SPATIAL DISTRIBUTION OF SOME CLIMATE PARAMETERS IN BRAŞOV MOUNTAINS FOR DIFFERENT CLIMATE CHANGE SCENARIOS

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Abstract: *The paper presents some results of the researches undertaken for establishing the spatial distribution of important climate parameters in Braşov Mountains (Postăvaru and Piatra Mare). The main factors considered for modelling the temperature spatial variation are the altitude and the solar energy available at cell level, its distribution in the study region being determined using the digital elevation models and SAGA GIS. There were considered two climate change scenarios corresponding to an increase of CO_2 at 450 ppm and CH_4 at 2 ppm (scenario 1), respectively a CO_2 content of 800 ppm (scenario 2).*

Key words: *climate parameters, spatial distribution, climate change.*

1. Introduction

In mountain areas the local climate conditions are highly variable, due to the pronounced variation in slope gradient, aspect and hillslope position, associated with differences in the soil and vegetation cover. Especially, the trees as organisms with a fixed position are very sensitive even to slight differences in the climate factors regime, given the cumulative effects. Thus, the analysis of the climate parameters spatial distribution is a prerequisite for the sustainable management of mountain forests. Its importance is enhanced in the context of the possible climate changes. For example, assuming a warming trend, its effects would be buffered on northern aspects, in deep valleys, but these would be emphasised to extreme on steep southern slopes, with shallow dry soils and exposed to strong winds.

Presently, the development of the geographic information systems allows researchers and engineers to quantify the spatial variation of the natural conditions, including the climate parameters [3].

The researches regarding the climate parameters spatial distribution in steep terrain areas, synthesized in this paper, focused the region, located south of Braşov city, comprising two mountains: Postăvaru and Piatra Mare.

2. Spatial Distribution of Solar Radiation

Solar radiation is the main energy source for all the processes taking place in the

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earth atmosphere, and consequently it plays the central role in climate genesis. This energy is not entering the atmosphere system directly but through the interaction with ground surface, that influences the climate by its shape (landform) and reflective properties.

The amount of incident solar energy depends on astronomic factors (time of the year, moment of the day) that could be easily computed and also on stochastic factors, such as air masses transparency.

The inclination and aspect influence the incident beam, diffuse and reflected radiation. The effect of slope and aspect is higher under clear-sky as compared to the cloudy conditions, when diffuse radiation dominates and the main influence factor is the visible sky.

According to Lambert's law [1], the solar direct radiation received by the surface unit is a function of the angle formed by the

solar beam with the surface (it could be computed [4] as the product between the intensity on the beam cross section and the cosine of the beam inclination angle).

The sunshine duration and the amount of diffuse radiation depend on the visible sky that is determined in GIS by taking into account the height of the mountain ridges which delineate the horizon, considering the main cardinal directions.

For calculating the incoming solar radiation and sunshine duration, it was used the SAGA software (System for Automated Geo-Scientific Analysis), primarily developed in two German Universities [2].

In order to establish the radiation factors to be used for modelling the distribution of air temperature in the study areas, the above mentioned solar parameters were calculated for each month (considering the sun position at the monthly middle). Some examples are presented in Figure 1.
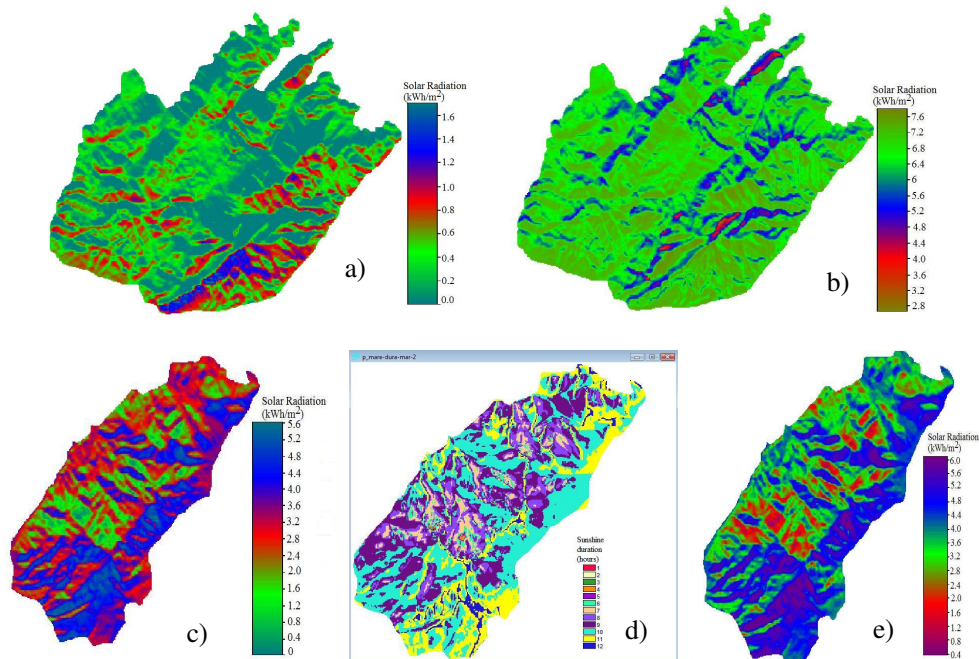
Fig. 1. *Solar radiation in Braşov Mountains: examples of thematic maps for incoming radiation* (kWh/m^2) *in Postăvaru* (*a - January, b - June*) *and Piatra Mare* (*c - March, e - September) and sunshine duration* (*d - in March, Piatra Mare*)

In January, when the sun position is low, the incoming energy on the slopes of Postăvaru (Figure 1a) is reduced, higher values occurring on the southern cliffs (marked in blue). In June, with the sun at maximum apparent height, despite the differences at particular moments between various slopes, the daily amounts are less variable (Figure 1b). The examples for Piatra Mare, in March and September, show that the range of values is similar but the spatial distribution of received energy is completely different (Figure 1c-e).

