Spatio-temporal variations of snow cover in the southern slope of central Alborz

Ghasem Azizi*
Associate Professor of Climatology, Faculty of Geography, University of Tehran, Tehran, Iran
Mojtaba Rahimi
PhD student in Climatology, Faculty of Geography, University of Tehran, Tehran, Iran
Hossien Mohammadi
Professor of Climatology, Faculty of Geography, University of Tehran, Tehran, Iran
Faramarz Khoshakhlagh
Assistant Professor of Climatology, Faculty of Geography, University of Tehran, Tehran, Iran

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Extended Abstract

Introduction
Snow cover as one of the most important components of the Earth's surface plays an important role in the global hydro climate processes. Snow acts as a temporary reservoir of water and keeps the rivers flowing long time and recharges underground aquifers to provide water during the dry season for billions of consumer. Study of spatial and temporal variability of snow cover in arid and semiarid region such as Iran can indicate very high temporal and spatial variations of precipitation. In Iran, about 60% of surface water and 57% of groundwater is in snow covered areas. Hence, the purpose of this study is to evaluate the accuracy of MODIS snow products and combines remote sensing and terrestrial data to investigate the spatiotemporal changes of snow cover in South Central Alborz slopes. Eventually, this research assesses the relevance of this change with climatic elements.

Materials and Methods
In the present study, we have used data from 16 synoptic stations located in the study area and MODIS data. At first, the MOD10A and MOD10A2 products have been used to extract snow cover. Then, snow depth, precipitation and temperature (on a scale of hourly and monthly) data of the selected stations have been used to evaluate the accuracy of MODIS data and relationship between snow cover changes and climatic elements. MODIS images have also been used for the detection of snow cover by the NDSI index = (band4-band 6) / (band4 + band6). In this equation, Band4 is the spectral reflectance in the visible band (0.555 micrometers) and band6 is the spectral reflectance in the intermediate-infrared band (1.64 micrometers). Hence, in this sensor products addition to snow other phenomena is indivisible. Therefore, in order to separate and identify the pixels of different phenomena, the images have been processed in ArcGIS. For

*E-mail: ghazizi@ut.ac.ir Tel: +98 9123841192

evaluation of the pictures, daily images (MOD10A1) for three years (2007-2009) winter (December to February) have been processed and accuracy assessment conducted by snow depth data. If the depth of snow at the station is one centimeter or more, the pixel located at the station is considered as snow cover and otherwise as no snow. The adaptation degree between the image and the station has been obtained by a coefficient divided by the number of days for the correct classification (snow-snow and no snow-no snow) divided to the total number of days in each month, as a percentage. Finally, the variability of snow cover has been evaluated by Mann-Kendall test. To examine the relationships of snow cover anomalies and climatic conditions, Z index has also been employed.

Results and discussion

The percentage of adaptation of the earth data and satellite images for three months of December, January, and February is 81, 67 and 75 percent, respectively. However, these results are the average of all the stations and in the snowy areas the average image precision is even reduced by 40%. The studies show that errors are often caused by clouds in the location pixel. Therefore, the second assessment has been performed by removing cloudy days. The results show that at this phase image accuracy and the adaption percentage is increased for each quarter to more than 95 percent. According to the movement of the clouds, the eight days product of this sensor has been used to monitor and evaluate changes in snow cover. The snowfall in the region began in October, with the fall in air temperature and increase in snow accumulation, reaching a maximum of 34 percent during the period ending January 9. The snow cover in January and February were 31.4 and 25.6 percent, respectively, with the highest monthly values. The highest and lowest snow cover values for these two months were 76.2% and 9.7%, respectively, in January 9, 2008, and February 2, 2015. The coefficient of snow cover variations is increased with decreasing height, and is extremely severe in less than 1500 m, while in the areas above 2500 m in autumn and winter, it is less than 20%. A survey of monthly snow cover changes shows that in October, November and March, the trend is increasing, although not significant. While in January, February, April, and especially in May most snow covers are declined over the last 15 years. This negative trend is significant in May with a score of -2.18. Comparison of the average rainfall, temperature and snow cover percentage indicate that most of the positive anomalies of snow cover with positive anomalies of rainfall and negative anomalies of temperature and its negative anomalies are consistent with the positive anomalies of temperature and negative rainfall.

Conclusion

The results of the satellite image accuracy estimation showed that the MODIS snow product has a good ability to estimate the snow cover area of the study area. But the cloud is one of the main limitations of MOD10A1. As in the present study, after removing cloudy days, the average accuracy of these images has risen from 67% to over 95% and even in snowflake stations to 100%. Since the clouds are changing rapidly and daily, but snow is gradual, it is recommended to use this sensor product (MOD10A2) to monitor the long-term snow cover. The monitoring results showed that the January and December have the highest snow cover area. In terms of spatial changes, the continuity and the extent of snow cover decreases from West to East in the study area. The percentage of snow covers in the Shahrood and Karaj river basins are more than the Semnan and Hablehrood basins. The results of the trend show that although snow cover changes tend to be negative for most of the months and high altitude zones, rarely this decline is significant. The highest increase was observed in March with a score of 1and the most severe declining trend in May, with a score of -2.18, and a maximum reduction in peak space was also observed in the altitudes of 2500 to 3750 meters. In most of the years, the positive anomalies of the snow cover are coincided with the positive anomalies of rainfall and the negative anomalies temperature.

Keywords: southern Alborz, snow, remote sensing, MOD 10.

Identification of snow reservoirs in Iran

Mohammad Sadegh Keikhosrvai Kiany
PHD student of climatology, University of Esfahan, Esfahan, Iran
Seyed Abolfazl Masoudian[*]
Professor of climatology, University of Esfahan, Esfahan, Iran

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Extended abstract

Introduction

At the high elevations of river basins, precipitations are mainly in the form of snow and its accumulation provides water of the rivers in warm seasons. Having accurate and on time information of the phenomena is of great importance for flood controlling and also estimation of snow water equivalent. The extent of snow cover and its variations are important in hydrologic and climatic systems. Suitable and accurate evaluation of snow cover on both small and large scales is very crucial. Lack of information on the high elevations is an issue which causes increasing concerns due to climate change as many large rivers are originated from these highlands. In the last few decades many researches have carried out the studies of snow cover using remote sensing data. For instance, Maskey et al (2011) used MODIS Terra data to examine seasonal snow cover in Nepal for the period from 2000 to 2008. His findings revealed that snow cover is more in the elevation zone of 3000 to 4000 meters compared with the elevation zone of 4000 to 5000 and 5000 to 6000. Khadka et al (2014) evaluated snow cover in different seasons in Tamakoshi in the highlands of Himalaya using MODIS data for the time coverage from 2000 to 2009. The results indicated that snow cover below the elevation of 4500 meters above sea level is not much significant. In winter and spring at the elevation above 4500 meters the snow cover areas are very noticeable. However, in summer the elevation zones above 5500 meters have significant extent of snow cover.

