Adv. Space Res. Vol. 10, No. 8, pp. (8)71–(8)74, 1990
Printed in Great Britain.

0273–1177/90 $0.00 + .50

IONOSPHERIC MAPPING USING SATELLITE DATA OF NATURAL HF NOISE

S. A. Pulinets,* A. Kiraga** and Z. Klos**

*Institute of Terrestrial Magnetism, Ionosphere and Radiowave Propagation (IZMIRAN), U.S.S.R. Academy of Sciences, SU–142092, Troitsk, Moscow Region, U.S.S.R.

**Space Research Center, Polish Academy of Sciences, Ul. Ordona 21, PL–01–237 Warsaw, Poland

ABSTRACT

Natural HF noise measured by the radiospectrometer IRS-1 aboard satellite InterKosmos-19 was used for ionospheric mapping. The topside sounder aboard the satellite KOSMOS-18o9 could also be used to the same end because its AGC voltage corresponds to the natural noise level near the satellite. From the cut-off frequency of the noise spectrum can the distribution of the local plasma density be derived. Global maps could be deduced that can be helpful when modelling the ionosphere.

INTRODUCTION

High Frequency (HF) spectra of electromagnetic noise observed aboard a satellite in the ionosphere manifest a few features that are related with specific ionospheric phenomena and characteristics. The spectra recorded by the radiospectrometer IRS-1 aboard the satellite IK-19 cover a frequency range of o,6 to 6.o MHz /1/: they show a cut-off near the local upper hybrid frequency/2/. When taking due account of the interaction between plasma and antenna, the correct value of the local electron density can be inferred /3/. Provided the sensitivity scale is correctly calibrated, the general structure along the satellite path can simply be perceived from a set of successive spectra along the path. The Automatic Gain Control (AGC) voltage in the receiver of a topside sounder can be used for the same purpose. Figure 1 shows examples of HF spectra recorded aboard IK-19 and of AGC voltage records of the topside sounder IS-338 on KOSMOS-18o9.

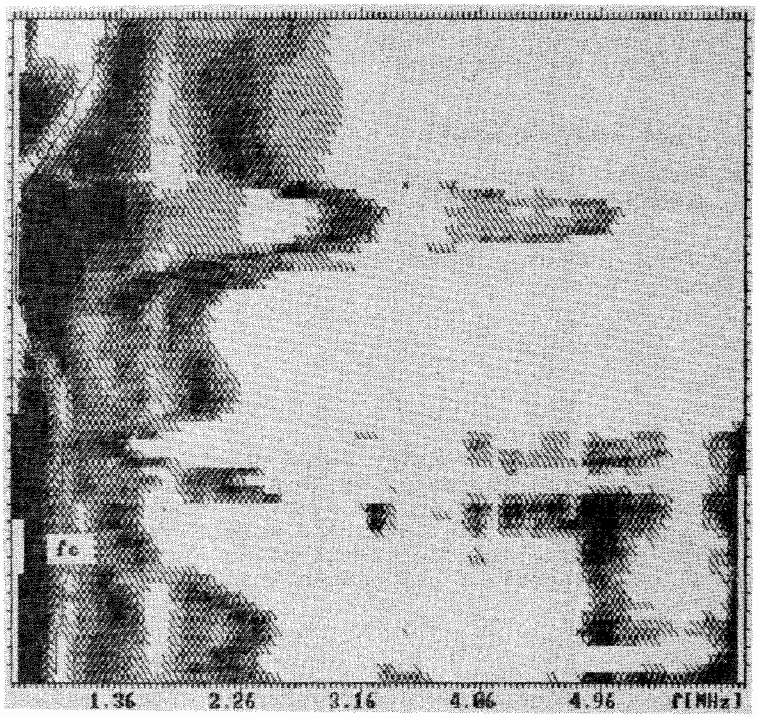
Several ionospheric features can be recognized when considering the variations of the noise level along the satellite orbit, in particular the equatorial anomaly, the main trough, the polar caps and the terminator. Increased noise intensity is observed in the polar regions (in the whistler range and in the upper hybrid range as well); this confirms precipitating electrons as the main noise source in this area. After crossing the terminator, the critical frequency falls rapidly down so that ground-based broadcasting transmitters are received aboard the satellite.

