Efficiency of Statistical Downscaling Models of SDSM and LARS-WG in the Simulation of Meteorological Parameters in Lake Urmia Basin

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Extanded Abstract

Introduction

Linking resolution global climate models to local scale as a micro climatic process is a significant issue. Recently, attempts have been made by the climatology scientists to develop dynamics and statistical downscaling methods to express climate change at a local and regional scale. Two general techniques are been used for downscaling of the output of general circulation models (GCM). The further is by statistical methods in which the output of a statistical model (MOS) and a planned approach to weather short-term numerical prediction is presented. The later is regional climate model (RCM), same as limited GCM model in a subnet of network global model by dynamic method that uses climatic conditions temporal changes according to GCM model. Both methods play an important role to determine the potential effects of the climate change caused by increased greenhouse gas emissions. Much work is done to use this method for downscaling of the global model output in different areas in which the performance of the model is assessed. Uncertainty analysis has been done on these methods or compared by other statistical methods.

Materials and Methods

In this study for more accurate validation of the two methods, uncertainty analysis is done on input data of daily temperature and precipitation. In uncertainty analysis of daily temperature

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data because of similarity of the statistical distribution to normal distribution, the monthly mean of downscaled data are statistically compared with observed data. In this case, parametric or non-parametric tests can be used to compare means. However, in uncertainty analysis of daily rainfall data because of lack of normality, comparison of the averages of downscaled data and observed data are not sufficient and should be compared with the dry and wet periods. In this method, the statistical distribution of downscaled dry and wet period durations is compared with the observed ones.

Before the uncertainty analysis, first, an exploratory analysis is performed on the data in the data statistical condition and the approach to data analysis to be ascertained. This analysis is based on the study of statistical assumptions of the model. If these assumptions are not established, the statistical analysis parametric methods and respective tests lose their credibility and nonparametric methods must be used. These assumptions are:

1. Data come from normal or near to normal distribution.
2. Data standard average is close to zero or there is no outlier.
3. Data have little temporary correlation.

Daily rainfall varies because of the skewness of the right (frequency of daily precipitation amounts toward zero), the normal assumption is questionable. Therefore, power transformations are used for normality of rainfall data in statistical analysis and modeling. On the other hand, the daily temperature data are normal in nature and there is not outlier. But, because of temporary correlation of daily temperature, the third assumption did not establish for them. Therefore, parametric methods are used for statistical analysis and comparative tests.

Results and Discussion

According to the three basic assumptions of the model, daily rainfall data are far from a normal distribution and the data have a lot of outlier points. But, there is not significant correlation period. Unlike the daily maximum and minimum temperature data of relatively normal distribution, they have not had many outlier points. But, there is a significant correlation of the data with time. Therefore, it can be concluded that none of the data of temperature and precipitation have conditions of the three basic assumptions. Therefore, non-parametric methods must be used for statistical analysis and modeling. Or alternative parameters are used such as the number of days wet or dry.

For the uncertainty analysis and comparison of the two models SDSM and LARS-WG we have used graphical and statistical methods. In this study, the absolute values of the differences between downscaled values and observed values in the 1961-1990 statistical periods are used as an indicator in the graphical analysis. Results of graphical analysis show that values of the absolute differences in different months of the SDSM model parameters are the minimum and maximum daily temperature LARS-WG is better than the model. The daily rainfall amounts during the months of absolute difference of the two models are relatively close to each other. Of course, the results of stations in Tabriz and Urmia are slightly different but are not significant.

To evaluate the significance difference between observation and downscaled values in two models, we have used Mann-Whitney test. The results show that for the minimum temperature, in both models SDSM and LARS-WG almost in half of the months, the model error is significant, although the SDSM model is better. However, the tendency to work and choose the

most appropriate model for large-scale predictor variables from the NCEP-NCAR data were obtained from the appropriate geographic region and it is possible to achieve better performance. Parameter maximum daily temperature for the SDSM model has better performance than the LARS-WG, which confirmed the results of the chart. The downscaled maximum daily temperature has less error than the minimum daily temperature. Especially in SDSM model in Tabriz station only January has a significant error in the model. It has good performance for daily precipitation models. Especially in Tabriz station the values of the model error is not significant in any of the months. In accordance with the similar results, the performance of the two models is similar for the daily rainfall.

Conclusion

The results of this study indicates that in accordance with the results of the statistical downscaling SDSM and LARS-WG on stations of Tabriz and Urmia for daily minimum and maximum parameters, SDSM model has better performance than the LARS-WG. For daily precipitation performance, the two models are similar in the two stations. However, as the statistical distribution of daily rainfall data is not normal, the results of the models cannot be trusted. It is suggested that instead of precipitation, in the analysis we used the number of dry and wet days.

Keywords: climate change model, downscaling, LARS-WG, SDSM, uncertainty.

