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Uncertainty of Climate Change and Synoptic Parameters and modeling the trends

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Abstract

Climate changes is a natural phenomenon which have long-term sequence occurrence and return period. Impact of human activities may aggravate the effects of climate change in ecosystems, intensity of climate change trend and intervals between changes. Climate change can be reviewed using synoptical parameters as their indicators.In this study, based on average annual precipitation trend, temperature and relative humidity using De Martonne index were estimated for the recent 20-year period in Mazandaran Province, IRAN. Mathematical modeling of these changes and trends was conducted using regression models and Curve Expert software. Results showed meaningful changes in temperature and relative humidity during the selected period. The amount of precipitation did not show a significant trend, but a increase at the end of the period as compared with the beginning. There are also relative changes in De Martonne index during recent two decades, but no significant sign of climate change was spotted for this region.

Keywords: Climate Change, Trend, Modeling, Predict, Mazandaran

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1. Introduction

There are two main methodologies for predicting future climate change caused by global warming due to increased greenhouse gases. One is to describe the atmospheric system analytically and construct a general circulation model (GCM). Such a model has a physical basis, but requires extensive data and numerical computation and has limitations for assessing regional impacts (Brad, 1994). A second option is to define statistical relationships between different climate parameters which is relatively easy to apply although it has the disadvantage of not having a physical basis.

In this study, five parameters were selected for analysis, including annual precipitation, temperature indices (Max, Min & Mean Annual Temperature) and relative humidity. De Matronne method was selected to investigate the climate index and analyzing the climate changes in Mazandaran Province, North of Iran.

2. Matrials and Methods

2.1. Study area

The general area for the study is Mazandaran Province in the north of Iran. The study area is the western part of this province which is limited to Caspian Sea in the north, central part of Alborz Mountain in the south, Sefid Rud River in Guilan Province in the west and BabolRud watershed basin in the east. Mazandaran is one of the most populated areas with fertile soil, different water resources and suitable climate, making it as one of the most important agricultural centers in Iran, and especially rice culture. Based on De Martonne classification, Mazandaran climate is very moist in the west, humid in the center, mediteranean in the east and semi-humid mountainous parts.

2.2. Date and Stations

There are five synoptic meteorological stations named Rasmar, Nowshahr, Babolsar, Gharakheyl and Sari. These stations have a long time data and in this research a 30 year period (1978-2007) was selected to investigate the regional climate changes.

Mean annual precipitation, temperature indices (Max, Min and Mean Annual Temperature) and mean annual relative humidity were the meteorological parameters which are analyzed in this research.

2.3. Statistical Methods

For the statistical analysis, first we investigated the data in terms of quantity, correctness, hemogenity using double mass curve and run test methods, and rebuilt the missing data.

The, we analyzed the selected parameters, separately in each station and for the whole region. The trend of the selected parameters was analyzed using moving average method and the correctness of this trend was test through Mann Kenedal method. In the next step, the trends were modeled using Curve Expert software. We also evaluated the aridity index (Climate index) using De Martonne method.

3. Results and Discussion

Data from five meteorological observatories in the selected stations were used in the analysis of climate change. The observed monthly and annual mean temperature, the estimated moving average and the observed values and trend of precipitation, humidity and temperature data were plotted for all stations and for regional analysis (Figures 1 to 3). These results indicate a statistical relationship between climate variability and temperature and can be used to estimate the impact of future climate variability. Precipitation did not show a significant trend (Figure 4 and Table 1). However, it showed a weak increase in annual time series. On the other hand, temperature parameters (Max, Min & Mean) showed increasing trends which was significant in 5% level where as the relative humidity showed a significantly decreasing trend (Figures 5 and 6 and Table 2). Figures 7 and 8 show the graphs for temperature trend assessment and Table 3 depicts the relevant modeling and its results.

