

# **Long-term tendencies of sea ice concentration and air temperature in the Okhotsk Sea coast of Hokkaido**

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The Okhotsk Sea Coast of Hokkaido is located between 43°50'N and 45°30'N, and is covered with sea ice in winter season. These latitudes are the lowest among seas which are frozen in winter, except the very shallow Bohai Sea filled with much fresher water. The period when the coastal region is ice covered has been decreasing during recent years.

Long-term observations of sea ice coverage are rare, but along the Okhotsk Coast of Hokkaido, the Abashiri Weather Station of Hokkaido started sea ice observation in 1892. The Abashiri District Meteorological Observatory took over this observation later, and it is still continuing. This is one of the longest records of sea ice observation. Using these data, we discuss the long-term trend of the sea ice coverage of the Okhotsk Sea Coast of Hokkaido and its relation to the yearly mean air temperature.

## **Data and definition of accumulated ice concentration**

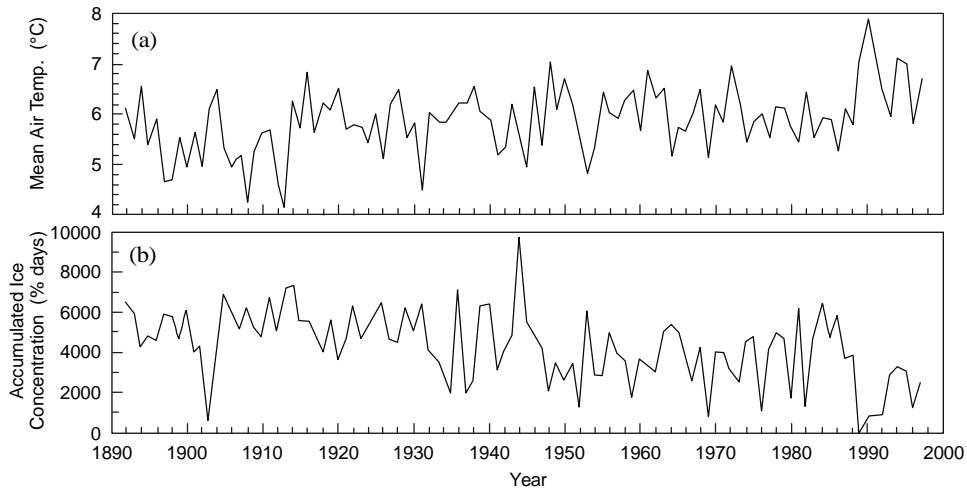
The visual sea ice observations have been made from top of a coastal hill (approximately 40 m high). The observable radius is about 20 km. In the early period from 1892 to 1929, only the day of first appearance of sea ice and that of the last day are available. We call this the period from the day of the first appearance to the last day the sea ice period. Daily data on sea ice concentration are available after 1930. The first appearance of sea ice along the Okhotsk Coast of Hokkaido is in late January or in February. The ice disappears usually in late March, but it may stay until May in some years. The sea ice

concentration is defined as the area of ice cover within the range of observation, in percent.

Characteristics of the sea ice are represented both by the sea ice extent or the sea ice concentration and by the duration of ice stay. For the years after 1930, the daily value of sea ice concentration (%) is summed for the period of ice cover in each year, and this accumulated sea ice concentration (%-days) is used as a measure of annual sea ice strength. The correlation between the obtained accumulated concentration and the sea ice period were examined for the period after 1930, and we found a good correlation with a coefficient of about 0.8 ( $n=68$ ). For the period before 1929, we estimated the accumulated concentration from the observed sea ice period, by using the regression line of the correlation plots, and used this result in our analysis.

## **Interannual variation of the accumulated sea ice concentration and the mean air temperature**

The mean air temperature averaged over the period from April in the preceding year to March are calculated for each year, and its temporal variation is shown (Fig. 1a) for the period from 1892 to 1998. The corresponding temporal variation of the accumulated sea ice concentration is also shown (Fig. 1b). Though relatively short-period fluctuations are dominant in both curves, the linear trends of the variation can be recognized in both curves. The mean air temperature tends to increase for the analyzed period, while the accumulated sea ice concentration to decrease.



**Fig. 1** Variations of the yearly mean air temperature (a: upper panel) and the accumulated sea ice concentration (b: lower panel) at Abashiri, Hokkaido.

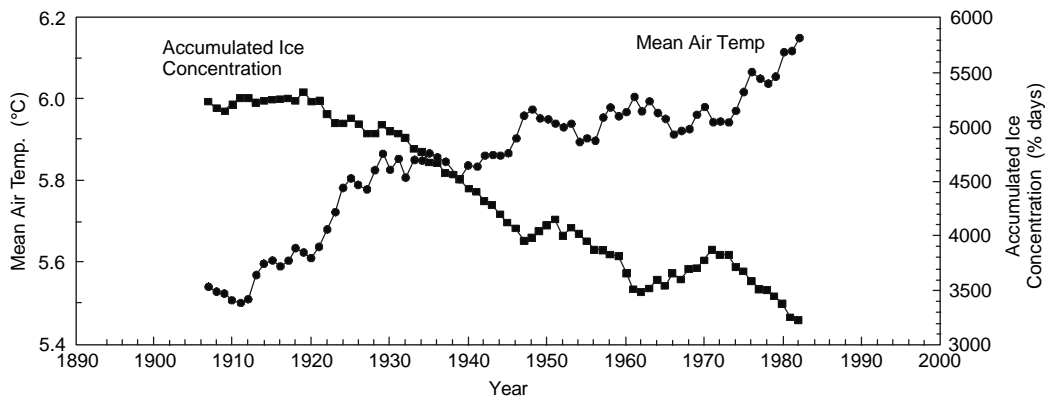
**Long-term tendencies of accumulated sea ice concentration and mean air temperature**

Thirty year running averages of the yearly values of the accumulated sea ice concentration were calculated, and the obtained smoothed temporal variations are shown (Fig. 2). The smoothed air temperature (black circles in Fig. 2) exhibits a clear increasing tendency, and the amount of temperature increase during the past 106 years is about 0.6°C. On the other hand, the smoothed accumulated sea ice concentration (black squares in Fig. 2) tends to decrease during the analyzed period, and the sea ice

concentration in 1980 is only 60% of that in 1920s.

**Conclusion**

The clear decreasing tendency of the sea ice amount along the Okhotsk Coast of Hokkaido during the past 106 years can be shown from the ice concentration record taken at Abashiri, Hokkaido. The long-term variation of the sea ice concentration is well correlated with that of the yearly mean air temperature, which exhibits the clear increasing tendency during the same period. This would be one of the symptoms of the global warming, and is a warning to human beings!



**Fig. 2** Thirty year running averages of the yearly mean air temperature (●) and accumulated ice concentration (■) at Abashiri, Hokkaido.