Investigation on the Factors Controlling the Response of Mountain Rivers to Extreme Flood Event (*Case Study: Upstream Ilam Dam*)

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Extended abstract

Introduction

Large severe floods can have enormous influence on the fluvial system in comparison with the floods with lower magnitude and more frequencies. This work addresses the geomorphic response of mountainous rivers to extreme floods to explore the relationships between morphological changes and controlling factors. In October 2015, following the occurrence of a sudden extreme rainfall, a large and devastating flood occurred in Ilam province. The flood caused major changes in the morphology of Ilam's rivers. The rate of channel expansion is various in different sections of the studied rivers. Thus, we can examine the influential and controlling factors that led to diversity of river behavior. The hypothesis of this research is that explanation of geomorphic effects requires models that include other variables, e.g., lateral confinement, degree of sediment, besides hydraulic related variables (cross-sectional or unit stream power). The main purpose of this research is to explore the relationship between channel widening and arrange of controlling factors. We have addressed channel width (i.e: pre- or post-flood width) to calculate unit stream power in order to have a better explanation of channel response? Since few studies have been done in this field, this research was conducted with the aim of investigating the factors controlling the response of Mountain Rivers to extreme flood events in upstream of Ilam dam.

Materials and methods

The research has examined three tributaries of the Konjancham River (upstream of Ilam dam)

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whose catchments were affected by an extreme flood on 7th October, 2015. An integrated approach was taken to study this flood, including (i) Analysis of channel width changes by comparing aerial photographs before and after the flood, (ii) Estimation of peak discharges in studied reaches, and (iii) Determining the degree of sedimentation in studied reaches. Delineation of spatial units was carried out according to the approach proposed by Rinaldi et al. (2013), which is a modification of the approach by Brierley and Fryirs (2005). According to the approach, stream sectors were defined as macro reaches having similar characteristics in terms of lateral confinement, while the reaches are homogeneous in terms of channel morphology (channel pattern, width, and slope) and hydrology. We have used the reach scale (reach length was commonly from 200 to 1300 m) for an overall assessment of magnitude of channel changes and for a preliminary investigation of controlling factors. The dominant process observed in the study reaches was channel widening, which was analyzed by comparing aerial photographs taken before and after the flood. To assess the changes in channel width, channel banks, and islands, these features were digitized on pre- and post-flood orthophotos. The channel width was calculated by dividing channel area by the length of the reach, and changes in channel width were expressed as a width ratio (ratio of channel width after the flood to channel width before that flood). The estimation of peak discharges has been used to calculate cross-sectional stream power and unit stream power. The last part of the methodological section deals with statistical analysis carried out to explain channel response to the flood event by exploring the relationships between the changes in channel width and controlling factors.

Results and discussion

The relationships between the degree of channel widening and possible controlling factors were explored using multiple regression analysis. The analysis was carried out for the widening (width ratio) at reach scale. The entire data set includes 38 reaches. We analyzed seven controlling variables including confinement index, percentage of reach length with artificial structures, degree of sedimentation, channel slope, cross-sectional stream power, and unit stream power using pre-flood and post-flood channel width. Each regression model included only three to four variables. Each model included only one of the variables expressing potential or flood flow energy, e.g., channel slope, cross-sectional stream power, unit stream power. All four multiple regression models turned out to be significant ($p< 0.001$) and gave high coefficients of multiple determinations. The values of $R^2$and adjusted R^2 are ranged between 0.73 and 0.8 and between 0.69 and 0.77, respectively. The best model embraced unit stream power calculated based on pre flood channel width and confinement index as explanatory variables.

Conclusion

The results confirmed the main hypothesis of this work that hydraulic variables alone are not sufficient to explain channel response to an extreme flood event. The inclusion of other factors, specifically lateral confinement, degree of sedimentation, and percentage of reach length with artificial structures can lead to satisfactory models explaining the observed variability in the degree of channel widening. These results suggest that the widening process is essentially controlled by two factors: flood power and valley confinement. Flood duration exceeding a critical threshold was not included in our analysis, but it is a variable that very likely would

increase the robustness of regression models in these reaches. The analysis carried out in the three subcatchments of the Konjancham River basin showed that unit stream power calculated based on pre-flood channel width has stronger relations with channel widening in comparison with that based on post-flood channel width and cross-sectional stream power. Because peak discharge was used for stream power calculation, we are aware that neither pre-flood nor post-flood channel width is actually appropriate for the estimation of unit stream power, as the most appropriate would be the (unknown) width at the flood-peak time. The pre-flood width has stronger relations with the degree of channel widening (width ratio). This could suggest the width changes occurred after the flood peak.

Keywords: lateral confinement, multivariate regression, Ilam dam, extreme flood, channel expansion.

Application of Dune Vulnerability Index (DVI), in Evaluation of Coastal Dunes, from Sirik Port to Ziarat Port in Southeastern Hormozgan

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Extended abstract

Introduction

Coastal sand dunes are one of the important morphological landforms of coastal areas. These hills have been developed by interactions of sea waves, sea currents, winds and sediment materials on the coast. The sand dunes can protect the coast against waves and erosion. Thus, it is essential to protect these hills using management measures. The study area of this research is located between the Sirik port and the port of Ziarat, in the southeast part of Hormozgan province. Since the construction of new docks in recent years has led to changes in the coast of this region, so awareness of the vulnerability of the coastal hills can be effective in managing and protecting them. The purpose of this study is to assess vulnerability of the sand dunes by model DVI (Dune Vulnerability Index). A checklist is usually employed to evaluate the vulnerability index. In this research, effective factors in coastal sand dunes, geomorphologic conditions of sand dunes, marine factors, wind processes, vegetation, effects of human activities and management factors were evaluated using the checklist.

Materials and methods

In this study, the data from Google Earth, Landsat, and aerial photos, and questionnaires and field observations were used to complete the checklist. The steps to complete the checklist are as follows: in the first step, the value range for the quantitative variables was determined on the basis of the available structured checklists. Partial vulnerability indices are geomorphological

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condition (GC), marine influence (MI), aeolian influence (AI), vegetation condition (VC) and anthropogenic effects (AE). The indices were calculated as the ratio between the summations of given variable ranks within each variable class (PVi) and the total maximum possible rank within the class. A total DVI was calculated as the average of the five partial vulnerability indices (PV). The Protection Measure index (PM) was calculated separately from other factors. Lastly, the residual value as the difference between DVI and PM (DVI-PM) has been calculated to describe the stability of the dune system.

