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Antarctic Ocean Polynyas

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Satellite Passive Microwave Sea Ice Observations and Oceanic Processes in the Ross Sea, Antarctica

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Sea ice distribution in the Ross Sea is influenced by the ocean circulation, atmospheric forcing and sea floor topography. In this paper we investigate the spatial and temporal variability of sea ice concentrations derived from Nimbus-7 Scanning Multichannel Microwave Radiometer (SMMR) brightness temperatures. Our emphasis is upon the continental shelf region during 1984, when supporting data were obtained from oceanographic stations and moored instruments. A residual summer sea ice field common to the NE Ross Sea drifts slowly WNW and acts as an accretion center for new growth in autumn, including southward advance across the continental shelf. Ice concentrations are lower above the shelf than above the adjacent deep ocean throughout the year. The lowest concentrations are on the west-central shelf due to the persistent SSW winds in that sector, and result in the highest-salinity shelf water in the Antarctic. The low SMMR resolution can result in significant boundary problems, but ice concentrations average near 86% on the shelf during winter, with little month-to-month or interannual variability. Low ice concentration features can be tracked for several months within the winter pack. Migratory cyclones from lower latitudes cause a temporary decreases in regional sea ice cover, but may result in a net decrease in the rate of ice production. Two polynyas are identified near the continental shelf break, where they are maintained by upwelling of warmer water above the slope front and divergence above topographic highs near the shelf edge. That upwelling occurs year-round, providing sensible heat to polynyas over the continental shelf. The large spring polynya in the western Ross Sea leads to a longer period of summer insolation, greater surface layer heat storage there and later autumn ice formation. Ice concentrations on the shelf, total ice extent, and subsurface ocean temperatures along the ice shelf all lag southern Ross Sea air temperatures by 1-2 months. A change in the circulation of high-salinity shelf water during August 1984 was reflected in the overlying sea ice field and may relate to a seasonal shift in the rate of deep ocean ventilation.

SMMR Observations of the Sea Ice Regime in the Ross Sea, 1979-1985

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Sea ice concentrations derived from the Nimbus-7 Scanning Multichannel Microwave Radiometer (SMMR) can be related to the sea floor topography, ocean circulation and atmospheric forcing. In the Ross Sea, ice concentrations are lower year-round over the continental shelf than above the adjacent deep ocean. The lowest concentrations appear on the west-central shelf, where persistent SSW winds move the sea ice away from the coastline and result in the highest-salinity shelf water in the Antarctic. There is little monthly or interannual variability in the average 86% ice concentration over the shelf during the 7-8 month winter period when that region is south of the marginal ice zone. There is considerable variability in summer, with early open water in spring followed by greater heating and insolation of the surface layer and later ice formation in autumn. In terms of ice cover, that ocean heat storage resulted in an austral summer that was more than a month longer in 1979-80 than in 1984-85 (Fig. 1).

Stationary regions of relatively lower ice concentration occur intermittently within the winter ice pack at locations remote from continental boundaries. These features are attributed to quasi-permanent upwelling and divergence along portions of the continental shelf break and near topographic highs on the shelf. Temperature records from long-term current meter moorings show that warmer water upwells onto the continental shelf year-round, providing a potential source of sensible heat for shelf polynyas. One of the offshore regions of lower ice concentration, which we refer to as the Pennell Polynya, is associated with the shallowest (~250m) submarine bank in the Ross Sea. Closer to the coast and probably driven in part by barrier winds in the northwest Ross Sea is another area of lower ice concentration which we call the Admiralty Polynya. This shelf-break polynya, is characterized by open water in early spring and late autumn and an ice cover that can drop to 70% during winter. A temperature section through this region (Fig. 2) suggests that the ocean plays a primary role in the maintenance of the Admiralty Polynya, by means of the warmer deep water that upwells into the surface layer.

Migratory cyclones produce regionally-lower ice concentrations for periods of several days, but probably result in an overall net decrease in ice production. The potential for enhanced ice formation due to the greater ocean exposure is roughly balanced by the accompanying rise in air temperatures, along with deeper mixing and release of sensible heat from below the surface layer. Current velocities at 200-500 m depths on the shelf increased during the passage of a major winter storm in June, 1984. Other mesoscale low ice concentration areas moving with or through the ice pack can be tracked for periods of several months on the SMMR 2-day average images. Assuming that storm-induced weaknesses in the ice cover would heal in a few weeks time, those features may indicate the presence of eddies within the mean ocean flow. Ice concentration maxima northeast tinental shelf drifted slowly to the northwest in February and 4, and may also owe their coherence to mesoscale ocean eddies. ıal summer sea ice field becomes an accretion center for autumn , which occurs both at the margins and in the interior of the ice

