Identification of Mesoclimate in Puerto Rico Using Remote Sensing

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ABSTRACT

There are a mesoclimate when exist differences between in an urban, suburban, small-town, forest, etc. where the temperature, rainfall, wind, humidity, soil moisture, vegetation index, topography are different, but it is referred to from tens to hundreds of meters (or yards) across.

In the present paper is presented a technique which allows identifying mesoclimate to Puerto Rico by employing data set of remote sensing. This is possible by using 5 indicators night temperature, day temperature, elevation (or topography), accumulated rain and vegetation index (NDVI).

INTRODUCTION

Urban development, as a major type of land cover change in human history, has a great impact on the environment. In the process of urbanization, trees are cut and natural vegetation cover is largely replaced by paved surfaces. Open spaces are maintained for recreational or ornamental purposes rather than for the production of food or timber, so that the ecosystem dynamics of the remaining 'green' areas of the city are usually quite different from those of the open countryside (Weng G. and Yang S. 2004)

Remote sensing and geographic information systems (GIS) have long been used and been recognized as a powerful and effective tool in detecting urban growth patterns or land uses (Harris and Ventura 1995; Stefanov, Ramsey and Christensen 2001; WENG 2001), but this techniques can be also employed to study microclimate because is possible to obtain several parameters of the sensors, this will be explained later.

The study of micro-climate has been historically linked to agriculture, biology, and ecology, where the viability of organisms and their habitats is dependent upon weather conditions locally and regionally. Therefore is very important to study the microclimate.

Micro-climate is a climate of a small and specific place within an area as contrasted with the climate of the entire area; where the temperature, rainfall, wind, humidity, soil moisture, vegetation index, topography, may be subtly different compared to the prevailing conditions over the area as a whole and from those that might be reasonably expected under certain types of pressure or cloud cover (Scott, Simpson and Mcpherson 1999).

But the term "microclimate" refers to a very specific area, few meters (or yards) across and frequently much smaller. The term "Mesoclimate" refers to from tens to hundreds of meters (or yards) across. So in the present paper the word used will be meso-climate, because our research is about one kilometer.

By using satellite data as sensor AVHRR is possible to obtain the vegetation index, the temperature was obtained of Modis, with radar NEXRAD the rain fall is estimated and the topography is obtained in Partnership for Spatial and Computational Research (PaSCoR) in Mayaguez Campus. All parameters have one kilometer of special resolution and the temporal resolution is limited to June – July – August of present year.

MATERIALS AND METHODS

Study Site

The project is developed in Puerto Rico, which is between latitude 17.88 & 18.62 and longitude -67.3 & -65.55 (Figure 1).

By dividing the land of Puerto Rico in one kilometer there are 8701 grids. So, each grid has 5 parameters, which will be analyzed by employing a technique which will be explained in the next

pages. Therefore, each grid is now a line of values and each different line is “probably” a different mesoclimate.

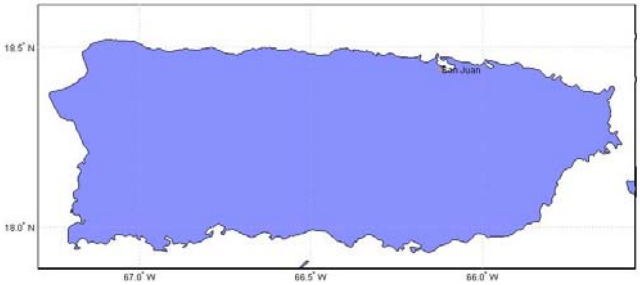

Figure 1: Puerto Rico place where the study is made.

Data Acquisitions

To our study were used 5 parameters, day temperature, night temperature, elevation, accumulated rain and NDVI.

The day and night temperature were obtained of the web site http://edcimswww.cr.usgs.gov/pub/imswelcome/ to June of the 2005, the data selected were to Terra next select the temperature to each 15 days, so we average the two series to obtain the average of temperature to June, this same way is made to obtain the night temperature. The web site gives an archive in HDF format, therefore we need to process the archive and to transform the archive in an ASCII format, and this is possible using a program in Matlab to decode the archive.

The elevation was said that was provided of the Partnership for Spatial and Computational Research (PaSCoR) in Mayaguez Campus, in this laboratory used data of Land Sat TM to obtain the elevation.

Next, to the accumulated rain was necessary to use a radar data, the agency is called NEXRAD which has a 1 kilometer of spatial resolution. There are 158 operational NEXRAD radar systems deployed throughout the United States and at selected overseas locations. The maximum range of the NEXRAD radar is 250 nautical miles. The NEXRAD network provides significant improvements in severe weather and flash flood warnings, air traffic safety, flow control for air traffic, resource protection at military bases, and management of water, agriculture, forest, and snow removal. The data is able in this website http://dipper.nws.noaa.gov/hdsb/data/nexrad/sjrfc_mpe.php, the data to use is XMRG.

