Temperature Mapping in Nova Scotia's Annapolis Valley

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Abstract

The Applied Geomatics Research Group (AGRG) has been monitoring the weather conditions of the Annapolis Valley region for more than five years. Temperature and other meteorological parameters have been monitored via AGRG's sensor network. Many of the monitoring locations are on existing vineyard locations owned by members of the Grape Growers Association of Nova Scotia (GGANS). In addition to understanding the temperature regime in existing vineyards, there is also interest in knowing the temperature potential of other areas in the Valley where no sensors have been deployed. This information is of specific interest to those involved in expanding the Valley's vineyard footprint. The AGRG set out to create a temperature map for the entire Valley area, based on five years (2004-2008) of temperature data and a collection of GIS data layers including elevation, slope, aspect, solar radiation, and coastal proximity. This presentation will highlight the data layers, interpolation methods, and results that have been generated to date in this on-going project.

Background and Relevance

Nova Scotia's Annapolis Valley is well known for its agricultural production and is home to a burgeoning grape growing industry. In 2002 the Applied Geomatics Research Group (AGRG) began deploying environmental instrumentation throughout the Valley region (approximately 150km x 25km in size) to better understand the meteorological regime of the area. Today the AGRG has a sensor network (i.e., 15 Campbell Scientific weather stations and 75 Onset temperature data loggers) used to monitor temperatures and other meteorological parameters. Many of the monitoring locations are on existing vineyards; other are located to sample the temperature extremes (i.e., shoreline, hill tops, etc.). To share project results the AGRG provides web-based geospatial temperature summaries to members of the Grape Growers Association of Nova Scotia (GGANS). These summaries provide growers with valuable information (i.e., duration of the growing season, heat unit accumulation, and minimum winter temperatures) which is used to assist in the selection of grape varieties suitable for growing in the Valley area.

In addition to understanding the temperature regime in existing vineyards, there is also interest in knowing the temperature potential of other areas in the Valley where no sensors have been deployed. This information is of specific interest to those involved in expanding the Valley's vineyard footprint. Thus the AGRG has been working to create a temperature map for the entire Valley area. Temperature has a strong co-variation with topological characteristics, and thus the temperature data that has been collected over the past five years has been modeled with a collection of GIS data layers including elevation, slope, aspect, solar radiation, and coastal proximity.

Certainly the use of GIS in climatology and meteorology studies is increasing (Hartwig et al., 2007). There are numerous spatial interpolation techniques that have been used to model temperature (Shen, et al., 2001). Based on the results of a comparative study of various techniques (Bater 2005), this study used multiple regression analysis (Ninyerola, et al., 2000; Daly, et al., 2002; Joly et al., 2003) to derive temperature maps.

Methods and Data

The three initial data layers employed in this study were: temperature, elevation, and coastline mapping. The temperature data was harvested from the AGRG sensor network (~90 sensors). Temperature sampled every 15 minutes was used to compute the annual heat accumulation units (i.e., Growing Degree Day values using base 10^{o} Celsius) between the months of April and November for five years (i.e., 2004-2008). The elevation data was acquired from the Nova Scotia Geomatics Centre (NSGC) provincial mapping. This was a 20m resolution raster dataset that was used in ArcGIS v9.2 to generate slope, aspect, and solar radiation layers with the same resolution. A heat load index (McCune & Grace, 2002) was calculated from the aspect layer to circumvent the difficulties of modeling aspect data (where 1^{o} is essentially the same as 359^{o}). The coastline mapping was also from the NSGC; it is 1:10,000 scale vector data derived from aerial photography. This layer was used to compute a 20m resolution raster layer depicting the proximity to the coast.

The sensor sites were each mapped using a Real Time Kinematic Global Positioning System (RTK GPS). The resulting locations were used to sample the elevation, slope, aspect, solar radiation, and coastal proximity layers. The sampled measures from these associated landscape layers were then copied into an Excel spreadsheet. The heat accumulation units for each year were copied to the same spreadsheet and multiple regression calculations were conducted on various combinations of the temperature (the dependent variable) and associated landscape attributes (the independent geographical variables). The resulting regression coefficients were used in the ArcGIS raster calculator to create a new 20m resolution layer representing predicted temperature values throughout the study area. This process was carried out using temperature data for each of the five years, and once using an average of the five years of temperature data.

A subset of the temperature data (withheld from the above calculation) was then used to conduct a validation exercise on each of the six resulting temperature layers.

Results

Six temperature maps have been created, one representing each of the five years (i.e., 2004 to 2008) and one representing an average of the five years. These represent draft results in our ongoing investigation. Most of the maps exhibit similar overall patterns. The coastal proximity and solar radiation layers have been found to have the best fit to the temperature data; the slope and elevation layers had the weakest fit. Final results complete with validation information will be delivered during the presentation.

Conclusions

Similar patterns exist in most of the resulting temperature maps. Thus the results should prove useful to those interested in better understanding the April to November temperatures of the Annapolis Valley region. Grape growers will now be better able to identify areas within the Valley area that have a temperature regime that will support the production of grapes.

References

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