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DEFORMATION OF THE TOTAL OZONE CONTENT FIELD IN THE TROPICAL ZONE

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ABSTRACT

Presented are the ozone investigation results obtained in the tropical zone. Measurements of the total ozone content (TOC) were carried out by the ozonometer M-124. The ozonometer was automated to investigate the ozone intradiurnal variations and to increase precision of the TOC measurements. Obtained results allowed to follow the effect of tropical cyclones (TC) on the TOC field. Several days before the TC formation the TOC increase is observed in daily mean course compared with the background one.

Three types of a trend can be singled out in the TOC intradiurnal course: zero, parabolic, quasi-linear. Maximum velocities of a trend are observed some days before the TC formation.

Analogous harmonic constituents are mainly presented in spectrum of daily means of ozone, mean and absolute velocities of trend and dispersion as well as in spectra of meteorological, hydrometeorological and actinometric values.

Revealed is a number of day-to-day ozone variations concerned with large-scale circulations, moisture content in the atmosphere.

Obtained are the data about short-period ozone waves, which period is less than a day.

Thin-film silver sensors were used to measure the vertical ozone distribution (VOD). Atmospheric aerosol and VOD measurements were carried out simultaneously, they gave data of the VOD layered structure, where the VOD local minima coincided with the position of aerosol layers' maxima.

1. INTRODUCTION

Experimental investigations of the ozone peculiar variations concerned with dynamical processes in the tropical zone

and hardware of these measurements were began by the author in 1984. Reliable and detailed information about ozone is important for using it as indicator of dynamical processes in the atmosphere. During those years the studying of ozone was carried out in four tropical expeditions: 1984, 1987, 1989 and 1990. First three expeditions were on the Cuba island, the fourth one was in the north-west of the Pacific Ocean, where the ozone measurements were carried out using the scientific-research vessel "Ocean". The time of measurements involved end of summer, autumn and beginning of winter. The data of all expeditions include the TOC daily means, intradiurnal ozone variations and in 1987 and 1989 the vertical ozone distribution was also measured.

To measure the TOC and short-period variations the automated ozonometers M-124 were used (Vasilyev, 1989). The maximum frequency of the TOC determination was 1 min. Number of measurements per day varied from 600 to a less number. Switching time from the first light filter for the second was not more than 3 s. The recording of measurement results was produced on recorder and magnetic tape (Vasilyev et al., 1991).

To identify the discrepancies in determination of intradiurnal course and TOC values in the tropical zone in 1984 the long-period measurements were simultaneously carried out by several instruments. The instruments were set up close to each other, the measurements were at the TOC different daily means and cloud position in zenith. The results showed that in rare cases the maximum discrepancy in the TOC determination obtained by different instruments was 3.3% relative to the mean for a day. The characteristic of the TOC daytime course was repeated by all instruments with sufficient precision, the maximum departure from the curve of the TOC

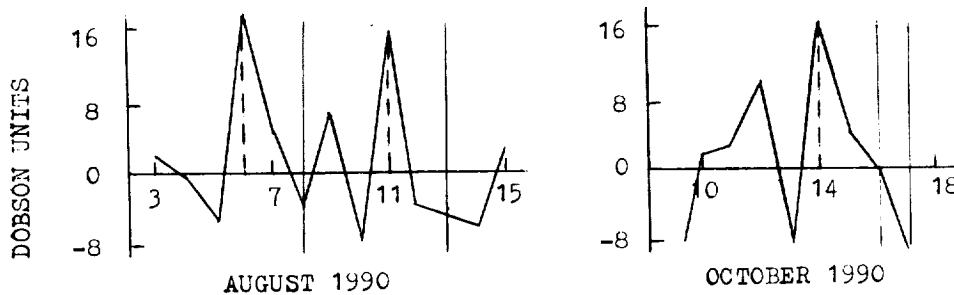


Fig.1. Random variations in the TOC daily means.

daily mean course was 3%. To compare precision of the TOC determination on zenith relative to the sun measurements, the simultaneous and long-period investigations for 120 days were carried out. As the result analysis showed the measurement error on zenith did not prevail 4% relative to the sun measurements. Normal precision of determination of the TOC on the sun was 4% compared to the standart.

The vertical ozone distribution (VOD) was obtained by MARZ radiosonde and thin-film silver sensors (Vasilyev et al., 1991). Ozonosensors were set up on a radiosonde instead of humidity sensor. To correlate ozonosensor with radiosonde the supplementary electronic block and power battery was set up in the radiosonde. The sensor was closed by glass cap to guard the ozonosensor from cloudiness and rain drops. The sensor disclosure was produced by a breaking device. Disclosure height and ozonometer sensitivity were positioned on the ground before the radiosonde launch. Precision of the VOD determination was 20%.

