THE ANALYSIS OF THE SNOW LAYER IN THE CONTEXT OF GLOBAL CLIMATE CHANGE IN THE SOUTHERN CARPATHIANS (ROMANIAN CARPATHIANS)

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Abstract: The study was done in the Southern Carpathians which are also called the Transylvanian Alps, the most representative mountain unit of the Romanian Carpathians. Southern Carpathians have a central position in Romania with a general east-west orientation and a total surface of 14 040 km^2. Southern Carpathians have a high massivity and maximum altitudes above 2500 m. They are formed by four major ranges: Bucegi Mountains, Făgăraş-Iezer Mountains, Parâng Mountains and Retezat-Godeanu Mountains. Analysis of the data from the meteorological stations shows, for the last 40 years, a slight decreasing trend of the snow cover duration, higher decrease occurred after 1985 and spatially at altitudes below 1700 m. The spatial analysis was based on the Digital Terrain Model obtained from a SRTM file (Shuttle Radar Topography Mission), with a 90 m resolution. We used the linear regression between the altitude and the snow cover duration to calculate a map of territorial distribution of snow cover duration, and also a digital map which present the space and time differences of this parameter for two intervals considered (15 years before 1985 and 15 years after 1985).
Key words: *snow layer, GIS, global climate change, Southern Carpathians.*

1. INTRODUCTION

This analysis was done in the Southern Carpathians which are also called the Transylvanian Alps a representative mountain unit of the Romanian Carpathians. Southern Carpathians have a central position in Romania (Fig. 1), have a general east-west position, 300 km long and a total surface of 14.040 km^2 i.e. 21% of the entire Romanian Carpathians and 5.91% from the surface of Romania (according to *Geografia României, III, Carpaţii Româneşti şi Depresiunea Transilvaniei*, 1987; Velcea, Savu, 1983).

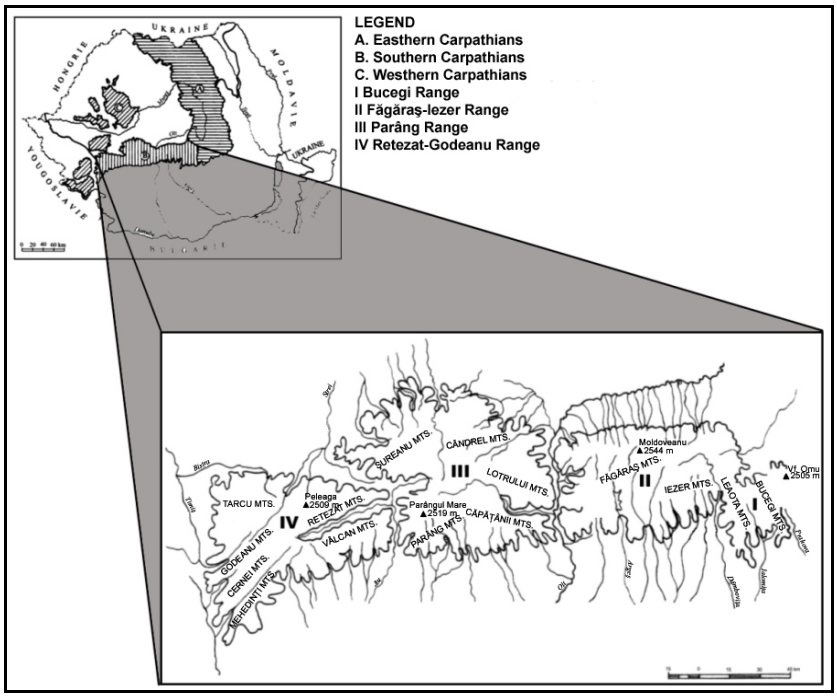

Figure 1: Geographical location of the Southern Carpathians.

Southern Carpathians have a high massivity and dominant altitudes. They are made of 4 majour mountain divisions from East to West as follows: Bucegi Mountains, Făgăraş-Iezer Mountains, Parâng Mountains and Retezat-Godeanu Mountains (Fig. 1). The major elements of the Southern Carpathian's landscape are represented by the glacial and periglacial landforms. Typical landcover includes deciduous and

coniferous forests below the timberline, and grassy alpine meadow above it. Vegetated areas are broken up by the presence of steep slopes and barren rocks.

