IMPACT OF THE MACRO-SCALE ATMOSPHERIC CIRCULATION ON SNOW COVER DURATION IN ROMANIA

Liana-Victoria Cazacioc[1], Andreea Cazacioc[2]

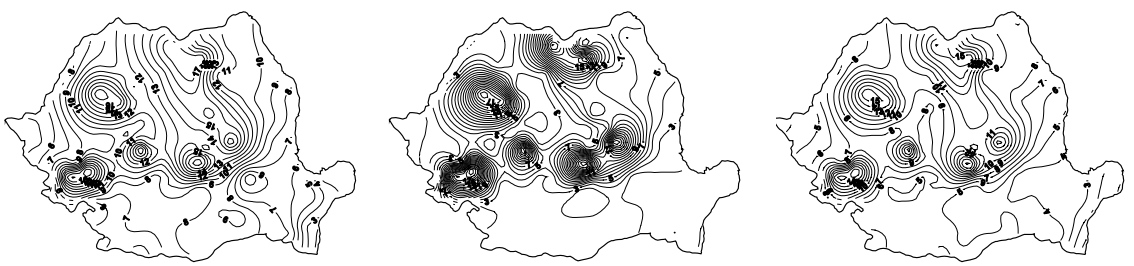
[1]National Meteorological Administration, Sos.Bucuresti-Ploiesti 97, Bucuresti 013686, Romania, fax: +40-0212303143
[2] National Environmental Protection Agency, Aleea Lacul Morii 151, sector 6, Bucuresti 060841, Romania, tel: +40-0745054018
E-mail: *liana.cazacioc@meteo.inmh.ro*

Abstract. The main purpose of this paper is to analyze the influence of atmospheric circulation, expressed by the North Atlantic Oscillation (NAO) index on snow cover duration in Romania. The correlation coefficients between the NAO index values and the monthly number of days with snow cover at 99 stations from December to March 1961-1990 are mostly negative. The strongest correlation was obtained in southwestern Romania in January. The monthly mean number of days with snow cover decreases from the northwestern to the southeastern Romania, reaching the greatest values in the mountainous area. The snow cover is more persistent in January and March during the NAO positive phase and in December during the negative one. The dependency of snow cover duration on altitude appeared both for the positive and negative NAO phase. There was also examined the connection between Hess-Brezowsky circulation types frequency and NAO index. A strong positive correlation was obtained for the westerly airflows and a strong negative correlation for the northeasterly airflows. It was pointed out that the NAO positive phase leads to less snowy winter months in Romania, whereas the NAO negative phase increases the probability of snowy winters.

Keywords *– Romania, snow cover, NAO index, correlation*

1. INTRODUCTION

The basic characteristics of snow cover occurrence and the influence of temperature, precipitation and atmospheric circulation expressed by NAO index on the snow cover duration have already been investigated (Bednorz, 2004) in Eastern Europe without Romania. The aim of this study is to present the relationship between the duration of snow cover in Romania and the North Atlantic Oscillation (NAO). Snow cover duration displays a large variability over Romanian territory. The monthly mean number of days with snow cover decreases from the northwest to the southeast, reaching the greatest values in the mountain areas both for the positive and negative NAO phase. The snowy months in Romania are January and March when NAO is positive, and December when NAO is negative (figure 1).



January March December

Figure 1. The mean monthly number of days with snow cover in Romania (1961-1990)

2. DATA AND METHODS

This study is based on daily data of snow cover recorded from December to March 1961-1990 at 99 meteorological stations evenly distributed on Romania's territory. Days with snow cover are those when the snow cover depth ≥ 1 cm. For each of the 99 stations, the annual mean number of days with snow cover was calculated.

The NAO index used in this paper was defined as the difference between the normalized sea level pressure over Azores and the normalized sea level pressure over Iceland (Jones et al., 1997).

Another source used in this study was the classification of the atmospheric circulation types proposed by P. Hess and H. Brezowsky (1977). They have defined 30 meteorological patterns for the Atlantic-European region, each of them consisting of the map at the ground level and the map at the isobaric level of 500 hPa. There were established the monthly frequencies of all these patterns in December-March 1961-1990 period.

The linear correlation was used to determine the impact of the atmospheric circulation in the North Atlantic region, expressed by NAO index, on the snow cover in Romania. The mean number of days with snow cover was separately estimated for the winter months with positive and negative NAO indexes.

3. RESULTS

The correlation coefficients between the NAO index and the number of days with snow cover in Romania were mostly negative during the winter months from 1961 to 1990 (figure 2). The statistically significant values at the 99% level were observed in January, February and March in western, southern and eastern parts of Romania's territory. The strongest correlation (values <-0.7) was found in southwestern Romania in January. The correlation was weaker in the central and southeastern Romania and almost the entire mountain area.

