

A case study of a Siple Coast mesocyclone

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The polar meteorology group from the Byrd Polar Research Center deployed a four-member field team to West Antarctica on 8 November 1992. Two-person teams established acoustic and radar surface-based remote-sensing sites at both Upstream B Camp (83.5°S 136.1°W) and South Camp (84.5°S 134.3°W) to profile boundary-layer winds and temperatures within the drainage flow on the ice slopes facing the Siple Coast (see figure 1 for station locations). During the early days of the deployment before the remote-sensing systems were operational, the two field sites were affected by a strong mesocyclone, a cyclonic perturbation less than 1,000 kilometers (km) in diameter. Antarctic mesocyclones have been studied in Terra Nova Bay and near the foot of Byrd Glacier (Bromwich 1991; Carrasco and Bromwich 1991, 1993) and also on both sides of the Antarctic Peninsula (Turner and Row 1989, pp. 347–356; Heinemann 1990). The current perception of mesocyclones in the antarctic interior is that they are relatively weak features (Turner, Lachlan-Cope, and Thomas 1993). This was not the case for the storm of 11 and 12 November 1992 along the Siple Coast. This mesocyclone had a minimum central sea-level pressure of 953 hPa with sustained winds of 28 meters per second ($m s^{-1}$) gusting to over $35 m s^{-1}$. The worst weather was at South Camp, where the field party encountered zero visibility due to blowing snow for over 24 hours (h).

The mesocyclone began its rapid development near 0000 universal coordinated time (UTC) on 11 November. At 0000 UTC a strong synoptic-scale surface cyclone (a cyclonic perturbation greater than 1,000 km in diameter) was present near the antarctic

coast at 130°W. A surface-pressure trough extended from the synoptic cyclone to the south and west, reaching all the way to the base of Byrd Glacier. Also, a midtropospheric geopotential height ridge extended southward into Marie Byrd Land with an axis located near 80°W. The combination of the upper-level ridge and the large surface low off the antarctic coast brought warm air into Marie Byrd Land at the surface. This warm air in conjunction with the pressure field from the synoptic-scale cyclone set up a baroclinic zone, a region where enhanced pressure and potential temperature gradients cross one another, between Upstream B Camp and Byrd Station. Bromwich (1989, pp. 331–345) found that baroclinic

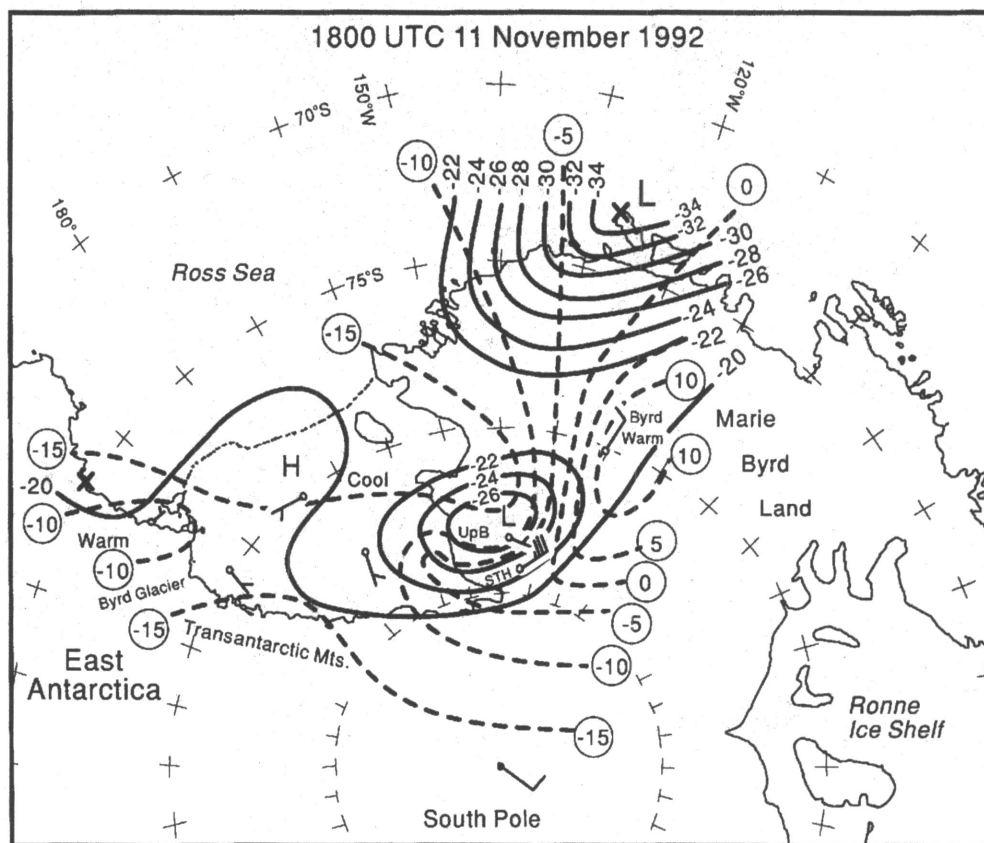


Figure 1. Surface analysis of pressure anomaly (solid—hPa), potential temperature (dashed—°C), and winds ($m s^{-1}$) at 1800 UTC on 11 November 1992 created using automatic weather station and staffed surface station data. Winds plotted with a half barb = $2.5 m s^{-1}$ and a full barb = $5.0 m s^{-1}$. Pressure anomalies were created by subtracting the November mean from the hourly values. Labels include staffed summer camps at South Camp (STH), Upstream B Camp (UpB), and Byrd Station along with other geographic features mentioned in the text. Automatic weather stations reporting only temperature and pressure data are marked with a bold "X."