According to the studies by Davis (1995), to calculate the vulnerability index (VI), the calculation of the partial Vulnerability Index is not done and the vulnerability score from the division of the total variables obtained from all the group of variables, based on the maximum total sum of the concessions of the entire group of variables. This is obtained for each site.

Results and discussion

Partial Vulnerability (PV), for geomorphologic agent is above 0.75 in all sites. The degree of vulnerability is very severe because of characteristics of the sand dunes of the region with fine-to-good sorting on the slopes over 30 degrees.

The vulnerability to wind processes in all areas is above 0.5 and this shows high sensitivity of this factor. One of the reasons for vulnerability of the dunes to the wind processes is the small average diameter of coastal sediments in this area. The fine sands here are exposed to retrogressive waves and are more sensitive to erosion, so beaches with fine sand grains have less resistance to erosion.

The low vegetation of the dunes in this part of the sea, in the distance between the hills and relatively high percentage of uncovered areas are other factors of high sensitivity of dunes to wind processes.

The degree of vulnerability to vegetation condition is very severe in sites 4, 5 and 6, and is low in enclosures 1, 2 and 3. The vegetation condition was compared with 1966 aerial photos and satellite imagery from 2000 to 2016. This implies an increase in vegetation in 1966 and 2000, due to planting and plant care by government office like office of natural resource in Hormozgan.

The level of vulnerability to the human factors of sites 1 and 2 is moderate and in the other sites it is negligible. With the use of aerial photographs and satellite imagery, during the years mentioned above, the roads in this area have been increased and in some areas the roads cross the dunes. During these years, some parts of the dunes have been cleared for construction. In addition, the construction of three new wharfs in 3 Sirik (2007), Ziarat (2012) and Taheroi port (2013) has also been associated with shore changes.

According to the field observations and the results of the questionnaires (interviews with local people and experts), it can be asserted that no management action such as specifying buffer areas for access restrictions has been taken to protect the beaches.

The only protective measure is the planting of seedlings in sites 1, 2 and 3 through natural resources organization.

Coclusion

The overall values of DVI in all areas were moderate. Among the investigated factors, the morphological condition of sand dunes and the wind processes have the highest influence on the

vulnerability of the dunes. The results for the DVI-PM index indicate that all sites need quick management.

Based on the obtained equilibrium index, there is no equilibrium between vulnerability and dune management in any of the sites. This indicated the lack of management or inadequacy. One of the reasons for lack of management or efficent management is that there is no a certain organization responsible for these kinds of protection measures.

Comparison of the two methods for calculation of vulnerability, DiPanjun (2014) and the Davis (1995) method), shows that the severity of the vulnerability of the sites is moderate in both methods. There is no difference between the qualitive results obtained in the two methods.

Keywords: coastal sand dunes, vulnerability, Sirik port, Ziarat port.

Investigating the Effects of Global Warming on Subtropical High Pressure

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Extended abstract

Introduction

Climate change in the recent years has led to changes in atmospheric patterns and the appearance of climatic anomalies in most parts of the world. Earth's climate is a complex dynamic system that involves hydrosphere, cryosphere, biosphere and lithosphere**.** If any of these systems are altered, other systems will quickly or slowly align themselves with that and the outcome of this coordination can also affect the system change. Eventually, an endless chain of links is created between these systems. The interaction between these four systems is responsible for the concern of weather and climate scientists in recent years about the "climate change". The result of global warming is climate change. The process of climate change, especially temperature changes, is one of the most important discussions in the field of environmental sciences. Many of the environmental problems, such as floods, storms, droughts, changes in atmospheric patterns, and so on, are rooted in climate change, especially in air temperature rises. The objective of this study is to investigate the effects of global warming on subtropical high pressure behavior.

Materials and methods

In order to investigate the influence of global warming on the subtropical high pressure behavior, the following steps have been taken. In the first step, maximum daily temperature data of 49 synoptic stations during the period from 1977 to 2016 were used to study the frequency of temperature records higher than percentile 95 in each year. Given the frequency of temperature higher than percentile 95, this trend has been dramatically increased in 1996, so this year has been set as the border between the two pre-warming and post-warming periods. In the second stage, given that global warming is expected to increase these extreme temperature, frequency of temperature higher than percentile 95 was investigated in both periods.

In the third stage, the changes in the behavior of subtropical high-pressure in terms of height and spatial extent were determined based on 500-hPa geopotential data, derived from European

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Center for Medium – Range Weather Forecasts (ECMWF). Finally, to prove the existing relationship between the data, the 500-hPa geopotential height anomalies were plotted over the two periods and analyzed to determine that what changes occured in height of the middle level.

Results and discussion

The results have indicated that the long-term average of core height of the subtropical high pressure during the second period (1996-1997) is increased by 10 meters relative to the first period (1996-2016). Given the frequency of the thresholds of percentile 95 of the second period, it can be said that most stations have experienced extreme temperatures, so it can be said that global warming has been proven. It can be said that during the current period, a temperature of 40°C is a normal temperature. Therefore, due to the mutual and direct relationship between temperature and height of the atmosphere, it can be said that the reason for increasing the height of the core of the subtropical high pressure is the temperature increase in the lower layers of the atmosphere. The temperature increases in the layers near the earth surface can create thermal low pressure on the land surface and the dynamical high pressure resulted from the subtropical high pressure subsidence and some systems including Monsoon. This situation for every 1000 meters, while increasing power increases air temperature by 6˚C. Thus, the core height of the subtropical high pressure is increased and the maximum temperatures are recorded, especially during the warm months. Pearson correlations also indicate a very strong and positive correlation between the core height of the subtropical high pressure and the maximum temperature in both the periods.

Conclusion

The results of the analysis of the maximum temperature data showed that during the first period, the temperature reached 30.5 ° C in percentile 95 while during the second period with 1˚C increase it reached 40.5˚C. It can be said that in the first period of global warming we did not have much intensity in Iran, but in the second period the temperature reached its maximum and the effect of this warming can be seen in the recorded temperature. In other words, occurrence of global warming has been proven and the frequency of temperatures above 40.5 ˚ C has become prevalent in most stations. Spatial analysis of the core of subtropical high pressure has indicated that its highest level in the first period over Iran is 5910 m which affect fewer stations. But in the second period, the core height of subtropical high pressure is 5940 meters, which, in comparison with the first period, shows an increase in both the height and extent resulted in higher temperature. It was found that the long-term average height of the subtropical high pressure core during the second period (1996-1997) is increased by 10 meters relative to the first period (1996-2016). Given the frequency of the thresholds of percentile 95 of the second period, it can be said that most stations have experienced extreme temperatures, so it can prove global warming. In other words, during the current period, the temperature of 40 degrees is a normal temperature. The results of the direct and indirect correlation between temperature and elevation of the atmosphere showed that the increase in the height of the adjacent high pressure core is a rise in temperature in the lower layers of the atmosphere.

