

## On certain features of atmospheric circulations in periods of droughts

T. S. KRUZHKOVA

Hydromet Research Centre of the USSR, Moscow, USSR

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सार—1971 से 1980 तक की अवधि में उत्तरी गोलार्ध में हुई अनावृष्टि के आंकड़ों को विश्लेषण के आधार पर अनावृष्टि होने के साथ-साथ वायुमंडलीय परिसंचन के मुख्य अभिलक्षणों को पहचानने का प्रयास किया गया है। इसके लिए 1972 में उत्तरी गोलार्ध के क्षोभमंडल में परिसंचन की दशाओं पर विचार किया गया है। उस वर्ष अफ्रीका के सीमावर्ती क्षेत्रों में, उत्तर भारत और पूर्व यूरोप में अनावृष्टि हुई थी। सहारा और 15° उ० के सीमावर्ती क्षेत्रों में उस अवधि में कुल वार्षिक वर्षण वार्षिक सामान्य वर्षण की दीर्घपरिमा के आधे से ज्यादा रहा। जून, जुलाई और अगस्त में निजेर और माली में वर्षा की कमी मासिक माध्यों का 35-40 प्रतिशत रही। जून 1972 में मानसून के शुरुआत में देरी और जुलाई में काफी समय तक के लिए इसके रुकने के कारण उत्तर भारत के अनेक क्षेत्रों में अनावृष्टि हुई। यूरोप और सोवियत रूस पर ग्रीष्म ऋतु में वायु तापमानों का माध्य सामान्य से 4-6° ऊपर रहा।

1972 में वायुमंडलीय परिसंचन की दशाएँ, विशेषतः गर्मी के महीनों में सामान्य से काफी भिन्न रही। गर्मी और सर्दी दोनों की विस्तृत अवधि के दौरान उपरोक्त दशाएँ गए सीमावर्ती क्षेत्रों में असामान्य गहन एवं विरोधी परिस्थितियाँ प्रकृत की गईं।

ट्रोपेक्स-72 के अनुसार जून 1972 में उष्णकटिबंधीय क्षोभमंडल में आंकड़े काफी अपवादों के नाम से अभिलक्षित हुए जैसाकि उनकी जलवायु स्थिति की तुलना से पता चलता है कि उप उष्णकटिबंधीय जेट धाराएँ शीत जलवायु वाली अधिकतम ग्रहीय पवन के अक्षांशों पर से व्यावसायिक जेट धाराएँ भूमध्यरेखा की ओर 10° विक्षेपित हो गईं।

**ABSTRACT.** An attempt to identify the main features of atmospheric circulation accompanying drought formation was made based on the analysis of data describing droughts occurred in the Northern Hemisphere in the period from 1970 to 1980. Conditions of circulation in the troposphere of the Northern Hemisphere in 1972 were considered for this purpose. In that year the drought spread over vast territories of Africa, North India and East Europe. The total annual precipitation in that period on the territory between Sahara and 15 deg. N was less than half the long-range annual normal precipitation. The deficit of rainfall in Niger, Mali in June, July and August amounted to 35-40 per cent of relevant monthly means. Delay of the beginning of monsoon in June 1972 and its long interruption in July resulted in drought occurrence in many regions of North India. In summer mean air temperatures over the European USSR were 4-6 deg. above normal.

Conditions of atmospheric circulation in 1972, particularly in summer months, were significantly different from normal. Unusually intensive and blocking situations were observed in the above mentioned territories both in summer and in winter during extended periods; mean pressure was considerably above normal.

Tropical troposphere in June 1972 according to "TROPEX-72" data was characterized by considerable anomalies, namely, the subtropical jet stream was at the latitude of winter climatic planetary maximum of wind, trade jet streams were shifted by 10 degrees towards the equator, as compared with their climatic location.

### 1. Introduction

The main role in a drought occurrence is played by atmospheric circulation. Under conditions of an atmospheric drought, the process of active air warming and relative drying takes place in the absence of precipitation and the presence of a

great radiation heat flux. The nature of droughts is the same both in moderate and tropical latitude. It presents the process of continuous anticyclogenesis. Drought occurs in the anticyclonic field which remains for a long time. Anomaly of the height of the 500 hPa isobaric surface is characteristic for the above phenomenon.

