Investigation of Januarys Polar Low genesis conditions over the North Atlantic using satellite, reanalysis and model data for the period between 2003 and 2011

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Introduction

Polar lows (PLs) are high latitude maritime cyclones whose characteristics are:

- small diameter (< 600 km)
- strong winds (> 15 m/s)
- short life time (can be only 3h)

These cyclones bring large amounts of precipitation that combined with strong winds cause great damage to coastal communities but are still hard to predict.

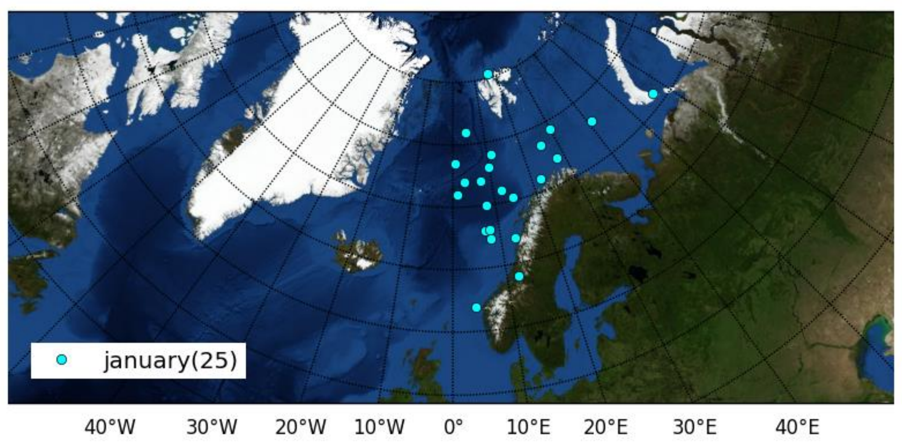


Fig. 1: *January polar low cases (blue dots) between 2003-2011 using list of polar lows from Noer and Lien, 2010 [1]*

Summary

AMSU-B observations – able to detect PL with strongly precipitating clouds at 183.31±1, ±3, ± 7 GHz frequencies

AMSU-B simulations – able to represent PL and strongly precipitating clouds

ASR genesis conditions – RH of ≈85 % at ≈1 km, LR –strong surface inversion, $T_{surf} - T_{500hPa}$ usually > 40 K

Motivation

The **AMSU –B** (**A**dvanced **M**icrowave **S**ounding **U**nit –**B**) and the **MHS** (**M**icrowave **H**umidity **S**ounder) onboard NOAA KLM and MetOp satellites, respectively offer an excellent coverage of the Arctic (≅**10 times/day**).

We use satellite measurements together with atmospheric reanalysis [2] to better understand PLs and to answer the following questions:

1. Can we detect the occurrence of PLs from microwave satellite observations?
2. Is atmospheric reanalysis able to represent the precipitation signature of PLs?
3. What are the conditions necessary for the genesis of PLs?

