JP2.8 Monitoring A Piteraq Storm System Using DMSP Imagery And QuikSCAT Wind Data

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1.0 Introduction

The channeling of katabatic flow in large valleys along the East Greenland coast leads to a convergence and the generation of cyclonic vorticity. This convergence can be strong enough to produce intense katabatic storms called Piteraqs, which are a much-feared phenomenon in that area of Greenland (Rasmussen 1989; Klein and Heinemann 2002). These storms can have gale to hurricane force wind speeds. Rasmussen (1989) described a disastrous Piteraq occurring in 1970, during which wind gusts estimated at 80 m/s caused significant damage in the Angmagssalik area. High resolution satellite images occasionally show the existence of Piteraqs close to the eastern coast of Greenland.

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Piteraqs formed between southeastern Greenland and western Iceland between February 21st and 22nd, 2002. Satellites of the Defense Meteorological Satellite Program (DMSP) recorded the event. In addition, Navy Operational Global Atmospheric Prediction System (NOGAPS) model output was used to analyze the mesoscale storms. Wind data from the QuikSCAT scatterometer was also used. The QuikSCAT scatterometer measured winds over 25 m/s near the Piteraqs. The QuikSCAT wind information was in good agreement with surface observations that were available.

2.0 Data and Methodology

DMSP thermal imagery was obtained through the Satellite Data Handling System (SDHS) of the Air Force Weather Agency (AFWA). The imagery was fused with the NOGAPS analysis data using the Satellite Imagery Display and Analysis System (SIDAS) at AFWA. Also QuikSCAT wind data was merged with DMSP imagery on SIDAS

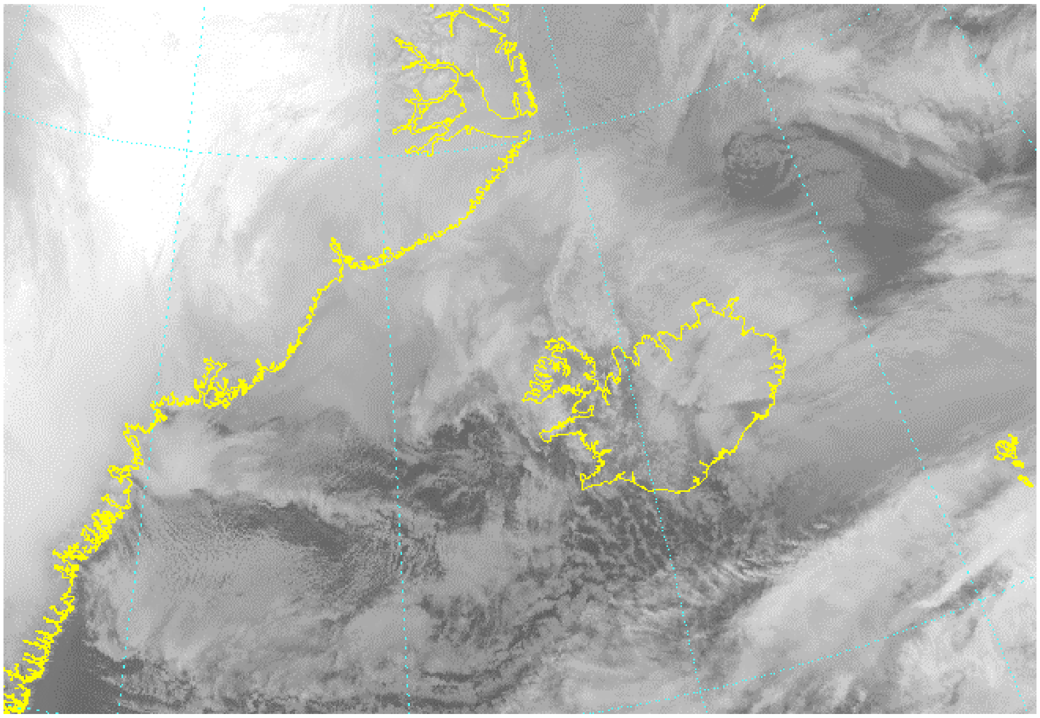


Figure 1. DMSP thermal smooth image of early cloud development on February 21, 2002 at 1142 UTC.

