CORRESPONDENCE

THERMAL EFFECTS OF THE TIBETAN PLATEAU DURING THE ASIAN MONSOON SEASON

by H. Flohn

In his paper of this title Rangarajan (1) has rejected the concept of the Tibetan Plateau acting as a heat source introduced by Flohn (2, 3). His objections are based mainly on maps of the average 500 mb temperatures during June and July 1957 (1, Fig. 2 and 3) showing a narrow band of highest temperatures reaching, near Lat. 28°N, from Asswan (Egypt) through northern India to SW-China, i.e. from Long. 30°E to 115°E. In these maps the instrumental errors of the radiosonde data, as revealed by the comparison of radiosondes at Payerne (4), are disregarded. In all areas with different radiosonde types (including Europe, cf. 5) these differences are large enough to demonstrate the necessity to use appropriate corrections; this is the more true in tropical latitudes with only weak isobaric temperature gradients. Each meteorologist analysing, on a routine base, contour maps for 300, 200 or 100 mb in lower latitudes and especially in the Indo-Pakistan area is well acquainted with these difficulties. During summer they are greatest at the transition layer between the lower monsoon and the upper easterlies mostly situated near 500 mb.

The author has recently discussed (6) - using all available upper air data during July and August 1957-1962 - these systematic differences. It has been shown, that the geostrophic winds computed from these data are incompatible with reliable actual wind observations. If a complete set of Rawin data is available, the computation of the thermal wind is certainly the most reliable check for the temperature field. The resultant upper winds at New Delhi (1) show clearly, that in the layer 500-200 mb (6-12km) the warmest region is situated NE of Delhi. Preliminary computations of thermal winds above Gauhati confirm this position of the temperature maximum. It has been demonstrated (6) by this comparison that the temperature data above Jodhpur and Allahabad are slightly too warm compared with Karachi and Tengchung at the same latitude or with other stations of the Indian network. The analysis of an elongated tongue of the -1° isotherm for July 1957 west of 65°E, in (1) is only based on the value of Asswan, which appears to be 1-2° too warm compared with neighbouring data and with other

Table 1. Average temperatures during July and August, 1957-62, above the heat center between the Sahara and Southern China (cf. Lit. 6)

Station	Lat. (N)	Long. (E)	700	500	300	200	100 mb
			°C	°C	°C	°C	°C
Helwan	29.9°	31.3°	13.0	-3.3	-28.1	-48.4	-75.0
Asswan	24.0°	32.8°	12.3	-3.5	-28.6	-49.4	-76.6
Bahrein	26.3°	50.6°	15.8	-3.9	-27.2	-48.3	-77.4
Karachi	24.9°	67.8°	14.1	-3.5	-25.8	-46.8	
N. Delhi	28.6°	77.6°	14.3	-0.2	-23.4	-44.0	-73.6
Lhasa	29.7°	91.0°		-0.9	-23.8	-45.6	-73.2
Heiho	32.0°	92.1°		-0.6	-23.9	-45.8	-73.6
Changtu	31.2°	97.3°		-1.4	-23.9	-45.8	-74.0
Hsihchang	27.9°	102.3°	12.1	-2.0	-25.0	-46.2	-72.6
Tengchung	25.1°	98.5°	11.0	-2.4	-25.4	-46.7	-74.7

months at the same station. Similarly the value of Karachi for June 1957 seems to be comparatively too warm. A thorough and critical discussion of all available upper air data - as given in (6) and Table 1 - indicates that in the layer 500-100 mb the highest temperatures are found above southern and southeastern Tibet as well as above the Himalayas, i.e. between Lat. 28° and 31°N and somewhere between 80°E and 100°E. This is confirmed by a careful day-to-day analysis of the 100 mb contours performed by the highly experienced group of Prof. Scherhag (Free University of Berlin) published since 1962. Table 2 contains the average height of the 100 mb level derived from 244 daily maps during June-September 1962-63. These data indicate the center of the 100 mb anticylone near 29-30°N, 88°E; the critical reader may compare the average monthly contour maps of the 100 mb level (7) - also for 1964 - with the 100 mb map of July 1957 from the U.S. Weather Bureau (8). If we take the 100 mb contours derived from Table 2 together with the surface pressure, which has its northern hemisphere minimum at the northern Punjab, near 32°N, 72°E, we cannot escape the conclusion, that the highest average virtual summer temperatures of the layer 1000-200 mb is situated along 30°N and between the longitudes 70°E and 100°E, i.e. above the Himalayas and the adjacent fringes of southern Tibet and northernmost India.

