Coastal Features and Settlement Geomorphic Rules (Case study: Northern Coast of Persian Gulf)

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Extended abstract

Introduction

The settlement space has certain logic and rules. The Persian Gulf was 70 meters higher than today sea level. The result of this uplift is the coastal plains which in phenomenological term is called marine context. It is important for a geomorphologist to understand the geomorphological analysis of the rules of the residence in marine context. This study attempted to raise new concepts in geomorphology based on discourse analysis and a phenomenological interpretation to derive the mathematical logic of residence on the shores of the Persian Gulf. The results obtained by this method show that urban residence in the marine context of Khuzestan follow Bifurcation rule, rural residence in the marine context of Khuzestan follow meandering convex rule, and the coastal residence in the marine context of Bushehr - Bandar Abbas follow frequency.

Materials and methods

The data used in this study includes five factors of climate, temperature, precipitation, relative humidity, pressure and evaporation to prepare land context, data from Delaware, GPCC and NCEP / NCAR of global networks. These were processed in programming environment. For homogeneity of spatial resolution, conventional method of resampling was used. The output of this operation was matrices with monthly intervals and 0.5 × 0.5 separation of geographic latitude. After preparing the data, they were descaled and then standardized layers were prepared using linear relation. The next step was preparation of the results of the matrix difference in ArcMap; raster analysis was conducted by combining layers to obtain the final map. After recognition of two distinct texture using Hillier's Space Syntax, analysis of urban

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layout and the arrangement of drainage networks of Karkheh and Karun rivers were extracted to determine the extent of rural civilization. The village layout was determined using river meanders. In the second image, the layout logic of coastal population centers was specified with coastal terraces 5, 10, 25 and 50 meters and the logical arrangement of this population were assessed against them.

Results and discussion

The logic syntax in marine context is associated with sea water level changes in the Persian Gulf and Karkheh and Karun rivers. To explain and extract the syntax logic of residence centers on the marine context, we initially specified the networks of Karun and Karkheh rivers, based on Hillier's syntax logic. In addition, the organization was compared with residence centers. This comparison showed that urban areas are located only in places where rivers have split. To analyze the behavior of the river in connection with rural residence, meanders of Karkheh and Karun rivers were identified. By contrasting rural residence, it was attempted to explain the space identity of each village location with regard to the fluvial meanders. The results showed that the villages in the marine context are settled along the slopes of meanders convexity. The concavities of the rivers have no remnants of residence. To achieve the coastal context syntax logic, the relationship between population centers and coastal terraces were examined through matching the residence spot layers and marine terraces.

The analysis of terraces 5, 10, 25 and 50 meters has indicated that there is a specific relationship between the number of population centers and their population with the distance of the terraces to the coastline and their arrangement along the marine terraces. As the distance of the population centers from the beach are changed largely in number and size; in other words, spatial syntax logic is consistent with Newton's law of gravity inverse.

Conclusion

From the discussion provided, it can be concluded that marine Context defines the syntax rules of settlements and the mathematical rules of layout logic in the area of Iran.

* The first mathematical rule states that marine areas impose Bifurcation rule on river behaviors (Karkheh and Karun). This indicates that urban residence is formed in the division spot.

* The second identifying rule of rivers in marine area is known as river meander which starts to meandering as they enter into marine context. Each wave has a convex side and a concave side. The convex face of wave creates a special place identity that leads to a social organization.

* The results of marine context indicate another rule for the logic of residence centers' layout that can be summarized as the frequency- magnitude rule.

Keywords: phenomenological, marine terrace, space syntax, Persian Gulf, land-context.

Estimation of Evaporation from the Surface of the Caspian Sea and its Temporal and Spatial Analysis

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Extended abstract

Introduction

Increase in the population of the Caspian Sea, particularly in its coastal zones, will force the governments to use water in the years ahead to gain water from the sea. Therefore, the study of seawater fluctuations influencing the sea ecosystem and the changes resulting from these perceptions will be necessary to prevent serious damage to this environment. In order to investigate the fluctuations in lake water, we need to calculate their water balance, to estimate inputs and outputs, and to determine the level of seawater. One of the most important outguns is evaporation. Calculating evaporation from the lakes is carried out in a variety of ways, with different results. The most accurate estimation of evaporation shows the highest accuracy in estimating the sea level. Thus, the aim of this study is to identify the most accurate and easiest method for estimating evaporation from the Caspian Sea water surface based on available data.

Materials and methods

The data used in this study were collected from three data centers on a daily basis: the Russian Academy of Sciences, the Princeton University of Hydrology, and the NCEP / NCAR database center in 1982-2010. The data were initially reviewed, verified and synchronized. To do this, the data from 1982 to 1998 were selected and the evaporation rate of water was estimated by balance method, Hefner, SHahtin, Meyer, US Bureau of Civil Engineering, Marciano and Ivanov. It should be noted that as in the method, discharge the output water into the Gulf of Kara Bogaz is extracted from the equation of the water balance, in order to compare the evaporation rate with the selected methods, the accuracy of the sampling is decreased. In all these methods, the Gulf of Kara Bogaz is reduced from the Caspian Sea level. Assuming that the water balance method is the most accurate estimation for evaporation, the other methods were compared with. The method that had the least difference in estimation with this method

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was selected as the optimal method. Then, with the selected method, the evaporation rate was estimated in 1982-2010 .The evaporation zonation of the sea level was calculated and plotted on monthly, seasonal and yearly maps.

Results and discussion

The findings of the research showed that Meyer's method in comparison with other selected methods in this study has the closest distance and the highest correlation with the balance method. The amount of annual evaporation by Meyer method in different parts of the Caspian Sea is not the same and varies from 688 mm to 1769 mm from north to south. However, the average of the total body weight is from the body. In the Caspian Sea, during the cold season, the least evaporation rate occurs in the northern part and the most in the southern part of the Gorgan Bay.

Conclusion

According to the results of the base method (balance method), the results showed that Meyer's method has more potential than the other selected methods for estimating evaporation from the Caspian Sea. The methods main relying on climatology element, such as temperature (USBR method), we cannot accurately estimate the evaporation, as a complex and multi-dimensional phenomenon, in the Caspian Sea. On the other hand, among the selected methods, when an influential element such as wind speed can be studied only at one level (the Hefner and Marciano method) alone, we cannot provide an accurate estimate of evaporation changes from the Caspian Sea. Finally, it can be said that among different methods, any method that can check the relationship between at least three factors of wind speed, temperature and water vapor pressure on two levels can provide a better and more realistic picture of evaporation changes from the Caspian Sea level.

Keywords: evaporation, fluctuation of water level, gridded data, Caspian Sea.