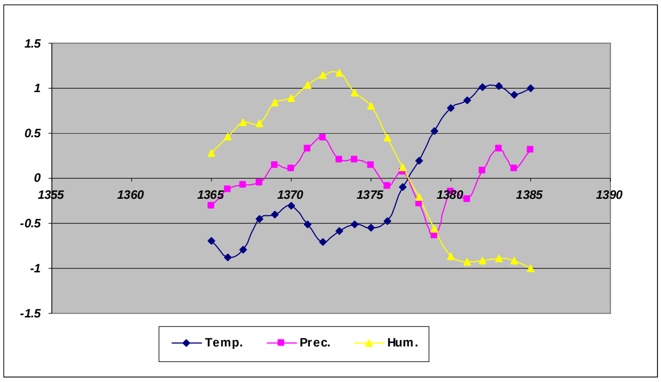

Figure 1. Trend of precipitation, humidity and temperature data

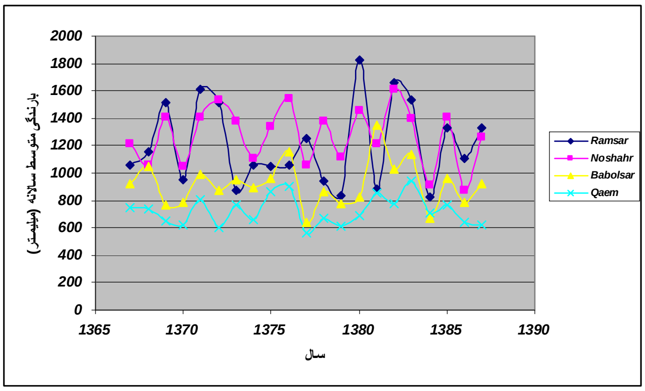

Figure 2. Precipitation annual alteration in synoptic stations

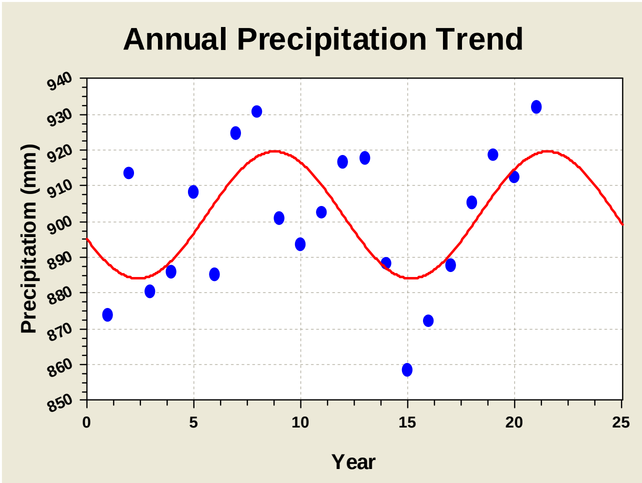

Figure 3. Modeling the annual precipitation trend

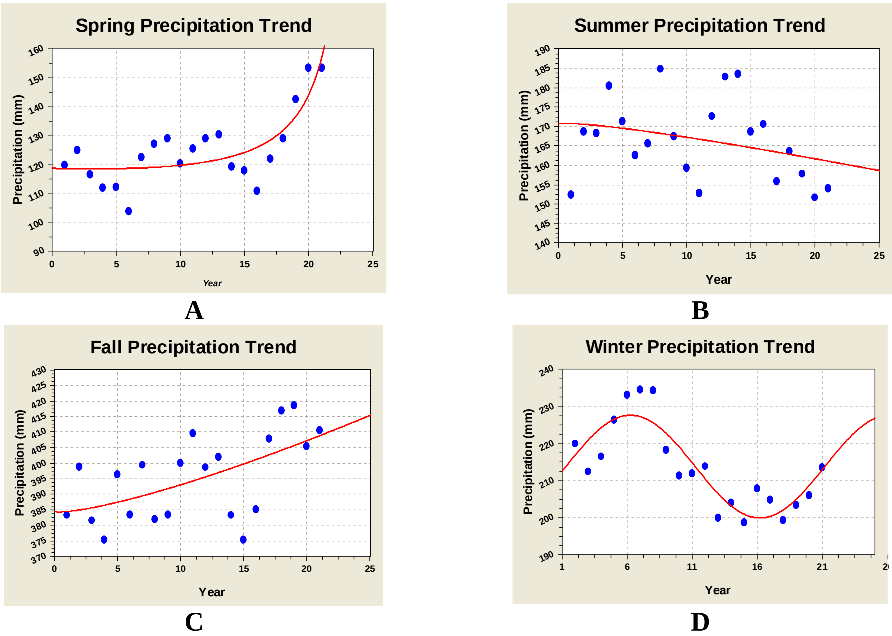

Figure 4. Modeling the seasonal precipitation trend
(A: Spring, B: Summer, C: Fall, D: Winter)

