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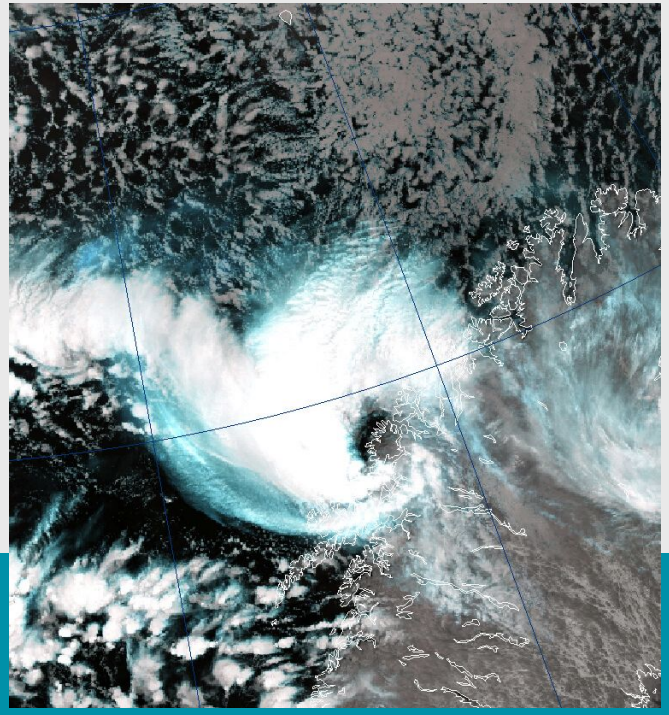


Polar Lows – Arctic hurricanes

Gunnar Noer

The Norwegian Meteorological Institute

Forecasting division of Northern Norway

30.01.2022

MET-Norway in brief...

National Weather Service:

- Land/Media: YR.no
- Maritime: MET area XIX
- Aviation: 64 airports, Norway/Oceanic FIR

Oslo

- SE-Norway, Administrative, Climate, R&D

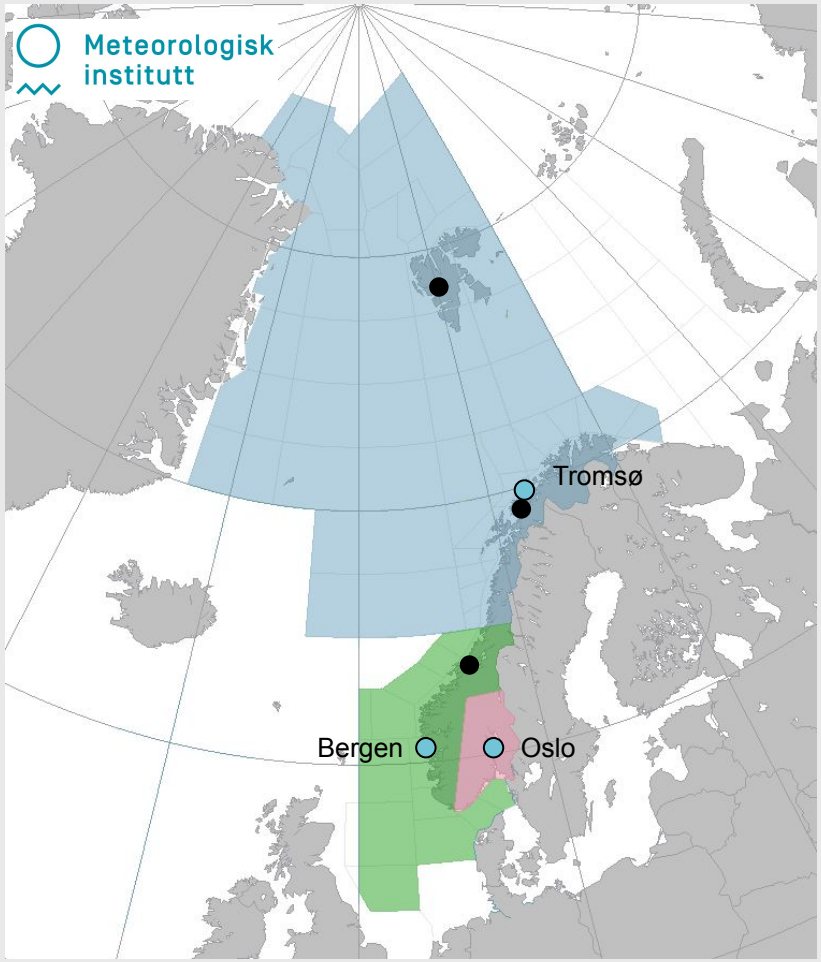
Bergen

- SW-Norway, Maritime

Tromsø

- N-Norway, Ice service

Local Met Service



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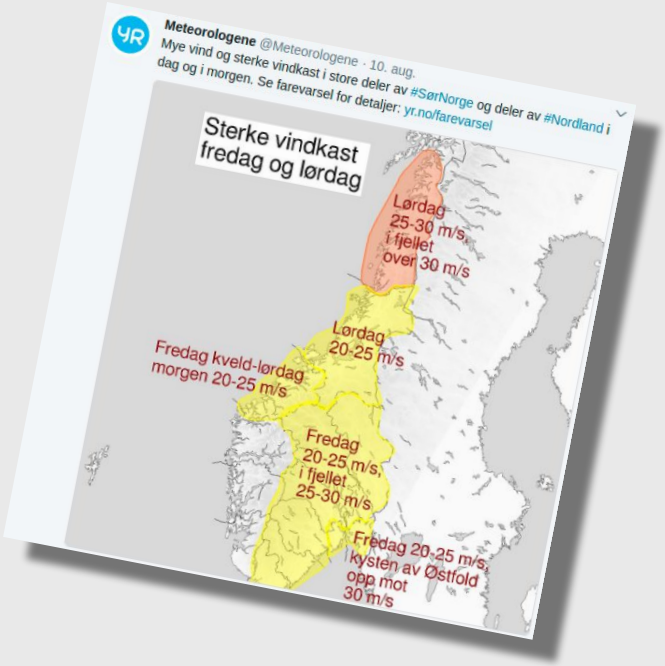
Primary forecasting tasks:

Met alerts, common alerting protocol (CAP)

- Wind / gusts
- Gale warnings
- Rain, snow, flash floods
- Difficult driving conditions
- Polar lows
- Vessel Icing
- High tides
- Forest fire



Other forecasting formats:

- Land: YR.no, Text forecasts ++
- Media (social): YR.no, Twitter, TV and newspapers
- Marine: MET area XIX
- Aviation: TAF, IGA, SIG-maps, Route forecasts

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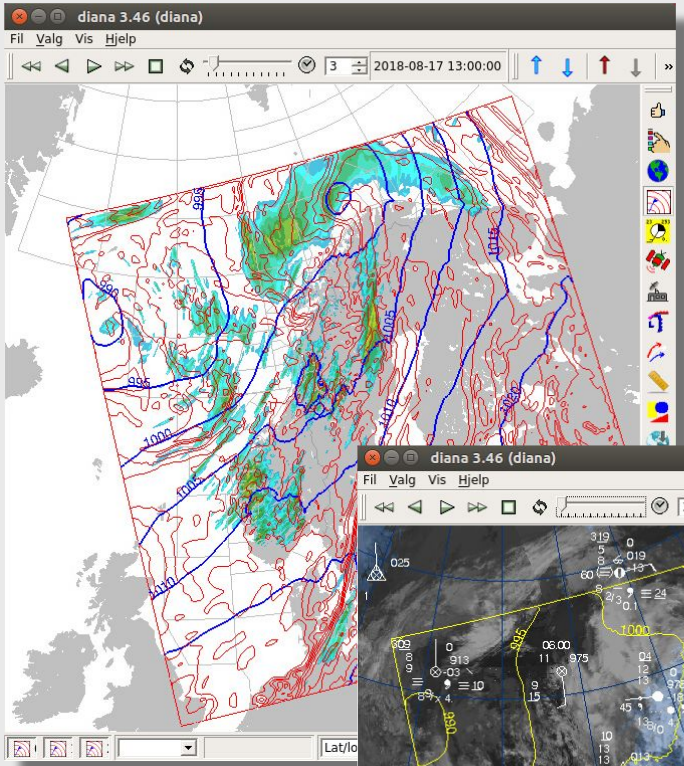
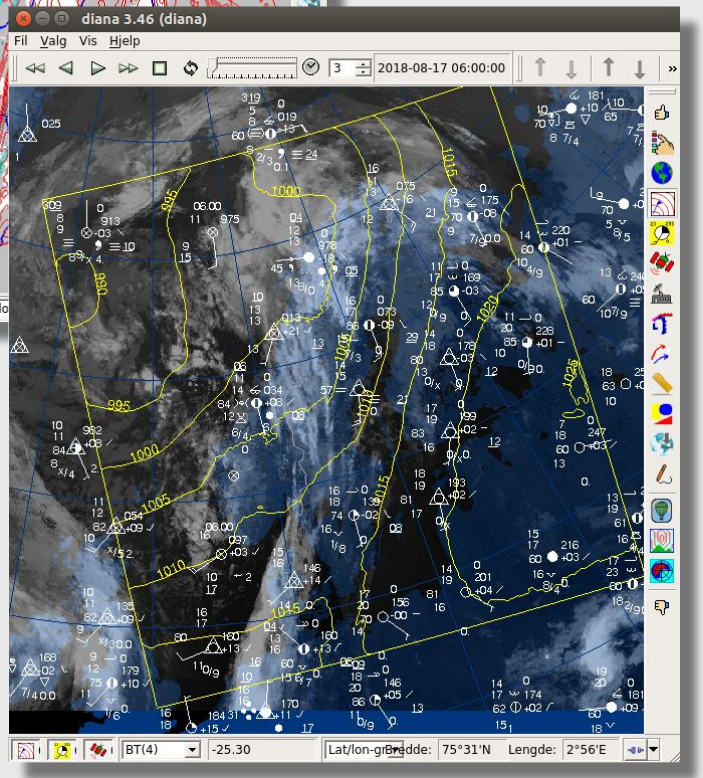
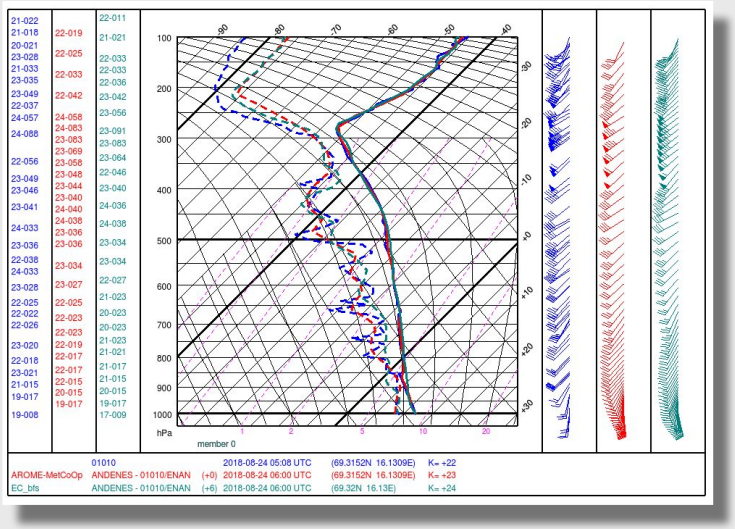
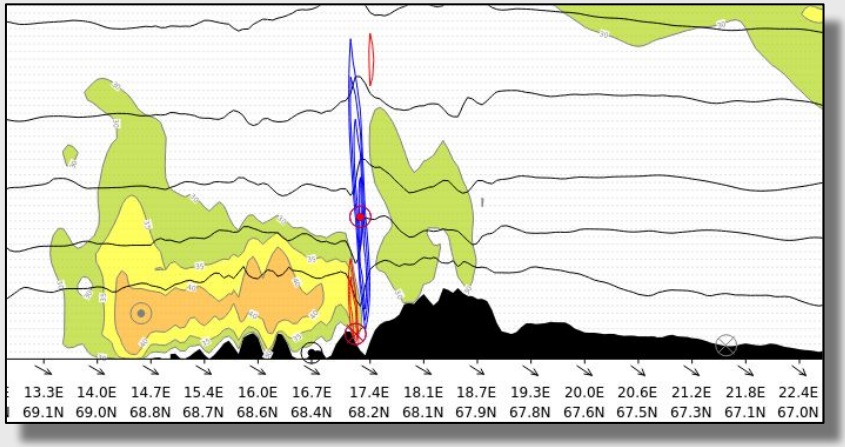
The DIgital ANAlysis (DIANA) presentation tool:



NWP models, satellites and observations integrated







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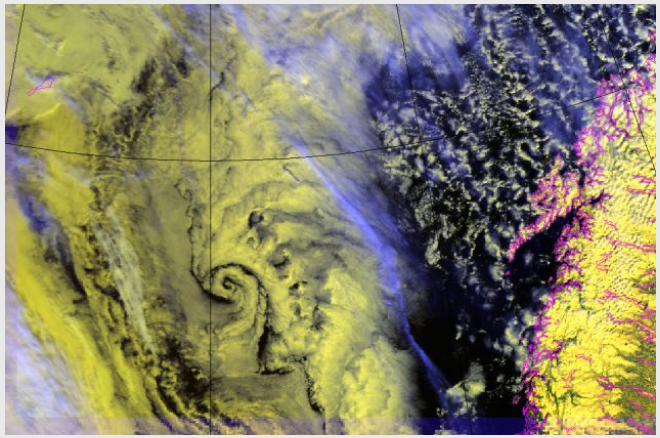
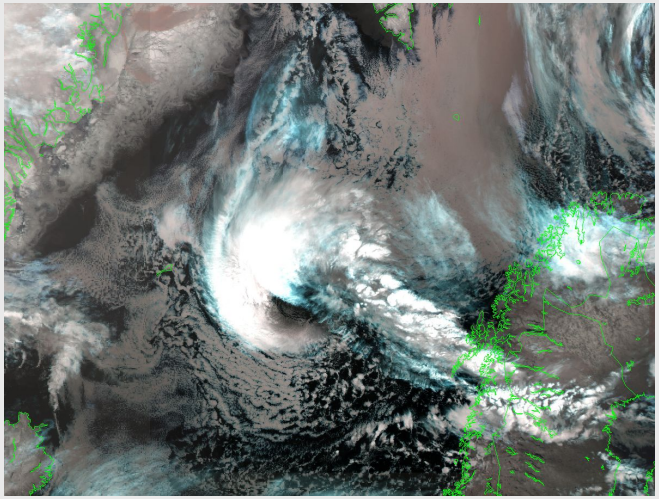
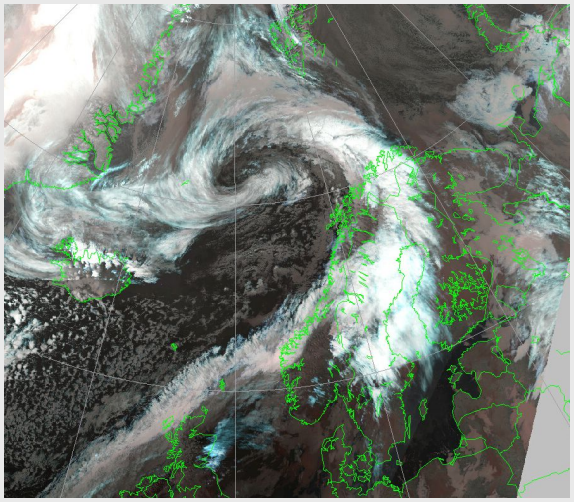
An introduction to the polar low:

Which one is a polar low ?







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An introduction to the polar low:

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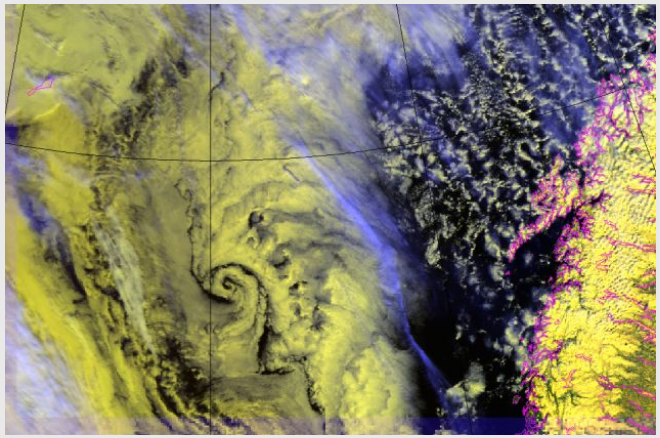

