A 2012-2013-AS TÉL SZINOPTIKUS KLIMATOLÓGIAI ELEMZÉSE

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SYNOPTIC CLIMATOLOGICAL ANALYSIS OF THE 2012-2013 WINTER

Abstract

The 2012-2013 winter was unusual in the Carpathian region from several aspects. Especially the precipitation anomaly was very high. Our motivations are (i) to evaluate the series of synoptic patterns in late winter and early spring leading to these extremes, and (ii) to provide possible explanation of the physical processes behind them. The main characteristics of the dominant patterns are as follows: the jet-stream is nearly stationary above the Mediterranean region and Mediterranean cyclones formed frequently along the jet. According to the literature there is a link between the North Atlantic Oscillation (NAO), the Arctic Oscillation (AO), and the position and intensity of the jet-stream and these are also linked to the local weather conditions. First, we calculate correlation patterns between daily data of several elements near the surface and at different isobaric levels, and daily NAO and AO index values for 30 years (1981-2010). Then, similar analysis is carried out for all the seasons and months .

Keywords: precipitation, winter, NAO, AO, jet-stream

Introduction

The 2012-2013 winter resulted in about half of the annual precipitation amount in some part of the Carpathian Basin (VINCZE, E. 2013). This is quite unusual and certainly worth to analyze in details. In some area the winter precipitation exceeded 250 mm, which is two and a half times more than the climatological winter mean precipitation sum. The temperature was a bit (+0,4 °C) warmer than average, however, this difference is not so rare as the measured precipitation excess. The main features of the anomalies are: (i) nearly stationary jet-stream above the Mediterranean region, and (ii) frequent cyclogenesis in this region. These cyclones brought huge amount of precipitation to the Carpathian Basin, for instance, one of these cyclones caused

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the snowdrift on 14th-15th March in 2013. The large scale circulation patterns clearly suggest a strong relationship between the jet-stream position and the Mediterranean cyclogenesis.

In December (2012) and January (2013) the main synoptic systems affecting the weather in the Carpathian Basin arrived from the Icelandic region. However, around the end of January and also in February almost every cyclone arrived from the Mediterranean region and cyclogenesis occurred about every 2–3 days, which is very unusual in this region (e.g., BARTHOLY, J. *et al.* 2006), moreover, all of these cylones were associated with the jet-stream. The main aim of our current research is to explore the possible causes of this special long-lasting macrocirculation regime over Europe. In this paper, first, the North Atlantic Oscillation (NAO) and the Arctic Oscillation (AO) are briefly described followed by the data used in our analysis. Then, our results are presented and discussed with the final summary at the end of the paper.

NAO and AO

According to the literature (e.g., GREATBATCH, R.J. 2001) there is an indirect relationship between the state of NAO and AO systems and the weather conditions of the North-Atlantic region. NAO and AO are also strongly inter-related to each other, since both of them involve some fluctuations of the air pressure above the Northern Hemisphere (AMBAUM, M.H.P. *et al*., 2001). These systems are usually characterized by indices defined as pressure differences of special regions (WALLACE, J.M. 1999).

The winter of 2012-2013 showed the characteristical features of negative phase of NAO (HURREL, J. W. 1995). The index values for NAO were negative during more than half of the whole winter, whereas for AO they were clearly negative during the entire period. So first, the correlations between several weather conditions and the daily index values are evaluated on climatological time scale. Then, correlation coefficients are also calculated separately for all seasons and months for the entire 30-year-long analysis period, and finally, for the selected winter period only.