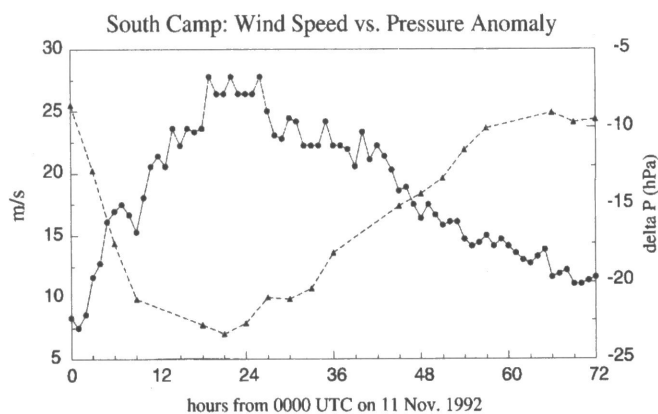


Figure 2. Graph of hourly mean wind speeds (solid—m s⁻¹) and surface-pressure anomalies (dashed—hPa) at South Camp from 0000 UTC on 11 November to 0000 UTC on 14 November 1992.

zones are often associated with mesocyclone development over the southwestern Ross Sea.

The mesocyclone was first noted on analyses of surface-pressure anomalies at 0300 UTC on 11 November and probably developed along the baroclinic zone just to the east of Upstream B Camp. Pressure anomalies created by subtracting the November 1992 mean from hourly observations were used to remove the topographic influence on surface-pressure values. The mesocyclone rapidly deepened from 0000 to 0900 UTC on 11 November, as seen by the surface-pressure decrease of 14 hPa at South Camp during this time (figure 2). This explosive deepening has been found in middle-latitude and polar lows in the past (Uccellini 1990, pp. 81–105); however, to our knowledge the 11 November case is the first documented mesocyclone in the interior of Antarctica to be observed showing explosive development. Figure 2 also shows hourly wind averages from a Lambrecht recording anemometer running at South Camp during the storm. A clear pressure decrease/wind increase relationship is observed. By 0944 UTC on 11 November, the now very strong mesocyclone first became clearly identifiable on the infrared

satellite imagery from the National Oceanic and Atmospheric Administration (NOAA) polar orbiters and was located almost directly over Upstream B Camp, where the surface winds were calm.

Over the next 9 h, the mesocyclone continued to increase in intensity as it drifted slowly to the west toward the Ross Ice Shelf. By 1800 UTC on 11 November, the mesocyclone had a very well developed surface-pressure anomaly and potential temperature structure (figure 1). The central pressure at Upstream B Camp was 27 hPa below the monthly mean, which is equivalent to a 953 hPa sea-level pressure. Furthermore, the cyclone was drawing in a new supply of warm air from the top of the Marie Byrd Land plateau. This warm air is clearly seen on the infrared satellite image from 1805 UTC as a dark streak spiraling into the cyclone from the east (figure 3). Cool air was also advecting into the storm from the Ross Ice Shelf to the northwest of the cyclone (figure 1).

