

Spatial Analysis of Cyclone-Generating Centers in United States of America (USA) in 1991

Kaveh Ostad-Ali-Askari^{1*}, Seyed Abolfazl Masudian², Tahere Faramarzi², Saeid Eslamian³, Theodore C. Crusberg⁴, Vijay P. Singh⁵, Nicolas R. Dalezios⁶

¹Department of Civil Engineering, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran.

²Department of Climatology, Isfahan University, Isfahan, Iran.

³Department of Water Engineering, Isfahan University of Technology, Isfahan, Iran.

⁴Department of Biology and Biotechnology, Worcester Polytechnic Institute, Worcester, MA 01609-2280, U.S.A.

⁵Department of Biological and Agricultural Engineering & Zachry Department of Civil Engineering, Texas A and M University, 321 Scoates Hall, 2117 TAMU, College Station, Texas 77843-2117, U.S.A.

⁶Laboratory of Hydrology, Department of Civil Engineering, University of Thessaly, Volos, Greece & Department of Natural Resources Development and Agricultural Engineering, Agricultural University of Athens, Athens, Greece.

***Corresponding Author:** Dr. Kaveh Ostad-Ali-Askari, Department of Civil Engineering, Isfahan (Khorasgan) Branch, Islamic Azad University, Isfahan, Iran. **Email:** Koa.askari@khuisf.ac.ir, Kaveh.oaa2000@gmail.com

Abstract: Cyclones are monolithic and instable systems in which the air pressure is low, the air flow is ascending and the wind direction in the northern hemisphere is counter clockwise. Due to vertical movement of the air in cyclones, the possibility of the appearance of clouds, precipitation and even a thunderstorm is provided. In this research, in order to recognize the cyclones and to study the spatial situation of the influencing cyclones on Iran during 1991, the evaluated data of geopotential height of NCEP/NCAR related to the National Oceanic and Oceanographic Authority of the United States with a 6-hour time zone and spatial separation of $2/5 \times 2/5$ degrees in 6 height levels of 1000, 925, 850, 700, 600, 500 hectors Pascal. The data has been taken for the range between the -30 western to 80 eastern longitudes and the 0 to 80 northern latitudes. The results show that the highest and the lowest cyclone frequencies are related to the levels of 500 and 700 hectors Pascal and also in the 6 studied levels (500, 1000, 925, 850, 700 and 600 hectors Pascal), winter and fall have the highest cyclones, while with a little difference, spring and summer have the lowest cyclones. The spot analysis of the recognized cyclones represented that Gang cyclone is the main cyclonic occurrence in the maps of 1000 level in spring and summer but in higher levels and in the fall, they would disappear and in the Mediterranean Sea at the level of 1000 hectors Pascal and in spring and summer, no cyclonic centers are observed but gradually in higher levels, the frequency is increased such that it reaches the highest amount in the level of 500 hectors Pascal in the winter. The cyclone of north Atlas is approximately present in all the studied cyclones during the year.

Keywords: Cyclone, Geopotential Height, Geopotential

1. INTRODUCTION

Cyclones are systems on a scale that should be evaluated to understand the climate of a location. The location of cyclones' generation is called cyclone-generating area. These areas are limited on the earth and Middle East is considered as one of the most important cyclone-generating regions due to the Mediterranean basin and the particular position of the Alps. The cyclones of this region influence the western winds of Iran during their activity and cause precipitation in different parts of the country, especially Zagros (Masudian, Kaviani, 2006). About 70 to 80 % of winter precipitations in Europe come from 15 cyclones with fronts (Blender, 1997:727). Considering the importance of cycling systems and their role in climatic elements for a dry country like Iran, each research conducted in the field of cyclones and their features as one of the most important and influential systems on the climate of Iran could be valuable to forecast the weather in the future. Numerous studies have been conducted about cyclones' spatial distribution that would be mentioned in the following.

Alpert et al, (1990:1478) in a study “Monthly changes of cyclonic directions in Mediterranean”, evaluated the outgoing directions of the cyclones in the Mediterranean. They concluded that cyclonic directions of the Mediterranean represent monthly meaningful changes, for example the cyclonic direction from Aegean Sea to Black Sea is important in January, but it is a little weaker in December and February. They believe that recognizing monthly changes is important in 2 ways: first, cyclones’ mechanism would be better understood and second, understanding the depth of the climate changes, such as precipitation and pressure, is easier.

