterly sector winds at Barrow. However, in contrast with 2005 and 2007 this year is much cloudier (Figure 3). Circulation patterns continue to favor northward advection of ice that is superimposed on ice retreat patterns and is a key factor in seasonal migration of, e.g., walrus. For example, a buoy deployed by our collaborators in Wales, Bering Strait in mid-May was well north of Wrangell Island in mid-July, a voyage of more than 600 km.

This outlook is based on heuristics and a statistical model for break-up timing (see website at http://www.gi.alaska.edu/snowice/sea-lake-ice/Brw09/forecast/). Jing Zhang and Jeremy Krieger kindly provided two-week WRF weather forecast model runs (http://knik.iarc.uaf.edu).

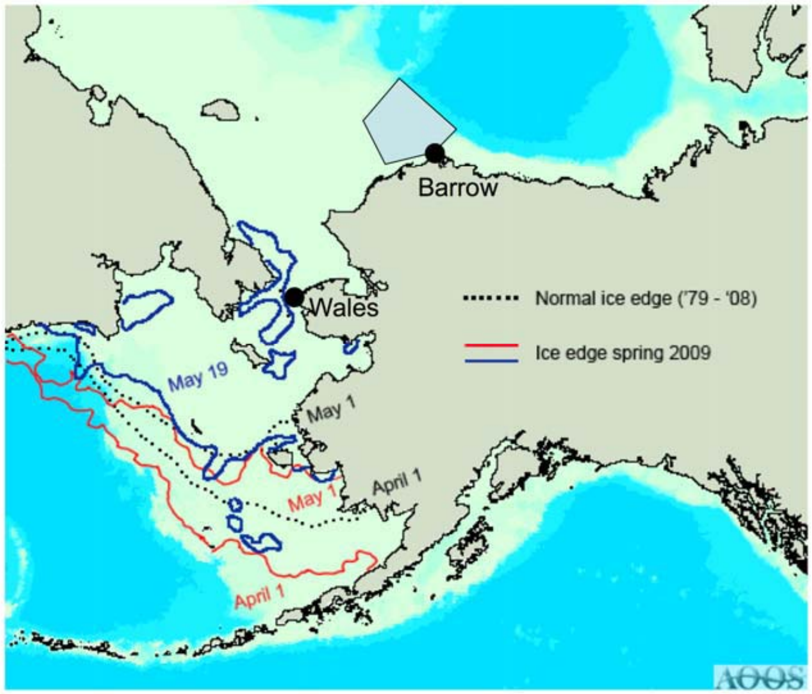

Figure 1. Ice extent derived from passive microwave satellite data (SSM/I, data provided by the National Snow and Ice Data Center (NSIDC, http://www.nsidc.org)) for the Pacific Arctic sector. Shown are observed ice edges for April and May along with "normal" ice edges (median positions) from 1979 to 2008. Locations of the airborne surveys and coastal stations are also shown.

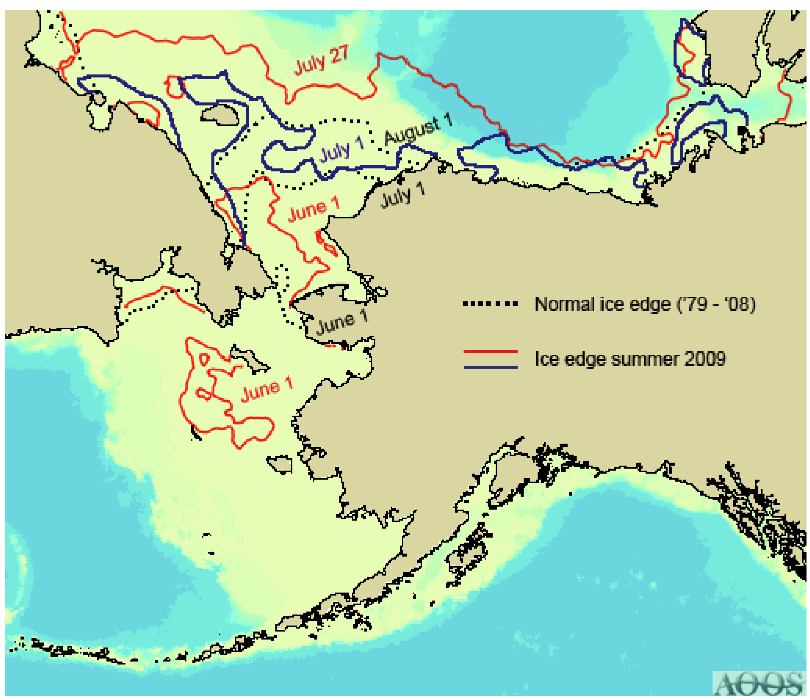

Figure 2. Same as Figure 1, but for ice extent on 1 June, 1 July, and 27 July 2009.

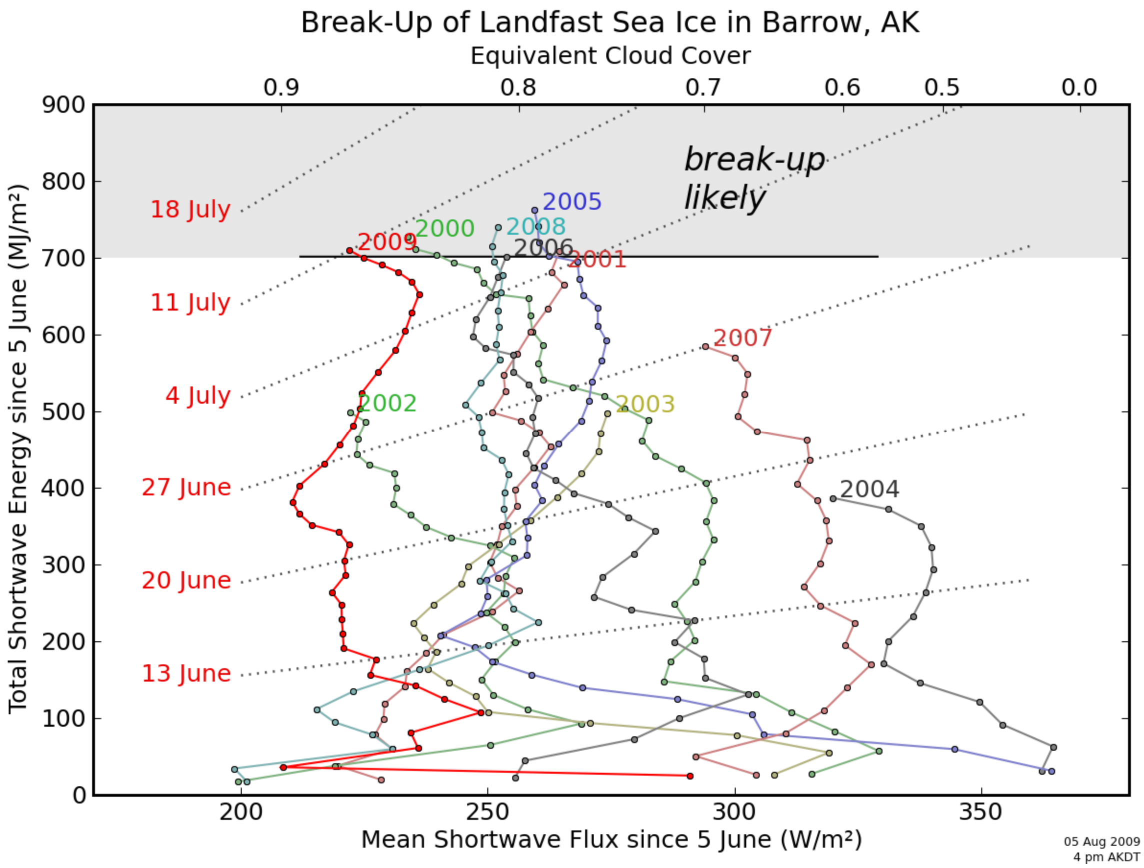

Figure 3. Break-up timing and solar shortwave energy incident at the surface (mean and cumulative shown on bottom and left axis, respectively) for 2009 (thick red line) and other recent years. Curves terminate at observed break-up. The shortwave flux is used as an indicator for radiative forcings. The grey area at the top corresponds to the seasonal stage at which ice break-up is imminent and determined by local sea level and winds. Details at http://www.gi.alaska.edu/snowice/sea-lake-ice/Brw09/forecast/.

