3.6 The Sea Ice Outlook

Lead Author:
John Calder

Contributing Authors:
Hajo Eicken and James Overland

Reviewers:
David Barber and Eduard Sarukhanian

Introduction

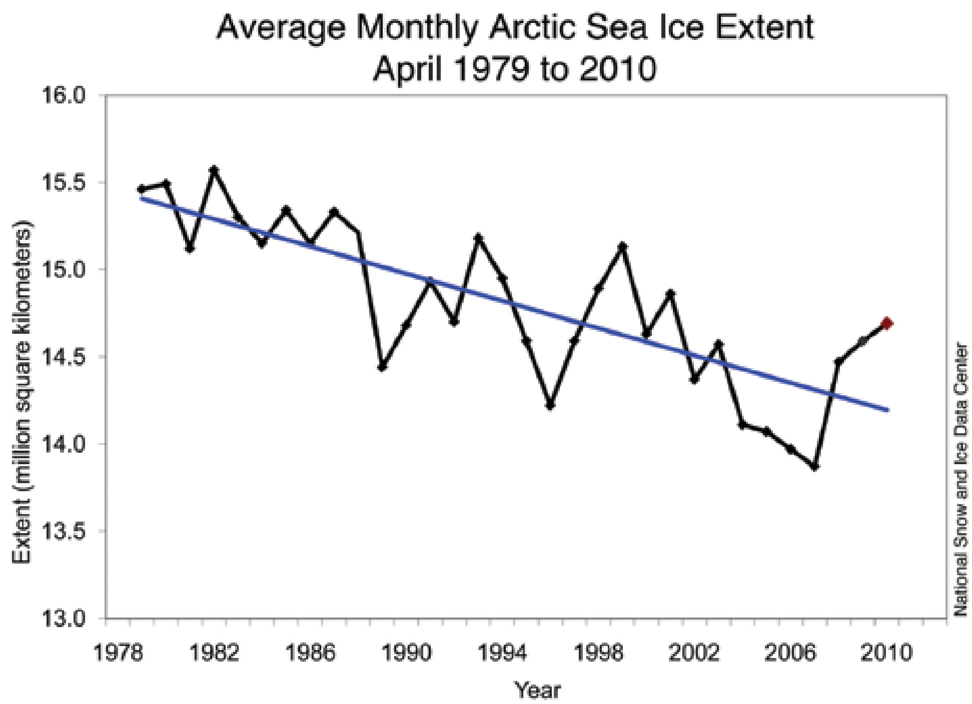
IPY catalyzed significant additional funding and redirection of some existing support that was used to investigate a number of critical scientific issues in the Arctic. Enhanced study of Arctic sea ice was a focus for a number of research groups. In the U.S., the pre-existing Study of Environmental Arctic Change (SEARCH) program supported a number of activities related to Arctic sea ice. In Europe, IPY project Developing Arctic Modeling and Observing Capabilities for Long-term Environmental Studies (DAMOCLES) was supported as an integrated ice-atmosphere-ocean monitoring and forecasting system. The SEARCH and DAMOCLES activities were linked through a special coordinating activity called "SEARCH for DAMOCLES (S4D)". One of the coordinating activities was a joint workshop held in March 2008 at Palisades, NY (SEARCH, 2008; see www.arcus.org/search/meetings/2008/aow/index.php for more information). One outcome of the workshop was recognition by the participants of the need for better understanding of the Arctic sea ice system, given the drastic and unexpected sea ice decline observed by satellites in summer 2007 (Fig. 3.6-1). The sea ice cover retreated to well below its previous record minimum extent, with potentially substantial physical, biological and socio-economic impacts on the Arctic. This fact underscores the immediate need for increased integration and coordination of sea ice observations and modeling. As a result, several participants agreed to pool their insights and work collaboratively to prepare an "outlook" on how Arctic sea ice extent might evolve over summer 2008. It was also agreed that other interested experts should be invited to participate in this activity and thus the SEARCH-DAMOCLES Sea Ice Outlook (SIO) effort was initiated.