Materials and methods

In the present research, MODIS Terra and MODIS Aqua data were used to detect snow reservoirs of the country. The selected study period covers the years from 2003 to 2014. As MODIS Aqua data are missing before the year 2003, we had to limit the study period only to the aforementioned years. Before the analysis of the data, we have applied two different algorithms to minimize cloud contamination that is a big obstacle against snow cover monitoring. One of the applied algorithms is based on three days filtering and the second is made on the combination of the two products. By merging the two products we managed to develop a regional snow cover data set over Iran. We have also used a Digital Elevation Model that was exactly like the snow cover data both on the special resolution and projection system.

[*]E-mail: porcista@yahoo.ie Tel: +98 9133131101

Results and discussion

The findings of the present study revealed that there are three major snow reservoirs that are very suitable for the accumulation of snow cover. The snow reservoir is an area snow-covered in long period of time in a year. The three main snow reservoirs of the country are Alborz, North-west and Zagrous and the most number of snow covered days on the heart of these snow reservoir is 153, 132 and 127 days, respectively. The analysis has revealed that the heart of Alborz snow reservoir is a point in Alamkooh which has a north facing slopes that is suitable for snow accumulation. The findings have also revealed that in the snow reservoir of Zagrous the relation between snow covered days and elevation is not very matched in west to east direction. This is due to a decrease in precipitation from west to east in this area.

Conclusion

In this study, the daily time series of MODIS Terra and MODIS Aqua data have been applied to detect snow reservoirs of Iran. Before using the daily data, some cloud removal technics have been applied on the raw daily data to minimize cloud cover effects. The findings have also revealed that in Iran there are three main snow reservoirs which are Alborz, North-west and Zagrous. The most number of snow covered days was detected to be on Alborz snow reservoirs. It has been detected in this study that in eastern Zagrous the changes of snow cover with elevation is not a positive direct relation and it tends to be reduced as elevation increases. It can also be concluded that the most number of snow covered days are not necessarily seen on the highest mountains in Iran but in lower elevations. It was discovered that the role of topographic conditions is of great importance for the accumulation of the snow cover. The eastern and northern aspects are suitable for the persistence of snow cover days and the highest number of snow covered days was detected in these aspects in the country.

Keywords: Snow reservoirs, MODIS Terra, MODIS Aqua, Iran

Estimation of Snow Characteristics by Wavelet and Geostatistic Methods (Case Study: North-West Basins)

Maryam Bayat Varkeshi*
Assistant Professor of Water Engineering, Faculty of Agriculture, University of Malayer, Iran
Alireza Ildoromi
Associate Professor, Faculty of Natural Resources and Environment, Malayer University, Malayer, Iran
Hamid Nouri
Assistant professor in Climatology, Malayer University, Malayer, Iran
Hamid Zareabyaneh
Associate Professor of Irrigation and Drainage Engineering, Agriculture Faculty Bu-Ali Sina University, Hamedan, Iran

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Extended Abstract

Introduction

Snow is an important hydrological phenomenon and snow water equivalent is suitable water resource in many parts of the world. Snow and snow water equivalent have a significant contribution in streamflow and groundwater recharge. For this reason, it is important modeling of snow accumulation and melting. So, estimation of snow spatial distribution in different time scales is one of the key stages in the studies of water resources.

Due to the successful application of wavelet network model method in different sciences, the purpose of this study is to estimate the snow characteristics. In this study, the spatial analysis of snow water equivalent, snow depth and snow density, as one of major components of the water balance, is evaluated in watershed of the north-west country.

Materials and methods

In this study, we have used geostatistical methods to estimate spatial distribution of snow height, snow density and snow water equivalent. Thus, by measurement data of three provinces of Azabbayjan- Sharghi, Azarbayjan- Gharbi and Ardebil during four years (2008-2012) in north-west, we have also evaluated capability of Artificial Neural Network, Wavelet model (Wavelet-ANN) and geostatistical methods. Figure 1 shows location of study area and the data.

*Email: m.bayat.v@gmail.com Tel: +98 9188184123

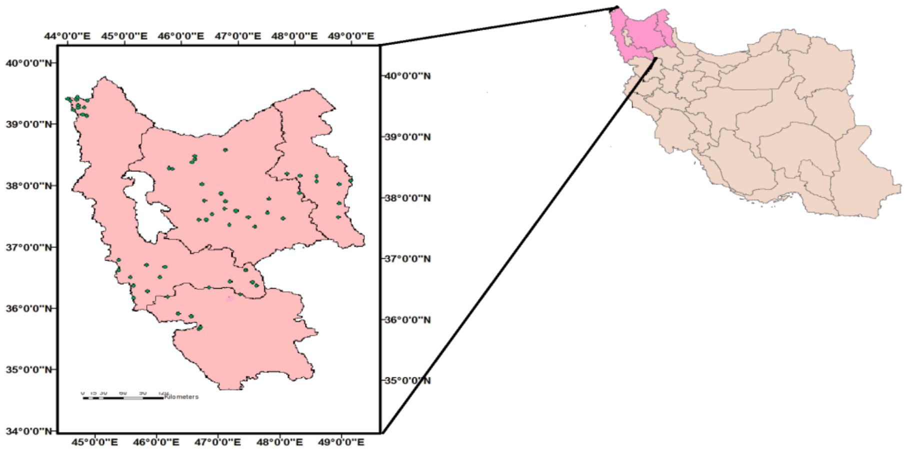

Figure 1. Location of study area

For estimation of snow characteristics in non-measurement estimated points, we have used the evaluation by longitude and latitude parameters. The results the comparison between each geostatistical methods has been conducted by the Normal Root Mean Square Error (NRMSE) index.

$$NRMSE = \frac{\sqrt{\frac{\sum_{i=1}^{n}(X_i - Y_i)^2}{n}}}{\bar{Y}} \quad (1)$$

Where X_i ,Y_i: i^{th} are estimated snow data, n: number examples. The drawing of zoning maps has been carried out by ArcGIS.

Results and discussion

Before zoning, correlation coefficient values of snow density, snow height and snow water equivalent as dependent geographic properties has been obtained in SPSS (Table 1).

Table 1. The correlation coefficient matrix of used variables

Snow height	Snow water equivalent	Snow density	Elevation	Latitude	Longitude	
0.218	0.270*	0.167	0.276*	-0.456**	1	Longitude
-0.103	-0.107	-0.053	0.105	1	-0.456**	Latitude
0.500**	0.489**	0.221	1	0.105	0.276*	Elevation
0.035	0.410**	1	0.221	-0.053	0.167	Snow density
0.893**	1	0.410**	0.489**	-0.107	0.270*	Snow water equivalent
1	0.893**	0.035	0.500**	-0.103	0.218	Snow height

In addition to Table 2, elevation and longitude with correlation coefficients of 0.489 and 0.270, respectively, have the most effect on snow water equivalent. The positive sign indicates straight relative relation of elevation and longitude with snow water equivalent.

