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Seasonal variation of Potential Gradient in the free atmosphere at Poona during the I.G.Y.

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1. Introduction

Measurements of atmospheric electricity in the regions near the surface of the earth are influenced variously by factors peculiar to local conditions, *e.g.*, there are very often temperature differences giving rise to convection currents producing turbulent mixing of the air throughout this portion of the atmosphere. The phenomenon is often referred to as "austausch" (borrowed from German) and the part of the atmosphere affected is called the "austausch region". The vertical thickness of the austausch region is generally quite definite and can be recognized visually by clouds or by the top of haze and also by the measurement of the electrical potential gradient. Venkiteshwaran and Huddar (1956) have described some of the observations made at Poona in the austausch region and their diurnal variation in October and November 1953. It has been observed that during this period higher values of potential gradient and large day-to-day variations are confined to a region extending from the ground to about 600 mb (about 4·5 km). Above the height it remains low with only small variations. The present note describes the seasonal variation in the electrical potential gradient during the I.G.Y. including the monsoon, both in the austausch and in the upper regions upto the heights for which data are available.

2. Data used for the study

The measurment of potential gradient by radiosonde (Venkiteshwaran *et al.* 1953) is being made at Poona from time to time since 1953, and they were made regularly during the International Geophysical period 1957-59. The weather at Poona is generally clear in all months except during the monsoon months, June to August, when it is mostly cloudy with frequent rain or drizzle. Thunderstorms occur only very rarely. However during the summer months March-May, preceding the monsoon, and September-October after the monsoon, thundery conditions may occur more frequently. This paper summarises the variation of electrical potential gradient on those days when thundery conditions did not prevail at Poona.

The radiosonde data of potential gradient have been grouped into the four periods, *viz.*, (*a*) November-February when winter conditions prevail, (*b*) March-May when summer conditions prevail, with mostly clear skies and occasional thundery days, (*c*) the cloudy monsoon months June-August and (*d*) September-October when the monsoon is withdrawing and the skies are clear or partly covered with low clouds and it is occasionally thundery. Tables 1 to 4 on pages 293–294 give the available data. Figs. 1 to 4 show the variation of potential gradient

