SPECIAL PROJECT FINAL REPORT

All the following mandatory information needs to be provided.

Project Title:	Investigations of polar lows using AROME Arctic
Computer Project Account:	SPNOGRAV
Start Year - End Year :	2017 - 2018
Principal Investigator(s)	Patrick Stoll, Rune Graversen
Affiliation/Address:	University of Tromsø (UiT) Department of Physics and Technology (IFT) Postboks 6050 Langnes 9037 Tromsø
Other Researchers (Name/Affiliation):	

The following should cover the entire project duration.

Summary of project objectives

(10 lines max)

This project is divided into two work packages (WPs):

1) the downscaling of polar low cases to derive a polar low climatology and

2) the investigation of physical mechanisms important for polar low development.

Summary of problems encountered

(If you encountered any problems of a more technical nature, please describe them here.)

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Experience with the Special Project framework

(Please let us know about your experience with administrative aspects like the application procedure, progress reporting etc.)

We have been fully satisfied with the ECMWF facilities.

Summary of results

(This section should comprise up to 10 pages, reflecting the complexity and duration of the project, and can be replaced by a short summary plus an existing scientific report on the project.)

The two WPs mentioned above have each led to two publications indicated below. Here follows abstract from each of the publications:

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Stoll, P., R. G. Graversen, G. Noer, and K. Hodges: An objective global climatology of polar lows based on reanalysis data. Q. J. R. Meteo. S., 144, 2099-2117 (2018)

Abstract: Here we present an objective global climatology of polar lows. In order to obtain objective detection criteria, the efficacy of several parameters for separating polar lows from other cyclones has been compared. The comparison and the climatology are based on the ERA-Interim reanalysis from 1979 to 2016 and the high-resolution Arctic System Reanalysis from 2000 to 2012. The most effective parameters in separating polar lows from other extratropical cyclones were found to be the difference between the sea-level pressure at the centre of the low and its surroundings, the difference in the potential temperature between the sea surface and the 500 hPa level, and the tropopause wind speed poleward of the system. Other parameters often used to identify polar lows, such as the 10 m wind speed and the temperature difference between the sea surface and the 700 hPa level, were found to be less effective. The climatologies reveal that polar lows occur in all marine basins at high latitudes, but with high occurrence density in the vicinity of the sea-ice edge and coastal zones. The regions showing the highest degree of polar-low activity are the Denmark Strait and the Nordic Seas, especially for the most intense polar lows. In the North

Atlantic and Pacific, the main polar-low season ranges from November to March. In the Southern Hemisphere, polar lows are mainly detected between 50 and 65°S from April to October, indicating that this hemisphere compared to its northern counterpart has a two months longer, but less intense, polar-low season. No significant hemispheric long-term trends are observed, although some regions, such as the Denmark Strait and the Nordic Seas, experience significant downward and upward trends in polar lows, respectively, over the last decades. For intense polar lows, a significant declining trend has been observed for the Northern Hemisphere. © 2018 Royal Meteorological Society

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Stoll, P., T. Valkonen, R. G. Graversen, and G. Noer: A polar low analysed with the convection-permitting weather forecasting model AROME-Arctic. Q. J. R. Meteo. S., In review

Abstract: In this study the capability of the weather-prediction model AROME-Arctic for simulating a well-observed polar low is investigated. This polar low developed on 3-4 March 2008 and was measured by dropsondes released from three flights during the IPY-THORPEX campaign. Validation against these dropsondes and satellite images reveal high quality, but also weaknesses, of the forecasting model. The model captures a realistic cloud structure, but seems to overestimate convection and underestimate the strength of the capping inversion on top of the cold-air outbreak. A comparison of the AROME-Arctic simulation to the ECMWF operational forecast model, and the reanalyses datasets ERA-Interim, ERA-5 and ASR, shows that differences in terms of intensity and position of the polar low are surprisingly small among the data sets, but that the local variability is more realistically presented in AROME-Arctic. However, error statistics, derived from comparisons to the dropsondes, do not improve for AROME-Arctic as compared to the other model products. Also, AROME-Arctic seems to deviate more from reality for forecast lead times longer than 24 hours than the ECMWF operational forecast. The polar low is observed to have two phases, an initial baroclinic and a mature convective phase. Sensitivity experiments performed with AROME-Arctic reveal that sensible heat fluxes and condensational heat release are fundamental for the development of the baroclinicity in the initial phase. In the mature phase the baroclinicity decreases and latent heat release seem to maintain the polar low. At this stage, less than half of the moisture is locally produced. The mature phase only develops if the polar low has a sufficient intensity and enough moisture for consumption. It is also found that the intensity of the PL increases non-linearly for incrementally increased sea-surface temperatures.

List of publications/reports from the project with complete references

Stoll, P., R. G. Graversen, G. Noer, and K. Hodges: An objective global climatology of polar lows based on reanalysis data. Q. J. R. Meteo. S., 144, 2099-2117 (2018)

Stoll, P., T. Valkonen, R. G. Graversen, and G. Noer: A polar low analysed with the convection-permitting weather forecasting model AROME-Arctic. Q. J. R. Meteo. S., In review

Future plans