A multi-decadal climatology of North Pacific Polar Lows Employing Dynamical Downscaling

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The North Pacific is an area where frequently sub-synoptic Polar Lows form in the winter season, especially over the Japan Sea, Bering Sea and Gulf of Alaska. We employed a dynamical downscaling method for constructing realistically the formation and life cycles during the past decades without exploiting sub-synoptic information in initial fields. A regional climate model is conditioned by large-scale information of NCEP re-analyses data.

The method consists of running a regional climate model (RCM) on the North Pacific Ocean region, and dynamically downscaling the NCEP 1 re-analysis data (Kalnay et al., 1996) for 1949 to 2010. A first study has shown that realistic Polar Lows are formed in the simulation with more detail than in the driving NCEP re-analysis (Chen et al., 2012).

Model used

All the initial and boundary conditions were provided by the NCEP 1 re-analysis data. The large-scale constraining technique in which known as spectral nudging (von Storch *et al.,* 2000) has been used in order to keep the large scale variability close to the NCEP re-analysis, which is available four times a day, and is interpolated to the shorter model time step. We applied this nudging at 750hPa and above, it goes stronger with height. It is limited to horizontal wind velocities and spatial scales larger than 800km.

Tracking Polar Lows

The detection and tracking-algorithm previously developed by Zahn and von Storch (2008a), for finding Polar Lows in the output of COSMO-CLM simulations works in three steps: First the local minima are identified in the band-pass filtered mean sea level pressure field. In the second step the detected positions of pressure minima are combined time-step by time-step to form tracks. In the final third step, some constraints are employed to remove remaining synoptic cyclones. We modified some of the fulfilled parameters to adapt the North Pacific.

Results

Figure 1 a shows the yearly time series of the number of detected polar lows per polar low season (PLS) from October to April. The mean number is 184 polar lows for each PLS with a strong year-to-year variability indicated by a standard deviation of approximately 31. Maximum and minimum numbers of detected cases are found in PLS 1969 with 258 cases and 2008 with only 137 cases. The decadal variability is weak. The overall trend in the frequency of polar lows is positive with 0.675 cases/year. The annual cycle of monthly numbers of detected polar lows reveals highest frequency in winter with maxima in December and January and almost no polar low activity in summer (not shown).

The spatial distribution of polar low occurrences is plotted in Figure 1 b. The location of each polar low is defined as the location at which its track is detected for the first time. Highest absolute frequency and frequency per maritime area are found in the region of

Japan Sea in accordance with investigation of *Yarnal et al.* By a collection of 7 winter seasons Defence Meteorological Satellite Program (DMSP) infrared imagery, Yarnal concluded that the most active polar low cyclogenesis takes place in the western extratropical North Pacific, with the greatest rates of formation found east of northern Japan. A second maximum in counts per maritime area unit is found in the south-west of Bering Sea and the Gulf of Alaska.

By a Canonical Correlation Analysis (CCA) between the polar low density and mean sea level pressure field (not shown), we were able to detect links to large scale pressure patterns. We determined MSLP patterns, averaged across a polar low year, which favour or disfavour the formation of spatial polar low occurrence. Southward or pole-ward mean flows were found to establish large-scale time mean environments with which less or more polar lows develop. Details will be reported in a forthcoming article.

In this study, the model did not reproduce all polar lows observed in reality ; however, relevant statistics of polar low dynamics are realistically reproduced – in particular the number of polar lows, their spatial distribution and the link to the large scale MSLP field.

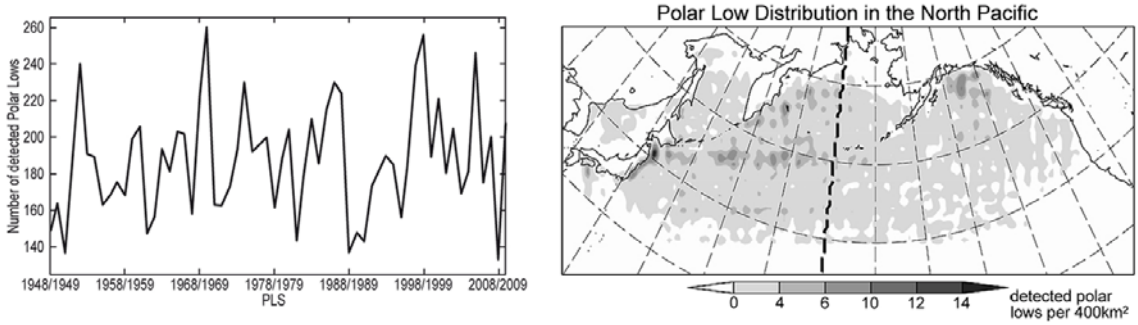

Figure 1. a) Number of detected polar lows per polar low season. One polar low season is defined as the period starting 1 October and ending 30 April the following year. b) Polar low density distribution. Unit:detected polar lows per 400 square kilometres.

Reference

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