Investigating long-term trends of climate change and their spatial interactions with local environments through data mining techniques

*Yichun Xie[1], Anbing Zhang[2]

1.Eastern Michigan University, 2.Hebei University of Engineering

Climate change is a global phenomenon but is also modified by regional and local environmental conditions. Climate change displays apparent regional variations. For instance, mountainous regions are usually more sensitive to climate change than flat and low elevation regions. Unique landscape structures of land masses, oceans or water bodies, dominant air flows, topographies and elevations can have significant impacts on local meteorological conditions and thus lead to distinct regional patterns of climate change. Moreover, climate change exhibits remarkable cyclical oscillations and disturbances, which often mask and distort the long-term trends of climate change we would like to identify. Traditional analytical methods based on the comparisons between minimum, average and maximum values of temperature and precipitation are not capable of separating long-term trends from cyclical fluctuations and abrupt changes or capturing temporal dynamics or regional patterns of climate change. As a result, it is almost impossible to study long-term interactions between meteorological conditions and underneath landscape, vegetation and topography by simply analyzing the records of temperature and precipitation. Therefore it is desirable to apply an effective data analysis method to break down the climate variations into individual processes, i.e., cyclical, long-term and abrupt components. Only with this type of data mining and pre-processing is it feasible to investigate spatial patterns and interactions between climate change and regional environmental factors.
In this paper, we attempted to apply computational data mining approaches that were developed in recent years. In particular, we synthesized advanced signal processing and denoising techniques to extract long-term trends of climate change. In specifics, we experimented with the empirical mode decomposition (EMD) technique to extract long-term change trends from climate data that contained significant cyclical oscillations. We then applied 2.5D surfaces, 2.0D contours, and cross-station similarity plots to examine and visualize spatial variations of the extracted change trends over regions, biomes and weather-stations to reveal modifications of climate change at regional and local scales. We conducted a case study to investigate the climate change in Inner Mongolia, China based on the daily records of precipitation and temperature at 45 meteorological stations from 1959 to 2010. The EMD curves effectively illustrated the long-term trends of climate change. The 2.5D surfaces, 2.0D contours and cross-station similarity plots revealed that the change trends of temperature were significantly different from those of precipitation. Noticeable regional patterns and local disturbances of the changes in both temperature and precipitation were identified. These regional patterns and local disturbances were also confirmed by the similarity statistics. In brief, no simple statements could be made concerning either increasing or declining trends of temperature and precipitation over Inner Mongolia. The trends of change were modified by regional and local vegetation covers and topographical characteristics. Our findings provide very convincing evidences to support the IPCC predictions that the climate change varies significantly by location and through time. The data-mining based statistical-cum-visual method is very effective in revealing spatial patterns of regional and local climate changes. The methods developed in this study are also suitable for investigating long-term trends and spatial patterns of other ecological processes that are noted with cyclical or seasonable fluctuations.

Keywords: climate change, regional variation, trend analysis, data mining