National Aeronautics and Space Administration
Goddard Space Flight Center
Contract No.NAS-5-12487

ST – AI – 10859

RESULTS OF EXPERIMENTAL STUDIES OF IONOSPHERIC DRIFTS IN EASTERN SIBERIA

by

E. S. Kazimirovskiy &
V. D. Kokourov

(USSR)

25 AUGUST 1969

ST - AI - 10859

RESULTS OF EXPERIMENTAL STUDIES OF IONOSPHERIC DRIFTS IN EASTERN SIBERIA

P R E P R I N T *
Siberian Division of the
USSR Acadmey of Sciences
IRKUTSK, 1968

by E. S. Kazimirovskiy
and V. D. Kokourov
Siberian IZMIRAN

ABSTRACT

The results are communicated of the study of the horizontal drifts of ionization's small-scale inhomogeneities in the ionosphere by the method of spaced reception with small base, conducted in Irkutsk (52°28' N.lat., 104°02' W.long.) during the period from 1957 to 1967.

The results are discussed of measurements for the period of high solar activity alongside with the balance sheet of the special 1965-1966 program.

It is stressed that the basic drift regularities in the IQSY period do not vary substantially by comparison with those in the IGY period.

*
* *

The investigation of dynamics of ionization's small-scale irregularities in the ionosphere above Irkutsk has begun in 1957, when the ionospheric laboratory of the Siberian Izmiran of the USSR Academy of Sciences undertook the preparation of the experimental measurement complex for the study of the horizontal ionospheric drifts.

As of April 1958 regular measurements have been conducted according to the international program using the method of space reception with small base.

---

* Probably destined for publication in the IGY Series "Investigations on Geomagnetism, Aeronomy and Physics of the Sun"- Sub-title: "IONOSPHERE".

The apparatus, method of measurements and the data processing are described in detail in the works [1, 2]. The observations of ionospheric drifts conducted in the course of these years above the city of Irkutsk allowed us to establish the fundamental parameters of motion in the lower (90 - 140 km) as well as upper (185 - 500 km) regions of the ionosphere, the latter corresponding to the F-region. Correspondingly with the conclusions of theory of ionosphere inhomogeneities' formation and motion [3], the results of measurements related to the lower ionosphere are interpreted by us as neutral wind parameters, while the results of measurements related to the upper ionosphere are considered as the parameters of plasma horizontal drift at reflection level.

The characteristics of ionospheric motions in the period of high solar activity are described in detail in [2], where it is shown that in the winter time easterly winds prevail in the lower ionosphere, while westerlies are predominant in the summer. During equinoctial periods the wind directions are quite unstable; however, the motion toward the southeast contributes considerably to wind patterns in these periods. A substantial increase of the prevailing motion velocity was clearly manifest in the winter period. In the upper ionosphere the seasonal course of drift directions was very feebly expressed, i. e. the westerly direction remained predominant in all seasons. The increase of inhomogeneity motion velocity in the autumn-winter period took also place in this region of the ionosphere.

It was ascertained that the basic contribution to daily variations of ionospheric drift velocity is made by the 2400-th, 1200-th and 0800-th hourly wave, whereupon, as a rule, there also exists a constant component in the variations of zonal (U) and meridional (V) velocity components, comparable in magnitude with the amplitude of basic harmonics.

The dimensions of inhomogeneities, estimated by the parameter $\lambda = CT$, where C is the horizontal drift velocity and T in the mean period of radiosignal fading in the period, for which velocity C is computed, were found to be about identical for both regions of the ionosphere: 200 - 300 m for the upper and 200 - 400 m for the lower.

The results of measurements during the period of solar activity drop in 1960 - 1964 have been analyzed in [4]. No substantial departures from those qualitative regularities that were revealed in the IGY period were observed.

By the beginning of the IQSY and, as a result of works performed by a large number of researchers, it became quite clear to us that ionospheric drifts have a statistical character and that, despite a strong variation in time, they are endowed with steady average space-time characteristics. It became indisputable that for a correct quantitative analysis of drift parameters, the conducting of programs of synoptic measurements, analogous to meteorological wind measurements in the free atmosphere, is a necessity. In connection with this the applied observation program, i. e. 3 - 4 days of observations per month, was evidently unacceptable on account of both the small number of data of quantitative nature and of the "smearing" of separate measurements within the investigated time interval.