Application of Chaos Theory in Modeling and Analysis of River Discharge under Different Time Scales (Case Study: Karun River)

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Extended abstract

Introduction

One of the main issues in hydrology and water resources is investigation of river flow. Due to innovations and capabilities of the chaos theory, nowadays, chaos analyses are used to analyze river-flow time series. Since investigation of the presence of different characteristics at different time scales in rivers is one of the main challenges of hydrology in recent years, the aim of this paper is to study the behavior of river flow at different time scales. The behavior of river discharge can be studied precisely by applying nonlinear and chaotic analyses. The chaos theory, as the foundation of nonlinear dynamic systems has created great changes in understanding and expressing the mode of different phenomena in recent decades. This theory deals with the study of systems that at first glance may seem irregular; but in fact they are governed by clear rules. Such systems are very sensitive to primary conditions, so that seemingly minor inputs could have a significant impact on that. Such systems are called chaotic. With regard to recent studies, based on chaos theory for flow discharges, the chaotic or random nature of a system could be identified by using some discriminative indices. Despite chaotic studies conducted on the river discharges, chaotic analysis of flow discharge in Karun River has not been implemented for different time scales.

Materials and methods

In this study, the presence of chaos at daily, monthly and seasonal scales in discharge data of Karun River, Mollasani station, is discussed. Mollasani station is located downstream Ghir barrage (where, Dez, Gargar and Shotait River join together) and upstream Mollasani city.

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Daily, monthly and seasonal flow discharge data in Mollasani station (1967 to 2011) are used. Four nonlinear dynamic methods were used: 1) phase space reconstruction, 2) correlation dimension method, 3) largest Lyapunov exponent, and 4) spectral power. The state (phase) space is a useful tool for studying dynamic systems. According to this concept, a dynamic system can be described by means of a state space diagram. Each dynamic system consists of differential equations with partial derivatives. To determine these equations and their type, the embedding dimension and time delay parameter must be determined. The delay time could be obtained from the method of assessment of correlation function (ACF) or average mutual information (AMI). In this study, the average mutual information is used to estimate delay time of the dynamic system. In this method, time of first minimum occurrence in the average mutual information function is selected as the appropriate delay time. The embedding dimension is obtained from the false nearest neighbor (FNN) method. This algorithm provided information concerning optimal embedding dimension for the dynamic system.

Results and discussion

The results showed that the daily times for daily, monthly and seasonal data are 97, 2 and 1, respectively, and the optimal embedding dimensions are 9, 6 and 2, respectively. To determine chaotic nature of the system, correlation coefficient was calculated. The correlation dimension at the monthly scales, due to saturation of the diagram, is obtained as 2.704. Therefore, Karun River system is chaotic at this scale. But at the daily and seasonal scales, the diagram's trend was ascending and as a result, the river discharge is random. Another indicative criterion of the chaotic system is the largest Lyapunov exponent. The behavior could be measured in each dimension by using the Lyapunov exponent. Presence of positive Lyapunov exponent is an important indicator of the chaotic system. In this study, elongation factors and largest Lyapunov exponent are calculated on the basis of Rosenstein's method. Taking the value of optimal embedding dimension as *m*, the value of this exponent can be calculated. In the absence of the optimal embedding dimension, this parameter is predicted based on different *m* values. At monthly tile scale, the largest Lyapunov exponent was positive (0.0093). The extent of band width at monthly scale is another proof of chaotic nature of this river's discharge. The chaotic nature of the discharge data can also be calculated by power range. These methods can estimate the chaotic or non-chaotic behavior and cannot estimate the complexity of data.

Conclusion

At daily and seasonal scales, according to correlation dimension, the river discharge is random (non-chaotic). But, flow is chaotic at the monthly scale. It seems that the geographical location of Mollasani station may affect the chaotic or randomness of Karun River's discharge.

Keywords: chaos theory, correlation dimension, largest Lyapunov exponent, prediction, time scale.

Sensitivity of Form and Evolutionary Parameters of Meanders to Small Rivers Dynamics, (Case Study: Ghere – Sou River in Kermanshah)

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Extended abstract

Introduction

Shield (2000), using some geometric activity parameters, explains how reservoir can be effective on downstream river channel migration. After that, Magdaleno and Fernández-Yuste (2011) recognized that these parameters may complement the classical form parameters and represent the real functioning of the river corridor, in geomorphological analyses of meander dynamics. However, the effectiveness of these indices is not clear on other channels where meandering is not very developed and it is not clear if or not the geometrical parameters can indicate the type of functional and dynamics of this type of rivers.

Materials and methods

We have selected an area about 52 km wide along the total length, 219 km, of the Ghere- Sou River as the study area; this is because of location of Kermanshah Plain on a fault line that allows smaller changes. The study of the sinuosity of the river during the 54 years (1955 to 2009) shows that the number of meanders has been increased and decreased constantly. The meanders are included just a quarter of windings, at this study.

To study the dynamics of sinuosity, we used form parameters such as the radius of curvature, wavelength, amplitude, meander length, and evolutionary parameter such as bankfull width, magnitude of channel lateral migration, area occupied by the active channel and channel activity coefficient to determine the evolution of the meander belt in the central sector of Ghere-Sou River.

At first, aerial photos from 1954 and 1967 (black and white; approximate scale 1:55,000 and 1:20,000) and satellite images of IRS 2004 and 2009 (colour; with 2 m. resolution) were digitized and the factors was measured in ArcGIS. Using the Kolmogorov-Smirnov normality test for three form factors (wavelength and the radius of curvature and amplitude), Friedman tests were examined for abnormal data and ANOVA test for normal data. Finally, the spatial distribution for the morphology parameters was analyzed in order to determine if they showed a change downstream. Comparing the form and geomorphic activity parameters elucidated which groups of parameters are powerful to show the dynamics of river.

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Results and discussion

Ghere-Sou River has curvatures as sinuosity and meanders at 81 points, totally. The curvatures numbered 1 to 81 from up to downstream. Comparing these points at four years (1955, 1967, 2004 and 2009) showed that sinuosity has decreased at some points and it has increased at some other points. Thus, we can see that the number of arcs has been changed from 77 to 79 and then 77 and finally to 65. The sinuosity characteristics of arcs have been changed through these periods. However, three parameters including radius of curvature, wavelength, and amplitude have suffered from very little fluctuations. The results of Friedman and ANOVA show that there is not significant difference between them. However, other parameters including meander length, bankfull width, magnitude of channel lateral migration, the area occupied by the active channel and channel activity coefficient have indicated a progressive trend from 2005 to 2009.

