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Rain bearing processes in tropical latitudes

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सार — उष्णकटिबंधीय पट्टी के लिए चार प्रमुख वर्षाधारी प्रक्रियाओं का विवेचन किया गया है वे हैं (i) सिनाप्टिक पैमाना विक्षोभ (ii) समीर परिसंचलन (iii) पर्वतीय परिसंचलन और (iv) समांगी सतहों पर संवहन हवाना की ग्रीष्म ऋतु और सरद ऋतु 50 वर्षों के सामान्यों के सिनाप्टिक प्रदर्शों का महावारी विश्लेषण भी किया गया है जो कि नम और शुष्क वर्षों में वर्षाधारी प्रक्रियाओं की संख्या को प्रदर्शित करता है। प्राप्त परिणाम बड़े पैमाने पर विक्षोभ, वर्षा के समय के विचरणों को ज्ञात करना दर्शाते हैं।

ABSTRACT. Four major rain bearing processes for tropical belt, *viz*. (*i*) Synoptic scale disturbances, (*ii*) breeze circulations, (*iii*) Orographic circulations and (*iv*) convection over homogeneous surface have been discussed. Synoptic patterns for summer & winter for Havana have been analysed monthwise based on 50 years normals which give the number of rain bearing patterns in wet and dry years. The results derived show that the large scale disturbances determine time variations of rainfall.

1. Introduction

We can point out four major rain-bearing processes : (1) synoptic scale disturbances, (2) breeze circulations, (3) orographically induced circulations, (4) convection inside the horizontally homogeneous air mass over homogeneous surface. The relative significance of each of these processes in tropical rainfall is the matter of discussion. In spite of the fact that the largest contribution can be caused by different processes in different regions of tropics, the investigations presented below implies the large rainfall anomalies to be the consequence of the large scale processes in all tropical belt.

2. Result and discussion

Fig. 1 shows frequency of clouds at 7 and 16 hours of local time over Cuba and surrounding seas by radar in Havana. The maximum of cloud frequency in morning time occurs over seas in 50-100 km from the shore, the corresponding minimum along the axis of the island. The afternoon maximum and minimum change the places. Such diurnal course of cloudiness reflects strong impact of breeze circulation on cloud frequency over the central part of the island. The frequency changes 5 times there. Over the shore the breeze effect is insignificant cloud frequency changing 1, 5-2 times only. Thus only two of four processes — synoptic disturbances and thermal convection — determine rainfalls in Havana. Bearing that fact in mind let us consider in details the rainfall regime in Havana.

Fig. 2 presents mean frequency of different 5-day rainfall totals (upper curve) and contribution of each gradation into mean annual total (lower curve) in Havana. The sum of ordinates of upper curve presents the number of pentads a year (50), and the sum of ordinates of lower curve presents mean annual total (1133 mm).

Different amounts of five day rainfalls correlate with different rain-bearing processes. Rainfall totals up to 40 mm and over 40 mm are correspondingly the result of the convective processes and synoptic-scale processes. Rainfall upto 40 mm present 82 per cent of all pentads with rainfalls and give 40 per cent (469 mm) of mean annual total. Rainfalls over 40 mm present only 18 per cent of all pentads with rainfalls and give 60 per cent (664 mm) of mean annual total.

Fig. 3 shows examples of synoptic patterns bearing more than 40 mm rainfalls at Havana. Table 1 presents frequencies of these patterns by months. The large-scale disturbances of tropical origin determine rainfalls in the warm half of a year, and that of frontal origin—in the cold half of a year. Consider now the impact of these processes on variability of annual totals.

The annual totals in Havana range from 600 mm to 1800 mm. It seems striking that the contribution of rainfalls up to 40 mm remains