Table 1. The Model of Precipitation Trend

Equation	R^2	S.D.	Model	Time
$Y = 901.9 + 17.7Cos(0.5X + 1.96)$	0.64	16.93	Sinusoidal	Annual
$Y = 213.8 + 13.8Cos(0.32X - 1.97)$	0.8	8.24	Sinusoidal	Spring
$Y = 384.5X^{0.001X}$	0.3	10.25	Geometric Fit	Summer
$Y = 170.8X^{-0.001X}$	0.58	11.3	Geometric Fit	Fall
$Y = \dfrac{118.8 - 4.67X}{1 - 0.04X - 0.0001X^2}$	0.88	5.78	Rational M.	Winter

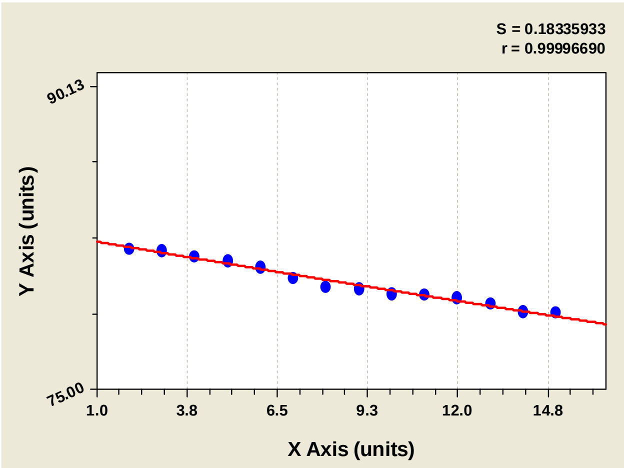

Figure 5. Modeling the annual relative humidity trend

Table 2. The Model of Precipitation Trend

Equation	R^2	S.D.	Model	Time
$Y = 80.7 + 2.1Cos(0.23X - 1.44)$	0.99	0.15	Sinusoidal	Annual
$Y = 80.6 + 1.9Cos(0.25X - 1.7)$	0.97	0.25	Sinusoidal	Spring
$Y = 79.4 + 2.6Cos(0.2X - 1.3)$	0.98	0.28	Sinusoidal	Summer
$Y = 81.5 + 0.8X - 0.09X^2 + 0.002X^3$	0.96	0.28	Polynomial	Fall
$Y = 81 + 0.9X - 0.1X^2 + 0.003X^3$	0.99	0.22	Polynomial.	Winter

