2009 Sea Ice Outlook: Regional Summary Report

Community Contributions

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The perennial pack ice in the southern Beaufort Sea was not as it appeared in the summer of 2009.

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In situ observations of the atmosphere-sea ice-ocean system in the southeastern Beaufort Sea were made from the Canadian Research Icebreaker (NGCC) *Amundsen* deployed for the ArcticNet/IPY–GeoTraces project between 27 August and 12 September 2009. The cruise track is shown in Figure 1. Canadian Ice Service (CIS) digital ice charts were employed for real-time planning of station locations and sailing routes during the cruise. In situ observations from CCGS *Amundsen* indicate that the MY sea ice pack in the southern Beaufort Sea was not as ubiquitous as it appeared within satellite remote sensing data products (Figure 1) in early September 2009. A large sector of what was remotely sensed to be MY sea ice at 7 to 9+tenths ice cover, consisting primarily of MY ice floes, was in fact a surface of heavily decayed ice composed of some small MY floes (1 tenth) interspersed in a cover dominated by heavily decayed FY floes (1 tenths) and overlain by new sea ice in areas of negative freeboard and in open water between floes. In some areas (e.g., stations L1 and MYI: Figure 1) the ocean surface was dominated in some areas by MY sea ice that was much thicker than the heavily decayed FY sea ice previously discussed.

In situ measurements of active microwave scattering (to a C-band polarimetric scatterometer) and to passive microwave radiometers (37 and 89 GHz) showed that the rotten ice and the late season multiyear sea ice had overlapping signatures. This case of mistaken identity is physically explained by the factors which contribute to the return to Radarsat-1 from the two surfaces; both ice regimes had similar temperature and salinity profiles in the near-surface volume, both ice types existed with a similar amount of open water between and within the floes, and finally both ice regimes were overlain by similar, recently formed new sea ice in areas of negative freeboard and in open water areas. The fact that these two very different ice regimes could not be differentiated using Radarsat-1 data, *in situ* C-band scatterometer or microwave radiometer measurements, has significant implications for climate studies and for marine vessel navigation in the Canada Basin. The results also suggest that operational agencies (such as the CIS) should consider making ice decay a variable in their ice charts. Our results are also consistent with ice age estimates (Fowler and Maslanik, http://nsidc.org/news/press/20091005_minimumpr.html) that show the amount of multiyear sea ice in the northern hemisphere was the lowest on record in 2009 suggesting that multiyear sea ice continues to diminish rapidly in the Southern Beaufort Sea. This work is presented in more detail in Barber et al. 2009.

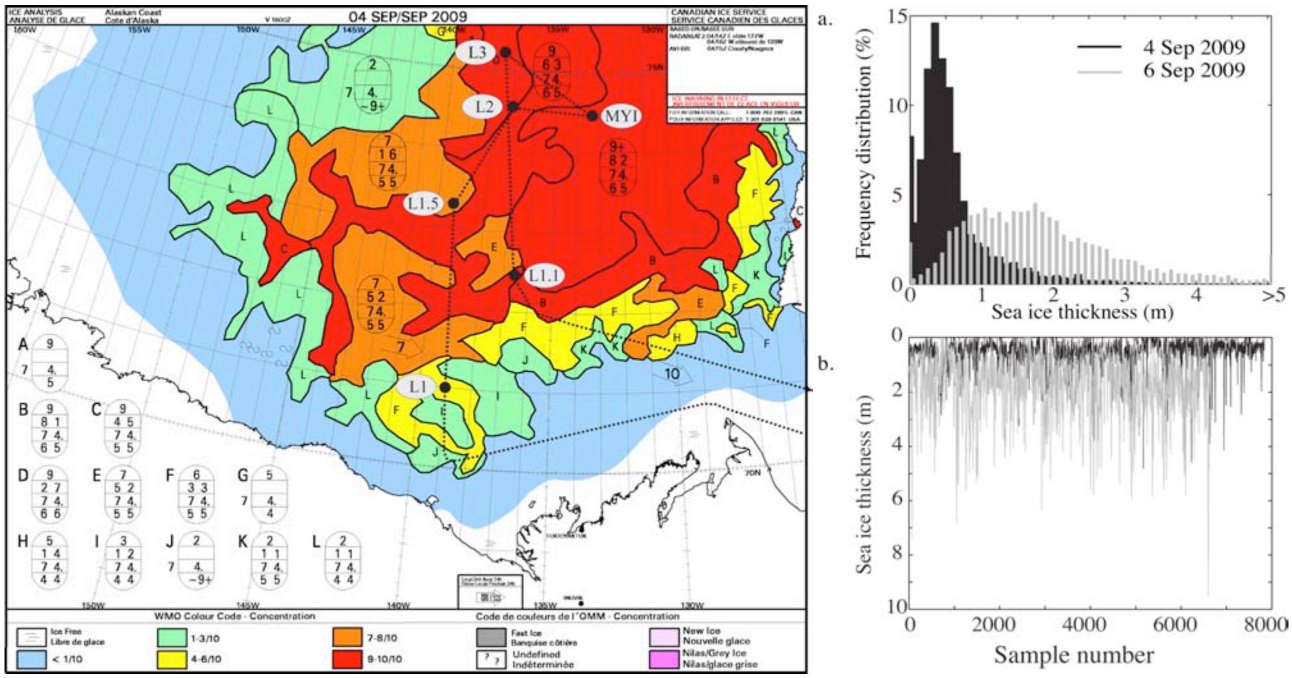


Figure 1. Canadian Ice service (CIS) icechart for Sept 4, 2009. Amundsen transect went from L1 to L1.5 then to L2. This entire transect was in rotten ice (very thin first-year and heavily decayed MY ice forms; see text). We then headed eastwards to MYI (to seek out Multiyear sea ice). At the MYI station we found what was the more expected; thick MY forms of sea ice. EM induction estimates of ice thickness for station MYI (grey) and the rotten ice at L2 (black) are depicted in a histogram (a) and a linear profile of thickness (b).