Karst Landscape as a Settling Factor in Kamyaran Area: Past and Present

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Extanded Abstract

Introduction

In several perspectives including geographical determinism, possibilism, exceptionalism, ecological and other views, it is discussed about understanding how human and the environment interact. Human in dealing with different environments, depending on the capabilities of environment and existing tools and techniques, adopt themselves with the nature or interfere in it. Karst landscapes are one of the most sensitive and fragile environments that any interference by habitants could led to irreversible conditions. These environments are one of the most valuable resources of fresh water. Nearly 25% of the world population lives in karst areas-landscapes that are characterized by sinkholes, caves, and underground drainage (Veni, 2001). The interaction of human and karst has been regarded in the many studies mostly about the impacts of human activities on karst. In general, there are few studies concentrated on the various effects of karst on the human societies. Andrejchuk (2005) and Lovász and Gyenizse (2012) have regarded karst landscapes as a settling factor. These studies show that comparing with non-karstic areas because of the specific hydrology and geomorphology of karstlands the population mostly has concentrated around karst springs and in the other parts settlements are highly sparse. In fact, the history of human settlement dates back far into the past in karst environments. A significant number of protected areas as the world heritage belong to karst areas (UNESCO, 2008). Many of them, such as Yunnan, Guizhou and Chongqing in south western China, Cradle of Humankind World Heritage Site in South Africa, Lascaux cave in France and Shanidar cave in Zagros Mounts in Iraqi kurdistan have been protected for their archeological and historical values.

Karst areas are spread in substantial parts of Iran. About 90% of the Zagros Mountains contain carbonate rocks (Afrasiabian, 1980). Karst features are common along this mountain belt. The oldest evidence of human settlement dates back to Paleolithic era. The evidence is found in the karstic caves and rock shelters of Zagros. During the history, Zagros Mountains

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and their surrounded areas have been the cradle of many civilizations. Karst morphology has an important role in this respect. Zagros is still one of the highly populated areas in Iran.
In this paper, based on the effect of karst landscape, three patterns of human settlement including caveman, cemi-nomadic and sedentism have been studied in the karst lands of north western High Zagros in Kamyaran area. This area is characterized by karst landforms. Karst features have been mostly formed in pure and thick limestone of Biseton Formation (Jurassic to Cretaceous) and younger carbonate rocks of Tertiary. Comparing with tertiary karstlands, the karst features of older Biseton Formation are more developed. More development of karstification results in more developments of conduit networks and the concentration of groundwater that decreases the number of karst springs at surface. In the more developed karst systems like Biseton Formation the karst springs are sparse and have a high discharge and the dryness of the surface is a major problem for settlement. On the contrary, in less developed settings like tertiary limestone the number of karst springs is more and the discharge is not comparable with those of more developed formations. In the area, the less developed Karstlands of Tertiary limestone with more number of karst springs have had a great potential for settlement development.

Materials and Methods

In this research, in addition to some archeological and historical data, the data mostly were derived from geological maps (1:100000), topographic maps (1:50000), SRTM 27 meters, Google Earth, Flash Earth and field works. Data processing software was Global Mapper15 and ArcGIS 10 and the final maps were produced in ArcGIS 10. GPS, compass and camera were used in field works. A descriptive-analytical method has been applied in the research and the comparison of karstic and non-karstic areas was used as a technique. In this method, after collecting data, different data layers including elevation, geology, Karstlands, the distribution of caves and karst spring, the distribution of summer huts and rural and urban areas were prepared for further analysis. The layer of Karstlands was overlaid and compared with each layer and the relationships between the layers were analyzed based on info tables. It should be noted that the analysis of the caves and rock shelters was according to the existing historical and archeological studies about the area and surrounding places.

Results and Discussion

In the area, three patterns including caveman, semi-nomadic and sedentism as a major and dominant kinds of settlements have been studied. Many of the world's greatest archaeological sites have been found in caves, where fragile materials that would easily be destroyed in other settings have been preserved. Caves were reliable sources of water when other sources went dry, and minerals and clays were mined for both practical and ceremonial use (Veni, 2001, 22). Pure carbonate rocks of Biseton Formation and also the younger limestone of Tertiary have a significant extension in Kamyaran area. Therefore, the area is dominated by karst features specially cave. Vertical and horizontal caves are common landforms in the area and have been formed at the bottom of sinkholes, along fault lines and bedding planes. However, all of the features were not interesting for caveman. Positions of archeological caves show that they are mostly distributed at the margin of Karstlands of tertiary limestone where the karst springs are

available. Because of the dryness of karst lands of Biseton formation the caves were not interested by caveman.

Throughout the territory in Zagros a way of living is common that is known as semi-nomadic life. This way of living that exists even today, has tied with sedentism. This means that the semi-nomads are groups that spend a part of their lives in highlands nearby and in the cold seasons return to their villages. In the Kamyaran area, the semi-nomadic life is intimately linked with karst region. It starts from early spring and lasts to early autumn. It takes almost more than half a year. During the immigration, semi-nomads live in specified places that are called Hawar or Hawargah. Hawar is a hut, usually with dry stone walls more than a meter tall and their roofs are covered by branches of trees or Rshmal (black tent). As it gets warmer this way of living depends more on the karst region. The nomads follow snow patches. When it retreats toward the highlands they change their Hawar. Thus, there are a lot of Hawars in the karst region distributed between piedmont to the summits and each group or village has several Hawars in different elevations. Karst sinkholes play a critical role in preserving snow. By the midsummer the snow cover at surface is almost melted and the only places which still have snow are inside the Noors (a local term for Aven) and sinkholes. The nomads also cover some snow by patches of local vegetation for preserving it.

