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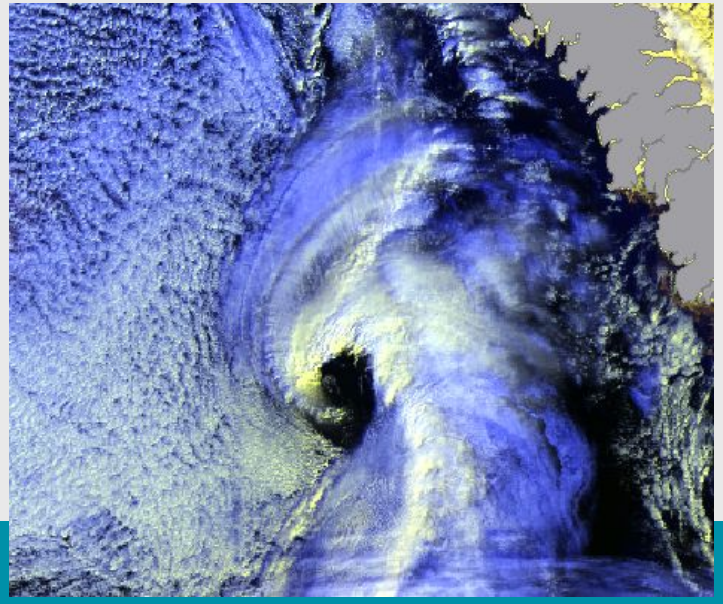


# Polar Lows – Arctic hurricanes

Gunnar Noer

The Norwegian Meteorological Institute

Forecasting division of Northern Norway

30.10.2018

# MET-Norway in brief...

National Weather Service:

- Land/Media, YR.no
- Maritime, MET area XIX
- Aviation, 31 airports, Norway/Oceanic FIR

Oslo

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

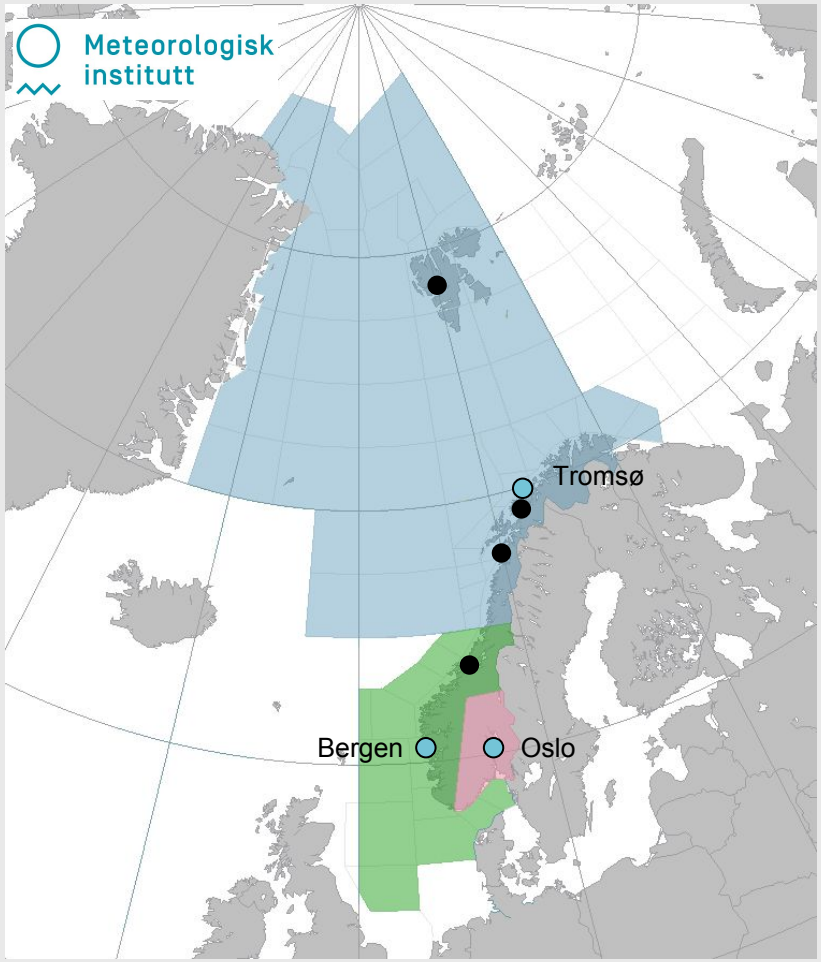
Bergen

- SW-Norway, Maritime

Tromsø

- N-Norway, Ice service

Local Met Service

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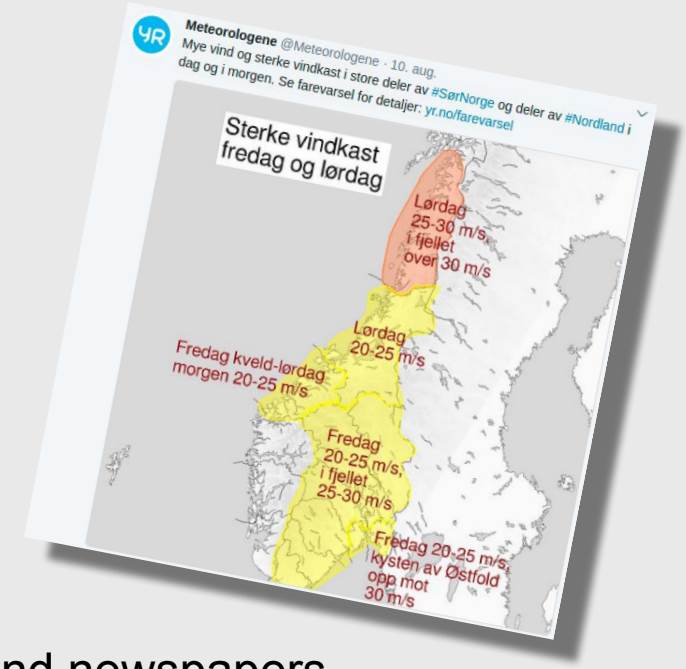
# Primary forecasting tasks:

Met alerts, common alerting protocol (CAP)

- Wind / gusts
- Gale warnings
- Precipitation
- High tides
- Forest fire
- Difficult driving conditions
- Polar lows
- Vessel Icing




Land: YR.no, Text forecasts ++

Media (social): YR.no, Twitter, Instagram, TV and newspapers

Marine: MET area XIX

Aviation: TAF, IGA, SIG-maps, Route forecasts



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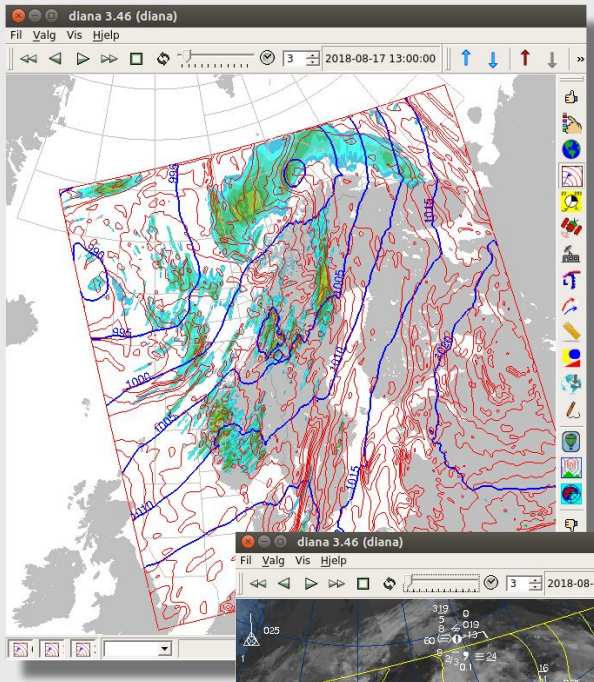
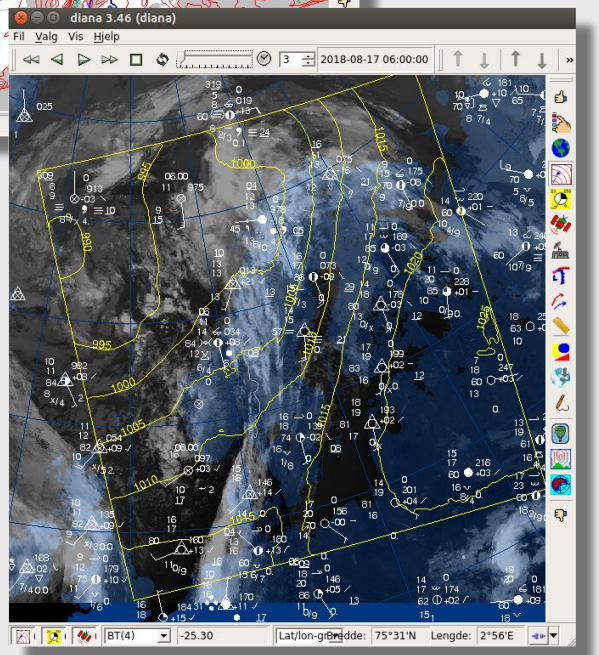
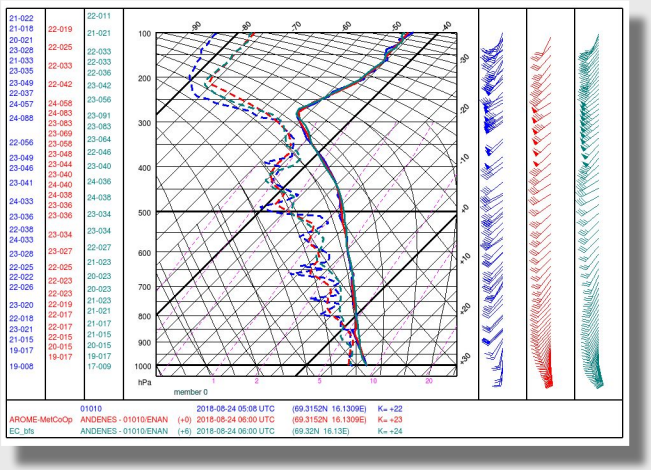
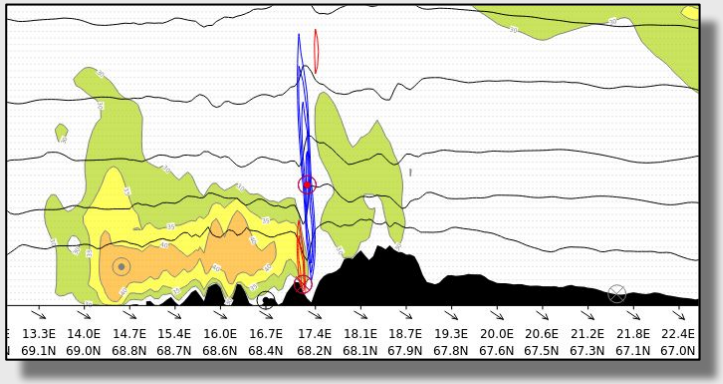
# The DIgital ANAlysis (DIANA) presentation tool:




NWP models, satellites and observations integrated

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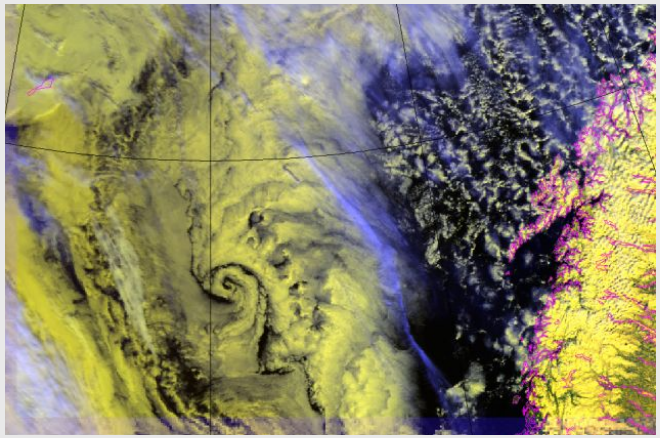
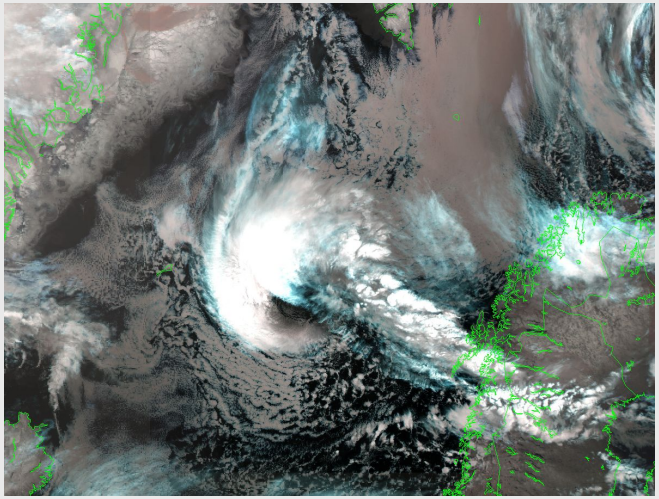
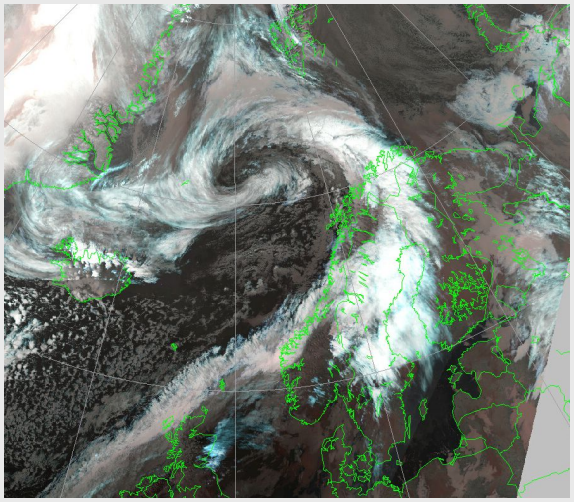
# An introduction to the polar low:

Which one is a polar low ?







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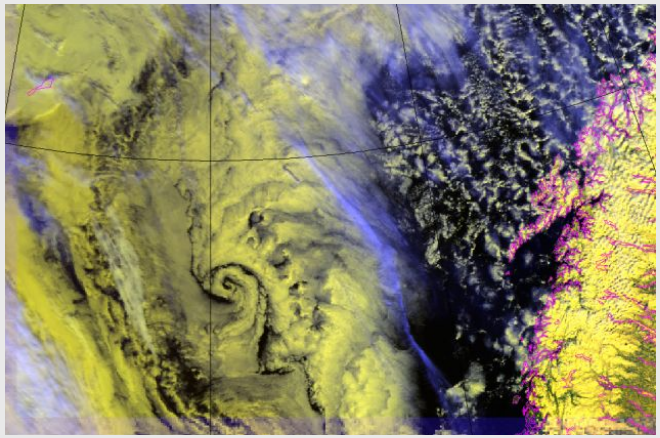

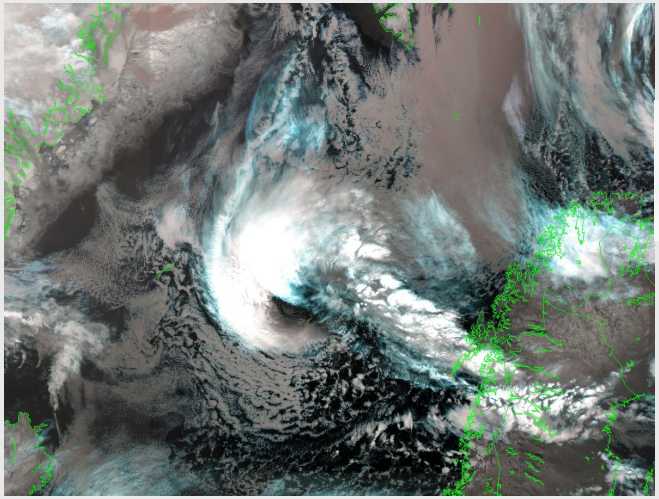

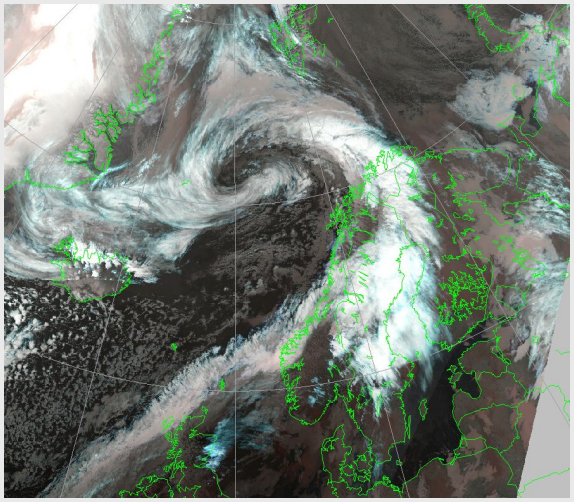

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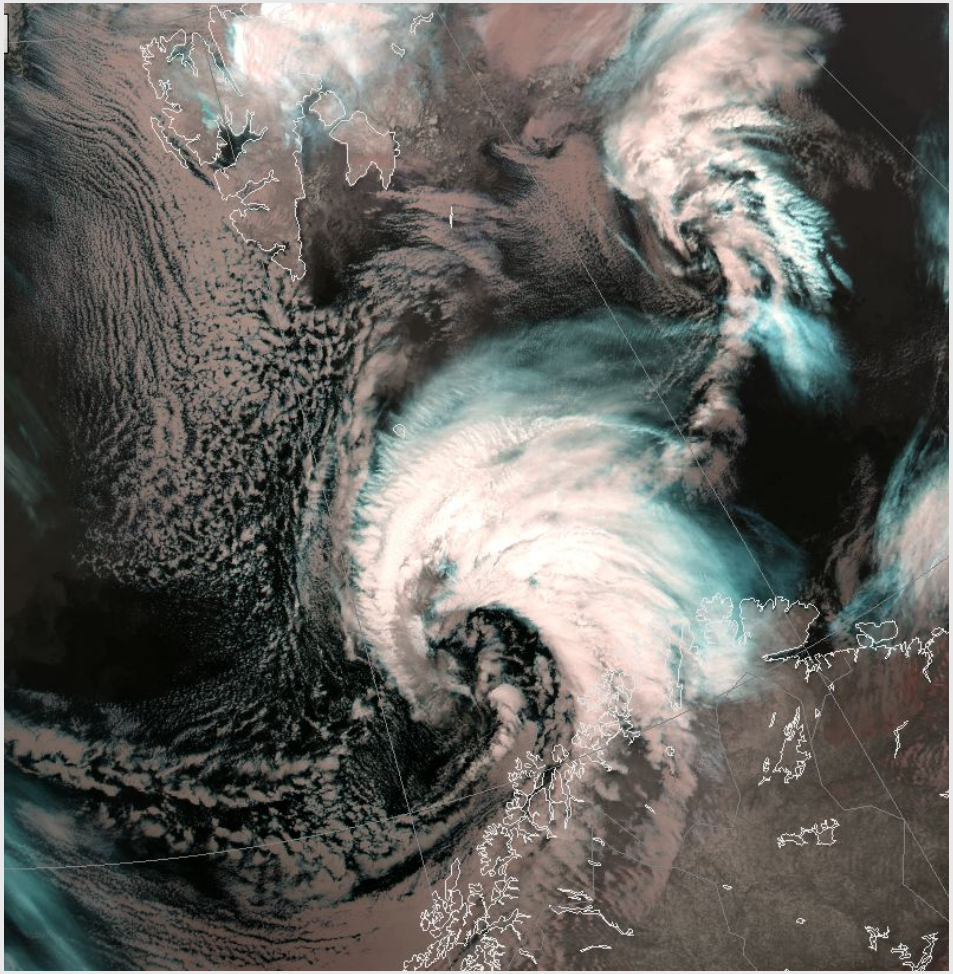
# Definition of the polar low:

*'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

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# The weather in a polar low:

- 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

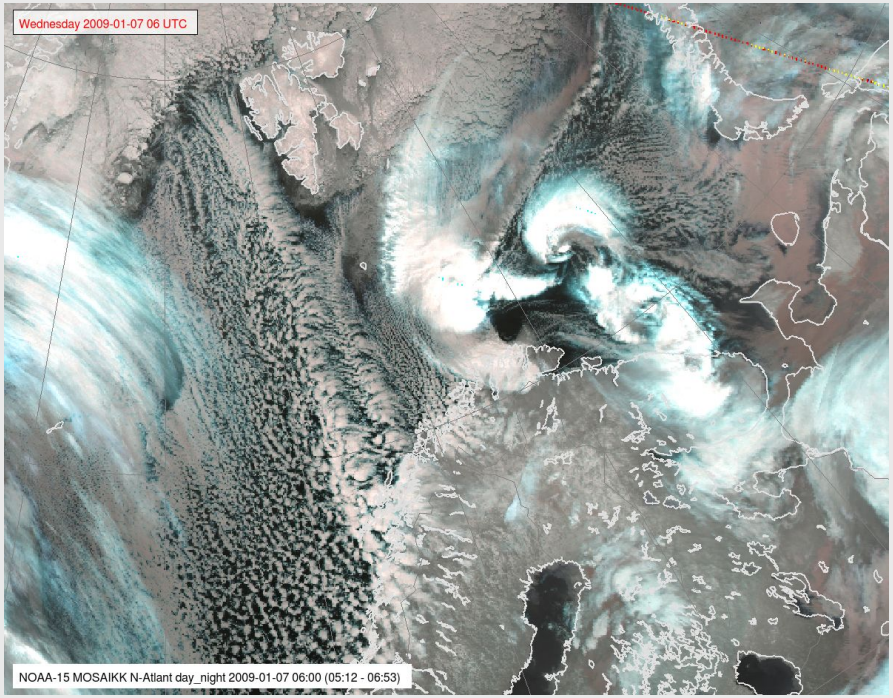


Photo: Gunnar Noer



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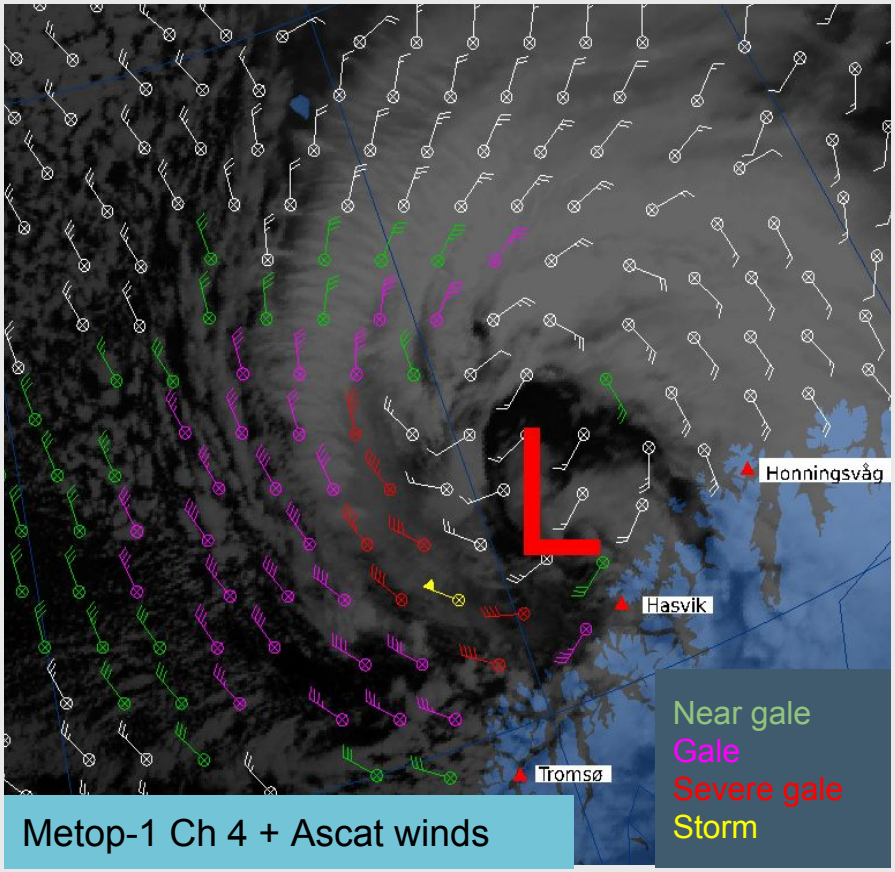
# Wind characteristics of the polar low

- 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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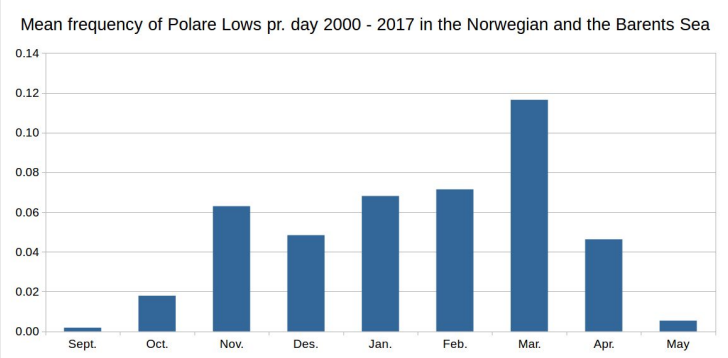
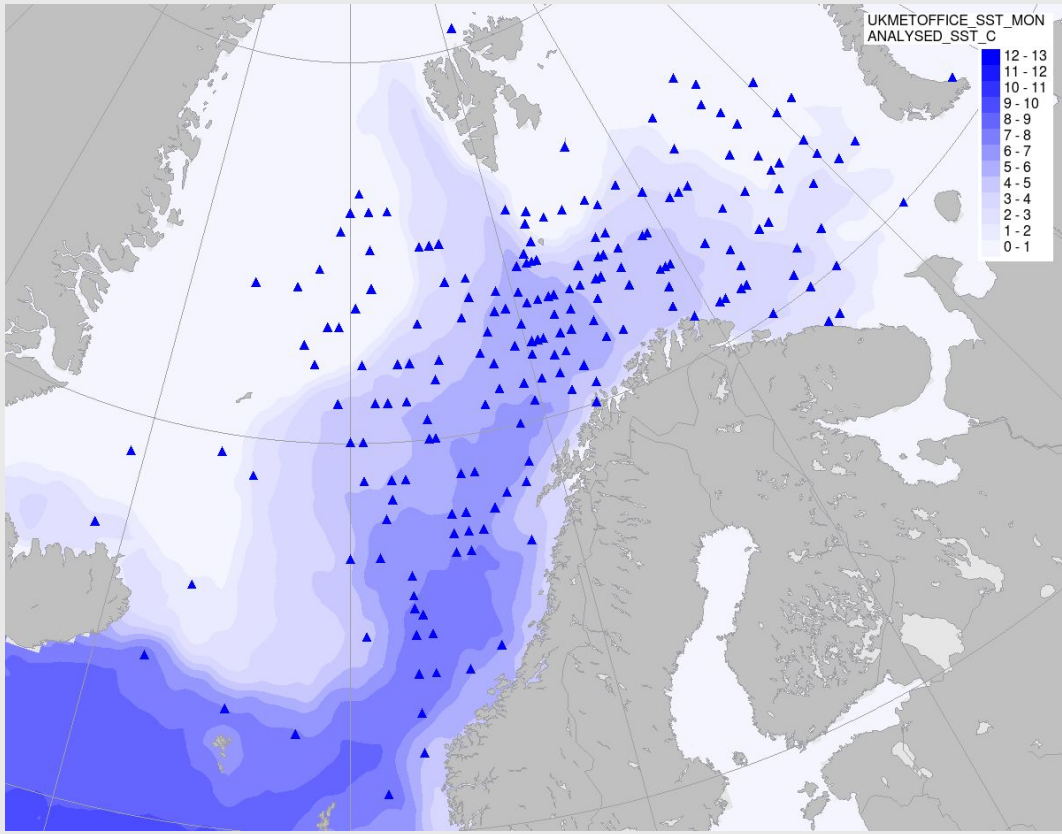
# Some climatology:

- 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




Polar low genesis area 2000 - 2017. SST in blue shading.



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# 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.

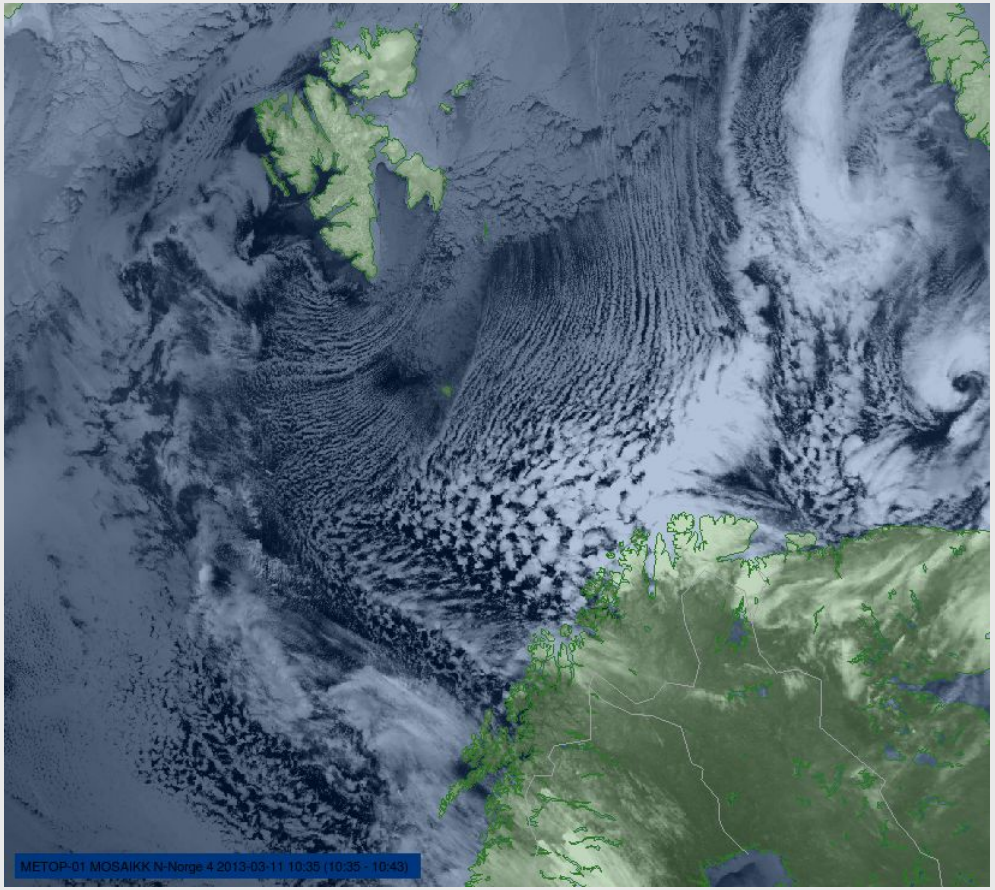
4. Positive vorticity advection, for stretching and further destabilizing.

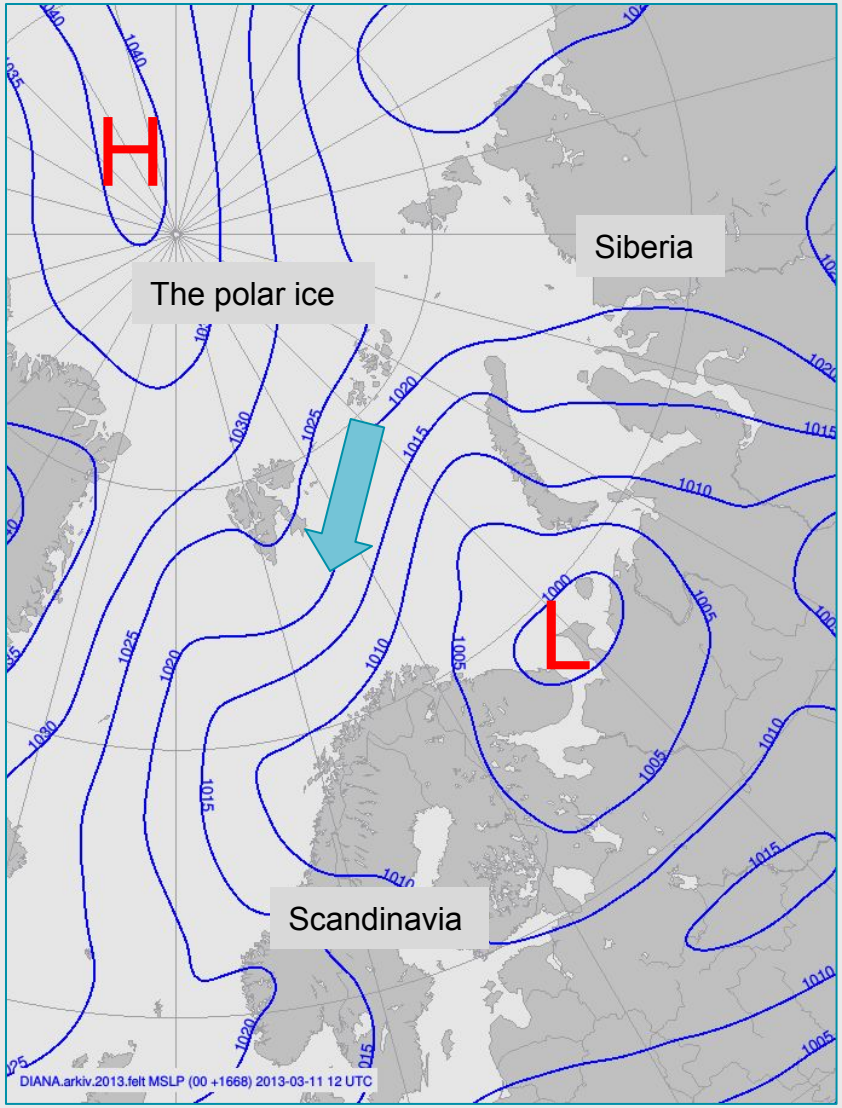
5. An area of instability at low levels;
   - Baroclinic, convective, convergence

6. Favorable conditions: CISK and reversed shear.

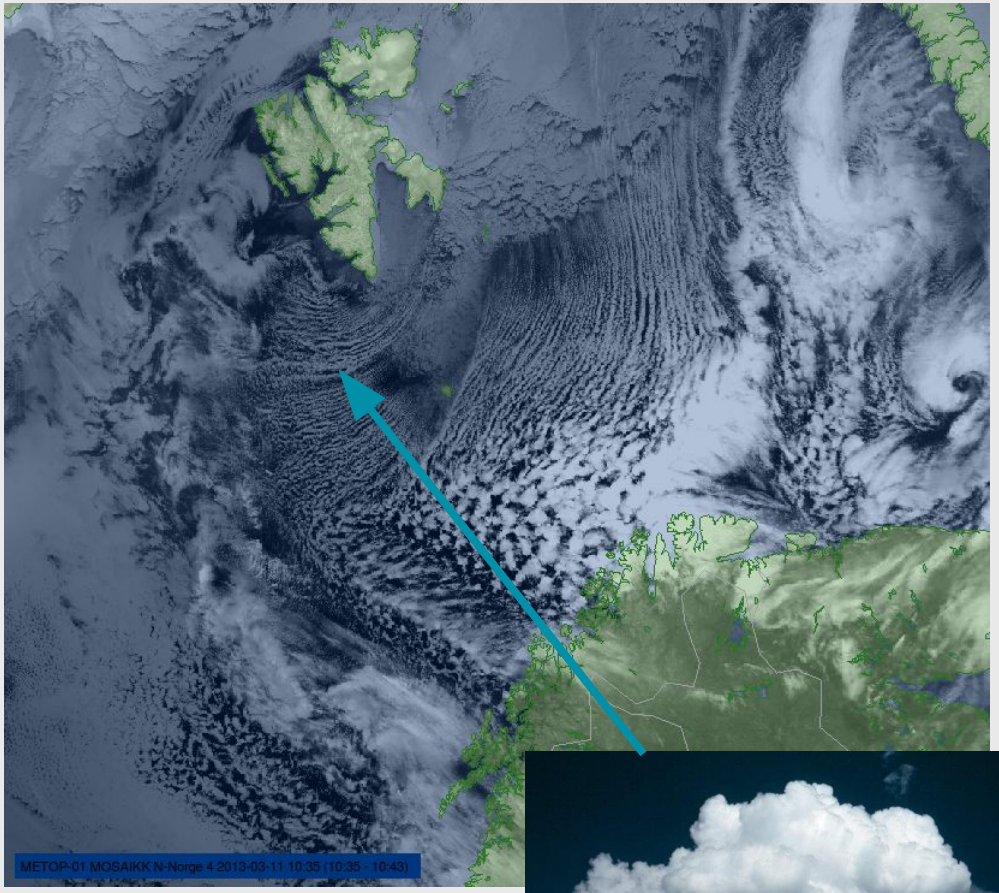
- **Polar lows develop when the MML inversion is broken down, from a mix of different kinds of instabilities and dynamic forcings.**