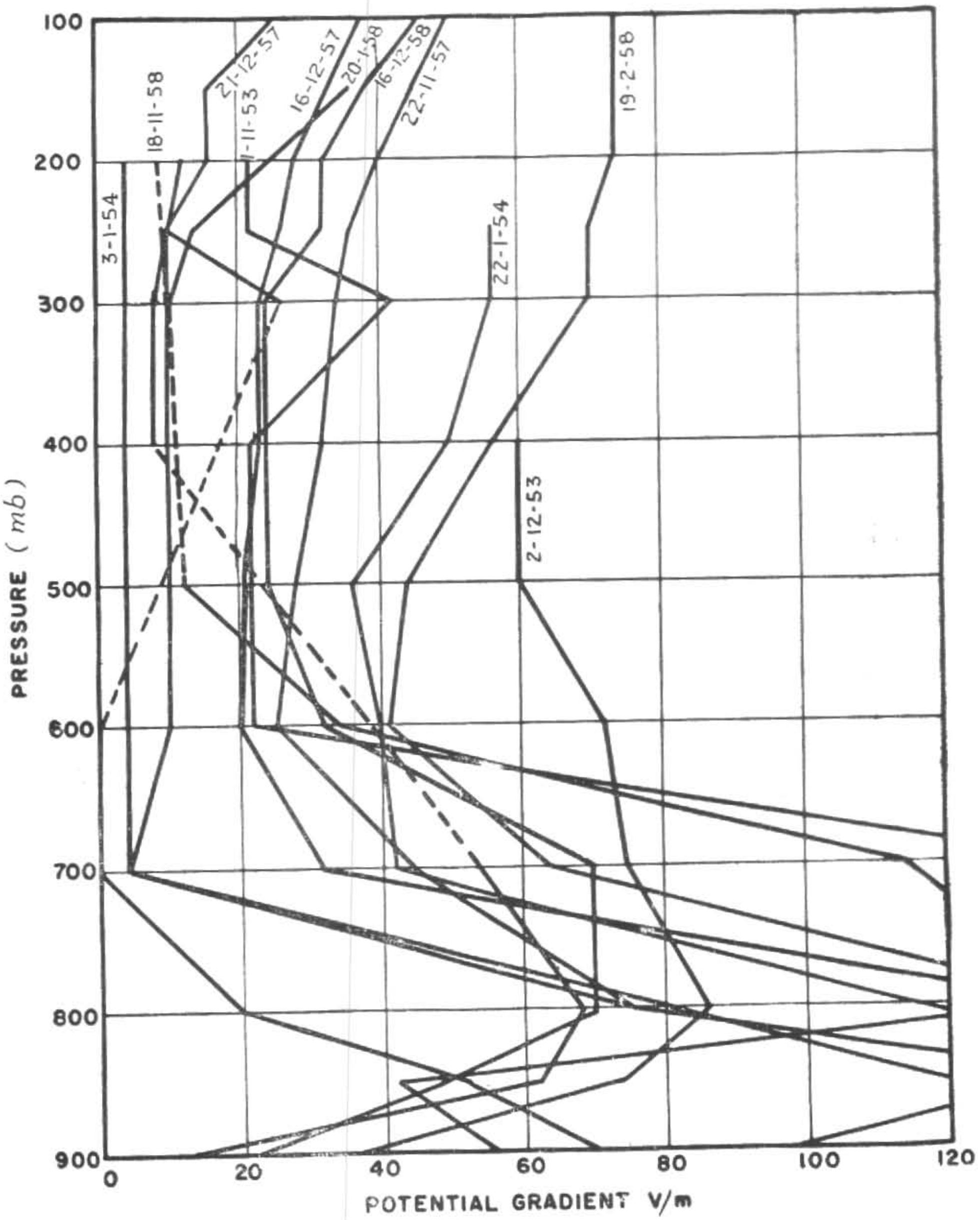

Fig. 1(a) Potential Gradient in the free atmosphere at Poona during November to February

with height for all the flights, grouped seasonwise. During winter (November–February) the number of flights being larger, the data have been plotted in two figures [Figs. 1(a) and 1(b)] to reduce over-crowding.

3. Variation of potential gradient with height in the lower layers

During winter, November to February (Fig. 1), it is observed that the potential gradient is large and it varies from day to