Kamyaran is a fertile region in the south of Kurdistan province and has a long history of residence. This area is one of the most important passages between Western Iran and Mesopotamia. There are several ancient mounds, forts, inscriptions and prehistoric caves in this area that represent a long history of human habitation. Karstlands in terms of security, water and rich pastures have had a significant role in habitant's life. The sedentism has been affected in a different way by karst. As mentioned above inside the Karstlands are dry in general. Karst springs are rare and spars. At the margin of karst lands that karst springs are mostly discharged, the number of villages is plentiful. Because of dryness, there is not any village or settlement inside the karst lands. In this respect, the number of villages (141) in different settings has been compared. The results show that the villages have been mostly constructed on the quaternary alluviums and other non- karstic formations. The key reason behind this condition is water. Throughout the area, only 6.33% of villages belong to marginal parts of the karst lands. At the same time because of the presence of karst springs at the contact line between karstic and non-karstic settings the number of villages is excessive in this part. Although these villages are on the non-karstic setting but they exist because of the karst water. Many of the most populated and important villages in the area use karst water.

Conclusion

Surveys in the karst lands of Kamyaran show that humans settled in the area in the far past. Inside the caves and rock shelters of the area, traces and remnants of human presence from the Middle Paleolithic era to contemporary periods were obtained. Therefore, topographical and geomorphological features of the region had provided very favorable conditions in the distant past and even in the Ice Ages for caveman. The presence of rich pastures and vegetation and also the important role of karst geomorphology in preserving snow for a remarkable time, has led to forming a semi-nomadic life in the area. This study shows that the pattern of caveman is completely and semi-nomadic pattern to a high extent dependent upon karst system. In contrast,

sedentary pattern has been affected differently by karst system. Settlements are rare and sparse inside the karst lands. They have mainly been distributed around the karst lands. Compared with non-karst and quaternary alluvium this condition represents that karst has had a coercive effects on the sedentary living. Rich aquifers in quaternary alluvial and easier access to the water via springs, wells and canals in these areas have resulted in a high density of rural areas. Despite the widespread use of modern technology to overcome nature, the complicated structure of karst system seems to be a great barrier for interference of human.

Keywords: caveman, Kamyaran, karst, sedentism, semi-nomadic.

Development of a Spectrograph Unmanned Aerial Vehicle for Aerial Imaging of Agricultural Farms

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Extanded Abstract

Introduction

Todays, the application of new methods for monitoring and online management of agricultural farms is necessary to increase quality and quantity of agricultural products. Remote sensing is one of the technologies that can be used to monitor agricultural farms and natural resources. This technology is capable of detection and prediction of farm changes by application of satellite and aerial images. Satellite images have some limitations for application in agriculture, namely, high cost, low revisit time and low spatial and spectral resolutions.

Thus, recently design of low altitude remote sensing system is considered as a useful tool for ground observations with high spatial resolutions. This system is used to monitor and collect online images for agricultural farms of small spatial farms. So, by the importance of aerial imaging in agricultural farm management and limitations of satellite imagery, the main objective of this research is to develop an unmanned aerial remote sensing system for imaging agricultural farms with high spectral and spatial resolutions.

Materials and Methods

The constructed unmanned aerial vehicle (UAV) is composed of aerial part and ground station. Aerial part is composed of carbon fiber body and arms, 8 brushless DC electric motors, 8 control speeds, control board, PID controller, AHRS system for roll, pitch and yaw angles measurements (with 3 gyroscopes, 3 accelerometers, 3 Magnetometers, one barometer), GPS, camera mount with 2 servo motor for compensation of camera vibration, 3-cell chargeable Li-Po battery (5000mA, 11.1 V) and voltage measurement unit. A multispectral camera (ADC-Micro, Tetracam Company) with 520-920 nm wavelengths and 3.2 Megapixel CMOS sensor in Green, Red and Near Infra Red bands (6-12 V, 2 Gb memory).

Ground station is constructed for conduction and control of aerial part and, indeed, it is connected with operator to aerial part. Ground station is composed of 8 frequency radio control

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(2.4 GH frequencies), flight monitor software and control software. Total system weight is 2 kg with 78 cm length and width and 29 cm height. The main duty of ground station is following current position and coordination of the UAV, visiting flight parameters and adjustment of primary flight parameters. Sending online imagery of regain to the ground station is carried out by a CCD camera.

To connect aerial and ground parts together, a telemetry system is used. To evaluate the performance of the system, collecting data is carried out in a wheat farm in the Mohammad Shahr, Karaj, Iran.

Results and Discussion

Some factors such as flight endurance, flight maximum preload, maximum and minimum UAV speed, flight altitude, camera mount performance and spatial resolution are investigated. So, imagery are processed, NDVI and supervised classification map is extracted. To evaluate the results of classification, error matrix and overall accuracy is calculated. Based on the results, manuaribilty and stability of the UAV during the flight and also in takeoff and landing positions were satisfactory. The results of experiments showed that the average time endurance of the UAV with installation of GPS, CCD camera, Multispectral camera is 10 minutes. Thus, the results of UAV preload experiments indicated that the maximum preload of the developed UAV is 1 kg. Also, the maximum wind speed for the UAV flight based on the result of this research was 15km/hr. The performance of the system is decreased by increasing wind speed. The optimum UAV speed for collecting qualified imagery is 0-40 km/hr. In higher speed, the quality of imagery will be decreased.

Conclusion

The obtained results from this study are:

- Spatial resolution: based on the results of experiments in the height of 250 m by image dimension (2048*1536), the total covered area in imagery is 2.8 ha. So, time resolution based on the UAV speed and imagery saving file format is 2-5s. So, spatial resolution of imagery in the height of 10m was 3.6 mm/pixel and in the height of 250m the obtained image is 95mm/pixel.