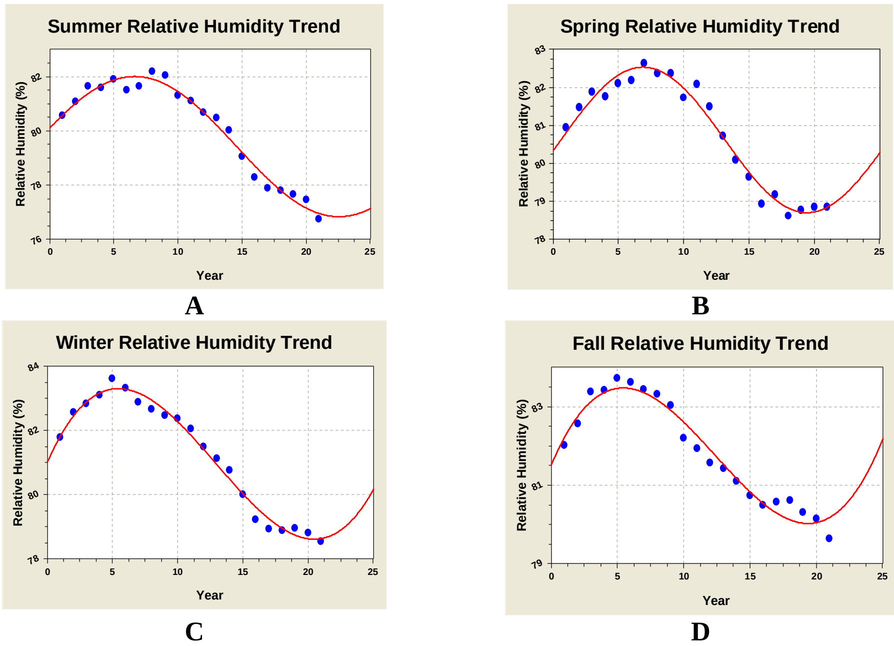

Figure 6. Modeling the seasonal relative humidity trend (A: Spring, B: Summer, C: Fall, D: Winter)

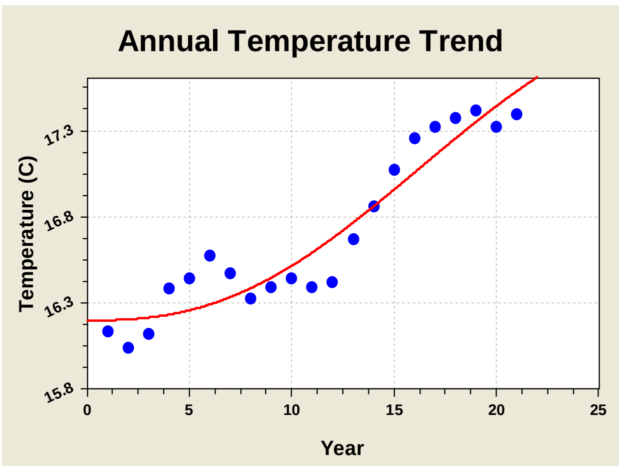

Figure 7. Modeling the annual temperature trend

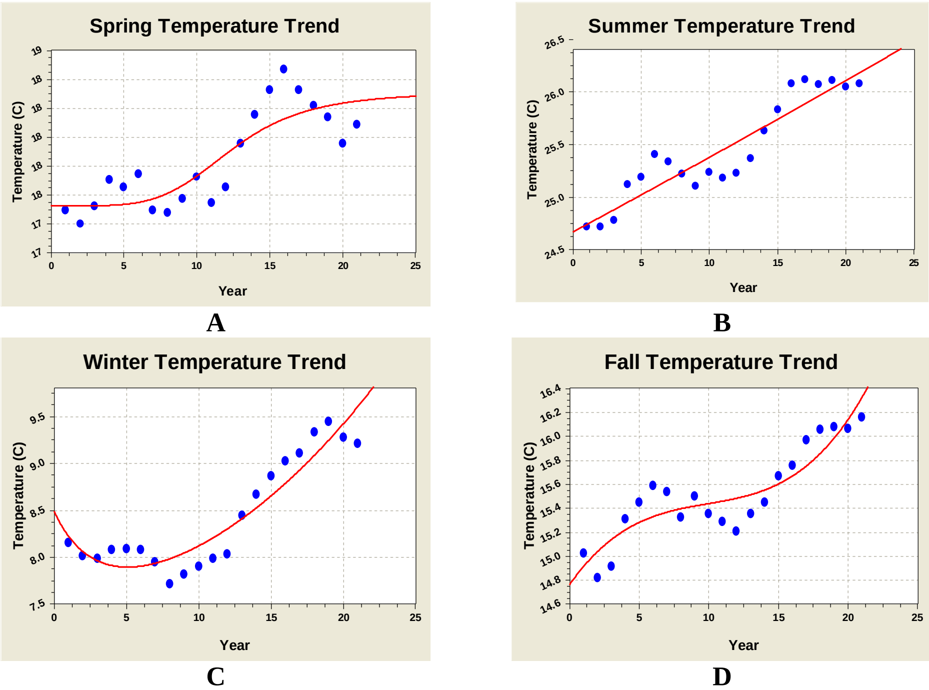

Figure 8. Modeling the seasonal temperature trend
(A: Spring, B: Summer, C: Fall, D: Winter)