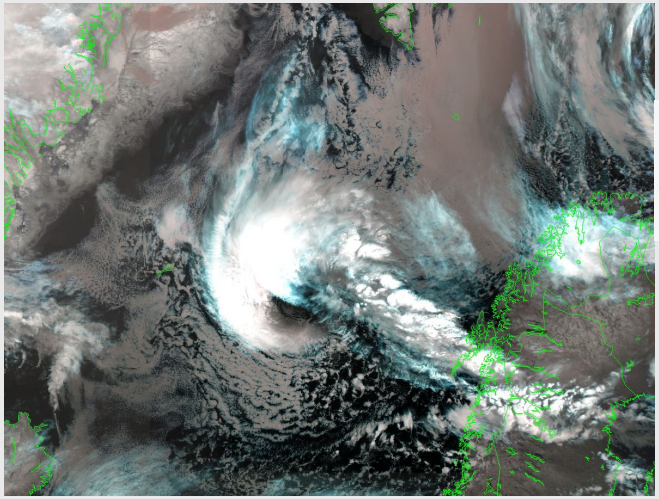

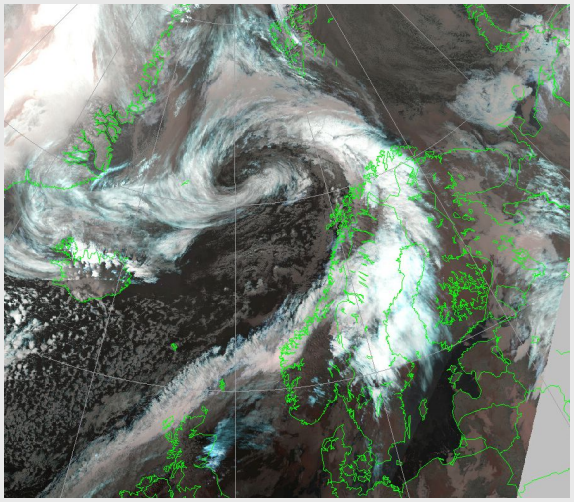

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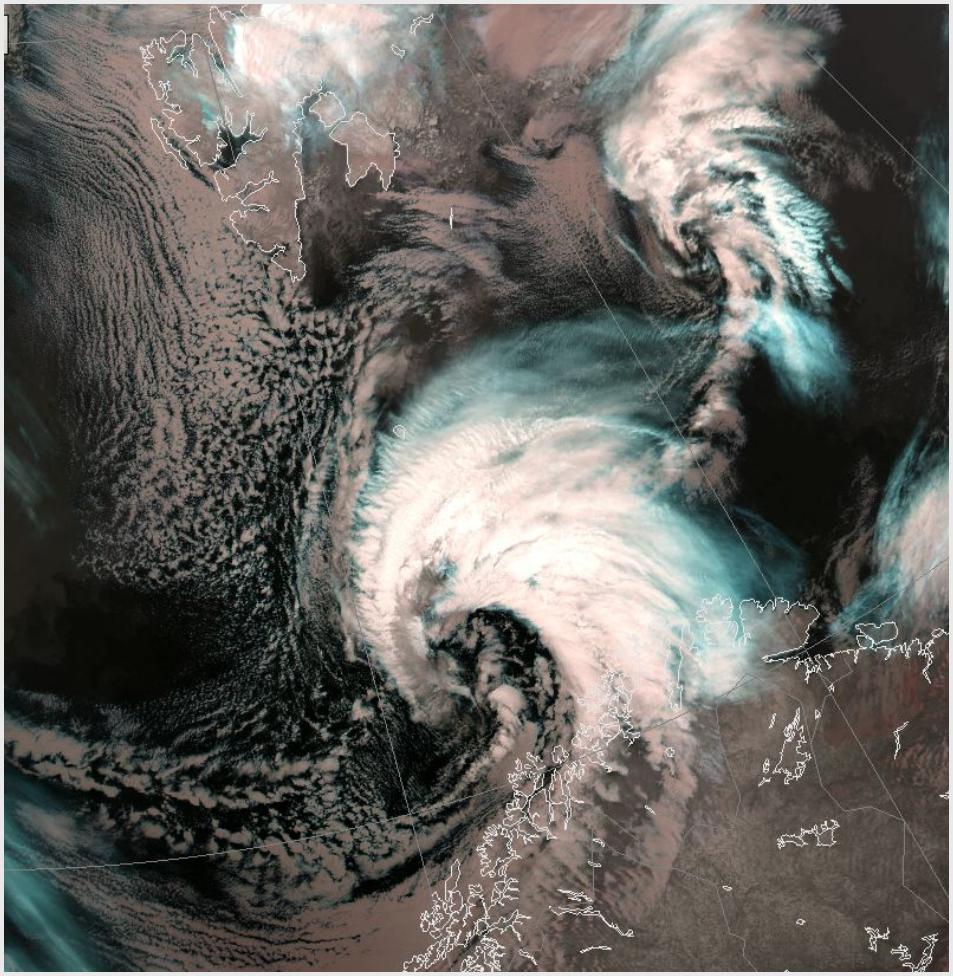
Definition of the polar low:

'A small but fairly intense low i maritime regions well north of the polar front. Diameter 150 to 600km, 10 m wind > 13,8 m/s (near gale)'



A polar low over the Barents Sea, 24.March 2014

Norwegian Meteorological Institute

Weather and consequences:

- Gale or storm force winds with sudden changes in wind speed and direction
- Heavy snow and hail showers, visibility less than 100m in blowing snow
- Widespread traffic disruptions
- Avalanches
- Vessel icing
- Risk of damage to coastal fisheries

Photo: Torgeir Bråthen


Photo: Torgeir Bråthen

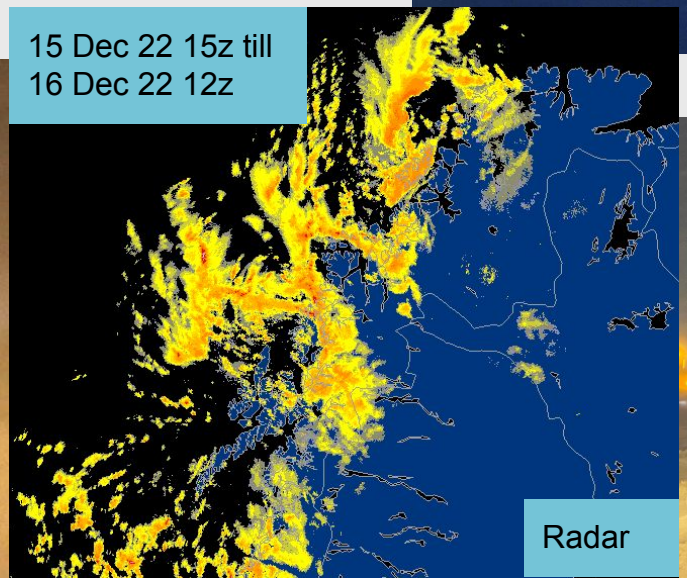
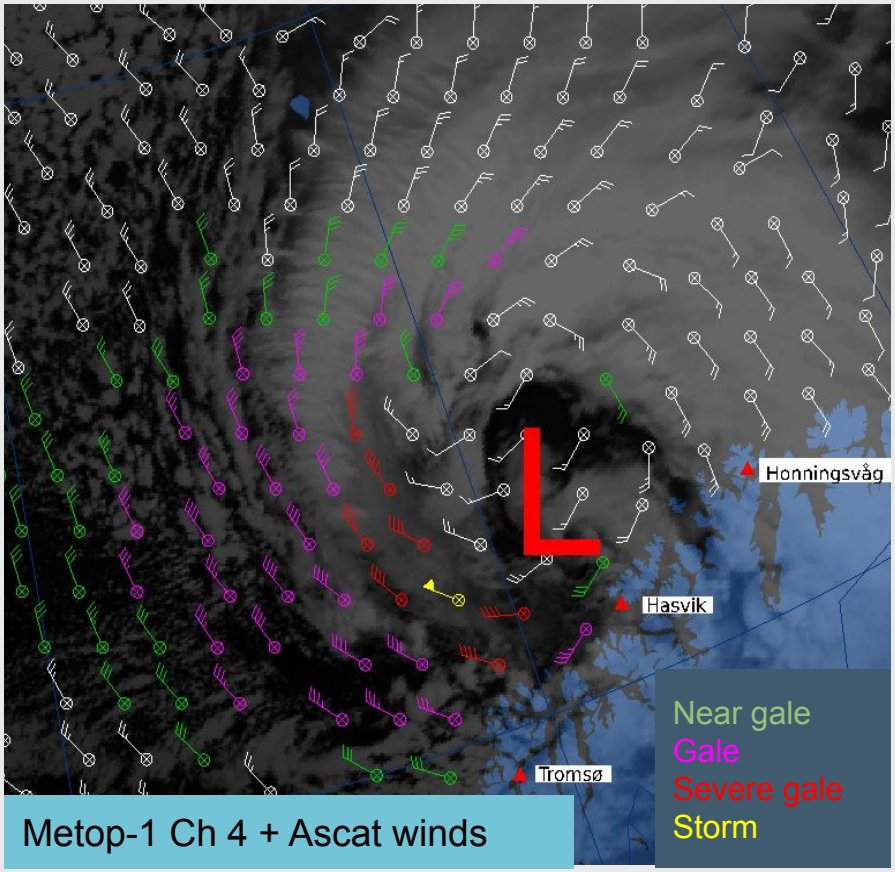



Photo: Malin Straumsnes

Wind characteristics of the polar low

- Average observed max wind 21 m/s (B9, strong gale)
- 25% have 25 m/s (Storm B10) or more
- Strongest recorded since 2000 had 35 m/s for more than 12 hours
- Strongest wind usually in the west or southwest side of the low, from NW to NE
- Rapid changes of wind, 5 to 25 m/s in less than 15 minutes



Metop-1 Ch 4 + Ascat winds

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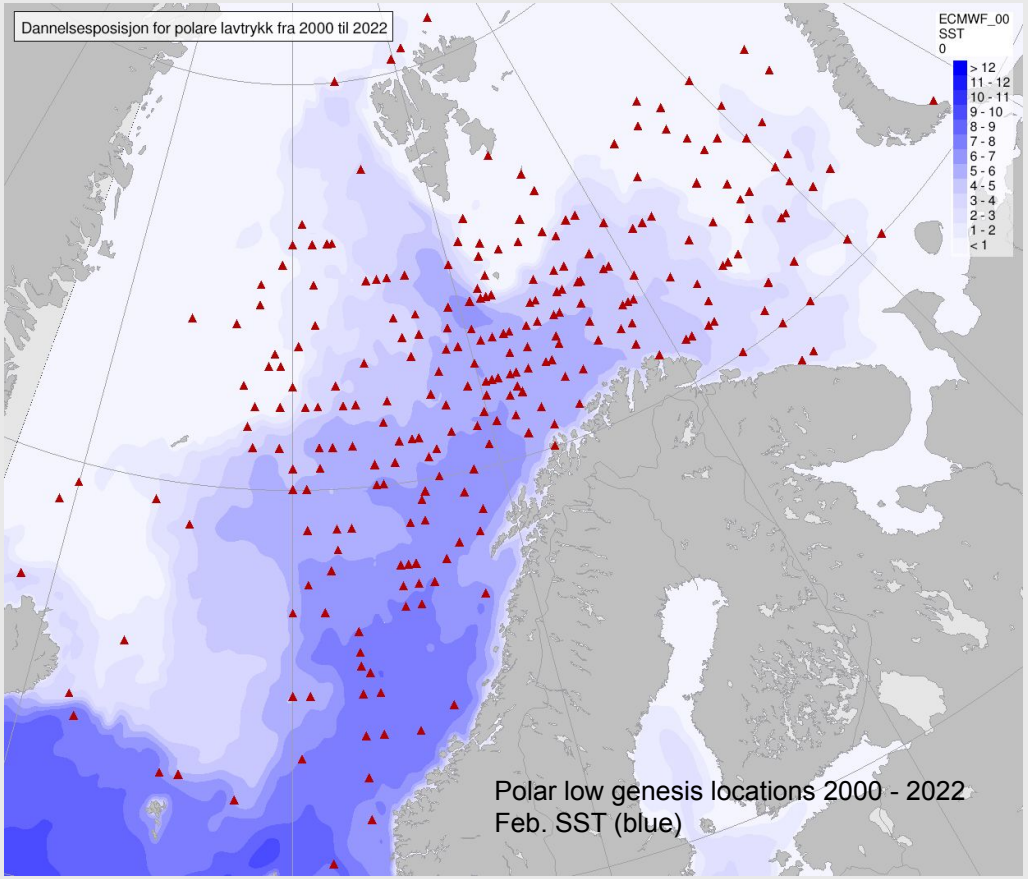
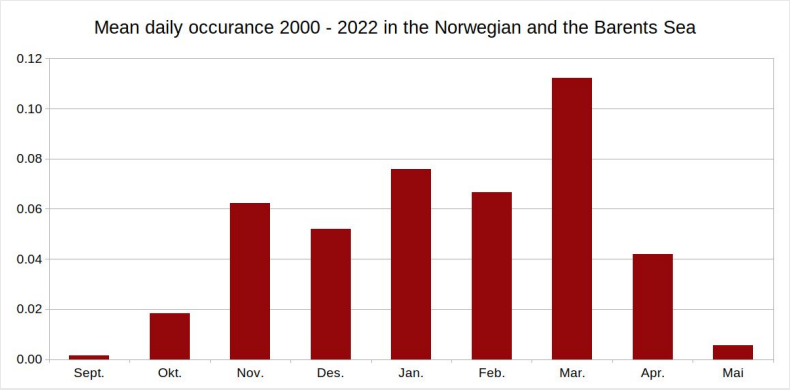
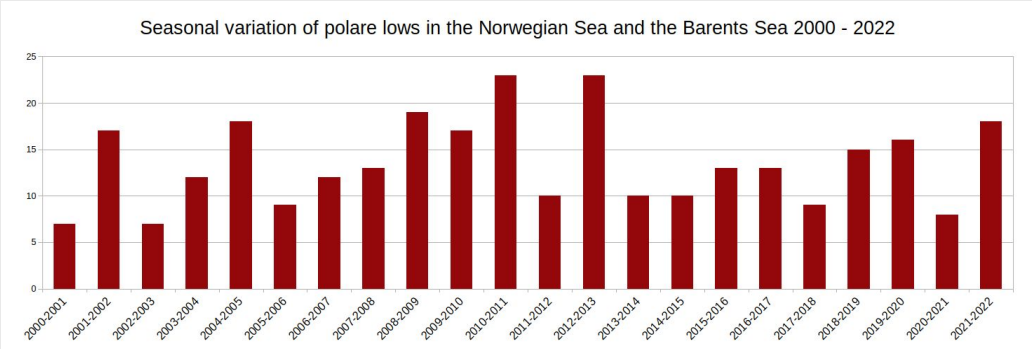
Some climatology:

- Season from October till May, max in Dec. to March
- On average 14 events pr. year with one or more low centras in the Norwegian and Barents Sea
- Large interannual variation, especially at the start and end of the season
- Little or no trend in occurrence or intensity from 2000 til present







Key physical preconditions:

1. A Cold Air Outbreak (CAO) from the Arctic ice

2. A marine mixed layer (MML) that is heated and destabilized from the sea surface. Strong inversion at the top.

3. A cold core from the marine mixed-layer inversion and up to above 500 hPa.

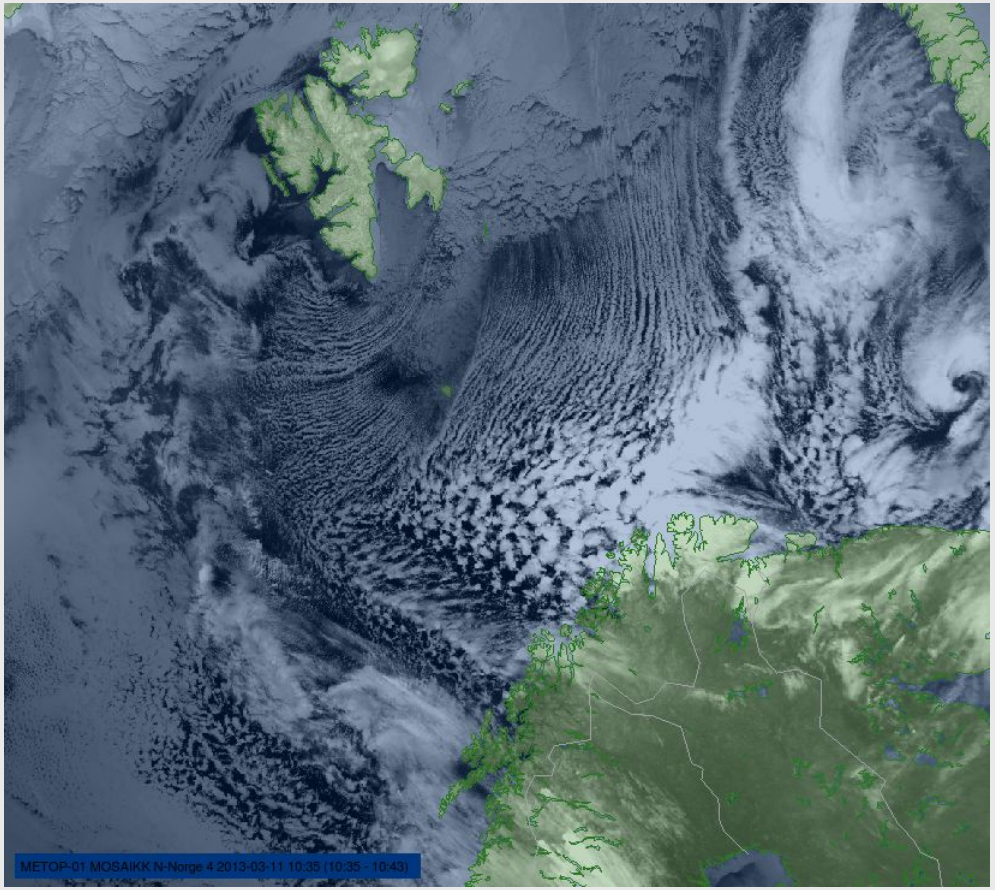
4. Positive vorticity advection, for stretching and further destabilizing.