Keywords: tropical high pressure, frequency, maximum temperature, global warming.

Investigating the Trend of Surface Biophysical Changes due to the Sungun Copper Mine Activities by Integrating Reflective and Thermal Remote Sensing Capabilities

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Extended abstract

Introduction

Land use has always been one of the most important indicators through which humans have influenced their environment. Nowadays, mining activites and related operations are parts of the activities have potential to harm the environment. The mining operations have something to do with nature and the environment with important effects on the nature. The negative effects of mining activities on changes in surface biophysical parameters such as greenness, brightness, wetness and land surface temperature (LST) depend on the type of minerals, geographical location, extraction method and other factors. Remote sensing technology provides useful information to understand temporal and spatial changes of land use/cover and land development processes.

Sungun is a large porphyry copper mine and open pit mining extraction method. The important environmental pollutions by this method of mining are land and landscape degradation, mass production of waste mineral extraction and loss of vegetation covers. Due to Sungun copper mine geographic location adjacent to the Arasbaran forests and Dezmar protected area, the activities of this mine have remarkable environmental impacts. The objective of the present study is to integrate reflective and thermal remote sensing capabilities to analyze and monitor changes in the surface biophysical parameters of the Sungun copper mine region caused by mineral activities over the past three decades.

Materials and methods

In the current study, the reflective and thermal bands of satellite images acquired by Landsat 4, 5, 7, and 8 have been used to calculate the LST and biophysical parameters. We have also used the water vapor products (MOD07) and the LST products (MOD11) of MODIS sensor of TERRA satellite, the air temperature data at the meteorological stations and ground data. In the first step, using reflective bands set of Landsat images we extracted and analyzed the land use

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change trends in the study area for the period 1989 to 2017. Satellite images were classified based on maximum likelihood classifier. The cross tab model was used to study land use changes trend. The changes in biophysical parameters such as greenness, brightness and wetness resulted from mineral activities have been investigated in the second step. In order to model the surface biophysical parameters of brightness, greenness and wetness for the period from 1989 to 2017, we used Albedo, NDVI and NDWI parameters, respectively. In the third step, we integrated the reflective and thermal remote sensing capabilities to extract the LST maps of different years and the trend of LST changes due to land use changes in different time periods. For LST retrieval, a single-channel (SC) algorithm was applied. Finally, the zonal analysis has been used to analyze the trend of LST changes resulted from the land use changes in the study area.

Results and discussion

Over the past two decades, with the increase in the activities of Sungun mining activites, the area of this land use has increased dramatically. The results indicate that the area of the mine class would increase from 13.41 ha in 1993 to 621.54 ha in 2017. During the same period, as a result of the expansion and development of mining activities, the area of the forests decreased from 995.94 to 594.27 ha. In this period, 2295 ha of forest area has converted into mine land use. Also, more than 2632 ha of pasture land have converted into mine land. The results demonstrated that during the period from 1989 to 2017, the mean values of Albedo, NDVI and NDWI parameters have had increase, decrease and increase, respectively. The mean surface albedo values for the study area have been increased from 0.17 in 1989 to 0.25 in 2017. Also, the mean value of the NDVI index has been decreased by almost 0.09 during the period from 1989 to 2017. The major reason for a decrease in NDVI mean values is the reduction of the forest lands and the conversion of them into the mine and pasture lands in past years. In all dates, the lowest and highest LST were related to the forest and bare land classes, respectively. In these years, the mean value of LST of the forest is, on average, 6.36 °C below the mean value of the LST of the mine land use. The results revealed that land use changes from forest to mine, pasture to mine, forest to pasture, forest to bare land and pasture to bare land have changed the LST 5.8, -0.1, -1.4, -1.6, 3.3, and 0.9 °C, respectively.

Conclusion

One of the most important negative impacts of human activities is the change in the surface biophysical parameters. Changes in the earth surface biophysical parameters cause a change in many natural cycles and processes of the earth, including the energy billing cycle. The results of this study are a major warning to environmental authorities to provide sound plans and solutions to reduce the negative effects of Sungun copper mining activities. The results of the study have also indicated the usefulness and efficiency of the integration of reflective and thermal remote sensing capabilities for monitoring and managing various human, environmental and natural phenomena.

Keywords: biophysical parameters, reflective remote sensing, thermal remote sensing. Sungun copper mine.

Relationship of Synoptic Patterns of Effective Precipitation with Planting Date and Yield of Rain-fed Wheat in Kermanshah

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Extended abstract

Introduction

Understanding climate parameters and their effects on crop growth is one of the most important agricultural issues. This understanding can help increase crop yield and thereby increase production. The position of Iran and its natural geographic features have led to a variety of climate and seasonal variations. These variations in each season have created different conditions for agricultural products. Among the climatic elements, the amount and temporal distribution of rainfall and temperature fluctuations in different stages of crop growth have the greatest impact on the yield of agricultural products, especially rain-fed wheat cultivation. In the growth stages of each crop, especially in rain-fed agriculture, the planting date with the first effective rainfall is important environmental-managerial factor in effective yield. The main goal of current study is to investigate the relationship of synoptic patterns of effective precipitation with planting date and yield of rain-fed wheat in Kermanshah County.

Materials and methods

In this study, we gathered data from growth stages (phenology) of wheat, Azar-2 variety, and precipitation data of agrometeorological research station of Sararood, Kermanshah, from 2004-2005 to 2015-2016. In the next step, the data of geopotential heights, wind speed and direction and specific humidity from 850 and 500 hPa levels were taken from NCEP / NCAR reanalysis dataset. The planting date of rain-fed wheat has been calculated based on 2 methods. In the first method, the starting dates for the first effective rainfall were determined. Accordingly, the date of cultivation was when the total precipitation of 5 mm within one or two consecutive days occurred and after that, the precipitation occurred by 10 days. The second method was to determine the planting date on the basis of climatic data of sowing and germination dates

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recorded in Sararood agrometeorological research station during the years of study. The effective rainfall was defined as 5 mm rain to wet 5 cm of soil depth in loamy soil. Moreover, the staring date of sowing wheat was calculated according to Weibull formula with a 75-percent probability of success. In the following, taking into account the first days of precipitation and based on the number of rainy days, the synoptic patterns of the occurrence of effective rainfall have been derived using a correlation-based method.