A glance at the average bankfull width of river in different years show that this factor was about 108 m in 1955, 95 m in 1967, and 77 m in 2004 and finally reached to 89 m in 2009. This means that river has been more dynamic during last 5 years and it has added 11 meters to its width on average. The same is also true about average of lateral migration of river, so that the first until 2.5, 0.92, and 3.5 m per year, respectively. The total area occupied by means of channel activity had increased in the period. Channel activity coefficient is reached from 2.51 at the first period to 0.82 at the second period and finally to 2.76 at the third period. Therefore, the river is desired to have a state of static equilibrium at the first and second period and now try to have a state of dynamic equilibrium. The evolutionary changes are conducted in GIS and cause to promote the analysis capacity.

The river has been divided into 11 reaches in the two Google earth images in 2005 and 2015 and they were union together at the ArcMap. The results illustrate that the river has had up to 70% overlapping in the fifth reach. However, the changes of river have become more apparent at sixth reach while going to be channelized. This situation is to be the same downstream because of river balancing nature.

Conclusion

This study about the dynamics of Gher-Sou River elucidated that only the form parameters (wavelength, amplitude, curve radius) don't explain evolutionary characteristics and we need some morphological parameters such as magnitude of channel lateral migration, the area occupied by the active channel and channel activity coefficient. Some compositional parameters such as radius of curvature to the average bankfull width can also show these changes. These results confirmed by Magdaleno and Fernández-Yuste (2011) highlighted dynamic equilibrium of Ghare-Sou River in Kermanshah plain since 2004. The dynamics are coincided with urbanization and the expansion of activities and projects implementation.

Further study on the parameters may be a cause to produce more accurate parameters in relation to evolutionary characteristics; for example, the remaining of active channels overlapping may provide better results in some cases. The parameter is obtained from overlaying of two periods and calculation of non-intersected area. Using GIS, it can be obtained by combination of different layers of the area.

Keywords: river dynamics, Ghare-Sou River, geomorphology, channel change, meander.

Spectral Analysis of Spatial Relationship between Surface Wind Speed (SWS) and Sea Surface Temperature (SST) in Oman Sea

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Extended abstract

Introduction

Surface wind speed (SWS) and sea surface temperature (SST) are interacting as climatic, atmospheric and oceanic parameters. In such a way, variations in the SST are considered to be the factors in wind speed values and in the future weather forecasting model, monitoring SWS changes plays an important role in identifying the SST heating pattern. Over the past few years, wind speed has indicated a clear decrease in many areas. When wind speed decreases, urban air pollution does not stagnant. On the other hand, changes in SST can bring about various effects on marine environments. One of the most important effects in long term is reduction of the pattern of ocean cycles, which brings nutrients from the depths to the sea surface. This can carry dissolved oxygen from the surface into the deep ocean. Furthermore, due to the interaction between the atmosphere and oceans, SST can bring about dramatic effects on global climate. An important point in the SWS and SST studies is that simultaneous examination of these two parameters makes it possible to study the interactions between atmosphere and ocean. Accordingly, the present study aims to investigate the relationship between surface wind speed and sea surface temperatures in the Gulf of Oman using one of the most important instruments of spatial statistics (spatial autocorrelation techniques) from 2003 to 2015.

Study area

The Gulf of Oman is a watershed located in the northwest part of Arabian Sea and the Indian Ocean and in east part of the Strait of Hormuz and the Persian Gulf. Through this sea, the Persian Gulf is connected to the Indian Ocean. The gulf is relatively deep and has a depth of

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3550 meters, which the depth is reduced in the west and reaches 72 meters near the Strait of Hormuz. Due to the passage of Tropic of Cancer from this watershed zone, this gulf is one of the warmest seas in Southwest Asia. The orientation of surface currents is along the coast of the Gulf of Oman from north-west to south-east during the winter, but during the winter general currents are from the Oman Sea towards the Persian Gulf and reverse in the summer. Iran and Pakistan are located in the northern areas of the Gulf and Oman, and a small part of the UAE in the south. The Gulf of Oman is located at coordinates 22°-27° of northern latitude and 56°-61° of Eastern longitude.

Materials and methods

According to Anselin, the place has two kinds of effects, spatial dependence and spatial heterogeneity. The first is the spatial correlation or spatial continuity that follows directly the first Law of Geography, Tobler law. This means that the values close to each other are more similar to each other and this leads to spatial aggregation. The second is the spatial impact belonging to regional or spatial differences that follow the inherent uniqueness of each place. Determination of the degree of scattering or clustering of complications in space is possible using Global Spatial Moran Autocorrelation, Global Moran's I. In fact, this index is intended to describe the spatial characteristics of a variable in the whole region, and it can be used to determine the mean space difference between all spatial cells and their adjacent cells. In global Moran index, in addition to application of the arrangement of complications, remarkable attention is also paid to the characteristics of the complications and the status of spatial autocorrelation based on the location and the internal values of the complications. There are various spatial techniques to represent the statistical distribution of phenomena in space; one of the most authentic indices derived from the Anselin Local Moran's I. Using weighted spatial features and with the aid of this statistic, we can find points with small or high distribution represented in clusters or values with high difference (outliers). The Anselin local Moran'I explains the pattern of a spatial correlation of a spatial parameter in neighborhoods. This index was developed by Anselin in 1995 with the aim of identifying local sites and proposing effective individual sites in spatial links.

Result and discussion

In order to evaluate the relationship between SWS and SST and determine the type of spatial distribution, two variable Global Moran is calculated for monthly and yearly periods. The results of this study in monthly periods indicate that there is a positive relationship among evaluated parameters during cold months but, the relationship is negative and reverse during warm months. Previous surveys documented that from January, as a cold month of year, toward warm months the relationship become more negative and reverse. The most negative form of that is related to July. Then, with the start of cold season, relation of parameters is changed again to positive and direct, as the most positive case occurs on January. The values of two variables of Global Moran between SWS and SST which is examined for a period of 13 years show a negative number and represent a reverse relationship between them. In addition, Moran index values follow a decreasing and negative pattern over time. The surface wind speed and surface temperature of Gulf of Oman is being more reverse. Analysis of local Moran shows that cold months have the most number of spatial clusters (High-High and Low-Low) and warm months experience the most number of spatial outliers (High-Low and Low-High). It could be

concluded that the greater number of spatial clusters in comparison to spatial outliers may lead to positive and direct relationship between surface wind speed statistics with sea surface temperature. The negative autocorrelation and reverse relation of these parameters are due to the greater number of spatial outliers. At the next step, the annual changes of High-High and Low-Low clusters is evaluated and it was found that spatial clusters formed in the Gulf of Oman during annual period were very small and the number of spatial outliers formed was much higher. This is consistent with the results indicated by negative values of Global Moran index. Also, there are rise and falls in the number of High-Low outliers during 13 years but in general, the formation of these outliers in the Oman Sea has been declining. On the other hand, changes in the timing of the diagram of Low-High outliers don't show an increasing or decreasing pattern but closer looks show that from 2009, these outliers are increasing and decreasing by a periodic form. These points tend to increase. By this interpretation, the increasing pattern of negative autocorrelation and reverse relation, which was obtained by Global Moran analysis, could be attributed to Low-High outliers.

