UiO : Department of Geosciences
University of Oslo

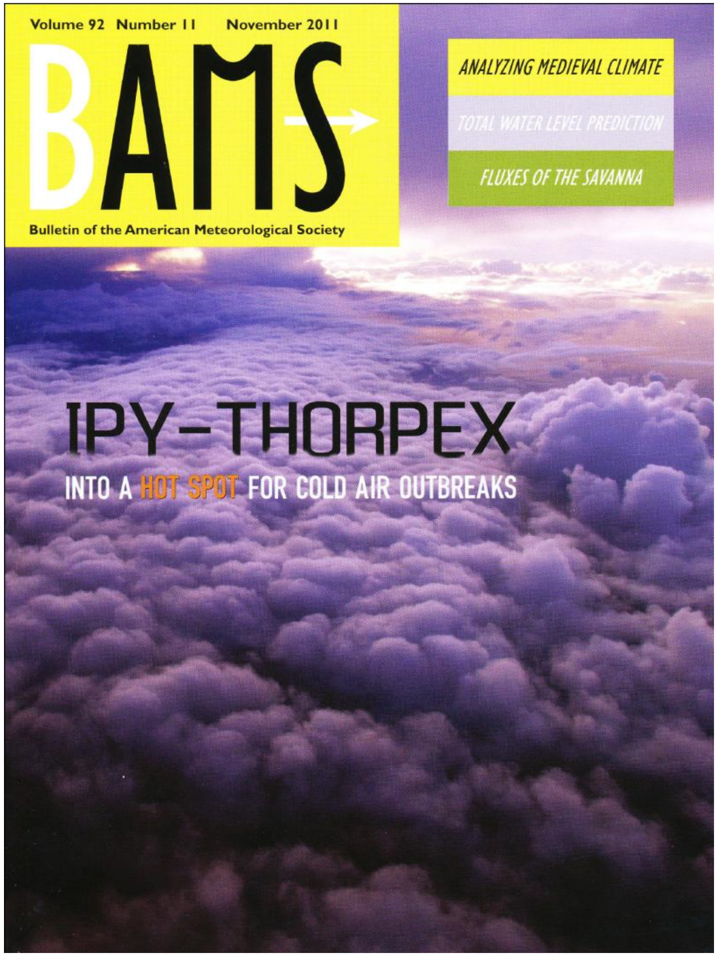
What did we learn about polar lows from the 2008 Andøya campaign?

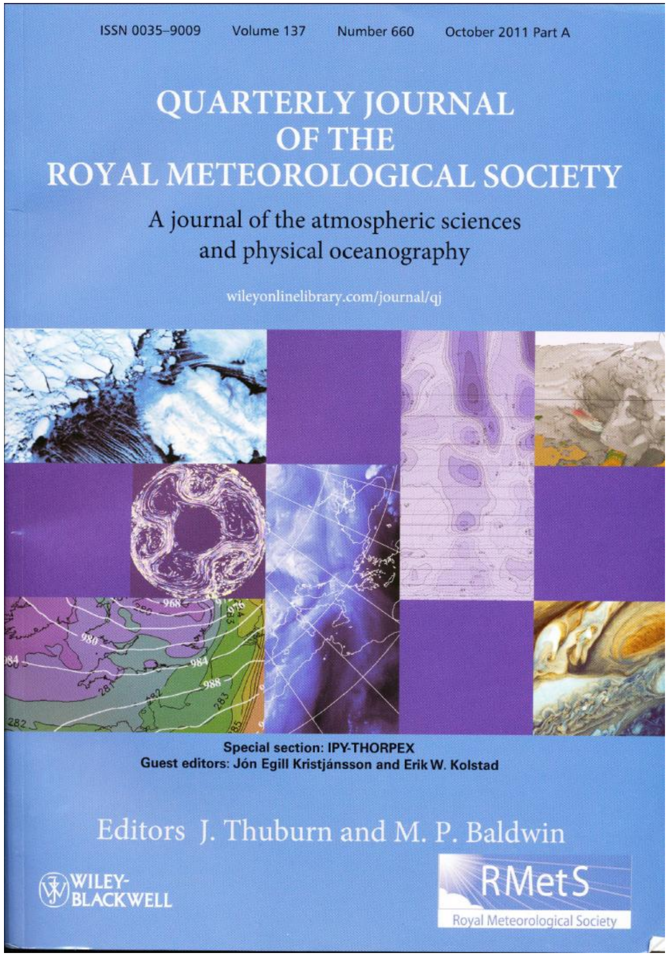
Jón Egill Kristjánsson

+

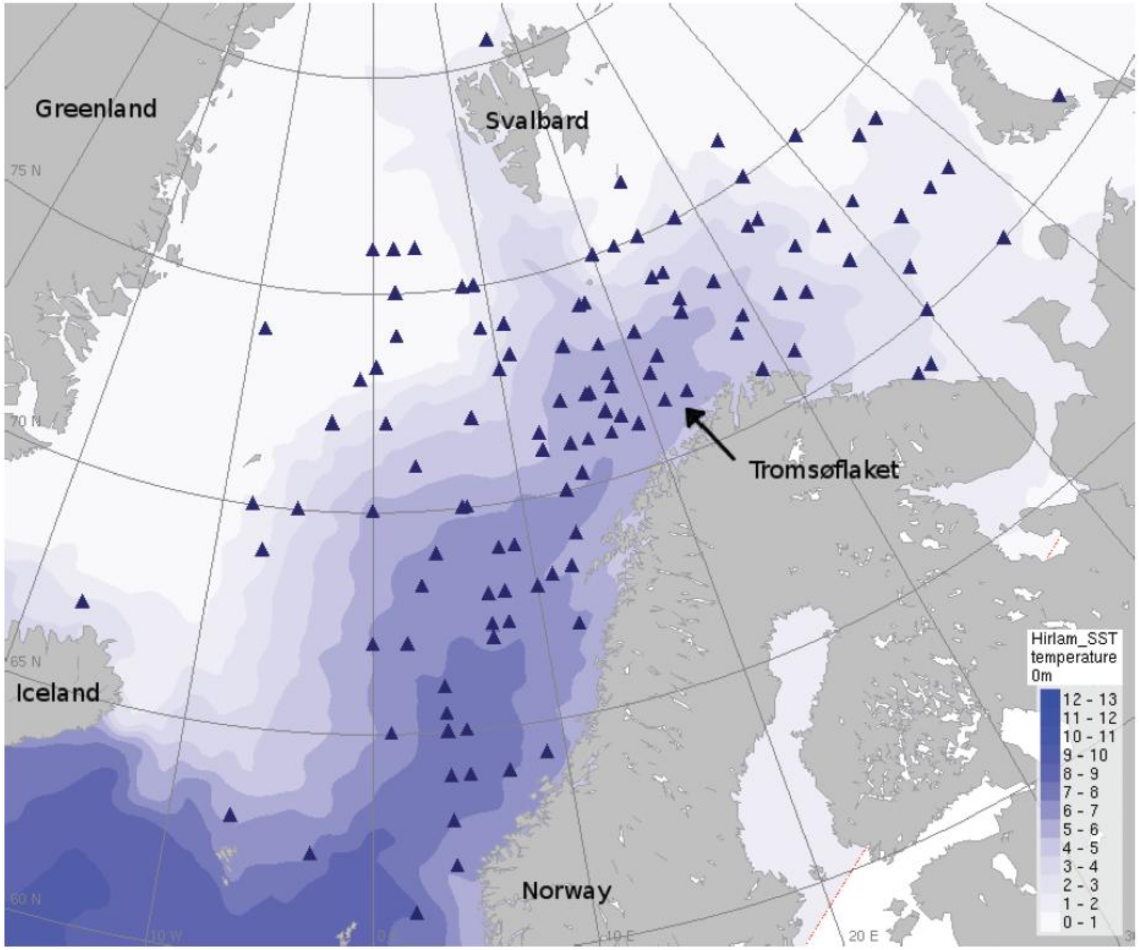
IPY-THORPEX team

Documentation



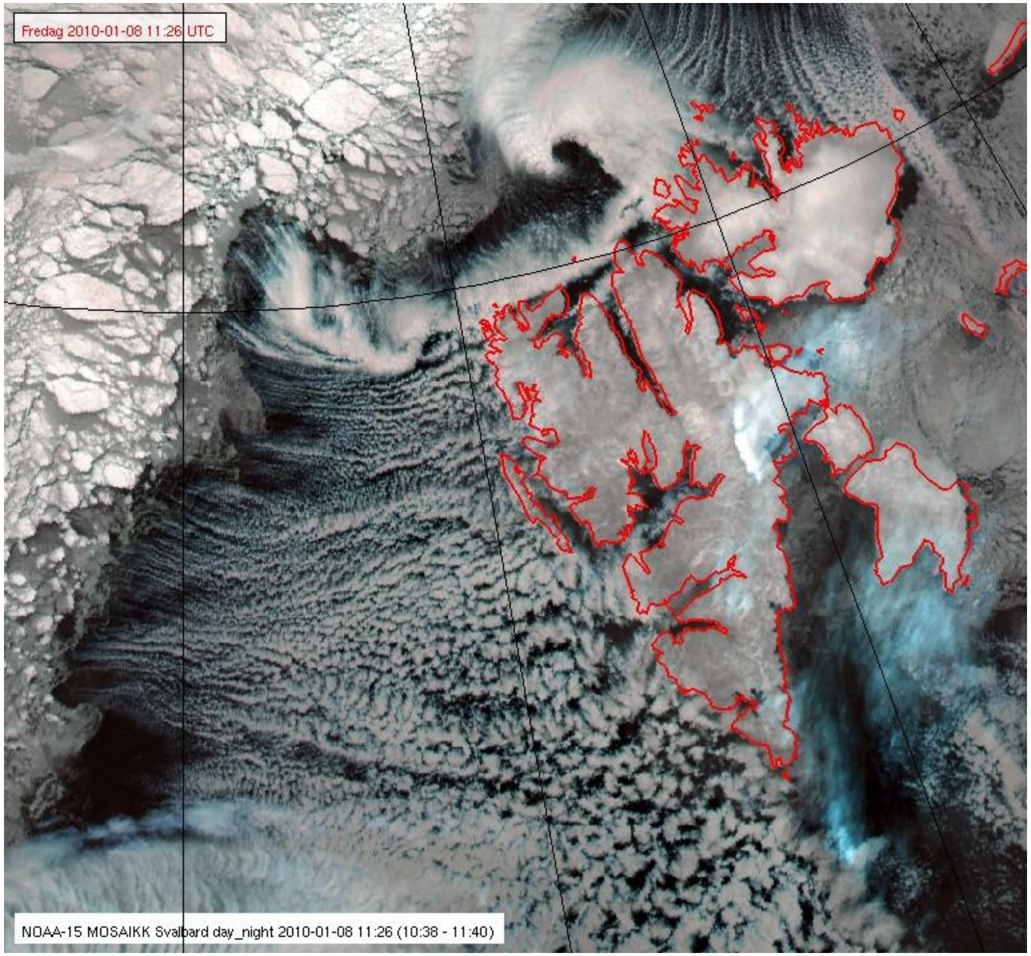


Where do Polar Lows in the Nordic Seas occur?



Noer et al. (2011: QJRMS)

8 January 2010: A First-Ever Wintertime Polar Low North of Svalbard



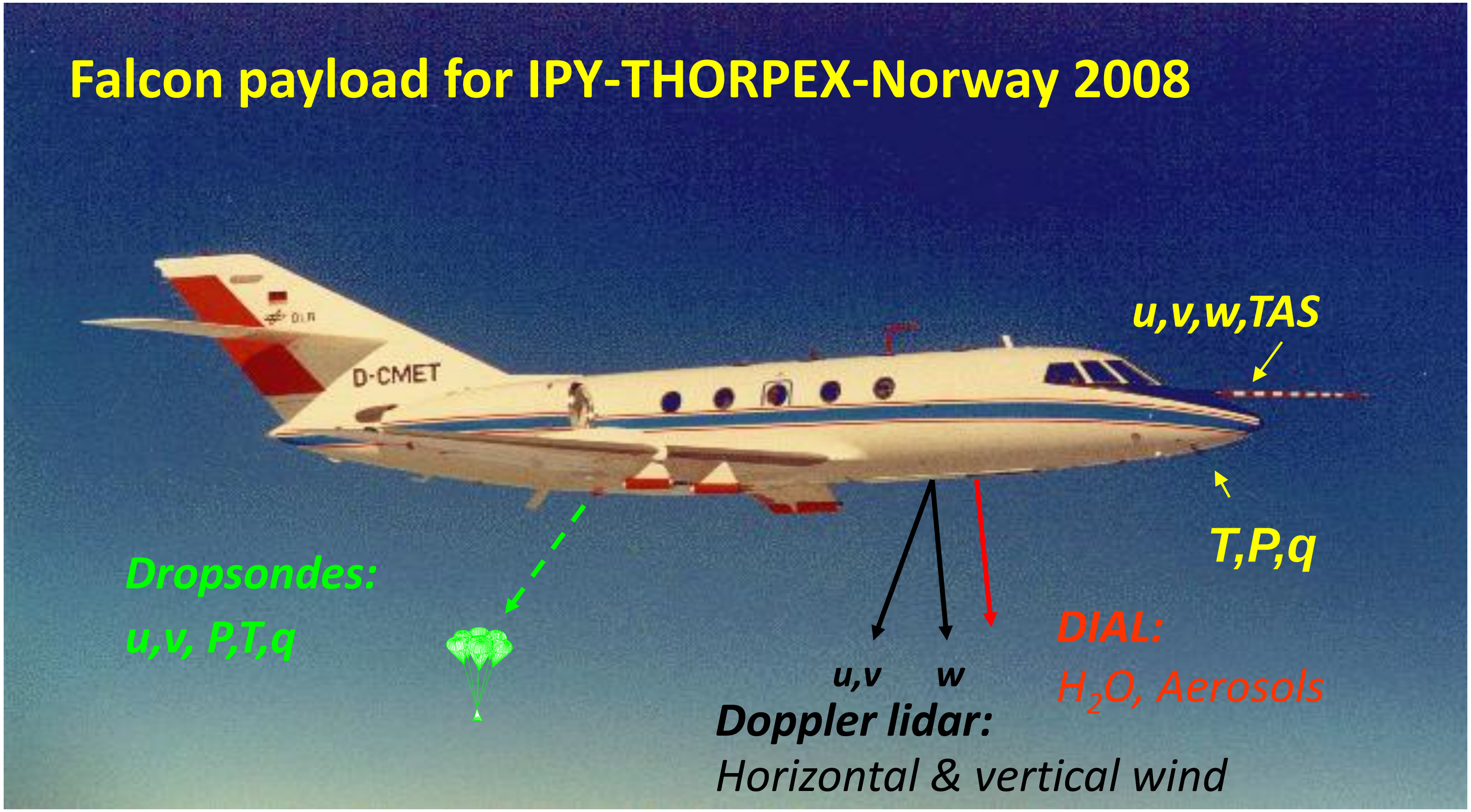
Research Questions

- What are the **roles of various dynamical and physical factors** (surface fluxes, deep convection, upper-level forcing, low-level baroclinicity) in PL developments?
- To what extent can PL predictions be improved by **additional observations**?
- To what extent do current NWP models capture PL structure, and what **model resolution** is needed to do so?