Results and discussion

According to the results, suitable dates for Rain-fed wheat cultivation in Kermanshah Province were considered from October 25 to November 5. Determining the threshold of correlation coefficient (0.57), we found 4 general synoptic patterns. The features of each pattern were as follows: pattern 1 had the highest share in severe rainfall. This pattern in the pre-germination stage (sowing) had the highest frequency in the occurrence of effective rainfall of 5 mm and more. Pattern 2 was in contrast with Pattern 1, and it was most frequent occurrence in rainfall. Patterns 3 and 4 had characteristics such as limited rainy days and extreme daily rainfall. In addition, synoptic patterns of effective precipitation more than 5 mm were minor trough, Mediterranean trough, Omega Block and cut-off low. The results of synoptic studies of atmospheric patterns also showed that the northern seas of Indian Ocean (Red and Arabian Seas) are the main sources of moisture for all synoptic patterns.

Conclusion

The main goal of current study was to investigate the relationship of synoptic patterns of effective precipitation with planting date and yield of rain-fed wheat in Kermanshah County. The effective precipitation of the examined synoptic patterns provided helpful conditions for germination of plant in the next priority after the first pattern. The results indicated that the lowest wheat yield as compared to average yield (2113 kilograms per hectare) occurred in the years with the forth precipitation pattern. On the other hand, the highest wheat yield observed when the synoptic patterns of 2nd and 3rd were occurred simultaneously within a year. For example, the years of 2006-2007, 2014-2015 and 2015-2016 had wheat yield of 2888, 2486 and 2700 kilograms per hectare, respectively. Moreover, the effects of synoptic patterns on planting date showed that the commence of first effective rainfall with patterns 1, 2, 3 and 4 delayed germination stage abour nearly 4, 10, 3 and 5 days, respectively. It should be noted that to take more precise results, it is reasonable to work with long-period data.

Keywords: Rain-fed Cultivation, Climate Conditions, Indian Ocean, Kermanshah.

Changes in Effective Components of Peak Rainfalls in Iran

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Extended abstract

Introduction

Since the spatial and temporal distribution of rainfall in Iran is influenced by distribution of global circulation systems, the slightest change in its pattern can lead to severe weather abnormalities. Therefore, spatial and temporal abnormalities of rainfall and extreme changes in rainfall intensity and differences in precipitation types are one of the main characteristics of Iranian rainfall. Climate change is one of the problems of human society and is a threat to the planet Earth. The increase in the temperature of the earth has caused profound and extensive changes in the Earth's climate, causing changes in the time and place of precipitation, which has caused a lot of damage, especially in the last decade. The purpose of this study was to identify and study the changes in the heavy rainfall components of Iran in relation to changes in the middle tropospheric systems.

Materials and methods

In this study, we received daily rainfall data of 53 synoptic stations from Iran Meteorological Organization from 1984 to 2013. The cluster analysis and zoning were conducted using Euclidean distance method and Ward's method. For zoning based on cluster analysis, we also used seven variables of consecutive rainy days. The final result was the division of the country into 3 regions according to the number of days. In the following, data from the upper atmosphere levels were used to investigate changes in the mechanisms of rainfall forming. The data are including discovery data of geopotential heights, u wind, v wind, omega, in 500 hpa level, and specific humidity at level 700 in daily average, and 1 * 1 degrees from the European Center for Medium Term Forecast (ECMWF). The statistical period of study was divided into two periods of 15 years (first study period 1984-1998 and second study period 1999-2013), the peak days for each area were determined in each of the two time periods. For each time period,

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the peak rainfall was 5 days. Then, the synoptic parameters were analyzed and compared in each study period.

Results and discussion

In the second study period, the range of trough decreased and the depth of trough increased. The central core of geo-potential heights in the first time period is greater than the second period of study. In other words, the core in the first period is 5400 geo-potential meters, which in the second interval it decreased to 5350 geo-potential meters. In area 2, in the second period of study, the high elevation in the convergence region of the Arabian Sea is more shallow and in a more inappropriate position than the first pattern. The area 3, in the second study period, is located in northwest Iran behind the trough, and cold weather is falling with low amount of rainfall. In 3 areas, in the second period of study, the amount of moisture has decreased and caused the rainfall of the second interval to decrease relative to the first interval.

Conclusion

In the second period of study (1999-2013), the range of trough has decreased and the depth of trough has increased. The Omega component showed that in the second study period, the mean omega-negative peak of the area was reduced. The Omega component study showed that in the second study period, the mean omega-negative in the target area was reduced. It was also found that the direction of the wind streams in the second period was reduced due to the flow. The amount of moisture in the second period of study has also decreased and has caused the second period rainfall to decrease over the first period. In the study of the synoptic components of second area, it was found that in the second period of studies (1999-2013), located on the convergence area of the Arabian Sea, is more shallow and in a more inappropriate position than the first pattern. This caused the maximum moisture content to fall to 5 grams per kilogram. Investigation of the synoptic components of the third region, revealed that in the second study period, the study area, especially the northeast Iran, is somewhat ahead of the trough, and the average annual precipitation in this is increasing in the second period. It can also be understood that the northwest Iran is located behind the trough with a fall in the cold weather. The rainfall in this part has decreased during the period.

Keywords: Zoning, Components of rainfall. Middle troposphere, Iran.

Investigation of Sea Level Changes due to Climate Parameters Using Decision Tree Algorithm, Makran Coast, the Northern Oman Sea

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Extended abstract

Introduction

The relationship between form and process is very important in geomorphology. By changing in the process, the forms will be changed and new processes will be created in reponse to the new forms. Sea level changes mainly include tidal variations and changes due to atmospheric factors. Tidal flows are also affected by coastal washing during their daily advancement and retreat on tidal slopes and tidal zones. The formation of many coastal geomorphologic forms is the result of their involvement. Climatic factors cause short time fluctuations and tidal cycles and long term fluctuations in medium level of sea. Sea level fluctuations influence important aspects of coastal climate, economic planning, agricultural issues, environmental problems and all other affairs related to sailing and marine constructions.

Torabi Azad and Honarmand (2016) performed a concise investigation about sea level changes in Bandar Abbas and Booshehr Stations in a period of 11 years (2000 to 2010) and analyzed and computed barometric effects, wind force and temperature on the sea level mean. The results showed that sea level mean in these stations has incremental trend by 5 cm and 4 cm respectively in the mentioned seaports.

Srivastava (2016) investigated the combined use of quantitative forecasting methods for sea level rise using exponential smoothing state space models (ESMs) and an Autoregressive Integrated Moving Average (ARIMA) model with sea level data over 17 years (1994–2010). The results of this present study suggest that the rate of Arabian Sea level rise is high, and if this is not taken into consideration, many coastal areas may be affected by climate-change-induced

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habitat loss in future.