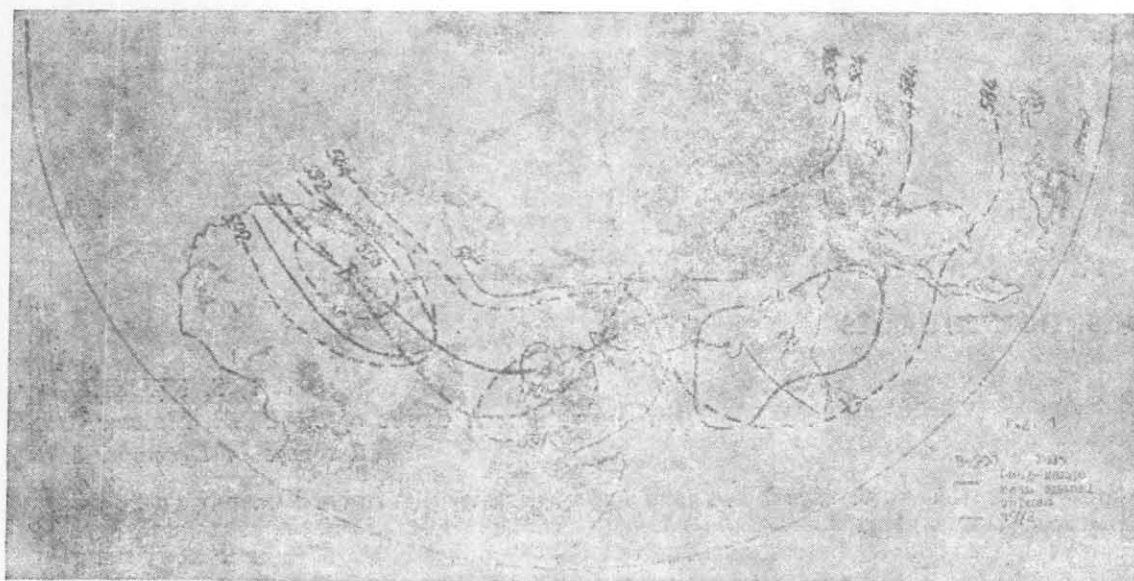


Fig. 1

## 2. Methodology and analysis of data

Required and sufficient indications of drought occurrence are revealed from the presence of hearths of  $H_{500}$  positive anomaly. It was established from the analysis of  $H_{500}$  that the intensity of geopotential anomaly hearths of 500 hPa surface level has its regional peculiarities during dry periods, *namely* for moderate latitudes  $\Delta H_{500} \geq 4$  dam, for tropical African regions  $\Delta H_{500} \geq 2$  dam, and for India it is more or equal to  $-2$  dam.

Thus, if  $H_{500}$  differs much from the established criterion, the degree of droughtiness should either increase or decrease.

As investigations carried out by the Soviet scientist D.A. Ped have shown, the degree of droughtiness is expressed best of all by the index  $Si$  denoting the sum of anomal conditions most important in drought formation.