Conclusion

It can be concluded that two parameters of surface wind speed and surface sea temperature have a direct and positive relationship during cold months and a reverse and negative relation in warm months. The reason of these phenomena could be related to interaction of the factors such as latent heat flux and humidity changes. The effects of surface evaporation and Manson air masses are likely possible to create this situation. Therefore, it is necessary to study these parameters simultaneously. Annually changes in scales show that surface wind speed is gradually decreasing and sea surface temperature is increasing. It should be mentioned that the sea surface temperature in Oman Sea was evaluated by this technique and found that during a period of 13 years, the temperature variable follows an increasing pattern in this region. According to the results, the effects of climate change and global warming on surface wind speed and sea surface temperature in Oman Sea are very likely and possible and it is needed to continue monitoring of these parameters and the other climatic and oceanic factors which are affected by them.

Keywords: surface wind speed, sea surface temperature, spatial autocorrelation, arcgis, oman sea.

Effects of Spatial Movement of Arabia Subtropical High Pressure and Subtropical Jet on Synoptic and Thermodynamic Patterns of Intense Wet Years in the South and South West Iran

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Extended abstract

Introduction

Although precipitation is of great importance in all climates, it plays a vital role in the arid and semi-arid regions. The spatial and temporal distribution of precipitation in all climates is affected by special synoptic structures in which one or two systems play the controlling role. The southern Iran is located adjacent to two important climate systems whose spatial arrangements determine the timing and amount of precipitation in the mentioned region. Therefore, it is important to study the possibility of predicting the drought and wet years in this geographical region of Iran according to its strategic role in the ecology, agriculture, industry, transportation, and politics. The study was conducted on Hormozgan, Boushehr, Kohkilouyeh-va-Boyerahmad, Chahar-mahal-va-Bakhtiari, and Khuzestan Provinces in Iran.

Materials and methods

The daily precipitations in the selected stations were extracted, harmonized and arranged in a 30 year statistical period. Then, the situation of each station was determined from the viewpoint of drought and humidity using the SIPA criterion and DIP software. We have selected the years in which intense wet years were half of the selected stations, based on the mentioned criteria. These years have been selected as the samples of intense wet years. The atmospheric data of the mentioned years were extracted from the website http://www.esrl.noaa.gov, and the daily maps of these years were created at levels of 1000 and 500 hPa in the longitude of-40 degree west to 100 degree east and the latitude of zero (the equator) to 80 degree north using Grads software. The Arabian subtropical high pressure nuclei were determined for all days and their maps were created as the output maps using ArcGIS10.3 software. The data were reproduced in a matrix with the dimensions of 67×2145 based on the daily precipitation of more than 5 millimeters. The study area, located between the latitudes 0 to 80 degree north and -40 to 100 degrees east, has a number of days according to the spatial data resolution which was 2.5×2.5 geographical

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degree. Afterwards, justification of the data distribution according to the special values, variance percentage and accumulation variance was determined for analysis of the factors. Just 12 factors had the values larger than 1 in the primary analysis. The principle component analysis and Varimax rotation showed that concentrating on the correlation of 13 factors can explain 89.18 percent of the pattern's behavior.

Finally, the dominant patterns in the selected intense wet year samples were extracted through studying the maps of 1000 and 500 hPa from the twelve extracted factors. Then, we have analyzed the maps of subtropical jet stream, divergent and convergent flux, special moisture, temperature blow, and etc. Moreover, the maps of different levels in all rainy days of the intense wet years were reviewed. Comparison of the repetitive patterns resulting from the review and the principle factor analysis provided similar results.

Results and discussion

Our study showed that in all the rainy days, the central nucleus of the Arabian anticyclone cell at all levels of 850 and 700 hPa was located in the east part of the longitude 45 degree E. When the anticyclone central nucleus is located in the east part of the longitude 55 degree E, the precipitations are more extensive, and cover all the regions from Khuzestan to Hormozgan. As it can be seen, in the rainy days, one or two divergent flux nuclei are located on Oman Sea or western Arab Sea and Gulf of Aden. In such condition, the streams in the lower levels of troposphere (from sea level to 850 hPa) are changed into eastern streams in northern Oman Sea and gradually on the Arab Sea. This condition is the most suitable mechanism for moisture advection towards the Sudan low pressure. In the same day, two strong nuclei of convergent moisture flux are dominated on Ethiopia and central Arabia which receive the moisture transmitted from the warm seas. The highest moisture advection towards the Sudan system is done under the layer of 850 hPa from Arab Sea, Oman Sea and the Gulf of Aden. Because of the topographic condition at levels higher than 850 hPa, this advection comes much lower, and the moisture transmitted from the transition branch may add to this moisture from the tropical convergence region. With the moisture advection in the lower levels, proper thermodynamic condition is provided for the development of convection clouds on the region. These clouds initially appear as mass clouds on Sudan and Red Sea, and then on Arabia, and then gradually move to Iran through the southern streams before trough at levels of 850 hPa and higher. Then, the clouds grow and extend through involving in the upward streams dominated on the front trough and under the subtropical jet stream, which are located on Red Sea and northwest Arabia. The proper temperature blow and diabatic warming resulting from condensation process provide a severe condition in the northern part of the jet.

Conclusion

In order to have an intense wet year in the south and south west of Iran, the eastern movement of Arabian high pressure is considered as an important factor. With the eastern movement of this high pressure, a proper synoptic condition for advection of moisture toward the precipitation system is provided. A proper condition is also provided for the extension of the Mediterranean trough towards the southern latitudes on the south east part of African desert and cold advection on the region at the middle and upper layers of troposphere. The Arabian high pressure has very high ability for wet condition, especially at the lower layers, because of its dynamic structure. Therefore, the moisture moved through the divergent flux toward the

southern systems is considerable and provides significant potential energy for the convection systems. The cold advection from the northern latitudes and the warm advection from the subtropical latitudes provide proper heat gradient for intensification of the subtropical streams in the northwest domain of the Arabian high pressure. These jet streams are formed in the limits of northeast Arabia and provide proper dynamic condition for intensification of intense convection streams in the Northern Arabia and Southern Iran. The convection clouds cause intense precipitations on the region because of the access it has to the moisture of the southern warm seas and also the moisture moved from the northern branch of the tropical convergence region.

