Mechanisms for the polar low formation in January over the Nordic Seas using Arctic System Reanalysis

Ana Radovan, S. Crewell, A. Rinke, E.M. Kudsen

GA

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UNIVERSITÄT LEIPZIG

Universität Bremen

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TROPOS

Leibniz Institute for Tropospheric Research

Outline

- Polar lows – the „hurricanes” of the Arctic
  - Polar low case study
- Conditions of a polar low formation
  - Are conditions fulfilled?
- WV, LIQUID and ICE of a polar low
- „Key” condition?
- Summary

Polar lows – the „hurricanes" of the Arctic

- small (diameter < 600 km)
- intense maritime cyclone (winds > 15 m/s)
- short-lived (3-72h)
- bring large amounts of precipitations

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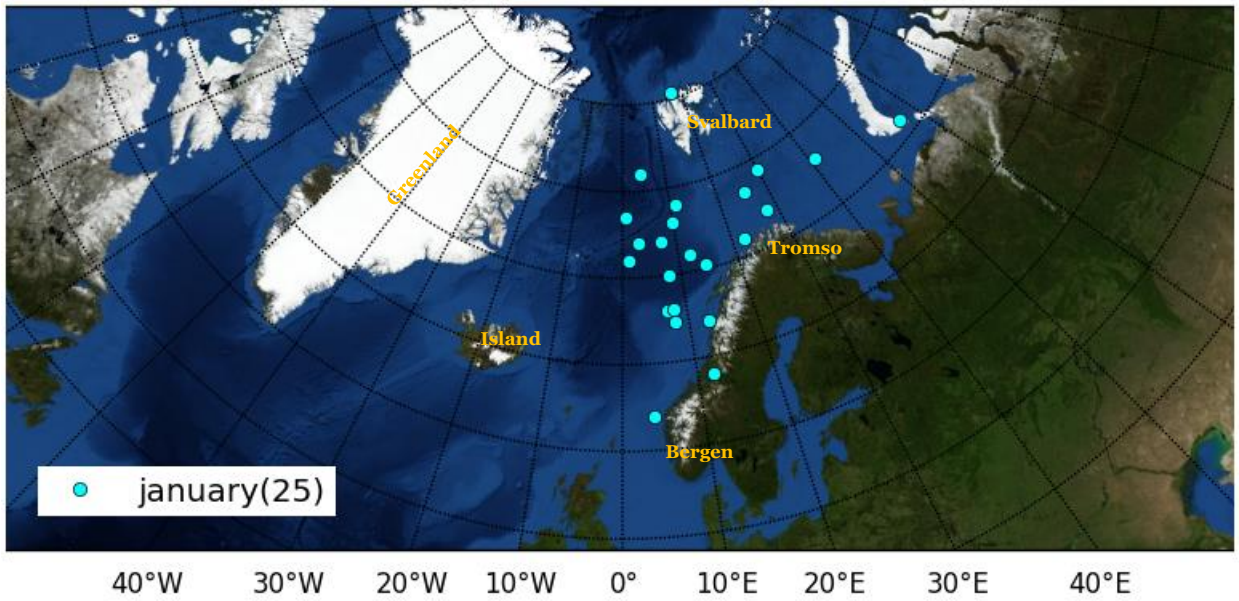
Polar lows – the „hurricanes" of the Arctic

SEASON: October – May
(max in January and March)



DYNAMICS:

- **convective,**
- **baroclinic,**
- **Both**

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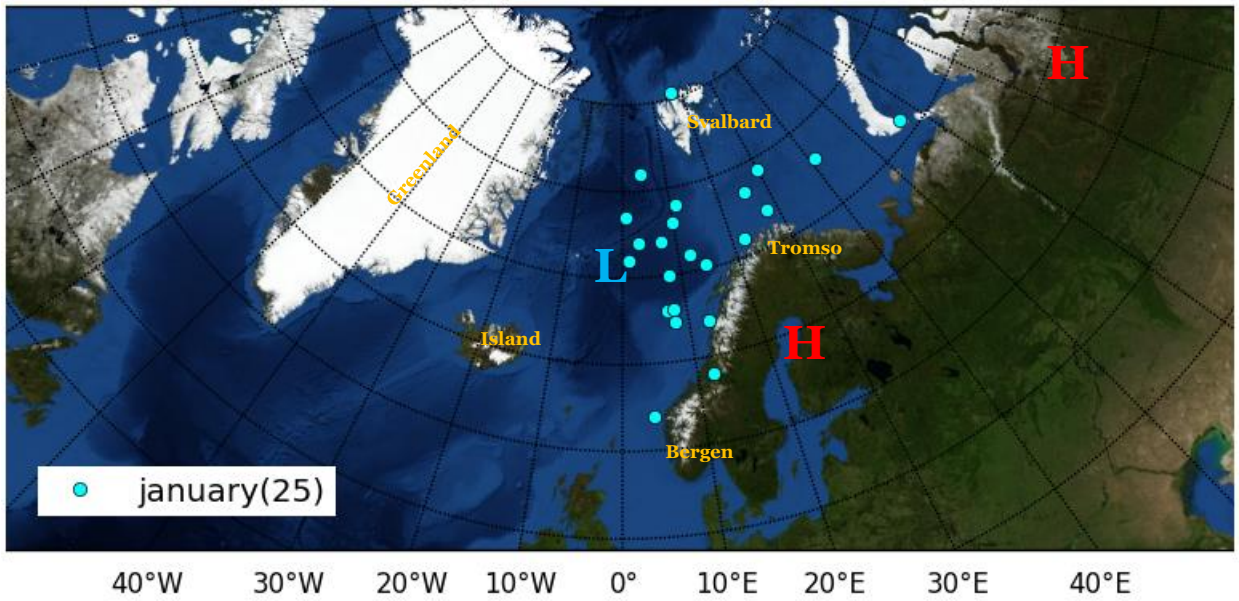
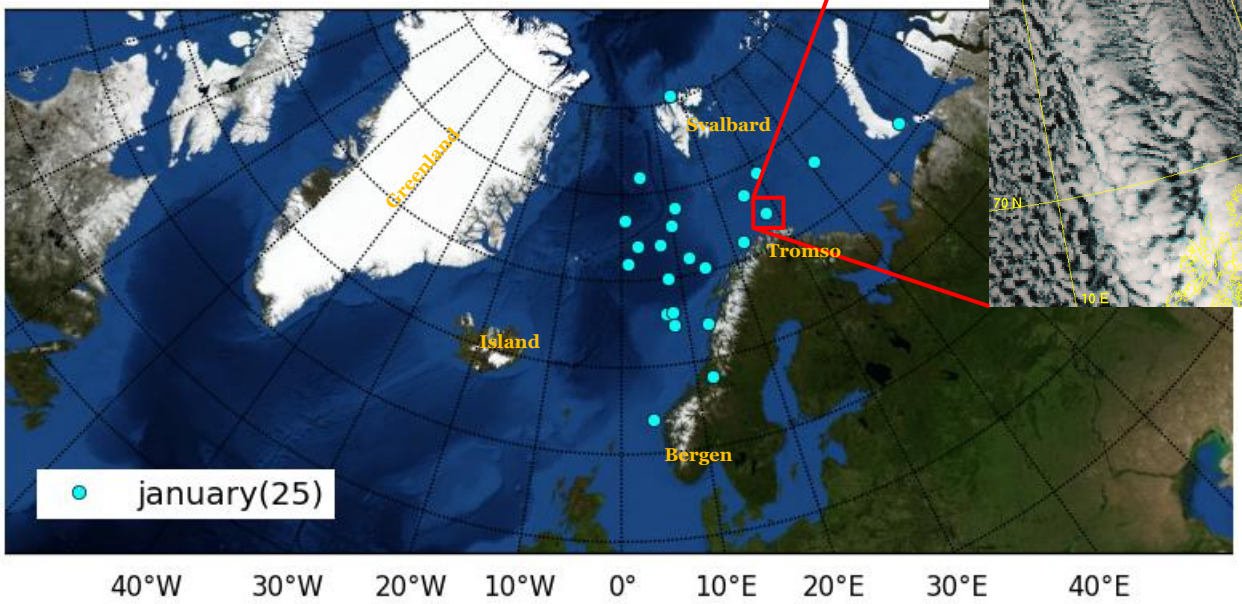
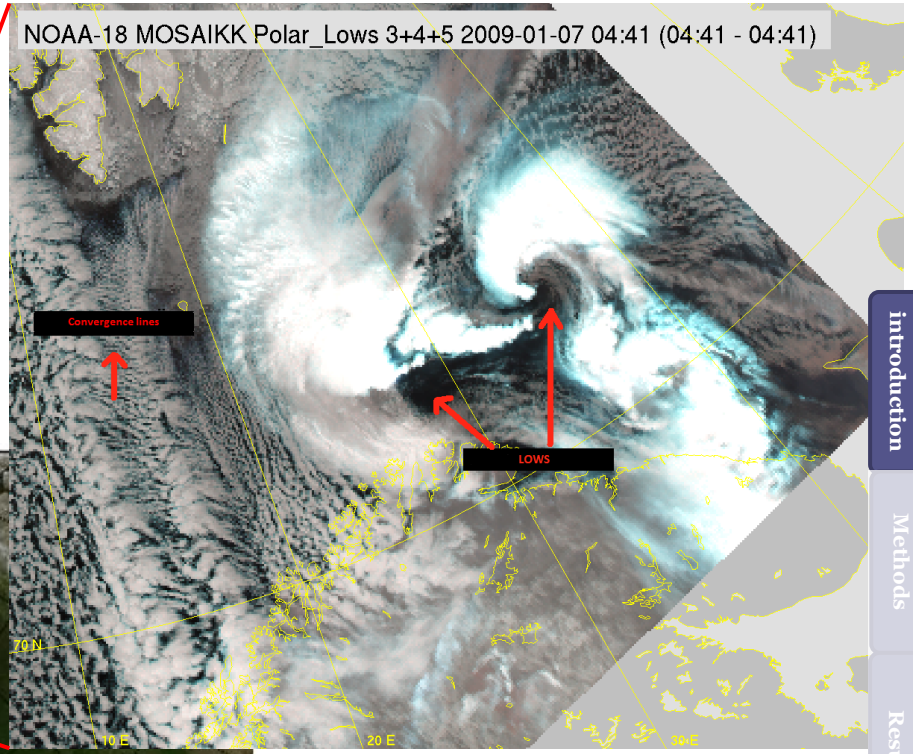


