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Temperature Trend Analysis by Considering the Hurst Coefficient (Case Study: West Azarbayjan Province)

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Introduction: Climate change in the current century is an important environmental challenge facing the world. Increase in atmospheric concentration of greenhouse gases such as CO_2 as a result of human activities has caused a change in a number of hydroclimatic parameters. Climate change and global warming are the most important issues that have attracted many attentions in recent years. Climatic changes have interpreted as significant changes in average weather over a long period (Salari and ghandomkar, 2012). Global warming may cause drastic fluctuations in various processes and also it can significantly affect mean and variance of relative humidity, precipitation, solar radiation and etc. Global warming phenomena can change the components of the hydrological cycle and re-distribute the world's water resources in time and space. This may exacerbate desertification in arid and semi-arid countries such as Iran (Ahmadi and Radmanesh, 2014). Therefore, a large part of hydroclimatic researches has focused on temperature trend analysis at different spatial and temporal scales,

Materials and Methods: In the present study, the long-term temperature data from 24 climatological stations uniformly distributed over the West Azarbayjan province during 1981-2013 were used for investigating the temperature trends. The aim of trend test is to specify whether an increasing or decreasing trend exists in time series. Since parametric tests have some assumptions such as normality, stability, and independence of variables which may not be valid for most hydrologic series, the nonparametric methods are more preferred in meteorological and hydrological studies. In addition, the nonparametric trend analysis methods are less sensitive to extreme values compared to parametric trend tests. Nonparametric tests can also be applied regardless of linearity or nonlinearity of time series trend (Khalili et al. 2015). One of the most well-known nonparametric tests is the Mann–Kendall test (Mann 1945; Kendall 1975). Existence of more than one significant autocorrelation among data is long-term persistence (LTP). The presence of LTP in time series results in the underestimation of serial correlation and overestimation of the significance of the Mann-Kendall test (Koutsoyiannis 2003). In addition, Koutsoyiannis and Montanari (2007) pointed out that the Hurst phenomenon (Hurst 1951) is one of the most major sources of uncertainty in hydrometeorological trend analysis. Hamed (2008) studied the impact of LTP and Hurst phenomenon on the Mann–Kendall test, and Kumar et al. (2009) named it as the MK4. Since the MK3 test (Mann-Kendall method after the removal of the effect of all significant auto-correlation coefficients) is a generalized version of the MK2 (Mann-Kendall method after removing the effect of significant lag-1 auto-correlation), the MK3 and MK4 tests were used in this study and explained briefly in the following sections according to Kumar et al. (2009) and Dinpashoh et al. (2014). In the current study, the MK4 test was employed.

Results and Discussion: In this study, the mean monthly and annual air temperature trends were investigated using non-parametric Mann-Kendall test by considering the Hurst coefficient (MK4) for West Azarbayjan province. The Sen's slope estimator was also used for estimation of the slope of the trend line. Results indicate that 71% of selected stations (17 stations out of 24 considered stations) experienced a significant positive trend and only 7 stations (%29 of studied stations) did not show a significant upward trend in annual temperature time series. The highest increasing temperature rate (0.12 °C/Year) in annual timescale was found in Chehriq station. On monthly time scale, the numbers of months with increasing trends were 6 times greater than those with negative trends. Most of the stations had significant positive trends in mean temperature in February and March, Moreover, according to calculated Sen's slope, the mean air temperature of West Azarbayjan province increased by 0.05 °C/Year (1.65 °C during the study period).

Conclusion: The results show that the temperature of West Azarbayjan province substantially increased. The

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temperature increment can cause more drought occurrence and crop yield loss. As most of people's income in this province depends on agricultural activates, temperature rise seems to have led to many social and economic problems in our studied area. Further, drying up of Urmia Lake and decreasing water input to the Urmia Lake basin can intensify the environmental problems.

Keywords: Mann-Kendall test, Confidence level, Sen's slope, Persistence, Hurst coefficient