Upper tropospheric circulation and thermal anomalies over central Asia associated with major droughts and floods in India

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The composite upper tropospheric (200 hPa) circulation and thermal anomalies during April to June were examined in respect of seven drought years (1965, 1966, 1968, 1972, 1974, 1979 and 1982), three flood years (1961, 1970 and 1975) and twelve normal years (1962, 1963, 1964, 1967, 1969, 1971, 1973, 1976, 1977, 1978, 1980 and 1981) using the upper air data of 21 stations of 22 years (1961–1982). There were significant differences between the anomalies during drought and flood years. The anomaly patterns during the normal years were similar to those of flood years but the anomalies were weaker. It was found that a cyclonic (anticyclonic) anomalous circulation with cold (warm) temperature developed over central Asia near Caspian sea during April of drought (flood) years. These anomalies persisted and strengthened during the later months. The cold cyclonic anomalous circulation adversely affects monsoon performance due to excess Eurasian snow cover and the large-scale intrusion of dry westerlies into Indian region.

THE diagnostic studies made by earlier researchers[1–3] on circulation and thermal features in association with fluctuations in Indian summer monsoon rainfall reported cyclonic (anticyclonic) circulation anomalies and cold (warm) thermal anomalies over northwestern parts of India during major droughts (floods).

Krishnamurti *et al.*[4] studied the summer monsoon of 1987 and found the evolution of a negative streamfunction anomaly at 200 hPa over Central Asia. This anomaly was found to be a major element in the drought scenario of 1987 summer monsoon.

The present study is therefore designed to examine whether such anomalies observed over central Asia were observed during other major drought and flood years and also to examine the aerial extent and phase. Anomalies at 200 hPa only were examined since the anomalies at this level are found larger.

Data used for the computation of circulation, thermal and height anomalies are respectively monthly mean vector winds, monthly mean temperature and mean heights of 200 hPa surface derived from the NOAA publication *Monthly Climatic Records of the World*. All India summer monsoon rainfall data were taken from Parthasarathy *et al.*[5], the Eurasian snow cover data were obtained from Climate Analysis Centre, Washington, USA. In the present study, the upper air data of 21 stations of 22 years (1961–1982) were used.

Circulation, thermal and height anomalies at 200 hPa surface were calculated monthwise from April to June with respect to seven drought years, i.e. 1965, 1966, 1968, 1972, 1974, 1979 and 1982; three flood years, i.e. 1961, 1970 and 1975; and twelve normal years, i.e. 1962, 1963, 1964, 1967, 1969, 1971, 1973, 1976, 1977, 1978, 1980 and 1981. The drought (flood) years are the years in which the normalized rainfall deviate of All India summer monsoon rainfall was less (more) than −1.0 (+1.0). The actual values of All India summer monsoon rainfall, yearwise are given in Table 1, along with the mean and standard deviation.

The 22-year (1961–1962) mean is subtracted vectorially from the calculated mean wind of the particular month to obtain the circulation anomaly from which composite anomalies in respect of flood, normal and drought years were calculated.

Figure 1 shows the composite anomalies at 200 hPa in respect of drought years during April, May and June respectively. During April a negative anomaly with cyclonic anomalous circulation developed over Central Asia, north of Caspian sea. Another negative anomaly area with anomalous cyclonic circulation was observed just northwest of India. During May, a large area with negative height anomaly and anomalous cyclonic circulation was observed south of Caspian sea. During June these anomalies intensified and covered a larger area. An area of negative temperature anomaly of the order of −1.0° C was seen over NW parts of India. Height anomaly was of the order of −40 to −50 gpm.

Figure 2 shows the composite anomalies at 200 hPa in respect of flood years during April, May and June respectively. During April positive height anomalies and anomalous anticyclonic circulation developed over west of Caspian sea. During May the positive height anomaly shifted to lower latitudes. The temperature anomalies were positive and of the order of +2° C. The positive height and thermal anomalies and the

Table 1. All India summer (June–September) monsoon rainfall (in mm)

Decade/Year	0	1	2	3	4	5	6	7	8	9
1960		1017*	807	856	920	707**	735**	859	754**	829
1970	940*	886	653**	912	747**	960*	855	881	908	708**
1980	883	853	735**							

Mean = 852 mm, Standard deviation = 84 mm.
* – Flood year; ** – Drought year.