There were about 80 launches of radiosondes with ozonosensors during that period of time. Obtained were the results of 300 intradiurnal long-period observations of ozone and more then 600 TOC daily means (9 series). The TOC measurements were carried out simultaneously in several locations, therefore the space-time ozone relations could be investigated. During the given works besides ozone carried out was the study of integral content of water vapor and stratospheric aerosol (Nerushev et al., 1989).

2. DEFORMATION OF THE TOTAL OZONE CONTENT FIELD UNDER THE TROPICAL CYCLONE FORMATION

The space-time ozone variations in periods preceeding the TOC origination are of great interest. In July-October of 1990 the TOC observation was carried

out by the author in the tropics of the north-west of the Pacific Ocean by the scientific-research vessel "Ocean" using the automated ozonometer. During that period of time 14 TC were registered, it was a higher number than during the previous expeditions. Under tropical disturbance development from depression (TD) to a storm the TOC increased on the average of 5-8% compared to the background level before some days of TD transformation to TC. Such TOC disturbances were registered at a distance up to 300 km from observation site to TD, which later reached the TC stage. Random variations of the TOC daily means obtained by subtracting trend and periodic component from the initial series are shown in fig. 1. The vertical lines denote the days of TD transformation to TC.

The same ozone increase some days before TD transformation to TC was detected in the previous expeditions, fig. 2, (Arefyev et al., 1987).

The effect of processes favouring the TC formation is good visible on local minima in time course of the TOC daily means which appeared before the TC formation and were divided between each other and later changed by rather high minima. The analysis of synoptic situation allowed to conclude that the TOC increase was caused to a great extent by intrusion of cold air more enriched with ozone from the temperate latitudes. Such an intrusion promoted the cloud accumulation development and its transformation to TC. Analysis of the TOC latest results gave two peaks (maxima) divided between each other by the ozone minimum those were to be observed before the TC formation (fig. 2). The TOC first increase was as response to a formation or future formation of cyclonic circulation and cloud accumulation, the second ozone peak was response to TC future formation. The second ozone peak appeared in 1-5 (several) days before TC formation, but the first in 7-14 days i.e. some days

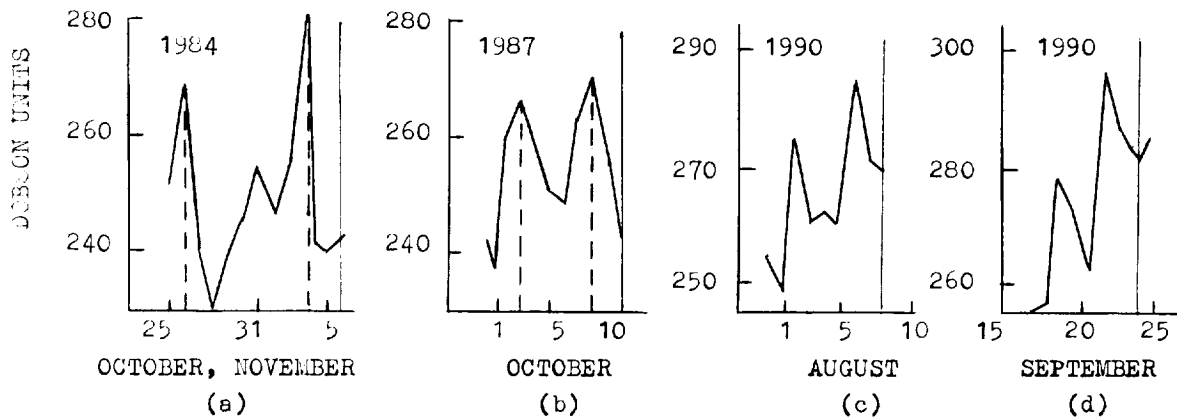


Fig.2. The TOC variation before the TC formation.

before formation of the second.

Atmosphere processes favoring TD transformation to TC, formation of cyclonic circulation, cloud accumulations and TD caused ozone increase in the region, which was registered by the ozonometers at a rather long distance from a place of the TC formation. Such an ozone increase was revealed in that region where an effect of extratropical zone of convergence presented. Local ozone peaks are good visible on the background of the TOC increase, that occurs due to an effect of extratropical zone of convergence (fig. 2d).

3. SOME PECULIARITIES OF DAY-TO-DAY OZONE VARIABILITY

The TOC daily means in the tropical zone variate every day. Besides the local maxima appeared are the days (rather prolonged time) with an increased ozone content relative to the TOC monthly means. An excess of the TOC monthly means during rather prolonged period of time is caused by predomination of meridional circulation, an effect of frontal systems, cold fronts on observation sites. It is caused by an intrusion of air masses from temperate latitudes with higher ozone content relative to the tropical air masses. The TOC increase was observed in passing the extratropical zone of convergence.

