

THUNDERSTORM FREQUENCY OVER PAKISTAN (1961–1990)

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Abstract:

A thunderstorm is simply a storm that generates lightning and thunder. It frequently produces gusty winds, heavy rain and hail. A thunderstorm may be produced by a single cumulonimbus cloud which influences a small area or it may be associated with cluster of cumulonimbus clouds covering a large area. This study explores mean monthly and total-annual thunderstorm frequency for thirty years over various meteorological stations of Pakistan. From the analysis of the data, it is evident that Parachinar and Kakul are at the top with the maximum numbers of thunderstorm days annually. July and August are the months with maximum thunderstorm frequency at nearly all stations, except southwestern parts of the country such as Jiwani whose maximum thunderstorm frequency occurs during December to February.

Knowledge of thunderstorm activity over Pakistan can be of immense help to the weather forecasters, aircraft pilots, agriculturists and also to the planners associated with the management of natural disasters.

Introduction:

A Thunderstorm (TS) forms when warm humid air rises in an unstable environment. It is a weather hazard from the view points of aviation, agriculture, building constructions, electrical and strategic installations on the ground. Thunderstorms are hazards on account of the squalls which sometimes come with them and the low clouds, heavy rains, poor visibility and electrical discharge as well. Thunder heard (with or without lightning seen) has been regarded as a thunderstorm phenomenon occurring at an observing station. According to observational practices, a thunderstorm is reported whenever a thundershower is occurring at the station, or when a thunder is heard at the station or vicinity. At any given time, there are estimated 2000 thunderstorms in progress on the earth. The greatest proportion occurs in the tropics, where warmth, plentiful moisture and instability are always present. About 45000 thunderstorms take place everyday and more than 16 million occur annually around the world. The lightning from these thunderstorms strikes the earth 100 times each second (Lutgens and Tarbuk, 2004).

A thunderstorm possesses great potential to become a natural hazard. The fury with which a thunderstorm unleashes its power can cause loss of life and property of various degrees. The objective of study of thunderstorm frequency, therefore, is to help weather forecasters to predict occurrence of thunderstorm activity in any area of Pakistan. The strong wind gust, heavy precipitation, lightning and hails can damage an aircraft whether parked or in the air. Lightning and hails also damage standing crops and

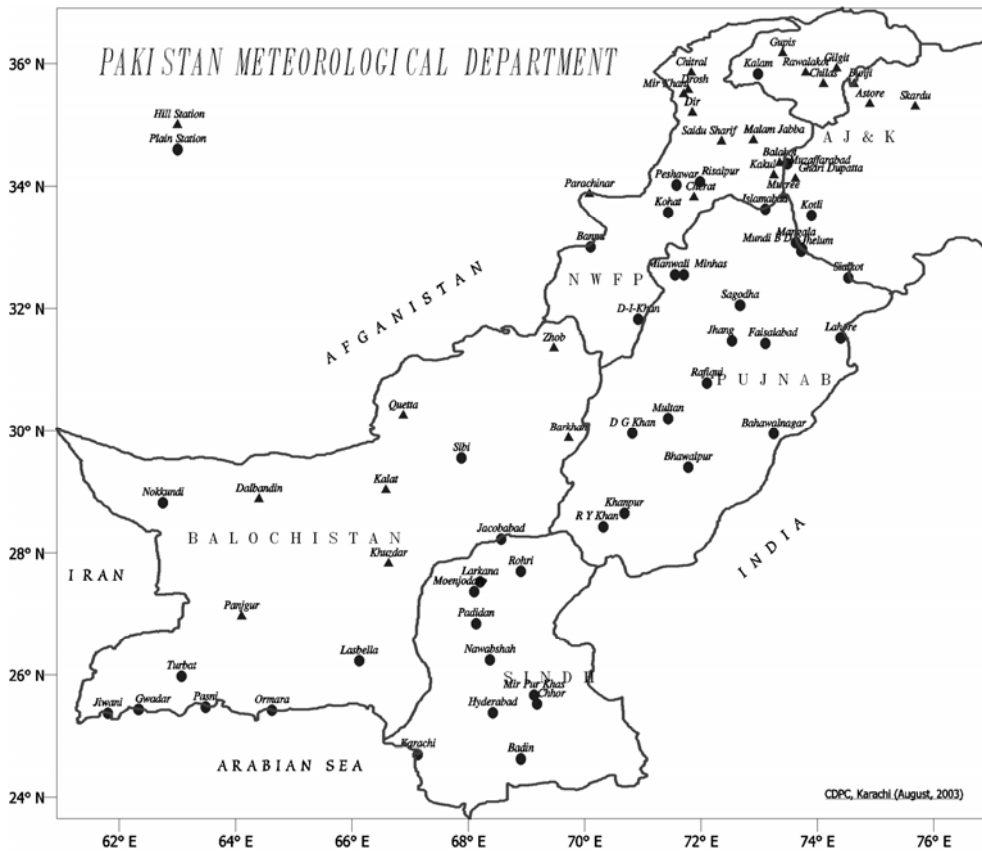
¹ Pakistan Meteorological Department.

sometimes cause deaths of farm animals giving economic blow to farmers and agriculturists. The information contained in this paper regarding the frequency of occurrence of thunderstorms in Pakistan will help the weather forecasters to predict its occurrence. The operators of aviation industries can do rescheduling of flights in order to avoid any possibility of accident. Agriculturists may also adopt safety measures to prevent damage to crops and animals. This paper will also help the planners involved in disaster planning, preparedness and prevention.

Data and Methodology:

Forty eight synoptic observing stations were selected for the period 1961-1990 to study the thunderstorm frequency distribution over Pakistan (Map-1). The criterion for selection of these stations is that they cover almost whole of Pakistan. The data comprises of all types of thunderstorms, i.e. convective, orographic, and seasonal. The study however does not show the actual preferred times of occurrence, whether occurring in the morning, afternoon or night. Any number of occurrence in 24 hours have been counted as "one" day. For example, if on a particular day, thunderstorm occurs a number of times with breaks, it is considered as "one" or if the occurrence is only once in 24 hours, the thunderstorm day is counted to be "one". All stations have been arranged in latitudinal ascending order. Monthly average and the total annual thunderstorm frequency of each station is calculated and given in Table-14(Annex-A). Thunderstorm frequencies were then plotted on the maps of Pakistan (Map-2 to Map-14) and isolines were drawn. The interval of the isolines for each month is different and adjusted according to the density of occurrence of thunderstorm days. These maps also show the areas where maximum, minimum or medium numbers of thunderstorms occur. In this way data were compiled and monthly and total annual thunderstorm frequency charts for Pakistan were prepared. Above data were also utilized to generate bar-graphs (Graph-1 to Graph-13) to compare station-wise distribution of each month and total-annual thunderstorm frequency. The bar-graph (Graph-14) showing total values of thunderstorm days occurring annually over Pakistan also provides the month-wise trend of thunderstorm frequency. Month-wise and total annual distribution of thunderstorm days over different regions of Pakistan have been arranged into three categories of maximum, medium and minimum depending on the frequency of occurrence monthly or annually (Table-2 to Table-14).