January

- **DYNAMICS:**
  - **convective,**
  - **baroclinic,**
  - **both**
- PL „hot spot"
  72°N 18°E

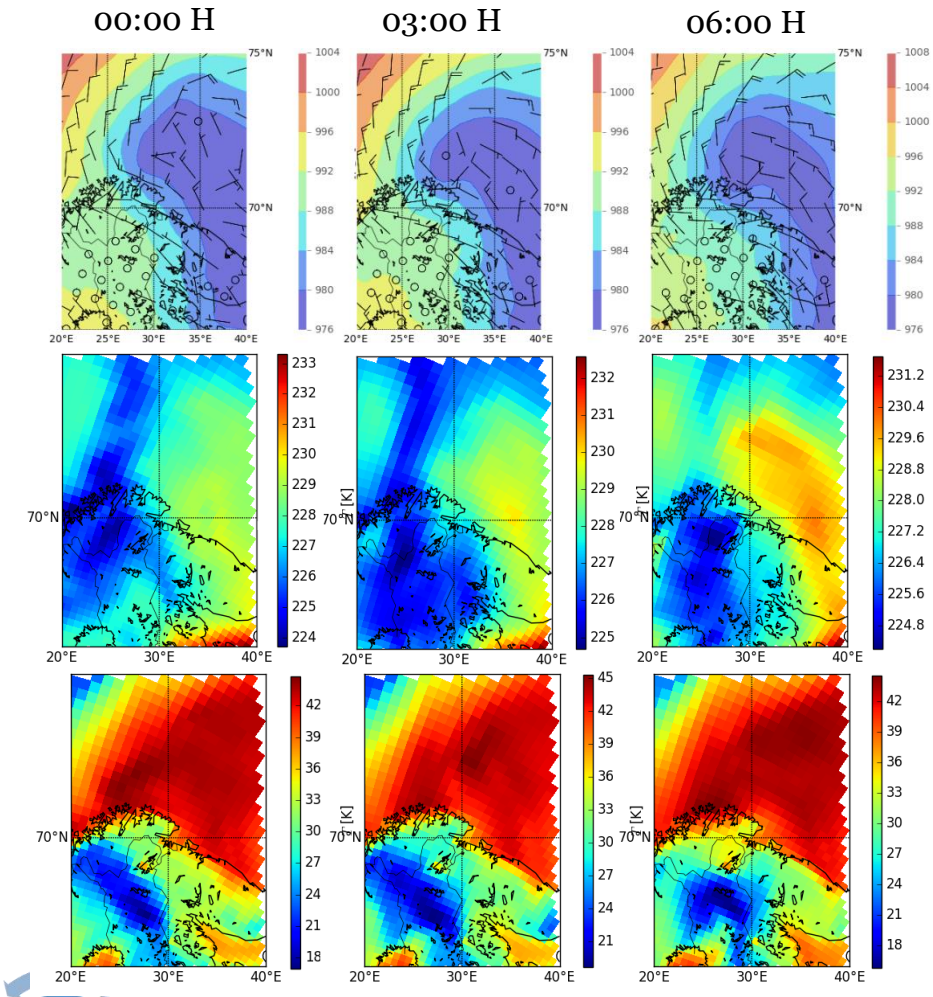
Polar low case study January, 07, 2009





Reported large amounts of snow and severe problems for coastal and inland communities

Polar low case study January, 07, 2009



winds > 15 m/s

T @ 500 hPa: CAO is visible

$T_{diff} = T_{1000hPa} - T_{500} > 40\ K$

$SST - T(2m) = 51.40\ K$

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Conditions of a polar low formations

- Arctic system reanalysis (ASRv1, 30km)
- cut 200 km radius around genesis point to find average of variables considered in conditions

SST – T(500 hPa) > 40K

RH close to surface ~ 75 %
close to 900 hPa
max of 85%

LR conditionaly unstable below 850 hPa

MSLP low

SST – T2m : 6 – 7 K

GPH lower than climatological mean

air masses moderatly baroclinic
Eady growth rate

geostrophic winds are weak and backed with height

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$$\sigma \equiv 0.31 \frac{f}{N} \left| \frac{\partial \boldsymbol{V}}{\partial Z} \right|$$

geostrophic winds are weak and backed with height

Conditions of a polar low formations

THERMAL WIND

$$u_T = -\frac{1}{f}\frac{\partial(\Phi_{700}-\Phi_{925})}{a\partial\varphi} \quad \text{and} \quad v_T = -\frac{1}{f}\frac{\partial(\Phi_{700}-\Phi_{925})}{a\cos\varphi\partial\lambda}$$

THERMAL WIND

$$u_m = -\frac{1}{2f}\left(\frac{\partial\Phi_{700}}{a\partial\varphi}+\frac{\partial\Phi_{925}}{a\partial\varphi}\right) \quad \text{and} \quad v_m = \frac{1}{2f}\left(\frac{\partial\Phi_{700}}{a\cos\varphi\partial\lambda}+\frac{\partial\Phi_{925}}{a\cos\varphi\partial\lambda}\right)$$

φ – lat, λ –lon

Kolstad 2006

$$\alpha = \arccos\left(\frac{v_T \cdot \bar{v}}{\|v_T\|\|\bar{v}\|}\right)$$

forward shear

$0° \leq \alpha \leq 45°$

aligned with mean wind flow

increases with height

east

THERMAL WIND

WIND SPEED

PROPAGATION

reverse shear

$135° \leq \alpha \leq 180°$

aligned with mean wind flow but opposite direction

decreases with height

south

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Are conditions fulfilled?