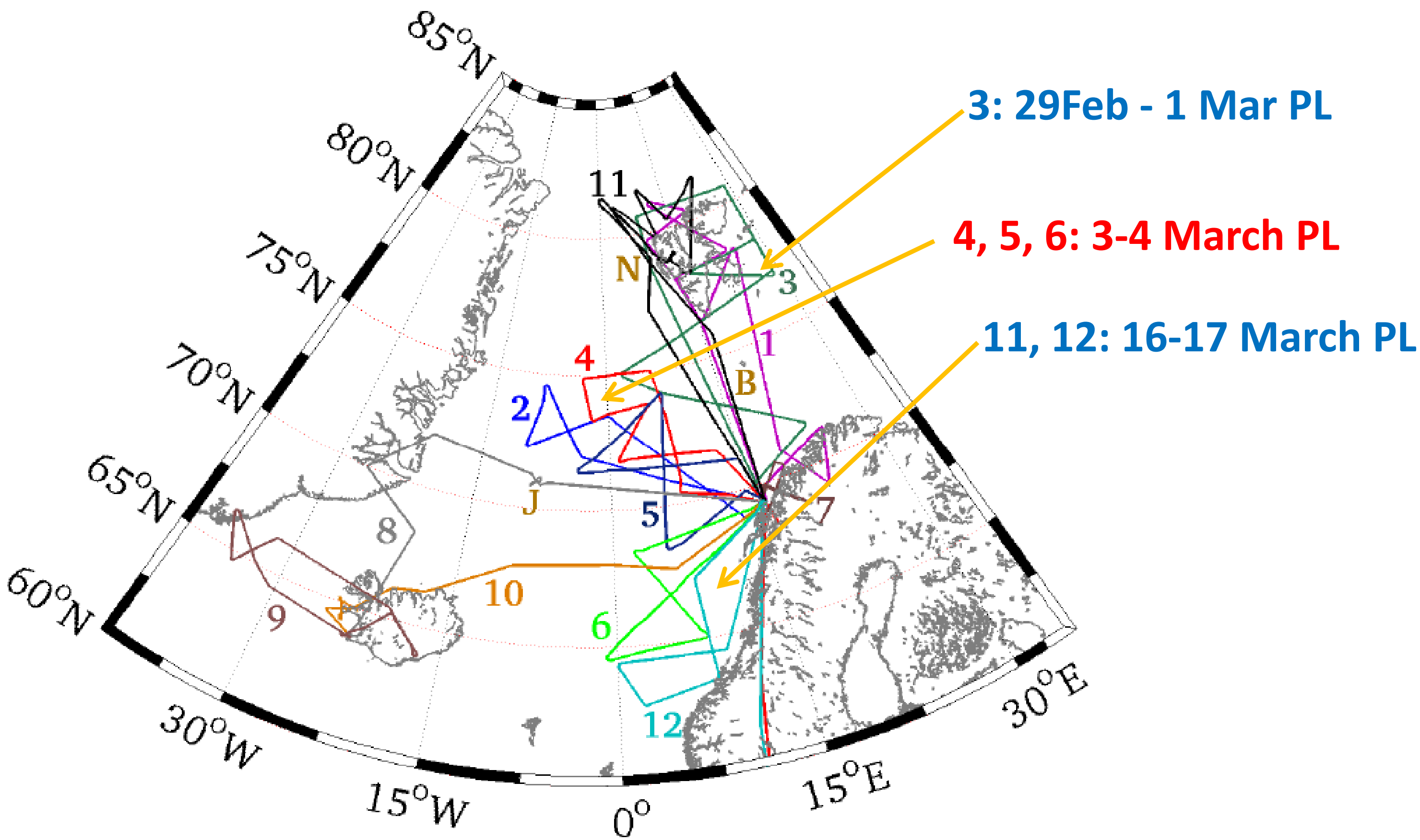
The Field Campaign

- Field programme: 25 Feb – 16 Mar 2008
- Base of operations: Andenes, Norway (69°N, 16°E)
- **DLR Falcon aircraft**: 56 flight hours; 150 dropsondes
- Coast Guard vessels: KV Senja, KV Svalbard
- Unmanned Aerial Vehicles (UAV) at Spitzbergen
- Additional radiosondes at Norwegian and Russian sites
- Drifting buoys

- Unique data set for validation of NWP models


Falcon payload for IPY-THORPEX-Norway 2008
D-CMET
u,v,w,TAS
T,P,q
Dropsondes:
u,v, P,T,q
u,v
w
DIAL:
H2O, Aerosols
Doppler lidar:
Horizontal & vertical wind

The Andøya Campaign



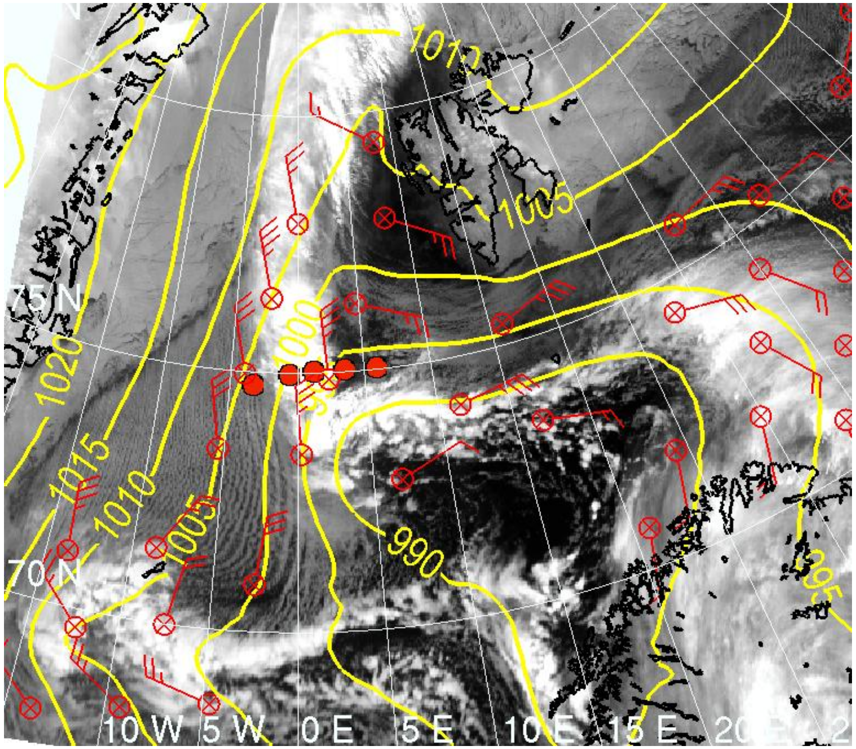
Kristjánsson et al. (2011: BAMS)

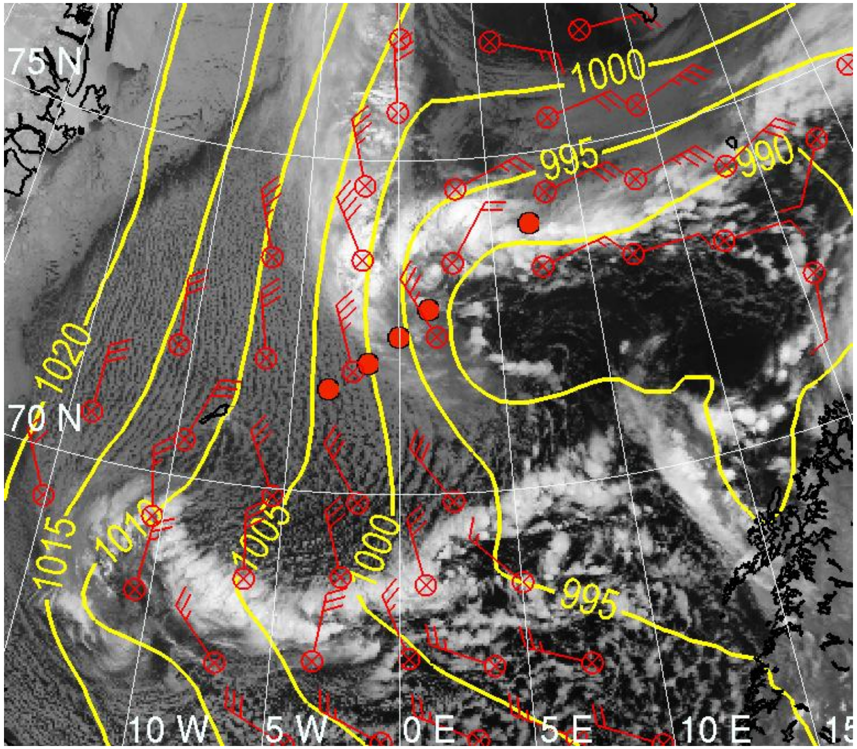
Polar Low Structure

The 3-4 March Polar Low

Baroclinic Development Phase

12:21 UTC on 3 March **16:01 UTC on 3 March**



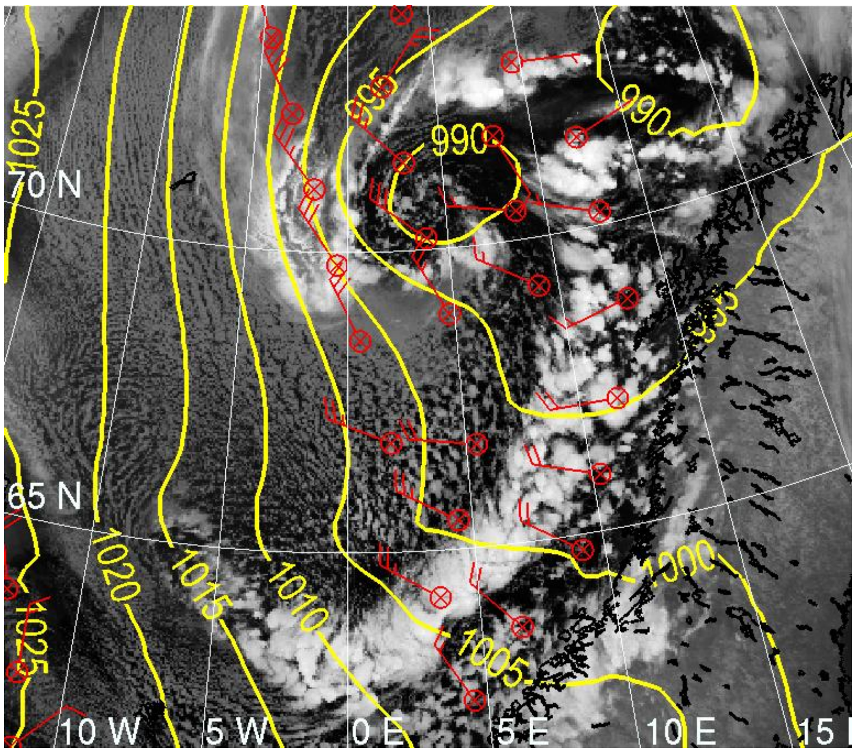


Kristjánsson et al. (2011: BAMS)

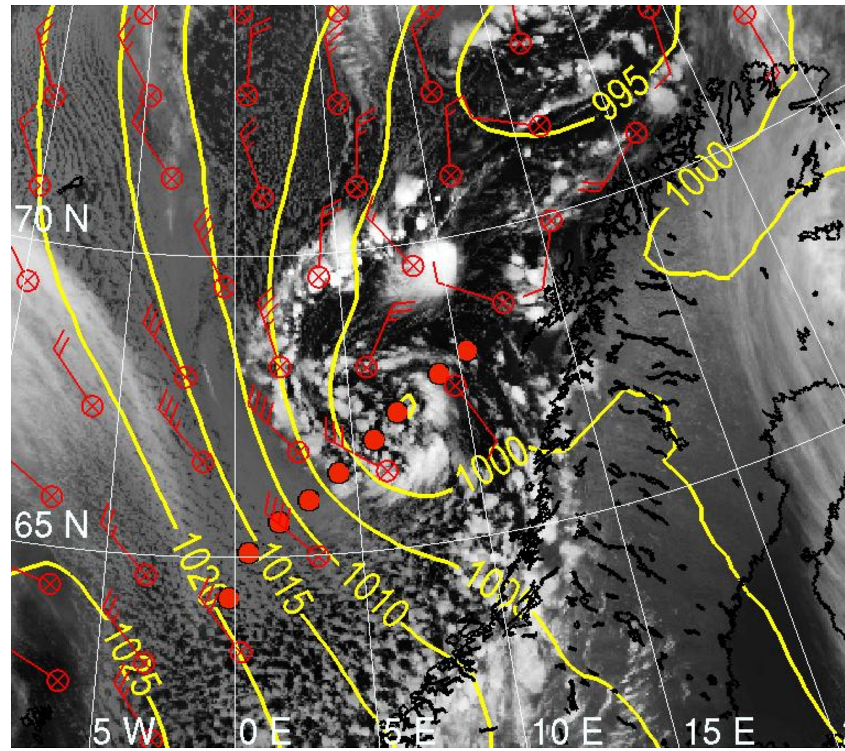
The 3-4 March Polar Low

Mature Convective Phase

03:07 UTC on 4 March



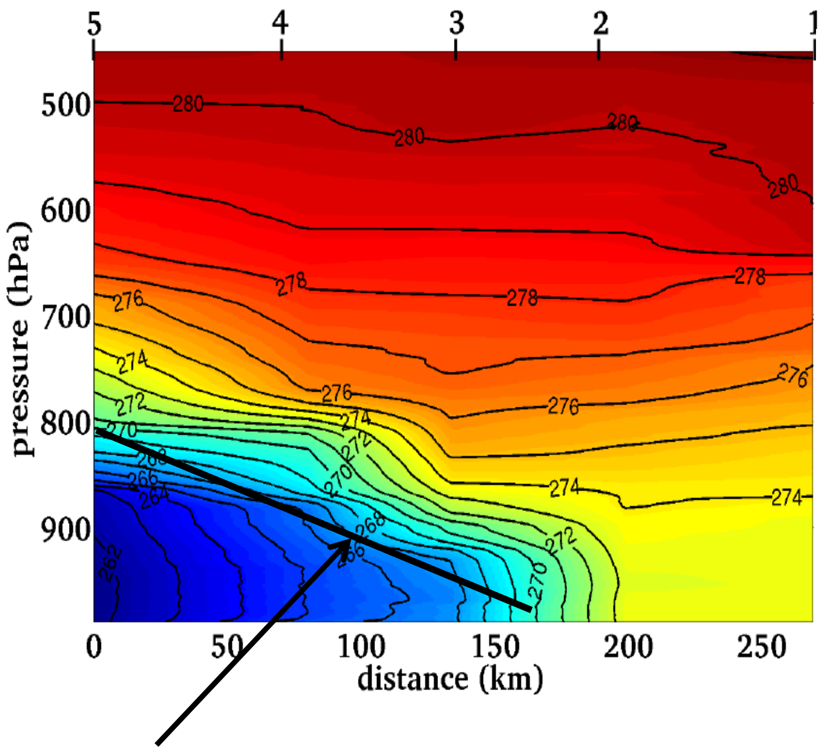
11:28 UTC on 4 March



Kristjánsson et al. (2011: BAMS)

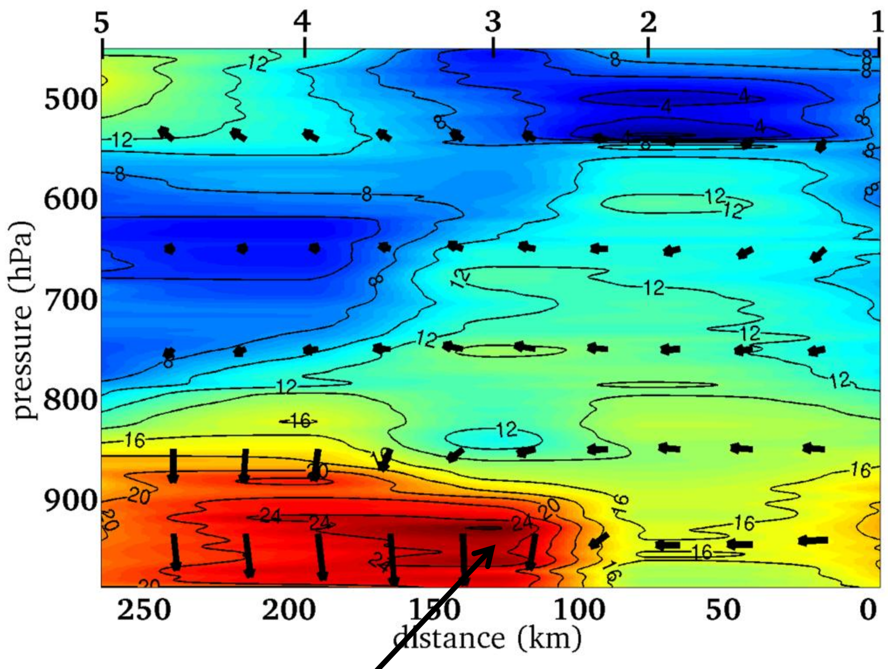
W-E sections at 11:40 UTC 3 March

Potential Temperature



Sloping frontal surface

Horizontal Wind

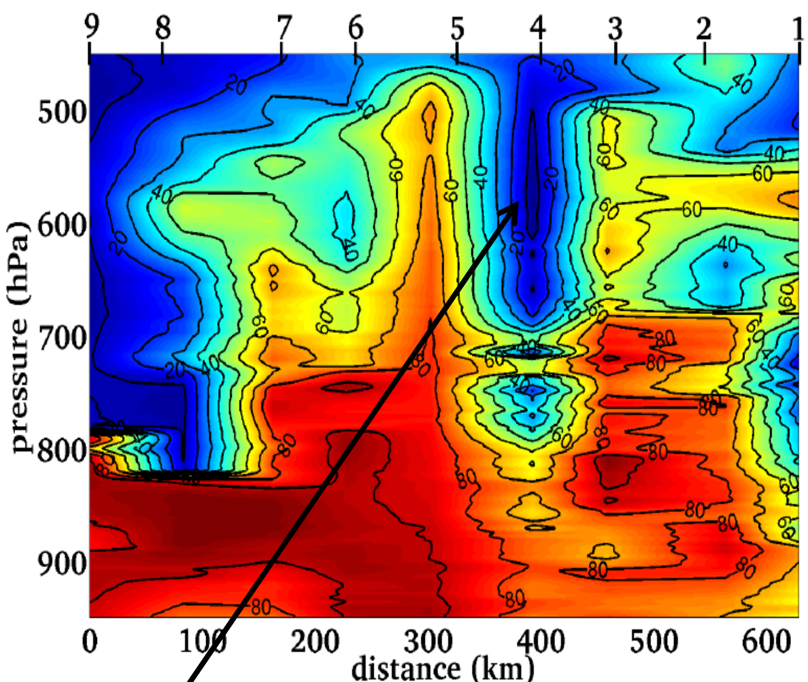


Low-level jet of 27 m s^{-1}

Kristjánsson et al. (2011: BAMS)

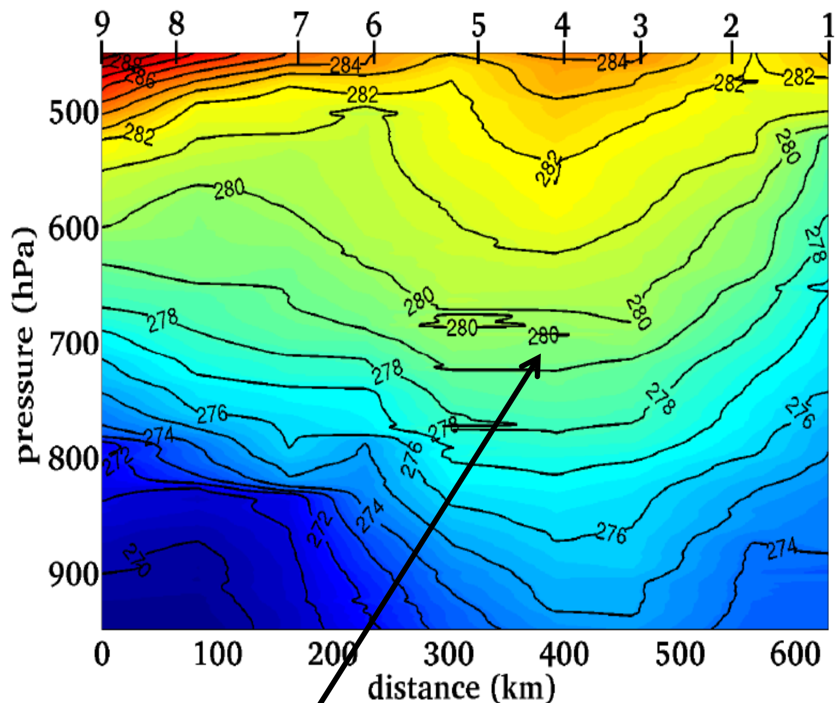
SW-NE sections at 11:05 UTC 4 March

Relative Humidity



Dry slot (eye of the PL)