The criteria for maximum, medium and minimum numbers of thunderstorm days have been fixed separately for each month by the authors by considering the range of values of thunderstorm days in each month.



Map 1

Discussion:

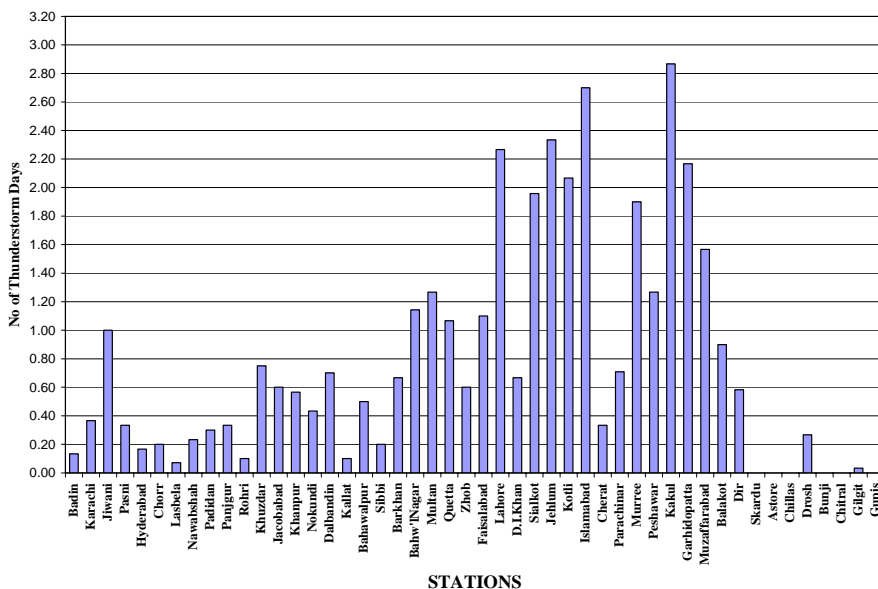
January:

In January, it is winter season in the whole region. This is the time for passing active western disturbances. Sometimes these western disturbances may produce a front over the western part of Pakistan. If there is a strong trough, then the air mass may get moisture supply from the Arabian Sea. The areas which show maximum TS days are along the path of western disturbances. The plain areas generally have no triggering mechanism, hence Cb clouds rarely form. If this system is consisted of two parts i.e. primary and secondary, then more parts of the country may come under its influence.

Table 1: **January**

Maximum no. of TS days	> 1 day	Sialkot, Jehlum, Islamabad, Kakul, Kotli
Medium no. of TS days	0.3 to 1 day	Muzafarabad, Garhidupata, Murree, Lahore, Faislabad, Peshawer, Karachi, Jiwani
Minimum no. of TS days	< 0.3 days	South Punjab, Sindh and Balochistan excluding coasts, extreme Northern areas

FEBRUARY (1961-1990)



Graph 2

March:

The month of March is the ending of winter season in which tracks of western disturbance lie more towards southern Pakistan. Clouds are mostly cumuli, which give showers for small intervals. Thunderstorm may be more frequent and accompanied by squalls and sometimes hail. The secondary Low pressure areas are quite frequent and nearly whole of the Pakistan comes under their influence. The western disturbance normally enters through Quetta and moves towards NE. That's why the TS days are more in mountainous NWFP & Punjab and less in the plains of Balochistan and Sindh. Again extreme north of Pakistan have very few or zero TS days.

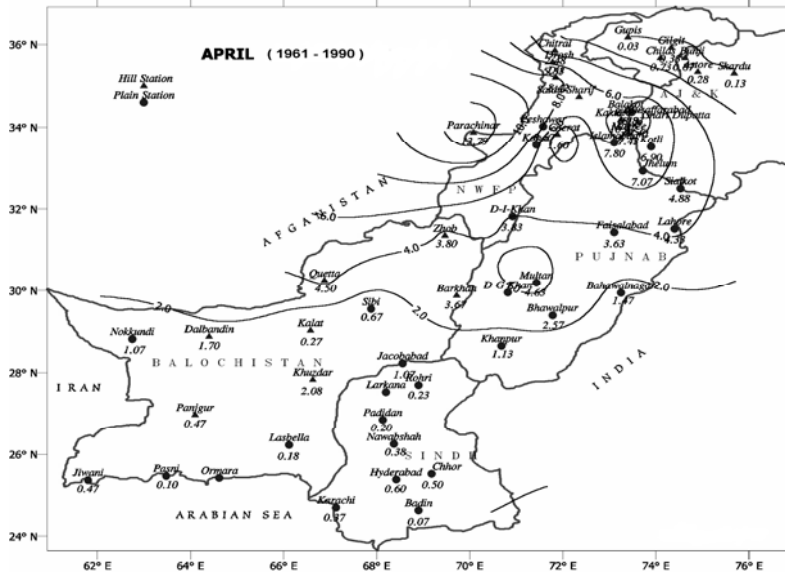
Table 3: **March**

Maximum no.of TS days	> 4 days	Kakul, Islamabad, Murree, Muzaffarabad, Garhidupatta, Northern Punjab, Parachinar
Medium no.of TS days	1 to 4 days	Central & South Punjab, NWFP (plain areas), Northern Balochistan
Minimum no.of TS days	< 1 day	Whole Sindh, Southern Balochistan, Extreme northern areas except Drosh.

of western disturbance and its secondary is continued towards the mountainous NWFP & Punjab. Clouds are of cumuliform in type. The maximum TS activity is in the NWFP and northern Punjab.

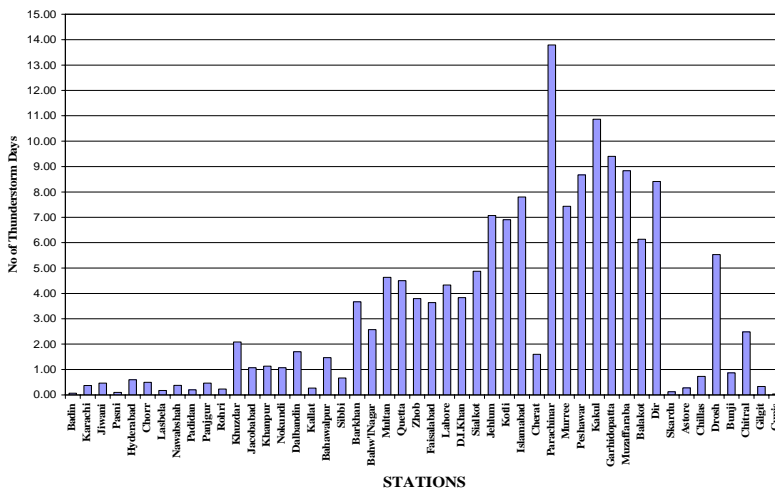
Table 4: April

Maximum no. of TS days	> 7 days	Islamabad, Northern Punjab, Parachinar, Kakul, Peshawer, Dir, Azad Kashmir
Medium no. of TS days	1.5 to 7 days	Northern Balochistan, Lahore, Central & South Punjab, NWFP (plain areas)
Minimum no. of TS days	< 1 day	Whole Sindh, Central & South Balochistan, extreme Northern areas.