As a general result, each three snow characteristics have positive relationship with elevation. It is because the elevation is an important topography factor and increase in height leads to decreased air temperature and enhancement of snow.

The results indicated that the Ordinary Kriging method with Gaussian semi-variogram have had the best results than all other geostatistical methods. The results have indicated that mean accurate kriging method with Guassian semi variogram for snow density, snow water equivalent and snow height during four years based on Normal Root Mean Square Error (NRMSE) are 0.259, 0.429 and 0.390, respectively. The results of application modeling of Wavelet-ANN have indicated that the NRMSE values for snow density, snow water equivalent and snow height are 0.122, 0.002 and 0.001, respectively. Therefore, it can be said that accuracy of Wavelet-ANN method in estimation of snow characteristics is more than geostatistical methods. Also, the accuracy of both methods in simulation of snow height is the most. Another results illustrated that with applying Wavelet-ANN, difference between minimum and maximum values of snow characteristics is decreased.

Conclusion

The purpose of this research is to develop interpolation methods to assess the estimation of snow components in the non-measurement points. In addition to equipment and preparation problems of snow stations, it is necessary to use modern methods to estimate the snow spatial distribution. The results of this study have also indicated that in the study area and in a four years period, ordinary kriging has given better results than other geostatistical methods. But, the difference in the results of geostatistical methods with Wavelet-ANN in estimation of snow characteristics is high. Applying wavelet-ANN method has decreased error values. Thus, it is recommended to use Wavelet-ANN method in estimation of snow characteristics of study area. Since the used independent variables are located in available variable categories (access to the data at a lower cost and higher accuracy), we can expect good results with high accuracy.

Keywords: ArcGIS, geostatistical, snow water equivalent, snow density, snow depth

Comparison of Holiday Climate Index (HCI) and Tourism Climate Index (TCI) in Urmia

Khadijeh Javan[*]
Assistant Professor of geography, Department of geography, Urmia University, Urmia, Iran

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Extended Abstract

Introduction

Tourism has become one of the largest global economic sectors in the world and contributes significantly to national and local economies. Climate has a significant influence on tourism decision-making process. It is a key factor considered by the tourists either explicitly for the purpose of travel planning or as a primary motivator. The first attempt to develop a numerical index to evaluate climate for tourism purposes was by Mieczkowski (1985) who designed the 'Tourism Climate Index' (TCI). The purpose of the TCI was to present a quantitative composite measure to evaluate the world's climate for general tourism activities by integrating all climatic variables relevant to tourism into a single index.

The TCI has been widely applied to assess the future climate suitability of destinations. Despite the TCI's wide application, it has been subject to substantial critiques. The four key deficiencies of the TCI are (1) the subjective rating and weighting system of climatic variables; (2) it neglects the possibility of an overriding influence of physical climatic parameters; (3) the low temporal resolution of climate data, i.e., monthly data, has limited relevance for tourist decision-making; and (4) it disregards the varying climatic requirements of major tourism segments and destination types. To overcome the above noted limitations of the TCI, a Holiday Climate Index (HCI) was developed to more accurately assess the climatic suitability of destinations for tourism. The main purpose of this study is to evaluate and compare tourism climatic condition in Urmia using holiday Climate Index (HCI) and tourism climate index (TCI).

Materials and methods

In this study, two tourism climate indices of the Tourism Climate Index (1985) and newly designed Holiday Climate Index have been applied. Daily data of air temperature, relative humidity, precipitation, cloud cover, sunshine and wind speed have been obtained to calculate both indices. The TCI was designed by Mieczkowski (1985) as a method to evaluate climate suitability for general tourism activities. The TCI assesses a climate suitability of location for tourism by grouping seven climatic variables into five sub-indices. In this study, daily climatic data have also been used as the TCI's input for the purpose of comparing the rating differences

[*] Email: kh.javan@urmia.ac.ir Tel: +98 9143815390

between the two tourism climate indices. The index score calculated by the TCI formula is then adapted to the classification scheme designed by Mieczkowski (1985) to describe a climate suitability of location for tourism. A new tourism climate index, the Holiday Climate Index (HCI), was designed with the purpose of overcoming all identified deficiencies and limitations of the TCI. The HCI uses five climatic variables related to the three facets essential to tourism: thermal comfort (TC), aesthetic (A), and physical (P) facet. A major advancement of the HCI is that its variable rating scales and the weighting component system were designed based on the available literature on visitor's climatic preferences that have been obtained from a range of surveys from the last 10 years.

Results and discussion

Current climatic conditions (1981-2010) of Urmia have been rated using both TCI and HCI. This station has a summer peak climate distribution when rated by the TCI. This means that summer months have the most suitable climate for urban tourism. Similar to the TCI ratings, Urmia has a summer peak climate distribution when rated by the HCI. By comparing the HCI and TCI monthly, what can be seen in the rating differences between the two indices is more prominent in winter months. The comparison has also indicated that the HCI rates the climate for tourism higher than TCI. Then, rating differences between the two indices have been compared in thermal, aesthetic and physical facet. When the HCI is compared with the TCI in assessing climatic conditions of Urmia, rating differences are observed from temporal aspects. The HCI ratings are generally higher than the TCI ratings in most months of the year. Seasonally, a major disagreement between the two indices exists in the rating of winter climate conditions, as winter has the widest gap in ratings between the TCI and HCI. When temperatures become warmer, the gap between the two indices becomes narrower.

Conclusion

In assessing a climatic suitability of a destination for tourism, the TCI has a dominant place literature. An ideal tourism climate index is able to integrate the effects of all facets of climate, simple to calculate, easy to use and understand, recognize overriding effects of certain weather conditions and most importantly, based on actual tourist preferences. This paper intended to fill this gap by introducing a new tourism climate index, the Holiday Climate Index (HCI). By comparing the rating differences between the two indices under specified weather conditions and comparing the ratings against visitation data, a reasonable conclusion could be drawn regarding to whether the HCI is a better index than the TCI in rating the climate suitability for tourism and whether existing studies using the TCI to assess tourism climate resources should be reassessed.

Keywords: Tourism Climate Index (TCI), Holiday Climate Index (HCI), climate index, tourism, Urmia.