September 2009 Regional Sea Ice Outlook: July Report
By: Oleg Pokrovsky

1. *A sea ice projection for the September monthly mean arctic sea ice extent (million square kilometers),* **4.5-4.6**

2-*The type of estimate:* heuristic, and statistical

3-*The physical rationale for the estimate.*

1. Major impact factor to the ice extent variability in the Atlantic sector of the Arctic Ocean is the SST anomalies in the Northern Atlantic in previous month. The SST anomaly in May 2009 (fig.1), which is now available but was not for previous report, demonstrated a "warm tongue" of the inflow stream directed to Eastern part of Arctic. That explained a more ice degradation in this part of Arctic Ocean (fig.2) with account to reference 1979-2000. Invasion of more warm Atlantic waters appeared recently in North Atlantic could lead to further reduction of the ice extent here. Thus there is some uncertainty in the September ice extent **estimate: 4.5-4.6.**

2. Major impact factor to the ice extent variability in the Pacific sector of the Arctic Ocean is the vector wind anomalies occurred in the Northern Pacific. May picture (fig. 3) is very similar to those for previous month. That explains the ice edge in Chukcha Sea is close to reference border (red curve at fig.2). Thus there is no trend in our previous estimate in this part of Arctic.

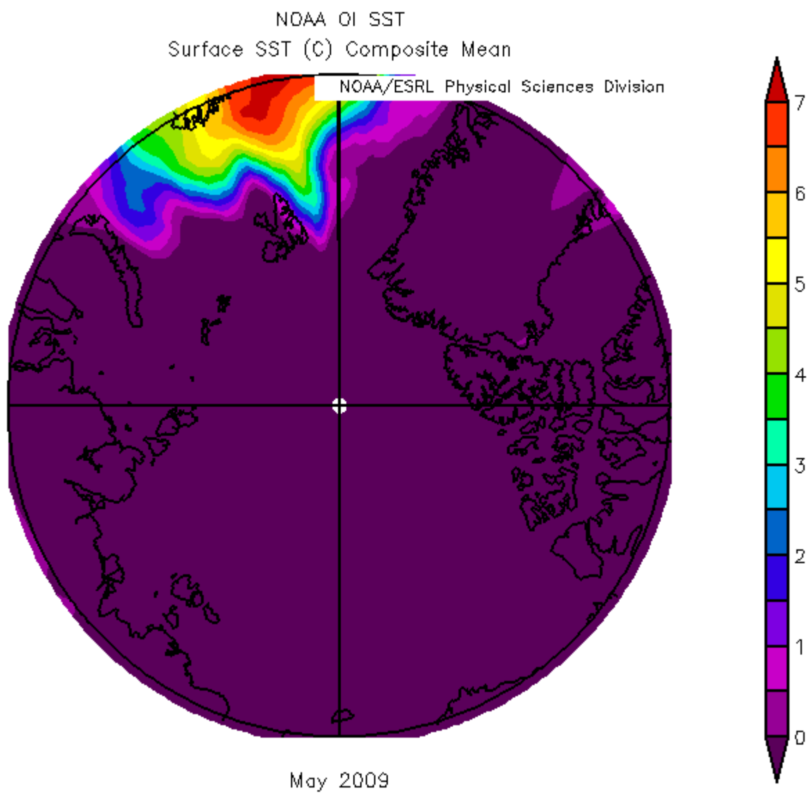

Figure 1. SST anomaly in May 2009

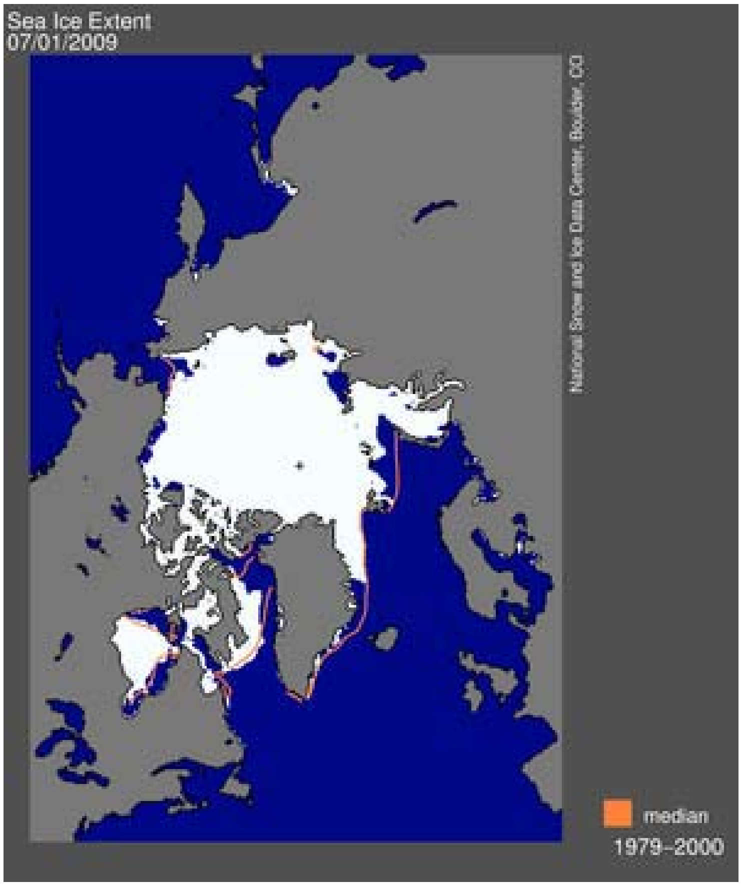

Figure 2. Arctic ice extent at 01 July 2009.