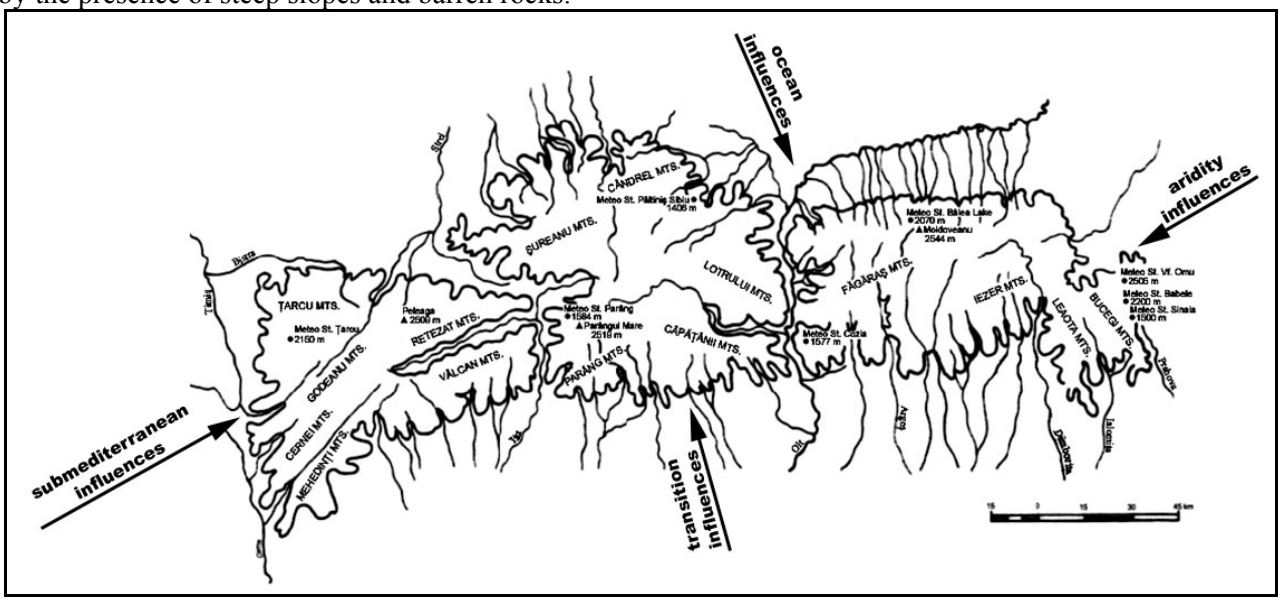

Figure 2: The climatic influences about Southern Carpathians

Due to the existence of the 2 macro slopes, the northern and the southern one caused by the general orientation, the Southern Carpathians are affected by a few major types of climate influence which creates a typical climate at local and regional level. The Southern macro slope is under the influence of western humid air masses. The southern macro slope is affected in its south-western part by submediterranean influences, the eastern part by continental influences from the east and the central part of the slope by transition influences (from submediterraneean to transition influences) (according to *Geografia României, I, Geografia fizică*, 1983) (Fig. 2). That is why both the thermal regime as well as the repartition of humidity and of the snow fall are differentiated vertically (in the alpine and forest level) and within the 2 large ways of exposition the northern and the southern one.

The data of apparition, formation, duration and data of disappearance of the snow layer are directly influenced by many factors: altitude isotherm of 0^{o} C, the snow fall frequency, the slope exposition to the sun and general circulation of atmosphere and the existence and structure of the vegetal cover (according to Voiculescu, 2002a, 2002b, Voiculescu, Török-Oance, 2004).

2. DATA AND METHODS

For this study we used climate data (temperatures, precipitations, snow cover duration) from the meteorological stations in Southern Carpathians (Tab. 1) placed above 1400 m.

The digital climate models and space analysis was based on Digital Terrain Model. This was obtained from a SRTM file (Shuttle Radar Topography Mission) with a 90 m resolution. The following steps were made: georeferentiation of the model in the UTM coordinate system, ellipsoid WGS84; cutting out the studied area; correcting the altitude errors and modification of the resolution of the model from 90 m to 30 m towards GIS integration of the Landsat satellite images with a 30 m resolution.

The analysis of the climate data allowed observing the general tendencies i.e. the slight raise of the values of the average annual temperatures, decrease of the snow cover duration. Even though these climate elements have a high temporal variability there can be seen a „threshold” in 1985 beyond which these tendencies are obvious. There is also a slight difference between the meteorological stations placed above 2000 m (Țarcu, Bâlea Lac and Omu), with more diffuse tendencies comparing to the stations placed at lower altitudes where tendencies are obvious.

Table 1: The climatic characteristics of the Southern Carpathians

Nr	Meteo. Station (m)	Lat. N/ Long. E	Range/ Exposure	T°C				Sunshine duration		Pp (mm)		Snow cover duration			Wind	
				mean annual	min.	max.	ampl.	hour/year	number of days	mean annual	>0.1	number of days	average (cm)	max. (cm)	average speed m/s	average frequency on direction
1.	**Vf. Omu 2505**	45°27'/ 25°27'	Bucegi horizontal surface	-2.5	-10.9	5.8	16.8	1597.6	230	1134	163.5	>270	39.7	>115	9.7	SW
2.	**Babele 2200**	45°24'/ 25°28'	Bucegi easthern	-0,2	-9,2	7,9	17,1	-	-	582,2	-	>200	117,1	229	9	N
3.	**Ţarcu 2150**	45°16'/ 22°32'	Retezat-Godeanu horizontal surface	-0.6	-8,7	7,5	16,2	-	-	980,8	-	>180	35,5	147	10	N
4.	**Bâlea Lac 2070**	45°36'/ 24°37'	Făgăraş-Iezer northern	0.2	-8.7	8.8	17.5	-	-	1246.2	277.8	>240	66.4	308	3	N
5.	**Parâng 1584**	45°23'/ 23°27'	Parâng westhern	3,5	-5	12,4	17,4	-		834	-	>150	30	>300	3-4	W
6.	**Cozia 1577**	45°18'/ 24°20'	Făgăraş-Iezer westhern	3.0	-6.3	12.3	18.9	-	-	844.2	146,.3	>200	39.5	211	2	E
7.	**Sinaia 1500**	45°21'/ 25°30'	Bucegi easthern	3,8	-4,5	13,1	17,6	-	-	902,7	-	>140	35	>178	5.8	N

