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A PROPOSED MECHANISM OF HEAVY RAINFALL SITUATIONS OVER NORTH INDIA

In the context of heavy rainfall over north India leading to floods in the north Indian rivers it had been surmised "when it (heavy rainfall) occurs specially at the end or just after the southwest monsoon it is caused by a combination of a number of weather factors a few of which are of definite tropical origin while others are of extra-tropical region. It appears that when these two different systems affect Indian areas simultaneously, the occurrence of very heavy rainfall is experienced (Bose 1958)." This surmise was based on studies of Eurasian charts then available (1958). Recently, a great deal more information has become available through the surface and upper air Northern Hemispherical synoptic charts for several times each day. Although the data available for the area over the Tien Shan Plateau, Tibet and the Himalayas is still not enough for verification of any quantitative theory, one can venture a few guesses, on the basis of information now available, on the possible mechanisms of this interaction between the middle-latitude and tropical weather systems. The geographical locations are identified on the map in Fig 1. A specific role, though only in qualitative terms, has been visualized here for the massive landmass of central Asia.

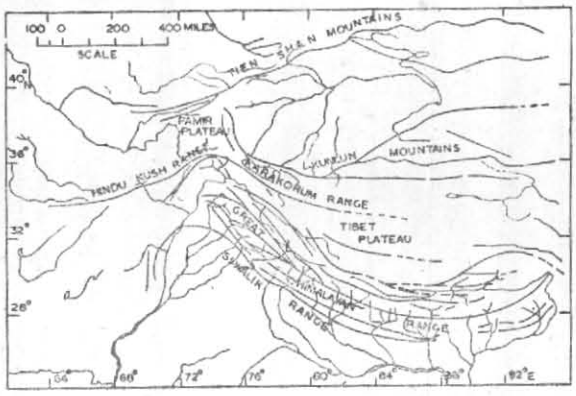

Fig. 1. It shows the mountain ranges and plateaus of central Asia (*After* Burrard)

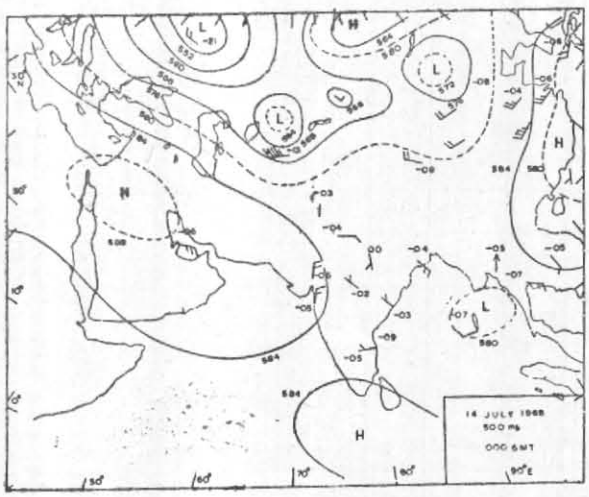

Fig. 2 (a)

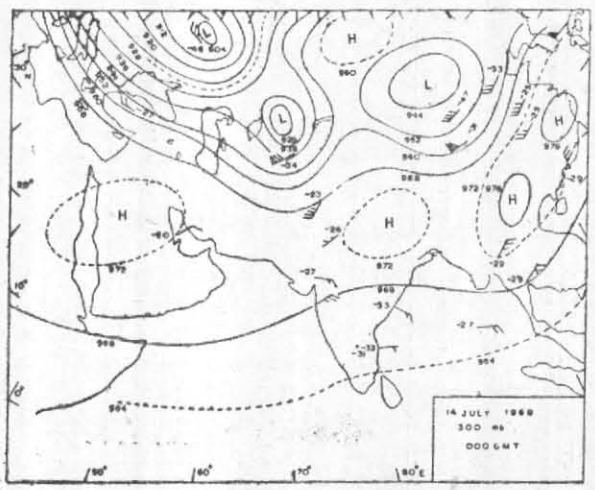

Fig. 2 (b)

