Indian J. Met. Geophys.(1972), 23, 3,367-378

551.551.5: 511.6: 551.552 (540)

Temperature inversions and stable layers near ground over India

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(*Received 8 October 1971*)

ABSTRACT. Change in air temperature with altitude in the lowest layers of the atmosphere is an important consideration in the incidence of air pollution. The paper gives basic information on ground inversions including isothermal layers and those with lapse rates less than 2°C/km near the ground utilising daily radiosonde data of 16 Indian stations.

The frequency of ground inversions over India south of latitude 18°N is very low as compared to the northern stations. The ground inversions form nearly a daily feature at almost all the northern stations during the months November to February. The frequency increases very considerably by including under ground inversions, layers which are isothermal or have a lapse rate less than 2°C/km. The most frequent thickness of ground inversion is in the range of 201-500 metres. Lapse rates of the order of 1 to 10°C/km are observed on 50 per cent of the occasions over the northern parts of the country. Over the southern parts, however, this percentage is higher and is of the order of 85.

1. Introduction

Certain weather conditions play an important role in the air pollution problem. The change in air temperature with altitude in the lowest layers of the atmosphere is an important consideration in the incidence of air pollution.

The vertical distribution of temperature varies widely from time to time under different weather situations. When the temperature decreases sharply with height there could be considerable mixing in the atmosphere.

When a marked increase of air temperature is noticed with height at lower levels of the atmosphere known otherwise as a temperature inversion, air tends to stagnate. Stable layers include inversions, isothermals and layers where lapse rate is less than 2°C/km.

2. Data

Temperature inversions and other stable layers near the ground utilising daily radiosonde data of 15 stations in India for the five-year period 1965-69 and of one station (Amritsar) for the period 1957-60 have been tabulated from the original tephigrams. These data have been analysed and the main features of ground inversions and stable layers are presented in this paper. In the present study, the analysis is confined to the layer 1 km above ground.

3. Ground inversions

To facilitate analysis of the frequency of ground inversions, their thickness and lapse rates, and to get an idea of persistence, tables have been prepared. Tables 1 to 6 are based on observations made at 00 GMT (0530 hours IST). Table 7 pertains to inversions at 12 GMT (1730 hours IST).

Fig. 1 shows the frequency distribution of ground inversions in the morning all over the country. Fig. 2 pictorially represents the persistence of ground inversions at consecutive hours of observations over New Delhi, Calcutta, Bombay and Madras (1960-61).

3.1. *Frequency of ground inversions*

A striking feature as may be seen from Fig. 1 is that the frequency of ground inversions south of Lat. 18°N is generally very low as compared to the northern stations except during July and August.

Srinagar situated at the northern-most latitude (34°05'N) shows very low frequency of ground inversions amongst the northern stations mainly because the station comes under the influence of the western disturbances for a longer period in a year. These values have not been taken into account while preparing the isolines in Fig. 1.