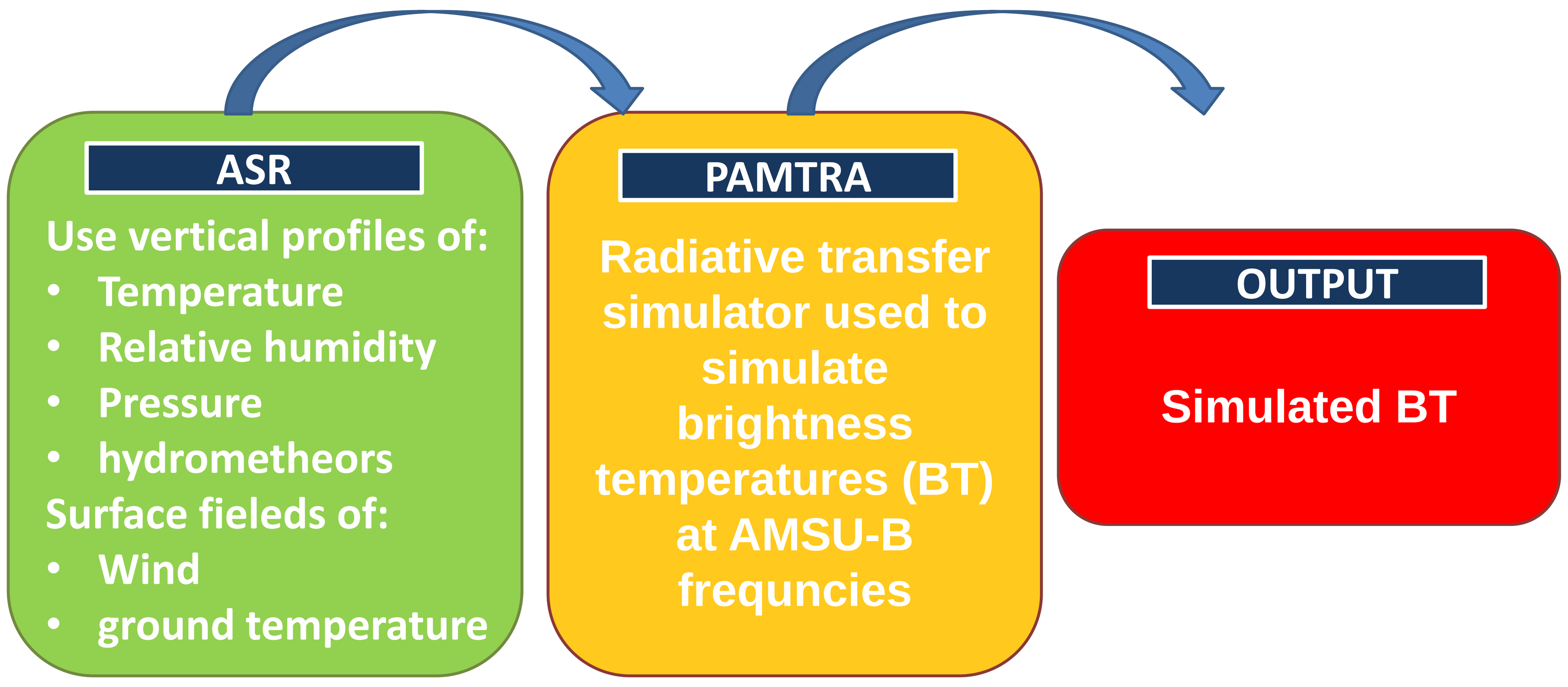
Tools & Methods

AMSU-B/MHS — 5 channels

2 window: 89 and 150 GHz (157 GHz MHS) **and** **3 around strong water vapor line:** 183.31 ± 1, 183.31 ±3, 183.31 ± 7 GHz (190 GHz MHS)

ASR v1 – **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

PAMTRA – **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



Convective cores calculated as in Melsheimer et al., 2015 [3] using Hong et al., 2009 algorithm [4]:

