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Variation of static stability measure in the atmosphere over India

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ABSTRACT. Static stability measure (σ) plays an important role in the construction of dynamic models for numerical weather prediction. In the present study, monthly normal values of σ have been computed for different levels of the atmosphere for 14 radiosonde stations in India. It has also been computed for a few depressions/storms and the values compared to the normal values. Vertical, horizontal and seasonal variations of σ have also been discussed.

1. Introduction

In the construction of dynamic models for prediction of weather, the static stability parameter σ plays an important role. Thus, in quasi geostrophic models, σ enters as a coefficient for vertical velocity. The equations of conservation of vorticity and the first law of thermodynamics are written as

$$\nabla^2\phi_t + f\,\overline{V}\,\nabla\eta = f^2\omega_p \qquad (1)$$

$$\phi_{pt} + \overline{V}\,\nabla\phi_p = -\sigma\omega \qquad (2)$$

where the symbols have their standard meanings. The static stability parameter σ is given by

$$-\frac{1}{\rho}\ \frac{\partial}{\partial p}\ln\theta = \frac{1}{\rho\theta}\ \frac{\partial\theta}{\partial p} \qquad (3)$$

θ being the potential temperature.

In all calculations of ω values, σ values have to be computed separately. As shown by Danard (1966) it suffices, in many cases, to utilise the normal values of σ instead of computing it for specific cases. In the present paper, an effort has been made to provide the normal values of σ for all the months at different atmospheric levels over India. The vertical, horizontal and seasonal variations are also discussed. In addition, the σ values for a few depressions have been computed and compared with the normal values for corresponding months.

2. Method of computation

We know, potential temperature,

$$\theta = T(p_o\,/\,p)^k,$$

where $k = R/C_p$, p_o = 1000 mb and p is any other pressure level. R stands for specfiic gas constant for dry air. From here, we find,

$$-\frac{\partial\theta}{\partial p} = (p_o/\,p)^k\frac{1}{\rho g}\,(\gamma_d-\gamma), \qquad (4)$$

where γ_d is the dry abiabatic lapse rate g/C_p Also, $\gamma = -\,\partial T\,/\,\partial z$ stands for the lapse rate. Then the stability parmeter

$$\sigma = -\ \frac{1}{\rho\theta}\ \frac{\partial\theta}{\partial p} = \frac{1}{\rho^2 Tg}\,(\gamma_d-\gamma) \qquad (5)$$

Substituting for ρ from $P = \rho RT$,

$$\sigma = \frac{R^2\,T^2}{P^2 g}\,(\gamma_d-\gamma) \qquad (6)$$

The unit of σ is cm^4 sec^2 gm^{-2}

3. Data utilised

The radiosonde data for 14 Indian stations, were extracted from the values available in *Normals of Climate Temp.* The data for the depressions were obtained from radiosonde data of respective stations. The normals of temperature for many of the stations, are not available above 100 mb and as such the σ values could not be computed for these levels.

4. Results

Vertical variation of σ

(*a*) The computed values of σ for 14 radiosonde stations for different levels are presented in Table 1. In calcualtion, simple average values of upper and lower level pressures and temperatures were used for substitution for P and T in Eq. (6). The value of γ_d was taken to be 9·8°C/km and the standard value of R as 2·87 × 10^6 erg/gm/°K