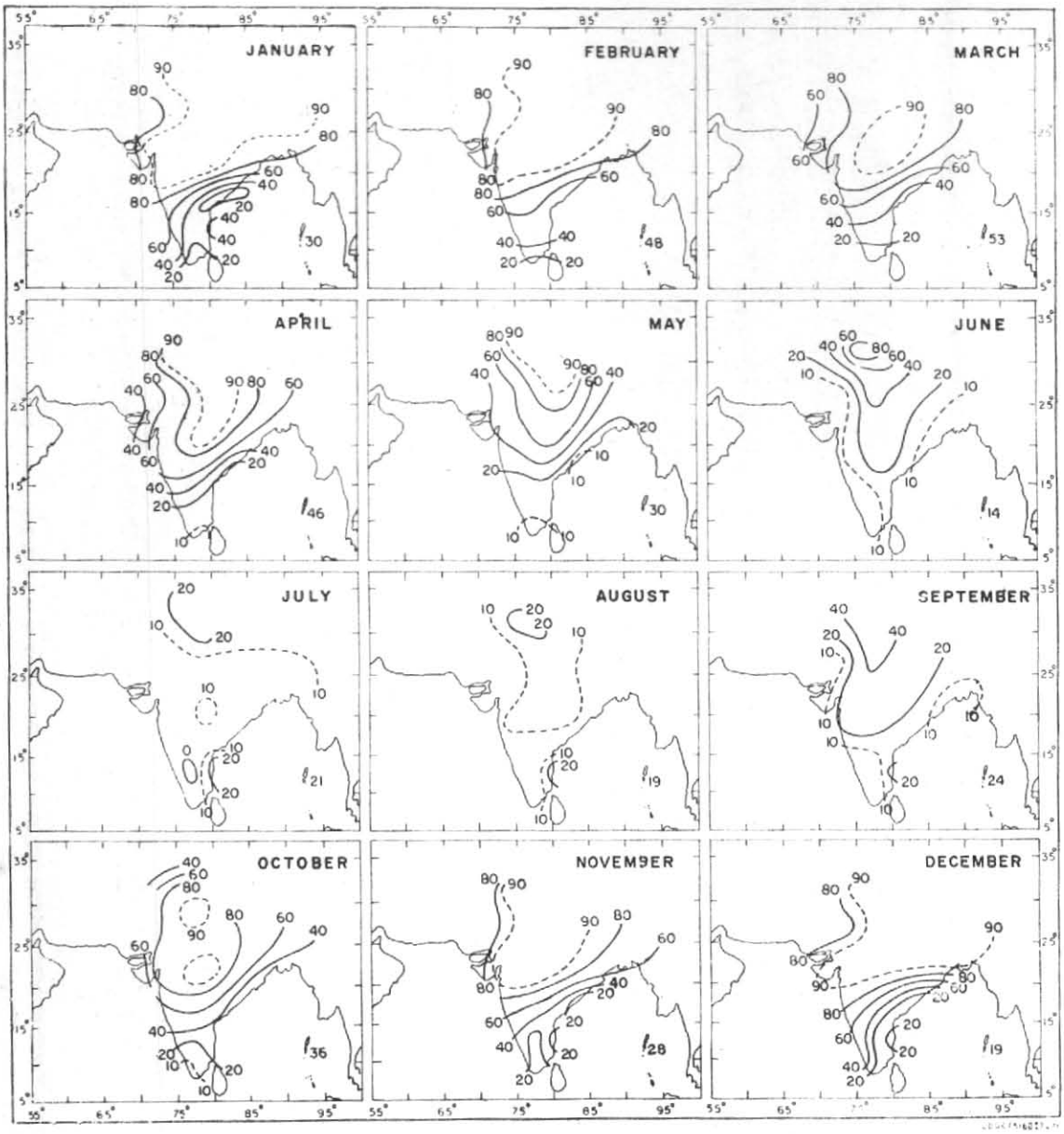

Fig. 1

Percentage frequencies of ground inversions (00 GMT)

3.1.1. *January & February* — Temperature inversions are most frequent in the morning. At all north Indian stations (excepting Srinagar), the frequency of morning inversions is very high on 80 to 95 per cent of the days. Out of 9 north Indian stations, 7 of them (excepting Jodhpur and Calcutta) experience inversions almost daily (frequency 90 per cent or more).

3.1.2. *March to May* — The general trend is towards a decrease all over the country, though the frequency continues to be as high as in Jan & Feb over the area west and north of Lucknow. In the Peninsular part south of Lat. 18°N the frequency is low, being only 5 to 15 per cent in May. Srinagar continues to be an exception.

March — The frequency continues to be high though significant decrease is noticed at Jodhpur (73 per cent) and Calcutta (69 per cent).

April — Amritsar, New Delhi, Lucknow and Nagpur continue to show almost daily inversions (90 per cent or more) while at Gauhati and Calcutta, the frequency has declined to less than 60 per cent.

May — Frequency continues to be high at Nagpur, Lucknow, New Delhi and Amritsar. Else-

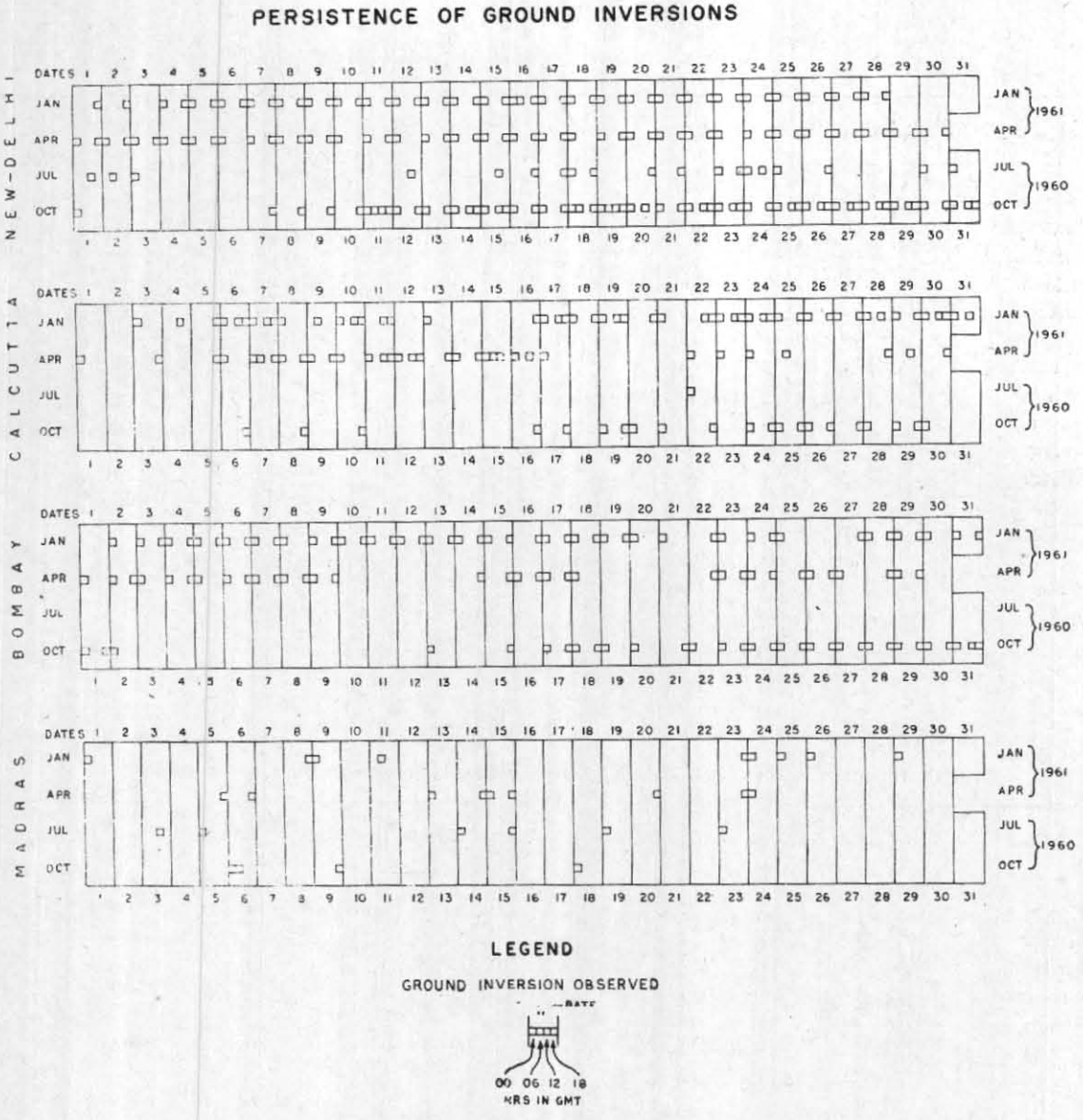

Fig. 2

where, the frequencies are less than 50 per cent. At Calcutta it is only 17 per cent.

