Synoptic and Thermodynamic Analysis of Thunderstorms in Hamadan's Meteorology Stations

Fakhr-al-din Iranpour[a1] , Hojjatollah Yazdanpanah[b], Ali Hanafi[c]

[a] *M.A in Synoptic Climatology, Hamadan Meterologic Research Center,Hamadan, IRAN.*
[b] *Department of Physical Geography, Esfahan University, IRAN.*
[c] *Ph.D Candidate in Climatology, Department of Physical Geography, Esfahan University, IRAN.*

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1. Introduction

Thunderstorms are one of the most important, abundant and uncontrollable weather climates which cause human casualties all over the world, as well as perish large quantities of crops and infrastructure developments each year. Just between 1953 and 1957 financial losses caused by the hurricanes in America were over 3.6 million dollars(Changnon,2003,p.1231). Many storms with different intensities have been identified, while their horizontal range is several tens of kilometers, their vertical range is about 10000 meters, and their lifetime is 30 minutes (Henderson, 2006). Often, these storms are formed by cumulus, rainy cumulus and tower-shaped clouds. Due to excessive warming of surface, thunderstorms are usually developed either by air mass or air front, especially cold front. Therefore, thunder is formed by air mass or has frontal origin. Thunderstorm climate adventure, as part of natural climate in northwest of Iran. compels extensive social-financial and bio-environmental losses on the people, especially farmers and stockmen every year (Khoshhal Dastjerdi, & Ghavidel Rahimi, ,2007, p.101). Sari Sarraf et al. (2007,p.123) have studied showery precipitation in the southern part of Aras river, and concluded that the most important reason for showery precipitation in this area is mainly due to two factors: local instability (in warm seasons of year) and cold front coming (in cold seasons). By surveying the atmosphere during storm formation, meteorologists have found that these factors demonstrate the appropriateness of conditions about it as well as how unstable the atmosphere is, or convection possibility. High levels of cold air, low levels of warm air and moisture abundance, are all factors relating to atmosphere instability. According to the atmosphere dynamic dimension, using instability indicators is considered as the most important scientific method of atmosphere instabilities leading to storms.

1 Corresponding author: Fakhr-al-din Iranpour. Tel: 00989183177169 E-mail: fa.iranpour@gmail.com

2. Study Area

Hamadan province with approximately 19545/82 square kilometers, is located on (33 degrees 33 minutes) circuits to (35 degrees and 38 minutes) north latitude, between (47 degrees and 45 minutes) meridians and (49 degrees and 36 minutes) east longitude.It is surrounded by Zanjan and Qazvin from north, Lorestan from south, Markazi from east and Kermanshah and Kordestan from west, and based on the last country division, includes 8 states, 21 cities, 20 districts, 71 rural districts, and 1120 villages. The average height of sea levels in this region is about 1800 meters. The highest point in Hamadan province is Alvand with 3584 meters and the lowest point is Omar Abad with 1600 meters altitude. Specifications of the studied stations are given in the following table.

Table (1): Specifications of studied synoptic stations

Station name	Longitude	Latitude	Altitude
Hamadan Airport	48.32	34.52	1741.5
Nojeh in Kaboudar-Ahang	48.71	35.20	1679.7

3. Material and Methods

To study the incidence of storms, we have used synoptic data from two stations, Nojeh and Hamadan airport during 15-years statistical periods(1992–2006). Firstly, preliminary data relating to 1992 to 2006 were taken from the general department of meteorological center of Hamadan province. After data controlling, initial tests were conducted and storm data have been extracted according to present and previous weather codes in hourly scale. During surveys, it was specified based on a 15-year statistical period that 270 thunderstorm have happened in this region. In the following, a cluster analysis has been done upon 270 days with thunderstorms to identify synoptic patterns causing storms in the region, then the occurred storms in Hamadan were clustered and considerable severity and duration of storms and showery precipitation were synoptically studied. Analyzing storms in the statistical periods, was done by synoptic method relating to atmospheric condition maps of surface and daily 500 mlbar firstly, then thermodynamic method. To draw them, 500 hPa level and surface raw data were taken from the center of environmental prediction, and then the related days map was traced by GrADS software. Also, for example, thermodynamic diagrams regarding to April, 10th 2005 and October, 31st 2006 due to intensive thunderstorm occurrence were chosen and applied from Wyoming University Website. Skew-T thermodynamic diagrams (high atmosphere) and monthly, seasonal and yearly averages were calculated for both stations and atmosphere instabilities and were studied using instability indicators. These indexes, all demonstrated high possibility of instability occurrence and especially storms in mentioned days.

