

Time series of Drake Passage Oscillation Index (DPOI) from 1952 to 2003, Antarctica

Mikio NAGANOBU (NRIFS) and Kunio KUTSUWADA (Tokai Univ.)

1. Introduction An assessment of the environmental processes influencing variability in the recruitment and density of Antarctic krill (*Euphausia superba* DANA) is important as variability in krill stocks affects the Antarctic marine ecosystem as a whole. Naganobu et al. (1999) had assessed variability in krill recruitment and density with hypothesized environmental factors; strength of westerly winds (westerlies) determined from sea-level pressure differences across the Drake Passage, between Rio Gallegos (51° 32'S, 69° 17'W), Argentina, and Base Esperanza (63° 24'S, 56° 59'W), at the tip of the Antarctic Peninsula, sea ice cover and chlorophyll-a in the Antarctic Peninsula area during 1982-1998. They found significant correlations between krill recruitment and those factors. The westerlies were especially regarded as a key environmental index. Fluctuations in the westerlies across the Drake Passage were referred to as the Drake Passage Oscillation Index (DPOI).

2. Data We planned to extend time series of DPOI using historical data. Naganobu et al. had used the time series of the World Surface Meteorological Database (WSMD), Japan Meteorological Agency, from 1982 to 1998. The third assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2001) reviewed DPOI as a factor of physical impacts on biology of the Antarctic Ocean and took interest in its variability in the future. Although the new data are added to WSMD, no historical data exist in the database before 1982. We searched the historical data and found the time series since the 1950s until 1988 at the Web sites of the Carbon Dioxide Information Analysis Center (CDIAC, 2002) for Rio Gallegos and since the 1940s until 1998 at British Antarctic Survey (BAS, 2002) for Esperanza. We combined the WSMD and CDIAC/BAS dataset. Here we calculated a time series of DPOI from January 1952 to May 2003 at this stage. Time series since June 2003 will be processed additionally after obtaining new data.

3. Results A time series of DPOI monthly mean from 1952 to 2003 was calculated. The total number of monthly data used from May 1952 to May 2003 was 613. The mean, median, and mode were 14.2, 14.2, and 13.0 hPa, respectively. The maximum, minimum, and range were 30.3, -5.9, and 36.2 hPa, respectively. The standard deviation was 4.1 hPa. A time series of 3-month running mean suggested considerable seasonal variability of climate. A time series of 12-month running mean indicated various year-to-year changes other than seasonal variability (Figure 1). High DPOI periods, not less than 15 hPa, were observed in most of the period before 1964 and only in 1973 and after 1985. Low DPOI periods, less than 15 hPa, persisted for two decades after 1964. Event of extremely low DPOI less than 12 hPa appeared in 1967, 1972, 1980, 1989 and 2000. Time intervals between these low DPOI events are approximately 4 years.

References
 BAS, 2002: Sea level pressure data at Esperanza used in this study are available at the Web site for the British Antarctic Survey, <http://www.antarctica.ac.uk/met/gjma/>
 CDIAC, 2002: Sea level pressure data at Rio Gallegos used in this study are available at the Web site for the Carbon Dioxide Information Analysis Center, <http://cdiac.esd.ornl.gov/>
 IPCC, 2001: Climate Change 2001: Impacts, Adaptation, and Vulnerability. Cambridge University Press, 1032pp.
 Japan Meteorological Agency, 2003: World surface meteorological database (1982-2003).
 Naganobu, M., K. Kutsuwada, Y. Sasai, S. Taguchi and V. Siegel, 1999: Relationships between Antarctic krill (*Euphausia superba*) variability and westerly fluctuations and ozone depletion in the Antarctic Peninsula area. *Journal of Geophysical Research*, 104, C9, 20,651-20,665.
 Naganobu, M. and K. Kutsuwada, 2002: Short note: Time series of Drake Passage Oscillation Index (DPOI) from 1952 to 1988. *WG-EMM-02/44*.

