Characteristics and Genesis Conditions of Polar Lows in between 2000-2012: Microwave satellites, Arctic System Reanalysis and Radiative Transfer Simulations

A. Radovan[1], S. Crewell[1], E. M. Knudsen[1], M. Mech[1], A. Rinke[2]

[1]Institute of Geophysics and Meteorology, University of Cologne, [2]Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research

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Research Questions

RQ1. Is the Arctic System Reanalysis (ASR) able to represent polar lows (PLs) and their precipitation signature?

RQ2. Can we identify thresholds in environmental conditions or combinations of them that are required for PL formation?

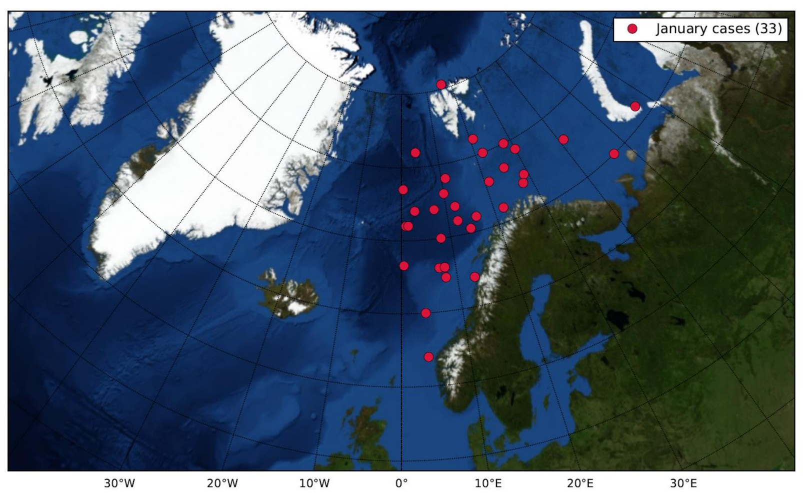


Fig. 1: Distribution of January polar low cases (blue dots) between 2000-2012 using list of polar lows from Noer and Lien, 2010 [1]

Tools & Methods

<u>**ASR v1**</u> – **A**rctic **S**ystem **R**eanalysis version 1 with 30 km spatial resolution and 29 vertical levels that has best estimate of atmospheric state including precipitation[2]

<u>Analyse 200 km around genesis point and time using:</u>

Conditions	Threshold
SST –T(500 hPa)	> 43 K[3]
SST – T(2m)	~ 6 – 7 K[4]
Near surface wind speed	> 15 m/s[5]
RH (850 -950 hPa)	~ 82 % [4]
$\Delta MSLP_{mg}$	≥ 1 hPa[6]
Lapse rate (LR) below 850 hPa	Unstable[4]