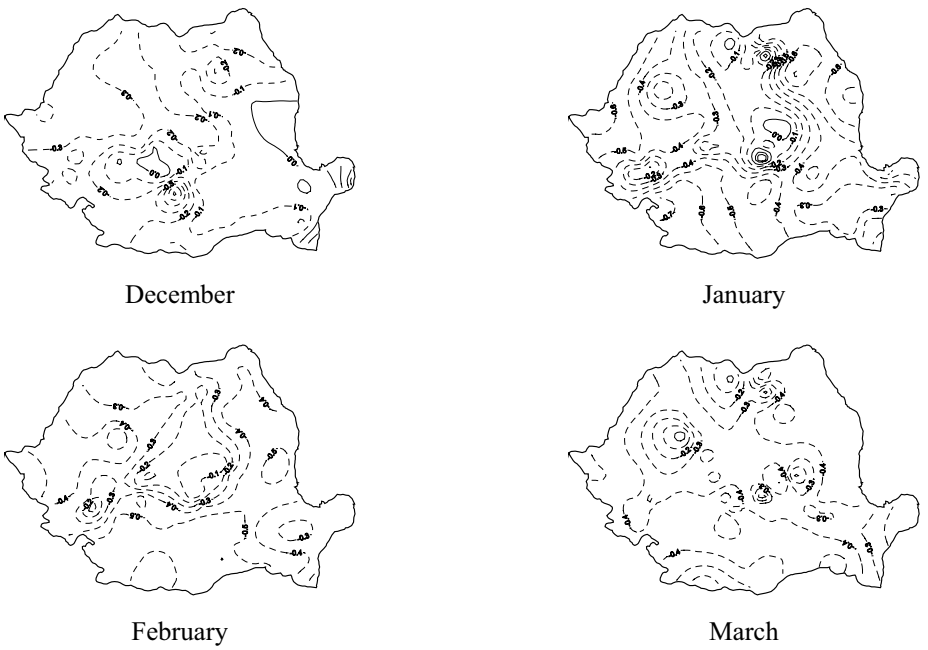


Figure 2. Correlation coefficients between the winter NAO index (December-March) and the number of days with snow cover in Romania

Furthermore, the influence of the altitude on the number of days with snow cover is better highlighted during the positive phase of the oscillation than the negative one. For a better interpretation of the number of the snow cover days variation with the altitude, there were tested multiple statistical regression models.

The best results were obtained by using a 4th degree polynomial function (figure 3). The snowiest winter months in Romania are January and February, when most stations report over 100 days with snow cover during the positive NAO phase from 1961 to 1990. These results clearly suggest the increase of the number of snowy days with the altitude. Two groups of stations are distinctive, the one including the stations with altitude below 1000 m and the other, the high altitude stations. The number of the days with snow cover reaches the greatest values at the stations from high altitude (> 1000 m), but there are also some low-altitude stations, located in northern part of Romania, where the snow cover occurrence is very frequently.

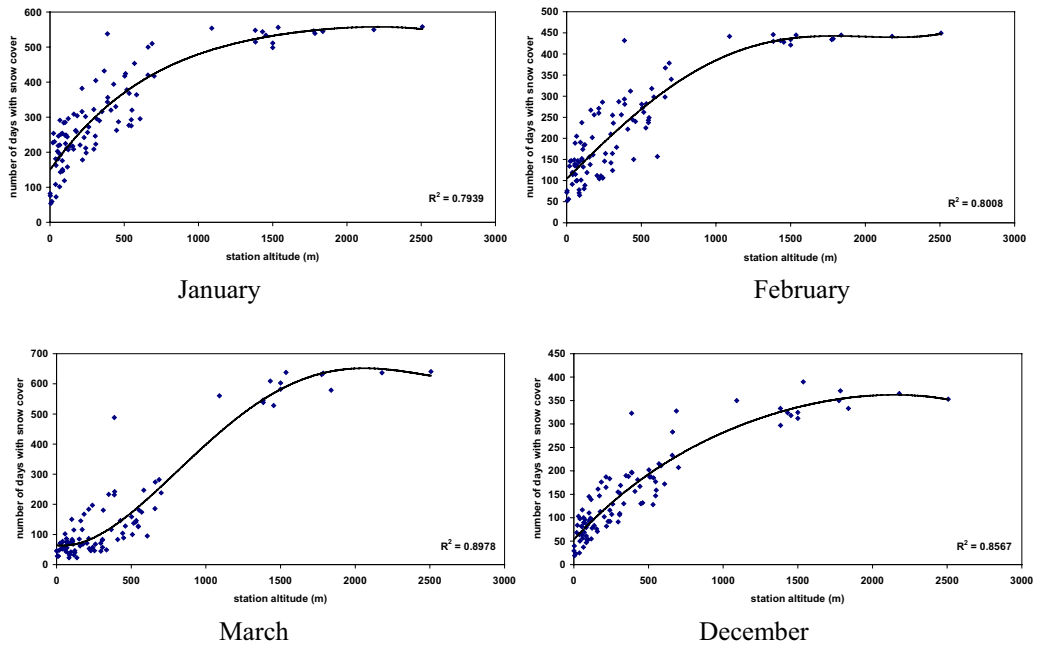


Figure 3. The dependency of the number of days with snow cover on station altitude, during the positive phase of NAO (1961-1990)

A similar relationship between the number of snowy days and the altitude was found during the negative NAO phase (not shown).