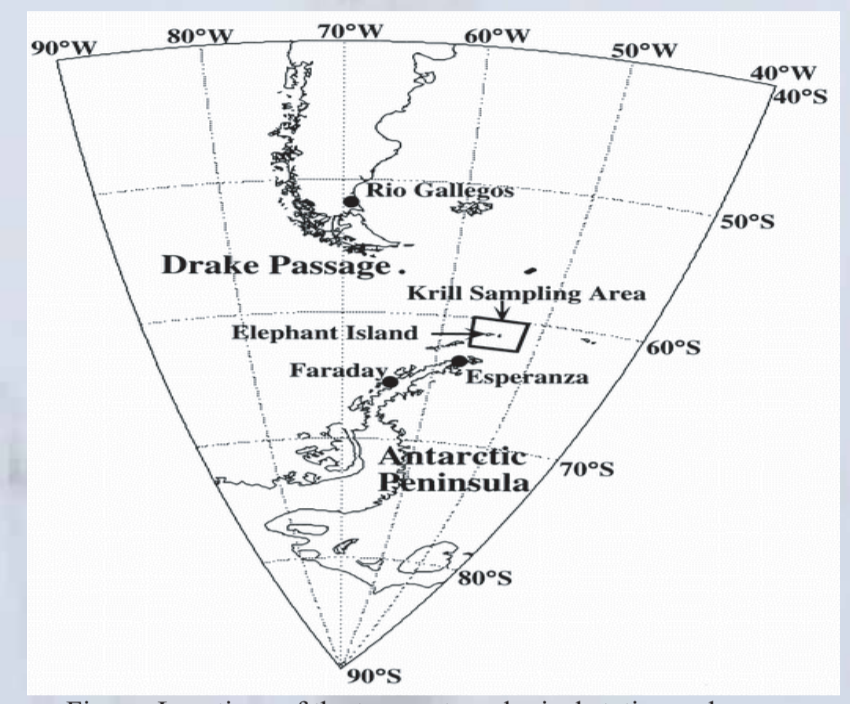
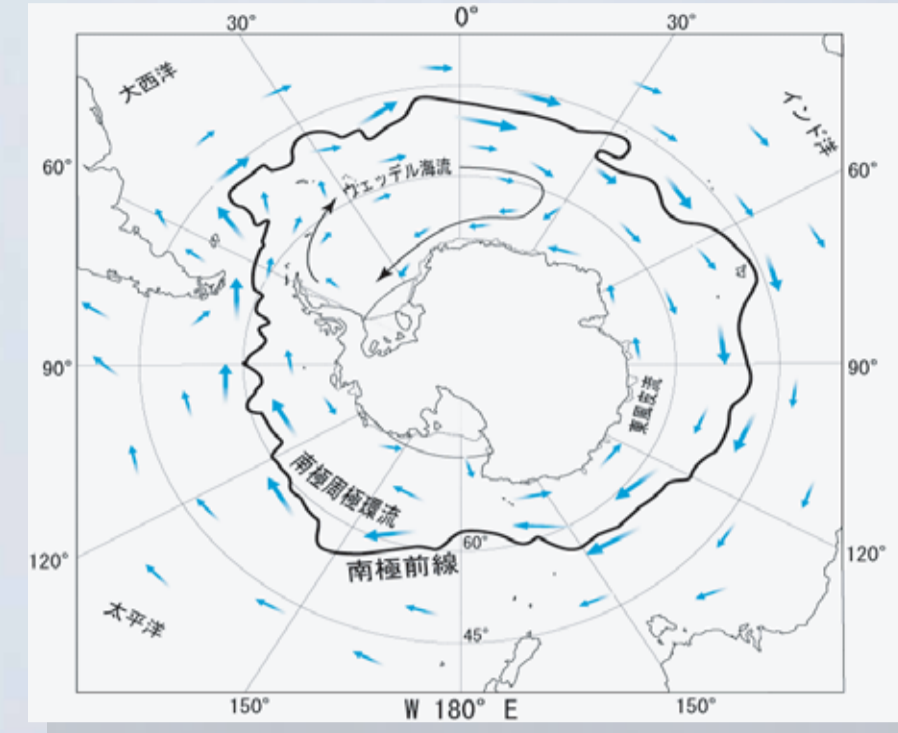
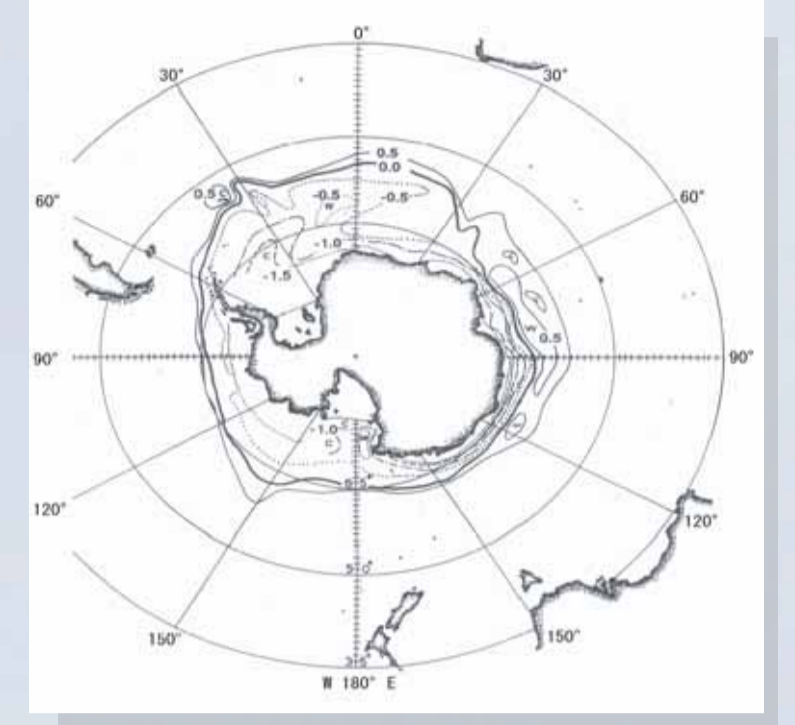


Figure. Locations of the two meteorological stations where sea level pressure data were sampled: Rio Gallegos (518329S, 698179W) and Esperanza (638249S, 568599W). Fluctuations of westerly winds were indicated by the time series of data on sea level pressure differences between both stations across the Drake Passage. Instrumental ozone value data were obtained at Faraday (renamed Vernadsky in 1996) Station (648259S, 648529W). Krill sampling area, shown by the square, was located in the vicinity of Elephant Island, between 608S to 628309S and 528W, 578309W.