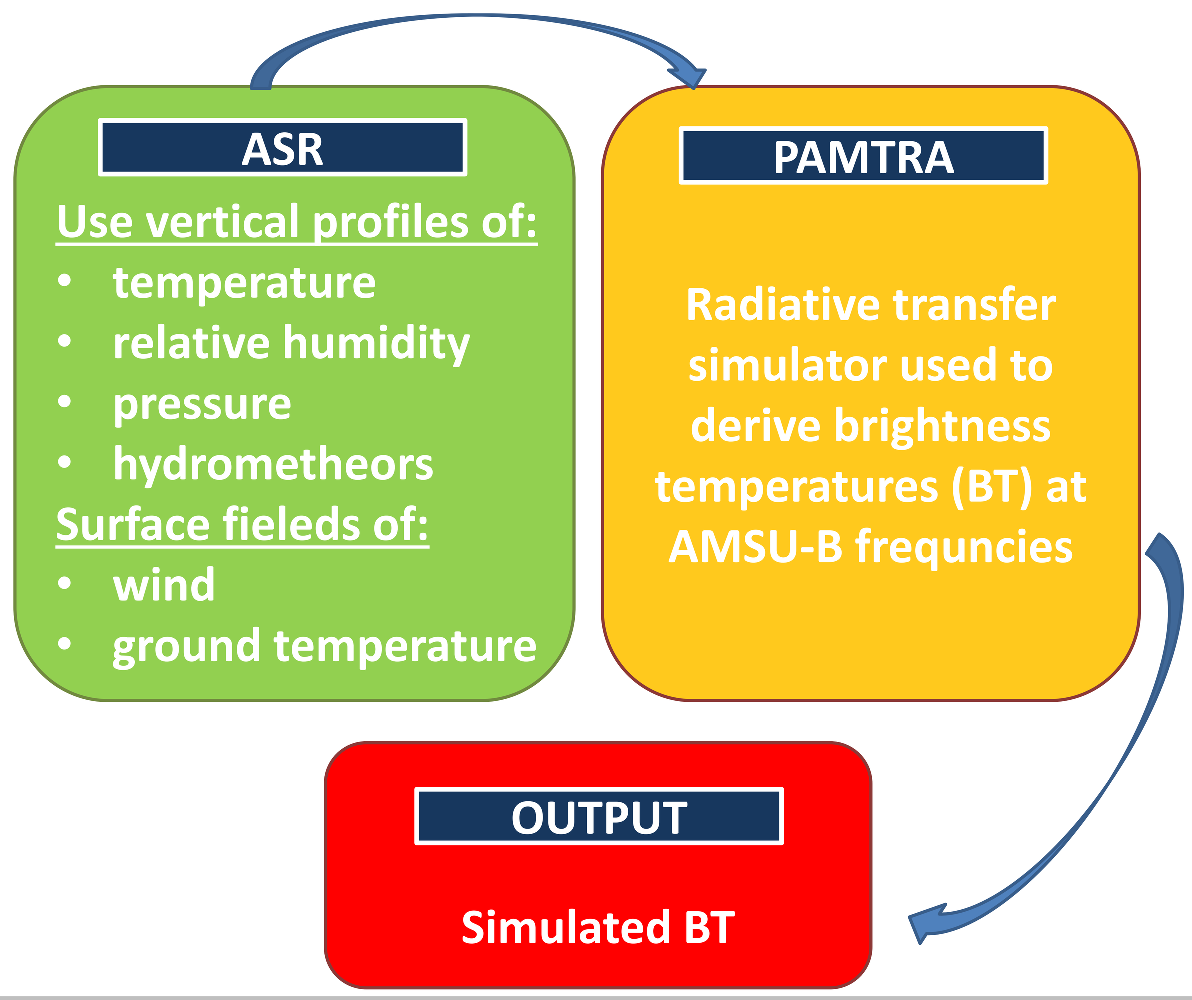
<u>**A**dvanced **M**icrowave **S**ounding **U**nit –**B (AMSU-B) and M**icrowave **H**umidity **S**ounder **(MHS)**</u>

- coverage of the Arctic (≅**10 times/day**) with 5 channels

2 window: 89 and 150 GHz (157 GHz MHS)

3 within strong water vapor line: 183.31 ± 1, 183.31 ±3, 183.31 ± 7 GHz (190 GHz MHS)

<u>**PAMTRA**</u> – **P**assive and **A**ctive **M**icrowave **R**adiative **TRA**nsfer that connects ASR to AMSU-B and is able to simulate the 1-800 GHz frequency range using scattering



Results

RQ1: Representation of PLs in AMSU-B and ASR

AMSU-B observations

- strong brightness temperature (BT) depression in precipitating ice cores
- BT difference to environment can reach more than 40 K

AMSU-B simulations using PAMTRA

- general structure of the PL from ASR is captured in the simulations
- BT signature difficult to see close to orography and sea ice due to emissivity change

ASR integrated values of PL

- general structure of the PL from ASR is visible in simulations

Possible reasons for the disagreement

- satellite has coarser resolution of the ASR (at nadir point doubled)
- parametrization of precipitation processes including assumptions of hydrometheor size and shape

