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Aspects of Solar Radiation Analysis using ArcGis

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Abstract. The solar radiation distribution on Earth's surface is strongly influenced by topographic factors and surface features such as elevation, surface orientation, slope and slope shape, shadows determined by topographic features. All these factors in turn affect the quantification of the light environment. Modeling the solar radiation can be extremely efficient in understanding the spatial and temporal variation of solar radiation over landscape scales. Spatial Analyst extension provided by ArcGIS allows us to analyze the effects of sun on a geographical area for specific time periods. In this paper we propose to represent the amount of solar radiation on a geographical area (Stowe, Vermont), during a period of three months.

Keywords: solar radiation, ArcGIS, Spatial Analyst.

INTRODUCTION

Acting as a source of energy in photosynthesis, the light is the basic condition for obtaining high quality agricultural productions.

The progress of knowledge regarding the procedures based on estimating the insolation on various geographical locations is important for numerous applications, including the solar energy and irrigation systems, the cultures' growth patterns and the forecasts of the evapotranspiration. Those stipulated emphasize the fact that the solar radiation is one of the most important vegetation factors and the interaction of the solar radiation with the plants represents a major interest for creating the forecasts on the agricultural production. (Rich *et al.*, 1994)

The global radiation received from the sun, on a horizontal surface at the ground level for one clear sky day, consists of the added value of the direct radiation and the diffused radiation.

The direct radiation reaches the terrestrial surface in an unmodified form, without other interactions with the atmosphere's particles. Diffuse radiation is scattered out of the solar beam by gases and by aerosols. Reflected radiation is mainly reflected from terrain and is therefore more important in mountainous areas. Direct radiation is the most important component of global radiation because it contributes the most to the energy balance and also the other components depend on it, either directly or indirectly (Kumar *et al.*, 1997).

The existence of some patterns for estimating the solar radiation as well as its components in certain geographical areas is extremely useful in various applicable domains: agriculture, climatology, ecology, building design, land management. (Baldocchi *et al.*, 1985)

Additionally, the topographic factors such as elevation, slope, slope orientation (azimuth or aspect), and shadowing, fulfill an important role within the overall solar energy received by a particular location on Earth. (Crişan *et al.*, 2009)

Modeling the solar radiation can be extremely efficient in understanding the spatial and temporal variation of solar radiation over landscape scales. Spatial Analyst extension

provided by ArcGIS allows us to analyze the effects of sun on a geographical area for specific time periods. (Fu *and* Rich, 1999)

In this paper we propose to represent the amount of solar radiation on a geographical area (Stowe, Vermont), during a period of three months (February, July and September 2013). In this respect we use a mathematical algorithm implemented in ArcGis.

Also, using Spatial Analysis tools, starting with the Digital Elevation Model (DEM) of the analyzed region, we illustrated the Slope map, Aspect map and Hillshade map, useful in researches on solar radiation analysis for a particular geographical area.

MATERIALS AND METHODS

The Digital Elevation Model (DEM) is the start point both for executing the digital geo-morphological maps, as well as for the spatial analysis and the mathematical modeling, methods that are specific for the Geographic Information System (GIS), in view of solving several theoretical and practical problems from various domains.

For estimating and analyzing the total amount of insolation in a geographic area with complex topography we used as input data a DEM from Stowe, Vermont. The information provided by DEM technique such as slope or aspect and integrated within a geographical information system allows fast and efficient estimation of solar radiation over a large area (Tovar-Pescador *et al., 2006).*

Spatial Analyst extension provided by ArcGIS allows us to illustrate, starting from DEM, the Aspect map, the Slope map and the Hillshade map. The mountains' orientation map (Aspect) is highly important for emphasizing the mountains' orientation towards sunny or less sunny areas. The Hillshade map illustrates the shadowy and the bright areas, being useful in order to see the eligibility of some agricultural cultures according to their need for light.