Preparations for undertaking the SIO involved formation of a "core integration group", led by James Overland, and an "advisory group". Broad international participation was sought; North America and Europe were well represented in these two groups from the outset. A Japanese group joined the effort later in 2008 and 2009.

The SIO groups developed an open and inclusive process for conducting the work to ensure that any scientist could participate. The objective of the SIO is to produce monthly reports during the arctic summer sea ice season that synthesizes input received from participating scientists representing a broad range of scientific perspectives:

1. Each month during the summer sea ice melt season, a request to the international arctic science community (http://siempre.arcus.org/4DACTION/wi_ai_getArcticInfo/3606) solicits information on the expected state of the September arctic sea ice.
2. The community submissions are synthesized and reviewed by the Sea Ice Outlook Core Integration Group and Advisory Group (www.arcus.org/search/seaiceoutlook/organizers.php).
3. An integrated monthly report is produced that summarizes the evolution and expected state of Arctic sea ice for the September mean Arctic sea ice extent, based on the observations and analyses submitted by the science community. These reports are posted in the "monthly reports" section of the SIO website (www.arcus.org/search/seaiceoutlook) and widely distributed (see Fig. 3.6-2, June 2009 Report).
4. The process for producing the monthly Sea Ice Outlook reports is repeated through September of each sea ice season.

Fig. 3.6-1. Average monthly sea ice extent from 1979 to 2010 shows a continued decline. The rate of sea ice decline since 1979 has increased to 11.2 percent per decade. (NSIDC - http://nsidc.org/images/arcticseaicenews/20100504_Figure3.png)



5. Retrospective analyses after the season examines the success of the Sea Ice Outlook in advancing scientific understanding of the arctic sea ice system, and provide guidance to future research efforts.

The results from the Outlook activities as of late spring 2009 are summarized in a paper by Overland et al., (2009).

Summary of 2008 and 2009 efforts

The projections of the Sea Ice Outlook groups for the September 2008 minimum ice extent, based on May data, had a median value of 4.2 million square kilometers (msk) and a range of 3.1 to 5.5 msk (see Fig. 3.6-1). The median value is roughly the same as the minimum observed in September 2007 (4.3 msk). With observations from early summer, the projected median sea ice extent value increased to 4.9 msk for the July Outlook with a range of 3.2 to 5.6 msk. Both of these Outlook projections are substantially lower and nearer to the observed September 2008 minimum value (4.5 msk) than to the 1979–2000 mean value (7.1 msk) or to the linear trend line of previous September minima (5.6 msk). Both sea ice models and seasonal melting projections provided the main semi-quantitative information for the 2008 SIO.

In a retrospective analysis, the SIO team determined that the agreement between projections and observations is consistent with the conclusion that initial conditions of spring sea ice are often an important factor in determining ice development over the course of the summer. They also noted that the role of summer atmospheric forcing is important, but was less important in 2008 compared to 2007, which had very unusual atmospheric circulation patterns. The SIO team felt that this result bodes well for future seasonal Sea Ice Outlooks. They concluded that during the next few summers it will be important to track potential recovery or further decline of the summer ice pack with late spring/early summer satellite and *in situ* sea ice observations providing important information.

Following the SIO effort for summer 2008, the participants agreed to continue and prepare similar reports during summer 2009 and again in 2010. The same process used in 2008 was repeated for 2009. The initial Outlook released in June and based on May data showed a mean projected value for September sea ice extent minimum of 4.7 msk and a range of 3.2 to 5.0 msk (see Fig. 3.6-1). For the August report, based in July data, the mean projected value for September sea ice extent minimum was 4.6 msk, with a range of 4.2 to 5.0 msk, with more than half of the 14 estimates in a narrow range of 4.4 to 4.6 million square kilometers, representing a near-record minimum. All estimates were well below the 1979–2007 September climatological mean value of 6.7 million square kilometers. The uncertainty/error values, from those groups that provided them, were about 0.4 million square kilometers, thus most of the estimates overlapped.

