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ATMOSPHERE DYNAMICS IN THE EQUATORIAL METEOR ZONE

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The study of the atmospheric circulation of the earth from its surface to the altitudes of 100-110 km is essential for establishing atmospheric motion regularities with a view to perfecting weather forecasting.

Meteorological satellites, rocket soundings and radar tracking of meteor motion have been used for over 20 years, along with the more conventional methods of data acquisition.

The global network of meteorological observation stations is distributed very unevenly over the earth's surface. There are vast regions of the ocean, where observations are practically non existent, particularly in the southern hemisphere. 90% of the stations carry out observations only in a thin layer above the earth; about 10% sound the air to altitudes of 30-40 km (aerological stations) and less than 1% conduct observations at the altitudes of 100 km and higher using meteorological rockets (LOSEV, 1985).

It should be noted that half of aerological stations are located between 30° N and 50° N in the zone covering only 16% of the earth's surface. Only 5% of the aerological stations are in the equatorial zone between 10° N and 10° S, which covers 35% of the planet's area. It must be stressed as well that the members of the MAP Study Group 6 who suggested an equatorial location for an observatory in May 1982, believe that such an observatory should be placed at no more than 5° off the equator.

Radiometeor stations are distributed still more unevenly, being mainly confined to middle latitudes of the northern hemisphere.

Several years ago, the middle atmosphere over the equator was studied by the Soviet equatorial meteor expedition (SEME), from August 1968, to July 1970. Observations of meteor trail drift, measurements of individual radiants and meteor numbers were carried out by SEME, for the first time ever, in Mogadishu, Somali (2° N , 45° E) (BABAJANOV et al., 1970; BABAJANOV et al., 1973). The observations were conducted during 326 full days. About 450,000 meteors were recorded, which is considered an adequate number for identification of meteor winds. The Manning method was used for 12 azimuthal directions, with 6-minute measurements in each, thereby determining, both components of the wind velocity.

The radio equipment consisted of an amplitude-phase altimeter ensuring altitude estimation with an error of ±(2...3) km (DUDNIK 1963). The overwhelming majority of meteors occurred at 80-105 km, the maximum being registered at 93-94 km. Most of the measurements, however, were carried out without an altimeter.

The diurnal variation was clearly marked over the equator, the quantity of meteors decreasing sharply at 16.00-20.00 local time. The hourly rate was observed to change by as many as 50-60 echoes over a day.

Despite the 15 years that have passed since the expedition nobody so far has carried out measurement over the equator. Some meteor trails drift research has been carried out since in Jamaica, India nad Puerto Rico, but in all these cases the radars were situated further from the equator, at approximately 18°N.

Here we present the main results of the SEME. A continuous 40-day cycle of measurements was carried out in September-October 1968. Considerable interdiurnal variation of the zonal component was observed. In particular, in the meridional component, the prevalence of a two day component was established in the equatorial meteor zone for the first time. it is worth noting the pronounced westward motion of the atmosphere over the equator. The measurements show eastward wind velocity values of 1-3 mps only for two months (December 1969 and June 1970) out of the 24 from August 1968 to July 1970. In all the other months the wind was clearly directed to the west, wind velocity reaching 40 mps in certain months. Average monthly mean values yield a semi-annual wind velocity with an amplitude of 15 mps. The semi-annual wave phase is such that maximum breaking of the atmosphere rotating with the earth takes place in March and September and the minimum - in June and December.

The meridional wind was essentially directed to the North over the biannual cycle of observation. The most common velocity of mid-month estimates exceeded ten mps only in three instances.

For the equatorial zone, as well as for the other zones, the presence of diurnal and semi-diurnal wind velocity components at the altitudes of 80-105 km is characteristic. However, the relation between these components over the equator is different from that at mid-latitudes. The zonal diurnal component is larger than the semi-diurnal in approximately 50% of the months measured, and for the meridional component, in 75%. The mean value of the diurnal component amplitude in both directions amounts to 13 mps, with the semi-diurnal somewhat less: for the zonal wind it equals 12.6 mps, and for the meridional, 9.9 mps.

