

Arctic Seasonal Sea Ice Statistics Dataset (1979–2012)

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Abstract: The change of Arctic sea ice is an indicator reflecting climate change. Based on sea ice concentration data published by the National Snow and Ice Data Center of USA (NSIDC), the arctic seasonal sea ice statistics dataset (less than 15% areas of sea ices was not included) was developed. The dataset includes: (1) Arctic seasonal sea ice statistics data in 1979–2012, including three tables in the data file: Table 1 Arctic seasonal sea ice statistic data; Table 2 Arctic seasonal sea ice anomaly statistic data; Table 3 Arctic sea ice extent and statistics of MTT (Moving t-test technique) in spring and summer. (2) Arctic regional and seasonal sea ice statistics data in 1979–2012, including statistic data of the sea ice in the eastern hemisphere, the western hemisphere, the Pacific sector and the Atlantic sector (eight tables). (3) The spatial data of sea ice concentration in Arctic in September 2007 and 2012. (4) The spatial data of Arctic seasonal sea ice concentration anomaly in 1979–1988, 1989–1998, 1999–2008 and 2009–2012. (5) Wavelet analysis data of seasonal Arctic sea ice extent. The dataset was archived in .xlsx, .shp and .dat formats with the data size of 52.9 MB.

Keywords: Arctic; sea ice concentrations; sea ice area; spatial and temporal variation; 1979–2012

1 Introduction

The Arctic Ocean is the most important cold source in the northern hemisphere, whereby the Arctic sea ice has a major and long-term effect on global atmospheric conditions and ocean circulation^[1–4]. One of the key points in global climate change studies and prediction is the availability of accurate information on changes in Arctic sea ice that make sure the response of sea ice to the global climate^[5]. The reduction of Arctic sea ice has played a significant role in the occurrence of cold winters with extreme snowfalls in North America, Europe and East Asia. In recent years, the rapid warming of the Arctic has made possible navigation of the Northwest Passage and Northeast Passage of the Arctic Ocean. In this context, the M.V. Yongsheng of the COSCO group successfully navigated the Northeast Passage in the summer of 2013, becoming

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the first Chinese merchant ship to reach Europe via the Arctic Ocean.

Sea ice has been monitored via satellites for more than 30 years since the advent of the scanning multichannel microwave radiometer (SMMR) sensor system, which has provided records since July 1978 (data area as shown in Figure 1). The National Snow and Ice Data Center of the USA changed the baseline climatological period between 1981 and 2010 (instead of 1979 and 2000); this development indicated that such a time series of sea ice observations was sufficiently long to permit analysis of the interannual variability of sea ice for the whole of the Arctic Ocean. Parkinson and Cavalieri have described the long-term sequence and trends of Arctic sea ice from 1978–1996, 1979–2006 and 1979–2008^[6–8]. In this paper, we extend the time series to 2012 and use statistical methods, wavelet analysis and mutation testing to produce seasonal Arctic sea ice statistics for the period 1979–2012.

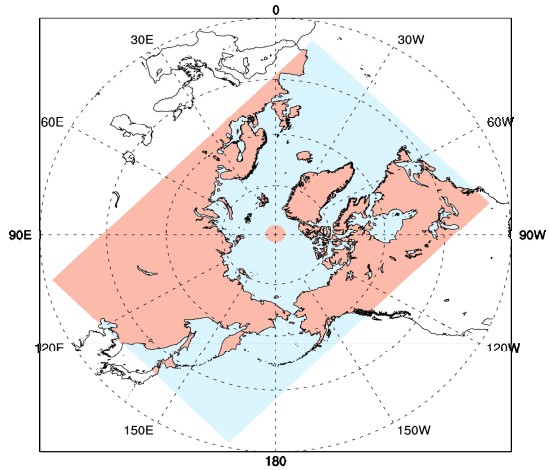


Figure 1 Area of sea ice concentration published by NSIDC (Pink color stands for land and the missing value)

2 Metadata of Dataset

The metadata of the Arctic seasonal sea ice statistical dataset^[9] is summarised in Table 1. It includes the dataset's full name, short name, authors, year of the dataset, temporal and spatial resolution, data format, data size, data files, data publisher, and data sharing policy.

3 Methods

3.1 Data Source

The sea ice concentration data used in this dataset cover January 1979–December 2012. The data are derived from brightness temperature inversions from sensors on different satellites, including the SMMR of the Nimbus-7 satellite (October 1978–August 1987), the Special Sensor Microwave Imagers (SSM/I) of the US Defense Meteorological Satellite Program F8, F11, F13 (September 1987–December 1991, January 1992–May 1995, June 1995–December 2007) and the Special Sensor Microwave Imager Sounder (SSMIS) of F17 (January 2008–December 2012).