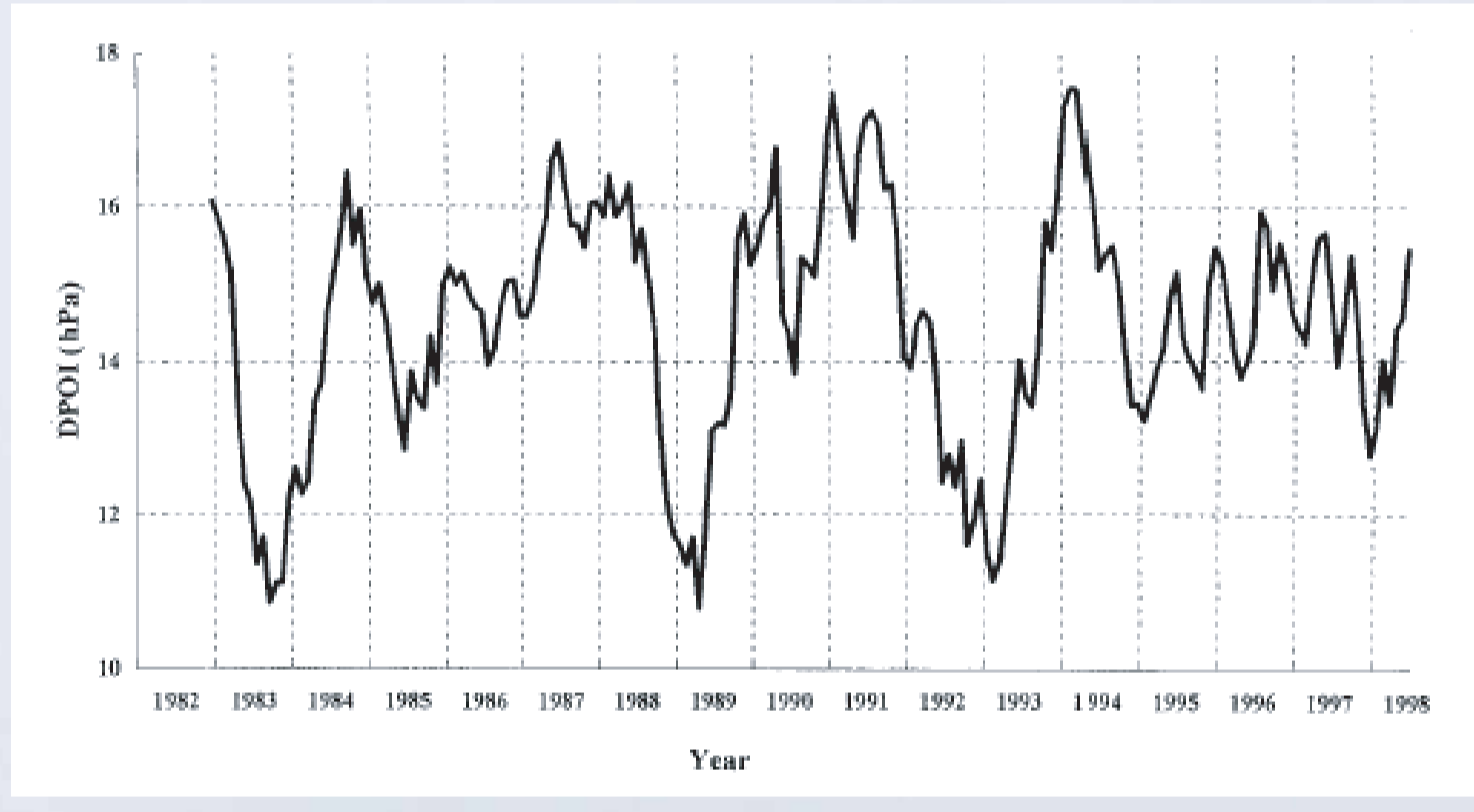
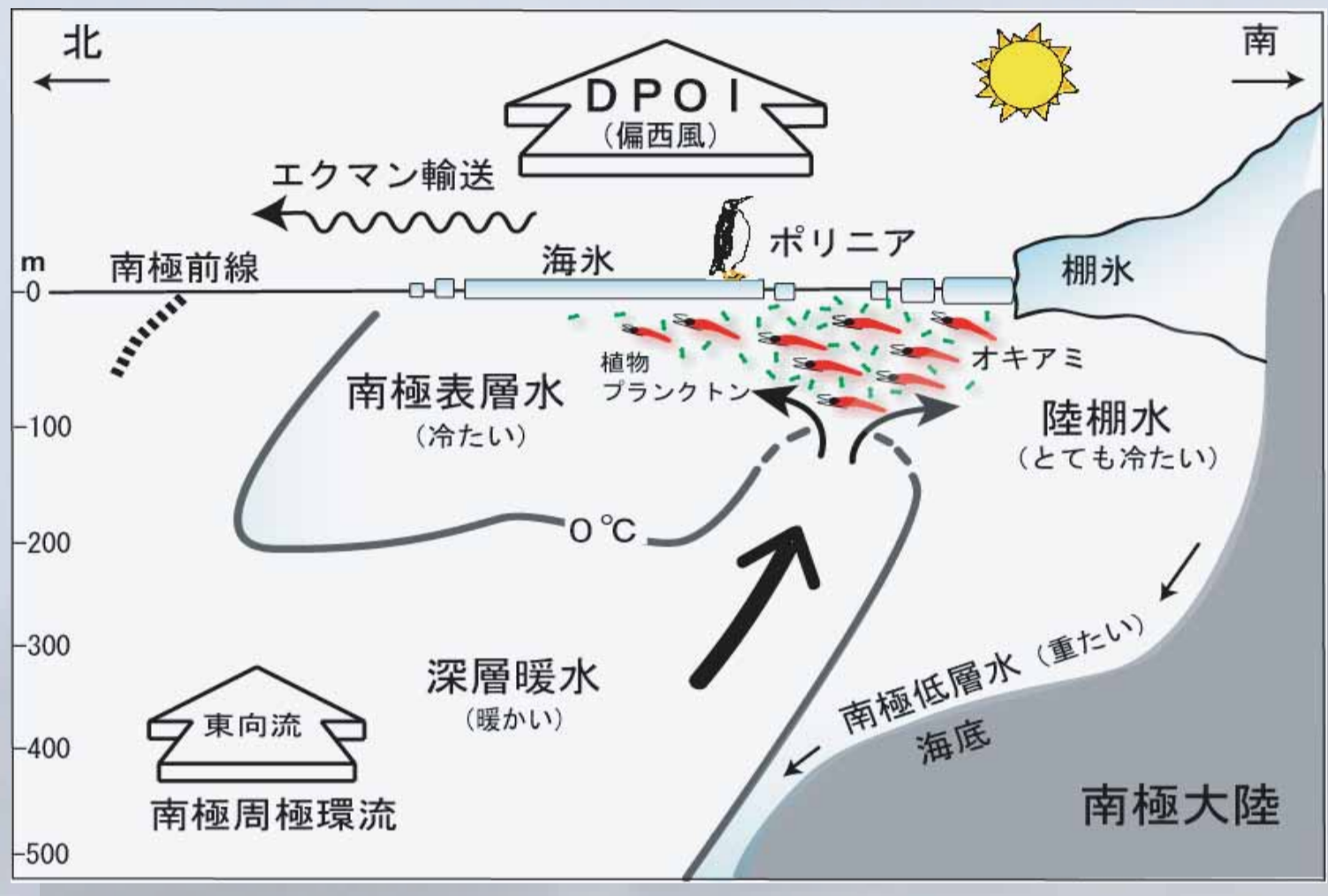