Map 5

APRIL (1961-1990)



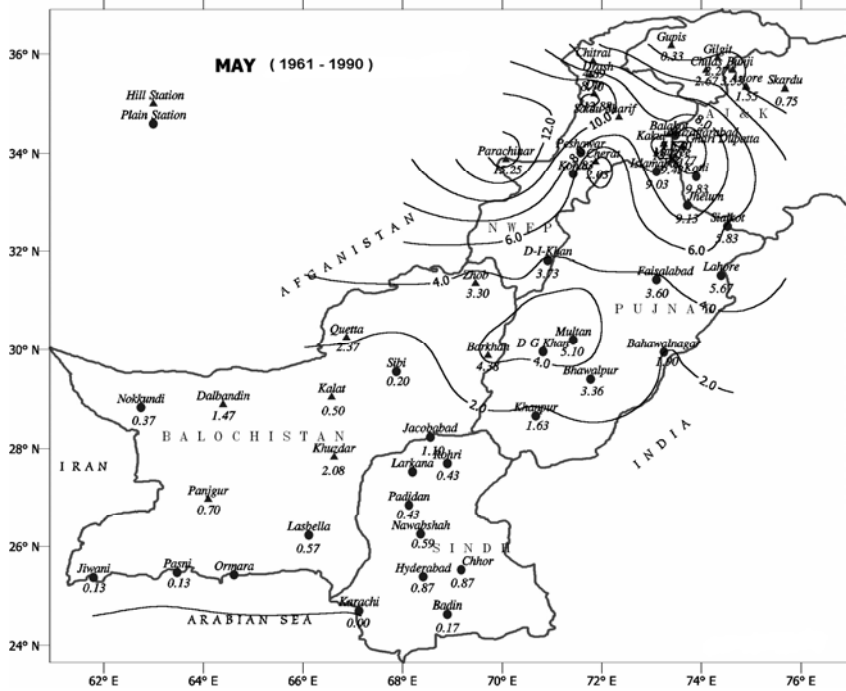
Graph 4

May:

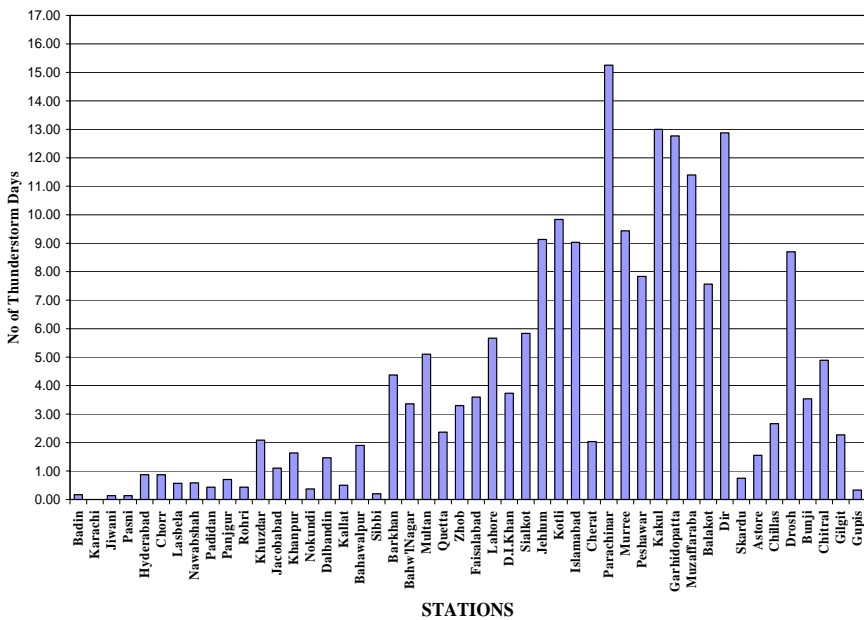
The month of May falls in the pre– monsoon period. The heating is at its peak in many plain areas. Thunderstorm is very frequent in the NWFP and northern Punjab. Dust storms and thunderstorms are very common in the sub-mountain areas generally as a result of local instability conditions and are accompanied by squally weather.

Table 5: **May**

Maximum no. of TS days	> 9 days	Parachinar, Dir, Murree, Islamabad, Jehlum, Kakul, Muzaffarabad, Kotli, Garhidopatta.
Medium no. of TS days	2 to 9 days	Peshawer, Drosh, Chitral, Bunji, Chillas, Gilgit, Balakot, Lahore, Sialkot, Multan, Faisalabad, Quetta, Zhob, Barkhan
Minimum no. of TS days	< 2 days	Whole Sindh, south & central Punjab except Multan & Bw!Nagar, south & central Balochistan except Khuzdar



MAY (1961-1990)



STATIONS

Map 6

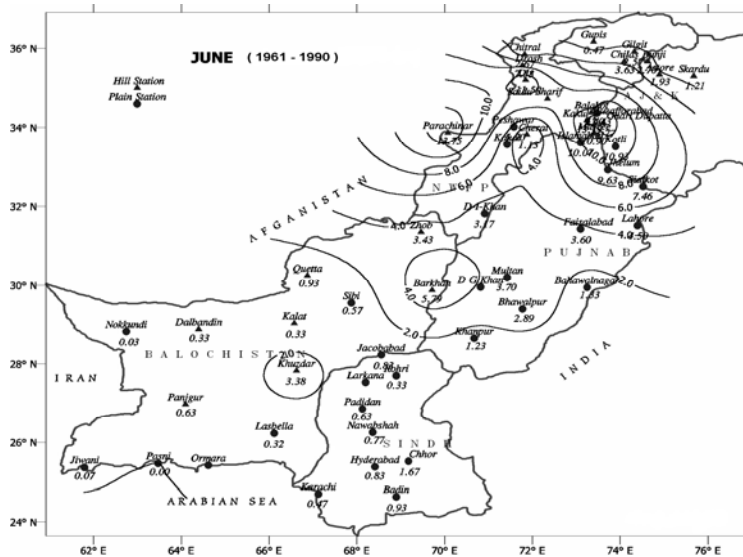
Graph 5

June:

The temperature reaches to highest annual values in the southern and western lowlands of Pakistan. There is a trough of low pressure over the Gangetic Plain with its core of lowest pressure over Balochistan. Thunderstorm activity is much more in northern Pakistan and whole NWFP. The thunderstorm or dust storm occurring over the plains, sometimes show a frontal behavior.