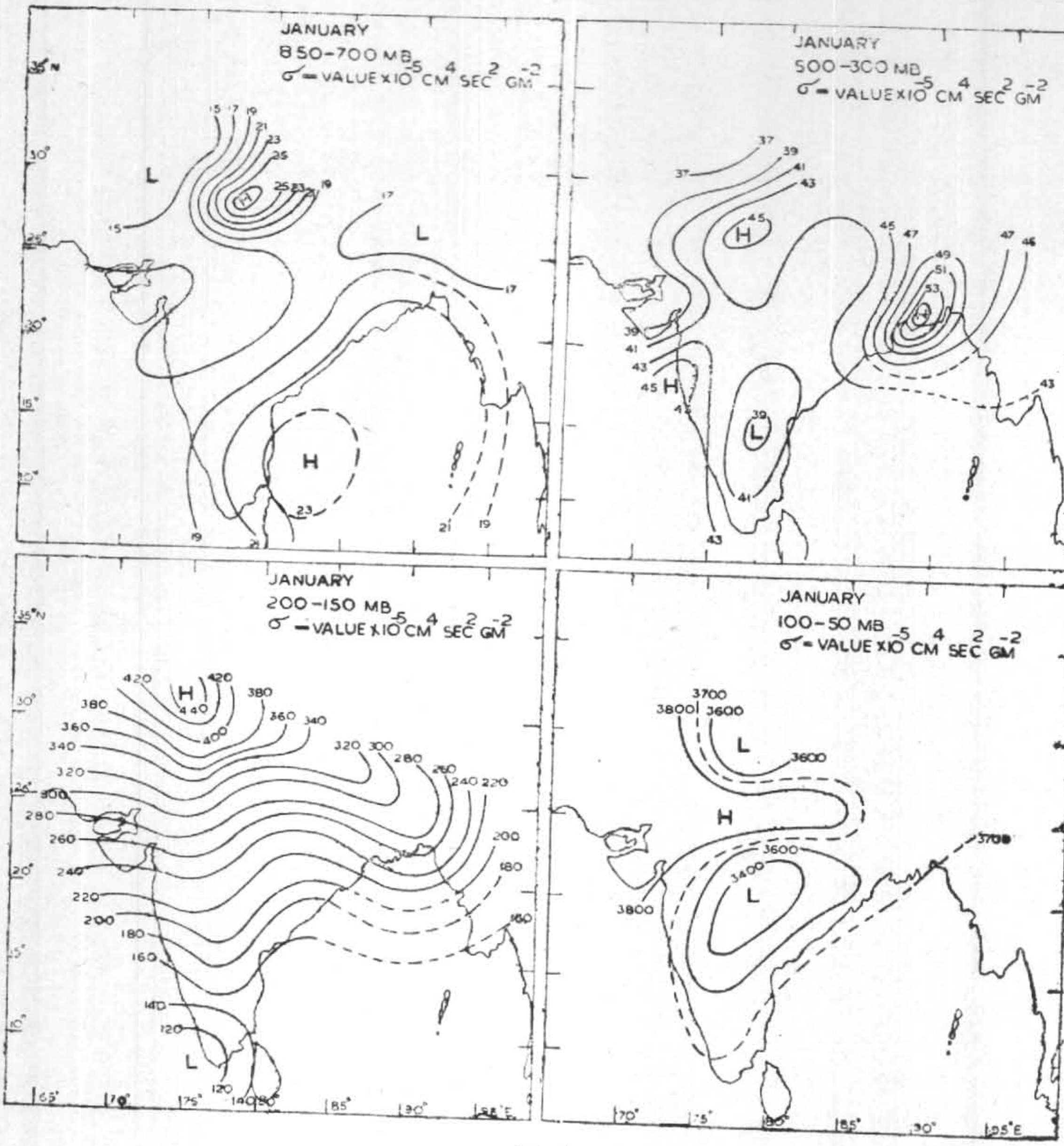

Fig. 1

(*b*) In general, it is found that the stability parameter increases rapidly as the height increases. This can be attributed mainly to the pressure or density bias of the formula used for the computation. Thus above 700 mb, it becomes nearly twice the value at 300-mb level. Higher up, in the lower stratosphere upto 50 mb, there is rapid increase, σ becoming 300 to 400 times of its value at the surface level. It thus becomes apparent that this static stability measure provides non-uniform representation of the stability of the atmosphere, but brings out the more stable nature of the stratosphere by providing large values of σ there.

(*c*) In the layer 850-700 mb, the stability parameter shows a tendency to fall during certain months. Thus for an inland station like Nagpur, σ values is less than that between surface and 850 mb, during the months of February to April. For a coastal station like Bombay, it is so during the months of October to May. But Trivandrum, also on the west coast like Bombay, does not show this phenomena. On the east coast, Madras and Calcutta show a fall in σ at the same level during March, April and May. Visakhapatnam shows this fall between March and June. For a sea-locked station like Port Blair, this effect is absent. From this it seems that in most cases this instability is due to surface heating during the premonsoon months. In most cases it ceases by June. It also brings out the fact that this layer is more unstable than the layer below it, which is in contact with the ground. For some

