Recent Arctic Ice Extent Minima Observed with the Sea Ice Index

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https://nsidc.org/data/seaice_index

Abstract

In September of 2002, arctic sea ice extent reached a minimum unprecedented in 24 years of satellite passive microwave observations, and almost certainly unmatched in 50 years of charting arctic ice (*Serreze et al.*, GRL, 2003). Again in September 2003, ice retreated to an unusually low extent, almost reaching last year's minimum. The Sea Ice Index (http://nsidc.org/data/seaice_index/) a Web site developed in response to a need for a readily accessible, easy-to-use source of information on sea ice trends and anomalies, assisted in monitoring and diagnosing these extent minima. Sea ice extent anomaly images reveal the distinctive characteristics of the 2002 and 2003 summer minima: ice that has retreated well north of its median extent in the East Siberian and Beaufort sectors, as well as the strikingly anomalous lack of ice off east Greenland. We attribute the shape and position of these summer extent contours to persistent high spring temperatures, enhanced summertime cyclonic conditions, and smaller than usual ice flux through Fram Strait due to larger than normal SLP differences across the strait. Possibly thinner winter ice cover preceding summer melt may be a factor as well, and is suggested by negative September ice concentration anomalies.

Sea Ice Index Features

Ice conditions, trends, and anomalies give at-a-glance answers to general questions such as "Is the ice extent in the Chuckchi about where it usually is this time of year?" and "Was there less ice in the Beaufort Sea last spring than is typical?". The product is intended for both researchers and the scientifically inclined general public.

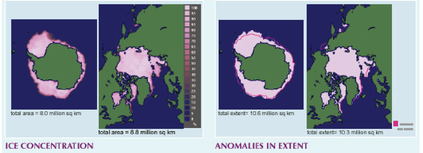
Documentation explains in detail
- Image derivation
- Data sources
- Validation issues

Interpretive text touches on
- Natural variability of sea ice, with bibliography
- Uses and limitations of linear regression for trend analysis

Index Archives with
- Animations
- Web Image Spreadsheet Tool for multiple image display
- FTP access to images, extent and area data

Presentation of trends and anomalies demands an internally consistent data set. For this reason the Sea Ice Index time series goes back only to 1987, the beginning of NSIDC's Standard NASA Team data set record. The Near Real-Time (NRTSI) DMSP SSM/I Daily Polar Gridded Sea Ice Concentrations, used to update the index for the months when the Standard NASA Team data set is not yet available, is consistent with the Standard Team data set , but is not consistent with the longer Goddard Space Flight Center SMMR and SSM/I time-series data set.

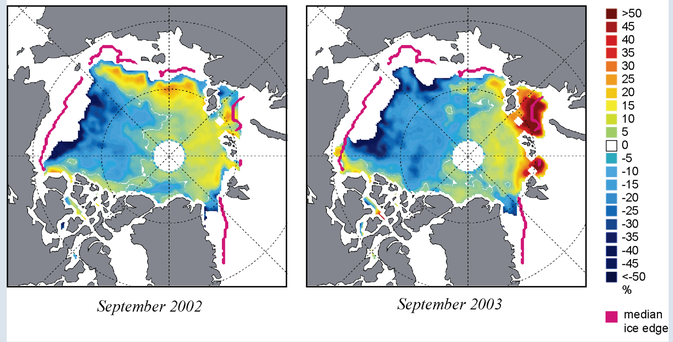
Data Set Title (Only Std. Team and NRTSI are used in Sea Ice Index)	Time Period	Source of Tbs	Sea Ice Algorithm	Correction for Land Contamination; Weather Filter
Sea Ice Concentrations from Nimbus-7 SSMR and DMSP SSM/I Passive Microwave Data (GSFC)	10/1978 - 12/2000	RSS	Modified NASA Team	Yes; Yes - special
DMSP SSM/I Daily and Monthly Polar Gridded Sea Ice Concentrations (Standard Team)	7/1987 - 6/2002 (ongoing)	RSS	NASA Team	No; Yes - standard
Near Real-Time DMSP SSM/I Daily Polar Gridded Sea Ice Concentrations (NRTSI)	Last 3 months	MSFC	NASA Team	No; Yes - standard



Products from the Sea Ice Index Web site, for April and May, 2003

Extent and Concentration Anomalies, September 2002 and 2003

The position of the ice edge in September 2003 is markedly similar to 2002. The retreat in of the ice margin in the Beaufort and Chukchi Seas is common to other low extent years. The absence of ice in the East Greenland Sea appears in the satellite data record for the first time in 2002.