Citation:

Barber, D. G., M.Asplin, R.Galley, K. Warner, M.Pucko, M.Gupta, S. Prinsenberg, R. De Abreu[3] , Captain S.Julien. The summer perennial pack ice in the southern Beaufort Sea is not as it appears. Geophysical Research Letters. In review (Oct'09).

Contribution to summary evaluation of Regional Sea Ice Outlook

Coastal sea-ice break-up at Barrow

(Hajo Eicken, Chris Petrich, Mette Kaufman)

The June contribution to the regional outlook by our team anticipated sluggish melt onset with lighter ice conditions in the later season due to the lack of multiyear ice. Mostly, this assessment proved to be correct and details can be found in the monthly outlook contributions.

Of particular interest was the exploratory forecast of coastal ice break-up at Barrow which proved to be interesting, both as a tool to chart the progress of the melt season, and in its comparative success in predicting sluggish melt over a period of 1-2 weeks out. The progression of seasonal melt is summarized in Figure 1, which indicates that 2009 had the latest break-up on record over the past 10 years and that this was largely driven by above normal cloudiness, tying in with large-scale observations for the Arctic Ocean region as a whole.

Factors driving the 2009 minimum

Barrow break-up was characterized by moderately heavy ridging leading to landfast ice breaking out south of Barrow before break-up occurred offshore Barrow. Disintegration of on-shore landfast ice happened late in the season due to generally overcast skies in June and July.

Additional data or data products that would be useful for improving outlooks in the future, including any critical gaps in field observations

An improved characterization of grounded pressure ridges in spring, i.e. prior to the onset of melt, would enable the detection of very early break-up. General forecasts of cloudiness one month ahead (e.g. weekly mean downward shortwave flux) would be sufficient for a long-term prediction of near-shore melt.

Implications, based on this year's results, for the future state of arctic sea ice

Break-up of landfast ice at Barrow continues to be at the mercy of the agitation of sea ice in the Chukchi Sea in winter and cloudiness in June and July.

Other "lessons learned"

The Outlook helped focus different forecasting efforts and analysis of a decade’s worth of data from the Barrow Sea Ice Observatory, potentially also providing guidance for larger-scale regional forecasting efforts.

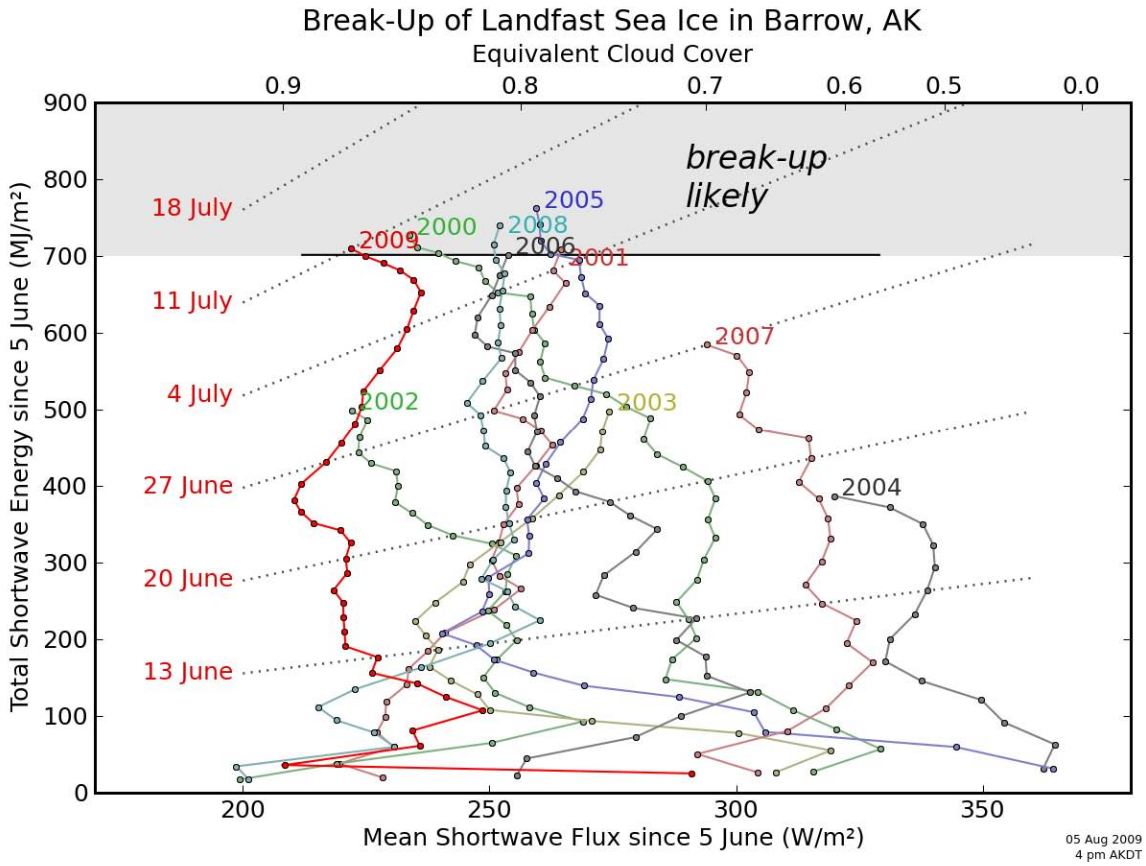


Fig. 1: Break-up timing and solar shortwave energy incident at the surface (mean and cumulative shown on bottom and left axis, respectively) for 2009 (thick red line) and other recent years. Curves terminate at observed break-up. The shortwave flux is used as an indicator for radiative forcings. The grey area at the top corresponds to the seasonal stage at which ice break-up is imminent and determined by local sealevel and winds. Details at www.gi.alaska.edu/snowice/sea-lake-ice/Brw09/forecast/.

