Detection of North Atlantic Polar Lows in Climate Mode Simulations

Matthias Zahn[1,2], Hans v. Storch[1,2], Stephan Bakan[3]

(1) University Hamburg, Meteorological Institute, Germany
(2) GKSS Research Centre, Institute for Coastal Research, Germany
(3) Max-Planck-Institut für Meteorologie (MPI-M), Germany

CONCLUSIONS

- Polar Low cases **can reasonably** be simulated in climate mode (i.e., independent of intial conditions), if the regional climate model is large-scale-constrained with global re-analyses. Though comparison with observational data reveals differences in detail.
- Without nudging the large scale, the formation of Polar Lows is subject to considerable ensemble variability.
- Spatial digital **bandpass filters** applied to LAM output fields represent a simple method to automatically identify and **track meso-scale** disturbances.
- In a two year long simulation, an application of an automatic detection algorithm based on the bandpass filtered mslp fields indicates a **reasonable spatial and temporal distribution** of Polar Low occurrences.
- As in the simulated cases, **higher variability** emerges, if **no** large scale constraints are applied

INTRODUCTION

Polar lows are mesoscale sized, gale producing maritime ground level storms in subpolar regions , which can be of hazardous impact on human ofshore activities. Due to their scale, polar lows are not properly resolved in global reanalysis data. In this study, we

(1) investigated the quality of climate mode simulated Polar Lows in a LAM/RCM

(2) used the findings of point 1 to detect polar lows in longterm simulations

Model

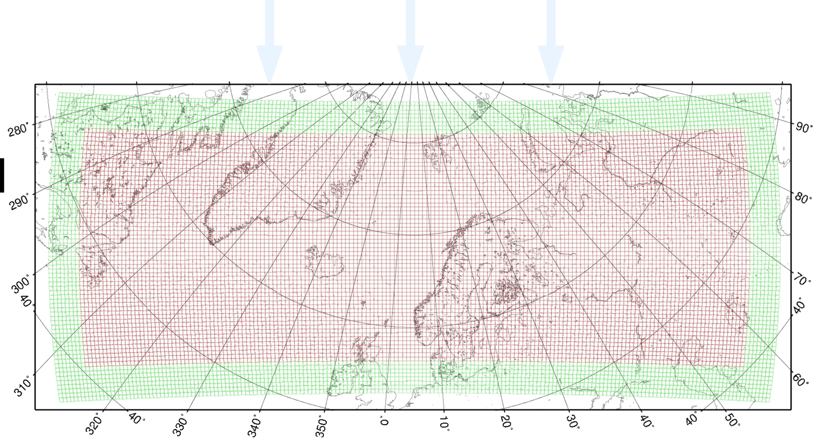
Used model: CLM
driven by NCEP/NCAR

Setup

run in **climate mode** as opposed to the usual forcast mode

- Simulations are only constrained at the lateral boundaries and by the SST (nn)
- Additionally the large scale conditions are enforced (sn, spectral nudging)