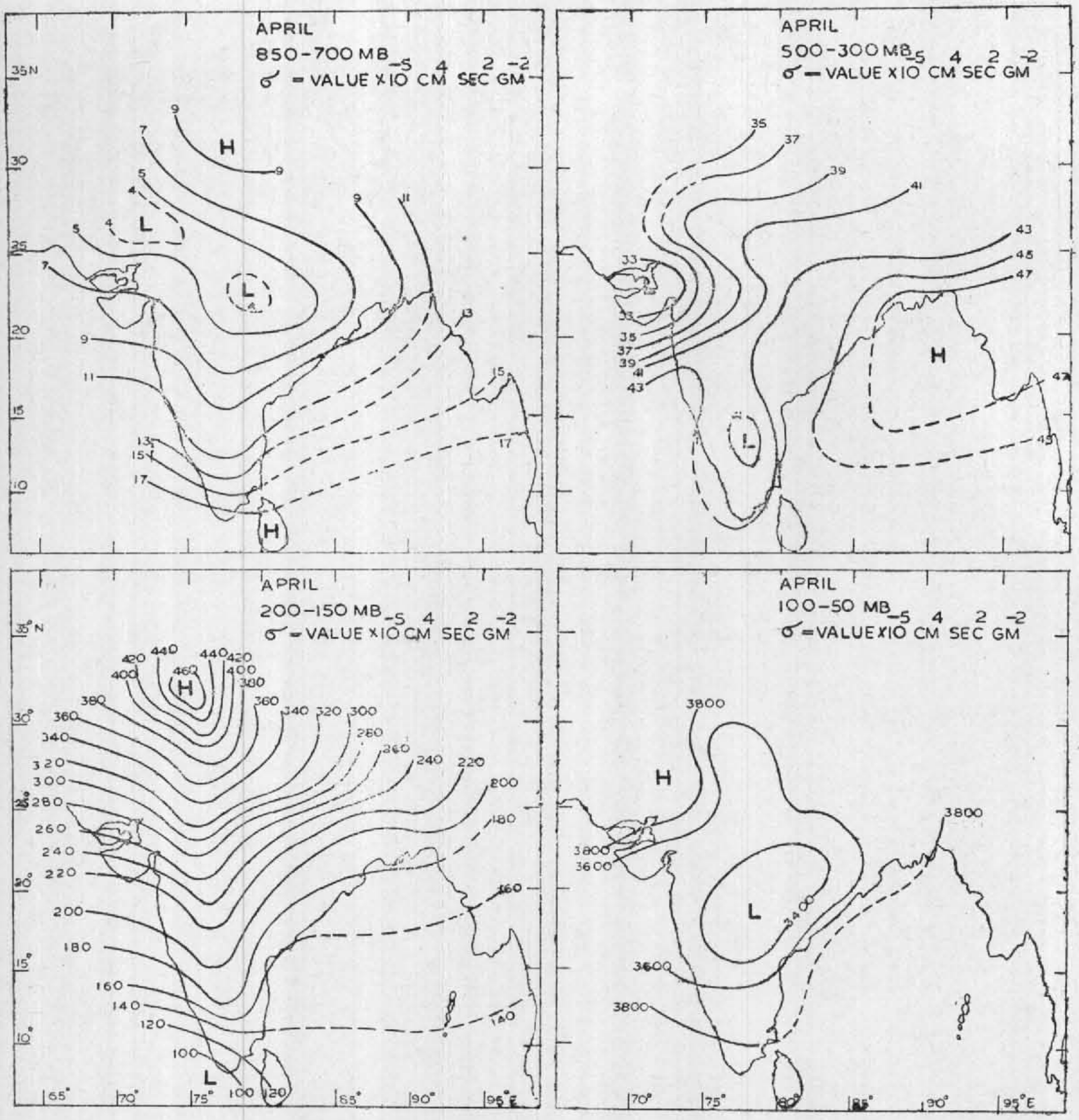

Fig. 2

stations, this effect is prominent during winter months also indicating that the lowest layer may be comparatively more stable due to temperature inversion, compared to the 850-700 mb level.

(*d*) The order of magnitude of static stability parmeters over the Indian region compare favourably with those calculated for USA (Gates 1961).

Horizontal variation of σ

(*a*) The analysed values of σ at four layers, *viz.*, 850-700, 500-300, 200-150 and 100-50 mb, over the Indian region are shown in Figs. 1 to 4.

It will be seen that during January at 850-700 mb level, the stability is maximum over Delhi area. Another area of high stability is near Madras. Rest of the areas are regions of comparative less stability. At the next higher level, Calcutta and adjoining areas are having the highest stability. The high stability centre near Delhi is still present, but the gradient of stability around it is very much reduced. The high σ region near Madras has disappeared, but another has appeared near Bombay. A significant lowering of stability is observed near Bangalore. At 200-150 mb level, the cellular structure of stability values, has completely disappeared. A well marked stability gradient exists from the south to the north. At the next higher there are two centres of low stability index, one over the central parts of the country and the other to the