Figure. Time series of DPOI, 12-month running mean from 1982 to 1998.

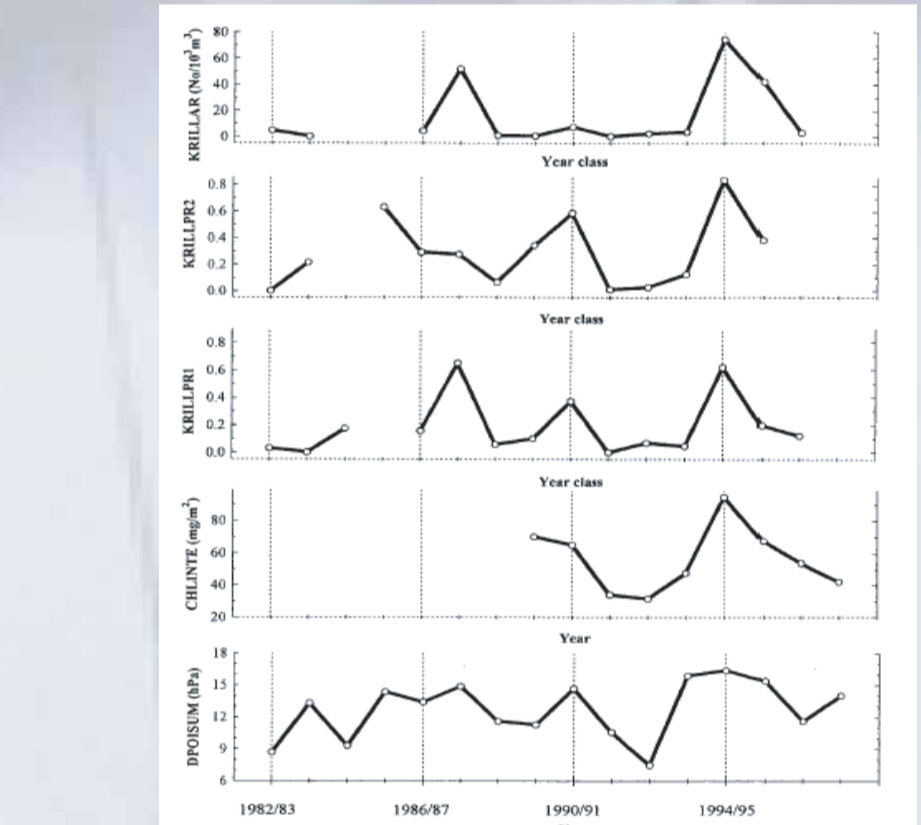


Figure. Comparison between line graphs of the summer DPOI (DPOISUM), integrated chlorophyll concentrations (CHLINT), krill recruitment R1 (KRILLPR1), R2 (KRILLPR2), and R3 (KRILLAR). DPOISUM and CHLINT are based on years. KRILLPR1, KRILLPR2, and KRILLAR are based on year classes.

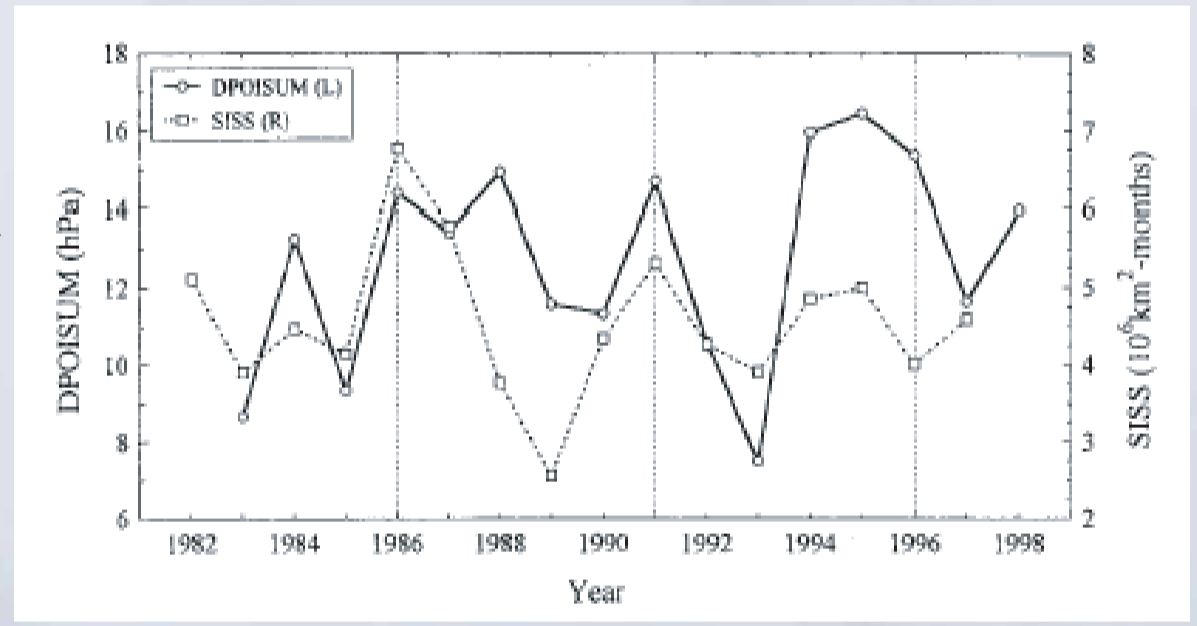


Figure. Comparison between DPOI mean during December-February in summer (DPOISUM) and SISS during 1982-1997.

	DPOISUM	CHLINT	KRILLPR1	KRILLPR2	KRILLAR	KRILLDEN
DPOISUM	1.00					
CHLINT	0.63	1.00				
KRILLPR1	0.57	0.84	1.00			
KRILLPR2	0.69	0.95	0.77	1.00		
KRILLAR	0.60	0.78	0.81	0.71	1.00	
KRILLDEN	0.029	0.023	0.001	0.006	0.31	1.00
	N = 14	N = 9	N = 15	N = 12	N = 14	N = 16
	p = 0.465	p = 0.698	p = 0.960	p = 0.761	p = 0.287	

Abbreviations are defined as follows: DPOISUM, the mean DPOI from December to February of the following year in austral summer; CHLINT, the integrated chlorophyll a concentrations from 0 to 100 m over the entire U.S. AMLR survey area; KRILLPR1, proportional recruitment of 1-year-old krill (R₁); KRILLPR2, proportional recruitment of 2-year-old krill (R₂); KRILLAR, absolute recruitment of krill; and KRILLDEN, krill density. Values denote the correlation coefficient, effective number of data (N) and probability (p). Pearson's product moment correlation coefficient was used.