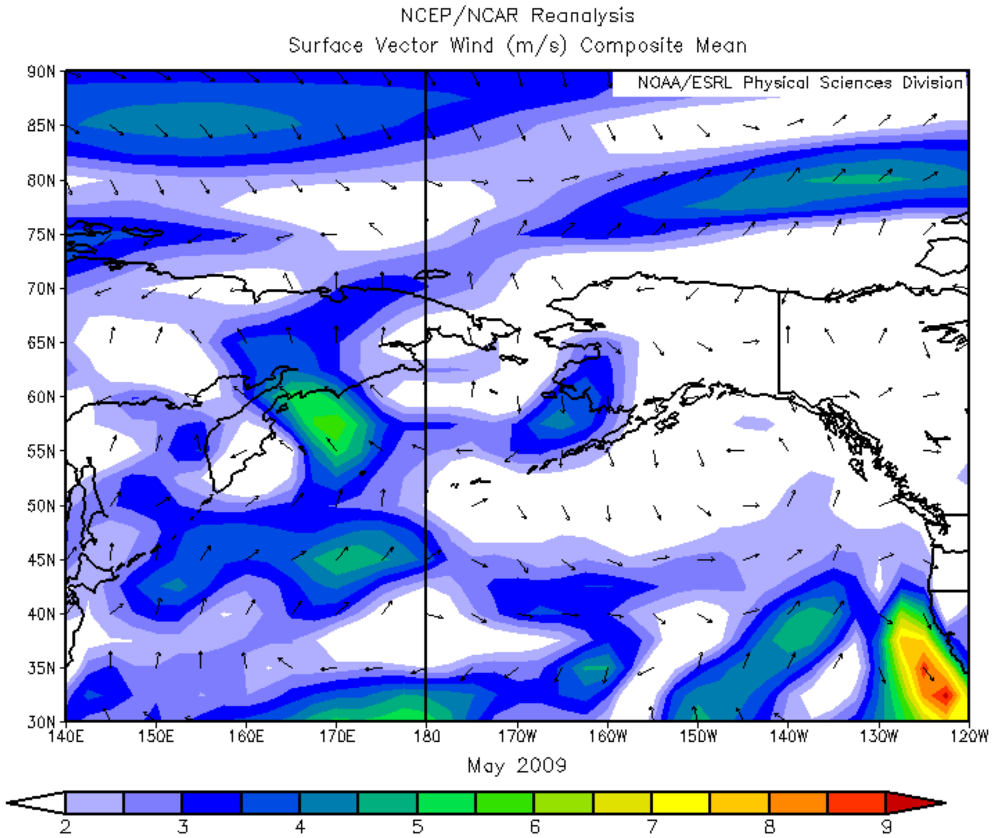

Figure 3. Anomaly vector wind field in May 2009.

September 2009 Regional Sea Ice Outlook
By: Don Perovich

Region:
Southern Beaufort Sea and north of Greenland

A Tale of Two Buoys

It was the best of melt seasons, it was the worst of melt seasons. It was a time of extreme melt, it was a time of modest changes... So much for Dickensian allusions. However, it is important to recognize that while there may be general trends in the ice cover, there is regional variability. This is evident in the end of July melt results from two ice mass balance buoys located in the Southern Beaufort Sea and north of Greenland (Figure 1). These buoys were deployed as part of Beaufort Gyre Environmental Observatory (BGEO) and North Pole Environmental Observatory (NPEO), all part of the Arctic Observing Network.

Table 1 summarizes melt results for these two buoys through 26 July 2009. Pre-melt ice thicknesses were 2.1 at the NPEO site and 2.5 m in the Beaufort. There was more snow at the North Pole site (0.43 m vs. 0.28 m). Through July, the Beaufort buoy had much more surface melting (0.55 m vs. 0.05 m) and bottom melting (0.28 m vs. 0.04 m) than the North Pole buoy. Figure 2 (top panel) compares air temperatures and shows that summer melt started a couple of weeks earlier at the Beaufort buoy and air temperatures were consistently higher than at the NPEO buoy. Air temperature at the Beaufort buoy also exhibited a very strong diurnal cycle. Water temperature, roughly 1 m below the ice bottom, is plotted in the middle panel. Water temperatures at the Beaufort buoy have increased by about 0.4^{o}C, compared to 0.1 ^{o}C for the NPEO buoy. There is also a difference in bottom melting, which started in early June at the Beaufort buoy and has totaled 0.28 m so far. Bottom melt at the NPEO site did not begin until mid-July and is only 0.04 m.

Looking ahead, surface melt usually begins to wane by mid-August. At the NPEO buoy, large ice concentrations and modest upper ocean heat content indicate that modest additional bottom melting is likely. In contrast, lower ice concentration, significant upper ocean temperature elevation, and a position near the ice edge raised the possibility of significant additional bottom melting at the Beaufort site.

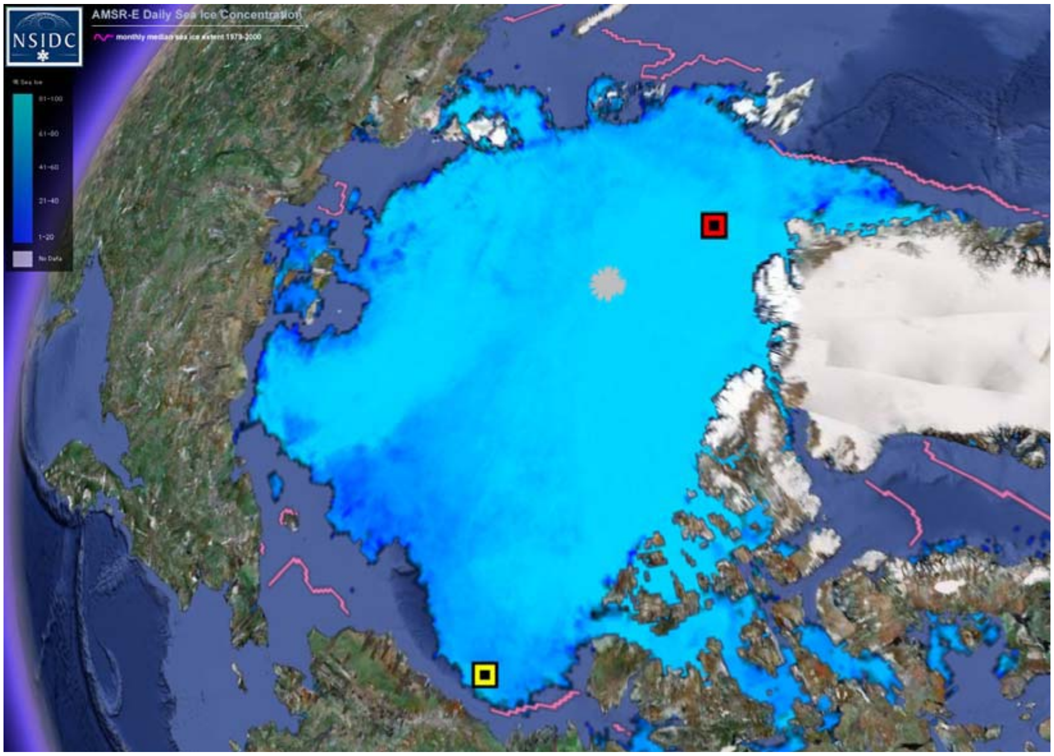

Figure 1. Position of buoys deployed at theBeaufort Gyre Environmental Observatory (yellow) and North Pole Environmental Observatory (red). The map is the 31 July 2009 ice concentration from NSIDC.

Table 1. Summary of ice melt through 26 July 2009. The units are meters.