$$Si = \frac{\Delta T}{\sigma T} - \frac{\Delta R}{\sigma R},$$

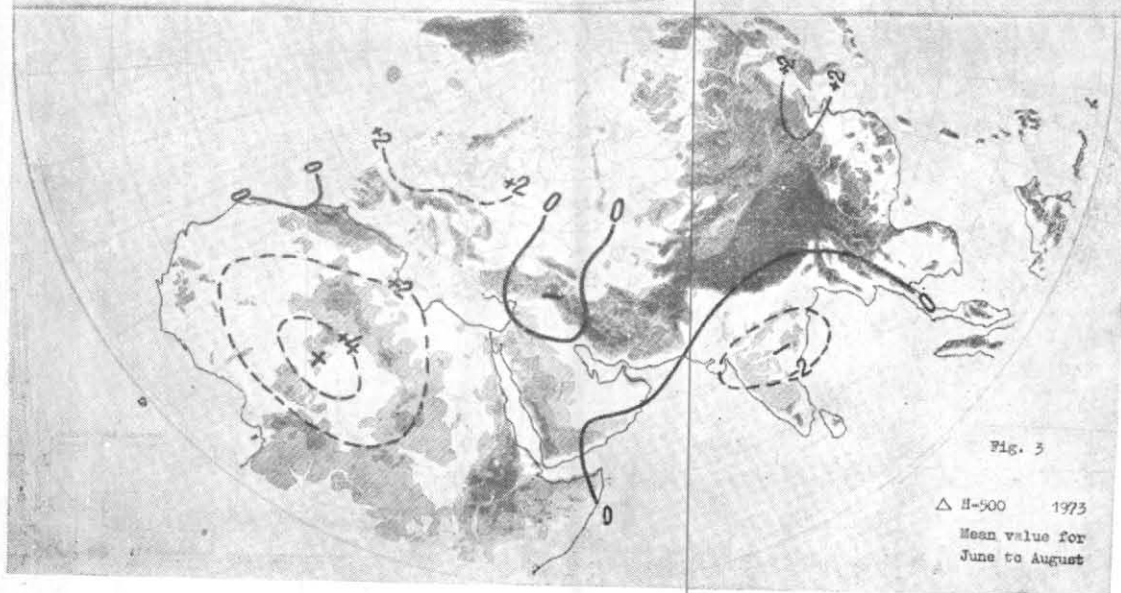
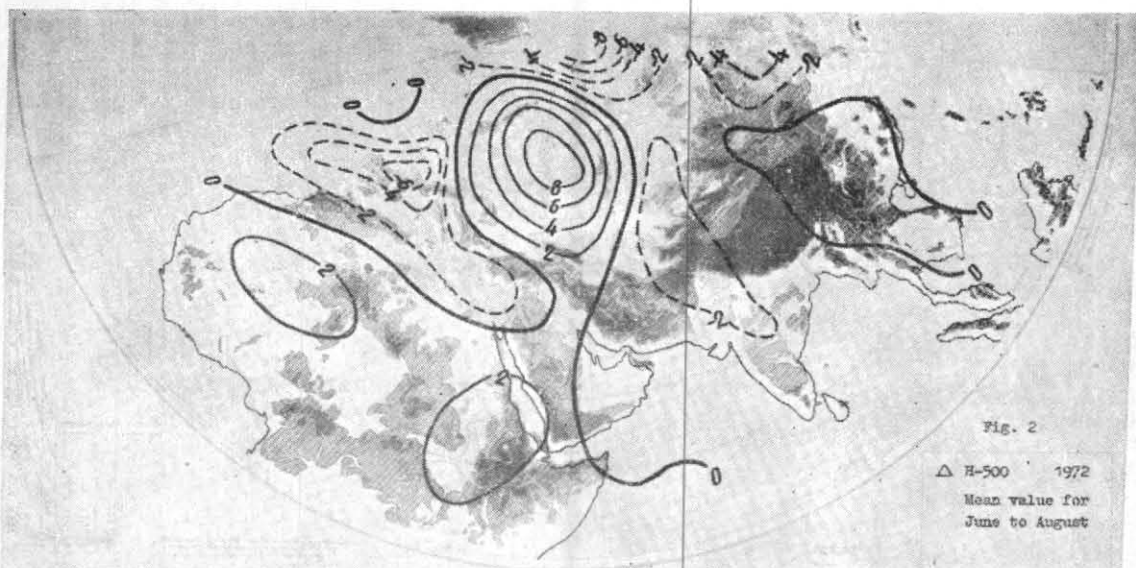
where  $\Delta T$  and  $\Delta R$  are anomalies of air temperature and precipitation respectively.

