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THE JULY SURFACE TEMPERATURE LAPSE IN THE ROMANIAN CARPATHIANS

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Abstract: Based on July land surface temperature (LST) in the Romanian Carpathians derived from MODIS (Moderate Resolution Imaging Spectroradiometer) images, this paper investigates the vertical thermal lapse and the influence of several factors. The astronomical parameters, atmospheric circulation and geographical factors are relatively similar in the area of interest, so that the influence of elevation, aspect, and land cover becomes more relevant at regional scale. Slope angle has a marginal influence in influencing the daily vertical lapse. In the Romanian Carpathians, the temperature lapse rate of –0.65°C varies considerably both in time, and space, according to local conditions. The LST and air temperature eventually follows a similar diurnal regime, but their lapse rates are different. The screen temperature lapse rate is steeper by daytime, and milder during the night, while the situation reverses for LST. Despite some inherent shortcomings, the spatial and temporal resolution of the MODIS products MOD11_L2 and MYD11_L2 used in this study are suitable for mountain climatology.

Keywords: land surface temperature (LST); vertical gradient; MODIS; Carpathians

1. INTRODUCTION

Climatic factors control the characteristics of the mountain environment, and their monitoring represents a significant challenge for the contemporary meteorology. The thermal variations over complex terrain are crucial for numerous applications (i.e. ecosystem studies, hydrological models, tourist activities, avalanche prediction) and many researchers approached the topic (Neacşa et al., 1972; De Scally, 1997; Rolland, 2003; Lundquist & Cayan, 2007; Blandford et al., 2008). Barry (2008) refers to early investigation on the thermal vertical lapse at the end of the 18th century. Numerous variables influence the meteorological characteristics of mountain environment and determine dramatic temperature gradients and noteworthy territorial variations. The only meteorological traits generally characteristic of mountainous environment are altitude–dependent decreases in atmospheric pressure and temperature (Richardson et al., 2004). The commonly used average environmental lapse rate is –0.65°C/100 m (Barry & Chorely, 1987; Whiteman, 2000), but significant variations can be claimed. Blandford et al. (2008) affirm that for daily average temperatures, regional vertical lapse rate perform better than the environmental lapse.

Most mountain climatology studies rely on data retrieved by sparse meteorological networks, samples collected in certain spots, or calculation of radiation fluxes from topographic analysis (Barry, 2008). Bica et al. (2007) propose the concept of Low Level Temperature to be used in analyzing the temperature in complex terrain, and Yang et al. (2007) utilize Digital Elevation Model and solar radiation for similar purposes. While GIS–based analyses have fostered significantly the climatologic perspective of the mountain environment (Dubuyah and Rich, 1995; Ustrnul & Czekierda, 2005), satellite images can add valuable information. Despite some limitations such as narrow period available or cloudiness, they enhance both the accuracy and the spatial coverage of the data. Further, Lundquist & Cayan (2007) assert that even short – term datasets collected in patches between the ground weather stations may improve the mountainous thermal picture.

Some scholars argue that the satellite temperature measurements provide better results than interpolating ground stations (Mendelsohn et al., 2007). Dash et al. (2002) provide a theoretical basis and overview of the research dedicated to the retrieval of the LST from passive sensor data. Particularly for mountains, Liu et al. (2006) and Sheng et al. (2009) argue the efficiency of using both MODIS (Moderate Resolution Imaging Spectroradiometer) and ASTER (Advanced Spaceborne Thermal Emission Reflection Radiometer) images in Land Surface Temperature (LST) retrieving. Colombi et al. (2007) demonstrate the viability of the MODIS LST products for analyzing daily mean air temperature, while Yong & Fenling (2006) and Jain et al. (2008) calculated the LST lapse rate in a mountain area based on MODIS and AVHRR (Advanced Very High Resolution Radiometer) products.

This research contributes to better understanding the temperature behaviour in complex terrain, depicts the thermal background of the Romanian Carpathians in July, and explores the potential of using MODIS images in mountain climatology. Provided the regional and local variations of the LST vertical gradient, we analyze the influence of elevation, aspect, slope, geographical location (longitude and latitude), land cover and time (day or night). Since the influence of elevation, aspect, slope, and land cover are quite significant in the area of interest (Dan et al., 2008), this study focuses on these variables.

1.1. Topographic and climatic context

The Carpathians are the largest, longest and most twisted and fragmented mountain chain in Europe, with about 43% of the total area extended in Romania (UNEP/DEWA, 2007). The Romanian Carpathians, also known as South–Eastern Carpathians, lies over 70,000 km^2 and the highest altitude reaches 2,544 m a.s.l. They have a temperate climate and play a major role in the regional air masses circulation.