Evaluation of the feasibility of wind energy utilization in Sistan and Baluchestan Province

Parisa Kahkha Moghaddam*
Assistant professor of water engineering, Faculty of Water and Soil, University of Zabol, Iran
Masoomeh Delbari
Associate professor of Water engineering, Faculty of Water and Soil, University of Zabol, Iran

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Extended Abstract

Introduction

Energy is one of the most important demands in development of human societies. As world population continues to grow and the limited and non-renewable resources of fossil fuels begin to diminish, countries must take action to facilitate a greater use of renewable energy resources such as geothermal and wind energies. Iran has a high wind energy potential, but except in a few specific regions such as Binalud and Manjil, the use and exploitation of such clean renewable source is still not addressed enough. Wind speed in Sistan and Baluchistan province especially in the cities like Zabol is very high and sometimes it goes near 120 km/h. Thus, the purpose of this study is to investigate the feasibility of wind harvesting in synoptic stations of Sistan and Baluchestan province. Moreover, the trend analysis of wind data is to be investigated in this paper.

Materials and methods

This study is based on wind data in 8 synoptic stations, for a period of 10 years (2005-2014). The analysis is based on 3 hours interval wind speed data measured in 10 m height above ground surface.

The most widely used model to describe the wind speed distribution is the Weibull two-parameter. These two parameters include k and c: the first is the shape parameter and the second is the scale parameter. There are several methods to calculate these parameters. In this paper, these two parameters have been determined through the Maximum Likelihood (ML) technique. The Weibull distribution function is expressed mathematically as:

$$f(V)=\frac{k}{c}\left(\frac{V}{c}\right)^{k-1}\exp\left[-\left(\frac{V}{c}\right)^{k}\right],\qquad \left(k\rangle 0, V\rangle 0, c\rangle 1\right) \tag{1}$$

Where f (v) is the probability density function, k is the shape parameter, c is the scale parameter (m/s), and v is the wind speed (m/s). The probability of having a wind speed between two values of interest V_1 and V_2 is given by the equation

* Email: keykhamoghadam.parisa@gmail.com Tel: +98 9155441540

$$P\left(V_1 < V < V_2\right) = \exp\left[-\left(\frac{V_1}{c}\right)^k\right] - \exp\left[-\left(\frac{V_2}{c}\right)^k\right] \quad (2)$$

The maximum likelihood method estimates the parameter k by solving the following equation iteratively:

$$k = \left[\frac{\sum_{i=1}^{n}(V_i^k \ln V_i)}{\sum_{i=1}^{n} V_i^k} - \frac{1}{n}\sum_{i=1}^{n}\ln V_i\right]^{-1} \quad (3)$$

Where n is the number of wind observations and V_i is the observed wind speed value for the i observation. Parameter c can be expressed using the values of shape parameter (k) as follows:

$$c = \left[\left(\frac{1}{n}\right)\sum_{i=1}^{n} V_i^k\right]^{1/k} \quad (4)$$

Given k and c, the most probable wind speed (V_{mp}) and optimal wind speed (V_{op}) are calculated for every synoptic station. Wind energy density and wind power density are also calculated for the selected stations.

Moreover, the trend analysis are performed for monthly and annual wind speed data for a period of about 25-40 years up to 2014 using Mann Kendal test and Thiel Sen's estimator.

Results and discussion

Monthly mean and standard deviation of wind speed data have been calculated for the selected stations during 2005-2014. The results have indicated that the monthly variation (2 to 5 m/s) of mean wind speed for all the years is similar as the highest and lowest mean wind speed was happened in winter and autumn, respectively.

The wind speed characteristics required to evaluate the feasibility of wind energy utilization have been calculated for the selected stations. The results have also represented that the maximum wind power density has been observed for Zabol with the values of 257.227 W/m^2 and 512.713 W/m^2 in 10 m and 50 m high, respectively. The lowest wind power density has been observed in Iranshahr with the values of 40.196 W/m^2 and 80.12 W/m^2 in 10 m and 50 m high, respectively. Comparing these data and the data calculated for other stations with the standard classification criteria indicated that Zabol, Zahak and Konarak are the most suitable sites for wind turbines installation. Moreover, Zabol has the maximum probability of having the wind speed of 3 to 25 m/s, i.e. 0.71 and 0.82 for 10 m and 50 m high, respectively. Therefore, given a wind turbine installed in 50 m high, the probability of blowing wind with the speed of 3 to 25 m/s, is about 0.82 multiply by total hours of wind existence during a year (82*7566 hrs/year), i.e. 5822 hrs/year.

The results of the trend analysis by Mann-Kandal test have also revealed that there is either an increasing trend or decreasing trend in the selected stations; however, increasing trends (e.g. Zabol, Iranshahr, Zahedan and Konarak) were more often. Wind speed in Zabol has shown a positive trend for all months (except September). However, the trend was significant in 41.6 percent of times. In annual basis, wind speed in Zabol has positively increased at a significance level of 5%. Wind speed in Iranshahr has shown a significant positive trend in both monthly (except April) and annual scale. Overall, annual wind speed has a positive trend in half the stations considered and a negative trend in others.

Conclusion

According to the findings achieved in this study, wind speed is lower in the last months of the year for all stations in Sistan and Baluchistan province. The highest variation of wind speed has been observed for Zabol. Based on trend analysis, some significant positive trends of annual and monthly wind speed has been observed in Iranshahr, Zabol, Zahedan, and Konarak in descending order. According to the results, the highest wind power density in the height of 50 m has been seen for Zabol (513 W/m^2) and Zahak (434 W/m^2) and the lowest for Iranshahr (80 W/m^2). Overall, based on wind speed existence and its annual continuity, three stations of Zabol, Zahak and Konarak has been realized to be appropriate for installing wind turbines.

Keywords: trend analysis, Weibull distribution, wind energy potential, wind power density

The Analysis of Seasonal Precipitation Time Series in Iran

Jafar Masoumpour Samakosh*
Assistant professor of climatology, department of geography, Razi University, Kermanshah, Iran
Abdollah Jalilian
Assistant professor of statistics, department of statistics, Razi University, Kermanshah, Iran
Ehteram Yari
MSc in Climatology, Razi University, Kermanshah, Iran

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Extended Abstract

Introduction
Due to the increasing significance of water supply in Iran, the management of water resources is of a particular importance. Precipitation is regarded as the most considerable source of water that is faced with great temporal (daily, monthly, seasonal and yearly) and spatial changes among other climatic factors. Therefore, the studies, focusing extensively on this issue are really useful, for they would provide the ways for optimal use and water management in the temporal and spatial scales.

Generally, there are a lot of predictive methods trying to determine the relationship between dependent and independent variables. Moreover, different statistical models have been applied to predict climatic variables. In recent years, the analysis of time series has been extensively used in scientific issues.