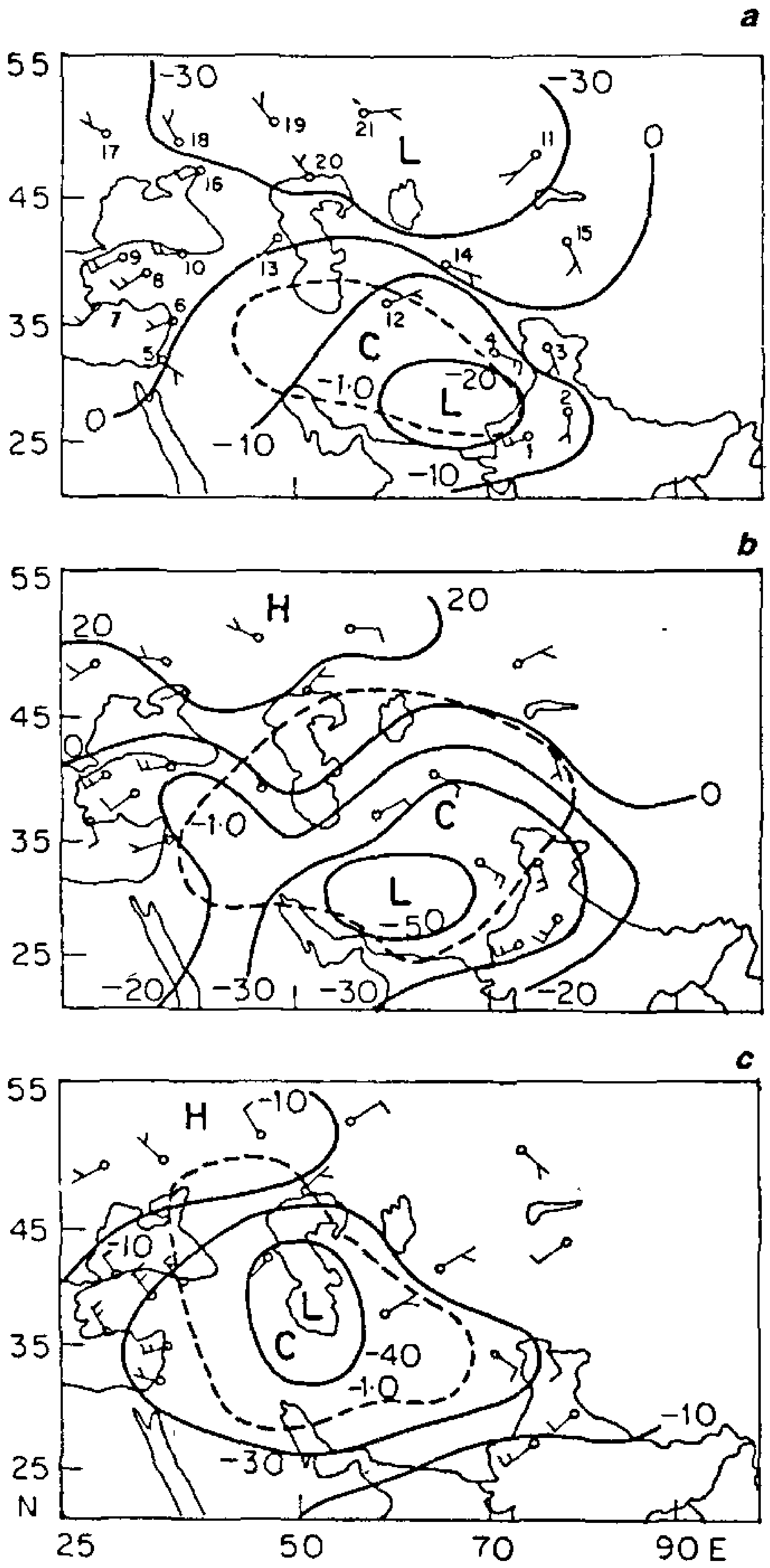

Figure 1. Composite circulation, geopotential height and thermal anomalies in respect of drought years during *a*, April; *b*, May and *c*, June. L, negative geopotential height anomaly; H, positive geopotential height anomaly; C, negative thermal anomaly; W, positive thermal anomaly.