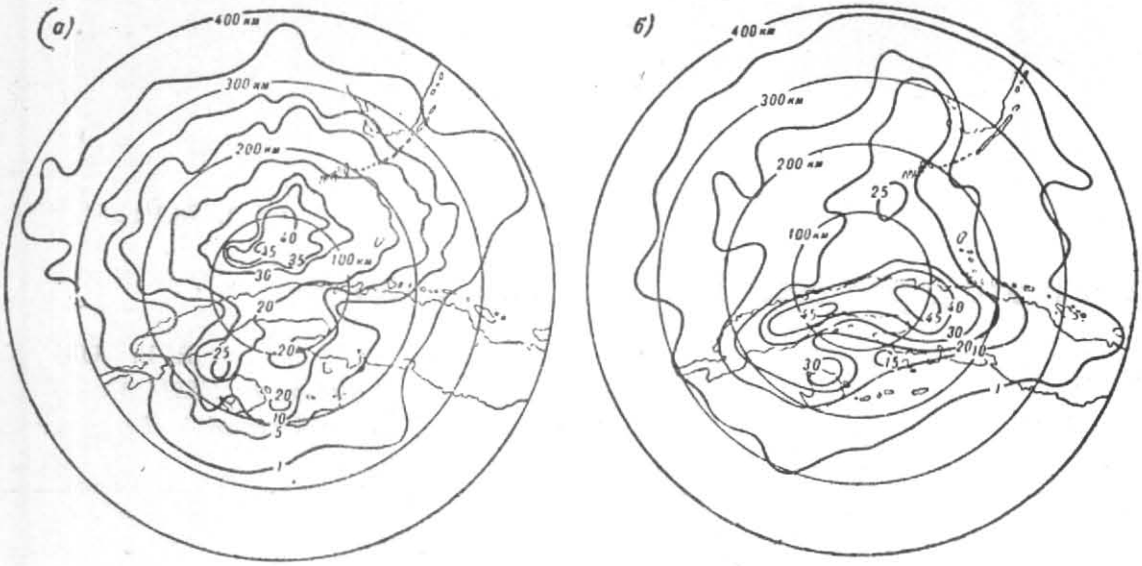

Fig. 1. Frequency of clouds at 7(a) and 16(b) hours of local time over Cuba and surrounding seas by radar at Havana

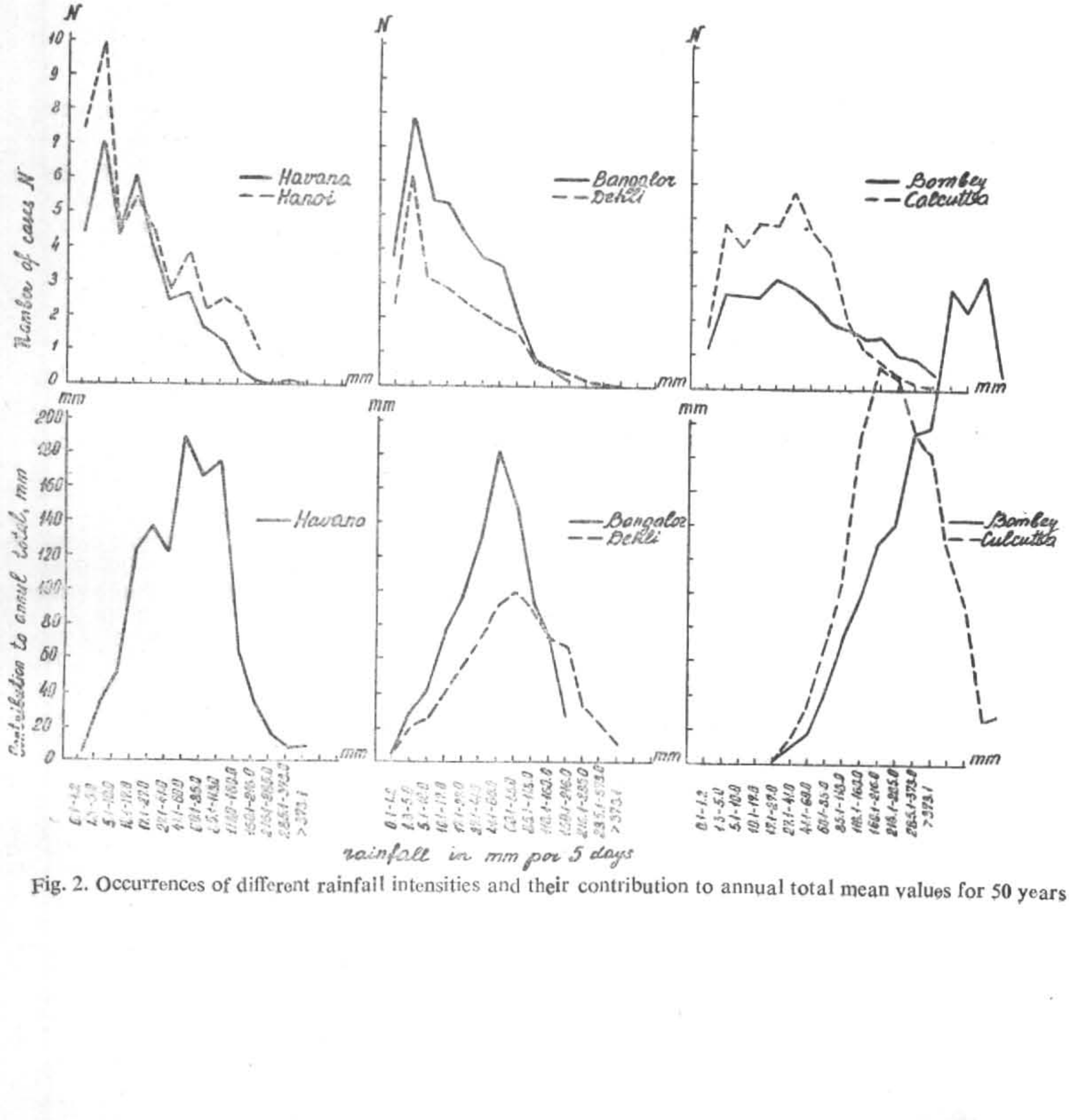

Fig. 2. Occurrences of different rainfall intensities and their contribution to annual total mean values for 50 years