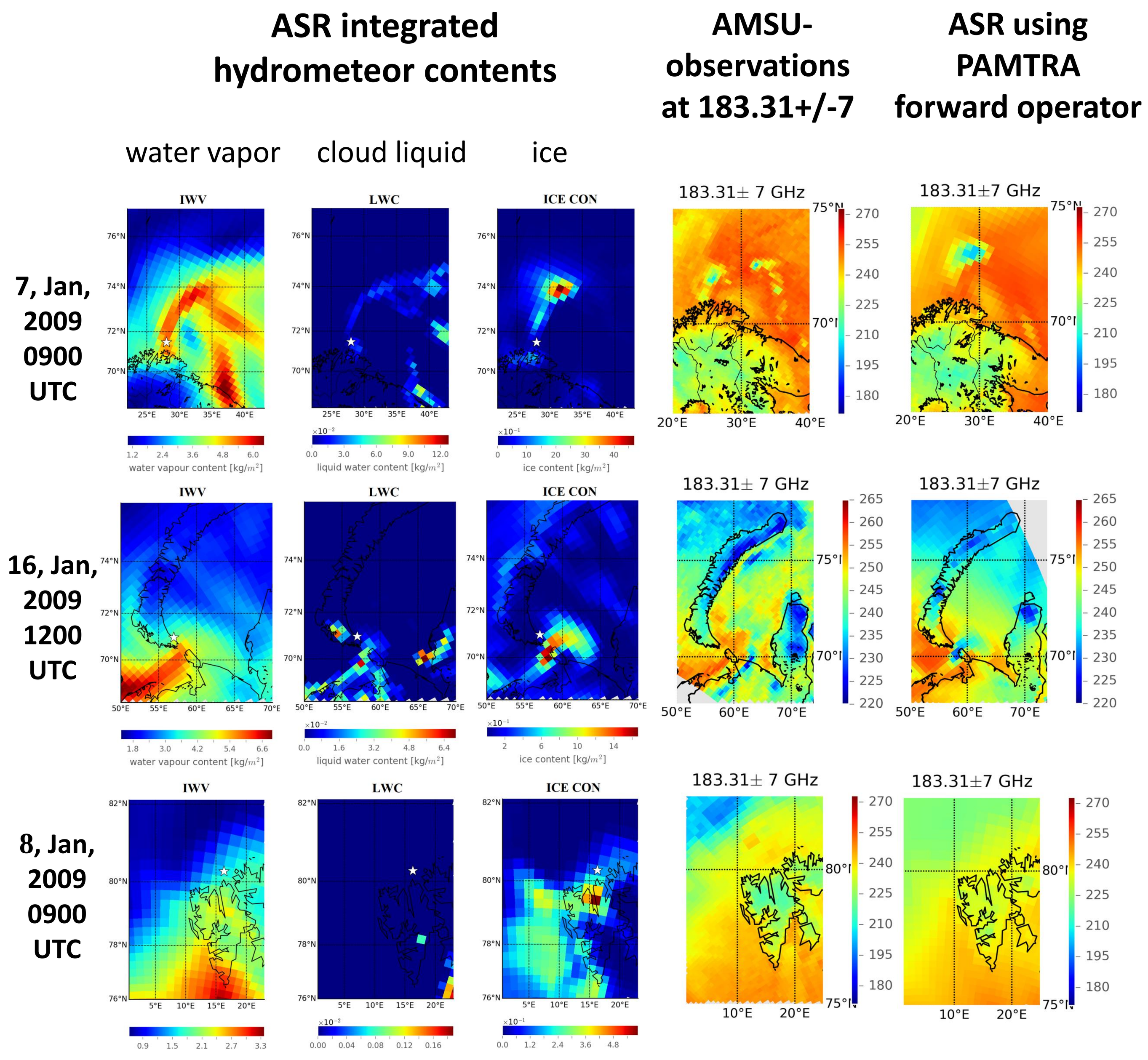


Fig. 2: PL case on 7th, Jan, 2009 (top), 16th, Jan, 2009 (middle) and 8th, Jan, 2010 (bottom). Integrated water vapour (IWV) (first column), liquid water content (LWC) (second column), ice content (ICE CON) (third column); AMSU-B observations at 183.31±7 GHz channel (fourth column), PAMTRA simulations at 183.31±7 GHz channels (fifth column).