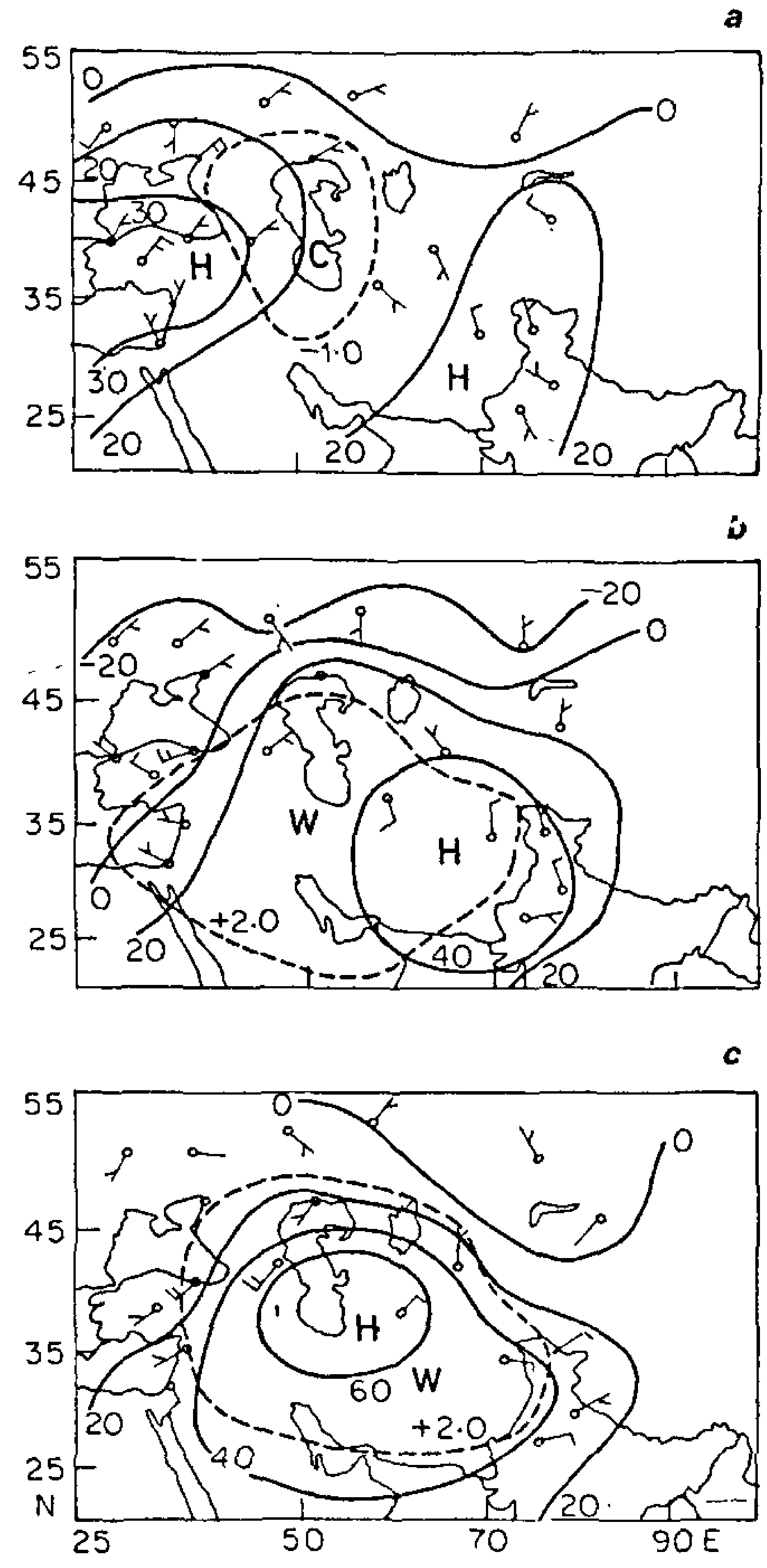

Figure 2. Composite circulation, geopotential height and thermal anomalies in respect of flood years during *a*, April; *b*, May and *c*, June.

anomalous anticyclonic circulation persisted during June and covered a larger area.