Based on their geographical characteristics, the Romanian Carpathians are commonly divided in 3 main branches: Orientali (Eastern), Meridionali (Southern) and Apuseni (Western). Since the temperature lapse rate is influenced by local conditions, this study concentrates on more homogenous subdivisions of the main branches, namely: Orientali – Northern (ON), Central (OC), and Curvature (OCv), Meridionali (M), Banatului (B), Poiana Ruscă (PR), and Apuseni (A). Table 2 and Figures 1 – 3 synthesize some general topographic, land cover and climatic features of the seven sub-divisions relevant for this study. Despite the common geographic background (i.e. temperate climate, similar land coverage and aspect), there are many elements to differentiate the seven groups (i.e. altitude, slope) (Table 1).

2. MATERIALS AND METHODS

The investigation focuses on areas above 800 m a.s.l. in the Romanian Carpathians, analyzing the LST data provided by the MODIS sensors aboard the Terra (EOS AM) and Aqua (EOS PM) NASA satellites.

Table 1. Topographic, land cover and climatic features of the Romanian Carpathians. Topography was derived from SRTM Digital Elevation Model (1 km resolution), land cover from CORINE database, and the climate is based on weather station data interpolated over the area of interest

	ON	*OC*	*OCv*	*M*	*B*	*PR*	*A*
Surface (km^2)	5530	11438	4053	11012	759	537	3789
Maximum altitude (m)	2094	1930	1765	2383	1406	1281	1787
Average slope (degrees)	4.3	3.7	5.0	7.1	3.9	3.7	4.3
Aspect (maximum/ minimum frequency of orientation, in %)	26.2/ 23.4	28.5/ 20.6	29.3/ 20.2	26.8/ 23.5	30.1/ 21.3	30.8/ 14.9	27.5/ 22.2
Land cover (forest frequency, % from total)	75.1	78.2	88.4	77.4	87.1	82.2	70.3
Mean annual air temperature (ºC)	3.7	3.8	4.5	4.0	6.2	5.8	4.8
Mean July air temperature (ºC)	12.9	13.4	13.7	12.7	15.4	14.7	13.9

Table 2. Number of July MODIS images retrieving the LST for at least 1 pixel in the sub-divisions of the Romanian Carpathians (2000 – 2007)

	ON	*OC*	*OCv*	*M*	*B*	*PR*	*A*	*Total*
Daytime	518	554	505	559	440	403	483	937
Nighttime	517	556	488	567	461	419	491	954

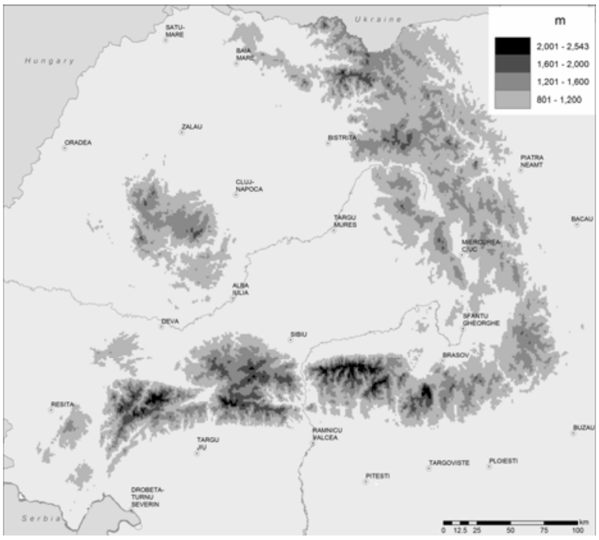

Figure 1. Altitudes of the Romanian Carpathians.

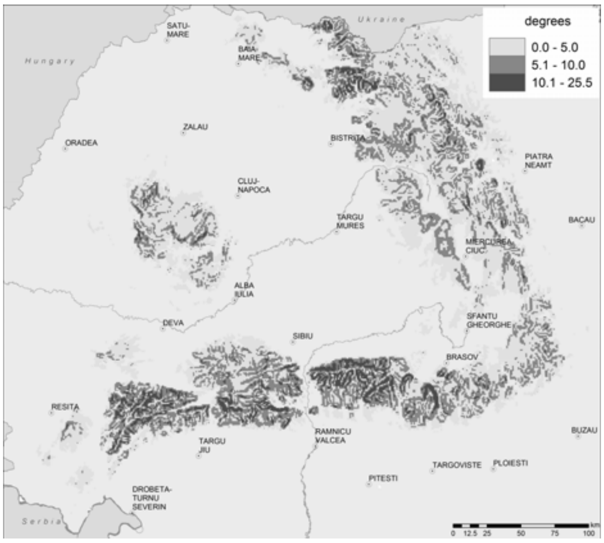

Figure 2. DEM-based slope inclination in the Romanian Carpathians.

Wan et al. (2004) documented that in clear sky conditions, at 1 km resolution, the MODIS LST accuracy is higher than 1°C in the –10 to 50°C range, attesting its proficiency for studying the LST in heterogeneous areas.