Akbari et al (2017) applied 3D FVCOM Model in order to investigate and analyze important tidal components in a vast area including Persian Gulf, Hormuz Strait, Oman Sea and Arab sea. The results of this research showed that there is four kinds of tides in Persian Gulf including Daily, semi-Daily, daily compounded and semi-daily compounded tides. On the other regions, there is just semi-daily compounded tide. The purpose of this research is to investigate the effects of climate change parameters (temperature, pressure, and wind rate) on the sea level fluctuations in an annual, seasonal and monthly intervals and 20-year period in northern coasts of Oman Sea.

Matarials and methods

The study area of this research is stretched from Jask port (with longitude of 57^0 46' E and latitude of 25^0 40' N) to Gowatre Bay in the terminal point of southeast Iran and at Pakistan border (with longitude of 57^0 46' E and latitude 25^0 10' N).

The sea level changes have been obtained from tide gauges of IOC (Intergovernmental Oceanographic Commission) in the stations of hydrography of Jask and Chabhar ports during 1997 to 2016. The tide gauges for the mentioned stations presented 1440 datum. In fact, they registered sea level in every minutes. In order to compute the data based on monthly averages, the tidal effects should be deleted and computed into level fragment that means sea level minus tidal effect. According to the presented information in meteorological organization since 1997 to 2016, we used pressure, temperature and wind data in research stations as monthly means and the monthly, seasonal and annual diagrams.

In this research, Meta heurestic-Algorithm (Decision Tree Algorithm) and CARD regression tree decomposition algorithm (Classification and regression tree) is used as a type of regression decision tree for prediction purposes. Different elements have been used in simulation using decision tree model. These elements have been introduced as independent variables to the model and simulations have been made to predict the target variable. In order to verify the relationship between the final decision trees based on the statistical index, graphical graphs and correlation coefficients were obtained from the field operation method, visual inspection, ground monitoring and verification of control points.

Results and discussion

The model has been executed with three independent variables including temperature, pressure and wind in 240 data rows. It should be noted that we have used these 72 rows in the training phase and 168 rows in the test phase. The decision tree model in the Jask area has three parameters of wind pressure and wind speed, and the tree is based on these two parameters that the model did not use the temperature parameter in the decision tree. It was not selected as an effective parameter. In Chabahar region, all three parameters are used in the model. The above-mentioned model has a very high performance in predicting values. In most of the 12-month intervals, the model performed its predictions close to real values; in other words, the tree created using the data has a good prediction process and can simulate the changes well. According to the above figure, the predictions were evaluated. The results indicate that this model can be predicted with high accuracy in 95% confidence level for the region. Since the

temperature parameter has not been able to predict the response variable in the decision tree, the model has been eliminated, and the final equation of Jask and Chabahar is as follows.

$MSL_{(Jask)} = 13.197 + 5.619\, T^{(1.102)} - 11.092\, P^{(0.195)} + 7.208\, W^{(0.71)}$

$MSL_{(Chabahar)} = 4.520 + 1.529\, T^{(1.089)} - 1.596\, P^{(0.87)} + 2.776\, W^{(0.316)}$

Conclusion

The fluctuations of MSL are among the general methods of analysis. Therefore, accurate prediction can provide conditions for assessing the status. The purpose of this study was to investigate the effects of data pre-processing on the performance of nonlinear decision tree model in predicting MSL in Jask and Chabahar. The results of this study in all simulations show that pressure and wind parameters are more effective in the final model. This indicates the importance of these parameters in predicting future MSL. The close relationship between wind speed and water level changes is evident with the strong positive correlation coefficient of the Jask station compared with the Chabahar station in the annual windfall of both regions. The relationship between the final models is derived from the decision tree algorithm in MSL prediction using available data. Investigating the related geomorphologic forms in the study area, the tidal range fluctuations in the Chabahar region are ranged from 1 to 1.5 meters. Therefore, in a closer examination of the processes governing the environments around the coastline, it is necessary to study the status of the tidal region and the influential climatic parameters.

Keywords: Climate Indicators, Decision Tree Algorithm, Mean Sea Level, Northern Coasts Of Oman Sea (Makran Coast).

The Trend of Dust Storm Frequencies and its Impact on Public Health, Ilam Province

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Extended abstract

Introduction
Dust is one of the most important environmental events that can dramatically affect and destroy living areas of a region. The environmental problems of dust can cause many health diseases for many people especially those with background records. The purpose of this study was to investigate the long-term trends in dust events and to investigate the effects of these events in the city of Ilam on the record of respiratory diseases.

Materials and methods
In this regard, data of recorded events of dusty days during the 1995-2015 statistical periods was taken from two synoptic stations in Ilam and Dehloran. The relationship between time series of dust events could be detected throughout the day as TDE (Total Dust Event). Using TDE, the total dust storms, including local and overflow and sandstorms and light to medium dust, are used in this research. Fitting a linear model at a confidence level of 0.95 (P_value = 0.05), the process of this time series was analyzed. The annual registration of pulmonary and respiratory diseases was obtained from male and female patients of Shahid Mostafa Khomeini Hospital in Ilam during the statistical period of 1380-1384. In order to reveal the relationship between the time series of the diseases, two methods of Pearson correlation of matrix at confidence level of 0.95 (P_value = 0.05) and linear model is used at confidence level.

Results and discussion
The results of this study showed that the increase of dust records in Ilam and Dehloran stations was 0.8 and 0.96 records per year, respectively. Correlation matrix indicates that at the confidence level, a significant direct correlation was found between the annual number of patients with pulmonary and perfused patients registered in Shahid Mostafa Khomeini Hospital. In spite of the fact that the number of records in the two stations in Ilam and Dehloran, a record

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of the respiratory examination was significantly higher than other stations. The models based on the relationship between the number of male patient admissions and the events recorded in the two waves of two synoptic stations in Ilam and Dehloran indicate that these two models, respectively, verified 0.79 and 0.69, of the variability of the time series of client hospital records. In the case of the women with pulmonary and respiratory diseases, the model has been fitted with dust in Ilam and Dehloran stations. This showed that these models could define 0.70 and 0.83 of the number of female patients.