Potential Temperature

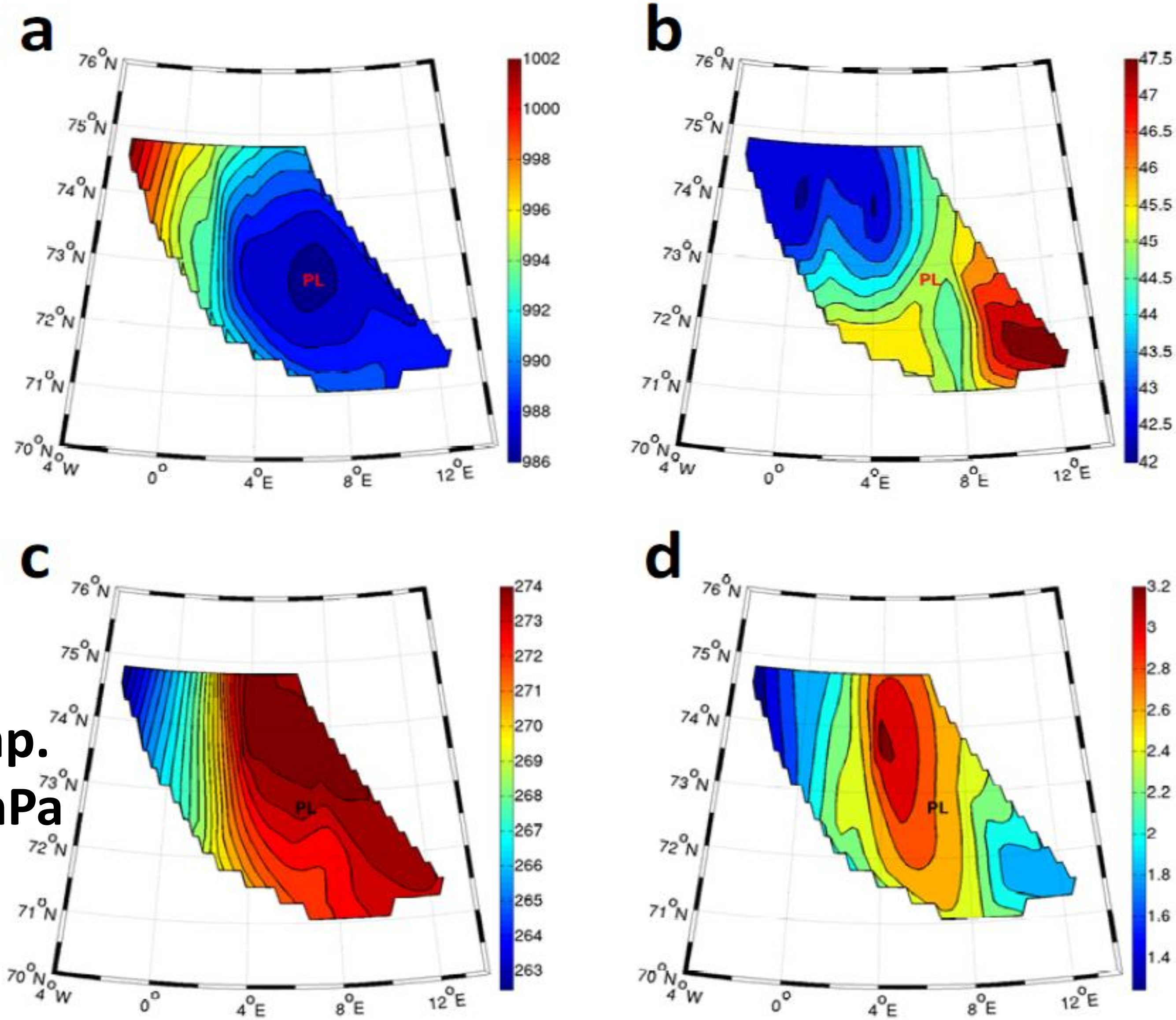


Warm air in the eye (descent?)

Kristjánsson et al. (2011: BAMS)

10:30 – 13:30 UTC 3 March 2008

M
S
L
P



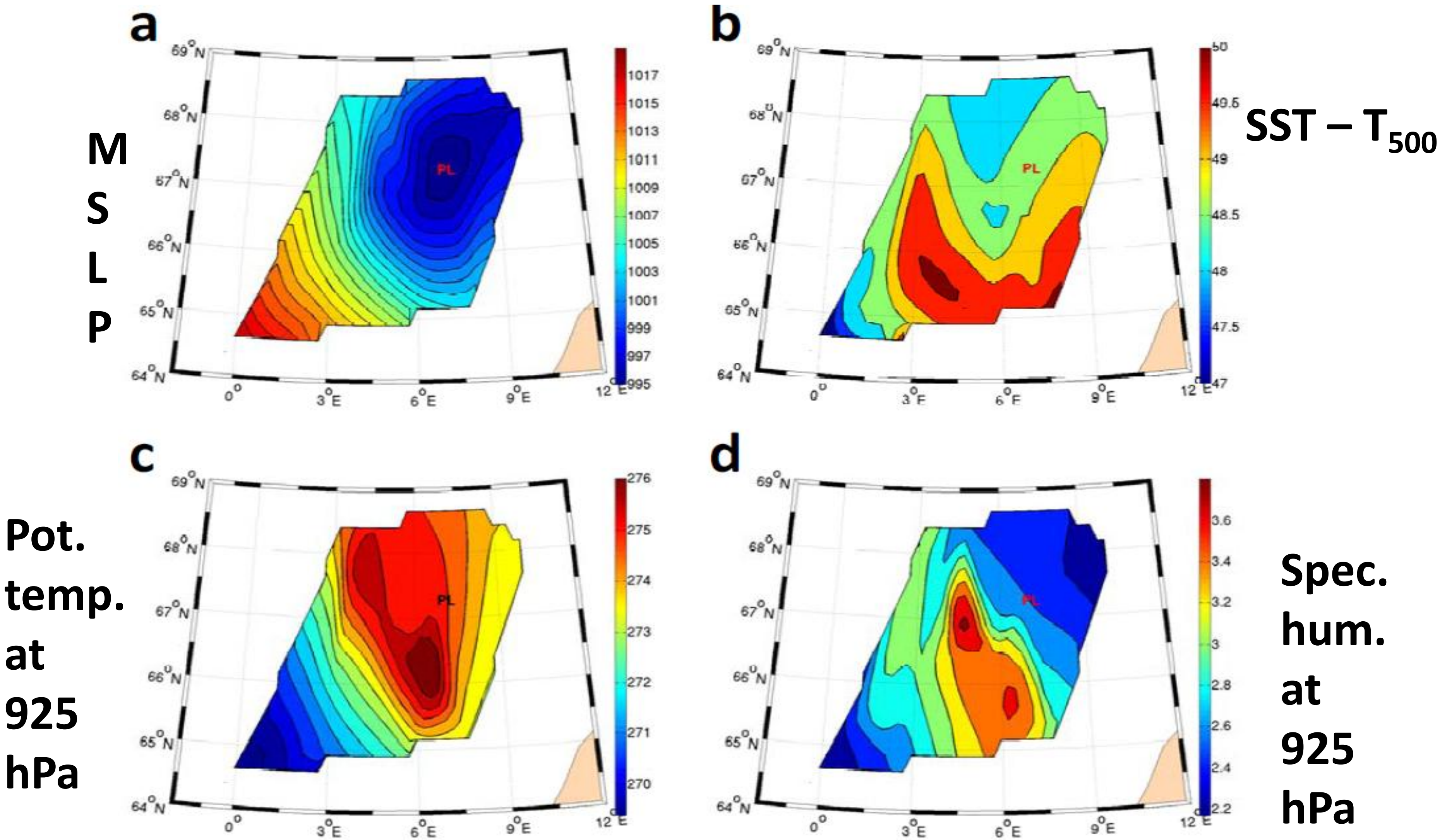
SST – T_{500}

Pot.temp. at 925 hPa

Spec.hum. at 925 hPa

Føre et al. (2011: QJRMS)

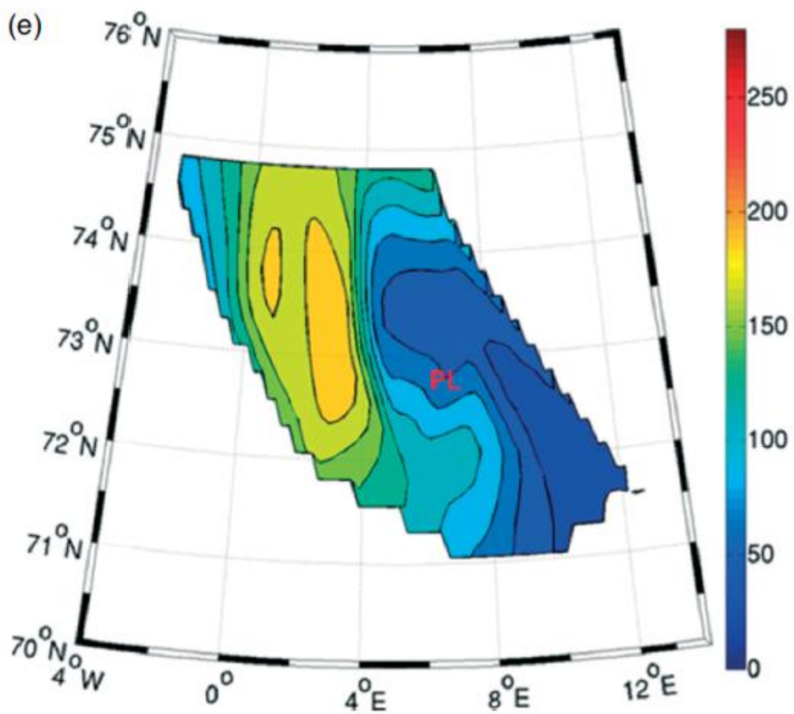
10:30 – 13:30 UTC 4 March 2008



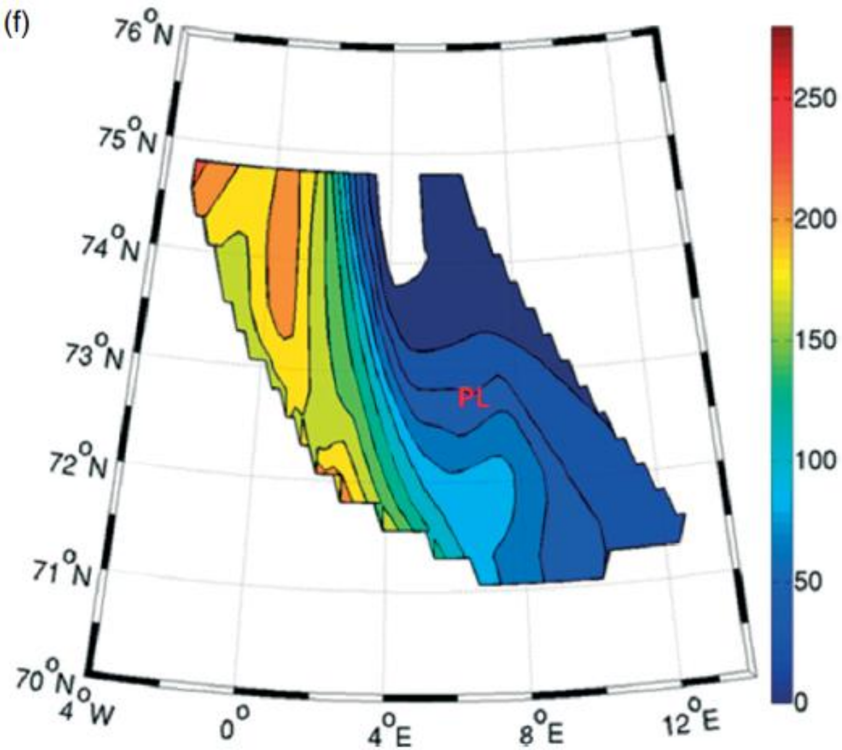
Føre et al. (2011: QJRMS)

Surface Fluxes on 3 March

Latent Heat flux



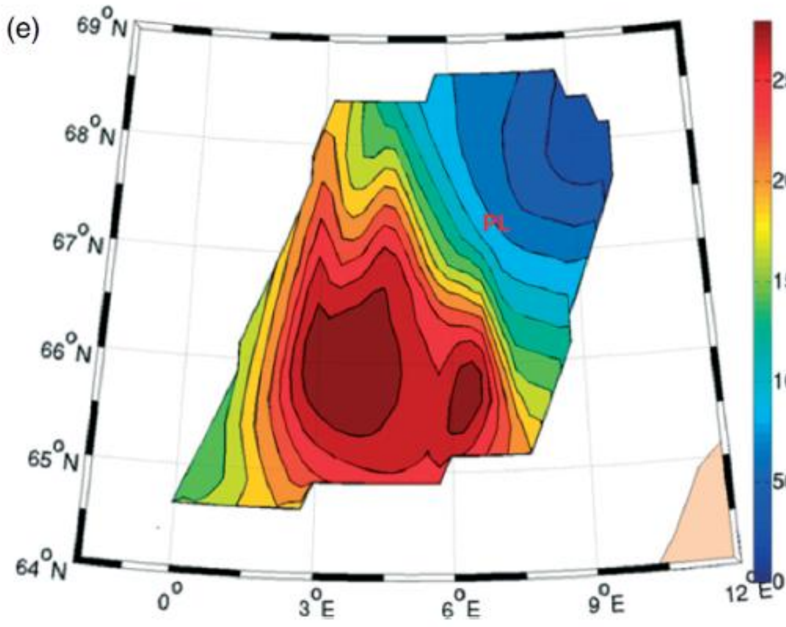
Sensible Heat flux



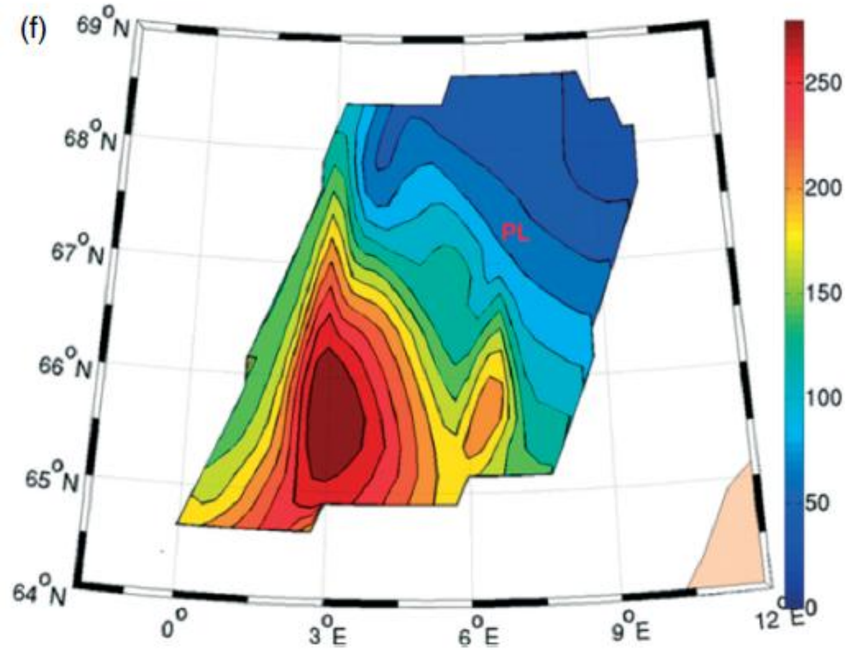
Føre et al. (2011: QJRMS)

Surface Fluxes on 4 March

Latent Heat flux



Sensible Heat flux



Føre et al. (2011: QJRMS)