Two MODIS products, MOD11_L2 and MYD11_L2, supply instantaneous views of the LST, at 1–km resolution, twice a day each (two night– and two day–time images) and they were examined consequently. The brightness temperature and the surface emissivity are incorporated in the algorithm of the MOD11_L2 and MYD_L2 products. General information about MODIS is currently available (http://modis.gsfc.nasa.gov/) and many sources supply technical details on the products and their application in LST studies. Dash *et al*. (2002) provides a theoretical basis and an overview of the research dedicated to the retrieval of the LST from passive sensor data. More specific technical details on the products MOD11_L2 and MYD11_L2 can be extracted from committed Web sites (edcdaac.usgs.gov/modis/mod11_l2v4.asp, edcdaac.usgs.gov/modis/myd11_l2v4.asp.

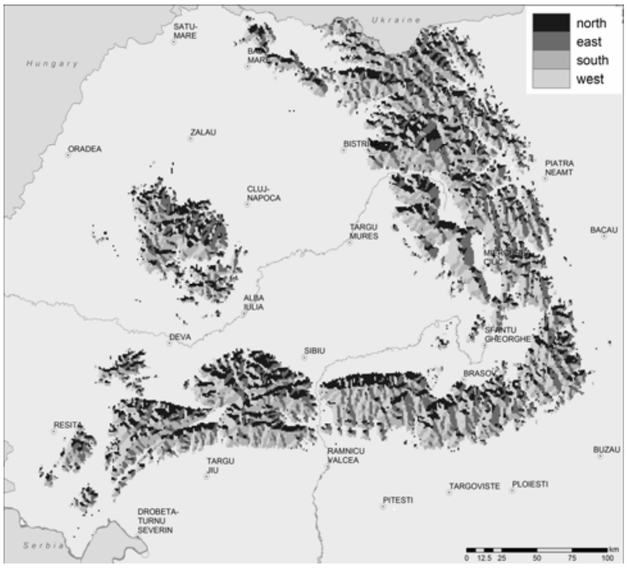

Figure 3. DEM-based slope aspect in the Romanian Carpathians.

There are 1891 images retrieving data for the area of interest in the months of July 2000 – 2007, from which 937 for day and 954 for night. The daytime images cover the interval 08.00 – 12.40 UTC, and the nighttime LST is retrieved between 18.45 and 01.55 UTC. In July, the sun raises at 02.35 – 03.01 UTC and sets at 18.03 – 17.41 UTC. The Bucharest local summer time is UTC+3. The satellite derived LST is controlled by objective factors (e.g. cloudiness, blurry atmosphere), so that some images cannot be used. This analysis utilized the July MOD11_L2 and MYD11_L2 products having at least one pixel with LST registered in the Romanian Carpathians at elevations above 800 m a.s.l., through 2000 – 2007. In order to get a homogenous dataset and avoid including erroneous values, a double filter was applied to the satellite products. First, for each pixel, the data placed beyond the interval (*ave* ± 2**stdev*), where *ave* is the average and *stdev* is the standard deviation, were eliminated. Second, the same filter was applied for each image, removing the extreme values that might have artificially biased the results. Basically, the mean coverage of the Romanian Carpathians with MODIS images useful for this study is 30 – 50%, while the maximum values reach 100% (Table 2, Fig. 4). Taking into account that the dataset samples the entire area (1), covers diverse environment settings (2), and represents different synoptic conditions (3), we assume that the general patterns and relationships investigated here, as well as the proposed methodology are robust and can fundament further applications.

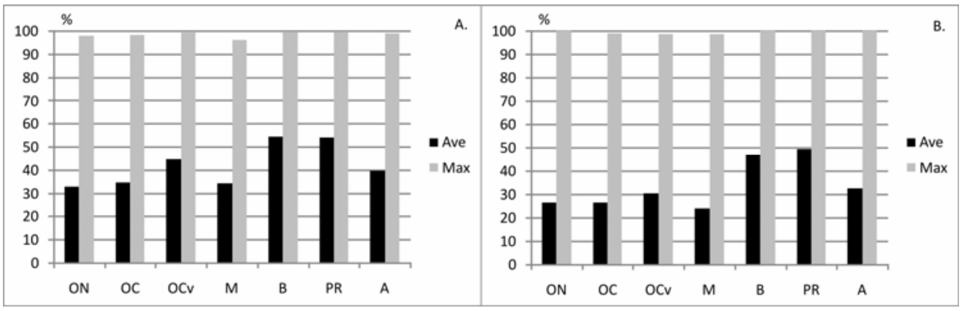

Figure 4. Average and maximum coverage of diurnal (A.) and nocturnal (B.) MODIS images (% from sub-division total surface).

Striving to retrieve LST lapse values that take into account the local conditions as much as possible, the dataset has been explored considering the following demarcations: (a) Time: day (08.00 – 12.40 UTC) or night (18.45 – 01.55 UTC); (b) Sub–divisions: ON, OC, OCv, M, B, PR or A (as explained in Figure 2); (c) Aspect: North, East, South, West; the orientation was recorded as the angle between the North vector and actual orientation, and the statistical analyses used values assigned as E (East) for angles between 45º – 135º, S (South) between 135º – 225º, W (West) between 225º – 315º, or N (North) otherwise; (d) Slope: inclination against the horizontal plane, in degrees; (e) Land cover: forest and grassland, extracted from the database - http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=667, at the same resolution as the MODIS images (1 km); the barren rocks were assimilated to grassland and other land covers (i.e. lakes, settlements) were not included in the survey. The Processed SRTM 90 m Digital Elevation Data (DEM)[1] supplied the topographic information, which was converted to 1 km resolution.