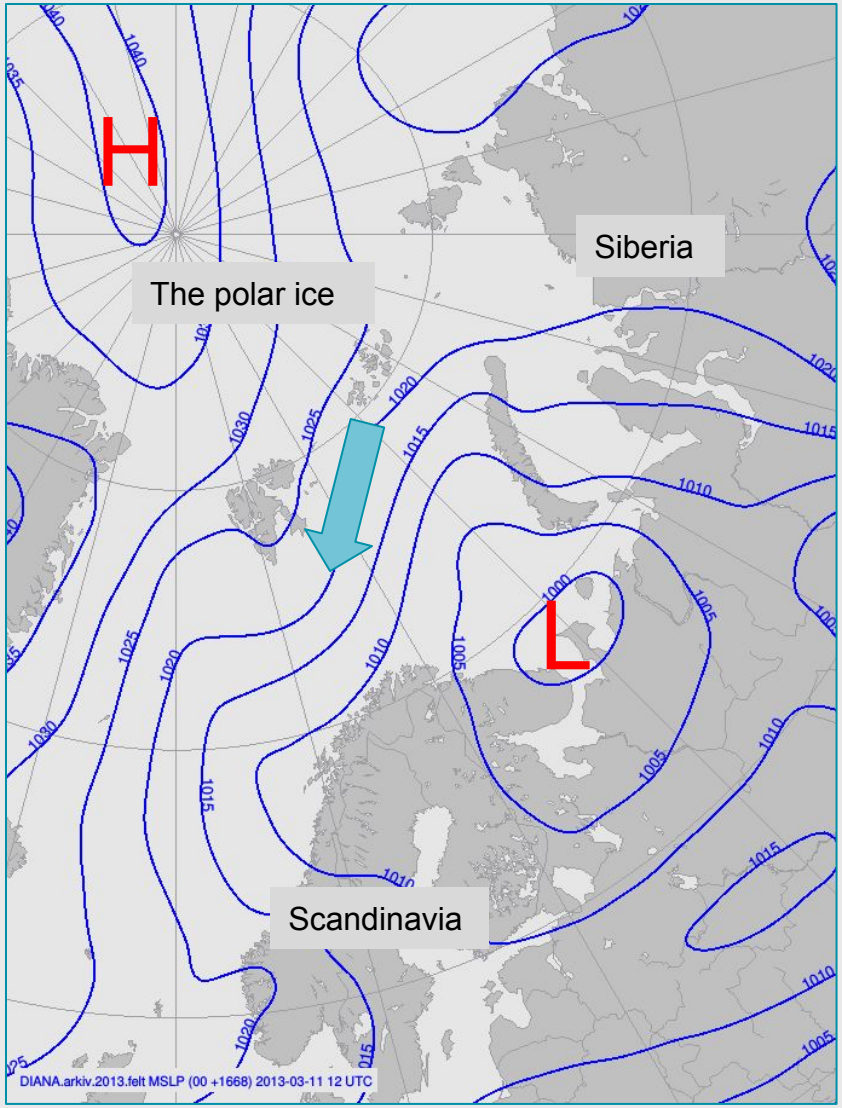
5. An area of instability at low levels;
   - Baroclinic, convective, convergence

6. Favorable conditions: CISK and reversed shear.

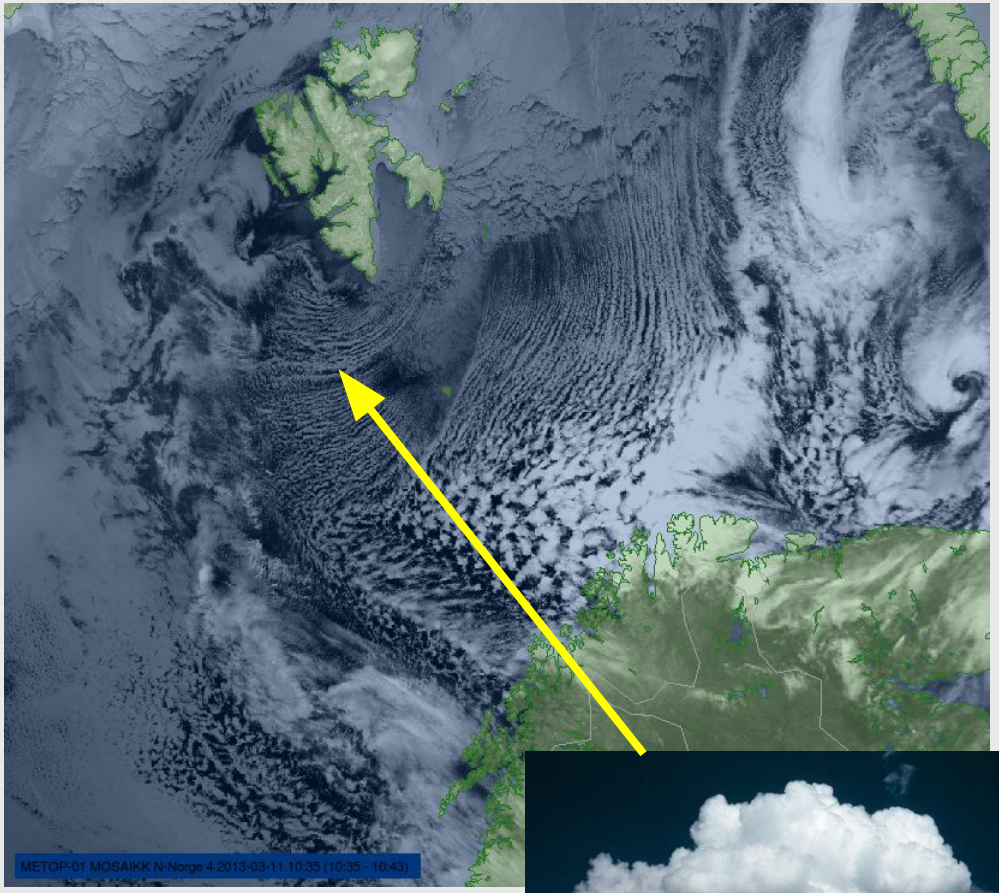
- **Polar lows develop when the MML inversion is broken down, from a mix of different kinds of instabilities and dynamic forcings.**

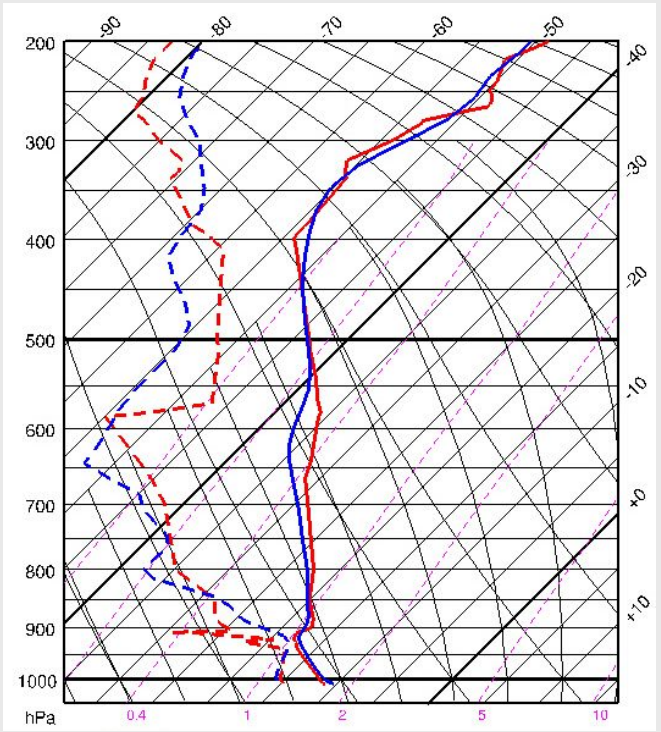
The Cold Air Outbreak





The Cold Air Outbreak

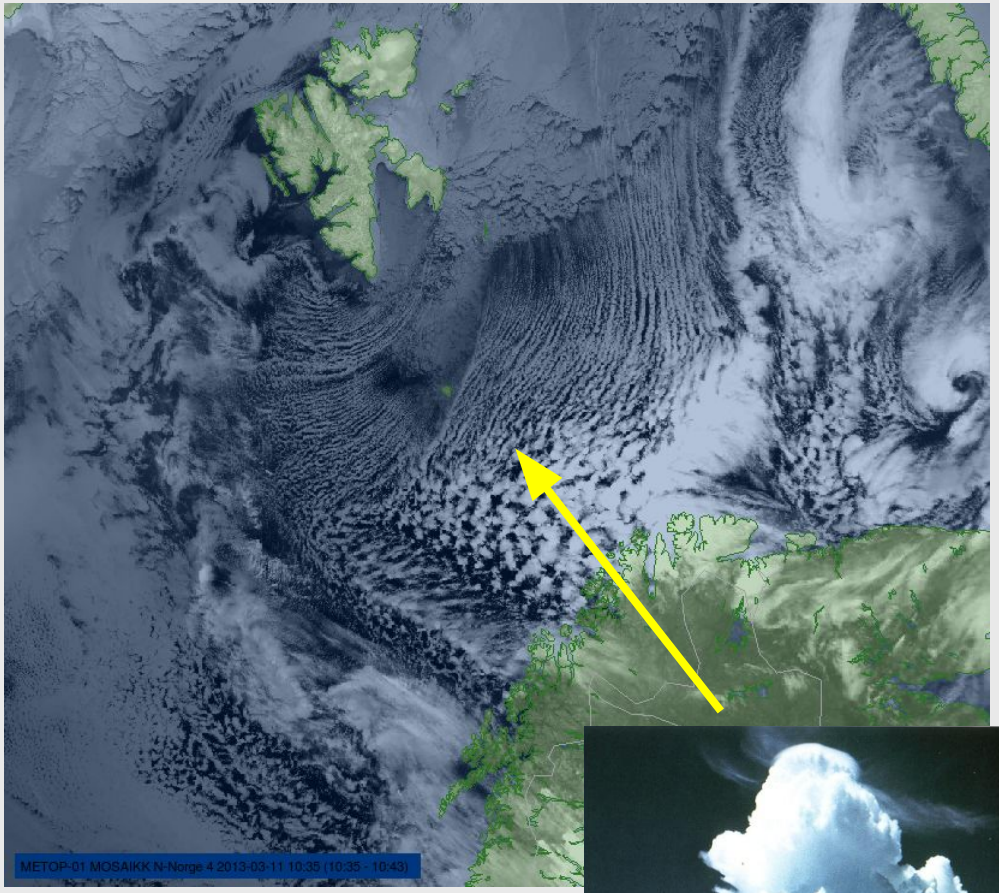




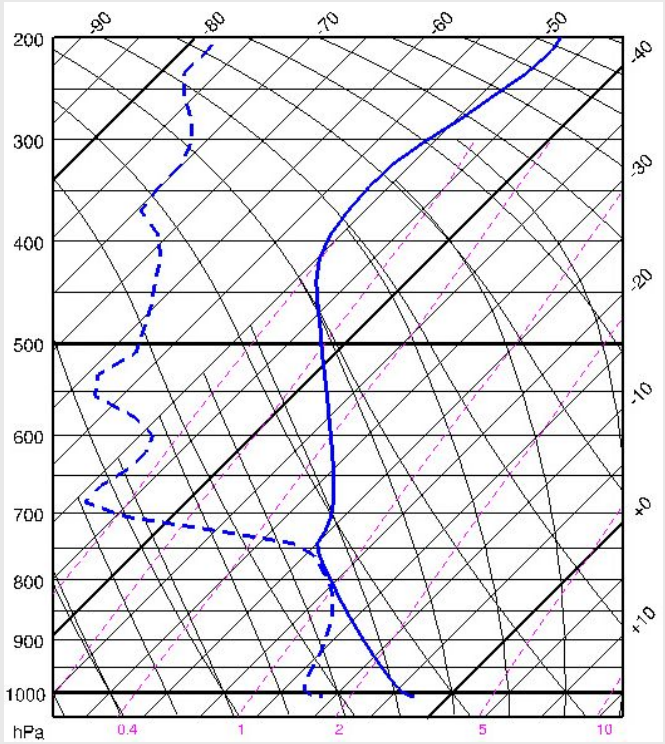
Cumulus Humilis / Fractus

Norwegian Meteorological Institute

The Cold Air Outbreak



Cumulus
Congestus (TCu)



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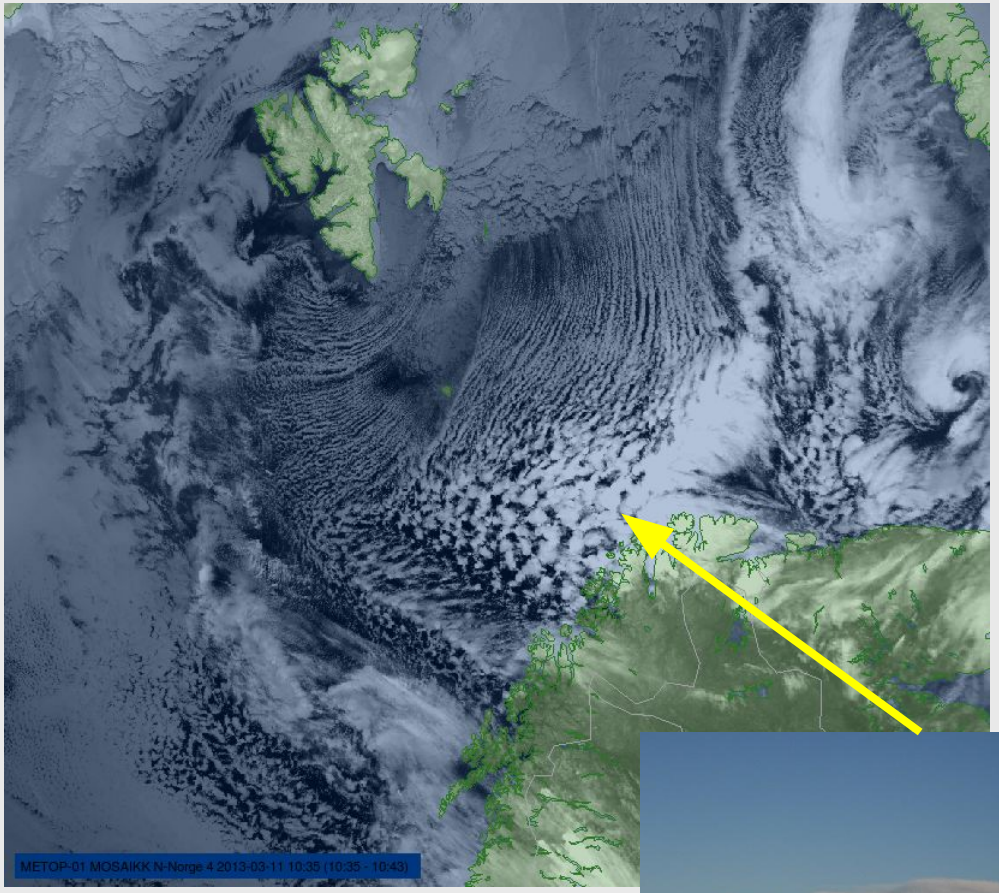
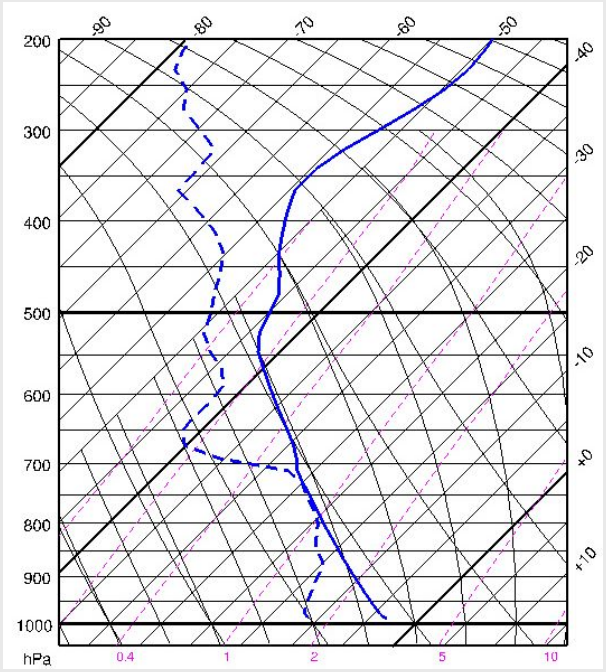
The Cold Air Outbreak





Cumulonimbus
Incus (Cb)

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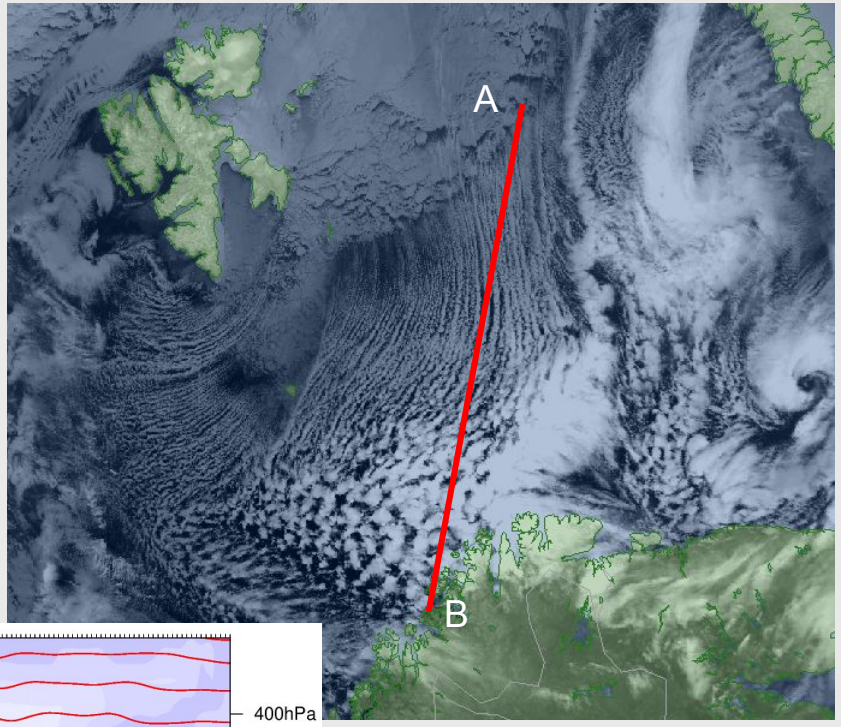
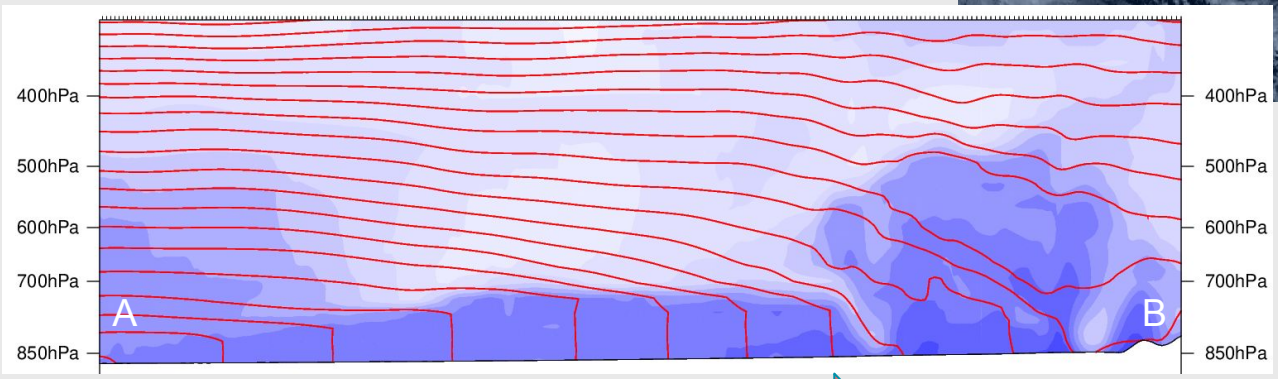
The Marine Mixed Layer



