SPATIAL DIFFERENCES OVER ROMANIA OF THE SNOW COVER VARIABILITY IN RELATIONSHIP TO TEMPERATURE AND ATMOSPHERIC CIRCULATION

Liana Cazacioc

National Meteorological Administration, Bucharest, Romania,
E-mail: *liana.cazacioc@meteo.inmh.ro*

Abstract. Some basic characteristics of the snow cover duration in Romania, like the annual mean number and the variability index of days with snow cover in the cold season (December-March) from 1961 until 1990 are presented. In all the winter months, the largest values of the annual mean number have been recorded in the mountainous region of Romania, where the variability index is the smallest. For each month from December until March the "active" snow cover areas have been determined by using the climatological frequencies of snow cover occurrence. The relationship between the snow cover duration and the temperature was analysed in the winter months (December-March). The correlation coefficients between the number of days with snow cover and monthly mean temperature are mostly negative over Romanian territory. The strongest correlations were found in January, February and March in the southern, eastern and central parts of Romania. The influence of the atmospheric circulation in the Atlantic-European region on the snow cover in Romania is studied by using the frequency of Hess-Brezowsky weather types. The westerly and northerly atmospheric circulation types have been taken into consideration and their association with snow cover duration in Romania was examined. Most of the correlations are negative for the westerly air flow directions and positive for the northerly ones.

Keywords*: ICAM, snow cover duration, Romania, correlation analysis*

1. INTRODUCTION

The snow cover is an important climatic variable and its variability strongly depends on latitude. Several studies have investigated the snow cover occurrence in different regions of Europe, the areas of "active" snow cover fluctuations being identified as those areas where the probability of snow cover is between 10 and 90%, according to Frei (1997, cited in Clark *et al*. (1999)). The snow cover dependence on winter months temperature and atmospheric circulation has been analysed on local scale: Hantel et al. (2000) in Austria, Paczos (1985, cited in Bednorz (2004)) and Bednorz (2002) in Poland, Dobrovolny (1993, cited in Bednorz (2004)) in Czech Republic, Jaagus (1997) in Estonia, Jackson (1978) in Great Britain.

This paper presents the basic characteristics of snow cover occurrence in Romania for each month from December to March over the 1961-1990 period. Then the influence of temperature and atmospheric circulation expressed by Hess-Brezowsky weather types on the number of days with snow cover have been analysed in particular winter months. This study is based on a snow cover dataset from 99 meteorological stations distributed on the entire Romanian territory. The results show a pronounced difference between the climate variability in the mountainous area and the lowlands ones.

2. DATA AND METHOD

This study is based on daily data of snow cover for 30 winters (from December to March) from the 1961-1990 period at 99 meteorological stations evenly distributed on Romania's territory. Days with snow cover (DSC) are those when the snow cover depth ≥ 1 cm. For each of the 99 stations some statistics have been calculated, like the annual mean number of days with snow cover and the variability index defined as the quotient of standard deviation and arithmetic mean expressed as a percentage.

The climatological frequencies of snow cover occurrence in Romania have been calculated for all the winter months for each station, too. Thus, the "active" snow cover areas have been determined.

Correlation coefficients between the following parameters have been calculated for each station:

- Mean monthly temperature and days with snow cover (for each month separately)
- Monthly frequencies of Hess-Brezowsky weather types and days with snow cover (for each month separately).

3. RESULTS

3.1 Annual mean number of days with snow cover

The annual mean number of days with snow cover ranges between 12 at Mangalia on Romanian Black Sea coast and 147.5 at Virfu Omu, in the mountainous area. The annual mean number of DSC decreases from the mountainous area to the lowland (Fig.1a), as expected. The smallest annual mean number of DSC is characteristic of the south-eastern and extreme western parts of Romania where the variability index is the highest (>60%). High annual mean number of DSC recorded in the mountains implies weak inter-annual variability (Fig.1b).