Finally, to the NDVI was employed the data set of NOAA Satellite with the AVHRR sensor. In the Mayaguez Campus is possible to have access of this data in the office of the Space Information Languages (SIL) where employing a language Linux, Unix and a software TerraScan are read data of the satellite, first is very important to examine if the image pass for the area of interest (Puerto Rico) and by finding image with fewer clouds cover to have a clear image.

Preprocessing

Each indicator, except the elevation was necessary to do a data process, because or their format is different or need special software to read the data.

For example to obtain the temperature data was necessary to run a script in Matlab which read and interpolate the data to carry it a same resolution with the elevation and this gives a data in ASCII format, which is import to begin to do the study.

To read the accumulated rain was necessary to run a script in Unix to decode the data. Next, similar steps that to the temperature were made to use a script in Matlab to read and interpolate the data to carry a same resolution.

In the NDVI was necessary to do several steps before to obtain the data. First, to find a good image which has to Puerto Rico, the pass must be by the morning local hour, the image can not have clouds o the fewer possible. Second, to download the image of the tape and to change in a format “1b”, then so the image can be read with ENVI to obtain the NDVI using the channel 1 and 2 of the AVHRR sensor.

Processing

Hence, we have 5 indicators and known that in each mesoclimate there is a specific behavior, where each grid has a characteristic trend. So, if there are others grids that seemed is possible these grids can be equals and have a same mesoclimate.

The challenge here was how is possible to compare each pixel and to see which are same? This question was answered by employing a statistical technique called correlation. This tool gives a value of -1 until 1, to positive value 1 mean if the independent variable increases the dependent decrease. It is temping to conclude that the relationship is one based cause effect. When it

is 1 both increases o decreases (Montgomery, 2001).

In Figure 2 is possible to see that both trend are different, in the "x" direction are the number of the indicators 1,2 ..., 5, the "y" direction are the value of each indicator night temperature, day temperature, elevation, accumulated rain and NDVI. The figure shows two trend different and therefore two different correlation index, for example to values to the blue line corr = -0.8488 and red line corr = -0.7365.

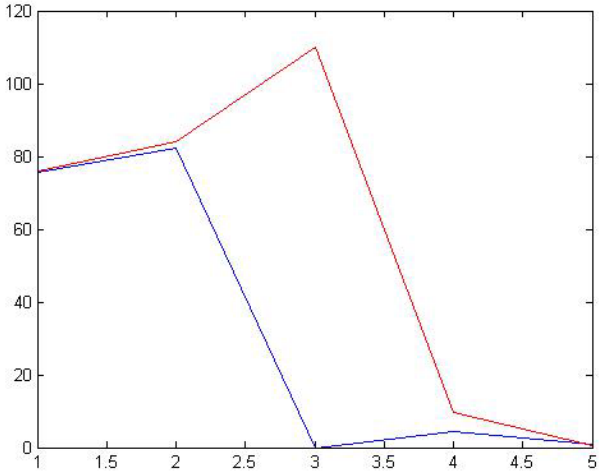

Figure 2: Here is possible to see the trend of two specific grinds 1 with localization in -67.265 18.378 (blue line) and 1000 with -67.038 18.494 (red line) longitude and latitude respect.

Therefore, by employing this technique is possible to have groups with the same correlation index, assuming that if there are similar correlation will have a Mesoclima similar.

RESULTS & DISCUSSION

In Figures 3, 4, 5, 6 and 7 are the values to each indicator where shown their value being easier identify cooler, hotter, higher, etc. place. On the other hand, each figure has a range value that shown the minimum and maximum value of the indicator.

By using these figure is possible to have an idea of the specific behavior of each area, this behavior have relation, for example it is known that in the Yunque and West area the rain is extremely strong, the central region have cooler temperature and this are the higher area of the Island, the south area the rain is poor or minimum in comparison with other place. Therefore, the values have relation with specific value measured by stations in the island and can be used in the present study.

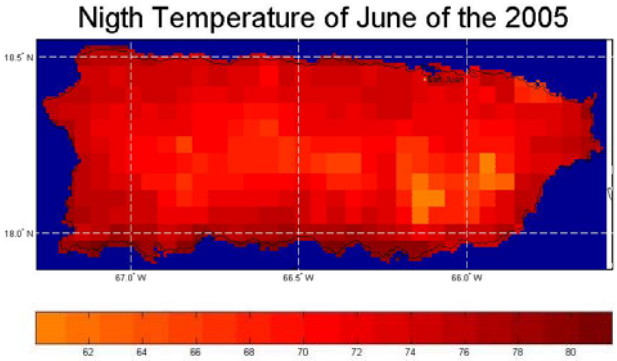

Figure 3: Data of the night temperature to the last June, here is possible to watch the cooler place in Puerto Rico to this specific month.

