



The University of Reading

# A new climatology of polar low activity

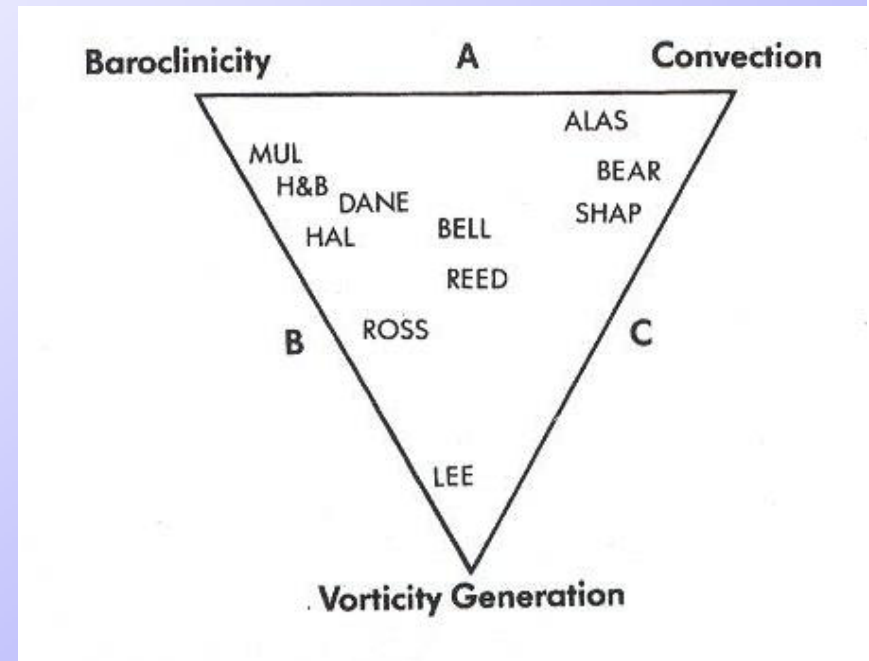
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# Introduction

- Polar lows are a more intense subset of high latitude mesoscale cyclones (mesocyclones).
- They occur in the winter months during outbreaks of Arctic air over relatively warm oceans.
- A range of factors contribute to the intensification of polar lows.
- Thought to occupy a 'spectrum' of types.

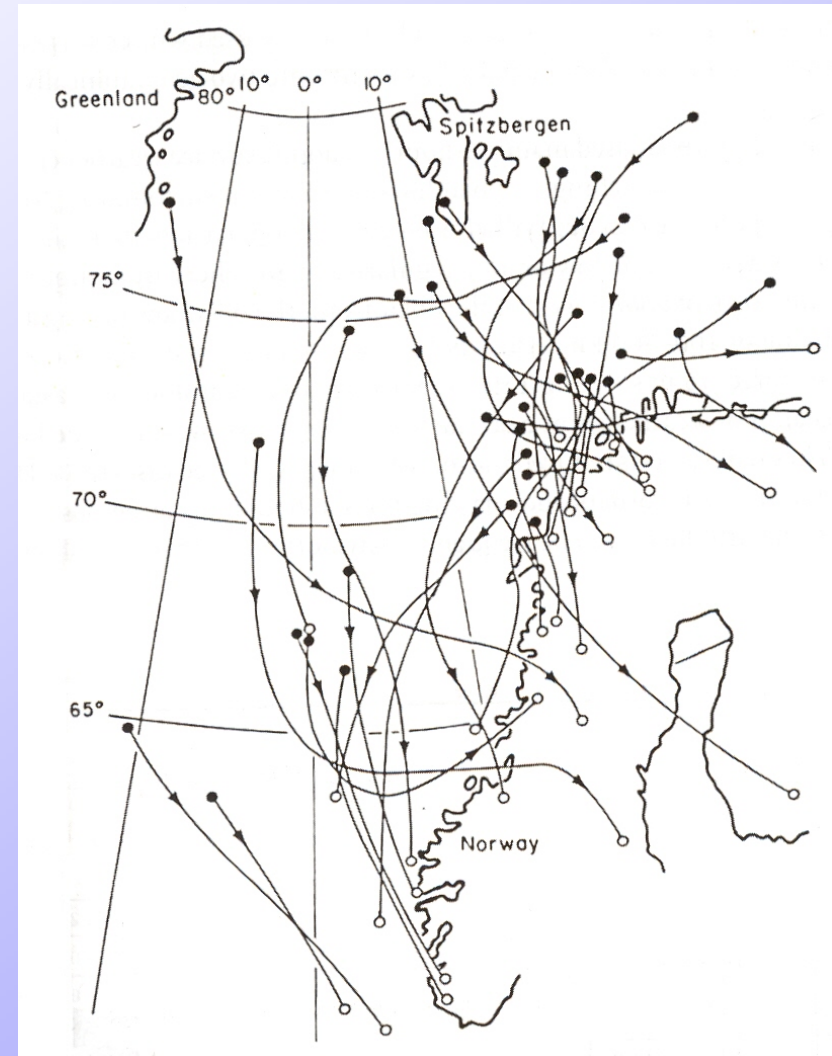


Turner et al (1993)



# Motivation

- No objective systematic study of polar lows has yet been carried out to determine their patterns of activity and the relative importance of different processes that can influence their intensification.
- This knowledge is important for issues such as targeting observations and model development.



Polar lows for the period 1978-1982,  
Wilhelmsen (1985)



# Questions

- What are the key regions of polar low activity?
- What mechanisms are potentially important in these regions, i.e. which part of the polar low spectrum do they occupy?

# The Cyclone Database

What is the Cyclone Database?