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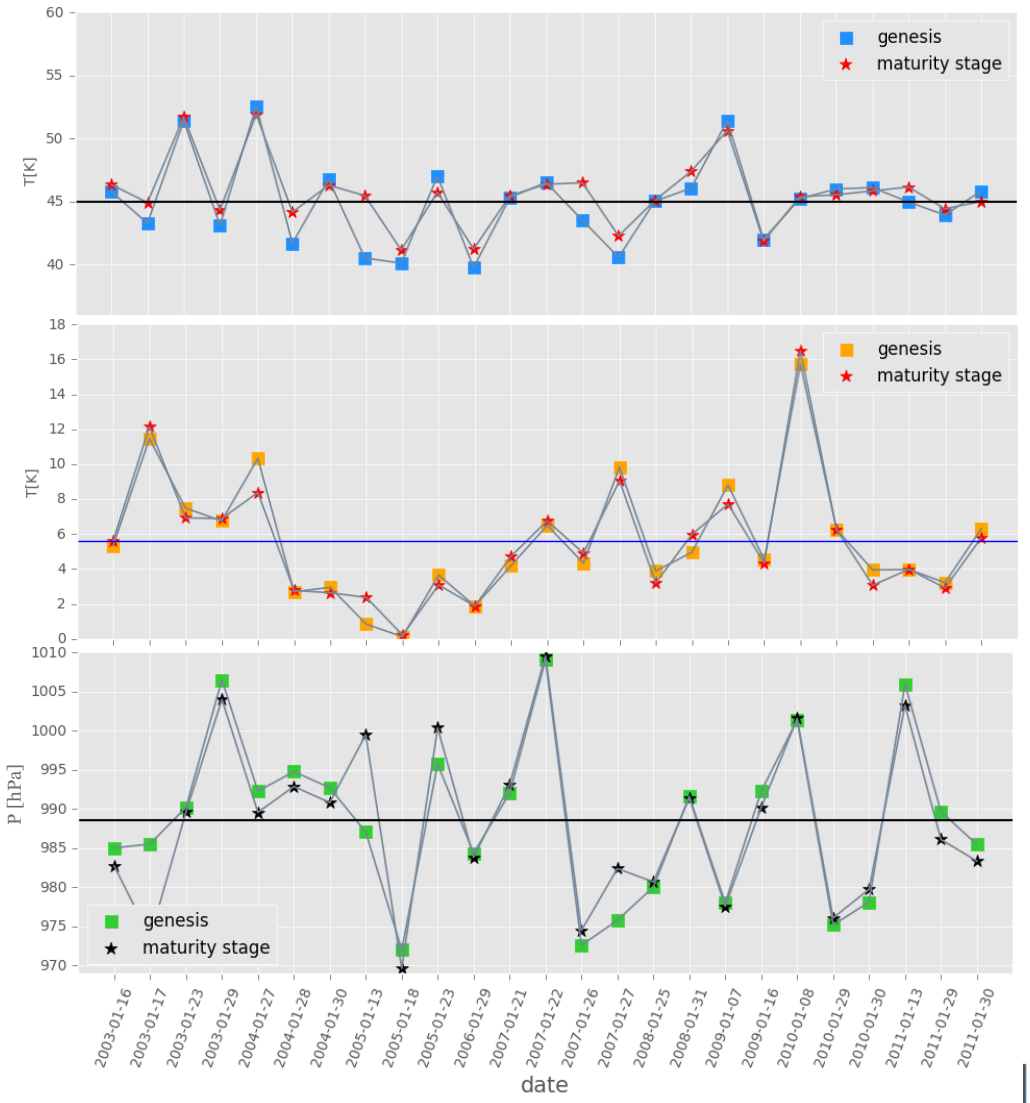
> 40K

SST – T(2m)

6-7 K

MSLP

1 hPa difference K



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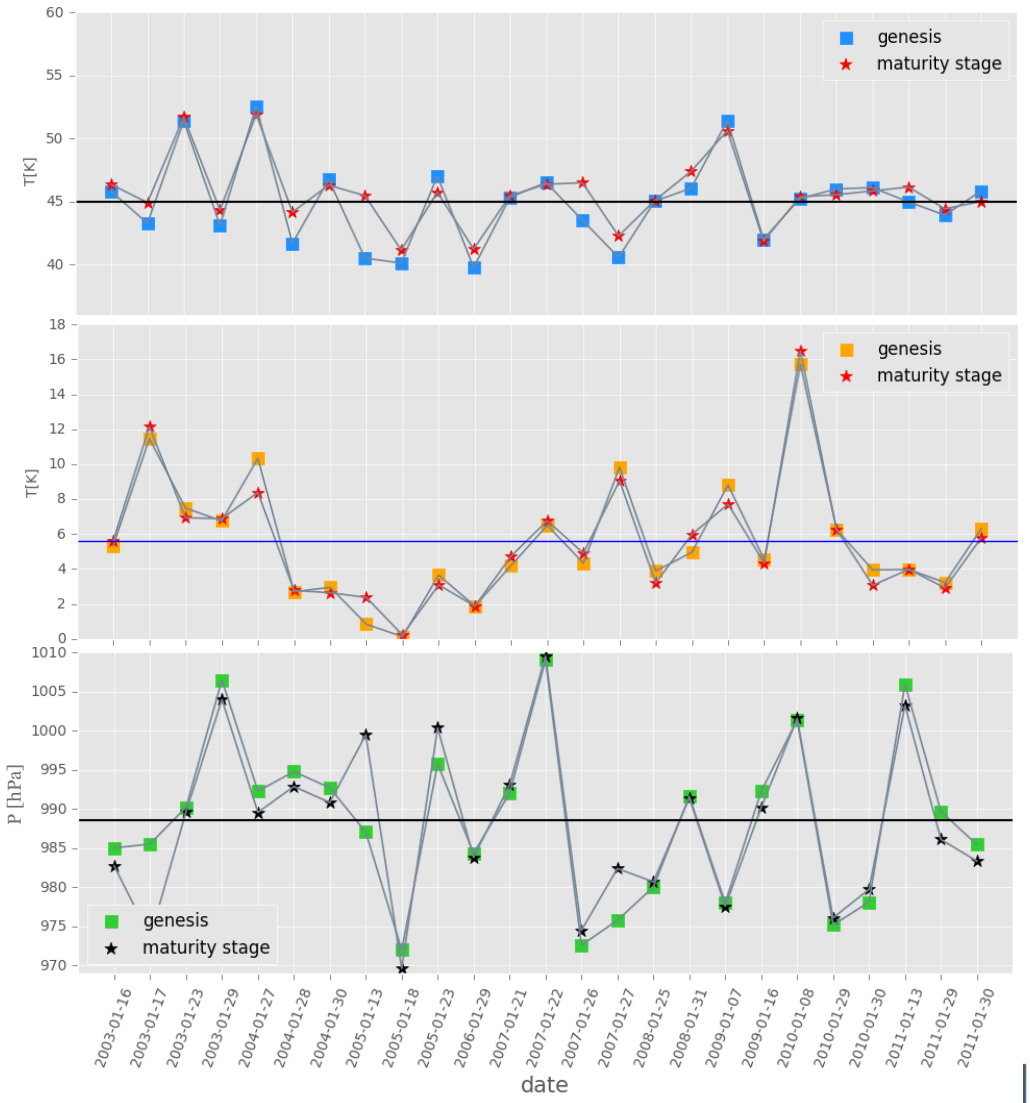