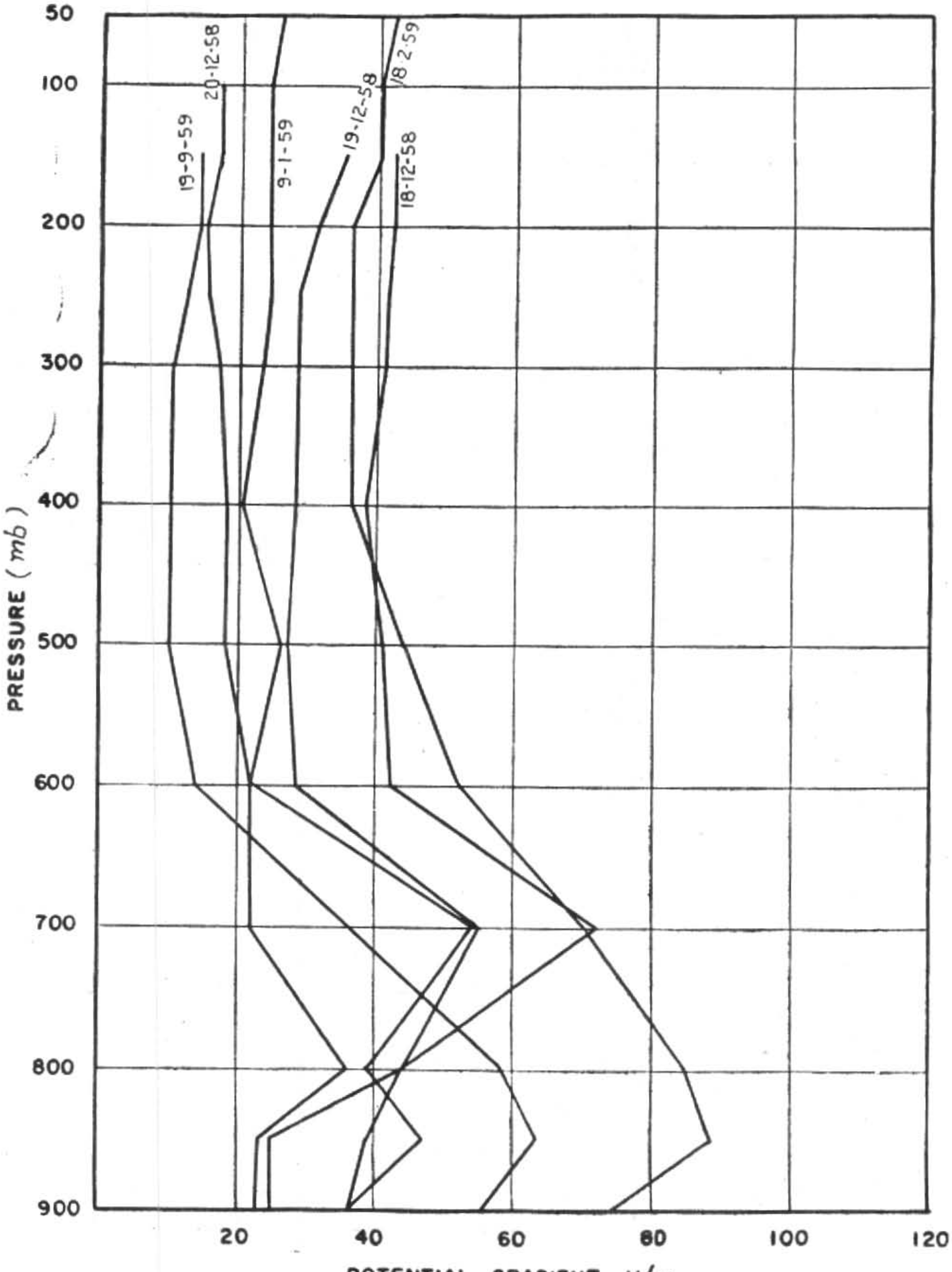

Fig. 1(b). Potential Gradient in the free atmosphere at Poona during November to February

