

Records of late quaternary climate changes in magnetic susceptibility of Azadshahr Loess

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Extended Abstract

Introduction

In general, loess sediments are one of the most widespread forms of aeolian sediments. During the past few decades, loess stratigraphy studies played key role in the investigation about global climate changes. These sediments are usually yellowish in color and silt makes 70 to 90 percent of its volume. In Iran, loesses outcrop are often in northeast part of south Caspian Sea. The previous studies revealed that loess/paleosol sequences correspond to cold/ warm period of climate, especially during quaternary period. Therefore, loess deposits are the most important natural archive of climate changes and are ideal for reconstruction of paleoclimate and geomorphological change in Quaternary. The thick loess/paleosol sequences of northeast Iran provide unique opportunity to reconstruct the terrestrial paleoclimate changes recorded in these sediments.

A number of loesse-paleosol sequences contain a magnetic record of palaeoclimate through the Quaternary period. Anisotropy of magnetic susceptibility (AMS) was mentioned as a good tool to determine paleocurrent or paleodirection. AMS measurements were mostly used in the investigation of igneous, metamorphic and sedimentary rocks with an increasing number of applications in Quaternary loess and paleosol studies since the end of the 1980s. The sediment magnetic properties depend on the magnetic content and characteristics of the source material

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and post-depositional weathering/soil formation processes. Loess in north of Iran is part of world loess belt and evidence of paleoclimate changes in continent.

Materials and Methods

In this study, Azadshar (Nowdeh Loess Section) was selected to reconstruct Late Quaternary climate change. The Nowdeh loess section with about 24 m thickness was sampled in 10 cm intervals for magnetometry analysis. For this aim, sampling location and method was determined after consecutive study area. This study used reformed review of library references and lab practices combination. Magnetic susceptibility of all samples was measured in Environmental and Paleomagnetic laboratory based on Geological Survey of Iran. All samples were placed in an 11 cm³ plastic cylinders to be used in magnetic measurement instruments.

Magnetic susceptibility was measured using AGICO company made Kappabridge model MFK1-A instrument. Magnetic susceptibility of all samples was measured. Based on results of this study, samples with high frequency in magnetic susceptibility (increasing or decreasing) were selected for other studies of magnetic parameters.

Results and Discussion

The variation of magnetic susceptibility signal in the Nowdeh section suggests variation in climate conditions and mechanisms during the Late Quaternary. The magnetic susceptibility relationship with Loess/paleosol deposits resulted in low magnetic susceptibility values in cold and dry climate periods (Loess) and high magnetic susceptibility values in warm and humid climate periods (paleosol). Therefore, one can say that Loess and paleosol sequences of this area were formed in glacial and interglacial periods and under different climate condition. Results of this study indicated that Magnetic Susceptibility, Natural remanent magnetization, Saturation isothermal remanent magnetization and HIRM in loess was less than paleosol. Instead, the amount of S-0.3 in loess layers was more than paleosol. Results of this study show that Nowdeh section has seen 8 periods of hot and humid climate (paleosol layers and similar paleosol layers with high magnetic susceptibility) in cold and dry periods (loess layers with low magnetic susceptibility) during past 150 ka.

Conclusion

This study was conducted to investigate and evaluate the capability of magnetite properties in reconstruction of Late Quaternary paleoclimate condition recorded in loess/paleosol deposits of Nowdeh section in Golestan province, northeast Iran. Nowdeh loess/paleosol sequence is an indicator for periodic dry-cool (deposition of loess) and moist-warm (formation of paleosol) conditions. Formation of the studied loess and paleosols has probably taken place in glacial and interglacial cycles with different climatic conditions, respectively. Nowdeh section magnetic properties are completely matched with Neka sediment result that has obtained by Mahdipour et al. (2013). In 20 to 48 ka of past years, in two sediment sections magnetic susceptibility was similar and wherever increased, hot and humid period are integrated with paleosol layer formation. The results of this research are also in accordance with Bear and Storm (1995) in saturation of beryllium in Xifeng section and isotope δ^{18} of marine sediment. This indicate that climate change event in two section are simultaneous. Finally, we should say that magnetic

properties depending on sensible mineral to climate change, is a very useful variable for climate change reconstruction.

Keywords: climate change, magnetic parameters, Nowdeh outcrop, loess sediments.

Investigation and prediction of the temperature changes of Arak station based on statistical downscaling model

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Extended Abstract

Introduction

The city population, in particular at the industrialized cities and centers of provinces, has increased dramatically in Iran during recent decades. Arak city as center of Markazi Province is among those industrialized cities which has experienced a fast increase in population. These changes in population numbers tend to increase consuming water resources as well as increasing in energy resources demand. This situation is accompanied with global warming and caused an increase in temperature values during recent decades.

In current research, in order to understand the nature of temperature changes in Arak, the temperature trends were analyzed for previous and future states based on SDSM. Because, according to IPCC (2014: 563) it is vital to understand the nature of climate change in order to reduce its negative effects.

Materials and Methods

In order to study temperature trends during recent decades in Arak, the temperature data selected based on having sufficient temporal records to carry out the investigation and also sufficient accuracy that extend from 1961 until the end of the 2010 as the longest period of accessible temperature data record in Iran. The data of daily temperature is derived from Meteorological Organization of Iran. An initial check was carried out in order to test the quality of data. The NCEP/NCAR data and HadcM3 under scenario A2 and B2 are also used in current study in order to model and predict the temperature values.