In the last part was examined the correlation between the frequency of airflow directions in winter months and the NAO index (figure 4). The most correlations are negative. The strongest negative correlation coefficients with 99% significance level were obtained for the northeasterly circulation in February and March and for the southeasterly one in December. High statistically significant values of the positive correlation coefficients at the 99% level were obtained for westerly cyclonic circulation in December, January and February. These directions of air masses circulation are consistent with the presence of the NAO phases; during the negative phase, intense northerly and easterly circulations lead to a drop of the winter temperature in Europe and favor the occurrence of snow cover, while the positive one brings warm and wet air over Europe.

These results are in a good correlation with a recent study about Eurasian snow cover. It was proved that the correlation between the NAO index and the number of days with snow cover is strong and statistically significant only in central Europe, decreasing towards the west of Europe.

4. CONCLUSION

The snow cover is an important meteorological parameter, depending both on the air temperature and the precipitation and hence on atmospheric circulation. The NAO significantly influences the temperature and

precipitation of winter months in Europe. Therefore, we have concluded that NAO influences the snow cover occurrence, too. The analysis of the relationship between the NAO index and the number of days with snow cover over Romania revealed a stronger correlation in the plane area, compared to the one in the mountain area. Most correlation coefficients are negative, reaching their highest values in southwestern Romania in January. Additionally, we have examined the correlation between the NAO index and the frequency of the Hess-Brezowsky weather types. A strong positive correlation was obtained for westerly airflows and a strong negative correlation resulted for the northeasterly airflows. These results are consistent with the westerly circulations during the positive NAO phase and with the northerly circulations during the negative phase. In brief, the positive phase of NAO leads to less snowy winter in Romania, whereas the negative NAO phase increases the probability of snowy winters.

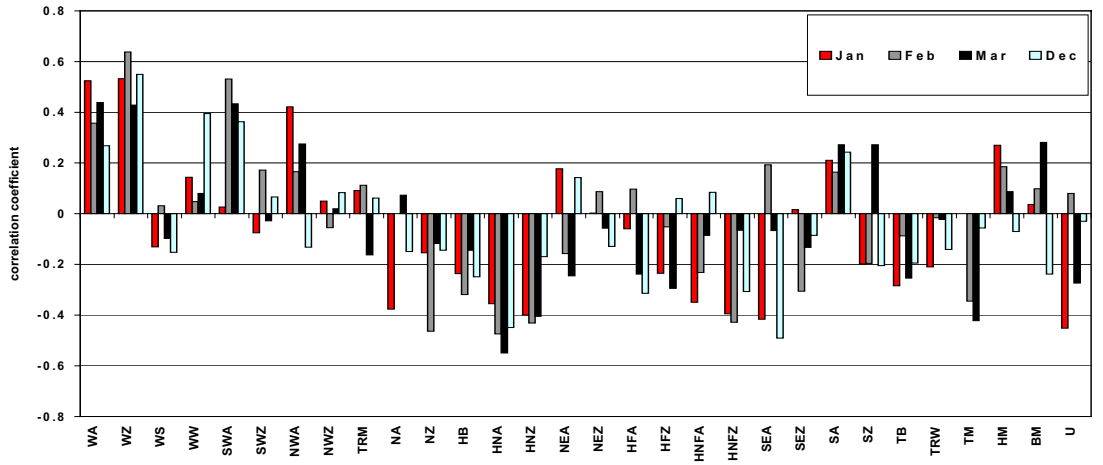


Figure 4. The correlation coefficients between Hess-Brezowsky circulation types frequency and the NAO index in winter months (1961-1990)

The spatial distribution of the number of days with snow cover is in tight relation to the Carpathian chain influence by its shape and massiveness, the geographical position of the station and its altitude. There are some differences in spatially variability of snow cover during the positive and negative phases of NAO. In all the winter months, the largest number of snowy days is recorded in the mountain region of Romania both on positive and negative NAO phases. The snow cover is less persistent in western and southeastern parts of Romania. A remarkable dependency of the number of snowy days with the altitude of the station is observed, namely, the number of days with snow cover increases with the altitude of the station. The relationship between snow cover and altitude is stronger in the positive NAO index months than in the negative NAO index months.

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