World Academy of Science, Engineering and Technology
International Journal of Environmental and Ecological Engineering
Vol:17, No:01, 2023

Climate Indices: A Key Element for Climate Change Adaptation and Ecosystem Forecasting - A Case Study for Alberta, Canada

Authors : Stefan W. Kienzle

Abstract : The increasing number of occurrences of extreme weather and climate events have significant impacts on society and are the cause of continued and increasing loss of human and animal lives, loss or damage to property (houses, cars), and associated stresses to the public in coping with a changing climate. A climate index breaks down daily climate time series into meaningful derivatives, such as the annual number of frost days. Climate indices allow for the spatially consistent analysis of a wide range of climate-dependent variables, which enables the quantification and mapping of historical and future climate change across regions. As trends of phenomena such as the length of the growing season change differently in different hydro-climatological regions, mapping needs to be carried out at a high spatial resolution, such as the 10km by 10km Canadian Climate Grid, which has interpolated daily values from 1950 to 2017 for minimum and maximum temperature and precipitation. Climate indices form the basis for the analysis and comparison of means, extremes, trends, the quantification of changes, and their respective confidence levels. A total of 39 temperature indices and 16 precipitation indices were computed for the period 1951 to 2017 for the Province of Alberta. Temperature indices include the annual number of days with temperatures above or below certain threshold temperatures (0, +-10, +-20, +25, +30ºC), frost days, and timing of frost days, freeze-thaw days, growing or degree days, and energy demands for air conditioning and heating. Precipitation indices include daily and accumulated 3- and 5-day extremes, days with precipitation, period of days without precipitation, and snow and potential evapotranspiration. The rank-based nonparametric Mann-Kendall statistical test was used to determine the existence and significant levels of all associated trends. The slope of the trends was determined using the non-parametric Sen's slope test. The Google mapping interface was developed to create the website albertaclimaterecords.com, from which beach of the 55 climate indices can be queried for any of the 6833 grid cells that make up Alberta. In addition to the climate indices, climate normals were calculated and mapped for four historical 30-year periods and one future period (1951-1980, 1961-1990, 1971-2000, 1981-2017, 2041-2070). While winters have warmed since the 1950s by between 4 - 5°C in the South and 6 - 7°C in the North, summers are showing the weakest warming during the same period, ranging from about 0.5 - 1.5°C. New agricultural opportunities exist in central regions where the number of heat units and growing degree days are increasing, and the number of frost days is decreasing. While the number of days below -20ºC has about halved across Alberta, the growing season has expanded by between two and five weeks since the 1950s. Interestingly, both the number of days with heat waves and cold spells have doubled to four-folded during the same period. This research demonstrates the enormous potential of using climate indices at the best regional spatial resolution possible to enable society to understand historical and future climate changes of their region.

Keywords : climate change, climate indices, habitat risk, regional, mapping, extremes
Conference Title : ICCICC 2023 : International Conference on Climate Informatics and Climate Change
Conference Location : Sydney, Australia
Conference Dates : January 30-31, 2023