Trigo et al, (1999) recognized and navigated the cyclones of the Mediterranean basin with an outward method and using the data of the European Weather Forecast Center. Their results represented that Mediterranean cyclones are weaker compared to northern hemisphere cyclones and are smaller and less stable than effective northern Atlas systems. In addition, they recognized that cyclone generating in some areas like Genoa Gulf and south of Atlas Mountains that are strongly topographic influenced, results in generating the greatest cyclones.

Blender and Schubert (2000) determined the relationship between cyclonic directions with output models using Hamburg ECHAM4 climate model and the provided maps from the re-evaluated data bases with positional separation of 1/125 and 1/125 degrees and time separation of 2 hours. The results showed that the greater the resolution of the data, the more accurate the navigation, but due to the large number of detected cyclones, navigating becomes more complicated.

Zhang et al, (2004) have studied the climatic and seasonal variability of the Arctic cyclones. In this study, the 6-hour data of the sea level from United States National Oceanographic and Oceanographic Database has been used during 1948-2000.

Korner et al, (2005) have confirmed the long-term increase in the dryness of the Eastern Mediterranean by providing evidence for the Samos Island. The Eastern Mediterranean region is among the areas that are predicted to become dry under the IPCC scenarios. There has also been a gradual decline in rainfall and tree growth and the disappearance of crop springs during the last decade of the twentieth century.

Bartholy et al (2008) studied the emergence, intensity and Mediterranean cyclonic directions during 1957 to 2002 using the data of the sea level from the ECMWF evaluated data in horizontal network resolution. The results showed that the number of cyclones in western Mediterranean region has increased in summer and fall and it has decreased in winter and spring.

Ahmadi Givi and Najibi far (2004) studied the cyclones’ generation and behavior located in Alp lees and their possible influence on the Middle East and Iran climate during different cold, hot and moderate periods for one year (2002) using ECMWF data. The results showed that the behavior of these cyclones is different during various seasons. The number of cyclones in Genoa Gulf is considerably higher compared to hot seasons. Also, the cyclones in cold seasons influence Iran’s climate while the cyclones in warm seasons have a little impact on Iran due to moving in higher latitudes. Owji (2006) studied the atmospheric patterns, frequency and the direction of cyclones in drowsiness period in western middle of Iran and he has used the Earth’s air maps with 850, 700 and 500 hecto-pascals. The results represent that in very wet periods, west of Iran is weak in upper levels of high-altitude Saudi Arabia and it moves towards east or south in high altitude of North Africa’s tropical zone and the cyclones entering with a western-eastern and then a south western direction in the region have a greater impact on the precipitation of the area. Habibi (2006) has studied the role of blocking systems in surface cyclone generation east of Mediterranean Sea. Data includes the upper levels maps, the pressure of medium level of the sea with 12-hour distance during 16 to 26 of the March, 2000 of NCEP Center. The results show that the eastern groove front of the block system in Atlas Ocean is the main result of causing flood in western areas of Iran.

Iran Nejad et al (2008) studied the influence of annual cyclones frequency of important centers of Mediterranean and also the annual average of sea surface pressure if these centers on annual precipitation of Iran during 1960-2002. The results showed that except south eastern and east regions and a part of central area, the annual influence of other regions of the country is under the meaningful influence of the mentioned cyclones.

Biglu et al (2009) studied 66 cyclone systems in drowsiness period in Midwest of Iran for 30 years (1973-2003). The results showed that during this period, the Mediterranean basin with generating the

total number of 33 cyclones that is 50 % of the generated cyclones in the wet period especially around Cyprus Island, is more predominant compared to other regions.

2. DATA AND METHODOLOGY

In this research, in order to recognize and navigate the cyclones, the evaluated data of NCEP/NCAR databases in levels of 1000, 925, 850, 700, 600 and 500 hecto pascals in 1991 and 1992 was used. The spatial separation of these data is 2/5×2/5 degrees and their time separation is 6 hours, daily (00, 06, 12, 18 zulu). The framework of the studied area includes all the regions that the generated cyclones have passed Iran and influenced its climate. Therefore, we studied and evaluated the data of -30 western to 80 eastern lengths and 80 northern widths from www.cdc.noaa.gov website.

Recognizing the output of cyclones could be performed using Eulerian or Lagrangian methods. The Eulerian method determines the storm directions in regions in which the activity of the instable storms is very extreme using the maps of geopotential height of 500 hecto pascals and Lagrangian method studies the duration of cyclones from the beginning to the end and also the change of their characteristics (Barsuli et al, 2008: 133).