These images combine two Sea Ice Index features: ice concentration anomaly images, and median ice edge position, with respect to the period 1988-2000.

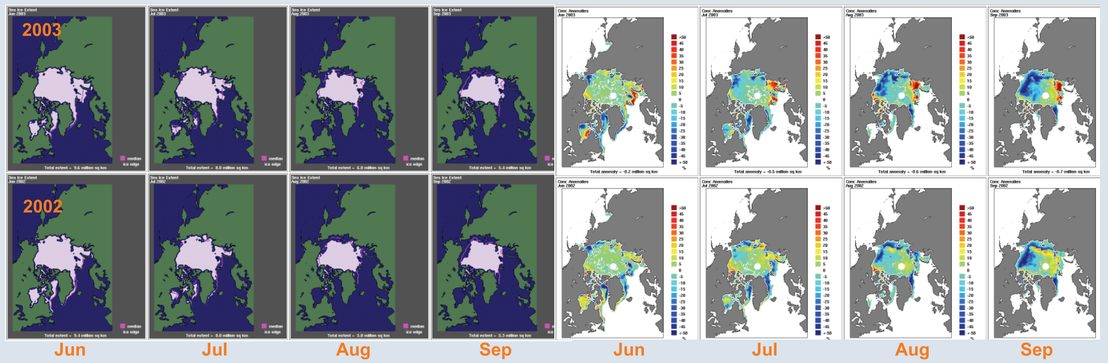
Ice Retreat, Summer 2002 and 2003

Ice Extent Anomalies

Evolution of minima both years shows ice at median extent the preceding winter and spring, but rapidly retreating in summer

Ice Concentration Anomalies

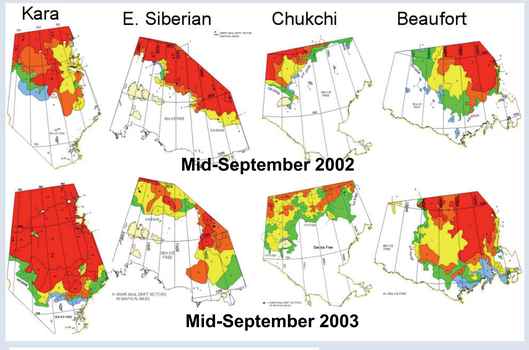
Persistent high temperatures in autumn and spring may have resulted in thinner ice, which melts out in summer leaving lower than average central Arctic concentrations



The Web Image Spreadsheet Tool allows archived images to be displayed in tabular format.

A More Diffuse Ice Edge in 2003

Passive microwave ice concentrations are biased low relative to observations made using other data sources by about 10% to 20%, with the bias being greater in summer (Partington *et al.,* submitted). Charts from the U. S. National Ice Center (NIC) reveal that passive microwave data may not detect ice concentrations as high as 60%. These limitations do not invalidate trends and anomalies derived using passive microwave data, as long as it is understood that trends in concentration may be due in part to trends in surface melt effects.



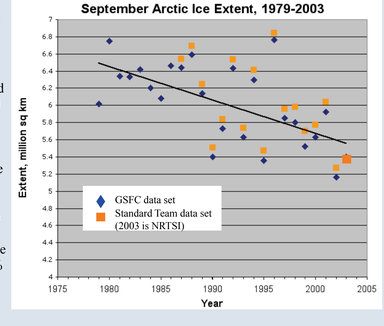
Charts from the National Ice Center (http://www.natice.noaa.gov)

NIC charts show that while the ice edge was in about the same position in Sept 2002 and Sept 2003, 2003 had a wider band of lower concentration ice within the edge for much of the Arctic. The Kara Sea was an exception, with a broad diffuse band within the edge in 2002, and a compact edge in 2003

Higher resolution passive microwave instruments will improve the accuracy of ice edge detection in the future, as illustrated by this comparison of MODIS (visible band) and AMSR (passive microwave) imagery with SSM/I.

Trend in Ice Extent

The Sea Ice Index calculates and displays trends based on a record that begins in 1987 (orange points). Here the GSFC data set is used to extend the record back to 1979. The trend is -0.39 x 10^6 km^2 per decade +- 0.256 x 10^6 km^2, at a 98% confidence interval. The trend is less negative than it will be when GSFC data are available to replace the NRTSI data point for 2003, since GSFC data are about 2% lower than NRTSI/Standard Team data.