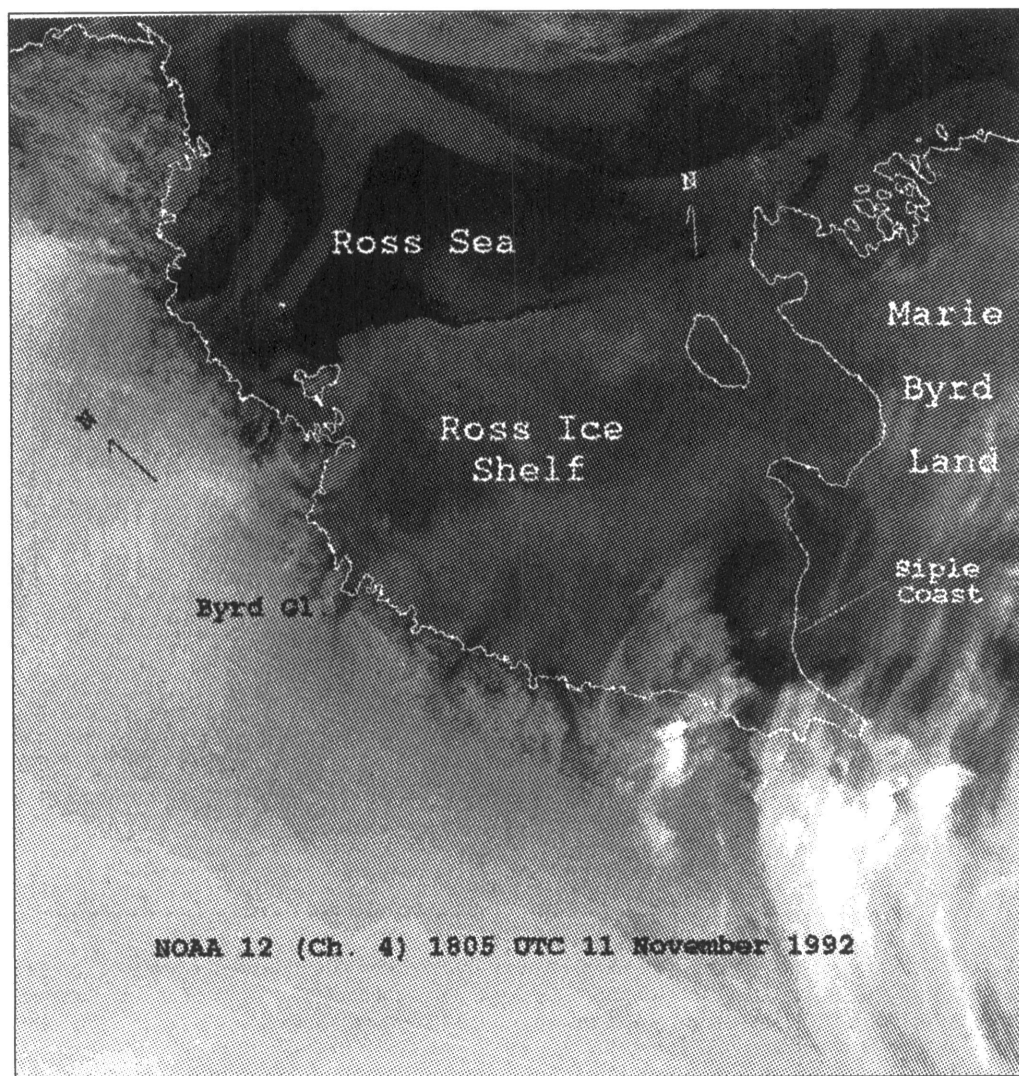


Figure 3. NOAA-12 thermal infrared (channel 4) satellite image at 1805 UTC on 11 November 1992.

By 0000 UTC on 12 November, the mesocyclone reached its peak intensity with the largest pressure anomaly of 27.4 hPa below the monthly mean at Upstream B Camp and sustained winds of 26 m s⁻¹ at South Camp. Near this time, South Camp recorded a wind gust that exceeded the maximum range of the camp's anemometer, which means the wind gust surpassed 35 m s⁻¹. Interestingly, at this time Upstream B Camp, less than 100 km north of South Camp, was having a pleasant day with a wind speed of only 2.5 m s⁻¹. After 9 h of sustained winds over 25 m s⁻¹ at South Camp, the pressures started to rise and the winds began to decrease in intensity (figure 2). By 1200 UTC on 12 November, the mesocyclone had moved onto the southern Ross Ice Shelf and was beginning to weaken.

In summary, the presence of a strong-synoptic scale low off the coast of Marie Byrd Land along with a midtropospheric ridge resulted in a sharp baroclinic zone between Upstream B Camp and Byrd Station in West Antarctica. A mesoscale cyclone formed along this baroclinic zone on or near 0000 UTC on 11 November 1992 and underwent explosive development over the next 9 h. The mesocyclone reached its peak intensity around 0000 UTC on 12 November, treating the field party at South Camp to an antarctic blizzard while the team at Upstream B Camp enjoyed a fairly calm day.

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A katabatic-wind–forced mesoscale cyclone development over the Ross Ice Shelf near Byrd Glacier during summer

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Studies carried out by Bromwich (1991) and Bromwich et al. (1993) revealed that the pressure field near Franklin Island is, in general, lower than that of the surrounding areas, reflecting the presence of a semipermanent subsynoptic surface trough. The katabatic winds near Terra Nova Bay (Bromwich 1989a,b) can induce the formation of a mesoscale boundary-layer front, which along with the above subsynoptic trough makes this region a very active area for mesoscale cyclogenesis (Bromwich 1991; Carrasco 1992; Carrasco and Bromwich 1993). These two factors are less frequently present over the northwestern side of the Ross Ice Shelf in association with per-

sistent katabatic winds from Byrd, Mulock, and Skelton glaciers (Bromwich 1989c; Parish and Bromwich 1987; Carrasco and Bromwich 1991) and with a southward extension of the semipermanent subsynoptic trough along the Transantarctic Mountains. These factors appear to be present in this case, which occurred during the first few days of December 1987.

According to the available satellite images collected at McMurdo Station (Van Woert et al. 1992) at 0530 UTC (universal coordinated time) on 1 December, 0519 and 1702 UTC on 2 December, 1641 UTC on 3 December, and 1114 UTC on 4 December and according to the surface analyses construct-