Relative humidity
Potential temperature



Increasing sea surface temperature

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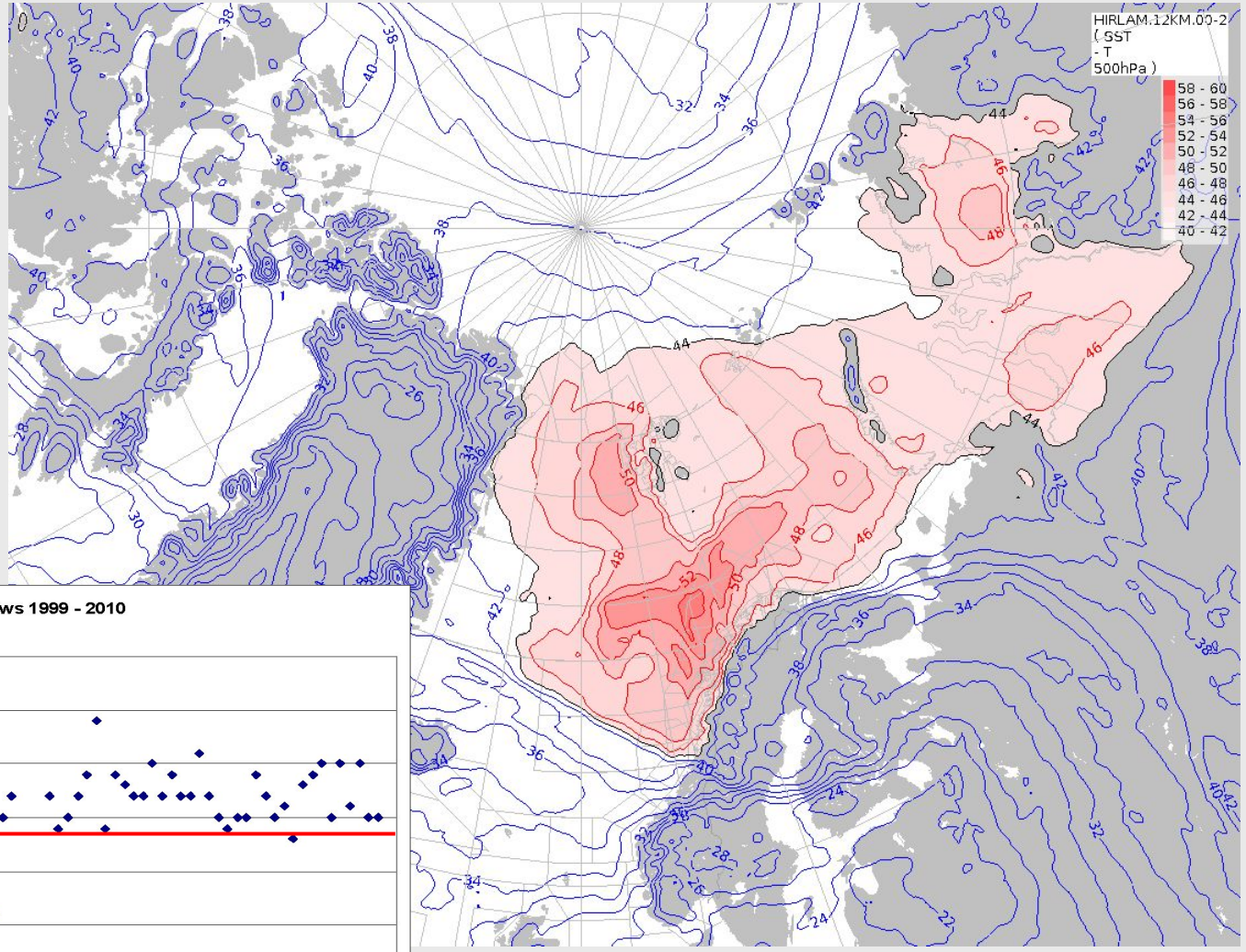
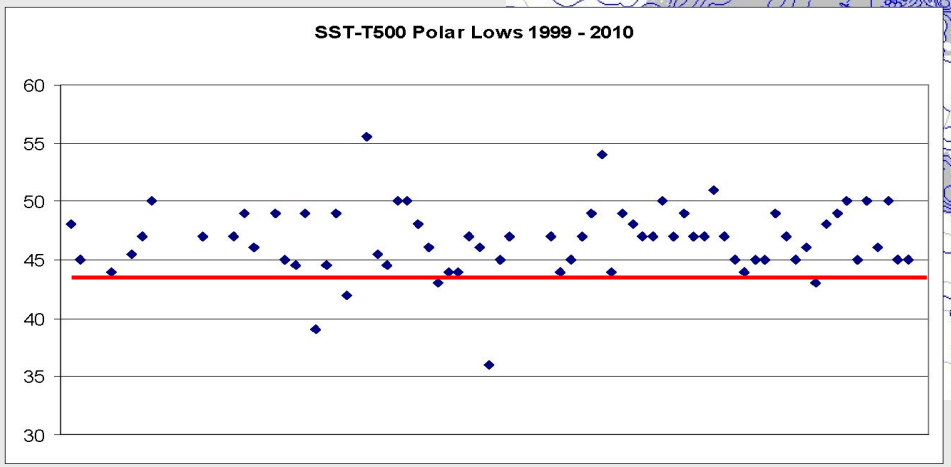
The upper cold core:

Criteria:

Maximum values for the cold cores:
SST - T_{500hPa} > 44 ℃

Vertical (gridpoint) values:
SST - T_{500hPa} > 40 ℃





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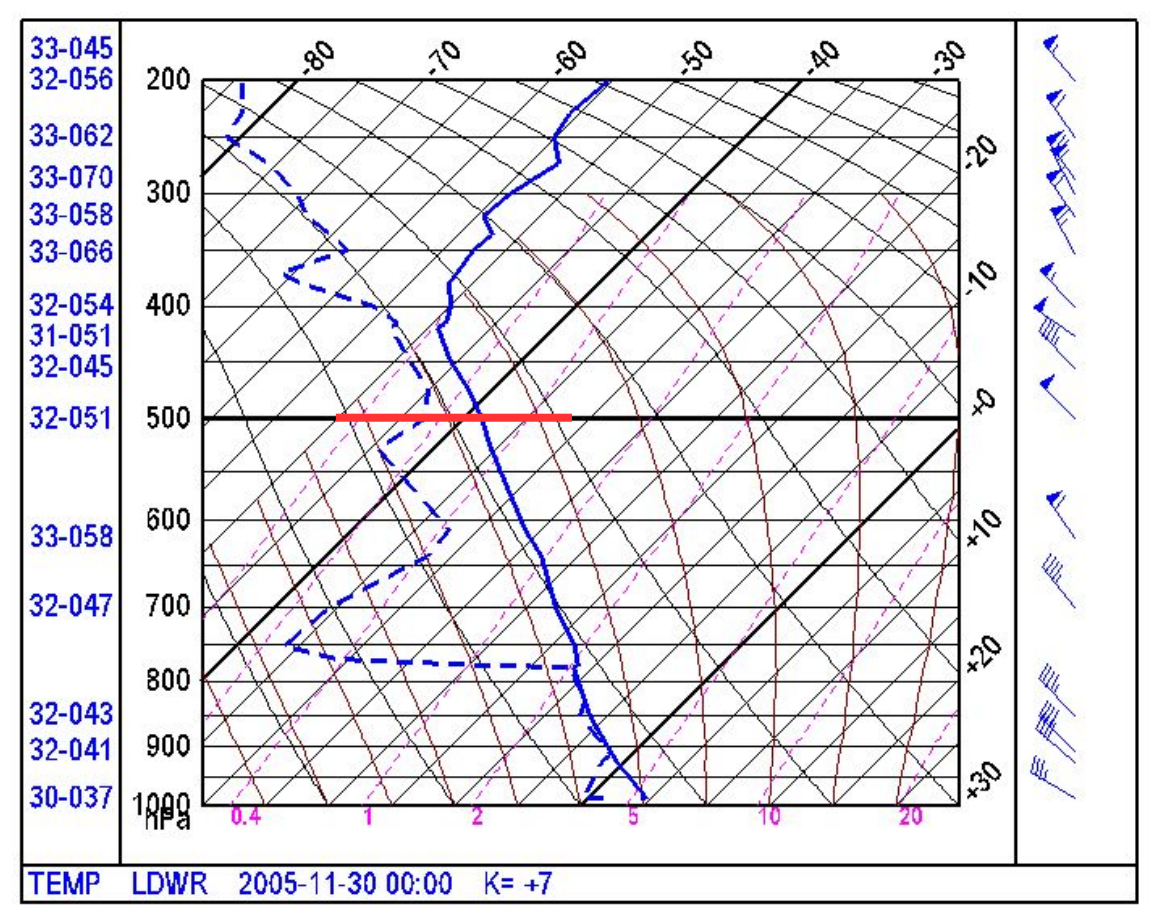
Instability up to 500 – 400 hPa

Actual sounding from the ‘Mike’ weathership from Nov. 2005, passing through a polar low



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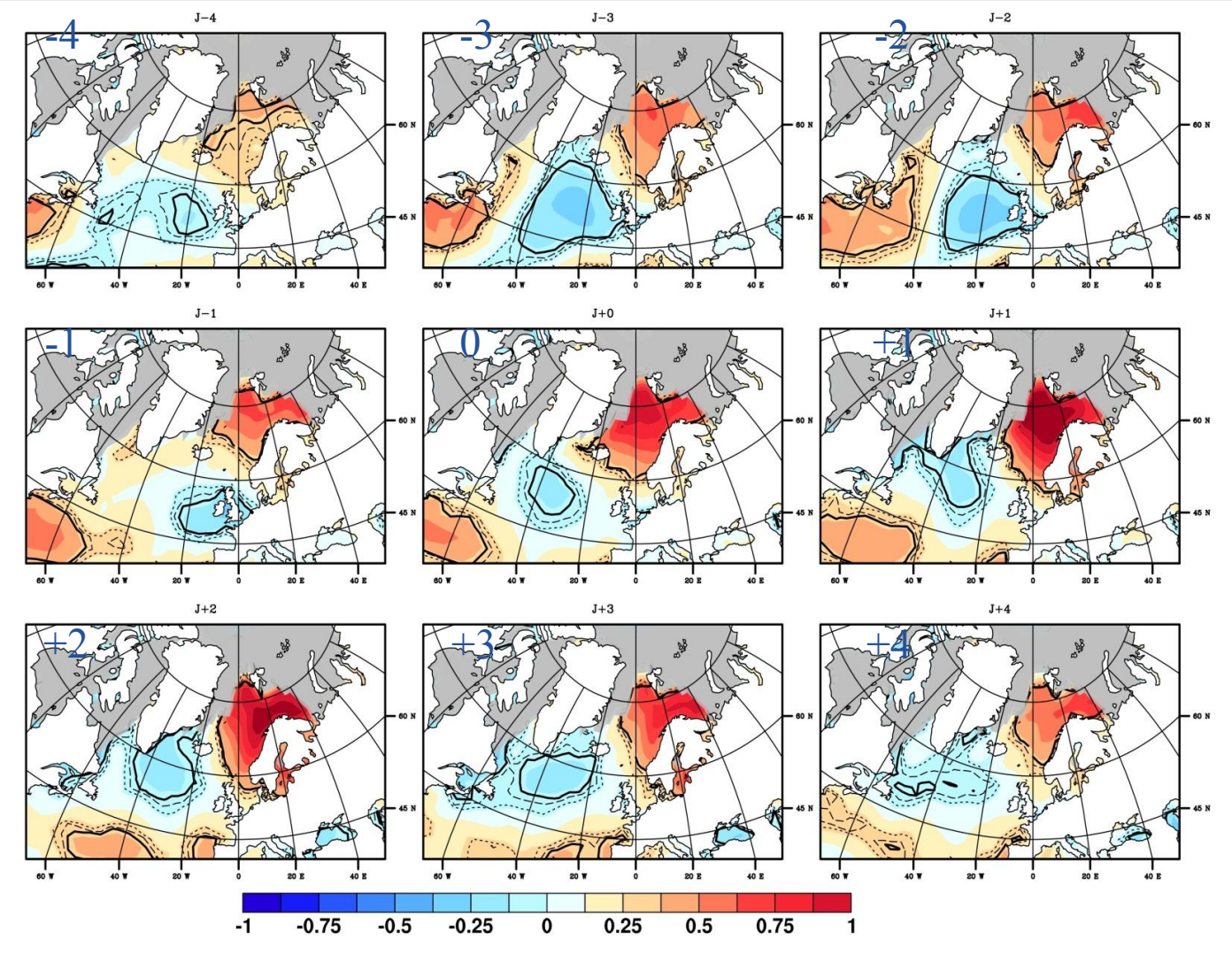
Time evolution in the Cold Air Outbreak

Standard deviation of the temperature potential SST - T_{500}

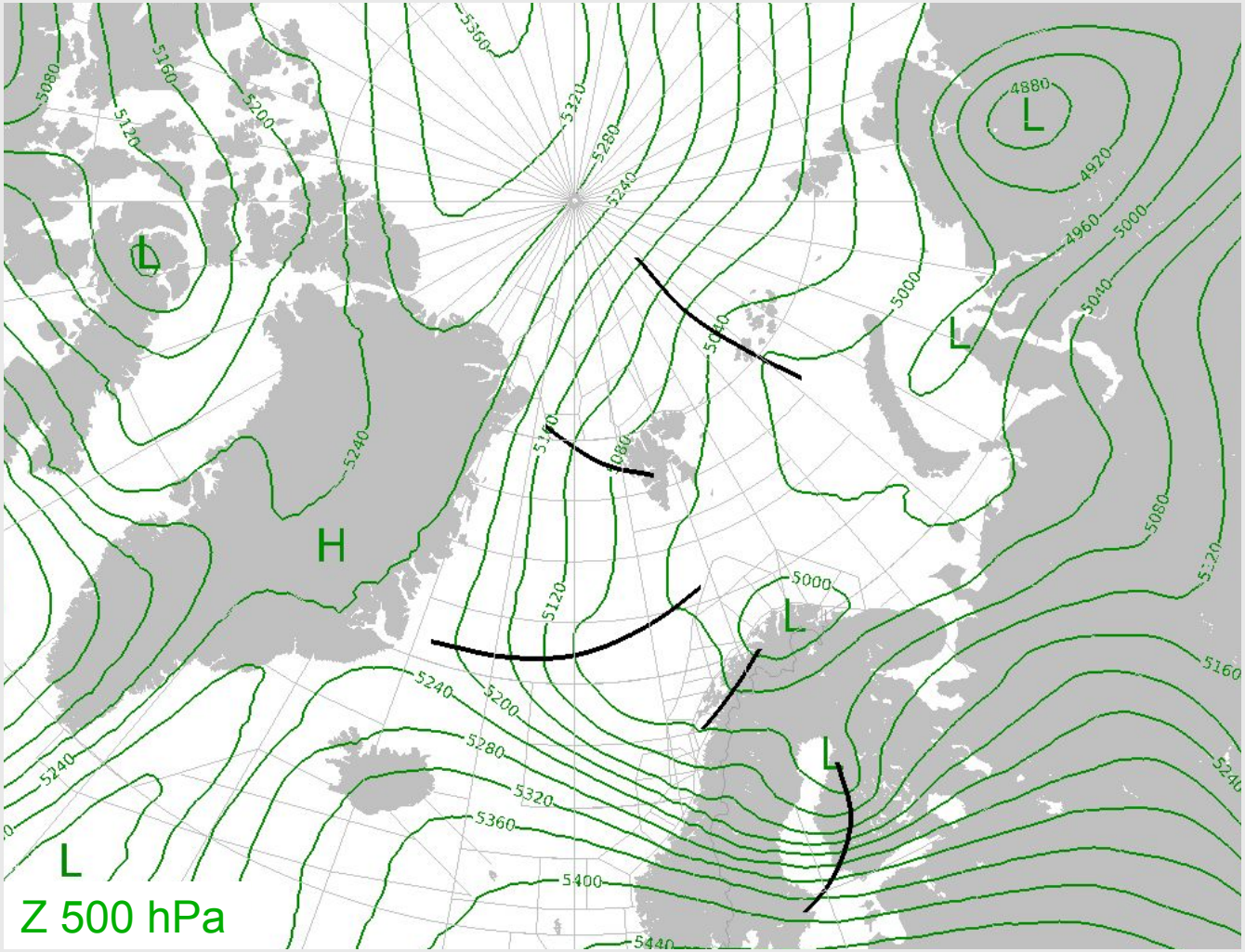
J+0 is day of development



Polar lows over the Nordic and Labrador Seas: Synoptic circulation patterns and associations with North Atlantic-Europe wintertime weather regimes.
Mallet, Claud, Cassou, Noer, and Kodera, 2012

The upper trough and PVA:

- Slow moving
- Phase lock
- Low values of PVA



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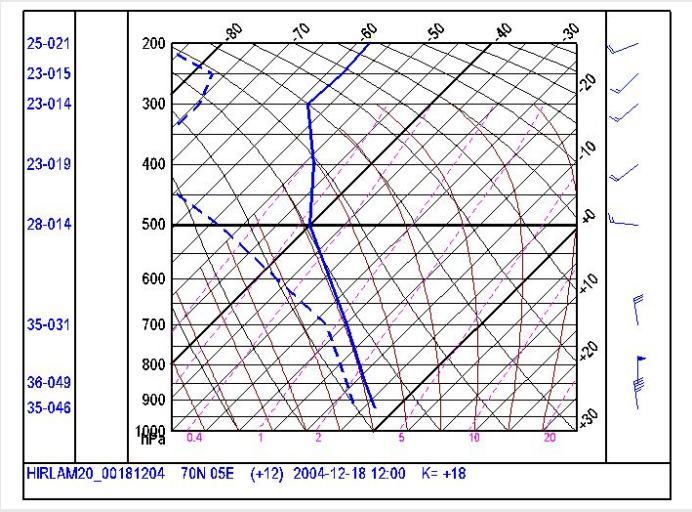
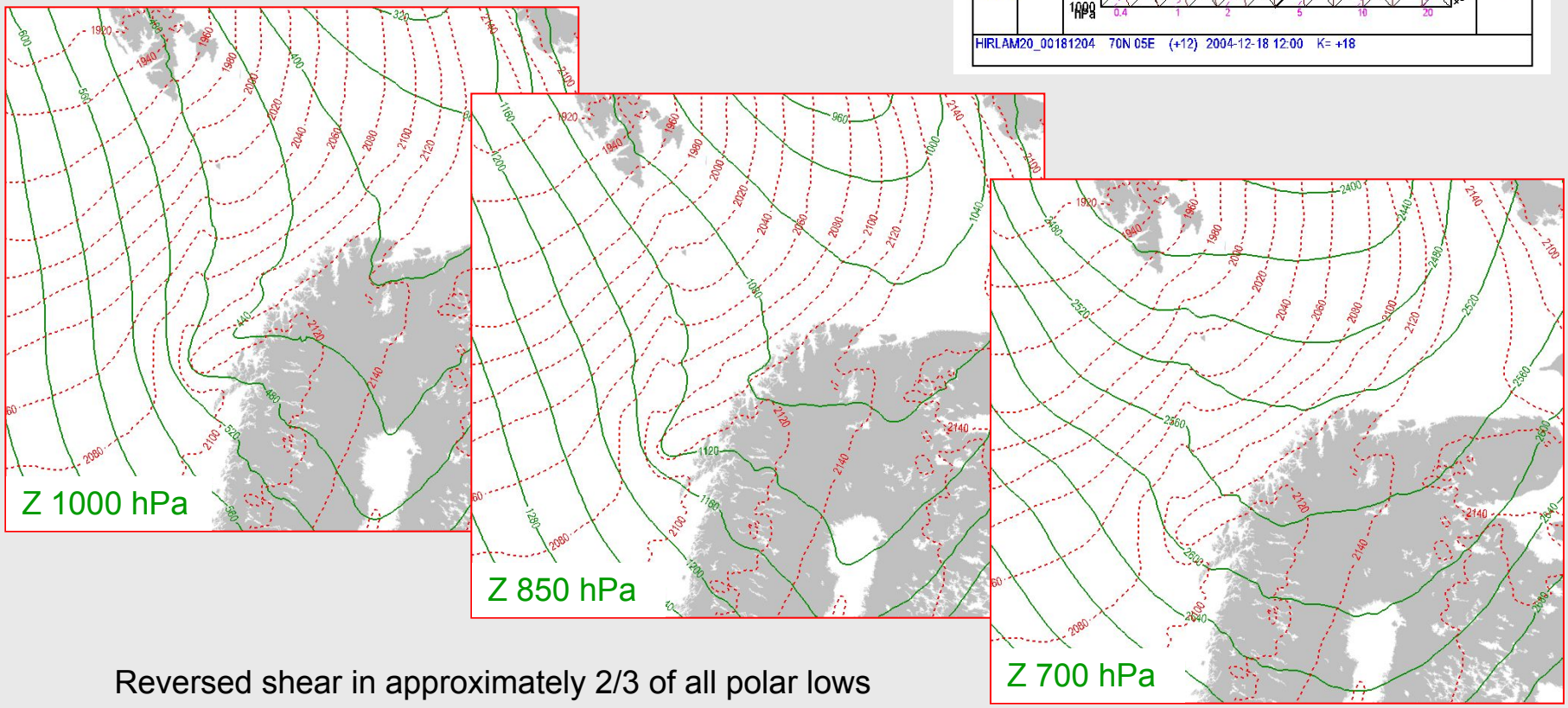
Reversed shear:

Thermal wind acting against the large scale wind field, strongest horizontal pressure gradient and wind at low levels





Reversed shear in approximately 2/3 of all polar lows

Shear usually in a narrow layer at 850 to 700 hPa

Steering level at the top of the bottom layer

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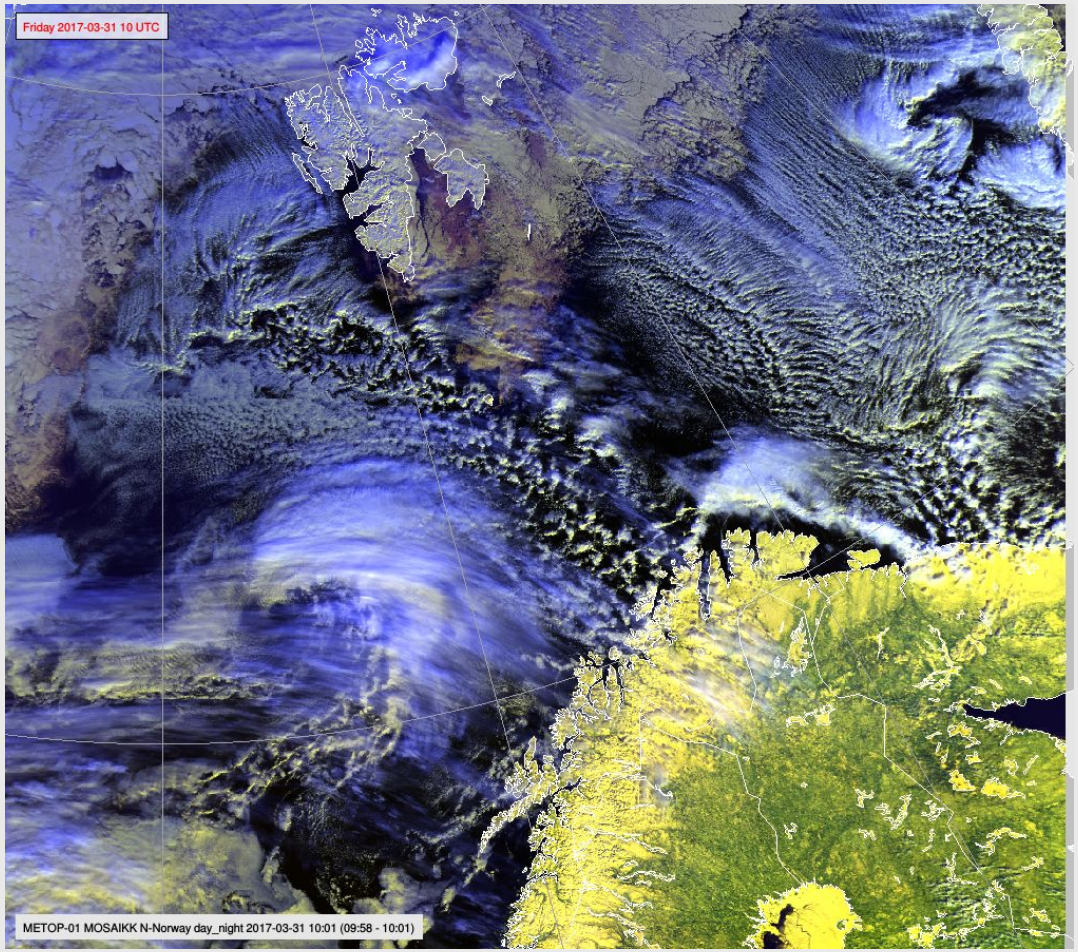
A case for forecasting:

31.3.2017:

Current situation 10 z:



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A case for forecasting:

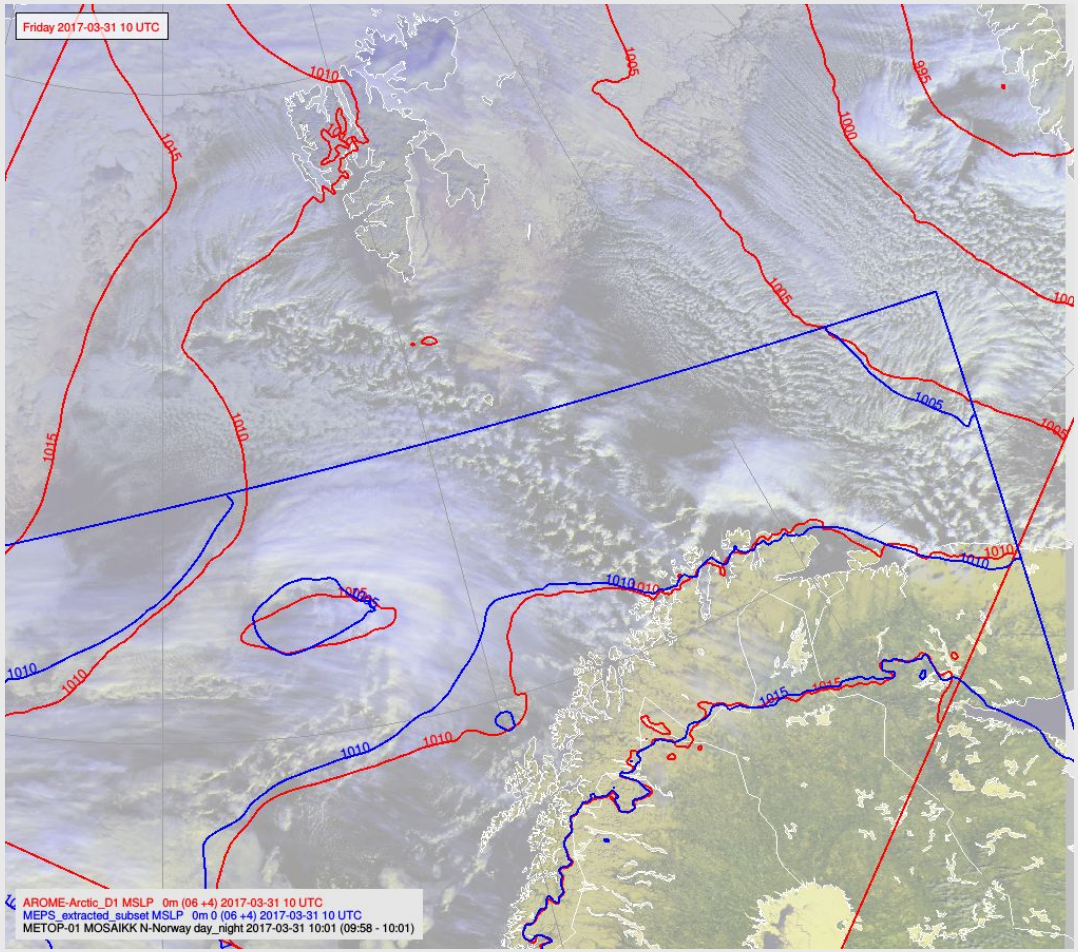
31.3.2017:

Current situation 10 z:

Arome MetCoOp MSLP

ECMWF MSLP

Is the model correct ?



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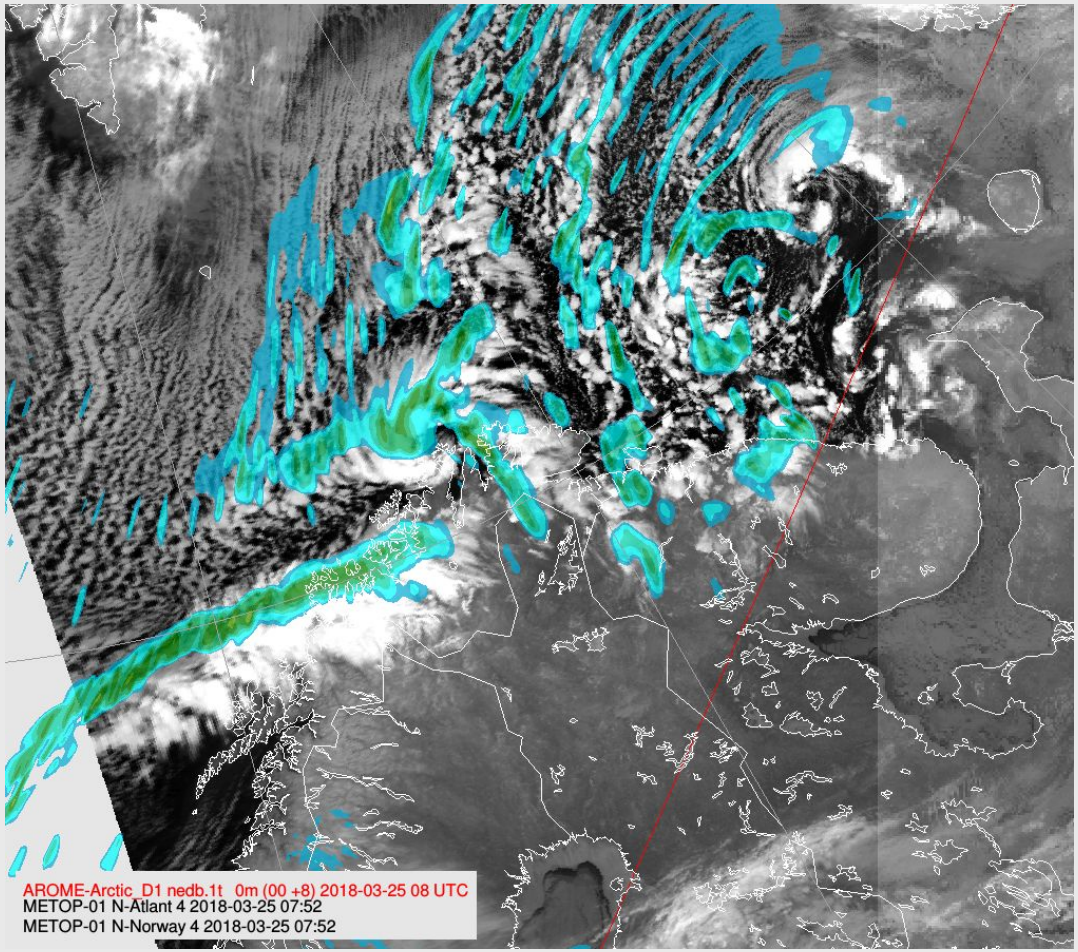
A case for forecasting:

31.3.2017:

Current situation 10 z:

Arome MetCoOp 1 hr. precipitation

Is the model correct ?



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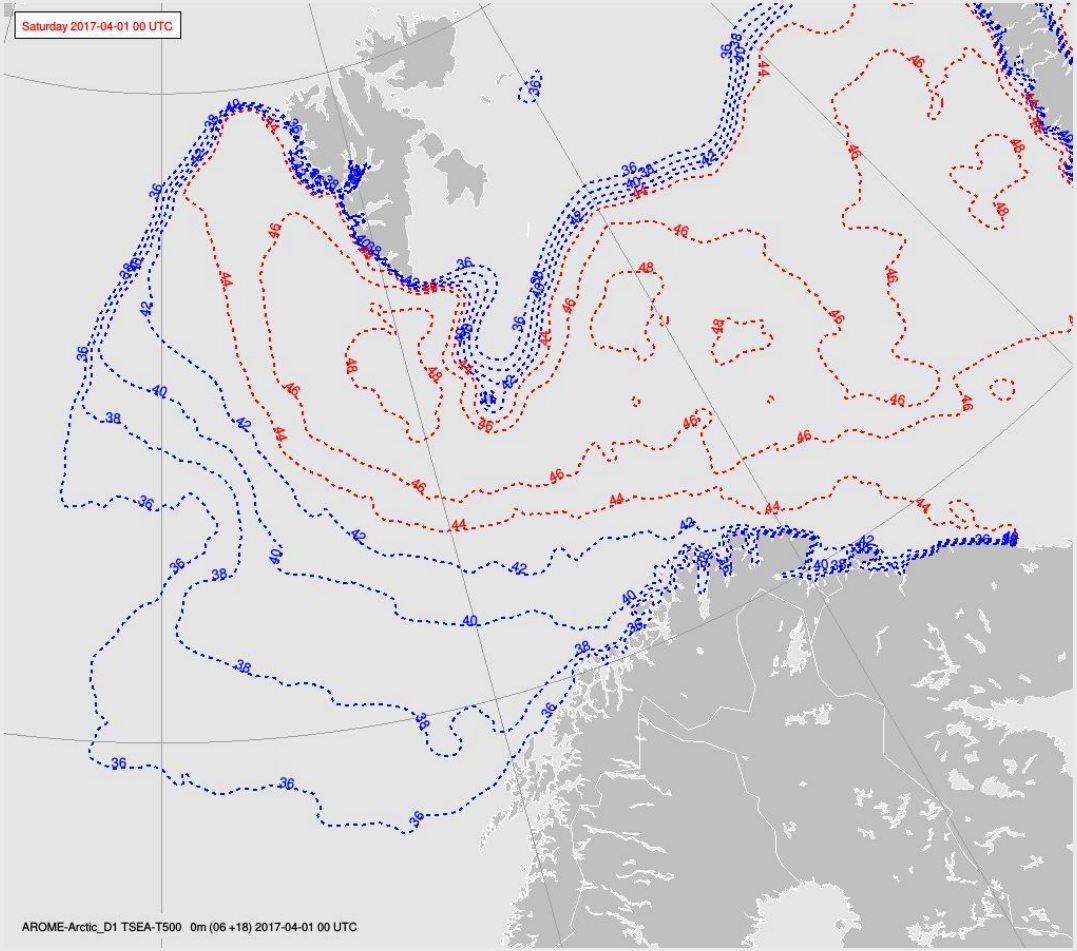
A case for forecasting:

31.3.2017:

At landfall, +18 hrs prognosis :

Is the cold core still present ?



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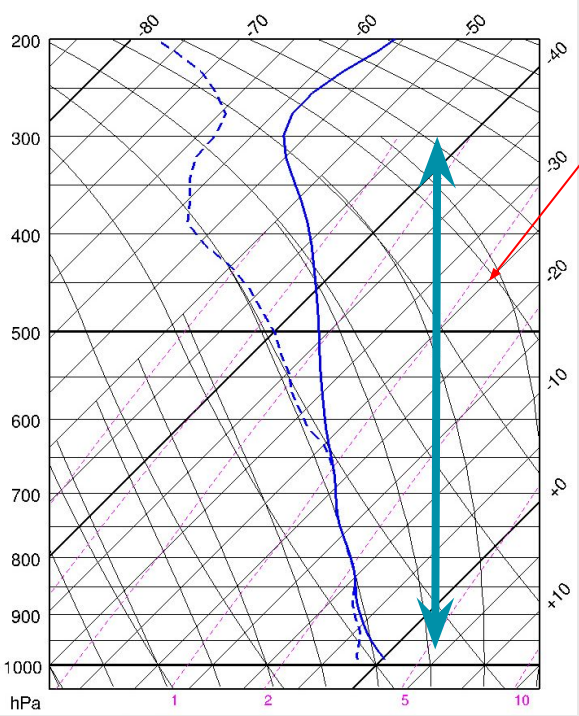
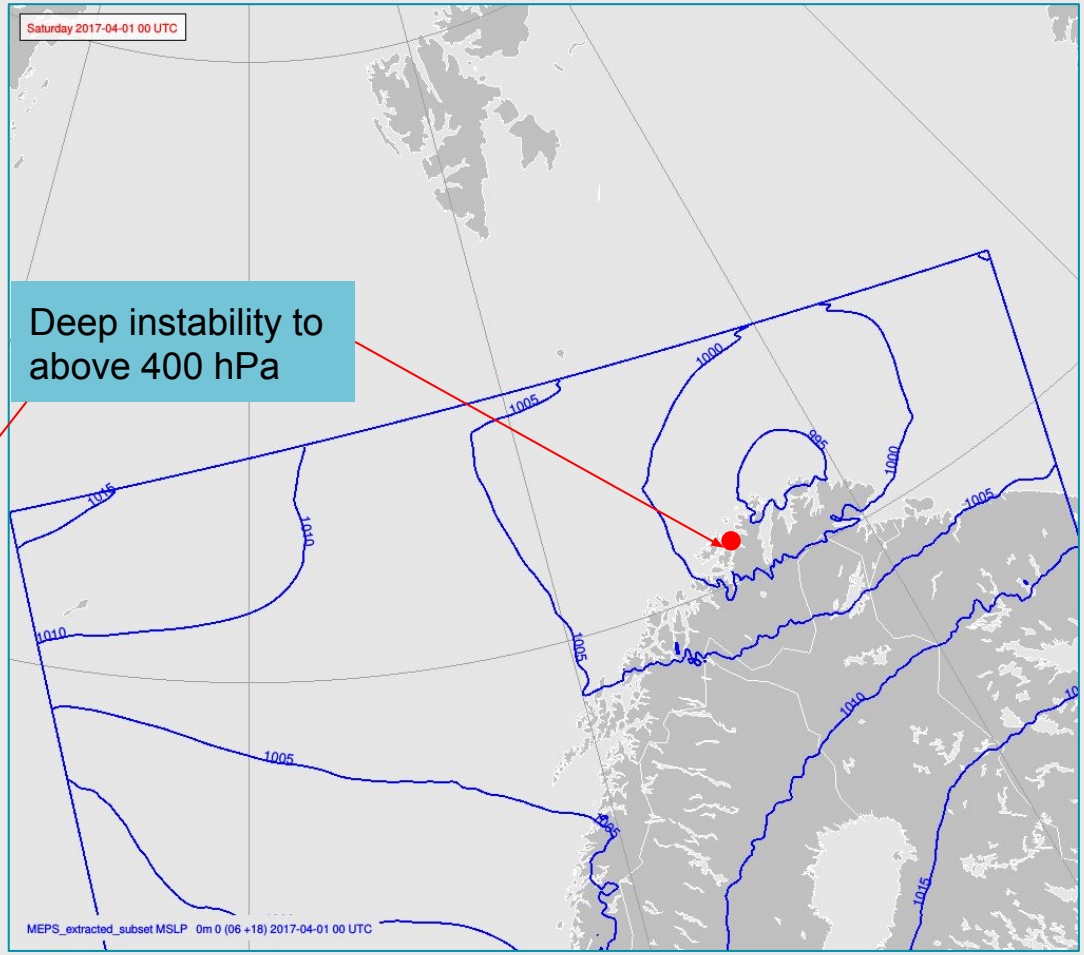
A case for forecasting:

31.3.2017:

At landfall, +18 hrs prognosis :

Arome MetCoOp MSLP





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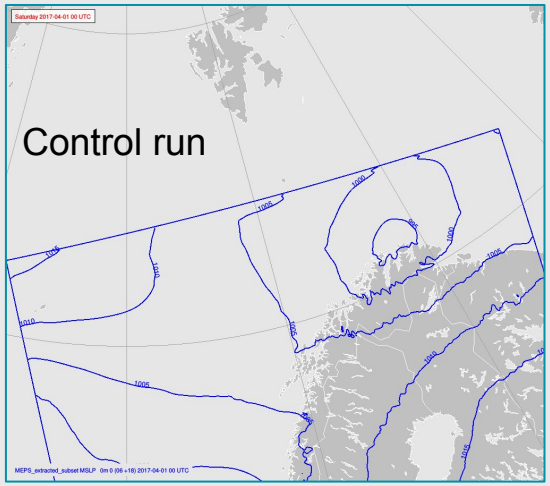
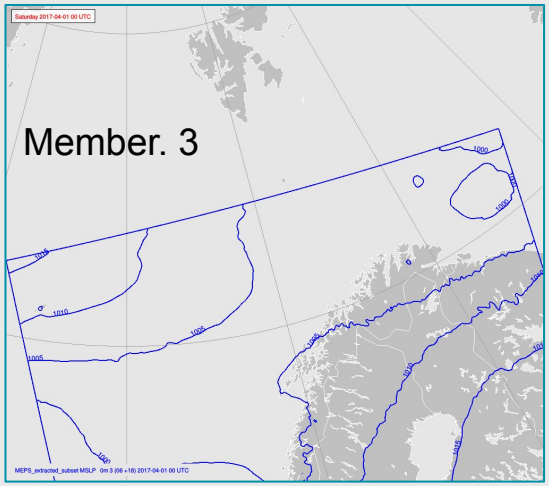
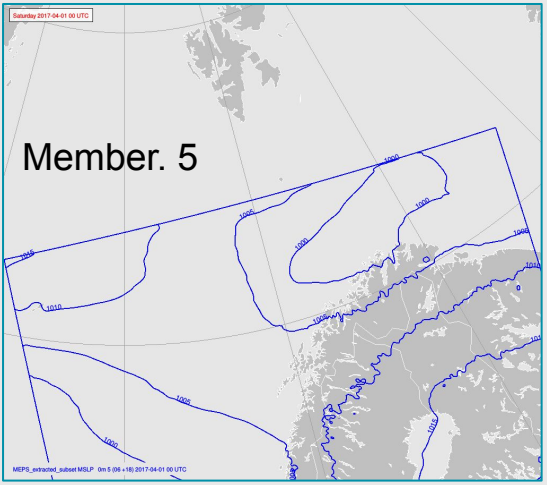
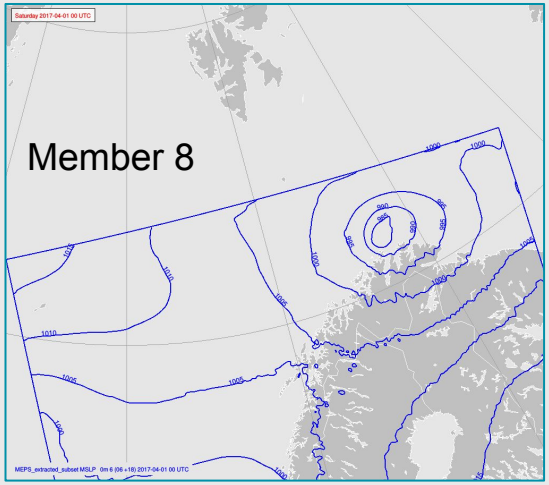
Don’t forget to check the ensemble members









Often large model uncertainties in the details of mesoscale phenomena at high latitudes

But: Large scale favorable conditions, e.g. high values of SST-T_{500hPa} are well seen in the deterministic out to medium range

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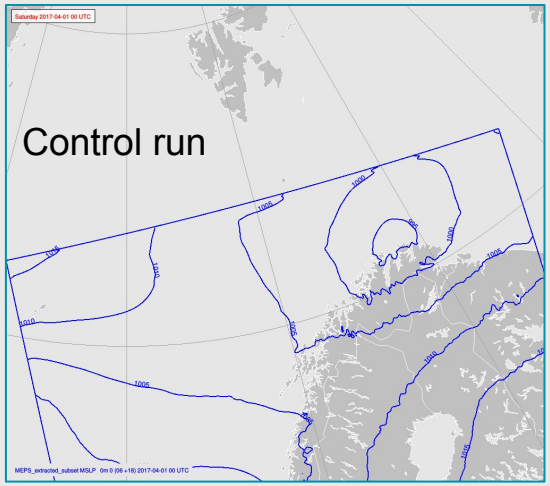
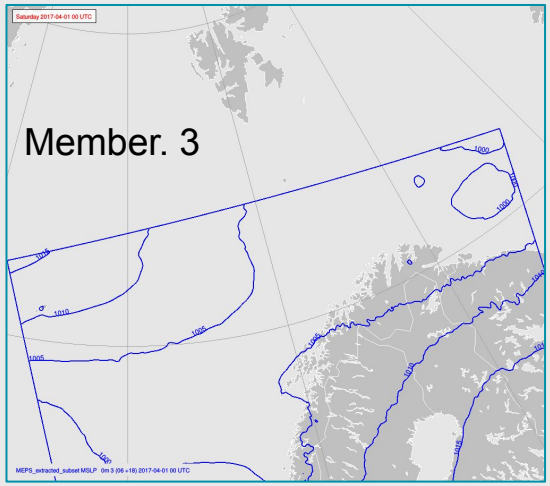
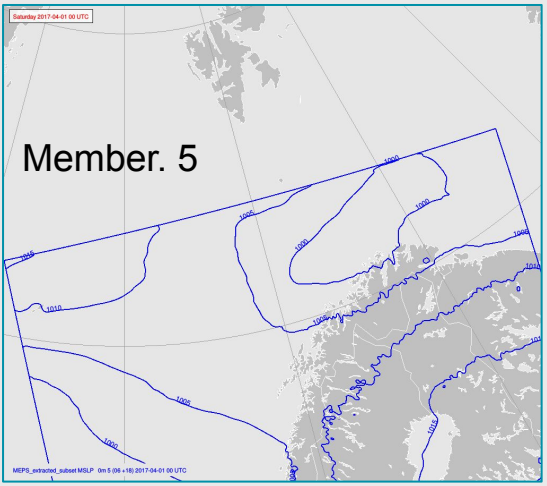
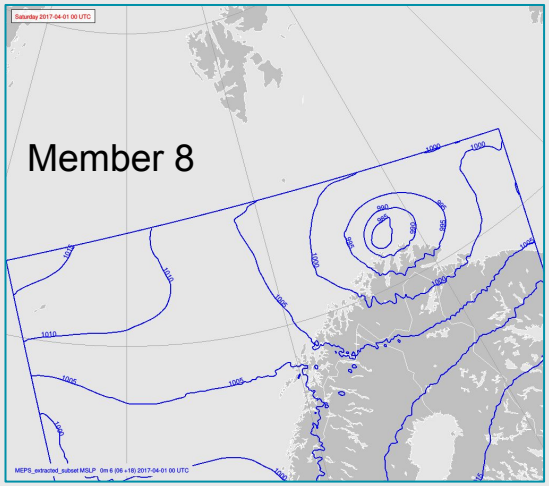
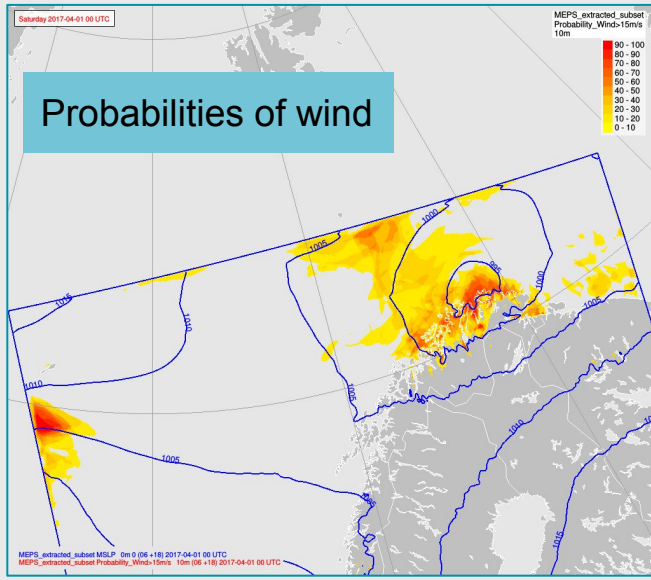
Don’t forget to check the ensemble members











Always check probabilities !

Norwegian Meteorological Institute

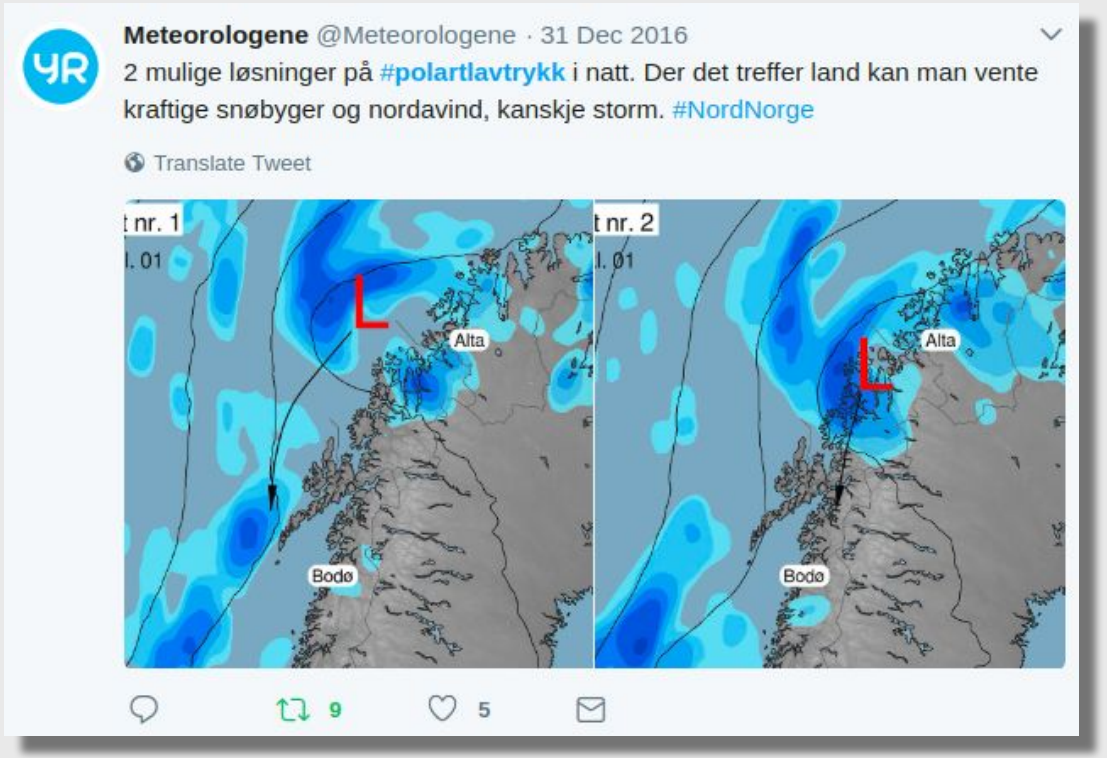
To the public and the media...

@Meteorologene

YR.no

A probability forecast:

‘Two possible solutions of the polar low tonight. Where it hits land there is expected heavy snow sower and northerly winds, possibly of storm force’



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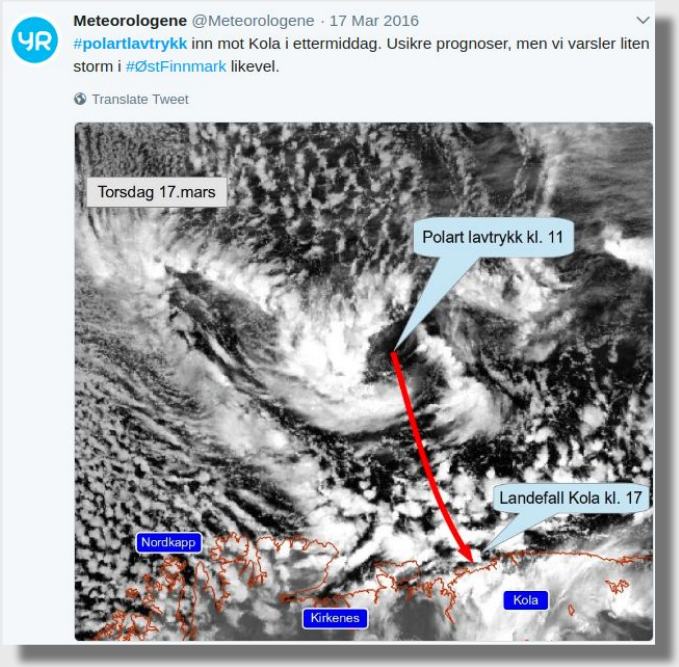
To the public and media:

@Meteorologene

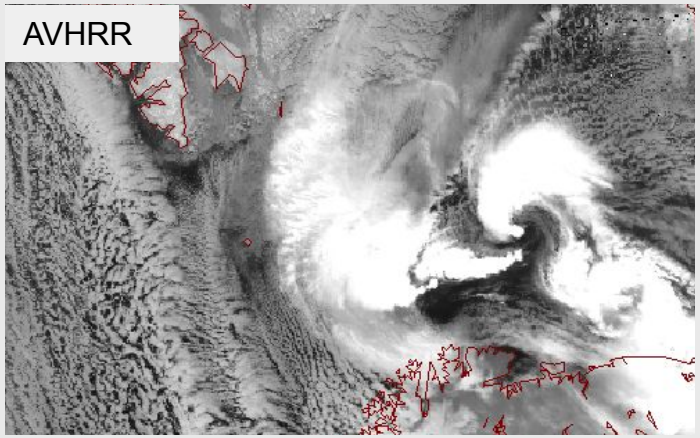
YR.no

‘Polar low is developing west of Troms, and is heading northeast. Prognosis is uncertain, stay updated.

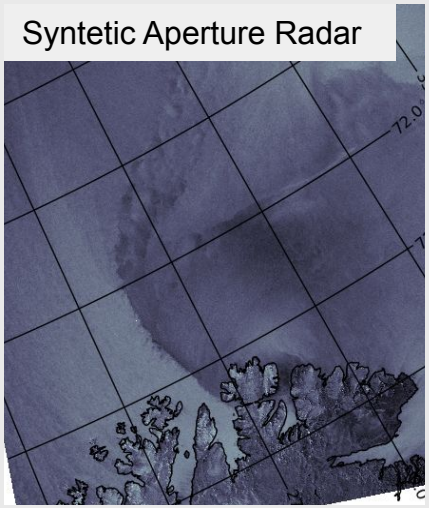


Observing the polar low:

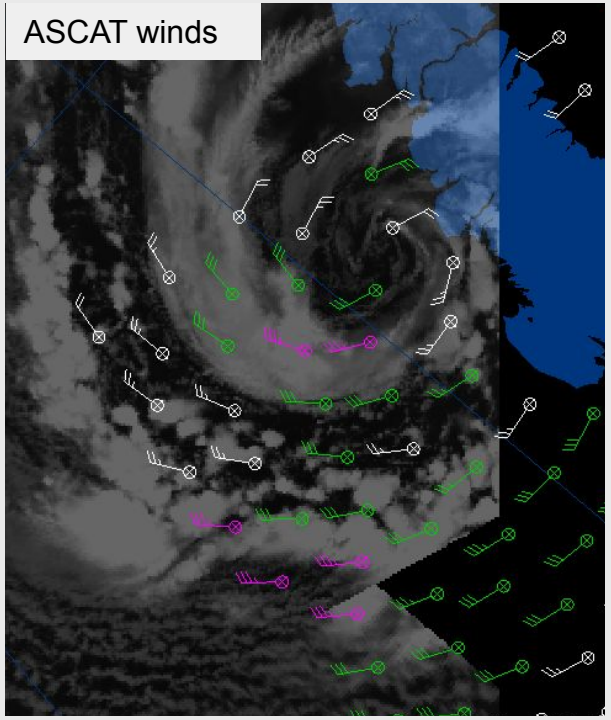
AVHRR



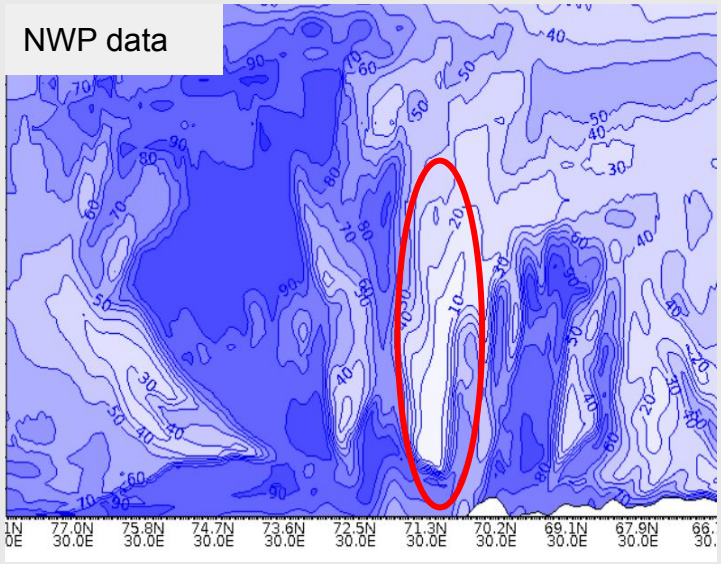
Syntetic Aperture Radar



ASCAT winds

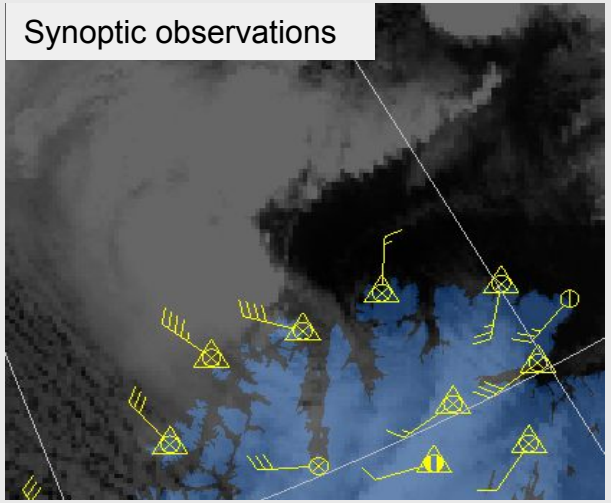


NWP data



The dry ‘eye’ of the low has an almost vertical structure, hence the position of the surface low can be approximated from satellite AVHRR images