The Aspect map, along with the Slope map contribute to the analysis of the global radiation map, on surface units, as the plants' need for light and temperature are well known, also contributing to the division by areas of various agricultural cultures.

Solar radiation analysis tools in the ArcGIS Spatial Analyst extension allow as illustrating the map of insolation and analyzing the effects of the sun over a geographic area for specific time periods. In our paper, we consider a surface from Stowe, Vermont (Environmental Systems Research Institute Channel 2013).

RESULTS AND DISCUSSIONS

As we mentioned before, a Digital Elevation Model plays an important role for achieving the digital map, but also for spatial analysis, Geographic Information System (GIS) specific methods, in view of modeling some theoretical issues or interpreting and analyzing certain phenomena.

A DEM is usually described by an image matrix in which the value of each pixel is associated with a specific topographic height. For our purpose we consider a surface Digital Elevation Model from Stowe, Vermont.

The analysis of a climatic potential of a region based on the DEM occurs when estimating the solar radiation and the temperature's irregular distribution on the terrestrial surface. The slope and the mountains' exposure are two parameters that influence the solar radiation while the altitude and latitude set the temperature's distribution. Additionally, the model presented in this project emphasizes the influence of the shading factor's patterns on the direct radiation by using the ArcInfo Hillshade function.

The map of exposing the mountains, slopes and shadows was generated by using the Spaţial Analyst: Aspect (Fig. 1), Slope (Fig. 2) and Hillshade (Fig. 3). The ArcInfo Solar Analyst provides two models for estimating solar radiation at the surface. Point specific model computes insolation for a specific location and area based model is useful to calculate insolation for every location over a landscape (Tovar-Pescador *et al., 2006).*

In the present work, we illustrated the insolation using the latter. The result is emphasized by comparison in Fig. 4, the map of insolation for February, Fig. 5, the map of insolation for July, Fig. 6, the map of insolation for September. The ArcInfo Solar Analyst tool is used to estimate the global radiation data in the area of Stowe, Vermont.