In order to discover the negative/positive trends of the data, the temperature data were analyzed by Mann-Kendal trend test. In order to fit a proper model on each character of Arak's temperature, linear and non-linear regression models were used. The best models are chosen based on conformation of ordinary statistics and indices.

All the results are performed by SPSS and MATLAB applications and depicted in figures and shapes. Statistical downscaling model is used to simulate and predict the temperature of Arak station using SDSM software.

Results and Discussion

According to our study, the best fitted models on annual mean temperature, annual average of minimum temperature, and annual average of maximum temperature are cubic and quadratic models, while these models are fitted on absolute maximum temperature for spring and winter. There is no non-linear model to be fitted on minimal absolute temperature, due to the huge variability in this parameter. Based on correlation and partial correlation analyses which are used in current study, the explanatory variables for annual mean temperature are Sea Level Pressure (SLP), 500 hpa geopotential heights (500hpa HGT). The explanatory variables for mean maximum temperature are Vorticity at 500 hpa, 500hpa HGT, relative humidity at 500 hpa, and mean temperature at 2m. Ultimately, explanatory variables for mean minimal temperature are SLP, 500hpa HGT, relative humidity at 500 hpa, and also mean temperature at height of 2 meters. After calibrating with using estimated models and abovementioned variables for period of 1961 to 2010, the data were evaluated. It became clear that the difference between simulated data with recorded data is very low. Then, based on two scenario A2 and B2 the temperature variables of Arak are predicted. Based on scenario A2 and B2 during 100 years there will be about 0.24 and 0.19 degree centigrade increase in annual mean temperature, while 0.25 and 0.2 degree centigrade will increase the mean maximum temperature. The mean minimum temperature will be increased by 0.19 and 0.16 degree centigrade.

Conclusion

According to our findings, the Arak temperature trends are non-linear during the study period (1961 to 2010). Average of minimal temperature during summer shows an increasing trend. Therefore, energy and water demanding are increased in summer. Absolute values of maximum temperature of winter and summer have recently increased during last two decades. Therefore, the snow melts will have accrued very fast during winter and spring in future. The results of current research and several other studies performed in Iran and also in global scale have testified temperature increasing of cities and also the IPCC reports on increasing trends at least during the recent five decades and continue the increase at least during next two decades. This temperature increasing trends can also influence other climate variables such as evaporation, rainfall, relative humidity and so on and accordingly can affect human activities such as consuming energy, and human environment such as air pollution. Accordingly, the environmental management as well as environmental planning should consider this reality.

Keywords: *Arak, linear and non-linear regression, Statistical Downscaling Model (SDSM), trend detection.*

Climate change in Gavkhouni Basin at the late Quaternary phase

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Extended Abstract

Introduction

In spite of its short time period compared with the earth long evolution history, quaternary has had a significant effect on the final formation of the landforms and vital resources. It is the final analysis of these levels and fully dependent on the earth genetic diseases and, above all, significant climate changes that have happened during this period. Gavkhouni basin morphological perspectives demonstrate several climate changes in quaternary. The effects of these changes are a completely known phenomenon on the lake. Indeed, the lake can be viewed as an archive within which quaternary climate changes evidence has been maintained.

Gavkhouni basin in the past had weather different from today weather. Thus, geomorphic forms and processes have experienced great evolutions during quaternary and have been different from today. Since the geomorphic evolution of Gavkhouni basin have been affected by the external processes, i.e., climate fluctuations of the Fourth Era, is the result of these processes operations at the present. Referring to these operations, the past climate fluctuations in the area can be demonstrated.

Materials and Methods

The purpose of this study is to determine the temperature and moisture changes and transitions through tracing and revival of hot-waters and lake terraces and presenting a schematic image of the recovered lake of quaternary in Gavkhouni basin. In order to achieve this aim, the statistics

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related to annual temperature and rainfall of 13 stations within the basin and around it were selected and, in the next stage, quaternary temperature was reconstructed using the Wright method based on the snow line, and the changes were plotted. Then, using the Peltier model with its two basic parameters of temperature and rainfall, the survey of morphoclimatic regions of Gavkhouni basin was measured both in Vurm and the current.

Results and Discussion

To estimate the current annual mean temperature and to provide isotherm map using the annual mean temperature and height of each station, a thermal gradient with correlation coefficient of 0.92 was obtained. Then, applying equation (1) in the height model of the basin isotherm lines provided minimum, maximum, and the mean statistics of the Gavkhouni lake basin. Then the locations of 153 glacial cirques within Gavkhouni Basin were determined using the curve form of topographical map within a height range of 2500-3400 meters. The snow line of the basin measured based on Wright model was 2500 meters. Assuming the annual mean temperature at snow line as 0°C and by exploiting the relation of temperature and height as well as given the 5°C reduction in past temperature compared to that of the present, the mean temperature map during the cold period of the year was plotted and its minimum, maximum and mean were calculated. In the next stage, the nine-tuple regions were segregated using the Peltier graph, temperature parameters and annual rainfall and its result was plotted in the form of current morphoclimatic maps and the late quaternary phase.