Keywords: Arabian high pressure, synoptic pattern, Sudan low, wet year, south and south west Iran.

Future Impacts of Climate Change on Actual Evapotranspiration and Soil Water in the Talar Watershed in Mazandran Province

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Extended abstract

Introduction

Climate change is recognized as a major environmental problem by a majority of the international scientific community. According to the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (IPCC, 2007), "global atmospheric concentrations of carbon dioxide, methane and nitrous oxide have increased markedly as a result of human activities since 1750 and now it exceeded pre-industrial values". This report further suggests that most of the observed increase in global average temperatures since the mid-twentieth century is very likely resulted from rising anthropogenic greenhouse gas concentrations and that, if not controlled, climate effects such as rising sea level, disruption to weather patterns, and ocean acidification pose serious harms to human health, water supplies, agricultural systems, economic performance, and global security. Such projections have triggered calls for prompt and coordinated action to reduce greenhouse gas emissions and adapt to changes in the climate system. Paying attention to climate change event affecting all sections of hydrologic cycle, the goal of this research is to study these phenomena on actual evapotranspiration and soil humidity that play important role in this cycle, with available water for plant, decrease or increase in annual runoff. This can affect all sections of the environmental factors.

Materials and methods

Watershed models are essential for studying hydrologic processes and their responses to both natural and anthropogenic factors, but due to model limitations in representation of complex

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natural processes and conditions, these models usually must be calibrated prior to application to closely matching with SWAT (Soil and Water Assessment Tool). This is a comprehensive and semi-distributed river basin model that requires a large number of input parameters, which complicates model parameterization and calibration. Several calibration techniques have been developed for SWAT, including manual calibration procedures and automated procedures using the shuffled complex evolution method and other common methods. In SWAT, a basin is delineated into sub-basins, which are then further subdivided into Hydrologic Response Units (HRUs). HRUs consist of homogeneous land use and soil type (also, management characteristics) and based on two options in SWAT, they may either represent different parts of the sub-basin area or a dominant land use or soil type (also, management characteristics). With this semi-distributed (sub-basins) set-up, SWAT is attractive for its computational efficiency as it offers some compromise between the constraints imposed by other model types such as lumped, conceptual or fully distributed, and physically based models. For this goals in the boundary of Talar watersheds of Mazandaran province, we selected 8 stations for precipitation, 5 for temperature and discharge, with Shirgah-Talar station in output. After preparing maps and necessary weather data, we conducted output of SWAT model for this watershed. In this research, we used water year of 2003-2004 until 2006-2007 by a duration of 4 years for calibration and water year of 2008-2009 by duration of 2 years for validation. For calibration and validation of this model, we also used SWAT-CUP package software and SUFI2 program.

Results and discussion

The entire Talar watershed is divided into 219 Hydrologic Response Unite in 23 sub-watersheds. For assessment of SWAT model from climate change on actual evapotranspiration and available soil water, the SWAT model, further run for this area with new condition. In this stage with definition of HRU for the model, only variated precipitation and temperature are entered into the model to study the influence of these effects on assessment factors in output of the model. To do so, we used variable precipitation and temperature, forecasted by LARS-WG model as one of the important model output for random data of weather condition. After change of daily temperature and precipitation for these stations, variation values enter into SWAT model for second run.

Conclusion

It can be concluded that the mean daily evapotranspiration (to year) in the time of calibration and validation, is increased for all duration and higher evaporation in majority of future month. This can be compared with present time that is high index evaporation in May, June, July and August. Study about available water shows unregularly process in decrease or increase of this factor and at least available water in May, June, July and August in the future time that affected hydrologic regularity of the watershed. This can provide water for plant in any month where water is necessary as another environmental factor of area.

Keywords: hydrologic cycle, temperature and precipitation, calibration, validation, modeling.

Economic Effects of Land Use and Land Cover Changes through Remote Sensing Techniques and Survey Studies, Behbahan

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Extended abstract

Introduction

Human beings have always attempted to meet their requirements by using agriculture lands for many years. This is changed in such a way that today with present population with diversity of human needs and overuse of land, they created many adverse effects. Wide areas of natural resources disregarding ecological principles to meet their needs have been turned into the degraded lands, while many of these lands have not been cultivated with a high erosion potential. Having knowledge of land use and its changes and reviewing possible causes are important in planning and policy-making in the country. The ratio of land use changes can help to anticipate upcoming changes and perform appropriate actions. Remote sensing techniques can be helpful to detect changes in land-use patterns as great resources for management and planning. The aim of this study was to investigate changes in land use and land cover based on the data derived from satellite images, since these changes along with environmental effects have different impacts on the economy and living conditions of beneficiaries. In addition, the assessment of the following direct economic impacts on land use change considered living and livelihoods of all residents of the area.

Materials and methods

Behbehan city is located in the southeastern areas of Khuzestan and limited to the cities of Kohgiluyeh and Boyer Ahmad provinces. The job activity of the majority of the villagers is agriculture and animal husbandry. There are three types of vegetation, bushes and grass cover in Behbehan. In this study, we used Landsat satellite images, Landsat TM data in 1991 and the Landsat OLI satellite images of in 2016, general aerial photographs of 1: 20000, numerical

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topographic map of 1: 25000, and GPS data (Etrex Model). In the first step, the satellite images were processed and geometric and atmospheric corrections are made to prepare the raw image data. Then, we have used maximum likelihood method for supervised classification. After selecting training samples of the images from 1991 to 2016, we used maximum likelihood classification in ENVI to classify the images. Using the clasification method, we divided the images into 6 classes of woods, grassland, agricultural areas, abandoned land, residential areas and water groups. The classification accuracy for image was assessed by using the kappa index. The communities affected by changes in land use were identified in order to evaluate the effects of changes on economic dimension of beneficiaries. At the end, we have analyzed the changes in economic situation of people due to landuse changes.