This is why a special program, namely, monthly intervals of observations in a quarter, was adopted by us at the end of 1965. From 24 to 48 sessions of observations were conducted once or twice in an hour every day. This program was implemented in the periods of the winter solstice 1965-1966, spring and autumn equinoxes of 1966 and the summer solstice of the year 1966. The yearly cycle of observations allowed us to analyze about 5000 recordings, of which 1426 attested to the presence of regular drift order and were valid for quantitative calculations. If we take into account that in the period 1958-1960 the quantitative analysis was based upon 916 registrations [2], the measurement statistics may be acknowledged as satisfactory.

The distributions of velocities and directions of ionospheric drifts separately by seasons for the lower and upper atmosphere are plotted in Figures 1 and 2. Comparing them with analogous distributions for the period of high solar activity [1], it is easy to be convinced that the most probable velocities have become somewhat higher, and this is characteristic for both the lower and upper ionosphere. As to the directions, the prevalence of westward motions in the F-region, the sign change in prevailing directions from winter to summer in the lower ionosphere, the significant scattering of direction in the equinoctial periods, particularly in the lower ionosphere, are all characteristic also of low solar activity. Once must only note the comparatively large

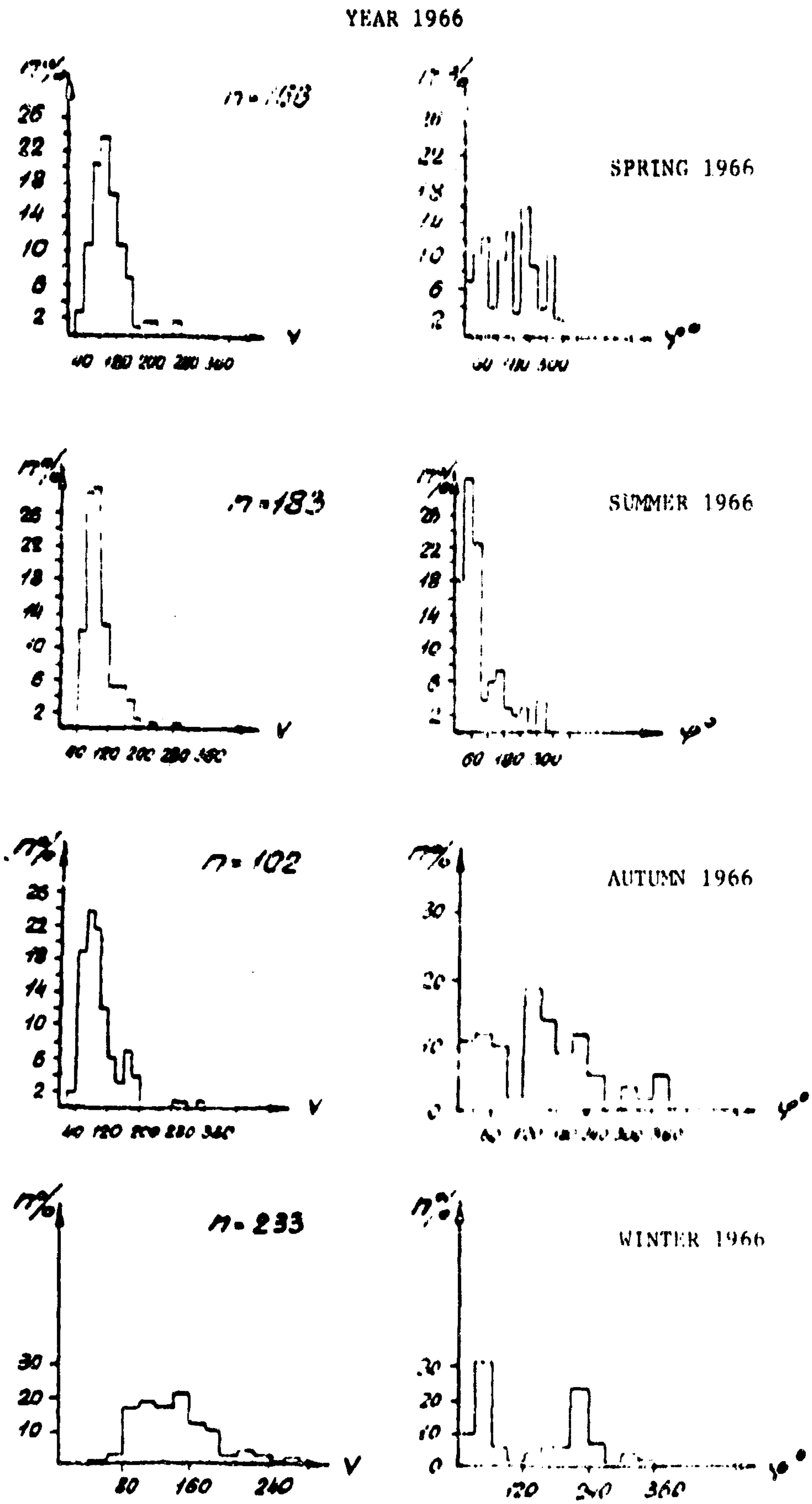

Fig.1