3.1.3. *June to September (southwest monsoon)* — The frequency is generally very low — less than 10 per cent. A few stations, New Delhi and Srinagar show 50 to 60 per cent frequency during June and September. Amritsar shows high frequency of 88 per cent during June. Specially during July and August over Jodhpur and Ahmadabad the occurrences are very rare. Over most of the country, the frequency is less than 5 per cent.

3.1.4. *October to December* — Though marked increase is noted in October in northern stations at Calcutta it is still only 35 per cent and Gauhati 52 per cent. At Nagpur and New Delhi, the rise is most marked, the inversion becoming almost a daily feature (95 per cent). November-December features are similar to January-February except at Srinagar which reports high frequency (60 per cent) during these months.

3.1.5. Summing up, the ground inversions form nearly a daily feature at almost all the northern stations excluding Srinagar (which is an elevated station), during the months November to February.

3.2. *Thickness of Inversions*

Only a small percentage of inversions exceed 600 metres in thickness. Thickness 600 metres has been noticed over Srinagar and Bangalore

TABLE 1

Percentage frequencies of ground inversions (00 GMT)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Srinagar	13	8	28	23	24	47	25	16	54	41	66	53
Amritsar	95	97	90	96	93	88	24	28	49	81	95	95
New Delhi	89	91	86	91	88	51	19	17	59	95	97	93
Lucknow	90	95	98	95	91	38	6	11	36	84	96	97
Gauhati	91	87	78	59	24	9	7	6	13	52	74	91
Jodhpur	79	85	73	54	46	4	1	1	7	80	82	75
Ahmadabad	97	91	83	62	45	4	1	1	18	84	95	95
Calcutta	84	84	69	55	17	6	3	3	5	35	75	91
Nagpur	95	97	96	95	72	35	12	17	38	94	92	89
Bombay	92	91	81	68	23	9	3	9	23	76	89	89
Vishakhapatnam	14	44	30	16	9	9	1	8	11	24	17	17
Madras	46	55	34	15	14	18	29	31	21	36	33	31
Bangalore	23	56	35	21	15	4	0	1	2	20	18	18
Port Blair	30	48	53	46	30	14	21	19	24	36	28	19
Cochin	55	39	16	12	10	6	2	2	4	9	25	49
Trivandrum	18	18	14	10	5	6	3	3	2	10	18	14

TABLE 2

Percentage frequencies of thickness of ground inversion layers exceeding 600 metres (00 GMT)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Srinagar	50	22	11	10	9	11	12	—	7	8	13	16
Amritsar	13	17	11	20	24	29	10	20	5	13	9	13
New Delhi	5	4	9	2	6	10	14	4	8	7	2	3
Lucknow	10	19	13	8	18	27	—	20	9	15	12	18
Gauhati	20	29	30	29	34	16	10	34	—	24	23	25
Jodhpur	13	15	13	25	13	—	—	10	12	15	20	12
Ahmadabad	11	13	17	27	43	40	—	—	11	13	11	16
Calcutta	3	9	25	25	36	13	—	25	14	2	5	8
Nagpur	9	9	8	9	15	24	33	—	7	11	4	5
Bombay	11	10	14	35	29	7	—	—	3	8	6	6
Vishakhapatnam	—	2	8	33	16	8	—	—	—	—	—	—
Madras	1	10	16	5	13	7	—	10	3	—	4	—
Bangalore	23	19	17	9	21	17	—	—	—	12	23	50
Port Blair	3	4	7	—	2	5	3	—	—	—	—	—
Cochin	—	6	—	—	—	—	—	—	—	—	—	2
Trivandrum	—	4	—	—	—	—	—	25	—	—	—	—

on 50 per cent of the days during January and December respectively, which is the highest percentage for any of the stations. At Calcutta during January-February and November-December, the frequency is less than 10 per cent. Ahmadabad has values of 10 to 15 per cent. Inversions of thickness which exceed 1 km are rare throughout the country and are negligible. The most frequent thickness of inversions is in the range of 201 to 500 metres.

3.3. *Lapse rates*

Lapse rates of the order of 1 to 10°C/km are observed on 50 per cent occasions over stations

TABLE 3

Percentage frequencies of thickness of ground inversion layers exceeding 1 km (00 GMT)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Srinagar	7	—	—	—	—	—	—	—	—	—	—	4
Amritsar	3	2	1	0	0	2	0	0	0	0	0	1
New Delhi	1	1	—	—	—	—	—	—	—	—	—	—
Lucknow	1	—	—	—	—	—	—	—	—	—	—	—
Gauhati	--	3	1	2	6	—	—	—	—	—	—	—
Jodhpur	—	2	—	—	1	—	—	—	—	2	—	—
Ahmadabad	—	—	2	—	2	20	—	—	—	—	—	1
Calcutta	—	—	—	1	—	—	—	—	—	—	—	—
Nagpur	—	—	1	—	—	—	—	—	—	—	—	—
Bombay	—	1	1	4	—	—	—	—	—	—	—	—
Vishakhapatnam	—	—	2	—	—	—	—	—	—	—	—	—
Madras	—	—	—	—	—	—	—	—	—	—	—	—
Bangalore	3	2	2	3	4	—	—	—	—	3	--	3
Port Blair	—	—	—	—	—	—	—	—	—	—	—	—
Cochin	—	—	—	—	—	—	—	—	—	—	—	—
Trivandrum	—	—	—	—	—	—	—	—	—	—	—	—