Results and discussion

After classifying maximum likelihood classification in ENVI, land use maps were obtained from 1991 and 2016. The maps are related to the two time periods (1991-2016) evaluated by overlaying the two maps in GIS environment to obtain change map. The results indicate that the forest area in 1991 was 9348.93 hectares and with 4.57 percent decrease reached to 8812.53 hectares in 2016. The area of pasture is also decreased by 36.63 percent and it has decreased from 86596.92 hectares in 1991 to 82297.71 hectares in 2016. The agriculture land-use has increased 11.72% from191.61 hectares in 1991 to 1567.26 hectares in 2016. The area of abandoned lands has also increased from 15137.19 hectares in 1991 to 18413.91 hectares until now. Residential areas have also increased from 1044.27 hectares in 1991 to 2337.39 hectares in 2016. Water level is faced with a reduction in 2016 and it was more than 1399.05 hectares in 1991 and reached to 444.69 hectares in 2016, a decrease of 8.13 percent. The reduction of 536.4 acre in the use of forest and palm groves caused £ 25064958204decrease. A decrease in 4299.21 acre of pasture caused £2923462800 of devaluation. Increase in the agricultural use of lands caused increased income, equivalent to £ 825390000000. Increase in abandoned lands caused decrease in income and consequently devaluation of £ 318168655183.

Conclusion

Given that in this study period, residential areas has increased due to increased urban population and immigration, the need of people for housing has, consequently, increased. The pasture area has been reduced in this period since they are changed these lands over time in recent years. Because of increase in the use of agricultural lands and unprincipled irrigation using traditional methods, water resource and droughts are, consequently, declined in recent years. With increasing population and development of residential areas, it is needed to fix the problem and this reduces natural resources (pasture, water and forest). Although land use change and decrease in the level of natural resources during this period had not so negative complications, but continuation of this process and non-normative change of land use can have more negative consequences in the long run. Therefore, we have to determine uses which are compatible with the environmental potential and capacity of lands.

Keywords: land use, land use changes, Remote Sensing, economy of residents, Behbahan.

Detection of Dust Storms in Jazmoriyan Drainage Basin Using Multispectral Techniques and MODIS Image

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Extended abstract

Introduction

Based on the importance of dust storm phenomenon, negative effects of the dusts on human health and social and economic consequences, it is essential to identify the dust source locations for planning and to eliminate the production factors of the dust storms. The last improvement in remote sensing makes a situation for using the satellite image for exploration of the dust sources. In this study, the MODIS image data were used for detection of the sources of dust storm in Jazmoriyan seasonal wetland and their corresponding watersheds. In order to achieve this target, we used three methods including Xie (2009), Zhao et al. (2010) and Liu (2011). The performance of the methods was investigated by AOD and horizontal visibility. In order to simulate the path of dust aerosol, we used HYSPLIT model Lagrangian approach for forward trajectory.

Materials and methods

Jazmurian is a dried wetland in a closed drainage basin in south-east Iran. Population growth, irrigation in surrounding farmland, dam building on feeding river, climate change and drought made the wetland to dry. The Jazmoriyan wetland, 300 km^2 in area, is located between Sistan-va-Baluchistan and Kerman provinces, 58° 39' to 59° 14' E and 27° 10' to 27° 38' N.

In this research, we have used field data (horizontal visibility), satellite data (MODIS level1B and Level 2 products), and meteorological data and Hysplit model output data.

The Xie (2009) method is based on decision tree through several indexes. Zhao et al. (2010) method was developed for dust detection on earth and ocean in daytime. Liu and Liu (2011) suggested the Thermal Infrared Integrated Dust Index (TIIDI) for separating the dust, sand surface and cloud. Representing the intensity of dust storm is the main advantage of this method. The most important feature of this method is to show the intensity of the dust storm.

Statistical analysis was conducted using Excel (Microsoft). Image processing was done with ENVI 5.3 software. Afterward the appropriate band for dust detection was identified. Then,

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some image was selected for extracting the thresholds.

Finally, based on extracted thresholds, dust storm over the Jazmoriyan watershed by MODIS images data on January 4, 2017, to January 7, 2017, was detected. The intensity of the dust was classified by TIIDI method, and dust source was introduced based on the region with the highest dust intensity. Three critical points of dust were identified with this method.

Results and discussion

The results have demonstrated that these methods are useful for dust detection. The results of dust detection show that, there aren't any dust storms in Jazmoriyan on January 4, 2017. The dust storm began at 6:40 on January 5, 2017, in center of swamp Jazmotiyan and it had increasing trend until 9:55 at that time. Following of this process, the dust storm reaches to the highest txtent on January 6, 2017, at 7:25 and decreasing trend was started at 9 AM at the same day. The dust storm was finished in Jazmoriyan watershed in next day (January 7, 2017). Furthermore, the two-days forward air-mass trajectories with HYSPLIT model show that the dusty air masses at all altitudes are moved to the south-east part of Iran and will affect Oman Sea and Makran Mountain. The analysis of meteorological maps showed that a jet with a speed more than 30 m/s has covered all study area. It increased the dust storm possibility in the region. Based on the results, the extracted bands and thresholds in Jazmoriyan watershed is in agreement with other researchers. The results of dust detection obtained from MODIS confirm the results from obtained myd04 products and horizontal visibility.

Conclusion

Unsuitable distribution of synoptic station and lack of ground monitoring stations around the Jazmoriyan swamp are the issues in dust monitoring. MODIS image data can be used for dust storm detection. Performance of Xie (2009), Zhao 2010, et al. and TIIDI methods were investigated. The results of these methods using MODIS image data on January 4, 2017, to January 7, 2017, showed that the dust storm that began on January 5, 2017, was approximating at 6:40 AM. The dust had an increasing trend until the next day. The dust was spreading in a vast area on January 6, 2017, at 7:25 and completely was disappeared on January 7, 2017. In addition, the results of path tracing of aerosols of dust source represent the aerosol movement to the south-east Iran, Makran Coasts, and Persian Gulf. This is same as the results of other researcher.

Keywords: dust detection, Jazmoriyan swamp, TIIDI method, AOD.

Accuracy of PERSIANN-CDR Precipitation Satellite Database in Simulation Assessment of Runoff in SWAT Model on Maharlu Basin

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Extended abstract

Introduction

Rainfall is the most important meteorological factor driving the hydrology of river basins. For the development and management of water resources, it is required to have a reliable coverage of rain gauges, rainfall satellite data and weather radars. Well-maintained ground-based rainfall stations give the best rainfall estimation with high accuracy over time for a small area. The spatial sampling error becomes higher in estimating rainfall when using interpolation techniques. This issue becomes particularly critical in data scarce regions with unevenly distributed rain gauge stations. This is recognized as one of the principal sources of uncertainty in hydrological modeling. Currently, with more and more global precipitation datasets developed, a decline is seen in the application of reanalysis products in hydrological modelling. As a hot research field, many studies focus on the application of directly measured precipitation data on flood risk evaluation at basin scales and discuss their potential for hydrological prediction of ungauged/poorly gauged basins. In this study, we used PERSIANN-CDR gridded database precipitation for modeling runoff in SWAT model in Maharlu Lake basin.