As a matter of fact, the analysis of a time series provides the ways to determine its possible structure, recognize its components to analyze and predict the process and future values. Therefore, the investigation and prediction of precipitation in different temporal dimension (daily, monthly, seasonal, and yearly) for each region and watershed are considered as the most important climatic parameters for optimal use of water resources affecting temporal and spatial distribution of other climatic factors. Accordingly, it is necessary to recognize the seasonal pattern of precipitation, and spatial similarities and differences of this time pattern, especially when they are not the same for different regions of Iran. The present research aims at studying the seasonal precipitation of Iran. It turns out that the precipitation does not follow a distinct unique pattern in each part of Iran, so the recognition of seasonal precipitation, separating different region, would help the authorities for environmental planning and management. Moreover, it even can lead to more successful predictions.

Materials and methods
In the present study, seasonal precipitation time series of synoptic stations (during the statistical period of 1985- 2014) is modeled applying SARIMA model. The accuracy of the fitted models

*E-mail: j.masoompour@razi.ac.ir Tel: +98 9183317989

to the data series for each station is evaluated by the standardized residuals graph, autocorrelation graph of residuals models and Ljung-Box test (in the significance level of 0.05). Then, the appropriate model for seasonal precipitations is presented for each station (Table. 1) according to Akaik Information Criterion (AIC). Furthermore, seasonal and inter-seasonal autoregressive rate (P, p) and moving average rate (Q, q), which were found by fitted models, are studied to investigate the seasonal and interseasonal precipitation relationship in each station. At the end, the relationship of seasonal precipitation patterns is mapped by applying ArcGIS.

Moreover, all statistical tests and temporal series computations are conducted in the environment of R software.

Results and discussion

Evaluating the adequacy of the fitted models has revealed that the model of correlation structure is able to describe the data for all stations in this study (except for Booshehr, Shahr-e-Kurd, Birjand, Omidiye Aghajari, and Rasht). This can analyze seasonal precipitations for the stations correctly. Therefore, it is adequate enough. Seasonal and interseasonal autoregressive rate (P. p) and moving average (Q, q) from the fitted models have been used to determine the relationship of seasonal and interseasonal precipitation for each station. Except for Kashan, Abali, Doushantape, Semnan and Shahroud stations, the other 62 studying stations (93%) follow the seasonal pattern showing seasonal behavior. Furthermore, the rate of seasonal part of the model (P) shows that there is a direct relationship between the precipitation of each season and the precipitations of that season in the previous years (1 to 2). The (Q) rate has revealed that random oscillation of seasonal precipitations of 1 to 2 years before is also indirectly effective for some stations. The rates of interseasonal difference (d) have been investigated to analyze the process of time series of precipitation for the studying stations. It has demonstrated that the stations of Maraghe, Sanandaj, Hamedan-Nouzhe, and Ferdos have a decreasing process in their data, while, in the other stations, seasonal precipitation does not follow a decreasing or increasing process. In fact, it follows a constant process having no static process.

Conclusion

Applying SARIMA model, the relationship of seasonal and interseasonal precipitations of Iran has been recognized. Hence, first, the adequacy of SARIMA model has been evaluated. The findings prove that the aforesaid model can describe the correlation structure of the data for the studying stations (except for Booshehr, Shahr-e-Kurd, Birjand, Omidiye Aghajari and Rasht) well and it is adequate enough. This fact is in accordance with the findings of Alijani and Ramezani (2002), Golabi et al (2013), Chang et al (2012), Bari et al (2015) who used SARIMA model to predict drought and temporal series of precipitation to prove its adequacy.

The investigation of seasonal and interseasonal precipitation dependency and the analysis of temporal series process of seasonal precipitation in each station show that, according to seasonal autoregressive rate (P) in all studying stations (except for Kashan, Abali, Doushantape, Semnan and Shahroud), the precipitations of each season is directly dependent upon the precipitations of that seasons in the previous years (1 to 2). Besides, the random oscillation of seasonal precipitation of the previous years (1 to 2) also affects the seasonal precipitations on some stations. Therefore, it can be concluded that the precipitations of the stations (93%) follow the seasonal patterns showing seasonal behavior. Furthermore, the findings of interseasonal autoregressive rate (p) for all stations prove that the precipitations of each season have a direct relationship with the precipitations of the previous season for 19 stations (28%).

Analyzing the process of seasonal precipitations has indicated that, except for Maraghe, Sanandaj, Hamedan-Nouzhe and Ferdos stations, time series of seasonal precipitation has no process (random or non-random) in the stations. This process has a decreasing process for these 4 stations, while it is static in the other stations.

Keywords: seasonal precipitation, SARIMA Model, Akaike Information Criterion (AIC), model evaluation, trend, Iran

The Role of Sistan 120 Days Wind in Thermal Advection of East and Southeast Iran

Shoaieb Abkharabat
PhD Student in Climatology, Tabriz University, Tabriz, Iran
Mostafa Karimi*
Assistant Professor of Climatology, University of Tehran, Tehran, Iran
Amanallah Fathnia
Assistant Professor of Climatology, Razi University, Iran
Mohamad Hamed Shambaiati
MA in climatology, Jahad Daneshgahi, Kermanshah, Iran

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Extended Abstract

Introduction
The 120-day winds of Sistan are considered as the most important and well-known climatic factors in eastern regions of Iran during hot period. They have various effects on the region. For example, these winds make dust storm, more evapotranspiration and sand prairie in this region. Generally, as these winds have great impacts on the environment and human life, they should be studied from different climatic aspects. Given the importance of the winds, this study aimed at evaluating the role of these winds in declining the temperature of the region. The results will prove one of the positive environmental aspects of these winds during hot period of year in eastern dessert regions of Iran. However most effects of these winds were negative and considered as one of the life limiting factors in the east Iran.

Materials and methods
The period used in this study is the 2480 days in 22 years (2012-1993) from May until end of September. The atmospheric circulation types have been extracted using daily mean of the 850 hPa geopotential height data. Then, the agglomerative hierarchical cluster analysis with the ward algorithm and Euclidean distance has been used to identify atmospheric circulation types over Iran in the mentioned period of years. Finally, 5 atmospheric circulation types have been identified in this period of years. We, then, have analyzed wind speed and direction, the wind thermal advection in levels of 1000, 925, 850 and 700 hPa, and also the thermal advection of atmospheric vertical profiles.