Table 3. The Model of Temperature Trend

Equation	R^2	S.D.	Model	Time
$Y = 18.1 - 1.9e^{-0.0005X^{2.5}}$	0.9	0.16	Sinusoidal	Annual
$Y = \frac{2473680 + 18.3X^{4.7}}{138971 + X^{4.7}}$	0.74	0.18	Sinusoidal	Spring
$Y = 24.7e^{0.003X}$	0.86	0.18	Sinusoidal	Summer
$Y = 14.7 + 0.16X - 0.01X^2 + 0.005X^3$	0.82	0.18	Polynomial	Fall
$Y = \frac{8.5 + 1.15X}{1 + 0.17X - 0.003X^2}$	0.88	0.22	Polynomial.	Winter

Considerable research effort has been directed towards estimating the response of global and regional climate to increased greenhouse gases. The change in temperature has been studied most extensively and comparative results have been gained using GCM simulations (JM A, 1990; JUCHWR, 1992, 1995). Assuming the concentration of greenhouse gases in the atmosphere increases continuously at the present rate, it will double by around 2030 compared with 1958. The global average temperature for the year 2030 is estimated to increase by 1.2-3.0°C compared with the mean temperature for the past 100 years (H. Yao, 1997).

In this paper, a hypothetical scenario of yearly increase of 0.06°C (1.2°C in last two decades) is showed by analyzing the temperature data in the study area. Temperatures in 2030 are given by $T(N + 20, j) = A_T(j) + 1.4$, where $A_j(j)$ is the total average of temperatures during N years (1800-2006) and y is the month number. Furthermore, it is assumed that the temperature rise would take place in a linear manner.

Stepwise regression equations for precipitation and temperature variables were not significant for Aug., Dec., Jan. and Feb. This was the same for humidity in Nov. and Feb. too. The results of stepwise regression method for humidity were better than precipitations.

The statistical relationship of temperature to other climatic factors was derived from long term data records and is assumed representative of the climate system of both present and future. It may be supposed that the climate system itself will not change dramatically under the global warming condition, and that the regression relationships can be used to estimate future conditions.

The results showed the increasing trend in mean annual temperature (0.06°C each year) and a decreasing trend for humidity simultaneous with temperature changes. Precipitation has a normal soft increasing trend in annul data (Figures 9 to 12). It can be claimed that precipitation changes had a regular variation in the last two decades and each yearit occurs around long mean precipitation value. So, increasing temperature and decreasing humidity are the effective parameters in regional climate changes in the study area.