DISTRIBUTION OF VFLOCITIES AND DIRECTIONS OF DRIFT FOR THE LOWER IONONSPHERE

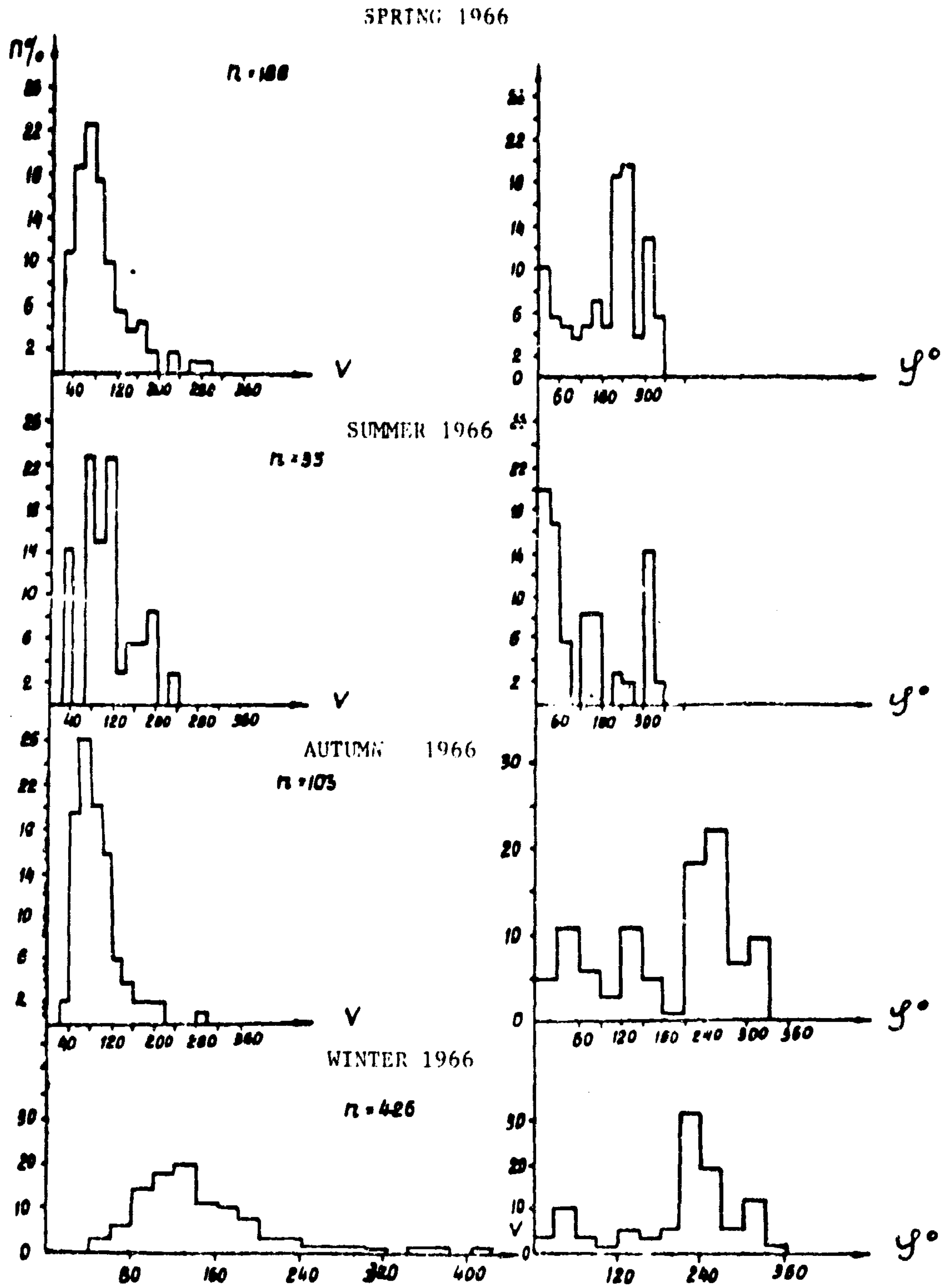

Fig.2

DISTRIBUTION OF VELOCITIES AND DIRECTION OF THE DRIFT LOWER IONOSPHERE. 1966

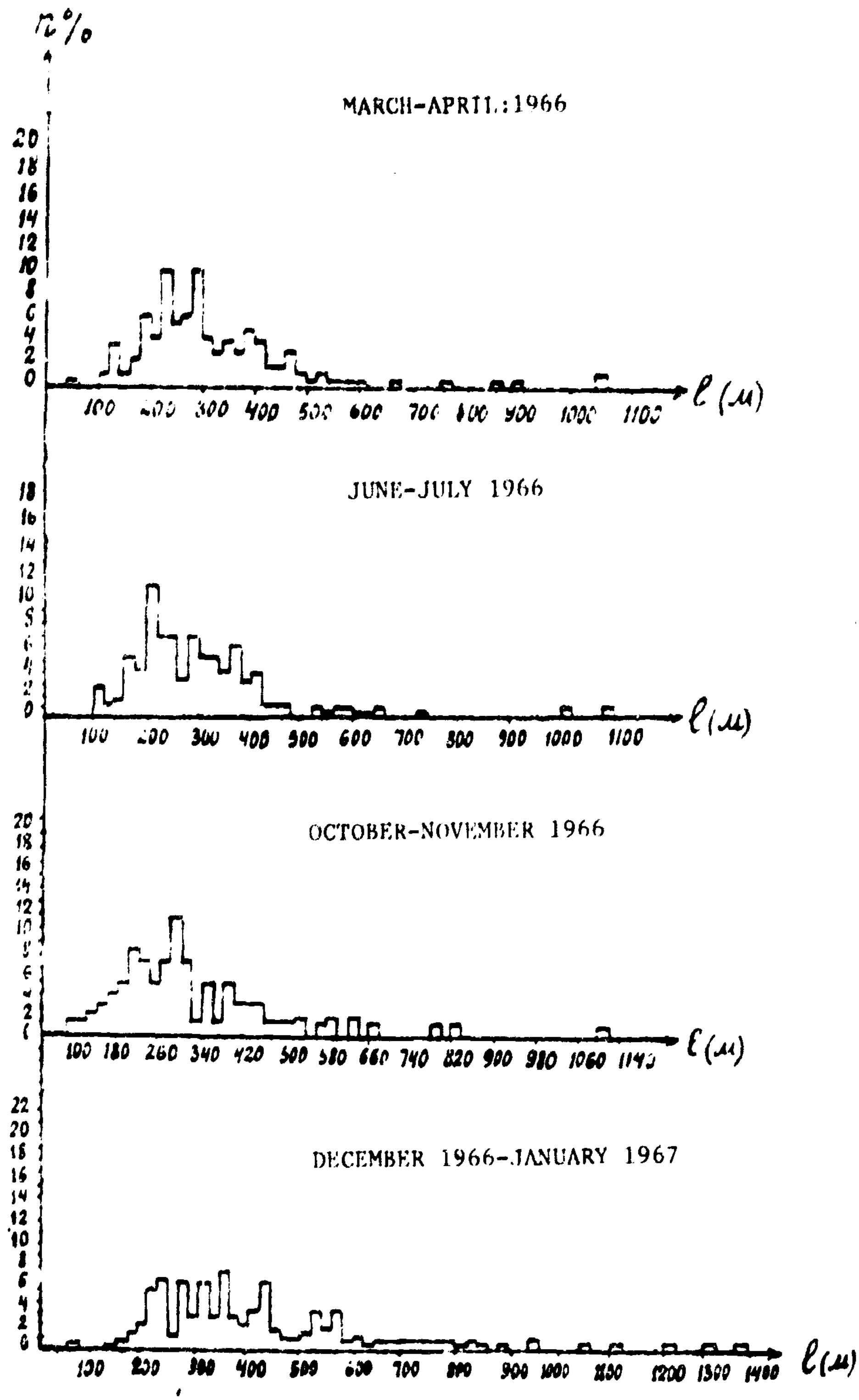

Fig.3

Distribution of dimensions of inhomogeneities
Lower Ionosphere

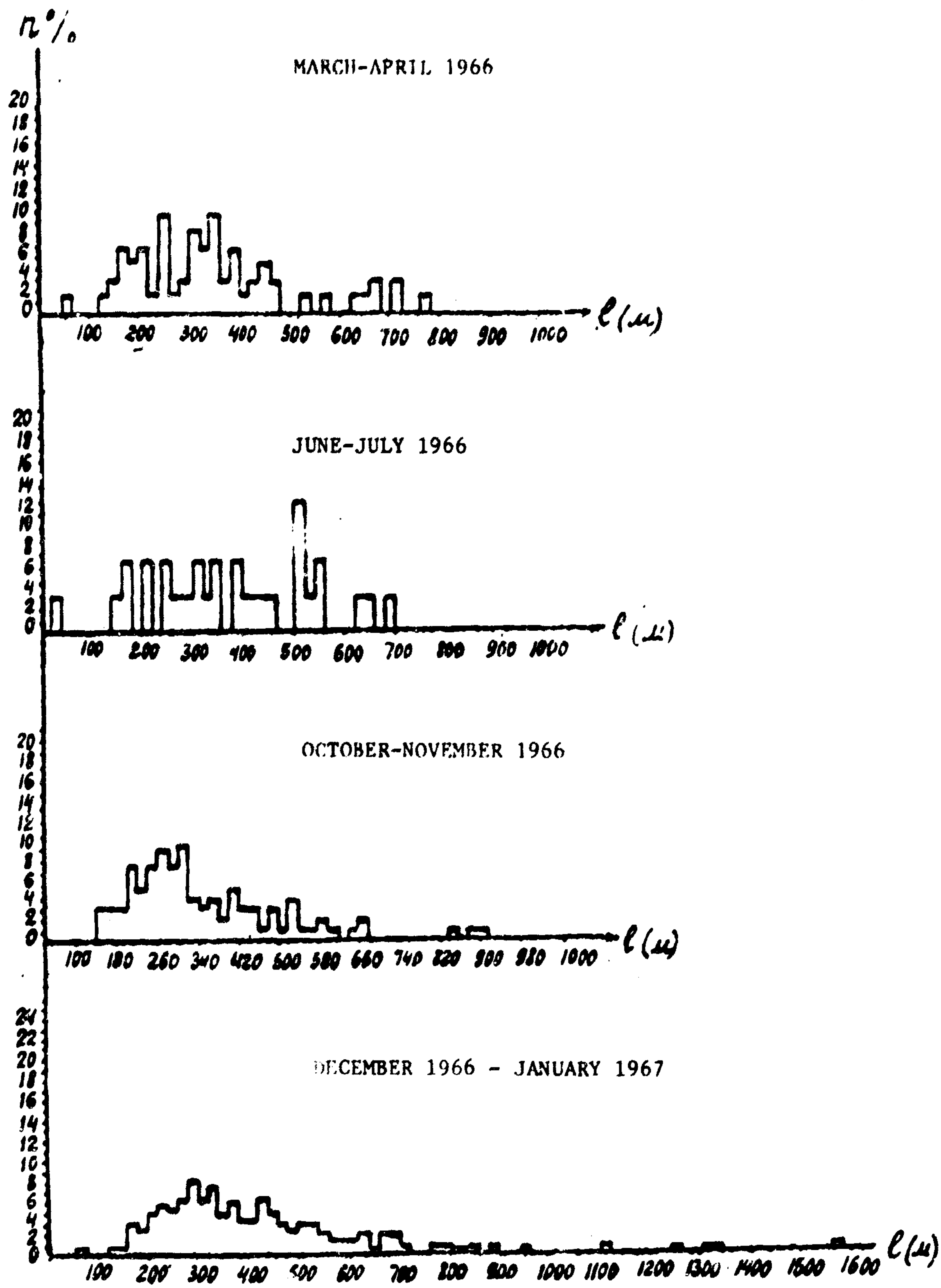

Fig.4

Distribution of dimensions of imhomogeneities
Upper Ionosphere

contribution to wind pattern of directions close to meridional, which is the case in both the E- and F-regions.