PV at 290 K

12 UTC 2 Mar

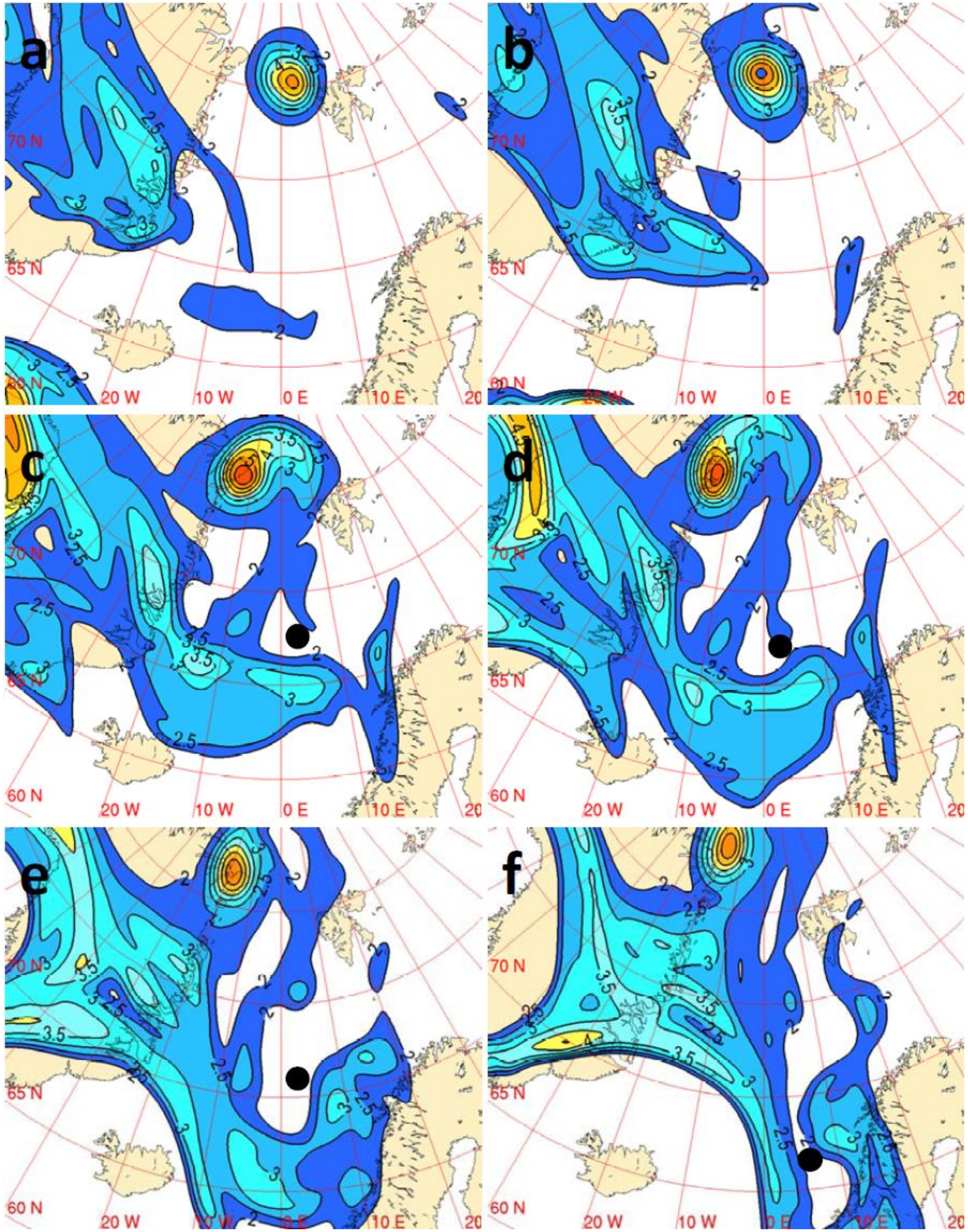
00 UTC 3 Mar

12 UTC 3 Mar

18 UTC 2 Mar

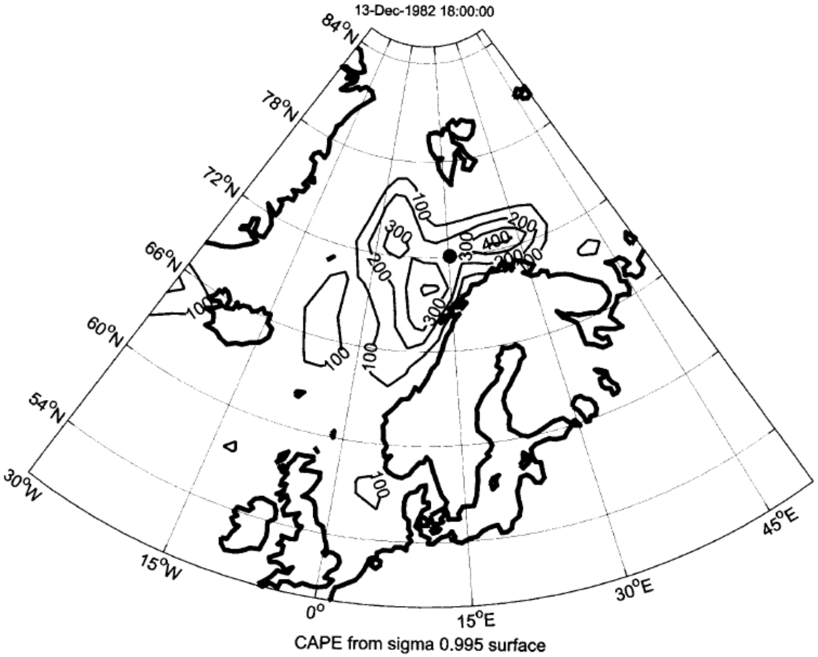
00 UTC 4 Mar

12 UTC 4 Mar

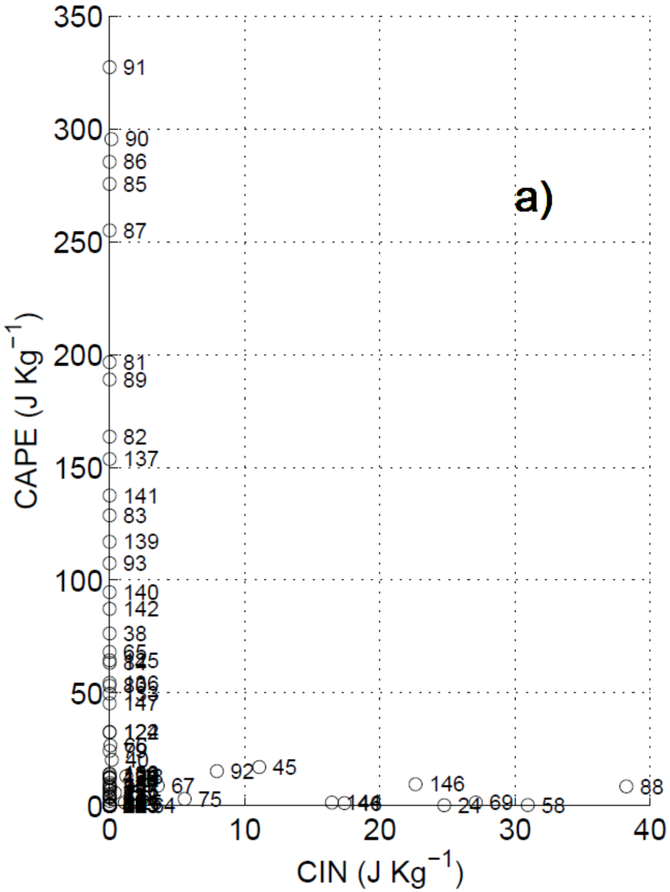


Føre et al. (2011: QJRMS)

The role of CAPE in Polar Low development



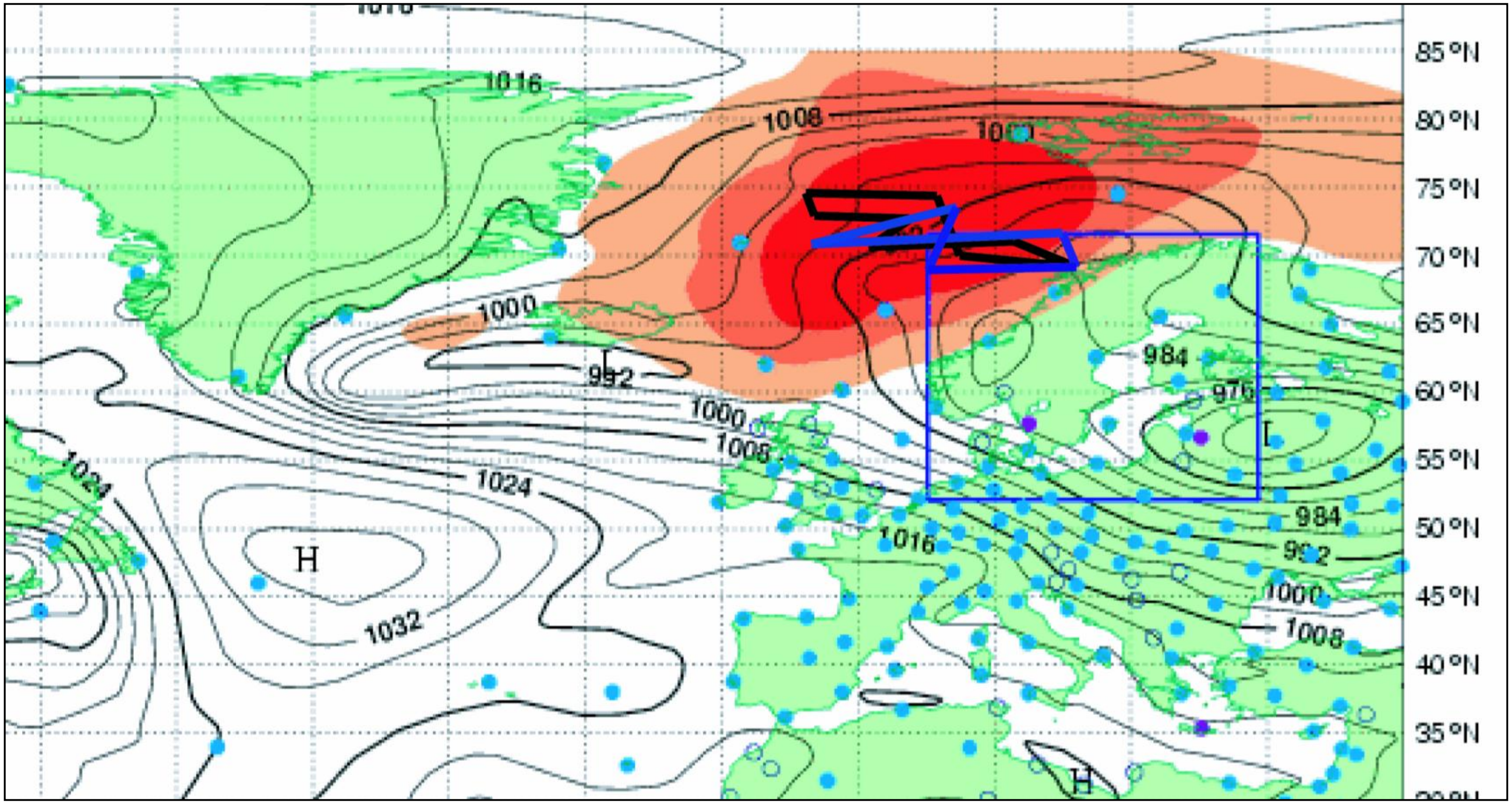
Van Delden et al. (2003)



Linders & Saetra (2010: J. Atmos. Sci.)

Observation Systems

03 March 2008
ETKF Sensitive Area Prediction

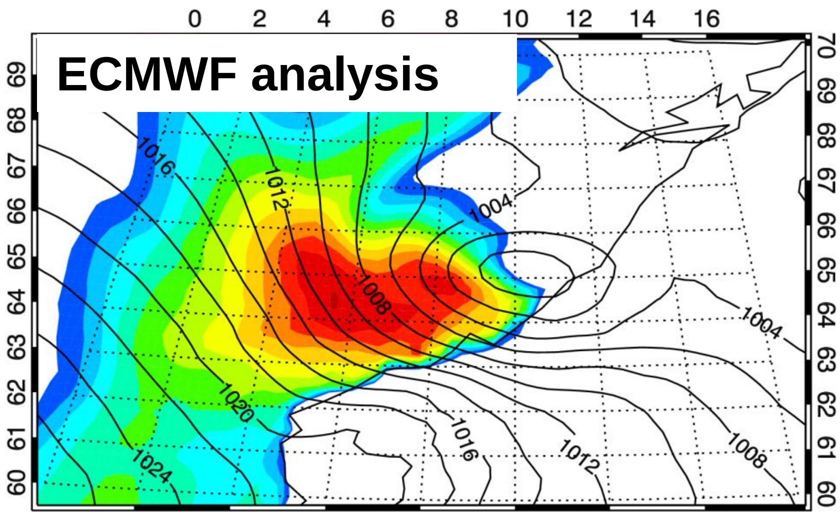


Flight 1: 19 sondes in 12Z forecast

Flight 2: 13 sondes in 18Z forecast

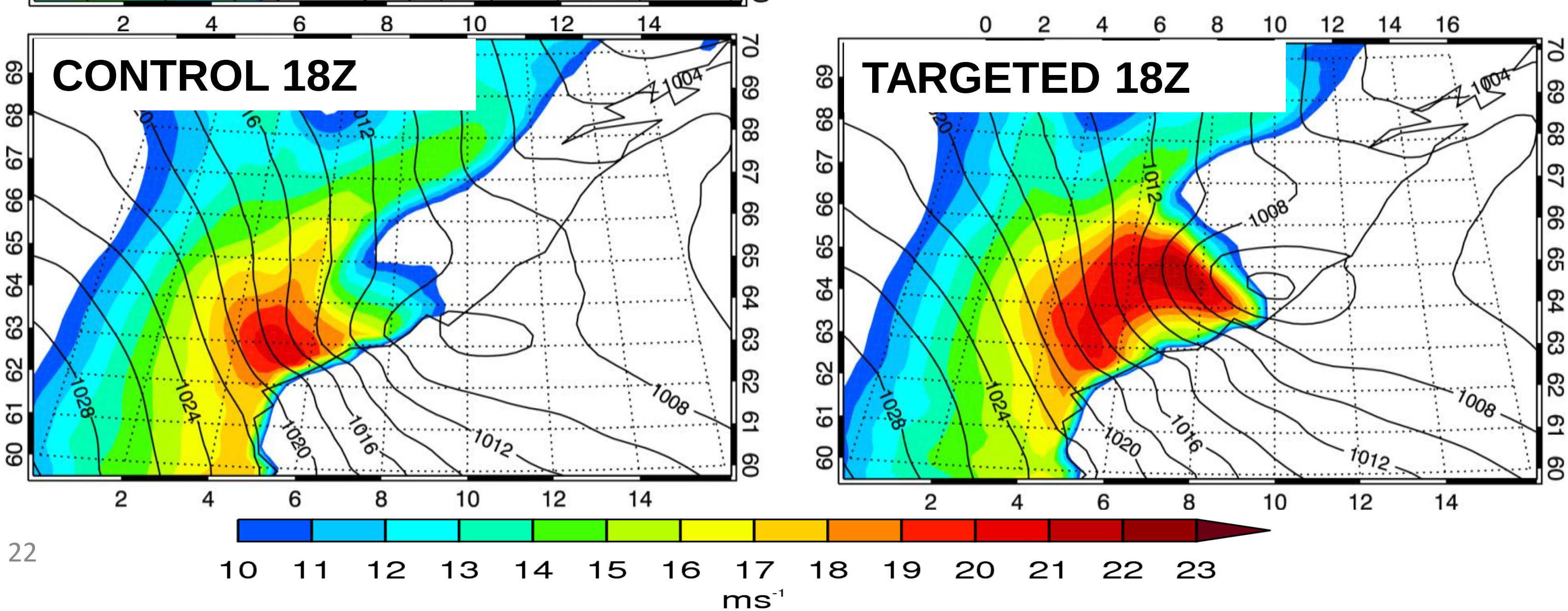
From: Emma Irvine

T+24 Forecast of Polar Low Landfall

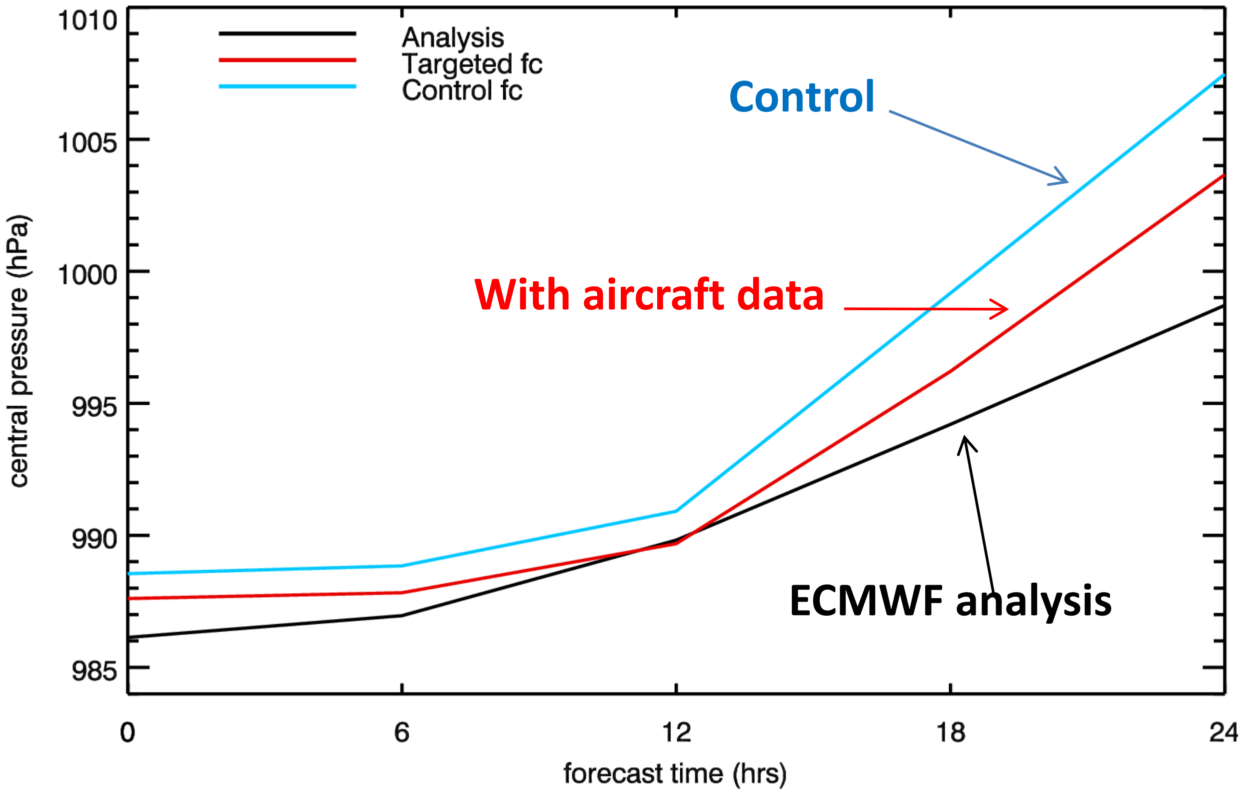


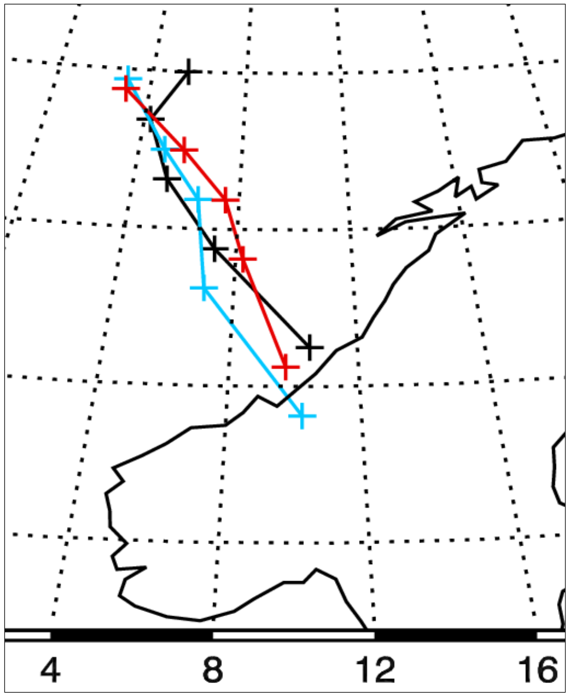
- Improvement to forecast of polar low position and intensity