Conclusion

The correlation matrix indicated that at the confidence level, a significant direct relationship was established between these two time series so that the number of annual records of patients with respiratory diseases recorded in Shaheed Mostafa Khomeini Hospital in Ilam during the period. This had a higher number of dusty days recorded in the two stations in Ilam and Dehloran. The correlation matrix indicated that only the direction and severity of the relationship were used to quantify this association. The proposed model can be meaningfully able to model the association between dust events (as independent variables) and the records of patients with respiratory diseases, as a dependent variable. there were a positive correlation between the number of refers of the people to the hospitl and the number of dust events in the city. For the total population of patients with pulmonary and respiratory diseases (without attention), the model was also fitted according to the number of days with dust in Ilam and Dehloran stations. This showed that these models were 0.67 and 0.83 for the two Ilam and Dehloran stations, respectively. Comparing the results of this study with other researches revealed that the results obtained in Ilam are in agreement with the results of other researchers in Kermanshah and Ahwaz.

Keywords: Correlation Matrix, Dust, Ilam, Respiratory Patients, Trend.

Spatial Autocorrelation of Annual Frequency of Heavy Rainfalls in Caspian Region

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Extended abstract

Introduction

Precipitation is considered as one of the most important climate elements with high temporal-spatial variations. The variable can affect different environmental aspects represented through several different behavioral forms in extreme precipitation. Heavy and extreme rainfalls can occur in the form of flashfloods and usually in draught conditions with considerable negative consequences on human-environment. Therefore, the study of this type of precipitation in the area is an area suitable for agricultural activities. Recognition of such patterns can determine the success in environmental management as well as certainty in resources planning. There is considerable heavy and super heavy precipitation in coastal regions of Caspian Sea, Iran, especially in eastern areas. Thus, understanding the spatial auto-correlation of such a phenomenon can facilitate environmental planning and the reduction of vulnerability to increase adaptability with such a disaster.

Materials and methods

In order to analyze the auto-correlation of the sum of annual frequency of heavy and super heavy precipitations of this region, we examined the 90-95, 95-99 and 99 percentiles of precipitation for each pixel of the map. Accordingly, the data were gathered from 385 stations including synoptic, climatology, and rain gauge stations during the time period from 1966 to 2016. At first, the frequency of annually heavy and super heavy precipitation was plotted in the Surfer software. We have used spatial statistics techniques (global Moran index (1), local Moran (2), and Gi* index (3)) to analyze spatial auto-correlation features.

$$\mathrm{I} = \frac{n \sum_{i=1}^{n} \sum_{i=1}^{n} w_{ij} z_i z_j}{s_o \sum_{i=1}^{n} z_i^2} \quad (1)$$

$$I_i = \frac{x_i - \bar{x}}{s_i^2} \quad \sum_{j=1, j\neq i}^{n} w_{i,j}(x_i - \bar{x}) \quad s_i^2 = \frac{\sum_{j=1, j\neq i}^{n} w_{i,j}}{n-1} - \bar{x}^2 \quad (2)$$

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$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j}x_j - \bar{x}\sum_{j=1}^{n} w_{i,j}}{S\sqrt{\frac{\left[n\sum_{j=1}^{n} w_{i,j}^2 - \left(\sum_{j=1}^{n} w_{i,j}\right)^2\right]}{n-1}}} \quad \bar{x} = \frac{\sum_{j=1}^{n} x_j}{n} \quad S = \sqrt{\frac{\sum_{j=1}^{n} x_j^2}{n} - (\bar{x})^2} \tag{3}$$

In order to investigate the relationship between spatial factors (latitude, longitude, slope and gradient) with the annual frequency of heavy and super heavy precipitation, we used the ArcGIS spatial analyst using the Digital Elevation Model (DEM) for this reign. Finally, sampling for all pixel points in the interpolation of daily rainfall data was calculated bassed on the following steps: Extracting altitudes, slopes and geographic directions of the subsurface points from the digital elevation model, the slope and the direction of slope were obtained during the extraction-sample steps. Then, the connection of the descriptive table of the layers with the elevation, slope and geographic directions of the slope were obtained for the points. In the last step, the relationship between the spatial factors and annual precipitation frequency was calculated using general Moran multivariate statistics (4).

$$I_{kl} = \frac{z_k\ w_{zl}}{n} \qquad z_k = \frac{\left[x_k - \overline{x_k}\right]}{\sigma_k}\ , \qquad z_l = \frac{\left[x_l - \overline{x_{kl}}\right]}{\sigma_l} \tag{4}$$

Results and discussion

Study of spatial relationships in order to recognize spatial distribution and spatial auto-correlation is one of the best methods for recognizing the spatial behavior of extreme rains. The purpose of this study is to determine the spatial pattern of the total annual precipitation frequency (90-95, 95-99 and 99 percentile of precipitation) using the spatial statistics techniques. Accordingly, 385 stations (synoptic, climatology, and rain gauge of Islamic Republic Organization of Meteorology, and rain gauge of the Ministry of Power) were studied during the time period from 1966 to 2016. The results of the present study showed that the dominant behavior in total annual frequency of precipitation in the study region followed a cluster pattern in three groups. The patterns indicated that the global Moran index is above 0.9, which indicates a statistical significance of this coefficient at a confidence level of 99%. Frequency maps of the annual occurrence of extreme precipitation represent that the highest occurrence of these precipitations is in the first order of the third group and then the first group of precipitation and the second group of precipitation is less in this respect. The results showed that the maximum nucleus of this precipitation was assigned in the first and second groups in the central and western areas, and in the third group in the eastern regions. This also shows the influence of the third group in this area. Positive and negative auto-correlations of spatial clusters have showed the impact of the Alborz Mountains Systems in different parts of the Caspian region. On the first and second thresholds, most cluster patterns of positive auto-correlations are located in the central and western parts. The third threshold as most positive auto-correlations is located in the eastern and central parts of the Caspian region. The negative correlation patterns were observed in the first and second groups in the eastern parts and the third group in the central and southwestern regions of the district. The G* test approved the frequency of clusters with high and low values.

Conclusion

In general, it can be said that the Caspian region is more affected by the precipitation of the third and the first group. This covers a large area of this region, especially in the western and central parts due to the frequency of occurrence of this type of precipitation in this area. The analysis of spatial dispersion and spatial relationships of this phenomenon can be effective in identifying the areas where flooding is greater and this can be used for planning environmental hazards to reduce vulnerability and increasing adaptability.

Keywords: heavy and super heavy precipitation, annual frequency, Spatial Analysis, Moran and G* Index, Caspian region.