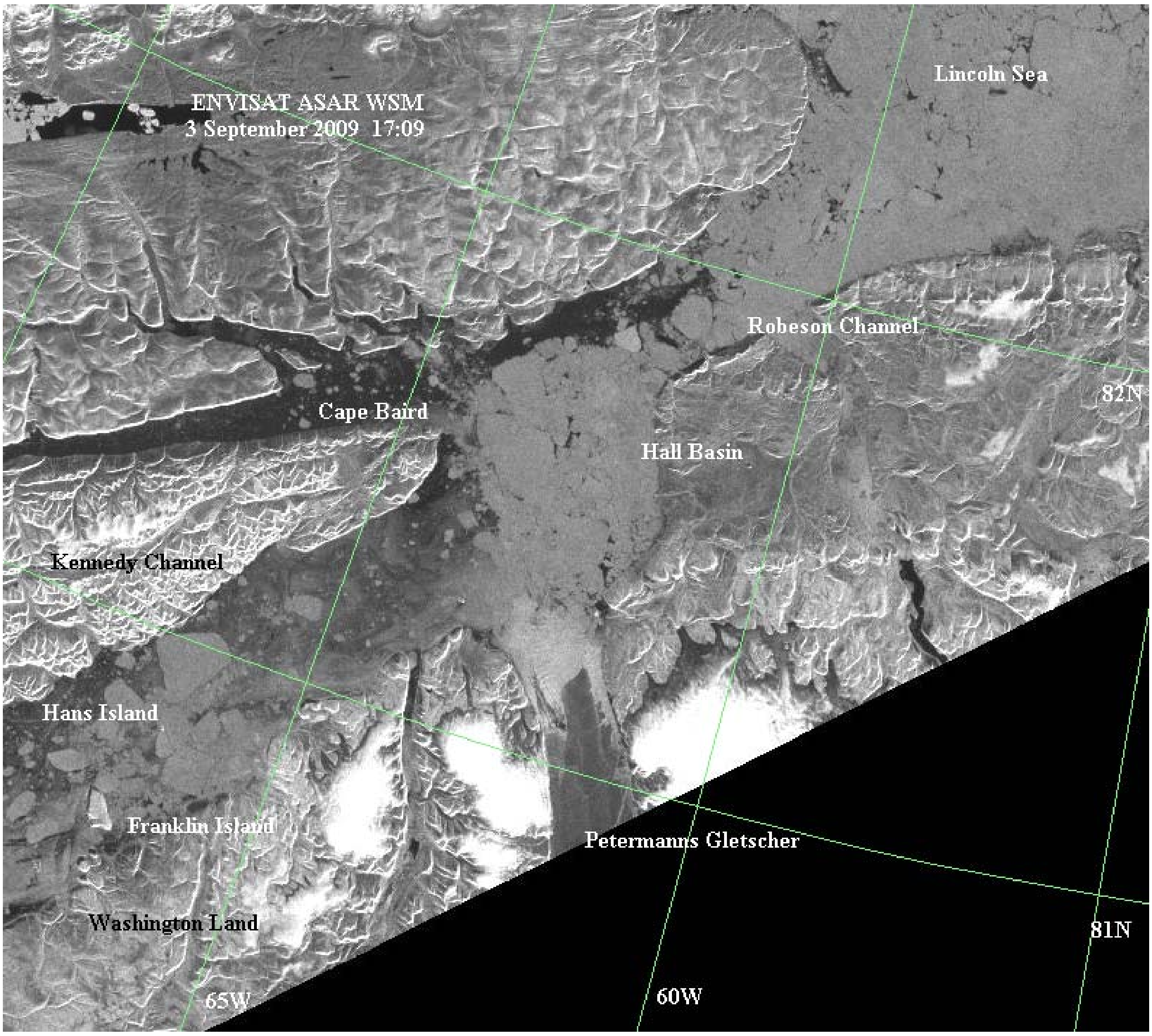
Nares Strait, an outlet of the Arctic Ocean

After the break down of the ice barrier in southern Lincoln Sea in the beginning of July, sea ice drifted unhindered through Nares Strait to Baffin Bay in July and August. Large potentially blocking floes break in pieces, small enough to pass the narrow parts of the Strait – when properly oriented. New blockings may occur during the coming winter with the recurrent ice bridge in southern Kane Basin as an outstanding example. Generally it forms in the November-March period to break-down by the following summer. So far we have no means of predicting the occurrence of this and other hindrances. A short-term example is the observation of the ice being caught in a cyclonic gyre in Hall Basin by 18-20 August 2009 reducing the flow of multiyear ice into Kennedy Channel. By 3 September it is still present.

During its August cruise to Nares Strait the Canadian icebreaker CCGS Henry Larsen was blocked in front of Petermann Gletscher during a 15-hour period by this gyre. Ice thickness of 3-6 meter were reported from this place. At other places an average ice thickness of 9 m with a maximum of 20 m were recorded by a drill team from the ship. (Progress Reports by Humfrey Melling, Institute of Ocean Sciences, Sidney BC).

During its cruise, a number of moorings was recovered in southern Kennedy Channel (deployed in 2007) and new moorings deployed at Franklin Island, to be retrieved in 2011. With the installation of an automatic weather station at Cape Baird that juts out in Hall Basin, refurbishment of one on Brevoort Island (in Kane Basin) and that on Hans Island (in the centre of Kennedy Channel) good meteorological monitoring is accomplished in this very dynamic region.

Radar image on next page.



Near-range scene from the Advanced Synthetic Aperture Radar on ENVISAT in its Wide Swath Mode processed to a spatial resolution of 150 m showing the ice blocking in Hall Basin. The wind-roughened open-water surface in front of Petermanns Gletscher is due to a katabatic wind. The thickness of the front of the glacier was measured to 60 m. The white surfaces on the ice caps indicate that freezing has begun at these altitudes while this is not the case on the surface of the glacier.

The 2009 Sea Ice Outlook

Lincoln Sea and Nares Strait.