- NDVI map showed higher value in denser regains.

- Supervised classification map (maximum likelihood): the results of experiments showed that the overall accuracy of classification map was 93.99% and Kappa coefficient obtained 0.9. Classification results showed that different classes such as soil, crop canopy, shadow and etc. were separated and recognized completely. High value of the overall accuracy and Kappa coefficient indicates that the UAV is capable of taking good imagery without nose which shows the satisfied performance of control system of the UAV and control system of camera mount in order to keep the UAV in the right situation and to fix camera in the desired position.

Keywords: multispectral camera, precision agriculture, remote sensing, spectrograph, unmanned aerial vehicle.

Optimal Algorithm for Zonation of Spring and Autumn Frosts in Kurdistan Province, Using NOAA-AVHRR Images

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Extanded Abstract

Introduction

Frost as a harmful climatologic phenomenon affects various human activities and biological processes. Due to mountainous nature of Kurdistan Province as the study area of this research in one hand and type and diversity of effective air masses on the other, the frequency, severity and duration of this phenomenon in the province are outstanding. Confronting frost could be one of the major programs of the province authorities especially in the agricultural sector. Satellite images can be a good way to study the frost because of the continuity and repeatability of the relevant data. With the previous studies and the lack of researches related to the frost and estimation of land surface temperature by satellite images in the country, this study aims at determining the optimal algorithm in order to study and extract the earth's surface frost zones in the spring and autumn in the region using night-time images of the AVHRR sensor.

Materials and Methods

The study area in this research is the Kurdistan Province located in the west of Iran. To do this, the daily temperature data from seven weather stations of the region in a 10-year period (2001-2010) were used. After the spring and autumn frost dates were determined in the stations, 24 night-time images were taken from NOAA satellite website, and their thermal bands (AVHRR channels 4 and 5) were used to calculate the temperature. Then, the satellite images were corrected geometrically by ENVI software using GCP files of images, and after that radiometric calibration was performed by histogram equalization method. Likewise, thermal band radiances and brightness temperatures were calculated. To calculate the surface emissivity (ε), the land-use layer must be taken into account. NDVI values were used in this study so that 10 daily images for each year (5 images for spring and 5 images for autumn) in total 100 images for the

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study period were taken and accordingly, NDVI values were calculated for the images. After eliminating the cloudiness effect and calculating the surface emissivity, land surface temperature equation was applied to the images with the surface emissivity. From the proposed various techniques for calculating the surface temperatures, the Split-Window Technique (SWT) was used in this research and finally, three algorithms were used for calculating the night-time temperatures namely Price (1984: 7236), Coll et al. (1994: 113) and Ulivieri et al. (1994: 62). The equations used in the mentioned algorithms were applied to the images using ERDAS software. The last step in the study was to validate the estimates by comparing the temperatures derived from satellite images with recorded ones at the weather stations using three indexes, namely Mean Absolute Error (MAE), Mean Bias Error (MBE) and Root Mean Square Error (RMSE), and consequently, calculating the correlation coefficients between these two temperature series.

Results and Discussion

Land surface temperatures in the Kurdistan Province were estimated using NOAA satellite images by Price, Coll, and Ulivieri algorithms. The resultant error values from MAE, MBE and RMSE indexes indicated a better match between temperatures derived from Coll algorithm and the observed ones in the weather stations. Observed and estimated temperatures based on Coll algorithm at the stations for all of the 24 selected images were presented in a table. After doing corrections and applying various algorithms on the satellite images, temperature zoning maps were prepared to extract and analyze the frost zones. The number of these maps was equivalent to the number of used images, i.e. 24. In some images there were pixels, identified as white color, without any information. Coll algorithm's temperature estimation errors in the stations is ranged from -0.1° to 6.3°C according to MAE, MBE and RMSE indices. Statistically significant correlations were also found at the 0.01 level between observed and estimated temperatures at Sanandaj, Marivan, Bijar and Zarrineh-obato stations, and at the 0.05 level of confidence at Saghez, Ghorveh and Baneh stations.

Conclusion

NOAA satellite data are used by scientists and researchers of different fields to separate temperature zones because of their appropriate temporal, spatial and spectral resolution. In this study, we tried to analyze the spring and autumn frosts in the Kurdistan Province using NOAA-AVHRR images, and prepare zoning maps derived from the optimal algorithm. Out of the three algorithms used to estimate the land surface temperature, Coll algorithm led to better results. The use of NDVI index in calculating the surface emissivity was also helpful in estimating the temperature. It is noteworthy that in all three algorithms, temperature estimates at Sanandaj, Marivan and Saghez stations- which have lower altitudes- were better than the elevated stations like Zarrineh-obato, Ghorveh and Bijar. There seems to be a direct or indirect relationship between the altitude and the accuracy of estimation. This needs to be investigated. Generally the elevation role in the occurrence of night-time frost in the province is obvious, both in terms of intensity and development.

Keywords: Kurdistan Province, NOAA-AVHRR Images, spring and autumn frosts, zoning.