0	0	0
0	1	0
0	0	0

Figure1-1. Eight neighboring points of Kernel Window

There are two conditions to recognize the cyclones, including:

1. The height of the examined area is the lowest compared to its surrounding neighbors therefore code 1 was given to it (figure 10-1):
2. The average of the geopotential height area on the 9 present areas in kernel window should be at least 100/1000 m/Km. Therefore, thermal and dynamic cyclones have been eliminated. This threshold has been derived from Blender work (2000) which equals 100/1000 m/km. The reason of utilizing this threshold for geopotential height is using very powerful cyclones in computations and the geopotential height was calculated using the following method. In this function δx is Longitude metric coordinates and y represents latitude metric coordinates.

Then, to accurately calculate the pressure, the average weight of pressure in each kernel was computed considering the difference of each area on each latitude. The metric distance of 2 points on each latitude corresponds the cos of that latitude.

Utilizing these two conditions in Script program in Grads Software, cyclone generating centers were recognized. This program includes 4 outputs, including:

1. Cyclonic centers which were specified by 0 and 1 codes. Therefore, each region having these two conditions was recognized as the cyclonic center with code 1 and the other regions with one of these conditions or not having them were recognized by code 0.
2. Geopotential height of each region
3. Magnitude of the geopotential
4. Longitude and latitude

In the next step, the output data were transferred to MATLAB Software and the frequency of cyclonic centers was calculated as percent, then the seasonal frequency of the cyclones was determined and their seasonal diagram was drawn. Finally, the resulting maps using the mentioned method in 2 levels of 500 and 1000 hecto Pascal were analyzed.

3. STUDYING THE TIME FREQUENCY OF THE CYCLONES

For many years, recognizing cyclones and studying their spatial behavior and frequency was under consideration. In this research, the number and frequency percent of cyclones in 6 levels was computed and their maps were drawn and finally, the frequency of cyclones occurrence in different seasons, considering their maps and frequency table was studied. The highest frequency of the cyclones is for 500 hecters Pascal and the lowest is for the level with 700 hector Pascal. In figure (2-1), the studied initial and final levels of 500 and 1000 hecters Pascal have more cyclones compared to middle levels. The reason is that in sea level that is 1000 hecters Pascal, especially in warm seasons

(spring and summer), there are more thermal cyclones and they have less power and severity due to their thermal source and a lower height development. Consequently, they are not observed in higher levels in the maps. The reason of having more cyclones in the level of 500 hectors Pascal is that there have been many dynamic cyclones that due to weakness have developed to lower levels by a vertical development. So middle levels have less cyclones compared to the initial and final levels.

Generally, considering table (1-1) in 6 levels of 500, 600, 700, 850, 925 and 1000 hectors Pascal, winter and fall have the highest frequency of the cyclones. While, spring and summer, with a small difference toward each other, have the lowest frequency of the cyclones.

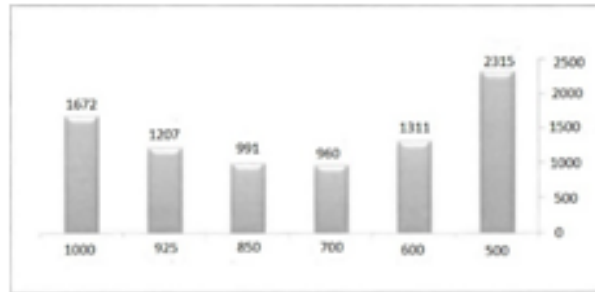


Figure1-2. The frequency of cyclones in 6 height levels of 1000 to 500hp in 1991

Table1-1. The seasonal frequency of cyclones in 1000 and 500 hp in 1991

The frequency of cyclones in levels	spring	summer	Fall	winter
1000	17	13/6	33/1	36
925	18/9	16/5	32/9	42/9
850	19/5	16/7	32/6	42
700	19/3	22	31/7	26/7
600	21/7	24	27/5	26/6
500	23/9	23/1	29/9	35/2