Kristjánsson et al. (2011: BAMS)



Polar Low Central Pressure and Track in the 18Z forecast



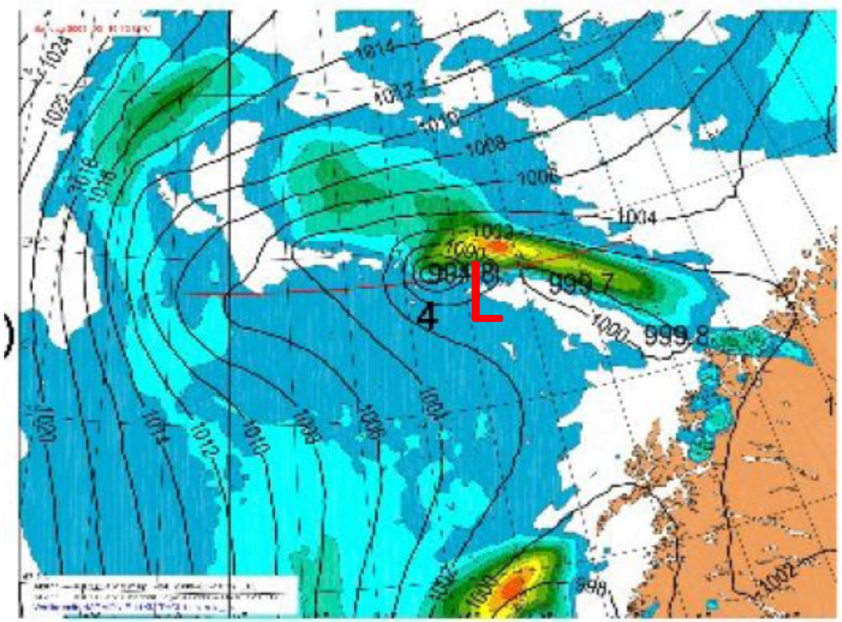


• Polar low intensity and location are both improved in the 18Z targeted forecast – but, improvement is moderate compared to EPS forecast spread

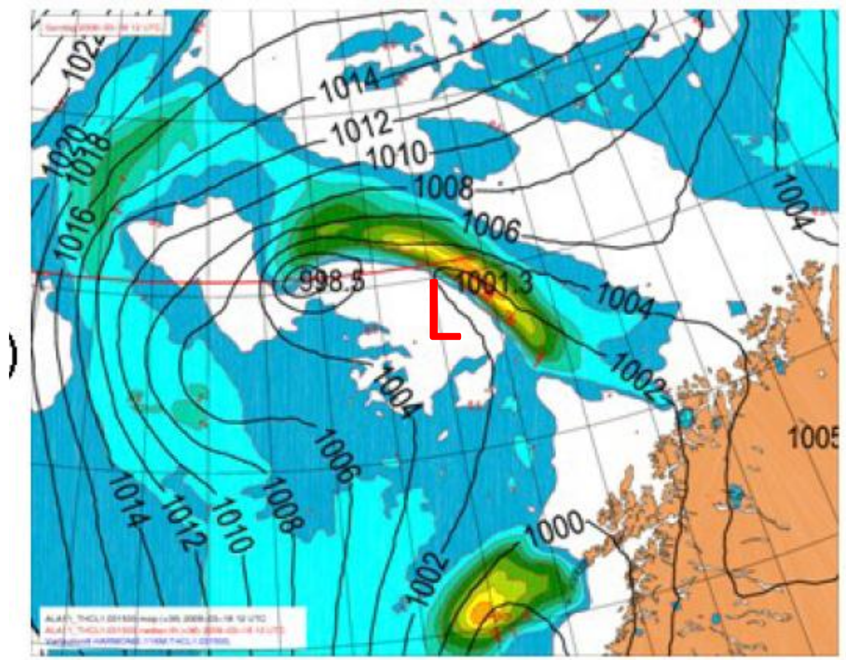
Irvine et al. (2011: QJRMS)

Polar Low 16-17 March 2008: HARMONIE simulations at +24 h

With IASI radiances

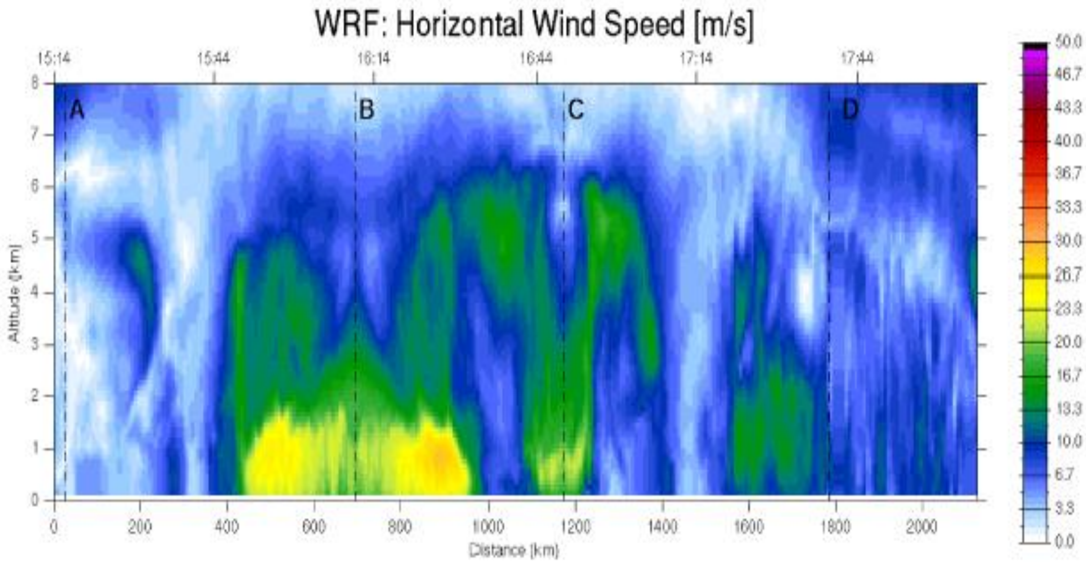


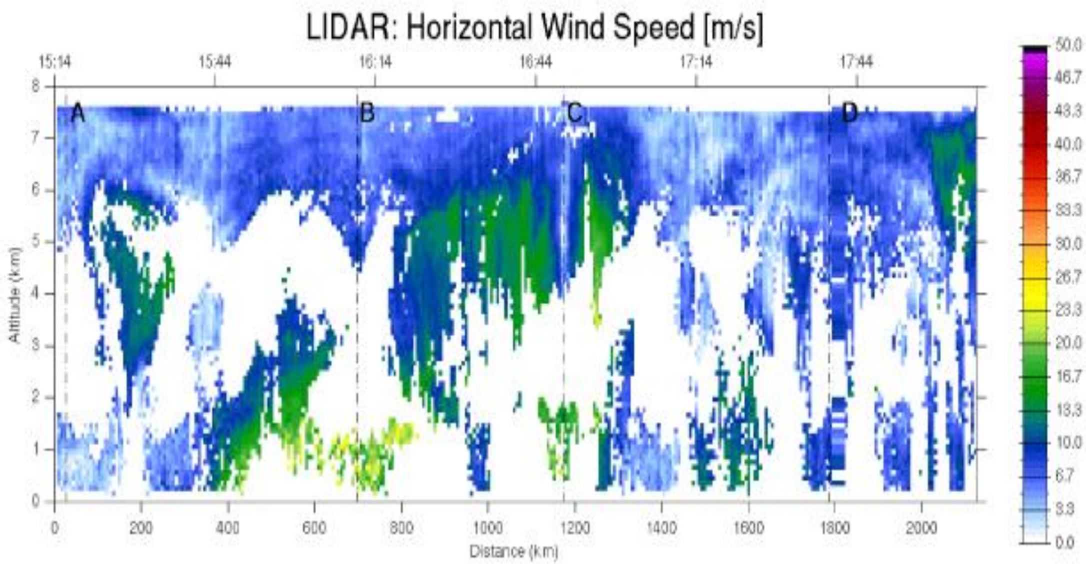
Without IASI radiances



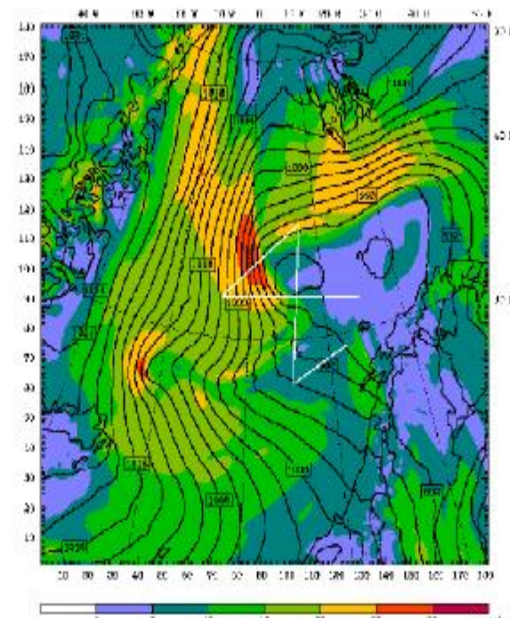
Randriamampianina et al. (2011: QJRMS)

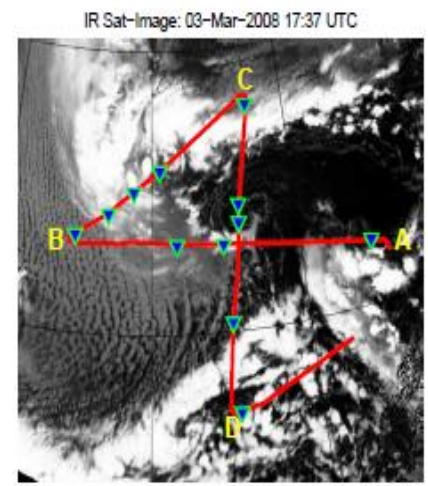
Model - LIDAR: Wind





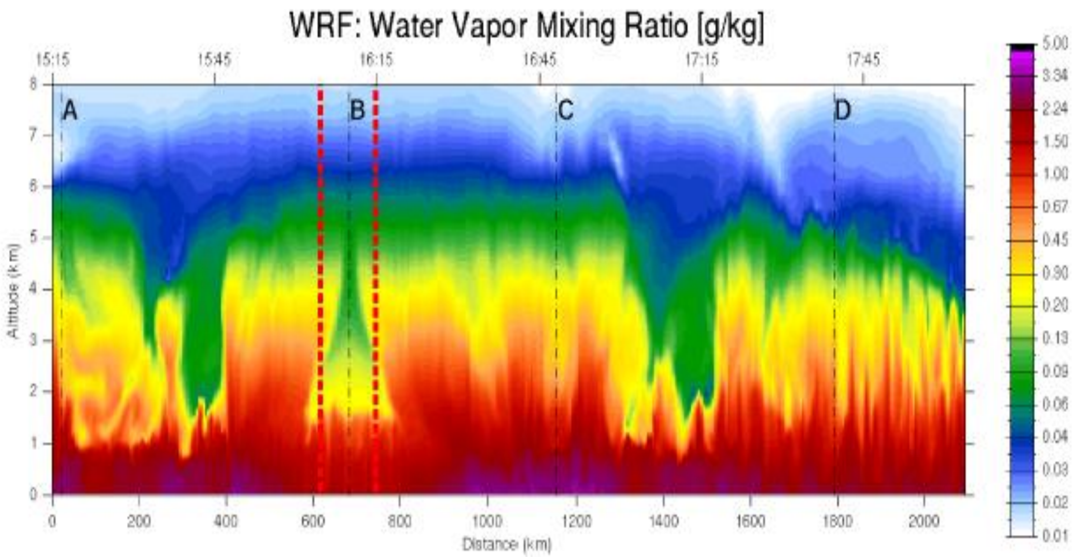
Windspeed 925 hPa 16 UTC

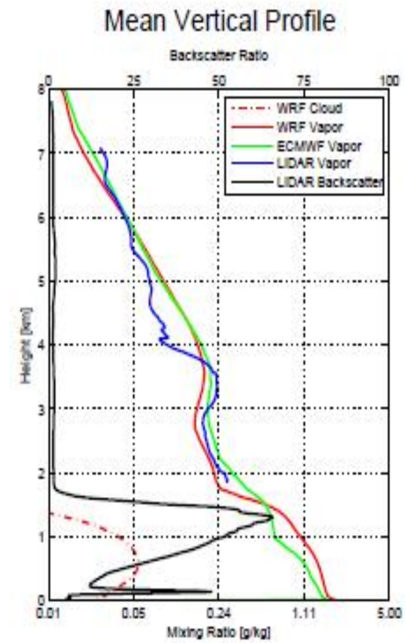


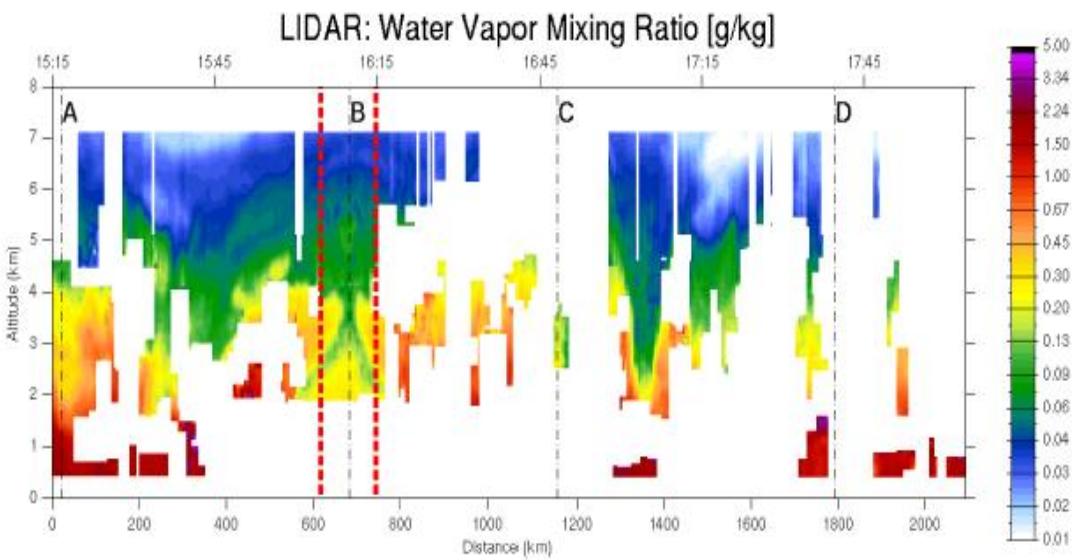


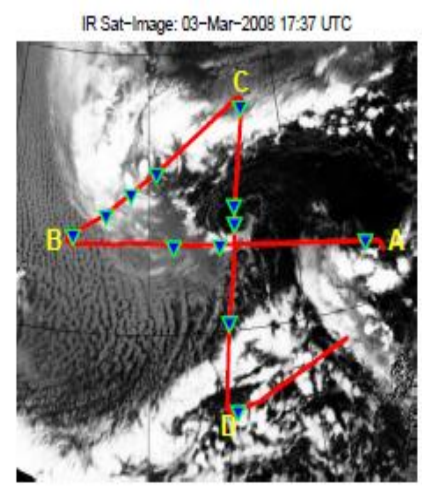
Wagner et al. (2011: QJRMS)