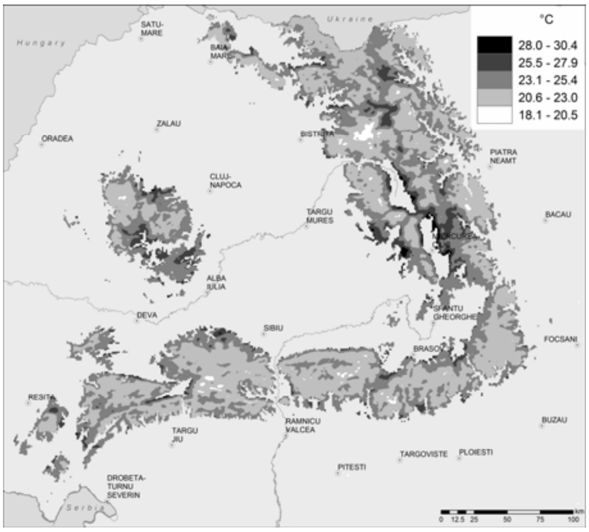

Figure 5. The daytime July LST in the Romanian Carpathians as derived by MODIS images.

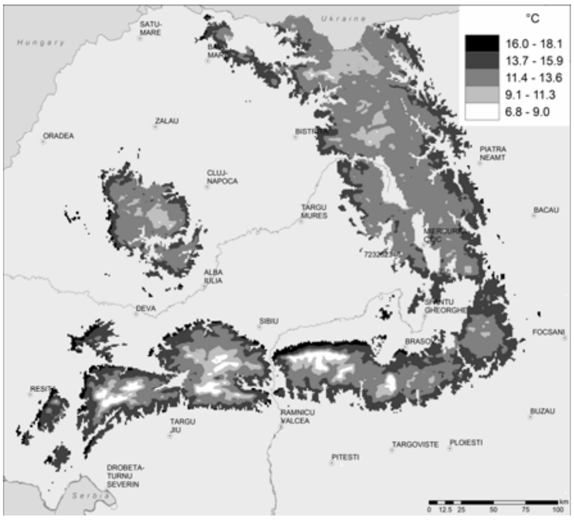

Figure 6. The nighttime July LST in the Roma-nian Carpathians derived by MODIS images.

Statistical analyses assessed the individual and simultaneous influence of quantitative and qualitative predictors on LST. The quantitative predictors were the longitude, latitude, altitude and slope, while the qualitative predictors were the land cover, massif and aspect. The method used to test the influence of predictors acting individually was simple linear regression, while simultaneous influence was assessed using the Analysis of Co-Variance (ANACOVA), implemented via the Generalized Linear Models. The dataset was analyzed for day and night separately, and data for each combination between the moment of the day and massif. The magnitude of the individual influence of predictors on mean LST was assessed within each model based on the coefficients of determination R^2, measuring the amount (percentage) of variation. Whereas in ANACOVA the R^2 refers to the simultaneous effect of all predictors, we used the R^2 from individual models to quantify the particular influence of each predictor. Even though the sum of R^2 obtained from individual models does not equal the value of the R^2 from the global model, the two are generally close, suggesting that individual influences are preserved when all predictors act simultaneously.

[1] http://srtm.csi.cgiar.org

Table 3. ANACOVA-based values of the coefficient of determination R^2. Unless marked by ^{n}, $p<0.05$

		Geographic divisions of the Romanian Carpathians							
Moment	Variable	All	ON	OC	OCv	CM	B	PR	A
Daytime	Ensemble	0.50	0.45	0.59	0.51	0.42	0.53	0.57	0.63
	Longitude	<0.01	<0.01	0.01	0.01	0.01	<0.01^{n}	0.30	0.12
	Latitude	<0.01	0.04	0.09	<0.01	<0.01	<0.01^{n}	<0.01^{n}	0.13
	Altitude	0.29	0.21	0.40	0.40	0.24	0.29	0.31	0.48
	Slope	0.03	0.01	0.05	0.01	0.01	<0.01^{n}	<0.01^{n}	0.01
	Aspect	<0.01	0.02	0.02	0.02	<0.01	0.03	0.02	0.01
	Land cover	0.10	0.15	0.18	0.04	0.03	0.20	0.17	0.12
Nighttime	Ensemble	0.57	0.52	0.38	0.47	0.70	0.47	0.49	0.51
	Longitude	<0.01	0.13	0.08	0.05	<0.01	0.17	0.32	0.02
	Latitude	0.01	0.01	0.04	0.04	<0.01	0.05	0.01^{n}	0.01
	Altitude	0.42	0.33	0.17	0.38	0.64	0.11	0.03	0.38
	Slope	<0.01^{n}	0.01	0.01	0.02	<0.01	0.12	0.09	0.05
	Aspect	0.01	0.01	<0.01	0.02	0.04	0.1	0.14	0.01
	Land cover	0.12	0.09	0.11	0.05	0.18	0.12	0.10	0.01