In actuality, the 2009 Arctic sea ice minimum extent was reached on 12 September 2009, according to the National Snow and Ice Data Center (NSIDC; http://nsidc.org/arcticseaicenews/2009/091709.html), with a value of 5.1 msk (Fig. 3.6-3). In a retrospective analysis, the SIO team concluded that September 2009 sea ice extent was driven by preexisting sea ice conditions at the end of spring, as well as variable wind patterns and cloudiness over the course of the summer. They stated that 2007 remains as an anomalous year, dominated by steady meteorological conditions during the entire summer that were favourable for sea ice loss, while in 2009, August and September wind patterns and increased cloudiness were not conducive to major sea ice loss.

The SIO team stated concern over the fact that all 2009 Outlook projections were below the observed September 2009 value. Yet they noted that, when projection uncertainty is taken into account, as well as it can be, the observed value is within an expected range of values. This was explored further by two groups from Germany and the U.S.A. that provided ensemble simulations with coupled ice-ocean models allowing for probabilistic assessments of expected minimum ice extent (Zhang et al., 2008; Kauker et al., 2009). The Outlook participants remained concerned over the convergence of the Outlook projections into a narrow range. They agreed that the last point emphasizes that further development and analysis of probabilistic

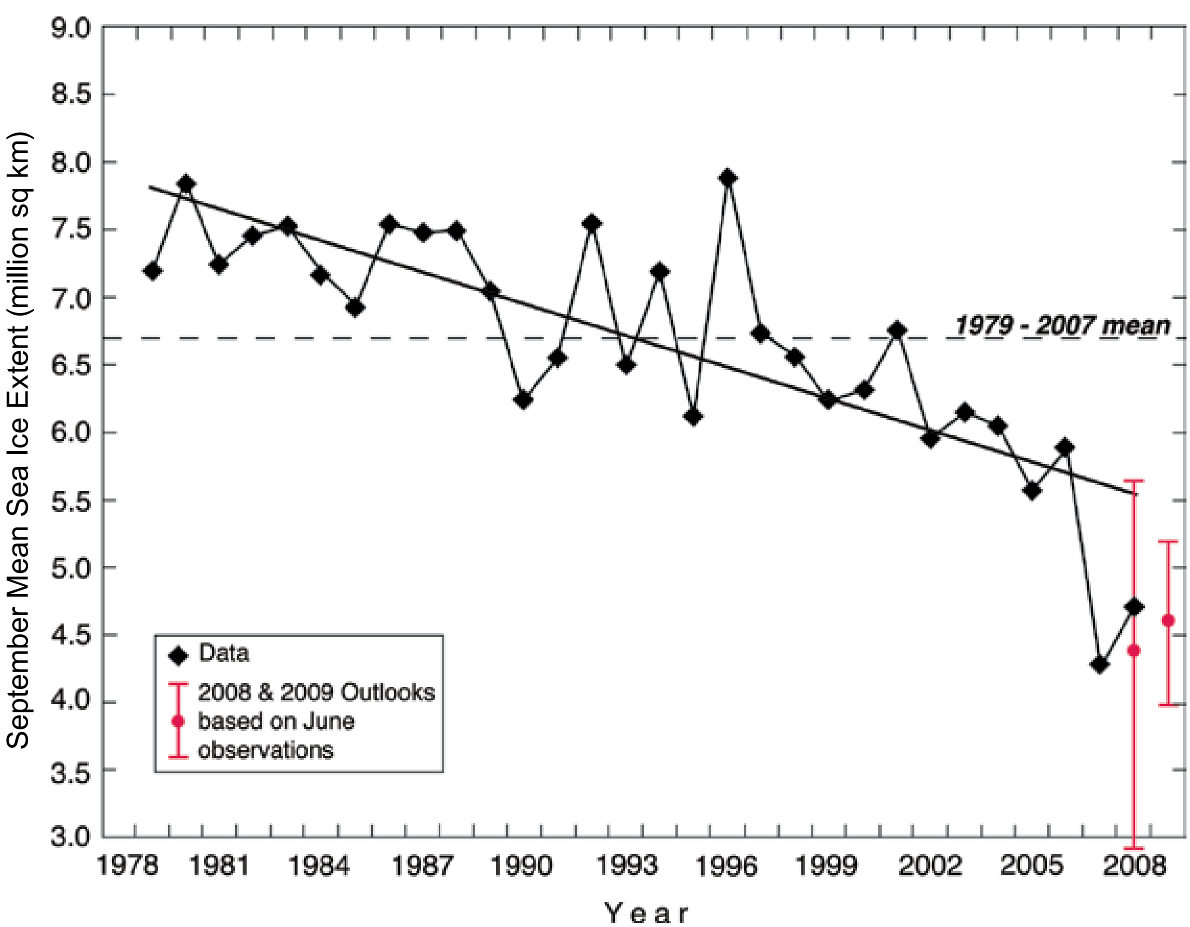


Fig.3.6-2. Observed monthly mean Arctic sea ice extent in September (million sq km), 1979–2008. The vertical red lines shows the median value and range of estimates for the June 2008 and 2009 outlook forecasts for the following September sea ice extent.