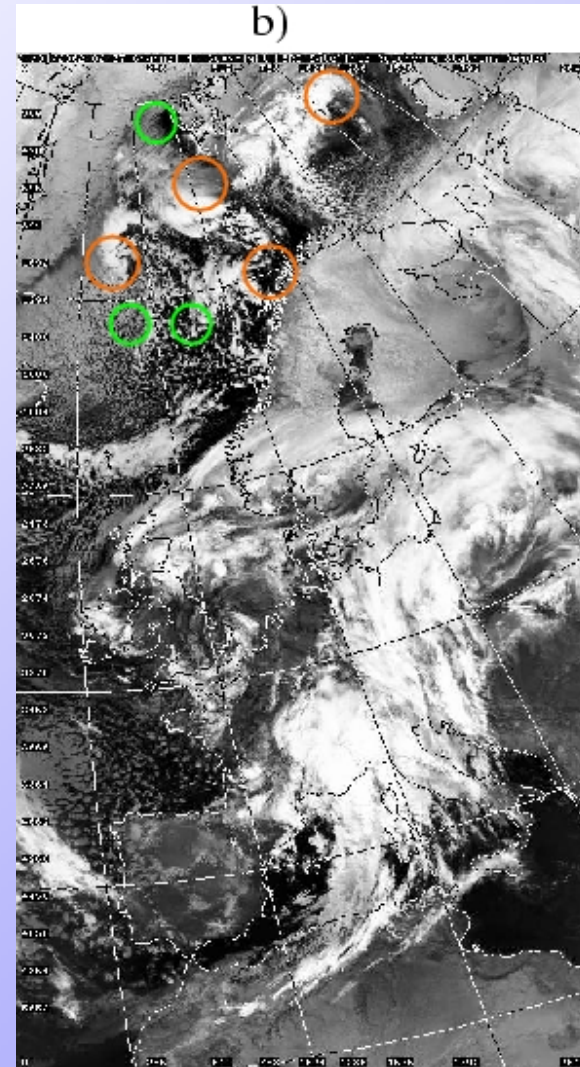
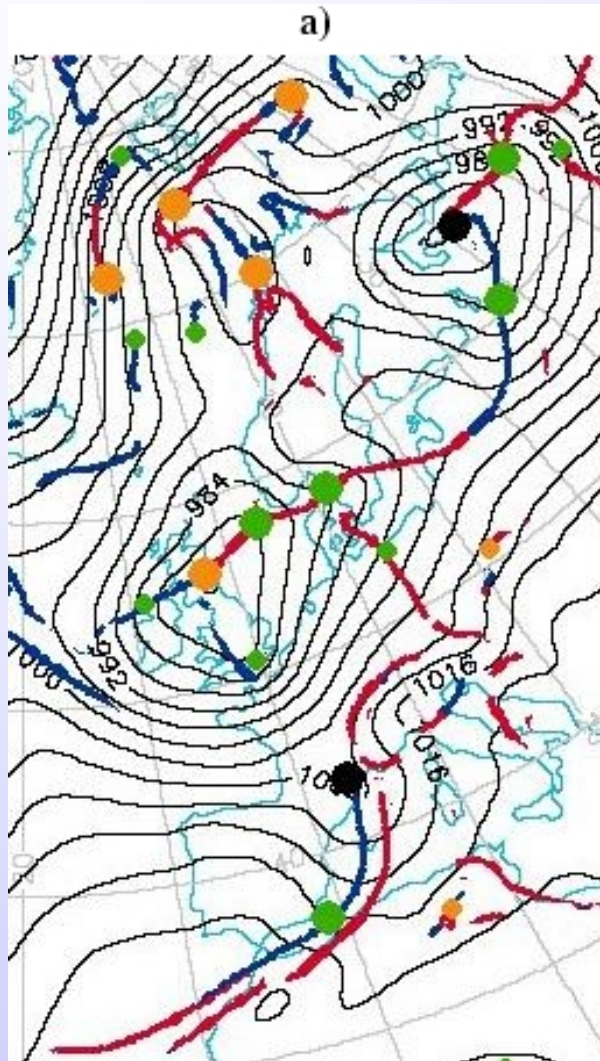
- A database of cyclones objectively identified in the UK Met Office global model. It covers the period from January 2000 to April 2004. Hewson (2001).
- For each cyclone a range of diagnostics and variables are stored.

Why choose the Cyclone Database to study polar lows?

- High resolution compared to reanalysis datasets.
- Designed to detect many features, including very weak disturbances. Typically 50 at any one time in the North Atlantic / Europe region.