ature cycles along the southern periphery of the Ross Sea, as y Automatic Weather Stations, lead sea ice extent in the Ross l-2 months (Fig. 3). There are suggestions of correlations between temperatures and higher ice concentrations. The seasonal change ce ocean temperature along the ice shelf front also lags air by 1-2 months, and has an amplitude of about 0.3°C, or 10% of 1 range between the freezing point and and the large Circumpolar r reservoir. A change in the mean direction of flow was recorded current meter mooring sites in August, 1984, in association with a ower ice concentration. This may have signified an adjustment to mohaline forcing that resulted in a temporary change in the rate ean ventilation near the shelf break.

the relatively low resolution of the gridded SMMR data, boundary ın lead to significant errors in the estimation of sea ice n in small study areas (Fig. 4). In addition, ice shelves advance along half of the Antarctic coastline, which is thus rarely in available maps. This complicates the investigation of narrow ʼnyas, which experience the highest rates of ice production and modification. We discuss the above in more detail in Jacobs and 39), Satellite Passive Microwave Sea Ice Observations and Oceanic the Ross Sea, Antarctica, subm. to J. Geophys. Res., 1 Feb 89.

ROSS SEA CONTINENTAL SHELF

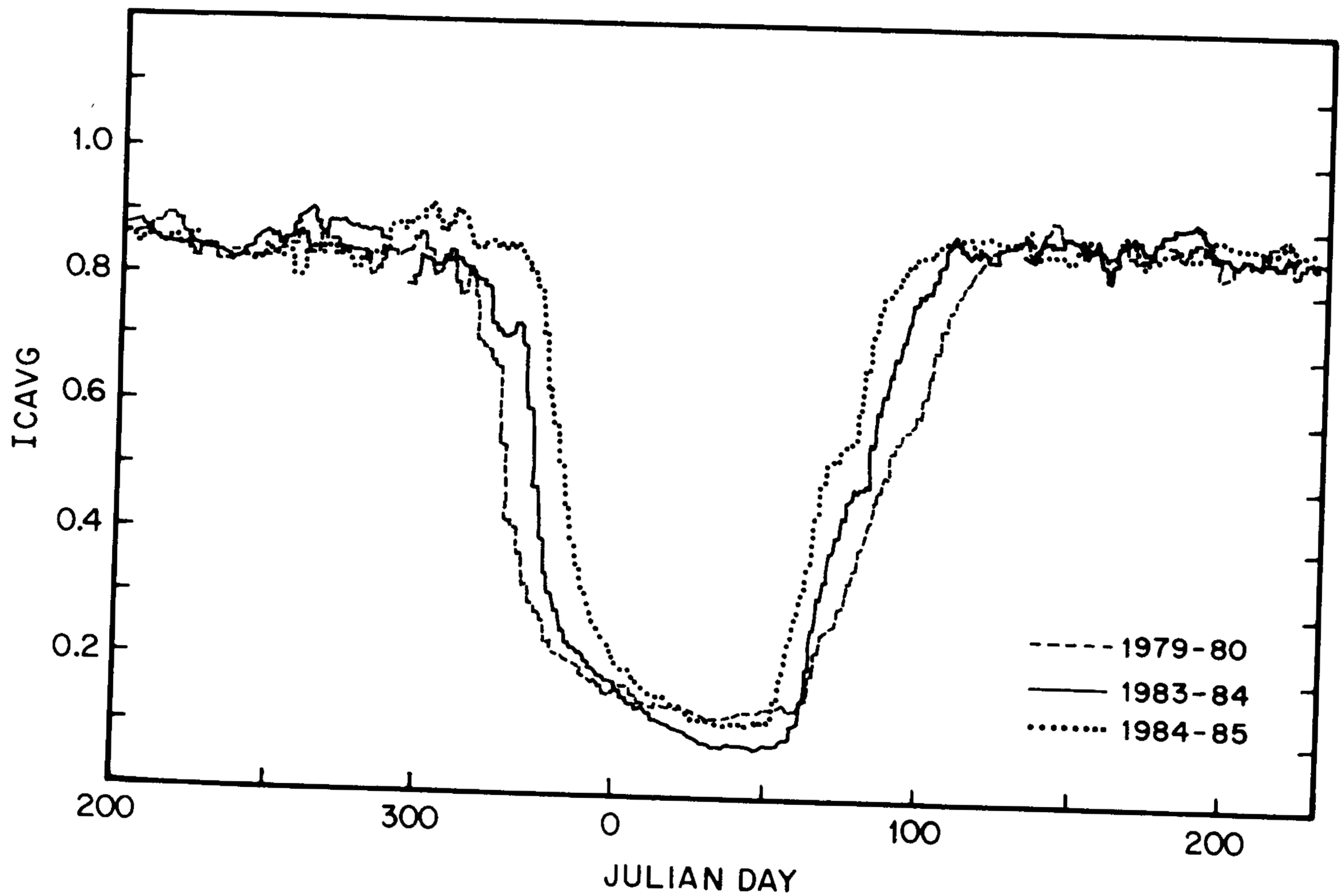
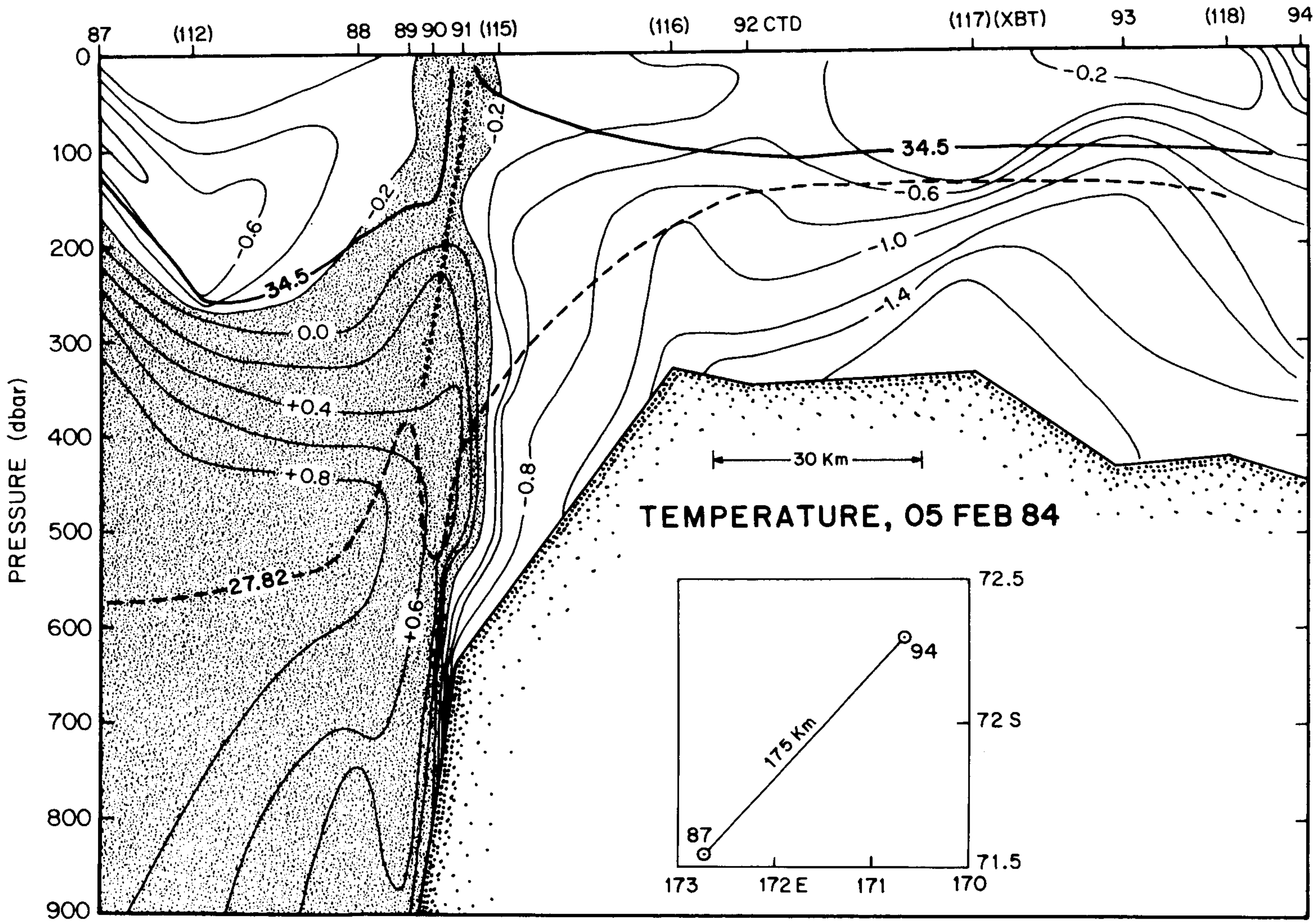


Fig.