Land Suitability Assessment in Climate Change Condition (Case Study: Canola Cultivation in West Azerbaijan Providence)

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Extanded Abstract

Introduction

Today, with the increasing population and the need for strategic and industrial crops the farmers are simulated to grow these kinds of crops. Thus, this subject has now been caused the inappropriate use of land and natural resources. On the other hand, the natural environment resources have limited the ability to use its resources and the climate change intensifies this limit ability. Agriculture is one of the most sensitive parts of human activities to changes in climate parameters. The slightest shift in climatological factors of plant growth, the growth of plant processes affected these changes in the performance and quality of crops. In climate change condition, some natural environments with the most appropriate conditions and resources are provided for the development and optimal use of human and with the least appropriate condition the human manipulation can lead to damages to natural environment. Therefore, to any manipulate and development in environment, before planning to use it, we need to evaluate the potential of the environment. In addition to the potential of environments for the future, due to climate change, it is required to consider any planning. The aim of current study is to provide a land suitability assessment in the condition of climate change. Given the sensitivity of crops to climate change, one of the agricultural products as a sample product has been selected to implement the procedure.

One of the strategic and industrial products is Oil-seeds such as canola. Oil-seeds compose the second largest food resources of the world after cereals, and Canola is the third largest

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source of vegetable oil in the world. A variety of factors and parameters are effective in determination of suitability of any area of land for cultivation and in condition of climate change and changes in temperature and precipitation changes in suitability of lands may be occurred for cultivation of canola. In this study, a new method based on the Geographic Information System (GIS) and climate change model, has been developed for cultivation of canola in West Azerbaijan-Iran.

Material and Methods

In the first step, the effective criteria (canolaplant requirements) were recognized using library study. In this study, the GIS based on Artificial Neural Network (ANN), Network Analysis (ANP) and LARS-WG, for modeling the land suitably has been developed. Thus, for evaluating the lands suitability, the climatological data such as temperature, precipitation, growth degree day, relative humidity, freezing days, and sunshine hours were collected for the west Azerbaijan Province from synoptic stations data in 1987-2010 associated with the phonologic stages of canola growth. In addition to the climatological data, the earth resources like topographic layers, lands capability, soil depth and land uses were analyzed with focusing on the climatologic and ecological needs of canola.

All of canola plant requirements in base period (1987-2010) were simulated for three periods in the future. Therefore, the impact of climate change on temperature, precipitation, solar radiation and relative humidity were modeled using LARS-WG and ANN in the future climate condition. Also for simulating the data of future climate, the HADCAM3 of General Circulation Model and A1B and A2 scenarios were used. The importance of each criterion was completed by experts' opinions. Due to the interaction of the criteria in the actual world, DEMATEL technique was used to recognize the relations among the criteria. ANP was used after completing the pairwise comparisons questionnaires by expert's viewpoints.

Results and Dissection

In this study, the outputs of the minimum and maximum temperatures, the output rainfall and radiation of the model HADCM3, are used to estimate the relative humidity in the periods 2011-2030, 2046–2065 and 2081-2099. Based on the estimates through modelling in the artificial neural networks, the measures of relative humidity have been simulated. The results of the application of the introduced ANN structure for estimating the relative humidity in different modes of the functions and the number of neurons in the first and middle layers show that ANN have a good ability to estimate the relative humidity in the future periods. Results of ANP show that the most important canola plant requirement is elevation and after that are temperature and rainfall.

Implementation of the model shows that in the base period (1987-2010), 15% of lands in study area are in condition of very suitable and 31, 29 and 25% are in suitable, moderate suitable and unsuitable classes, respectively. Based on the results of HADCM3 model, in the second period (2011-2030) the very suitable class is 11% of the province and other classes are 38, 31 and 24 percent of the lands. Thus, in this period the suitable class compared with base period will increase. In the third period, with changes in temperature and rainfall, climate change will cause decrease of lands in condition of unsuitable and very suitable for canola

cultivation and the percent of 2 and 3 classes will be increased. In the fourth period, following the changes in temperature and precipitation due to decreases in very suitable class, about 5% of lands and inappropriate lands (about 23 %) will cause decrease in suitable lands for cultivation of canola in West Azerbaijan.

Conclusion

The results indicate that the proposed method can well simulate the effects of climate change on Land Suitability Assessment to grow crops. Generally, changes in temperature and precipitation resulted in decreases in the areas of very suitable and suitable lands for cultivation of canola in West Azerbaijan providence. Additionally, the low limits lands will be increased significantly in comparison with the baseline period. As suitable lands for canola cultivation will be changed from 47% in the base period to 34% in the future periods.

Keywords：canola, climate change, land suitability assessment, network analysis, West Azerbaijan.

Investigation about Temperature and Humidity Anomalies between Pleistocene and Present Times; Reconstruction of Climate Condition Using Geomorphic Evidence (Case Study: Khezrabad-Yazd)

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Extanded Abstract

Introduction

The study of climate change and its trend have usually been complicated as problems for specific scientists in these subjects. Obviously, climate has been changed during the history of earth many times, and their evidence are landforms in many regions of the world, where we can readily observe now. The landforms could not be justified with the present climate. In fact, any climate creates specific geomorphic systems. Therefore, the existence of different geomorphic systems in different regions of the world shows that climate has changed frequently over time. In the KhezrAbad basin of Yazd Province we can observe landforms that have been created in different periods of climate of different temperature and precipitation conditions. Thus, with studying of present landforms in the basin, it has been tried to reconstruct past climate. The climate could justify such landforms reasonably. KhezrAbad Basin is located in the south-west Yazd city in the slope of Shirkuh Mountain along 31° 48´ 7" to 32° of northern latitudes and 53° 49´ 42" to 54° of eastern longitudes.