TABLE 4

Percentage frequencies of thickness of ground inversion layers 201 to 500 metres (00 GMT)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Srinagar	35	78	65	64	64	68	56	73	73	62	71	64
Amritsar	56	60	67	64	60	47	58	68	87	66	65	70
New Delhi	61	68	66	72	61	63	51	66	62	59	60	50
Lucknow	58	43	51	54	57	55	75	40	59	60	57	52
Gauhati	59	50	48	45	47	53	70	44	50	46	54	52
Jodhpur	67	58	67	47	67	80	100	—	76	61	54	56
Ahmadabad	69	60	66	51	31	60	100	50	60	66	61	60
Calcutta	67	75	51	59	28	64	50	75	42	69	68	64
Nagpur	65	71	74	68	62	59	45	41	59	76	69	65
Bombay	64	57	61	39	34	50	75	36	56	60	71	71
Vishakhapatnam	59	51	60	38	69	69	100	82	87	67	46	65
Madras	62	52	45	49	46	66	76	51	72	64	53	45
Bangalore	32	23	39	36	13	17	—	—	33	33	43	18
Port Blair	65	65	57	66	63	65	58	64	67	62	54	58
Cochin	84	58	80	73	100	80	100	67	80	100	97	75
Trivandrum	78	72	77	87	71	89	60	75	67	87	63	63

north of 18°N, whereas the percentage is of the order of 85 over stations south of this latitude. The most frequent lapse rate is in the range of 1 to 20°C/km throughout the country.

Very high lapse rates exceeding 100°C/km have been noted on a very small percentage of occasions but these appear to be confined to extremely small thickness intervals. Analysis of data of Gauhati and Calcutta indicates that such very high lapse rates exceeding 100°C/km are associated with thickness intervals of 1 to 100 metres.

TABLE 5

Percentage frequencies of lapse rate 1 to 10°C/km (00 GMT)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Srinagar	71	78	81	50	77	71	91	82	66	54	52	49
Amritsar	38	26	18	33	37	55	64	84	62	35	32	31
New Delhi	13	29	23	26	30	67	83	81	54	22	12	11
Lucknow	25	14	32	35	39	54	100	50	62	42	28	26
Gauhati	40	42	42	66	73	84	90	88	77	77	76	52
Jodhpur	74	68	51	65	62	80	100	100	75	61	65	52
Ahmadabad	18	25	41	57	83	80	100	100	62	34	18	29
Calcutta	33	43	54	82	88	100	75	100	72	68	53	38
Nagpur	27	21	33	34	54	77	55	78	60	26	18	18
Bombay	31	37	46	69	79	64	75	43	59	36	35	43
Vishakhapatnam	77	72	87	96	77	92	100	91	100	72	58	77
Madras	58	67	69	63	64	74	89	75	87	68	65	69
Bangalore	69	83	56	87	91	34	—	50	100	87	81	94
Port Blair	68	71	75	76	75	75	74	89	76	75	77	73
Cochin	90	76	80	100	78	100	100	100	100	100	93	83
Trivandrum	86	84	91	87	71	89	100	100	100	100	81	86

TABLE 6

Percentage frequencies of lapse rate 1 to 20°C/km (00 GMT)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Srinagar	100	100	97	83	96	94	100	96	91	86	85	82
Amritsar	78	70	59	66	71	90	90	100	89	82	75	70
New Delhi	45	59	57	66	61	92	97	100	81	56	37	29
Lucknow	59	50	62	61	74	84	100	50	97	74	53	47
Gauhati	84	82	75	84	100	92	100	100	88	92	96	90
Jodhpur	94	90	70	89	80	100	100	100	100	88	95	77
Ahmadabad	58	57	75	89	93	100	100	100	92	72	62	70
Calcutta	67	79	88	97	100	100	100	100	86	94	83	73
Nagpur	61	55	64	64	79	96	100	93	83	65	51	54
Bombay	68	74	81	93	88	93	100	72	94	72	69	80
Vishakhapatnam	86	92	98	100	92	100	100	91	100	100	79	96
Madras	93	96	84	86	73	82	96	83	100	92	84	92
Bangalore	78	96	74	90	100	67	—	100	100	100	100	97
Port Blair	92	90	88	87	95	95	93	100	91	94	92	88
Cochin	98	94	93	100	100	100	100	100	100	100	100	98
Trivandrum	100	96	100	100	100	100	100	100	100	100	96	91

3.4. *Evening Inversions*

As may be seen from Table 7, the frequency of inversions in the evening ascents is small over most of the stations excepting Gauhati and Calcutta which are significant exceptions.

3.5. *Analysis of four ascents daily*

In 1960-61, 4 ascents (00, 06, 12 and 18 GMT) were taken at New Delhi, Calcutta, Bombay and Madras in the months of July and October 1960 and January and April 1961. The percentage of occasions when two and three consecutive ascents had ground inversions are shown in pictorial form in Fig. 2.

It is interesting to note that inversions persisted for 6 consecutive hours of observations (Fig. 2)

