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Climatological study of gale-producing polar lows near Norway

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ABSTRACT

Weather maps have been scrutinized in order to document polar lows over the sea surrounding Norway. The study emphasizes the period 1978–1982, and 33 cases of gale-producing polar lows have been identified. The results are presented in frequency tables and one case study is shown.

The polar lows were most frequent in December and January. In February, there were only two cases. The lows were observed in weather situations with wind from NE, N or NW in the Norwegian Sea, and/or the Barents Sea, and with synoptic scale cyclones somewhere between Iceland and Novaya Zemlya. Half of the tracks crossed the area between Bear Island and the coast of North Norway. The propagation speed was usually between 8 and 13 ms^{-1} over the sea, and between 15 and 20 ms^{-1} over land.

1. Introduction

Polar lows over North Norway have been described by Rabbe (1975) and Wilhelmsen (1981). These lows are often accompanied by strong surface winds. Some unexplained shipwrecks seem to be caused by strong winds in connection with polar lows (Wilhelmsen, 1981). This climatological study of polar lows has been focused on cases where strong winds are observed, i.e., gale-producing polar lows.

Polar lows over the British Isles have been studied by, for instance, Stevenson (1968), and Harrold and Browning (1969). They are also described in HMSO (1975). Harrold and Browning concluded that "a low-level baroclinic field is necessary, but perhaps not sufficient condition for development of a polar low", and "a high-level disturbance may be a factor contributing to the development of well-developed polar lows". We will present a case study (from February 17, 1978) which seems to support these statements about the conditions for development of polar lows.

Others, for instance, Økland (1977) and Rasmussen (1979), explain the development of polar lows as "a thermal instability phenomenon" (the CISK theory). According to this theory, the cold air outbreak at high-levels over a relatively warm surface, is important for the development of polar lows (Rasmussen, 1979).

The purpose of this paper is to present statistics about polar lows near the Norwegian coast. We have used weather maps, observations, a few satellite pictures, reports of shipwrecks, etc., over the last 15 years. Weather maps for the period 1972–1982 have been examined. The analysis for the period 1972–1977 has, however, not yet been completed. The study has therefore been concentrated on the years 1978–1982. The maps have been reanalysed to find tracks and evolution of polar lows. The accuracy of the pressure in the centre is ± 5 mb. The cases are presented in tables with accompanying synoptic observations and as frequency distributions. We also show a case study of a polar low.

2. Data handling

A polar low is a meso-scale low or an irregularity in an otherwise uniform cold air stream north of and/or west of the polar front. The horizontal extension is 100–500 km. When a low passes, the wind increases suddenly to the west of and behind the low, but sometimes also in front of the low. The windshift is significant. Heavy precipitation (snow) is often observed in connection with the low, followed by quickly clearing weather (Rabbe, 1975; HMSO, 1975). Thunder and hail have also been reported. A small increase in surface temperature is often observed when a polar low is passing (Wilhelmsen, 1981). The pressure fall in front of the low is usually weak and concentrated to a small area. The pressure rise behind the low is steep and concentrated to a narrow zone. The weather in connection with polar lows is quite different from the weather near fronts and troughs. Due to the usual distance between synoptic stations, only a few stations (normally only one or two) are affected at the same time.

We selected weather situations where polar lows were expected to occur. We scrutinized reports from all available synoptic weather stations and notified strong winds, windshifts, abrupt change in pressure tendency, etc. Only those polar lows giving wind force near gale (15 ms^{-1}) or more at