In 2009 the state of sea ice in the region has been dominated by the formation of an ice barrier in the southern Lincoln Sea by 16 January blocking the export of sea ice southwards into Nares Strait during a 5.5-month period. Sea ice present in the Strait - including multiyear ice - moved southwards after the blockage to pass Smith Sound into North Water and Baffin Bay by the end of February. This was followed by new ice formation in the open water below the barrier, drifting southwards into the Strait and Baffin Bay, a process that continued until the summer-melt began by early June. In the course of June all Nares Strait became ice-free so that Arctic Sunrise, a Greenpeace ship, could anchor at the barrier at 82.6 N by the end of the month.

A consequence of the establishment of the barrier is that the amount of multiyear ice that entered Baffin Bay is very much reduced relative to ‘normal’ export, perhaps by a factor of 0.5, but it also means that the ice remaining in the Lincoln Sea after the barrier formation increased in thickness being subject to low winter temperatures during four to five months. This is likely to partly remedy the situation in Lincoln Sea after the great outflow in 2007 and 2008.

This great outflow – twice the average outflow in the preceding 11-year period – was due to the fact that no barrier formed in Lincoln Sea and the Strait during 2007 and that the stoppage of export in 2008 lasted only two months and in the late part of the winter. Consequently, the Lincoln Sea lost a great deal of the thick multiyear ice normally present, resulting in a lower probability of formation of ice barriers in the future and thereby an increase of the discharge of multiyear ice from the Arctic Ocean via Lincoln Sea and Nares Strait into Baffin Bay.

Regional 2009 Outlook Summary: Western Parry Channel Route of the Northwest Passage

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1. Sea Ice Evolution:

At the start of the 2009 melt season, multi-year ice (MYI) conditions were lighter than average within Western Parry Channel region of the Northwest Passage (Figure 1). The amount of MYI was even less than 2007 when the region cleared for the first time during the satellite era but the initial spatial distribution was different than the light years of 2007 and 2008 (Figure 2). The date of melt onset for 2009 (year day 155) occurred much later than 2008 (year day 142; the earliest on record) but 1-day earlier than 2007 (Figure 3). As the melt season got underway, total sea ice the Western Parry Channel remained near the normal up until September (Figure 4). Below normal decreases occurred in September but still remained well above the low years of 1999, 2007, and 2008. As expected, the high MYI concentrations within the Western Parry Channel delayed breakup compared to 2007 and 2008. When the ice eventually became mobile it slowly drifted towards the M'Clintock Channel which, acts as a sea ice "drain-trap" within the Canadian Arctic Archipelago (Figure 5). The flux of MYI from the Queen Elizabeth Islands via Byam-Martin Channel was minimal in 2009 because of blockage from MYI at the mouth of the M'Clintock Channel. With southward advection limited and temperatures not being sufficient to completely ablate the sea ice, high concentrations remained in the Western Parry Channel throughout the season (Figure 5).

2. Lessons Learned:

The spatial distribution of MYI at the start of the melt season is an important factor to consider with respect to the clearing of the Western Parry Channel. If MYI concentrations are high at the mouth of the M'Clintock Channel this does limit the flow of MYI from the Queen Elizabeth Islands but it also means less sea ice will be transported southward hence, concentrations remains high in the central Western Parry Channel – this was the case in 2009. Conversely, if the mouth of the M'Clintock Channel clears, then MYI can be transported southward but the flux of MYI from the Queen Elizabeth Islands directly across the Western Parry Channel increases – this was the case in 2008. When the region cleared in 2007, the only major difference with respect to 2008 was winds forced MYI streaming through Byam-Martin Channel along the coast of Melville Island rather, than directly across the Western Parry Channel.

3. Implications for 2010:

Although the sea ice has not consolidated within the Western Parry Channel, the MYI spatial distribution should be remain relatively similar leading up to 2010 (Figure 5). Considerable amounts of seasonal first-year ice will be present in the WPC but the mouth M'Clintock Channel will still exhibit high concentrations of MYI. The latter will likely facilitate ice congestion within Western Parry Channel similar to 2009. Currently, there also appears to be high concentrations of MYI at the entrance to the M'Clure Strait that potentially poses another problem to clearing in 2010