3.2 Algorithm

The sea ice extent (SIE) is calculated by summing the areas of grids with sea ice concentration greater than 15% (Equation 1), where C_i is the sea ice concentration at grid i , A_i is the area of the grid and ω_i is the weight coefficient. The sea ice area (SIA) is the sum of the area multiplied by the density of the grid points where the density is greater than 15% (Equation 2)^[11]. Therefore, theoretically, the sea ice range is greater than the sea ice area

(because C_i is less than 1).

$$SIE = \sum_{i=1}^n \omega_i A_i \quad \begin{cases} \omega_i = 1 & C_i \geq 15\% \\ \omega_i = 0 & C_i < 15\% \end{cases} \quad (1)$$

$$SIE = \sum_{i=1}^n \omega_i C_i A_i \quad \begin{cases} \omega_i = 1 & C_i \geq 15\% \\ \omega_i = 0 & C_i < 15\% \end{cases} \quad (2)$$

Table 1 Metadata summary of the ArcticSeasonalSeaIce1979_2012

Items	Description
Dataset full name	Arctic seasonal sea ice statistics dataset (1979–2012)
Dataset short name	ArcticSeasonalSeaIce1979_2012
Authors	Sui, C. J. K-8793-2017, National Marine Environmental Forecasting Center, suicj@nmefc.gov.cn Zhang, Z. H. D-8383-2018, State Oceanic Administration, P. R. China, zhangzhanhai@pric.org.cn Wu, H. D. D-8409-2018, National Marine Environmental Forecasting Center, wuhuid-ing@pric.org.cn Li, Y. V-8491-2017, National Marine Environmental Forecasting Center, liyi@nmefc.gov.cn
Geographic region	Arctic domain
Year	1979–2012
Temporal resolution	Monthly
	Spatial resolution 25 km
Data format	.xlsx, .dat, .shp
	Data size 52.9 MB (zipped)
Data files	The dataset includes: (1) Arctic seasonal sea ice statistics data (1979–2012); (2) Arctic regional and seasonal sea ice statistics data (1979–2012), including statistic data of the sea ice in the eastern hemisphere, the western hemisphere, the Pacific sector and the Atlantic sector. (3) The spatial data of sea ice concentration in Arctic in September 2007 and 2012. (4) The spatial data of Arctic seasonal sea ice concentration anomaly in 1979–1988, 1989–1998, 1999–2008, and 2009–2012. (5) Wavelet analysis data of seasonal Arctic sea ice extent
Foundation(s)	National Natural Science Foundation of China (41106165, 41106159); State Oceanic Administration of P. R. China (CHINARE2014-04-04)
Data publisher	Global Change Research Data Publishing & Repository, http://www.geodoi.ac.cn
Address	No. 11A, Datun Road, Chaoyang District, Beijing 100101, China
Data sharing policy	Data from the Global Change Research Data Publishing & Repository includes metadata, datasets (data products), and publications (in this case, in the <i>Journal of Global Change Data & Discovery</i>). Data sharing policy includes: (1) Data are openly available and can be free downloaded via the Internet; (2) End users are encouraged to use Data subject to citation; (3) Users, who are by definition also value-added service providers, are welcome to redistribute Data subject to written permission from the GCdataPR Editorial Office and the issuance of a Data redistribution license; and (4) If Data are used to compile new datasets, the ‘ten per cent principal’ should be followed such that Data records utilized should not surpass 10% of the new dataset contents, while sources should be clearly noted in suitable places in the new dataset ^[10]

Table 2 Data source statistics

Satellite	Sensor	Period	Spatial resolution	Data type	Data size
Nimbus-7	SMMR	1978.10–1987.08	25 km	Binary	13.9 MB
DMSP-F8	SSMI	1987.09–1991.12	25 km	Binary	6.76 MB
DMSP-F11	SSMI	1992.01–1995.05	25 km	Binary	5.33 MB
DMSP-F13	SSMI	1995.06–2007.12	25 km	Binary	21.2 MB
DMSP-F17	SSMIS	2008.01–2012.12	25 km	Binary	7.8 MB

3.3 Procedure

The reduction of sea ice shows different features at different locations. For calculation of the sea ice range, the whole region is subdivided into the eastern hemisphere (0°–180°E), the western hemisphere (0°–180°W), the Pacific sector (120°E–120°W) and the Atlantic sector (60°W–60°E). The data are also subdivided by season given that there is a strong seasonality in sea ice variation. In addition, the baseline climatological data is defined as the average for 1981–2010, and the anomaly field is calculated by subtracting the climatology from the original field.