TEMPERATURE, 05 FEB 84
87
(112)
88
89 90 91 (115)
(116)
92 CTD
(117) (XBT)
93
(118)
94
PRESSURE (dbar)
0
100
200
300
400
500
600
700
800
900
-0.2
-0.6
34.5
0.0
+0.4
+0.8
27.82
+0.6
-0.8
-1.0
-1.4
30 Km
175 Km
72.5
72 S
71.5
173
172 E
171
170

Fig. 2

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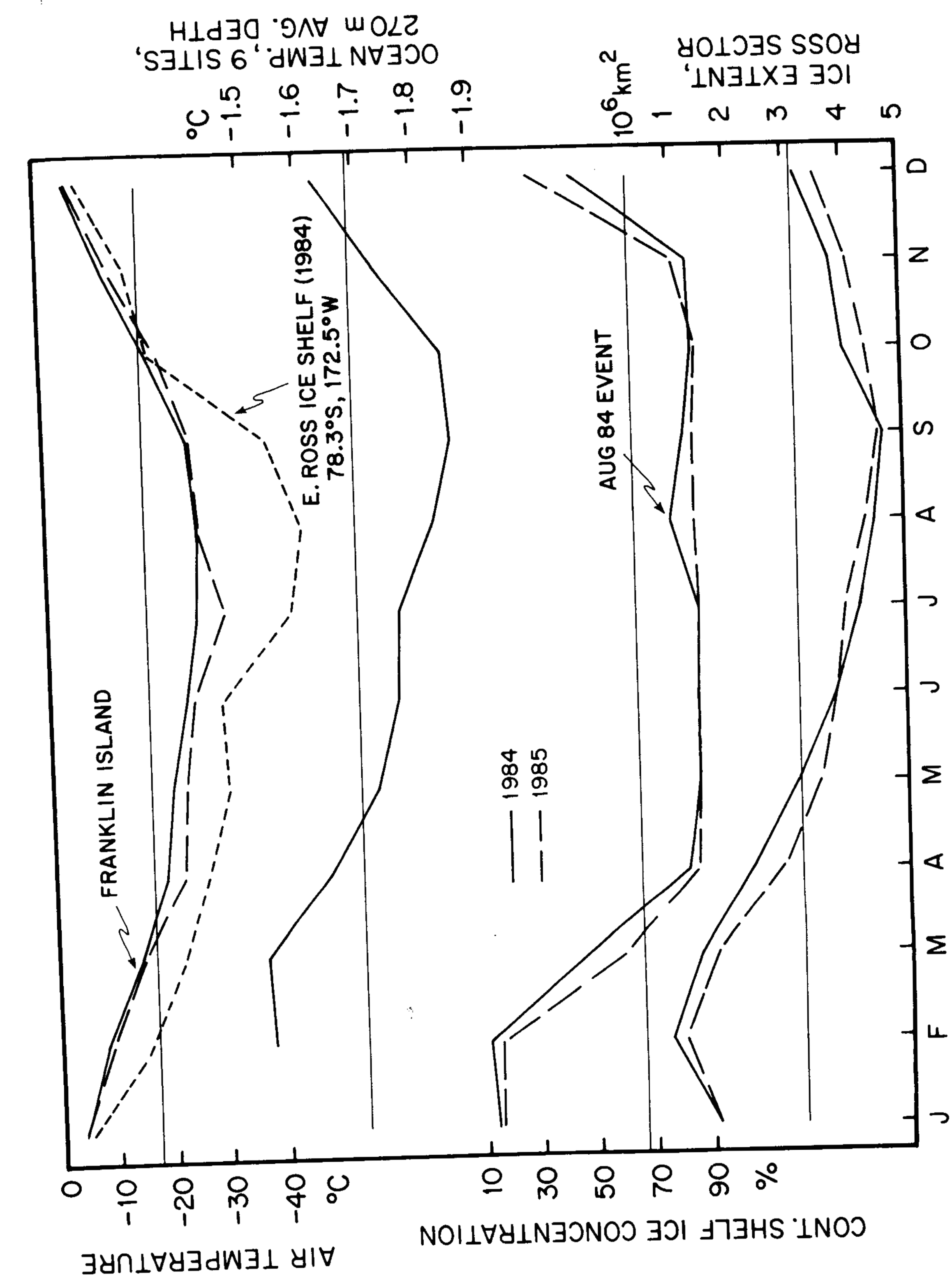
Fig. 3



