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VARIATION OF TEMPERATURE, WIND AND MOISTURE OVER NORTH AND NORTH EAST INDIA DURING GEWEX 1998

1. To understand and study the phenomenon of Global Energy and Water Cycle, an Experiment (GEWEX) was launched in 1996 as a part of World Climate and Research Programme of WMO. During its first phase (1996 – 2000) the scientist community in Japan conducted an experiment called GAME (GEWEX Asian Monsoon Experiment) during April to September in 1998 and as many as 10 countries including India have taken part. Fig. 1 shows the countries participated and their periods in the GAME. An extensive data set has thus been generated during this Intensive Operational Period (IOP). Nine RS / RW stations, *viz*., (*i*) Patiala (PTL), (*ii*) New Delhi (DLH), (*iii*) Lucknow (LKN), (*iv*) Gorakhpur (GRK), (*v*) Ranchi (RNC), (*vi*) Patna (PTN), (*vii*) Kolkata (KOL), (*viii*) Mohanbari (MHN/DBH) and (*ix*) Guwahati (GWH) spread close to the Indian monsoon trough region over the northern and northeastern parts were earmarked for taking four observations daily (*viz*., 0000, 0600, 1200 and 1800 UTC) during the period of 15th May to 15th June and

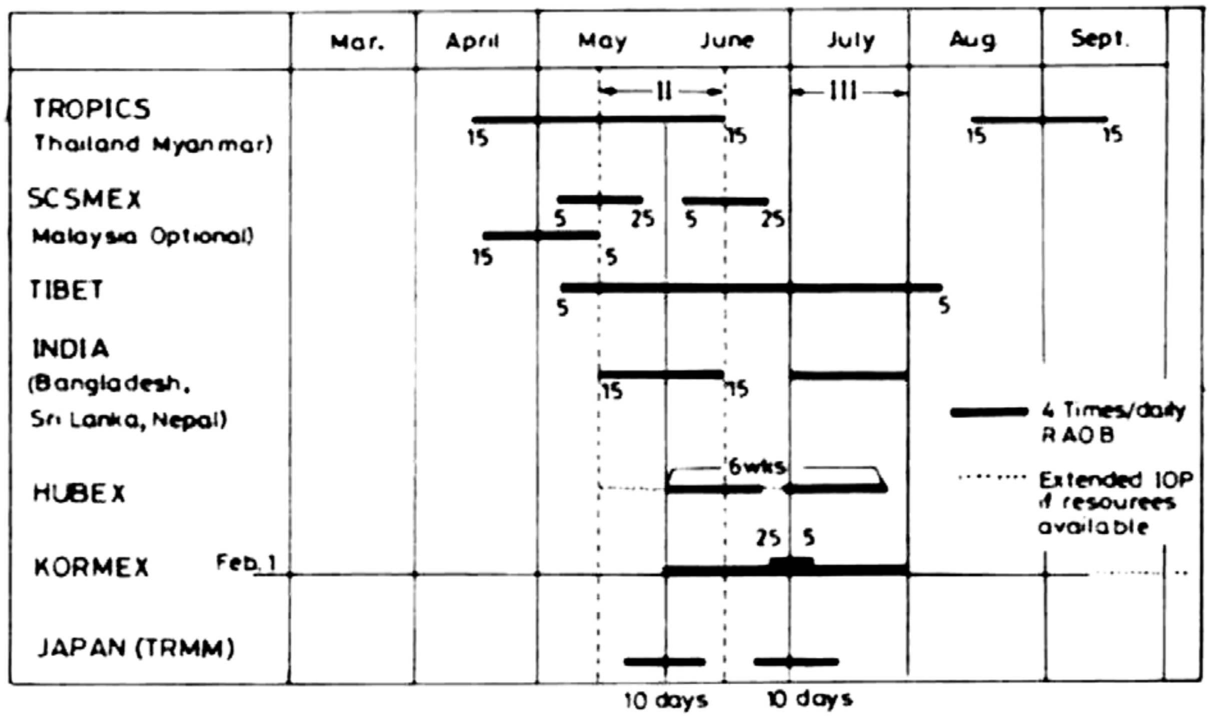


Fig. 1. Countries participated and their periods during GAME 1998

TABLE 1

Variations of temperatures over some GEWEX stations

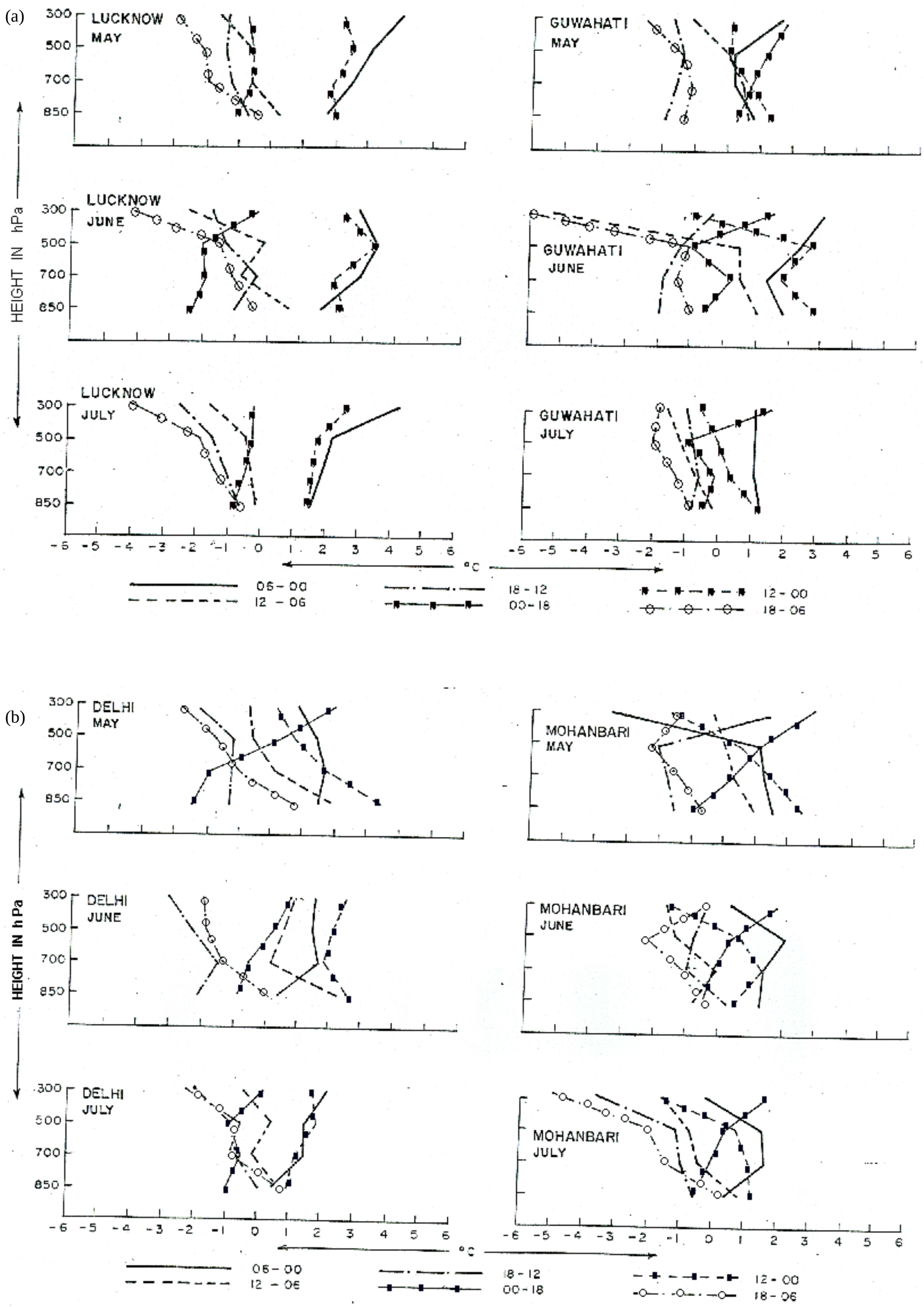
Station	Month	*Tmax* – Tmin (in º C) At various levels (hPa)			
		850	700	500	300
Lucknow	May	4.4	4.8 *	5.0 *	4.8 *
	June	4.9 *	4.4	4.6	4.6
	July	4.8 *	4.6	4.3	6.0 *
Gorakhpur	May	4.2	3.4	3.0	2.7
	June	4.0	2.9	3.1	3.1
	July	3.4	3.1	2.3	3.5
Ranchi	May	5.6 *	4.2	4.1	9.7 *
	June	7.1 *	5.6 *	4.8 *	6.0 *
	July	4.1	4.3	4.4	7.8 *
Patna	May	6.3 *	5.6 *	5.5 *	5.4 *
	June	5.7 *	5.2 *	4.4	4.1
	July	4.1	4.6	3.4	6.3 *
New Delhi	May	5.2 *	4.3	4.0	4.4
	June	4.5	4.0	5.4 *	5.1 *
	July	3.2	3.3	3.6	4.4
Mohanbari	May	3.7	3.8	3.5	7.0 *
	June	4.3	4.0	4.4	5.4 *
	July	4.5	3.7	3.8	8.5*

(* Values significant at 5% level)

TABLE 2

Moisture flux values (10^{10} metric tons)