Modeling Spatial Distribution of Thunderstorm Rainfalls in Mountainous Areas of the Northwest Iran

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Extended abstract

Introduction

Thunderstorm is one of the meteorological phenomena mainly observed in most parts of the world. It is a major threat to modern societies operating in more local-scale. This natural event, despite having advantages in most cases, is the most severe and destructive natural disaster due to the sudden occurrence. So, this can cause severe damage to many economic activities and human casualties. Convective storms usually affect small areas relative to tropical cyclones. Moreover, destructive effects are often less than the actual value. The thunderstorms are in the most frequent mode in the warm seasons on the land surface and in the cold seasons. Many factors influencing the occurrence of thunder storms are thermodynamic and kinematic conditions of the atmosphere, topography, and surface cover, coastal configuration and atmospheric flows. In this study, daily large-scale circulation patterns are initially characterized in the northwest area of Iran through SOMs technique. Then, the potential implications of circulation patterns to explain variability and change of the Ardabil precipitation are also attempted. Therefore, studying this phenomenon and identifying synoptic patterns have great influence on the region.

Materials and method

The observed daily extreme precipitation records more than 50 mm during the 1961–2016 was used in this study using Ardabil Meteorological Data. Additionally, the daily geopotential heights at 500 hPa isobaric level (GH500) with the spatial resolution of 2.5° latitude × 2.5° longitude based on extreme precipitation days is used for circulation types. The data were obtained from the National Centers for Environmental Prediction/National Center for Atmospheric Research reanalysis dataset to identify circulation types. The circulation patterns in Ardabil were objectively evaluated with Pettit test. Based on this method, a significant abrupt

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change is detected in the series of the sum of q-error and t-error. This indicates 9 distinct circulation patterns with a 3 × 36 SOM topology to describe the changes in synoptic positions in the Ardabil area. In addition, the maps were created in the Grads software.

Results and discussion

In this study, daily circulation patterns are objectively examined through the use of SOM technique and are further linked to the extreme precipitation more than 50 mm characteristics in the northern areas of Iran, Ardabil, during the period 1961–2016. The results show that the SOM method could reasonably classify the daily geopotential height field at the 500 hPa vertical level over Ardabil province. By using an objective method (the Pettit test), 9 circulation types are qualified. Most of the severe precipitation patterns in Ardebil are related to the spring months. This is the time of the occurrence of thunderstorm in Ardebil. The 500 hpa HGT patterns during spring rainfall are associated with Omega Block, Rex Block and deep wave on Caspian Sea. This atmospheric pattern at the level of 500 Hpa has a completely baroclinic and unstable atmosphere in Ardabil which produced thunderstorm. In summer patterns, Ring Of Fire Block and Cut off Block are mainly observed in the region. This type of block occurs during the summer and the conditions of high pressure system are very stable. Cut off Block is a deep craft that occur with high-altitude change. In autumn pattern, a deep wave is seen in the northern part of Iran with a cut off block. Deep Wave is supplemented by cold weather in northern latitudes. In winter pattern, there is a Rex Block which is a set of systems with a strong high stack in the vicinity of a low-altitude strong layer. Ardebil is located on the eastern side of the wave with western winds that creates barocilinc atmosphere and precipitation. In the A1 group, the highest frequency is in May with 30%, in the A2 group with 34% the highest frequency is in April and the lowest frequency is in October with 5%. In the A3 group, the frequency is 15% in February, March, April and May. Also in group B2, the frequency of April, May and August are 8%. In group B3, the highest frequency with 25% and 15% are for October and November. In the C1 group, the July-September months are more than 16%. In the C2 group, January-April is 16% and 8% and in the C3 group, May, June and September are 8%. In the spring, the highest percentage of precipitation belongs to the B3 model with 45% fluctuation and the lowest amount of precipitation belongs to the A1 pattern with 20%. The patterns of A1 and C1 (45%), B1 (35%) and C3 (20%) are summer season patterns. The C1 pattern (45%) has only some rainfall in winter. The C3 pattern has a rainfall of only 25% and 15% in spring and summer. In autumn, the patterns of A1 (28%), A2 (10%), B1 (15%) and B3 (45%) are high-end models. In winter, only the patterns of A3 (35%) and B3 (20%) can account for the rainfall events.

Keywords: Self-organized SOM maps, Circulation patterns, Thunderstorms, Ardabil.

Evaluation of WRF Model for Temperature Forecasting and frosting Occurrence in Zayandeh Rud Basin

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Extended abstract

Introduction

Occurrence of weather hazards such as freezing, annually late spring frost can create much damage in agricultural section. Programming and decision making with suitable action can decrease damages resulted from weather hazards. Therefore, it is necessary to consider comprehensive and precision of this phenomenon. Nowadays, use of numerical weather prediction (NWP) models and recognition of weather hazards can prevent such damages.

In the recent years, direct numerical weather prediction models can forecast near surface parameters suffering from systematic errors mainly due to the low resolution of the model topography and inaccuracies in the physical parameterization schemes incorporated in the model. On the other hand, verification is a critical component of the development and use of forecasting systems. The verification should play a major role in monitoring the quality of forecasts, providing feedback to developers and forecasters to help improve forecasts, and provide meaningful information to forecast users to apply in their decision-making processes. The purpose of this study is to evaluate the performance of the WRF model for Temperature Forecast and frosting occurrence in Zayandeh Rud Basin.

Materials and methods

The study area of this research is Zayandeh Rud Basin. This Basin geographical coordinates are at 50° 20′ to 52° 24′ eastern longitude and 31° 12′ to 33° 42′ northern latitude.

In this study, for temperature forecasting, we used weather data from 11 meteorological stations near Zayandeh Rud Basin with 1 Km horizontal resolution via the WRF model for late spring frost. We also used schemes model (KFMYJ and GDMYJ) for simulation. Then, simulated temperatures and the corresponding observed values were evaluated by two methods of point prediction of of 24 and 48 hours of surface temperature (2m). For evaluation of forecast

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models, we employed different indicator functions including Determination coefficient (R^2), Root Mean Square Error (RMSE), Mean Square Error (MSE), Mean Absolute Deviation (MAD), Relative Error (Error), correlation coefficient (R), Mean Bias Error (MBE), Mean Absolute Percentage Error (MAPE), and Mean Square Skill Score(MSSS).

$$RMSE = \sqrt{\frac{\sum_{t=1}^{n}(A_t - F_t)^2}{n}} \quad MSE = \frac{\sum_{t=1}^{n}(A_t - F_t)^2}{n} \quad MBE = \frac{1}{n}\left(\sum_{i=1}^{n} F_i - \sum_{i=1}^{n} A_i\right)$$

$$RE = \frac{\frac{1}{n}\left(\sum_{i=1}^{n} F_i - \sum_{i=1}^{n} A_i\right)}{\sum_{i=1}^{n} A_i} \quad MAD = \frac{\sum_{t=1}^{n}|A_t - F_t|}{n} \quad MAPE = \frac{\sum_{t=1}^{n}\left|\frac{A_t - F_t}{A_t}\right|}{n} \times 100$$

$$MSSS = 1 - \frac{RMSE_F}{RMSE_A}$$

For the forecasting, A_t ، F_t and n are observed values, forecast values and number of data, respectively.