3. Temperature Spatial Distribution

For determining the temperature spatial distribution in this mountain region, a simple model was developed, considering two main variation factors: local heating (produced by the incoming solar energy) and air circulation that brings air with a certain temperature from the same level in the free atmosphere. The first factor was modelled as discussed above, by computing for each month the ratio between the incoming solar radiation in each cell of the raster layer and the value corresponding to the position of the Braşov-Prund weather station. As regards the second factor, despite the differences in the vertical temperature profile in shorter time intervals, for the monthly values it was adopted the mean troposphere gradient [5].

In these researches two climate change scenarios were taken into account. The first scenario was simulated using EdGCM, for the increase of CO_2 to 450 ppm and of CH_4 to 2 ppm, and the data were extracted for the decade 2011-2020. The second scenario was produced for the hypothesis of a CO_2 content reaching 800 ppm and the data were computed for the interval 2021-2030. A few examples are given in Figure 2.
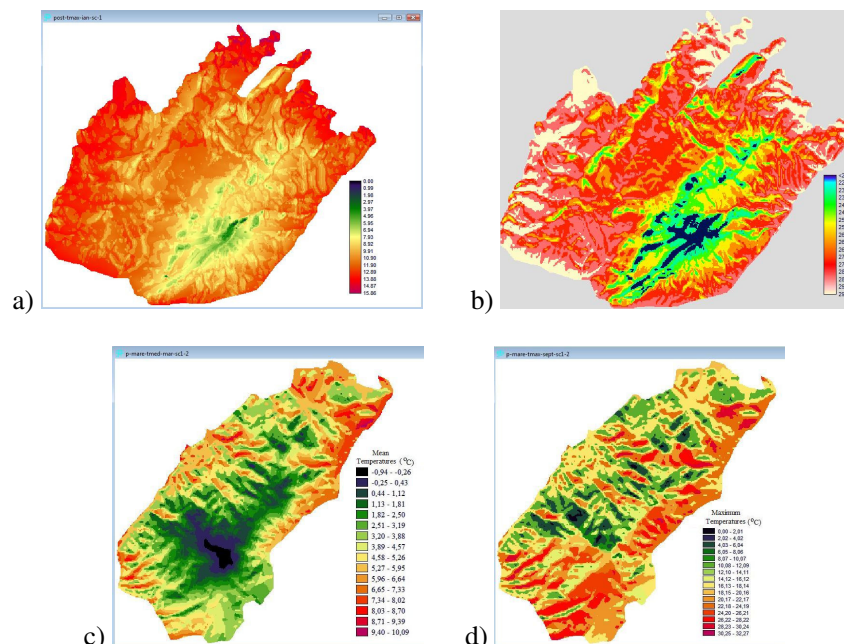

Fig. 2. *Temperature spatial distribution maps: examples for Postăvaru (maximum temperatures, a - in January, scenario 1; b - June, scenario 2) and Piatra Mare (c - mean temperatures in March, d - maximum temperatures in September, both for scenario 1)*

As shown in Figure 2a, for the first climate change scenario, the January maximum temperatures in Postăvaru are positive, between 2 and 6 °C in the highest areas, ranging from 7 to 12 °C on the extended middle elevation areas and reaching 12-15 °C in the mountain foot area. For the second scenario, the maximum temperatures in June (2021-2030), appear to exceed 27 °C over very large areas, only above 1500 m and on few northern slopes the values remain between 22 and 26 °C (Figure 2b). The mean temperatures in March, for scenario 1, in the decade 2011-2020 (Figure 2c) are ranging in Piatra Mare from −1 to 10 °C. In September, which occurs to experience a clear warming trend for the scenarios considered, the maximum temperatures on the southern and eastern slopes of Piatra Mare are higher than 22 °C and in some spots go over 30 °C (Figure 2d).

3. Conclusions

As regards the possible climate changes issues, the forest management decision making process requires data for the stand level. Consequently, for mountain regions it is not enough to use regional climate models or accurate techniques for downscaling GCM results, because the local climate conditions are modified on the mountain slopes, in accordance with aspect, inclination and shading.

The GIS layers with the temperature spatial distribution, determined for each month and climate change scenario, as shown in the examples presented in this paper are very useful. From these spatial databases, climate parameters values could be extracted for each forest management unit. Such sets of local climate parameters (significantly different from those established for the regional reference weather station, as shown above) are necessary for feeding the forest growth models, in order to estimate the impact of a certain climate change scenario.

Acknowledgements

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