Table 2. Average height of the 100 mb surface (16,000 gpm +) during June-September, 1962-63, (data kindly provided from Institute of Meteorology, Free University of Berlin)

Lat. \ Long.	40°	50°	60°	70°	80°	90°	100°	110°	120°E
40°N	649	673	678	675	680	680	678	667	651
30°N	760	786	797	804	806	812	802	774	736
20°N	721	732	740	745	750	744	732	702	678

It is therefore misleading to speak of an "observed absence of a warm region over Tibet" (1, p. 33). Following the critical and reliable evaluation by von Wissmann (9) the total glaciated area of High Asia during summer is 88,200 km^2 (disregarding here Pamir and Transalai), 61,200 km^2 of which (69 percent) are situated in the marginal mountains (Himalaya, Karakorum, Kvenlun). Since these mountains occupy less than 10 percent of the total area (very near to 2.10^6 km^2 between 76° and 100°E and south of 38°N), less than 2 percent of the bulk of the plateau is glaciated. During summer we cannot expect any appreciable snow-cover in the interior, ince the snow-line - averaged from the excellent map of von Wissmann - lies at 5700 m, in the center more than 6400 m (between about 33°N, 81°E and 30°N, 87°E), instead of 5000 m, which is only valid for the strongly precipitated and glaciated marginal chains. The average cloudiness of Central Tibet (derived from five years data of Sven Hedin) is in July 48 percent, in August 55 percent; Depsang (35.3°N, 78.0°E, 5362 m, east of Karakorum) has 49 percent during July (10, 11). Similar values for other stations exist for 0800 hr local time only, and are therefore unrepresentative. The rainfall frequency varies around 10-15 days/month, mostly afternoon showers; only at the southeastern fringe it is much larger (20-28 days).

An estimation of the global radiation and especially the net radiation can be based on Zuev's measurements (cf. 12) in the arid center of the Pamir Plateau, at an altitude of 4000 m, where the values are almost exactly the same as at sea level, at the same latitude. The transfer of sensible heat into the atmosphere cannot be larger than the net radiation, which yields, at the Pamir, slightly less than 300 Ly/day. On an earlier occasion it has been stressed (13), that the amount of latent heat released by orographic rains can be much larger; in the region of Assam, Sikkim and Bhutan in the mountains at both sides of the Brahmaputra gorges and in the area of meridional gorges near the Sino-Burmese border, the rainfall averages from May to September well above 300-500 mm/month. A rainfall amount of only 300 mm/month is equivalent to an average release of latent heat of 600 Ly/day, the bulk of which is released in the cloud layer between 500 and 850 mb. This effect has its maximum at the southern and southeastern fringe of Tibet, i.e. at the slopes of the Himalayas; due to radiation and advection processes this warming may extend far into Burma and southern China. Both sources of internal and potential energy act together and are responsible for the remarkable heat zone centered along 29-30°N, and its role in the mechanism of the summer monsoon at the Indo-Pakistan subcontinent. Due to the early start of summer rain during May in the above-mentioned area, it contributes significantly to the reversal of high-tropospheric flow during early June (14).

University of Bonn,
Kurfursten Str. 74,
Bonn, West Germany.

7 January 1965.

REFERENCES

1) S. Rangarajan, Aust. Met. Mag. 42 (1963), 24-34.

2) H. Flohn, Bericht Dt. Wetterdienst US-Zone 18 (1950).

3) H. Flohn, Monsoons of the World, New Delhi 1960, 75-87.

4) P. Beelitz, Meteor. Abh., Inst. Meteor. Geophys. Fr. Univ. Berlin 7, No.4 (1958).

5) G. Warnecke, Meteor. Abh., Inst. Meteor. Geophys. Fr. Univ. Berlin 36, 517-525 (1963).

6) H. Flohn, Bonner Meteor. Abh. 4 (1964).

7) Meteor. Abh., Inst. Meteor. Geophys. Fr. Univ. Berlin 23 (1962), 37 (1963) and (1964).

8) R.B. Mason, C.E. Anderson, Monthly Weather Review 91, 3-12 (1963).

9) H. v. Wissmann, Abh. Akad. Wiss. Lit. Mainz, Math. Nat. Kl. 1959, 1103-1407.

10) H. Flohn, Erdkunde 12 (1958), 294-308.

11) H. Flohn, Abh. Akad. Wiss. Lit. Mainz, Math. Nat. Kl. 1959, 1409-1431.

12) H. Flohn, Meteor. Rundschau 17 (1964), 83-86.

13) H. Flohn, Arch. Meteor. Geophys. Biokl. B 6 (1955), 193-206.

14) H. Flohn, Paper presented at the WMO-FAO-Symposium Teheran (Dec. 1963), (in press).