	Snow depth 1 June	Ice thickness 1 June	Surface ice melt	Bottom ice melt
BGEO	0.28	2.5	0.55	0.28
NPEO	0.43	2.1	0.05	0.04

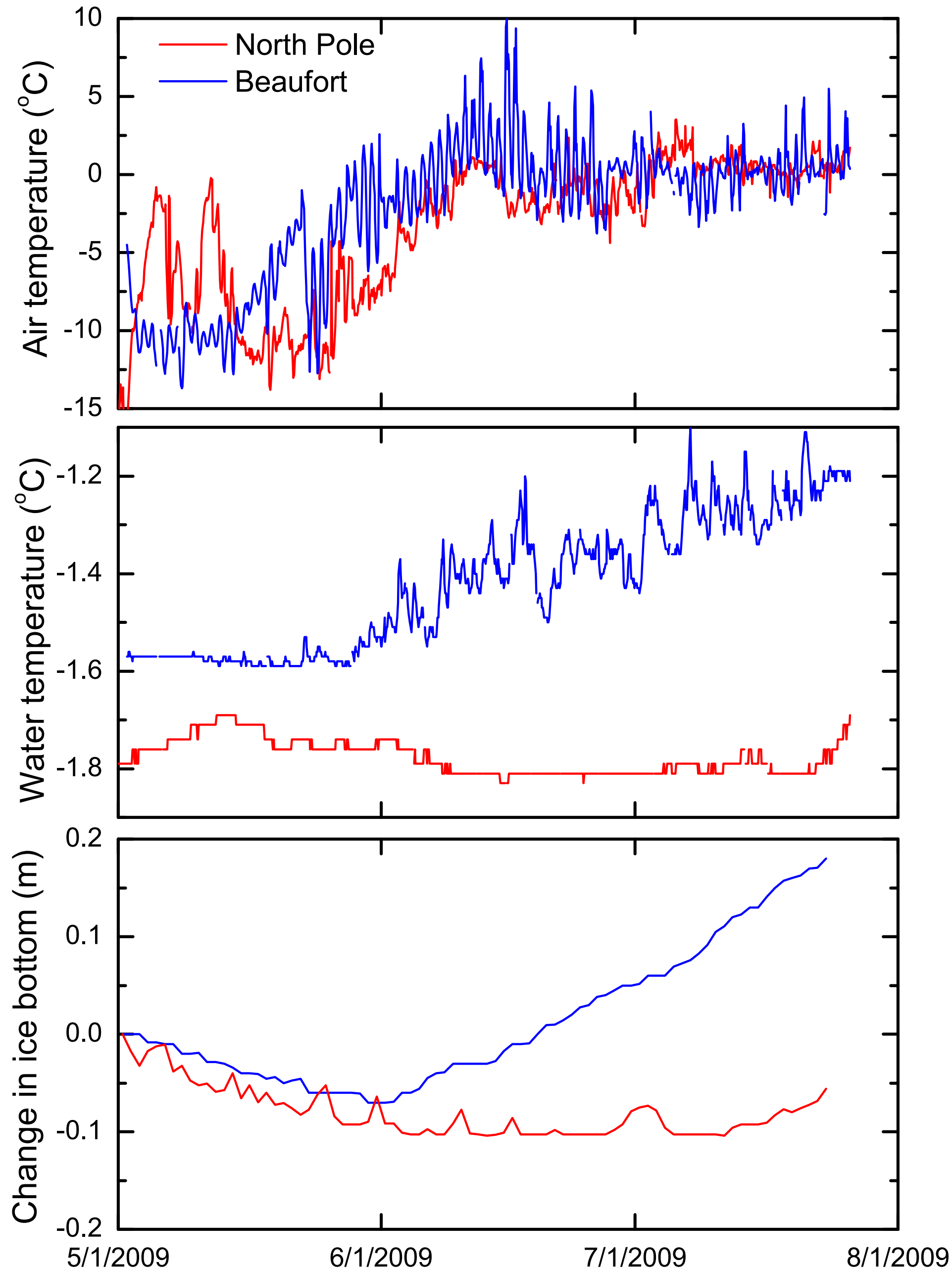

Figure 2. Observations of air temperature, water temperature (just below the ice), and change in the ice bottom for the North Pole and Beaufort buoys from May 1 to August 1, 2009.

September 2009 Regional Sea Ice Outlook: June Report
Regional: Beaufort and Chuckchi Seas, High Arctic, and Northwest Passage
By: **Charles Fowler, Sheldon Drobot, James Maslanik**

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1A. Extent Projection

Predicted minimum extent based on data to date is 4.89 million sq. km. Estimated confidence interval for this estimate is +/- 0.39 million sq. km.

As noted below, the potential exists for more extensive ice loss if the large expanse of 2nd.-year ice in the central Arctic does not survive or if substantial amounts are transported northward toward the Canadian Archipelago or through Fram Strait. This is in part due to the fact that so little of the older, thicker multiyear ice exists at present in the Arctic Basin compared to previous years.

2A. Method

This estimate is based on a statistical regression model that uses passive microwave derived sea-ice concentrations, and estimates of ice age and thickness regressed against the minimum ice extents over the past 26 years. The ice age and thickness information used are derived from Lagrangian tracking of ice regions, with a different mean ice thickness assigned to each ice age category of multiyear ice, for 2nd.-year through 10th.-year ice. This is combined with a simple temperature-driven ice growth model and melt parameterization to estimate first-year ice thickness. In this implementation, "open water" is defined as less than 40% ice concentration.

3A. Rationale

The approach assumes relationships between ice disappearance and concentration, age, and thickness. In this approach, the model does not directly factor in the removal of ice due to transport. Instead, the parameters relate mostly to ice melt. To the degree that the parameters influence susceptibility to transport though, the statistical model probably captures some of these indirect affects. For example, assuming that thinner ice and/or first-year ice is more affected by ice kinematics and transport, then the model would include such effects indirectly.

A key driver for the prediction is extent of ice of different ages. Figure 1 shows our estimate of ice age at the end of April, 2009 (panel 4) along with the ice age coverage at the end of April for the three previous years. The main points to take from these maps are the relatively small coverage of the older, thicker age classes, and the extent of 2nd.-year ice within the central Arctic Basin. This ice is less susceptible to melt than first-year ice but still presumably more susceptible to loss than the older ice classes. In addition, our data suggest a considerable amount of first-year ice mixed in with the 2nd.-year ice in this area, perhaps predisposing the region toward greater melt and convergence. A switch to positive NAO wind patterns could also drive this 2nd.-ice northward, exposing more open water within the central Arctic Ocean, perhaps extending to the vicinity of the North Pole.