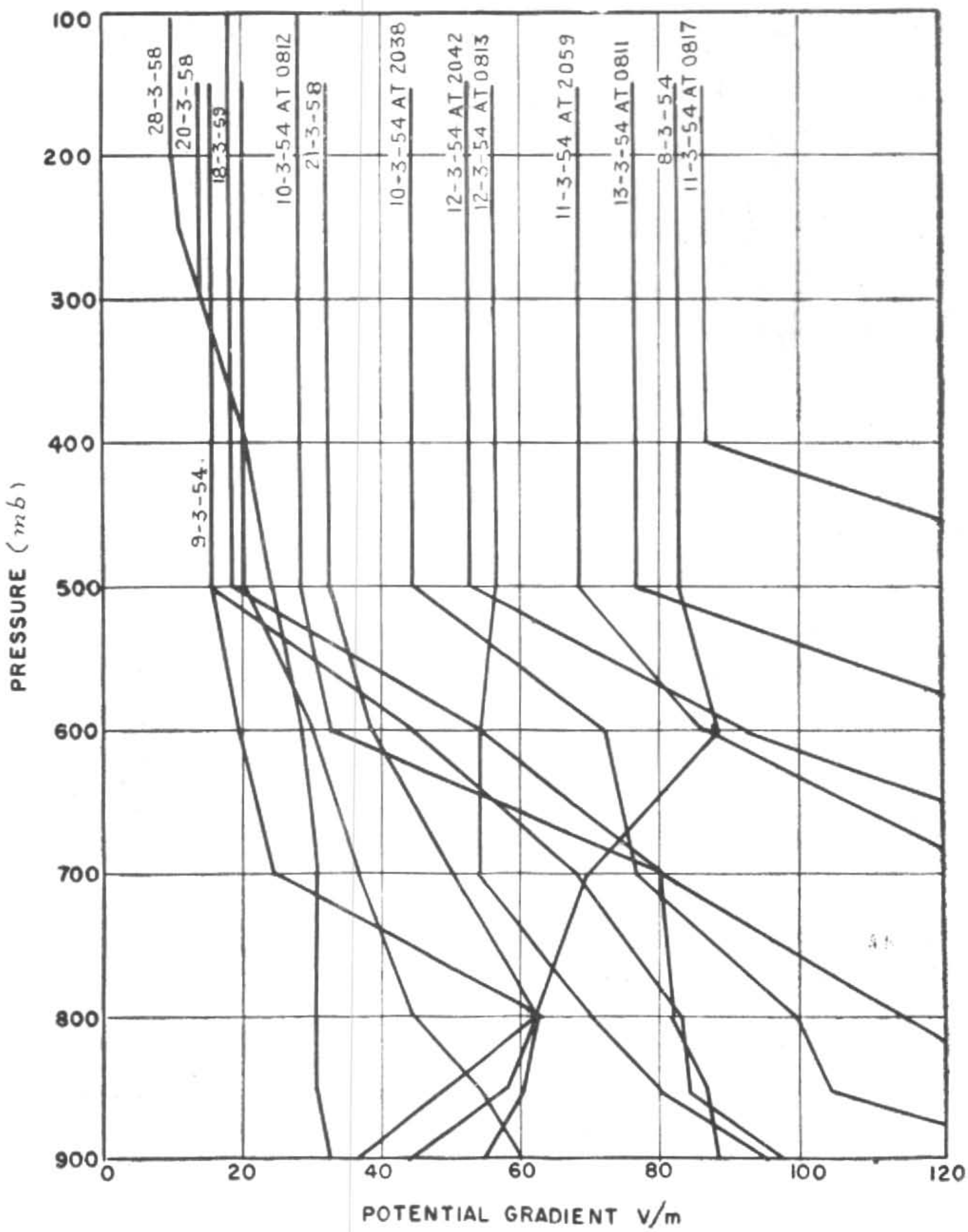

Fig. 2. Potential Gradient in the free atmosphere at Poona during March to May

day, and during the day, upto a height of about 600 mb (4·5 km) above which variation is much smaller. Thus the atmospheric layer upto 600 mb represents the austausch region over Poona during winter. One may infer that convection currents, mixing and raising of dust and thereby the formation of haze layers extends up to this level. The highest value of potential gradient occurs in a region between 850 mb (1·5 km) and

700 mb (3·1 km). It is generally observed that the highest value of potential gradient does not occur near the ground, but at a height above, which varies day-to-day.

Above the 600-mb level which represents the top of the austausch region, the potential gradient remains almost steady with increasing height, but above the 300-mb (9·7 km) level, there is in general a tendency to increase with height during the winter season, November-February. The steady value between 600—300 mb varies between about 10 to 40 V/m. The increase above the 300-mb region has been observed upto the maximum height of the soundings which have occasionally reached the 50-mb (about 19 km) level. The increase in the gradient from the 300 to the 100-mb (16·6 km) level is of the order of 10–15 V/m.

The conditions in the summer season over Poona, *viz.*, March-May are shown in Fig. 2. The chief difference in the features of the austausch region from those in winter is that this region extends upto 500 mb (5·8 km) in this season, *i.e.*, to a height of approximately 1·4 km above the level in winter. While in winter, the region of maximum potential gradient lies between 850 and 700 mb, during summer, this region is very near the ground and the potential gradient generally decreases with height upto the 500 mb. Above the austausch region, the potential gradient is quite steady at the 500 mb upto all levels extending upto 150 mb (14·2 km) or above. This is a characteristic and important feature different from those observed in the winter months. Also, while the potential gradient above the austausch region is between 10-40 V/m in winter, it is between about 20-80 V/m in the summer months.

The potential gradient soundings during the monsoon months, June-August (Fig. 3), show some features which are markedly different from those observed in winter and summer. The austausch region extends upto about 500 mb (5·8 km). The potential gradient seems to attain the highest value in the layer between 800 and 600 mb and this represents the region of cloudiness during this season. The top of the austausch region, *viz.*, 500 mb where the temperature is about 270°A also represents roughly the top of the clouds during this season when the monsoon is not strong and it is not raining steadily. The most interesting feature is observed above the austausch region in this season. While during the winter, the potential gradient was steady above 600 mb and showed a rise above the 300-mb level, and while later in the year in summer, the potential gradient remained steady above the 500-mb level, a steady fall in the potential gradient is observed during the monsoon above the 500-mb level. The potential gradient is between 20-60 V/m at the top of the austausch region, and it reaches about 20-40 V/m at the 200-mb level, further falling with height to less than 10 V/m at about 100 mb.

Fig. 4 shows the distribution of potential gradient with height at Poona during September-October. This represents a transition period when the monsoon is withdrawing and winter conditions are setting. The potential gradient ascents also show the features of these two seasons. It has also to be remembered that thunderstorm activity is fairly strong in this season. Though it may not be thundery over the station, it may be so in the regions near Poona.

4. Discussion

Stergis, Rein and Kangas (1957) have measured the electric field upto the stratosphere in the summers of 1955 and 1956 at Cape Canaveral, Florida. It was observed by them that "the electric field not only decreases rapidly in the first few thousand feet above the ground, as found by other investigators, but that it continues to diminish to the highest altitude at which measurements were made". They also calculated the variation of electric field *versus* altitude from the average negative conductivity *versus* altitude for the flights made on 10, 12 and 16 July 1955. Comparison of the theoretical curve thus obtained showed that the observed values of electric field agree very closely with the calculated average values.