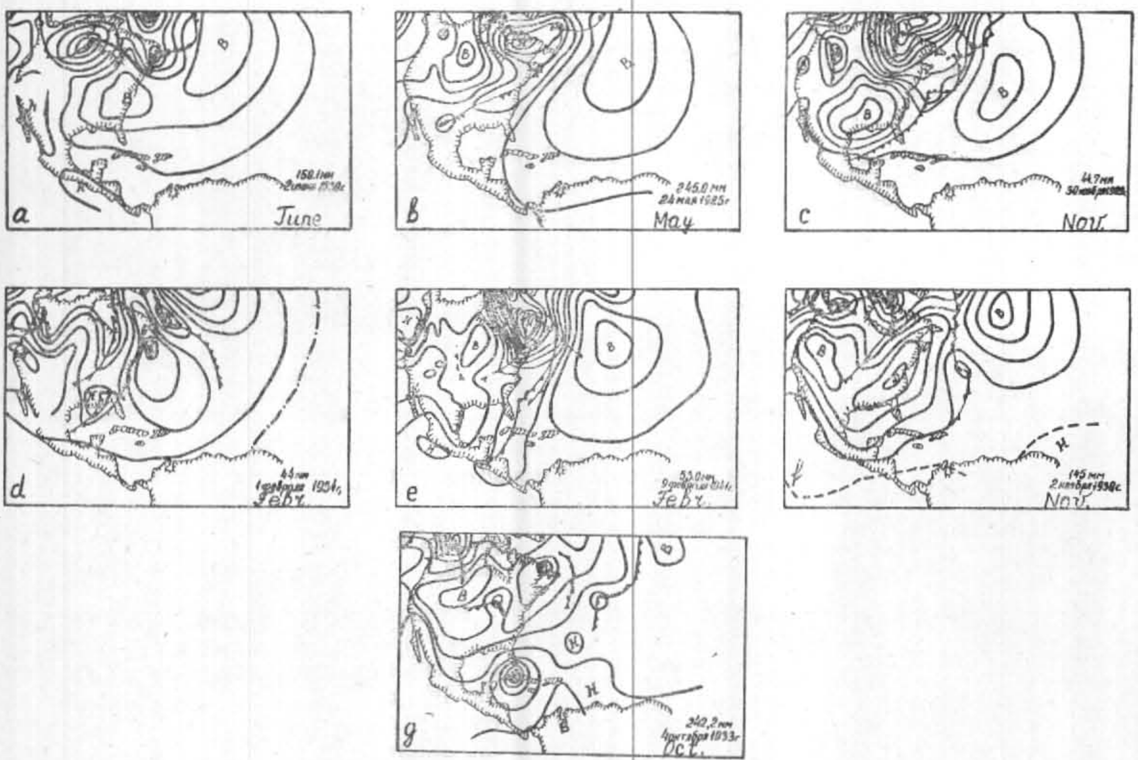

Fig. 3. Synoptic patterns bearing more than 40 mm rainfall in 5 days

TABLE 1

Frequency of different synoptic pattern bearing more than 40 mm rainfall in Havana (50 years)

Synoptic patterns	Month												Total
	1	2	3	4	5	6	7	8	9	10	11	12	
					Summer patterns								
South or south-west fringe of sub-tropical high	1	2	2	8	23	44	24	25	25	5	2	2	167
Tropical cyclones					2	8	3	3	15	18	1	0	50
					Winter patterns								
Tropical disturbances	7	7	9	7	13	1	4	3	14	21	13	6	105
South fringe of extra-tropical high	11	5	5	2	0	0	0	1	5	16	8	2	55
Summer patterns	1	2	2	8	25	52	27	28	40	23	3	2	217
Winter patterns	18	12	14	9	13	1	4	4	19	37	21	8	160

(Material for discussion at IPM on Tropical Disturbances (12-16 December 81) [Dr. Burlutsky]

practically constant, about 460 mm, no matter a drought or wet year it is. It implies that convective processes remain more or less on the same level through years. The contribution of rainfalls over 40 mm changes drastically through drought to wet years. It varies from 126 mm up to 1440 mm. So we can see that the rainfall anomaly for a year is completely determined by the large-scale atmospheric processes.