Model - LIDAR: Vapor





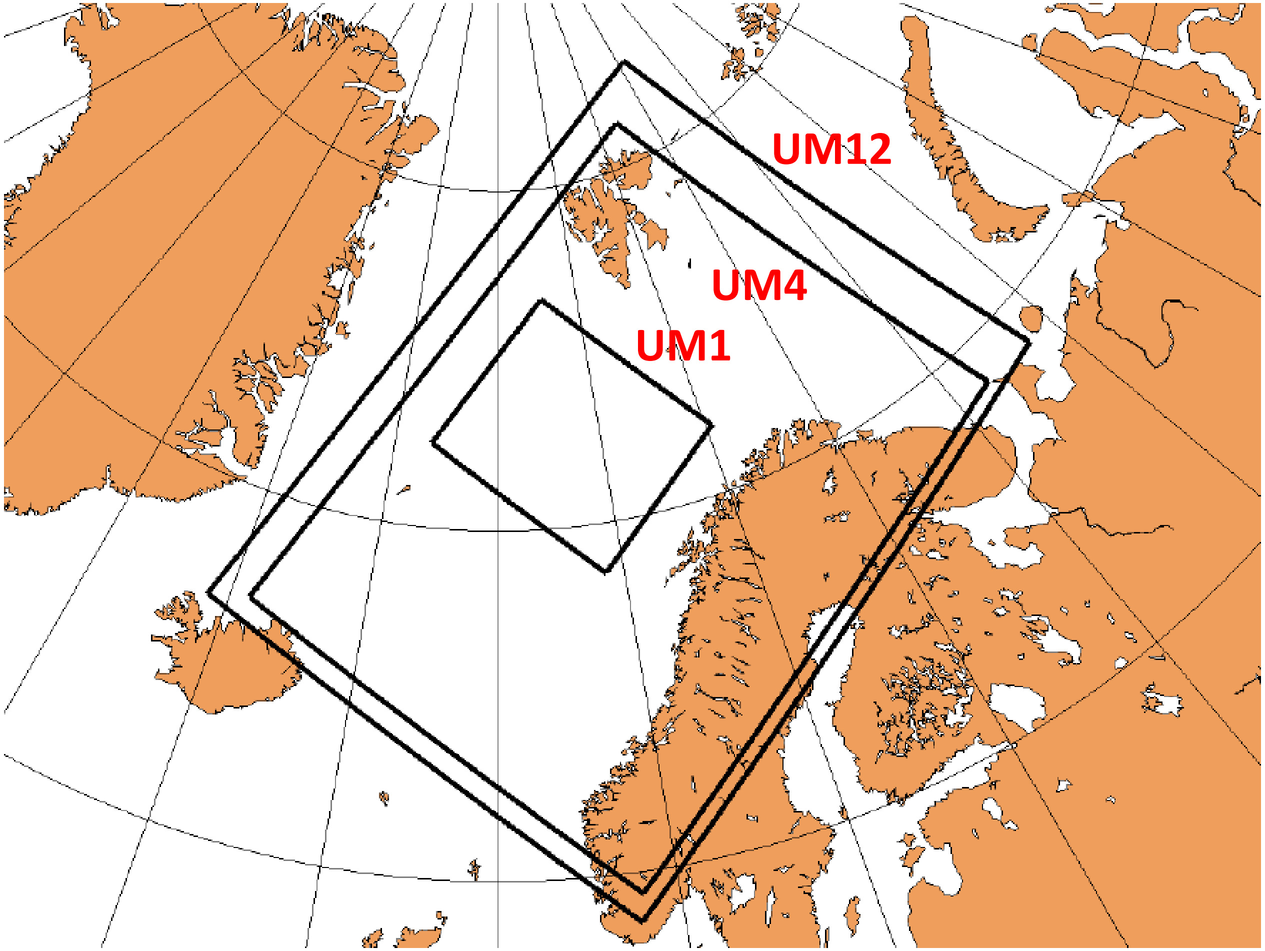




Wagner et al. (2011: QJRMS)

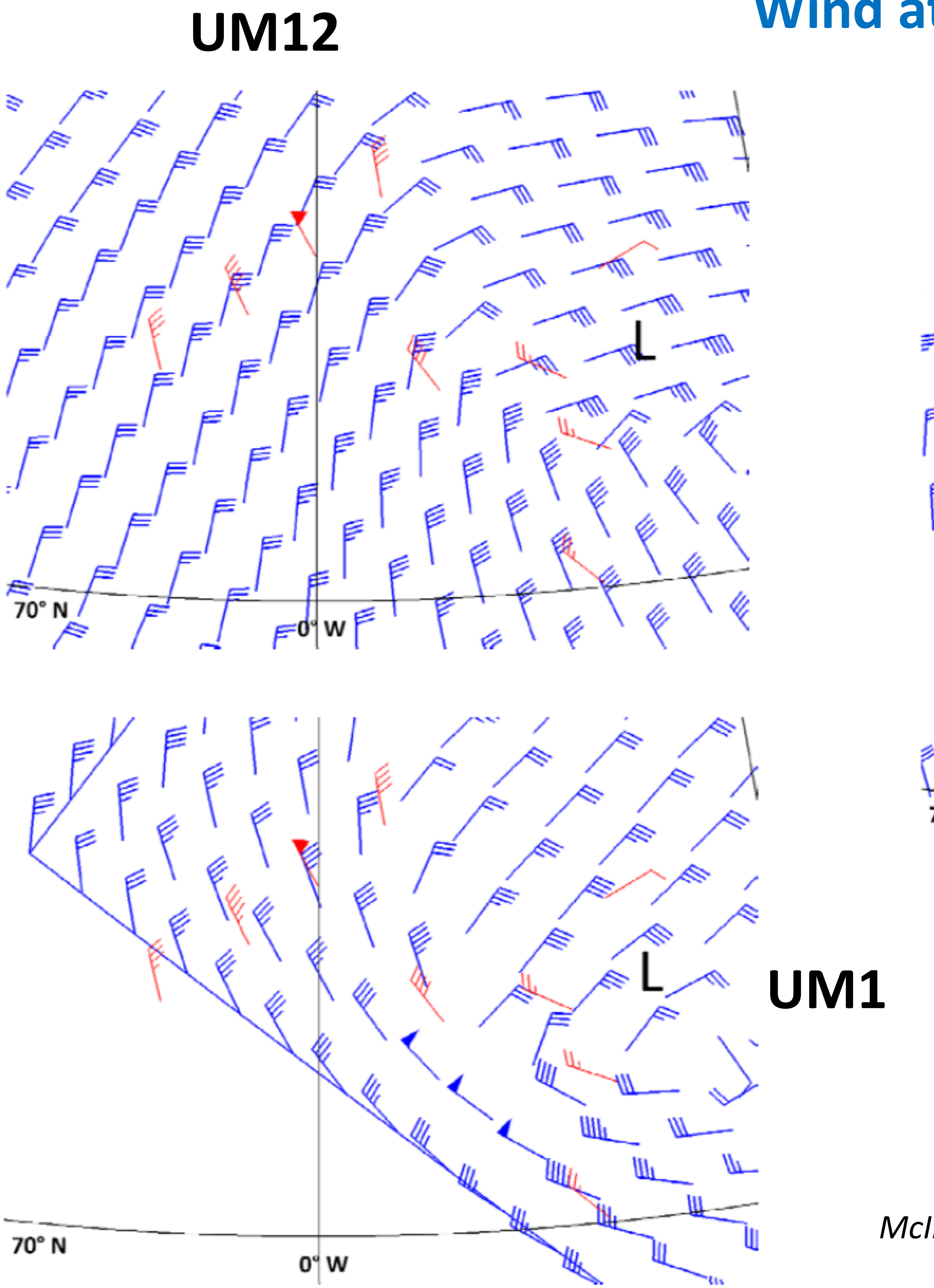
Modeling Aspects

UM simulations



McInnes et al. (2011: QJRMS)

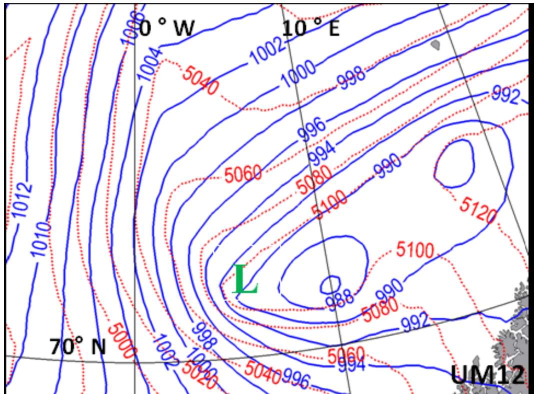
Wind at 925 hPa: 18 UTC 3 Mar (+42 h)



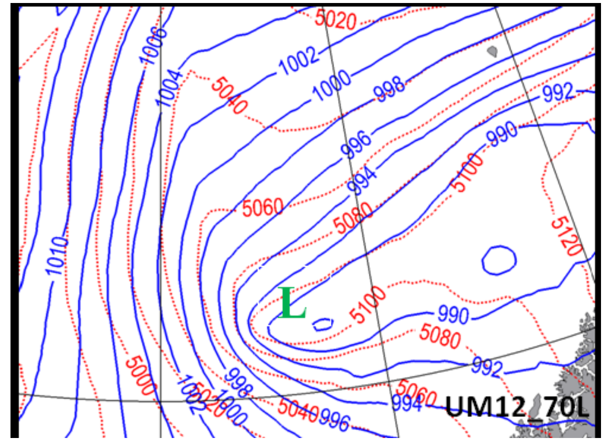
McInnes et al. (2011: QJRMS)

MSLP+thickness: 18 UTC 3 Mar (+42 h)

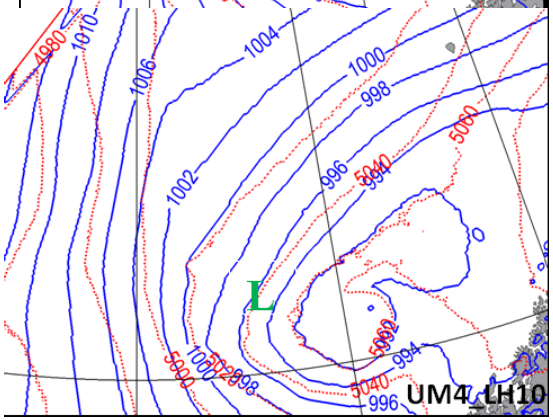
UM12



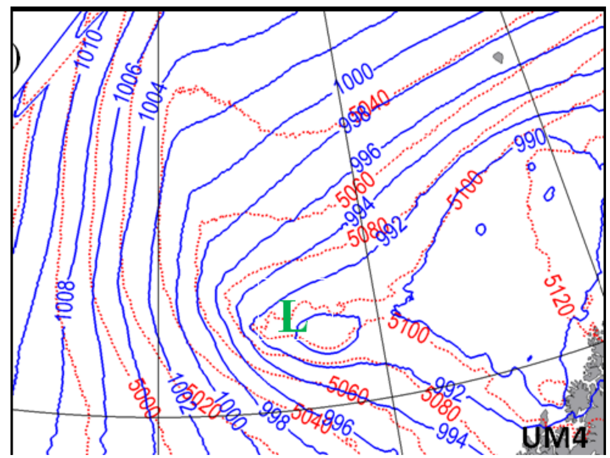
UM12_ 70levs



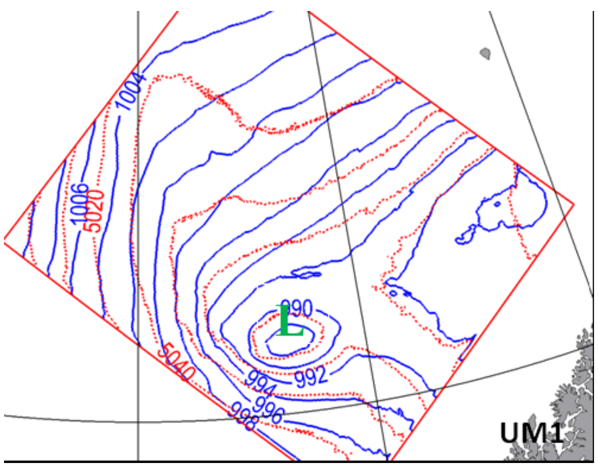
UM4_ 10%LAT. HEAT



UM4

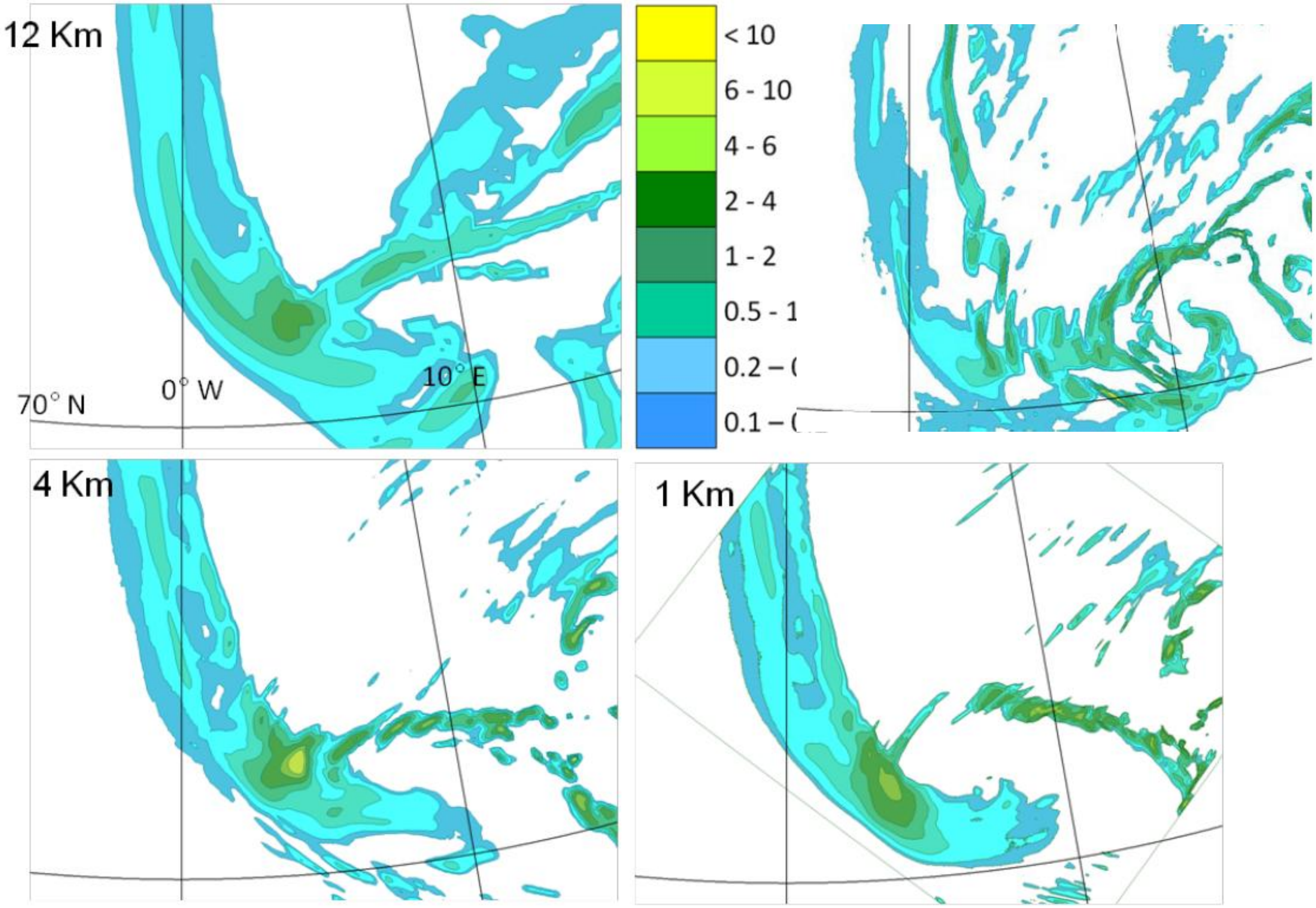


UM1



McInnes et al. (2011: QJRMS)

1 h acc precip (mm) 17-18 UTC 3 Mar (+42 h)



4 km; 10% lat.heating

Summary of findings

- Polar Low Structure: Low-level jets in developing stage, eye formation in mature stage
- Systematic precursors identified: SST-T500 threshold, propagating UPV anomaly, low-level baroclinicity
- Predictability of Polar Lows highly variable from case to case – **not well understood**
- Targeted observations can improve the forecasts in some cases – **not well understood**
- New satellite data (IASI) can improve the forecasts
- LIDAR retrievals can yield useful information on mesoscale features despite cloud limitations
- Sensitivity simulations: Latent heating and surface fluxes crucial; sensible heat flux often larger than latent heat flux

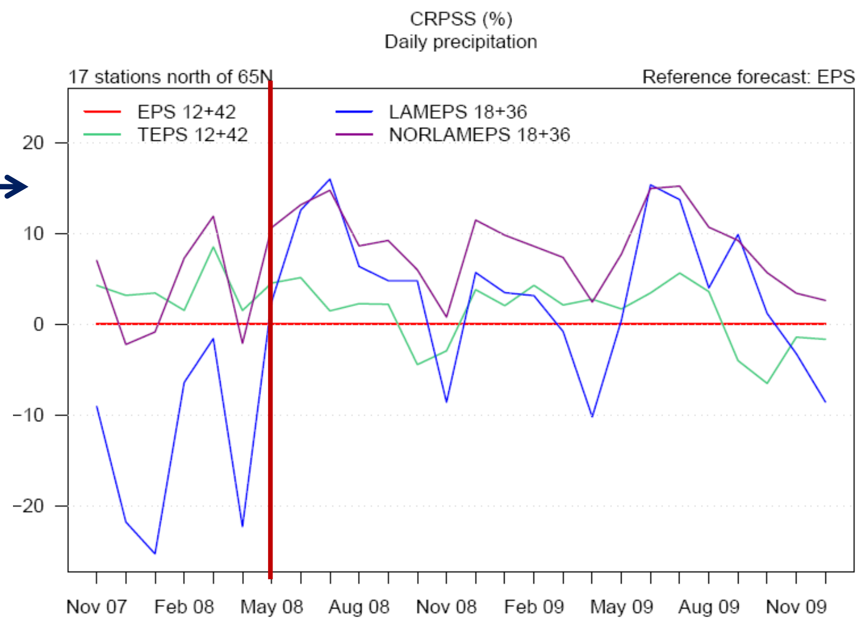
Thank you!