Results and discussion

The Position of Maximal Cores of Temperature (Thermal Equator)
As a matter of fact, maximal cores of temperature imply the position of earth thermal equator. Pattern 1, in which 120- day winds of Sistan cover east and southeast parts of Iran more

*E-mail: mostafakarimi.a@ut.ac.ir Tel: +98 9354483912

intensely and more widely, reveals that maximal temperature covers Iraq and west part of Iran, while in the same latitude there is cool weather in east part of Iran. Pattern 2 in which the 120-days winds of Sistan have less intensity and expansion shows that thermal equator belt of east is penetrating into northern latitudes, even though lower temperature is still recorded in east and southeast Iran. This is compared with west parts of Iran and Iraq. Generally, these 2 synoptic patterns reveal that 120-day winds of Sistan with northern direction lead to a decrease in the temperature of east and southeast Iran. Besides it makes thermal equator belt move to southern latitudes. There are the patterns 3, 4, and 5. In these patterns, 120-day Sistan winds are not dominant in the area. This leads to an increase in the temperature of the area and a core formation of maximal temperature in east and southeast Iran. Unlike patterns 1 and 2, in these patterns eastern regions of Iran have higher temperature than Mesopotamia and west Iran. As a result, the advection of eastern winds in the region makes thermal equator penetrate northern altitudes as it covers east and southeast Iran. Due to this phenomenon, eastern regions record much higher temperature than the regions in Mesopotamia and west Iran, although they are in the same latitude.

Conclusion

Wind advection in eastern and southeastern regions of Iran during hot period of year is considered as one of the most important and most effective climatic phenomena having great impacts on environment and communities. There are two advection orders during this period of year, the advection of northern winds (120- day winds of Sistan) and the advection of eastern winds. Eastern winds mostly cover eastern and northeastern regions of Iran, while northern winds mostly cover eastern and southeastern regions. The calculation of thermal advection during the existence of each wind demonstrates that during the advection of northern winds, a core of negative thermal advection is made in east and southeast Iran. As these winds are intensified, the intensity of this negative thermal core is also increased. This phenomenon reveals that this is the heat transmission from the dominant regions of this negative thermal advection to surrounding regions which provide cool weather in east and southeast areas of the country. Besides, vertical profile of atmosphere also proves the altitudinal expansion of this core of negative thermal advection through higher levels. A core of negative thermal advection is made during the advection of eastern winds, although this core dominates less regions limiting to eastern regions of Iran. Besides, a core of positive thermal advection is made in southeast part of Iran. This phenomenon not only leads to heat aggregation, but also makes a core of maximal temperature in the region and transfers thermal equator to east and southeast of Iran. Moreover, temperature in eastern half of Iran is lower than that of the west and also that of Mesopotamia during the advection of 120- day winds, while this region shows higher temperature than west of Iran and Mesopotamia in the absence of 120- day winds. Therefore, the advection of northern winds (120- day winds of Sistan) makes thermal equator of the earth move to southern latitudes in southeast Iran to decrease the temperature of the region.

Keywords: Sistan 120 days wind, synoptic, thermal advection, Iran.

The effects of urbanization and Heat island over summer temperature variations in Babol

Yadolah Yousefi*
Assistant Professor of Geography and Urban Planning, Faculty of Social Sciences and Humanities, University of Mazandaran, Mazandaran, Iran
Fatemeh Kardel
Assistant Professor of Marine and Ocean Sciences, University of Mazandaran, Mazandaran, Iran
Hematolah Roradeh
Assistant Professor of Geography and Urban Planning, Faculty of Social Sciences and Humanities, University of Mazandaran, Mazandaran, Iran
Molod Mohtasebi Khalatbari
MSc in Urban Climatology, University of Mazandaran, Mazandaran, Iran

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Extended Abstract

Introduction

The rapid growth of urbanization formed in the 19th century after the industrial revolution in the developed countries. After the revolution, the urban areas of many cities extended rapidly. In those cities many different activities such as transportation, industrial and construction activities is much higher than rural environments. In the urban environments, vegetation and green spaces are lower than those in rural areas. Thus, these activities cause the increased level of temperature in the urban environments compared with surrounding **areas**. This phenomenon is called "urban heat island". This urban heat island is one of the main concerns in the urban environments due to its impacts on biological, meteorological, environmental, social and economic issues. For instance, urban heat island causes earlier bloom and the blossom of plants and trees and also prolongation of the growing season. Thus, Babol is one of the densely built cities of Mazandaran province. It is confronted with rapid population growth during the few last decades. The aim of this research is to investigate the impacts of urbanization on heat island and day to day temperature variation in that city.

Materials and methods

The study area is in the Babol city, Mazandaran. Due to the lack of meteorological station in the Babol city, three devices with data logger (MIC 98583 USB-Data Logger, Taiwan) have been equipped to record temperature and relative humidity in three environments of urban, suburban, and green areas. The temperature and relative humidity have been recorded every hour throughout the course of 80 days (July 6 to September 22) in 2015.

The monitoring boxes have been placed at a height of about 2.5 m above the ground surface. This study has investigated the day to day temperature variation with respect to the impacts of

* Email: y.yousefi@umz.ac.ir Tel: +98 9127978671

urbanization on temperature variations. For this purpose, the two following integrated methods have been used: 1) the day to day temperature variation (DTD); 2) the difference between day to day variability of daily maximum temperature (DTD max) and day to day variability of daily minimum temperature (DTDmin).

The day to day temperature variation is based on the following equations:

$$DTD = \sum |t_i - t_{i-1}| / (n-1) \quad (1)$$

Where Σ is the sum over all n data elements, t is daily temperature, i is the counter that marches through the days in a time period (e.g. a month),| | gives the absolute value, and n is the number of days elements.

$$\Delta DTD = DTD(tmax) - DTD(tmin) \quad (2)$$

Where, ΔDTD is the difference between day to day variability of daily T_{max} ($DTDt_{max}$) and day to day variability of daily T_{min} ($DTDt_{min}$). A positive value indicates greater day-time day to day temperature variation and a negative value indicates greater night-time day to day temperature variation. The significant difference for temperature (maximum and minimum) and daily relative humidity in different environments has been tested using the One-Way Analysis Of Variance (ANOVA); and then the day to day variability of temperature has been calculated based on a DTD and ΔDTD equations for all three environments. Analysis of the data has been conducted using Excel and R software.

Results and discussion

The difference between the mean temperature of urban and suburban environments in our study area is around 1°C. This difference between urban and green environments is around 1.8°C. The mean relative humidity in the urban and green environments is minimum (67%) and maximum (77%), respectively. Day to day temperature variation of daily temperature DTD (t_{mean}) and temperature maximum DTD(t_{max}) in the urban environment is higher than those of suburban and green environments, but the day to day temperature variation of daily temperature minimum DTD(t_{min}) is less than those of the two other environments. The difference of DTD (t_{max}) and DTD (t_{min}) in the urban environment is higher than that of the two other environments and is nearly zero for the green environment. These values indicate higher variation of the daily temperature in the urban and a very small difference in the daily and nightly temperatures variation for the green environment. The results of this research have demonstrated that the heat island not only affects the temperature in Babol city, but also influences its day to day temperature variation.

Conclusion

The results of this research have indicated the impacts of urbanization on climatic parameters in particular temperature and humidity. The results have also revealed that the green environment can play an important role on the climate change of Babol city.