forecast ranges and measures of uncertainty will be critical to improvement in future efforts.

The SIO team stated that the sea ice evolution in 2009 signals that it could be several more years, in a probabilistic sense, before conditions favour another major sea ice loss event. Nevertheless, they noted that the increase in sea ice extent for 2009 relative to 2008 does not exceed past interannual variability in a near-continuous, 30-year downward trend in summer sea ice extent (Fig. 3.6-4).

They also noted that melt-out of sea ice near the North Pole continues to be less than in the Beaufort and Siberian sectors because of the decreasing importance of solar forcing. They concluded that this may be a limiting factor in the rate of future sea ice loss.

In 2009, the outlook also included a regional outlook examining ice evolution in several regional sectors of the Arctic by nine contributing research groups (Fig.3.6-5). Combining statistical models, ensemble simulations and heuristic approaches, seven of the nine categorical forecasts were accurate. These results indicate that a thorough understanding of local ice conditions and long-term records of ice variability can go a long way towards enhancing the reliability of such regional projections on seasonal time scales. Forecasts of seasonal break-up of coastal ice, of relevance for a number of different stakeholder groups, also demonstrated that cloudiness and down-welling shortwave radiation plays a key role in driving summer ice retreat, both at the hemispheric and local level (Petrich et al., in prep.).

In thinking about how to improve the ability to forecast sea ice conditions in future summers, the SIO team stated:

- Consideration of multiple sources of data, including visual observations, is important for reducing