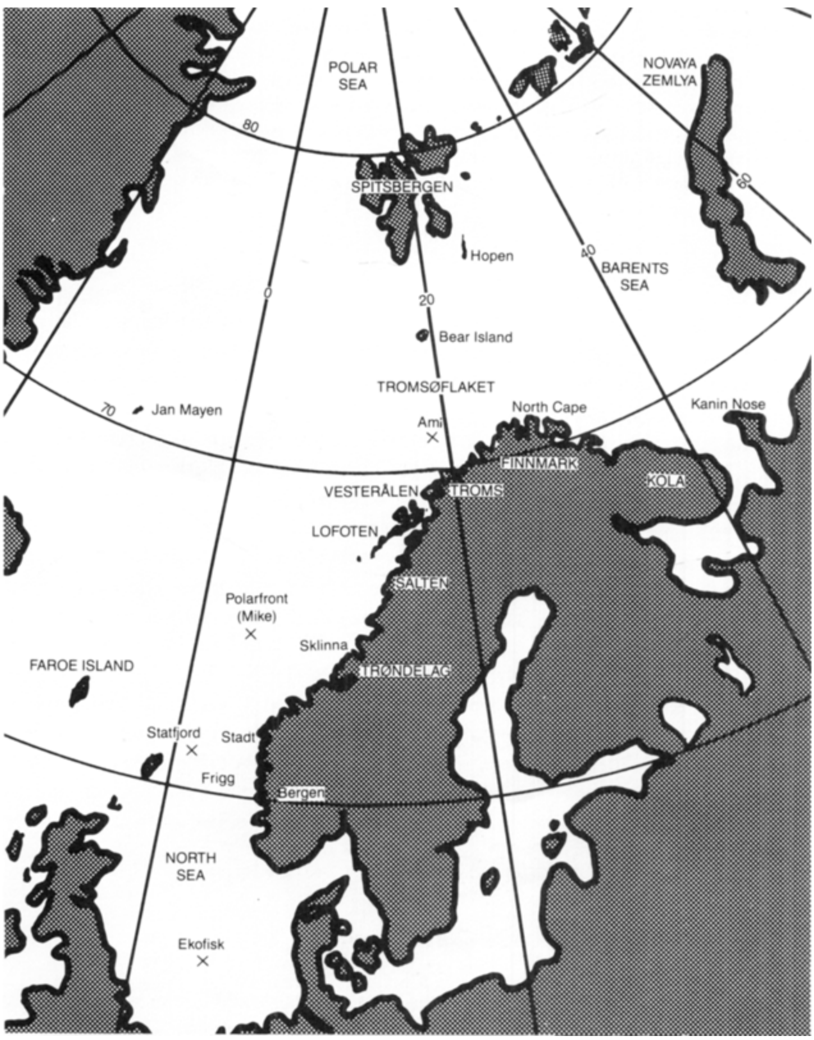

Fig. 1. The investigated area.

Norwegian meteorological stations or at weather ships near the Norwegian coast have been included in this study.

3. Statistical results

Fig. 1 shows the region we investigated (the North Atlantic Ocean and the Barents Sea). A map of northern Norway with local names is found in Fig. 2.

3.1. The period 1972–1982

Fig. 3 shows the frequency distribution of polar lows for the period 1972–82. The period is divided into two parts; the still uncompleted period 1972–77, (38 cases, hatched) and 1978–82 (33 cases). Polar lows occur from September through April.

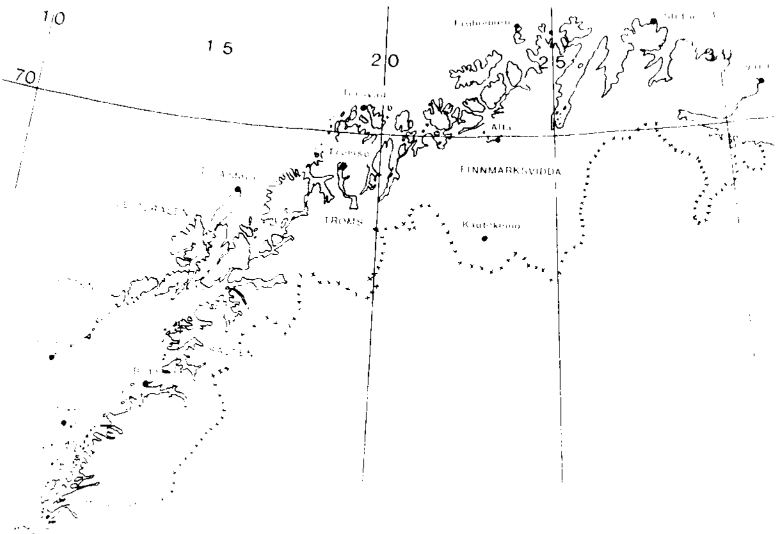

Fig. 2. North Norway.