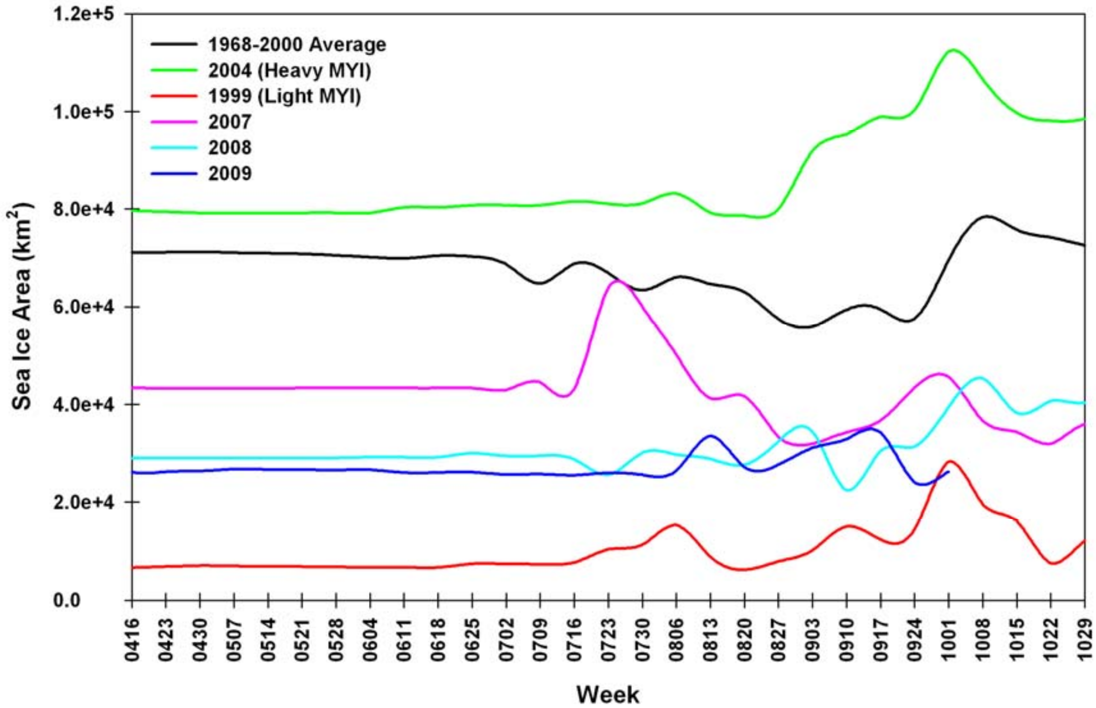

Figure 1. Time series of the evolution of multi-year ice within the Western Parry Channel region of the Northwest Passage. Data is from the Canadian Ice Service.

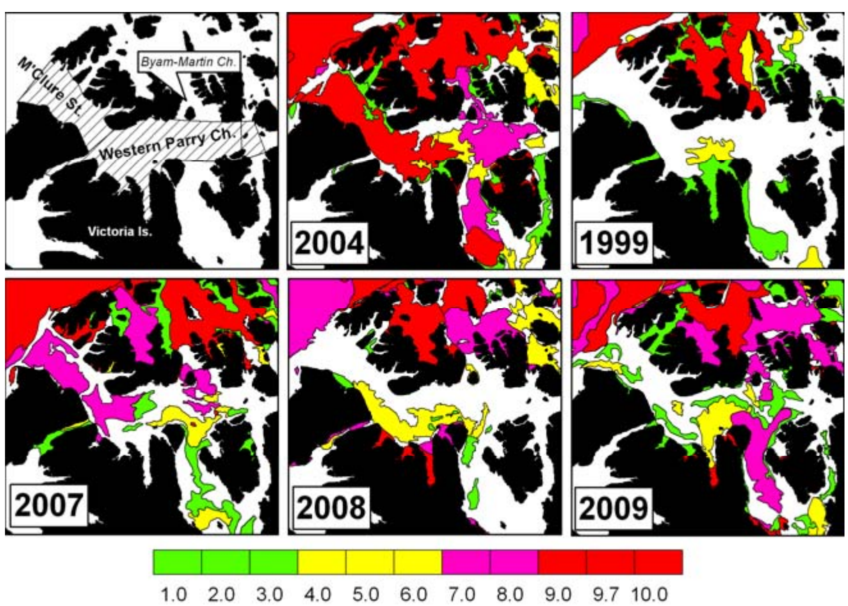

Figure 2. Spatial distribution of multi-year ice (in tenths) within the Western Parry Channel region of the Northwest Passage on May 1st for a heavy ice year (2004), a light year ice (1999) and the last three years. Data is from the Canadian Ice Service.

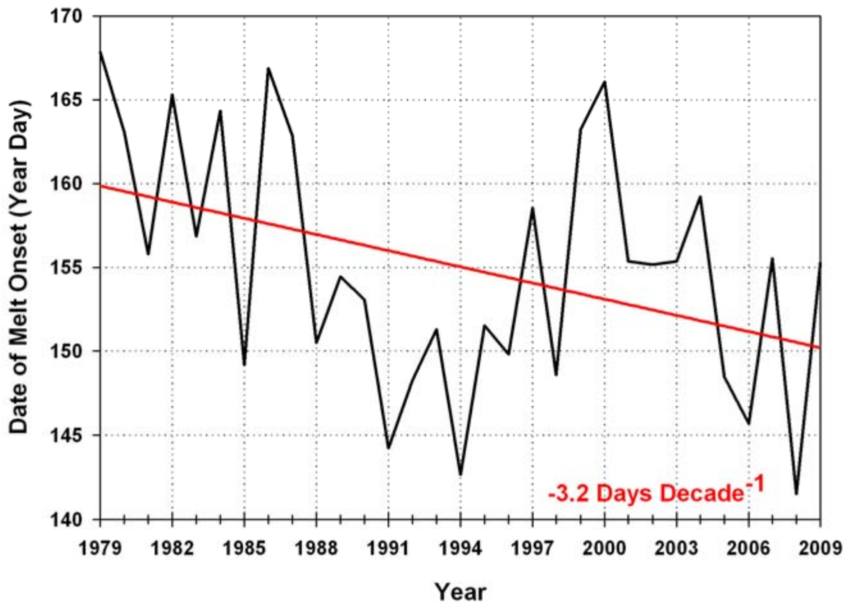

Figure 3. Date of melt onset in the Western Parry Channel region of the Northwest Passage from 1979-2009. Data are from the Defense Meteorological Satellite Program (DMSP) F-series satellite SSM/I and SSMIS sensors. Algorithm provided by Thorsten Markus, Goddard Space Flight Center.