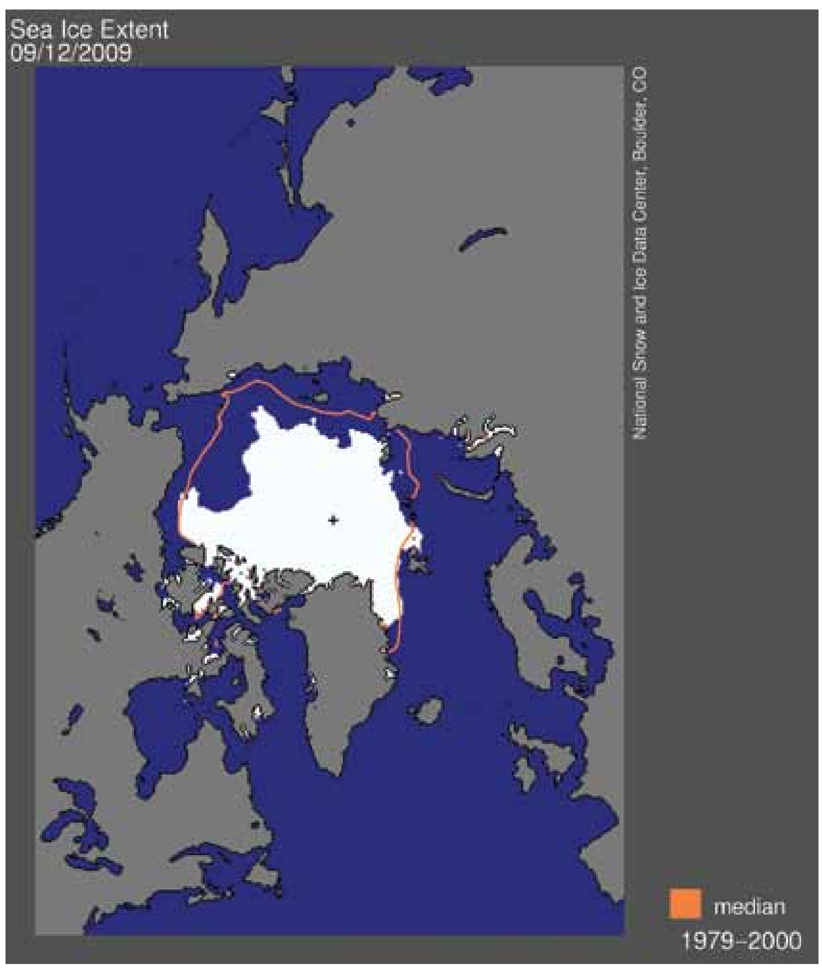


Fig.3.6-3. Minimal sea ice extent for summer 2009 reported on 12 September 2009.
(Photo: NSIDC)

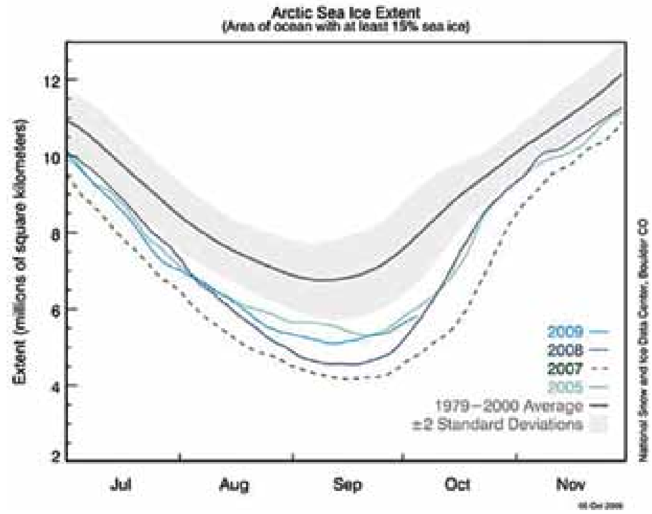


Fig.3.6-4. Daily arctic sea ice extent from passive microwave satellite data (SSM/I). The solid light blue line indicates 2009 relative to 2005, 2007 and 2008. The solid gray line indicates average extent from 1979 to 2000.
(National Snow and Ice Data Center)

uncertainty in the Outlooks. Buoys provide key observations for mapping and attributing summer ice loss: drift, bottom vs. top melt, amount of snow accumulation, nature of ponds (even if anecdotal from webcams) and thickness of level ice. Considerable effort should be made to estimate thickness distributions of ice and snow cover needed to initialize simulations. Aircraft and other reconnaissance are also helpful.

- Because of the importance of initial conditions for the sea ice state, more work is needed on remote sensing retrieval and interpretation of spring and summer ice concentrations and ice conditions, even if the present operational algorithms are not changed.
- Both full sea ice models and seasonal melt projections applied to detailed sea ice distributions and trajectories provided the main semi-quantitative information for the Outlook.