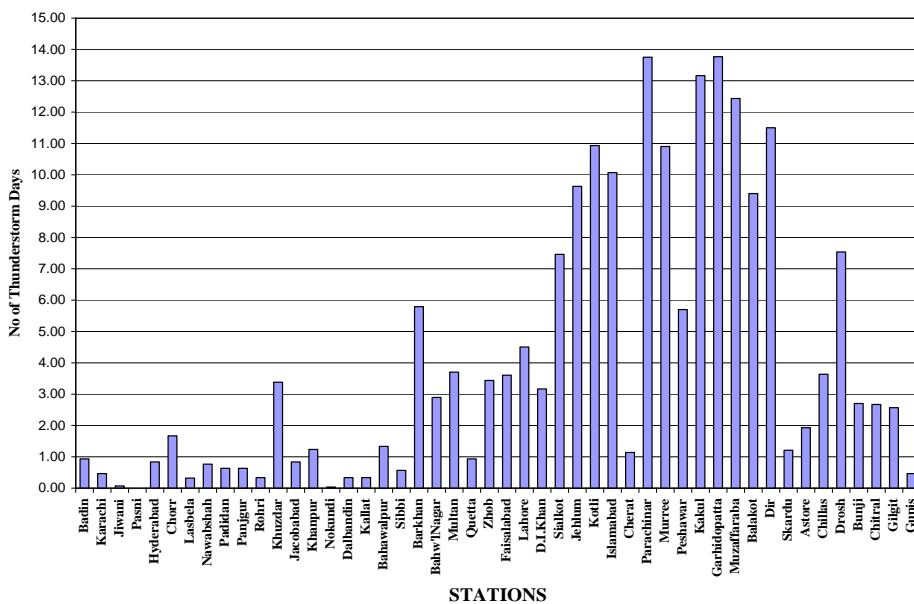
Table 6: **June**

Maximum no. of TS days	> 10 days	Parachinar, Kakul, Garhidopatta, Muzaffarabad, Kotli, Dir, Islamabad, Murree.
Medium no. of TS days	2 to 10 days	Peshawar, DI.Khan, Balakot, Drosh, Chillas, Bunji, Chitral, Gilgit, north & central Punjab, Khuzdar, Barkhan, Zhob
Minimum no. of TS days	< 2 days	Whole Sindh, whole Balochistan except, Barkhan, Zhob, & Khuzdar, Southern Punjab, Quetta, Cherat, Astore, Gupis



Map 7

JUNE (1961-1990)



Graph 6

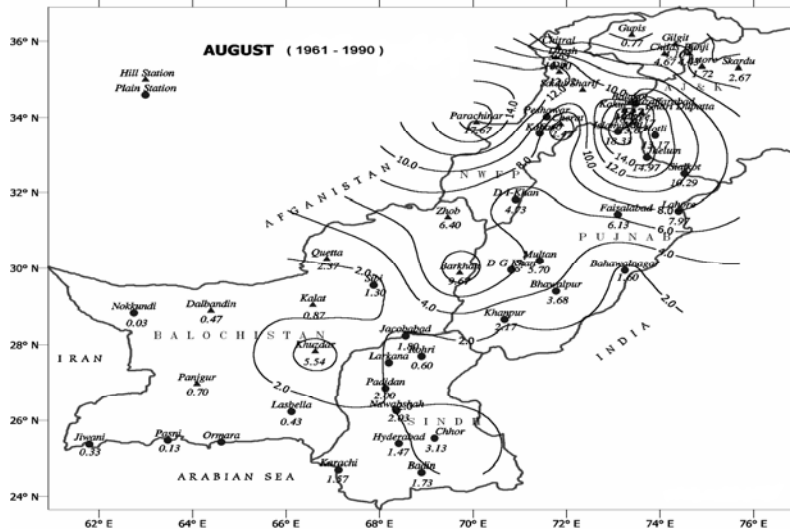
July:

In the month of July, onset of monsoon takes place in Pakistan. The first monsoon rains occurs at the north-eastern and northern part. Therefore Sialkot, Jehlum, Kotli etc are showing maximum thunderstorm frequency. Minimum thunderstorm frequency is observed in some parts of southern Punjab, Sindh and Balochistan. During the first half of July, at coastal areas, little thunderstorm activity is due to the effect of mid-tropospheric cyclones, while during the second half, thunderstorm activity is due to the start of monsoon.

Table 7: July

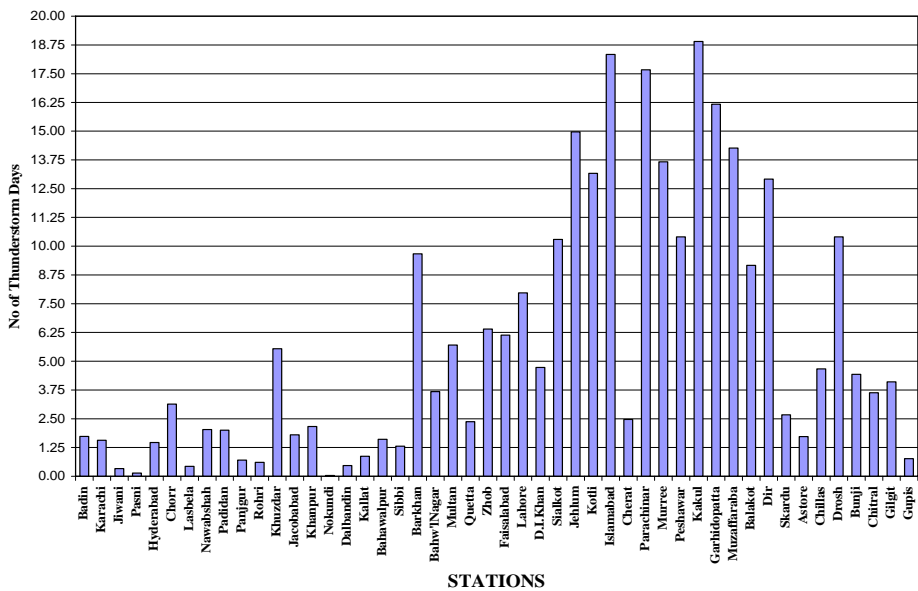
Maximum no. of TS days	> 12 days	Parachinar, Kakul, Garhidupatta, Muzaffarabad, Dir, Murree, Islamabad, Jehlum, Kotli.
Medium no. of TS days	3 to 12 days	Central parts of Punjab, Gilgit, Chillas, Drosh, Bunji, northern Balochistan.
Minimum no. of TS days	< 3 days	Skardu, Astore, Gupis, Whole Sindh & whole Balochistan except northern parts, southern parts of Punjab.