Materials and methods

The PERSIANN-CDR was used as a gridded database of precipitation for modeling runoff in SWAT model in Maharlu Lake basin. The PERSIANN-CDR is initially compared with rain gauged data and after that it was used as input to SWAT model. SWAT model was calibrated by rain gauge data during 1983 to 2013. The Warmup period set to 3 years. Three discharge stations were used for calibration. Correlation coefficient of, Nash-Sutcliff, POD, CSI, FAR,

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RMSE, ME and BIAS had been assessed to determine the accuracy of PERSIANN-CDR. SWAT model uncertainty and sensitivity were calculated in SWAT-CUP by SUFI2 method.

Results and discussion

Comparing the PERSIANN-CDR in monthly scales, we found that this satellite wheatear database less estimates the variables in all months. The results showed average of correlation coefficient is 0.6 and RMSE showed a high error in rainy seasons. In SWAT model, calibration period was set to 1983 to 2010 with validation from 2011 to 2013. Calibration with gauged data showed satisfactory Nash-Sutcliff and R2 statistical indices about 0.6 for the area. The best result was occurred in Chenar-Sokhte-khosh discharge station, R2 was about 72% in calibration and 81% in validation. Calibration with PERSIANN-CDR database showed that this database is not good enough to be used in this semi-distributed model. In Chenar-Sokhte-khosh discharge station, R2 is calculated about 0.59 and Nash-Sutcliff about 0.21. R-factor and P-factor was presented about 0.5 in all discharge stations. These factors show that uncertainty calculation was occurred in good form. The simulation of annual runoff showed that the average runoff simulated using observation database was 1.68 m3/s, the mean runoff simulated by PERSIANN-CDR is 0.84 m3/s, and mean runoff of discharge stations were 1.77 cubic meters per second. On monthly scale, PERSIANN-CDR estimated less runoff like rainfall over all months. Both databases simulate runoff values relative to those recorded in the autumn months less than actual values. The results of this study, which were conducted using the PERSIANN-CDR satellite product, unlike the other studies with global exploratory bases, displayed that in the simulation with the SWAT model, this base cannot be accurately high in simulation. The error of estimating precipitation has been entered directly into the model and caused an error.

Conclusion

In this study, with the accuracy of precipitation data, PERSIANN-CDR satellite data on rainfall estimation revealed that this database estimated precipitation values less than real values in all months of the year. Runoff simulation using this satellite product expresses the explanatory factor and the efficiency of Nash-Sutcliff about 0.59 and 0.21.

Despites the time series of precipitation values, this satellite database has a high correlation with the actual values observed on rain-fed stations, but as the findings show the estimated rainfall values are always lower than actual recorded values. Based on the findings from this study, the PERSIANN-CDR satellite is not very accurate on the area of the Maharlou Lake Basin, located in eastern Zagros. In the semi-distributed SWAT model, it cannot simulate runoff. Therefore, it is suggested that before applying estimated rainfall data, this satellite database will have its error and bias values compared with the observed data on rain gauge stations and, then, the estimated precipitation values are corrected based on the bias.

Keywords: hydrology, Maharlu Lake, PERSIANN-CDR, runoff, SWAT Model.

Relationship between Arctic Oscillation and Precipitation in Iran

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Extended abstract

Introduction

Simultaneous variations in weather and climate over widely separated regions have long been noted in the meteorological literature. Such variations are commonly referred to as "teleconnections". In the extra-tropics, teleconnections link neighboring regions mainly through the transient behavior of atmospheric planetary-scale waves. One of the most well-known teleconnections is the Arctic Oscillation. Arctic Oscillation is the leading mode of extratropical circulation from the surface to the lower-level stratosphere in the northern hemisphere. Fluctuations in the Arctic Oscillation create a seesaw pattern in which atmospheric pressure at polar and middle latitudes fluctuates between negative and positive phases. For instance, a positive Arctic Oscillation phase is accompanied by low pressure over the north Polar Regions and high pressure at the mid-latitudes. These features are reversed in a negative Arctic Oscillation phase. The Arctic Oscillation trends are highly correlated with atmospheric phenomena such as variability in sea level pressure, storm tracks and precipitation throughout northern hemisphere.

Materials and methods

The purpose of this study is to examine the impact of the Arctic Oscillation on the frequency of days with rainfall event in Iran. For doing so, we used three dataset. 1) The gridded daily precipitation of GPCC in a 1˚ latitude × 1˚ longitude resolution. These data have been extracted for 154 grid points within the political boundary of Iran. Therefore, our initial matrix of daily precipitation have been consisted of 9125 rows, one for each day from March 21, 1988 (Farvardin 1, 1367), to March 20, 2013 (Esfand 29, 1391), and 154 columns, one for each grid point in Iran. 2) The daily Arctic Oscillation index from the Climate Prediction Center of the National weather service, NOAA. These data have formed a matrix in 9125×1. 3) The mean daily geopotential height data of 700 hPa level at 2.5˚ × 2.5˚ grid resolution from National Center Environmental/ Department of Energy (NCEP-DOE). This matrix is also consisted of 9125 rows, one for each day from March 21, 1988, to March 20, 2013, and 5328 columns, one

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for each grid point in northern hemisphere. In this study, χ^2 was used to investigate the impact of the Arctic Oscillation on the frequency of rainfall evens. Then, the lag correlation was used to find the highest correlation between the Arctic Oscillation and the frequency of the days with rainfall event. Based on this, the frequency of rainfall event was investigated. Finally, the long term mean geopotential height of the 700 hPa level in association with the highest correlation was analyzed. MATLAB software was employed to analyze the data.

Results and discussion

The χ^2 statistic and its significant test showed that the relationship between the Arctic Oscillation and the frequency of days with rainfall event is significant from October 23- November 21 (Aban) to April 21 – May 21 (Ordibehesht). Then, the obtained results of lag correlation showed simultaneous correlation in the two months of October 23- December 21 (Aban and Azar) and lag time for December 22 – March 20 (winter) and March 21- May 21 (Farvardin and Ordibehesht). Based on the obtained correlation results, the frequency of the days with rainfall event from November to May was investigated during the positive and the negative phases of the Arctic Oscillation. The results have indicated that the probability of rainfall events during the positive phase of the Arctic Oscillation is the highest. A survey on mean daily geopotential height of 700 hPa level, when the Arctic oscillation is positive, reveals that 700-hPa level is anomalously low over the polar caps and over the region of the Icelandic Low while it is anomalously high over the western half of Africa to southwest Europe. This pattern leads to enhanced pressure gradient over the eastern half of Atlantic and northwest Europe. This 700 hPa level pattern forms a trough over the eastern Mediterranean. Positive vorticity and northerly flow in this area create dynamic conditions to develop low pressure system. When the system is accompanied with other weather conditions can cause rainfall in Iran. In addition to the eastern Mediterranean trough, the sub-tropical high pressure also plays an important role in the rainfall events. Reduction in the zonal range of high pressure at the time of the occurrence of a positive phase of the Arctic Oscillation and its retreat from the southern half of Iran and even in the formation a divergent core over north Arab Sea as the most important source of humidity can increase the probability of rainfall event in Iran.