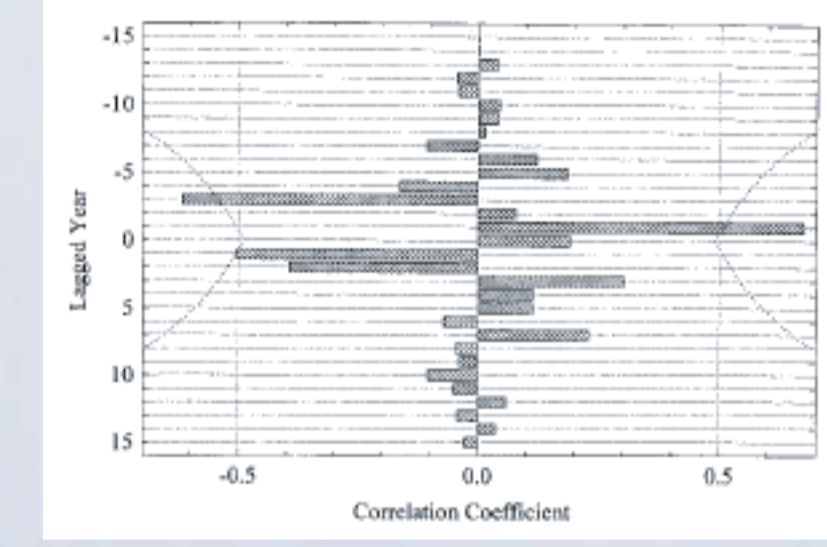


Figure. Lagged cross correlation between DPOI mean during June-October in winter (DPOIWIN) and yearly sea ice cover index for the South Shetland area (SISS). Fixed function was DPOIWIN; lagged function was SISS. Dotted curves indicate 95% confidence limits.

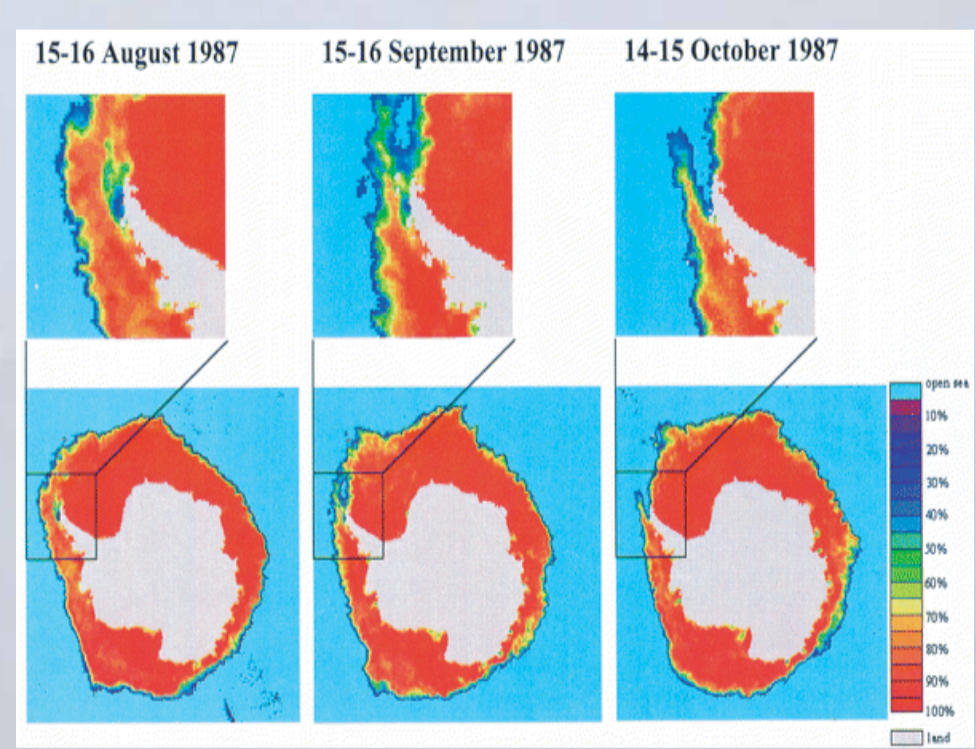


Plate a. Typical cases showing low density of sea ice concentrations and/or coastal polynyas with a wide sea ice extent off the northern Antarctic Peninsula in August, September, and October 1987 with strong westerlies. The strong westerlies lead to a high development of Winter Water and a large extent of sea ice through the strong Ekman transport. There was a low-density area of sea ice on the coast of the Antarctic Peninsula in August. In September, polynyas appeared in the vicinity of the South Orkney Islands, and then open sea spread on the northern coast of the peninsula earlier than in the offshore regions during October. 20,655 NAGANOBU ET AL.: ANTARCTIC ENVIRONMENT AND KRILL VARIABILITY