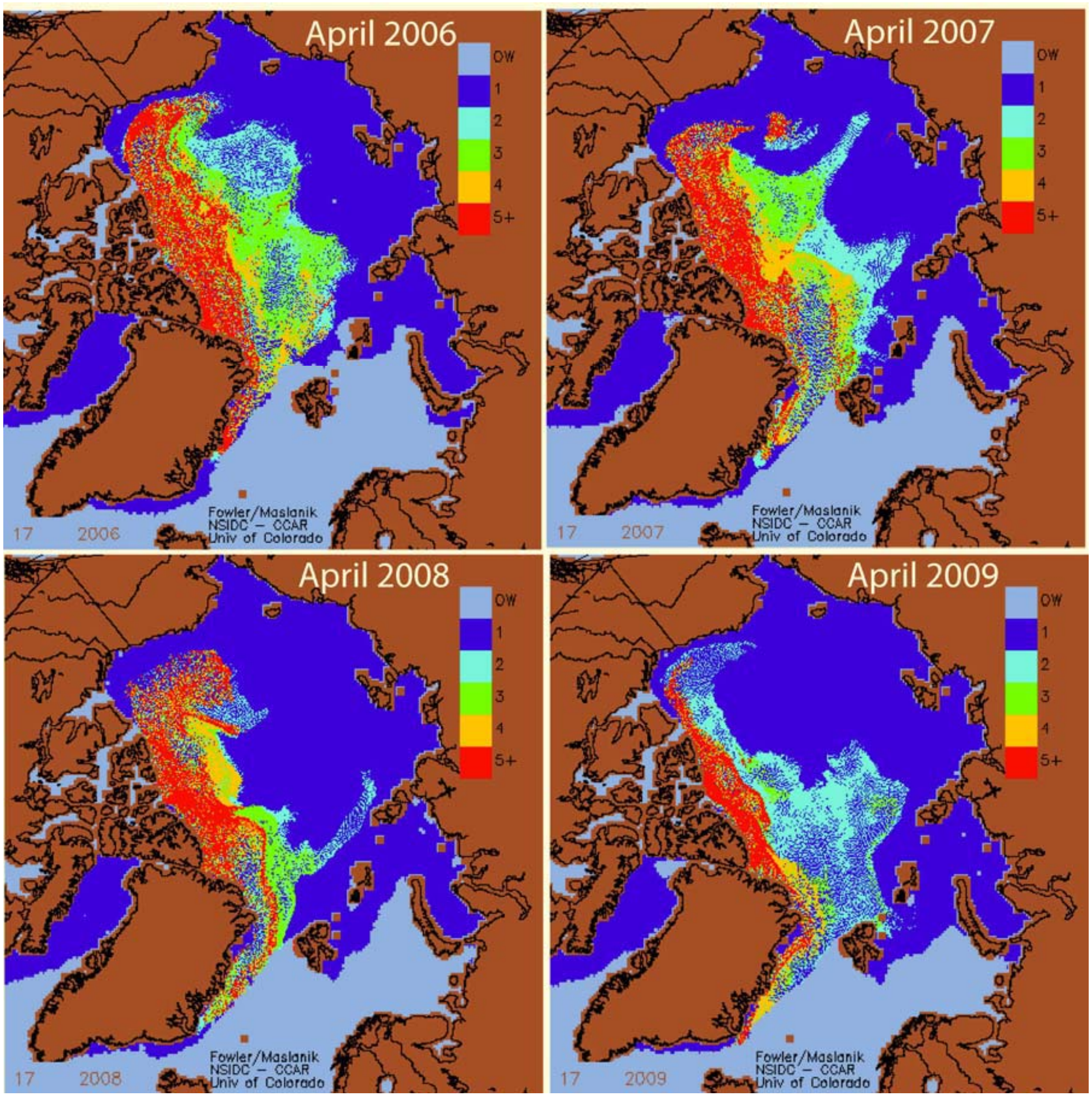

Figure 1. Estimated ice age for the end of April for 2006-2009.

1B. Estimates of Ice Conditions in Specific Regions

Two discussions are provided. The first draws from ice-pack opening dates that we have estimated for each 25km grid cell in the Arctic. Here, we limit the opening-date results to the Beaufort and Chukchi seas. The full grid of opening dates is available, but our confidence in performance for other areas is considerably less. The second discussion addresses distributions of multiyear ice of different ages and the possible effects on ice conditions through summer.

1B. 1. Opening Dates in the Beaufort and Chukchi Seas

Estimated opening dates are shown in Figure 2.

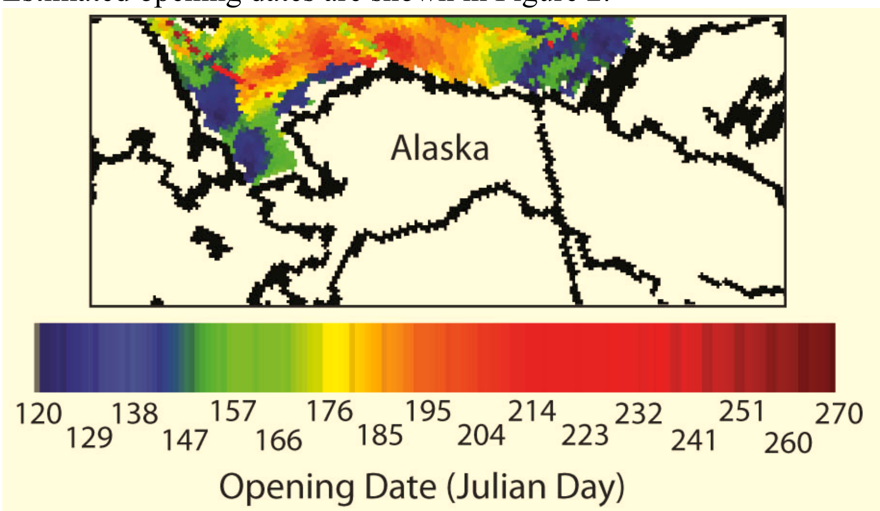

Figure 2. Estimated opening dates in the western Arctic.

At the time of this writing (end of May), open water has formed in the southern Chukchi Sea – reasonably consistent with the dates in Figure 2. The eastern Beaufort Sea is still mostly ice covered (albeit with reduced concentration), so the our estimated opening dates for that area were too early.

1B.2. Distribution of Multiyear Ice Types

<u>Beaufort and Chukchi seas</u>

As indicated in Figure 1, the most recent ice age map suggests that some multiyear ice is present further south in the Beaufort Sea than during the past 2 years. However, this ice appears to be predominantly 2nd.-year ice, in contrast to previous years (including years earlier than those shown in Figure 1) when the multiyear ice in the Beaufort Sea was some of the oldest and presumably thickest ice in the Arctic Basin (as a result of ice transport from the Canada Basin and central Arctic). The mixture of 2nd.-year and first-year ice is also more diffuse than previously, so as melt progresses through summer, it seems likely that scattered, isolated multiyear floes will persist, but within otherwise open-water areas. It is also likely that the remaining 2nd.-year floes will disappear faster due to melt than was the case in summer 2008, when multiyear ice persisted in small bands, particularly north of Barrow. Last year's multiyear ice was likely to have been older, thicker ice though, as noted above, so this summer's multiyear ice in the area may not last as long. As in recent years, we expect that the remaining multiyear ice in the Beaufort Sea will melt out as in moves westward into the Chukchi Sea, with virtually none of this ice recirculating into the Canada Basin to replenish the loss of multiyear ice due to melt.

High Arctic (Central Arctic/Canada Basin)

Our data show the western sector of the High Arctic (along with most of the Canada Basin) region to be covered nearly entirely by first-year ice, unlike any previous spring over the 1979-present satellite record. We anticipate that most of this area will become ice free by the end of summer. The High Arctic areas adjacent to the Canadian Archipelago continues to experience reductions in coverage of the oldest ice types, with the remaining oldest ice compacted against the Archipelago coast.

The remainder of the High Arctic north of 85 deg. is covered by predominantly multiyear ice, but this ice is mostly 2nd-year ice. Based on climatological conditions though, it is unlikely that under "normal" conditions, this ice would melt out, so heavy ice may remain in this area throughout summer. The most likely scenario for a retreat of this multiyear ice edge would be if atmospheric circulation produces persistent and strong southerly winds that reduce ice extent through ice transport.

Northeast Passage

Also depending on ice transport patterns (for example, if the ice is pushed northward), the potential exists for the remaining first-year ice to melt out along the Northeast Passage. (Caution: As noted above, our definition of "open water" is an ice coverage of 40% or less. So, there may be ice present even in areas that we describe as open – a significant distinction for operations in areas that satellite products such as ours define as "open water.")

Other

More multiyear ice is present along the northeastern Svalbard coast than is typical. Ice free dates may therefore be delayed in this area, although wind patterns will probably be the main factor affecting the date due to the relatively short distances the ice edge needs to retreat to free the Svalbard coast.

2B. Methods

The opening dates are estimated by regressing the opening dates for the past 10 years against the above-described ice thickness/age conditions and 2-m air temperatures for the end of April 2009.

The discussion of the location and significance of multiyear ice types is based on the ice age data noted above.

3B. Rationale

The basis for the opening date results is the same as for the extent prediction above. For the discussion of multiyear ice, we rely on subjective interpretations of conditions in previous years and on general knowledge of ice behavior in different locations.