RQ2: Environmental conditions from ASR

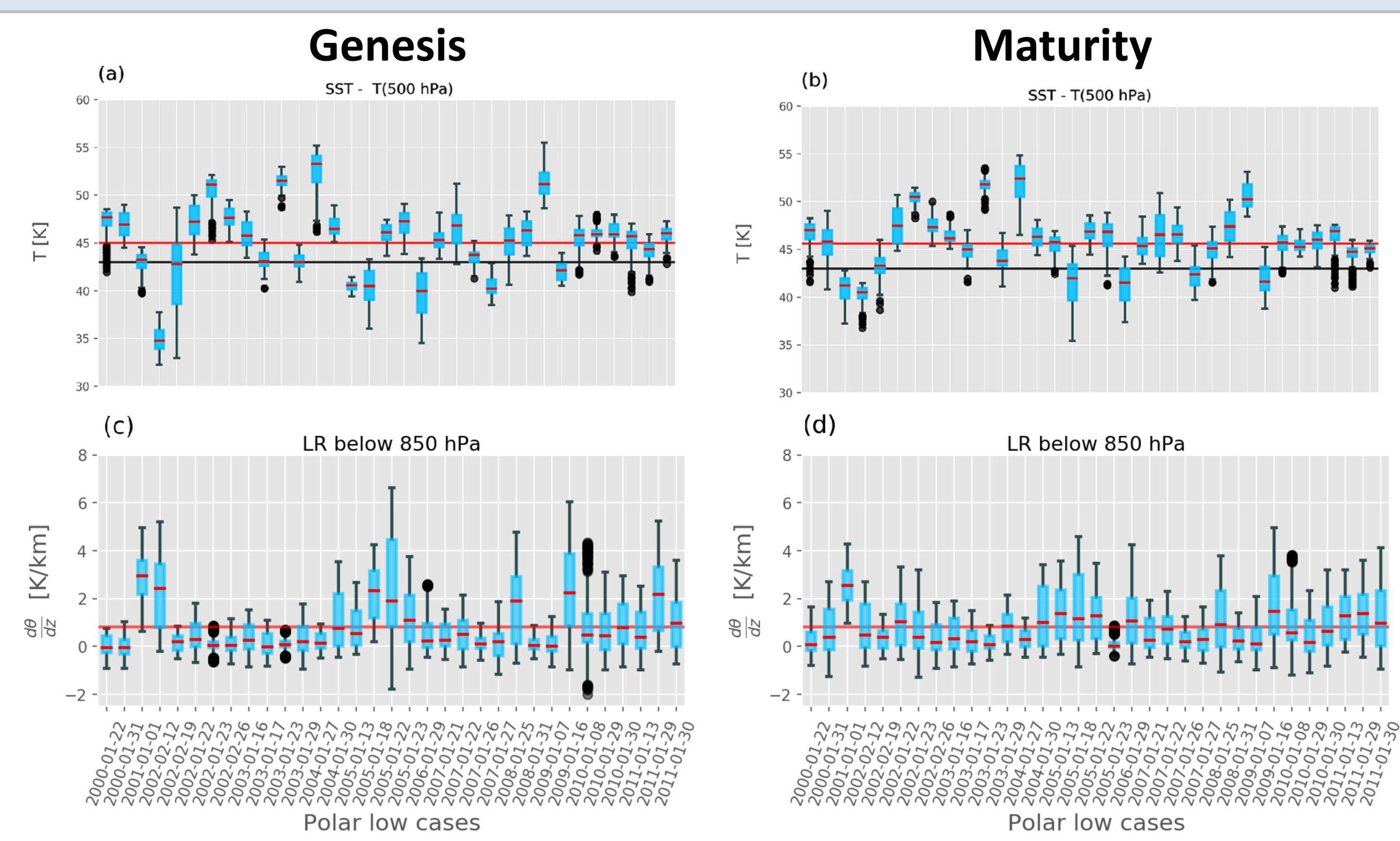


Fig. 3: Box-whisker representation (interquartile range in blue) of SST – T(500 hPa) (top) and lapse rate (LR) bellow 850 hPa (bottom) during genesis (left) and maturity stage (right) within a 220 km radius..