# The Cyclone Database



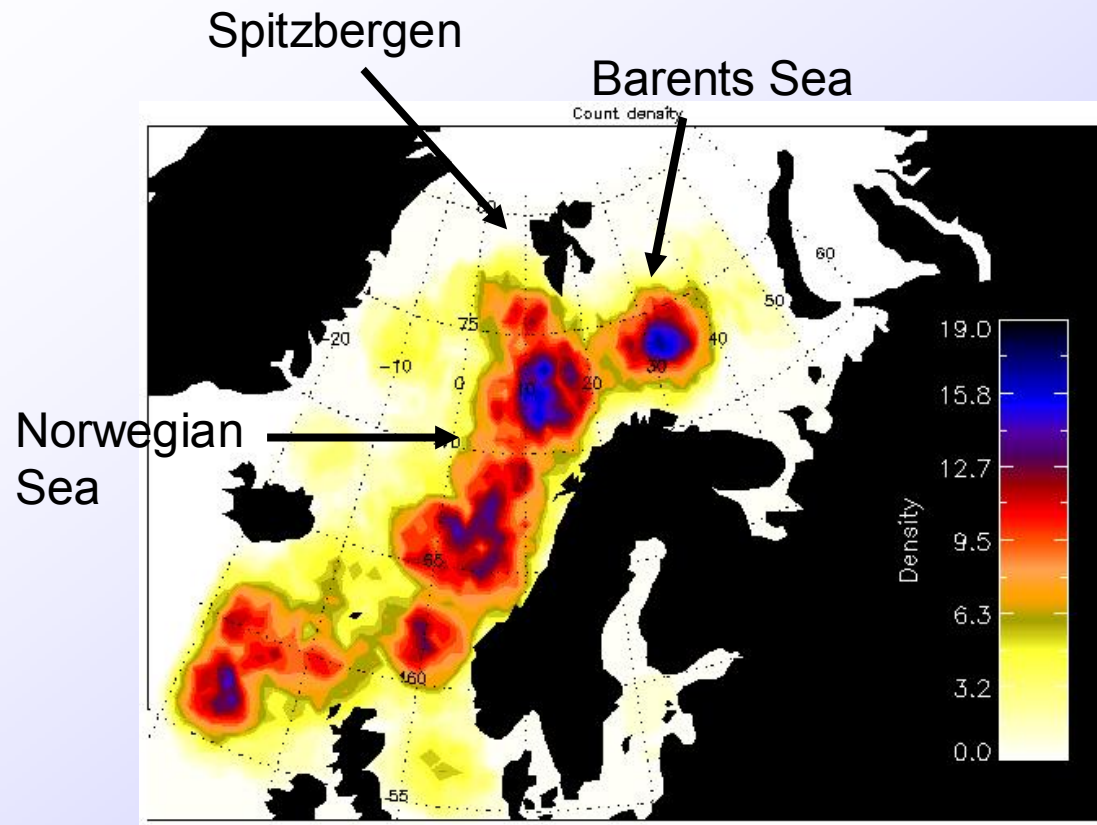


# Identifying polar lows in the Cyclone Database

- Polar lows were identified by constraining parameters in the Cyclone Database.
- Constraints and threshold values were chosen after identifying polar mesocyclones in satellite imagery for the period DJF '01/'02
- 76% of the polar mesocyclones subjectively identified on satellite imagery were collocated with cyclones in the Cyclone Database.
- After an assessment of various possibilities the following constraints were chosen:
  - Cold air outbreak.  $(\theta_{w700 \text{ hPa}} - \text{SST}) < -2.8^{\circ}\text{C}$
  - A vorticity-based strength constraint.

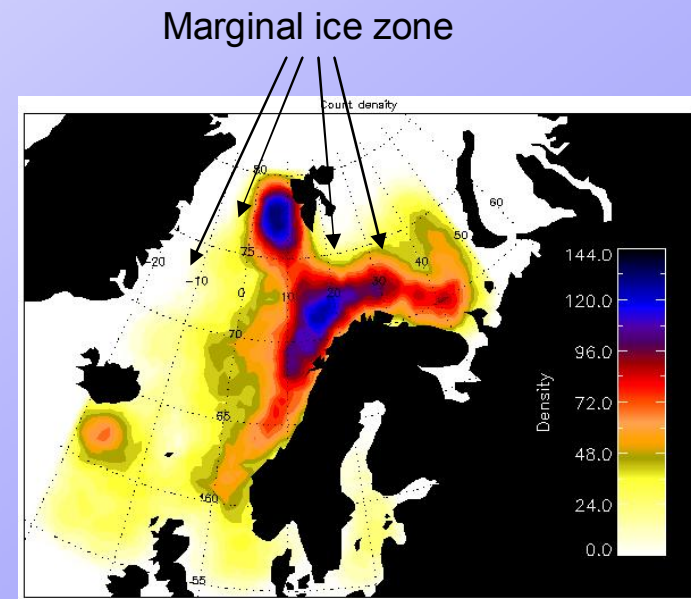


# Results: The spatial distribution of polar low activity



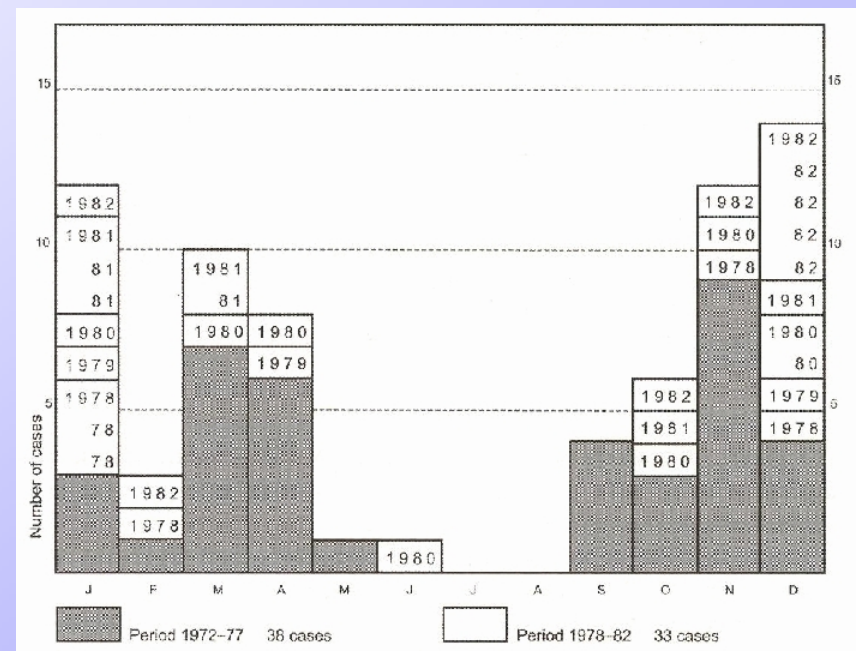
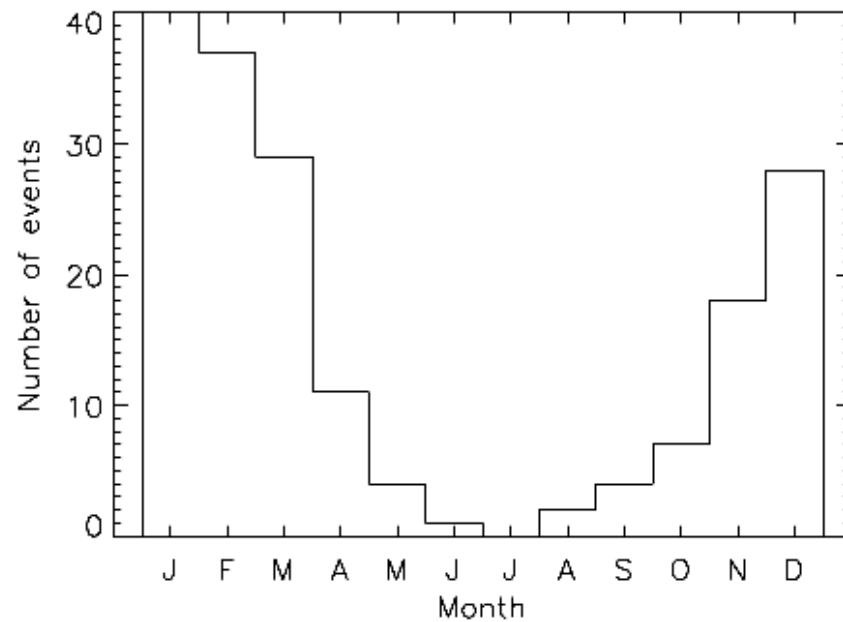
- Polar low **count density** from Jan 2000 to April 2004 calculated for area bins of  $\sim 125,000 \text{ km}^2$  (200 km radius)