Fig. 1 (a-b) shows an example of semi-diurnal variations of the prevailing wind (V_o), of semi-diurnal (V_{12}) and diurnal V_{24} fluctuations of wind velocity at 85, 93 and 97 km on May 7-8, 1970. At the same time, we note a tendency to variation of the zonal circulation direction in the upper part of the meteor zone as compared with the lower one. Studies carried out in 1977-79 in Puerto Rico and in France confirm such variation of direction (Fig. 2, taken from MASSABEUF et al., 1981).

A stable prevalence of the diurnal component of wind velocity over semi-diurnal is clearly observed for the considered period.

The initial stage of the semi-diurnal zonal component within the two-year period was more stable than that of the meridional component in the variations of which the semiannual period with a span of 180° was traced. The mean value of the initial stage of the semi-diurnal tide for the zonal component constituted 268° (9 hours) and for the meridional one - 215° (7 hours). During a year the horizontal vector of the semi-diurnal tide can rotate clockwise as well as counter-clockwise.

The SEME data analysis has shown that the meteor zone is characterized by flashes of intensity of IGW and turbulence at highest instability moments of atmosphere due to tidal motions.

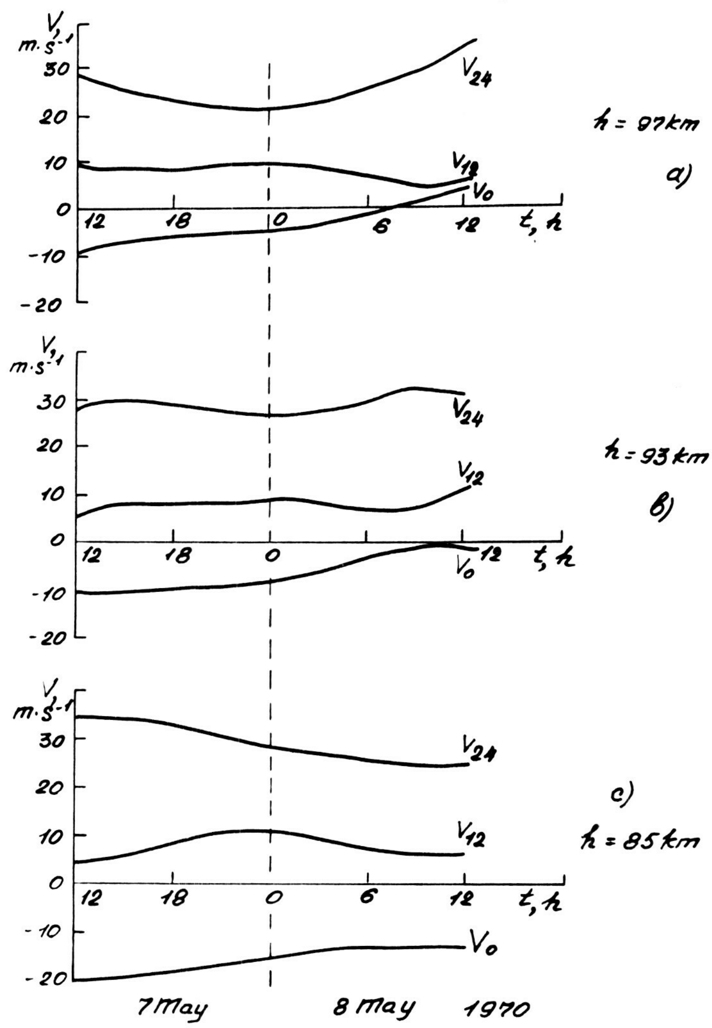

Fig. 1 Prevailing wind v_o, and semidirunal v_{12} and diurnal v_{24} oscillations over Mogadishu (2° N, 45° E) on May 7 and 8, 1970 at a) 97 km, b) 93 km, and c) 85 km.