Results and discussion

According to the results, Root Mean Square Error, Adjusted Rsquare and Mean Bias Error for 24-hours temperature simulation are better than 48 and were about 2.8 , 0.88 and 0.48 respectively. The results of output data for 24 with 48 hours indicated that error of 48 hours forecast data is higher than 24 hours. Acceptable relations from the viewpoint of statistical tests (correlation coefficients and coefficient of determination) are between independent variables (WRF model values) and dependent variable (observed values) that is significant in 5% level.

Substantially, the maps of 850mb in the dates of late spring frost occurrence can find out nature of late spring frost that is in radiation or advection. For instance, existence of cold advection on the maps of 850mb is obvious well. Contour lines and isotherm have almost intersected vertically and has created a strong cold advection. It is worth mentioning that whatever condition of Baroclinic (intersection isotherm by contour with good angle) get better and angle of intersection approach the vertical angle, advection is stronger. The existence of cold advection is obvious. We conclude that occurrence of late spring frost in this paper is mostly advectional motions.

Zoning maps of the used indicators show predictions of 24 and 48 hours. The stations have low level rate of model error. The output of the model is nearly proportional to the stations. This indicates that forecast of surface parameters can imply the topography.

Conclusion

Daily temperature was suitable for forecasting in time scale of 24 and 48 hours. Although 24 hours forecast have high accuracy, the verification scores of model in estimation of quantitative temperature in 24 forecasts are better than 48h forecasts. In addition to accuracy forecast of 2 meters temperature is intense relation in zone topography of the study area. The accuracy of the model can estimate plain areas in mountainous areas. The results of this paper indicate that the WRF model forecasts can be used well for Temperature Forecast and frosting occurrences.

Keywords: Verification, WRF model, horizontal resolution, Temperature Forecast.

Analysis of Geomorphologic Hazards of Landslide and Flood using VIKOR-AHP and Fr Models in the Alborz Province

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Extended abstract

Introduction

Natural hazards with their varieties and their extent of influence as repetitive and destructive phenomena have always been present through the life in the planet; they have always been a serious threat to human beings since the advent of mankind. Accordingly, it can be said that no community can be safe from natural hazards, and humans always suffer from objective and subjective harmful effects. Natural hazards by destroying income sources, biological resources, and people activity centers (houses, workshops, farms, etc.), increase their economic and physical harms. Related to the history of the hazards studies, the following notes could be mentioned.

Materials and methods

In this research, in order to make a zonation of the flood and landslide hazards in the Alborz Province based on the used models, the indices of each model were extracted to provide the risk map of these hazards. For the landslide hazard zonation of the Alborz Province, one of the outranking methods entitled VIKOR consensus optimization method is based on calculation of maximum utility and minimum losses. The susceptibility map of the sub-basins of the Alborz Province was prepared according to the occurrence of the landslide phenomenon. In order to study the flood hazard of the Alborz Province, we used the Frequency Ratio Model (FR). In order to perform these two models, it is necessary to extract the most important indices affecting the occurrence of the hazards. For this purpose, based on a deep investigation on previous studies in this field as well as the features of the study area, 9 indices were determined for landslide zoning by VIKOR-AHP compound model. The model is conducted via the layers of lithology, drainage density, soil type, precipitation, altitude, and distance from the fault, land use, dip gradient, and vegetation. For the flood zonnation using the frequency ratio model, we applied 11 indices including lithological factors, land use, distance from the river, soil type, the

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dip gradient, the dip direction, surface curvature map, Topographic Wetness Index (TWI), drainage density, altitude and amount of precipitation.

Results and discussion

In order to make a zonation of the risk of the landslide in the Alborz Province, we initially considered nine criteria regarding the basin tendency to land-sliding in sub-basins. After selecting the main criteria, in the next stage, the maps for each selected criterion were prepared for weighting and evaluating sub-basins in the GIS environment. Given the effects of the nine criteria in the occurrence of landslide, the criterion of distance from fault and vegetation cover have a decreasing effect and the other seven criteria have an increasing effect. After preparing the selected criteria, the significance coefficient of the mentioned criteria were determined by the AHP hierarchical algorithm based on the importance level of the landslide occurrence and basin susceptibility to this phenomenon. In this investigation, in order to make a weighting of the options based on the role of each criterion in the considered option, the definitive weighting was ranged from one to ten. Thus, weight 1 has the least effect and weight 10 the highest in the landslide risk evaluation. After determining the importance coefficient of the criteria, the weights decision matrix was prepared for the VIKOR algorithm. As it is known, the nine criteria are effective in evaluation of the watershed basins. Table 2 shows the decision matrix based on the effective parameters in the sub-basins. After weighting and preparing the weight matrix, the matrix values were normalized.

Conclusion

The results of the landslide study in the Alborz Province indicates that in Taleghan and Karaj counties, the possibility of the occurrence of landslide is high due to the natural conditions of the region in terms of these indices. Since in these counties the precipitation conditions are relatively poor and vegetation is mainly of pasture type, there are no proper drainage conditions. The presence of less developed soils and almost impermeable bedrock, high altitude and relatively steep slope in these areas and the presence of frequent faults increased the occurrence possibility of landslide. Therefore, according to the output of the landslide zoning map, more than 60% of the area in these two counties is located in high-risk zones. The natural conditions in relation to the flood risk is persistent and some indices such as susceptibility to erosion, land use, rivers distance, amount of precipitation, altitude, precipitation, slope angle and slope direction have led to possibility of flooding in the Alborz Province. Consequently, due to the dominance of these indices in Taleghan, Karaj and Savojbolagh counties, the highest flood risk could be observed in these areas in order.

The Taleghan and Karaj counties are more susceptible and vulnerable to the geomorphic hazards; because the percentage of the high and high risk classes in these two counties is considerablly high. On the other hand, most of the habitat areas of the province are situated in high risk places in terms of flood and landslide hazards; it shows the necessities of more detailed planning to prevent the hazards and the related damages.

The results also indicated that most urban and rural centers are established in high-risk zones. In order to reduce the probable losses, people should be aware of possible risks.

Keywords: Geomorphic hazards, VIKOR-AHP model, Frequency Ratio model, Alborz province.