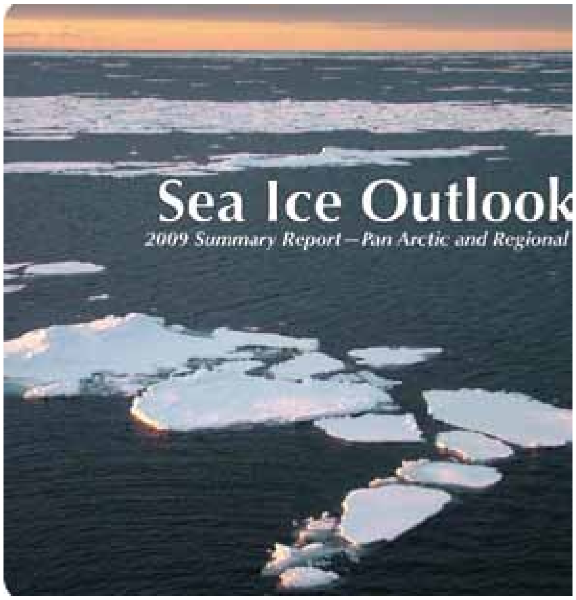
The SIO for 2009 went further than in 2008 by looking not only at the progression of ice melt, but also evaluating the rate of regrowth of ice in the fall. There was evidence that growth of ice in October and November was retarded and in fact the sea ice extent in portions of fall 2009 was less than in the corresponding period of the record minimum year of 2007.

The SIO team is continuing the Outlook process again in 2010. While it is too early to state with confidence, there is a possibility that the SIO process might continue and evolve into one of the valuable "legacy" activities of the IPY.

The specific outcomes of the Outlook activities include the following:

- Synthesis of remote-sensing or ground-based observations and modeling efforts to further understanding of variability and seasonal-scale predictability of the Arctic atmosphere-ice-ocean system.
- Creation of a forum that allows both the scientific community and educated laypeople to obtain better insight into cutting-edge Arctic system research.
- Enhanced scientific communication between field researchers, remote-sensing experts and modelers at time scales commensurate with the rapid change observed in the Arctic (i.e. faster than typical scientific publication cycles).
- Improved information exchange between researchers in academia and government agencies tasked with operational support in Arctic areas, in particular by providing a testbed for different forecasting approaches and creating a forum that allows agency personnel to draw on the broad expertise of the international research community.

Fig.3.6-5. Sea Ice Outlook: 2009 Summary Report www.arcus.org/search/seaiceoutlook/2009_outlook/2009_pan-arctic_summary.php



How the IPY changed the science

One of the major goals of the IPY was to encourage greater international collaboration. The SIO is an excellent example of the added value that can be obtained by bringing together scientists from diverse institutions. Would there have been a SIO effort at all if the joint SEARCH-DAMOCLES workshop hadn't been held? Or would the effort have been a U.S.-only effort rather than an international one? We can't answer these questions, but we do know that as a result of an international workshop, there were 18 groups participating in the 2009 Outlook process from seven different countries. They employed different approaches to the problem, including sophisticated numerical models, statistical evaluations and pattern matches with prior years. Each group was willing to state openly their projection for the sea ice minimum extent and their method for arriving at the value. In addition to the value of collaboration and information sharing, the rapid communication required to complete the monthly reports meant that the groups were quickly reanalyzing based on rapidly changing environmental conditions and learning from each other as the reports were released. The pace of advancement of scientific understanding most certainly exceeded that which would have resulted from traditional single group publications that were months to years in arrears of actual events.

References

Kauker, F., T. Kaminski, M. Karcher, R. Giering, R. Gerdes and M. Vossbeck, 2009. Adjoint analysis of the 2007 all time Arctic sea-ice minimum. *Geophys. Res. Lett.,* 36: L03707, doi:10.1029/2008GL036323.

Overland, J., H. Eicken, W. Meier and H. Wiggins, 2009. International Arctic sea ice monitoring program continues into second summer. *Eos, Trans. Am. Geophys. Un.,* 90:321-322.

Petrich, C., H. Eicken, J. Zhang and J. Krieger, in prep. Forecasting coastal ice decay and break-up in northern Alaska.

SEARCH, 2008. Arctic Observation Integration Workshops Report. Fairbanks, AK: SEARCH Project Office, Arctic Research Consortium of the United States (ARCUS), 63pp.

Zhang, J., M. Steele, R. Lindsay, A. Schweiger and J. Morison, 2008. Ensemble 1-Year predictions of Arctic sea ice for the spring and summer of 2008. *Geophys. Res. Lett.,* 35: L08502, doi:10.1029/2008GL033244.