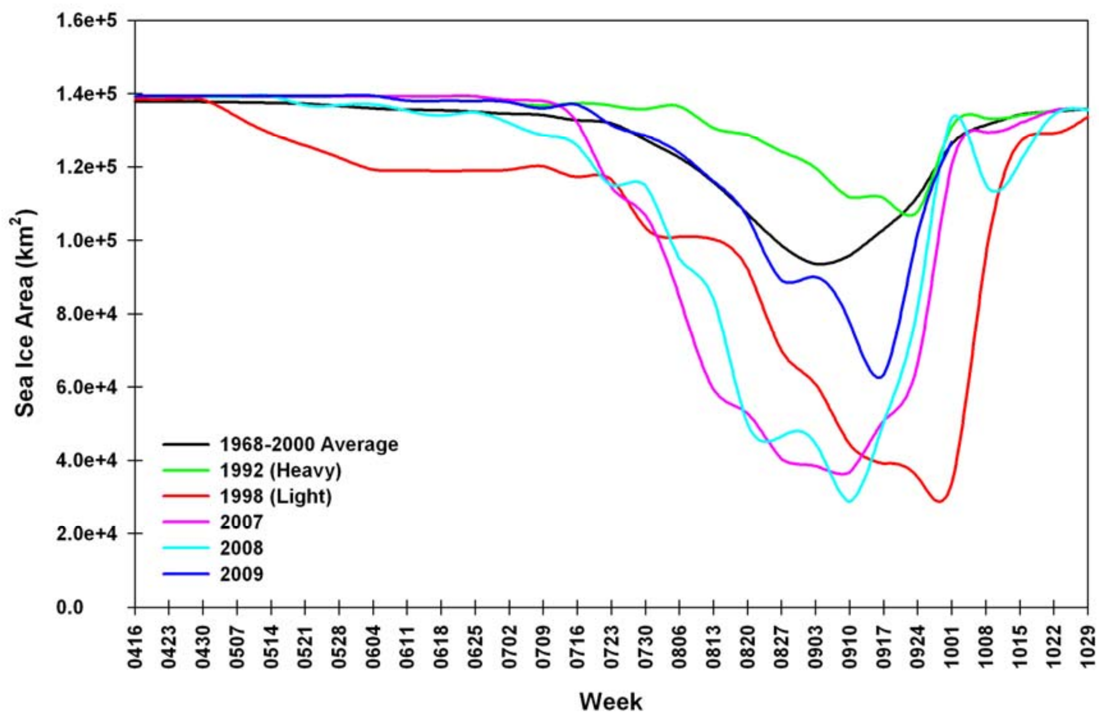

Figure 4. Time series of the evolution of total sea ice within the Western Parry Channel region of the Northwest Passage. Data is from the Canadian Ice Service.

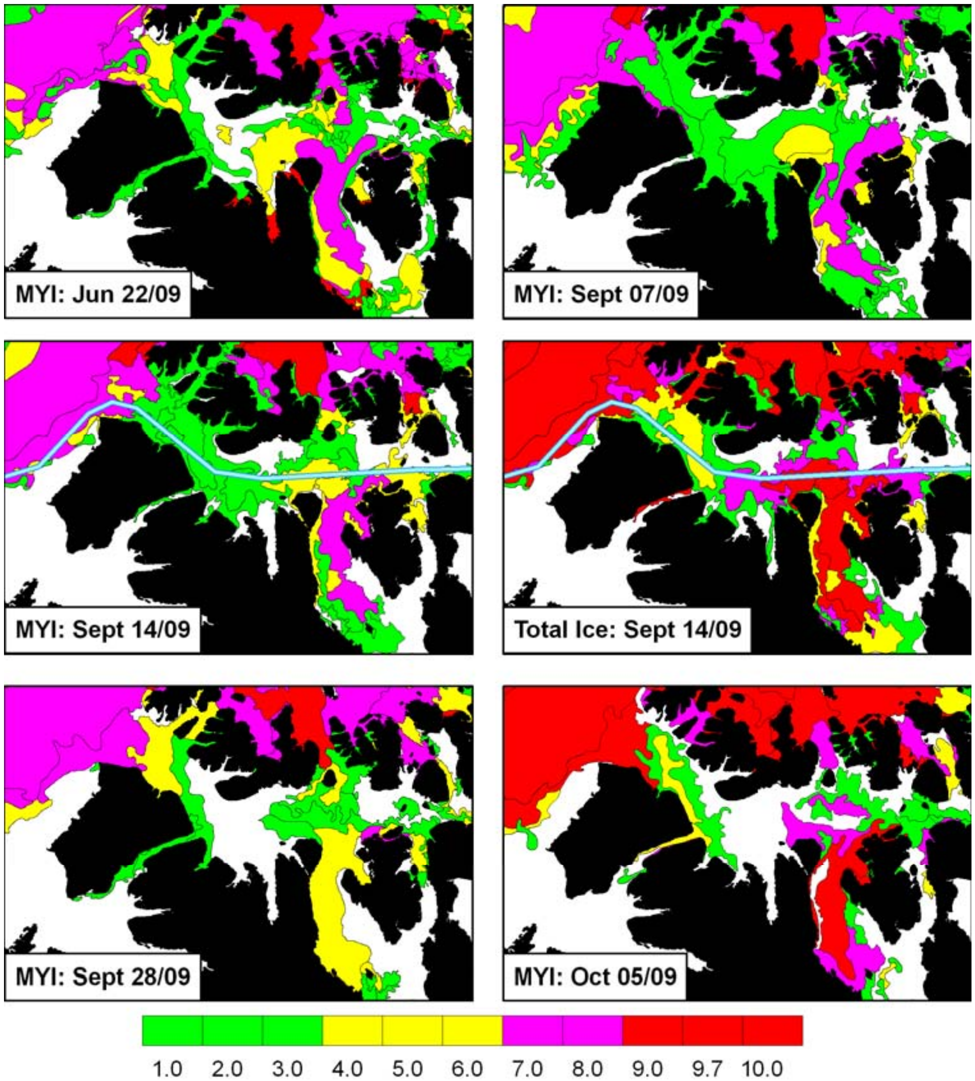

Figure 5. Spatial distribution of sea ice concentration (in tenths) within the Western Parry Channel region of the Northwest Passage on selected days during the 2009 melt season. The minimum total ice area (September 14) within the region is shown on the middle right panel. Data is from the Canadian Ice Service.