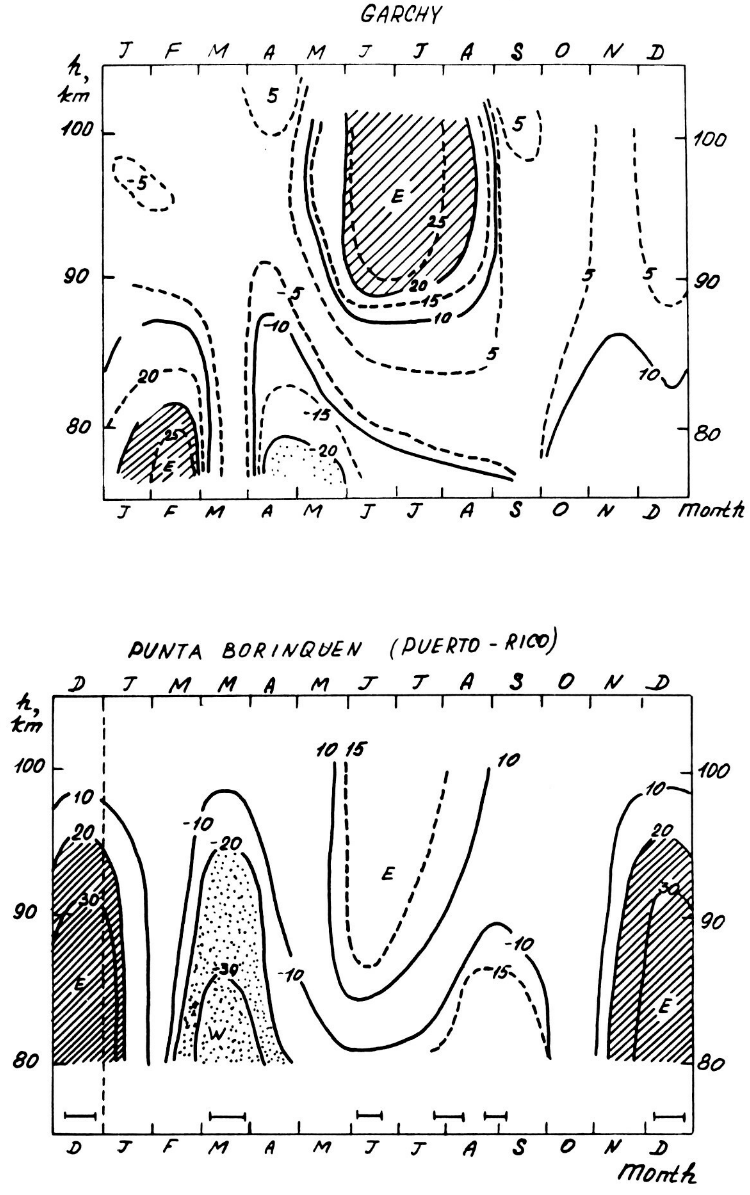

Fig. 2 Prevailing winds over Garchy, France, and Punta Borinquen, Puerto Rico, as determined from radio meteor data, 1977-1979.

Fig. 3 shows an example of the wind velocity spectrum variations of May 7-8, 1970, at 90 km. The local time is indicated over each curve. The spectra change greatly with altitude.

The harmonic analysis of the experimental data obtained during long-term continuous measurement cycles over the equator has shown that the presence of 3-4 and 8-day periods of the zonal component variation is characteristic of the altitudes of 80-100 km. The main component of the meridional wind velocity is a two-day wave, its amplitude generally exceeding those of both the diurnal and semi-diurnal components.

It is interesting to note that the direction of the steady component of the meridional wind for middle latitude stations and Mogadishu is often convergent: in middle latitudes wind is directed southward and over the equator - northward. The diurnal component amplitude analysis of the meridional wind velocity obtained from Mogadishu, Dushanbe and Kharkov shown similar variations during a year of observations (Fig. 4). There was no such similarity in the zonal component.