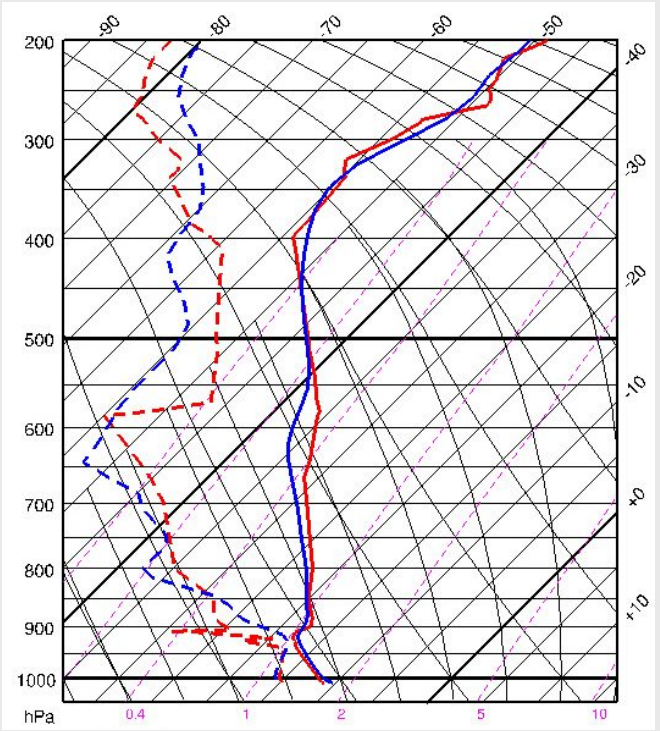
# The Cold Air Outbreak

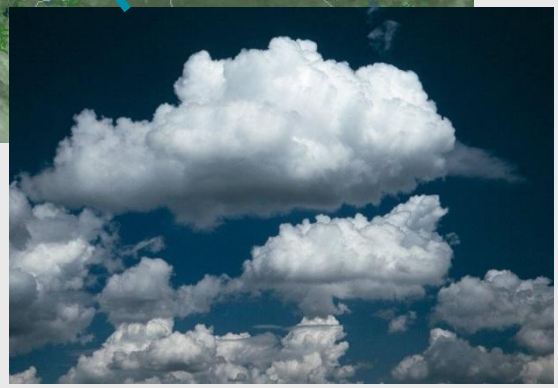


# The Cold Air Outbreak



Cumulus Humilis / Fractus



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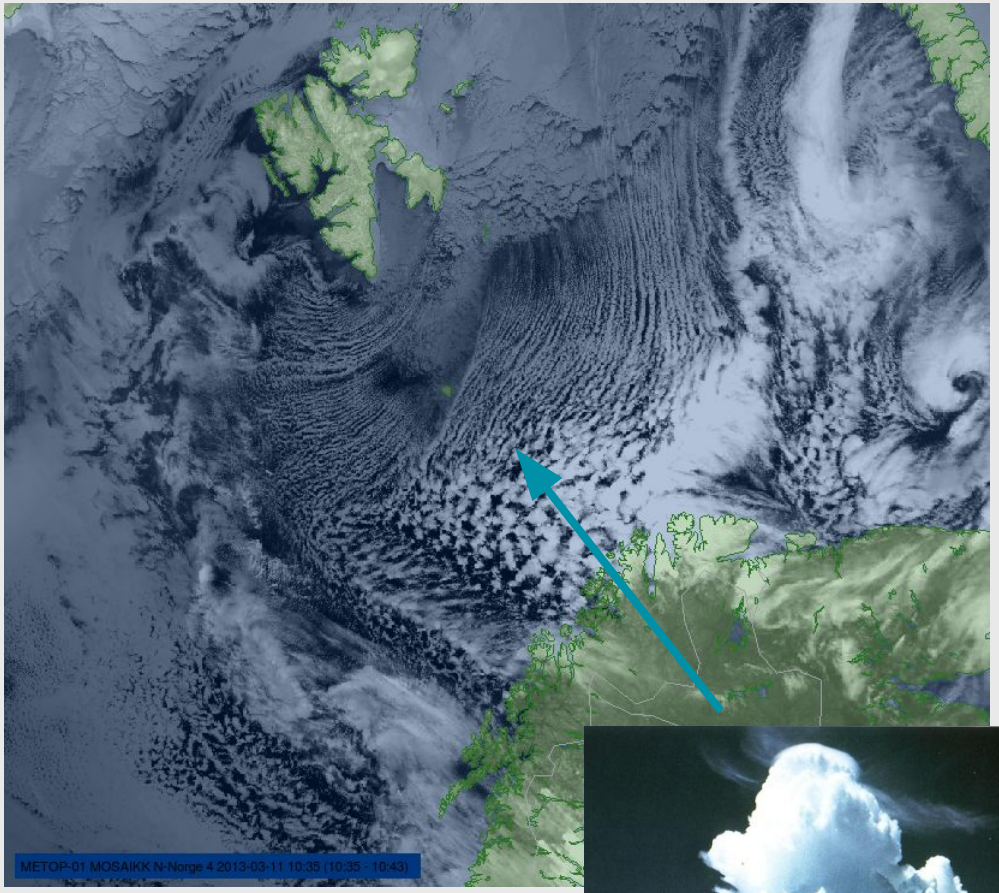
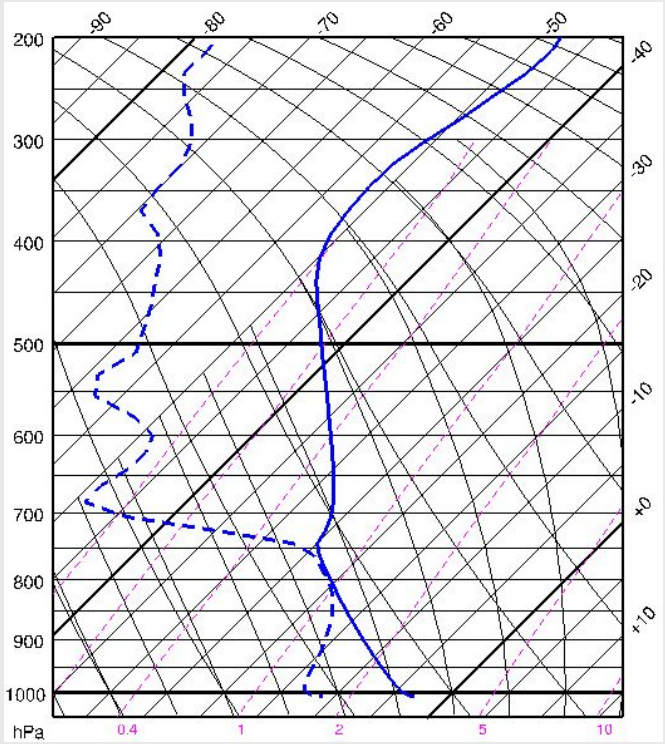
# The Cold Air Outbreak




Cumulus
Congestus (TCu)



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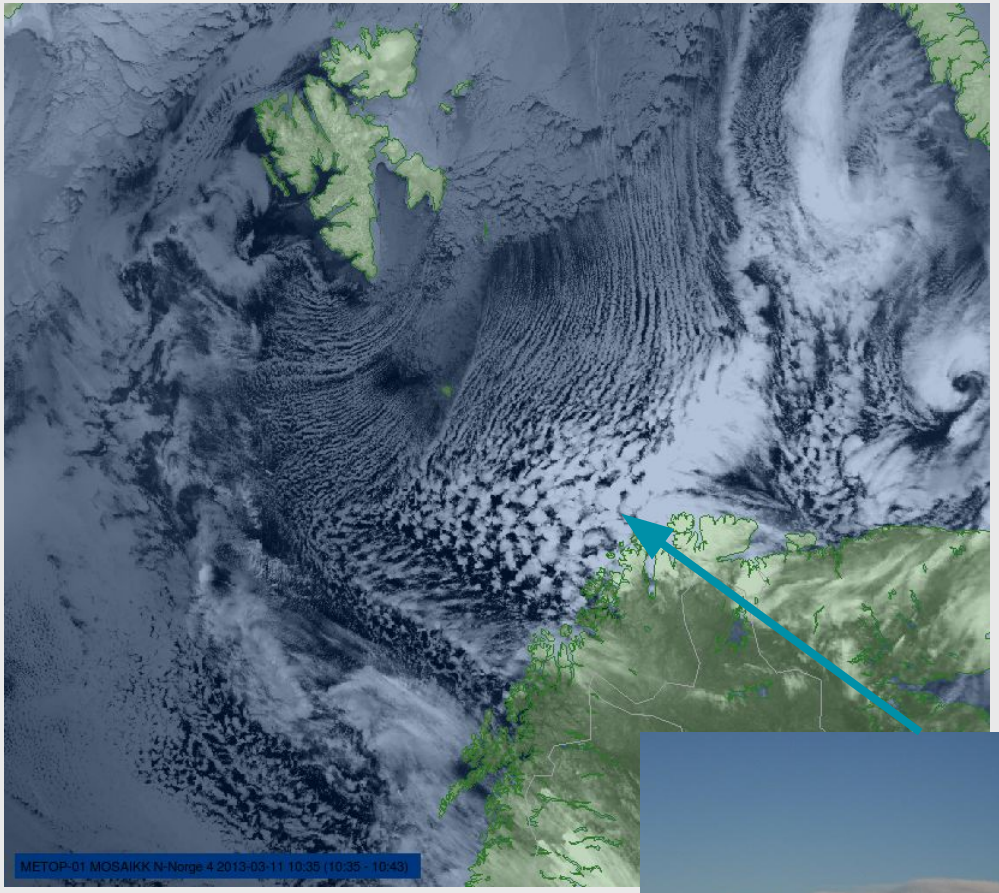
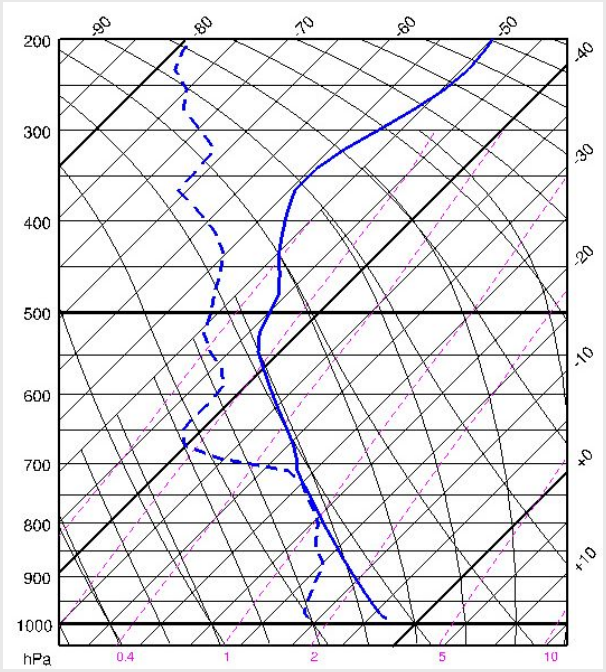
# The Cold Air Outbreak




Cumulonimbus
Incus (Cb)



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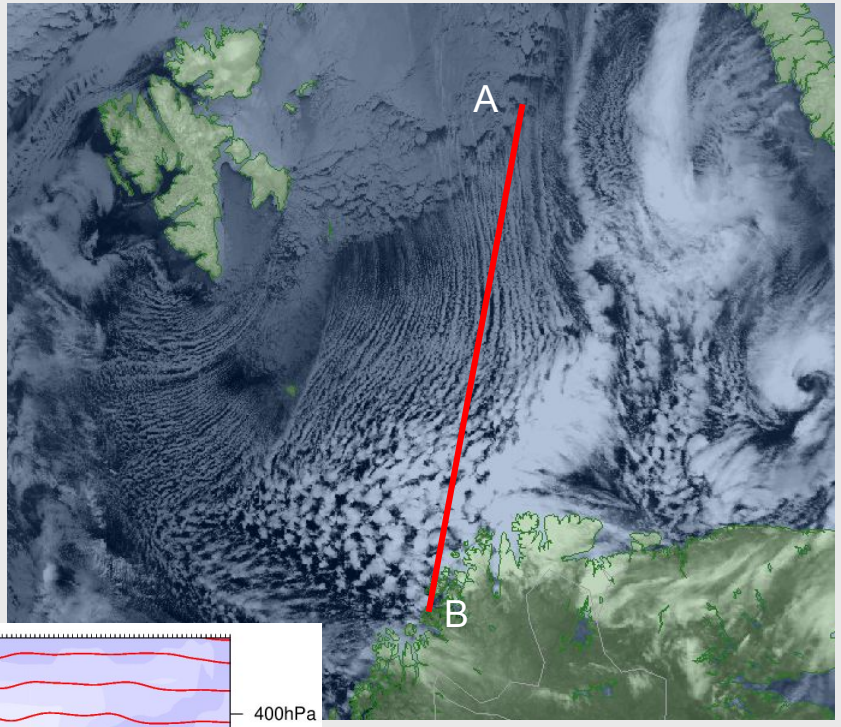
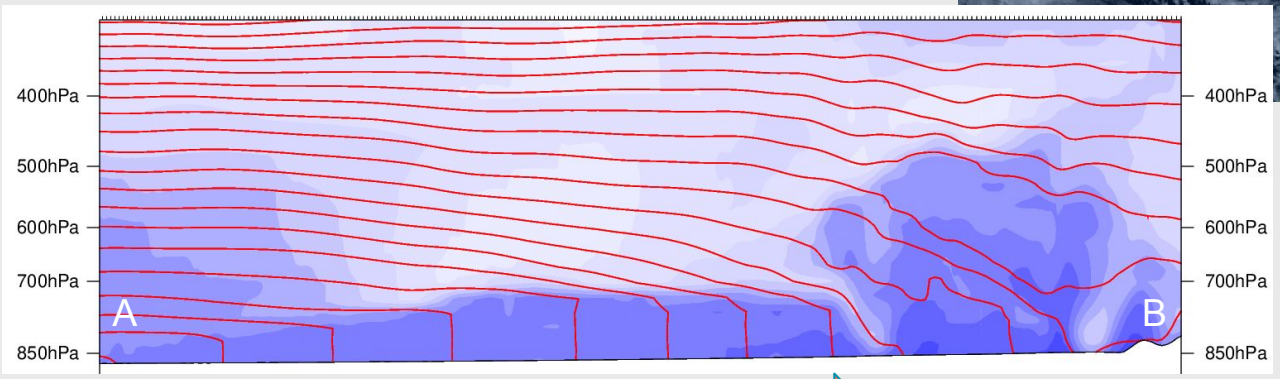
# The Marine Mixed Layer