Table 1 presents the frequencies of different synoptic patterns bearing over 40 mm rainfall through 10 drought and 10 wet years. The number of rain-bearing patterns in wet years exceeds that of dry years on 54. That means 5.4 more processes a year. So we may state that the dryness or wetness of a particular year depends on occurrence of only a few large-scale synoptic patterns. It is also interesting to note a large contribution of rainfalls connected with anticyclones into annual anomalies. Their contribution to variance of annual totals is even larger than

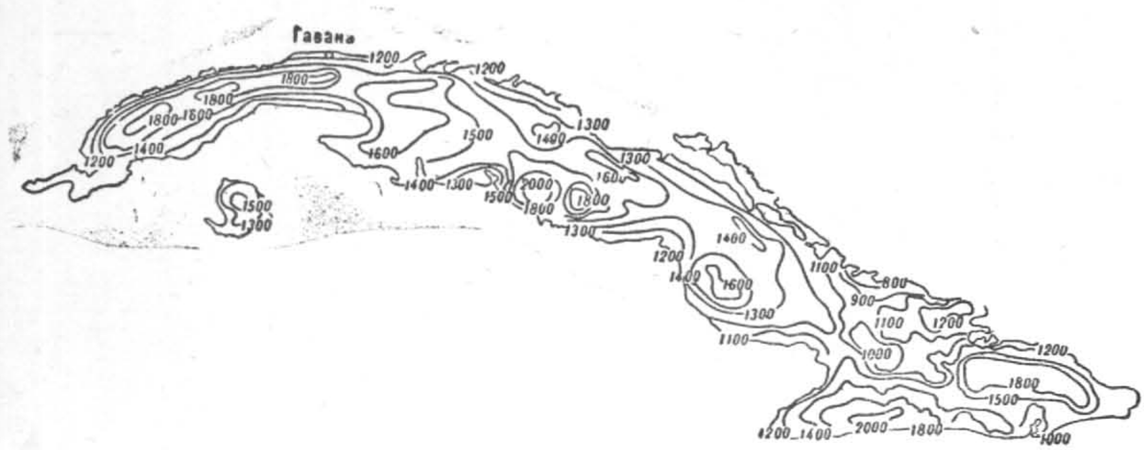

Fig. 4. Mean annual rainfall over Cuba

Fig. 5. Frequency of different rainfall intensties and difference between rainfall in Havana and simultaneous rainfall in Las Vegas

that of tropical cyclones (compare the first and fourth lines with the second line). It proves once more that only an anticyclonic circulation is not yet sufficient for a drought formation.

The impact of different rain-bearing processes on space distribution of rainfalls is discussed lower. Figs. 4, 5 show space distribution of rainfalls and frequency of different 5 - day rainfall totals in Havana, Las Vegas and America Libre. In spite of little width of the island rainfall in central areas of it rises with respect to shore on 500-800 mm. The distance between Havana and Las Vegas is only 30 km, but rainfalls in Las Vegas exceed that in Havana on 580 mm. Rainfalls in America Libre, which stays also in central part but at lee side of mountains, amount to 1000 mm.

As Fig. 5 shows rainfall decrement at America Libre is the result of less frequency of convective rainfall. The predominant easterly flow suppresses convection to the west of the mountain ridge.

Rainfalls in Las Vegas present more complicated case. As was shown earlier the breeze circulation intensifies convection in the center of the island significantly so as rainfall intensities reach that of synoptic disturbances. That is why the difference in rainfall frequencies displaces on gradations more than 40 mm. But in that particular cases, when rainfalls exceed 40 mm in Havana, the rainfalls are homogeneously distributed in space, because they are connected with large-scale disturbances. In these cases rainfalls in Las Vegas have to be equal to that in Havana. When rainfall in Havana are less than 40 mm (and consequently are connected with thermal convection) than rainfalls have to be much heavier in Las Vegas due to breeze effect. The differences between different amount of rainfall in Havana and the simultaneous rainfall in Las Vegas are shown in Fig. 5. As we see the difference between the two is practically absent when more than 40 mm fall in Havana. But the differences are very large when rainfalls in Havana are light.

3. Conclusion

Thus the large-scale disturbances determine time variations of rainfall. The breeze and orographic effects determine space variations of rainfall. These conclusions are also proved by other point in tropical belt (Fig. 2). Rainfall regime in Hanoi looks very similar to that in Havana. The same is true for inland stations of India. But Bombay rainfalls show striking combination of all three factors — synoptic disturbances, breeze and orography.