Then, with regard to the studies conducted on Zagros basin lakes and the resulted linear relation between the two variables, ice maker survey and lakes survey, with the correlation coefficient 0.70, it was demonstrated that there was a kind of coupling between the height and survey of the ice maker and the survey of the lake. The more the height of the peaks are, the more is the survey of the ice maker and, as the result, the more the survey of the lake. Certainly, the lake survey and volume have decreased by the reduction of these variables at the present time. This suggests evidently the climate changes in the late quaternary phase compared to that of the present.

Conclusion

In order to investigate the weather fluctuations and environmental responses of Gavkhouni Basin, we concentrated on the past temperature and rainfall reconstruction. This measures the depth and volume of the lake and the survey of the lake ice maker in the past. Reconstruction of past temperature and rainfall and comparison with the present indicates a 1.5 times reduction in rainfall and 5 degrees increase in the mean temperature of Gavkhouni Basin. A contradict which has had so many climate and geomorphic changes as the consequence. Peltier method-based morphoclimatic maps show that the vastest survey of the basin was related to semi-arid region with 48.45% followed by Savan and Bouril regions with 35.28% and 14.95%, respectively. At the present, the semi-arid region with almost a double increase up to 83.24% has still the most survey of the region. Dried region with 13.79% is placed in the second rank. On the other hand, defining the limits of traced lake terraces through hot-waters represents the existence of a huge lake with a greater volume in the past. In other words, with correspondence of wet periods with glacial periods in the region, the basin extent has been augmented during the cold era by

increasing the rainfall and consequently increasing the river discharge. Therefore, the volume of Gavkhouni lake water reached to 892 km³ at the time, but during the warm era it reached to 21 km³ because of the reduction of ice maker concentrations in the region.

Keywords: allometry, cirque, climate change, morphoclimate, Peltier.

***Spatial analysis of aeolian landforms by fractal theory
(Case study: Ardestan Rig)***

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Extended Abstract

Introduction

Today, mathematics is a strong way to explain process and the complexity of nature so this turmoil has to be made in the form of mathematical and quantitative relationships and to some extent predict their effects. For this purpose, to illustrate the complexity, we used fractal geometry and its dimension to understand the heterogeneity in natural environments. The purpose of this study is to examine the morphological behavior of each wind geomorphic forms in the environment. It should be noted that the behavior of landforms are nonlinear in nature. They can be analyzed with statistical methods and fractal geometry as one of the approaches that attempt to use their theories and formulas to represent the complexity and quantity in the form of mathematics. The term nonlinear is unequal relations between influential forces or stress and geomorphic response to states.

This paper aims to explain the behavior of fractal geometry and morphological landforms using geometry and use of mathematics to determine the rate of changes. Therefore, we focus on wind landform because of having more variability compared with other landforms because faster and better results may be achieved in a shorter timeframe. Special analyses are the major challenges by researchers. We have also evaluated the fractal dimension as other goal of this study.

Materials and Methods

The study area is located between 33° 30' - 33° 45' North longitude and 52° 15' - 53° East longitude in the Zavareh- Ardestan-Isfahan. The elevation from southwestern region to the north is ranged from 1410 to 910 m and the area has an average slope of 0.5 percent.

In this study we attempt to identify 5 index landforms and determine the limit of the development. The data used for this purpose are:

- CARTOSAT1 image 2008
- CARTOSAT1 image 2011
- Geological map 1: 100,000

Box counting as one of the most widely used methods in fractal studies has been employed in this research. The difference between the fractal dimensions obtained in different periods show that they will have more changes occurred in the phenomenon. In addition, this study shows the ability of fractal geometry to identify the changes that happened in landforms.

Result and Discussion

The purpose of this study is to apply fractal analysis of aeolian landforms of Ardestan Region. For this purpose, we used Cartosat images of 2008 and 2011, and for fractal analysis, we divided typical aeolian landforms of study area into four categories; longitudinal sand dunes, cross sand dunes, barchans, and planted sand dunes. To determine the fractal dimension, we used Box counting method.

The results indicated that natural sciences, such as geomorphology are faced with inherent variable that are not very repeatable or predictable. They are highly sensitive to initial conditions. Since geomorphologic landforms have a special sizes and dimension, the spatial arrangement of these shapes to each other can determine many effective factors in their formation and we can identify these effective factors accurately.

Behavior of landforms in nature is non-linear and can be analyzed by statistical methods. Wind landforms of complex systems sometimes act in a rotational manner. This complex behavior is contrasts with the simple laws of physics and is nonlinear and dynamic. In this study, it was observed that mathematics is a powerful tool to describe landforms and processes, in nature.

Because of the size and dimensions of the special landforms, they could analyze mathematics and statistics. In this study, the fractal theory in geomorphology and particularly in landforms can be analyzed exactly. It could give us satisfactory results by mathematic and statics. The fractal dimension of landforms was studied. In addition, this study indicated the ability of fractal theory to identify the changes that happened in landforms.