NCEP/NCAR



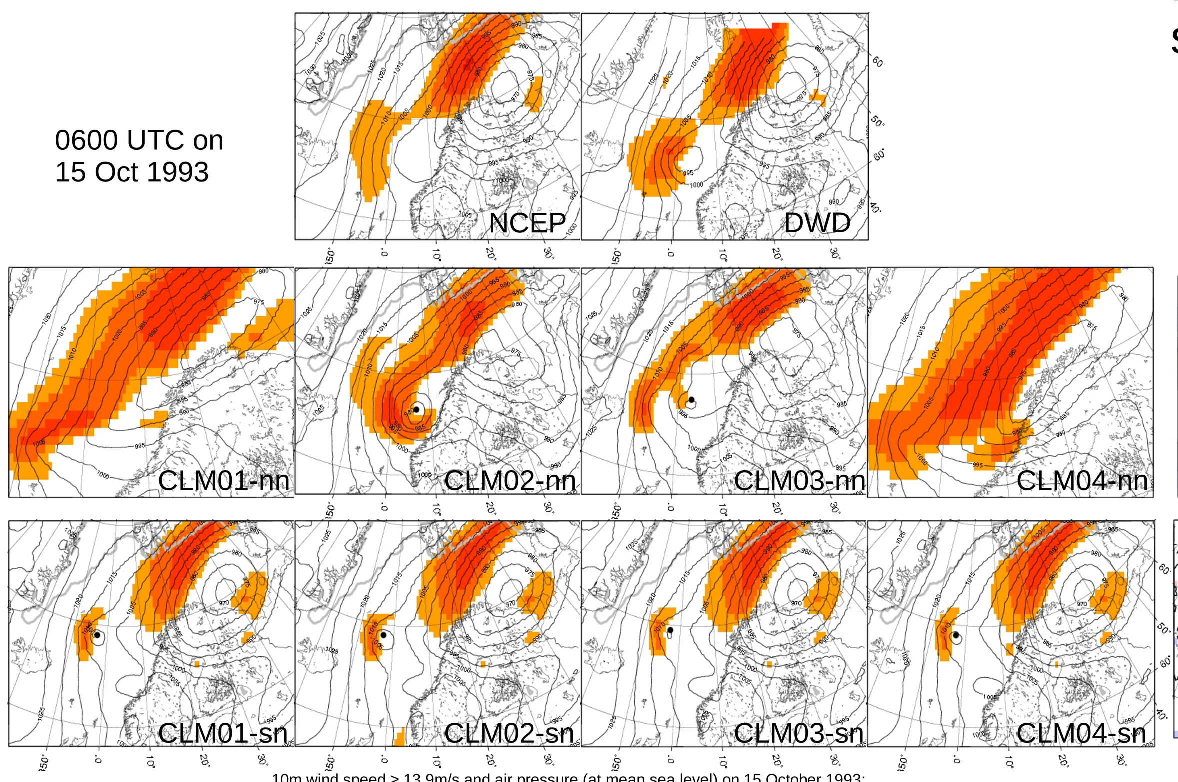
Simulation area used in this study

RESULTS (part 1/ simulated cases)

Case studies for three cases Oct 1993,Dec 1993,Jan 1998, 4x nn and 4x sn, respectively:

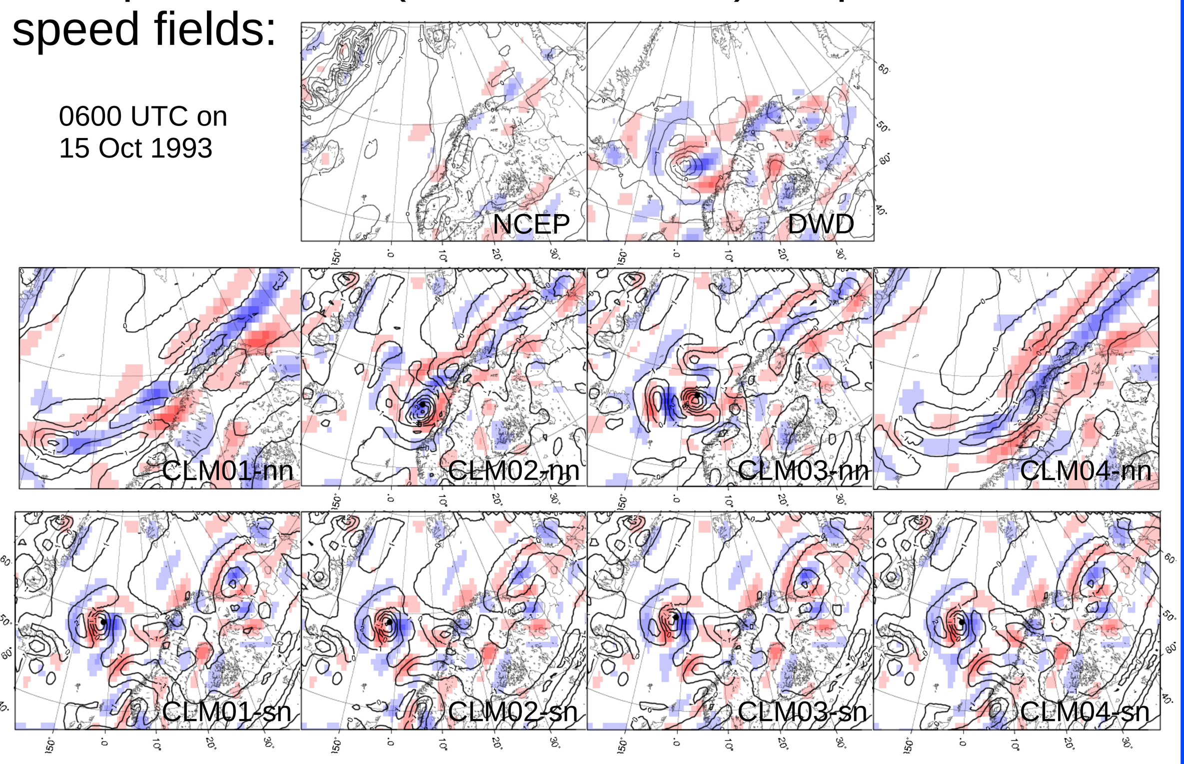
Simualated mature state polar low for Oct. 1993 case is shown to the left, in the other two cases, the polar develops in none of the nn simulations, but in all of the sn.
In the bandpass filtered mslp fields, the polar low becomes more distinctive.