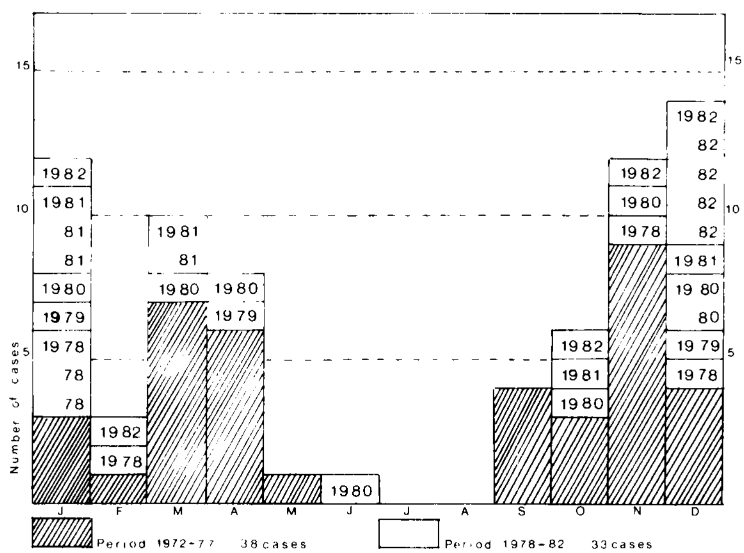

Fig. 3. Frequency distribution of polar lows 1972–1982 (71 cases in 11 years) in the Norwegian Sea and the Barents Sea.

Occasionally they develop in May and June. They are most frequent during November to January. There are two interesting features in Fig. 3: there is a minimum in February, and the maximum is found during different months for the two investigated periods.

3.2. The period 1978–82

We have listed all 33 cases with gale-producing polar lows during 1978–1982 in Table 1. The tracks are specified by using geographical names. Characteristic observations in connection with the polar