3. RESULTS AND DISCUSSION

3.1. The July list and the vertical lapse in the Romanian Carpathians

Figures 5 and 6 show the distribution of the LST in July over the Romanian Carpathians, both for day- and nighttime, as retrieved from the MODIS products MOD11_L2 and MYD11_L2, averaged through 2000–2007. While the values are strongly biased by the moment of the day, there is also noticed a strong influence of the altitude. The average daytime LST ranges between 18.1 and 30.4ºC, and the highest values occur at lower elevations (i.e. intra-mountainous depressions, low mountains). The average nighttime LST varies between 6.7 and 18.2ºC, and the spatial pattern is similar to the diurnal one. Table 3 shows the magnitude of the individual and combined influence of longitude, latitude, altitude, slope, aspect, and land cover on the mean day– and nighttime LST. The influence is statistical significant in most of the cases ($p<0.05$). The results of the ANACOVA suggest that in the Romanian Carpathians the variables ensemble explain 50% of the LST variation at daytime and 57% at nighttime. This influence is very active in all the geographic divisions, varying between 38% and 70%. The same statistic test highlighted that the altitude and the land cover are the most powerful controlling factors for the LST, both for all the Carpathian range or its geographic divisions. That is, once the influence of the altitude and land cover is removed from the LST values, additional co–variables can explain only a small amount of the remaining variance, which is in agreement with other findings (Blandford et al., 2008).

The following sections focus on the individual influence of the elevation, aspect, slope, land cover, latitude and longitude on the LST and its vertical gradient.

3.2. Elevation

The linear regression between LST and altitude retrieves vertical gradients of –0.28ºC/100 m for daytime and –0.39º/100 m for nighttime (Figs. 7 and 8).

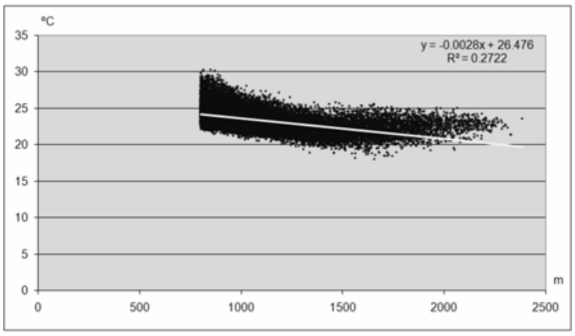

Figure 7. Daytime vertical lapse of the LST in the Romanian Carpathians.

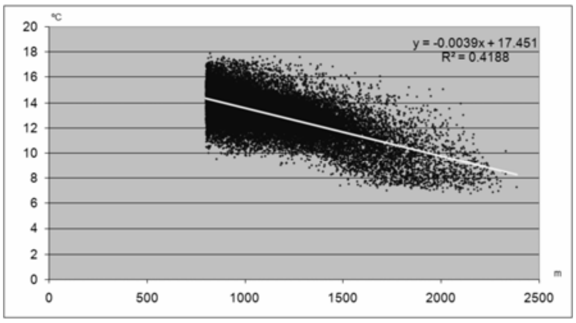

Figure 8. Nighttime vertical lapse of the LST in the Romanian Carpathians

The low correlation coefficients and the distribution of the data suggest that the elevation cannot explain alone the LST variations. This is more evident during the day, as a result of the heterogeneous allocation of the solar radiation over the surface, while this input is absent by night. The simple regression analysis has been extensively used for assessing temperature decrease with altitude (De Scally, 1997; Rolland, 2003). However, Lundquist and Cayan (2007) argue that the variations of the mountain temperatures cannot be adequately represented by linear lapse rates. Yong and Fenling (2006) found good linear relationship between LST and altitude, but they acknowledge the influence of geospatial factors may disturb the fitness. At the same time, the relationship between solar radiation and thermal gradients is usually non-linear and site-specific (Bennie et al., 2008), and the moist adiabatic lapse rate is not constant along the altitude (Whiteman, 2000). Therefore, the logarithmic trend fits better the relationship between elevation and LST lapse, and gives the possibility to scrutinize the values of the gradient at different altitudinal levels. Table 4 shows the values of the LST and the vertical lapse based on logarithmic functions in the area of interest. The surface temperature decreasing is lower once the influence of the Earth atmosphere becomes more intense, namely at higher altitudes. Other studies reported similar patterns (Yong & Fenling, 2005). On the other hand, Pepin (2001) and Blandford et al. (2008) reported lapse rates generally steeper by day and weaker by night, apparently unlike our findings for the Romanian Carpathians. In reality, the sharper diurnal gradient refers to screen temperature, measured in similar topography and land cover circumstances, while the LST derived from MODIS images integrates the information over 1 km^2. During the day, the mountain parcels are heated quite heterogeneously due to the diverse repartition of the solar radiation. At a certain moment, the LST can have very close values in a forest at 1,000 m and over lawn patches at 1,500 m, leading to a very low vertical gradient. On the contrary, the solar radiation is absent by night, so that the surface properties decide the LSTs. Regardless of the elevation, the forest can retain more heat than grasslands, and since most forested areas are located at lower altitudes, the nocturnal LST vertical gradient is steeper (Table 4).