MSLP and wind speed fields:



10m wind speed ≥ 13.9m/s and air pressure (at mean sea level) on 15 October 1993: NCEP/NCAR analysis after interpolation onto the CLM grid, 0600 UTC, DWD analysis data, 0600 UTC, CLM ensemble run without (nn) and with(sn) spectral nudging , 0900 UTC

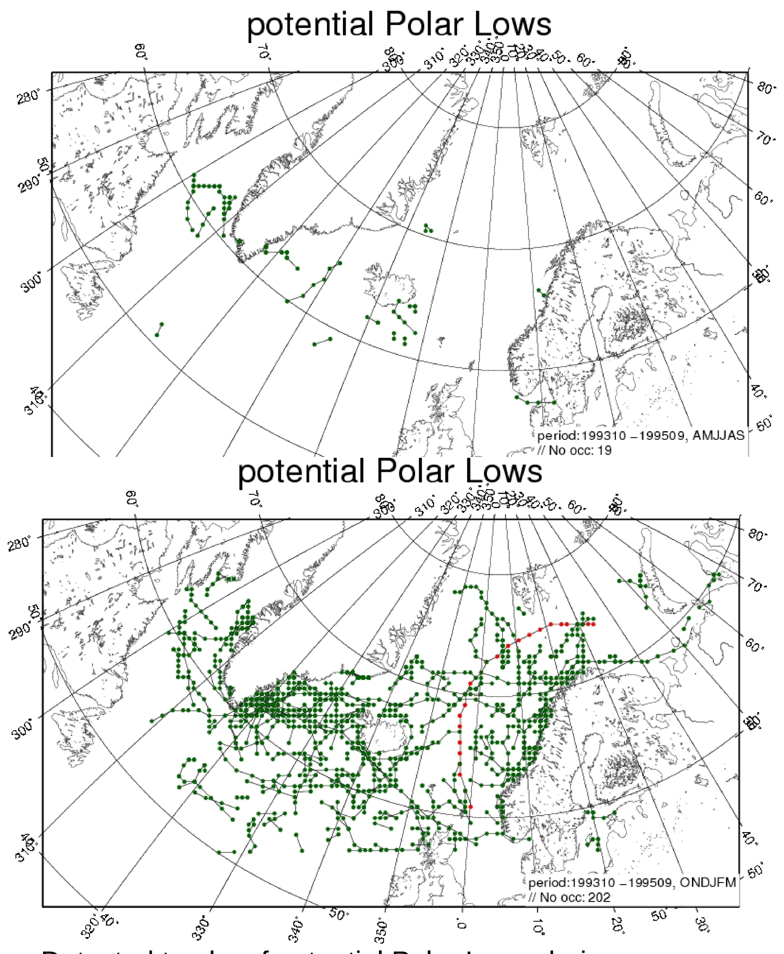
Bandpass filtered (~230km-450km) mslp and wind speed fields:



Band-pass filtered mslp (isolines; hPa) and 10m wind speed anomalies, NCEP/NCAR analysis after interpolation onto the CLM grid, 0600 UTC, DWD analysis data, 0600 UTC, CLM ensemble run without and with spectral nudging, 0900 UTC. Black dots indicate the positions of the polar low's pressure minimum in the respective untreated field of the ensemble run.