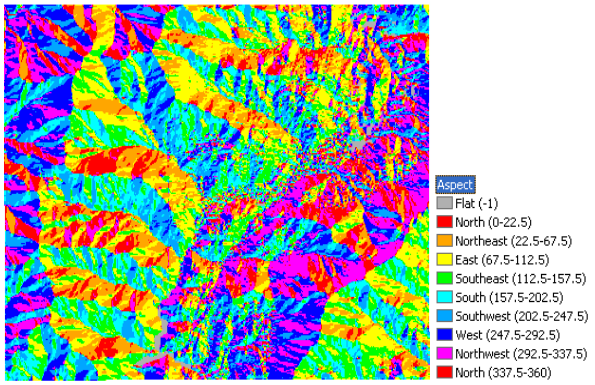

Fig. 1. Aspect

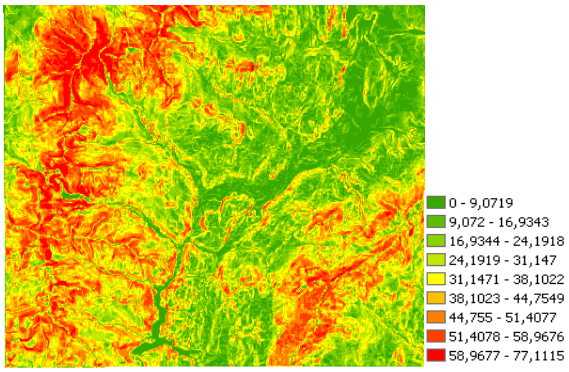

Fig. 2. Slope

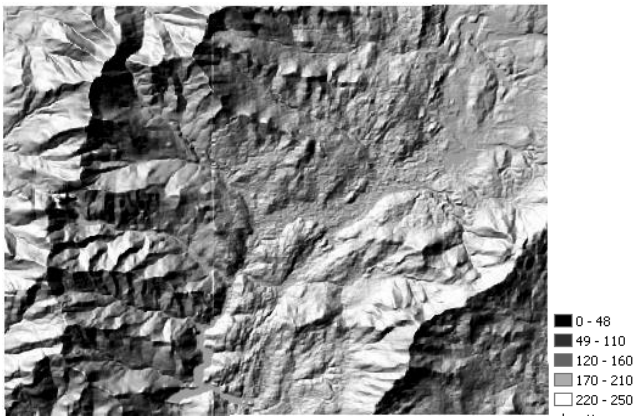

Fig. 3. Hillshade

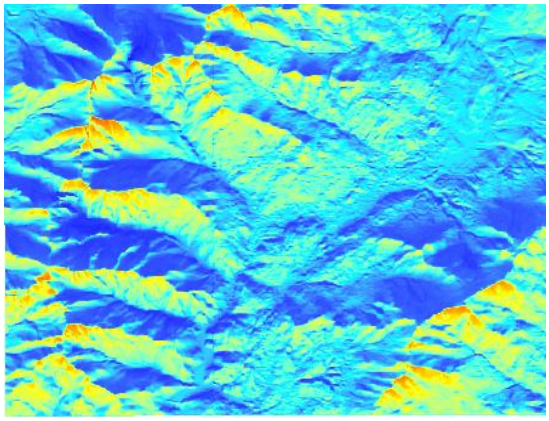

Fig. 4. Map of insolation for February 2013

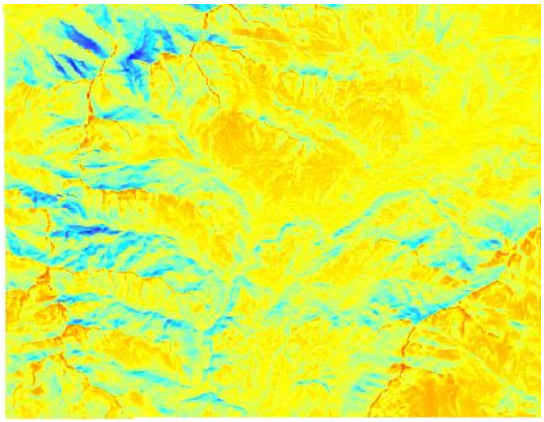

Fig. 5. Map of insolation for July 2013

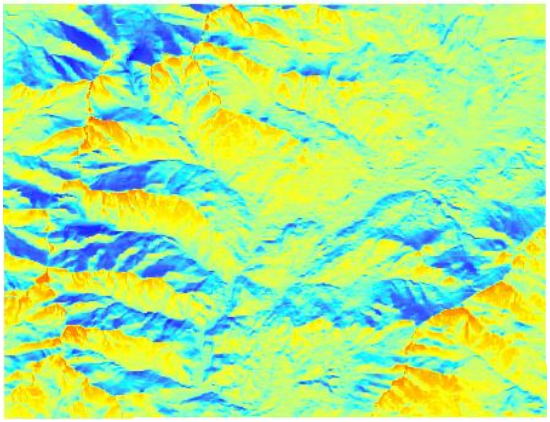

Fig. 6. Map of insolation for September 2013

CONCLUSION

- The solar radiation is one of the most important factors which stimulates the biophysical and biochemical processes of the plants, thus influencing the achievement of a large and high quality agricultural production input.
- In the matter of the solar radiation distribution on Earth's surface, the analysis instruments provided by ArcGIS Spatial Analyst allow a map drawing and an analysis of Sun's effects on a geographical area during a certain specific time frame.
- The information provided by DEM allows an efficient and low-cost forecast of the solar radiation for a certain area, considering the topographic parameters in the radiation transfer model.
- The maps of slope, aspect and hillshade for a solar radiation study surface offers the possibility of a subsequent analysis of the solar radiation, considering the importance of the topographic factors in the presented model.

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