Outlook of 9/2009 sea ice in the Northwest Passage region from 7/1/2009

Jinlun Zhang
Polar Science Center, Applied Physics Lab, University of Washington

This outlook from July 1, 2009 shows that more of the Northwest Passage (NWP) is ice free in September 2009 (Figure 1) than the outlook from June 1 (Figure 2). The ensemble predictions are made by the Pan-arctic Ice-Ocean Modeling and Assimilation System (PIOMAS), which is forced by NCEP/NCAR reanalysis data and assimilates satellite ice concentration data. The ensemble consists of seven members each of which uses a unique set of NCEP/NCAR atmospheric forcing fields from recent years, representing recent climate, such that ensemble member 1 uses 2002 NCEP/NCAR forcing, member 2 uses 2003 forcing, …, and member 7 uses 2008 forcing. Each ensemble prediction starts with the same initial ice–ocean conditions on 6/1/2009. The initial ice-ocean conditions are obtained by a retrospective simulation that assimilates satellite ice concentration. Ensemble median is considered to have a 50% probability of occurrence and taken as the outlook product. More details about the prediction procedure can be found in Zhang et al. (2008) http://psc.apl.washington.edu/zhang/Pubs/Zhang_etal2008GL033244.pdf.

Figures 1 and 2 are compared below:

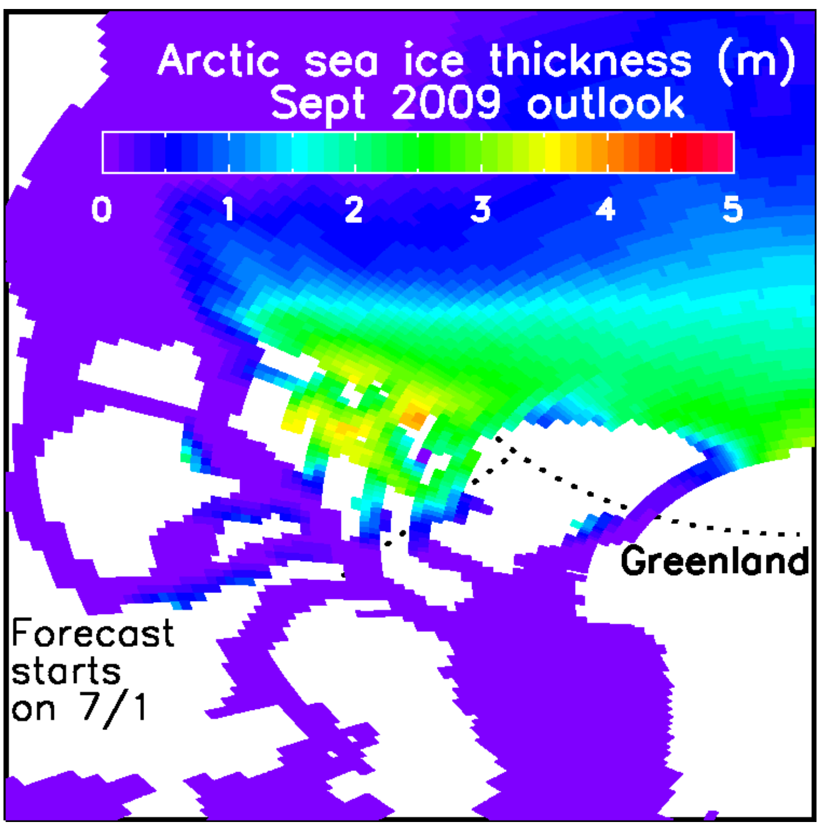

Figure 1. Ensemble prediction of September 2009 sea ice thickness in the NWP region. Prediction starts on 7/1/2009.

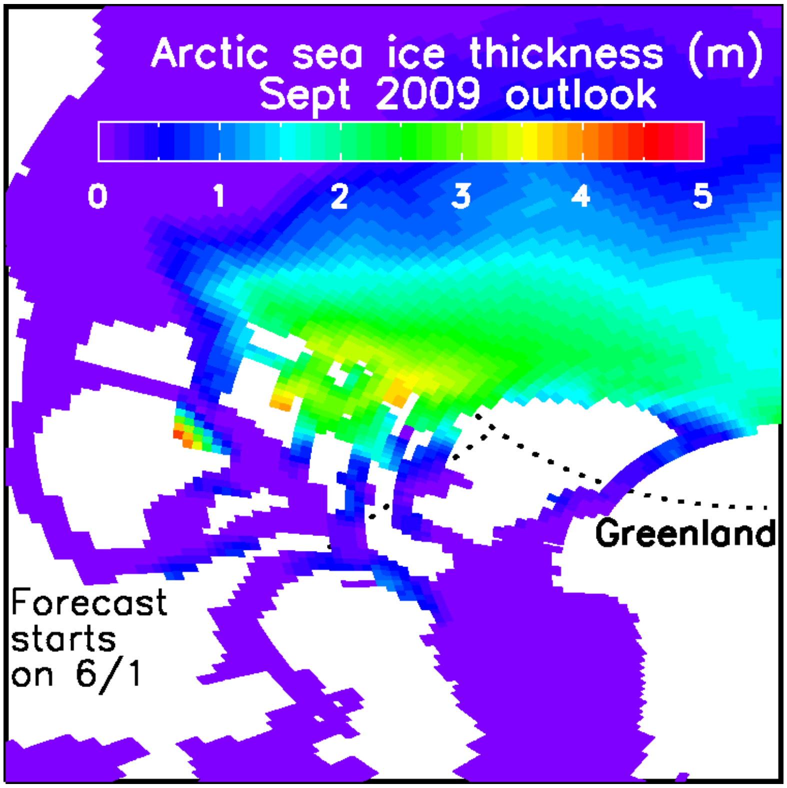

Figure 2. Ensemble prediction of September 2009 sea ice thickness in the NWP region. Prediction starts on 6/1/2009.

September 2009 Sea Ice Outlook: August Report
By: Preben Gudmandsen

Region: Nares Strait, an outlet of the Arctic Ocean

The ice barrier that formed in Lincoln Sea by 16 January 2009 began a slow disintegration by 6–7 July and advection of ice into Robeson Channel resumed in the following weeks. During the previous five months the inactive ice canopy in Lincoln Sea grew in thickness subject to air temperatures at about –25 C. It was not until 17 June that radar scenes showed signatures of wet snow surfaces. Without being able to estimate the thickness it is worth mentioning that the very first large floe (11 km by 6 km) that drifted into the Strait by 9 July continued unchanged in shape to North Water south of Nares Strait in 19 days—a tour of 540 km at an average velocity of 28 km/day (3.3 cm/s)—in ice-free waters.

Since the first break-offs, the ice canopy in Lincoln Sea has been subject to a slow disintegration. The interest has been concentrated on a large floe with the dimensions 60 km by 50 km about 30 km north of the entrance to Nares Strait as a likely candidate for a renewed blockage of ice drift. By 3 August, however, it began breaking into smaller floes that may be able to pass the 30-km wide entrance to the Strait. We may therefore see an appreciable ice drift in August creating difficulties for the Canadian icebreaker CCGS Henry Larsen in recovering moorings in southern Kennedy Channel and refitting automatic weather stations including that on Hans Island in the middle of Kennedy Channel (Wilkinson et al. 2009, Hans Island: Meteorological Data From an International Borderline, EOS Trans, A.G.U., *90,* 2 June 2009, 190-191).