Conclusion

Natural sciences are faced with a great revolution, nowadays. Now, scientists think the world as a collection of complex systems can predict consequences of this complex system. In this situation, the systems have rotational behavior. In the meantime, geomorphic landforms have special shapes, sizes and special aspects, and the spatial arrangement of these shapes to each other can be determined by many influence factors in their formation. Since the landforms behaviors are nonlinear in nature, it can be analyzed using statistical methods which Fractal geometric is one of them. The theory attempts to use its equations to represent the complexity

by mathematical way. Thus, results of this study show that the geometric patterns of landforms have fractal characteristics and it can be analyzed for different years. The dimension of fractal as a main index shows that planted sand dunes have a great dimension because it cannot change during the study period and indicate the stabilization of sand dunes. The maximum rate of change belongs to longitudinal and cross sand dunes that their extent is decreasing and this has been shown to reduce the fractal dimension and its implementation. In general, the result of fractal analysis is consistent with realities of aeolian landforms.

Keywords: *Aeolian landforms, Ardestan Rig, fractal theory, geomorphic landforms.*

The effects of Atmospheric Rivers on Iran climate

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Extended Abstract

Introduction

Water vapor can spread in molecular, unstable and erratic phase and can also transfer by convection and advection process. This transfer happens from the earth and ocean surfaces to the atmosphere in hot air. This type of transfer is considered as the main pattern. In the studies of the atmosphere, one of the prominent factors to be considered is the complexity of water vapor and its cycle. Water structure is different above the surface of the earth and the oceans. The study on water structure was initially conducted in 1960, in which a great deal of information gathered by the meteoric satellites and many researches were carried out about this phenomenon. One of the water structures is the atmospheric river, which is recently considered as a separate factor. The definition of the atmospheric river as the Tropospheric River was initially introduced by Riginald Newell in 1992. Given the fact that Middle East, especially Iran, is facing an overwhelming trend of drought, it is necessary to provide programs and plans to prevent this phenomenon. Moreover, the vast and small water sources and the moisture entries have to be identified.

Materials and Methods

In this research the specific humidity maps were reanalyzed in three years (2011, 12, 13), as provided by NOAA administration. About 1000 maps from different surfaces were drawn in this period. After the days with the occurrence of Atmospheric River were identified, jet stream maps were produced. For the jet stream maps two types of winds were used: UWND and VWND. They are derived from the NOAA administration. The maps were designed by the GRADS program by the use of 300 hPa of the defined day. Then, we studied the relation between the atmospheric river and jet stream of 300 hPa for the defined day. These relations with zonal wind were calculated in SPSS program by using the Pearson correlation coefficient.

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Results and Discussion

The average occurrence of ARS phenomenon in Iran is 13. These are entering to the country from different directions. In 2012, the highest amount of atmospheric river was reported. Approximately, 27 percent of the rivers were from the West, and the southeast, southwest and south with 8, 46 and 19 percent, respectively. West ARS happened mostly in February, 80 percent in the winter. The other 20 percent happened in the late autumn in December. The ARS are considered in 400hPa height, with 90 percent of them at this height level. East south ARS occurrence rate is the least with just 8 percent. Based on the seasons, these Atmospheric Rivers happen more in August and July. Their movement level is 600 hPa, which is in a lower level compared with the western ARS. West south ARS are considered as the main entries, due to the fact that 46 percent of the ARS are from this direction. These rivers are in lower levels, 600 and 700 hPa. About 60 percent of these rivers happened in the autumn, as the winter has the second rate. The other direction of the rivers is the southern part, which is considered as the most unregulated AR and can happen during all seasons except the winter. This direction is on the third stage according to the occurrence, and includes only 19 percent of the rivers. It enters Iran at the level of 700hPa, and is rarely reported by other levels.

Conclusion

The occurrence of Massive flood in the southern regions in the one hand, and reduction of the average total rainfall in the country on the other hand are influencing Iran from the destructive and climate events and phenomena. To predict flooding and accordance of economic activities related to water, it is necessary to recognize their sources and the transport of moisture factors in different levels of the atmosphere. In this study, we have studied transportation of water vapor through distinct phenomena on synoptic atmospheric rivers (ARS). In the beginning of the research re-processed data of specific humidity, were taken for a period of three years (2011-2013) from the NOAA. Then, the maps were prepared by Software GRADS. The results show that about 12 atmospheric rivers were observed during the study period on average annually and have been classified so-called western, southwestern, southern and southeastern Atmospheric Rivers. The studies show that River Winds have created the phenomena. Moisture in the river is about 6 times of surroundings on the average. Atmospheric rivers feed atmospheric spring head along the way. Southern and southwestern Atmospheric Rivers have the highest amount of moisture. Rainfall maps also showed the rainfall of Southern Atmospheric Rivers that lead to the flood and water logging passages in the southern cities. Pearson correlation coefficients indicated the relationship between atmospheric rivers with orbital indexes, respectively. The southern, southwestern and western ARS have correlation values of 28, 53, and 85 percent.

Keywords: *Atmospheric waterspout, climate of Iran, Jet Stream, moisture transfer, tropic index.*

***Estimation of the spatial distribution pattern of wind speed for
assessment of wind energy potential in Iran***

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Extended Abstract

Introduction

Nowadays, the exploitation of the renewable energy sources such as wind plays a key role in human life. Although, Iran has a high potential for wind power generation, there is not an efficient energy planning yet. Environmental variables such as wind speed have variations according to spatial points. It seems reasonable to consider that there exists a spatial correlation between wind speed data at different locations. In geostatistics the spatial autocorrelation of data could be investigated by calculating the experimental semivariogram. The parameters of the fitted semivariogram model may be used to estimate the wind speed at unknown locations through kriging algorithms.

