Space plasma environment at high and polar latitudes by the Cosmos 1809 satellite topside sounder data

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Abstract

The paper presents results of Cosmos 1809 satellite topside sounder data processing. Analogous records of topside ionograms collected during the icebreaker Sibir' cruise to the North Pole in 1987 were transformed in the digital ionograms dataset for the more than 90 cross-pole passes (more than 8000 ionograms). For different plasma conditions ($f_p>f_{he}$ and $f_p<f_{he}$) we demonstrate the power of topside sounding using not only traditional critical frequency and vertical profile parameters but also the plasma resonances distribution, natural emissions registered both on ionograms and on dynamic spectrograms created from AGC records which permit to map magnetospheric structures.

1. Introduction

This work is a result of the fourth stage of the Russian topside sounding database rescue project started with NASA grant NRA 98-OSS-03(5.2) "Intercosmos-19 topside sounder data rescue project" in 1999. Present experiment was conducted onboard the icebreaker Sibir' during its cruise in summer 1987 [1]. Data were transmitted by 137 MHz analogous telemetry from Cosmos 1809 satellite and recorded on tape recorder. In 2010-2011 the recorded ionograms were digitized and special software was created to scale ionograms and calculate the topside profiles. Example of digitized ionogram is presented in Fig. 1. The database includes period of the vessel cruise from 8 of May till 18 of June 1987 and contains more than 8000 topside ionograms. Their spatial distribution is uniform in longitudes (see Fig. 2). It should be noted that we deal with completely sunlit ionosphere (close to the summer solstice) during the minimum of solar cycle. So it would be interesting to monitor the MLT dependence in sunlit conditions. The geomagnetic conditions were quiet except period at the end of May and small geomagnetic storm (near -60 nT) on 6 of June.

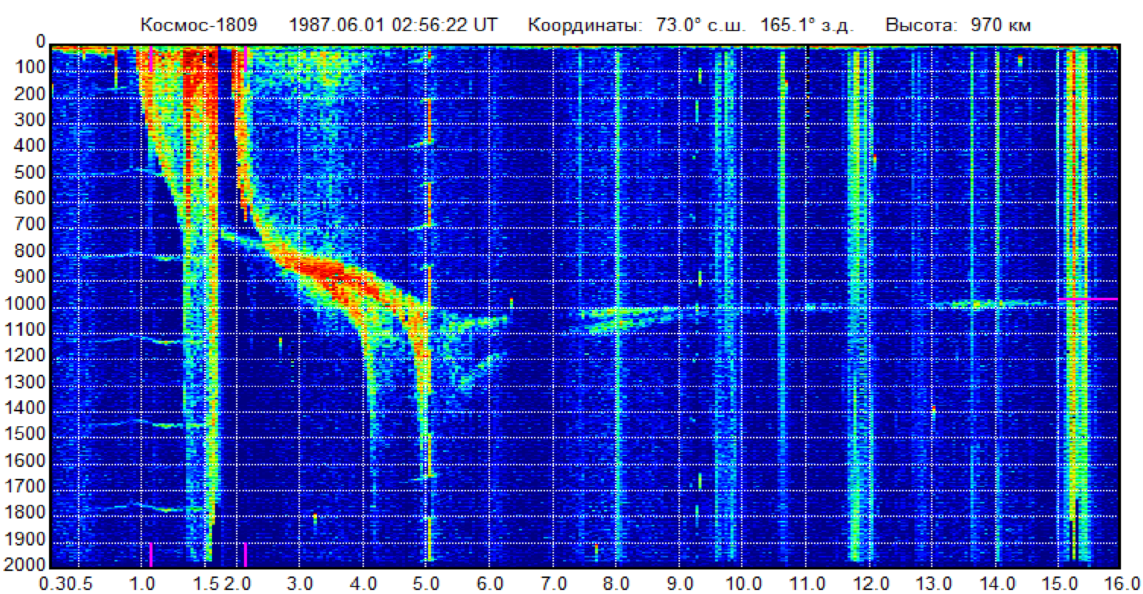

Fig. 1 Example of the Cosmos 1809 topside ionograms for the North Pole cruise database