Plotted in Figures 3 and 4 are the distributions of parameter λ, characterizing the dimension of the investigated inhomogeneities. It may be seen that the prevailing dimensions are the same as in the IGY period, that is $\sim$ 300 m; only the range of the observed dimensions has increased, and tinier inhomogeneities seem to occur comparatively more often.

Finally, the daily variations of zonal u(t) and merodional V(t) components of drift velocity for the upper and lower ionosphere are respectively shown in Figures 5 and 6. These curves were subject to harmonic analysis, which allowed us to compute the constant components and amplitudes of tidal harmonics, starting from the fact that

$$U, V(t) = A_0 + \sum_{i=1}^{3} A_i \sin (it + \phi_i)_i.$$

The results of computations are compiled in Table 1.

During the seasons when the information on drift velocity was available for all the 24 hours of a day, parameters of third harmonics were determined; when the period of observations did not exceed 12 hours, only the amplitude of the 1200-th hour wave was determined. It may be seen that in the F-region the constant component of zonal velocity, directed westward during all seasons, is quite insignificant. In winter, when drifts in the F_2-region were observed in day and night time, the 2400-th hour wave predominated.

In the E-region the constant component U_0 was found to be substantially greater in summer and autumn than in the spring and particularly in the winter. The eastward direction of the zonal component takes place in the spring, summer and autumn, while in winter its motion to the west is observed.

The meridional component (V_0) of motions is directed toward the equator in both regions in the spring, winter and autumn. In the summer we failed to establish its character for the F-region, while in the lower ionosphere motion toward the pole is observed. It should be noted that V_0 became higher than in the work [2]. Thus, the character of daily variations also did not undergo substantial variations by comparison the IGY period.