Meteorologists pay considerable attention to the epoch of the equinox. Such measurements were carried out in 1968-1970. Fig. 5 shows the diurnal variation of zonal and meridional components from data obtained in the epoch of the vernal equinox (March 1969), local time. The character of wind velocity variations in Mogadishu, Dushanbe and Kharkov in this epoch was practically the same, which is indicative of the global character of the dependence of atmospheric circulation on the tidal mechanism.

On the basis of data obtained in the above-mentioned locations an approximate scheme of atmospheric circulation in the meteor zone is given in BABAJANOV, et al., (1974) for March, June, September and December 1969, for low and middle latitudes.

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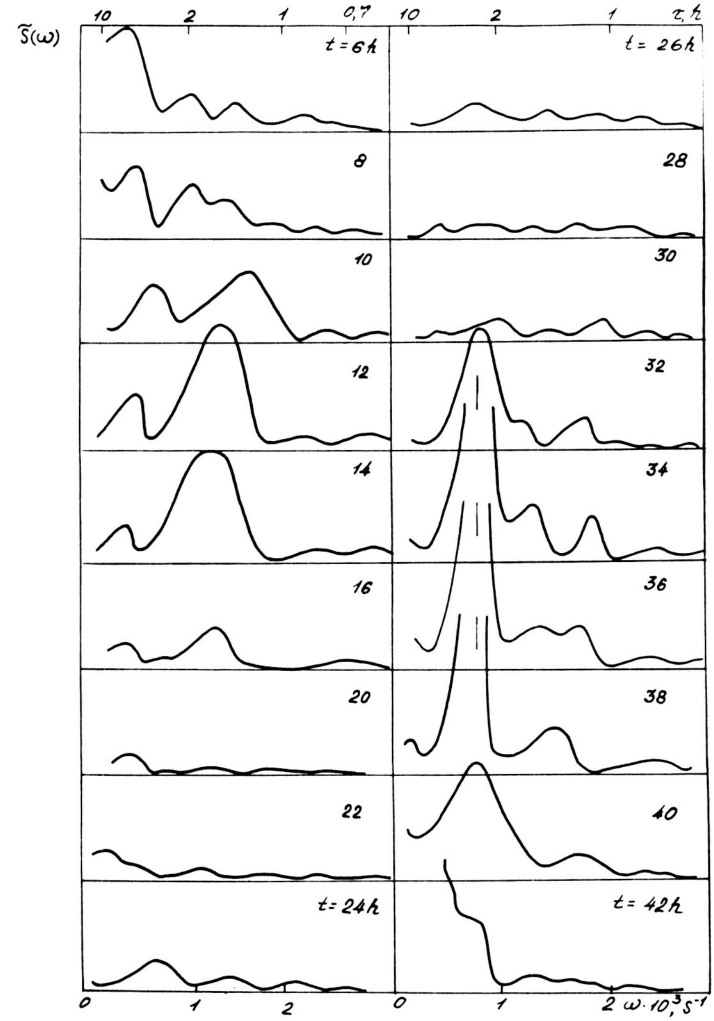

Fig. 3 Variation with local time t of the wind velocity spectrum at 90 km for May 7-8, 1970, over Mogadishu.