Table 1. *The tracks of polar lows with surface observations along the tracks*

		Max. wind (ms^{-1})	Pressure tendency ($mb\ 3\ h^{-1}$)	Max. sea temp. (°C)	Air temperature (°C) Start ca.	Coast ca.	Land ca.	Max. precipitation >10 mm in 24 h–(12 h)
1978								
1. Jan. 2	Polarfront–Sola	23	−2.6/+6.3	8	0	2	−4	—
2. Jan. 11	Nordkapp–Kanin Nose	25–28	−5.7/+2.2	4	−5	−5	−15	—
3. Jan. 23	Hopen–Helgeland	21–24	−3.7/+2.4	8	−19	−6	−20	14
4. Feb. 17	The Barents Sea–Bodø	25–28	−8.6/+4.2	6	−20	−12	−16	14 (9)
5. Nov. 20	Fruholmen	25–28	−1.1/+5.0	4	−1	−1	−15	41 (37)
6. Dec. 26	Ami–Andøya	23	−1.8/+2.7	5	−5	−6	−21	—
1979								
1. Jan. 29	Torsvåg	23	−1.0/+5.3	4	−3	−3	−30	13 (9)
2. Apr. 13	Hopen–Tromsø	25–28	−5.0/+8.0	4	−21	−7	−9	22
3. Dec. 30	Spitsbergen–Bodø	25–28	—/+4.3	6	−18	−1	−10	24 (22)*
1980								
1. Jan. 14	The Barents Sea–Tromsø	21–24	−2.4/+6.0	6	−12	−4	−14	—
2. Mar. 1	Spitsbergen–Sola	21–24	−4.7/+6.2	8	0	−1	−4	—
3. Apr. 7	Ami–Bodø	14–17	−1.5/+2.8	5	1	2	1	—
4. Jun. 10	Spitsbergen–Ami	23	−3.7/+4.3	8	0	3	6	13 (9)
5. Oct. 16	Hopen–Kautokeino	21–24	−5.4/+7.1	8	−3	−1	−1	21 (15)
6. Nov. 17	Ami–Bergen	20	−1.3/+5.2	8	0	1	−4	—
7. Dec. 2	Hopen–Trøndelag	21–24	−4.9/+4.3	6	−19	−1	−8	—
8. Dec. 16	Ami–Vardø	21–24	−1.6/+5.0	6	4	3	−20	—
1981								
1. Jan. 3	Iceland–Sola	20	−1.5/+7.9	6	—	0	−20	—
2. Jan. 8	Jan Mayen–Helgeland	21–24	−0.4/+5.4	8	8	3	−6	—
3. Jan. 14	Polarfront–Sola	35	−5.4/+5.3	8	−2	1	−10	24 (18)
4. Mar. 2	Fruholmen–Polarfront	21–24	−2.9/+4.5	8	−4	−4	−10	—
5. Mar. 26	Ami–Kiruna	20	−3.2/+6.9	4	−3	−3	−11	—
6. Oct. 12	Faroe Islands–Hamburg	25	−3.5/+5.3	11	2	8	−1	—
7. Dec. 3	Bear Island–Trøndelag	25–28	−1.4/+3.3	8	−3	1	−6	—
1982								
1. Jan. 27	The Barents Sea–Vardø	25–28	−3.0/+5.6	4	−6	−5	−28	—
2. Feb. 25	Bear Island–Fruholmen	25–28	−2.5/+10.7	5	—	−1	−8	—
3. Oct. 11	Spitsbergen–Ami	17–21	−2.3/+5.9	8	−8	−3	0	10 (10)
4. Nov. 3	Spitsbergen–Andøya	21–24	−0.8/+7.6	9	—	2	−12	—
5. Dec. 5	Jan Mayen–Trøndelag	25–28	−4.2/+7.6	8	−1	3	−10	22 (13)
6. Dec. 13	Hopen–Ami	20	−5.9/+1.6	7	−15	−3	−21	—
7. Dec. 14	Novaya Zemlya–Ami	14–17	−3.9/+0.4	7	−15	−1	−21	—
8. Dec. 15	Hopen–Jan Mayen–Trøndelag	35	−6.8/+5.7	9	−4	2	−10	−13 (13)
9. Dec. 21	Polarfront–Sola	25	−1.2/+5.4	10	5	5	−2	—

* Not the same station.

lows are presented in the table. The maximum sea surface temperature along the track north of Bodø is mainly between 4° and 6 °C. In autumn and in late spring, the temperature is higher. The tracks south of Bodø are found over warmer water (6 °C–11 °C). The temperature near the starting point is about −20 °C over the ice and up to 0 °C over open water. The temperature along the coast varies mainly between −5 °C and +5 °C. Sometimes there is a cold high above Finnmarksvidda. Rapid rise of pressure behind the polar low is typical, but rapid pressure fall in front of the low is not so common. In 27 out of the 33 cases, strong gale (23 ms^{-1}) or more was observed. Heavy precipitation was often observed. The precipitation usually fell as snow and lasted for 3 to 6 h.

Most of the polar lows originated in the regions around Spitsbergen and the Barents Sea. In these areas, the sea surface temperature gradient is pronounced. Polar lows coming from the region Iceland—Greenland—Spitsbergen mostly affect Iceland and Scotland. The propagation speed was between 8 and 13 ms^{-1} over the sea, and between 15 and 20 ms^{-1} over land.

Fig. 4 shows that most of the polar lows move towards or along the coast of Troms and West-Finnmark. If the temperature on land is very low,