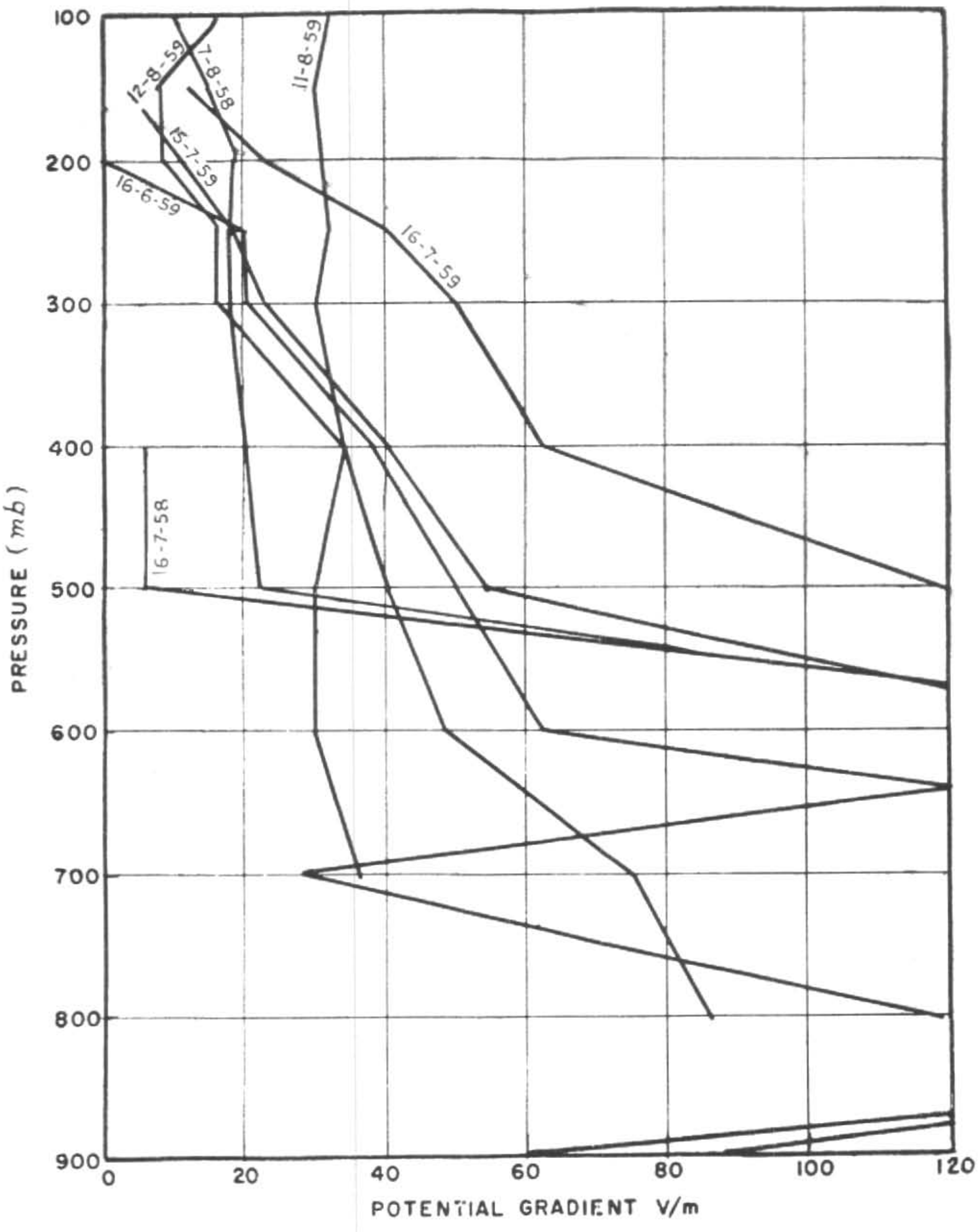

Fig. 3. Potential Gradient in the free atmosphere at Poona during June to August

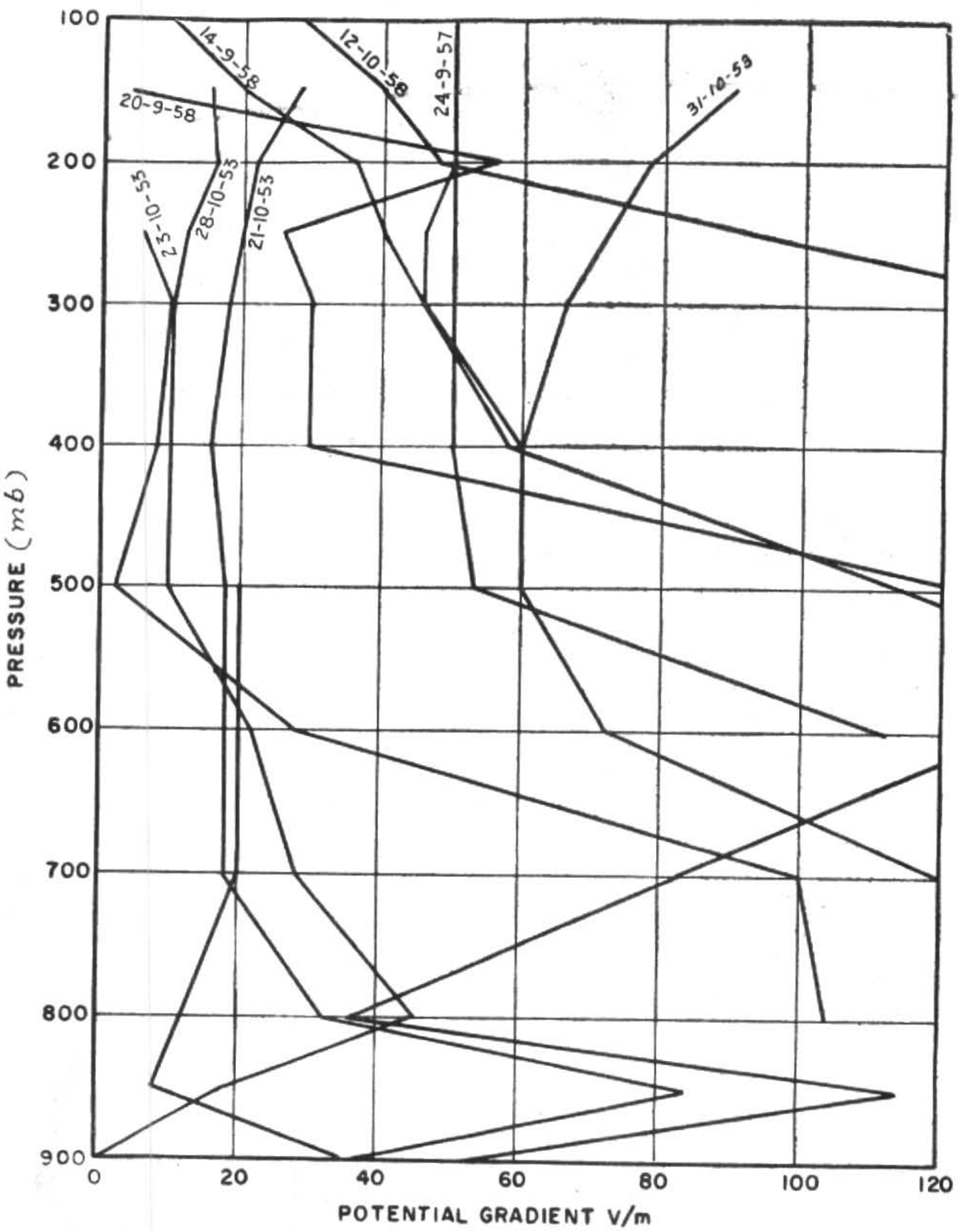

Fig. 4. Potential Gradient in the free atmosphere at Poona during September to October

Mulheisen and Weissenau (1957) have argued that since the passage of the electrical current through the atmosphere in a fine weather region up to a height of about 60 km runs vertical and with an almost constant value J_v, the strengh of the electric field is given by $E=J_v/\lambda$ if λ denotes the total conductivity. Therefore, the strength of the electric field decreases with increasing height as shown in Fig. 5 for average conditions.