EQUATORIAL ANOMALY

Close to the equator the latitudinal structure of the F-region peak has two humps; this is the equatorial anomaly. The phenomenon is controlled by the terrestrial magnetic field via plasma transport processes and has been studied with different techniques: ground-based ionosondes, topside sounders and incoherent scatter radars. So, a morphological picture of the diurnal, seasonal and solar activity related variations of the phenomenon was obtained, and the effect of geomagnetic activity was studied. It was found that the anomaly extends into the topside where its aspect changes; it remains symmetric to the magnetic equator but is different at different longitudes.

It is known that for solar maximum conditions the equatorial anomaly clearly appears between 19 and 21 h LT /4/. In order to demonstrate the longitudinal effect, we have selected periods when IK-19 was in the equatorial belt and crossed the 5oo to 6oo km height range at about 21 h MLT. Figure 2 was obtained at longitudes of (a) -155° and (b) -125°, respectively. The latitudinal position and the shape of the anomaly are both different: in (a) the

IK19 R: 8308 DATE: 23- 9-1980 UT 21:34: 0.590



LAT	H	L	MLT
64.3	665.2	9.1	12.1
58.3	696.8	6.6	13.1
51.9	729.0	4.6	13.9
45.4	761.0	3.4	14.4
38.7	792.3	2.6	14.8
32.2	821.6	2.1	15.1
25.5	849.7	1.7	15.3
18.8	875.5	1.5	15.5
12.1	898.5	1.3	15.7
5.4	918.2	1.2	15.9
-1.3	934.5	1.2	16.1
-7.9	947.2	1.2	16.2
-14.5	955.9	1.2	16.4
-20.9	960.7	1.2	16.5
-27.4	961.8	1.3	16.7
-33.9	958.9	1.4	16.9
-40.3	952.4	1.5	17.0
-46.6	942.3	1.6	17.3
-52.8	928.9	1.9	17.5
-58.8	912.4	2.2	17.8
-64.4	893.3	2.7	18.2
-69.2	872.2	3.4	18.8
-72.8	848.7	4.3	19.5
-74.1	823.6	5.4	20.4
-72.5	797.2	6.4	21.6
-68.7	770.0	6.7	22.9
-63.5	742.3	6.2	5.4
-57.5	714.4	5.1	1.1
-51.1	686.9	4.0	1.8
-44.5	660.5	3.1	2.3
-37.6	634.4	2.4	2.7
-30.5	609.6	1.9	3.0
-23.3	586.3	1.5	3.3
-16.0	564.8	1.3	3.5
-8.7	545.5	1.1	3.8
-1.2	528.5	1.0	4.0
6.2	514.3	1.0	4.2

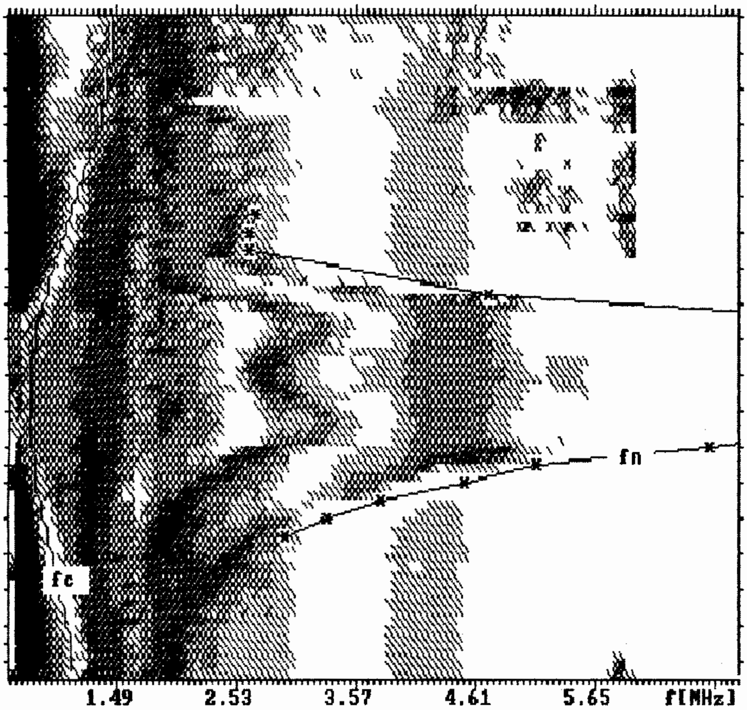
COSMOS-1809 R: 735 DATE: 09-02-1987 UT 09:47:33