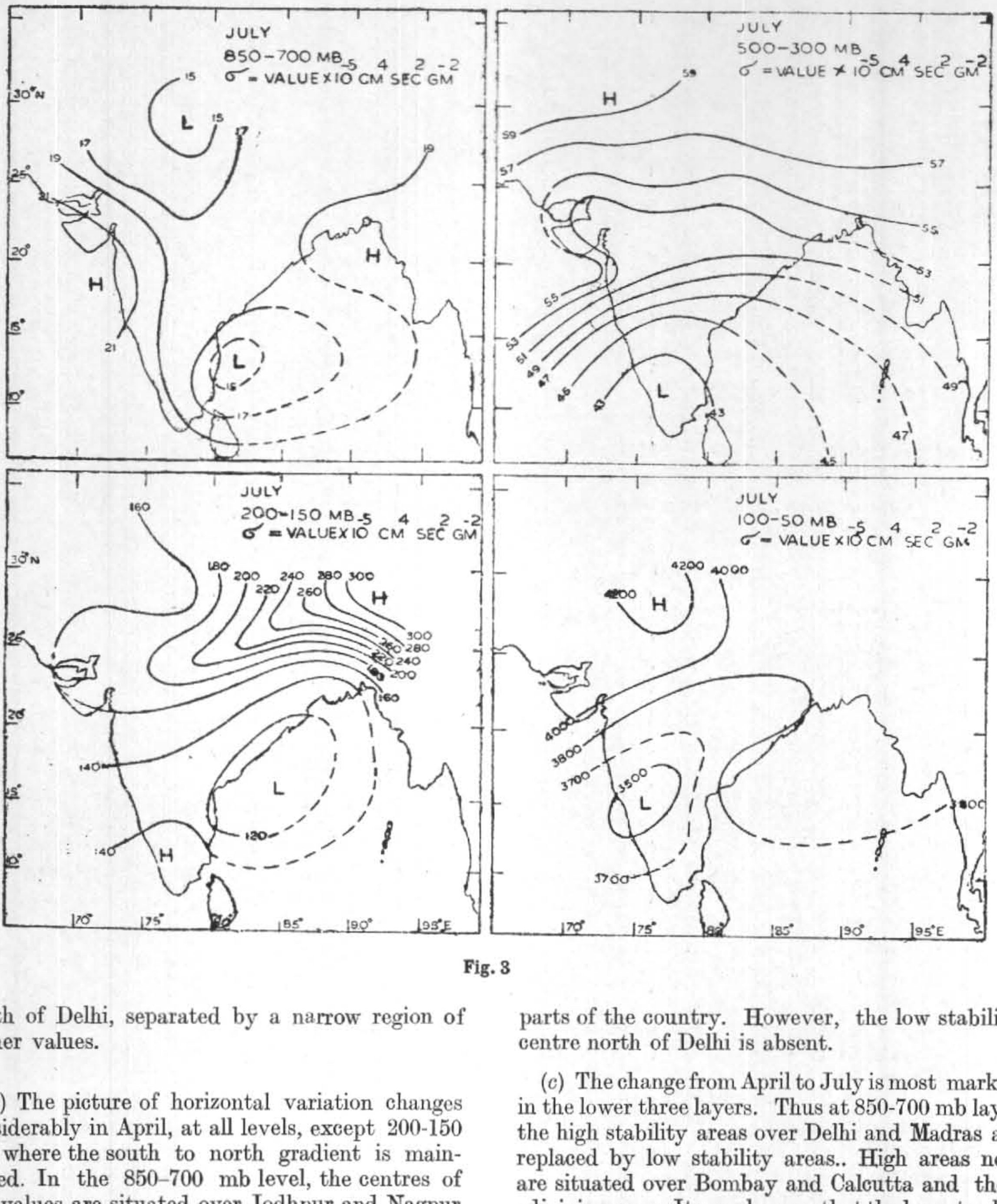

Fig. 3

north of Delhi, separated by a narrow region of higher values.

(*b*) The picture of horizontal variation changes considerably in April, at all levels, except 200-150 mb, where the south to north gradient is maintained. In the 850–700 mb level, the centres of low values are situated over Jodhpur and Nagpur areas, with comparatively higher values all around. But in comaprison to January, the air mass at this level is much less stable. This should be expected also, due to the general heating of the lower layers in summer and consequent thermal instability produced. At the 500-300 mb level, the general pattern is almost similar to that in January except that the core of high σ values near Calcutta is broken down, as is the cell near Delhi. The situation is similar to that in January at the 100-50 mb layer, with the lowest σ values at the central parts of the country. However, the low stability centre north of Delhi is absent.

(*c*) The change from April to July is most marked in the lower three layers. Thus at 850-700 mb layer the high stability areas over Delhi and Madras are replaced by low stability areas.. High areas now are situated over Bombay and Calcutta and their adjoining areas. It may be seen that the lowest value of σ have increased form 4×10^{-5} to 15×10^{-5} units and the highest values have increased from 17×10^{-5} to 21×10^{-5} units, indicating that in general, the layer has become more stable.

In the 500-300 mb level highest values of σ are situated over the northern parts of the country and lowest values over the southern parts. The stable cell over Calcutta and the north Bay of Bengal has disappeared. The gradient of σ has been completely reversed compared to the previous month.