Conclusion

The results showed that the impact of the Arctic Oscillation on the frequency of the days with rainfall event starts from October 23- November 21 (Aban) and continues to April 21 – May 21 (Ordibehsht). The probability of rainfall event during the positive phase of the Arctic Oscillation is the highest as well. Synoptic pattern of 700 hPa showed that the positive phase of the Arctic Oscillation increase pressure gradient over the eastern half of Atlantic. This pattern provides conditions to develop eastern Mediterranean trough in mid troposphere and low pressure system in low troposphere over the eastern Mediterranean. Decrease of pressure due to the positive phase of Arctic Oscillation in mid-latitude affects subtropical high pressure and retreat from southern half of Iran. Its retreat and even formation of a divergent core over north Arab Sea can increase the probability of rainfall events in Iran.

Keywords: rainfall event, Arctic Oscillation, lag correlation, frequency, Iran.

Performance of Series Model CMIP5 in Simulation and Projection of Climatic Variables of Rainfall, Temperature and Wind Speed (Case Study: Yazd)

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Extended abstract

Introduction

According to the IPCC (2014) definition, climate change is a change in the state of the climate in which the average or its modifiable properties varies for a long period. To date various versions of climate change models have been presented for different purposes. These models are including (1) the assessment models of the Intergovernmental Panel on Climate Change (FAR), (2) the models entitled SAR, (3) the report model of TAR, and (4) the model report titled AR4 (CMIP3) and, finally, the 5th Assessment Report models, AR5 (CMIP5). These models use new emission scenarios called "RCP". These scenarios have four key lines called RCP2.6, RCP4.5, RCP6 and RCP8.5. General circulation models are considered as the most reliable tools for simulating climatic variables. These models can simulate the present climate and illustrate the conditions of the future climate under specific scenarios. Although these models are very helpful in the investigation and predictions based on future changes in climate, the outputs of these models are based on a large grid scale (250 to 600 km). Therefore, the application of these models is not suitable on a regional or local scale. The most important tool to create a bridge

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between a regional/local scale and GCM scales is downscaling. Among statistical downscaling methods, SDSM has been widely used for the downscaling of climate variables in the world. Most of the studies on climate change have been used in AR4 models. The majority of the studies in the word used AR5 models to investigate changes in climatic variables. As mentioned, most of the studies about climate change modeling have been performed using AR4 models. Therefore, studying and updating of that with CMIP5 data is necessary to reduce the uncertainty of modeling climate change in recent decades. Thus, in this study, three variables of rainfall, averaged temperature and maximum wind speed are modeled using AR5 models. These parameters are modeled according to the basic period of 1961-2005 and the future climate change will be simulated in a 95-year period from 2006 to 2100. The investigation on changes of the maximum wind speed in this region, as windy areas, is affected by dust storms every year. This can be of great importance in the studies of dust and wind erosion in the future.

Material and method

In this study, we use three types of data including daily rainfall, average temperature and maximum wind speed from synoptic station. Second sources of data are NCEP variables and the third are CanESM2 outputs.

For analysis of General Circulation Model, we used in this study the second generation of Canadian Earth System Model (CanESM2) developed by Canadian Centre for Climate Modeling and Analysis (CCCma) of Environment Canada. This is the only model that made daily predictor variables available to be directly fed into SDSM. Also this model has three scenarios such as RCP2.6, RCP4.5 and RCP8.5.

The model SDSM has four main parts including identification of predictors, model calibration, weather generator and generation of future series of climate variables.

Results and discussion

After reviewing data quality control, predictive variables were determined by NCEP. Calibration of the model was carried out using 70% of the observational data during the statistical period of 1961-1992 to determine the coefficients of the equation for modeling rainfall data, temperature and wind speed. The coefficients obtained in the calibration phase were used for 30% of the remaining data (1993-2005) for model verification. The performance of the SDSM was evaluated based on comparison of the results of verification and observational data in 1993-2005. The performance of the model on downscaling of temperature is higher than rainfall and wind speed. The reason for this is that the temperature parameter is continuous variable and there are no zero values.

The results of evaluation of performance and model uncertainty showed that NSE, RMSE, R^2, PBIAS, RSR and Pearson correlation coefficient for mean temperature were 0.96, 1.64, 0.96, 1.63, 0.18, and 0.97 based on downscaled data by the NCEP and 0.88, 1.3, 0.91, 6.8, 0.33, 0.49 based on the downscaled data of CanESM2, which is of a fairly good value. The assessment criteria of rainfall and wind speed are less than the average temperature, which can be explained by the fact that the rainfall data and wind speed are not normal due to the presence of zero values. Based on the results of the Man-Kendall test, observation and modeled rainfall under two scenarios of RCP2.6 and RCP8.5 have no significant trend. While the data generated by the RCP4.5 scenario shows a significant decreasing trend. The results of the Mean-Kendall test on average showed that the series modeled by RCP scenarios, as well as observational data,

have a significant incremental trend. Incremental trend of temperature indicates the existence of climate change in the study area. The maximum wind speed showed that the observation and modeled data by RCP2.6 and RCP4.5 scenarios had a significant decreasing trend, while the generated data based on the RCP8.5 scenario had an increasing trend.

Conclusion

Based on the results of CanESM2 model and SDSM, study area is not excluded from the climate change phenomenon. The trend model predicted an increase in average temperature in future under three RCP scenarios. The average temperature will increase by 1.54 degrees. According to the RCP2.6 scenario, the average temperature is 4.5 degrees, the scenario RCP4.5 is 7.7 degrees and the RCP8.5 scenario is 18.12 degrees higher than the base period. Unlike temperature variable, there is no significant change pattern for rainfall. According to RCP2.6 and RCP8.5 scenarios, rainfall will be increased in the future, while under RCP4.5 scenario, it will be decreased. The maximum wind speed will be increased by an average of 0.53 m/s compared with the base period. The RCP2.6 scenario is 4.9%, the scenario RCP4.5 44.4%, and the scenario RCP8.5 53.5% of increase compared with observational data.

Keywords: Fifth Assessment Report, CanESM2, SDSM, statistical evaluation, trend.