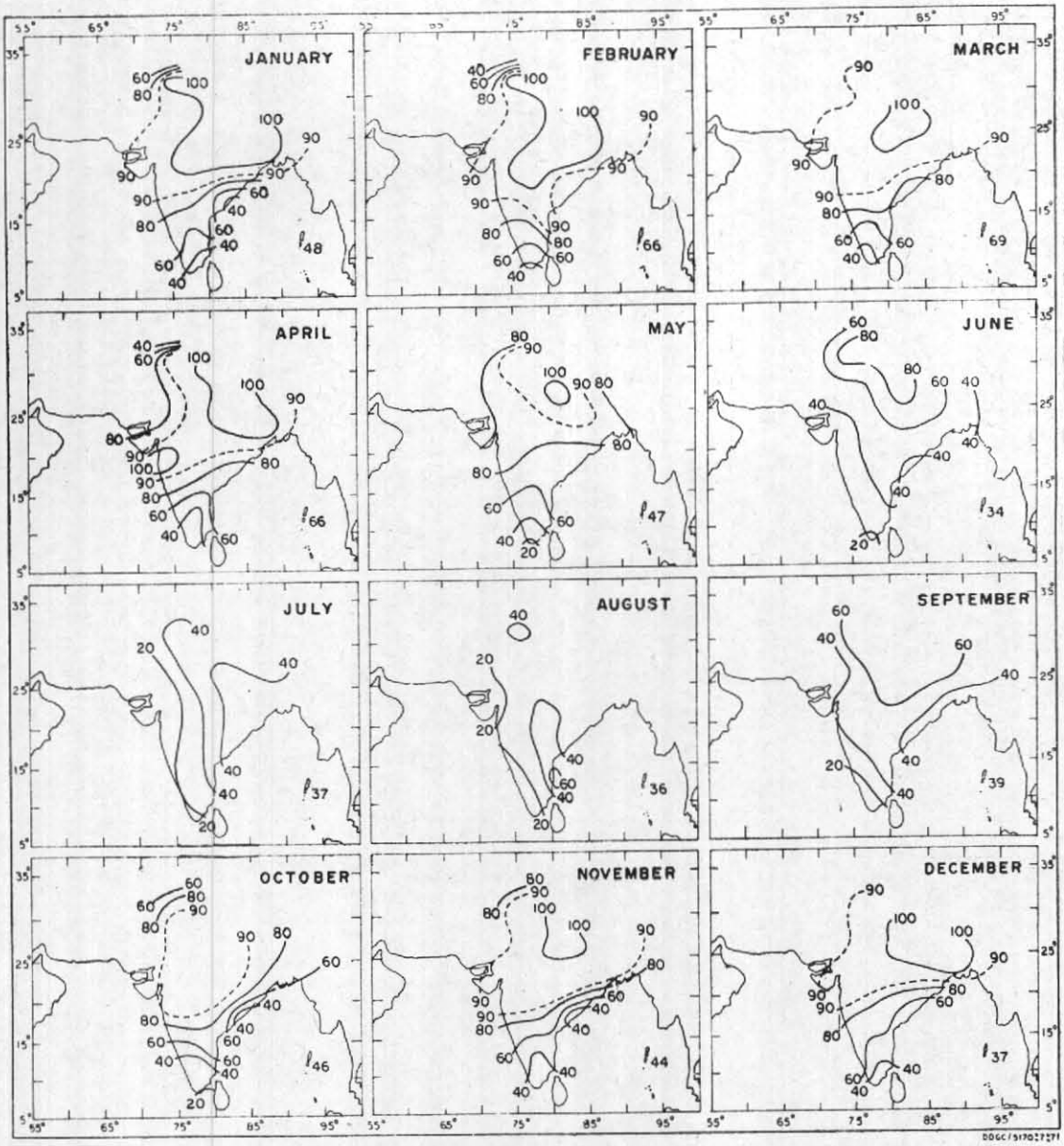

Fig. 3

Percentage frequencies of stable layers (00 GMT)

during two occasions in October over New Delhi. Persistence of inversions is a rare phenomenon over Madras.

3.6. *Persistence*

As inversions are almost a daily occurrence in the morning during December, January and February in northern stations and have been noticed on about 30 to 35 per cent of the days in the evening ascents at Gauhati and Calcutta, it may be inferred that persistence of inversions of longer duration are frequent in northeast India. Elsewhere such frequency is negligible.

4. Stable Layers

Tables 8 and 9 and Figs. 3 and 4 show the frequency of stable layers in the morning and in the evening. Fig. 5 pictorially depicts the persistence of stable layers at consecutive hours of observations over New Delhi, Calcutta, Bombay and Madras (1960-61).

4.1. *Frequency of stable layers*

Winter (January-February) — In northern latitudes north of Lat. 20°N, stable layers in the