The proposed index  $Si$  makes it possible to classify objectively all cases with respect to the degree of droughtiness since both drought and excessive moistening are characterized by specific fields with different degree of intensity, coverage

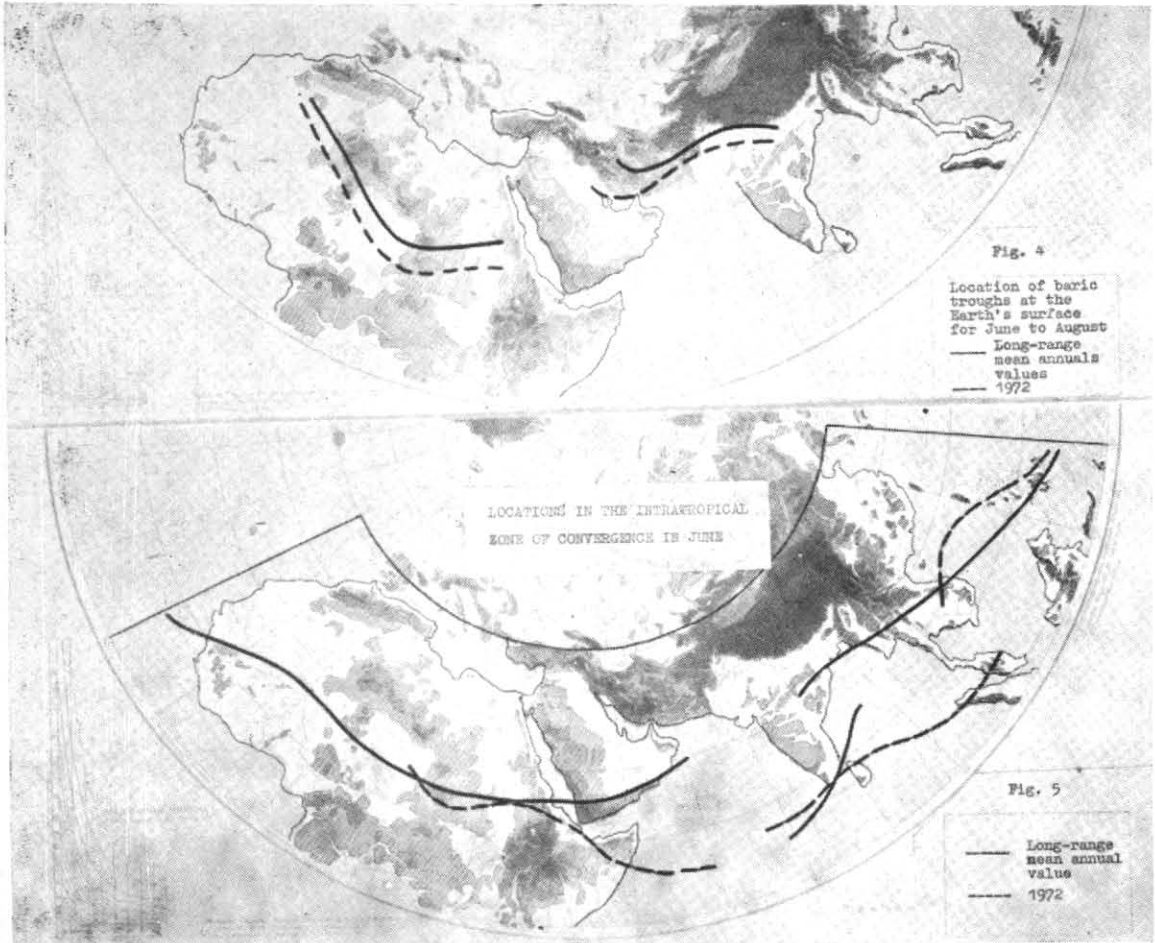
of the territory and their duration. It should be noted that to define such a dangerous phenomenon as drought is a complicated problem. Numerous criteria were suggested: only in the USSR their number is about a hundred. We also know criteria by Henery Palmerd etc. In our opinion, the parameter  $Si$  is advantageous since it takes into account the two main factors typical of a drought—the anomaly of air temperature and that of precipitation

Let us consider the circulation aspects of droughts in moderate and tropical latitudes. In moderate latitudes, the formation of a tropospheric ridge to which droughts are related occurs due to a combination of the initial field of circulation over the northern hemisphere with the thermal fields of oceans, mainly, with that of north Atlantic. In this combination, the location of the hearth of the water temperature negative anomaly ( $-\Delta t_w$ ) in north Atlantic is significant, and hence the presence of atrough or a ridge profile of heights of isobaric surfaces above the ocean and conjugately above the continent. It turned out that a ridge over East Europe occurs in the presence of ( $-\Delta t_w$  in the east part of north Atlantic, and *vice versa* in the presence of  $-\Delta t_w$  in the west part of North Atlantic a trough is formed over East Europe.