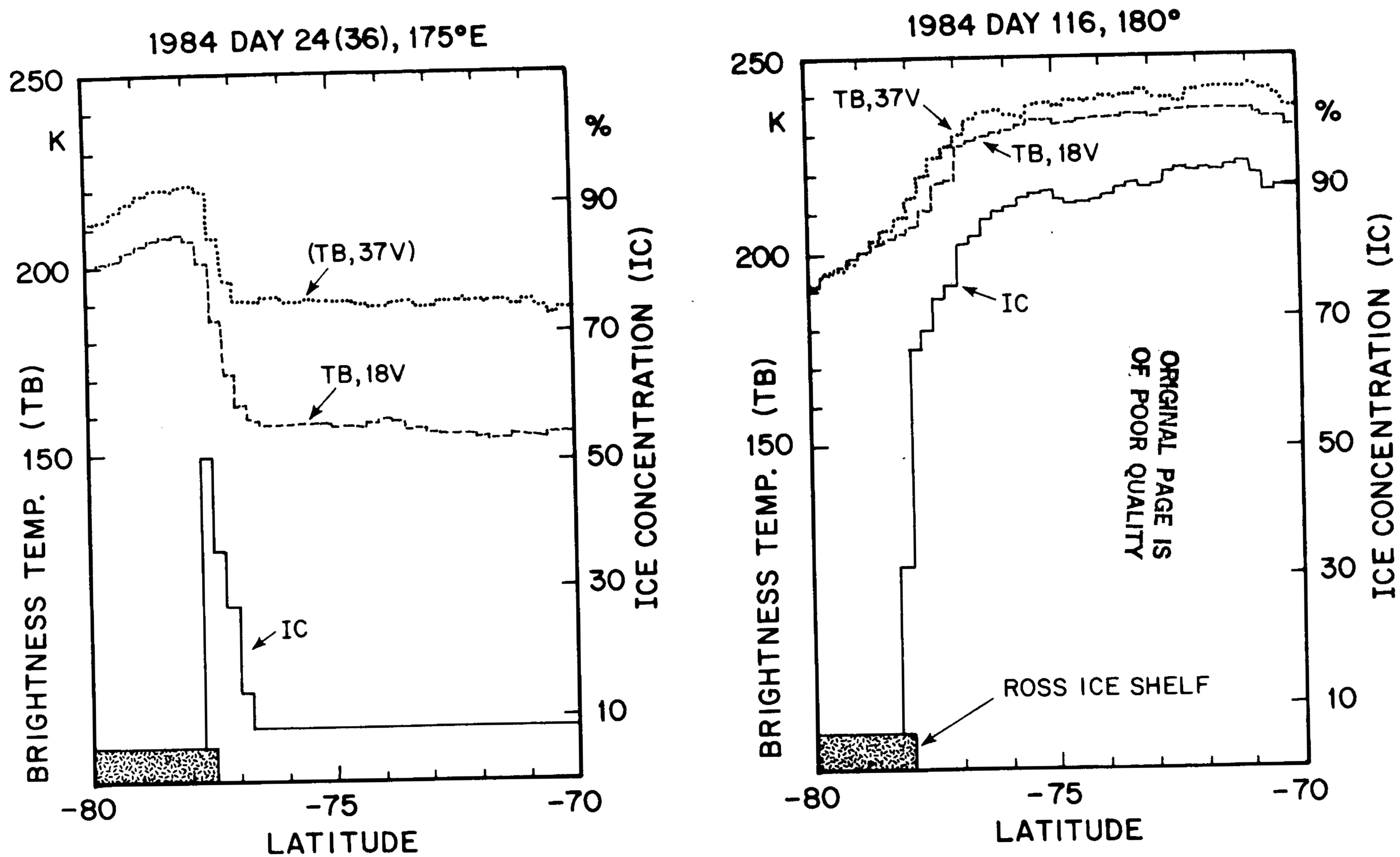

1984 DAY 24(36), 175°E
250
K
200
150
BRIGHTNESS TEMP. (TB)
%
90
70
50
30
10
ICE CONCENTRATION (IC)
(TB, 37V)
TB, 18V
IC
-80
-75
-70
LATITUDE
1984 DAY 116, 180°
250
K
200
150
BRIGHTNESS TEMP. (TB)
%
90
70
50
30
10
ICE CONCENTRATION (IC)
TB, 37V
TB, 18V
IC
ROSS ICE SHELF
-80
-75
-70
LATITUDE

Fig. 7