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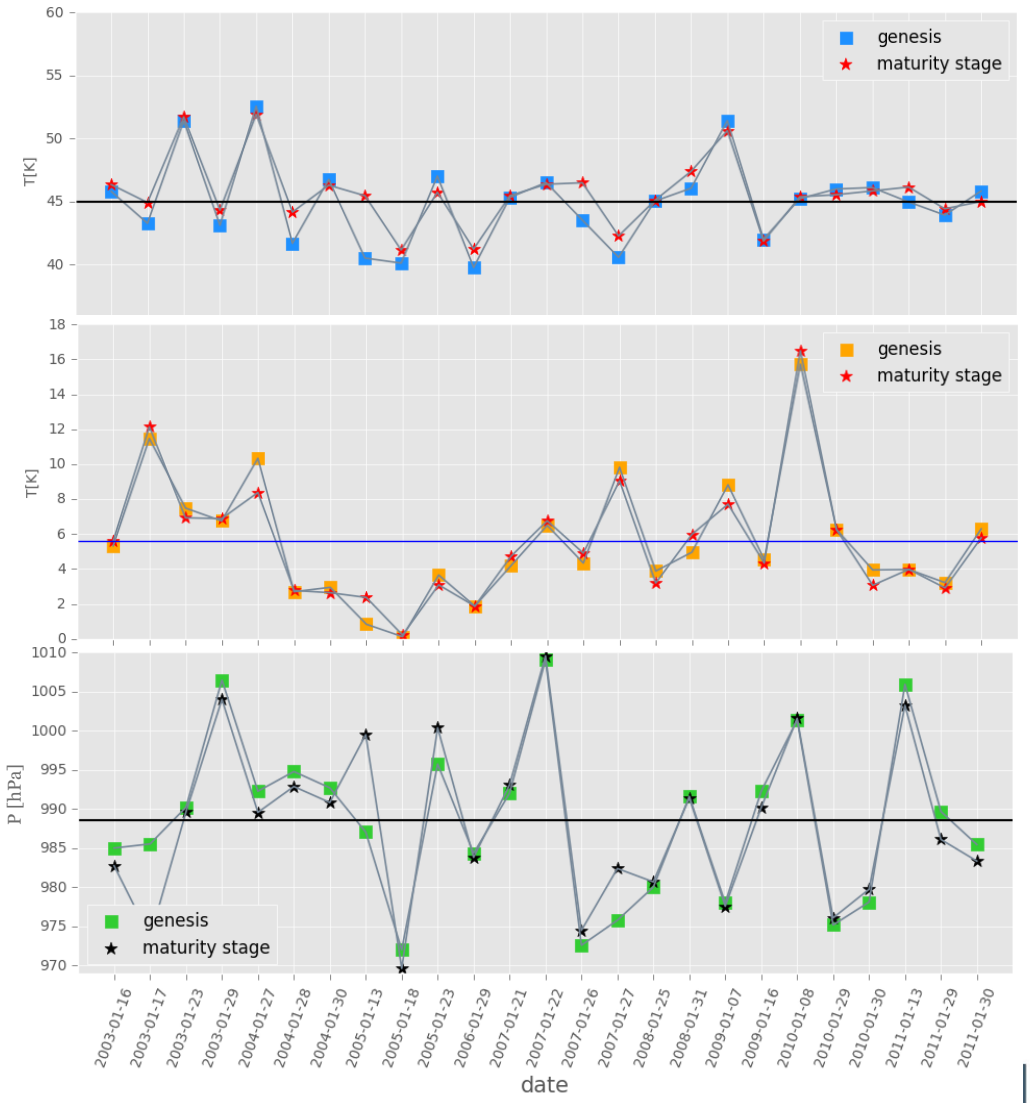

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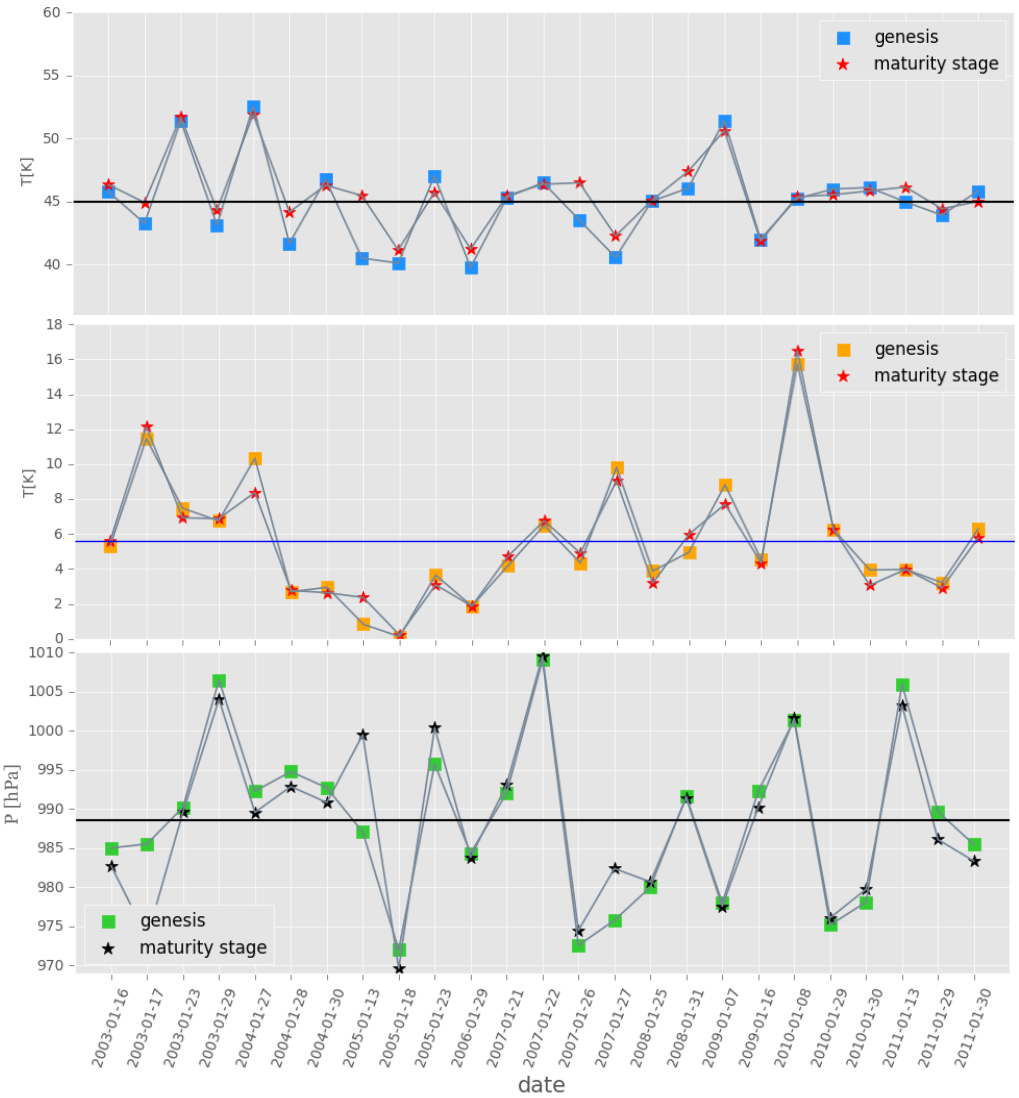


SST – T(2m)