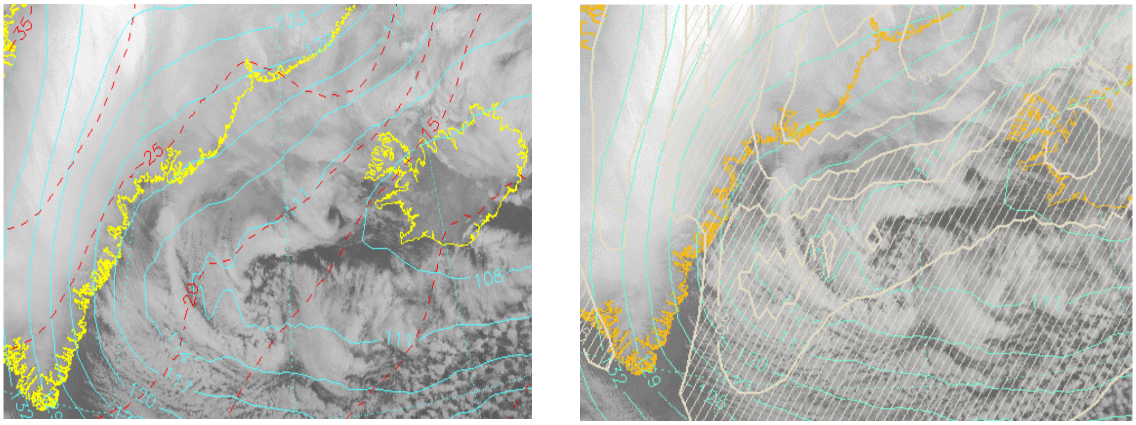
to analyze the wind intensity of the storms. The wind data is a visualization of "Near Real Time" (NRT) data calculated and sent from Dr. Paul Chang of NOAA NESDIS (McCrone, 2001).

3.0 Results and Discussion

A synoptic scale, surface low pressure system had developed between eastern Greenland and western Iceland on February 21, 2002 at 0000 UTC. The low pressure area moved eastward and intensified near eastern Iceland twelve hours later. Subsequently, the deepening of the surface low pressure center caused a steep pressure gradient from eastern Greenland to Iceland. The winds were coming from the north-northwest off the Greenland ice sheet as strong katabatic flow.

The NOGAPS mean sea level pressure analysis on February 21, 2002 1200 UTC identified a trough of low pressure stretching from the low center westward across Iceland to Greenland's east coast. At approximately 1142 UTC, DMSP imagery (Fig.1) showed the beginning of organized cloudiness near Iceland's west coast. By 1421 UTC, QuikSCAT wind data (not shown) identified winds between 10 and 25 m/s. Cloud streets, evidence of strong winds, could be identified west and south of comma cloud features near the coast of Greenland

The NOGAPS upper air analysis on February 21, 2002 at 1800 UTC for the 925 and 850 hPa levels showed a low centered off Iceland's east coast. Cold air advection is very pronounced at 850 hPa near Greenland's southeast coast (Fig 2a). NOGAPS analysis indicated moderate to strong 850 hPa absolute vorticity (20 to 25 x 10^{-5} s^{-1}) in the vicinity of the Piteraqs (Fig. 2b).



a. b.

Figure 2. DMSP thermal smooth images on February 21 2002 at 2141 UTC with NOGAPS analysis valid at 1800 UTC : (a) 850 hPa heights as solid blue isopleths in meters and temperature as red dash isopleths every 5 °C (b) 850 hPa heights as solid blue isopleths in meters and beige isopleths are vorticity values in 5 x 10^{-5} s^{-1} increments with hatch areas representing areas of absolute vorticity greater than 15 x 10^{-5} s^{-1}.

The 700 hPa analysis on February 21, 2002 at 1800 UTC had the 700 hPa low centered over western Iceland with a trough axis extending westward to Greenland. However, the 500 hPa low center was located further west near the Greenland coast with a broad trough overlaying the channel between Greenland and Iceland. The absolute vorticity at 500 hPa was weaker (15 to 20 x 10^{-5} s^{-1}) than at the 850 hPa level. The 300 hPa
analysis for the same time showed the 300 hPa trough along the east coast of Greenland.

The surface low pressure center had moved east and had deepened by February 22, 2002 at 0000 UTC. A strong pressure gradient continued to strengthen over the water between Greenland and Iceland. A DMSP image at 2215 UTC depicts the mesoscale cyclones (Fig. 3). A few of these mesoscale systems had developed from comma to spiral cloud patterns with eye-like structures in last ten hours. QuikSCAT wind data indicated the winds ranged from 18 to 27 m/s.