It should be noted that investigations of the impact of the thermal state of the ocean on the

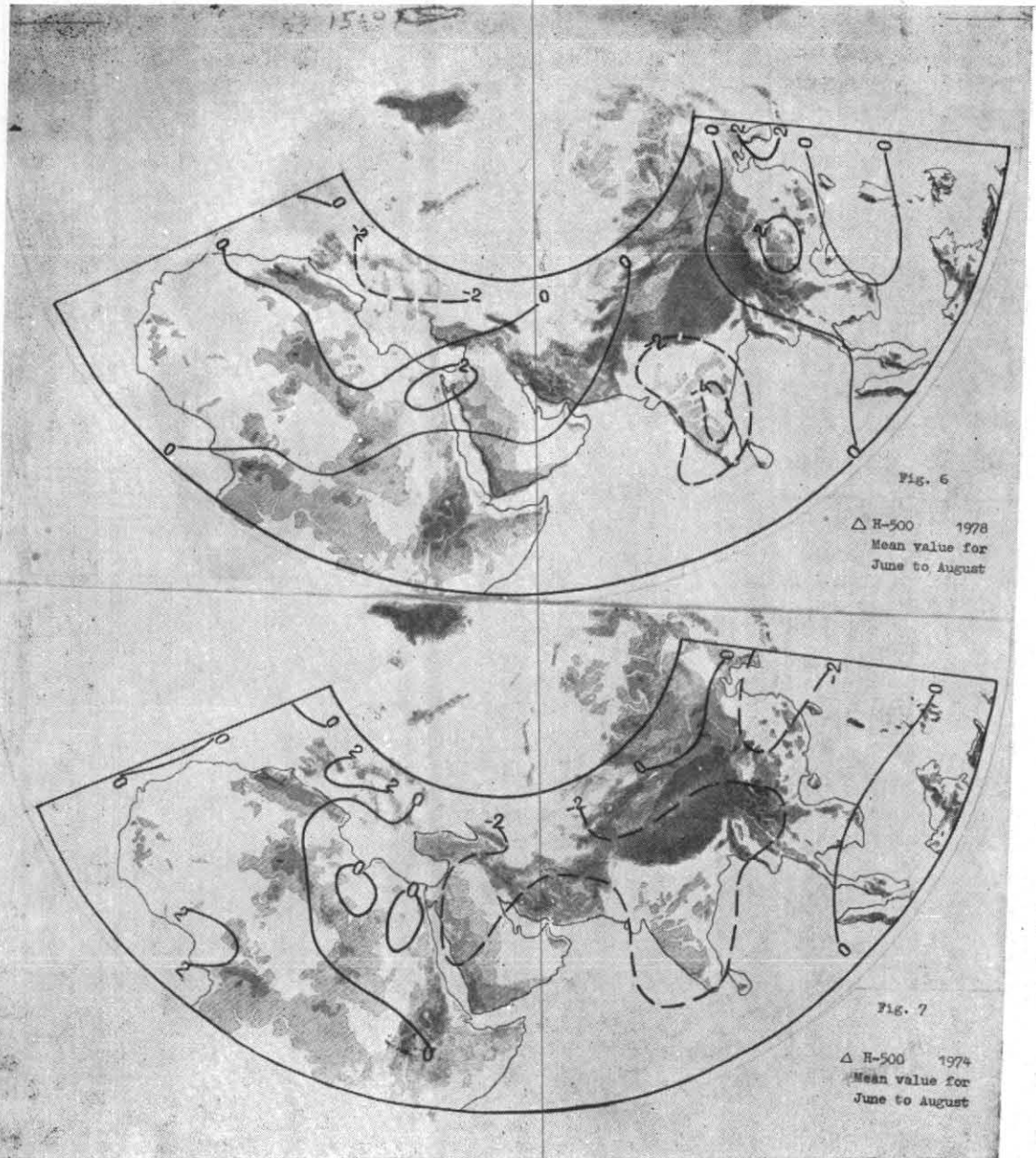


Figs. 2 & 3



Figs. 4 & 5