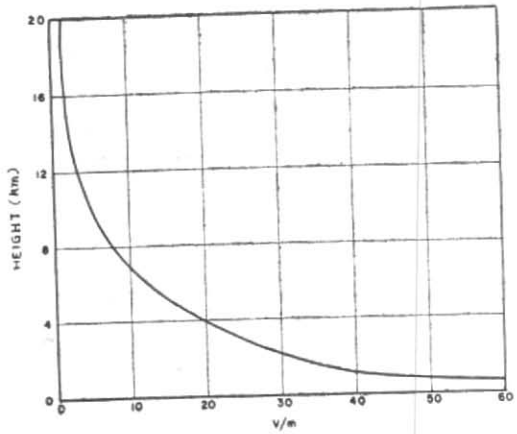

Fig. 5. Theoretical variation of Potential Gradient with height (Mulheisen)

However, these ideal conditions are met with when the atmosphere is free from suspended particles, condensation nuclei and cloud elements. Particles suspended in the atmosphere attract a portion of the small ions due to diffusion and on account of the force of electrical attraction and thus decrease the electrical conductivity of the air, thereby increasing the potential gradient.

Thus, the observations at Poona seem to indicate an approach to the ideal conditions in the atmosphere free from all particles, during the monsoon months July-August, above limit of the austausch region at 500 mb. It is interesting to note that the observations of Stergis *et al.* (1957) are also during this season, and the similarity seems to be present in both the regions.

However, during the winter, the monsoon feature is not observed at Poona. On the other hand, while the potential gradient remains almost steady from 600—300 mb there is a definite tendency for the value to increase above this height; indicating thereby an increase in the particle content of the atmosphere. The 300-mb region nearly corresponds to the base of the stratosphere in the extra tropical latitudes; it nearly corresponds also to the position of the jet stream over India to the north of Poona (Venkiteshwaran 1950). The increase in the potential gradient above the 300 mb may be due to fine suspended particles, of extra terrestrial origin above the stratosphere flowing into the troposphere through the breaks in the tropopause. Since this region moves to northern latitudes in the summer and monsoon months, this feature is not observed in the troposphere over Poona then. In October, when the winter conditions are in the process of setting over India, it is observed occasionally.

The above explanation for the seasonal variation of potential gradient in the upper troposphere should be now considered as tentative pending further confirmation of the observations from soundings extending to regions above the stratosphere both in India and elsewhere.

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Stergis, C. G., Rein, G. C. and Kangas, T.	1957	*J. atmos. terr. Phys.*, **11**, pp. 77-82.
Venkiteshwaran, S. P.	1950	*Mem. India met. Dep.*, **28**, Pt 2.
Venkiteshwaran, S. P., Dhar, N. C. and Huddar, B. B.	1953	*Proc. Indian Acad. Sci.*, **37**, 2, pp. 260-67.
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TABLE 1

Potential Gradient (V/m) by radiosonde—Winter (November-February)

Date	Time (IST)	Levels (mb)													Weather remarks
		900	850	800	700	600	500	400	300	250	200	150	100	50	
1-11-53	2141	618	572	406	140	22	22	22	42	22	22				Clear sky
2-12-53	2027	36	74	86	75	72	60	60							Do.
22-1-54	2025	228	150	116	42	40	36	50	56	56					Do.
23-1-54	2034	194	120	80	4	4	4	4	4	4	4				Do.
22-11-57	1703	316	170	76	44	25	28	32	34	36	40	45	50		*Sc* 2
16-12-57	1711	56	42	150	32	20	21	23	23	26	28	33	38		*Ci* T
21-12-57	1630	10	62	68	54	..	..	8	8	10	16	16	26		*Ci* 2, *Cc* 5
20-1-58	1638	..	..	76	4	10	10	10	10	14	92	36	..		*Ci* 5
19-2-58	1557	160	166	144	64	41	44	56	70	70	74	74	74		Clear sky
11-11-58	1532	70	52	20	0	0	..	..	26	10	12	96	..		*Ci* 1
18-11-58	1553	96	190	178	114	34	12	..	..	..	9	38	..		*Ci* 1
16-12-58	2322	22	48	70	70	32	24	24	24	32	32	38	46		*Ac* 2
17-12-58	2326	4	4	29	36	12	16	16	22	22	28	26	38		*Ac* 1
18-12-58	2326	36	39	44	72	42	41	38	41	41	42	42	42		*Cu* 1, *Ac* 1
19-12-58	2334	25	25	44	55	28	27	28	28	28	31	35	39		*Ac* 1 (high)
20-12-58	2334	36	47	39	54	22	18	18	17	15	15	17	17		*Sc* 2 (high)
9-1-59	1634	23	23	36	22	22	26	20	23	24	24	24	24	26	*Cu* T
18-2-59	1622	74	88	85	70	52	44	36	36	36	36	40	40	42	Clear sky
19-2-59	1616	55	63	58	36	14	10	10	10	12	14	14	14		Do.