No strength constraint applied



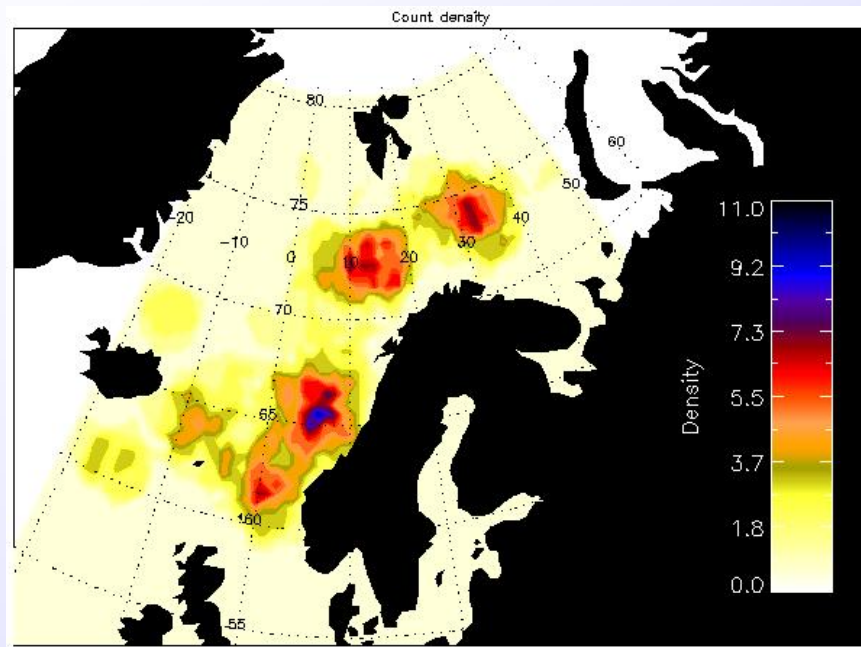


# Seasonal activity

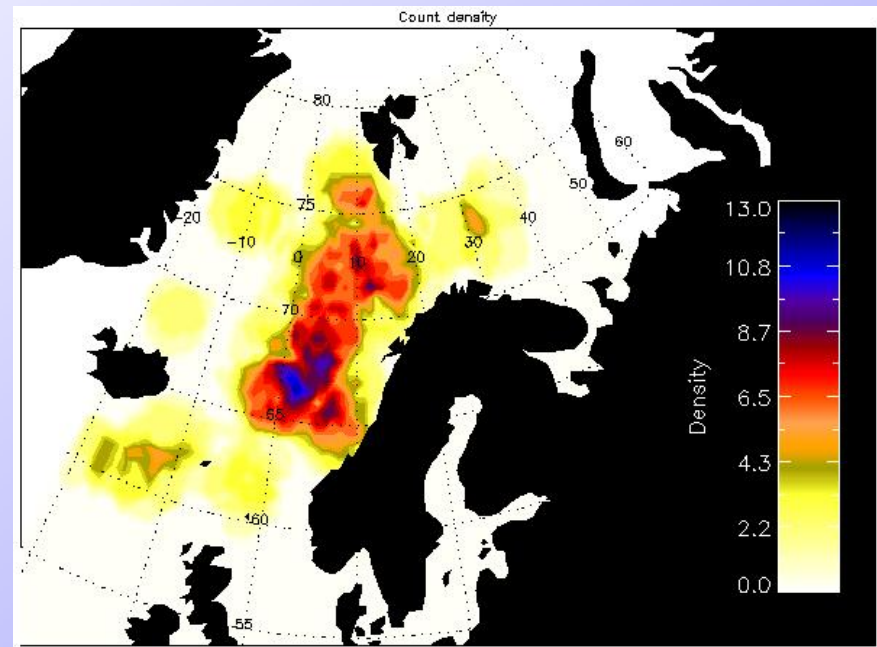


From Wilhelmsen (1985)