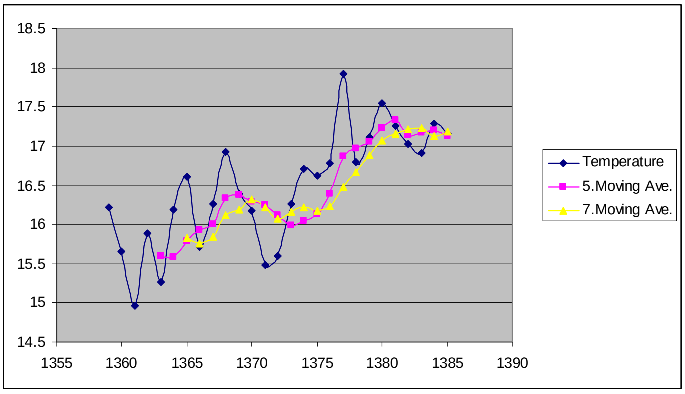

Figure 9. Mean annual temperature observed and its trend

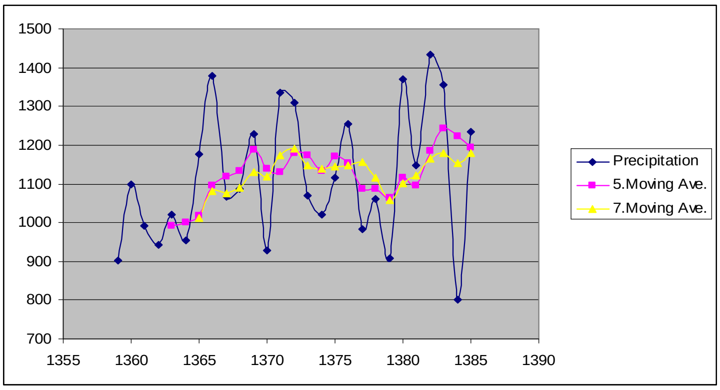

Figure 10. Mean annual precipitation observed and its trend

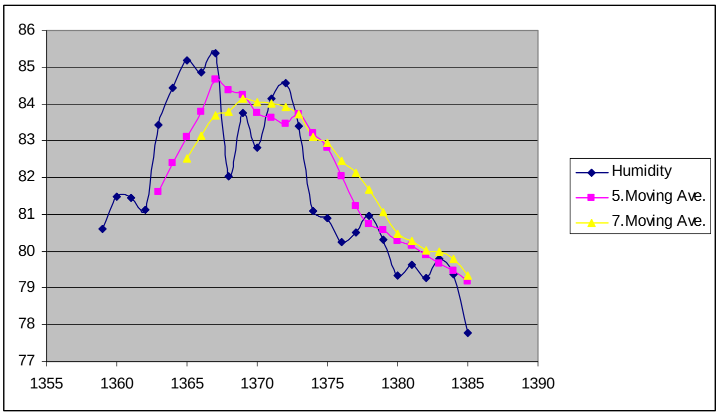

Figure 11. Mean annual humidity observed and its trend

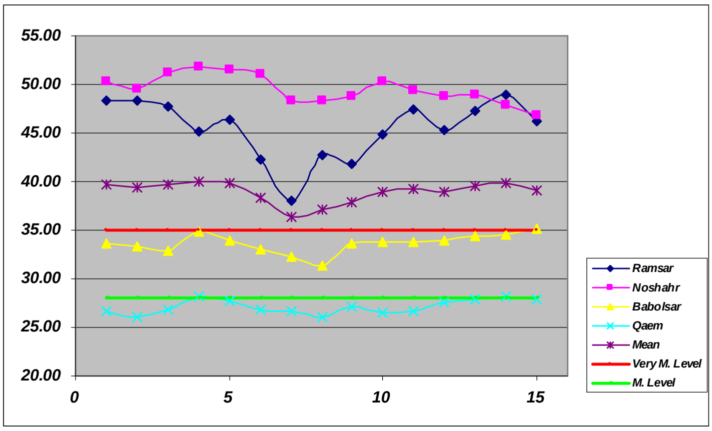

Figure 12. De Martonne Climate Index

Regarding the year 2030, a 20-year average temperature is produced from the assumed temperature series of 2021-2040. This value is then substituted into the regression formula and the corresponding average values for monthly precipitation, net radiation, humidity and wind speed were calculated and predicted respectively. These predicted values of 2021-2040 were compared with those of 1987-2006 which represent the present climate status; through which climate changes (in percentages) could be determined for the three sites. Usually there are five seasons in North of Iran: spring (March-April-May, MAM), rainy summer (June-July, JJ), hot summer (August-September, AS), autumn (October-November, ON) and winter (December- January-February, DJF).

4. Conclusion

There are two conclusive points about climate change results of this study. First, under the same scenario of future temperature rise, seasonal and annual climate at each site seems to change in a similar way. It may also mean that local climate responds to global warming and there are consistent regional trends. The results predicted that the potential evaporation increases seasonally and annually for all sites. The reason for this is that temperatures are estimated to become higher and humidity lower, both of which increase evaporative demand. Therefore, water demand would increase, which might result in more severe water supply conditions in future. However, we should note the De Martonne method results for climate index which showed no significant changes in the last three decades although temperature increased and relative humidity decreased. The amount of precipitation did not show significant changes but the precipitation systems has changed in the last two decades for winter precipitation (Snow to Rain) as a result of regional warming under influence of forest destruction and the increasing the CO2 concentration.

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