Classification and analysis Synoptic patterns of the most sever wet year Uremia Lake Basin during 1977-2012

Nader. Parvin

Assistant Professor, Department of geography, Payame Noor University, PO BOX 19395-3697 Tehran, IRAN.

Corresponding Author email: n.parvin@kpnu.ac.ir

ABSTRACT: The aim of this research is recognizing and Classifying Synoptic patterns of the most severe wet year over Uremia Lake Basin during 1977-2012. After determining rain temporal-local threshold, rainy days spread over Basin were extracted. Then, level 500 HP height data located in a scope of 20-65˚ northern latitude and 20-65˚ eastern longitude was formulated as an S-mode matrix for raining days. After that, the synoptic patterns were classified using statistical method of Component Analysis and Ward’s clustering method. Finally, the composite map of each cluster was prepared and analyzed synoptically. The findings show that at the time of the most severe wet year over the catchments area, synoptic patterns prevailed in to three main groups: Short waves trough, Blocking system, Cut-Off Low system synoptic. So that, these systems play an important role in increasing instability and extreme raining in 1993 in the area.

Key words: Wet Year; Component Analysis; Trough & Ridge; Synoptic pattern; Uremia Lake basin.

INTRODUCTION

Climate is one of the important aspects of man whose effects on human activities are evident. Climatic fluctuations like extreme wet periods could often leave disastrous human and financial losses in the form of flooding and erosion. From the climatologically perspective, wet periods are a kind of temporal lapse from the normal level in a positive direction which are affected by factors and global, local and regional as well as atmospheric circulations (Ramazani, 2002). On the other hand, the threshold of the wet period occurrence is a geographical quantity which varies with respect to temporal and spatial scales (Bahalem and Mola, 1980).

Compared to other countries, Iran because of its natural diversity has a high ranking with regards to natural disasters. In such a way, 31 instances out of 40 kinds of natural disasters in the world have occurred in Iran (Mirkhani, 2000: 8). According to the FAO report, Iran ranks tenth in terms of potentiality to natural disasters (Chen, 2003). Thus the occurrence of extreme wet periods and the following disasters is common. In the synoptic climatology, all the air variations or climatological fluctuations (wet and drought periods, floods and etc….) are justifiable and explainable based on atmospheric movements of high levels of the atmosphere (direct factor). However, the lack of researches that would use appropriate and relatively accurate statistical methods to investigate wet periods in a synoptic analysis in a watershed level from the perspective of geography is quite evident. This research aims for the first time to identify and classify synoptic patterns of rainy days with respect to the most extreme drought of the Urmia river watershed using the factor and cluster analysis in order that policy makers are assisted with the way they adopt decisions as to how to reduce impacts by the extreme wet periods.

Review of the sources

Up to now, numerous studies in connection with natural threats have been carried out by researchers in different fields including seminal works by Roger et al, 2000; Hillocks and Nichols, 2000; and Salinger and Griffiths, 2001. Furthermore, most researchers have investigated wet periods, heavy rainfallss, floods and the effects derived from the wet periods in connection with El Nino and La Nino, climate variations, different climatological factors and etc…. Researchers like Kerrychak et al, 2004; Underwood and Schultz, 2004; Lehman et al, 2005 have investigated floods as synoptic factors through case studies. In the literature of the world synoptic climatology, using factor analysis methods and clustering for the synoptic classification, classifying weather maps and climatic
zonation is common. Attention should be made to works by Asonsen, 1999; Andres et al, 2000. Results obtained from a study by Elli et al. (1994) with respect to identifying and investigating synoptic patterns of 700 hPa (hector Pascal) balance governing six large floods below the southwest watershed of the United States using the main component and cluster analysis revealed that, spatial variations of high and low anomalies over the northern Pacific Ocean and the effect on the high topographic forms of the region have had major impacts on the formation of unstable air masses as well as creation of extreme tropical front systems and high cold holes followed by extreme regional floods during summer and winter. Despite a variety of domestic studies on wet periods, based on the researcher’s investigation, no study has been carried out from a synoptic-statistical perspective to classify and analyze synoptic patterns of the most extreme wet period of the region under study.

**Region under study**

The Urmia watershed is located in the northwestern part of Iran with an area of 51866, comprising 43 city centers and 44 rural districts which are home to 3.7 millions of people (Figure. 1).

![Geographic map of Lake Basin](Source: Author)

**Data and Methodology**

In this research, first through the temporal standard of long term data (1977-2012) the annual rainfall of four meteorology stations of the watershed level including Urmia, Tabriz, Myandoab, Saqqez in 1993 were determined as the most extreme regional wet period. Choosing the mentioned stations could cover the whole watershed level. Then, rainy days of a wet period (October to June) were chosen provided that at least 50% of the stations had registered daily rainfall of more than 5 millimeters. The Greenwich zero hour data of the height of 500hPa level for rainy days situated in a range of 20-65 degrees of northern latitude and 20-65 degrees of eastern longitude were then taken from the internet site of (NCEP/NCAR). This selection was made due to the occurrence of the highest atmospheric fluctuations at the 500hPa balance and the direct control of environmental conditions as well as the earth surface air condition by the variations in the height of the pressure level. To make sure, they said data were investigated and controlled quantitatively and qualitatively. Then, the data related to the height of the 500hPa balance of rainy days consisting 400 confluences (points of height) were arranged as a matrix of 20 rows in 20 columns in S-mode status, so that the statistical methods of the factor analysis for processing the data could be applied. Prior to beginning with the factor analysis, its validation was tested through calculating the correlation coefficient determinant among the variables as well as calculating the Keiser-Meyer-Olkin (KMO) criterion. Using the Varimax method which guarantees the independence among the factors, the axis of the factors was rotated in order that factors are easily interpreted without making changes to the degree of the shared variance (Gong and Richman, 1995; Stephan et al, 2005). In this study, the factor analysis formula converting 400 variables to 7 factors is written as follows:
\[ Y_i = \mu_i + \lambda_{ij} F_1 + \lambda_{ij} F_2 + \ldots + \lambda_{ij} F_{13} + e_i, \quad i = 1, 2, \ldots, 400 \]  