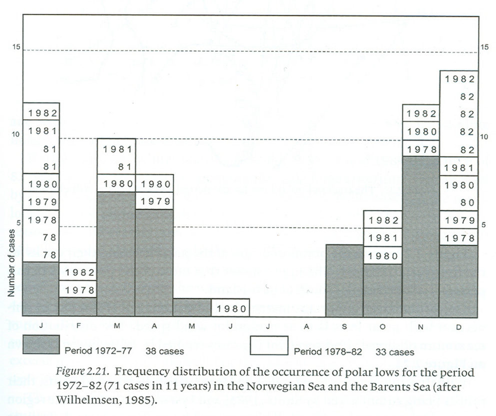
RESULTS (part 2/ long term application)

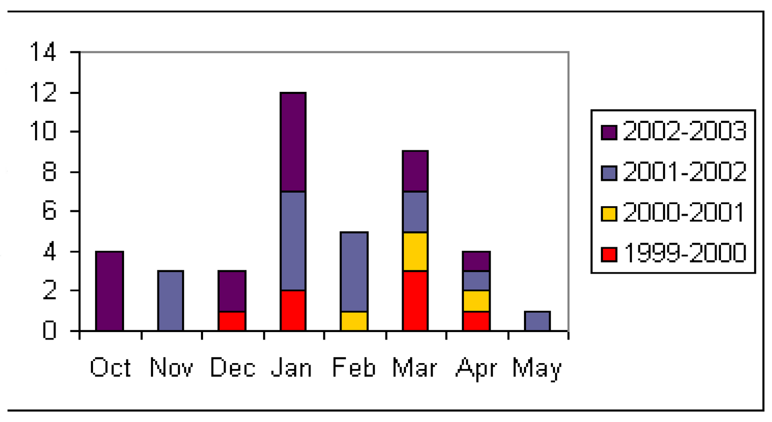
Based on the bandpass filtered mslp fields, a detection algotithm (see lower right corner) for Polar Lows was developed. This algorithm was applied to two year long simulations (2x sn and 2x nn). Results are shown here.



Detected tracks of potential Polar Lows during summer (AMJJAS, top) and winter months (ONDJFM, bottom) . Simulation period from Oct. 1993 - Sep.1995)

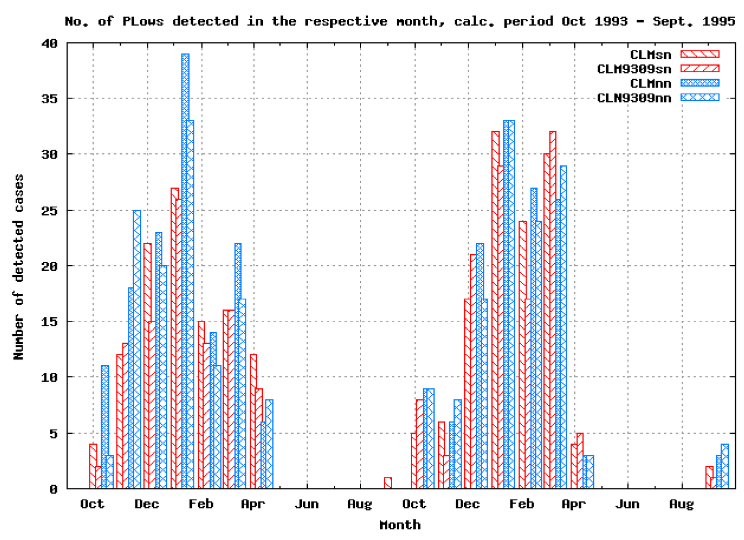
Reasonable distribution of Polar Lows, which preferably occur during the winter months.



