SPECIAL PROJECT PROGRESS REPORT

Progress Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year 2017

Project Title: Investigations of polar lows using AROME Arctic

Computer Project Account: SPNOGRAV

Principal Investigator(s): Patrick Stoll, Rune Graversen

Affiliation: University of Tromsø

Name of ECMWF scientist(s) collaborating to the project (if applicable) ……

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Start date of the project: November 2016

Expected end date: December 2018

Computer resources allocated/used for the current year and the previous one (if applicable)
Please answer for all project resources

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	400000	36203	4000000	0
Data storage capacity	(Gbytes)	3000	133	3000	133

Summary of project objectives

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.

At this stage the focus is on WP1: Polar lows are mesoscale cyclones being only poorly resolved in global reanalysis as ERA-interim. For a more realistic representation of the polar lows downscaling is necessary. The aim is to derive an improved objective climatology of polar low cases. The climatology will include a classification into different polar low types, based on the governing processes. AROME-Arctic, which is installed at ECMWF, will be used to investigate categories defined in WP1. The model will also be applied for sensibility experiments and idealized cases in WP2 in order to investigate different physical mechanisms important for polar low development.

Summary of problems encountered

AROME-Arctic is a high resolution regional weather forecasting model set-up by the Norwegian meteorological institute for the North Atlantic Arctic. It is considered to be one of the best models for simulations in the Arctic.

AROME-Arctic uses boundary data from the ECMWF IFS which are continuously updated when it comes to the model itself and the assimilation system. This is not appropriate when using the model to derive a time consistent climatology over several years. It was therefore attempted to use ERA-interim as boundary data for AROME-Arctic since the ERA-interim model and assimilation system are kept fixed. However the ERA-interim boundary data turned out to be of insufficient accuracy in terms of resolution for downscaling of polar lows.

After downscaling two recent polar low cases with AROME-Arctic in the end of last year, we decided to use the time-consistent data set of ERA-interim and the Arctic System Reanalysis (ASR) for the development of a polar low climatology. Hence we did not need ECMWF computing resources for this in spring. However, we will use such resources from autumn when studying different polar low categories and for WP2 for investigating physical mechanisms important for polar low development.

Summary of results of the current year

In this section the development of time consistent and objective polar low climatologies is described.

ERA-interim is used for the creation of a polar low climatology covering the whole spatial and temporal extend of the datasets. ERA-interim is a global reanalysis with a resolution of about 80 km starting from 1979 and going until present. Data until 2016 is used. Due to the short-lived nature of polar lows the 6-hourly fields from the ERA-interim analysis are filled up by the ERA-interim forecast to obtain 3-hourly sampling.

In the following the method applied for creation of the climatologies is described:
The 850hPa relative vorticity from ERA-interim is filtered by spectral wavenumbers smaller than 40 and larger than 100, to identify mesoscale systems (200-500km). Filtered local vorticity maxima are tracked in time by applying constraints on track smoothness and speed. The set of the detected features are in the following referred to as TRACK cyclones. The STARS dataset version 2 provides a list of polar low tracks over the Nordic Seas from January 2001 to March 2011. They were subjectively identified by forecasters at the Norwegian meteorological institute. STARS is the polar low list is considered as one of the best and most frequently used lists of subjectively identified polar lows. An algorithm was developed to identify the TRACK cyclones matching with a polar low from STARS. These are in the following called STARS polar lows.

Criteria for the distinguishing STARS polar lows and other TRACK cyclones are developed. After the inspection of different variables, the most efficient set of criteria to identify a cyclone as a polar low is, if one point in time during the cyclone satisfy the following:
- occurrence over open water
- vorticity filtered by T40-T100 larger than 5.5 * 10^-5 1/s
- a potential temperature difference between the sea surface and the 500 hPa level bigger than -11.9 K
- wind speed at the tropopause, defined by the 2 PVU level not higher than 30.5 m/s north of the cyclone.

By applying these criteria 0.8% of the TRACK cyclones poleward of 30 degree latitude were classified as polar lows. They are giving a global climatology of polar low cases for the time period from 1979 to 2016. The climatology gives us the opportunity to investigate a large number of polar lows not listed in the STARS database. The climatology also allows to apply polar low classification to distinguish between different types of polar lows.

Composite analysis of different types of polar lows and non-polar lows will be applied to investigate differences. Polar low downscaling with AROME-Arctic as originally intended for WP1 can be applied to derive higher resolved composite fields. Based on the climatology it is possible to select representative polar lows for different categories for the sensitivity experiments in WP2

The derivation of a comparable climatology with the Arctic System Reanalysis (ASR) is in advanced progress. The used ASR version 2 is a regional reanalysis of the Arctic (> 50N) based on the NCAR Weather Research and Forecasting Model WRF with a resolution of 15 km going from 2000 to 2012. It includes an own data assimilation system and the output contains fields in 3 hourly resolution. Several studies investigated an improved polar low representation in ASR compared to ERA-interim. The ASR polar low climatology is therefore expected to be advanced in comparison to the ERA-interim polar low climatology.

List of publications/reports from the project with complete references

Poster “Polar Low Dynamics” at the CIRFA Annual Conference in September 2016

Summary of plans for the continuation of the project

The derivation of the polar low climatologies is almost finished. The ERA-interim and ASR climatologies are giving us the possibility to objectively select the most interesting cases out of a large dataset. Classification based on the climatologies allows for investigation of different polar types and for comparison between the classes. Downscaling with AROME-Arctic will be performed to apply composite analysis of the different polar lows types. In WP2 the most interesting cases will be used for sensitivity experiments of the underlying physical mechanisms.