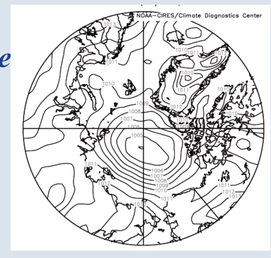
Influence of Atmospheric Circulation Patterns on 2002 and 2003 Arctic Ice Exte Minima

We attribute the 2002 ice minima to

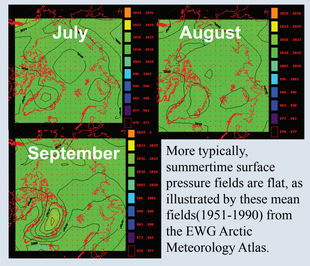
- Poleward wind anomalies in spring
- Unusually persistent cyclonic activity in summer, with ice divergence increasing positive albedo feedback and enhancing melting
- Larger than usual negative atmospheric pressure gradient across Fram Strait, inhibiting ice export into the East Greenland Sea.

The 2003 minima resulted from broadly similar conditions with the addition of unusually high temperatures in Oct-Dec 2002 (see figure). Positive temperature anomalies for the East Siberian Sea in Jan-Jun 2003 would limit further ice growth in late winter, and bring early onset of melt.

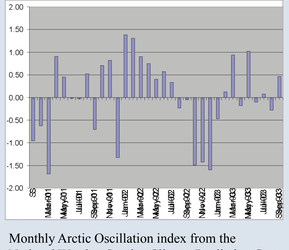
While the positive phase of the Arctic Oscillation is sometimes cited as being associated with negative pressure anomalies and positive temperature anomalies, this association was not consistently sustained in the winter, spring and summer of 2002 and 2003. For example, positive AO values in March and May 2003 were associated with high temperatures in the eastern Arctic, but the strongly negative October to December AO values occurred during a time of positive temperature anomalies over much of the Arctic.



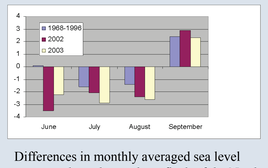
Mean sea level pressure for July-September, 2003, based on the NCEP/NCAR reanalysis. The strongly cyclonic average field implies ice divergence, opening of the pack, and increased rate of melting. Note that the circulation pattern drives ice into the Kara Sea, resulting in positive extent and concentration anomalies in this region.



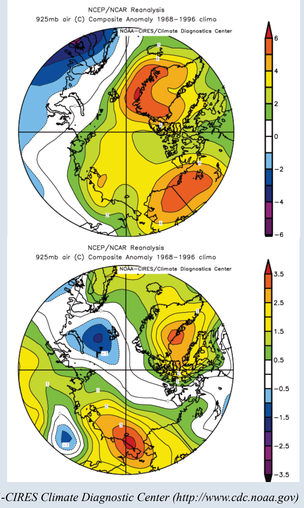
More typically, summertime surface pressure fields are flat, as illustrated by these mean fields(1951-1990) from the EWG Arctic Meteorology Atlas.



Monthly Arctic Oscillation index from the National Weather Service Climate Prediction Center.



Differences in monthly averaged sea level pressure along the northern flank of the Northeast Atlantic trough, June through September.



Mean 925 hPa temperature anomalies (w.r.t. 1968-1996) for October through December 2002 (top) and January through June 2003 (bottom), based on the NCEP/NCAR reanalysis. The positive anomalies in Oct-Dec correspond to a period with strongly negative AO.

From the NOAA-CIRES Climate Diagnostic Center (http://www.cdc.noaa.gov)

CONCLUSION The annual minimum sea ice extent edge position is strongly linked to summertime atmospheric conditions. The markedly similar ice conditions in September 2002 and 2003 resulted from similar atmospheric circulation patterns. These patterns were not associated in a consistent way with the value or sign of the Arctic Oscillation index.

References

Partington *et al.*, The late twentieth century northern hemisphere sea-ice record from US National Ice Center ice charts, submitted to the *Journal of Geophysical Research*, 2002

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Serreze, M.C., J. Maslanik, T.A. Scambos, F. Fetterer, J. Stroeve, K. Knowles, C. Fowler, S. Drobot, R. G. Barry, and T.M. Haran, A Record Minimum Arctic Sea Ice Extent and Area in 2002, *Geophys. Res. Lett.* 2003.

Acknowledgment

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