H: 960-995 km

LAT	LONG	L	MLT
13.42	83.76	1.08	15.41
-19.72	85.80	1.50	15.50
-56.02	91.59	8.34	15.65
-81.90	191.39	18.93	03.12
-49.70	246.25	2.02	03.39
-13.37	250.63	1.17	03.42
23.33	252.95	1.58	03.41
59.63	259.90	9.38	03.32

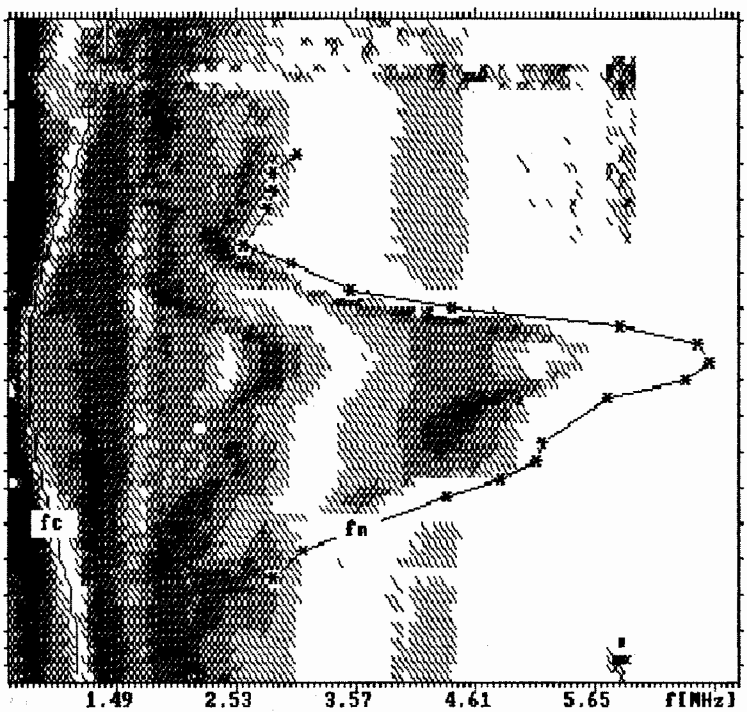
Fig. 1. Sequences of (a - top-) spectra and (b - bottom-) AGC voltages along the orbits of satellites, (a) IK-19 and (b) KOSMOS-1809, respectively. Intensity scale is linear in dB, reaching from 13 dB/μV (white) to 40 dB/μV (black).

IK19 R: 1511 DATE: 12- 6-1979 UT 7:23: 8.710



LAT	LON	H	MLT
-70.5	160.0	500.8	20.2
-65.3	174.7	499.6	20.7
-59.1	-175.9	494.8	20.9
-52.3	-169.7	494.6	21.0
-45.5	-165.3	498.5	21.1
-38.3	-162.0	506.7	21.2
-31.0	-159.4	518.7	21.3
-23.6	-157.2	534.1	21.3
-16.3	-155.3	552.6	21.4
-8.9	-153.6	573.7	21.4
-1.6	-152.0	597.0	21.5
5.7	-150.4	622.1	21.5
12.8	-148.8	647.9	21.5
19.9	-147.1	675.2	21.6
26.9	-145.2	703.0	21.6
33.9	-143.0	731.0	21.7
40.7	-140.4	758.8	21.7
47.3	-137.1	786.2	21.8
53.7	-132.7	812.8	21.9