3.3. Aspect

The different insulation of the mountain slopes has plain ecological consequences, such as the variations of the timberline limit and distinctive biodiversity. The aspect strongly affects the amount of solar radiation intercepted by surface (Bennie et al., 2008), and the LST varies accordingly. Neacşa et al. (1972) documented the correlation between slope exposure and air temperature in the Romanian Carpathians, considering three aspect categories: south (a), east and west (b), and north, valleys and depressions (c). Even if the temperature values are very different, they found that the July thermal lapse at elevations above 800 m a.s.l. is quite similar for the three categories.

Table 4. July land surface temperature and vertical lapse for different elevations in Romanian Carpathians

Altitude (m)	LST (ºC)	Lapse (ºC/100 m)	LST (ºC)	Lapse (ºC/100 m)
	Daytime		Nighttime	
800	24.50	-	14.57	-
900	24.05	-0.44	14.02	-0.55
1000	23.66	-0.40	13.53	-0.49
1100	23.30	-0.36	13.09	-0.44
1200	22.97	-0.33	12.69	-0.40
1300	22.67	-0.30	12.31	-0.37
1400	22.40	-0.28	11.97	-0.34
1500	22.14	-0.26	11.65	-0.32
1600	21.89	-0.24	11.35	-0.30
1700	21.67	-0.23	11.07	-0.28
1800	21.45	-0.21	10.80	-0.27
1900	21.25	-0.20	10.55	-0.25
2000	21.06	-0.19	10.31	-0.24
2100	20.87	-0.18	10.08	-0.23
2200	20.70	-0.17	9.87	-0.22
2300	20.53	-0.17	9.66	-0.21
2400	20.37	-0.16	9.46	-0.20

Despite the strong relationship between LST and aspect, the vertical gradient has no clear aspect induced pattern. While analyzed at the scale of the Carpathians' geographical divisions, the thermal lapse is quite close for different exposures, both for day- and nighttime, with no distinct pattern revealed (Fig. 9). Its highest diurnal value (–0.67ºC/100 m) occurs on the western slopes of the Carpații Orientali's central branch (OC), and we assume two major causes: (1) the depressions Giurgeu and Ciuc, narrow and elongated, north–south oriented, favor air stability, so that strong temperature inversions are frequent; as a consequence, while the western slopes inside the depressions are subjected to low temperatures, the outside west-oriented surfaces are well warmed; (2) the afternoon sunrays act vigorously on some western slopes and quite ineffectively on others, located in the shadow of the first ones (Fig. 10). Such combination can be also found in other Carpathian areas, but not at the same extension and intensity. The nocturnal record belongs to the Carpații Meridionali division (M), the thermal lapse reaching –0.63º/100 m on its southern slopes. It is the effect of the noticeable heterogeneity of the land cover in the area, besides the higher altitudinal array. The nocturnal cooling in the abundant woodland rising up to 2,148 m is substantial different than in the alpine meadows and barren patches that dominate the higher areas (Fig. 11). The control of the slope orientation on the LST gradient is blurred even more by the shadow effects specific to the complex mountain topography. Thus, western slopes receive very different solar radiation amounts according the width of the local horizon.

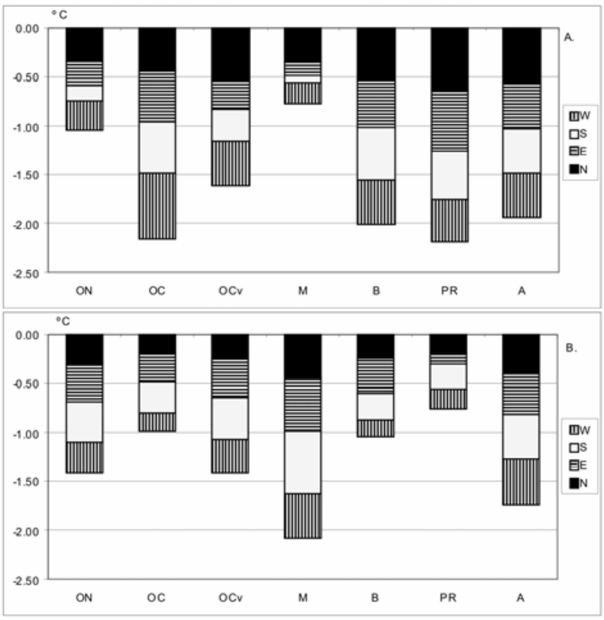

Figure 9. Aspect-based July vertical thermal lapse (°C/100 m) in the geographical divisions of the Romanian Carpathians, by daytime (A.) and nighttime (B.)