Ensemble Predictions of September 2009 NWP Sea Ice Conditions (Summary)

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10/9/2009

Ensemble predictions of September 2009 sea ice conditions in the Northwest Passage (NWP) region were conducted as a part of community-wide Arctic Regional Sea Ice Outlook. Here is a summary, followed by 4 figures:

(1) Satellite ice concentration data appear to show that sailing along NWP in September 2009 was possible without escort of ice breaker (Figure 1).
(2) With the starting date of prediction being 7/1, the model under-predicts sea ice in the NWP region (Figure 2 upper). It is not clear why. Maybe it is related to the under-prediction of ice extent in the Arctic Basin. With the starting date of prediction being 9/1, the predicted sea ice conditions appear to be quite closer to satellite observations (Figure 1 and Figure 2 lower). This is because as the prediction range becomes shorter, the initial prediction conditions, out of assimilation of satellite ice concentration data, approach to the actual September ice conditions. So obtaining right initial conditions are as important for the outlook of ice conditions in the NWP region as for that in the Arctic Basin.
(3) Except in a small area, most of the NWP region in September 2009 has less ice than the 2002-2008 September mean (Figure 3d). This may be attributed to the fact that it was warmer than usual in the NWP region in July and August (Figures 4b and 4c).
(4) Given that NWP in September was largely open and less ice was observed in most areas than the recent average and warmer SAT in July and August, we may deduce that the probability of a complete open NWP will increase in the future.

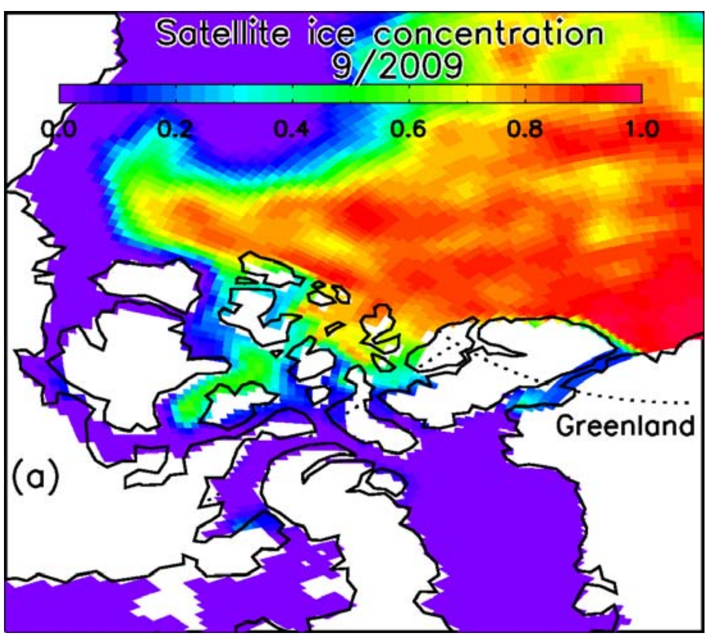

Figure 1. Satellite observed September 2009 sea ice concentration in the Northwest Passage region.

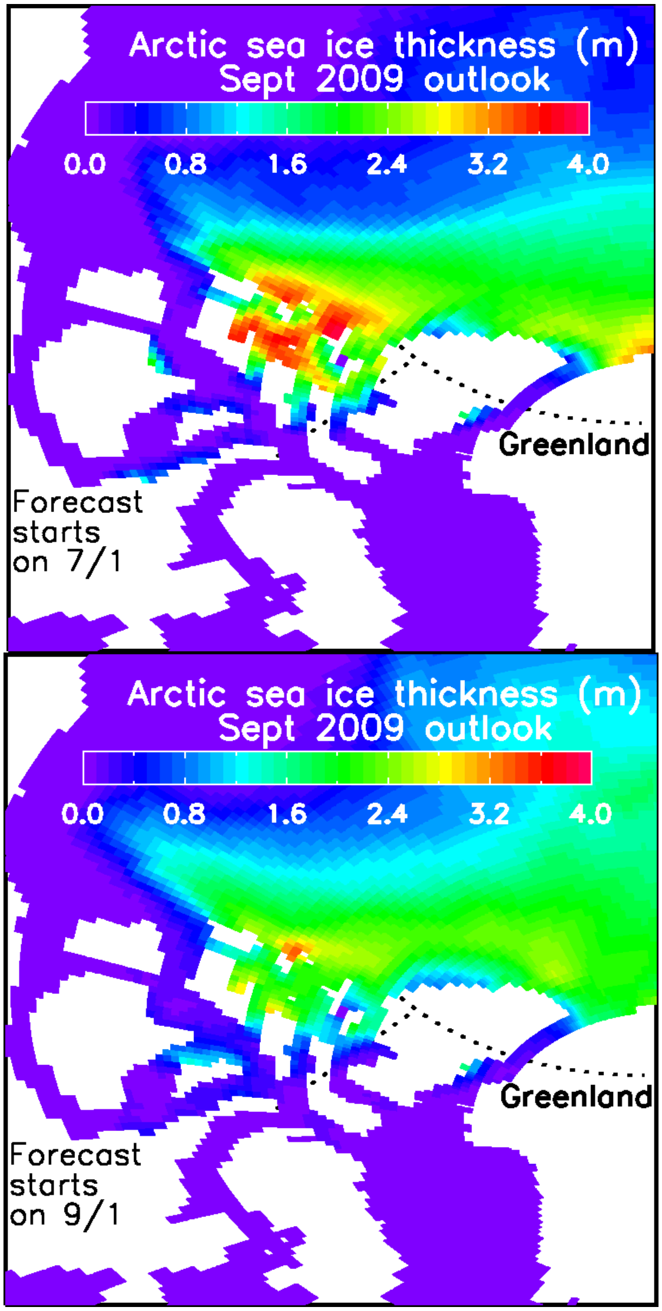

Figure 2. Ensemble predicted September 2009 sea ice thickness in the NWP region with two different starting dates of prediction (July 1 and September 1).