4. Results and Discussion

Analyzing circulation patterns of storm and showery precipitations

In order to identify patterns developing showery storms and index days, a cluster analysis upon 270 days with thunderstorms in this region has been done. And these days were divided into six clusters. By then, the day with the most intensive instability in each cluster chooses as the representative day. And for instance, its synoptic pattern was studied. Studying 500 hPa level and surface maps relating to longtime patterns demonstrates that several continuous systems have come to Iran from northwest and Iraq, and have led to storm and showery precipitation in this region. Also, at the surface level from the southwest of Iran and by the Arabian Peninsula, Sudanese low pressure came to Iran and caused storms and showery precipitations. To draw Isobar and contour of 500 hPa level and surface, the required data were taken from the center of environmental prediction of America and then the related days map was traced by GrADS software.

Storm changes assessment in studying stations

Hourly changes of thunderstorm occurrence in the airport station are shown in the following figure. Most of the thunderstorm occurrence in this station is between 15:00 and 18:00, respectively, and after that synoptic hours as 12:00 and 21:00 have the most storm occurrence. Monthly changes in the number of days having storm in Airport station is in such a way that the most frequent occurrence is in April and May and its lowest frequency is in December. Also, among the seasons, spring has the most days of thunder and winter has the lowest. More than half of storms are reported in spring season. After that, autumn with the most storm occurrence in the studying region is developing increasingly, as it shows the lowest occurrence in the region in 1993, and year 2004 is reported as the most significant in terms of occurring this phenomenon.

The most frequent occurrence of thunderstorms in Nojeh station is between 15:00 and 18:00. After that, synoptic hours of 12:00 and 21:00 had the most frequency of occurrence. Also, among months in a year, April and May have the most occurrence of thunderstorms and December and February have the lowest. Among the seasons, spring shows the most frequency. More than half of storms are reported in spring season. Moreover, yearly changes processing off the occurrence of this phenomenon in the studying region, are almost increasing in such a way that 1993 had the lowest frequency and 2003 had the most frequency of thunderstorm occurrence.

5. Conclusion

Map analysis results and weather patterns show that among the most important large-scale indicators of storm happening, we could mention the intensive gradient of pressure at the surface, dryness of atmosphere middle-layer and rainy cumulus which are more or less the same as atmosphere instabilities. Therefore, large-scale patterns do not effectively support precise identification of this phenomenon and we may just predict the quality of occurrence of these atmospheric phenomena. However, instability indexes such as Ki, Si, Sweat and numerical thresholds of these indicators are appropriate guidelines for predicting storm occurrence in the region. Occurrence of storms in the province follows a specific process which its most frequency was in Nojeh station with 534 times and the lowest in the Airport station with 312 times (during 15 years). Due to rainy systems coming to the region, most of these storms have frontal and synoptic nature, because of that 81 percent of storms in Airport station and 71 percent of storms in Nojeh station were synoptic and frontal, and the rest of storms happened as 19 percent in Airport station and 29 percent in Nojeh station were thermodynamical and

local. The most storms happening in both stations were in spring season, April, in the afternoon and early evening. As you may observe in spring, this phenomenon rises itself to the higher latitudes, when southern low pressure containing hot and humid streams is acting on the region, and simultaneously, it moves to the lower altitudes in the western areas, while cold high pressure is acting on the northwestern part of the country. Hence, collision of these two different weathers may lead to effective atmosphere frontals on the north, west and west-east of country, then produces cumulus and cumulonimbus clouds; which are mostly along with torrential rainfalls on the mentioned areas. Also, during storms in 500 hPa level, an instable deep Nawa is formed on the Black Sea.

Keywords: thunderstorms, Synoptic Systems, Thermodynamic, Instability indicators, Hamadan.

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