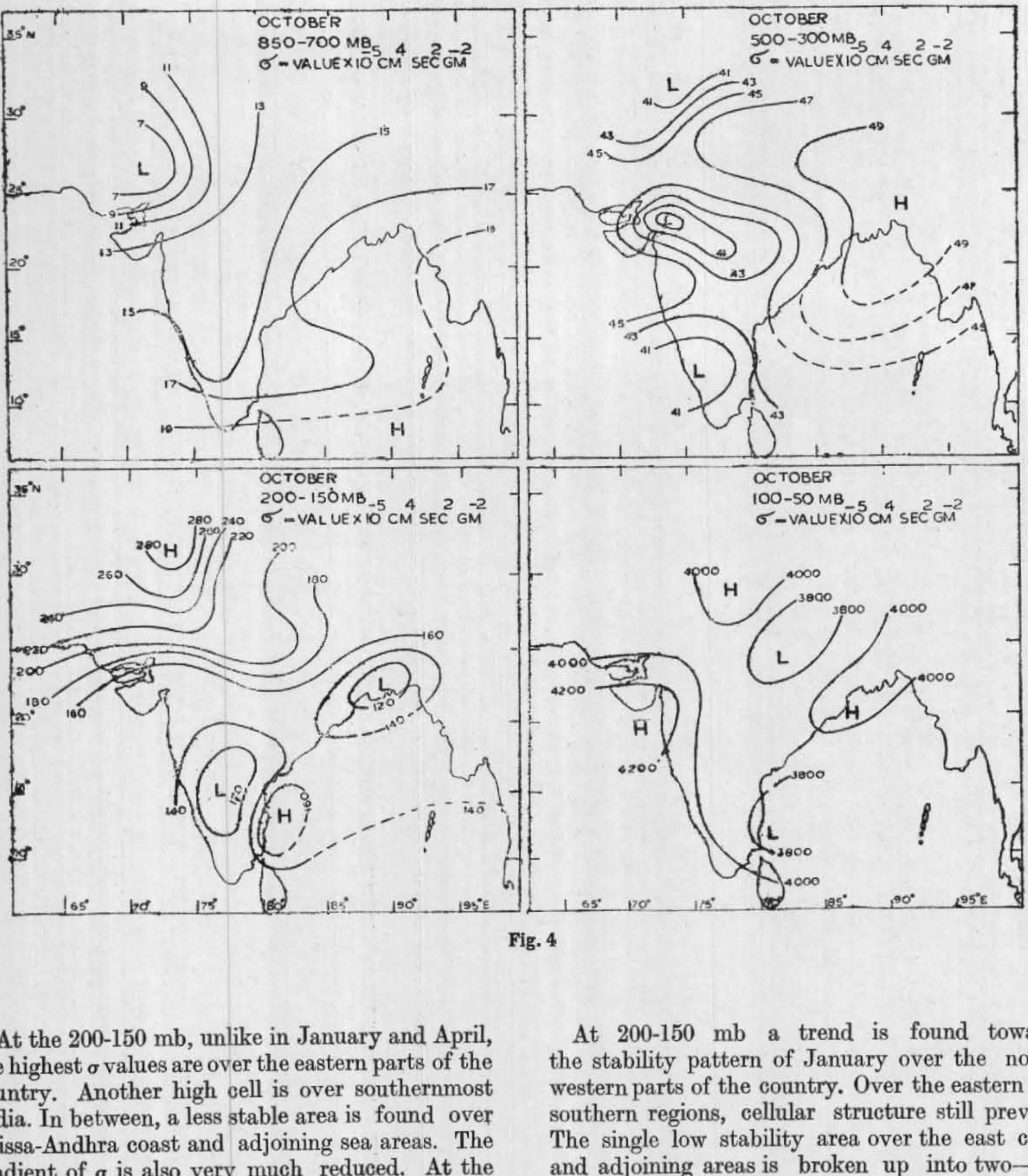

Fig. 4

At the 200-150 mb, unlike in January and April, the highest σ values are over the eastern parts of the country. Another high cell is over southernmost India. In between, a less stable area is found over Orissa-Andhra coast and adjoining sea areas. The gradient of σ is also very much reduced. At the next high layer, the pattern of April is generally maintained.

(*d*) In October, the 850-700 mb σ values are lowest over Rajasthan, gradually increasing towards the south. The low stability area over Orissa-Andhra coast has disappeared.

The structure has become more cellular at the 500-300 mb layer, with a cell of low σ values over Gujarat area and another over Mysore and Kerala areas. A third region of low stability lies to the northernmost parts of the country. The high stability area is situated over eastern parts of the country and adjoining sea areas.

At 200-150 mb a trend is found towards the stability pattern of January over the north-western parts of the country. Over the eastern and southern regions, cellular structure still prevails. The single low stability area over the east coast and adjoining areas is broken up into two—one lying over Calcutta region and another over Bangalore. A high σ cell is also observed off Madras.

The cellular structure is seen to be most prominent at 100-50 mb layer, with more stable air over Delhi, Calcutta and Ahmedabad areas and less over Allahabad and Madras regions.

5. Stability parmeter for depressions

In order to find the nature of variation undergone by the stability parameter with the approach of depressions or storms a number of case studies of recent storms were made. The stability parameters were computed from radiosonde data of stations

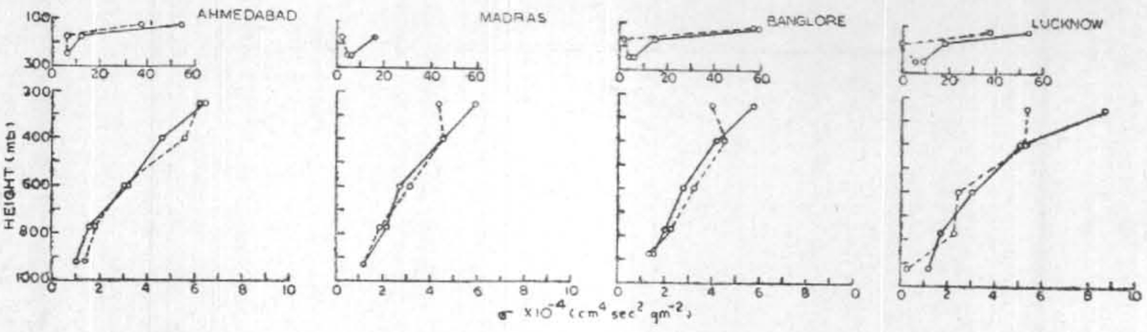

Fig. 5 Fig. 6 Fig. 7 Fig. 8

which were in the grip of the storms. Four representative cases are discussed here.

(*a*) *Case study 1* (*Fig. 5*) — The depression, which was situated over Ahmedabad on 00 GMT of 7 September 1970, caused widespread havoc in that area. In Fig. 5, stability indices are plotted with height. For comparison, the normal values of σ for September are also shown. It will be seen that upto 680 mb, the static stability in the depression is actually greater than the normal. In the 680-560 mb layer σ is less than normal. But between 560-280 mb σ is again greater than the normal. Higher up, upto 125 mb, the stability parameters are appreciably lower than the normal values.

(*b*) *Case study 2* (*Fig.* 6) — This was a depression which crossed Madras coast on the evening of 20 November 1970. It moved across the Peninsula, emerged into the Arabian Sea and developed into a cyclonic storm. In Fig. 6, the stability parameter for Madras for 20 November is shown against the normals of Madras for November. It is seen that upto 700 mb, the stability parameter is lower than normal. Then upto 400 mb it is more stable than normal. Higher up, the strom is more unstable than the normal atmosphere.

(*c*) *Case study 3* (*Fig. 7*) — The depression of the preceding case affected Bangalore the next day and the stability parameters for Bangalore are given in Fig. 7 together with the normal σ values of Bangalore. In this case the layers below 850 mb and those above 380 mb are less stable and the intermediate levels are more stable than the normals.

(*d*) *Case study 4* (*Fig. 8*) — This is the depression which was centred near Lucknow on 12 September 1970. It caused torrential downpour and heavy damage in Uttar Pradesh. The stability parameters for this system are compared with the normal σ values of Allahabad for September. Here the layer upto 830 mb is very much less stable than normal. There are alternate layers of higher and lower stability values till 400 mb, above which all layers upto 125 mb are less stable than normal.

A study of these four cases, though not sufficient, do bring out certain common features. In all cases of storms/depressions, the layers above 300 mb are invariably less stable than the normal values. It is seen that generally the lowest level is less stable than normal and more intense is the storm, more is the departure from the normal values. Also there is atleast one layer inside the storm, which is more stable than the normal atmosphere.