Materials and Methods

For studding the condition of past climate in the research, we have used topographical maps (1/50000), geological map (1/100000), aerial photographs (1/55000), and satellite images. In addition, to study present climate and its changes relative to the past, we have used climate data including temperature and precipitation of 6 stations for 9 years in the region and its surrounding. At first, using topographical maps we have defined the basin. Then, according to

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the form of contours, aerial photographs, satellite images as well as field study, we marked glacier cirques. For drawing the maps of present isotherm, we created the correlation between altitudes and annual temperature (for 9 years) amongst surrounding stations of the region to obtain the linear equation. Then, using the elevation points extracted from DEM and above equation, we provided isotherm and isohyets maps for present time. As ever, for drawing past isotherm and isohyets maps, we calculated zero C. line (snowline) for the past with Wright and Porter methods. Afterwards, we obtained an equation according to the correlation between altitude and temperature, which replaced once 1000 meters instead of "h" and next time 2000 meters. Therefore, with subtraction of these two numbers, we evaluated adiabatic lapse rate. Using permanent snowline altitude and adiabatic lapse rate it would result in past isotherm map. In the next stage, according to line correlation between temperature and precipitation, we got the equation: P= -15.803T+355.16. On the equation basis, it helps draw past isohyets map. In the Wright method, we used the average of 60% of cirques. In the Porter method, we calculated the snowline of the region according to accumulation area ratio, cirque-floor altitude, and altitude ratios.

Results and Discussion

Investigation about the region at present shows some landforms such as a number of glacier cirque, a U form origin valley and a few secondary valleys as well as a great fan that could not be created with present climatic processes. Therefore, these landforms indicate a big climatic change in temperature that was lower with higher precipitation. With statistical analysis and also Wright and Porter methods, the snowline has been found between 2100-2200 altitudes in Pleistocene. On the snowline basis as well as adiabatic lapse rate for 0.65 and 0.8 C., we have calculated differences between past and present temperatures in the region orderly 12.92 and 13.4° C. In addition, studies showed that the rate of precipitation in the Pleistocene increased to about 176 millimeter more than present average. Thus, the ice and water equilibrium line has been in 1560 meters equivalent to 4.8° C.

With more precise study, the rate of precipitation in Pleistocene has been about 3.38 million cubic meters above 1200 meters height. This volume is about 1.88 as much more than present. The most precipitation volume has been calculated for the altitudes between 2200-2300 meters, and the least for 3000 meters.

Conclusion

The results of this research in the KhezrAbad Basin show some glacial evidence of past climates. The evidence can be observed as 15 small and big cirques, a glacier broad valley, much volume of moraines such as lateral moraines, medial moraines, and terminal moraines, and also tillites. On the basis of these witnesses, the permanent snowline has been on the height of 2200 meters, but the ice and water equilibrium line on 1560 meters. In fact, glacier's tongue has been descended more than 600 meters and there has been melted ice; because temperature in the altitude increased to 5° C. The remained erratic in the region affirm the hypothesis. Therefore, with comparison of isotherm and isohyets maps of the basin for present and past times, we estimated about 13°C anomalies. Moreover, research findings show the reduction of 176.52 millimeter of precipitation in comparison with the quaternary. Precise calculation

confirms that the volume of precipitation in Pleistocene period has been 3.38 million cubic meters above 2200 m. The volume is about 1.88 as much more than present time.

Keywords: climate changes, geomorphic data, KhezrAbad basin, Pleistocene, snowline.

Spatial analysis of Precipitation with Elevation and Distance to Sea (Case Study: Sistan and Baluchestan Province)

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Extanded Abstract

Introduction

The knowledge about spatial variability of precipitation is a key issue for regionalization in hydro-climatic studies. Measurements of meteorological parameters by the traditional methods require a dense rain gauge network. But, due to the topography and cost problems, it is not possible to create such a network in practice. In these cases the spatial distribution pattern of precipitation can be produced using different methods of interpolation. Interpolation could be done only based on the data of the main variable (i.e. through univariate methods) or on the information obtained from both the main and one or more auxiliary variables (i.e. through multivariate methods). The classical interpolation methods such as arithmetic mean and linear regression (LR) methods are independent of the spatial relationship between observations, while geostatistical methods (such as kriging) use the spatial correlation between observations in the estimation processes (Isaaks and Srivastava, 1989). The previous studies showed that the choice of interpolation method depends on data type, desired accuracy, area of interest, computation capacity, and the spatial scale used. Hence, different interpolation methods, including geostatistical methods (OK, SK, Sklm, KED, UK and COK), univariate deterministic methods

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(IDW, LPI, GPI and RBF) and linear regression (LR) were compared to estimate monthly and annual precipitation in Sistan and Baluchestan Province. The auxiliary variables used in the multivariate approaches were DEM, distance to Sea and spatial coordinates.

Materials and Methods

Study area

Sistan and Baluchistan Province is located in southeast of Iran and covers an area of 181471 km^2. It is located between the latitudes 25°03′and 31°27′N and the longitudes 58°50′ and 63°21′E. The precipitation data collected from 50 precipitation stations over the same period of 25 years (1988-2012) were used in this study.

Interpolation methods

Detailed description of geostatistical interpolation methods used in this study including OK, SK, Sklm, KED, UK and COK are provided in the variety of resources, such as Goovaerts (1997) and Deutsch and Journel (1998).