Relative humidity
Potential temperature




Increasing sea surface temperature



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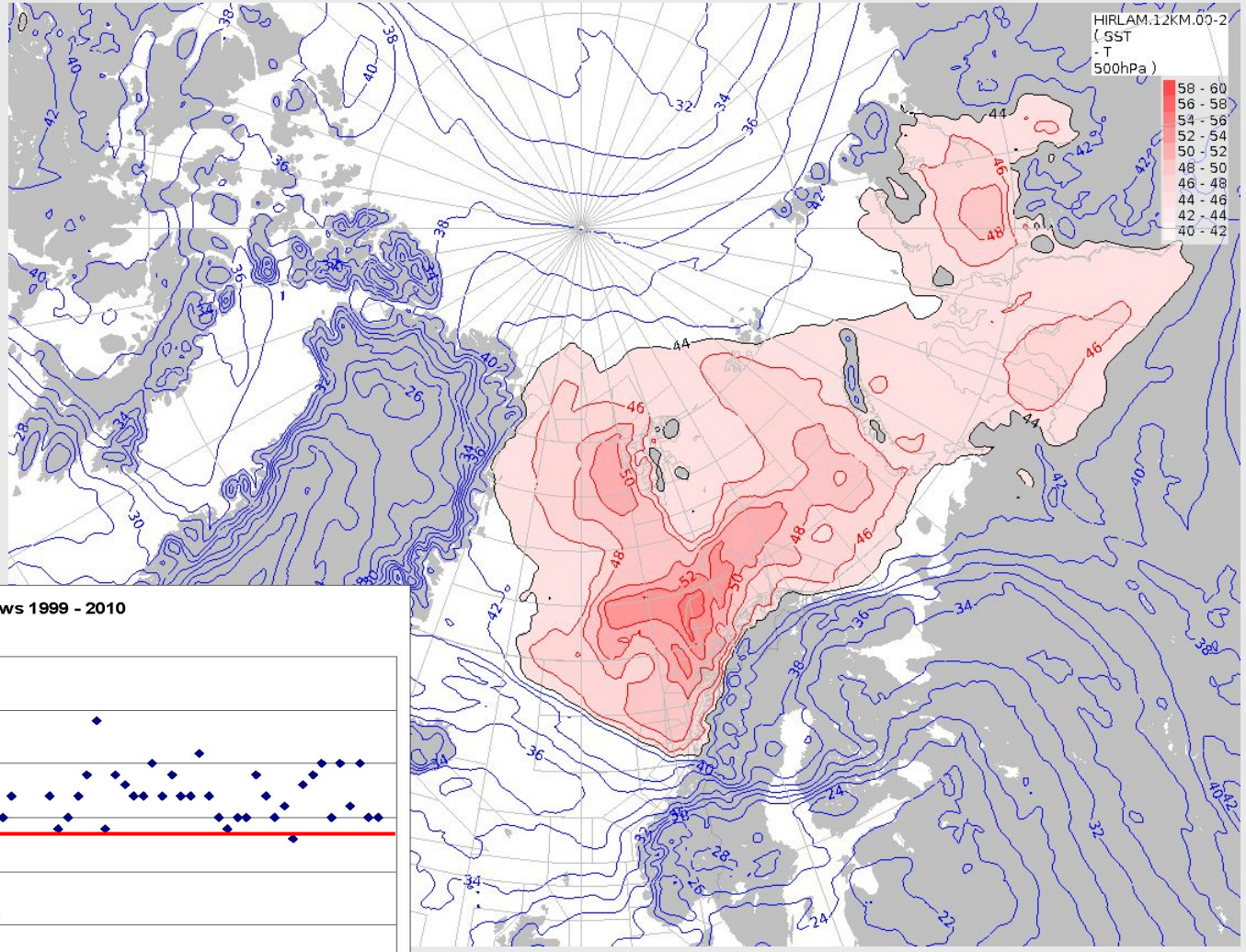
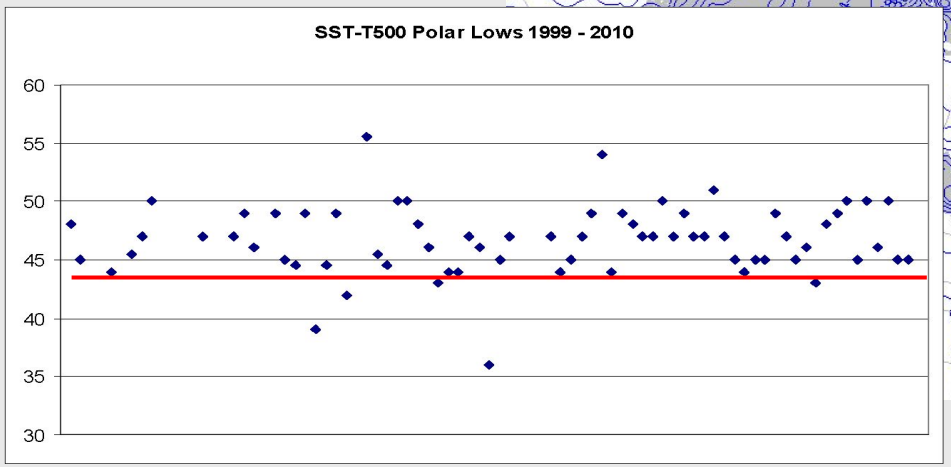
# The upper cold core:

**Criteria:**

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

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

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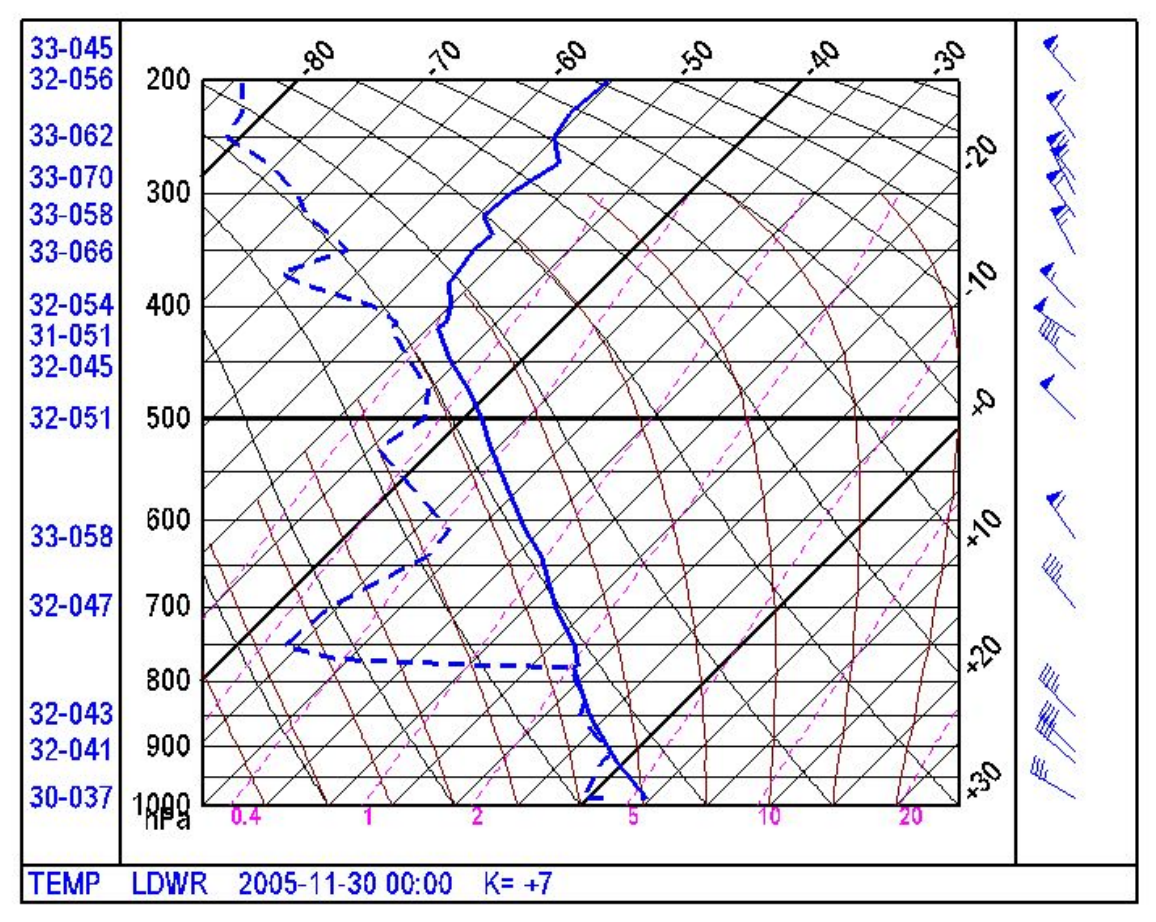
# Instability up to 500 – 400 hPa

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



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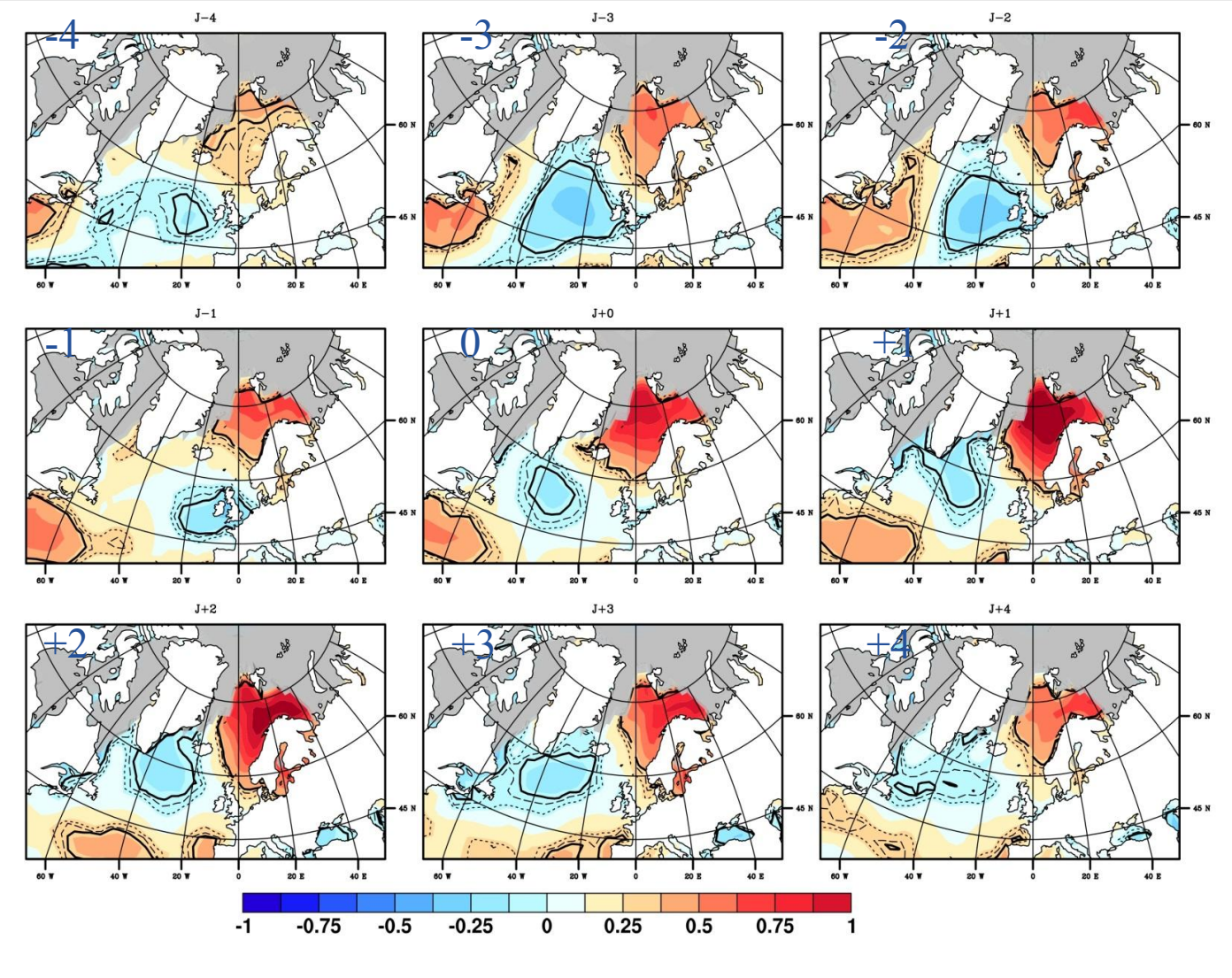
# Time evolution in the Cold Air Outbreak

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

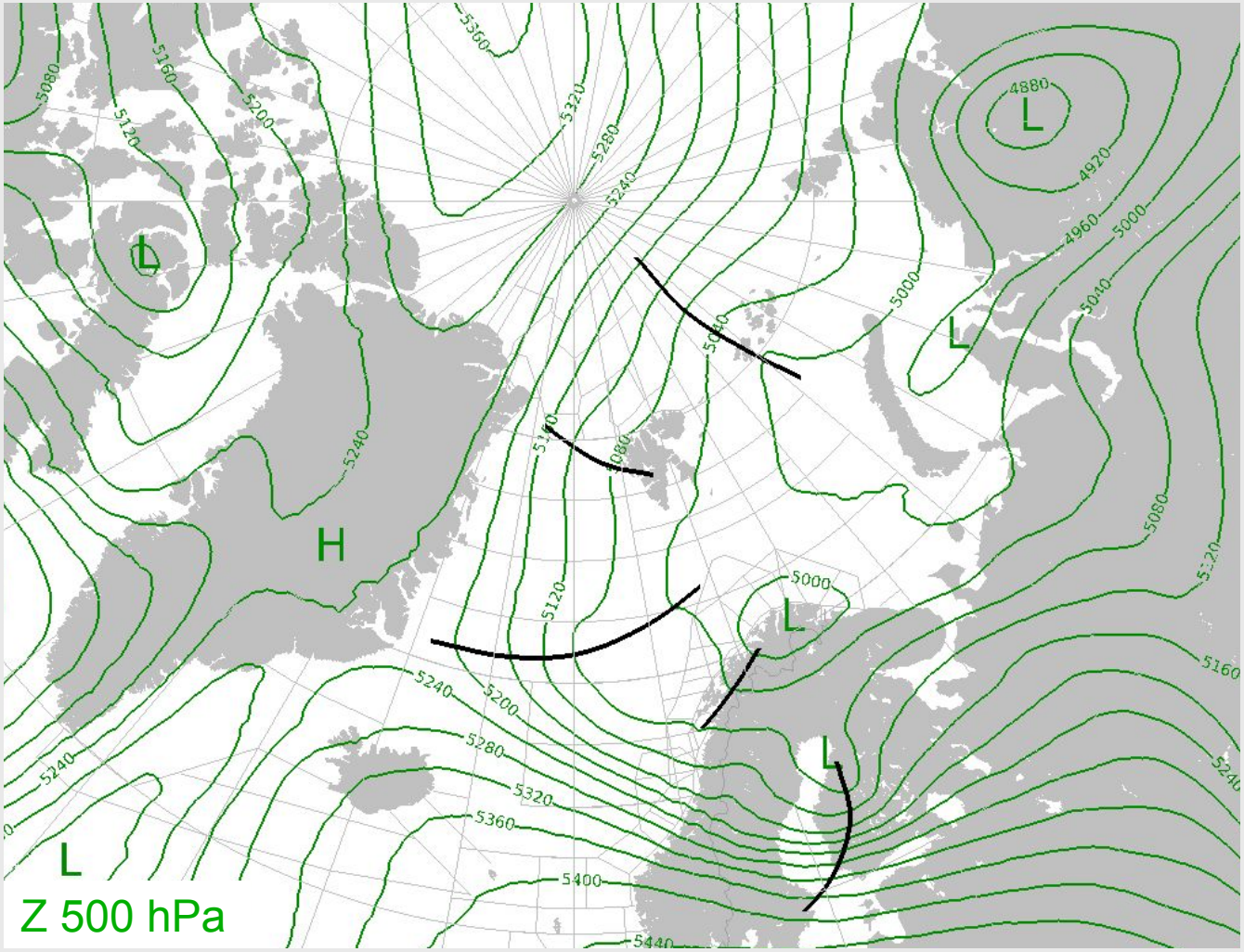
J+0 is day of development




**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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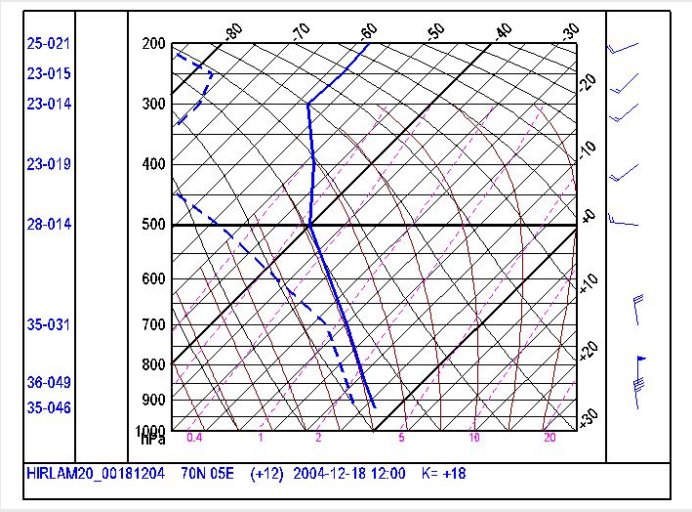
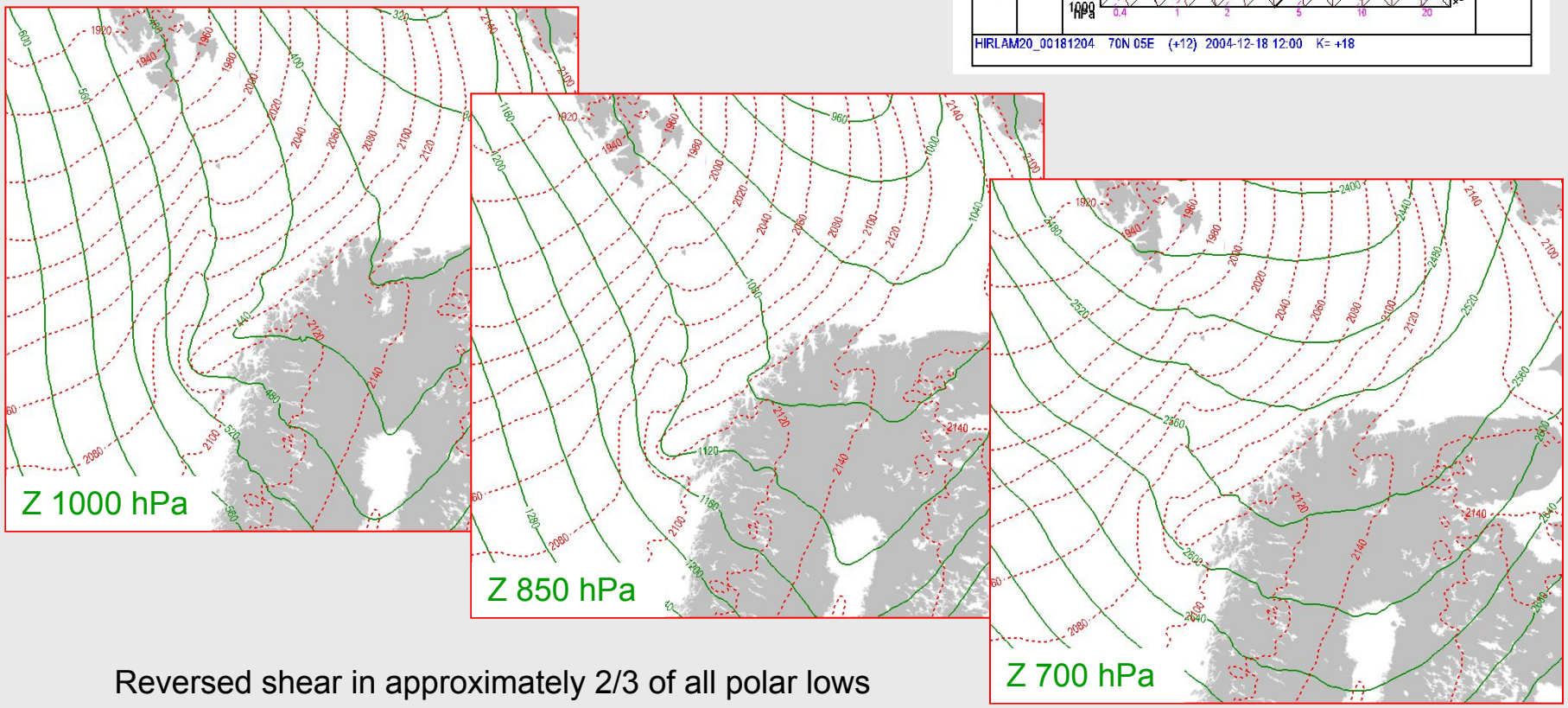
# Reversed shear:

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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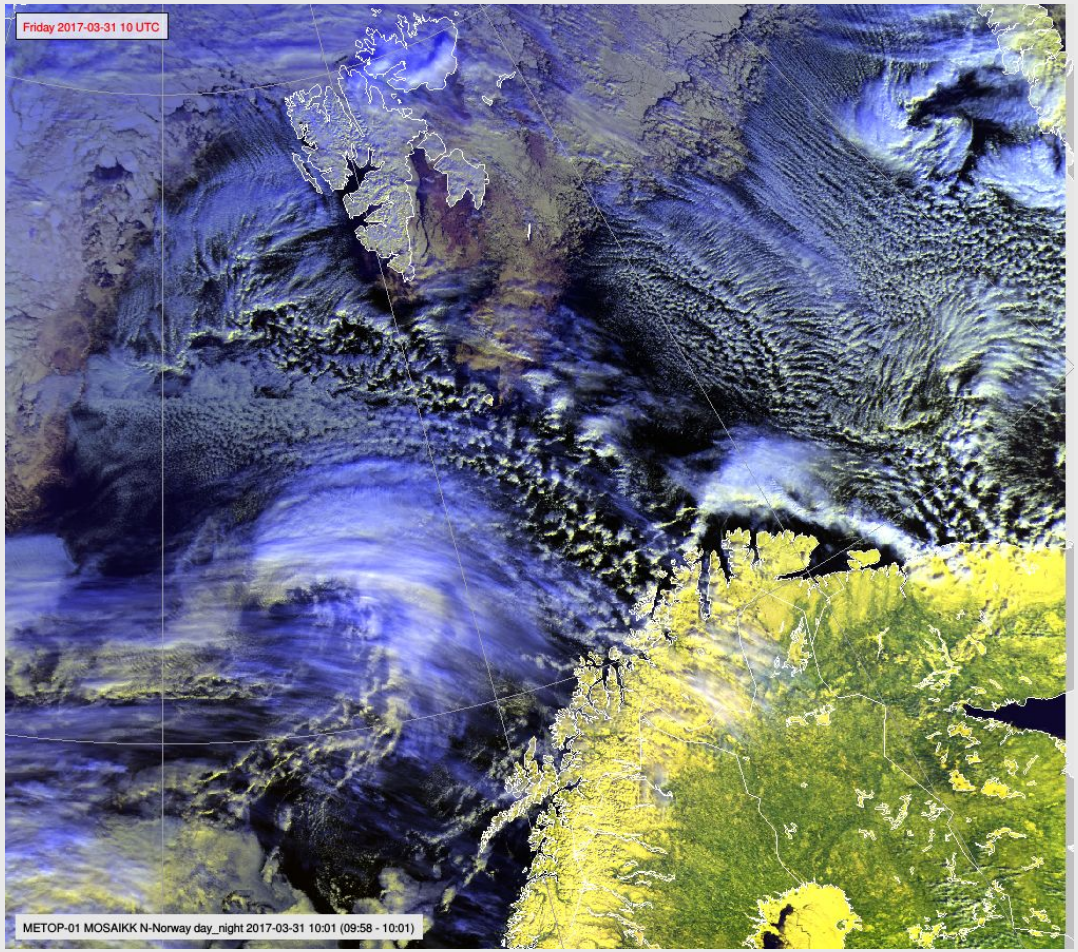
# A case for forecasting:

31.3.2017:

Current situation 10 z:

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# A case for forecasting:

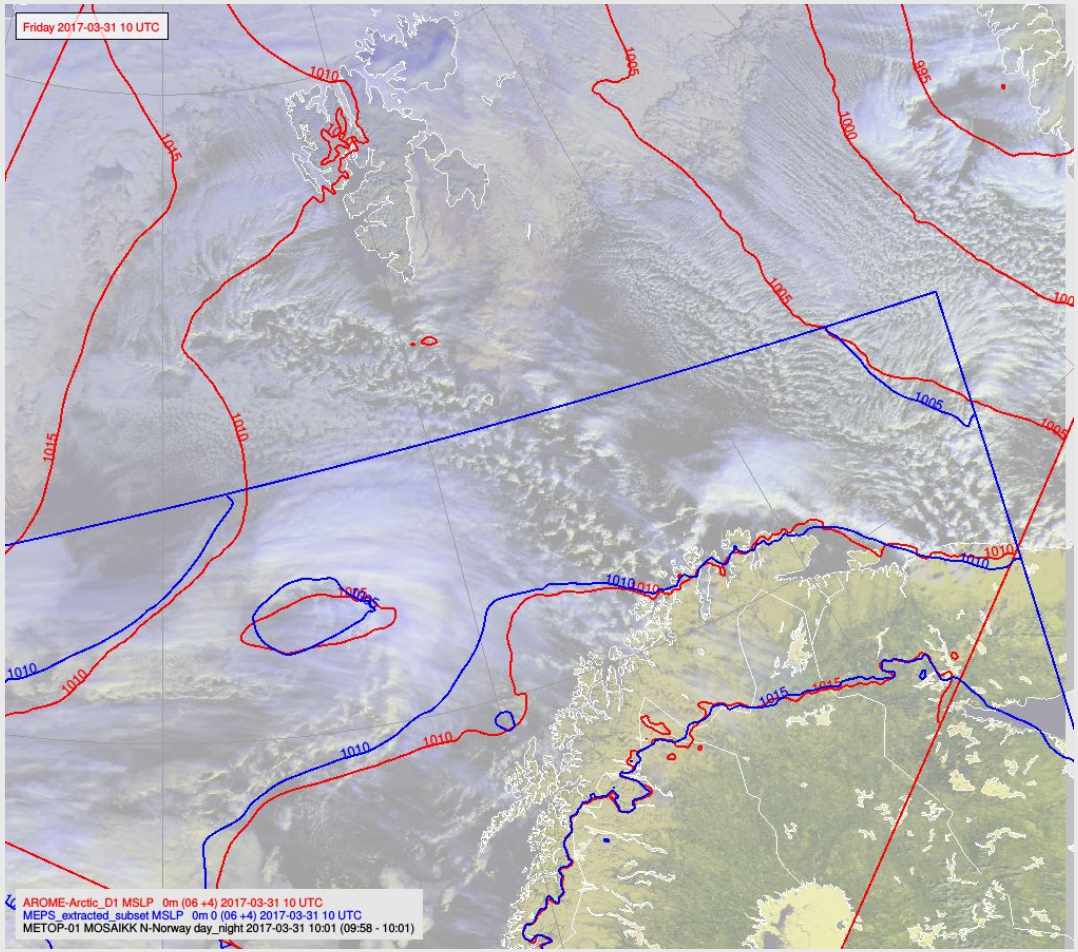
31.3.2017:

Current situation 10 z:

Arome MetCoOp MSLP

ECMWF MSLP

Is the model correct ?



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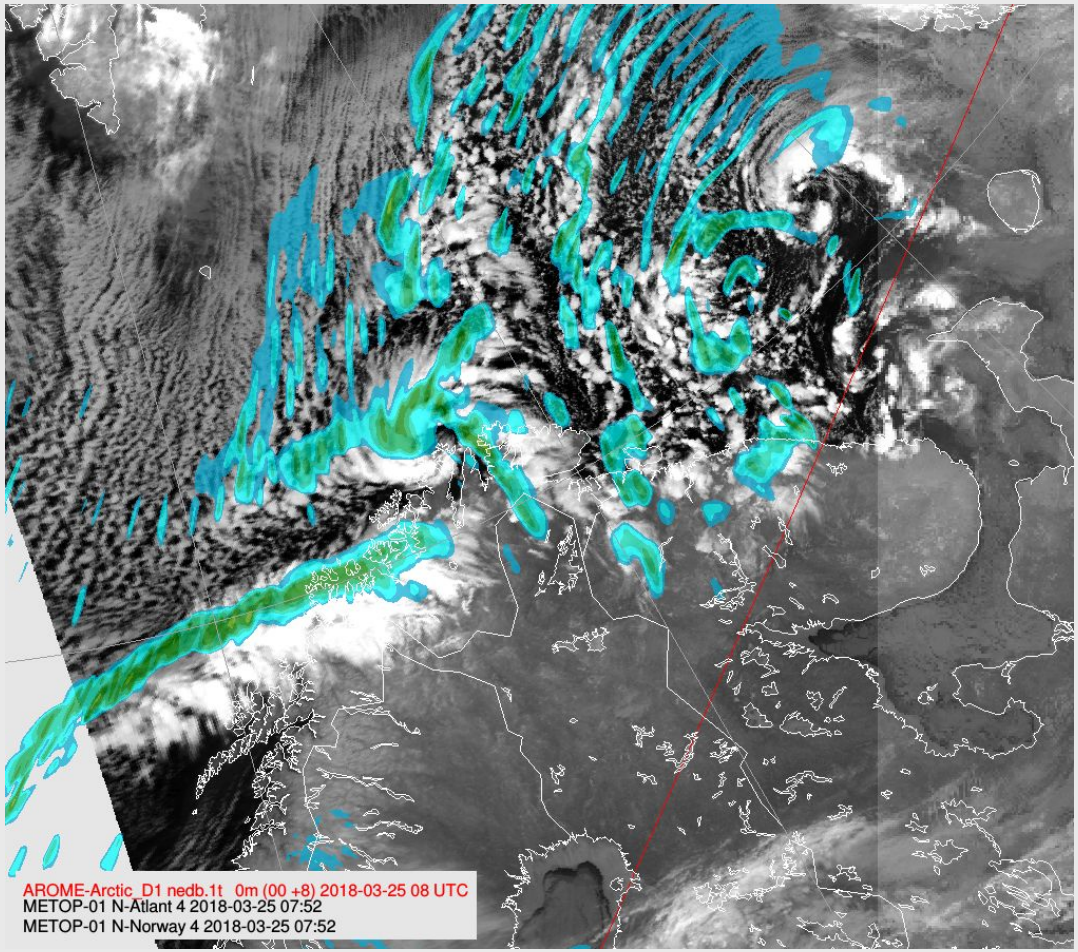
# A case for forecasting:

31.3.2017:

Current situation 10 z:

Arome MetCoOp 1 hr. precipitation

Is the model correct ?

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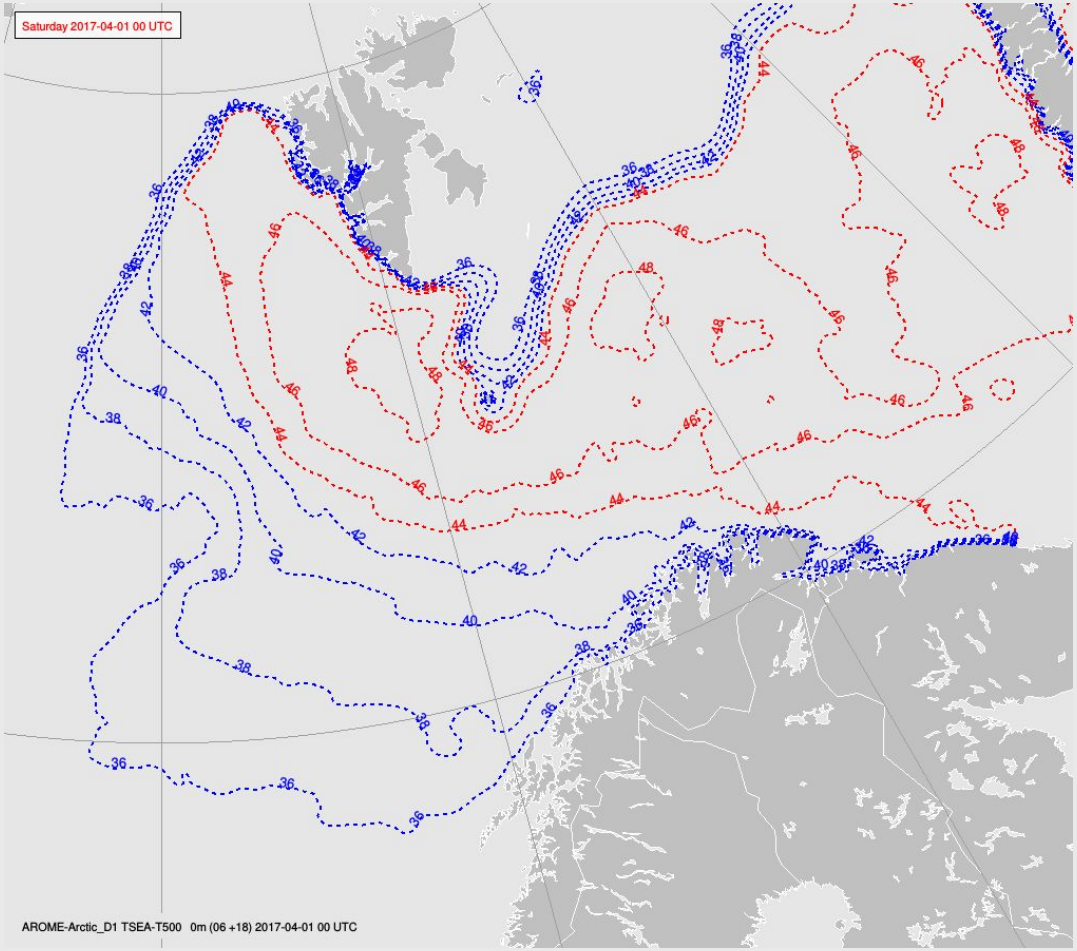
# A case for forecasting:

31.3.2017:

At landfall, +18 hrs prognosis :

Qualitative assessment of the cold core

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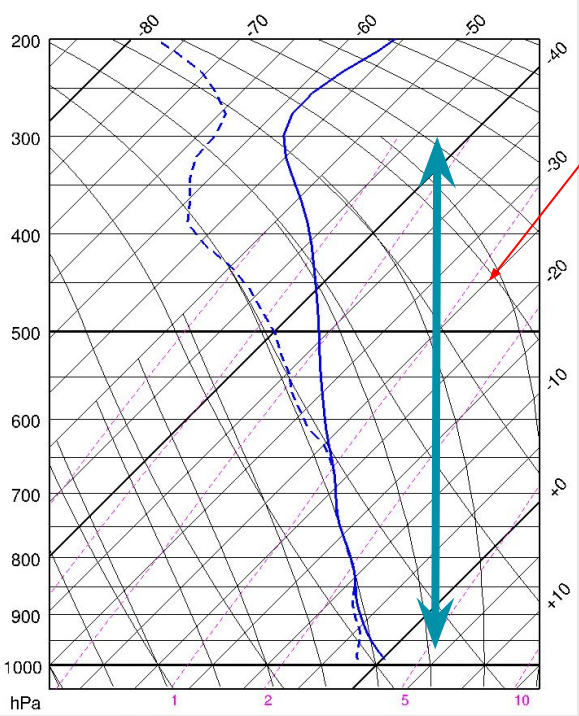
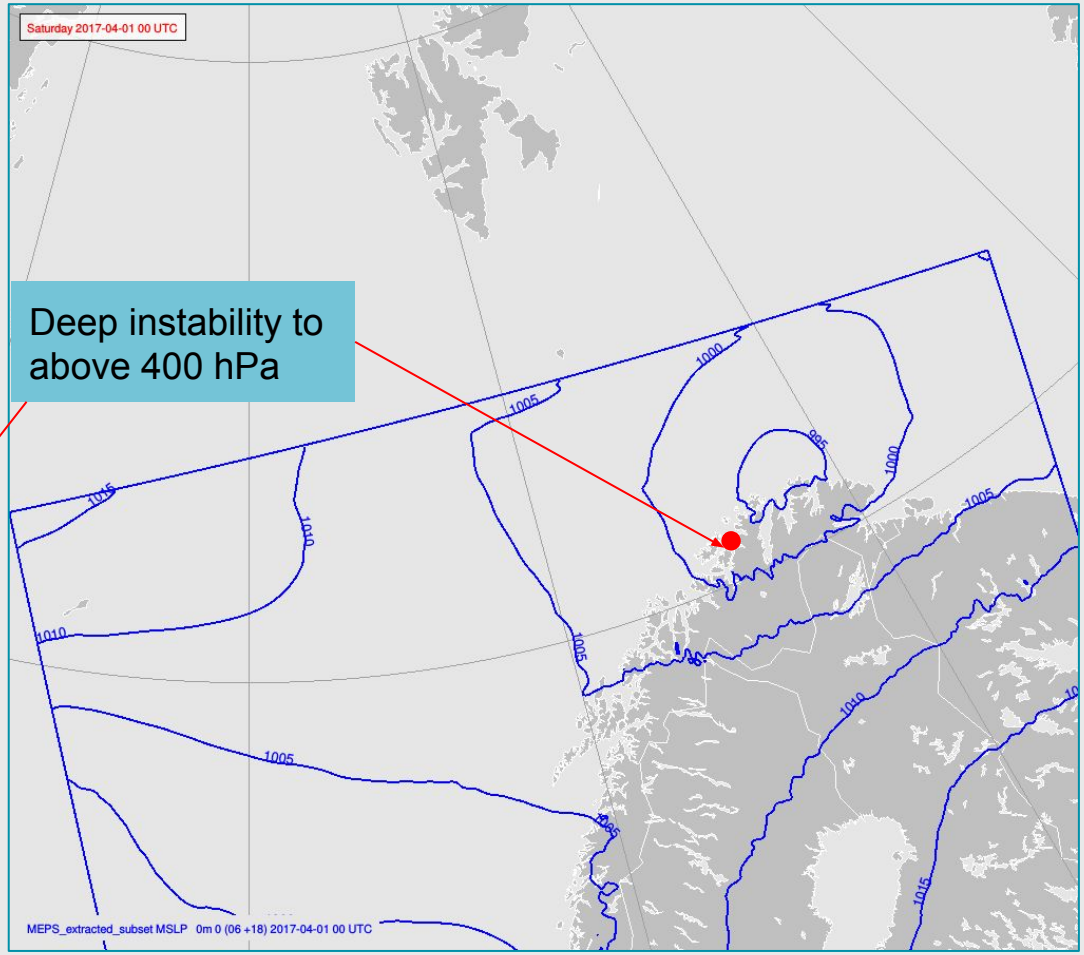
# A case for forecasting:

31.3.2017:

At landfall, +18 hrs prognosis :

Arome MetCoOp MSLP



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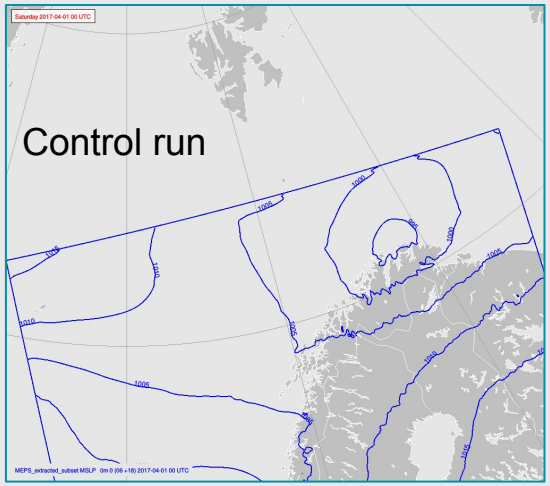
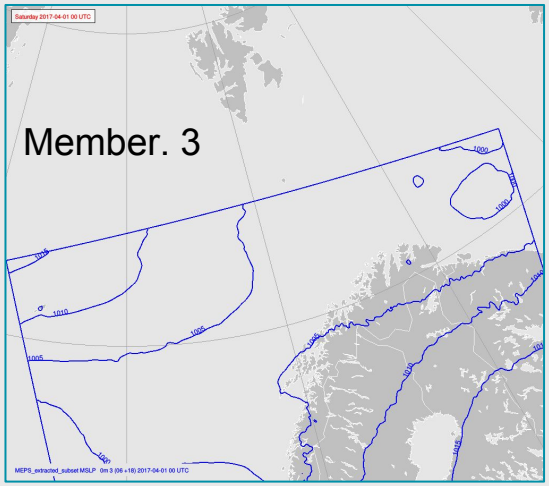
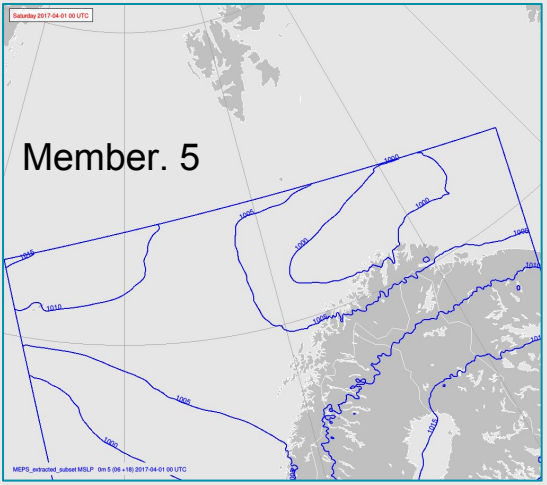
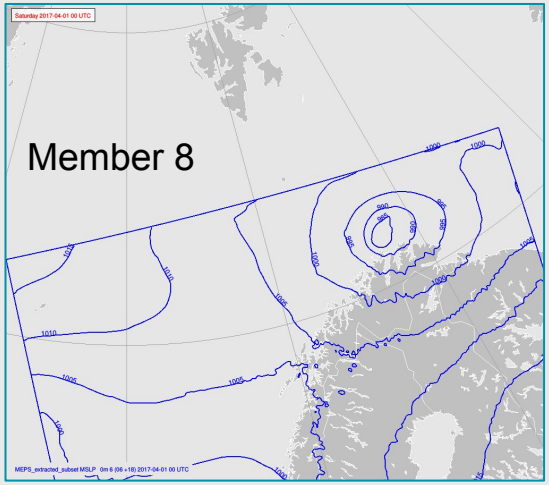
# Don’t forget to check the ensemble members




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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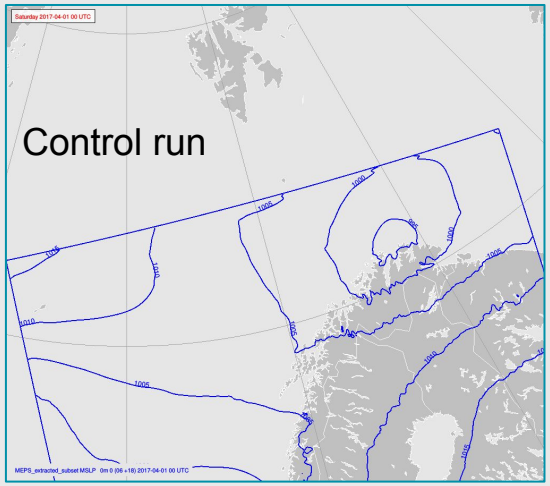
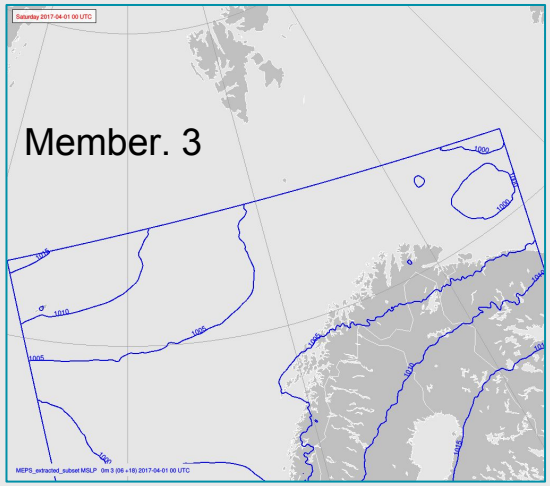
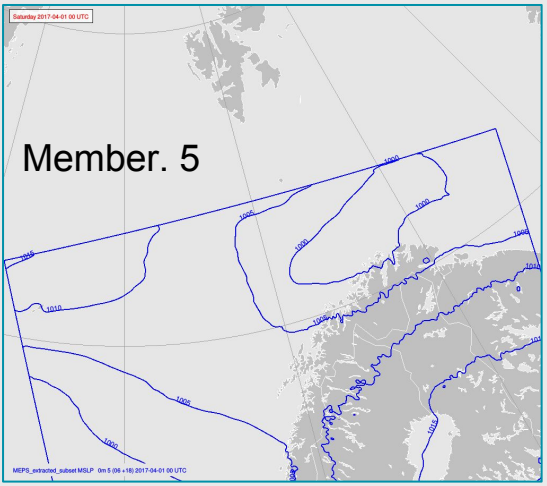
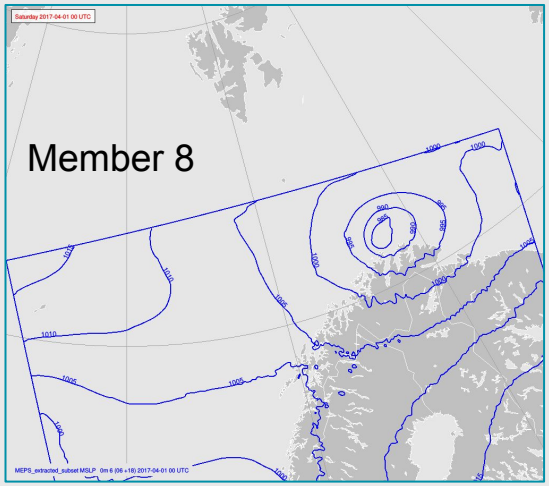
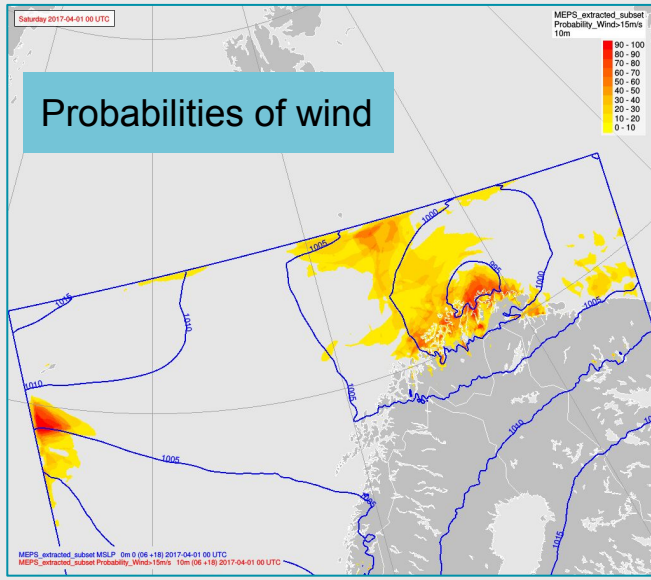
# Don’t forget to check the ensemble members




If in doubt; check the probabilities !



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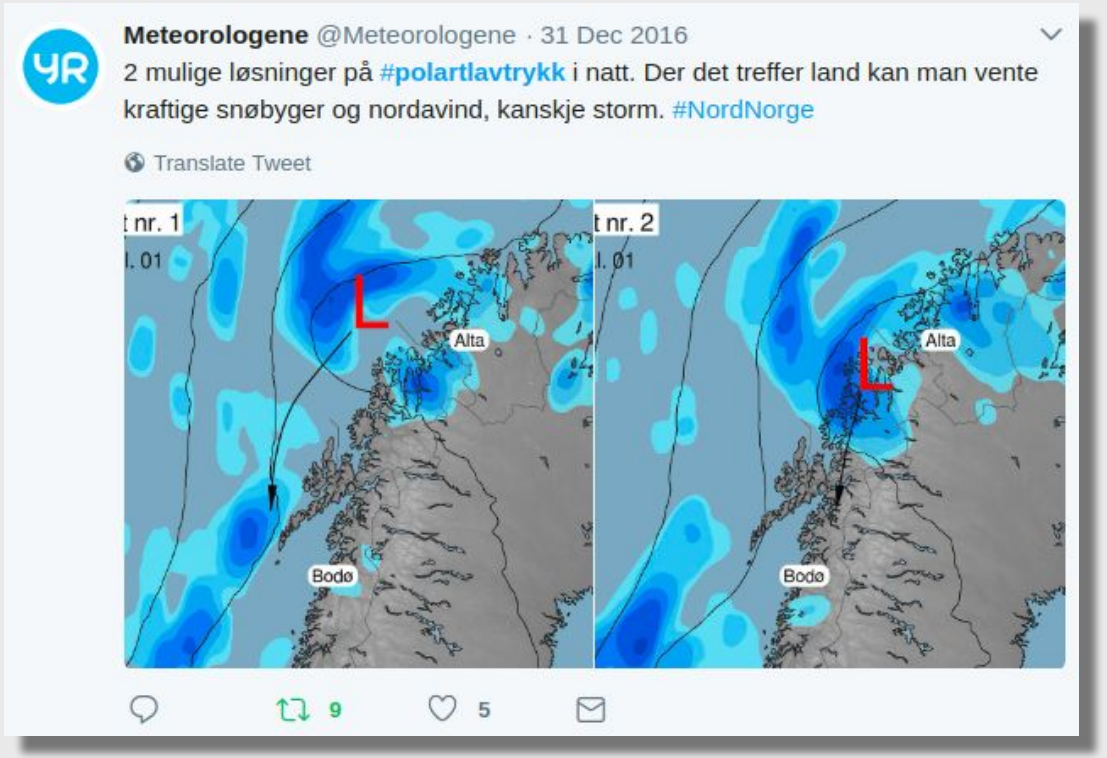
# To the public and the media...

@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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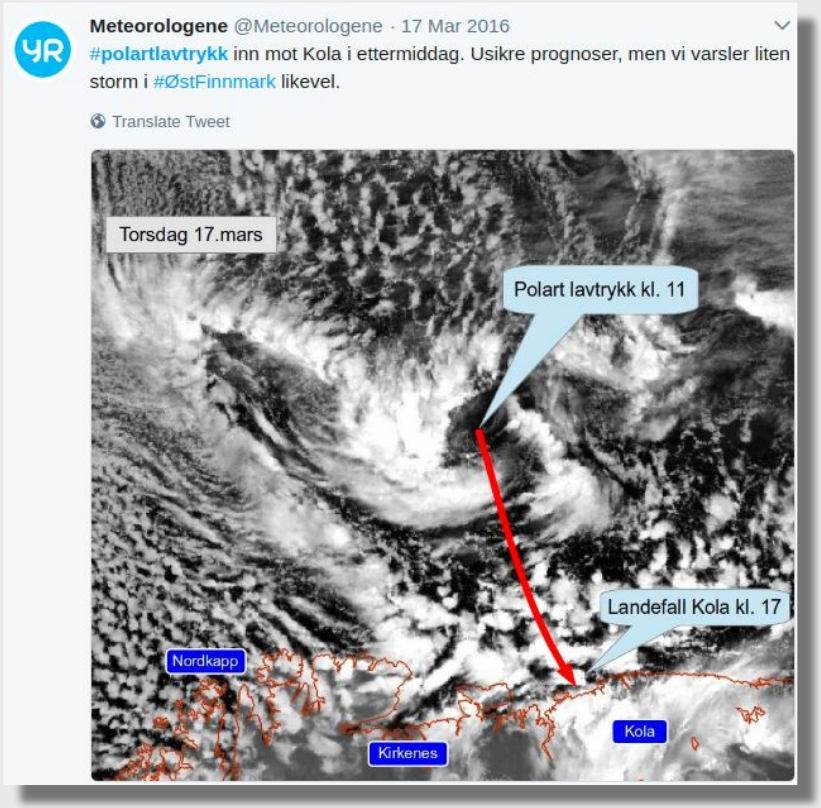
# To the public and the media...

@Meteorologene

YR.no

Probability forecast II:

‘Polar low inn towards Kola tonight. Uncertain prognosis, but we forecast a severe gale in eastern Finnmark anyway’



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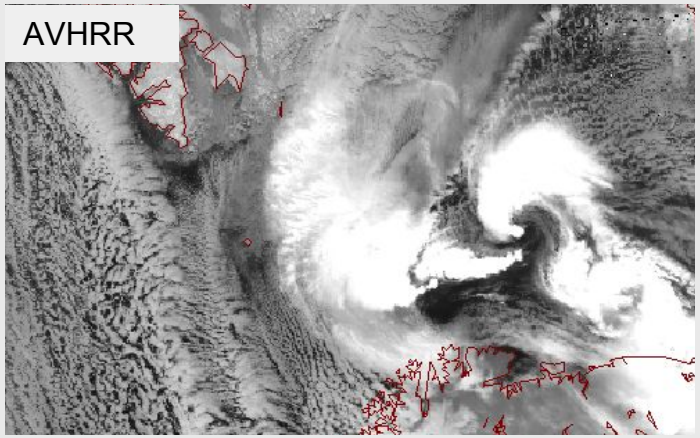
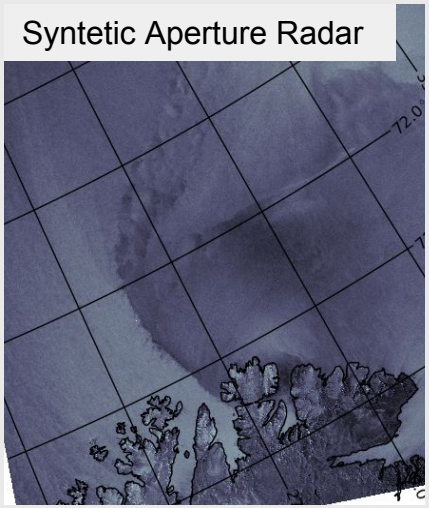
# Observing the polar low:

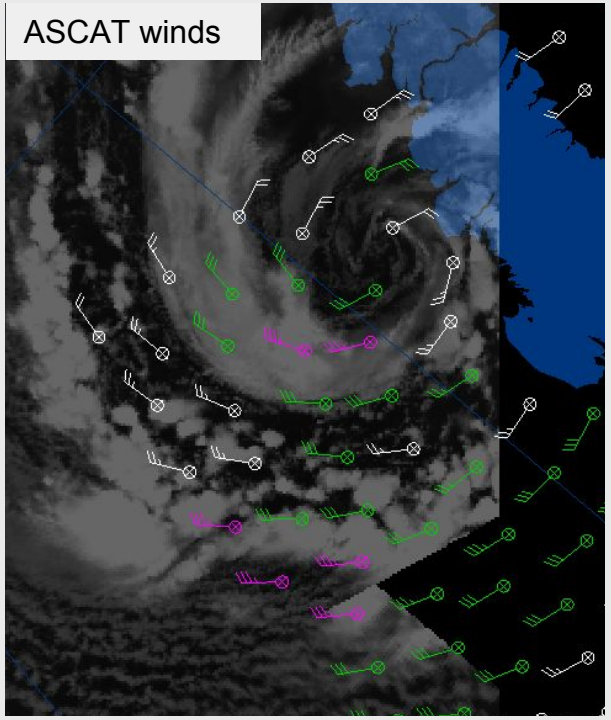
AVHRR



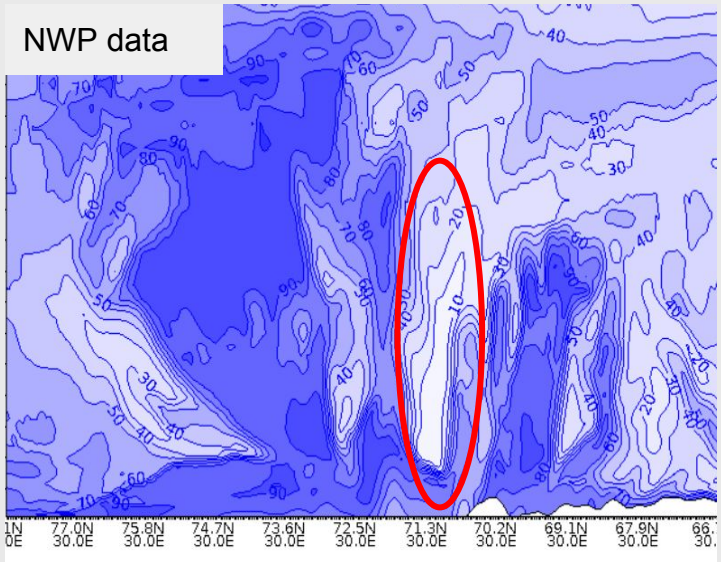
Syntetic Aperture Radar



ASCAT winds

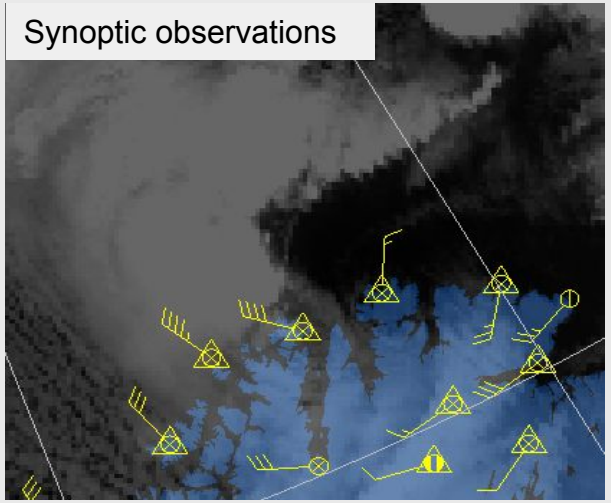


NWP data



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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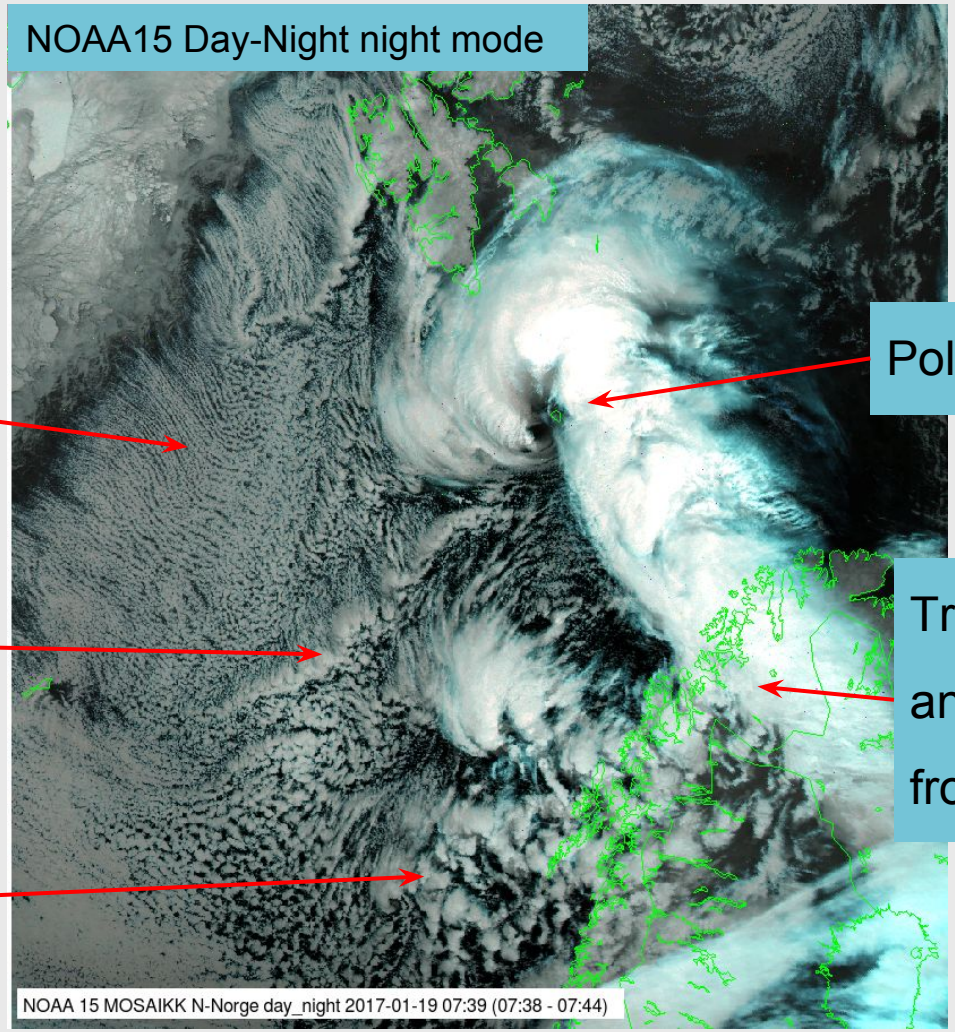
# Analysis in the mesoscale:




Cloud streets

Arctic fronts

Cumulus clusters

Polar low

Troughs and fronts



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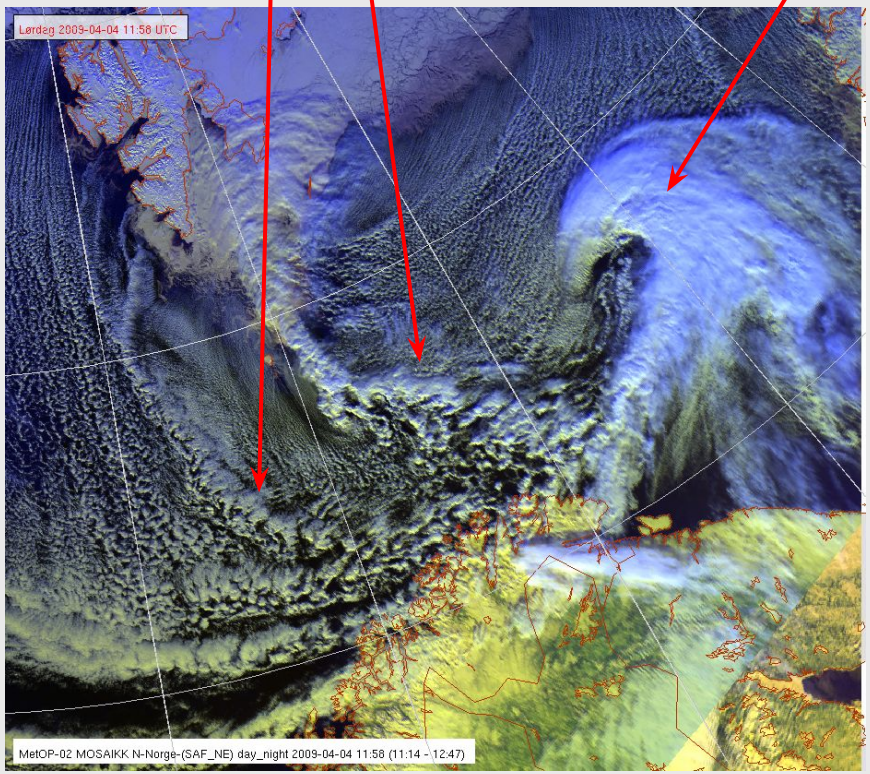
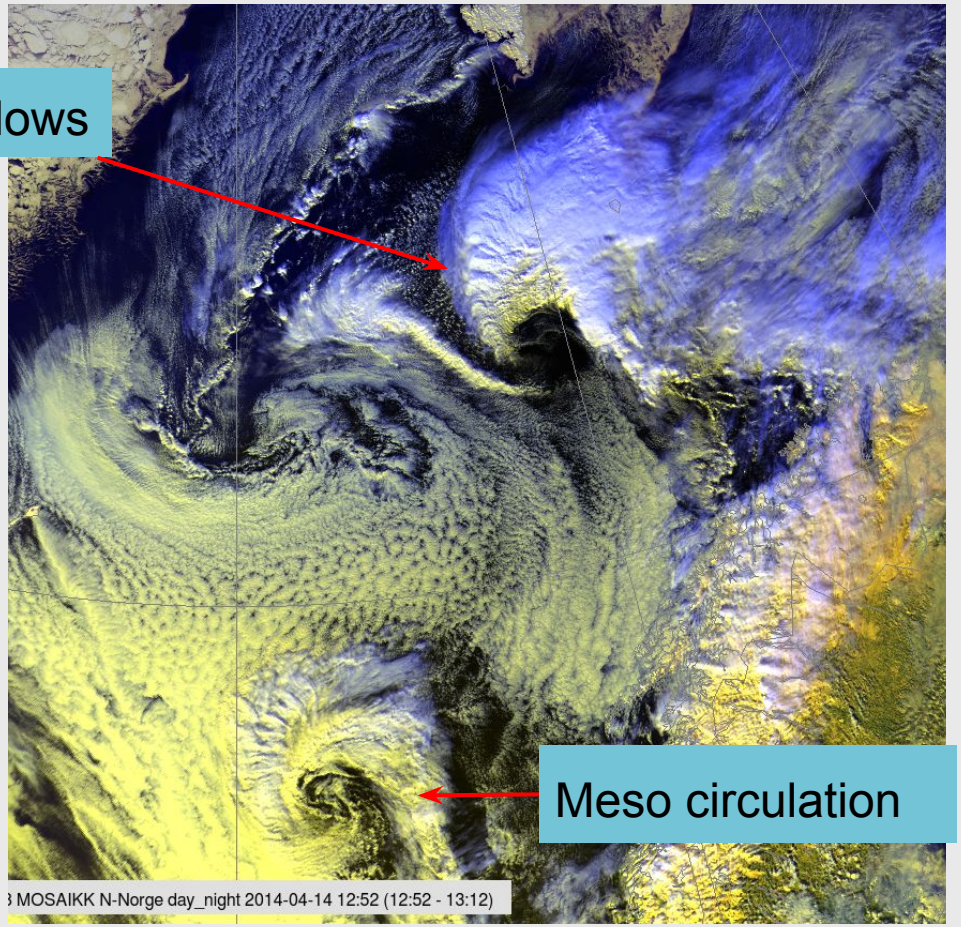
# Analysis in the mesoscale:

Convergence lines

Polar lows




Meso circulation



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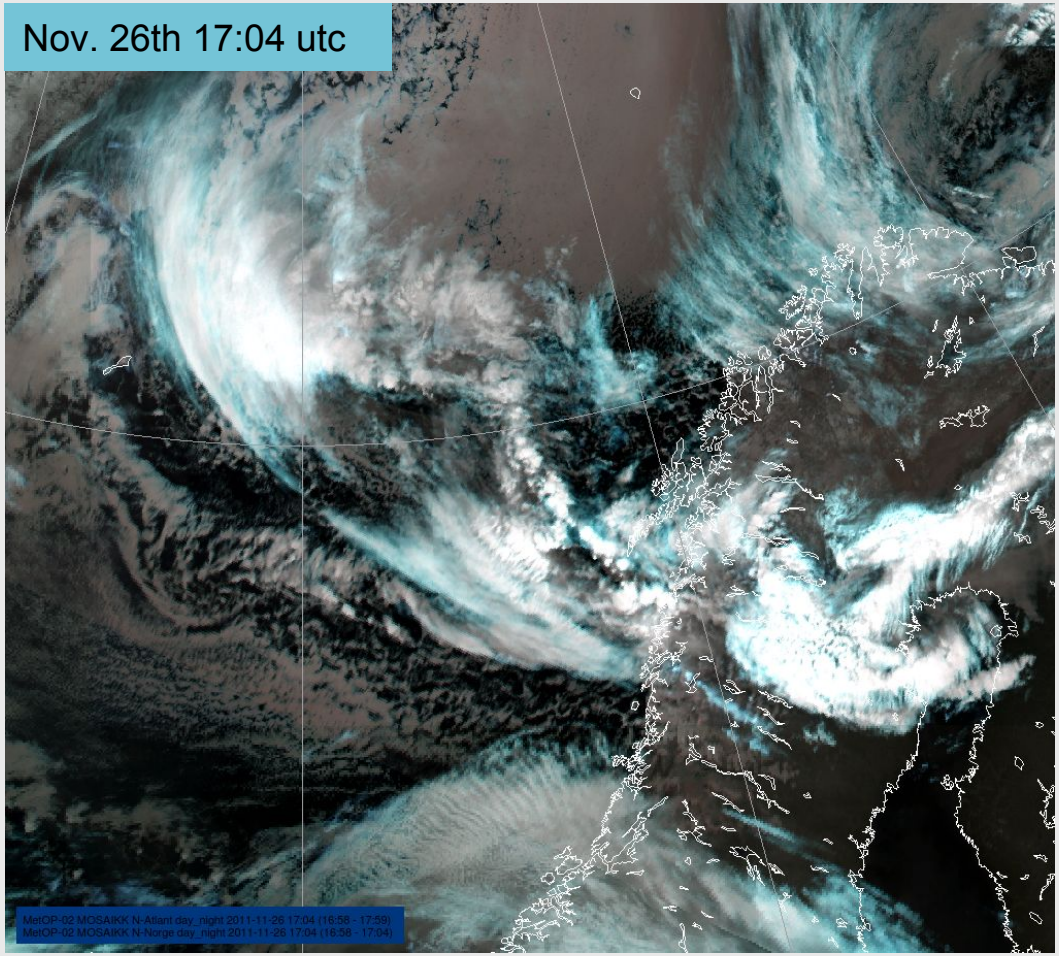
# The polar low, incipient stage:

First signs in the cloud patterns:

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

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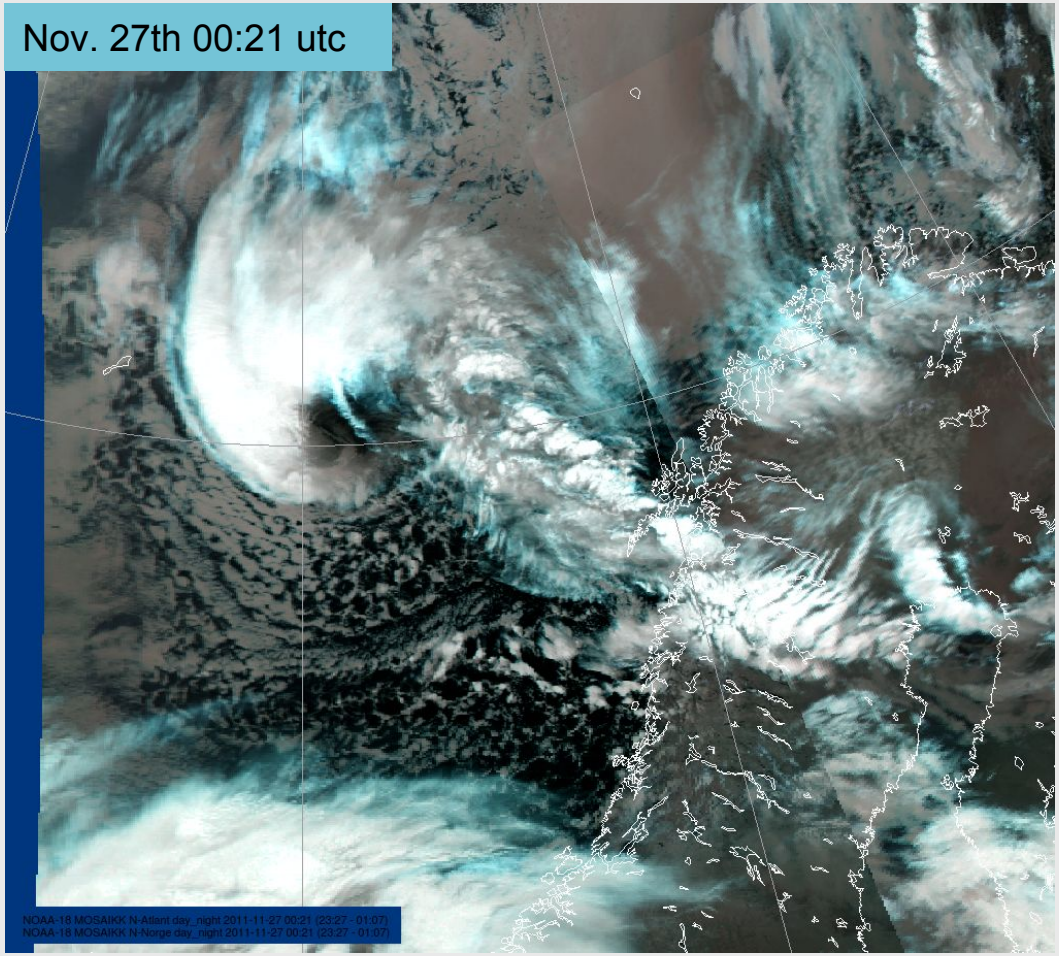
# The polar low, mature stage:

Typical features in the cloud patterns:

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

Baroclinic or convective ?