$\Delta T_{1,3} = T_{B,183.31\pm1} - T_{B,183\pm3}$,

$\Delta T_{1,7} = T_{B,183.31\pm1} - T_{B,183\pm7}$,

$\Delta T_{3,7} = T_{B,183.31\pm3} - T_{B,183\pm7}$,

$\Delta T_{1,3} > 0 \quad \Delta T_{1,7} > 0 \quad \Delta T_{3,7} > 0$

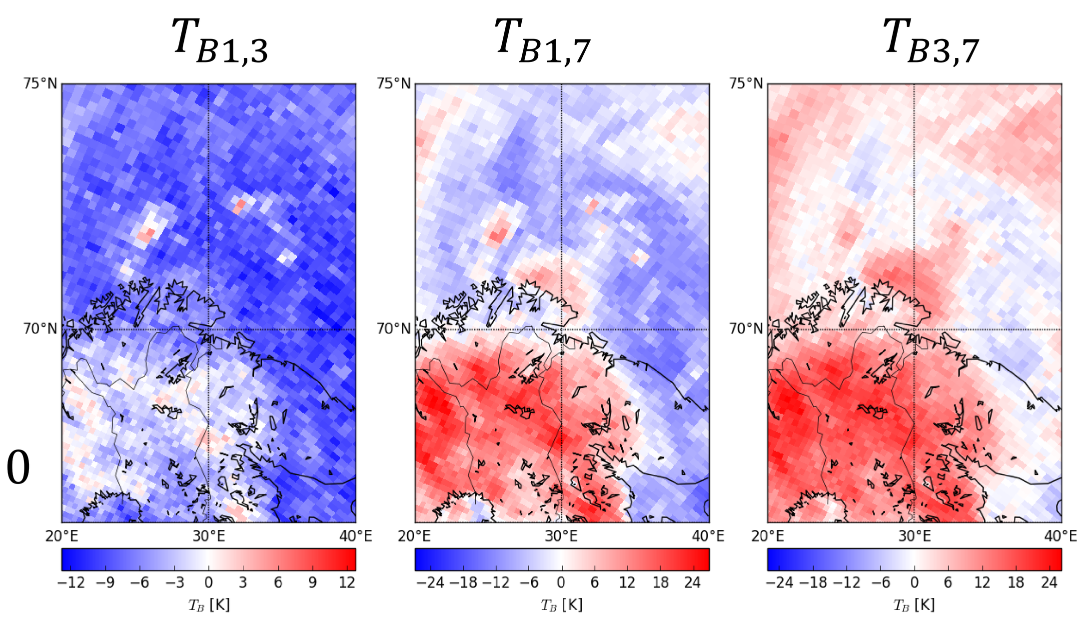


Fig 2: *Difference between: 183.31±1 GHz and 183.31±3 GHz (left), 183.31±1 and 183.31±7 GHz (middle) and 183.31 ± 3 and 183.31± 7 GHz (right) channels.*