Figure 3 shows the composite anomalies at 200 hPa in respect of normal years during April, May and June. The anomaly pattern was similar to that of flood years, however, *the magnitudes of the anomalies were weaker.*

Thus there were significant differences in the anomaly patterns between drought and flood years. For reference, the geopotential height anomalies during June, stationwise, and in chronological order, are given in Table 2.

Apparently these anomalies developed *in situ* over

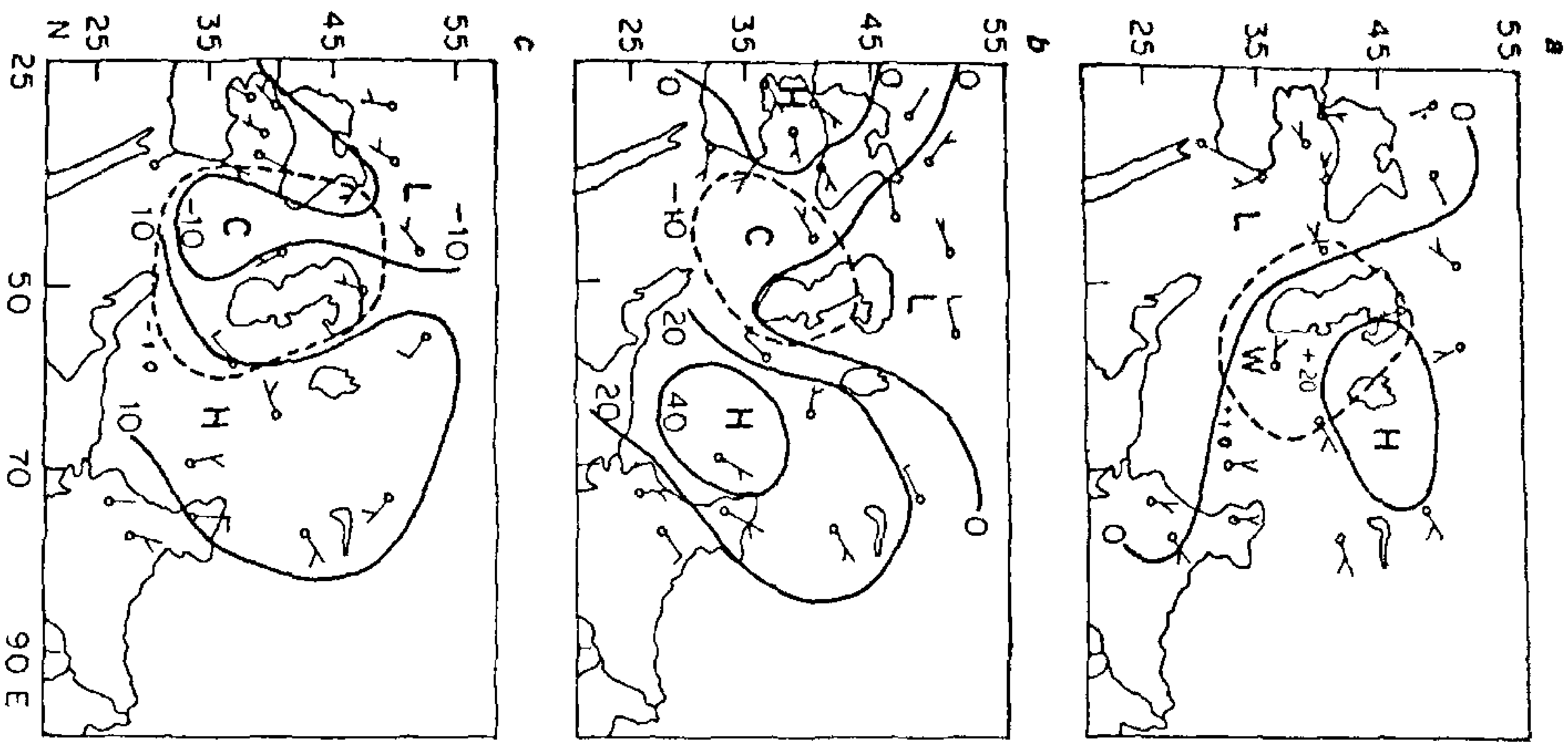

Figure 3. Composite circulation, geopotential height and thermal anomalies in respect of normal years during a, April; b, May and c, June