http://ipy-thorpex.no/en/the-research

Photo: Gudmund Dalsbø

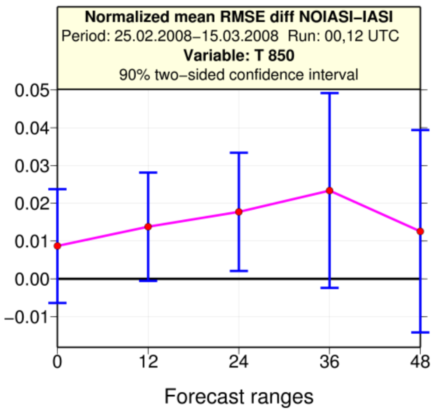
Forecast Improvements at *met.no*

- **New** probabilistic **weather prediction system** (NORLAMEPS)



Aspelien et al. (2011: Tellus)

- Exploitation of **new satellite data** (IASI)



Randriamampianina et al. (2011: QJRMS)

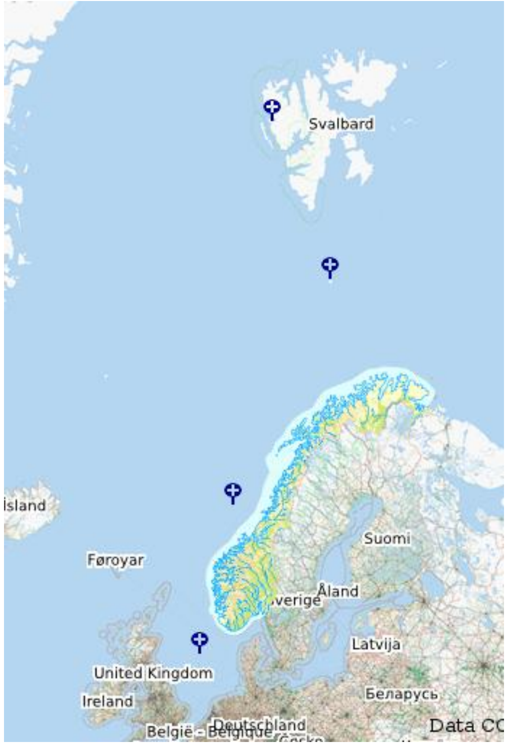
Sensitivity simulations

	12_03	15_03	18_03	21_03	00_04	03_04	06_04	09_04	12_04	15_04	18_04
CTL	986	987	988	988	988	989	990	991	995	997	1001
Cu	2	2	1	1	1	0	0	1	-1	0	0
NoCH	6	6	5	7	8	9	9	11	10		
NoCH-D36		1	0	1	2	2	2	4	2	4	
NoCH-D48						0	1	3	2	2	2
NoF	No PL										
NoF+NoCH	No PL										
NoF-D36		0	1	3	5	6	8	11	12	No PL	
NoF-D48						0	1	5	5	7	No PL
NoSHF	2	2	2	3	3	4	5	6	6	8	
NoSHF-D48						0	1	3	2		
NoLHF	3	4	4	4	5	7	9	No PL			
NoLHF-D48						0	0	3	2		

Føre and Nordeng (2012: QJRMS, in press)

Forecast errors as a function of latitude

Station	LAT	Mean error	STD	RMSE
Ny Ålesund	78.9	0.6	1.3	1.5
Bjørnøya	74.5	0.5	1.4	1.5
Heidrun	65.3	0.2	1.2	1.2
Ekofisk	56.5	0.0	1.1	1.1



Error statistics for MSLP for selected SYNOP stations in the North Sea, Norwegian Sea and the Barents Sea in units of hPa.
The table shows a composite of all forecast lengths from +18 to + 42 hours with the Norwegian operational limited area model HIRLAM between 1 Jan 2010 and 30 Sept 2010.

From: Thor Erik Nordeng

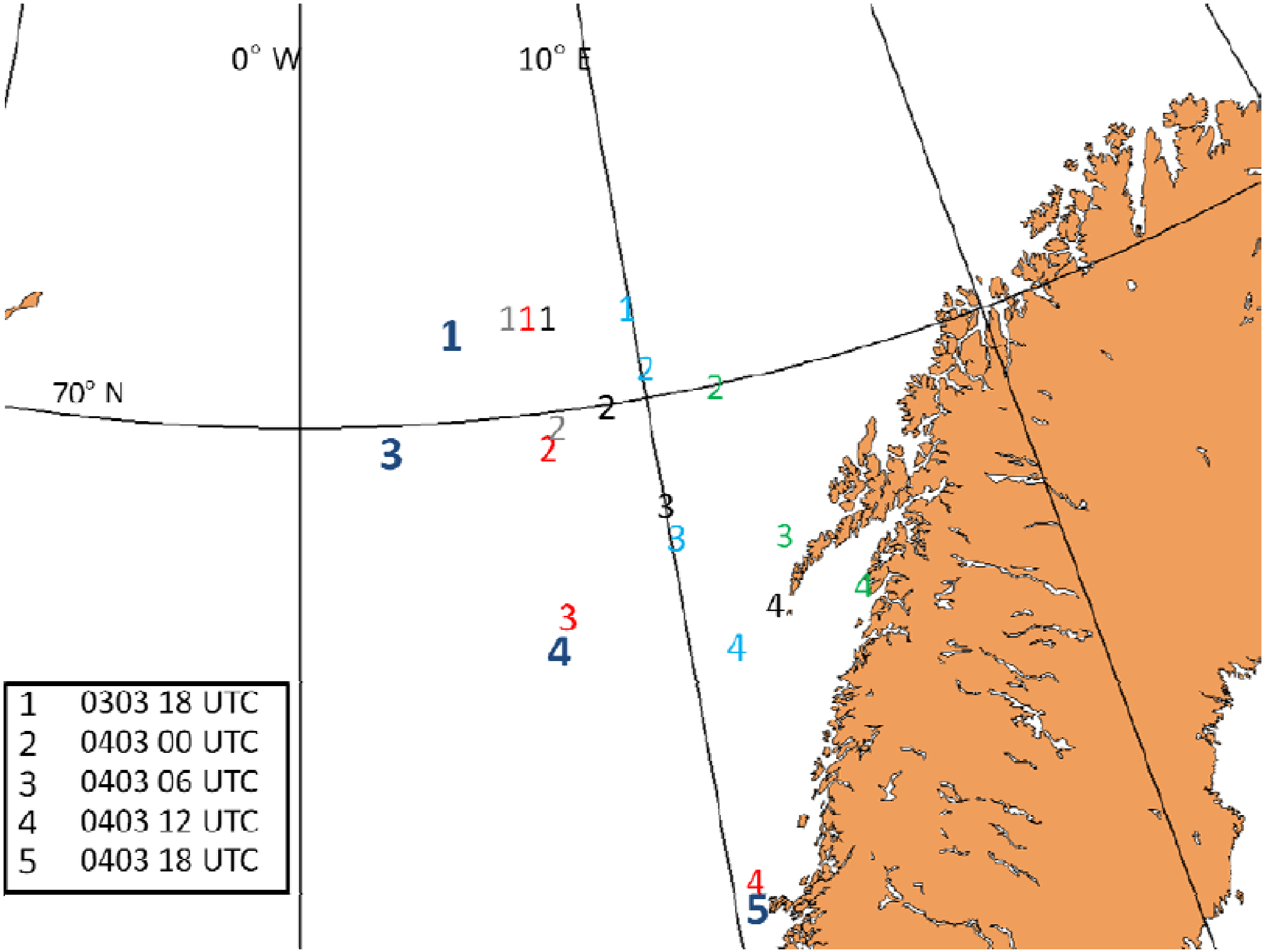
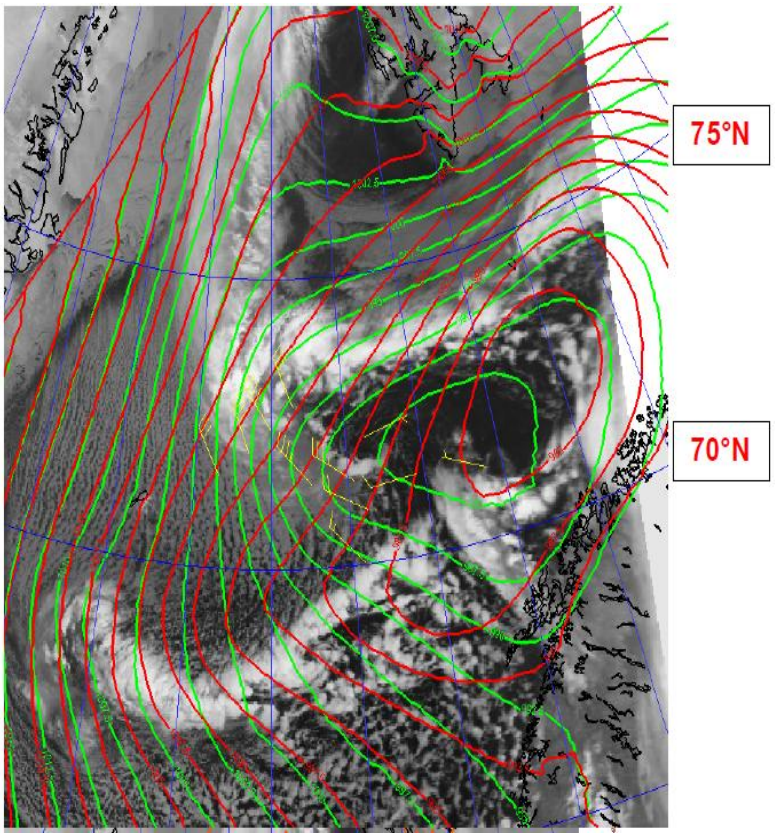


Figure 16: Position of polar low from UM12 (light blue), UM12_70L (black), UM4 (red), UM1 (gray) UM4_Lat10 (green) and analysis (dark blue). For the analyses the position is shown between 3 March 18 UTC and 4 March 18 UTC at 6 hours intervals, except for 4 March 000 UTC. For the model runs the positions are shown between 3 March 18 UTC and 4 March 12 UTC with excepions for UM4_Lat10, where we have not shown the position for 3 March 18 UTC and UM1, where we only have shown the positions for 3 March 18 UTC and 4 March 00 UTC.

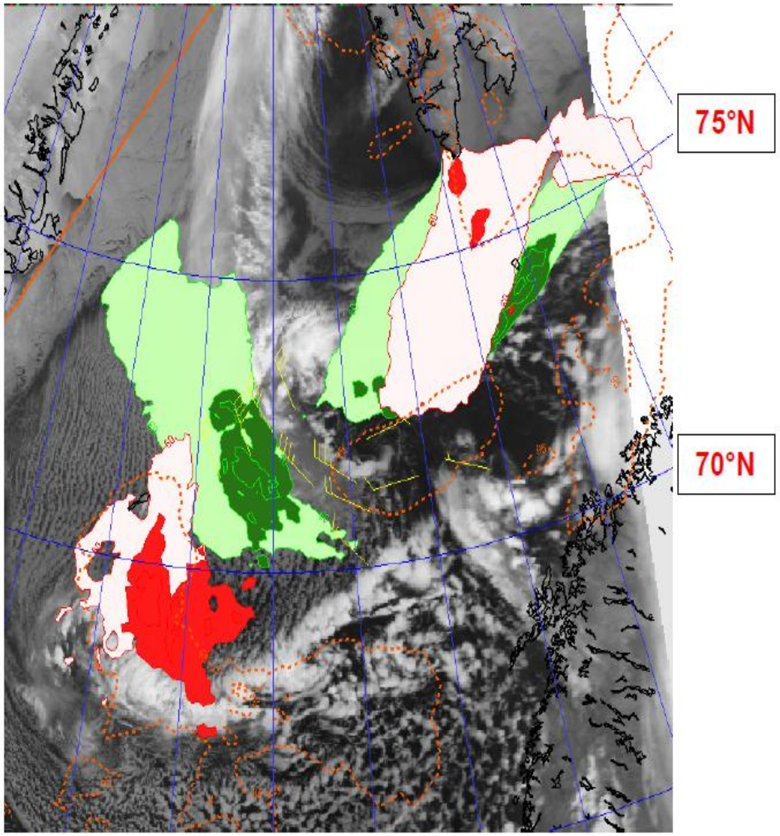
McInnes et al. (2011: QJRMS)

Probabilistic Forecasting (LAMEPS)

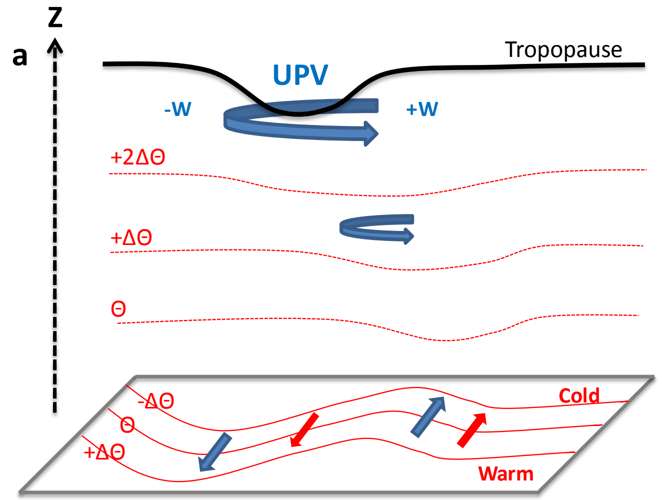
Sea-Level Pressure

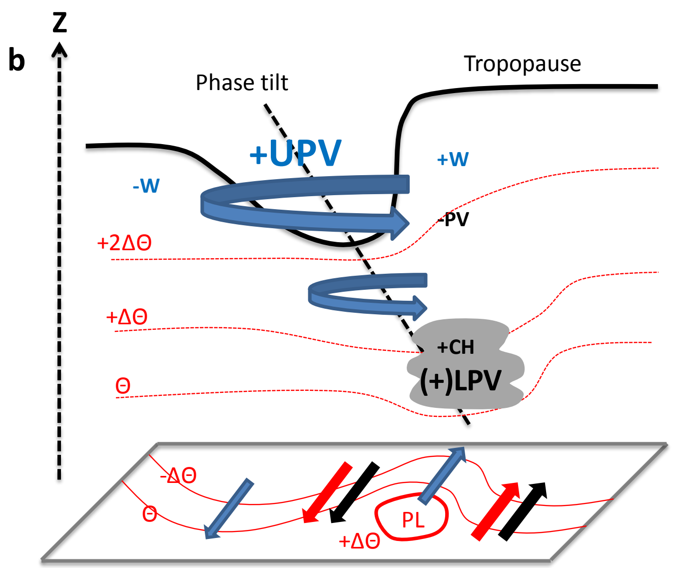


Precipitation



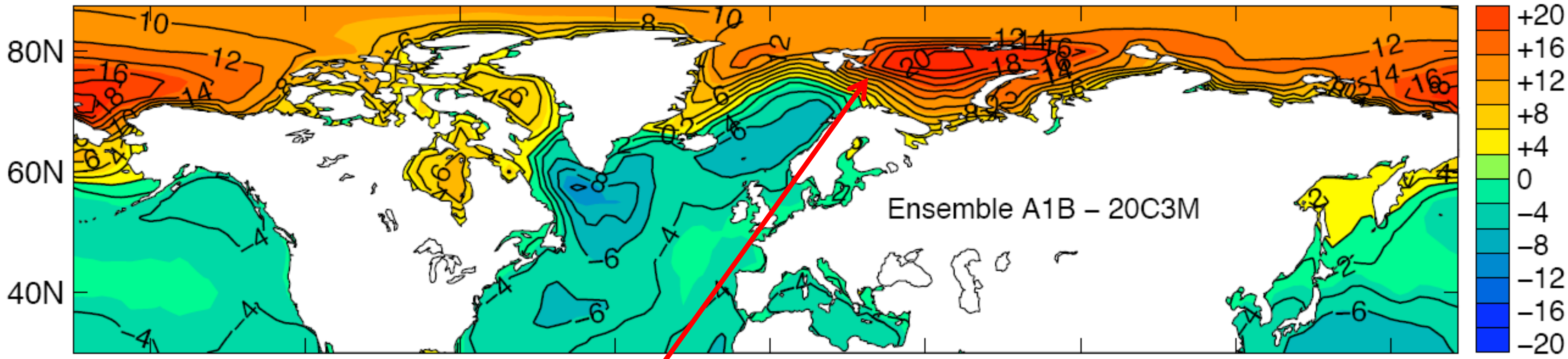
Kristjánsson et al. (2011: BAMS)





Ivan Føre (2012: Ph.D. thesis)

Polar Lows in the Future



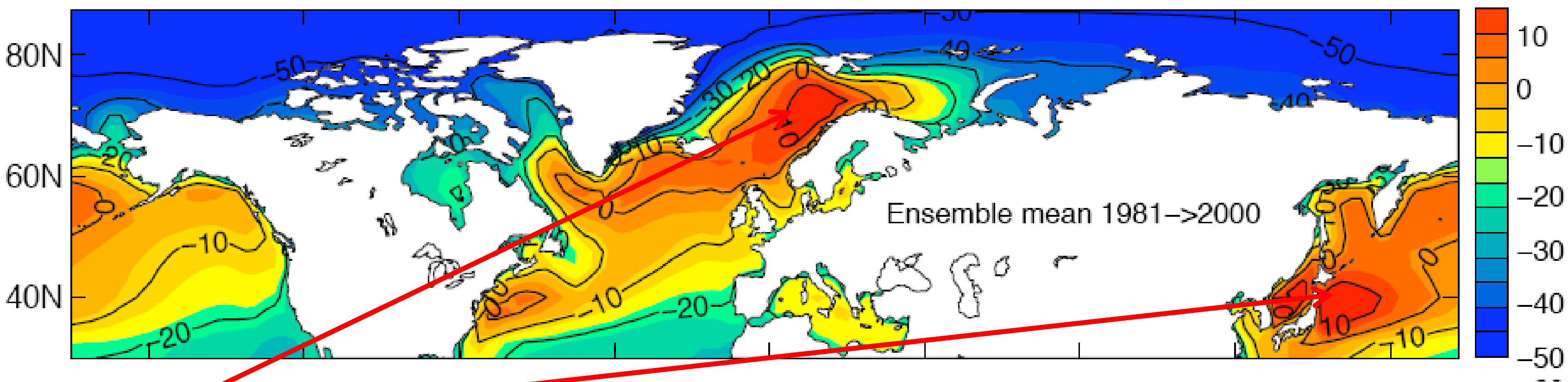
Blue: Fewer polar lows than now

Red: More numerous polar lows than now

Note increase in the Barents Sea

Kolstad & Bracegirdle (2007: Clim. Dyn.)