4. EVALUATING SEASONAL MAPS OF CYCLONE GENERATING CENTERS IN TWO LEVELS OF 1000 AND 500 HECTARS PASCAL

In order to draw the map of spring (figure 3-1 and 4-1), the total frequencies of cyclonic centers in Mars, April and May have been used. As it was mentioned in table (1-1), the total frequency of cyclones in 1000 hectors Pascal, 285 cyclones in spring have been studied which includes 17 percent of all the cyclones, while in 500 hectors Pascal, the frequency of spring cyclones reaches the maximum number of 544 which includes 23.9 percent of all the cyclones of this level in 1991. The most dominant feature of this season in 1000 hectors Pascal is the Gang low pressure zone on Pakistan which is visible as the east and south eastern seasonal precipitations of Iran and there’s no cyclonic activity in the Mediterranean Sea, while in the higher level, that is 500 hectors Pascal, Mediterranean basin is the main generating center of out-tropical cyclones, especially in some areas like Middle East and Iran which are the main cyclonic centers in this level. On the contrary, in 1000 hectors Pascal, there’s no influence of thermal low pressure in this level. Considering spring map in 500 hectors Pascal, there’s a relatively powerful cyclone on Khazar Sea and single cyclonic centers in north east. The Atlas northern cyclones have been present in the two examined levels with a difference that in 500 hectors Pascal, a relatively widespread area has been formed. Totally, in spring and in 500 hectors Pascal, more widespread cyclonic areas are present compared to 1000 hectors Pascal.

In summer (figure 5-1 and 6-1), cyclones have a limited area compared to other seasons. The dominant phenomenon of this season is Gang low pressure appearing in 1000 hectors Pascal and another relatively powerful cyclonic center is observed in western regions that could be the result of dust in summer. In other regions of the Mediterranean area and the surrounding parts, especially Iran, important cyclonic phenomena are not observed in this level while in higher levels like 500 hectors Pascal on the Mediterranean Sea, some cyclonic centers have been emerged. In north eastern of Iran and also on Kharazm Lake, some cyclonic phenomena are observed. Based on table (1-1), the frequency of cyclones in 500 hectors Pascal in summer is 537 which includes 23/1 percent of the whole cyclones of this level in 1370 and the generated cyclones in 1000 hectors Pascal in this season

is 229 in the whole range of the study. Totally, the frequency of cyclones occurrence in this season is the lowest percent of 13/6 which has the lowest number among the other seasons.