Keywords: heat island, DTD, ΔDTD, Babol, green space

Analysis of rainy days in Iran based on output Aphrodite Precipitation Database

AbdolReza Kashki*
Assistant Professor of Climatology, Hakim Sabzevari University, Sabzevar, Iran
AbbasAli Dadashi Roudbari
PH.D Student Urban Climatology, Shahid Beheshti University, Tehran, Iran

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Extended abstract

Introduction
Knowledge of the amount, spatial distribution and temporal variation of rainy days is essential to provide public information, hydrological modelling and flood forecasting, climate monitoring and climate model validation. Data Grids Database provides valuable information about the amount and frequency of rainfall.

A rainy day indicates a day when all the conditions of precipitation, humidity, instability and condensation nuclei have been provided in the atmosphere.

Iran is located between the vast territories of Siberia in the north, the Mediterranean Sea in the west, the African deserts in Saudi Arabia in the southwest and the Arabian Sea and India in the east. This is a factor for interacting with different atmospheric systems on Iran. Interaction deep, complex and continuous rainfall is caused by climate change and a variety of other elements in space and time. Therefore, the aim of this study is to study the number of days of Iranian rainfall using the Aphrodite precipitation database in the 56-year period (1/1/1951 to 31/12/2007).

Materials and methods
In the present study, data of the Middle East region (APHRO_ME) have been obtained from the latest Aphrodite database product (Yatagai et al. 2014) under the name of v1101, with a resolution of 0.25 × 0.25 °, equivalent to 25.5 x 25.5 km with the format of NC" NetCDF. Given the programming capabilities of Grads 2.0.a9 and Matlab R2013 software, the 57-year precipitation data (1951-2007) have been selected from the total precipitation database (APHRO_ME) on a daily basis. In this research, the Root Mean Square Error (RMSE) and the coefficient of determination (R2) have been used.

Results and discussion
The values are different in every area of rainfalls and every time. The skewness provided shows that the spatial distribution of precipitation is skewed to the right, towards the low-rainfall areas relative to the areas with high rainfall. According to the dynamic and thermodynamic systems

* Email: r.kashki@yahoo.com Tel: +98 9151731453

considered as a cause for precipitation and dependent on the geographic location, these systems in dealing with local conditions can cause different precipitation regions. Therefore, the amount of precipitation can be estimated by a variety of statistical parameters. The difference in median, mean and deviation indicates that the data does not follow a normal distribution.

The number of rainy days is ranged from 9 to 147 days. The average number of rainy days in Iran is 38 days, while the number of rainy days is 36.62% of the area of the country, less than 38 days. The rainy day of region in terms of the number of rainy days is located iin southwest part of the Caspian Sea (32 km south part of the Bandar Anzali West synoptic). Similarly, the lowest number of rainy days with 9 days in South East Iran has located 116 kilometers East of Khash synoptic stations.

Conclusion

The results have indicated that the average of rainy days is 38 days and, however, the number of rainy days is 36.62% of the area of the country. The maximum rainfall Iran with 147 days is located on the Caspian Sea in the South West. On the other hand, a minimum of 9 days of rainy days is in the South East Iran. Iran is divided into four zones of rainy days in the entire north coast, the northern part of North Khorasan, North West and West Highlands in a group. Finally, the division offered the best zone division of rainy days. The country is divided into six zones. The six zones are the Khazary zones with 126 rainy days, across the mountainous regions of West, North West and Northeast with 77 rainy days across the mountainous area, a zone between the highlands and lowlands of leeward with 38 rainy days. Finally, the relationship between the number of rainy days with latitude and elevation has been evaluated for the entire zone in Iran and the six zones. There is a correlation of 0.57 for entire Iran. This has determined the most important factor in the equation. The differences between the average and the maximum number of rainy days in Iran have been compared with other studies. The comparison has revealed accuracy of the results.

Keywords: rainy day, rainy areas, stepwise regression, Aphrodite Database, Iran.

Nature and structure of the atmospheric circulation in pervasive rains of spring, Iran

Esmaeil Haghighi*
PhD in Climatology, Physical Geography Department, University of Tabriz, Iran
Mohammad Hissein Gholizadeh
Assistant Professor of Geography, Faculty of Natural Recourses, University of Kurdistan, Iran
Mahdi Doostkamian
PhD candidate in Climatology, Zanjan University, Iran
Fatemeh Ghaderi
PhD candidate in Climatology, University of Tabriz, Iran

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Extended Abstract

Introduction

Atmospheric circulation patterns play a major role in temporal distribution and geographical distribution of precipitation. According to most researchers, the changes in climatic circulation patterns are controller of swing shifts, and also the intensity of precipitation and changes in atmospheric moisture content. Thus, increases in atmospheric temperature will follow moisture content. On the other hand, the changes in precipitation patterns may be affected by carbon dioxide. How much the increase in greenhouse gases can affect climate processes is still a question by many researchers. But it is obvious that the density increases the concentration of greenhouse gases directly or indirectly in climate elements, and that both space and time is affected. However, many studies have indicated that rainfall patterns in tropical areas, especially over the oceans, are heavily influenced by changes in temperature (SST) patterns at sea level.

Materials and methods

In order to perform an analysis of extensive spring rains in Iran, this study uses two groups of different environmental data.

1. Environmental Data: This group of data contains interpolation of daily spring rainfall quantities of station in April, May and June throughout the country from 1961 to 2010 (4650 days). Using daily precipitation data from 551 synoptic and climatology stations have been measured by the National Meteorological Organization of Iran. Finally, by combining these three matrices, matrix dimensions can be obtained for the studied period (4650×7187). After identifying rainy days, the percent coverage (pervasiveness of precipitation) has been considered. Given that most researchers in their studies have selected fifty percent coverage as the threshold for pervasive rains, this study also uses the 50% threshold. Thus, 265 days have been selected and subsequently analyzed.

2. Atmospheric data: these data consists of sea level pressure and geopotential height at 500

*E-mail: es_haghighi@ut.ac.ir Tel: +98 9120772261

hPa with zonal and meridional wind data. They have been received from the database of National Center for Environmental Prediction of National Center for Atmospheric Research (National Centers for Environmental Prediction / National Center for Atmospheric Research).

Results and discussion

The results of this study have indicated that spring rainfall of pervasive rains is increasing towards June. The results of the study have also revealed that four patterns, the Saudi low pressure, Iran central low pressure, the Europe low pressure, Sudan low pressure, the Persian Gulf low pressure, Siberian high pressure and the multi-core patterns of the Middle East low pressure have the highest influence on the pervasive rainfall in spring. In all four patterns, the convergence centers of 1000 hPa are consistent with low pressure systems. In 1000 hPa level moisture flux maps, humidity injection has been done mainly through the anticyclone on the Arabian Sea into the Sudanese system. It was strengthened by injecting humidity from the Red Sea and the Persian Gulf. Therefore, the cold air advection of high pressure centers on the system has been occurred due to its dynamic and moisture transport in the North to the Persian Gulf and Iraq. According to the maps, Front Genesis at 850 hPa at all the patterns is frontogeneses mainly in accordance with the transmission path. It is hot and humid weather that extends north.