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Minimum no. of TS days	< 3 days	Skardu, Astore, Gupis, Whole Sindh & whole Balochistan except northern parts, southern parts of Punjab.



Map 9

AUGUST (1961-1990)



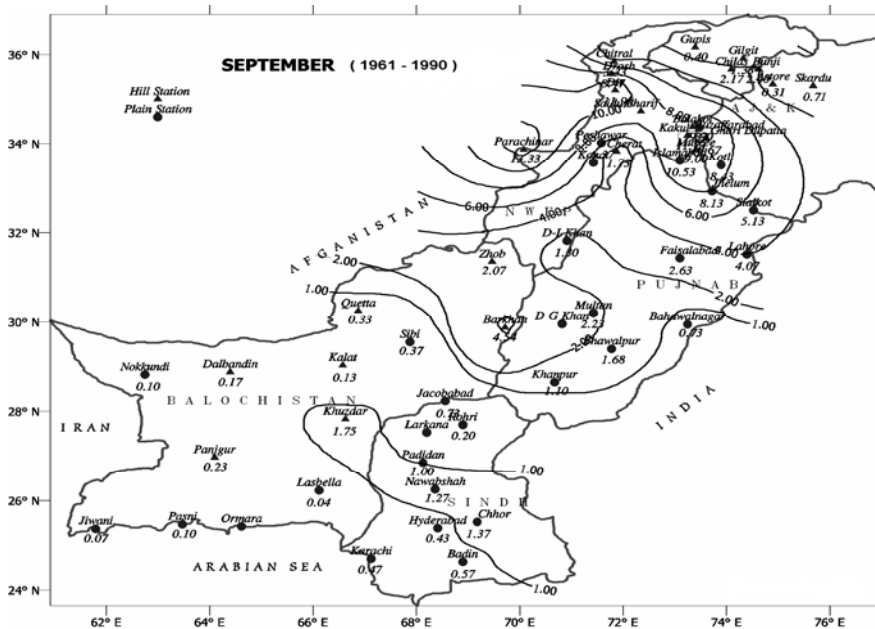
Graph 8

September:

It is the month of ending of monsoon. The seasonal low over Balochistan is now dissipating; therefore, there is no triggering mechanism to lift the moisture in the plains and coastal areas of Sindh, Balochistan, central & southern Punjab. Hence these areas do not show enough thunderstorms. NWFP, northern Punjab and AJK including Parachinar, Dir, Murree, Kakul and Muzaffarabad are showing maximum TS frequency due to their orography. Plains of north-east and south-west Punjab, south NWFP, plains of AJK are showing medium TS frequency. Extreme northern areas of Pakistan like Gilgit, Gupics, Astore, Chelas, Bunji and Skardu ,etc., are showing very less TS frequency.

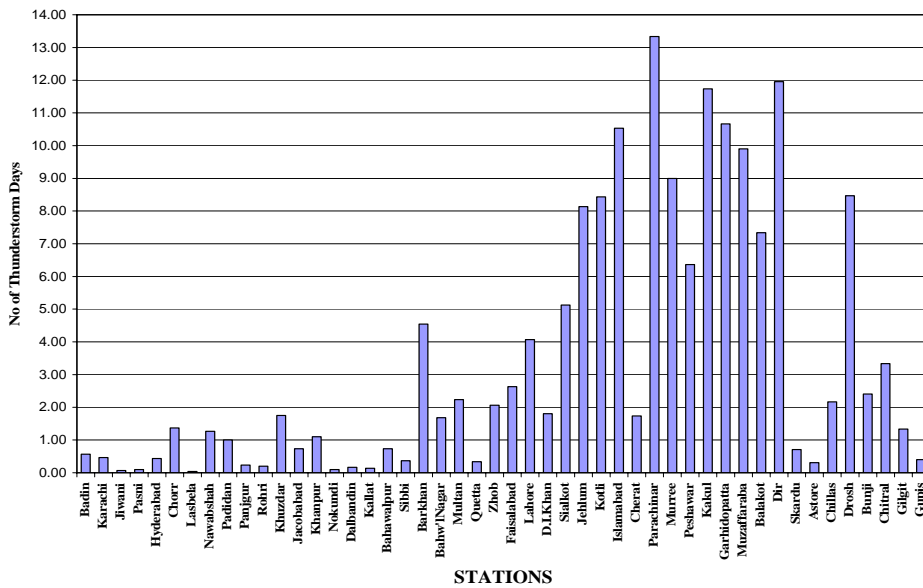
Table 9: **September**

Maximum no. of TS days	> 9 days	Parachinar, Kakul, Islamabad, Murree, Garhidupatta, Muzaffarabad, Dir.
Medium no. of TS days	2 to 9 days	Central parts of Punjab, Balakot, Chitral, Chillas, Drosh, Bunji, Barkhan, Zhob., Peshawer, Balakot.
Minimum no. of TS days	< 2 days	Skardu, Astore, Gilgit, Whole Sindh & whole Balochistan except Barkhan & Zhob, southern Punjab.



Map 10

SEPTEMBER (1961-1990)



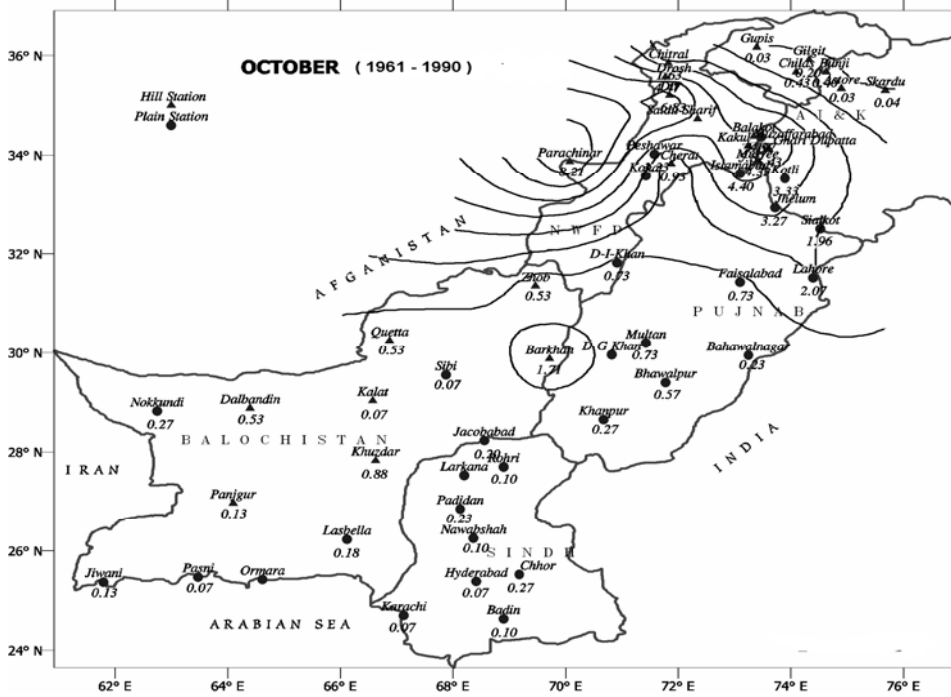
Graph 9

October:

This month falls in the post-monsoon season. Western disturbances are infrequent. In October, there is no weather system of pronounced nature. Moisture supply is only from Arabian sea which moves northward causing higher TS frequency at hill stations like Barkhan & Parachinar and then at the footsteps of hills in NWFP and Punjab. Air loses its maximum moisture at this mountain belt and becomes nearly dry on reaching the extreme north. That is why thunderstorm frequency again drops to its minimum count in extreme north of Pakistan.