In order to describe the behaviour of wind speed at a particular location, the data distribution should be first fitted by a suitable distribution function. There are different wind speed distribution models used to fit the wind speed distributions over a period of time. Among them, Weibull distribution function has been found to be the best all over the world because of its great flexibility and simplicity.

The aim of this study is to simulate the daily mean and maximum wind speed probability distribution using Weibull distribution function and to investigate spatial variability of the wind

speed data. This study was also aimed to interpolate the means of Weibull distribution functions of daily mean wind speed data observed at stations over Iran.

Materials and Methods

Study area and data set

The study is based on a long term (20 years) wind data recorded in 104 synoptic stations spread over Iran. The wind data are recorded at 10m above the ground level (a.g.l.) and contain daily mean and maximum wind speed (m/s).

The Weibull distribution function

For each site, the daily mean and maximum wind speed data were fitted by a two-parameter Weibull distribution, whose parameters (shape and scale) were determined through the maximum likelihood (ML) technique. The Weibull probability density function is defined as follows:

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

where V is wind speed (m/s), c is the scale parameter (m/s) and k is shape parameter (dimensionless). The high and low k values indicate the sharpness and the broadening of Weibull peak, respectively. The Weibull probability density function curve could be displayed if the k and c values are obtained. This could be conducted through different ways, such as maximum likelihood method as:

$$c = \left[\frac{1}{n} \sum_{j=1}^n V_j^k \right]^{1/k} \quad (2)$$

$$k = \frac{n}{(1/c) \sum_{j=1}^n V_j^k \log V_j - \sum_{j=1}^n \log V_j} \quad (3)$$

where V_j is the wind speed for j th sample and n is the number of sample data. Equation (3) is an implicit equation and could be solved through an iteration method.

Methodology

Two interpolation methods including inverse distance weighing and ordinary kriging were used to estimate the theoretical mean values of the previously determined Weibull distributions of the wind speed data at unsampled locations.

Inverse Distance Weighing (IDW)

In absence of data spatial autocorrelation, IDW is usually used as an alternative method for spatial estimation of random field. IDW is a weighted averaging interpolator in which data is

weighted according to their distance to the estimation point such that more distant points get less weight than closer points.

Ordinary Kriging (OK)

The OK is the most popular kriging approach used in the spatial interpolation of the regionalized variables. It needs the parameters of the best fitted semivariogram model to incorporate spatial dependence of data on the estimation process. The semivariogram quantifies the dissimilarity between observations as the separation distance between them increases.

Results and Discussion

According to the obtained results, Semnan and Bandar-Abbass had the lowest and highest shape (k) factor of the fitted weibull distribution functions to the daily maximum wind speed data, respectively. For daily mean wind speed data, Nehbandan and Bandar-Abbass had the lowest and highest shape (k) factor of the fitted theoretical Weibull distributions, respectively. A high k value means less variation of the wind speed.

The annual duration of daily wind velocity exceed 4 m/s. It is also calculated for each site in order to obtain the first diagnostic sign of most promising areas in terms of wind energy potential. According to the results, the cities of Rafsanjan, Zabol, Torbate Jam, Khodabandeh, Ardebil, Bijar and Kahnouj have the highest potential in high wind speed.

The auto-correlation analysis showed that wind speed is moderately correlated in space with spatial structure model of spherical and a correlation distance of about 500 km (Figure 1 (a)). There was no apparent drift within the range of 500 km. The best semivariogram model was selected according to the cross validation results as well as the highest correlation coefficient (r) and the lowest residual sum of squares (RSS) functionally of GS+ software.

To predict the spatial distribution pattern of wind speed over Iran, Weibull mean wind speed data were interpolated over a point grid superimposed to the map of Iran using IDW and OK. The cross validation results indicated that both methods performed similarly. However, the maps generated were visually different. Besides, unlike IDW, OK represented the map of estimation error which is useful in decision-making as it provides a measure of uncertainty.

According to wind speed map generated by OK (Figure 1 (b)), eastern Iran (e.g. the cities of Zabol, Rafsanjan and Torbate Jam) and northwestern provinces (e.g. Ardebil) are the most promising areas for wind energy planning.

Conclusion

The spatial variability of wind speed and duration across Iran has been investigated. First, the frequency distribution of daily mean and maximum wind speed data during recent 20 years was simulated by Weibull function. Then, the mean values of the theoretical Weibull probability distribution functions are used to investigate the spatial variability and predict the spatial distribution pattern of wind speed across the country. According to the results, wind speed is moderately correlated in space with an influence range of about 500 km. The maps of wind speed at 10 m a.g.l. generated using IDW and OK encourage the utilization of wind energy on the eastern (e.g. Rafsanjan, Zabol, Torbate Jam) and northwestern (e.g. Ardebil) regions. Besides, additional measurements may be considered in the areas of highest estimation of uncertainty (e.g. center and eastern parts).