TABLE 2

Potential Gradient (V/m) by radiosonde—Summer (March–May)

Date	Time (IST)	Levels (mb)													Weather remarks
		900	850	800	700	600	500	400	300	250	200	150	100	50	
8-3-54	2034	54	60	62	70	88	82	82	82	82	82	82	..	..	*Ac* 3, *Cu* T
9-3-54	2030	98	84	83	68	44	15	15	15	15	15	15			Clear sky
10-3-54	0812	88	86	82	80	32	28	28	28	28	28	28	28		*Ac* T
10-3-54	2038	140	104	100	76	72	44	44	44	44	44	44			Clear sky
11-3-54	0817	230	220	216	208	166	154	86	86	86	86	86			Hazy sky
11-3-54	2059	238	162	150	128	86	68	68	68	68	68	68			Clear sky
12-3-54	0813	96	80	70	54	54	56	56	56	56	56	56			Do.
12-3-54	2042	220	208	208	150	92	52	52	52	52	52	52			Do.
13-3-54	0811	240	218	200	172	136	76	76	76	76	76	76			Do.
13-3-54	2041	158	128	116	80	54	18	18	18	18	18	18			*Ac* T
20-3-58	1619	32	30	30	30	28	24	20	16	14	14	14			*Cu* 3, *Sc* 1, *Ac* T
21-3-58	1733	44	58	62	50	38	32	32	32	32	32	32			*Sc* 1, *Ac* 3
28-3-58	1618	36	49	63	24	19	16	15	14	11	10	10	10		*Cu* T, *Ac* T, *Ci* T
20-4-58	1635	93	100	100	46	24	16	12	12	10	10	10			*Cs* 2, *Cu* 1
18-3-59	1539	60	54	44	36	30	21	20	18	18	18	18	18	18	*Cu* 2

NOTE—The cloud amounts are in oktas

TABLE 3

Pontential Gradient (V m) by radiosonde—Monsoon (June–August)

Date	Time (IST)	Levels (mb)													Wheather remarks
		900	850	800	700	600	500	400	300	250	200	150	100	50	
16-7-58	1634	56	168	118	28	174	6	6							*Fs* 8
17-7-58	1648	94	280	320	114	14	6	6							*Cu* 4, *Ci* T
7-8-58	1614	86	154	224	233	146	22	20	18	18	18	14	10		*Cu* 6, *Ci* T
16-6-59	1720	120	122	228	208	62	50	38	20	20	0				*Cu* 2
15-7-59	1624	150	314	240	376	145	54	40	22	18	10	0	0		Rain from 1600-1620 IST
16-7-59	1636	180	446	370	95	450	118	62	50	40	22	12	0		As 5, *Fs* 3
11-8-59	1617	60	260	188	36	30	30	34	30	32	31	30	32		*Fs* 5, *As* 3,*
12-8-59	1631	199	358	86	75	48	40	34	16	16	8	8	16		*Ac* 3, (*Cu*, *Fs*) 4

* Rain 1635–1645 IST; sky partially cleared up at 1700 IST

TABLE 4

Potential Gradient (V/m) by radiosonde—Post-monsoon (September–October)

Date	Time (IST)	Levels (mb)													Weather remarks
		900	850	800	700	600	500	400	300	250	200	150	100	50	
21-10-53	2025	34	84	32	18	18	18	16	18	20	22	28			(*Ci*, *Cs*) 3
23-10-53	2016	0	18	45	28	22	10	10	10	6	..	34			*Ci* 2
28-10-53	2016	260	220	104	100	28	2	8	10	12	16	16			*Sc* 2, *As* 4
30-10-53	2025	436	436	436	436	214	6	6	6	6	6	6			*Ci* T
31-10-53	2025	546	498	404	120	72	60	60	66	..	78	90			Clear sky
24-9-57	1648	52	114	36	83	376	310	58	46	46	50	50			*Sc* 4
22-10-57	1746	36	8	12	20	20	20								*Sc* 2, *Cs* 3, *Ci* 1
14-9-58	1643	290	423	480	418	216	60	60	46	40	36	20	10		*Ci* 2, *Cu* 3
20-9-58	1557	316	175	194	348	236	122	30	30	26	56	4			*Cu* 2, *Ci* T
12-10-58	1600	142	185	256	234	112	53	50	158	92	48	40	28		*Cu* 2, *Sc* 2, *Ci* T
13-10-58	1717	100	110	154	95	63	52	52							*Ci* 2, *Cu* T, *Ac* T

NOTE—The cloud amounts are in oktas