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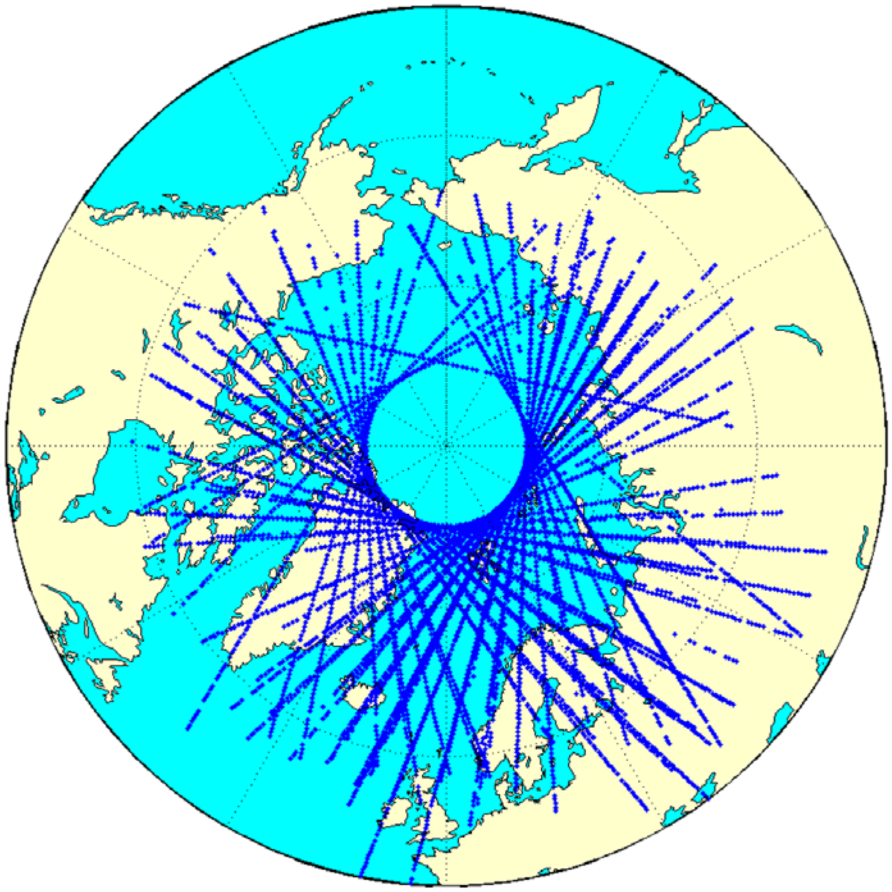

Fig. 2 Cosmos 1809 satellite passes distribution registered during the icebreaker Sibir' North Pole cruise

2. Topside Profiles and Critical Frequency Variations

We calculated topside profiles for different locations of the satellite (main trough, auroral oval, polar cup, different MLT) and produced the latitudinal plots of the critical frequency *foF2* variations. The differences of the profile parameters are discussed.

3. Dynamic HF Spectra as a Source for the Mapping of Magnetospheric Regions on Ionosphere

The dynamic HF Spectra diagram produced from ionosondes Automatic Gain Control (AGC) data is presented in Fig. 3. Such presentation gives opportunity to locate the auroral oval position through the mapping of quasi-AKR emissions registered on HF noises spectra [2]. Cusp location can also be determined from the emission of particles registered in the cusp region. Main trough and equatorial anomaly positions can be determined by studying the envelope of noises from broadcast transmitters penetrating into the topside ionosphere at frequencies higher than critical frequency *foF2*.