# Further constraints



Cold air advection  
 $-\mathbf{V} \cdot \nabla \theta_{600 \text{ hPa}} < 0$

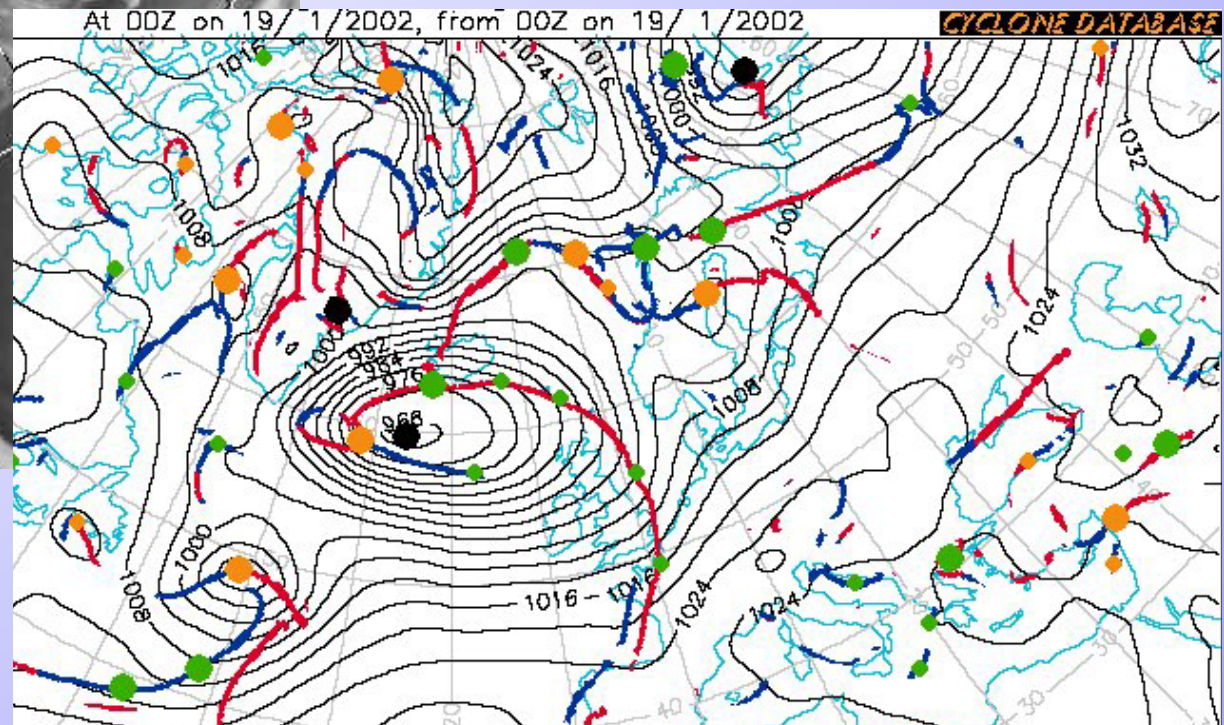


Northerly flow  
 $\mathbf{V}_{700 \text{ hPa}} < 0$



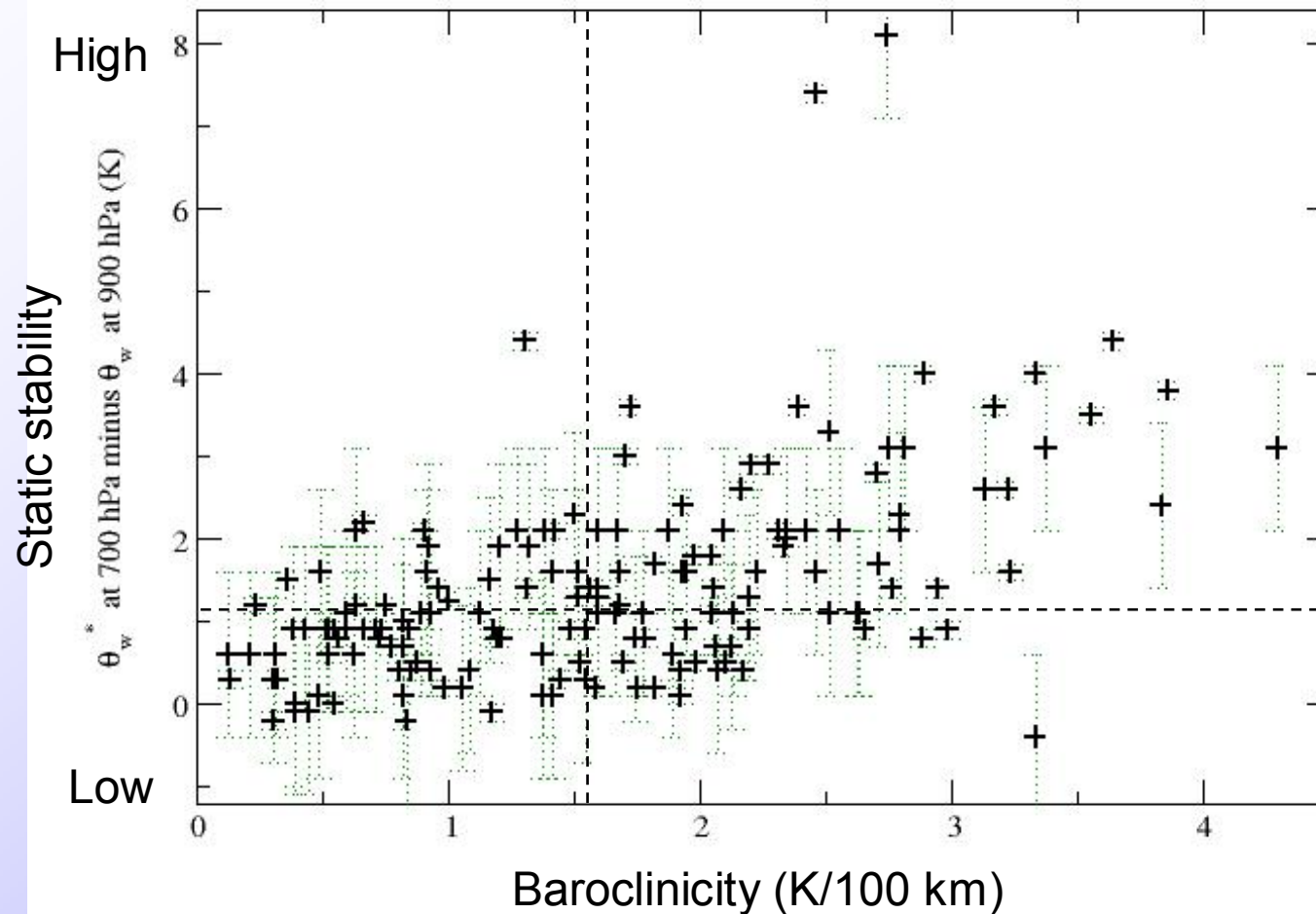
Channel 4. Copyright NERC Satellite Receiving Station, Dundee

The main image is a grayscale satellite photograph of the North Atlantic region, showing cloud patterns and landmasses including North America, Europe, and Africa. A grid of latitude and longitude lines is overlaid. At the top, a series of numbers (256, 512, 768, 1024, 1280, 1536, 1792) are displayed, likely representing data values or coordinates. In the bottom right corner, there is an inset map titled "At 00Z on 19/". This inset map shows a detailed view of a storm system with isobars (lines of equal pressure) and other meteorological features. The inset map includes a color scale at the bottom right, ranging from 0 to 100, which likely represents cloud top height or intensity.