The TOC simultaneous measurements obtained in three sites at the distance 300-500 km from each other on the Cuba island show sequential appearance of the TOC local maxima in these observations over 1-3 days (Nerushev et al., 1989). It denotes the TOC relation with the circulation processes in the atmosphere. It is confirmed by correlation of time course of the TOC daily means and height of H_{200}

isobaric surface, comparison with synoptic situation effecting the observation sites and also dependence of the TOC variation and integral content of water vapor from the type of large-scale circulation in the atmosphere.

Local maxima are appeared one-several days before cold front passage. It is caused by cold front advance, when fall of temperature at great heights and consequently ozone increase begin earlier than near the Earth.

4. INTRADIURNAL COURSE OF THE TOTAL OZONE CONTENT

The TOC variations during a day have a complex structure: slow variations (trend) are superimposed by fast variations. Trend is determined as a process constituent, which period (peculiar time scale of constituent) exceeded a length of realization. To find a form of a diurnal trend the initial data bulk was approximated by polynomials. Polynomial coefficients were determined by the least-square method, a degree of polynomial was chose by the best approximation (the least mean-square method) to the initial data set.

In accordance with ozone variations during a day there were three types of trend changes: zero, when TOC variations occur over TOC certain value per day, parabolic with minimum or maximum during a day, peculiarity of trend variation is good described by polynomial in the 2-3 degree, quasi-linear when monotone increase or decrease of ozone occurs during a day (Vasilyev et al., 1988). All papers concerned with the ozone studying describe all three types of trend. Figure 3 shows peculiar type of a diurnal trend for the tropical zone. Parabolic type of trend was presented in a half of the TOC measurements (50%), then quasi-linear trend

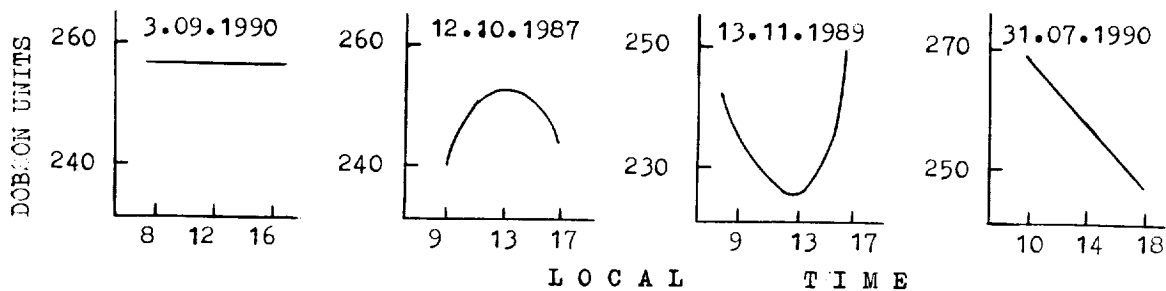


Fig.3. Types of diurnal trend for the tropical zone.

(29%) followed, it was close to the zero one (21%). Least of all there were the increased trends (21%), parabolic with maximum during a day and increased quasi-linear ones in the tropical zone. The present paper does not consider the zero trend with other types of trend which have low velocities of variations. Therefore, in most of cases the ozone was in "excited" state during a day, then it varied permanently and slowly. Parabolic type of trend was mainly observed in the day of TC formation. Besides, several days before it (fig. 1-2, dotted lines) registered were the maximum velocities of trend with parabolic form.

5. WAVE VARIATIONS OF THE DAILY MEANS OF THE TOTAL OZONE CONTENT

The presence of close relations of ozone with elements of the total circulation with meteorological, hydrometeorological and actinometric values in the tropical zone allows to propose that analogous periodic constituents to be present in these time series. As far as ozone is quasi-conservative constituent of the atmosphere, its variations and periodic constituents can account for some processes occurring in the atmosphere. As the ozone formation occurs in the tropics appeared is its permanent run-off to the poles, the studying of wave processes in this region more distinctly would clarify it. Ozone wave motions are to propagate from the tropical zone to the temperate latitudes and vice versa. The wave processes can be in some way a source of ozone removal from the tropical zone. All these reasons described above point to the fact that significant TOC spectrum to be observed in the tropical zone. An increase of wave variations must result from modulated interaction of waves of different scales, from interaction with waves of temperate latitudes. To identify the latent periodicities in a series of the TOC daily means the spectral analysis was carried out. It covered data with eliminated trend. 9 series of measurements have been

processed, each series included the TOC data of three months observations which were carried out almost in one and the same time. We can rather surely say about authenticity of the obtained calculations for the given period. The studies showed that in the energetic spectra of the TOC presented were mainly the analogous variations similar to those in meteorological, hydrometeorological and actinometric values. The analysis showed the presence of waves with the period of 4, 9, 11, 13, 15-16, 17-20, 36-39 days. Besides these wave processes discovered were the additional variations with period of 5-7, 8, 10, 12, 29-30, 42-45 days by measurements carried out in Cuba. The analogous wave processes are presented in a series of absolute and daily mean velocities of trend and in dispersion of the TOC daily means.

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