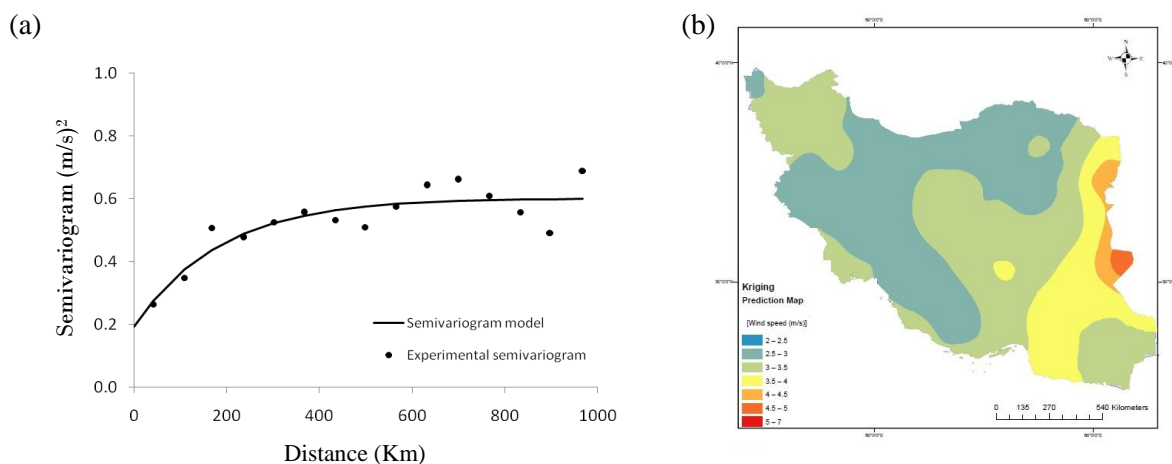


Fig. 1. Experimental semivariogram along with the best fitted model (a) and the interpolation map of mean wind speed at 10 m a.g.l. generated by OK (b)

Keywords: interpolation, spatial variability, Weibull Distribution, wind speed.

Calibration of TRMM satellite 3B42 and 3B43 rainfall data in climatic zones of Iran

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Extended Abstract

Introduction

Rainfall prediction at regional and global scales is mostly the principle component of hydro-meteorological studies in un-gauged regions. Ground-based measurements of precipitation are available with high accuracy in synoptic stations. Spatial distribution of operational stations is now as one of the biggest problems in the developing countries such as Iran, which the spatial distribution of the stations is not enough. In recent decades, remote sensing data have widely been used by many researchers in the world for drought monitoring and management of water resources. The satellites data can be used as compensation for temporal and spatial distribution of rainfall. The satellite-based rainfall estimates provided by the Tropical Rainfall Measuring Mission (TRMM) satellite at global scale, are now available freely as the only data source in the regions without in-situ measurements. Most regions of Iran have arid and semi-arid climates. The evaluation and calibration of TRMM data in different regions of Iran at daily and monthly time scales is very important before those data are used by researchers, experts, climate scientist, hydrologist, and etc. Therefore, a comprehensive evaluation and calibration of the TRMM 3B43 and 3B42 dataset at 87 synoptic stations in Iran including six climatic zones, is the main objective of this present research.

Materials and Methods

This research was carried out in Iran. It is located between 44°14' to 63°20' E longitude and 25°03' to 39°47' N latitude, with an area of more than 1.6 million Km². Alijani et al. (2008)

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classified Iran climate according to climatological parameters to six separate climatic classes: desert, semi desert, mountainous, semi-mountainous, coastal wet, and coastal desert. This study aims to evaluate the accuracy of the Tropical Rainfall Measuring Mission (TRMM) satellite and its calibration on the daily, monthly, seasonal and annual scales at the synoptic stations located in climate zones of Iran. The daily TRMM-3B42 and monthly TRMM-3B43 collection data were downloaded from the NASA website. After early processing, a comparative analysis was carried out for satellite data and observed rainfall data at 87 synoptic stations during a 12-year data period of 2009-1998. The Desert, semi desert, mountain, semi-mountain, coastal desert and coastal wet climate zones are containing 22, 19, 19, 12, 8 and 7 stations, respectively. We utilized different error measures (R, ME, MAE and RMSE), and agreement indices (POD, FAR, CSI and TSS) for satellite data evaluation. Since there were noticeable errors, regional mean data were calibrated in the daily and monthly scales and finally two correction coefficients were introduced based on regression analysis.

Results and Discussion

Day-to-day rainfall comparisons showed that the TRMM rainfall estimates are very similar to the observed data values, even if a general overestimation in the satellite products must be highlighted. We found out a high similarity between two sources of rainfall data at 87 synoptic stations in most of climatic zones. Furthermore, The TRMM revealed the highest error at Ramsar, Bandar Anzali, Rasht and Babolsar stations, and the lowest errors at Zahedan, Bam and Esfahan stations. In other words, the TRMM revealed the highest error in coastal wet zone and the lowest error in desert zone. The False Alarm ratio (FAR) indicator has the lowest value in coastal wet zone that shows TRMM applicability to predict rainfall amount at these stations. The highest correlation coefficients on monthly and daily scales were 0.86 and 0.998 in the semi mountainous zone, respectively. The lowest values were 0.49 and 0.78 in the humid zone, respectively. After applying the calibration coefficients, The RMSE values were significantly reduced at monthly scale. This indicates that the calibrated TRMM data is mostly similar to the observed rainfall data at different time scales and climatic zones.