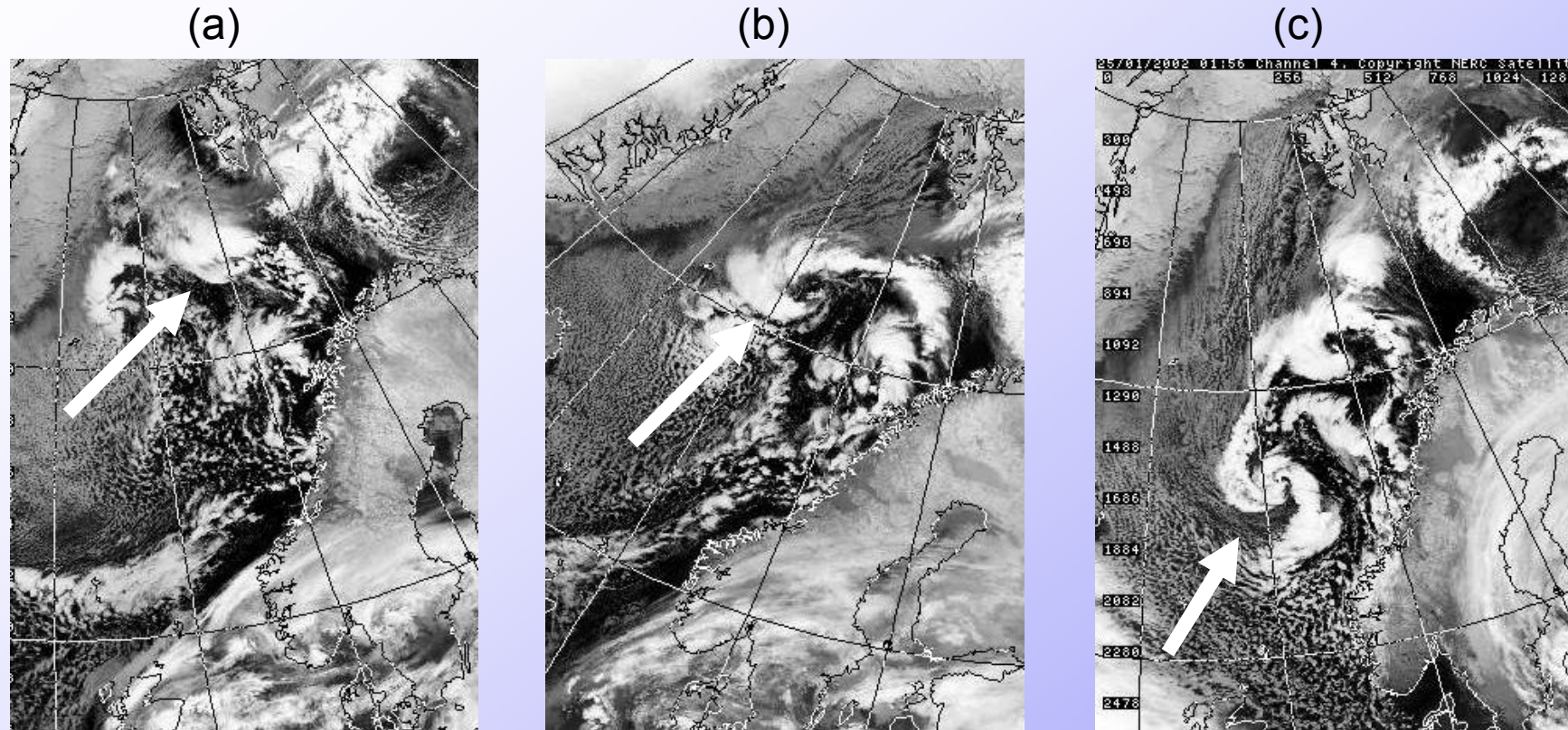




# The polar low spectrum in the Nordic seas, as seen in the Cyclone Database



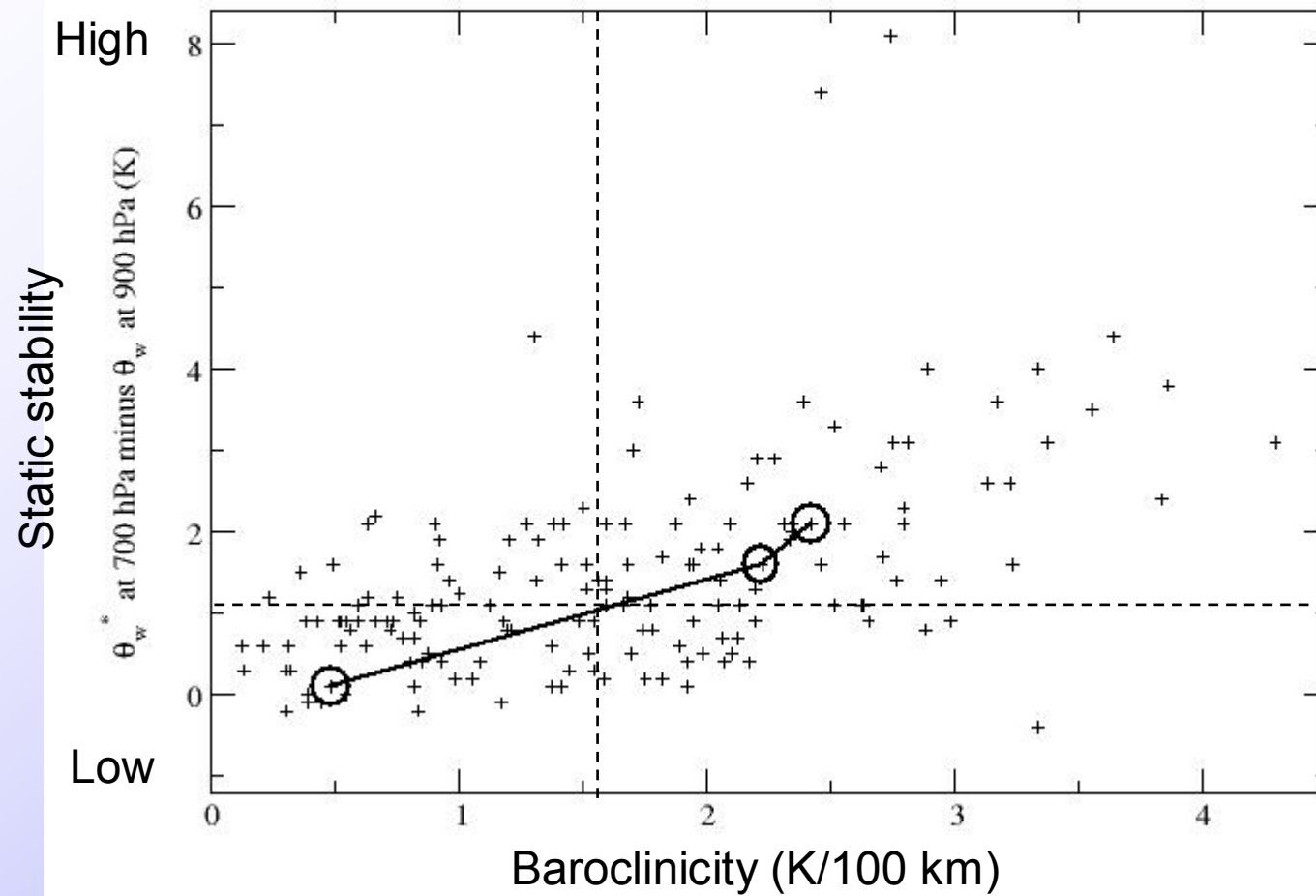
# A long-lasting polar low



NOAA IR imagery for (a) 0207UTC 24/1/2002, (b) 1202UTC 24/1/2002 and (c) 0156UTC 25/1/2002. Courtesy of the NERC Dundee Satellite Receiving Station.