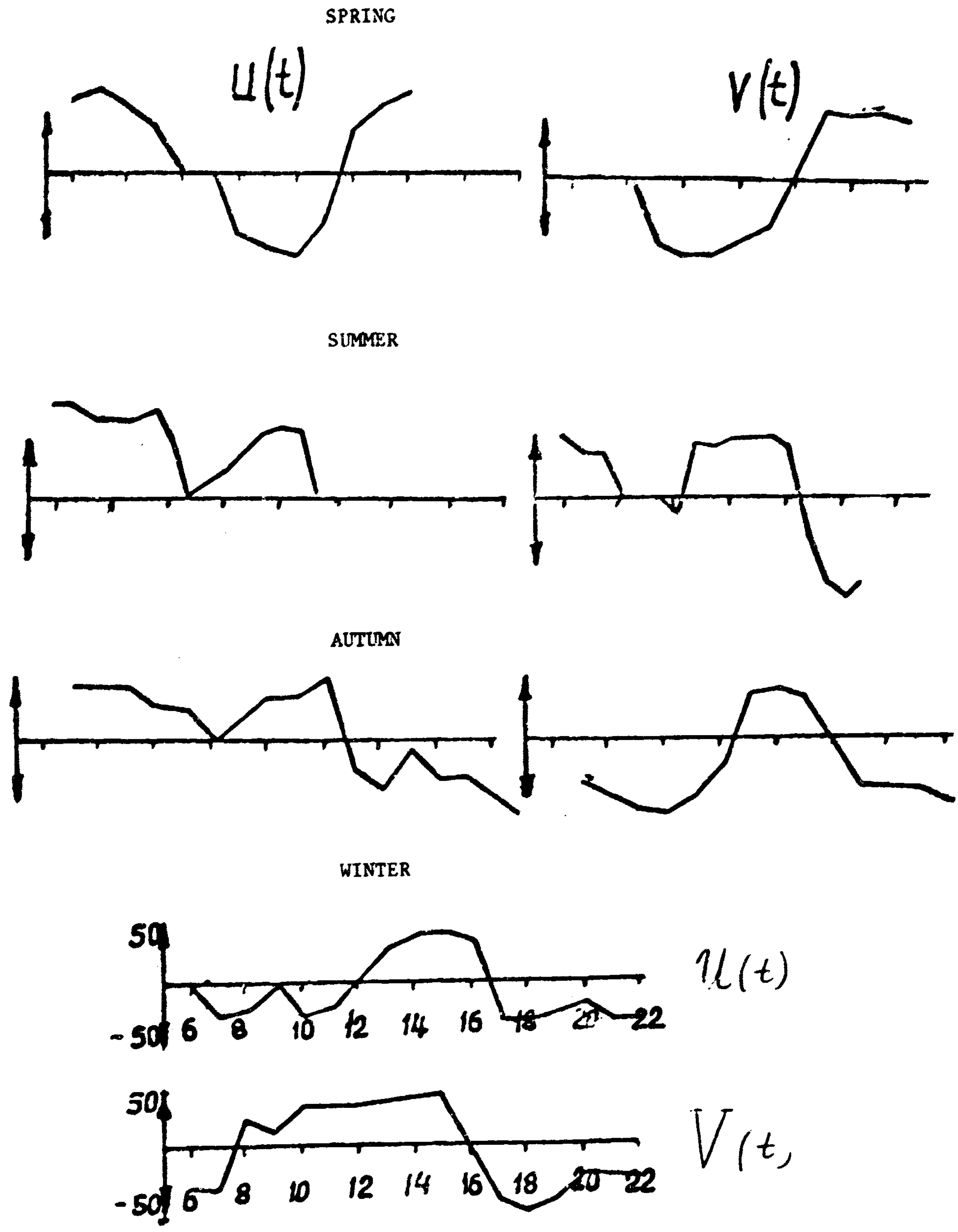

Fig.5. Daily variations of drift velocity (lower ionosphere)
Year 1966

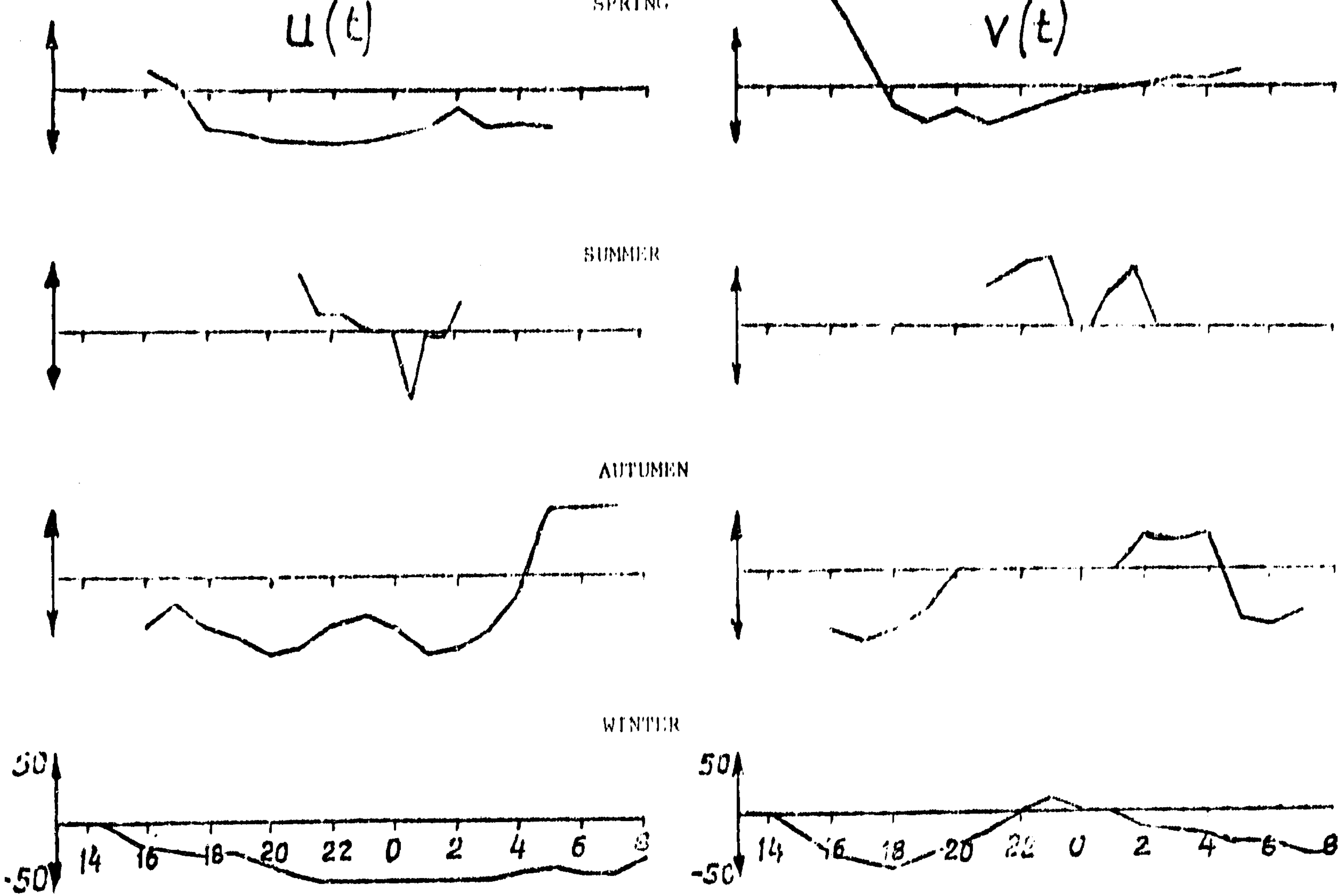

Fig.6

DAILY VARIATIONS OF DRIFT VELOCITY IN THE UPPER IONOSPHERE

TABLE 1

UPPER IONO-SPHERE	u_0 m/sec	u_1 m/sec	u_2 m/sec	u_3 m/sec	ϕ_1 °	ϕ_2 °	ϕ_3 °	V_0 m/sec	V_1 m/sec	V_2 m/sec	V_3 m/sec	ϕ_1 °	ϕ_2 °	ϕ_3 °	
SPRING	-32.7		12.7			123		7.4		21.2			142		(*)
WINTER	-50.4	56.2	21.0	17.1	81.8	58.7	-86.0	-20.5	9.8	16.3	12.4	21.8	61.7	63.7	
AUTUMN	-45.5		8.0			110.0		-5.1		23.2			215.0		(*)

(*) night

LOWER IONO-SPHERE	u_0 m/sec	u_1 m/sec	u_2 m/sec	u_3 m/sec	ϕ_1 °	ϕ_2 °	ϕ_3 °	V_0 m/sec	V_1 m/sec	V_2 m/sec	V_3 m/sec	ϕ_1 °	ϕ_2 °	ϕ_3 °	
SPRING	8.8		70.0			62.0		-4.8		66.2			131.0		(**
SUMMER	39.8	22.5	22.4	28.0	-29.0	77.0	-33.0	18.1	31.4	49.4	12.3	-35.0	-16.0	56.0	
AUTUMN	23.6		10.4			131.0		-23.5		46.1			200.0		
WINTER	-3.8	11.3	23.1	13.6	-62.7	10.3	38.0	-27.2	82.0	34.7	21.2	83.2	83.1	16.0	(**

(**) Daytime

Drawing the balance sheet of the experimental study of ionospheric drifts in Eastern Siberia for the years 1958 - 1966, one may consider that by now the basic regularities of motions are established. Subsequent measurements must be conducted mainly with the view of studying rapidly-varying dynamic