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Some statistical relationships in upper air temperatures and pressures over Agra

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1. Introduction

In temperate latitudes, definite relationships have been established between the upper air temperatures in the troposphere and the stratosphere, the general pressure distribution in the troposphere and the level of the tropopause. Dines (1919) worked out many correlation coefficients and found that when a low pressure area passes across the British Isles of Europe, (*i*) the temperature of the air column from 1 to 9 km also falls, (*ii*) the value of height of tropopause decreases and (*iii*) the temperature in the stratosphere increases. As the depression moves away, (*i*) temperature in the troposphere increases, (*ii*) the height of the tropopause increases and (*iii*) the temperature in the stratosphere decreases. Working with Indian (Agra) data, Harwood (1921) found that the upper air pressure has a greater correspondence with the temperature than the surface pressure, the nature of this correspondence being in the same direction as that of pressure in Europe. Later, Gopal Rao (1931) made analysis of the relation between temperature and pressure at the same level over Agra in winter and the monsoon and found high positive correlation between pressure and temperature from 2 to 10 gkm in winter and 6 to 14 gkm in the monsoon. For Agra, Chiplonkar (1936), further found that there is no correlation between surface pressure and upper air temperature in winter while there is a negative correlation in other months. Following a graphical method, he also found that low pressures from 2 to 10 gkm are associated with high temperatures at and above 16 gkm and *vice versa* in winter while low pressures from 6 to 16 gkm are associated with high temperatures from 16 to 20 gkm in other months.

Bannon and Gilchrist (1956) evaluated a series of correlation coefficients for 4 stations, *viz.*, Lerwick, Larkhill, Arctic Bay and Aden, in order to find out for what range of latitudes the model found out by Dines is applicable to the atmosphere and the relative merits of the model for different latitudes and seasons and to find how high in the stratosphere the model is applicable. The object of this note is to find out whether in Agra* there exist relations between upper air temperatures and tropopause pressures and between upper troposphere and lower stratosphere analogous to those for temperate latitudes.

2. Data

All the sounding balloon data for Agra during the period 1926 to 1940 published in the *India Weather Reviews* for 1926-1927 and *Upper Air Data*, Part 14 or B of 1928–1940 have been used for this study.

3. Results

The following correlation coefficients have been worked out—

(*a*) Between the pressure at the tropopause (P_T) and temperatures at (*i*) 500 mb (T_{500})—which is approximately the mean temperature of the troposphere—and (*ii*) 6 levels in the stratosphere, *viz.*, 18 km, 20 km, 21 km, 22 km, 23 km, and 24 km. ρ has been

*Agra was chosen because the results of a large number of sounding balloon ascents made from there are available. The dates of the ascents were more or less random.

TABLE 1

		Pre-monsoon	Monsoon	Post monsoon	Winter
Correlation between P_T and T_{500}	n	111	112	75	124
	P_T	95	99	100	108
	T_{500}	263·3	272·4	256·5	259·8
	σP_T	11·7	16·4	14·0	16·2
	σT_{500}	3·5	2·9	3·1	2·7
	ρ	—0·04	—0·21*	0	—0·34†
Correlation between P_T and T_{18}	n	116	107	77	128
	T_{18}	199·2	197·3	200·9	203·6
	σT_{18}	4·2	5·2	6·6	4·8
	ρ	+0·33†	+0·56†	+0·08	+0·42†
Correlation between P_T and T_{20}	n	72	42	50	77
	T_{20}	207·3	207·4	207·6	208·2
	σT_{20}	4·6	6·1	4·9	6·0
	ρ	+0·30†	+0·48†	+0·29*	+0·32†
Correlation between P_T and T_{21}	n	41	32	33	53
	T_{21}	211·6	211·8	210·7	210·6
	σT_{21}	5·7	7·0	4·0	6·7
	ρ	+0·29	+0·34	+0·33	+0·41†
Correlation between P_T and T_{22}	n	24	14	18	39
	T_{22}	215·6	217·2	213·2	212·9
	σT_{22}	6·8	4·1	3·5	8·0
	ρ	+0·09	+0·50	+0·19	+0·34*
Correlation between P_T and T_{23}	n	14	11	12	25
	T_{23}	219·5	219·9	216·7	215·4
	σT_{23}	4·6	4·5	3·4	9·8
	ρ	—0·21	+0·34	+0·16	+0·25
Correlation between P_T and T_{24}	n	—	—	10	16
	T_{24}	—	—	219·0	216·2
	σT_{24}	—	—	3·1	11·1
	ρ	—	—	—0·14	+0·21
Correlation between H_{300} and T_{500}	n	109	109	71	114
	H_{300}	9·38	9·59	9·44	9·26
	σH_{300}	0·09	0·06	0·08	0·08
	ρ	+0·92†	+0·73†	+0·90†	+0·89†

*Significant at 5% level of significance † Significant at 1% level of significance

TABLE 1 *(contd)*

		Pre-monsoon	Monsoon	Post monsoon	Winter
Correlation between H_{300} and T_{100}	n	109	107	72	117
	T_{100}	199·2	195.2	198·1	203·4
	σT_{100}	3·7	4·5	4·5	4·5
	ρ	—0·31†	+0·42†	—0·44†	—0·25†
Correlation between H_{300} and T_{18}	n	101	91	60	103
	ρ	—0·26†	—0·12	—0·17	—0·27†
Correlation between H_{300} and T_{20}	n	66	40	42	63
	ρ	+0·08	+0·04	+0·10	—0·23
Correlation between H_{300} and T_{21}	n	38	32	27	45
	ρ	+0·35*	+0·19	+0·30	—0·10
Correlation between H_{300} and T_{22}	n	24	14	15	33
	ρ	+0·26	+0·29	+0·45	—0·01
Correlation between H_{300} and T_{23}	n	14	11	10	20
	ρ	+0·04	—0·05	+0·62	—0·10
Correlation between H_{300} and T_{24}	n	—	—	—	14
	ρ	—	—	—	—0·07

*Significant at 5 % level of significance

†Significant at 1 % level of significance

P_T =Pressure at tropopause in mb

T_{500} =Temperature at 500 mb in °A

T_{100} =Temperature at 100 mb in °A

T_{18} =Temperature at 18 km in °A

T_{20} =Temperature at 20 km in °A etc

H_{300} =Height at 300 mb in geodynamic kilometres

σ =Standard deviation

ρ =Correlation coefficient

computed only in those cases where the number of pairs of observations is more than 10.

(*b*) Between the height at 300-mb level (H_{300}) and the temperatures of all levels mentioned above and at 100 mb — which roughly corresponds to the tropopause level. They have been computed for the four seasons, *viz.*, pre-monsoon (March to May), monsoon (June to September), post monsoon (October to November) and winter (December to February). Table 1 gives the various correlation coefficients and their significance at 5% and 1% levels and the corresponding mean and standard deviations. In case of elements which occur more than once, the means and standard deviations have been given in the first instance only.

It will be seen that though a number of correlation coefficients are statistically significant under the Nul-hypothesis, the population values of these correlations are zero; correlations of high order as in the case of temperate latitudes are found only between H_{300} and T_{500} mb, others are less that 0·5, baring a few exceptions. Among the stratospheric correlation coefficients, only ρ between P_T and T_{18} and P_T and T_{20} reveal some continuity in sign and are statistically significant. In the post monsoon season, however, even the above are low. The correlation coefficients of P_T and H_{300} with temperatures at levels higher than 20 km are not at all significant except for 3 values.

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