A comparison of the actual numerical values of σ in storms and the normal values indicates that the normal values can be used in calculations involving storms, upto 300-mb level, as the order of these values are similar. However, above 300 mb, values of σ considerably higher than the normals are to be used. But in numerical prediction of rainfall, the layers above 300 mb are normally neglected and as such, use of normals of σ in such cases will give a good approximation (Danard 1966).

6. Conclusion

The main results of this study may be summarised as follows—

(*i*) The static stability parameters, for different layers of the atmosphere, have been computed for 14 radiosonde stations in India. These compare favourably in order of magnitude with values obtained for other parts of the world.

(*ii*) The parameter shows a rapid increase in value with height. However for the 800-700 mb layer, it shows a lowering during certain months of the year.

(*iii*) The horizontal and seasonal variations in the value of the parameter bring out a cellular distribution over most of India. Only at 200-150 mb, during January and April, it shows a steep gradient from one end of the country to the other.

TABLE 1

Monthly values of static stability parameter σ in 10^{-5} cm^4 sec^2 gm^{-2}

Pressure level (mb)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
					Ahmedabad							
Surface-850	15·36	14·04	12·49	12·14	10·99	7·78	10·16	9·85	10·21	11·90	13·70	15·69
850-700	17·47	12·71	8·13	6·88	6·65	14·37	20·14	21·84	15·76	12·17	15·13	16·32
700-500	24·88	20·98	20·53	18·07	20·71	25·51	28·71	28·58	32·39	28·82	24·62	24·81
500-300	38·78	42·57	38·93	32·05	49·05	50·43	50·96	49·21	46·66	38·88	20·77	22·55
300-200	73·48	106·79	114·70	131·63	98·44	83·78	77·93	71·28	65·05	78·18	136·47	142·02
200-150	283·94	244·29	268·34	266·40	178·18	139·35	173·85	119·79	125·20	151·60	214.17	244·05
150-100	695·63	667·42	661·98	734·27	527·60	519·27	488·66	520·36	544·80	602·48	688·76	712·03
100- 50	3878·07	—	3719·88	—	4069·81	4049·75	4016·28	4134·12	4154·98	4193·75	3856·33	3763·65
					Allahabad							
Surface-850	15·00	18·14	9·66	9·00	13·60	11·81	11·71	12·93	12·39	13·99	17·32	20·79
850-700	17·87	13·44	7·94	5·68	3·85	9·01	17·89	18·51	16·21	14·86	21·50	20·53
700-500	19·17	21·98	23·71	17·03	17·42	24·69	30·62	26·80	30·18	29·52	24·20	24·64
500-300	38·78	46·05	37·44	42·23	51·55	32·24	54·76	53·31	51·63	47·04	43·76	39·61
300-200	73·43	127·80	145·60	135·70	104·10	100·40	83·56	86·64	87·21	88·12	102·57	112·90
200-150	284·10	314·30	378·90	319·00	229·20	184·97	224·20	164·40	175·20	200·80	226·00	274·20
150-100	696·00	680·80	623·10	631·80	560·30	468·50	439·70	493·80	533·80	585·60	701·60	771·80
100- 50	3879·00	3798·00	3438·00	3622·00	3957·00	3906·00	3996·00	—	3822·00	3715·00	—	—
					Amritsar							
Surface-850	20·13	19·21	20·90	18·23	19·08	17·83	14·64	13·45	15·28	17·06	20·36	21·61
850-700	14·72	12·55	9·64	8·86	6·44	8·67	15·18	16·96	14·59	10·97	21·90	17·28
700-500	19·53	20·57	14·85	15·51	14·41	14·35	28·61	27·01	24·47	20·69	12·75	21·97
500-300	36·52	44·75	34·38	33·76	42·14	54·21	59·14	56·01	50·42	40·65	34·33	34·24
300-200	170·53	173·28	142·01	115·69	129·48	105·90	80·29	80·44	98·86	119·54	128·73	123·32
200-150	452·07	386·86	465·18	462·87	391·90	237·81	159·22	186·56	189·25	283·05	387·20	451·91
150-100	—	904·71	803·09	871·66	726·42	632·48	—	568·96	611·90	754·88	922·21	—
100- 50	—	—	—	—	—	—	—	—	—	—	—	—
					Banglore							
Surface-850	13·29	16·10	15·16	14·24	12·00	10·68	8·59	11·61	9·99	12·37	14·43	18·72
850-700	21·59	13·61	8·45	10·57	12·79	16·02	17·38	17·65	16·77	14·93	19·49	20·93
700-500	27·00	28·53	27·63	24·44	25·99	27·41	28·11	29·10	27·38	29·47	27·34	26·41
500-300	39·24	39·48	39·85	40·95	45·98	42·89	42·58	42·06	48·74	40·37	41·61	38·40
300-200	60·27	59·28	58·45	65·84	64·23	74·28	65·70	67·37	49·12	55·79	56·72	64·67
200-150	160·48	166·46	181·06	191·01	150·33	159·98	148·83	134·97	144·52	109·98	149·79	169·57
150-100	577·46	602·45	601·00	591·18	515·34	547·39	644·42	649·32	648·86	673·92	585·11	594·89
100- 50	3619·34	3598·14	3649·98	3674·48	3732.46	3881·98	3670·51	3880·12	4048·73	3969·49	3834·14	3759·91

TABLE 1(*contd*)