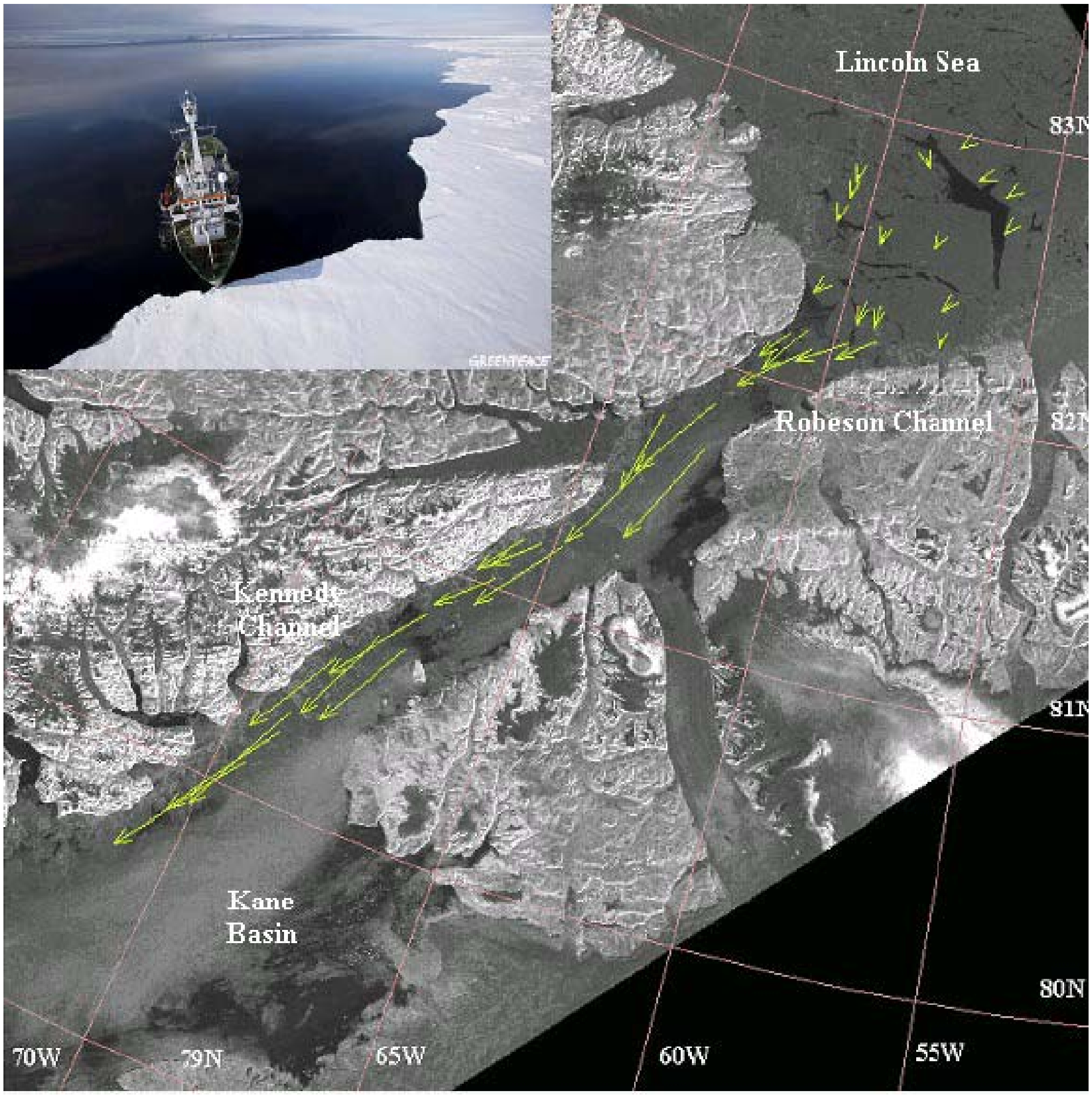

Figure 1. Radar scene of Nares Strait acquired by ENVISAT advance synthetic aperture radar on 3 August 2009, 16:52, showing the break-up of the ice in Lincoln Sea and the drift of ice through Nares Strait. The vectors show the drift through 17 hours (2–3 August) at 4–9 km in southern Lincoln Sea and 40–60 km in southern Kennedy Channel and Kane Basin.

The inset shows the ice barrier in Lincoln Sea observed from a helicopter at the end of June. The Greenpeace ship *Arctic Sunrise* that anchored at the ice edge took advantage of the very special situation in Nares Strait where no ice was present all along the Strait due to the ice barrier and the above-freezing temperatures in the greater part of June. The ship position is at 82.58ºN, 61.22ºW. Ellesmere Island is seen in the horizon.

August Report: Outlook Based on July Data
Regional 2009 Outlook: Western Parry Channel Route of the Northwest Passage

By: Stephen Howell (showell@uwaterloo.ca) and Claude Duguay
Interdisciplinary Centre on Climate Change (IC3), University of Waterloo

August Update:

As of July 27, a considerable amount of sea ice within the Western Parry Channel route through the Northwest Passage was still landfast (Figure 1), which was approximately 2 weeks later than observed for 2007 and 2008. This delay in breakup reduces the possibility of the route clearing in 2009. The date of melt onset for 2009 (year day 155) within the region was also later than 2008 (year day 142, the earliest on record) however, 2009 was 1-day earlier than 2007 (Figure 2) when this region cleared for the first time in the satellite era. It should be noted that early melt onset dates alone are not sufficient enough to clear this region of the Northwest Passage. For clearing in August 2009 to occur, rapid melt would soon have to take place and thereafter, atmospheric conditions must restrict the flow of multi-year ice (MYI) from the Queen Elizabeth Islands through Byam-Martin Channel into the Western Parry Channel.

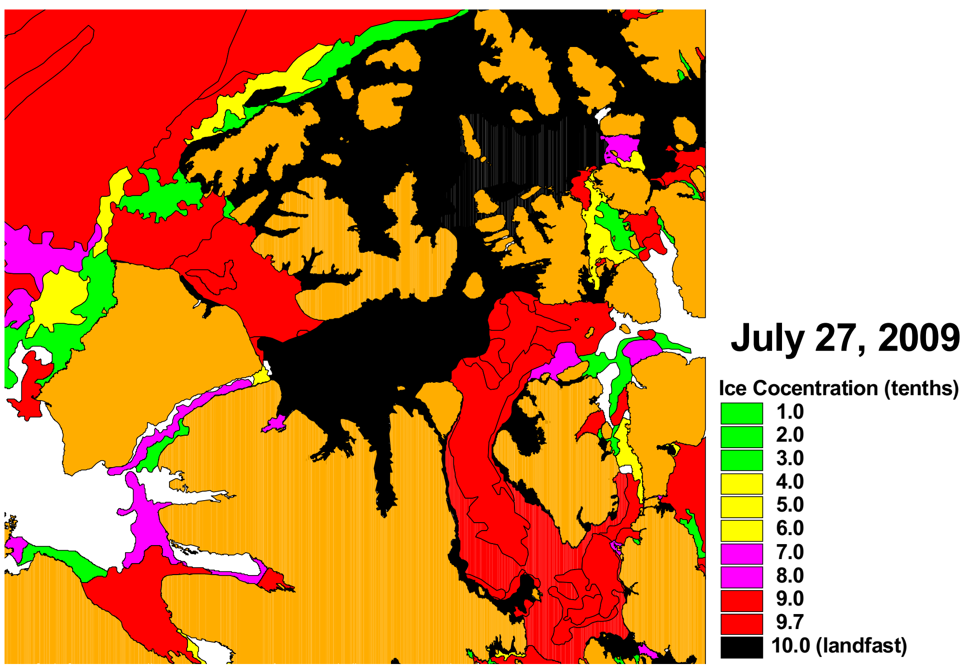

Figure 1. Sea ice concentration (tenths) in the Western Parry Channel region of the Northwest Passage on July 27, 2009. Data is from the Canadian Ice Service.