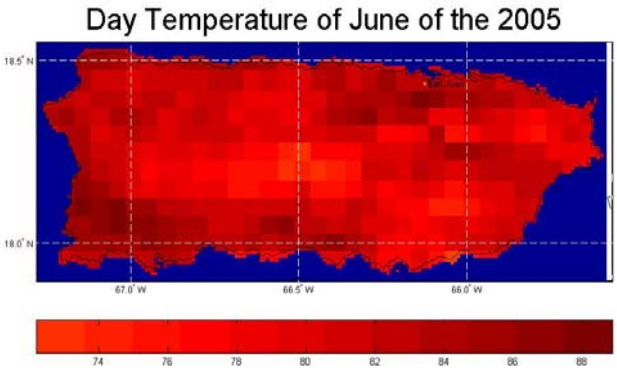

Figure 4: Data of the day temperature to the last June, here is possible to watch the hotter place in Puerto Rico to this specific month.

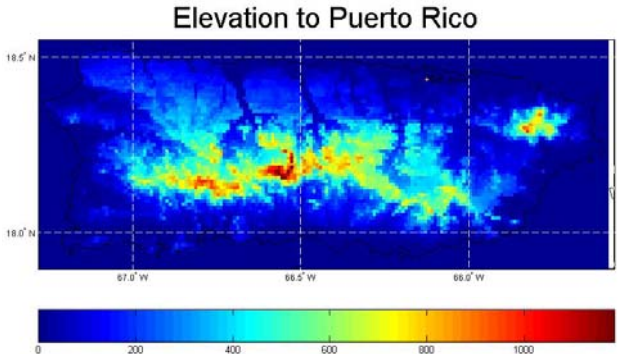

Figure 5: Data of the elevation, here is possible to watch the higher place in Puerto.

Next of to apply the algorithm, we obtain a matrix with several grids (8701), where each grid have a specific correlation index, but if the correlation are the same to two grids then could have the same mesoclimate. So, by employing a

script in Malab was possible to plot the values, by putting a color bar to watch better the differences. This is shown in grids with the same correlation and, maybe, to have the same mesoclimate.

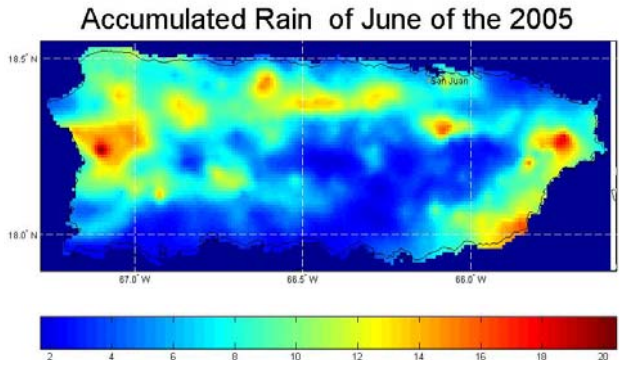

Figure 6: Data of the accumulated rain to the last June, here is possible to watch the rainier place in Puerto Rico to this specific month.

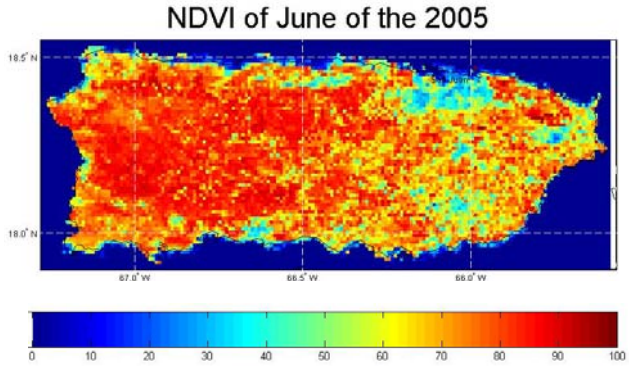

Figure 7: Data of the vegetation index called NDVI to the last June, here is possible to watch where there are more vegetation in Puerto Rico to this specific month.

Figure 8 shows the results by using our technique, it was obtained by employing the 5 indicators index. Then, is possible to identify areas with similar behavior or said in other words a mesoclimate.

The Yunque, Las Marias, Maricao, Adjuntas have the similar mesoclimate; metropolitan area and some coast areas have the same behavior, but with this technique is easy to identify the urban heat island (UHI), which have relation with big cities, for example the metropolitan area (Gonzales and others, 2005).

In spite of being results preliminaries, this have relation with others results, but we need to do the same procedure to another month and to do each step to the seasons as summer, autumn, winter and spring, to understand how many have change the results to each area.