Station	8th Jun	9th Jun	10th Jun	11th Jun	12th Jun
Active monsoon phase 10th June 1998					
KOL	0.76	0.88	0.42	0.53	0.67
RNC	0.97	0.90	0.84	1.03	0.85
PTN	0.8	0.86	1.16	1.01	0.88
GHT	0.51	0.31	0.43	0.36	0.38
GRK	1.04	1.08	1.11	0.93	0.81
LKN	1.03	0.96	0.95	0.69	0.83
MHN	0.21	0.25	0.28	0.32	0.32
DLH	0.49	0.47	0.50	0.27	0.26
PTL	0.43	0.43	0.43	0.25	0.28
Weak monsoon phase 25th July 1998					
Station	23rd Jul	24th Jul	25th Jul	26th Jul	27th Jul
KOL	0.68	0.53	0.24	0.21	0.17
RNC	0.53	0.56	0.36	0.27	0.22
PTN	0.48	0.49	0.40	0.31	0.28
GHT	0.51	0.41	0.24	0.18	0.45
GRK	0.35	0.31	0.71	0.50	0.34
LKN	0.44	0.37	0.41	0.58	0.48
MHN	0.37	0.40	1.06	0.84	0.60
DLH	0.41	0.52	0.45	0.52	0.58
PTL	0.39	0.48	0.71	0.90	1.04



Figs. 2(a&b). Variation of upper air temperature

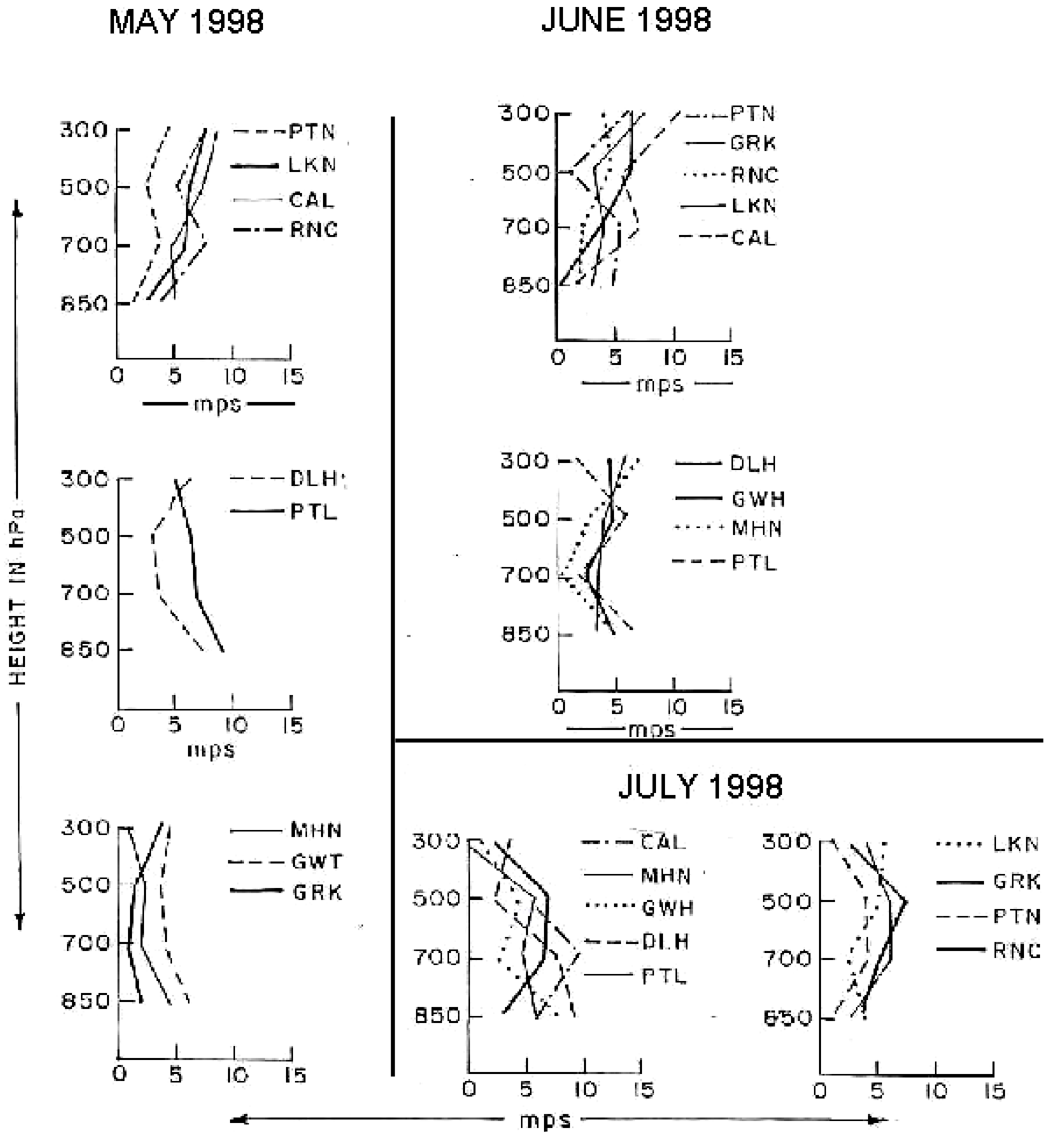


Fig. 3. Variation of upper winds (*U* comp.)