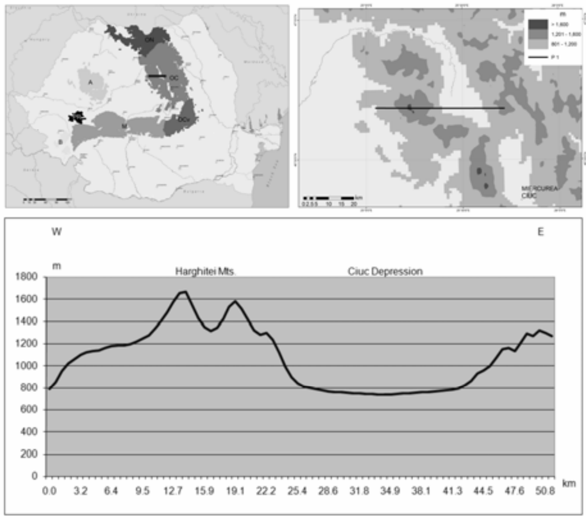

Figure 10. W – E cross-profile through the DEM in the central sector of the OC.

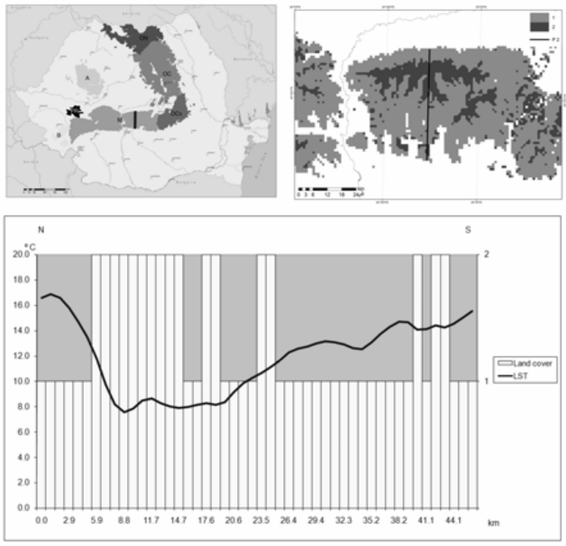

Figure 11. N – S cross-profile through the land cover (1. forest; 2. grassland) and night LST in the sub-division M.

3.4. Slope

The Earth surface heating depends directly on the sun radiation received, and the contact angle between the sunrays and earth surface plays a considerable role. In the absence of sun radiation, the slope influence on the LST is null. By daytime, the radiation values can have similar values on horizontal surfaces and on 45° – slopes, due to the major effect of other variables (i.e. aspect, land cover, shadow effect etc.). Lipton (1992) and Whiteman (2000) provide theoretical solar radiation and temperature on slopes of different inclination, suggesting their large diurnal variations and aspect– dependency. The simulated surface temperature variability increases quickly after sunrise, as steep slopes facing the low sun are heated strongly while other steep slopes remain little or unexposed to the sun. The LST is more homogenous around noon, and its spatial distribution broadens again in the afternoon (Lipton & Ward, 1997).

Yang et al. (2007) stress that the relationship between slope and mean annual temperature increases only after "terrain revision", that is to take into account other topographical co-variables. Barry (2008) provides a few examples on the unsystematic character of slope influence on radiation: in the Caucasus, under clear sky conditions, the June average net radiation at 3,600 m a.s.l. reaches 42 kJ/cm^2 on a horizontal surface, 28 kJ/cm^2 on 30°N slopes, and 68 kJ/cm^2 on 30°S slopes (Borzenkova, 1967, in Barry, 2008). In the Romanian Carpathians, the slope influences very weakly both the LST and its vertical lapse. The linear correlation coefficient between the July LST and slope angle has very low values (Figure 14), and analyzed in combination with other potential bias factors, the slope confirms its marginal control on the LST (Table 3).

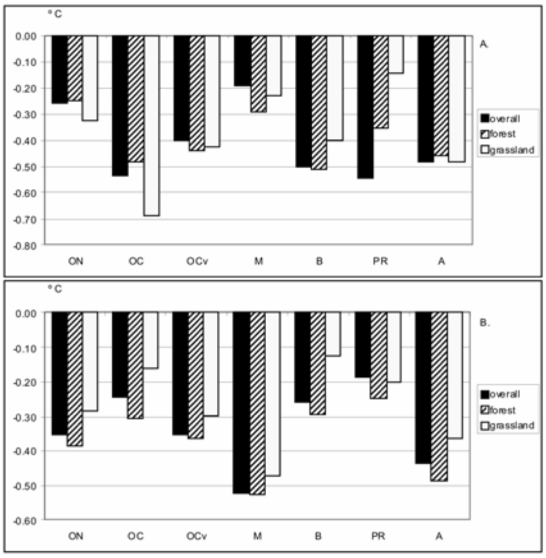

Figure 13. Land cover-based July vertical thermal lapse in the geographical divisions of the Romanian Carpathians, by daytime (A.) and nighttime (B.)