Data

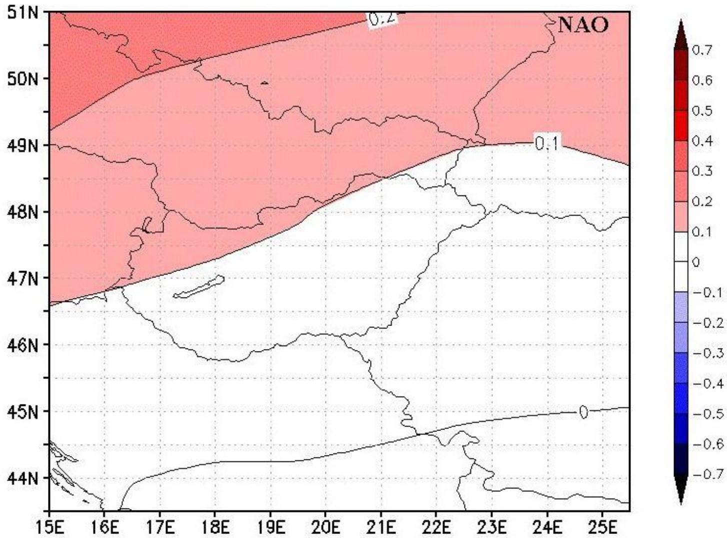
For the climatological time scale, the ERA-Interim reanalysis and forecast datasets of the European Centre for Medium-Range Weather Forecasts (ECMWF) are used from 1981 to 2010 with 1.5°×1.5° horizontal grid resolution. The Carpathian Basin is represented by 48 grid points in our analysis. For the selected winter period, subsets of the same ERA-Interim data are used. The following variables are selected from the entire ERA-Interim database: 2 meter air temperature, geopotential height of the 500 hPa level, relative moisture at the 850 hPa level, daily precipitation amount, wind speed at 300 hPa level, and sea level air pressure.

Daily NAO and AO index values are available on-line from the Climate Prediction Center of the U.S. National Oceanic and Atmospheric Administration (NOAA) (http://www.cpc.ncep.noaa.gov/).

Results

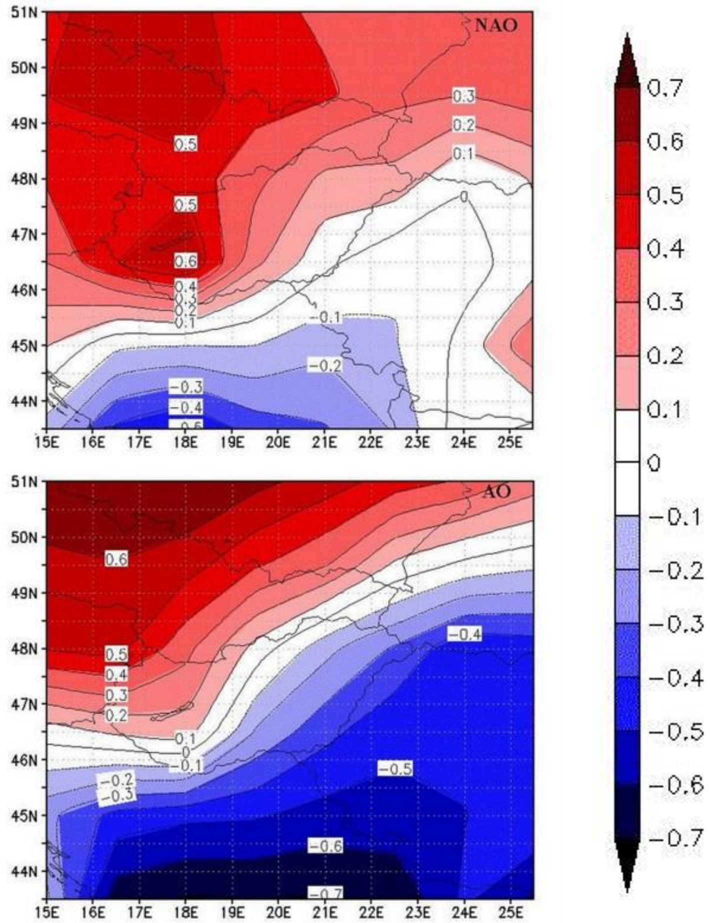
First, the linear correlation coefficients are calculated on the 30-year-long climatological time scale between daily values of different weather parameters and the daily index values of NAO and AO. Our results suggest relatively weak linear relationships since maximum values **of** the correlation coefficients do not exceed +0.3, however, the results are statistically significant at 0.05 level (the threshold value is quite low, 0.02 in absolute value). Results are illustrated in *Figure 1* as an example where correlation coefficients are mapped between 2-meter height air temperature anomalies, and daily NAO index values for the full period. In addition to the simultaneous daily local observations represented by the reanalysis data and the daily AO or NAO index values, possible shifts of the relationships are also analyzed. For this purpose, we used several lag time periods (i.e., from 1 day to 9 days) between the indices and the weather elements, as well as moving average time series with different window-lengths (e.g., 3 days, 5 days, 10 days). The strongest linear relationships are found in case of simultaneous daily time series with no lag time.