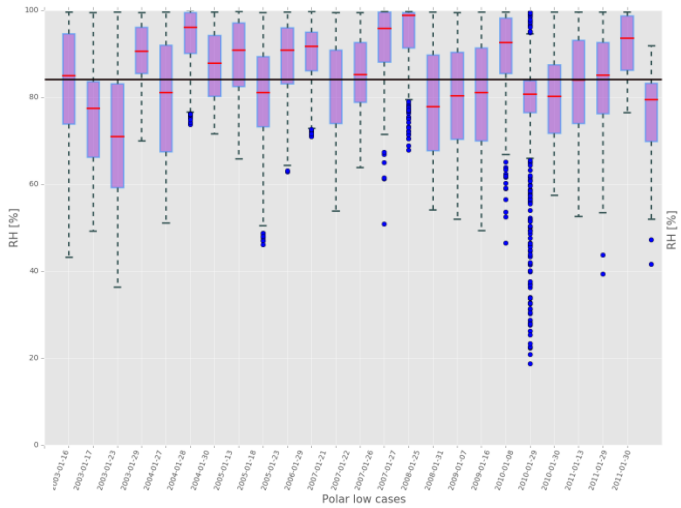
6-7 K

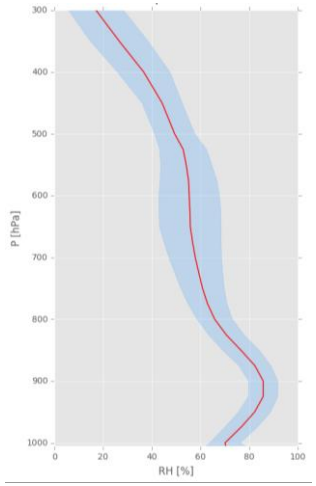
MSLP

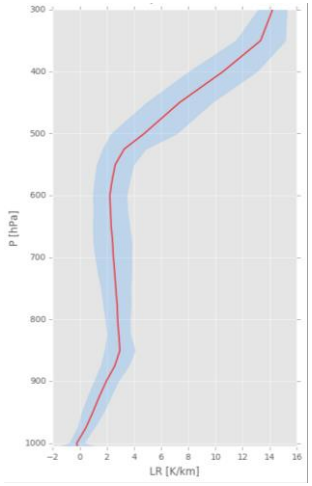
1 hPa difference K

Are conditions fulfilled?

RH

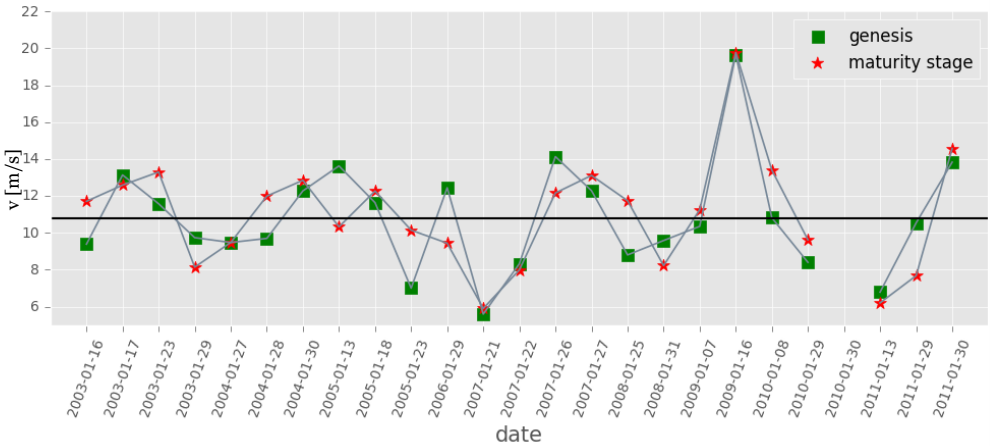


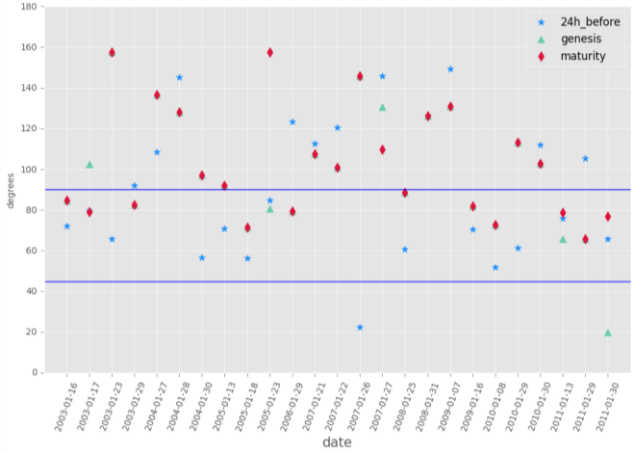




LR

WIND SPEED





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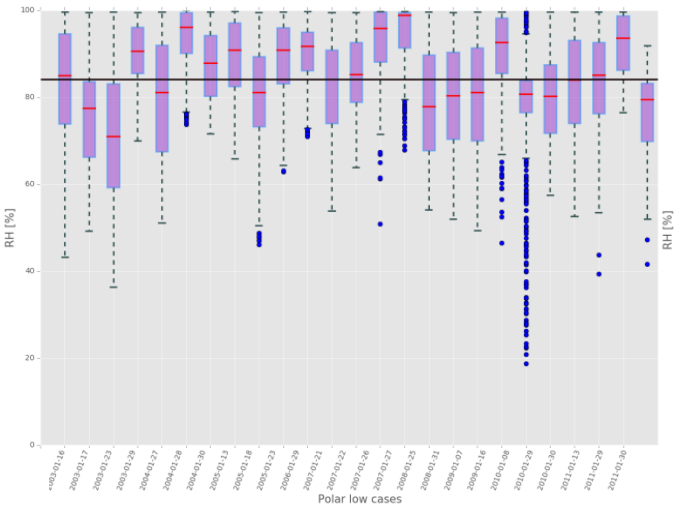
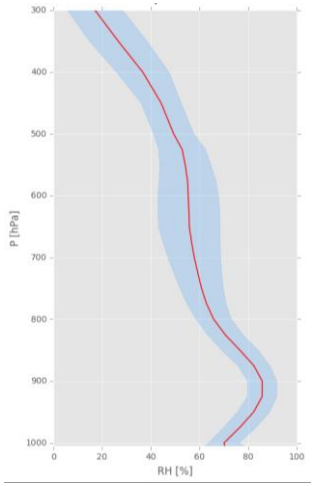
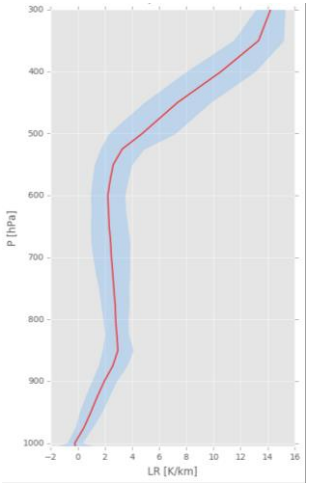
Are conditions fulfilled?