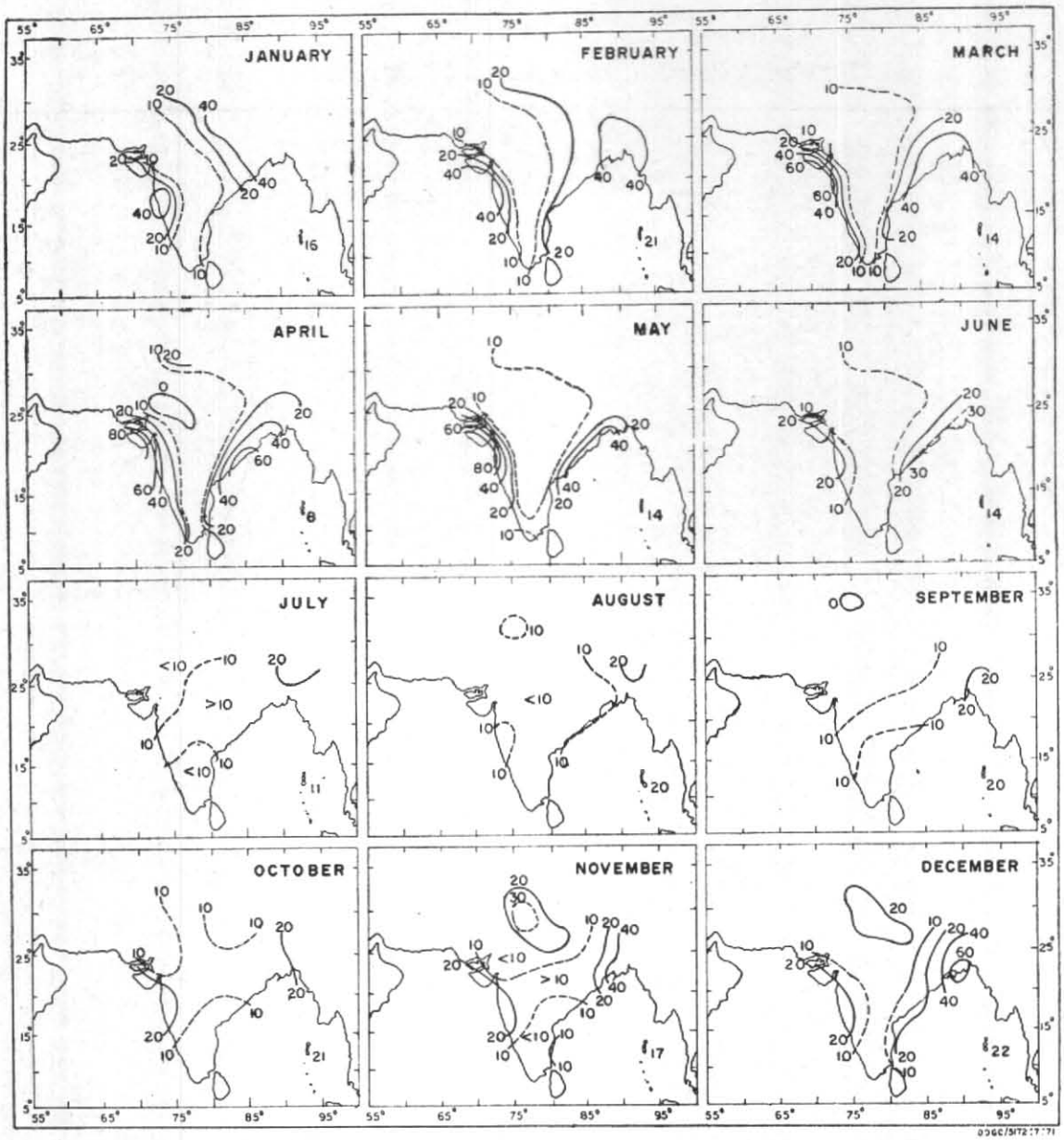

Fig. 4

Percentage frequencies of stable layers (12 GMT)

first km are almost a daily feature. At Amritsar, Lucknow and Nagpur the frequency is 100 per cent. At Jodhpur it is 91 per cent. South of Bombay the frequency rapidly diminishes to 60 per cent at Madras and Cochin during January. At Vishakhapatnam the frequency is only 40 per cent. The lowest frequency at Trivandrum is about 30 per cent. It is of intrerest to note that in February the frequency at Madras is 90 per cent — stable layers being nearly a daily feature. Bangalore though slightly less is still high (72 per cent).

Summer (*March-May*) — An examination of Fig. 3 shows that the pattern in March-April is similar to that of winter months January-February. The highest frequencies — nearly daily occurrence are north of a line joining Bombay-Calcutta. The lowest is over Trivandrum area 25 to 30 per cent. The east coast frequency from Vishakhapatnam to Madras is 60 to 70 per cent, Madras being higher. In May the frequency generally decreases, the maximum decrease in northern latitudes being 25 per cent at Gauhati. Elsewhere the frequency percentages are mostly

TABLE 7

Percentage frequencies of ground inversions (12 GMT)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Srinagar	1	—	—	—	—	4	2	—	—	—	2	1
Amritsar	14	10	7	20	14	4	1	1	4	10	17	5
New Delhi	1	1	—	1	3	3	1	1	1	5	2	1
Lucknow	2	1	—	—	—	—	—	—	—	2	5	4
Gauhati	36	25	21	5	1	7	4	2	1	15	28	31
Jodhpur	—	—	2	—	—	—	1	—	—	1	1	2
Ahmadabad	—	—	1	—	—	1	—	—	—	—	—	—
Calcutta	36	30	29	7	5	3	1	1	—	4	23	32
Nagpur	1	1	1	—	1	5	4	1	5	8	10	3
Bombay	7	6	8	8	3	1	1	2	—	5	1	2
Vishakhapatnam	—	3	2	1	1	6	3	2	—	1	—	—
Madras	4	1	1	1	1	1	1	1	2	1	3	2
Bangalore	—	—	—	1	3	1	—	1	—	1	1	—
Port Blair		8	1	2	5	3	5	7	8	9	7	10
Cochin	-	—	—	—	1	1	—	1	—	1	—	—
Trivandrum	-	—	—	1	1	—	—	1	—	1	1	1
Minicoy	1	—	—	—	1	—	—	1	—	—	—	1

TABLE 8 (a)

Percentage frequencies of stable layers (00 GMT)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Srinagar	51	33	39	34	35	60	38	29	65	55	72	66
Amritsar	100	100	96	99	96	91	48	45	63	88	98	95
New Delhi	96	95	91	95	93	67	46	32	71	95	98	96
Lucknow	100	100	100	100	100	81	37	32	72	97	100	100
Gauhati	97	94	95	89	64	40	39	32	53	72	90	99
Jodhpur	92	89	95	70	87	52	17	23	31	90	88	86
Ahmadabad	97	92	93	83	80	31	12	8	41	90	96	96
Calcutta	100	98	93	100	89	51	25	23	25	64	90	100
Nagpur	100	100	99	96	80	53	41	42	57	97	94	92
Bombay	95	97	97	100	83	33	13	23	39	90	93	92
Vishakhapatnam	39	68	64	69	64	34	23	24	23	34	24	34
Madras	62	90	76	62	65	42	51	61	47	60	54	57
Bangalore	50	72	51	39	43	28	24	22	22	36	39	43
Port Blair	48	66	69	66	47	34	37	36	39	46	44	37
Cochin	60	55	40	39	31	30	20	15	16	22	41	65
Trivandrum	33	32	29	23	16	13	17	12	9	21	32	29

about 80 to 90 per cent. South of Bombay latitude, the frequency is higher along the east coast with 65 per cent at Madras and lowest in Trivandrum area with only 16 per cent. The elevated station of Srinagar shows the same frequency of about 35 per cent in all the months March to May.