Pressure level (mb)	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
						Bombay						
Surface-850	17·66	19·47	19·94	20·12	16·09	10·21	11·05	11·28	11·55	14·46	18·40	16·55
850-700	16·40	12·84	10·50	10·57	14·24	20·21	21·36	22·96	20·11	14·10	14·50	16·65
700-500	26·17	28·80	12·39	19·93	22·72	29·82	34·34	32·41	32·31	31·56	28·28	26·25
500-300	45·28	42·74	43·82	42·64	51·24	54·41	55·88	53·19	51·58	47·22	42·87	41·31
300-200	96·72	98·09	102·70	99·82	88·65	73·30	76·74	79·68	94·56	75·58	64·60	83·95
200-150	220·30	184·30	226·20	214·60	138·00	114·40	145·20	163·50	156·40	143·00	208·10	213·00
150-100	587·20	596·00	587·80	553·00	508·40	463·80	444·90	559·70	630·10	572·70	596·50	628·40
100- 50	3747·00	—	3514·00	3497·20	—	—	—	—	4326·00	—	—	3770·00
						Calcutta						
Surface-850	16·55	15·25	14·70	16·15	16·25	11·45	12·75	12·45	12·50	12·52	14·20	12·85
850-700	21·00	16·80	9·60	7·30	11·10	16·90	20·50	20·40	19·10	18·50	23·80	29·80
700-500	21·30	26·20	22·70	21·40	23·20	27·70	30·90	30·30	29·40	28·20	27·30	26·80
500-300	56·60	50·70	45·50	47·80	52·60	54·90	53·60	47·10	50·20	49·80	43·60	43·80
300-200	116·00	108·50	127·50	112·50	91·80	73·50	79·50	87·40	86·00	78·90	94·50	197·70
200-150	256·00	254·00	233·00	184·80	162·50	96·70	127·00	124·00	114·00	108·50	174·50	193·30
150-100	356·00	634·00	683·00	584·00	505·00	484·00	456·00	520·00	428·00	550·30	607·00	644·00
100- 50	3680·00	3930·00	3710·00	3670·00	3857·00	3950·00	380·00	3850·00	4070·00	4120·00	3850·00	3655·00
						Delhi						
Surface-850	20·38	19·20	24·40	17·25	17·60	14·55	13·28	11·30	17·95	18·35	24·75	23·80
850-700	27·93	12·50	9·45	7·40	4·50	8·05	14·75	18·35	8·81	11·65	15·15	17·10
700-500	22·40	20·00	17·20	15·50	14·80	14·05	30·20	30·40	31·40	24·80	21·18	21·80
500-300	44·70	42·00	36·20	38·70	49·30	64·40	57·00	54·50	55·90	47·50	39·20	41·00
300-200	154·90	152·00	153·50	138·70	129·00	96·40	76·20	78·50	93·10	96·30	95·50	130·50
200-150	394·00	381·00	420·00	384·80	255·00	187·50	150·50	119·50	140·00	216·20	229·00	198·00
150-100	756·00	726·00	757·00	722·00	610·00	475·00	670·00	475·00	509·00	586·00	748·00	732·00
100- 50	3520·00	3940·00	3470·00	3581·00	3843·00	4030·00	4290·00	3960·00	4110·00	4050·00	3800·00	3420·00
						Gauhati						
Surface-850	16·30	15·00	15·66	14·51	14·37	13·17	12·58	12·65	13·50	13·48	15·49	16·82
850-700	15·82	12·08	10·14	12·31	14·84	18·12	18·92	18·65	17·59	16·47	15·18	16·78
700-500	31·98	30·06	25·02	25·82	29·40	30·76	31·17	30·83	29·40	28·53	31·34	31·65
500-300	48·06	49·98	43·26	42·10	52·96	55·68	56·89	55·00	52·12	49·62	44·80	40·99
300-200	125·27	142·44	145·01	124·44	103·57	98·28	88·51	78·52	89·52	85·38	108·79	133·72
200-150	280·63	270·32	311·14	223·72	196·17	137·42	302·42	167·65	184·48	167·86	209·53	276·69
150-100	—	804·89	713·28	681·46	487·62	389·44	316·28	527·27	491·27	610·50	763·48	690·54
100- 50	—	—	—	—	—	—	—	—	—	—	—	—

TABLE 1 (*contd*)