RH







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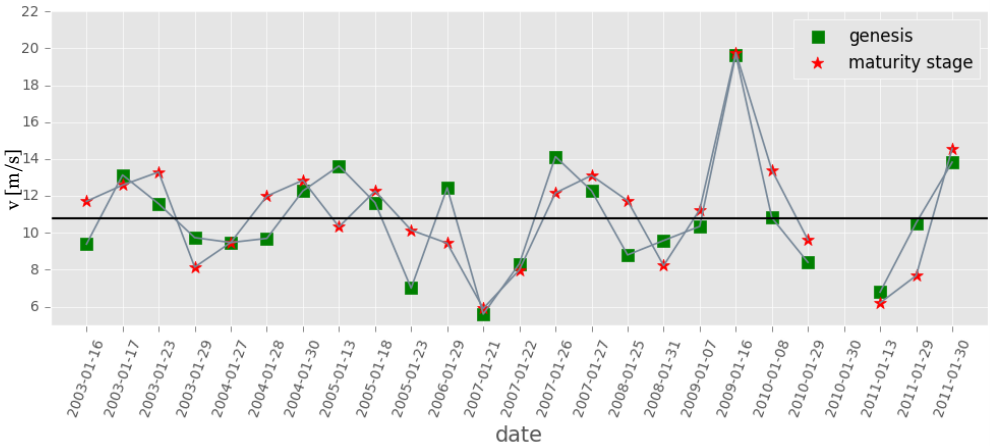
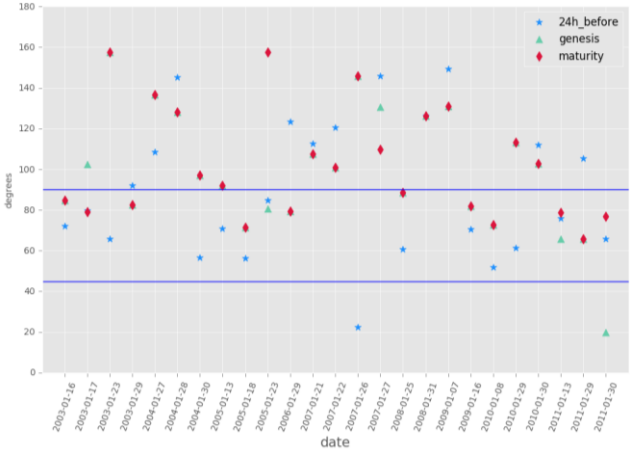
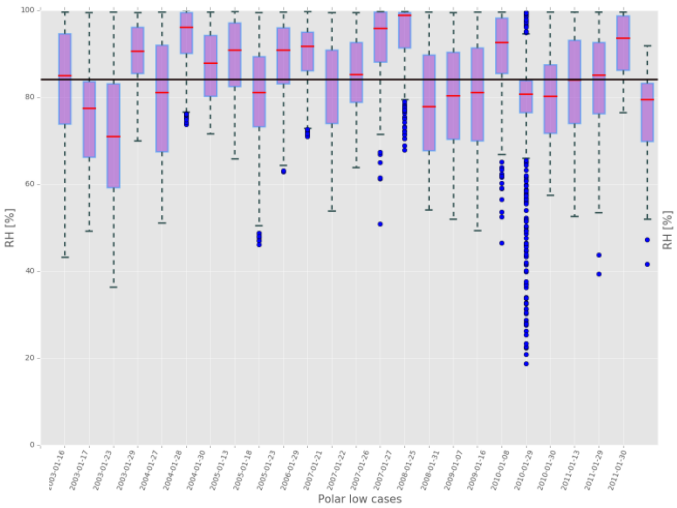
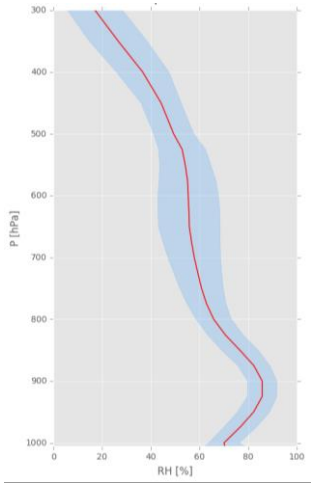


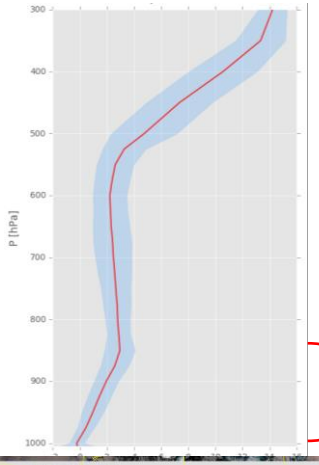


Are conditions fulfilled?

RH ✓







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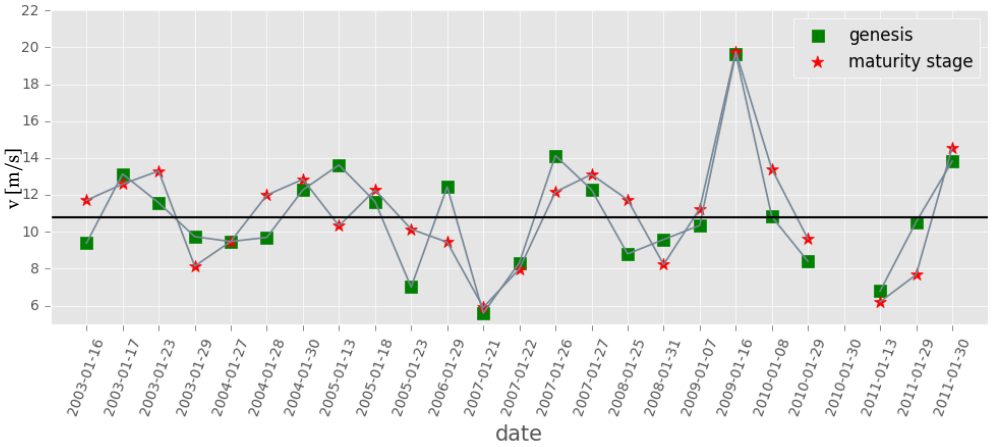

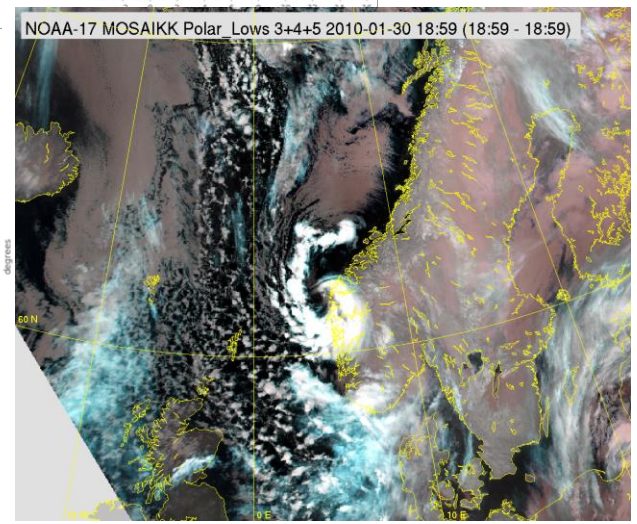

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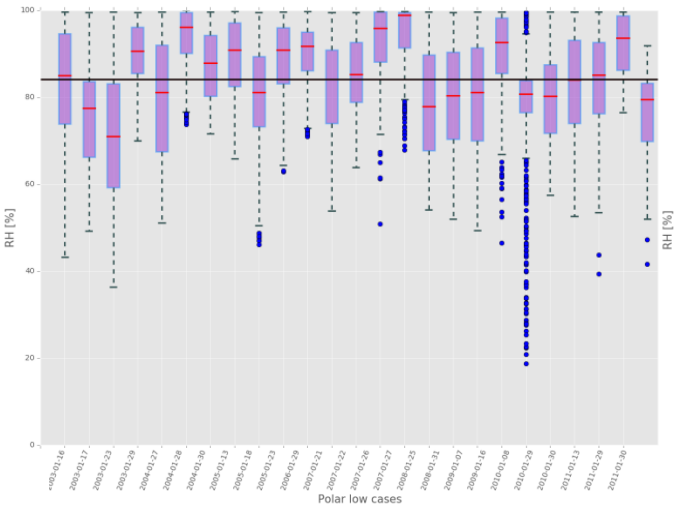