Conclusion

In the recent years, the accurate measurement of precipitation and its spatial and temporal distribution have been addressed frequently at un-gauged regions of the world. At present, the estimation of rainfall by the TRMM satellite is only data source, which is available freely at global scale. The main purpose of present study is to evaluate the TRMM rainfall data and to provide the correction coefficients in desert, semi-desert, mountainous, semi-mountainous, coastal wet and coastal desert climatic zones, on daily and monthly scale. The main advantage of this work is to apply various statistical error criteria and newly introduced agreement indicators to evaluate TRMM data. The results reveal that the TRMM overestimates rainfall on daily and monthly scales at 68% of stations. In general, The TRMM could detect most of rainy days in the climate zone and Iran during 1998-2009 period. The calibrated data were very similar to the measured values. Therefore, our research findings revealed that the calibration process could improve rainfall estimates at most of climatic zones, significantly.

Keywords: *calibration, rainfall, synoptic, TRMM.*

Desertification susceptibility in ecoregions of Khorasan-Razavi based on Life Cycle Assessment (LCA)

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Extended abstract

Introduction

In the recent decades, mismanagement, human activities and climatic conditions developed a new view of Iran ecosystems, called desertification. Life cycle assessment (LCA) is a method to construct environmental profile of production systems. That was developed by industrial instruments, but in recent years it is applied by agricultural production process as well. Today, it is acknowledged that land use should be assessed by LCA, but there is still no consensus on the parameters for assessment. In order to assess such land use impact, it is initially necessary to define the variables in the LCI. Once the inventory data is gathered, the LCI results have to be characterized in the impact assessment phase. The main framework of LCA is based on the "from cradle to grave" where we are able to evaluate environmental impacts truly from start point to the end. In this way, we can use the theory of LCA to assess desertification indicators and estimation of ecosystem resistance to this phenomenon. Thus, in this research an LCA approach was applied for estimate ecosystem susceptibility to desertification.

Materials and Methods

This research concentrated on the role of LCA to distinguish ecosystem susceptibility to desertification phenomenon. In this way, at first the land units were considered Ecoregions, the region with similar ecological and climatic characteristics, and six ecoregions has been identified. Then, based on Delphi methodology, six main factors were determined. These are aridity, landuse, wind erosion, soil erodibility, salinity, and vegetation density. To calculate aridity, FAO/UNEP aridity index (P/ETP) was used. The land use map was developed by ETM⁺

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imagery data and distinguished six classes including; desert, bare lands, cultivated lands, settlements, rangelands and forest. A report of critical center of wind erosion prepared by KR organization of Natural Resources and watershed management was applied for wind erosion. Soil erodibility was calculated based on the Sepehr et al. 2014. Salinity and vegetation indices were calculated by spectral ratio of imagery data. To assess susceptibility degree a characteristic factor (CF) for each ecoregion has been calculated. One of the main contributions of this study is the establishment of desertification impact CFs for the ecoregion. The divisions between these areas are based on climatic and vegetative cover factors, both aspects having a major influence on soil desertification risk. Thus, after calculating CF for each ecoregion total characteristic factor was developed by geometric mean of each CF. Ultimately, the susceptibility degree to the desertification was evaluated and mapped.

Results and Discussion

The results indicated the high preference aridity and wind erosion at Khorasan Razavi province which is in relation to the climatic conditions and land use changes in the recent years. The greatest desertification risk is found in the moderate arid desert ecoregion, with a CF of 2.21. The susceptible ecoregions mainly covered more than 70% of the KR areas. In this case, the desertification impact of the activity should not be integrated in LCA studies. This can be used to identify those cases without desertification impact. The LCIA Desertification value is also zero when CFi or any other variable is zero. A value of zero for CFi means that the activity being studied is in an ecoregion with no desertification risk. The LCI Desertification value of the activity being assessed is determined by the addition of the individual values given to each of the six variables, according to a scale of values. This paper provides CFs including desertification impact in LCA studies, and the variables suggested allow the comparison of the benefits and threats posed by different human activities.

Conclusion

In this research, an LCA methodology was developed for assessment of ecosystem susceptibility to desertification phenomenon. Main biophysical variables including aridity, wind erosion, landuse, erodibility, salinity, and vegetation density belong to the driving force, state and pressure frameworks. The desertification impact evaluation of any human activity in a LCA should include these common, basic four variables. The purpose of this research is to investigate desertification susceptibility degree of ecoregions at Khorasan Razavi as vulnerable province to land degradation and desertification in Iran. In this study, we applied Life Cycle Assessment (LCA) framework to assess susceptibility. In the first, an ecoregions map was provided by adjusted De-Marton climate index. Six main indicators including aridity, land use, wind erosion, soil erodibility, salinity, and vegetation cover were determined by Delphi methodology. The preference degree of each indicator was calculated using Entropy algorithm. Ultimately, we estimated characterization factor (CF) for each ecoregion. The layer integration was done using geometric mean with desertification susceptibility map. The results showed that the ecoregion of moderate arid desert is most susceptible to desertification.