Synoptic observations



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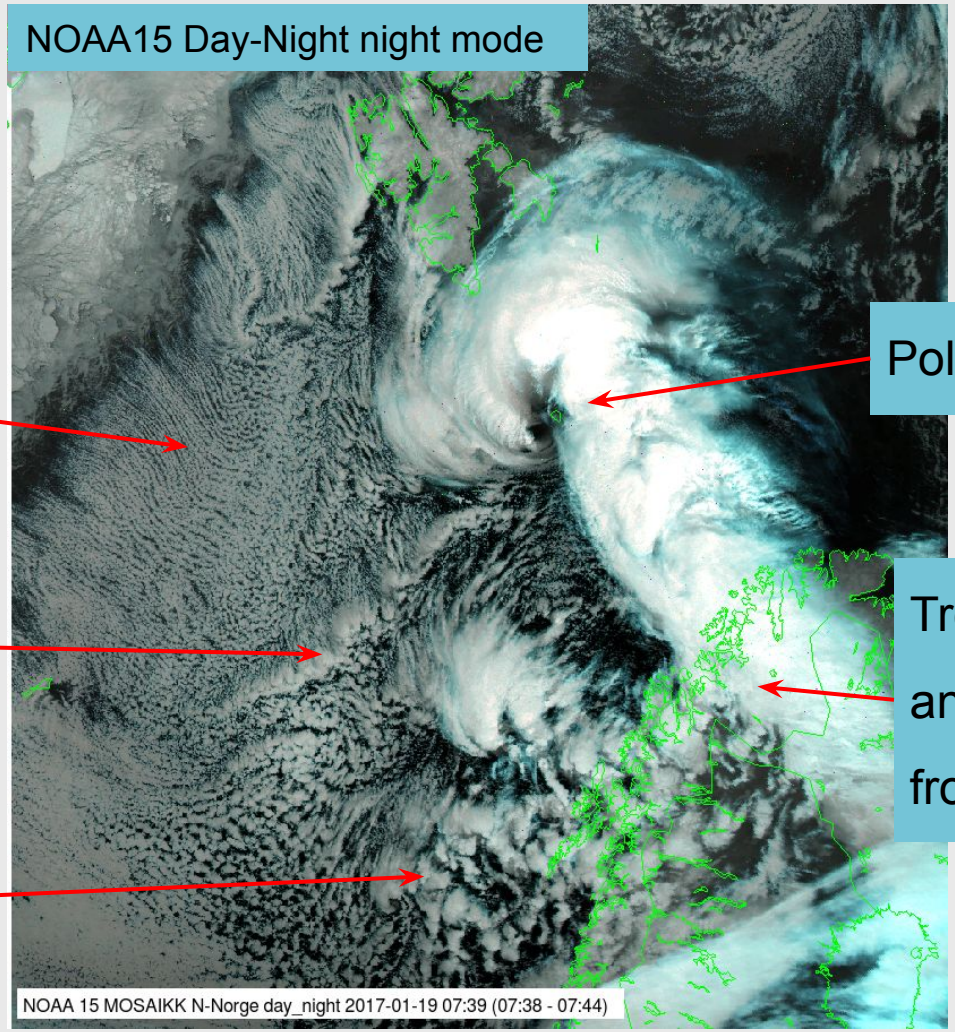
Analysis in the mesoscale:



Cloud streets

Arctic fronts

Cumulus clusters

Polar low

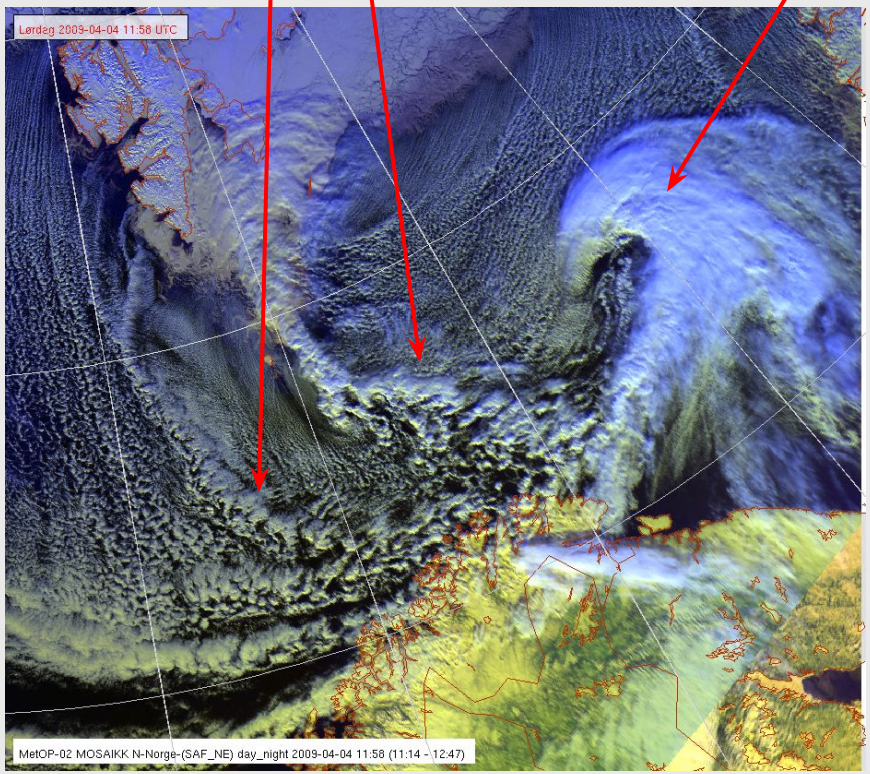
Troughs and fronts

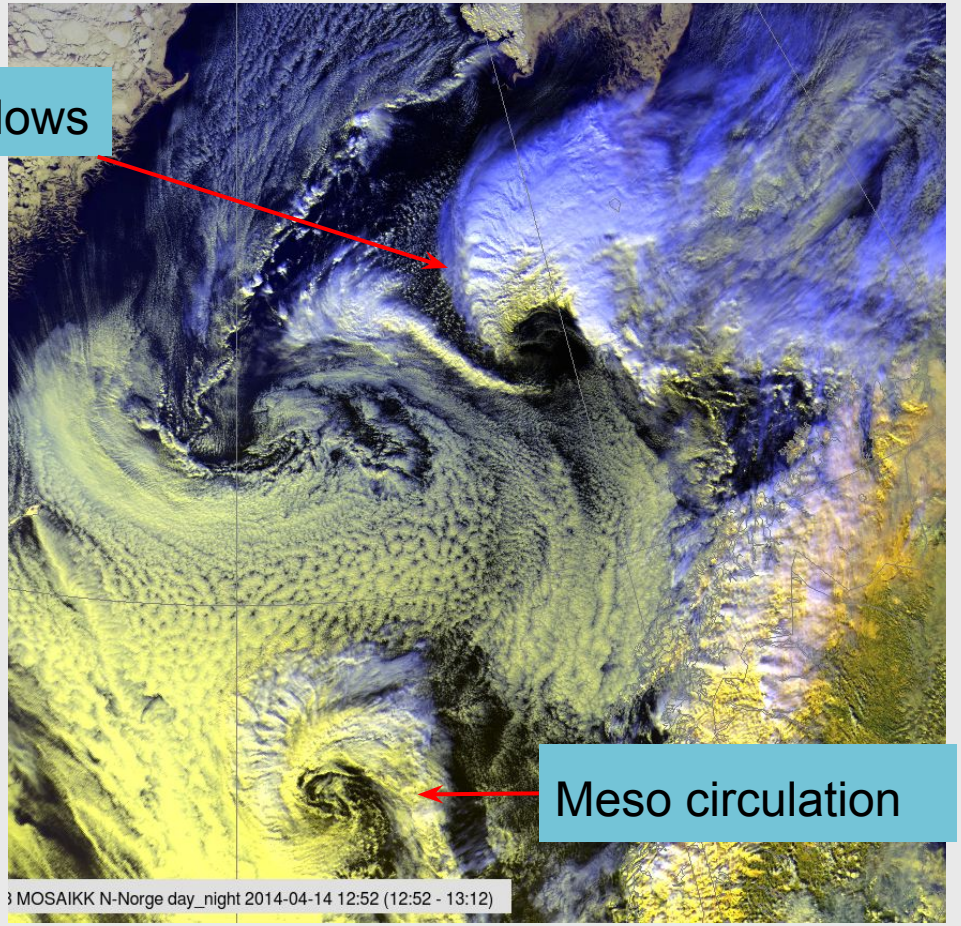
Norwegian Meteorological Institute

Analysis in the mesoscale:

Convergence lines

Polar lows





Meso circulation

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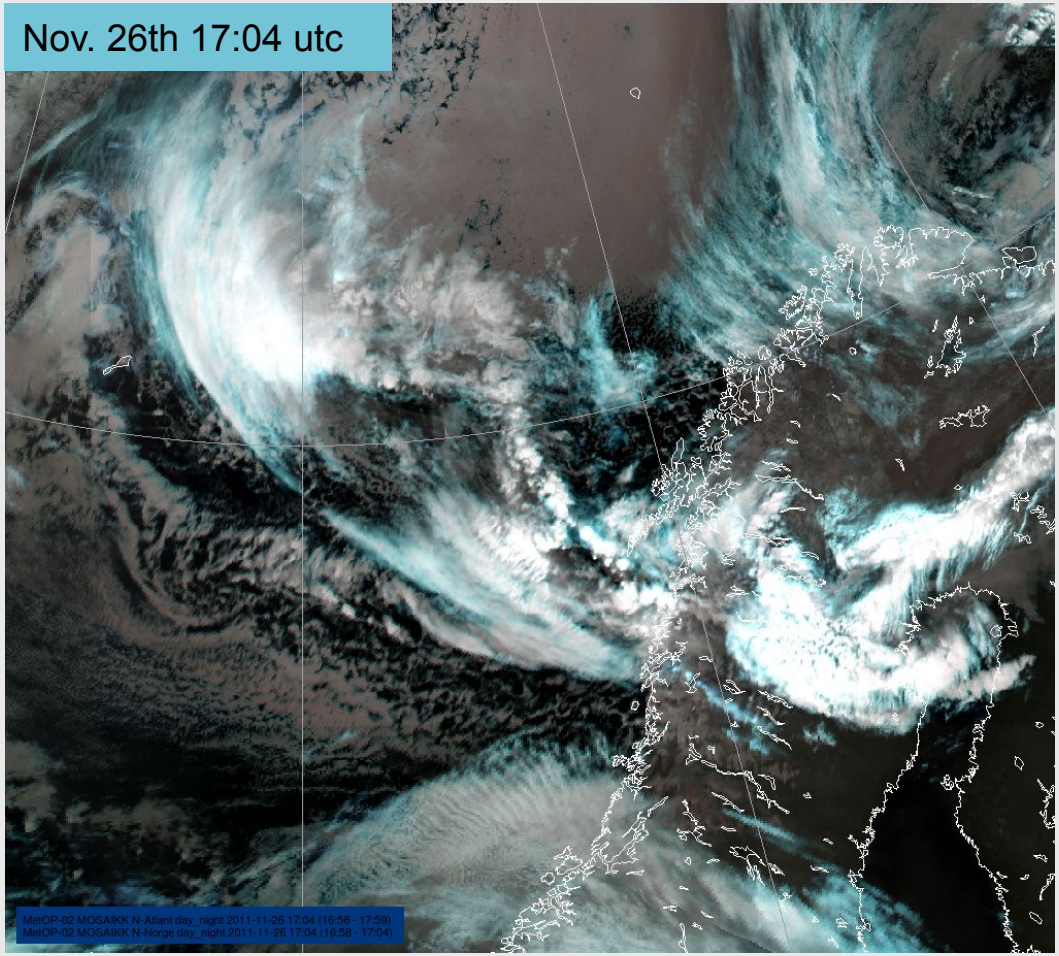
The polar low, incipient stage:

First signs in the cloud patterns:

- A cloud area indicating baroclinic or convective instability
- Cyclonic curvature
- Emerging eye



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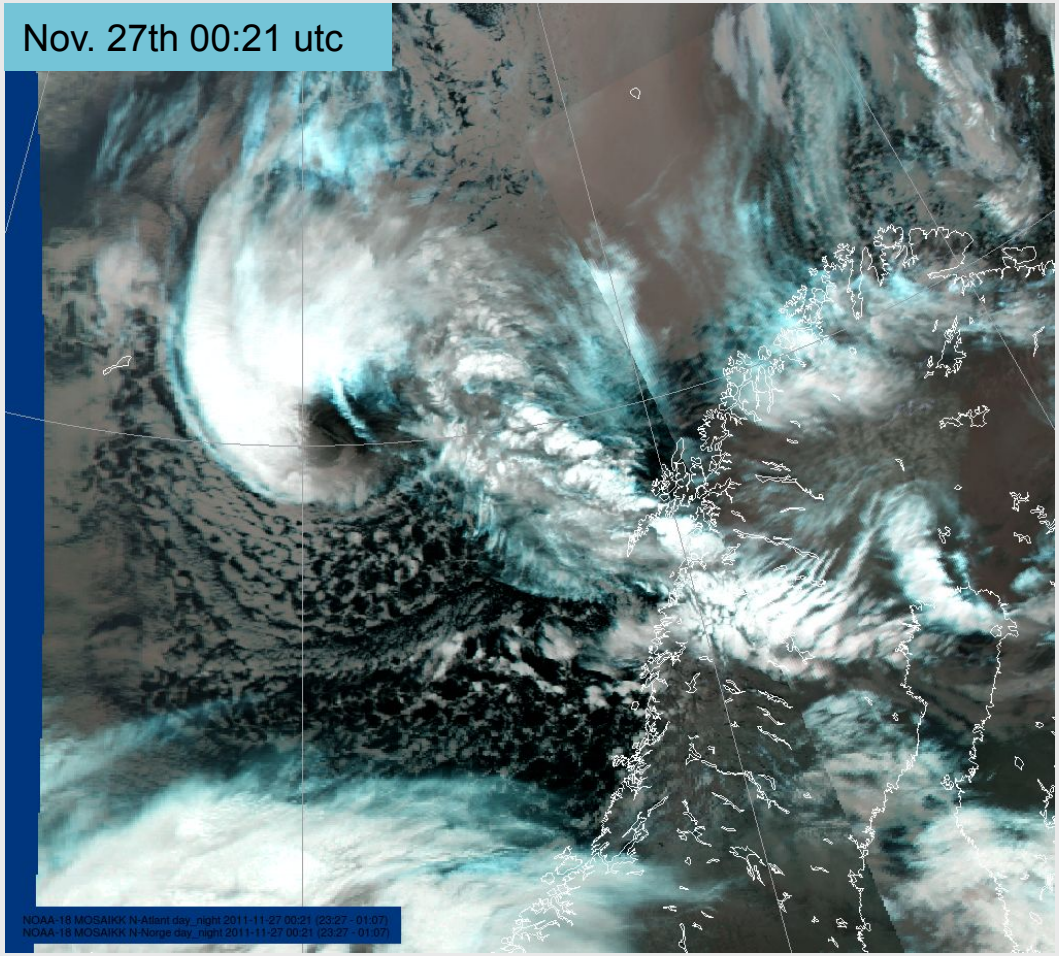
The polar low, mature stage:

Typical features in the cloud patterns:

- Cyclonic curvature
- Smooth cirrus on top
- A well visible warm eye

Baroclinic or convective ?