where it is assumed \( e_i \sim N(0, \sigma^2) \). \( Y_i \) is the height size of the 500hPa level of the confluence variable \( i \) and \( \mu_i \) is the average height of the 500hpa of the confluence \( i \) for 37 rainy days. \( \lambda_{ij} \) is the relationship coefficient of confluence \( i \) with factor \( j \) and \( F_j \) are factors affecting variables (confluence). \( e_i \) is error terms which is assumed are independent from each other and existing factors (Amar Pardazan Company, 1999). After this stage, rainy days based on factor scores and using the hierarchical clustering technique were classified form of the tree graph using the Ward method. Because, in the synoptic patterns classification based on the Euclidian distance method, no optional or contractual criteria to get to the clusters are used and all the clusters are obtained based on calculating their true distance, the merger of the clusters is done on the basis of the following formula.

\[ e_{jk} = \sqrt{\sum_{i=1}^{n} (x_{ij} - x_{ik})^2} \]  

In which \( e_{jk} \) is the distance between observing \( j \) and \( k \) in a series of observations? The amount of the Euclidian distance coefficient varies between zero and infinity. \( x_{ij} \) is the varied amount of \( i \) on the \( j \) member and \( x_{ik} \) is the varied amount of \( i \) on the \( k \) member and \( n \) is the number of the variables of each member. The formula of the combination of the clusters through the minimum variance of the Ward method is as follows in which \( m \) and \( k \) are clusters and \( \bar{x}_k \) is the center of the cluster (Amar Pardazan, 1999: 325).

\[ W_{km} = \frac{N_k N_m}{N_k + N_m} (\bar{x}_k - \bar{x}_m)(\bar{x}_k - \bar{x}_m) \]  

In the end, the composite maps of the 500hPa related to days in each cluster were provided and synoptically interpreted.

**CONCLUSIONS**

Generally speaking, results obtained from investigating the annual rainfall of the selected meteorology stations of the watershed and calculating their temporal Z-score suggested the most extreme drought period of the region under investigation occurred in 1993, during a long term 35-year period (1977-2012). Having the matrix of data been arranged, and since the statistical amount became KMO>0.9 and the result of the matrix determinant of the correlation coefficient equaled zero, conducting the factor analysis was recognized as appropriate. Applying the factor analysis technique on the height data matrix of the 500hPa balance of rainy days, seven factors which in general explained 91.8% of the total variance of the data was extracted (Table 1).

<table>
<thead>
<tr>
<th>Component</th>
<th>Total</th>
<th>Initial Eigenvalues</th>
<th>Cumulative%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2032514</td>
<td>51.2</td>
<td>51.2</td>
</tr>
<tr>
<td>2</td>
<td>406503</td>
<td>18.3</td>
<td>69.5</td>
</tr>
<tr>
<td>3</td>
<td>345526</td>
<td>12.2</td>
<td>81.7</td>
</tr>
<tr>
<td>4</td>
<td>156458</td>
<td>5.3</td>
<td>87</td>
</tr>
<tr>
<td>5</td>
<td>905321</td>
<td>2.2</td>
<td>89.2</td>
</tr>
<tr>
<td>6</td>
<td>652589</td>
<td>1.5</td>
<td>90.7</td>
</tr>
<tr>
<td>7</td>
<td>324081</td>
<td>1.1</td>
<td>91.8</td>
</tr>
</tbody>
</table>

(Source: Author)

Meanwhile, because the first factor could alone explain 51.2% of the total variance of the data and the extracted factors didn’t have a meaningful correlation together and were independent totally, the mentioned model was accepted. When the composite maps of each cluster provided, the following three synoptic patterns were obtained: Due to movements anomalies, the polar vertex, the jet stream position as well as storm bands related to them, transferring energy from high latitudes towards lower latitudes has occurred excessively and as a result, the scope of activity and the dominant west winds have increased on the region under study.

Generally the results of the research indicate at the 500hpa balance, the deployment of three Short waves trough, Blocking system, Cut-Off Low system synoptic, have resulted in rainfalls and the most extreme wet period of the Urmia river watershed (Figure 2a,b,c). Thus, the formation of these systems results in enhancing and deepening the axis of troughs and ridges. More importantly rainfall synoptic systems cause rainfalls at the watershed level.
According to identifying the six synoptic patterns at the 500hPa balance affecting the most extreme wet period of the watershed level of the Urmia river, it is recommended, that experts in line with management and reducing the losses originating from the extreme wet periods, and based on identified synoptic patterns, design a warning system for the said watershed level in order that preventive measures are adopted and enough information is supplied.

> Figure 2a. short wave trough synoptic pattern
> Figure 2b. the Blocking synoptic pattern
> Figure 2c. Cut-Off Low system synoptic

Figure 2ab, c. view of three main groups: Short waves trough, Blocking system, Cut-Off Low system synoptic
(Source: Author)

REFERENCES