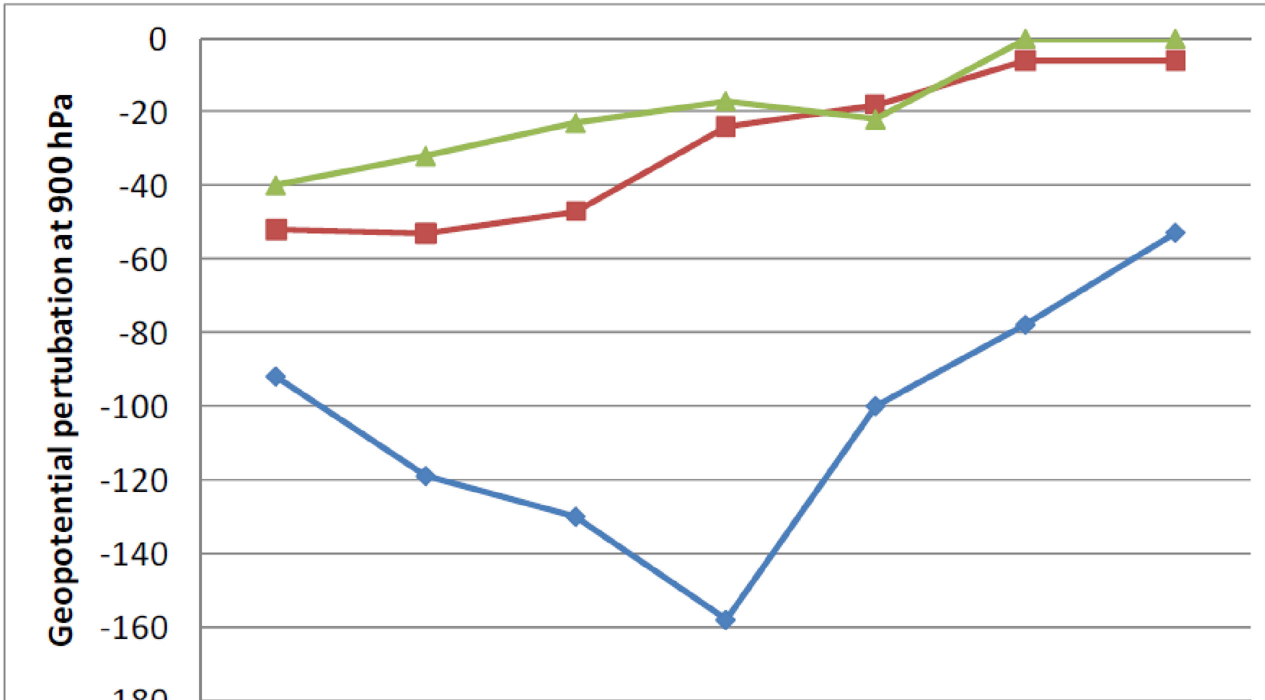
Where do we find polar lows today?



Red: Marine cold air outbreaks => polar lows

Kolstad & Bracegirdle (2007: Clim. Dyn.)

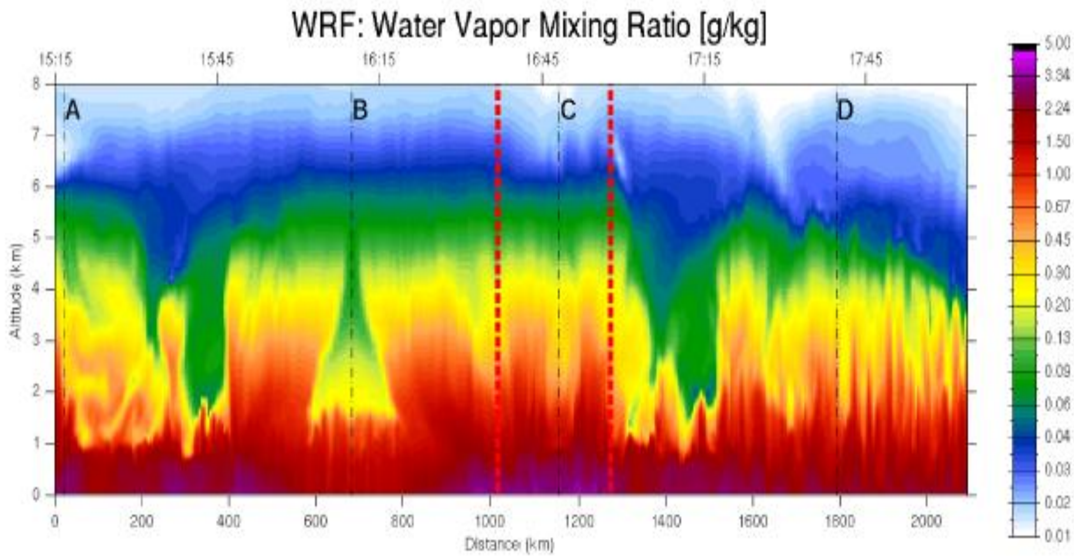
Contributions from different PV anomalies

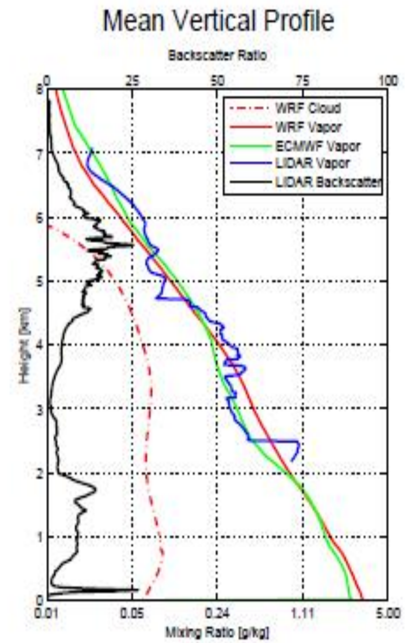


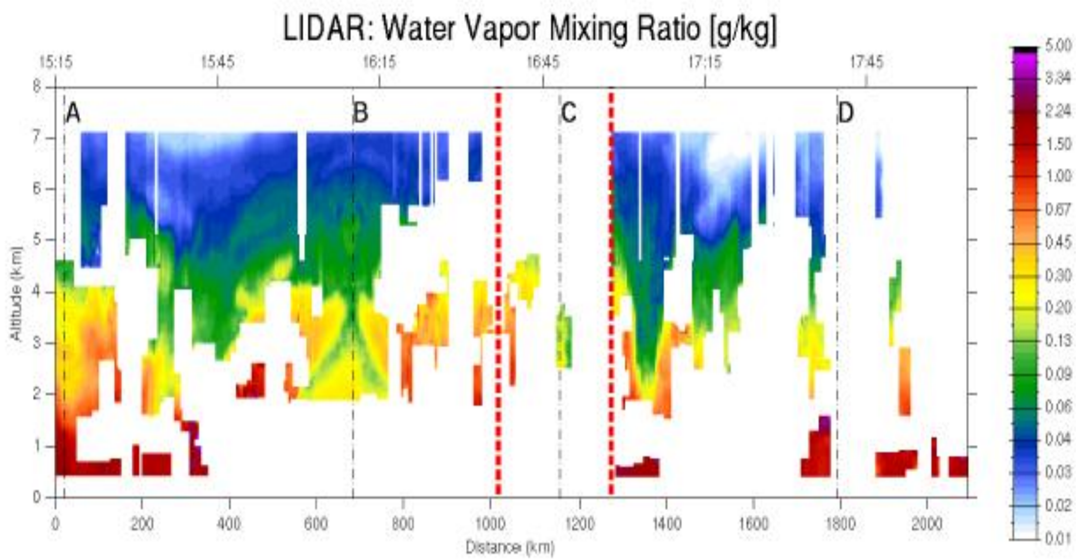
	00_3	06_3	12_3	18_3	00_4	06_4	12_4
UPV	-92	-119	-130	-158	-100	-78	-53
LPV	-52	-53	-47	-24	-18	-6	-6
Theta	-40	-32	-23	-17	-22	0	0

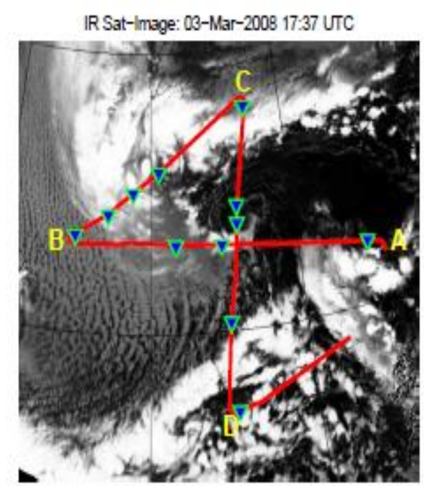
Føre et al. (2011: QJRMS)

Model - LIDAR: Vapor



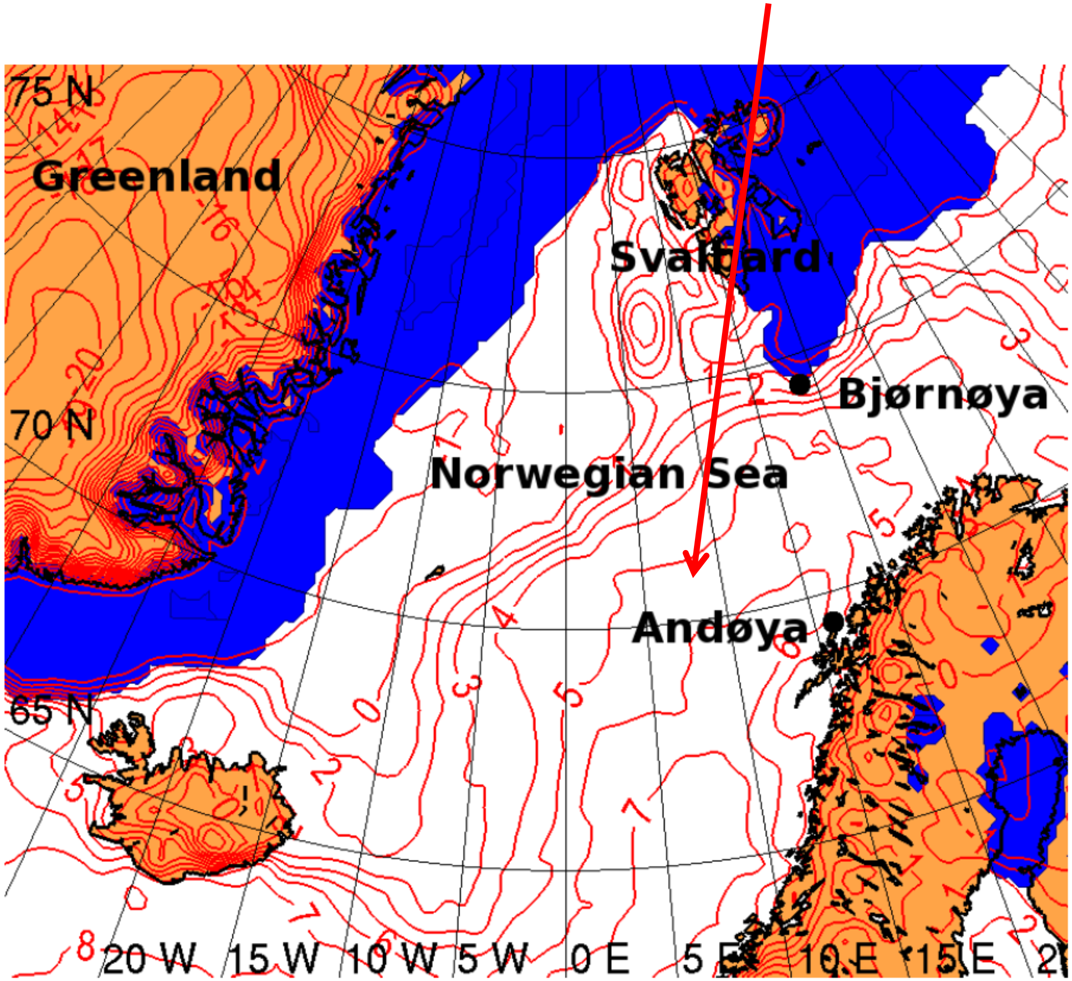






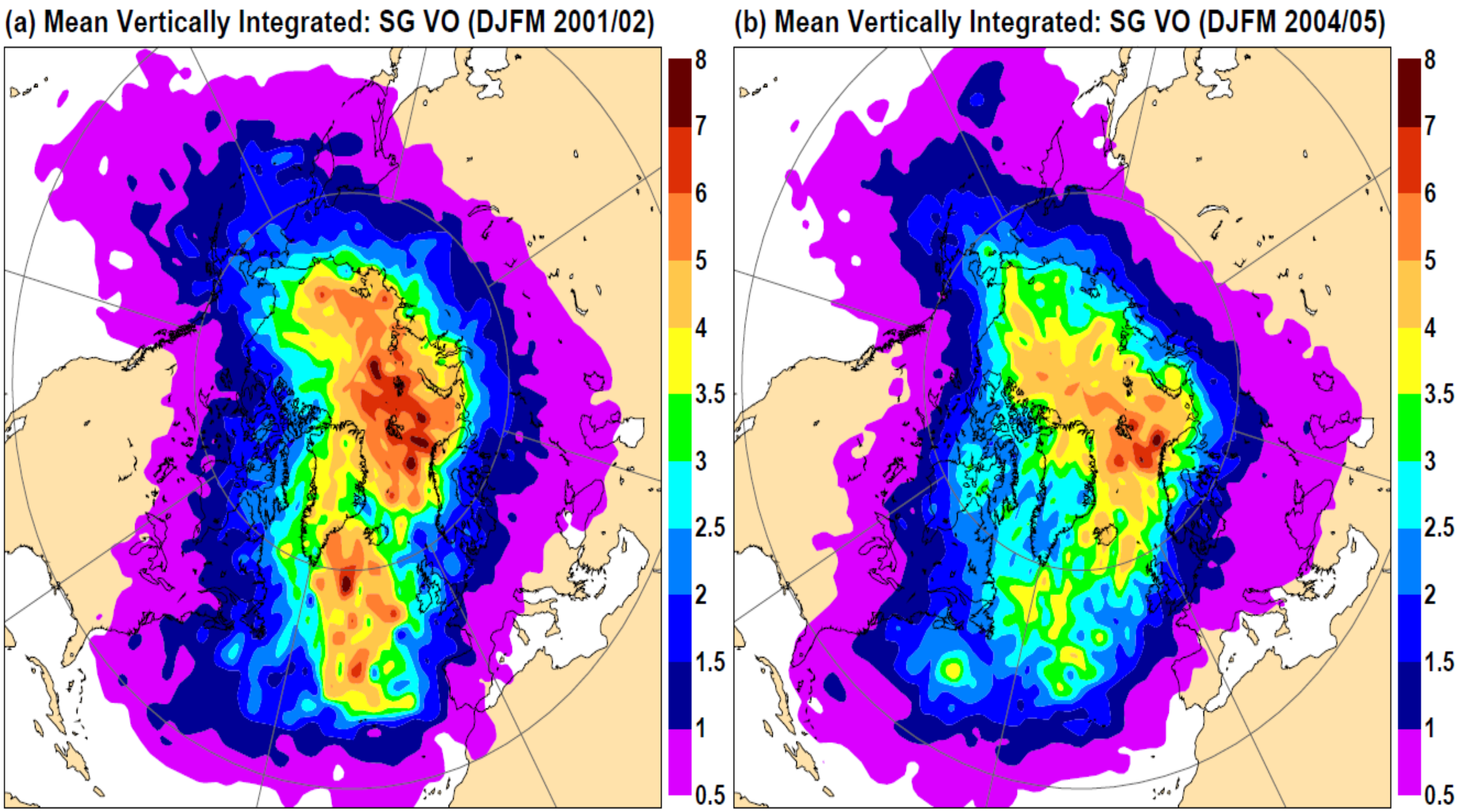
Wagner et al. (2011: QJRMS)

High SSTs in the area of interest



Føre et al. (2011: QJRMS)

Sensitivity of forecast error north of 70N to initial conditions



Jung & Leutbecher (2007: QJRMS)