- for the majority of the cases the SST – T(500 hPa) threshold of 43 K is reached (Fig 3).
- cases with stronger static stability show stronger and steeper lapse rates: → convection acts as driving mechanism

- higher amount of boundary layer rel. humidity during genesis stage (Fig. 4)
- more intense winds and lower MSLP at maturity stage
- boundary layer RH during PL days over region (Fig. 5) increased compared to January climatology

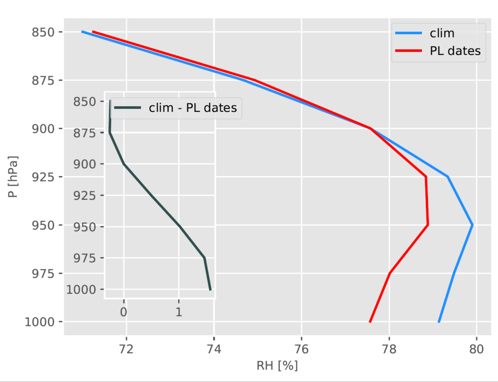


Fig. 5: RH profile for climatology (blue) and PL dates (red) over the whole region of investigation. Inserted figure is the difference between the two.

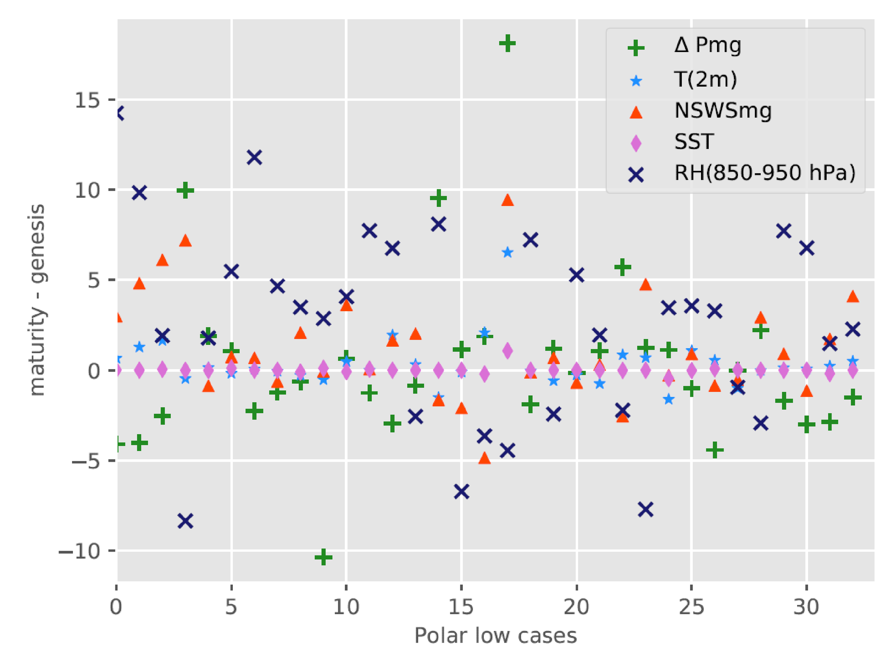


Fig. 4: Difference between genesis and maturity stage next variables: MSLP difference (+), temperature at 2 m (*), near-surface wind speed (NSWSmg ▲), SST (♦), and RH in the layer between 850 and 950 hPa (x).

Conclusions and next steps

- investigate the role of moisture intrusions or atmospheric rivers prior to a PL event
- analyze precipitation produced by PL

RQ1: • ASR transformed into observation space using forward simulator reproduces PL as detected by satellite measurements; validation technique difficult close to sea ice and orography

RQ2: • environmental conditions reveal the relative importance of thermal instability and convection for PL genesis; find the amount of precipitation brought by PL when making landfall

Acknowledgements

This work was supported by Transregional Collaborative Research Center TR172 "ArctiC Amplification: Climate Relevant Atmospheric and SurfaCe Processes, and Feedback Mechanisms (AC)³" funded by the German Research Foundation (DFG).

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Correspondence to: aradovan@uni-koeln.de