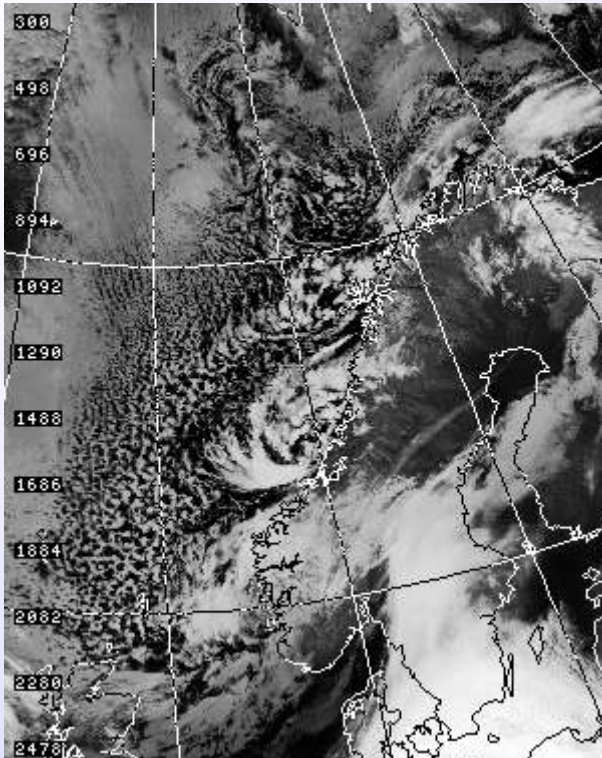


# A long-lasting polar low

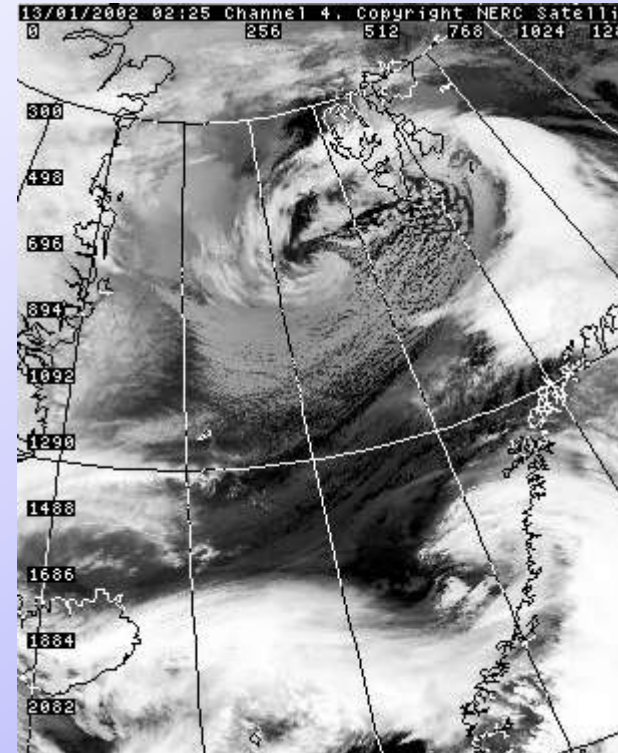




# Other examples



Low static stability and weak baroclinicity. 22/2/04

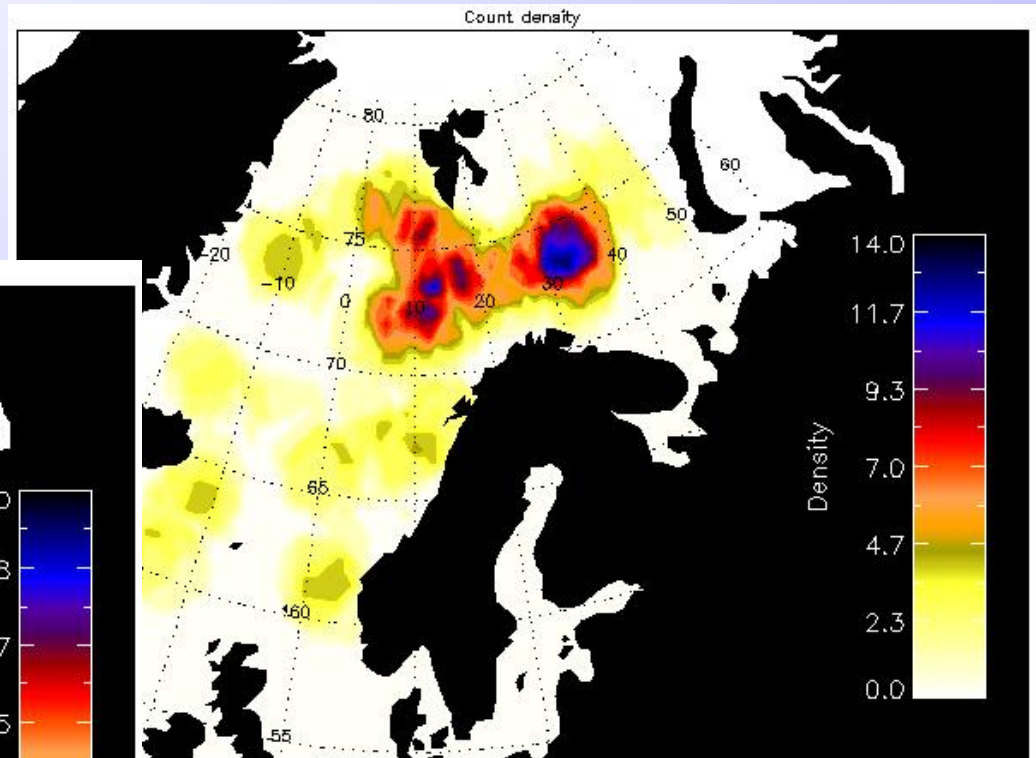
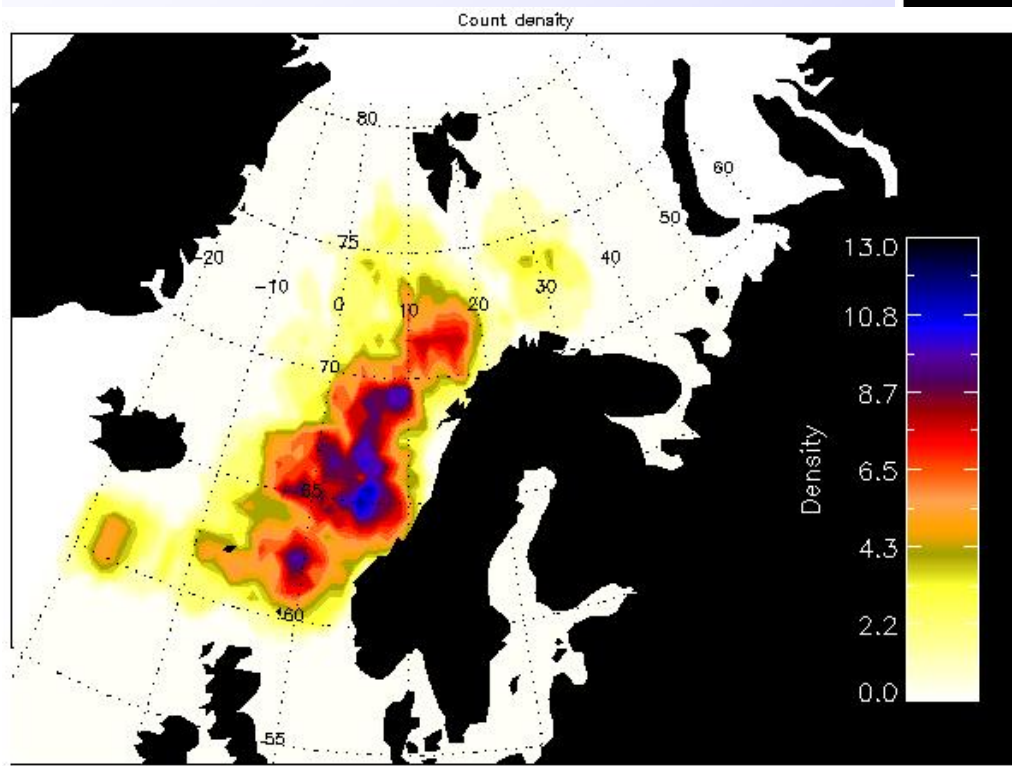


High static stability and strong baroclinicity. 13/1/02 00Z



# The spatial distribution of different polar low types.

Weak baroclinicity



Strong baroclinicity



# Conclusions

- A new systematic objective climatology of polar low activity has been derived from NWP data.
- Key regions identified are the Norwegian Sea, where the strongest polar low activity occurs, and potentially important genesis regions along the marginal ice zone.
- The results show a high frequency of weak cyclonic activity adjacent to Spitzbergen.
- The results are consistent with the concept of a 'continuous spectrum' of polar lows, with strong baroclinicity over the marginal ice zone and convection more likely to influence polar lows further to the south over the warmer Norwegian Sea.