central Asia and extended to larger areas during the later months. Thus the anomalies reported by earlier workers were in fact extending over major parts of Central Asia with significant differences between the composite anomalies during drought and flood years. The cyclonic anomalies observed by Krishnamurti *et al.*[4] during 1987 seem to be a significant feature of all drought years.

Table 2. Geopotential height anomalies during June stationwise* and yearwise. (Unit-gpm)

Station	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
1	143	–	5	101	52	53	24	8	–92	25	11	–21	21	21	17	–41	–79	–75	–135	–38	–	–
2	76	65	–13	30	30	73	38	–83	–64	58	28	–37	18	–22	93	–60	–28	–37	–122	–47	–	–
3	–	–	–25	10	26	110	75	44	8	–155	130	–46	126	–95	–86	–120	–49	129	82	–167	–	–
4	–	–	–	–	–	–56	–	–11	–	–171	131	–32	154	–9	10	11	87	87	–44	–155	–	–
5	53	120	19	40	2	45	–22	–21	–53	61	32	–115	–34	–28	–5	–28	–9	14	–59	57	–51	–25
6	–34	76	–32	–55	–71	17	–43	–20	–43	81	34	–63	–7	–4	39	31	9	–5	–11	93	–	7
7	112	14	–56	–	–57	–3	–33	–31	–44	–20	–5	–35	40	–	–48	–85	16	73	–74	–	137	107
8	38	25	–12	–52	–58	–42	–79	–48	00	17	–13	–15	–14	–34	31	–40	–116	65	–33	118	225	38
9	167	37	–52	–54	–46	–24	–	–69	–62	–30	–62	–42	–70	–7	–2	–65	–14	76	107	19	128	38
10	18	–14	–25	41	–	–37	–	–76	–38	–10	49	–24	–24	–	90	–18	–7	–	–	27	46	–2
11	–	17	41	00	–21	26	43	–28	–	–73	–59	–85	14	–39	–26	–58	60	60	67	–4	66	–
12	101	–55	–42	–16	–46	44	–16	–	–	–	–	–57	153	–75	35	–4	–	36	–33	49	–79	–
13	154	55	–15	–	–20	29	4	–61	–	–	128	–	59	–78	–	–159	17	–36	–75	–33	–12	–23
14	–22	–	–5	–60	–64	38	5	–35	–	17	97	–55	149	–50	–37	–43	38	59	–21	18	–25	–
15	–30	–40	–	–25	–73	47	8	–	–	–36	61	–47	41	–3	–30	–	59	71	–4	–13	15	–
16	102	38	103	103	–	–6	–3	–20	–	–60	–107	49	–41	–42	86	–73	–32	–82	11	–11	68	–79
17	51	13	–33	133	0	–31	–12	62	125	–22	–92	0	–58	–110	76	–103	–29	–44	57	–29	118	–72
18	49	16	–43	–	3	–47	–31	15	–	–	–37	–	–8	–14	142	–6	–56	–84	39	–16	130	–52
19	6	–	–79	49	–23	–11	–27	–29	–	–	–59	51	30	–26	128	–37	51	–38	–2	24	9	–17
20	–	–37	–	–	20	9	–11	–58	–	–12	–6	21	21	–18	–	–55	8	–11	–14	49	93	–
21	38	–35	105	–	23	2	17	–31	–	–127	–55	–33	53	–34	50	21	30	33	–81	25	–	–

*, For the serial no of the station refer Figure 1*a*. –, Data not available.