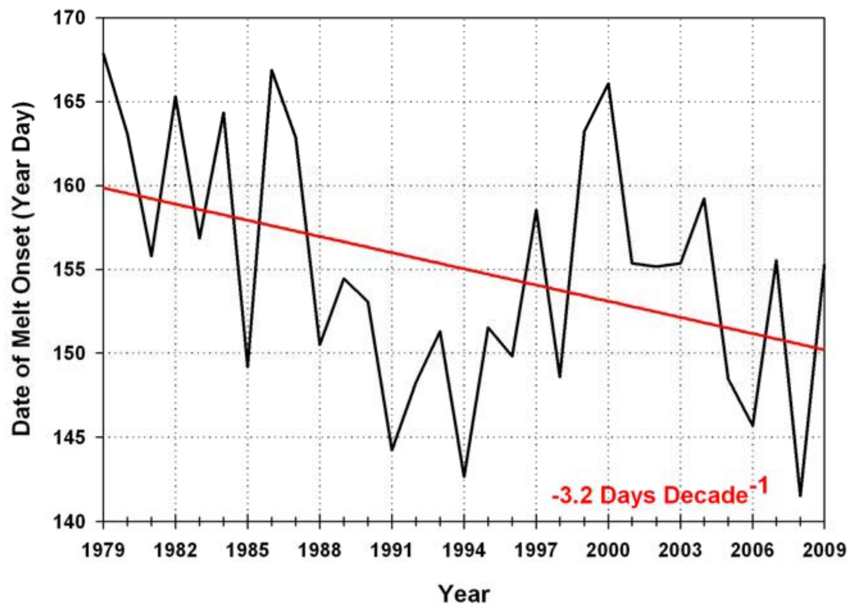

Figure 2. Date of melt onset in the Western Parry Channel region of the Northwest Passage from 1979-2009. Data are from the Defense Meteorological Satellite Program (DMSP) F-series satellite SSM/I and SSMIS sensors. Algorithm provided by Thorsten Markus, Goddard Space Flight Center.

Update to Regional Sea Ice Outlook for Greenland Sea and Barents Sea - Based on Data Until the End of July 2009

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Sea ice extent, based on satellite data (passive microwave)

Monthly mean sea ice extent (30% concentration threshold) is compared with the corresponding monthly mean for July (Fig. 1) for the record minimum year 2007, and with 30, 20, and 10 year averages for monthly means for the periods 79-08, 80-99 and 99-08. For reference, see also the Arctic Sea Ice June Outlook that came out in July 2009, where June and May data were discussed (Gerland and Goodwin 2009).

In the northern **Greenland Sea** ice extent appears roughly similar for all calculated means (Fig. 1). In the central Greenland Sea, the ice edge for July 2009 is located together with the last 10-year average, slightly further north than ice extent for 2007 and for the 20-year (80-99) and 30-year (79-08) averages calculated and plotted. The situation is similar in the southern Greenland Sea close to Greenland, but here ice edge from July 2009 shows is less straight as the edges for the means calculated over 10-30 years (the smoother nature of the edges of the means can be explained by the averaging).

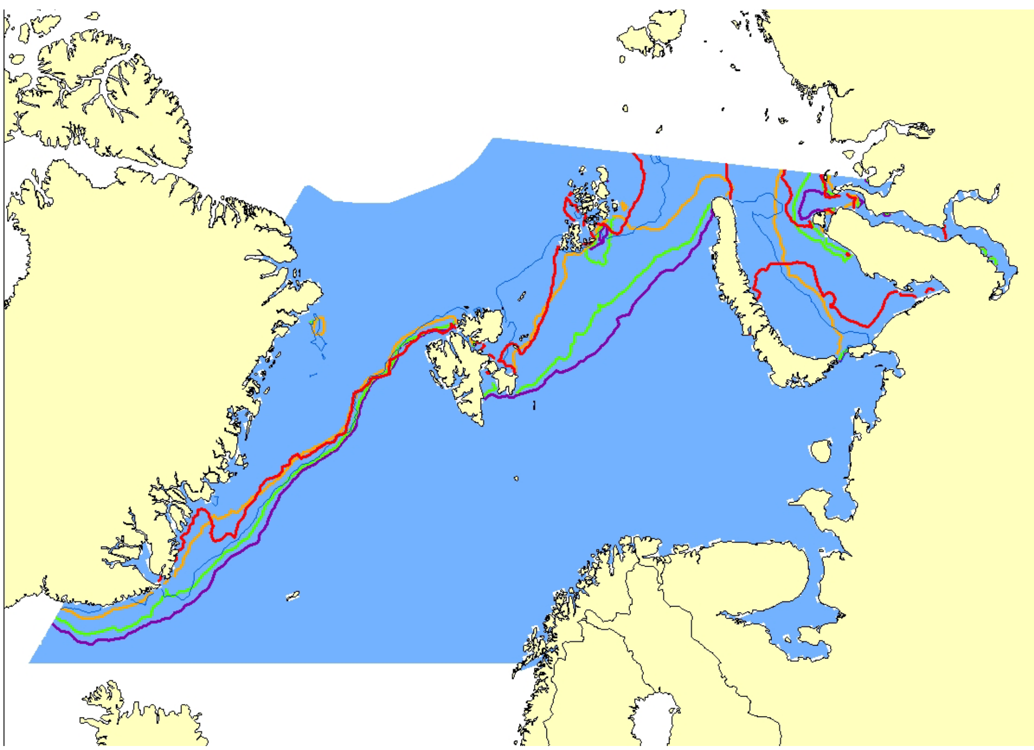

Fig. 1: Ice extent (monthly means, July) southern border of 30% ice concentration, in the Greenland Sea / Fram Strait and Barents Sea, based on passive microwave satellite data (red = July 2009, orange = mean July 1999-2008, green = mean July 1979-2008, purple = mean July 1980-1999). The thin blue line indicates the ice extent for June 2007.

As for the June means (Gerland and Goodwin 2009), in July the sea ice extent in the **Barents Sea** shows more variability between individual years and also between 10, 20 and 30 year averages.

In July 2009, ice extent was substantially less than the 10, 20 and 30 year averages in the northeastern Barents Sea (area between Franz Josef Land and Novaya Zemlya). There, the July 2009 ice edge is even north of the July ice edge from the minimum record year 2007.

Further west, between Svalbard and Franz Josef Land, the July 2007 ice edge marks the minimum of the edges displayed, followed by the July 2009 edge and the past 10-years average. The older averages lay substantially further south. This picture shows that the general ice situation of the northern Barents Sea in July has changed significantly over the last decades, with a larger area, earlier ice covered, now with open water.

Acknowledgements

Passive microwave satellite data are from SSM/I satellites and accessed from the National Snow and Ice Data Center (NSIDC) in Boulder, Colorado, USA.

References

Gerland, S., and Goodwin, H., 2009: Regional sea ice outlook for Greenland Sea and Barents Sea - based on data until the end of June 2009. http://www.arcus.org/search/seaiceoutlook/2009_outlook/july_report/downloads/pdf/regional/8_Gerland_Goodwin_GreenlandBarentsSea_%20JulyReport_JuneData.pdf