In geostatistics the most important tool for investigating the spatial correlation between observations is the semivariogram. In practice, experimental semivariogram is calculated from the following equation:

$$\hat{\gamma}(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} [Z(u_i + h) - Z(u_i)]^2 \qquad (1)$$

where $\hat{\gamma}(h)$ is the experimental semivariogram, N(h) is the total number of data pairs of observations separated by a distance h, $Z(u_i)$ and $Z(u_i+ h)$ are the observed values of the variable Z in locations u_i and u_i +h, respectively. After calculating experimental semivariogram, the most appropriate theoretical model is fitted to the data. Unknown values are estimated using the semivariogram model and a geostatistics estimator.

Comparison method and evaluation criteria

To assess the accuracy of interpolation methods and the best method for estimating precipitation, cross-validation technique is used (Isaaks and Srivastava, 1989). Evaluation criteria are including the Root Mean Square Error (RMSE) and the Mean Bias Error (MBE).

Results and Discussion

Statistical analysis showed a high coefficient of variation of precipitation in August, September and July. Kolmogorov-Smirnov test showed that precipitation data are normally distributed over the study area. The precipitation semivariogram was considered isotropic as a little change was seen for different directions. Results of autocorrelation analysis showed a high spatial correlation of precipitation in all periods (except for January and February) with a spherical semivarioram model. This confirms the results of previous studies (Lloyd, 2005; Haberlandt, 2007; Mair and Fares, 2010). The maximum sill was observed for months January, February and March with a higher amount of mean and variance. The maximum radius of influence was seen for January (511 km) followed by May (205 km). The performance of UK was evaluated using the trend function of the first and the second order polynomial. The evaluation results indicate that the first order polynomial is the more accurate one.

The cross validation results showed that the best method for precipitation estimation was

linear regression (precipitation versus elevation) for April, KED for May, UK for June and September, RBF for July, August, October, December, January, February and annual precipitation and SK for November and March. The LPI and GPI methods did not perform well in any of the time periods. This could be possibly due to large changes in surface topography of province. RBF method had the highest accuracy in most of the periods. The estimated values in this method are based on a mathematical function that minimizes total curvature of the surface, generating quite smooth surfaces (Zandi et al., 2011). Geostatistical methods had the highest accuracy for other periods. One of the reasons for good performance of geostatistical methods may be due to the low density of the meteorological stations. It confirms other researchers' results (Creutin and Obled, 1982; Goovaerts, 2000). The use of elevation as covariate has improved the estimation results only for April and May. However, the distance to Sea did not improve the estimation results in any cases. The reasons for little improvement of the precipitation estimation through the multivariate methods could be due to the complex topography, low density of meteorological stations, and low correlation between precipitation and covariates.

Conclusion

Geostatistical interpolation methods, in deterministic and linear regression methods, were evaluated for precipitation data in Sistan and Balouchestan province. According to the results of cross-validation, linear regression (elevation- precipitation) for April, geostatistical methods for May, June, September, December and March and RBF method for other periods had the highest accuracy. According to the estimation error maps produced by the geostatistical methods, the highest estimation errors were seen in the area with a low density of stations and the boundaries of the province. These areas are recommended for developing the meteorological network in the future. Also, due to the variability of climate, distance from Oman Sea and changes in the surface topography for the precipitation stations, we recommend that the province is divided into more homogeneous regions and the proposed approaches are investigated in each section, separately.

Keywords: co-variable, geostatistics, precipitation, regression, spatial variability.

Spatial Analysis of Humidity Propagation Over Iran

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Extanded Abstract

Introduction

The consequence of cooperation between environmental factors and circulation patterns in a long time can determine the arrangement of type and manner in humidity in geographical area. The knowledge about space dispersion in geographical areas assists preparing sound programming and proper environmental decision making. Relative Humidity is the most commonly used measurements of moisture content in the air. The key to understand relative humidity is to understand that it is a measure of the 'actual humidity', relative to the maximum possible humidity at a given temperature. Let's explain it a bit further. In this context a number of studies have been conducted to refer this. Some of these studies are Diffenbaugh and et al. (2008), Ohayon (2011), Jia and et al. (2011), Homar and et al. (2010), Chao-bing and et al. (2011), Allard and Soubeyrand (2012), Ageena and et al. (2013), Del Río and et al. (2013), Kim and et al (2014) and Bajat and et al. (2014). This research is fulfilled to detect the temporal and place spatial autocorrelation of humidity in Iran.

Materials and Method

In order to reach the expressed goal, the base of network data of relative humidity in Iran has been established. Similarity of data of the stations has been evaluated by the Kolmogorov-Smirnov Test in SPSS software and their similarity has been proved. Then, from the data of the stations a statistical period of 30 years in a daily period from 1982/1/1 until 2012/12/31 is used as the base of the present research and a network in range of 15×15 kilometer have been spread over the study area. In reviewing the changes of Transmittal Humidity of Iran during a year, modern spatial statistics method such as spatial auto correlation global moran, local insulin moral index and hot spots were used by using (GIS) and MATLAB.