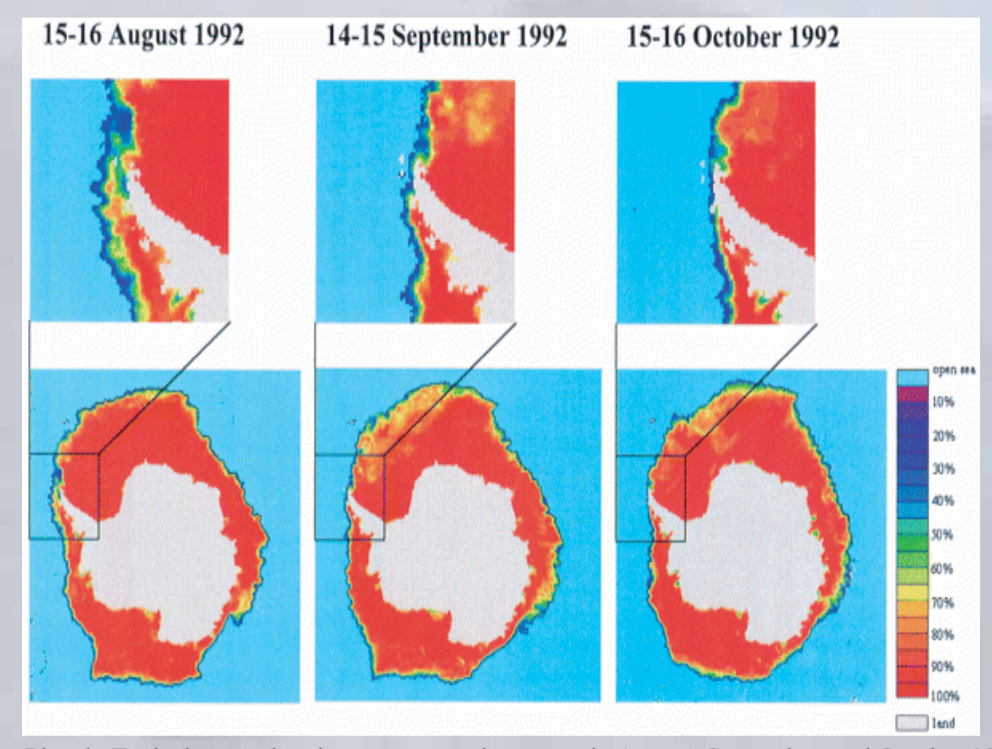


Plate b. Typical cases showing narrow sea ice extent in August, September, and October 1992 with weak westerlies. The weak westerlies merely lead to a low development of Winter Water and low extent of sea ice. Sea ice was scarce off the tip of the Antarctic Peninsula compared with 1987, with its strong westerlies, as shown in Plate a.