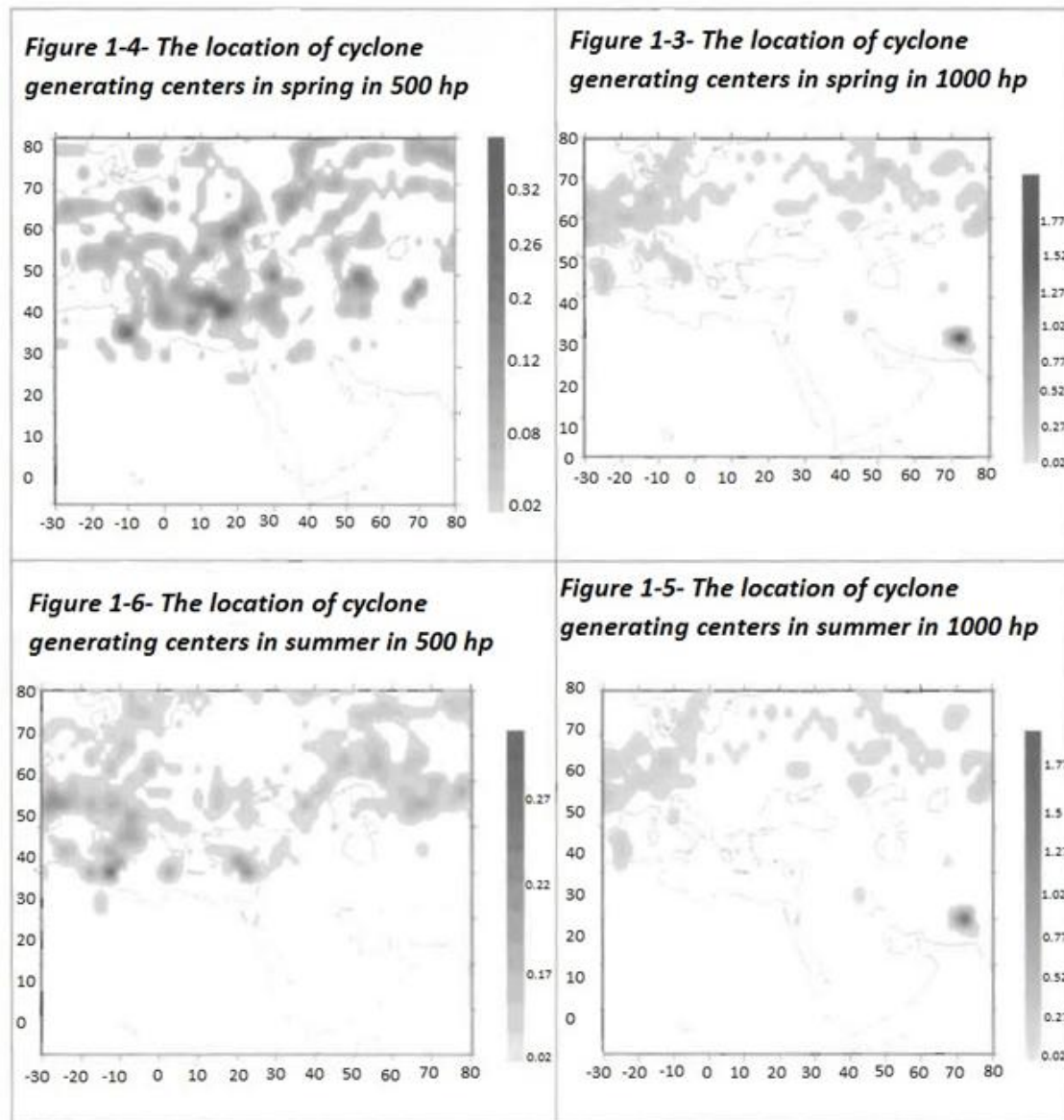


Figure1-3. The location of cyclone generating centers in spring in 1000 hp

Figure1-4. The location of cyclone generating centers in spring in 500 hp

Figure1-5. The location of cyclone generating centers in summer in 1000 hp

Figure1-6. The location of cyclone generating centers in summer in 500 hp

In the fall (figures 7-1 and 8-1), the center of activity is the continuity and generating cyclones in 1000 hectors Pascal on Atlas Ocean and Iceland. Generally, the cyclonic centers in this level between 60-80 northern widths have been stretched as a continuous zone with widespread development toward east of Russia. In this season, due to the movement of western winds toward low latitudes, cyclonic phenomena happen on this Mediterranean basin. Based on frequency maps, the cyclones exist in 2 studied levels in this area with this difference that in 500 hectors Pascal, the frequency of cyclones has been increased such that it includes many parts of west and east of Mediterranean Sea, Turkey and also some parts of Iraq. Also, the weak and scattered centers of cyclonic centers in 1000 hectors Pascal which includes Khazar Sea basin toward Kharazm Lake have been developed as continuous centers, such that a powerful cyclonic center has been generated in south east of Khazar Sea. The highest frequency of cyclonic phenomena in this season (table 1-1) has happened in 1000 hectors Pascal which includes 32/1 % of all the fall cyclones in 1991. The lowest frequency in 500 hectors Pascal is 29/9 % of all the cyclones in this season.