Figure 1. Correlation coefficient map of daily NAO indices and 2 meter air temperature anomalies (for which the 30 year mean of daily values are subtracted from the actual daily values) for the full period (1981-2010). Correlation coefficients exceeding 0.02 in absolute value are significant at 0.05 level.



Because the observed effects of the NAO and AO systems are not identical throughout the year, similar calculations can be repeated for each season and for each month individually for the entire 30-year-long analyzed period. This analysis results generally higher linear coefficient values, which can be partially explained by the lower sample size compared to the full period. However, correlation coefficients exceeding 0.2 and 0.3 in absolute value are statistically significant at 0.05 level in case of season-based and month-based period Our results clearly suggest weaker correlation values in summer than in the rest of the year. Furthermore, the strongest correlations occur in winter, which corresponds perfectly with the literature (e.g., GREATBATCH, R.J. 2001). The spatial structures of the correlation coefficents between weather parameters and index values show zonal patterns both in the strength and the sign of the relationship. In case of the season- and month-based analyses the linear relationships with the AO index are generally stronger than with the NAO index. However, in some of the individual months and seasons, the linear relationship with NAO is stronger than that with AO.

Figure 2. Correlation coefficient maps of daily NAO (upper panel) and AO (lower panel) indices with 2 meter air temperature anomalies (for which the 30 year mean of daily values are subtracted from the actual daily values) for January of 2013. Correlation coefficients exceeding 0.3 in absolute value are significant at 0.05 level.



After completing the climatological analysis, the winter of 2012-2013 is also analyzed in details. Similarly, linear correlation coefficients are calculated between the gridded time series of the daily weather parameters and the daily values of AO and NAO indices. Our results suggest stronger linear relationships for this specific winter period, especially, for the individual months. The maximum values of correlation coefficients are between 0.5 and 0.9 in absolute values. In some cases the full climatological scale analysis and the specific 2012-2013 winter analysis result in different signs of coefficients. For example, the correlation coefficients of both the 500 hPa geopotential heights and the sea level pressures with the oscillation indices are positive, but they are strongly negative for the winter of 2012-2013.

For most of the weather elements, substantial spatial differences in the signs of the correlation coefficients are found within the selected region, i.e., in some parts of the Carpathian region positive coefficient values can be detected for AO and NAO, whereas in other parts they are negative (*Figure 2*). This implies opposite simultaneous effects over the Carpathian Basin, which is certainly an important result. The border of the sign change is considerably moving in time from one month to the other, therefore, an individual grid point can be characterized by either negative or positive coefficients but in different periods. If the analysis covers relatively longer time scale, the fluctuations play larger role than in shorter periods, so ultimately correlation coefficients for the entire time series are lower than for the shorter periods.

Summary

Synoptical climatological analysis of the possible relationships between local weather elements and large-scale oscillation phenomena has been presented in this paper using statistical tools (i.e., correlation coefficient maps). Based on the results the following conlcusions can be drawn.

(1) Statistically significant relationships can be detected between the weather conditions of the Carpathian region and the daily values of the NAO and AO index on climatological scale considering either the entire year, indiviual seasons, or individual months. The relationship is highly variable both in time and space, more specifically, zonal spatial patterns are recongnized with different signs of correlation coefficients in the northern and southern parts of the selected domain.

(2) For the specific winter of 2012-2013, correlation coefficients are larger in absolute values than for the entire climatological period (especially in case of month-based analysis), which indicates stronger than usual relationships between meteorological conditions and the oscillation phenomena.

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