Table 10: **October**

Maximum no. of TS days	> 4 days	Parachinar, Kakul, Islamabad, Murree, Garhidupatta, Muzaffarabad, Dir, Drosh.
Medium no. of TS days	0.5 to 4 days	Central parts of Punjab, Hill stations of Northern & Central Balochistan, Peshawar, D.I.Khan, Balakot.
Minimum no. of TS days	< 0.5 days	Skardu, Astore, Gupis, Chillas, Bunji, Gilgit, Whole sindh, plain stations of Balochistan, southern parts of Punjab.

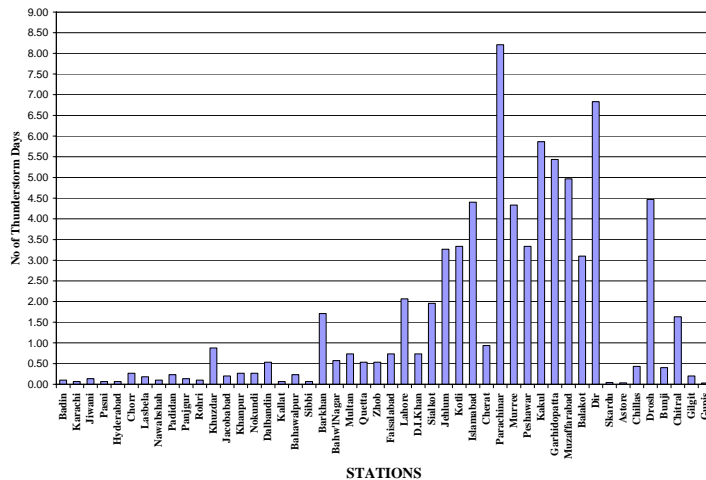


Map 11

November:

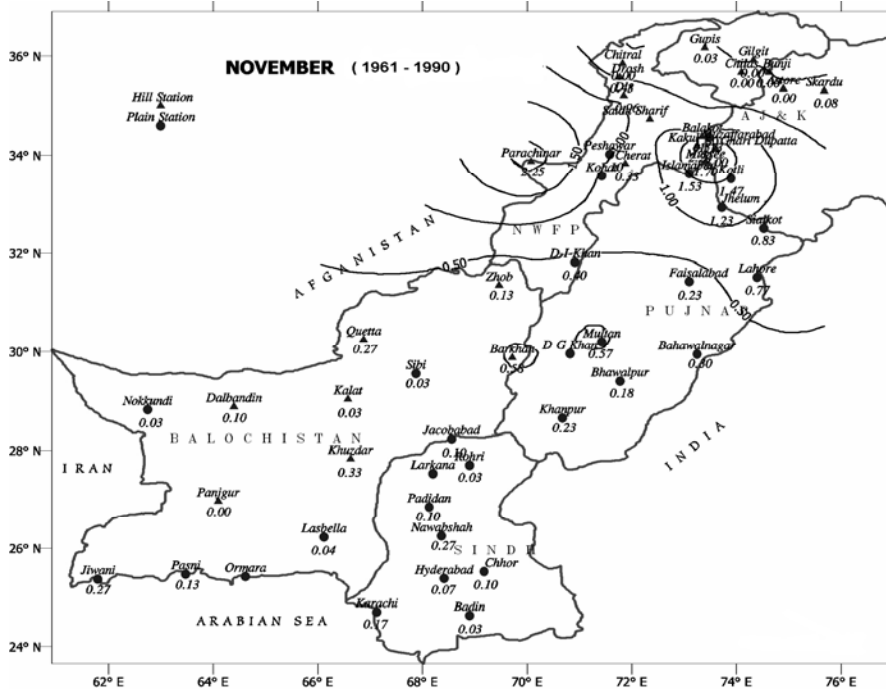
During this month western disturbances are not very common. If some disturbance reach Pakistan, it affects only the NWFP, northern areas and western areas of central/northern Punjab and to some extent the hills of northeast Balochistan. Thunderstorm frequency is maximum at Gharidupatta and Kakul and it decreases up to central Punjab and northeast Balochistan. The thunderstorm frequency is almost zero in the Northern areas and northwest of NWFP. It is very rare in Sindh, almost at all the areas of Balochistan and eastern & southern parts of the Punjab.

OCTOBER (1961-1990)



STATIONS

Graph 10

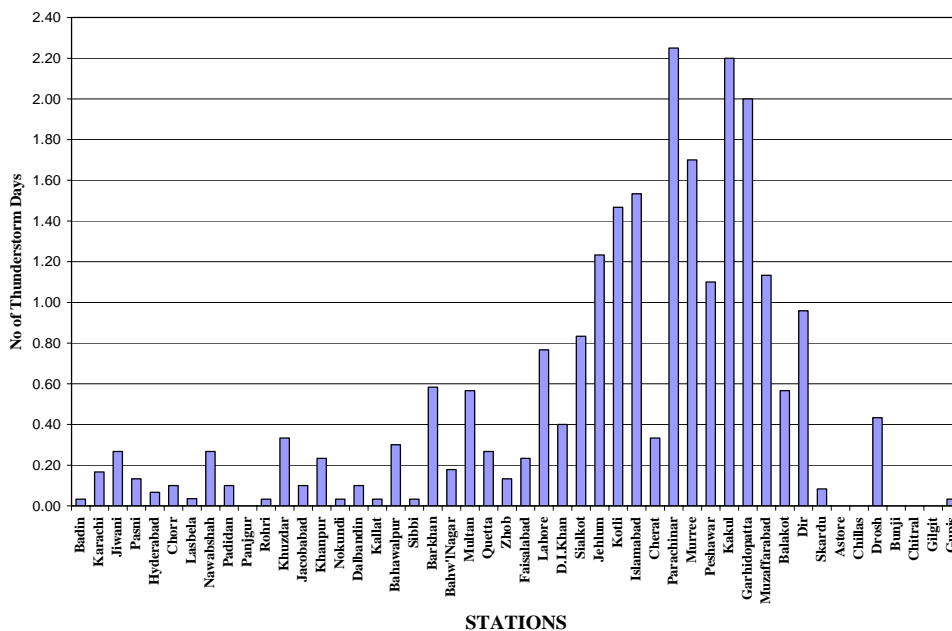


Map 12

Table 11: November

Maximum no. of TS days	> 1 day	Parachinar, Kakul, Muzaffarabad, Garhidupatta, Peshawar, Murree, Islamabad, Jhelum, Kotli.
Medium no. of TS days	0.1 to 1 day	Central & Southern Punjab, most of NWFP, northern Balochistan, coastal areas
Minimum no. of TS days	< 0.1 days	Gilgit, Skardu, Astore, Chillas, Gupis, Whole Sindh & Balochistan except coastal & northern parts of the provinces.