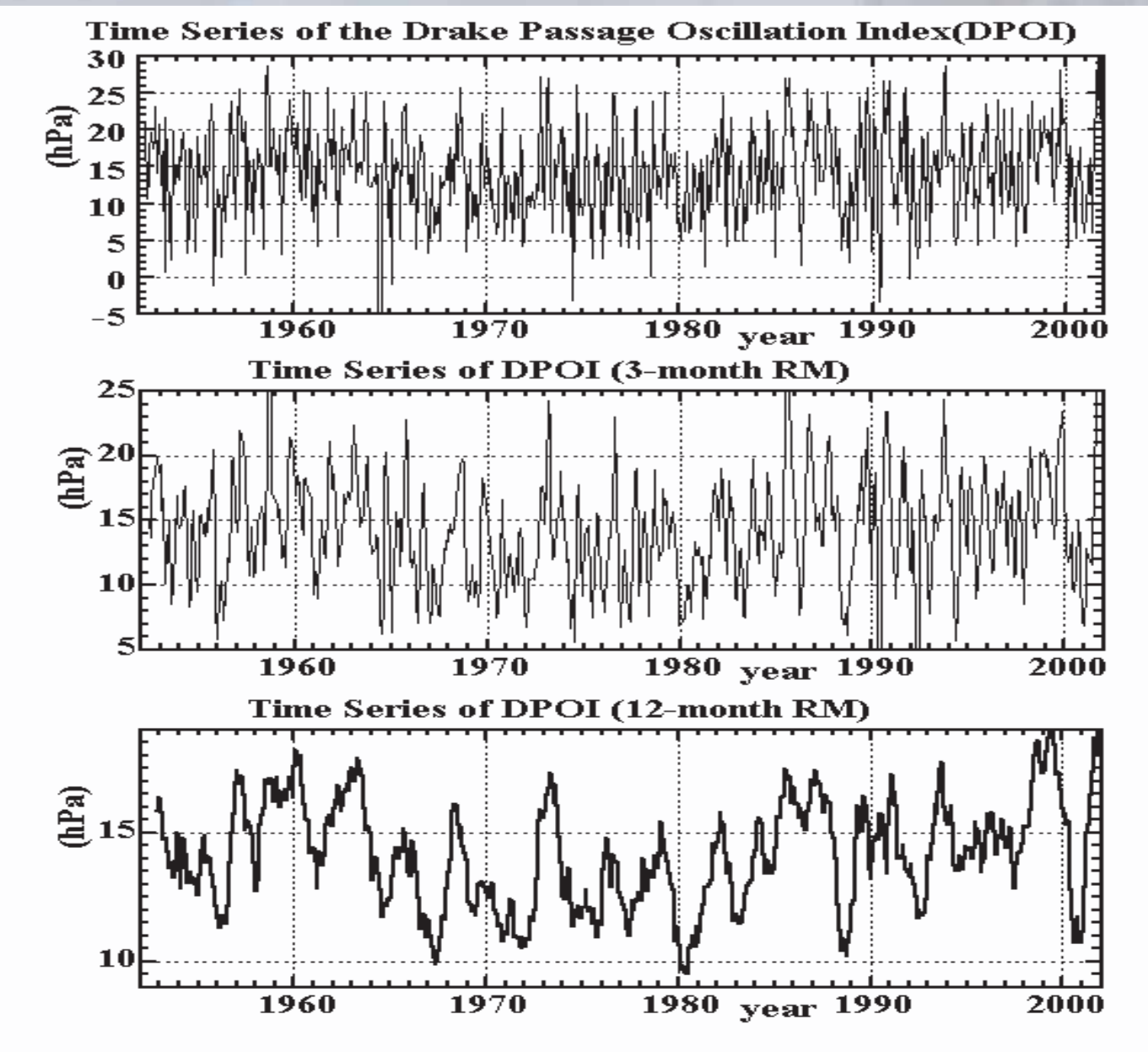


Figure. Time series of Drake Passage Oscillation Index (DPOI) which are defined as the sea level pressure differences between Rio Gallegos and Esperanza during 1952-2003: (top) monthly mean, (middle) 3-month running