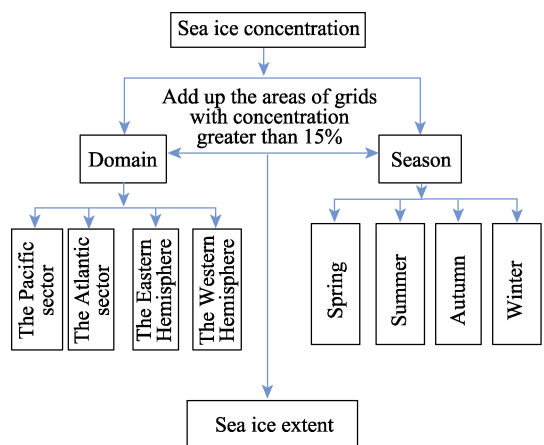


Figure 2 Procedure of developing the extent of sea ice in the Arctic Ocean

4 Results and Validation

The ArcticSeasonalSeaIce1979_2012 includes: (1) Arctic seasonal sea ice statistics data in 1979–2012, including three tables in the data file: Table 1 Arctic seasonal sea ice statistic data; Table 2 Arctic seasonal sea ice anomaly statistic data; Table 3 Arctic sea ice extent and statistics of MTT (Moving t-test technique) in spring and summer. (2) Arctic regional and seasonal sea ice statistics data 1979–2012, including statistic data of the sea ice in the eastern hemisphere, the western hemisphere, the Pacific sector and the Atlantic sector (eight tables). (3) The spatial data of sea ice concentration in Arctic in September 2007 and 2012. (4) The spatial data of Arctic seasonal sea ice concentration anomaly in 1979–1988, 1989–1998, 1999–2008 and 2009–2012. (5) Wavelet analysis data of seasonal Arctic sea ice extent. The dataset are archived in .xlsx, .shp and .dat formats with the data size of 52.9 MB.

Figure 3 shows the anomaly of Arctic sea ice extent in different seasons. The results show that the dataset is consistent with the observation.

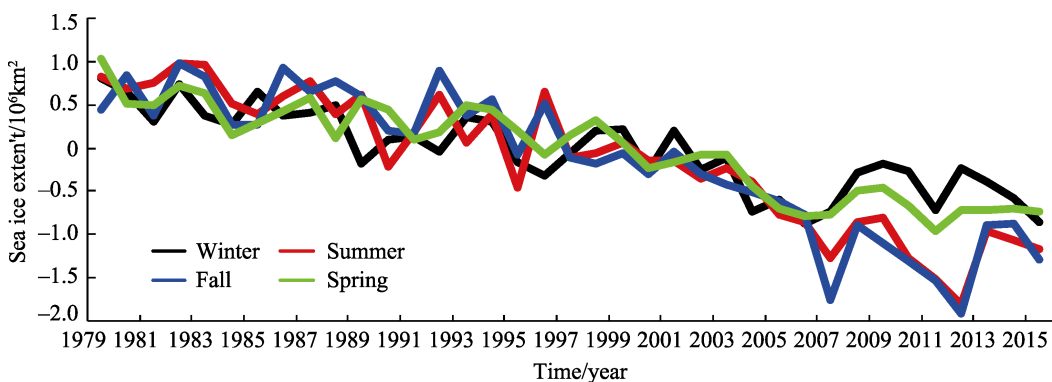


Figure 3 Time series for the anomaly of Arctic sea ice extent in different seasons^[12]

5 Discussion and Conclusion

An increasing climatic effect is revealed which shows a rapid reduction in Arctic sea ice production. Three criteria are often used to characterize the reduction in sea ice, that is, the sea ice extent (SIE), the thickness of the sea ice and the age of the sea ice. Among these, the SIE is the most accurate physical quantity available from the standpoint of describing the spatial and temporal coverage. Thus, the SIE is the preferred criterion for studies concerning the reduction of Arctic sea ice. The data has been subdivided into 4 regions, that is, the Eastern Hemisphere, the Western Hemisphere, the Pacific sector and the Atlantic sector, and into the four seasons due to the spatial and seasonal variability of sea ice melting. It is noteworthy that the growth rate of sea ice has been slowing down in the growth period in recent years. For instance, a minimum monthly sea ice range for October was observed in 2016. So it is timely to undertake a follow-up study to update the time series.

Author Contributions

Sui, C. J. designed algorithm of developing the dataset; Li, Y., *et al.* processed and validated the data; Sui, C. J, Li, Y. and Li, K. finished the paper.

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