Southwest monsoon season (June to september)— With the setting in of the monsoon during June over most of the country, there is marked decrease in frequency at most of the stations. At New Delhi, it is only 67 per cent, 26 per cent less than in May. Gauhati shows a similar decrease with only 40 per cent frequency. Where the

TABLE 8 (b)

Percentage frequency of stable layers [Table 8(a)] *minus* percentage frequency of ground inversions (Table 1)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Srinagar	38	25	11	11	11	13	13	13	11	14	6	13
Amritsar	5	3	6	3	3	3	24	17	14	7	3	0
New Delhi	7	4	5	4	5	16	27	15	12	0	1	3
Lucknow	10	5	2	5	9	43	31	21	36	13	4	3
Gauhati	6	7	17	30	40	31	32	26	40	20	16	8
Jodhpur	13	4	22	16	41	48	16	22	24	10	6	11
Ahmadabad	0	1	10	21	35	27	11	7	23	6	1	1
Calcutta	16	14	24	45	72	45	22	20	20	29	15	9
Nagpur	5	3	3	1	8	18	29	25	19	3	2	3
Bombay	3	6	16	32	60	24	10	14	16	14	4	3
Vishakhapatnam	25	24	34	53	55	25	22	16	12	10	7	17
Madras	16	35	42	47	51	24	22	30	26	24	21	26
Bangalore	27	16	16	18	28	24	24	21	20	16	21	25
Port Blair	18	18	16	20	17	20	16	17	15	10	16	18
Cochin	5	16	24	27	21	24	18	13	12	13	16	16
Trivandrum	15	14	15	13	11	7	14	9	7	11	14	15

TABLE 9 (a)

Percentage frequencies of stable layers (12 GMT)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Srinagar	39	16	5	4	2	6	4	2	—	4	3	12
Amritsar	30	31	21	30	20	12	6	14	8	14	29	28
New Delhi	20	10	3	3	4	9	8	6	4	11	31	34
Lucknow	43	14	6	2	5	5	10	6	4	6	23	24
Gauhati	57	40	30	20	16	30	22	20	20	31	53	50
Jodhpur	5	3	2	—	1	1	9	2	4	7	3	6
Ahmadabad	3	—	1	—	1	2	1	—	—	2	1	—
Calcutta	58	45	51	48	41	30	16	9	18	14	44	64
Nagpur	3	1	1	1	4	8	11	6	13	12	15	7
Bombay	26	47	62	69	83	25	7	8	7	26	16	21
Vishakhapatnam	12	27	40	60	47	34	14	10	7	6	2	16
Madras	19	25	35	28	18	8	7	4	7	6	14	20
Bangalore	5	1	1	2	5	1	1	2	2	2	4	2
Port Blair	16	21	14	8	14	14	11	20	20	21	17	22
Cochin	5	11	32	20	14	7	5	7	9	7	6	4
Trivandrum	6	9	8	9	8	7	3	3	3	6	4	5
Minicoy	8	19	14	12	6	7	1	3	3	3	3	4

onset of monsoon is delayed beyond June as at Amritsar, the frequency continues to be high. At Bombay, the frequency is only once in three days. In fact, most of the Peninsular area south of Bombay has a frequency of only about once in three days or less as at Trivandrum where it is once in a week.

July & August — These are the rainiest months over most of the country. Everywhere the frequency of stable layers is low but at Madras it is still 50 to 60 per cent. At Ahmadabad the frequency is very low about 10 per cent only. The frequency at Jodhpur is 20 per cent. Notwithstanding the good monsoon conditions, the frequency is as high as 30 to 40 per cent at Gauhati and Lucknow and 40 per cent at Nagpur.