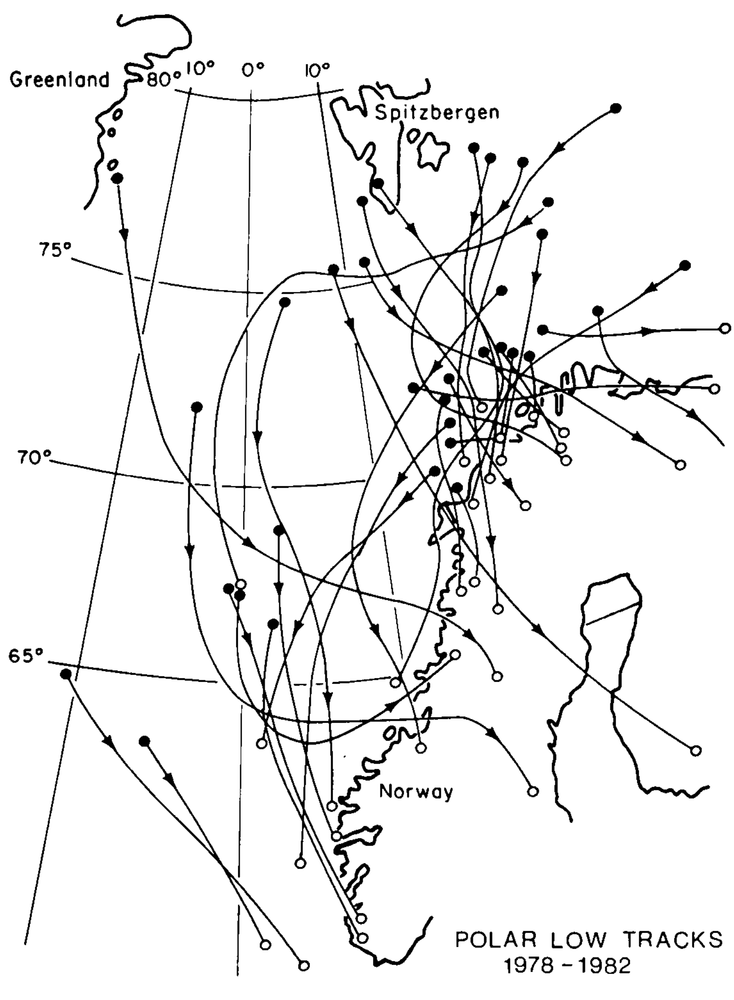

Fig. 4. The tracks of polar lows 1978–1982.

below −20 °C, they move along the coast. Some of them proceed southwards over the Norwegian Sea along the coast of the western part of southern Norway, and a few end up in Denmark, Germany or the Netherlands.

4. Description of a typical weather situation

We will present one of the 33 cases and we have chosen case number 4, 1978 (cf. Table 1). This polar low crossed Tromsøflaket, a fishing bank west of North Cape. In Fig. 4 we see that about half of the polar lows pass this area. A shipwreck at the coast of Troms might have been caused by strong winds in connection with this polar low.

This low originated east of Vardø (cf. Figs. 5, 6). It passed the weather ship Ami (71.5° N, 19° E) and reached the coast of Troms 3 hours later (Fig. 5). Ami reported an increase in mean wave height from 5.1 m to 9 m and the maximum wave height increased from 7 m to 16.3 m.

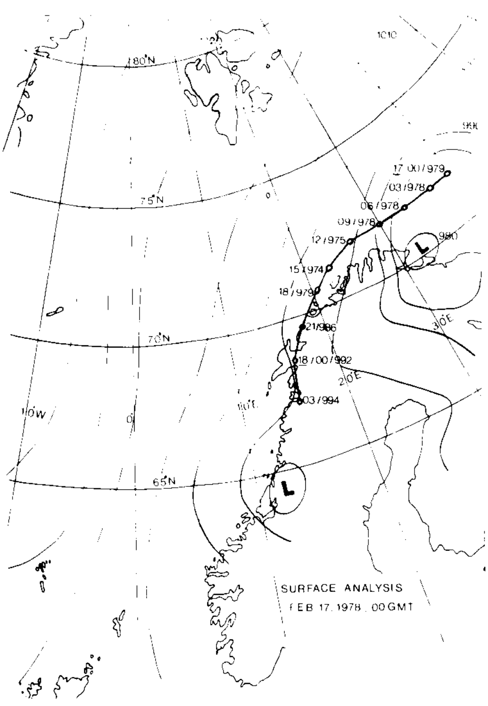

Fig. 5. The track of the polar low, February 17, 1978 and the estimated pressure. Surface map from 00 GMT. *17*/00/979 mean 979 mb at 00 GMT on the date 17.