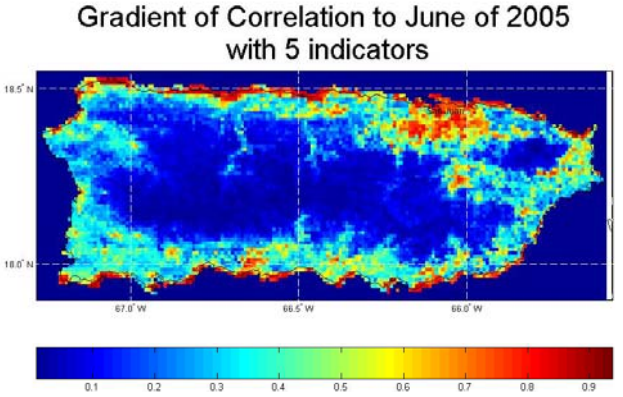

Figure 8: This is the gradient of correlation using the 5 indicators to a specific month, here is easy to identify the difference between a specific place and other.

To Figure 9 we apply the same algorithm, but without the elevation in the indicators, so we can see that the results are different, therefore is important to put the elevation in the algorithm and this have relation, because to climate of the higher area is very different of the lower areas. Hence, is very important to use this indicator to calculate the mesoclimate, although will be necessary to use another techniques to see which are the more important, said in others words, which are the critical indicators.

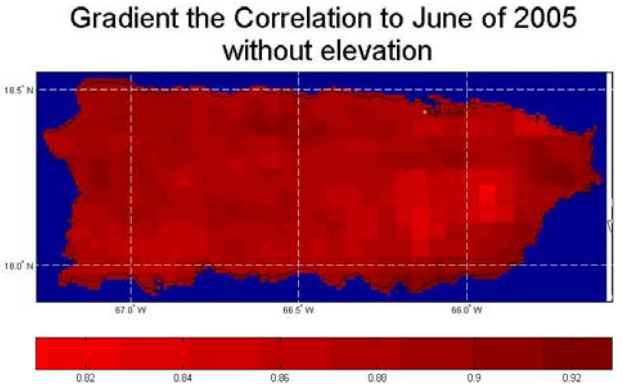

Figure 9: This is the gradient of correlation using the 4 indicators to a specific month without the elevation, here is a bit difficult to identify the difference between a specific place and other.

CONCLUSIONS

The values of the indicator have relation with real measurements or observations, because most of the indicators have been processed and this are final product.

The technique have interesting results, because identify the mesoclimate in each area of the island, which have relation with others publication, example the urban heat island or the same sensibility to the indicators when someone are in other areas of the island.

With the technique used is possible to monitor the mesoclimate in bigger area without spend too much money and time.

The 5 indicators are important at the employ of the algorithm, and for the result shown; the elevation is a very important indicator to identify mesoclimate.

RECOMMENDATIONS FOR FUTURE WORK

To study statistically which indicator is (or are) the more important in the time series and so can use only this to find the mesoclimate, without to spend too much time and money.

In the next steps will be necessary to validate the data with stations on the land, to have annual data to each month. And so, we can obtain behaviors to each month, season and year.

The main idea is to use the technique to monitor the mesoclimate using remote sensing; next to each pixel we will have a value in the time (month, season or year). By using this to apply another program of detection of change in a time series, by finding if the time series has changed in the time and when the event occurred.

ACKNOWLEDGEMENTS

This work was possible to do it with the support technique of Christian Calderon graduate student of Mechanical Department, Ana Picon graduate student of Electrical Department and Professor Nazario Ramirez of Industrial Department and Luis Collasos, undergraduate student of Electrical Department who works in SIL.

REFERENCES

González J., Luvall J., Rickman D., Comarazamy D., Picón A., Harmsen E., Parsiani H, Ramírez N, Vásquez R, Williams R, Waide R. & Tepley C., (2005), Urban Heat Islands Developing in Coastal Tropical Cities, *Eos, Transactions, American Geophysical Union,* Vol. 86, No. 42, pp. 397–412.

Montgomery, D. (2001), Introduction to Statistical Quality Control, 4th Edition, John Wiley & Sons, Inc.

Scott K., Simpson J. and Mcpherson E. (1999). Effects of Tree Cover on Parking Lot Microclimate and Vehicle Emissions. *Journal of Arboriculture*, Vol. 25, pp. 129-142.

Stefanov W. Ramsey M. and Christensen P. (2001). Monitoring urban land cover change: An expert system approach to land cover classification of semiarid to arid urban centers, *Remote Sensing of Environment,* Vol. 77, pp. 173– 185.

Weng Q. (2001). Modeling Urban Growth Effects on Surface Runoff with the Integration of Remote Sensing and GIS, *Journal of Environmental Management,* Vol. 28, No. 6, pp. 737–748.

Weng Q. and Yang S. (2004). Managing the adverse thermal effects of urban development in a densely populated chinese city, *Journal of Environmental Management,* Vol. 70, pp 145–156.