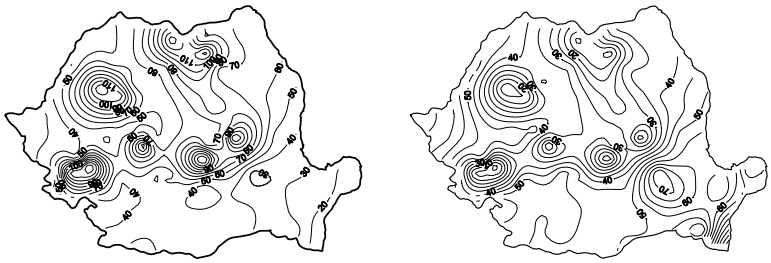
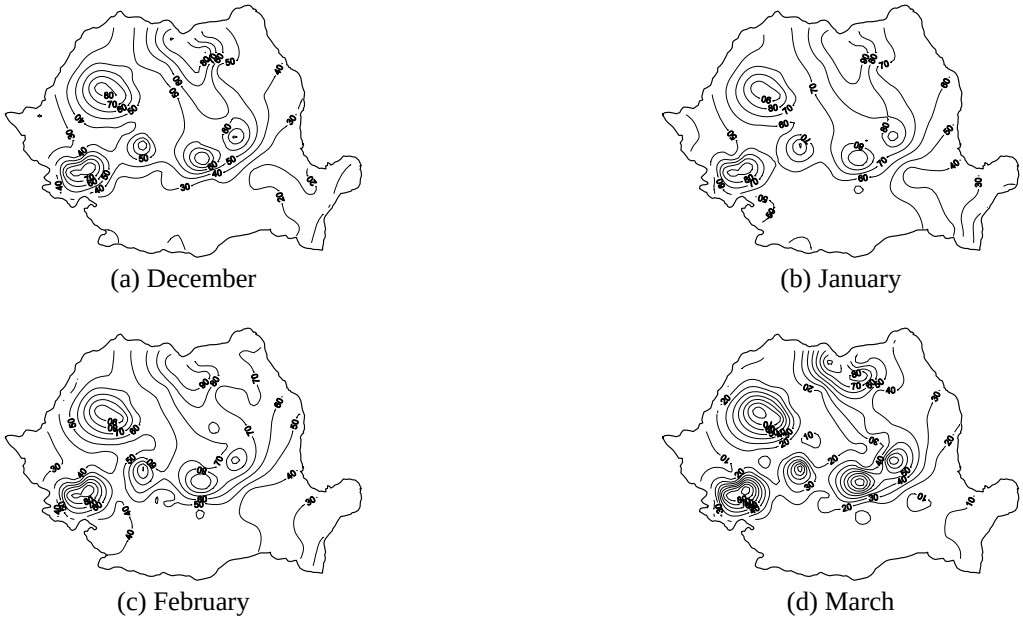


Figure 1: (a) Mean annual number of DSC and (b) variability index in Romania (1961-1990)

3.2 "Active" snow cover areas

In January and February, the probability of snow cover occurrence in Romania is greater then 10% over the entire territory (Fig.2b and Fig.2c). In December, there is a limited "non-active" snow cover area, namely the coast of the Black Sea (Fig.2a). The smallest "active" snow cover area is in March, when the probability of DSC occurrence does not exceed 10% in a few zones from western, south-eastern and central Romania (Fig.2d). The probability of DSC occurrence reaches the highest values in the mountainous area in all the winter months.



(a) December (b) January

(c) February (d) March

Figure 2: Probability of snow cover (%) in Romania (1961-1990)

3.3 Relationship between snow cover duration and temperature

The correlation coefficients between the number of DSC and the monthly mean temperature are mostly negative in all the winter months over the Romanian territory. Statistically significant values at 99% level were observed in southern and eastern regions and partly in western and central Romania (Fig.3). The strongest negative correlation reaches -0.88 and was found in north-eastern of Romanian territory in March. The correlation decreases with the altitude becoming positive in certain mountainous areas.