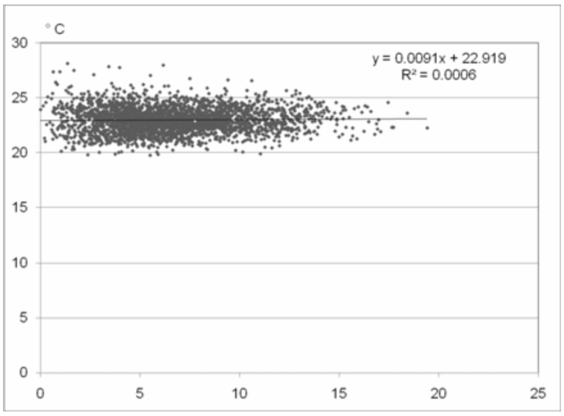

Figure 14. Linear regression between slope angle (in degrees, on the horizontal axis) and LST in Carpații Meridionali

3.5. Land cover

Over complex terrain areas, the remotely sensed pixels reflect a mixture of land covers that complicates data assimilation and analysis (Liu, 2006). Gallo et al. (1996) demonstrate that even changes in land cover within 10,000 m radius can influence the LST and its diurnal regime. Besides, Sheng et al. (2009) assume that the summer LST estimates are not as much sensitive to terrain factors like land cover and aspect as the winter ones. Yet, the ANACOVA placed the land cover as the second influencing factor on the July LST in the Romanian Carpathians (Table 3). Further, by using the gradients specific to each situation, we calculated the average diurnal and nocturnal LST at 1,000 m a.s.l., for different aspect and land cover (Table 5). During the day, the woodland is 1.2–1.5°C cooler than the grassland areas, while by night it is 0.8–1.2°C warmer. Since the values of some factors are considered constant (i.e. time, elevation, aspect) or insignificant (i.e. slope), one can argue that the land cover role on the July LST is noteworthy. On the other hand, the LST vertical gradients calculated over forested areas and over grassland and barren perimeters are quite close, with differences below 0.2°C in every branch of the Romanian Carpathians (Fig. 13). That is to say that the land cover structure is equally sensitive for LST independent of elevation.

3.6. Latitude and longitude

Rolland (2003) shows that the alpine lapse rate is consistent within 1° width latitude, whereas the influence of the longitude is less relevant. The Romanian Carpathians higher than 800 m range between 21 and 27°N, and 44 and 48°E. Apparently, the correlations between both latitude, longitude and, respectively, LST have very low values (R^2 <0.03, p<0.05), although at the level of homogenous geographic divisions, some relevant dependency of the vertical lapse on the longitude might be claimed (Table 3).

Table 5. Average land surface temperature in July at 1,000 m

	Daytime				*Nighttime*			
Landcover	*N*	*E*	*S*	*W*	*N*	*E*	*S*	*W*
Forest	23.8	23.3	23.2	23.6	14.1	13.8	13.7	13.8
Grassland	25.0	24.7	24.6	25.1	12.9	12.8	13.0	12.8

It might be explained by the different exposure to the western circulation, which dominates the area. The vertical lapse calculated within 1 degree / 1 degree frames does not depend on the geographic coordinates.

4. CONCLUSIONS

The access to satellite LST images depends on atmospheric factors (i.e. cloudiness, transparency) and technical routines, so that one cannot count on a constant data delivery. Another shortcoming refers to the fact that the dataset accumulated so far does not support standard climatologic uses. Sometimes, the current mountain activities require very local information which MODIS images cannot retrieve. In addition more data would change mainly some quantitative results, and not the general patterns identified in this study.

The elevation, land cover, and aspect exert – in this order – the most significant influence, while other factors (i.e. slope) may induce local variety. Other biases must be always mentioned (i.e. wind, cloudiness). Since the LST strongly controls the lapse rate (Rennick, 1977), one can expect that altitude, aspect, and land cover remain the major biases. This research has revealed that elevation is the by far the prominent weighting factor. The average environmental lapse rate of –0.65°C must be used cautiously in applied studies, as it always varies regionally and temporally. In the Romanian Carpathians, we have found July variations between –0.2 and –0.68°C. The LST and air temperature eventually follows a similar diurnal regime, but their lapse rates are different. Previous researches showed that the screen temperature lapse rate is steeper by daytime, and milder during the night (Blandford et al., 2008), while the situation changes for LST, as a result of the different radiation input. At the same time, the coupling between land surface and atmosphere weakens with altitude so that the gradient becomes lower and less controlled by land surface. The survey has confirmed a few benefits of using satellite images for retrieving the LST in a complex terrain. It can significantly enlarge the spatial data coverage from a few points to the whole area of interest, reaching even the least accessible territories. For a certain spot, the satellite products can provide direct information, while other procedures supply data derived from interpolation or models. The spatial and temporal resolutions of the products MOD11_L2 and MYD11_L2 fit quite well the mountain climatology needs at a regional scale. Recent progresses foster the use of the MODIS LST products for near–real time applications as well (Pinheiro et al., 2007), and this study provides a corresponding scientific background.

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