Table 3. Monthly Eurasian snow cover anomaly (in sq million km) (1967–1982)

		Months					
Year		Jan. (28.8)	Feb. (29.1)	Mar. (25.1)	Apr. (17.8)	May (10.8)	Jun. (4.8)
1967		−1.8	−1.7	−1.3	−3.0	−1.6	−0.3
1968		1.0	3.5	0.8	−2.3	−2.3	−0.2
1969		−2.8	−2.6	−1.7	1.4	1.2	−1.5
1970		−2.1	−4.6	−3.2	−0.3	−1.8	0.0
1971		−1.6	1.0	2.4	−0.8	1.6	0.8
1972		2.6	5.3	−0.3	0.9	0.4	−0.1
1973		1.5	2.1	0.8	1.1	1.4	0.3
1974		−0.2	0.1	1.3	1.3	0.8	3.2
1975		−1.1	−0.6	−0.1	−0.2	−0.5	0.6
1976		−0.9	0.2	2.3	1.1	3.5	2.9
1977		3.5	−0.7	1.6	1.2	1.7	−1.1
1978		3.4	4.8	2.4	−1.2	2.5	2.5
1979		3.9	2.2	2.4	3.0	1.7	0.2
1980		−0.8	1.8	2.5	4.1	2.0	2.0
1981		−3.4	−1.6	2.5	2.6	0.9	1.6
1982		0.5	−1.5	−1.0	−1.3	−2.1	−1.4
Drought	yrs (5)	1.6	1.9	0.6	0.3	−0.3	0.3
Mean flood	yrs (2)	−1.6	−2.6	−1.7	−0.3	−1.2	0.3
Normal	yrs (9)	−0.3	0.3	1.3	0.6	1.4	0.7

The cold cyclonic anomalies during the drought years have an adverse effect on Indian summer monsoon. They can be responsible for more snow cover over Eurasia which subsequently can affect the Indian summer monsoon by delay of summer heating of land masses[6].

Table 3 shows yearwise (1967–1982) snow cover anomaly during January to June. The mean value of each month is also given in brackets. The mean is calculated using the data of 24-year period, i.e. 1967–1990. It reveals that Eurasian snow cover was generally more than normal during the winter and premonsoon months of the drought years except 1982. Another conspicuous exception is the excess snow cover anomaly for the normal rainfall year 1978 which is very similar to the anomaly for drought year 1979.

In the study of Rajeevan[2], large upper tropospheric westerlies were observed over northwestern India during drought years. They are, in fact, associated with the cold anomalous cyclonic circulation reported in this study. The equatorial side of the cyclonic circulation brings cold dry air from west and northwest which may suppress organized convective activity.

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Crystal structure of monochloro trinitro Cu(II) lignocaine complex

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The crystal structure of monochloro trinitro copper (II) lignocaine complex, $CuC_{28}H_{44}O_{11}N_7Cl$, has been determined by X-ray diffraction using CuK_α radiation. The compound crystallizes in the monoclinic space group P $2_1/n$ with unit cell parameters $a = 10.554(2)$ Å, $b = 24.402(7)$ Å, $c = 14.124(3)$ Å, $\beta = 100.025(20)°$ with $Z = 4$, $D_c = 1.398$ Mg m^{-3}, $D_m = 1.391$ Mg m^{-3}, $\mu = 2.08$ mm^{-1}. The structure was solved using 5242 reflections [$I > 2.5\sigma(I)$] out of 6764 reflections using MULTAN. The final residuals are $R_f = 0.120$ ($R_w = 0.109$). The copper coordination is seven in the complex. The plane of one of the nitrate groups almost bisects the molecule.

LIGNOCAINE hydrochloride metal complexes command a very wide interest owing to their importance in medical applications[1–17]. The coordination property of ligands with nitrogen atoms has received modest attention in recent years. Generally the ligand group will be nitrogen bonded to the metal atom either directly or through hydrogen bonding[18–25]. The present investigation was undertaken in order to get an insight into the activity of the complex. Of particular interest is the coordination around copper. Earlier reports[26–33] have revealed the numerous possible geometries around the Cu(II) atom, which solely depend upon the type of donor atom linked to the acceptors. Crystal structure studies of complexes of lignocaine hydrochloride with various metals have been undertaken by us to get an insight into the activity of these substances. In this paper we report the structural study of the monochloro trinitro copper (II) lignocaine complex. We have earlier reported the structure of lignocaine tetrachlorocuprate complex[34].

Crystals suitable for single crystal X-ray diffraction work were obtained from ethanol. The crystals were of