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Results and Discussion

The results of this research showed that the global moran index for each 12 monthes of a year is one more than 0.90. This point indicates that in accordance to global moran, Transmittal Humidity of Iran in the study period has the high cluster pattern in 90, 95 and 99 level percent. Then, the highest index of global moran in scale of 0.97 is related to the February in winter. Z statics for every 12 monthes of a studied statistic period is high and between 247 and 263. Therefore, according to global moran it can be concluded that during a year in the index in Iran shows a very high cluster pattern. Alteration of spatial autocorrelation of Transmittal Humidity of Iran used the local moran index and analysis of hot spots. According to both the indicators, the north, north west, north east, west and south west areas like east Azarbaijan, west Azarbaijan, Ardabil, Zanjan, Guilan, Mazandaran, Ghorgan, Khorasan and Kermanshah stations plays a significant role in forming the Humidity patterns with high cluster. This is in a way that the named areas of Iran have positive spatial autocorrelation. This is while the regions have negative spatial auto correlation or in other words dry humidity in 12 months of a year limited to high regions. Totally, a considerable area of the province in all 12 months is without significant or disciplined pattern or they lack sound virtual spatial autocorrelation statistically. The results of this research showed the humidity pattern is formed through a long time period and under local and distributional elements with a different role.

Conclusion

Generally, the geographical arrangement of humidity patterns are formed by regional factors specially heights, latitude and in a clearer explanation formation and structure and the role of latitude. This is while we should not ignore the role of outer factors in formation of humidity patterns. Outer factors or the general circulation atmosphere elements play a significant role in determination of a humidity regime and humidity lapse. If we look at the humidity cluster of Iran we see that the clusters in high and low level are not the same. This contrast is because of influence of circulation element factors.

Keywords: hotspot index, Iran, moran index, relative humidity, spatial autocorrelation.

Evaluation of Spatio-Temporal Accuracy of Precipitation of European Center for Medium-Range Weather Forecasts (ECMWF) over Iran

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Extanded Abstract

Introduction

Precipitation is one of the most important meteorological variables in comparison with other climatic parameters. It varies extremely over time and space. The occurrence of this climate phenomenon requires specific circumstances in environment. Its accurate measurement is important to a wide range of decision makers including hydrologists, agriculturalists, industrialists and etc. The density of rain gauges and meteorological radars is often too poor to satisfactorily capture rainfall characteristics at fine spatial resolutions. To overcome this problem gridded precipitation data base was developed based on interpolation of the daily precipitation data. ERA-Interim is the latest gridded global atmospheric reanalysis produced by the European Center for Medium-Range Weather Forecasts (ECMWF). This data covers the period from 1 January 1979 to the present. The precipitation analysis and estimation is based on obtained precipitation data from rain gauge stations, meteorological radars and satellite sensors. The forecasted precipitation is available at 3-hourly based on applying different models. The horizontal spatial resolution is available at 3, 2.5, 1.5, 1.125, 1, 0.75, 0.5, 0.25 and 125 Gaussian degrees over globe. Information about the current status of ERA-Interim production, availability of data online, and near-real-time updates of various climate indicators derived from ERA-Interim data, can be found at http://www.ecmwf.int/research/era. The purpose of this research is to evaluate temporal-spatial accuracy of gridded precipitation data of ERA-Interim version from European Center for Medium-Range Weather Forecasts (ECMWF) data base over Iran country.

Material and Methods

In order to conduct this research the 3-hourly gridded precipitation data from ECMWF version ERA-Interim over Iran country has been extracted during 1/1/1979 to 31/12/2013. The high

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spatial resolution data with 0.125 degree has been selected. By accumulation of 3-hourly data the daily, monthly and yearly time series have been created. A Matrix with dimension 12784×9965 has been created that located time (Days) on the rows and location (Pixels in Iran's country political boundary) on the columns. During the same period, Iran's daily precipitation data of the synoptic stations have been extracted from Iranian Meteorological Organization. The national precipitation gridded data base of ASFEZARI with 15 km spatial resolution was also prepared. By nearest neighbor algorithm and conversion of high density to low density approach, the spatial resolutions were even. To evaluate temporal-spatial accuracy of the estimated ECMWF precipitation we applied different indices.

Results and Discussion

The results of this research indicate that not only there is a high temporal correlation between estimated ECMWF precipitations and two national data bases but also there is high correlation between amounts of precipitations. At spatial view, the high correlation observed over Zagros Mountains is covered over southwestern and northeastern parts of country. Over these regions correlation coefficient (R) and Index of Agreement (IA) are over 0.94 and close to 1, respectively. The Bias index rate (Bias) of estimated precipitation relevant to this data base is negative over very rainy regions at southern parts of Caspian Sea and northern parts of Persian Gulf. While the Bias rate on the other regions is positive. The bias and Root Mean Square Error (RMSE) rate are considerable rather than other regions but the estimated precipitation error is very low to total observation precipitation. Thus, the Relatively Root Mean Square Error (RRMSE) show low rate over these regions rather than other regions. In other words, it can be said that the bias and error rate of estimated precipitation over dry regions including southeastern, some regions in northwestern and central parts is higher than very rainy regions cores in southwestern parts of Caspian Sea and Zagros mountain ranges. The results of probabilities of detection (POD), False Alarm Ratio (FAR) and Critical Success Index (CSI) indices imply high ability of ECMWF data base to isolation of these days over Zagros mountain ranges, southern parts of Caspian Sea and northeastern parts of country. The results show that the accuracy of this data base is higher during rainy months rather than dry and low rainy months.

Conclusion

This research has provided further evidence of the capability of ECMWF precipitation data base to capture precipitation characteristics at fine temporal-spatial resolutions. Agreement between ECMWF precipitation data base and synoptic stations data (Stations) is as good as with gridded national ASFEZARI data base. This provides confidence in the quality of ECMWF precipitation data base and confirm the findings of other researches.

Keywords: ASFEZARI, ECMWF Data Base, Iran, Precipitation.