1st July to 31st July, 1998 of IOP. (For this study, data were taken from the archives of National Data Centre, Pune). Among many research articles and publications based on the GAME-IOP data, those by IMD (1999) and Japan (1999) are worth mentioning. Using the upper-air data at levels 850, 700, 500 and 300 hPa, an analysis of temperature, wind and moisture over these stations and a comparison with the available normal values were made and results are presented in the following paragraphs.

2. Using the temperature data, the 6 and 12 hourly variations (*viz.*, 0600 - 0000, 1200 - 0600, 1800 - 1200 and 1200 – 0000 UTC), the nocturnal ($00_{d+1} - 12_d$, where d stands for the day of observation) and the apparent ($T_{max} - T_{min}$) variations were computed. Table 1 gives these variations of which some are found significant (under *t* – test at 5 % level).

2.1. The 6 hourly variations over PTN & LKN for 0600 – 0000 UTC, at 300 hPa during July showed maximum variations as 4.4° C and 4.3° C respectively. In June, the 12 hourly variation at 300 hPa over GHT showed – 6.2° C (*i.e.*, a cooling and stable layer) for 1800 – 0600 UTC . But for 1200 – 0000 UTC, RNC in

May, and PTL in July showed a maximum variation of 4.3° C (unstable layer). Over GRK, PTN and RNC in May and June, the values for the respective levels indicated a large departure (from 1971-90 normals) and as such the monsoon onset was delayed over the northern regions and became active there only by middle of June whereas over the north east it was active phase since 1st June.

2.2. The nocturnal cooling was found to be significant at level 850 hPa for PTL (2.5° C) and DLH (2.4° C) in the month of May. Pant (1960) studied the data of 1957 and 1958 and showed that nocturnal cooling over DLH at 850 hPa to be around 1.5° C and Rangarajan & Sikka (1963) from data of 1960 and 1961 showed the value as 2.5° C in the month of July. The values in May over northern parts thus exhibited a significant night cooling.

2.3. Apparent variation values showed by Pant (1960) was 2° C upto 700 hPa where as in the present study it has been observed as 9.7° C at 300 hPa in the case of RNC in May and 8.5° C in the case of MHN in July. These variations might have attributed to cause for rapid changes in the air mass condition.

2.4. Generally, all the diurnal variations were found to be increasing with height except for DLH in May and GHT in June. DLH showed a decrease while GHT showed a sharp decrease pattern [Figs. 2(a&b)].

3. Monthly means of winds at various levels over all the 9 stations indicated that *u* components are predominant thereby confirming the westerly patterns. These patterns were analysed during the onset (25th May 1998) and weak phase (26th July 1998) of monsoon which indicated a shift towards south of the normal ridge position. During the active (10th June 1998), the ridge position was found to be (around 20° N) normal. Fig. 3 shows that *u* component value is decreasing with increase in height in May for PTL and increasing with increase in height over LKN in May & June.

4. To understand the moisture pattern during the active and weak phases of the monsoon over the country, the daily moisture flux values upto 300 hPa from surface were computed considering the 1200 UTC wind values for all the 9 stations on the same lines of Appa Rao (1985). As 10th June and 26th July are two dates in the active and weak phases respectively, during the monsoon 1998, the values are presented in Table 2 for a few dates during the active and weak phases. The flux values over MHN during weak phase are more (1.06×10^{10} metric tons) compared to those in active period. This may be due to the shift of monsoon trough at the foothills. It can be seen that the moisture values over DLH (0.5×10^{10} metric tons) in both the phases are comparable. The stations in the same latitudinal belts of 22 - 24° N (KOL & RNC), 24 - 26° N (PTN & GHT) , 26 - 28° N (GRK, LKN & MHN) and >28° N (DLH & PTL) were grouped. Using these patterns of division, the monthly mean values of moisture were also computed. From this we infer that the higher moisture content was found in May (1.02×10^{10} metric tons) and July (0.95×10^{10} metric tons) over DLH & PTL latitudinal belt and in June (0.83×10^{10} metric tons) over KOL & RNC belt.

5. The authors wish to acknowledge Dr. U.S. De, former ADGM (R) and Shri Prakasa Rao, Director, National Data Centre, Pune, for their valuable suggestions and support. Thanks are also due to the referee for the useful comments.

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(*1 April 2002, Modified 18 January 2007*)