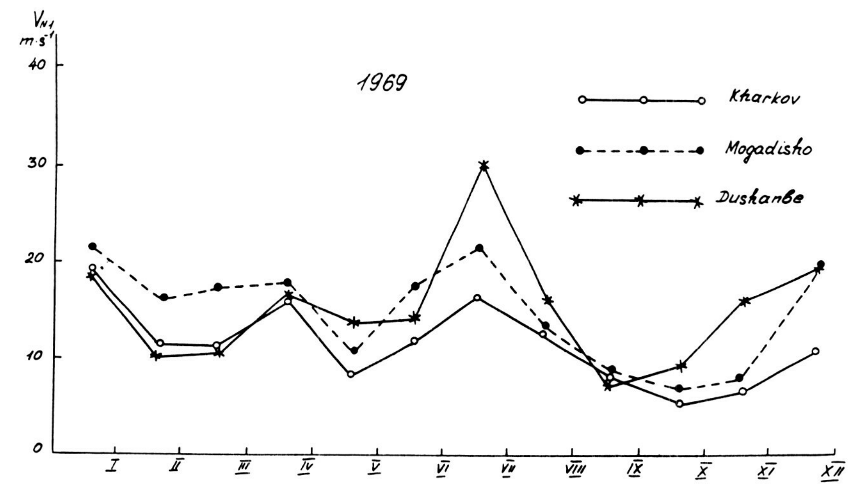

Fig. 4 Monthly mean meridional diurnal amplitudes for Kharkov, Mogadishu and Dushanbe in 1969.

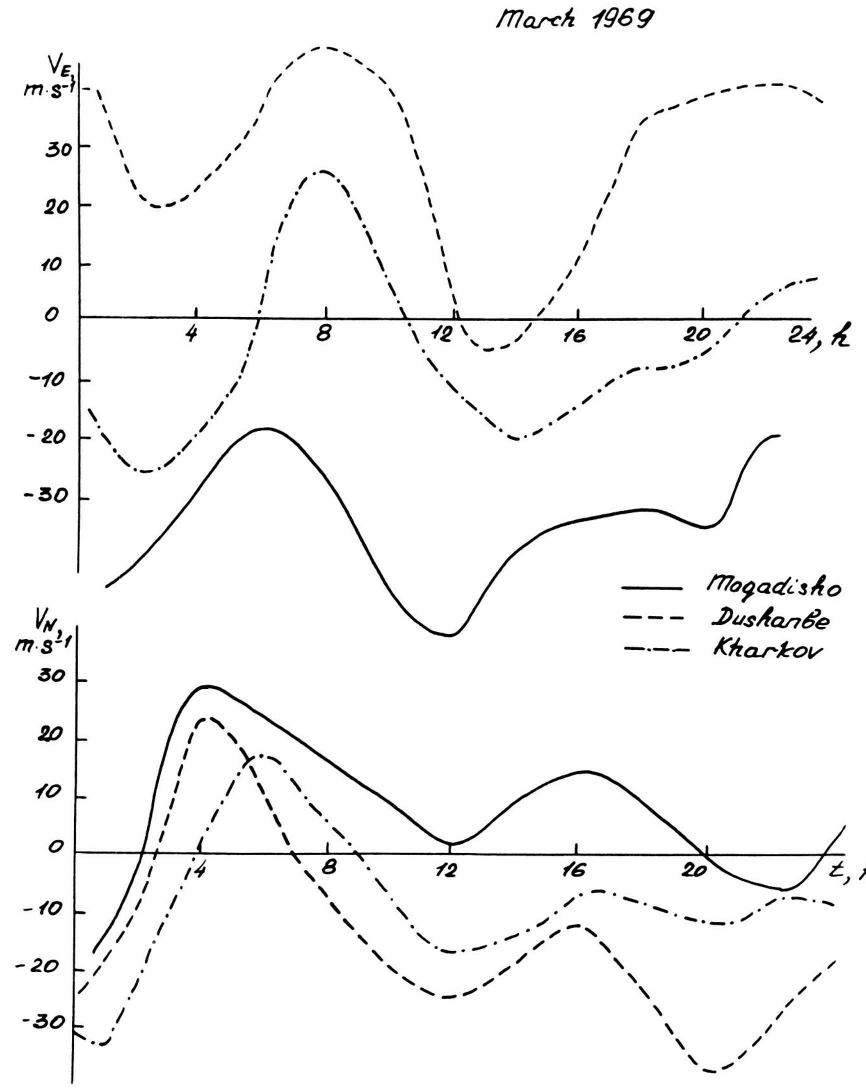

Fig. 5 Diurnal variation of zonal and meridional components obtained in the epoch of the vernal equinox (March 1969), local time.