NOVEMBER (1961-1990)



Graph 11

December:

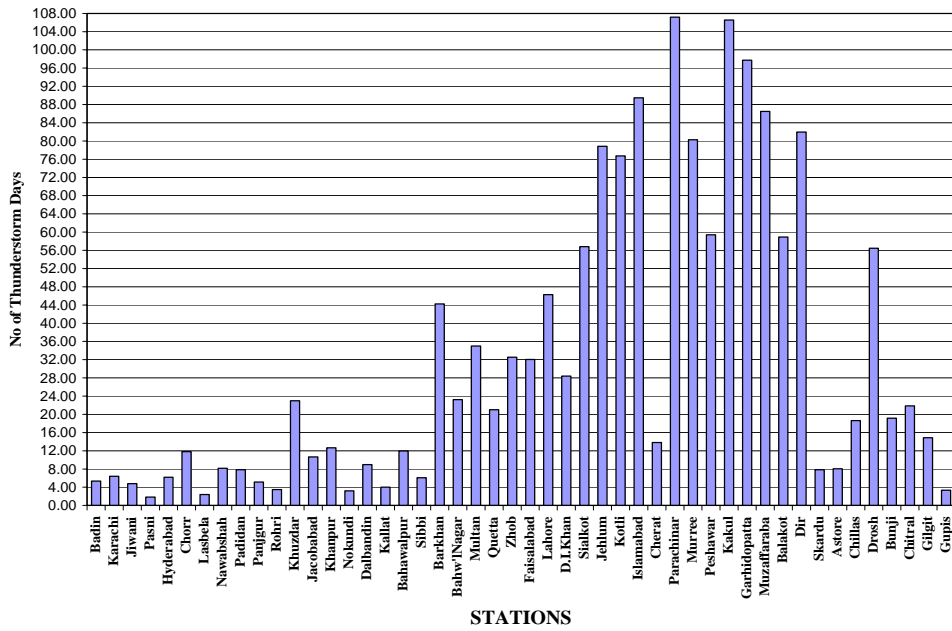
December is the month of beginning of winter season in Pakistan. During this month western disturbances reach Pakistan and cause thunderstorm and rain in almost all over Pakistan except southern part of Sindh where they are rare. Maximum TS is observed in northern Punjab, Garhidupatta and Islamabad. TS frequency is 0.5 over the hills of west and central Balochistan and Jiwani in southwest Balochistan.

Thunderstorm frequency is almost zero in Northern areas and northwestern part of NWFP. It is less than 0.1 in southern Punjab, in almost all the Sindh except Karachi and all the areas of Balochistan except Jiwani and west central hills of Balochistan.

Table 12: **December**

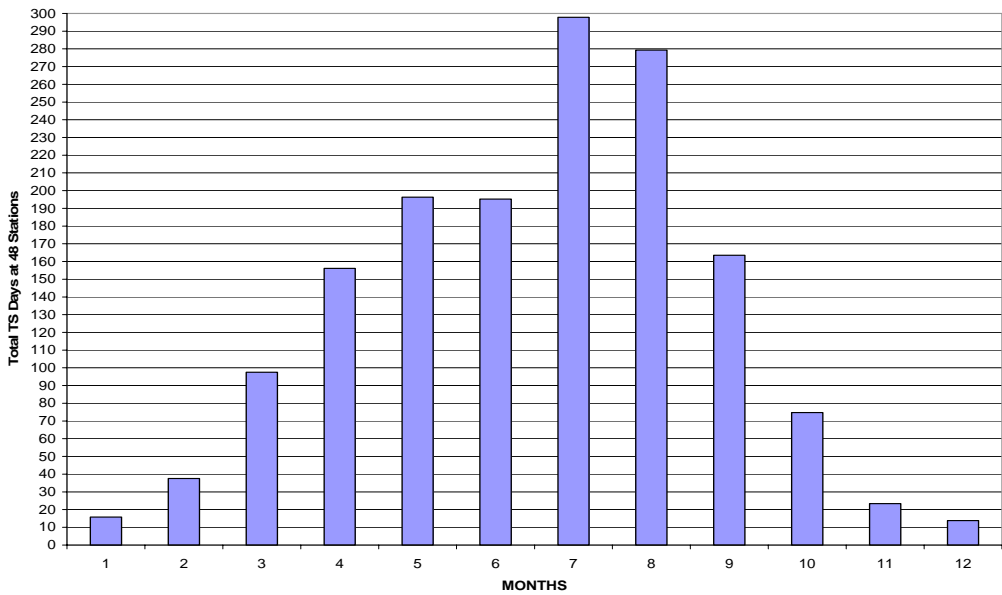
Maximum no. of TS days	> 0.6 days	Quetta, Lahore, Kakul, Garhidupatta, Islamabad, Murree, Jehlum, Sialkot, Kotli
Medium no. of TS days	0.1 to 0.6 days	Whole NWFP, central Punjab, hill stations of Balochistan, Coastal areas of Sindh & Balochistan,
Minimum no. of TS days	< 0.1 day	Extreme northern areas, southern Punjab, whole Sindh except coastal areas, plain stations of central Balochistan.

Total Annual (1961-1990)



Graph 13

PAKISTAN MONTH-WISE



Graph 14

Months of July and August are showing the maximum TS frequency in Pakistan because this is the season of southwest monsoon. During this season the seasonal low lies over

Balochistan and central Pakistan and in association with the axis of monsoon trough produce maximum of thunderstorms in the region.

Acknowledgment:

The authors of this paper are very much thankful to Mr. Muhammad Muslehuddin, (Rtd) Director and Mr. Syed Anzar Ali Jafri, (Rtd) Deputy Director, of Pakistan Meteorological Department, for their valuable suggestions.