The NOGAPS mean sea level pressure chart on February 22, 2002 1200 UTC identified a trough of low pressure stretching from the surface low center located approximately 500 nautical miles east-southeast of Iceland westward to Greenland's southeast coast.

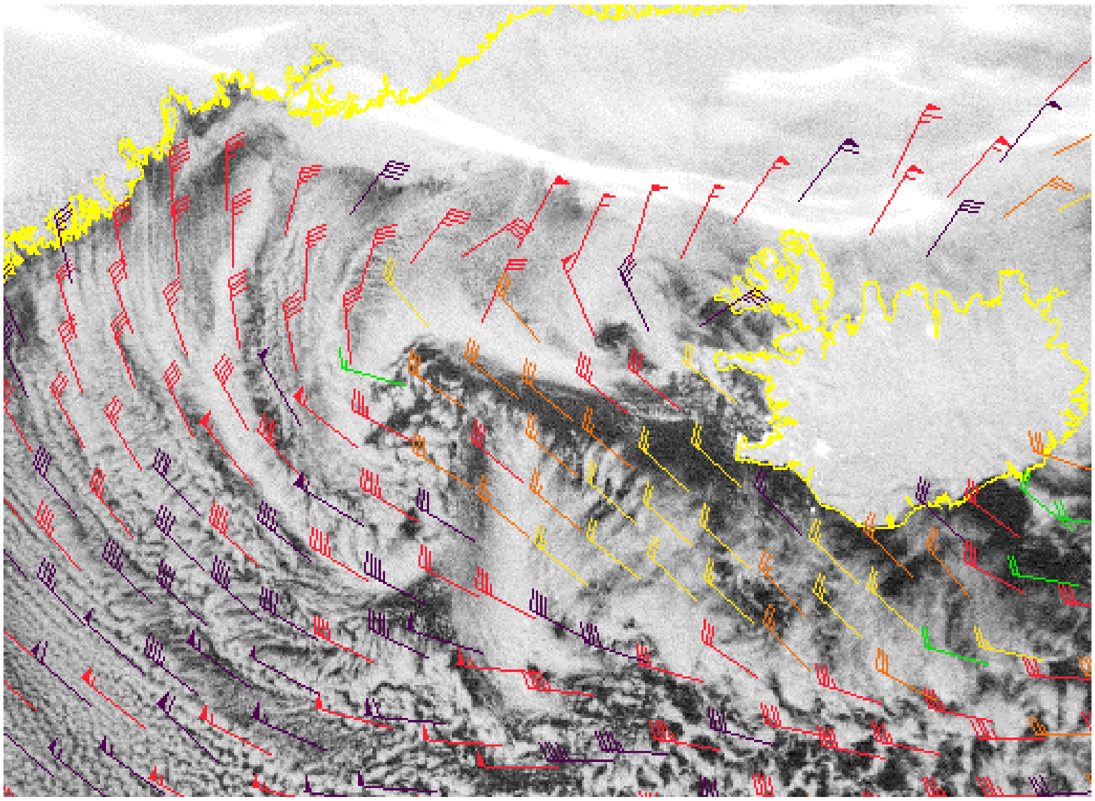


Figure 3. DMSP thermal smooth image with QuikSCAT wind data (in knots) depicting Piteraqs on February 21, 2002 at 2215 UTC.

The mesoscale features moved east and south along the trough of low pressure. Satellite imagery at 1128 UTC with 1200 UTC surface observations overlaid (Fig. 4) indicated one Piteraq moved inland over northwest Iceland where one observation on the coast indicated moderate snow and winds blowing at 20 m/s. Another Piteraq formed southeast of Iceland during this time period with winds at 22 m/s and associated snow showers. Several other mesoscale cyclonic features can be seen on satellite imagery south of Iceland along the trough axis. The upper air analysis on February 22, 2002 at 1200 UTC was nearly identical to the preceding twenty-four hour analysis except the trough features had shifted southward. The 850 hPa still indicated the presence of cold air advection over Iceland and waters to the south. Absolute vorticity at 850 hPa indicated a maximum center (25 x 10^{-5} s^{-1}) south of Iceland. But the 500 hPa low had moved northeast trailing a trough that extended northeast to southwest across Iceland. Absolute vorticity at 500 hPa remained the same for twenty-fours.