Results

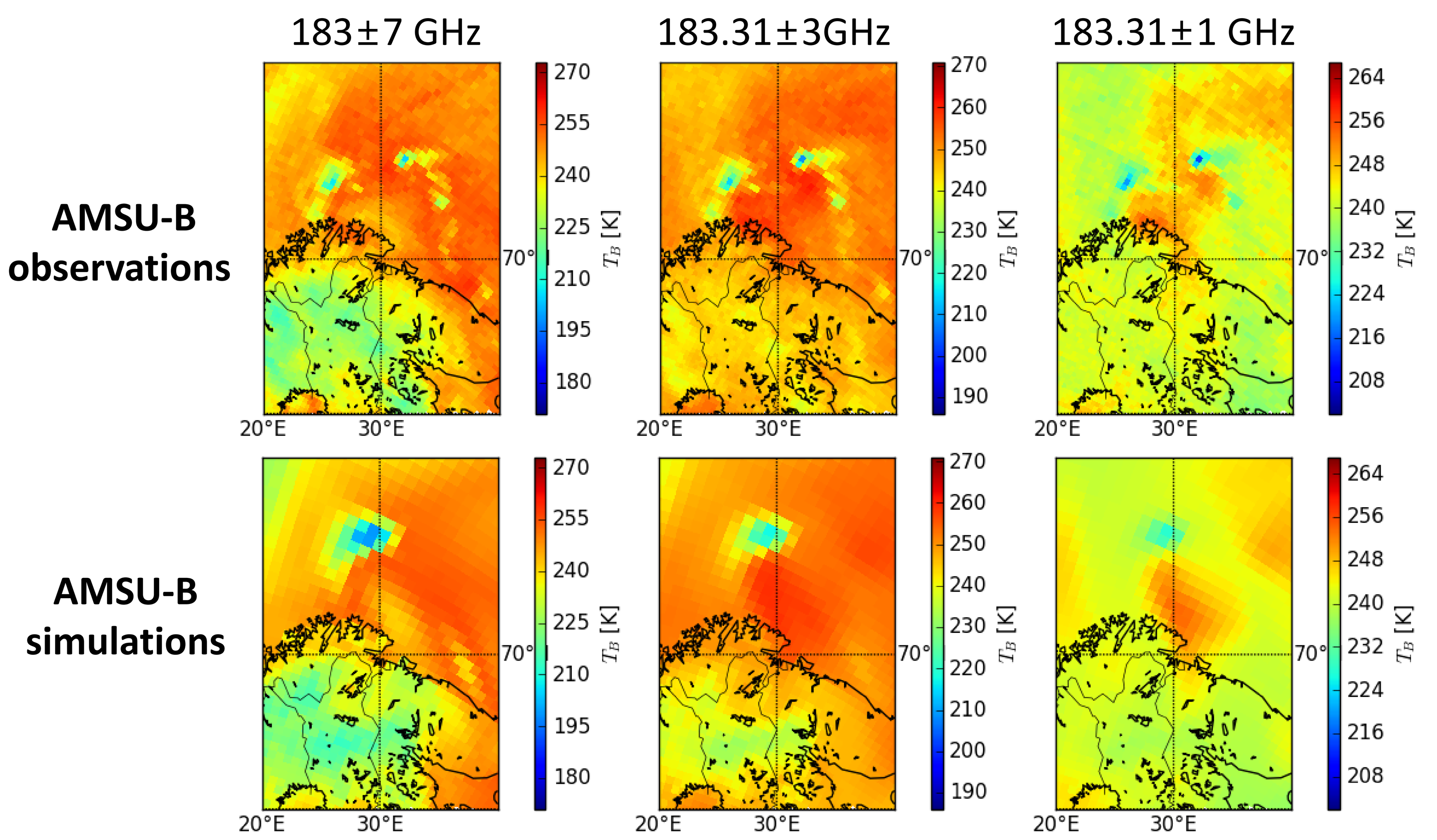


Fig 3*: PL case on 7th, Jan, 2009 at 09:17UTC for 183.31±7 (left), 183.31±3 (middle) and 183.31±1 GHz (right) channels from AMSU-B observations (upper panel) and PAMTRA simulations (lower panel)*

AMSU-B observations	AMSU-B simulations
strong BT depression in the cloud bands around lows at 183.31 GHz channels	general structure of the PL
183.31±7 GHz channel - largest difference between cloud and PL core at times reaching more than 40 K	able to represent precipitating clouds

Possible reason for the disagreement:

- coarser resolution of the ASR (at nadir point being double)
- ASR's parameterization of precipitation processes and the description of hydrometheors in terms of size and density

ASR - PL genesis conditions

- **RH**: max of ≈85 % at ≈1 km
- **Wind speed** ~ 7 m/s close to surface, with steady increase above2 km
- **LR** – strong surface inversion
- T_{surf} and T_{500hPa} difference usually greater than 40 K

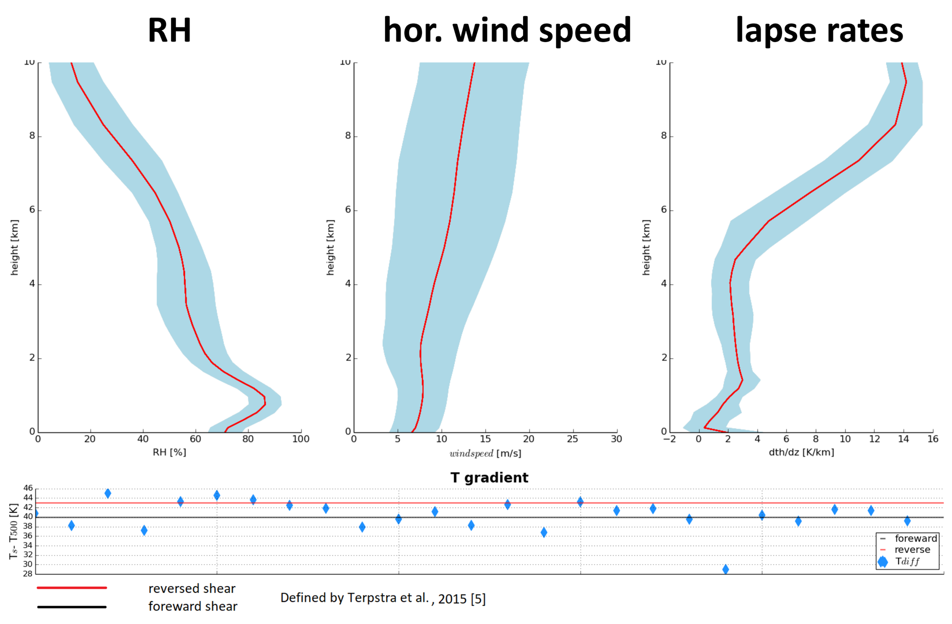


Fig 4 *Mean vertical profiles of RH, wind speed and lapse rates for a 200 km radius around genesis point at genesis time (list of PLs [1]) for all 25 January cases. Red is the mean of all 25 cases and light blue shaded area is the one standard deviation.*

Next step

- extend study for the entire PL season (October-May)
- find the amount of precipitation brought by PL when making landfall using the disappearance of the convective cores
- use the HIRHAM5 regional model with 15 km resolution to simulate the PL cases

Acknowledgements

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