Conclusion

Spring rains have also daily rise and fall with high spatial variation coefficients. Towards the June the changes become more significant. The results of the study have indicated that there are four patterns, the Saudi low pressure- Iran central low pressure, the Europe low pressure - Sudan low pressure, the Persian Gulf low pressure- Siberian high pressure pattern and the multi-core pattern of Middle East low pressure. These systems play the most important role in pervasive rainfall in spring on Iran.

Keywords: spring pervasive precipitation, moisture flux, Frontogenesis, perceptible water, convergence and divergence

Geomorphological equilibrium by Rosgen and River Style Framework methods (Case study: Tarwal River, Kurdistan)

Hadi Nayyeri*
Assistant Professor of Geomorphology, Faculty of Natural Resources, University of Kurdistan, Iran
Khaled Osati
Assistant Professor of Range and Watershed Management, Faculty of Natural Resources, University of Kurdistan, Iran
Parisa Osmani
MSc in Natural Hazards, Faculty of Natural Resources, University of Kurdistan, Iran

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Extended abstract

Introduction
There are many different factors changing rivers in terms of size, shape, direction and pattern. These changes highlight that rivers tend to equilibrate. The balance between erosion and deposition in a river is defined as equilibrium while the stability of stream morphology is defined as the ability to resist morphological changes for a long time. Doyle and Harbor (2003) showed that bed sediments type has a great impact on the equilibrium, so that the time needed for a sandy-bed channel to equilibrate is almost half of that needed for a gravel-bed channel. It's because sediments transport more rapidly in sandy-bed channels and such channels equilibrate faster than those having fine sediments. A well-known method to evaluate river stability is Rosgen stream classification system. Savery et al (2007) reported that Rosgen stream classification system is applicable for flat and low steep areas. This method is applicable in river engineering designs, management purposes and stream restoration. River Style Framework method is another applicable method to evaluate river stability. Equilibrium, stability and the role of environmental variables on Tarwal River have not been studied yet. As a result, there is no proper knowledge of its equilibrium and stability. Therefore, this case study is trying to study the equilibrium and stability issues in Tarwal basin.

Materials and methods
This case study demonstrates the capabilities of Rosgen and River Style Framework methods in Tarwal River, the main tributary of Sefid Rud. The tributary is located in the eastern part of Kurdistan province. For each river style segment of Tarwal River network, equilibrium capacity and geomorphic conditions have been determined by river style framework using three parameters of channel properties, channel planform and bed characteristics. In the next step, stability of Tarwal River has been determined by Rosgen stream classification system using 15 parameters (bank vegetation, channel capacity, section cuts, aggradation, degradation, sediment

* E-mail: nayyerihadi@yahoo.com Tel: +98 9143059879

and etc.). In addition to extensive field campaigns, topographic maps, aerial photos and Google Earth software have been used to determine cross section dimensions and vegetation condition as well as trenches and terraces. During field campaigns, cross sections dimensions have been measured by a laser meter Leica D5 and locations of sections and trenches have been recorded by GPS. Then, the data have been digitized by ArcGIS. Furthermore, required photos have also been collected from different features in situ.

Results and discussion

Based on river style framework method, river style segments of fine-grained bed having low sinuosity, clay-bed and sandy-bed meandering have represented a local equilibrium capacity. These rivers style segments have indicated limited vertical and lateral movements and their sediments sorted well while river style segments of gravel-bed having low sinuosity or sandy-bed multichannel in Ozon Darreh River, sandy-bed with low sinuosity in Tarwal River and fine-grained meandering in Sang Siah River all have indicated a high equilibrium capacity. This is because of vertical and lateral movements and non-homogeneous sediments. In fine-grained meandering river style segments of Sang Siah River, equilibrium capacity was increased because of vertical (bed incision) and lateral movements in the form of channel contraction (alluvial terraces). This was dominated by vertical movements. These results support Nayyeri and Rezaei Moghadam (2005) findings in meandering river of Siminehrood where bed equilibrium reported as the form of bed incision. By River Style Framework method, the geomorphic conditions of the river were assessed through river characteristics and behavior. River style segments of gravel-bed river with low sinuosity in Sis River and a small tributary (in the northeast part of Tarwal River), a sandy-bed river with low sinuosity in Tarwal River and sandy-bed multichannel in Ozon Darreh River have represented a relatively high width to depth ratio, low sinuosity, compound and irregular channel shapes and erosional banks. These river style segments have represented poor geomorphic conditions because of non-homogenous poor-sorting sediments and bed erosion. River style segments of fine-grained bed with low sinuosity in Esmail Jamal, Jorvandi, Ozon Darreh and Tarwal Rivers, clay-bed ada in Sang Siah and Jorvandi Rivers and sandy-bed meandering in Tarwal River have also indicated a good geomorphic condition because of well-sorted sediments, considerable vegetation cover and lack of erosional banks.

The stability of all sections has been analyzed by Rosgen stream classification system. For this purpose, each river style segment, 1-3 sections (totally 34 sections) have been studied and their dimensions measured in situ. River style segments of clay-bed ada in Sang Siah River with sandy-bed meandering, sandy-bed multichannel, fine-grained river with low sinuosity and fine-grained meanders in Tarwal Main River are stable while river style segments of gravel-bed river with low sinuosity in Sis and a small tributary (in the northeast of Tarwal River), sandy-bed with low sinuosity in Tarwal River and sandy-bed multichannel in Ozon Darreh River are unstable. This instability is because of significant incision, high roundness of sediments grain distribution and their poor sorting as well as filled pools.

Conclusion

Instability of River style segment in downstream Jorvandi and Ozon Darreh Rivers and upstream Tarwal and Sang Siah Rivers might be related to numerous faults in some sections. Increase in sediment size is a good evidence of recent faulting activities in these sections. Faults possibly increase stream channel slope that results in increased velocity of streamflow and creating unstable reaches. Increasing streamflow velocity causes considerable movements of sediments so as fine sediments washed out and only coarse sediments remain in the streambed. Such evidences supports that the riverbed of these segments has affected small-scale tectonic activities. Due to non-steepness of the study area, Rosgen stream classification system is suitable for the field data very well. This supports Savery et al (2007)'s recommendation about benefits of Rosgen method in flat areas. The results of this study can help us improve integrated evaluation of watershed management activities, hydrological designs and river rehabilitation projects.

Keywords: geomorphologic equilibrium, river style framework, Rosgen Stream Classification System, Tarwal River.