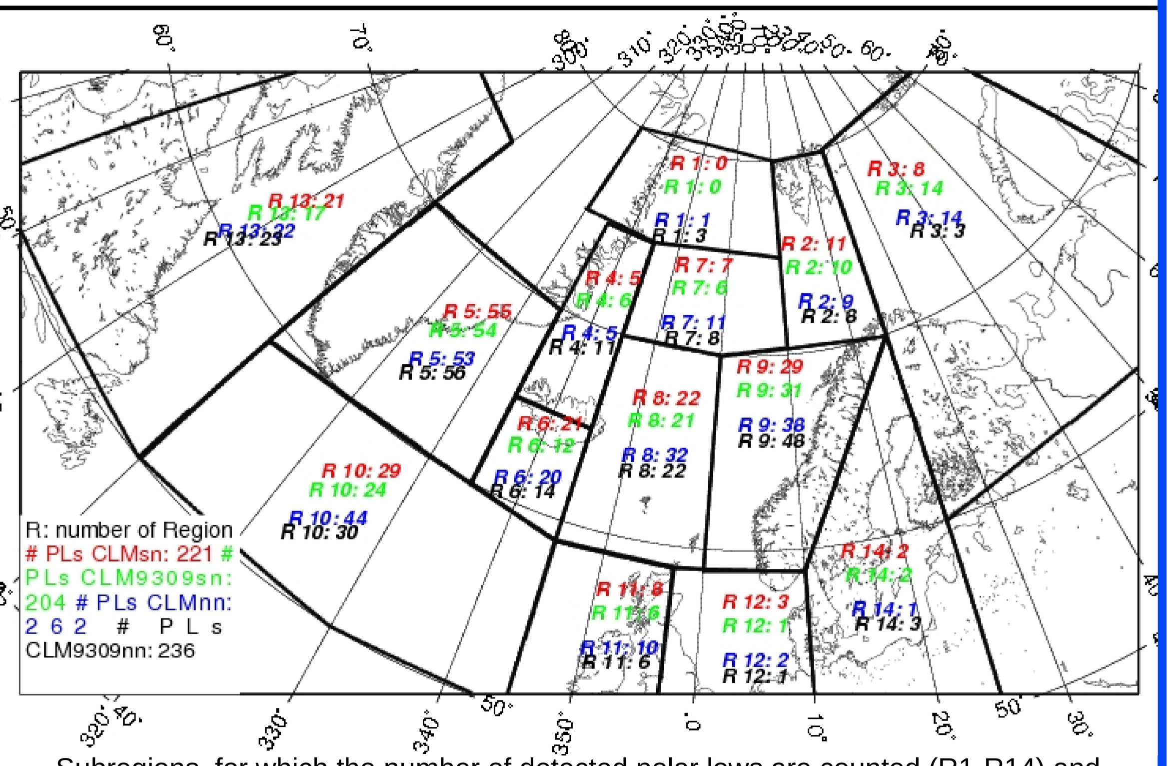


Top: Monthly Frequency distributions as observed by Wilhelmsen (taken from Rasmussen (2003))(left) or Noer and Ovhed (2003) (right)

Left: Detected Number of detected Polar Lows in the respecticve simulations from Oct. 1993 - Sep. 1995



Maxima in January and March are consistent with observations, higher variability emerges in the non nudged simulations.



Subregions, for which the number of detected polar lows are counted (R1-R14) and respective number of detected mature state polar lows Simulation period from Oct. 1993 - Sep.1995)

The detection algorithm work in three steps:
1[st] bandpass filtered mslp minima (<-1hPa) are located
2[nd] positions are merged to individual tracks
3[rd] further conditions are requested along the individual tracks:

1. minimum in the filtered mslp field
2. wind speed >= 13,5 m/s
3. no synoptic low
4. a local minimum or trough in the untreated mslp field
5. atmospheric instability (decreasing vertical potential temperature between sea level and 700 hPa)

Further reading:

Zahn, M., H. von Storch, and S. Bakan, 2008: Climate mode simulation of North Atlantic Polar Lows in a limited area model, submitted
Zahn, M., and H. von Storch, 2008: Climatological differences of reproduced North Atlantic Polar Lows in long term simulations with CLM, submitted
see:"http://coast.gkss.de/staff/zahn/" or "http://coast.gkss.de/staff/storch/"

Acknowledgements: This work was conducted within the Virtual Institute (VI) EXTROP which is promoted by the "Initiative and Networking Fund" of the Helmholtz Association.