The surface maps (Figs. 5, 6) indicate strong winds north of the front. At 500 mb (Fig. 7), cold air (−50 °C) is found west of Troms and warm air is present north of Kola. From 00 GMT February 17 to the next day, the temperature in the air over the southern Barents Sea increased between 1000 and 500 mb. For instance, from 00 to 12 GMT on February 17, the temperature rose about 8 °C between 800 and 900 mb over Bear Island. The warm air at 850 mb (Fig. 8) seemed to come from the east.

The surface maps in Fig. 9 show some observations from coastal stations. We have also listed the observations in Table 2. We notice abrupt windshifts. The strongest wind reported is 28 ms^{-1}. This case is unusual in that there is a large pressure fall followed by a moderate pressure rise. Heavy snowfall was reported close to the track. The air

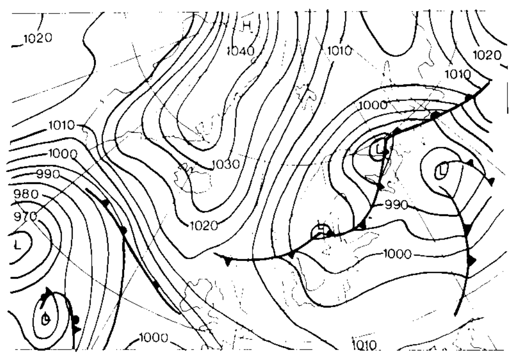

Fig. 6. Surface map 00 GMT February 17, 1978.

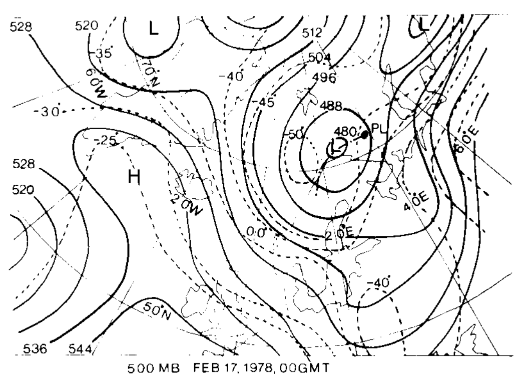

Fig. 7. 500 mb 00 GMT February 17, 1978. Position of the polar low at the same hour, and the track.

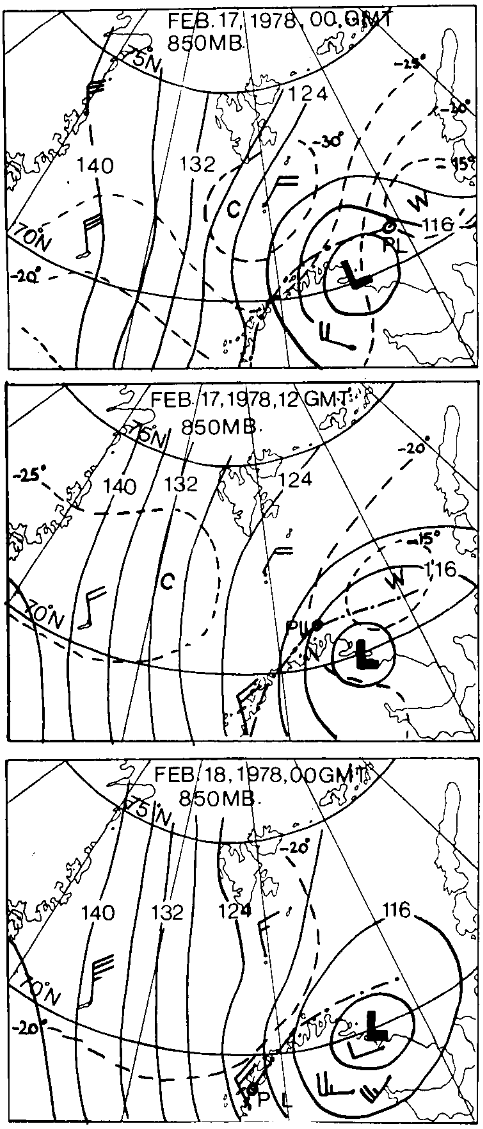

Fig. 8. 850 mb (a) 00 GMT February 17, 1978; (b) 12 GMT February 17, 1978; (c) 00 GMT February 18, 1978. Positions of the polar low at the same hours, and the track.