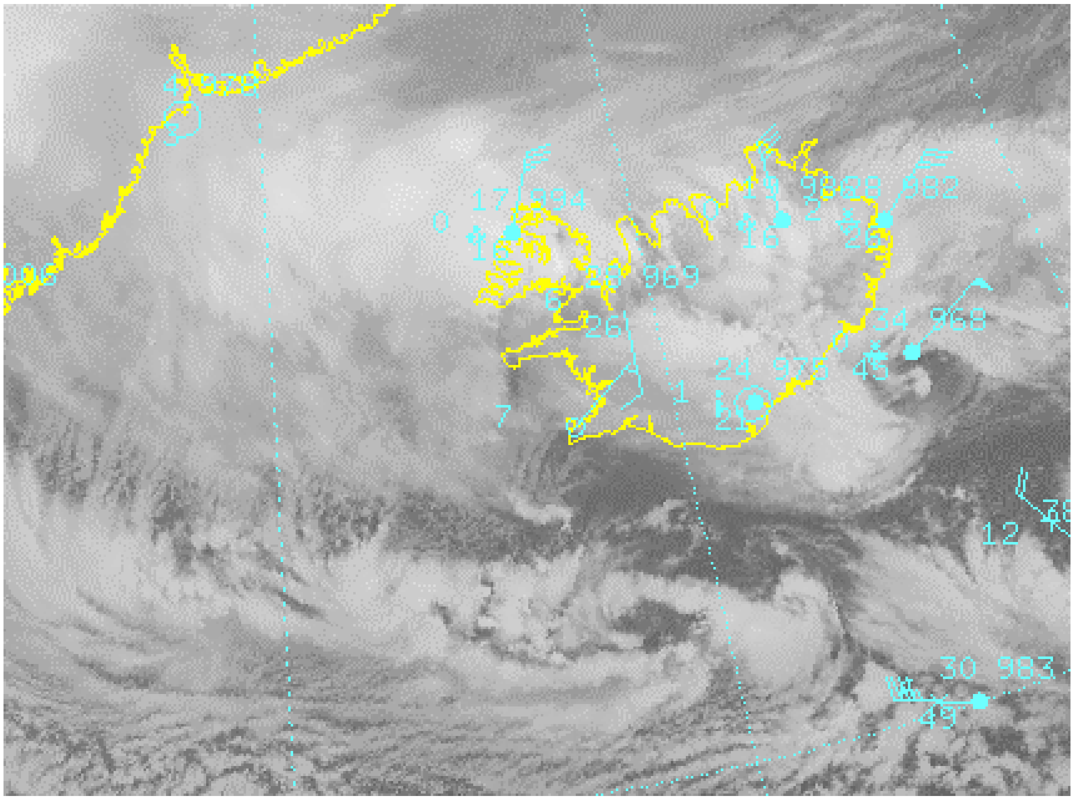


Figure 4. DMSP thermal smooth image of mesoscale cyclones on February 22, 2002 at 1128 UTC with 1200 UTC surface observations.

4.0 Conclusions

The Piteraqs developed between southeast Greenland and western Iceland after surface pressure gradient increased and cold air surged over the warmer ocean waters. DMSP satellite images showed the detailed development of Piteraqs over a twenty-hour period. QuikSCAT wind data was also used with the satellite imagery to better understand the wind flow through this region during Piteraq development. The QuikSCAT wind data indicated winds ranging from 18 and 27 m/s in the vicinity of the Piteraqs. This was in good agreement with observational data.

NOGAPS upper air analysis helped provide some insight into the dynamics of these storms. As on the surface, low pressure existed over the region at the upper levels. Cold air advection at 850 hPa was evident during this event. Low-level absolute vorticity at 850 hPa was moderate to strong during the mature stage of growth. By contrast, the 500 hPa vorticity was weaker. Although upper air support appears to maintain these storms, high katabatic winds, low level convergence zone and vorticity appear to be the necessary physical processes to spawn these mesoscale cyclones.

5.0 Acknowledgements

The authors would like to thank Paul J. McCrone and the staff of AFWA Offutt AFB, NE for providing the imagery and the time on their computer systems.

6.0 References

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