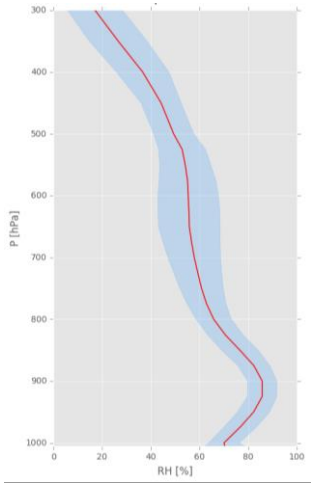

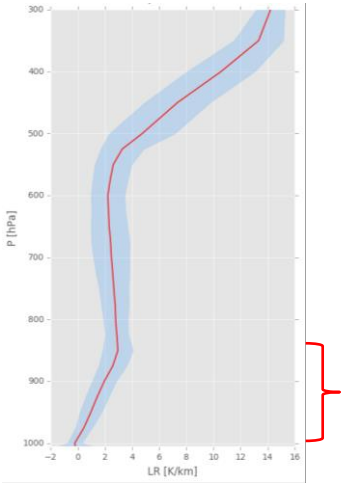

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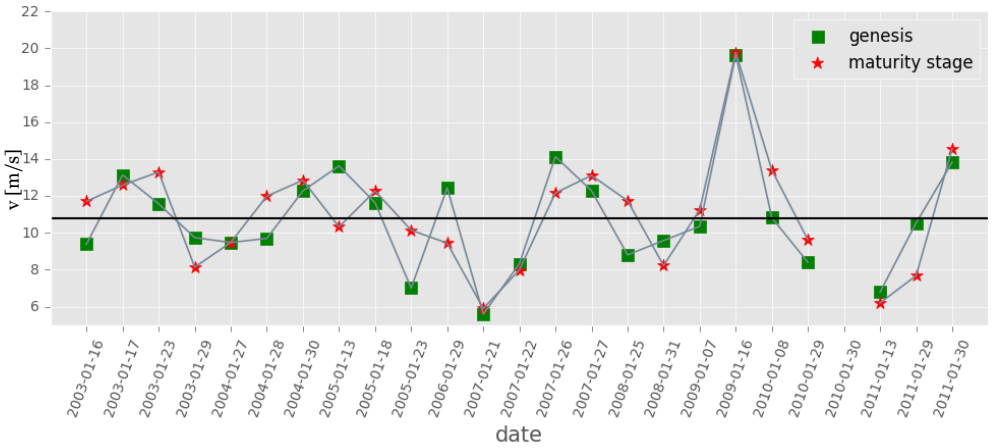

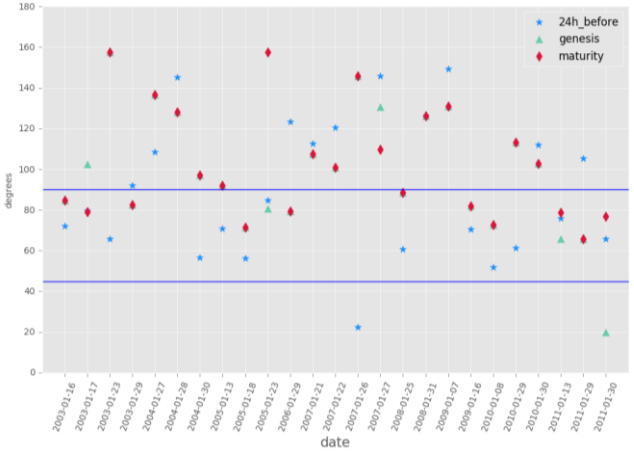

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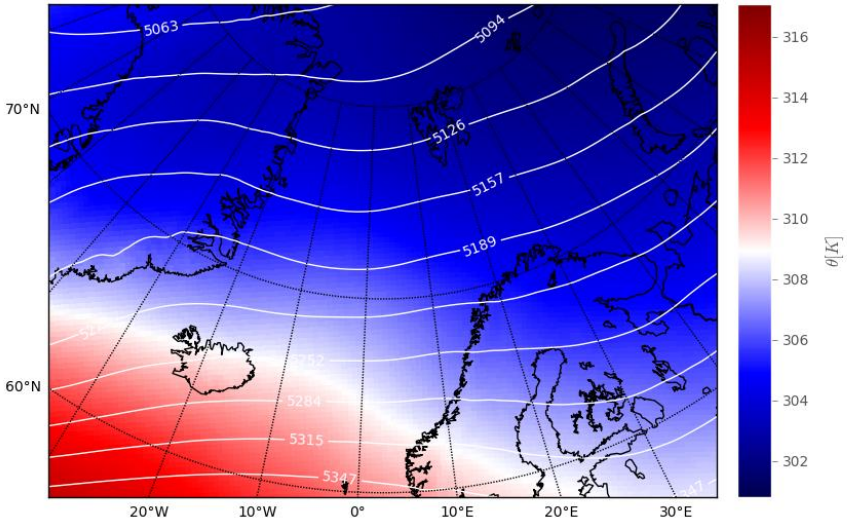
Are conditions fulfilled?

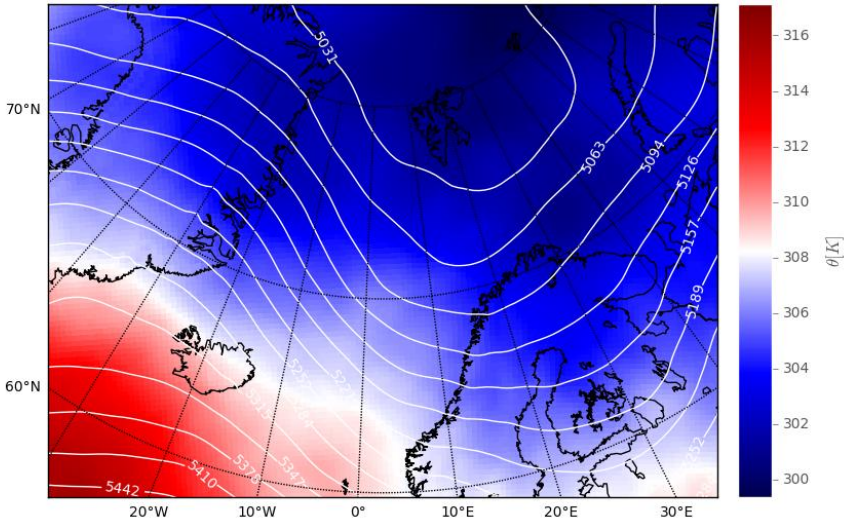
GPH at 500 hPa & θ (300 hPa)

linked to the energy of air flowing into the storm

January climatology



PL dates



GPH are below climatological mean

60 -100 m

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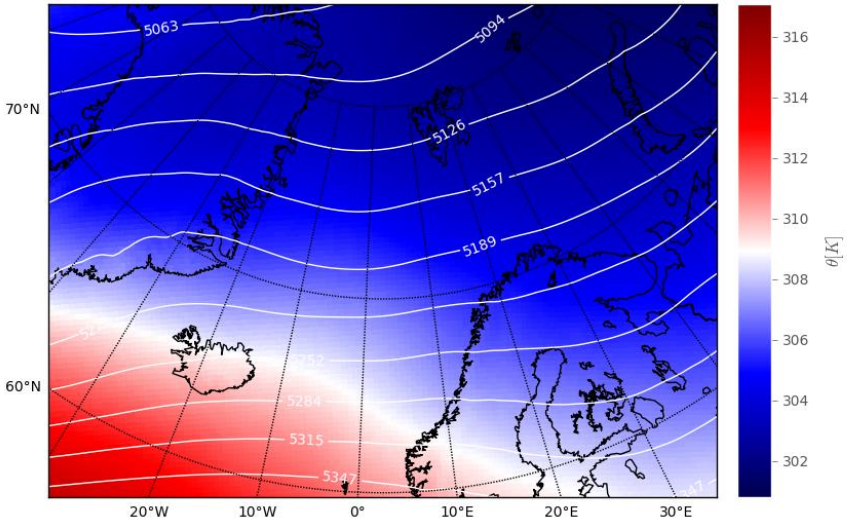

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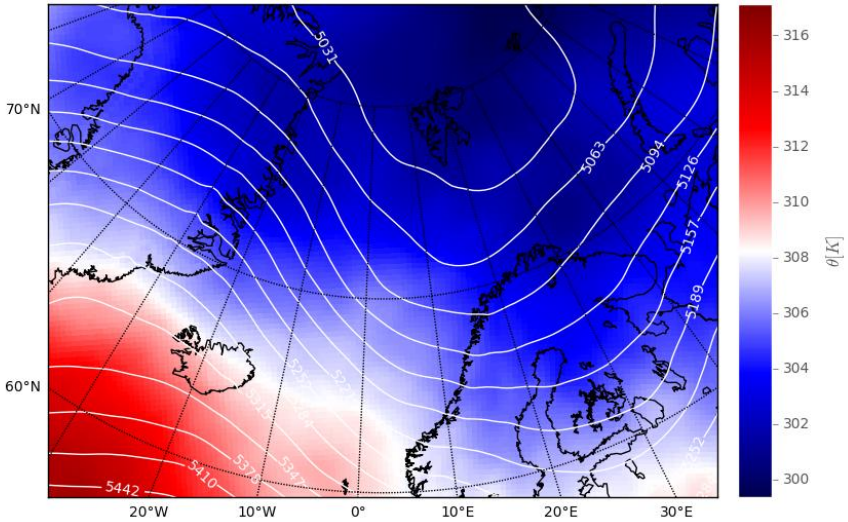