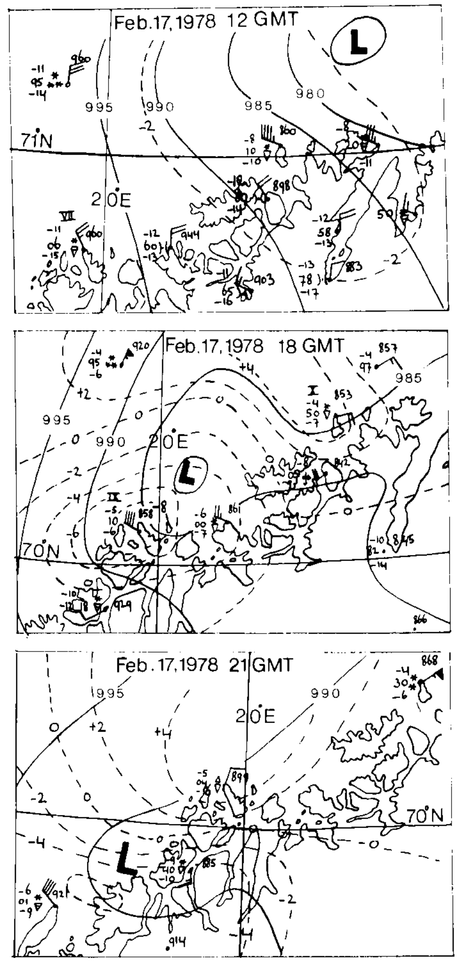

Fig. 9. Surface map February 17, 1978: (a) 12 GMT; (b) 18 GMT; (c) 21 GMT.

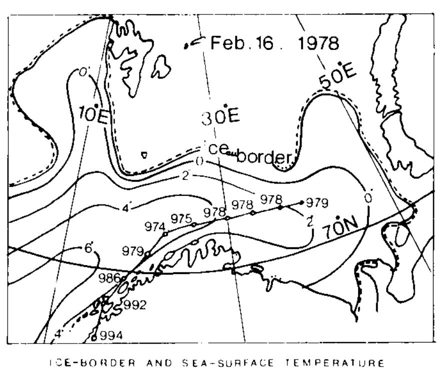

Fig. 10. Ice-map February 16, 1978 and the polar low track on February 17, 1978.

temperature increased at Ami from −11 °C to −6 °C within three hours when the polar low approached, and to −4 °C when the low passed. Some coastal stations also reported a temperature increase. In Fig. 10 we have plotted the track of the low on the map showing the ice-edge and the sea surface temperature. When it moved towards

Table 2. *Surface observations for the polar low, February 17, 18, 1978* (*local names see Fig. 2*)

Affected stations	Date/ time (GMT)	Wind (ms^{-1})	Visibility (km)	Weather	Pressure tendency (mb 3 h^{-1})	Temp. (°C)	Precipitation mm (period)	Period/ waves (s/m)	Max. wind (ms^{-1})
01055 (Fruholmen)	17/12	W23	1	showers	−4.3	−8			21–24
01055	17/18	E10	5	showers	+4.2	−4	4 (06–18)		25–28
01053 (Hammerfest)	17/15	SE13	0.2	drifting snow	−6.7	−9	5 (06–18)		
Ami	17/12	N15	2–4	snow	−1.8	−11		06/5	
Ami	17–15	N23	2–4	snow	−7.0	−6		07/7.5	
Ami	18/00	N28	2–4	snow	+3.0	−4		07/16	
01033 (Torsvåg)	17/18	NW20	1	past snow	−8.6	−5	3 (06–18)		21–24
01033	18/00	NE23	10	past snow	+3.3	−5	9 (18–06)		25–28
01010 (Andøya)	17/21	NW20	0.1	showers	−5.1	−6			
01010	18/00	NE23	0.3	showers	+1.3	−4	2 + 11 (18–18)		
01025 (Tromsø)	18/06						6 + 4 (06–06)		
01035 (Kvesmenes)	18/06						1 + 0.2 (06–06)		
01043 (Loppa)	18/06						1 + 2 (06–06)		
01023 (Bardufoss)	18/06						5 + 9 (06–06)		
01160 (Skrova)	18/06	N13	0.0				2 + 0.3 (06–06)		