Examination of a number of case studies shows one type of interaction in which a very deep middle-latitude weather system associated with a depression moving eastward roughly within the latitude belt of 35 to 40 deg. N gives rise to a decelerating huge anti-cyclonic vortex on reaching the region of the Pamir plateau. Initially the system is clearly seen on 500 and 300 mb levels. By the time the system advances to the Pamir plateau a portion is detached from the main system and is thrown off in an anti-cyclonic vortex over the region comprised of Hindukush, Karakorum, Kunlun Mountain, Great Himalayan range and even beyond over the Siwalik Himalayas, sometimes extending over to the plains of north India. The initial velocity imparted by the forces, impulsive in nature, cease to operate. Therefore the air in this whorl decelerates ; whorl here meaning a mass of air of varying dimension, with an initial momentum, mainly in a horizontal plane, decelerating to rest or very small velocity after having traversed a clockwise trajectory overlying an area depending on the initial volume detached. Consequently, wind flow within it and over northwest India at 500 and 300 mb is of the order of 5 to 10 kt or less.

The part which the tropical system plays is confined to the lower levels. As a result of (*i*) formation of a tropical depression and its movement across Indo-Gangetic and Brahmaputra

plain and its breaking up over the mountains, (*ii*) strengthening of any other low pressure system developing *in situ* over land, (*iii*) inflow of very vigorous southwest monsoon, moist air pervades the entire Indo-Gangetic plain, tributaries of Indus and Brahmaputra valleys from surface upto say approximately 700 mb levels. This moist air penetrates into the innumerable valleys in the Siwalik as well as the Great Himalayan ranges. The changes in temperature, density, moisture content brought about at 500 and 300 mb and the presence of very moist air below 700 mb substantially alter the thermodynamic structure of the air over the region concerned and create the situation necessary for the spells of heavy rainfall. Figs. 2 (a) & (b) show upper air synoptic charts for one such situation as an illustration.

The subsequent developments are pronouncedly tropical in character, as can be inferred, for example, from the marked diurnal preference of the time of occurrence of heavy rainfall and recurrences of weather phenomena for a number of days (calendar) at the same hour with clockwork precision.

This heavy rainfall is due to the release of the instability thus produced. It seems, this heavy precipitation which is very often accompanied by violent thunderstorms is triggered by afternoon surface heating. However, the manner of triggering off in the case of early hours of *morning-thunderstorms* (not infrequent) is not yet fully understood. Further the triggering off of the convective activity may occur at about sunset by some process which again is not yet fully understood. Of course the triggering off by the more familiar undercutting by downdraughts from neighbouring thunderstorms of mountain slopes etc also occur. In the mountainous region the orographic lift in combination with one of the mechanisms mentioned above increase the chances of occurrence of convective activity. *Later on as more and more moisture is lifted into middle tropospheric levels the cloud system become different and extensive and radiational factors become more predominant.* Such cloud systems may be visible in a lucky satellite-cloud-picture over the Pamir-Hindukush region.

The situation depicted is essentially a tropical-quasi-stationary phenomena, most probably on a meso scale. Although the systems mentioned earlier are on synoptic scale the breakdown of instability occurs, at least initially, on meso-scale at one or more locations. We must remember that the massive land masses of the Pamir, Hindukush-Karakoram, Kunlun, Himalayan ranges and Tibetan plateau produce enormous perturbing effects which are extremely difficult to assess in precise terms. Therefore, development of a mathematical model seems to be beset with unsurmountable difficulties, at least for the present. One must recognize that with the available aerological data it is not possible to differentiate between contending models proposed. The satellite pictures may, at best, give a qualitative indication.

More accurate and extensive ground-based aerological measurements together with development of a more realistic thermodynamic theory of convective activity, including the microphysical process of precipitation will certainly give a deeper understanding of the mechanism of such heavy rainfall.

Thus, it will be seen that the interaction between the tropical system and extratropical system suggested takes place through juxtaposition of the tropical system confined within the valleys in the mountains and sometimes over the northern Indian Plains with comparatively colder air injected at mid-tropospheric levels into this area by the extra-tropical system. The subsequent developments are due to release of instability initially on meso-scale and are tropical in character ; precipitation is set off by any one of the mechanisms mentioned earlier.

Reference

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