Figs. 6 & 7

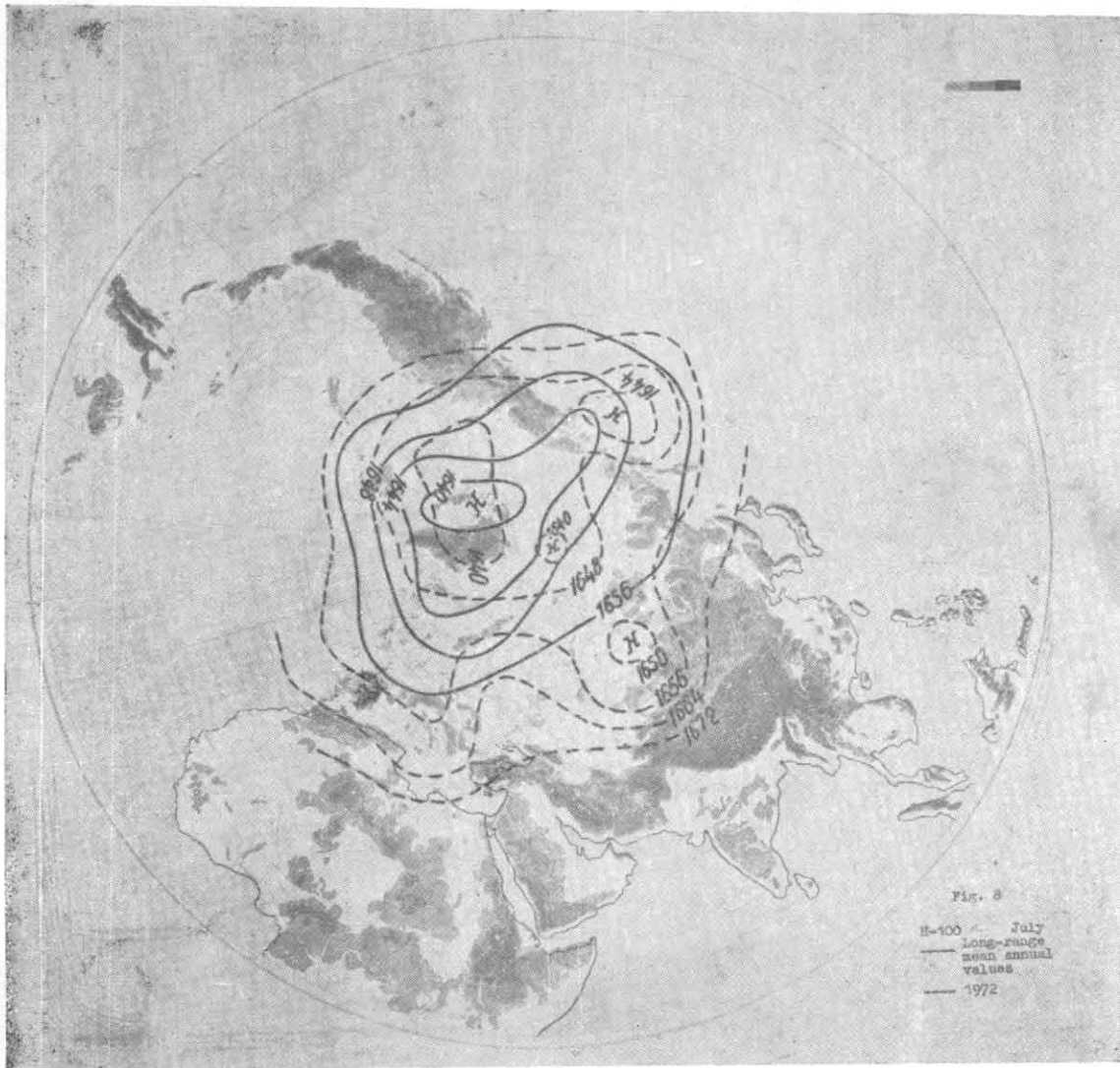


Fig. 8

atmospheric circulation and weather under conditions of the west transfer have a long history.