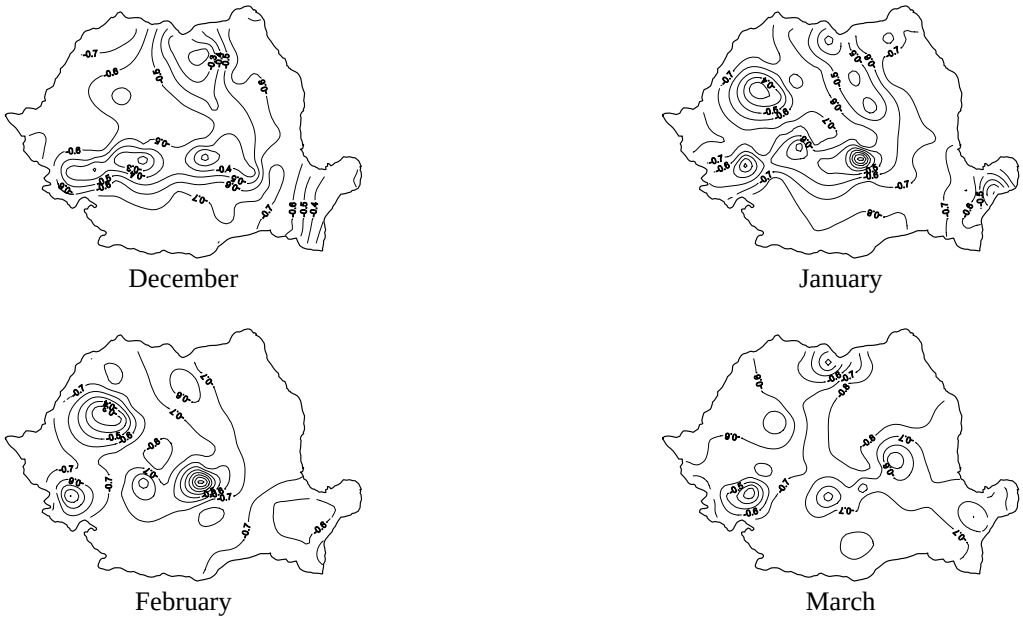


Figure 3: Correlation coefficient between the monthly number of DSC and monthly mean temperature in Romania for the 1961-1990 period

3.4 The influence of air circulation on snow cover duration

The atmospheric circulation influences the temperature and precipitation and, consequently, the snow cover occurrence. Westerly and northerly patterns of large-scale circulation have been considered for examining their impact on snow cover in Romania. For each winter month have been calculated the correlation coefficients between the frequency of westerly and northerly weather types expressed by the Hess-Brezowsky classification (Hess and Brezowsky, 1977) and the number of DSC. In January and February westerly atmospheric circulations over the Atlantic-European region are stronger related with the number of DSC then the northerly ones. Most of the correlations are negative for the westerly air flow directions and positive for the northerly ones. In Fig.4 is shown the distribution of the correlation coefficients in January and February, when the statistical significance is greater then in the remaining winter months. The sign of the correlation expresses the fluctuations in the air temperature connected to the weather types. The predominant westerly airflow brings mild maritime air over Europe and produces an increase in the air temperature, which leads to the disappearance of the snow cover. The situation is quite different in the presence of the northerly circulation, which causes a winter temperature drop, determining the appearance of snow cover.

4. CONCLUSION

The spatial distribution of the annual mean number of DSC, the variability index and the probability of occurrence of snow cover is highly influenced by the Carpathian mountain chain. The annual mean number of DSC and the probability of occurrence reach their greatest values in the mountainous area of Romania where the variability index is smaller then 50%. In the southern and western lowland regions there is high inter-annual diversity of DSC, accordingly to the reduced number of DSC. The probability of occurrence of snow cover is higher in the middle winter months, i.e. in January and February. Almost the entire territory of Romania can by characterized as an “active” snow cover area, with the exception of some small zones in December and March.

Correlation analysis revealed the impact of temperature and atmospheric circulation on snow cover duration in Romania. Negative correlations between the number of DSC and the monthly mean temperature have been found over the most of the Romanian territory in each month from December until March. The correlation is stronger in regions with a small number of DSC (up to -0.88) and decreases with the altitude. High statistically significant results are observed over large areas in January, February and March.

The fluctuations in the air temperature during winter represent the main factor which determines the appearance and disappearance of snow cover. Therefore it has been analyzed the relationship between the number of DSC in Romania and the westerly and northerly atmospheric circulations on large-scale. The westerly circulations causing an increase in the air temperature lead to less snowy winter, whereas the northerly circulations determine a drop of the temperature, growing the probability of snowy winters in Romania.