Pressure level (mb)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Jodhpur						
Surface-850	14·28	11·21	8·88	11·08	10·33	8·28	9·17	10·03	9·91	14·01	16·00	14·92
850-700	15·67	13·12	5·99	3·81	4·59	11·28	16·30	18·40	14·01	6·86	13·55	18·77
700-500	26·48	24·00	18·88	16·85	16·09	21·71	27·52	26·94	30·10	30·35	25·05	21·36
500-300	42·44	41·76	39·08	39·54	48·31	55·29	56·95	55·40	47·52	45·30	52·00	43·07
300-200	138·60	131·60	161·30	137·00	121·80	168·50	108·20	90·47	82·74	90·99	111·50	113·50
200-150	332·00	344·20	326·10	327·60	254·10	352·10	164·40	161·40	193·40	221·40	225·90	347·90
150-100	835·40	761·50	765·80	741·30	602·80	575·30	438·90	508·40	415·70	629·90	732·50	786·00
100- 50	—	—	3786·00	3887·00	4112·00	—	4099·00	4069·00	—	3917·00	3638·00	—
						Madras						
Surface-850	16·44	14·11	15·71	14·98	15·68	10·32	10·49	9·47	11·55	11·67	11·76	11·76
850-700	24·03	18·98	14·58	13·27	12·29	13·70	13·82	16·48	14·51	15·40	21·16	25·00
700-500	25·12	28·02	26·39	24·11	23·79	27·03	28·06	28·77	28·34	30·19	27·07	27·34
500-300	42·44	40·51	42·21	44·94	46·85	46·31	43·70	44·09	42·46	43·24	44·75	40·09
300,200	67·76	65·01	67·28	63·96	62·91	47·10	63·84	61·99	61·38	44·34	58·74	68·10
200-150	149·83	155·23	147·23	148·33	128·25	151·60	120·89	128·58	134·82	171·20	155·94	134·21
150-100	604·43	577·88	618·28	570·62	571·82	675·62	697·78	699·75	653·73	658·56	621·39	691·21
100- 50	3747·58	3645·38	3630·22	3713·38	3899·40	—	3783·19	3875·90	3912·37	3719·09	3964·89	3348·91
						Nagpur						
Surface-850	9·70	16·03	17·75	15·29	12·54	8·93	13·04	12·39	13·26	14·33	15·92	16·12
850-700	15·90	9·60	5·65	4·49	4·52	10·20	17·68	19·01	16·15	14·08	19·19	21·44
700-500	27·28	27·34	21·66	17·13	16·78	20·63	30·45	30·45	30·36	30·18	26·22	24·86
500-300	42·31	40·68	39·60	43·86	50·90	59·29	51·64	48·89	47·35	41·56	38·68	39·76
300-200	92·76	86·72	119·70	92·99	78·47	69·69	60·32	60·17	69·45	62·30	74·25	83·45
200-150	224·40	200·50	285·60	231·40	160·60	155·80	155·80	125·30	113·30	153·00	199·50	217·80
150-100	627·70	648·20	564·80	631·00	583·90	553·30	519·80	561·10	582·00	591·30	645·50	682·20
100- 50	3392·00	3524·00	3466·00	3373·00	3860·00	3526·00	3724·00	3717·00	3815·00	3892·00	3744·00	3567·00
						Port Blair						
Surface-850	10·91	12·72	12·79	12·53	13·20	13·54	13·33	13·30	13·12	13·47	12·70	11·12
850-700	21·86	20·22	18·09	17·46	18·74	18·69	18·63	18·33	19·81	18·80	19·29	21·87
700-500	26·77	20·82	27·30	27·69	28·29	26·56	27·89	27·95	27·60	27·57	27·46	27·28
500-300	41·38	50·81	48·18	44·87	48·23	51·28	46·51	45·47	43·38	43·88	42·54	40·40
300-200	61·99	62·95	41·88	59·60	62·23	55·18	60·13	57·39	65·41	43·46	52·54	67·27
200-150	151·27	141·79	167·28	141·39	127·00	129·49	143·03	191·16	110·31	125·26	111·98	179·12
150-100	645·60	599·35	593·96	553·77	561·14	529·42	693·46	666·37	730·45	709·91	650·67	467·91
100- 50	—	3760·69	—	—	—	—	3794·34	—	—	—	—	—

TABLE 1 (*contd*)

Pressure level(mb)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
						Trivandrum						
Surface-850	9·85	9·65	10·30	12·60	11·60	12·70	9·60	10·78	10·90	11·38	11·23	13·40
859-700	20·47	19·80	18·80	18·30	19·20	16·60	20·00	22·00	20·50	19·50	19·20	20·40
700-500	27·00	26·60	37·90	26·60	27·10	30·00	26·40	25·58	27·40	28·00	28·40	27·25
500-300	42·00	41·50	25·30	42·30	46·30	44·30	42·20	41·50	41·00	42·00	41·70	40·50
300-200	64·50	62·20	65·70	67·60	58·70	67·00	57·50	55·70	62·90	85·10	62·20	56·00
200-150	119·50	120·00	146·00	100·00	159·00	122·70	155·00	128·00	118·80	30·60	113·00	161·50
150-100	594·00	520·00	592·00	600·00	538·00	655·00	731·00	775·00	765·00	713·00	610·00	702·00
100- 50	3710·00	3790·00	3663·00	3947·00	4030·00	4030·00	3740·00	3930·00	4080·00	4030·00	3895·00	3550·00
						Vissakhapatnam						
Surface-850	12·36	14·11	17·10	18·11	17·47	17·07	12·96	12·59	12·58	11·68	11·43	12·75
850-700	21·68	14·91	10·63	9·91	11·80	10·99	17·36	17·08	17·03	18·13	22·12	22·97
700-500	27·27	27·96	25·42	22·51	20·92	25·05	28·15	28·88	28·33	27·65	26·63	26·45
500-300	42·80	44·57	42·73	44·83	50·31	50·08	47·04	49·90	52·94	47·00	41·35	41·51
300-200	78·98	60·66	87·02	79·42	72·81	67·47	66·79	59·07	40·77	54·44	60·43	68·33
200-150	166·00	170·55	208·17	163·75	142·57	124·75	116·76	112·24	132·64	141·43	156·66	168·15
150-100	585·26	610·82	569·59	566·96	525·00	536·38	596·82	618·93	620·71	597·11	641·64	537·19
100- 50	3644·38	3762·24	3499·98	3827·92	3903·94	4047·57	3847·15	—	3961·28	3917·31	3736·88	3750·89

(*iv*) A comparison with values of the parameter in storm fields to the normals show that the layers above 300 mb are generally less stable than the normal atmosphere. It also brings out the existence of at least one layer inside the storm field which is more stable than the normal.

(*v*) In calculations involving storm fields, the normal σ values can be used in place of actual values, without much loss of accuracy, upto 300-mb level.

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