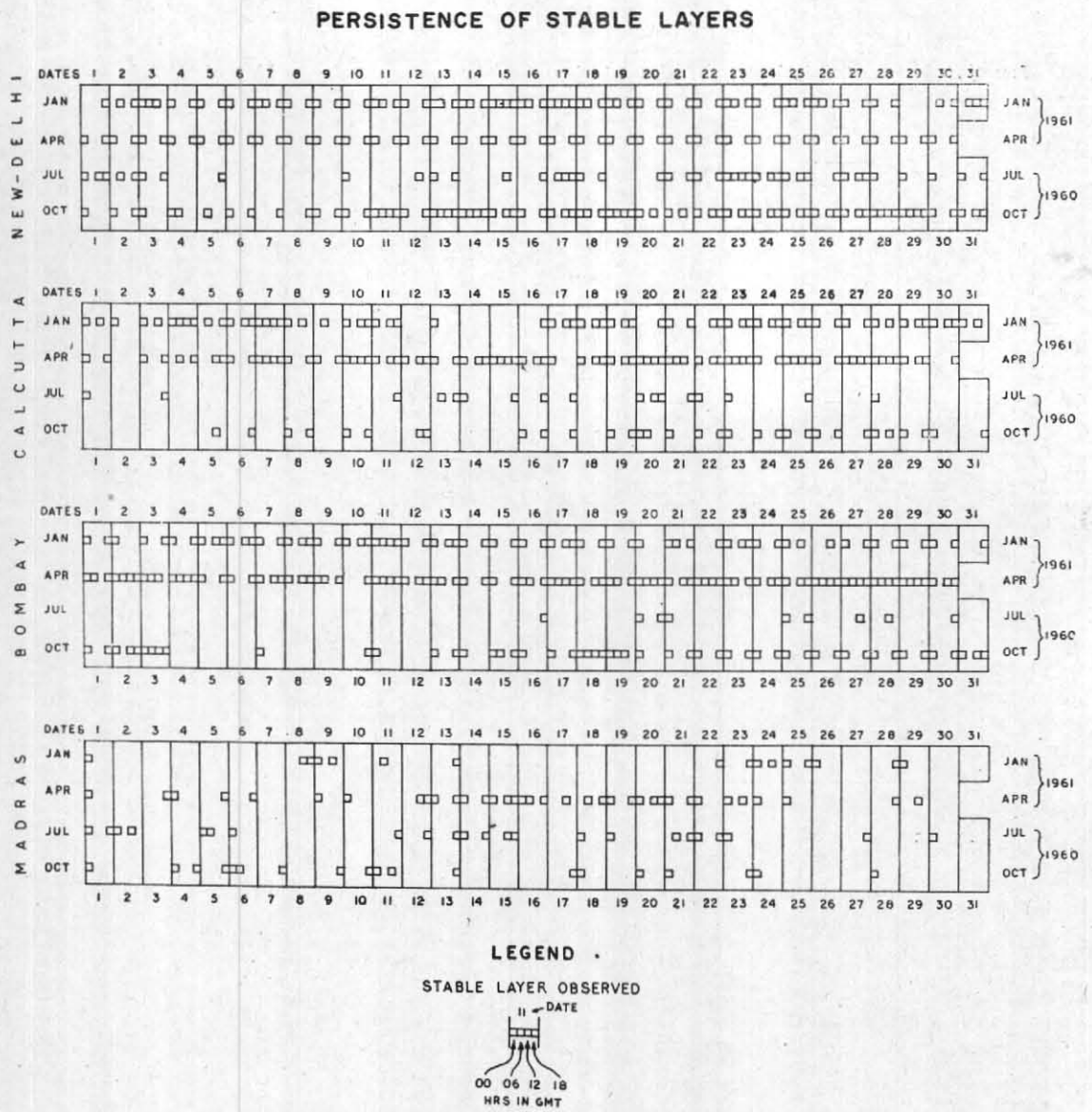

Fig. 5

September — With the withdrawal of the monsoon over northwest India in this month, the percentage frequency rises steeply to 70 at New Delhi and Lucknow. In the southern latitudes, the changes are not as marked. At Madras the percentage has diminished from 61 to 47 while at Trivandrum and Cochin, there is no significant changes.

Retreating (N.E.) monsoon season (October to December)—During this season, the general pattern north of Bombay latitude is practically the same as in January-February with almost daily occurrence of stable layers. Interestingly Vishakhapatnam has an average frequency of about 30 per cent nearly the same as in the S.W. monsoon (26 per cent). In the case of Madras, the average for October to December is higher by 7 per cent over the average of 50 per cent for the southwest monsoon season, though the former is the rainiest period for Madras. Trivandrum shows twice the average of S.W. monsoon for November-December (30 per cent).

4.2. *Analysis of four ascents daily*

The percentage occasions when two to eight consecutive ascents had stable layers (within 1 km above ground) are shown in Fig. 5.

It may be added that stable layers persisted for 9 to 11 consecutive hours of observations

TABLE 9 (b)

Percentage frequency of stable layers [Table 9(a)] *minus* percentage frequency of ground inversion (Table 7)

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Srinagar	38	16	5	4	2	2	2	2	—	4	1	11
Amritsar	16	21	14	10	6	8	5	13	4	4	12	23
New Delhi	19	9	3	2	1	6	7	5	3	6	29	33
Lucknow	41	13	6	2	5	5	10	6	4	4	18	20
Gauhati	21	15	9	15	15	23	18	18	19	16	25	19
Jodhpur	5	3	0	—	1	1	8	2	4	6	2	4
Ahmadabad	3	—	0	—	1	1	1	—	—	2	1	—
Calcutta	22	15	22	41	36	27	15	8	18	10	21	32
Nagpur	2	0	0	1	3	3	7	5	8	4	5	4
Bombay	19	41	54	61	80	24	6	6	7	21	15	19
Vishakhapatnam	12	24	38	59	46	28	11	8	7	5	2	16
Madras	15	24	34	27	17	7	6	3	5	5	11	18
Bangalore	5	1	1	1	2	0	1	1	2	1	3	2
Port Blair	10	13	13	6	9	11	6	13	12	12	10	12
Cochin	5	11	32	20	13	6	5	6	9	6	6	4
Trivandrum	6	9	8	8	7	7	3	2	3	5	3	4
Minicoy	7	19	14	12	5	7	1	2	3	3	3	3

during 3 occasions in January and October over New Delhi and 2 occasions over Dum Dum (Table 8a). Over Bombay, a case of stable layer persisting for 19 consecutive hours of observations (12 GMT of 25 April to 00 GMT of 30 April 1961) has been noticed.

5. Ground Inversions and Isothermal Layers

By including under 'ground inversions', layers which are isothermal or have a lapse rate less than 2°C/km the frequency increases very considerably. Tables 8 (b) and 9 (b) show the differences. Some of the main features are briefly referred to.

In January-February, the increase is marked 15 to 25 per cent generally at stations south of 18°N (Peninsula). Srinagar registers also substantial increase as compared to the near absence when only inversions excluding stable layers were considered. The change during March to May is marked. The increase at Calcutta, Vishakhapatnam and Madras is as high as 47 per cent. During this season, May is the month of maximum increase, the rise in frequency being as high as 50 to 70 per cent.

When we come to the SW Monsoon season also, a general rise of 20 to 30 per cent frequency is noted all over the country.

A study of afternoon ascents reveals substantial increase at Gauhati, Calcutta, Bombay and Madras in many of the months. In the winter months, the frequency rise is also noted at Lucknow, New Delhi and Amritsar.

6. Concluding Remarks

In this paper an attempt has been made to provide basic information on inversions including isothermal and layers with lapse rates less than 2°C/km. The main features have been analysed and summarised. The figures bring out clearly the preponderance of inversions in northern India during November-March. In order to study the subject in greater detail a network of stations with more frequent low level ascents would be required.

Acknowledgement

The authors are thankful to Dr. P. Koteswaram, Director General of Observatories for the suggestion of the problem and for useful comments during the study. Thanks are also due to Dr. Bh. V. Ramana Murty for going through the paper and to the members of staff of the Upper Air Section who helped in data compilation and the preparation of the diagrams.