4. Plasma Resonances

Plasma resonances were scaled by semi-automatic processing software and resonances distribution in p-q coordinates where $p = f_p/f_{he}$ and $q = f/f_p$. The difference of plasma resonances distribution for cases of $f_p > f_{he}$ and $f_p < f_{he}$ is considered.

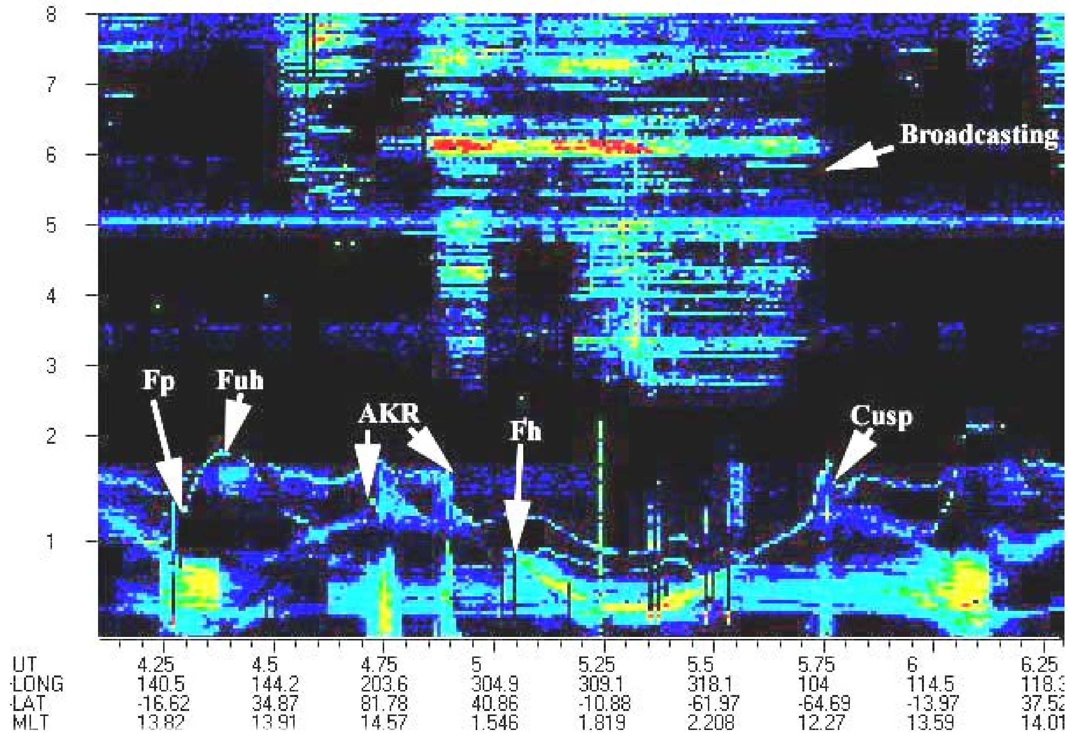

Fig. 3 Example of dynamic HF emissions spectra constructed from AGC signal of Cosmos 1809 topside sounder

5. Natural Wideband Noises

Except plasma resonances stimulated by the powerful pulses of topside sounder transmitter the wide band noises are often observed on the ionograms. It was demonstrated [3] that the p-q diagram in different latitudinal regions and different morphological structures (auroral oval, main ionospheric trough, cusp projection) show the different pattern manifesting different physical mechanism of registered noises.

6. Complex ionograms

Some part of topside ionograms demonstrates the multiple traces implying reflection from additional structure on auroral ionosphere. We were able to identify at least two of them: reflections from auroral electrojet during magnetically disturbed periods and reflections from the walls of main ionospheric trough.

7. References

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3. S. A. Pulinets, “The wave processes within the Earth's ionosphere as a means for ionospheric plasma diagnostics”, Doctor of Physics and Mathematics Thesis, IZMIRAN, Moscow, 1990, 315 p.