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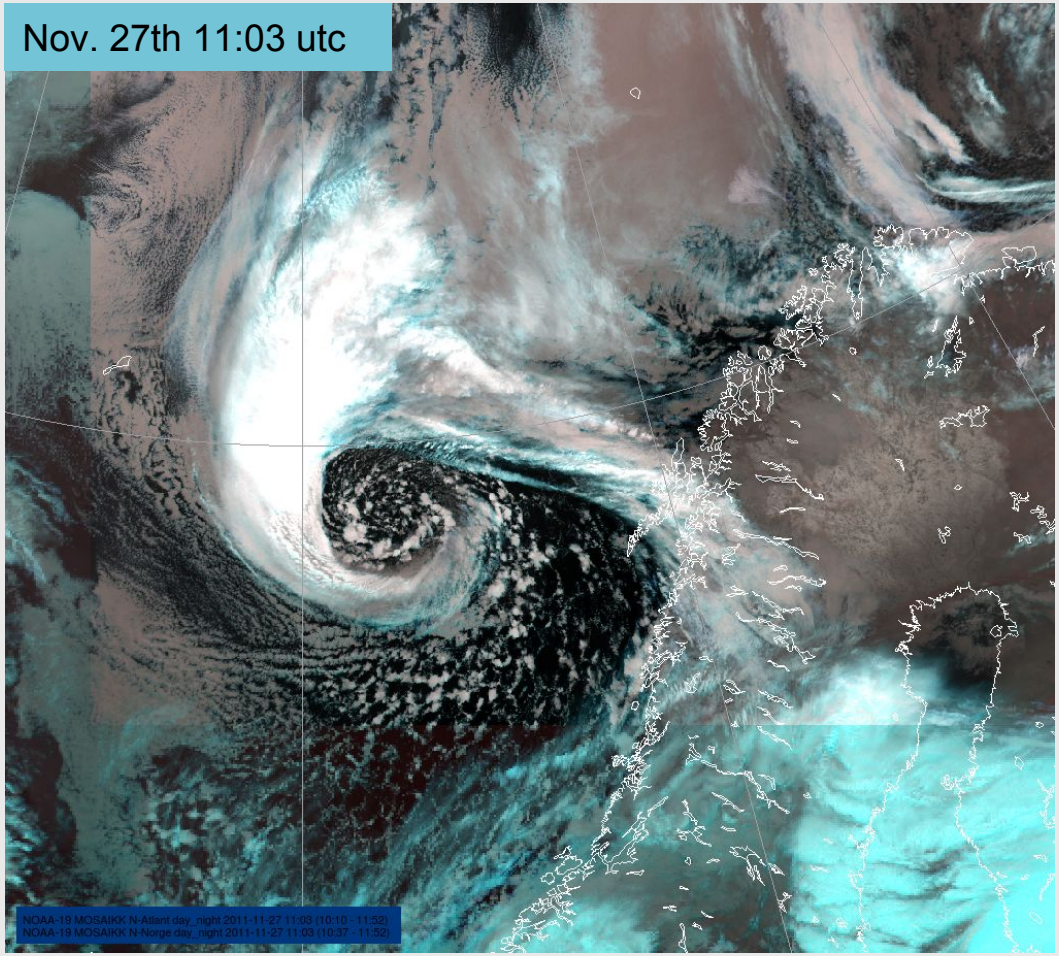
# The polar low, late mature stage:

Resembles an occluded low

Convection emerging in the ‘eye’.

Usually less wind at later stages than at intensification

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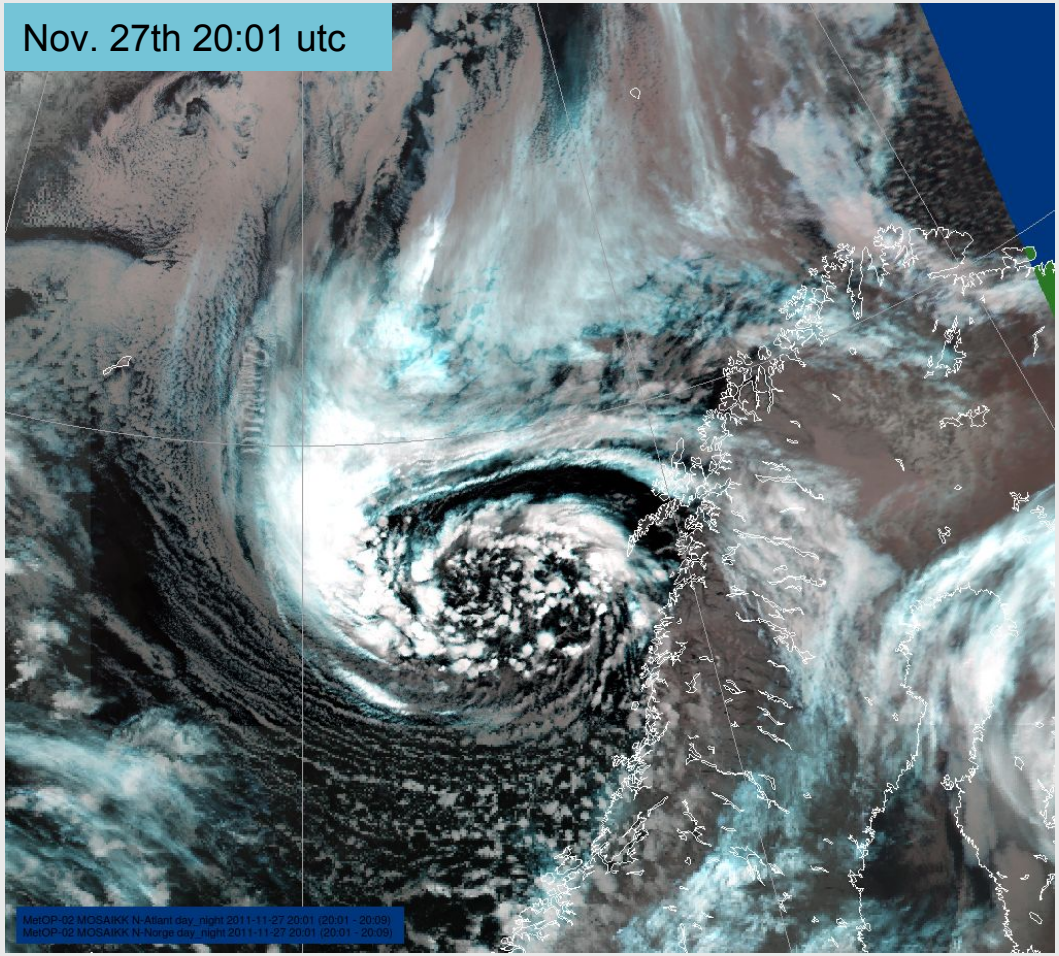
# The polar low, dissipating stage:

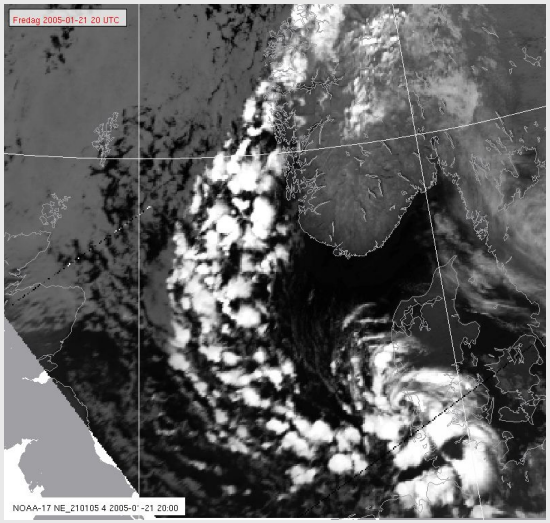
Typical features in the cloud patterns:

- 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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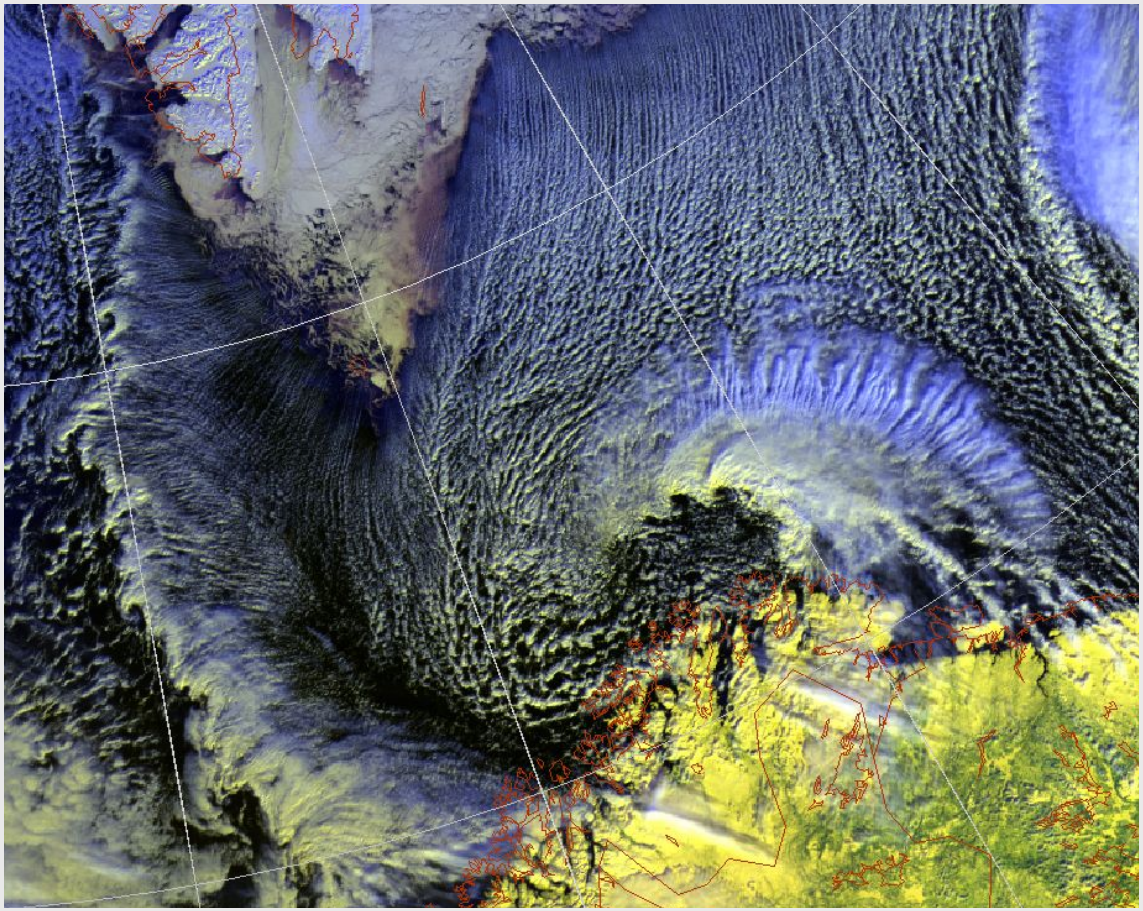
# Some variations:

Wave pattern on the periphery of the low:

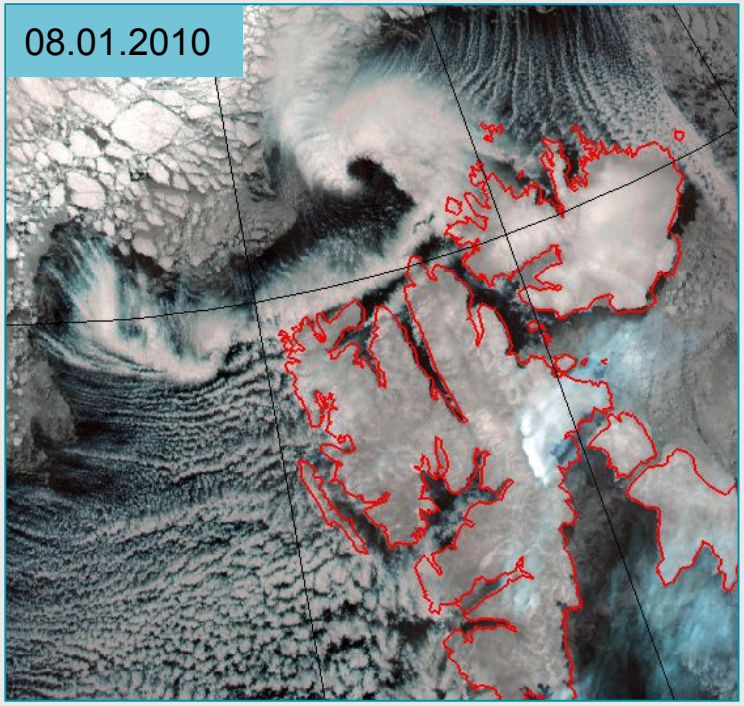
- Reversed shear
- Vertical shear on top of the convective layer
- Jet above
- Low vertical extent
- Moderately strong PL

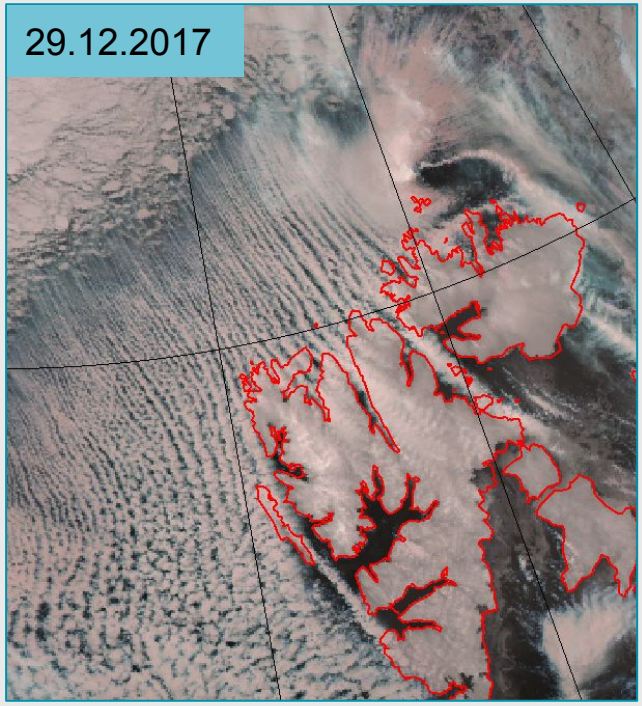


# Some variations:

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:

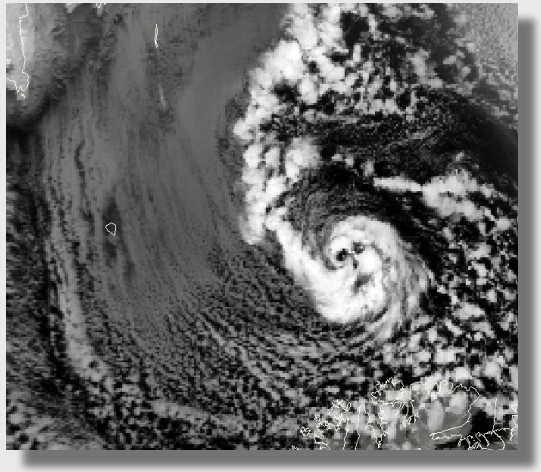
In the winter, in the Nordic Seas and surrounding coastal areas

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

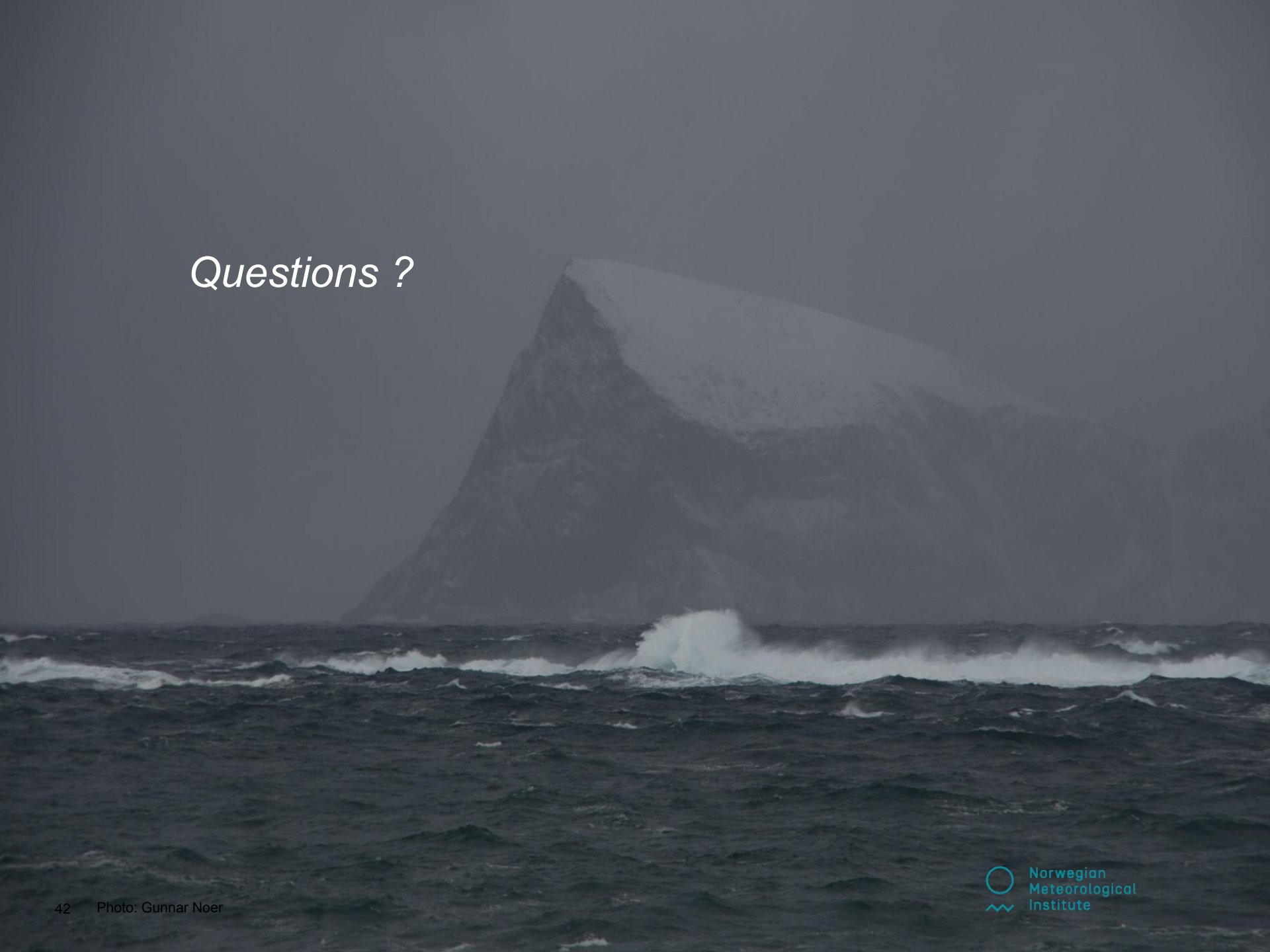




Photo: Gunnar Noer

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