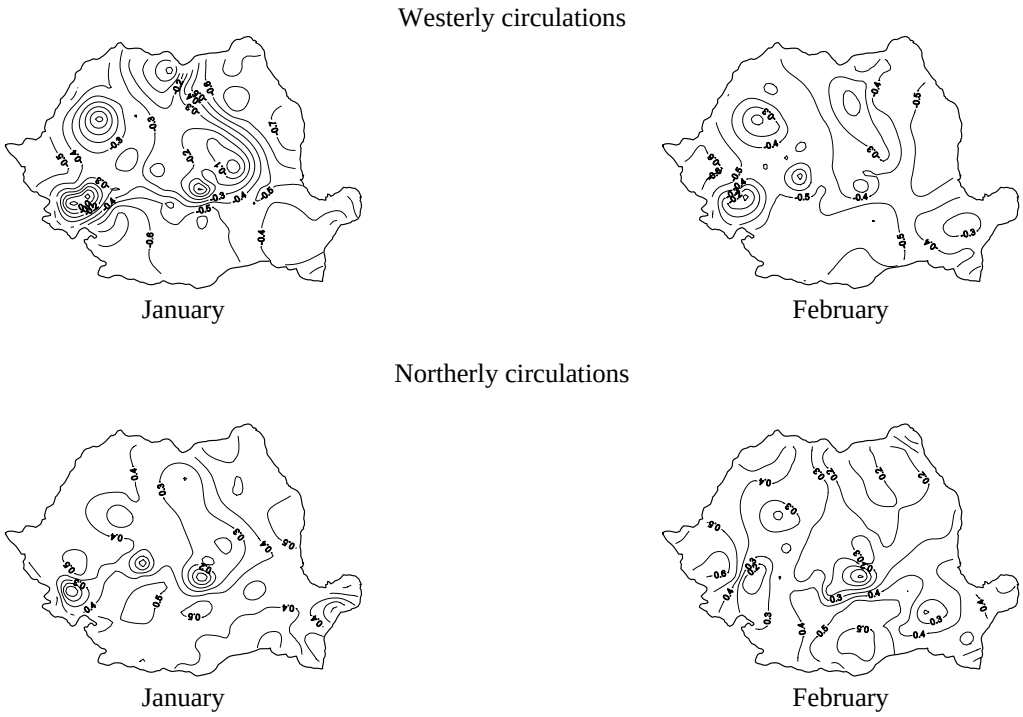


Figure 4: Correlation coefficients between the number of DSC and the atmospheric weather types frequency for the 1961-1990 period

REFERENCES

Bednorz, E., 2002: Snow cover in western Poland and macro-scale circulation conditions. *International Journal of Climatology* **22**, 533-541.

Bednorz, E., 2004: Snow cover in eastern Europe in relation to temperature, precipitation and circulation. *International Journal of Climatology* **24**, 591-601.

Clark, M.P., Serreze M.C., Robinson, A.D., 1999: Atmospheric controls on Eurasian snow extent. *International Journal of Climatology* **19**, 27-40.

Dobrovolny, P., 1993: Snow as an indicator of climatic change. *Scripta Facultatis Scientiarum Naturalium Universitatis Masaryk Brunensis* **23**, 25-34.

Frei, C., 1997: Towards a snow cover finger print for climate change detection. Disertation submitted to the Graduate School, New Brunswick-Rutgers, The State University of New Jersey, USA in partial fulfillment of the degree of Doctor of Philosophy, Graduate Program in Geography.

Hantel, M., Ehrendorfer, M., Haslinger, A., 2000: Climate sensitivity of snow cover duration in Austria. *International Journal of Climatology* **20**, 615-640.

Hess, P., Brezowsky, H., 1977: *Katalog der Grosswetterlagen Europas.* Berichte des Deutschen Wetterdienstes, no**.113**.

Jaagus, J., 1997: The impact of climate change on the snow cover pattern in Estonia. *Climatic Change* **36**, 65-77.

Jackson, M., 1978: Snow cover in Great Britain. *Weather* **3**, 298-309.

Paczos, S., 1985: Snow cover in Poland. *Universitatis Mariae Curie-Sklodovska, Lublin-Polonia* **40**, 77-104.