mean, and (bottom) 12-month running mean.

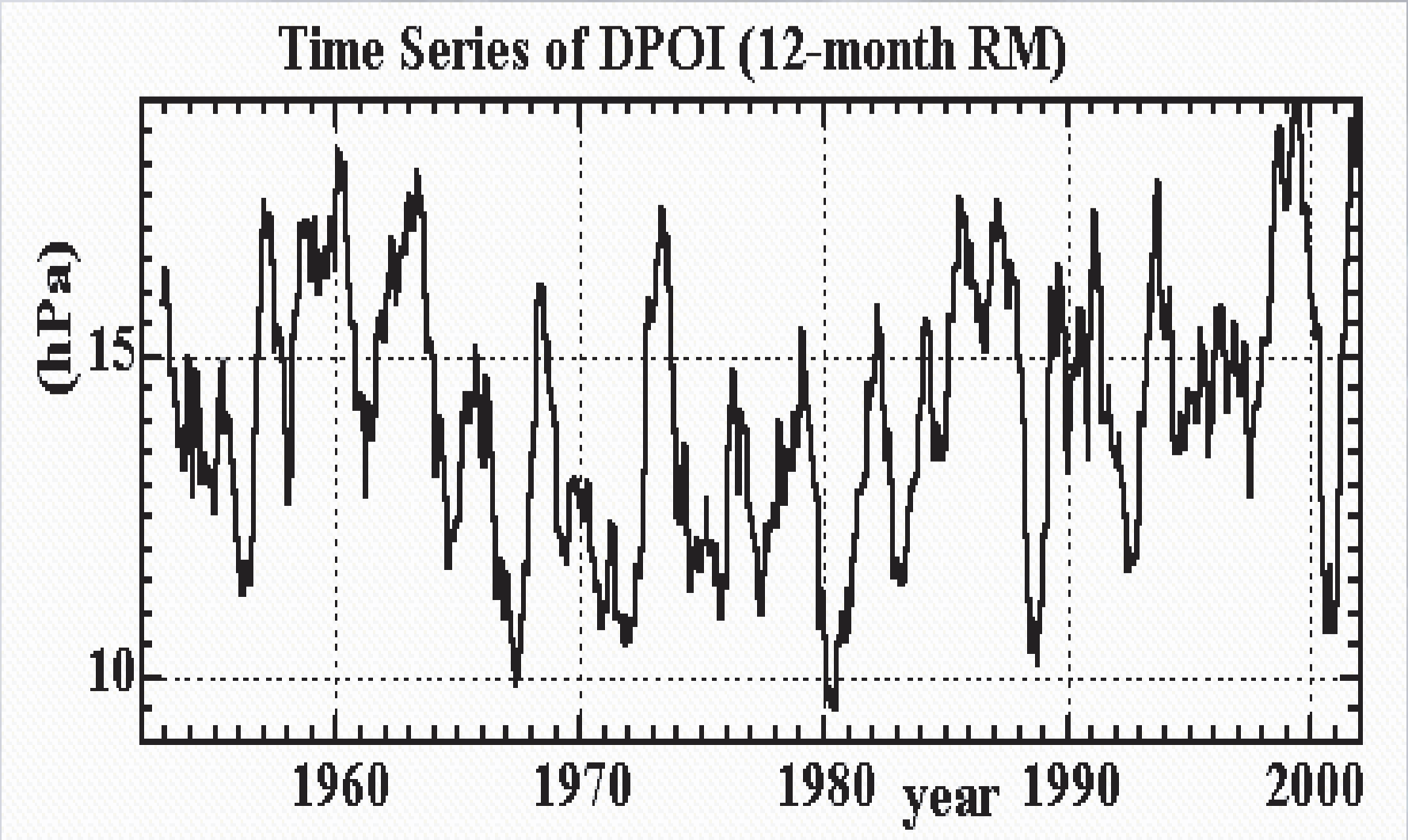


Figure. Time series of Drake Passage Oscillation Index (DPOI) which are defined as the sea level pressure differences between Rio Gallegos and Esperanza during 1952-2003.