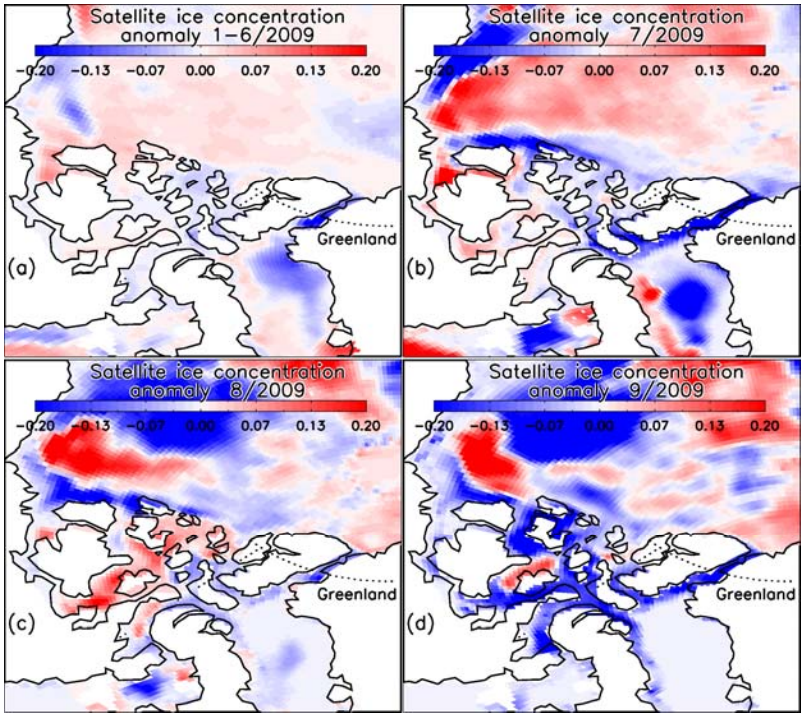

Figure 3. Anomalies of satellite observed sea ice concentration. An anomaly is defined as the difference between the 2009 value and the 2002–2008 average.

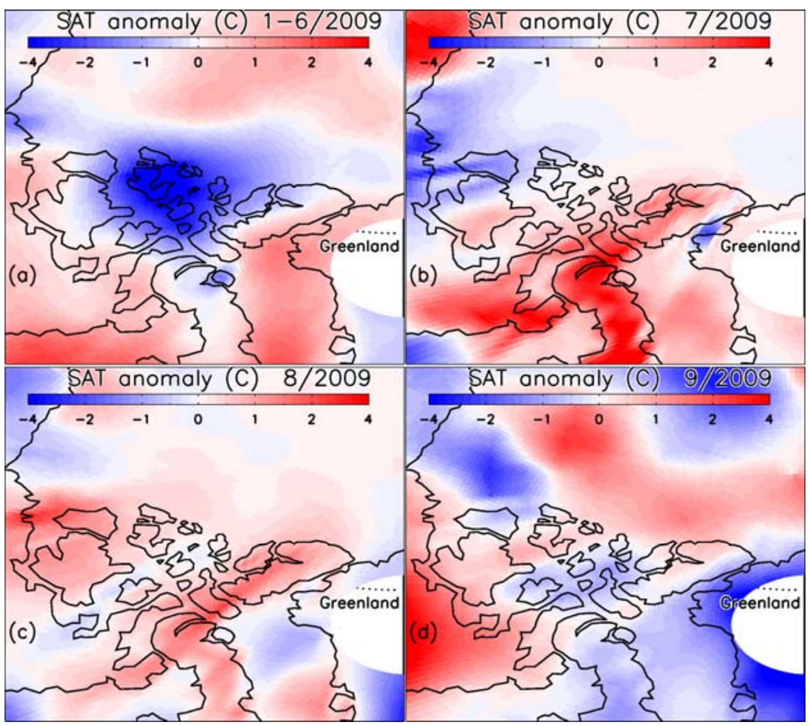

Figure 4. Anomalies of the NCEP/NCAR reanalysis surface air temperature (SAT). An anomaly is defined as the difference between the 2009 value and the 2002–2008 average.

Information about ensemble predictions:

The ensemble predictions are based on a synthesis of a model, NCEP/NCAR reanalysis data, and satellite ice concentration data. The model is the Pan-arctic Ice-Ocean Modeling and Assimilation System (PIOMAS), which is forced by NCEP/NCAR reanalysis data. It is able to assimilate 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 the first day of a particular month in 2009. The initial ice-ocean conditions are obtained by a retrospective simulation that assimilates satellite ice concentration data. Of course, no data assimilation is performed during the predictions. More details about the prediction procedure can be found in Zhang et al. (2008).

Reference

Zhang, J., M. Steele, R.W. Lindsay, A. Schweiger, and J. Morison, Ensemble one-year predictions of arctic sea ice for the spring and summer of 2008. *Geophys. Res. Lett.*, *35*, L08502, doi:10.1029/2008GL033244, 2008. (http://psc.apl.washington.edu/zhang/Pubs/Zhang_etal2008GL033244.pdf)

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We are also interested in your thoughts and ideas on the following:
1. Factors driving the 2009 minimum.

Two major factors: (i)warm Atlantic water inflow in Russian sector of Arctic and (ii)unusual North Pacific SST field configuration during late Spring and Summer of 2009.
First factor maintains previous year minimum ice extent in Russian shelf seas (I mean Barents and Kara Seas).
Second one - Changes in the SST spatial structure in North Pacific caused an short term atmospheric circulation regime which accelerate thin ice destruction in Chukchi Sea at late summer. In September the PDO again turns into its negative phase. Thus Pacific sector of Arctic will be at high level of ice extent values.

2. Additional data or data products that would be useful for improving outlooks in the future, including any critical gaps in field observations.

Data on the core North Atlantic water inflow (e.g. temperatures at depth of 150-300 m)
in Iceland domain.
We need reliable forecasts of the SST fields in North Pacific.
Early signs of changes in the SST fields in North Atlantic.

3. Implications, based on this year's results, for the future state of arctic sea ice.

There are two major ice extent regulated mechanisms:
(i) core Atlantic waters
(ii) SST in North Pacific which determine the atmospheric circulation types govern ice extent in East Russian and Alaska/Canada Arctic.

4. Any other "lessons learned" - including the usefulness of the Outlook as a community synthesis tool, suggestions for future outlook activities, or any other topic you want to comment on.

It very urgent to develop more flexible prediction tools than GCM which are very inertial to any external disturbances.