Keywords: *Desertification Susceptibility, ecoregion, Entropy, Khorasan Razavi, Life Cycle Assessment (LCA).*

Assessment of accuracy in CFSR data and LARS-WG model in simulation of climate parameters, Chaharmahal and Bakhtiari province

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Extended Abstract

Introduction

Daily weather information is currently available for about 40000 stations across the world. But, distribution of these stations is relatively uneven in some parts of the world. Moreover, there are often large amounts of missing values (Schuol and Abbaspour, 2007: 301). Using generated data can help fill missing or even to correct erroneously measured data (Fodor et al., 2010: 91). LARS-WG is a stochastic weather generator which can simulate weather data under both current and future climate conditions at a single site (Semenov and Barrow, 2002: 3).

There is another watershed modeling problem, which weather stations are often outside of/or at a long distance from the watersheds. Thus, the recorded data may not meaningfully indicate the weather taking place over a watershed. Therefore, some researchers have developed radar data to supply precipitation inputs in watershed modeling (Fuka et al., 2013: 1). But, these data are only available in small parts of the world. therefore, considering additional methods to generate weather conditions over watersheds is necessary. Using reanalysis dataset (CFSR) is one option (Fuka et al., 2013: 1).

Dile and Srinivasan (2013) investigated CFSR climate data in the Lake Tana basin in the Nile basin. The results showed simulations with CFSR and conventional weather gave trivial differences in the water balance components in all except one watershed. In the four zones, both weather simulations indicated similar annual crop yields. Nevertheless, the conventional weather simulation results were better than the CFSR weather simulation, but they can be applied as important option for the regions where no weather stations exist such as remote subbasin of the Upper Nile basin. Soltani and Hoogenboom (2003) evaluated the weather generators WGEN and SIMMETEO for 5 Iranian locations. The results revealed that WGEN

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was successful to generate maximum and minimum temperatures and SIMMETEO was acceptable to reproduce minimum temperature and solar radiation.

The objective of current study is to make an assessment of accuracy of weather generator of LARS-WG and CFSR data in simulation of climate parameters of Chaharmahal and Bakhtiari province.

Materials and Methods

The study was conducted in Chaharmahal and Bakhtiari province. This province, with an area of 16532 km², is located between 31° 09' to 32° 48' north latitude and 49° 28' to 51° 25' East longitude and provides more than 10% of the water resources of Iran.

1. LARS-WG model

LARS-WG model applies complex statistical distributions for simulation of meteorological variables. The basis of this model to simulate dry and wet periods is daily precipitation and radiation series of semi-empirical distribution. The temperature is estimated by Fourier series. The output of this model includes minimum temperature, maximum temperature, precipitation and solar radiation (Babaeian et al., 2007: 62).

2. Required data for LARS-WG model

Required data for LARS-WG model includes daily maximum temperature, minimum temperature, precipitation and solar radiation (sunshine hours). These data were provided for four selected synoptic weather stations (Shahrekord, Koohrang, Boroojen and Lordegan).

3. CFSR data

Reanalysis is a systematic approach to produce data sets for climate monitoring. Reanalysis data are created through a fixed data assimilation design and models which use all available observations every 6 hours over the period being analyzed. CFSR data has a global horizontal resolution of 38 km. The CFSR adjacent stations were determined for the four mentioned stations.

Daily weather data of each station during 1991-2010 was implemented in the LARS-WG model. For assessment of both data, the comparison of statistical indices such as RMSE, MBE, MAE and R² was used in daily, monthly, annual and decade scales.

Results and Discussion

The results showed that there is no correlation between the output of LARS-WG model and observed daily precipitation data in each of the four stations. The values of these coefficients for minimum and maximum temperatures increased in all stations. In general, due to high values of RMSE and MAE, this model was not successful in simulation of daily climate parameters. Performance of the model to simulate monthly and annual scale was better than daily. Ability of LARS-WG model in simulation of long-term period (decade) was satisfactory. The results indicated that monthly and annual climate parameters by CFSR data have been predicted by a more effective performance. Because statistical indices of CFSR data are lower than LARS-WG. These data underestimated the precipitation in Shahrekord station. RMSE and MAE values of monthly precipitation are 20.49 and 11.19, respectively in Shahrekord station, for CFSR data. These values for annual precipitation are 92.88 and 72.51. For LARS-WG model in monthly scale, RMSE and MAE values are 41.45 and 24.75 and these values in annual scale are 164.75 and 123.43.

Conclusion

In recent years, it is necessary to get accurate and long-term meteorological data due to climate events and scarcity of meteorological stations across the country. Thus, it is a reasonable solution to use weather generators. The objective of current study was assessment of accuracy of weather generator LARS-WG and CFSR data in simulation of climate parameters of Chaharmahal and Bakhtiari province. In general, the results showed the ability of LARS-WG model in simulation of long-term period (decade) data. Thus, values of statistical indicators are not satisfying in short-time periods. Statistical indices of CFSR data are lower than LARS-WG in simulation of short-time period (monthly and annual). They are highly correlated with the observations and they can simulate climate parameters in short- time. Therefore, with the purposes of any specific research, both LARS-WG model and CFSR dataset can be used. Moreover, CFSR data can be applied as valuable option for the regions where there are no weather stations.

Keywords: CFSR, LARS-WG, maximum temperature, minimum temperature, precipitation.