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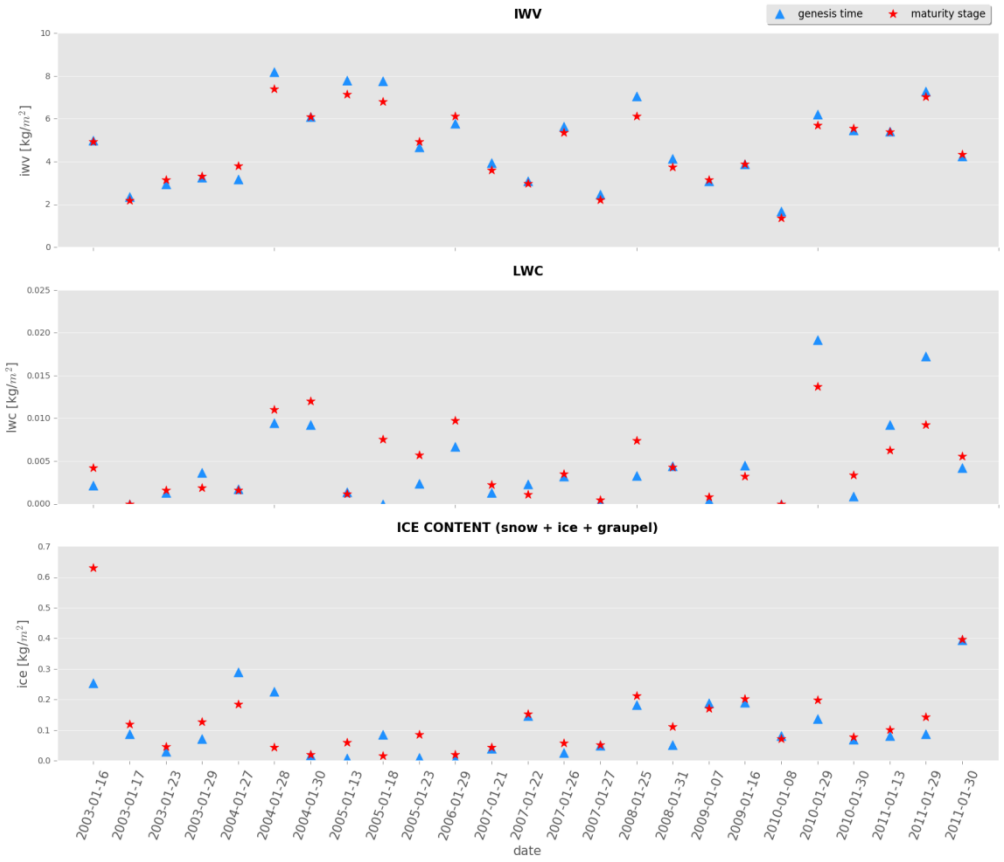
WV, LIQUID and ICE of a polar low



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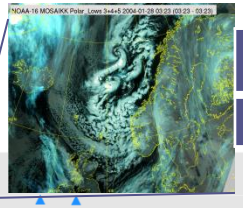
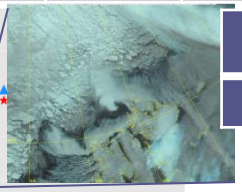


SST – T(500hPa)	SST – (2m)	RH below 1km ~ 85%	LR below 850 hPa unstable above 1.2 K/km	MSLP	WIND R↑/F↓
41.68	2.69	Yes	Yes	994	R



SST – T(500hPa)	SST – (2m)	RH below 1km ~ 85%	LR below 850 hPa unstable above 1.2 K/km	MSLP	WIND R↑/F↓
45.22	15.72	No	Yes	1001	-

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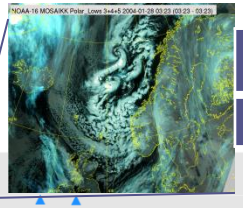
WV, LIQUID and ICE of a polar low



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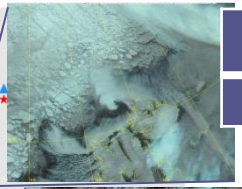

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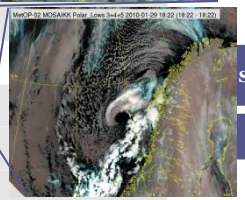

SST – T(500hPa)	SST – (2m)	RH below 1km ~ 85%	LR below 850 hPa unstable above 1.2 K/km	MSLP	WIND R↑/F↓
45.98	6.25	No	Yes	975	R

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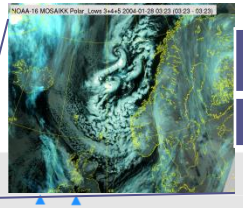
WV, LIQUID and ICE of a polar low



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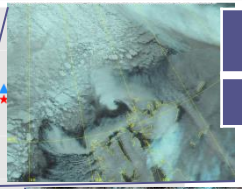

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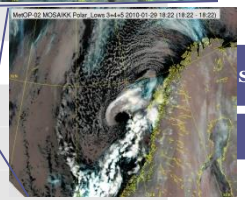

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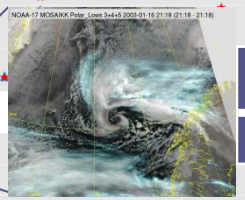

SST – T(500hPa)	SST – (2m)	RH below 1km ~ 85%	LR below 850 hPa unstable above 1.2 K/km	MSLP	WIND R↑/F↓
45.79	5.32	Yes	No	984	-

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„Key" condition?

	CASE	SST – T(500hPa)	SST – (2m)	RH below 1km ~ 85%	LR below 850 hPa unstable above 1.2 K/km	MSLP	WIND R↑/F↓	GPH low
1	2003-01-16	45.79	5.32	Yes	No	984	-	
2	2003-01-17	43.26	11.46	No	No	985	-	
3	2003-01-23	51.39	7.48	No	No	990	R	
4	2003-01-29	43.11	6.74	Yes	No	1006	-	
5	2004-01-27	52.55	10.33	No	No	992	R	
6	2004-01-28	41.68	2.69	Yes	Yes	994	R	
7	2004-01-30	46.74	2.95	Yes	Yes	992	R	
8	2005-01-13	40.51	0.38	Yes	Yes	987	R	
9	2005-01-18	40.11	0.12	No	Yes	971	-	
10	2005-01-23	47.01	3.65	Yes	Yes	995	-	
11	2006-01-29	39.76	1.87	Yes	Yes	984	-	
12	2007-01-21	45.32	4.19	Yes	No	991	R	
13	2007-01-22	46.50	6.49	Yes	No	1009	R	
14	2007-01-26	43.52	4.33	Yes	No	972	R	
15	2007-01-27	40.56	9.82	Yes	Yes	975	R	
16	2008-01-25	45.02	3.87	No	Yes	980	-R	
17	2008-01-31	46.05	4.95	No	No	991	R	
18	2009-01-07	51.40	8.81	No	No	977	R	
19	2009-01-16	42.00	4.53	Yes	Yes	992	-R	
20	2010-01-08	45.22	15.72	No	Yes	1001	-	
21	2010-01-29	45.98	6.25	No	Yes	975	R	
22	2010-01-30	46.10	3.94	Yes		978	R	
23	2011-01-13	44.96	3.97	Yes	No	1005	R	
24	2011-01-29	43.92	3.21	Yes	Yes	989	-	
25	2010-01-30	45.82	6.29	No	Yes	985	-	

Summary

- PL – small, intense, short-lived martime cyclones that are hard to predict
- Majority of the conditions are fulfilled
- Quanticification of conditions can't reach the importance of a single one for a PL formation.

Check:

- Layering of and combination of conditions

Thank you for your attention!