Because the snow cover duration depends directly on air temperatures (Jaagus, 1997) the correlation between the snow cover duration and the average temperature of winter season (November-March) was made. In this case too, the state is different according to the altitude: at high altitude stations, the correlation is less obvious (r=-0.5) while at the stations placed between 1400-1500 m the connection is obvious and the correlation coefficient has values between -0.7 and -0.81.

The strong correlation between altitude and snow cover duration (r=0,89) allowed, using GIS, to use the linear regression equation – together with the terrain model – in order to get the digital models of the snow cover duration both for the multiannual average as well as for the two intervals considered: 15 years before 1985 and 15 years after 1985. By subtracting the last two models of the snow cover duration a digital map was obtained which present the space and time differences of this parameter for the studied area (Fig. 3). Models were made only for areas placed above 1400 m.

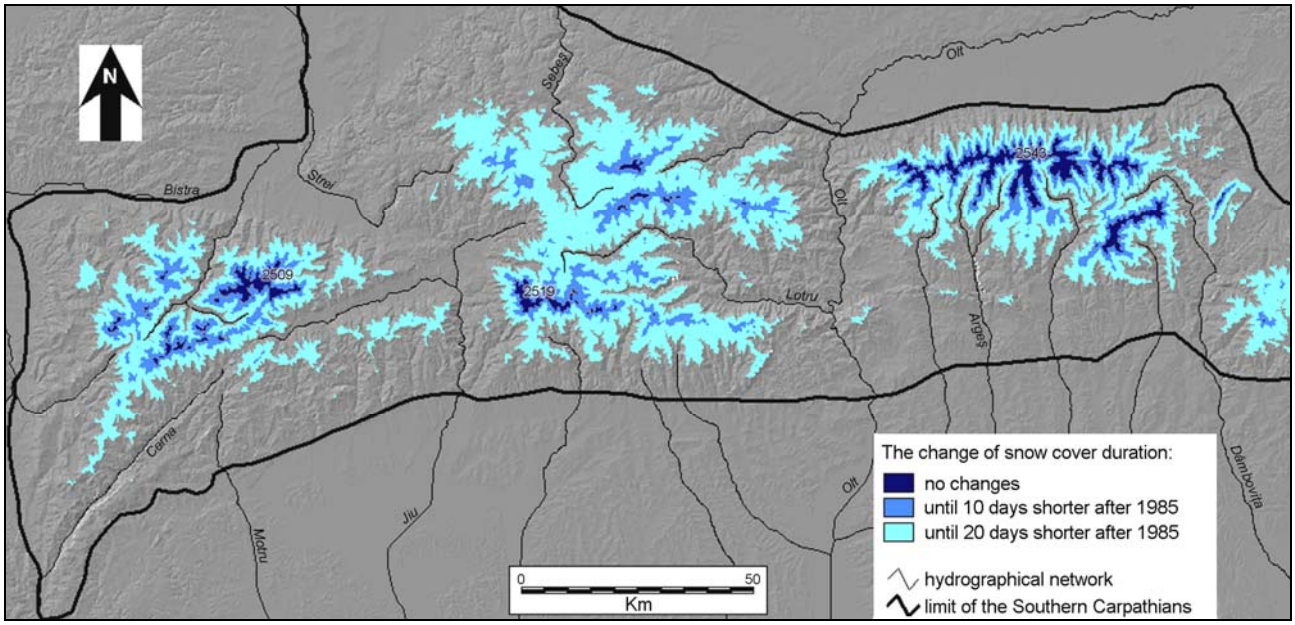

Figure 3: The differences of the mean snow cover duration for the two intervals considered (15 years before 1985 and 15 years after 1985).

3. CONCLUSIONS

The results lead to the following conclusions:

- during the last 40 years there has been a slight tendency of decreasing the number of days with snow layer. High decrease occurred after 1985 and spatially at altitudes below 1700 m (Fig. 3). A

high variability of the number of days with snow layer at low altitudes was also shown by other researchers (Harrison et. al., 2001):
- the highest variability of snow layer duration is registered at the upper limit of the forest (timberline) and at treeline, areas that characterize fragile ecosystems with a high atrophic impact;
- it was also determined the existence of a connection between the snow cover duration and the average temperature of air in the cold season for the stations placed under 1700 m. This situation is not very obvious for areas placed above 2000 m where, probably due to the high amounts of solid precipitation during winter, the duration of the snow layer has a reduced variability despite the slow growth of the average temperature of winter.

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