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Annex –A

Table 14: Monthly Mean (1961-1990) of “No. of Thunderstorm Days” of 48 Stations of Pakistan

1961-1990	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Badin	0.17	0.13	0.13	0.07	0.17	0.93	1.30	1.73	0.57	0.10	0.03	0.00	5.33
Karachi	0.33	0.37	0.33	0.37	0.00	0.47	2.10	1.57	0.47	0.07	0.17	0.17	6.40
Jiwani	0.67	1.00	0.57	0.47	0.13	0.07	0.50	0.33	0.07	0.13	0.27	0.60	4.80
Pasni	0.23	0.33	0.13	0.10	0.13	0.00	0.27	0.13	0.10	0.07	0.13	0.20	1.83
Hyderabad	0.07	0.17	0.33	0.60	0.87	0.83	1.27	1.47	0.43	0.07	0.07	0.03	6.20
Chorr	0.13	0.20	0.40	0.50	0.87	1.67	3.17	3.13	1.37	0.27	0.10	0.03	11.83
Lasbela	0.00	0.07	0.18	0.18	0.57	0.32	0.43	0.43	0.04	0.18	0.04	0.00	2.43
Nawabshah	0.07	0.23	0.44	0.38	0.59	0.77	2.01	2.03	1.27	0.10	0.27	0.03	8.18
Padidan	0.03	0.30	0.50	0.20	0.43	0.63	2.33	2.00	1.00	0.23	0.10	0.10	7.87
Panjgur	0.13	0.33	0.57	0.47	0.70	0.63	1.17	0.70	0.23	0.13	0.00	0.07	5.13
Rohri	0.10	0.10	0.43	0.23	0.43	0.33	0.87	0.60	0.20	0.10	0.03	0.03	3.47
Khuzdar	0.13	0.75	1.50	2.08	2.08	3.38	4.46	5.54	1.75	0.88	0.33	0.13	23.00
Jacobabad	0.10	0.60	1.30	1.07	1.10	0.83	2.77	1.80	0.73	0.20	0.10	0.07	10.67
Khanpur	0.23	0.57	1.33	1.13	1.63	1.23	2.70	2.17	1.10	0.27	0.23	0.07	12.67
Nokundi	0.17	0.43	0.43	1.07	0.37	0.03	0.23	0.03	0.10	0.27	0.03	0.03	3.20
Dalbandin	0.30	0.70	1.20	1.70	1.47	0.33	1.53	0.47	0.17	0.53	0.10	0.47	8.97
Kallat	0.17	0.10	0.50	0.27	0.50	0.33	0.97	0.87	0.13	0.07	0.03	0.07	4.00
Bahawalpur	0.20	0.50	1.23	1.47	1.90	1.33	2.43	1.60	0.73	0.23	0.30	0.03	11.97
Sibbi	0.00	0.20	0.67	0.67	0.20	0.57	2.00	1.30	0.37	0.07	0.03	0.03	6.10
Barkhan	0.17	0.67	2.96	3.67	4.38	5.79	10.04	9.67	4.54	1.71	0.58	0.08	44.25
Bahw'INagar	0.29	1.14	1.75	2.57	3.36	2.89	4.86	3.68	1.68	0.57	0.18	0.29	23.25
Multan	0.53	1.27	3.40	4.63	5.10	3.70	6.73	5.70	2.23	0.73	0.57	0.40	35.00
Quetta	0.87	1.07	3.40	4.50	2.37	0.93	3.77	2.37	0.33	0.53	0.27	0.63	21.03
Zhob	0.07	0.60	2.20	3.80	3.30	3.43	9.97	6.40	2.07	0.53	0.13	0.07	32.57
Faisalabad	0.40	1.10	2.77	3.63	3.60	3.60	6.87	6.13	2.63	0.73	0.23	0.33	32.03
Lahore	0.97	2.27	4.20	4.33	5.67	4.50	8.83	7.97	4.07	2.07	0.77	0.63	46.27
D.I.Khan	0.30	0.67	3.07	3.83	3.73	3.17	5.73	4.73	1.80	0.73	0.40	0.20	28.37
Sialkot	1.42	1.96	4.13	4.88	5.83	7.46	11.83	10.29	5.13	1.96	0.83	1.13	56.83
Jehlum	1.20	2.33	5.30	7.07	9.13	9.63	15.33	14.97	8.13	3.27	1.23	1.23	78.83
Kotli	1.17	2.07	4.83	6.90	9.83	10.93	13.80	13.17	8.43	3.33	1.47	0.80	76.73
Islamabad	1.10	2.70	6.20	7.80	9.03	10.07	16.50	18.33	10.53	4.40	1.53	1.27	89.47
Cherat	0.10	0.33	0.83	1.60	2.03	1.13	2.20	2.47	1.73	0.93	0.33	0.13	13.83
Parachinar	0.13	0.71	4.54	13.79	15.25	13.75	17.13	17.67	13.33	8.21	2.25	0.42	107.17
Murree	0.97	1.90	5.60	7.43	9.43	10.90	14.67	13.67	9.00	4.33	1.70	0.67	80.27
Peshawar	0.37	1.27	4.80	8.67	7.83	5.70	9.33	10.40	6.37	3.33	1.10	0.23	59.40
Kakul	1.23	2.87	7.10	10.87	13.00	13.17	18.70	18.90	11.73	5.87	2.20	0.93	106.57
Garhidopatta	0.80	2.17	5.93	9.40	12.77	13.77	17.53	16.17	10.67	5.43	2.00	1.10	97.73
Muzaffarabad	0.37	1.57	4.70	8.83	11.40	12.43	16.47	14.27	9.90	4.97	1.13	0.43	86.47
Balakot	0.03	0.90	3.03	6.13	7.57	9.40	11.17	9.17	7.33	3.10	0.57	0.53	58.93
Dir	0.13	0.58	2.75	8.42	12.88	11.50	12.92	12.92	11.96	6.83	0.96	0.13	81.96
Skardu	0.00	0.00	0.00	0.13	0.75	1.21	2.29	2.67	0.71	0.04	0.08	0.00	7.88
Astore	0.00	0.00	0.03	0.28	1.55	1.93	2.21	1.72	0.31	0.03	0.00	0.00	8.07
Chillas	0.00	0.00	0.00	0.73	2.67	3.63	4.33	4.67	2.17	0.43	0.00	0.00	18.63

1961-1990	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Drosh	0.00	0.27	1.33	5.53	8.70	7.53	9.30	10.40	8.47	4.47	0.43	0.00	56.43
Bunji	0.00	0.00	0.07	0.87	3.53	2.70	4.77	4.43	2.40	0.40	0.00	0.00	19.17
Chitral	0.04	0.00	0.30	2.48	4.89	2.67	2.89	3.63	3.33	1.63	0.00	0.00	21.85
Gilgit	0.00	0.03	0.17	0.33	2.27	2.57	3.87	4.10	1.33	0.20	0.00	0.00	14.87
Gupis	0.00	0.00	0.00	0.03	0.33	0.47	1.27	0.77	0.40	0.03	0.03	0.00	3.33