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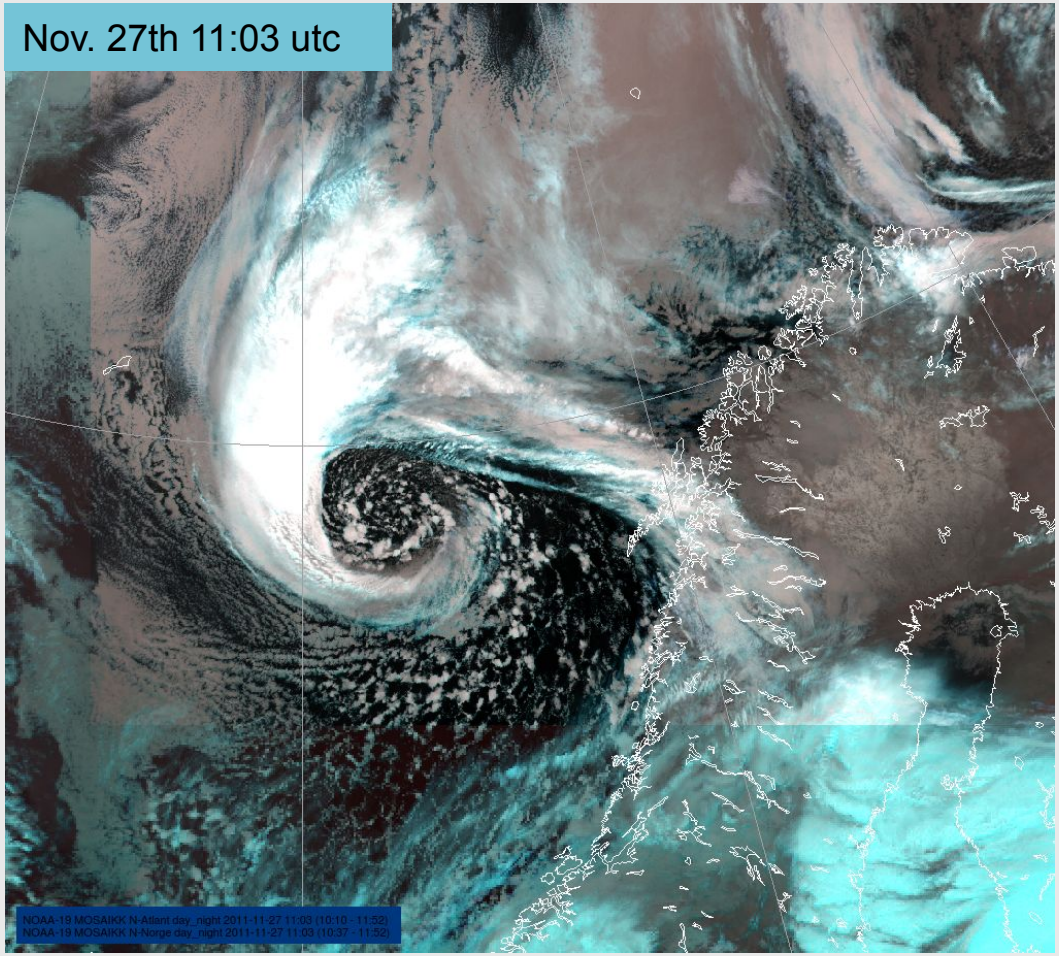
The polar low, late mature stage:

Resembles an occluded low

Convection emerging in the ‘eye’.

Usually less wind at later stages than at intensification



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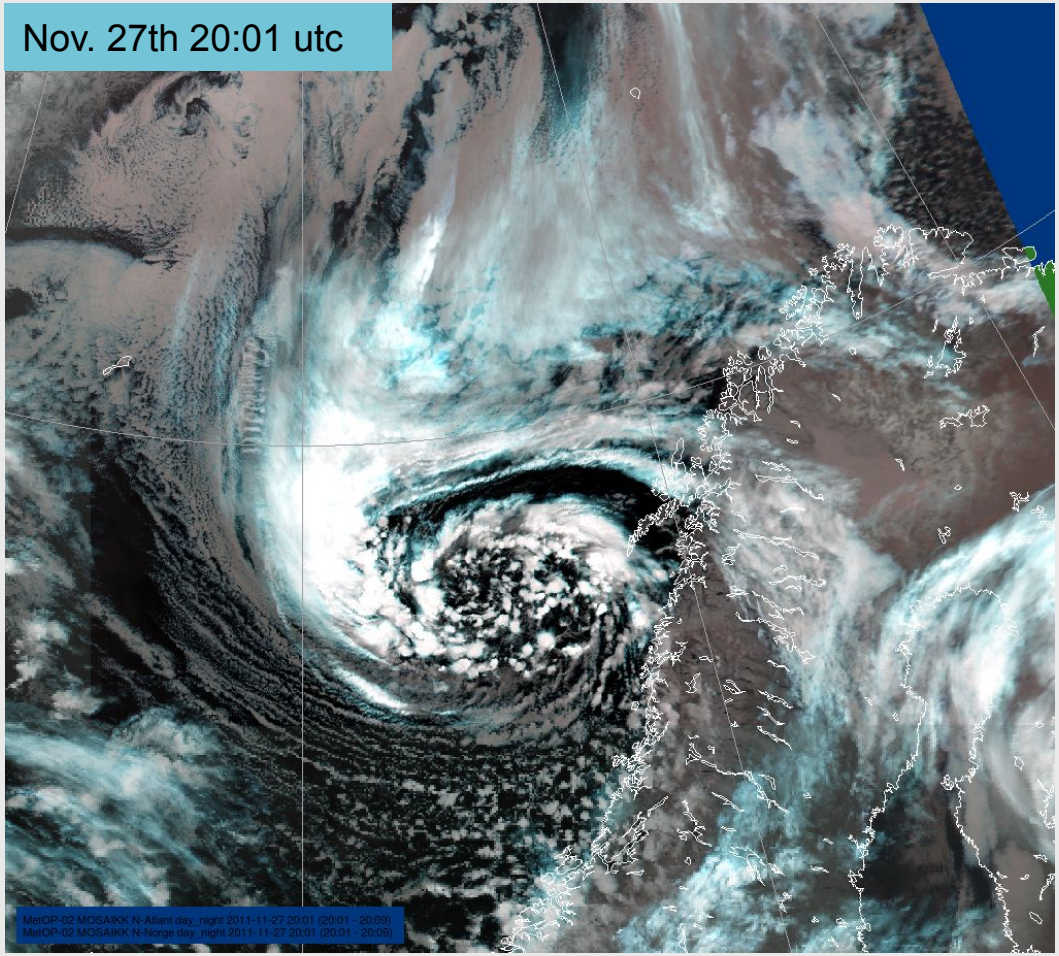
The polar low, dissipating stage:

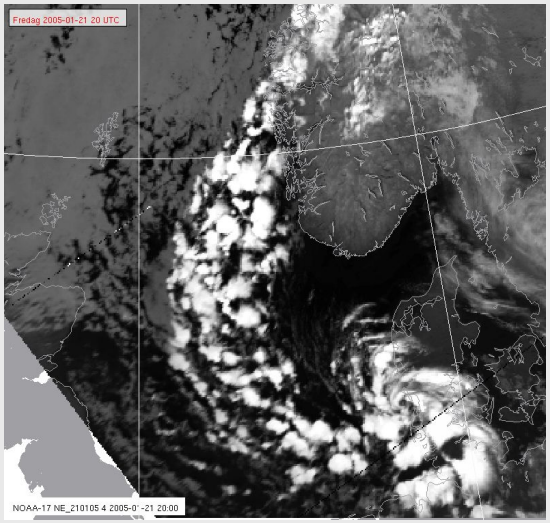
Typical features in the cloud patterns:

- Individual Cb's emerging
- Cirrus becoming less visible
- The 'eye' filling

Nov. 27th 20:01 utc



Landfall over Denmark 21st Jan. 2005



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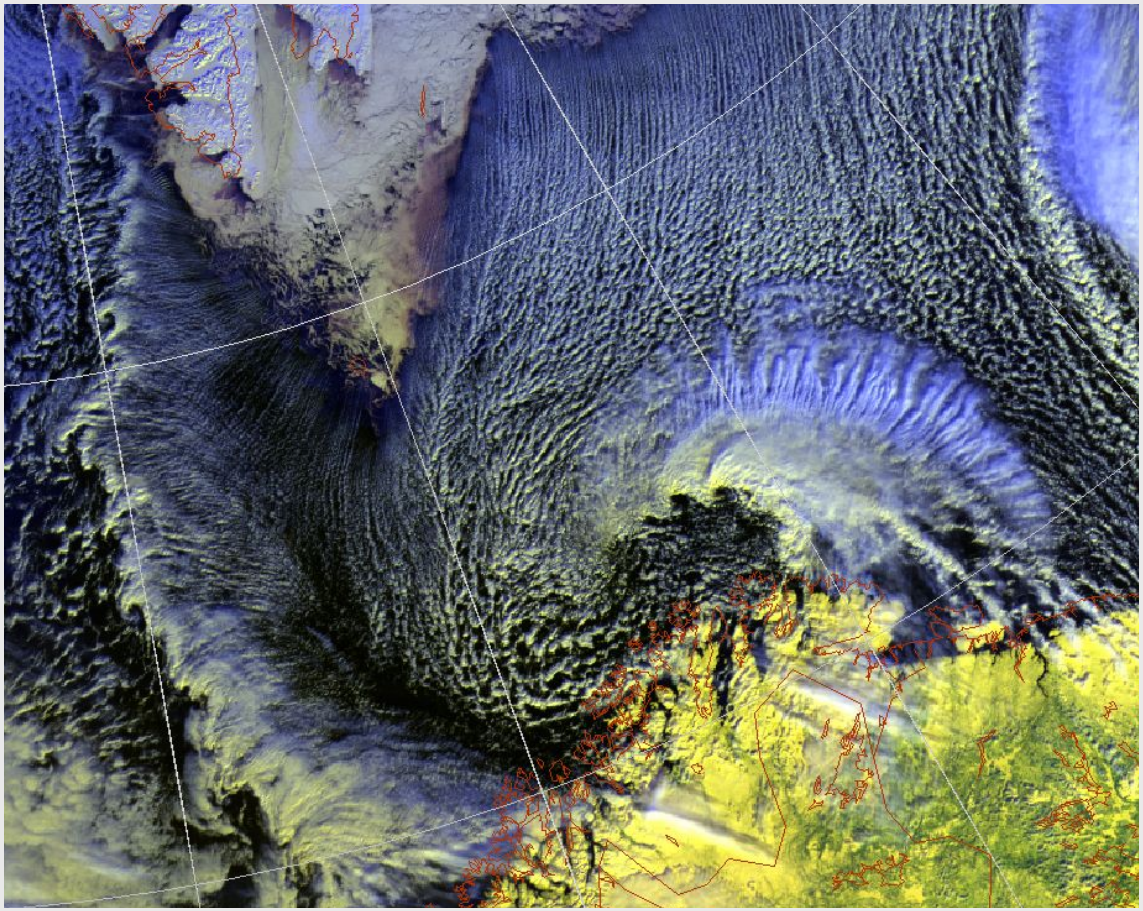
Some variations:

Wave pattern on the periphery of the low:

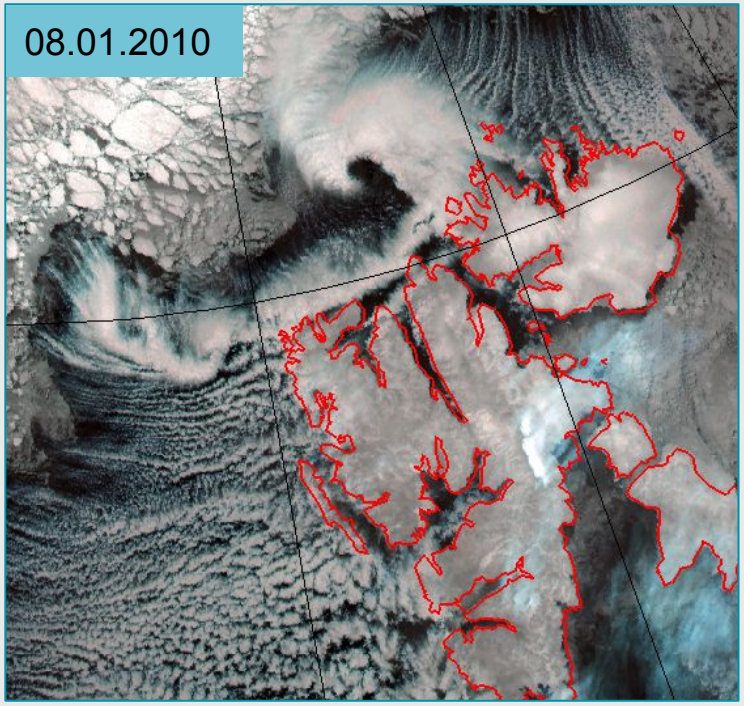
- Reversed shear
- Vertical shear on top of the convective layer
- Jet above
- Low vertical extent
- Moderately strong PL

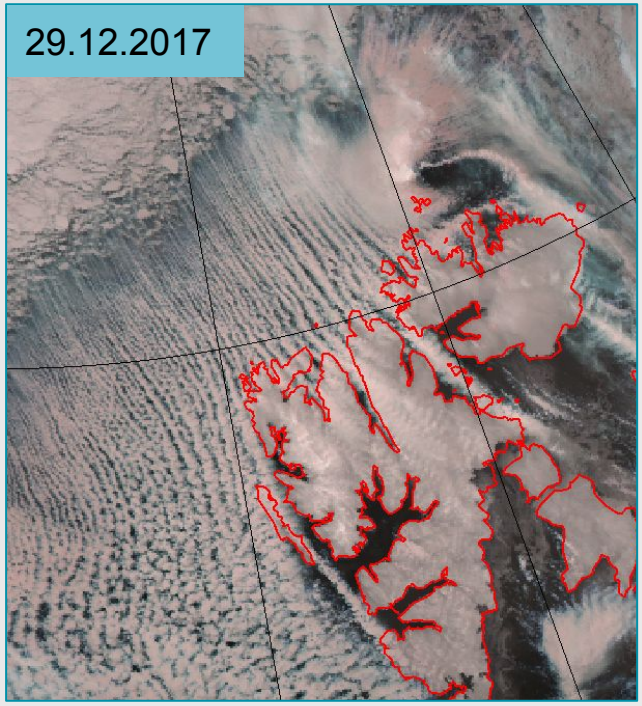


Some variations:

Polar lows north of Spitsbergen:

- Mesocyclones at low sea ice extent
- Winds 15 to 20 m/s





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Polar lows, why worry ?

ENTC TROMSO/LANGNES -- NO

Raw surface observations for station ENTC

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```

Tromsø airport mountain observation at 2600ft:
13:20z: 290 03KT (Westerly force 1)
13:50z: 340 53KT gusting 69KT (Northwesterly storm force 10)

Summary on polar lows:

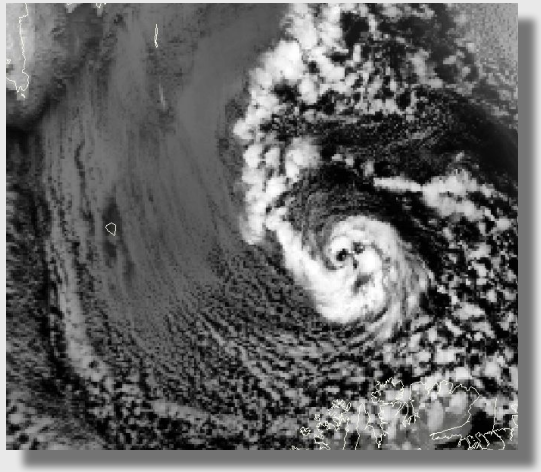
In the winter, in the Nordic Seas and surrounding coastal areas

Adverse weather: Gale or storm force winds, snow blizzards, avalanches, and widespread traffic disruptions

Associated with cold air outbreaks and spells of showery weather

Moderate model performance, EPS is nessecary. Large scale favorable conditions predictable to medium range.

Interpretation of polar orbiting satellites is essential.



A polar low north of Finnmark 22nd January 2000

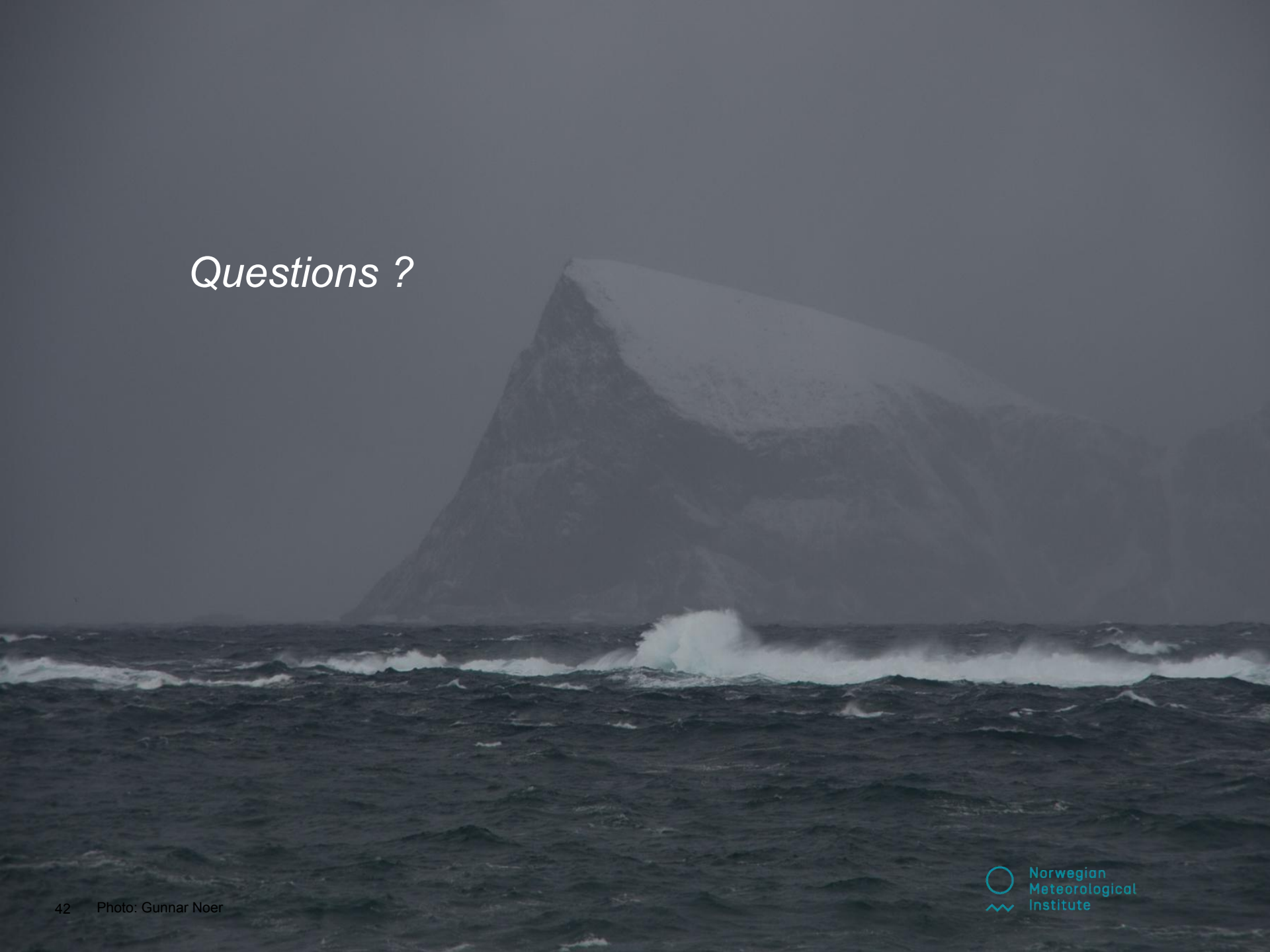


 Photo: Gunnar Noer

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