processes in the ionosphere, ascertaining the role of horizontal ionization drifts in space-time variations of electron concentration in the ionosphere, improving the method of measurements and processing of information and finally obtaining in the future "climatic" characteristics of ionosphere circulation of numerous years' standing so as to study the relationships of the dynamics of the ionosphere with that of the atmosphere as a whole.

**** T H E E N D ****

REFERENCES

1. E. S. KAZIMIROVSKIY, V. D. KOKOUROV. Sb."Issledovaniye neodnorodnoy struktury i dreyfov v ionosfere" (Investigation of inhomogenous structure and drifts in the ionosphere). Izd-vo "NAUKA". IGY ser. No.4,1960.

2. E. S. KAZIMIROVSKIY, V. D. KOKOUROV. Geomagnetizm i Aeronomiya, 1, 5, 1961

3. V. P. DOKUCHAYEV. Izv. VUZov, Radiofizika, T.4, No.1, 5, 1961.

4. E. S. KAZIMIROVSKIY, V. D. KOKOUROV, Sb."Rezul'taty nablyudeniy i issledovaniy v period MGGS" (Results of Measurements and Investigations in the IQSY). Izd."NAUKA" vyp.2, 105, 1966.

4. E. S. KAZIMIROVSKIY, V. D. KOKOUROV. Geomagnetizm i Aeronomiya, 7, 2, 1967

CONTRACT No.NAS-5-12487
VOLT INFORMATION SCIENCES, INC.
Tel: (301)-577-5200 or
(202)-223-6700

Translated by ANDRE L. BRICHANT
by special request
On 23 August 1969