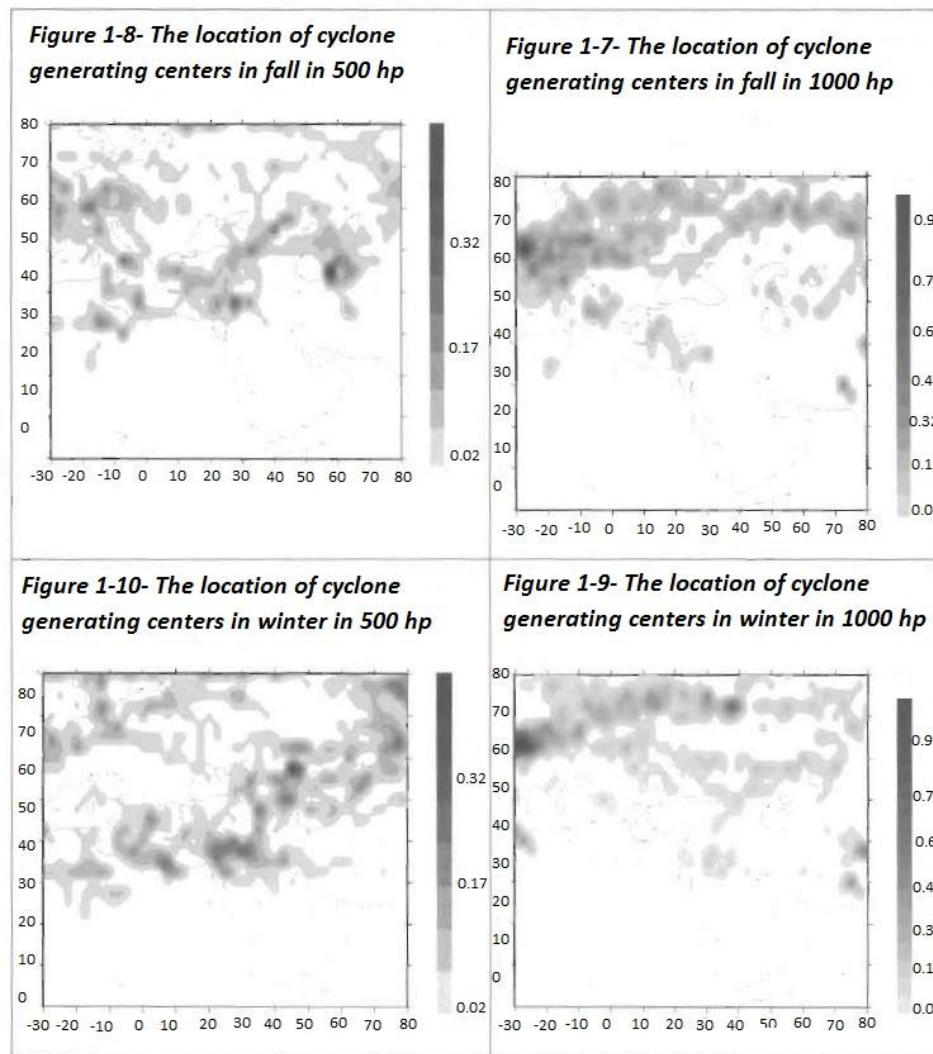


Figure1-7. The location of cyclone generating centers in fall in 1000 hp

Figure1-8. The location of cyclone generating centers in fall in 500 hp

Figure1-9. The location of cyclone generating centers in winter in 1000 hp

Figure1-10. The location of cyclone generating centers in winter in 500 hp

In winter, figure (9-1 and 10-1), all the important activities related to cyclones like flood and storms are happening. What is certain is the existence of a thermal inconsistency between high and low latitudes which reaches its maximum in this season and shows the front cyclonic centers occurrence and the evidence of this happening is the development of areas between 50 to 80 northern latitudes in 1000 hectors Pascal as a continuous zone with a widespread area to middle of Russia and also the relatively powerful cyclonic region of Gang is observable on Pakistan. In 500 hectors Pascal, the tendency of cyclonic areas is toward lower latitudes compared to other seasons such that even in fall, widespread areas are present on Mediterranean Sea compared to other seasons. Cyclonic centers of Sicily Island have been developed such that some parts are stretched toward west of Iran and has passed the central parts. Generally, in 500 hectors Pascal, the cyclonic areas have been more developed than the other levels and they even include some regions of the North Africa. The statistical studies on the cyclones in winter (table 1-1) represents that the number of 603 cyclones in 1000 level has reached 577 in 500 hectors Pascal and also the frequency percent of cyclones in 1000 hectors Pascal has reached from 36 % to 35.2 % in 500 hectors Pascal.

5. CONCLUSION

In addition to local factors, the climate of each region is under the influence of systems, pressure and the fronts of other areas. Due to a close relationship between climate systems, the existence of a system in one area influences the other present systems. On the other hand, low pressures and

cyclones are the main natural risk factors therefore, they are very important for recognizing the location and intensity of cyclonic directions. The main purpose of this research is recognizing powerful cyclones with an average local pressure more than 100/1000 m/km and studying the spatial condition of their frequency centers. The results show that the highest frequency of cyclones was for 500 hectors Pascal and the lowest number was for 700 hp. The winter has the highest cyclones and after that, fall has the highest number with a small difference. With a relatively small difference, spring and summer have the lowest cyclones compared to other seasons. In low levels like 1000 hectors Pascal, limited cyclonic areas exist with low frequency such that in 500 hectors Pascal, cyclonic areas even cover some parts of north of Africa. Spatial study of frequency centers of the recognized cyclones represented that Gang cyclone is the main phenomenon in maps with 1000 level in spring and summer, but in higher levels and in the fall, they will be disappeared and in Mediterranean Sea in 1000 hp, there's no cyclonic center in spring and summer. But gradually in higher levels, their frequency percent increases and reaches its maximum in winter in 500 hp. The cyclone of northern Atlas is present in all levels during the year. It is wrong to assume that these analyses are able to recognize all the cyclones, because the computations were toward recognizing large and powerful cyclones, so they lead to recognizing cyclones in parallel scales and does not include the middle ones.

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