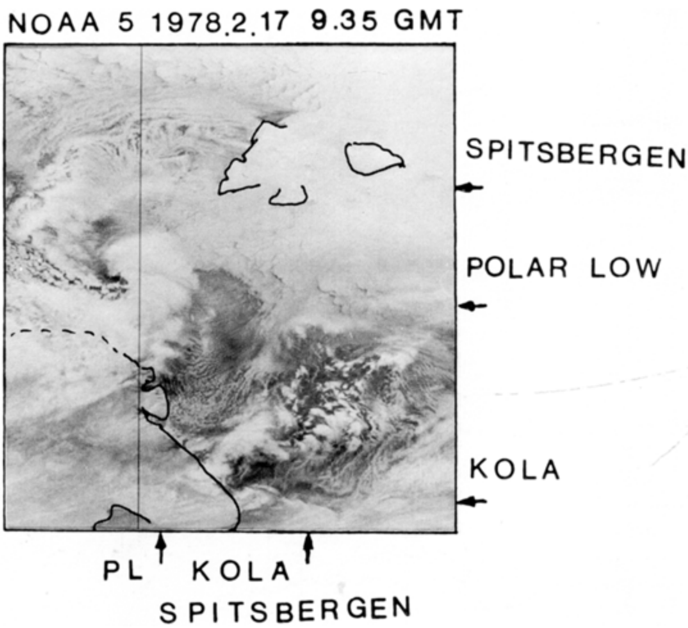

Fig. 11. Satellite picture, 09.35 GMT, February 17, 1978.

warmer water, the pressure in the centre seemed to fall. It rose again when the low moved towards colder water and over cold land.

The satellite pictures (Fig. 11, 12) were taken in the morning, when the polar low was east of Ami. Outside the coast of Finnmark (Fig. 11) and the coast of Troms (Fig. 12), we noticed a white half-moon shaped cloud. We also noticed a smaller white cloud with a black "eye". This is probably the centre of the low.

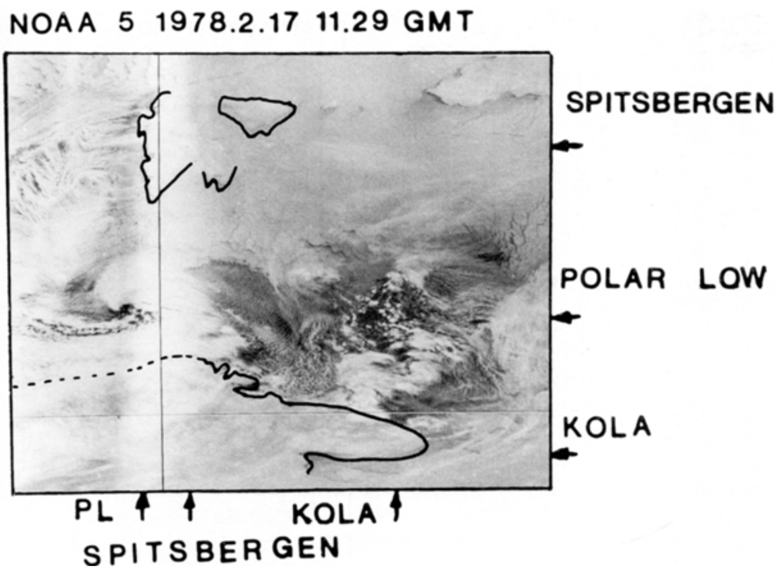

Fig. 12. Satellite picture, 11.29 GMT, February 17, 1978.

5. Acknowledgement

The Norwegian project on polar lows is partly financed by oil companies with licences north of 60 °N on the Norwegian continental shelf. The satellite pictures have been received by Tromsø Telemetri station, Tromsø, Norway. The sea ice map is made by the Norwegian Meteorological Institute, Oslo. The surface maps 850 mb and 500 mb have been redrawn from the European Meteorological Bulletin.

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