Some regularities discovered by now may be considered sufficiently reliable since they supported by a number of independent studies. Thus, several hearths of interaction in which an increased amount of heat is released by the ocean are singled out in the Atlantic. It is shown in a number of studies that positive anomalies of water temperature ( $\Delta t_w > 0$ ) are responsible for an increase in the heat content of the lower half of the troposphere and formation of a high ridge with the relevant deformation of the planetary high-altitude frontal zone (PHFZ). The reverse process takes place in those ocean regions where  $\Delta t_w < 0$ .

According to observations of weather ships in the Atlantic Ocean and ships participating in "TROPEX-72" the ocean surface temperature over the region from Newfoundland to the Cape Verde was by 1-2 deg. below normal in summer 1972.

Modern models of the global interaction show that anomalies of the zonal atmospheric circulation in many respects should be related to anomalies of interaction between the ocean and the atmosphere in the tropical belt where the ocean gives the greatest amount of heat and moisture to the atmosphere.

In subtropical and tropical latitudes the mechanism of forming the hearths of droughtiness  $\Delta H_{500}$  is closely related to the variations of the subtropical zone of high pressure. In dry 1972, the subtropical zone of high pressure both over Africa and South-East Asia had an anomalously south location (Fig. 1). Besides, the African zone of high pressure was characterized by high intensity: in 1972 the geopotential positive anomaly of the 500 hPa surface amounted on the average to 2 dam for three summer months; in 1973 when a heavy drought occurred in the Sahelian zone  $\Delta H_{500}$  was equal to 4 dam (Figs. 2 & 3).

Near the earth the axis of thermal depression and inter-tropical convergence zone were also subjected to the southward migration (Figs. 4 & 5) as compared with their long-time location. The opposite picture of circulation conditions was observed in 1974 and 1978 when droughts in the Sahel and north India changed for considerable

moistening (Figs. 6&7). In 1974, monsoon in India persisted for a longer period than usually (approximately by 10 days longer).

Why do sharp variations of the subtropical zone of high pressure occur?

From preliminary data such variations should to a great extent be related to the circumpolar vortex pulsations (CVP).

A great many of investigations carried out in the USSR to reveal a relationship between the circumpolar vortex state and weather conditions. All of them show that the circumpolar vortex is the greatest object that determines the circulation conditions in the Northern Hemisphere and is of great importance for development of long-range weather forecast methods.

Investigations have shown that this object is prone to considerable variations with time with respect to its intensity location and territorial coverage. With widening of the circumpolar vortex the maximum pressure zone should descend to the south; with narrowing of the vortex that zone moves northwards. It is this circulation pattern that was observed in 1972 when a circumpolar vortex at the level of the middle and upper troposphere (100 hPa) widened considerably toward Africa and India (Fig. 8). In their turn, pulsation of the circumpolar tropospheric vortex, in the opinion of the Soviet scientists, are related to thermal features of the Arctic basin.

Some foreign scientists, in particular those of Japan, relate these pulsations to the solar activity.

Investigations in the problem of circumpolar vortex pulsations are of great interest in many respects and in particular for the study and forecasts of atmospheric droughts in subtropical and tropical zones. Local peculiarities naturally also play a certain role in drought formation.

### 3. Conclusions

From the analysis performed it follows that a drought is the product of certain anomalies of the global atmospheric circulation related to anomalies of temperature regime of the World Ocean surface. Impossibility to prevent such an unfavourable and sometimes catastrophic phenomenon requires more and more efforts for its further comprehensive study.

However, we should not limit ourselves to only the discovery of causes for drought formation. Our main task should be the development by common efforts of methods for long-range forecasting the possible drought occurrence at a definite time and in a definite region. The existing methods of drought forecasts are insufficiently reliable though different approaches were tried. One of them described in literature consists in the use of solar-terrestrial relationships, others use

purely terrestrial factors-data describing the stratosphere, circulation of the troposphere and the impact of the North Atlantic.

We think that the problem of forecasting the conditions for drought formation both in tropical and moderate latitudes of our planet should be given the first priority in the activities of meteorological services concerned and within the framework of international co-operation.

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