IK19 R: 1510 DATE: 12- 6-1979 UT 5:43:28.550



LAT	LON	H	MLT
-70.5	-174.8	500.9	20.2
-65.3	-160.1	499.7	20.6
-59.1	-150.8	494.9	20.8
-52.3	-144.5	494.6	21.0
-45.4	-140.2	498.5	21.1
-38.2	-136.9	506.6	21.2
-30.9	-134.2	518.5	21.3
-23.6	-132.0	533.9	21.4
-16.2	-130.2	552.3	21.4
-8.9	-128.5	573.4	21.5
-1.5	-126.9	596.7	21.5
5.7	-125.3	621.7	21.6
12.8	-123.7	647.5	21.7
19.9	-122.0	674.7	21.7
27.0	-120.1	702.5	21.8
33.9	-117.9	730.5	21.9
40.7	-115.2	758.4	22.0
47.3	-111.9	785.8	22.1
53.7	-107.6	812.3	22.3

Fig. 2. Electron density distribution (blackening) derived from noise records at longitudes of (a - top-) -155° and (b - bottom) -126°E. Stars: local electron density from topside sounder. Density is lower at position (b).

shape is symmetric, in (b) it is asymmetric. Figure 3 shows latitudinal cross sections of the electron density at nine different longitudes as recorded aboard the satellite IK-19, No. 2 and 3 corresponding to (a) and (b) of Figure 2. The comparison shows the utility of HF monitoring.

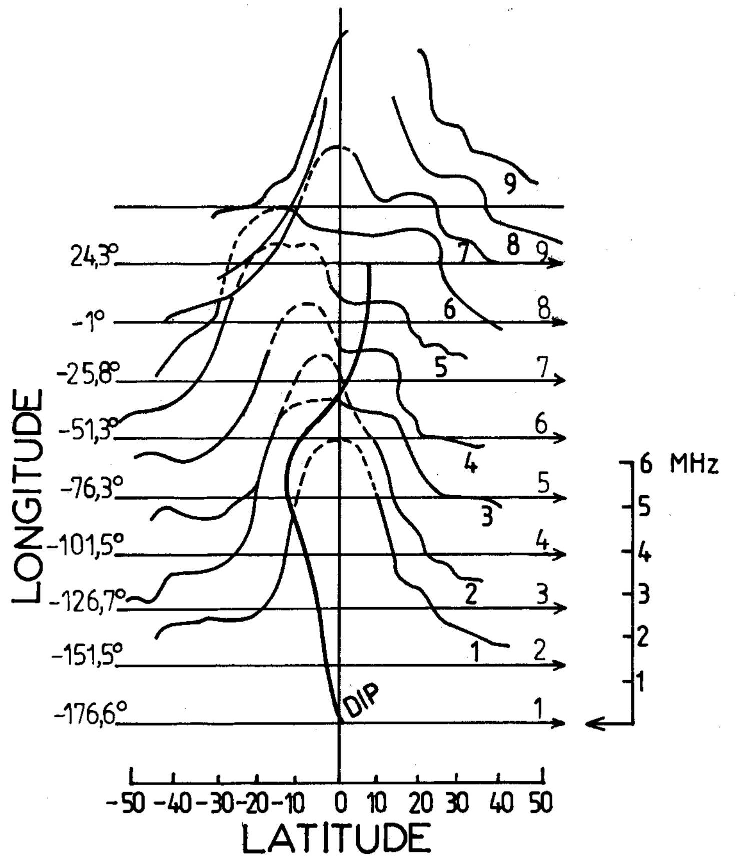


Fig. 3. Latitudinal electron density distribution at nine longitudes observed by IK-19 on 12 June 1979, 21 h MLT.

CONCLUSION

The examples presented above show that a global picture of the ionospheric structure can well be derived from natural noise data, for certain features even in a more comprehensive manner than from topside sounding. Such topics are, for example, the plasma patterns of ionospheric irregularities, in particular in the polar and equatorial areas. So, the new technique of HF noise recording may become a powerful tool for ionospheric mapping.

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